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IEC 61158-2

Edition 6.0 2014-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition

Réseaux de communication industriels – Spécifications des bus de terrain – Partie 2: Spécification et définition des services de la couche physique

IEC 61158-2:2014-07(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 2: Physical layer specification and service definition

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NOTE Combinations of protocol types are specified in IEC 61784-1 and IEC 61784-2.

International Standard IEC 61158-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This sixth edition cancels and replaces the fifth edition published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

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- new Type 20 specification in 3.12, 4.1.11, 4.2.11, 5.12, Clause 34 and Annex T;
- new Type 24 specification in 3.11, 4.2.10, 5.11, 6.9, 9.12, Clause 33 and Annex S;
- Clause 17 Type 1: Medium attachment unit: radio signaling deleted due to lack of support;
- RS232 media specification for Type 4 removed, because it is not in use any more.

The text of this standard is based on the following documents:

FDIS	Report on voting
65C/758A/FDIS	65C/775/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with ISO/IEC Directives, Part 2.

NOTE Slight variances from the directives have been allowed by the IEC Central Office to provide continuity of subclause numbering with prior editions.

The list of all the parts of the IEC 61158 series, published under the general title *Industrial communication networks – Fieldbus specifications,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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0 Introduction

0.1 General

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the “three-layer” fieldbus reference model described in IEC 61158-1.

0.2 Physical layer overview

The primary aim of this standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer Ph-entities at the time of communication.

The physical layer receives data units from the data-link Layer, encodes them, if necessary by adding communications framing information, and transmits the resulting physical signals to the transmission medium at one node. Signals are then received at one or more other node(s), decoded, if necessary by removing the communications framing information, before the data units are passed to the data-link Layer of the receiving device.

0.3 Document overview

This standard comprises physical layer specifications corresponding to many of the different DL-Layer protocol Types specified in IEC 61158 series.

NOTE 1 The protocol Type numbers used are consistent throughout the IEC 61158 series.

NOTE 2 Specifications for Types 1, 2, 3, 4, 8, 16, 18, 20 and 24 are included. Type 7 uses Type 1 specifications. The other Types do not use any of the specifications given in this standard.

NOTE 3 For ease of reference, Type numbers are given in clause names. This means that the specification given therein applies to this Type, but does not exclude its use for other Types.

NOTE 4 It is up to the user of this standard to select interoperating sets of provisions. Refer to IEC 61784-1 or IEC 61784-2 for standardized communication profiles based on the IEC 61158 series.

A general model of the physical layer is shown in Figure 1.

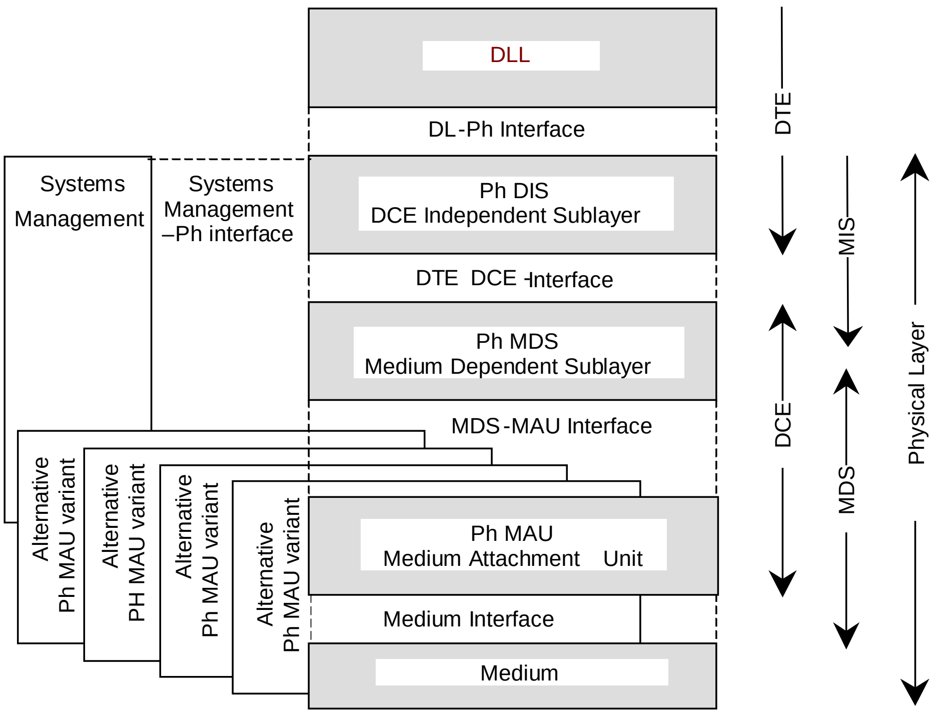

Figure 1 – General model of physical layer

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NOTE 5 The protocol types use a subset of the structure elements.

NOTE 6 Since Type 8 uses a more complex DIS than the other types, it uses the term MIS to differentiate.

The common characteristics for all variants and types are as follows:

- digital data transmission;
- no separate clock transmission;
- either half-duplex communication (bi-directional but in only one direction at a time) or full-duplex communication.

0.4 Major physical layer variations specified in this standard

0.4.1 Type 1 media

0.4.1.1 Type 1: Wire media

For twisted-pair wire media, Type 1 specifies two modes of coupling and different signaling speeds as follows:

a) voltage mode (parallel coupling), 150 Ω, data rates from 31,25 kbit/s to 25 Mbit/s;
b) voltage mode (parallel coupling), 100 Ω, 31,25 kbit/s;
c) current mode (serial coupling), 1,0 Mbit/s including two current options.

The voltage mode variations may be implemented with inductive coupling using transformers. This is not mandatory if the isolation requirements of this standard are met by other means.

The Type 1 twisted-pair (or untwisted-pair) wire medium physical layer provides the options:

- no power via the bus conductors; not intrinsically safe;
- power via the bus conductors; not intrinsically safe;
- no power via the bus conductors; intrinsically safe;
- power via the bus conductors; intrinsically safe.

0.4.1.2 Type 1: Optical media

The major variations of the Type 1 optic fiber media are as follows:

- dual fiber mode, data rates from 31,25 kbit/s to 25 Mbit/s;
- single fiber mode, 31,25 kbit/s.

0.4.2 Type 2: Coaxial wire and optical media

Type 2 specifies the following variants:

- coaxial copper wire medium, 5 Mbit/s;
- optical fiber medium, 5 Mbit/s;
- network access port (NAP), a point-to-point temporary attachment mechanism that can be used for programming, configuration, diagnostics or other purposes;
- repeater machine sublayers (RM, RRM) and redundant physical layers.

0.4.3 Type 3: Twisted-pair wire and optical media

Type 3 specifies the following synchronous transmission:

a) twisted-pair wire medium, 31,25 kbit/s, voltage mode (parallel coupling) with the options:
   - power via the bus conductors: not intrinsically safe;
   - power via the bus conductors: intrinsically safe;

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and the following asynchronous transmission variants:

b) twisted-pair wire medium, up to 12 Mbit/s, ANSI TIA/EIA-485-A;

c) optical fiber medium, up to 12 Mbit/s, with type A4a of IEC 60793-2-40 and type A3c of IEC 60793-2-30.

0.4.4 Type 4: Wire medium

Type 4 specifies wire media with the following characteristics:

– RS-485 wire medium up to 76,8 kbit/s;

0.4.5 Type 8: Twisted-pair wire and optical media

The physical layer also allows transmitting data units that have been received through a medium access by the transmission medium directly through another medium access and its transmission protocol to another device.

Type 8 specifies the following variants:

– twisted-pair wire medium, up to 16 Mbit/s;
– optical fiber medium, up to 16 Mbit/s.

The general characteristics of these transmission media are as follows:

– full-duplex transmission;
– non-return-to-zero (NRZ) coding.

The wire media type provides the following options:

– no power supply via the bus cable, not intrinsically safe;
– power supply via the bus cable and on additional conductors, not intrinsically safe.

0.4.6 Type 12: Wire medium

Type 12 specifies wire media with the following characteristics:

– LVDS wire medium up 100 Mbit/s.

0.4.7 Type 16: optical media

Type 16 specifies a synchronous transmission using optical fiber medium, at 2 Mbit/s, 4 Mbit/s, 8 Mbit/s and 16 Mbit/s.

0.4.8 Type 18: Media

0.4.8.1 Type 18: Basic media

The Type 18-PhL-B specifies a balanced transmission signal over a shielded 3-core twisted cable. Communication data rates as high as 10 Mbit/s and transmission distances as great as 1,2 km are specified.

0.4.8.2 Type 18: Powered media

The Type 18-PhL-P specifies a balanced transmission signal over a 4-core unshielded cable in both flat and round configurations with conductors specified for communications signal and network-embedded power distribution. Communication data rates as high as 2,5 Mbit/s and transmission distances as great as 500 m are specified.

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0.4.9 Type 20: Media

Type 20 uses binary phase continuous Frequency Shift Keying (FSK). A relatively high frequency current is superimposed on a low-frequency analog current, which is usually in 4 mA to 20 mA range. The digital signal and analog signal share the same medium, but differ in frequency contents. The communicating devices signal with either current or voltage, and all signaling appear as voltage when sensed across low impedance. Thus digital signaling is an extension of conventional analog signaling.

The physical layer commonly uses twisted pair copper cable as its medium and provides solely digital or simultaneous digital and analog communication to distances of at least 1 500 m (ca. 5 000 feet). Maximum communication distances vary depending on network construction and environmental conditions.

0.4.10 Type 24: Media

Type 24 specifies twisted-pair wire medium at 10 Mbit/s. The general characteristics of this transmission medium are as follows;

- ANSI TIA/EIA-485-A bus interface with galvanic isolation using transformer;
- half-duplex transmission;
- Manchester coding.

0.5 Patent declaration

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning Type 2 given in Subclauses 5.3, 9.4, 10.4, Clauses 18 through 20, Annex F through Annex H, as follows:

US 5,396,197 Network Node TAP

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 2: Physical layer specification and service definition

1 Scope

This part of IEC 61158 specifies the requirements for fieldbus component parts. It also specifies the media and network configuration requirements necessary to ensure agreed levels of

a) data integrity before data-link layer error checking;

b) interoperability between devices at the physical layer.

The fieldbus physical layer conforms to layer 1 of the OSI 7-layer model as defined by ISO 7498 with the exception that, for some types, frame delimiters are in the physical layer while for other types they are in the data-link layer.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies."

NOTE All parts of the IEC 61158 series, as well as IEC 61784-1 and IEC 61784-2 are maintained simultaneously. Cross-references to these documents within the text therefore refer to the editions as dated in this list of normative references.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-14:2007, *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

IEC 60079-25, *Explosive atmospheres – Part 25: Intrinsically safe electrical systems*

IEC 60169-17, *Radio-frequency connectors – Part 17: R.F. coaxial connectors with inner diameter of outer conductor 6,5 mm (0,256 in) with screw coupling – Characteristic impedance 50 ohms (Type TNC)*

IEC 60189-1:2007, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods*

IEC 60255-22-1:1988[1], *Electrical relays – Part 22-1: Electrical disturbance tests for measuring relays and protection equipment – Section 1: 1 MHz burst disturbance tests*

IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

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IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60603-7-4, *Connectors for electronic equipment – Part 7-4: Detail specification for 8-way, unshielded, free and fixed connectors, for data transmissions with frequencies up to 250 MHz*

IEC 60754-2, *Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity*

IEC 60793 (all parts), *Optical fibres*

IEC 60793-2-30:2012, *Optical fibres – Part 2-30: Product specifications – Sectional specification for category A3 multimode fibres*

IEC 60793-2-40:2009, *Optical fibres – Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres*

IEC 60794-1-2:2003[2], *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*

IEC 60807-3, *Rectangular connectors for frequencies below 3 MHz – Part 3: Detail specification for a range of connectors with trapezoidal shaped metal shells and round contacts – Removable crimp contact types with closed crimp barrels, rear insertion/rear extraction*

IEC 60811-403, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 403: Miscellaneous tests – Ozone resistance test on cross-linked compounds*

IEC 60811-404:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 404: Miscellaneous tests – Mineral oil immersion tests for sheaths*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test* (Basic EMC Publication)

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test* (Basic EMC Publication)

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 44: Testing and measurement techniques — Electrical fast transient/burst immunity test* (Basic EMC Publication)

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IEC 61158-3-20:2014, *Industrial communication networks – Fieldbus specifications – Part 3-20: Data-link layer service definition – Type 20 elements*

IEC 61158-4-2:2014, *Industrial communication networks – Fieldbus specifications – Part 4-2: Data-link protocol specification – Type 2 elements*

2 There exists a new edition of IEC 60794-1-2 (2013). This will be considered in the next edition of IEC 61158-2.

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IEC 61158-4-3:2014, *Industrial communication networks – Fieldbus specifications – Part 4-3: Data-link protocol specification – Type 3 elements*

IEC 61169-8:2007, *Radio-frequency connectors – Part 8: Sectional specification – RF coaxial connectors with inner diameter of outer conductor 6,5 mm (0,256 in) with bayonet lock – Characteristic impedance 50 Ω (type BNC)*

IEC 61210:2010, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

IEC 61754-2, *Fibre optic connector interfaces – Part 2: Type BFOC/2,5 connector family*

IEC 61754-13, *Fibre optic connector interfaces – Part 13: Type FC-PC connector*

IEC 61754-22, *Fibre optic connector interfaces – Part 22: Type F-SMA connector family*

ISO/IEC 7498 (all parts), *Information technology – Open Systems Interconnection – Basic Reference Model*

ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 8482, *Information technology – Telecommunications and information exchange between systems – Twisted pair multipoint interconnections*

ISO/IEC 8802-3, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO 9314-1, *Information processing systems – Fibre Distributed Data Interface (FDDI) Part 1: Token Ring Physical Layer Protocol (PHY)*

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ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

ANSI TIA/EIA-422-B, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits*

ANSI TIA/EIA-485-A, *Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

ANSI TIA/EIA-644-A, *Electrical Characteristics of Low Voltage Differential Signaling (LVDS) Interface Circuits*

3 Terms and definitions

For the purposes of this document, the terms and definitions of ISO/IEC 7498, and the following definitions apply.

3.1 Common terms and definitions

NOTE Many definitions are common to more than one protocol type; they are not necessarily used by all protocol types.

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3.1.1
activity
presence of a signal or noise at the input terminals of a fieldbus device that is of a level that is above the receiver signal level threshold of that device

3.1.2
barrier
physical entity that limits current and voltage into a hazardous area in order to satisfy intrinsic safety requirements

3.1.3
bit
unit of data consisting of a 1 or a 0

Note 1 to entry: A bit is the smallest data unit that can be transmitted.

3.1.4
bus
trunk and all devices connected to it

3.1.5
cable plant interface connector
CPIC
point at which test and conformance measurements are made and that the interface between the network device and the cable plant

3.1.6
communication element
part of a fieldbus device that communicates with other elements via the bus

3.1.7
connector
coupling device employed to connect the medium of one circuit or communication element with that of another circuit or communication element

3.1.8
coupler
physical interface between trunk and spur or trunk and device

3.1.9
Data Communications Equipment
DCE
embodiment of the media, modulation and coding-dependent portion of a fieldbus-connected device, comprising the lower portions of the physical layer within the device

3.1.10
Data Terminal Equipment
DTE
embodiment of the media, modulation and coding-independent portion of a fieldbus-connected device, comprising the uppermost portion of the physical layer and all higher layers within the device

3.1.11
decibel(milliwatt)
dB(mW)
logarithmic unit of power, referenced to 1 mW

$$P_{dBm} = 10 \log (P_{mW})$$

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Note 1 to entry: db(mW) is also written dBm.

Note 2 to entry: If P_{mW} is the measured power in mW, then P_{dBm} is the power expressed logarithmically in dB(mW), or equivalently, dBm.

3.1.12
delimiter
flag that separates and organizes items of data

3.1.13
device
physical entity connected to the fieldbus composed of at least one communication element (the network element) and which may have a control element and/or a final element (transducer, actuator, etc.)

Note 1 to entry: A device may contain more than one node.

3.1.14
effective launch power
effective power coupled into the core of a fiber optic waveguide by the transmitter

Note 1 to entry: Effective launch power is measured with a standard test fiber connected to the CPIC.

3.1.15
effective power
the difference, expressed in dBm, between the absolute optical power measured in milliwatt at the midpoint in time of the Hi level to the absolute optical power measured in milliwatt at the midpoint of the Lo level

Note 1 to entry: Effective power is believed to give a more accurate measurement of the conditions that affect the receivers than traditional measurements, such as peak and average power. methods for measuring effective power are for further study.

3.1.16
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.1.17
extinction ratio
ratio of the absolute optical power measured in milliwatt at the midpoint in time of the Hi level to the absolute optical power measured in milliwatt at the midpoint in time of the Lo level.

Note 1 to entry: The following gives an example of the computation of effective power and extinction ratio. If the midpoint of Hi level is measured as 105 μW, and if the midpoint of Lo level is measured as 5 μW, then the difference is 100 μW. Therefore, the effective power is 10 log ((100 μW) / 1 mW)), which equals –10,0 dBm. The extinction ratio is (105/5), which equals 21:1.

3.1.18
fiber optic cable
cable containing one or more fiber optic waveguides with jacketing material provided to facilitate handling and to protect the fiber

3.1.19
fiber optic receiver
combined optics and electronics in the communicating device that accept the optical signal received by the communicating device through the CPIC

3.1.20
fiber optic receiver operating range
range of optical power that has to be present at the CPIC to ensure that the bit error rate specifications are met

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3.1.21
fiber optic transmitter
device that emits optical signals for propagation into a fiber optic waveguide through the CPIC

3.1.22
fiber optic waveguide
flexible, optically transparent strand that is used to transport optical signals from one geographic point to another geographic point

3.1.23
frame
set of consecutive digit time slots in which the position of each digit time slot can be identified by reference to a framing signal

3.1.24
intrinsic safety
design methodology for a circuit or an assembly of circuits in which any spark or thermal effect produced under normal operating and specified fault conditions is not capable under prescribed test conditions of causing ignition of a given explosive atmosphere

3.1.25
isolation
physical and electrical arrangement of the parts of a signal transmission system to prevent electrical interference currents within or between the parts

3.1.26
jabber
continuous transmission on the medium due to a faulty device

3.1.27
jitter
offset of the 50 % transition points of pulse edges from their ideal position as the result of all causes

3.1.28
Manchester encoding
means by which separate data and clock signals can be combined into a single, self-synchronizing data stream, suitable for transmission on a serial channel

3.1.29
medium
cable, optical fiber, or other means by which communication signals are transmitted between two or more points

Note 1 to entry: In this part of IEC 61158 "media" is used only as the plural of medium.

3.1.30
network
all of the media, connectors, repeaters, routers, gateways and associated node communication elements by which a given set of communicating devices are interconnected

3.1.31
node
end-point of a branch in a network or a point at which one or more branches meet

3.1.32
optical active star
active device in which a signal from an input fiber is received, amplified and retransmitted to a larger number of output optical fibers

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Note 1 to entry: Retiming of the received signal is optional.

3.1.33
optical fall time
time it takes for a pulse to go from 90 % effective power to 10 % effective power, specified as a per cent of the nominal bit time

3.1.34
optical passive star
passive device in which signals from input fibers are combined and then distributed among output optical fibers

3.1.35
optical rise time
time it takes for a pulse to go from 10 % effective power to 90 % effective power, specified as a per cent of the nominal bit time

3.1.36
peak emission wavelength
λp
wavelength at which radiant intensity is maximized

3.1.37
receiver
receive circuitry of a communication element

3.1.38
repeater
two–port active physical layer device that receives and retransmits all signals to increase the distance and number of devices for which signals can be correctly transferred for a given medium

3.1.39
segment
trunk–cable section of a fieldbus that is terminated in its characteristic impedance

Note 1 to entry: Segments are linked by repeaters within a logical link and by bridges to form a fieldbus network.

3.1.40
separately powered device
device that does not receive its operating power via the fieldbus signal conductors

3.1.41
shield
surrounding earthed metallic layer to confine the electric field within the cable and to protect the cable from external electrical influence

Note 1 to entry: Metallic sheaths, armours and earthed concentric conductors may also serve as a shield.

3.1.42
spur
branch-line (i.e. a link connected to a larger one at a point on its route) that is a final circuit

Note 1 to entry: The alternative term ‘drop cable’ is used in this standard.

3.1.43
terminator
resistor connecting conductor pairs at both ends of a wire medium segment to prevent reflections from occurring at the ends of cables

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Note 1 to entry: For Type 2 the terminator is mounted in a BNC or TNC plug.

3.1.44
transceiver
combination of receiving and transmitting equipment in a common housing employing common circuit components for both transmitting and receiving

Note 1 to entry: A medium attachment unit can be the transceiver or can contain the transceiver, depending on Type and implementation.

[SOURCE: IEEE Std 100-1996 modified for non-radio use]

3.1.45
transmitter
transmit circuitry of a communication element

3.1.46
trunk
main communication highway acting as a source of main supply to a number of other lines (spurs)

3.1.47
typical half-intensity wavelength
$\Delta\lambda$
range of wavelength of spectral distribution in which the radiant intensity is no less than one-half of the maximum intensity

3.2 Type 1: Terms and definitions

3.2.1
activity
[SEE: 3.1.1]

3.2.2
barrier
[SEE: 3.1.2]

3.2.3
bus
[SEE: 3.1.4]

3.2.4
cable plant interface connector
CPIC
[SEE: 3.1.5]

3.2.5
communication element
[SEE: 3.1.6]

3.2.6
connector
[SEE: 3.1.7]

3.2.7
coupler
[SEE: 3.1.8]

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3.2.8
Data Communications Equipment
DCE
[SEE: 3.1.9]

3.2.9
Data Terminal Equipment
DTE
[SEE: 3.1.10]

3.2.10
dBm
[SEE: 3.1.11]

3.2.11
delimiter
[SEE: 3.1.12]

3.2.12
device
[SEE: 3.1.13]

3.2.13
effective launch power
[SEE: 3.1.14]

3.2.14
effective power
[SEE: 3.1.15]

3.2.15
fiber optic cable
[SEE: 3.1.18]

3.2.16
fiber optic receiver
[SEE: 3.1.19]

3.2.17
fiber optic receiver operating range
[SEE: 3.1.20]

3.2.18
fiber optic transmitter
[SEE: 3.1.21]

3.2.19
fiber optic waveguide
[SEE: 3.1.22]

3.2.20
frame
[SEE: 3.1.23]

3.2.21
intrinsic safety
[SEE: 3.1.24]

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3.2.22
isolation
[SEE: 3.1.25]

3.2.23
jabber
[SEE: 3.1.26]

3.2.24
Manchester encoding
[SEE: 3.1.28]

3.2.25
medium
[SEE: 3.1.29]

3.2.26
network
[SEE: 3.1.30]

3.2.27
node
[SEE: 3.1.31]

3.2.28
optical fall time
[SEE: 3.1.33]

3.2.29
optical rise time
[SEE: 3.1.35]

3.2.30
peak emission wavelength
λp
[SEE: 3.1.36]

3.2.31
repeater
[SEE: 3.1.38]

3.2.32
segment
[SEE: 3.1.39]

3.2.33
separately powered device
[SEE: 3.1.40]

3.2.34
shield
[SEE: 3.1.41]

3.2.35
spur
[SEE: 3.1.42]

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3.2.36
terminator
[SEE: 3.1.43]

3.2.37
transceiver
[SEE: 3.1.44]

3.2.38
transmitter
[SEE: 3.1.45]

3.2.39
trunk
[SEE: 3.1.46]

3.3 Type 2: Terms and definitions

3.3.1
activity
[SEE: 3.1.1]

3.3.2
bit
[SEE: 3.1.3]

3.3.3
blanking or blanking time
length of time required after transmitting before a node is allowed to receive

3.3.4
bus
[SEE: 3.1.4]

3.3.5
communication element
[SEE: 3.1.6]

3.3.6
connector
[SEE: 3.1.7]

3.3.7
Data Communications Equipment
DCE
[SEE: 3.1.9]

3.3.8
dBm
[SEE: 3.1.11]

3.3.9
delimiter
[SEE: 3.1.12]

3.3.10
device
[SEE: 3.1.13]

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3.3.11
end delimiter
unique sequence of symbols that identifies the end of a frame

3.3.12
end node
producing or consuming node

3.3.13
error
[SEE: 3.1.16]

3.3.14
frame
[SEE: 3.1.23]

3.3.15
isolation
[SEE: 3.1.25]

3.3.16
jabber
[SEE: 3.1.26]

3.3.17
Manchester encoding
[SEE: 3.1.28]

3.3.18
medium
[SEE: 3.1.29]

3.3.19
M_symbol
representation of the MAC data bits to be encoded and transmitted by the physical layer

3.3.20
MAC frame
collection of M_symbols transmitted on the medium that contains a preamble, start delimiter, data, CRC and end delimiter

3.3.21
network
[SEE: 3.1.30]

3.3.22
network access port
physical layer variant that allows a temporary node to be connected to the link by connection to the NAP of a permanent node

3.3.23
node
[SEE: 3.1.31]

Note 1 to entry: A node is additionally a connection to a link that requires a single M_ID.

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3.3.24
non-data symbol
physical layer Manchester coded signal, used for delimiters, carrying no data

3.3.25
optical isolators, optos
components located within the physical layer transceiver of a node that converts current into light, and then back to an electrical signal

3.3.26
permanent node
node whose connection to the network does not utilize the network access port (NAP) physical layer variant

Note 1 to entry: This node may optionally support a NAP physical layer variant to allow temporary nodes to connect to the network.

3.3.27
redundant media
more than one medium to minimize communication failures

3.3.28
repeater
[SEE: 3.1.38]

3.3.29
segment
[SEE: 3.1.39]

3.3.30
shield
[SEE: 3.1.41]

3.3.31
slot time
maximum time required for detecting an expected transmission

Note 1 to entry: Each node waits a slot time for each missing node during the implied token pass.

3.3.32
spur
[SEE: 3.1.42]

Note 1 to entry: This is an integral part of network taps.

3.3.33
start delimiter
unique sequence of symbols that identifies the beginning of a frame

3.3.34
tap
point of attachment from a node or spur to the trunk cable

Note 1 to entry: A tap provides easy removal of a node without disrupting the link.

3.3.35
terminator
[SEE: 3.1.43]

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3.3.36
tool
executable software program that interacts with the user to perform some function

3.3.37
transceiver
[SEE: 3.1.44]

3.3.38
transient node
node that is only intended to be connected to the network on a temporary basis using the NAP physical layer medium connected to the NAP of a permanent node

3.3.39
transmitter
[SEE: 3.1.45

3.3.40
trunk
[SEE: 3.1.46]

3.3.41
trunk cable
bus or central part of a cable system

3.3.42
trunk–cable section
length of trunk cable between any two taps

3.4 Type 3: Terms and definitions

3.4.1
activity
[SEE: 3.1.1]

3.4.2
barrier
[SEE: 3.1.2]

3.4.3
bit time
time to transmit one bit

3.4.4
bus
[SEE: 3.1.4]

3.4.5
communication element
[SEE: 3.1.6]

3.4.6
confirmation (primitive)

[SOURCE: ISO/IEC 10731:1994]

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3.4.7
connector
[SEE: 3.1.7]

3.4.8
coupler
[SEE: 3.1.8]

3.4.9
Data Communications Equipment
DCE
[SEE: 3.1.9]

3.4.10
Data Terminal Equipment
DTE
[SEE: 3.1.10]

3.4.11
dBm
[SEE: 3.1.11]

3.4.12
device
[SEE: 3.1.13]

3.4.13
DL-entity

[SOURCE: ISO/IEC 7498-1:1994, 5.2.1.11, modified – (N) replaced by DL for the data link layer]

3.4.14
fiber optic cable
FOC
[SEE: 3.1.18]

3.4.15
frame
[SEE: 3.1.23]

3.4.16
indication (primitive)

[SOURCE: ISO/IEC 10731:1994]

3.4.17
intrinsic safety
[SEE: 3.1.24]

3.4.18
isolation
[SEE: 3.1.25]

3.4.19
jabber
[SEE: 3.1.26]

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3.4.20
medium
[SEE: 3.1.29]

3.4.21
(N)-entity

[SOURCE: ISO/IEC 7498-1:1994, 5.2.1.11]

3.4.22
(N)-service

[SOURCE: ISO/IEC 7498-1:1994, 5.2.1.5]

3.4.23
network
[SEE: 3.1.30]

3.4.24
node
[SEE: 3.1.31]

3.4.25
Ph-entity

[SOURCE: ISO/IEC 7498-1:1994, 5.2.1.11]

3.4.26
Ph-service

[SOURCE: ISO/IEC 7498-1, 5.2.1.5, modified – (N) replaced by Ph for the physical layer]

3.4.27
repeater
[SEE: 3.1.38]

3.4.28
request (primitive)

[SOURCE: ISO/IEC 10731:1994]

3.4.29
reset

[SOURCE: ISO/IEC 7498-1:1994, 5.8.1.17]

3.4.30
segment
[SEE: 3.1.39]

3.4.31
separately powered device
[SEE: 3.1.40]

3.4.32
shield
[SEE: 3.1.41]

3.4.33
spur
[SEE: 3.1.42]

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3.4.34
station
node

3.4.35
terminator
[SEE: 3.1.43]

3.4.36
transceiver
[SEE: 3.1.44]

3.4.37
transmitter
[SEE: 0]

3.4.38
trunk
[SEE: 3.1.46]

3.5 Type 4: Terms and definitions

3.5.1
activity
[SEE: 3.1.1]

3.5.2
bus
[SEE: 3.1.4]

3.5.3
connector
[SEE: 3.1.7]

3.5.4
Data Communications Equipment
DCE
[SEE: 3.1.9]

3.5.5
Data Terminal Equipment
DTE
[SEE: 3.1.10]

3.5.6
device
[SEE: 3.1.13]

3.5.7
idle counter
counter to measure the number of bit periods for which the signal level on the physical link has been high for normal class and simple class devices in half duplex mode

3.5.8
isolation
[SEE: 3.1.25]

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3.5.9
medium
[SEE: 3.1.29]

3.5.10
network
[SEE: 3.1.30]

3.5.11
normal class device
device that initiates transmission and replies to requests and that can act as a server (responder) and as a client (requestor) (also called a peer)

3.5.12
shield
[SEE: 3.1.41]

3.5.13
simple class device
device that replies to requests from Normal Class Devices and acts as a server or responder only

3.5.14
transmitter
[SEE: 3.1.45]

3.6 *Void*

NOTE Subclause 3.6 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

3.7 Type 8: Terms and definitions

3.7.1
activity
[SEE: 3.1.1]

3.7.2
bus coupler
device that divides the ring into segments by opening the ring and integrating another ring at this point

3.7.3
cable plant interface connector
CPIC
[SEE: 3.1.5]

3.7.4
communication element
[SEE: 3.1.6]

3.7.5
connector
[SEE: 3.1.7]

3.7.6
dBm
[SEE: 3.1.11]

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3.7.7
effective launch power
[SEE: 3.1.14]

3.7.8
effective power
[SEE: 3.1.15]

3.7.9
fiber optic cable
[SEE: 3.1.18]

3.7.10
fiber optic receiver
[SEE: 3.1.19]

3.7.11
fiber optic receiver operating range
[SEE: 3.1.20]

3.7.12
fiber optic transmitter
[SEE: 3.1.21]

3.7.13
fiber optic waveguide
[SEE: 3.1.22]

3.7.14
frame
[SEE: 3.1.23]

3.7.15
incoming interface
interface to receive data from the previous device and to send data, which are received via an outgoing interface, to the previous device

3.7.16
isolation
[SEE: 3.1.25]

3.7.17
local bus
ring segment of a network with alternate media specifications, which is coupled to a remote bus via the bus coupler

3.7.18
local bus device
device that operates as a slave on a local bus

3.7.19
master
device that controls the data transfer on the network and initiates the media access of the slaves by sending messages and that constitutes the interface to the control system

3.7.20
medium
[SEE: 3.1.29]

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3.7.21
minimum optical receiver sensitivity
minimum optical power at the optical receiver input required to achieve a bit error rate of less than 10^{-9} for the optical transmission system

3.7.22
network
[SEE: 3.1.30]

3.7.23
optical fall time
[SEE: 3.1.33]

3.7.24
optical rise time
[SEE: 3.1.35]

3.7.25
outgoing interface
interface to send data to the next slave in a way, that data that is received through this interface is sent via another outgoing interface to the next slave or via an incoming interface to the previous slave and back to the master

3.7.26
peak emission wavelength
λp
[SEE: 3.1.36]

3.7.27
polymer optical fiber
POF
plastic fiber optic waveguide whose nominal characteristics are compatible with IEC 60793 [fiber type: A4a (980/1000)]

3.7.28
plastic clad silica fiber
PCS
fiber optic waveguide consisting of a glass core and a plastic cladding and whose nominal characteristics are compatible with IEC 60793 [fiber type: A3c (200/230 μm)]

3.7.29
remote bus
ring segment of a network

3.7.30
remote bus device
device operating as a slave on a remote bus

3.7.31
remote bus link
connection of two remote bus devices

3.7.32
ring segment
one section of a network

Note 1 to entry: The master constitutes the first ring segment, further ring segments may be linked by bus couplers.

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3.7.33
shield
[SEE: 3.1.41]

3.7.34
slave
device that accesses the medium only after it has been initiated by the preceding slave or master

3.7.35
spectral full width half maximum
Δλ
range of wavelength of spectral distribution in which the radiant intensity is no less than one-half of the maximum intensity

3.7.36
terminator
[SEE: 3.1.43]

3.8 Type 12: Terms and definitions

3.8.1
activity
[SEE: 3.1.1]

3.8.2
bit
[SEE: 3.1.3]

3.8.3
connector
[SEE: 3.1.7]

3.8.4
coupler
[SEE: 3.1.8]

3.8.5
Data Communications Equipment
DCE
[SEE: 3.1.9]

3.8.6
Data Terminal Equipment
DTE
[SEE: 3.1.10]

3.8.7
delimiter
[SEE: 3.1.12]

3.8.8
device
[SEE: 3.1.13]

3.8.9
error
[SEE: 3.1.16]

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3.8.10
frame
[SEE: 3.1.23]

3.8.11
idle
symbol at the media between EOF and SOF

3.8.12
isolation
[SEE: 3.1.25]

3.8.13
jitter
[SEE: 3.1.27]

3.8.14
Manchester encoding
[SEE: 3.1.28]

3.8.15
medium
[SEE: 3.1.29]

3.8.16
network
[SEE: 3.1.30]

3.8.17
receiver
[SEE: 3.1.37]

3.8.18
shield
[SEE: 3.1.41]

3.8.19
terminator
[SEE: 3.1.43]

3.9 Type 16: Terms and definitions

3.9.1
attenuation
fact that the optical power at the receiver is less than at the transmitter

3.9.2
barrier
[SEE: 3.1.2]

3.9.3
bit
[SEE: 3.1.3]

3.9.4
bit stuffing
procedure, by which after five logical 1's, the transmitter automatically inserts a zero which is then removed again by the receiver

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Note 1 to entry: This zero causes a change in signal edges which makes it possible for the receiver to retrieve a receiving clock.

3.9.5
connector
[SEE: 3.1.7]

3.9.6
Data Communications Equipment
DCE
[SEE: 3.1.9]

3.9.7
Data Terminal Equipment
DTE
[SEE: 3.1.10]

3.9.8
dBm
[SEE: 3.1.11]

3.9.9
delimiter
[SEE: 3.1.12]

3.9.10
device
[SEE: 3.1.13]

3.9.11
error
[SEE: 3.1.16]

3.9.12
fiber optic cable
[SEE: 3.1.18]

3.9.13
frame
[SEE: 3.1.23]

3.9.14
F-SMA connector
connector meeting the F-SMA standard in accordance with IEC 61754-22

3.9.15
fill signals
sequence of seven 1's followed by a 0

3.9.16
jitter
[SEE: 3.1.27]

3.9.17
medium
[SEE: 3.1.29]

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3.9.18
network
[SEE: 3.1.30]

3.9.19
node
[SEE: 3.1.31]

3.9.20
non-return-to-zero-inverted
NRZI
signal exchanges taking place only at regular, fixed points in time in synchronization with the transmitting clock pulse of the bit rate

Note 1 to entry: A signal edge change is assigned to a logical 0 only.

3.9.21
optical fall time
[SEE: 3.1.33]

3.9.22
optical rise time
[SEE: 3.1.35]

3.9.23
pad
sequence of octets added to assure that the telegram is long enough for proper operation

3.9.24
peak emission wavelength
λp
[SEE: 3.1.36]

3.9.25
receiver
[SEE: 3.1.37]

3.9.26
repeater
[SEE: 3.1.38]

3.9.27
repeater function
feature by which a telegram that has been received by a node is passed on and reclocked to the next node on the network, while being logically

3.9.28
transmitter
[SEE: 3.1.45]

3.9.29
typical half-intensity wavelength
$\Delta\lambda$
[SEE: 3.1.47]

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3.9.30
zero bit stream
sequence of logical zeros which, in NRZI coding, results in a regular signal edge change on the transmission line (only used in test mode)

3.10 Type 18: Terms and definitions

3.10.1
activity
[SEE: 3.1.1]

3.10.2
bit
[SEE: 3.1.3]

3.10.3
bus
[SEE: 3.1.4]

3.10.4
communication element
[SEE: 3.1.6]

3.10.5
connector
[SEE: 3.1.7]

3.10.6
Data Communications Equipment
DCE
[SEE: 3.1.9]

3.10.7
Data Terminal Equipment
DTE
[SEE: 3.1.10]

3.10.8
device
[SEE: 3.1.13]

3.10.9
error
[SEE: 3.1.16]

3.10.10
isolation
[SEE: 3.1.25]

3.10.11
medium
[SEE: 3.1.29]

3.10.12
network
[SEE: 3.1.30]

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3.10.13
node
[SEE: 3.1.31]

3.10.14
receiver
[SEE: 3.1.37]

3.10.15
segment
[SEE: 3.1.39]

3.10.16
shield
[SEE: 3.1.41]

3.10.17
spur
[SEE: 3.1.42]

3.10.18
station
network device embodying one node

3.10.19
terminator
[SEE: 3.1.43]

3.10.20
transceiver
[SEE: 3.1.44]

3.10.21
transmitter
[SEE: 3.1.45]

3.10.22
trunk
[SEE: 3.1.46]

3.11 Type 24: Terms and definitions

3.11.1
bit
[SEE: 3.1.3]

3.11.2
bus
[SEE: 3.1.4]

3.11.3
communication element
[SEE: 3.1.6]

3.11.4
connector
[SEE: 3.1.7]

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3.11.5
Data Communications Equipment
DCE
[SEE: 3.1.9]

3.11.6
delimiter
[SEE: 3.1.12]

3.11.7
device
[SEE: 3.1.13]

3.11.8
error
[SEE: 3.1.16]

3.11.9
frame
[SEE: 3.1.23]

3.11.10
isolation
[SEE: 3.1.25]

3.11.11
Manchester encoding
[SEE: 3.1.28]

3.11.12
medium
[SEE: 3.1.29]

3.11.13
network
[SEE: 3.1.30]

3.11.14
node
[SEE: 3.1.31]

3.11.15
repeater
[SEE: 3.1.38]

3.11.16
shield
[SEE: 3.1.41]

3.11.17
terminator
[SEE: 3.1.43]

3.11.18
transceiver
[SEE: 3.1.44]

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3.11.19
transmitter
[SEE: 3.1.45]

3.12 Type 20 terms and definitions

3.12.1
analog signal
low frequency current, predominantly 4 mA to 20 mA signal sent to or originating from a field device

3.12.2
analog signal spectrum
frequencies from zero to 25 Hz at unit amplitude and decreasing at 40 dB per decade above 25 Hz

3.12.3
analog test filter
two-pole low-pass Butterworth filter with the cutoff frequency of 25 Hz

3.12.4
barrier
physical entity which limits current and voltage into a hazardous area in order to satisfy intrinsic safety requirements

3.12.5
cable capacitance per unit length
capacitance per unit length of cable, measured at 1 kHz from one conductor other than the shield to all other conductors including the shield

Note 1 to entry: For networks comprised of more than one type or gauge of cable, the highest capacitance value of any cable type or gauge is used to determine this value.

3.12.6
character
the 8-bits of data and overhead bits that are transmitted as one continuous unit by the PhE

3.12.7
character time
amount of time required to transmit one character

3.12.8
current sense resistor
resistor that is used to convert analog current signal into a voltage signal

3.12.9
delay distortion
difference in propagation time delays of sine waves of different frequencies when observing the time delay through a network or circuit

3.12.10
device
any entity containing an implementation of this standard

3.12.11
digital signal
communication of information using the 1 200 bits per second frequency shift keying signal

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3.12.12
digital frequency band
range of frequencies from 950 Hz to 2 500 Hz that is used for digital signal

3.12.13
digital signal spectrum
frequencies from 500 Hz to 10 kHz at unit amplitude, decreasing at 40 dB per decade below 500 Hz and decreasing at 20 dB per decade above 10 kHz

3.12.14
extended frequency band
range of frequencies from 500 Hz to 10 kHz

Note 1 to entry: This frequency band is digital frequency band plus guard band.

3.12.15
field device
physical entity that is connected to the process or to plant equipment and has at least one signalling element that communicates with other signalling element(s) via a cable

Note 1 to entry: It directly connects to the sensor or actuator or performs process control function and it is directly connected to the physical layer specified in this standard. It may generate or receive an analog signal in addition to a digital signal.

3.12.16
ground
surface of the earth or the conduits or pipes that are so connected, or the safety bus bar or the zero volt rail to which the barriers are connected

Note 1 to entry: Ground may or may not be the same as network power supply common.

3.12.17
intrinsic safety
design methodology for a circuit or an assembly of circuits in which any spark or thermal effect produced under normal operating and specified fault conditions is not capable under prescribed test conditions of causing ignition of a given explosive atmosphere

3.12.18
junction
any splice of two cables or any attachment point of another cable or of a field device to an existing cable

3.12.19
multi-drop network
network with more than one slave device connected to one network

3.12.20
network power supply
source that supplies operating power directly to a network

3.12.21
network resistance
resistance or real part of the impedance of a network

Note 1 to entry: It is computed as the equivalent impedance of all devices connected in parallel to the network. Therefore it is usually dominated by one low impedance device.

3.12.22
non-signaling element
physical entity or an element that does not use or produce analog signal or digital signal

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Note 1 to entry: A network power supply is an example of non-signaling element.

3.12.23
point-to-point network
network with only one slave and zero or one master device

Note 1 to entry: The point-to-point Network need not have any master device. This situation would exist, for example, when only an analog controller is used, the single field device having been programmed by a secondary master that was subsequently disconnected.

3.12.24
signaling element
physical entity or an element that uses or produces digital signal

Note 1 to entry: The entity that only uses or produces an analog signal is not part of this definition; the entity that uses/produces only a digital signal, but not an analog signal is part of this definition.

3.12.25
silence
state of the network when there is no digital signal is present

3.12.26
start of message
the preamble of physical layer protocol data unit followed by the delimiter of data link layer protocol data unit without any reception error and inter-character gap

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4 Symbols and abbreviations

4.1 Symbols

4.1.1 Type 1: Symbols

Symbol	Definition	Unit
A_{max}	Maximum inter-device attenuation	dB
AD_{max}	Maximum inter-device attenuation distortion	dB
BR	Nominal bit rate	Mbit/s
ΔBR	Maximum deviation from BR	–
CS_{max}	Maximum coupler spacing to form a cluster	m
Din_{min}	Minimum device input impedance	kΩ
dBm	Logarithmic unit of power referenced to 1 mW	dB(mW)
F_c	Center carrier frequency used in frequency shift keying	kHz
F_{c+f}	Frequency that corresponds to logical 1 in frequency shift keying	kHz
$F_{c–f}$	Frequency that corresponds to logical 0 in frequency shift keying	kHz
f_r	Frequency corresponding to the nominal bit rate	MHz
f_{min}	Nominal minimum frequency for the nominal bit rate	MHz
f_{max}	Nominal maximum frequency for the nominal bit rate	MHz
$f_{QTO_{max}}$	Maximum frequency for QTO_{max} measurement	MHz
L_{max}	Maximum inter-device distance	m
MD_{max}	Maximum inter-device mismatching distortion	dB
N+	Non-data symbol – positive; Manchester coded signal with a high level for one bit time, used for delimiters, carrying no data	–
N–	Non-data symbol – negative; Manchester coded signal with a low level for one bit time, used for delimiters, carrying no data	–
N_{max}	Maximum number of devices	–
P	Nominal period of octet transmission	s
PICS	Protocol Implementation Conformance Statement	–
QTO_{max}	Maximum quiescent transmitter output	mV
T_{bit}	Nominal bit duration	µs
ΔT_{bit}	Maximum deviation from T_{bit}	–
T_{rf}	Maximum signal rise or fall time	ns
V_{DD}	The most positive (or least negative) supply level	V
V_{IH}	Minimum high-level input voltage	V
V_{IL}	Maximum low-level input voltage	V
V_{OH}	Minimum high-level output voltage	V
V_{OL}	Maximum low-level output voltage	V
Z	Impedance; vector sum of resistance and reactance (inductive or capacitive)	Ω
Z_{f_r}	Characteristic impedance ; impedance of a cable, and of its terminators, at frequency f_r	Ω
Z_O	Characteristic impedance ; impedance of a cable, and of its terminators, over the defined frequency range	Ω

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4.1.2 Type 2: Symbols

Symbol	Definition	Unit
dBm	Logarithmic unit of power referenced to 1 mW	dB (mW)
f_r	Frequency corresponding to the bit rate	Hz
GND	Ground supply level	V
H	Physical symbol – high level	–
L	Physical symbol – low level	–
M_0	Medium Access Control – data symbol – “zero”; Symbol at the DL-Ph interface, representing the transmitted and received Manchester coded signal with a high level for half a bit time, and a low level for half a bit time, carrying data “zero”	–
M_1	Medium Access Control – data symbol – “one”; Symbol at the DL-Ph interface, representing the transmitted and received Manchester coded signal with a low level for half a bit time, and a high level for half a bit time, carrying data “one”	–
M_ND+	Medium Access Control – non-data symbol – positive; Symbol at the DL-Ph interface, representing the transmitted and received Manchester coded signal with a high level for one complete bit time, used for delimiters, carrying no data	–
M_ND–	Medium Access Control – non-data symbol – negative; Symbol at the DL-Ph interface, representing the transmitted and received Manchester coded signal with a low level for one complete bit time, used for delimiters, carrying no data	–
Rx_H	Receive – high level (NAP interface)	V
Rx_L	Receive – low level (NAP interface)	V
Tx_H	Transmit – high level (NAP interface)	V
Tx_L	Transmit – low level (NAP interface)	V
V_{in}	Voltage on the coaxial cable center conductor (V_{in}+ or V_{in}–) as referenced to the coaxial shield	V
V_{sense}+	Positive data sensitivity limit	V
V_{sense}–	Negative data sensitivity limit	V
V_{sense}H	High carrier sensitivity limit	V
V_{sense}L	Low carrier sensitivity limit	V

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4.1.3 Type 3: Symbols

Symbol	Definition	Unit
dBm	Logarithmic unit of power referenced to 1 mW	dB (mW)
f_r	Frequency corresponding to the bit rate	Hz, kHz, MHz
N–	Non-data symbol – negative; Manchester coded signal with a low level for one bit time, used for delimiters, carrying no data	–
N+	Non-data symbol – positive; Manchester coded signal with a high level for one bit time, used for delimiters, carrying no data	–
P	Nominal period of octet transmission	s
R_d	Pull-down resistor	Ω
R_t	Bus terminator	Ω
R_u	Pull-up resistor	Ω
SYN	Synchronizing bits of a frame (period of idle)	s
t_{BIT}	The bit time t_{BIT} is the time, which elapses during the transmission of one bit.	s
T_{SBIT}	Extended tolerance (only for stop bit)	s
T_{SYN}	Synchronization time	s
T_{SYNI}	Synchronization interval time	s
V_{DD}	The most positive (or least negative) supply level	V
V_{IH}	Minimum high-level input voltage	V
V_{IL}	Maximum low-level input voltage	V
V_{OH}	Minimum high-level output voltage	V
V_{OL}	Maximum low-level output voltage	V
VP	Voltage-Plus	V
Z	Impedance; vector sum of resistance and reactance (inductive or capacitive)	Ω
Z_O	Characteristic impedance ; impedance of a cable, and of its terminators, over the defined frequency range	Ω

4.1.4 Type 4: Symbols

Symbol	Definition	Unit
Vcc	The most positive (or least negative) supply level	V
GND	Ground supply level	V

4.1.5 *Void*

NOTE Subclause 4.1.5 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

4.1.6 Type 8: Symbols

Symbol	Definition	Unit
dBm	Logarithmic unit of power referenced to 1 mW	dB (mW)
f_r	Frequency corresponding to the bit rate	Hz
Vdd	The most positive (or least negative) supply level	V
GND	Ground supply level	V

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4.1.7 Type 12: Symbols

Symbol	Definition	Unit
fr	Frequency corresponding to the nominal bit rate	MHz
N+	Non-data symbol – positive; Manchester coded signal with a high level for one bit time, used for delimiters, carrying no data	–
N–	Non-data symbol – negative; Manchester coded signal with a low level for one bit time, used for delimiters, carrying no data	–
T_{bit}	Nominal bit duration	µs
Z	Impedance; vector sum of resistance and reactance (inductive or capacitive)	Ω
Z_O	Characteristic impedance ; impedance of a cable, and of its terminators, over the defined frequency range	Ω

4.1.8 Type 16: Symbols

Symbol	Definition	Unit
j	Jitter	µs
J_{noise}	Jitter of the optical signal	µs
J_{t2}	Jitter in t_2	µs
J_{tscyc}	Jitter in t_{Scyc}	µs
P	Power	dBm or µW
P_{RmaxH}	Maximum received power at optical high level	dBm or µW
P_{RmaxL}	Maximum received power at optical low level	dBm or µW
P_{RminH}	Minimum received power at optical high level	dBm or µW
P_{TmaxH}	Maximum transmission power at optical high level	dBm or µW
P_{TmaxL}	Maximum transmission power at optical low level	dBm or µW
PTminH	Minimum transmission power at optical high level	dBm or µW
P_X	Power threshold	dBm or µW
t_{cable}	Time, by which the transmitted signal is delayed by the cable, for each unit of length (approx., 5 ns/m)	ns
t_{fri}	Time for the optical low level at the input of a slave	ns
t_{fro}	Time for the optical low level at the output of a slave	ns
t_{rep}	Time, by which the received signal is delayed by a forwarding slave (input-output)	ns
t_{ring}	Time, which a master telegram needs, until it has passed through the network and reached the master again	µs
t_{RPAT}	Maximum transition time in a slave to switch from the repeater function to the transmitter function for the AT	µs
$t_{RPAT.2}$	Maximum transition time in slave 2 to switch from the repeater function to the transmitter function for the AT	µs

4.1.9 Type 18: Symbols

Symbol	Definition	Unit
V_{DD}	Voltage potential supplied to power digital logic components	V
V_{OL}	Output voltage, low level	V
V_{OH}	Output voltage, high level	V
V_{IL}	Input voltage, low level	V
V_{IH}	Input voltage, high level	V

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4.1.10 Type 24: Symbols

Symbol	Definition	Unit
GND	Ground supply level	V
H	Physical symbol – high level	–
L	Physical symbol – low level	–
DL_Symbols	representation of the DL data bits to be encoded and transmitted by the physical layer	–
Ph_Symbols	representation of data bits which shall be encoded by the MAC (Medium Access Control) and transmitted by the physical layer	–
Tbit	The bit time Tbit is the time, which elapses during the transmission of one bit.	Ms
V_{DD}	The most positive supply level	V

4.1.11 Type 20: symbols

Symbol	Definition
C_{cbl}	Cable capacitance per unit length
C_{dev}	Equivalent device capacitance
C_{tg}	Terminal to ground capacitance
C_{tt}	Terminal to terminal capacitance
HOLD	Hold time
R_{cbl}	Cable resistance per unit length
R_{dev}	Equivalent device resistance
Rp	Network parallel resistance
RT1	Link quiet time
RT2	Link grant time
R_{tg}	Terminal to ground resistance
R_{tt}	Terminal to terminal resistance
STO	Slave time out
Z_{tt}	Terminal to terminal impedance

4.2 Abbreviations

4.2.1 Type 1: Abbreviations

CTS	Clear-to-send signal (from DCE)
DCE	Data communication equipment
DIS	DCE independent sublayer
DL	Data-link (as a prefix) [ISO/IEC 7498-1]
DLE	Data-link entity
DLL	Data-link layer [ISO/IEC 7498-1]
DTE	Data terminal equipment
EMI	Electro-magnetic interference
IDU	Interface data unit [ISO/IEC 7498-1]
IS	Intrinsic safety
LbE	Loopback-enable signal (to MAU)
MAU	Medium attachment unit (for wire media, MAU = transceiver)

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MDS	Medium dependent sublayer
min o/p	Minimum output voltage peak-to-peak
MIS	Media independent sublayer
NRZ	Non-return-to-zero code

NOTE High level = logic 1, Low level = logic 0

Ph	Physical (as a prefix) [ISO/IEC 7498-1]
PhE	Physical layer entity [ISO/IEC 7498-1]
PhL	Physical layer [ISO/IEC 7498-1]
PhICI	Physical layer interface control information [ISO/IEC 7498-1]
PhID	Physical layer interface data [ISO/IEC 7498-1]
PhIDU	Physical layer interface data unit [ISO/IEC 7498-1]
PhPCI	Physical layer protocol control information [ISO/IEC 7498-1]
PhPDU	Physical layer protocol data unit [ISO/IEC 7498-1]
PhS	Physical layer service [ISO/IEC 7498-1]
PhSAP	Physical layer service access point [ISO/IEC 7498-1]
PhSDU	Physical layer service data unit [ISO/IEC 7498-1]
pk	Peak
pk-pk	Peak-to-peak
RDF	Receive-data-and-framing signal (from DCE)
RFI	Radio frequency interference
RTS	Request-to-send signal (to DCE)
RxA	Receive-activity signal (from DCE)
RxC	Receive-clock signal (from DCE)
RxS	Receive signal (from MAU)
SDU	Service data unit [ISO/IEC 7498-1]
TxC	Transmit-clock signal (from DCE)
TxD	Transmit -data signal (to DCE)
TxE	Transmit -enable signal (to MAU)
TxS	Transmit signal (to MAU)

4.2.2 Type 2: Abbreviations

BNC	Bayonet Neill Concelman (connector for coaxial cable having a bayonet-type shell with two small knobs on the female connector, which lock into spiral slots in the male connector when it is twisted) [IEC 61169–8]
DCE	Data communication equipment
DL	Data-link (as a prefix) [ISO/IEC 7498-1]
DLL	Data-link layer [ISO/IEC 7498-1]
MAC	Medium access control (lower section of the data-link layer, interfacing with the physical layer)
MAC ID	Medium access control identification – address of a node
MAU	Medium attachment unit (for wire media, MAU = transceiver)
MDS	Medium dependent sublayer
MIS	Media independent sublayer

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NAP	Network access port (local access to a device, i.e. not via the bus)
NetEnable	Transmit-enable signal
NUT	Network update time [IEC 61158-4-2]
Ph	Physical (as a prefix) [ISO/IEC 7498-1]
PhL	Physical layer [ISO/IEC 7498-1]
pk	Peak
Rcv	Receive
Rx	Receive
RxCarrier	Receive-carrier signal
RxData	Receive-data signal
RxPTC	Receive-data signal (NAP interface)
RM	Repeater machine (mechanism for extending bus length, providing multiple medium interfaces, and allowing medium redundancy)
RRM	Ring repeater machine (mechanism for providing a ring topology on optical medium)
SMAX	Scheduled maximum address [IEC 61158-4-2]
TNC	Threaded Neill Concelman (threaded version of the BNC connector) [IEC 60169–17]
Tx	Transmit
TxDataBar	Transmit-data signal (inverted)
TxDataOut	Transmit-data signal
TxPTC	Transmit-data signal (NAP interface)
Xmit	Transmit

4.2.3 Type 3: Abbreviations

ASC	Active star coupler
BER	Bit error rate
CO	Converter
CTS	Clear-to-send signal (from DCE)
DCE	Data communication equipment
DGND	Data ground
DIS	DCE independent sublayer
DL	Data-link (as a prefix)
DLE	Data-link entity
DLL	Data-link layer [ISO/IEC 7498-1]
DLPDU	Data-link protocol data unit [ISO/IEC 7498-1]
DTE	Data terminal equipment
DUT	Device under test
EMC	Electro-magnetic-compatibility
EMI	Electro-magnetic interference
FEC	Forward error correction
FISCO	Fieldbus intrinsically safe concept
FO	Fiber optic
FOC	Fiber optic cable

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IS	Intrinsic safety
LbE	Loopback enable signal (to MAU)
LSS	Line selector switch
M/S	Master / slave station
MAU	Medium attachment unit (for wire media, MAU = transceiver)
MDS	Medium dependent sublayer
MIS	Media independent sublayer
n	Number of a station
NRZ	Non-return-to-zero code

NOTE High level = logic 1, Low level = logic 0

OST	Overshot of transition
PC	Physical contact
Ph	Physical (as a prefix)
Ph-ASYN-DATA	Physical data service for asynchronous transmission
PhE	Physical layer entity [ISO/IEC 7498-1]
PhICI	Physical layer interface control information [ISO/IEC 7498-1]
PhID	Physical layer interface data [ISO/IEC 7498-1]
PhIDU	Physical layer interface data unit [ISO/IEC 7498-1]
PhL	Physical layer [ISO/IEC 7498-1]
PhM	Ph-management
PhMS	Ph-management service
PhPCI	Physical layer protocol control information [ISO/IEC 7498-1]
PhPDU	Physical layer protocol data unit [ISO/IEC 7498-1]
PhS	Physical layer service [ISO/IEC 7498-1]
PhSAP	Physical layer service access point [ISO/IEC 7498-1]
PhSDU	Physical layer service data unit [ISO/IEC 7498-1]
pk-pk	Peak-to-peak
RDF	Receive-data-and-framing signal (from DCE)
REP	Repeater
RFI	Radio frequency interference
RTS	Request-to-send signal (to DCE)
RxA	Receive-activity signal (from DCE)
RxC	Receive-clock signal (from DCE)
RxS	Receive Signal (from MAU)
Stn	Stations (master or slave)
TPC	Twisted-pair cable
TxC	Transmit-clock signal (from DCE)
TxD	Transmit-data signal (to DCE)
TxE	Transmit-enable signal (to MAU)
TxS	Transmit Signal (to MAU)
UART	Universal asynchronous receiver/transmitter

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4.2.4 Type 4: Abbreviations

CTS	Clear-to-send signal (from DCE)
DCE	Data communication Equipment
DL	Data-link (as a prefix) [ISO/IEC 7498-1]
DLE	Data-link entity
DLL	Data-link layer [ISO/IEC 7498-1]
DTE	Data terminal equipment
MAU	Medium attachment unit (for wire media, MAU = transceiver)
MDS	Medium dependent sublayer
MIS	Media independent sublayer
NRZ	Non-return-to-zero code

NOTE High level = logic 1, Low level = logic 0

Ph	Physical (as a prefix) [ISO/IEC 7498-1]
PhE	Physical layer entity [ISO/IEC 7498-1]
PhL	Physical layer [ISO/IEC 7498-1]
PhID	Physical layer interface data [ISO/IEC 7498-1]
PhPDU	Physical layer protocol data unit [ISO/IEC 7498-1]
RTS	Request-to-send signal (to DCE)
RxS	Receive Signal (from MAU)
TxE	Transmit-enable signal (to MAU)
TxS	Transmit Signal (to MAU)

4.2.5 *Void*

NOTE Subclause 4.2.5 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

4.2.6 Type 8: Abbreviations

BC	Bus connector
BLL	Basic link layer
BSY	Busy
CPIC	Cable plant interface connector
CRC	Cyclic redundancy check
CTS	Clear-to-send
DL	Data-link (as a prefix) [ISO/IEC 7498-1]
DLL	Data-link layer [ISO/IEC 7498-1]
DI	Data In
DLPDU	Data-link process data unit
DO	Data out
DS	Data select
GND	Ground
ICI	Interface control information
ID	Identifier

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LbE	Loopback enable
LSB	Least significant byte (octet)
MA	Medium activity
MAC	Medium access control
MAU	Medium attachment unit
MDS	Medium dependent sublayer
MIS	Media independent sublayer
MSB	Most significant bit
NRZ	Non-return-to-zero
PCS	Plastic-clad silica fiber
Ph	Physical (as a prefix) [ISO/IEC 7498-1]
PhE	Physical layer entity [ISO/IEC 7498-1]
PhICI	Physical interface control information
PhIDU	Physical interface data unit
PhL	Physical layer [ISO/IEC 7498-1]
PhPDU	Physical protocol data unit
PhSDU	Physical service data unit
PNM1	Peripherals network management of layer 1
POF	Polymer optical fiber
RI	Reset-in
RO	Reset-out
RqDly1	Request delay 1
RqDly2	Request delay 2
RTS	Request-to-send
RxA	Receive-activity
RxC	Receive-clock
RxCR	Receive control line
RxD	Receive data
RxS	Receive sequence
RxSL	Receive select line
SL	Select line
T_{Rst}	Coding and decoding (of the Reset PhPDU)
TxC	Transmit clock
TxCR	Transmit control line
TxD	Transmit data
TxS	Transmit sequence
TxSL	Transmit select line

4.2.7 Type 12: Abbreviations

EBUS	A Type 12 physical layer as described in this international standard
EOF	End of Frame

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LVDS	Low Voltage Differential Signaling
PCB	Printed Circuit Board
RxS	Receive Signal
SOF	Start of Frame
TxS	Transmit Signal

4.2.8 Type 16: Abbreviations

DPLL	digital phase locked loop
HCS	hard clad silica (glass fiber)
IC	Integrated circuit
LED	light emitting diode
LSB	least significant bit
MSB	most significant bit
NRZI	non-return-to-zero-inverted
POF	polymer optical fiber (plastic fiber)
RxCLK	receiving clock
RxD	received data
TxCLK	transmitting clock
TxD	transmitted data

4.2.9 Type 18: Abbreviations

AWG	American wire gauge
CMOS	Complementary Metal Oxide Silicon – a class of digital logic interface specifications
DA / DB	Data A and Data B – the communications signal pair
DG	Data Ground – zero potential communications signal reference
FG	Field Ground – the zero potential device reference
NRZI	Non-Return to Zero Inverted
PhL-B	Physical layer – Basic type
PhL-P	Physical layer – Powered type
RxS	Receive Signal
SLD	Shield – linear Faraday cage
TTL	Transistor-Transistor Logic – a class of digital logic interface specifications
TxE	Transmit Enable
TxS	Transmit Signal
UL	Unit Load

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4.2.10 Type 24: Abbreviations

AWG	American wire gauge
DL	Data-link (as a prefix) [ISO/IEC 7498-1]
DLL	Data-link layer [ISO/IEC 7498-1]
NC	No connection
Ph	Physical (as a prefix) [ISO/IEC 7498-1]
PhL	Physical layer [ISO/IEC 7498-1]
pk	Peak
pk-pk	Peak-to-peak
SRD	Send data Receive data
RxS	Receive signal
TxE	Transmit enable signal
TxS	Transmit signal

4.2.11 Type 20: Abbreviations

AWG	American wire gauge
bit/s	Bits per second
DUT	Device under test
EMI	Electro-magnetic interference
FSK	Frequency shift keying
HCF	HART™ Communication Foundation
RMS	Root mean square
SOM	Start of message
STX	Start of transaction

5 DLL – PhL interface

5.1 General

Clause 5 defines the required physical service (PhS) primitives and constraints on their use.

NOTE 1 The data-link – Physical interface is a virtual service interface between virtual machines; there are no requirements for physical signal lines as the standard does not require this interface to be exposed.

PhIDUs shall be transferred between the DLL and the PhL in accordance with the requirements of ISO/IEC 7498 as shown in Figure 2.

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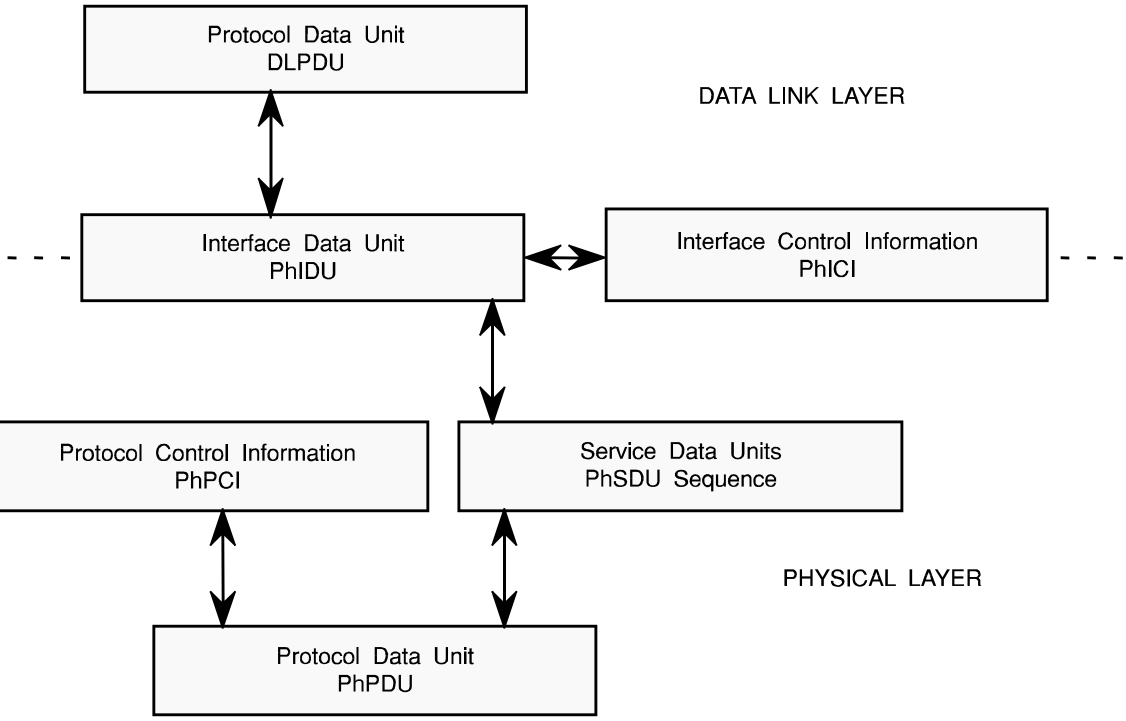

NOTE PhPCI and PhICI support are type specific.

Figure 2 – Mapping between data units across the DLL – PhL interface

NOTE 2 These services provide for the interchange of PhIDUs between a DLL entity and its associated PhL entity. Such a transfer is part of a transaction between cooperating DLL entities. The services listed in this section are the minimum that can jointly provide the means by which cooperating DLL entities can coordinate their transmission and their exchange of data on the shared communication medium. Synchronization of data exchange and related actions is also provided if needed.

NOTE 3 Proper layering ensures that an (N+1)-layer entity be not concerned with, and that an (N)-service interface not overly constrain, the means by which an (N)-layer provides its (N)-services. Thus, the Ph-service interface does not demand that DLEs are aware of internal details of the PhE (e.g. preamble, postamble and frame delimiter signal patterns, number of bits per baud), and prevents the PhE not from using appropriate evolving technologies.

NOTE 4 A number of different DLL – PhL interfaces are specified, based on industry practice.

5.2 Type 1: Required services

5.2.1 Primitives of the PhS

5.2.1.1 General

The granularity of PhS-user data exchanged at the PhL – DLL interface is one octet.

5.2.1.2 Ph-CHARACTERISTICS Indication

The PhS shall provide the following service primitive to report essential PhS characteristics (which may be used in DLL transmission, reception, and scheduling activities):

Ph-CHARACTERISTICS indication (minimum-data-rate, framing-overhead)

where

minimum-data-rate – shall specify the effective minimum rate of data conveyance in bits/s, including any timing tolerances

NOTE 1 A PhE with a nominal data rate of 1 Mbit/s ± 0,01 % would specify a minimum data rate of 0,999 9 Mbit/s.

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framing overhead – shall specify the maximum number of bit periods (where the period is the inverse of the data rate) used in any transmission for PhPDUs that do not directly convey data (e.g. PhPDUs conveying preamble, frame delimiters, postamble, inter-frame "silence", etc.).

NOTE 2 If the framing overhead is F and two DL message lengths are L_1 and L_2, then the time to send one message of length $L_1 + F + L_2$ will be at least as great as the time required to send two immediately consecutive messages of lengths L_1 and L_2.

5.2.1.3 PhS transmission and reception services

The PhS shall provide the following service primitives for transmission and reception:

PH-DATA request (class, data)

PH-DATA indication (class, data)

PH-DATA confirm (status)

where

class – shall specify the PhICI component of the PhIDU.

For a PH-DATA request, its possible values shall be:

START-OF-ACTIVITY – transmission of the PhPDUs which precede Ph-user data shall commence;

DATA – the single-octet value of the associated data parameter shall be transmitted as part of a continuous correctly formed transmission; and

END-OF-DATA-AND-ACTIVITY – the PhPDUs that terminate Ph-user data shall be transmitted after the last preceding octet of Ph-user data, culminating in the cessation of active transmission.

For a PH-DATA indication, its possible values shall be:

START-OF-ACTIVITY – reception of an apparent transmission from one or more PhEs has commenced;

DATA – the associated data parameter was received as part of a continuous correctly formed reception;

END-OF-DATA – the ongoing continuous correctly formed reception of Ph-user data has concluded with correct reception of PhPDUs implying END-OF-DATA;

END-OF-ACTIVITY – the ongoing reception (of an apparent transmission from one or more PhEs) has concluded, with no further evidence of PhE transmission; and

END-OF-DATA-AND-ACTIVITY – simultaneous occurrence of END-OF-DATA and END-OF-ACTIVITY.

data – shall specify the PhID component of the PhIDU. It consists of one octet of Ph-user-data to be transmitted (PH-DATA request) or which was received successfully (PH-DATA indication).

status – shall specify either success or the locally detected reason for inferring failure.

The PH-DATA confirm primitive shall provide the critical physical timing feedback necessary to inhibit the DLE from starting a second transmission before the first is complete. The final PH-DATA confirm of a transmission shall not be issued until the PhE has completed the transmission.

5.2.2 Notification of PhS characteristics

The PhE has the responsibility for notifying the DLE of those characteristics of the PhS that may be relevant to DLE operation. The PhE shall do this by issuing a single Ph-CHARACTERISTICS indication primitive at each of the PhEs PhSAPs at PhE start-up.

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5.2.3 Transmission of Ph-user-data

The PhE shall determine the timing of all transmissions. When a DLE transmits a sequence of PhSDUs, the DLE shall send the sequence of PhSDUs by making a well-formed sequence of PH-DATA requests, consisting of a single request specifying START-OF-ACTIVITY, followed by 3 to 300 consecutive requests, inclusive, specifying DATA, each conveying a PhSDU, and concluded by a single request specifying END-OF-DATA-AND-ACTIVITY.

The PhE shall signal its completion of each PH-DATA request, and its readiness to accept a new PH-DATA request, by issuing a PH-DATA confirm primitive; the status parameter of the PH-DATA confirm primitive shall convey the success or failure of the associated PH-DATA request. A second PH-DATA request shall not be issued by the DLE until after the PH-DATA confirm corresponding to the first request has been issued by the PhE.

5.2.4 Reception of Ph-user-data

The PhE shall report a received transmission with a well-formed sequence of PH-DATA indications, which shall consist of

a) a single indication specifying START-OF-ACTIVITY; followed by consecutive indications specifying DATA, each conveying a PhSDU; followed by a single indication specifying END-OF-DATA; and concluded by a single indication specifying END-OF-ACTIVITY; or
b) a single indication specifying START-OF-ACTIVITY; followed by consecutive indications specifying DATA, each conveying a PhSDU; followed by a single indication specifying END-OF-DATA-AND-ACTIVITY; or
c) a single indication specifying START-OF-ACTIVITY; optionally followed by one or more consecutive indications specifying DATA, each conveying a PhSDU; and concluded by a single indication specifying END-OF-ACTIVITY.

This last sequence is indicative of an incomplete or incorrect reception. Detection of an error in the sequence of received PhPDUs, or in the PhEs reception process, shall disable further PH-DATA indications with a class parameter specifying DATA, END-OF-DATA, or END-OF-DATA-AND-ACTIVITY until after both the end of the current period of activity and the start of a subsequent period of activity have been reported by PH-DATA indications specifying END-OF-ACTIVITY and START-OF-ACTIVITY, respectively.

5.3 Type 2: Required services

5.3.1 General

Subclause 5.3 defines the required physical service (PhS) primitives and constraints on their use.

The DLL-PhL interface need not be exposed in the implementation of any PhL variant. This interface may be internal to the node and may be implemented as internal to a semiconductor device. If, however, conformance to the DLL–PhL interface is claimed, it shall conform to the requirements of 5.3.

5.3.2 M_symbols

The PhL Interface Data Units present at the DLL-PhL interface shall be M_symbols, as shown in Table 1. The M_ND symbols shall be used to create unique data patterns used for start and end delimiters.

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Table 1 – Data encoding rules

Data bits (common name)	M_symbol representation
data “zero”	M_0 or {0}
data “one”	M_1 or {1}
“non_data+”	M_ND+ or {+}
“non_data–”	M_ND– or {–}

5.3.3 PH-LOCK indication

PH-LOCK indication shall provide an indication of either data lock or Ph-symbol synchronization by the MDS. Valid states for PH-LOCK indication shall be true and false. PH-LOCK indication shall be true whenever valid Ph-symbols are present at the MDS-MAU interface and the DLL-PhL interface timing of M_symbols conform to the requirements for clock accuracy. It shall be false between frames (when no Ph-symbols are present on the medium) or whenever data synchronization is lost or the timing fails to conform to the requirements for clock accuracy. PH-LOCK indication shall be true prior to the beginning of the start delimiter.

5.3.4 PH-FRAME indication

PH-FRAME indication shall provide an indication of a valid data frame from the MAU. Valid states for PH-FRAME indication shall be true and false. PH-FRAME indication shall be true upon PH-LOCK indication = true and reception of the first valid start delimiter. PH-FRAME indication shall be false at reception of next M_ND symbol (following the start delimiter) or PH-LOCK indication = false.

NOTE This signal provides octet synchronization to the DLL.

5.3.5 PH-CARRIER indication

PH-CARRIER indication shall represent the presence of a signal carrier on the medium. PH-CARRIER indication shall be true if RXCARRIER at the MDS-MAU interface has been true during any of the last 4 M_symbol times and it shall be false otherwise.

5.3.6 PH-DATA indication

PH-DATA indication shall represent the M_symbols shown in Table 1. Valid symbols shall be M_0, M_1, M_ND+ or M_ND– (or M_symbols). The PH-DATA indication shall represent the M_Symbols as decoded from the MAU whenever PH-LOCK indication is true.

5.3.7 PH-STATUS indication

PH-STATUS indication shall represent the status of the frame that was received from the MAU as shown in Table 2. Valid symbols shall be Normal, Abort, and Invalid. PH-STATUS indication shall indicate Normal after reception of a frame (PH-FRAME indication = true) composed of a start delimiter, valid Manchester encoded data (no M_ND symbols) and an end delimiter. PH-STATUS indication shall indicate Abort after reception of a frame (PH-FRAME indication = true) composed of a start delimiter, valid Manchester encoded data, and a second start delimiter. PH-STATUS indication shall indicate Invalid after reception of a frame (PH-FRAME indication = true) composed of a start delimiter and the detection of any M_ND symbol that was not part of a start or end delimiter.

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Table 2 – Ph-STATUS indication truth table

Ph-STATUS indication	Ph-FRAME indication	Start delimiters in a single frame	End delimiter detection	Any non-delimiter Manchester violations
Normal	true	1	true	false
Abort	true	2	don't care	false
Invalid	true	1	don't care	true

5.3.8 PH-DATA request

PH-DATA request shall represent the M_symbols to be transmitted. Valid symbols shall be M_0, M_1, M_ND+ or M_ND– as shown in Table 1. PH-DATA request shall indicate M_0 when no data is to be transmitted (and PH-FRAME request = false).

5.3.9 PH-FRAME request

PH-FRAME request shall be true when PH-DATA request represents M_symbols to be encoded to the appropriate Ph-symbols and transferred to the MAU, and shall be false when no valid M_symbols are to be transferred to the MAU.

5.3.10 PH-JABBER indication

PH-JABBER indication shall be true if the MDS-MAU interface detects a single frame (PH-FRAME indication = true) that equals or exceeds 1 024 octets (8 192 M_symbols) and PH-JABBER-TYPE request is true. PH-JABBER indication shall be true if the MDS-MAU interface detects a single frame (PH-FRAME indication = true) that equals or exceeds 2 048 octets (16 384 M_symbols) and PH-JABBER-TYPE request is false. PH-JABBER indication shall be false otherwise. If PH-JABBER indication goes true, it shall be latched in this state by the MDS until the Ph-JABBER-CLEAR request is true or power to the node is removed and restored or the node is initialised.

5.3.11 Ph-JABBER-CLEAR request

Ph-JABBER-CLEAR request (optional) shall be false under normal operating conditions and shall be true to reset a PH-JABBER indication that has been latched in a true state.

5.3.12 Ph-JABBER-TYPE request

PH-JABBER-TYPE request shall be true if the node is the source of transmit data ("NODE") and shall be false if the node is retransmitting data received from another node (e.g. acting as a "REPEATER" of data from another node, see Annex G).

The combinations for PH-JABBER indication and PH-JABBER-TYPE request shall be as shown in Table 3.

Table 3 – Jabber indications

Ph-JABBER indication	Ph-JABBER-TYPE request	Frame length
true	true = "NODE"	≥ 1 024 octets
true	false = "REPEATER"	≥ 2 048 octets
false	true = "NODE"	< 1 024 octets
false	false = "REPEATER"	< 2 048 octets

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5.4 Type 3: Required services

5.4.1 Synchronous transmission

The services specified for Type 1 shall be used (see 5.2).

5.4.2 Asynchronous transmission

5.4.2.1 PhS transmission and reception services

The data service for asynchronous transmission (Ph-ASYN-DATA) includes two service primitives. A request primitive is used to request a service by the DLE; an indication primitive is used to indicate a reception to the DLE. The names of the respective primitives are as follows:

Ph-ASYN-DATA request

Ph-ASYN-DATA indication

The temporal relationship of the primitives is shown in Figure 3.

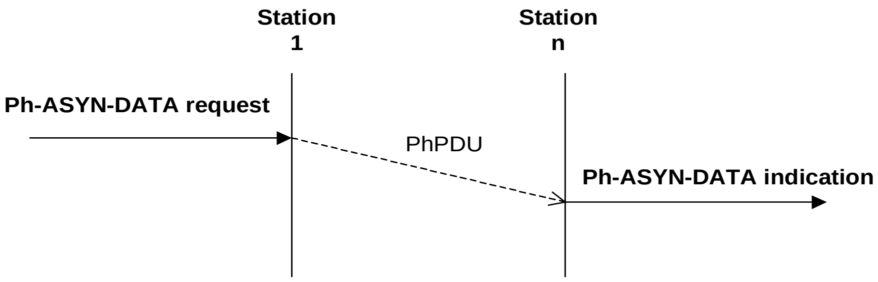

Figure 3 – Data service for asynchronous transmission

5.4.2.2 Detailed specification of the service and interaction

Subclause 5.4.2.2 describes in detail the service primitives and the related parameter in an abstract way. The parameter contains the PhS-user data exchanged at the PhL – DLL interface with the granularity of one bit.

Parameters of the primitives:

Ph-ASYN-DATA request (DL_symbol)

The parameter DL_symbol shall have one of the following values specifying the PhID component of the PhIDU. Its possible values shall be:

a) ZERO corresponds to a binary "0";
b) ONE corresponds to a binary "1";
c) SILENCE disables the transmitter when no DL_symbol is to be transmitted.

The Ph-ASYN-DATA request primitive is passed from the DLE to the PhE to request that the given symbol shall be sent to the fieldbus medium.

The reception of this primitive shall cause the PhE to attempt encoding and transmission of the DL-symbol.

The Ph-ASYN-DATA request is a primitive, which shall only be generated once per DL-symbol period (t_{BIT}). The PhE may confirm this primitive with a locally defined confirmation primitive.

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Ph-ASYN-DATA indication (DL_symbol).

The parameter DL_symbol shall have one of the following values:

a) ZERO corresponds to a binary "0";
b) ONE corresponds to a binary "1".

The Ph-ASYN-DATA indication primitive is passed from the PhE to the DLE to indicate that a DL-symbol was received from the fieldbus medium. The effect of receipt of this primitive by the DLE is not specified.

The Ph-ASYN-DATA indication is a primitive, which shall only be generated once per received DL-symbol period (t_{BIT}).

5.5 Type 4: Required services

5.5.1 General

PhIDUs shall be transferred between the DLL and the PhL in accordance with the requirements of ISO/IEC 7498.

5.5.2 Primitives of the PhS

5.5.2.1 General

The granularity of transmission in the fieldbus protocol is one octet. This is the granularity of PhS-user data exchanged at the PhL – DLL interface.

5.5.2.2 PhS Transmission and reception services

The PhS shall provide the following service primitives for transmission and reception:

PH-DATA request (class, data)
PH-DATA indication (class, data, status)
PH-DATA confirm (status)

where

class – specifies the Ph-interface-control-information (PhICI) component of the Ph-interface-data-unit (PhIDU).

For a PH-DATA request, its possible values are

START-OF-ACTIVITY-11 – the PhE shall initiate transmission by transmitting the associated data parameter as an "Address character". The PhE shall do this immediately, though not until the value of the PhEs idle counter has reached 11. This class only applies to half duplex mode.

START-OF-ACTIVITY-2 – the PhE shall enable its driver, and initiate transmission by transmitting the associated data parameter as an "Address character". The PhE shall do this immediately, though not until the value of the PhEs idle counter modulus 10 has reached 2 if in half duplex mode.

DATA – the PhE shall transmit the associated data parameter as a “Data character”.

END-OF-ACTIVITY – the PhE shall wait until transmission of all formerly received data from the DLE has finished, and then terminate transmission. The associated data parameter shall not be transmitted.

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For a PH-DATA indication, its possible values are

START-OF-ACTIVITY – the PhE has received an "Address character", the value of which is reported in the associated data parameter. The associated status parameter specifies success or the locally detected reason for failure.

DATA – the PhE has received a "Data character", the value of which is reported in the associated data parameter. The associated status parameter specifies success or the locally detected reason for failure.

LINK-IDLE – the PhE has detected, that the signal level on the Link has been "Idle" for 30, 35, 40, 50, 60... bit periods. The associated status parameter specifies if the Link has been idle for 30 bit periods, for 35 bit periods, or for 40 or more bit periods. This class only applies to half duplex mode.

data – specifies the Ph-interface-data (PhID) component of the PhIDU. It consists of one octet of Ph-user data to be transmitted (PH-DATA request), or one octet of Ph-user data that was received (PH-DATA indication).

status – specifies either success or the locally detected reason for failure, or specifies if the associated LINK-IDLE indication indicates "30", "35" or "40 or more" bit periods of idle after Link activity.

The PH-DATA confirm primitive provides the feedback necessary to enable the DLE to report failures such as Link short-circuit or noise resulting in framing error to the DLS-user, and provides the critical physical timing necessary to prevent the DLE from starting a second transmission before the first is complete.

5.5.3 Transmission of Ph-user data

5.5.3.1 General

When a DLE has a DLPDU to transmit, and the Link-access system gives that DLE the right to transmit, then the DLE should send the DLPDU, including a concatenated FCS. Making a sequence of PH-DATA requests as follows does this:

a) In half duplex mode, the first request should specify START-OF-ACTIVITY-11 if the DLPDU to transmit is an Acknowledge or Immediate-reply DLPDU, or if the transmission is an immediate re-transmission of a Confirmed or Unconfirmed DLPDU. The first request should specify START-OF-ACTIVITY-2 if transmission of a Confirmed or Unconfirmed DLPDU from the queue is commenced. In full duplex mode, the first request should always specify START-OF-ACTIVITY-2.
b) This first request should be followed by consecutive requests specifying DATA, and concluded by a single request specifying END-OF-ACTIVITY.

The PhE signals its completion of each PH-DATA request, and its readiness to accept a new PH-DATA request, with a PH-DATA confirm primitive. The status parameter of the PH-DATA confirm primitive conveys the success or failure of the associated PH-DATA request.

5.5.3.2 Reception of Ph-user data

The PhE reports a received transmission with PH-DATA indications, which shall consist of either

– a single indication specifying START-OF-ACTIVITY, or
– a single indication specifying START-OF-ACTIVITY; followed by consecutive indications specifying DATA.

Each indication has an associated status parameter, specifying successful reception of the associated data, or the locally detected reason for failure.

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5.6 *Void*

NOTE Subclause 5.6 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

5.7 Type 8: Required services

5.7.1 General

PhIDUs are exchanged between the DLL (DLL) and the PhL (PhL). For the data transfer, the DL-Ph interface (MAC-MIS interface) shall make the following service primitives available:

PH-DATA request

PH-DATA confirm

PH-DATA indication

5.7.2 Primitives of the PhS

5.7.2.1 PH-DATA request (PhICI, PhIDU)

This service primitive is used to transfer a data unit from the MAC sublayer to the MIS. The **PhICI** parameter determines the interface components of the interface data unit (PhIDU) to be transmitted and can contain the following values:

ID_transfer
The beginning of a data sequence for the transmission of identification/control data is requested.

data_transfer
The beginning of a data sequence for the transmission of user data is requested.

start_ID_cycle
The beginning of an identification cycle for the transmission of identification/control data is requested by the master.

start_data_cycle
The beginning of a data cycle for the transmission of user data is requested by the master.

user_data
The transmission of the data unit of user data defined by the PhIDU parameter (identification/control data or user data) is requested.

CRC_data
The transmission of the data unit of checksum data defined by the PhIDU parameter is requested.

CRC_status
The transmission of the data unit for the checksum status defined by the PhIDU parameter is requested.

user_data_idle
The transmission of user_data_idle messages is requested.

CRC_data_idle
The transmission of CRC_data_idle messages is requested.

CRC_status_idle
The transmission of CRC_status_idle messages is requested.

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NOTE The start_data_cycle and start_ID_cycle parameters are supported by the MAC sublayer of a master only.

The **PhIDU** parameter defines the data component of the interface data unit to be transmitted. It consists of one bit, only if PhICI = user_data, CRC_data or CRC_status

5.7.2.2 PH-DATA confirm (status)

This service primitive is the acknowledgement to a PH-DATA request primitive and is used for synchronisation. The **status** parameter indicates whether the associated PH-DATA request primitive was executed successfully or not.

5.7.2.3 PH-DATA indication (PhICI, PhIDU)

This service primitive is used to transfer a data unit from the MIS to the MAC sublayer. The **PhICI** parameter defines the interface component of the interface data unit (PhIDU) to be transmitted and can assume the following values:

ID_transfer
Indicates the beginning of a data sequence for the transmission of identification/control data.

data_transfer
Indicates the beginning of a data sequence for the transmission of user data.

user_data
The correct receipt of the data unit for the transmission of user data (identification/control data or user data) defined by the PhIDU parameter is indicated.

CRC_data
The correct receipt of the data unit for transmission of the checksum defined by the PhIDU parameter is indicated.

CRC_status
The correct receipt of the data unit for the transmission of the checksum status defined by the PhIDU parameter is indicated.

user_data_idle
The receipt of user_data_idle messages is indicated.

CRC_data_idle
The receipt of CRC_data_idle messages is indicated.

CRC_status_idle
The receipt of CRC_status_idle messages is indicated.

The **PhIDU** parameter defines the data components of the received interface data unit. It consists of one bit.

5.7.3 Overview of the Interactions

NOTE For the data transfer via the DL-Ph interface, a difference is made between the data sequence (transmission of user or identification data) and the check sequence (transmission of checksum data).

The following apply to Figure 4 through Figure 7.

– If a data sequence of a data cycle is followed by a data sequence of an identification cycle, the interactions marked with (+) are omitted for an identification cycle.
– If a data sequence of an identification cycle is followed by a data sequence of a data cycle, the interactions marked with (+) are omitted for a data cycle.

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5.7.3.1 Data Sequence

5.7.3.1.1 Master

Figure 4 and Figure 5 show the interactions for a data sequence (identification cycle and data cycle) at the DL-Ph interface of a master (controller board).

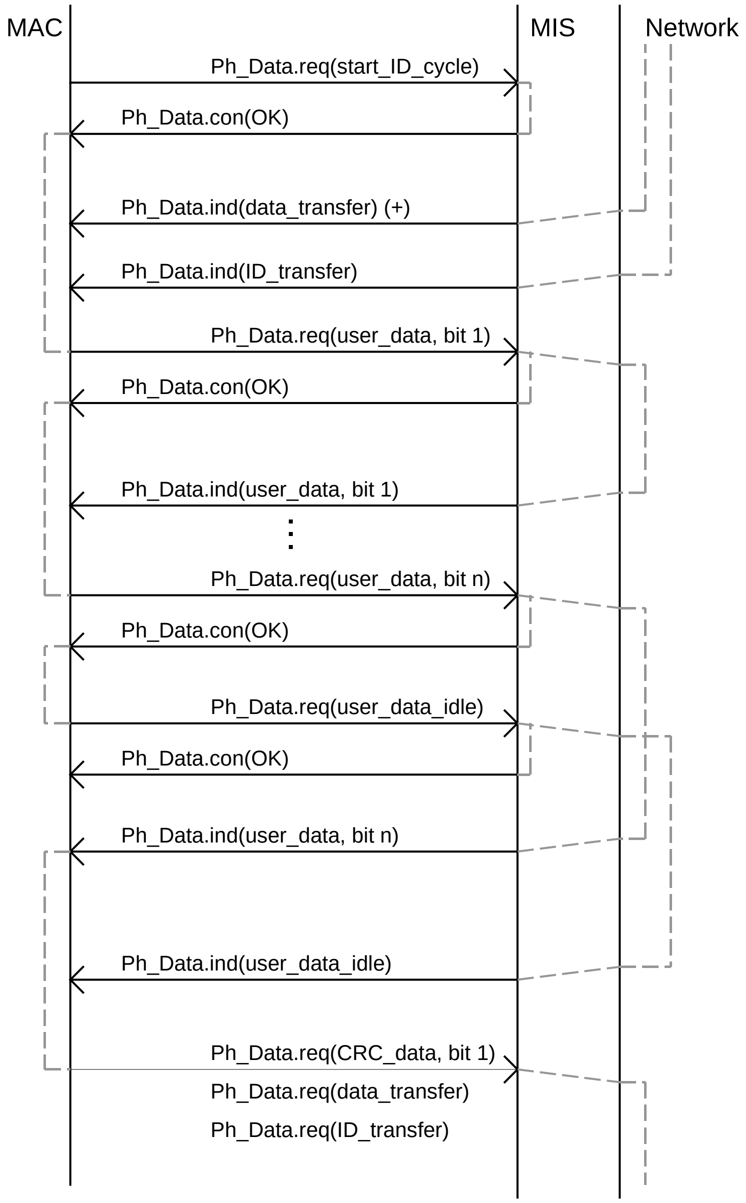

Figure 4 – Interactions for a data sequence of a master: identification cycle

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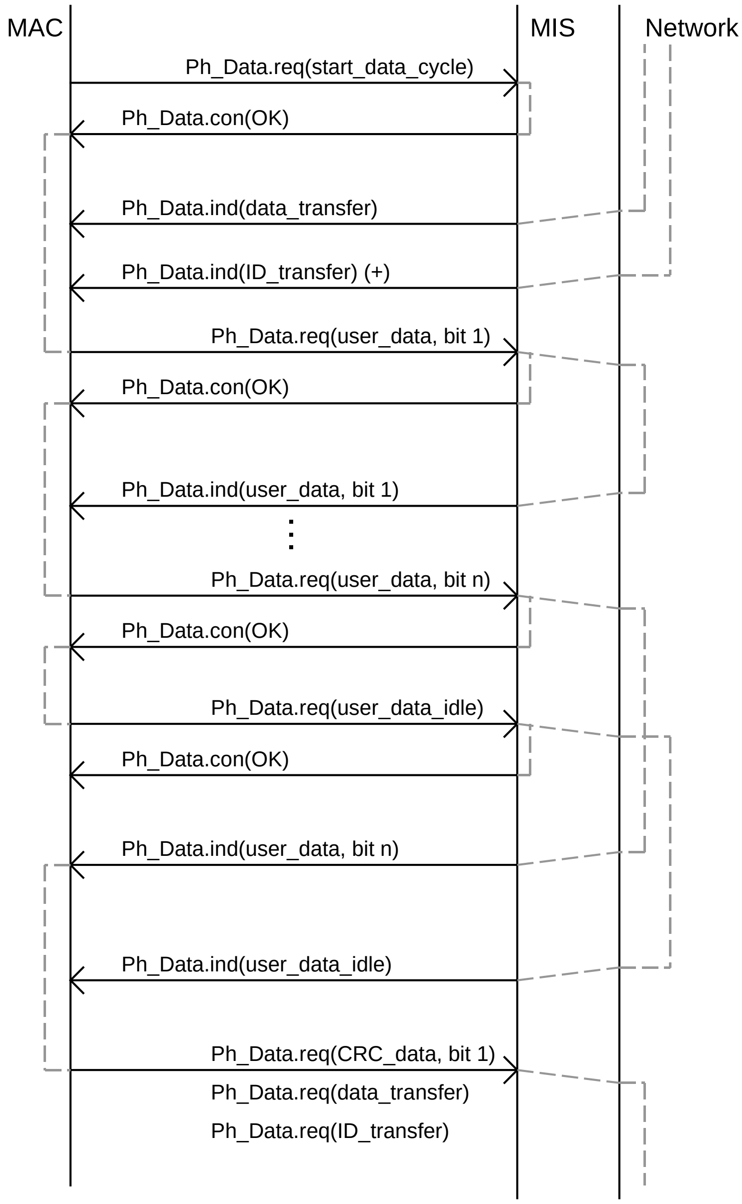

Figure 5 – Interactions for a data sequence of a master: data cycle

5.7.3.1.2 Slave

Figure 6 and Figure 7 show the interactions for a data sequence (identification cycle and data cycle) at the DL-Ph interface of a slave (remote bus device, local bus device or bus coupler).

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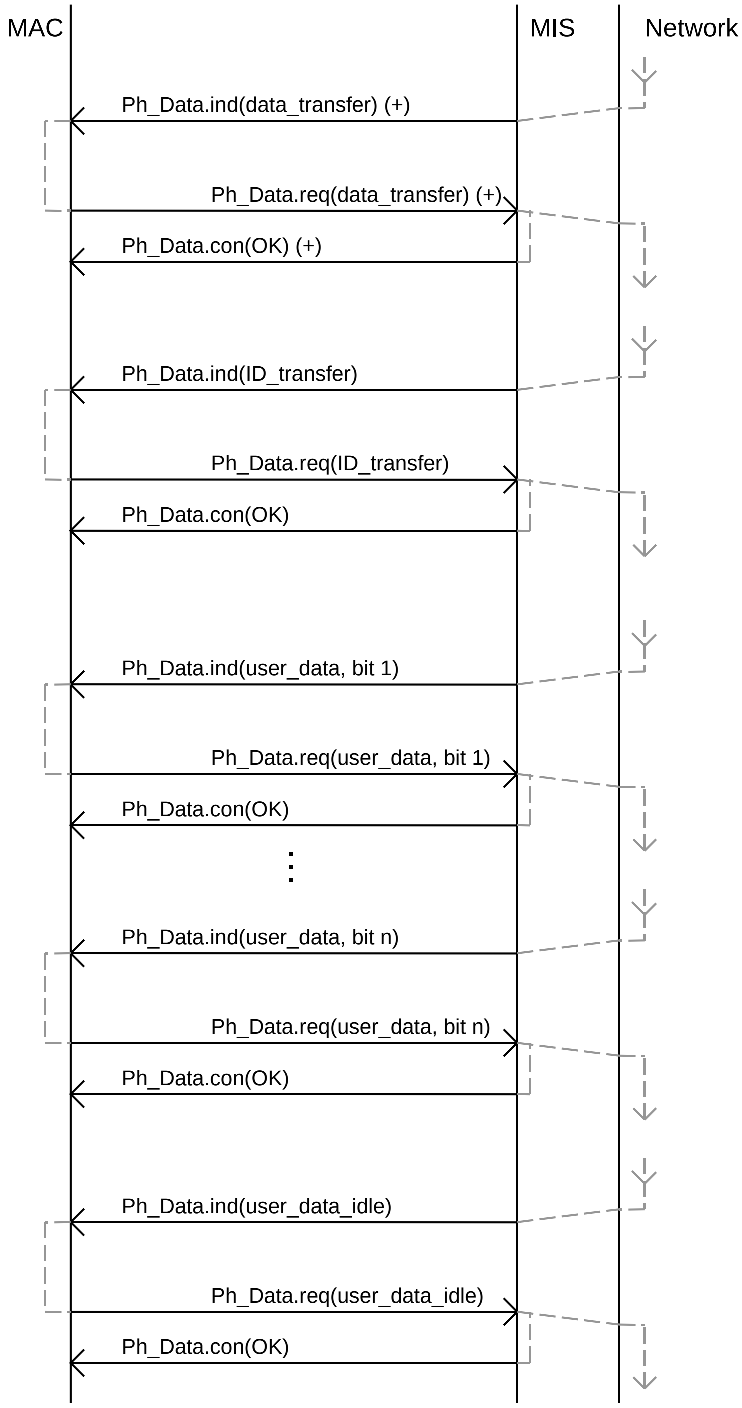

Figure 6 – Interactions for a data sequence of a slave: identification cycle

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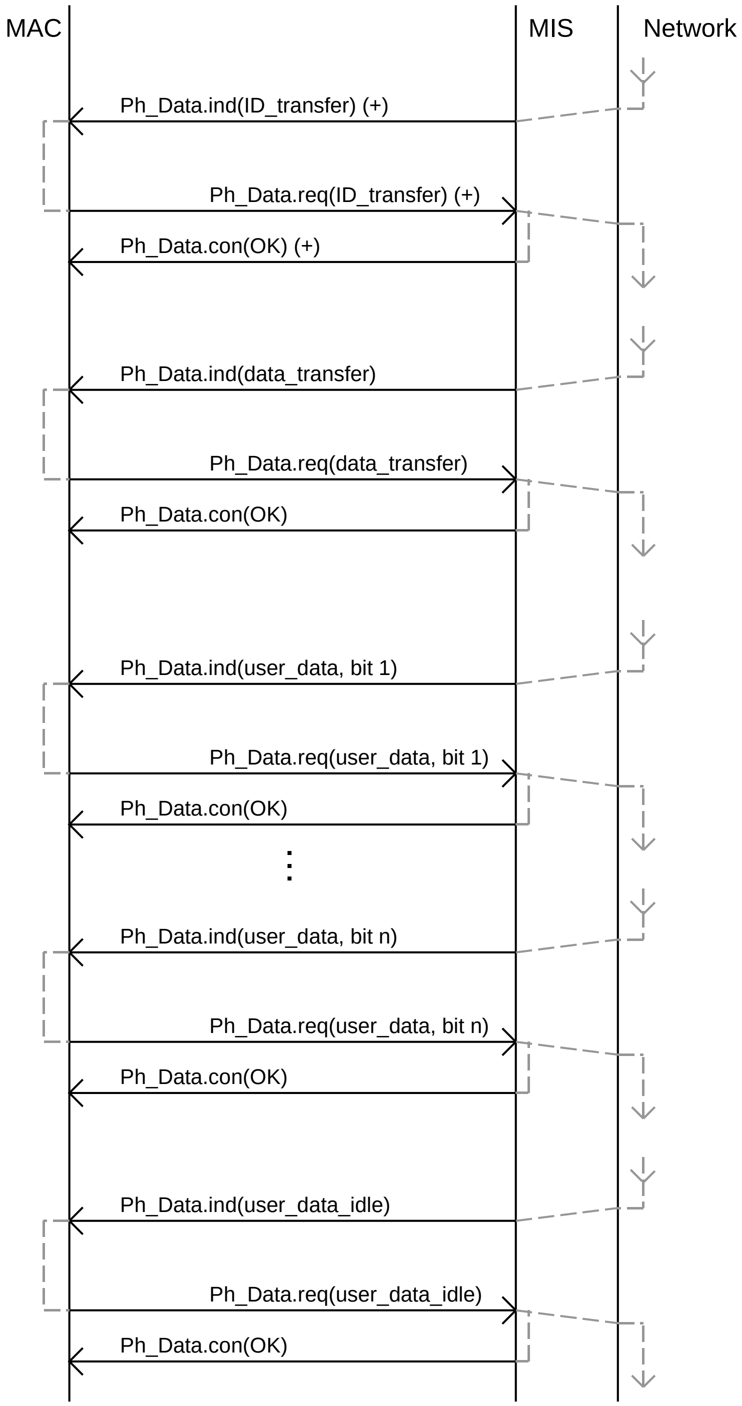

Figure 7 – Interactions for a data sequence of a slave: data cycle

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5.7.3.2 Check sequence

5.7.3.2.1 Master

Figure 8 shows the interactions for a check sequence at the DL-Ph interface of a master.

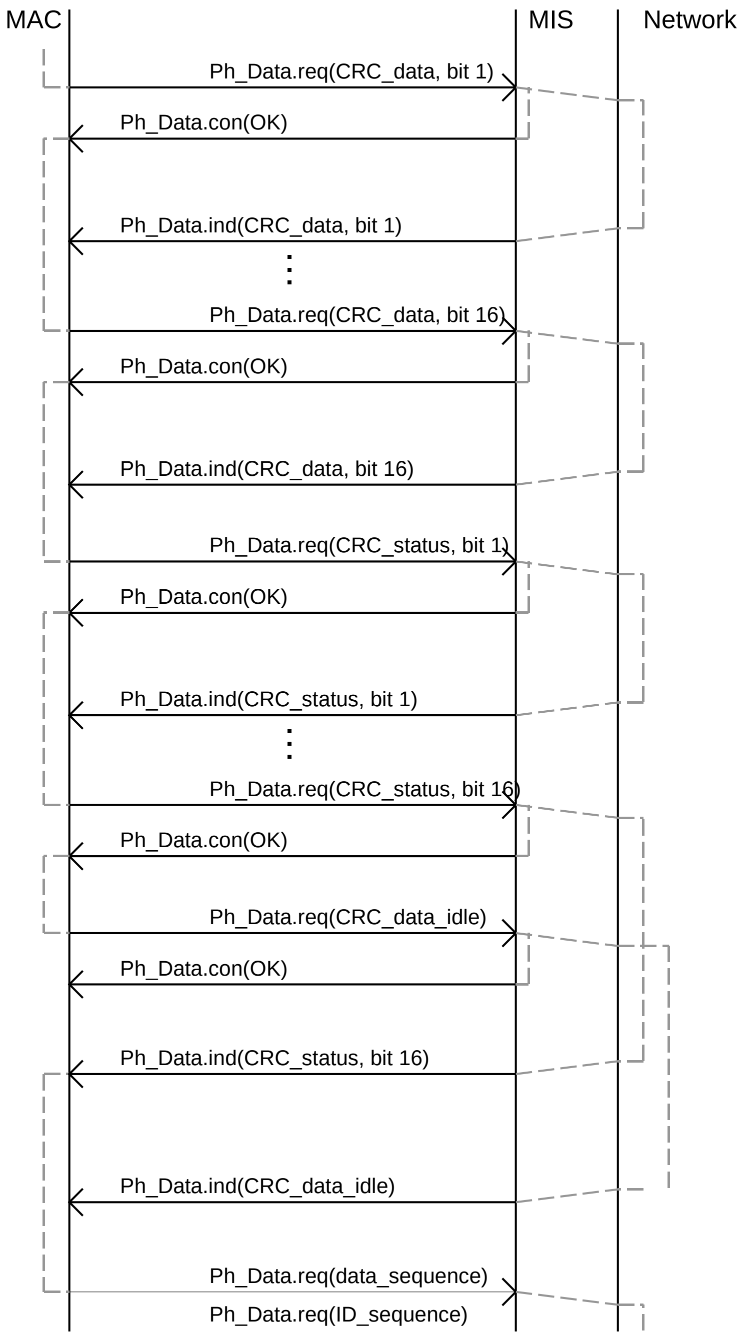

Figure 8 – Interactions for a check sequence of a master

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5.7.3.3 Slave

Figure 9 shows the interactions for a check sequence at the DL-Ph interface of a slave.

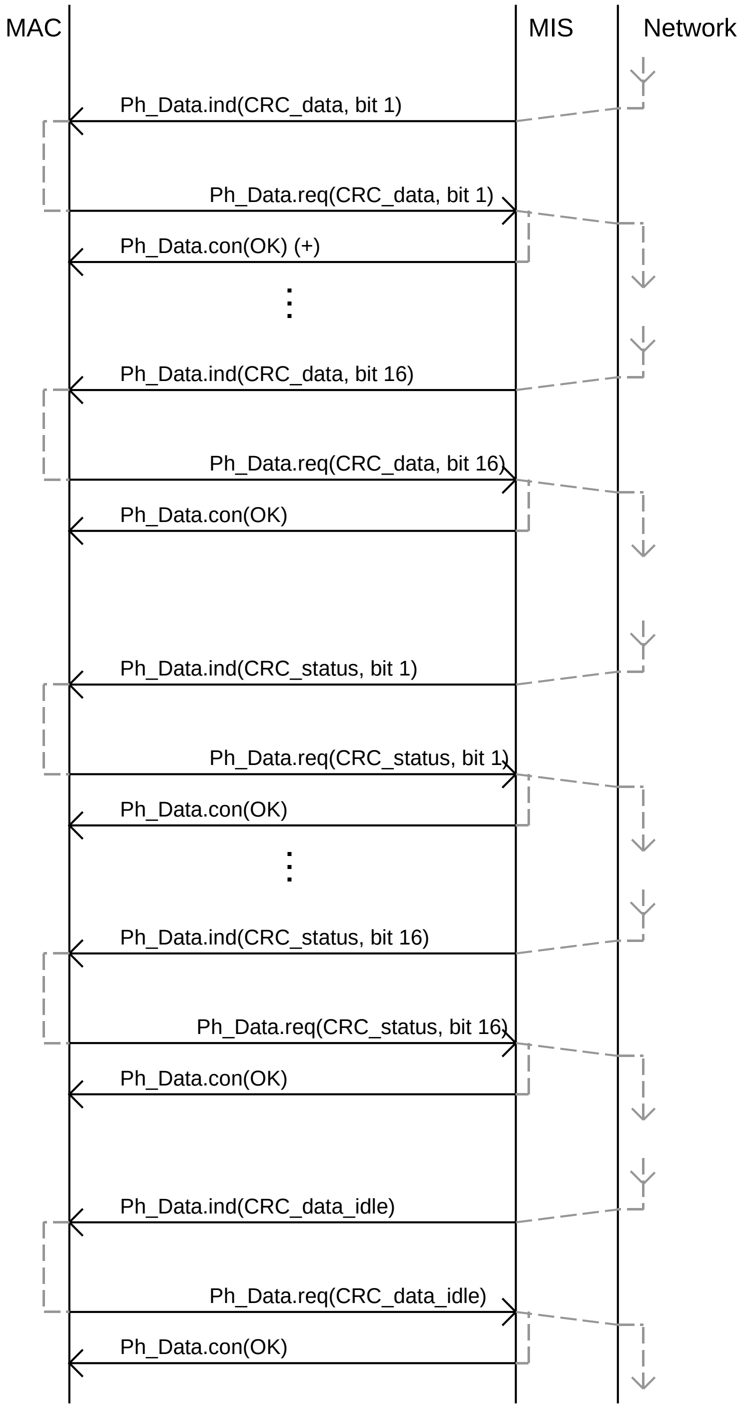

Figure 9 – Interactions for a check sequence of a slave

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5.8 Type 12: Required services

5.8.1 Primitives of the PhS

5.8.1.1 General

The granularity of PhS-user data exchanged at the PhL – DLL interface is one octet.

5.8.1.2 Ph-CHARACTERISTICS Indication

The PhS shall provide the following service primitive to report essential PhS characteristics (which may be used in DLL transmission, reception, and scheduling activities):

– Ph-CHARACTERISTICS indication (minimum-data-rate, framing-overhead)

where

– minimum-data-rate – shall specify the effective minimum rate of data conveyance in bits per second, including any timing tolerances;

NOTE 1 A PhE with a nominal data rate of 100 Mbit/s ± 0,01 % would specify a minimum data rate of 99,99 Mbit/s.

– framing overhead – shall specify the maximum number of bit periods (where the period is the inverse of the data rate) used in any transmission for PhPDUs that do not directly convey data (e.g. PhPDUs conveying frame delimiters, inter-frame "silence", etc.).

NOTE 2 If the framing overhead is F and two DL message lengths are L_1 and L_2, then the time to send one message of length $L_1 + F + L_2$ will be at least as great as the time required to send two immediately consecutive messages of lengths L_1 and L_2.

5.8.1.3 PhS transmission and reception services

The PhS shall provide the following service primitives for transmission and reception:

– PH-DATA request (class, data);

– PH-DATA indication (class, data);

– PH-DATA confirm (status).

where

– class – shall specify the PhICI component of the PhIDU.

For a PH-DATA request, its possible values shall be:

– START-OF-FRAME – transmission of the PhPDUs which precede Ph-user data shall commence;

– DATA – the single-octet value of the associated data parameter shall be transmitted as part of a continuous correctly formed transmission; and

– END-OF-FRAME – the PhPDUs that terminate Ph-user data shall be transmitted after the last preceding octet of Ph-user data.

For a PH-DATA indication, its possible values shall be:

– START-OF-FRAME – reception of an apparent transmission from one or more PhEs has commenced;

– DATA – the associated data parameter was received as part of a continuous correctly formed reception;

– END-OF-FRAME – the ongoing continuous correctly formed reception of Ph-user data has concluded with correct reception of PhPDUs;

– END-W-ERROR – the ongoing continuous correctly formed reception of Ph-user data was disrupted with not correct formed reception implying END-OF-FRAME WITH ERROR;

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– data – shall specify the PhID component of the PhIDU. It consists of one octet of Ph-user-data to be transmitted (PH-DATA request) or which was received successfully (PH-DATA indication);
– status – shall specify either success or the locally detected reason for inferring failure.

The PH-DATA confirm primitive shall provide the critical physical timing feedback necessary to inhibit the DLE from starting a second transmission before the first is complete. The final PH-DATA confirm of a transmission shall not be issued until the PhE has completed the transmission.

5.8.2 Notification of PhS characteristics

The PhE has the responsibility for notifying the DLE of those characteristics of the PhS that may be relevant to DLE operation. The PhE shall do this by issuing a single Ph-CHARACTERISTICS indication primitive at each of the PhEs at PhE start-up.

5.8.3 Transmission of Ph-user-data

The PhE shall determine the timing of all transmissions. When a DLE transmits a sequence of PhSDUs, the DLE shall send the sequence of PhSDUs by making a well-formed sequence of PH-DATA requests, consisting of a single request specifying START-OF-FRAME, followed by 72 to 1 535 consecutive requests, inclusive, specifying DATA, each conveying a PhSDU, and concluded by a single request specifying END-OF-FRAME.

The PhE shall signal its completion of each PH-DATA request, and its readiness to accept a new PH-DATA request, by issuing a PH-DATA confirm primitive; the status parameter of the PH-DATA confirm primitive shall convey the success or failure of the associated PH-DATA request. A second PH-DATA request shall not be issued by the DLE until after the PH-DATA confirm corresponding to the first request has been issued by the PhE.

5.8.4 Reception of Ph-user-data

The PhE shall report a received transmission with a well-formed sequence of PH-DATA indications, which shall consist of

a) a single indication specifying START-OF-FRAME; followed by consecutive indications specifying DATA, each conveying a PhSDU; and concluded by a single indication specifying END-OF-FRAME; or
b) a single indication specifying START-OF-FRAME; optionally followed by one or more consecutive indications specifying DATA, each conveying a PhSDU; and concluded by a single indication specifying END-W-ERROR.

This last sequence is indicative of an incomplete or incorrect reception. Detection of an error in the sequence of received PhPDUs, or in the PhEs reception process, shall disable further PH-DATA indications with a class parameter specifying DATA, or END-OF-FRAME until after both the end of the current period of activity and the start of a subsequent period of activity have been reported by PH-DATA indications specifying START-OF-FRAME.

5.9 Type 16: Required services

5.9.1 Primitives of the PhS

5.9.1.1 General

The granularity of PhS-user data exchanged at the PhL – DLL interface shall be one octet.

5.9.1.2 PhS transmission and reception services

The PhS shall provide the following service primitives for transmission and reception:

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– Ph-Data request (class, data);
– Ph-Data indication (class, data);
– Ph-Data confirm (status)

where

– class – shall specify the PhICI component of the PhIDU.

For a Ph-Data request, its possible values shall be:

– start-of-activity – transmission of the PhPDUs which precede Ph-user data shall commence;
– data – the single-octet value of the associated data parameter shall be transmitted as part of a continuous correctly formed transmission; and
– end-of-data-and-activity – the PhPDUs that terminate Ph-user data shall be transmitted after the last preceding octet of Ph-user data, culminating in the cessation of active transmission.

For a Ph-Data indication, its possible values shall be:

– start-of-activity – reception of an apparent transmission from the PhE has commenced;
– data – the associated data parameter was received as part of a continuous correctly formed reception;
– end-of-data – the ongoing continuous correctly formed reception of Ph-user data has concluded with correct reception of PhPDUs implying end-of-data;
– data – shall specify the PhID component of the PhIDU. It consists of one octet of Ph-user-data to be transmitted (Ph-Data request) or which was received successfully (Ph-Data indication);
– status – shall specify either success or the locally detected reason for inferring failure.

The Ph-Data confirm primitive shall provide the critical physical timing feedback necessary to inhibit the DLE from starting a second transmission before the first is complete. The final Ph-Data confirm of a transmission shall not be issued until the PhE has completed the transmission.

5.9.2 Transmission of Ph-user-data

The PhE shall determine the timing of all transmissions. When the DLE transmits a sequence of PhSDUs, it shall send the sequence of PhSDUs by making a well-formed sequence of Ph-Data requests, consisting of a single request specifying start-of-activity, followed by the required number of consecutive requests, inclusive, specifying data, each conveying a PhSDU, and concluded by a single request specifying end-of-data-and-activity.

The PhE shall signal its completion of each Ph-Data request, and its readiness to accept a new Ph-Data request, by issuing a Ph-Data confirm primitive; the status parameter of the Ph-Data confirm primitive shall convey the success or failure of the associated Ph-Data request. A second Ph-Data request shall not be issued by the DLE until after the Ph-Data confirm corresponding to the first request has been issued by the PhE.

5.9.3 Reception of Ph-user-data

The PhE shall report a received transmission with a well-formed sequence of Ph-Data indications, which shall consist of

a) a single indication specifying start-of-activity; followed by consecutive indications specifying data, each conveying a PhSDU; followed by a single indication specifying end-of-data; and concluded by a single indication specifying end-of-activity; or

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b) a single indication specifying start-of-activity; followed by consecutive indications specifying data, each conveying a PhSDU; followed by a single indication specifying end-of-data-and-activity; or

c) a single indication specifying start-of-activity; optionally followed by one or more consecutive indications specifying data, each conveying a PhSDU; and concluded by a single indication specifying end-of-activity.

This last sequence is indicative of an incomplete or incorrect reception. Detection of an error in the sequence of received PhPDUs, or in the PhEs reception process, shall disable further Ph-Data indications with a class parameter specifying data, end-of-data, or end-of-data-and-activity until after both the end of the current period of activity and the start of a subsequent period of activity have been reported by Ph-Data indications specifying end-of-activity and start-of-activity, respectively.

5.10 Type 18: Required services

5.10.1 General

The DLL-PhL interface need not be exposed in the implementation of a Type 18 PhE. This interface may be internal to the node and may be implemented as internal to a semiconductor device.

5.10.2 Primitives of the PhS

5.10.2.1 General

The granularity of PhS-user data exchanged at the DLL – PhL interface is one bit.

5.10.2.2 PhS transmission and reception services

The PhS shall provide the following service primitives for transmission and reception:

– PH-DATA request (class, data);

– PH-DATA indication (class, data);

– PH-DATA confirm (status).

where:

- **class** – specifies the Ph-interface-control-information (PhICI) component of the Ph-interface-data-unit (PhIDU).

For a PH-DATA request, possible values of class are:

– START-OF-ACTIVITY – transmission of the PhPDUs which precede Ph-user data shall commence;

– DATA – the single-bit value of the associated data parameter shall be transmitted as part of a continuous correctly formed transmission; and

– END-OF-ACTIVITY – the PhPDUs that terminate Ph-user data shall be transmitted after the last preceding bit of Ph-user data, culminating in the cessation of active transmission.

For a PH-DATA indication, possible values of class are:

– START-OF-ACTIVITY – reception of an apparent transmission from one or more PhEs has commenced;

– DATA – the associated data parameter was received as part of a continuous correctly formed reception;

– END-OF-ACTIVITY – the ongoing reception (of an apparent transmission from one or more PhEs) has concluded, with no further evidence of PhE transmission; and

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- **data** – shall specify the PhID component of the PhIDU. It consists of one bit of Ph-user-data to be transmitted (PH-DATA request) or which was received successfully (PH-DATA indication).

  and

- **status** – shall specify either success or the locally detected reason for inferring failure.

The PH-DATA confirm primitive shall provide the critical physical timing feedback necessary to inhibit the DL-user from starting a second transmission before the first is complete. The final PH-DATA confirm of a transmission shall not be issued until the PhE has completed the transmission.

5.10.3 Transmission of Ph-user-data

The PhE shall determine the timing of all transmissions. When a DLE transmits a sequence of PhSDUs, the DLE shall send the sequence of PhSDUs by making a well-formed sequence of PH-DATA requests, consisting of a single request specifying START-OF-ACTIVITY, followed by a series of consecutive requests specifying DATA, each conveying a PhSDU, and concluded by a single request specifying END-OF-ACTIVITY.

The PhE shall signal its completion of each PH-DATA request, and its readiness to accept a new PH-DATA request, by issuing a PH-DATA confirm primitive; the status parameter of the PH-DATA confirm primitive shall convey the success or failure of the associated PH-DATA request. A second PH-DATA request shall not be issued by the DLE until after the PH-DATA confirm corresponding to the first request has been issued by the PhE.

5.10.4 Reception of Ph-user-data

The PhE shall report a received transmission with a well-formed sequence of PH-DATA indications, which shall consist of a single indication specifying START-OF-ACTIVITY; followed by consecutive indications specifying DATA, each conveying a PhSDU; followed by a single indication specifying END-OF-ACTIVITY.

5.11 Type 24: Required services

5.11.1 General

The DLL-PhL interface need not be exposed in the implementation of Type 24 PhL. This interface may be internal to the node and may be implemented as internal to a semiconductor device.

Table 4 shows the primitives and the parameters that are exchanged between DLL and PhL.

Table 4 – Primitives and parameters in DLL-PhL interface

Service primitives	Parameters
PLS_CARRIER.indication {CARRIER_STATUS}	CARRIER_ON, CARRIER_OFF
PLS_DATA_VALID.indication {DATA_VALID_STATUS}	DATA_VALID, DATA_NOT_VALID
PLS_SIGNAL.indication {SIGNAL_STATUS}	SIGNAL_ERROR, NO_SIGNAL_ERROR
PLS_DATA.indication {INPUT_UNIT}	ZERO, ONE
PLS_DATA.request {OUTPUT_UNIT}	ZERO, ONE

5.11.2 DL_Symbols

The PhL Interface Data Units present at the DLL-PhL interface shall be DL_symbols. DL_symbol shall have one of the following values:

a) ZERO corresponds to a binary "0";

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b) ONE corresponds to a binary "1".

5.11.3 PLS_CARRIER indication

PLS_CARRIER indication shall represent the presence of a signal carrier on the medium. The parameter CARRIER_STATUS shall take on one of two values; CARRIER_ON or CARRIER_OFF. The CARRIER_ON indicates that the MDS detect the change of Ph_Symbol that has been inputted from MAU. The CARRIER_OFF indicate that the MDS detected the state without the change in Ph_Symbol continuing more than 3 times. This primitive is generated whenever the CARRIER_STATUS make a transition from CARRIER_OFF to CARRIER_ON or vice versa.

5.11.4 PLS_SIGNAL indication

PLS_SIGNAL indication shall provide an indication of decoding status by the MDS. The parameter SIGNAL_STATUS shall take on one of two values; NO_SIGNAL_ERROR or SIGNAL_ERROR. The NO_SIGNAL_ERROR indicates that MDS detect the manchester code pattern “L, H” or “H, L” from Ph_Symbols that has been inputted from MAU. The SIGNAL_STATUS indicates that the MDS detect manchester violation. This primitive is generated whenever the SIGNAL_STATUS make a transition from SIGNAL_ERROR to NO_SIGNAL_ERROR or vice versa.

5.11.5 PLS_DATA_VALID indication

PLS_DATA_VALID indication shall provide an indication of Ph_Symbol synchronization by the MDS. The parameter DATA_VALID_STATUS shall take on one of two values; DATA_VALID or DATA_NOT_VALID. The DATA_VALID indicates that MDS detect the sequence of bit pattern “0, 1, 0” or “1, 0 , 1” from DL_Symbol to be passed to DLL. The DATA_NOT_VALID indicates that the MDS detect carrier off. This primitive is generated whenever the DATA_VALID_STATUS make a transition from DATA_NOT_VALID to DATA_VALID or vice versa.

5.11.6 PLS_DATA indication

PLS_DATA indication shall represent the DL_Symbol. Valid symbols shall be ZERO {0} or ONE {1}. PLS_DATA indication shall represent the DL_Symbol as decoded from the MAU whenever the parameter of PLS_DATA_VALID indication is DATA_VALID.

5.11.7 PLS_DATA request

PLS_DATA request shall represent the DL_Symbol to be transmitted. The OUTPUT_UNIT parameter shall take on one of tree value, ZERO, ONE.

5.12 Type 20: Required services

5.12.1 Facilities of the physical layer services

The PhE provides following services:

- Data service – it supports the transfer of Physical layer service (PhS) -user-data from a source PhS-user to a destination PhS-user, and
- PhL-management services – it supports configuration of the PhL.

5.12.2 Sequence of primitives

The relations of primitives of each type at the interface of PhS-user and one PhE to primitives at the PhS-user and the other PhEs are summarized in the diagrams of Figure 10.

Before using the PhE, the PhS-user should start transmission of the activity on the medium using service shown in the sequence of Figure 10 a). At the destination, the reception starts with PH-START indication after the activity has been detected by the PhE. The sequence of

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Figure 10 b) shows the transmission of PhPDU from the source PhL entity (PhE) to the destination PhE, one octet data per request. The reception ends with Ph-Data indication at the destination. If there is any error in the reception then the PhE at the destination indicates it by a status parameter and may deliver PhS-user-data. After transmitting all data, the PhS-user should stop transmission of the activity as shown in the sequence of Figure 10 c).

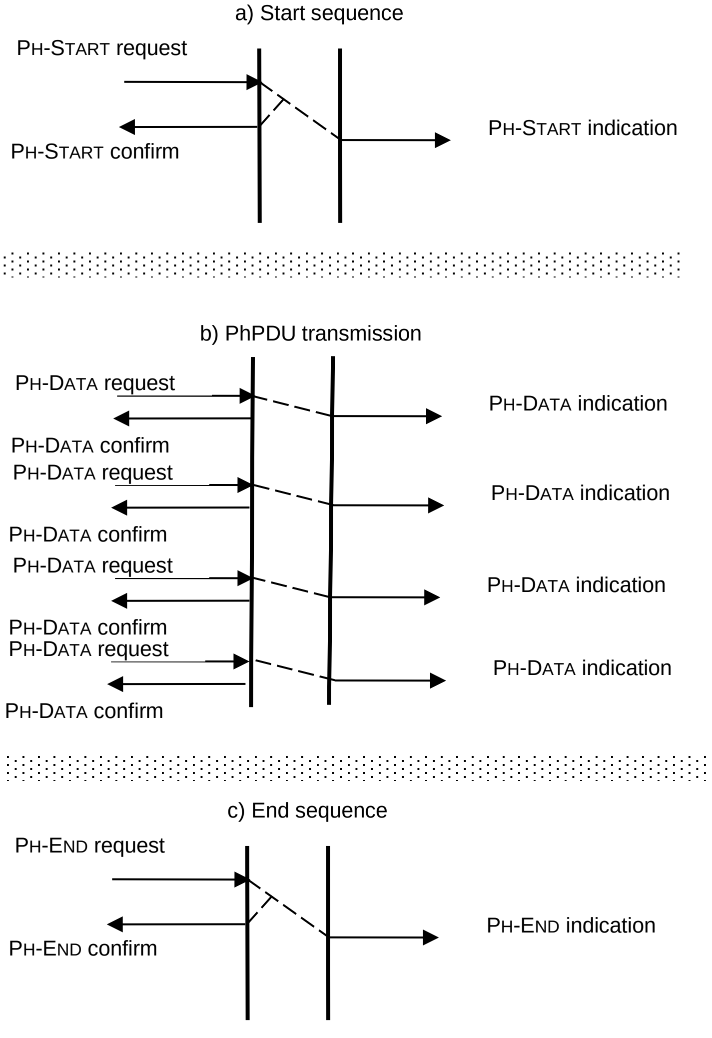

Figure 10 – Physical layer data service sequences

5.12.3 PH-START service

5.12.3.1 Types of primitives and parameters

Table 5 indicates the types of primitives and the parameters needed for the PH-START service. This service is used to start the activity in the medium and transmit the PhPDUs which precede Ph-user data. The request service is successful only if the medium is in idle state. The confirm primitive does not imply the successful indication at any other device connected to the medium. The receiving device senses the presence of the activity and after a delay it provides the indication to the PhS-user.

Table 5 – PH-START primitives and parameters

Parameter name	Request	Indication	Confirm
Status			M

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5.12.3.2 Parameters

The request primitive does not require any parameter. The indication primitive does not convey any parameter. The confirm primitive indicates either success or a reason for error.

5.12.4 PH-DATA service

5.12.4.1 Types of primitives and parameters

Table 6 indicates the types of primitives and the parameters needed for the PH-DATA service.

Table 6 – PH-DATA primitives and parameters

Parameter name	Request	Indication	Confirm
PhS-user-data	M	C(=)	
Status		M	M

5.12.4.2 Parameters

5.12.4.2.1 PhS-user-data

This parameter allows the transmission of single-octet data between PhS-users without alteration by the PhS-provider. After PH-START confirm, the PhS-users should issue PH-DATA requests such that all data is transmitted as part of a continuous correctly-formed transmission. If there is any error in reception then this parameter is either absent in the indication primitive, or its value may have error. Else, its value is identical to the value in the request primitive.

5.12.4.2.2 Status

In the indication primitive, this parameter indicates either success or one of the following reasons for error:

– receive buffer overflow,
– parity error,
– framing error,
– discontinuous data reception.

In the Confirm primitive, this parameter indicates either success or one of the following reasons for error:

– transmitter busy,
– inactive medium.

5.12.5 PH-END service

This service is used to end the activity in the medium and transmit the PhPDUs which follow Ph user data. The confirm primitive does not imply the successful indication at any device connected to the medium. This service does not require any parameter. The indication primitive is provided by the PhE when lack of medium activity is detected.

6 Systems management – PhL interface

6.1 General

This interface provides services to the PhL, which are required for initialisation and selection of options.

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One of the objectives of the PhL is to allow for future variations such as radio, fiber optics, redundant channels (e.g. cables), different modulation techniques, etc. A general form of Systems management – PhL Interface is specified which provides the services required by implementations of these variations. Services provided by this interface are specified in 6.2 through 6.5. The standard does not require this interface to be exposed.

The complete set of management services can only be used when the device is directly coupled to the medium. In the case of actively coupled equipment (e.g. active coupler, repeater, radio/telephone modem, opto-electronics, etc.) some of the services can be implicit to the active coupler. Moreover, each device can use a subset of the described primitives.

NOTE A number of different Systems management – PhL interfaces are specified, based on industry practice.

6.2 Type 1: Systems management – PhL interface

6.2.1 Required services

The minimum service primitive for PhL (PhL) management shall be:

a) PH-RESET request – reset of the Ph-layer.

The following additional services may be provided:

b) Ph-SET-VALUE request/Ph-SET-VALUE confirm – set parameters;

c) Ph-GET-VALUE request/Ph-GET-VALUE confirm – read parameters;

d) Ph-EVENT indication – report Ph-layer events.

6.2.2 Service primitive requirements

6.2.2.1 PH-RESET request

This primitive has no parameter. Upon reception of this primitive the PhL shall reset all its functions.

6.2.2.2 Ph-SET-VALUE request (parameter name, new value)

If this primitive is used it shall allow Systems management to modify the parameters of the PhL. Standard parameter names and value ranges are given in Table 7. The value assumed for each parameter at reset shall be the first of those shown for the parameter.

Table 7 – Parameter names and values for Ph-SET-VALUE request

Parameter name	Range of values
Interface mode	• FULL_DUPLEX • HALF_DUPLEX
Loop-back mode	• DISABLED • in MDS at DTE – DCE interface • in MAU near line connection
Preamble extension	• 0..7 (preamble extension sequences)
Post-transmission gap extension	• 0..7 (gap extension sequences)
Maximum inter-channel signal skew	• 0..7 (gap extension sequences)
Transmitter output channel *N* ($1 \le N \le 8$)	• ENABLED • DISABLED
Receiver input channel *N* ($1 \le N \le 8$)	• ENABLED • DISABLED
Preferred receive channel	• NONE • 1..8

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NOTE 1 Not all implementations require every parameter, and some may need more.

NOTE 2 Each DCE standard specifies both the basic and extension sequences of PhPDUs to be sent as preamble. These extension sequences are always prefixed to the basic sequence.

NOTE 3 Each DCE standard specifies the lengths of both the basic and extension sequences of post-transmission gap during which the transmitter is silent.

NOTE 4 From the above, the default value at reset is minimum preamble (no extension), minimum post-transmission gap (no extension), full-duplex interface mode, not in loopback, with all transmit and receive channels enabled, and with no preferred receive channel.

6.2.2.3 Ph-SET-VALUE confirm (status)

This primitive has a single parameter indicating the status of the request: Success or Failure. If this primitive is used it shall acknowledge completion of the Ph-SET-VALUE request in the PhL.

6.2.2.4 Ph-GET-VALUE request (parameter name)

If this primitive is used it shall allow the Systems management to read the parameters of the PhL. The parameter shall have one of the names given in Table 7.

6.2.2.5 Ph-GET-VALUE confirm (current value)

This primitive is the response of the PhL to the Ph-GET-VALUE request. If this primitive is used it shall have a single parameter reporting either the failure of the request – Failure – or the present value of the requested parameter. The current value shall be one of those permitted by 6.2.2.2.

6.2.2.6 Ph-EVENT indication (parameter name)

If this primitive is used it shall notify the Systems management of a PhL parameter modification which has not been requested by the Systems management. The parameter shall have one of the names given in Table 8, based on names specified in 8.2.

Table 8 – Parameter names for Ph-EVENT indication

Parameter name
DTE fault
DCE fault

NOTE Additions to Table 8 are possible if required by specific implementations.

6.3 Type 3: Systems management – PhL interface

6.3.1 Synchronous transmission

The services and the service primitive requirements specified for Type 1 shall be used (see 6.2).

6.3.2 Asynchronous transmission

6.3.2.1 General

Subclause 6.3.2 describe the interface between the PhL asynchronous transmission and a PhMS-user and the associated service primitives and parameters.

The service model, service primitives, and time-sequence diagrams used are entirely abstract descriptions; they do not represent a specification for implementation.

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Service primitives, used to represent service user/service provider interactions (see ISO/IEC 10731), convey parameters that indicate information available in the user/provider interaction.

This Type of this standard uses a tabular format to describe the component parameters of the PhMS primitives. Each table consists of up to three columns, containing the name of the service parameter, and a column each for those primitives and parameter-transfer directions used by the PhMS:

- the request primitive's input parameters;
- the indication primitive's output parameters; and
- the confirm primitive's output parameters.

One parameter (or part of it) is listed in each row of each table. Under the appropriate service primitive columns, a code is used to specify the type of usage of the parameter on the primitive and parameter direction specified in the column:

M – parameter is mandatory for the primitive.

(**blank**) – parameter is never present.

6.3.2.2 Facilities of the PhMS

Ph-management organizes the initialisation and the configuration of the PhE, and the event and error handling between the PhMS-user and the logical functions in the PhE. The following functions are provided to the PhMS-user.

a) Reset of the local PhE
b) Request for and modification of the actual operating parameters of the local PhE
c) Notification of unexpected events and status changes of the local PhE

6.3.2.3 Overview of services

Ph-management provides the following services to the PhMS-user:

a) Reset

   The PhMS-user employs this service to cause Ph-management to reset the PhE. A reset is equivalent to power on. The PhMS-user receives a confirmation thereof.

b) Set Value

   The PhMS-user employs this service to assign a new value to the variables of the PhE. The PhMS-user receives a confirmation whether the specified variables have been set to the new value.

c) Get Value

   This service enables Ph-management to read the variables of the PhE. The response of the Ph-management returns the actual value of the specified variables.

d) Event

   Ph-management employs this service to inform the PhMS-user about certain events or errors in the PhL.

The services Reset and Event are mandatory. The services Set Value and Get Value are optional.

6.3.2.4 Overview of interactions

Ph-management services and their primitives are summarized in Table 9.

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Table 9 – Summary of Ph-management services and primitives

Service	Primitive	Possible for the following stations
Reset	PhM-RESET request PhM-RESET confirm	Master and slave
Set Value	PhM-SET-VALUE request PhM-SET-VALUE confirm	Master and slave
Get Value	PhM-GET-VALUE request PhM-GET-VALUE confirm	Master and slave
Event	PhM-EVENT indication	Master and slave

The temporal relationships of the Ph-management primitives are shown in Figure 11 and Figure 12.

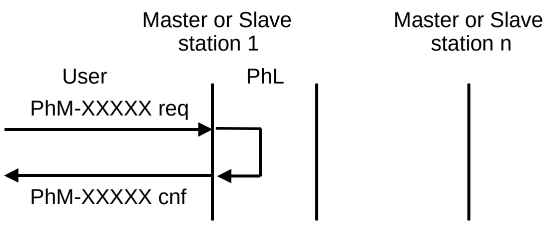

Figure 11 – Reset, Set-value, Get-value

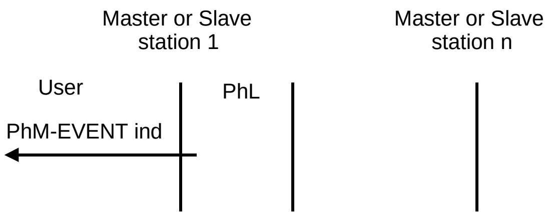

Figure 12 – Event service

6.3.2.5 Detailed specification of services and interactions

6.3.2.5.1 Reset

6.3.2.5.1.1 Function

The PhMS-user passes a PhM-RESET request primitive to Ph-management causing it to reset the PhE. This is carried out in the same manner as at a Power On (Transmitter_output: enabled; Receiver_signal_source: primary; Loop: disabled). As a result, Ph-management passes a PhM-RESET confirm primitive to the PhMS-user to indicate the success or failure of the corresponding service request.

6.3.2.5.1.2 Types of primitives and parameters

Table 10 indicates the primitives and parameters of the Reset service.

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Table 10 – Reset primitives and parameters

PhM-RESET	Request	Confirm
Parameter name	**input**	**output**
PhM-STATUS		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

PhM-Status

This parameter specifies the status of the execution of the associated service request. Permitted values for this parameter are specified in Table 11.

Table 11 – Values of PhM-Status for the Reset service

Short name	Status	Definition	Temporary (t) or permanent (p)
OK	success	The Reset function was carried out successfully	--
NO	failure	The Reset function was not carried out successfully	t/p
IV	failure	Invalid parameters in request	--

6.3.2.5.2 Set Value

6.3.2.5.2.1 Function

The PhMS-user passes a PhM-SET-VALUE request primitive to Ph-management to assign a desired value to one or more specified variables of the PhE. After receiving this primitive Ph-management tries to select these variables and to set the new values. If the requested service was executed Ph-management passes a PhM-SET-VALUE confirm primitive to the PhMS-user to indicate the success or failure of the corresponding service request.

6.3.2.5.2.2 Types of primitives and parameters

Table 12 indicates the primitives and parameters of the Set Value service.

Table 12 – Set value primitives and parameters

PhM-SET-VALUE	Request	Confirm
Parameter name	**input**	**output**
Variable_name (1 to 3)	M	
Desired_value (1 to 3)	M	
PhM-STATUS (1 to 3)		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

Variable_name

This array parameter specifies one or more variables (1 to 3) that are to be assigned values from the corresponding elements of the Desired_value parameter. The selectable variables are operating parameters; they are specified in Table 13.

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Table 13 – Mandatory PhE-variables

Operating parameters	
Name	**Definition**
Transmitter_output	Transmitter output
Receiver_signal_source	Receiver input
Loop	The transmitter output is directed to the receiver input and not to the medium

Desired_value

This array parameter specifies the actual value to be written to the variables (1 to 3) that are specified by the Variable_name parameter. This parameter specifies a list of one or more (1 to 3) new values for the specified PhE-variables. The permissible value or range of values for each of these variables is specified in Table 14.

Table 14 – Permissible values of PhE-variables

Operating parameters	
Variable	**Range of values**
Transmitter_output	enabled or disabled
Receiver_signal_source	primary: bus cable "a" (standard source) alternative: bus cable "b" (alternative source) random: either "a" or "b"
Loop	disabled or enabled

PhM-Status

This array parameter specifies, for each variable in the corresponding request, the status of that component of the requested service. Permitted values for the individual components of this array parameter are specified in Table 15.

Table 15 – Values of PhM-Status for the set-value service

Short name	Status	Definition	Temporary (t) or permanent (p)
OK	success	The variable has been set to the new value	--
NO	failure	The variable does not exist or could not be set to the new value	t/p
IV	failure	Invalid parameters in request	--

6.3.2.5.3 Get Value

6.3.2.5.3.1 Function

The PhMS-user passes a PhM-GET-VALUE request primitive to Ph-management to read the current value of one or more variables of the PhE. After receipt of this primitive Ph-management tries to select the specified variables and to deliver their current values and passes a PhM-GET-VALUE confirm primitive to the PhMS-user to indicate the success or failure of the corresponding service request. This primitive returns as a parameter one or more of the requested variable values.

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6.3.2.5.3.2 Types of primitives and parameters

Table 16 indicates the primitives and parameters of the Get Value service.

Table 16 – Get value primitives and parameters

PhM-GET-VALUE	Request	Confirm
Parameter name	**input**	**output**
Variable_name (1 to 3)	M	
Current_value (1 to 3)		M
PhM-STATUS		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

Variable_name

This array parameter specifies one or more variables (1 to 3) whose values are to be read. The variables that may be selected are specified in Table 13.

Current_value

This array parameter specifies the actual value of the (1 to 3) variables that were specified by the Variable_name parameter of the corresponding request. The permissible value, or range of values, for each of these variables is specified in Table 17.

Table 17 – Current values of PhE-variables

Operating parameters	
Variable	**Range of values**
Transmitter_output	enabled or disabled
Receiver_signal_source	primary or alternative
Loop	disabled or enabled

PhM-Status

This array parameter specifies for each variable in the corresponding request a confirmation about the execution of the service. Permitted values for this parameter are specified in Table 18.

Table 18 – Values of PhM-Status for the get value service

Short name	Status	Definition	Temporary (t) or permanent (p)
)OK	success	The variable could be read	--
NO	failure	The variable does not exist or could not be read. The corresponding value of Current_value is not defined	t/p
IV	failure	Invalid parameters in request	--

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6.3.2.5.4 Event

6.3.2.5.4.1 Function

The PhE informs Ph-management that it has detected an event. After that, Ph-management passes a Ph-EVENT indication primitive to the PhMS-user to inform it about important events in the PhL.

6.3.2.5.4.2 Types of primitives and parameters

Table 19 indicates the primitive and parameters of the Event service.

Table 19 – Event primitive and parameters

PhM-EVENT	Indication
Parameter name	**output**
Variable_name (1 to 2)	M
New_value (1 to 2)	M

Variable_name

This array parameter specifies one or more variables (1 to 2) whose values were changed. The variables that may be present are specified in Table 13.

New_value

This parameter specifies the new value of the variable. The various values are shown in Table 20.

Table 20 – New values of PhE-variables

Variable	Range of values
Transmitter_output	enabled or disabled
Receiver_signal_source	primary or alternative

6.4 Type 4: Systems management – PhL interface

6.4.1 Required Services

The services specified in 6.2 are used.

6.4.2 Service primitive requirements

The service primitive requirements are specified in 6.2.2 with the following restriction:

The parameters specified in Table 7 are not supported.

The parameters that can be modified and read by the PhL management services are shown in Table 21. Supported values and default value for each parameter depend on the actual medium and implementation.

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Table 21 – Parameter names and values for management

Parameter name	Range of values
Interface mode	HALF_DUPLEX FULL_DUPLEX_UDP
Baud rate (kbaud/s)	230 400 76 800 38 400 19 200 9 600

6.5 *Void*

NOTE Subclause 6.5 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

6.6 Type 8: Systems management – PhL interface

6.6.1 Functionality of the PhL Management

The management of the PhL is the part of the PhL that produces the management functionality of the PhL that are demanded by the PNM1. The management of the PhL handles the initialisation, the monitoring, and the error recovery in the PhL.

6.6.2 PhL-PNM1 Interface

6.6.2.1 General

Subclause 6.6.2 defines the administrative PhL management services that are available to the PNM1, together with their service primitives and associated parameters. Figure 13 shows the interface between PhL and PNM1 in the layer model.

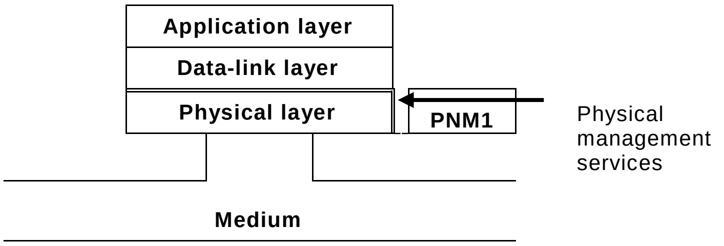

Figure 13 – Interface between PhL and PNM1 in the layer model

The service interface between PhL and PNM1 provides the following functions:

– Reset of the PhL
– Request and change of the current operating parameters of the PhL
– Indication of unexpected events, errors and status changes, which occurred or were detected in the PhL

6.6.2.2 Overview of the Services

The PhL makes the following services available to the PNM1:

– Reset PhL
– Set Value PhL or Get Value PhL
– Event PhL

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Reset PhL (mandatory)

The PNM1 uses this service to reset the PhL. The reset is equivalent to power on. Upon execution of the service, the PNM1 receives a confirmation.

Set Value PhL (optional)

The PNM1 uses this service to set new values to the PhL variables. Upon completion, the PNM1 of the PhL receives a confirmation whether the defined variables assumed the new values.

Get Value PhL (optional)

The PNM1 uses this service to read out variables of the PhL. The current value of the defined variable is returned in the response of the PhL.

Event PhL (mandatory)

The PhL uses this service to inform the PNM1 user about certain events or errors in the PhL.

6.6.2.3 Overview of the Interactions

The PhL services are described by the following primitives (beginning with Ph-…):

Reset PhL

PH-RESET request
PH-RESET confirm

Set Value PhL

Ph-SET-VALUE request
Ph-SET-VALUE confirm

Get Value PhL

Ph-GET-VALUE request
Ph-GET-VALUE confirm

Event PhL
Ph-Event indication

Figure 14 and Figure 15 show the time relations of the service primitives.

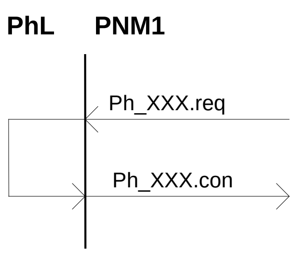

Figure 14 – Reset, Set-value, Get-value PhL services

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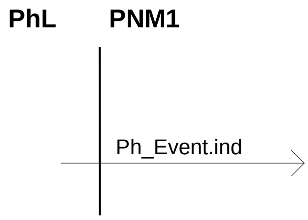

Figure 15 – Event PhL service

6.6.2.4 Detailed definitions of the services and Interactions

6.6.2.4.1 PH-RESET

The PH-RESET service is mandatory. The PNM1 transfers a PH-RESET request primitive to the PhL to reset it (see Table 22).

Table 22 – PH-RESET

Parameter name	Request	Confirm
Argument	M	
Result(+)		M

6.6.2.4.2 Ph-SET-VALUE

The Ph-SET-VALUE service is optional. The PNM1 transfers a Ph-SET-VALUE request primitive to the PhL, to set a defined Ph variable to a desired value. After receipt of this primitive, the PhL tries to select the variable and to set the new value. Upon completion, the PhL transfers a Ph-SET-VALUE confirm primitive to the PNM1 (see Table 23).

Table 23 – Ph-SET-VALUE

Parameter name	Request	Confirm
Argument	M	
variable_name	M	
desired_value	M	
Result(+)		M

variable_name:

This parameter defines the PhL variable that is set to a new value.

desired_value:

This parameter declares the new value for the PhL variable.

Table 24 provides information on which PhL variable may be set to which new value.

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Table 24 – PhL variables

Name of PhL variable
loopback_mode
medium_attachment
bus_ interfaces
short_ bus_reset_time
long_bus_reset_time
data_select

loopback_mode:

This parameter defines whether the receive circuit of the MAU is connected to the send circuit or to the medium.

Parameter structure:

- interface number
  Defines the number of the incoming and outgoing interface (see Figure 16).
- status
  This parameter defines whether the receive circuit of the MAU is connected (enabled) or not (disabled). After power on this value is equivalent to "enabled".

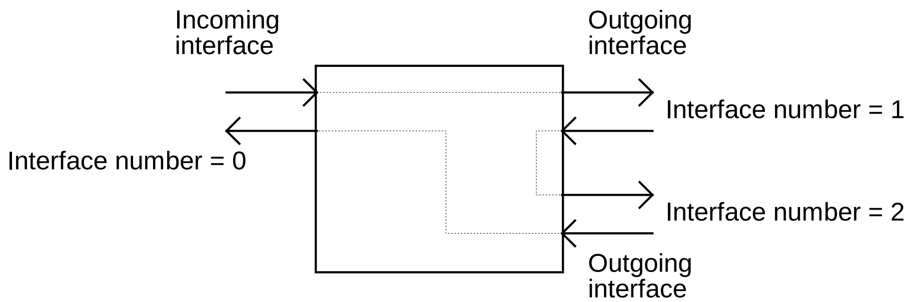

Figure 16 – Allocation of the interface number

NOTE A master has always the interface number = 2.

medium_attachment:

This parameter indicates whether the MAU is coupled to the transmission medium. This is done by detecting whether a connector is plugged to the outgoing interface.

Parameter structure:

- interface number
  Declares the number of the bus interface (see Figure 16).
- attachment
  This parameter defines whether the interface is connected to the transmission medium.

bus_interfaces:

- interface number
  Declares the number of the bus interface (see Figure 16).
- interface type
  Defines the type of the physical interface and the transmission medium:
    - Incoming interface, 2-wire
    - Outgoing interface, 2-wire

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short_bus_reset_time:

This parameter defines the duration of the short reset. The value after power on is 5 ms.

long_bus_reset_time:

This parameter defines the duration of the long reset. The value after power on is 100 ms.

data_select:

This parameter indicates a Reset_PhPDU or a medium_activity_status_PhPDU is sent on the transmission medium for a passive outgoing MAU (loopback mode= disable)

Parameter structure

– interface number
  Defines the number of the bus interface (see Figure 16). Value range (1 to 2)

– coupling
  Disable: A reset PHPDU is transmitted on the transmission medium;
  Enable: The medium activity status PhPDU is transmitted on the transmission medium after "power on" this value is "disable".

6.6.2.4.3 Ph-GET-VALUE

The Ph-GET-VALUE service is optional. The PNM1 transfers a Ph-GET-VALUE request primitive to the PhL to read out the current value of a defined PhL variable. After the PhL has received this primitive it tries to select the defined variable and to transfer the present value to the PNM1 by means of a Ph-GET-VALUE confirm primitive (see Table 25).

Table 25 – Ph-GET-VALUE

Parameter name	Request	Confirm
Argument	M	
variable_name	M	
Result(+)		M
current_value		M

variable_name:

This parameter defines the PhL variable the value of which is to be read out.

current_value:

This parameter contains the read-out value of the PhL variable. The PhL variables to be read are those variables that can be written to with the Ph-SET-VALUE.

6.6.2.4.4 Ph-EVENT

The Ph-EVENT service is mandatory. The PhL transfers a Ph-EVENT indication primitive to the PNM1, to inform it about important events or errors in the PhL (see Table 26).

Table 26 – Ph-EVENT

Parameter name	Indication
Argument	M
event	M

event:

This parameter defines the event that occurred or the error source in the PhL and may according to Table 27 have the following values:

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Table 27 – PhL events

Name	Meaning
stop_bit_error	Stop bit error detected in the MDS sublayer
medium_attachment	The medium attachment changed at an outgoing MAU

6.7 Type 12: Systems management – PhL interface

6.7.1 Required service

The minimum service primitive for PhL (PhL) management shall be:

PH-RESET request – reset of the Ph-layer.

6.7.2 Service primitive PH-RESET request

This primitive has no parameter. Upon reception of this primitive the PhL shall reset all its functions.

6.8 Type 18: Systems management – PhL interface

6.8.1 General

The Systems management – PhL interface need not be exposed in the implementation of a Type 18 PhE. This interface may be internal to the node and may be implemented as internal to a semiconductor device.

6.8.2 Required services

The minimum service primitive for PhL management shall be:

a) PH-RESET request – reset of the Ph-layer;
b) Ph-SET-VALUE request – set parameters.

6.8.3 Service primitive requirements

6.8.3.1 PH-RESET request

This primitive has no parameter. Upon reception of this primitive the PhL shall reset all its functions.

6.8.3.2 Ph-SET-VALUE request (parameter name, new value)

This primitive shall allow Systems management to modify the parameters of the PhL. Standard parameter names and value ranges are given in Table 7.

Not all values are supported by all Type 18 PhE variants. Baud rate limitations are associated with the Type 18 MAU variant implemented.

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Table 28 – Parameter names and values for Ph-SET-VALUE request

Parameter name	Range of values
Baud rate (kbaud/s)	10 000
	5 000
	2 500
	625
	156

6.9 Type 24: Systems management – PhL interface

The following service primitives for PhL management shall be supported. Detailed specification for each service primitive depends on the actual medium and implementation.

a) PH-RESET request – reset of the Ph-Layer

b) Ph-SET-VALUE request/Ph-SET-VALUE confirm – set parameters

c) Ph-GET-VALUE request/Ph-GET-VALUE confirm – read parameters

d) Ph-EVENT indication – report Ph-Layer events

7 DCE independent sublayer (DIS)

7.1 General

The PhL entity is partitioned into a Data Terminal Equipment (DTE) component and a Data Communication Equipment (DCE) component. The DTE component interfaces with the DLL entity, and forms the DCE Independent Sublayer (DIS). It exchanges Interface Data Units across the DL – Ph interface defined in Clause 5, and provides the basic conversions between the PhIDU "at-a-time" viewpoint of the DL – Ph interface and the bit serial viewpoint required for physical transmission and reception.

This sublayer is independent of all the PhL variations, including encoding and/or modulation, speed, voltage/current/optical mode, medium etc. All these variations are grouped under the designation Data Communication Equipment (DCE).

NOTE A number of different DIS entities are specified, based on industry practice.

7.2 Type 1: DIS

The DIS shall sequence the transmission of the PhID as a sequence of serial PhSDUs. Similarly, the DIS shall form the PhID to be reported to the DLL from the sequence of received serial PhSDUs.

The PhID shall be converted to a sequence of PhSDUs for serial transmission in octets up to a maximum of 300 octets. A PhSDU representing more significant octets of the PhID shall be sent before or at the same time as a PhSDU representing less significant octets and such that within each octet, a PhSDU representing a more significant bit will be transmitted before or at the same time as a PhSDU representing a less significant bit. On reception, each sequence of PhSDUs shall be converted to PhID such that, in the absence of errors, the PhIDU indicated to the receiving DLL entity shall be unchanged from the PhIDU whose transmission was requested by the originating DLL entity.

NOTE This is a guarantee of transparency.

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7.3 Type 3: DIS

7.3.1 Synchronous transmission

The DCE Independent Sublayer (DIS) specified for Type 1 shall be used (see 7.2).

7.3.2 Asynchronous transmission

There is no DCE Independent Sublayer (DIS) for asynchronous transmission.

7.4 *Void*

NOTE Subclause 7.4 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

7.5 Type 8: DIS

7.5.1 General

The PhL is subdivided into a medium-independent sublayer (MIS), a medium-dependent sublayer (MDS) and the medium attachment unit (MAU). The MIS is independent of all characteristics of the PhL, such as coding, transmission method, transmission speed, and the type of transmission medium. All these instances are described by the sublayers MDS and MAU.

7.5.2 Function

On the one hand, the MIS has to transmit the PhSDU which was received by the MAC sublayer through the DL-Ph-interface in the form of a PhIDU via the MIS-MDS interface to the MDS. On the other hand, it forms the PhIDU of a PhSDU, which has been received through the MIS-MDS interface, and transfers it via the DL-Ph interface to the MAC sublayer.

In addition, the MIS allows transmitting a PhSDU between two MDSs through the MIS-MDS interface (MDS coupling).

The MIS may consist of several channels that are configured correspondingly. One channel is used to transmit the PhSDU to the MDS and to transmit one PhSDU through a PhIDU to the MAC sublayer. All other channels are used to transmit a PhSDU between two MDS sublayers.

7.5.3 Serial transmission

For the serial transmission a sequence of PhIDUs shall be converted into a sequence of PhSDUs. A PhSDU that represents a more significant bit is transferred after a PhSDU that represents a less significant bit.

When it is received each sequence of PhSDUs shall be converted into a sequence of PhIDUs so that the sequence of PhIDUs formed in such a way corresponds to the one that is transmitted from the MAC sublayer to the PhL.

7.5.4 MDS coupling

When MDSs are coupled in pairs and have the same or different characteristics (alternative type of transmission) each PhSDU that is received from a MDS through the MIS-MDS interface is sent unchanged via the MIS-MDS interface to another MDS.

In this case, it is allowed to buffer a received PhSDU.

Figure 17, Figure 18 and Figure 19 show possible configurations for the bus master and slaves using the 2-wire medium and an alternative type of transmission.

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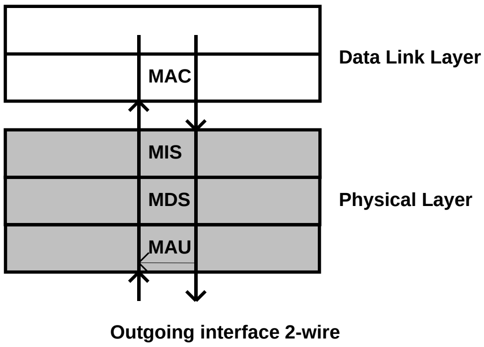

Figure 17 – Configuration of a master

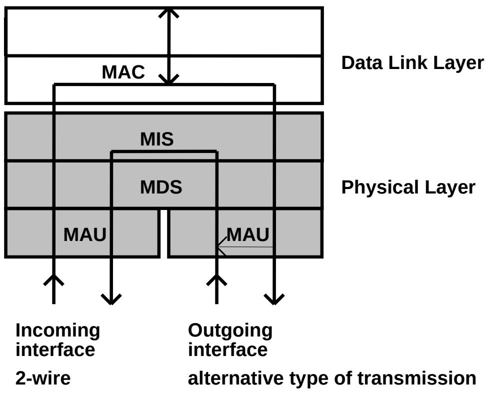

Figure 18 – Configuration of a slave with an alternative type of transmission

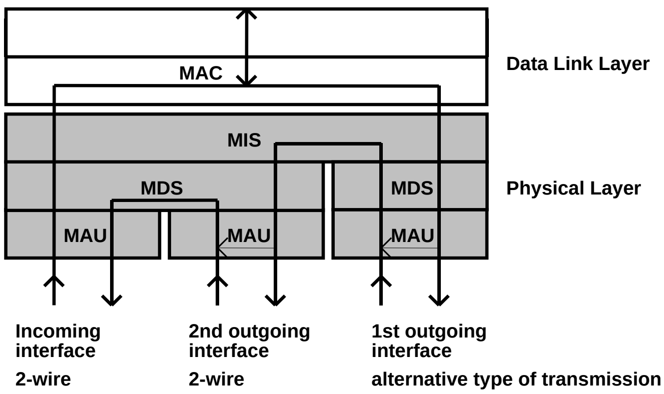

Figure 19 – Configuration of a bus coupler with an alternative type of transmission

7.6 Type 12: DIS

The DIS shall sequence the transmission of the PhID as a sequence of serial PhSDUs. Similarly, the DIS shall form the PhID to be reported to the DLL from the sequence of received serial PhSDUs.

The PhID shall be converted to a sequence of PhSDUs for serial transmission in octets from a minimum of 72 octets up to a maximum of 1 535 octets.

For the serial transmission a sequence of PhIDUs shall be converted into a sequence of PhSDUs. A PhSDU that represents a more significant bit is transferred after a PhSDU that represents a less significant bit.

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When it is received each sequence of PhSDUs shall be converted into a sequence of PhIDUs so that the sequence of PhIDUs formed in such a way corresponds to the one that is transmitted from the MAC sublayer to the PhL.

8 DTE – DCE interface and MIS-specific functions

8.1 General

The PhL entity is partitioned into a Data Terminal Equipment (DTE) component containing the DIS, and a Data Communication Equipment (DCE) component containing the MDS and lower sublayers. The DTE – DCE interface connects these two physical components, and is itself within the MIS. (See Figure 1.)

NOTE A number of different DTE – DCE interfaces are specified, based on industry practice.

It is not mandatory for the DTE – DCE interface, or any other interface, to be exposed.

For Type 3 synchronous transmission mode, Type 1 and Type 7, the DTE – DCE interface is a functional and electrical, but not mechanical, interface that supports a set of services. Each of these services is implemented by a sequence of defined signaling interactions at the interface.

8.2 Type 1: DTE – DCE interface

8.2.1 Services

8.2.1.1 Overview

The following services, defined in 8.2, shall be supported by the DTE – DCE interface:

a) DTE to DCE reset service;
b) DTE to DCE configuration service;
c) DTE to DCE message-transmission service;
d) DCE to DTE fault notification service;
e) DCE to DTE media-activity indication service;
f) DCE to DTE message-reporting service.

8.2.1.2 DTE to DCE reset service

This service shall provide a means by which the DTE, at any time, can reset the DCE to its initial (power-on) state.

8.2.1.3 DTE to DCE configuration service

This service shall provide a means by which the DTE can configure various characteristics of the DCE, including those characteristics which systems management can adjust via Ph-SET-VALUE requests (see Table 7). It shall also provide a DCE-optional means by which the DTE can initiate reporting of DCE status by pre-emptive use of the DCE to DTE message-reporting service.

8.2.1.4 DTE to DCE message-transmission service

This service shall provide a means by which the DTE can transmit a message through the DCE to either the connected medium (media), or back to the DTE, or both, as determined by the current operational values of the parameters specified in Table 7. The DCE shall provide the pacing for this service.

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This service is invoked upon receipt of a PH-DATA request specifying START-OF-ACTIVITY at the PhL service interface, and runs until receipt of and completion of the PH-DATA request specifying END-OF-DATA-AND-ACTIVITY.

8.2.1.5 DCE to DTE fault notification service

This service shall provide a means by which the DCE, at any time, can report a fault. The specific nature of the fault is not reported by this service, but may be determinable by use of the DTE to DCE configuration service to initiate a DCE-optional DCE status report.

8.2.1.6 DCE to DTE media-activity indication service

This service shall provide a means by which the DCE reports the inferred detection, on any of its connected media for which receiving is enabled (see Table 7), of signaling from itself or other Ph-layer entities. While loopback is enabled, this service reports only the signaling of the DCE itself.

When the DTE – DCE interface is in half-duplex mode and loopback is not enabled, this service need not report media activity resulting directly from the DTE to DCE message-transmission service.

8.2.1.7 DCE to DTE message-reporting service

This service shall provide a means by which the DCE reports the receipt of a sequence of PhPDUs from any one of the connected media for which receiving is enabled. This service terminates with an indication of whether the sequence of received PhPDUs was well formed. Errors in the sequence, including number of PhPDUs such that they could not have been a correct transmission resulting from an invocation of the DCE to DTE message-transmission service shall be reported as a malformed (erroneous) sequence.

Errors in the octet alignment of a received end delimiter with respect to the preceding start delimiter (i.e., not separated by an integral number of octets of data bits) shall be reported as a malformed sequence.

When the DTE – DCE interface is in half-duplex mode and loopback is not enabled, this service need not report the message transmitted by the DCE to DTE message-transmission service.

8.2.2 Signaling interfaces

8.2.2.1 Overview

Two signaling interfaces are defined for Type 1 PhLs. The first interface existed in prior editions of this standard and is retained for compatibility, although there are no known implementations. It is defined in 8.2.2.2 through 8.2.2.4.

The second interface uses the well-known serial peripheral interface (SPI) protocol and signals, or equivalent, in which octet registers and FIFOs in the DCE are read and written by the DTE and in which the DCE can interrupt the DTE.

NOTE There is no formal standard for the SPI protocol, although it is used by many electronics vendors.

8.2.2.2 Interface signals (historic version from prior editions)

8.2.2.2.1 Overview

If the DTE – DCE interface is exposed it shall provide the signals specified in Table 29.

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Table 29 – Signals at DTE – DCE interface

Signal	Abbreviation	Source
Transmit Clock	TxC	DCE
Request-to-send	RTS	DTE
Clear-to-send	CTS	DCE
Transmit Data	TxD	DTE
Receive Clock	RxC	DCE
Receive Activity	RxA	DCE
Receive Data and Framing	RDF	DCE

The signal levels shall be as shown in Table 30. In general, both sides of the interface shall operate with the same approximate value of V_{DD}. However, it is recognized that a DTE and a DCE with separate power supplies may not both reach operational V_{DD} simultaneously. It is desirable, but not mandatory, that the DTE to DCE reset service be operational when the DCE has not yet reached operational V_{DD}. It is also desirable that the DTE invoke this service whenever its own V_{DD} is below operational margins.

Table 30 – Signal levels for an exposed DTE – DCE interface

Symbol	Parameter	Condition	Limit	Unit	Remark
V_{OL}	Maximum low-level output voltage	I_{out} = ±100 μA	0,1	V	see Note 1
		I_{out} = +1,6 mA	0,4	V	
V_{OH}	Min. high-level output voltage	I_{out} = ±100 μA	V_{DD} – 0,1	V	see Note 1
		I_{out} = –0,8 mA	V_{DD} – 0,8	V	see Note 2
V_{IL}	Max. low-level input voltage		0,2 V_{DD}	V	
V_{IH}	Min. high-level input voltage		0,7 V_{DD}	V	see Note 3

NOTE 1 Provides the capability to drive two typical CMOS loads.

NOTE 2 CMOS input compatibility with TTL output requires a "pull-up" resistor from signal input to V_{DD}.

NOTE 3 Compatible with CMOS output for 3,0 V ≤ V_{DD} ≤ 5,5 V. Compatibility with TTL output (4,75 V ≤ V_{DD} ≤ 5,25 V) requires a "pull-up" resistor from signal input to V_{DD}.

The timing characteristics of these signals shall be at least equal to those specified for the relevant DCE in the requirements of this standard. However, in no case shall the transition time between 0,3 V_{DD} and 0,6 V_{DD} be greater than either 100 ns or 0,025 *P*, whichever is smaller. *P* is defined as the nominal period of octet transmission – the inverse of the nominal PhSDU rate.

An implementation of the DTE – DCE interface shall function correctly with transmit and receive (TxC and RxC) clock frequencies between 1 kHz and 8,8 times the highest supported PhSDU rate of the DTE or DCE implementation.

NOTE The PhSDU and equivalent bit data rates available in an implementation are stated in the Protocol Implementation Conformance Statement (PICS).

8.2.2.2.2 Transmit clock (TxC)

The Transmit Clock signal (TxC) shall provide the DTE with a continuous timing signal, such that any eight consecutive full cycles of this signal shall have the same octet period as the nominal transmit period for one data octet. The DCE shall source this nominally two-phase signal such that each phase has duration of at least 0,04 *P*.

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NOTE This specification permits TxC to be a continuous, constant-period clock at the nominal bit rate (8 times the nominal octet rate) with a duty cycle of 32 % to 68 %, or for TxC to be a higher-frequency clock with some cycles omitted and with a duty cycle closer to 50 %. This permits, for example, simple clocking in a DCE that recodes each 4 bits into 5 bauds; the DCE could have a clock 10 times the nominal octet rate, with a duty cycle of between 40 % and 60 %, and would omit (the same) two cycles every octet.

TxC supports the DTE to DCE configuration and message-transmission services.

8.2.2.2.3 Request-to-send (RTS)

The request-to-send (RTS) signal supports the DTE to DCE reset, configuration, and message-transmission services. The DTE shall source this signal. The initial (power-on) and idle (no DTE to DCE service active) state of this signal shall be low.

When referenced to TxC at the DTE – DCE interface, this signal shall have a minimum setup time of the smaller of either 100 ns or 0,025 *P*; the hold time shall be zero or greater.

8.2.2.2.4 Clear-to-send (CTS)

The clear-to-send (CTS) signal supports the DTE to DCE configuration and message-transmission services. The DCE shall source this signal. The initial (power-on) and idle (no DTE to DCE service active) state of this signal shall be low.

When referenced to TxC at the DTE – DCE interface, this signal shall have a minimum setup time of the smaller of either 100 ns or 0,025 *P*; the hold time shall be zero or greater.

8.2.2.2.5 Transmit Data (TxD)

The Transmit Data (TxD) signal supports the DTE to DCE reset, configuration, and message-transmission services. Binary data is transmitted from DTE to DCE during one phase of the latter two services, and during this phase a binary 0 is represented by a low level on TxD and a binary 1 by a high level on TxD, both sampled at the falling edge of TxC.

The DTE shall source this signal. The initial (power-on) and idle (no DTE to DCE service active) state of this signal shall be high.

When referenced to TxC at the DTE – DCE interface, this signal shall have a minimum setup time of the smaller of either 100 ns or 0,025 *P*; the hold time shall be zero or greater.

8.2.2.2.6 Receive Clock (RxC)

The Receive Clock signal (RxC) shall provide the DTE with an intermittent (semi-continuous) nominally two-phase timing signal that defines the timing of information being reported via the RDF signal. The DCE shall source this signal such that, where RxC is defined to be meaningful (see 8.2.2.3.7), each phase has duration of at least 0,04 *P*.

NOTE This specification permits RxC to be a recovered clock at the nominal bit rate (8 times the nominal octet rate) with a duty cycle of 32 % to 68 %, or to be a higher-frequency clock with some cycles omitted and with a duty cycle closer to 50 %. This permits, for example, simple clocking in a DCE that decodes 4 bits from each received 5 bauds; the DCE could have a clock 10 times the nominal octet rate, with a duty cycle of between 40 % and 60 %, and would omit two cycles every octet.

This specification also permits the DCE to omit cycles of RxC during recognition of long end-delimiter sequences of PhPDUs, so that the delimiter can be reported in real time using 8 or fewer cycles of RxC (see 8.2.2.3.7).

RxC shall support the DCE to DTE message-reporting service.

8.2.2.2.7 Receive Activity (RxA)

The Receive Activity (RxA) signal shall support the DCE to DTE fault notification, media-activity indication, and message-reporting services. The DCE shall source this signal. The initial (power-on) and idle (no DCE to DTE service active) state of this signal shall be low.

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8.2.2.2.8 Receive Data and Framing (RDF)

The Receive Data and Framing (RDF) signal shall support the DCE to DTE fault notification and message-reporting services. Binary data is transmitted from DCE to DTE during some phases of the latter service, and during these phases a binary 0 is represented by a low level on RDF and a binary 1 by a high level on RDF, both sampled at the falling edge of RxC.

The DCE shall source this signal. The initial (power-on) and idle (no DCE to DTE service active) state of this signal shall be high.

When referenced to RxC at the DTE – DCE interface, this signal shall have a minimum setup time of the smaller of either 100 ns or 0,025 *P*; the hold time shall be zero or greater.

8.2.2.3 Encoding of services in signals

8.2.2.3.1 Summary

The services of 8.1 shall be implemented by the following sequences and combinations of the signals of 8.2.

NOTE Typical transmit and receive sequencing machines are shown in Figure 20, which is included in this standard for explanatory purposes and does not imply a specific implementation.

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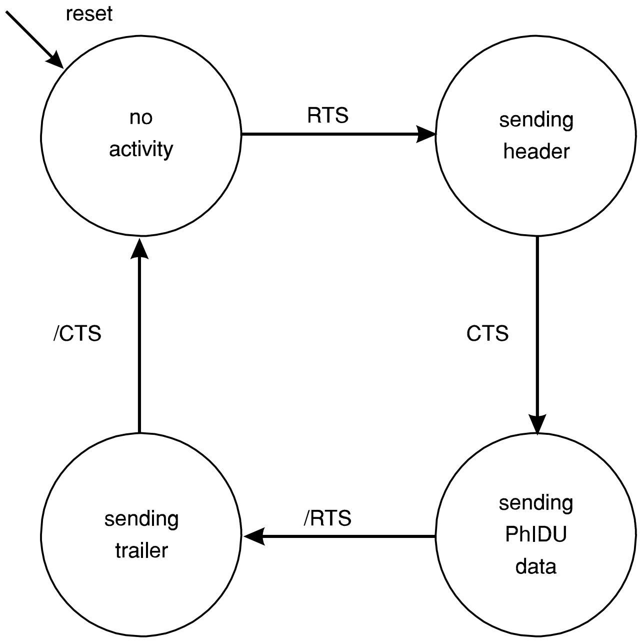
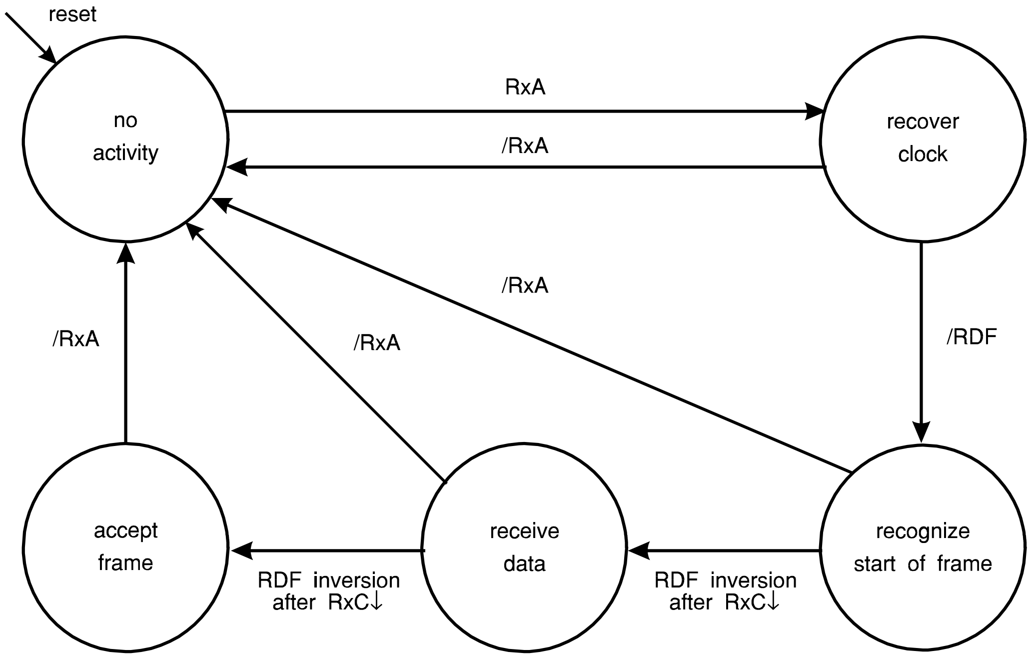


Transmit machine



Receive machine

Figure 20 – DTE/DCE sequencing machines

8.2.2.3.2 DTE to DCE reset service

This service shall be mutually exclusive with the DTE to DCE configuration and message-transmission services; at most one of them may be active at any given time. This service may pre-empt the DTE to DCE configuration and message-transmission services at any time.

This service shall be encoded as a simultaneous low level on both RTS and TxD. When asserted by the DTE, this simultaneous low level shall be held for at least the nominal transmission period of two PhSDUs (octets).

NOTE 1 This is an asynchronous service, and is not referenced to TxC.

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When a DTE is itself being reset, possibly during power-up, it should attempt to reset the DCE even when the DTEs own V_{DD} is below normal operational limits.

NOTE 2 This reset is under the control of the DTE. It does not preclude the existence of a separate reset pin on the DCE.

If the DTE concurrently changes both RTS and TxD during the implementation of either the DTE to DCE configuration or message-transmission services, then the DTE shall ensure that an interval of at least the minimum required setup time exists between changing the one signal to a high level, and subsequently changing the other signal to a low level, to eliminate potential logic hazards in the DCEs implementation of the DTE to DCE reset service.

8.2.2.3.3 DTE to DCE configuration service

This service is mutually exclusive with the DTE to DCE reset and message-transmission services; at most one of them may be active at any given time. This service may initiate the DCE to DTE message-reporting service to report DCE-internal status. The DTE to DCE reset service may pre-empt this service at any time.

This service shall be implemented in three phases; each of the latter two phases shall follow immediately upon completion of the prior phase.

These phases can be implemented as a minor variation on the three phases specified for the DTE to DCE message-transmission service. As a result, the DTE to DCE configuration service induces very little added complexity on the DTE and DCE.

1) The DTE shall assert (raise) RTS after the falling edge, and before the rising edge, of TxC. The DCE shall respond by anticipating configuration data.
2) When it is ready for configuration data from the DTE, the DCE shall raise CTS before the falling edge of TxC. The DTE shall respond by encoding the first bit of configuration data (1 as high, 0 as low) on TxD before the falling edge of the next TxC, and shall continue this process without interruption until between 2 and 200 bits of data (see 8.2.2.4) have been so encoded. The DTE shall then assert (raise) TxD and negate (lower) RTS before the falling edge of the next TxC.

   The DTE should ensure that TxD is raised at least one setup time before RTS is lowered, to avoid potential logic hazards in the DCE implementation of the DTE to DCE reset service.
3) The DCE shall conclude any necessary reconfiguration before negating (lowering) CTS, which shall occur between two consecutive falling edges of TxC.

Both standardized and extendible configuration messages are defined in 8.2.2.4. Standardized messages cover the ranges of application of this interface that are anticipated to be most cost sensitive. Extendible messages permit differing forms of DCE configuration where required, and can serve to initiate the DCE to DTE message-reporting service to report DCE-internal status (a DCE option further described in 8.2.2.4).

8.2.2.3.4 DTE to DCE message-transmission service

This service is mutually exclusive with the DTE to DCE reset and configuration services; at most one of them may be active at any given time. The DTE to DCE reset service may pre-empt this service at any time.

This service shall be implemented in three phases; each of the latter two phases shall follow immediately upon completion of the prior phase.

a) The DTE shall assert (raise) RTS after the rising edge, and before the falling edge, of TxC. The DCE shall respond by generating and transmitting the appropriate-length sequence of preamble and start delimiter PhPDUs.

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b) When it is ready for transparent data from the DTE, the DCE shall raise CTS before the falling edge of TxC. The DTE shall respond by encoding the first bit of transparent data (1 as high, 0 as low) on TxD before the next falling edge of TxC, and shall continue this process without interruption until between 3 and 300 integral octets of data have been so encoded. The DTE shall then assert (raise) TxD and negate (lower) RTS before the next falling edge of TxC.The DTE shall ensure that TxD is raised at least one setup time before RTS is lowered, to avoid potential logic hazards in the DCE implementation of the DTE to DCE reset service.

c) The DCE shall conclude transmission of all of the encoded transparent data received from the DTE, shall then generate and transmit the appropriate-length sequence of end delimiter PhPDUs, and shall then cease transmission. The DCE shall then wait an amount of time equal to the configured minimum post-transmission gap (see Table 7) before negating (lowering) CTS, which shall occur after a falling edge, and before the next falling edge, of TxC.

8.2.2.3.5 DCE to DTE fault notification service

This service shall be mutually exclusive with the DCE to DTE media-activity indication and message-reporting services; at most one of them may be active at any given time. This service may pre-empt the DCE to DTE media-activity indication and message-reporting services at any time.

This service shall be encoded as a simultaneous low level on both RxA and RDF. Once asserted by the DCE, this simultaneous low level shall be held until activation of either the DTE to DCE reset or configuration services.

NOTE This is an asynchronous service, and is not referenced to RxC.

The DCE may concurrently change both RxA and RDF during the concurrent termination of the DCE to DTE media-activity indication and message-reporting services. The DTE is responsible for avoiding any logic hazards induced by this concurrent change.

8.2.2.3.6 DCE to DTE media-activity indication service

This service is mutually exclusive with the DCE to DTE fault notification service; at most one of them may be active at any given time. The DCE to DTE fault notification service may pre-empt this service at any time.

This service shall be encoded as a high level on RxA. Once asserted by the DCE, this high level enables recognition of a high-to-low transition on RDF to initiate the DCE to DTE message-reporting service. Any subsequent high-to-low transition on RxA terminates that DCE to DTE message-reporting service.

NOTE The DCE to DTE media-activity indication service is an asynchronous service, and is not referenced to RxC.

8.2.2.3.7 DCE to DTE message-reporting service

This service is mutually exclusive with the DCE to DTE fault notification service; at most one of them may be active at any given time. This service can only occur while the DCE to DTE media-activity indication service is active. The DCE to DTE fault notification service may pre-empt this service at any time.

8.2.2.3.7.1 Non-erroneous reception

This service shall be implemented in four phases when reporting a well-formed message, each of which shall follow immediately upon completion of the prior phase.

The following description applies to DCEs which have end delimiter sequences of eight PhPDUs or less, and which do not require any extra decoding delay for an FEC (forward error correcting) code. DCEs that do not meet these conditions may introduce extra delay into their

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decoding and reporting processes so that, with respect to signaling on RxC and RDF, they do meet these conditions.

a) After detecting received signaling, training on that signaling, and recovering a data clock from that signaling whose nominal octet frequency is the same as TxC, the DCE shall initiate the DCE to DTE message-reporting service by sourcing that recovered clock on RxC and then negating (lowering) RDF after the rising edge, and before the next falling edge, of RxC.

   NOTE 1 RxA is already asserted at this time.

b) The DCE shall continue training and attempting to match the received signaling against its expected preamble and start delimiter PhPDUs.

   If the DCE supports *N* channels of redundant media, then it may report on RDF the identity of the channel from which the signaling is being received by encoding that channel number, in the range 0 to *N*–1, as a binary number which is reported most significant bit first during reception of the last three of those start delimiter PhPDUs. The bits reported on RDF shall be presented in series after successive rising edges of RxC, each before the immediately subsequent falling edge of RxC.

   Upon detecting an exact match between the received signaling and the expected start delimiter, the DCE shall invert RDF after the falling edge, and before the next rising edge, of RxC.

   NOTE 2 If the identity of the receiving channel was being reported on RDF, then this inversion will occur during the low phase of \1,\2 which immediately follows the high phase (of \1,\2) during which the last (low-order) bit of the channel number was reported.

c) The DCE shall continue reception and attempting to match the received signaling against potential data and expected end delimiter PhPDUs.

   The DCE shall report each data bit decoded from the received signaling on RDF. The bits reported on RDF shall be presented in series after successive rising edges of \1,\2, each before the immediately subsequent falling edge of RxC. In the absence of errors these bits shall be reported in the same order and with the same values as they were transmitted by a peer PhL entity.

   NOTE 3 This is a guarantee of transparency.

   An end delimiter may be composed of both data and non-data PhPDUs. The DCE may report similarly on RDF each data bit decoded from an end delimiter, and may report also on RDF an appropriate number of data values for the non-data PhPDUs decoded from an end delimiter, except that

   1) the total number of "bits" so reported shall be seven or less, and
   2) upon detecting an exact match between the received signaling and the expected end delimiter, the DCE shall not report on RDF another bit corresponding to the end delimiter’s last "bit", but rather shall first assert (raise) RDF after the rising edge, and before the next falling edge, of RxC, and then shall negate (lower) RDF after the falling edge, and before the next rising edge, of RxC.

   NOTE 4 Most implementations will decode, and report on RDF as data, any initial data PhPDUs in a received end-delimiter sequence. The first non-data PhPDU, and subsequent PhPDUs, need not be reported. However, a final report will be made on RDF, indicating correct end-delimiter recognition.

   NOTE 5 Each reported bit, except the last, is maintained on RDF for a full cycle of RxC. The last bit is replaced by a high-low sequence, each of which is maintained for just one phase of RxC.

   NOTE 6 This terminating high-low sequence will occur during the first eight "bit" reports which occur after the last (pre-delimiter) data bit was reported. That last (pre-delimiter) data bit will have been the 8*N*'th data bit so reported in this phase, where *N* should be at least three and no greater than 300.

d) The DCE shall assert (raise) RDF before the next falling edge of RxC and shall not initiate another instance of the DCE to DTE message-reporting service until after the conclusion of the current DCE to DTE media-activity indication service.

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8.2.2.3.7.2 Erroneous reception

An error may be detected during any phase of the reception process described in 8.2.2.3.7.1. When that occurs, the DCE shall modify its sequencing of those phases as follows.

If the DCE should detect invalid PhPDUs, or an invalid sequence of PhPDUs, or a valid end delimiter sequence of PhPDUs which is not separated from the start delimiter PhPDUs by an integral number of data-octets of PhPDUs; and if the DCE can establish a valid signal on RxC (for example, by substituting TxC or some other local signal for the recovered clock source, if necessary); then

a) if phase 2 has not already been initiated, the DCE shall immediately initiate phase 2;
b) if phase 2 has not already been concluded, the DCE shall immediately conclude phase 2 as rapidly as possible, ignoring the requirement for matching of the start delimiter PhPDU sequence;
c) otherwise, the DCE shall immediately negate (lower) RDF after the rising edge, and before the next falling edge, of RxC, and then shall assert (raise) RDF after the falling edge, and before the next rising edge, of RxC.

NOTE This sequence permits the DCE to

– enable DTE use of RxC;
– identify the channel with the erroneous signaling; and
– indicate a reception error.

When the DCE has completed as many of the above steps a), b) and c) as appropriate and possible, the DCE shall immediately initiate phase 4.

8.2.2.4 DCE configuration messages

8.2.2.4.1 Summary

Subclause 8.2.2.4 defines both standardized configuration messages, and the standardized portion of extendible configuration messages. Standardized messages cover the ranges of application of this interface that are anticipated to be most commonly used. Extendible messages permit differing forms of DCE configuration where required, and can serve to initiate the DCE to DTE message-reporting service to report DCE-internal status (a DCE option).

Two standardized messages, and two classes of extendible messages, are defined. All messages are transmitted across the interface in the order in which the bits are defined. Integers are transmitted most significant bit (MSB) first.

The two standardized messages and two classes of extendible messages are distinguished by the first two data bits of the configuration message, as follows:

00 – basic configuration message;

01 – path-diversity control message;

10 – extendible configuration message;

11 – extendible status-report invocation message.

8.2.2.4.2 Basic configuration message

Following its initial two bits of (00), the basic configuration message specifies operational aspects common to most DCEs. The defined components of this message are, in order of transmission:

a) the operational mode of the DCE, encoded in one data bit as shown. The value for this parameter after activation of the DTE to DCE reset service is 0;

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0 Two-way simultaneous (full-duplex), where each invocation of the DTE to DCE message-transmission service automatically activates the DCE to DTE media-activity indication and message-reporting services. This mode is desirable for dual-channel media such as fiber-optic-pair cabling.

NOTE 1 Some DTEs may only be able to operate in this mode.

1 Two-way alternate (half-duplex), where an invocation of the DTE to DCE message-transmission service does not automatically activate the DCE to DTE media-activity indication and message-reporting services.

NOTE 2 This mode minimizes DCE and DTE – DCE interface power consumption. Some DTEs may only be able to operate in this mode.

b) the selection of the DCE-internal data source for the message-reporting service, encoded in two data bits as shown (see Table 7). The value for this parameter after activation of the DTE to DCE reset service is 00. When this selection is non-zero, transmission on all attached media shall be disabled and the DTE – DCE interface shall operate in two-way simultaneous (full-duplex) mode;

00 decoded signaling, received from one of the attached media as specified in 8.2.2.4.3 b) and c). The interface mode is as specified in 8.2.2.4.2 a);

01 internal-status reporting, see 8.2.2.5.1 and 8.2.2.6;

10 loopback as close as possible to the DTE – DCE interface, with no transmission to connected media, where each invocation of the DTE to DCE message-transmission service automatically activates the DCE to DTE media-activity indication and message-reporting services. This mode is desirable for DCE vs. DTE vs. inter-connect fault localization.

11 loopback as close as possible to the media interface(s), with no transmission to connected media, where each invocation of the DTE to DCE message-transmission service automatically activates the DCE to DTE media-activity indication and message-reporting services. This mode is desirable for self-assessment before entry to an operating network.

c) the amount by which the preamble, which is the initial sequence of PhPDUs in each transmission, should be extended. Its range is zero to seven units of extension, encoded in three data bits as 0 (000) to 7 (111). The value for this parameter after activation of the DTE to DCE reset service is 0 (000) (see Note 2 of 6.2.2.2);

d) the amount by which the mandatory post-transmission gap, which is the period of non-transmission between successive sequences of PhPDUs, should be extended. Its range is zero to seven units of extension, encoded in three data bits as 0 (000) to 7 (111). The value for this parameter after activation of the DTE to DCE reset service is 0 (000) (see Note 3 of 6.2.2.2).

8.2.2.4.3 Path-diversity control message

Following its initial two bits of (01), the path-diversity control message specifies additional configuration data commonly required for management and fault-assessment of redundant paths: separate transmission and reception controls for each of the attached redundant media (channels and paths). The defined components of this message are, in order of transmission:

a) two bits of zero (00), which provide quartet and octet alignment within the message for the following fields;

b) the algorithm for choosing between redundant media as the source of received signaling when more than one of the media is enabled for reception, coded in four bits as shown. The value for this parameter after activation of the DTE to DCE reset service is 0000;

0000 – The medium selected for reception should be the first medium on which signaling which is suitable for receiver-training is detected;

1000 to 1111 (= 7 + N, $1 \le N \le 8$) – The Nth medium should be selected, except when signaling suitable for receiver-training has been detected on another medium for a period of time equal to the extra period of inter-frame-gap extension specified in 8.2.2.4.2 d), in which case that other medium should be selected;

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c) the selection of whether reception is enabled (0) or inhibited (1) on each of eight or fewer redundant media, coded in eight consecutive bits for channels 1 through 8, respectively (see Table 7). The value for this parameter after activation of the DTE to DCE reset service is 0000 0000;

d) the selection of whether transmission is enabled (0) or inhibited (1) on each of eight or fewer redundant media, coded in eight consecutive bits for channels 1 through 8, respectively (see Table 7). The value for this parameter after activation of the DTE to DCE reset service is 0000 0000;

e) the amount of post-transmission gap extension due to potential signal skew between redundant media. Its range is zero to seven units of extension, encoded in three data bits as 0 (000) to 7 (111). The value for this parameter after activation of the DTE to DCE reset service is 0 (000) (see 8.2.2.4.2 d), 8.2.2.4.3 b), and Note 3 of 6.2.2.2).

8.2.2.5 Extendible configuration messages

Following its initial two bits of (10), the coding of extendible configuration messages may be implementation dependent. The structure and form of extendible configuration messages shall be the same as the basic configuration message specified in 8.2.2.4.2.

8.2.2.5.1 Extendible status-report invocation messages

Following its initial two bits of (11), the coding of extendible status-report invocation messages may be implementation dependent. The structure and form of extendible status-report invocation messages shall be the same as the basic configuration message specified in 8.2.2.4.2. The information specified shall select some DCE-internal source of received signaling, and if the DCE-internal-data-source mode is status-reporting (see 8.2.2.4.2 b)), then the DCE shall generate a multi-data-octet message, padded as necessary to an octet multiple, and shall report it using the DCE to DTE media-activity indication and message-reporting services.

8.2.2.6 DCE-generated status reports

These reports are generated within the DCE upon request, and reported when the DCE-internal-data-source is internal-status report (see 8.2.2.4.2 b)).

8.3 Type 3: DTE – DCE interface

8.3.1 Synchronous transmission

The DTE – DCE interface specified for Type 1 shall be used (see 8.2).

8.3.2 Asynchronous transmission

The DTE – DCE interface is not exposed for asynchronous transmission.

8.4 Type 8: MIS – MDS interface

8.4.1 General

The PhL is subdivided into a medium-independent sublayer (MIS) and a medium-dependent sublayer (MDS). The MIS-MDS interface connects these two sublayers.

The MIS-MDS interface is a functional interface that supports certain services; it is not mandatory to implement this interface electrically. Each of these services is implemented through a sequence of interactions of the interface signals.

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8.4.2 Services

8.4.2.1 General

The MIS-MDS interface supports the services listed below:

– ID cycle request service
– Data cycle request service
– Data sequence classification service
– Data sequence identification service
– Message transmission service
– Message receipt service
– Bus reset

8.4.2.2 ID cycle request service

With this service the MIS starts a data sequence to transmit identification and control data (identification cycle).

NOTE This service is used by a master only.

8.4.2.3 Data cycle request service

With this service, the MIS starts a data sequence for the transmission of user data (data cycle).

NOTE This service is used by a master only.

8.4.2.4 Data sequence classification service

With this service the MIS starts an identification or data cycle.

NOTE This service is used by a bus coupler or a slave only.

8.4.2.5 Data sequence identification service

With this service the MDS indicates the beginning of an identification or data cycle.

8.4.2.6 Message transmission service

With this service the MIS sends a message via the MDS either to the connected medium or via the MDS back to another MDS. The MDS determines how fast this service is executed.

NOTE 1 This service transmits the PhIDUs that were passed on to the PhL.

NOTE 2 This service runs simultaneously with the message receipt service.

8.4.2.7 Message receipt service

With this service the MDS indicates receipt of a message to the MIS or another connected MDS. The service ends with the indication whether the received PhPDU was correctly formed.

This service shall be preceded by a data sequence identification service.

8.4.2.8 Bus reset

A reset is sent to and received from all slaves with this service. Table 31 shows the parameter of the MDS bus reset.

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Table 31 – MDS bus reset

Service parameter	Request	Indication
reset_type	M	M

reset_type:

This service parameter defines whether the reset is short or long.

Value range: short, long

NOTE This service is used by a master only.

8.4.3 Interface signals

The MIS-MDS interface makes signals available that are listed in Table 32.

Table 32 – Signals at the MIS-MDS interface

Interface signal	Mnemonic	Source
Transmit Clock	TxC	MIS
Request-to-send	RTS	MIS
Clear-to-send	CTS	MDS
Transmit Sequence	TxS	MIS
Transmit Select Line	TxSL	MIS
Transmit Control Line	TxCR	MIS
Transmit Data	TxD	MIS
Request Delay 1	RqDly1	MIS
Request Delay 2	RqDly2	MIS
Busy	BSY	MDS
Receive Clock	RxC	MDS
Receive Activity	RxA	MDS
Receive Sequence	RxS	MDS
Receive Select Line	RxSL	MDS
Receive Control Line	RxCR	MDS
Receive Data	RxD	MDS
Reset Out	RO	MIS
Reset In	RI	MDS

8.4.4 Converting the services to the interface signals

8.4.4.1 General

The services of the MIS-MDS interface are represented by the protocol machines and signal sequences described in 8.4.4.1 through 8.4.4.8.

NOTE The following applies to the state diagrams shown in Figure 21 to Figure 29:
The symbol "*" corresponds to "logically and", the symbol "/" corresponds to "negated".

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8.4.4.2 Identification cycle request service

Figure 21 describes this service with the four services marked in grey and their transitions.

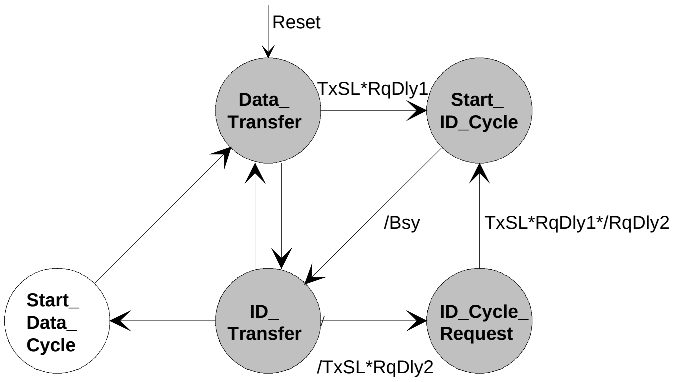

Figure 21 – State transitions with the ID cycle request service

NOTE 1 Transitions not shown in Figure 21 are used for other services see Figure 24 and Figure 26 for the states and transitions.

The identification cycle was preceded by a data cycle or a reset:

Data_Transfer state:
The MIS initiates an identification cycle request service by changing the TxSL signal from logical 0 to logical 1 and at the same time the RqDly1 signal from logical 0 to logical 1.

Start_ID_Cycle state:
After that, the MDS transmits the corresponding status PhPDU, starts a timer with the duration t1 and sets the BSY signal from logical 0 to logical 1. The MIS resets the RqDly1 signal to logical 0.

After the time t1 has elapsed, the MDS sets the BSY signal to logical 0 and terminates the identification cycle request service. The MIS communicates this to the DLL through a PH-DATA confirm primitive and assumes the ID_Transfer state.

The minimum time for t1 is 5 bit times.

Figure 22 shows the corresponding signal forms at the MIS-MDS interface for an identification cycle request service after a preceding data cycle.

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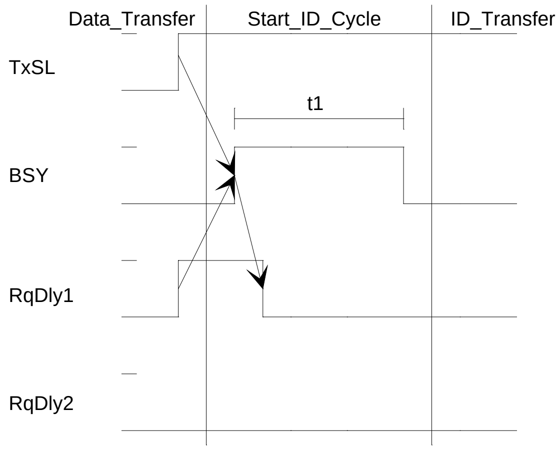

Figure 22 – MIS-MDS interface: identification cycle request service

The identification cycle was preceded by an identification cycle:

ID_Transfer state:
The MIS initiates an identification cycle request service by changing the TxSL signal from logical 1 to logical 0 and at the same time the RqDly2 signal from logical 0 to logical 1.

ID_Cycle_Request state:
After that, the MDS transmits the corresponding status PhPDU, starts a timer with the duration t2 and sets the BSY signal from logical 0 to logical 1. The MIS resets the RqDly2 signal to logical 0.

After the time t2 has elapsed, the MDS sets the BSY signal to logical 0. The MIS sublayer then changes the TxSL signal from logical 0 to logical 1 and at the same time the RqDly1 signal from logical 0 to logical 1.

The minimum time for t2 is 25 bit times.

Start_ID_Cycle state:
After that, the MDS transfers the corresponding status PhPDU, starts a timer with the duration T1 and sets the BSY signal from logical 0 to logical 1. The MIS then resets the RqDly1 signal to logical 0.

After the time t1 has elapsed, the MDS sets the BSY signal to logical 0 and terminates the identification cycle request service. The MIS communicates this to the DLL by means of a PH-DATA confirm primitive and assumes the ID_Transfer state.

Figure 23 shows the corresponding signal forms at the MIS-MDS interface for an identification cycle request service after a preceding identification cycle.

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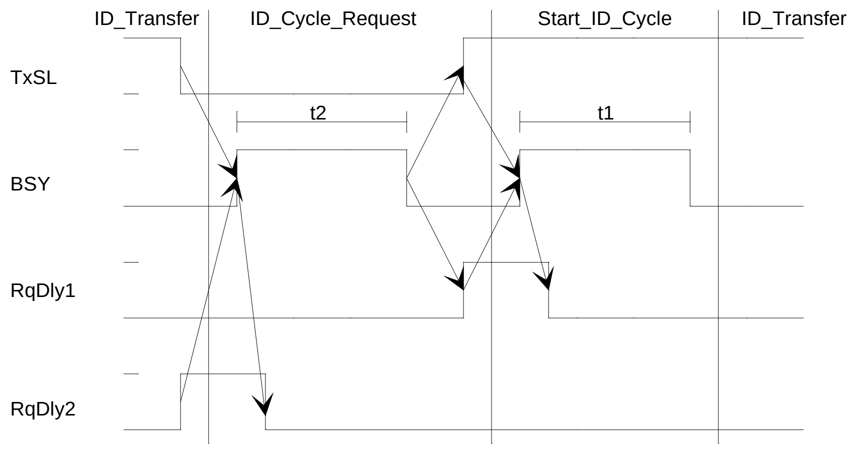

Figure 23 – MIS-MDS interface: identification cycle request service

NOTE 2 The identification cycle request service is an asynchronous service and is not related to TxC.

8.4.4.3 Data cycle request service

Figure 24 describes this service with the three states marked in grey and their transitions.

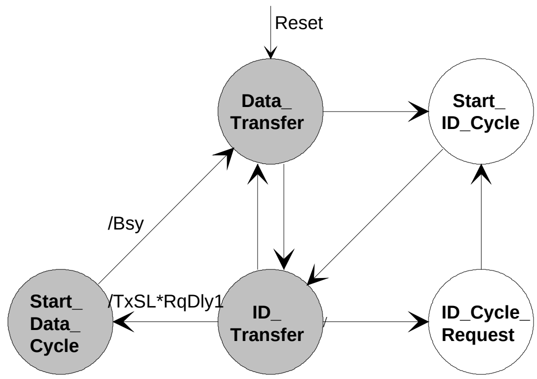

Figure 24 – State transitions with the data cycle request service

NOTE 1 Transitions not shown in Figure 24 are used for other services; see Figure 21 and Figure 26 for the states and transitions.

The data cycle was preceded by an identification cycle:

ID_Transfer state:
The MIS initiates a data cycle request service by changing the TxSL signal from logical 1 to logical 0 and at the same time the RqDly1 signal from logical 0 to logical 1.

Start_Data_Cycle state:
After that, the MDS transmits the corresponding status PhPDU, starts a timer with the duration t1 and sets the BSY signal from logical 0 to logical 1. The MIS resets the RqDly1 signal to logical 0.

After the time t1 has elapsed, the MDS sets the BSY signal to logical 0 and terminates the data cycle request service. The MIS communicates this to the DLL by means of a PH-DATA confirm primitive and assumes the Data_Transfer state.

Figure 25 shows the corresponding signal forms at the MIS-MDS interface for a data cycle request service after a preceding identification cycle.

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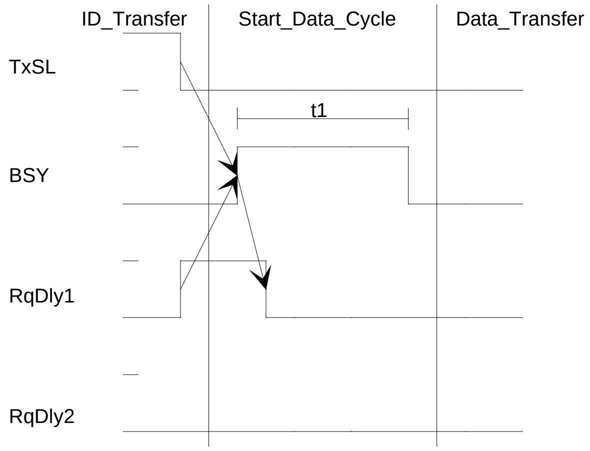

Figure 25 – MIS-MDS interface: data cycle request service

The data cycle was preceded by a data cycle:

If the DLL requests the beginning of a data cycle with a PH-DATA request primitive (PhICI=start_data_cycle), and the DLL did not request the beginning of an identification cycle by means of an PH-DATA request primitive (PhICI=start_ID_cycle) before, the MIS communicates to the DLL the end of the data cycle request service with a PH-DATA confirm primitive. The status of the signals TxSL, RqDly1 and RqDly2 remains unchanged.

NOTE 2 The data cycle request service is an asynchronous service and is not related to TxC.

8.4.4.4 Data sequence classification service

Figure 26 describes this service with the two states marked in grey and their transitions.

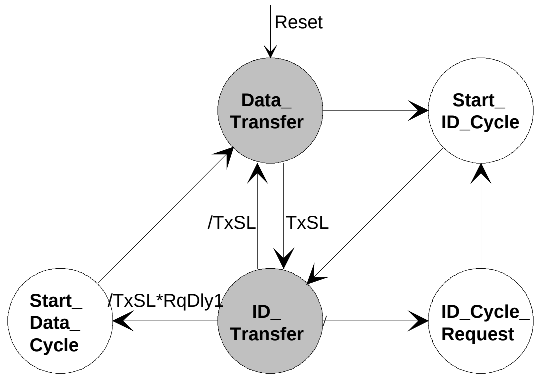

Figure 26 – State transitions with the data sequence classification service

NOTE 1 Transitions not shown in Figure 26 are used for other services; see Figure 21 and Figure 24 for the states and transitions.

Data_Transfer state:
The MIS initiates an identification cycle (transmission of identification and control data in the PhPDU) by changing the TxSL signal from logical 0 to logical 1.

ID_Transfer state
The MIS initiates a data cycle (transmission of user data in PhPDU) by changing the signal from logical 1 to logical 0.

NOTE 2 The data sequence classification service is an asynchronous service and is not related to TxC.

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8.4.4.5 Message transmission service

Figure 27 describes this service with the six states and their transitions.

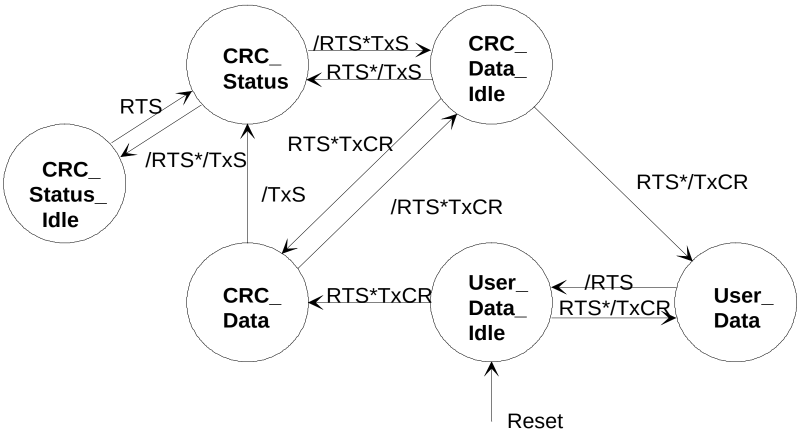

Figure 27 – Protocol machine for the message transmission service

NOTE 1 A data bit sequence is transmitted in multiples of octets. After the MIS has set its RTS interface signal from logical 1 to logical 0, it waits for a falling edge of the active low CTS signal from the MDS. The MIS communicates this to the DLL by means of a PH-DATA confirm primitive (mandatory for the master only).

CRC_Data_Idle state:
The MIS initiates a message transmission service by setting the RTS signal to logical 1 during the rising edge of TxC, at the same time setting the TxCR signal to logical 0, and transmitting with the TxD signal the first data bit within an octet to the MDS.

NOTE 2 Instead of initiating a message transmission service the MIS can start to transmit the checksum status by setting the RTS signal to logical 1 during the following rising edge of TxC, at the same time setting the TxS signal to logical 0 and transmitting the first bit of the checksum status with the TxD signal to the MDS.

User_Data state:
The MIS shall continue data transmission by transmitting the next data bit within an octet with the TxD signal to the MDS during each rising edge of TxC. The MIS completes the data transmission by setting the RTS signal to logical 0 after the last bit has been transmitted and before the next falling edge of TxC.

NOTE 3 The MIS continues data transmission by setting the RTS signal to logical 1 during the rising edge of TxC and at the same time transmitting with the TxD signal the first bit within an octet to the MDS.

User_Data_Idle state:
The MIS starts the check sequence by setting the RTS signal to logical 1 during the rising edge of TxC, at the same time setting the TxCR signal to logical 1, and transmitting the first bit of the checksum (CRC data) with the TxD signal to the MDS.

NOTE 4 Instead of the check sequence the MIS can initiate a new message transmission service by setting the RTS signal to logical 1 during the rising edge of TxC, and at the same time transmitting with the TxD signal the first data bit to the MDS. This is equivalent to a continuation of the message transmission service.

CRC_Data state:
The MIS shall continue to transmit the checksum data by transmitting the next data bit within an octet with the TxD signal to the MDS during each rising edge of TxC.

After the transmission of checksum data has been completed, the MIS starts the transmission of the checksum status (CRC status) by transmitting the TxS signal to logical 0 during the rising edge of TxC and at the same time transmitting with the TxD signal the first bit of the checksum status to the MDS.

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NOTE 5 The MIS continues the transmission of the checksum by setting the RTS signal to logical 1 before the falling edge of TxC and at the same time transmitting with the TXD signal the first bit of the next octet of the checksum to the MDS.

NOTE 6 The MIS starts with the transmission of the checksum status by setting the RTS signal to logical 1 during the rising edge of TxC, at the same time setting the TxS signal to logical 0, and transmitting the first bit of the checksum status to the MDS.

CRC_Status state:
The MIS shall continue checksum status transmission by transmitting the next bit within an octet with the TxD signal to the MDS during each rising edge of TxC. The MIS terminates the transmission of the checksum status by setting the RTS signal to logical 0 and the TxS signal to logical 1 before the falling edge of TxC and after the last bit of the octet to be transmitted.

CRC_Status_Idle state:
The MIS continues the transmission of the checksum status by setting the RTS signal to logical 1 during the rising edge of TxC, and at the same time transmitting with the TxD signal the first bit of the next octet to the MDS.

8.4.4.6 Data sequence identification service

Figure 28 describes this service with the two states and their transitions.

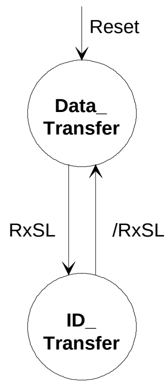

Figure 28 – Protocol machine for the data sequence identification service

Data_Transfer state:
The beginning of an identification cycle (transmission of identification data or control data in the received PhPDU) is indicated to the MIS by a change of the RxSL signal from logical 1 to logical 0.

ID_Transfer state:
The beginning of a data cycle (transmission of user data in the received PhPDU) is indicated to the MIS by a change of the RxSL signal from logical 1 to logical 0.

NOTE The data sequence identification service is an asynchronous service and not related to RxC.

8.4.4.7 Message receipt service

Figure 29 describes this service with the six states and their transitions.

NOTE 1 Data is received in multiples of octets.

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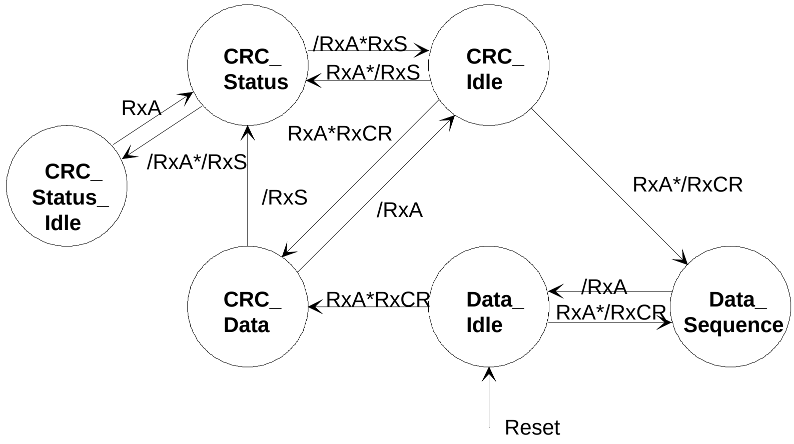

Figure 29 – Protocol machine for the message receipt service

CRC_Idle state:
If the MDS recognises the beginning of a data sequence PhPDU, it initiates the message receipt service by adapting the time pulses transmitted with the RxC signal to the received ones and at the same time during the rising edge of the RxC signal setting the RxA signal to logical 1, the RxCR signal to logical 0, as well as transmitting the first decoded data bit of an octet with the RxD signal to the MIS.

If the MDS recognises the beginning of a checksum status in a check sequence PhPDU instead of the beginning of a data sequence PhPDU, it sets the RxA signal to logical 1, at the same time the RxS signal to logical 0, and transmits the first decoded bit with the RxD signal to the MIS.

As long as the MDS recognises the CRC_Idle state it shall retain the RxA signal at logical 0 and the RxCR signal at logical 1.

Data_Sequence state:
The MDS shall continue to transmit the received and decoded data with the RxD signal to the MIS, and at the same time adapt the transmitted time pulses to the received ones with the RxC signal. If the MDS recognises the Data_Idle state after it has received the last data bit within an octet, it shall set the RxA signal to logical 0 during the falling edge of RxC.

Data_Idle state:
As long as the MDS recognises the Data_Idle state, it shall retain the RxA signal at logical 0 and the RxCR signal at logical 0.

If the MDS recognises the beginning of a check sequence PhPDU, it adapts the time pulses transmitted with the RxC signal to the received ones, sets the RxA signal to logical 1 during the rising edge of RxC, at the same time sets the RxCR signal to logical 1 and transmits with the RxD signal the decoded first received bit of the checksum (CRC data) to the MIS.

If the MDS recognises the first bit within an octet of a data sequence PhPDU instead of the beginning of a check sequence, it continues to receive the data sequence by adapting the transmitted time pulses to the received ones with the RxC signal and at the same time setting the RxA signal to logical 1 during the rising edge of RxC and transmitting the received and decoded data bit with the RxD signal to the MIS.

CRC_Data state:
The MDS shall continue to transmit the received and decoded checksum data with the RxD signal to the MIS and to adapt with the RxC signal the transmitted time pulses to the received ones.

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If the MDS recognises the first bit of the checksum status after it has received the checksum data completely, it shall adapt the time pulses transmitted with the RxC signal, set the RxS signal during the rising edge of RxC to logical 0, and at the same time transmit the received and decoded bit of the checksum status with the RxD signal to the MIS.

If the MDS recognises the CRC_Idle state after it has received the last bit within an octet it shall set the RxA signal to logical 0 during the falling edge of RxC.

If the MDS recognises the first bit within an octet of the checksum data, it shall continue to receive the checksum data by adapting the time transmitted pulses to the received ones with the RxC signal, setting the RxA signal during the rising edge of RxC to logical 1 and at the same time transmitting with the RxD signal the received and decoded checksum bit to the MIS.

CRC_Status state:
The MDS shall continue to transmit the received and decoded checksum status with the RxD signal to the MIS and, at the same time adapt the transmitted time pulses to the received ones with the RxC signal. After it has completely received the checksum status, the MDS sets the RxA signal to logical 0 during the falling edge of RxC and at the same time sets the RxS signal to logical 1.

If the MDS recognises the CRC_Idle state after it has received the last bit within an octet it shall set the RxA signal to logical 0 during the falling edge of RxC.

CRC_Status_Idle state:
If the MDS recognises the first bit within an octet of the checksum data, it shall continue to receive the checksum status by adapting the time pulses transmitted with the RxC signal to the received ones, setting the RxA signal during the rising edge of RxC to logical 1 and at the same time transmitting with the RxD signal the received and decoded bit of the checksum status to the MIS.

8.4.4.8 Reset service

This service is sent from the MIS to the MDS by setting the RO signal. The receipt of a reset is passed from the MDS to the MIS with the RI signal. Value ranges: short, long

8.5 Type 12: DTE – DCE interface

The DTE – DCE interface is not exposed for Type 12 transmission.

9 Medium dependent sublayer (MDS)

9.1 General

The medium dependent sublayer (MDS) is part of the data communication equipment (DCE). (See Figure 1.) It exchanges information across the DTE – DCE interface specified in Clause 8 and it communicates encoded Ph-symbols across the MDS – MAU interface specified in Clause 10. The MDS functions are logical encoding and decoding for transmission and reception respectively and the addition/removal of preamble and delimiters together with timing and synchronization functions.

NOTE A number of different MDS sublayer entities are specified, based on industry practice.

9.2 Type 1: MDS: Wire and optical media

9.2.1 PhPDU

The MDS shall produce the PhPDU shown in Figure 30 by adding preamble and delimiters to frame the serial sequence of PhSDUs (bits) transferred from the DIS across the DTE – DCE

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interface. Transmission sequence shall be from left to right as shown in Figure 30, i.e. preamble first, followed by start delimiter, PhSDU sequence and finally end delimiter.

PREAMBLE	START DELIMITER	PhSDU SEQUENCE	END DELIMITER

Figure 30 – Protocol data unit (PhPDU)

Conversely, the MDS shall remove preamble and delimiters from a received PhPDU to produce a corresponding serial sequence of PhSDUs. If a non-binary data unit is detected in the received PhSDU sequence, the MDS shall immediately stop transferring PhSDUs to the DIS, the MDS shall report an error, and the MDS shall indicate the end of activity to the DIS when it happens.

9.2.2 Encoding and decoding

Data units shall be encoded by the MDS for application to the MAU using the code shown in Figure 31 (Manchester Biphase L). The encoding rules are formally given in Figure 32 and Table 33.

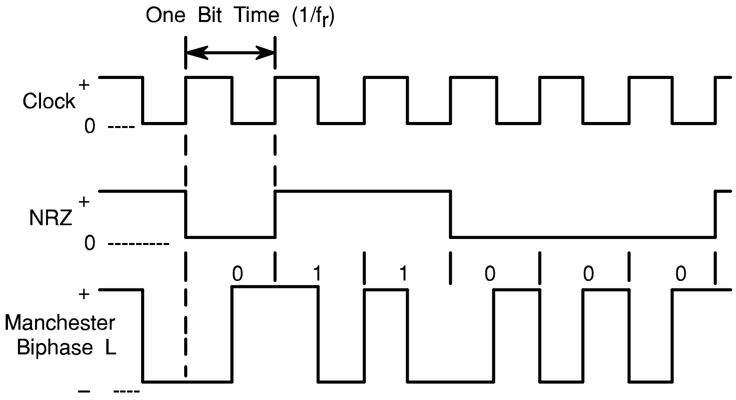

Figure 31 – PhSDU encoding and decoding

NOTE Figure 31 is included for explanatory purposes and does not imply a specific implementation.

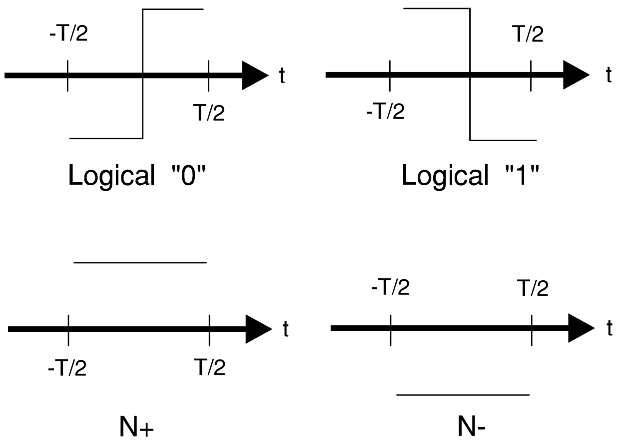

Figure 32 – Manchester encoding rules

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Table 33 – Manchester encoding rules

Symbols	Encoding
1 (ONE)	Hi–Lo transition (mid-bit)
0 (ZERO)	Lo–Hi transition (mid-bit)
N+ (NON-DATA PLUS)	Hi (No transition)
N– (NON-DATA MINUS)	Lo (No transition)
NOTE It may be seen that data symbols (1 and 0, conveyed by PhSDUs) are encoded to always contain a mid-bit transition. Non-data symbols (N+ and N–) are encoded so that they never have a mid-bit transition. Frame delimiters (see 9.2.4 and 9.2.5) are constructed so that non-data symbols are conveyed in pairs of opposite polarity.	

Decoding shall normally be the opposite of encoding. At reception, the MDS shall verify that each symbol is encoded in accordance with Figure 32 and Table 33 and shall detect the following errors:

a) invalid Manchester code;

b) half-bit-slip errors.

Any of these errors shall be reported as PH-DATA indication (PhIDU, error).

9.2.3 Polarity detection

The option of automatic polarity detection of the received Manchester encoded signal shall be required where it is specified in the relevant MAU.

9.2.4 Start of frame delimiter

The following sequence of symbols, shown from left to right in order of transmission, shall immediately precede the PhSDU sequence to delimit the start of a frame:

1, N+, N–, 1, 0, N–, N+, 0.

(shown as a waveform in Figure 33)

The MDS shall only accept a received signal burst as a PhPDU after verifying this sequence and shall remove this sequence before transferring the PhSDU sequence to the DIS.

9.2.5 End of frame delimiter

The following sequence of symbols, shown from left to right in order of transmission, shall immediately follow the PhSDU sequence to delimit the end of a frame:

1, N+, N–, N+, N–, 1, 0, 1.

(shown as a waveform in Figure 33)

The MDS shall remove this sequence from the PhPDU before transferring the PhSDU sequence to the DIS. The MDS shall report to the corresponding DLL entity any frames received via the medium which do not include this sequence within 300 octets of start of frame (from beginning of start delimiter) as PH-DATA indication (PhIDU, frame_too_long). The MDS shall report to the corresponding DLL entity, via the corresponding DIS, any frames received via the medium that have an end delimiter which is not located at an octet boundary as PH-DATA indication (PhIDU, received_timing_error).

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9.2.6 Preamble

In order to synchronize bit times a preamble shall be transmitted at the beginning of each PhPDU consisting of the following sequence of bits, shown from left to right in order of transmission:

1, 0, 1, 0, 1, 0, 1, 0.

(shown as a waveform in Figure 33)

NOTE 1 It is possible that the received preamble contains as few as four bits due to loss of one bit through each of four repeaters (as specified in the MAU Network Configuration Rules).

The period may be extended, but not reduced, by Systems management as given in Table 7. A preamble extension sequence as listed in Table 7 shall be defined as the following sequence of bits, shown from left to right in order of transmission:

1, 0, 1, 0, 1, 0, 1, 0.

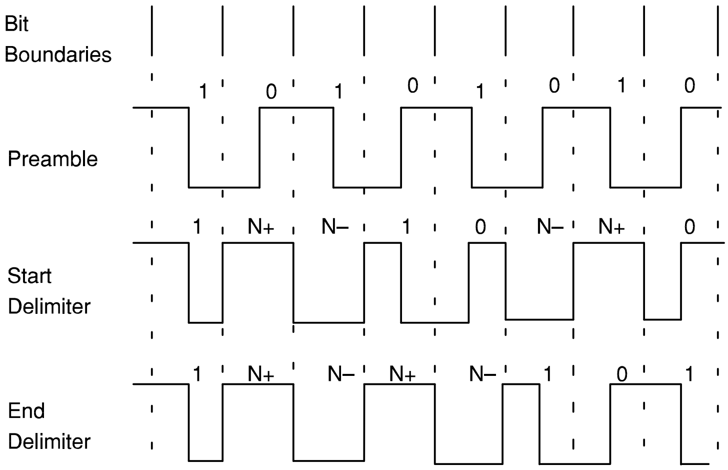

Figure 33 – Preamble and delimiters

NOTE 2 These waveforms do not extend the frequency range outside the band required for transmission of binary PhSDUs (conveying data symbols) in accordance with Figure 32 and Table 33.

9.2.7 Synchronization

After the reception of the fourth bit of the frame and until end of frame or frame termination the receiver shall detect and report half-bit-slip errors.

NOTE 1 This synchronization specification allows the loss of 4 bits of the preamble.

After the preamble, half-bit-slip errors shall be reported as PH-DATA indication (PhIDU, error).

NOTE 2 Half-bit-slip errors can be detected as excessive bit cell jitter and/or excessive variation in bit period.

9.2.8 Post-transmission gap

After transmission of a PhPDU there shall be a minimum period during which a subsequent transmission shall not commence. For the same minimum period after reception of a PhPDU the receiving PhL entity shall ignore all received signaling. An MDS entity shall set a minimum post transmission period of four nominal bit times. The period may be extended, but not reduced, by Systems management as given in Table 7 or by an associated MAU entity. A gap extension sequence as listed in Table 7 shall be defined as four nominal bit times.

NOTE The MAU transmit enable/disable time may reduce the duration of silence between frames.

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9.2.9 Inter-channel signal skew

If the device is configured (by Systems management) to receive concurrently on more than one channel, then the maximum accepted differential delay between any two active channels, as measured from the first PhPDU of a start delimiter, shall not exceed five nominal bit times. This period may be extended, but not reduced, by Systems management as given in Table 7. A gap extension sequence as listed in Table 7 shall be defined as four nominal bit times. The value of post-transmission gap shall be greater than the value of inter-channel skew.

9.3 Void

NOTE Subclause 9.3 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

9.4 Type 2: MDS: Wire and optical media

NOTE The Medium Dependent Sublayer (MDS) is part of the Data Communication Equipment (DCE). It communicates encoded bits across the MDS – MAU interface specified in 10.4.

9.4.1 Clock accuracy

The timing specifications for PhL Signaling shall be as defined in Table 34.

Table 34 – MDS timing characteristics

Specification	Limits / characteristics	Comments
Bit Rate	5 Mbit/s ± CA	Also called M-symbol rate, *data 'zero' or 'one'*
Bit Time	200 ns ± CA	Also called M-symbol time, *data 'zero' or 'one'*
PhL symbol time	100 ns ± CA	Also called Ph-symbol time, see data encoding rules
Clock Accuracy (CA)	± 150 µHz/Hz max.	Including temperature, long term and short term stability

9.4.2 Data recovery

The signals at the DLL to PhL interface shall be synchronized to the local bit rate as shown in Table 34. Each PhL implementation shall provide a data recovery mechanism that recovers or reconstructs the data received from the appropriate medium to meet the timing requirements shown in Table 34. When data synchronization has been attained by the MDS, PH-LOCK indication shall be true.

A portion of the received data frame may be lost or discarded in the process of attaining data synchronization. The specification for data timing shown in Table 34 shall be achieved prior to the beginning of the start delimiter (see IEC 61158-4-2).

9.4.3 Data encoding rules

The M_symbols present at the DLL to PhL interface shall be encoded into the appropriate Ph-symbols as shown in Table 35 and Figure 34. The M_0 and M_1 symbols shall be encoded into Ph-symbols that represent Manchester Biphase L data encoding rules as shown in Table 35. The M_ND symbols shall be used to create unique data patterns used for start and end delimiters. The signal voltage waveform (from the MAU) is shown in an idealized form in Figure 34 to provide an example of the data encoding rules shown in Table 35.

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Table 35 – MDS data encoding rules

Data bits (common name)	M_symbol representation	Ph-symbol encoding	Manchester encoded
data ‘zero’	M_0 or {0}	{L,H}	0
data ‘one’	M_1 or {1}	{H,L}	1
‘non_data+’	M_ND+ or {+}	{H,H}	no data
‘non_data–’	M_ND– or {–}	{L,L}	no data

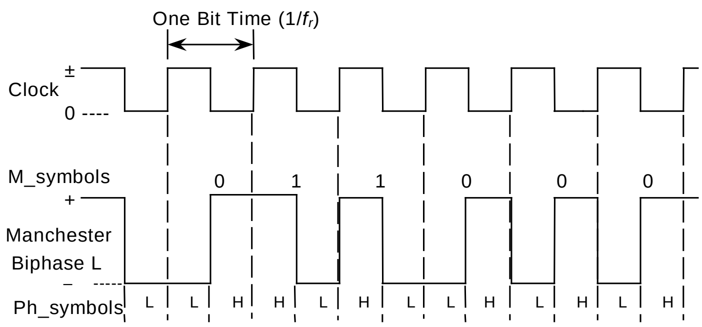

Figure 34 – Manchester coded symbols

9.5 Type 3: MDS: Wire and optical media

9.5.1 Synchronous transmission

The Medium Dependent Sublayer (MDS) specified for Type 1 shall be used (see 9.2).

9.5.2 Asynchronous transmission

There is no Medium Dependent Sublayer (MDS) for asynchronous transmission.

9.6 Type 4: MDS: Wire medium

9.6.1 Half-duplex

9.6.1.1 Overview

NOTE 1 The PhL entity is partitioned into a Data Terminal Equipment (DTE) component containing the MDS, and a Data Communication Equipment (DCE) component containing the MAU.

NOTE 2 The functionality of the MDS is similar to the functionality of what is commonly known as a UART. In addition the half duplex MDS has some timing functionality. The functionality of the MAU is similar to the functionality of what is commonly known as a driver circuitry.

The half-duplex MDS shall sequence the transmission of the PhID as a sequence of bits. Similarly, the MDS shall form the PhID to be reported to the DLL from the sequence of received bits. Bits are sent and received in NRZ code (non-return-to-zero).

The PhID shall be converted to a sequence of bits for serial transmission in PhPDUs. Within each PhPDU, a bit representing a more significant bit shall be transmitted before a bit representing a less significant bit. On reception, each sequence of bits shall be converted to PhID such that, in the absence of errors, the PhID indicated to the receiving DLL entity is unchanged from the PhID whose transmission was requested by the originating DLL entity.

The MDS receives a single PhID or a sequence of PhID octets from the DLE. The first octet is received from the DLE by one of the services START-OF-ACTIVITY-11 or START-OF-ACTIVITY-2. The remaining octets are received from the DLE by the service DATA. End of transmission is indicated by the service END-OF-ACTIVITY. From each PhID octet the MDS shall form a PhPDU

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and transmit the formed PhPDU as a sequence of bits to the MAU. Each PhPDU shall consist of 1 start bit, 8 data bit, 1 address/data bit, and finally 1 stop-bit. This is indicated in Figure 35.

Start	Data8 ... Data1	Address/data	Stop
0	X....X	1 for first octet, 0 for remaining	1

Figure 35 – PhPDU format, half duplex

The MDS shall report when the signal level on the attached medium has been idle for 30, 35 and 40 or more bit periods, by **LINK-IDLE** indications to the DLE.

The transmitted bit rate shall be that of the selected baud rate, ± 0,2 %.

9.6.1.2 Transmission

9.6.1.2.1 START-OF-ACTIVITY-11

The following shall be performed as a result of the DLE issuing a **START-OF-ACTIVITY-11** PH-DATA request:

a) wait for Idle counter equal to or higher than 11;
b) form first PhPDU with Address/data bit = "1" and data = data parameter of **START-OF-ACTIVITY-11** request;
c) confirm reception to DLE to enable the DLE to issue the next transmission request;
d) activate Transmit Enable (TxE);
e) start transmitting the PhPDU to the MAU.

9.6.1.2.2 START-OF-ACTIVITY-2

The following shall be performed as a result of the DLE issuing a **START-OF-ACTIVITY-2** PH-DATA request:

a) wait for Idle counter modulus 10 equal to or higher than 2;
b) form first PhPDU with Address/data bit = "1" and data = data parameter of **START-OF-ACTIVITY-2** request;
c) confirm reception to DLE to enable the DLE to issue the next transmission request;
d) activate Transmit Enable (TxE);
e) start transmitting the PhPDU to the MAU.

9.6.1.2.3 DATA

The following shall be performed as a result of the DLE issuing a **DATA** PH-DATA request:

a) wait till transmission of former PhPDUs has finished;
b) form a new PhPDU with Address/data bit = "0" and data = data parameter of **DATA** request;
c) confirm reception to DLE to enable the DLE to issue the next transmission request;
d) start transmitting the PhPDU to the MAU.

It shall be ensured, that there are no idle periods between transmissions of PhPDUs. The DLE should issue the next transmission request within 11 bit periods after confirmation of the former.

9.6.1.2.4 END-OF-ACTIVITY

The following shall be performed as a result of the DLE issuing an **END-OF-ACTIVITY** PH-DATA request:

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a) wait till transmission of former PhPDU has finished;
b) wait for minimum 3, maximum 10 bit periods;
c) deactivate Transmit Enable (TxE).

9.6.1.3 Reception

9.6.1.3.1 START-OF-ACTIVITY

As a result of receiving a frame from the MAU with address/data bit = "1", or receiving a frame when the value of the Idle counter is higher than or equal to 11, the MDS shall issue a PH-DATA indication of class **START-OF-ACTIVITY**. The associated data parameter shall hold the received data. The value of the associated status parameter shall be set according to the following:

a) receiving a frame with address/data bit = "1" and stop bit = "1", when the value of the Idle counter is higher than or equal to 11 shall result in an associated status parameter indicating SUCCESS;
b) receiving a frame with stop bit = "0", shall result in an associated status parameter indicating FRAMING_ERROR;
c) receiving a frame with address/data bit = "1", but when the value of the Idle counter is lower than 11 shall result in an associated status parameter indicating IDLE_ERROR;
d) receiving a frame with address/data bit = "0", but when the value of the Idle counter is higher than or equal to 11 shall result in an associated status parameter indicating ADDRESS_DATA_ERROR.

9.6.1.3.2 DATA

As a result of receiving a frame from the MAU with address/data bit = "0", when the value of the Idle counter is lower than 11, the MDS shall issue a PH-DATA indication of class **DATA**. The associated data parameter shall hold the received data. The value of the associated status parameter shall be set according to the following:

a) receiving a frame with stop bit = "1" from the MAU shall result in an associated status parameter indicating SUCCESS;
b) receiving a frame with stop bit = "0", shall result in an associated status parameter indicating FRAMING_ERROR.

9.6.1.4 Idle counter

The MDS holds an idle counter. This counter is incremented by one for each bit period, and is cleared each time a bit with value "0" is sent to or received from the MAU. When the Idle counter reaches 30, the MDS shall report this with a PH-DATA indication of class LINK-IDLE, and associated status indicating 30 bit periods. 5 bit periods later, if the Link is still idle, the PhE reports this with another PH-DATA indication of class LINK-IDLE, and associated status indicating 35 bit periods. 5 bit periods later, if the Link is still idle, the PhE reports this with another PH-DATA indication of class LINK-IDLE, and associated status indicating 40 or more bit periods. This goes on for each 10 bit periods with indications specifying 40 or more bit periods. The speed of the idle counter shall be that of the selected baud rate, ± 0,2 %.

9.6.2 Full-duplex

9.6.2.1 Overview

NOTE 1 The PhL entity is partitioned into a Data Terminal Equipment (DTE) component containing the MDS, and a Data Communication Equipment (DCE) component containing the MAU.

NOTE 2 The functionality of the MDS is similar to the functionality of what is commonly known as a UART. In addition the full duplex MDS has some "byte stuffing" functionality. The functionality of the MAU is similar to the functionality of what is commonly known as a driver circuitry.

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The full duplex MDS shall sequence the transmission of the PhID as a sequence of bits. Similarly, the MDS shall form the PhID to be reported to the DLL from the sequence of received bits. Bits are sent and received in NRZ code (non-return-to-zero).

The PhID shall be converted to a sequence of bits for serial transmission in PhPDUs. Within each PhPDU, a bit representing a more significant bit shall be transmitted before a bit representing a less significant bit. On reception, each sequence of bits shall be converted to PhID such that, in the absence of errors, the PhID indicated to the receiving DLL entity is unchanged from the PhID whose transmission was requested by the originating DLL entity.

The MDS receives a single PhID or a sequence of PhID octets from the DLE. The first octet is received from the DLE by the service **START-OF-ACTIVITY-2**. The remaining octets are received from the DLE by the service **DATA**. End of transmission is indicated by the service **END-OF-ACTIVITY**. From each PhID octet the MDS shall form a PhPDU and transmit the formed PhPDU as a sequence of bits to the MAU. Each PhPDU shall consist of 1 start bit, 8 data bit, and finally 1 stop-bit. This is indicated in Figure 36.

Start	Data8 ... Data1	Stop
0	X….X	1

Figure 36 – PhPDU format, full duplex

9.6.2.2 Transmission

9.6.2.2.1 START-OF-ACTIVITY-2

The following shall be performed as a result of the DLE issuing a **START-OF-ACTIVITY-2** PH-DATA request:

a) form first PhPDU with data = $D7 (hex);
b) form second PhPDU with data = data parameter of **START-OF-ACTIVITY-2** request;
c) confirm reception to DLE to enable the DLE to issue the next transmission request;
d) activate request-to-send signal (RTS);
e) wait for clear-to-send signal (CTS) to be activated;
f) start transmitting the formed PhPDUs to the MAU.

9.6.2.2.2 DATA

The following shall be performed as a result of the DLE issuing a **DATA** PH-DATA request:

a) wait till transmission of former PhPDUs is finished;
b) wait for clear-to-send signal (CTS) to be active;
c) form new PhPDU(s) with data according to the following:
d) if the value of data parameter of **DATA** request = $D7 (hex), form a PhPDU with the data value $D9 (hex), followed by an additional PhPDU with the data value $00;
e) if the value of data parameter of **DATA** request = $D9 (hex), form a PhPDU with the data value $D9 (hex), followed by an additional PhPDU with the data value $01;
f) if the value of data parameter of **DATA** request is different from $D7 (hex) and $D9 (hex), form a PhPDU with the data value = data parameter of **DATA** request;
g) confirm reception to DLE to enable the DLE to issue the next transmission service;
h) start transmitting the PhPDU(s) to the MAU.

9.6.2.2.3 END-OF-ACTIVITY

The following shall be performed as a result of the DLE issuing an **END-OF-ACTIVITY** PH-DATA request:

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a) wait till transmission of former PhPDUs has finished;

b) deactivate request-to-send (RTS) signal.

9.6.2.3 Reception

9.6.2.3.1 START-OF-ACTIVITY

As a result of receiving a PhPDU from the MAU with a data value of $D7 (hex), the MDS shall wait for the following PhPDU, and when this PhPDU is received issue a PH-DATA indication of class **START-OF-ACTIVITY**. The associated data parameter shall hold the received data from the PhPDU following $D7 (hex). The value of the associated status parameter shall be set according to the following:

a) receiving a PhPDU with stop bit = “1” shall result in an associated status parameter indicating SUCCESS;

b) receiving a PhPDU with stop bit = “0”, shall result in an associated status parameter indicating FRAMING_ERROR.

9.6.2.3.2 DATA

Receiving a PhPDU from the MAU with a data value different from $D7 (hex) shall result in the following:

receiving a PhPDU with stop bit = “1” and a data value = $D9 (hex), shall result in the MDS waiting for the following PhPDU from the MAU. The result of receiving the following PhPDU shall be:

a) if the data value of the following PhPDU is $00 (hex), and the stop bit is = “1”, issue a PH-DATA indication of class **DATA**. The associated data parameter shall hold the value $D7. The value of the associated status parameter shall indicate SUCCESS.

b) if the data value of the following PhPDU is $01 (hex), and the stop bit is = “1”, issue a PH-DATA indication of class **DATA**. The associated data parameter shall hold the value $D9. The value of the associated status parameter shall indicate SUCCESS.

c) if the data value of the following PhPDU is different from $00 (hex) and from $01 (hex), and the stop bit is = “1”, issue a PH-DATA indication of class **DATA**. The associated data parameter shall hold the received data value. The value of the associated status parameter shall indicate BYTE_STUFFING_ERROR.

d) if the stop bit is “0”, issue a PH-DATA indication of class **DATA**. The associated data parameter shall hold the received value. The value of the associated status parameter shall indicate FRAMING_ERROR.

e) receiving a PhPDU with stop bit = “1” and a data value different from $D9 (hex), shall result in the MDS issuing a PH-DATA indication of class **DATA**. The associated data parameter shall hold the received value. The value of the associated status parameter shall indicate SUCCESS;

f) receiving a PhPDU with stop bit = “0” shall result in the MIS issuing a PH-DATA indication of class **DATA**. The associated data parameter shall hold the received value. The value of the associated status parameter shall indicate FRAMING_ERROR.

9.6.3 Full-duplex UDP

9.6.3.1 Overview

The PhID shall be sent in accordance with ISO/IEC 8802-3.

The MDS receives a single PhID or a sequence of PhID octets from the DLE. The first octet is received from the DLE by the service **START-OF-ACTIVITY-2**. The remaining octets are received from the DLE by the service **DATA**. End of transmission is indicated by the service **END-OF-ACTIVITY**.

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9.6.3.2 Transmission

9.6.3.2.1 START-OF-ACTIVITY-2

The following shall be performed as a result of the DLE issuing a **START-OF-ACTIVITY-2** PH-DATA request:

a) reserve MAC sublayer packet;

b) form PhPDU with data = data parameter of **START-OF-ACTIVITY-2** request;

c) insert the formed PhPDU at the first location in the reserved packet;

d) confirm reception to DLE to enable the DLE to issue the next transmission request;

The following shall be performed as a result of the DLE issuing a **DATA** PH-DATA request:

a) form PhPDU with data = data parameter of the **DATA** request;

b) insert the formed PhPDU at the next location in the reserved packet;

c) confirm reception to DLE to enable the DLE to issue the next transmission service.

9.6.3.2.2 END-OF-ACTIVITY

The following shall be performed as a result of the DLE issuing an **END-OF-ACTIVITY** PH-DATA request:

a) transfer the reserved packet to the MAC sublayer.

9.6.3.3 Reception

9.6.3.3.1 START-OF-ACTIVITY

As a result of receiving a packet from the MAC sublayer, issue a PH-DATA indication of class **START-OF-ACTIVITY**. The associated data parameter shall hold the first octet of the received packet. The value of the associated status parameter shall be set to SUCCESS.

9.6.3.3.2 DATA

The following data in the received packet shall result in the MDS issuing PH-DATA indications of class **DATA**. The associated data parameters shall hold the received values. The value of the associated status parameters shall indicate SUCCESS.

9.7 Void

NOTE Subclause 9.7 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

9.8 Type 8: MDS: Wire and optical media

9.8.1 Function

The medium-dependent sublayer (MDS) exchanges PhSDU sequences via the MIS-MDS interface, as described in 6.5, and transmits the PhPDU via the MDS-MAU interface as described in Clause 9. The MDS encodes and decodes the PhSDU, adds and removes the transmission frame (header and stop bit) for the PhSDU subsequences to be transmitted and received, synchronises the MIS-MDS interface and the MDS-MAU interface and the PhPDUs, time functions, and directly transmits a PhPDU between MAUs via the MDS-MAU interface (MAU coupling).

The MDS may consist of several channels. The PhPDU shall generate one channel of the MDS corresponding to the PhSDU sequences transmitted via the MIS-MDS interface and encode the PhSDU sequence accordingly. Conversely, this channel shall recognise the format of the received PhPDU and transmit the decoded PhSDU sequence via the MIS-MDS

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interface to the MIS. All other channels are used to directly transfer a PhPDU between two MAUs.

The channel of the MDS of a slave, which has an interface to the MIS shall have the following relation between the send and receive direction: If the MIS-MDS interface signal RTS is 0, the contents of DI is transmitted on the MDS-MAU interface signal DO with a delay time of exactly one bit time. If RTS is 1, DO is coupled to TxD (only applicable when there is no MDS coupling).

In the MDS of a master it is possible that a sequence of 8 PhSDUs is first buffered and then a corresponding data sequence or check sequence PhPDU is generated.

9.8.2 PhPDU formats

The MDS can recognise and generate the following PhPDU formats: **data sequence PhPDU**, **check sequence PhPDU**, **status PhPDU** and **reset PhPDU**.

9.8.2.1 Data sequence PhPDU

The MDS generates data sequence PhPDU by adding a start bit, header, and stop bit to the data unit. The data unit itself consists of eight PhSDUs that, as a PhSDU sequence, have been transmitted as a part of the data sequence DLPDU via the MIS-MDS interface with the message transmission service. Figure 37 shows the structure of the data sequence PhPDU.

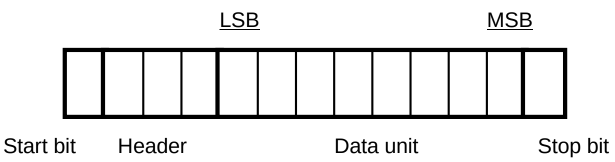

Figure 37 – Data sequence PhPDU

The data sequence PhPDU thus generated is transmitted from left to right via the MDS-MAU interface in the following order: start bit, header, data unit, stop bit. The PhSDUs of the data unit are transmitted via the MDS-MAU interface in the order in which they have been transmitted through the MIS-MDS interface.

According to Figure 37, a data sequence PhPDU is received from left to right and in the order: start bit, header, data unit, stop bit. The MDS removes start bit, stop bit and header and transmits the PhSDU sequence contained in the data unit with the message receipt service as a part of a data sequence DLPDU through the MIS-MDS interface to the MIS. The transmission begins with the first PhSDU that follows the header and ends with the last PhSDU before the stop bit.

NOTE 1 Each data sequence PhPDU begins with a start bit and ends with a stop bit.

NOTE 2 A data sequence DLPDU is transmitted by a sequence of data sequence PhPDUs.

The header in a data sequence PhPDU is structured as shown in Figure 38.

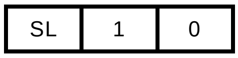

Figure 38 – Structure of the header in a data sequence PhPDU

The header of the data sequence PhPDU is transmitted and received from left to right via the MDS-MAU interface, beginning with the SL bit.

For a data sequence PhPDU to be sent, the logical symbol which is transferred in the SL bit is equivalent to the negated logical state of the TxSL signal of the MIS-MDS interface at the time

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at which the data sequence PhPDU is to be transmitted via the MDS-MAU interface to the MAU (see Table 36):

Table 36 – SL bit and TxSL signal assignment

TxSL signal	SL bit
Logical 1	0
Logical 0	1

For a received data sequence PhPDU the logical state of the RxSL signal of the MIS-MDS interface is equivalent to the negated logical symbol that is transmitted in the SL bit (see Table 37).

Table 37 – SL bit and RxSL signal assignment

SL bit	RxSL signal
0	Logical 1
1	Logical 0

9.8.2.2 Check sequence PhPDU

The MDS generates the check sequence PhPDU by adding a start bit, header and stop bit to the data unit. The data unit itself consists of eight PhSDUs that have been transmitted as a PhSDU sequence with a message transmission service as a part of a check sequence DLPDU via the MIS-MDS interface. Figure 39 shows the structure of the check sequence PhPDU.

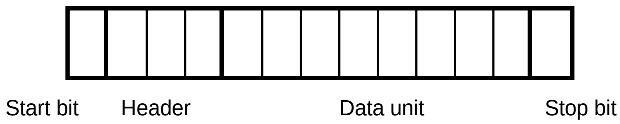

Figure 39 – Check sequence PhPDU

A check sequence PhPDU thus generated is transmitted from left to right via the MDS-MAU interface in the following order: start bit, header, data unit, stop bit. The PhSDUs of the data unit are transmitted via the MDS-MAU interface in the order in which they have been transmitted through the MIS-MDS interface.

A check sequence PhPDU is received, according to Figure 39, from left to right and in the order: start bit, header, data unit, stop bit. The MDS removes start bit, stop bit and header and transmits the PhSDU sequence contained in the data unit with the message receipt service as a part of a check sequence DLPDU via the MIS-MDS interface to the MIS. The transmission starts with the first PhSDU that follows the header and ends with the last PhSDU before the stop bit.

NOTE 1 Each check sequence PhPDU begins with a start bit and ends with a stop bit.

NOTE 2 A check sequence DLPDU is transmitted with a series of four check sequence PhPDUs.

The header in a check sequence PhPDU is structured according to Figure 40.

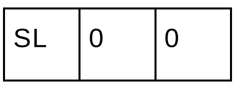

Figure 40 – Structure of a header in a check sequence PhPDU

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The header of the check sequence PhPDU is transmitted and received from left to right via the MDS-MAU interface, beginning with the SL bit.

For a check sequence PhPDU to be sent, the logical symbol to be transferred in the SL bit is equivalent to the negated logical state of the TxSL signal of the MIS-MDS interface at the time at which the check sequence PhPDU is to be transmitted via the MDS-MAU interface to the MAU (see Table 38).

Table 38 – SL bit and TxSL signal assignment

TxSL signal	SL bit
Logical 1	0
Logical 0	1

For a received check sequence PhPDU the logical state of the RxSL signal of the MIS-MDS interface is equivalent to the negated logical symbol that is transmitted in the SL bit (see Table 39).

Table 39 – SL bit and RxSL signal assignment

SL bit	RxSL signal
0	Logical 1
1	Logical 0

9.8.2.3 Status PhPDU

The status PhPDU which is formed by the MDS consists of a start bit, the header, and a stop bit. The status PhPDU is structured as shown in Figure 41.

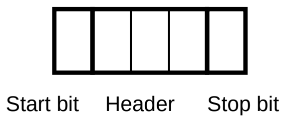

Figure 41 – Structure of the status PhPDU

The status PhPDU is transmitted and received via the MDS-MAU interface from left to right beginning with the stop bit, followed by the header and ending with the stop bit.

The header in a status PhPDU is structured according to Figure 42.

SL	0/1	1

Figure 42 – Structure of the header in a status PhPDU

According to Figure 42 the header is transmitted and received from left to right via the MDS-MAU interface, starting with the SL bit. The state of the bit which comes after the SL bit is not defined and can assume the values "0" or "1".

For a status PhPDU to be sent the logical symbol to be transmitted in the SL bit is equivalent to the negated logical state of the TxSL signals of the MIS-MDS interface at the time at which the status PhPDU is to be transmitted through the MDS-MAU interface to the MAU (see Table 40).

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Table 40 – SL bit and TxSL signal assignment

TxSL signal	SL bit
Logical 1	0
Logical 0	1

For a received status PhPDU the logical state of the RxSL signal of the MIS-MDS interface is equivalent to the negated logical symbol that is transmitted in the SL bit (see Table 41).

Table 41 – SL bit and RxSL signal assignment

SL bit	RxSL signal
0	Logical 1
1	Logical 0

Each status PhPDU begins with a start bit and ends with a stop bit.

If no sequences of PhSDUs are transmitted to the MDS via the MIS-MDS interface, the MDS automatically begins to transmit successive status PhPDUs. Idle states may be generated between two successive status PhPDUs. The transmission of status PhPDUs is terminated synchronously to the message as soon as the first PhSDU of a data sequence or check sequence PhPDU was transmitted from MIS to the MDS.

The status PhPDUs are transmitted after a reset PhPDU, if no check sequence PhPDU or data sequence PhPDU is to be transmitted.

NOTE Receipt of a status PhPDU does not change the logical state of the RxCR signal of the MIS-MDS interface.

9.8.2.4 Medium activity status PhPDU

The medium activity status PhPDU that is formed by the MDS consists of a start bit, the header, and a stop bit. The medium activity status PhPDU is structured as shown in Figure 43.

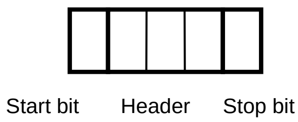

Figure 43 – Structure of the medium activity status PhPDU

The header in a medium activity status PhPDU is structured according to Figure 44.

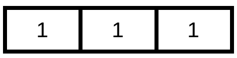

Figure 44 – Structure of the header in a medium activity status PhPDU

According to Figure 44 the header is transmitted and received from left to right via the MDS-MAU interface. The medium activity status PhPDU is only transmitted via an outgoing passive MAU (loopback mode = disable) when the systems management set the variable data select = enable.

9.8.2.5 Coding and decoding

Coding and decoding is done in accordance with the rules in Table 42.

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Table 42 – Coding and decoding rules

Logical symbol bit	Coding DO, DI
1	High level
0	Low level

The high and low levels shall each be taken from the beginning of a bit for the duration of one bit time.

NOTE 1 For the coding the logical symbols are converted to the corresponding state of the DO signal of the MDS-MAU interface.

NOTE 2 For the decoding the status of the DI signal of the MDS-MAU interface is converted to the corresponding logical symbol.

9.8.2.6 Start bit

The start bit corresponds to the logical symbol "1".

The MDS shall synchronise its receive clock with the beginning of the start bits (low-high transitions).

9.8.2.7 Stop bit

The stop bit corresponds to the logical symbol "0".

NOTE The MDS may synchronise its receive clock to a newly arriving start bit only after a stop bit (low-high transition).

9.8.3 Idle states

The sender of the bus master may generate idle states during the transitions of status PhPDUs to data sequence PhPDUs or check sequence PhPDUs. Idle states have always a low level on DO. The maximum length of the idle states shall not exceed 26 bit times. The decoding rules for idle states recognised on the medium are given in Table 43.

Table 43 – Decoding rules for the idle states

Idle state	State RxCR	Decoding DI
Data_Idle	Logical 0	Low level
CRC_Idle	Logical 1	Low level
CRC_Status_Idle	Logical 1	Low level

9.8.4 Reset PhPDU

9.8.4.1 Structure of the Reset PhPDU

The reset PhPDU transmits the logical symbols "short reset" or "long reset". Figure 45 shows the structure of the reset PhPDU.

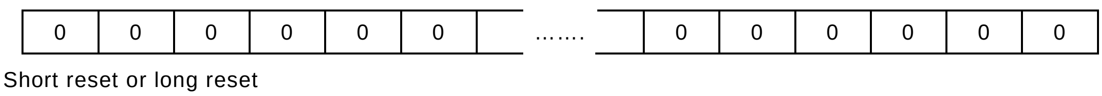

Figure 45 – Reset PhPDU

NOTE The symbols "short reset" and "long reset" only differ in the time during which the signals DO or DI of the MDS-MAU interface transmit a low level.

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9.8.4.2 Coding and decoding

The coding rules for the reset PhPDU are given in Table 44 and Table 45.

Table 44 – Coding rules for the reset PhPDU

Logical symbol	Time interval	Coding DO
Short bus reset	2 ms ≤ T_{Rst} < 25,6 ms	Low level
Long bus reset	T_{Rst} ≥ 25,6 ms	Low level

Table 45 – Decoding rules of the reset PhPDU

DI	Time interval	Logical symbol
Low level	2 ms ≤ T_{Rst} < 25,6 ms	Short bus reset
Low level	T_{Rst} ≥ 25,6 ms	Long bus reset

NOTE 1 A reset PhPDU is terminated with the start bit of a data sequence PhPDU, a check sequence PhPDU or a status PhPDU.

NOTE 2 During the coding, the logical symbols are converted to the corresponding state of the DO signal of the MDS-MAU interface during the time T_{Rst}.

NOTE 3 During the decoding, in the time T_{Rst} the state of the DI signal of the MDS-MAU interface is converted to the corresponding logical symbol.

The times given in Table 44 and Table 45 do not apply to the sender of the master. For the sender of the bus master the corresponding reset PhPDU shall be generated upon request of the RO service in accordance with the definitions specified in the PhL variables *short bus reset time* and *long bus reset time*.

NOTE 4 The encoding rules for the reset PhPDU apply only to a MDS coupling in the MIS.

9.8.5 MAU coupling

When MAUs of the same type are coupled pairs, each PhPDU and all idle states are transmitted unchanged between two MAUs. Figure 46, Figure 47 and Figure 48 show possible configurations for the bus devices when the 2-wire medium is used.

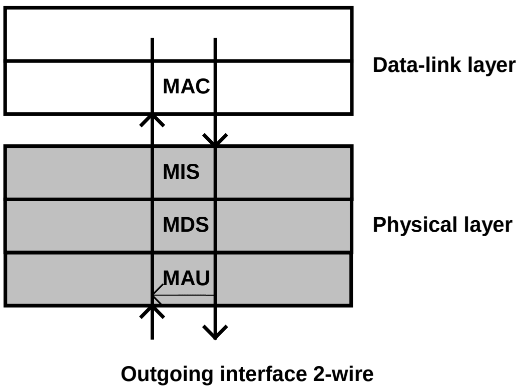

Figure 46 – Configuration of a master

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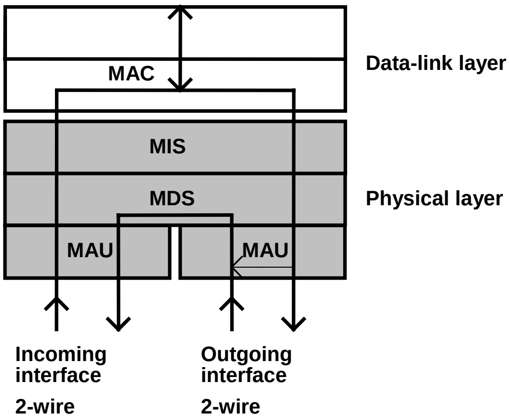

Figure 47 – Configuration of a slave

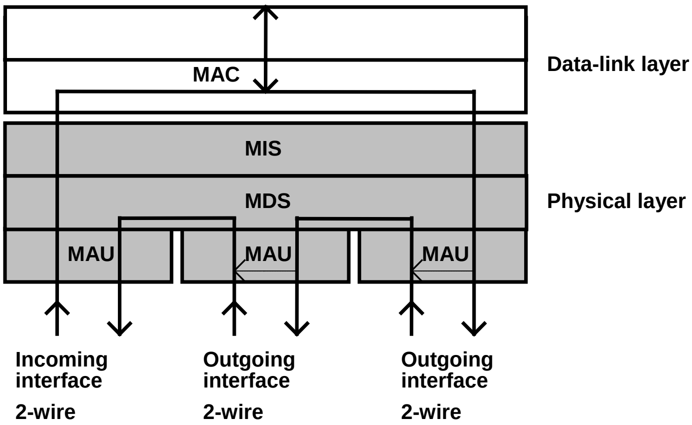

Figure 48 – Configuration of a bus coupler

When two MAUs are directly coupled, code-transparent repeaters may be used for the time regeneration.

9.9 Type 12: MDS: Wire media

9.9.1 PhPDU

The MDS shall produce the PhPDU shown in Figure 49 by adding delimiters and minimal idle sequences to frame the serial sequence of PhSDUs (bits) transferred from the DIS across the DTE – DCE interface. Transmission sequence shall be from left to right as shown in Figure 49, i.e. SOF first, followed by PhSDU sequence and finally EOF.

idle	SOF	PhSDU SEQUENCE	EOF	idle

Figure 49 – Protocol data unit

Conversely, the MDS shall remove idle, SOF and EOF from a received PhPDU to produce a corresponding serial sequence of PhSDUs. If a non-binary data unit is detected in the received PhSDU sequence, the MDS shall immediately stop transferring PhSDUs to the DIS, the MDS shall report an error, and the MDS shall indicate the end of activity to the DIS when it happens.

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9.9.2 Encoding and decoding

Data units shall be encoded by the MDS for application to the MAU using the code shown in Figure 50 (Manchester Biphase L). The encoding rules are given formally in Figure 51 and Table 46.

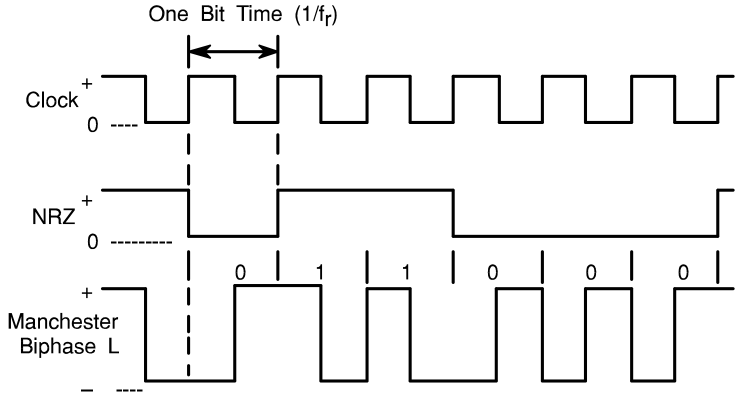

Figure 50 – PhSDU encoding and decoding

NOTE Figure 50 is included for explanatory purposes and does not imply a specific implementation.

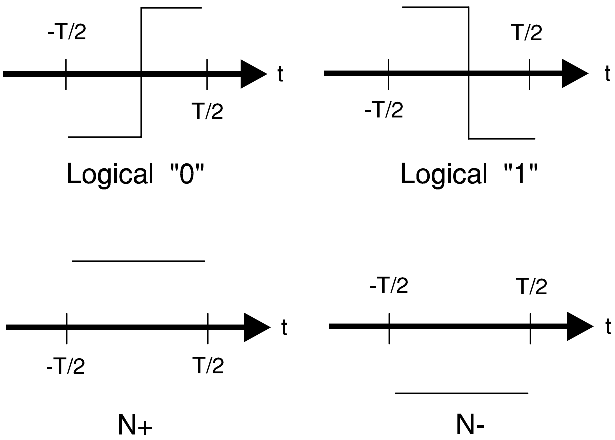

Figure 51 – Manchester encoding rules

Table 46 – Manchester encoding rules

Symbols	Encoding
1 (ONE)	Hi–Lo transition (mid-bit)
0 (ZERO)	Lo–Hi transition (mid-bit)
N+ (NON-DATA PLUS)	Hi (No transition)
N– (NON-DATA MINUS)	Lo (No transition)
NOTE It may be seen that data symbols (1 and 0, conveyed by PhSDUs) are encoded to always contain a mid-bit transition. Non-data symbols (N+ and N–) are encoded so that they never have a mid-bit transition.	

Decoding shall normally be the opposite of encoding. At reception, the MDS shall verify that each symbol is encoded in accordance with Figure 51 and Table 46 and shall detect the following errors:

a) invalid Manchester code;

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b) half-bit-slip errors;

c) misalignment of EOF (number of bits is not a multiple of 8).

Any of these errors shall be reported as:

PH-DATA indication (class=END-W-ERROR, data=error).

9.9.3 Polarity detection

There is no automatic polarity detection of the received Manchester Biphase L encoded signal.

9.9.4 SOF

The following sequence of symbols, shown from left to right in order of transmission, shall immediately precede the PhSDU sequence to delimit the start of a frame:

0, N+

The MDS shall only accept a received signal burst as a PhPDU after verifying this sequence and shall remove this sequence before transferring the PhSDU sequence to the DIS.

9.9.5 EOF

The following sequence of symbols, shown from left to right in order of transmission, shall immediately follow the PhSDU sequence to delimit the end of a frame:

N–, 0

The MDS shall remove this sequence from the PhPDU before transferring the PhSDU sequence to the DIS. The MDS shall report to the corresponding DLL entity any frames received via the medium which do not include this sequence within 1 535 octets of start of frame (from end of SOF) as:

PH-DATA indication (class=END-W-ERROR, data=frame_too_long).

The MDS shall report to the corresponding DLL entity, via the corresponding DIS, any frames received via the medium that have an end delimiter which is not located at an octet boundary as:

PH-DATA indication (class=END-W-ERROR, data=alignment_error).

9.9.6 Idle

In order to synchronize bit times an idle sequence shall be send out if no PhSDU or SOF/EOF are transmitted:

0

An idle sequence is always bit aligned.

NOTE A series of 1 in a PhSDU can be interpreted as idle. Following 0-symbols or EOF will readjust bit cell detection.

9.9.7 Synchronization

After activation and reception of a sufficient number of signals the receiver shall detect and report half-bit-slip errors.

NOTE 1 This synchronization specification allows the loss of 4 bits of the preamble.

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After SOF, half-bit-slip errors shall be reported as:

PH-DATA indication (class=END-W-ERROR, data=half_bit_slip_error).

NOTE 2 Half-bit-slip errors can be detected as excessive bit cell jitter and/or excessive variation in bit period.

9.9.8 Inter frame gap

After transmission of a PhPDU there shall be a minimum period during which a subsequent transmission shall not commence. For the same minimum period after reception of a PhPDU the receiving PhL entity shall ignore all received signaling. An MDS entity shall set a minimum post transmission period of 92 nominal bit times (96 with SOF, EOF). The period may be extended, but not reduced, by systems management.

9.10 Type 16: MDS: Optical media

9.10.1 Data encoding rules

Signals on the transmission lines shall be NRZI-coded. Signal changes are only allowed to take place in synchronization with the transmitting clock. Every time a 0 is transmitted, the signal shall change its status in synchronization with the transmitting clock, whereas the signal shall remain unchanged when a 1 is transmitted.

By a suitable method (i.e., bit-stuffing), the transmitter shall ensure that enough zeros occur in the transmitted bit stream. This generates additional signal changes. In this way, conditions are created which make it possible to retrieve a receiving clock from the received signal. The retrieved receiving clock shall also have a fixed phase position with respect to the clock of the transmitter. The clock shall be retrievable by means of a digital phase locked loop (DPLL) which shall be synchronized to the signal change of the received signal transformed to an electrical signal. Figure 52 d) is an example of a NRZI-coded signal. Therefore, the transmitting clock provides the pattern for the system timing via the signal transitions.

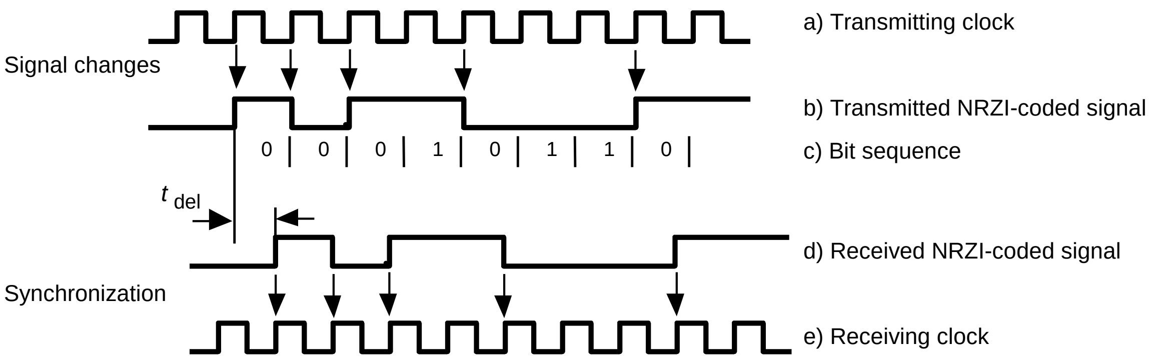

Figure 52 – Example of an NRZI-coded signal

9.10.2 Telegrams and fill characters

On the physical level, it is sufficient to know that a telegram shall start and end with the bit sequence 0111 1110. This bit sequence is also known as a delimiter. Due to bit-stuffing, this bit sequence is prevented from occurring inside the telegram.

Other fields of the telegram belong to higher protocol layers and are discussed elsewhere.

If a unit does not place its own telegram on the network, two possibilities arise:

a) the master shall transmit a so-called fill signal (fill bits) between its own telegrams. It shall consist of a sequence of one binary 0 and seven binary 1's (i.e., 0111 1111). This generates a symmetric fill signal with 16 times the period of the transmitting clock, due to NRZI-coding (see Figure 53);

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b) between its own telegrams, a slave shall transmit with its synchronized local clock the physically regenerated, received signals (repeater mode).

During the transition from telegram to fill signal (master) or from telegram to repeater mode (slave), signal changes shall follow the pattern of the current clock.

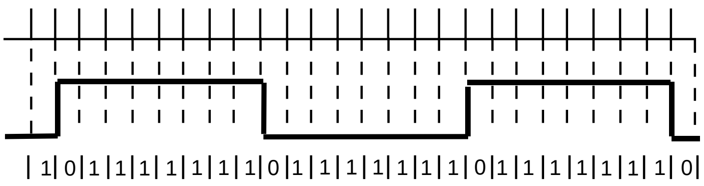

Figure 53 – Fill signal

NOTE Due to bit-stuffing and a), the slave physically located first in the network is able to derive its local clock from its received signal at any time. Because of b), this is also the case for all subsequent units, all the way to the receiver of the master. In this way, digital phase locked loops, which are eventually used to obtain the local clock, remain locked on, preventing time-consuming synchronization before the start of the actual telegram.

9.11 Type 18: MDS: Wire media

9.11.1 Overview

The Type 18 MDS shall be able to sense the initiation and subsequent termination of data reception, the means of which are beyond the scope of this specification.

9.11.2 Transmission

Data transmission is started upon receipt of a PH-DATA (START-OF-ACTIVITY) request from the DL-user. This is translated by the MDS into a TRANSMIT-ENABLE signal assertion with the value specified in the DATA field being transmitted on the TRANSMIT-SIGNAL.

The MDS shall issue a PH-DATA (SUCCESS) confirmation and shall receive the next PH-DATA (DATA) request before the expiration of the MDS baud rate bit timer. It is not until this request is acted upon that the subsequent PH-DATA (SUCCESS) confirmation is produced. In this way, the MDS baud rate timer regulates the flow rate of data.

Upon receipt of a PH-DATA (END-OF-ACTIVITY) request from the DL-user, the MDS completes the transmission in process and concludes with a TRANSMIT-ENABLE signal deassertion.

9.11.3 Reception

Upon receipt of data activity, the MDS issues a PH-DATA (START-OF-ACTIVITY) indication with the DATA value received. Each subsequent datum received results in a PH-DATA (DATA) indication with the DATA value received. Upon completion of the data reception, the MDS issues a PH-DATA (END-OF-ACTIVITY) indication to the DL-user.

9.12 Type 24: MDS: Twisted-pair wire

9.12.1 General

The Medium Dependent Sublayer (MDS) is part of the Data Communication Equipment (DCE). It communicates encoded bits across the MDS – MAU interface specified in 10.8.

9.12.2 Clock accuracy

The timing specifications for PhL Signaling shall be as defined in Table 47.

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Table 47 – MDS timing characteristics

Specification	Limits / characteristics	Comments
Bit Rate	10 Mbit/s ± CA	Also called DL-symbol rate, data ‘zero’ or ‘one’
Bit Time	100 ns ± CA	Also called DL-symbol time, data ‘zero’ or ‘one’
PhL symbol time	50 ns ± CA	Also called Ph-symbol time, see data encoding rules
Clock Accuracy (CA)	± 100 µHz/Hz max.	Including temperature, long term and short term stability

9.12.3 Data recovery

The signals at the DLL to PhL interface shall be synchronized to the local bit rate as shown in Table 47. Each PhL implementation shall provide a data recovery mechanism that recovers or reconstructs the data received from the appropriate medium to meet the timing requirements shown in Table 47. When data synchronization has been attained by the MDS, PH-LOCK indication shall be true.

A portion of the received data frame may be lost or discarded in the process of attaining data synchronization. The specification for data timing shown in Table 47 shall be achieved prior to the beginning of the start flag.

9.12.4 Data encoding rules

The DL_symbols present at the DLL to PhL interface shall be encoded into the appropriate Ph-symbols as shown in Table 48 and Figure 54. The ZERO and ONE symbols shall be encoded into Ph-symbols that represent Manchester Biphase L data encoding rules as shown in Table 48. The signal voltage waveform (from the MAU) is shown in an idealized form in Figure 54 to provide an example of the data encoding rules shown in Table 48.

Table 48 – MDS data encoding rules

Data bits (common name)	DL_symbol representation	Ph-symbol encoding	Manchester encoded
data ‘zero’	ZERO or {0}	{L,H}	0
data ‘one’	ONE or {1}	{H,L}	1

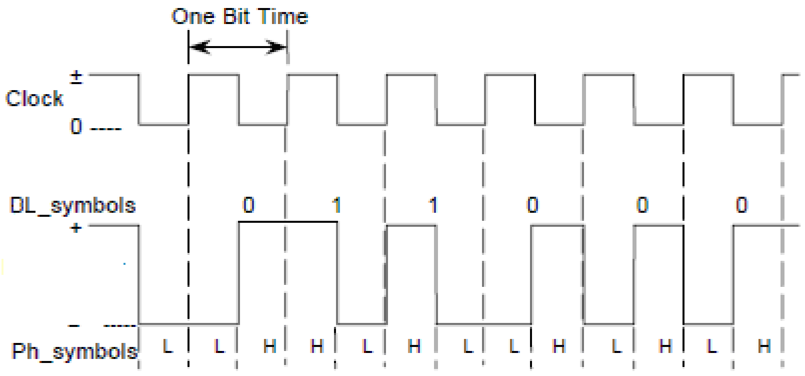

Figure 54 – Manchester coded symbols

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10 MDS – MAU interface

10.1 General

The medium attachment unit (MAU) is an optionally separate part of a communication element that connects to the medium directly or via passive components, (see Figure 1). For electrical signaling variants the MAU is the transceiver, which provides level shifting and wave shaping for transmitted and received signals. The MDS – MAU interface links the MAU to the MDS. The services are defined as physical signals to facilitate this interface optionally being exposed. The following subclauses list for each Type specifies the minimum set of required services at the MDS – MAU interface. See Clause 6 for management services.

NOTE A number of different MDS – MAU interfaces are specified, based on industry practice.

10.2 Type 1: MDS – MAU interface: Wire and optical media

10.2.1 Services

If the MDS – MAU interface is exposed it shall support at least the set of required services given in Table 49 and specified in 10.2.2.

Table 49 – Minimum services at MDS – MAU interface

Service	Abbreviation	Direction
Required:		
Transmit Signal	TxS	To MAU
Receive Signal	RxS	From MAU
Transmit Enable	TxE	To MAU
Optional:		
Loopback enable	LbE	To MAU

10.2.2 Service specifications

10.2.2.1 Transmit signal (TxS)

The Transmit Signal service (TxS) shall transfer the encoded PhPDU signal sequence across the MDS – MAU interface to the MAU, where the sequence shall be transmitted on to the medium if the Transmit Enable (TxE) is set to logic 1 (high level).

10.2.2.2 Receive signal (RxS)

The Receive Signal service (RxS) shall transfer the encoded PhPDU signal sequence or silence across the MAU – MDS interface to the MDS. The RxS shall echo the signal transmitted via TxS by simultaneously receiving the transmissions from the medium.

10.2.2.3 Transmit enable (TxE)

The Transmit Enable service (TxE) shall provide the MDS with the facility to enable the MAU to transmit. The TxE shall be set to logic 1 (high level) at the commencement of preamble transmission and then set to logic 0 (low level) after the last bit of the end delimiter has been transmitted.

If redundant media are in use and the method of implementing redundancy is to receive on all channels but transmit on only one then the channel (cable) that is currently used for transmission shall be selected by setting its TxE to logic 1 (high level). All channels that are not currently in use for transmission shall be disabled by setting the TxE to logic 0 (low level).

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10.2.2.4 Loopback enable (LbE)

If the optional Loopback Enable (LbE) service shown in Table 49 is used it shall disable the final output stage of the MAU transmit circuit, connect the output of the previous stage of the MAU transmit circuit to the MAU receive circuit and disconnect the MAU receive circuit from the medium. The state of the Loopback Enable shall not change while the MAU is transmitting or receiving.

NOTE This confirmation service is of local significance only and provides a device with the facility to test the integrity and functionality of the PhL circuitry, excluding the medium.

10.2.3 Signal characteristics

Timing characteristics shall be compatible with those specified in the requirements of this standard for the relevant MDS.

If the MDS – MAU interface is exposed it shall operate with digital signal levels as shown in Table 50. Both sides of the interface shall operate with the same value of V_{DD}.

Table 50 – Signal levels for an exposed MDS – MAU interface

Symbol	Parameter	Conditions	Limits	Units	Remarks
V_{OL}	Maximum low-level output voltage	I_{out} = ±100 μA	0,1	V	See Note 1
		I_{out} = +1,6 mA	0,4	V	
V_{OH}	Min.high-level output voltage	I_{out} = ±100 μA	V_{DD} – 0,1	V	See Note 1
		I_{out} = –0,8 mA	V_{DD} – 0,8	V	See Note 2
V_{IL}	Max.low-level input voltage		0,2 V_{DD}	V	
V_{IH}	Min.high-level input voltage		0,7 V_{DD}	V	See Note 3

NOTE 1 Provides the capability to drive two typical CMOS loads.

NOTE 2 CMOS input compatibility with TTL output requires a "pull-up" resistor from signal input to V_{DD}.

NOTE 3 Compatible with CMOS output for 3,0 V ≤ V_{DD} ≤ 5,5 V. Compatibility with TTL output (4,75 V ≤ V_{DD} ≤ 5,25 V) requires a "pull-up" resistor from signal input to V_{DD}.

10.2.4 Communication mode

The communication mode at this interface shall allow simultaneous transmission and reception.

10.2.5 Timing characteristics

The MDS – MAU interface shall function correctly with a PhSDU bit rate of between 1 kbit/s and 1,1 times the highest stated MAU bit rate.

NOTE The bit rates available in an implementation are stated in the Protocol Implementation Conformance Statement (PICS).

10.3 Void

NOTE Subclause 10.3 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the subclause numbering of the prior edition.

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10.4 Type 2: MDS – MAU interface: Wire and optical media

10.4.1 MDS-MAU interface: general

10.4.1.1 Conformance

A node may include any (or more than one) PhL variant but the appropriate medium interface shall be provided for each PhL variant implemented.

The MDS-MAU interface need not be exposed in the implementation of any PhL variant. This interface may be internal to the node and may be internal to a semiconductor device. If, however, conformance to the MDS-MAU interface is claimed, the implementation shall conform to the requirements of Subclause 10.4.

10.4.1.2 Delay from medium to MDS–MAU interface

For all implementations conformant to the MDS-MAU interface, the receive delay from the medium to the MDS-MAU interface shall be less than 200 ns and the transmit delay from the MDS-MAU interface to the medium shall be less than 200 ns.

10.4.2 MDS-MAU interface: 5 Mbit/s, voltage-mode, coaxial wire

10.4.2.1 Signal definitions

Subclause 10.4.2 lists the signals defined for the 5 Mbit/s, voltage-mode, coaxial wire medium MDS-MAU interface, as shown in Table 51.

Table 51 – MDS-MAU interface definitions: 5 Mbit/s, voltage-mode, coaxial wire

TXDATAOUT	TXDATABAR	NETENABLE	RXDATA	RXCARRIER	Ph-symbol
x	x	0	undefined	0	No transmission MAU_FRAME_REQUEST = false
0	0	1	undefined	0	No transmission MAU_FRAME_REQUEST = false
1	0	1	1	1	H
0	1	1	0	0	L
1	1	1	-	-	Not allowed, transmitter damage may occur

10.4.2.2 TxDataOut

TXDATAOUT shall be true to represent H from the MAU, and shall be false to represent L as shown in Table 51. TXDATAOUT shall be false when no Ph-symbol data is to be transmitted (MAU_FRAME_REQUEST = false).

10.4.2.3 TxDataBar

TXDATABAR shall be true to represent L from the MAU, and shall be false to represent H as shown in Table 51. TXDATABAR shall be false when no Ph-symbol data is to be transmitted (MAU_FRAME_REQUEST = false).

10.4.2.4 NetEnable

NETENABLE shall be true to enable the MAU for transmission of TXDATAOUT and TXDATABAR Ph-symbol data on the coaxial wire medium. NETENABLE false shall prevent transmission of TXDATAOUT and TXDATABAR Ph-symbol data as shown in Table 51.

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10.4.2.5 RxData

RxData shall represent the raw, distorted, unsynchronised Ph-symbols (H or L) as recovered from the coaxial wire medium. This signal shall be true or false based on the requirements shown in Table 90. After data recovery and resynchronisation to meet the MDS timing requirements (from Table 34), these Ph-symbols shall be decoded into the appropriate MDS M_symbols as shown in Table 35.

10.4.2.6 RxCarrier

RxCarrier shall be true when the signal level on the coaxial wire medium exceeds the carrier detection threshold voltage as shown in Table 91; otherwise, it shall be false. This signal shall be used to create the Ph-CARRIER indication at the DLL-PhL interface as defined in 5.3.5.

10.4.3 MDS – MAU interface 5 Mbit/s, optical medium

10.4.3.1 Signal definitions

Subclause 10.4.3 lists the signals defined for the 5 Mbit/s, optical fiber medium MDS – MAU interface, as shown in Table 52.

Table 52 – MDS – MAU interface 5 Mbit/s, optical fiber medium

TXDATAOUT	NETENABLE	RXDATA	RXCARRIER	Ph-symbol
Don't care	0	0	0	L or 'light off'
1	1	1	1	H or 'light on'
0	1	0	0	L or 'light off'

10.4.3.2 TxDataOut

TXDATAOUT shall be true to represent H from the MAU, and shall be false to represent L as shown in Table 98. A true signal shall be represented on the fiber medium as 'light on'. A false signal shall be represented on the fiber medium as 'light off'. The fiber transmit level requirements that define 'light on' (or Coupled Power, PT on) and 'light off' (or Coupled Power, PT off) shall be as defined in 19.6.

10.4.3.3 NetEnable

NETENABLE shall be true to indicate the MDS sublayer has valid Ph-symbols to be transmitted onto the fiber medium. NETENABLE shall enable the MAU for transmission of TXDATAOUT light levels on the fiber medium. NETENABLE false shall prevent transmission of TXDATAOUT signals, as shown in Table 52.

10.4.3.4 RxData

RXDATA shall represent the raw, distorted, unsynchronised Ph-symbols (H or L) as recovered from the fiber medium. This signal shall be true when the light level on the medium meets the 'light on' requirements defined in 19.6, otherwise this signal shall be false. After data recovery and resynchronisation to meet the MDS timing requirements (from Table 34), these Ph-symbols shall be decoded into the appropriate PLS_DATA_INDICATION M_symbols as shown in Table 35. RXDATA shall report false if the medium is broken, missing or power is removed from the transmitting end of the fiber.

10.4.3.5 RxCarrier

RXCARRIER shall be true when the light level on the medium meets the 'light on' requirements defined in 19.6, otherwise this signal shall be false. This signal shall be used directly to create the PLS_CARRIER_INDICATION at the DLL-PhL interface. If the fiber transceiver does not support

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a carrier indication mechanism, this interface signal shall be connected to the RxData interface signal. The RxCarrier shall report false if the medium is broken, missing or power removed from the transmitting end of the fiber.

10.4.4 MDS – MAU interface Network Access Port (NAP)

The following signals shall be required for the NAP MDS-MAU interface:

a) /TxPTC shall be false to represent H transmit data from the MAU, and shall be true to represent L;
b) /RxPTC shall be false to represent H receive data from the MDS, and shall be true to represent L. This signal shall be true if the NAP medium is removed, broken, short-circuited or the source transmitter is disabled.

10.5 Type 3: MDS – MAU interface: Wire and optical media

10.5.1 Synchronous transmission

The MDS – MAU interface specified for Type 1 shall be used (see 10.2).

10.5.2 Asynchronous transmission

Instead of the MDS – MAU interface as described in 10.2 the DL – Ph interface for asynchronous transmission shall be used (see 5.1 and 5.4.2).

10.6 Type 8: MDS – MAU interface: Wire and optical media

10.6.1 Overview of the services

The MDS-MAU interface makes services available to connect the MDS with a corresponding MAU. The services are defined as logical signals that the MAU sublayer directly converts into physical signals (see Table 53).

Table 53 – Services of the MDS-MAU interface

Service	Mnemonic	Direction
Data Out	DO	From MDS
Data In	DI	From MAU
Bus Connector	BC	From MAU
Loopback Enable	LbE	From MDS
Data Select	DS	From MDS
Medium Activity	MA	From MDS

NOTE The Bus Connector, Loopback Enable, Data Select and Medium Activity services are only supported by the MAU of an outgoing interface.

10.6.2 Description of the services

10.6.2.1 Data-out (DO)

This service transmits the PhPDU from the MDS to the MAU.

10.6.2.2 Data-in (DI)

This service transmits the PhPDU from the MAU to the MDS.

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10.6.2.3 Bus connector (BC)

This service indicates to a MDS whether the transmission medium is connected to the MAU of an outgoing interface. If the transmission medium is not connected to the MAU of an outgoing interface, the systems management shall, for this MAU, disconnect the receive circuit from the medium with the Loopback Enable (LbE) service and connect the send circuit with the receive circuit.

NOTE 1 The Bus Connector service is only supported by the MAU of an outgoing interface. It is not related to the other services of the MDS-MAU interface.

NOTE 2 This service is a local management service that indicates whether another bus device is connected to the outgoing interface of the MAU, which allows the systems management to close or open the transmission ring with the Loopback Enable service.

NOTE 3 The detection of another connected bus device is caused by a signal that is led through a bridge in the connector of the outgoing cable (see cable definition).

10.6.2.4 Loopback enable (LbE)

This service allows the systems management to decouple the receive circuit from the transmission medium for a MAU of an outgoing interface, and to connect the send circuit with the input circuit.

NOTE 1 The Loopback Enable service is only supported by the MAU of an outgoing interface and is not related to the other services of the MDS-MAU interface.

NOTE 2 This service is a local management service that allows the systems management to close the transmission ring if no other bus slave is connected to the MAU of an outgoing interface.

10.6.2.5 Medium activity (MA)

This service transmits a special status PhPDU from the MDS to the MAU if the active ring was decoupled from the medium and the send and receive circuit were connected but controlled activity is to be generated on the medium.

NOTE 1 This service is used by a slave only.

NOTE 2 The Medium Activity service is only supported by MAU of an outgoing interface and has no time relation to the other services of the MDS-MAU interface.

10.6.2.6 Data select (DS)

The systems management uses this service to transmit on the decoupled medium of an outgoing MAU either a reset PhPDU or with the Medium Activity service certain status PhPDUs.

NOTE 1 This service is used by a slave only.

NOTE 2 The Data Select service is only supported by MAU of an outgoing interface and is not related to the other services of the MDS-MAU interface.

10.6.3 Time response

The MDS shall be able to correctly decode a bit with bit jitter specified in Figure 55. The variation for the sample clock shall be within the range of ± 0,1 %.

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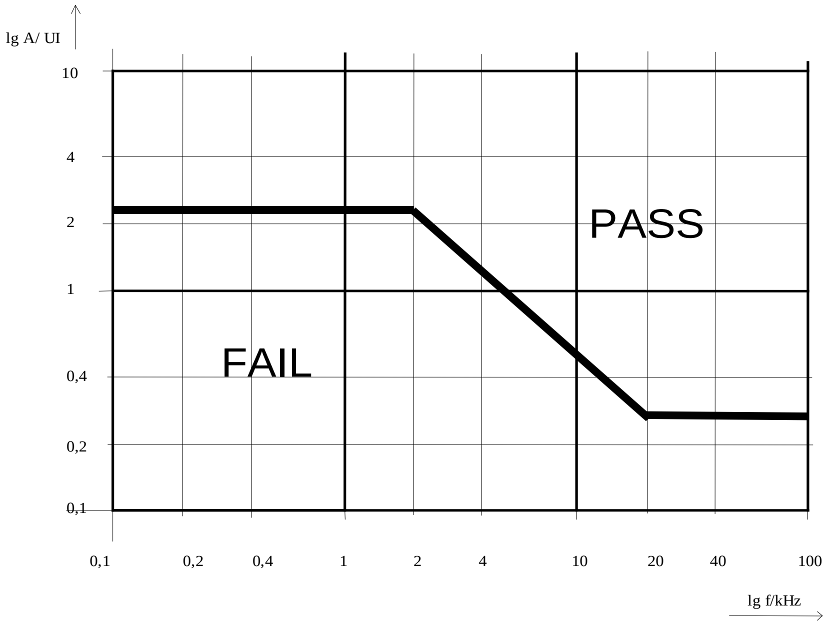

Figure 55 – Jitter tolerance

10.6.4 Transmission mode

The MDS-MAU interface shall allow a simultaneous, independent sending and receiving.

10.7 Type 18: MDS – MAU interface: Wire media

10.7.1 General

The granularity of PhPDU exchanged at the MAU interface is one bit.

10.7.2 Services

If the MAU interface is exposed it shall support at least the set of required services given in Table 54 and specified in 10.7.3.

Table 54 – Minimum services at MAU interface

Service	Abbreviation	Direction
Transmit Signal	TxS	To MAU
Receive Signal	RxS	From MAU
Transmit Enable	TxE	To MAU

10.7.3 Service specifications

10.7.3.1 Transmit Signal (TxS)

The Transmit Signal service (TxS) shall transfer the encoded PhPDU signal sequence across the interface to the MAU, where the sequence shall be transmitted on to the medium if the Transmit Enable (TxE) is set to logic one (high level).

10.7.3.2 Receive Signal (RxS)

The Receive Signal service (RxS) shall transfer the encoded PhPDU signal sequence or silence across the interface to the MDS. The RxS shall echo the signal transmitted via TxS by simultaneously receiving the transmissions from the medium.

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10.7.3.3 Transmit Enable (TxE)

The Transmit Enable service (TxE) shall provide the facility to enable the MAU to transmit. The TxE shall be set to logic one (high level) at the commencement of preamble transmission and then set to logic zero (low level) after the last bit of the end delimiter has been transmitted.

10.7.4 Signal characteristics

If the MAU interface is exposed it shall operate with digital signal levels as shown in Table 55. Both sides of the interface shall operate with the same value of V_{DD}.

Table 55 – Signal levels for an exposed MAU interface

Symbol	Parameter	Conditions	Limits	Units	Remarks
V_{OL}	Maximum low-level output voltage	I_{out} = ±100 µA	0,1	V	See Note 1
		I_{out} = +1,6 mA	0,4	V	
V_{OH}	Minimum high-level output voltage	I_{out} = ±100 µA	V_{DD} – 0,1	V	See Note 1
		I_{out} = –0,8 mA	V_{DD} – 0,8	V	See Note 2
V_{IL}	Maximum low-level input voltage		0,2 V_{DD}	V	
V_{IH}	Minimum high-level input voltage		0,7 V_{DD}	V	See Note 3

NOTE 1 Provides the capability to drive two typical CMOS loads.

NOTE 2 CMOS input compatibility with TTL output requires a "pull-up" resistor from signal input to V_{DD}.

NOTE 3 Compatible with CMOS output for 3,0 V ≤ V_{DD} ≤ 5,5 V. Compatibility with TTL output (4,75 V ≤ V_{DD} ≤ 5,25 V) requires a "pull-up" resistor from signal input to V_{DD}.

10.7.5 Communication mode

The communication mode at this interface shall allow simultaneous transmission and reception.

10.7.6 Timing characteristics

The MAU shall function correctly with a PhSDU bit rate of between 1 kbit/s and 1,1 times the highest stated MAU bit rate. The clocking frequency shall be implemented accurate to within 150 µHz/Hz of the specified rate.

10.8 Type 24: MDS – MAU interface: Twisted-pair wire medium

10.8.1 Overview of service

If the MDS – MAU interface is exposed it shall support at least the set of required services given in Table 56 and specified in 10.8.2.

Table 56 – Minimum services of the MDS-MAU interface

Signal name	Mnemonic	Direction
Transmit Signal	TxS	To MAU
Transmit Enable	TxE	To MAU
Receive Signal	RxS	From MAU

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10.8.2 Description of the services

10.8.2.1 Transmit signal (TxS)

This service transmits the PhPDU from the MDS to the MAU, where it shall be transmitted on to the medium if Transmit Enable (TxE) is set to logic 1 (high level).

10.8.2.2 Transmit enable (TxE)

The Transmit Enable service (TxE) shall provide the MDS with the facility to enable the MAU to transmit. TxE shall be set to logic 1 (high level) by the MDS immediately before the transmission begins, and to logic 0 (low level) after transmission ends.

10.8.2.3 Receive signal (RxS)

This service transmits the PhPDU from the MAU to the MDS.

10.8.2.4 Signal characteristics

If the MDS – MAU interface is exposed it shall operate with digital signal levels as shown in Table 57. Both sides of the interface shall operate with the same value of V_{DD}.

Table 57 – Signal levels for an exposed MDS – MAU interface (V_{DD}=5V)

Symbol	Parameter	Conditions	limits	Units	Remarks
V_{OL}	Maximum low-level output voltage	Iout = ±100 μA	0,1	V	See Note1
V_{OH}	Min.high-level output voltage	Iout = ±100 μA Iout = –0,8 mA	V_{DD}–0,1 V_{DD}–0,8	V	See Note 2
V_{IL}	Max.low-level input voltage		0,2V_{DD}	V	
V_{IH}	Min.high-level input voltage		0,7V_{DD}	V	See Note3

NOTE 1 Provides the capability to drive two typical CMOS loads.

NOTE 2 CMOS input compatibility with TTL output requires a "pull-up" resistor from signal input to V_{DD}.

NOTE 3 Compatible with CMOS output for 3,0 V ≤ V_{DD} ≤ 5,5 V. Compatibility with TTL output (4,75 V ≤ V_{DD} ≤ 5,25 V) requires a "pull-up" resistor from signal input to V_{DD}.

10.8.2.5 Timing characteristics

Timing characteristics shall be compatible with those specified in the requirements of this standard for the relevant MDS. The MDS – MAU interface shall function correctly with a PhSDU bit rate of 10 Mbit/s.

11 Types 1 and 7: Medium attachment unit: voltage mode, linear-bus-topology 150 Ω twisted-pair wire medium

11.1 General

NOTE These MAU requirements are not specifically intended to facilitate the options of power distribution via the signal conductors and suitability for intrinsic safety certification.

The network medium consists of shielded twisted-pair cable. Independent of topology, all attached devices, other than possibly the transmitting device, present a high impedance to prevent significant network loading. Trapezoidal waveforms are used to reduce electromagnetic emissions and signal distortion.

A linear bus topology is supported, as are some branched acyclic topologies. A network contains one trunk cable, terminated at its ends.

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11.2 Bit-rate-dependent quantities

Six bit rates are defined for the voltage-mode twisted-pair medium attachment unit (MAU). A given MAU shall support at least one of these bit rates.

Table 58 specifies the supported bit rates, and defines symbols for bit-rate-dependent quantities used throughout Clause 11.

Table 58 – Bit-rate-dependent quantities of voltage-mode networks

Quantity		Symbol	Unit	Value					
Nominal bit rate		BR	Mbit/s	0,031 25	1	2,5	5	10	25
Maximum deviation from BR		ΔBR		0,2 %	0,01 %				
Nominal bit duration		T_{bit}	µs	32	1,0	0,4	0,2	0,1	0,04
Maximum deviation from T_{bit}		ΔT_{bit}	–	0,9 µs	0,025 %				
Signaling frequencies	Nominal for a repeated bit	f_r	MHz	0,031 25	1	2,5	5	10	25
	Nominal minimum = 0,25 f_r	f_{min}	MHz	0,007 8	0,25	0,625	1,25	2,5	6,25
	Nominal maximum = 1,25 f_r	f_{max}	MHz	0,039	1,25	3,125	6,25	12,5	31,25
Maximum number of devices		N_{max}		32				16	
Maximum inter-device distance		L_{max}	m	4 000	750	500	400	200	100
Maximum inter-device attenuation		A_{max}	dB	15	17	18			
Maximum inter-device attenuation distortion		AD_{max}	dB	8		10			
Maximum inter-device mismatching distortion		MD_{max}	dB	0,2			0,4	0,6	
Maximum signal rise or fall time		T_{rf}	ns	8 000	200	80	40	20	8
Maximum coupler spacing to form a cluster		CS_{max}	m	4		2	1	0,5	0,25
Minimum device input impedance		Din_{min}	kΩ	8			4	2	1
Maximum quiescent transmitter output		QTO_{max}	mV rms	1	5	10	20	40	80
Maximum frequency for QTO_{max} measurement		f_{QTOmax}	MHz	0,1	4 f_r				

The average bit rate shall be BR ± ΔBR, averaged over a frame having a minimum length of 16 octets. The instantaneous bit time shall be $T_{bit} \pm \Delta T_{bit}$.

11.3 Network specifications

11.3.1 Components

A voltage-mode MAU operates in a network composed of the following components:

a) twisted-pair wire cable;

b) devices (containing at least one communication element);

c) connectors;

d) couplers;

e) terminators.

11.3.2 Topologies

A wire MAU shall operate in a network with an acyclic nominally linear bus topology, consisting of a trunk, terminated at each end as specified in 11.8.5, to which communication

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elements are connected via couplers. Each communication element shall be connected in parallel with the trunk cable.

NOTE The coupler and communication element are generally integrated in one device.

Active repeaters may be used to establish branches or to extend the length of the trunk beyond that of a single segment as permitted by the network configuration rules. Branches shall be considered as segments, and may make the bus non-linear. Cycles (closed loops) are never permitted.

11.3.3 Network configuration rules

An MAU that claims conformance to Clause 11 shall meet the requirements of Clause 11 when used in a network that complies with these rules.

Rule 1: A fieldbus shall be capable of communication between two and N_{max} devices, all operating at the same bit rate.

NOTE 1 This rule does not preclude the use of more than N_{max} devices in an installed system.

Rule 2: A fully loaded (maximum number of connected devices) fieldbus segment shall have a total cable length, including branches, between any two devices, of up to L_{max}.

NOTE 2 Support of this maximum cable length is a requirement for MAU conformance to Clause 11, but this does not preclude the use of longer lengths in an installed system.

Rule 3: The total number of waveform regenerations by repeaters and active couplers between any two devices is repeater implementation dependent.

NOTE 3 Prior editions of this standard limited this total number to four.

Rule 4: The maximum propagation delay between any two devices shall not exceed 40 T_{bit}. For efficiency of the network, that part of the turn-around time of any device on the network caused by a PhE between the end of a received frame and the beginning of the transmitted frame containing an associated immediate response should not exceed 30 bit times, no more than 2 bit times of which should be due to the MAU.

NOTE 4 As it is not mandatory to expose either the DLL – PhL interface or the MDS – MAU interface, that part of the turn-around time of a fieldbus device caused by the PhL or the MAU is not specified and thus not available for conformance tests.

Rule 5: The fieldbus shall be capable of continued operation while a device is being connected or disconnected. Data errors induced during connection or disconnection shall be detected.

Rule 6: For a fieldbus that is not powered via the signal conductors, a single failure in any one communication element (including a short circuit but excluding jabber) shall not interfere with transactions between other communication elements for more than 1 ms.

Rule 7: In polarity sensitive systems, the medium wire pairs shall have distinctly marked conductors that uniquely identify individual conductors. Consistent polarization shall be maintained at all connection points.

Rule 8: The degradation of the electrical characteristics of the signal, between any two devices, due to attenuation, attenuation distortion and mismatching distortion shall be limited to the values indicated below.

a) Signal attenuation: The configuration of the bus (trunk length, number of devices, and possible matching devices) shall be such that the attenuation between any two devices at frequency f_r shall not exceed A_{max};

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b) Attenuation distortion: The configuration of the bus (trunk and spur lengths and number of devices) shall be such that between any two devices:

$0 \leq [\text{Attenuation } (f_{max}) - \text{Attenuation } (f_{min})] \leq AD_{max}$

Attenuation shall be monotonic non-decreasing for all frequencies from f_{min} to f_{max};

c) Mismatching Distortion: Mismatching (due to any effect) on the bus shall be such that, at any point along the trunk, in the frequency band f_{min} to f_{max}:

$|Z - Z_{fr}| / |Z + Z_{fr}| \leq MD_{max}$

where Z_{fr} is the characteristic impedance of the trunk cable at frequency f_r and Z is the parallel combination of Z_{fr} and the load impedance at the coupler.

NOTE 5 This rule minimizes restrictions on trunk and spur length, number of devices etc. by specifying only the transmission limitations imposed by combinations of these factors. It is possible to use different combinations depending on the needs of the application.

NOTE 6 The usual cause of a large mismatch is the concentration of several couplers on a short length of the trunk.

If the distance between two consecutive couplers is less than CS_{max}, then the propagation delay between them is smaller than T_{rf} and the concentration appears as a single mismatched element inducing large reflections of the signal transitions.

A concentration of couplers where the distance between two consecutive couplers is less than CS_{max} is defined as a cluster. In order to comply with Rule 8c using devices with an input impedance of minimum value Din_{min} and zero-length spurs, it is recommended that a cluster does not include more than 4 couplers.

Using devices with input impedance significantly higher than the minimum value Din_{min} allows clusters with more couplers. Using non-zero-length spurs could require clusters to have fewer than 4 couplers.

NOTE 7 It is possible to reduce the mismatching due to a cluster by the following means:

– using active multiport couplers,
– inserting matching devices (passive attenuators) on each side of the cluster while satisfying Rule 8.

Rule 9: The following rules shall apply to systems implemented with redundant media:

a) each channel (cable) shall comply with the network configuration rules;
b) there shall not be a non-redundant segment between two redundant segments;
c) repeaters shall also be redundant;
d) if the devices of the system are configured (by Systems management) to transmit on more than one channel simultaneously then the propagation time difference between any two devices on any two channels shall not exceed five bit times;

   This period may be extended, but not reduced, by Systems management as given in Table 7 (see 6.2.2.2 and 9.2.9).
e) channel numbers and association with the physical transmission media shall be maintained consistently throughout the fieldbus, i.e. channels 1, 2, 3… from Systems management shall always connect to physical channels 1, 2, 3…;

11.3.4 Power distribution rules for network configuration

The cable shield shall not be used as a power conductor.

11.4 MAU transmit circuit specification

11.4.1 Summary

Table 59 through Table 61 summarise the requirements of the MAU.

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Table 59 – MAU transmit level specification summary

Transmit level characteristics, values referred to trunk (but measured using test load as shown in Figure 56)	Limits
Output level (peak-to-peak, see Figure 57) With test load (0,5 nominal Z_o of the trunk cable at f_r)	5,5 V to 9,0 V 75 Ω ± 1 %
Maximum positive and negative amplitude difference (signaling bias) as shown in Figure 58	± 0,45 V
Output level with one terminator removed (peak-to-peak) with test load (nominal impedance of the trunk cable at f_r)	5,5 V to 11,0 V 150 Ω ± 1 %
Maximum output level; open circuit (peak-to-peak)	5,5 V to 30,0 V
Maximum output signal distortion; i.e., overvoltage, ringing and droop (see Figure 57)	±10 %
Quiescent transmitter output; i.e. transmitter noise (measured over the frequency band 1 kHz to f_{QTOmax})	≤ QTO_{max} (r.m.s.)

Table 60 – MAU transmit timing specification summary for 31,25 kbit/s operation

Transmit timing characteristics, values referred to trunk (but measured using test load as shown in Figure 56)	Limits
Transmitted bit rate	BR ± ΔBR
Instantaneous bit time	T_{bit} ± ΔT_{bit}
Rise and fall times (10 % to 90 % of peak-to-peak signal, see Figure 57)	≤ 25 % T_{bit}
Slew rate (at any point from 10 % to 90 % of peak-to-peak signal)	≤ 0,2 V/μs
Maximum transmitted bit cell jitter (zero-crossing point deviation, see Figure 58)	± 2,5 % T_{bit}
Transmit enable/disable time (i.e. time during which the output waveform may not meet the transmit requirements)	≤ 2,0 T_{bit}

Table 61 – MAU transmit timing specification summary for ≥ 1 Mbit/s operation

Transmit timing characteristics, values referred to trunk (but measured using test load as shown in Figure 56)	Limits
Transmitted bit rate	BR ± ΔBR
Instantaneous bit time	T_{bit} ± ΔT_{bit}
Rise and fall times (10 % to 90 % of peak-to-peak signal, see Figure 57)	≤ 20 % T_{bit}
Slew rate (at any point from 10 % to 90 % of peak-to-peak signal)	≤ 100 V/μs × ($f_{r/MHz}$)
Maximum transmitted bit cell jitter (zero-crossing point deviation, see Figure 58)	± 2,5 % T_{bit}
Transmit enable/disable time (i.e. time during which the output waveform may not meet the transmit requirements)	≤ 2,0 T_{bit}

11.4.2 MAU test configuration

Figure 56 shows the configuration that shall be used for testing MAUs, as follows.

- Differential signal voltage: $V_d = V_a – V_b$
- Test load resistance R = 75 Ω (0,5 nominal impedance of the trunk cable at f_r) and C = 0,15 μF except where otherwise stated in a specific requirement.
- Data "+" terminal connected to the power "+" terminal and data "–" terminal connected to the power "–" terminal.

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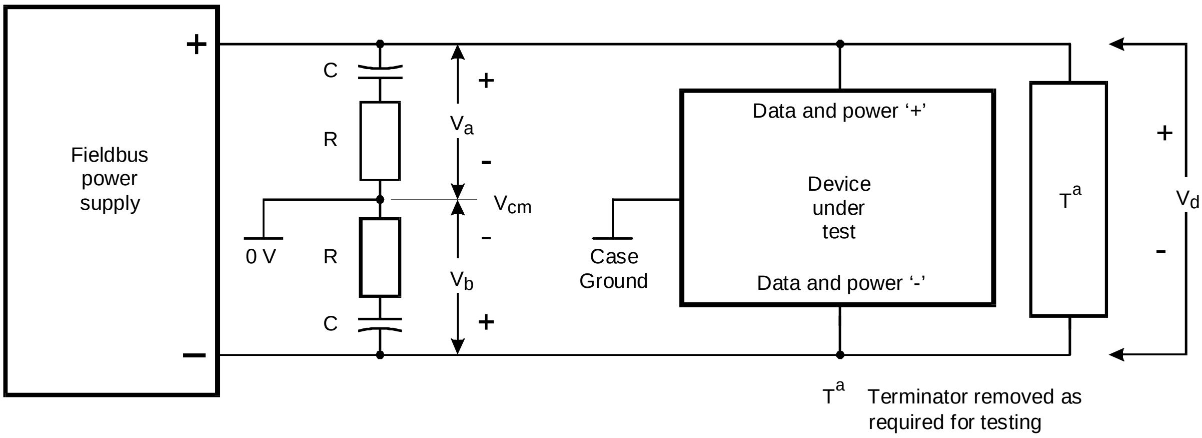

Figure 56 – Transmit circuit test configuration

11.4.3 MAU output level requirements

Figure 57 describes the output form of the signal for the twisted-pair voltage output level requirements.

NOTE Figure 57 shows an example of the a.c. component of one cycle of a fieldbus waveform, illustrating some key items from the transmit circuit specification. Only signal voltages are shown; this diagram takes no account of power supply voltages.

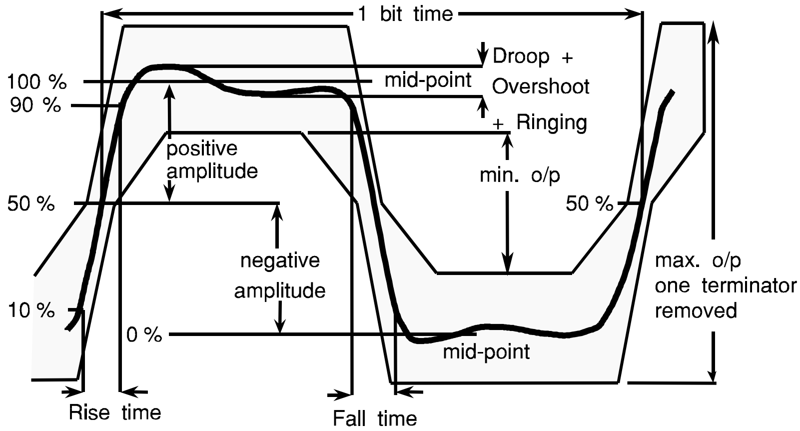

Figure 57 – Output waveform

The MAU transmit circuit shall conform to the following output level requirements, all amplitudes being measured at the estimated mid-point between any peaks or troughs in the top and bottom of the waveform ("mid-point" in Figure 57):

a) the output voltage across the test load after transformer step up/down (if applicable) shall be between 5,5 V and 9,0 V peak-to-peak with a load resistance of 75 Ω ± 1 % ("min. o/p" in Figure 57);

b) the output voltage at the trunk, or at the transmit terminals, with a load resistance of 150 Ω ± 1 % (i.e. with one trunk terminator removed) shall be between 5,5 V and 11,0 V peak-to-peak ("max. o/p one terminator removed" in Figure 57);

c) the output voltage at the trunk, or at the transmit terminals, with any load including an open circuit shall be between 5,5 V and 30,0 V peak-to-peak. For test purposes open circuit shall be defined as a load of 100 kΩ resistance in parallel with 15 pF capacitance;

d) during transmission a device shall not suffer permanent failure when a load resistance of ≤1 Ω is applied for 1 s;

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e) the difference between positive amplitude and negative amplitude, measured as shown in Figure 57, shall not exceed ±0,45 V peak;

f) the output noise from an MAU which is receiving or not powered shall not exceed QTO_{max} r.m.s., measured differentially over the frequency band 1 kHz to f_{QTOmax}, referred to the trunk;

g) the differential voltage across the test load shall be such that the voltage monotonically changes between 10 % and 90 % of peak-to-peak value. Thereafter, the signal voltage shall not vary more than ±10 % of peak-to-peak value until the next transition occurs. This permitted variation shall include all forms of output signal distortion, i.e. overvoltage, ringing and droop.

11.4.4 MAU output timing requirements

11.4.4.1 Common output timing requirements for all data rates

An MAU transmit circuit shall conform to the following output timing requirements:

a) transmitted bit cell jitter shall not exceed ΔT_{bit} from the ideal zero crossing point, measured with respect to the previous zero crossing (see Figure 58);

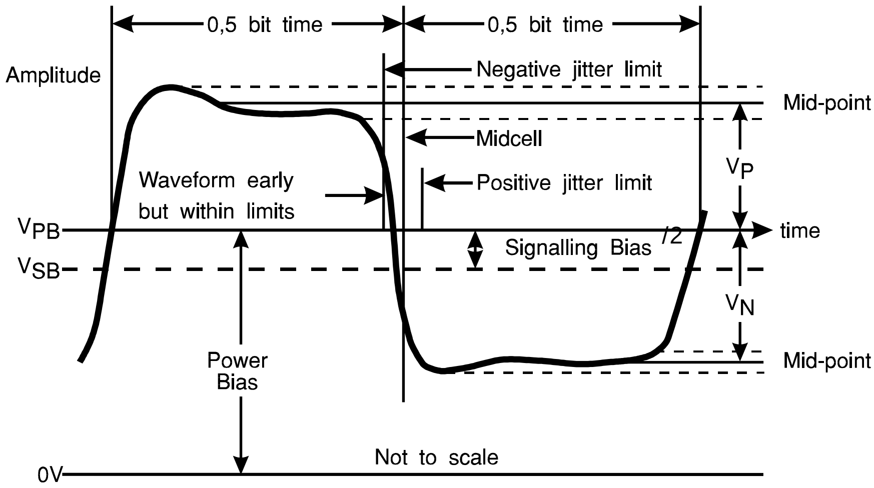

Figure 58 – Transmitted and received bit cell jitter (zero crossing point deviation)

b) the transmit circuit shall turn on, i.e. the signal shall rise from below the transmit circuit maximum output noise level as specified in 11.4.3 f) to full output level, in less than 2,0 T_{bit}. The waveform corresponding to the third and later bit times shall be as specified in Figure 57;

c) the transmit circuit shall turn off, i.e. the signal shall fall from full output level to below the transmit circuit maximum output noise level as specified in 11.4.3 f), in less than 2,0 T_{bit}. The time for the transmit circuit to return to its off-state impedance shall not exceed 4,0 T_{bit}. For the purposes of testing, this requirement shall be met with the transmit circuit test configuration of Figure 56 with the equivalent capacitance of a maximum length cable across the DUT terminals.

NOTE This requirement is to ensure that the transition of the transmit circuit from active to passive leaves the line capacitance fully discharged.

11.4.4.2 Additional output timing requirements for 31,25 kbit/s operation

The MAU transmit circuit shall conform to the following additional output timing requirements:

a) rise and fall times, measured from 10 % to 90 % of the peak-to-peak signal amplitude shall not exceed 0,25 T_{bit} (see Figure 57);

b) slew rate shall not exceed 0,2 V/µs measured at any point in the range 10 % to 90 % of the peak-to-peak signal amplitude (see Figure 57).

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NOTE Requirements a) and b) produce a trapezoidal waveform at the transmit circuit output. Requirement b) limits the level of interference emissions that may be coupled to adjacent circuits etc. Requirement b) is calculated from the formula:

$$\text{max. slew rate} = 2 \times \text{min. slew rate} = 2 \times 0,8\ V_o / 0,25\ T_{bit} = 6,4 \times V_o / T_{bit},$$

where V_o is the maximum peak-to-peak output voltage (9,0 V) with a standard load.

11.4.4.3 Additional output timing requirements for ≥ 1 Mbit/s operation

The MAU transmit circuit shall conform to the following additional output timing requirements:

a) rise and fall times, measured from 10 % to 90 % of the peak-to-peak signal amplitude shall not exceed 0,2 T_{bit} (see Figure 57);

b) slew rate shall not exceed 100 V/μs × ($f_{r/MHz}$) measured at any point in the range 10 % to 90 % of the peak-to-peak signal amplitude (see Figure 57).

NOTE Requirements a) and b) produce a trapezoidal waveform at the transmit circuit output. Requirement b) limits the level of interference emissions that may be coupled to adjacent circuits etc. Requirement b) is calculated from the formula:

$$\text{max. slew rate} = 36 \times \text{min. slew rate} = 3 \times 0,8\ V_o / 0,2\ T_{bit} = 12 \times V_o / T_{bit},$$

where V_o is the maximum peak-to-peak output voltage (9,0 V) with a standard load.

11.4.5 Signal polarity

For a bus-powered device, the data “+” terminal shall be connected to the power “+” terminal, and the data “–” terminal shall be connected to the power “–” terminal. See Figure 56.

When transmission is enabled, a high to low transition of the Manchester encoded signal shall result in a high to low transition in V_d on the bus. A low to high transition of the Manchester encoded signal shall result in a low to high transition in V_d on the bus. The signal polarity is defined in Figure 59.

During reception, a high to low transition in V_d on the bus shall result in a high to low transition of the Manchester encoded signal. A low to high transition in V_d on the bus shall result in a low to high transition of the Manchester encoded signal.

NOTE 1 Manchester encoding is defined in 9.2.2.

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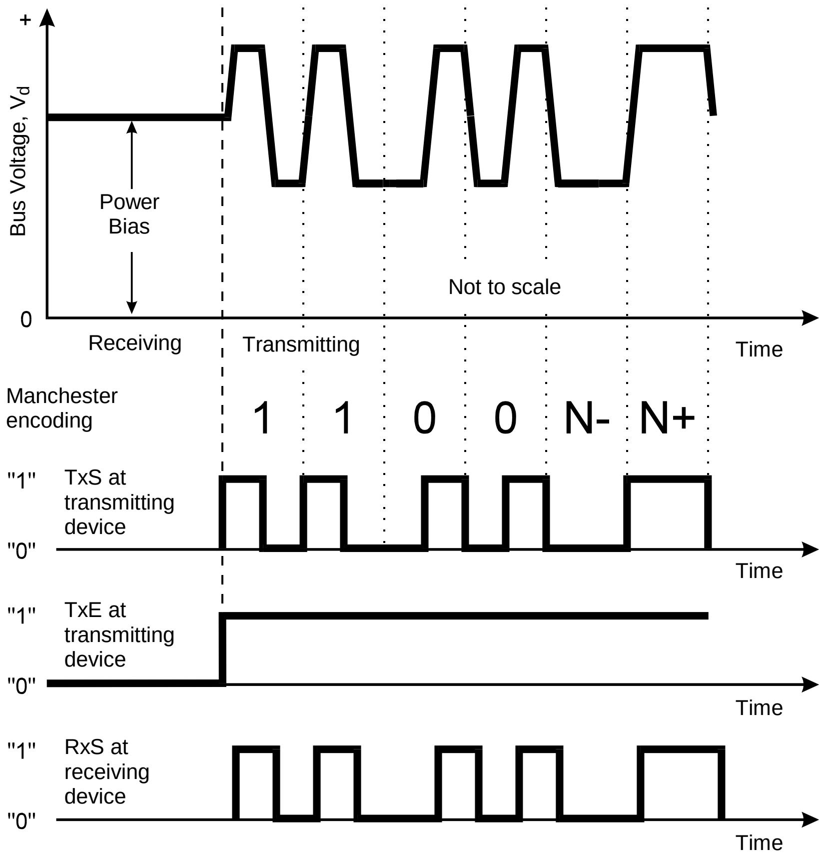

Figure 59 – Signal polarity

NOTE 2 The waveform in Figure 59 is shown to provide an example of the "1", "0", "N+", and "N–" symbols. This waveform does not represent an actual PhPDU. See 9.2.2 for the encoding rules.

NOTE 3 The TxS and RxS waveforms in Figure 59 are indeterminate in the time period marked "Receiving".

NOTE 4 The signals at the MDS-MAU interface are defined in Clause 10. The TxS, TxE, and RxS signals shown in Figure 59 are only accessible if the MDS-MAU interface is exposed.

11.5 MAU receive circuit specification

11.5.1 Summary

Table 62 summarises the specification.

Table 62 – MAU receive circuit specification summary

Receive circuit characteristics (values referred to trunk)	Limits
Input impedance, measured over the frequency range f_{min} to f_{max}	≥8 kΩ
Sensitivity; min. peak-to-peak signal required to be accepted (see Figure 60)	700 mV
Noise rejection; max. peak-to-peak noise required to be rejected (see Figure 60)	280 mV
Maximum received bit cell jitter (zero crossing-point deviation, see Figure 57)	±0,10 T_{bit}

11.5.2 Input impedance

The differential input impedance of an MAU receive circuit shall be no less than Din_{min} over the frequency range f_{min} to f_{max}. This requirement shall be met in the power-off and power-on (not transmitting) states and in transition between these states. This impedance shall be

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measured at the communication element terminals using a sine wave with a signal amplitude greater than the receiver sensitivity threshold and lower than 9,0 V peak-to-peak.

NOTE The requirement for ≥Din_{min} input impedance during power-up and power-down may be met by automatic disabling of the transmitter during these periods.

11.5.3 Receiver sensitivity and noise rejection

An MAU receive circuit shall be capable of accepting an input signal of amplitude no less than 700 mV peak-to-peak, including overvoltage and oscillation (see "signal level" together with "positive amplitude" and "negative amplitude", all in Figure 60).

An MAU receive circuit shall not respond to an input signal with a peak-to-peak amplitude which does not exceed 280 mV (see "noise rejection" in Figure 60).

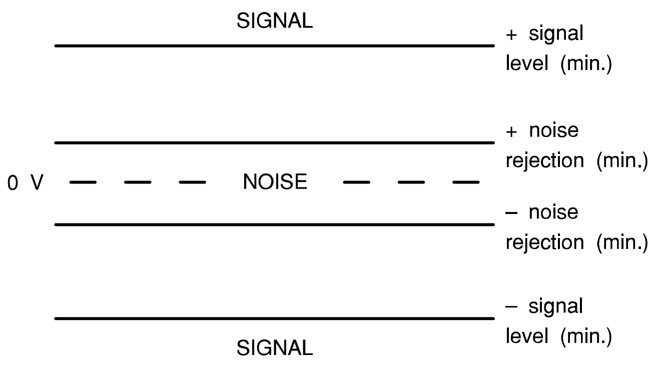

Figure 60 – Receiver sensitivity and noise rejection

11.5.4 Received bit cell jitter

The receive circuit shall accept a Manchester encoded signal transmitted in accordance with 11.2 and 11.4. In addition, the receiver shall work properly with signals with the time variation between any two adjacent signal transition points (zero crossing) of ±0,10 T_{bit} or less. See Figure 58.

NOTE 1 This specification does not preclude the use of receivers that perform better than this specification.

NOTE 2 Depending on the symbol pattern, the nominal time between zero crossings is 0,5 T_{bit} or 1,0 T_{bit}.

NOTE 3 There is no requirement to reject a signal with a specified time variation value. The receiver reports an error when the received bit cell jitter exceeds the receiver's ability to reliably decode signaling.

11.5.5 Interference susceptibility and error rates

When a fieldbus is operating in a variety of standard noise environments the probability that an Application Layer User Data Unit contains an undetected error, due to operation of the conveying Physical and DLL entities, should be less than 1 in 10^{12} (1 error in 20 years at 1 600 messages/s).

A communication element is regarded as conforming to this theoretical requirement when it meets the following interference susceptibility requirements. These are specified by a detected frame error rate which is derived by using a ratio of detected to undetected errors of 10^6.

NOTE 1 This should be readily achievable with a 16 bit Frame Check Sequence at the DLL.

A communication element which includes an MAU, operating with frames containing 64 random user data bits, with maximum frame rate and with signals of 1,4 V pk-pk amplitude, shall produce no more than three detected frame errors in 3 × 10^6 frames during operation in the presence of common-mode voltage or Gaussian noise as follows:

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a) a common-mode sinusoidal signal of any frequency from 63 Hz to 2 f_r, with an amplitude of 4 V r.m.s. and from 47 Hz to 63 Hz with an amplitude of 250 V r.m.s.;

b) a common-mode d.c. signal of ±10 V;

c) white Gaussian additive differential noise in the frequency band 1 kHz to 4 f_r, with a noise density of 30 μV/√Hz r.m.s.

NOTE 2 The common-mode voltage and Gaussian noise specifications are for receive circuit conformance testing with balanced loads and are not indicative of system installation practice.

A communication element which includes an MAU, operating with frames containing 64 random user data bits, at an average of 1 600 messages/s, with signals of 1,4 V peak-to-peak amplitude, shall produce no more than six detected frame errors in 100 000 frames during operation in the presence of electromagnetic or electrical interference environments as follows:

1) 10 V/m electromagnetic field as specified in IEC 61000-4-3 at severity level 3;
2) electrical fast transient as specified in IEC 61000-4-4 at severity level 3.

The above error rate specification shall also be satisfied after but not during operation in the following noise environments:

i) 8 kV electrostatic discharge to exposed metalwork as specified in IEC 61000-4-2 at severity level 3. If the device suffers temporary loss of function or performance as a result of this test it shall recover from any such loss without operator intervention within 3 s after the end of the test;

ii) high-frequency disturbance tests as specified in IEC 60255-22-1:1988, Test voltage class III (2,5 kV and 1 kV peak values of first half-cycle in longitudinal and transverse mode respectively). If the device suffers temporary loss of function or performance because of this test, it shall recover from any such loss without operator intervention within 3 s after the end of the test.

11.6 Jabber inhibit

The MAU shall contain a self-interrupt capability to inhibit transmitted signals from reaching the medium. Hardware within the MAU (with no external message other than the detection of output signals or leakage via the transmit function) shall provide a window of between 5 000 T_{bit} and 15 000 T_{bit} during which time a normal frame may be transmitted. If the frame length exceeds this duration, the jabber inhibit function shall inhibit further output signals from reaching the medium and shall disable echo on the RxS line (see 10.2.2.2) to indicate jabber detection to the MDS.

For a data rate of 31,25 kbit/s, the MAU shall reset the self-interrupt function after a period of 3 s ± 50 %.

NOTE 1 This inhibits bus traffic for no more than 8 % (≈ 1/12,5) of the available time.

For a data rate of 1 Mbit/s or greater, the MAU shall reset the self-interrupt function after a period of 500 000 T_{bit} ± 50 %.

NOTE 2 This inhibits bus traffic for no more than 3 % (≈ 1/32) of the available time.

11.7 Power distribution

11.7.1 Overview

Voltage mode MAUs operating at a data rate of ≤ 2,5 Mbit/s can optionally receive power via the signal conductors or be separately powered. Voltage mode MAUs operating at a data rate of > 2,5 Mbit/s are separately powered. A separately powered device can be connected to a powered fieldbus.

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For ease of reference, the requirements of 11.7 for network-powered devices and network power supplies are summarized in Table 63 and Table 64, respectively.

Table 63 – Network powered device characteristics

Network powered device characteristics	Limits		
	31,25 kbit/s	1 Mbit/s	> 1 Mbit/s
Maximum rate of change of quiescent current (non-transmitting)	1 mA/µs	0,05 mA/µs	0,1 mA/µs
Operating voltage	9,0 V to 32,0 V d.c.		
Minimum withstand voltage, either polarity, for no damage	35 V		

Table 64 – Network power supply requirements

Network power supply requirements	Limits
Output voltage	≤ 32 V d.c.
Output ripple and noise	See Figure 61
Output impedance, measured over the frequency range f_{min} to f_{max}	≥ Din_{min}

11.7.2 Supply voltage

A fieldbus device claiming conformance to Clause 11 shall be capable of operating within a voltage range of 9 V to 32 V d.c. between the two conductors including ripple. The device shall withstand a minimum voltage of ±35 V d.c. without damage.

A fieldbus device claiming conformance to Clause 11 shall conform to the requirements of Clause 11 when powered by a supply with the following specifications:

a) The output voltage of the power supply shall be 32 V d.c. maximum including ripple.

   The voltage of the power supply added to the open circuit transmitter output voltage should be less than the limit specified by the local regulatory agency for the particular implementation.

b) The output impedance of the power supply shall be ≥8 kΩ over the frequency range f_{min} to f_{max}.

c) The breakdown requirements of the isolation of the signal circuit and the power distribution circuit from ground and from each other shall be in accordance with IEC 61131-2.

   The equivalent test voltage is to be applied between independent isolated circuits or between isolated circuits and accessible conducting parts. For circuits with a nominal voltage ≤50 V d.c. or r.m.s., the equivalent test voltages at sea level are 444 V r.m.s., 635 V d.c. and 635 V peak impulse test. For circuits with a nominal voltage between 150 V and 300 V r.m.s., the equivalent test voltages at sea level are 2 260 V r.m.s., 3 175 V d.c. and 3 175 V peak impulse test.

d) When a power supply powers two or more segments, the isolation impedance to each segment shall be split ±10 % between the two signal conductors of the segment.

11.7.3 Powered via signal conductors

A fieldbus device claiming conformance to Clause 11 that is powered via the signal conductors shall conform to the requirements of Clause 11 when operating with maximum levels of power supply ripple and noise as follows:

a) 30 mV peak-to-peak over the frequency range f_{min} to f_{max};

b) 2 V peak-to-peak over the frequency range 47 Hz to 63 Hz;

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c) 300 mV peak-to-peak at frequencies greater than 12,5 f_r, up to a maximum of 50 MHz;

d) levels at intermediate frequencies generally in accordance with Figure 61, which gives the level and the frequencies for power via signal conductors.

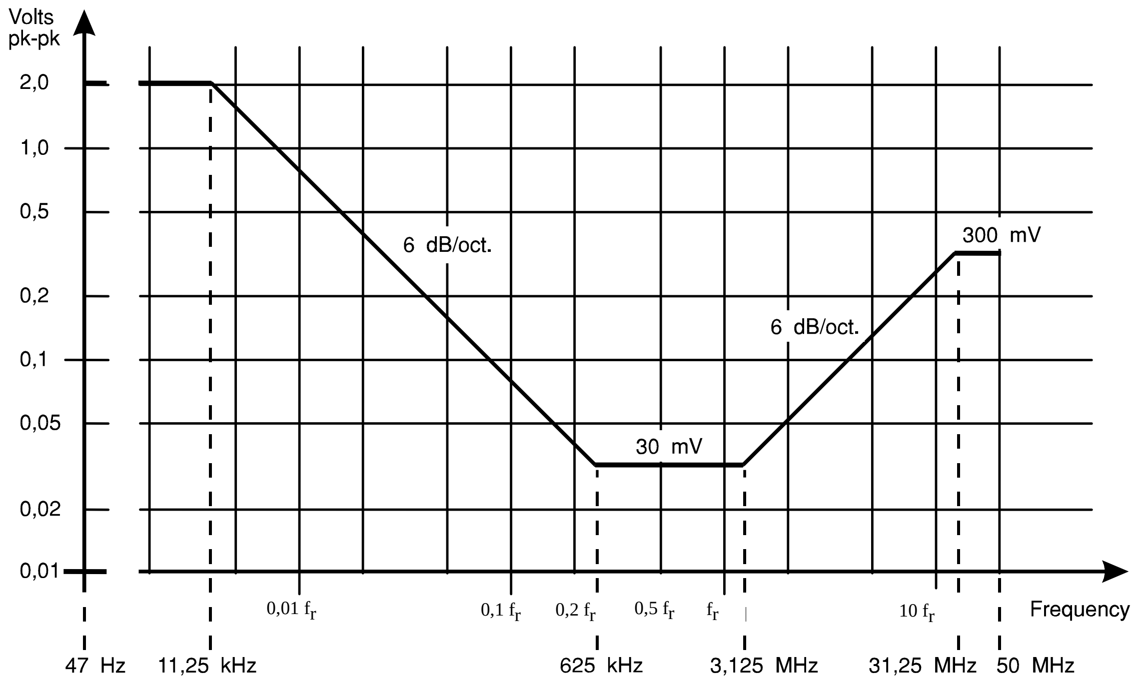

Figure 61 – Power supply ripple and noise

The device shall have a maximum rate of change of quiescent current in the non-transmitting condition of 0,1 mA/μs.

NOTE This requirement limits the effect of power transients on the signals.

11.7.4 Powered separately from signal conductors

NOTE Power distribution to non-bus-powered fieldbus devices is by separate conductors feeding local power supplies or regulators. It is possible that these conductors are in a separate cable or in the same cable as the signal conductors.

A separately powered fieldbus device claiming conformance to Clause 11 shall draw no more than 100 μA direct current from the signal conductors, nor shall it supply more than 100 μA direct current to the signal conductors when not transmitting.

11.7.5 Electrical isolation

All fieldbus devices, whether separately powered or powered via the signal conductors, shall provide low-frequency isolation between ground and the fieldbus trunk cable.

NOTE 1 This is possible by isolation of the entire device from ground or by use of a transformer, opto-coupler or some other isolating component between trunk cable and device.

A combined power supply and communication element shall not require electrical isolation.

For electrical installations providing different grounds, the isolation impedance measured between the shield of the fieldbus cable and the fieldbus device ground shall be greater than 250 kΩ at all frequencies below 63 Hz.

The isolation shall be bypassed at high frequencies by capacitance, such that the impedance measured between the shield of the fieldbus cable and the fieldbus device ground shall be less than 15 Ω between 3 MHz and 100 MHz.

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NOTE 2 The capacitance between ground and trunk cable shield necessary to meet both these requirements can be any value between 3,5 nF and 10,6 nF.

For electrical installations providing a common ground in conformance with IEC 60364-4-41 and IEC 60364-5-54, the shield of the fieldbus cable and the fieldbus device ground may be directly connected.

The maximum unbalanced capacitance to ground from either input terminal of a device shall not exceed 250 pF.

The breakdown requirements of the isolation of the signal circuit and the power distribution circuit from ground and from each other shall be in accordance with IEC 61131-2.

NOTE 3 The equivalent test voltage is applied between independent isolated circuits or between isolated circuits and accessible conducting parts. For circuits which is powered from a supply with rated voltage ≤50 V d.c. or r.m.s., the equivalent test voltages at sea-level are 444 V r.m.s., 635 V d.c. and 635 V peak impulse test. For a device which is powered from a supply with rated voltage between 150 V and 300 V r.m.s., the equivalent test voltages at sea-level are 2 260 V r.m.s., 3 175 V d.c. and 3 175 V peak impulse test.

11.8 Medium specifications

11.8.1 Connector

Cable connectors, if used, shall be in accordance with this standard (see Annex A). Field termination techniques such as screw or blade terminals and permanent terminations (splices) may also be used.

11.8.2 Standard test cable

The cable used for testing fieldbus devices with a 150 Ω voltage-mode MAU for conformance to the requirements of Clause 11, shall be a single twisted-pair cable with overall shield meeting the following minimum requirements at 25 °C:

a) Z_O = 150 Ω ± 10 % over the range 0,25 f_r to 1,25 f_r;
b) maximum attenuation at ,25 f_r to 1,25 f_r, as specified in Table 65;
c) maximum capacitive unbalance to shield = 1,5 nF/km
d) maximum d.c. resistance (per conductor) = 57,1 Ω/km;
e) conductor cross-sectional area (wire size) = nominal 0,33 mm^2;
f) minimum resistivity between either conductor and shield = 16 GΩ km;
g) minimum shield coverage shall be 95 %.

Table 65 – Test cable attenuation limits

Bit rate	Maximum attenuation at	
	0,25 f_r	1,25 f_r
31,25 kbit/s	1,5 dB	3 dB
1 Mbit/s	6,5 dB	13 dB
2,5 Mbit/s	10 B	20 dB
5 Mbit/s	13 dB	26 dB
10 Mbit/s	17 dB	37 dB
25 Mbit/s	26 dB	60 dB

The preceding specification is for conformance testing an MAU. Other types of cable may be used in real installations (see Annex B.) Cables with improved specifications may enable increased trunk length or superior interference immunity or may be required to meet environmental or installation conditions. Conversely, cables with inferior specifications may be

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used subject to length limitations for both trunk and spurs, plus possible non-conformance to the RFI/EMI susceptibility requirements.

11.8.3 Coupler

The coupler, as shown in Figure 62, shall provide one or several point(s) of connection to the trunk. It is generally integrated with a fieldbus device.

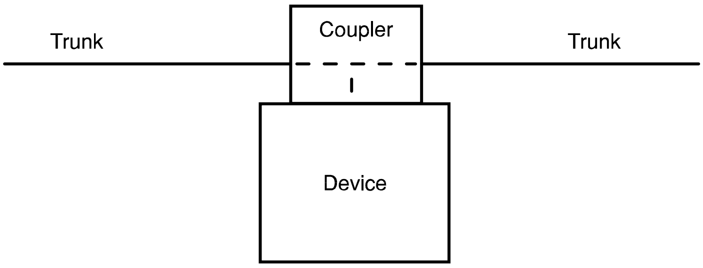

Figure 62 – Fieldbus coupler

A passive coupler may contain any or all of the optional elements as described below:

a) a transformer, to provide galvanic isolation and impedance transformation between trunk and device;
b) connectors, to provide easy connection to trunk.

Active couplers, which require external power supplies, contain components for signal amplification and re-transmission. The transmit level and timing requirements shall conform to 11.4.

11.8.4 Splices

NOTE A splice is any part of the network in which the characteristic impedance of the network cable is not preserved. This is possibly due to separation of the cable conductors, removal of the cable shield, change of wire gauge or type, attachment to terminal strips, etc. A practical definition of a splice is therefore any part of the network that is not a continuous length of the specified medium.

The continuity of all conductors of the cable shall be maintained in a splice.

11.8.5 Terminator

A terminator shall be located at both ends of the trunk cable, connected from one signal conductor to the other. No connection shall be made between terminator and cable shield.

For test purposes, using the cable specified in 11.8.2, the terminator shall have an impedance value of 150 Ω ± 2 % over the overall frequency range 625 kHz to 31,25 MHz.

NOTE In practical implementations this value would be selected to be approximately equal to the average cable characteristic impedance value at the relevant frequencies to minimize transmission line reflections.

The direct current leakage through the terminator shall not exceed 100 μA. The terminator shall be non-polarized.

11.8.6 Shielding rules

For full conformance to the noise immunity requirements of 11.5.3 it is necessary to ensure the integrity of shielding throughout the cabling, connectors and couplers by the following means:

a) the coverage of the cable shield shall be greater than 95 % of the full cable length;
b) shielding shall completely cover the electrical circuits in connectors, couplers, and splices.

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NOTE Deviation from these shielding rules may degrade noise immunity.

11.8.7 Grounding (earthing) rules

NOTE 1 Grounding (earthing) means permanently connected to earth through sufficiently low impedance and with sufficient current-carrying capability to prevent voltage build-up which might result in undue hazard to connected equipment or persons.

Zero volts (common) lines may be connected to ground where they are galvanically isolated from the fieldbus trunk.

Fieldbus devices shall be required to function to the requirements of Clause 11 with the mid-point of one terminator or one inductive coupler connected directly to ground.

Fieldbus devices shall not connect either conductor of the twisted pair to ground at any point in the network. Signals shall be applied and preserved differentially throughout the network.

It is standard practice for the shield of the fieldbus trunk cable (if applicable) to be effectively grounded at one point along the length of the cable. For this reason fieldbus devices should allow d.c. isolation of the cable shield from ground.

It is also standard practice to connect the signal conductors to ground in a balanced manner at the same point, e.g. by using the center tap of a terminator or coupling transformer.

For bus-powered systems the grounding of the shield and balanced signal conductors should be close to the power supply unit. Capacitive coupling between the shield or the balanced signal conductors and device local ground for EMI control is permitted.

11.8.8 Color coding of cables

Regional practice should be considered in the choice of cable colors.

Within North America, colors of inner cable conductors and outer cable sheath (jacket) should be assigned as specified in Table 66.

Table 66 – Recommended color coding of cables in North America

Color for inner conductors	
'+' (positive voltage) inner conductor	Orange, or red/orange/brown end of the spectrum
'–' (negative voltage) inner conductor	Blue, or blue/violet end of the spectrum
Shield conductor (which may be earthed)	Bare, clear, or green
Color for outer sheath (jacket)	
General purpose construction rules	Orange
Non-incendive construction rules	Orange/blue stripe
IS construction rules	Blue or blue/orange stripe or blue/black stripe

12 Types 1 and 3: Medium attachment unit: 31,25 kbit/s, voltage-mode with low-power option, bus- and tree-topology, 100 Ω wire medium

NOTE Type 3 uses this MAU only for synchronous transmission.

12.1 General

The 31,25 kbit/s 100 Ω voltage-mode MAU simultaneously provides access to a communication network and to an optional power distribution network. Devices attached to the network communicate via the medium and may or may not be powered from it. If bus

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powered, power is distributed as direct voltage and current, and communication signals are superimposed on the d.c. power. In Intrinsically Safe applications, available power may limit the number of devices.

The network medium consists of a one pair cable, usually, but not always, a twisted pair. Independent of topology, all attached devices, other than possibly the transmitting device, present a high impedance to prevent significant network loading. Trapezoidal waveforms are used to reduce electromagnetic emissions.

Bus and tree topologies are supported. In either topology, a network contains one trunk cable, terminated at its ends. In the bus topology, spurs are distributed along the length of the trunk. In the tree topology, spurs are concentrated at one end of the trunk. A spur may connect more than one device to the network, with the maximum number of devices on a spur depending on spur length.

At the power frequency (d.c.), devices appear to the network as current sinks, with a limited rate of change of the supply current drawn from the medium. This prevents transient changes in load current from interfering with communication signals.

Clause 12 specifies a low-power option that allows devices to reduce their current draw from the network when not transmitting.

To minimize oscillations and ringing on the network, the power supply impedance is specified as a function of the bus terminator impedance such that the total network reactance is minimized over the frequency range 50 Hz to 39 kHz.

12.2 Transmitted bit rate

The average bit rate, BR, shall be 31,25 kbit/s ± 0,2 %, averaged over a frame having a minimum length of 16 octets. The instantaneous bit time, T_{bit}, shall be 32 μs ± 0,9 μs.

12.3 Network specifications

12.3.1 Components

An MAU operates in a network composed of the following components:

a) wire cable;

b) devices (containing at least one communication element);

c) couplers;

d) terminators.

The network may optionally include the following components:

e) connectors;

f) power supplies;

g) devices which include power supplies;

h) intrinsic safety barriers.

12.3.2 Topologies

A wire MAU shall operate in a network with an acyclic nominally linear or tree-like bus topology, consisting of a trunk, terminated at each end as specified in 12.8.5, to which communication elements are connected via couplers and spurs. A tree topology with all the communication elements located at the ends of the trunk is regarded as a special case of a bus for the purpose of Clause 12. Each communication element shall be connected in parallel with the trunk cable.

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The coupler and communication element may be integrated in one device (i.e. a zero length spur). Several communication elements may be connected to the trunk at one point using a multi-port coupler. An active coupler may be used to extend a spur to a length that requires termination to avoid reflections and distortions. Active repeaters may be used to extend the length of the trunk beyond that of a single segment as permitted by the network configuration rules. Branches shall be considered as segments, and may make the bus non-linear. Cycles (closed loops) are never permitted.

12.3.3 Network configuration rules

An MAU that claims conformance to Clause 12 shall meet the requirements of Clause 12 when used in a network that complies with these rules.

Rule 1: A fieldbus shall be capable of communication between the following numbers of devices, all operating at the same bit rate:

a) for a non IS fieldbus without power supplied via the signal conductors: between two and 32 devices;

b) for a non IS fieldbus with power supplied via the signal conductors: between two and the number of devices which can be powered via the signal conductors, assuming that a minimum of 120 mA (aggregate) shall be available to devices at the remote end from the power supply, communicating with one device at the power supply end drawing 10 mA;

c) for an IS fieldbus: between two and the number of devices which can be powered via the signal conductors, assuming that a minimum of 40 mA (aggregate) shall be available to devices in the hazardous area.

NOTE 1 This rule does not preclude the use of more than the specified number of devices in an installed system. Since the device power consumption is not specified, the number of bus-powered devices cannot be specified.
Item b) assumes that the minimum power supply voltage is 20 V d.c.
Item c) assumes that the IS barrier operates with a 19 V d.c. output.

Rule 2: A fully loaded (maximum number of connected devices) fieldbus segment shall have a total cable length, including spurs, between any two devices, of up to 1 900 m.

NOTE 2 Support of this maximum cable length is a requirement for conformance to Clause 12, but this does not preclude the use of longer lengths in an installed system.

Rule 3: The total number of waveform regenerations by repeaters and active couplers between any two devices is repeater implementation dependent.

NOTE 3 Prior editions of this standard limited this total number to four.

Rule 4: The maximum propagation delay between any two devices shall not exceed 20 T_{bit}.

For efficiency of the network, that part of the turn-around time of any device on the network caused by a PhE between the end of a received frame and the beginning of the transmitted frame containing an associated immediate response should not exceed 30 bit times, no more than 2 bit times of which should be due to the MAU.

NOTE 4 As it is not mandatory to expose either the DLL – PhL interface or the MDS – MAU interface, that part of the turn-around time of a fieldbus device caused by the PhL or the MAU is not specified and thus not available for conformance testing.

Rule 5: The fieldbus shall be capable of continued operation while a device is being connected or disconnected. Data errors induced during connection or disconnection shall be detected.

Rule 6: Failure of any communication element or spur (with the exception of a short circuit, low impedance, or jabber) shall not interfere with transactions between other communication elements for more than 1 ms.

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Rule 7: In polarity sensitive systems, the medium wire pairs shall have distinctly marked conductors that uniquely identify individual conductors. Consistent polarization shall be maintained at all connection points.

Rule 8: The degradation of the electrical characteristics of the signal, between any two devices, due to attenuation, attenuation distortion and mismatching distortion shall be limited to the values indicated below.

a) Signal attenuation: The configuration of the bus (trunk and spur lengths, number of devices, IS barriers, galvanic isolators, and possible matching devices) shall be such that the attenuation between any two devices at f_r (31,25 kHz) shall not exceed 10,5 dB.

b) Attenuation distortion: The configuration of the bus (trunk and spur lengths and number of devices, IS barriers, and galvanic isolators) shall be such that between any two devices:

   $0 \leq [\text{Attenuation } (1{,}25\ f_r) - \text{Attenuation } (0{,}25\ f_r)] \leq 6 \text{ dB}$

   Attenuation shall be monotonic non-decreasing for all frequencies from 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz).

c) Mismatching distortion: Mismatching (due to any effect, including one open circuit spur of maximum length) on the bus shall be such that, at any point along the trunk, in the frequency band 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz):

   $|Z - Zfr| / |Z + Zfr| \leq 0{,}2$

   where Z_{fr} is the impedance of the trunk cable at frequency f_r (31,25 kHz) and Z is the parallel combination of Z_{fr} and the load impedance at the coupler.

The concentration of couplers shall be less than 15 per 250 m.

NOTE 5 This rule minimizes restrictions on trunk and spur length, number of devices etc. by specifying only the transmission limitations imposed by combinations of these factors. It is possible to use different combinationsdepending on the needs of the application.

Rule 9: The following rules shall apply to systems implemented with redundant media:

a) each channel (cable) shall comply with the network configuration rules;

b) there shall not be a non-redundant segment between two redundant segments;

c) repeaters shall also be redundant;

d) if the devices of the system are configured (by Systems management) to transmit on more than one channel simultaneously then the propagation time difference between any two devices on any two channels shall not exceed five bit times;

   This period may be extended, but not reduced, by Systems management as given in Table 4 (see 6.2.2.2 and 9.2.9).

e) channel numbers and association with the physical transmission media shall be maintained consistently throughout the fieldbus, i.e. channels 1, 2, 3… from Systems management shall always connect to physical channels 1, 2, 3…;

Rule 10: For a bus-powered fieldbus segment, the voltage available to all devices, including ripple and the d.c. component of the voltage drop caused by signaling, shall be within the range of 9,0 V to 32,0 V d.c.

NOTE 6 The d.c. component of the voltage drop caused by signaling is dependent upon the configuration of the network. The d.c. component is caused by the step change in device current through the network resistance (cable resistance, IS barrier resistance, etc.).

12.3.4 Power distribution rules for network configuration

See 11.3.4.

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12.4 MAU transmit circuit specification

12.4.1 Summary

For ease of reference, the requirements of 12.2 and 12.4 are summarized in Table 67 and Table 68.

Table 67 – MAU transmit level specification summary

Transmit level characteristics, values referred to trunk (but measured using test load as shown in Figure 56)	**Limits**
Output level (peak-to-peak, see Figure 57) With test load (0,5 nominal impedance of the trunk cable at f_r (31,25 kHz))	0,75 V to 1 V 50 Ω ± 1 %
Maximum positive and negative amplitude difference (signaling bias) as shown in Figure 58	±50 mV
Output level; with one terminator removed (peak-to-peak) with test load (nominal impedance of the trunk cable at f_r (31,25 kHz))	0,75 V to 2,0 V 100 Ω ± 1 %
Maximum output level; open circuit (peak-to-peak)	35 V
Maximum output signal distortion; i.e. overvoltage, ringing and droop (see Figure 57)	±10 %
Quiescent transmitter output; i.e. transmitter noise (measured over the frequency band 1 kHz to 100 kHz)	≤1 mV (r.m.s.)

Table 68 – MAU transmit timing specification summary

Transmit timing characteristics, values referred to trunk (but measured using test load as shown in Figure 56)	**Limits for 31,25 kbit/s (bus powered and/or IS)**
Transmitted bit rate	31,25 kbit/s ± 0,2 %
Instantaneous bit time	32 µs ± 0,9 µs
Rise and fall times (10 % to 90 % of peak-to-peak signal, see Figure 57)	≤ 25 % T_{bit}
Slew rate (at any point from 10 % to 90 % of peak-to-peak signal)	≤0,2 V/µs
Maximum transmitted bit cell jitter (zero-crossing point deviation, see Figure 58)	± 2,5 % T_{bit}
Transmit enable/disable time (i.e. time during which the output waveform may not meet the transmit requirements)	≤ 2,0 T_{bit}

12.4.2 MAU test configuration

Figure 56 shows the configuration that shall be used for testing MAUs.

Differential signal voltage: $V_d = V_a – V_b$.

Except where otherwise stated in a specific requirement, test load resistance R = 50 Ω (0,5 nominal impedance of the trunk cable at f_r (31,25 kHz)) and C = 2 µF (2 × the capacitance of one terminator).

Data "+" terminal connected to the power "+" terminal and data "–" terminal connected to the power "–" terminal.

NOTE See 12.7 for the power supply specification and 12.8.5 for the terminator specification.

12.4.3 MAU output level requirements

Figure 57 describes the output form of the signal for the twisted-pair voltage output level requirements.

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NOTE 1 Figure 57 shows an example of the a.c. component of one cycle of a fieldbus waveform, illustrating some key items from the transmit circuit specification. Only signal voltages are shown; this diagram takes no account of power supply voltages.

The MAU transmit circuit shall conform to the following output level requirements, all amplitudes being measured at the estimated mid-point between any peaks or troughs in the top and bottom of the waveform ("mid-point" in Figure 57):

a) the output voltage across the test load after transformer step up/down (if applicable) shall be between 0,75 V and 1,0 V peak-to-peak, with a load resistance of 50 Ω ± 1 % ("min o/p" in Figure 57);
b) the output voltage at the trunk, or at the transmit terminals, with a load resistance of 100 Ω ± 1 % (i.e. with one trunk terminator removed) shall be between 0,75 V and 2,0 V peak-to-peak ("max. o/p one terminator removed" in Figure 57);
c) the output voltage at the trunk, or at the transmit terminals, with any load including an open circuit shall not exceed 35 V in either polarity. For test purposes, open circuit shall be defined as a load of 100 kΩ resistance in parallel with 15 pF capacitance;
d) during transmission a device shall not suffer permanent failure when a load resistance of ≤1 Ω is applied for 1 s;
e) the difference between positive amplitude and negative amplitude, measured as shown in Figure 57, shall not exceed ±50 mV peak;
f) the output noise from an MAU which is receiving or not powered shall not exceed 1 mV r.m.s., measured differentially over a frequency band of 1 kHz to 100 kHz, referred to the trunk;
g) the differential voltage across the test load shall be such that the voltage monotonically changes between 10 % and 90 % of peak-to-peak value. Thereafter, the signal voltage shall not vary more than ±10 % of peak-to-peak value until the next transition occurs. This permitted variation shall include all forms of output signal distortion, i.e. overvoltage, ringing and droop.

NOTE 2 During transmission, the output voltage developed at the device terminals may increase substantially over that specified in Subclause 12.4.3 g), but within the limit specified by 12.4.3 c), due to the affects of the combined series impedance of the device, the spur cable, and any bus protective device such as that described in 12.8.3 c).

12.4.4 Output timing requirements

An MAU transmit circuit shall conform to the following output timing requirements:

a) transmitted bit cell jitter shall not exceed ±0,025 T_{bit} from the ideal zero crossing point, measured with respect to the previous zero crossing (see Figure 58);
b) the transmit circuit shall turn on, i.e. the signal shall rise from below the transmit circuit maximum output noise level as specified in 12.4.3 f) to full output level, in less than 2,0 T_{bit}. The waveform corresponding to the third and later bit times shall be as specified in Figure 57;
c) the transmit circuit shall turn off, i.e. the signal shall fall from full output level to below the transmit circuit maximum output noise level as specified in 12.4.3 f), in less than 2,0 T_{bit}. The time for the transmit circuit to return to its off state impedance shall not exceed 4 T_{bit}. For the purposes of testing, this requirement shall be met with the transmit circuit test configuration of 12.4.2 with the equivalent capacitance of a maximum length cable across the DUT terminals.

NOTE 1 This requirement is to ensure that the transition of the transmit circuit from active to passive leaves the line capacitance fully discharged.

d) rise and fall times, measured from 10 % to 90 % of the peak-to-peak signal amplitude shall not exceed 0,25 T_{bit} (see Figure 57);
e) slew rate shall not exceed 0,2 V/μs measured at any point in the range 10 % to 90 % of the peak-to-peak signal amplitude (see Figure 57).

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NOTE 2 Requirements d) and e) produce a trapezoidal waveform at the transmit circuit output. Requirement d) limits the level of interference emissions that may be coupled to adjacent circuits, etc. Requirement d) is calculated from the formula:

$$\text{max. slew rate} = 2 \times \text{min. slew rate} = 2 \times 0{,}8\ V_o / 0{,}25\ T_{bit} = 6{,}4 \times V_o / T_{bit},$$

where V_o is the maximum peak-to-peak output voltage (1,0 V) with a standard load.

12.4.5 Signal polarity

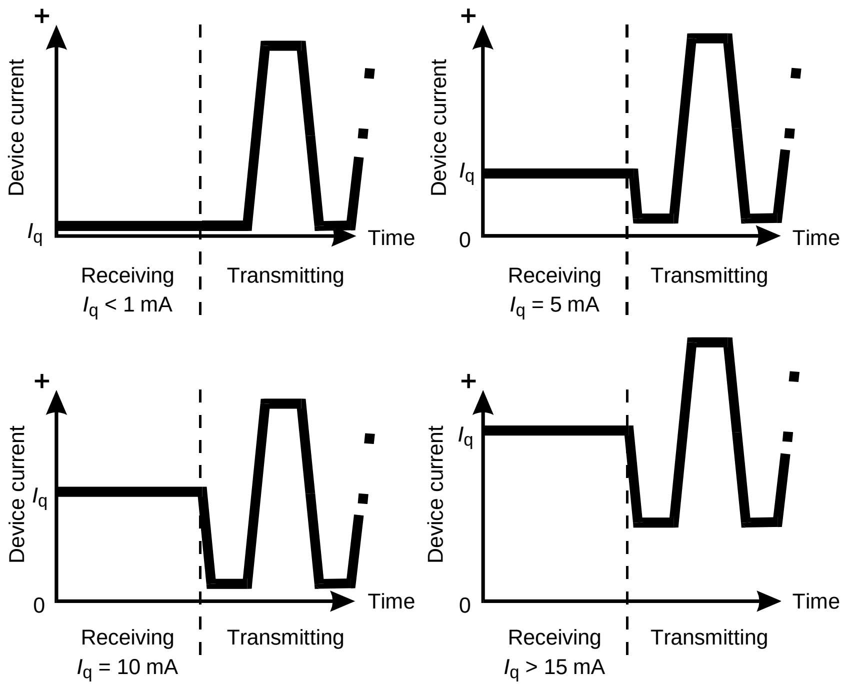
See 11.4.5.

12.4.6 Transition from receive to transmit

When a device starts to transmit, the output waveform shall immediately comply with the requirements of 12.4.3.

NOTE There is no requirement to ramp the device current from its receive value to the transmit value.

Figure 63 shows four examples of different values of device quiescent current.



NOTE This figure is included in this standard for explanatory purposes and does not imply a specific implementation.

Figure 63 – Transition from receiving to transmitting

12.5 MAU receive circuit specification

12.5.1 Summary

Table 69 summarises the specification.

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Table 69 – MAU receive circuit specification summary

Receive circuit characteristics (values referred to trunk)	Limits (bus powered and/or IS)
Input impedance, measured over the frequency range 0,25 f_r to 1,25 f_r	≥ 3 kΩ
Sensitivity; min. peak-to-peak signal required to be accepted (see Figure 60)	150 mV
Noise rejection; max. peak-to-peak noise required to be rejected (see Figure 60)	75 mV
Maximum received bit cell jitter (zero crossing-point deviation, see Figure 57)	±0,10 T_{bit}

12.5.2 Input impedance

The differential input impedance of an MAU receive circuit shall be no less than 3 kΩ over the frequency range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz). This requirement shall apply after a 20 ms startup time following connection to the network or application of power to the network. Independently powered devices, and network-powered devices capable of being turned off while connected to the network, shall meet this requirement in the power-on and power-off states, and in transition between those states. This impedance shall be measured at the communication element terminals using a sine wave with a signal amplitude greater than the receiver sensitivity threshold and lower than 2,0 V peak-to-peak.

NOTE 1 The requirement for ≥3 kΩ input impedance during power-up and power-down may be met by automatic disabling of the transmitter during these periods.

NOTE 2 It is possible that devices with fault disconnection electronic circuits have impedances less than the specified amount under fault conditions.

12.5.3 Receiver sensitivity and noise rejection

An MAU receive circuit shall be capable of accepting an input signal of amplitude no less than 150 mV peak-to-peak, including overvoltage and oscillation (see "signal level" together with "positive amplitude" and "negative amplitude", all in Figure 60).

An MAU receive circuit shall not respond to an input signal with a peak-to-peak amplitude which does not exceed 75 mV (see "noise rejection" in Figure 60).

12.5.4 Received bit cell jitter

The receive circuit shall accept a Manchester encoded signal transmitted in accordance with 12.2 and 12.4. In addition, the receiver shall work properly with signals with the time variation between any two adjacent signal transition points (zero crossing) of ±0,10 T_{bit} or less. See Figure 58.

NOTE 1 This does not preclude the use of receivers that perform better than this specification.

NOTE 2 Depending on the symbol pattern, the nominal time between zero crossings is one-half or one bit time.

NOTE 3 There is no requirement to reject a signal with a specified time variation value. The receiver reports an error when the received bit cell jitter exceeds the receiver's ability to reliably decode signaling.

12.5.5 Interference susceptibility and error rates

When a fieldbus is operating in a variety of standard noise environments, the probability that an Application Layer User Data Unit contains an undetected error, due to operation of the conveying Physical and DLL entities, should be less than 1 in 6×10^9 (1 error in 20 years at 10 messages/s).

A communication element is regarded as conforming to this theoretical requirement when it meets the following interference susceptibility requirements. These are specified by a detected frame error rate which is derived by using a ratio of detected to undetected errors of 10^6.

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NOTE 1 This is readily achievable with a 16 bit Frame Check Sequence at the DLL.

A communication element which includes an MAU, operating with frames containing 32 random user data bits, with maximum frame rate and with signals of 375 mV peak-to-peak amplitude, shall produce no more than 10 detected frame errors in 60 000 frames during operation in the presence of common mode voltage or Gaussian noise as follows:

a) a common mode sinusoidal signal of any frequency from 63 Hz to 2 MHz, with an amplitude of 4 V r.m.s. and from 47 Hz to 63 Hz with an amplitude of 250 V r.m.s.;

b) a common mode d.c. signal of ±10 V;

c) white Gaussian additive differential noise in the frequency band 1 kHz to 100 kHz, with a noise density of 70 μV/√Hz r.m.s.

NOTE 2 The common mode voltage and Gaussian noise specifications are for receive circuit conformance testing with balanced loads and are not indicative of system installation practice.

A communication element which includes an MAU, operating with frames containing 32 random user data bits, at an average of 10 messages per second, with signals of 375 mV peak-to-peak amplitude, shall produce no more than 10 detected frame errors in 1 000 frames during operation in the presence of electromagnetic or electrical interference environments as follows:

1) 10 V/m electromagnetic field as specified in IEC 61000-4-3 at severity level 3;

2) electrical fast transient as specified in IEC 61000-4-4 at severity level 3.

The noise above error rate specification shall also be satisfied after but not during operation in the following noise environments:

i) 8 kV electrostatic discharge to exposed metalwork as specified in IEC 61000-4-2 at severity level 3. If the device suffers temporary loss of function or performance as a result of this test it shall recover from any such loss without operator intervention within 3 s after the end of the test;

ii) high frequency disturbance tests as specified in IEC 60255-22-1:1988, appendix E, Test voltage class III (2,5 kV and 1 kV peak values of first half-cycle in longitudinal and transverse mode respectively). If the device suffers temporary loss of function or performance because of this test, it shall recover from any such loss without operator intervention within 3 s after the end of the test.

12.6 Jabber inhibit

The MAU shall contain a self-interrupt capability to inhibit transmitted signals from reaching the medium. Hardware within the MAU (with no external message other than the detection of output signals or leakage via the transmit function) shall provide a window of between 120 ms and 240 ms during which time a normal frame may be transmitted. If the frame length exceeds this duration, the jabber inhibit function shall inhibit further output signals from reaching the medium and shall disable echo on the RxS line (see 10.2.2.2) to indicate jabber detection to the MDS.

The MAU shall reset the self-interrupt function after a period of 3,0 s ± 50 %.

NOTE This inhibits bus traffic for no more than 16 % (≈ 240 ms / 1,5 s) of the available time.

12.7 Power distribution

12.7.1 General

A device can receive power via the signal conductors or can be separately powered.

A device can be certified as Intrinsically Safe with either method of receiving power.

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NOTE This standard does not include requirements for IS certification but seeks to exclude conditions or situations that would prevent IS certification.

A separately powered device can be connected to a powered fieldbus.

For ease of reference, the requirements of 12.7 for network-powered devices and network power supplies are summarized in Table 70 and Table 71.

Table 70 – Network powered device characteristics

Network powered device characteristics	Limits for 31,25 kbit/s
Operating voltage	9,0 V to 32,0 V d.c.
Minimum withstand voltage, either polarity, for no damage	35 V
Maximum rate of change of quiescent current (non-transmitting); this requirement does not apply within the first 20 ms after the connection of the device to an operating network or within the first 20 ms after the application of power to the network.	1,0 mA/ms [a, b]
Maximum current; this requirement applies during the time interval of 500 µs to 20 ms after the connection of the device to an operating network or 500 µs to 20 ms after the application of power to the network (see note)	Rated quiescent current plus 20 mA

[a] The first 500 µs is excluded to allow for the charging of RFI filters and other capacitance in the device. The rate of change specification applies after 20 ms.

[b] The maximum current during that first 500 µs should be no more than twice the maximum current specified above, to minimize effects of the current inrush on the rest of the connected fieldbus network.

NOTE 1 These exclusions have the potential to cause a "brown out" at devices powered from the same power supply during the exclusion interval.

NOTE 2 These exclusions can substantially increase the current requirements of the power supply during the exclusion interval which occurs immediately after power is applied to the PhL segment.

Table 71 – Network power supply requirements

Network power supply requirements [a]	Limits for 31,25 kbit/s
Output voltage, non-IS	≤ 32 V d.c.
Output voltage, IS	Depends on barrier rating
Output ripple and noise	See Figure 64
Output impedance	See 12.7.4

[a] Power supply designs should take into account the current surge at device connection or power-up permitted by Table 70.

12.7.2 Supply voltage

A fieldbus device claiming conformance to Clause 12 shall be capable of operating within a voltage range of 9 V to 32 V d.c. between the two conductors including ripple. The device shall withstand a minimum voltage of ±35 V d.c. without damage.

12.7.3 Powered via signal conductors

A fieldbus device claiming conformance to Clause 12 shall conform to the requirements of Clause 12 when powered by a supply with the following specifications:

a) The output voltage of the power supply for non IS networks shall be 32 V d.c. maximum including ripple.

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NOTE 1 For IS systems the operating voltage may be limited by the certification requirements. In this case, the power supply will be located in the safe area and its output voltage will be attenuated by a safety barrier or equivalent component.

b) The breakdown requirements of the isolation of the signal circuit and the power distribution circuit from ground and from each other shall be in accordance with IEC 61131-2.

NOTE 2 See 11.7.5, Note 3.

c) When a power supply powers two or more segments, the isolation impedance to each segment shall be split ±10 % between the two signal conductors of the segment.

A fieldbus device claiming conformance to Clause 12 that is powered via the signal conductors shall conform to the requirements of Clause 12 when operating with maximum levels of power supply ripple and noise as follows:

d) 16 mV peak-to-peak over the frequency range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz);

e) 2,0 V peak-to-peak over the frequency range 47 Hz to 63 Hz for non-IS applications;

f) 0,2 V peak-to-peak over the frequency range 47 Hz to 625 Hz for IS applications;

g) 1,6 V peak-to-peak at frequencies greater than 125 f_r, up to a maximum of 25 MHz;

h) levels at intermediate frequencies generally in accordance with Figure 64.

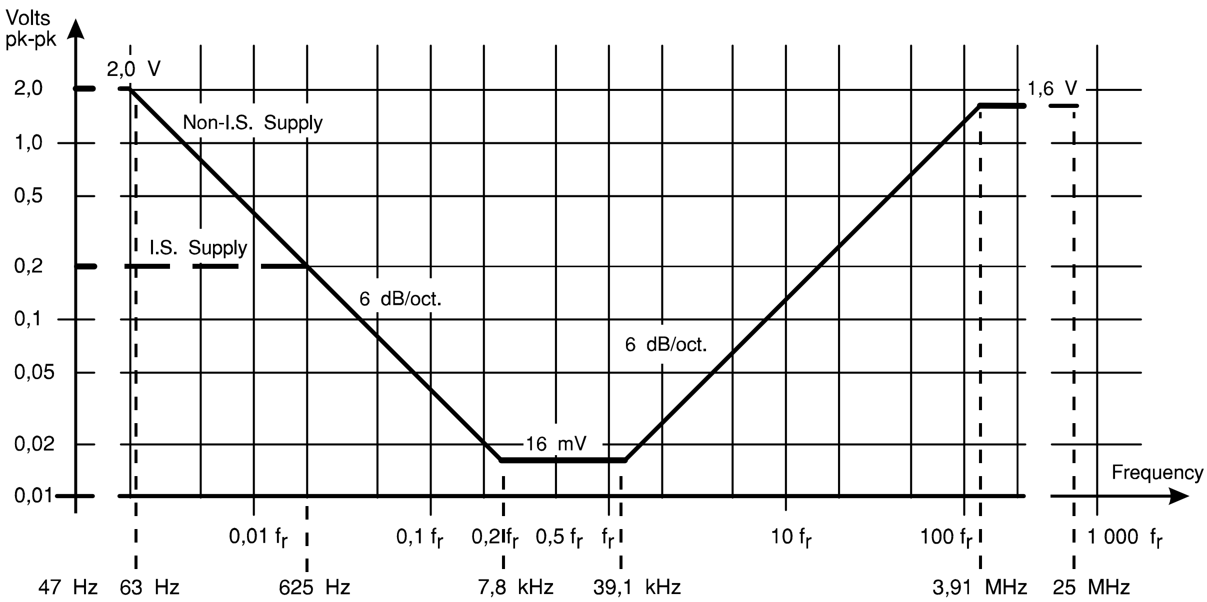

Figure 64 – Power supply ripple and noise

A fieldbus device claiming conformance to Clause 12 which is powered via the signal conductors shall exhibit a maximum rate of change of current drawn from the network of 1 mA/ms. This requirement does not apply:

1) when transmitting,
2) within the first 20 ms after the connection of the device to an operating network,
3) within the first 20 ms after the application of power to the network, or
4) upon disconnection from the network or removal of power to the network.

A device shall be marked with its rated quiescent current. A device shall draw no more than 20 mA above its rated current from the network during the time interval of 500 µs to 20 ms after the connection of the device to an operating network or 500 µs to 20 ms after the application of power to the network.

NOTE 3 The first 500 µs are excluded to allow for the charging of RFI filters and other capacitance in the device. The rate of change specification applies after 20 ms.

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The maximum current during that initial 500 µs should be no more than twice the maximum current specified above, to minimize effects of the current inrush on the rest of the connected fieldbus network.

NOTE 4 These exclusions have the potential to cause a "brown out" at devices powered from the same power supply during the exclusion interval.

NOTE 5 These exclusions can substantially increase the current requirements of the power supply during the exclusion interval which occurs immediately after power is applied to the PhL segment.

12.7.4 Power supply impedance

The power supply used to provide power on the signal conductors shall comply with the impedance specification in 12.7.4.1, 12.7.4.2, or 12.7.4.3.

Power supply designs should take into account the current surge at device connection or power-up permitted by 12.7.3.

12.7.4.1 Power supply impedance for single output power supplies

For power supplies having a single output, power supply impedance shall be measured using the test circuit of Figure 65.

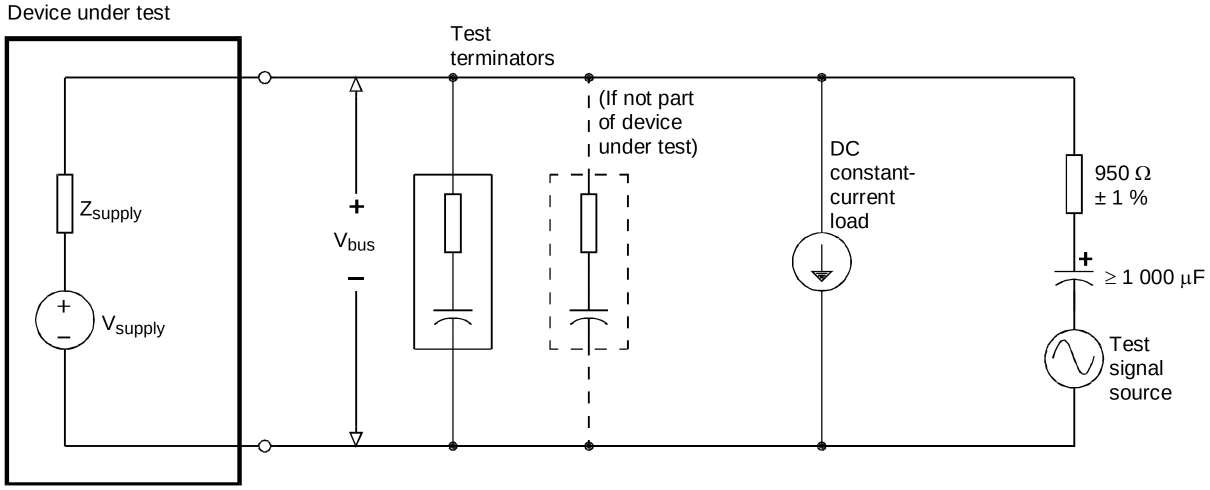

Figure 65 – Test circuit for single-output power supplies

The test terminators shown in Figure 65 shall each be 100 Ω ± 1 % in series with 1 µF ± 5 %. Two test terminators shall be used in the test circuit if the supply under test does not contain an internal terminator. If the supply under test contains an internal terminator that is always connected, only one test terminator shall be used in the test circuit. If the supply under test contains an internal terminator that can be optionally connected into the circuit, the supply shall be tested a) with the internal terminator and one test terminator and b) with two test terminators and no internal terminator.

If the power supply is intended to be used with an external impedance-determining network (for example, as might be the case with supplies designed to be used redundantly), the supply shall be tested with the external network connected.

The supply shall be tested at 20 %, 50 %, and 80 % of its rated output current (or 20 mA, whichever is greater), with the supply loaded by a d.c. constant-current load having 1 mA/V compliance or better (i.e. ≥1 kΩ impedance).

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The power supply shall be tested by monitoring the a.c. bus voltage V_{BUS} while applying a 10 V_{pk-pk} sine wave from a test signal source through a 950 Ω ± 1 % resistor and a coupling capacitor of at least 1 000 μF.

The measured a.c. bus voltage V_{BUS} shall conform to the following.

a) **For non-IS power supplies intended for feeding IS barriers:** V_{BUS} shall be between 0,40 V_{pk-pk} and 0,60 V_{pk-pk} at all frequencies from 50 Hz to 39 kHz.

b) **For IS power supplies, and for non-IS power supplies not intended for feeding IS barriers:** V_{BUS} shall be between 0,40 V_{pk-pk} and 0,60 V_{pk-pk} from 3 kHz to 39 kHz, and shall not increase or decrease at a rate greater than 20 dB per decade at any frequency from 50 Hz to 3 kHz.

NOTE It is acceptable for the functions of power supply and terminator to be combined as long as the combination is electrically equivalent to the independent devices meeting the requirements of Clause 12, and if the network configuration rules of 12.3 are followed.

Power supplies not intended for feeding IS barriers shall be marked "Not for use with IS barriers".

12.7.4.2 Power distribution through an IS barrier

Intrinsic safety barrier output impedance shall be defined in terms of its frequency dependent characteristics when connected in the test circuit of Figure 66.

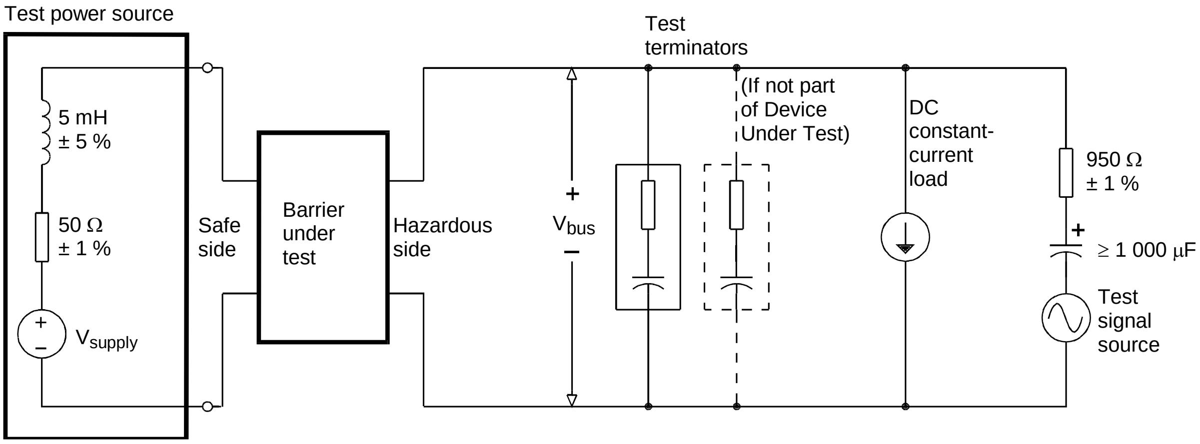

Figure 66 – Test circuit for power distribution through an IS barrier

The test power source shown in Figure 66 consists of a low-impedance d.c. voltage source in series with 5 mH ± 5 % and 50 Ω ± 1 %. The test terminators shall each be 100 Ω ± 1 % in series with 1 μF ± 5 %. If the barrier contains an internal terminator, the barrier shall be tested with one test terminator. Otherwise, the barrier shall be tested with two test terminators.

The barrier shall be tested at 20 %, 50 %, and 80 % of rated output current (or 20 mA, whichever is greater), when loaded by a d.c. constant-current load having 1 mA/V compliance or better (i.e. ≥1 kΩ impedance).

The barrier shall be tested by monitoring the bus voltage V_{BUS} while applying a 10 V_{pk-pk} sine wave from a test signal source through a 950 Ω ± 1 % resistor and a coupling capacitor of at least 1 000 μF.

The measured a.c. bus voltage V_{BUS} on the hazardous side of the barrier shall be between 0,40 V_{pk-pk} and 0,60 V_{pk-pk} from 3 kHz to 39 kHz, and shall not increase or decrease at a rate greater than 20 dB per decade at any frequency from 50 Hz to 3 kHz.

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NOTE It is acceptable for the functions of power supply, IS barrier and terminator to be combined in various ways as long as the combination is electrically equivalent to the independent devices meeting the requirements of Clause 12, and if the network configuration rules of 12.3 are followed.

12.7.4.3 Power supply impedance for multiple-output supplies with signal coupling between outputs

NOTE 1 Subclause 12.7.4.3 is applicable to galvanic isolators, active couplers, and other devices providing multiple power and signal ports.

For multiple-output power supplies with a coupling of fieldbus communication signal between outputs, power supply impedance shall be measured using the test circuit of Figure 67.

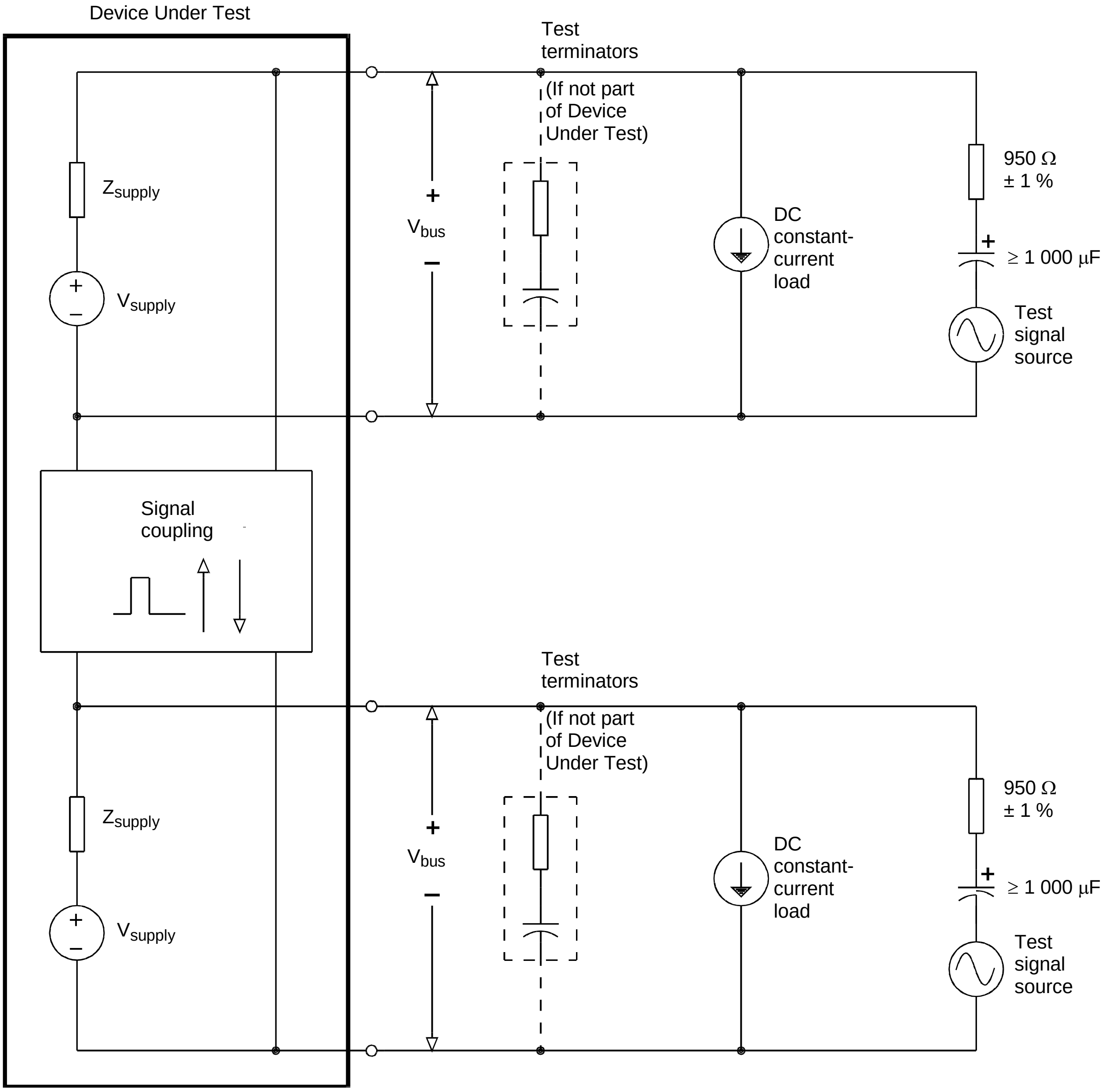

Figure 67 – Test circuit for multiple output supplies with signal coupling

The test terminators shown in Figure 67 shall each be 100 Ω ± 1 % in series with 1 μF ± 5 %. Two test terminators shall be used in the test circuit if the device under test does not contain an internal terminator. If the device under test contains an internal terminator that is always connected, only one test terminator shall be used in the test circuit. If the device under test contains an internal terminator that can be optionally connected into the circuit, the device shall be tested a) with the internal terminator and one test terminator and b) with two test terminators and no internal terminator.

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If the device under test is intended to be used with an external impedance-determining network (for example, as might be the case with supplies designed to be used redundantly), the supply shall be tested with the external network connected.

The device under test shall be tested at 20 %, 50 %, and 80 % of its rated output current (or 20 mA, whichever is greater) on each output, with the device loaded by a d.c. constant-current load having 1 mA/V compliance or better (i.e. ≥1 kΩ impedance).

The measured a.c. bus voltage V_{BUS} shall be between 0,40 V_{pk-pk} and 0,60 V_{pk-pk} from 3 kHz to 39 kHz, and shall not increase or decrease at a rate greater than 20 dB per decade at any frequency from 50 Hz to 3 kHz.

NOTE 2 It is acceptable for the functions of power supply, isolator or coupler, and terminator to be combined in various ways as long as the impedance of the combination is equivalent to the parallel impedance of independent devices meeting the requirements of Clause 12 and the network configuration rules of 12.3 are followed.

12.7.5 Powered separately from signal conductors

NOTE Power distribution to non-bus powered fieldbus devices is by separate conductors feeding local power supplies, regulators or safety barriers. IS certification may require these conductors to be in a separate cable from the signal conductors and may also impose more stringent requirements for current levels than specified.

A separately powered fieldbus device shall draw no more than 10 mA direct current from the signal conductors nor shall it supply more than 100 μA direct current to the signal conductors when not transmitting. A device shall be marked with its rated quiescent current draw from the network.

12.7.6 Electrical isolation

All fieldbus devices, whether separately powered or powered via the signal conductors, shall provide low frequency isolation between ground and the fieldbus trunk cable.

NOTE 1 This is by isolation of the entire device from ground or by use of a transformer, opto-coupler or some other isolating component between trunk cable and device.

A combined power supply and communication element shall not require electrical isolation.

For shielded cables, the isolation impedance measured between the shield of the fieldbus cable and the fieldbus device ground shall be greater than 250 kΩ at all frequencies below 63 Hz.

The maximum unbalanced capacitance to ground from either input terminal of a device shall not exceed 250 pF.

The breakdown requirements of the isolation of the signal circuit and the power distribution circuit from ground and from each other shall be in accordance with IEC 61131-2.

NOTE 2 See 11.7.5, Note 3.

12.8 Medium specifications

12.8.1 Connector

Cable connectors, if used, shall be in accordance with this standard (see Annex A for Type 1, and Annex I for Type 3 synchronous transmission). Field termination techniques such as screw or blade terminals and permanent termination may also be used.

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12.8.2 Standard test cable

The cable used for testing fieldbus devices which claim conformance to Clause 12 shall be a single twisted-pair cable with overall shield meeting the following minimum requirements at 25 °C:

a) impedance at f_r (31,25 kHz) = 100 Ω ± 20 %;

b) maximum attenuation at 1,25 f_r (39 kHz) = 3,0 dB/km;

c) maximum capacitive unbalance to shield = 4 nF/km, tested using a 30 m or longer sample;

d) maximum d.c. resistance (per conductor) = 24 Ω/km;

e) maximum propagation delay change 0,25 f_r to 1,25 f_r = 1,7 μs/km;

f) conductor cross-sectional area (wire size) = nominal 0,8 mm^2;

g) minimum shield coverage shall be 90 %.

The preceding specification is for conformance testing an MAU. Other types of cable may be used in real installations. (See Annex B.) Cables with improved specifications may enable increased trunk length or superior interference immunity or may be required to meet environmental or installation conditions. Conversely, cables with inferior specifications may be used subject to length limitations for both trunk and spurs, plus possible non-conformance to the RFI/EMI susceptibility requirements.

For intrinsically safe applications, the inductance/resistance ratio (L/R) should be less than the limit specified by the local regulatory agency for the particular implementation.

12.8.3 Coupler

The coupler shall provide one or several point(s) of connection to the trunk. It may be integrated in a fieldbus device, in which case there is no spur. Otherwise, it has at least three access points as shown in Figure 68: one for the spur and one for each side of the trunk.

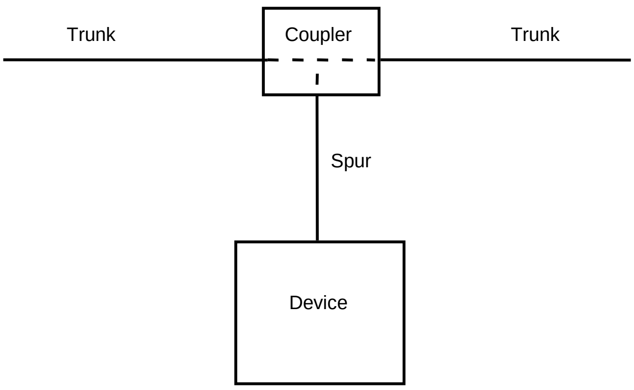

Figure 68 – Fieldbus coupler

A passive coupler may contain any or all of the optional elements as described below:

a) a transformer, to provide galvanic isolation and impedance transformation between trunk and spur;

b) connectors, to provide easy connection to spur and/or trunk;

c) protection resistors, as shown in Figure 69, to protect bus traffic between other devices from the effects of a short-circuit spur on an unpowered, non-intrinsically-safe trunk.

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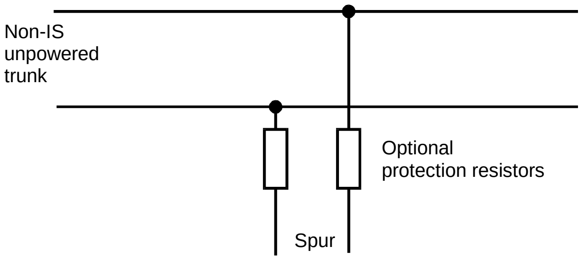

Figure 69 – Protection resistors

NOTE Such series resistors inherently increase the voltage at the device terminals when it is transmitting. This will affect the voltage at the receiving terminals of electrically “nearby” devices. See 12.4.3 for the maximum withstand voltage required of all such devices.

Active couplers, which require external power supplies, contain components for signal amplification and re-transmission. The transmit level and timing requirements shall conform to 12.3.

12.8.4 Splices

NOTE 1 A splice is any part of the network in which the characteristic impedance of the network cable is not preserved. This is possibly due to separation of the cable conductors, removal of the cable shield, change of wire gauge or type, connection to spurs, attachment to terminal strips, etc. A practical definition of a splice is therefore any part of the network that is not a continuous length of the specified medium.

For networks having a total cable length (trunk and spurs) of greater than 400 m, the sum of the lengths of all splices shall not exceed 2,0 % of the total cable length. For cable lengths of 400 m or less, the sum of the lengths of all splices shall not exceed 8 m.

NOTE 2 The motivation for this specification is to preserve transmission quality by requiring that the network be constructed almost entirely of the specified medium.

The continuity of all conductors of the cable shall be maintained in a splice.

12.8.5 Terminator

A terminator shall be located at both ends of the trunk cable, connected from one signal conductor to the other. No connection shall be made between terminator and cable shield.

The terminator impedance value shall be 100 Ω – 2 Ω/+ 6 Ω over the frequency range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz). The terminator impedance shall be equivalent to a 100 Ω resistor in series with a 1,0 μF capacitor. The maximum component tolerances shall be 100 Ω ± 2 Ω and 1,0 μF ± 0,2 μF.

NOTE 1 This impedance value is approximately the average cable characteristic impedance value for suitable cables at the relevant frequencies and is chosen to minimize transmission line reflections.

The terminator components should be chosen to meet the specified values over the temperature range and operating life of the installation. It is recommended that the 25 °C rating of the components be 100 Ω ± 1 Ω and 1 μF ± 0,1 μF.

The direct current leakage through the terminator shall not exceed 100 μA. The terminator shall be non-polarized.

All terminators used for IS applications shall comply with isolation requirements (creepage and clearance) commensurate with the required IS approval. Terminators for non-IS applications shall not be required to have IS approval.

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NOTE 2 It is acceptable for the functions of power supply, safety barrier, and terminator to be combined in various ways as long as the impedance of the combination is equivalent to the parallel impedance of independent devices meeting the requirements of Clause 12 and the network configuration rules of 12.3.3 are followed.

12.8.6 Shielding rules

Where conformance to the noise immunity requirements of 12.5 is to be met by the use of shielding it is necessary to ensure the integrity of shielding throughout the cabling, connectors and couplers. The following rules can assist in meeting these requirements, but are not themselves a requirement:

a) the cable should be shielded for more than 90 % of its full length;
b) shielding should completely cover the electrical circuits in connectors, couplers, and splices.

NOTE 1 Deviation from these shielding rules can degrade noise immunity.

NOTE 2 Due to the long wavelengths involved, breaks in the shield coverage of 25 cm or so at connectors, couplers and splices, including where spurs are attached, will not usually be a problem, provided that shield continuity is maintained.

NOTE 3 Enclosure of connectors, couplers and splices in a metallic junction box can provide shielding from noise sources outside the junction box.

12.8.7 Grounding (earthing) rules

NOTE Grounding (earthing) means permanently connected to earth through sufficiently low impedance and with sufficient current-carrying capability to prevent voltage build-up which might result in undue hazard to connected equipment or persons.

Fieldbus devices shall be required to function to the requirements of Clause 12 with the mid-point of one terminator or one inductive coupler connected directly to ground.

Fieldbus devices shall not connect either conductor of the twisted pair to ground at any point in the network. Signals shall be applied and preserved differentially throughout the network. Zero volts (common) lines may be connected to ground where they are galvanically isolated from the fieldbus trunk.

It is standard practice for the shield of the fieldbus trunk cable (if applicable) to be effectively grounded at one point along the length of the cable. For this reason fieldbus devices should allow d.c. isolation of the cable shield from ground.

It is also standard practice to connect the signal conductors to ground in a balanced manner at the same point, e.g. by using the center tap of a terminator or coupling transformer.

For bus-powered systems the grounding of the shield and balanced signal conductors should be close to the power supply unit.

For IS systems the grounding should be at the safety barrier earth connection.

Capacitive coupling between the shield or the balanced signal conductors and device local ground for EMI control is permitted, subject to IS requirements.

12.8.8 Color coding of cables

See 11.8.8.

Where consideration of regional practices, such as those specified in 11.8.8, does not override, the following cable colors are recommended for Type 3 systems, as shown in Table 72.

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Table 72 – Type 3 cable color specification

Cable Parameter	Color
Color of sheath non-IS	Black
Color of sheath IS	Blue or blue/black stripe
Color of inner cable conductor A (PA-)	Green
Color inner cable conductor B (PA+)	Red

12.9 Intrinsic safety

12.9.1 General

This standard does not attempt to list the requirements by which an item of equipment may be certified as intrinsically safe nor does it require equipment to be intrinsically safe. Rather, it seeks to exclude conditions or situations that would prevent IS certification.

12.9.2 Intrinsic safety barrier

The barrier impedance shall be greater than 460 Ω at any frequency in the range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz). The IS barrier impedance specification shall apply to all barriers used as part of the PhL, whether installed as a separate item of network hardware or embedded in a power supply card. The barrier impedance shall be measured across the terminals on both sides of the barrier. The barrier impedance shall be measured while the network power supply is set at the rated working voltage (not safety voltage) of the barrier.

NOTE It is acceptable for the functions of power supply, safety barrier, and terminator to be combined in various ways as long as the impedance of the combination is equivalent to the parallel impedance of independent devices meeting the requirements of Clause 12 and the network configuration rules of 12.3.3 are followed.

At the rated working voltage of the barrier, and at any frequency in the range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz), the capacitance measured from the "+" (positive) network terminal (hazardous side) to ground shall differ by no more than 250 pF from the capacitance measured from the "–" (negative) network terminal (hazardous side) to ground.

12.9.3 Barrier and terminator placement

A barrier shall be separated from the nearest terminator by no more than 100 m of cable.

12.10 Galvanic isolators

The communications characteristics of galvanic isolators used on the fieldbus shall comply with the specifications of 12.4, 12.5 and 12.9. Galvanic isolators that provide power to fieldbus devices shall also comply with the power supply specifications of 12.7.

13 Type 1: Medium attachment unit: current mode, twisted-pair wire medium

13.1 General

The 1,0 Mbit/s current-mode MAU simultaneously provides access to a communication network and to a power distribution network. Devices attached to the network communicate via the medium and may or may not be powered from it. Power is distributed as a constant a.c. current. The communications signals are superimposed on the a.c. power.

The network medium consists of shielded twisted-pair cable.

Trapezoidal waveforms are used to reduce electromagnetic emissions and signal distortion.

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In Intrinsically Safe applications, available power may limit the number of devices.

The devices are connected in series on the bus whereas in the voltage-mode variants the devices are connected in parallel to the bus.

13.2 Transmitted bit rate

The average bit rate, BR ± ΔBR, shall be 1,0 Mbit/s ± 0,01 %, averaged over a frame having a minimum length of 16 octets. The instantaneous bit time, $T_{bit} \pm \Delta T_{bit}$, shall be 1,0 μs ± 0,025 μs.

13.3 Network specifications

13.3.1 Components

An MAU operates in a network composed of the following components:

a) cable;

b) terminators;

c) couplers;

d) devices (containing at least one communication element).

A wire network in current mode may additionally include the following components:

e) connectors;

f) power supplies;

g) devices which include power supplies;

h) intrinsic safety barriers.

The network medium consists of shielded twisted-pair cable. Independent of topology, all attached devices, other than possibly the transmitting device, are low impedance to prevent significant network loading.

13.3.2 Topologies

A wire MAU shall operate in a network with a linear bus topology, consisting of a trunk, terminated at each end as specified in 13.8.5, to which communication elements are connected via couplers and spurs.

The coupler and communication element may be integrated in one device (i.e. zero-length spur).

A tree topology with all the communication elements located at the ends of the trunk is regarded as a special case of a bus for the purpose of Clause 13.

Several communication elements may be connected to the trunk at one point using a multi-port coupler. An active coupler may be used to extend a spur to a length that requires termination to avoid reflections and distortions. Active repeaters may be used to extend the length of the trunk beyond that of a single segment as permitted by the network configuration rules.

13.3.3 Network configuration rules

An MAU that claims conformance to Clause.13 shall meet the requirements of Clause 13 when used in a network that complies with these rules.

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Rule 1: One fieldbus shall be capable of communication between two and 32 devices, all operating at the same bit rate, both for a powered and a non-powered bus and in a hazardous area using distributed barriers.

NOTE 1 The use of a single barrier in the safe area may limit the number of devices in the hazardous area.

NOTE 2 This rule does not preclude the use of more than the specified number of devices in an installed system. The numbers of devices were calculated on the assumption that a bus-powered device draws 100 mW.

Rule 2: A fully loaded (maximum number of connected devices), current-mode fieldbus segment shall have a total cable length, between any two devices, of up to 750 m.

NOTE 3 750 m maximum cable length is the requirement for conformance to Clause 13 but this does not preclude the use of longer lengths in an installed system.

Rule 3: The total number of waveform regenerations by repeaters and active couplers between any two devices is repeater implementation dependent.

NOTE 4 Prior editions of this standard limited this total number to four.

Rule 4: The maximum propagation delay between any two devices shall not exceed 40 T_{bit}.

For efficiency of the network, that part of the turn-around time of any device on the network caused by a PhE between the end of a received frame and the beginning of the transmitted frame containing an associated immediate response should not exceed 5 bit times, no more than 2 bit times of which should be due to the MAU.

NOTE 5 As it is not mandatory to expose the DLL – PhL interface or the MDS – MAU interface, that part of the turn-around time of a fieldbus device caused by the PhL or the MAU is not specified and thus not available for conformance testing.

Rule 5: The fieldbus shall be capable of continued operation while a device is being connected or disconnected. Data errors induced during connection or disconnection shall be detected.

Rule 6: Failure of any communication element or spur (including a short circuit or open circuit, but excluding jabber) shall not interfere with transactions between other communication elements for more than 1 ms.

Rule 7: The network shall not be polarity sensitive with or without power injected on the line.

Rule 8: The degradation of the electrical characteristics of the signal, between any two devices, due to attenuation, attenuation distortion and mismatching shall be limited to the values indicated below.

a) Signal attenuation: The signal attenuation due to each device shall not exceed 0,2 dB. The configuration of the bus (trunk and spur lengths, number of devices, IS barriers, galvanic isolators, and possible matching devices) shall be such that the attenuation between any two devices at the frequency corresponding to the bit rate shall not exceed 16 dB.

b) Attenuation distortion: The configuration of the bus (trunk and spur lengths and number of devices) shall be such that between any two devices:

   [Attenuation (1,25 f_r) – Attenuation (0,25 f_r)] $\leq$ 6 dB

   Attenuation (1,25 f_r) $\geq$ Attenuation (0,25 f_r)

   where f_r is the frequency corresponding to the bit rate. Attenuation shall be monotonic for all frequencies from 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz).

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c) Mismatching distortion: Mismatching (due to spurs or any other effect, including one open circuit spur of maximum length) on the bus shall be such that, at any point along the trunk, in the frequency band 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz):

$$|Z - Zfr| / |Z + Zfr| \leq 0,2$$

where

Z_o is the characteristic impedance of the trunk cable;
Z is the parallel combination of Z_o and the load impedance at the coupler.

NOTE 6 This rule minimizes restrictions on trunk and spur length, number of devices etc. by specifying only the transmission limitations imposed by combinations of these factors. It is possible to use different combinations depending on the needs of the application.

Rule 9: The following rules shall apply to systems implemented with redundant media:

a) each channel (cable) shall comply with the network configuration rules;

b) there shall not be a non-redundant segment between two redundant segments;

c) repeaters shall also be redundant;

d) if the system is configured (by Systems management) to transmit on more than one channel simultaneously then the propagation time difference between any two devices on any two channels shall not exceed five bit times;

e) channel numbers shall be maintained throughout the fieldbus, i.e. channels 1,2,3… from Systems management shall always connect to physical channels 1,2,3…

13.3.4 Power distribution rules for network configuration

See 11.3.4.

13.4 MAU transmit circuit specification

The requirements of Subclause 13.4 are summarized in Table 73 and Table 74.

Table 73 – MAU transmit level specification summary

Transmit level characteristics, values referred to trunk (but measured using test load as shown in Figure 70)	**Limits (bus-powered and/or IS)**
Output level (peak-to-peak, see Figure 57) With test load (>2 × nominal Z_o of trunk cable)	≥2,5 V 320 Ω ± 1 %
Maximum positive and negative amplitude difference (signaling bias) as shown in Figure 58	±0,2 V
Output level; open circuit (peak-to-peak)	≤4,0 V
Maximum output signal distortion; i.e., overvoltage, ringing and droop (see Figure 57)	±10 %
Quiescent transmitter output; i.e. transmitter noise (measured over the frequency band 1 kHz to 4 MHz)	≤1 mV (r.m.s.)

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Table 74 – MAU transmit timing specification summary

Transmit timing characteristics, values referred to trunk (but measured using test load as shown in Figure 70)	Limits (bus-powered and/or IS)
Transmitted bit rate	1 Mbit/s ± 0,01 %
Instantaneous bit time	1 µs ± 0,025 µs
Rise and fall times (10 % to 90 % of pk-pk signal, see Figure 57)	≤ 20 % T_{bit}
Slew rate (at any point from 10 % to 90 % of pk-pk signal)	≤40,0 V/µs
Maximum transmitted bit cell jitter (zero crossing-point deviation, see Figure 58)	± 2,5 % T_{bit}
Transmit enable/disable time (i.e. time during which the output waveform may not meet the transmit requirements)	≤ 2,0 T_{bit}

13.4.1 Test configuration

Figure 70 shows the configuration that shall be used for testing.

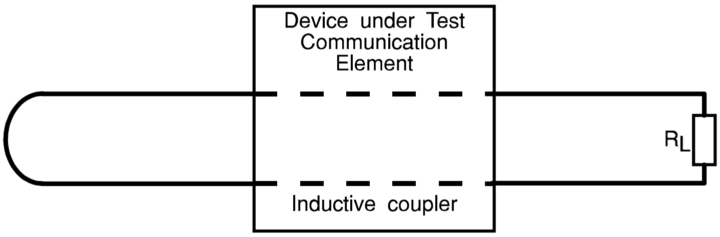

Figure 70 – Test configuration for current-mode MAU

The test configuration for Clause 13 shall be as shown in Figure 70 except where otherwise stated in a specific requirement.

NOTE Test load resistance R = 320 Ω (twice maximum cable Z_o) as the output is loaded by a series loop of the trunk.

13.4.2 Output level requirements

NOTE Figure 57 shows an example of one cycle of a fieldbus waveform, illustrating some key items from the transmit circuit specification. Only signal voltages are shown; this diagram takes no account of power-supply voltages.

A current-mode MAU transmit circuit shall conform to the following output level requirements, all amplitudes being measured at the estimated mid-point between any peaks or troughs in the top and bottom of the waveform ("mid-point" in Figure 57):

a) the output voltage across the test load after transformer step up/down shall be no less than 2,5 V peak-to-peak with a load resistance of 320 Ω ± 1 % ("min o/p" in Figure 57);
b) the output voltage at the trunk, or at the transmit terminals, with any load including an open circuit shall not exceed 4,0 V peak-to-peak ("max. o/c at trunk" in Figure 57). For test purposes, open circuit shall be defined as a load of 100 kΩ resistance in parallel with 15 pF capacitance;
c) during transmission a device shall not suffer permanent failure when a load resistance of ≤1 Ω is applied for 1 s;
d) the difference between positive amplitude and negative amplitude, measured as shown in Figure 57, shall not exceed ±0,2 V peak;
e) the output noise from a current-mode MAU which is receiving or not powered shall not exceed 1 mV r.m.s., measured differentially over the frequency band 1 kHz to 4 MHz, referred to the trunk;

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f) the differential voltage across the test load shall be such that the voltage monotonically changes between 10 % and 90 % of peak-to-peak value. Thereafter, the signal voltage shall not vary more than ±10 % of peak-to-peak value until next transition occurs. This permitted variation shall include all forms of output signal distortion, i.e. overvoltage, ringing and droop.

13.4.3 Output timing requirements

A current-mode MAU transmit circuit shall conform to the following output timing requirements:

a) rise and fall times, measured from 10 % to 90 % of the peak-to-peak signal amplitude shall not exceed 0,2 T_{bit} (see Figure 57);

b) slew rate shall not exceed 40 V/µs measured at any point in the range 10 % to 90 % of the peak-to-peak signal amplitude (see Figure 57);

NOTE 1 Requirements a) and b) produce a trapezoidal waveform at the transmit circuit output. Requirement b) limits the level of interference emissions that may be coupled to adjacent circuits etc. Requirement b) is calculated from the formula:

Max. slew rate = 3 × min. slew rate = $3 \times 0{,}8\ V_o / 0{,}2\ T = 12 \times V_o / T_{bit}$,
where V_o is an estimated maximum pk-pk output voltage with standard load (3,3 V).

c) transmitted bit cell jitter shall not exceed ±0,025 nominal bit time from the ideal zero crossing-point, measured with respect to previous zero crossing (see Figure 71);

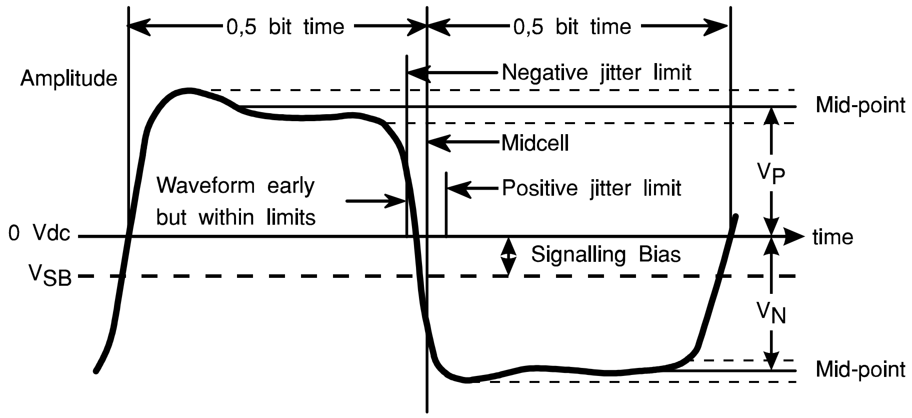

Figure 71 – Transmitted and received bit cell jitter (zero crossing point deviation)

d) the transmit circuit shall turn on, i.e. the signal shall rise from below the transmit circuit maximum output noise level as specified in 13.4.2 e) to full output level, in less than 2,0 T_{bit}. The waveform corresponding to the third and later bit times shall be as specified by other Subclauses of 13.4;

e) the transmit circuit shall turn off, i.e. the signal shall fall from full output level to below the transmit circuit maximum output noise level as specified in 13.4.2 e), in less than 2,0 T_{bit}. The time for the transmit circuit to return to its off state impedance shall not exceed 4,0 T_{bit}. For the purposes of testing, this requirement shall be met with the transmit circuit test configuration of 13.4.1 with the equivalent capacitance of a maximum length cable across the DUT terminals.

NOTE 2 This requirement is to ensure that the transition of the transmit circuit from active to passive leaves the line capacitance fully discharged.

13.5 MAU receive circuit specification

13.5.1 General

For ease of reference the requirements of 13.4 are summarized in Table 75.

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Table 75 – Receive circuit specification summary

Receive circuit characteristics (values referred to trunk)	Limits (bus-powered and/or IS)
Input impedance, measured over the frequency range 0,25 f_r to 1,25 f_r	≤2,5 Ω
Sensitivity; min. peak-to-peak signal required to be accepted (see Figure 60)	1,3 mA
Noise rejection; max. peak-to-peak noise required to be rejected (see Figure 60)	0,8 mA
Maximum received bit cell jitter (zero crossing-point deviation, see Figure 71)	±0,10 T_{bit}

13.5.2 Input impedance

The differential input impedance of a current-mode MAU receive circuit shall not exceed 2,5 Ω in series with the line over the frequency range 0,25 f_r to 1,25 f_r. (250 kHz to 1,25 MHz) This requirement shall be met in the power-off and power-on (not transmitting) states and in transition between these states. This impedance shall be measured at the inductive coupler using a sinusoidal current waveform with an amplitude greater than the receiver sensitivity threshold and lower than 20 mA peak-to-peak.

NOTE The requirement for ≤2,5 Ω input impedance during power-up and power-down may be met by automatic disabling of the transmitter during these periods.

13.5.3 Receiver sensitivity and noise rejection

An MAU receive circuit shall be capable of accepting an input signal from 1,3 mA peak-to-peak to 20,0 mA peak-to-peak, including overvoltage and oscillation (see "signal level" together with "positive amplitude" and "negative amplitude", all in Figure 57).

An MAU receive circuit shall not respond to an input signal with a peak-to-peak line current amplitude which does not exceed 0,8 mA (see "noise rejection" in Figure 60).

13.5.4 Received bit cell jitter

The receive circuit shall accept a Manchester encoded signal transmitted in accordance with 13.2 and 13.4. In addition, the receiver shall work properly with signals with the time variation between any two adjacent signal transition points (zero crossing) of ±0,10 T_{bit} or less. See Figure 71.

NOTE 1 This does not preclude the use of receivers that perform better than this specification.

NOTE 2 Depending on the symbol pattern, the nominal time between zero crossings is one-half or one bit time.

NOTE 3 There is no requirement to reject a signal with a specified time variation value. The receiver reports an error when the received bit cell jitter exceeds the receiver's ability to reliably decode signaling.

13.5.5 Interference susceptibility and error rates

When the fieldbus is operating in a variety of standard noise environments the probability that an Application Layer User Data Unit contains an undetected error, due to operation of the conveying Physical and DLL entities, should be less than 1 in 10^{12} (1 error in 20 years at 1 600 messages/s).

A communication element is regarded as conforming to this theoretical requirement when it meets the following interference susceptibility requirements. These are specified by a detected frame error rate which is derived by using a ratio of detected to undetected errors of 10^6.

NOTE 1 This is readily achievable with a 16 bit Frame Check Sequence at the DLL.

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A communication element which includes a current-mode MAU, operating with frames containing 64 random user data bits, with maximum frame rate and with signals of 4,0 mA peak-to-peak amplitude, shall produce no more than 3 detected frame errors in 3×10^6 frames during operation in the presence of common mode voltage or Gaussian noise as follows:

a) a common-mode sinusoidal signal of any frequency from 63 Hz to 2 MHz, with an amplitude of 4 V r.m.s. and from 47 Hz to 63 Hz with an amplitude of 250 V r.m.s.;

b) a common-mode d.c. signal of ±10 V;

c) white Gaussian additive differential noise in the frequency band 1 kHz to 4 MHz, with a noise density of 0,09 µA/√Hz r.m.s. using the test circuit of Figure 72.

NOTE 2 The common mode voltage and Gaussian noise specifications are for receive circuit conformance testing with balanced loads and are not indicative of system installation practice.

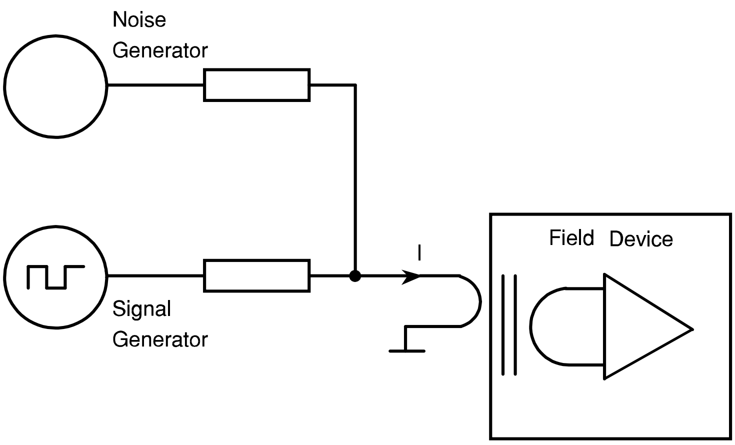

Figure 72 – Noise test circuit for current-mode MAU

A communication element which includes a current-mode MAU, operating with frames containing 64 random user data bits, at an average of 1 600 messages/s, with signals of 4,0 mA peak-to-peak amplitude, shall produce no more than six detected frame errors in 100 000 frames during operation in the presence of electromagnetic or electrical interference environments as follows:

1) 10 V/m electromagnetic field as specified in IEC 61000-4-3 at severity level 3;

2) electrical fast transient as specified in IEC 61000-4-4 at severity level 3.

The above error-rate specification shall also be satisfied after but not during operation in the following noise environments:

i) 8 kV electrostatic discharge to exposed metalwork as specified in IEC 61000-4-2 at severity level 3. If the device suffers temporary loss of function or performance as a result of this test it shall recover from any such loss without operator intervention within 3 s after the end of the test;

ii) high-frequency disturbance tests as specified in IEC 60255-22-1:1988, Test voltage class III (2,5 kV and 1 kV peak values of first half-cycle in longitudinal and transverse mode respectively). If the device suffers temporary loss of function or performance because of this test it shall recover from any such loss without operator intervention within 3 s after the end of the test.

13.6 Jabber inhibit

The MAU shall contain a self-interrupt capability to inhibit transmitted signals from reaching the medium. Hardware within the MAU (with no external message other than the detection of output signals or leakage via the transmit function) shall provide a window of between 5 ms and 15 ms during which time a normal frame may be transmitted. If the frame length exceeds

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this duration, the jabber inhibit function shall inhibit further output signals from reaching the medium and shall disable echo on the RxS line (see 10.2.2.2) to indicate jabber detection to the MDS.

The MAU shall reset the self-interrupt function after a period of 500 ms ± 50 %.

NOTE This inhibits bus traffic for no more than 6 % (= 15/250) of the available time.

13.7 Power distribution

13.7.1 General

A device can optionally receive power via the signal conductors or be separately powered.

A device can be certified as Intrinsically safe with either method of receiving power.

This standard does not include requirements for IS certification but seeks to exclude conditions or situations that would prevent IS certification.

A separately powered device can be connected to a powered fieldbus.

For ease of reference, the requirements of 13.7 are summarized in Table 76.

Table 76 – Network power supply requirements

Network power supply requirements	Limits
Output current	50 mA to 200 mA r.m.s.
Output frequency	16 kHz ± 0,5 %
Maximum output voltage, IS	Depends on barrier rating
Harmonic distortion of supply current	≤ 0,2 %
Output impedance, measured over the frequency range 0,25 f_r to 1,25 f_r	≤ 5 Ω

13.7.2 Powered via signal conductors

A device shall operate over a range of constant current, from 50 mA to 200 mA.

NOTE The output voltage from the supply is a function of cable loss and power consumed per device.

A fieldbus device may be designed to consume one or more standard loads. A standard load is 100 mW.

The power-supply open-circuit output voltage shall be less than the limit specified by the local regulatory agency for the particular implementation. The output impedance of the power supply shall be ≤5 Ω over the frequency range 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz).

The voltage drop in the signal coupler shall be less than 0,1 V at 16 kHz.

The voltage drop in the terminations shall be less than 0,3 V at 16 kHz.

The power waveform shall be a clean sinusoid of frequency 16 kHz ± 0,5 % and maximum harmonic distortion of 0,2 %.

The device shall not introduce harmonic components of the power frequency larger than 1,0 mV peak-to-peak line to line in the main trunk.

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13.7.3 Powered separately from signal

NOTE Power distribution to non-bus powered fieldbus devices is by separate conductors feeding local power supplies, regulators or safety barriers. IS certification may require these conductors to be in a separate cable from the signal conductors and may also impose more stringent requirements for current levels than specified.

A separately powered fieldbus device which claims conformance to Clause 13 shall drop no more than 1 mV r.m.s. at the power frequency on the signal conductors nor shall it supply a current of more than 100 μA r.m.s. to the signal conductors when not transmitting.

13.7.4 Electrical isolation

All fieldbus devices, whether separately powered or powered via the signal conductors, shall provide low-frequency isolation between ground and the fieldbus trunk cable.

NOTE 1 This is possible by use of an inductive coupler with sufficient isolation, by isolation of the entire device from ground or by use of a transformer, opto-coupler or some other isolating component between trunk cable and device.

A combined power supply and communication element shall not require electrical isolation.

The isolation impedance measured between the shield of the fieldbus cable and the fieldbus device ground shall be greater than 250 kΩ at all frequencies below 63 Hz.

The isolation shall be bypassed at high frequencies by capacitance, so that the impedance measured between the shield of the fieldbus cable and the fieldbus device ground shall be less than 15 Ω between 3 MHz and 30 MHz.

NOTE 2 The capacitance between ground and trunk cable shield necessary to meet both these requirements can be any value between 3,5 nF and 10,6 nF.

The maximum unbalanced capacitance to ground from either input terminal of a device shall not exceed 250 pF.

The breakdown requirements of the isolation of the signal circuit and the power distribution circuit from ground and from each other shall be in accordance with IEC 61131-2.

The equivalent test voltage is to be applied between independent isolated circuits or between isolated circuits and accessible conducting parts.

NOTE 3 For circuits with a nominal voltage ≤ 50 V d.c. or r.m.s., the equivalent test voltages at sea level are 444 V r.m.s., 635 V d.c. and 635 V peak impulse test. For circuits with a nominal voltage between 150 V and 300 V r.m.s., the equivalent test voltages at sea level are 2 260 V r.m.s., 3 175 V d.c. and 3 175 V peak impulse test.

13.8 Medium specifications

13.8.1 Connector

Cable connectors, if used, shall be to the IEC fieldbus standard (see Annex A). Field termination techniques such as screw or blade terminals and permanent termination may also be used.

13.8.2 Standard test cable

The cable used for testing fieldbus devices with a current-mode MAU for conformance to the requirements of Clause 13 shall be a single twisted pair cable with overall shield meeting the following minimum requirements at 25 °C:

a) Z_0 at 0,25 f_r (250 kHz) = 150 Ω ± 10 %;

b) Z_0 at 1,25 f_r (1,25 MHz) = 150 Ω ± 10 %;

c) maximum attenuation at 0,25 f_r (250 kHz) = 6,5 dB/km;

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d) maximum attenuation at 1,25 f_r (1,25 MHz) = 13 dB/km;
e) maximum capacitive unbalance to shield = 1,5 nF/km
f) maximum d.c. resistance (per conductor) = 57,1 Ω/km;
g) conductor cross-sectional area (wire size) = nominal 0,33 mm^2;
h) minimum resistivity between either conductor and shield = 16 GΩ/km;
i) minimum shield coverage shall be 95 %.

The preceding specification is for conformance testing an MAU. Other types of cable may be used in real installations. (See Annex B.) Cables with improved specifications may enable increased trunk length and/or superior interference immunity. Conversely, cables with inferior specifications may be used subject to length limitations for both trunk and spurs plus possible non-conformance to the RFI/EMI susceptibility requirements.

For intrinsically safe applications the inductance/resistance ratio (L/R) should be less than the limit specified by the local Regulatory Agency for the particular implementation.

13.8.3 Coupler

An inductive coupler connects one device or spur to the trunk. It transfers data signals to and from the device and may transfer power to the device. The trunk cable operates as a single primary turn in the inductive coupler transformer. The following options are permitted:

a) the coupling may be performed without violation of the cable insulation;
b) the inductive coupler may be used as a connector;
c) an IS barrier element may be included as an integral part of the inductive coupler.

The coupler shall be an integral part of the MAU if the device is connected in the trunk. The input impedance of the coupler shall be a maximum of 2,5 Ω in series with the line.

13.8.4 Splices

NOTE A splice is any part of the network in which the characteristic impedance of the network cable is not preserved. This is possibly due to separation of the cable conductors, removal of the cable shield, change of wire gauge or type, connection to spurs, etc. A practical definition of a splice is therefore any part of the network that is not a continuous length of the specified medium.

The continuity of all conductors of the cable shall be maintained in a splice.

13.8.5 Terminator

A terminator shall be located at both ends of the trunk cable, connected from one signal conductor to the other. No connection shall be made between terminator and cable shield.

For test purposes, using the cable specified in 13.8.2, the terminator shall have an impedance value of 120 Ω ± 2 % over the frequency range 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz).

NOTE 1 The terminator resistance value was selected to be lower than the test cable characteristic impedance value because the current-mode devices add impedances in series with the terminator. The value was chosen to reduce transmission line reflections for a fieldbus with 2 to 32 devices.

NOTE 2 In practical implementations with power supplied via the signal conductors the terminator would be by-passed at power frequencies to minimize power losses.

The direct current leakage through the terminator shall not exceed 100 μA. The terminator shall be non-polarized.

All terminators used for IS applications shall comply with isolation requirements (creepage and clearance) commensurate with the required IS approval. Terminators for non-IS applications shall not be required to have IS approval.

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13.8.6 Shielding rules

For full conformance to the noise immunity requirements of 13.5 it is necessary to ensure the integrity of shielding throughout the cabling, connectors and couplers by the following means:

a) the coverage of the cable shield shall be greater than 95 % of the full cable length;

b) shielding shall completely cover the electrical circuits in connectors, couplers, and splices.

NOTE Deviation from these shielding rules may degrade noise immunity.

13.8.7 Grounding rules

NOTE 1 Grounding means permanently connected to earth through a sufficiently low impedance and with sufficient current-carrying capability to prevent voltage build-up which might result in undue hazard to connected equipment or persons.

Zero volts (common) lines may be connected to ground where they are galvanically isolated from the fieldbus trunk.

Fieldbus devices shall be required to function to the requirements of Clause 13 with the mid-point of one terminator or one inductive coupler connected directly to ground.

Fieldbus devices shall not connect either conductor of the twisted pair to ground at any point in the network. Signals shall be applied and preserved differentially throughout the network.

It is standard practice for the shield of the fieldbus trunk cable (if applicable) to be effectively grounded at one point along the length of the cable. For this reason fieldbus devices should allow d.c. isolation of the cable shield from ground.

For bus-powered systems the grounding of the shield and balanced signal conductors should be close to the power supply unit.

For IS systems the grounding should be at the safety barrier earth connection. Capacitive coupling between the shield or the balanced signal conductors and device local ground for EMI control is permitted subject to IS requirements.

13.8.8 Color coding of cables

See 11.8.8.

14 Type 1: Medium attachment unit: current mode (1 A), twisted-pair wire medium

14.1 General

A 1,0 Mbit/s current-mode MAU simultaneously provides access to a communication network, and to a power distribution network with extended power capacity. Devices attached to the network communicate via the medium, and may or may not be powered from it. Power is distributed as a constant a.c. current with a frequency far below the signal frequency. The communication signals are superimposed on the a.c. power.

The network medium consists of shielded twisted-pair cable.

In hazardous area applications, a non-IS bus may have IS barriers incorporated in connected devices thereby increasing the number of devices permissible in the hazardous area over a single barrier arrangement.

The devices are connected in series on the bus, whereas in the voltage-mode variants the devices are connected in parallel to the bus.

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14.2 Transmitted bit rate

See 13.2.

14.3 Network specifications

14.3.1 Components

An MAU operates in a network composed of the following components:

a) cable;
b) terminators;
c) couplers;
d) coupler mounts;
e) devices (containing at least one communication element).

A wire network in current mode may additionally include the following components:

f) connectors;
g) power supplies;
h) devices which include power supplies;
i) intrinsic safety (IS) barriers.

The network medium consists of shielded twisted-pair cable. Independent of topology, all attached devices, other than possibly the transmitting device, are low impedance to prevent significant network loading.

A coupler mount is a network element that allows a coupler to be connected to the network medium. It may be considered as a primary winding in a transformer (inductive coupler) and has, as such, electrical characteristics that affect the network.

14.3.2 Topologies

A wire MAU shall operate in a network with a linear bus topology, consisting of a trunk, terminated at each end as specified in 14.8.5, to which communication elements are connected via couplers.

The coupler and communication element may be integrated in one device (such as zero-length spur).

Several communication elements may be connected to the trunk at one point, using a multiport coupler. An active coupler may be used to extend a spur to a length that requires termination to avoid reflections and distortions. Active repeaters may be used to extend the length of the trunk beyond that of a single segment, as permitted by the network configuration rules.

14.3.3 Network configuration rules

An MAU that claims conformance to Clause 14 shall meet the requirements of Clause 14 when used in a network that complies with these rules.

Rule 1: One fieldbus shall be capable of communication between two and 30 devices, all operating at the same bit rate, for both a powered and a non-powered bus, and in a hazardous area using distributed barriers.

NOTE 1 This rule does not preclude the use of more than the specified number of devices in an installed system. The numbers of devices were calculated on the assumption that a bus-powered device draws 1,0 W.

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Rule 2: A fully loaded (maximum number of connected devices), current-mode fieldbus segment shall have a total cable length, between any two devices, of up to 400 m.

NOTE 2 400 m maximum cable length is the requirement for conformance to Clause 14, but this does not preclude the use of longer lengths in an installed system.

Rule 3: The total number of waveform regenerations by repeaters and active couplers between any two devices is repeater implementation dependent.

NOTE 3 Prior editions of this standard limited this total number to five.

Rule 4: The maximum propagation delay between any two devices shall not exceed 40 Tbit.

For efficiency of the network, that part of the turnaround time of any device on the network caused by a PhE between the end of a received frame and the beginning of the transmitted frame containing an associated immediate response should not exceed five bit times, no more than two bit times of which should be due to the MAU.

NOTE 4 As it is not mandatory to expose the DLL-PhL interface, or the MDS-MAU interface, that part of the turnaround time of a fieldbus device caused by the PhL or the MAU is not specified, and thus not available for conformance testing.

Rule 5: The fieldbus shall be capable of continued operation while a device is being connected or disconnected. Data errors induced during connection or disconnection shall be detected.

Rule 6: Failure of any communication element or spur (including a short circuit or open circuit, but excluding jabber) shall not interfere with transactions between other communication elements for more than 1 ms.

Rule 7: The network shall not be polarity sensitive with or without power injected on the line.

Rule 8: The degradation of the electrical characteristics of the signal, between any two devices, due to attenuation, attenuation distortion and mismatching shall be limited to the values indicated below.

a) Signal attenuation: the signal attenuation due to each device shall not exceed 0,35 dB. The signal attenuation due to each full or empty coupler mount shall not exceed 0,6 dB. The configuration of the bus (trunk and spur lengths, number of devices, IS barriers, galvanic isolators, and possible matching devices) shall be such that the attenuation between any two devices at the frequency corresponding to the bit rate shall not exceed 10 dB.

   NOTE 5 The signal attenuation due to a device is with a cable of 80 Ω characteristic impedance. If a lower impedance cable is used, then the attenuation per device will increase.

   It will be required that the devices be connected to the bus using a mount to reach the maximum number of connected devices.

b) Attenuation distortion: the configuration of the bus (trunk and spur lengths and number of devices) shall be such that between any two devices:

   [Attenuation (1,25 f_r) – Attenuation (0,25 f_r)] ≤ 6 dB

   Attenuation (1,25 f_r) ≥ Attenuation (0,25 f_r)

   where f_r is the frequency corresponding to the bit rate. Attenuation shall be monotonic for all frequencies from 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz).

c) Mismatching distortion: mismatching (due to spurs or any other effect, including one open-circuit spur of maximum length) on the bus shall be such that, at any point along the trunk, in the frequency band 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz):

   $$|Z - Z_{fr}| / |Z + Z_{fr}| \le 0,2$$

   where

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Z_o is the characteristic impedance of the trunk cable;
Z is the series combination of Z_o and the load impedance at the coupler.

NOTE 6 This rule minimizes restrictions on trunk and spur length, number of devices etc., by specifying only the transmission limitations imposed by combinations of these factors. It is possible to use different combinations, depending on the needs of the application.

Rule 9: The following rules shall apply to systems implemented with redundant media:

a) each channel (cable) shall comply with the network configuration rules;
b) there shall not be a non-redundant segment between two redundant segments;
c) repeaters shall also be redundant;
d) if the system is configured (by systems management) to transmit on more than one channel simultaneously, then the propagation time difference between any two devices on any two channels shall not exceed five bit times;

NOTE 7 This delay is equal to the default value of the inter-channel signal skew (see 9.2.9). The propagation delay difference can be larger, if the inter-channel signal skew parameter is set to match this difference.

e) channel numbers shall be maintained throughout the fieldbus, that is channels 1,2,3… from systems management shall always connect to physical channels 1,2,3…

14.3.4 Power distribution rules for network configuration

See 11.3.4.

14.4 MAU transmit circuit specification

The requirements of Subclause 14.4 are summarized in Table 77 and Table 78.

Table 77 – Transmit level specification summary for current-mode MAU

Transmit level characteristics, values referred to trunk (but measured using test load as shown in Figure 70)	Limits (bus powered and/or IS)
Output level (peak-to-peak, see Figure 57) With test load (>2 × nominal Z_o of trunk cable)	≥2,25 V 160 Ω ± 1 %
Maximum output signal distortion; this is overvoltage, ringing and droop (see Figure 57)	±10 %
Quiescent transmitter output; that is transmitter noise (measured over the frequency band 1 kHz to 4 MHz)	≤1 mV (r.m.s.)

Table 78 – Transmit timing specification summary for current-mode MAU

Transmit level characteristics, values referred to trunk (but measured using test load as shown in Figure 70)	Limits (bus powered and/or IS)
Transmitted bit rate	1 Mbit/s ± 0,01 %
Instantaneous bit time	1 µs ± 0,025 µs
Rise and fall times (10 % to 90 % of peak-to-peak signal, see Figure 57)	≤ 20 % T_{bit}
Slew rate (at any point from 10 % to 90 % of peak-to-peak signal)	≤200,0 V/µs
Maximum transmitted bit cell jitter (zero-crossing point deviation, see Figure 73)	± 2,5 % T_{bit}
Transmit enable/disable time (that is, time during which the output waveform may not meet the transmit requirements)	≤ 2,0 T_{bit}

14.4.1 Configuration

Figure 70 shows the configuration which shall be used for testing.

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The test configuration for Clause 14 shall be as shown in Figure 70 except where otherwise stated in a specific requirement.

NOTE Test load resistance R_L = 160 Ω ± 1 % as the output is loaded by a series loop of the trunk.

14.4.2 Output level requirements

NOTE Figure 57 shows an example of one cycle of a fieldbus waveform, illustrating some key items from the transmit circuit specification. Only signal voltages are shown; this diagram takes no account of power supply voltages.

A current-mode MAU transmit circuit shall conform to the following output level requirements, all amplitudes being measured at the estimated mid-point between any peaks or troughs in the top and bottom of the waveform ("Mid-point" in Figure 57):

a) the output voltage across the test load after transformer step up/down shall be no less than 2,25 V peak-to-peak, with a load resistance of 160 Ω ± 1 % ("min. o/p" in Figure 57);
b) during transmission, a device shall not suffer permanent failure when a load resistance of ≤1 Ω is applied for 1 s;
c) the output noise from a current-mode MAU which is receiving or not powered shall not exceed 1 mV (r.m.s.), measured differentially over the frequency band 100 kHz to 4 MHz, referred to the trunk;
d) the differential voltage across the test load shall be such that the voltage monotonically changes between 10 % and 90 % of peak-to-peak value. Thereafter, the signal voltage shall not vary more than ±10 % of peak-to-peak value until next transition occurs. This permitted variation shall include all forms of output signal distortion, such as overvoltage, ringing and droop.

14.4.3 Output timing requirements

An MAU transmit circuit shall conform to the following output timing requirements:

a) rise and fall times, measured from 10 % to 90 % of the peak-to-peak signal amplitude shall not exceed 0,2 (see Figure 57);
b) slew rate shall not exceed 200,0 V/µs measured at any point in the range 10 % to 90 % of the peak-to-peak signal amplitude (see Figure 57);

transmitted bit cell jitter shall not exceed ±0,025 Tbit from the ideal zero crossing point, measured with respect to previous zero crossing (see Figure 73);

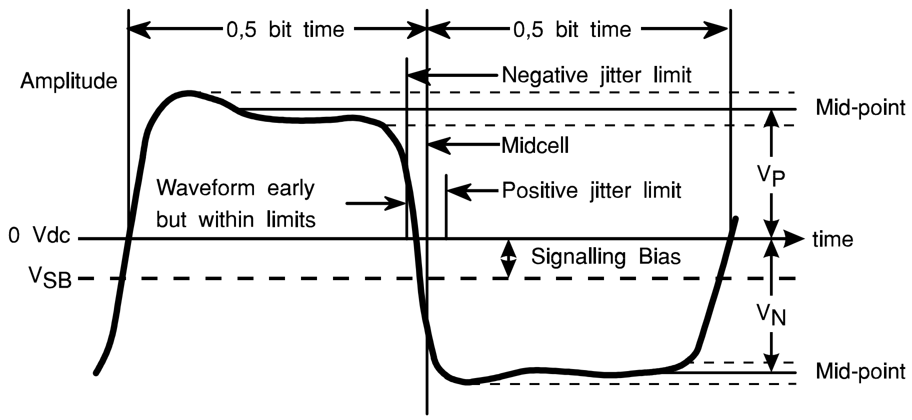

Figure 73 – Transmitted and received bit cell jitter (zero crossing point deviation)

d) the transmit circuit shall turn on, that is the signal shall rise from below the transmit circuit maximum output noise level as specified in 14.4.2 c) to full output level, in less than 2,0 Tbit. The waveform corresponding to the third and later bit times shall be as specified by other Subclauses of 14.4;

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e) the transmit circuit shall turn off, that is the signal shall fall from full output level to below the transmit circuit maximum output noise level as specified in 14.4.2 c), in less than 2,0 Tbit. The time for the transmit circuit to return to its off-state impedance shall not exceed 4,0 Tbit. For the purposes of testing, this requirement shall be met with the transmit circuit test configuration of 14.4.1.

NOTE This requirement is to ensure that the transition of the transmit circuit from active to passive leaves the line capacitance fully discharged.

14.5 MAU receive circuit specification

14.5.1 General

The requirements of Subclause 14.5 are summarized in Table 79.

The input impedance of the receive circuit is allowed to be inductive. To prevent that the resistive part of the impedance becomes too high, both the maximum total input impedance and the maximum input resistance are specified in Table 79.

Table 79 – Receive circuit specification summary for current-mode MAU

Receive circuit characteristics (values referred to trunk)	Limits for current mode (bus powered and/or IS)
Input resistance, measured over the frequency range 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz)	≤0,5 Ω
Sensitivity; min. peak-to-peak signal required to be accepted (see Figure 60)	4,0 mA
Noise rejection; max. peak-to-peak noise required to be rejected (see Figure 60)	2,0 mA
Maximum received bit cell jitter (zero crossing-point deviation, see Figure 71)	±0,10 T_{bit}
Input impedance, measured over the frequency range 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz)	≤4,0 Ω

14.5.2 Input impedance

The differential input resistance of a current-mode MAU receive circuit shall not exceed 0,5 Ω, and the differential input impedance of a current-mode MAU receive circuit shall not exceed 4,0 Ω in series with the line over the frequency 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz).This requirement shall be met in the power-off and power-on (not transmitting) states, and in transition between these states. This impedance shall be measured at the inductive coupler, using a sinusoidal current waveform with an amplitude greater than the receiver sensitivity threshold, and lower than 20 mA peak-to-peak.

14.5.3 Receiver sensitivity and noise rejection

An MAU receive circuit shall be capable of accepting an input signal from 4,0 mA peak-to-peak to 20,0 mA peak-to-peak, including overvoltage and oscillation (see “signal level” together with “positive amplitude” and “negative amplitude”, all in Figure 57).

An MAU receive circuit shall not respond to an input signal with a peak-to-peak line current amplitude which does not exceed 2,0 mA (see “noise rejection” in Figure 60).

14.5.4 Received bit cell jitter

The receive circuit shall accept a Manchester encoded signal transmitted in accordance with 14.2 and 14.4. In addition, the receiver shall work properly with signals with the time variation between any two adjacent signal transition points (zero crossing) of ±0,10 Tbit or less. See Figure 73.

NOTE 1 This does not preclude the use of receivers that perform better than this specification.

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Depending on the symbol pattern, the nominal time between zero crossings may be one-half or one bit time.

NOTE 2 There is no requirement to reject a signal with a specified time variation value. The receiver reports an error when the received bit cell jitter exceeds the receiver's ability to reliably decode signaling.

14.5.5 Interference susceptibility and error rates

See 13.5.5.

14.6 Jabber inhibit

See 13.6.

14.7 Power distribution

14.7.1 General

A device can optionally receive power via the signal conductors, or be separately powered.

A device can be certified as intrinsically safe with either method of receiving power.

NOTE 1 This standard does not include requirements for intrinsic safety certification, but seeks to exclude conditions or situations that would prevent intrinsic safety certification.

A separately powered device can be connected to a powered fieldbus.

NOTE 2 For ease of reference, the requirements of 14.7 are summarized in Table 80.

Table 80 – Network power supply requirements

Network power supply requirements	Limits
Output current	1,0 A r.m.s. ± 5 %
Output frequency	16 kHz ± 0,5 %
Harmonic distortion and noise of supply current	See Figure 74
Output impedance, measured over the frequency range 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz)	≤5 Ω

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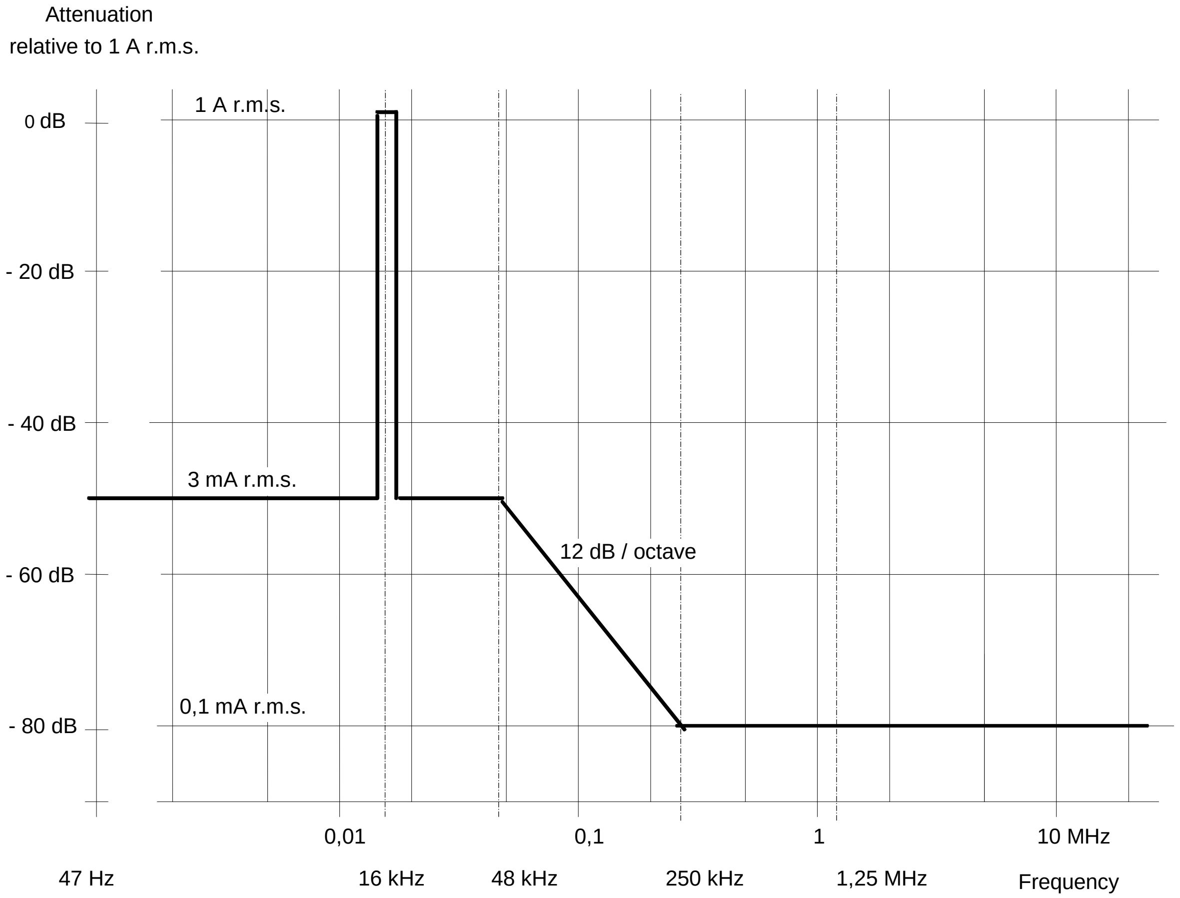

Figure 74 – Power supply harmonic distortion and noise

14.7.2 Powered via signal conductors

A fieldbus device claiming conformance to Clause 14 that is powered via the signal conductors shall conform to the requirements of Clause 14 when powered by a supply with the following specifications.

a) The output current of the power supply shall be a current of 1,0 A r.m.s. ± 5 %.

NOTE 1 The output voltage from the supply is a function of cable loss and power consumed per device.

A fieldbus device may be designed to consume one or more standard loads. A standard load is 1,0 W.

NOTE 2 The power supply open-circuit output voltage will be less than the limit specified by the local regulatory agency for the particular implementation.

b) The output impedance of the power supply shall be ≤5 Ω over the frequency range 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz).

c) The power waveform shall be a sinusoid of frequency and maximum harmonic distortion and noise as follows:

1) 0,1 mA r.m.s. over the frequency range 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz);

2) 3,0 mA r.m.s. over the frequency range 47 Hz to 48 kHz, with the exception of 16 kHz ± 0,5 %;

3) levels at other frequencies in accordance with Figure 74.

The device shall not introduce harmonic components of the power frequency larger than 15 µA r.m.s. in the main trunk.

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14.7.3 Powered separately from signal

NOTE Power distribution to non-bus powered fieldbus devices is by separate conductors feeding local power supplies, regulators or safety barriers. IS certification may require these conductors to be in a separate cable from the signal conductors, and may also impose more stringent requirements for current levels than specified.

A separately powered fieldbus device claiming conformance to Clause 14 shall drop no more than 200 mV r.m.s. at the power frequency on the signal conductors, nor shall it supply a current of more than 100 μA r.m.s. to the signal conductors when not transmitting.

14.7.4 Electrical isolation

See 13.7.4.

14.8 Medium specifications

14.8.1 Connector

See 13.8.1.

14.8.2 Standard test cable

The cable used for testing fieldbus devices with a current-mode MAU for conformance to the requirements of Clause 14 shall be a single twisted-pair cable with overall shield meeting the following minimum requirements at 25 °C:

a) Z_o at 0,25 f_r (250 kHz) = 80 Ω ± 10 %;

b) Z_o at 1,25 f_r (1,25 MHz) = 80 Ω ± 10 %;

c) maximum attenuation at 0,25 f_r (250 kHz) = 11,0 dB/km;

d) maximum attenuation at 1,25 f_r (1,25 MHz) = 20,0 dB/km;

e) maximum d.c. resistance (per conductor) = 15,0 Ω/km;

f) conductor cross-sectional area (wire size) = nominal 1,5 mm^2.

The preceding specification is for conformance testing an MAU. Other types of cable may be used in real installations. (See Annex B.) Cables with improved specifications may enable increased trunk length and/or superior interference immunity. Conversely, cables with inferior specifications may be used, subject to length limitations for both trunk and spurs, plus possible non-conformance to the RFI/EMI susceptibility requirements.

14.8.3 Coupler

See 13.8.3.

14.8.4 Splices

See 13.8.4.

14.8.5 Terminator

A terminator shall be located at both ends of the trunk cable, connected from one signal conductor to the other. No connection shall be made between terminator and cable shield.

For test purposes, using the cable specified in 14.8.2, the terminator shall have an impedance value of 80 Ω ± 2 % over the frequency range 0,25 f_r to 1,25 f_r (250 kHz to 1,25 MHz).

The voltage drop in the terminations shall be less than 0,3 V at 16 kHz.

NOTE In practical implementations with power supplied via the signal conductors, the terminator would be bypassed at power frequencies to minimize power losses.

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The terminator shall be non-polarized.

All terminators used for potentially explosive atmospheres shall comply with requirements commensurate with the required approval documents.

14.8.6 Shielding rules

For full conformance to the noise immunity requirements of 14.5, it is necessary to ensure the integrity of shielding throughout the cabling, connectors and couplers by the following means:

a) the coverage of the cable shield shall be greater than 95 % of the full cable length;

b) shielding shall completely cover the electrical circuits in connectors, couplers, and splices.

NOTE Deviation from these shielding rules may degrade noise immunity.

14.8.7 Grounding rules

See 13.8.7.

14.8.8 Color coding of cables

See 11.8.8.

15 Types 1 and 7: Medium attachment unit: dual-fiber optical media

15.1 General

The network medium consists of a pair of fiber optic waveguides providing bidirectionality by use of a separate fiber for each direction of signal propagation. These are known collectively as an elementary optical path.

In all networks involving more than two devices, the fiber optic waveguides conveying signals from the devices are combined by a passive or active star coupler, then rebroadcast on all the waveguides conveying signals to the devices. A point-to-point link between a pair of devices using a single elementary optical path is also possible.

These dual fibers connect to the CPIC of a fieldbus device. The fiber optic transmission system is itself intrinsically safe.

15.2 Bit-rate-dependent quantities

Six bit rates are defined for a medium attachment unit (MAU) for dual-fiber optical media, where the network medium consists of a pair of unidirectional optical waveguides. A given MAU shall support at least one of these bit rates. Table 81 specifies the supported bit rates, and defines symbols for bit-rate-dependent quantities used throughout of Subclause 15.2:

Table 81 – Bit-rate-dependent quantities of high-speed (≥1 Mbit/s) dual-fiber networks

Quantity	Symbol	Unit	Value					
Nominal bit rate	BR	Mbit/s	0,031 25	1	2,5	5	10	25
Maximum deviation from BR	ΔBR		0,2 %	0,01 %				
Nominal bit duration	T_{bit}	µs	32,0	1,0	0,4	0,2	0,1	0,04
Maximum deviation from T_{bit}	ΔT_{bit}	–	0,025 %	0,015 %				
Maximum propagation delay	PD_{max}	T_{bit}	20	40				

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The average bit rate shall be BR ± ΔBR, averaged over a frame having a minimum length of 16 octets. The instantaneous bit time shall be Tbit ± ΔTbit.

15.3 Network specifications

15.3.1 Components

An optical MAU operates in a network composed of the following components:

a) optical cable;
b) devices (containing at least one communication element);
c) connectors;
d) optical passive stars;
e) optical active stars.

15.3.2 Topologies

An optical MAU shall operate in a network with a star topology, or in a point-to-point network. Devices are connected to the optical stars or peer devices by elementary optical paths. Optical stars are interconnected by elementary optical paths.

15.3.3 Network configuration rules

An MAU that claims conformance to Clause 15 shall meet the requirements of Clause 15 when used in a network that complies with these rules.

Rule 1: All network devices operate at the same bit rate.

Rule 2: The total number of optical active stars between any two devices shall not exceed four.

Rule 3: The maximum propagation delay between any two devices shall not exceed that specified in Table 81.

For network efficiency, the part of the turn-around time of any device on the network caused by a PhE between the end of a received frame and the beginning of the transmitted frame containing an associated immediate response should not exceed five bit times, no more than two bit times of which should be due to the MAU.

NOTE As it is not mandatory to expose either the DLL-PhL interface or the MDS-MAU interface, that part of the turn-around time of a fieldbus device caused by the PhL or the MAU is not specified and thus not available for conformance testing.

Rule 4: The fieldbus shall be capable of continuing operation while a device is being connected or disconnected. Data errors induced during connection or disconnection shall be detected.

Rule 5: The network shall be acyclic, with a single path between any two devices.

Rule 6: The following rules shall apply to systems implemented with redundant media:

a) each channel shall comply with the network configuration rules;
b) there shall not be a non-redundant segment or equipment between two redundant segments;
c) if the devices of the system are configured (by systems management) to transmit on more than one channel simultaneously then the propagation time difference between any two devices on any two channels shall not exceed five bit times;

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d) channel numbers and association with the physical transmission media shall be maintained consistently throughout the fieldbus, i.e. channels 1, 2, 3,… from systems management shall always connect to physical channels 1, 2, 3,…

15.4 MAU transmit circuit specifications

NOTE For ease of reference, the requirements of 15.4 are summarized in Table 82 and Table 83.

15.4.1 Test configuration

The output level, spectral and timing specifications are measured at the end of a 1 m standard test fiber connected to the CPIC.

15.4.2 Output level specification

An optical MAU transmit circuit shall conform to the following output level and spectral requirements. Level and spectral characteristics are measured at a temperature of 25 °C. Output level is the effective launch power of a Hi level. Output level specification is shown in Table 82.

Table 82 – Transmit level and spectral specification summary

Transmit level and spectral characteristics (values referred to the CPIC with standard test fiber)	Limits, using 62,5/125 μm fiber
Peak emission wavelength (λp)	(850 ± 30) nm
Typical half-intensity wavelength (Δλ)	≤50 nm
Effective launch power Hi level	(–11,5 ± 1,5) dBm
Overshoot of transitions	≤15 % effective power
Extinction ratio	≥20:1

15.4.3 Output timing specification

An optical MAU transmit circuit shall conform to the following output timing requirements (see Figure 75). Timing characteristics are measured at a temperature of 25 °C. The output timing specification is shown in Table 83.

Table 83 – Transmit timing specification summary

Transmit timing characteristics (values referred to the CPIC with standard test fiber)	Limits
Transmitted bit rate	BR ± ΔBR
Instantaneous bit time	$T_{bit} \pm \Delta T_{bit}$
Rise and fall times (10 % to 90 % of peak-peak signal)	≤ 2,0 % T_{bit}
Difference between rise and fall times	≤ 0,5 % T_{bit}
Maximum transmitted bit cell jitter	± 2,0 % T_{bit}

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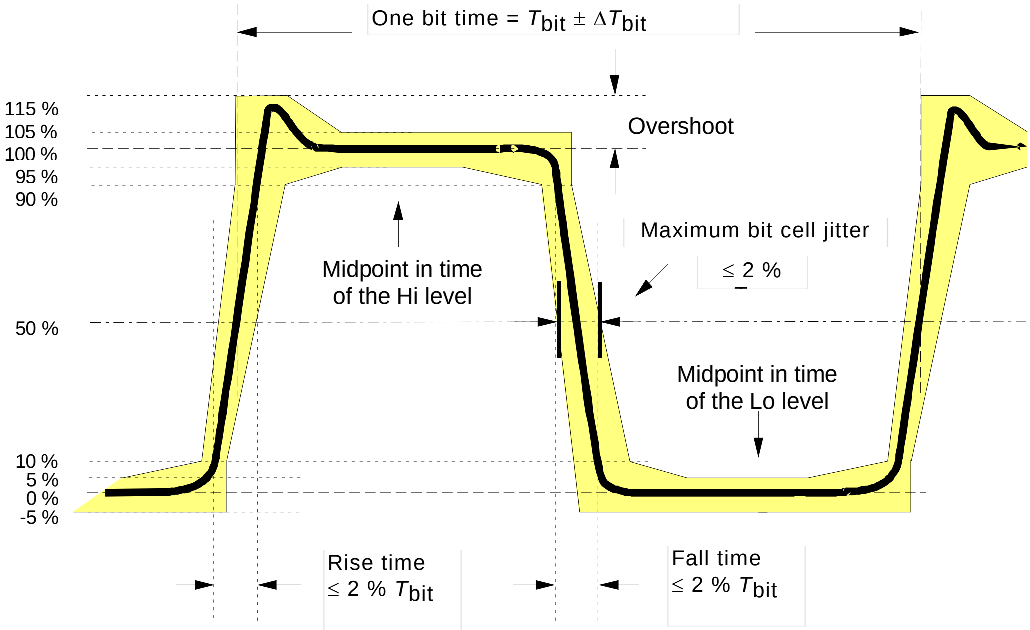

NOTE 0 % effective power is the Lo level state power level.

100 % effective power is the Hi level state power level.

Figure 75 – Optical wave shape template

15.5 MAU receive circuit specifications

15.5.1 General

The requirements of Subclause 15.5 are summarized in Table 84.

Table 84 – Receive circuit specification summary

Receive circuit characteristics (values referred to the CPIC with standard test fiber)	Limits	
	Low sensitivity system	**High sensitivity system**
Receiver operating range	–30,0 dBm to –10,0 dBm	–40,0 dBm to –20,0 dBm
Maximum received bit cell jitter	±14 % Tbit	

15.5.2 Receiver operating range

The specified receiver sensitivity range is

a) –30,0 dBm to –10,0 dBm effective power for low sensitivity;

b) –40,0 dBm to –20,0 dBm effective power for high sensitivity.

15.5.3 Maximum received bit cell jitter

The receive circuit shall accept a Manchester encoded signal transmitted in accordance with 15.4. In addition, the receiver shall accept signals with time variation between two adjacent signal transition points (50 % crossing) of ±14,0 % Tbit or less.

NOTE This does not preclude the use of receivers that perform better than this specification but in accordance with the tolerance of the received bit cell jitter of the MDS (see 9.2.6).

Depending on the symbol pattern, the nominal time between 50 % crossings may be either 1,0 Tbit or 0,5 Tbit.

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15.5.4 Interference susceptibility and error rates

15.5.4.1 Low-speed (31,25 kbit/s)

When the fieldbus is operating in a variety of standard noise environments, the probability that an Application Layer User Data Unit contains an undetected error, due to operation of the conveying Physical and DLL entities, should be less than 1 in 6×10^9 (one error in 20 years at 10 messages/s).

A communication element is regarded as conforming to this theoretical requirement when it meets the following interference susceptibility requirements. These are specified by a detected frame error rate which is derived by using a ratio of detected to undetected errors of 10^6.

A communication element which includes an optical MAU operating at 31,25 kbit/s with frames containing 32 random user data bits, at an average of 10 messages per second, with signals of –25 dBm, shall produce no more than 10 detected frame errors in 60 000 frames during operation in the presence of electromagnetic or electrical interference environments as follows:

a) 10 V/m electromagnetic field as specified in IEC 61000-4-3 at severity level 3;

b) electrical fast transient as specified in IEC 61000-4-4 at severity level 3.

15.5.4.2 High-speed (≥1 Mbit/s)

When the fieldbus is operating in a variety of standard noise environments, the probability that an Application Layer User Data Unit contains an undetected error, due to operation of the conveying Physical and DLL entities, should be less than 1 in 10^{12} (one error in 20 years at 1 600 messages/s).

A communication element is regarded as conforming to this theoretical requirement when it meets the following interference susceptibility requirements. These are specified by a detected frame error rate which is derived by using a ratio of detected to undetected errors of 10^6.

A communication element which includes an optical MAU operating at ≥1 Mbit/s with frames containing 64 random user data bits, at an average of 1 600 messages/s, with signals of -25 dBm, shall produce no more than 6 detected frame errors in 100 000 frames during operation in the presence of electromagnetic or electrical interference environments as follows:

a) 10 V/m electromagnetic field as specified in IEC 61000-4-3 at severity level 3;

b) electrical fast transient as specified in IEC 61000-4-4 at severity level 3.

15.5.4.3 Common

The error rate specifications shall also be satisfied after, but not during, operation in the following noise environments:

a) 8 kV electrical discharge to exposed metalwork as specified in IEC 61000-4-2 at severity level 3. If the device suffers temporary loss of function or performance as a result of this test, it shall recover from any such loss without operator intervention within 3 s after the end of the test;

b) high frequency disturbance tests as specified in IEC 60255-22-1:1988, 3.1 (test voltage class III, 2,5 kV and 1 kV peak values of first half-cycle in longitudinal and transverse mode respectively). If the device suffers temporary loss of function or performance because of this test it shall recover from any such loss without operator intervention within 3 s after the end of the test.

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15.6 Jabber inhibit

The MAU shall contain a self-interrupt capability to inhibit transmitted signals from reaching the medium. Hardware within the MAU (with no external message other than the detection of output signals or leakage via the transmit function) shall provide a window of between 3 750 Tbit and 7 500 Tbit, during which time a normal frame may be transmitted. If the frame length exceeds this duration, the jabber inhibit function shall inhibit further output signals from reaching the medium and shall disable echo on the RxS line (see 10.2.2.2) to indicate jabber detection to the MDS.

For a data rate of 31,25 kbit/s, the MAU shall reset the self-interrupt function after a period of 3 s ± 50 %.

NOTE 1 This inhibits bus traffic for no more than 8 % (≈ 1/12,5) of the available time.

For a data rate of 1 Mbit/s or greater, the MAU shall reset the self-interrupt function after a period of 500 000 Tbit ± 50 %.

NOTE 2 This inhibits bus traffic for no more than 3 % (≈ 1/32) of the available time.

15.7 Medium specifications

15.7.1 Connector

Cable connectors, if used, shall be in accordance with this standard (see Annex A). Permanent terminations (splices) may also be used.

15.7.2 Standard test fiber

The cable used for testing fieldbus devices or optical active stars with an optical MAU, for conformance to the requirements of Clause 15, shall be a 1 m fiber optic cable with two silica fiber optic waveguides. The characteristics of those waveguides shall be compatible with IEC 60793 [fiber type: A1b (62,5/125 μm)] as follows:

– core diameter (μm): 62,5 ± 3
– cladding diameter (μm): 125 ± 3
– core/cladding concentricity (%): ≤6
– no circularity core (%): ≤6
– no circularity cladding (%): ≤2
– external primary coating diameter (μm): 250 ± 15
– numerical aperture: 0,275 ± 0,015
– attenuation for 850 nm (dB/km): ≤3,0
– bandwidth for 850 nm (MHz x km): ≥200

Alternate test fibers are allowed.

NOTE Operation using a 50 μm or 100 μm alternate test fiber is described in Annex E.

15.7.3 Optical passive star

NOTE For more information, see Annex C.

15.7.4 Optical active star

15.7.4.1 Definition

An opto-electronic device or module in an optical communication system, that receives a signal, amplifies it and retransmits it (retiming is optional).

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15.7.4.2 Operating

Three types of link shall be considered.

a) Link between two optical active stars

Any frame coming directly from an optical active star and reaching an optical access of another optical active star is retransmitted without feedback (the access which receives the frame does not retransmit that frame).

b) Link between an optical active star and a fieldbus device

Any frame coming from an optical active star and reaching a fieldbus device is received and not retransmitted. Any frame coming from a fieldbus device and reaching an optical active star is retransmitted without feedback.

c) Link between an optical passive star and an optical active star

Any frame coming from an optical passive star and reaching an optical active star is retransmitted without feedback. A passive star reflects all frames by design. An optical active star shall not retransmit the feedback signs of an optical passive star.

Regenerative functions

An optical active star restores signals to standard transmit power levels. The timing characteristics (jitter) can be regenerated or not; that function is optional.

15.7.4.3 Transmit and receive characteristics

The following characteristics are given:

a) Level characteristics

Transmit and receive level specifications are the same as those of an optical MAU (15.4.2 and 15.5.2). Level and spectral characteristics are measured at a temperature of 25 °C. These specifications are summarized in Table 85.

Table 85 – Transmit and receive level and spectral specifications for an optical active star

Transmit level and spectral characteristics (values referred to the CPIC with standard test fiber)	Limits, with 62,5/125 μm fiber	
Peak emission wavelength (λp)	(850 ± 30) nm	
Typical half-intensity wavelength (Δλ)	≤50 nm	
Extinction ratio	≥20:1	
Effective launch power Hi level	(–11,5 ± 1,5) dBm	
Receiver operating range (effective power)	Low sensitivity system	High sensitivity system
	–30,0 dBm to –10,0 dBm	–40,0 dBm to –20,0 dBm

b) Timing characteristics

Transmit and receive timing specifications of an optical active star concern (see Table 86):

– rise and fall times of the transmitted signal;

– temporal deformation of signals due to an optical active star.

Timing characteristics are measured at a temperature of 25 °C. For optical active stars that have a timing regenerative function, the timing characteristics are the same as those of an optical MAU.

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Table 86 – Timing characteristics of an optical active star

Timing characteristics (values referred to the CPIC)	Limits
Rise and fall times of transmitted signals (10 % to 90 % of peak-peak signal)	≤2 % Tbit
Maximum temporal deformation between optical input ports and optical output ports (see Note 1)	±3 % Tbit
Propagation time of a data bit between an optical input port and any output ports for an active star with timing regenerative function (see NOTE 2)	≤2 Tbit
Maximum transmitted bit cell jitter for an optical active star with timing regenerative function (see Note 2)	±2,0 % Tbit
NOTE 1 The temporal deformation due to an optical active star is the temporal difference of width of a same physical bit, bit pattern, waveform, or other appropriate term. NOTE 2 Only for optical active stars with timing regenerative function.	

16 Type 1: Medium attachment unit: 31,25 kbit/s, single-fiber optical medium

16.1 General

The network medium consists of a set of bidirectional single-fiber optic waveguides, each known as an elementary optical path.

In all networks involving more than two devices, the fiber optic waveguides conveying signals from the devices are combined by a reflective passive star coupler, where the received signals are retransmitted on all the fiber optic waveguides to the devices. A point-to-point link between a pair of devices using a single elementary optical path is also possible.

These bidirectional single fibers connect to the CPIC of a fieldbus device. The fiber optic transmission system is itself intrinsically safe.

16.2 Transmitted bit rate

The transmitted bit rate, BR ± ΔBR, shall be 31,25 kbit/s ± 0,2 %, averaged over a frame having a minimum length of 16 octets. The instantaneous bit time, Tbit ± ΔTbit, shall be 32 µs ± 0,025 %.

16.3 Network specifications

16.3.1 Components

See 15.3.1.

16.3.2 Topologies

See 15.3.2.

16.3.3 Network configuration rules

An MAU that claims conformance to Clause 16 shall meet the requirements of Clause 16 when used in a network that complies with these rules.

The rules are the same as 15.3.3, except as follows.

16.4 MAU transmit circuit specifications

NOTE For ease of reference, the requirements of 16.4 are summarized in Table 87 and Table 83.

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16.4.1 Test configuration

See 15.4.1.

16.4.2 Output level specification

An optical MAU transmit circuit shall conform to the following output level and spectral requirements. Level and spectral characteristics are measured at a temperature of 25 °C. Output level is the effective launch power of a Hi level. Output level specification is shown in Table 87.

Table 87 – Transmit level and spectral specification summary

Transmit level and spectral characteristics (values referred to the CPIC with standard test fiber)	Limits for 31,25 kbit/s (100/140 μm fiber)
Peak emission wavelength (λp)	(850 ± 30) nm
Typical half-intensity wavelength (Δλ)	≤50 nm
Effective launch power Hi level	(–13,5 ± 1,0) dBm
Overshoot of transitions	≤15 % effective power
Extinction ratio	≥20:1

16.4.3 Output timing specification

An optical MAU transmit circuit shall conform to the following output timing requirements (see Figure 75). Timing characteristics are measured at a temperature of 25 °C. The output timing specification is shown in Table 83.

16.5 MAU receive circuit specifications

16.5.1 General

The requirements of 16.5 are summarized in Table 84, but relative to the standard 100/140 μm test fiber of Clause 16.

16.5.2 Receiver operating range

The specified receiver sensitivity range is

a) –30,0 dBm to –12,5 dBm effective power for low sensitivity;

b) –40,0 dBm to –20,0 dBm effective power for high sensitivity.

16.5.3 Maximum received bit cell jitter

See 15.5.3.

16.5.4 Interference susceptibility and error rates

See 15.5.4.1 and 15.5.4.3.

16.6 Jabber inhibit

The requirement is the same as 15.6, except as follows:

The MAU shall reset the self-interrupt function after a period of 3 s ± 50 %.

NOTE This inhibits bus traffic for no more than 8 % (≈ 1/12,5) of the available time.

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16.7 Medium specifications

16.7.1 Connector

See 15.7.1

16.7.2 Standard test fiber

Silica fiber optic waveguide whose nominal characteristics are compatible with IEC 60793 [fiber type: A1d (100/140 μm)].

The cable used for testing fieldbus devices or optical active stars with an optical MAU, for conformance to the requirements of Clause 16, shall be a 1 m fiber optic cable with one fiber optic waveguides, whose characteristics are as follows:

– core diameter (μm): 100 ± 5
– cladding diameter (μm): 140 ± 4
– core/cladding concentricity (%): ≤6
– no circularity core (%): ≤6
– no circularity cladding (%): ≤4
– numerical aperture: 0,26 ± 0,03
– attenuation for 850 nm (dB/km): ≤4,0
– bandwidth for 850 nm (MHz x km): ≥100

Alternate test fibers are allowed.

NOTE Operation using a 50 μm or 62,5 μm alternate test fibers is described in Annex E.

16.7.3 Optical passive star

NOTE For more information, see Annex C.

16.7.4 Optical active star

16.7.4.1 Definition

Subclause 15.7.4.1 applies.

16.7.4.2 Operating

Subclause 15.7.4.2 applies.

16.7.4.3 Transmit and receive characteristics

16.7.4.3.1 Level characteristics

Transmit and receive level specifications are the same as those of an optical MAU (see 16.4.2 and 16.5.2). Level and spectral characteristics are measured at a temperature of 25 °C. These specifications, summarized in Table 88.

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Table 88 – Transmit and receive level and spectral specifications for an optical active star

Transmit level and spectral characteristics (values referred to the CPIC with standard test fiber)	Limits, with 100/140 μm fiber	
Peak emission wavelength (λp)	(850 ± 30) nm	
Typical half intensity wavelength (Δλ)	≤50 nm	
Extinction ratio	≥20:1	
Effective launch power Hi level	(–13,5 ± 1,0) dBm	
Receiver operating range (effective power)	Low sensitivity system	High sensitivity system
	–30,0 dBm to –12,5 dBm	–40,0 dBm to –20,0 dBm

16.7.4.3.2 Timing characteristics

The timing characteristics of 15.7.4.3 apply.

17 *Void*

NOTE Clause 17 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the clause numbering of the prior edition.

18 Type 2: Medium attachment unit: 5 Mbit/s, voltage-mode, coaxial wire medium

18.1 General

Only one attachment method is specified for the 5 Mbit/s, voltage-mode, coaxial wire medium. Other methods may be used but they shall conform to the same signaling and performance characteristics. If the specified coaxial wire medium attachment method is used, then it shall incorporate transformer coupling at the node and it shall use a Passive Tap for attachment to the medium. The tap shall include a 1 m spur.

The 5 Mbit/s, voltage-mode, coaxial wire PhL variant shall connect to coaxial wire medium with network segments up to 1 km long with up to 48 nodes (see 18.5).

NOTE The physical layer can be implemented to allow certification for operation in explosive atmospheres, without sacrificing distance or reducing the number of nodes. This standard does not include requirements for intrinsic safety certification, but seeks to exclude conditions or situations that would prevent intrinsic safety certification.

The MAU shall consist of a transceiver, transformer, and connector as shown in Figure 76. The transceiver shall use the signals defined in the MDS-MAU interface to generate those necessary to drive the transformer. Attachment to the medium shall be via BNC or TNC connectors as specified in Annex F. Ground isolation shall be provided via the transformer as specified in 18.3.

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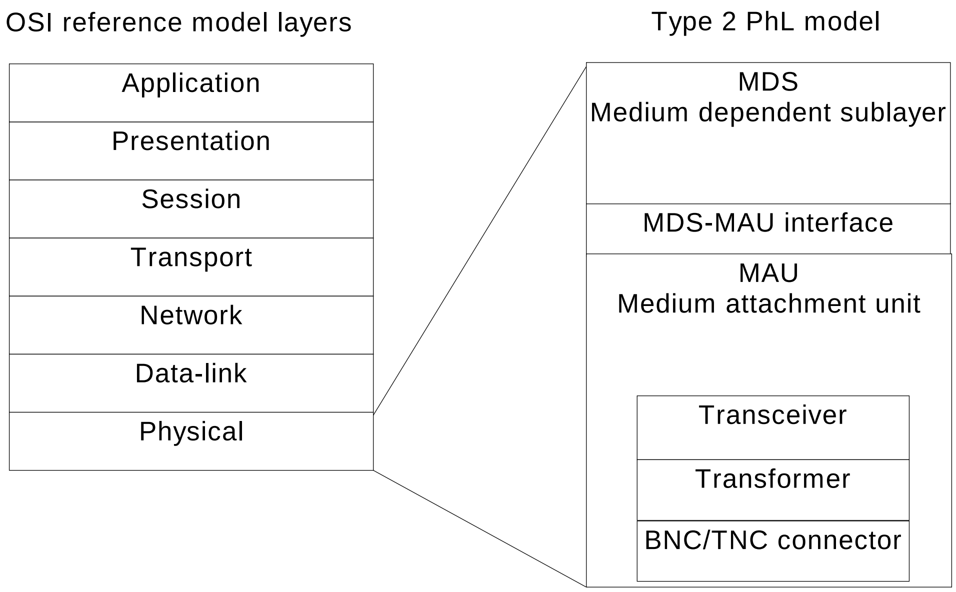


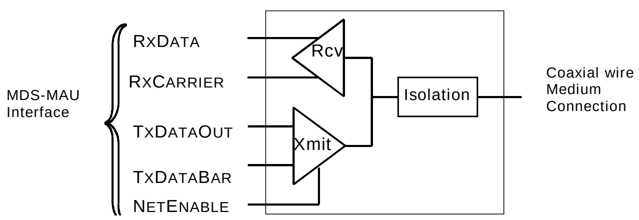
Figure 76 – Components of 5 Mbit/s, voltage-mode, coaxial wire PhL variant

18.2 Transceiver: 5 Mbit/s, voltage-mode, coaxial wire

When using a 5 Mbit/s, voltage-mode, coaxial wire medium, a coaxial wire transceiver shall be used to transmit and receive the L and H signals. The transmitter portion of the transceiver shall obtain transmit signals from the MDS-MAU interface, representing H and L symbols. It shall transmit a single-ended, ground-isolated signal onto the cable via the isolation transformer. The complement of this function shall be performed in the receiver that shall provide RxData and RxCarrier indications to the MDS-MAU interface.

A functional block diagram depicting the MAU sublayer components is shown in Figure 77.

NOTE 1 Figure H.3 shows an example of a redundant transceiver and Figure H.4 shows an example of a single channel transceiver.



NOTE The blocks labeled Xmit and Isolation combine to represent the transmitter.

Figure 77 – Coaxial wire MAU block diagram

Figure 78 shows a simplified functional diagram of the transmitter.

NOTE 2 Refer to the example schematics found in Figure H.3 and Figure H.4 for more detail.

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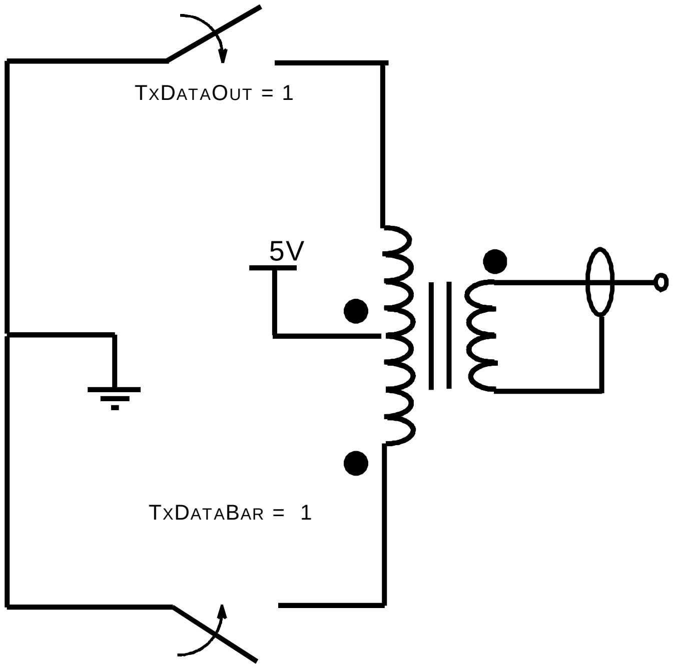

Figure 78 – Coaxial wire MAU transmitter

Three signals shall be available at the MDS-MAU interface for controlling transmission onto the medium, TxDataOut, TxDataBar, and NetEnable. These three transmit signals, when connected to the transceiver, shall define the physical symbols on the wire. The relationship between these transceiver request lines and the signals on the medium shall be as specified in Table 89.

Table 89 – Transmit control line definitions 5 Mbit/s, voltage-mode, coaxial wire

TxDataOut	TxDataBar	NetEnable	Physical symbol	Signal on medium
don't care(x)	don't care(x)	false(0)	none	Transmitter off, see Table 92.
false(0)	false(0)	true(1)	none	Transmitter off, see Table 92.
true(1)	false(0)	true(1)	H	+ voltage (positive), see Table 92.
false(0)	true(1)	true(1)	L	- voltage (negative), see Table 92.
true(1)	true(1)	true(1)	not allowed (see note)	Not allowed (see note)
NOTE This state can result in damage to the transmitter circuitry.				

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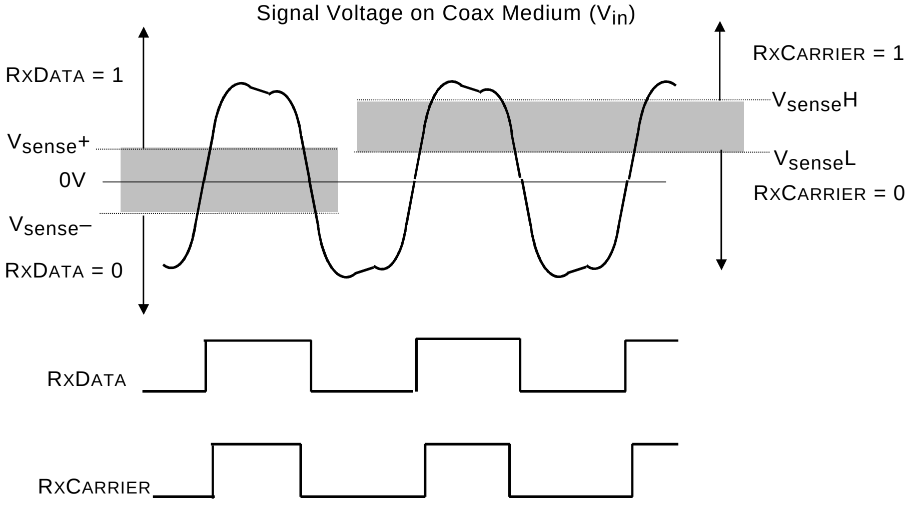

NOTE The shaded areas shown above are not defined.

Figure 79 – Coaxial wire MAU receiver operation

Two indication signals shall be provided at the MDS-MAU interface from the MAU with RxDATA and RxCARRIER as shown in Table 89. The relationship between the signal voltage on the wire and these two signals for nominal thresholds shall be as shown in Table 90 and Table 91. The values referenced in Table 90 and Table 91 are defined in Table 93. The input level (V_{in}) as shown in Figure 79 shall be defined as the voltage as measured between the coaxial cable center conductor and the coaxial shield. All polarities shall be defined in terms of the voltage on the coaxial cable center conductor (V_{in}+ or V_{in}–) as referenced to the coaxial shield.

Table 90 – Receiver data output definitions: 5 Mbit/s, voltage-mode, coaxial wire

Input level at medium	RxDATA	Comments
V_{in} more positive than positive data sensitivity limit (V_{sense}+)	true (1)	See Table 93
V_{in} more negative than negative data sensitivity limit (V_{sense}–)	false (0)	See Table 93
V_{in} between positive and negative data sensitive limits	undefined	Allows for hysteresis and tolerance

Table 91 – Receiver carrier output definitions: 5 Mbit/s, voltage-mode, coaxial wire

Input level at medium	RxCARRIER	Comments
V_{in} more positive than high carrier sensitivity limit (V_{sense}H)	true (1)	See Table 93
V_{in} lower than low carrier sensitivity limit (or negative) (V_{sense}L)	false (0)	See Table 93
V_{in} between low and high carrier sensitivity limits	undefined	Allows for hysteresis and tolerance

The medium interface shall conform to the requirements shown in Table 92, Table 93 and Table 94.

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Table 92 – Coaxial wire medium interface – transmit specifications

Specification	Limits / characteristics	Comments
Transmit level (Tx level) peak-to-peak	8,2 V ± 1,3 V [a, b, c]	See Figure 80
Transmit level asymmetry (between 0 and 1)	< 450 mV max [b, d]	
Transmit signal distortion (over voltage, droop, ring)	± 10 % [a, e]	See Figure 80
Total transmit jitter (Tx Jitter)	< 5 ns	See Figure 80
Transmitter output impedance	20 Ω max	
Maximum transmitter off noise level	5 mV max [a]	
Time from NETENABLE false to transmitter off noise level	400 ns [a]	
Slew limit	1 V/ns max [a]	See Figure 80
Rise / fall limit (10 % to 90 % of peak-to-peak)	30 ns max [a]	See Figure 80

[a] This shall be a peak-to-peak voltage as measured into a 37,5 Ω load from 0 MHz to 20 MHz.

[b] The transmit level shall be measured at the estimated mid-point between any peaks or troughs in both top and bottom of the waveform.

[c] This level shall be 0,5 V lower when measured as inside of eye pattern when driving a tap for a minimum signal of 6,4 V (peak-to-peak).

[d] This shall be measured as the absolute difference between the absolute value of Transmit level for 1 (+ voltage) and the absolute value of transmit level for 0 (– voltage) as measured into a 37,5 Ω load from 0 MHz to 20 MHz.

[e] Levels shall be a function of the actual measured transmit voltage.

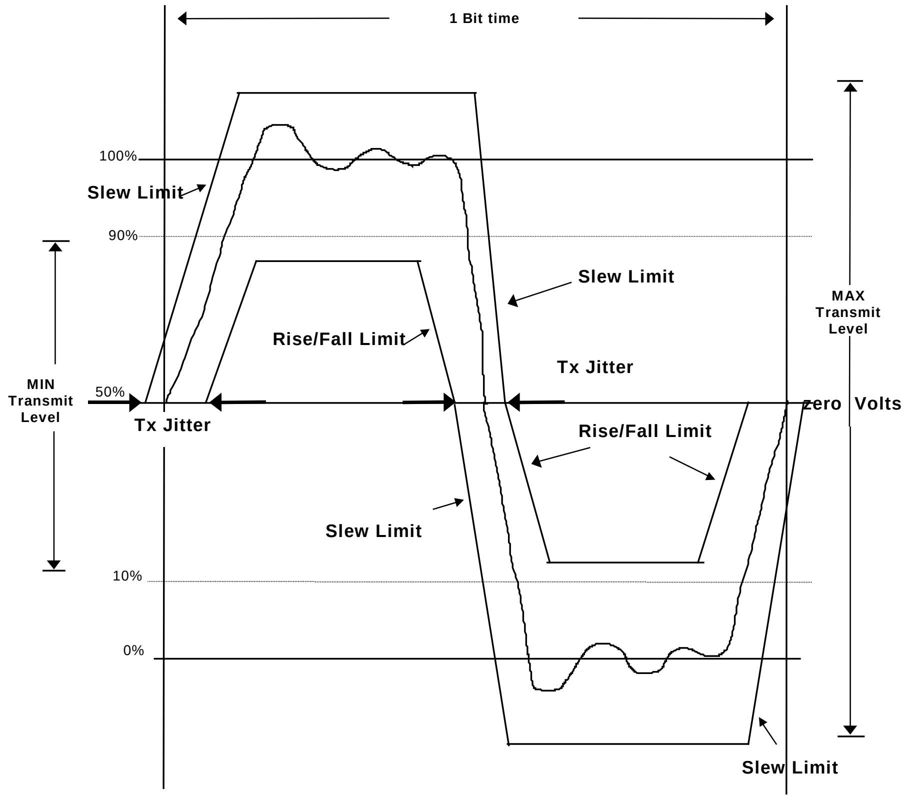

Figure 80 – Coaxial wire MAU transmit mask

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Table 93 – Coaxial wire medium interface – receive

Specification	Limits / characteristics	Comments
Minimum receive signal level (peak-to-peak)	510 mV	Inside of eye pattern as shown in Figure 81
Data threshold voltage	zero V	Negative and positive sensitivity limits allow for hysteresis and tolerance
Negative data sensitivity limits (V_{sense}–)	– 140 mV	Allows for hysteresis and tolerance
Positive data sensitivity limits (V_{sense}+)	+140 mV	Allows for hysteresis and tolerance
Low carrier sensitivity limit (V_{sense}L)	+ 23 mV	Allows for hysteresis and tolerance
High carrier sensitivity limit (V_{sense}H)	+ 255 mV	Allows for hysteresis and tolerance
RxData pattern jitter (peak-to-peak) for V_{in} > 510 mV	< 40 ns	Inside of eye pattern as shown in Figure 81 shall be true when V_{in} > minimum receive signal level

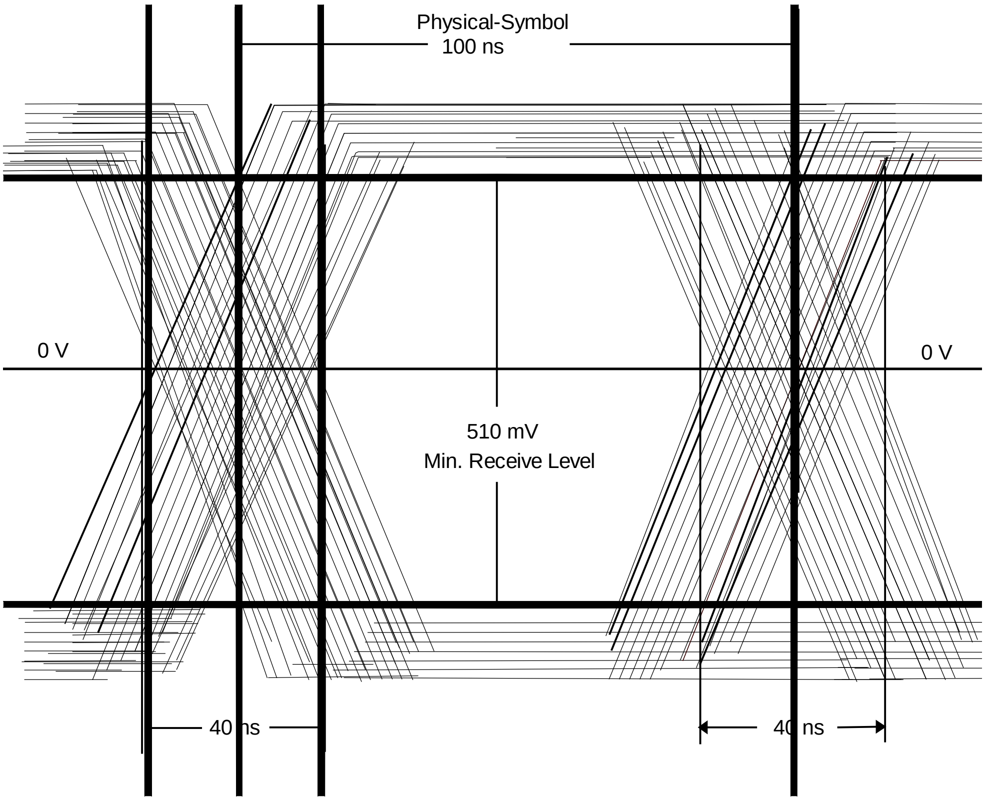

Figure 81 – Coaxial wire MAU receive mask

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Table 94 – Coaxial wire medium interface – general

Specification	Limits / characteristics	Comments
Coupling	Transformer coupled	Ground isolated
Isolation at 0 Hz	500 kΩ min [a]	Shield shall be R/C coupled to local earth
Input impedance (Tx Off)	0,2 dB tap loss	(See Figure 85) Alternative to impedance model
Impedance model (Tx Off)		Alternative to input impedance
Series inductance	0,56 µH ± 20 % [b]	Power on
Parallel inductance	425 µH ± 20 % [b]	Power on
Parallel capacitance	50 pF max [b] 55 pF max [b]	Power on Power off
Parallel resistance	3,9 kΩ ± 20 % [b] 3,4 kΩ ± 20 % [b]	Power on Power off
Connector	BNC or TNC	See Annex F for more details

[a] Capacitor value shall be 0,01 µF/500 V minimum. This requirement applies to all medium interfaces connected to the network.

[b] All impedance specifications shall be met with the transmitter off and with power applied or removed as shown. All impedance specifications shall be met over the entire receiver dynamic range from minimum receive level to maximum transmit level.

NOTE 3 A reference design example for a 5 Mbit/s, voltage mode, coaxial wire MAU transceiver is shown in H.1.1.

18.3 Transformer 5 Mbit/s, voltage-mode, coaxial wire

NOTE 1 The Transformer couples the transmit and receive signals to and from the medium. An important feature of the transformer is that it provides galvanic isolation or ground isolation between nodes. This prevents large common-mode voltages due to ground voltage differences between nodes. Also prevented are large ground loops, which can be susceptible to low frequency magnetic coupling.

Figure 82 shows the schematic symbol for the transformer.

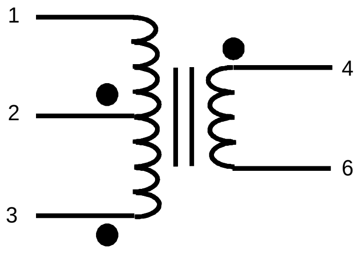

Figure 82 – Transformer symbol

Coupling transformers shall conform to the requirements specified in Table 95.

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Table 95 – 5 Mbit/s, voltage-mode, coaxial wire transformer electrical specifications

Specification	Min.	Typical	Max.
Inductance (measured at 40 kHz and 100 mV)	350 µH	750 µH	
Winding capacitance (measured at 10 MHz)	16,0 pF	24,8 pF	29,5 pF
Parallel resistance (core loss)	8,0 kΩ	9,1 kΩ	11,2 kΩ
Leakage inductance	255 nH	441 nH	625 nH
Galvanic isolation (at 47-63 Hz, less than 1,0 mA)	500 V_{rms} for 60 s 600 V_{rms} for 1 s		
Resonant frequency	1,0 MHz	1,4 MHz	1,8 MHz

Leakage inductance shall be measured between pins 1 and 2 with pins 4 and 6 connected together. Galvanic isolation shall be measured with pins 1, 2 and 3 tied together and with pins 4 and 6 tied together. The galvanic isolation requirement shall be met from pin 1 to pin 4, from pin 1 to core, and from pin 4 to core. All other measurements shall be made between pins 4 and 6 with pin 2 connected to instrument ground.

NOTE 2 A reference design example for a 5 Mbit/s, voltage mode, coaxial wire MAU transformer is shown in H.1.2.

18.4 Connector 5 Mbit/s, voltage-mode, coaxial wire medium

The connector used on a node shall be a BNC or TNC jack, in accordance with the requirements of this standard (see Annex F).

18.5 Topology 5 Mbit/s, voltage-mode, coaxial wire medium

A segment shall comprise a trunk–spur architecture. The trunk shall consist of coaxial cable and shall be terminated at both ends by a resistor equal to 75 Ω ± 5 %.

NOTE 1 This limits the reflections from transmitted signals on the trunk reflecting at the ends of the cable.

Nodes shall be attached to the network via drop cables. The drop cables shall attach to the trunk using the specified taps. These taps shall contain passive circuitry that allows trunk attachment while minimizing reflections due to attachment loading.

Nodes connected to the deterministic control network shall not terminate the drop cable shield directly to ground. Termination of the shield shall be in accordance with Table 94. To properly terminate each drop cable's shield, a resistor in parallel with a 0,01 µF capacitor shall be used. The parallel R/C shall be connected from shield to ground.

Figure 83 shows a topology example.

NOTE 2 In this example, two segments are connected by a repeater to form a seven node link.

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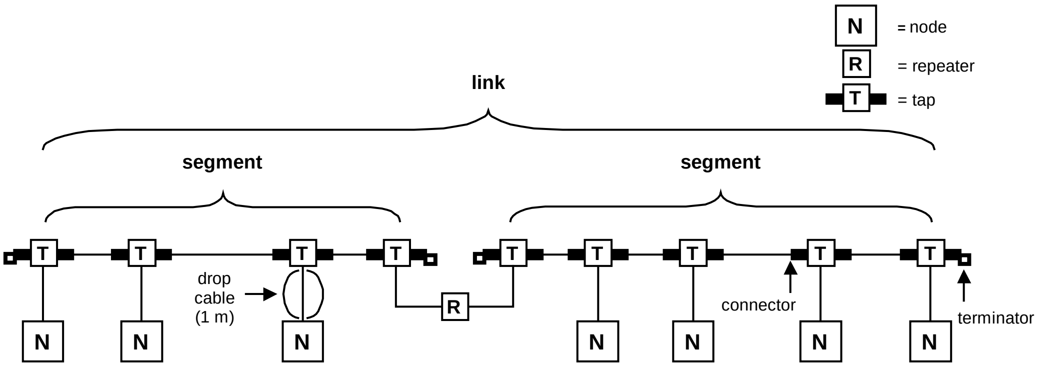

Figure 83 – 5 Mbit/s, voltage-mode, coaxial wire topology example

Topology limits are shown in Figure 84. Up to 48 nodes can be connected to a segment of length up to 1 km as shown in Figure 84. The trade-off between distance and number of nodes is shown in Figure 84. If a combination of nodes and distance is required that exceeds the segment limits, then a PhL repeater device shall be used (see Annex G). With respect to the medium, a PhL repeater device shall appear, electrically and mechanically, to be the same as a node. The PhL repeater device shall require a tap for each segment to which it is connected, and therefore, can be attached anywhere on each segment. The repeaters shall not be placed in a manner that causes more than one connection between segments.

Any topology that supports a single path between any two PhL entities shall be supported. Multiple paths between PhL entities shall not be allowed by an implementation that claims conformance to Clause 18.

This PhL variant may be combined with other PhL variants within the same node, or in different nodes, by using the RM (repeater machine) and/or PhL repeater devices (see Annex G).

NOTE 3 See Annex G for more information on repeaters.

NOTE 4 These limits are based upon the cable specifications in 18.7.1.

Figure 84 shall apply when using taps as specified in 18.6 and trunk coaxial cable as specified in Table 97. Cables with attenuation characteristics other than those shown in Table 97 may be used if an appropriate segment length multiplier is applied to Figure 84.

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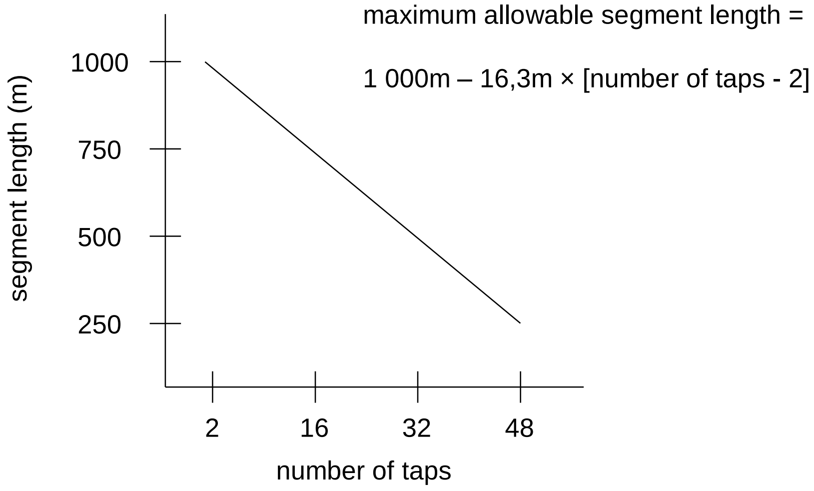

Figure 84 – Coaxial wire medium topology limits

18.6 Taps 5 Mbit/s, voltage-mode, coaxial wire medium

18.6.1 Description

The tap shall contain passive circuitry that compensates for the added loading of the attached node.

NOTE 1 In this way, a small amount of transmission loss is experienced rather than an impedance discontinuity, and therefore a reflection, on the trunk for every node.

A tap shall be used for all nodes that conform to the specified coaxial wire medium attachment method.

NOTE 2 A reference design example for a 5 Mbit/s, voltage mode, coaxial wire MAU Tap is shown in H.1.3.

18.6.2 Requirements

The standard tap variant shall provide BNC jack connections at the trunk and a BNC plug at the node, the IP67 sealed tap variant shall provide TNC jack connections at the trunk and a TNC or BNC plug at the node, in accordance with the requirements of this standard (see Annex F). A 1 m length of spur cable of the specified type shall be used in the tap if proper compensation for the spur cable is to be achieved.

NOTE 1 The electrical requirements of the tap are defined by the transmitted and reflected characteristics as seen by the trunk when the tap port is properly connected by the required spur and a node equivalent load. Although the tap has three ports, it can be viewed as a two port device when it is configured this way. The term, node equivalent load, means a load that represents the nominal impedance of a node. A node equivalent load may be constructed from discrete components so long as the equivalent load meets all requirements in Clause 18.

The transmission and reflection requirements shall be as shown in Figure 85. Scattering parameters (S11, S22, S12, and S21) shall be used to define the tap electrical requirements. S11 and S22 shall be used to define the reflection characteristics of the trunk connector of a tap while the spur is terminated by a node equivalent load and the other trunk connector is terminated with a trunk terminator (75 Ω ± 5 %). S12 and S21 shall be used to define the transmission characteristics of the tap from one trunk connector to the other with the drop cable terminated by a node equivalent load. The transmission and reflection characteristics of all taps shall fall in the pass region defined in Figure 85.

NOTE 2 The tap is a reciprocal device (S11=S22, S12=S21) so trunk port orientation is arbitrary.

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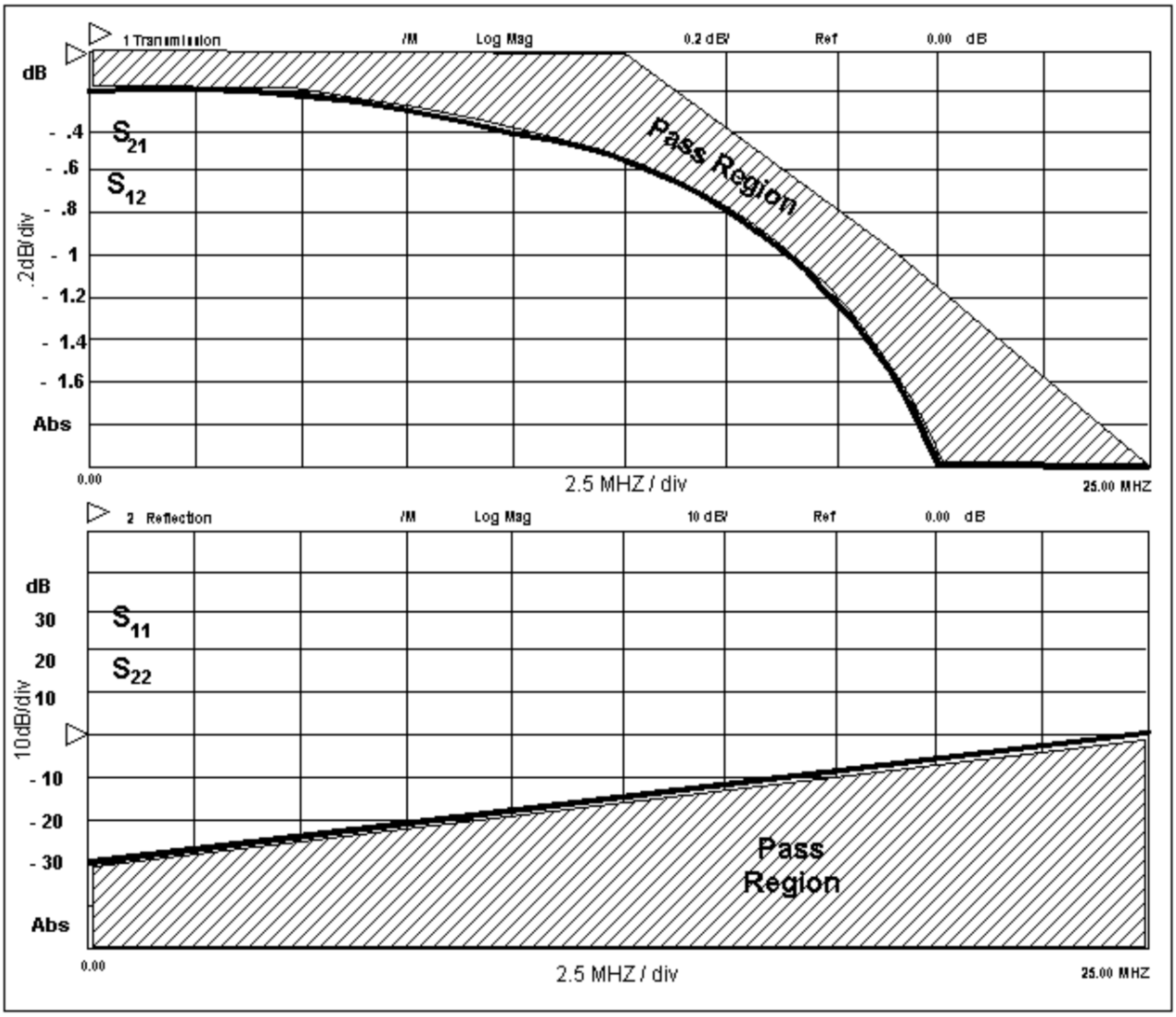

Figure 85 – Coaxial wire medium tap electrical characteristics

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18.6.3 Spur

The spur cable shall conform to the limits and characteristics shown in Table 96.

Table 96 – Coaxial spur cable specifications

Specification	Limits / characteristics
Shielding	Dual braided shield, each braid is 95 % coverage
Impedance	75 Ω ± 3 Ω
Delay	4,1 ns/m ± 0,1 ns/m
Attenuation (dB/100 m) at	
1 MHz	1,25
5 MHz	3,01
10 MHz	4,33
25 MHz	6,89
50 MHz	10,1
Structural return loss	23 dB minimum from 5 MHz to 50 MHz
Conductor DC resistance	92 Ω/km nominal
Shield DC resistance	10,5 Ω/km nominal
Nominal capacitance	54,13 pF/m

18.7 Trunk 5 Mbit/s, voltage-mode, coaxial wire medium

18.7.1 Trunk Cable

The trunk cable shall meet the specification given in Table 97.

Table 97 – Coaxial trunk cable specifications

Specification	Limits / characteristics
Shielding	Quad shield
Impedance	75 Ω ± 3 Ω
Delay	4,1 ns/m ± 0,1 ns/m
Attenuation (dB/100 m) at	
1 MHz	1,15
2 MHz	1,25
5 MHz	1,48
10 MHz	1,94
20 MHz	2,82
50 MHz	4,49
Structural return loss	23 dB minimum from 5 MHz to 50 MHz
Conductor DC resistance	92 Ω/km nominal
Shield DC resistance	24 Ω/km nominal
Nominal capacitance	53,15 pF/m

Spur cable as specified in Table 96 may also be used for trunk cable in limited lengths (up to 10 m per segment).

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18.7.2 Connectors

The trunk connection shall use a BNC or TNC plug, in accordance with the requirements of this standard (see Annex F).

19 Type 2: Medium attachment unit: 5 Mbit/s, optical medium

19.1 General

NOTE 1 Clause 19 specifies the optical medium and PhL variant. Information important to designing the PhL connection is captured here.

NOTE 2 The fiber medium attachment method defines three fiber media and PhL variants. The first variant covers fiber media and PhL requirements for a short-range system for distances of up to 300 m (nominal), the second variant covers fiber media and PhL requirements for a medium-range system for distances of up to 7 km (nominal), and the last variant covers fiber media and PhL requirements for a long-range system for distances of up to 20 km (nominal).

The fiber medium attachment method shall incorporate a full duplex point to point or ring topology using a transmitter and receiver at each end of a pair of fibers.

For all variants, the fiber medium attachment methods shall be defined either as a point to point link or as a ring topology. The point to point link shall connect between end nodes, end nodes and PhL repeater devices, or PhL repeater and PhL repeater. The ring topology shall connect between any two or more nodes or devices that implement the ring repeater machine (RRM), which is described in Annex G. Switching between media or topologies shall require the use of a PhL repeater device. This shall be implemented as an active hub, active star or active ring. An active hub or active star shall consist of a minimum of two ports.

NOTE 3 The physical layer can be implemented to allow certification for operation in explosive atmospheres, without sacrificing distance or reducing the number of nodes. This standard does not include requirements for intrinsic safety certification, but seeks to exclude conditions or situations that would prevent intrinsic safety certification.

The fiber medium MAU shall consist of the fiber transceiver and fiber connector. The transceiver shall use the signals defined in the MDS-MAU interface to generate those necessary to drive the transceiver. Attachment to the medium shall be via fiber connectors.

19.2 Transceiver 5 Mbit/s, optical medium

To support a fiber medium, a fiber transceiver shall transmit and receive the L and H signals from the MDS. The transmitter portion of the transceiver shall obtain transmit signals from the MDS-MAU interface, representing H and L symbols, and transmits either 'light on' (for H) or 'light off' (for L) using a direct coupled transceiver. This means that the transceiver shall be capable of transmitting and receiving PhL signaling at frequencies from zero (no Ph-symbol transitions) to 10 MHz minimum.

NOTE Direct coupled transceivers are required because the MDS and MAU sublayers, as specified, do not provide for the insertion and deletion of an idle sequence when there is no L or H data to be sent, i.e. during periods of no Ph-symbol activity.

The complement of this function shall be performed in the receiver, which shall provide RxDATA and RxCARRIER indications to the MDS-MAU interface as shown in Figure 86, a functional block diagram depicting the MAU components.

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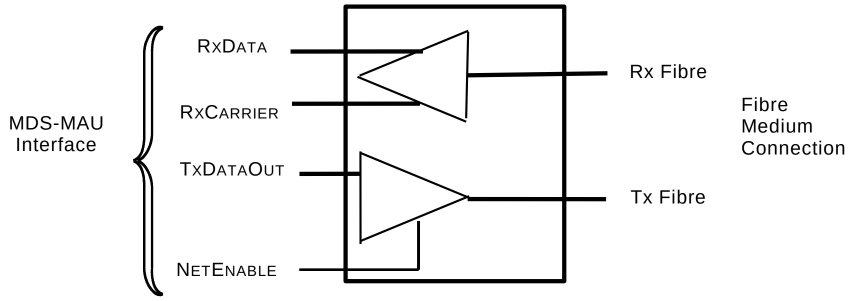

Figure 86 – MAU block diagram 5 Mbit/s, optical fiber medium

The transmit signals shall be as shown in Table 98.

Table 98 – Transmit control line definitions 5 Mbit/s, optical fiber medium

TXDATAOUT	NETENABLE	Physical symbol	Signal on fiber medium
don't care(x)	false(0)	don't care (x)	light off
false(0)	true(1)	L	light off
true(1)	true(1)	H	light on

The fiber interface transmit and receive limits shall be as shown in Table 99.

Table 99 – Fiber medium interface 5,0 Mbit/s, optical

Specification	Limits / Characteristics	Comments
Input pattern jitter	40 ns peak-to-peak max.	Measured on RXDATA
Total transmit jitter	< 5 ns peak-to-peak	

19.3 Topology 5 Mbit/s, optical medium

The media topology defined for a fiber medium attachment variant shall be a point to point link or a ring topology. The point to point topology shall be between any two PhL entities that meet the requirements of Clause 19 and that do not implement the RRM. The ring topology shall be between any two PhL entities that meet the requirements of Clause 19 and that implement the RRM (see Annex G). Switching between these two topologies shall require the use of a PhL repeater or of any device implementing the RRM function and repeater PhL. In either case, nodes and repeaters shall be cascadable as long as each link meets the requirements specified in Clause 19. The total signal propagation delay shall be used in the calculation of the slot time value as described in IEC 61158-4-2.

Any topology that supports a single path between any two PhL entities shall be supported. Multiple paths between PhL entities shall not be allowed by an implementation that claims conformance to Clause 19.

This PhL variant may be combined with other PhL variants within the same node, or in different nodes, by using the RM (repeater machine) and/or PhL repeater devices (see Annex G).

19.4 Trunk fiber 5 Mbit/s, optical medium

The trunk fiber shall meet the requirements specified in 19.6 for the appropriate fiber PhL variant.

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19.5 Trunk connectors 5 Mbit/s, optical medium

The Trunk connectors shall be in accordance with the requirements of this standard (see Annex F) for the different fiber PhL variants.

19.6 Fiber specifications 5 Mbit/s, optical medium

The signal characteristics for fiber media and PhL variant at 25 ºC shall be as shown in Table 100, Table 101 and Table 102.

Table 100 – Fiber signal specification 5 Mbit/s, optical medium, short range

Specification	Min.	Nominal	Max.
Fiber			
Distance	0 m	300 m	
Fiber attenuation at λ		6 dB/km	
Fiber technology	Step index, hard clad silica (HCS)		
Core/cladding	200/230 μm		
Numerical aperture	0,5		
System			
BER	10^{-9}		
Power budget	3,9 dB	9,5 dB	
Transmitter			
Wavelength λ	640 nm	650 nm	660 nm
Spectral width	21 nm		
Coupled power, $P_{T\ on}$ (transmit light on)	-16,1 dBm, peak	-12,5 dBm, peak	-8,5 dBm, peak
Coupled power, $P_{T\ off}$ (transmit light off)			-44 dBm, peak
Optical rise time T_{rise}			
Optical fall time T_{fall}			
Receiver			
$P_{R\ MIN}$ (receive light on)		-25 dBm, pk	-23 dBm, peak
$P_{R\ MAX}$ (receive light on)	-1,0 dBm	+3,0 dBm	
Pulse width distortion			30 ns

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Table 101 – Fiber signal specification 5 Mbit/s, optical medium, medium range

Specification	Min.	Nominal	Max.
Fiber			
Distance	0 m	7 km	
Fiber attenuation at λ		1,5 dB/km	
Fiber technology	Graded index, multi-mode		
Core/cladding	62,5/125 μm		
Numerical aperture	0,275		
System			
BER	10^{-9}		
Power budget	11,3 dB	16,4 dB	
Transmitter			
Wavelength λ	1 270 nm	1 300 nm	1 370 nm
Spectral width		130 nm	185 nm
Coupled power, $P_{T\ on}$ (transmit light on)	-15,5 dBm, peak	-13,5 dBm, peak	-12,0 dBm, peak
Coupled power, $P_{T\ off}$ (transmit light off)			- 40 dBm, peak
Optical rise time T_{rise}		1,8 ns	4,0 ns
Optical fall time T_{fall}		2,2 ns	4,0 ns
Receiver			
$P_{R\ MIN}$ (receive light on)	-33,5 dBm, pk	-31,8 dBm, peak	-28,8 dBm, peak
$P_{R\ MAX}$ (receive light on)			
Pulse width distortion			2ns

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Table 102 – Fiber signal specification 5 Mbit/s, optical medium, long range

Specification	Min.	Nominal	Max.
Fiber			
Distance			20 km
Fiber attenuation at λ		0,5 dB/km	
Fiber technology	Graded index, single mode		
Core/cladding	10/125 µm		
Numerical aperture	0,1		
System			
BER	10^{-9}		
Power budget	10 dB		
Transmitter			
Wavelength λ	1 270 nm	1 300 nm	1 370 nm
Spectral width		70 nm	
Coupled power, $P_{T\ on}$ (transmit light on)	-18 dBm, pk	-15 dBm, pk	-10 dBm, pk
Coupled power, $P_{T\ off}$ (transmit light off)			-40 dBm pk
Optical rise time T_{rise}		2 ns	4,0 ns
Optical fall time T_{fall}		2,2 ns	4,0 ns
Receiver			
$P_{R\ MIN}$ (receive light on)		-32 dBm, pk	-30 dBm, pk
$P_{R\ MAX}$ (receive light On)	-10 dBm		
Pulse width distortion			2 ns

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20 Type 2: Medium attachment unit: network access port (NAP)

20.1 General

Figure 87 shows the location of the network access port (NAP) PhL and Medium within the ISO/OSI reference model.

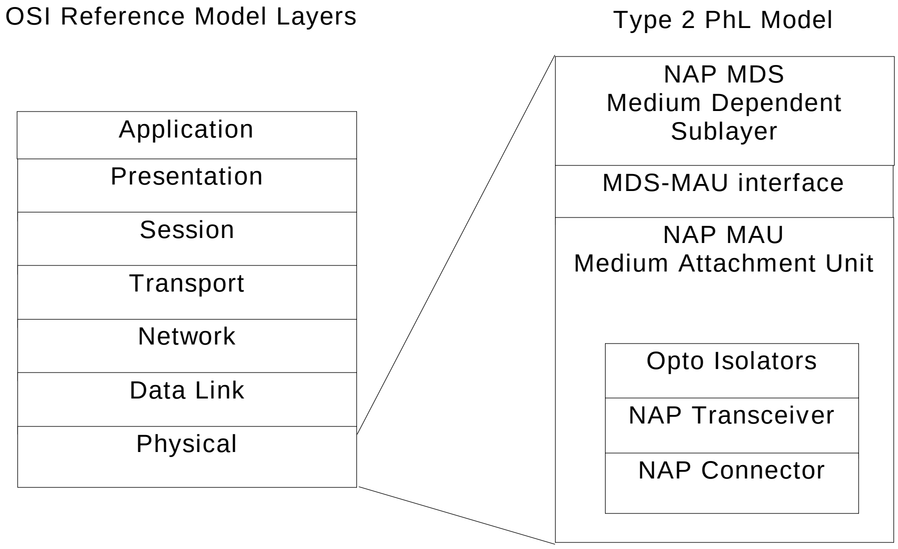

Figure 87 – NAP reference model

Local connection to a computer (desktop or laptop), hand held programming device or other temporary network connection shall be made through the NAP transceiver using protocol and data rates as specified for the trunk. The NAP transceiver shall obtain a single transmit line from the MDS-MAU interface, transmit to and receive from, another node at the other end of the NAP cable and provide a single receive line back to the MDS-MAU interface.

As these are single lines, no representation of carrier on/off shall be present. These signals shall be either a logical ‘zero’ or a logical ‘one’ at all times. The medium shall be driven from the single transmit line at all times.

The NAP PhL shall support a point to point connection between two nodes. This topology shall not be multi-dropped to support more than two nodes.

Any topology that supports a single path between any two PhL entities shall be supported. Multiple paths between PhL entities shall not be allowed by an implementation that claims conformance to Clause 20.

A node, whose primary connection to the link is through the NAP PhL variant, shall be considered a transient network node. A node, whose primary connection to the link is via any other PhL variant, shall be considered a permanent network node. A transient node shall communicate with another transient node or a permanent node using the NAP medium. The permanent node shall utilize the repeater machine (RM) functionality (see Annex G) contained in the DLL of that node to allow the transient node to communicate to other permanent nodes as shown in Figure 88. A permanent node shall function as a transient node when no other PhL medium is connected as shown in Figure 88.

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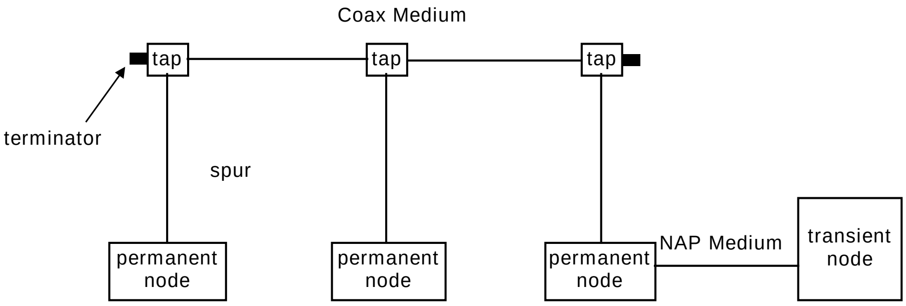

Figure 88 – Example of transient and permanent nodes

This PhL variant may be combined with other PhL variants within the same node, or in different nodes, by using the RM (repeater machine) and/or PhL repeater devices (see Annex G).

20.2 Signaling

The signaling requirements for the NAP port shall be as shown in Table 103.

Table 103 – NAP requirements

NAP interface specification	Design specification	Comments
NAP interface – General		
Coupling	DC	Opto-isolator required for programming nodes
Link configuration	Two uni-directional RS-422 pair	One Rx, one Tx
Connector	Shielded RJ-45	See Annex F
Termination	100 Ω internal on /RxPTC only	
NAP – Transmit		
Output level at NAP medium with /TxPTC = true	2,5 V min.	Measured between Tx_H and GND REF pin with 100 Ω NAP receive load connected (see Table F.2)
Output level at NAP medium with /TxPTC = false	2,5 V min.	Measured between Tx_L and GND REF pin with 100 Ω NAP receive load connected (see Table F.2)
Output level at NAP medium with /TxPTC = true	0,5 V max.	measured between Tx_L and GND REF pin with 100 Ω NAP receive load connected (see Table F.2)
Output level at NAP medium with /TxPTC= false	0,5 V max.	measured between Tx_H and GND REF pin with 100 Ω NAP receive load connected (see Table F.2)
Output level at NAP medium with /TxPTC = data	4,0 V min.	(Tx_H – Tx_L) measured as peak to peak with 100 Ω load (see Table F.2)
Total Transmit Jitter	± 5 ns max.	
Termination	None	
NAP – Receive		
Receive level at NAP medium with /TxPTC = data	2,5 V min.	(Rx_H – Rx_L) measured as peak to peak (see Table F.2)
Receive jitter	± 15 ns max.	
Termination	100 Ω ± 10 %	Across differential lines
Fault receive signal	/RxPTC = true	If medium is disconnected, shorted, receiver turned off or disabled, /RxPTC shall be true

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20.3 Transceiver

The NAP MAU block diagram shown in Figure 89 represents both the isolated and non-isolated implementations. The isolated NAP shall be used on transient nodes. Opto-isolation shall be provided to prevent ground loop currents from flowing between nodes at different ground potentials. Opto-isolation shall not be required if the node is self powered and is not grounded. The non-isolated NAP shall be used on permanent nodes.

NOTE 1 A transient node is defined as a node with primary and normal connection to the network through the NAP of another node. This includes, but is not limited to, computer interface cards, configuration nodes and other nodes that are transient or temporary network connections.

NOTE 2 A permanent node is defined as a node with primary and normal connection to the network through a PhL other than the NAP. This includes, but is not limited to: PLCs, I/O rack adapters, controllers, robots, welders and other nodes that are connected to the network on a mostly permanent basis.

If a node can be used as both a transient and permanent node, it shall include opto-isolation in the design of the NAP (unless it is self-powered and cannot be grounded).

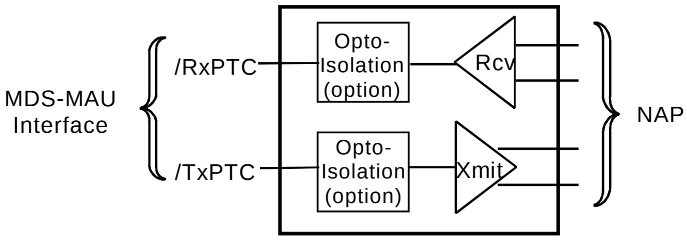

Figure 89 – NAP transceiver

NOTE 3 A reference design example for a Network Access Port MAU is shown in Clause H.2.

20.4 Connector

The connector used at both ends of a NAP connection shall be a shielded 8-pin RJ-45 type connector, as specified in Annex F.

20.5 Cable

The NAP cable shall have 8 conductors and an overall shield. The shield shall be designed to minimize electromagnetic interference. The cable connector pins shall be as shown in Table F.2.

As the NAP connector and pin connections are the same for both a node and a transient node, the cable shall be built in a way that allows the correct transmit data and receive data connection. This shall be accomplished be reversing the connection on one end of the NAP cable as shown in Figure 90.

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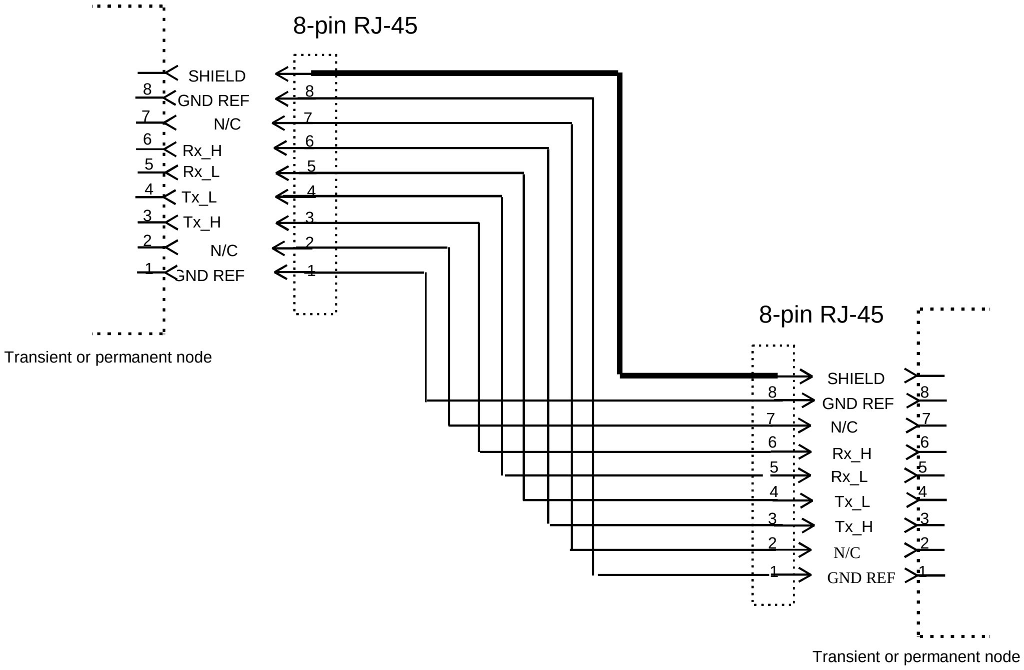

NOTE The NAP cable connectors are installed so that the signal lines are reversed to allow the correct connection. This allows the equipment to use the same pinout independent of function.

Figure 90 – NAP cable

The NAP cable shall meet the following requirements:

a) paired line characteristics = 100 Ω;

b) resistance (at 0 Hz) = 0,122 Ω/m;

c) wire gauge = 26 (7 strands, diameter 0,16 mm);

d) conductors = 8 plus overall shield;

e) maximum cable length = 10 m.

21 Type 3: Medium attachment unit: synchronous transmission, 31,25 kbit/s, voltage mode, wire medium

21.1 General

The 31,25 kbit/s voltage-mode MAU simultaneously provides access to a communication network and to an optional power distribution network. Devices attached to the network communicate via the medium and may or may not be powered from it. If bus-powered, power is distributed as direct voltage and current, and communications signals are superimposed on the d.c. power. In Intrinsically Safe applications, available power may limit the number of devices.

The network medium consists of twisted pair cable. Independent of topology, all attached devices, other than possibly the transmitting device, are high impedance to prevent significant network loading. Trapezoidal waveforms are used to reduce electromagnetic emissions.

Bus and tree topologies are supported. In either topology a network contains one trunk cable, terminated at both ends. In the bus topology, spurs are distributed along the length of the trunk. In the tree topology, spurs are concentrated at one end of the trunk. A spur may connect more than one device to the network, the number of devices depending on spur length.

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At the power frequency (d.c.), devices appear to the network as current sinks, with a limited rate of change of the supply current drawn from the medium. This prevents transient changes in load current from interfering with communication signals.

21.2 Transmitted bit rate

See 12.2.

21.3 Network specifications

21.3.1 Components

Subclause 12.3.1 applies.

When selecting the individual components, make sure that all components meet the requirements of the FISCO model. Only components that are identified as an intrinsically safe electrical apparatus or as an associated electrical apparatus in accordance with IEC 60079-11 may be installed in intrinsically safe fieldbus segments. To comply with 12.2.5.1 of IEC 60079-14, the permitted values of the input parameters U_I, I_I, and P_I of an intrinsically safe apparatus (e.g. a field devices) shall not be less then the certified maximum values of the output parameters U_0, I_0 and P_0 of the associated power device. Additional restrictions applicable to the individual components (e.g., limitation of the supply power of ≤1,2 W) have to be taken into account as well.

Table 104 lists possible combinations of devices from different system categories.

Table 104 – Mixing devices from different categories

Explosion protection of the bus-segment	Explosion protection of the power device	Explosion protection of the field device					
		EEx ia			EEx ib		
		IIC	IIB	IIC/IIB	IIC	IIB	IIC/IIB
EEx ia IIC (Group IIC)	[EEx ia] IIC	x		x			
EEx ia IIB (Group IIB)	[EEx ia] IIB	x	x	x			
	[EEx ia] IIC	x	x	x			
EEx ib IIC (Group IIC)	[EEx ib] IIC	x		x	x		x
	[EEx ia] IIC	x		x	x		x
EEx ib IIB (Group IIC)	[EEx ib] IIB	(x)[1)]	x	x	(x)[1)]	x	x
	[EEx ib] IIC	x	x	x	x	x	x
	[EEx ia] IIB	(x)[1)]	x	x	(x)[1)]	x	x
	[EEx ia] IIC	x	x	x	x	x	x

1) These combinations are possible in theory but in practice they are irrelevant, because the field devices may be certified for group IIC and for group IIB as well (see column IIC/IIB).

By any combination it shall be assured that the absolute maximum ratings for the input of the field device fit to the output characteristics of the power device:

$U_I \geq U_O$

$I_I \geq I_O$

$P_I \geq P_O$

Connection of bus-powered devices and local-powered devices on an intrinsically safe fieldbus is permitted if the local-powered devices are provided with suitable isolation in accordance with IEC 60079-11.

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Although connection of a fieldbus station (i.e., field device, hand-held terminal, and coupler for the bus master) with its poles reversed does not affect the functionality of the other devices connected to the fieldbus, an incorrectly installed bus station which is not equipped with automatic polarity detection will not be supplied with power or be able to send and receive. Stations with automatic polarity detection operate correctly with any allocation of the input terminals to the wires.

21.3.2 Topologies

A wire MAU shall operate in a network with a linear bus topology, consisting of a trunk, terminated at each end as specified in 21.8.5, to which communication elements are connected via couplers and spurs.

The coupler and communication element may be integrated in one device (i.e. zero length spur).

A tree topology with all the communication elements located at the ends of the trunk is regarded as a special case of a bus for the purpose of Clause 21.

Several communication elements may be connected to the trunk at one point using a multi-port coupler. An active coupler may be used to extend a spur to a length that requires termination to avoid reflections and distortions. Active repeaters may be used to extend the length of the trunk beyond that of a single segment as permitted by the network configuration rules.

21.3.3 Network configuration rules

A 31,25 kbit/s voltage-mode MAU shall be required to conform to the requirements of Clause 21 when used in a network which complies with these rules.

Rule 1: One fieldbus shall be capable of communication between the following numbers of devices, all operating at the same bit rate:

a) for a non IS fieldbus without power supplied via the signal conductors: between two and 32 devices;
b) for a non IS fieldbus with power supplied via the signal conductors: between two and the number of devices which can be powered via the signal conductors, assuming that a minimum of 120 mA shall be available to devices at the remote end from the power supply communicating with one device at the power supply end drawing 10 mA;
c) for an IS fieldbus: between two and the number of devices that can be powered via the signal conductors, assuming that a minimum of 40 mA shall be available to devices in the hazardous area.

NOTE 1 Rule 1 does not preclude the use of more than the specified number of devices in an installed system. Since the device power consumption is not specified, the number of bus-powered devices cannot be specified. Item b) assumes that the minimum power supply voltage is 20 V d.c. Item c) assumes that the IS barrier operates with a 19 V d.c. output.

Rule 2: A fully loaded (maximum number of connected devices) 31,25 kbit/s voltage-mode fieldbus segment shall have a total cable length, including spurs, between any two devices, of up to 1 900 m.

NOTE 2 1 900 m maximum cable length is the requirement for conformance to Clause 21 but this does not preclude the use of longer lengths in an installed system.

Rule 3: The total number of waveform regenerations by repeaters and active couplers between any two devices shall not exceed four.

Rule 4: The maximum propagation delay between any two devices shall not exceed 20 Tbit.

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For efficiency of the network, that part of the turn-around time of any device on the network caused by a PhE between the end of a received frame and the beginning of the transmitted frame containing an associated immediate response should not exceed 5 bit times, no more than 2 bit times of which should be due to the MAU.

NOTE 3 As it is not mandatory to expose the DLL – PhL interface or the MDS – MAU interface, that part of the turn-around time of a fieldbus device caused by the PhL or the MAU is not specified and thus not available for conformance testing.

Rule 5: The fieldbus shall be capable of continued operation while a device is being connected or disconnected. Data errors induced during connection or disconnection shall be detected.

Rule 6: Failure of any communication element or spur (with the exception of a short circuit, low impedance, or jabber) shall not interfere with transactions between other communication elements for more than 1 ms.

Rule 7: In polarity sensitive systems the medium twisted pairs shall have distinctly marked conductors that uniquely identify individual conductors. The polarization shall be maintained at all connection points.

Rule 8: The degradation of the electrical characteristics of the signal, between any two devices, due to attenuation, attenuation distortion and mismatching shall be limited to the values indicated below.

a) Signal attenuation: The configuration of the bus (trunk and spur lengths, number of devices, IS barriers, galvanic isolators, and possible matching devices) shall be such that the attenuation between any two devices at the frequency corresponding to the bit rate shall not exceed 10,5 dB.

b) Attenuation distortion: The configuration of the bus (trunk and spur lengths and number of devices, IS barriers, and galvanic isolators) shall be such that between any two devices:

   [Attenuation (1,25 f_r) – Attenuation (0,25 f_r)] $\leq$ 6 dB

   Attenuation (1,25 f_r) $\geq$ Attenuation (0,25 f_r)

   where f_r is the frequency corresponding to the bit rate. Attenuation shall be monotonic for all frequencies from 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz).

c) Mismatching distortion: Mismatching (due to spurs or any other effect, including one open circuit spur of maximum length) on the bus shall be such that, at any point along the trunk, in the frequency band 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz):

   $|Z – Zfr| / |Z + Zfr| \leq 0,2$

   where Z_o is the characteristic impedance of the trunk cable and Z is the parallel combination of Z_o and the load impedance at the coupler.

The concentration of couplers shall be less than 15 per 250 m.

NOTE 4 Rule 8 minimizes restrictions on trunk and spur length, number of devices etc. by specifying only the transmission limitations imposed by combinations of these factors. It is possible to use different combinations depending on the needs of the application.

Rule 9: The following rules shall apply to systems implemented with redundant media:

a) each channel (cable) shall comply with the network configuration rules;
b) there shall not be a non-redundant segment between two redundant segments;
c) repeaters shall also be redundant;
d) if the system is configured (by Systems management) to transmit on more than one channel simultaneously then the propagation time difference between any two devices on any two channels shall not exceed five bit times;

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e) channel numbers shall be maintained throughout the fieldbus, i.e. channels 1, 2, 3... from Systems management shall always connect to physical channels 1, 2, 3...

21.3.4 Power distribution rules for network configuration

See 12.3.4.

21.4 Transmit circuit specification for 31,25 kbit/s voltage-mode MAU

21.4.1 Summary

For ease of reference, the requirements of 21.2 and 21.4 are summarized in Table 67 and Table 68 (see 12.4.1).

21.4.2 Test configuration

Figure 56 (see 11.4.2) shows the configuration that shall be used for testing.

Differential signal voltage: $V_d = V_a – V_b$.

Test load resistance R = 50 Ω (0,5 cable Z_0) and C = 10 μF except where otherwise stated in a specific requirement.

21.4.3 Impedance

For both the bus interfaces (i.e., medium attachment unit MAU) of the field devices and coupling elements and the power supplies, 11.4 requires that the input impedance (can be measured from the bus line) in the signal frequency range (7,8 kHz to 39 kHz) does not pass below a minimum value during normal operation. With the exception of the first 10 ms following connection of a field device to a power supply, this requirement applies to all aspects of operation. Table 105 shows the input impedances of bus interfaces and power supplies.

Table 105 – Input Impedances of bus interfaces and power supplies

	Impedance	Voltage range	Current range
Bus interface (e.g., field device)	≥ 3 kΩ	9 V to 32 V	For operating current
Intrinsically safe bus power supply	≥ 400 Ω	For operating voltage	0 to I_{Max}
Non intrinsically safe bus power supply	≥ 3 kΩ	For operating voltage	0 to I_{Max}

The input impedance of the bus interface shall be measured with a sinus signal whose amplitude shall be greater than the receiver sensitivity but always less than 2 Vss.

NOTE No measuring signal is defined for the power supply.

Impedance of the field device and the power supply shall be determined using the measuring circuit shown in Figure 91.

Impedance X of the tested device is calculated from the ratio of the two voltages U_D and U_R.

$$X = R_M \times \frac{U_D}{U_R}$$

The two measured voltages represent complex values whose phase difference is included in the result. If U_R is used as the reference, then:

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$$X = R_M \times \frac{|U_D|}{|U_R|} \times e^{j\varphi}$$

where

φ is the phase angle $\varphi(U_D)$- $\varphi(U_R)$

This reduces impedance measurement to a ratio measurement of two voltages and one phase difference measurement.

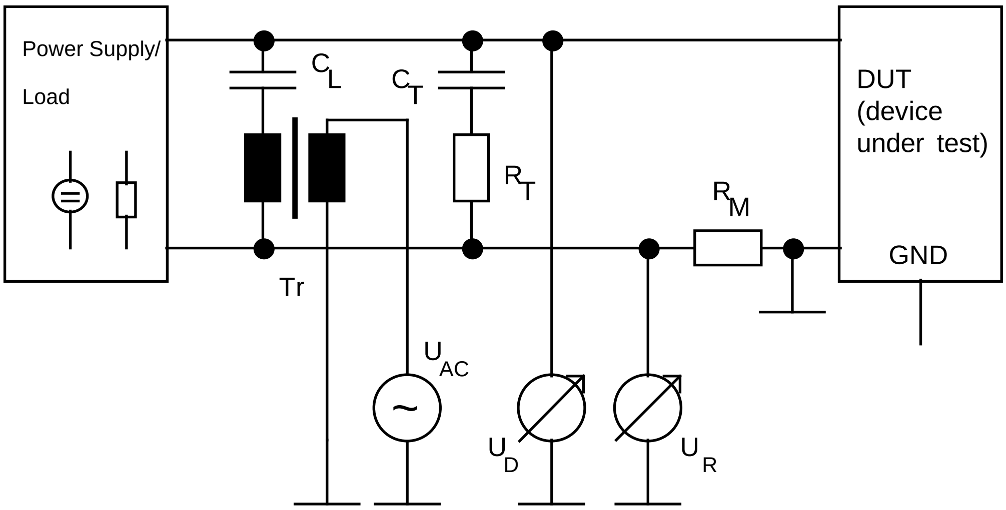

Figure 91 – Circuit diagram of the principle of measuring impedance

Example

CL = CT = 2 µF, RT = RM = 100 Ω

The phase angle can also be negative. If so, the object to be measured represents a negative load that amplifies rather than attenuates. This can be disregarded (it even has positive effects) for the signal frequency range from 7,9 kHz to 39 kHz as long as |X| remains within the specified range.

NOTE There is no specification for the impedance. Any low value is possible. In combination with unfavourable outside circuiting conditions (e.g., long stub lines), negative impedance can create an unattenuated oscillating circuit which turns the bus system into an oscillator although the object to be measured remains stabile in the measuring circuit.

The following sources of errors can affect the result of the impedance measurement.

a) Non-linear distortions. Correction: Use frequency-selective measurement (i.e., only evaluate the fundamental wave) and oscillographic monitoring of the measuring signal.

b) Asymmetries in the measuring setup. Correction: Use symmetrical transformer Tr and avoid ground capacitances. Leave open any ground connection on the test object (e.g., caused by EMC filter) when measuring the impedance.

c) Noise signals generated by the test object. Correction: Measure the background noise. It shall be ≤ 1 mV_{eff} (measured at 50 Ω). If this condition is met, the effect on the impedance measurement can be disregarded.

21.4.4 Symmetry

All bus interfaces shall be isolated from earth. The unbalanced capacitance between the two bus terminals and earth shall not exceed 250 pF. That is also required for barriers and power supplies.

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Under the condition that the impedance between each of the two bus terminals and earth only contains one capacitive component, measuring the two effective earth capacitances and then calculating the difference can determine asymmetry. Particularly when non-intrinsically safe bus interfaces, which can be coupled to the bus via a transformer, are used, significant inductive components are present. Even when coupling elements are used, which do not contain inductivities as components, inductive behaviour caused by parasitic effects can be detected particularly for higher frequencies. At best, a purely capacitive asymmetry only can be assumed within a limited frequency range. For this reason, it is recommended to determine the Common Mode Rejection Ratio CMRR as defined in Figure 92 to evaluate the characteristics of symmetry.

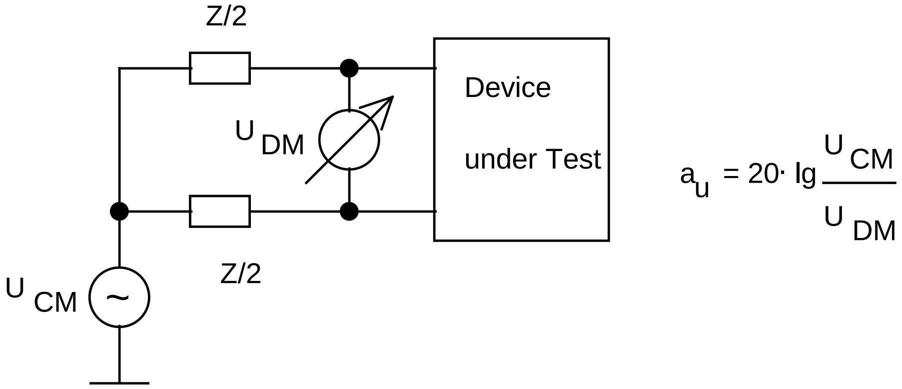

Figure 92 – Definition of CMRR

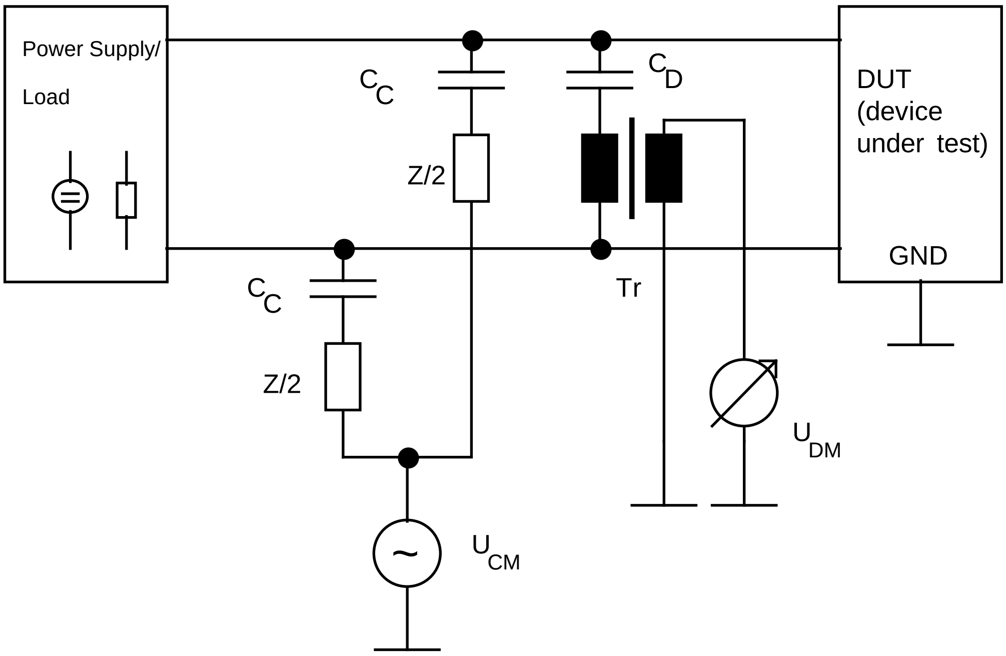

Figure 93 – Block circuit diagram of the principle of measuring CMRR

Example

$C_C = C_D = 2\ \mu F$, $Z/2 = 25\ \Omega \pm 0{,}1\ \%$.

Field device, barrier or power supply shall meet the required CMRR of Table 106. With regard to the unbalanced capacitance, the CMRR shall be higher than the values listed in Table 106. CMRR of the measuring instrument (e.g. as shown in Figure 93) without the device under test (i.e., DUT) shall be at least 10 dB above the listed values.

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Table 106 – Required CMRR

Frequency	kHz	≤ 40	120	400	1 200
CMRR	dB	≥ 50	≥ 40	≥ 30	≥ 20

21.4.5 Output level requirements

See 12.4.3.

21.4.6 Output timing requirements

See 12.4.4.

21.4.7 Signal polarity

See 11.4.5.

21.5 Receive circuit specification for 31,25 kbit/s voltage-mode MAU

See 12.5.

21.6 Jabber inhibit

See 12.6.

21.7 Power distribution

21.7.1 General

A device can optionally receive power via the signal conductors or be separately powered.

A device can be certified as Intrinsically safe with either method of receiving power.

NOTE This standard does not include requirements for IS-certification but seeks to exclude conditions or situations that would prevent IS certification.

A separately powered device can be connected to a powered fieldbus.

For ease of reference, the requirements of 21.7 are summarized in Table 107 and Table 108.

Table 107 – Network powered device characteristics for the 31,25 kbit/s voltage-mode MAU

Network powered device characteristics	Limits for 31,25 kbit/s
Operating voltage	9,0 V d.c. to 32,0 V d.c.
Minimum withstand voltage, either polarity, for no damage	35 V
Maximum rate of change of quiescent current (non-transmitting); this requirement does not apply within the first 10 ms after the connection of the device to an operating network or within the first 10 ms after the application of power to the network	1,0 mA/ms
Maximum current; this requirement applies during the time interval of 100 µs to 10 ms after the connection of the device to an operating network or 100 µs to 10 ms after the application of power to the network (see note)	Rated quiescent current plus 10 mA
NOTE The first 100 µs is excluded to allow for the charging of RFI filters and other capacitances in the device. The rate of change specification applies after 10 ms.	

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Table 108 – Network power supply requirements for the 31,25 kbit/s voltage-mode MAU

Network power supply requirements	Limits for 31,25 kbit/s
Output voltage, non-IS	≤ 32 V d.c.
Output voltage, IS	Depends on barrier rating
Output ripple and noise	See Figure 94
Output impedance, non-IS, measured over the frequency range 0,25 f_r to 1,25 f_r	≥3 kΩ
Output impedance, IS, measured over the frequency range 0,25 f_r to 1,25 f_r	≥400 Ω (See note)
NOTE The IS power supply is assumed to include an IS barrier.	

21.7.2 Supply voltage

A fieldbus device that includes a 31,25 kbit/s voltage-mode MAU shall be capable of operating within a voltage range of 9 V to 32 V d.c. between the two conductors including ripple. The device shall withstand a minimum voltage of ±35 V d.c. without damage.

NOTE 1 For IS systems the operating voltage is possibly limited by the certification requirements. In this case the power supply will be located in the safe area and its output voltage will be attenuated by a safety barrier or equivalent component.

A fieldbus device that includes a 31,25 kbit/s voltage-mode MAU shall conform to the requirements of Clause 21 when powered by a supply with the following specifications.

a) The output voltage of the power supply for non-IS networks shall be 32 V d.c. maximum including ripple.

b) The output impedance of the power supply for non-IS networks shall be ≥3 kΩ over the frequency range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz). This requirement does not apply within 10 ms of the connection or removal of a field device.

c) The output impedance of an IS power supply shall be ≥400 Ω over the frequency range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz).

NOTE 2 The IS power supply is assumed to include an IS barrier.

d) The breakdown requirements of the isolation of the signal circuit and the power distribution circuit from ground and from each other shall be in accordance with IEC 61131-2.

   The equivalent test voltage is to be applied between independent isolated circuits or between isolated circuits and accessible conducting parts.

NOTE 3 For circuits with a nominal voltage ≤ 50 V d.c. or r.m.s., the equivalent test voltages at sea level are 444 V r.m.s., 635 V d.c. and 635 V peak impulse test. For circuits with a nominal voltage between 150 V r.m.s. and 300 V r.m.s., the equivalent test voltages at sea level are 2 260 V r.m.s., 3 175 V d.c. and 3 175 V peak impulse test.

21.7.3 Powered via signal conductors

A fieldbus device which includes a 31,25 kbit/s voltage-mode MAU and is powered via the signal conductors shall be required to conform to the requirements of Clause 21 when operating with maximum levels of power supply ripple and noise as follows:

a) 16 mV peak-to-peak over the frequency range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz);

b) 2,0 V peak-to-peak over the frequency range 47 Hz to 63 Hz for non-IS applications;

c) 0,2 V peak-to-peak over the frequency range 47 Hz to 625 Hz for IS applications;

d) 1,6 V peak-to-peak at frequencies greater than 125 f_r, up to a maximum of 25 MHz;

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e) levels at intermediate frequencies generally in accordance with Figure 94.

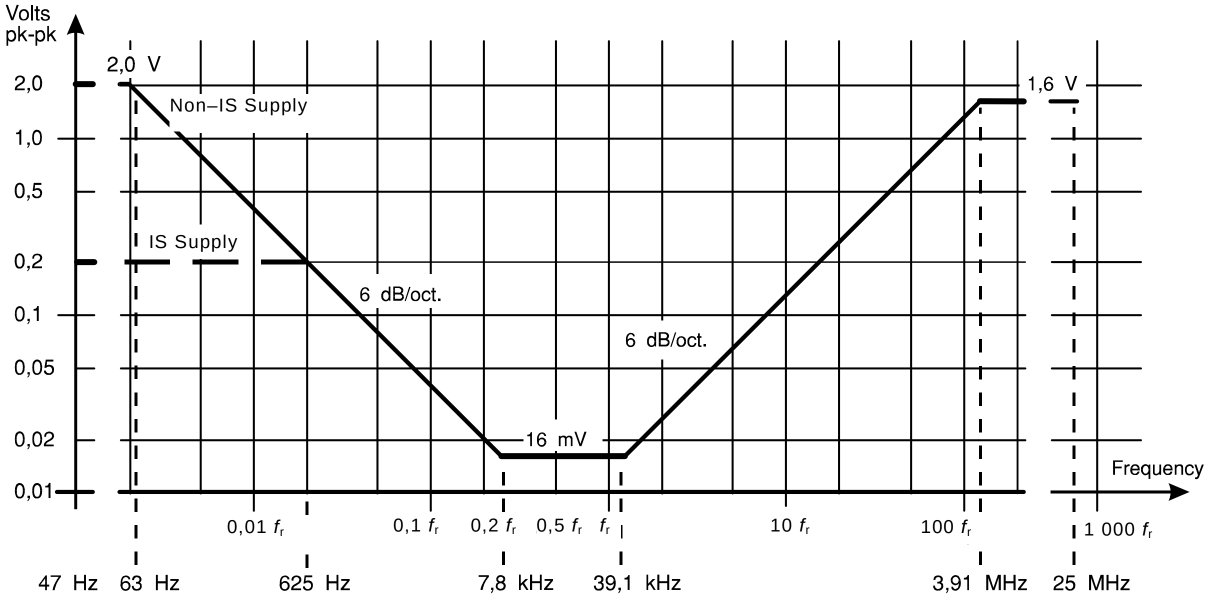

Figure 94 – Power supply ripple and noise

A fieldbus device which includes a 31,25 kbit/s voltage-mode MAU and is powered via the signal conductors shall exhibit a maximum rate of change of current drawn from the network of 1 mA/ms. This requirement does not apply:

- when transmitting;
- within the first 10 ms after the connection of the device to an operating network;
- within the first 10 ms after the application of power to the network;
- upon disconnection from the network or removal of power to the network.

A device shall be marked with a rated quiescent current. A device shall draw no more than 10 mA above its rated current from the network during the time interval of 100 μs to 10 ms after the connection of the device to an operating network or 100 μs to 10 ms after the application of power to the network.

NOTE The first 100 μs is excluded to allow for the charging of RFI filters and other capacitance in the device. The rate of change specification applies after 10 ms.

21.7.4 Electrical isolation

All fieldbus devices that use wire medium, whether separately powered or powered via the signal conductors, shall provide low-frequency isolation between ground and the fieldbus trunk cable.

NOTE 1 This is possible by isolation of the entire device from ground or by use of a transformer, opto-coupler or some other isolating component between trunk cable and device.

A combined power supply and communication element shall not require electrical isolation.

For shielded cables, the isolation impedance measured between the shield of the fieldbus cable and the fieldbus device ground shall be greater than 250 kΩ at all frequencies below 63 Hz.

The maximum unbalanced capacitance to ground from either input terminal of a device shall not exceed 250 pF.

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The breakdown requirements of the isolation of the signal circuit and the power distribution circuit from ground and from each other shall be in accordance with IEC 61131-2.

The equivalent test voltage is to be applied between independent isolated circuits or between isolated circuits and accessible conducting parts.

NOTE 2 For circuits with a nominal voltage ≤ 50 V d.c. or r.m.s., the equivalent test voltages at sea level are 444 V r.m.s., 635 V d.c. and 635 V peak impulse test. For circuits with a nominal voltage between 150 V r.m.s. and 300 V r.m.s., the equivalent test voltages at sea level are 2 260 V r.m.s., 3 175 V d.c. and 3 175 V peak impulse test.

21.8 Medium specifications

21.8.1 Connector

The connector is specified in Clause I.1.

21.8.2 Standard test cable

The cable used for testing fieldbus devices with a 31,25 kbit/s voltage-mode MAU for conformance to the requirements of Clause 21 shall be a single twisted pair cable with overall shield meeting the following minimum requirements at 25 °C:

a) Z_o at f_r (31,25 kHz) = 100 Ω ± 20 Ω;
b) maximum attenuation at 1,25 f_r (39 kHz) = 3,0 dB/km;
c) maximum capacitive unbalance to shield = 2 nF/km;
d) maximum d.c. resistance (per conductor) = 24 Ω/km;
e) maximum propagation delay change 0,25 f_r to 1,25 f_r = 1,7 μs/km;
f) conductor cross-sectional area (wire size) = nominal 0,8 mm^2;
g) minimum shield coverage shall be 90 %.

The preceding specification is for conformance testing an MAU. Other types of cable may be used in real installations. (See Annex B.) Cables with improved specifications may enable increased trunk length and/or superior interference immunity. Conversely, cables with inferior specifications may be used subject to length limitations for both trunk and spurs plus possible non-conformance to the RFI/EMI susceptibility requirements.

For Intrinsically Safe applications special requirements should be met such as specified by relevant Intrinsically Safe standards, e.g. IEC 60079-11 and IEC 60079-25.

21.8.3 Coupler

See 12.8.3.

21.8.4 Splices

See 12.8.4.

21.8.5 Terminator

A terminator shall be located at both ends of the trunk cable, connected from one signal conductor to the other. No connection shall be made between terminator and cable shield.

The terminator impedance value shall be 100 Ω ± 2 Ω over the frequency range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz).

NOTE 1 This value is approximately the average cable characteristic impedance value for suitable cables at the relevant frequencies and is chosen to minimize transmission line reflections.

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The direct current leakage through the terminator shall not exceed 100 μA. The terminator shall be non-polarized.

All terminators used for IS applications shall comply with isolation requirements (creepage and clearance) commensurate with the required IS approval. Terminators for non-IS applications shall not be required to have IS approval.

NOTE 2 It is acceptable for the functions of power supply, safety barrier, and terminator to be combined in various ways as long as the impedance of the combination is equivalent to the parallel impedance of independent devices meeting the requirements of Clause 21 and the network configuration rules of 21.3.3 are followed.

21.8.6 Shielding rules

See 12.8.6.

21.8.7 Grounding rules

NOTE 1 Grounding means permanently connected to earth through a sufficiently low impedance and with sufficient current-carrying capability to prevent voltage build-up which might result in undue hazard to connected equipment or persons. Zero volts (common) lines may be connected to ground where they are galvanically isolated from the fieldbus trunk.

Fieldbus devices shall be required to function to the requirements of Clause 21 with the mid-point of one terminator or one inductive coupler connected directly to ground.

Fieldbus devices shall not connect either conductor of the twisted pair to ground at any point in the network. Signals shall be applied and preserved differentially throughout the network.

It is best practice for the shield of the fieldbus trunk cable (if applicable) to be effectively grounded at several points along the length of the cable. But the fieldbus devices should allow d.c. isolation of the cable shield from ground.

It is also standard practice to connect the signal conductors to ground in a balanced manner at one central grounding point, e.g. by using the center tap of a terminator or coupling transformer. For bus powered systems the grounding of the shield and balanced signal conductors should be close to the power supply unit. For IS systems the grounding should be in accordance with the related Intrinsic safety standards, e.g. IEC 60079-11 and IEC 60079-25.

21.8.8 Cable colours

See 12.8.8.

21.9 Intrinsic safety

21.9.1 General

This standard does not attempt to list the requirements by which an item of equipment may be certified as intrinsically safe nor does it require equipment to be intrinsically safe. Rather, it seeks to exclude conditions or situations that would prevent IS certification.

21.9.2 Intrinsic safety barrier

The barrier impedance shall be greater than 460 Ω at any frequency in the range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz). The IS barrier impedance specification shall apply to all barriers used as part of the PhL, whether installed as a separate item of network hardware or embedded in a power supply card. The barrier impedance shall be measured across the terminals on both sides of the barrier. The barrier impedance shall be measured while the network power supply is set at the rated working voltage (not safety voltage) of the barrier.

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NOTE It is acceptable for the functions of power supply, safety barrier, and terminator to be combined in various ways as long as the impedance of the combination is equivalent to the parallel impedance of independent devices meeting the requirements of Clause 21 and the network configuration rules of 21.3.3 are followed.

At the rated working voltage of the barrier, and at any frequency in the range 0,25 f_r to 1,25 f_r (7,8 kHz to 39 kHz), the capacitance measured from the "+" (positive) network terminal (hazardous side) to ground shall differ by no more than 250 pF from the capacitance measured from the "–" (negative) network terminal (hazardous side) to ground.

21.9.3 Barrier and terminator placement

A barrier shall be separated from the nearest terminator by no more than 100 m of cable.

NOTE The barrier can appear as a shunt impedance as low as 460 Ω at the signaling frequencies. The terminator resistance is sufficiently low that when it is placed in parallel with the barrier impedance, the resulting impedance is almost entirely resistive (non-reactive).

21.10 Galvanic Isolators

The communications characteristics of galvanic isolators used on the fieldbus shall comply with the specifications of 21.9.

21.11 Coupling elements

21.11.1 General

Coupling elements are used to connect different Type 3 segments with the same PhL or a different PhL.

With the exception of signal levels this document does not describe the required characteristics of a coupling element. This means that it is the task of the system planner to ensure that "Network Configuration Rules" standard is complied with when coupling elements are used. The following specifications are important.

- Maximum signal delay;
- Maximum deviation from nominal signal zero crossing (signal jitter).

Two types of coupling elements can be used:

- MBP-IS repeaters;
- MBP-IS – RS 485 signal couplers.

21.11.2 MBP-IS repeater

A MBP-IS repeater connects two MBP-IS segments. It contains a MAU on each segment and a galvanic isolation between the two MAU. The electrical characteristics shown in Table 109 are mandatory for both fieldbus interfaces. MAU related requirements in Clause 12 and 21.1 to 21.10 also apply to repeaters.

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Table 109 – Electrical characteristics of fieldbus interfaces

Parameter	Values	Subclause of this standard
Signal coding	Manchester II	9.2.2
Start delimiter	1, N+, N-, 1, 0, N-, N+, 0 (Note 1)	9.2.4
End delimiter	1, N+, N-, N+, N-,1, 0, 1 (Note 1)	9.2.5
Preamble	1, 0, 1, 0, 1, 0, 1, 0	9.2.6
Data transmission rate	31,25 kbit/s ± 0,2 %	21.2
Output level (peak to peak)	0,75 V to 1 V	21.4.5
Max. difference between positive and negative transmit amplitude	± 50 mV	21.4.5
Max. transmit signal distortion (oversvoltage, ringing an drop)	± 10 %	21.4.5
Transmitter noise	1 mV (RMS) (Note 2)	21.4.5
Output impedance	≥ 3 kΩ (Note 3)	21.7.1
Operating voltage	9 V to 32 V (Note 4)	21.7.1
Common Mode Rejection Ratio (CMRR)	≥ 50 dB (Note 5)	
Leakage current (Note 6)	50 μA	

NOTES

1 N+ and N- are non-data symbols.

2 In frequency range of 1 kHz to 100 kHz.

3 In frequency range of 7,8 kHz to 39 kHz.

4 Operational voltage range. Can be limited to 9 V to 17,5 V or to 9 V to 24 V for intrinsically safe devices.

5 Corresponds to a unbalanced capacitance of 250 pF at 39 kHz.

6 Only for intrinsic safety.

Repeaters which are connected to intrinsically safe bus segments shall be certified as intrinsically safe apparatus. The certificate shall contain a statement that the devices conform to the FISCO model. The specifications of IEC 60079-11 shall be adhered to for galvanic isolation.

To be able to determine whether the network configuration rules in 21.3.3 are met, the system planner requires information on the signal delay caused by repeaters and the maximum deviation from the nominal signal zero crossing (i.e., signal jitter). This information shall be documented in the data sheet.

A repeater can be combined with a power supply and with line terminators.

21.11.3 MBP-IS – RS 485 signal coupler

A MBP-IS – RS 485 signal coupler connects a MBP-IS segment with a RS 485 segment. It contains a MAU on each segment, a galvanic isolation between the two MAU, and a Manchester encoding/decoding.

The electrical characteristics shown in Table 109 are mandatory for the MBP-IS interface. MAU related requirements in Clause 12 and 21.1 to 21.10 also apply. Clause 22 applies to the design of the RS 485 bus interface.

Signal couplers which are connected to intrinsically safe bus segments shall be certified as intrinsically safe apparatus. The certificate shall contain a statement that the devices conform

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to the FISCO model. The specifications of IEC 60079-11 shall be adhered to for galvanic isolation (see 21.10).

To be able to determine whether the network configuration rules in 21.3.3 are met, the system planner requires information on the signal delay caused by repeaters and the maximum deviation from the nominal signal zero crossing (i.e., signal jitter). This information shall be documented in the data sheet of a signal coupler.

A signal coupler can be combined with a power supply and with a bus terminator.

NOTE Such a device is usually called segment coupler.

21.12 Power supply

21.12.1 General

A power supply shall be connected to the bus to supply the field devices with power. The supply voltage depends on the requirements of the particular application.

The power for an intrinsically safe bus can either be provided by a power supply with intrinsically safe output or by a non intrinsically safe power supply supplemented by a barrier.

To prevent any impact on the data transmission, the electrical characteristics in Clause 21 of this standard and listed in Table 110 are mandatory for all power supplies.

The output terminals of a power supply shall be clearly marked with "+" and "-".

Although a power supply isolated against earth is not specifically required, asymmetrical grounding of the bus cable conductors is not permitted. It is essential that any connection between the conductors and earth is balanced. For more details, see 21.8.7.

Table 110 – Electrical characteristics of power supplies

	Not intrinsically safe	**Intrinsically safe, IIC FISCO** [a]	**Intrinsically safe, IIB FISCO** [a]	**Intrinsically safe, IIC linear barrier** [b]
According to FISCO model	no	yes	ja	
Max. DC supply voltage U_0	≤ 32 V	≤ 17,5 V	≤ 17,5 V	≤ 24 V
Max. DC short-circuit current I_0		≤ 360 mA	≤ 380 mA [g]	≤ 250 mA
Max. output power P_0		≤ 2,52 W	≤ 5,32 W	≤ 1,2 W
Ripple, noise	≤ 16 mV [c]	≤ 16 mV [c]	≤ 16 mV [c]	≤ 16 mV [c]
Output impedance [g]	≥3 k Ω [c d]	≥ 400 Ω [c d]	≥ 400 Ω [c d]	≥ 400 Ω [c d e]
Ripple, noise	≤ 16 mV [c]			
Asymmetry attenuation	≥ 50 dB [f]			≥ 50 dB [e f]

[a] Power supply with rectangular or trapezoidal characteristic in accordance with the FISCO model.

[b] Power supply or barrier with linear characteristic.

[c] In frequency range from 7,8 kHz to 39 kHz. Otherwise see Figure 94.

[d] With integrated line terminator: 100 Ω ± 2 %. It is recommended to provide each power supply with a terminating resistor.

[e] Including barrier if required.

[f] No mandatory specification in the standard, but required functionally.

[g] The current limit results from a rectangular characteristic.

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Power supplies that are used to supply field devices located in potentially explosive areas shall be certified as intrisically safe associated apparatus for use in hazardous locations.

21.12.2 Non-intrinsically safe power supply

Non intrinsically safe power supplies shall have the technical characteristics listed in Table 110.

Non intrinsically safe power supplies can be used together with an approved barrier to supply an intrinsically safe bus.

21.12.3 Intrinsically safe power supply

To supply field devices in potentially explosive areas, a power supply with intrinsically safe output can be connected to the bus instead of the combination of non intrinsically safe power supply and barrier. This device is usually located outside the hazardous area in the control room. In the sense of IEC 60079-11, this is a so-called associated apparatus since, although it is not protected against explosion itself, it does generate an intrinsically safe electric circuit which leads to the potentially explosive area.

In addition to the requirements in Clause 21 especially in Table 110, intrinsically safe power supplies shall meet the safety requirements stated in IEC 60079-14 and IEC 60079-11.

If the power supply is located within the hazardous area, an additional standardized type of protection shall be provided (e.g., installation in a housing of protection type “flameproof enclosure d").

Intrinsically safe power supplies can be part of other fieldbus components (e.g., segment couplers, see 21.11).

The FISCO model is based on a rated DC voltage of 13,5 V. The ignition curves for power supplies with rectangular characteristic indicate that the maximum permissible power considerably decreases if the voltage increases. On the other hand, a low voltage power supply may not be advantageous because of the voltage drop caused by the transmission line. Therefore the voltage of 13,5 V seems to be an acceptable compromise.

Due to tolerances and in order to offer a margin for the signal amplitude the maximum output voltage U_0 of a power device shall be greater than the rated output voltage. The signal amplitude is $\leq 1\ V_{PP}$, therefore a margin of 0,5 V is needed. If the tolerances are assumed to be ≤ 1 V the calculation results in a guaranteed maximum output voltage U_0 = 15 V. The admissible maximum output current (short circuit current), depending on the gas group, can be taken from available ignition curves or can be derived from ignition tests. In group IIC the allowed output current is I_0 = 128 mA. Other voltage/current combination in accordance with FISCO may be chosen.

Design and implementation of the safety-related voltage, and current limiters depends on the chosen category of the intrisically safe circuit (“ia“ or “ib“) The maximum values of the output parameters have to meet the requirements of FISCO.

An inspection certificate shall be obtained for the bus power supply as "associated apparatus" in the sense of IEC 60079-11. This certificate shall state that the power supply conforms to the FISCO model.

In addition to the usual data (i.e maximum output parameters), the certificate may also contain primary specifications applicable to permissible fieldbus configuration.

NOTE Usually limit values for the maximum permissible external inductance La and capacity Ca are not required. If these values had been included, it would create the impression that La and Ca are present in the intrinsically safe circuit as unprotected inductivity and capacity, which is not the case for the FISCO model. The cable here is

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not considered as concentrated inductivity and capacity as long as the parameters of the system remain within the range of limits defined in the FISCO model.

21.12.4 Power supply of the category "ib"

NOTE 1 Since the output current circuit of the power supply should have a low inner resistance for direct current, use of a power supply with a voltage regulator and an active current control (i.e., electronic current limitation) comes to mind. For example it is possible to achieve an inner resistance ≥ 400 Ω in the signal frequency range according Table 110 by using a frequency-dependent negative feedback.

The ideal output characteristic curve of a power supply (i.e., current/voltage characteristic) is rectangular (see Figure 95). When the output current increases, the output voltage remains constant until the current reaches a certain limit. IEC 60079-11 permits such a solution under the assumption that redundant current and voltage limitation has been set up and reliable galvanic isolation (optional) from the non intrinsically safe electric circuits has been provided.

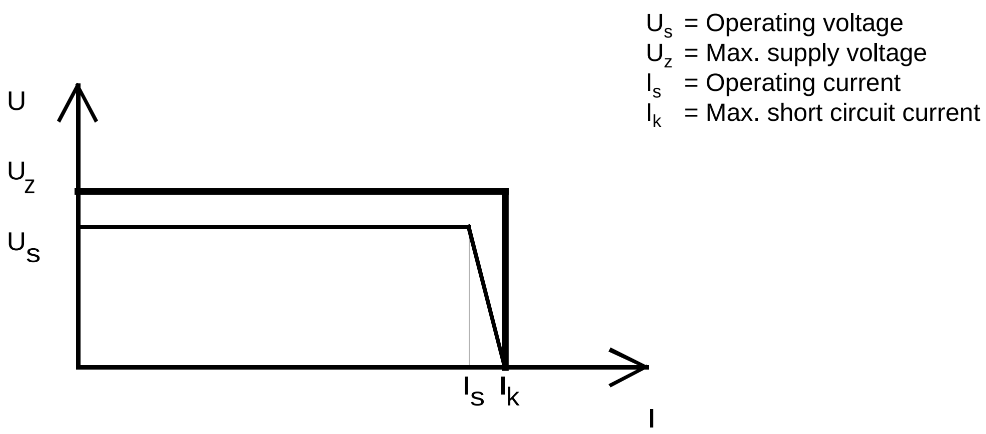

Figure 95 – Output characteristic curve of a power supply of the category EEx ib

NOTE 2 A voltage of 13,5 V direct current seems realistic since higher voltages would restrict the available power. The explosion limit curves for sources with square output characteristic curve show that the permissible power decreases significantly when the voltage increases.

21.12.5 Power supply in category "ia"

Power supplies with electronic current limitation shall be certified in accordance with IEC 60079-11 for category "ib".

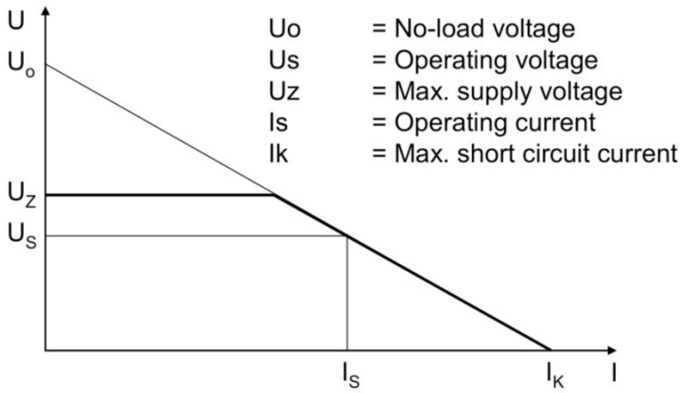

Figure 96 – Output characteristic curve of a power supply of the category EEx ia

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The ia-power supply shall be according FISCO. The maximum output current IK of Figure 95 corresponds to the current IZul (at U = Uz) of Figure 96.

Example

An example of a power supply suitable for category "ia" contains the following safey-related elements: Voltage source with Uo = 34 V, fixed resistance with R = 158 Ω, and Zener diodes with UZD = 15 V (maximum value). Such a circuit has a trapezoidal output characteristic curve as shown in Figure 96. The approximate operational values which can be achieved for the power supply are listed below.

U = 13,5 V

I = 120 mA

P = 1,7 W

$$P_{v\,max} = \frac{U_0^2}{R_v} = 7{,}32\ \text{W}$$

NOTE 1 Thus, the operational values are comparable to those of the "ib" concept with electronic current limitation. A disadvantage is the requirement of a relatively high thermal stress of the series resistor and the power loss in the series resistor which is always present under operational conditions.

Applying a safety factor of 1,5, the allowed power dissipation of the resistor shall be 11 W.

NOTE 2 Use of two resistors in series may be helpful.

The maximum power dissipation of the Zener diodes is 1,8 W.

$$P_{v\,max} = \frac{U_o - U_z}{R_v} \times 15\ \text{V} = \frac{34\ \text{V} - 15\ \text{V}}{158\ \Omega} \times 15\ \text{V} = 1{,}8\ \text{W}$$

Taking into account the safety factor, the Zener diodes shall be suitable for a maximum power dissipation of 2,7 W.

NOTE 3 The use of two diodes in series is also possible here.

IEC 60079-14 and IEC 60079-11 apply.

21.12.6 Reverse powering

With the exception of one power supply per segment, the FISCO model does not permit devices that are connected to the intrinsically safe fieldbus to feed power back to the fieldbus, even when a short circuit occurs on the fieldbus line. This is usually ensured by connection in series of two (for EEx ib) or three (for EEx ia) silicon or Schottky diodes in the input electric circuit. The field device conforms to the FISCO model when the leakage current of these diodes (up to the maximum reverse voltage in the permissible temperature range) does not exceed 50 μA. Diode manufacturer specifications (i.e., typical values as per data sheet) usually apply here in addition to a safety factor.

Final judgment of these measures is the responsibility of the certifying authority performing the safety tests and certification of the particular field device.

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22 Type 3: Medium attachment unit: asynchronous transmission, wire medium

22.1 Medium attachment unit for non intrinsic safety

22.1.1 Characteristics

This MAU specification describes a balanced line transmission corresponding to ANSI TIA/EIA RS-485-A. Terminators, located at both ends of the twisted-pair cable, enable the PhL to support in particular higher speed transmission. The maximum cable length is 1 200 m for data rates ≤ 93,75 kbit/s. For 1 500 kbit/s the maximum length is reduced to 70 m for type B and 200 m for type A cable. For 12 Mbit/s the maximum length is 100 m (only cable type A, see 22.1.2.2).

NRZ bit encoding is combined with ANSI TIA/EIA RS-485-A signaling targeted to low cost line couplers, which may or may not isolate the station from the line (galvanic isolation); line terminators are required, especially for higher date rates (up to 12 Mbit/s).

Table 111 shows the required characteristics.

Table 111 – Characteristics for non intrinsic safety

Characteristic	Constraints
Topology:	Linear bus, terminated at both ends, stubs ≤ 0,3 m, no branches; see Note. The total line length includes the sum of the stub lengths.
Medium:	Shielded twisted pair cable recommended, see "Medium specifications"
Line Length:[a]	≤ 1 200 m, depending on the data rate and cable type
Number of stations:[a]	32 (Master stations, slave stations or repeaters)
Data rates:	9,6 / 19,2 / 45,45 / 93,75 / 187,5 / 500 / 1 500 / 3 000 / 6 000 / 12 000 kbit/s, additional data rates can be supported.
[a] Repeater extents the characterists, see Table 112.	
NOTE In contrast to the ANSI TIA/EIA RS-485-A recommendations it is good practice to allow longer stubs, if the total of the capacities of all stubs (Cstges) does not exceed the following values: 0,05 nF at 3, 6 and 12 Mbit/s. 0,2 nF at 1,5 Mbit/s. 0,6 nF at 500 kbit/s. 1,5 nF at 187,5 kbit/s. 3,0 nF at 93,75 kbit/s. 15 nF at 9,6 and 19,2 kbit/s.	

The line length and number of connected stations may be increased by using repeaters. A maximum of 3 repeaters between two stations is permissible. If the data rate is ≤ 93,75 kbit/s and if the linked sections form a chain (linear bus topology, no active star, for example, as in Figure 97) and assuming a conductor cross-sectional are of 0,22 mm^2, the maximum permissible topology is shown in Table 112.

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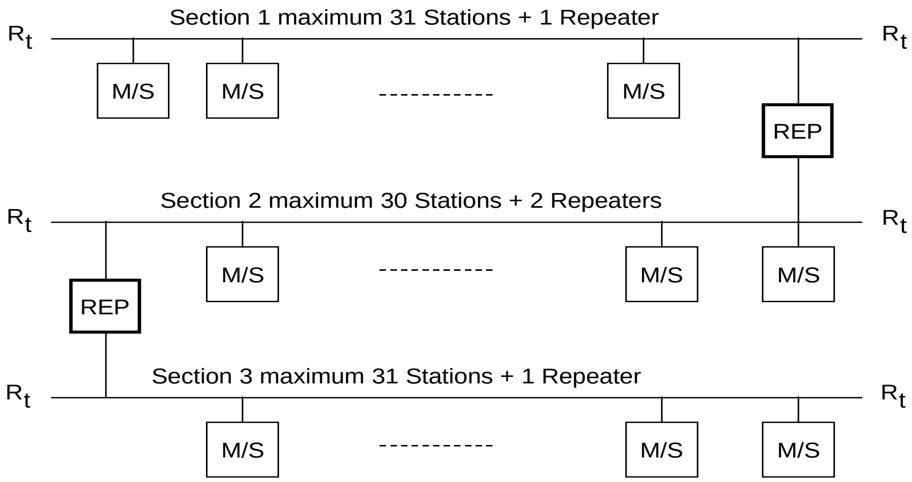
Table 112 – Characteristics using repeaters

Number of repeaters	Characteristic	Constraints
1	Line Length	< 2,4 km
	Number of stations	62 (Master stations, slave stations or repeaters)
2	Line Length	< 3,6 km
	Number of stations	92 (Master stations, slave stations or repeaters), see Figure 97
3	Line Length	< 4,8 km
	Number of stations	122 (Master stations, slave stations or repeaters)



where
M/S Master/Slave Station
REP Repeater
R_t Bus Terminator

Figure 97 – Repeater in linear bus topology

In a tree topology, for example, as in Figure 98, more than 3 repeaters may be used and more than 122 stations may be connected, for example, 5 repeaters and 127 stations. A large area may be covered by this topology, for example, 4,8 km length at a data rate less than 93,75 kbit/s and a cross-sectional area of 0,22 mm^2.

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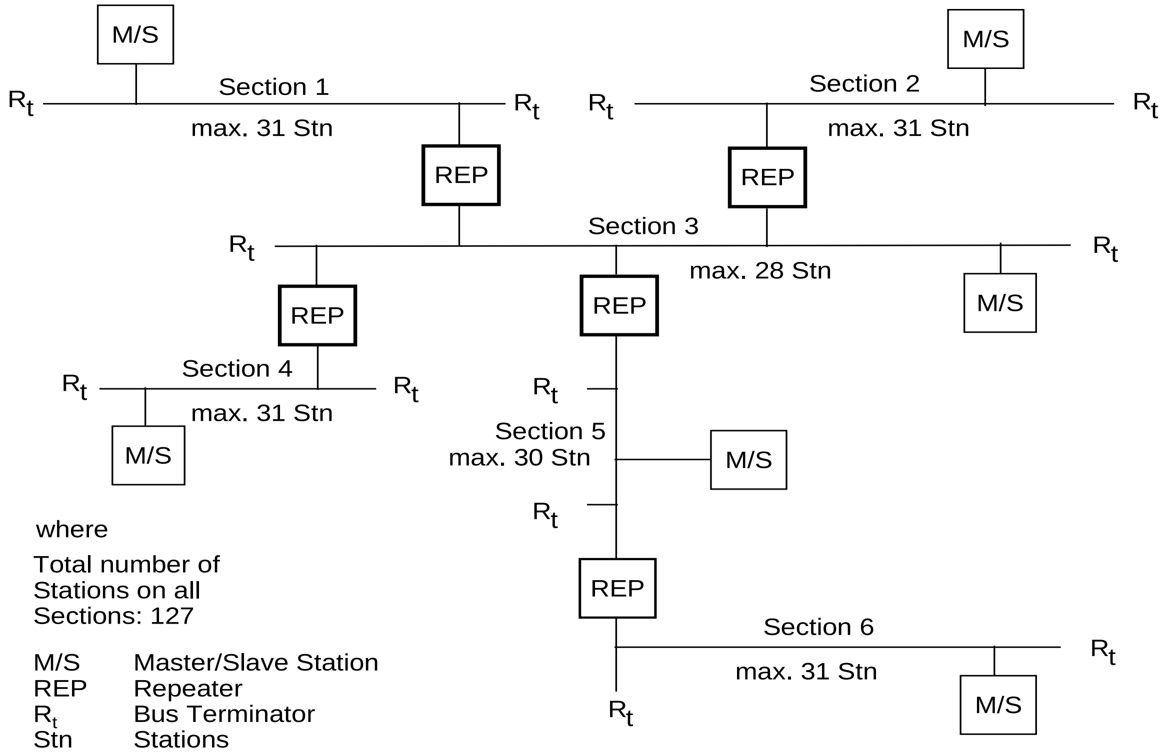

Figure 98 – Repeater in tree topology

22.1.2 Medium specifications

22.1.2.1 Connector

The connector is specified in I.2.1.

22.1.2.2 Cable

The bus medium is a shielded twisted-pair cable. The shield helps to improve the electromagnetic compatibility (EMC). Unshielded twisted-pair may be used, if there is no severe electromagnetic interference (EMI).

The characteristic impedance of the cable shall be in the range between 100 and 220 Ω, the cable capacity (conductor – conductor) should be less than 60 pF/m and the conductor cross-sectional area should be equal or greater than 0,22 mm^2. Cable selection criteria are included in the appendix of the ANSI TIA/EIA RS-485-A.

Two types of cables are defined, as specified in Table 113.

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Table 113 – Cable specifications

Cable parameter	Type A	Type B
Impedance	135 to 165 Ω (f = 3 to 20 MHz)	100 to 130 Ω (f > 100 kHz)
Capacity	< 30 pF/m	< 60 pF/m
Resistance	< 110 Ω/km	not specified
Conductor cross-sectional area	≥ 0,34 mm^2	≥ 0,22 mm^2
Colour of sheath non-IS	Violet	Not specified
Colour of inner cable conductor A (RxD/TxD-N)	Green	Not specified
Colour inner cable conductor B (RxD/TxD-P)	Red	Not specified

Table 114 shows the maximum length of cable type A and cable type B for the different transmission speeds.

Table 114 – Maximum cable length for the different transmission speeds

Item	Unit	Value								
Data rate	kbit/s	9,6	19,2	93,75	187,5	500	1 500	3 000	6 000	12 000
Cable type A	m	1 200	1 200	1 200	1 000	400	200	100	100	100
Cable type B	m	1 200	1 200	1 200	600	200	70	Not permissible		

For data rates equal or less 1 500 kbit/s the sum of the stub lengths (total of the capacities of all stubs (Cstges)) is specified in 22.1. For example at 1 500 kbit/s the maximum stub length for cable type A is 6,6 m.

At 3 Mbit/s and higher data rates the total capacities of all stubs shall be less than 0,05 nF. For cable type A the total stub length is therefore 1,6 m. At this data rate it is necessary to integrate impedance into the wiring to avoid reflections.

The following example, Figure 99, shows the integration of inductances L1 to L4 in the connector.

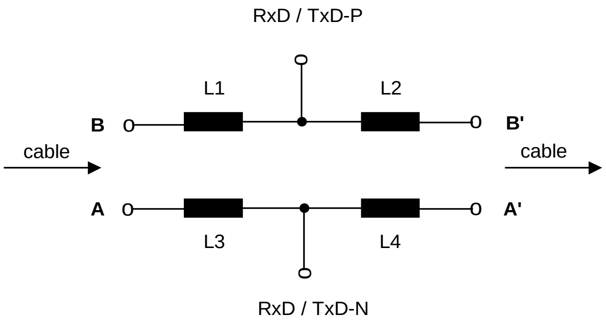

Figure 99 – Example for a connector with integrated inductance

For cable type A the inductances L1 to L4 shall have the value of 110 nH ±22 nH with the following constraint:

The resistance between A and A' as well as B and B' shall be ≤ 0,35 Ω.

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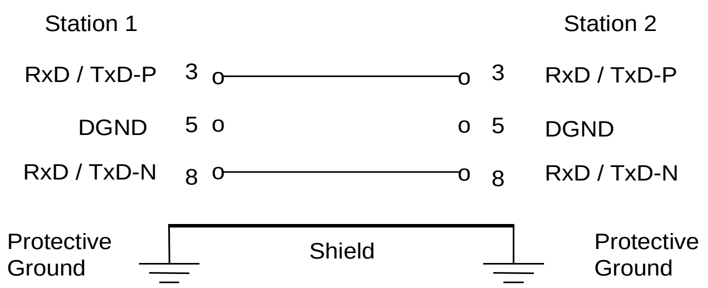
The typical capacity of each connected station (connector, cable to ANSI TIA/EIA RS-485-A Transceivers, Transceivers itself and other parts) shall be: 15 to 25 pF.

NOTE 1 The calculation of the inductance includes the contribution of the connected station. In case of disconnection of such connectors wiring reflections may occur which cause distortion on the bus.

The dependency of the permissible data rate upon the local link expanse (maximum distance between two stations) is shown in Figure 2-A.1 of the ANSI TIA/EIA-422-B (also included in ITU-T V.11).

NOTE 2 The recommendations concerning the line length presume a maximum signal attenuation of 6 dB. Experience shows that the distances possibly is doubled if conductors with a cross-sectional area ≥ 0,5 mm^2 are used.

The minimum wiring between two stations is shown in Figure 100.



NOTE Inversion of the two wires is not allowed!

Figure 100 – Interconnecting wiring

The wiring shown in Figure 100 allows a common mode voltage between both stations (that is, the voltage difference between the protective grounds) of at most ± 7 V. If a higher common mode voltage is expected, a compensation conductor between the grounding points shall be installed.

22.1.2.3 Grounding and shielding rules

If a shielded twisted-pair cable is used it is recommended to connect the shield to the protective ground at both ends of the cable via low impedance (that is, low inductance) connections. This is necessary to achieve a reasonable electromagnetic compatibility.

Preferably the connections between the cable shield and the protective ground (for example, the metallic station housing) should be made via the metallic housings and the metallic fixing screws of the sub-D connectors. If this is not possible the pin 1 of the connectors may be used.

22.1.2.4 Bus terminator

The bus cable type A and type B shall be terminated at both ends with R_{tA} respectively R_{tB}. The termination resistor R_t specified in ANSI TIA/EIA RS-485-A shall be complemented by a pulldown resistor R_d (connected to Data Ground DGND) and by a pullup resistor R_u (connected to Voltage-Plus VP), as shown in Figure 101. This supplement forces the differential mode voltage (that is, the voltage between the conductors) to a well-defined value when no station is transmitting (during the idle periods).

Each station that is destined to terminate the line (in common with a bus terminator) shall make Voltage-Plus (for example, + 5 V ± 0,25 V) available at pin 6 of the bus connector.

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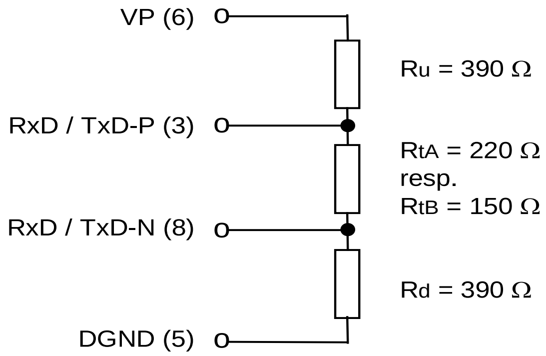

Figure 101 – Bus terminator

Assuming a power supply voltage of +5 V ±0,25 V the following resistor values are recommended:

R_{tA} = 220 Ω ±4,4 Ω, min. 1/4 W;

R_{tB} = 150 Ω ±3 Ω, min. 1/4 W;

R_u = R_d = 390 Ω ±7,8 Ω, min. 1/4 W

The power source supplying pin 6 (VP) shall be able to deliver a current of at least 10 mA within the specified voltage tolerances.

A mixture of both cable types and cable termination resistors as described above is allowed. However, the maximum line length has to be reduced up to the half of the above fixed values if line termination and line impedance do not match.

22.1.3 Transmission method

22.1.3.1 Bit coding

The "Non Return to Zero" (NRZ) coded data from DLL is transmitted via a twisted pair cable. A binary "1" (DL_symbol = "ONE") is represented by a constant positive differential voltage between pin 3 (RxD/TxD-P) and pin 8 (RxD/TxD-N) of the bus connector, a binary "0" (DL_symbol = "ZERO") by a constant negative differential voltage.

22.1.3.2 Transceiver control

When a station is not transmitting the transmitter output shall be disabled (DL_symbol = "SILENCE"), it shall present a high impedance to the line. During the idle periods, that is, when no data is transmitted by any station, the receive line signal shall represent a binary "1" (DL_symbol = "ONE"). Therefore the Bus Terminator shall force the differential voltage between the connector pins 3 and 8 to be positive when all transmitters are disabled. The line receivers shall always be enabled, therefore during idle the binary signal "1" is received by every station.

22.2 Medium attachment unit for intrinsic safety

22.2.1 Characteristics

This MAU specification describes a MAU for explosion protection type Ex i in accordance with IEC 60079-11 and IEC 60079-25 on the basis of balanced line transmission corresponding to ANSI TIA/EIA RS-485-A. Terminators, located at both ends of the twisted-pair cable, enable the PhL to support in particular higher speed transmission. The maximum cable length is 1 200 m for data rates ≤ 93,75 kbit/s. For the maximum transmission rate of 1 500 kbit/s the maximum cable length is reduced to 200 m. Only cable type A, see 22.2.2.2, shall be used with this MAU.

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NRZ bit encoding is combined with ANSI TIA/EIA RS-485-A signaling targeted to low cost line couplers. Line terminators are required.

In all devices connected to the fieldbus the bus interface circuit shall be galvanically isolated from all other electrical circuits. Separation distances and insulation voltages between intrinsically safe circuits and/or non-intrinsically-safe circuits shall meet the relevant applicable standards (e.g. IEC 60079-11).

Table 118 shows the required characteristics.

Table 115 – Characteristics for intrinsic safety

Characteristic	Constraints
Topology	Linear bus, terminated at both ends, stubs ≤ 0,3 m, no branches
Medium	Shielded twisted pair cable recommended, see "Medium specifications"
Line Length:	≤ 1 200 m, depending on the data rate
Number of stations:	32 (Master stations, Slave stations or fieldbus isolating repeaters and additionally 2 external bus terminators)
Data rates	9,6 / 19,2 / 45,45 / 93,75 / 187,5 / 500 / 1 500 kbit/s

The linear structure, as in Figure 102, permits connection points along the field bus segment similar to the installation of power supply circuits. The field bus cable should be looped through the individual field devices in order to avoid stubs.

A fieldbus isolating repeater or a comparable device normally forms the beginning of an intrinsically safe fieldbus segment. This fieldbus isolating repeater connects a non-intrinsically-safe fieldbus segment with the intrinsically safe fieldbus segment and simultaneously ensures reliable galvanic isolation between the two. The intrinsically safe fieldbus segment is terminated at both ends with an active bus termination. Up to 32 bus participants (field devices, fieldbus isolating repeater, external bus terminators etc.) can be arranged along the fieldbus segment. The bus participants are connected to a segment of the fieldbus in an electrically-floating arrangement.

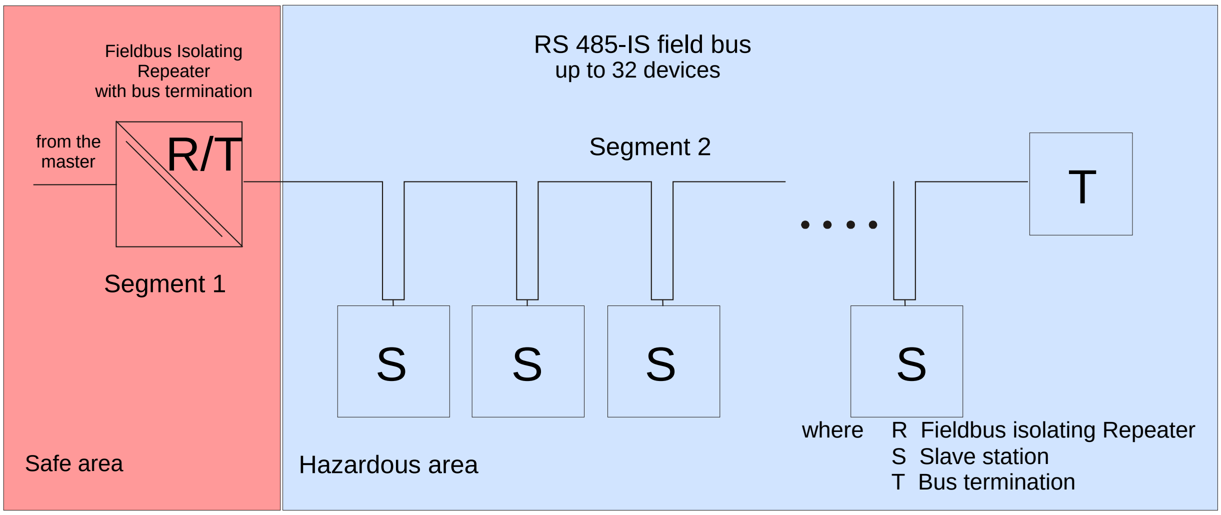

Figure 102 – Linear structure of an intrinsically safe segment

Figure 103 shows an example of the set-up and the segmentation of a fieldbus system with fieldbus isolating repeaters. The fieldbus segments 2 and 3 are intrinsically safe. The fieldbus isolating repeater between the intrinsically safe segments 2 and 3 shall maintain galvanic

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isolation. The number of cascadable repeaters depends on the signal distortion and the delay of the signal (pay attention to the manufacturer's specifications).

Segment 3 in Figure 103 is started by means of a fieldbus isolating repeater in the middle of segment 3. Bus termination is provided at one end by means of an active bus termination and at the other end by means of another fieldbus isolating repeater which opens segment 4 into the safe area.

The bus terminations of an fieldbus segment can be located in a fieldbus isolating repeater, field device, in an active bus termination (as a stand-alone device), or in a connector powered from a filedbus isolating repeater or field device.

The repeater between segments 2 and 3 in Figure 103 shall be installed either outside of the hazardous area, as associated apparatus. The installation in the hazardous area requires additional explosion protection measures (e.g. Ex e, Ex d, Ex I, etc., in accordance with IEC 60079-0).

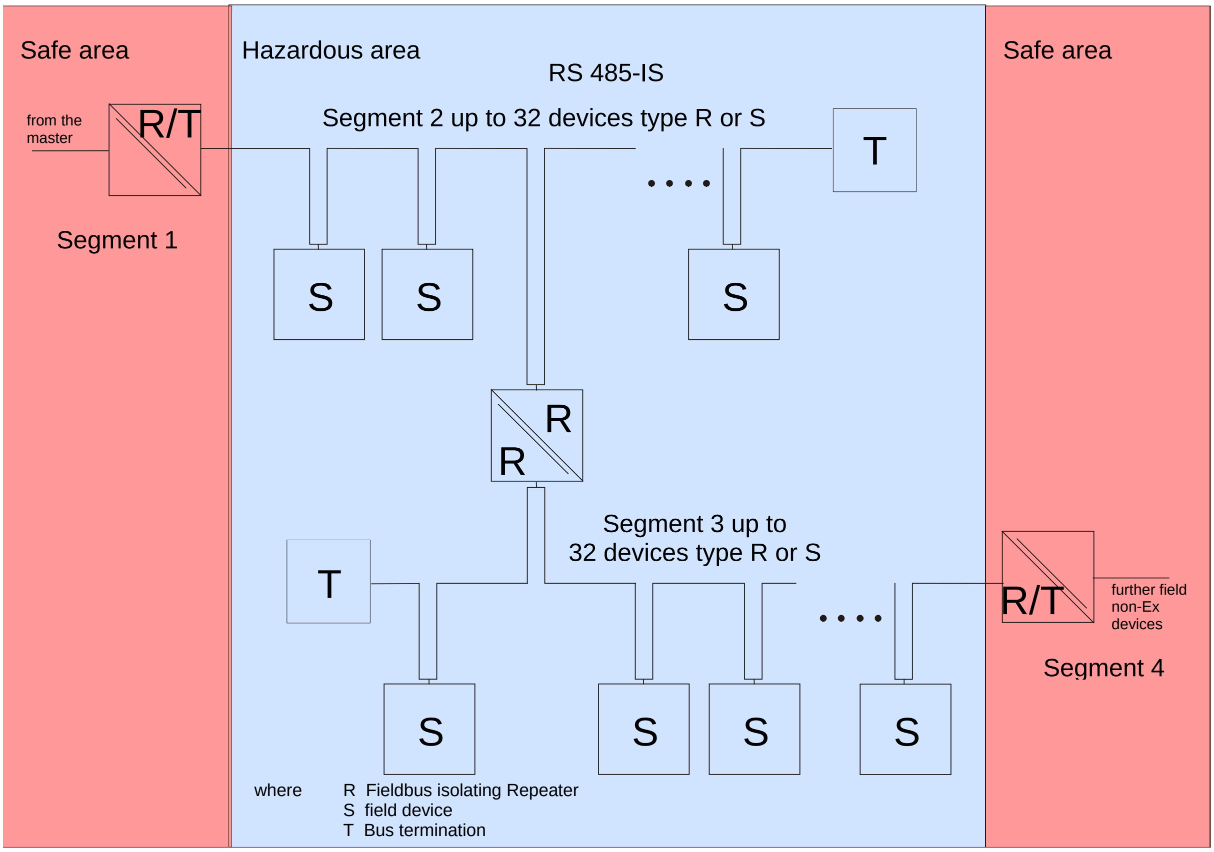

Figure 103 – Topology example extended by repeaters

22.2.2 Medium specifications

22.2.2.1 Connector

The connector is specified in I.2.2.

22.2.2.2 Cable

Table 116 shows the specified cable parameters related to function and intrinsic safety.

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Table 116 – Cable specification (function- and safety-related)

Cable parameter	Cable type A [a]	Limiting safety values
Surge impedance (Ω)	135…165 at a frequency of 3…20 MHz	Not relevant
Working capacitance (nF/km)	≤ 30	Not relevant
Wire diameter (mm)	> 0,64	> 0,1 single wire for a fine-stranded conductor [b] > 0,35 [c]
Core cross-sectional area (mm²)	> 0,34	> 0,096 2 [c]
Loop resistance (Ω/km)	≤ 110	Not relevant
L/R ratio (μH/Ω)	≤ 15	≤ 15 for the lowest ambient temperature (see Note)
Colour of sheath IS	Light blue	If colour is used for marking
Colour of inner cable conductor A (RxD/TxD-N)	Green	
Colour inner cable conductor B (RxD/TxD-P)	Red	

a In accordance with IEC 60079-14. The cable shall fulfil the requirements for cables.

b In accordance with IEC 60079-14. The wire ends of fine-stranded conductors shall be protected against separation of the strands, e.g. by means of cable lugs or core end sleeves.

c This minimum value applies for a maximum ambient temperature of 40 °C and the temperature class T6 for a total current in the field bus cable of max. 4,8 A. According to IEC 60079-11 To get information on the ampacity at other ambient temperatures, this shall be deduced from the existing requirements.In the case of the RS 485-IS, a maximum current of 4,8 A occurs in the field bus cable. This necessitates a wire cross section of ≥ 0,096 2 mm2 (diameter: ≥ 0,35 mm) for a cable used in T6 and for a maximum ambient temperature of 40 °C. Because the permissible surface temperature of the cable shall not exceed 80 °C in the case of T6, the maximum temperature rise is 40 K for 4,8 A and the above-specified wire cross section. For cables deployed in T4 and higher ambient temperatures than 40 °C, the sum of the ambient temperature and the cable's temperature rise shall not exceed 130 °C for a current of 4,8 A. In all cases, the insulation of the cable shall be suitable for the maximum expected cable temperatures.

NOTE Cable type A fulfils this requirement for a ambient temperature above –40 °C.

Table 117 shows the permissible maximum cable length depending on the transmission speeds.

Table 117 – Maximum cable length for the different transmission speeds

Item	Unit	Value					
Data rate	kbit/s	9,6	19,2	93,75	187,5	500	1 500
Cable type A	m	1 200	1 200	1 200	1 000	400	200

22.2.2.3 Grounding and shielding rules

NOTE Grounding means permanently connected to earth through a sufficiently low impedance and with sufficient current-carrying capability to prevent voltage build-up which might result in undue hazard to connected equipment or persons.

Zero volts (common) lines may be connected to ground where they are galvanically isolated from the fieldbus trunk.

Fieldbus devices shall not connect either conductor of the twisted pair to ground at any point in the network. Signals shall be applied and preserved differentially throughout the network.

The fieldbus devices should allow d.c. isolation of the cable shield from ground.

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For intrinsically safe installations the grounding shall be in accordance with IEC 60079-14.

For shielding, see 12.8.6.

22.2.2.4 Bus terminator

The bus cable type A shall be terminated at both ends with R_t. The termination resistor R_t specified in ANSI TIA/EIA RS-485-A shall be complemented by a pulldown resistor R_d (connected to Bus termination ground ISGND) and by a pullup resistor R_u (connected to Bus termination plus ISP), as shown in Figure 104. This supplement forces the differential mode voltage (that is, the voltage between the conductors) to a well-defined value when no station is transmitting (during the idle periods).

The termination of this MAU specification for explosion protection type Ex i differs from the specification of the non-intrinsic safe MAU on account of the modified electrical specification. In this context, the resistance values of the bus termination (see Figure 104) and the modified arrangement of the bus termination (see I.2.2) shall be paid attention when integrated into communication devices or plug connectors.

Each station that is destined to terminate the line (in common with a bus terminator) shall make a internal supply voltage U+ of + 3,3 V ± 5 % available.

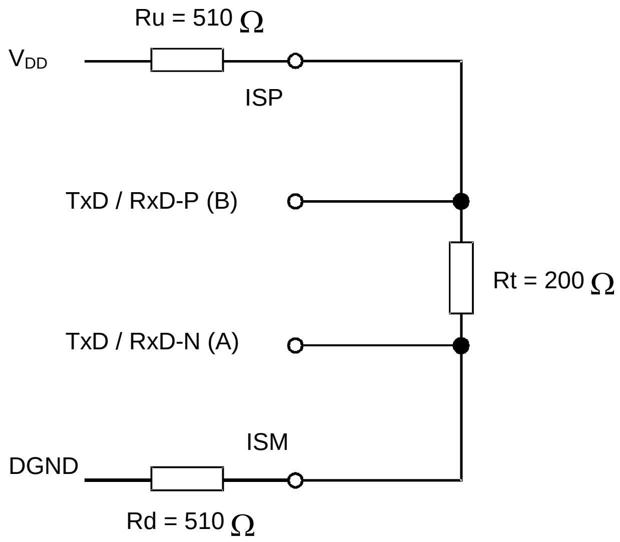

Figure 104 – Bus terminator

22.2.3 Transmission method

22.2.3.1 Bit coding

See 22.1.3.1.

22.2.3.2 Transceiver control

See 22.1.3.2.

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22.2.3.3 Signal characteristics

22.2.3.3.1 Signal specification

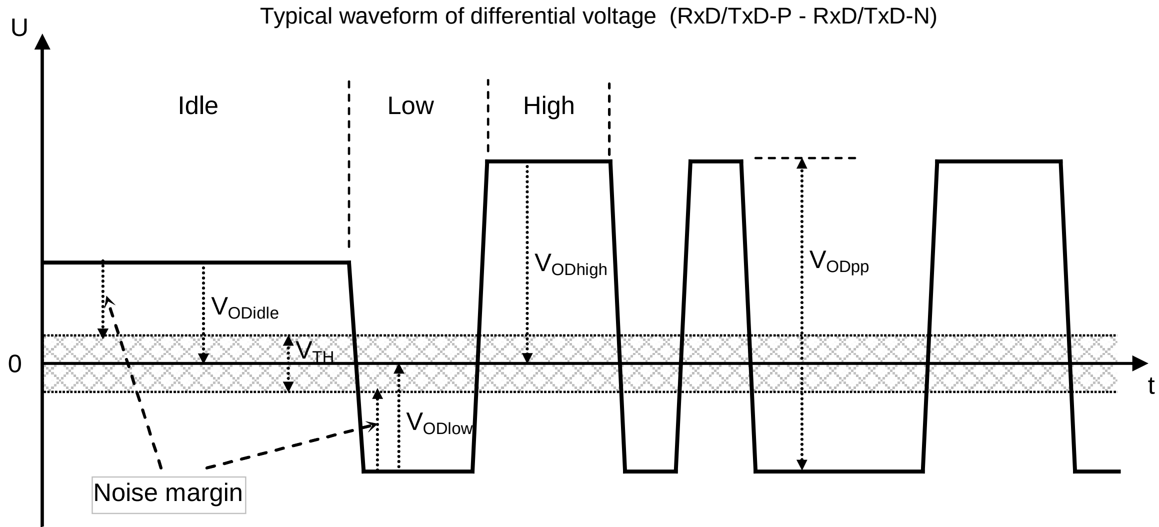
A typical voltage waveform on the intrinsically safe fieldbus is shown in Figure 105. Three phases are defined in which characteristic signal levels are generated on the bus:

– idle state with V_{ODidle}

– low phase with V_{ODlow}

– high phase with V_{ODhigh}

The noise margin plays a crucial role in the definition of signal levels. The noise margin of a signal level is always the difference between the voltage corresponding to this level and the threshold voltage. The threshold voltage U_{TH} is an attribute of the ANSI TIA/EIA RS-485-A receiver according to ANSI TIA/EIA RS-485-A and is defined in the range of ±0,2 V. For reliable data transmission the noise margin shall be as large as possible. In the case of the MAU for intrinsically safe fieldbus, a minimum noise margin of 0,2 V shall be assured under "worst case" conditions.



Key

V_{ODidle} = differential voltage in the idle state (no transmitter active)
V_{ODlow} = differential voltage in the low phase
V_{ODhigh} = differential voltage in the high phase
V_{ODpp} = full output level (peak-to-peak)
V_{TH} = threshold voltage of the receiver (±0,2V acc. to ANSI TIA/EIA-485-A)

Figure 105 – Waveform of the differential voltage

The parameters listed in Table 118 are mandatory for the communication devices.

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Table 118 – Electrical characteristics of the intrinsically safe interface

Parameter	Description	Value	Remark
Minimum idle level	V_{ODidle} [V]	0,50	Only relevant for devices with an integrated or a connectable bus termination
Transmission level on the bus connection (peak-to-peak)	V_{ODss} [V]	≥ 2,7	For the worst-case bus configuration and maximum load on the transmitter
Positive and negative transmission level on the bus connection	V_{ODhigh} [V]	≥ 1,5	For the worst-case bus configuration and maximum load on the transmitter
	V_{ODlow} [V]	≤ – 1,1	
Signal level on the receiver input	V_{IDhigh} [V]	≥ 0,8	For the worst-case bus configuration
	V_{IDlow} [V]	≤ – 0,4	
Data transmission rates	kbit/s	9,6; 19,2; 45,45; 93,75; 187,5; 500; 1 500	A field device can be designed with limited data transmission rate
Input impedance (receiver)	R_{IN} [kOhm] C_{IN} [pF] L_{IN}	≥ 12 ≤ 40 ≈ 0	For a device supplied or not supplied
Supply voltage RS 485 driver and bus termination	V_{DD} [V]	3,3 ±5 %	

22.2.3.3.2 Test circuits

22.2.3.3.2.1 General

The purpose of these measurements is the verification of the signal levels required by Table 118. The measurements should be performed statically at a low data transmission rate so that the existing reactances, like input capacitances, do not influence the measurement results. Furthermore, the bus cable is substituted by an equivalent resistance corresponding to the loop resistance for the maximum length of the bus cable.

NOTE Only the measurements which are specific for the intrinsically safe interface are described here.

Additionally the compliance with ANSI TIA/EIA RS-485-A should be verified.

22.2.3.3.2.2 Measurement of the idle level

This measurement determines the characteristics of the termination resistance. For this reason, this measurement shall only be performed on devices under test which are either equipped with a bus termination, see Figure 106, or provide a power supply for an external bus termination (the connections ISM and ISP are realised), see Figure 107.

The additional components as well as switch and resistors should be connected directly to the DUT terminals (5 cm to.15 cm). When a connecting cable shall be used, the length of the cable shall not exceed 1 m.

The measurement is undertaken in two steps:

Step 1: the open circuit voltage V1 is measured and shall be greater than specified in Table 118, line 1.

Step 2: the voltage V2 is measured under load conditions (330 Ω load). V2 shall be in a specified range (0,65·V1 ≤ V2 ≤ 0,72· V1). That guarantees that the termination resistor is in the range 130 Ω to 180 Ω.

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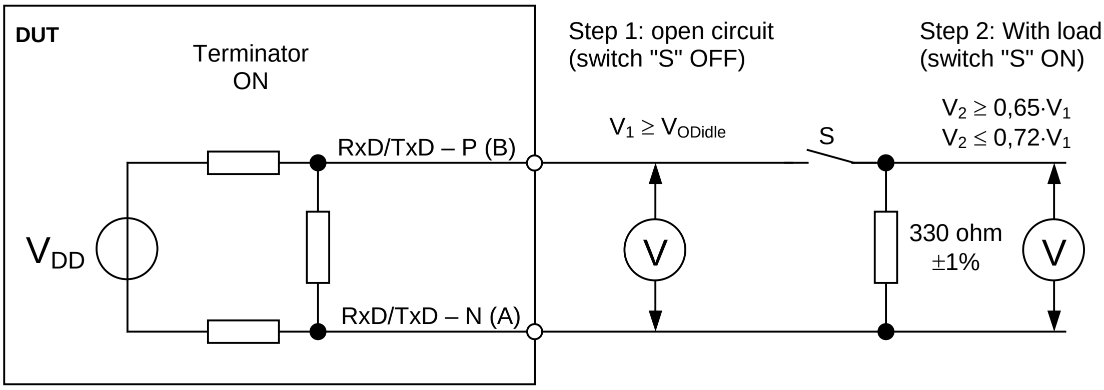

Figure 106 – Test set-up for the measurement of the idle level for devices with an integrated termination resistor

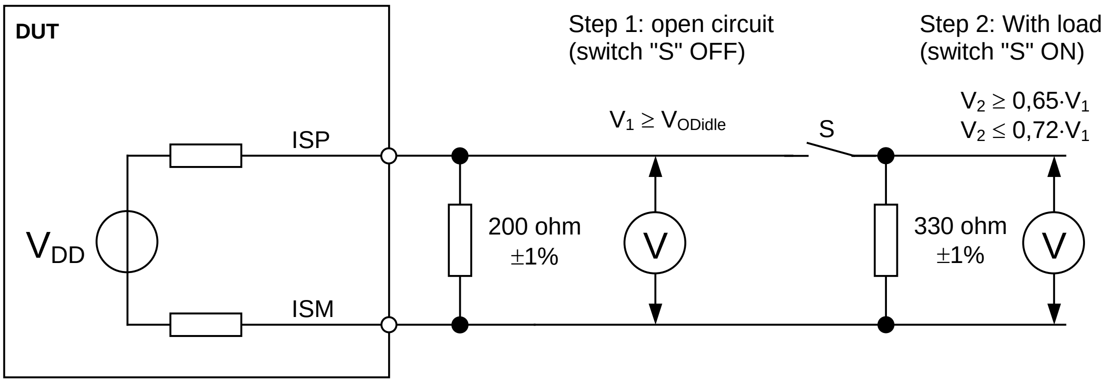

Figure 107 – Test set-up for the measurement of the idle level for devices with a connectable termination resistor

22.2.3.3.2.3 Measurement of the signal levels

For the measurement set-ups below A compliant fieldbus isolating repeater shall be employed for connection on the master system. During the test, the intrinsically safe fieldbus shall be terminated at both ends in accordance with 22.2.2.4. If the bus termination is not integrated in the device under test, then an external compliant bus termination shall be used.

In order to measure the signals on the intrinsically safe fieldbus without external influences, it is necessary to connect an electrically isolated oscilloscope (e.g. a hand-held with a battery supply).

The additional components as well as resistor and resistor network should be connected as short as possible to the terminals of the DUT and the fieldbus isolating repeater. When a connecting cable shall be used, the entire length of the cable(s) shall not exceed 2 m. The oscilloscope can be attached to any suitable terminals according to set-up.

The measurement shown in Figure 108 determines the transmission levels on the transmitter connections and for a worst-case load. This is the case for a fieldbus cable length equal to zero. In this case, the output current of the transmitter and consequently the load is at maximum. The rated values for the transmission levels are shown in Table 118, lines 2 and 3.

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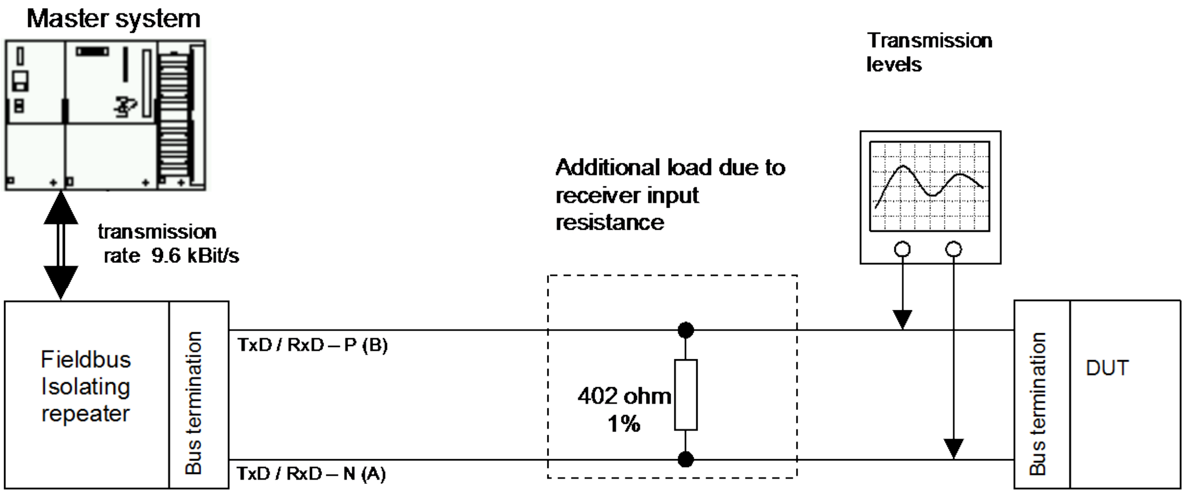

Figure 108 – Test set-up for measurement of the transmission levels

The measurement shown in Figure 109 attempts to verify the capability of the transmitter to generate a sufficient level for every receiver for a worst-case load. For a maximum fieldbus cable length of 1 200 m and additional load, this is the case roughly in the middle of the cable. The measurement values shall fulfill the requirements of Table 118, line 4.

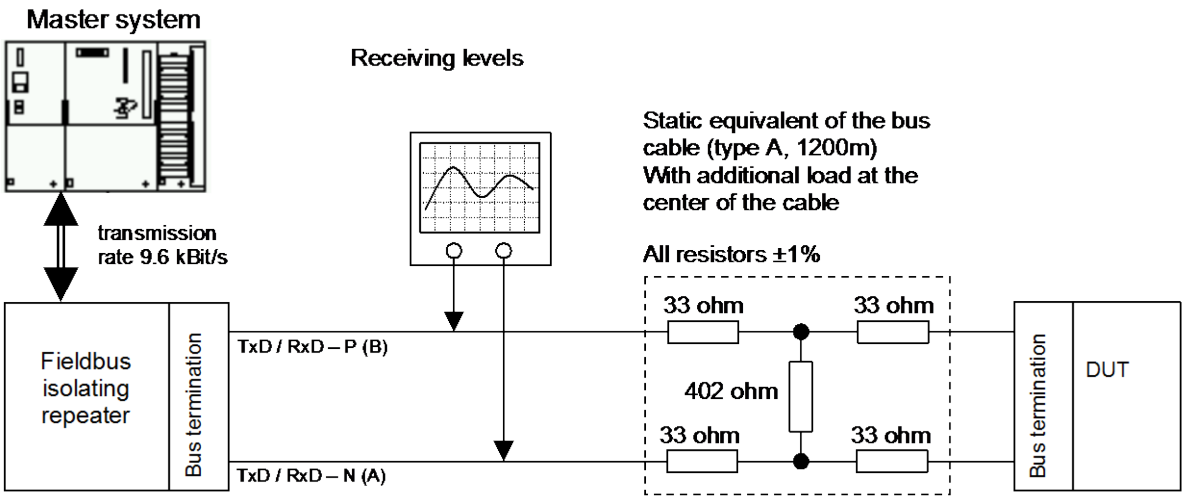

Figure 109 – Test set-up for the measurement of the receiving levels

22.2.4 Intrinsic safety

22.2.4.1 General

This standard does not attempt to list the requirements by which an item of equipment may be certified as intrinsically safe nor does it require equipment to be intrinsically safe. Rather, it seeks to exclude conditions or situations that would prevent intrinsic safety certification.

22.2.4.2 Fieldbus model for intrinsic safety

The intrinsically safe fieldbus is based on a model, in which all devices are active. All devices are supplied from outside and can provide power to the field bus. In an intrinsically safe circuit, only a maximum amount of energy is permissible when considering the inductances

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and capacitances which exist. This maximum amount of energy is described by the ignition curves.

NOTE The analysis carried out by the PTB (Physikalisch-Technische Bundesanstalt) forms the basis for the intrinsically safe fieldbus. PTB-Mitteilungen, 113 Jahrgang, Heft 2/2003, Die Bewertung der Zündfähigkeit eigensicherer Stromkreise anhand eines Rechenverfahrens. Abschnitt: Der eigensichere RS 485 Feldbus als Anwendungsbeispiel.

A basic set-up of the fieldbus model is shown in Figure 110. A fieldbus isolating repeater is (usually) located in the non-hazardous area for the safe separation of the intrinsically-safe bus segment from the non-intrinsically-safe bus segment. Other connected communications devices are located in the hazardous area. The bus cable is terminated at both ends by means of an external active bus termination or a bus termination integrated in a field device. All communications devices are supplied by external voltage sources and possess the means of safely limiting the current and voltage on the bus.

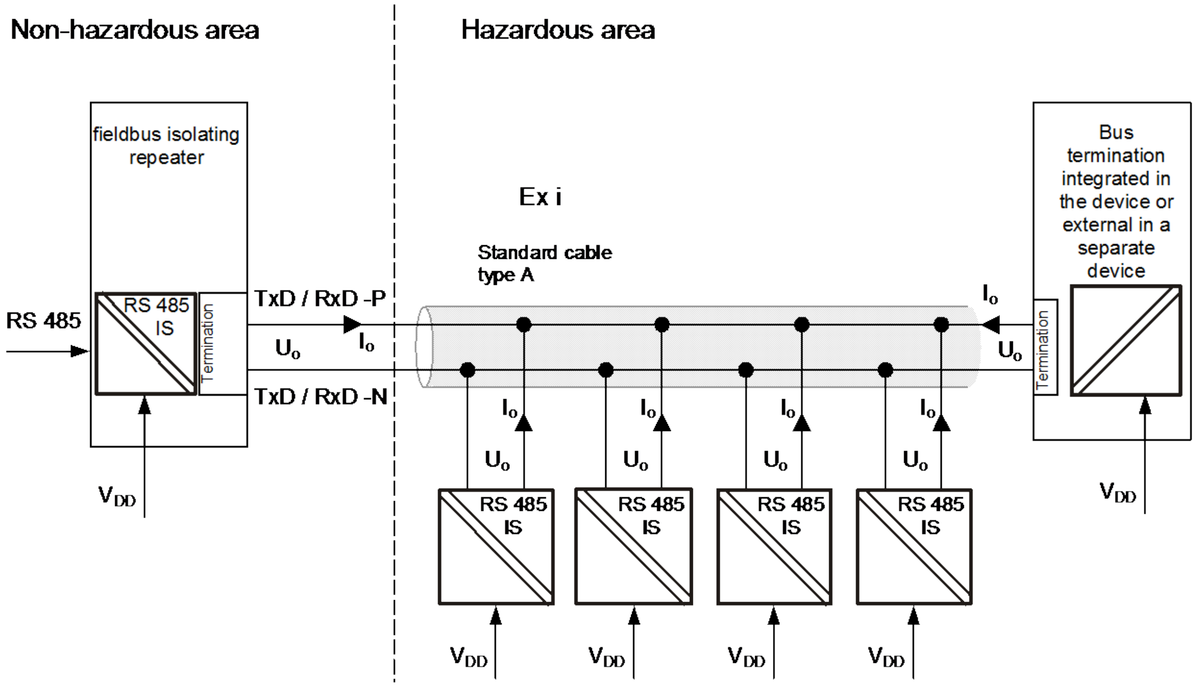

Figure 110 – Fieldbus model for intrinsic safety

Under certain circumstances, devices which are installed in the hazardous area shall be protected with additional explosion measures (e.g. Ex e, d, m in accordance with IEC 60079-0).

22.2.4.3 Model of a communication device

A circuit diagram for the RS 485-IS interface is described in Figure 111. The interface is composed of the components for galvanic isolation, voltage limitation, current limitation and an RS 485 transceiver.

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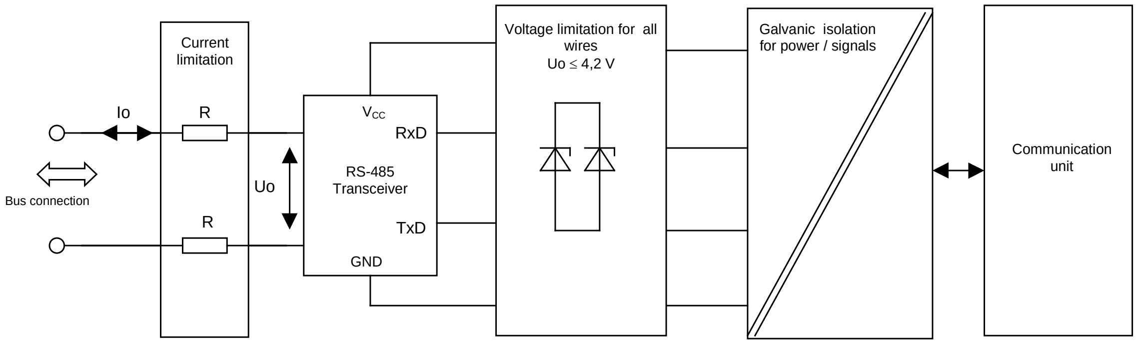

Figure 111 – Communication device model for intrinsic safety

To meet the limit for U_o given in Table 119 all connections to the bus interface (power supply and data lines) shall be limited by appropriate voltage limiting components. In this context, the tolerances and the maximum power rating of the components shall be taken into account. Under certain circumstances, suitable measures for power limitation should be introduced in the communications unit / power supply.

In all devices connected to the intrinsically safe the bus interface circuit shall be galvanically isolated from all other electrical circuits.

Separation distances and insulation voltages between intrinsically safe circuits and/or non-intrinsically-safe circuits shall meet IEC 60079-11.

NOTE Current limitation is determind by the maxium output voltage and the sum of the internal resistance. The internal resitace is formed by the series resistors of the data lines RxD/TxD-N and RxD/TxD-P and series resistors Ru and Rd for the supply of the bus terminator.

In this context, the tolerances and power ratings of the resistances shall also be taken into account. Detailed requirements for the current- and voltage-limiting components are outlined in IEC 60079-11.

22.2.4.4 Maximum safety values

Table 119 shows the safety relevant parameters and their values for the entire fieldbus system.

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Table 119 – Maximum safety values

Parameter	Description	Value	Remark
Bus system			
Maximum input voltage	U_I [V]	|±4,2|	
Maximum input current	I_I [A]	4,8	The characteristic of the circuit is linear Rs = Uo/Io
Maximum inductance to resistance ratio (see note)	L'/R' [μH/Ω]	15	For the whole operation temperature range of the bus system
Number of devices	N_{TN}	≤ 32	A field device can be designed with limited data transmission rate
Communication Device			
Maximum output voltage	Uo [V]	|±4,2|	
Maximum output current	Io [mA]	149	Total current from wires A, B and supply for bus termination
Maximum input voltage	U_I [V]	|±4,2|	
Maximum internal inductance	L_I [H]	0	No concentrated inductances are permissible along the fieldbus
Maximum internal capacitance	C_I [nF]	N/A	Insignificant for safety
External active bus termination			
Maximum output voltage	Uo [V]	|±4,2|	
Maximum output current	Io [mA]	16	
Maximum input voltage	U_I [V]	|±4,2|	
Maximum internal inductance	L_I [H]	0	No concentrated inductances are permissible along the fieldbus
Maximum internal capacitance	C_I [nF]	N/A	Insignificant for safety
NOTE For a voltage less than 10 V, the cable capacitance does not cause any additional danger. However, for functional reasons, the cable capacitance for the bus cable is limited to C' < 40 nF/km.			

For functional reasons, the current limitation resistance should be subdivided symmetrically.

22.2.4.5 Fieldbus isolating repeater

In order to create or connect intrinsically safe fieldbus segments, fieldbus isolating repeaters (see Figure 102 and Figure 103) are required. The intrinsically safe fieldbus interfaces of these devices shall also be implemented in accordance with this MAU specification. In particular, the maximum safety data (see 22.2.4.4) and the galvanic isolation from all other circuits (see 22.2.1) shall be considered from the safety point of view.

The fieldbus isolating repeater shall be designed as associated apparatus. If the fieldbus isolating repeaters are to be installed in the hazardous area, additional explosion-protection measures are necessary.

23 Type 3: Medium attachment unit: asynchronous transmission, optical medium

23.1 Characteristic features of optical data transmission

Table 120 shows the characteristic features of an optical data transmission.

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Table 120 – Characteristic features

Item	Feature
Transfer medium	Fiber optic cable (FOC) manufactured from quartz or plastic
Characteristics	– Large range, independent of the transmission speed – Insensitivity to electromagnetic disturbance – Galvanic isolation between the connected nodes – Non-reacting connection – even to existing implementations – Configuration of the optical components with economical, standard components
Network structure	Star, ring, line and mixed topologies (tree) Connection to electrical network segments
Network components	Active star coupler, Repeater, Opto-electrical converter } with or without retiming
Data rates	9,6 kbit/s; 19,2 kbit/s; 45,45 kbit/s; 93,75 kbit/s; 187,5 kbit/s; 500 kbit/s; 1,5 Mbit/s; 3 Mbit/s; 6 Mbit/s; 12 Mbit/s
Network range and number of nodes	Dependent on the number and type of network components used EXAMPLE 1 Network segment with 1 active star coupler and glass fiber optic cable (multimode) : - 3 400 m (independent of the number of nodes). EXAMPLE 2 Network segment with 1 active star coupler and plastic fiber optic cable: - 88 m (independent of the number of nodes). NOTE Increasing of ranges and numbers of nodes is possible through linking network segments.

Figure 112 shows the optical MAU beside an ANSI TIA/EIA RS-485-A MAU. This means that the optical MAU shall be connected over a DL-Ph interface to a DLL in the same manner as an ANSI TIA/EIA RS-485-A MAU. The mentioned interface is described in 5.4.2.

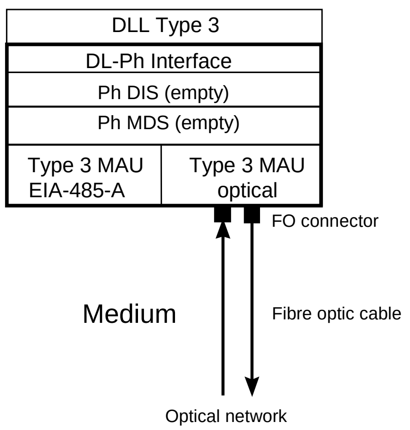

Figure 112 – Connection to the optical network

23.2 Basic characteristics of an optical data transmission medium

An optical data transmission medium is characterized by:

– Insensitivity to electromagnetic interference, i.e.:
   a) no cross talk between different fiber optic signal lines,

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b) immunity to interference injection from and to electrical lines,
c) immunity to interference from electromagnetic fields which can occur e.g. when switching large electrical loads.

– Galvanic isolation between the connected nodes, i.e.:
  a) no equalizing currents between differing ground potentials
  b) no special lightning protection measures are required for the transmission link.
– The capability to use fiber optics to bridge large distances at high transmission speeds.
– Simple and economical installation of shorter networks based on plastic fibers.
– Low weight.
– No corrosion.
– Simplified standard cabling of buildings through identical reference fibers for many other communication standards.

23.3 Optical network

Significant components of the optical MAU of a node are the electro-optical converters that interface the electrical part of the MAU and an optical network medium.

An optical transmitter converts electrical signals into optical ones and feeds these signals into the optical medium. Conversely, an optical receiver converts the received optical signals from the optical medium into electrical signals.

Figure 113 shows the principal structure of an optical network.

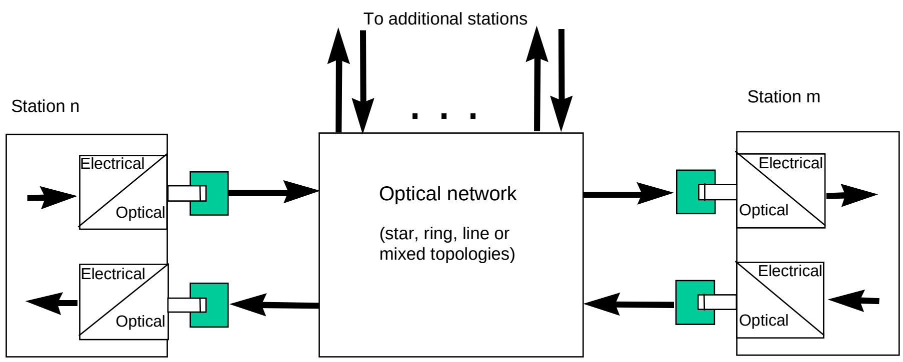

Figure 113 – Principle structure of optical networking

Electrical-optical converters with a specific signal level budget that take into account of the physical differences between glass and plastic fibers are specified for each fiber type.

The user can “consume” the signal level budget as attenuation along the optical link.

23.4 Standard optical link

The standard optical link is a theoretical construction that is used to specify the admissible range of signal levels and signal distortions, see Figure 114.

Network topologies of any complexity can be calculated from the standard optical link. The standard optical link consists of

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– an electro-optical converter (transmitter) that converts an electrical signal into an optical signal which lies within the admissible limits specified by the signal template (see Figure 115);
– a passive optical link consisting of a fiber optic cable and characterized by signal amplitude attenuation and signal timing distortion;
– an opto-electrical converter (receiver) that detects the received optical signal as described in 23.7.3 and converts this signal to an electrical signal with characteristics specified in 23.8.

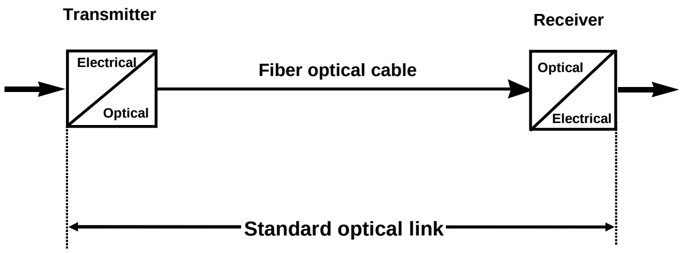

Figure 114 – Definition of the standard optical link

23.5 Network structures built from a combination of standard optical links

According to the definition above, a standard optical link forms an end-to-end connection. Standard optical links can be interconnected (chained) to build complex networks by interconnecting the electric interfaces. Chaining rules are specified in 23.8.3.

The user can thus specify the network structure by choosing the signal distribution to best meet the requirements of the system to be networked.

The following topologies are supported: star, ring or linear topologies, as well as their combination to form a mixed topology. Coupling of optical and electrical segments of the network (such as ANSI TIA/EIA RS-485-A MAU) is both possible and permissible.

23.6 Bit coding

NRZ bit coding (non return to zero) from the DLL is represented with optical signals as follows:

– binary "1" (DL_symbol = "ONE") means no light on the FOC,
– binary "0" (DL_symbol = "ZERO") means light on the FOC.

The idle state (DL_symbol = "SILENCE") has the “1” binary state, i.e. no light.

23.7 Optical signal level

23.7.1 General

Taking into account the physical differences between glass and plastic fibers, a specific level budget is applicable for both fiber types.

23.7.2 Characteristics of optical transmitters

The transmitted power is specified in dBm.

The specified levels are defined at the end of a 1m long glass fiber optic cable or a 0,5 m long plastic fiber optic cable and measured with a large detector area. Cladding modes shall not be included in the measured value. The fiber optic cable shall be connected to the transmitter

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using the connector specified in 23.10. That is, the attenuation of the connector at the optical transmitter is included in the measured value.

The signal level tolerances are applicable for the entire operating temperature range (ambient temperature of the transmitter element).

All values specified in the following Table 121 to Table 124 are based on the shape of the transmit signal specified by the signal template in Figure 115. The technical terms used in the table (peak wavelength, etc.) are explained in IEC 60050-731.

Table 121 – Characteristics of optical transmitters for multi-mode glass fiber

Quantity	Value	Unit
Peak wavelength	790 to 910	nm
Spectral width	≤ 75	nm
Operating temperature	0 to 70	°C
Test fiber (graded index) (see note)	62,5/125	µm
NA (numerical aperture of the test fiber)	0,275 ± 0,015	
$P_{Smax“0“}$ (max. transmit power for binary “0“)	-10	dBm
$P_{Smin“0“}$ (min. transmit power for binary “0“)	-15	dBm
$P_{Smax“1“}$ (max. transmit power for binary “1“)	-40	dBm
P_{Sost} (max. overshoot, transmit power for binary “0“)	-8,8	dBm
NOTE Test fiber as specified in IEC 60793, Type A1b.		

Table 122 – Characteristics of optical transmitters for single-mode glass fiber

Quantity	Value	Unit
Peak wavelength	1 260 to 1 380	nm
Spectral width	≤ 120	nm
Operating temperature	0 to 70	°C
Test fiber (graded index) (see note)	9/125	µm
NA (numerical aperture of the test fiber)	0,113 ± 0,02	
$P_{Smax“0“}$ (max. transmit power for binary “0“)	-10	dBm
$P_{Smin“0“}$ (min. transmit power for binary "0“)	-20	dBm
$P_{Smax“1“}$ (max. transmit power for binary “1“)	-40	dBm
P_{Sost} (max. overshoot, tx power for “0“)	-8,8	dBm
NOTE Test fiber as specified in IEC 60793, Type B1.1, B3.		

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Table 123 – Characteristics of optical transmitters for plastic fiber

Quantity	Value		Unit
Peak wavelength	640 to 675		nm
Spectral width	≤ 35		nm
Operating temperature	0 to 70		°C
Test fiber (graded index) (see Note)	980/1 000		µm
NA (numerical aperture of the test fiber)	0,5 ± 0,15		
Transmitter power level	Standard	Increased	
$P_{Smax“0“}$ (max. transmit power for binary “0“)	-5,0	0	dBm
$P_{Smin“0“}$ (min. transmit power for binary “0“)	-11	-6	dBm
$P_{Smax“1“}$ (max. transmit power for binary “1“)	-42	-42	dBm
P_{Sost} (max. overshoot, transmit power for binary “0“)	-4,3	2,3	dBm
NOTE Test fiber as specified in IEC 60793, Type A4a.			

Table 124 – Characteristics of optical transmitters for 200/230 µm glass fiber

Quantity	Value	Unit
Peak wavelength	640 to 675	nm
Spectral width	≤ 35	nm
Operating temperature	0 to 70	°C
Test fiber (stepped index) (see Note)	200/230	µm
NA (numerical aperture of the test fiber)	0,37 ± 0,02	
$P_{Smax“0“}$ (max. transmit power for binary “0“)	-8	dBm
$P_{Smin“0“}$ (min. transmit power for binary “0“)	-17	dBm
$P_{Smax“1“}$ (max. transmit power for binary “1“)	-44	dBm
P_{Sost} (max. overshoot, transmit power for binary “0“)	-6,8	dBm
NOTE Test fiber in IEC 60793, Type A3c: NA = 0,4 ± 0,04.		

23.7.3 Characteristics of optical receivers

The input sensitivity of receivers is also specified in dBm see Table 125 to Table 128 The input sensitivity is measured at the end of the specified reference fiber with a large detector area. Cladding modes shall not be included in the measured value.

The signal level tolerances are applicable for the entire operating temperature range (ambient temperature of the receiver element). They shall be maintained throughout the specified lifetime of the receive element. The shape of the receive signal is based on the shape of the transmit signal shown in the signal template in Figure 115.

The receiver shall tolerate an overshoot of the input signal at the beginning of a binary “0” pulse. However, the receiver shall not require an overshoot, e.g. to maintain a required signal distortion.

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Table 125 – Characteristics of optical receivers for multi-mode glass fiber

Quantity	Value	Unit
Peak wavelength	790 to 910	nm
Operating temperature	0 to 70	°C
$P_{Emax“0“}$ (max. receive power for binary “0“)	-10	dBm
$P_{Emin“0“}$ (min. receive power for binary “0“)	-24	dBm
$P_{Emax“1“}$ (max. receive power for binary “1“)	-42	dBm

Table 126 – Characteristics of optical receivers for single-mode glass fiber

Quantity	Value	Unit
Peak wavelength	1 260 to 1 380	nm
Operating temperature	0 to 70	°C
$P_{Emax“0“}$ (max. receive power for binary “0“)	-10	dBm
$P_{Emin“0“}$ (min. receive power for binary “0“)	-27	dBm
$P_{Emax“1“}$ (max. receive power for binary “1“)	-40	dBm

Table 127 – Characteristics of optical receivers for plastic fiber

Quantity	Value		Unit
Peak wavelength	640 to 675		nm
Operating temperature	0 to 70		°C
Receiver for tx performance level	Standard	Increased	
$P_{Emax“0“}$ (max. receive power for binary “0“)	-5	0	dBm
$P_{Emin“0“}$ (min. receive power for binary “0“)	-20		dBm
$P_{Emax“1“}$ (max. receive power for binary “1“)	-42		dBm

Table 128 – Characteristics of optical receivers for 200/230 µm glass fiber

Quantity	Value	Unit
Peak wavelength	640 to 675	nm
Operating temperature	0 to 70	°C
$P_{Emax“0“}$ (max. receive power for binary “0“)	-8	dBm
$P_{Emin“0“}$ (min. receive power for binary “0“)	-22	dBm
$P_{Emax“1“}$ (max. receive power for binary “1“)	-44	dBm

23.8 Temporal signal distortion

23.8.1 General

The following sections describe the signal distortion due to each of the elements in the transmission link.

Evaluation of the electrical digital signals always takes place at the intersection with 50 % of the signal amplitude.

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23.8.2 Signal shape at the electrical input of the optical transmitter

The permissible signal distortion at the electrical input of the optical transmitter of a station or a component with retiming is shown in Table 129.

Table 129 – Permissible signal distortion at the electrical input of the optical transmitter

Signal	**Limits for data rates < 1,5 Mbit/s**	**Limits for data rates ≥ 1,5 Mbit/s** (Note 1)
t_{BIT} (Note 2)	1/ Data_rate × (1 ± 0,3 %)	1/ Data_rate × (1 ± 0,03 %)
t_{SBIT} (only for stop bit) (Note 3)	t_{BIT} × (1 ± 6,25 %)	

NOTE 1 Data rate is the nominal data rate specified in Table 120.

NOTE 2 t_{BIT} is the time, which elapses during the transmission of one bit. It is equivalent to the reciprocal value of the transmission rate.

NOTE 3 t_{SBIT} is the extended tolerance for the permissible bit duration in the optical network that applies exclusively to the transmitted stop bit. This extension of the tolerance allows repeaters with retiming to equalize deviations in the receive and transmit clocks.

23.8.3 Signal distortion due to the optical transmitter

To meet the specified requirements, the transmit signal of the optical transmitter shall be within the shaded section of the signal template in Figure 115, with parameters as given in Table 130.

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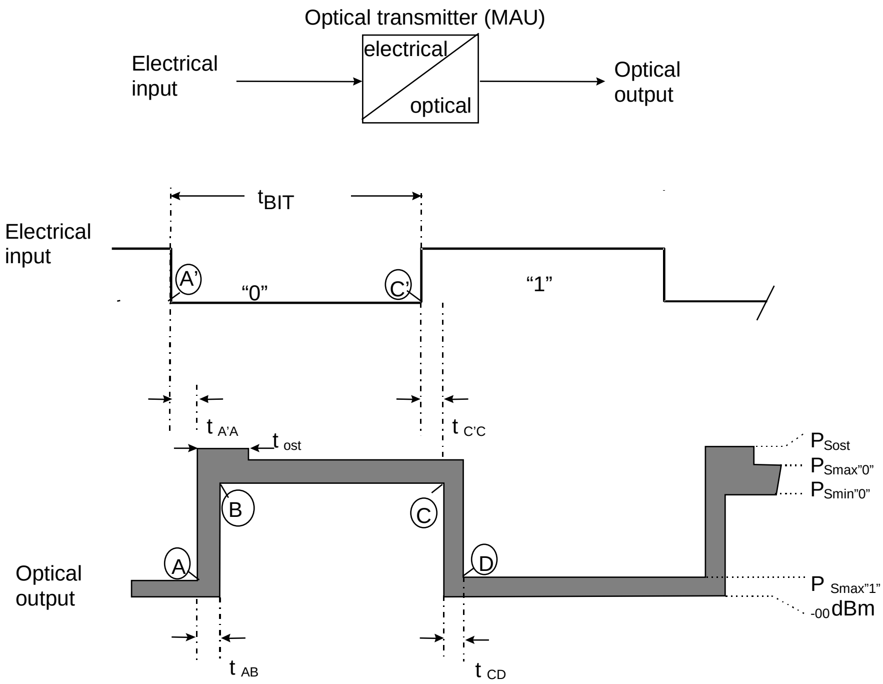

where

t_{ost} = the maximum duration that the maximum optical transmit power can be exceeded dynamically.

t_{AB} = the rising edge of the optical signal shall pass through $P_{Smax“1“}$ to $P_{Smin“0“}$ within this time.

t_{CD} the falling edge of the optical signal shall pass through $P_{Smin“0“}$ to $P_{Smax“1“}$ within this time.

$t_{A’A}$ the shortest duration signal delay due to the electro-optical converter for a level change from “1“ to “0“ (rising optical edge).

$t_{C’C}$ the shortest duration signal delay due to the electro-optical converter for a level change from “0“ to “1“ (falling optical edge).

Figure 115 – Signal template for the optical transmitter

The optical transmitter shall meet the template specifications at ≤1,5 Mbit/s and 3 Mbit/s to 12 Mbit/s as shown in Table 130.

Table 130 – Permissible signal distortion due to the optical transmitter

Time	≤ 1,5 Mbit/s	3 Mbit/s to 12 Mbit/s	Unit
t_{ost}	200	20	ns
t_{AB}	40	25	ns
t_{CD}	95	25	ns
$t_{A’A} – t_{C’C}$	65	5	ns

23.8.4 Signal distortion due to the optical receiver

The maximum distortion of the receiver’s electrical output signal compared to the optical input signal is specified in Table 131. This applies to the entire input level range specified in 23.7.3.

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Table 131 – Permissible signal distortion due to the optical receiver

Time	≤ 1,5 Mbit/s	3 Mbit/s to 12 Mbit/s	Unit
$t_{dis“0“}$ (see note)	-20 to 95	-25 to 25	ns
NOTE $t_{dis“0“}$ describes the permissible limits of the bit duration distortion for a “0“ bit.			

23.8.5 Signal influence due to coupling components

Coupling components, such as active star couplers, ANSI TIA/EIA RS-485-A/optical-MAU converters or repeaters contain internal logic that influences the propagated signal beyond that due to the electro-optical converter that was described above.

The maximum influence shall be within the limits specified in Table 132:

Table 132 – Permissible signal influence due to internal electronic circuits of a coupling component

Time	≤ 1,5 Mbit/s	3 Mbit/s to 12 Mbit/s	Unit
t_{log} (see Note 1)	-0 to 10	-0 to 10	ns
t_{delay} (see Note 2)	≤ 3 t_{BIT}	≤ 8 t_{BIT}	ns
NOTE 1 t_{log} describes the maximum permissible signal distortion due to the internal logic of a coupling component (for example an active star coupler) with no retiming. This factor is relevant when chaining standard optical links and is already taken into account in Table 133. NOTE 2 t_{delay} describes the maximum permissible signal delay between any input and output when passing through a coupling component (for example an active star coupler).			

23.8.6 Chaining standard optical links

If the network consists of standard optical links connected in series (chaining), the sum of the distortions of individual links shall not exceed the overall permissible bit duration distortion of a node interface, which is 25 % (≤ 1,5 Mbit/s) or 30 % (12 Mbit/s).

Since the distortions of the electro-optical converters represent absolute values, they become increasingly important at higher data transmission rates.

If standard optical links are chained without a retiming device, the calculated maximum number of links between two nodes and/or retiming components shall not exceed the values shown in Table 133.

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Table 133 – Maximum chaining of standard optical links without retiming

Data rate	Number of links in series (≤1,5 Mbit/s, see Note 1)	Number of links in series (3 Mbit/s to 12 Mbit/s, see Note 2)
12 Mbit/s	–	1
6 Mbit/s	–	2
3 Mbit/s	–	4
1,5 Mbit/s	1	8
500 kbit/s	3	24
187,5 kbit/s	8	64
93,75 kbit/s	16	128
45,45 kbit/s	33	264
19,2 kbit/s	78	625
9,6 kbit/s	156	1 250
NOTE 1 Devices designed for max. data transmission rate of 1,5 Mbit/s.		
NOTE 2 Devices designed for max. data transmission rate of 12 Mbit/s.		

Any required degree of chaining is possible if the coupling components re-establish the timing between the optical links (retiming).

23.9 Bit error rate

A maximum bit error rate (BER) of 10^{-9} is permitted at the electrical output of a standard optical link.

23.10 Connectors for fiber optic cable

The connectors are specified in I.2.2.

23.11 Redundancy in optical transmission networks

A redundant optical link analogous to the Type 3 electrical transmission technology is also possible. The functional principle is described in Annex J.

24 Type 4: Medium attachment unit: RS-485

24.1 General

The RS-485 MAU can be used to connect up to 125 fieldbus devices on the same cable. The length of the cable can be up to 1 200 m, and the Baud rate can be 9 600, 19 200, 38 400 or 76 800.

24.2 Overview of the services

The MDS-MAU interface makes services available to connect the MDS with a corresponding MAU. The TxS and RxS services are defined as logical signals that the MAU sublayer directly converts into physical signals. The TxE service is defined as a logical signal that is used internally in the MAU. The services of the RS-485 MDS-MAU interface are shown in Table 134.

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Table 134 – Services of the MDS-MAU interface, RS-485, Type 4

Signal name	Mnemonic	Direction
Transmit Signal	TxS	To MAU
Transmit Enable	TxE	To MAU
Receive Signal	RxS	From MAU

24.3 Description of the services

24.3.1 Transmit signal (TxS)

This service transmits the PhPDU from the MDS to the MAU, where it shall be transmitted on to the medium if Transmit Enable (TxE) is set to logic 1 (high level).

24.3.2 Transmit enable (TxE)

The Transmit Enable service (TxE) shall provide the MDS with the facility to enable the MAU to transmit. TxE shall be set to logic 1 (high level) by the MDS immediately before the transmission begins, and to logic 0 (low level) minimum 3, maximum 10 bit periods after transmission ends.

24.3.3 Receive signal (RxS)

This service transmits the PhPDU from the MAU to the MDS.

24.4 Network

24.4.1 General

This MAU operates in a network that consists of the following components:

- cable;
- connectors;
- devices (containing at least one communication element).

24.4.2 Topology

This MAU shall operate in a bus structure organized as a physical ring without termination. Up to 125 fieldbus devices are connected directly or via stubs of maximum length 2 m. The total length of the cable shall not exceed 1 200 m.

24.5 Electrical specification

The voltage levels of the transmitter and receiver can be taken from ANSI TIA/EIA-485-A.

24.6 Time response

The time response of the transmitter and receiver can be taken from ANSI TIA/EIA-485-A.

24.7 Interface to the transmission medium

A recommended circuit for coupling to the transmission medium is shown in Figure 116.

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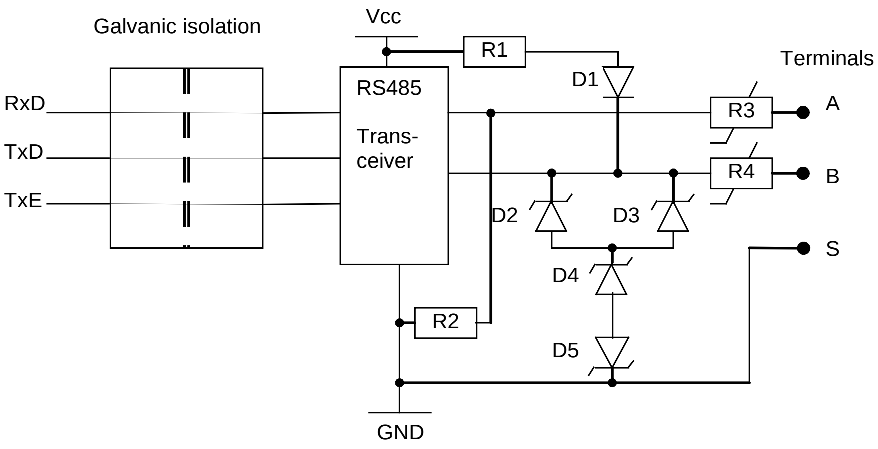

Component values:

R1, R2	15 kΩ
R3, R4	PTC, max 13 Ω; hold current 100 mA
D1	100 mA small signal diode
D2, D3, D4, D5	3.9 V / 1 W Voltage regulator diode

Figure 116 – Recommended interface circuit

24.8 Specification of the transmission medium

24.8.1 Cable connectors

Normally, fieldbus devices are equipped with screw terminals marked A, B and S for shield.

24.8.2 Cable

A shielded twisted pair cable with conductors with minimum 0,22 mm^2 cross section and a characteristic impedance of 100 Ω to 120 Ω.

25 *Void*

NOTE Clause 25 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the clause numbering of the prior edition.

26 *Void*

NOTE Clause 26 is a placeholder in this edition to minimize the disruption to existing national and multi-national standards and consortia documents that reference the clause numbering of the prior edition.

27 Type 8: Medium attachment unit: twisted-pair wire medium

27.1 MAU signals

A MAU of an outgoing and incoming interface is shown in Figure 117 and Figure 118.

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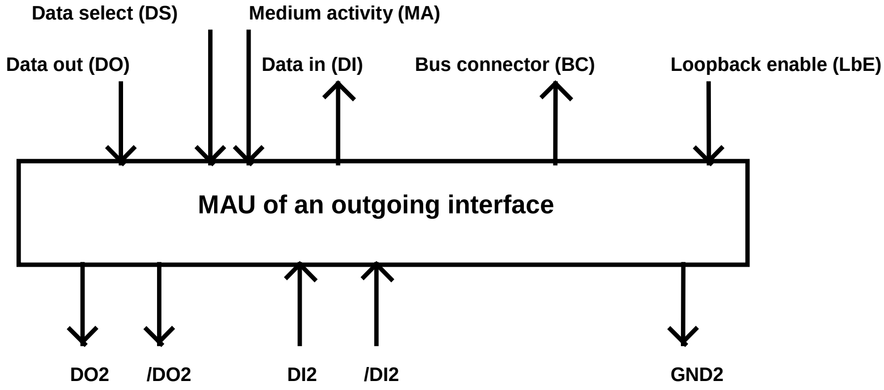

Figure 117 – MAU of an outgoing interface

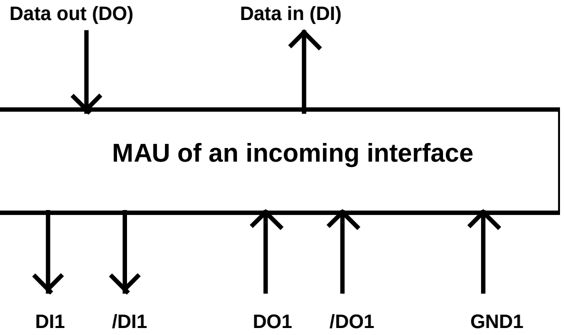

Figure 118 – MAU of an incoming interface

27.2 Transmission bit rate dependent quantities

Four bit rates are defined for the twisted pair wire medium attachment unit (MAU). A given MAU shall support at least one of these bit rates. Table 135 defines the bit rates and bit rate dependent quantities.

Table 135 – Bit rate dependent quantities twisted pair wire medium MAU

Quantity	Value				Unit
Nominal bit rate (see note)	0,5	2	8	16	Mbit/s
Maximum deviation from bit rate	± 0,1 %	± 0,1 %	± 0,1 %	± 0,1 %	—
Nominal bit duration (T)	2 000	500	125	62,5	ns
Minimum remote bus length	0	0	0	0	m
Maximum remote bus length	400	150	125	100	m
Maximum transmitted bit cell jitter	± 240	± 60	± 15	± 7,5	ns
NOTE Average transmission bit rate for 13 bits.					

27.3 Network

27.3.1 General

A twisted-pair wire medium MAU operates in a network that consists of the following components:

– cable;

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– connectors;
– electrical isolation;
– devices (with at least one communication element).

27.3.2 Topology

The twisted-pair wire medium MAU shall operate in one remote bus with one further device. A remote bus link (see Figure 119) consists of two point-to point connections. The connections are unidirectional. Thus each MAU has one transmitter and one receiver.

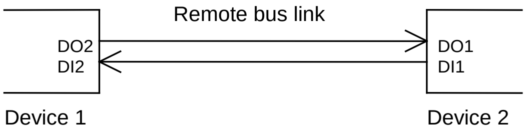

Figure 119 – Remote bus link

A remote bus link shall be between 0 and the maximum length for a given bit rate (see Table 135).

27.4 Electrical specification

The voltage levels of the transmitter and receiver shall be taken from ANSI TIA/EIA-422-B.

27.5 Time response

The time response of the transmitter and the receiver shall be taken from ANSI TIA/EIA-422-B.

27.6 Interface to the transmission medium

27.6.1 General

The coupling to the transmission medium is effected via one incoming (optional) and one or several outgoing interfaces which are independent of the medium (see Figure 120).

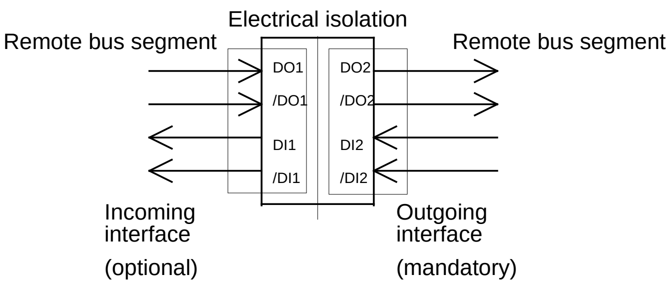

Figure 120 – Interface to the transmission medium

27.6.2 Incoming interface

The incoming interface comprises five signal lines (see Table 136) for the connection to the network. These signal lines have to be electrically isolated from the device. The isolation voltage shall amount to ≥500 V (direct voltage).

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Table 136 – Incoming interface signals

Short name	Name
DO1	Receive data line +
/DO1	Receive data line -
DI1	Send data line +
/DI1	Send data line -
GND1	Ground line

27.6.3 Outgoing interface

The outgoing interface comprises five signal lines (see Table 137) for the connection to the network.

Table 137 – Outgoing interface signals

Short name	Name
DO2	Send data line +
/DO2	Send data line -
DI2	Receive data line +
/DI2	Receive data line -
GND2	Ground line

27.7 Specification of the transmission medium

27.7.1 Cable connectors

If used, the 9-position subminiature D connectors shall use a standard connector pin assignment (see M.1.1).

Field termination elements, such as screw-clamp or flat-type connectors and fixed connectors, can also be used. In this case the connector pin assignment given in M.1.2 should be used.

27.7.2 Cable

A shielded cable with two twisted cable pairs is to be used as a bus cable. The shielding is to improve the electromagnetic compatibility (EMC). The remote bus cable should at least fulfil the requirements indicated in Table 138.

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Table 138 – Remote bus cable characteristics

Characteristic quantity (20 °C)	Value	Test method
Number of wires (twisted pairs)	3 x 2, twisted pair	
Cross section	Min. 0,20 mm^2	
Direct current conductor resistance/100 m	Max. 9,6 Ω	IEC 60189-1, 8.1
Characteristic impedance	120 Ω ± 20 % at f = 0,064 MHz 100 Ω ± 15 Ω at f > 1 MHz	IEC 61156-1, 6.3.1
Dielectric strength - Conductor/conductor - Conductor/shield	 1 kV_{rms}, 1 min 1 kV_{rms}, 1 min	IEC 60189-1, 8.2
Insulation resistance (after dielectric strength test)	Min 150 MΩ for a cable of 1 km in length	IEC 60189-1, 8.3
Maximum transfer impedance - at 30 MHz	 250 mΩ/m	
Mutual capacitance (at 800 Hz)	Max. 60 nF for a cable of 1 km in length	IEC 60189-1, 8.4
Min. near end cross talk loss (NEXT) for a cable of 100 m - at 0,772 MHz - at 1 MHz - at 2 MHz - at 4 MHz - at 8 MHz - at 10 MHz - at 16 MHz - at 20 MHz	 61 dB 59 dB 55 dB 50 dB 46 dB 44 dB 41 dB 40 dB	IEC 61156-1, 6.3.5
Max. attenuation for a cable of 100 m - at 0,256 MHz - at 0,772 MHz - at 1 MHz - at 4 MHz - at 10 MHz - at 16 MHz - at 20 MHz	 1,5 dB 2,4 dB 2,7 dB 5,2 dB 8,4 dB 11,2 dB 11,9 dB	IEC 61156-1, 6.3.3.

The minimum wiring with a shield between two communicating devices is shown in Figure 121.

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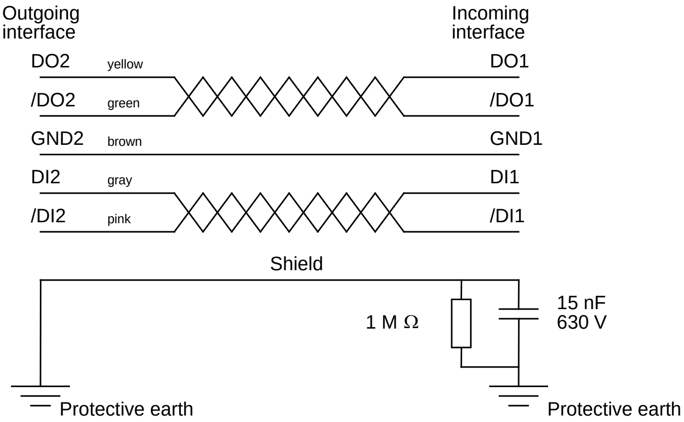

Figure 121 – Wiring

27.7.3 Terminal resistor

The cable pair of the receive line is to be connected with a resistor network (see Figure 122) directly before the receiver of the MAU. The circuit may be used for the polarisation of the MAU, for the detection of a short or open circuit on a wire. It shall be observed that the resulting equivalent resistance is at least 100 Ω.

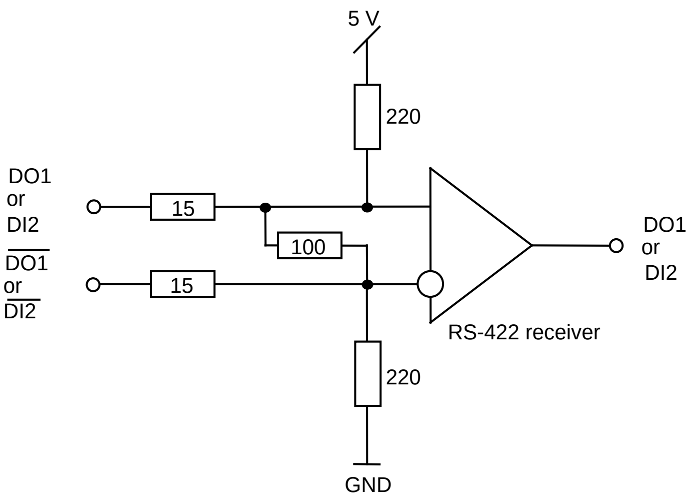

Figure 122 – Terminal resistor network

28 Type 8: Medium attachment unit: optical media

28.1 General

The object of Clause 28 is to give the operating and optical specifications of the duplex fiber mode optical MAU.

The fiber optic remote bus cable consists of a pair of optical fiber (see Figure 123) waveguides providing bidirectionality by use of a separate fiber for each direction of signal propagation. These dual fibers connect to the CPIC of a network device.

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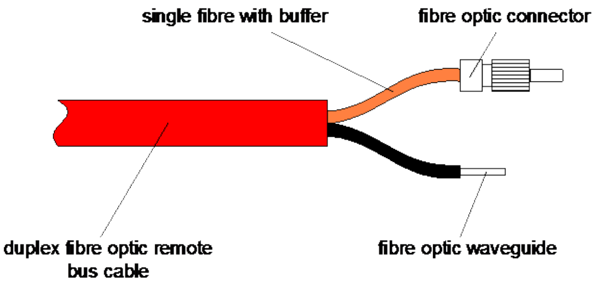

Figure 123 – Fiber optic remote bus cable

Two optical fiber types are supported:

– polymer optical fiber;
– plastic clad silica fiber.

28.2 Transmission bit rate dependent quantities

Four bit rates are defined for the optical medium attachment unit (MAU). A given MAU shall support at least one of these bit rates. Table 139 defines the bit rates and bit rate dependent quantities.

Table 139 – Bit rate dependent quantities optical MAU

Transmit timing characteristics	Value				Unit
Nominal bit rate	0,5	2	8	16	Mbit/s
Maximum deviation from bit rate	± 0,1 %	± 0,1 %	± 0,1 %	± 0,1 %	
Nominal bit duration (T)	2 000	500	125	62,5	ns

28.3 Network topology

An optical MAU operates in a network that consists of the following components:

– optical cable;
– connectors;
– devices (containing at least one communication element).

An optical MAU shall operate in one remote bus with one further device. A remote bus link (see Figure 124) consists of two point-to-point connections. The connections are unidirectional. Thus each MAU has one fiber optic transmitter and one fiber optic receiver.

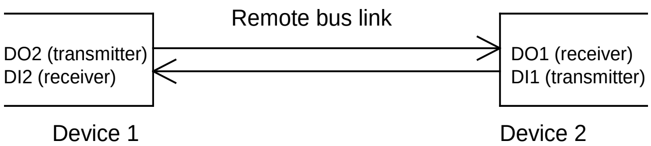

Figure 124 – Optical fiber remote bus link

The cable length shall be in the range specified in Table 140.

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Table 140 – Remote bus fiber optic cable length

Fiber type	Minimum length	Maximum length
Polymer optical fiber	1 m	50 m (see [a] [b])
Plastic clad silica fiber	1 m	300 m (see [a] [b])

[a] This does not exclude longer distances between two devices, e.g. by using receive circuits with a lower minimum optical receiver sensitivity than specified in 28.5.2.

[b] The maximum length may be reduced in cases where special cables with higher attenuation than the standard cables specified in 28.6.2 are used.

28.4 Transmit circuit specifications

28.4.1 Data encoding rules

NRZ Coding is specified for the optical transmission following the encoding rules given in Table 141.

Table 141 – Encoding rules

Logical symbol bit	Encoding
1	Low optical output level
0	High optical output level

In the case of no bus activity an idle state of logic 0 shall be used.

28.4.2 Test configuration

The output level, spectral and timing specifications are measured at the end of a standard test fiber (as specified in 28.6.4) connected to the CPIC.

The requirements relative to Subclause 28.4 are summarized in Table 142 and Table 139.

28.4.3 Output level specification

An optical MAU transmit circuit shall conform to the following output level and spectral requirements. The specified level and spectral characteristics shall be maintained over the whole temperature range specified for the network device. Output level is the effective launch power of logic 0. The output level specification is shown in Table 142.

Table 142 – Transmit level and spectral specification summary for an optical MAU

Transmit level and spectral characteristics (values referred to CPIC with standard test fiber)	Polymer optical fiber (980/1 000 μm fiber)		Plastic-clad silica fiber (200/230 μm fiber)
Maximum peak emission wavelength (λp)	660 nm	520 nm	660 nm
Typical spectral full width half maximum (Δλ)	< 30 nm		< 30 nm
Maximum output level	–2,0 dBm		–8 dBm
Minimum output level	–6,2 dBm		–16,9 dBm
Maximum effective launch power of a logic 1	–43 dBm	–41 dBm	–45 dBm
NOTE Standard test fiber specification, see 28.6.4.			

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28.4.4 Output timing specification

An optical MAU transmit circuit shall conform to the following output timing requirements (see Figure 125). Timing characteristics shall be maintained over the whole temperature range specified for the network device.

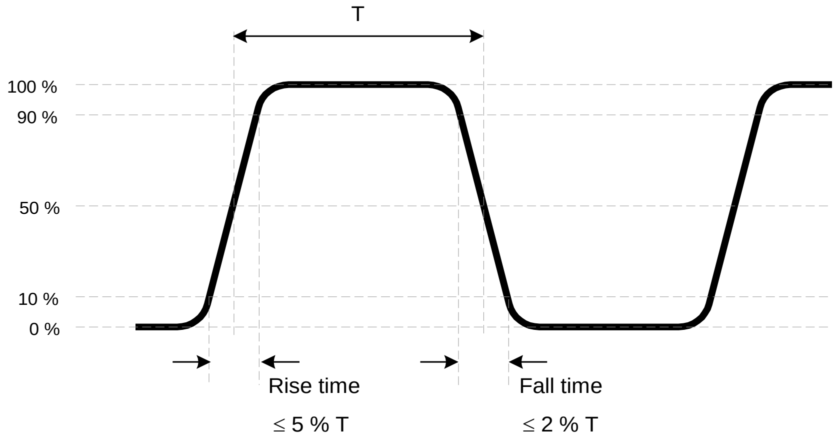

Figure 125 – Optical wave shape template optical MAU

NOTE 1 For ease of reference, the requirements of 28.4.4 are summarized in Table 139.

NOTE 2 0 % effective power is the low optical output power state (logic 1).

NOTE 3 100 % effective power is the high optical output power state (logic 0).

Rise time, fall time and bit cell jitter shall be chosen in that manner, that the electrical output timing specifications of the optical MAU receive circuit given in Table 143 are still fulfilled.

28.5 Receive circuit specifications

28.5.1 Decoding rules

Decoding rules according to Table 141 shall be used.

28.5.2 Fiber optic receiver operating range

An optical MAU receive circuit shall have the minimum optical receiver sensitivity defined in Table 143 over the whole temperature range specified for the network device. The maximum optical power for logic 0, measured with a standard test fiber specified in 28.6.4, of an optical MAU receive circuit shall not exceed the value defined in Table 143.

The fiber optic receive circuit used for 0,5 Mbit/s and 2 Mbit/s systems shall be capable of detecting a 01010 bit stream after a 200 ms long idle state where the optical power level of the second logical 0 is reduced by up to 65 % against the others. This capability shall be maintained over the whole fiber optic receiver operating range.

28.5.3 Maximum received bit cell jitter

The receive circuit shall accept a NRZ encoded signal transmitted in accordance with 28.4. In addition, the fiber optic receiver shall accept signals with the time variation between any two adjacent signal transition points (50 % crossing) of ± 25 %.

The requirements relative to Subclause 28.5 are summarized in Table 143.

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Table 143 – Optical MAU receive circuit specification summary

Receive circuit characteristics (values referred to the CPIC)	Polymer optical fiber (980/1 000 μm fiber)	Plastic-clad silica fiber (200/230 μm fiber)
Minimum optical receiver sensitivity	≤ -21,6 dBm	≤ -23 dBm
Maximum optical power for logic 0	- 2,0 dBm	- 8 dBm
Maximum received bit cell jitter	± 25 % of nominal bit time	± 25 % of nominal bit time

28.6 Specification of the transmission medium

28.6.1 Connector

Cable connectors, if used, shall be in accordance with the specification given in Clause M.2.

28.6.2 Fiber optic cable specification: polymer optical fiber cable

28.6.2.1 General

A polymer optical fiber cable for fixed routing in indoor installations shall be compatible to the following specifications. Special fiber optic cables used for special environmental or physical applications where e.g. high flexibility of the cable is essential may differ from the following specification concerning the cable attenuation.

28.6.2.2 Fiber optic waveguide

A fiber optic waveguide of a polymer optical fiber cable for a network optical MAU shall fulfil the following requirements given in Table 144.

Table 144 – Specification of the fiber optic waveguide

Parameter	Value
Core diameter	(980 ± 60) μm
Cladding diameter	(1 000 ± 60) μm
Cladding non-circularity	≤ 6 %
Core material	Polymethylmethacrylate (PMMA)
Numerical aperture	0,47 ± 0,03
Refractive index profile	Step index
Bandwidth at 660 nm	≥ 10 MHz × 100 m
Attenuation at 650 nm (monochromatic)	≤ 160 dB/km
Attenuation at 660 nm (measured with LED and 50 m cable length)	≤ 230 dB/km

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28.6.2.3 Single fiber

A single fiber of a polymer optical fiber cable for an optical MAU shall conform to the following requirements given in Table 145.

Table 145 – Specification of the single fiber

Parameter	Value
Buffer material	Polyamide (PA)
Buffer color	Black or orange
External diameter	2,20 mm ± 0,07 mm
Minimum long term bending radius	30 mm

28.6.2.4 Cable sheath and mechanical properties of the cable

The sheath of a polymer optical fiber cable for an optical MAU should conform to the following requirements given in Table 146.

Table 146 – Specification of the cable sheath and mechanical properties of the cable

Parameter	Value
Sheath material	Polyurethane (PUR)
Sheath color	Red
Strain relief elements	Non-metallic
Marking	Running length in m, production date
Temperature range (in operation)	–20 °C to +70 °C
Minimum long-term bending radius	≤ 65 mm
Maximum long-term tensile strength	≥ 100 N
Maximum long-term lateral pressure	≥ 20 N/cm

28.6.2.5 Material properties of the cable

The polymer optical fiber cable for an optical MAU should have the following further material properties as shown in Table 147.

Table 147 – Recommended further material properties of the cable

Parameter	Value
Oil resistance	ASTM Oil No. 2, 100 °C, IEC 60811-404
Halogen-free	IEC 60754-2
Ozone resistance	IEC 60811-403
UV resistance	ISO 4892-1
Abrasion resistance	IEC 60794-1-2 method E2A Minimum 5 000 cycles, 1 mm radius of the point of the steel needle, 500 g
NOTE Dependent on the application, other material properties may also be required, for example, free from substances impairing paint-wetting performance (chloroform test).	

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28.6.3 Fiber optic cable specification: plastic clad silica fiber cable

28.6.3.1 General

A plastic clad silica fiber optic cable for fixed routing in indoor installations shall be compatible to the following specifications. Special plastic clad silica fiber optic cables used for special environmental applications such as outdoor cables may differ from the following specification concerning the cable attenuation.

28.6.3.2 Fiber optic waveguide

A fiber optic waveguide of a plastic clad silica fiber optic cable for an optical MAU shall fulfil the following requirements given in Table 148.

Table 148 – Specification of the fiber optic waveguide

Parameter	Value
Core diameter	(200 ± 8) μm
Cladding diameter	(230 ± 10) μm
Cladding non-circularity	≤ 6 %
Numerical aperture	0,40 ± 0,04
Refractive index profile	Step index
Bandwidth at 650 nm	≥ 17 MHz × km
Attenuation at 650 nm	≤ 10 dB/km

28.6.3.3 Single fiber

A single fiber of a plastic clad silica fiber optical cable for an optical MAU shall conform to the following requirements given in Table 149.

Table 149 – Specification of the single fiber

Parameter	Value
Buffer material	FRNC material
Buffer color	Red or green
External diameter	2,2 mm or 2,9 mm
Minimum long term bending radius	30 mm

28.6.3.4 Cable sheath and mechanical properties of the cable

The sheath of a plastic clad silica fiber optic cable for an optical MAU should conform to the following requirements given in Table 150.

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Table 150 – Specification of the cable sheath and mechanical properties of the cable

Parameter	Value
Sheath color	Red
Strain relief elements	Non-metallic
Marking	Running length (m); production date
Temperature range (in operation)	–20 °C to +70 °C
Minimum long-term bending radius	≤ 50 mm
Maximum long-term tensile strength	≥ 200 N
Maximum long-term lateral pressure	≥ 100 N/cm

28.6.3.5 Material properties of the cable

The plastic clad silica fiber optic cable for an optical MAU should have further material properties as shown in Table 147.

28.6.4 Standard test fiber

The cable used for testing network devices with an optical MAU for conformance to the requirements of the Clause 28 shall be a cable with one or more fiber optic waveguides whose characteristics are as shown in Table 151.

Table 151 – Specification of the standard test fiber for an optical MAU

Parameter	Polymer optical fiber (980/1 000 µm fiber)	Plastic-clad silica fiber (200/230 µm fiber)
Length	1 m	1 m
Core diameter	(980 ± 60) µm	(200 ± 8) µm
Cladding diameter	(1 000 ± 60) µm	(230 ± 10) µm
Cladding non-circularity	≤ 6 %	≤ 6 %
Numerical aperture	0,47 ± 0,03	0,40 ± 0,04
Bandwidth for 660 nm	≥ 10 MHz × 100 m	≥ 17 MHz × 1 km
Attenuation for 660 nm (monochromatic)	≤ 160 dB/km	≤ 10 dB/km
Buffer diameter	2,2 mm	2,9 mm
Insertion loss (see note)	1,5 dB to 2,0 dB	1,0 dB to 1,5 dB
NOTE Measured in conformance with IEC 61300-3-4 (insertion procedure B).		

29 Type 12: Medium attachment unit: electrical medium

29.1 Electrical characteristics

This MAU specification describes a balanced line unidirectional transmission via a pair of wires corresponding to ANSI TIA/EIA-644-A. A terminator, located at receiving end of the wire, enables the PhL to support in particular higher speed transmission. The maximum wire length should not exceed 20 m. This transmission method is offered in addition to the ISO/IEC 8802-3 technologies known as 100BASE-TX and 100BASE-FX. Its main purpose is to connect devices within a control cabinet. Thus, it assumes a common signal ground.

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Manchester bit encoding is combined with ANSI TIA/EIA-644-A signaling targeted to low cost line couplers, which may not isolate the station from the line (galvanic isolation); a line terminator is required (recommended resistor value is 100 Ω).

The topology supported is a pair of wires with exactly one sender and one receiver on a single pair.

A connection consists or two pairs of wire which connects exactly two DTE.

The term wire specifies a media which is able to transmit signals according to ANSI TIA/EIA-644-A at the specified length. A conformance statement of the device manufacturer shall specify these parameters.

29.2 Medium specifications

29.2.1 Connector

There is no connector specified for this media. A conformance statement of the device manufacturer shall specify the connection capabilities.

29.2.2 Wire

The medium is a pair of wires. Shielding can be used to improve the electromagnetic compatibility (EMC). Unshielded wires can be used, if there is no severe electromagnetic interference (EMI).

The characteristic impedance Z_O of the wire pair should be in the range between 80 and 120 Ω, the wire capacity (conductor – conductor) should be less than 60 pF/m. Wire selection criteria should follow the ANSI TIA/EIA-644-A implementation guidelines, especially for backplane and PCB interconnection.

NOTE Assuming an output common-mode voltage of approximately 1,2 V, it is possible to model the output resistor as two 50 Ω resistors in series with their center-tap sitting at 1,2 V. This provides a match to a typical PCB trace characteristic impedance (Z_O) of 50 Ω and minimizes reflections.

A pair of wire should have a symmetrical design (same length, closely related to each other and same distance to ground signal). The two pair of wires shall have the same length. A skew of less than 2 ns is acceptable.

29.3 Transmission method

29.3.1 Bit coding

The Manchester coded data from DLL is transmitted via a pair of wires. A binary "1" (N+ or first half of DL_symbol = “ONE” or second half of DL_symbol = “ZERO”) is represented by a constant positive differential voltage on TxS/RxS and a binary "0" (N- or first half of DL_symbol = "ZERO" or second half of DL_symbol = “ONE”) by a constant negative differential voltage on TxS/RxS.

29.3.2 Representation as ANSI TIA/EIA-644-A signals

TxS will be represented as OUT+ and OUT- in ANSI TIA/EIA-644-A terms. RxS inputs at ANSI TIA/EIA-644-A level will be denominated as IN+ and IN-.

NOTE Assuming an output current of 3,5 mA common-mode voltage of approximately 1,2 V, the nominal voltage difference between OUT+ and OUT- is 350 mV (in a range between 247 mV and 454 mV). A differential voltage of 100 mV is needed to detect a signal.

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30 Type 16: Medium attachment unit: optical fiber medium at 2, 4, 8 and 16 Mbit/s

30.1 Structure of the transmission lines

The structure of the optical transmission line is shown in Figure 126.

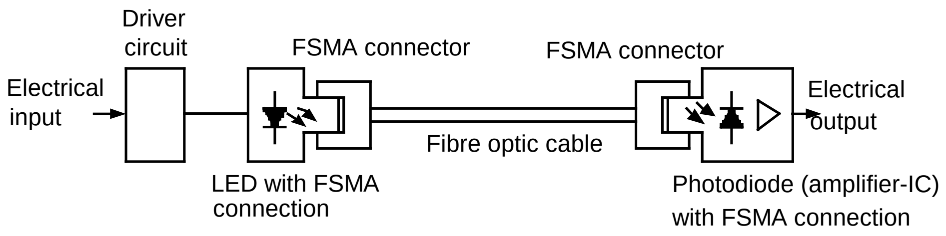

Figure 126 – Optical transmission line

The driver circuit for the transmitting LED shall be activated by an electrical impulse. The high-performance LED (transmitter) shall emit light of a wavelength of 650 nm. The transmission power shall be switchable between “low attenuation” and “high attenuation”, using a manually operated switch.

The fiber optic cable shall be made of plastic or glass and have a step index profile or graded index profile. Fiber optic cables and cores may be used depending on application. Attenuation taking place along the transmission line is caused by the fiber optic cable and possibly other couplings. These additional couplings can become necessary when routing through a wall, for example. The factors which contribute to attenuation along the line are explained in more detail in Clause O.2.

NOTE For fiber optic materials currently in use, the attenuation is approximately 220 dB/km for plastic and 6 dB/km for glass.

The receiver component shall consist of a photodiode and an integrated amplifier circuit.

It shall be possible that the signal is inverted while passing through a slave (i.e., a light-on signal at the optical slave input shall not necessarily lead to a light-on signal at the optical output).

30.2 Time performance of bit transmission

30.2.1 Introduction

The distance between rising and falling edges of the optical signal is specified in Subclause 30.2. An edge is a change in level between the optically low and optically high levels. The specification is based on an envelope which has been defined for the optical signal. Any optical output signal of a transmitter shall remain within this specific envelope at all times.

Furthermore, the run-time performance between optical slave input and output is specified. A slave shall be synchronized to the transmission clock of the bit stream coming into its optical input. Although the transmission clock of a slave can deviate from the clock at its input for a short time, the slave needs to be synchronized to the predetermined clock (e.g., by means of a phase locked loop). Thus, all units connected to the network are required by definition to transmit the same averaged transmission clock pulse. In other words, all units shall use the transmission clock pulse of the master.

The slave shall be synchronized to the transmission clock on its optical input by means of light-on edges (rising edges).

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30.2.2 Master and slave in test mode

30.2.2.1 Introduction

In Subclause 30.2.2, the run-time performance at the optical output of the master is specified while the master is operating both in its normal and test modes.

It shall be possible to activate the test mode externally by special means (e.g. pressing a key). Master and slave shall then be able to provide a continuous signal light, as well as a zero bit stream at the optical output, without the presence of an input signal.

30.2.2.2 Continuous light signal test mode

A continuous light signal implies a logical high level without a level change at the optical output. This mode is only required for the master. The slave may generate a continuous light signal, depending on whether or not a continuous light signal comes in at the optical input. Due to its function as a repeater, the slave shall be able to echo the light at its optical output, which it receives at its optical input (or the lack thereof).

Optical signal inversion by the slave shall be possible.

30.2.2.3 Zero bit stream test mode

The zero bit stream test mode implies that the transmitter shall transmit consecutive zeros which, based on the NRZI code, result in continuous level changes in the signaling pattern of the transmission clock (this results in a 1 MHz signal for a data rate at 2 Mbit/s). A slave shall use its local clock to synchronize the transmitting clock at its optical output signal. No clock adjustments may occur at the optical output (e.g., due to the phase locked loop, → t_{cad}) and only statistically distributed jitter of the optical signal is allowed. This requirement is important because it allows the system to isolate and separate jitter noise (→ J_{noise}) from possible clock adjustments due to the phase locked loop (→ t_{cad}), as will be discussed later. The curve shapes of optical signals which are generated while the system is in the zero bit stream test mode, are not allowed to deviate from the signals during normal mode near the rising and falling edges (e.g. different rise and fall times, different excess levels during the test mode). Specifically, the same driver circuit shall be used during the zero bit stream test mode as is used during normal mode.

The following parameters shall be used to specify the optical output signal of the master and slave (see Figure 127 and Figure 128):

t_r: This is the time delay between points 1 and 2 (= 1-1' or 2-2'). It shall be the upper limit of the time required by the optical signal to pass through P_{TmaxL} to P_{TminH} on the rising edge. This time does not correspond to the rise time of the transmitter which is given between 10 % and 90 % of the optical signal in the data sheet.

t_f: This is the time delay between points 3 and 4 (= 3-3' or 4-4'). It shall be the upper limit of the time required by the optical signal to pass through P_{TminH} to P_{TmaxL} on the falling edge. This time does not correspond to the fall time of the transmitter, which is given between 10 % and 90 % of the optical signal in the data sheet.

NOTE See item remark below regarding t_r and t_f.

t_{os}: This parameter indicates length of time the maximum optical transmission power may be exceeded dynamically. This interval shall start at time ① (see Figure 127).

t_{BIT}: This is the arithmetic mean value (measured over several seconds) of the transmission clock period (duration of a bit cell) by the master (not in test mode) and shall correspond to the reciprocal value of the data rate. The nominal duration shall be described by t_{BITnom}. t_{BIT} shall be measured between edges with the same direction (= 2 × t_{BIT}) at optical power levels

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of 0,5 × P_{TminH} ± 20 %. t_{BIT} shall be considered to be constant in the range of seconds. Only fluctuations due to noise are allowed. Relatively long measurement duration of t_{BIT} ensures that the influence of short-term deviations of the delays between edges (jitter → J_{noise}) is negligible. Hence, t_{BIT} shall describe the time between points 1 and 3, as well as the time between points 3 and 5 (which shall correspond to point 1 of the next period) (see Figure 127).

$t_{BITtest}$: This is the arithmetic mean value measured over several seconds of the master or slave transmission clock period (duration of a bit cell) in the zero bit stream test mode. All measurements and properties of $t_{BITtest}$ shall correspond to t_{BIT}.

J_{noise}: This parameter describes the jitter of the optical signal. It shall be the purely statistical deviation of the distance between both edges, compared with the value $t_{BITtest}$ measured over a long time interval. J_{noise} shall be obtained by overlaying the signals of several periods (e.g. on an oscilloscope) such that they come together at one optical power level (e.g. P_{TmaxL} on the falling or rising edge). The jitter of the optical signal is then determined by the width of the overlaid optical signals (which gives a time). This width shall not exceed the value J_{noise} in the power region between P_{TmaxL} and P_{TminH} vice versa. By this definition, the jitter of the optical signals is limited, that is, the signal curve shapes shall be reproducible in the power region P_{TmaxL} through P_{TminH} vice versa.

The times t_r and t_f are not fully available as rise time and fall time. Due to non-symmetrical ON/OFF performance of the driver circuit (duty cycle, propagation delay), the falling edge can be time-shifted with respect to the rising edge, resulting in a remaining difference for $t_{BITtest}$. In this case, the high level can be extended by some time interval and the low level could be shortened by the same interval. This extending/shortening interval is not considered part of the rising and falling interval. In addition, the signal with added J_{noise} shall remain completely within the envelope, which implies that the jitter shall be taken into consideration for the times t_r and t_f.

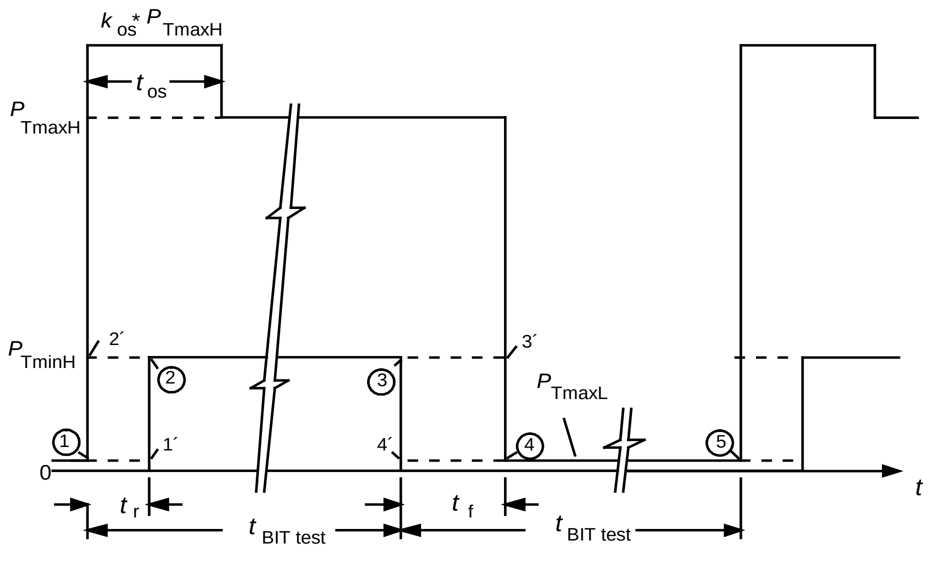

Figure 127 – Optical signal envelope

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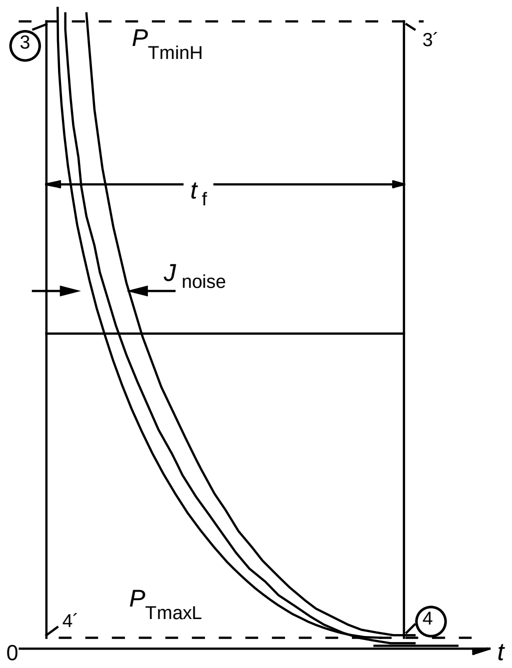

Figure 128 – Display of jitter (J_{noise})

30.2.3 Data rate

The data rate is the baud rate measured at the optical output of the master. Its nominal value shall be 2 Mbit/s, 4 Mbit/s, 8 Mbit/s or 16 Mbit/s. The measured value is allowed to deviate by ±0,01 %. The data rate is a time average measured over several seconds. The short-term performance (nanoseconds range) may deviate slightly and is specified through J_{noise} (see Table 153).

Table 152 specifies which data rates shall be supported by Type16, and the way baud rate shall be selected, for two performance classes called CP16/1 and CP16/2.

Table 152 – Transmission rate support

Performance class	CP16/1	CP16/2
2 Mbit/s	Mandatory	Mandatory
4 Mbit/s	Optional	Optional
8 Mbit/s	No	Optional
16 Mbit/s	No	Optional
Baud rate	Manual setting (e.g. switch)	Manual setting (e.g. switch), or automatic baud rate recognition

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Table 153 – Transmission data parameters

Transmission rate (data rate)	Bit times			
	2 Mbit/s ± 0,2 kbit/s	**4 Mbit/s ± 0,4 kbit/s**	**8 Mbit/s ± 0,8 kbit/s**	**16 Mbit/s ± 1,6 kbit/s**
t_{BIT} [ns]	500 ± 0,05	250 ± 0,025	125 ± 0,012 5	62,5 ± 0,006 25
t_{BITnom} [ns]	500	250	125	62,5
$t_{BITtest}$ [ns]	500 ± 0,05	250 ± 0,025	125 ± 0,012 5	62,5 ± 0,006 25
Data frequency (max.)	1 MHz	2 MHz	4 MHz	8 MHz
Times for curve shapes				
t_{OS} [ns]	200	100	50	25
t_r [ns]	100	40	20	10
t_f [ns]	150	110	25	15
Jitter [ns]	$0 \leq J_{noise} \leq 10$	$0 \leq J_{noise} \leq 10$	$0 \leq J_{noise} \leq 5$	$0 \leq J_{noise} \leq 5$

30.2.4 Input-output performance of the slave

30.2.4.1 General

In Subclause 30.2.4, the input-output performance of the slave synchronization performance is specified. A slave shall receive a signal with a certain clock at its optical input. The mean value of this clock is equal to the transmitting clock of the master. In the long run, a slave shall be synchronized to this clock (by evaluation of one of the rising or falling edges).

The slave shall generate its own local clock. This local clock shall be used to receive and to transmit data. The local clock of a slave shall run freely between the synchronizing edges of the incoming bit stream. During synchronization, the slave shall adjust the phases of the local clock (phase locked loop). This performance can be observed at the optical output because the duration of the high or low level becomes shortened or lengthened with respect to the average bit duration (t_{BIT}). The amount of shortening or lengthening shall be called clock adjustment time t_{cad}.

Clock adjustment time shall not exceed a specific value (t_{cadmax}). In addition, the implemented maximum clock adjustment time ($t_{cadreal}$) of every slave shall be specified by the manufacturer (e.g. $t_{BIT}/16$).

The optical signal shall run through the range P_{TmaxL} – P_{TminH} resp. vice versa of the envelope always at the same position (taking J_{noise} into account). The envelope can be shifted over the optical signal (due to short rise and fall times), but this possible shift shall not be taken into account as a “bonus” to the clock adjustment.

A slave shall be able to receive signals correctly if its clock adjustment time is smaller or equal to the maximum clock adjustment time, $t_{cadreal}$, implemented in that slave. If the slaves are physically located in the ring in an ascending $t_{cadreal}$ sequence, the system shall make sure that correct receiving conditions are established for any slave. The receiver of the master, being the last unit in the ring, shall be able to process the maximum allowable clock adjustment time t_{cadmax}.

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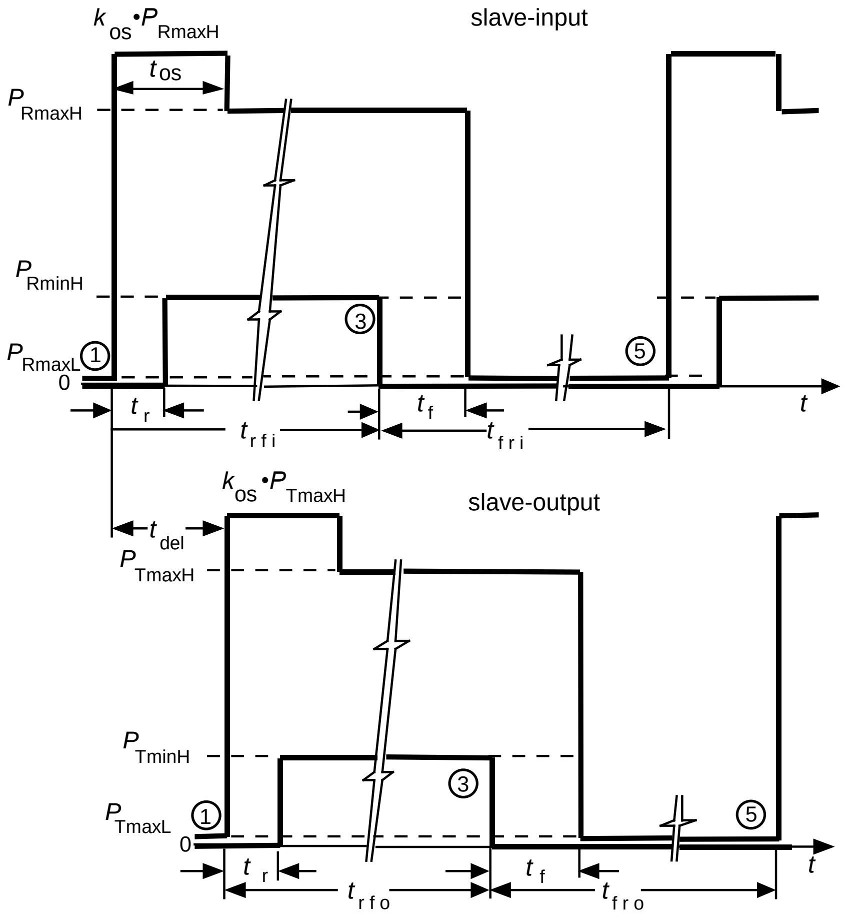

Figure 129 – Input-output performance of a slave

In addition to the clock adjustment time just described, a minimum clock adjustment time (t_{cadmin}) shall be specified. Every slave shall be able to process data if the clock has been adjusted by t_{cadmin} at its input. The input/output performance of a slave is specified by the following parameters.

t_{rfi}: this is the time between points 1 and 3 in Figure 129 on the receiver input.

t_{fri}: this is the time between points 3 and 5 in Figure 129 on the receiver input.

$t_{cadreal}$: This is the maximum clock adjustment time (shortening or lengthening a level) which a slave generates at its optical output. This value shall be specified by the manufacturer. The slave shall also be able to correctly process this maximum clock adjustment time at its input, within the scope of the specified bit error rate.

t_{cadmin}: this is the minimum clock adjustment time which a slave shall be able to process correctly within the scope of the specified bit error rate.

t_{cadmax}: this is the upper limit for $t_{cadreal}$ and also describes the maximum clock adjustment time that the master shall be able to process correctly within the scope of the specified bit error rate.

t_{rfo}: this is the time between points 1 and 3 in Figure 129 at the transmitter output.

t_{fro}: this is the time between points 3 and 5 in Figure 129 at the transmitter output.

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t_{del}: this is the time delay of the envelope between the optical input and output, measured at the slave (see Figure 129). This parameter describes the signal delay (run-time) of the optical signal through a slave in a repeater mode (see also Table 158). The delay shall be measured between the light-ON edge at the optical input and the associated light signal edge at the optical output (in non-inverting slaves, this is the light-ON edge; in inverting slaves, this is the light-OFF edge).

t_{del}-optic: max. delay in the electro-optical elements of receiver and transmitter.

t_{del}-electric: max. delay of the electric signal routing through the slave (e.g. using an ASIC).

A receiver shall be provided with an input signal as defined by cases a) or b) of Table 154. Changing between cases a) and b) is not allowed. Thus the clock adjustment time will shorten or lengthen only the high level, or only the low level.

Table 154 – Possible slave input signals

Case	t_{rfi}	t_{fri}
a)	$i \times t_{BIT} - t_{cadreal} \le t_{rfi} \le i \times t_{BIT} + t_{cadreal}$	$j \times t_{BIT}$
b)	$i \times t_{BIT}$	$j \times t_{BIT} - t_{cadreal} \le t_{rfi} \le j \times t_{BIT} + t_{cadreal}$
NOTE 1 i and j are ordinary digits; i is not identical to the sequence of networks as given in the abbreviations. NOTE 2 For normal operation i = 1 to 8 and j = 1 to 8, so that I + j = 2 to 16. When switching from telegram to fill signal and vice versa, i = 1 to 12 and j = 1 to 12, but I + j = 2 to 20.		

With these specific input signals, the slave shall be able to perform following tasks:

a) receiving and processing data correctly within the scope of the bit error rate;

b) generating valid output signals.

Valid output signals shall have a signal timing within the specified limits and be generated according to cases c) or d) of Table 155. The slave shall be able to either shorten or lengthen only the high level or only the low level through clock adjustment. Alternating between the two is not allowed.

Table 155 – Possible slave output signals

Case	t_{rfo}	t_{fro}
c)	$m \times t_{BIT} - t_{cadreal} \le t_{rfo} \le m \times t_{BIT} + t_{cadreal}$	$n \times t_{BIT}$
d)	$m \times t_{BIT}$	$n \times t_{BIT} - t_{cadreal} \le t_{rfo} \le n \times t_{BIT} + t_{cadreal}$
NOTE m and n are ordinary digits. They are not identical to the explanation given in the abbreviations.		

Four cases (shown in Table 156) shall be distinguished for the allowable values m and n:

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Table 156 – Valid slave output signals

Status / slave	Non-inverting slave		Inverting slave	
Repeater	**i = m; j = n**		**i = n; j = m**	
Slave transmits own telegram	Normal operation i, j = 8 m, n = 1 .. 8 m + n = 2 .. 16	When switching from telegram to fill signal (1 .. 12) (2 .. 20)	Normal operation i, j =8 m, n = 1 .. 8 m + n = 2 .. 16	When switching from telegram to fill signal (1 .. 12) (2 .. 20)
NOTE Numbers in brackets represent values which may occur when switching from telegram to fill signal.				

30.2.4.2 Clock adjustment

The limit values of clock adjustment times are specified in Table 157.

Table 157 – Specifications of the clock adjustment times

Time	**Value**
t_{cadmin}	$= t_{BITnom} / 64$
t_{cadmax}	$= t_{BITnom} / 11$
$t_{cadreal}$	$0 \leq t_{cadreal} \leq t_{cadmax}$

30.2.4.3 Signal delay due to the slave

Signal delay due to the slave (in repeater mode) is specified in Table 158.

Table 158 – Optical signal delay in a slave

Baud rate	t_{del}-max	t_{del}-electric	t_{del}-optic
2 Mbit/s	750 ns	400 ns	350 ns
4 Mbit/s	375 ns	200 ns	175 ns
8 Mbit/s	250 ns	100 ns	150 ns
16 Mbit/s	200 ns	50 ns	150 ns

30.2.5 Idealized waveform

The idealized waveform is characterized by status changes of the optical signal. The optical signal is replaced by rectangular wave shapes of equal height and infinitely short rise and fall times. The status change (edge) of the idealized waveform (rectangle) is defined at the transmitter output as the instant of time at which the optical power is 0,5 × P_{TminH} ± 20 %. Both threshold levels (low attenuation and high attenuation) shall always fall within the interval P_{TmaxL} and P_{TminH}.

All subsequent times shall be measured between the status changes defined above.

30.3 Connection to the optical fiber

30.3.1 Introduction

In Subclause 30.3, the connections to the optical fiber for master and slave as well as their interaction are described in more detail.

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Table 159 shows all basic functions that shall be performed by a connection.

Table 159 – Basic functions of the connection

Function to be performed by →		Master	Slave
1	Retrieve clock from received signal	x	x
2	Regenerate and transmit received signal		x
3	Transmit 0111 1111 as fill signal	x	
4	Transmit own telegram	x	x
5	Phase-correct and spike-free transition between numbers	4 → 3 3 → 4	4 → 2 2 → 4

30.3.2 Master connection

30.3.2.1 Function

Figure 130 shows the functions that a master connection shall have.

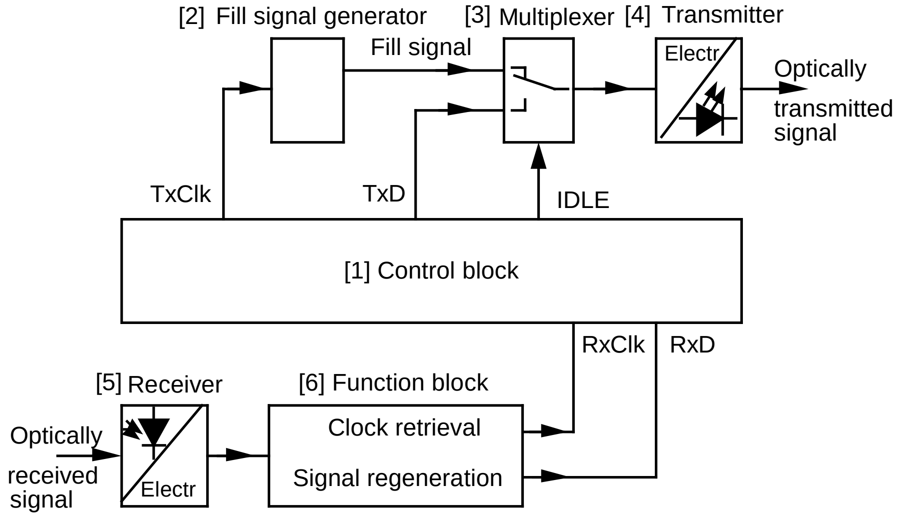

Figure 130 – Functions of a master connection

The control block – [1] in Figure 130 – shall construct the telegram to be sent according to Figure 130 and convert it into a NRZI-coded signal. When receiving a telegram, the master's control block shall recognize the NRZI-coded and regenerated telegram as one for the master based upon its telegram delimiters and the address field. In addition, the control block [1] shall check the telegram and transmit only correct data fields to the signal processing unit.

Except for NRZI coding/decoding and the generation/recognition of the telegram delimiters, the functions above will be discussed with higher protocol layers.

30.3.2.2 Generating a fill signal

According to Figure 130, the control block [1] shall generate the transmitting clock (TxClk) for the master. This shall be sent to the fill signal generator – [2] in Figure 130 –, where the fill signal is generated according to 9.10.2, Figure 53.

When the master is transmitting the fill signal (IDLE = 1), the signal shall reach the electro-optical converter [4] via the switch [3]. The switch shall work in such a way that a signal change at its output always coincides with the pattern of the transmitting clock. In this way,

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subsequent units can use phase locked loops for clock retrieval. Thus, they can always be synchronized to the transmitting clock of the master.

Function block [6] will be discussed in 30.3.3.

30.3.2.3 Switching from fill signal to telegram delimiters and vice versa

During transitions from fill signal 0111 1111 to telegram delimiters:

a) it shall be possible to interrupt the bit string 0111 1111 at any point;

b) it shall be possible to insert up to two arbitrary (transitioning) bits xx (e.g., for simplifying implementation).

All signal changes generated this way, however, shall be synchronized with the transmitting clock.

Figure 131 shows some examples of valid signal patterns of the transmitting signal during transitions from fill signal to a telegram to be sent, where occasionally inserted (transitioning) bits are shaded.

As shown in Figure 131, bit sequences having several delimiters can be generated. The receiver shall be able to recognize the highlighted, double-lined signal as the leading telegram delimiter.

During the transition from telegram delimiters to fill signals, i.e. after the bit sequence 01111110_B (delimiter):

a) up to four arbitrary transitioning bits can be inserted;

b) followed by switching to an arbitrary point in the bit sequence 0111 1111 (fill bits).

All generated signal changes shall be synchronized to the transmitting clock. Figure 132 shows some examples. Occasionally inserted (transitioning) bits are shaded. It is possible to have several delimiters appear. A receiver shall be able to recognize the first delimiter as an enclosing telegram delimiter.

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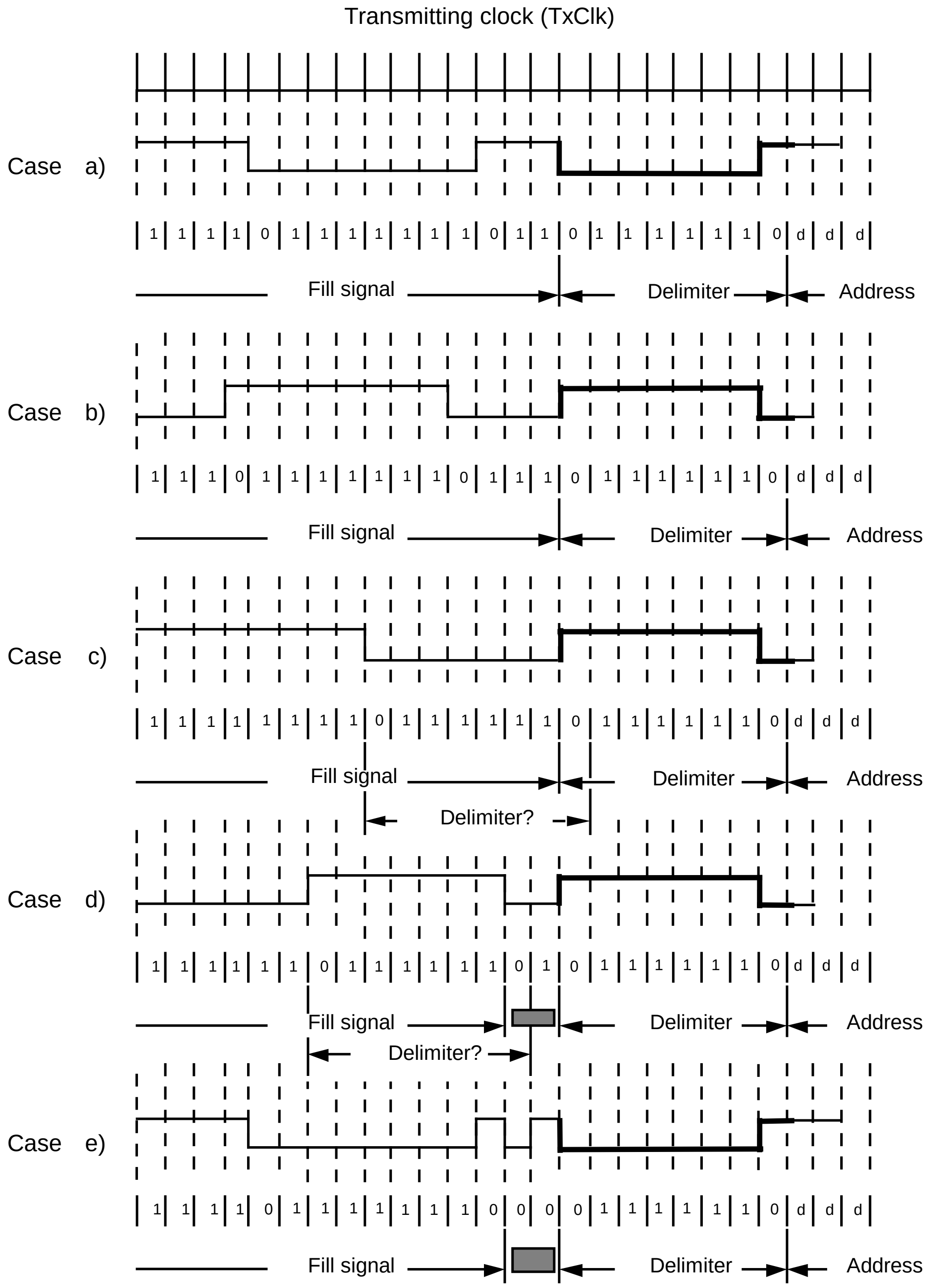

Figure 131 – Valid transmitting signals during the transition from fill signal to telegram delimiters

In Figure 132, case e) is identified by the fact that two consecutive edges of opposite directions shall be separated by a maximum of 12 transmitting clock cycles (t_{BIT}) and two sequential edges with the same direction shall be separated by a maximum of 20 transmitting clock cycles (t_{BIT}). This is important for the proper operation of a DPLL.

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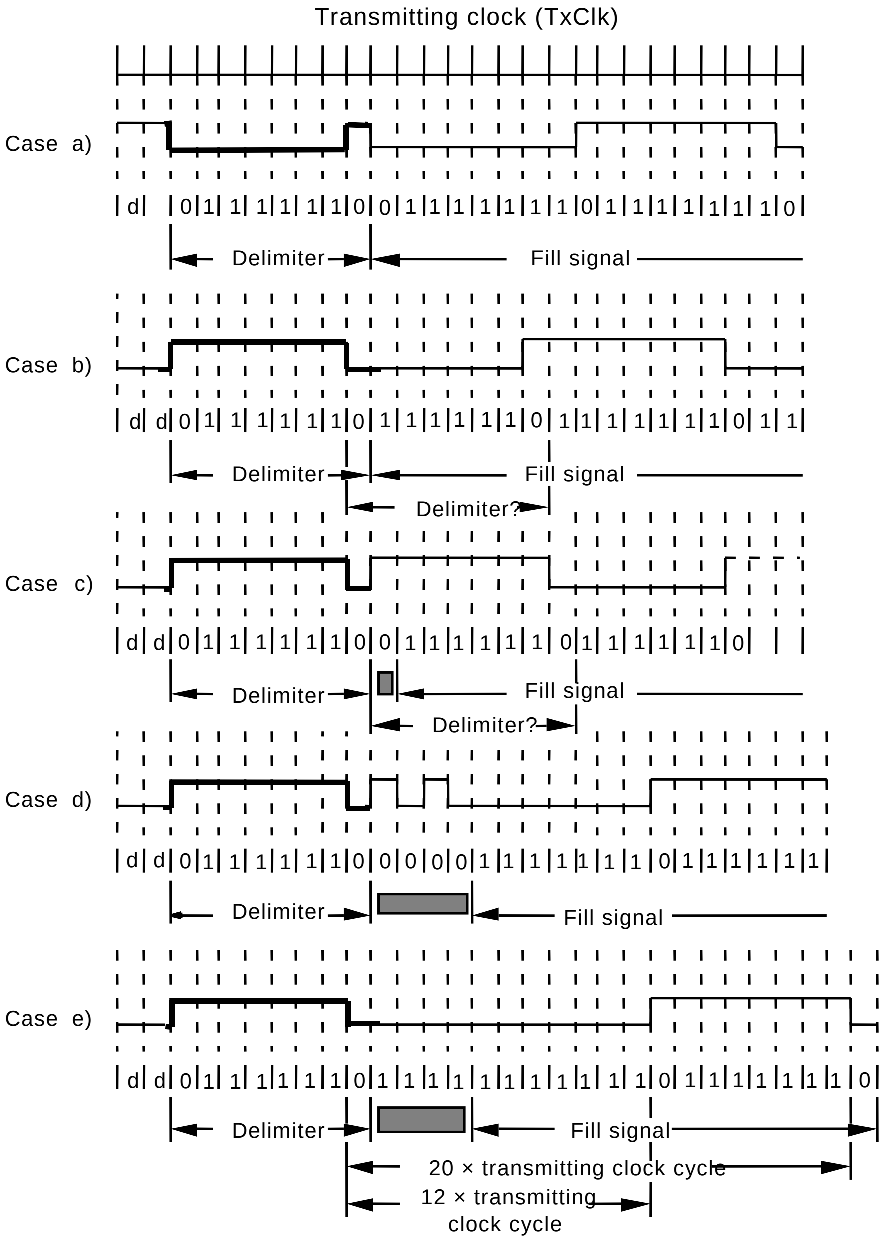

Figure 132 – Valid transmitting signals during the transition from telegram delimiter to fill signal

30.3.3 Slave connection

Figure 133 shows the functions that a slave connection shall have.

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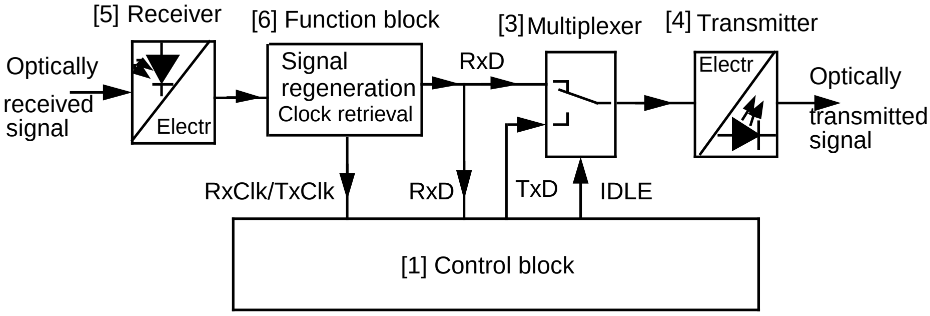

Figure 133 – Functions of a slave connection

The function block [6] has the following tasks:

a) Retrieving the clock from the electrical received signal (clock retrieval, possibly with DPLL). The clock retrieved in [6] shall be used as transmitting and receiving clock for [1] (for the master, transmitting and receiving clocks are different signals);

b) Regenerating the received signal, care shall be taken that any signal changes occur synchronously with the clock retrieved in a). If the slave does not need to transmit its own telegram, the regenerated received signal shall be sent (repeater mode, IDLE = 1).

The multiplexer [3] shall work according to the transitioning parameters as shown in 30.3.2.3.

Power supply:

In order to perform the above functions, the electronic components shall continue to work (e.g. during start-up and diagnostics), even if the power supply of the associated devices is shut-down. The slaves shall at least be able to regenerate the stream of data and to function as repeaters by transmitting the data.

30.3.4 Interactions of the connections

In Figure 134, the interaction of the connection of two slaves in a network is illustrated. The assumption is made that slave 1 is in the process of transmitting a telegram to the master. The multiplexer [3] in the master shall pass the fill signal so that the function block [6] of slave 1 can retrieve the clock. Slave 2 multiplexer [3] shall pass its regenerated received signal (i.e., the slave 1 telegram) to the master. The master, in turn, shall retrieve the receiver clock from the received signal by means of its function block [6]. All three phase locked loops in Figure 134 shall be synchronized at any time. This synchronization shall always be maintained, even if a transition [3] is activated. During switch over of [3], it is important to avoid any signal edges which do not follow the clock pattern.

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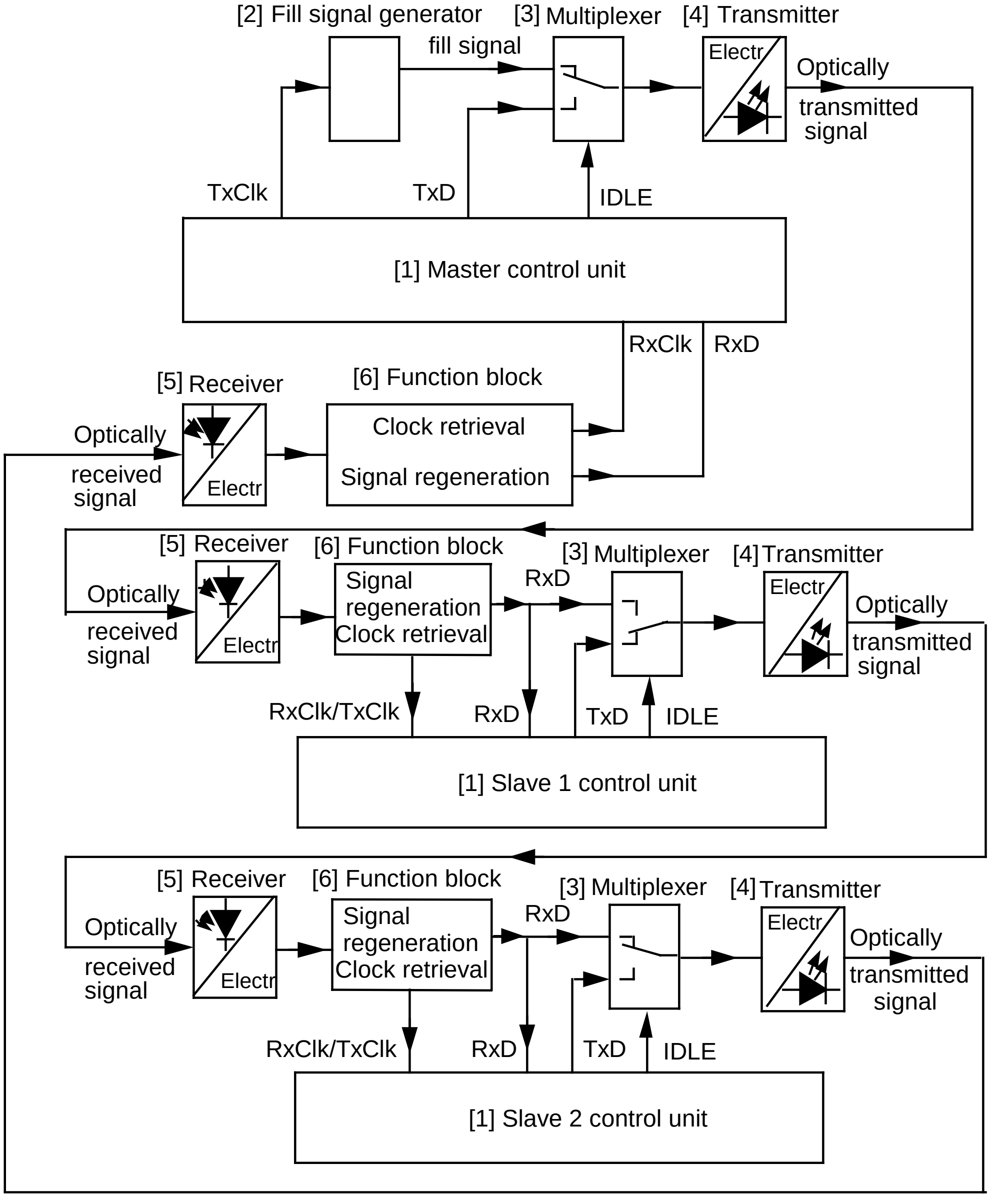

Figure 134 – Network with two slaves

31 Type 18: Medium attachment unit: basic medium

31.1 General

Type 18-PhL-B implements an MAU compliant with ISO/IEC 8482 twisted pair multipoint interconnections, named TPMI throughout the remainder of Clause 31, and is a derivative of ANSI TIA/EIA-485-A.

Added to the TPMI requirements are the following:

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- data signal encoding specifications
- MAU bus signal loading
- signal conveyance requirements
- media specifications
  - topology descriptions
  - cable specifications
  - transmission line termination specifications
- endpoint and branch trunk cable connectors
- recommended interface circuitry

The resulting Type 18-PhL-B bus can support bit rates as high as 10 Mbit/s and transmission lengths as long as 1,2 km.

NOTE Throughout Clause 31, the term *station* refers to a network device and is used for consistency with the Type 18 DLL and AL where various types of stations are defined.

31.2 Data signal encoding

Type 18-PhL-B specifies NRZI (Non-Return to Zero Inverted) data signal encoding as defined by ISO/IEC 9314-1. Accordingly, a Mark-to-Space transition or a Space-to-Mark transition represents a PhPDU logical one; and a lack of transition (Mark-to-Mark or Space-to-Space) presents a PhPDU zero.

31.3 Signal loading

A Type 18-PhL-B MAU communication element implementation requires transceiver devices that are specified not to exceed 0,5 Unit Loads (UL). Thus, the maximum number of connected devices is 64.

31.4 Signal conveyance requirements

The minimum wiring between communicating devices is shown in Figure 135.

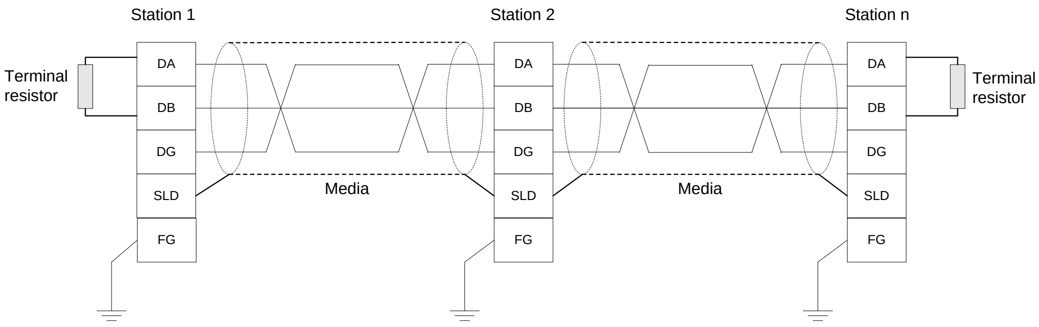

Figure 135 – Minimum interconnecting wiring

It is recommended to connect the SLD (shield) to the FG (field ground) at both ends of the trunk line cable via low impedance (that is, low inductance) connections. This is necessary to achieve a reasonable electromagnetic compatibility.

31.5 Media

31.5.1 General

The medium of each bus segment (trunk) and spurs (branches) is a shielded twisted-pair cable. The shield helps to improve the electromagnetic compatibility (EMC).

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31.5.2 Topology

31.5.2.1 Pass-through topology

A dedicated cable is configured with a pass-through type connector for each device as shown in Figure 136.

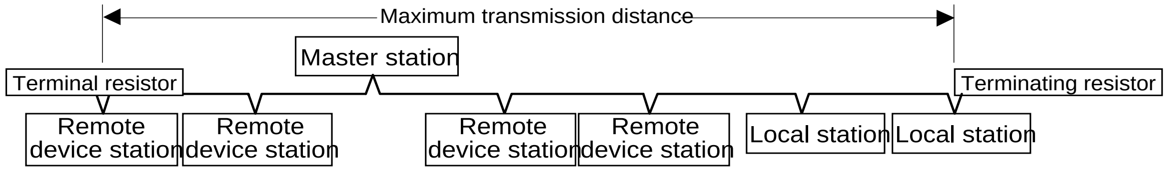

Figure 136 – Dedicated cable topology

31.5.2.2 T-branch topology

A T-branch topology is configured with T-connectors as couplers to provide node points for spurs (branches) as shown in Figure 137.

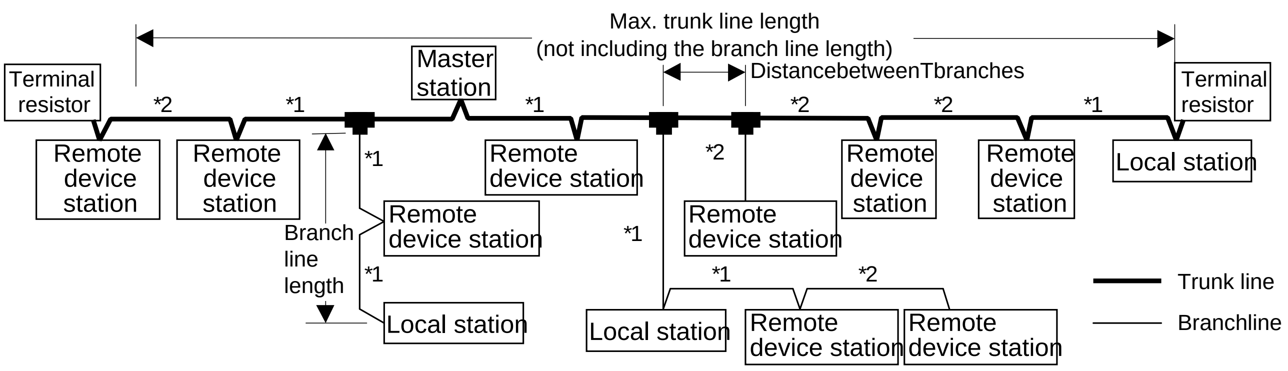

Figure 137 – T-branch topology

31.5.2.3 Topology requirements

31.5.2.3.1 Pass-through topology

The maximum cable length as a function of bit-rate is specified in Table 160. The minimum cable distance device-to-device is 20 cm.

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Table 160 – Pass-through topology limits

Bit rate kbit/s	Max. cable length m
10 000	100
5 000	160
2 500	400
625	900
156	1 200

31.5.2.3.2 T-branch topology

The only allowable bit rates for the T-branch topology are 156 kbit/s and 625 kbit/s. The maximum cable lengths (as a function of bit-rate) and other topology limitations are specified in Table 161. See Figure 137 for a description of the referenced bus components.

Table 161 – T-branch topology limits

Parameter		Value	Comment
Max. trunk length	625 kbit/s	100 m	
	156 kbit/s	500 m	
Max. branch length	625 kbit/s	50 cm	Cable length per branch (spur)
	156 kbit/s	200 cm	
Max. overall branch length		8 m	Total length of all branch lines combined
Max. distance between T-branches		No limit	This distance measured on trunk line
Max. number of stations connected per branch		6	
Min. distance to master station		2 m	See ***1** in Figure 137. This parameter is reduced to 1 m for systems configured without Local Stations or Intelligent Device Stations.
Min. distance between stations		30 cm	See ***2** in Figure 137.
NOTE Station types (e.g., master station) are defined in Type 18 DLL and AP.			

31.5.3 Signal cable specifications

The 3-core twisted-pair cable Type 18-PhL-B medium is specified in Clause R.1.

31.5.4 Media termination

The trunk line segment shall be terminated at each end with its characteristic impedance. Requirements for these two transmission line terminating resistors are specified in Table 162.

Table 162 – Terminating resistor requirements

Parameter	Value
Resistance	110 Ω
Power	0,5 W
Tolerance	< 5 %

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31.6 Endpoint and branch trunk cable connectors

There is no physical connector specified for use with Type 18-PhL-B.

The type of connector shall be a screw-compression type with each terminal able to accommodate two conductors of the type specified for the media cable. It is also required that sufficient terminals are provided for all five connection points, or alternatively, four connection points with a separate connection point provided for the FG circuit.

It is recommended that two-piece connectors be implemented for disconnecting online devices. It is further recommended that the implementer evaluate appropriate industry partnership associations and consortia for commonly implemented connector solutions for the industry of targeted application. See the IEC 61784 series for references to these and other related specifications.

31.7 Recommended type 18-PhL-B MAU circuitry

Galvanic isolation of the communications element is not required, but it is recommended and strongly encouraged for stable performance. It is minimally recommended that the communications element be configured with galvanic isolation as shown in Figure 138. It is further recommended that the input/output element be configured with its own galvanic isolation as shown in Figure 139.

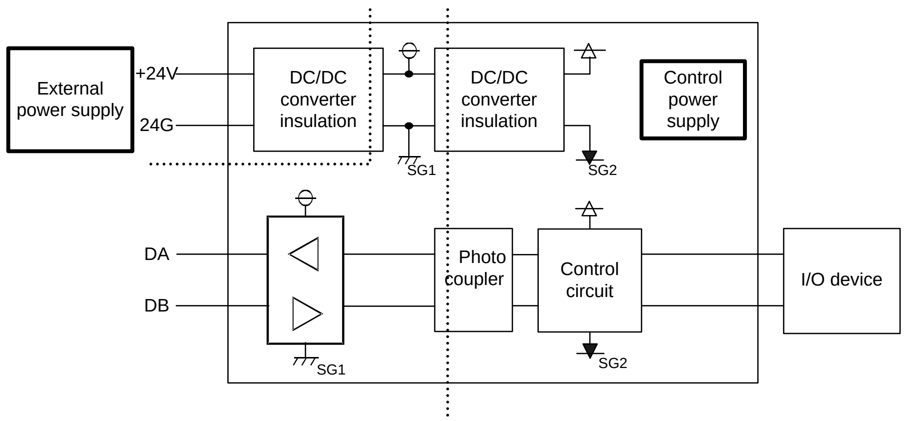

Figure 138 – Communication element isolation

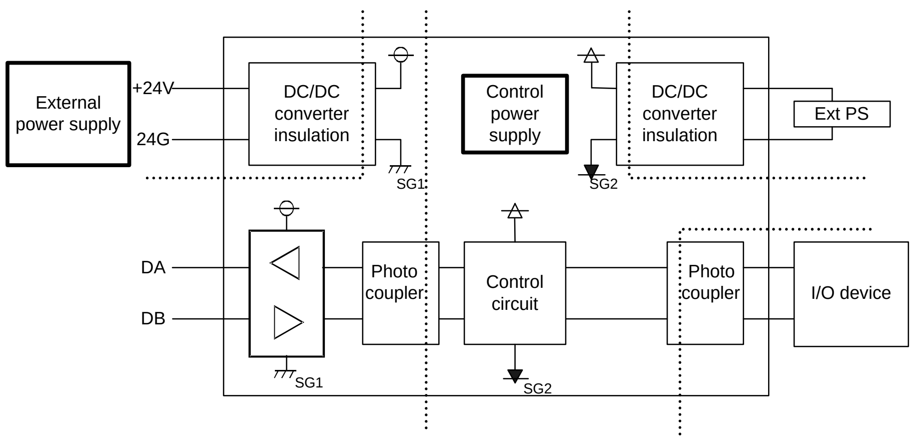

Figure 139 – Communication element and I/O isolation

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32 Type 18: Medium attachment unit: powered medium

32.1 General

Type 18-PhL-P implements a MAU compliant with ISO/IEC 8482 twisted pair multipoint interconnections, named TPMI throughout the remainder of Clause 32, and is a derivative of ANSI TIA/EIA-485-A.

Added to the TPMI requirements are the following:

- data signal encoding specifications
- MAU bus signal loading
- signal conveyance requirements
- media specifications
  - topology descriptions
  - cable specifications
  - transmission line termination specifications
- endpoint and branch trunk cable connectors
- embedded power distribution
- recommended interface circuitry

The resulting Type 18-PhL-P bus can support bit rates as high as 2,5 Mbit/s and transmission lengths as long as 500 m.

NOTE Throughout Clause 32, the term *station* refers to a network device and is used for consistency with the Type 18 DLL and AL where various types of stations are defined.

32.2 Data signal encoding

Type 18-PhL-U specifies NRZI (Non-Return to Zero Inverted) data signal encoding as defined by ISO/IEC 9314-1. Accordingly, a Mark-to-Space transition or a Space-to-Mark transition represents a PhPDU logical one; and a lack of transition (Mark-to-Mark or Space-to-Space) presents a PhPDU zero.

32.3 Signal loading

Type 18-PhL-U MAU communication element implementation requires transceiver devices that are specified not to exceed 0,5 Unit Loads (UL). Thus, the maximum number of node devices is 64.

32.4 Signal conveyance requirements

The minimum wiring between two communicating devices is shown in Figure 140.

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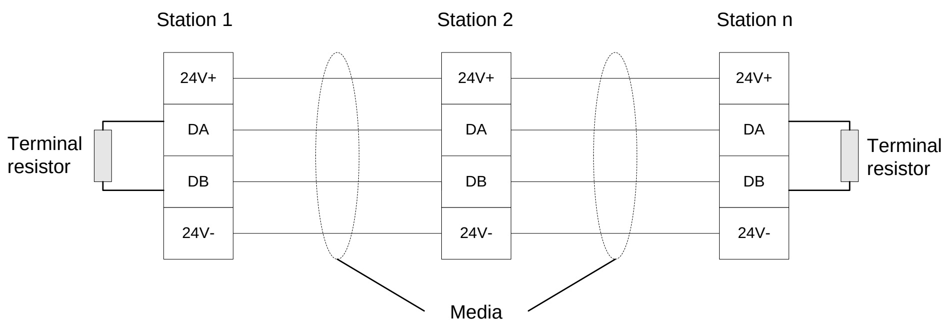

Figure 140 – Minimum interconnecting wiring

32.5 Media

32.5.1 General

The medium of each bus segment (trunks) and spurs (braches) is a 4-core unshielded cable. These cables are specified in both flat cable and round cable configurations with conductors for both communications and embedded power distribution.

32.5.2 Topology

32.5.2.1 General

An example flat cable configuration with embedded power distribution is shown in Figure 141. The bus contains a trunk and may contain spurs (branches).

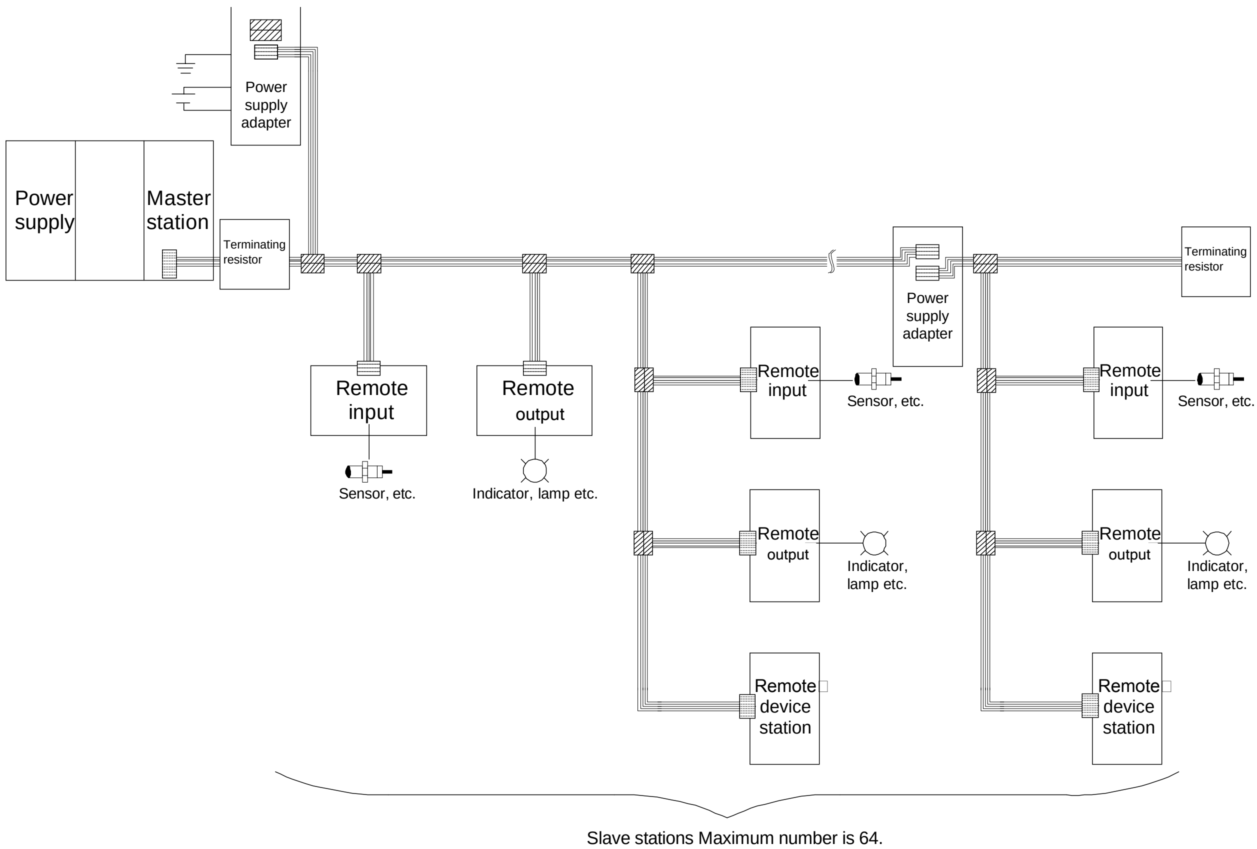

Figure 141 – Flat cable topology

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32.5.2.2 Pass-through topology

A dedicated cable is configured with a pass-through type connector for each device as shown in Figure 142.

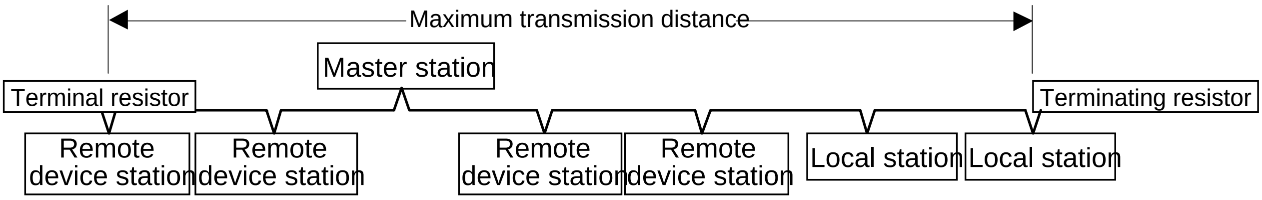

Figure 142 – Dedicated cable topology

32.5.2.3 T-branch topology

A T-branch topology is shown in Figure 143. The cable types can be mixed in the network, but shall remain consistent for a given branch of trunk segment.

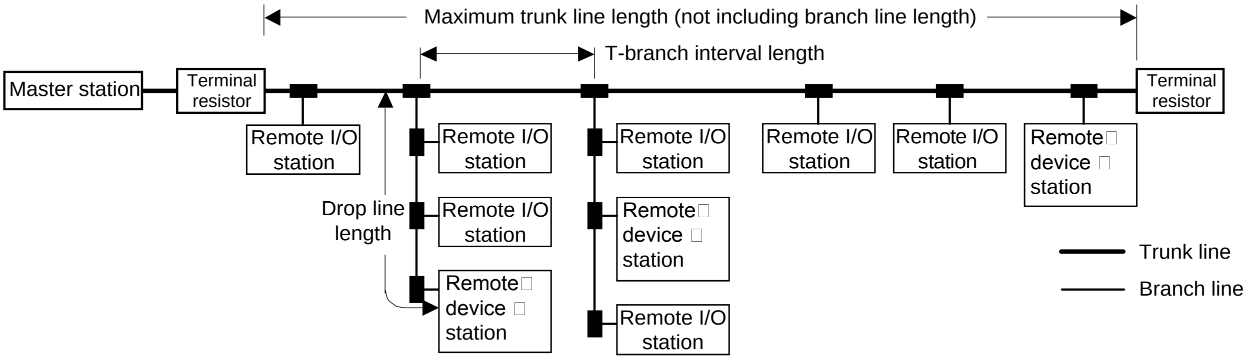

Figure 143 – T-branch topology

32.5.3 Topology requirements

32.5.3.1 Pass-through topology

The maximum cable length, as a function of bit-rate, is specified in Table 163.

Table 163 – Pass-through topology limits

Bit rate kbit/s	**Max. cable length** m
2 500	35
625	100
156	500

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32.5.3.2 T-branch topology

The type 18-PhL-P topological implementation is restricted in that the trunk segment shall be constructed using only one type of cable (flat, round preferred, or round alternate). Similarly, each branch (spur) shall be self-consistent, that is, constructed of only one type of cable. However, branch cable types need not match the trunk cable type or that of other branches in the PhL-segment bus.

The only allowable bit rates for the T-branch topology are 156 kbit/s, 625 kbit/s and 2,5 Mbit/s.

The maximum cable lengths as a function of bit-rate and other topology limitation are specified in Table 164.

Table 164 – T-branch topology limits

Parameter	Value			Comment
	156 kbit/s	625 kbit/s	2 500 kbit/s	
Max. trunk segment length	500 m	100 m	35 m	Not including branch line length
Max. branch length	60 m	16 m	4 m	Cable length per branch (spur)
Max. overall branch length	200 m	50 m	15 m	Total length of all branch lines combined
Max. cable length between connected devices	500 m	100 m	35 m	
Max. cable length between T-branches	No limit			This distance measured on trunk line
Max. number of devices connected per branch	8			

32.5.4 Signal cable specifications

32.5.4.1 Flat cable

The 4-core unshielded flat cable Type-18-PhL-P medium is specified in R.2.1.

32.5.4.2 Round cable – preferred

The preferred 4-core unshielded round cable for the Type-18-PhL-P medium is specified in R.2.2. This cable type is also known as VCTF cord.

32.5.4.3 Round cable – alternate

The alternate 4-core unshielded round cable for the Type-18-PhL-P medium is specified in R.2.3.

32.5.5 Media termination

The trunk line segment shall be terminated at each end with its characteristic impedance. Requirements for these two transmission line terminating resistors are specified in Table 165 for flat cable and Table 166 for round cable.

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Table 165 – Terminating resistor requirements – flat cable

Parameter	Value
Resistance	680 Ω
Power	0,5 W
Tolerance	<10 %

Table 166 – Terminating resistor requirements – round cable

Parameter	Value
Resistance	680 Ω
Power	0,5 W
Tolerance	<10 %

32.6 Endpoint and branch trunk cable connectors

32.6.1 Device connector

The required dimensions of the Type 18-PhL-P device connector are specified in Clause Q.2.

32.6.2 Flat-cable connector

The required dimensions of the Type 18-PhL-P flat cable connector are specified in Clause Q.3.

32.6.3 Round cable connector

The required dimensions of the Type 18-PhL-P round cable connector are specified in Clause Q.4. This connector is applicable to both styles of Type 18-PhL-P round cable.

32.6.4 Round cable alternate connector

The required dimensions of the Type 18-PhL-P round cable alternate connector is specified in Clause Q.5.

32.6.5 T-branch coupler

There are no required dimensions for the Type 18-PhL-P T-branch coupler. Any suitable commercially available terminal block can be used.

32.7 Embedded power distribution

32.7.1 General

Type 18-PhL-P includes specifications for network embedded power distribution. The power component of a PhL-segment can be either a single interconnected power distribution system or partitioned into more than one power allocation segments. The example block diagram in Figure 144 demonstrates a PhL-segment with two power allocation segments.

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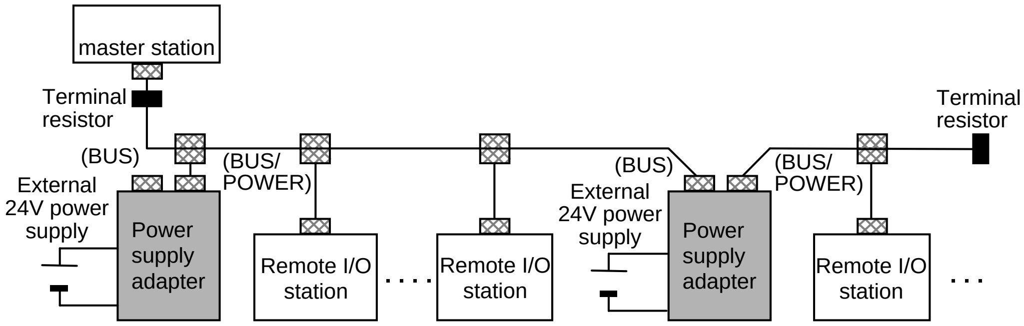

Figure 144 – Type 18-PhL-P power distribution

32.7.2 Power source

Power supply devices shall be implemented with two device bus connectors that provide pass-through connectivity for the data signals but power sourced to only one connector. The circuit diagram in Figure 145 shows the interconnection for the power source.

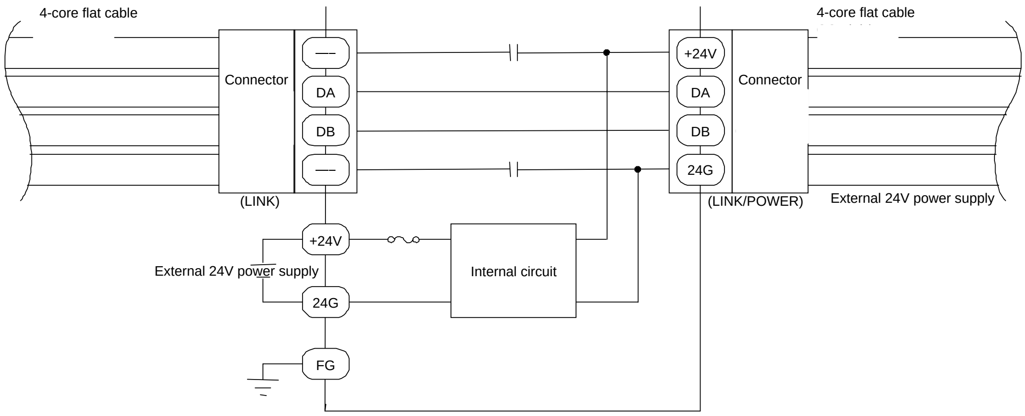

Figure 145 – Type 18-PhL-P power distribution

The 24 V power supply for the Type 18-PhL-P shall comply with the specifications given in Table 167.

Table 167 – 24 V Power supply specifications

Parameter	Specification
Max. operating voltage	28,8 V
Min. operating voltage	20,4 V
Max. current	5 A
Isolation – power to data signals	500 Vrms
Reverse over voltage protection	95 V
Current surge tolerance	Output voltage within 19,2 V to 30,0 V for ±5 A/1 mS pulse

32.7.3 Power loading

Each device connected to the Type 18-PhL-P bus that also consumes power shall comply with the requirements specified in Table 168.

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Table 168 – 24V Power consumption specifications

Parameter	Specification
Max. operating voltage	30,0 V
Min. operating voltage	19,2 V
Max. current	5 A [a]
Start current	1,33 times operating current [b]
Reverse current protection	no damage to device or network from reverse wired power

[a] For full transmission distances, it is necessary to limit power consumption to 0,1 A per device.

[b] This does not include the inrush current required to charge the input bypass capacitors. When these are included, it is necessary to limit the overall inrush current such that the bus power shall not droop to less than 19,2 V for more than 1 ms when a device is plugged into an operating network.

The specifications for start current and inrush current (Table 168, Note 2) are required to support hot-pluggable devices, that is, devices that can be plugged into, or removed from, an operating network without harm to the network or the devices.

Filtering of the power input circuitry and protecting against reverse power connection is also required for stable performance at the higher bit rates. The filter parameters are not specified. A typical filter and protection circuit is shown in Figure 146 with critical components labelled.

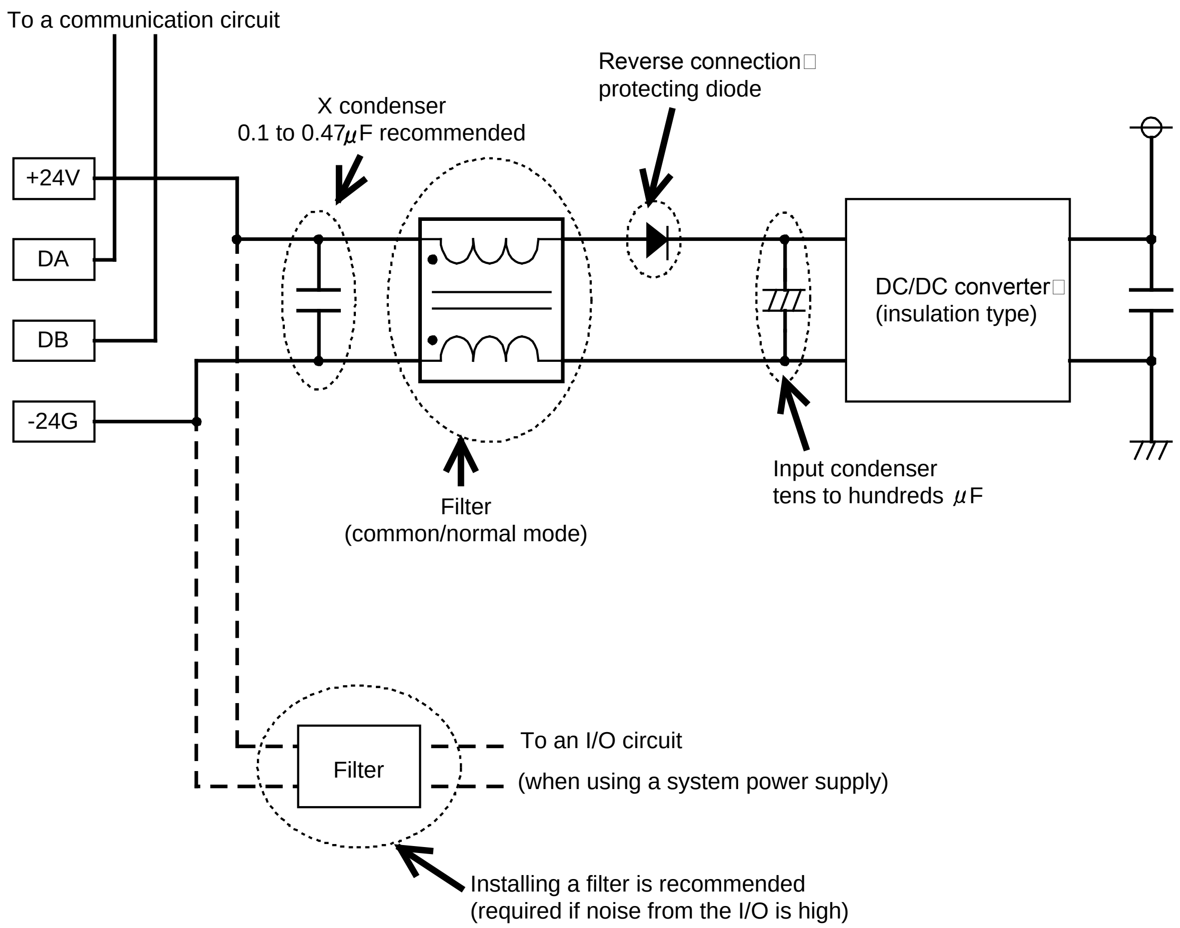

Figure 146 – Type 18-PhL-P power supply filtering and protection

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32.8 Recommended type 18-PhL-P MAU circuitry

32.8.1 General

The circuit diagrams in Subclause 32.8.2 and Subclause 32.8.3 are included for informational purposes.

32.8.2 Communications element galvanic isolation

Galvanic isolation of the communications element is not required, but it is recommended and strongly encouraged for stable performance. It is minimally recommended that the communications element be configured with galvanic isolation as shown in Figure 147. It is further recommended that the input/output element be configured with its own galvanic isolation as shown in Figure 148.

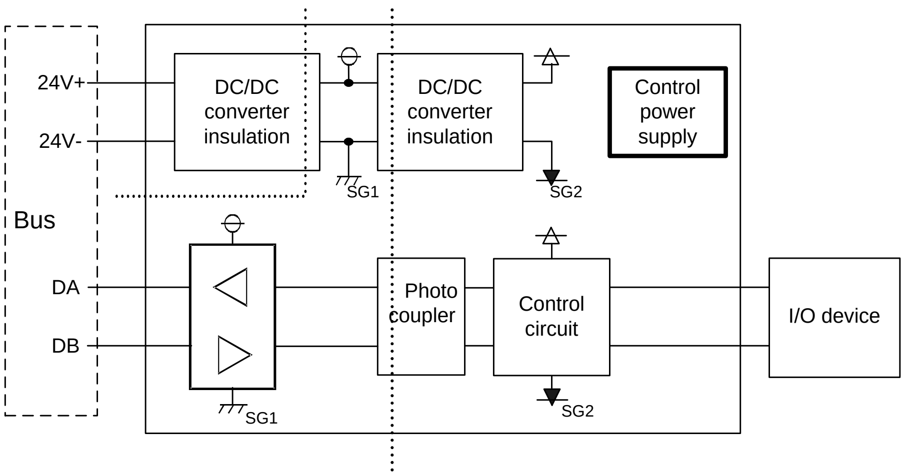

Figure 147 – Communication element isolation

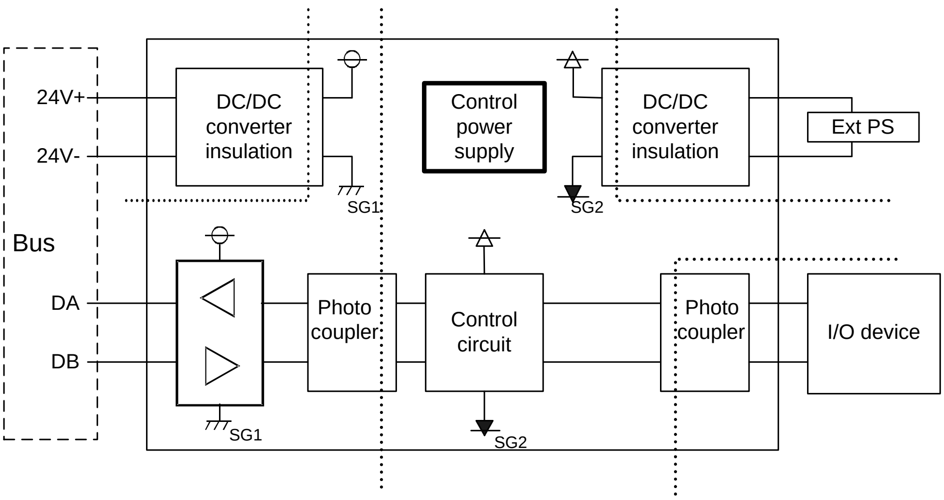

Figure 148 – Communication element and i/o isolation

32.8.3 Power

A complete power conditioning circuit is shown in Figure 149. This diagram serves as an informative guide for a recommended implementation of Type 18-PhL-P power supply components.

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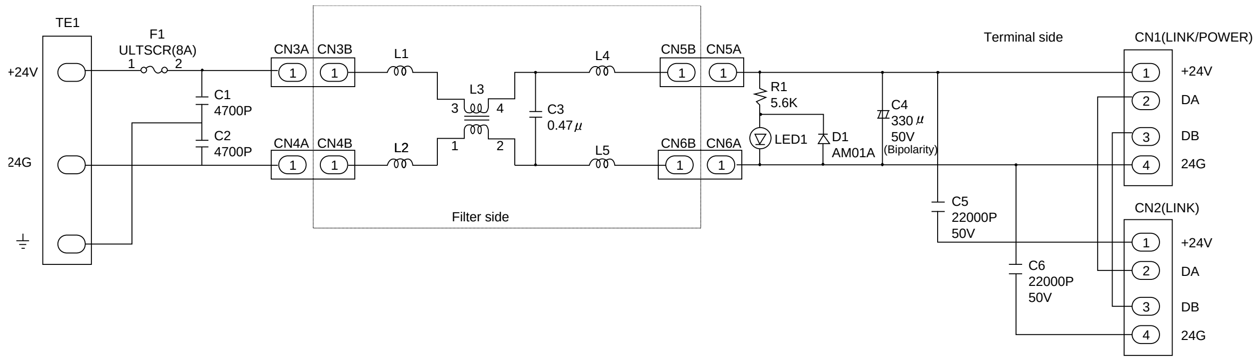

Figure 149 – PhL-P power supply circuit

33 Type 24: Medium attachment unit: twisted-pair wire medium

33.1 General

This MAU specification describes a balanced line transmission corresponding to ANSI TIA/EIA -485-A. The maximum cable length is 50 m and the data rate is 10 Mbit/s. Terminators are located at both ends of the twisted-pair cable. The MAU transceiver is isolated from the transmission line by galvanic isolation using transformer. In Table 169 the MAU characteristics are summarized.

Table 169 – MAU summary

Characteristic	Constraints
Topology	Linear bus, terminated at both ends, no branches
Medium	Shielded twisted pair cable, see 33.4
Line Length	≤ 50 m
Number of devices	17(Line Length ≤ 30 m) 16(Line Length >30 m and ≤ 50 m)
Data rate	10 Mbit/s

33.2 Network

33.2.1 Component

This MAU operates in a network that consists of the following components:

– cable;

– connectors;

– devices (containing at least one communication element).

33.2.2 Topology

This MAU shall operate in a linear bus topology with terminators at both ends. Up to 17 fieldbus devices are connected directly. The total length of the cable shall not exceed 50 m. The maximum number of connected devices varies with the line length as shown in Table 169. The line length and number of devices may be increased by using a repeater. Only one repeater is permissible. Figure 150 shows an example of expanded network using a repeater.

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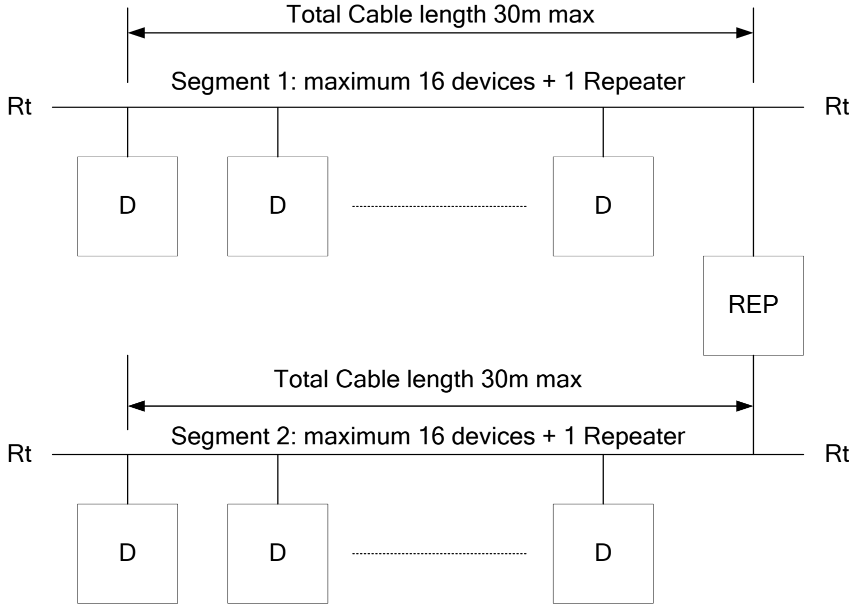


Key

D Device

REP Repeater

Rt Bus Terminator

Figure 150 – Expanded type-24 network using repeater

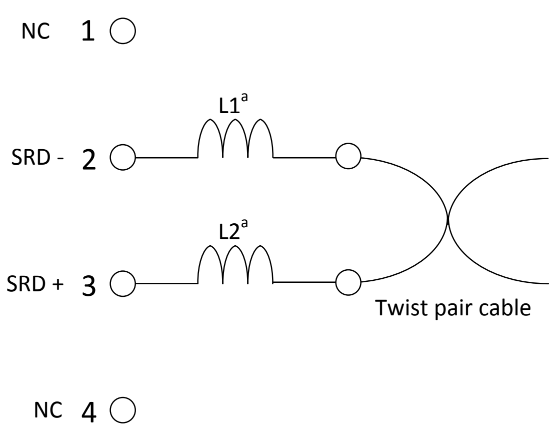
33.3 Electrical specification

The voltage levels of the transmitter output and receiver input are according to ANSI TIA/EIA-485-A. Transmitter output and receiver input are galvanically isolated by a pulse transformer.

33.4 Medium specifications

33.4.1 Connector

The connector is specified in Clause S.2. To take the impedance matching with the transmission line, the inductor of 100 nH shall be mounted in the cable side connector as shown in Figure 151.



[a] L1, L2: 100 nH ±5 %

Figure 151 – Connector with inductor

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33.4.2 Cable

The bus medium is a shielded twisted-pair cable. The shield helps to improve the electromagnetic compatibility (EMC). The structure and specification of the cable are shown in Figure 152 and Table 170 respectively.

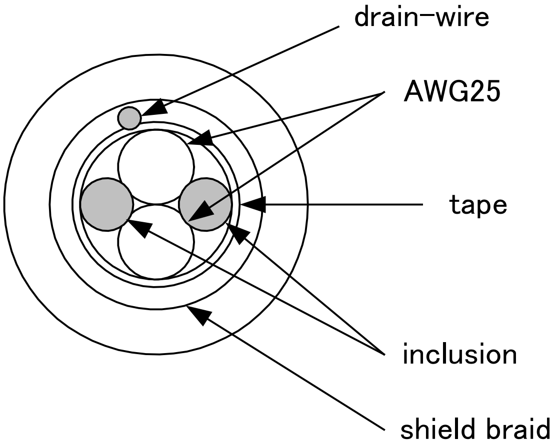

Figure 152 – Cable structure

Table 170 – Cable specification

Characteristic	Constraints
Overall diameter	4,8±0,2 mm
Conductor	Tinned annealed copper
Electrical resistance of conductor	≤ 114,4 Ω/km
Withstand voltage	AC 1 000 V, 1 min
Insulation resistance	≥ 100 MΩ/km
Impedance	130 Ω
Capacity	110 nF/km
Attenuation	40 dB/km (at 4 MHz) 60 dB/km (at 10 MHz)
Color code	Black / Red

The wiring between two devices is shown in Figure 153.

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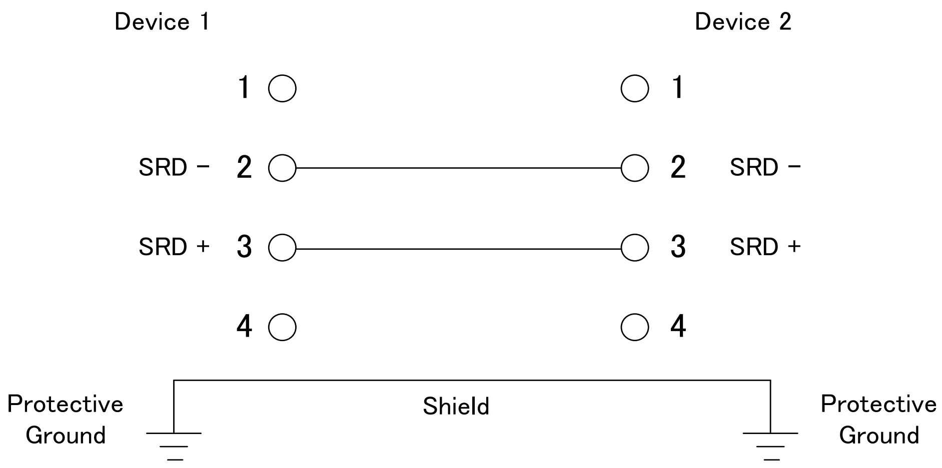

Inversion of the two wires SRD– and SRD+ is not allowed

Figure 153 – Interconnecting wiring

The wiring shown in Figure 153 allows a common mode voltage between both devices (that is, the voltage difference between the protective grounds) of at most 7 V. If higher common mode voltage is expected, a compensation conductor between the grounding points shall be installed.

33.4.3 Grounding and shielding rules

It is recommended to connect the shield to the protective ground at both ends of the cable via low impedance (that is, low inductance) connections. This is necessary to achieve a reasonable electromagnetic compatibility.

Preferably the connections between the cable shield and the protective ground (for example, the metallic device housing) should be made via the metallic housings of the connectors.

33.4.4 Bus terminator

The bus cable shall be terminated at both ends with Rt. The value of the terminator shall be 130 Ω ± 5% (1/2 W min.), as shown in Figure 154.

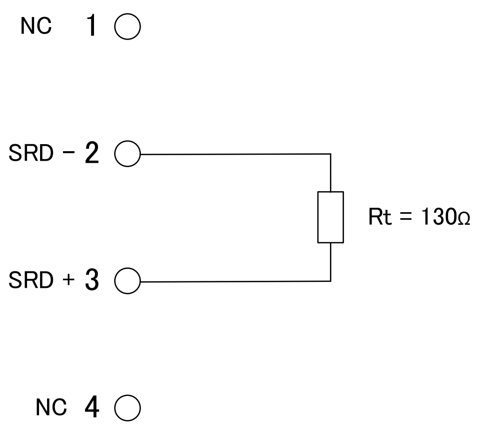

Figure 154 – Bus terminator

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33.5 Transmission method

33.5.1 Bit coding

The Manchester coded data from MDS is transmitted via a twisted pair cable. A differential signal of the transmission line is obtained from pin2 (SRD-) and pin3 (SRD+) of the bus connector.

When it is Low and the latter half is High, the first half of the bit of a differential signal becomes a binary "1" (DL_symbol = "ONE"). When it is High and the latter half is Low, the first half of the bit becomes a binary "0" (DL_symbol = "ZERO").

33.5.2 Transceiver control

Transceiver of Type 24 MAU shall be in accordance with the transmitter and receiver specifications shown in Table 171 and Table 172. Other specifications not listed on those tables shall be in accordance with ANSI TIA/EIA-485-A.

Table 171 – Transmitter specification

Specification	Limits / characteristics
High level output current High-current, IOH	-100 mA min.
Low level output current Low-current, IOL	100 mA min.

Table 172 – Receiver specification

Specification	Limits / characteristics
Positive-going input threshold voltage	-10 mV max.
Negative-going input threshold voltage	-200 mV min.

When a device is not transmitting the transmitter output shall be disabled and present high impedance to the line. During the idle periods, that is, when no data is transmitted by any device, the receive line signal shall represent a binary "1". The voltage level of the differential signal received during idle periods is 0 V. Therefore the threshold voltage of the receiver shall be lower than 0 V as specified in Table 172 for the receiver to represent a binary “1”. Also the received signal shall conform to the eye pattern specified in Figure 155.

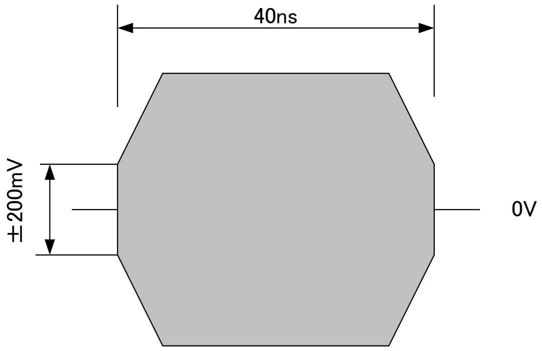

Figure 155 – Eye pattern

33.5.3 Transformer

For galvanic isolation between medium and MAU, a pulse transformer specified in Figure 156 and Table 173 shall be used.

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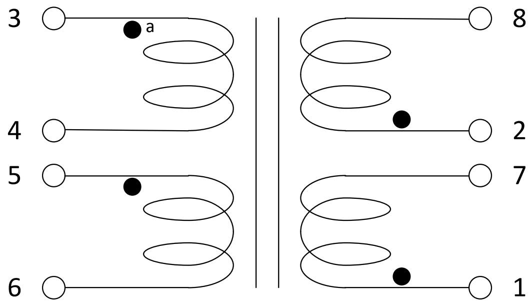

[a] sign: same pole

Figure 156 – Transformer symbol

Table 173 – Specification of transformer

Item	Specification	Note
Response frequency	2/4/10 MHz	
Inductance	0,5 mH min	L (1-8) (2-7 short) 10 kHz 0,1v
Turn ratio	(2-8):(1-7) = 1:1 (2-8):(3-4) = 1:2 (2-8):(5-6) = 1:2	
DC resistance	600 mΩ (1-8) 300 mΩ (4-3)	(2-7 short) (4-6 short & 3-5 short)
Leakage inductance	400 nH max.	L (1-8) (2-7 short & 3-6-4-5 short)
Capacity	12 pF max.	(1-2-7-8 short & 3-6-4-5 short) 1MHz
Insertion loss	0,5 dB max.	(3-4) to (1-8) (2-7short & 4-6 short & 3-5 short) 50 Ω: 2 MHz~10 MHz
Insulation resistance	100 MΩ min.	AC 500 V

33.5.4 Output level requirement

Refer to ANSI TIA/EIA-485-A for the voltage level of the transmission and the reception.

33.5.5 Interface to the transmission medium

The recommended circuit of Type 24 MAU is shown in Figure 157.

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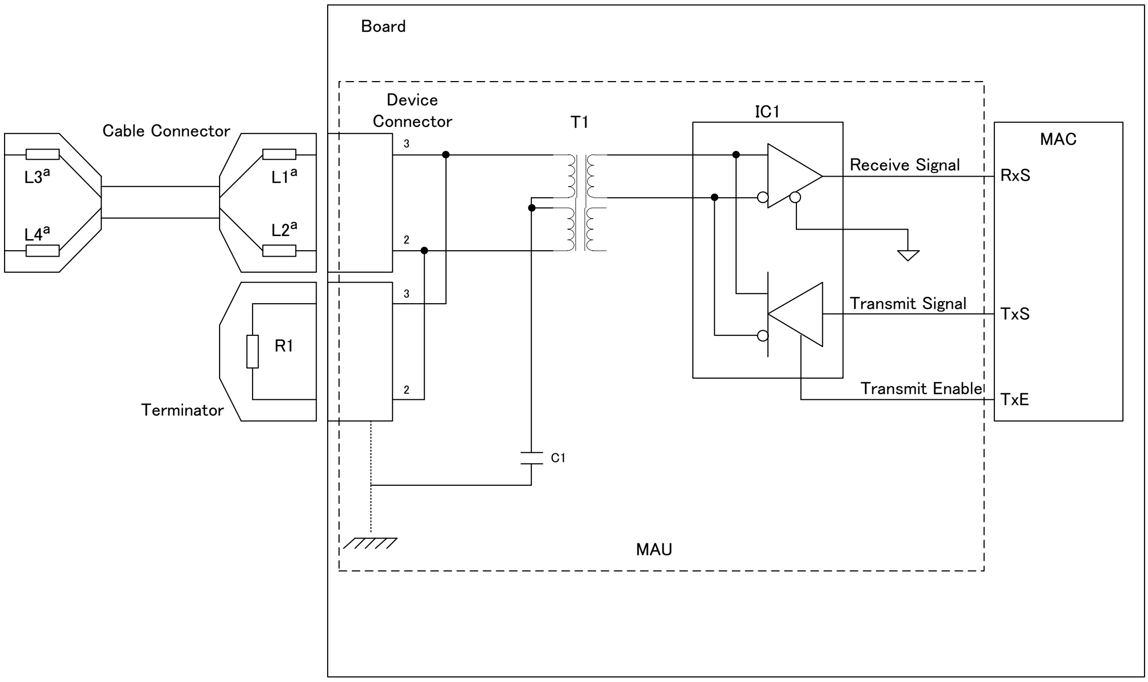

Key

IC1: Transceiver IC

T1: Isolation transformer

R1: 130 Ω ±5%, 1/2 W

C1: 1000 pF, 1 kV

[a] L1, L2, L3, L4 : 100 nH ± 5 %

Figure 157 – Recommended MAU circuit

34 Type 20: Medium attachment unit: FSK medium

34.1 Overview

The digital signaling protocol of this standard uses 1 200 bit/s binary phase-continuous Frequency-Shift-Keying (FSK) to superimpose digital communications on to a 4 mA to 20 mA current loop. Devices signal by either modulating current or by supplying voltage; all signaling appears as voltage when sensed across low impedance. Phase-continuous frequency-shift-keying requires the phase angle of the mark (1 200 Hz = binary 1) and the space (2 200 Hz = binary 0) to remain continuous at the 1 200 Hz bit boundaries as shown in Figure 158.

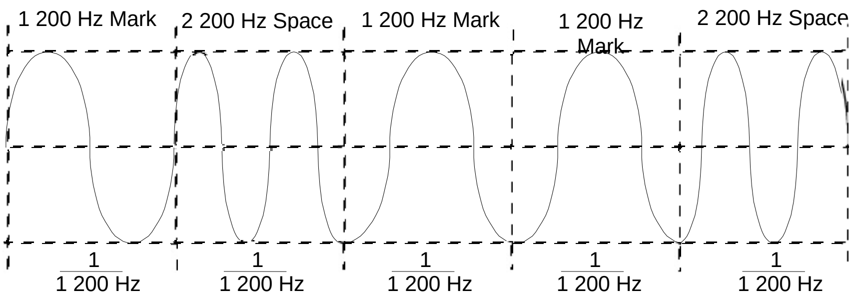

Figure 158 – Phase-continuous Frequency-Shift-Keying

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The device that modulates the current appears as high impedance across the medium and thus several such devices can be connected in parallel. The device that supplies the voltage signal has low series impedance. Many of the devices also use current to send or receive analog signal. The frequency and amplitude of the digital signal is such that it does not interfere with the analog signal. This standard specifies the analog signal such that it does not interfere with digital signal. The device can also draw the power from the medium using analog signal.

This standard also specifies devices that do not use analog or digital signal. Examples of such devices are power supply and barrier.

34.2 PhPDU

34.2.1 PhPDU structure

Figure 159 shows the structure of a PhPDU. The PhSDU is the sequence of Ph-user-data octets of PH-DATA primitive. The preamble is sequence of hexadecimal ‘0xFF’ octets.

Figure 159 – PhPDU Structure

34.2.2 PhPDU transmission

34.2.2.1 Character transmission

Upon receiving the PH-START request primitive, the PhE shall transmit at least five (5) and no more than twenty (20) preamble characters. The number of preamble characters is configurable parameter. After the transmission of the last preamble, the PhE shall provide PH-START confirm. The PhE shall transmit PhSDU octets as it is received from the PhS-user. Characters forming a PhPDU shall be transmitted in a single contiguous stream.

NOTE The 5 preamble characters allow sufficient time for asserting a carrier, training the modem circuit and for the listening device to begin receiving the PhPDU.

Although the maximum number of preamble octets is 20, the number of preamble octets affects system performance. In data acquisition applications, transmission of long preamble sequences can be detrimental. As a result, transmission of excessive preamble characters is strongly discouraged.

34.2.2.2 Character format

Each character shall be transmitted asynchronously and consist of eleven bits. These are, in order of transmission, one start bit, eight data bits (least significant bit first), one odd parity bit, and one stop bit as shown in Figure 160. There shall be no more than one idle bit (i.e., additional stop bits) between consecutive characters. The consecutive characters in a PhPDU shall have intervening inter-character gap of less than one (1) character time.

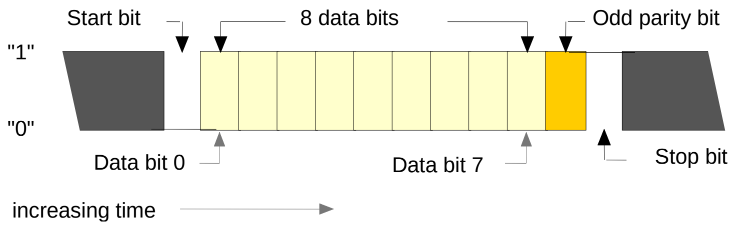

Figure 160 – Character format

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NOTE At 1 200 bit/s, transmitting a character takes 9,167 ms. This time period is the character time for the FSK Physical Layer.

34.2.3 PhPDU reception

After detecting the carrier, the PhE receiver shall look for preamble characters and synchronize with the start and stop bits. After receiving two error-free preamble characters, it shall provide PH-START indication. It is equivalent to carrier detection.

During the reception of PhSDU characters, the receiver shall check for parity bit for correct value. If any error is detected the PhE shall provide PH-DATA indication with error status.

If the PhE detects the lack of medium activity then it shall provide PH-END indication primitive. The medium activity is inferred by a signal level higher than the noise rejection levels specified in 34.6 and Table 176.

If the gap between two received character is equal to or more than one (1) character time then the PhE shall provide PH-DATA indication with discontinuous data reception error status.

34.2.4 Preamble length

The length of preamble in a PhPDU from master to slave device is specified in DL-DATA-EXCHANGE request – see IEC 61158-3-20. The length of preamble in a PhPDU from slave to master device is set as a parameter as defined in IEC 61158-3-20.

34.3 Device types

34.3.1 General

The devices are classified based on following two criteria:

- Input or output impedance and
- Connection to the network.

All devices have parameters depending upon its type. These parameters are also defined in 34.3.2, 34.3.3 and 34.3.4.

34.3.2 Impedance type

34.3.2.1 General

All devices are classified as one of the two types based on its input or output impedance in digital frequency band. Low impedance device has signaling element that is intended to receive analog current signal or serve as the master device for a multi-drop network. High impedance device controls the current as an analog signal or in a multi-drop network sets its analog signal at a fixed value.

34.3.2.2 Low impedance device

The low impedance device shall have an impedance of 230 Ω to 600 Ω in the digital frequency band. The variation of the impedance over the extended frequency band shall be within ± 3 dB of its value at the center of the digital frequency band.

NOTE 1 The impedance variation limit prevents excessive signal distortion.

NOTE 2 Any device that receives the analog current signal such as an analog input controller device or an actuator has low input impedance so that it is possible to use lower DC voltage to power the device that sends the analog current signal. It is impractical for devices of this type to have high impedance at digital frequency band.

NOTE 3 The device at the low end of the impedance range limits the use of parallel resistance connected to the network. The device at the high end of the impedance range limits the total cable capacitance.

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34.3.2.3 High impedance device

The high impedance device shall have an impedance of more than 600 Ω in the digital frequency band.

A high impedance device should be designed to have as high impedance as possible within other design constraints.

NOTE For multi-drop network application, the total impedance connected to the medium is parallel combination of input impedance of all devices connected to the medium.

34.3.3 Connection type

34.3.3.1 General

A device shall be classified as having one of the following types of connection to the network:

1) Current input,
2) Current output,
3) Voltage input,
4) Voltage output,
5) Secondary,
6) Analog transmitter,
7) Actuator,
8) Non-DC isolated, or
9) DC isolated.

A device may exhibit characteristics of more than one of these connection types. The manufacturer should identify the connection types for which the device can be configured.

34.3.3.2 Current input

A device that uses a resistor to measure the analog current signal is defined as device with current input connection. The current sense resistor can be either internal to the device or it can be attached externally. In either case, the sense resistor is considered as part of the device, and the impedance of a current input device shall be specified to include this resistor.

Current input devices may include the network power supply and provide DC power to the loop. If the device can use a range of sense resistance values, instead one fixed value, then the device parameters shall be specified as a function of the sensor resistor value.

NOTE Current input device have low impedance and are usually not isolated from the ground. The most common example of a current input device is the controller connection for an analog input loop (a loop with a common 4 mA to 20 mA transmitter as the field device).

34.3.3.3 Current output

A device that sources the current as analog signal is defined as device with current output connection. Current output device may include the network power supply and provide DC power to the loop. Otherwise, it can be connected in series with an external power supply and only control the loop current.

NOTE Current output device has high impedance. Usually these devices are not isolated from the ground. Examples of current output devices are the controller connection for an analog output loop (a loop with a common 4 mA to 20 mA actuator or positioner as the field device) or a separately-powered field device that sources current to the loop rather than sinking it from the loop.

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34.3.3.4 Voltage input

A device that measures the voltage input signal is defined as device with voltage input connection. A device of this type shall have high input impedance. Voltage input device does not provide DC power to the loop, and may or may not be isolated from ground.

NOTE High input impedance is required so that the resistance in the cable loop does not introduce an error in the voltage signal. Examples of voltage input device are the controller connection for an analog input loop where the analog signal is voltage (e.g., from a voltage output transmitter) or a separately powered output device that accepts voltage as its analog input signal rather than current.

34.3.3.5 Voltage output

A device that sources the voltage output signal is defined as device with voltage output connection. A device of this type shall have low impedance in digital frequency band. Voltage output device does not provide DC power to the loop, and may or may not be isolated from ground.

NOTE Low output impedance is required so that the resistance in the cable loop does not introduce an error in the voltage signal. The most common example of voltage output device is a 3-wire voltage output transmitter. Another example is a controller designed to drive a separately powered field device. A network with analog voltage signaling cannot carry DC power since this causes voltage drop in loop wiring and an unacceptable error in the analog signal.

34.3.3.6 Secondary

A device that has a removable connection, is not required for communication on the network and is connected only on a temporary basis is defined as secondary device. Secondary device shall have high impedance and be DC isolated from the current loop.

The network analysis for maximum wire length should include the secondary device.

NOTE The most common example of a secondary device is the handheld terminal.

34.3.3.7 Analog transmitter

A device that draws DC current from the loop and varies the amount of current drawn as a means of analog signaling is defined as analog transmitter. The device may use the DC current as the power source or it may be separately powered.

NOTE Analog transmitter has high impedance and it is usually DC isolated from the ground. Examples of analog transmitter type are 2-wire transmitters or separately powered transmitters with loop interface that draw DC from the loop.

34.3.3.8 Actuator

A device that draws DC current from the loop at a value determined by the current sourcing device is defined as actuator. The device may use the DC current as the power source or it may be separately powered.

NOTE Actuator has low impedance and it is usually DC isolated from the ground. The most common examples of actuators are 2-wire devices that receive an analog signal via 4 mA to 20 mA loop current supplied by a controller.

34.3.3.9 Non DC isolated

A device that draws constant value of DC current from the loop and does not use analog signal is defined as non DC isolated device. The device may use the DC current as the power source or it may be separately powered. It uses digital signal for communication.

NOTE Non DC isolated device has high impedance and it is usually DC isolated from the ground. The most common example of this type of device is a 2-wire transmitter when in a fixed current mode.

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34.3.3.10 DC isolated

A device that does not draw DC current from the loop and does not use analog signal is defined as non DC isolated device. The device is separately powered. It uses digital signal for communication.

NOTE DC isolated device has high impedance. It is possible that DC isolated bus devices exist on any loop, including loops with analog signaling, since it does affect the analog signal. A network is possibly constructed with all devices of this type, that is, loops with no DC current flowing at all.

34.3.4 Device parameters

One or more parameters defined in this Table 174 apply to a device based on its impedance and connection type.

Table 174 – Device parameters

Device type	Parameter
DC isolated from the ground	Minimum Rtt and maximum Ctt under worst-case conditions of an unbalanced network
Non DC isolated from the ground	Minimum Rtt and maximum Ctt as normally connected and a description of the ground reference
Device that draws DC current from the loop	The amount of current drawn and the minimum voltage at the device terminal that is required for the device to operate
Device that sources DC current to the loop	The minimum and maximum values of the sourced current and the voltage, and the maximum load voltage at which the device can operate
Device that produces analog signal	The minimum and maximum values of the sourced current and the minimum voltage at the device terminal that is required for the device to operate
Low impedance device	Minimum and maximum impedance magnitudes in the digital frequency band

The values of the applicable parameters shall be specified by the device manufacturer.

34.4 Network configuration rules

A device shall conform to the requirements of this standard when used in a network which comply with these rules.

Rule 1: The network has at least one low impedance device. The combined parallel impedance of all connected devices shall be in the range of 170 Ω to 600 Ω.

NOTE 1 The network possibly has more than one low impedance device as long as the total parallel impedance is in the range specified above.

Rule 2: The network has only one analog signaling device.

NOTE 2 More than one analog signaling device in one network causes the two analog signals to interfere and thus make it ineffective.

Rule 3: One secondary device is connected to the network.

Rule 4: A point-to-point network with one primary master.

Rule 5: The cable for a point-to-point network has capacitance of 150 pF per meter, resistance of 0,05 Ω per meter, the length of 1 200 m and total device capacitance – C_{dev} of all devices 5 000 pF.

NOTE 3 The cable length is the requirement for the conformance test but it does not preclude the use of longer lengths in an installed network.

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Rule 6: The device specified for multi-drop network connected to a network with 16 devices

NOTE 4 This limit was derived by the noise calculations. This rule does not preclude the use of more than the specified number of devices in an installed network. The maximum number of devices connected to one network depends upon the cable length, noise environment and availability of the required DC power at the device terminal.

Rule 7: The cable for a multi-drop network has capacitance of 400 pF per meter, resistance of 0,0368 Ω per meter, the length of 500 m and total device capacitance – C_{dev} of all devices 25 000 pF.

NOTE 5 The cable length is the requirement for the conformance test but is does not preclude the use of longer lengths in an installed network.

The network configuration rules are for the conformance test of a device. The network can be installed with various topologies. Clause T.1 shows some of these topologies.

The guidelines for cable lengths are given in Clause T.2.

34.5 Digital transmitter specification

34.5.1 Test configuration

Figure 161 shows the configuration that shall be used for testing. Figure 161 (a), ‘Analog transmitter’ is an example of device under test. In Figure 161 (b) either ‘Current output’ or ‘Actuator’ can be the device under test. For device under test of the other types defined in 34.3.3, the test configuration shall be similar. All devices shall be tested using this test configuration and digital transmitter parameters shall be measured across the test load.

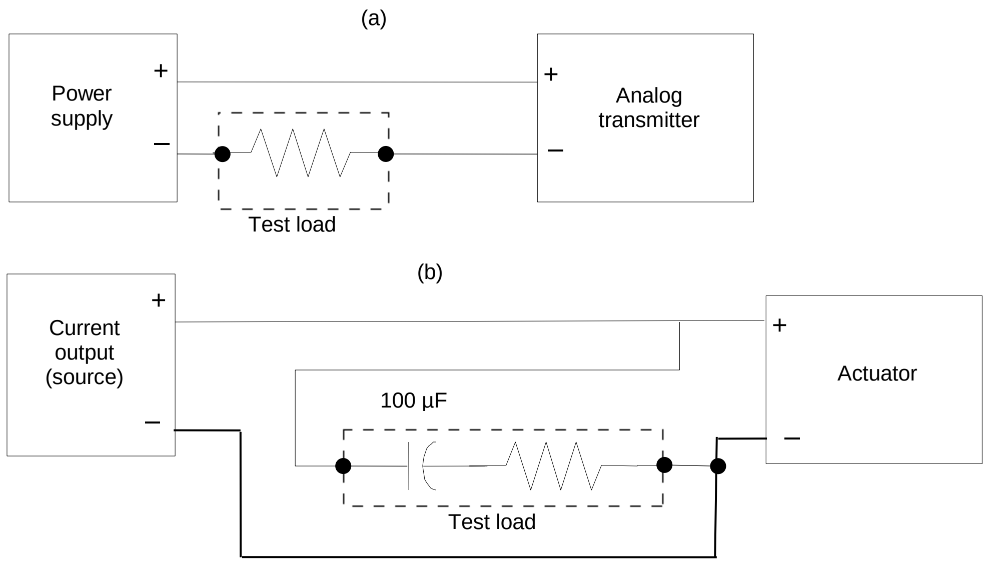

Figure 161 – Transmit test configuration

In some cases, it is necessary to prevent DC current flow through the test load. When this is necessary, a 100 microfarad DC blocking capacitor should be placed in series with test load as shown in Figure 161 (b).

In the case of analog signaling device such as analog transmitter or current output device, the test load may also serve as the current sense impedance.

The value of the resistance part of the test load shall be:

- 1 000 Ω for low impedance device, and

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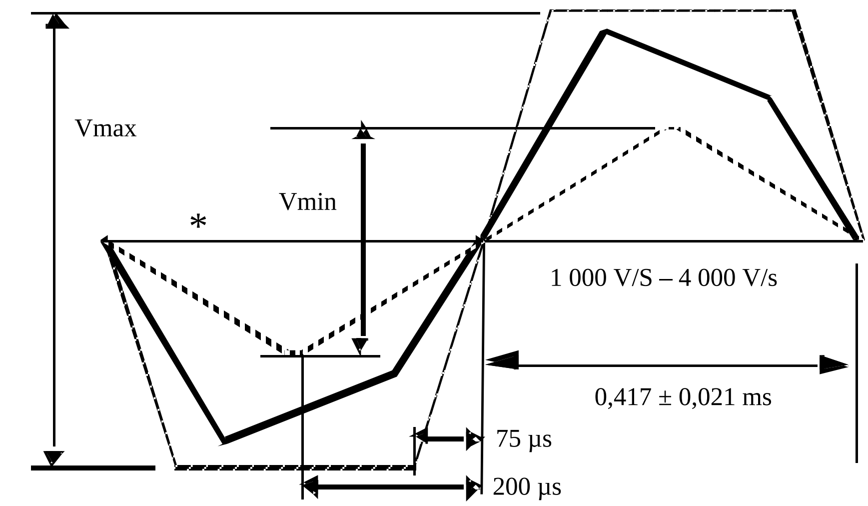
- 500 Ω for high impedance device.

34.5.2 Bit rate and modulation

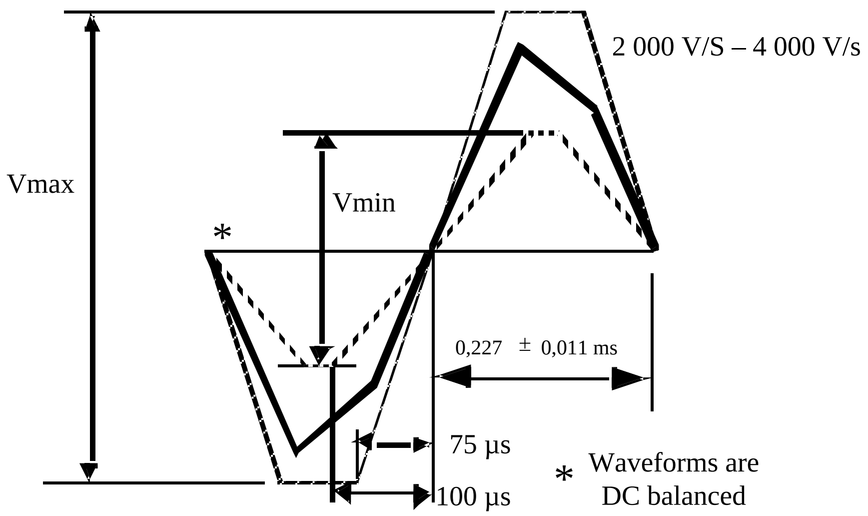
The bit rate shall be 1 200 bit/s ± 1 %. The device shall either modulate the current drawn or apply the voltage on the medium. All signals appear as voltage when sensed across a low impedance load. The modulation technique shall be phase-continuous frequency-shift-keying i.e. the phase angle of the Mark and the Space shall remain continuous at the bit boundaries. The frequency for the Mark (logic 1) shall be 1 200 Hz ± 1 %; the frequency for the Space (logic 0) shall be 2 200 Hz ± 1 %.

34.5.3 Amplitude

Figure 162 shows an example of the AC component of one cycle of the Mark and Space waveforms, illustrating some key items from the transmit circuit specification. Only signal voltages are shown; this diagram takes no account of power supply voltages. The transmit amplitude limits are summarized in Table 175.



1 200 Hz transmit waveform limits



2 200 Hz transmit waveform limits

Figure 162 – Transmit waveform

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Table 175 – Transmit amplitude limits

Device impedance	Vmin – minimum peak-to-peak level	Vmax – maximum peak-to-peak level	Test load
Low	400 mV	800 mV	1 000 Ω ± 1 %
High	400 mV	600 mV (see text)	500 Ω ± 1 %

The output voltage of a low impedance device shall be between 400 mV and 800 mV peak-to-peak, with a load resistance of 1 000 Ω ± 1 %.

The output voltage of a high impedance device shall be

a) Either, between 400 mV and 600 mV peak-to-peak, with a load resistance of 500 Ω ± 1 %,

b) or between 400 mV and 800 mV peak-to-peak, with a load resistance of 500 Ω ± 1 % and less than or equal to 800 mV peak-to-peak with a load resistance of 1 000 Ω ± 1 %.

34.5.4 Timing

As shown in Figure 162 the transmit waveform of a device shall conform to the following timing.

a) The rise and fall times measured from one peak to the next peak shall be more than or equal to 150 µs.

b) The rise and fall times measured from one peak to the next peak for Mark shall be shall be less than or equal to 400 µs.

c) The rise and fall times measured from one peak to the next peak for Space shall be shall be less than or equal to 200 µs.

d) The slew rate for Mark shall be between 1 000 V/s and 4 000 V/s.

e) The slew rate for Space shall be between 2 000 V/s and 4 000 V/s.

As shown in Figure 163, Figure 164 and Figure 165 the carrier shall conform to the following timing.

f) Carrier start time

The transmit circuit shall turn on, i.e. the signal shall rise from quiescent level to the minimum required transmit level specified in 34.5.3, in less than five (5) nominal bit times.

g) Carrier stop time

After having transmitted the last bit, the transmit circuit shall turn off, i.e. the signal shall fall below the minimum required receive level specified in 34.6, in less than three (3) nominal bit times.

NOTE 1 The minimum required receive level is 120 mV peak to peak.

h) Carrier decay time

After having transmitted the last bit, the transmit circuit shall turn off and the signal shall fall below the maximum acceptable noise level specified in 34.6, in less than six (6) nominal bit times.

The maximum acceptable noise level is 80 mV peak to peak.

NOTE 2 The carrier start, stop and decay time specifications are such that it keeps the interference to analog signal at an acceptable level. These timings are such that when the digital signal waveform, using a 250 Ω test load, is passed through a 2-pole 25 Hz low-pass Butterworth filter, the output of the filter does not exceed 10 mV at any time. The amplitude response of this filter is same as analog signal spectrum specified in 34.7.1.

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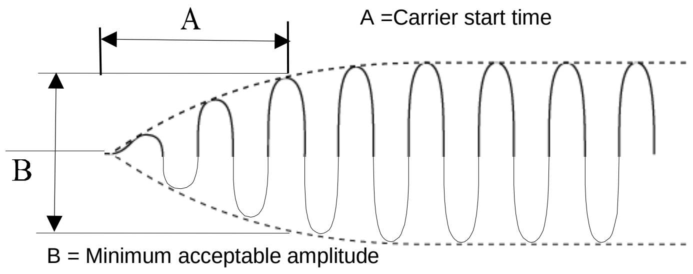

Figure 163 – Carrier start time

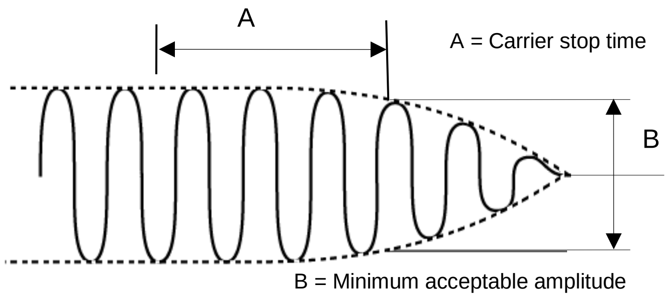

Figure 164 – Carrier stop time

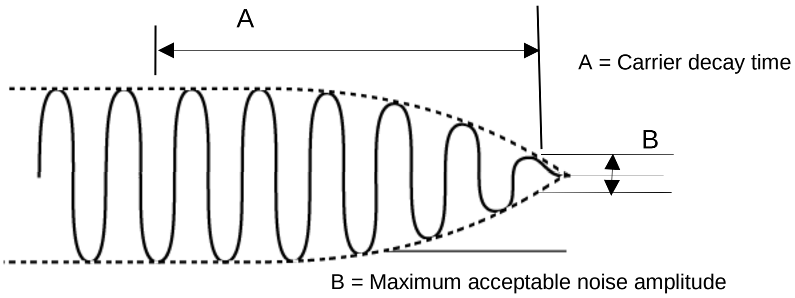

Figure 165 – Carrier decay time

34.5.5 Digital signal spectrum

The digital signaling spectrum is defined as the frequencies from 500 Hz to 10 kHz as defined in 3.12.13 and shown in Figure 166. It decreases at a rate of 40 dB per decade below 500 Hz and 20 dB per decade above 10 kHz.

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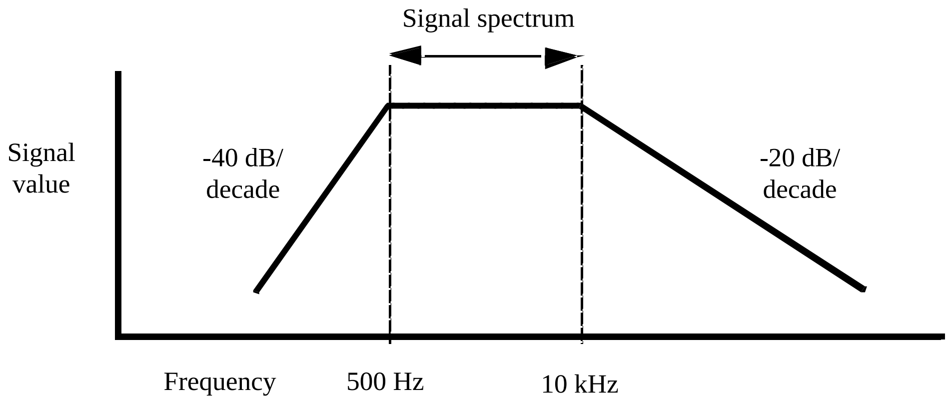

Figure 166 – Digital signal spectrum

NOTE There is no conformance test for the digital signal spectrum. If the device conforms to the timing specified in 34.5.4, then the spectrum is expected to be as shown.

34.6 Digital receiver specification

The digital receiver specifications are summarized in Table 176.

Figure 167 shows the requirements for the interference tolerance.

Table 176 – Digital receiver specifications

Receiver circuit parameter	Test condition	Limits
Sensitivity – minimum peak-to-peak signal required to be accepted		120 mV
Noise rejection –maximum peak-to-peak signal required to be rejected		80 mV
Maximum peak-to-peak signal required to be accepted	High impedance device under test	1 500 mV
Maximum peak-to-peak signal required to be accepted	Low impedance device under test	800 mV
Maximum error rate	Signal level 200 mV peak-to-peak, added Gaussian noise of constant density of 163 microvolt/root Hz over the extended frequency band, pseudo-random bit sequence	1 in 10 000 bits
In-band common mode interference with no degradation in receiver performance – see note	Extended Frequency Band i. e. 500 Hz to 10 kHz	200 mV peak-to-peak
In-band normal mode interference with no degradation in receiver performance	Extended Frequency Band i. e. 500 Hz to 10 kHz	55 mV peak-to-peak
Below-band common mode interference with no degradation in receiver performance – see note	47 Hz to 500 Hz	2 V peak-to-peak
Out-of-band normal mode interference with no degradation in receiver performance	0 Hz to 500 Hz 10 kHz to 1 MHz	See Figure 167
NOTE The common mode requirements apply only to those devices that have all inputs floating with respect to the ground.		

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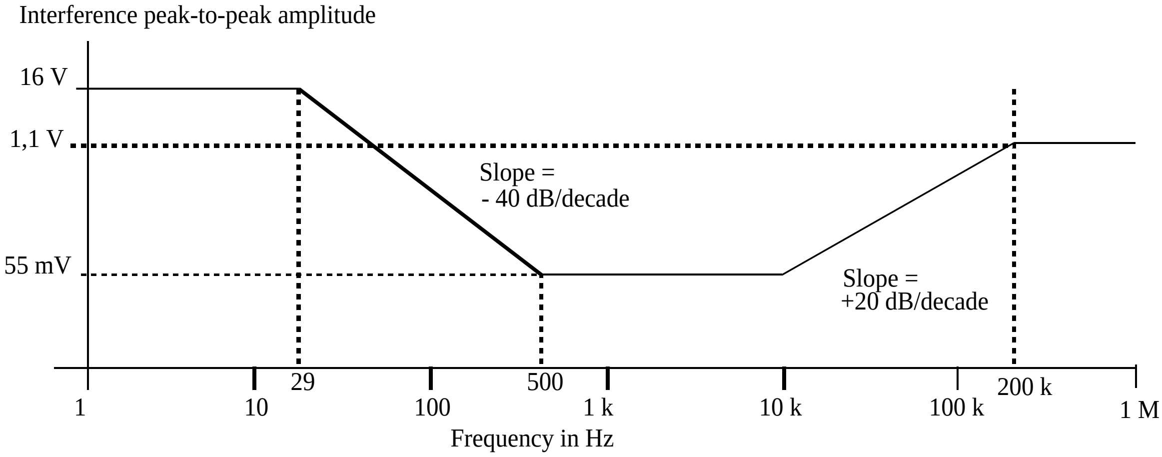

Figure 167 – Digital receiver interference

The receive circuit shall be capable of accepting an input signal of amplitude no less than 120 mV peak-to-peak, including overvoltage and oscillation. The receive circuit shall not respond to an input signal with a peak-to-peak amplitude which does not exceed 80 mV. The receiver shall operate without error, with following peak-to-peak input signal level:

- 1 500 mV at the input of the high impedance device,
- 800 mV at the input of the low impedance device.

The receiver shall operate with no degradation in its performance (no more than 1 error in 10 000 bits) in the presence of common mode voltage or interference as follows:

a) a common mode sinusoidal signal of any frequency from 500 Hz to 10 kHz with an amplitude of 200 mV peak-to-peak;
b) a normal mode sinusoidal signal of any frequency from 500 Hz to 10 kHz with an amplitude of 55 mV peak-to-peak;
c) a common mode sinusoidal signal of any frequency from 47 Hz to 500 Hz with an amplitude of 2 V peak-to-peak;
d) a normal mode sinusoidal signal interference of any frequency below 29 Hz with an amplitude of16 V peak-to-peak;
e) and specified for few frequencies below:
   - at 63 Hz, 3,52 V peak-to-peak,
   - at 125 Hz, 880 mV peak-to-peak,
   - at 250 Hz, 220 mV peak-to-peak.

NOTE The interference due to analog signal for low impedance device is impedance x 16 mA. The maximum value of this impedance is 600 Ω. Thus, maximum interference due to analog signal over zero to 25 Hz is 9,6 V.

The receiver with input signal of 200 mV peak-to-peak and pseudo-random bit sequence shall produce no more than 1 detected frame errors in 10 000 bits during operation in the presence of Gaussian noise of constant density of 163 microvolt/root Hz over the extended frequency band.

34.7 Analog signaling

34.7.1 Analog signal spectrum

The analog signal spectrum is defined as the frequencies from DC to 25 Hz decreasing at a rate of 40 dB per decade above 25 Hz.

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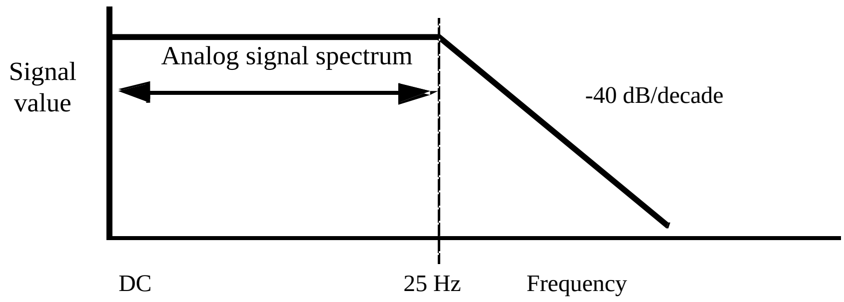

Figure 168 – Analog signal spectrum

The device that produces analog signal shall comply with the frequency spectrum shown in Figure 168.

NOTE This specification does not define analog signal type and signal values, but it defines the frequency spectrum. This is done so that analog signal does not interfere with digital signal defined in this specification. The analog signal is current or voltage output.

34.7.2 Interference to digital signal

The analog signal changes shall be such that when analog signal is applied to 500 Ω ± 1 % load for a high impedance device, or 1 000 Ω ± 1 % load for a low impedance device, and filtered through the digital test filter the instantaneous peak voltage at the filter output shall be less than or equal to 15 mV.

The digital test filter is a Butterworth bandpass filter with a pass band of 500 Hz to 10 kHz, 2nd order roll-off below 500 Hz, and 1st order roll-off above 10 kHz.

NOTE 1 This specification is such that the analog output signal generated by an analog signaling device (i.e., analog transmitter or current output device) does not interfere with the digital signal.

NOTE 2 The digital test filter has the same amplitude response as the digital signal spectrum specified in 34.5.5.

The analog input devices, such as current inputs and actuators should filter the analog signal with a low-pass filter within the analog signaling spectrum defined above, to avoid interference from the digital signal.

34.8 Device impedance

34.8.1 High impedance device

The high impedance device should have impedance as high as possible. The recommended values measured over the digital frequency band are shown in Table 177. The bus powered and self-powered device should have the recommended high impedance.

Table 177 – High impedance device characteristics

Parameter	Test condition	Value
Equivalent device capacitance – C_{dev}	Not transmitting	5 000 pF max
Equivalent device resistance – R_{dev}	Not transmitting	100 kΩ min.

The polarized devices shall exhibit the same or larger high impedance when connected across the voltage of reverse polarity as when it is connected with the correct polarity voltage. The self-powered device shall exhibit the same or larger high impedance when not powered as when it is powered.

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34.8.2 Low impedance device

The low impedance device shall have impedance as shown in Table 178.

Table 178 – Low impedance device characteristics

Parameter	Test condition	Limits
Terminal to terminal impedance – Z_{tt}	Not transmitting	230 Ω to 600 Ω
Terminal to terminal impedance – Z_{tt}	Transmitting	230 Ω to 600 Ω

The terminal to terminal impedance, not including the current sense resistor in the device, measured over the digital frequency band shall be:

- in the range of 230 Ω to 600 Ω when not transmitting,
- the impedance over the extended frequency band, within ± 3 db of the value measured over the digital frequency band,
- in the range of 230 Ω to 600 Ω when transmitting and less than or equal to the value measured when not transmitting.

The impedance shall be measured without using the test load as specified in 34.5.3.

34.8.3 Secondary device

The secondary device shall have impedance as shown in Table 179.

Table 179 – Secondary device characteristics

Parameter	Test condition	Limits
Terminal to terminal impedance – Z_{tt}	Not transmitting	5 kΩ min.
Terminal to terminal resistance – R_{tt}	Transmitting	See text below
Terminal to ground capacitance – C_{tg}	All conditions	250 pF max.
Terminal to ground resistance – R_{tg}		100 kΩ min.

The terminal to terminal impedance of the secondary device measured over the digital frequency band shall be:

- when not transmitting, a minimum of 5 kΩ,
- when transmitting, less than or equal to the value measured when not transmitting.

The terminal to ground capacitance of the secondary device measured over the digital frequency band shall be less than or equal to 250 pF.

The terminal to ground resistance of the secondary device measured over the digital frequency band shall be more than or equal to 100 kΩ.

The polarized devices shall exhibit the same or larger high impedance when connected across the voltage of reverse polarity as when it is connected with the correct polarity voltage.

34.9 Interference to analog and digital signals

34.9.1 Connection or disconnection of secondary device

When a secondary device is connected to the network or disconnected from the network, the transients on the medium shall be such that

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- the peak value is less than or equal to 160 uA (1 % of the span) analog signal current averaged over 10 ms,
- interference to digital signal shall comply with the requirements of 34.7.2.

34.9.2 Cyclic connection

When a low impedance is connected to the network or disconnected from the network, the transients on the medium shall be such that

- the peak value is less than or equal to 160 uA (1 % of the span) analog signal current averaged over 10 ms,
- interference to digital signal shall comply with the requirements of 34.7.2.

34.9.3 Output during silence

During silence the device output voltage, averaged over 1 s or more, shall contain less than 2,2 mV RMS of combined broadband and correlated noise in the extended frequency band as shown below in Figure 169. For devices capable of analog signaling, the requirement shall apply while it is adjusted to produce a constant analog output current.

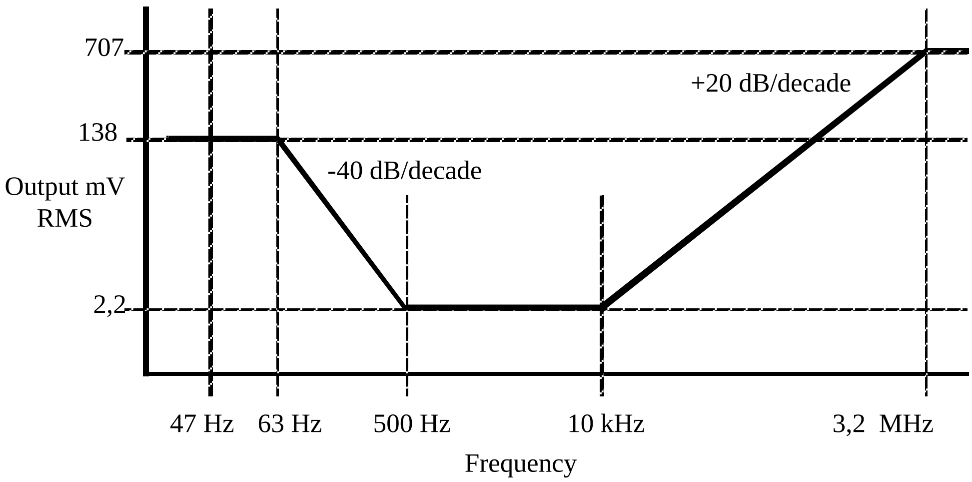

Figure 169 – Output during silence

NOTE The peak-to-peak sinusoidal noise is equal to 2,8 x RMS value. The peak-to-peak white noise is approximately equal to 6 x RMS value.

34.10 Non-communicating devices

34.10.1 Network power supply

The network power supply provides DC power to the network. If the supply is intended to be used with external fuses or external current limit resistances, the supply shall be tested with these external components. The network power supply requirements are stated in Table 180 and Figure 170.

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Table 180 – Network power supply characteristics

Parameter	Test condition	Limits
Ripple	47 Hz to 63 Hz at all rated loads	138 mV RMS max.
Ripple	94 Hz to 126 Hz at all rated loads	35 mV RMS max.
Noise	Extended frequency band at all rated loads	2,2 mV RMS max.
Noise	Outside of extended frequency band at all rated loads	See Figure 170
Impedance magnitude	Extended frequency band at all rated loads	10 Ω max.

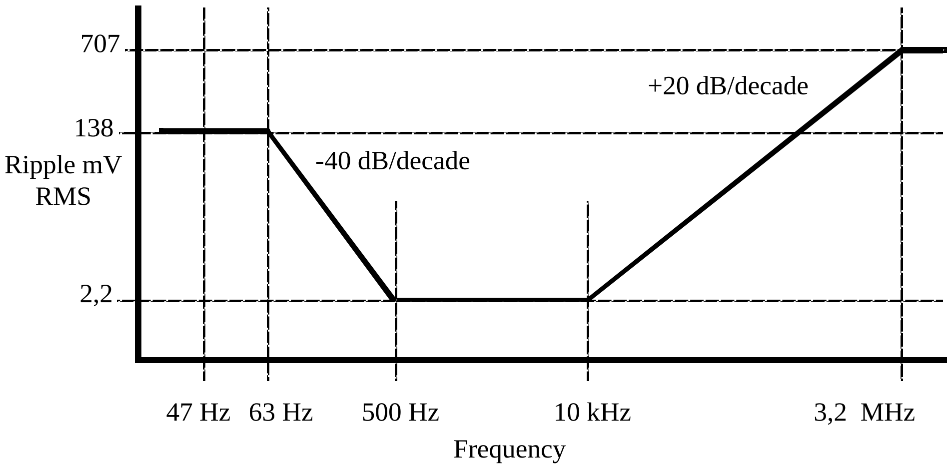

Figure 170 – Network power supply ripple

NOTE The peak-to-peak sinusoidal noise is equal to 2,8 x RMS value. The peak-to-peak white noise is approximately equal to 6 x RMS value.

For intrinsically safe applications, the network power supply voltage and barrier should be selected and operated such that an AC voltage of up to 1,4 volt peak-to-peak can be superimposed onto the DC at the hazardous (network) side of the barrier.

The connection of network power supply is shown in Figure T.28. The grounding and shielding recommendations are shown in Clause T.4.

34.10.2 Barrier

Barrier is characterized by its impedance, the attenuation and delay distortion of the digital signal as it passes through the barrier.

Intrinsic safety barrier output impedance shall be defined in terms of its frequency dependent characteristics when connected in the test circuits of Figure 171, Figure 172 and Figure 173. The real part of the measured impedance shall be between 230 Ω and 600 Ω. The imaginary part of the measured impedance shall be between (-350) Ω and 350 Ω. The test frequencies shall be:

- 200 Hz, 500 Hz, 950 Hz, 1,6 kHz, 2,5 kHz, 5,0 kHz and 10,0 kHz for the barriers specified to be used with the low impedance device.
- 500 Hz, 950 Hz, 1,6 kHz, 2,5 kHz, 5,0 kHz, 10,0 kHz, 20 kHz and 50 kHz for the barriers specified to be used with the high impedance device.

The attenuation and delay distortion of digital signal shall also be measured when connected in test circuits of Figure 171, Figure 172 and Figure 173. The requirements are summarized in Table 181.

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Table 181 – Barrier characteristics

Parameter	Test condition	Limits
Output voltage from hazardous side to safe side	Figure 171, test frequencies	185 mVpp min. 800 mVpp max.
Output voltage from hazardous side to safe side	Figure 172, test frequencies	135 mVpp min. 400 mVpp max.
Output voltage from safe side to hazardous side	Figure 173, test frequencies	270 mVpp min. 400 mVpp max.
Delay distortion	Digital frequency band	50 µs max.

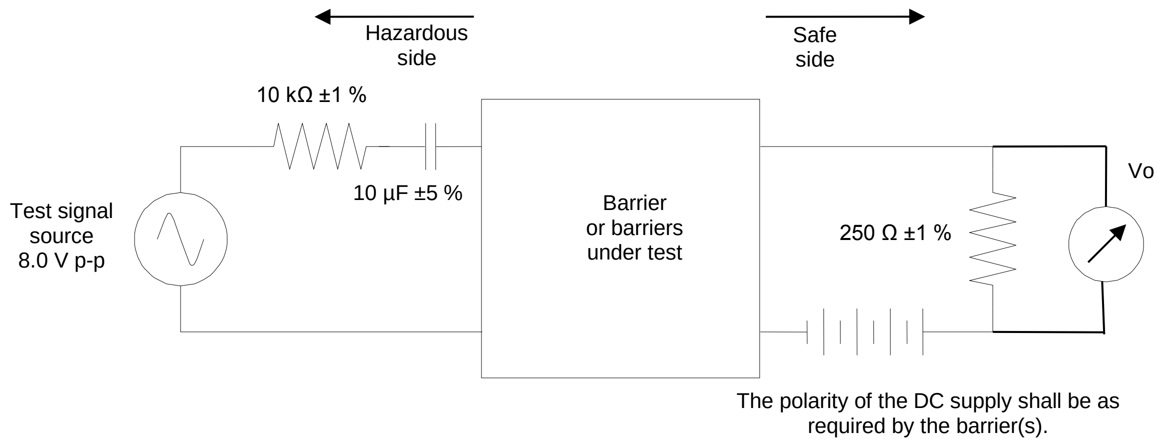

Figure 171 – Barrier test circuit A

For the test shown in Figure 171, the test signal source shall be set to 8,0 V peak to peak on the hazardous side and the output shall be measured across the 250 Ω ±1 % resistor on the safe side. The output voltage shall be between 185 mV and 800 mV peak-to-peak at the test frequencies.

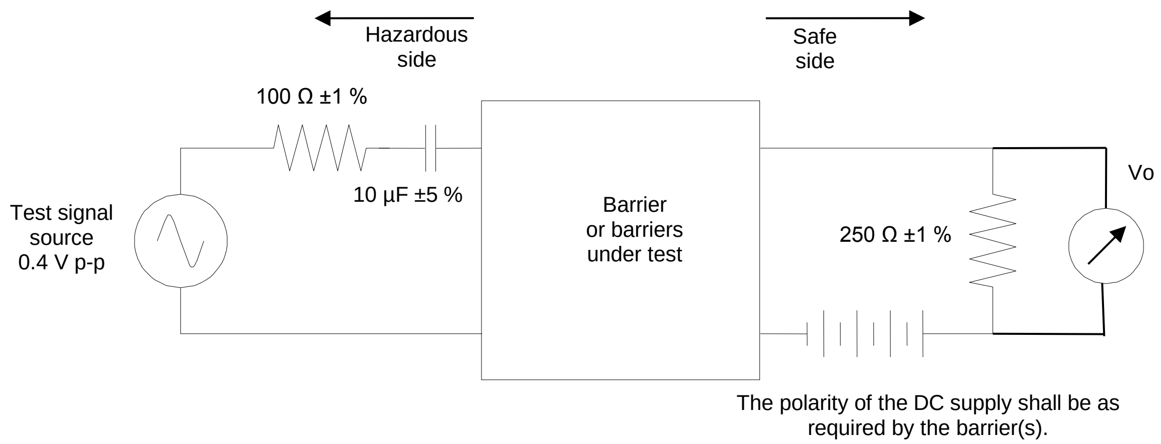

Figure 172 – Barrier test circuit B

For the test shown in Figure 172, the test signal source shall be set to 0,4 V peak-to-peak on the hazardous side and the output shall be measured across the 250 Ω ±1 % resistor on the

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safe side. The output voltage shall be between 135 mV and 400 mV peak-to-peak at the test frequencies.

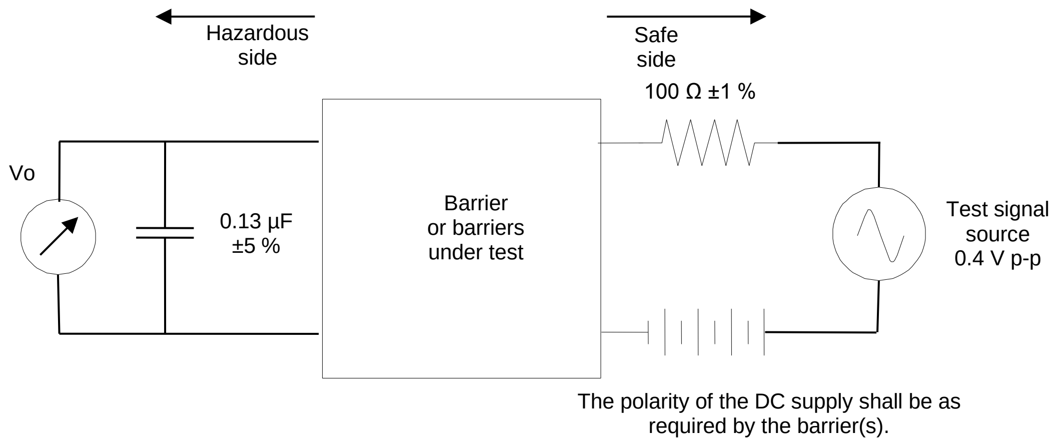

Figure 173 – Barrier test circuit C

For the test shown in Figure 173, the test signal source shall be set to 0,4 V peak-to-peak on the safe side and the output shall be measured across the 0,13 µF ±5 % capacitor on the hazardous side. The output voltage shall be between 270 mV and 400 mV peak-to-peak at the test frequencies.

The connection of network power supply and barriers is shown in Figure T.28.

34.10.3 Miscellaneous hardware

Miscellaneous hardware is connected in series with a field device or in parallel with field devices according to its function. Miscellaneous hardware shall not be connected in series with a network power supply such that it becomes a common element to two or more networks which share the same power supply. Miscellaneous hardware shall not be connected between the network and the ground. The requirements are summarized in Table 182. Some of the characteristics as shown in Table 183 are the recommended values, but not required for conformance to this standard.

NOTE 1 The recommended parameter limits are specified, so that the networks can be implemented using longer cable lengths.

Table 182 – Miscellaneous hardware required characteristics

Parameter	Test condition	Limits
Resistance to ground	Extended frequency band	100 kΩ min.
Impedance rate of change of series connected hardware	Extended frequency band	±5 Ω per ms max.
Impedance rate of change of parallel connected hardware	Extended frequency band	±5 kΩ per ms max.
Broadband or correlated noise or interference	Extended frequency band, 500 Ω load	2,2 mV RMS max. averaged over 1 s or more

NOTE 2 It is possible that a network accommodates more than one component of miscellaneous hardware provided that the electrical characteristics of the combined devices are within the limits given in Table 183.

The miscellaneous hardware shall be tested for impedance in the extended frequency band. Its resistance to the ground shall be at least 100 kΩ. If the hardware is intended to be

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connected in series with a field device, then its impedance should be less than or equal to 100 Ω and its impedance rate of change shall be less than or equal to ±5 Ω per ms. If the hardware is intended to be connected in parallel with field devices, then its impedance should be more than or equal to 10 kΩ and its impedance rate of change shall be less than or equal to ±5 kΩ per ms. The capacitance to the ground should be less than or equal to 1 000 pF. The broadband or correlated noise or interference shall be less than or equal to 2,2 mV RMS with 500 Ω load, when averaged over 1 s or more.

Table 183 – Miscellaneous hardware recommended characteristics

Parameter	Test condition	Limits
Capacitance to ground	Extended frequency band	1 000 pF max.
Impedance of series connected hardware	Extended frequency band	100 Ω max.
Impedance of parallel connected hardware	Extended frequency band	10 kΩ min.

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Annex A
(normative)

Type 1: Connector specification

A.1 Internal connector for wire medium

A fieldbus connector that is inside the enclosure of the fieldbus device and therefore requires no protection against the electromagnetic and physical environment shall be specified as an internal connector. An internal connector shall meet the following functional requirements:

a) distinctly marked to avoid conductors being interchanged;
b) positive locking with a minimum of 50 N extraction force locked;
c) field installation with hand tools shall be possible;
d) the fixed (device) side shall be 4,8 mm × 0,8 mm male tabs with hole as shown in Figure A.1, Table A.1, and specified in IEC 61210;
e) each conductor of the cable shall be terminated with a locking female connector with an insulating sleeve or housing;
f) the female connector with insulating sleeve or housing shall fit through a 9,5 mm diameter hole.

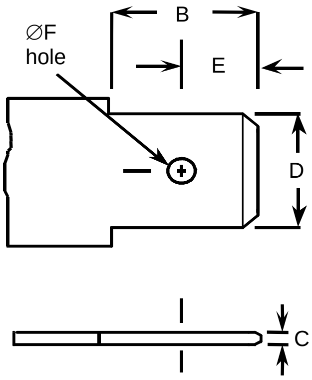

Figure A.1 – Internal fieldbus connector

Table A.1 – Internal connector dimensions

4,8 mm (0,187 in) Male tab				
	Millimetres		Inches	
	max.	min.	max.	min.
B	6,5	6,2	0,256	0,244
C	0,84	0,77	0,033	0,030
D	4,9	4,7	0,193	0,185
E	3,4	3,0	0,134	0,117
∅ F	1,5	1,3	0,060	0,050

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A.2 External connectors for wire medium

A fieldbus connector that is outside the enclosure of the fieldbus device and therefore requires protection against the electromagnetic and physical environment shall be specified as an external connector.

Two external connectors are specified in accordance with the environment of the installation.

A.2.1 External connector for harsh industrial environments

An external connector for harsh industrial environments shall meet the following functional requirements:

a) polarized to avoid conductors being interchanged, both mated and unmated;

b) available with sealing to IEC 60529: IP65 when mated or fitted with protective caps;

c) the free (cable) side shall be available with a cable clamp which secures the cable but does not subject the cable conductors to damaging stress;

d) the conductors shall be completely surrounded by a conductive shell which maintains the electrical continuity of the shield;

e) the conductive shell of the free (cable) side shall be covered by insulating material;

f) the conductive shell of the fixed (device) side shall be insulated from its mounting surface;

g) the fixed (device) side shall provide a connection to the shield, other than the shell;

h) the contacts shall accommodate wire sizes of 0,20 mm^2 to 0,64 mm^2;

i) provided with positive locking to prevent disconnection by cable strain;

j) provided with four pins (two signal pins and two power pins);

k) available with crimped conductors;

l) provided with male contacts on the fixed (device) side;

m) a cable connector with male pins shall be available for in-line connection;

n) dielectric strength from contacts to shell and from shell to ground shall be at least as high as specified under isolation for the appropriate MAU;

o) contacts shall be assigned to functions as shown in Table A.2 and Figure A.2;

p) connector dimensions (mating face) shall be as shown in Figure A.3, Figure A.4 and Figure A.5.

Table A.2 – Contact assignments for the external connector for harsh industrial environments

Contact No.	Function
A	DATA + with the option of power +
B	DATA – with the option of power –
C	Reserved for option of power +
D	Reserved for option of power –

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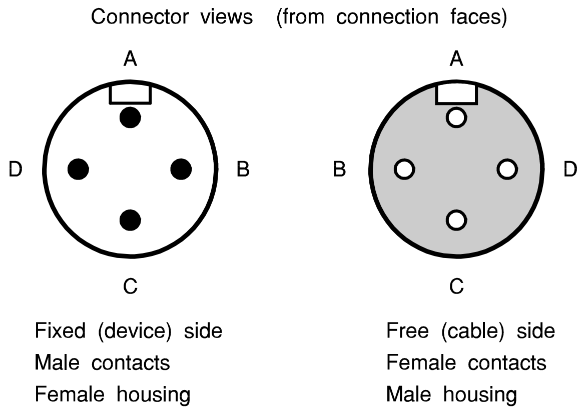

Figure A.2 – Contact designations for the external connector for harsh industrial environments

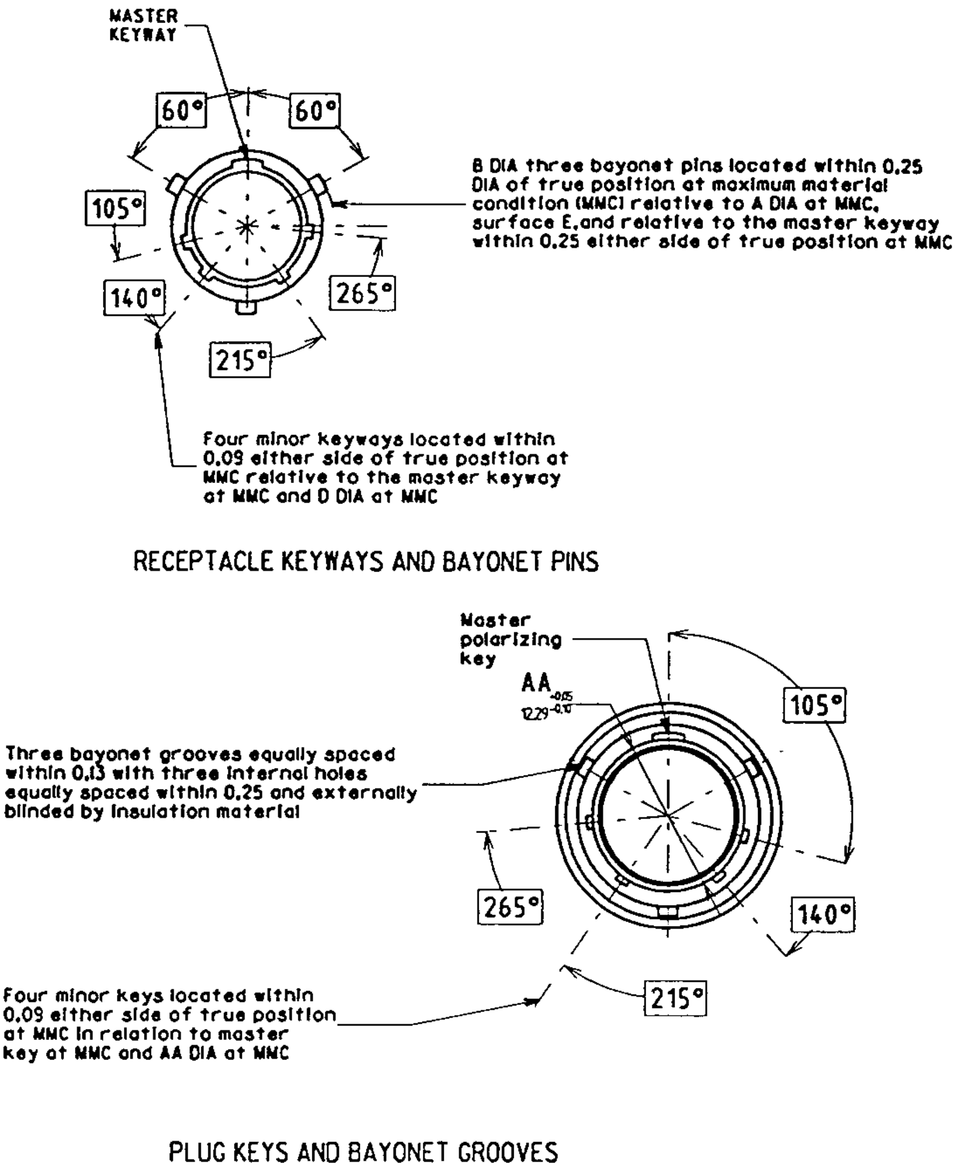

Figure A.3 – External fieldbus connector keyways, keys, and bayonet pins and grooves

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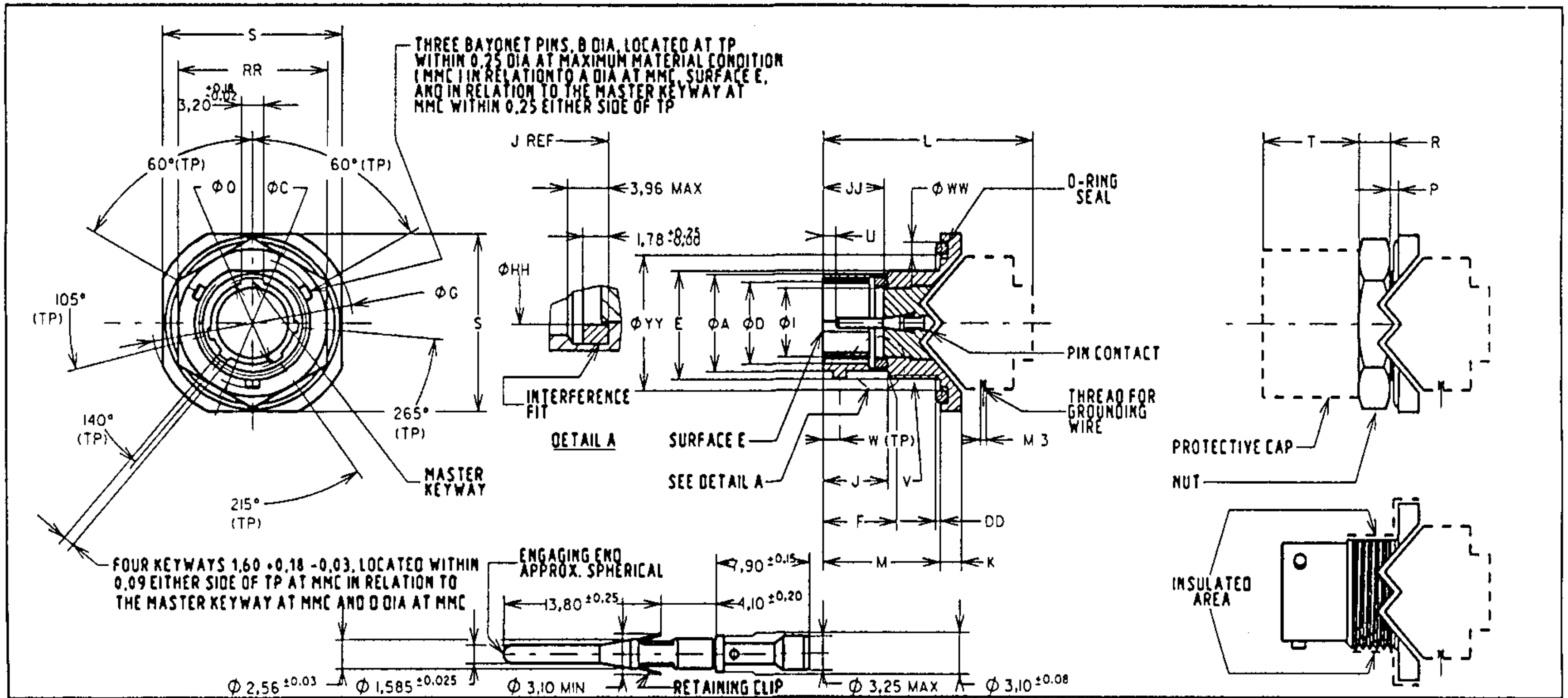


SIZE	ΦA	ΦB	ΦC	ΦD	E	F	ΦG	ΦI	J	JJ	K	L
	+0,03 -0,12 EXT. DIA.	+0,15 -0,05 BAY PIN	+0,00 -0,04 OVER BAY PINS	+0,13 -0,02 INT.DIA	+0,00 -0,25 MTG FLAT	MIN MTG THD LOC	+0,00 -0,82 ACROSS FLANGE COR	MAX INSERT	±0,25 PACK ING LOC	+0,00 -0,50 PIN INSERT LOC	± 0,51 THK MTG FLANGE	MAX OVER-ALL LENGTH
10	14,98	1,98	17,27	12,44	16,64	9,75	30,55	10,55	9,70	9,40	2,97	39,30

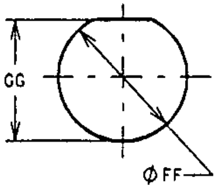
SIZE	M	P PANEL THK REF		ΦQ	R	RR	S	T	U	V	W	ΦWW	ΦYY
	+0,79 -0,00 MTG FLANGE LOC	MIN	MAX	+0,13 -0,15 OVER KEY-WAYS	+0,25 -1,79 NUT THK	±0,43 HEXAGON DIM	MAX LENGTH SIDE	MAX PROTEC-TIVE CAP LENGTH	+0,25 -0,51 PIN CONTACT LOC	CLASS 2A MOUNT-ING THREAD	(TP) BAY PIN LOC	±0,08 O-RING CROSS SECTION	± 0,15 O-RING SEAL INT.DIA.
10	17,55	1,57	3,17	13,71	4,52	22,22	27,38	15,30	2,16	11/16-24	2,54	1,78	20,35

NOTE 1 Dimensions are in millimetres

NOTE 2 True position (TP) tolerances

NOTE 3 Typical material: shell - aluminium alloy
bayonet pins (ΦB) - stainless, passivated
nut - glass filled thermoplastic

NOTE 4 Nut: thread size: 11/16 - 24 UNEF - 2B
Slot dimension shall provide sufficient clearance for mounting on applicable receptacle
Slots shall be 120° apart



PANEL MTG DIMS REF
REFERENCE DIMENSIONS

SIZE	DD	ΦHH			ΦFF	GG
	±0,28 O-RING PROTEC-TION	MAX INT.DIA. GASKET			+0,25 -0,13 PANEL MTG HOLE	+0,25 -0,13 PANEL FLAT LOC
10	0,58	11,60			17,71	16,89

Figure A.4 – External fieldbus connector intermateability dimensions

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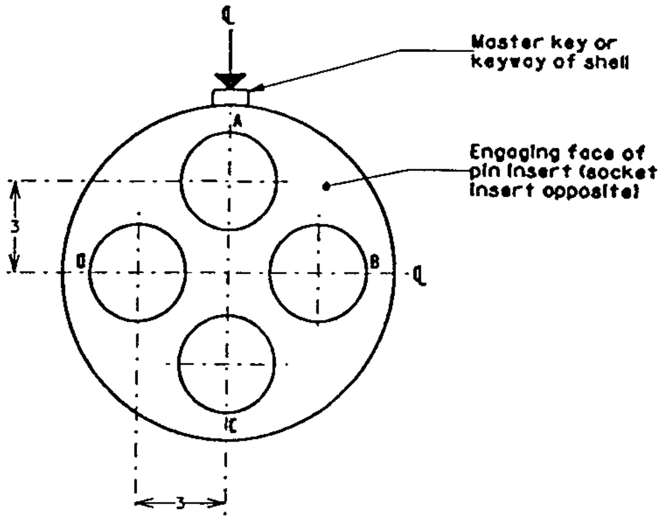

Shell size	Number of contacts	Size contacts
10	4	16

NOTE Dimensions are in millimetres.

Insert arrangement is shown in the normal position in the shell with the A cavity in front of the master key or keyway of the shell. Only this "normal position" shall be used.

Four keys or keyways (MMC) and insert shall be located within 0,09 mm either side of (TP) relative to master key or keyway (MMC) and shall be DD or ID (MMC).

Figure A.5 – External fieldbus connector contact arrangement

A.2.2 External connector for typical industrial environments

A connector for typical industrial environments shall meet the following functional requirements:

a) polarized to avoid conductors being interchanged, both mated and unmated;
b) completely surrounded by a conductive shell;
c) provided with male contacts on the fixed (device) side, and with female threaded stand-offs for screw type locking (4-40NC-2B thread);
d) provided with female contacts on the free (cable) side, and with locking screws (4-40 NC-2A thread);
e) provided with nine pins (two signal pins, two power pins, and five reserved pins);
f) contacts shall be assigned to functions as shown in Figure A.6 and Table A.3;
g) connector dimensions (mating face) shall be as shown in Figure A.7 and Figure A.8, Table A.4 and Table A.5, and specified in IEC 60807-3.

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Table A.3 – Contact assignments for the external connector for typical industrial environments

PIN number	Function
1	Reserved
2	Reserved
3	Reserved
4	Reserved
5	Reserved
6	DATA + with the option of power +
7	DATA – with the option of power –
8	Reserved for option of power +
9	Reserved for option of power –

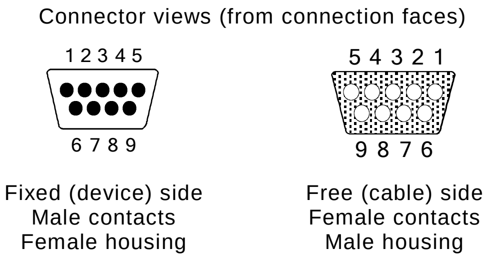

Figure A.6 – Contact designations for the external connector for typical industrial environments

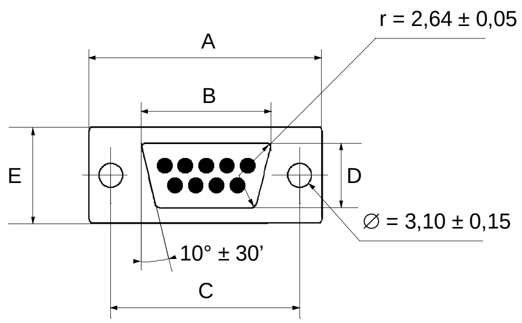

Figure A.7 – External fixed (device) side connector for typical industrial environments: dimensions

Table A.4 – Fixed (device) side connector dimensions

Fixed (device) side connector (male contacts, female housing)				
	Millimetres		Inches	
	max.	min.	max.	min.
A	31,19	30,43	1,23	1,20
B	17,04	16,79	0,67	0,66
C	25,12	24,87	0,99	0,98
D	8,48	8,23	0,33	0,32
E	12,93	12,17	0,51	0,48

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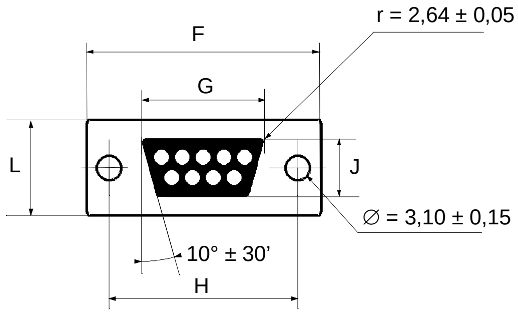

Figure A.8 – External free (cable) side connector for typical industrial environments: dimensions

Table A.5 – Free (cable) side connector dimensions

Free (cable) side connector (female contacts, male housing)				
	Millimetres		Inches	
	max.	min.	max.	min.
F	31,19	30,43	1,23	1,20
G	16,46	16,21	0,65	0,64
H	25,12	24,87	0,99	0,98
J	8,03	7,77	0,32	0,31
L	12,93	12,17	0,51	0,48

A.3 External connectors for optical medium

A fieldbus connector that is outside the enclosure of the fieldbus device and therefore requires protection against the electromagnetic and physical environment shall be specified as an external connector.

Two types of external connectors are specified in accordance with the environment of the installation.

A.3.1 External connector for typical industrial environments

A.3.1.1 External connector for typical industrial environments (1)

For the CPIC interface at the level of a fieldbus device, or an optical active star or an optical passive star, the connector used shall be compatible with the connector shown in Figure A.9 and Table A.6. (See IEC 61754-13.)

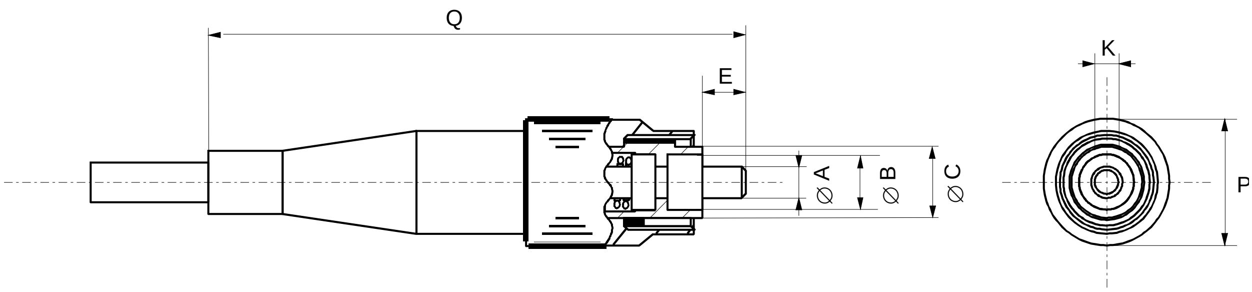

Figure A.9 – Optical connector for typical industrial environments (FC connector)

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Table A.6 – Connector dimensions

Reference	Millimetres	
	min.	max.
∅ A	2,498	2,500
∅ B	4,40	4,42
∅ C	5,95	6,00
E	3,75	4,05
K	1,85	2,14
P	–	10,5
Q	–	45

A.3.1.2 External connector for typical industrial environments (2)

For the CPIC interface at the level of a fieldbus device, or an optical active star or an optical passive star, the connector used shall be compatible with the connector shown in Figure A.10.

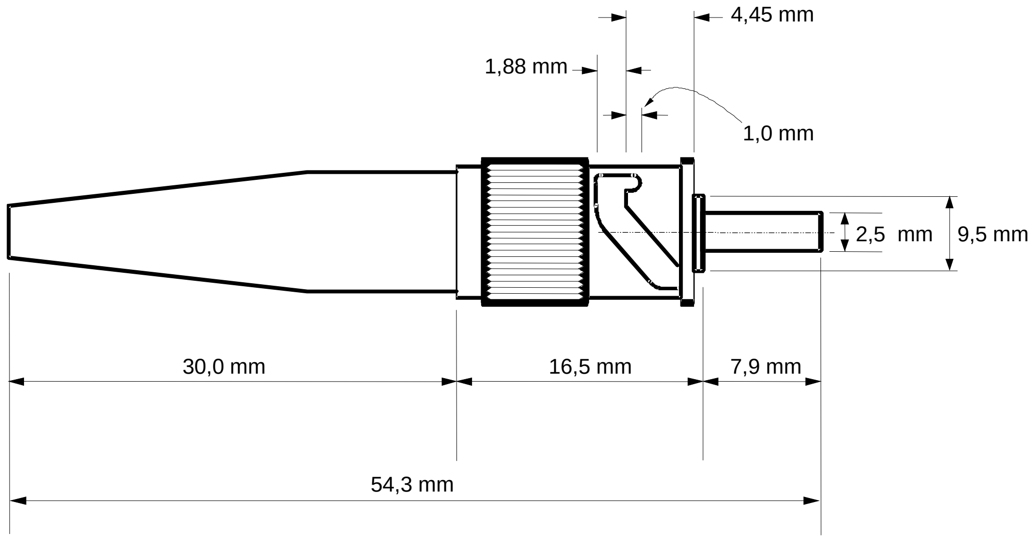

Figure A.10 – Optical connector for typical industrial environments (ST connector)

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Annex B
(informative)

Types 1 and 3: Cable specifications and trunk and spur lengths for the 31,25 kbit/s voltage-mode MAU

B.1 Cable description and specifications

The preferred fieldbus cable is specified in 12.8.2 for conformance testing, and it is referred to as type A fieldbus cable.

NOTE 1 This cable will probably be used in new installations.

Other types of cables can be used for fieldbus wiring, other than for conformance testing. The alternate preferred fieldbus cable is a multiple, twisted pair cable with an overall shield, hereinafter referred to as type B fieldbus cable.

NOTE 2 This cable will probably be used in both new and retrofit installations where multiple fieldbuses are run in the same area of the user's plant.

A less preferred fieldbus cable is a single or multiple, twisted pair cable without any shield, hereinafter referred to as type C fieldbus cable. The least preferred fieldbus cable is a multiple conductor cable without twisted pairs but with an overall shield, hereinafter referred to as type D fieldbus cable.

NOTE 3 Type C and type D cables will mainly be used in retrofit applications. They will have some limitations in fieldbus distance and S/N ratios that the type A and type B cables do not have. Therefore the use of type C and type D cables in certain applications is precluded.

Typical cable specifications at 25 °C are listed in Table B.1.

Table B.1 – Typical cable specifications

Parameter	Conditions	Type B	Type C	Type D
Impedance, Ω	f_r (31,25 kHz)	100 ± 30	Not specified	Not specified
Max. d.c. resistance, Ω/km	Per conductor	56	132	20
Max. attenuation, dB/km	1,25 f_r (39 kHz)	5,0	8,0	8,0
Nominal conductor cross-sectional area, mm^2 (wire size)		0,32	0,13	1,25
Max. capacitive unbalance, nF/km	≥30 m length	6	Not specified	Not specified

B.2 Typical trunk and spur lengths

Using the network configuration rules specified in 12.3.3, the maximum lengths for type B, type C and type D cables, including all spurs, typically will be:

- type B – 1 200 m;
- type C – 400 m;
- type D – 200 m.

NOTE These typical guidelines do not supersede the network configuration rules of 12.3.3.

Allowable spur lengths for either bus or tree topology are dependent on the number of communication elements on the fieldbus. Table B.2 relates the recommended number of communication elements to spur length. Maximum spur lengths are the same for type A,

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type B, type C, and type D cables. The table assumes one communication element per spur. When a spur with passive trunk coupler has more than one communication element, the length of that spur should be reduced by 30 m per communication element. As the recommended maximum total spur length is 120 m, the maximum number of communication elements per spur should be four.

Table B.2 – Recommended maximum spur lengths versus number of communication elements

Total number of communication elements	Recommended maximum spur length m
25 to 32	0
19 to 24	30
15 to 18	60
13 to 14	90
1 to 12	120

Spurs of length less than 1 m should be regarded as splices.

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Annex C
(informative)

Types 1 and 7: Optical passive stars

C.1 Definition

A passive device in which the signal from input optical fibers is distributed among a larger number of output optical fibers (input and output optical fibers may be the same).

a) Optical reflective passive star

A device whose purpose is to reflect optical power input at any output port (see Figure C.1). This device can only be used with a single fiber mode MAU.

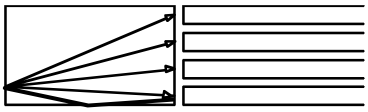

Figure C.1 – Example of an optical passive reflective star

b) Optical transmitive passive star

A device whose purpose is to divide optical power input at any output port (see Figure C.2). This device allows a broadcasting of information only over one direction. It can only be used with a dual fiber mode MAU.

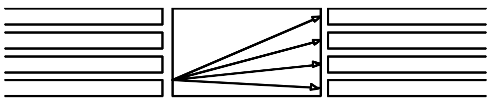

Figure C.2 – Example of an optical passive transmitive star

C.2 Example of attenuations

For a wavelength included between 700 nm and 900 nm, Table C.1 gives an example of minimal and maximal attenuations of optical passive star (these specifications are equally available for 62,5/125 fiber or 100/140 fiber).

Table C.1 – Optical passive star specification summary: example

700 nm ≤ λ_p ≤ 900 nm	Star 4/4	Star 8/8	Star 16/16	Star 32/32	Unit
Min. attenuation	–6,0	–9,0	–12,0	–16,0	dB
Max. attenuation	–9,0	–12,0	–16,0	–20,0	dB

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Annex D
(informative)

Types 1 and 7: Star topology

D.1 Examples of topology

Clause D.1 illustrates some of the network topologies that can be constructed in accordance with this standard. This does not imply that these are the only possible topologies.

The physical size of a network, both in geographic length and the number of desired fieldbus devices, will have a significant impact on the choice of network topology. When a limited number of fieldbus devices are required, almost any topology can be used. Figure D.1 illustrates a possible topology.

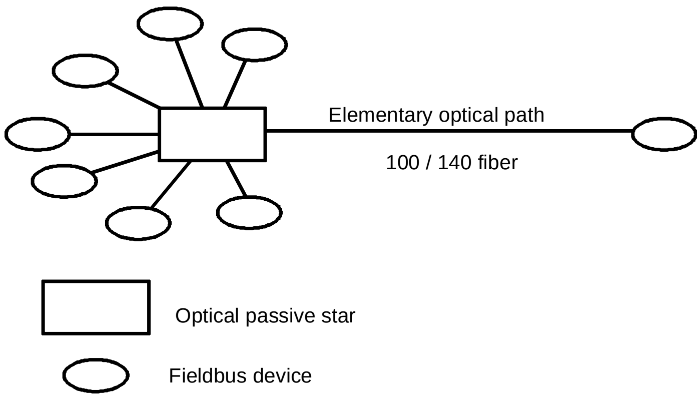

Figure D.1 – Example of star topology with 31,25 kbit/s, single fiber mode, optical MAU

For situations that require a large number of fieldbus devices located in widely separated geographic locations, a multi-star topology may be required. Topologies of this type may grow to very large numbers of communicating devices (see Figure D.2).

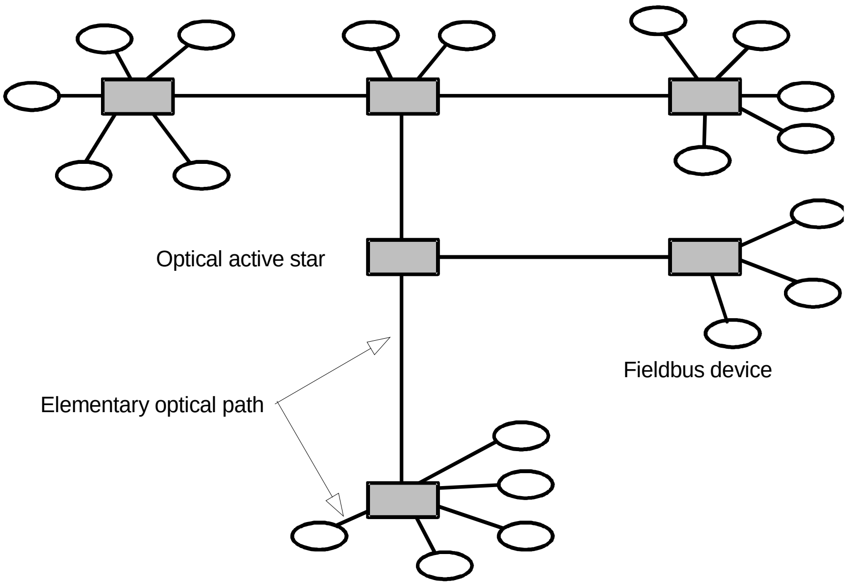

Figure D.2 – Multi-star topology with an optical MAU

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D.2 Optical power budget

An optical power budget allows anticipation of the distribution of different losses and attenuations of the optical signal along an optical link.

From the transmitter effective launch power levels and the receiver operating range, it is possible to establish the minimum and maximum length of the link.

Two cases are considered.

– Minimum power case: corresponds to the minimum transmitter effective launch power, maximum losses, maximum penalties and maximum margin system, and the lower limit of the receiver operating range. This case gives the maximum guaranteed length.
– Maximum power case: corresponds to the maximum transmitter effective launch power, minimum losses, minimum penalties and minimum margin system, and the upper limit of the receiver operating range. This case gives the minimum guaranteed length.

Two examples are given. The first corresponds to the topology shown in Figure D.1 and the second, to the topology given in Figure D.2.

D.2.1 Passive star topology (31,25 kbit/s, single fiber mode, optical MAU)

For this example the transmission between high sensitivity modems is considered. Table D.1 summarizes the passive star topology specifications.

Parameters that will be considered are the following:

– typical fiber 100/140 attenuation: 4,0 dB/km
– optical passive star 8/8 attenuation: 9,0 dBm to 12,0 dB
– effective launch power (100/140 μm fiber): –14,5 dBm to –12,5 dBm
– high sensitivity receiver operating range: –40,0 dBm to –20,0 dBm

Table D.1 – Passive star topology

Parameters	max.	min.	Units
Receiver operating range (high sensitivity)	–40,0	–20,0	dBm
Effective launch power	–14,5	–12,5	dBm
Dynamics for all losses and attenuations	25,5	7,5	dB
Margin system	3,0	0,0	dB
Losses due to two connectors	2,0	0,0	dB
Reflective optical passive star (8/8)	12,0	9,0	dB
Max. and min. attenuations due to fiber	8,5	–	dB
Length of fiber between modems (fiber attenuation: 4,0 dB/km)	2 125	0	m

D.2.2 Active star topology (optical MAU)

For this example, the transmission between low sensitivity modems is considered. Table D.2 summarizes the passive star topology specifications.

Parameters that will be considered are the following:

– typical fiber 62,5/125 attenuation: 3,0 dB/km
– transmitter (effective launch power): (–11,5 ± 1,5) dBm

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– low sensitivity receiver (receiver operating range): (–30,0 to –10,0) dBm.

Table D.2 – Active star topology

Parameters	max.	min.	Unit
Receiver operating range (high sensitivity) Transmitter effective launch power	–30,0 –13,0	–10,0 –10,0	dBm dBm
Dynamics for all losses and attenuations	17,0	0,0	dB
Margin system Losses due to two connectors Max. and min. attenuations due to fiber	3,0 2,0 12,0	0,0 0,0 0,0	dB dB dB
Length of fiber between modems (fiber attenuation 3,0 dB/km)	4 000	0	m

D.3 Mixed with wire media

The mixing of wire and optical media is achieved with an electro-optical converter. This element presents one or several wire medium accesses and one or several optical accesses. Each access, wire or optical, shall respect the transmit and receive circuit specifications.

This element regenerates the signal to their nominal optical power levels or electrical levels and to nominal timing characteristics (jitter, rise and fall times, slew rate, etc.).

Two examples are shown in Figure D.3 and Figure D.4.

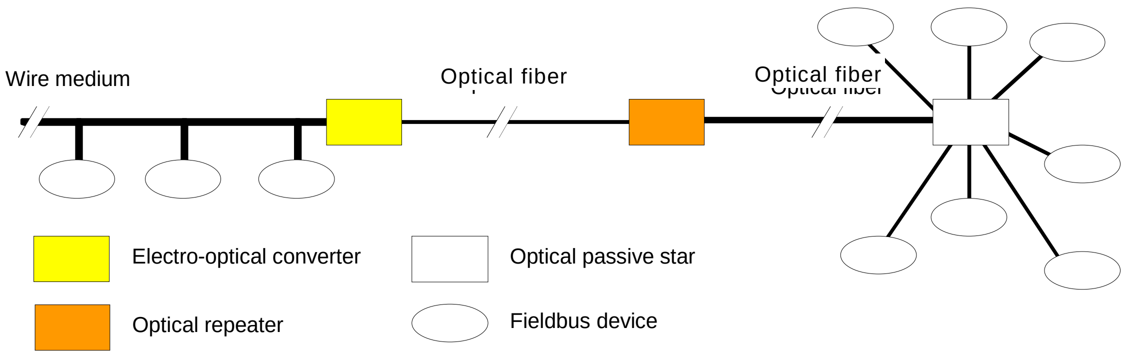

Figure D.3 – Example of mixture between wire and optical media for 31,25 kbit/s

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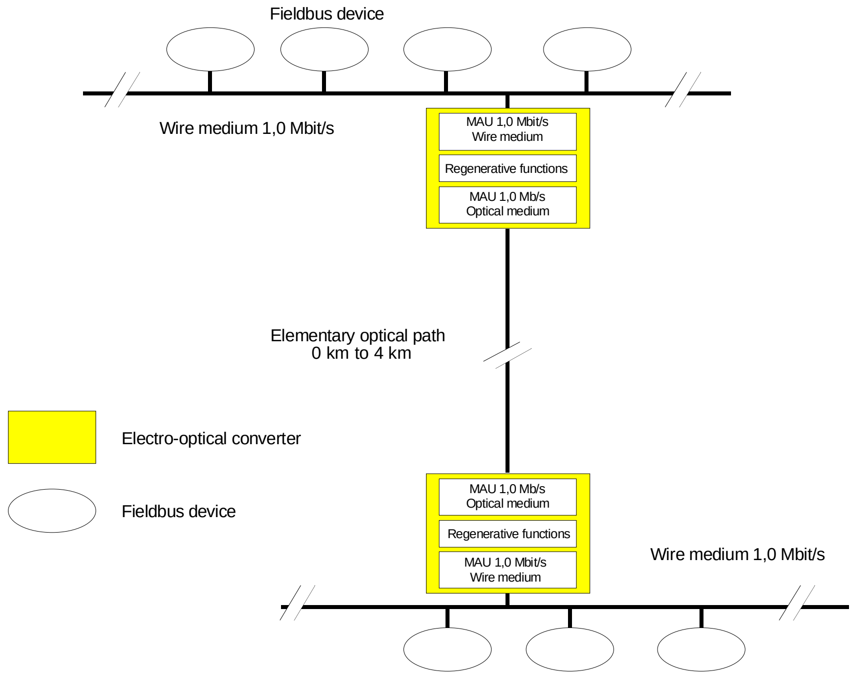

Figure D.4 – Example of mixture between wire and optical media

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Annex E
(informative)

Type 1: Alternate fibers

E.1 Alternate fibers for dual-fiber mode

It is possible to use other fibers than the fiber A1d specified as standard test fiber. Depending on the characteristics of these fibers, effective launch power levels differ. On the other hand, receiver operating ranges for low and high sensitivities are identical.

Table E.1 allows a comparison between these different fibers.

Table E.1 – Alternate fibers for dual-fiber mode

Parameters	Subclause	Specified fiber test standard	Specified alternate fiber	Specified alternate fiber
Fiber	15.7.2	A1b (62,5/125)	A1a (50/125)	A1d (100/140)
Effective launch power	15.4.2	(–11,5 ± 1,5) dBm	(–14,5 ± 1,5) dBm	(–7,5 ± 1,0) dBm
Receiver operating range low sensitivity	15.5.2	–30,0 dBm to –10,0 dBm	–30,0 dBm to –10,0 dBm	–30,0 dBm to –10,0 dBm
Receiver operating range high sensitivity	15.5.2	–40,0 dBm to –20,0 dBm	–40,0 dBm to –20,0 dBm	–40,0 dBm to –20,0 dBm

E.2 Alternate fibers for single-fiber mode

It is possible to use other fibers than the fiber A1d specified as standard test fiber. Depending on the characteristics of these fibers, effective launch power levels differ. On the other hand, receiver operating ranges for low and high sensitivities are identical.

Table E.2 allows a comparison between these different fibers.

Table E.2 – Alternate fibers for single-fiber mode

Parameters	Subclause	Specified fiber test standard	Specified alternate fiber	Specified alternate fiber
Fiber	16.7.2	A1d (100/140)	A1a (50/125)	A1b (62,5/125)
Effective launch power	16.4.2	(–13,5 ± 1,0) dBm	(–21,0 ± 1,0) dBm	(–17,5 ± 1,0) dBm
Receiver operating range low sensitivity	16.5.2	–30,0 dBm to –12,5 dBm	–30,0 dBm to –12,5 dBm	–30,0 dBm to –12,5 dBm
Receiver operating range high sensitivity	16.5.2	–40,0 dBm to –20,0 dBm	–40,0 dBm to –20,0 dBm	–40,0 dBm to –20,0 dBm

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Annex F
(normative)

Type 2: Connector specification

F.1 Connector for coaxial wire medium

Attachment to the coaxial medium shall be via BNC (see IEC 61169-8:2007, Annex A, 75 Ω variant) or TNC (see IEC 60169-17, 75 Ω variant) plug and jack connectors.

The TNC variant shall be sealed to IP67 minimum. Where sealing is required, the node shall also meet IP67 requirements.

NOTE It is possible to achieve sealing up to IP65 with the BNC.

The characteristic impedance shall be between 45 Ω and 80 Ω.

The center conductor contact shall be plated in conformance with one of the following specifications:

a) 0,75 μm gold minimum over 1,25 μm nickel minimum over base metal;
b) 0,05 μm to 0,2 μm gold flash over 1,25 μm palladium nickel minimum over 1,25 μm nickel minimum over base metal.

F.2 Connector for optical medium

F.2.1 General requirements

Connectors for optical medium shall meet the requirements specified in Table F.1.

Table F.1 – Connector requirements

Specification	Short range	Medium and long range
Connector Insertion Loss (nominal value)	1,5 dB	1,0 dB

F.2.2 Connector for short range optical medium

This variant shall use a two-part connector, composed of a pin connector (as specified in Figure F.1, and a crimp ring that crimps the cable to the pin connector (as specified in Figure F.2).

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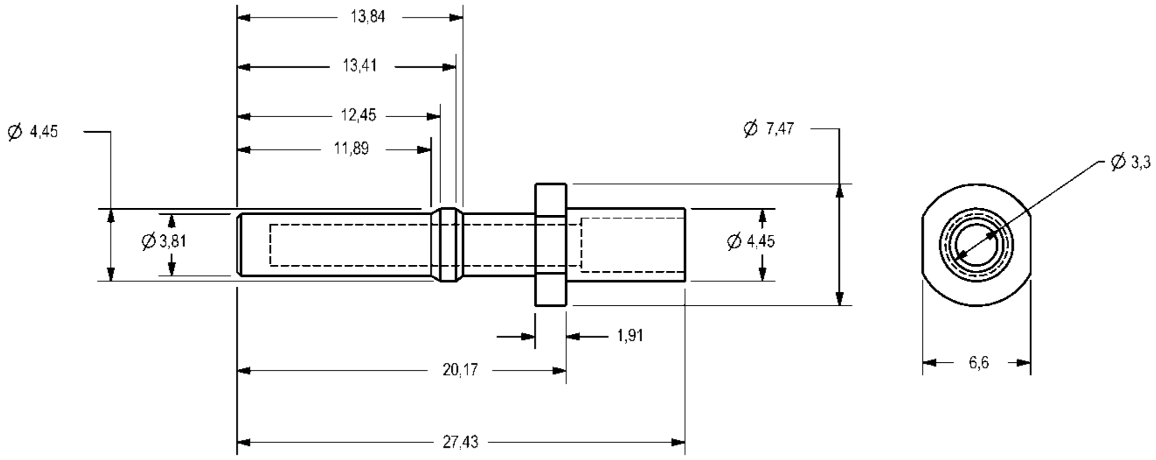
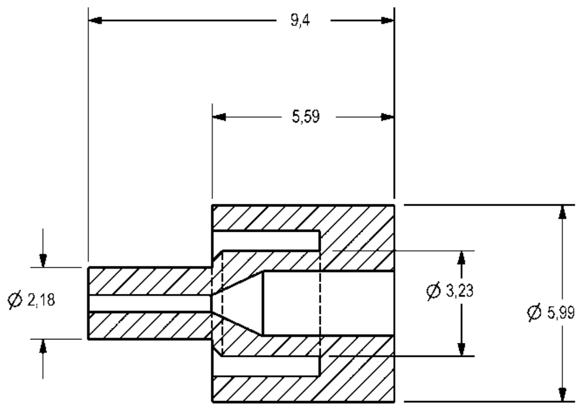


NOTE Dimensions are in mm.

Figure F.1 – Pin connector for short range optical medium



NOTE Dimensions are in mm.

Figure F.2 – Crimp ring for short range optical medium

F.2.3 Connector for medium and long range optical medium

These variants shall use an ST type connector, as specified in IEC 61754-2.

F.3 Connector for NAP medium

The connector used at both ends of a NAP connection shall be a shielded 8-pin RJ-45 type connector (see IEC 60603-7-4).

The NAP connector pins shall be as shown in Table F.2. This pin definition shall apply to both ends of the cable. The connector shall be installed on the cable to meet the requirements shown in Figure 90.

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Table F.2 – NAP connector pin definition

Pin number	Signal name
1	GND REF
2	N/C (no connection)
3	Tx_H
4	Tx_L
5	Rx_L
6	Rx_H
7	N/C (no connection)
8	GND REF

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Annex G
(normative)

Type 2: Repeater machine sublayers (RM, RRM) and redundant PhLs

G.1 General

A PhL repeater device (bus or ring) shall be used to increase trunk lengths and number of nodes by connecting full length and/or fully loaded sections of medium. Repeaters may also be used to connect between different PhL variants, for example between fiber and coaxial wire. In addition, a ring repeater device shall support media redundancy through the use of a ring topology.

Repeater devices shall conform to all applicable clauses concerning the MAU sublayer and the MDS-MAU interface. A PhL bus repeater device shall consist of two (or more) complete PhL interfaces (MDS/MAU, from the same or different variants) connected together by a Repeater Machine (RM) sublayer. A PhL ring repeater device shall consist of two or more complete PhL interfaces connected together by a Ring Repeater Machine (RRM) sublayer.

A PhL repeater (bus or ring) need not have a MAC ID. A PhL repeater device is not the source of network traffic and shall not support layers above the RM or RRM sublayers. Rather, it shall only be responsible for retransmitting network traffic from one segment to one or more other segments, and for the correct implementation of the RM or RRM sublayer.

Optionally, a node may include the RM or RRM sublayer functionality as part of that node's MAC sublayer to allow a network node to function as both a network node and a repeater between PhL variants. This type of node shall be considered a network node and shall have a MAC ID.

A node that supports multiple PhL variants and an RM sublayer shall function as both a node (that is the source of network traffic) with redundant PhL entities (see Clause G.3) and a PhL bus repeater device. A node that supports multiple PhL variants and a RRM sublayer shall function as both a node and a PhL ring repeater device.

G.2 Repeater machine (RM) sublayer

G.2.1 Requirements

Figure G.1 shows the reference model for a PhL bus repeater device.

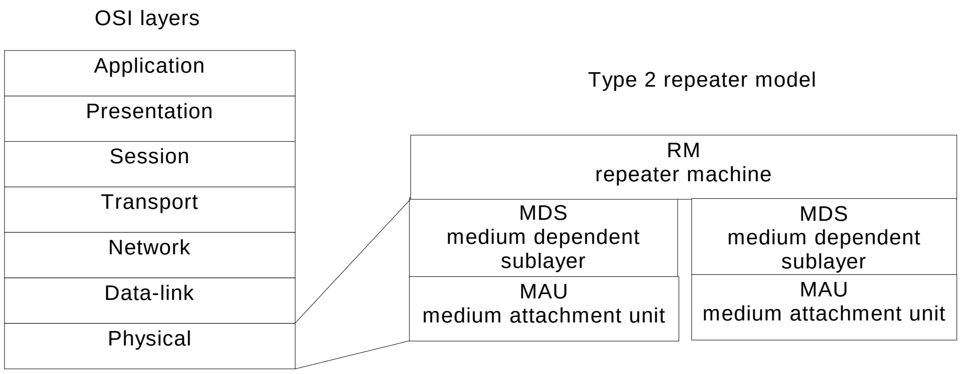

Figure G.1 – PhL repeater device reference model

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Each of the two (or more) PhL entities connected by the RM sublayer shall follow the specifications shown for a given PhL variant.

A RM sublayer shall be used as a connection between segments to form a link as shown in Figure 83. Any MAC ID used on one PhL variant that is connected to another PhL variant using the RM sublayer shall be unique as the two sides share a common link.

The RM sublayer shall be completely transparent to network traffic. All valid MAC symbols between the start and end delimiters (inclusive) that are received by one PhL entity in the RM shall be passed unaltered to all of the others for transmission. The preamble shall be regenerated by the RM sublayer to correct any discrepancies introduced by the MDS or MAU. Preamble regeneration shall recreate the original preamble of 16 consecutive {1} M_symbols and may introduce up to an additional 4 consecutive {1} M_symbols. Following the retransmission of the end delimiter, the RM sublayer may introduce up to 4 additional consecutive M_symbols of any value.

The RM shall be a half-duplex sublayer. Only one PhL entity connected to the RM shall receive data at any one time while all the other PhL entities are retransmitting the received data.

The RM sublayer shall not be the cause of collisions on any medium. At any point in time, only one PhL entity shall be selected for reception while all others shall be selected for transmission. The PhL entity that is selected for reception shall be based on the state of the PLS_CARRIER_INDICATION from the PhL entity that indicates PLS_CARRIER_INDICATION (true) first. All other PhL entities connected to the RM sublayer shall be set for transmission while the PhL entity is receiving PLS_CARRIER_INDICATION (true) and PLS_FRAME_INDICATION (true). While that PhL entity is selected for reception, any PLS_CARRIER_INDICATION (true) from other PhL entities shall be ignored. A new PhL entity shall be selected for reception after the completion of the previous frame (PLS_FRAME_INDICATION = false).

The RM sublayer shall be designed to minimize the length of time delay that is added to the PLS_DATA_INDICATION retransmission. The RM sublayer time delay shall be defined as the time delay from the end of the received start delimiter to the end of the retransmitted start delimiter as measured at the MDS-MAU interface. Any delay added by the RM sublayer shall be included in the calculation of slot time used by the MAC sublayer. The total amount of delay that is added by the RM sublayer shall be made available for use by network configuration tools and users.

NOTE Any delay in the RM sublayer reduces the total amount of medium that can be supported and reduces the efficiency of the network by increasing the slot time required by the DLL protocol (see IEC 61158-4-2).

The RM sublayer shall be designed to reconstruct the data as transmitted from the originating node. This requirement shall allow an unlimited number of repeaters to be cascaded (in series) with no distortion being added to the original data by the repeaters. The only limit to the total number of RM sublayers that can be cascaded shall be the ability of the slot time to be adjusted to compensate for the total amount of delay on the medium. The maximum slot time is defined in the DLL protocol (see IEC 61158-4-2).

G.2.2 RM sublayer state machine (informative)

NOTE Subclause G.2.2 describes an example implementation. There are no normative requirements.

The RM sublayer consists of two interconnected state machines. The first machine dictates which channel is receiving while all other channels are transmitting. The second state machine controls when the transmitting channel transmits data.

The first state machine consists of one state per channel to be arbitrated. When the second machine is in its idle state and a PLS_CARRIER_INDICATION arrives on any channel, this state machine moves to the state corresponding to the indication. If the second machine is in any state other than idle, this machine is locked and does not move, independent of

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PLS_CARRIER_INDICATION. The simultaneous first arrivals of two or more PLS_CARRIER_INDICATIONS is not a normal operating condition of the PhL and this machine's state transitions are unspecified.

The second state machine consists of 4 states: RM_IDLE, RM_CARRIER, RM_FRAME, RM_WAIT. If the node MAC sublayer is transmitting data, the RM should be forced to RM_WAIT:

– RM_Idle indicates that no activity is present on any channel. Other states move to RM_Idle when pls_carrier_indication is false for every channel. The presence of pls_carrier_indication on any channel causes the machine to move to the state RM_Carrier. While in RM_Idle, the pls_frame_request on all channels is false. The simultaneous first arrivals of two or more pls_carrier_indication is not a normal operating condition of the network and this machine should transition to RM_Wait;
– RM_Carrier indicates receive activity, but the MDS sublayer has not yet achieved lock (pls_lock_indication = false). This state should activate pls_frame_request on all channel's except the one indicated by the first machine as being the receive channel. The pls_data_request is preamble. If preamble regeneration is not used, this state serves as a placeholder to lock the first machine from transitioning. The presence of pls_lock_indication on the channel selected by the first machine causes the machine to move to the state RM_Frame;
– RM_Frame indicates the active repeating of data. This state activates pls_frame_request on all channels except the one indicated by the first machine as being the receive channel. It moves M_symbols from the receiving PhL entity to the transmitting channels, pls_data_indication => pls_data_request. At the point where the start delimiter of the repeated data is transmitted, it is required that at least 16 M_symbols of preamble have already been transmitted. The loss of pls_lock_indication on the channel selected by the first machine causes the machine to move to state RM_Wait;
– RM_Wait indicates the closing period of the repeated data. It holds off both state machines from moving to any other state to prevent repeating of echoes and end of packet noise. The machine remains in RM_Wait until pls_carrier_indication is false for all channels and the end of the blanking timer has occurred (see DLL protocol, IEC 61158-4-2). At that point, the machine moves to RM_Idle. While in RM_Wait, the pls_frame_request on all channels is false.

The PLS_FRAME_INDICATION of the receiving channel is not directly used by the repeater machines. Indirectly, the condition causing the end of frame should also force the receiver clock recovery to immediately unlock (PLS_LOCK_INDICATION = false) to eliminate repetition of noise after the end delimiter is repeated.

Failure to maintain PLS_LOCK_INDICATION or failure to detect a valid start delimiter probably indicates a corrupted data frame or a burst of noise on the medium. The RM should be designed to minimize the possibility of repeating a corrupted frame or noise.

G.3 Redundant PhL

Figure G.2 shows a reference model for a node that contains multiple MDS and MAU entities to achieve PhL redundancy.

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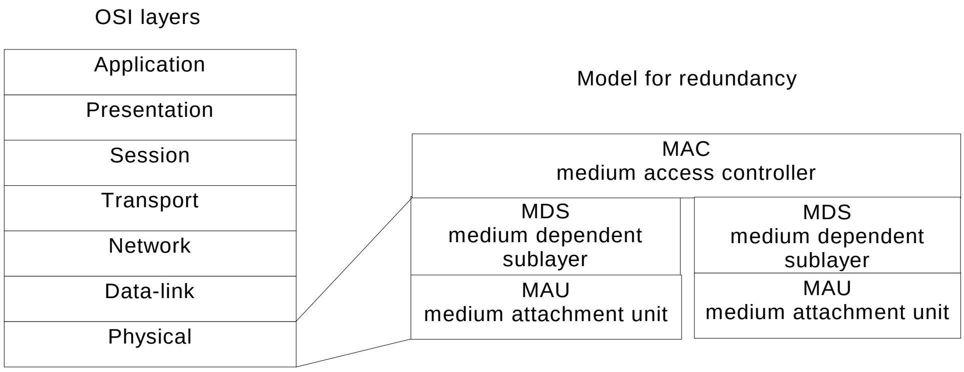

Figure G.2 – Reference model for redundancy

NOTE 1 The basic model is very similar to that used for the PhL Repeater devices specified in Clause G.2.

The redundant PhL entities ('channels') in a single node shall transmit the same information on all channels at all times. The PLS_FRAME_REQUEST and PLS_DATA_REQUEST shall be common to all redundant channels.

PLS_DATA_INDICATION, PLS_CARRIER_INDICATION, PLS_FRAME_INDICATION, PLS_LOCK_INDICATION and PLS_STATUS_INDICATION shall be independent for each channel. At any point in time, some nodes may listen to one channel while other nodes listen to the other channel. Since both channels are considered independent and identical, neither channel shall be considered to be primary or preferred even though they are generally referred to as channel A and channel B.

NOTE 2 The MAC sublayer on each node determines which channel to select for use by the upper layers of its node. This determination is made independently on each node.

As the same data is transmitted on both channels, the same data shall be received on both channels. If PLS_FRAME_INDICATION of a channel has not yet been true for a MAC frame when PLS_STATUS_INDICATION of the other channel signals Normal, an error shall be declared on the channel that did not detect the MAC frame. Because the smallest MAC frame has 64 Ph-symbols from the end of the start delimiter to the end of the end delimiter, the two channels shall be designed and installed such that the difference in MAC frame arrival times at the DLL is ≤ 64 Ph-symbol times.

NOTE 3 If one channel detects a Normal frame and the other channel does not, the DLL raises either DLL_EV_ERRA or DLL_EV_ERRB (see IEC 61158-4-2).

In the example of a node with redundant PhL entities and a NAP shown in Figure G.3, the MAC sublayer shall support the RM sublayer functionality to allow the data on the selected channel to be retransmitted onto the NAP port. At the same time, the data received on the NAP shall be transmitted onto both of the redundant channels. Any data sourced from this node shall be transmitted on both channels and the NAP at the same time.

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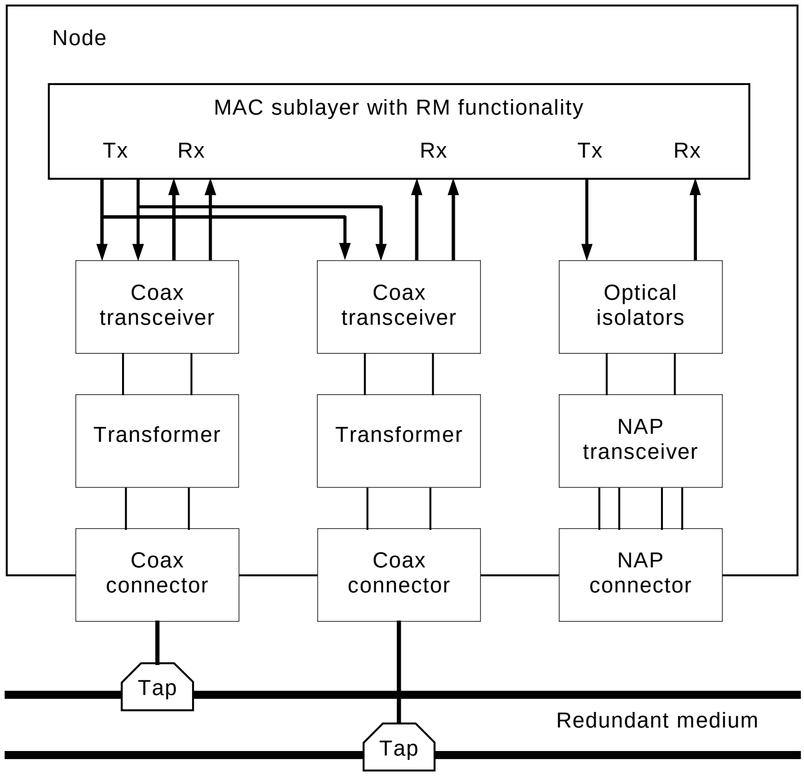

Figure G.3 – Block diagram showing redundant coaxial medium and NAP

G.4 Ring repeater machine (RRM) sublayer

G.4.1 Requirements

The minimum RRM shall be a three-port packet based switch (see Figure G.4). Port 1, the primary port, shall see a given data packet only once, and may be used as an interface to point to point network segments or to a node. The two secondary ports, port 2 and 3, shall be equal and shall participate in the ring. The RRM shall decide which port to repeat data packets from and shall prevent data packets from endlessly circling the ring.

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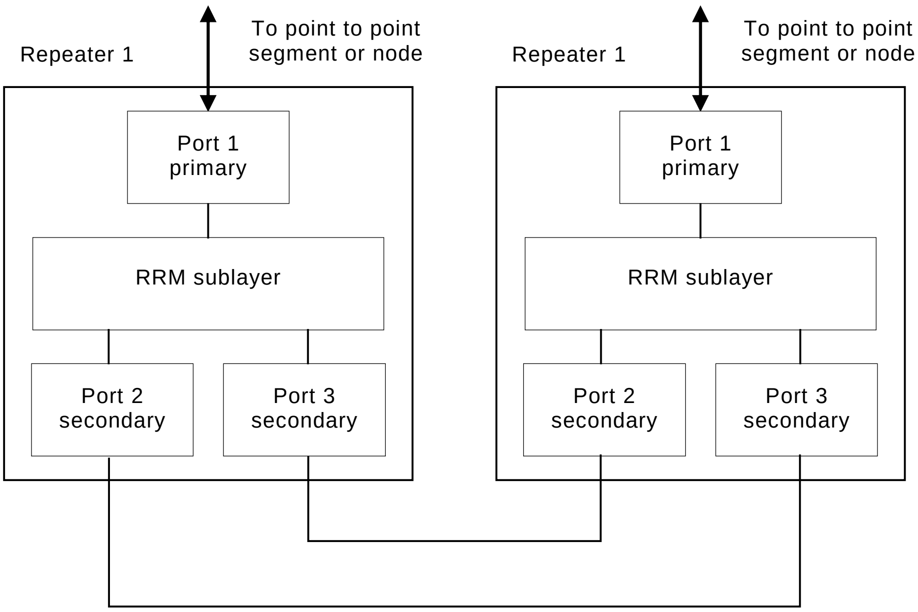

NOTE If one connection fails, the other may still be active.

Figure G.4 – Block diagram showing ring repeaters

G.4.2 RRM sublayer operation

G.4.2.1 RRM requirements

To support RRM operation, the ports in each ring repeater shall meet the following requirements:

a) The secondary ports in each repeater shall have the ability to send and receive data at the same time. Each secondary port shall be independent of the other port, and each secondary port shall also have the ability to operate in a duplex fashion with a separate receiver and transmitter for each port.

b) The RRM shall have the ability to detect the network slot time, either by deciphering the moderator packet or by monitoring network activity, or by some other means.

c) Each secondary port shall have its own fiber port stack counter, called `fps_portx`, where x is the port number.

RRM operation shall start in an idle state when there is no network activity and `fps_port2` and `fps_port3` are both zero.

G.4.2.2 Port segmentation

The segmentation process shall be used by the RRM to reset counters for the synchronization purpose. At power up ports 2 and 3 shall begin in segmentation mode. The ports shall return to segmentation mode any time that communication is lost between adjacent fiber connected repeater ports. A port in segmentation mode shall block all messages from the other ports within the same module/node. Further a port in segmentation mode shall not rebroadcast segmentation frames from other ports within the same module.

NOTE For example, a node will enter segmentation mode during power up, when a fiber cable is disconnected from one of the fiber ports, or when traffic stops for one second or more.

In addition, the RRM shall force segmentation mode at any time the RRM detects that the counters are out of sync with traffic. Counter synchronization/resynchronization can be performed by determining the correct NUT boundaries.

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A node shall enter segmentation mode based on the following conditions :

– upon power up,
– an echo of message is not received from an adjacent connected node,
– fiber link between two ports is quiet for more than one second, indicating no traffic (idle).

This method uses two special segmentation frames to acquire counter synchronization. The segmentations frames consist of M_symbols, as defined in 5.3.2. The segmentation frames are used for RRM handshaking during the segmentation process.

During segmentation, the affected port will broadcast as a query a preamble of 32 consecutive {1} M_symbols, as shown in Figure G.5. A port that is connected to a port broadcasting 32 consecutive {1} M_symbols that is in segmentation shall respond upon hearing this preamble with a (16 M_symbols preamble, start delimiter, 16 M_symbols preamble) sequence as shown in Figure G.6. A module transmitting preamble who is soliciting a response shall listen for a (preamble, start delimiter, preamble) sequence. Upon hearing a response it shall then reset the appropriate fps_portx counters, switch from port segmentation mode to port active mode. The port shall only be switched from segmentation mode to port active mode during a NUT boundary (quiet time). The segmentation process shall be used by the RRM to reset counters for the synchronization purpose. A port in segmentation mode and broadcasting queries shall continue until a response has been received back from a connected node. Upon receiving a response and during the NUT quiet time, the port may be put in service for transmission of data packets.

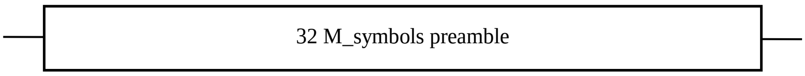

Figure G.5 – Segmentation query

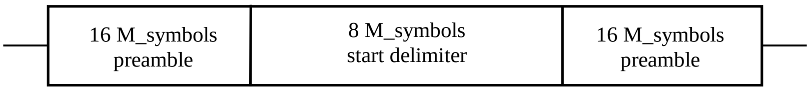

Figure G.6 – Segmentation response

G.4.2.3 Main operation

The port that sees network activity first shall define where the data shall be repeated to. If port 2 sees network activity first, data shall be repeated from port 2 to port 1 and port 3 (see details in G.4.2.4). Similarly, if port 1 sees network activity first, data shall be repeated from port 1 to port 2 and port 3 (see details in G.4.2.5). Port 2 and 3 are equal, so the behaviour of the RRM when port 2 sees activity first shall be identical to its behaviour when port 3 sees activity first.

For correct power up operation and to recover from a media failure, the RRM requires a timeout with no network activity equal to the slot time.

NOTE 1 It could be required that SMAX be set to one greater than the actual number of nodes on the network to get this timeout. This method will guarantee at least one quiet time per NUT. There is no problem with multiple quiet times per NUT.

NOTE 2 The RRM does not store parts of the frame to determine whether or not echoes are actually the same data packet that was sent transmitted. The order of data packets is guaranteed by the Type 2 DLL that specifies that nodes are transmitted sequentially. It is not possible for the order of the echoed frames to become garbled, unless a media or module malfunction occurs. At the instant of media malfunction a frame may be lost. However, the network will continue to function normally since the other message path still exists.

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NOTE 3 The maximum value of fps_portx can be calculated as follows. The shortest possible data packet length is 56 bits, or 11,2 µs. The minimum time between frames is the node turn around time of 11,2 µs. At a maximum distance between the repeaters of 22,5 km, no more than 10 data packets can be travelling between neighbouring modules.

The corresponding main switch state machine for RRM operation is shown in G.4.2.6.

G.4.2.4 RRM operation when port 2 (or port 3) is active first

In the case where port 2 is active first, the RRM operation shall be as follows.

Port 2 receives the data packet. Since fps_port2 is zero, the RRM shall repeat the data to port 1, port 2 and port 3 and shall increment fps_port3.

NOTE 1 The data is repeated out of the receive port, port 2, because the neighbouring RRM expects this to occur. This action generates an echo packet.

The RRM shall then wait for either:

1) Network activity on port 1.
   See G.4.2.5 for resulting behaviour.
2) New network activity on port 2.
   The RRM shall simply behave as it did previously.

NOTE 2 This requires that fps_port3 be allowed to be greater than one and less than 11, since the worst-case timeout will have occurred by the time fps_port3 reaches 11 (see case 4 below).

3) Reception of a data packet on port 3.
   This data packet should be the echo of the packet that was originally transmitted out of port 3 and is returned by the neighbouring module. Upon reception of this packet, fps_port3 shall be decremented and the RRM shall return to the original idle state. Reception of this data packet shall not cause the RRM to repeat the packet to ports 1 and 2.

NOTE 3 This is because the fps_port3 counter is non-zero, which indicates to the RRM that the received packet is an echo and is not a new data packet. Using this mechanism, the RRM prevents packets from endlessly circling the ring.

4) A timeout with no network activity equal to the slot time occurs.
   In this case, the neighbouring module has not returned the data packet transmitted out of port 3. This may have occurred due to a module malfunction or a media failure. If this occurs, fps_port2 and fps_port3 shall be reset to zero.

Port 2 and 3 are equal, so the behaviour of the RRM when port 3 sees activity first shall be identical to its behaviour when port 2 sees activity first (roles for port 2 and 3 shall be inverted in sequence above).

The corresponding state machine for port 2 (and 3) is shown in G.4.2.6.

G.4.2.5 RRM operation when port 1 is active first

In the case where port 1 is active first, the RRM operation shall be as follows.

Port 1 receives the data packet. The RMM shall repeat this packet by transmitting it out of port 2 and 3. When the port 2 and 3 transmit this data packet, they shall both increment their respective fps_portx counters.

The RRM shall then wait for either:

a) Network activity on port 1.
   The RRM shall simply behave as it did previously, namely transmitting the packet out of port 2 and port 3 and incrementing fps_port2 and fps_port3.

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b) Network activity on port 2 or port 3.
   Similar to case 3 in G.4.2.4: in this situation the next data packet that port 2 or port 3 receives should be an echo from a neighbouring module. Upon reception of this data packet, the port shall decrement its fps_portx counter. It shall not repeat this echoed packet.

c) A timeout with no network activity equal to the slot time occurs.
   Again, this means that echoes were not received (for whatever reason). In this case, `fps_port2` and `fps_port3` shall be reset to zero.

The corresponding state machine for port 1 is shown in G.4.2.6.

G.4.2.6 State machines

Figure G.7 shows the main switch state machine for RRM operation.

Figure G.7 – Main switch state machine

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Figure G.8 shows the RRM behaviour when port 1 is active first.

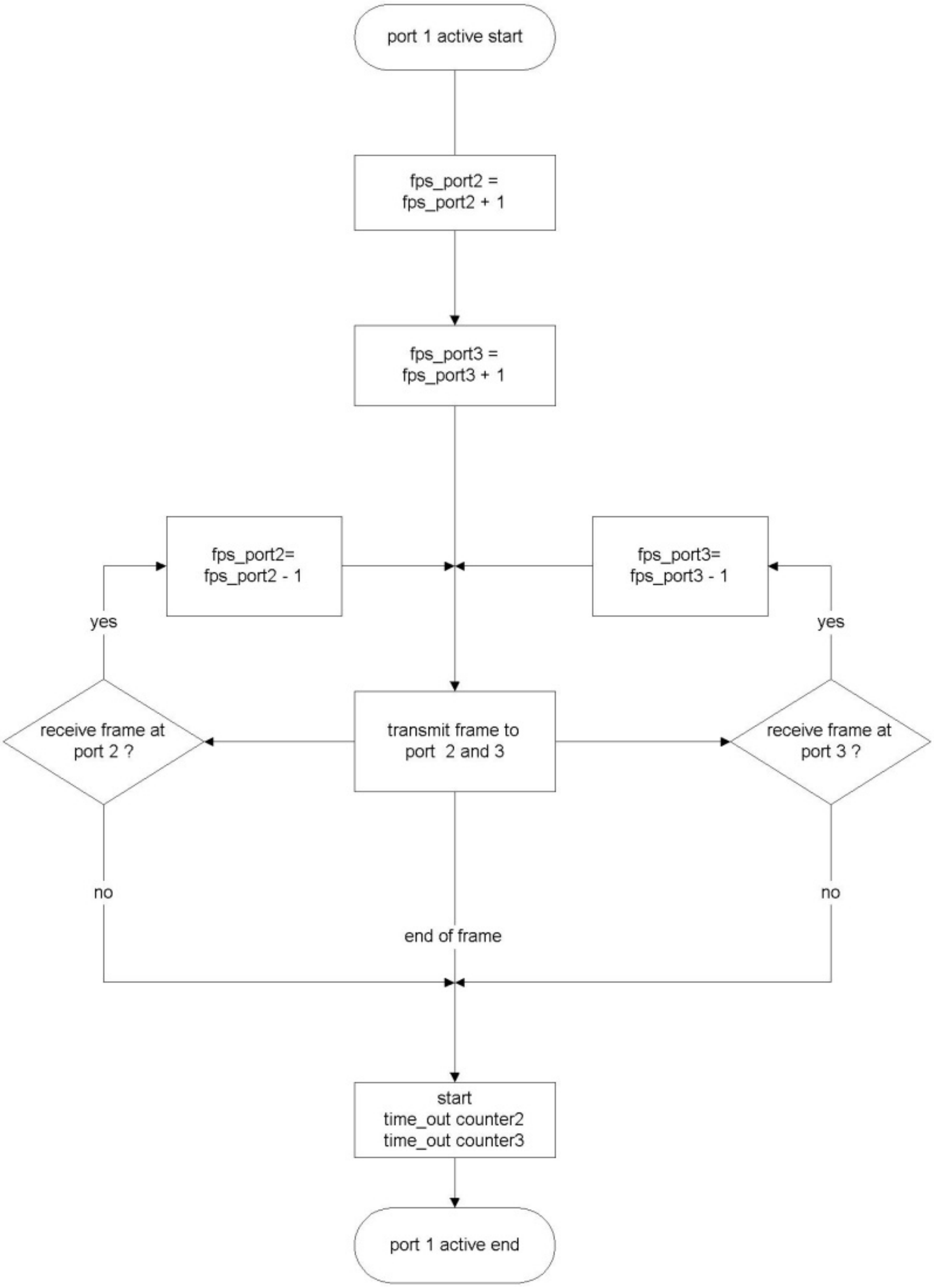

Figure G.8 – Port 1 sees network activity first

Figure G.5 shows the RRM behaviour when port 2 is active first. RRM behaviour when port 3 is active first shall be identical, with "2" and "3" being exchanged in Figure G.9.

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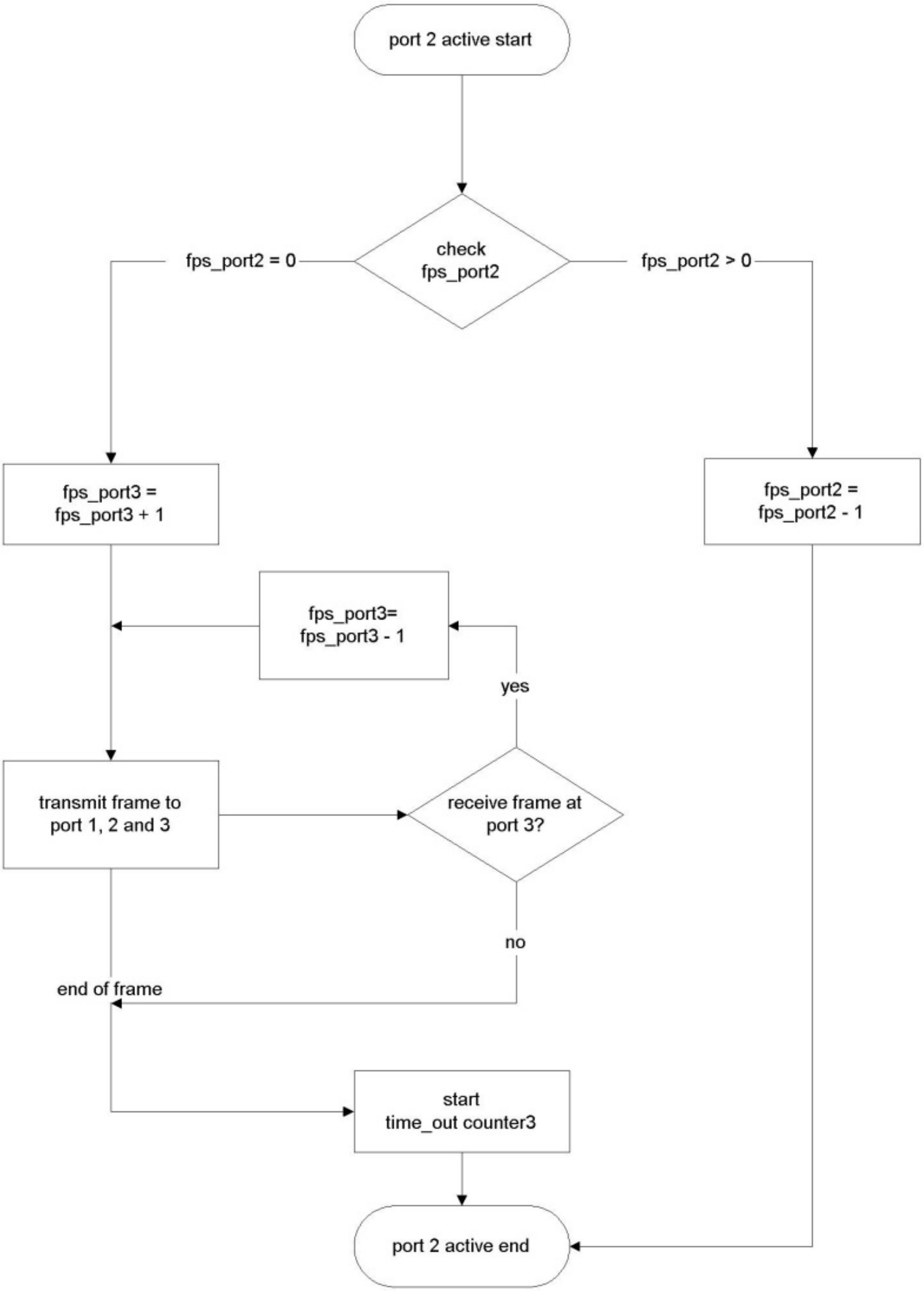

Figure G.9 – Port 2 sees network activity first

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Annex H
(informative)

Type 2: Reference design examples

H.1 MAU: 5 Mbit/s, voltage mode, coaxial wire

H.1.1 Transceiver reference design example

The transmitter, shown in Figure H.3 and Figure H.4 is made up of a CMOS pre-transmitter pair, transistor transmitter pair, and the transformer. The series Schottky diodes and over voltage diodes are discussed later in Clause H.1.

The pre-transmitter is a 74AC08. This device allows the combination of the data and enables signals and provides the base drive for the drive transistors.

The transistor driver uses a pair of MMBT2369 transistors. These are high-speed switches selected for important performance factors including the following

- collector current capability of at least 150 mA;
- fast switching characteristics typically better than 10 ns;
- small size SOT-23;
- low V_{ce} sat at I_c about 0,5 V;
- low output capacitance 4,0 pF nom.

The series base resistors define the required base drive and the shunt base resistors reduce turn off time. The base capacitors provide slew rate limiting that improves radiated emissions slightly.

The transformer (1:1:1) couples the transmit signal to the medium. Each side of the driver pair controls one side of the center tapped transformer, such that the driver operates in a push pull configuration. The voltage presented to each side of the driver is 4,2 V typical (at V_{cc} = 5 V) and 4,7 V maximum (at V_{cc} = 5,5 V). This corresponds to a peak driver output current (into 37,5 Ω) of about 110 mA typical and about 125 mA maximum. The total peak supply current including the base drive is about 140 mA.

The receiver circuitry is conceptually simple. The complexity arises in controlling the detection thresholds. Figure H.1 is a schematic reduced to include just the important components of the RXDATA detector.

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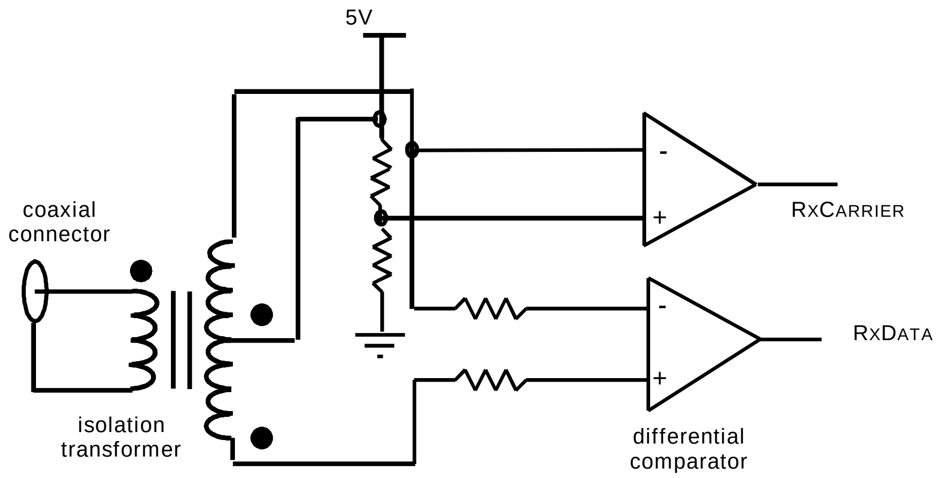

Figure H.1 – Coaxial wire MAU RxData detector

The detector example uses a 26LS32A (quad receiver) selected for high input impedance. Many devices of this class offer a minimum input impedance spec of 6 kΩ, whereas one supplier has a specification of 12 kΩ minimum. A special screening is required for this part, in the reference design, to allow an improved sensitivity over a smaller common-mode range. The important specifications for this device are the following:

a) high input impedance (this is required to meet the node input impedance requirements): 15 kΩ typical, 12 kΩ minimum;

b) low worst case threshold voltages: ± 100 mV over a common-mode range of 0 V to 5,5 V;

c) 0 °C to 85 °C temperature range;

d) single 5 V supply;

e) ±10 % supply tolerance;

f) fast enough to handle the Manchester encoded 5 Mbit/s bit rate.

For the Rx detector shown in Figure H.1 and in the schematic diagrams shown in Figure H.3 and Figure H.4, Table H.1 shows the input voltage levels for transition of RxData and RxCarrier.

Table H.1 – 5 Mbit/s, voltage-mode, coaxial wire receiver output definitions

Input voltage at medium	RxData	RxCarrier
V_{in}<–140 mV	false (0)	false(0)
–140 mV < V_{in}< 23 mV	undefined	false(0)
23 mV < V_{in}< 140 mV	undefined	undefined
140 mV < V_{in}< 255 mV	true(1)	undefined
255 mV < V_{in}	true(1)	true(1)

The series resistors on the input to the 26LS32A are different in value to counteract the threshold offset caused by the 26LS32A's fail-safe resistors.

Carrier detection uses another of the receivers in the 26LS32A. It performs a single ended comparison of the input signal to a DC threshold as shown in the simplified schematic of Figure H.2.

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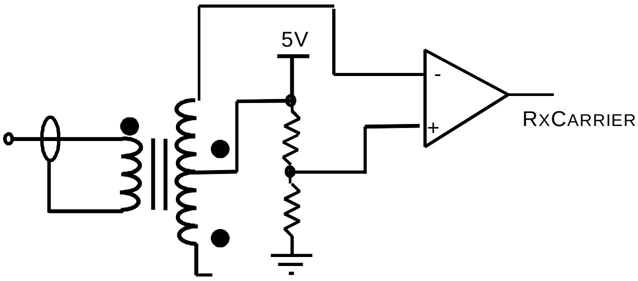

Figure H.2 – Coaxial wire MAU RxCarrier detection

The RxCarrier signal looks just like the RxData signal at high signals. At low signal levels it looks similar, except that the RxCarrier 'one' pulse widths are narrower than those of the data are. When no signal is present the RxCarrier output is always low, unlike the data, which is undefined and could be changing state with noise.

Figure H.3 shows an example of a redundant transceiver and Figure H.4 shows an example of a single channel transceiver.

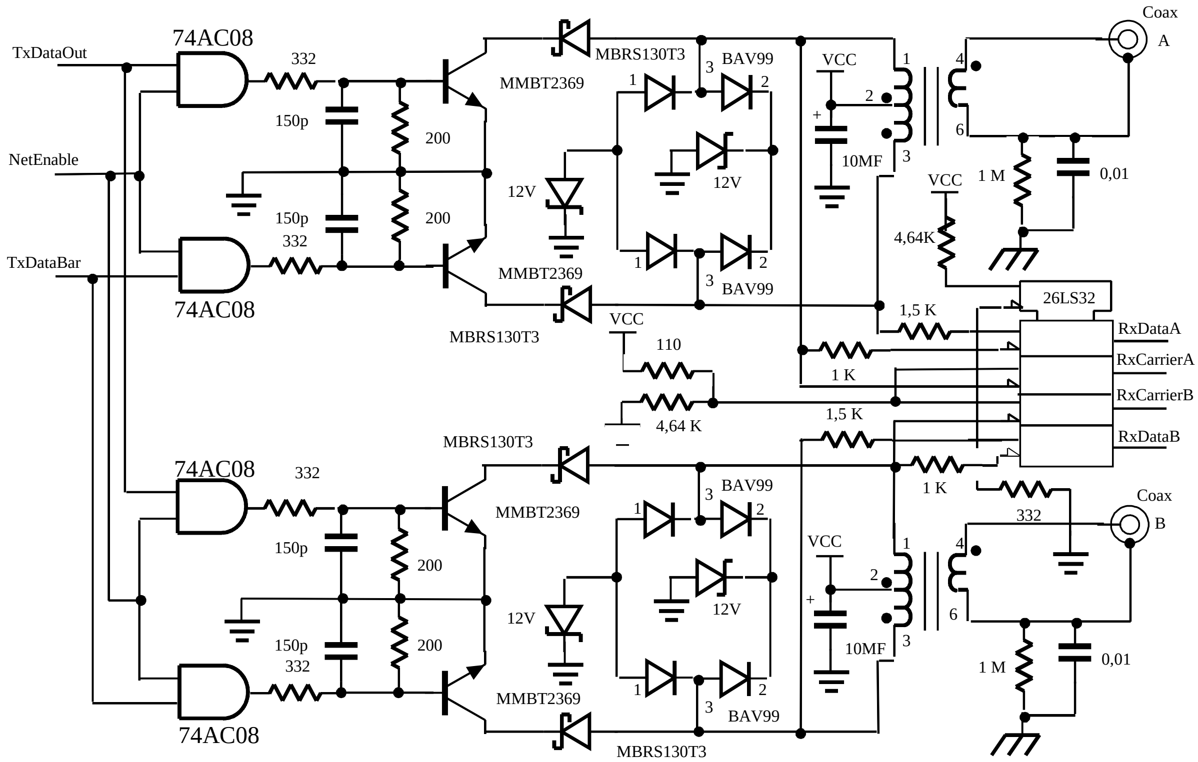

Figure H.3 – Redundant coaxial wire MAU transceiver

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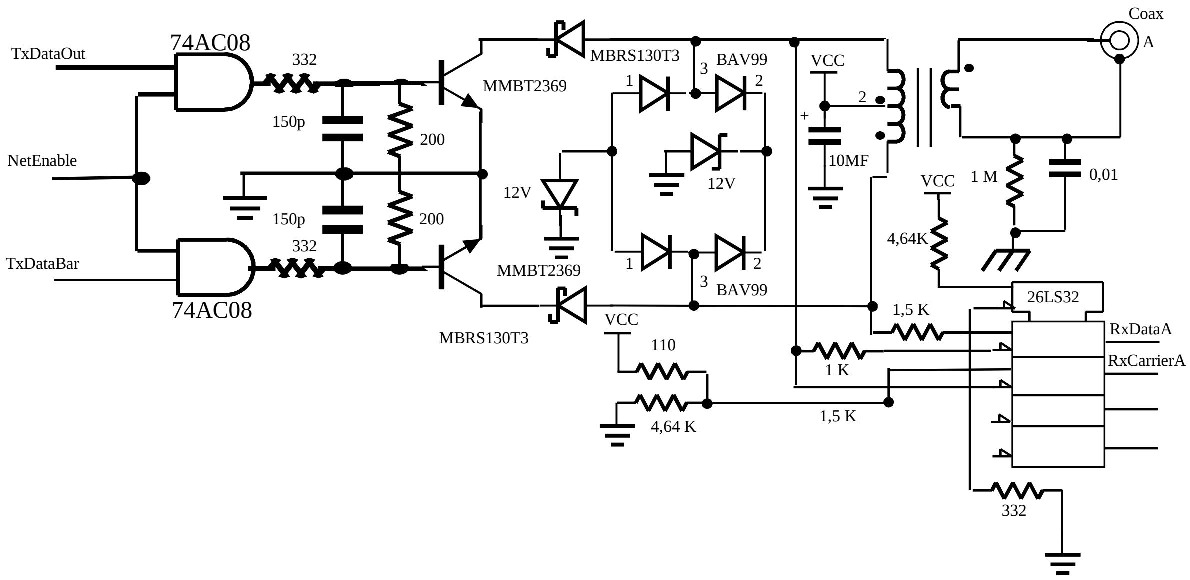

Figure H.4 – Single channel coaxial wire MAU transceiver

H.1.2 Transformer reference design example

Core is IEC 61596 type EP-7, ungapped, with minimum Al = 1 100 nH per turn^2. Construction sequence for the windings is as follows:

a) winding 1 between pins 3 and 2: diameter 0,127 mm, 18 turns;
b) 1 mil. tape;
c) winding 2 between pins 2 and 1: diameter 0,127 mm, 18 turns;
d) 1 mil. tape;
e) winding 3 between pins 4 and 6: diameter 0,127 mm, 18 turns;
f) outer wrap.

H.1.3 Tap reference design example

An example design of the Tap is shown in Figure H.5. The autotransformer (T1) is wound on a Ferronics 11-720B toroidal core. Winding is 18 turns bifilar, single strand, with minimum overlap of 0,254 mm diameter heavy poly-nylon magnet wire.

Measured electrical characteristics are as shown in Table H.2.

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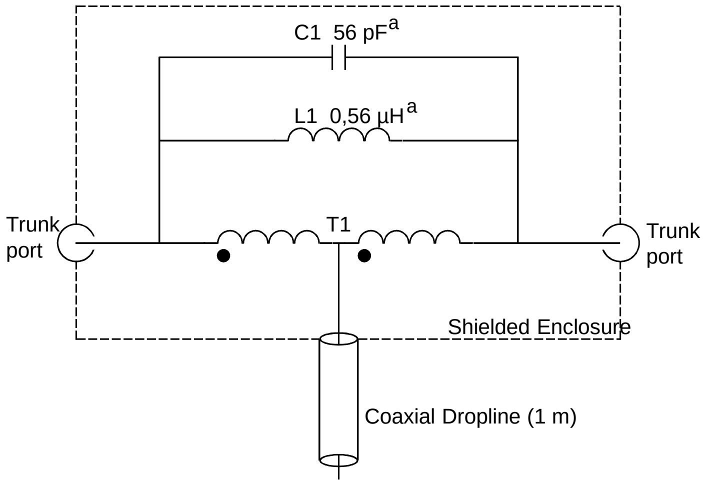
Table H.2 – Coaxial wire medium toroid specification

Parameter	Value
Leakage inductance	75 µH at 300 kHz
Magnetising inductance	890 µH at 300 kHz
Winding capacitance	20 pF at 25 MHz
Winding loss resistance	0,1 Ω at 300 kHz
Core loss resistance	16 kΩ at 1,3 MHz



[a] Values shown are nominal. The actual values should be adjusted to meet the scattering parameter requirements detailed in Figure 85.

Figure H.5 – Coaxial wire medium tap

H.2 Network access port (NAP)

The design of the node NAP circuitry shown in the schematic in Figure H.6 is relatively simple. A single transmitter and receiver are used. The receiver has an internal offset voltage added to produce a zero data state for the fault conditions (medium removed, short circuited, etc.) listed in the requirements shown in Table 103. The polarity of the receive signal is high for data zero. Differential RS-422 transmitters and receivers are used to improve noise rejection.

Back biased diodes are provided on the NAP transmitter lines to prevent damage due to electrostatic discharge.

For the fiber medium option, the NAP circuitry is the same. The coaxial wire medium transceivers are simply replaced by optical fiber transceivers.

The schematic for a non-isolated permanent node uses a transceiver similar to the one shown Figure H.6.

As in the node, a single transmitter / receiver is used for data. The same offset circuit is used to guarantee the correct disconnect and power off levels. In addition, the same transmitter protection diodes are used.

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For a transient node that derives its power from a grounded source, opto-isolators are used. The design shown in Figure H.7 shows how opto-isolators and a DC-DC converter can be used to supply the required ground isolation.

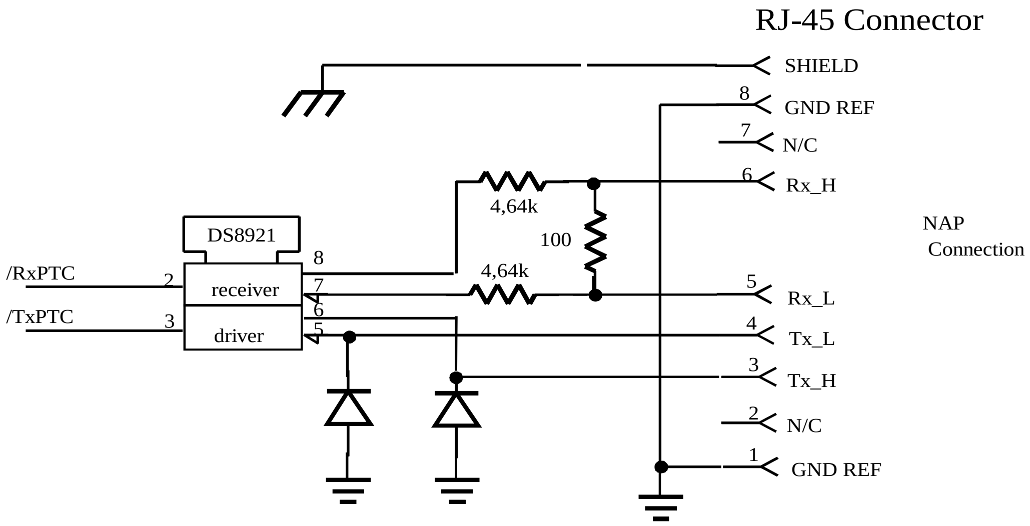

Figure H.6 – Non-isolated NAP transceiver

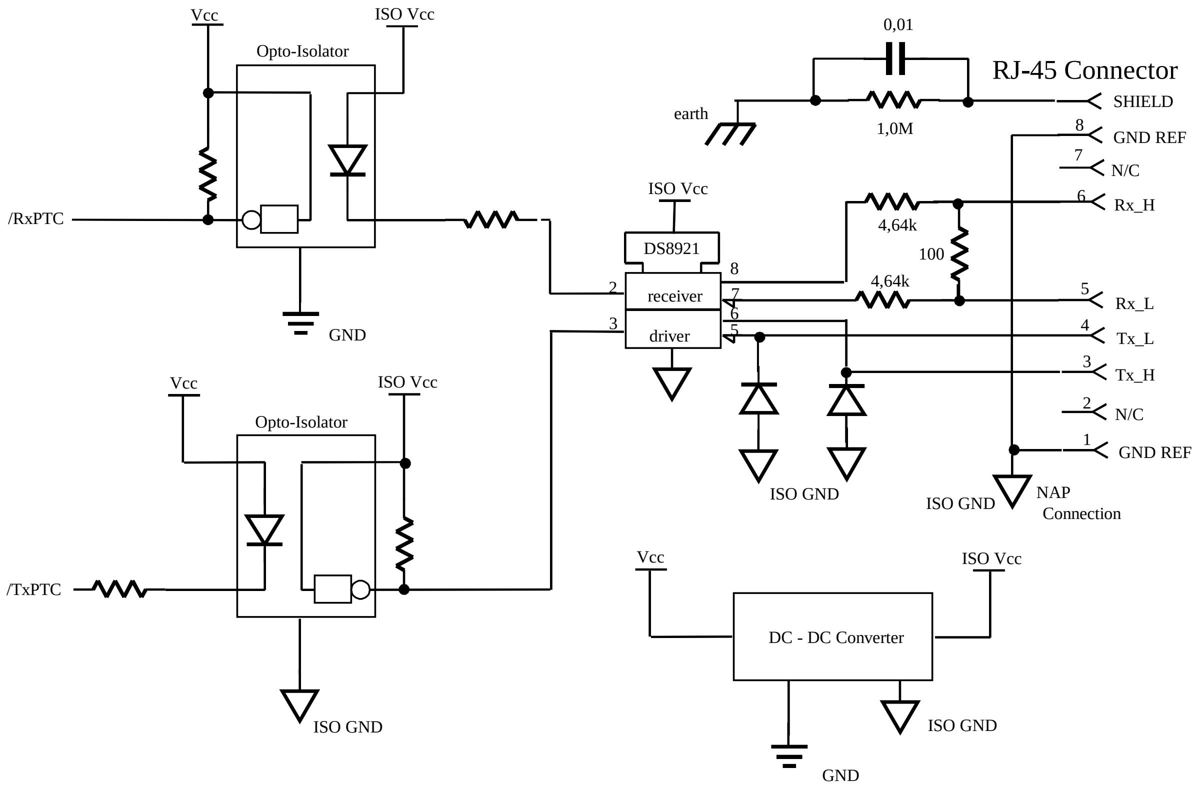

Figure H.7 – Isolated NAP transceiver

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Annex I
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Type 3: Connector specification

I.1 Connector for synchronous transmission

I.1.1 General

The topology can be in the form of a tree, line or a combination of the two. The tees connect the stations (e.g. field devices) to the bus cable; they shall have an IP 65 rating. The tee connect can be constructed in single T or multiple T, see Figure I.1. The tee function can also be integrated into the station.

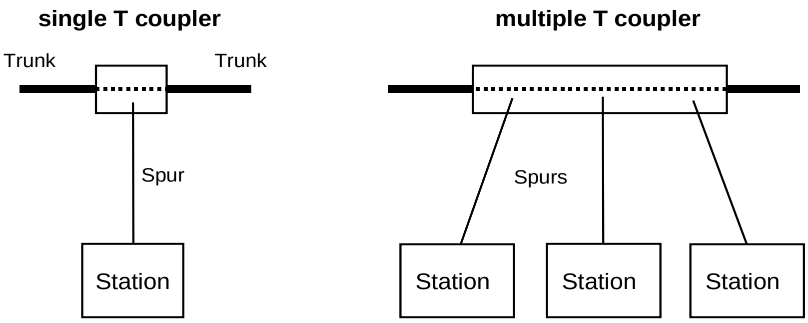

Figure I.1 – Schematic of the station coupler

I.1.2 Pin assignment of M12 circular connector

The contacts of the M12 circular connector shall be assigned to functions as shown in Table I.1 and Figure I.2.

Table I.1 – Contact assignments for the external connector for harsh industrial environments

Contact No.	Function
1	Data + with the option of power +
2	not connected
3	Data – with the option of power –
4	not connected
Thread	Shield

The shield shall be concentric around the thread. The shield potential shall be transmitted via the thread. Existing Type 3 devices with connected pin 4 are still conforming to this International Standard. For new devices the pin 4 shall not be used. Existing pre-harnessed Type 3 cables with connected pin 4 are still conform to this International Standard. For new cables the pin 4 shall not be connected.

The M12 circular connector and the female connector shall be IP 65 or higher.

The male and female contacts shall be designed such that they maintain their transmission properties even in a corrosive atmosphere, e.g. chemical environment.

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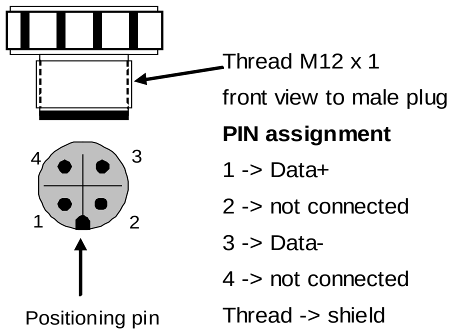
The centered hole of the female plug shall not be fitted because of the increased air and creepage distances in potentially explosive atmospheres, see Figure I.2.



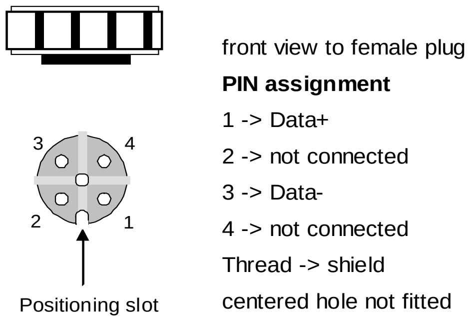


Figure I.2 – Pin assignment of the male and female connectors IEC 60947-5-2 (A coding)

I.1.3 Connection between a tee and a station

The tees and the stations are connected using a shielded circular connector M12. The tee can be connected directly to the station or a branch using a shielded M12 connector.

Always make sure that the bus cable shield is applied over a large surface according to the grounding guidelines (for grounding and shielding, see 21.8.6 and 21.8.7).

Field termination techniques such as screw or blade terminals and permanent termination may also be used.

I.2 Connector for asynchronous transmission

I.2.1 Connector for non-intrinsic safe asynchronous transmission

Each station is connected to the medium via a 9-pin sub-D connector. The female side of the connector is located in the station, while the male side is mounted to the bus cable.

The mechanical and electrical characteristics are specified in IEC 60807-3.

Preferably a metal connector housing should be used. When put together both parts of the connector should be fixed by conducting screws. The connection between the cable sections and the stations should be realized as T-connectors, containing three 9-pin sub-D connectors (two male connectors and one female connector). Such T-connectors allow disconnection or replacement of stations without cutting the cable and without interrupting operation (on line disconnection).

The pin assignments for the connectors are shown in Table I.2 and Figure I.3.

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Table I.2 – Contact designations

Pin number	RS-485 ref.	Signal name	Meaning
1		SHIELD (see notes 1, 2)	Shield, protective ground
2		M24V (see note 1)	Minus 24 V output voltage
3	**B/B'**	RxD/TxD-P	Receive/transmit-data-P
4		CNTR-P (see note 1)	Control-P
5	**C/C'**	DGND	Data ground
6		VP	Voltage-plus
7		P24V (see note 1)	Plus 24 V output voltage
8	**A/A'**	RxD/TxD-N	Receive/transmit-data-N
9		CNTR-N (see note 1)	Control-N
NOTE 1 Signals are optional. NOTE 2 Recommended to be not connected.			

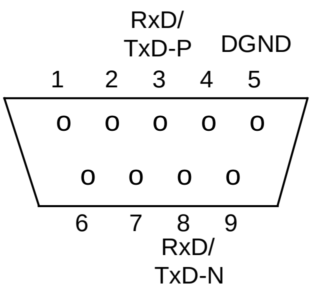

Figure I.3 – Connector pinout, front view of male and back view of female respectively

The Data Ground, connected to pin 5, and the Voltage-Plus, connected to pin 6, supply the Bus Terminator.

The control signals CNTR-P and CNTR-N, connected to pin 4 and pin 9, support direction control when repeaters without self control capability are used. ANSI TIA/EIA-485-A signaling is recommended. For simple devices the signal CNTR-P may be a TTL signal (1 TTL load) and the signal CNTR-N may be grounded (DGND). The definition of signaling is not a subject of this standard.

The 24 V output voltage, according to IEC 61131-2, Table 6, allows the connection of operator panels or service devices without integrated power supply. If a device offers 24 V output voltage it shall allow for a current load up to 100 mA.

I.2.2 Connector for intrinsic safe asynchronous transmission

I.2.2.1 IP20 connecting technique

For mechanical and electrical characteristics, see I.2.1.

The pin assignments for the connectors are shown in Table I.3.

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Table I.3 – Contact designations

Pin number	RS-485 ref.	Signal name	Meaning
1		SHIELD (see note 1)	Shield
2		NC	(Not connected)
3	**B**	RxD/TxD-P	Receive/transmit-data-P
4		NC	(Not connected)
5		ISM (see note 2)	Bus termination minus
6		ISP (see note 2)	Bus termination plus
7		NC	(Not connected)
8	**A**	RxD/TxD-N	Receive/transmit-data-N
9		NC	(Not connected)
NOTE 1 Signal is optional and recommended to be not connected.			
NOTE 2 Signal is current-limited by resistors.			

The ISM, connected to pin 5, and the ISP, connected to pin 6, supply the Bus Terminator.

Series inductances in the data lines, as used in non-intrinsic safe connectors, shall not be used. The wiring from bus input to bus output in the connector shall be designed for a maximum current of 4,8 A. The trap to the communication device (A, B, ISM and ISP wire) shall be designed for the maximum input current of 2 x Io (~300 mA). The appropriate values for the design of the connector (track widths, separation distances etc.) shall be according to IEC 60079-11.

The separation distances between A, B, ISM and ISP wire from the connector's trap to the current limiting resistors in the communication device shall be infallible in accordance IEC 60079-11.

I.2.2.2 IP65 connecting technique

The 4-pin M-12 connector according to IEC 60947-5-2 is used for fieldbus systems where extreme industrial environments exist. Only shielded connectors are permitted. The connectors feature a mechanical key (B-coding).The pin assignments for the connectors are shown in Table I.4.

Table I.4 – Contact designations

Pin number	RS-485 ref.	Signal name	Meaning
1		ISP (see note)	Bus termination plus
2	**A**	RxD/TxD-N	Receive/Transmit-Data-N
3		ISM (see note)	Bus termination minus
4	**B**	RxD/TxD-P	Receive/Transmit-Data-P
Threaded joint		SHIELD	Shield
NOTE Signal is current-limited by resistors.			

The ISM, connected to pin 3, and the ISP, connected to pin 1, supply the Bus Terminator.

Series inductances in the data lines, as used in non-intrinsic safe connectors, shall not be used. The connector contacts shall be designed for the maximum current of 4,8 A.

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The connector at the field device shall be a female type M12 connector, as shown in Figure I.4.

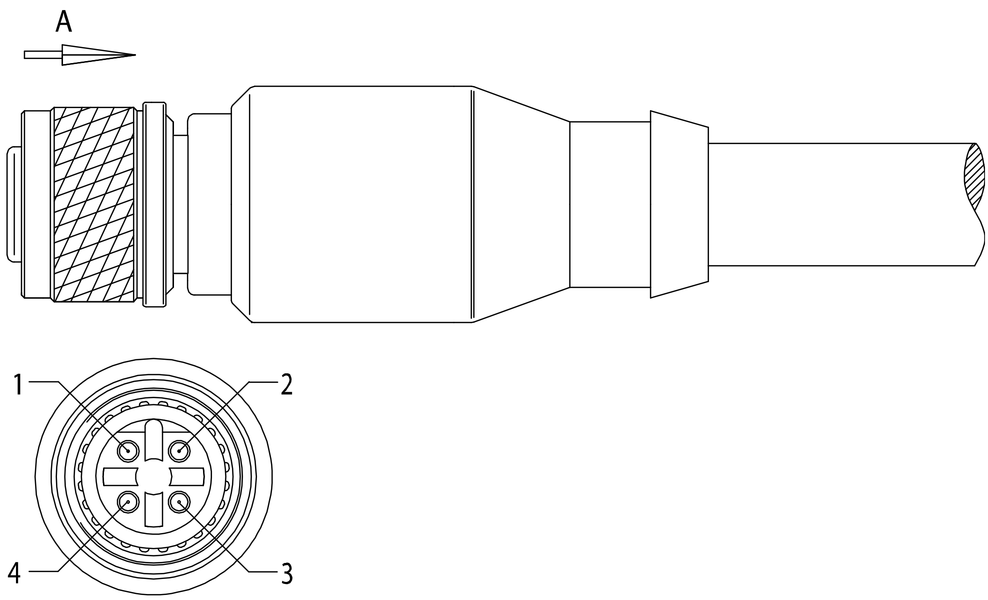

Figure I.4 – Connector pinout, front view of female M12 connector

The connector at the cable side shall be a male type M12 connector, as shown in Figure I.5.

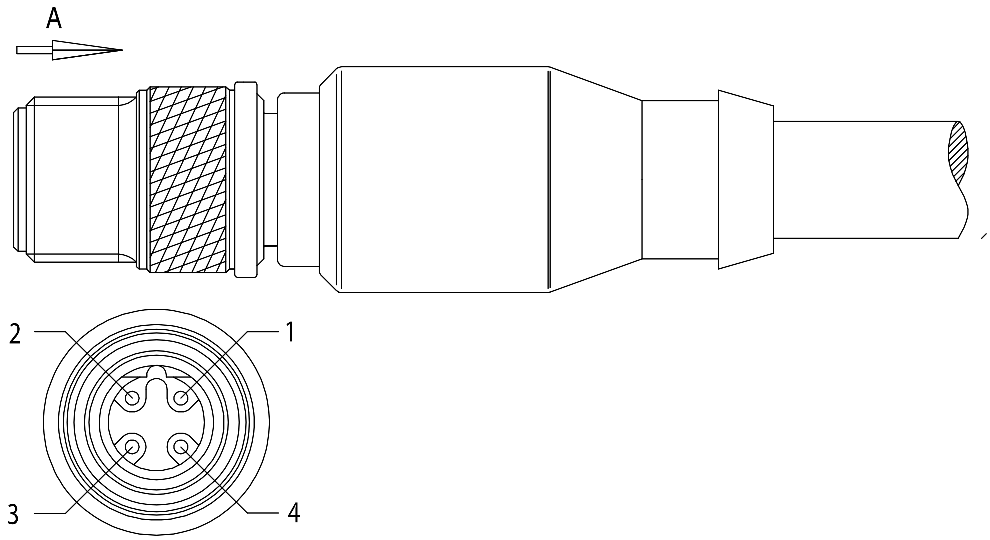

Figure I.5 – Connector pinout, front view of male M12 connector

The fieldbus topology has a linear structure. The junctions (tees), as shown in Figure I.6, connect the individual devices to the trunk cable. The stub length should be as short as possible. Series inductances in the data lines shall not be used.

The Tee shall be uniform and concentric all the way to the cap nut (Threaded joint), (metal connectors and similar).

The supply voltage provided by the devices for driving the termination resistance shall be passed on via the Tee.

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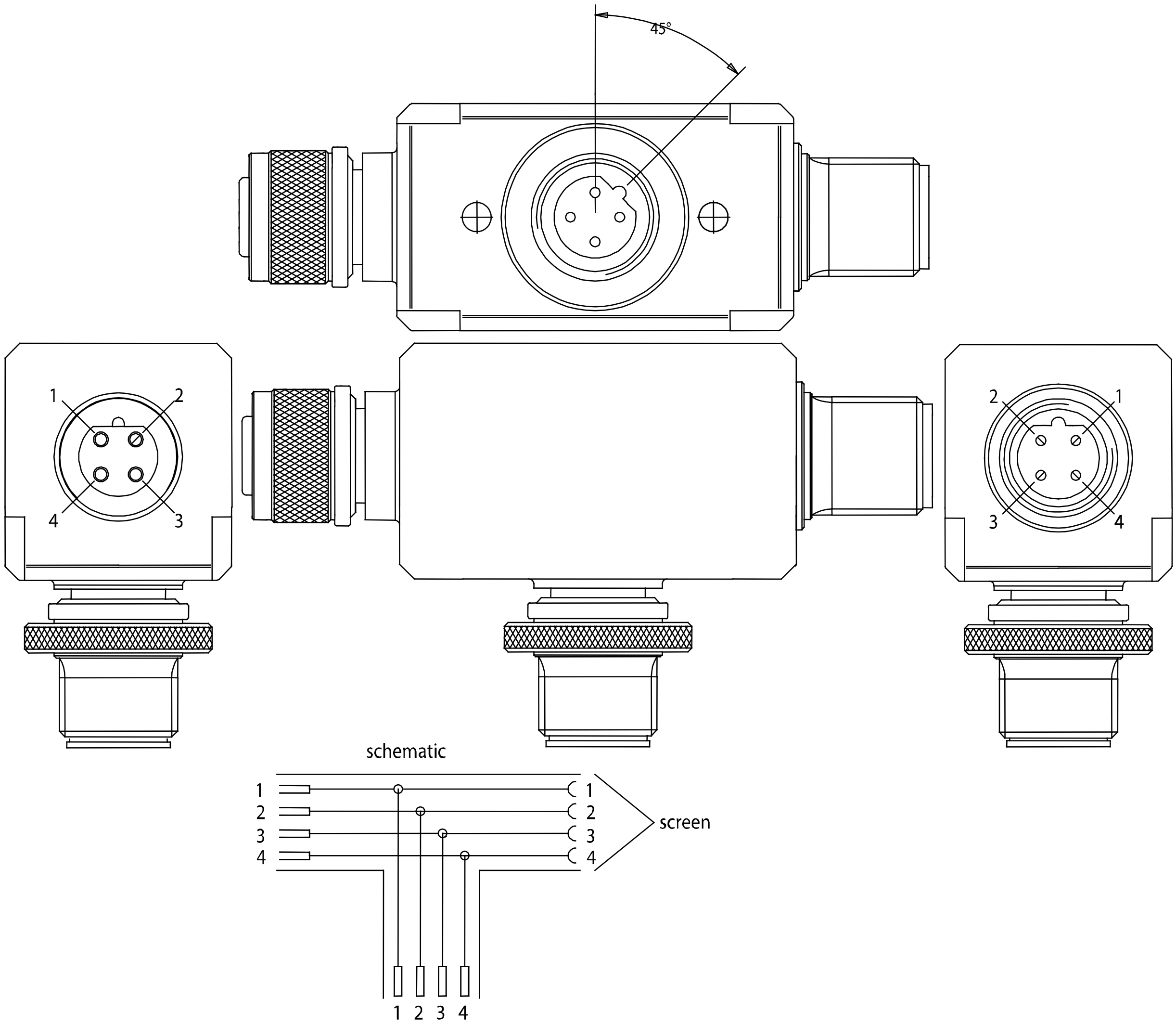

Figure I.6 – M12 Tee

Figure I.7 shows the pinout and schematic of the M12 bus termination.

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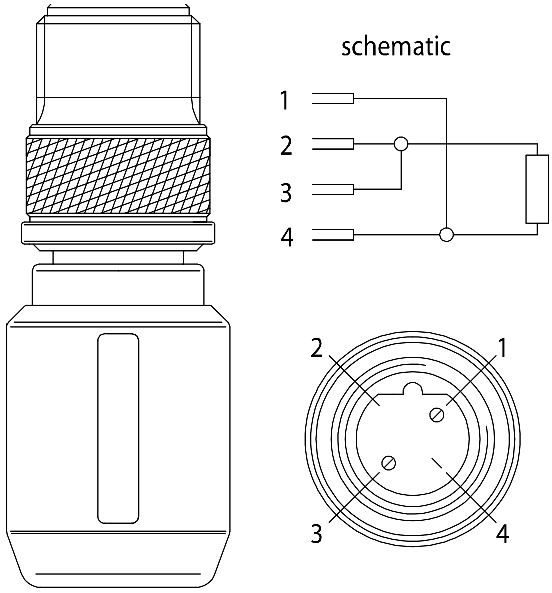

Figure I.7 – M12 Bus termination

I.2.2.3 Terminal connecting technique

The terminal connection shall provide the signals A, B, ISM and ISP. The terminal designation shall be according to the signal name. Alternatively, when internal bus termination is available, only the signals A and B may be provided. The communication device shall provide a suitable connection for cable shield.

The wiring from bus input to bus output in the terminal shall be designed for a maximum current of 4,8 A.

I.3 Connectors for fiber optic cable

I.3.1 Connectors for glass fiber optic cable (850 nm and 1 300 nm wavelength)

Glass fiber optic cables are connected or interconnected using type BFOC/2.5 connectors according to IEC 61754-2.

NOTE Butt joint contact of the fibers, so-called physical contact (PC), minimizes the attenuation and reflection for fiber-fiber connections.

I.3.2 Connectors for plastic and glass fiber optic cable (660 nm wavelength)

Plastic fiber optic cables are preferentially connected or interconnected using type BFOC/2.5 connectors.

Other connector elements are admissible if they are compatible to reference fiber 980/1 000 µm plastic fiber or 200/230 µm glass fiber.

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Annex J
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Type 3: Redundancy of PhL and medium

The use of a redundant PhL improves the reliability of the fieldbus. When implemented, the redundant PhL contains two separately installed medium (bus cable "a" and bus cable "b") and two complete Medium Attachment Units (MAUs) per station. The redundancy architecture in principle is shown in Figure J.1.

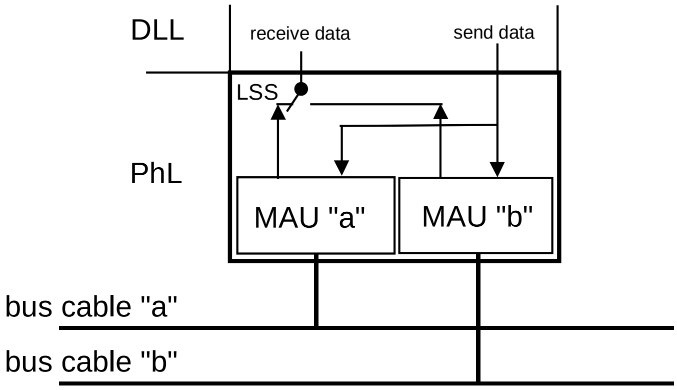

Figure J.1 – Redundancy of PhL MAU and Medium

The basic principle, shown in Figure J.1, assumes that data is sent out simultaneously by both MAUs (transceivers) onto both mediums (bus cable "a" and bus cable "b"). In contrast to this, each station receives from only one medium (either bus cable "a" or bus cable "b"). The receive channel is selected by a Line Selector Switch (LSS), which is located between both MAUs and the DLL. The Line Selector Switch is controlled by the Ph-management. For this the Medium Access Control (MAC) of each station's DLL monitors the medium activity, and gives corresponding information to DL-management (see IEC 61158-3-3 the DLMS Event and Get Value service) independently of any other station. The main switching conditions for masters and slaves are as follows:

– two or more successive invalid frames are received; invalid means frames with invalid format, invalid parity bit or invalid frame check sequence are detected;

– time out timer T_{TO} expires (see IEC 61158-4-3, 5.5);

– no Syn. Time T_{SYN} (i.e. line idle for at least T_{SYN}) was detected during one Synchronization Interval Time T_{SYNI} (see IEC 61158-4-3, 5.5).

NOTE 1 Dependent on the execution, further switch conditions may be selected.

The selected receive channel "a" (primary) or "b" (alternate) is notified to the Ph-management, see 6.3. The Ph-management then provides this information to the PHMS-user via the management interface.

NOTE 2 There is no preferred receive channel after the system initialisation is finished.

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Annex K
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Type 3: Optical network topology

K.1 Signal flow in an optical network

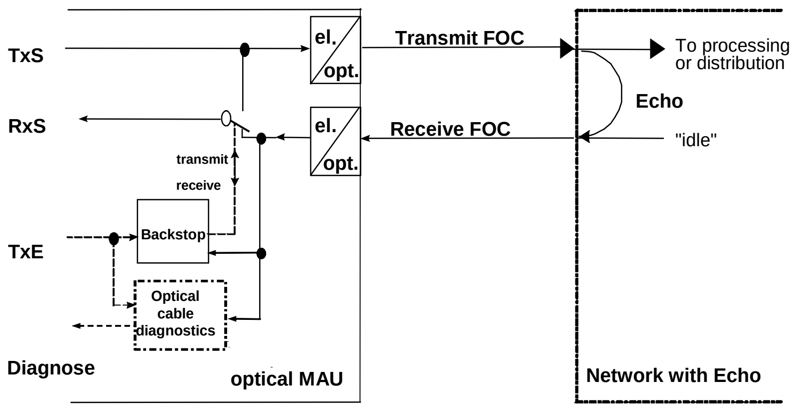
K.1.1 General

Connections to Master or Slave stations or coupling elements, such as star couplers, repeaters, etc. are the user's responsibility. However, the user shall make sure that the various interfaces are compatible with each other.

Clause K.1 contains the description of optical Medium Attachment Units (MAU) to connect to a fiber optical network with or without echo.

K.1.2 Connection to a network with echo

After a delay, the optical MAU receives its own transmit signal from the network again as an echo. Echo signal detection can be used to confirm the status of the physical connection to the optical MAU at the other end of the line (see Figure K.1).



Key:
FOC = Fiber optic cable
TxE = Transmit enable
TxS = Transmit signal
RxS = Receive signal
MAU = Medium attachment unit

Figure K.1 – Optical MAU in a network with echo

The echo is returned with a delay equal to twice the signal delay to the coupling element (e.g. star coupler) that generates the echo. With a ring structure, the delay corresponds to one cycle of the ring. The receive signal delay, which does not occur in asynchronous transmission networks, shall not cause operating faults or error messages. The transmitting optical MAU shall remove the echo signal from the network. The echo signal shall not be returned to the network by the transmitter again and shall not lead to duplication of the message as a "new" message within a field device.

K.1.3 Connection to a network without echo

The optical MAU does not receive its own transmit signal from the network again as an echo in such a network. The receive line remains idle during the transmit procedure as shown in Figure K.2. No information is available on the status of the link.

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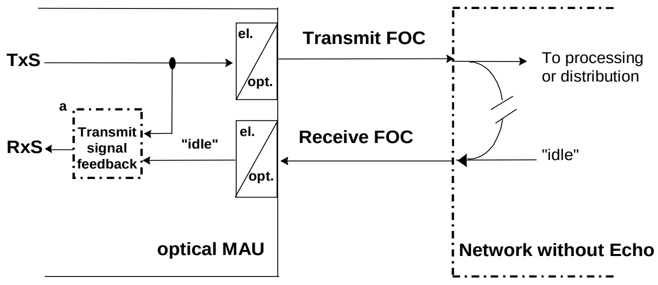


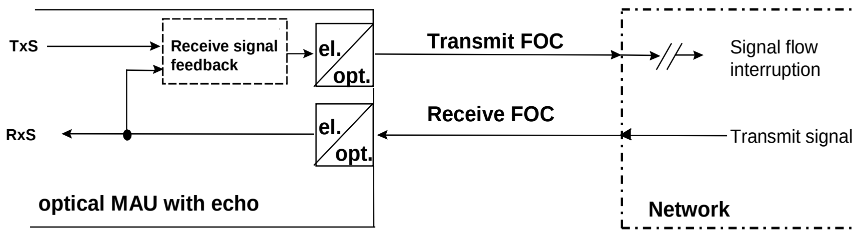
Key:
FOC = Fiber optic cable
TxS = Transmit signal
RxS = Receive signal
MAU = Medium attachment unit
[a] mandatory for Master

Figure K.2 – Optical MAU in a network without echo

Masters shall fulfil the requirements of token acknowledgement locally, for example with hardware feedback (emulation) of the transmit signal.

K.1.4 Optical MAU with echo function

An optical MAU with echo function returns the signal received at an input gate to the associated return line as shown in Figure K.3. This allows an appropriate optical MAU at the other end of the optical line to check for its own message by monitoring for the echo.



Key:
FOC = Fiber optic cable
TxS = Transmit signal
RxS = Receive signal
MAU = Medium attachment unit

Figure K.3 – Optical MAU with echo via internal electrical feedback of the receive signal

K.1.5 Optical MAU without echo function

An optical MAU without echo function does not return the signal received at an input gate to the associated return line. The output remains at the idle level (see Figure K.4).

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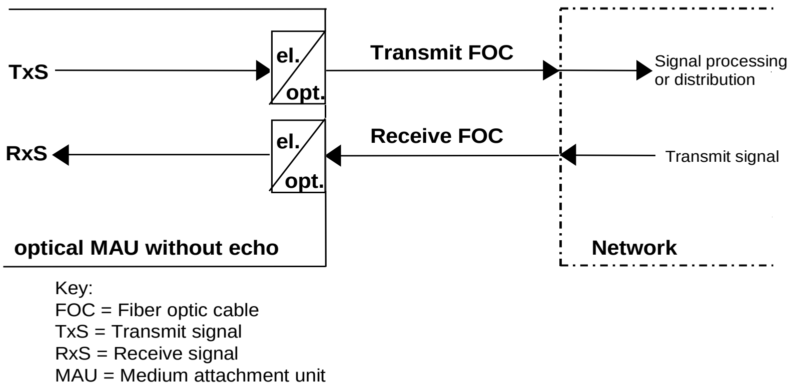

Figure K.4 – Optical MAU without echo function

K.1.6 Examples of topology

K.1.6.1 General

Subclause K.1.6 illustrates some of the network topologies that can be constructed in accordance with this standard. This does not imply that these are the only possible topologies.

K.1.6.2 Star topology

Central signal distribution using active star couplers results in a star-shaped structure for the optical network with the active star coupler as the central element (see Figure K.5).

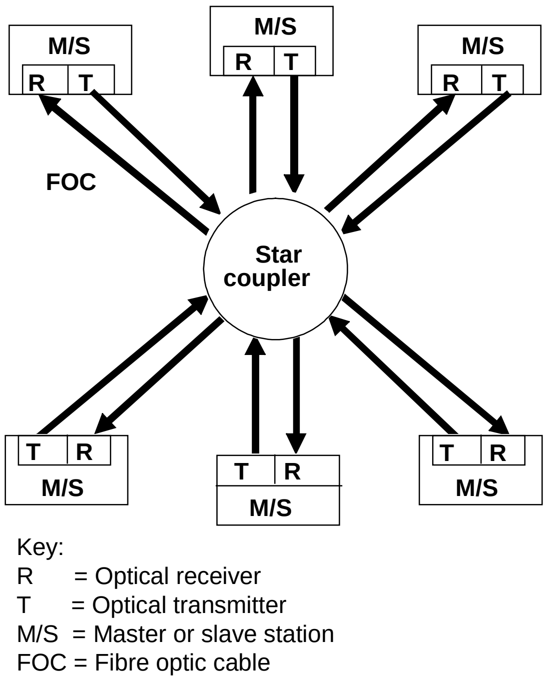

Figure K.5 – Optical network with star topology

The active star coupler is used in optical networks as a central signal distributor with signal level restoration. Regeneration of the signal timing (re-timing) is available as an option. The active star coupler requires an electrical power supply. The active star coupler converts

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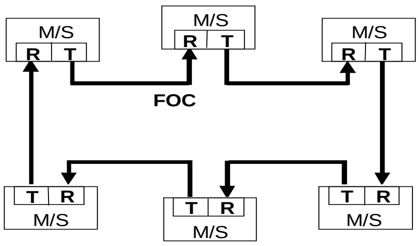
optical signals received at an input into electrical signals. Internal signal processing takes place electrically. Electro-optical converters at the output gates transmit an optical signal.

K.1.6.3 Ring topology

A ring structure, as shown in Figure K.6, requires additional control measures in the station. A transmitting station (Master/Slave) shall interrupt the ring logically and maintain the interruption after the end of the telegram until the telegram has passed around the ring once and returned to the transmitting station, where it is discarded.

Stations in receive mode shall output the received signal on the transmit side again.

Stations have to be provided with a protection, which prevents dropping the ring into a statically closed ring. This problem can occur if e.g. a fault spike occurs during an “idle” phase.

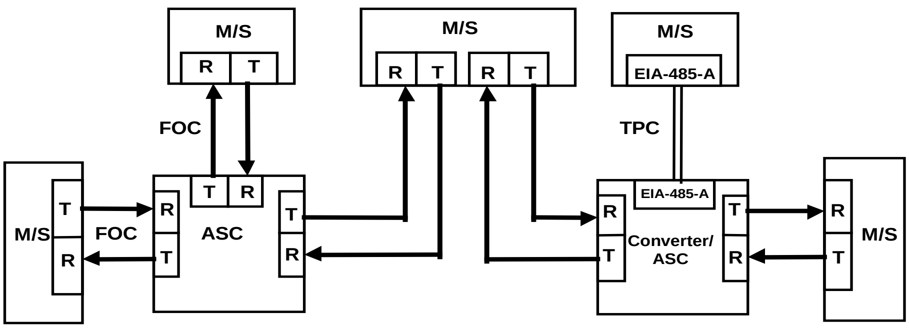


Key:
R = Optical receiver
T = Optical transmitter
M/S = Master or slave Station
FOC = Fiber optic cable

Figure K.6 – Optical network with ring topology

K.1.6.4 Bus topology

The bus topology is built with type 3x3 star couplers or stations with integrated optical interfaces (see Figure K.7).



Key:
FOC = Fibre optic cable
TPC = Twisted-pair cable
ASC = Active star coupler
M/S = Master or slave Station

R - Optical receiver
T - Optical transmitter
EIA-485-A: - Transceiver

Figure K.7 – Optical network with bus topology

K.1.6.5 Tree topology

Several active star couplers can be combined to build networks with a tree structure as shown in Figure K.8.

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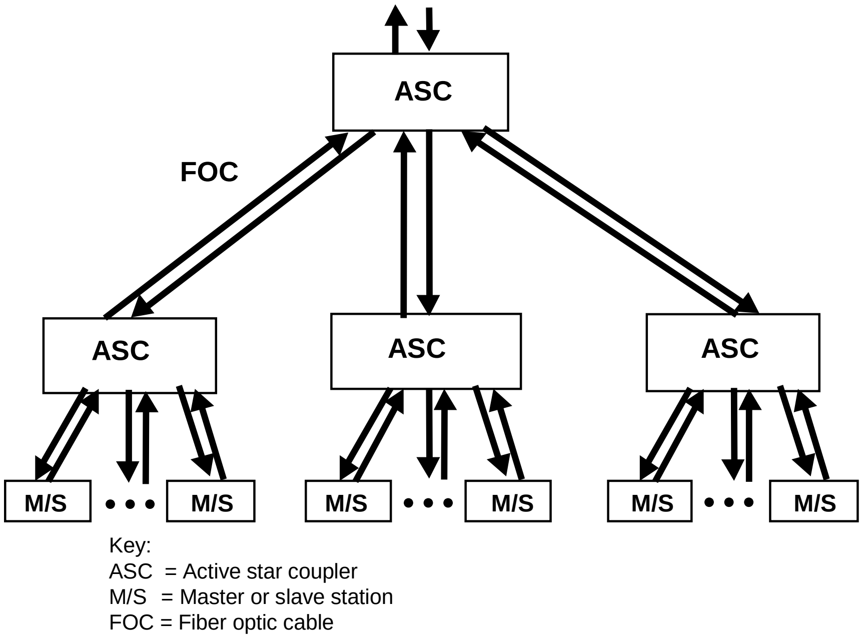

Figure K.8 – Tree structure built from a combination of star structures

K.1.6.6 ANSI TIA/EIA-485-A / fibre optic converter

An ANSI TIA/EIA-485-A / fiber optic converter is used to connect a station or a subnet based on the ANSI TIA/EIA-485-A technology to an optical network segment or an optical Master/Slave station.

Figure K.9 illustrates an application example for an ANSI TIA/EIA-485-A / fiber optic converter.

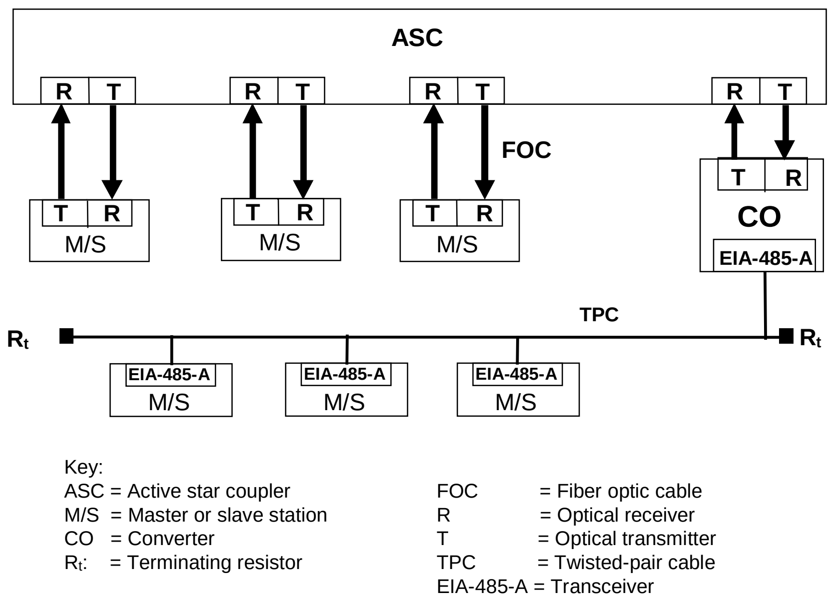

Figure K.9 – Application example for an ANSI TIA/EIA-485-A / fiber optic converter

The ANSI TIA/EIA-485-A / fiber optic converter can also be implemented internally in a modular active star coupler.

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K.1.7 Optical power budget

K.1.7.1 General

A fiber-specific optical signal level budget is available between two nodes that can be consumed in the form of attenuation along the optical link.

Specific budget calculations can be carried out using the specifications from the respective manufacturer.

Signal level budget refers to the difference between the output power from the optical transmitter and the input power required by an optical receiver for error-free signal detection. The overall attenuation shall be between the level budgets for overload and sensitivity.

Subclause K.1.7 provide examples of which network extents can be implemented with various fiber types and transmitter power levels.

K.1.7.2 Limiting conditions

The following limiting conditions shall be taken into consideration when interpreting the tables and dimensioning the optical links.

K.1.7.2.1 Numerical aperture (NA)

Numerical aperture (for description refer to IEC 60793-2).

K.1.7.2.2 Output power

Output power is the power level in the fiber for a “0” signal for the specified fiber for the entire temperature range giving consideration to sample diffusion and to the losses that are caused by the fiber connection at the transmitter (connector element).

K.1.7.2.3 Receiver limits

These values identify the acceptable signal range (dynamic range) for a “0” signal (“light” ON), whereby “overload” refers to the highest acceptable signal level (= brightest “light”) and “sensitivity” refers to the lowest signal level. Moving outside the dynamic range does not necessarily cause interruption of the data transfer, but increases the deviation of signal timing beyond the specified limits that increases the likelihood of transmission errors.

K.1.7.2.4 Level budget

Level budget is the dynamic range resulting from the specified transmitter/receiver combination. The bit error rate (BER) is $<10^{-9}$ within these limits.

K.1.7.2.5 Overall attenuation

Overall attenuation refers to the minimum required attenuation required for overload protection of the receiver or to the maximum allowed attenuation needed to utilize the entire sensitivity of the receiver.

The overall attenuation is composed of:

- fibre attenuation for the fiber optic cable;
- coupling losses for inserted connectors and splices, if applicable;
- a system margin.

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K.1.7.2.6 System reserve

System reserve takes account of the transmitter element's output power loss due to aging. The life expectancy of a transmitter element is usually defined by the time by which the transmitted power has fallen by 3dB compared to the value for a new element.

When determining the overload immunity of a receiver, it is assumed that this "system reserve" has not been consumed.

K.1.7.2.7 Fiber attenuation

Fiber attenuation refers to the maximum allowable attenuation or to the minimum required attenuation of the fiber optic cable.

K.1.7.2.8 Specific fiber attenuation

Specific fiber attenuation is the maximum or minimum attenuation of the fiber optic cable per length unit. It is dependent on the wavelength of the light.

Attenuation values for fibers are not stipulated in the specifications and shall be obtained from the data sheet for the respective fiber. The values in the tables are typical values based on experience.

The peak wavelength of the emitted light shifts with the operating temperature of the transmitter element. This wavelength shift has to be taken into consideration when determining the limiting values for the specific fiber attenuation.

K.1.7.2.9 Fiber length

The fiber length is calculated by dividing that part of the overall attenuation that is due to fiber attenuation by the specific fiber attenuation.

K.1.7.3 62,5/125 μm multi-mode glass fiber

The transmit power level is so chosen that the minimum optical link length is 0 m, i.e. receiver overload cannot occur with the 62,5/125 μm fiber. An example of a level budget calculation for this reference fiber is given in Table K.1.

Table K.1 – Example of a link budget calculation for 62,5/125 μm multi-mode glass fiber

Link budget for a 62,5/125 μm multi-mode glass fiber standard link (graded index profile) NA = 0,275			
Transmitter output power	–20 … –15		dBm
Receiver limits	**Overload** –10	**Sensitivity** –24	dBm
Level budget	0	9	dB
Overall attenuation	0	9	dB
System reserve	0	3	dB
Fiber attenuation	0	6	dB
Specific fiber attenuation	2,5	3,5	dB/km
Fiber length	min. 0	max. 1 700	m

K.1.7.4 9/125 μm single mode glass fiber

This fiber type has been included to be able to implement longer optical links.

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The transmit power level is so chosen that the minimum optical link length is 0 m, i.e. receiver overload cannot occur with the 9/125 μm fiber.

The Table K.2 shows typical values in practice, which do not represent specifications.

Table K.2 – Example of a link budget calculation for 9/125 μm single mode glass fiber

Link budget for a 9/ 125 μm single mode glass fiber standard link (step index profile) NA = 0,13			
Transmitter output power	–20 … –10		dBm
Receiver limits	**Overload** –10	**Sensitivity** –27	dBm
Level budget	0	7	dB
Overall attenuation	0	7	dB
System reserve	0	2	dB
Fiber attenuation	0	5	dB
Specific fiber attenuation	0,3	0,5	dB/km
Fiber length	min. 0	max. 10 000	m

K.1.7.5 980/1 000 μm multi-mode plastic fiber

Due to its larger diameter, plastic fiber places lower demands on absolute mechanical tolerances during installation. This generally leads to reduced installation costs.

However, due to the much higher fiber attenuation compared to glass fiber, plastic fiber is generally only suitable for relatively short optical links. The wavelength range of the optical signal is chosen to match the minimum attenuation of the plastic material. Numerical example for the level budget is given in Table K.3.

Table K.3 – Example of a link budget calculation for 980/1 000 μm multi-mode plastic fiber

Link budget for a 980/1 000 μm plastic fiber standard link (step index profile) NA = 0,47					
Transmitter output power	**Standard**		**Increased**		
Output power	–11 … – 5,5		–6 … 0		dBm
Receiver limits	**Overload** –5,0	**Sensitivity** –20,0	**Overload** 0	**Sensitivity** –20,0	dBm
Level budget	–0,5	9,0	0	14,0	dB
Overall attenuation	0	9,0	0	14,0	dB
System reserve	0	3,0	0	3,0	dB
Fiber attenuation	0	6,0	0	11,0	dB
Specific fiber attenuation	0,15	0,25 (see note)	0,15	0,25 (see note)	dB/m
Fiber length	min. 0	max. 24	min. 0	max. 44	m
NOTE Increased attenuation due to the fiber material and the wavelength shift due to temperature changes in the transmitter element.					

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K.1.7.6 Multi-mode glass fiber 200/230 μm fiber

This fiber type has been included to be able to implement longer optical links. The numerical example for the level budget is given in Table K.4.

Table K.4 – Example of a level budget calculation for 200/230 μm multi-mode glass fiber

Link budget for an 200/230 μm fiber standard link (step index profile) NA = 0,37			
Transmitter output power	– 16,0 to - 8,0		dBm
Receiver limits	**Overload** –8,0	**Sensitivity** –22,0	dBm
Level budget	0	6,0	dB
Overall attenuation	0	6,0	dB
System reserve	0	3,0	dB
Fiber attenuation	0	3,0	dB
Specific fiber attenuation	5	10	dB/km
Fiber length	min. 0	max. 300	m

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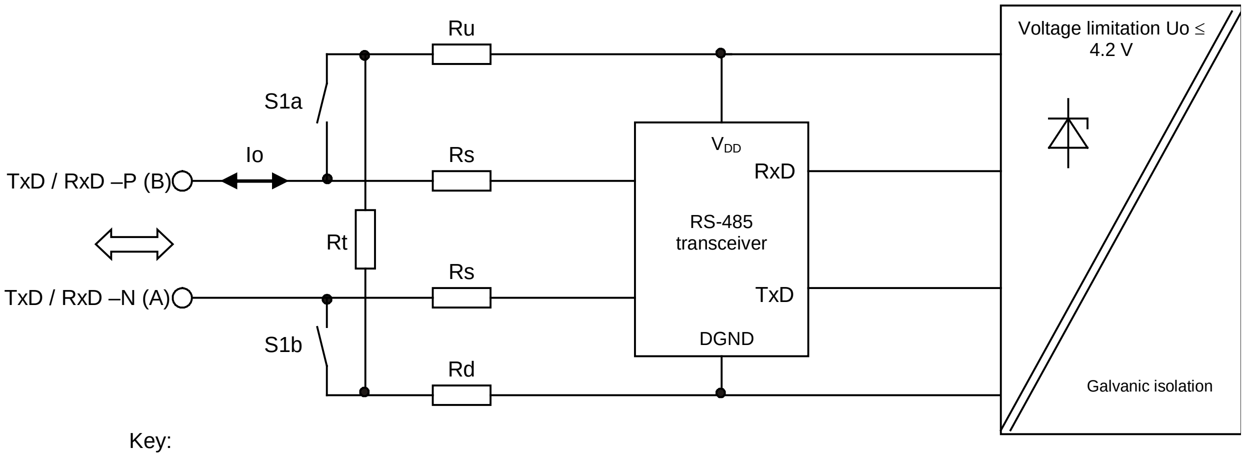
Annex L
(informative)

Type 3: Reference design examples for asynchronous transmission, wire medium, intrinsically safe

L.1 Bus termination in the communication device

In this version, the bus termination is already in the device by means of the resistors Rt, Ru and Rd, as shown in Figure L.1. Activation is done via the switch S1 for the device which is installed at the end of the bus segment.



Key:
Rs =Current-limiting resistors for the signal path
Rt, Ru; Rd : Bus-termination resistors

Figure L.1 – Bus termination integrated in the communication device

When determining the maximum output current Io, it shall be noted that, on account of the switch S1, the resistor R3 is connected in parallel to R1 and the resistor R4 is connected in parallel to R2.

Here, the safety-related limiting values as described in "PTB-Mitteilungen, 113 Jahrgang, Heft 2/2003, Die Bewertung der Zündfähigkeit eigensicherer Stromkreise anhand eines Rechenverfahrens. Abschnitt: Der eigensichere RS 485 Feldbus als Anwendungsbeispiel." shall also be adhered too.

For the design of the components and the required separation distances, the relevant applicable standard shall be met (e.g. IEC 60079-11).

L.2 Bus termination in the connector

In this version, the bus termination is realised in the connector, as shown in Figure L.2. For this, it is necessary that the communication devices provide the appropriate power supply. Activation is done via the switch S1 for the devices which are installed at the relevant end of the bus segment.

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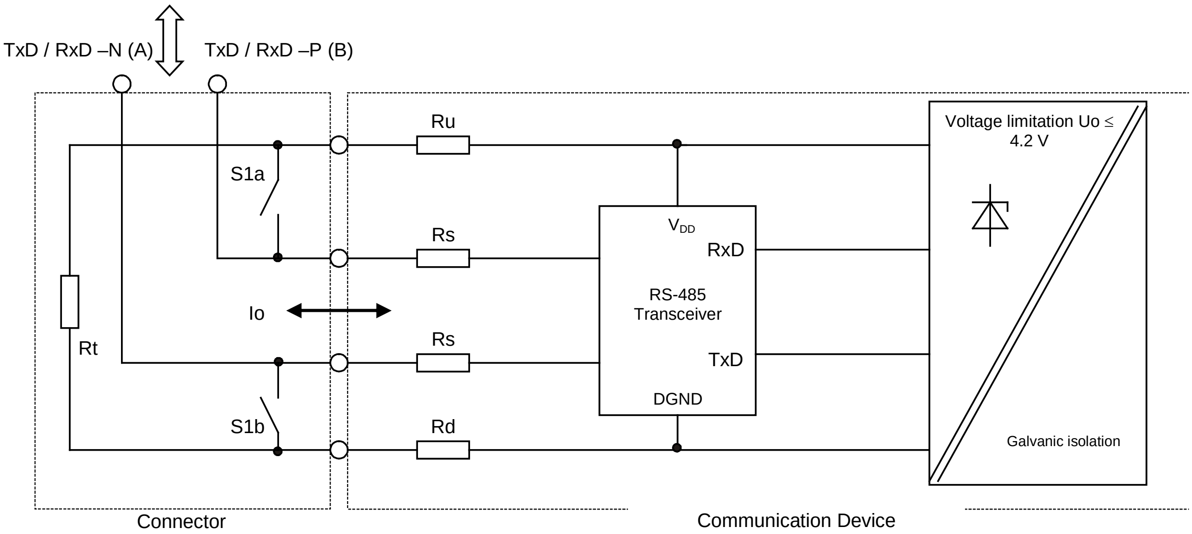


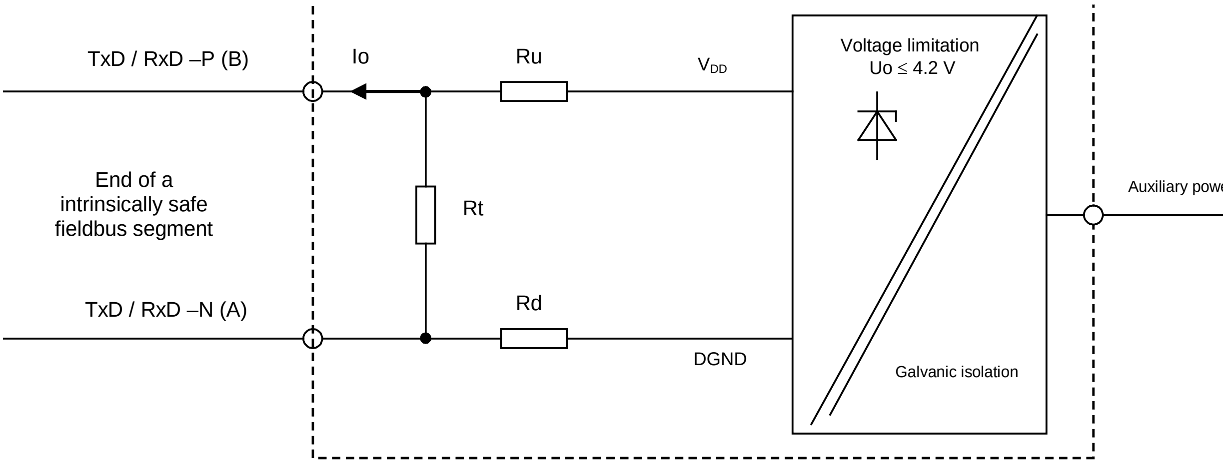
Key:
Rs : Current-limiting resistors for the signal path
R3, R4; R5 : Bus-termination resistors

Figure L.2 – Bus termination in the connector

L.3 External bus termination

The auxiliary power supply shall be galvanically isolated from the field bus circuit, as shown in Figure 110. Details of this are provided in 22.2.4.3.

In this version, the bus termination is realised externally in a seperate device, as shown in Figure L.3.



Key:
Rt, Ru; Rd : Bus termination resistors

Figure L.3 – External bus termination

The auxiliary power supply shall be galvanically isolated from the field bus circuit.

The resistors Ru and Rd are relevant for the calculation of the maximum output current I_o. In this context, the safety-related limiting values for external bus terminations shall be adhered

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too. Regarding to the design of the components and the necessary separation distances, the relevant applicable standard (e.g. IEC 60079-11) shall be applied.

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Annex M
(normative)

Type 8: Connector specification

M.1 External connectors for wire medium

M.1.1 Subminiature D connector pin assignment

The connector pin assignment is shown in Figure M.1, Figure M.2 and Table M.1.

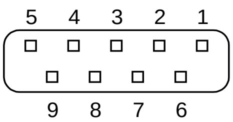

Figure M.1 – Outgoing interface 9-position female subminiature D connector at the device

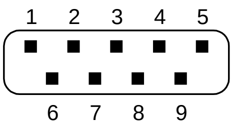

Figure M.2 – Incoming interface 9-position male subminiature D connector at the device

Table M.1 – Pin assignment of the 9-position subminiature D connector

Pin number	Signal line
1	DO
2	DI
3	GND
4	–
5	–
6	/DO
7	/DI
8	–
9	–

M.1.2 Terminal connector pin assignment

Figure M.3 shows the terminal connector position at the device and pin assignments of the terminal connector are shown in Table M.2.

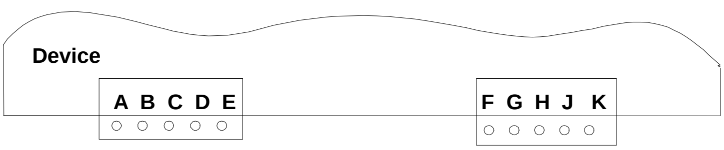

Figure M.3 – Terminal connector at the device

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Table M.2 – Pin assignment of the terminal connector

Incoming interface		Outgoing interface	
Pin	**Standard**	**Pin**	**Standard**
A	/DO1	F	/DO2
B	DO1	G	DO2
C	/DI1	H	/DI2
D	DI1	J	DI2
E	GND1	K	GND

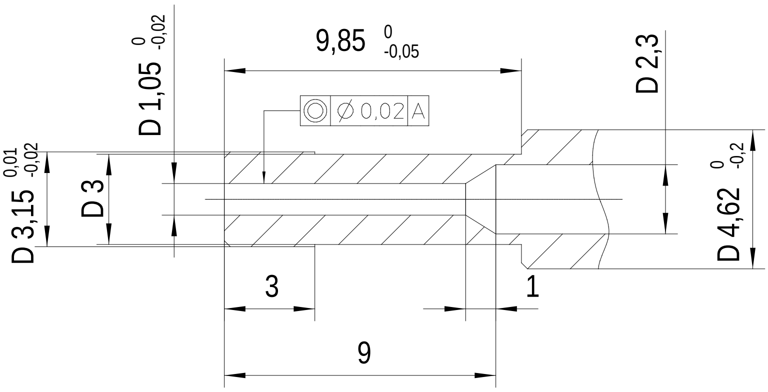
A separate terminal for protective earth shall be provided.

The sequence of terminal points should be observed.

M.2 External connectors for fiber optic medium

A network connector that is outside the enclosure of the device and therefore requires protection against the electromagnetic, chemical and physical environment shall be specified as an external connector.

If a degree of protection of IP20 or less is used for the device having an optical MAU implemented the connector used for the CPIC at the device level should be mechanically compatible with a F-SMA type connector as specified in IEC 61754-22. The ferrule of an optical F-SMA connector for polymer optical fiber (980/1 000 μm) is shown in Figure M.4.



NOTE All measures in mm.

Figure M.4 – Ferrule of an optical F-SMA connector for polymer optical fiber (980/1 000 μm)

M.3 External connectors for hybrid connectors for IP65 applications

If a hybrid connector for applications with a degree of protection of IP65 or higher is used for the device having an optical MAU implemented, this connector used for the CPIC at the device level should be as shown in Figure M.5 and Figure M.6 with the connector dimension specified in Table M.3.

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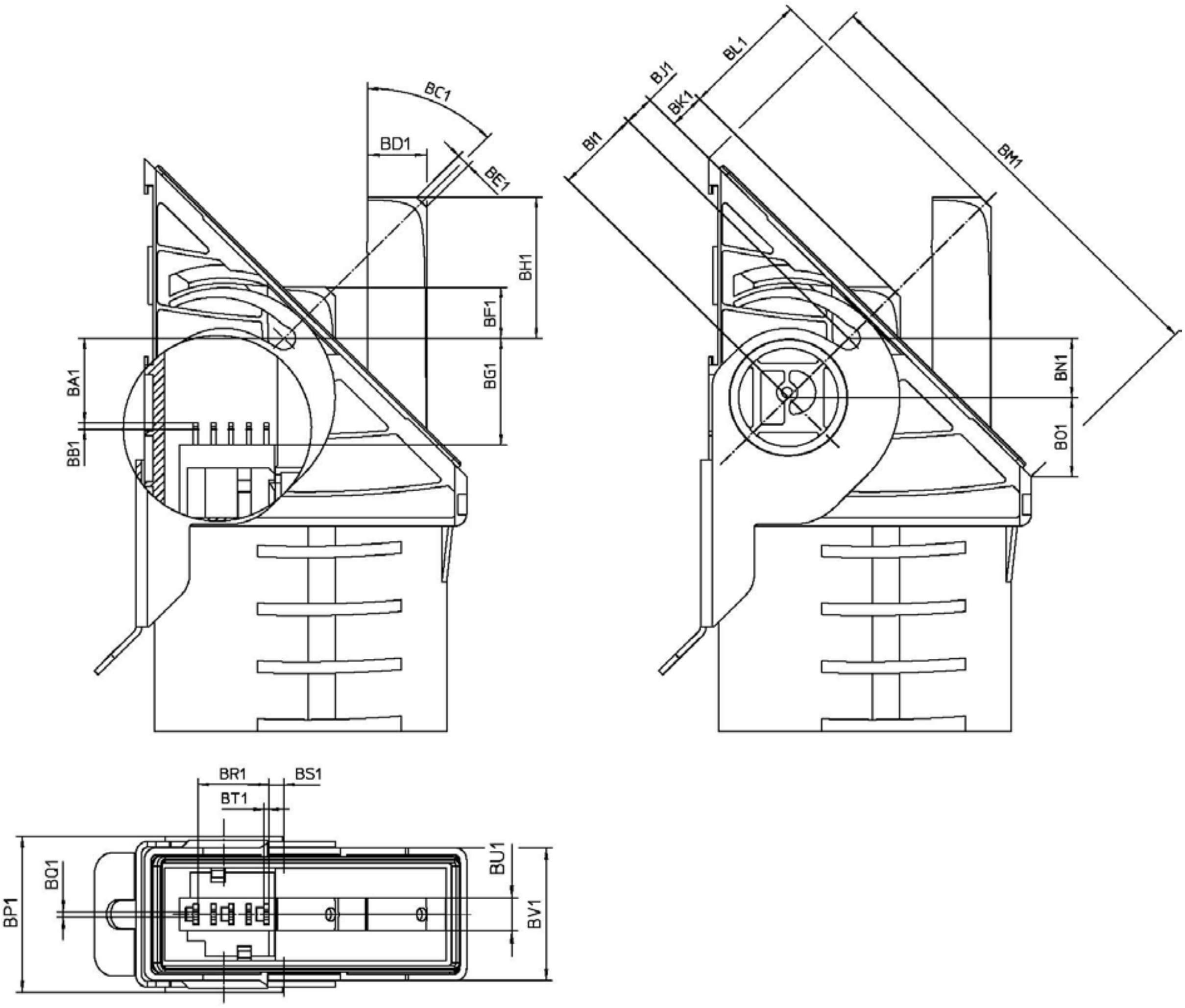

Figure M.5 – Type 8 fiber optic hybrid connector housing

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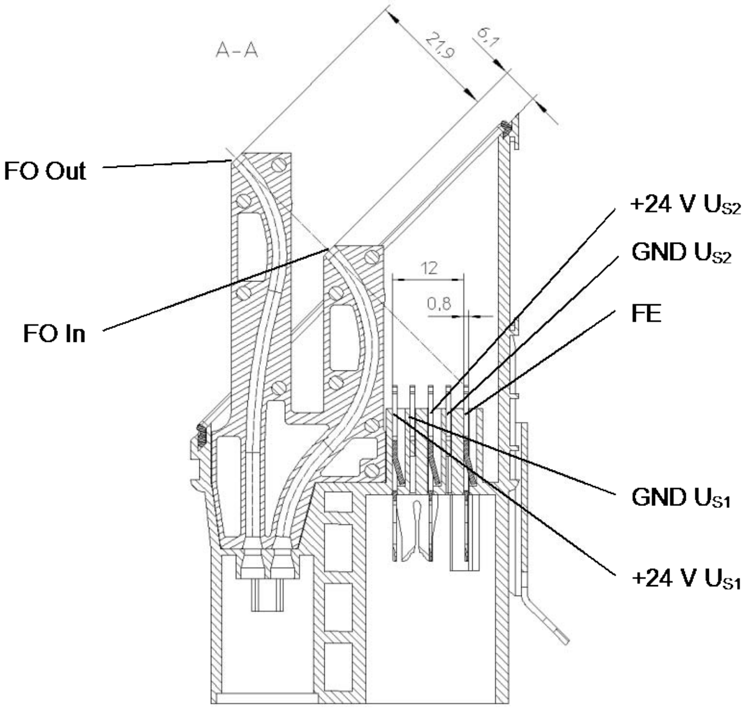

Key:

U_{S1} = Sensor and bus module power supply

U_{S2} = Actuator power supply

FO in = connection to the FO transmitter

FO out = Connection to the FO receiver

Figure M.6 – Type 8 fiber optic hybrid connector assignment

The electrical contacts for the power supplies should be capable of supporting a continuous maximum current of 16 A at 24 V.

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Table M.3 – Type 8 fiber optic hybrid connector dimensions

Letter	Max. mm	Min. mm	Nominal mm
BA1	14,9	14,5	14,7
BB1	1,2	1	1,1
BC1	45,5	44,5	45
BD1	10,2	9,8	10
BE1	2,5	2,3	2,4
BF1	9	8,6	8,8
BG1	18,7	18,3	18,5
BH1	24,5	24,1	24,3
BI1	14,7	14,3	14,5
BJ1	5,3	5,1	5,2
BK1	6,3	5,9	6,1
BL1	22,1	21,7	21,9
BM1	78	77,6	77,8
BN1	10,45	10,05	10,25
BO1	13,85	13,45	13,65
BP1	27,2	26,8	27
BQ1	0,95	0,75	0,85
BR1	12,2	11,8	12
BS1	2,7	2,5	2,6
BT1	0,9	0,7	0,8
BU1	5,7	5,5	5,6
BV1	23,2	22,8	23

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Annex N
(normative)

Type 16: Connector specification

Connectors for fiber optic cables shall

- correspond to F-SMA standard (see IEC 61754-22);
- have a quality level of at least 5;
- have a metallic connector ring.

The transmitter and receiver components shall be built into light-proof housings.

In addition, it is recommended that fiber optic cables have a strain relief.

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Annex O
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Type 16: Optical network topology

O.1 Topology

The topology shall consist of optical point-to-point transmission lines and subscribers. A transmission line shall consist of fiber optic cables having no optical branches. Transmission shall take place in only one direction. The master and the slaves are part of the network (subscribers).

Figure O.1 shows the structure in connection with the control unit and the devices. The control unit may encompass one or more masters, as needed by the application. A master shall handle only one network on the physical layer as well as in the overlying protocol layers. Slaves shall be used to connect the devices to the optical fiber network. On the physical layer, a slave can represent the connection of one or more devices to the optical fiber network. Logically, one slave with several devices shall act the same as several slaves with one device each. Although the slaves are connected to each other physically through the optical fiber network, all transmission of information takes place directly between the master and the slaves. A star-shaped topology is created if every master has only one slave connected to itself.

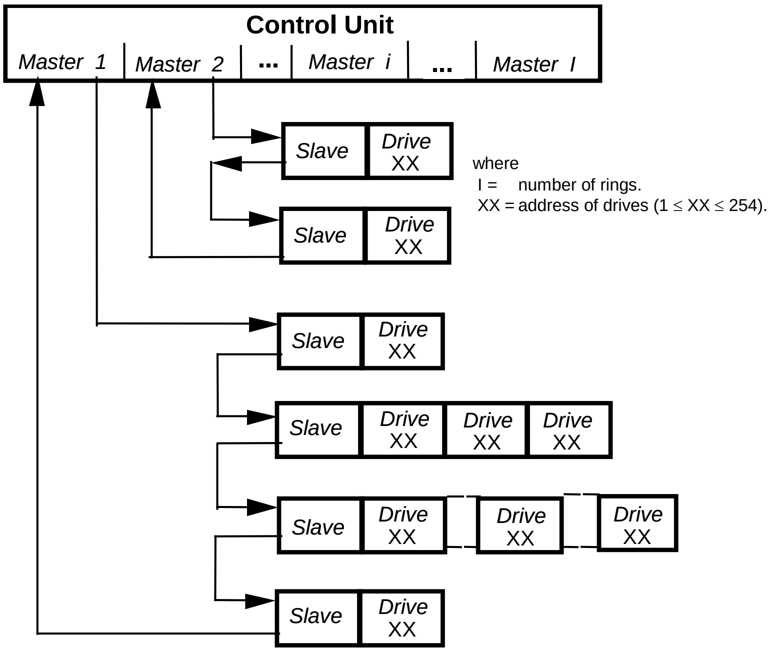

Figure O.1 – Topology

The physical arrangement of slaves in the network shall be independent from the device address set for the slave, as well as from the timing sequence of transmitting the acknowledge telegrams.

NOTE The number of devices in a network is M = K. The sequence of the AT is labeled as 1, 2, ..., M and the sequence of the device data records in the MDT is labelled as 1, 2, ... K.

The Types CP16/1 and CP16/2 interface determine any exchange of information within a network. Any cooperation of networks is controlled by the control unit and is not subject to this specification.

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O.2 Optical power budget

O.2.1 Optical signals on the transmission line

Optical power levels on the transmission line have units of dB_m or μW which are related as follows:

- level [dBm] = 10 × log (level [μW] / 1 000 μW):
- level [μW] = 10 level [dBm] / 10 dBm × 1 000 μW.

The optical signals given in Table O.1, Table O.2 and Table O.4 for the transmitter, the receiver, and the transmission line are measured with a plastic fiber cable (POF) with a 1 mm core diameter and a length of 1 m or with a glass fiber cable (HCS) with 200 μm diameter and a length of 1 m as specified in Table O.3.

Optical levels and edges (status changes) along the transmission line are specified by means of the following parameters:

a) P_{TmaxL}, the maximum transmission power at an optically low level. If the optical signal falls below this level, it is at a logic low state;

b) P_{TminH}, the minimum transmission power at an optically high level. If the optical signal goes above this level, it is at a logic high state;

c) P_{TmaxH}, the maximum transmission power at an optically high level. Stationary signals shall never exceed this limit. A rising optical edge, however, may dynamically exceed the upper limit of the optically high level. This makes it possible to accent the rising edge (minimizing the rise time). Both the magnitude, as well as the duration of the excess signal level are limited;

d) k_{os}, factor for optical power overshoot. This parameter indicates the factor by which the maximum optical transmission power may be exceeded dynamically. The excess power level is only permissible during an optical status change from low to high (rising signal edge).

NOTE PRxxx is used to express the PTxxx equivalent for a receiver.

The optical signal shall pass through P_{TmaxL} to P_{TminH} in a monotonic manner (which means that the signal noise is less than 100 nW = –40 dB_m). Therefore, the logic high level between P_{RmaxL} and P_{RminH}, can be recognized definitely without generating additional signal changes.

O.2.2 Transmitter specifications

Unless stated otherwise, these specifications shall be valid throughout the temperature range from 0 °C to +70 °C.

A transmitter shall follow the specifications in Table O.1.

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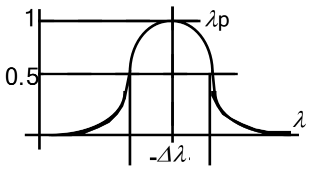
Table O.1 – Transmitter specifications

Position	Attenuation at 650 nm		
Fiber type	**POF**		**HCS**
Optical transmission power	**Low**	**High**	**High**
P_{TmaxL}	–31,2 dBm	–28,2 dBm	–33,2 dBm
	0,75 μW	1,5 μW	0,5 μW
P_{TminH}	–10,5 dBm	–7,5 dBm	–18 dBm
	90 μW	180 μW	16 μW
P_{TmaxH}	–5,5 dBm	–3,5 dBm	–10 dBm
	280 μW	450 μW	100 μW
Transmitting diode wavelength			
Peak wavelength	λ_{pk} = 640 nm to 675 nm		
Spectral bandwidth	$\Delta\lambda \leq$ 30 nm (25 °C)		
Optical spectrum			
k_{os}	120 %		
Temperature range	0 °C to 70 °C		
NOTE All data are for λ_{pk} (which is λ_p in the above inset drawing).			

O.2.3 Receiver specifications

Unless stated otherwise, these specifications are valid throughout the temperature range from 0 °C to +70 °C.

In order to process the data correctly, the receiver shall meet the requirements shown in Table O.2. Since the bandwidth of the fiber optic cable is relatively wide, distortion of the optical signals is insignificant.

Table O.2 – Receiver specifications

Wavelength	650 nm	
Fiber type	**Plastic fiber POF**	**Glass fiber HCS**
P_{RmaxL}	–31,2 dBm	–33,2 dBm
	0,75 μW	0,5 μW
P_{RminH}	–20 dBm	–22 dBm
	10 μW	6,3 μW
P_{RmaxH}	–5 dBm	–7 dBm
	316 μW	200 μW
Dynamic power (P_{RmaxH} to P_{RminH})	15 dB	
Bit error rate	$\leq 10^{-9}$	
Temperature range	0 °C to 70 °C	
NOTE All data are for λ_{pk}		

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O.2.4 Fiber optic cable

The fiber optic cable can consist of plastic or glass with a step index profile or graded index profile. An example is shown in Figure O.2 and Table O.3.

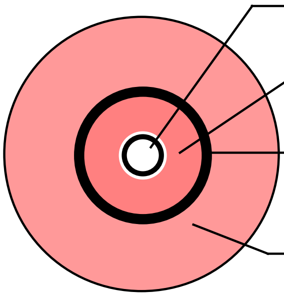

Figure O.2 – Structure of a single-core cable (example)

Table O.3 – Cable specifications (example)

	Plastic fiber POF	**Glass fiber HCS**
Core diameter	980 µm	200 µm
Cladding diameter	1 000 µm	230 µm
Numeric aperture	0,47	0,37
Bandwidth	≥5 MHz × 1 km	≥10 MHz × 1 km

O.2.5 System data of the optical transmission path

The optical power levels are shown in Figure O.3 and shall be in accordance with values in Table O.4.

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Table O.4 – System data of the optical transmission line at 650 nm

Fiber type		POF		HCS
Optical transmission power (see 30.1)		Low	High	High
Transmission power	P_{TmaxL}	–31,2 dBm	–28,2 dBm	–33,2 dBm
		0,75 µW	1,5 µW	0,5 µW
	P_{TminH}	–10,5 dBm	–7,5 dBm	–18 dBm
		90 µW	180 µW	16 µW
	P_{TmaxH}	–5,5 dBm	–3,5 dBm	–10 dBm
		280 µW	450 µW	100 µW
Received power	P_{RmaxL}	–31,2 dBm		
		0,75 µW		
	P_{RminH}	–20 dBm		
		10 µW		
	P_{RmaxH}	–5 dBm		
		315 µW		
	Dynamic power (P_{RmaxH} to P_{RminH})	15 dB		
System value	P_{TminH} to P_{RminH}	9,5 dB	12,5 dB	4 dB
System reserve (including lifetime of transmitting diode)		≥ 5,1 dB		≥ 2 dB
Line attenuation (System value – System reserve)		≤ 4,4 dB	≤ 7,4 dB	≤ 2 dB
Measuring cable attenuation (typical)		0,2 dB/m	0,2 dB/m	10 dB/km
Cable length		≤ 22 m	≤ 37 m	≤ 200 m
Transmission rate (NRZI)		2 Mbit/s, 4 Mbit/s, 8 Mbit/s and 16 Mbit/s		
Bit error rate		≤ 10-9		
Temperature range		0 °C to 70 °C		

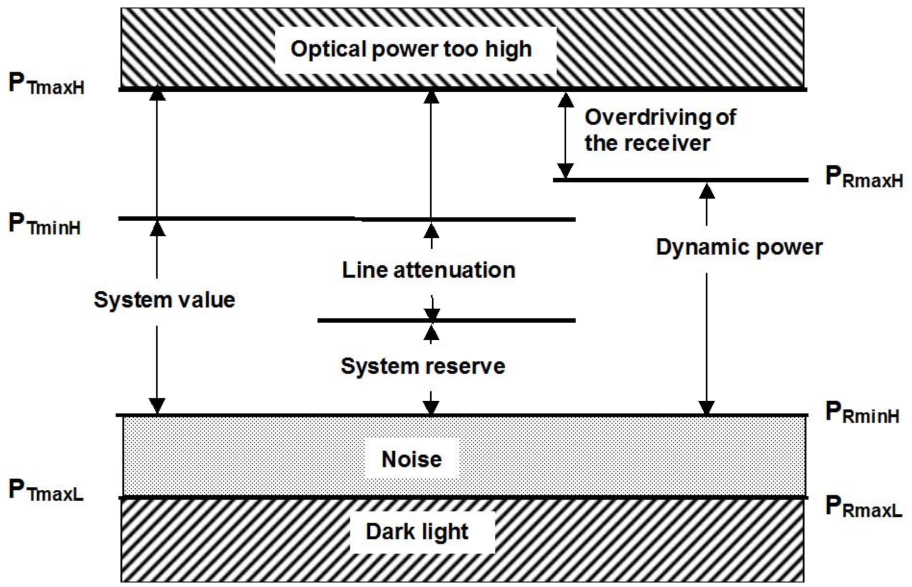

Figure O.3 – Optical power levels

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Annex P
(informative)

Type 16: Reference design example

P.1 Functional principles of the repeater circuit

Figure P.1 shows an example of an implementation of the signal-regeneration function from the repeater circuit. The primary task of this circuit consists of retrieving the clock RCLK from the NRZI-coded input signal IN. This may be accomplished e.g., by means of a digital phase-locked loop (DPLL). In addition, by sampling the input signal IN at appropriate times, a regenerated received signal RxD can be generated. The NRZI-coded signal is especially useful in the network structure.

The circuit consists of eight flip-flops and a combinational logic PLA. The flip-flops are driven by a common clock CX. This clock signal is generated by a crystal oscillator having 16 times the frequency of the data rate, which is 32 MHz at 2 Mbit/s transmission rate.

It is also possible to implement DPLLs having different sampling rates. In order to match the following condition, a sampling rate of at least 12 times is needed:

$$0 \le t_{cadreal} \le \frac{t_{bitnom}}{11}$$

Flip-flop 1 is used to initially synchronize the input signal. Flip-flop 2 is used for edge detection; it is always the case that if IN1 = 1 and IN2 = 0, a positive edge has been found. Flip-flops 5-8 in conjunction with the combinatorial logic are used to implement a finite-state machine.

The status diagram of Figure P.2 illustrates the behavior of the DPLL. States Z = 0 through Z = 15 correspond to the binary values which are given by the output signals of the flip-flops 5 to 8.

Depending on the status number (Z = 0 ... 15) in which E (event: light-on edge detected) or E* (event: no light-on edge detected) is detected, the DPLL reacts by repeating or skipping a status. If E is found to be in the state Z = 0, the DPLL does not repeat or skip (i.e., the DPLL is synchronized). Input signals are not sampled at the theoretical mean of the bit cell but in their shifted position. This enables the system to operate even with relatively strong distorted signals. During the transition from Z = 3 to Z = 4, RCLK = 1 is set. During the transition from Z = 10 or Z = 11 to Z = 12 and from Z = 11 to Z = 13, RCLK = 0 is set and the output signal RxD is set equal to the synchronized input signal IN1.

Figure P.3 illustrates the timing of various signals.

In general, the signal becomes distorted mainly by electrical-to-optical conversion and vice versa. In Figure P.3, it is shown what the signal IN1 looks like ideally, and what its typical shape is during minimum and maximum transmission power. The assumption is made that a series of NRZI-coded zeros is transferred. This corresponds to a rectangular signal with the period 2 × tBIT.

Increasing transmission power eventually overdrives the receiver. The electrical signal level corresponding to the optical "light-on" remains at the receiver output longer than the generating electrical signal at the transmitter's input. Since the signal IN1 is not symmetric, it is useful to synchronize the phase lock loop on one signal edge only. For this purpose, the light-on edge seems to be more stable. Depending on the physical circumstances (i.e.,

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inverted or non-inverted receiver) either the positive or the negative edge can be used as the input signal of the DPLL.

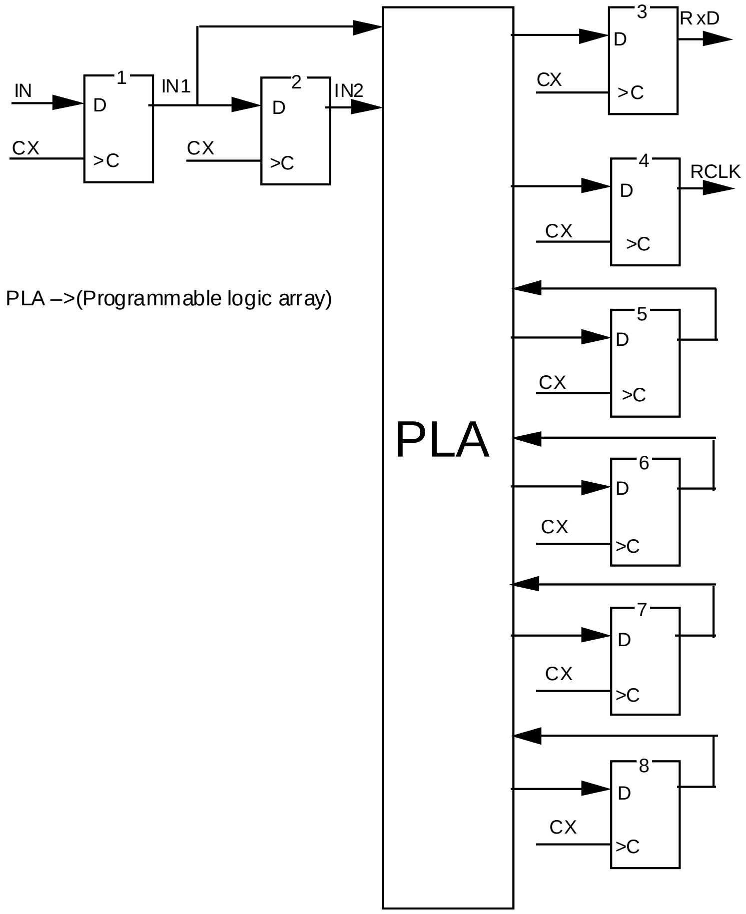

Figure P.1 – Example of an implemented DPLL

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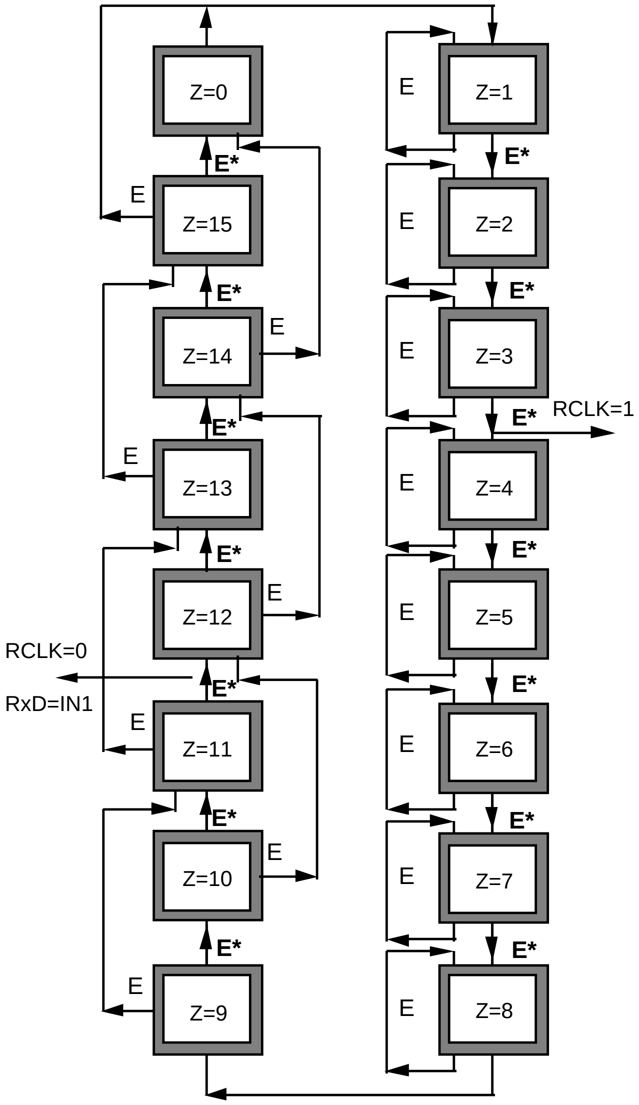

Key:

E = event that light-on edge is detected

E* = event that no light-on edge is detected.

Figure P.2 – DPLL status diagram

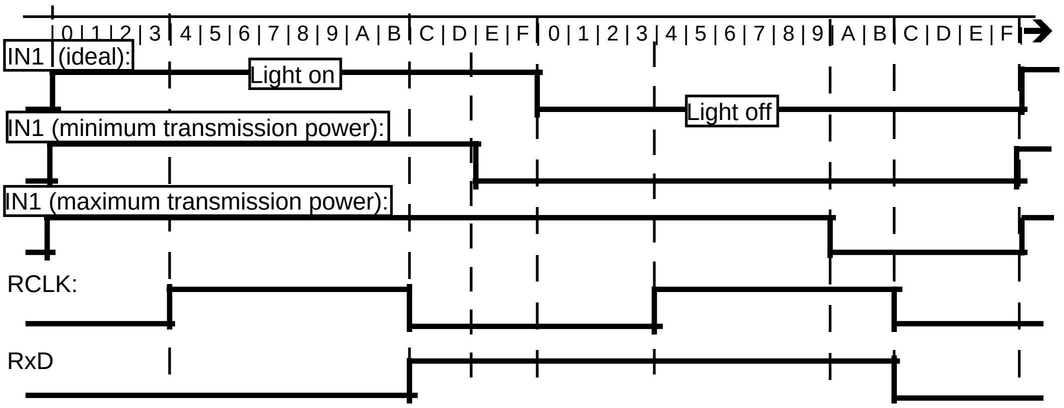

Figure P.3 – DPLL timing

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P.2 Attenuation on the transmission line

Clause P.2 shows which factors contribute to the attenuation along the transmission line.

Two levels of maximum allowable attenuation along the line are specified. A transmitter can be switched to drive a transmission line with "low attenuation" or "high attenuation". This reduces the effects of the large attenuation range (0 dB to 7,4 dB).

The following factors contribute to attenuation:

- the fiber optic cable
- possible additional couplings (e.g. wall breakthroughs)

The additional variable couplings do not include inserted attenuation due to F-SMA plug connectors on the transmitter output and receiver input.

The transmission "low attenuation" should be selected for a short transmission line without additional couplings (e.g., 2 dB attenuation along the line) whereas "high attenuation" is selected for a long transmission line with additional couplings (e.g., 7 dB attenuation along the line). When designing the line, care shall be taken that the maximum attenuation along the line does not exceed the power levels as defined by high and low attenuation, i.e. the level of the transmission power shall eventually be adapted to the expected attenuation along the line.

Attenuation due to the couplings is often specified by technical data for the plugs. Attenuation due to the fiber optic cable cannot be determined so simply. The reason is that the specific attenuation of the fiber optic cable is not constant in the range of the specified wavelength range. For instance, a cable with a specified attenuation of 220 dB/km may in fact have this rating for only a narrow range of wavelengths, around 650 nm. This specific attenuation rating can easily increase to a value in excess of 350 dB/km (at wavelengths of approximately 635 nm and approximately 680 nm).

Consider that the wavelength radiated by the transmitting diode shifts to longer wavelengths at increasing temperatures (λp and $\Delta\lambda$ increase), significant portions of the emitted light become attenuated by the fiber optic cable.

In order to determine the exact attenuation due to the fiber optic cable, the product of attenuation and radiated light power has to be integrated over the wavelength.

A 30 m long fiber optic cable with a typical attenuation rating of 220 dB/km may have an attenuation interval of 6 dB to 9 dB over the entire temperature range of 0 °C to +55 °C (due to shifted wavelength).

Another uncertainty factor contributing to attenuation along the line is assembly. A cleanly mounted and polished plug has a very low inserted attenuation, compared to a poorly installed plug.

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Annex Q
(normative)

Type 18: Connector specification

Q.1 Overview

Only Type 18-PhL-P defines specific connectors.

Q.2 Device connector

The required dimensions of the Type 18-PhL-P device connector are shown in Figure Q.1 for a right angle and Figure Q.2 for a straight board mount connector.

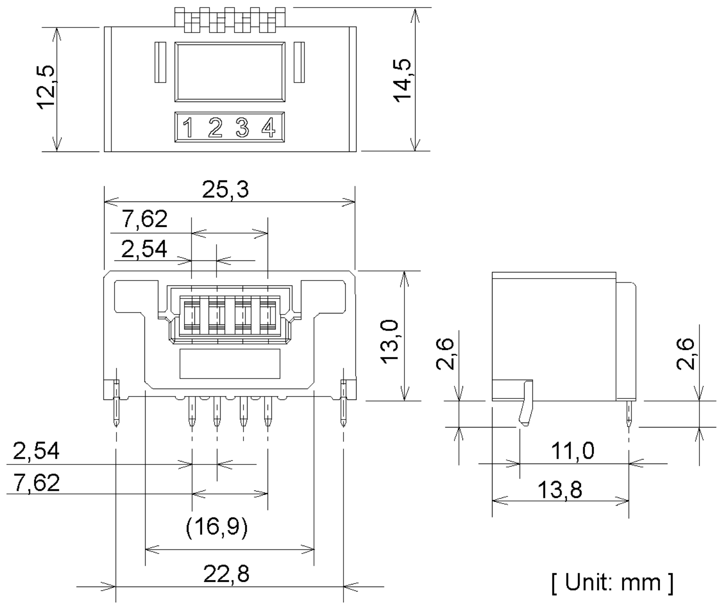

Figure Q.1 – PhL-P device connector r-a

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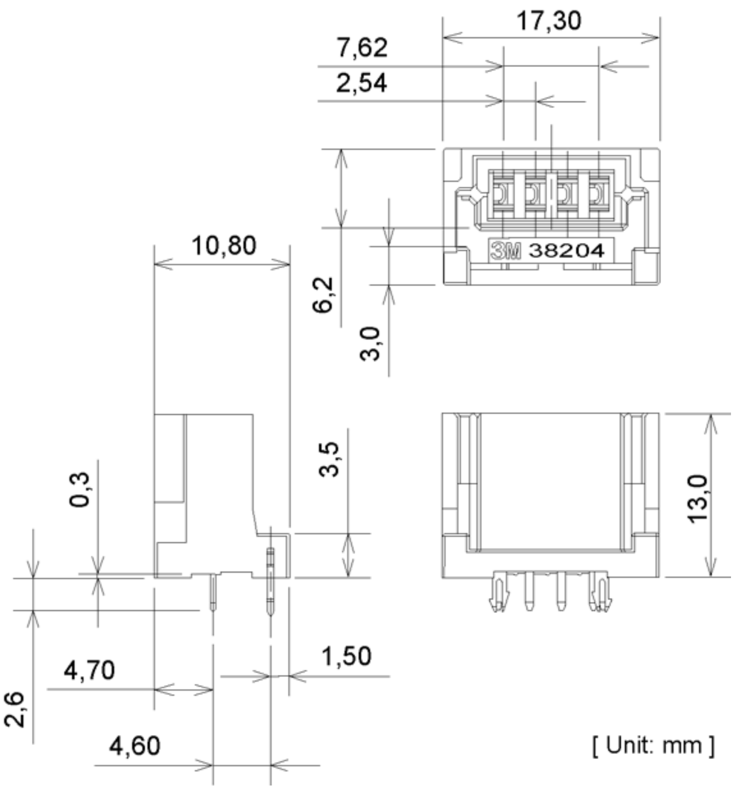

Figure Q.2 – PhL-P device connector straight

Q.3 Flat-cable connector

The required dimensions of the Type 18-PhL-P flat cable connector are shown in Figure Q.3 and Figure Q.4.

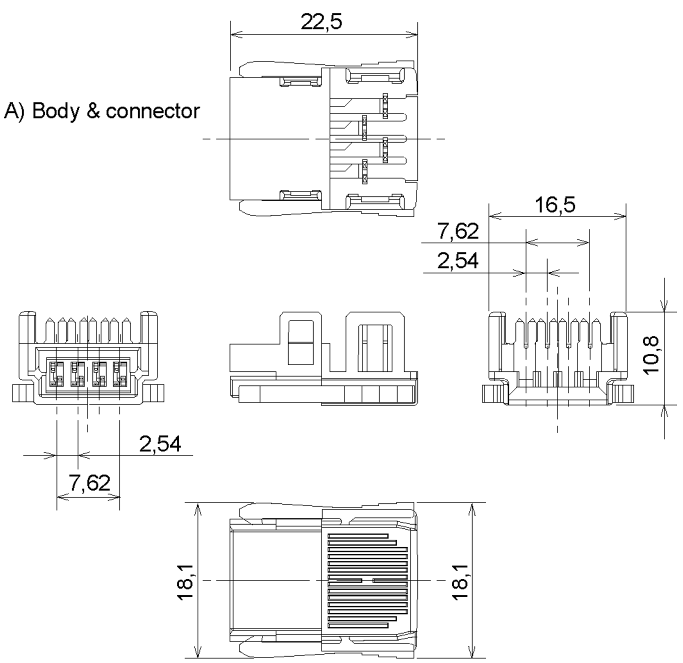

Figure Q.3 – PhL-P flat cable connector and terminal cover – body and connector

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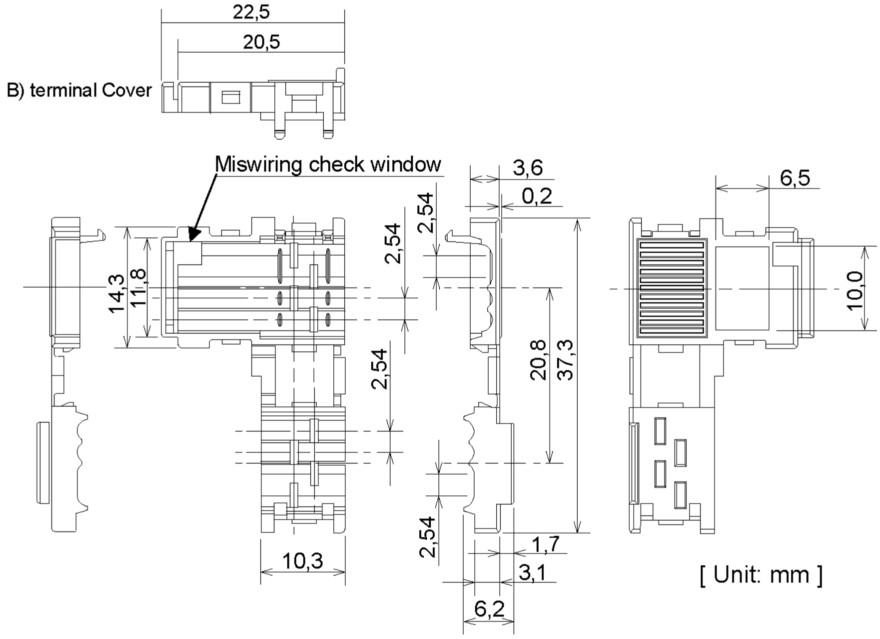

Figure Q.4 – PhL-P flat cable connector and terminal cover – terminal cover

Q.4 Round cable connector

The required dimensions of the Type 18-PhL-P round cable connector are shown in Figure Q.5 and Figure Q.6. This connector is applicable to both styles of Type 18-PhL-P round cable.

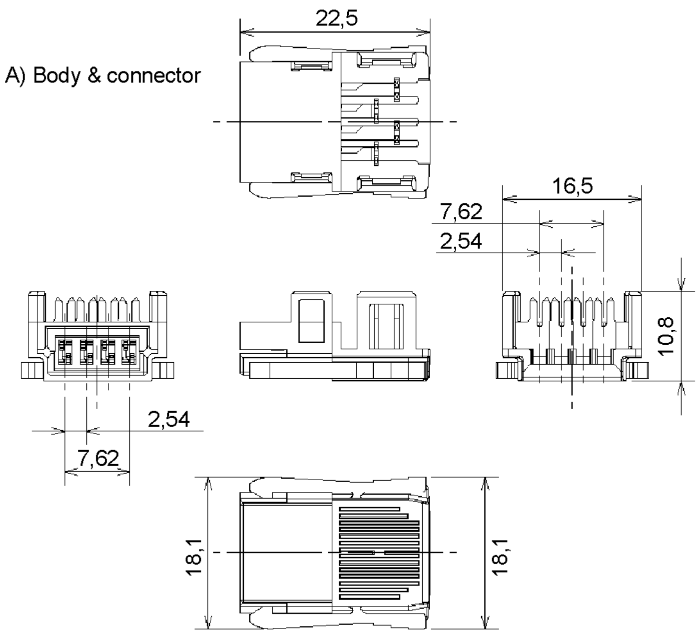

Figure Q.5 – Type 18-PhL-P round cable connector body

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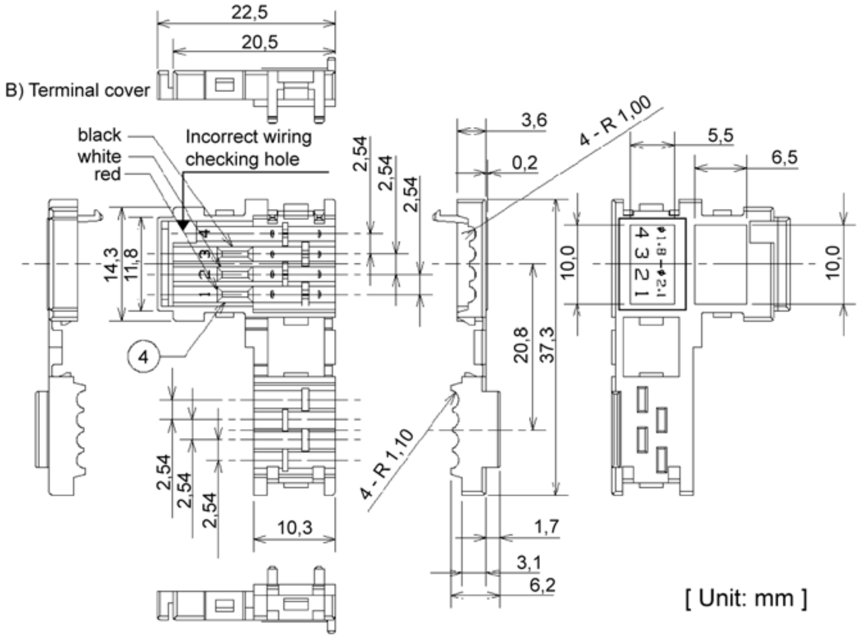

Figure Q.6 – Type 18-PhL-P round cable connector terminal cover

Q.5 Round cable alternate connector

The required dimensions of the Type 18-PhL-P round cable alternate connector is shown in Figure Q.7 and Figure Q.8.

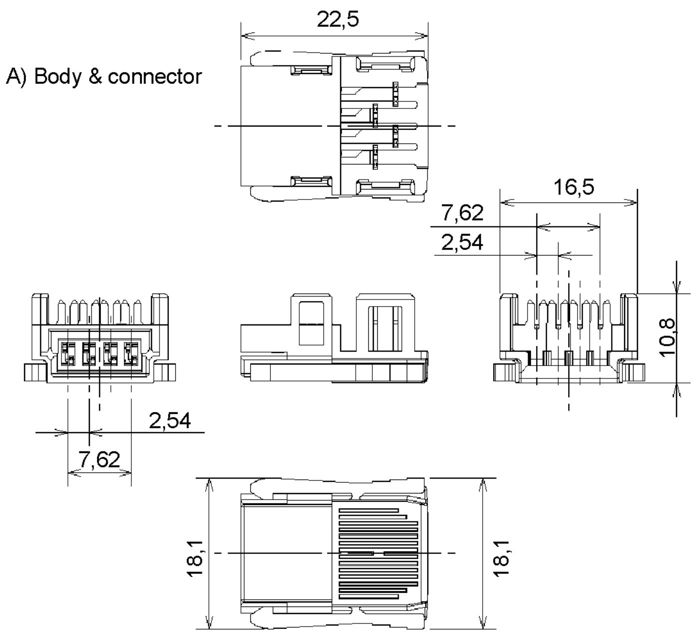

Figure Q.7 – Type 18-PhL-P round cable alternate connector and body

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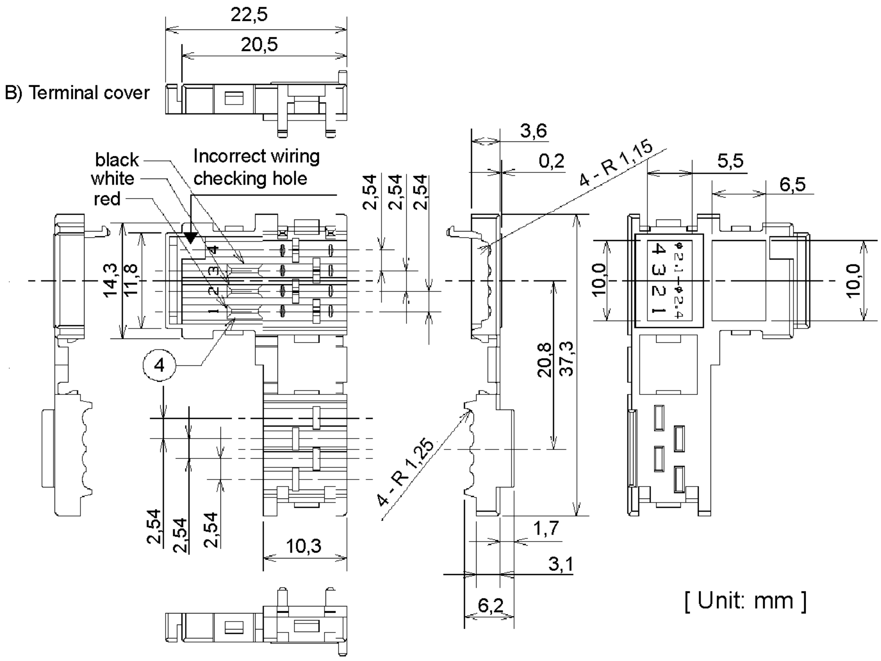

Figure Q.8 – Type 18-PhL-P round cable alternate connector terminal cover

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Annex R
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Type 18: Media cable specifications

R.1 Type 18-PhL-B cable

The 3-core twisted-pair cable Type 18-PhL-B medium is specified in Table R.1.

Table R.1 – PhL-B cable specifications

Item		Specifications
Cable type		Shielded twisted cable
Outer diameter		8,0 mm or less
Number of cores		3
Conductor size		20 AWG
Insulation size		0,55 mm to 0,80 mm
Drain line		20 lines/0,18 mm or 24 lines/0,18 mm Insert separately or in a bundle between the ground cable bundle and aluminium tape.
Conductor resistance (20 °C)		37,8 Ω/km or less
Insulation resistance		10 000 MΩ/km or more
Dielectric withstand voltage		500 VDC 1 min
Electrostatic capacity (1 kHz)		60 nF/km or less
Impedance characteristic	1 MHz	110 ± 15 Ω
	5 MHz	110 ± 6 Ω
Attenuation (20 °C)	1 MHz	1,6 dB/100 m or less
	5 MHz	3,5 dB/100 m or less
Cross section	Twisted drain	See Figure R.1
	Non-twisted drain	See Figure R.2

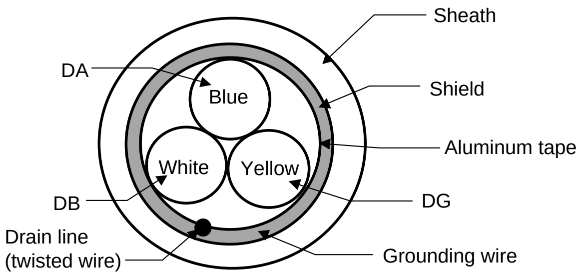

Figure R.1 – PhL-B cable cross section twisted drain

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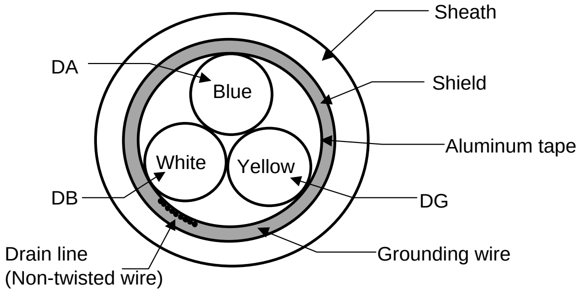

Figure R.2 – PhL-B cable cross section non-twisted drain

R.2 Type 18-PhL-P cable

R.2.1 Flat cable

The 4-core unshielded flat cable Type-18-PhL-P medium is specified in Table R.2.

Table R.2 – PhL-P flat cable specifications

Item		Unit	Specification	
Cable type		-	Flat cable	
Number of wire cores		-	4	
Conductor	Material	-	Tinned, annealed copper wire (collective twisting)	
	AWG	-	18	
	Construction	Lines/mm	43/0,16, 34/0,18, 30/0,18	
	Standard outline	mm	1,20 to 1,21	
	Pitch between twisted lines	mm	24,9 or less	
Insulating material	Material	-	Flexible resin	
	Standard thickness	mm	0,66 to 0,67	
	Outline (major axis × major axis)	mm	2,54 ± 0,15 × 10,16 ± 0,40	
	Line-to-line pitch	mm	2,54 ± 0,10	
Conductor resistance (at 20 °C)		Ω/km	23,4 or less	
Insulation resistance (at 20 °C)		MΩ/km	10 or more	
Withstand voltage		-	500 VAC, 1 min	
Characteristic impedance (reference value)		Ω	1 MHz	130 ± 25
			2 MHz	
Attenuation amount(reference value)		dB/100 m	1 MHz	3,04 or less
			2 MHz	4,83 or less
Electrostatic capacity (reference value)		nF/km	1 kHz	55 or less
Cross section – with key (recommended)		–	See Figure R.3	
Cross section – without key		-	See Figure R.4	
Polarity marking		-	See Figure R.5	

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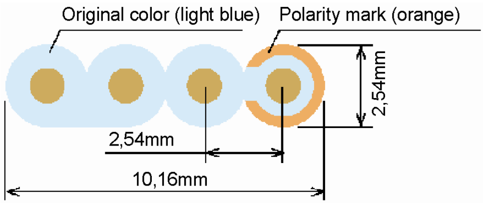

Figure R.3 – PhL-P flat cable cross section – with key

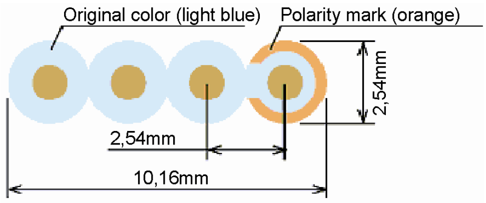

Figure R.4 – PhL-P flat cable cross section – without key

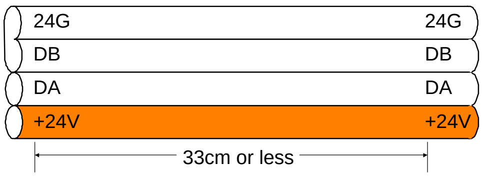

Figure R.5 – PhL-P flat cable polarity marking

R.2.2 Round cable – preferred

The preferred 4-core unshielded round cable for the Type-18-PhL-P medium is specified in Table R.3. This cable type is also known as VCTF cord.

Table R.3 – PhL-P round cable specifications – preferred

Item		Unit	Specification
Cable type		–	Polyvinyl chloride sheathed round cable
Number of wire cores		–	4
Conductor	Nominal cross-sectional area	mm^2	0,75
	Number of wires/diameter of a wire	wire/mm	30/0,18
	Outer diameter	mm	1,1
Insulator	Thickness	mm	0,6
	Outer diameter (approx.)	mm	2,3
Sheath	Thickness	mm	1,0
	Finish outer diameter (approx.)	mm	7,6
Conductor resistance (at 20 °C)		Ω/km	25,1
Cross-section		-	See Figure R.6

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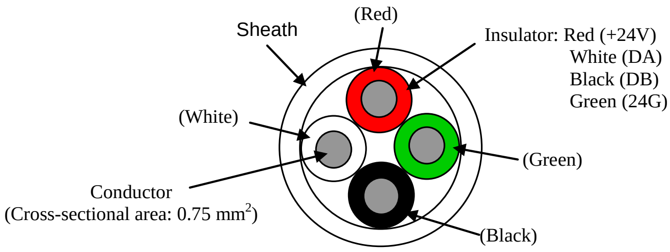

Figure R.6 – Round cable – preferred; cross section

R.2.3 Round cable – alternate

The alternate 4-core unshielded round cable for the Type-18-PhL-P medium is specified in Table R.4.

Table R.4 – PhL-P round cable specifications – alternate

Item		Unit	Specification	
Number of wire cores		-	4	
Conductor	Cross-sectional area	mm^2	0,75	
Insulator	Outer diameter	mm	1,8 to 2,4	
Conductor resistance (at 20 °C)		Ω/km	35 or less	
Conductor resistance (at 20 °C) (reference value)		MΩ/km	5 or more	
Withstand voltage (reference value)		-	500 VAC, 1 min	
Characteristic impedance (reference value)		Ω	1 MHz	90 ± 30
			2 MHz	
Drop in decibel level (reference value)		db/100 m	1 MHz	4 or less
			2 MHz	5 or less
Electric capacity (reference value)		nF/km	1 MHz	100 or less
Cross section		-	See Figure R.7	

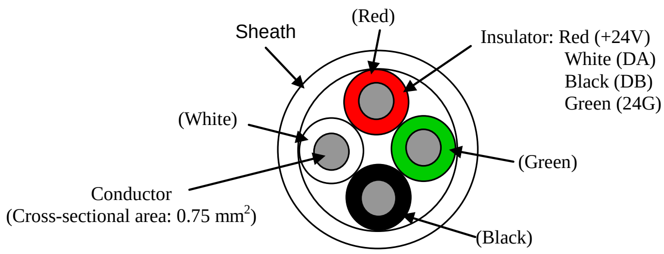

Figure R.7 – Round cable – alternate; cross-section

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Annex S
(normative)

Type 24: Connector specification

S.1 Overview

This annex specifies following two types of connectors based on media:

– type 24-1 connector for twisted-pair wire medium;
– type 24-2 connector for Ethernet based medium.

S.2 Type 24-1 connector

S.2.1 Type 24-1 device connector

The dimensions of type 24-1 device connector (1 row) are shown in Figure S.1.

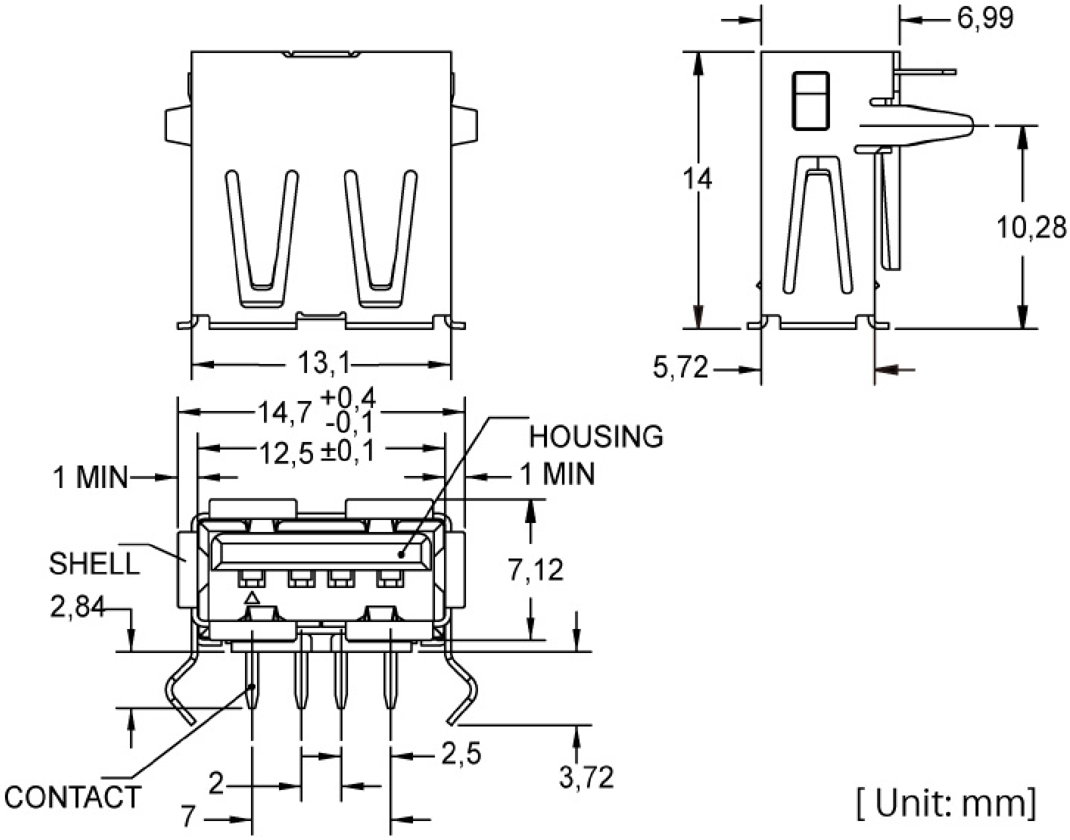

Figure S.1 – Type 24-1 device connector dimensions (1 row)

The dimensions of type 24-1 device connector (2 rows) are shown in Figure S.2.

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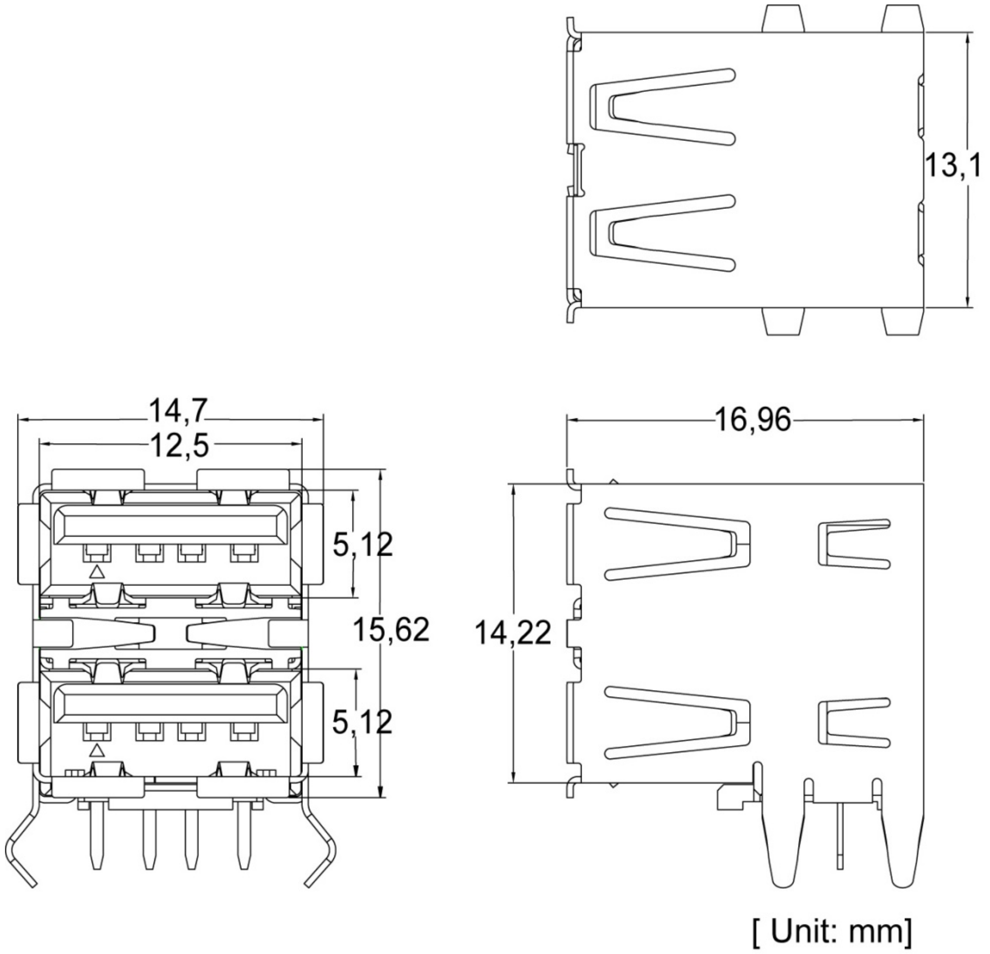

Figure S.2 – Type 24-1 device connector dimensions (2 rows)

S.2.2 Type 24-1 cable connector

The dimensions of type 24-1 cable connector are shown in Figure S.3.

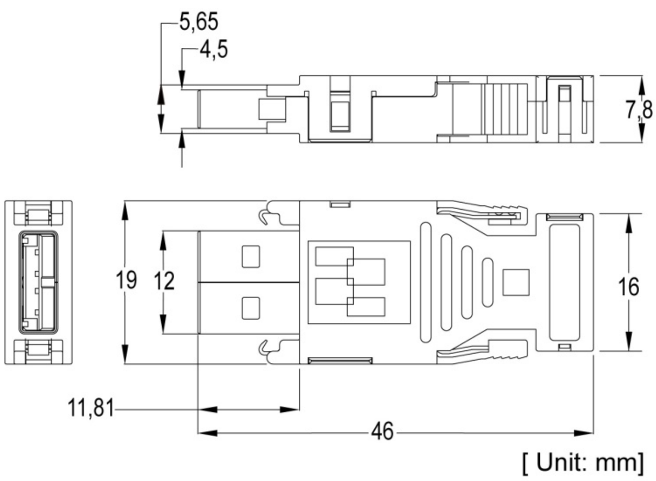

Figure S.3 – Type 24-1 cable connector dimensions

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S.3 Type 24-2 connector

S.3.1 Type 24-2 device connector

The dimensions of type 24-2 device connector are shown in Figure S.4.

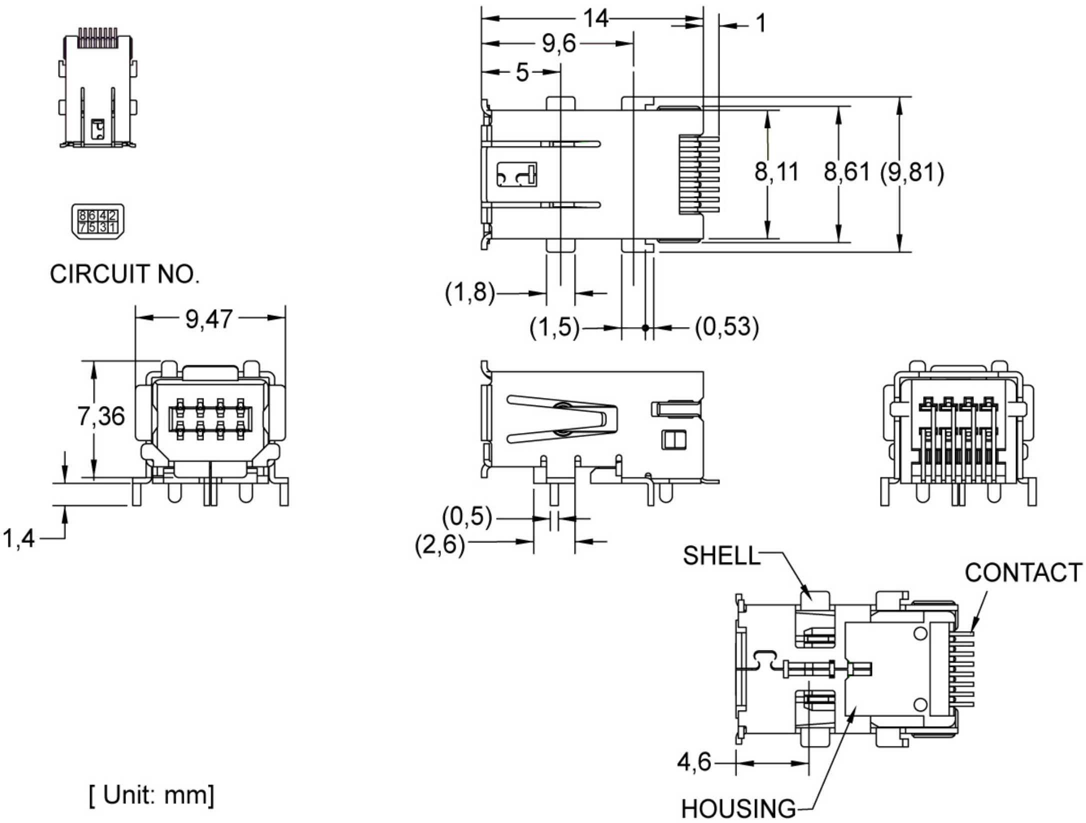

Figure S.4 – Type 24-2 device connector dimensions

S.3.2 Type 24-2 cable connector

The dimensions of type 24-2 cable connector are shown in Figure S.5.

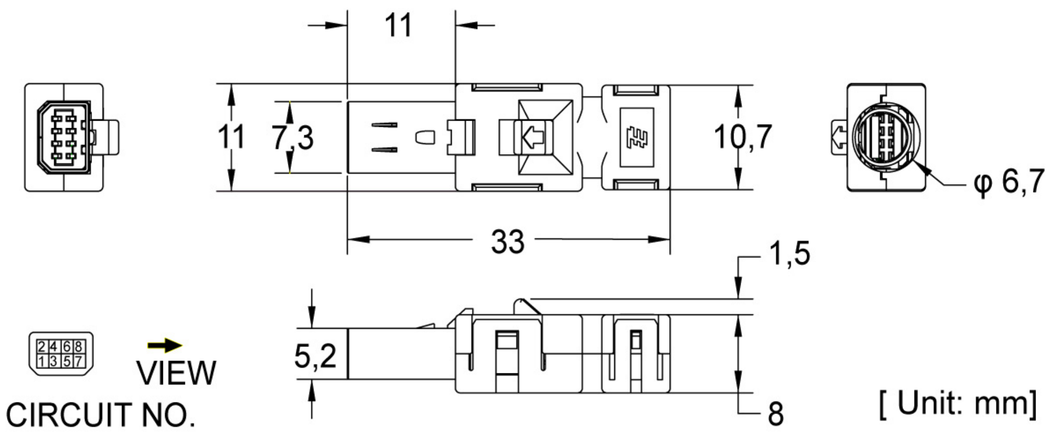

Figure S.5 – Type 24-2 cable connector dimensions

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Annex T
(informative)

Type 20: Network topology, cable characteristics and lengths, power distribution through barriers, and shielding and grounding

T.1 Topology examples

T.1.1 General

The devices conforming to this standard can be used in networks with various topologies. This annex provides some of the examples.

T.1.2 Point-to-point current input network

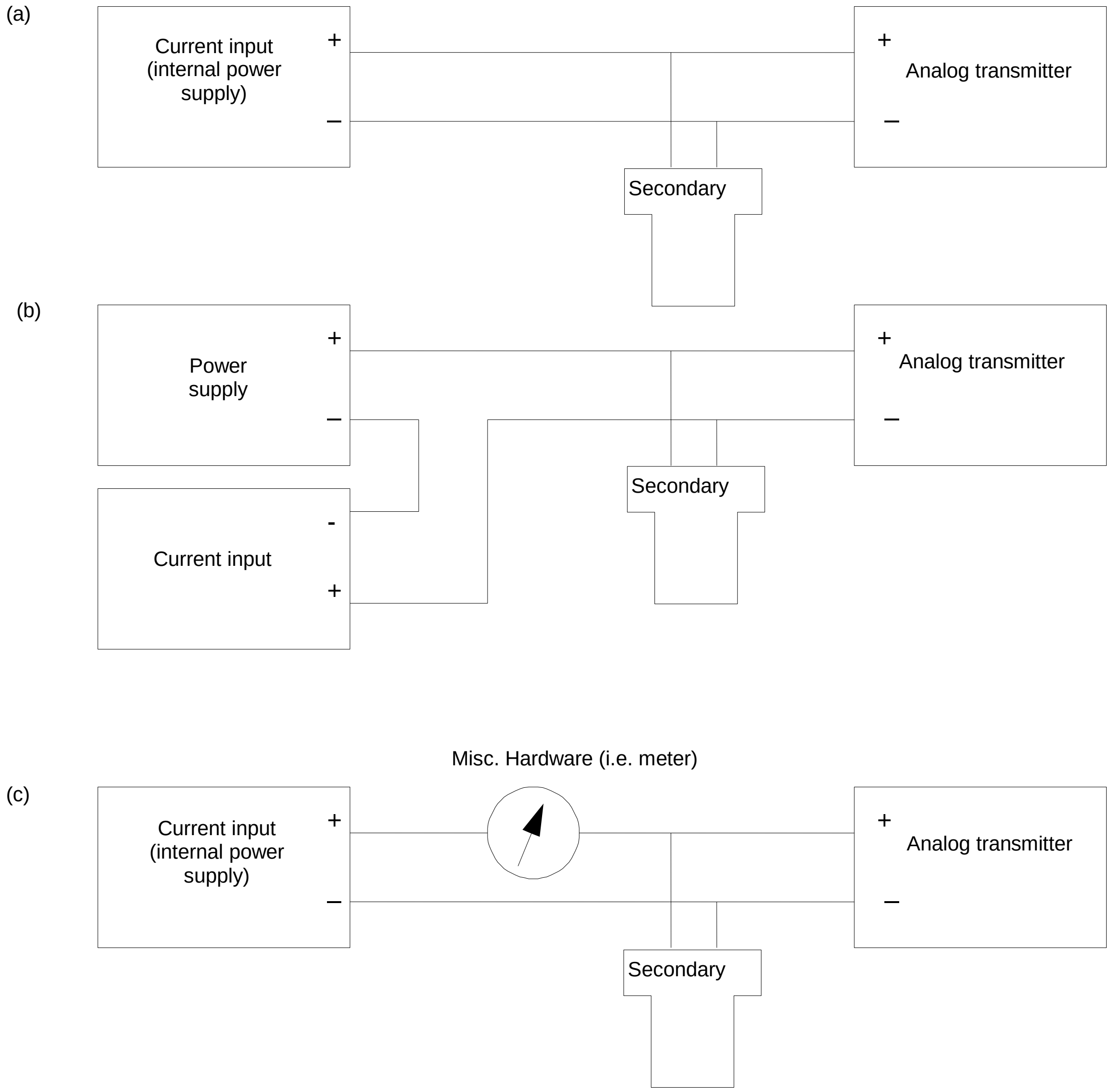

Figure T.1 – Point-to-point current input network

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The Figure T.1 shows a network with one Analog transmitter, one current input device and one secondary device – see 34.3.3 for connection types. The current input device in Figure T.1 (a) and Figure T.1 (c) has an internal power supply for the network. The topology of the Figure T.1 (b) uses a separate power supply. There can be other entity (meter) in the network as shown in the Figure T.1 (c), because it has low impedance in series with the cable.

T.1.3 Point-to-point current output network

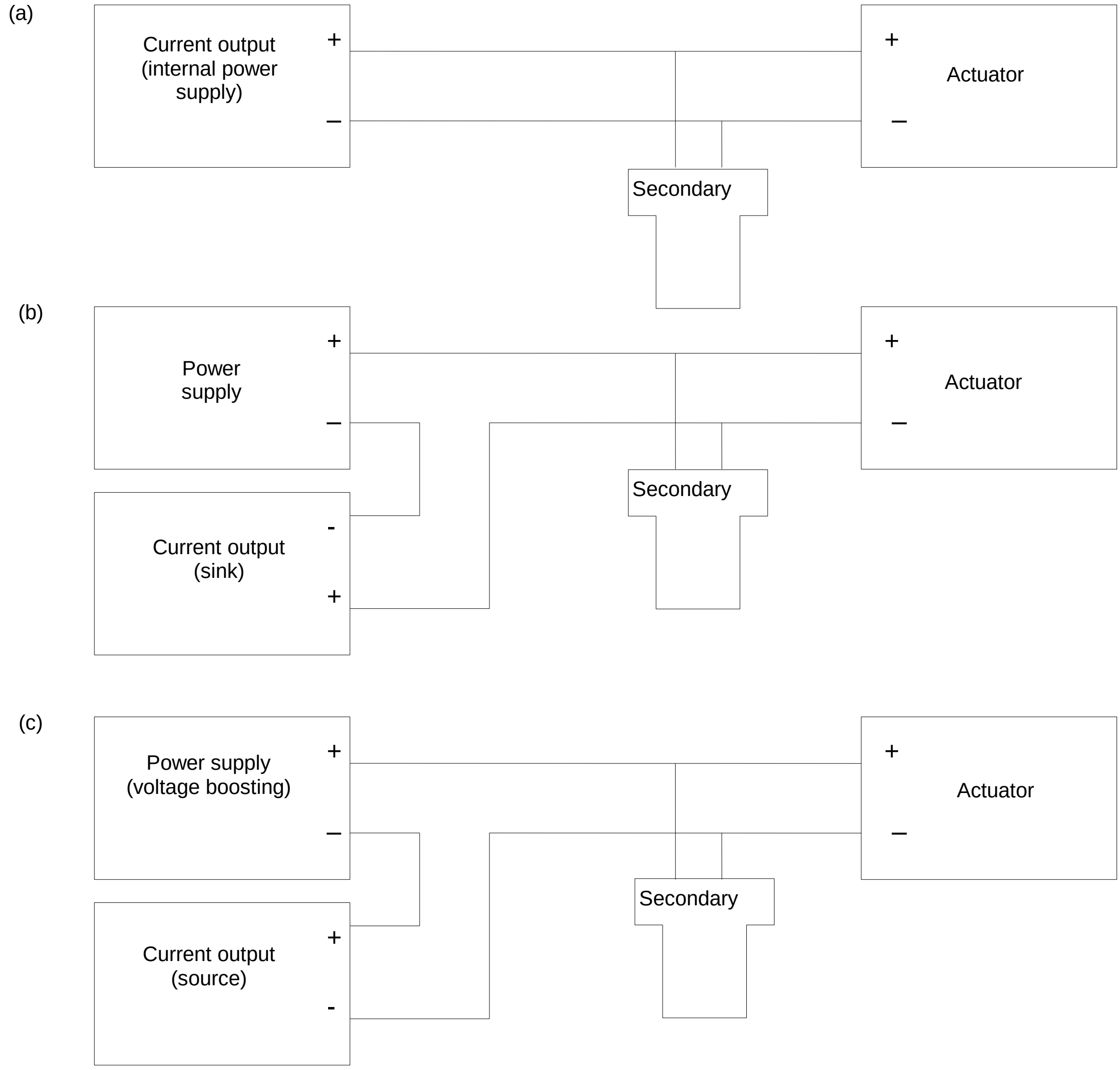

Figure T.2 – Point-to-point current output network

The Figure T.2 shows a network with one Actuator, one output device and one secondary device – see 34.3.3 for connection types. The current output device in Figure T.2 (a) has internal power supply for the network.

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T.1.4 Multi-drop network

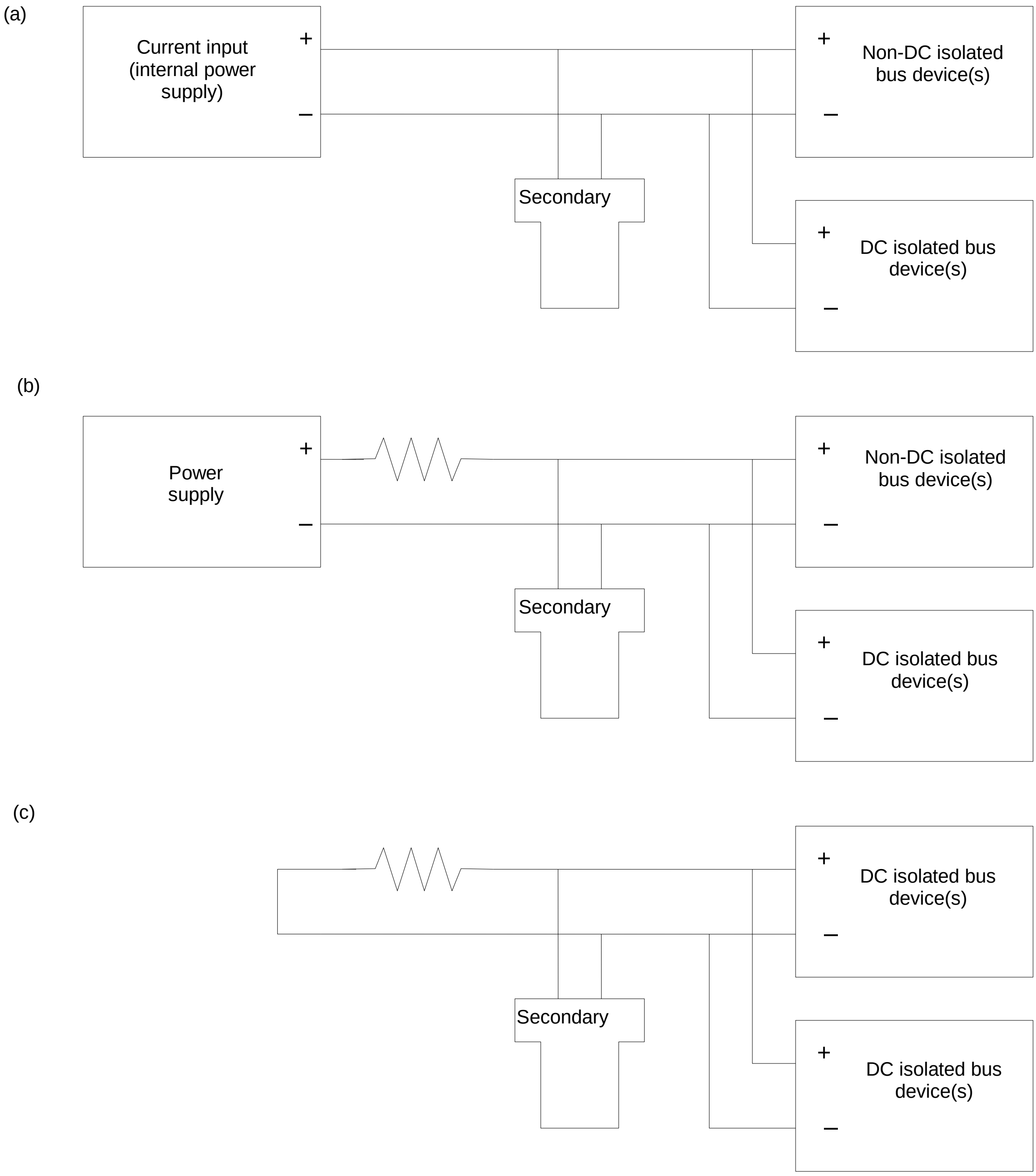

Figure T.3 – Multi-drop network

Figure T.3 shows a multi-dropped network with two slaves. As shown in Figure T.3 (b) and (c), it is not necessary to connect any current input device. But, it is necessary to have current sensing resistor in the network. The power supply is required only if the network has at least one device that draws DC current.

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T.1.5 Multi-drop network with analog signaling

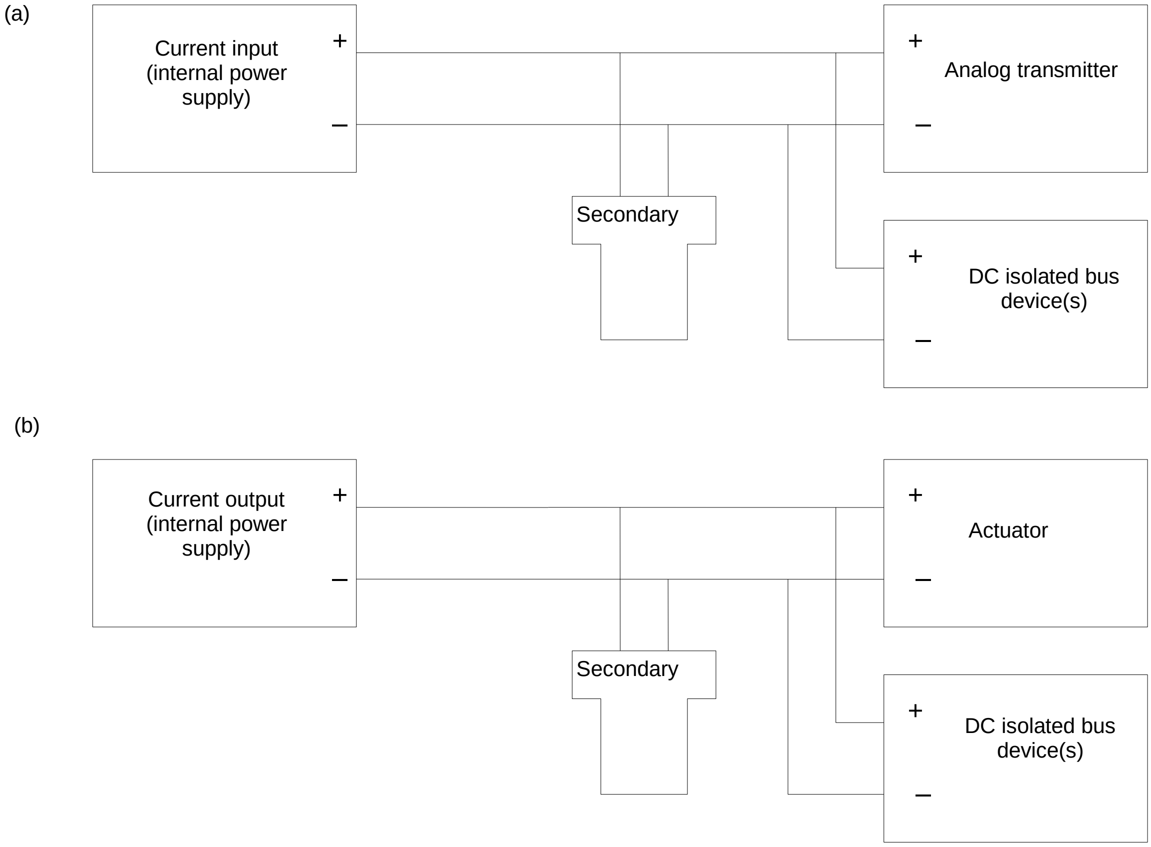

Figure T.4 – Multi-drop network with analog signaling

Figure T.4 shows a multi-dropped network with one slave that uses analog signaling and one slave that does not. It is necessary to connect a current input device for Analog transmitter as shown in the Figure T.4 (a), or current output device for Actuator.

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T.1.6 Series connected network

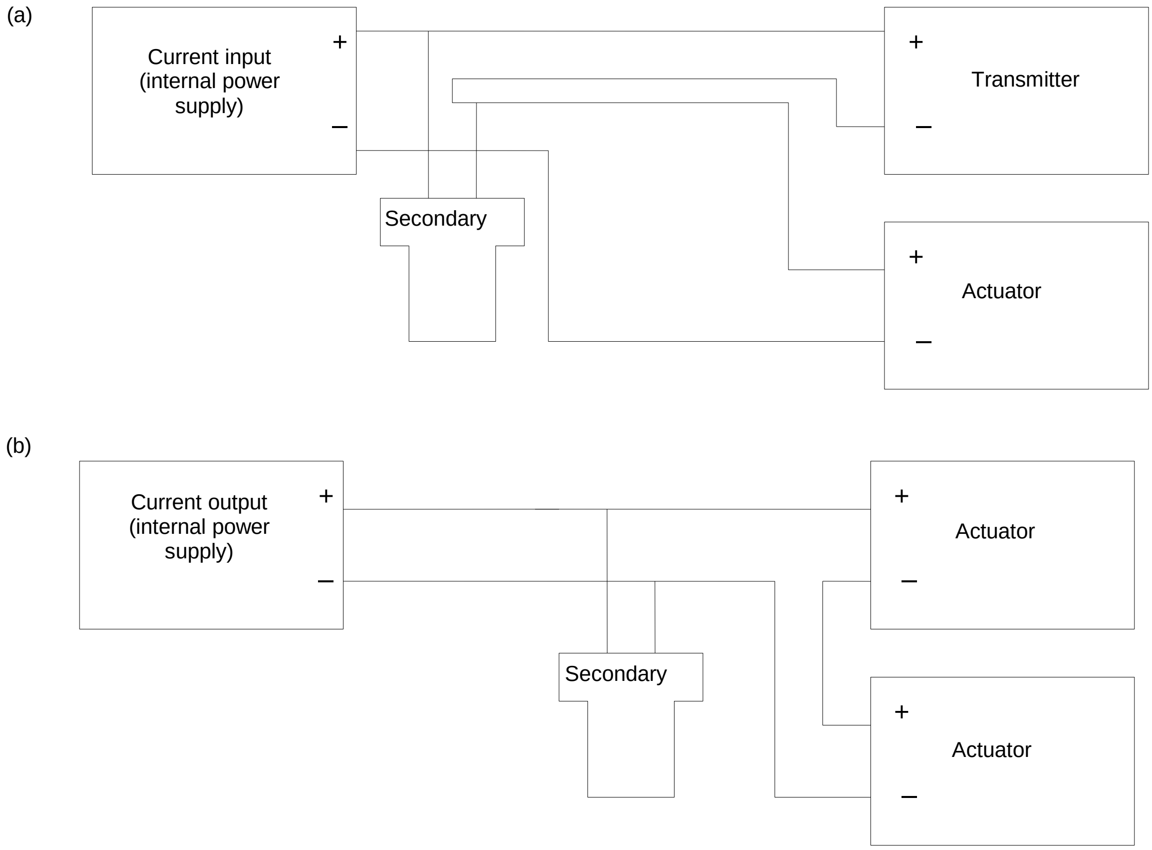

Figure T.5 – Series connected network 1

Figure T.5 shows a series connected network with two slaves, one secondary device and one current input or current output device. The secondary device has to be connected across high impedance device as shown in Figure T.5 (a). If the network does not have a high impedance device as shown in Figure T.5 (b), then the secondary has to be connected across the current output device. If this rule is not followed, then communication with all devices is not possible.

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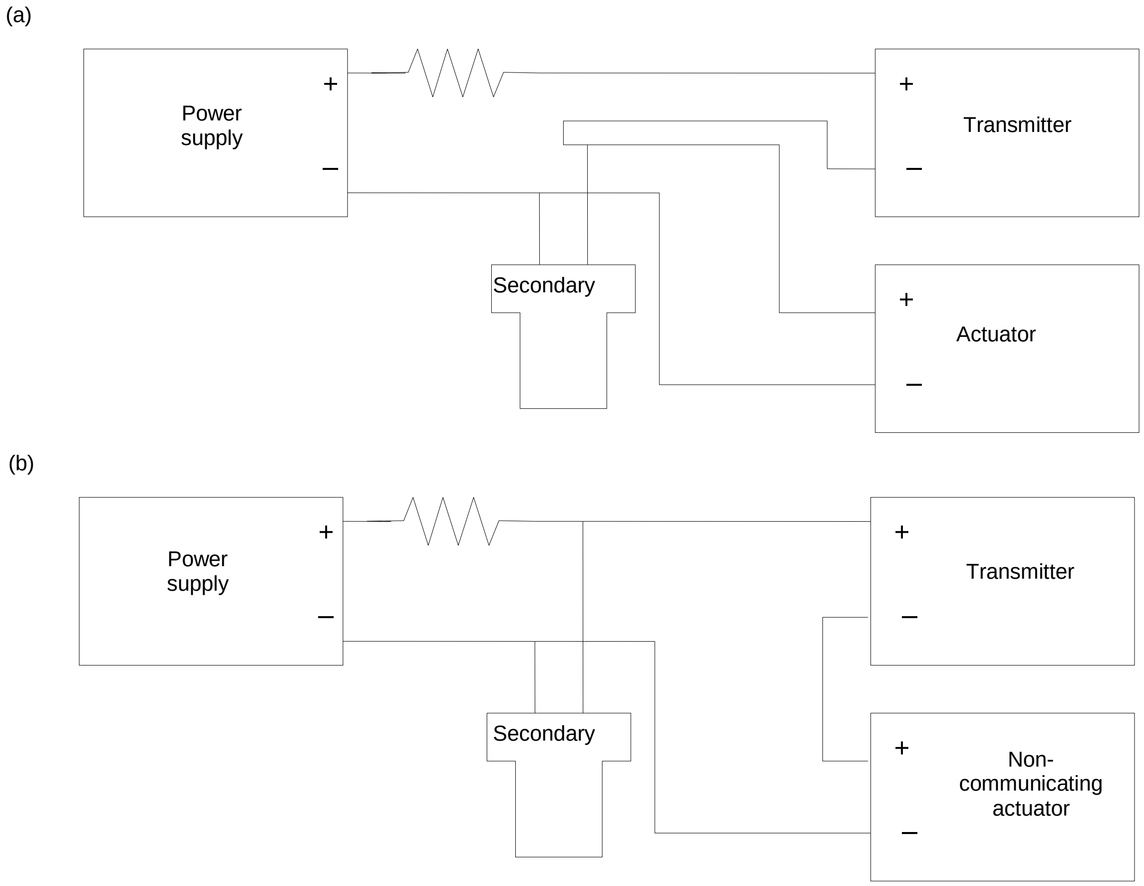

Figure T.6 – Series connected network 2

Figure T.6 shows a series connected network with two slaves, one secondary device and no current input or current output device. The secondary device has to be connected across one of the devices. If this rule is not followed, then communication with all devices is not possible. It is possible to connect a non-communicating device as shown in the Figure T.6 (b).

The communicating Actuator in all of series connected networks is a low impedance device. To achieve the longest cable length, it is necessary to match its impedance with the impedance of the other low impedance device in the network – the series sense resistor or the current input or current output device.

T.2 Cable description and specifications

T.2.1 General

The preferred cable is a single or multiple, twisted pair with overall shield. Single and multiple-pair may be combined in a given network provided all the devices at one end (typically the control room end) of the multi-pair cable share a common shield or chassis ground, and the overall shield is connected to this ground. Unshielded cable should be used only if it is known that the ambient noise or crosstalk is low enough to keep the communication error rate below acceptable limit. The following are the preferred minimum conductor sizes:

- Total cable length up to 1 500 m – 0,51 mm diameter,
  NOTE 1 This is the same as 24 AWG wire.
- Total cable length more than 1 500 m – 0,81 mm diameter
  NOTE 2 This is the same as 20 AWG wire.

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T.2.2 Single pair cable length

T.2.2.1 Parameters

The maximum length of cable for a network is dependent on the characteristics of the devices connected to the network and the characteristics of the cable to be used. For all cable length estimates, the parameters defined in Table T.1 are required.

Table T.1 – Device and cable parameters

Symbol	Parameter name	Parameter description
$\sum C_{dev}$	Parallel device capacitance	Sum of the equivalent device capacitance (C_{dev}) values of all connected devices
$\sum R_{dev}$	Parallel device resistance	Parallel combination of the equivalent device resistance (R_{dev}) values of all connected devices
R_{ser}	Miscellaneous series impedance	Sum of the maximum impedance over frequency range of 500 Hz to 10 kHz, of all devices connected in series between two communicating devices
C_{cbl}	Cable capacitance per unit length	The capacitance from one conductor to all other conductors (including the shield if shielded)
R_{cbl}	Cable resistance per unit length	The resistance of the both conductors in series

T.2.2.2 Procedure

Determine the parameter values defined in T.2.2.1. The C_{dev} and R_{dev} are provided by the device manufacturer. Typically there is only one low impedance device in the network for example, the current input device in an analog transmitter loop and it dominates the value of $\sum R_{dev}$. The effect of high impedance device connected to the network is usually negligible in calculating the $\sum R_{dev}$. Therefore, the R_{dev} of the single low-impedance device may be used for the parallel device resistance value. A typical non-intrinsically safe loop does not have miscellaneous series impedance. Passive IS barriers and current indicators are examples of series devices. Series topologies, such as field devices with PID capability or split-ranged actuator devices, are analyzed by treating one of the field devices as a miscellaneous series resistance while analyzing the network for the other. The values of C_{cbl} and R_{cbl} are provided by the cable manufacturer. After the parameter values are known, the charts shown in Figure T.7 to Figure T.27 are used to find the maximum cable length that can be used. It may be necessary to interpolate the values in the charts for actual parameter values.

Figure T.7 shows the maximum cable length that can be used for a network with one slave device and a 250 Ω series sense resistor. An ideal network has dominant low impedance device of 250 Ω, high impedance devices of 100 kΩ or larger and a cable with low capacitance.

Figure T.8, Figure T.9, Figure T.10 and Figure T.11 show the total allowable cable capacitance for a network that contains multiple devices and no miscellaneous series impedance. The maximum cable length can be calculated from the allowable cable capacitance value. Figure T.12, Figure T.13, Figure T.14 and Figure T.15 show the total allowable cable capacitance for a network that contains multiple devices and various values of series impedance for a cable with capacitance to resistance ratio of 1 000. Figure T.16, Figure T.17, Figure T.18 and Figure T.19 show the total allowable cable capacitance for a network that contains multiple devices and various values of series impedance for a cable with capacitance to resistance ratio of 2 000. Figure T.20, Figure T.21, Figure T.22 and Figure T.23 show the total allowable cable capacitance for a network that contains multiple devices and various values of series impedance for a cable with capacitance to resistance ratio of 5 000. Figure T.24, Figure T.25, Figure T.26 and Figure T.27 show the total allowable cable capacitance for a network that contains multiple devices and various values of series impedance for a cable with capacitance to resistance ratio of 10 000.

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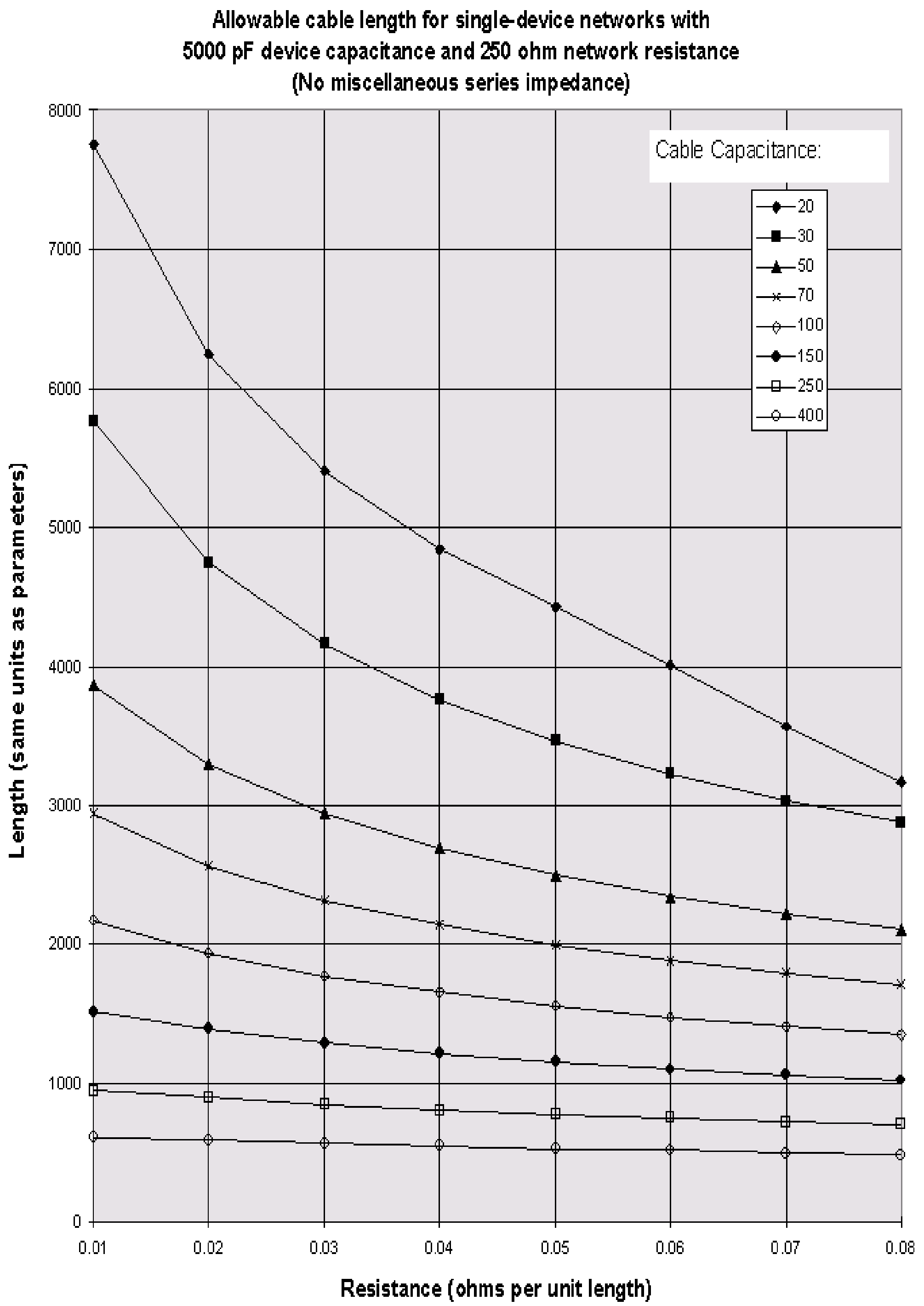

Figure T.7 – Cable length for single slave device network

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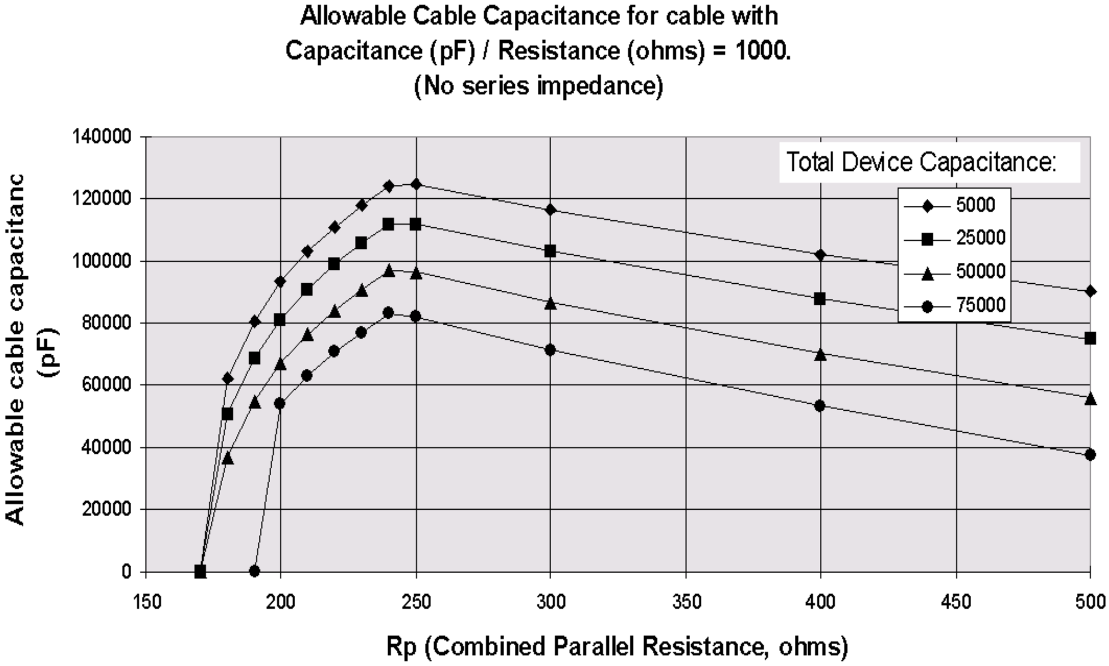

Figure T.8 – Cable capacitance for C_{cbl}/R_{cbl}=1 000

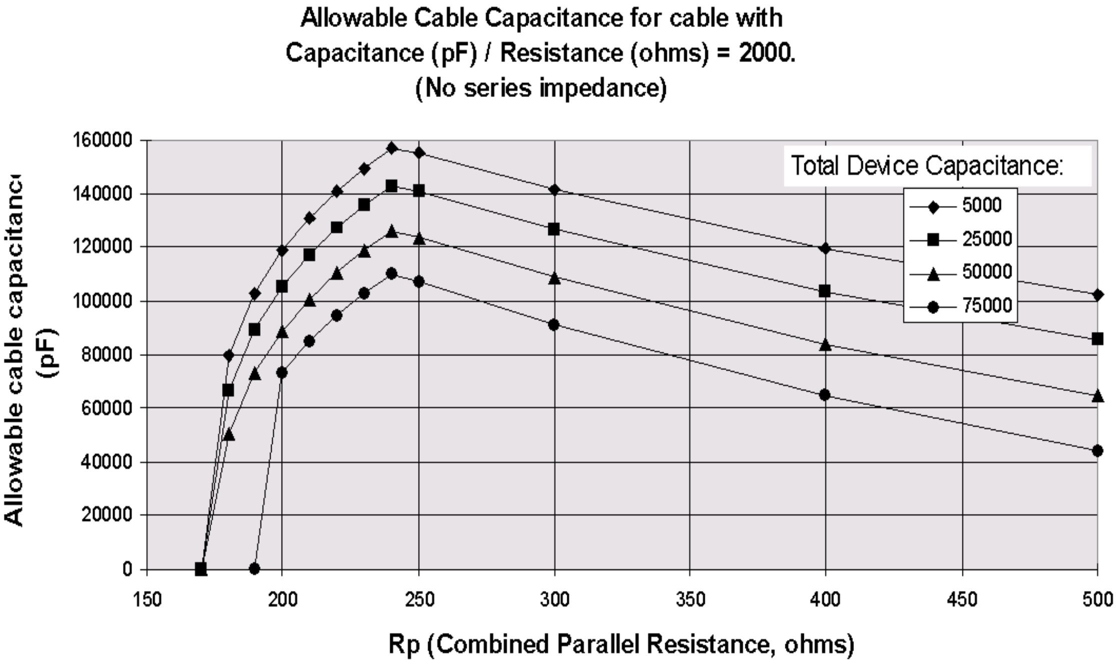

Figure T.9 – Cable capacitance for C_{cbl}/R_{cbl}=2 000

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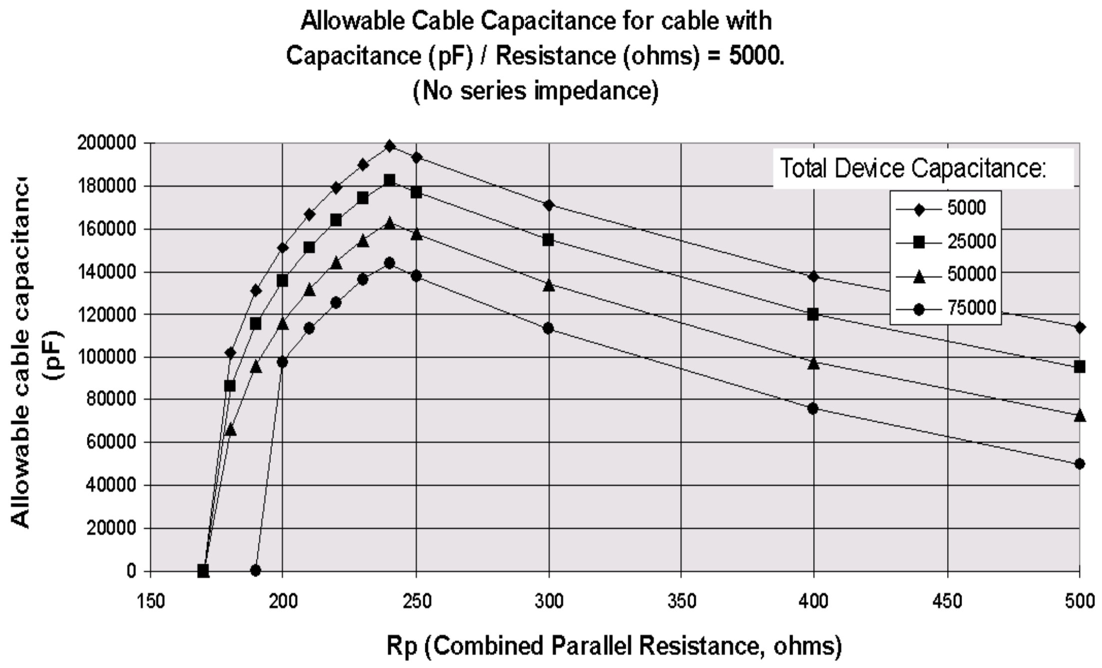

Figure T.10 – Cable capacitance for C_{cbl}/R_{cbl}=5 000

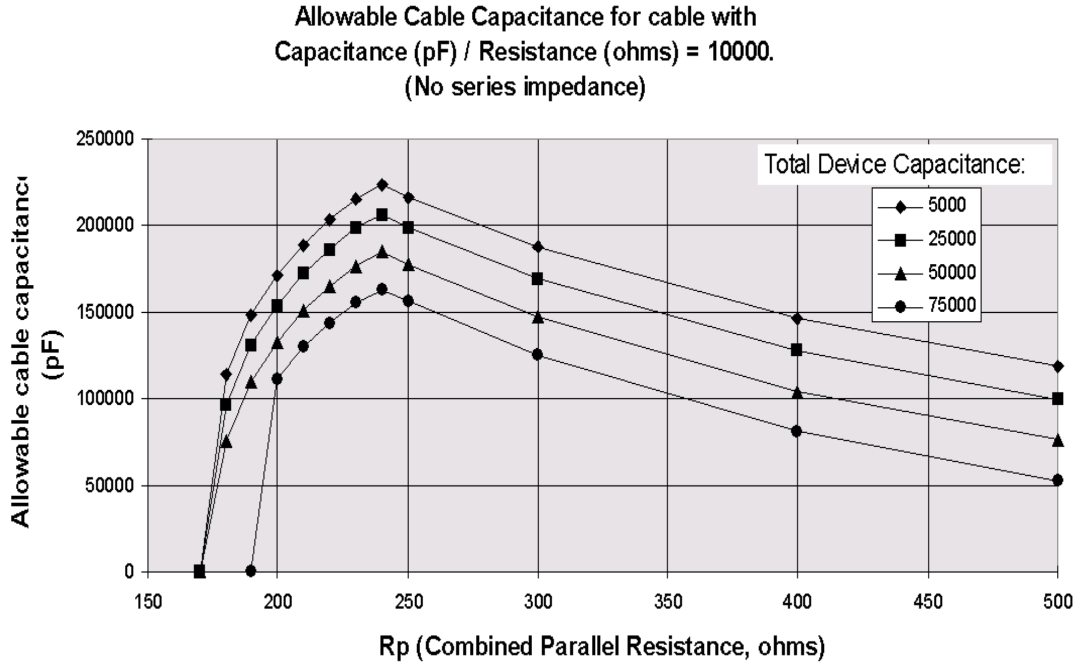

Figure T.11 – Cable capacitance for C_{cbl}/R_{cbl}=10 000

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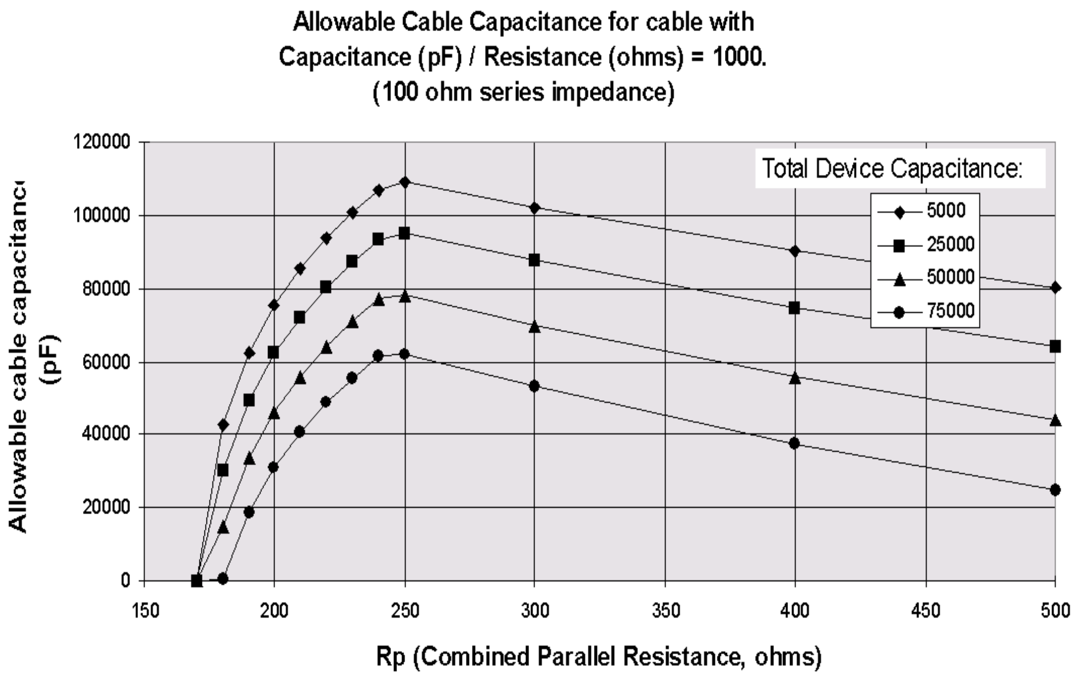

Figure T.12 – Cable capacitance for C_{cbl}/R_{cbl}=1 000, 100 Ω series resistance

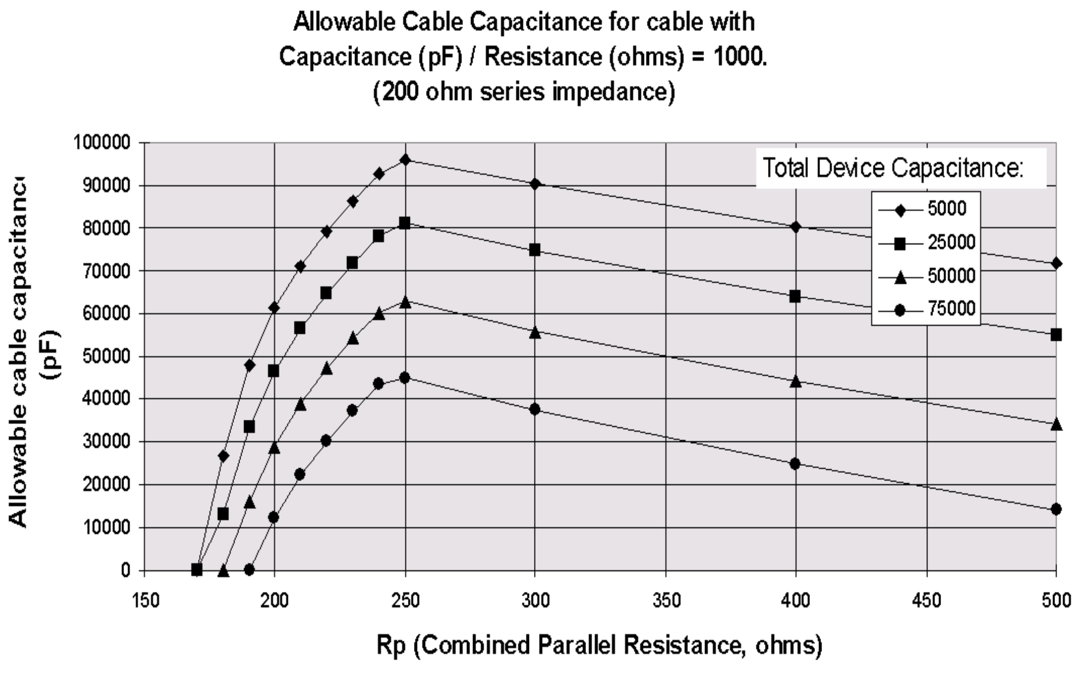

Figure T.13 – Cable capacitance for C_{cbl}/R_{cbl}=1 000, 200 Ω series resistance

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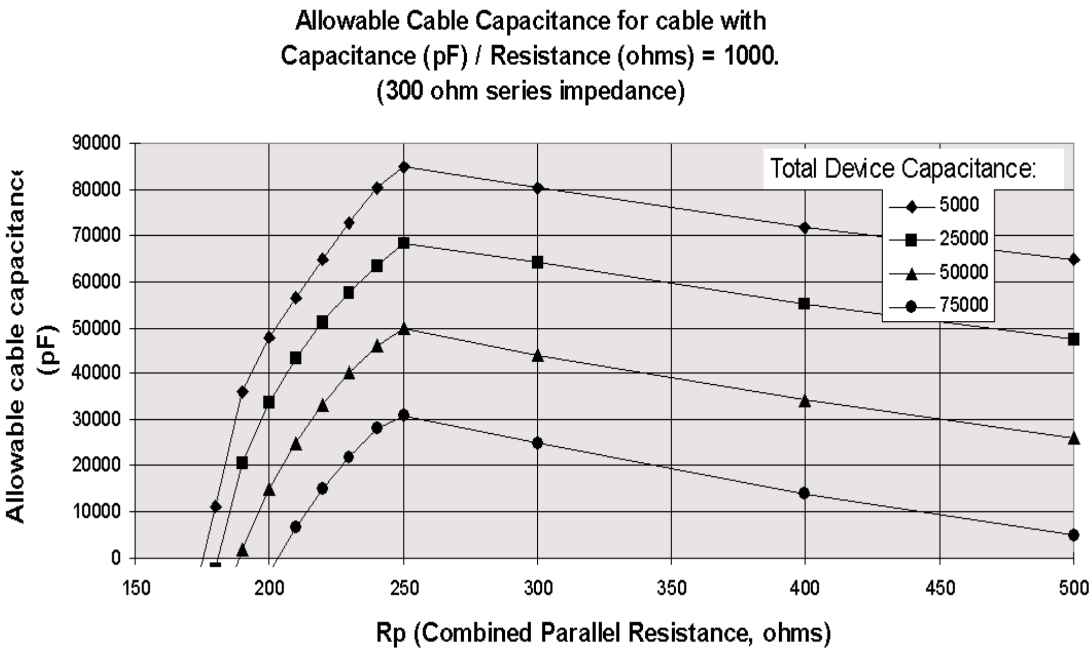

Figure T.14 – Cable capacitance for C_{cbl}/R_{cbl}=1 000, 300 Ω series resistance

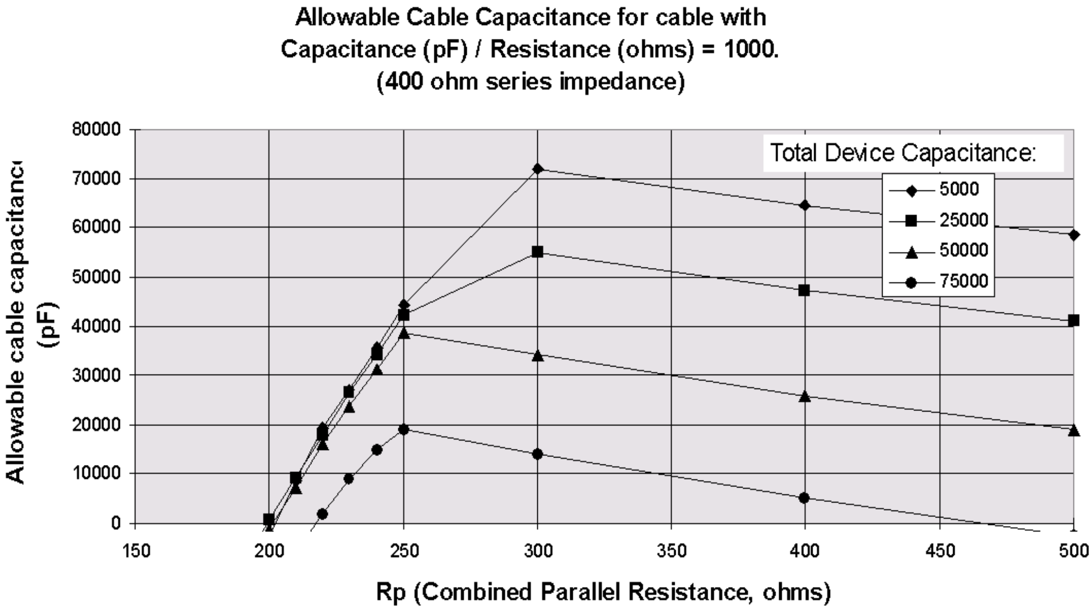

Figure T.15 – Cable capacitance for C_{cbl}/R_{cbl}=1 000, 400 Ω series resistance

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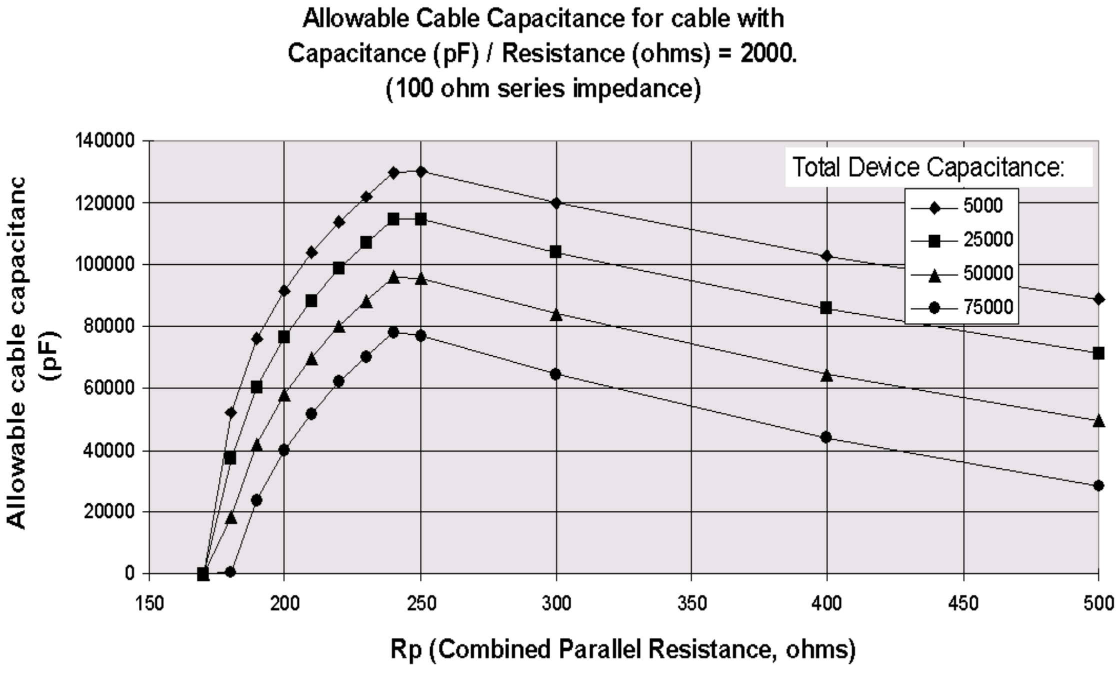

Figure T.16 – Cable capacitance for C_{cbl}/R_{cbl}=2 000, 100 Ω series resistance

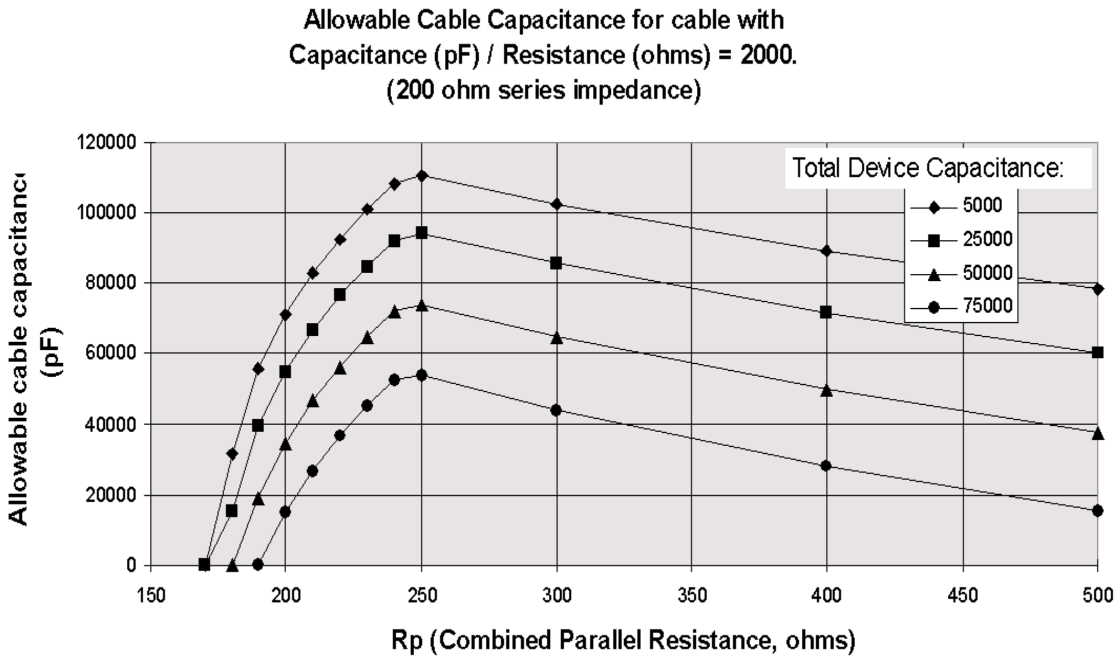

Figure T.17 – Cable capacitance for C_{cbl}/R_{cbl}=2 000, 200 Ω series resistance

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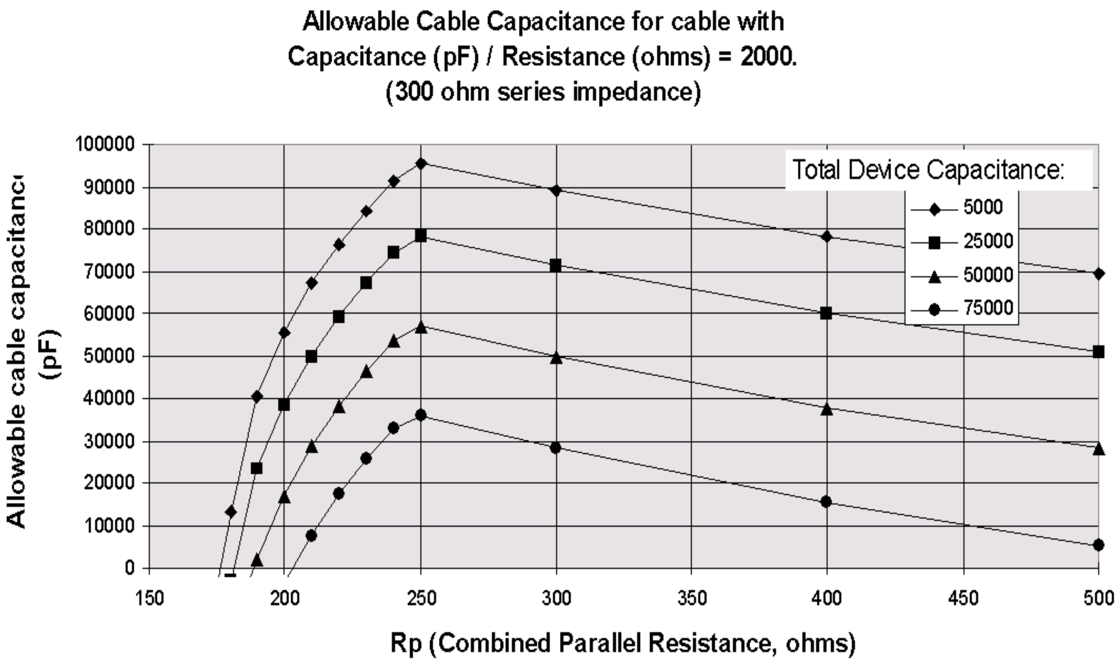

Figure T.18 – Cable capacitance for C_{cbl}/R_{cbl}=2 000, 300 Ω series resistance

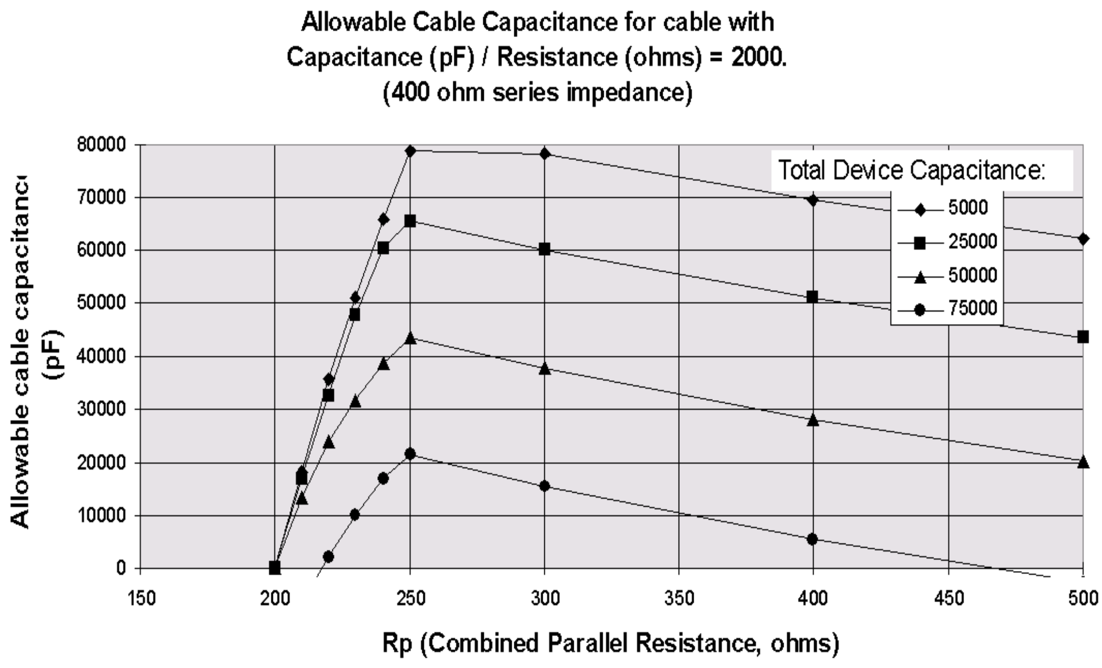

Figure T.19 – Cable capacitance for C_{cbl}/R_{cbl}=2 000, 400 Ω series resistance

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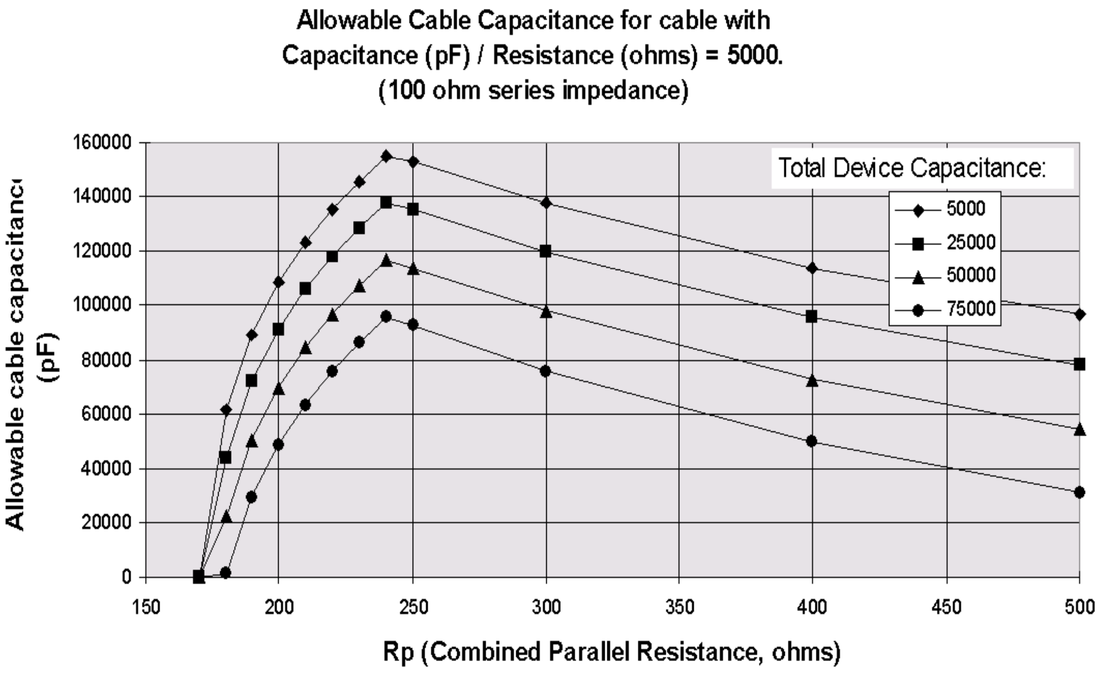

Figure T.20 – Cable capacitance for C_{cbl}/R_{cbl}=5000, 100 Ω series resistance

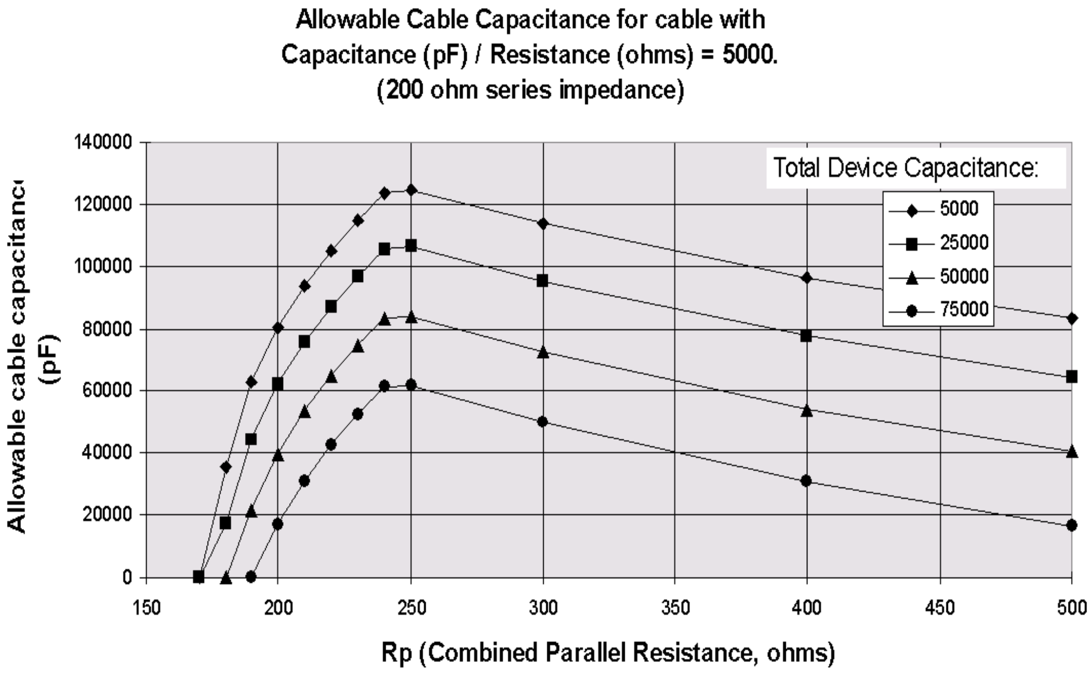

Figure T.21 – Cable capacitance for C_{cbl}/R_{cbl}=5 000, 200 Ω series resistance

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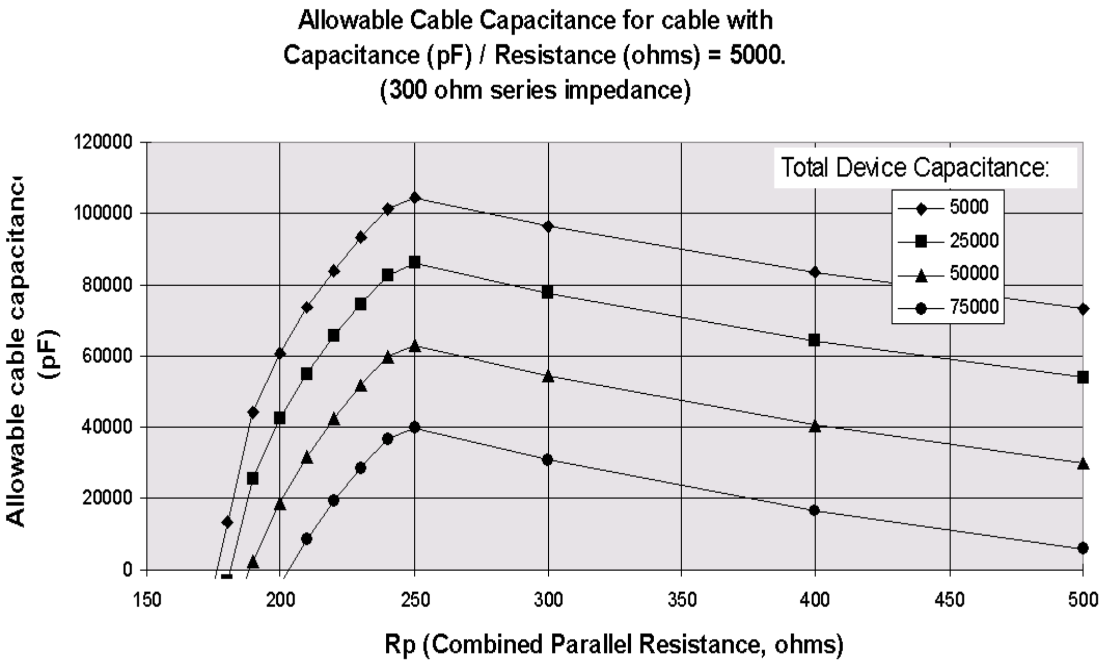

Figure T.22 – Cable capacitance for C_{cbl}/R_{cbl}=5 000, 300 Ω series resistance

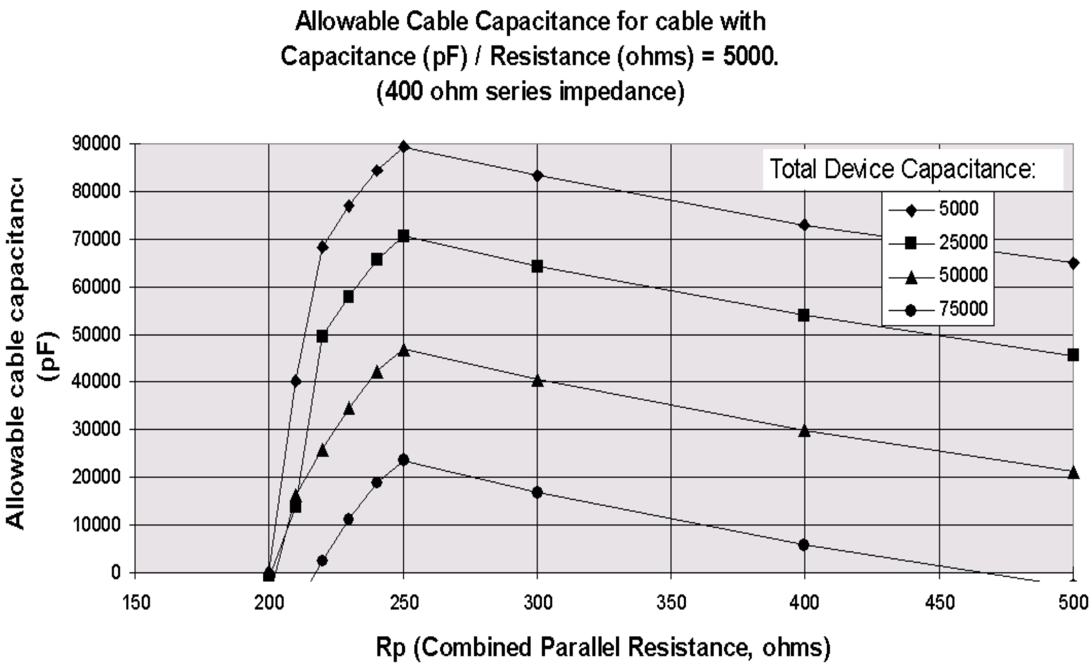

Figure T.23 – Cable capacitance for C_{cbl}/R_{cbl}=5 000, 400 Ω series resistance

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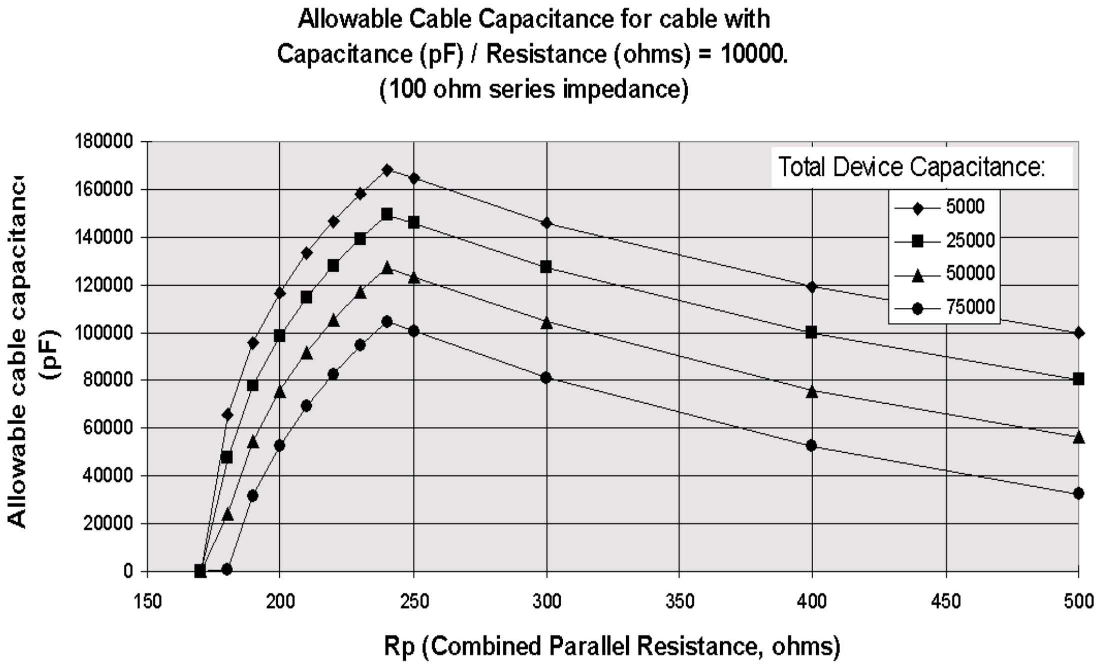

Figure T.24 – Cable capacitance for C_{cbl}/R_{cbl}=10 000, 100 Ω series resistance

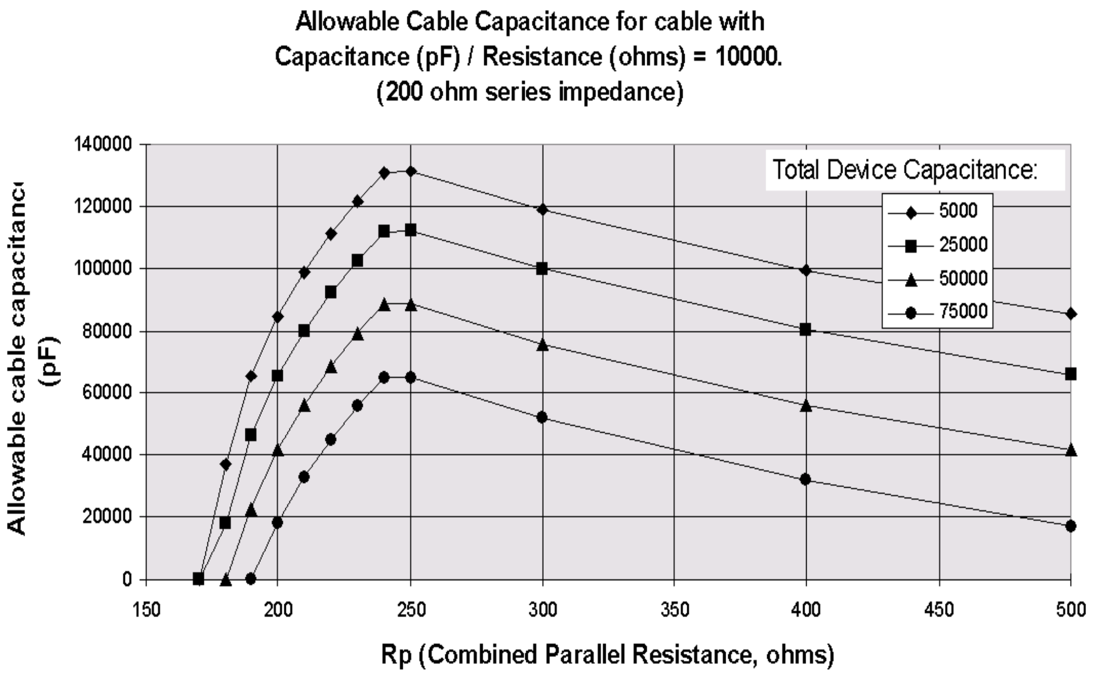

Figure T.25 – Cable capacitance for C_{cbl}/R_{cbl}=10 000, 200 Ω series resistance

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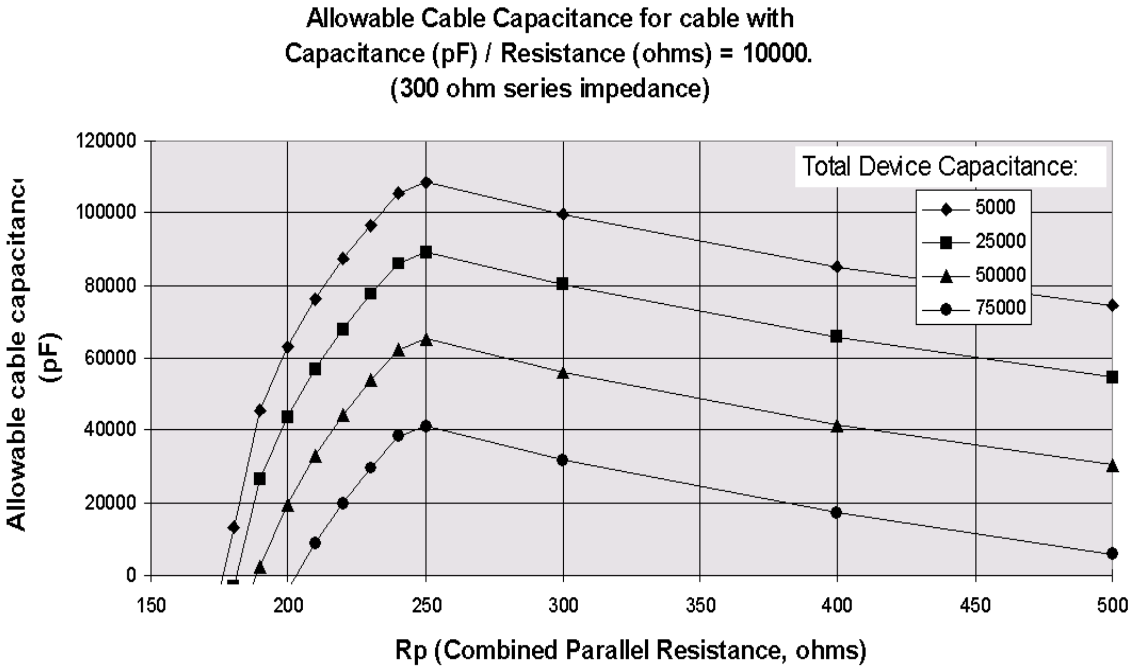

Figure T.26 – Cable capacitance for C_{cbl}/R_{cbl}=10 000, 300 Ω series resistance

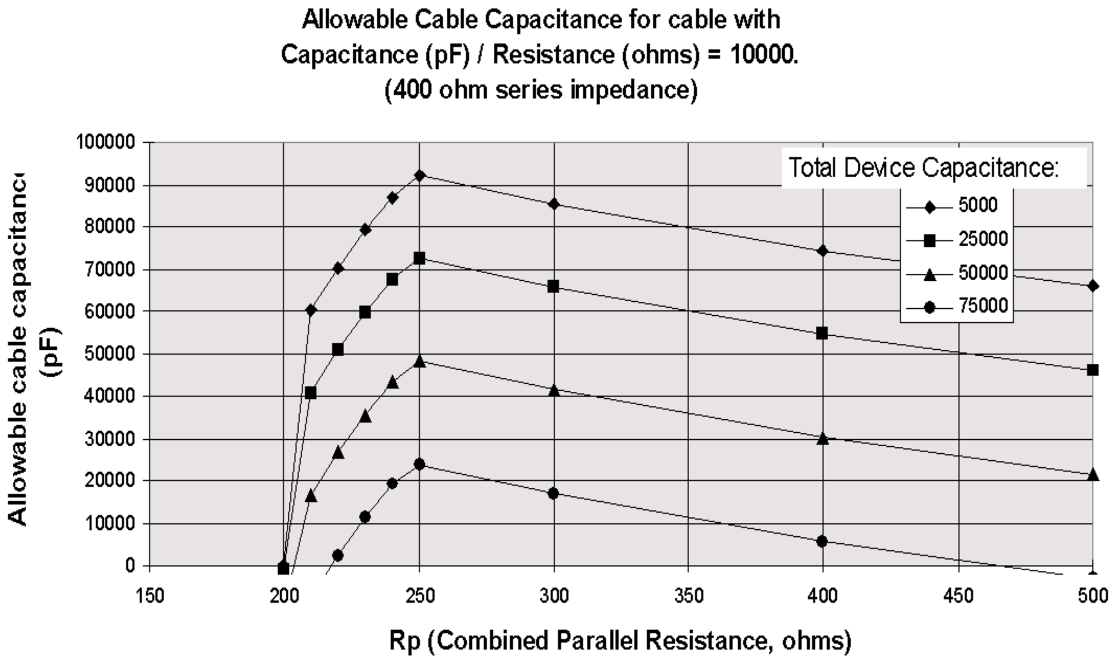

Figure T.27 – Cable capacitance for C_{cbl}/R_{cbl}=10 000, 400 Ω series resistance

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T.2.2.3 Cable length calculation examples

T.2.2.3.1 Example 1

The network has:

- Single device with capacitance C_{dev} = 5 000 pF,
- Parallel device resistance $\sum R_{dev}$ = 250 Ω,
- Cable capacitance C_{cbl} = 150 pF/m,
- Cable resistance R_{cbl} = 0,05 Ω /m
  NOTE This is the same resistance as that of a 22 AWG wire.

Use Figure T.7 to interpolate for C_{cbl} = 150 pF/unit length. The maximum cable length is 1 200 m.

T.2.2.3.2 Example 2

The network has:

- Three devices with capacitance C_{dev} = 5 000 pF, 10 000 pF and 10 000 pF,
- These three devices with resistance R_{dev} = 100 kΩ each,
- One low impedance device with R_{dev} = 250 Ω,
- No series device,
- Cable capacitance C_{cbl} = 400 pF/m, and
- Cable resistance R_{cbl} = 0,0368 Ω/m (0,800 mm wire).

Therefore the calculated parameters are:

- Parallel device capacitance $\sum C_{dev}$ = 5 000 + 10 000 + 10 000 = 25 000 pF,
- Parallel device resistance $\sum R_{dev}$ = 250 Ω,
- Series impedance R_{ser} = 0,
- Cable C_{cbl}/R_{cbl} = 400 / 0,0368 = 10 869.

The cable capacitance/resistance ratio is rounded to the nearest value of 10 000. Using Figure T.11, the allowable cable capacitance is 200 000 pF. The maximum cable length is calculated by dividing the allowable cable capacitance by the capacitance per unit length of the cable. In this example, the maximum allowable cable length is (200 000 pF) / (400pF/m) = 500 m.

T.2.2.3.3 Example 3

The network has:

- Three devices with capacitance C_{dev} = 5 000 pF, 10 000 pF and 10 000 pF,
- These three devices with resistance R_{dev} = 100 kΩ each,
- One low impedance device with R_{dev} = 250 Ω,
- One series device with 100 Ω resistance,
- Cable capacitance C_{cbl} = 400 pF/m, and
- Cable resistance R_{cbl} = 0,0368 Ω/m (0,800 mm wire).

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Thus, the network is same as in T.2.2.3.2, except that one series device has been added. Therefore the calculated parameters are:

- Parallel device capacitance $\sum C_{dev}$ = 5 000 + 10 000 + 10 000 = 25 000 pF,
- Parallel device resistance $\sum R_{dev}$ = 250 Ω,
- Series impedance R_{ser} = 100 Ω,
- Cable C_{cbl}/R_{cbl} = 400 / 0,0368 = 10 869.

The cable capacitance/resistance ratio is rounded to the nearest value of 10 000. Using Figure T.24, the allowable cable capacitance is 145 000 pF. The maximum cable length is calculated by dividing the allowable cable capacitance by the capacitance per unit length of the cable. In this example, the maximum allowable cable length is (145 000 pF) / (400pF/m) = 362,5 m.

T.2.3 Multi-pair cable length

If multi-pair cable is used with single-pair cable to form a network, the total length of cable in this network is determined as the lowest of the following values:

1) 1 500 m,
2) The length as determined using procedure of T.2.2.2 for single pair cable and
3) The length as determined using procedure of T.2.2.2 for single pair cable using the highest value parallel network resistance for all networks using the other cables in the multi-pair cable

T.3 Power distribution through barriers

The network power supply is usually located at the current input device and can be connected as shown in Figure T.28. It shows configurations with no barrier (Figure T.28 a)), two barriers (Figure T.28 b)) and one barrier (Figure T.28 c)).

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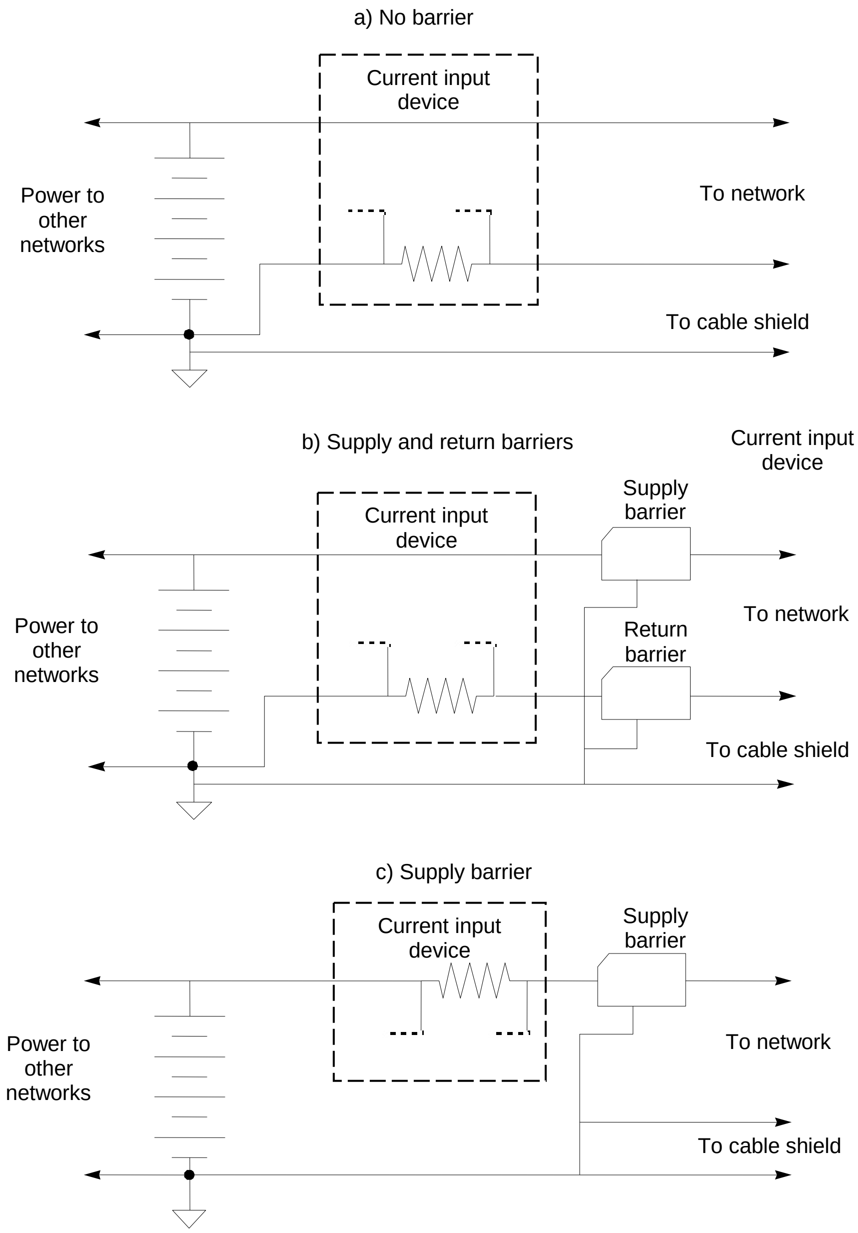

Figure T.28 – Network power supply connections

If a network power supply is not used, it should be replaced by an impedance network not exceeding the permitted power supply impedance specified in 34.10.1. A single network power supply may power more than one network, provided that it is connected to multiple networks as shown in Figure T.28.

Device that requires power from sources other than the network may be powered by twisted pairs in the same multi-pair cable that carries signal pairs, provided that variation in current consumption of these devices is within the limit specified in 34.7.2.

T.4 Shielding and grounding

This annex shows the preferred grounding schemes. The cable shield should be grounded at only one point. This is usually done in the control room at or near the source of loop power. However, the ground connection may alternatively occur in a junction box or other suitable location in the field area. Care has to be taken to avoid an inadvertent connection of grounded metal objects to the shield.

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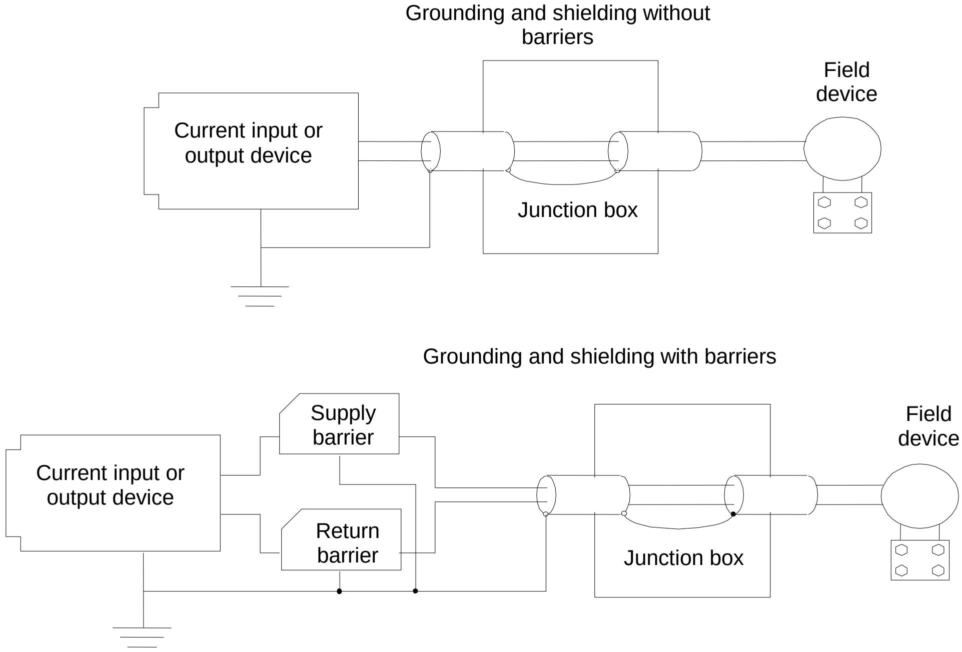

Figure T.29 – Grounding and shielding

Multiple networks that share a common connection should be grounded at the respective primary master or analog controller.

A cable shield is usually left open (unconnected) at a field device. Alternatively, the shield may be connected to the field device housing or the internal shield surrounding the device's circuits under either of the following conditions:

a) the device housing or the internal shield is isolated from ground, or

b) the connection of shield to ground is the only point in the network at which the shield is grounded.

For junctions not located at a signaling element, the shields of all cables brought to the junction are usually connected. To surround otherwise exposed wiring, cable shields may be connected to junction boxes and wiring panels, if the junction boxes or panels are isolated from ground or if the connection to ground is the only point at which the network shield is grounded.

Other grounding and shielding arrangements may be used if the coupling and EMI does not interfere with the digital signaling.

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Bibliography

NOTE 1 All parts of the IEC 61158 series, as well as IEC 61784-1 and IEC 61784-2 are maintained simultaneously. Cross-references to these documents within the text therefore refer to the editions as dated in this bibliography.

NOTE 2 A listing of relevant documents from consortia associated with some of the IEC 61158 series of fieldbus standards can be found in the bibliography of IEC 61158-1.

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60227-5, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (cords)*

IEC 60875-1, *Fibre optic interconnecting devices and passive components – Non-wavelength-selective fibre optic branching devices – Part 1: Generic specification*

IEC 60947-5-2, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*

IEC 61158 (all parts), *Industrial communication networks – Fieldbus specifications*

IEC 61158-1:2014, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

IEC 61158-4-1:2014, *Industrial communication networks – Fieldbus specifications – Part 4-1: Data-link layer protocol specification – Type 1 elements*

IEC 61158-4-4:2014, *Industrial communication networks – Fieldbus specifications – Part 4-4: Data-link layer protocol specification – Type 4 elements*

IEC 61158-4-7:2007, *Industrial communication networks – Fieldbus specifications – Part 4-7: Data-link layer protocol specification – Type 7 elements*

IEC 61158-4-8:2007, *Industrial communication networks – Fieldbus specifications – Part 4-8: Data-link layer protocol specification – Type 8 elements*

IEC 61158-4-12:2014, *Industrial communication networks – Fieldbus specifications – Part 4-12: Data-link layer protocol specification – Type 12 elements*

IEC 61158-4-16:2007, *Industrial communication networks – Fieldbus specifications – Part 4-16: Data-link layer protocol specification – Type 16 elements*

IEC 61158-4-18:2010, *Industrial communication networks – Fieldbus specifications – Part 4-18: Data-link layer protocol specification – Type 18 elements*

IEC 61158-4-20:2014, *Industrial communication networks – Fieldbus specifications – Part 4-20: Data-link layer protocol specification – Type 20 elements*

IEC 61158-4-24:2014, *Industrial communication networks – Fieldbus specifications – Part 4-24: Data-link layer protocol specification – Type 24 elements*

IEC 61300-3-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-4: Examinations and measurements – Attenuation*

IEC/TR 61491, *Electrical equipment of industrial machines – Serial data link for real-time communication between controls and drives*

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IEC 61596, *Magnetic oxide EP-cores and associated parts for use in inductors and transformers – Dimensions*

IEC 61784-1, *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*

IEC 61784-2, *Industrial communication networks – Profiles – Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3*

ISO/IEC 8886:1996, *Information technology – Open Systems Interconnection – Data link service definition*

ISO/IEC 10022:1996 *Information technology – Open Systems Interconnection – Physical Service Definition*

ITU-T V.11:1996, *Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s*

IEEE Std 100, *The IEEE Standard Dictionary of Electrical and Electronics Terms*

PTB-Mitteilungen, 113 Jahrgang, Heft 2/2003, *Die Bewertung der Zündfähigkeit eigensicherer Stromkreise anhand eines Rechenverfahrens* (available in German only)

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SOMMAIRE

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

RÉSEAUX DE COMMUNICATION INDUSTRIELS – SPÉCIFICATIONS DES BUS DE TERRAIN –

Partie 2: Spécification et définition des services de la couche physique

AVANT-PROPOS

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NOTE Les combinaisons de types de protocoles sont spécifiées dans la CEI 61784-1 et la CEI 61784-2.

La Norme Internationale CEI 61158-2 a été établie par le sous-comité 65C: Réseaux industriels, du comité d'études 65 de la CEI: Mesure, commande et automation dans les processus industriels.

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Cette sixième édition annule et remplace la cinquième édition parue en 2010. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- nouvelle spécification de Type 20 en 3.12, 4.1.11, 4.2.11, 5.12, Article 34 et Annexe T;
- nouvelle spécification de Type 24 en 3.11, 4.2.10, 5.11, 6.9, 9.12, Article 33 et Annexe S;
- Article 17 Type 1: Unité de liaison au support: signalisation radio supprimée en raison d'insuffisances en termes de prise en charge;
- spécification des supports RS232 pour Type 4 retirée pour cause d'obsolescence.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
65C/758A/FDIS	65C/775/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/CEI, Partie 2.

NOTE De légères variations par rapport aux directives ont été autorisées par le Bureau Central de la CEI pour assurer la continuité de la numérotation des paragraphes dans les éditions précédentes.

Une liste de toutes les parties de la série CEI 61158, publiées sous le titre général *Réseaux de communication industriels – Spécifications des bus de terrain,* peut être consultée sur le site web de la CEI.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de la CEI sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. À cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

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0 Introduction

0.1 Généralités

La présente partie de la CEI 61158 est une d'une série produite pour faciliter l'interconnexion de composants d'un système d'automation. Elle est liée à d'autres normes de la série telle que définie par le modèle de référence des bus de terrain "à trois couches" décrit dans le rapport CEI 61158–1.

0.2 Aperçu de la couche physique

Le principal objectif de la présente norme est de fournir un ensemble de règles de communication exprimées en termes de procédures à appliquer par les entités Ph homologues au cours de la communication.

La couche physique reçoit des unités de données de la couche liaison de données, les code si nécessaire en ajoutant des informations de trame de communication et transmet les signaux physiques résultants au support de transmission à un nœud donné. Les signaux sont ensuite reçus à un ou plusieurs autres nœuds, décodés si nécessaire en retirant les informations de trame de communication avant que les unités de données ne soient passées à la couche liaison de données de l'appareil de réception.

0.3 Aperçu des documents

La présente norme est constituée de spécifications de couche physique correspondant à de nombreux types de protocoles de couche physique spécifiés dans la série CEI 61158.

NOTE 1 La numérotation des types de protocoles utilisés est homogène dans l'ensemble de la série de normes CEI 61158.

NOTE 2 Les spécifications des Types 1, 2, 3, 4, 8, 16, 18, 20 et 24 sont incluses. Le Type 7 utilise des spécifications de Type 1. Les autres Types n'utilisent aucune des spécifications objet de la présente norme.

NOTE 3 Pour faciliter le renvoi aux textes correspondants, les numéros de Type sont indiqués dans le titre des articles. En d'autres termes, la spécification donnée dans ledit Article/paragraphe s'applique à ce type, ce qui n'exclut pas son utilisation pour d'autres Types.

NOTE 4 Les ensembles de dispositions d'interfonctionnement sont du ressort de l'utilisateur de la présente norme. Pour plus d'informations sur les profils de communication normalisés fondés sur la série de normes CEI 61158, se reporter à la CEI 61784-1 ou à la CEI 61784-2.

Un modèle général de la couche physique est illustré à la Figure 1.

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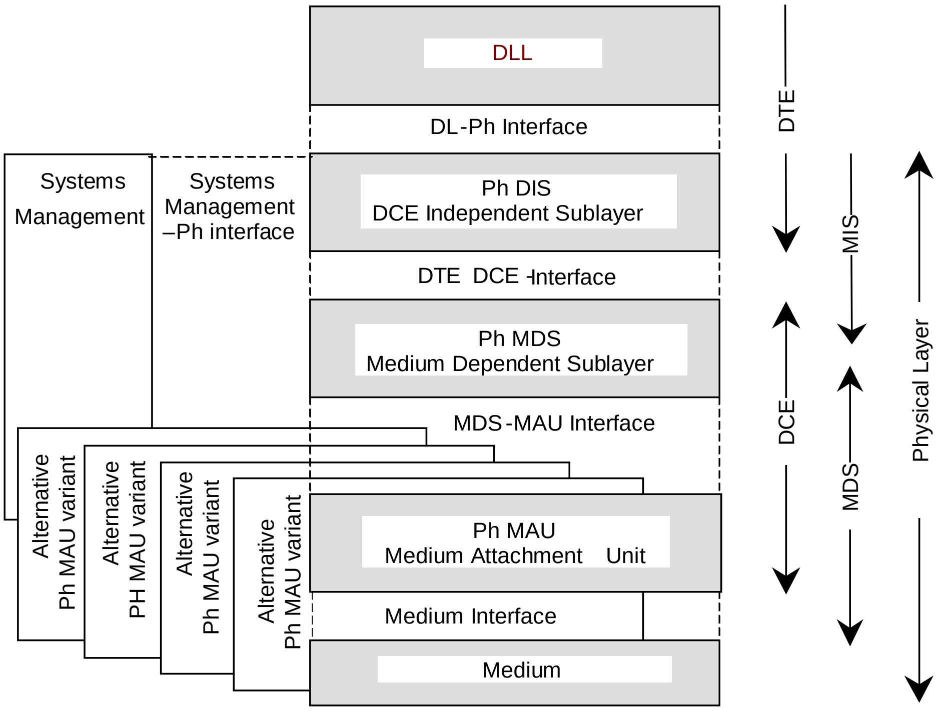

Légende

Anglais	Français
DL-Ph interface	Interface DL – Ph
Systems management	Gestion systèmes
Systems management – Ph interface	Interface Gestion systèmes – Ph
Ph DIS DCE Independent Sublayer	DIS de Ph: Sous-couche indépendante du DCE
DTE-DCE Interface	Interface ETTD – DCE
Ph MDS Medium dependent sublayer	MDS de Ph: Sous-couche dépendante du support
MDS – MAU interface	Interface MDS – MAU
Alternative Ph MAU variant	Variante de MAU de Ph
Ph – MAU Medium Attachment Unit	MAU de Ph: Unité de liaison au support
Medium interface	Interface de support
Medium	Support
DCE DTE	ETTDDCE
Physical Layer	Couche physique
Alternative Ph MAU variant	Variante Ph MAU alternative

Figure 1 – Modèle général de couche physique

NOTE 5 Les types de protocoles utilisent un sous-ensemble des éléments de structure.

NOTE 6 Etant donné que le Type 8 utilise un DIS plus complexe que celui des autres types, le terme MIS est employé pour le différencier.

Les caractéristiques communes de tous les types et variantes sont les suivantes:

– émission numérique de données;
– pas de transmission d'horloge séparée;
– communication soit en semi-duplex (bidirectionnelle mais dans un sens à la fois) soit en transmission bidirectionnelle simultanée.

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0.4 Principales variantes de couche physique spécifiées dans la présente norme

0.4.1 Support de Type 1

0.4.1.1 Type 1: Supports câblés

Pour les supports câblés à paire torsadée, le Type 1 spécifie deux modes de couplage et différentes vitesses de signalisation comme suit:

a) mode tension (couplage parallèle), 150 Ω, débits binaires de 31,25 kbit/s à 25 Mbit/s;

b) mode tension (couplage parallèle), 100 Ω, 31,25 kbit/s;

c) mode courant (couplage série), 1,0 Mbit/s comprenant deux options de courant.

Les variantes en mode tension peuvent être mises en œuvre avec un couplage inductif en utilisant des transformateurs. Ceci n'est pas obligatoire si les exigences d'isolation de la présente norme sont satisfaites par d'autres moyens.

La couche physique à support câblé de Type 1 (paire torsadée ou non) dispose des options suivantes:

– pas d'alimentation par l'intermédiaire des conducteurs de bus; pas de sécurité intrinsèque;
– alimentation par l'intermédiaire des conducteurs de bus; pas de sécurité intrinsèque;
– pas d'alimentation par l'intermédiaire des conducteurs de bus; sécurité intrinsèque;
– alimentation par l'intermédiaire des conducteurs de bus; sécurité intrinsèque.

0.4.1.2 Type 1: Supports optiques

Les principales variantes du support en fibre optique de Type 1 sont les suivantes:

– fibre optique double, débits binaires de 31,25 kbit/s à 25 Mbit/s;
– mode monofibre, 31,25 kbit/s.

0.4.2 Type 2: Supports à câble coaxial et optique

Le Type 2 spécifie les variantes suivantes:

– support à câble cuivre coaxial, 5 Mbit/s;
– support à fibre optique, 5 Mbit/s;
– port d'accès au réseau (NAP), un mécanisme de liaison temporaire point à point qui peut être utilisé pour la programmation, la configuration, le diagnostic ou à d'autres fins;
– sous-couches machine répéteur (RM, RRM) et couches physiques redondantes.

0.4.3 Type 3: Supports câblés et optiques à paire torsadée

Le Type 3 spécifie les émissions synchrones suivantes:

a) support câblé à paire torsadée, 31,25 kbit/s, mode tension (couplage parallèle) avec les options suivantes:
   – alimentation par l'intermédiaire des conducteurs de bus: pas de sécurité intrinsèque;
   – alimentation par l'intermédiaire des conducteurs de bus: sécurité intrinsèque;

   ainsi que les variantes de transmission asynchrone suivantes:

b) support câblé à paire torsadée, jusqu'à 12 Mbit/s, norme TIA/EIA-485-A de l'ANSI;

c) support à fibre optique, jusqu'à 12 Mbit/s, avec type A4a de la CEI 60793-2-40 et type A3c de la CEI 60793-2-30.

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0.4.4 Type 4: Support câblé

Le Type 4 spécifie des supports câblés ayant les caractéristiques suivantes:

– support câblé RS485, jusqu'à 76,8 kbit/s.

0.4.5 Type 8: Supports câblés et optiques à paire torsadée

La couche physique permet également l'émission d'unités de données reçues par l'intermédiaire d'un accès au support par le support de transmission directement à travers un autre accès au support et son protocole de transmission vers un autre appareil.

Le Type 8 spécifie les variantes suivantes:

– support câblé à paire torsadée, jusqu'à 16 Mbit/s;
– support à fibre optique, jusqu'à 16 Mbit/s.

Les caractéristiques générales de ces supports de transmission sont les suivantes:

– transmission bidirectionnelle simultanée;
– Codage NRZ (non-return-to-zero – non retour à zéro).

Les types de supports câblés disposent des options suivantes:

– pas d'alimentation par l'intermédiaire du câble de bus, pas de sécurité intrinsèque;
– alimentation par l'intermédiaire du câble de bus et sur des conducteurs supplémentaires, pas de sécurité intrinsèque.

0.4.6 Type 12: Supports câblés

Le Type 12 spécifie des supports câblés ayant les caractéristiques suivantes:

– Support câblé LVDS jusqu'à 100 Mbit/s.

0.4.7 Type 16: Supports optiques

Le Type 16 spécifie une transmission synchrone utilisant un support à fibre optique, à 2 Mbit/s, 4 Mbit/s, 8 Mbit/s et 16 Mbit/s.

0.4.8 Type 18: Supports

0.4.8.1 Type 18: Supports basiques

Le Type 18-PhL-B spécifie un signal de transmission équilibrée sur un câble torsadé blindé à 3 conducteurs. Il est spécifié des débits binaires pouvant atteindre 10 Mbit/s et des distances de transmission allant jusqu'à 1,2 km.

0.4.8.2 Type 18: Supports alimentés

Le Type 18-PhL-P spécifie un signal de transmission équilibrée sur un câble non blindé à 4 conducteurs, à profil plat ou rond dont les conducteurs sont conçus pour le signal de communications et la distribution d'une alimentation intégrée au réseau. Il est spécifié des débits binaires allant jusqu'à 2,5 Mbit/s et des distances de transmission allant jusqu'à 500 m.

0.4.9 Type 20: Supports

Le Type 20 utilise la modulation par déplacement de fréquence (FSK) continue de phase binaire. Un courant à fréquence relativement élevée est superposé à un courant analogique à basse fréquence, qui est habituellement dans la plage 4 mA à 20 mA. Les signaux numérique et analogique partagent le même support mais diffèrent en termes de contenu fréquentiel. Les appareils de communication envoient un signal soit avec le courant, soit avec la tension, et

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toutes les signalisations apparaissent en tant que tension lorsqu'elles sont détectées à basse impédance. Par conséquent, la signalisation numérique est une extension de la signalisation analogique conventionnelle.

La couche physique utilise généralement un câble en cuivre à paire torsadée en tant que support et fournit uniquement une communication numérique ou une communication numérique et analogique simultanée à des distances d'au moins 1 500 m (environ 5 000 pieds). Les distances de communication maximales peuvent varier en fonction de la construction du réseau et des conditions environnementales.

0.4.10 Type 24: Supports

Le Type 24 spécifie un support câblé à paire torsadée à 10 Mbit/s. Les caractéristiques générales de ce support de transmission sont les suivantes;

- L'interface de bus TIA/EIA-485 de l'ANSI avec isolation galvanique utilisant un transformateur;
- transmission semi-duplex;
- Codage de Manchester.

0.5 Déclaration de droits de propriété

La Commission Électrotechnique Internationale (CEI) attire l'attention sur le fait qu'il est déclaré que la conformité avec les dispositions du présent document peut impliquer l'utilisation d'un brevet intéressant le Type 2 traité en 5.3, 9.4, 10.4, des Articles 18 à 20, ainsi que de l'Annexe F à l'Annexe H, comme suit:

US 5,396,197: PRISE de nœud de réseau

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ODVA, Inc.
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Ann Arbor, Michigan 48104
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Attention: Service du Directeur Exécutif

e-mail: odva@odva.org

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RÉSEAUX DE COMMUNICATION INDUSTRIELS – SPÉCIFICATIONS DES BUS DE TERRAIN –

Partie 2: Spécification et définition des services de la couche physique

1 Domaine d'application

La présente partie de la CEI 61158 spécifie les exigences applicables aux composants de bus de terrain. Elle spécifie également les exigences de configuration des supports et des réseaux requises pour garantir un niveau d'intégrité des données

a) avant vérification d'erreur de la couche liaison de données;

b) l'interopérabilité entre appareils au niveau de la couche physique.

La couche physique des bus de terrain est conforme à la couche 1 du modèle OSI à 7 couches, telle que définie dans l'ISO/CEI 7498, à l'exception du fait que, pour certains types, les délimiteurs de trame se trouvent dans la couche physique tandis que pour d'autres types, ils se trouvent dans la couche liaison de données.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

NOTE Toutes les parties de la série CEI 61158, ainsi que la CEI 61784-1 et la CEI 61784-2 font l'objet d'une maintenance simultanée. Les références croisées à ces documents dans le texte se rapportent par conséquent aux éditions datées dans la présente liste de références normatives.

CEI 60050 (toutes les parties), *Vocabulaire Electrotechnique International* (disponible sur <http://www.electropedia.org/)

CEI 60079-11, *Atmosphères explosives – Partie 11: Protection de l'équipement par sécurité intrinsèque "i"*

CEI 60079-14:2007, *Atmosphères explosives – Partie 14: Conception, sélection et construction des installations électriques*

CEI 60079-25, *Atmosphères explosives – Partie 25: Systèmes électriques de sécurité intrinsèque*

CEI 60169-17, *Connecteurs pour fréquences radioélectriques – Partie 17: Connecteurs coaxiaux pour fréquences radioélectriques avec diamètre intérieur du conducteur extérieur de 6,5 mm (0,256 in) à verrouillage à vis – Impédance caractéristique 50 ohms (Type TNC)*

IEC 60189-1:2007, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods* (disponible en anglais seulement)

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CEI 60255-22-1:1988[1], *Relais électriques – Partie 22-1: Essais d'influence électrique concernant les relais de mesure et appareils de protection – Section 1: Essais à l'onde oscillatoire amortie à 1 Mhz*

CEI 60364-4-41, *Installations électriques à basse tension – Partie 4-41: Protection pour assurer la sécurité – Protection contre les chocs électriques*

CEI 60364-5-54 *Installations électriques basse-tension – Partie 5-54: Choix et mise en œuvre des matériels électriques – Installations de mise à la terre et conducteurs de protection*

CEI 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

CEI 60603-7-4, *Connecteurs pour équipements électroniques – Partie 7-4: Spécification particulière pour les fiches et les embases non blindées à 8 voies pour la transmission de données à des fréquences jusqu'à 250 MHz*

CEI 60754-2, *Essai sur les gaz émis lors de la combustion des matériaux prélevés sur câbles – Partie 2: Détermination de la conductivité et de l'acidité (par mesure du pH)*

CEI 60793 (toutes les parties), *Fibres optiques*

CEI 60793-2-30:2012, *Fibres optiques – Partie 2-30: Spécifications de produits – Spécification intermédiaire pour les fibres multimodales de catégorie A3*

CEI 60793-2-40:2009, *Fibres optiques – Partie 2-40: Spécifications de produits – Spécification intermédiaire pour les fibres multimodales de la catégorie A4*

CEI 60794-1-2:2003[2], *Câbles à fibre optique – Partie 1-2: Spécification générique – Procédures de base applicables aux essais des câbles optiques*

CEI 60807-3, *Connecteurs rectangulaires utilisés aux fréquences inférieures à 3 MHz – Partie 3: Spécification particulière pour une gamme de connecteurs ayant les boîtiers métalliques de forme trapézoïdale et les contacts ronds – Types de contacts à sertir démontables avec fûts fermés, à insérer et à extraire par l'arrière de l'isolant*

CEI 60811-403, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 403: Essais divers – Essai de résistance à l'ozone sur les mélanges réticulés*

CEI 60811-404:2012, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 404: Essais divers – Essais de résistance à l'huile minérale pour les gaines*

CEI 61000-4-2, *Compatibilité électromagnétique (CEM) – Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques* (Publication fondamentale en CEM)

CEI 61000-4-3, *Compatibilité électromagnétique (CEM) – Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques* (Publication fondamentale en CEM)

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1 Cette publication a été supprimée.

2 Il existe une nouvelle édition de la CEI 60794-1-2 (2013). Celle-ci sera prise en compte dans la prochaine édition de la CEI 61158-2.

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CEI 61000-4-4, *Compatibilité électromagnétique (CEM) – Partie 4-4: Techniques d'essai et de mesure – Essais d'immunité aux transitoires électriques rapides en salves* (Publication fondamentale en CEM)

CEI 61131-2:2007, *Automates programmables – Partie 2: Exigences et essais des équipements*

CEI 61156-1:2007, *Câbles multiconducteurs à paires symétriques et quartes pour transmissions numériques – Partie 1: Spécification générique*

CEI 61158-3-20:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 3-20: Définition des services de la couche liaison de données – Eléments de type 20*

CEI 61158-4-2:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-2: Spécification du protocole de la couche liaison de données – Éléments de type 2*

CEI 61158-4-3:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-3: Spécification du protocole de la couche liaison de données – Éléments de type 3*

CEI 61169-8:2007, *Connecteurs pour fréquences radioélectriques – Partie 8: Spécification intermédiaire – Connecteurs coaxiaux pour fréquences radioélectriques avec diamètre intérieur du conducteur extérieur de 6,5 mm (0,256 in) à verrouillage à baïonnette – Impédance caractéristique 50 Ω (type BNC)*

CEI 61210:2010, *Dispositifs de connexion – Bornes plates à connexion rapide pour conducteurs électriques en cuivre – Exigences de sécurité*

CEI 61754-2, *Interfaces de connecteurs pour fibres optiques – Partie 2: Famille de connecteurs de type BFOC/2,5*

CEI 61754-13, *Interfaces de connecteurs pour fibres optiques – Partie 13: Connecteurs de type FC-PC*

CEI 61754-22, *Interfaces de connecteurs pour fibres optiques – Partie 22: Famille de connecteurs de type F-SMA*

ISO/CEI 7498 (toutes les parties), *Technologies de l'information – Interconnexion de systèmes ouverts (OSI) – Modèle de référence de base*

ISO/CEI 7498-1:1994, *Technologies de l'information – Modèle de référence de base pour l'interconnexion de systèmes ouverts (OSI): Le modèle de base*

ISO/IEC 8482, *Information technology – Telecommunications and information exchange between systems – Twisted pair multipoint interconnections* (disponible en anglais seulement)

ISO/IEC 8802-3, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications* (disponible en anglais seulement)

ISO 9314-1, *Information processing systems – Fibre Distributed Data Interface (FDDI) Part 1: Token Ring Physical Layer Protocol (PHY)* (disponible en anglais seulement)

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ISO/IEC 10731:1994, *Technologies de l'information – Interconnexion de systèmes ouverts – Modèle de Référence de Base – Conventions pour la définition des services OSI*

ISO 4892-1, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 1: Guide général*

ANSI TIA/EIA-422-B, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits*

ANSI TIA/EIA-485-A, *Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

ANSI TIA/EIA-644-A, *Electrical Characteristics of Low Voltage Differential Signaling (LVDS) Interface Circuits*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions donnés dans l'ISO/CEI 7498 ainsi que les suivants s'appliquent.

3.1 Termes et définitions communs

NOTE De nombreuses définitions sont communes à plusieurs types de protocoles; elles ne sont pas nécessairement utilisées par tous les types de protocoles.

3.1.1
activité
présence d'un signal ou d'un bruit aux bornes d'entrée d'un appareil de bus de terrain qui est d'un niveau supérieur au seuil de niveau du signal du récepteur de cet appareil

3.1.2
barrière
entité physique qui limite le courant ou la tension dans une zone dangereuse afin de satisfaire aux exigences de sécurité intrinsèque

3.1.3
bit
unité de données constituée d'un 1 ou d'un 0

Note 1 à l'article: Un bit est la plus petite unité de données qui peut être transmise.

3.1.4
bus
ligne principale ainsi que tous les appareils qui y sont connectés

3.1.5
connecteur d'interface de canalisation de câbles
CPIC
point auquel les essais et mesures de conformité sont effectués et qui assurent l'interface entre l'appareil de réseau et la canalisation du câble

Note 1 à l'article: L'abréviation "CPIC" est dérivée du terme anglais développé correspondant "Cable Plant Interface Connector".

3.1.6
élément de communication
partie d'un appareil de bus de terrain qui communique avec d'autres éléments via le bus

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3.1.7
connecteur
appareil de couplage utilisé pour connecter le support d'un circuit ou d'un élément de communication avec celui d'un autre circuit ou élément de communication

3.1.8
coupleur
interface physique entre la ligne principale et une dérivation ou entre la ligne principale et l'appareil

3.1.9
équipement de transmission de données
DCE
mode de réalisation des supports, partie dépendante de la modulation et du codage d'un appareil connecté au bus de terrain, incluant les parties inférieures de la couche physique au sein de l'appareil

Note 1 à l'article: L'abréviation "DCE" est dérivée du terme anglais développé correspondant "Data Communication Equipment".

3.1.10
équipement terminal de traitement de données
ETTD
mode de réalisation des supports, partie indépendante de la modulation et du codage d'un appareil connecté au bus de terrain, incluant la partie la plus haute de la couche physique ainsi que toutes les parties supérieures dans l'appareil

3.1.11
décibel(milliwatt)
dB(mW)
unité logarithmique de puissance référencée à 1 mW

$$P_{dBm} = 10 \log (P_{mW})$$

Note 1 à l'article: dB(mW) est également exprimé dBm)

Note 2 à l'article: Si P_{mW} est la puissance mesurée en mW, P_{dBm} est la puissance logarithmique exprimée en dB(mW), ou de manière équivalente, en dBm.

3.1.12
délimiteur
drapeau (indicateur) qui sépare et organise des éléments de données

3.1.13
appareil
entité physique connectée au bus de terrain, constituée d'au moins un élément de communication (l'élément réseau) et qui peut être un élément de commande et/ou un élément final (transducteur, actionneur, etc.)

Note 1 à l'article: Un appareil peut contenir plusieurs nœuds.

3.1.14
puissance d'injection effective
puissance effective couplée dans le cœur d'un guide d'onde à fibre optique par l'émetteur

Note 1 à l'article: La puissance d'injection effective est mesurée au moyen d'une fibre d'essai normalisée connectée au CPIC.

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3.1.15
puissance effective
différence, exprimée en dBm, entre la puissance optique absolue, mesurée en milliwatts au point médian dans le temps du high-level (Hi) et la puissance optique absolue mesurée en milliwatts au point médian dans le temps du low-level (Lo)

Note 1 à l'article: On considère que la puissance effective donne une mesure plus précise des conditions qui affectent les récepteurs que des mesures conventionnelles telles que la puissance crête et la puissance moyenne. Des méthodes de mesure de la puissance effective feront l'objet d'études ultérieures.

3.1.16
erreur
écart ou discordance entre une valeur ou une condition calculée, observée ou mesurée et la valeur ou la condition prescrite ou théoriquement correcte

3.1.17
rapport d'extinction
rapport de la puissance optique absolue, mesurée en milliwatts au point médian dans le temps du high-level (Hi) à la puissance optique absolue mesurée en milliwatts au point médian dans le temps du low-level (Lo)

Note 1 à l'article: Un exemple de calcul de la puissance efficace et du rapport d'extinction est fourni ci-après. Si le point médian du high-level (Hi) est mesuré à 105 μW, et si le point médian du low-level (Lo) est mesuré à 5 μW, la différence est de 100 μW. Par conséquent, la puissance effective est de 10 log ((100 μW) / 1 mW)), ce qui est égal à –10,0 dBm. Le rapport d'extinction est (105/5), ce qui équivaut à 21:1.

3.1.18
câble à fibre optique
câble contenant un ou plusieurs guides d'onde à fibre optique, couvert de matériau d'enrobage destiné à faciliter le traitement et à protéger la fibre

3.1.19
récepteur à fibre optique
appareil de communication combinant l'optique et l'électronique qui accepte le signal optique reçu par l'intermédiaire du CPIC

3.1.20
domaine de fonctionnement d'un récepteur à fibre optique
plage de puissance optique devant être présente au niveau du CPIC pour assurer la conformité aux spécifications relatives au taux d'erreur sur les bits

3.1.21
émetteur à fibre optique
appareil qui émet des signaux optiques qui se propagent dans un guide d'onde à fibre optique à travers le CPIC

3.1.22
guide d'onde à fibre optique
brin souple, transparent du point de vue optique, utilisé pour transporter des signaux optiques d'un point géographique à un autre

3.1.23
trame
ensemble de créneaux temporels numériques consécutifs dans lesquels la position de chaque créneau temporel numérique peut être identifiée par référence à un signal de verrouillage de trame

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3.1.24
sécurité intrinsèque
méthodologie de conception d'un circuit ou d'un ensemble de circuits dans lequel toute étincelle ou effet thermique produit dans des conditions normales de fonctionnement et des conditions de défaut spécifiées, est incapable, dans des conditions d'essai prescrites, de provoquer l'inflammation d'une atmosphère explosive donnée

3.1.25
isolation
disposition physique et électrique des parties d'un système de transmission de signaux destinée à prévenir les courants de perturbations électriques dans ou entre ces composants

3.1.26
bavardage
transmission continue sur le support due à un appareil défectueux

3.1.27
instabilité (gigue)
décalage des points de transition à 50 % des fronts d'impulsion par rapport à leur position idéale, résultant de causes diverses

3.1.28
codage Manchester
méthode grâce à laquelle des signaux de données et d'horloge séparés peuvent être combinés en un seul flux de données à synchronisation automatique, transmissible sur un canal série

3.1.29
support
câble, fibre optique ou autre moyen permettant de transmettre des signaux de communication entre deux ou plusieurs points

Note 1 à l'article: Dans la version anglaise de cette partie de la présente norme CEI 61158, le terme "media" est utilisé comme pluriel du terme medium.

3.1.30
réseau
tous les supports, connecteurs, répéteurs, routeurs, passerelles et éléments de communication du nœud associés permettant d'interconnecter un ensemble donné d’appareils de communication

3.1.31
nœud
point d'extrémité d'une dérivation de réseau ou point où se rencontrent une ou plusieurs dérivations

3.1.32
étoile active optique
appareil actif dans lequel un signal provenant d'une fibre d'entrée est reçu, amplifié et retransmis à un plus grand nombre de fibres optiques de sortie.

Note 1 à l'article: La resynchronisation du signal reçu est facultative.

3.1.33
temps de décroissance optique
durée nécessaire pour qu'une impulsion passe d'une puissance efficace de 90 % à une puissance efficace de 10 %, spécifiée en pourcentage du temps binaire nominal

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3.1.34
étoile passive optique
appareil passif dans lequel des signaux provenant de fibres d'entrée sont combinés puis distribués entre des fibres optiques de sortie

3.1.35
temps de croissance optique
durée nécessaire pour qu'une impulsion passe d'une puissance efficace de 10 % à une puissance efficace de 90 %, spécifiée en pourcentage du temps binaire nominal

3.1.36
longueur d'onde de transmission crête
λp
longueur d'onde à laquelle l'intensité énergétique atteint son maximum

3.1.37
récepteur
ensemble des circuits de réception d'un élément de communication

3.1.38
répéteur
appareil de couche physique actif à deux accès qui reçoit et réémet tous les signaux pour accroître la distance et le nombre d'appareils auxquels les signaux peuvent être correctement transférés pour un support donné

3.1.39
segment
section de câble d'une ligne principale de bus de terrain dont la terminaison a une impédance caractéristique

Note 1 à l'article: Les segments sont reliés par des répéteurs au sein d'une liaison logique et par des ponts, de manière à constituer un réseau de bus de terrain.

3.1.40
appareil à alimentation séparée
appareil qui ne reçoit pas son alimentation de fonctionnement par l'intermédiaire des conducteurs de signal de bus de terrain

3.1.41
blindage
revêtement métallique mis à la terre enveloppant utilisé pour confiner le champ électrique dans le câble et pour protéger le câble des influences électriques externes

Note 1 à l'article: Les gaines et armatures métalliques ainsi que les conducteurs concentriques mis à la terre peuvent également servir de blindage.

3.1.42
ligne secondaire
dérivation (c'est-à-dire une connexion à une ligne plus importante en un point donné sur son itinéraire) qui constitue un circuit terminal

Note 1 à l'article: Le terme ‘câble de dérivation’ est également utilisé dans la présente norme.

3.1.43
terminateur
résistance reliant des paires de conducteurs aux deux extrémités d'un segment de support câblé afin d'éviter les réflexions aux extrémités des câbles

Note 1 à l'article: Pour le Type 2, le terminateur est monté dans un connecteur BNC ou TNC.

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3.1.44
émetteur-récepteur
appareil constitué d'équipements de réception et de transmission dans un même boîtier utilisant des composants de circuit communs pour la transmission et la réception

Note 1 à l'article: Une unité de liaison support peut être l'émetteur-récepteur ou peut contenir l'émetteur-récepteur, en fonction du type et de la mise en œuvre.

[SOURCE: IEEE Std 100-1996; définition modifiée pour l'usage non radioélectrique]

3.1.45
émetteur
ensemble des circuits de transmission d'un élément de communication

3.1.46
ligne principale
principal bus de communication agissant comme source d'alimentation principale pour un certain nombre d'autres lignes (secondaires)

3.1.47
longueur d'onde type de demi-intensité
$\Delta\lambda$
gamme de longueur d'onde de répartition spectrale dans laquelle l'intensité énergétique est au moins égale à la moitié de l'intensité maximale

3.2 Type 1: Termes et définitions

3.2.1
activité
[VOIR: 3.1.1]

3.2.2
barrière
[VOIR: 3.1.2]

3.2.3
bus
[VOIR: 3.1.4]

3.2.4
connecteur d'interface de canalisation de câbles
CPIC
[VOIR: 3.1.5]

3.2.5
élément de communication
[VOIR: 3.1.6]

3.2.6
connecteur
[VOIR: 3.1.7]

3.2.7
coupleur
[VOIR: 3.1.8]

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3.2.8
équipement de transmission de données
DCE
[VOIR: 3.1.9]

3.2.9
équipement terminal de traitement de données
ETTD
[VOIR: 3.1.10]

3.2.10
dBm
[VOIR: 3.1.11]

3.2.11
délimiteur
[VOIR: 3.1.12]

3.2.12
appareil
[VOIR: 3.1.13]

3.2.13
puissance d'injection effective
[VOIR: 3.1.14]

3.2.14
puissance effective
[VOIR: 3.1.15]

3.2.15
câble à fibre optique
[VOIR: 3.1.18]

3.2.16
récepteur à fibre optique
[VOIR: 3.1.19]

3.2.17
domaine de fonctionnement d'un récepteur à fibre optique
[VOIR: 3.1.20]

3.2.18
émetteur à fibre optique
[VOIR: 3.1.21]

3.2.19
guide d'onde à fibre optique
[VOIR: 3.1.22]

3.2.20
trame
[VOIR: 3.1.23]

3.2.21
sécurité intrinsèque
[VOIR: 3.1.24]

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3.2.22
isolation
[VOIR: 3.1.25]

3.2.23
bavardage
[VOIR: 3.1.26]

3.2.24
codage Manchester
[VOIR: 3.1.28]

3.2.25
support
[VOIR: 3.1.29]

3.2.26
réseau
[VOIR: 3.1.30]

3.2.27
nœud
[VOIR: 3.1.31]

3.2.28
temps de décroissance optique
[VOIR: 3.1.33]

3.2.29
temps de croissance optique
[VOIR: 3.1.35]

3.2.30
longueur d'onde de transmission crête
λp
[VOIR: 3.1.36]

3.2.31
répéteur
[VOIR: 3.1.38]

3.2.32
segment
[VOIR: 3.1.39]

3.2.33
appareil à alimentation séparée
[VOIR: 3.1.40]

3.2.34
blindage
[VOIR: 3.1.41]

3.2.35
ligne secondaire
[VOIR: 3.1.42]

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3.2.36
terminateur
[VOIR: 3.1.43]

3.2.37
émetteur-récepteur
[VOIR: 3.1.44]

3.2.38
émetteur
[VOIR: 3.1.45]

3.2.39
ligne principale
[VOIR: 3.1.46]

3.3 Type 2: Termes et définitions

3.3.1
activité
[VOIR: 3.1.1]

3.3.2
bit
[VOIR: 3.1.3]

3.3.3
suppression ou temps de suppression
intervalle de temps requis après émission avant qu'un nœud ne puisse recevoir

3.3.4
bus
[VOIR: 3.1.4]

3.3.5
élément de communication
[VOIR: 3.1.6]

3.3.6
connecteur
[VOIR: 3.1.7]

3.3.7
équipement de transmission de données
DCE
[VOIR: 3.1.9]

3.3.8
dBm
[VOIR: 3.1.11]

3.3.9
délimiteur
[VOIR: 3.1.12]

3.3.10
appareil
[VOIR: 3.1.13]

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3.3.11
délimiteur de fin
séquence unique de symboles qui identifie la fin d'une trame

3.3.12
nœud d'extrémité
nœud producteur ou consommateur

3.3.13
erreur
[VOIR: 3.1.16]

3.3.14
trame
[VOIR: 3.1.23]

3.3.15
isolation
[VOIR: 3.1.25]

3.3.16
bavardage
[VOIR: 3.1.26]

3.3.17
codage Manchester
[VOIR: 3.1.28]

3.3.18
support
[VOIR: 3.1.29]

3.3.19
M_symbol
représentation des bits de données MAC à coder et à émettre par la couche physique

3.3.20
trame MAC
ensemble de M-symbol émis sur le support et contenant un préambule, un délimiteur de début, des données, un CRC et un délimiteur de fin

3.3.21
réseau
[VOIR: 3.1.30]

3.3.22
port d'accès au réseau
variante de couche physique qui permet la connexion d'un nœud temporaire à la liaison par connexion au NAP d'un nœud permanent

3.3.23
nœud
[VOIR: 3.1.31]

Note 1 à l'article: En outre, un nœud est une connexion à une liaison qui nécessite un M_ID (identifiant de Support) unique.

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3.3.24
symbole non données
signal de couche physique codé Manchester utilisé pour des délimiteurs et ne transportant aucune donnée

3.3.25
isolateur optique
composant placé dans l'émetteur-récepteur de couche physique d'un nœud, qui convertit le courant en lumière et de nouveau en signal électrique

3.3.26
nœud permanent
nœud dont la connexion au réseau n'utilise pas la variante de couche physique port d'accès au réseau (NAP)

Note 1 à l'article: Ce nœud peut, en option, prendre en charge une variante de couche physique NAP pour permettre à des nœuds temporaires de se connecter au réseau.

3.3.27
supports redondants
plusieurs supports utilisés pour réduire les échecs de communication

3.3.28
répéteur
[VOIR: 3.1.38]

3.3.29
segment
[VOIR: 3.1.39]

3.3.30
blindage
[VOIR: 3.1.41]

3.3.31
durée de créneau
temps maximal requis pour détecter une émission prévue

Note 1 à l'article: Chaque nœud attend pendant une durée de créneau chaque nœud manquant pendant le passage de jeton implicite.

3.3.32
ligne secondaire
[VOIR: 3.1.42]

Note 1 à l'article: Elle fait partie intégrante des prises réseau.

3.3.33
délimiteur de début
séquence unique de symboles qui identifie le début d'une trame

3.3.34
prise
point de liaison d'un nœud ou d'une ligne secondaire au câble de ligne principale

Note 1 à l'article: Une prise permet de retirer un nœud sans interrompre la liaison.

3.3.35
terminateur
[VOIR: 3.1.43]

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3.3.36
outil
programme logiciel exécutable qui interagit avec l'utilisateur pour réaliser certaines fonctions

3.3.37
émetteur-récepteur
[VOIR: 3.1.44]

3.3.38
nœud transitoire
nœud uniquement destiné à être connecté au réseau de manière temporaire, en utilisant le support de couche physique NAP connecté au NAP d'un nœud permanent

3.3.39
émetteur
[VOIR: 3.1.45]

3.3.40
ligne principale
[VOIR: 3.1.46]

3.3.41
câble de ligne principale
bus ou partie centrale d'un système de câble

3.3.42
section de câble de ligne principale
longueur de câble de ligne principale entre deux prises quelconques

3.4 Type 3: Termes et définitions

3.4.1
activité
[VOIR: 3.1.1]

3.4.2
barrière
[VOIR: 3.1.2]

3.4.3
temps binaire
temps nécessaire pour transmettre un bit

3.4.4
bus
[VOIR: 3.1.4]

3.4.5
élément de communication
[VOIR: 3.1.6]

3.4.6
confirmation (primitive de)
[SOURCE: ISO/CEI 10731:1994]

3.4.7
connecteur
[VOIR: 3.1.7]

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3.4.8
coupleur
[VOIR: 3.1.8]

3.4.9
équipement de transmission de données
DCE
[VOIR: 3.1.9]

3.4.10
équipement terminal de traitement de données
ETTD
[VOIR: 3.1.10]

3.4.11
dBm
[VOIR: 3.1.11]

3.4.12
appareil
[VOIR: 3.1.13]

3.4.13
entité DL
[SOURCE: ISO/CEI 7498-1:1994, 5.2.1.11, modifiée – (N) remplacée par DL pour la couche liaison de données]

3.4.14
câble à fibre optique
FOC (Fiber Optic Cable)
[VOIR: 3.1.18]

3.4.15
trame
[VOIR: 3.1.23]

3.4.16
indication (primitive d')
[SOURCE: ISO/CEI 10731:1994]

3.4.17
sécurité intrinsèque
[VOIR: 3.1.24]

3.4.18
isolation
[VOIR: 3.1.25]

3.4.19
bavardage
[VOIR: 3.1.26]

3.4.20
support
[VOIR: 3.1.29]

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3.4.21
entité (N)
[SOURCE: ISO/CEI 7498-1:1994, 5.2.1.11]

3.4.22
service (N)
[SOURCE: ISO/CEI 7498-1:1994, 5.2.1.5]

3.4.23
réseau
[VOIR: 3.1.30]

3.4.24
nœud
[VOIR: 3.1.31]

3.4.25
entité Ph
[SOURCE: ISO/CEI 7498-1:1994, 5.2.1.11]

3.4.26
service Ph
[SOURCE: ISO/CEI 7498-1, 5.2.1.5, modifiée – (N) remplacée par Ph pour la couche physique]

3.4.27
répéteur
[VOIR: 3.1.38]

3.4.28
demande (primitive de)
[SOURCE: ISO/CEI 10731:1994]

3.4.29
réinitialisation
[SOURCE: ISO/CEI 7498-1:1994, 5.8.1.17]

3.4.30
segment
[VOIR: 3.1.39]

3.4.31
appareil à alimentation séparée
[VOIR: 3.1.40]

3.4.32
blindage
[VOIR: 3.1.41]

3.4.33
ligne secondaire
[VOIR: 3.1.42]

3.4.34
station
nœud

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3.4.35
terminateur
[VOIR: 3.1.43]

3.4.36
émetteur-récepteur
[VOIR: 3.1.44]

3.4.37
émetteur
[VOIR: 3.1.45]

3.4.38
ligne principale
[VOIR: 3.1.46]

3.5 Type 4: Termes et définitions

3.5.1
activité
[VOIR: 3.1.1]

3.5.2
bus
[VOIR: 3.1.4]

3.5.3
connecteur
[VOIR: 3.1.7]

3.5.4
équipement de transmission de données
DCE
[VOIR: 3.1.9]

3.5.5
équipement terminal de traitement de données
ETTD
[VOIR: 3.1.10]

3.5.6
appareil
[VOIR: 3.1.13]

3.5.7
compteur de repos
compteur mesurant le nombre de périodes binaires pendant lesquelles le niveau du signal sur la liaison physique a été élevé pour des appareils de classe normale ou de classe simple en mode semi-duplex

3.5.8
isolation
[VOIR: 3.1.25]

3.5.9
support
[VOIR: 3.1.29]

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3.5.10
réseau
[VOIR: 3.1.30]

3.5.11
appareil de classe normale
appareil qui lance l'émission et répond aux demandes et qui peut agir comme serveur (répondeur) et en tant que client (demandeur) (également appelé "homologue")

3.5.12
blindage
[VOIR: 3.1.41]

3.5.13
appareil de classe simple
appareil qui répond aux demandes d'appareils de classe normale et agit comme serveur ou répondeur uniquement

3.5.14
émetteur
[VOIR: 3.1.45]

3.6 *Vide*

NOTE Dans la présente édition, le Paragraphe 3.6 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

3.7 Type 8: Termes et définitions

3.7.1
activité
[VOIR: 3.1.1]

3.7.2
coupleur de bus
appareil qui divise l'anneau en segments, en ouvrant l'anneau et en intégrant un autre anneau à cet endroit

3.7.3
connecteur d'interface de canalisation de câbles
CPIC
[VOIR: 3.1.5]

3.7.4
élément de communication
[VOIR: 3.1.6]

3.7.5
connecteur
[VOIR: 3.1.7]

3.7.6
dBm
[VOIR: 3.1.11]

3.7.7
puissance d'injection effective
[VOIR: 3.1.14]

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3.7.8
puissance effective
[VOIR: 3.1.15]

3.7.9
câble à fibre optique
[VOIR: 3.1.18]

3.7.10
récepteur à fibre optique
[VOIR: 3.1.19]

3.7.11
domaine de fonctionnement d'un récepteur à fibre optique
[VOIR: 3.1.20]

3.7.12
émetteur à fibre optique
[VOIR: 3.1.21]

3.7.13
guide d'onde à fibre optique
[VOIR: 3.1.22]

3.7.14
trame
[VOIR: 3.1.23]

3.7.15
interface d'arrivée
interface qui reçoit des données de l'appareil précédent et qui envoie des données, reçues par l'intermédiaire d'une interface de départ, à l'appareil précédent

3.7.16
isolation
[VOIR: 3.1.25]

3.7.17
bus local
segment d'anneau d'un réseau ayant différentes spécifications de supports et couplé à un bus distant par l'intermédiaire du coupleur de bus

3.7.18
appareil de bus local
appareil fonctionnant comme un esclave sur un bus local

3.7.19
maître
appareil qui commande le transfert de données sur le réseau et lance l'accès aux supports (au support) des esclaves en envoyant des messages et qui constitue l'interface avec le système de commande

3.7.20
support
[VOIR: 3.1.29]

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3.7.21
sensibilité minimale du récepteur optique
puissance optique minimale à l'entrée du récepteur optique requise pour obtenir un taux d'erreur sur les éléments binaires inférieur à 10^{-9} pour le système de transmission optique

3.7.22
réseau
[VOIR: 3.1.30]

3.7.23
temps de décroissance optique
[VOIR: 3.1.33]

3.7.24
temps de croissance optique
[VOIR: 3.1.35]

3.7.25
interface de départ
interface qui envoie des données à l'esclave suivant de façon à ce que les données qui sont reçues par l'intermédiaire de cette interface soient envoyées, par l'intermédiaire d'une autre interface de départ, à l'esclave suivant ou, par l'intermédiaire d'une interface d'arrivée, à l'esclave précédent et renvoyées au maître

3.7.26
longueur d'onde de transmission crête
λpp
[VOIR: 3.1.36]

3.7.27
fibre optique polymère
POF
guide d'onde à fibre optique en matière plastique dont les caractéristiques nominales sont compatibles avec la série de normes CEI 60793 [type de fibre: A4a (980/1000)]

Note 1 à l'article: L'abréviation "POF" est dérivée du terme anglais développé correspondant "polymer optical fiber".

3.7.28
fibre de silice gainée de plastique
PCS
guide d'onde à fibre optique dont le cœur est en verre (silice) et la gaine en matière plastique et dont les caractéristiques nominales sont compatibles avec la CEI 60793 [type de fibre: A3c (200/230 μm)]

Note 1 à l'article: L'abréviation "PCS" est dérivée du terme anglais développé correspondant "plastic clad silicafiber ".

3.7.29
bus distant
segment d'anneau d'un réseau

3.7.30
appareil de bus distant
appareil fonctionnant comme esclave sur un bus distant

3.7.31
liaison de bus distant
connexion de deux appareils de bus distant

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3.7.32
segment d'anneau
une section de réseau

Note 1 à l'article: Le maître constitue le premier segment d'anneau et d'autres segments d'anneau peuvent être reliés par des coupleurs de bus.

3.7.33
blindage
[VOIR: 3.1.41]

3.7.34
esclave
appareil qui n'accède au support qu'après avoir été lancé par l'esclave précédent ou le maître

3.7.35
largeur spectrale à mi-crête
$\Delta\lambda$
gamme de longueur d'onde de répartition spectrale dans laquelle l'intensité énergétique est au moins égale à la moitié de l'intensité maximale

3.7.36
terminateur
[VOIR: 3.1.43]

3.8 Type 12: Termes et définitions

3.8.1
activité
[VOIR: 3.1.1]

3.8.2
bit
[VOIR: 3.1.3]

3.8.3
connecteur
[VOIR: 3.1.7]

3.8.4
coupleur
[VOIR: 3.1.8]

3.8.5
équipement de transmission de données
DCE
[VOIR: 3.1.9]

3.8.6
équipement terminal de traitement de données
ETTD
[VOIR: 3.1.10]

3.8.7
délimiteur
[VOIR: 3.1.12]

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3.8.8
appareil
[VOIR: 3.1.13]

3.8.9
erreur
[VOIR: 3.1.16]

3.8.10
trame
[VOIR: 3.1.23]

3.8.11
repos
symbole au niveau des supports entre EOF et SOF

3.8.12
isolation
[VOIR: 3.1.25]

3.8.13
instabilité (gigue)
[VOIR: 3.1.27]

3.8.14
codage Manchester
[VOIR: 3.1.28]

3.8.15
support
[VOIR: 3.1.29]

3.8.16
réseau
[VOIR: 3.1.30]

3.8.17
récepteur
[VOIR: 3.1.37]

3.8.18
blindage
[VOIR: 3.1.41]

3.8.19
terminateur
[VOIR: 3.1.43]

3.9 Type 16: Termes et définitions

3.9.1
atténuation
phénomène tel que la puissance optique au récepteur est inférieure à celle à l'émetteur

3.9.2
barrière
[VOIR: 3.1.2]

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3.9.3
bit
[VOIR: 3.1.3]

3.9.4
insertion binaire
procédure par laquelle, après cinq “1” logiques, l'émetteur insère automatiquement un zéro qui est ensuite enlevé par le récepteur

Note 1 à l'article: Ce zéro entraîne une modification des fronts de signaux qui permettent au récepteur de récupérer une horloge de réception.

3.9.5
connecteur
[VOIR: 3.1.7]

3.9.6
équipement de transmission de données
DCE
[VOIR: 3.1.9]

3.9.7
équipement terminal de traitement de données
ETTD
[VOIR: 3.1.10]

3.9.8
dBm
[VOIR: 3.1.11]

3.9.9
délimiteur
[VOIR: 3.1.12]

3.9.10
appareil
[VOIR: 3.1.13]

3.9.11
erreur
[VOIR: 3.1.16]

3.9.12
câble à fibre optique
[VOIR: 3.1.18]

3.9.13
trame
[VOIR: 3.1.23]

3.9.14
connecteur F-SMA
connecteur F-SMA conforme à la CEI 61754-22

3.9.15
caractère de remplissage
séquence de sept “1” suivie d'un “0”

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3.9.16
instabilité (gigue)
[VOIR: 3.1.27]

3.9.17
support
[VOIR: 3.1.29]

3.9.18
réseau
[VOIR: 3.1.30]

3.9.19
nœud
[VOIR: 3.1.31]

3.9.20
non retour à zéro inversé
NRZI
échange de signaux ayant lieu à des intervalles fixes et réguliers en synchronisation avec l’impulsion de l’horloge de transmission en débit binaire.

Note 1 à l'article: Un changement de front de signal n’est affecté qu’à un “0” logique.

Note 2 à l'article: L'abréviation "NRZI" est dérivée du terme anglais développé correspondant "non-return-to-zero".

3.9.21
temps de décroissance optique
[VOIR: 3.1.33]

3.9.22
temps de croissance optique
[VOIR: 3.1.35]

3.9.23
remplissage (octet de)
séquence d'octets ajoutée pour s'assurer que le télégramme est suffisamment long pour un fonctionnement approprié

3.9.24
longueur d'onde de transmission crête
λp
[VOIR: 3.1.36]

3.9.25
récepteur
[VOIR: 3.1.37]

3.9.26
répéteur
[VOIR: 3.1.38]

3.9.27
fonction répéteur
fonction par laquelle un télégramme est reçu par un nœud et passé et resynchronisé sur le nœud suivant du réseau, tout en restant logiquement inchangé

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3.9.28
émetteur
[VOIR: 3.1.45]

3.9.29
longueur d'onde type de demi-intensité
$\Delta\lambda$
[VOIR: 3.1.47]

3.9.30
flux zéro bit
séquence de zéros logiques qui, en codage NRZI, entraîne une modification périodique du front de signal sur la ligne de transmission (utilisée uniquement en mode d'essai)

3.10 Type 18: Termes et définitions

3.10.1
activité
[VOIR: 3.1.1]

3.10.2
bit
[VOIR: 3.1.3]

3.10.3
bus
[VOIR: 3.1.4]

3.10.4
élément de communication
[VOIR: 3.1.6]

3.10.5
connecteur
[VOIR: 3.1.7]

3.10.6
équipement de transmission de données
DCE
[VOIR: 3.1.9]

3.10.7
équipement terminal de traitement de données
ETTD
[VOIR: 3.1.10]

3.10.8
appareil
[VOIR: 3.1.13]

3.10.9
erreur
[VOIR: 3.1.16]

3.10.10
isolation
[VOIR: 3.1.25]

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3.10.11
support
[VOIR: 3.1.29]

3.10.12
réseau
[VOIR: 3.1.30]

3.10.13
nœud
[VOIR: 3.1.31]

3.10.14
récepteur
[VOIR: 3.1.37]

3.10.15
segment
[VOIR: 3.1.39]

3.10.16
blindage
[VOIR: 3.1.41]

3.10.17
ligne secondaire
[VOIR: 3.1.42]

3.10.18
station
appareil de réseau matérialisant un nœud

3.10.19
terminateur
[VOIR: 3.1.43]

3.10.20
émetteur-récepteur
[VOIR: 3.1.44]

3.10.21
émetteur
[VOIR: 3.1.45]

3.10.22
ligne principale
[VOIR: 3.1.46]

3.11 Type 24: Termes et définitions

3.11.1
bit
[VOIR: 3.1.3]

3.11.2
bus
[VOIR: 3.1.4]

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3.11.3
élément de communication
[VOIR: 3.1.6]

3.11.4
connecteur
[VOIR: 3.1.7]

3.11.5
équipement de transmission de données
DCE
[VOIR: 3.1.9]

3.11.6
délimiteur
[VOIR: 3.1.12]

3.11.7
appareil
[VOIR: 3.1.13]

3.11.8
erreur
[VOIR: 3.1.16]

3.11.9
trame
[VOIR: 3.1.23]

3.11.10
isolation
[VOIR: 3.1.25]

3.11.11
codage Manchester
[VOIR: 3.1.28]

3.11.12
support
[VOIR: 3.1.29]

3.11.13
réseau
[VOIR: 3.1.30]

3.11.14
nœud
[VOIR: 3.1.31]

3.11.15
répéteur
[VOIR: 3.1.38]

3.11.16
blindage
[VOIR: 3.1.41]

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3.11.17
terminateur
[VOIR: 3.1.43]

3.11.18
émetteur-récepteur
[VOIR: 3.1.44]

3.11.19
émetteur
[VOIR: 3.1.45]

3.12 Type 20: termes et définitions

3.12.1
signal analogique
courant basse fréquence, avec signal prédominant de 4 mA à 20 mA envoyé ou provenant d'un appareil de terrain

3.12.2
spectre de signal analogique
fréquences de 0 Hz à 25 Hz à amplitude unitaire et décroissant à 40 dB par décade au-dessus de 25 Hz

3.12.3
filtre d'essai analogique
filtre passe-bas bipolaire de Butterworth avec fréquence de coupure de 25 Hz

3.12.4
barrière
entité physique qui limite le courant ou la tension dans une zone dangereuse afin de satisfaire aux exigences de sécurité intrinsèque

3.12.5
capacité linéique du câble
capacité linéique du câble, mesurée à 1 kHz à partir d'un conducteur autre que le blindage jusqu'à tous les autres conducteurs y compris le blindage

Note 1 à l'article: Pour les réseaux comprenant plus d'un type ou d'un calibre de câble, on prend la plus grande valeur de capacité de tout type ou tout calibre de câble pour déterminer cette valeur.

3.12.6
caractère
les 8 bits de données et les bits supplémentaires qui sont transmis en tant qu'unité continue par le PhE

3.12.7
délai de caractère
durée nécessaire à la transmission d'un caractère

3.12.8
résistance de détection du courant
résistance utilisée pour convertir un signal de courant analogique en signal de tension

3.12.9
distorsion de temps
écart entre le temps de retard de propagation d'ondes sinusoïdales de différentes fréquences en cas d'observation du retard dans un réseau ou circuit

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3.12.10
appareil
toute entité contenant une mise en application de la présente norme

3.12.11
signal numérique
communication des informations à l'aide du signal de modulation par déplacement de fréquence de 1 200 bits par seconde

3.12.12
bande de fréquences numérique
gamme de fréquences de 950 Hz à 2 500 Hz qui sont utilisées pour le signal numérique

3.12.13
spectre de signal numérique
fréquences de 500 Hz à 10 kHz à amplitude unitaire, décroissant à 40 dB par décade en dessous de 500 Hz et décroissant à 20 dB par décade au-dessus de 10 kHz

3.12.14
bande de fréquences étendue
gamme de fréquences de 500 Hz à 10 kHz

Note 1 à l'article: Cette bande de fréquences est composée d'une bande de fréquences numérique et d'une bande de garde.

3.12.15
appareil de terrain
entité physique qui est connectée au processus ou à l'équipement de l'usine et qui a au moins un élément de signalisation qui communique avec le(s) autre(s) élément(s) de signalisation via un câble

Note 1 à l'article: Il relie directement le détecteur ou l'actionneur ou exécute la fonction de commande de processus et il est directement connecté à la couche physique spécifiée dans la présente norme. Il peut générer ou recevoir un signal analogique en plus d'un signal numérique.

3.12.16
masse
surface de la terre ou des conduits ou canalisations qui sont connectés, ou le bus de raccordement de sécurité ou le rail de zéro volt sur lequel les barrières sont connectées

Note 1 à l'article: La masse peut être ou peut ne pas être la même en tant qu'alimentation commune réseau.

3.12.17
sécurité intrinsèque
méthodologie de conception d'un circuit ou d'un ensemble de circuits dans lequel toute étincelle ou effet thermique produit dans des conditions normales de fonctionnement et des conditions de défaut spécifiées, est incapable, dans des conditions d'essai prescrites, de provoquer l'inflammation d'une atmosphère explosive donnée

3.12.18
jonction
toute jonction de fil de deux câbles ou tout point de contact d'un autre câble ou d'un appareil de terrain vers un câble existant

3.12.19
réseau multipoints
réseau avec plus d'un appareil esclave connecté sur un réseau

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3.12.20
alimentation réseau
source fournissant une puissance de fonctionnement directement à un réseau

3.12.21
résistance du réseau:
résistance ou partie réelle de l'impédance d'un réseau

Note 1 à l'article: Elle est calculée comme impédance équivalente de tous les appareils connectés en parallèle sur le réseau. Par conséquent, elle est généralement dominée par un appareil à faible impédance.

3.12.22
élément sans signalisation
entité physique ou élément n'utilisant pas ou ne produisant pas de signaux analogique ou numérique

Note 1 à l'article: Une alimentation électrique réseau constitue un exemple d'élément sans signalisation.

3.12.23
réseau point à point
réseau équipé d'un appareil esclave uniquement et d'un ou aucun appareil maître

Note 1 à l'article: Le réseau point à point peut ne pas être équipé d'un appareil maître. Cette situation se produirait, par exemple, dans le cas où seul un contrôleur analogique est utilisé, le seul appareil de terrain ayant été programmé par un maître secondaire qui aurait ensuite été déconnecté.

3.12.24
élément de signalisation
entité physique ou élément utilisant ou produisant un signal numérique

Note 1 à l'article: L'entité qui produit ou utilise uniquement un signal analogique n'entre pas dans le cadre de cette définition, l'entité qui utilise/produit uniquement un signal numérique et non pas un signal analogique entre dans le cadre de cette définition.

3.12.25
silence
état du réseau en cas d'absence de signal numérique

3.12.26
début de message
préambule de l'unité de données de protocole de la couche physique suivi par le délimiteur de l'unité de données de protocole de couche liaison de données sans aucune erreur de réception et distance entre les caractères

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4 Symboles et abréviations

4.1 Symboles

4.1.1 Type 1: Symboles

Symbole	Définition	Unité
A_{max}	Affaiblissement maximal entre appareils	dB
AD_{max}	Distorsion d'affaiblissement maximale entre appareils	dB
BR	Débit binaire nominal	Mbit/s
ΔBR	Ecart maximal par rapport à BR	–
CS_{max}	Espacement maximal des coupleurs pour former une grappe	m
Din_{min}	Impédance d'entrée minimale d'un appareil	kΩ
DBm	Unité logarithmique de puissance référencée à 1 mW	dB(mW)
F_c	Fréquence centrale de porteuse utilisée en modulation par déplacement de fréquence	kHz
F_{c+f}	Fréquence qui correspond au 1 logique en modulation par déplacement de fréquence	kHz
$F_{c–f}$	Fréquence qui correspond au 0 logique en modulation par déplacement de fréquence	kHz
F_r	Fréquence correspondant au débit binaire nominal	MHz
F_{min}	Fréquence nominale minimale pour le débit binaire nominal	MHz
F_{max}	Fréquence nominale maximale pour le débit binaire nominal	MHz
f_{QTOmax}	Fréquence maximale pour la mesure de QTO_{max}	MHz
L_{max}	Distance maximale entre appareils	m
MD_{max}	Distorsion de désadaptation maximale entre appareils	dB
N+	Symbole non données – positif; Signal codé Manchester à haut niveau pour un temps binaire, utilisé pour des délimiteurs et ne transportant aucune donnée	–
N–	Symbole non données – négatif; Signal codé Manchester à low-level pour un temps binaire, utilisé pour des délimiteurs et ne transportant aucune donnée	–
N_{max}	Nombre maximal d'appareils	–
P	Période nominale de transmission d'octet	s
PICS	Déclaration de conformité d'une instance de protocole	–
QTO_{max}	Sortie maximale d'émetteur passif	mV
T_{bit}	Durée binaire nominale	µs
ΔT_{bit}	Ecart maximal par rapport à T_{bit}	–
T_{rf}	Temps de croissance ou de décroissance de signal maximal	ns
V_{DD}	Le niveau d'alimentation le plus positif (ou le moins négatif)	V
V_{IH}	tension d'entrée de haut niveau minimale	V
V_{IL}	tension d'entrée de low-level maximale	V
V_{OH}	Tension de sortie de haut niveau minimale	V
V_{OL}	Tension de sortie de low-level maximale	V
Z	Impédance; somme vectorielle de la résistance et de réactance (inductive ou capacitive)	Ω
Z_{f_r}	Impédance caractéristique; impédance d'un câble, et de ses terminateurs, à la fréquence f_r	Ω
Z_O	Impédance caractéristique, impédance d'un câble, et de ses terminateurs, sur la gamme de fréquences définie	Ω

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4.1.2 Type 2: Symboles

Symbole	Définition	Unité
dBm	Unité logarithmique de puissance référencée à 1 mW	dB(mW)
f_r	Fréquence correspondant au débit binaire	Hz
GND	Niveau masse de référence de l'alimentation	V
H	Symbole physique – niveau haut	–
L	Symbole physique – niveau bas	–
M_0	Commande d'accès au support physique – symbole de données – “zéro”; Symbole à l'interface DL-Ph, représentant le signal codé Manchester émis et reçu, à un high-level pendant un demi temps binaire et à un low-level pendant un demi temps binaire, transportant des données “zéro”	–
M_1	Commande d'accès au support physique – symbole de données – “un”; Symbole à l'interface DL-Ph, représentant le signal codé Manchester émis et reçu, à un low-level pendant un demi temps binaire et à un high-level pendant un demi temps binaire, transportant des données “un”	–
M_ND+	Commande d'accès au support physique – symbole non données – positif; Symbole à l'interface DL-Ph, représentant le signal codé Manchester émis et reçu, à un high-level pendant un temps binaire complet, utilisé pour des délimiteurs et ne transportant aucune donnée	–
M_ND–	Commande d'accès au support physique – symbole non données – négatif; Symbole à l'interface DL-Ph, représentant le signal codé Manchester émis et reçu, à un low-level pendant un temps binaire complet, utilisé pour des délimiteurs et ne transportant aucune donnée	–
Rx_H	Réception – high-level (interface NAP)	V
Rx_L	Réception – low-level (interface NAP)	V
Tx_H	Emission – high-level (interface NAP)	V
Tx_L	Emission – low-level (interface NAP)	V
V_{in}	Tension sur le conducteur central du câble coaxial (V_{in}+ or V_{in}–) référencée au blindage coaxial	V
$V_{sense}+$	Limite positive de sensibilité des données	V
$V_{sense}–$	Limite négative de sensibilité des données	V
$V_{sense}H$	Limite haute de sensibilité de la porteuse	V
$V_{sense}L$	Limite basse de sensibilité de la porteuse	V

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4.1.3 Type 3: Symboles

Symbole	Définition	Unité
dBm	Unité logarithmique de puissance référencée à 1 mW	dB(mW)
f_r	Fréquence correspondant au débit binaire	Hz, kHz, MHz
N–	Symbole non données – négatif; Signal codé Manchester à low-level pour un temps binaire, utilisé pour des délimiteurs et ne transportant aucune donnée	–
N+	Symbole non données – positif; Signal codé Manchester à haut niveau pour un temps binaire, utilisé pour des délimiteurs et ne transportant aucune donnée	–
P	Période nominale de transmission d'octet	s
R_d	Résistance de polarisation à la masse	Ω
R_t	Terminateur de bus	Ω
R_u	Résistance de polarisation à l'alimentation	Ω
SYN	Bits de synchronisation d'une trame (période de repos)	s
t_{BIT}	Le temps binaire t_{BIT} est la durée qui s'écoule pendant l'émission d'un bit.	s
T_{SBIT}	Tolérance élargie (uniquement pour le bit d'arrêt)	s
T_{SYN}	Temps de synchronisation	s
T_{SYNI}	Temps d'intervalle de synchronisation	s
V_{DD}	Le niveau d'alimentation le plus positif (ou le moins négatif)	V
V_{IH}	Tension d'entrée de haut niveau minimale	V
V_{IL}	Tension d'entrée de low-level maximale	V
V_{OH}	Tension de sortie de haut niveau minimale	V
V_{OL}	Tension de sortie de low-level maximale	V
VP	Plus de la Tension	V
Z	Impédance; somme vectorielle de la résistance et de réactance (inductive ou capacitive)	Ω
Z_O	Impédance caractéristique, impédance d'un câble, et de ses terminateurs, sur la gamme de fréquences définie	Ω

4.1.4 Type 4: Symboles

Symbole	Définition	Unité
Vcc	Le niveau d'alimentation le plus positif (ou le moins négatif)	V
GND	Niveau masse de référence de l'alimentation	V

4.1.5 *Vide*

NOTE Dans la présente édition, le Paragraphe 4.1.5 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

4.1.6 Type 8: Symboles

Symbole	Définition	Unité
dBm	Unité logarithmique de puissance référencée à 1 mW	dB(mW)
f_r	Fréquence correspondant au débit binaire	Hz
Vdd	Le niveau d'alimentation le plus positif (ou le moins négatif)	V
GND	Niveau masse de référence de l'alimentation	V

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4.1.7 Type 12: Symboles

Symbole	Définition	Unité
Fr	Fréquence correspondant au débit binaire nominal	MHz
N+	Symbole non données – positif; Signal codé Manchester à haut niveau pour un temps binaire, utilisé pour des délimiteurs et ne transportant aucune donnée	–
N–	Symbole non données – négatif; Signal codé Manchester à low-level pour un temps binaire, utilisé pour des délimiteurs et ne transportant aucune donnée	–
T_{bit}	Durée binaire nominale	µs
Z	Impédance; somme vectorielle de la résistance et de réactance (inductive ou capacitive)	Ω
Z_O	Impédance caractéristique, impédance d'un câble, et de ses terminateurs, sur la gamme de fréquences définie	Ω

4.1.8 Type 16: Symboles

Symbole	Définition	Unité
j	Instabilité, gigue	µs
J_{noise}	Instabilité du signal optique	µs
J_{t2}	Instabilité en t_2	µs
J_{tscyc}	Instabilité en t_{Scyc}	µs
P	Puissance	dBm ou µW
P_{RmaxH}	Puissance maximale reçue à un haut niveau optique	dBm ou µW
P_{RmaxL}	Puissance maximale reçue à un bas niveau optique	dBm ou µW
P_{RminH}	Puissance minimale reçue à un haut niveau optique	dBm ou µW
P_{TmaxH}	Puissance de transmission maximale à un haut niveau optique	dBm ou µW
P_{TmaxL}	Puissance de transmission maximale à un bas niveau optique	dBm ou µW
PTminH	Puissance de transmission minimale à un haut niveau optique	dBm ou µW
P_x	Seuil de puissance	dBm ou µW
t_{cable}	Durée de retard du signal transmis, dû au câble, pour chaque unité de longueur (environ 5 ns/m)	ns
t_{fri}	Temps pour le niveau optique faible à l'entrée d'un esclave	ns
t_{fro}	Temps pour le niveau optique faible à la sortie d'un esclave	ns
t_{rep}	Temps de retard du signal reçu, dû à un esclave d'acheminement (entrée-sortie)	ns
t_{ring}	Temps nécessaire à un télégramme du maître pour passer à travers tout le réseau et revenir de nouveau au maître	µs
t_{RPAT}	Temps de transition maximal dans un esclave pour passer de la fonction répéteur à la fonction émetteur de l'AT	µs
$t_{RPAT.2}$	Temps de transition maximal dans l'esclave 2 pour passer de la fonction répéteur à la fonction émetteur de l'AT	µs

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4.1.9 Type 18: Symboles

Symbole	Définition	Unité
V_{DD}	Tension fournie aux composantes logiques numériques de puissance	V
V_{OL}	Tension de sortie, niveau bas	V
V_{OH}	Tension de sortie, niveau haut	V
V_{IL}	Tension d'entrée, niveau bas	V
V_{IH}	Tension d'entrée, niveau haut	V

4.1.10 Type 24: Symboles

Symbole	Définition	Unité
GND	Niveau masse de référence de l'alimentation	V
H	Symbole physique – niveau haut	–
L	Symbole physique – niveau bas	–
DL_Symbols	représentation des bits de données DL à coder et à émettre par la couche physique	–
Ph_Symbols	représentation des bits de données qui doivent être codés par la commande d'accès au support physique et qui doivent être émis par la couche physique	–
Tbit	Le temps binaire Tbit est la durée qui s'écoule pendant l'émission d'un bit.	Ms
V_{DD}	Le niveau d'alimentation le plus positif	V

4.1.11 Type 20: Symboles

Symbole	Définition
C_{cbl}	Capacité linéique de câble
C_{dev}	Capacité d’appareil équivalent
C_{tg}	Capacité de borne à terre
C_{tt}	Capacité de borne à borne
HOLD	Temps d'essai
R_{cbl}	Capacité linéique de résistance de câble
R_{dev}	Capacité d’appareil équivalent
Rp	résistance parallèle du réseau
RT1	temps de silence de liaison
RT2	temps d'autorisation de liaison
R_{tg}	Résistance borne à terre
R_{tt}	Résistance borne à borne
STO	Expiration de délai esclave
Z_{tt}	Impédance borne à borne

4.2 Abréviations

4.2.1 Type 1: Abréviations

CTS Clear-to-send signal (signal "Prêt à émettre") (du DCE))

DCE Data communication equipment (équipement de transmission de données)

DIS DCE independent sublayer (sous-couche indépendante du DCE)

DL Data-link (Liaison de données) (utilisée comme préfixe) [ISO/CEI 7498-1]

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DLE	Data-link entity (entité de liaison de données)
DLL	Data-link layer (couche Liaison de données) [ISO/CEI 7498-1]
ETTD	Equipement terminal de traitement de données
EMI	Electro-magnetic interference (brouillage électromagnétique)
IDU	Interface data unit (unité de données d'interface) [ISO/CEI 7498-1]
IS	Intrinsic safety (sécurité intrinsèque)
LbE	Loopback-enable signal (signal d'activation du rebouclage) (vers MAU)
MAU	Medium attachment unit (unité de liaison au support) (pour les supports câblés, MAU = émetteur-récepteur)
MDS	Medium dependent sublayer (sous-couche dépendante du support)
min o/p	Minimum output voltage peak-to-peak (tension minimale de sortie crête à crête)
MIS	Media independent sublayer (sous-couche indépendante des supports)
NRZ	Non-return-to-zero code (code de non retour à zéro)

NOTE High-level = 1 logique, low-level = 0 logique

Ph	Physical (physique) (utilisée comme préfixe)[ISO/CEI 7498-1]
PhE	Physical layer entity (entité de couche physique) [ISO/CEI 7498-1]
PhL	Physical layer (couche physique) [ISO/CEI 7498-1]
PhICI	Physical layer interface control information (informations de commande d'interface de couche physique) [ISO/CEI 7498-1]
PhID	Physical layer interface data (données d'interface de couche physique) [ISO/CEI 7498-1]
PhIDU	Physical layer interface data unit (unité de données d'interface de couche physique) [ISO/CEI 7498-1]
PhPCI	Physical layer protocol control information (informations de commande de protocole de couche physique)[ISO/CEI 7498-1]
PhPDU	Physical layer protocol data unit (unité (ensemble) de données de protocole de couche physique) [ISO/CEI 7498-1]
PhS	Physical layer service (service de couche physique) [ISO/CEI 7498-1]
PhSAP	Physical layer service access point (point d'accès de service de couche physique) [ISO/CEI 7498-1]
PhSDU	Physical layer service data unit (unité (ensemble) de données de service de couche physique) [ISO/CEI 7498-1]
PK	Peak (crête)
pk-pk	Peak-to-peak (crête-à crête)
RDF	Receive-data-and-framing signal (signal de réception de données et de verrouillage de trame) (du DCE)
RFI	Radio frequency interference (brouillage radioélectrique)
RTS	Demande-to-send signal (signal "Demande pour émettre") (vers le DCE)
RxA	Receive-activity signal (signal d'activité de réception) (du DCE)
RxC	Receive-clock signal (signal d'horloge de réception) (du DCE)
RxS	Receive signal (signal de réception) (de la MAU)
SDU	Service data unit (unité (ensemble) de données de service) [ISO/CEI 7498-1]
TxC	Transmit-clock signal (signal d'horloge de transmission) (du DCE)

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TxD	Transmit -data signal (signal de données de transmission) (vers DCE)
TxE	Transmit -enable signal (signal d'activation de l'émission) (vers MAU)
TxS	Transmit signal (signal de transmission) (vers MAU)

4.2.2 Type 2: Abréviations

BNC	Bayonet Neill Concelman (Connecteur pour câble coaxial ayant une enveloppe de type à baïonnette avec deux petits boutons sur le clip qui s'enclenchent dans les rainures spiralées du connecteur mâle lorsqu'il est tourné) [CEI 60169-8]
DCE	Data communication equipment (équipement de transmission de données)
DL	Data-link (liaison de données) (utilisée comme préfixe) [ISO/CEI 7498-1]
DLL	Data-link layer (couche Liaison de données) [ISO/CEI 7498-1]
MAC	Medium access control (commande d'accès au support physique) (section de niveau inférieur de la couche liaison de données en interface avec la couche physique)
MAC ID	Medium access control identification (identification de la commande d'accès au support physique) – adresse d'un nœud
MAU	Medium attachment unit (unité de liaison au support) (pour les supports câblés, MAU = émetteur-récepteur)
MDS	Medium dependent sublayer (sous-couche dépendante du support)
MIS	Media independent sublayer (sous-couche indépendante des supports)
NAP	Network access port (port d'accès au réseau) (accès local à un appareil, c'est-à-dire non par l'intermédiaire du bus)
NetEnable	Signal d'activation de transmission
NUT	Network update time (temps de mise à jour du réseau) [CEI 61158-4-2]
Ph	Physique (utilisée comme préfixe) [ISO/CEI 7498-1]
PhL	Physical layer (couche physique) [ISO/CEI 7498-1]
PK	Crête
Rcv	Réception
Rx	Réception
RxCarrier	Signal de porteuse de réception
RxData	Signal de données de réception
RxPTC	Signal de données de réception (interface NAP)
RM	Repeater machine (machine répéteur) (mécanisme d'extension de la longueur du bus, fournissant de multiples interfaces de supports, et permettant la redondance des supports)
RRM	Ring repeater machine (machine répéteur d'anneau) (mécanisme fournissant une topologie annulaire sur support optique)
SMAX	Scheduled maximum address (adresse maximale planifiée) [CEI 61158-4-2]
TNC	Threaded Neill Concelman (Neill Concelman fileté) (version filetée du connecteur BNC) [CEI 60169-17]
Tx	Transmettre
TxDataBar	Signal de données de transmission (inversé)
TxDataOut	Signal de données de transmission
TxPTC	Signal de données de transmission (interface NAP)

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Xmit Transmettre

4.2.3 Type 3: Abréviations

ASC	Active star coupler (coupleur en étoile actif)
BER	Bit error rate (taux d'erreurs sur les bits)
Co	Convertisseur
CTS	Clear-to-send signal (signal prêt à émettre) (du DCE)
DCE	Data communication equipment (Equipement de transmission de données)
DGND	Data ground (masse de référence des données)
DIS	DCE independent sublayer (sous-couche indépendante du DCE)
DL	Data-link (liaison de données) (utilisée comme préfixe)
DLE	Data-link entity (entité de liaison de données)
DLL	Data-link layer (couche liaison de données)[ISO/CEI 7498-1]
DLPDU	Data-link protocol data unit (ensemble (unité) de données de protocole de liaison de données) [ISO/CEI 7498-1]
ETTD	Equipement terminal de traitement de données
DUT	Device under test (appareil en essai)
CEM	Compatibilité électromagnétique
EMI	Electro-magnetic interference (brouillage électromagnétique)
FEC	Forward error correction (correction d'erreurs sans voie de retour)
FISCO	Fieldbus intrinsically safe concept (concept de bus de terrain de sécurité intrinsèque)
FO	Fibre optique
FOC	Fiber optic cable (câble à fibre optique)
IS	Intrinsic safety (sécurité intrinsèque)
LbE	Loopback enable signal (signal d'activation du rebouclage) (vers MAU)
LSS	Line selector switch (sélecteur de ligne)
M/S	Master / slave station (station maître / esclave)
MAU	Medium attachment unit (unité de liaison au support) (pour les supports câblés, MAU = émetteur-récepteur)
MDS	Medium dependent sublayer (sous-couche dépendante du support)
MIS	Media independent sublayer (sous-couche indépendante des supports)
n	Numéro d'une station
NRZ	Non-return-to-zero code (code de non retour à zéro)

NOTE High-level = 1 logique, low-level = 0 logique

OST	Overshot of transition (dépassement de transition)
PC	Physical contact (contact physique)
Ph	Physique (utilisée comme préfixe)
Ph-ASYN-DATA	Service de données physique pour transmission asynchrone
PhE	Physical layer entity (entité de couche physique) [ISO/CEI 7498-1]
PhICI	Physical layer interface control information (informations de commande d'interface de couche physique) [ISO/CEI 7498-1]

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PhID	Physical layer interface data (données d'interface de couche physique) [ISO/CEI 7498-1]
PhIDU	Physical layer interface data unit (unité de données d'interface de couche physique) [ISO/CEI 7498-1]
PhL	Physical layer interface data unit (couche physique) [ISO/CEI 7498-1]
PhM	Ph-management (gestion Ph)
PhMS	Ph-management service (service de gestion Ph)
PhPCI	Physical layer protocol control information (informations de commande de protocole de couche physique) [ISO/CEI 7498-1]
PhPDU	Physical layer protocol data unit (unité (ensemble) de données de protocole de couche physique [ISO/CEI 7498-1]
PhS	Physical layer service (service de couche physique) [ISO/CEI 7498-1]
PhSAP	Physical layer service access point (point d'accès de service de couche physique) [ISO/CEI 7498-1]
PhSDU	Physical layer service data unit (unité (ensemble) de données de service de couche physique) [ISO/CEI 7498-1]
pk-pk	Peak-to-peak (crête à crête)
RDF	Receive-data-and-framing signal (signal de réception de données et de verrouillage de trame) (du DCE)
REP	Répéteur
RFI	Radio frequency interference (brouillage radioélectrique)
RTS	Demande-to-send signal (signal "Demande pour émettre") (vers DCE)
RxA	Signal d'activité de réception (du DCE)
RxC	Signal d'horloge de réception (du DCE)
RxS	Signal de réception (de la MAU)
Stn	Stations (maître ou esclave)
TPC	Twisted-pair cable (câble twisted-pair)
TxC	Signal d'horloge de transmission (du DCE)
TxD	Signal de données de transmission (vers DCE)
TxE	Signal d'activation de l'émission (vers MAU)
TxS	Signal de transmission (vers MAU)
UART	Universal asynchronous receiver/transmitter (émetteur-récepteur asynchrone universel)

4.2.4 Type 4: Abréviations

CTS	Clear-to-send signal (signal "Prêt à émettre") (du DCE)
DCE	Data communication Equipment (équipement de transmission de données)
DL	Data-link (liaison de données) (utilisée comme préfixe) [ISO/CEI 7498-1]
DLE	Data-link entity (entité de liaison de données)
DLL	Data-link layer (couche liaison de données) [ISO/CEI 7498-1]
ETTD	Equipement terminal de traitement de données
MAU	Medium attachment unit (unité de liaison au support) (pour les supports câblés, MAU = émetteur-récepteur)
MDS	Medium dependent sublayer (sous-couche dépendante du support)

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MIS Media independent sublayer (sous-couche indépendante des supports)

NRZ Non-return-to-zero code (code de non retour à zéro)

NOTE High-level = 1 logique, low-level = 0 logique.

Ph Physique (utilisée comme préfixe) [ISO/CEI 7498-1]

PhE Physical layer entity (entité de couche physique) [ISO/CEI 7498-1]

PhL Physical layer (couche physique) [ISO/CEI 7498-1]

PhID Physical layer interface data (données d'interface de couche physique) [ISO/CEI 7498-1]

PhPDU Physical layer protocol data unit (unité (ensemble) de données de protocole de couche physique) [ISO/CEI 7498-1]

RTS Demande-to-send signal (signal "demande pour émettre") (vers DCE)

RxS Signal de réception (de la MAU)

TxE Signal d'activation de l'émission (vers MAU)

TxS Signal de transmission (vers MAU)

4.2.5 *Vide*

NOTE Dans la présente édition, le Paragraphe 4.2.5 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

4.2.6 Type 8: Abréviations

BC Bus connector (connecteur de bus)

BLL Basic link layer (couche de liaison basique)

BSY Busy (occupé)

CPIC Cable plant interface connector (connecteur d'interface de canalisation de câbles)

CRC Cyclic redundancy check (contrôle de redondance cyclique)

CTS Clear-to-send (prêt à émettre)

DL Data-link (liaison de données) (utilisée comme préfixe) [ISO/CEI 7498-1]

DLL Data-link layer (couche liaison de données) [ISO/CEI 7498-1]

DI Data In (données entrantes)

DLPDU Data-link process data unit (unité (ensemble) de données de processus de liaison de données)

DO Data out (données sortantes)

DS Data select (sélection de données)

GND Ground (masse (terre) de référence)

ICI Interface control information (informations de commande d'interface)

ID Identifiant

LbE Loopback enable (activation du rebouclage)

LSB Least significant byte (octet de poids faible)

MA Medium activity (activité du support)

MAC Medium access control (commande d'accès au support physique)

MAU Medium attachment unit (unité de liaison au support)

MDS Medium dependent sublayer (sous-couche dépendante du support)

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MIS	Media independent sublayer (sous-couche indépendante des supports)
MSB	Most significant bit (bit de poids fort)
NRZ	Non-return-to-zero (non retour à zéro)
PCS	Plastic-clad silica fiber (fibre de silice gainée de plastique; fibre silice-plastique)
Ph	Physique (utilisée comme préfixe) [ISO/CEI 7498-1]
PhE	Physical layer entity (entité de couche physique) [ISO/CEI 7498-1]
PhICI	Physical interface control information (informations de commande d'interface de couche physique)
PhIDU	Physical interface data unit (unité de données d'interface de couche physique)
PhL	Physical layer (couche physique) [ISO/CEI 7498-1]
PhPDU	Physical protocol data unit (unité (ensemble) de données de protocole de couche physique)
PhSDU	Physical service data unit (unité (ensemble) de données de service de couche physique)
PNM1	Peripherals network management of layer 1 (gestion de réseau de périphériques de couche 1)
POF	Polymer optical fiber (fibre optique polymère)
RI	Reset-in (réinitialisation-entrée)
RO	Reset-out (réinitialisation-sortie)
RqDly1	Demande delay 1 (délai de demande 1)
RqDly2	Demande delay 2 (délai de demande 2)
RTS	Demande-to-send (demande pour émettre)
RxA	Activité de réception
RxC	Horloge de réception
RxCR	Ligne de commande de réception
RxD	Données de réception
RxS	Séquence de réception
RxSL	Ligne de sélection de réception
SL	Select line (ligne de sélection)
T_{Rst}	Codage et décodage (du PhPDU de réinitialisation)
TxC	Horloge de transmission
TxCR	Ligne de commande de transmission
TxD	Données de transmission
TxS	Séquence de transmission
TxSL	Ligne de sélection de transmission

4.2.7 Type 12: Abréviation

EBUS	Une couche physique de Type 12 telle que décrite dans la présente Norme internationale
EOF	End of Frame (fin de trame)
LVDS	Low Voltage Differential Signaling (signalisation différentielle basse tension)
PCB	Printed Circuit Board (carte de circuit imprimé)

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RxS Signal de réception

SOF Start of Frame (début de trame)

TxS Signal de transmission

4.2.8 Type 16: Abréviations

DPLL digital phase locked loop (boucle numérique à verrouillage de phase)

HCS hard clad silica (silice gainée en dur) (fibre de verre)

CI circuit intégré

DEL diode électroluminescente

LSB least significant bit (bit de poids faible)

MSB most significant bit (bit de poids fort)

NRZI non-return-to-zero-inverted (non retour à zéro inversé)

POF polymer optical fiber (fibre optique polymère) (fibre plastique)

RxCLK horloge de réception

RxD données reçues

TxCLK horloge de transmission

TxD données émises

4.2.9 Type 18: Abréviations

AWG American Wire Gauge (calibre AWG)

CMOS Complementary Metal Oxide Silicon (semi-conducteur à oxyde métallique complémentaire) – une classe de spécification d'interface logique numérique

DA / DB Données A et données B – paire de signaux de télécommunication

DG Data Ground (masse de référence des données) – référence des signaux de télécommunication dont le potentiel est égal à zéro

FG Field Ground (masse de référence du bus de terrain) – référence des appareils dont le potentiel est égal à zéro

NRZI Non-Return to Zero Inverted (non retour à zéro inversé)

PhL-B Physical layer – Basic type (couche physique – de type basique)

PhL-P Physical layer – Powered type (couche physique – de type alimenté)

RxS Signal de réception

SLD Blindage – cage de Faraday linéaire

TTL Transistor-Transistor Logic (logique transistor-transistor) – une classe de spécification d'interface logique numérique

TxE Activation de transmission

TxS Signal de transmission

UL Unit Load (charge unitaire)

4.2.10 Type 24: Abréviations

AWG American Wire Gauge (calibre AWG)

DL Data-link (liaison de données) (utilisée comme préfixe) [ISO/CEI 7498-1]

DLL Data-link layer (couche liaison de données) [ISO/CEI 7498-1]

NC No connection (aucune connexion)

Ph Physique (utilisée comme préfixe)[ISO/CEI 7498-1]

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PhL	Physical layer (couche physique) [ISO/CEI 7498-1]
PK	Peak (crête)
pk-pk	Peak-to-peak (crête à crête)
SRD	Send data Receive data (données de transmission données de réception)
RxS	Signal de réception
TxE	Signal d'activation de transmission
TxS	Signal de transmission

4.2.11 Type 20: Abréviations

AWG	American Wire Gauge (calibre AWG)
bit(s)	Bits par seconde
DUT	Device under test (appareil en essai)
EMI	Electro-magnetic interference (brouillage électromagnétique)
FSK	Frequency shift keying (modulation par déplacement de fréquence)
HCF	HART™ Communication Foundation
RMS	Root mean square (valeur efficace)
SOM	Start of message (début de message)
STX	Début de transaction

5 Interface DLL – PhL

5.1 Généralités

L'Article 5 définit les primitives de services physiques (PhS) requises et les contraintes liées à leur utilisation.

NOTE 1 L'interface physique – liaison de données est une interface de service virtuelle entre machines virtuelles; il n'y a aucune exigence concernant les lignes de signaux physiques car la norme n'exige pas que cette interface soit exposée.

Les PhIDU doivent être transférées entre la DLL et la PhL conformément aux exigences de l'ISO/CEI 7498, comme illustré à la Figure 2.

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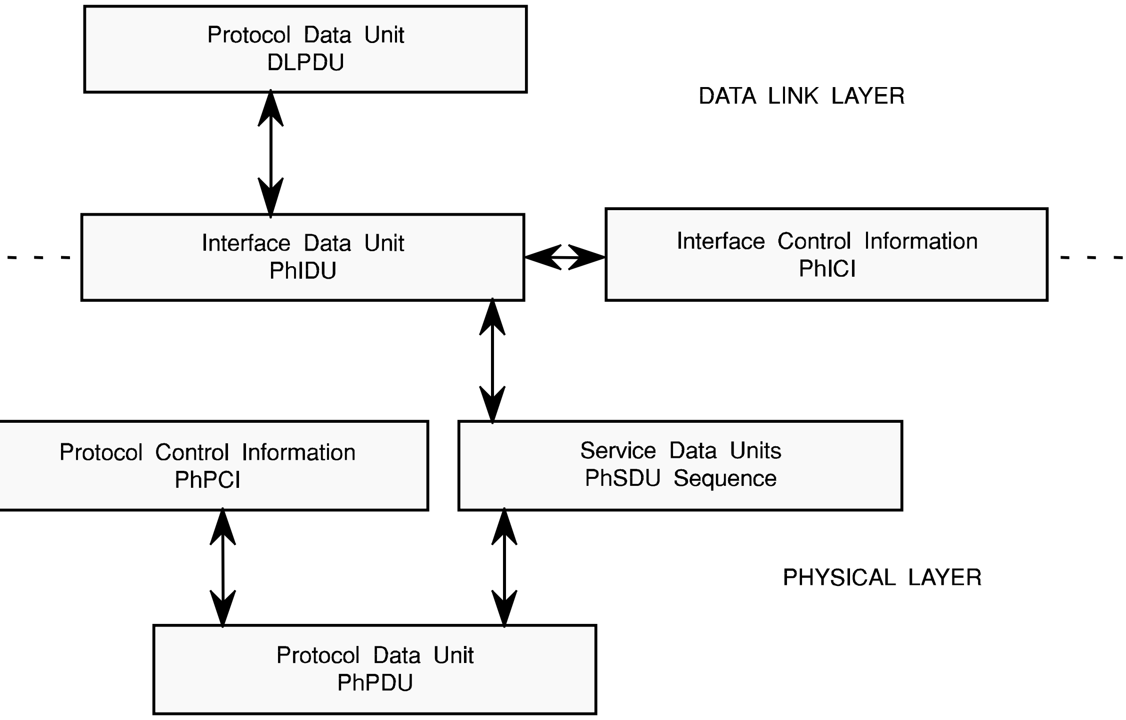

NOTE La prise en charge des PhPCI et PhICI est spécifique au type.

Légende

Anglais	Français
Protocol Data Unit DLPDU	Unité de données de protocole DLPDU
DATA LINK LAYER	COUCHE DE LIAISON DE DONNEES
Interface Data Unit PhIDU	Unité de données d'interface PhIDU
Interface Control Information PhICI	Informations de commande d'interface PhICI
Protocol Control Information PhPCI	Informations de commande de protocole PhPCI
Service Data Units PhSDU Sequence	Unité de données de service, Séquence de PhSDU
PHYSICAL LAYER	COUCHE PHYSIQUE
Protocol Data Unit PhPDU	Unité de données de protocole PhPDU

Figure 2 – Mapping entre unités de données sur l'interface DLL – PhL

NOTE 2 Ces services assurent l'échange de PhIDU entre une entité DLL et l'entité PhL correspondante. Ce transfert fait partie d'une transaction entre entités DLL coopérantes. Les services énumérés dans cette section constituent un minimum; ils peuvent conjointement fournir les moyens par lesquels des entités DLL coopérantes peuvent coordonner leurs émissions et leurs échanges de données sur le support de communication partagé. La synchronisation de l'échange de données et les actions correspondantes sont également prévues si nécessaire.

NOTE 3 Une organisation appropriée des couches assure qu'une entité de couche (N+1) ne soit pas concernée par les moyens utilisés par une couche (N) pour fournir ses services (N) et qu'une interface de services (N) ne restreigne pas exagérément ces moyens. Ainsi, l'interface de Ph-service ne réclame pas que les DLE soient informées des détails internes de la PhE (par exemple préambule (synchroniseur initial), synchroniseur final et configuration des signaux délimiteurs de trames, nombre de bits par baud) et n'empêche pas la PhE d'utiliser des avancées technologiques appropriées.

NOTE 4 Un certain nombre de différentes interfaces DLL – PhL sont spécifiées, sur la base des pratiques industrielles en la matière.

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5.2 Type 1: Services exigés

5.2.1 Primitives du PhS

5.2.1.1 Généralités

La granularité des données utilisateur PhS échangées au niveau de l'interface PhL – DLL est d'un octet.

5.2.1.2 Indication des Ph-CHARACTERISTICS

Le PhS doit fournir la primitive de service suivante afin de rendre compte des caractéristiques essentielles du PhS (qui peuvent être utilisées dans les activités de transmission, de réception et de planification de la DLL):

Indication des Ph-CHARACTERISTICS (débit binaire minimal, surdébit de trame)

où

minimum-data-rate – doit spécifier le débit minimal d'acheminement des données effectif, en bits/s, y compris d'éventuelles tolérances temporelles

NOTE 1 Une PhE ayant un débit binaire nominal de 1 Mbit/s ± 0,01 % indiquerait un débit binaire minimal de 0,999 9 Mbit/s.

le surdébit de trame – doit spécifier le nombre maximal de périodes binaires (la période binaire étant l'inverse du débit binaire) utilisées dans toute émission de PhPDU qui n'acheminent pas directement de données (par exemple des PhPDU qui acheminent des préambules (synchroniseurs initiaux), des délimiteurs de trames, des synchroniseurs finaux, des "silences" inter-trames, etc.).

NOTE 2 Si le surdébit de trame est F et si deux longueurs de messages DL sont L_1 et L_2, le temps nécessaire à l'envoi d'un message de longueur $L_1 + F + L_2$ sera au moins égal au temps nécessaire pour envoyer deux messages immédiatement consécutifs de longueurs L_1 et L_2.

5.2.1.3 Services PhS de transmission et de réception

Le PhS doit fournir les primitives de service suivantes pour la transmission et la réception:

Demande de PH-DATA (class, data)

Indication de PH-DATA (class, data)

confirmation de PH-DATA (status)

où

classe – doit spécifier la composante PhICI de la PhIDU.

Pour une demande de PH-DATA, les valeurs possibles doivent être:

START-OF-ACTIVITY – l'émission des PhPDU qui précèdent les données utilisateur Ph doit commencer;

DATA – la valeur d'octet unique du paramètre de données correspondant doit être transmise comme partie d'une émission continue correctement formée; et

END-OF-DATA-AND-ACTIVITY – les PhPDU qui mettent fin aux données utilisateur Ph doivent être émises après le dernier octet précédent des données Ph-user, aboutissant à la cessation de l'émission active.

Pour une indication de PH-DATA, les valeurs possibles doivent être:

START-OF-ACTIVITY – la réception d'une émission apparente d'une ou de plusieurs PhE a commencé;

DATA – le paramètre de données correspondant a été reçu comme partie d'une réception continue correctement formée;

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END-OF-DATA – la réception continue correctement formée des données d'utilisateur Ph en cours s'est terminée par la réception correcte des PhPDU impliquant la END-OF-DATA;

END-OF-ACTIVITY – la réception en cours (d'une émission apparente provenant d'une ou de plusieurs PhE) s'est achevée avec aucune preuve supplémentaire de transmission PhE; et

END-OF-DATA-AND-ACTIVITY – occurrence simultanée d'END-OF-DATA et d'END-OF-ACTIVITY.

données – doit spécifier la composante PhID de la PhIDU. Elle est constituée d'un octet de données Ph-user à émettre (demande de PH-DATA) ou qui a été reçu avec succès (indication de PH-DATA).

état – doit spécifier soit le succès, soit la raison détectée localement qui a donné lieu à l'échec.

La primitive de confirmation de Ph-Data doit fournir le retour d'informations critiques de temporisation physique nécessaires pour empêcher la DLE de démarrer une seconde émission avant que la première ne soit terminée. La confirmation de Ph-Data finale d'une émission ne doit pas être initiée avant que la PhE n'ait terminé l'émission.

5.2.2 Notification de caractéristiques PhS

La PhE a la responsabilité d'informer la DLE des caractéristiques du PhS qui peuvent être importantes pour le fonctionnement de la DLE. La PhE doit fournir ces informations à chaque PhSAP de PhE en émettant une primitive unique d'indication de Ph-CHARACTERISTICS, au démarrage de la PhE.

5.2.3 Emission des Ph-user-data

La PhE doit déterminer la temporisation de toutes les émissions. Lorsqu'une DLE émet une séquence de PhSDU, la DLE doit envoyer la séquence de PhSDU en réalisant une séquence bien formée de demandes de PH-DATA, constituée d'une seule demande spécifiant le START-OF-ACTIVITY, suivie d'une série de 3 à 300 demandes consécutives, y compris, qui spécifient également les DATA, chacune de ces demandes acheminant une PhSDU et se terminant par une demande unique spécifiant la END-OF-DATA-AND-ACTIVITY.

La PhE doit signaler l'achèvement de chaque demande de PH-DATA et indique qu'elle est prête à accepter une nouvelle demande de PH-DATA, via l'émission d'une primitive de confirmation de PH-DATA; le paramètre d'état de la primitive de confirmation de PH-DATA doit acheminer le résultat, succès ou échec, de la demande de PH-DATA correspondante. Une seconde demande de PH-DATA ne doit être lancée par la DLE qu'après que la PhE a émis la confirmation de PH-DATA correspondant à la première demande.

5.2.4 Réception des Ph-user-data

La PhE doit rendre compte d'une émission reçue par une séquence bien formée d'indications de PH-DATA, qui doit être constituée

a) soit d'une indication unique spécifiant START-OF-ACTIVITY, suivie par des indications consécutives spécifiant les DATA, chacune d'elles transportant une PhSDU, suivie par une indication unique spécifiant la END-OF-DATA; et terminée par une indication unique spécifiant la END-OF-ACTIVITY; ou
b) d'une indication unique spécifiant le START-OF-ACTIVITY; suivie par des indications consécutives spécifiant les DATA et acheminant chacune une PhSDU; et suivie par une indication unique spécifiant la END-OF-DATA-AND-ACTIVITY; ou
c) d'une indication unique spécifiant le START-OF-ACTIVITY; suivie, en option, par une ou des indications consécutives spécifiant des DATA et acheminant chacune une PhSDU; et terminée par une indication unique spécifiant la END-OF-ACTIVITY.

Cette dernière séquence indique une réception incomplète ou incorrecte. La détection d'une erreur dans la séquence de PhPDU reçues, ou dans le processus de réception des PhE, doit désactiver des indications de PH-DATA ultérieures avec un paramètre de classe spécifiant les DATA, de END-OF-DATA, ou de END-OF-DATA-AND-ACTIVITY jusqu'à ce que la fin de la période

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d'activité courante et le début d'une période d'activité suivante aient été notifiés par des indications de PH-DATA spécifiant respectivement la END-OF-ACTIVITY et le START-OF-ACTIVITY.

5.3 Type 2: Services exigés

5.3.1 Généralités

Le Paragraphe 5.3 définit les primitives de services physiques (PhS) requises et les contraintes liées à leur utilisation.

L'interface DLL-PhL peut ne pas être exposée lors de la mise en œuvre d'une quelconque variante de PhL. Cette interface peut être interne au nœud et peut être mise en œuvre comme interne à un appareil à semi-conducteur. Cependant, s'il est revendiqué une conformité à l'interface DLL-PhL, celle-ci doit satisfaire aux exigences de 5.3.

5.3.2 M_symbols

Les unités de données de l'interface PhL, présentes à l'interface DLL-PhL, doivent être des M_symbols, comme présenté dans le Tableau 1. Les symboles M_ND doivent être utilisés pour créer des modèles de données uniques utilisés pour les délimiteurs de début et de fin.

Tableau 1 – Règles de codage de données

Bits de données (nom commun)	Représentation de symbole M
données “zéro”	M_0 ou {0}
données “un”	M_1 ou {1}
“non_data+”	M_ND+ ou {+}
“non_data-”	M_ND– ou {–}

5.3.3 Indication de PH-LOCK

L'indication de PH-LOCK doit informer s'il y a verrouillage des données ou synchronisation du Ph-symbol par la MDS. Les états valides pour l'indication de PH-LOCK doivent être "vrai" et "faux". L'indication de PH-LOCK doit être "vrai" lorsque des Ph-symbols valides sont présents à l'interface MDS-MAU et lorsque la synchronisation d'interface DLL-PhL des M_symbols est conforme aux exigences de précision d'horloge. Cette indication doit être "faux" entre trames (lorsqu'aucun Ph-symbols n'est présent sur le support) ou lorsque la synchronisation des données est perdue ou que la temporisation n'est pas conforme aux exigences de précision d'horloge. L'indication de PH-LOCK doit être "vrai" avant le commencement du délimiteur de début.

5.3.4 Indication de PH-FRAME

L'indication de PH-FRAME doit fournir une information de trame de données valide en provenance de la MAU. Les états valides pour l'indication de PH-FRAME doivent être "vrai" et "faux". L'indication de PH-FRAME doit être "vrai" sur indication de PH-LOCK= "vrai" et sur réception du premier délimiteur de début valide. L'indication de PH-FRAME doit être "faux" à la réception du symbole M_ND suivant (à la suite du délimiteur de début) ou sur indication de PH-LOCK= "faux".

NOTE Ce signal fournit une synchronisation des octets vers la DLL.

5.3.5 Indication de PH-CARRIER

L'indication PH-CARRIER doit représenter la présence d'une porteuse de signal sur le support. L'indication de PH-CARRIER doit être "vrai" si RXCARRIER (porteuse de réception) à l'interface MDS-MAU était à l'état "vrai" au cours de l'une des 4 dernières durées de M_symbol et elle doit être "faux" dans le cas contraire.

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5.3.6 Indication de PH-DATA

L'indication de PH-DATA doit représenter les M-symbols définis dans le Tableau 1 Les symboles valides doivent être M_0, M_1, M_ND+ ou M_ND- (ou des M_symbols). L'indication de PH-DATA doit représenter les M_symbols tels que décodés à partir de la MAU si l'indication de PH-LOCK est "vrai".

5.3.7 Indication de PH-STATUS

L'indication de PH-STATUS doit représenter l'état de la trame qui a été reçue de la MAU, comme illustré au Tableau 2. Les symboles valides sont "Normal", "Abandon" et "Invalide". L'indication de PH-STATUS doit être "Normal" après réception d'une trame (Indication de PH-FRAME = "vrai") constituée d'un délimiteur de début, de données codées Manchester valides (pas de symboles M_ND) et d'un délimiteur de fin. L'indication de PH-STATUS doit être "Abandon" après réception d'une trame (Indication de PH-FRAME = "vrai") constituée d'un délimiteur de début, de données codées Manchester valides et d'un second délimiteur de début. L'indication de PH-STATUS doit être "Invalide" après réception d'une trame (Indication de PH-FRAME = "vrai") constituée d'un délimiteur de début et indiquer la détection de tout symbole M_ND qui ne faisait pas partie d'un délimiteur de début ou de fin.

Tableau 2 – Tableau de vérité de l'indication de PH-STATUS

Indication de PH-STATUS	Indication de Ph-FRAME	Délimiteurs de début dans une trame unique	Détection de délimiteur de fin	Toute violation de code Manchester non-délimiteur
Normal	Vrai	1	Vrai	Faux
Abandon	Vrai	2	sans effet	Faux
Invalide	Vrai	1	sans effet	Vrai

5.3.8 Demande de PH-DATA

La demande de PH-DATA doit représenter les M_symbols à émettre. Les symboles valides doivent être M_0, M_1, M_ND+ ou M_ND– comme présenté dans le Tableau 1. La demande de PH-DATA doit indiquer M_0 lorsqu'aucune donnée n'est à émettre (et demande de PH-FRAME = "Faux").

5.3.9 Demande de PH-FRAME

La demande de PH-FRAME doit être "vrai" lorsque la demande de PH-DATA représente des M_symbols à coder en Ph-symbols appropriés et à transférer à la MAU; elle doit être "faux" lorsqu'aucun M_symbols valide n'est à transférer à la MAU.

5.3.10 Indication de PH-JABBER

L'indication de PH-JABBER doit être "vrai" si l'interface MDS-MAU détecte une trame unique (indication de PH-FRAME = "vrai") supérieure ou égale à 1 024 octets (8 192 M_symbols) et que la demande de TYPE DE BAVARDAGE PH est "vrai". L'indication de PH-JABBER doit être "vrai" si l'interface MDS-MAU détecte une trame unique (indication de PH-FRAME = "vrai") supérieure ou égale à 2 048 octets (16 384 M_symbols) et que la demande de PH-JABBER-TYPE est "faux". Dans le cas contraire, l'indication de PH-JABBER doit être "faux". Si l'indication de PH-JABBER devient "vrai", elle doit être verrouillée dans cet état par le MDS jusqu'à ce que la demande de Ph-JABBER-CLEAR soit "vrai" ou que le nœud soit mis hors tension puis de nouveau sous tension ou que le nœud soit initialisé.

5.3.11 Demande de Ph-JABBER-CLEAR

La demande de Ph-JABBER-CLEAR (facultative) doit être "faux" dans des conditions normales de fonctionnement et doit être "vrai" pour réinitialiser une indication de PH-JABBER qui a été verrouillée à l'état "vrai".

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5.3.12 Demande de Ph-JABBER-TYPE

Une demande de Ph-JABBER-TYPE doit être "vrai" si le nœud est l'origine des données de transmission (“NODE”) et doit être "faux" si le nœud réémet des données reçues d'un autre nœud (lorsqu'il agit par exemple comme “REPEATER” de données provenant d'un autre nœud; voir l'Annexe G).

Les combinaisons d'indication de Ph-JABBER et de demande de Ph-JABBER-TYPE doivent être telles que présentées dans le Tableau 3.

Tableau 3 – Indications de Jabber

Indication de Ph-JABBER	Demande de Ph-JABBER-TYPE	Longueur de trame
Vrai	vrai = “NODE”	≥ 1 024 octets
vrai	faux = “REPEATER”	≥ 2 048 octets
Faux	vrai = “NODE”	< 1 024 octets
Faux	faux = “REPEATER”	< 2 048 octets

5.4 Type 3: Services exigés

5.4.1 Transmission synchrone

Les services définis pour le Type 1 doivent être utilisés (voir 5.2).

5.4.2 Transmission asynchrone

5.4.2.1 Services PhS de transmission et de réception

Le service de données pour transmission asynchrone (Ph-ASYN-DATA) comprend deux primitives de service. Une primitive de demande est utilisée pour une demande de service par la DLE; une primitive d'indication est utilisée pour indiquer une réception vers la DLE. Les primitives correspondantes portent les désignations suivantes:

Demande de Ph-ASYN-DATA

Indication de Ph-ASYN-DATA

La relation temporelle entre primitives est présentée à la Figure 3.

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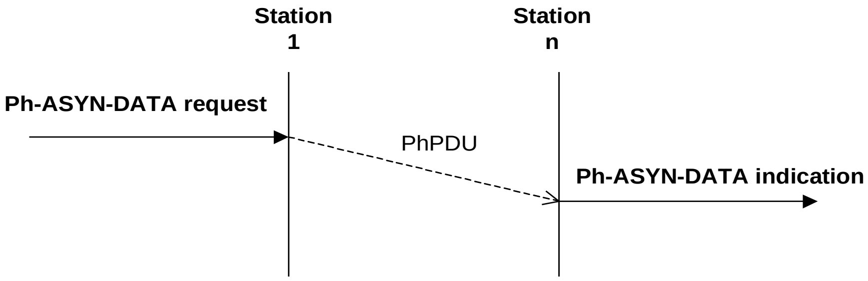

Légende

Anglais	Français
Station	Station
Ph-ASYN-DATA request	Demande de Ph-ASYN-DATA
Ph-ASYN-DATA Indication	Indication de Ph-ASYN-DATA

Figure 3 – Service de données pour transmission asynchrone

5.4.2.2 Spécification détaillée du service et interaction

Le Paragraphe 5.4.2.2 donne une description détaillée des primitives de service et des paramètres correspondants, de manière abstraite. Les paramètres contiennent les données PhS-user échangées au niveau de l'interface PhL-DLL avec une granularité d'un bit.

Paramètres des primitives:

Demande de Ph-ASYN-DATA (DL_symbol)

Le paramètre DL_symbol doit prendre l'une des valeurs suivantes qui spécifient la composante PhID de PhIDU. Ces valeurs doivent être:

a) ZERO qui correspond à un "0" binaire;
b) ONE qui correspond à un "1" binaire;
c) SILENCE qui désactive l'émetteur lorsqu'aucun symbole DL ne doit être transmis.

La primitive de demande Ph-ASYN-DATA est transmise de la DLE à la PhE afin de demander que le symbole indiqué doit être envoyé au support de bus de terrain.

La réception de cette primitive doit engendrer une tentative de codage et de transmission du symbole DL par la PhE.

La demande Ph-ASYN-DATA est une primitive qui ne doit être générée qu'une fois par période de symbole DL (t_{BIT}). La PhE peut confirmer cette primitive au moyen d'une primitive de confirmation définie localement.

Indication de Ph-ASYN-DATA (DL_symbol)

Le paramètre DL_symbol doit prendre l'une des valeurs suivantes:

a) ZERO qui correspond à un "0" binaire;
b) ONE qui correspond à un "1" binaire;

La primitive d'indication de Ph-ASYN-DATA est transmise de la PhE à la DLE pour indiquer qu'un DL-symbol a été reçu du support de bus de terrain. L'effet de la réception de cette primitive par la DLE n'est pas spécifié.

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La demande Ph-ASYN-DATA est une primitive qui ne doit être générée qu'une fois par période de DL-symbol (t_{BIT}).

5.5 Type 4: Services exigés

5.5.1 Généralités

Les PhIDU doivent être transférées entre la DLL et la PhL conformément aux exigences de l'ISO/CEI 7498.

5.5.2 Primitives du PhS

5.5.2.1 Généralités

La granularité de transmission dans le protocole de bus de terrain est d'un octet. Il s'agit de la granularité des données PhS-user échangées au niveau de l'interface PhL-DLL.

5.5.2.2 Services PhS de transmission et de réception

Le PhS doit fournir les primitives de service suivantes pour la transmission et la réception:

Demande de PH-DATA (class, data)

Indication de PH-DATA (class, data, status)

Confirmation de PH-DATA (status)

où

class – spécifie la composante Ph-interface-control-information (PhICI) de Ph-interface-data-unit (PhIDU).

Pour une demande de PH-DATA, les valeurs possibles doivent être:

START-OF-ACTIVITY-11 – la PhE doit entamer la transmission en émettant le paramètre de données correspondant, comme un "Caractère d'adresse". La PhE doit effectuer cette opération immédiatement, bien qu'il faille attendre que la valeur du compteur de repos des PhE ait atteint 11. Cette classe s'applique uniquement au mode semi-duplex.

START-OF-ACTIVITY-2 – la PhE doit activer son pilote et lancer la transmission en émettant le paramètre de données correspondant, comme un "Caractère d'adresse". La PhE doit effectuer cette opération immédiatement, bien qu'il faille attendre que la valeur du module 10 du compteur de repos des PhE ait atteint 2, en cas de mode semi-duplex.

DATA – la PhE doit émettre le paramètre de données correspondant, comme un “Caractère de données”.

END-OF-ACTIVITY – la PhE doit attendre la fin de l'émission de toutes les données précédemment reçues de la DLE puis ensuite mettre fin à l'émission. Le paramètre de données correspondant ne doit pas être émis.

Pour une indication de PH-DATA , les valeurs possibles sont:

START-OF-ACTIVITY – la PhE a reçu un “Caractère d'adresse”, dont la valeur est indiquée dans le paramètre de données correspondant. Le paramètre d'état correspondant spécifie le succès ou la raison de l'échec, détectée localement.

DATA – la PhE a reçu un “Caractère de données”, dont la valeur est indiquée dans le paramètre de données correspondant. Le paramètre d'état correspondant spécifie le succès ou la raison de l'échec, détectée localement.

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LINK-IDLE – la PhE a détecté que le niveau du signal sur la liaison a été “Au repos” pendant 30, 35, 40, 50, 60… périodes binaires. Le paramètre d'état correspondant indique si la liaison a été au repos pendant 30, 35 ou 40 périodes binaires ou plus. Cette classe s'applique uniquement au mode semi-duplex.

data – spécifie la composante données d'interface Ph (PhID) de la PhIDU. Elle est constituée d'un octet de données utilisateur Ph à émettre (demande de PH-DATA) ou d'un octet de données utilisateur PH qui a été reçu (indication de PH-DATA).

status – spécifie soit le succès soit la raison de l'échec détectée localement ou indique si l'indication LINK-IDLE correspondante est "30", "35", "40 ou plus" périodes binaires de repos après activité de la liaison.

La primitive de confirmation de PH-DATA fournit le retour d'informations nécessaire pour permettre à la DLE de rendre compte des échecs tels qu'un court-circuit de la liaison ou du bruit entraînant des erreurs de verrouillage de trame à l'utilisateur DLS; elle fournit également les indications de temps physique critique nécessaires pour éviter que la DLE ne démarre une seconde émission avant que la première ne soit terminée.

5.5.3 Transmission des Ph-user-data

5.5.3.1 Généralités

Lorsqu'une DLE a une DLPDU à émettre et que le système d'accès à la liaison donne à cette DLE le droit d'émettre, il convient que la DLE envoie la DLPDU, y compris une FCS concaténée. Le résultat d'une séquence de demande de PH-DATA est le suivant:

a) En mode semi-duplex, il convient que la première demande spécifie le START-OF-ACTIVITY-11 si la DLPDU à émettre est un acquittement ou une DLPDU de réponse immédiate ou si l'émission est une réémission immédiate d'une DLPDU confirmée ou non confirmée. Il convient que la première demande spécifie "START-OF-ACTIVITY-2" si l'émission d'une DLPDU confirmée ou non confirmée à partir de la file d'attente a commencé. En mode bidirectionnel simultané, il convient que la première demande spécifie toujours " START-OF-ACTIVITY-2".

b) Il convient que la première demande soit suivie de demandes consécutives spécifiant des DONNEES et se terminant par une simple demande indiquant la END-OF-ACTIVITY.

La PhE signale l'achèvement de chaque demande de PH-DATA et indique qu'elle est prête à accepter une nouvelle demande de PH-DATA au moyen d'une primitive de confirmation de PH-DATA. Le paramètre d'état de la primitive de confirmation de PH-DATA achemine le résultat, succès ou échec, de la demande de PH-DATA correspondante.

5.5.3.2 Réception des Ph-user data

La PhE rend compte d'une émission reçue avec des indications de PH-DATA qui doivent être constituées:

– soit d'une indication unique spécifiant le START-OF-ACTIVITY,

– soit d'une indication unique spécifiant le START-OF-ACTIVITY; suivie dans ce cas par des indications consécutives spécifiant les DATA.

Chaque indication dispose d'un paramètre d'état correspondant, spécifiant le succès de la réception des données associées ou la raison de l'échec, détectée localement.

5.6 *Vide*

NOTE Dans la présente édition, le Paragraphe 5.6 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

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5.7 Type 8: Services requis

5.7.1 Généralités

Les PhIDU sont échangées entre la DLL (DLL) et la PhL (PhL). Pour le transfert de données, l'interface DL-Ph (interface MAC-MIS) doit mettre à disposition les primitives de service suivantes:

Demande de PH-DATA

Confirmation de PH-DATA

Indication de PH-DATA

5.7.2 Primitives du PhS

5.7.2.1 Demande de PH-DATA (PhICI, PhIDU)

Cette primitive de service est utilisée pour transférer une unité de données de la sous-couche MAC à MIS. Le paramètre **PhICI** détermine les composantes d'interface de la PhIDU à émettre et peut contenir les valeurs suivantes:

ID_transfer
Le commencement d'une séquence de données pour la transmission de données d'identification/de commande est demandé.

data_transfer
Le commencement d'une séquence de données pour la transmission de données utilisateur est demandé.

start_ID_cycle
Le commencement d'un cycle d'identification pour la transmission de données d'identification/commande est demandé par le maître.

start_data_cycle
Le commencement d'un cycle de données pour la transmission de données utilisateur est demandé par le maître.

user_data
L'émission d'une unité de données utilisateur, définie par le paramètre PhIDU (données d'identification/commande ou données utilisateur) est demandée.

CRC_data
L'émission d'une unité de données de la somme de contrôle définie par le paramètre PhIDU est demandée.

CRC_status
L'émission d'une unité de données d'état de la somme de contrôle définie par le paramètre PhIDU est demandée.

user_data_idle
L'émission des messages user_data_idle est demandée.

CRC_data_idle
L'émission des messages CRC_data_idle est demandée.

CRC_status_idle
L'émission des messages CRC_status_idle est demandée.

NOTE Les paramètres start_data_cycle et start_ID_cycle sont pris en charge par la sous-couche MAC d'un maître uniquement.

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Le paramètre **PhIDU** définit la composante de données de l'unité de données d'interface à émettre. Elle est constituée d'un bit, uniquement si PhICI = user_data, CRC_data ou CRC_status

5.7.2.2 Confirmation de PH-DATA (status)

Cette primitive de service constitue l'acquittement d'une primitive de demande de PH-DATA et elle est utilisée pour la synchronisation. Le paramètre du status indique le succès ou l'échec de l'exécution de la primitive de demande de PH-DATA correspondante.

5.7.2.3 Indication de PH-DATA (PhICI, PhIDU)

Cette primitive de service est utilisée pour transférer une unité de données de la MIS à la sous-couche MAC. Le paramètre **PhICI** définit la composante Interface de la PhIDU à émettre et peut prendre les valeurs suivantes:

ID_transfer
Indique le commencement d'une séquence de données pour la transmission de données d'identification/de commande.

data_transfer
Indique le commencement d'une séquence de données pour la transmission de données utilisateur.

user_data
Indique la réception correcte d'une unité de données pour la transmission des données utilisateur (données d'identification/commande ou données utilisateur) définie par le paramètre PhIDU.

CRC_data
Indique la réception correcte d'une unité de données pour émission de la somme de contrôle définie par le paramètre PhIDU.

CRC_status
Indique la réception correcte de l'unité de données pour émission de l'état de la somme de contrôle défini par le paramètre PhIDU.

user_data_idle
Indique la réception de messages user_data_idle.

CRC_data_idle
Indique la réception des messages CRC_data_idle.

CRC_status_idle
Indique la réception des messages CRC_status_idle.

Le paramètre **PhIDU** définit les composantes de données de l'unité de données d'interface reçue. Il est constitué d'un bit.

5.7.3 Aperçu des interactions

NOTE Pour le transfert de données via l'interface DL-Ph, une distinction est faite entre la séquence de données (émission des données utilisateur ou d'identification) et la séquence de contrôle (transmission de données de la somme de contrôle).

Les points ci-après s'appliquent de la Figure 4 à la Figure 7.

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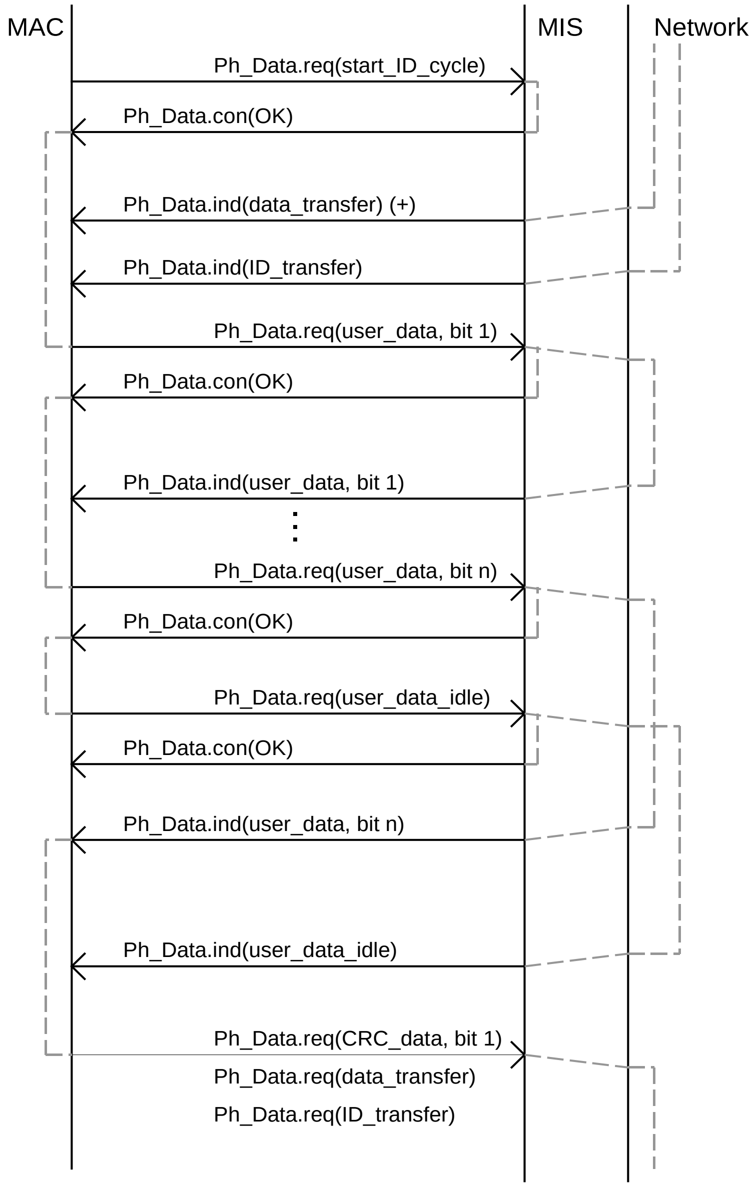
– Si une séquence de données d'un cycle de données est suivie par une séquence de données d'un cycle d'identification, les interactions indiquées par (+) sont omises pour un cycle d'identification.
– Si une séquence de données d'un cycle d'identification est suivie par une séquence de données d'un cycle de données, les interactions indiquées par (+) sont omises pour un cycle de données.

5.7.3.1 Séquence de données

5.7.3.1.1 Maître

La Figure 4 et la Figure 5 présentent les interactions pour une séquence de données (cycle d'identification et cycle de données) au niveau de l'interface DL-Ph d'un maître (carte contrôleur).



Légende

Anglais	Français
Network	Réseau

Figure 4 – Interactions pour une séquence de données de maître: cycle d'identification

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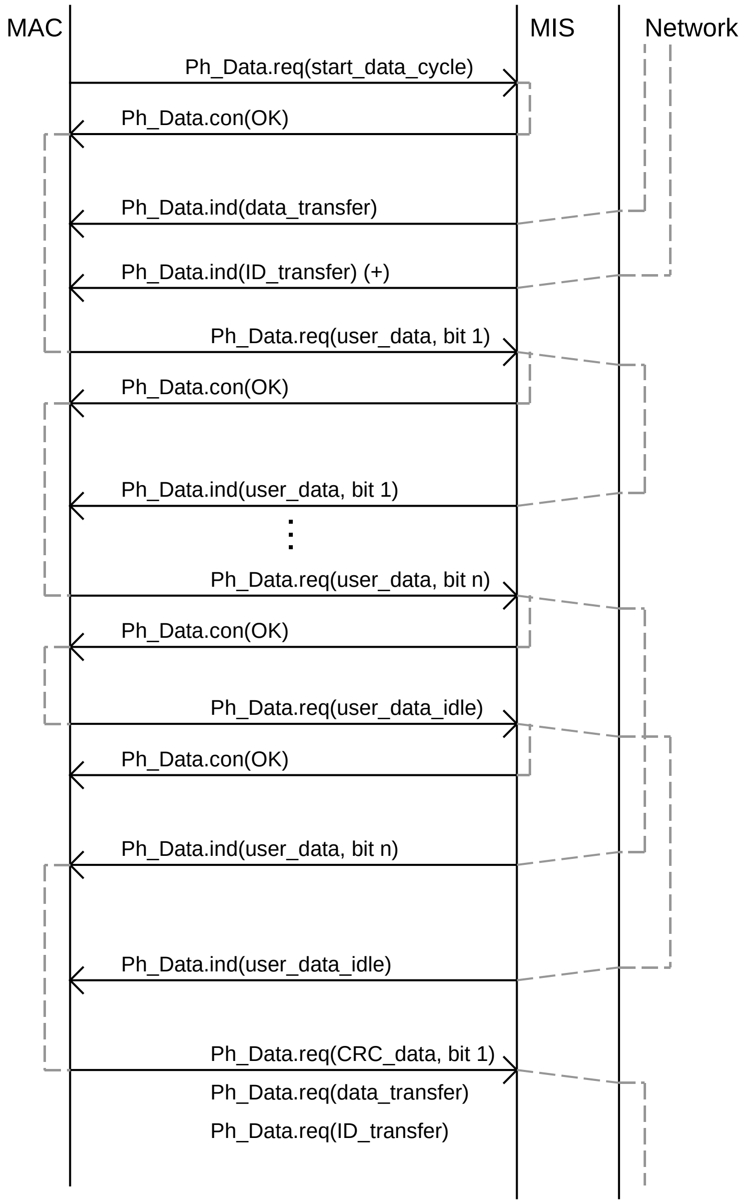

Légende

Anglais	Français
Network	Réseau

Figure 5 – Interactions pour une séquence de données de maître: cycle de données

5.7.3.1.2 Esclave

La Figure 6 et la Figure 7 présentent les interactions pour une séquence de données (cycle d'identification et cycle de données) au niveau de l'interface DL-Ph d'un esclave (appareil de bus distant, appareil de bus local ou coupleur de bus).

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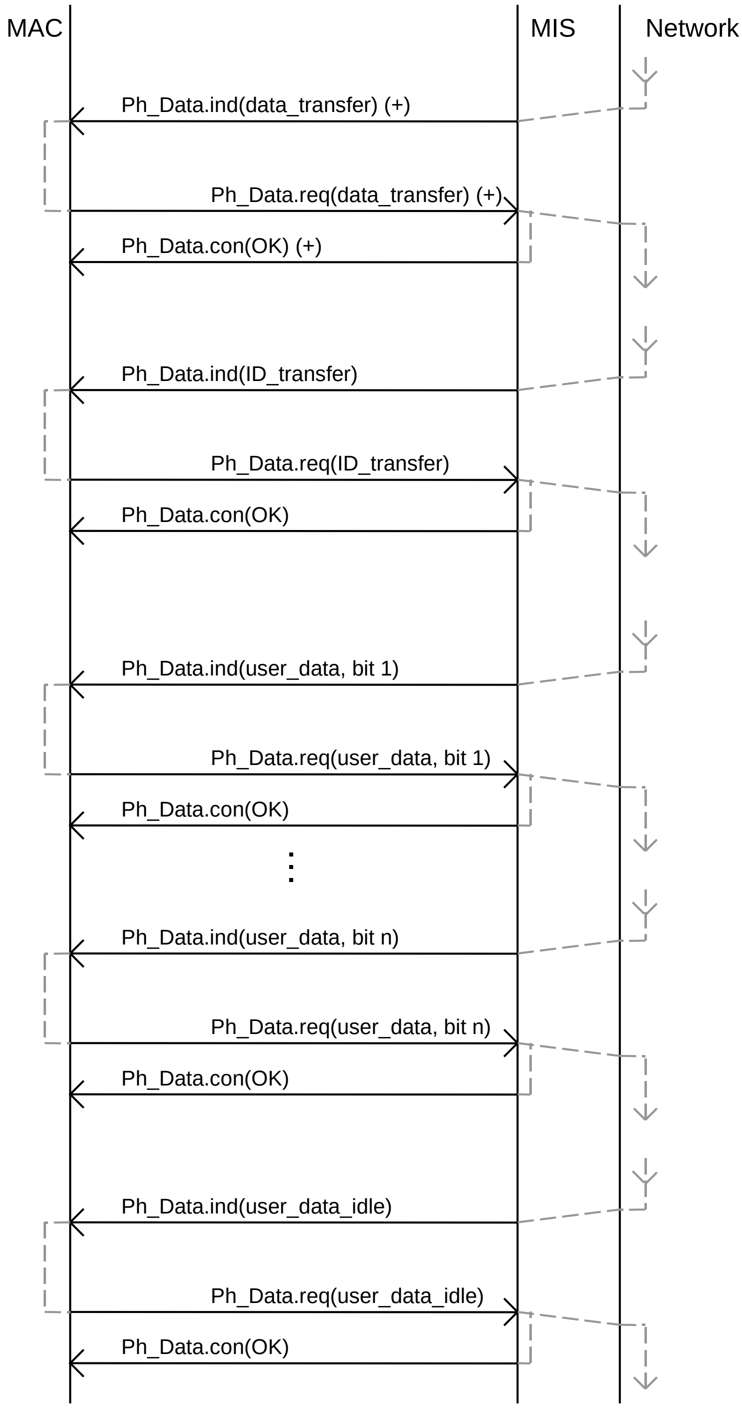

Légende

Anglais	Français
Network	Réseau

Figure 6 – Interactions pour une séquence de données d'esclave: cycle d'identification

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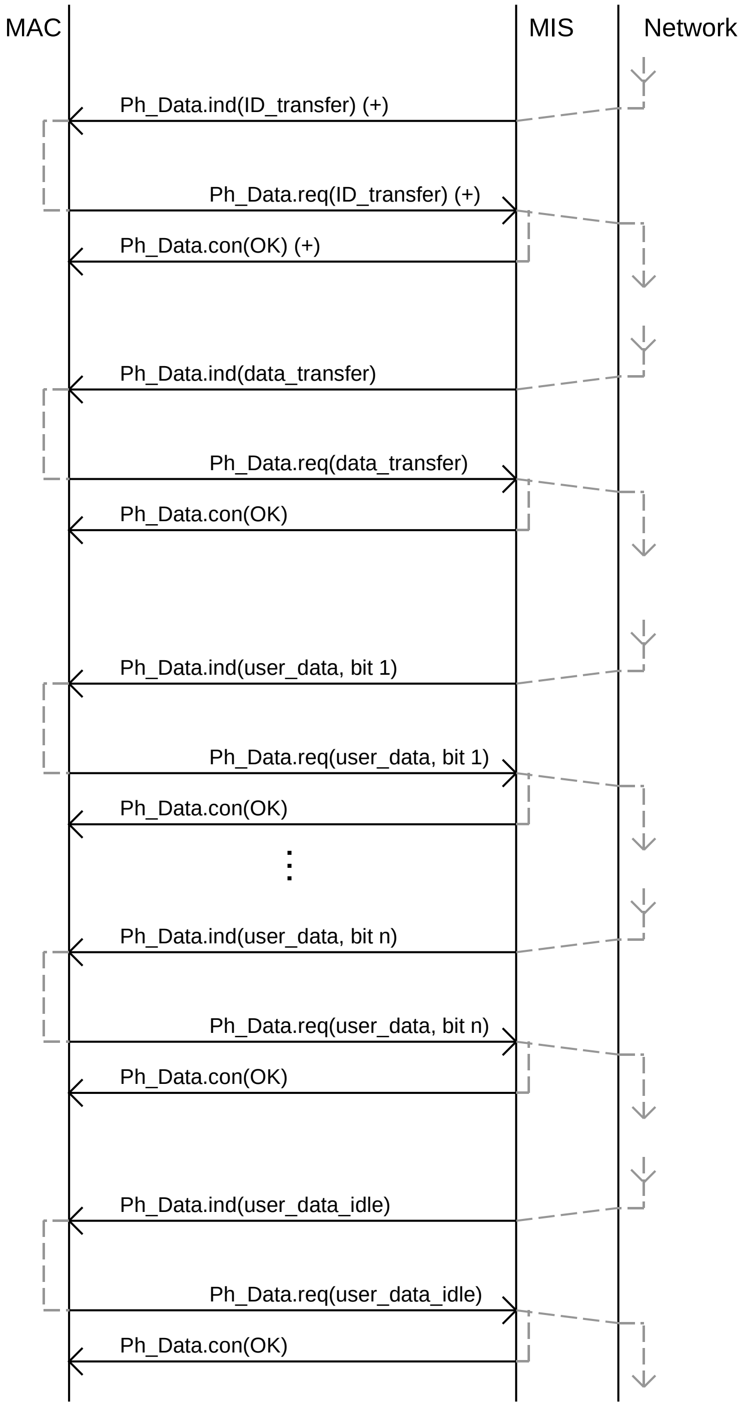

Légende

Anglais	Français
Network	Réseau

Figure 7 – Interactions pour une séquence de données d'esclave: cycle de données

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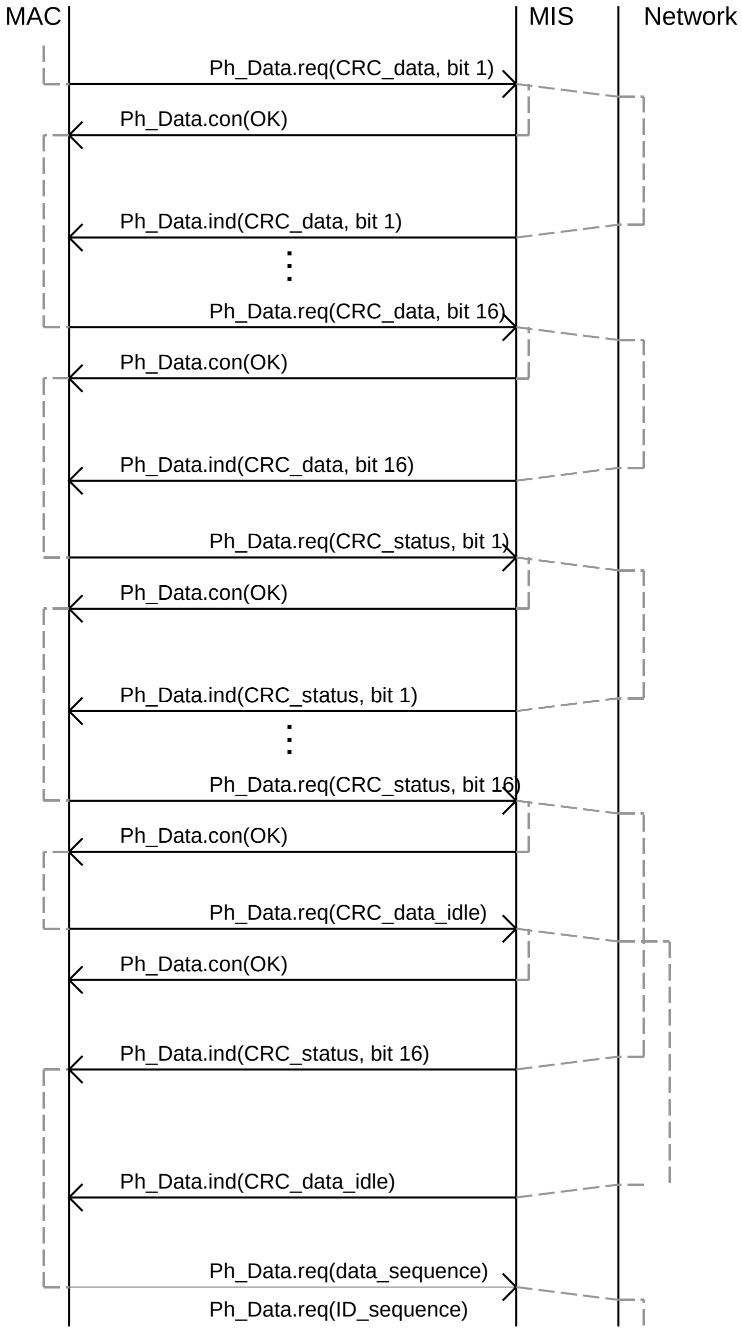
5.7.3.2 Séquence de contrôle

5.7.3.2.1 Maître

La Figure 8 présente les interactions pour une séquence de contrôle au niveau de l'interface DL-Ph d'un maître.



Légende

Anglais	Français
Network	Réseau

Figure 8 – Interactions pour une séquence de contrôle de maître

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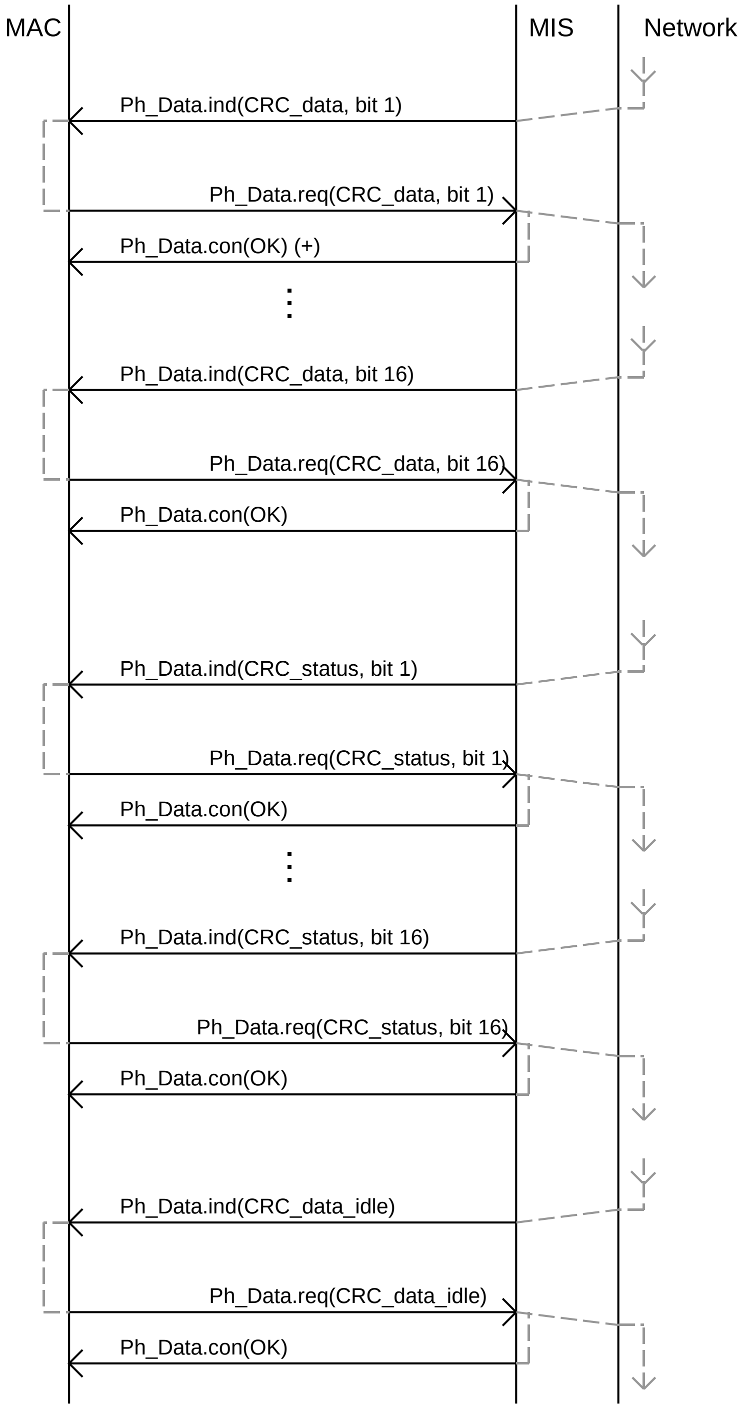
5.7.3.3 Esclave

La Figure 9 présente les interactions pour une séquence de contrôle au niveau de l'interface DL-Ph d'un esclave.



Légende

Anglais	Français
Network	Réseau

Figure 9 – Interactions pour une séquence de contrôle d'esclave

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5.8 Type 12: Services exigés

5.8.1 Primitives du PhS

5.8.1.1 Généralités

La granularité des données utilisateur PhS échangées au niveau de l'interface PhL-DLL est d'un octet.

5.8.1.2 Indication des Ph-CHARACTERISTICS

Le PhS doit fournir la primitive de service suivante afin de rendre compte des caractéristiques essentielles du PhS (qui peuvent être utilisées dans les activités de transmission, de réception et de planification de la DLL):

– Indication des Ph-CHARACTERISTICS (débit binaire minimal, surdébit de trame)

où

– le débit binaire minimal doit spécifier le débit minimal d'acheminement des données effectif, en bits par seconde, y compris d'éventuelles tolérances temporelles;

NOTE 1 Une PhE ayant un débit binaire nominal de 100 Mbit/s ± 0,01 % indiquerait un débit binaire minimal de 99,99 Mbit/s.

– le surdébit de trame – doit spécifier le nombre maximal de périodes binaires (la période binaire étant l'inverse du débit binaire) utilisées dans toute émission de PhPDU qui n'acheminent pas directement de données (par exemple des PhPDU qui acheminent des délimiteurs de trames, des "silences" inter-trames, etc.).

NOTE 2 Si le surdébit de trame est F et si deux longueurs de messages DL sont L_1 et L_2, le temps nécessaire à l'envoi d'un message de longueur $L_1 + F + L_2$ sera au moins égal au temps nécessaire pour envoyer deux messages immédiatement consécutifs de longueurs L_1 et L_2.

5.8.1.3 Services PhS de transmission et de réception

Le PhS doit fournir les primitives de service suivantes pour la transmission et la réception:

– Demande de PH-DATA (class, data);

– Indication de PH-DATA (class, data);

– Confirmation de PH-DATA (status).

où

– class – doit spécifier la composante PhICI de la PhIDU.

Pour une demande de PH-DATA, les valeurs possibles doivent être:

– START-OF-FRAME – l'émission des PhPDU qui précèdent les données Ph-user doit commencer;

– DATA– la valeur d'octet unique du paramètre de données correspondant doit être transmise comme partie d'une émission continue correctement formée; et

– END-OF-FRAME – les PhPDU qui mettent fin aux données utilisateur Ph doivent être émises après le dernier octet précédent des données Ph-user.

Pour une indication de PH-DATA, les valeurs possibles doivent être:

– START-OF-FRAME – la réception d'une émission apparente d'une ou de plusieurs PhE a commencé;

– DATA – le paramètre de données correspondant a été reçu comme partie d'une réception continue correctement formée;

– END-OF-FRAME – la réception continue correctement formée des données Ph-user en cours s'est terminée par la réception correcte des PhPDU;

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– END-W-ERROR – la réception continue correctement formée des données Ph-user en cours s'est interrompue avec réception formée incorrectement, impliquant une END-OF-FRAME WITH ERROR;
– data – doit spécifier la composante PhID de la PhIDU. Elle est constituée d'un octet de données utilisateur Ph à émettre (demande de PH-DATA) ou qui a été reçu avec succès (indication de PH-DATA);
– status – doit spécifier soit le succès, soit la raison détectée localement qui a donné lieu à l'échec.

La primitive de confirmation de PH-DATA doit fournir le retour d'informations critiques de temporisation physique nécessaires pour empêcher la DLE de démarrer une seconde émission avant que la première ne soit terminée. La confirmation de PH-DATA finale d'une émission ne doit pas être initiée avant que la PhE n'ait terminé l'émission.

5.8.2 Notification de Ph-CARACTERISTICS

La PhE a la responsabilité d'informer la DLE des caractéristiques du PhS qui peuvent être importantes pour le fonctionnement de la DLE. La PhE doit fournir ces informations à chaque PhE en émettant une primitive unique d'indication de Ph-CARACTERISTICS, au démarrage de la PhE.

5.8.3 Transmission des Ph-user-data

La PhE doit déterminer la temporisation de toutes les émissions. Lorsqu'une DLE émet une séquence de PhSDU, la DLE doit envoyer la séquence de PhSDU en réalisant une séquence bien formée de demandes de PH-DATA, constituée d'une seule demande spécifiant le START-OF-FRAME, suivie de 72 à 1 535 demandes consécutives qui spécifient également les DATA, chacune de ces demandes acheminant une PhSDU et se terminant par une demande unique spécifiant la END-OF-FRAME.

La PhE doit signaler l'achèvement de chaque demande de PH-DATA et indique qu'elle est prête à accepter une nouvelle demande de PH-DATA, via l'émission d'une primitive de confirmation de PH-DATA; le paramètre d'état de la primitive de confirmation de PH-DATA doit acheminer le résultat, succès ou échec, de la demande de PH-DATA correspondante. Une seconde demande de PH-DATA ne doit être lancée par la DLE qu'après que la PhE a émis la confirmation de PH-DATA correspondant à la première demande.

5.8.4 Réception des Ph-user-data

La PhE doit rendre compte d'une émission reçue par une séquence bien formée d'indications de PH-DATA, qui doit être constituée

a) d'une indication unique spécifiant le START-OF-FRAME; suivie par des indications consécutives spécifiant les DATA et acheminant chacune une PhSDU; et terminée par une indication unique spécifiant la END-OF-FRAME; ou
b) d'une indication unique spécifiant le START-OF-FRAME; suivie, en option, par une ou des indications consécutives spécifiant des DATA et acheminant chacune une PhSDU; et terminée par une indication unique spécifiant la END-W-ERROR.

Cette dernière séquence indique une réception incomplète ou incorrecte. La détection d'une erreur dans la séquence de PhPDU reçues, ou dans le processus de réception des PhE, doit désactiver des indications ultérieures de PH-DATA avec un paramètre de classe spécifiant les DATA ou la END-OF-FRAME jusqu'à ce que la fin de la période d'activité courante et le début d'une période d'activité suivante aient été rapportés par des indications de PH-DATA spécifiant le START-OF-FRAME.

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5.9 Type 16: Services exigés

5.9.1 Primitives du PhS

5.9.1.1 Généralités

La granularité des données utilisateur PhS échangées au niveau de l'interface PhL-DLL doit être d'un octet.

5.9.1.2 Services PhS de transmission et de réception

Le PhS doit fournir les primitives de service suivantes pour la transmission et la réception:

– Demande de Ph-Data (class, data);
– Indication de Ph-Data (class, data);
– Confirmation de Ph-Data (status)

où

– class – doit spécifier la composante PhICI de la PhIDU.

Pour une demande de Ph-Data, les valeurs possibles doivent être:

– start-of-activity – l'émission des PhPDU qui précèdent les Ph-user-data doit commencer;
– data – la valeur d'octet unique du paramètre de données correspondant doit être transmise comme partie d'une émission continue correctement formée; et
– end-of-data-and-activity – les PhPDU qui mettent fin aux Ph-user-data doivent être émises après le dernier octet précédent des Ph-user-data, aboutissant à la cessation de l'émission active.

Pour une indication de Ph-Data, les valeurs possibles doivent être:

– start-of-activity – la réception d'une émission apparente à partir d'une PhE a commencé;
– data – le paramètre de données correspondant a été reçu comme partie d'une réception continue correctement formée;
– end-of-data – la réception continue correctement formée des Ph-user-data en cours s'est terminée par la réception correcte des PhPDU impliquant la fin des données;
– data – doit spécifier la composante PhID de la PhIDU. Elle est constituée d'un octet de Ph-user-data à émettre (demande de Ph-Data) ou qui a été reçu avec succès (indication de Ph-Data);
– status – doit spécifier soit le succès, soit la raison détectée localement qui a donné lieu à l'échec.

La primitive de confirmation de Ph-Data doit fournir le retour d'informations critiques de temporisation physique nécessaires pour empêcher la DLE de démarrer une seconde émission avant que la première ne soit terminée. La confirmation de Ph-Data finale d'une émission ne doit pas être initiée avant que la PhE n'ait terminé l'émission.

5.9.2 Transmission des Ph-user-data

La PhE doit déterminer la temporisation de toutes les émissions. Lorsqu'une DLE transmet une séquence de PhSDU, elle doit envoyer la séquence de PhSDU en réalisant une séquence bien formée de demande de Ph-Data, constituée d'une seule demande spécifiant le start-of-activity, suivie du nombre requis de demandes consécutives qui spécifient également les données, chacune de ces demandes acheminant une PhSDU et se terminant par une demande unique spécifiant la end-of-data-and-activity.

La PhE doit signaler l'achèvement de chaque demande de Ph-Data et indique qu'elle est prête à accepter une nouvelle demande de Ph-Data, via l'émission d'une primitive de

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confirmation de Ph-Data; le paramètre d'état de la primitive de confirmation de Ph-Data doit acheminer le résultat, succès ou échec, de la demande de Ph-Data correspondante. Une seconde demande de Ph-Data ne doit être lancée par la DLE qu'après que la PhE a émis la confirmation de Ph-Data correspondant à la première demande.

5.9.3 Réception des Ph-user-data

La PhE doit rendre compte d'une émission reçue par une séquence bien formée des indications de Ph-Data, qui doit être constituée

a) d'une indication unique spécifiant le start-of-activity; suivie par des indications consécutives spécifiant les données et acheminant chacune une PhSDU; suivie par une indication unique spécifiant la end-of-data; et terminée par une indication unique spécifiant end-of-activity; ou
b) d'une indication unique spécifiant start-of-activity; suivie par des indications consécutives spécifiant les données et acheminant chacune une PhSDU; et suivie par une indication unique spécifiant end-of-data-and-activity; ou
c) d'une indication unique spécifiant le start-of-activity; suivie, en option, par une ou des indications consécutives spécifiant des données et acheminant chacune une PhSDU; et terminée par une indication unique spécifiant end-of-activity.

Cette dernière séquence indique une réception incomplète ou incorrecte. La détection d'une erreur dans la séquence de PhPDU reçues, ou dans le processus de réception des PhE, doit désactiver des indications ultérieures de Ph-Data avec un paramètre de classe spécifiant data, end-of-data ou end-of-data-and-activity jusqu'à ce que la fin de la période d'activité courante et le début d'une période d'activité suivante aient été rapportés par des indications de Ph-Data spécifiant end-of-activity et start-of-activity, respectivement.

5.10 Type 18: Services exigés

5.10.1 Généralités

L'interface DLL-PhL peut ne pas être exposée lors de la mise en œuvre d'une quelconque variante PhE de type 18. Cette interface peut être interne au nœud et peut être mise en œuvre comme interne à un appareil à semi-conducteur.

5.10.2 Primitives du PhS

5.10.2.1 Généralités

La granularité des données PhS-user échangées au niveau de l'interface DLL-PhL est d'un bit.

5.10.2.2 Services PhS de transmission et de réception

Le PhS doit fournir les primitives de service suivantes pour la transmission et la réception:

– Demande de PH-DATA (class, data);
– Indication de PH-DATA (class, data);
– Confirmation de PH-DATA (status).

où:

- **class** – spécifie la composante Ph-interface-control-information (PhICI) de Ph-interface-data-unit (PhIDU).

Pour une demande de PH-DATA, les valeurs de classe possibles sont:

– START-OF-ACTIVITY – l'émission des PhPDU qui précèdent les données Ph-user doit commencer;

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– DATA – la valeur de bit unique du paramètre de données correspondant doit être transmise comme partie d'une émission continue correctement formée; et
– END-OF-ACTIVITY – les PhPDU qui mettent fin aux données Ph-user doivent être émises après le dernier bit précédent des Ph-user data, aboutissant à la cessation de l'émission active.

Pour une indication de PH-DATA, les valeurs de class possibles sont:

– START-OF-ACTIVITY– la réception d'une émission apparente d'une ou de plusieurs PhE a commencé;
– DATA – le paramètre de données correspondant a été reçu comme partie d'une réception continue correctement formée;
– END-OF-ACTIVITY – la réception en cours (d'une émission apparente provenant d'une ou de plusieurs PhE) s'est achevée avec aucune preuve supplémentaire de transmission PhE; et

- **data** – doit spécifier la composante PhID de la PhIDU. Elle est constituée d'un bit de Ph-user-data à émettre (demande de PH-DATA) ou qui a été reçu avec succès (indication de PH-DATA);

  et

- **status** – doit spécifier soit le succès, soit la raison détectée localement qui a donné lieu à l'échec.

La primitive de confirmation de PH-DATA doit fournir le retour d'informations critiques de temporisation physique nécessaires pour empêcher l'utilisateur de DL de démarrer une seconde émission avant que la première ne soit terminée. La confirmation de PH-DATA finale d'une émission ne doit pas être initiée avant que la PhE n'ait terminé l'émission.

5.10.3 Transmission des Ph-user-data

La PhE doit déterminer la temporisation de toutes les émissions. Lorsqu'une DLE émet une séquence de PhSDU, la DLE doit envoyer la séquence de PhSDU en réalisant une séquence bien formée de demandes de PH-DATA, constituée d'une seule demande spécifiant le START-OF-ACTIVITY, suivie d'une série de demandes consécutives qui spécifient également les DATA, chacune de ces demandes acheminant une PhSDU et se terminant par une demande unique spécifiant la END-OF-ACTIVITY.

La PhE doit signaler l'achèvement de chaque PH-DATA demande et indique qu'elle est prête à accepter une nouvelle demande de PH-DATA via l'émission d'une primitive de confirmation de PH-DATA; le paramètre d'état de la primitive de confirmation de PH-DATA doit acheminer le résultat, succès ou échec, de demande de PH-DATA correspondante. Une seconde demande de PH-DATA ne doit être lancée par la DLE qu'après que la PhE a émis la confirmation de PH-DATA correspondant à la première demande.

5.10.4 Réception des Ph-user-data

La PhE doit rendre compte d'une émission reçue par une séquence bien formée de indications de PH-DATA, qui doit être constituée d'une indication unique spécifiant le START-OF-ACTIVITY; suivie par des indications consécutives spécifiant les DATA et acheminant chacune une PhSDU; suivie par une indication unique spécifiant la END-OF-ACTIVITY.

5.11 Type 24: Services exigés

5.11.1 Généralités

L'interface DLL-PhL peut ne pas être exposée lors de la mise en œuvre de PhL de Type 24. Cette interface peut être interne au nœud et peut être mise en œuvre comme interne à un appareil à semi-conducteur.

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Les primitives et les paramètres qui sont échangés entre la DLL et la PhL sont indiqués dans le Tableau 4.

Tableau 4 – Primitives et paramètres dans l'interface DLL-PhL

Primitives de service	Paramètres
PLS_CARRIER.indication {CARRIER_STATUS}	CARRIER_ON, CARRIER_OFF
PLS_DATA_VALID.indication {DATA_VALID_STATUS}	DATA_VALID, DATA_NOT_VALID
PLS_SIGNAL.indication {SIGNAL_STATUS}	SIGNAL_ERROR, NO_SIGNAL_ERROR
PLS_DATA.indication {INPUT_UNIT}	ZERO, ONE
PLS_DATA.demande {OUTPUT_UNIT}	ZERO, ONE

5.11.2 DL_Symbols

Les unités de données de l'interface PhL, présentes à l'interface DLL-PhL, doivent être des DL_symbols. DL_symbol doit prendre l'une des valeurs suivantes:

a) ZERO qui correspond à un "0" binaire;

b) ONE qui correspond à un "1" binaire.

5.11.3 Indication PLS_CARRIER

L'indication PLS_CARRIER doit représenter la présence d'une porteuse de signal sur le support. Le paramètre CARRIER_STATUS doit prendre l'une des deux valeurs; CARRIER_ON ou CARRIER_OFF. CARRIER_ON indique que la MDS détecte le changement de Ph_Symbol qui a été entré depuis la MAU. CARRIER_OFF indique que la MDS a détecté l'état sans que le changement de Ph_Symbol ne continue plus de 3 fois. Cette primitive est générée chaque fois que CARRIER_STATUS effectue une transition de CARRIER_OFF à CARRIER_ON ou inversement.

5.11.4 Indication PLS_SIGNAL

L'indication PLS_SIGNAL doit fournir une indication de l'état du décodage par la MDS. Le paramètre SIGNAL_STATUS doit prendre l'une des deux valeurs; NO_SIGNAL_ERROR ou SIGNAL_ERROR. NO_SIGNAL_ERROR indique que la MDS détecte le modèle de code Manchester "L, H" ou "H, L" depuis Ph_Symbols qui a été entré depuis la MAU. SIGNAL_STATUS indique que la MDS détecte une violation de code Manchester. Cette primitive est générée chaque fois que SIGNAL_STATUS effectue une transition de SIGNAL_ERROR à NO_SIGNAL_ERROR ou inversement.

5.11.5 Indication PLS_DATA_VALID

L'indication PLS_DATA_VALID doit fournir une indication de la synchronisation Ph_Symbol par la MDS. Le paramètre DATA_VALID_STATUS doit prendre l'une des deux valeurs; DATA_VALID ou DATA_NOT_VALID. DATA_VALID indique que la MDS détecte la séquence de configuration binaire "0, 1, 0" ou "1, 0, 1" depuis le DL_Symbol à transmettre à la DLL. DATA_NOT_VALID indique que la MDS détecte la disparition de la porteuse. Cette primitive est générée chaque fois que DATA_VALID_STATUS effectue une transition de DATA_NOT_VALID à DATA_VALID ou inversement.

5.11.6 Indication PLS_DATA

L'indication PLS_DATA doit représenter DL_Symbol. Les symboles valides doivent être ZERO {0} ou ONE {1}. L'indication PLS_DATA doit représenter DL_Symbol tel que décodé depuis la MAU chaque fois que le paramètre de l'indication PLS_DATA_VALID est DATA_VALID.

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5.11.7 Demande PLS_DATA

La demande PLS_DATA doit représenter le DL_Symbol à transmettre. Le paramètre OUTPUT_UNIT doit prendre l'une des trois valeurs, ZERO, ONE.

5.12 Type 20: Services exigés

5.12.1 Fonctionnalités des services de la couche physique

La PhE offre les services suivants:

- Data service – il prend en charge le transfert des user-data du service de couche physique (PhS) d'un PhS-user source à un PhS-user cible, et
- services de gestion de la PhL – ils prennent en charge la configuration du PhL.

5.12.2 Séquence des primitives

Les relations entre les primitives de chaque type au niveau de l'interface de l'utilisateur PhS et d'une PhE et les primitives au niveau de PhS-user et des autres PhE sont récapitulées dans les schémas de la Figure 10.

Avant d'utiliser la PhE, il convient que PhS-user démarre la transmission de l'activité sur le support utilisant le service représenté à la séquence de la Figure 10 a). Dans la cible, la réception démarre avec PH-START indication une fois que l'activité a été détectée par la PhE. La séquence de la Figure 10 b) représente l'émission de la PhPDU de l'entité PhL source (PhE) à la PhE cible, un octet de données par demande. La réception se termine avec indication de Ph-Data dans la cible. En cas d'erreur dans la réception, la PhE dans la cible l'indique par un paramètre d'état et peut délivrer des données PhS-user. Après avoir transmis toutes les données, il convient que l'utilisateur PhS arrête la transmission de l'activité telle que représentée dans la séquence de la Figure 10 c).

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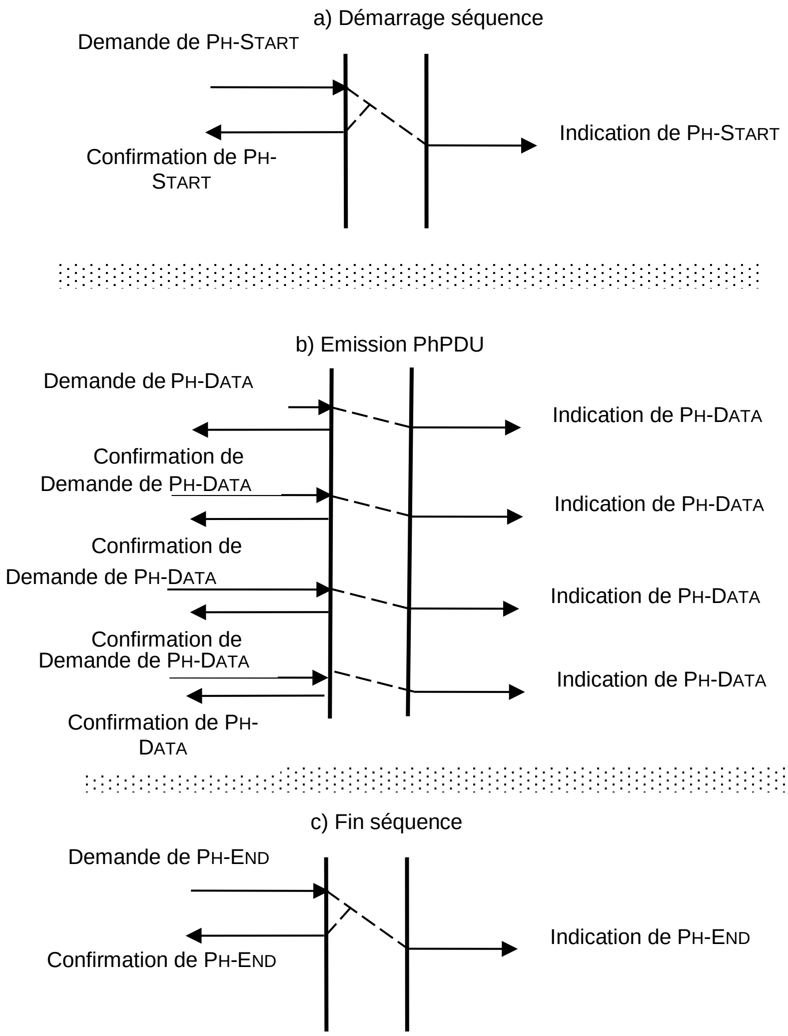

Figure 10 – Séquences de service de données de la couche physique

5.12.3 Service de PH-START

5.12.3.1 Types de primitives et de paramètres

Les types de primitives et de paramètres nécessaires au service de PH-START sont indiqués dans le Tableau 5. Ce service est utilisé pour démarrer l'activité dans le support et émettre les PhPDU qui précèdent les données Ph-user. Le service de demande est réussi uniquement si le support se trouve à l'état de repos. La primitive de confirmation n'implique pas l'indication réussie à tout autre appareil relié au support. L'appareil de réception détecte la présence de l'activité et après un délai, il fournit l'indication au PhS-user.

Tableau 5 – Primitives et paramètres de PH-START

Nom de paramètre	Demande	Indication	Confirmation
Status			M

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5.12.3.2 Paramètres

La primitive de demande ne requiert aucun paramètre. La primitive d'indication n'achemine aucun paramètre. La primitive de confirmation indique un succès ou la raison de l'erreur.

5.12.4 Service de PH-DATA

5.12.4.1 Types de primitives et de paramètres

Les types de primitives et de paramètres nécessaires au service de PH-DATA sont indiqués dans le Tableau 6.

Tableau 6 – Primitives et paramètres de DONNEES PH

Nom de paramètre	Demande	Indication	Confirmation
PhS-user-data	M	C(=)	
Status		M	M

5.12.4.2 Paramètres

5.12.4.2.1 PhS-user-data

Ce paramètre permet la transmission de données à octet unique entre les PhS-users sans altération par le PhS-provider. Après la confirmation de PH-START, il convient que les PhS-users lancent une demande de PH-DATA afin que toutes les données soient transmises comme partie d'une transmission continue correctement formée. En cas d'erreur de réception, soit ce paramètre est absent dans la primitive d'indication, soit sa valeur peut être erronée. Sinon, sa valeur est identique à la valeur dans la primitive de demande.

5.12.4.2.2 Status

Dans la primitive d'indication, ce paramètre indique un succès ou l'une des raisons d'erreur suivantes:

– dépassement de mémoire tampon de réception,
– erreur de parité,
– erreur de trame,
– réception de données discontinue.

Dans la primitive de confirmation, ce paramètre indique un succès ou l'une des raisons d'erreur suivantes:

– émetteur occupé,
– support inactif.

5.12.5 Service de PH-END

Ce service est utilisé pour terminer l'activité dans le support et émettre les PhPDU qui succèdent aux données Ph-user. La primitive de confirmation n'implique pas l'indication réussie à tout appareil relié au support. Ce service ne requiert aucun paramètre. La primitive d'indication est fournie par la PhE lorsqu'un manque d'activité du support est détecté.

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6 Interface Gestion systèmes – PhL

6.1 Généralités

Cette interface fournit à la PhL les services nécessaires à l'initialisation et à la sélection des options.

L'un des objectifs de la PhL est de permettre la prise en charge de variantes futures, telles que l'utilisation de radiofréquences, de fibres optiques, de canaux redondants (par exemple des câbles), de techniques de modulation différentes, etc. Il est spécifié un modèle général d'Interface Gestion systèmes – PhL qui fournit les services requis pour la mise en œuvre de ces variantes. Les services fournis par cette interface sont spécifiés de 6.2 à 6.5. La présente norme n'exige pas que cette interface soit exposée.

Le jeu complet de services de gestion ne peut être utilisé que lorsque l'appareil est directement couplé au support. Dans le cas de matériel à couplage actif (par exemple coupleur actif, répéteur, modem radio/téléphonique, appareils optoélectroniques, etc.), certains des services peuvent implicitement appartenir au coupleur actif. Par ailleurs, chaque appareil peut utiliser un sous-ensemble des primitives décrites.

NOTE Plusieurs interfaces Gestion systèmes – PhL différentes sont spécifiées, sur la base des pratiques industrielles en la matière.

6.2 Type 1: Gestion des systèmes– Interface PhL

6.2.1 Services exigés

La primitive de service minimal pour la gestion PhL (PhL) doit être:

a) Demande de PH-RESET– réinitialisation de la Ph-layer.

Les services supplémentaires suivants peuvent être fournis:

b) Demande de Ph-SET-VALUE / confirmation de Ph-SET-VALUE – set parameters;

c) Demande de Ph-GET-VALUE / confirmation de Ph-GET-VALUE – read parameters;

d) Indication de Ph-Event – report Ph-layer events.

6.2.2 Exigences relatives aux primitives de service

6.2.2.1 Demande de PH-RESET

Cette primitive n'a pas de paramètre. Sur réception de la primitive, la PhL doit réinitialiser toutes ses fonctions.

6.2.2.2 Demande de Ph-SET-VALUE (nom du paramètre, nouvelle valeur)

Si cette primitive est utilisée, elle doit permettre à la Gestion système de modifier les paramètres de la PhL. Le Tableau 7 donne les noms des paramètres et les plages de valeurs normalisés. La valeur que prend chaque paramètre lors de la réinitialisation doit être la première valeur parmi celles indiquées pour le paramètre.

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Tableau 7 – Noms et valeurs de paramètres pour la demande Ph-SET-VALUE

Nom de paramètre	Plage de valeurs
Mode d'interface	• FULL_DUPLEX • HALF_DUPLEX
Mode Loop-back	•DISABLED • dans la MDS à l'interface ETTD – DCE • dans la MAU à proximité de la connexion de la ligne
Extension du préambule	• 0..7 (séquences d'extension du préambule)
Extension du GapPost-transmission	• 0..7 (séquences d'extension du gap)
Dérive maximale du signal inter-channel	• 0..7 (séquences d'extension du gap)
Canal de sortie émetteur *N* (1 ≤*N*≤ 8)	• ENABLED • DISABLED
Canal de sortie récepteur *N* (1 ≤*N*≤ 8)	• ENABLED • DISABLED
Canal de réception préférentiel	• AUCUN • 1..8

NOTE 1 Toutes les mises en œuvre n'exigent pas chacun des paramètres et certaines mises en œuvre peuvent en nécessiter davantage.

NOTE 2 Chaque norme DCE spécifie les séquences de base et les séquences d'extension de PhPDU à envoyer comme préambule. Ces séquences d'extension sont toujours munies d'un préfixe qui renvoie à la séquence de base.

NOTE 3 Chaque norme DCE spécifie les longueurs des séquences de base et d'extension du gap post-émission au cours duquel l'émetteur reste silencieux.

NOTE 4 A partir de ce qui précède, la valeur par défaut lors de la réinitialisation est: un préambule minimal (pas d'extension), un gap post-émission minimal (pas d'extension), un mode d'interface bidirectionnel simultané, pas de rebouclage, avec tous les canaux de transmission et de réception activés et sans aucun canal de réception préférentiel.

6.2.2.3 Confirmation de Ph-SET-VALUE (status)

Cette primitive a un paramètre unique indiquant l'état de la demande: Succès ou échec. Si cette primitive est utilisée, elle doit acquitter l'achèvement de la demande Ph-SET-VALUE dans la PhL.

6.2.2.4 Demande de Ph-GET-VALUE (nom du paramètre)

Si cette primitive est utilisée, elle doit permettre à la Gestion système de lire les paramètres de la PhL. Le paramètre doit prendre l'un des noms donnés dans le Tableau 7.

6.2.2.5 Confirmation de Ph-GET-VALUE (valeur courante)

Cette primitive est la réponse de la PhL à la demande de Ph-GET-VALUE. Si cette primitive est utilisée, elle doit avoir un paramètre unique indiquant soit l'échec de la demande – Echec – soit la valeur courante du paramètre demandé. La valeur courante doit être l'une de celles autorisées en 6.2.2.2.

6.2.2.6 Indication de Ph-EVENT (nom du paramètre)

Si cette primitive est utilisée, elle doit indiquer à la Gestion système la modification d'un paramètre PhL qui n'a pas été demandé par la gestion des systèmes. Ce paramètre doit prendre l'un des noms indiqués dans le Tableau 8, qui repose sur ceux spécifiés en 8.2.

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Tableau 8 – Noms de paramètres pour l'indication de Ph-EVENT

Nom de paramètre
Défaut ETTD
Défaut DCE

NOTE Il est possible d'ajouter des noms au Tableau 8 si des mises en œuvre spécifiques l'exigent.

6.3 Type 3: Gestion des systèmes– Interface PhL

6.3.1 Transmission synchrone

Les services ainsi que les exigences liées aux primitives de service spécifiées pour le Type 1 doivent être utilisés (voir 6.2).

6.3.2 Transmission asynchrone

6.3.2.1 Généralités

Le paragraphe 6.3.2 décrit l'interface entre la transmission asynchrone PhL et un PhMS-user ainsi que les primitives de service et paramètres correspondants.

Le modèle de service, les primitives de service et les schémas de temps-séquence utilisés sont des descriptions totalement abstraites; ils ne constituent pas une spécification pour une mise en œuvre.

Les primitives de service utilisées pour représenter les interactions entre utilisateur de service et fournisseur de service (voir ISO/CEI 10731) acheminent des paramètres qui indiquent les informations disponibles dans l'interaction utilisateur/fournisseur.

Le présent type, tel que décrit dans la présente norme, utilise un format tabulaire pour décrire les paramètres constitutifs des primitives PhMS. Chaque tableau comprend jusqu'à trois colonnes, qui donnent le nom du paramètre de service, ainsi qu'une colonne pour ces primitives et les sens de transfert des paramètres utilisés par le PhMS:

– les paramètres d'entrée de la primitive de demande;
– les paramètres de sortie de la primitive d'indication; et
– les paramètres de sortie de la primitive de confirmation;

Un paramètre (ou partie de ce paramètre) est présenté dans chaque rangée de chaque tableau. Dans les colonnes des primitives de service concernées, un code permet de spécifier le type d'utilisation du paramètre sur la primitive et le sens du paramètre spécifié dans la colonne:

Le paramètre **M** est obligatoire pour la primitive.

Le paramètre (**blank**) n'est jamais présent.

6.3.2.2 Fonctionnalités du PhMS

La Gestion Ph organise l'initialisation et la configuration de la PhE ainsi que le traitement des événements et des erreurs entre PhMS-user et les fonctions logiques dans la PhE. PhMS-user dispose des fonctions suivantes.

a) Réinitialisation de la PhE locale
b) Demande et modification des paramètres de fonctionnement réels de la PhE locale
c) Notification des événements inattendus et modification d'état de la PhE locale

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6.3.2.3 Aperçu des services

La Gestion Ph fournit au PhMS-user les services suivants:

a) Réinitialiser

Le PhMS-user utilise ce service pour que la Ph-management réinitialise la PhE. Une réinitialisation équivaut à une mise sous tension. Le PhMS-user en reçoit confirmation.

b) Etablir valeur

Le PhMS-user utilise ce service pour attribuer une nouvelle valeur aux variables de la PhE. Le PhMS-user reçoit une confirmation indiquant si les variables spécifiées ont été établies à la nouvelle valeur.

c) Obtenir valeur

Ce service permet à la Gestion Ph de lire les variables de la PhE. La réponse de la gestion de DL retourne la valeur réelle des variables spécifiées.

d) Evénement

Ce service est utilisé par la Gestion Ph pour informer le PhMS-user de certains événements ou erreurs dans la PhL.

Les services Réinitialiser et Evénement sont obligatoires. Les services Etablir valeur et Obtenir valeur sont facultatifs.

6.3.2.4 Aperçu des interactions

Les services Ph-management et leurs primitives sont résumés dans le Tableau 9.

Tableau 9 – Résumé des primitives et des services de Ph

Service	Primitive	Possible pour les stations suivantes
Réinitialiser	Demande de PhM-RESET Confirmation de PhM-RESET	Maître et Esclave
Etablir valeur	Demande de PhM-SET-VALUE Confirmation de PhM-SET-VALUE	Maître et Esclave
Etablir valeur	Demande de PhM-GET-VALUE Confirmation de PhM-GET-VALUE	Maître et Esclave
Evénement	Indication de PhM-EVENT	Maître et Esclave

Les relations temporelles des primitives de Ph-management sont représentées dans la Figure 11 et la Figure 12.

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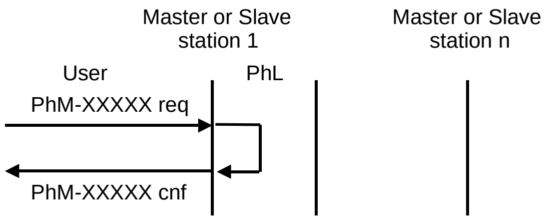
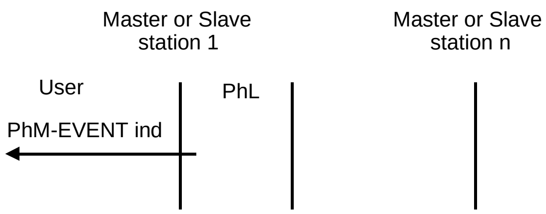


Légende

Anglais	Français
Master or slave	Maître ou Esclave
Station	Station
User	Utilisateur

Figure 11 – Réinitialiser, Etablir valeur, Obtenir valeur



Légende

Anglais	Français
Master or slave	Maître ou Esclave
Station	Station
User	Utilisateur

Figure 12 – Service d'événements

6.3.2.5 Spécification détaillée des services et interactions

6.3.2.5.1 Réinitialiser

6.3.2.5.1.1 Fonction

PhMS-user passe une primitive de demande de PhM-RESET au Ph-management pour qu'elle réinitialise la PhE. Ceci est réalisé de la même manière que lors de la mise sous tension (Transmitter_output: activée; Receiver_signal_source: primaire; Loop: désactivée). En conséquence, le Ph-management passe une primitive de confirmation de PhM-RESET au PhMS-user pour lui indiquer le succès ou l'échec de la demande de service correspondante.

6.3.2.5.1.2 Types de primitives et de paramètres

Les primitives et paramètres du service Réinitialiser sont indiqués dans le Tableau 10.

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Tableau 10 – Primitives et paramètres Réinitialiser

PhM-RESET	Demande	Confirmation
Nom de paramètre	**Entrée**	**Sortie**
PhM-STATUS		M
NOTE La méthode par laquelle une primitive de confirmation est corrélée à sa primitive de demande précédente correspondante relève d'une initiative locale.		

PhM-Status

Ce paramètre spécifie l'état de l'exécution de la demande de service correspondante. Les valeurs admises pour ce paramètre sont spécifiées dans le Tableau 11.

Tableau 11 – Valeurs de PhM-Status pour le service Réinitialiser

Nom abrégé	Etat	Définition	Temporaire (t) ou permanent (p)
OK	Succès	La fonction Réinitialiser a été menée avec succès	--
NO	Echec	La fonction Réinitialiser a échoué	t/p
IV	Echec	Paramètres non valides dans la demande	--

6.3.2.5.2 Etablir valeur

6.3.2.5.2.1 Fonction

PhMS-user passe une primitive de demande de PhM-SET-VALUE à la Ph-management pour attribuer la valeur souhaitée à une ou plusieurs variables spécifiées de la PhE. Après avoir reçu cette primitive, le Ph-management tente de sélectionner ces variables et d'attribuer de nouvelles valeurs. Si le service demandé a été exécuté, la Gestion Ph passe une primitive de confirmation de PhM-SET-VALUE au PhMS-user pour indiquer le succès ou l'échec de la demande de service correspondante.

6.3.2.5.2.2 Types de primitives et de paramètres

Les primitives et paramètres du service Etablir valeur sont indiqués dans le Tableau 12.

Tableau 12 – Primitives et paramètres Etablir valeur

PhM-SET-VALUE	Demande	Confirmation
Nom de paramètre	**Entrée**	**Sortie**
Variable_name (1 à 3)	M	
Desired_value (1 à 3)	M	
PhM-STATUS(1 à 3)		M
NOTE La méthode par laquelle une primitive de confirmation est corrélée à sa primitive de demande précédente correspondante relève d'une initiative locale.		

Variable_name

Ce paramètre de la matrice spécifie une ou plusieurs variables (1 à 3) auxquelles doivent être attribuées des valeurs à partir des éléments correspondants du paramètre Desired_value. Les variables qui peuvent être sélectionnées sont des paramètres de fonctionnement; elles sont spécifiées dans le Tableau 13.

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Tableau 13 – Variables PhE obligatoires

Paramètres de fonctionnement	
Nom	**Définition**
Transmitter_output	Sortie de l'émetteur
Receiver_signal_source	Entrée du récepteur
Boucle	La sortie de l'émetteur est dirigée vers l'entrée du récepteur et non vers le support.

Desired_value

Ce paramètre de la matrice spécifie la valeur réelle à attribuer aux variables (1 à 3) qui sont spécifiées par le paramètre Variable_name. Ce paramètre spécifie une liste d'une ou plusieurs (1 à 3) nouvelles valeurs pour les PhE-variables spécifiées. La valeur admissible ou la plage de valeurs correspondante pour chacune de ces variables est spécifiée dans le Tableau 14.

Tableau 14 – Valeurs admissibles des PhE-variables

Paramètres de fonctionnement	
Variable	**Plage de valeurs**
Transmitter_output	activée ou désactivée
Receiver_signal_source	primaire: câble bus "a" (origine normalisée) autre possibilité: câble bus "b" (origine alternative) aléatoire: soit "a" soit "b"
Loop	activée ou désactivée

PhM-Status

Ce paramètre de la matrice spécifie, pour chaque variable de la demande correspondante, l'état de cette composante du service demandé. Les valeurs admises pour les composantes individuelles de ce paramètre de matrice sont spécifiées dans le Tableau 15.

Tableau 15 – Valeurs PhM-Status pour le service Etablir valeur

Nom abrégé	Etat	Définition	Temporaire (t) ou permanent (p)
OK	Succès	La nouvelle valeur de la variable a été établie	--
NO	Echec	La variable n'existe pas ou la nouvelle valeur n'a pas pu être établie	t/p
IV	Echec	Paramètres non valides dans la demande	--

6.3.2.5.3 Obtenir valeur

6.3.2.5.3.1 Fonction

PhMS-user passe une primitive de demande PhM-GET-VALUE au Ph-management pour lire la valeur courante d'une ou de plusieurs variables de la PhE. Après réception de cette primitive, le Ph-management tente de sélectionner les variables spécifiées et de remettre leurs valeurs courantes; elle passe au PhMS-user une primitive de confirmation de PhM-GET-VALUE pour indiquer le succès ou l'échec de la demande de service correspondante. Cette primitive renvoie comme paramètre une ou plusieurs des valeurs de variables demandées.

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6.3.2.5.3.2 Types de primitives et de paramètres

Les primitives et paramètres du service Obtenir valeur sont indiqués dans le Tableau 16.

Tableau 16 – Primitives et paramètres Obtenir valeur

PhM-GET-VALUE	Demande	Confirmation
Nom de paramètre	**Entrée**	**Sortie**
Variable_Name (1 à 3)	M	
Current_value (1 à 3)		M
PhM-STATUS		M
NOTE La méthode par laquelle une primitive de confirmation est corrélée à sa primitive de demande précédente correspondante relève d'une initiative locale.		

Variable_Name

Ce paramètre spécifie une ou plusieurs variables (1 à 3) dont les valeurs sont à lire. Les variables qui peuvent être sélectionnées sont spécifiées dans le Tableau 13.

Current_value

Ce paramètre de la matrice spécifie la valeur réelle des variables (1 à 3) qui ont été spécifiées par le paramètre Variable_name de la demande correspondante. La valeur admissible ou la plage de valeurs correspondante pour chacune de ces variables est spécifiée dans le Tableau 17.

Tableau 17 – Valeurs courantes des PhE-variables

Paramètres de fonctionnement	
Variable	**Plage de valeurs**
Transmitter_output	activée ou désactivée
Receiver_signal_source	primaire ou alternative
Boucle	activée ou désactivée

PhM-Status

Ce paramètre de la matrice spécifie, pour chaque variable de la demande correspondante, une confirmation de l'exécution du service. Les valeurs admises pour ce paramètre sont spécifiées dans le Tableau 18.

Tableau 18 – Valeurs PhM-Status pour le service Obtenir valeur

Nom abrégé	Etat	Définition	Temporaire (t) ou permanent (p)
)OK	Succès	La variable a pu être lue	--
NO	Echec	La variable n'existe pas ou n'a pas pu être lue. La valeur correspondante de Current_value n'est pas définie	t/p
IV	Echec	Paramètres non valides dans la demande	--

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6.3.2.5.4 Evénement

6.3.2.5.4.1 Fonction

La PhE informe le Ph-management qu'elle a détecté un événement. Ensuite, le Ph-management passe une primitive d'indication de Ph-EVENT au PhMS-user pour l'informer d'événements importants dans la PhL.

6.3.2.5.4.2 Types de primitives et de paramètres

La primitive et les paramètres du service Evénement sont indiqués dans le Tableau 19.

Tableau 19 – Primitive et paramètres Evénement

PhM-EVENT	Indication
Nom de paramètre	**Sortie**
Variable_Name (1 à 2)	M
New_Value (1 à 2)	M

Variable_Name

Ce paramètre de la matrice spécifie une ou plusieurs variables (1 à 2) dont les valeurs ont été modifiées. Les variables qui peuvent être présentes sont spécifiées dans le Tableau 13.

New_value

Ce paramètre spécifie la nouvelle valeur de la variable. Les diverses valeurs sont présentées dans le Tableau 20.

Tableau 20 – Nouvelles valeurs des PhE-variables

Variable	Plage de valeurs
Transmitter_output	activée ou désactivée
Receiver_signal_source	primaire ou alternative

6.4 Type 4: Gestion des systèmes– Interface PhL

6.4.1 Services exigés

Les services spécifiés en 6.2 sont utilisés.

6.4.2 Exigences relatives aux primitives de service

Les exigences relatives aux primitives de service sont spécifiées en 6.2.2, en appliquant la restriction suivante:

Les paramètres spécifiés dans le Tableau 7 ne sont pas pris en charge.

Les paramètres qui peuvent être modifiés et lus par les services de gestion PhL sont présentés dans le Tableau 21. Les valeurs prises en charge ainsi que la valeur par défaut de chaque paramètre dépendent du support et de la mise en œuvre proprement dite.

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Tableau 21 – Noms des paramètres et valeurs de gestion

Nom de paramètre	Plage de valeurs
Mode d'interface	HALF_DUPLEX FULL_DUPLEX_UDP
Débit en bauds (kbaud/s)	230 400 76 800 38 400 19 200 9 600

6.5 *Vide*

NOTE Dans la présente édition, le Paragraphe 6.5 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

6.6 Type 8: Gestion des systèmes– Interface PhL

6.6.1 Fonctionnalité du PhL Management

PhL Management est la partie de la PhL qui produit la fonctionnalité de gestion de la PhL demandée par la PNM1. La gestion de la PhL traite l'initialisation, la surveillance et la récupération d'erreurs dans la PhL.

6.6.2 Interface PhL-PNM1

6.6.2.1 Généralités

Le Paragraphe 6.6.2 définit les services de gestion administrative de la PhL qui sont mis à la disposition de la PNM1, ainsi que les primitives de service et paramètres correspondants. La Figure 13 illustre l'interface entre PhL et PNM1 dans le modèle en couches.

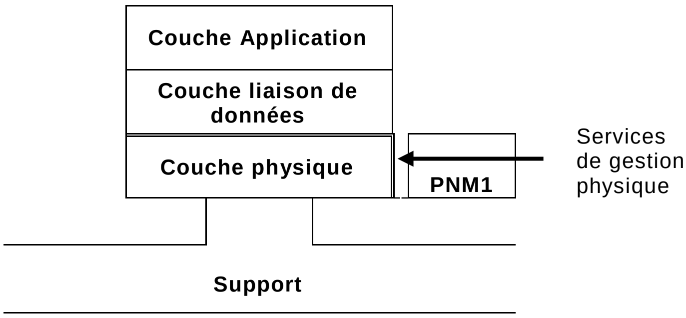

Figure 13 – Interface entre PhL et PNM1 dans le modèle en couches

L'interface de service entre PhL et PNM1 assure les fonctions suivantes:

- Réinitialisation de la PhL
- Demande et modification des paramètres de fonctionnement courants de la PhL
- Indication d'événements inattendus, d'erreurs et de modifications d'état, qui ont eu lieu ou ont été détectés dans la PhL

6.6.2.2 Aperçu des services

La PhL met les services suivants à la disposition de la PNM1:

- Réinitialiser PhL

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– Etablir valeur PhL ou Obtenir valeur PhL
– Evénement PhL

Réinitialiser PhL (obligatoire)

La PNM1 utilise ce service pour réinitialiser la PhL. La réinitialisation équivaut à une mise sous tension. Après exécution du service, la PNM1 reçoit une confirmation.

Etablir valeur PhL (facultatif)

La PNM1 utilise ce service pour établir de nouvelles valeurs des variables PhL. Après achèvement, la PNM1 de la PhL reçoit une confirmation indiquant si les variables définies ont pris de nouvelles valeurs.

Obtenir valeur PhL (facultatif)

La PNM1 utilise ce service pour lire des variables de la PhL. La valeur courante de la variable définie est renvoyée dans la réponse de la PhL.

Evénement PhL (obligatoire)

La PhL utilise ce service pour informer l'utilisateur PNM1 de certains événements ou erreurs dans la PhL.

6.6.2.3 Aperçu des interactions

Les services PhL sont décrits par les primitives suivantes (commençant par Ph…):

Réinitialiser PhL

Demande de PH-RESET
confirmation de PH-RESET

Etablir valeur PhL

Demande de Ph-GET-VALUE
confirmation de Ph-GET-VALUE

Obtenir valeur PhL

Demande Ph-GET-VALUE
Confirmation Ph-GET-VALUE

Evénement PhL
Indication Ph-Event

La Figure 14 et la Figure 15 présentent les relations temporelles entre primitives de service.

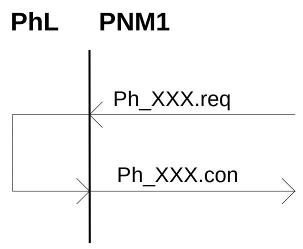

Figure 14 – Services Réinitialiser, Etablir valeur, Obtenir valeur PhL

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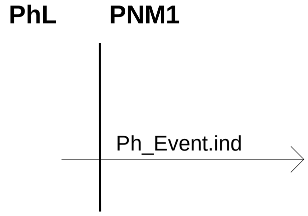

Figure 15 – Service d'événements PhL

6.6.2.4 Définitions détaillées des services et interactions

6.6.2.4.1 PH-RESET

Le service PH-RESET est obligatoire. La PNM1 transfère une primitive de demande de PH-RESET à la PhL pour la réinitialiser (voir le Tableau 22).

Tableau 22 –PH-RESET

Nom de paramètre	Demande	Confirmation
Argument	M	
Résultat(+)		M

6.6.2.4.2 Ph-SET-VALUE

Le service Ph-SET-VALUE est facultatif. La PNM1 transfère une primitive de demande de Ph-SET-VALUE pour régler une variable Ph définie à une valeur requise. Après réception de cette primitive, la PhL tente de sélectionner la variable et d'établir la nouvelle valeur. Après achèvement, la PhL transmet une primitive de confirmation de Ph-SET-VALUE à la PNM1 (voir le Tableau 23).

Tableau 23 – Ph-SET-VALUE

Nom de paramètre	Demande	Confirmation
Argument	M	
variable_name	M	
desired_value	M	
Résultat(+)		M

variable_name:

Ce paramètre définit la variable PhL qui a été établie à une nouvelle valeur.

Desired_value:

Ce paramètre déclare la nouvelle valeur de la variable PhL.

Le Tableau 24 fournit des informations grâce auxquelles la variable PhL peut être modifiée à la nouvelle valeur.

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Tableau 24 – Variables PhL

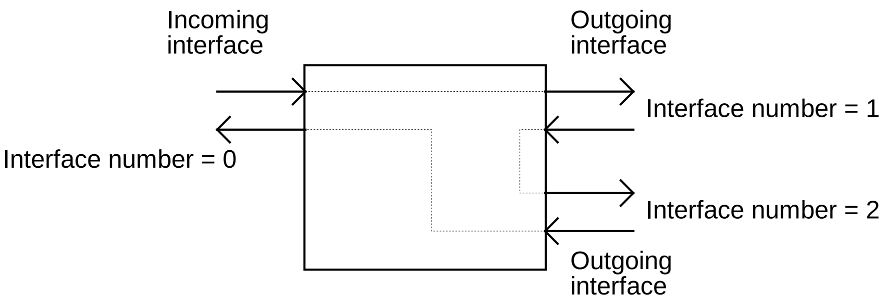
Nom de la variable PhL
loopback_mode
medium_attachment
bus_ interfaces
short_ bus_reset_time
long_bus_reset_time
data_select

loopback_mode:

Ce paramètre définit si le circuit de réception de la MAU est connecté au circuit de transmission ou au support.

Structure du paramètre:

– numéro d'interface
  Définit le numéro de l'interface d'arrivée et de départ (voir la Figure 16).
– état
  Ce paramètre définit si le circuit de réception de la MAU est connecté (activé) ou non (désactivé). Après mise sous tension, cette valeur est sur "activé".



Légende

Anglais	Français
Incoming interface	Interface d'arrivée
Outgoing interface	interface de départ
Interface number	Numéro d'interface

Figure 16 – Attribution du numéro d'interface

NOTE Un maître a toujours le numéro d'interface = 2.

medium_attachment:

Ce paramètre indique si la MAU est couplée au support de transmission. Cette information est obtenue en détectant la présence d'un connecteur branché à l'interface de départ.

Structure du paramètre:

– numéro d'interface
  Déclare le numéro de l'interface du bus (voir la Figure 16).
– branchement
  Ce paramètre définit si l'interface est branchée au support de transmission.

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bus_interfaces:

– numéro d'interface
  Déclare le numéro de l'interface du bus (voir la Figure 16).

– type d'interface
  Définit le type de l'interface physique et du support de transmission:

  - Interface d'arrivée, à 2 conducteurs
  - Interface de départ, à 2 conducteurs

short_bus_reset_time:

Ce paramètre définit la durée de la réinitialisation courte. Après mise sous tension, cette valeur est de 5 ms.

long_bus_reset_time:

Ce paramètre définit la durée de la réinitialisation longue. Après mise sous tension, cette valeur est de 100 ms.

data_select:

Ce paramètre indique qu'une Reset_PhPDU ou une medium_activity_status_PhPDU est envoyée sur le support de transmission pour une MAU passive de départ (mode rebouclage = désactivation)

Structure du paramètre:

– numéro d'interface
  Définit le numéro de l'interface du bus (voir la Figure 16). Plage de valeurs (1 à 2)

– couplage
  Désactivation: une PhPDU de réinitialisation est émise sur le support de transmission;
  Activation: la PhPDU d'état d'activité du support est émise sur le support de transmission après "mis sous tension" cette valeur est "désactivation".

6.6.2.4.3 Ph-GET-VALUE

Le service Ph-GET-VALUE est facultatif. La PNM1 transfère une primitive de demande de Ph-GET-VALUE à la PhL pour relever la valeur courante d'une variable PhL définie. Une fois que la PhL a reçu cette primitive, elle tente de sélectionner la variable définie et de transférer sa valeur courante à la PNM1 au moyen de la primitive de confirmation de Ph-GET-VALUE (voir le Tableau 25).

Tableau 25 – Ph-GET-VALUE

Nom de paramètre	Demande	Confirmation
Argument	M	
variable_name	M	
Résultat(+)		M
current_value		M

variable_name:

Ce paramètre définit la variable PhL dont la valeur doit être relevée.

current_value:

Ce paramètre contient la valeur relevée de la variable PhL. Les variables PhL à lire sont les variables qui peuvent être modifiées au moyen de Ph-SET-VALUE.

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6.6.2.4.4 Ph-EVENT

Le service Ph-EVENT est obligatoire. La PhL transfère une primitive d'indication de Ph-EVENT à la PNM1 pour l'informer d'événements importants ou d'erreurs dans la PhL (voir le Tableau 26).

Tableau 26 – Ph-EVENT

Nom de paramètre	Indication
Argument événement	M M

événement:

Ce paramètre définit l'événement qui a eu lieu ou la source de l'erreur dans la PhL et peut prendre les valeurs indiquées dans le Tableau 27:

Tableau 27 – Evénements PhL

Nom	Signification
stop_bit_error	Une erreur de bit d'arrêt a été détectée dans la sous-couche MDS
medium_attachment	Le branchement d'un support a changé au niveau d'une MAU de départ

6.7 Type 12: Gestion des systèmes– Interface PhL

6.7.1 Service requis

La primitive de service minimal pour la gestion PhL (PhL) doit être:

Demande de PH-RESET– réinitialisation de Ph-layer.

6.7.2 Primitive de service demande de PH-RESET

Cette primitive n'a pas de paramètre. Sur réception de la primitive, la PhL doit réinitialiser toutes ses fonctions.

6.8 Type 18: Gestion des systèmes – Interface PhL

6.8.1 Généralités

L'interface Gestion systèmes – PhL peut ne pas être exposée lors de la mise en œuvre d'une quelconque variante PhE de type 18. Cette interface peut être interne au nœud et peut être mise en œuvre comme interne à un appareil à semi-conducteur.

6.8.2 Services exigés

La primitive de service minimal pour la gestion PhL doit être:

a) Demande de PH-RESET – réinitialisation de la Ph-Layer;
b) Demande de Ph-SET-VALUE – réglage des paramètres.

6.8.3 Exigences relatives aux primitives de service

6.8.3.1 Demande de PH-RESET

Cette primitive n'a pas de paramètre. Sur réception de la primitive, la PhL doit réinitialiser toutes ses fonctions.

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6.8.3.2 Demande de Ph-SET-VALUE (nom du paramètre, nouvelle valeur)

Cette primitive doit permettre à la Gestion système de modifier les paramètres de la PhL. Le Tableau 7 donne les noms des paramètres et les plages de valeurs normalisés.

Toutes les valeurs ne sont pas prises en charge par toutes les variantes de PhE de Type 18. Des limites de débits en bauds sont associées à la variante de MAU de Type 18 mise en œuvre.

Tableau 28 – Noms et valeurs de paramètres pour la demande de Ph-SET-VALUE

Nom de paramètre	Plage de valeurs
Débit en bauds (kbaud/s)	10 000
	5 000
	2 500
	625
	156

6.9 Type 24: Gestion des systèmes– Interface PhL

Les primitives de service minimal pour la gestion PhL doivent être prises en charge: Une spécification détaillée pour chaque primitive de service dépend du support et de la mise en œuvre proprement dite.

a) Demande de PH-RESET – réinitialisation de la Ph-Layer.

b) Demande de Ph-SET-VALUE/ confirmation de Ph-SET-VALUE – réglage des paramètres

c) Demande de Ph-GET-VALUE/ confirmation de Ph-GET-VALUE – lecture des paramètres

d) Indication de Ph-EVENT – rapport d'événements de la Ph-Layer

7 Sous-couche indépendante du DCE (Equipement de transmission de données) (DIS)

7.1 Généralités

L'entité PhL est subdivisée en une composante Equipement terminal de traitement de données (ETTD) et en une composante Equipement de transmission de données (DCE). La composante ETTD est en interface avec l'entité DLL et constitue la DIS (sous-couche indépendante du DCE). Elle échange des unités de données d'interface sur l'interface DL-Ph définie à l'Article 5 et assure les conversions de base entre la perspective «d'une PhIDU à la fois» de l'interface DL-Ph et la perspective «bit série» exigée pour la transmission et la réception physiques.

La sous-couche est indépendante de toutes les variantes PhL, y compris le codage et/ou la modulation, la vitesse, le mode tension/courant/optique, le support, etc. Toutes ces variantes sont regroupées sous la désignation DCE (Equipement de transmission de données).

NOTE Un certain nombre d'entités DIS différentes sont spécifiées, sur la base des pratiques industrielles en la matière.

7.2 Type 1: DIS

La DIS doit ordonner l'émission de la PhID comme une séquence de PhSDU série. De la même manière, la DIS doit constituer la PhID à renvoyer à la DLL à partir de la séquence de PhSDU série reçues.

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La PhID doit être convertie en une séquence de PhSDU pour émission série en octets jusqu'à un maximum de 300 octets. Une PhSDU représentant des octets de poids fort de la PhID doit être envoyée avant ou en même temps qu'une PhSDU représentant des octets de poids faible et de façon à ce que, dans chaque octet, une PhSDU représentant un bit de poids fort soit transmise avant ou en même temps qu'une PhSDU représentant un bit de poids faible. A la réception, chaque séquence de PhSDU doit être convertie en PhID de façon à ce que, en l'absence d'erreurs, la PhIDU indiquée à l'entité DLL de réception demeure inchangée par rapport à la PhIDU dont l'émission a été demandée par l'entité DLL d'origine.

NOTE Ceci est une garantie de transparence.

7.3 Type 3: DIS

7.3.1 Transmission synchrone

La Sous-couche indépendante du DCE (Équipement de transmission de données) (DIS) spécifiée pour le Type 1 doit être utilisée (voir 7.2).

7.3.2 Transmission asynchrone

Il n'y a pas de DIS (sous-couche indépendante du DCE) en transmission asynchrone.

7.4 *Vide*

NOTE Dans la présente édition, le Paragraphe 7.4 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

7.5 Type 8: DIS

7.5.1 Généralités

La PhL est subdivisée en une MIS (Sous-couche indépendante du Support), une MDS (Sous-couche dépendante du support) et la MAU (Unité de liaison au Support). La MIS est indépendante de toutes les caractéristiques de la PhL, telles que le codage, la méthode de transmission, la vitesse de transmission et le type de support de transmission. Toutes ces instances sont décrites par les sous-couches MDS et MAU.

7.5.2 Fonction

D'une part, la MIS est tenue d'envoyer à la MDS la PhSDU qui a été reçue par la sous-couche MAC par le biais de l'interface DL-Ph sous la forme d'une PhIDU, par l'intermédiaire de l'interface MIS-MDS. D'autre part, elle constitue la PhIDU d'une PhSDU qui a été reçue par l'intermédiaire de l'interface MIS-MDS et la transfère, via l'interface DL-Ph, à la sous-couche MAC.

En outre, la MIS permet l'émission d'une PhSDU entre deux MDS par l'intermédiaire de l'interface MISMDS (couplage MDS).

La MIS peut comprendre plusieurs canaux qui sont configurés en conséquence. Un canal est utilisé pour émettre la PhSDU à la MDS et pour émettre une PhSDU par l'intermédiaire d'une PhIDU vers la sous-couche MAC. Tous les autres canaux sont utilisés pour transmettre une PhSDU entre deux sous-couches MDS.

7.5.3 Transmission série

Pour la transmission série, une séquence de PhIDU doit être convertie en une séquence de PhSDU. Une PhSDU qui représente un bit de poids fort est transférée à une PhSDU qui représente un bit de poids faible.

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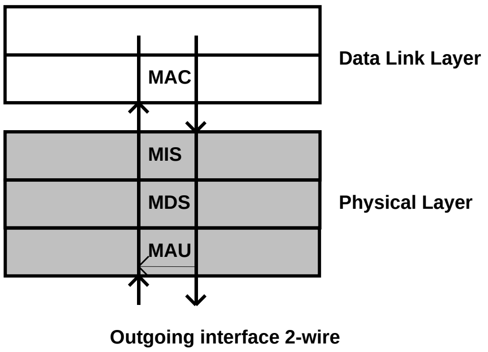
Une fois reçue, chaque séquence de PhSDU doit être convertie en une séquence de PhIDU, de façon à ce que la séquence de PhIDU constituée de cette manière corresponde à celle qui est envoyée de la sous-couche MAC à la PhL.

7.5.4 Couplage MDS

Lorsque des MDS sont couplées par paires et ont des caractéristiques identiques ou différentes (type de transmission alternative), chaque PhSDU qui est reçue d'une MDS par le biais de l'interface MIS-MDS est envoyée inchangée, via l'interface MIS-MDS, à une autre MDS.

Dans ce cas, on peut mettre en tampon une PhSDU reçue.

La Figure 17, la Figure 18 et la Figure 19 présentent les configurations possibles pour le maître du bus et les esclaves, en utilisant le support câblé à 2 conducteurs et le type alternatif de transmission.



Légende

Anglais	Français
Data Link Layer	Couche de liaison de données
Physical Layer	Couche physique
Outgoing interface 2-wire	Interface de départ, à 2 conducteurs

Figure 17 – Configuration d'un maître

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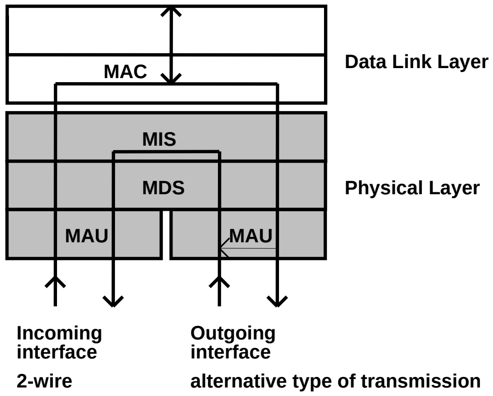
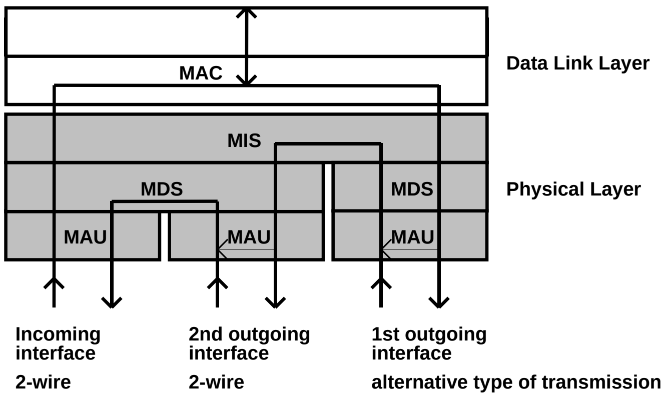


Légende

Anglais	Français
Incoming interface 2-wire	Interface d'arrivée, à 2 conducteurs
Outgoing interface	Interface de départ
Alternative type of transmission	Type de transmission alternatif
Data link layer	Couche de liaison de données
Physical Layer	Couche physique

Figure 18 – Configuration d'un esclave avec un type de transmission alternatif



Légende

Anglais	Français
Incoming interface 2-wire	Interface d'arrivée, à 2 conducteurs
2^{nd} outgoing interface 2-wire	$2^{ème}$ interface de départ, à 2 conducteurs
1^{st} outgoing interface	$1^{ère}$ interface de départ
Alternative type of transmission	Type de transmission alternatif
Data link layer	Couche de liaison de données
Physical Layer	Couche physique

Figure 19 –Configuration d'un coupleur de bus avec un type de transmission alternatif

7.6 Type 12: DIS

La DIS doit ordonner l'émission de la PhID comme une séquence de PhSDU série. De la même manière, la DIS doit constituer la PhID à renvoyer à la DLL à partir de la séquence de PhSDU série reçues.

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La PhID doit être convertie en une séquence de PhSDU pour émission série en octets, d'un minimum de 72 octets à un maximum de 1 535 octets.

Pour la transmission série, une séquence de PhIDU doit être convertie en une séquence de PhSDU. Une PhSDU qui représente un bit de poids fort est transférée à une PhSDU qui représente un bit de poids faible.

Une fois reçue, chaque séquence de PhSDU doit être convertie en une séquence de PhIDU, de façon à ce que la séquence de PhIDU constituée de cette manière corresponde à celle qui est envoyée de la sous-couche MAC à la PhL.

8 Interface ETTD – DCE et fonctions MIS-specific

8.1 Généralités

L'entité PhL est subdivisée en une composante Equipement terminal de traitement de données (ETTD) contenant la DIS et en une composante Equipement de transmission de données (DCE) contenant la MDS et des sous-couches de niveau inférieur. L'interface ETTD – DCE connecte ces deux composantes physiques et est elle-même contenue dans la MIS. (Voir Figure 1.)

NOTE Un certain nombre d'interfaces ETTD – DCE différentes sont spécifiées, sur la base des pratiques industrielles en la matière.

Pour l'interface ETTD – DCE ainsi que pour toute autre interface, l'exposition n'est pas obligatoire.

Pour le mode de transmission synchrone de Type 3, de Type 1 et de Type 7, l'interface ETTD – DCE est une interface fonctionnelle et électrique, mais non mécanique, qui prend en charge un ensemble de services. Chacun de ces services est mis en œuvre par une séquence d'interactions de signalisation définies au niveau de l'interface.

8.2 Type 1: Interface ETTD – DCE

8.2.1 Services

8.2.1.1 Vue d'ensemble

Les services suivants, définis en 8.2, doivent être pris en charge par l'interface ETTD – DCE:

a) Service de réinitialisation ETTD vers DCE;
b) Service de configuration ETTD vers DCE;
c) Service message-transmission ETTD vers DCE;
d) Service de notification de défauts ETTD vers DCE;
e) Service d'indication media-activity ETTD vers DCE;
f) Service de message-reporting ETTD vers DCE.

8.2.1.2 Service de réinitialisation ETTD vers DCE

Ce service doit fournir un moyen grâce auquel l'ETTD peut réinitialiser à tout moment le DCE et de le remettre à son état initial (power-on).

8.2.1.3 Service de configuration ETTD vers DCE

Ce service doit fournir un moyen grâce auquel l'ETTD peut configurer diverses caractéristiques du DCE, y compris celles que la gestion système peut régler en utilisant des demandes Ph-SET-VALUE (voir Tableau 7). Il doit également fournir un moyen facultatif au

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niveau du DCE grâce auquel le DCE peut lancer des rapports d'état du DCE par utilisation préemptive du service de message-reporting ETTD vers DCE.

8.2.1.4 Service de message-transmission ETTD vers DCE

Ce service doit fournir un moyen grâce auquel l'ETTD peut émettre un message à travers le DCE, destiné soit au(x) support(s) connecté(s) soit en retour vers l'ETTD proprement dit ou les deux à la fois, ces options étant déterminées par les valeurs opérationnelles courantes des paramètres spécifiés dans le Tableau 7. La régulation de ce service doit être assurée par le DCE.

Ce service est invoqué sur réception d'une demande PH-DATA spécifiant le START-OF-ACTIVITY à l'interface de service PhL et son exécution se poursuit jusqu'à réception et achèvement de la demande PH-DATA spécifiant la END-OF-DATA-AND-ACTIVITY.

8.2.1.5 Service de notification de défauts ETTD vers DCE

Ce service doit fournir un moyen grâce auquel l'ETTD peut à tout moment rendre compte d'un défaut au DCE. La nature spécifique du défaut n'est pas indiquée par ce service mais peut être déterminée en utilisant le service de configuration ETTD vers le DCE, pour lancer un rapport d'état DCE, facultatif au niveau du DCE.

8.2.1.6 Service d'indication media-activity ETTD vers DCE

Ce service doit fournir un moyen permettant au DCE de rendre compte de la détection supposée, sur l'un de ses supports connectés pour lesquels la réception est activée (voir Tableau 7), d'une signalisation provenant de lui-même ou d'autres entités de la couche Ph. Lorsque le rebouchage est activé, ce service rend uniquement compte de la signalisation du DCE lui-même.

Lorsque l'interface ETTD – DCE est en mode semi-duplex et que le rebouclage n'est pas activé, ce service peut ne pas rendre compte de l'activité de support résultant directement du service de transmission de messages ETTD vers DCE.

8.2.1.7 Service de message-reporting ETTD vers DCE

Ce service doit fournir un moyen permettant au DCE de rendre compte de la réception d'une séquence de PhPDU provenant de tout support connecté dont la réception est activée. Ce service s'achève par une indication précisant si la séquence de PhPDU reçues était bien formée. Des erreurs dans la séquence, y compris le nombre de PhPDU, laissant supposer une émission incorrecte résultant de l'invocation du service de transmission de messages ETTD vers DCE; doit être rapportée comme étant une séquence mal formée (erronée).

Des erreurs d'alignement d'octets d'un délimiteur de fin reçu par rapport au délimiteur de début précédent (c'est-à-dire non séparés par un nombre entier d'octets de bits de données) doivent être rapportées comme une séquence mal formée.

Lorsque l'interface ETTD – DCE est en mode semi-duplex et que le rebouclage n'est pas activé, ce service peut ne pas rendre compte du message transmis par le service de transmission de messages ETTD vers DCE.

8.2.2 Interfaces de signalisation

8.2.2.1 Vue d'ensemble

Deux interfaces de signalisation sont définies pour les couches PhL de Type 1. La première interface existait dans les éditions précédentes de la présente norme et elle est conservée à des fins de compatibilité, bien qu'il n'y ait pas de mise en œuvre connue. Elle est définie de 8.2.2.2 à 8.2.2.4.

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La seconde interface utilise le protocole bien connu SPI (serial peripheral interface – interface périphérique série) ainsi que des signaux, ou équivalent, dont les registres d'octets et les FIFO du DCE sont lus et écrits par l'ETTD, le DCE pouvant interrompre l'ETTD.

NOTE Il n'existe pas de norme officielle pour le protocole SPI, bien qu'il soit utilisé par de nombreux fournisseurs de matériel électronique.

8.2.2.2 Signaux d'interface (version historique des éditions précédentes)

8.2.2.2.1 Vue d'ensemble

Si l'interface ETTD – DCE est exposée, elle doit fournir les signaux spécifiés dans le Tableau 29.

Tableau 29 – Signaux à l'interface ETTD – DCE

Signal	Abréviation	Source
Horloge de transmission	TxC	DCE
Request-to-send	RTS	ETTD
Clear-to-send	CTS	DCE
Données de transmission	TxD	ETTD
Horloge de réception	RxC	DCE
Activité de réception	RxA	DCE
Réception de données et verrouillage de trame	RDF	DCE

Les niveaux de signaux doivent être tels que présentés dans le Tableau 30. En général, les deux côtés de l'interface doivent fonctionner à la même valeur approximative de V_{DD}. Il est cependant admis qu'un ETTD et un DCE ayant des alimentations séparées peuvent ne pas atteindre tous deux la tension opérationnelle V_{DD} de manière simultanée. Il est souhaitable, mais non obligatoire, que le service de réinitialisation ETTD vers DCE soit opérationnel avant que le DCE n'atteigne sa tension opérationnelle V_{DD}. Il est également souhaitable que l'ETTD invoque ce service à chaque fois que sa propre tension V_{DD} est inférieure aux marges opérationnelles.

Tableau 30 – Niveaux de signaux pour une interface ETTD – DCE exposée

Symbole	Paramètre	Condition	Limite	Unité	Remarque
V_{OL}	Tension de sortie de low-level maximale	I_{out} = ±100 μA	0,1	V	Voir la Note 1
		I_{out} = +1,6 mA	0,4	V	
V_{OH}	Tension de sortie de high-level minimale	I_{out} = ±100 μA	V_{DD} – 0,1	V	Voir la Note 1
		I_{out} = -0,8 mA	V_{DD}– 0,8	V	Voir la Note 2
V_{IL}	Tension d'entrée de low-level maximale		0,2 V_{DD}	V	
V_{IH}	Tension d'entrée de high-level minimale		0,7 V_{DD}	V	Voir la Note 3

NOTE 1 Donne la capacité d'entraîner deux charges CMOS typiques.

NOTE 2 La compatibilité d'une entrée CMOS avec une sortie TTL nécessite une résistance de polarisation de l'entrée du signal vers V_{DD}.

NOTE 3 La compatibilité d'une sortie CMOS pour 3,0 V ≤ V_{DD}≤ 5,5 V. La compatibilité d'une sortie TTL (4,75 V ≤ V_{DD}≤ 5,25 V) nécessite une résistance de polarisation de l'entrée du signal vers V_{DD}.

Les caractéristiques temporelles de ces signaux doivent être au moins égales à celles spécifiées pour le DCE concerné dans les exigences de la présente norme. Cependant, le

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temps de transition entre 0,3 V_{DD} et 0,6 V_{DD} ne doit en aucun cas être supérieur à 100 ns ou 0,025 *P*, selon que l'une ou l'autre valeur est la plus faible. *P* est défini comme étant la période nominale de transmission d'octet – l'inverse du débit nominal des PhSDU.

Une mise en œuvre de l'interface ETTD – DCE doit fonctionner correctement à des fréquences d'horloge de transmission et de réception (TxC et RxC) comprises entre 1 kHz et 8,8 fois le débit des PhSDU le plus élevé pris en charge dans la mise en œuvre de l'ETTD ou du DCE.

NOTE Le débit des PhSDU et le débit binaire équivalent, disponibles dans une mise en œuvre donnée sont fournis dans la Déclaration de conformité d'une mise en œuvre du protocole (PICS).

8.2.2.2.2 Horloge de transmission (TxC)

Le signal d'horloge de transmission (TxC) doit fournir à ETTD un signal de synchronisation continu, de sorte que huit cycles consécutifs complets de ce signal doivent avoir la même période d'octets que la période de transmission nominale d'un octet de données. Le DCE doit fournir ce signal à deux phases nominales, de façon à ce que chaque phase ait une durée d'au moins 0,04 *P*.

NOTE Cette spécification permet à TxC d'être une horloge continue, à période constante, à un débit binaire nominal (8 fois le débit nominal d'octets) avec un facteur d'utilisation de 32 % à 68 %; ou d'être une horloge de fréquence plus élevée dont certains cycles sont omis et ayant un facteur d'utilisation proche de 50 %. Ceci permet par exemple une synchronisation simple dans un DCE qui recode chaque 4 bits en 5 bauds; le DCE peut avoir une horloge égale à 10 fois le débit nominal d'octets avec un facteur d'utilisation compris entre 40 % et 60 %, et pourrait omettre (les mêmes) deux cycles à chaque octet.

TxC prend en charge les services de configuration et de transmission de messages ETTD vers DCE.

8.2.2.2.3 Request-to-send (Demande pour émettre) (RTS)

Le signal RTS (demande-to-send – demande pour émettre) prend en charge les services de réinitialisation, de configuration et de transmission de messages ETTD vers DCE. L’ETTD doit fournir ce signal. L'état initial (à la mise sous tension) et au repos (pas de service ETTD vers DCE actif) de ce signal doit être bas.

Lorsqu'il est référencé à TxC à l'interface ETTD-DCE, ce signal doit avoir un temps minimal de montée de 100 ns ou 0,025 *P* selon que l'une ou l'autre valeur est la plus faible; le temps de maintien doit être d'au moins zéro.

8.2.2.2.4 Clear-to-send (Prêt à émettre) (CTS)

Le signal CTS (clear-to-send – prêt à émettre) prend en charge les services de configuration et de transmission de messages ETTD vers DCE. Le DCE doit fournir ce signal. L'état initial (à la mise sous tension) et au repos (pas de service ETTD vers DCE actif) de ce signal doit être bas.

Lorsqu'il est référencé à TxC à l'interface ETTD – DCE, ce signal doit avoir un temps minimal de montée de 100 ns ou 0,025 *P* selon que l'une ou l'autre valeur est la plus faible; le temps de maintien doit être d'au moins zéro.

8.2.2.2.5 Données de transmission (TxD)

Le signal TxD (Transmit Data – données de transmission) prend en charge les services de réinitialisation, de configuration et de transmission de messages ETTD vers DCE. Les données binaires sont transmises de l'ETTD vers le DCE au cours d'une phase des deux derniers services et au cours de cette phase, un binaire 0 est représenté par un low-level sur TxD et un binaire 1 par un high-level sur TxD, tous deux étant prélevés sur le front descendant de TxC.

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L'ETTD doit fournir ce signal. L'état initial (à la mise sous tension) et au repos (pas de service ETTD vers DCE actif) de ce signal doit être haut.

Lorsqu'il est référencé à TxC à l'interface ETTD – DCE, ce signal doit avoir un temps minimal de montée de 100 ns ou 0,025 *P* selon que l'une ou l'autre valeur est la plus faible; le temps de maintien doit être d'au moins zéro.

8.2.2.2.6 Horloge de réception (RxC)

Le signal RxC (Receive Clock – horloge de réception) doit fournir à l'ETTD un signal de synchronisation à deux phases nominales, intermittent (semi-continu), qui définit la synchronisation des informations notifiées via le signal RDF. Le DCE doit fournir ce signal de façon à ce que lorsque RxC est défini pour être significatif (voir 8.2.2.3.7), chaque phase a une durée d'au moins 0,04*P*.

NOTE Cette spécification permet à RxC d'être une horloge récupérée au débit binaire nominal (8 fois le débit nominal d'octets) avec un facteur d'utilisation de 32 % à 68 %; ou d'être une horloge de fréquence plus élevée dont certains cycles sont omis et ayant un facteur d'utilisation proche de 50 %. Ceci permet par exemple une synchronisation simple dans un DCE qui décode 4 bits de chaque 5 bauds reçus; le DCE pourrait avoir une horloge égale à 10 fois le débit nominal d'octets avec un facteur d'utilisation compris entre 40 % et 60 %, et pourrait omettre deux cycles à chaque octet.

Cette spécification permet également au DCE d'omettre des cycles de RxC pendant la reconnaissance de séquences longues de délimiteurs de fin de PhPDU, de sorte que le délimiteur peut être notifié en temps réel en utilisant 8 cycles, ou moins, de RxC (voir 8.2.2.3.7).

RxC doit prendre en charge le service de message-reporting DCE vers ETTD.

8.2.2.2.7 Activité de réception (RxA)

Le signal RxA (Receive Activity – activité de réception) doit prendre en charge les services de notification de défauts, media-activity des supports et de message-reporting DCE vers ETTD. Le DCE doit fournir ce signal. L'état initial (power-on) et au repos (pas de service DCE vers ETTD actif) de ce signal doit être bas.

8.2.2.2.8 Réception de données et verrouillage de trame (RDF)

Le signal RDF (Receive Data and Framing – réception de données et verrouillage de trame) doit prendre en charge les services de notification de défauts et de rapports de messages DCE vers ETTD. Les données binaires sont transmises du DCE vers l'ETTD pendant certaines phases du dernier service et au cours de ces phases, un binaire 0 est représenté par un low-level sur RDF et un binaire 1 par un high-level sur RDF, tous deux étant prélevés sur le front descendant de RxC.

Le DCE doit fournir ce signal. L'état initial (à la mise sous tension) et au repos (pas de service DCE vers ETTD actif) de ce signal doit être haut.

Lorsqu'il est référence sur RxC au niveau de l'interface ETTD – DCE, ce signal doit avoir un temps de montée minimal de 100 ns ou 0,025 *P* selon que l'une ou l'autre valeur est la plus faible; le temps de maintien doit être d'au moins zéro.

8.2.2.3 Codage des services dans des signaux

8.2.2.3.1 Récapitulatif

Les services de 8.1 doivent être mis en œuvre par les séquences suivantes et les combinaisons de signaux décrites en 8.2.

NOTE Des machines types de séquencement de transmission et de réception sont illustrées à la Figure 20; cette dernière est incluse dans la présente norme à des fins d'explication et n'implique pas une mise en œuvre spécifique.

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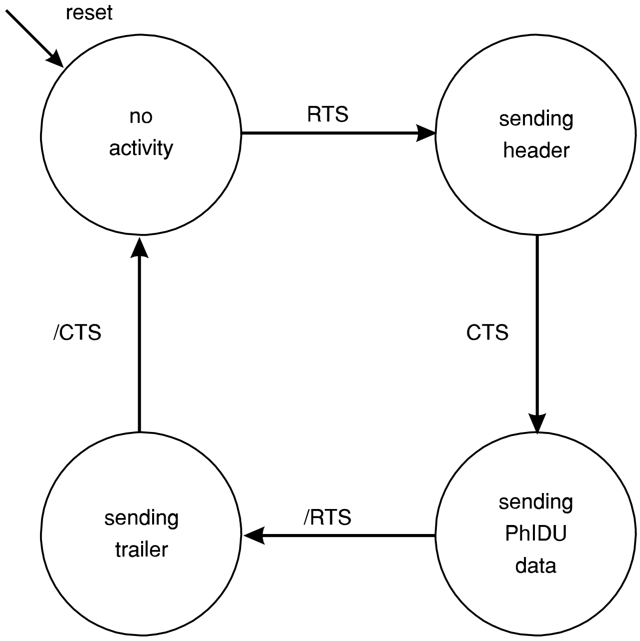
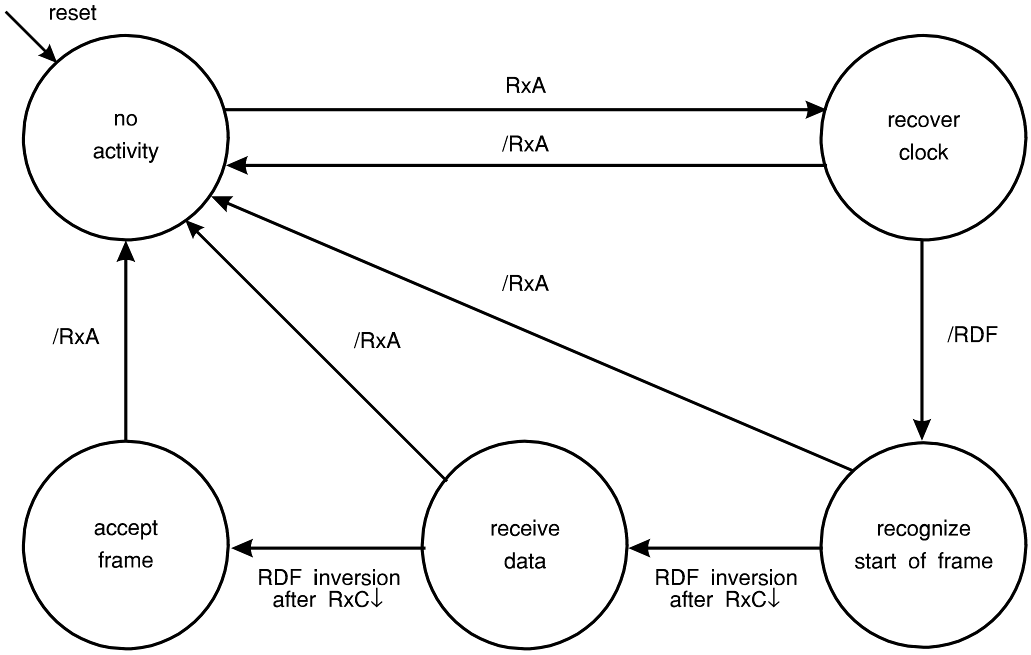


Machine de transmission



Machine de réception

Légende

Anglais	Français
Reset	Réinitialiser
No activity	Aucune activité
Sending header	Emission d'en-tête
Sending trailer	Emission de postambule
Sending PhIDU data	Emission de données PhIDU
Recover clock	Récupérer horloge
Accept frame	Accepter trame
RDF inversion after RxC	Inversion de RDF après RxC
Receive data	Données de réception
Recognize start of frame	Reconnaître début de trame

Figure 20 – Machines de séquencement ETTD/DCE

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8.2.2.3.2 Service de réinitialisation ETTD vers DCE

Ce service doit être mutuellement exclusif avec les services de configuration et de transmission de messages ETTD vers DCE; un seul d'entre eux au plus peut être actif à un moment donné. Ce service peut à tout moment préempter les services de configuration et de transmission de messages ETTD vers DCE.

Ce service doit être codé comme un low-level simultané à la fois sur RTS et TxD. Lorsqu'il est affirmé par l'ETTD, ce low-level simultané doit être maintenu pendant au moins la période de transmission nominale de deux PhSDU (octets).

NOTE 1 Il s'agit d'un service asynchrone et il n'est pas référencé à TxC.

Lorsqu'un ETTD est lui-même réinitialisé, éventuellement pendant la mise sous tension, il convient qu'il tente de réinitialiser le DCE même lorsque la tension V_{DD} propre aux ETTD est sous les limites opérationnelles normales.

NOTE 2 Cette réinitialisation est sous le contrôle de l'ETTD. Ceci n'exclut pas l'existence d'une broche de réinitialisation séparée sur le DCE.

Si l'ETTD modifie simultanément RTS et TxD au cours de la mise en œuvre du service de configuration ou du service message-transmission ETTD vers DCE, l'ETTD doit s'assurer qu'il existe un intervalle égal à au moins le temps de montée minimal exigé entre le passage d'un signal à un high-level et par la suite, le passage de l'autre signal à un niveau bas, de manière à éliminer les dangers logiques potentiels liés à la mise en œuvre dans les DCE du service de réinitialisation ETTD vers DCE.

8.2.2.3.3 Service de configuration ETTD vers DCE

Ce service est mutuellement exclusif avec les services de réinitialisation et de transmission de messages ETTD vers DCE; un seul d'entre eux au plus peut être actif à un moment donné. Ce service peut lancer le service de message-reporting DCE vers ETTD pour rendre compte de l'état interne du DCE. Le service de réinitialisation ETTD vers DCE peut à tout moment préempter ce service.

Ce service doit être mis en œuvre en trois phases; chacune des deux dernières phases doit suivre immédiatement l'achèvement de la phase précédente.

Ces phases peuvent être mises en œuvre comme une variation mineure des trois phases spécifiées pour le service message-transmission ETTD vers DCE. De ce fait, le service de configuration ETTD vers DCE induit un très léger supplément de complexité pour l'ETTD et le DCE.

1) L'ETTD doit affirmer (monter) RTS après le front descendant, et avant le front montant, de TxC. Le DCE doit répondre en anticipant les données de configuration.
2) Lorsqu'il est prêt pour les données de configuration en provenance de l'ETTD, le DCE doit monter CTS avant le front descendant de TxC. L'ETTD doit répondre en codant le premier bit des données de configuration (1 pour haut, 0 pour bas) sur TxD avant le front descendant de TxC suivant, et doit poursuivre ce processus sans interruption jusqu'à ce que de 2 à 200 bits de données (voir 8.2.2.4) aient été ainsi codés. L'ETTD doit ensuite affirmer (monter) TxD et inverser (descendre) RTS avant le front descendant de TxC suivant.

   Il convient que l'ETTD s'assure que TxD monte d'au moins une durée de montée avant que RTS ne descende, pour éviter les dangers logiques potentiels liés à la mise en œuvre dans les DCE du service de réinitialisation ETTD vers DCE.
3) Le DCE doit achever toute reconfiguration nécessaire avant d'inverser (descendre) CTS; ceci doit avoir lieu entre deux fronts descendants consécutifs de TxC.

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Les deux messages de configuration, normalisés et extensibles, sont définis en 8.2.2.4. Les messages normalisés couvrent les gammes d'application de cette interface qui pourraient être les plus sensibles au coût. Les messages extensibles permettent différentes formes de configuration du DCE lorsque cela est nécessaire et peuvent servir à lancer le service de message-reporting DCE vers ETTD pour rendre compte de l'état interne du DCE (une option supplémentaire du DCE est décrite en 8.2.2.4).

8.2.2.3.4 Service de transmission de messages ETTD vers DCE

Ce service est mutuellement exclusif avec les services de réinitialisation et de configuration ETTD vers DCE; un seul d'entre eux au plus peut être actif à un moment donné. Le service de réinitialisation ETTD vers DCE peut à tout moment préempter ce service.

Ce service doit être mis en œuvre en trois phases; chacune des deux dernières phases doit suivre immédiatement l'achèvement de la phase précédente.

a) L'ETTD doit affirmer (monter) RTS après le front montant, et avant le front descendant de TxC. Le DCE doit répondre en générant et en émettant la séquence de longueur appropriée de PhPDU de préambule (synchroniseur initial) et de délimiteur de début.
b) Lorsqu'il est prêt pour les données transparentes en provenance de l'ETTD, le DCE doit monter CTS avant le front descendant de TxC. L'ETTD doit répondre en codant le premier bit de données transparentes (1 pour haut, 0 pour bas) sur TxD avant le front descendant suivant de TxC, et doit poursuivre ce processus sans interruption jusqu'à ce que de 3 à 300 octets entiers de données aient été ainsi codés. L'ETTD doit ensuite affirmer (monter) TxD et inverser (descendre) RTS avant le front descendant suivant de TxC. L'ETTD doit s'assurer que TxD monte d'au moins une durée de montée avant que RTS ne descende, pour éviter les dangers logiques potentiels liés à la mise en œuvre dans les DCE du service de réinitialisation ETTD vers DCE.
c) Le DCE doit terminer l'émission de toutes les données transparentes codées, reçues de l'ETTD, il doit ensuite générer et émettre la séquence de longueur appropriée de PhPDU de délimiteur de fin et doit alors cesser l'émission. Le DCE doit ensuite attendre pendant une certaine durée égale au gap post-émission minimal configuré (voir Tableau 7) avant d'inverser (descendre) CTS, ce qui doit avoir lieu après un front descendant et avant le front descendant suivant de TxC.

8.2.2.3.5 Service de notification de défauts DCE vers ETTD

Ce service doit être mutuellement exclusif avec les services media-activity des supports et de message-reporting DCE vers ETTD; un seul d'entre eux au plus peut être actif à un moment donné. Ce service peut à tout moment préempter les services media-activity des supports et de message-reporting DCE vers ETTD.

Ce service doit être codé comme un low-level simultané à la fois sur RxA et RDF. Une fois affirmé par le DCE, ce bas niveau simultané doit être maintenu jusqu'à activation de l'un des deux services de réinitialisation ou de configuration ETTD vers DCE.

NOTE Il s'agit d'un service asynchrone et il n'est pas référencé à RxC.

Le DCE peut simultanément modifier à la fois RxA et RDF pendant l'achèvement simultané des services media-activity des supports et de message-reporting DCE vers ETTD. Il incombe à l'ETTD d'éviter les éventuels dangers logiques induits par cette modification concurrente.

8.2.2.3.6 Service d'indication de media-activity des supports DCE vers ETTD

Ce service est mutuellement exclusif avec le service de notification de défauts DCE vers ETTD; un seul d'entre eux au plus peut être actif à un moment donné. Le service de notification de défauts DCE vers ETTD peut à tout moment préempter ce service.

Ce service doit être codé comme un high-level sur RxA. Une fois affirmé par le DCE, ce haut niveau permet de reconnaître la transition high-to-low sur RDF afin de lancer le service de

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message-reporting DCE vers ETTD. Toute transition suivante de haut vers bas sur RxA met fin à ce service de message-reporting DCE vers ETTD.

NOTE Le service d'indication media-activity DCE vers ETTD est un service asynchrone et n'est pas référencé à RxC.

8.2.2.3.7 Service de message-reporting DCE vers ETTD

Ce service est mutuellement exclusif avec le service de notification de défauts DCE vers ETTD; un seul d'entre eux au plus peut être actif à un moment donné. Ce service peut uniquement avoir lieu lorsque le service media-activity des supports DCE vers ETTD est actif. Le service de notification de défauts DCE vers ETTD peut à tout moment préempter ce service.

8.2.2.3.7.1 Réception non erronée

Ce service doit être mis en œuvre en quatre phases au moment de rendre compte d'un message bien formé; chacune de ces phases doit immédiatement suivre l'achèvement de la phase précédente.

La description suivante s'applique aux DCE qui ont des séquences de délimiteur de fin de huit PhPDU ou moins et qui ne nécessitent pas un temps de décodage supplémentaire pour un code FEC (correction d'erreurs sans voie de retour). Les DCE qui ne satisfont pas à ces conditions peuvent introduire des délais supplémentaires dans leurs processus de décodage et de rapport, de façon à ce que, vis-à-vis de la signalisation sur RxC et RDF, ils puissent effectivement remplir ces conditions.

a) Après détection de la signalisation reçue, apprentissage relatif à cette signalisation et récupération d'une horloge de données dont la fréquence nominale d'octets est la même que TxC, le DCE doit lancer le service de message-reporting DCE vers ETTD en fournissant cette horloge récupérée sur RxC et en inversant (descendant) RDF après le front montant et avant le front descendant suivant de RxC.

   NOTE 1 A ce moment-là, RxA est déjà affirmé.

b) Le DCE doit continuer l'apprentissage et tenter de faire correspondre la signalisation reçue à ses PhPDU de préambule et de délimiteur de début.

   Si le DCE prend en charge *N* canaux de supports redondants, il peut rendre compte sur RDF de l'identité du canal dont la signalisation est reçue en codant ce numéro de canal dans une plage de 0 à *N*-1, comme nombre binaire qui est notifié en envoyant le bit de poids fort en premier lieu, pendant la réception des trois derniers de ces PhPDU de délimiteur de début. Les bits notifiés sur RDF doivent être présentés en série après des fronts montants successifs de RxC et à chaque fois avant le front descendant de RxC qui le suit immédiatement.

   Sur détection d'une correspondance exacte entre la signalisation reçue et le délimiteur de début attendu, le DCE doit inverser RDF après le front descendant et avant le front montant suivant de RxC.

   NOTE 2 Si l'identité du canal de réception a été notifiée sur RDF, cette inversion aura lieu au cours de la phase de low-level de \1,\2 qui suit immédiatement la phase de high-level (de \1,\2) au cours de laquelle le dernier bit (low-order) du numéro de canal a été notifié.

c) Le DCE doit poursuivre la réception et tenter de faire correspondre la signalisation reçue aux données éventuelles et aux PhPDU de délimiteur de fin attendues.

   Le DCE doit rendre compte de chaque bit de données décodé à partir de la signalisation reçue sur RDF. Les bits notifiés sur RDF doivent être présentés en série après des fronts montants successifs de \1,\2, à chaque fois avant le front descendant immédiatement suivant de RxC. En l'absence d'erreurs, ces bits doivent être notifiés dans le même ordre et avec les mêmes valeurs qu'en cas de transmission par une entité PhL homologue.

   NOTE 3 Ceci est une garantie de transparence.

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Un délimiteur de fin peut être constitué de PhPDU données et non données. Le DCE peut de la même manière rendre compte sur RDF de chaque bit de données décodé à partir d'un délimiteur de fin et peut également rendre compte sur RDF d'un nombre approprié de valeurs de données pour les PhPDU non données décodées à partir d'un délimiteur de fin, à l'exception du fait que

1) le nombre total de "bits" ainsi notifié doit être de sept ou moins, et

2) sur détection d'une correspondance exacte entre la signalisation reçue et les délimiteurs de fin attendus, le DCE ne doit pas rendre compte sur RDF d'un autre bit correspondant au dernier "bit" du délimiteur de fin mais doit plutôt d'abord affirmer (monter) RDF après le front montant et avant le front descendant suivant de RxC, et ensuite il doit inverser (descendre) RDF après le front descendant et avant le front montant suivant de RxC.

NOTE 4 La plupart des applications décoderont et notifieront, en tant que données, sur RDF, toutes les PhPDU de données initiales dans une séquence de délimiteur de fin reçue. On peut ne pas notifier la première PhPDU non-data et les PhPDU suivantes. Cependant, un rapport final sera effectué sur RDF pour indiquer la reconnaissance d'un délimiteur de fin correct.

NOTE 5 Chaque bit notifié, à l'exception du dernier, est maintenu sur RDF pendant un cycle complet de RxC. Le dernier bit est remplacé par une séquence high-low, chacune étant maintenue pendant seulement une phase de RxC.

NOTE 6 La séquence haut-bas d'achèvement aura lieu au cours des rapports du premier "bit" huit qui ont lieu après que le dernier bit de données (prédélimiteur) a été notifié. Le dernier bit de données (prédélimiteur) aura été le 8 $N^{\text{ème}}$ bit de données ainsi notifié au cours de cette phase et dans ce cas, il convient que N soit au moins égal à trois et ne dépasse pas 300.

d) Le DCE doit affirmer (monter) RDF avant le front descendant suivant de RxC et ne doit lancer une autre instance du service de message-reporting DCE vers ETTD qu'une fois terminé le service media-activity des supports DCE vers ETTD en cours.

8.2.2.3.7.2 Réception erronée

Une erreur peut être détectée au cours de toute phase du processus de réception décrit en 8.2.2.3.7.1. Lorsque cette détection a lieu, le DCE doit modifier le séquencement de ces phases de la manière suivante:

Si le DCE détecte des PhPDU invalides ou une séquence invalide de PhPDU, ou encore une séquence valide de PhPDU de délimiteur de fin qui n'est pas séparée des PhPDU de délimiteur de début par un nombre entier d'octets de données de PhPDU; et si le DCE peut établir un signal valide sur RxC (par exemple en remplaçant si nécessaire la source d'horloge récupérée par TxC ou par un autre signal local); dans ce cas

a) si la phase 2 n'a pas encore été lancée, le DCE doit immédiatement lancer la phase 2;

b) si la phase 2 ne s'est pas encore terminée, le DCE doit immédiatement terminer la phase 2 aussi rapidement que possible, en ignorant l'exigence de correspondance de la séquence de PhPDU de délimiteur de début;

c) dans le cas contraire, le DCE doit immédiatement inverser (descendre) RDF après le front montant et avant le front descendant suivant de RxC, puis il doit affirmer (monter) RDF après le front descendant et avant le front montant suivant de RxC.

NOTE Cette séquence permet au DCE

– d'activer l'utilisation de RxC par l'ETTD;

– d'identifier le canal qui comporte la signalisation erronée; et

– d'indiquer une erreur de réception.

Une fois que le DCE a achevé autant d'étapes a), b) et c) ci-dessus que nécessaire et possible, le DCE doit immédiatement lancer la phase 4.

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8.2.2.4 Messages de configuration DCE

8.2.2.4.1 Récapitulatif

Le Paragraphe 8.2.2.4 définit les messages de configuration normalisés ainsi que la partie normalisée des messages de configuration extensibles. Les messages normalisés couvrent les gammes d'application de cette interface qui devraient être les plus communément utilisées. Les messages extensibles permettent différentes formes de configuration du DCE, lorsque cela est nécessaire, et peuvent servir à lancer le service de message-reporting DCE vers ETTD pour rendre compte de l'état interne du DCE (une option du DCE).

Deux messages normalisés et deux classes de messages extensibles sont définis. Tous les messages sont transmis sur l'interface dans l'ordre de définition des bits. Les entiers sont transmis avec le bit de poids fort (MSB) en premier.

Les deux messages normalisés et les deux classes de messages extensibles sont différenciés par les deux premiers bits de données du message de configuration, de la manière suivante:

00 – message de configuration de base;

01 – message de commande de diversité de trajectoires;

10 – message de configuration extensible;

11 – message d'invocation du rapport d'état extensible.

8.2.2.4.2 Message de configuration de base

A la suite de ses deux bits initiaux (00), le message de configuration de base spécifie les aspects opérationnels communs à la plupart des DCE. Les composantes définies de ce message sont, par ordre de transmission:

a) le mode opérationnel du DCE, codé sur un bit de données comme présenté. La valeur de ce paramètre après activation du service de réinitialisation ETTD vers DCE est 0;

   0 Simultané bidirectionnel (full-duplex), où chaque invocation du Service de transmission de messages ETTD vers DCE active automatiquement les services d'indication media-activity et de message-reporting DCE vers ETTD. Ce mode est souhaitable pour les supports à dual-channel, tels que le câblage fiber-optic-pair.

   NOTE 1 Certains ETTD peuvent ne fonctionner que dans ce mode.

   1 Bidirectionnel à l'alternat (semi-duplex), où une invocation du service de transmission de messages ETTD vers DCE n'active pas automatiquement les services d'indication media-activity et de message-reporting DCE vers ETTD.

   NOTE 2 Ce mode permet de réduire la consommation d'énergie du DCE et de l'interface ETTD-DCE. Certains ETTD peuvent ne fonctionner que dans ce mode.

b) la sélection de l'origine des données internes au DCE pour le service de rapport de messages, codé sur deux bits de données comme présenté (voir Tableau 7). La valeur de ce paramètre après activation du service de réinitialisation ETTD vers DCE est 00. Lorsque la sélection est non zéro, l'émission sur tous les supports connectés doit être désactivée et l'interface ETTD-DCE doit fonctionner en mode bidirectionnel simultané (full-duplex);

   00 signalisation décodée, reçue de l'un des supports connectés, comme spécifié en 8.2.2.4.3 b) et c). Le mode d'interface est tel que spécifié en 8.2.2.4.2 a);

   01 rapport internal-status, voir 8.2.2.5.1 et 8.2.2.6;

   10 rebouclage aussi proche que possible de l'interface ETTD-DCE, avec aucune émission vers les supports connectés, et dans ce cas, chaque invocation du service message-transmission ETTD vers DCE active automatiquement les services d'indication media-activity et de message-reporting services DCE vers ETTD. Ce mode est souhaitable pour le DCE, par rapport à l'ETTD, en ce qui concerne la localisation des défauts d'interconnexion.

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11 rebouclage aussi proche que possible de la ou des interfaces de support, avec aucune émission vers les supports connectés, et dans ce cas, chaque invocation du service message-transmission ETTD vers DCE active automatiquement les services media-activity des supports et de message-reporting DCE vers ETTD. Ce mode est souhaitable pour une auto-évaluation avant entrée sur un réseau opérationnel.

c) il convient d'étendre la valeur du préambule qui est la séquence initiale de PhPDU dans chaque émission. Sa plage est de zéro à sept unités d'extension, codée en trois bits de données comme 0 (000) à 7 (111). La valeur de ce paramètre après activation du service de réinitialisation ETTD vers DCE est 0 (000) (Voir la Note 2 de 6.2.2.2);

d) il convient d'étendre la valeur du gap post-émission obligatoire qui est la période de non émission entre des séquences successives de PhPDU. Sa plage est de zéro à sept unités d'extension, codée en trois bits de données comme 0 (000) à 7 (111). La valeur de ce paramètre après activation du service de réinitialisation ETTD vers DCE est 0 (000) (Voir la Note 3 de 6.2.2.2).

8.2.2.4.3 Message de commande de diversité de trajectoires

A la suite de ses deux bits initiaux de (01), le message de commande de diversité de trajectoires spécifie des données de configuration supplémentaires, généralement requises pour la gestion et l'évaluation de défauts de trajectoires redondantes: les commandes séparées de transmission et de réception pour chacun des supports redondants connectés (canaux et trajectoires). Les composantes définies de ce message sont, par ordre de transmission:

a) deux bits zéro (00), qui assurent l'alignement des quartets et des octets dans le message pour les champs suivants;

b) l'algorithme de choix entre supports redondants comme origine de la signalisation reçue lorsque plusieurs supports sont activés pour la réception, codé en quatre bits comme indiqué. La valeur de ce paramètre après activation du service de réinitialisation ETTD vers DCE est 0000;

   0000 – Il convient que le support sélectionné pour la réception soit le premier support sur lequel est détectée la signalisation appropriée pour l'apprentissage du récepteur;

   1000 à 1111 (= 7 + *N*, 1 ≤*N*≤ 8) –Il convient de sélectionner le *N*ème support, sauf lorsque la signalisation appropriée pour l'apprentissage du récepteur a été détectée sur un autre support pendant une période de temps égale à la période supplémentaire d'extension du gap entre trames, spécifiée en 8.2.2.4.2 d), auquel cas il convient de sélectionner un autre support;

c) la sélection de l'activation (0) ou de l'inhibition (1) de la réception sur chacun des huit supports redondants, ou moins, codée sur huit bits consécutifs pour les canaux 1 à 8, respectivement (voir Tableau 7). La valeur de ce paramètre après activation du service de réinitialisation ETTD vers DCE est 0000 0000;

d) la sélection de l'activation (0) ou de l'inhibition (1) de l'émission sur chacun des huit supports redondants, ou moins, codée sur huit bits consécutifs pour les canaux 1 à 8, respectivement (voir Tableau 7). La valeur de ce paramètre après activation du service de réinitialisation ETTD vers DCE est 0000 0000;

e) la valeur d'extension du gap post-émission, due à une éventuelle dérive du signal entre supports redondants. Sa plage est de zéro à sept unités d'extension, codée en trois bits de données comme 0 (000) à 7 (111). La valeur de ce paramètre après activation du service de réinitialisation ETTD vers DCE est 0 (000) (voir 8.2.2.4.2 d), 8.2.2.4.3 b), et la Note 3 de 6.2.2.2).

8.2.2.5 Messages de configuration extensibles

A la suite de ses deux bits initiaux (10), le codage des messages de configuration extensibles peut dépendre de l'application. La structure et la forme des messages de configuration extensible doivent être les mêmes que celles du message de configuration de base spécifiées en 8.2.2.4.2.

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8.2.2.5.1 Messages d'invocation du rapport d'état extensible

A la suite de ses deux bits initiaux (11), le codage des messages d'invocation de rapport d'état extensible peut dépendre de l'application. La structure et la forme des messages d'invocation de rapport d'état extensible doivent être les mêmes que celles du message de configuration de base spécifiées en 8.2.2.4.2. Les informations spécifiées doivent sélectionner une source interne au DCE de signalisation reçue et si le mode DCE-internal-data-source est "status-reporting" (voir 8.2.2.4.2 b)), le DCE doit générer un message multi-data-octet, rempli (bourrage) autant que nécessaire pour obtenir un multiple d'octets et il doit le notifier en utilisant les services media-activity des supports et de message-reporting DCE vers ETTD.

8.2.2.6 Rapports d'état générés par le DCE

Ces rapports sont générés dans le DCE sur demande et notifiés lorsque la source de données internes au DCE est "rapport d'état interne" (voir 8.2.2.4.2 b)).

8.3 Type 3: Interface ETTD – DCE

8.3.1 Transmission synchrone

L'interface ETTD-DCE spécifiée pour le Type 1 doit être utilisée (voir 8.2).

8.3.2 Transmission asynchrone

L'interface ETTD-DCE n'est pas exposée en transmission asynchrone.

8.4 Type 8: Interface MIS – MDS

8.4.1 Généralités

La PhL est subdivisée en une MIS (Sous-couche indépendante du Support) et une MDS (Sous-couche dépendante du support). Ces deux couches sont connectées par l'interface MIS-MDS.

L'interface MIS-MDS est une interface fonctionnelle qui prend en charge certains services; il n'est pas obligatoire que cette interface soit réalisée électriquement. Chacun de ces services est mis en œuvre par une séquence d'interactions de signaux d'interface.

8.4.2 Services

8.4.2.1 Généralités

L'interface MIS-MDS prend en charge les services décrits ci-dessous:

– Service de demande de cycle d'identification
– Service de demande de cycle de données
– Service de classification de séquences de données
– Service d'identification de séquences de données
– Service de transmission de messages
– Service de réception de messages
– Réinitialisation du bus

8.4.2.2 Service de demande de cycle d'identification

Ce service permet à la MIS de démarrer une séquence de données pour transmettre des données d'identification et de commande (cycle d'identification).

NOTE Ce service est utilisé par un maître uniquement.

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8.4.2.3 Service de demande de cycle de données

Ce service permet à la MIS de démarrer une séquence de données pour la transmission de données utilisateur (cycle de données).

NOTE Ce service est utilisé par un maître uniquement.

8.4.2.4 Service de classification de séquences de données

Ce service permet à la MIS de démarrer un cycle d'identification ou de données.

NOTE Ce service est utilisé uniquement par un coupleur de bus ou un esclave.

8.4.2.5 Service d'identification de séquences de données

Ce service permet à la MDS d'indiquer le début d'un cycle d'identification ou de données.

8.4.2.6 Service de transmission de messages

Ce service permet à la MIS d'envoyer un message, via la MDS, soit au support connecté, soit en retour vers une autre MDS. La MDS détermine la vitesse d'exécution de ce service.

NOTE 1 Ce service émet les PhIDU acheminées vers la PhL.

NOTE 2 Ce service est exécuté simultanément au service de réception des messages.

8.4.2.7 Service de réception de messages

Ce service permet à la MDS d'indiquer la réception d'un message à la MIS ou à une autre MDS connectée. Le service se termine par une indication spécifiant si la PhPDU reçue était correctement formée.

Ce service doit être précédé par un service d'identification de séquences de données.

8.4.2.8 Réinitialisation du bus

Ce service permet d'envoyer et de recevoir une réinitialisation de tous les esclaves. Le Tableau 31 affiche le paramètre de la réinitialisation du bus MDS.

Tableau 31 – Réinitialisation du bus MDS

Paramètre du service	Demande	Indication
reset_type	M	M

reset_type:

Ce paramètre de service indique si la réinitialisation est courte ou longue.

Plage de valeurs: courte, longue

NOTE Ce service est utilisé par un maître uniquement.

8.4.3 Signaux d'interface

L'interface MIS-MDS met à disposition les signaux énumérés dans le Tableau 32.

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Tableau 32 – Signaux à l'interface MIS-MDS

Signal d'interface	Mnémonique	Source
Horloge de transmission	TxC	MIS
Request-to-send	RTS	MIS
Clear-to-send	CTS	MDS
Séquence de transmission	TxS	MIS
Ligne de sélection de transmission	TxSL	MIS
Ligne de commande de transmission	TxCR	MIS
Données de transmission	TxD	MIS
Délai de demande 1	RqDly1	MIS
Délai de demande 2	RqDly2	MIS
Occupé	BSY	MDS
Horloge de réception	RxC	MDS
Activité de réception	RxA	MDS
Séquence de réception	RxS	MDS
Ligne de sélection de réception	RxSL	MDS
Ligne de commande de réception	RxCR	MDS
Données de réception	RxD	MDS
Réinitialisation-sortie	RO	MIS
Réinitialisation-entrée	RI	MDS

8.4.4 Conversion des services en signaux d'interface

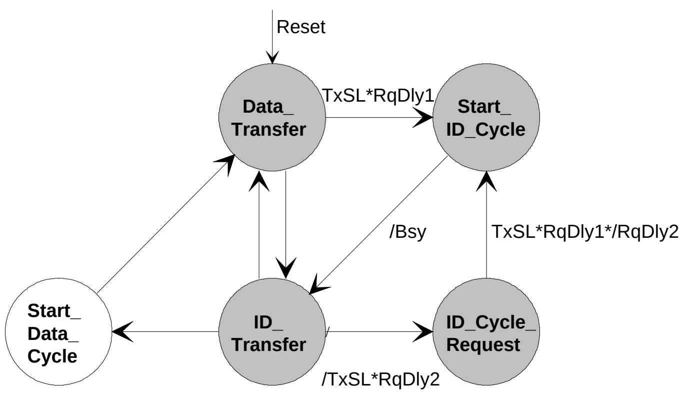
8.4.4.1 Généralités

Les services de l'interface MIS-MDS sont représentés par des machines de protocole et des séquences de signaux décrites de 8.4.4.1 à 8.4.4.8.

NOTE La convention suivante s'applique aux diagrammes d'états illustrés de la Figure 21 à la Figure 29: Le symbole "*" correspond au "Et Logique", le symbole "/" correspond à "inversion".

8.4.4.2 Demande de cycle d'identification

La Figure 21 décrit ce service avec les quatre services en gris ainsi que leurs transitions.



Légende

Anglais	Français
Reset	Réinitialiser

Figure 21 – Transitions d’état avec le service de demande de cycle d'identification

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NOTE 1 Les transitions qui ne sont pas illustrées à la Figure 21 sont utilisées pour d'autres services; voir la Figure 24 et la Figure 26 pour les états et transitions correspondants.

Le cycle d'identification était précédé d'un cycle de données ou d'une réinitialisation:

Etat **Data_Transfer**:
La MIS lance un service de demande de cycle d'identification en modifiant le signal TxSL (de 0 logique à 1 logique) ainsi que, simultanément, le signal RqDly1 (de 0 logique à 1 logique).

Etat **Start_ID_Cycle**:
Ensuite, la MDS transmet l'état PhPDU correspondant, démarre un temporisateur d'une durée t1 et établit le signal BSY (occupé) en le faisant passer du 0 logique au 1 logique. Le MIS réinitialise le signal RqDly1 sur 0 logique.

A la fin de la durée t1, la MDS met le signal BSY au 0 logique et achève le service de demande de cycle d'identification. La MIS communique cela à la DLL au moyen d'une primitive de confirmation de PhData et prend l'état ID_Transfer.

La durée minimale de t1 est de 5 temps binaires.

La Figure 22 illustre les formes de signaux correspondantes à l'interface MIS-MDS pour un service de demande de cycle d'identification à la suite d'un cycle de données.

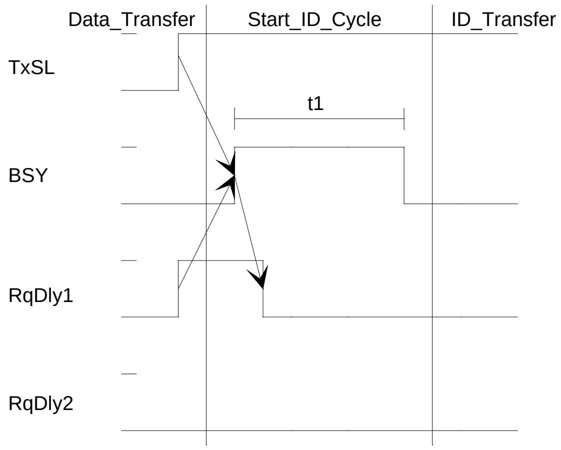

Figure 22 – Interface MIS-MDS: service de demande de cycle d'identification

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Le cycle d'identification était précédé d'un cycle d'identification:

Etat **ID_Transfer**:
La MIS lance un service de demande de cycle d'identification en modifiant le signal TxSL (de 1 logique à 0 logique) ainsi que, simultanément, le signal RqDly2 (de 0 logique à 1 logique).

Etat **ID_Cycle_Request**:
Ensuite, la MDS transmet l'état PhPDU correspondant, démarre un temporisateur d'une durée t2 et établit le signal BSY (occupé) en le faisant passer du 0 logique au 1 logique. Le MIS réinitialise le signal RqDly2 sur 0 logique.

Après l'écoulement du temps T2, le MDS réinitialise le signal BSY sur 0 logique. La sous-couche MIS modifie ensuite le signal TxSL (de 0 logique à 1 logique) ainsi que, simultanément, le signal RqDly1 (de 0 logique à 1 logique).

La durée minimale de t2 est de 25 temps binaires.

Etat **Start_ID_Cycle**:
Ensuite, la MDS transfère l'état PhPDU correspondant, démarre un temporisateur d'une durée T1 et établit le signal BSY (occupé) en le faisant passer du 0 logique au 1 logique. Le MIS réinitialise le signal RqDly1 sur 0 logique.

A la fin de la durée t1, la MDS met le signal BSY (occupé) au 0 logique et achève le service de demande de cycle d'identification. La MIS communique cela à la DLL au moyen d'une primitive de confirmation de PHDATA et prend l'état ID_Transfer.

La Figure 23 illustre les formes de signaux correspondantes à l'interface MIS-MDS pour un service de demande de cycle d'identification à la suite d'un cycle d'identification de données.

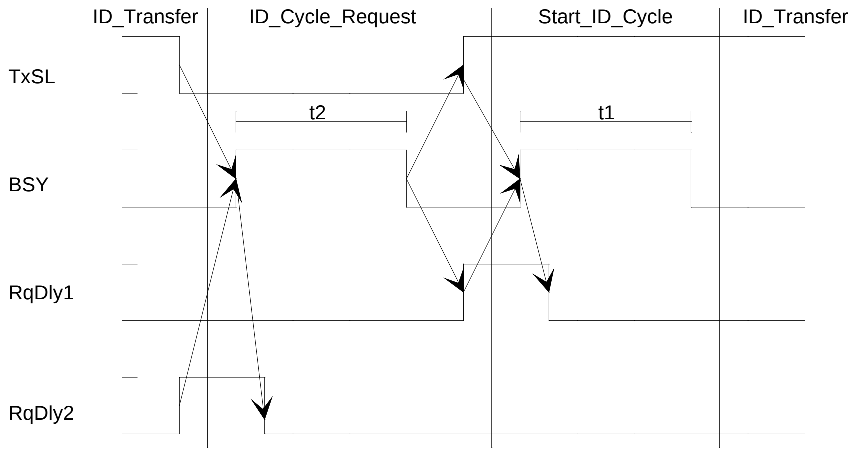

Figure 23 – Interface MIS-MDS: service de demande de cycle d'identification

NOTE 2 Le service de demande de cycle d'identification est un service asynchrone et n'est pas lié à TxC.

8.4.4.3 Service de demande de cycle de données

La Figure 24 décrit ce service avec les trois états en gris ainsi que leurs transitions.

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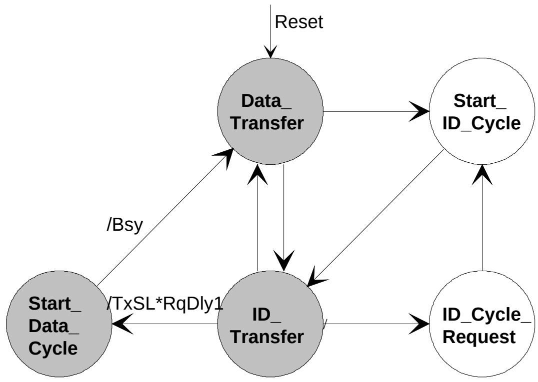

Légende

Anglais	Français
Reset	Réinitialiser

Figure 24 – Transitions d'état du service de demande de cycle de données

NOTE 1 Les transitions qui ne sont pas illustrées à la Figure 24 sont utilisées pour d'autres services; voir la Figure 21 et la Figure 26 pour les états et transitions correspondants.

Le cycle de données était précédé d'un cycle d'identification:

Etat ID_Transfer:
La MIS lance un service de demande de cycle de données en modifiant le signal TxSL (de 1 logique à 0 logique) ainsi que, simultanément, le signal RqDly1 (de 0 logique à 1 logique).

Etat Start_Data_Cycle:
Ensuite, la MDS transmet l'état PhPDU correspondant, démarre un temporisateur d'une durée t1 et établit le signal BSY en le faisant passer du 0 logique au 1 logique. Le MIS réinitialise le signal RqDly1 sur 0 logique.

A la fin de la durée t1, la MDS met le signal BSY au 0 logique et achève le service de demande de cycle de données. La MIS communique cela à la DLL au moyen d'une primitive de confirmation de PH-DATA et prend l'état Data_Transfer.

La Figure 25 illustre les formes de signaux correspondantes à l'interface MIS-MDS pour un service de demande de cycle de données à la suite d'un cycle d'identification.

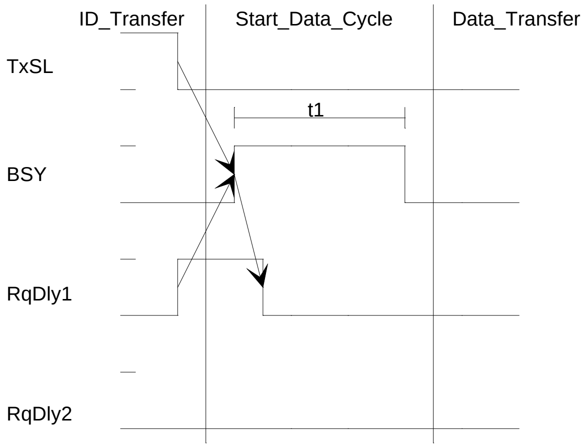

Figure 25 – Interface MIS-MDS: service de demande de cycle de données

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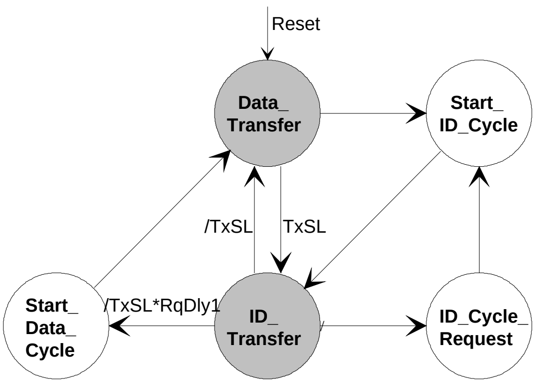
Le cycle de données était précédé d'un cycle de données:

Si la DLL demande le début d'un cycle de données avec une primitive de demande de DONNEES PH (PhICI=start_data_cycle), et si la DLL n'a pas auparavant demandé le début d'un cycle d'identification au moyen d'une primitive de demande de PH-DATA (PhICI=start_ID_cycle), la MIS communique à la DLL la fin du service de demande de cycle de données au moyen d'une primitive de confirmation de PH-DATA. L'état des signaux TxSL, RqDly1 et RqDly2 demeure inchangé.

NOTE 2 Le service de demande de cycle de données est un service asynchrone et n'est pas lié à TxC.

8.4.4.4 Service de classification de séquences de données

La Figure 26 décrit ce service avec les deux états en gris ainsi que leurs transitions.



Légende

Anglais	Français
Reset	Réinitialiser

Figure 26 – Transitions d'état du service de classification de séquences de données

NOTE 1 Les transitions qui ne sont pas illustrées à la Figure 26 sont utilisées pour d'autres services; voir la Figure 21 et la Figure 24 pour les états et transitions correspondants.

Etat **Data_Transfer**:
La MIS lance un cycle d'identification (transmission de données d'identification et de commande dans la PhPDU) en modifiant le signal TxSL (de 0 logique à 1 logique).

Etat **ID_Transfer**
La MIS lance un cycle de données (transmission de données utilisateur dans la PhPDU) en modifiant le signal (de 1 logique à 0 logique).

NOTE 2 Le service de classification de séquences de données est un service asynchrone et n'est pas lié à TxC.

8.4.4.5 Service de transmission de messages

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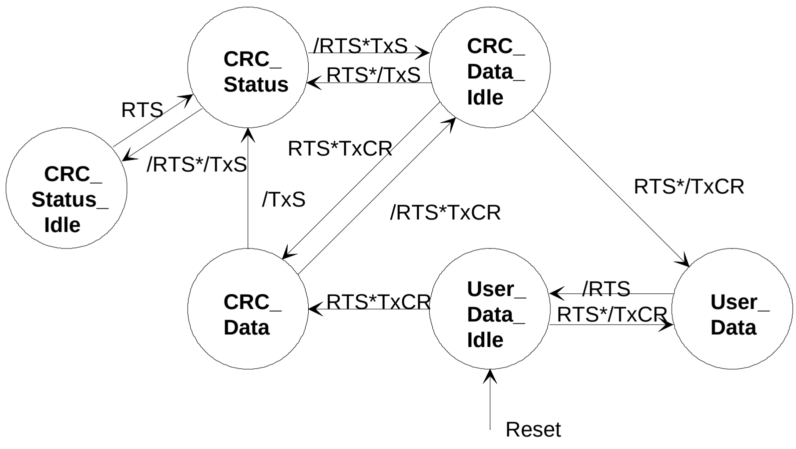
La Figure 27 décrit ce service avec les six états ainsi que leurs transitions.



Légende

Anglais	Français
Reset	Réinitialiser

Figure 27 – Machine de protocole du service de transmission de messages

NOTE 1 Une séquence de bits de données est émise en multiples d'octets. Une fois que la MIS a établi son signal d'interface RTS du 1 logique au 0 logique, elle attend le front descendant du signal CTS actif à l'état bas provenant de la MDS. La MIS communique cela à la DLL au moyen d'une primitive de confirmation de PHDATA (obligatoire pour le maître uniquement).

Etat **CRC_Data_Idle**:
La MIS lance un service de transmission de messages en établissant le signal RTS au 1 logique au cours du front montant de TxC, en établissant en même temps le signal TxCR au 0 logique et en émettant avec le signal TxD le premier bit de données dans un octet destiné à la MDS.

NOTE 2 Au lieu de lancer un service de transmission de messages, la MIS peut commencer à émettre l'état de la somme de contrôle en établissant le signal RTS au 1 logique au cours du front montant suivant de TxC, en établissant en même temps le signal TxS au 0 logique et en envoyant à la MDS le premier bit de l'état de la somme de contrôle avec le signal TxD.

Etat **User_Data**:
La MIS doit continuer l'émission des données en transmettant à la MDS le bit de données suivant dans un octet avec le signal TxD, au cours de chaque front montant de TxC. La MIS achève l'émission des données en établissant le signal RTS au 0 logique, une fois que le dernier bit a été transmis et avant le front descendant suivant de TxC.

NOTE 3 La MIS poursuit l'émission des données en établissant le signal RTS au 1 logique au cours du front montant de TxC, et en émettant en même temps avec le signal TxD le premier bit de données dans un octet destiné à la MDS.

Etat **User_Data_Idle**:
La MIS démarre la séquence de contrôle en établissant le signal RTS au 1 logique au cours du front montant de TxC, en établissant en même temps le signal TxCR au 1 logique et en envoyant à la MDS le premier bit de la somme de contrôle (données CRC) dans le signal TxD.

NOTE 4 Au lieu de la séquence de contrôle, la MIS peut lancer un nouveau service de transmission de messages en établissant le signal RTS au 1 logique au cours du front montant de TxC et en envoyant en même temps à la MDS, avec le signal TxD, le premier bit de données. Ceci équivaut à une poursuite du service de transmission de messages.

Etat **CRC_Data**:
La MIS doit continuer l'émission des données de somme de contrôle en envoyant le bit de

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données suivant dans un octet, en même temps que le signal TxD destiné à la MDS, au cours de chaque front montant de TxC.

Une fois terminée l'émission des données de la somme de contrôle, la MIS démarre l'émission de l'état de la somme de contrôle (état CRC) en envoyant le signal TxS au 0 logique au cours du front montant de TxC et en même temps en transmettant à la MDS, avec le signal TxD, le premier bit de l'état de la somme de contrôle.

NOTE 5 La MIS poursuit l'émission de la somme de contrôle en établissant le signal RTS au 1 logique avant le front descendant de TxC et en envoyant en même temps à la MDS, avec le signal TXD, le premier bit de l'octet suivant de la somme de contrôle.

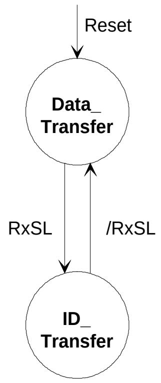
NOTE 6 La MIS commence par émettre l'état de la somme de contrôle en établissant le signal RTS au 1 logique au cours du front montant de TxC, en établissant en même temps le signal TxS au 0 logique, et en envoyant à la MDS le premier bit de l'état de la somme de contrôle.

Etat **CRC_Status**:
La MIS doit continuer l'émission de l'état de la somme de contrôle en transmettant à la MDS le bit suivant dans un octet, avec le signal TxD, au cours de chaque front montant de TxC. La MIS achève l'émission de l'état de la somme de contrôle en établissant le signal RTS au 0 logique et le signal TxS au 1 logique avant le front descendant de TxC et après le dernier bit de l'octet à transmettre.

Etat **CRC_Status_Idle**:
La MIS poursuit l'émission de l'état de la somme de contrôle en établissant le signal RTS au 1 logique au cours du front montant de TxC et en envoyant en même temps à la MDS, avec le signal TXD, le premier bit de l'octet suivant.

8.4.4.6 Service d'identification de séquences de données

La Figure 28 décrit ce service avec les deux états ainsi que leurs transitions.



Légende

Anglais	Français
Reset	Réinitialiser

Figure 28 – Machine de protocole du service d'identification de séquences de données

Etat **Data_Transfer**:
Le début d'un cycle d'identification (transmission de données d'identification ou de données de commande dans la PhPDU reçue) est indiqué à la MIS par une modification du signal RxSL (passage du 1 logique au 0 logique).

Etat **ID_Transfer**:
Le début d'un cycle de données (transmission de données utilisateur dans la PhPDU reçue) est indiqué à la MIS par une modification du signal RxSL (passage du 1 logique au 0 logique).

NOTE Le service d'identification de séquences de données est un service asynchrone et n'est pas lié à RxC.

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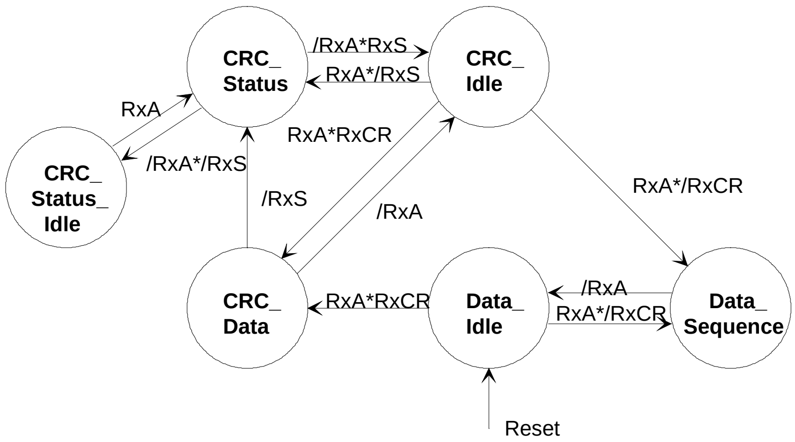
8.4.4.7 Service de réception de messages

La Figure 29 décrit ce service avec les six états ainsi que leurs transitions.

NOTE 1 Les données sont reçues en multiples d'octets.



Légende

Anglais	Français
Reset	Réinitialiser

Figure 29 – Machine de protocole du service de réception de messages

Etat **CRC_Idle**:
Si la MDS reconnaît le début d'une PhPDU de séquence de données, elle lance le service de réception de messages en adaptant les impulsions temporelles émises avec le signal RxC à celles qui sont reçues et en établissant en même temps, au cours du front montant du signal RxC, le signal RxA au 1 logique, le signal RxCR au 0 logique, ainsi qu'en envoyant à la MIS le premier bit de données décodé d'un octet avec le signal RxD.

Si la MDS reconnaît le début d'un état de la somme de contrôle dans une PhPDU de séquence de contrôle au lieu du début d'une PhPDU de séquence de données, elle établit le signal RxA au 1 logique et en même temps le signal RxS au 0 logique et envoie à la MIS le premier bit décodé avec le signal RxD.

Tant que la MDS reconnaît l'état CRC_Idle, elle doit conserver le signal RxA au 0 logique et le signal RxCR au 1 logique.

Etat **Data_Sequence**:
La MDS doit continuer à envoyer à la MIS les données reçues et décodées avec le signal RxD, en adaptant en même temps les impulsions temporelles émises à celles qui sont reçues avec le signal RxC. Si la MDS reconnaît l'état Data_Idle après avoir reçu le dernier bit de données dans un octet, elle doit établir le signal RxA au 0 logique au cours du front descendant de RxC.

Etat **Data_Idle**:
Tant que la MDS reconnaît l'état Data_Idle, elle doit conserver le signal RxA au 0 logique et le signal RxCR au 0 logique.

Si la MDS reconnaît le début d'une PhPDU de séquence de contrôle, elle adapte les impulsions temporelles transmises avec le signal RxC à celles qui sont reçues, elle établit le signal RxA au 1 logique au cours du front montant de RxC et établit en même temps le signal RxCR au 1 logique et transmet à la MIS, avec le signal RxD, les premiers bits reçus et décodés de la somme de contrôle (données CRC).

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Si la MDS reconnaît le premier bit dans un octet d'une PhPDU de séquence de données au lieu du début d'une séquence de contrôle, elle continue la réception de la séquence de données en adaptant les impulsions temporelles émises à celles qui sont reçues avec le signal RxC et en établissant en même temps le signal RxA au 1 logique, au cours du front montant de RxC, et en envoyant à la MIS le bit de données reçu et décodé avec le signal RxD.

Etat **CRC_Data**:
La MDS doit continuer à envoyer à la MIS les données reçues et décodées de la somme de contrôle avec le signal RxD et à adapter avec le signal RxC les impulsions temporelles émises à celles qui sont reçues.

Si la MDS reconnaît le premier bit de l'état de la somme de contrôle après avoir entièrement reçu les données de la somme de contrôle, elle doit adapter les impulsions temporelles émises avec le signal RxC, établir au 0 logique le signal RxS au cours du front montant de RxC et envoyer en même temps à la MIS le bit reçu et décodé de l'état de la somme de contrôle avec le signal RxD.

Si la MDS reconnaît l'état CRC_Idle après avoir reçu le dernier bit dans un octet, elle doit établir le signal RxA au 0 logique au cours du front descendant de RxC.

Si la MDS reconnaît le premier bit dans un octet des données de la somme de contrôle, elle doit poursuivre la réception des données de la somme de contrôle, en adaptant les impulsions temporelles émises à celles qui sont reçues avec le signal RxC et en établissant le signal RxA au 1 logique au cours du front montant de RxC, et en envoyant en même temps à la MIS, avec le signal RxD, le bit reçu et décodé de la somme de contrôle.

Etat **CRC_Status**:
La MDS doit continuer à envoyer à la MIS l'état de la somme de contrôle reçu et décodé avec le signal RxD, en adaptant en même temps les impulsions temporelles émises à celles qui sont reçues avec le signal RxC. Après avoir entièrement reçu l'état de la somme de contrôle, le MDS établit le signal RxA au 0 logique au cours du front descendant de RxC et établit en même temps le signal RxS au 1 logique.

Si la MDS reconnaît l'état CRC_Idle après avoir reçu le dernier bit dans un octet, elle doit établir le signal RxA au 0 logique au cours du front descendant de RxC.

Etat **CRC_Status_Idle**:
Si la MDS reconnaît le premier bit dans un octet des données de la somme de contrôle, elle doit poursuivre la réception de l'état de la somme de contrôle, en adaptant les impulsions temporelles émises à celles qui sont reçues avec le signal RxC et en établissant le signal RxA au 1 logique au cours du front montant de RxC, et en envoyant en même temps à la MIS, avec le signal RxD, le bit reçu et décodé de l'état de la somme de contrôle.

8.4.4.8 Service Réinitialiser

Ce service est envoyé de la MIS à la MDS en établissant le signal RO. La réception d'une réinitialisation est transmise de la MDS à la MIS avec le signal RI. Plage de valeurs: courte, longue

8.5 Type 12: Interface ETTD-DCE

L'interface ETTD-DCE n'est pas exposée en transmission de Type 12.

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9 Sous-couche dépendante du support (MDS)

9.1 Généralités

La sous-couche dépendante du support (MDS) fait partie de l'équipement de transmission de données (DCE). (Voir Figure 1.) Elle échange des informations à travers l'interface ETTD – DCE décrite à l'Article 8 et communique des Ph-symbols codés à travers l'interface MDS – MAU décrite à l'Article 10. La MDS assure des fonctions logiques de codage et de décodage, respectivement pour la transmission et la réception, d'ajout/retrait de préambule et de délimiteurs ainsi que des fonctions de temporisation et de synchronisation.

NOTE Un certain nombre d'entités sous-couches MDS différentes sont spécifiées, sur la base des pratiques industrielles en la matière.

9.2 Type 1: MDS: Supports câblés et optiques

9.2.1 PhPDU

La MDS doit produire la PhPDU présentée à la Figure 30 en ajoutant le préambule et les délimiteurs pour encadrer la séquence série de PhSDU (bits) transférée depuis la DIS par l'intermédiaire de l'interface ETTD-DCE. La séquence de transmission doit aller de gauche à droite comme présenté à la Figure 30, c'est-à-dire le préambule en premier lieu, suivi par le délimiteur de début, la séquence de PhSDU et se terminer par le délimiteur de fin.

PREAMBULE	DELIMITEUR DE DEBUT	SEQUENCE DE PhSDU	DELIMITEUR DE FIN

Figure 30 – Unité de données de protocole (PhPDU)

En revanche, la MDS doit retirer le synchroniseur initial et les délimiteurs d'une PhPDU reçue pour générer une séquence série correspondante de PhSDU. Si une unité de données non binaires est détectée dans la séquence de PhSDU reçue, la MDS doit immédiatement arrêter de transférer les PhSDU à la DIS, la MDS doit rendre compte d'une erreur et doit indiquer la fin de l'activité à la DIS au moment où elle a lieu.

9.2.2 Codage et décodage

Les unités de données doivent être codées par la MDS pour application à la MAU en utilisant le code présenté à la Figure 31 (Manchester Biphase L). Les règles de codage formelles sont données à la Figure 32 et au Tableau 33.

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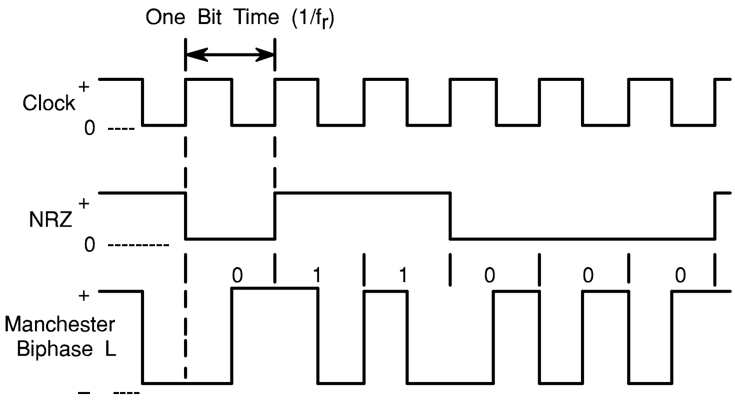
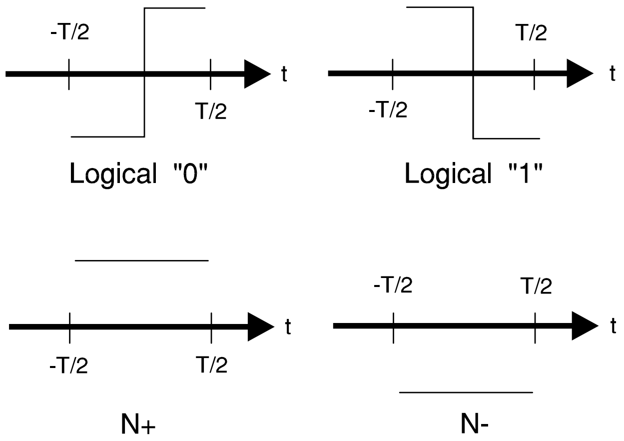


Légende

Anglais	Français
One Bit Time	Un temps binaire
Clock	Horloge
Manchester Biphase L	Manchester Biphase L

Figure 31 – Codage et décodage PhSDU

NOTE La Figure 31 est incluse à des fins d'explication et n'implique aucune mise en œuvre spécifique.



Légende

Anglais	Français
Logical “0”	Niveau logique “0”
Logical “1”	Niveau logique “1”

Figure 32 – Règles de codage Manchester

Tableau 33 – Règles de codage Manchester

Symboles	Codage
1(ONE)	Transition Hi–Lo (à mi-bit)
0 (ZERO)	Transition Lo–Hi (à mi-bit)
N+ (NON-DATA PLUS)	Hi (Pas de transition)
N– (NON-DATA MINUS)	Lo (Pas de transition)
NOTE On peut voir que les symboles de données (1 et 0, acheminés par des PhSDU) sont codés pour contenir toujours une transition à mi-bit. Les symboles non données (N+ et N–) sont codés de façon à ce qu'il n'y ait jamais de transition à mi-bit. Les délimiteurs de trame (voir 9.2.4 et 9.2.5) sont construits pour que les symboles non données soient acheminés dans des paires de polarité opposée.	

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Le décodage doit normalement correspondre à l'opposé du codage. A la réception, la MDS doit vérifier que chaque symbole est codé conformément à la Figure 32 et au Tableau 33 et doit détecter les erreurs suivantes:

a) code Manchester invalide;

b) erreurs de glissement d'un demi-bit.

Chacune de ces erreurs doit être notifiée comme une indication de PhData (PhIDU, erreur).

9.2.3 Détection de polarité

L'option de détection automatique de polarité d'un signal codé Manchester reçu doit être exigée lorsque cela est spécifié dans la MAU correspondante.

9.2.4 Délimiteur de début de trame

La séquence de symboles suivante, présentée de gauche à droite, dans l'ordre de transmission, doit précéder immédiatement la séquence de PhSDU pour délimiter le début d'une trame:

1, N+, N–, 1, 0, N–, N+, 0.

(présenté sous forme d'onde à la Figure 33)

La MDS ne doit accepter un train de signaux reçus comme une PhPDU qu'après avoir vérifié cette séquence et doit retirer cette séquence avant de transférer la séquence de PhSDU à la DIS.

9.2.5 Délimiteur de fin de trame

La séquence de symboles suivante, présentée de gauche à droite, dans l'ordre de transmission, doit immédiatement suivre la séquence de PhSDU pour délimiter la fin d'une trame:

1, N+, N–, N+, N–, 1, 0, 1.

(présenté sous forme d'onde à la Figure 33)

La MDS doit retirer cette séquence de la PhPDU avant de transférer la séquence de PhSDU à la DIS. La MDS doit rendre compte à l'entité DLL correspondante des éventuelles trames reçues via le support lorsque ces trames ne comprennent pas cette séquence dans les 300 octets à compter du début de la trame (du commencement du délimiteur de début) comme indication de PhData (PhIDU, frame_too_long – trame trop longue). La MDS doit rendre compte à l'entité DLL associée, via la DIS correspondante, des éventuelles trames reçues par l'intermédiaire du support si celles-ci ont un délimiteur de fin qui n'est pas placé à une frontière d'octet, comme une indication de PhData (PhIDU, received_timing_error – erreur de temporisation reçue).

9.2.6 Préambule

Pour synchroniser des temps binaires, un préambule doit être transmis au début de chaque PhPDU; ce préambule est constitué de la séquence suivante de bits, présentée de gauche à droite dans l'ordre de transmission:

1, 0, 1, 0, 1, 0, 1, 0.

(présenté sous forme d'onde à la Figure 33)

NOTE 1 Il est possible que le préambule reçu contienne au minimum quatre bits du fait de la perte d'un bit à travers chacun des quatre répéteurs (comme spécifié dans les règles de configuration du réseau pour la MAU).

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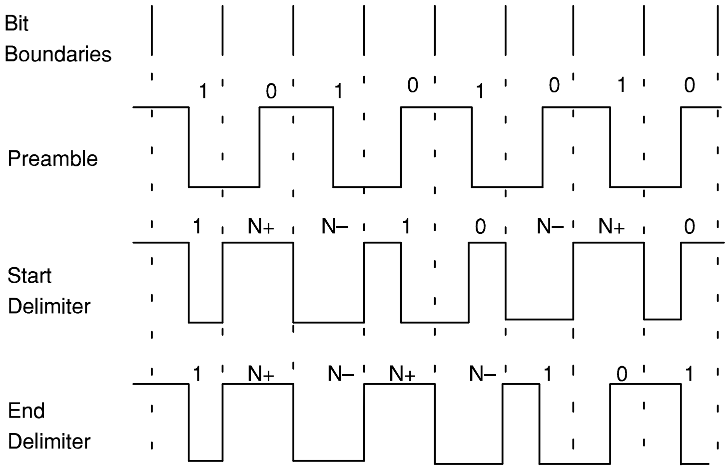
La période peut être étendue mais non réduite par la Gestion systèmes, comme indiqué dans le Tableau 7. Une séquence d'extension de préambule, comme indiqué dans le Tableau 7, doit être définie comme la séquence suivante de bits, présentée de gauche à droite dans l'ordre de transmission:

1, 0, 1, 0, 1, 0, 1, 0.



Légende

Anglais	Français
Bit boundaries	Frontières entre bits
Preamble	Préambule
Start Delimiter	Délimiteur de début
End Delimiter	Délimiteur de fin

Figure 33 – Préambule et délimiteurs

NOTE 2 Ces formes d'onde n'étendent pas la gamme de fréquences au-delà de la bande requise pour la transmission de PhSDU binaires (acheminant les symboles de données) conformément à la Figure 32 et au Tableau 33.

9.2.7 Synchronisation

Après réception du quatrième bit de la trame et jusqu'à la fin de la trame ou sa terminaison, le récepteur doit détecter et rendre compte des erreurs de glissement d'un demi-bit.

NOTE 1 Cette spécification de synchronisation autorise la perte de 4 bits du préambule.

Après le préambule, les erreurs de glissement d'un demi-bit doivent être rapportées comme indication de PH-DATA (PhIDU, erreur).

NOTE 2 Les erreurs de glissement d'un demi-bit peuvent être détectées comme une instabilité excessive (gigue) de bit élémentaire et/ou une variation excessive de la période binaire.

9.2.8 Gap (marque d'intervalle) post-émission

Après émission d'une PhPDU, il doit y avoir une période minimale au cours de laquelle l'émission suivante ne doit pas commencer. Pendant cette même période minimale, après réception d'une PhPDU, l'entité PhL de réception doit ignorer toute signalisation reçue. Une entité MDS doit établir une période minimale post-émission de quatre temps binaires nominaux. La période peut être étendue mais non réduite par la Gestion systèmes, comme indiqué dans le Tableau 7 ou par une entité MAS associée. Une séquence d'extension du gap, comme présenté dans le Tableau 7, doit être définie comme égale à quatre temps binaires nominaux.

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NOTE Le délai d'activation/désactivation de transmission de la MAU peut réduire la durée du silence entre trames.

9.2.9 Dérive du signal entre canaux

Si l'appareil est configuré (par la gestion systèmes) pour recevoir simultanément sur plusieurs canaux, le délai différentiel maximal admissible entre deux canaux actifs, quels qu'ils soient, tel que mesuré à partir de la première PhPDU d'un délimiteur de début, ne doit pas dépasser cinq temps binaires nominaux. Cette période peut être étendue mais non réduite par la Gestion systèmes, comme indiqué dans le Tableau 7. Une séquence d'extension du gap, comme présenté dans le Tableau 7, doit être définie comme égale à quatre temps binaires nominaux. La valeur du gap post-transmission doit être supérieure à la valeur de la dérive entre canaux.

9.3 *Vide*

NOTE Dans la présente édition, le Paragraphe 9.3 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

9.4 Type 2: MDS: Supports câblés et optiques

NOTE La sous-couche dépendante du support (MDS) fait partie de l'équipement de transmission de données (DCE). Elle communique des bits codés par le biais de l'interface MDS-MAU spécifiée en 10.4.

9.4.1 Précision d'horloge

Les spécifications temporelles de la signalisation PhL doivent être telles que définies dans le Tableau 34.

Tableau 34 – Caractéristiques temporelles de la MDS

Spécification	Limites / caractéristiques	Commentaires
Débit binaire	5 Mbit/s ± CA	Egalement appelé débit de M-symbol (rapidité de modulation),*données 'zéro' ou 'un'*
Temps binaire	200 ns ± CA	Egalement appelé débit de M-symbol (rapidité de modulation),*données 'zéro' ou 'un'*
Durée de symbole PhL	100 ns ± CA	Egalement appelé durée de Ph-symbol, voir les règles de codage de données
Précision d'horloge (CA, de l'anglais Clock Accuracy)	± 150 µHz/Hz max	Tenant compte de la température ainsi que de la stabilité à long et à court termes

9.4.2 Régénération de données

Les signaux à l'interface DLL-PhL doivent être synchronisés sur le débit binaire local, comme présenté dans le Tableau 34. Chaque application PhL doit prévoir un mécanisme de régénération des données qui récupère ou reconstruit les données reçues à partir du support approprié, de manière à satisfaire aux exigences de temporisation du Tableau 34. Lorsque la synchronisation des données a été atteinte par la MDS, l'Indication de PH-LOCK doit être "vrai".

Une partie de la trame des données reçue peut être perdue ou ignorée lors du processus d'obtention de la synchronisation des données. La spécification de temporisation des données présentée dans le Tableau 34 doit être atteinte avant le commencement du délimiteur de début (voir la CEI 61158-4-2).

9.4.3 Règles de codage des données

Les M-symbols présents à l'interface DLL-PhL doivent être codés en Ph-symbols appropriés comme indiqué dans le Tableau 35 et la Figure 34. Les symboles M_0 et M_1 doivent être

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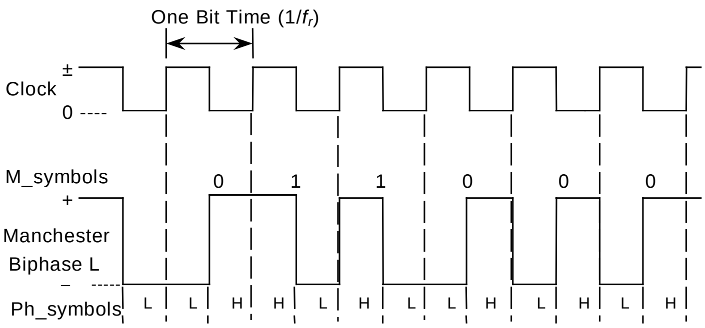
codés en Ph-symbols qui représentent les règles de codage de données Manchester Biphase L, comme indiqué dans le Tableau 35. Les symboles M_ND doivent être utilisés pour créer des modèles de données uniques utilisés pour les délimiteurs de début et de fin. La forme d'onde de tension du signal (provenant de la MAU) est présentée sous forme idéalisée à la Figure 34, de manière à fournir un exemple des règles de codage de données du Tableau 35.

Tableau 35 – Règles de codage des données MDS

Bits de données (nom commun)	Représentation de symbole M	Codage de symbole Ph	Codé Manchester
données ‘zéro’	M_0 ou {0}	{L,H}	0
données ‘un’	M_1 ou {1}	{H,L}	1
‘non_data+’	M_ND+ ou {+}	{H,H}	aucune donnée
‘non_data-’	M_ND– ou {–}	{L,L}	aucune donnée



Légende

Anglais	Français
One Bit Time	Un temps binaire
Clock	Horloge
Manchester Biphase L	Manchester Biphase L

Figure 34 – Symboles codés Manchester

9.5 Type 3: MDS: Supports câblés et optiques

9.5.1 Transmission synchrone

La sous-couche dépendante du support (MDS) spécifiée pour le Type 1 doit être utilisée (voir 9.2).

9.5.2 Transmission asynchrone

Il n'y a pas de MDS (sous-couche dépendante du support) en transmission asynchrone.

9.6 Type 4: MDS: Support câblé

9.6.1 Semi-duplex

9.6.1.1 Vue d'ensemble

NOTE 1 L'entité PhL est subdivisée en une composante Equipement terminal de traitement de données (ETTD) contenant la MDS et en une composante Equipement de transmission de données (DCE) contenant la MAU.

NOTE 2 La fonctionnalité de la MDS est semblable à la fonctionnalité de ce que l'on appelle communément un UART (Universal Asynchronous Receiver Transmitter:- émetteur-récepteur asynchrone universel). En outre, la MDS semi-duplex a une certaine fonctionnalité de temporisation. La fonctionnalité de la MAU est semblable à la fonctionnalité de ce qu'on appelle communément un circuit d'excitation (ou d'attaque).

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La MDS semi-duplex doit ordonner l'émission de la PhID comme une séquence de bits. De la même manière, la MDS doit constituer la PhID à renvoyer à la DLL à partir de la séquence de bits reçue. Les bits sont envoyés et reçus en code NRZ (non-return-to-zero).

La PhID doit être convertie en une séquence de bits pour transmission série dans des PhPDU. Dans chaque PhPDU, un bit représentant un bit de poids fort doit être transmis avant un bit représentant un bit de poids faible. A la réception, chaque séquence de bits doit être convertie en PhID de façon à ce que, en l'absence d'erreurs, la PhID indiquée à l'entité DLL de réception demeure inchangée par rapport à la PhID dont l'émission a été demandée par l'entité DLL d'origine.

La MDS reçoit une seule PhID ou une séquence d'octets de PhID à partir de la DLE. Le premier octet est reçu à partir de la DLE par l'un des services **START-OF-ACTIVITY-11** ou **START-OF-ACTIVITY-2**. Les octets restants sont reçus à partir de la DLE par le service **DATA**. La fin de transmission est indiquée par le service **END-OF-ACTIVITY**. A partir de chaque octet de PhID, la MDS doit constituer une PhPDU et transmettre à la MAU la PhPDU formée comme une séquence de bits. Chaque PhPDU doit être constituée de 1 bit de départ, de 8 bit de données, de 1 bit d'adresse/données, et finalement de 1 bit d'arrêt. Ceci est représenté à la Figure 35.

Début	Donnée8 ... Donnée1	Adresse/données	Stop
0	X....X	1 pour le premier octet, 0 pour le reste	1

Figure 35 – Format d'une PhPDU, semi-duplex

La MDS doit notifier le fait que le niveau du signal sur le support connecté est demeuré au repos pendant 30, 35 et 40 ou plus périodes binaires, par des indications **LINK-IDLE** destinées à la DLE.

Le débit binaire émis doit être celui du débit en bauds sélectionné, ± 0,2 %.

9.6.1.2 Emission

9.6.1.2.1 START-OF-ACTIVITY-11

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande de PH-DATA **START-OF-ACTIVITY-11**:

a) attendre que le compteur de repos atteigne ou dépasse 11;
b) constituer la première PhPDU avec bit d'adresse/données = “1” et données = paramètres de données de la demande **START-OF-ACTIVITY-11**;
c) confirmer la réception à la DLE pour lui permettre d'émettre la demande de transmission suivante;
d) activer TxE (activation de l'émission);
e) commencer à transmettre la PhPDU à la MAU.

9.6.1.2.2 START-OF-ACTIVITY-2

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande de PHDATA **START-OF-ACTIVITY-2:**

a) attendre que le module 10 de compteur de repos atteigne ou dépasse 2;
b) constituer la première PhPDU avec bit d'adresse/données = “1” et données = paramètres de données de la demande **START-OF-ACTIVITY-2**;
c) confirmer la réception à la DLE pour lui permettre d'émettre la demande de transmission suivante;
d) activer TxE (activation de l'émission);
e) commencer à transmettre la PhPDU à la MAU.

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9.6.1.2.3 DATA

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande PH-DATA **DATA**:

a) attendre que l'émission des PhPDU précédentes soit terminée;
b) constituer une nouvelle PhPDU avec bit d'adresse/données = “0” et données = paramètres de données de la demande **DATA**;
c) confirmer la réception à la DLE pour lui permettre d'émettre la demande de transmission suivante;
d) commencer à transmettre la PhPDU à la MAU.

On doit s'assurer qu'il n'y a pas de périodes de repos entre émissions de PhPDU. Il convient que la DLE envoie la demande de transmission suivante dans les 11 périodes binaires qui suivent la confirmation de la précédente.

9.6.1.2.4 END-OF-ACTIVITY

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande PHDATA **END-OF-ACTIVITY**:

a) attendre que l'émission de la PhPDU précédente soit terminée;
b) attente d'au minimum 3 et au maximum 10 périodes binaires;
c) désactiver TxE (activation de l'émission).

9.6.1.3 Réception

9.6.1.3.1 START-OF-ACTIVITY

A la suite de la réception d'une trame en provenance de la MAU avec bit d'adresse/données = “1”, ou la réception d'une trame dont la valeur du compteur de repos est supérieure ou égale à 11, la MDS doit émettre une indication PH-DATA de classe **START-OF-ACTIVITY**. Le paramètre de données correspondant doit détenir les données reçues. La valeur du paramètre d'état correspondant doit être établie de la manière suivante:

a) la réception d'une trame avec bit d'adresse/données = “1” et bit d'arrêt = “1”, la valeur du compteur de repos étant supérieure ou égale à 11 doit provoquer l'indication SUCCESS dans le paramètre d'état correspondant;
b) la réception d'une trame avec bit d'arrêt = “0” doit provoquer l'indication FRAMING_ERROR dans le paramètre d'état correspondant;
c) la réception d'une trame avec bit d'adresse/données = “1”, la valeur du compteur de repos étant inférieure ou égale à 11, doit provoquer l'indication IDLE_ERROR dans le paramètre d'état correspondant;
d) la réception d'une trame avec bit d'adresse/données = “0”, la valeur du compteur de repos étant supérieure ou égale à 11, doit provoquer l'indication ADDRESS_DATA_ERROR dans le paramètre d'état correspondant.

9.6.1.3.2 DATA

A la suite de la réception d'une trame en provenance de la MAU avec bit d'adresse/données = “0”, la valeur du compteur de repos étant inférieure à 11, la MDS doit émettre une indication de PH-DATA de classe DATA. Le paramètre de données correspondant doit détenir les données reçues. La valeur du paramètre d'état correspondant doit être établie de la manière suivante:

a) la réception d'une trame avec bit d'arrêt = “1” en provenance de la MAU doit provoquer l'indication SUCCESS dans le paramètre d'état correspondant;
b) la réception d'une trame avec bit d'arrêt = “0” doit provoquer l'indication FRAMING_ERROR dans le paramètre d'état correspondant.

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9.6.1.4 Compteur de repos

La MDS détient un compteur de repos. Ce compteur est incrémenté de un à chaque période binaire et il est remis à zéro à chaque fois qu'un bit de valeur “0” est envoyé ou reçu de la MAU. Lorsque le compteur de repos atteint 30, la MDS doit en rendre compte par une indication de PH-DATA de classe LINK-IDLE et l'indication de 30 périodes binaires dans l'état correspondant. 5 périodes binaires plus tard, si la liaison est toujours au repos, la PhE en rend compte au moyen d'une autre indication de PH-DATA de classe LINK-IDLE et en indiquant 35 périodes binaires dans l'état correspondant. 5 périodes binaires plus tard, si la liaison est toujours au repos, la PhE en rend compte au moyen d'une autre indication de PH-DATA de classe LINK-IDLE et en indiquant 40 périodes binaires ou plus dans l'état correspondant. Ceci continue à chaque 10 périodes binaires avec des indications spécifiant 40 périodes binaires ou plus. La vitesse du compteur de repos doit être celle du débit en bauds sélectionné, ± 0,2 %.

9.6.2 Bidirectionnelle simultanée

9.6.2.1 Vue d'ensemble

NOTE 1 L'entité PhL est subdivisée en une composante Equipement terminal de traitement de données (ETTD) contenant la MDS et en une composante Equipement de transmission de données (DCE) contenant la MAU.

NOTE 2 La fonctionnalité de la MDS est semblable à la fonctionnalité de ce que l'on appelle communément un UART (Universal Asynchronous Receiver Transmitter: – émetteur-récepteur asynchrone universel). En outre, la MDS bidirectionnelle simultanée a une certaine fonctionnalité de "bourrage d'octet". La fonctionnalité de la MAU est semblable à la fonctionnalité de ce qu'on appelle communément un circuit d'excitation (ou d'attaque).

La MDS bidirectionnelle simultanée doit ordonner l'émission de la PhID comme une séquence de bits. De la même manière, la MDS doit constituer la PhID à renvoyer à la DLL à partir de la séquence de bits reçue. Les bits sont envoyés et reçus en code NRZ (non-return-to-zero).

La PhID doit être convertie en une séquence de bits pour transmission série dans des PhPDU. Dans chaque PhPDU, un bit représentant un bit de poids fort doit être transmis avant un bit représentant un bit de poids faible. A la réception, chaque séquence de bits doit être convertie en PhID de façon à ce que, en l'absence d'erreurs, la PhID indiquée à l'entité DLL de réception demeure inchangée par rapport à la PhID dont l'émission a été demandée par l'entité DLL d'origine.

La MDS reçoit une seule PhID ou une séquence d'octets de PhID à partir de la DLE. Le premier octet est reçu de la DLE par le service **START-OF-ACTIVITY-2**. Les octets restants sont reçus à partir de la DLE par le service **DATA**. La fin de transmission est indiquée par le service **END-OF-ACTIVITY**. A partir de chaque octet de PhID, la MDS doit constituer une PhPDU et transmettre à la MAU la PhPDU formée comme une séquence de bits. Chaque PhPDU doit être constituée de 1 bit de départ, de 8 bit de données et de 1 bit d'arrêt. Ceci est représenté à la Figure 36.

Début	Donnée8 ... Donnée1	Stop
0	X....X	1

Figure 36 – Format d'une PhPDU, bidirectionnelle simultanée

9.6.2.2 Emission

9.6.2.2.1 START-OF-ACTIVITY-2

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande PHDATA**START-OF-ACTIVITY-2**:

a) constituer la première PhPDU avec données = $D7 (hex);

b) constituer la seconde PhPDU avec données = paramètre de données de demande **START-OF-ACTIVITY-2**;

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c) confirmer la réception à la DLE pour lui permettre d'émettre la demande de transmission suivante;
d) activer le signal request-to-send (RTS);
e) attente de l'activation du signal clear-to-send (CTS);
f) commencer à transmettre à la MAU les PhPDU formées.

9.6.2.2.2 DATA

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande PHDATA**DATA**:

a) attendre que l'émission des PhPDU précédentes soit terminée;
b) attente de l'activation du signal clear-to-send (CTS);
c) former une(des) PhPDU(s) nouvelle(s) avec des données selon les indications suivantes:
d) si la valeur de paramètre de données de la demande **DATA**= $D7 (hex), constituer une PhPDU ayant la valeur de données $D9 (hex), suivie par une PhPDU supplémentaire ayant la valeur de données $00;
e) si la valeur de paramètre de données de la demande **DATA**= $D9 (hex), constituer une PhPDU ayant la valeur de données $D9 (hex), suivie par une PhPDU supplémentaire ayant la valeur de données $01;
f) si la valeur de paramètre de données de la demande **DATA** est différente de $D7 (hex) et $D9, constituer une PhPDU ayant la valeur de données = paramètre de données de la demande **DATA**;
g) confirmer la réception à la DLE pour lui permettre d'émettre la demande de service suivante;
h) commencer à transmettre la(les) PhPDU à la MAU.

9.6.2.2.3 END-OF-ACTIVITY

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande PHDATA**END-OF-ACTIVITY**:

a) attendre que l'émission des PhPDU précédentes soit terminée;
b) désactiver le signal request-to-send (RTS).

9.6.2.3 Réception

9.6.2.3.1 START-OF-ACTIVITY

A la suite de la réception d'une PhPDU en provenance de la MAU, avec une valeur de données de $D7 (hex), la MDS doit attendre la PhPDU suivante et une fois celle-ci reçue, émettre une indication PH-DATA de classe **START-OF-ACTIVITY**. Le paramètre de données correspondant doit détenir les données de réception de la PhPDU qui suivent $D7 (hex). La valeur du paramètre d'état correspondant doit être établie de la manière suivante:

a) la réception d'une PhPDU avec bit d'arrêt = “1” doit provoquer l'indication SUCCESS dans le paramètre d'état correspondant;
b) la réception d'une PhPDU avec bit d'arrêt = “0” doit provoquer l'indication FRAMING_ERROR dans le paramètre d'état correspondant.

9.6.2.3.2 DATA

La réception d'une PhPDU en provenance de la MAU, avec une valeur de données différente de $D7 (hex) doit entraîner ce qui suit:

la réception d'une trame avec bit d'arrêt = “1” et valeur de données = $D9 (hex) doit provoquer l'attente par la MDS de la PhPDU suivante en provenance de la MAU. Le résultat de la réception de la PhPDU suivante doit être:

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a) si la valeur de données de la PhPDU suivante est $00 (hex) et si le bit d'arrêt = “1”, émission d'une indication PHDATA de classe **DATA**. Le paramètre de données correspondant doit détenir la valeur $D7. La valeur du paramètre d'état correspondant doit indiquer SUCCESS.

b) si la valeur de données de la PhPDU suivante est $01 (hex) et si le bit d'arrêt = “1”, émission d'une indication PH-DATA de classe **DATA**. Le paramètre de données correspondant doit détenir la valeur $D9. La valeur du paramètre d'état correspondant doit indiquer SUCCESS.

c) si la valeur de données de la PhPDU suivante est différente de $00 (hex) et de $01 (hex) et si le bit d'arrêt = “1”, émission d'une indication PH-DATA de classe **DATA**. Le paramètre de données correspondant doit détenir la valeur des données de réception. La valeur du paramètre d'état correspondant doit indiquer BYTE_STUFFING_ERROR.

d) si le bit d'arrêt est “0”, émission d'une indication PH-DATA de classe **DATA**. Le paramètre de données correspondant doit détenir la valeur reçue. La valeur du paramètre d'état correspondant doit indiquer FRAMING_ERROR.

e) la réception d'une PhPDU avec bit d'arrêt = “1” et une valeur de données différente de $D9 (hex), doit entraîner l'émission par la MDS d'une indication PH-DATA de classe **DATA**. Le paramètre de données correspondant doit détenir la valeur reçue. La valeur du paramètre d'état correspondant doit indiquer SUCCESS;

f) la réception d'une PhPDU avec bit d'arrêt = “0” doit entraîner dans la MIS l'émission d'une indication PH-DATA de classe **DATA**. Le paramètre de données correspondant doit détenir la valeur reçue. La valeur du paramètre d'état correspondant doit indiquer FRAMING_ERROR.

9.6.3 UDP bidirectionnel simultané

9.6.3.1 Vue d'ensemble

La PhID doit être envoyée conformément à l'ISO/CEI 8802-3.

La MDS reçoit une seule PhID ou une séquence d'octets de PhID à partir de la DLE. Le premier octet est reçu de la DLE par le service **START-OF-ACTIVITY-2**. Les octets restants sont reçus à partir de la DLE par le service **DATA**. La fin de transmission est indiquée par le service **END-OF-ACTIVITY**.

9.6.3.2 Emission

9.6.3.2.1 START-OF-ACTIVITY-2

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande PHDATA**START-OF-ACTIVITY-2**:

a) réserver le paquet de sous-couche MAC;

b) constituer la PhPDU avec données = paramètre de données de demande **START-OF-ACTIVITY-2**;

c) insérer la PhPDU formée au premier emplacement dans le paquet réservé;

d) confirmer la réception à la DLE pour lui permettre d'émettre la demande de transmission suivante.

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande PH-DATA **DATA**:

a) constituer la PhPDU avec données = paramètre de la demande **DATA**;

b) insérer la PhPDU formée à l'emplacement suivant dans le paquet réservé;

c) confirmer la réception à la DLE pour lui permettre d'émettre la demande de service suivante.

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9.6.3.2.2 END-OF-ACTIVITY

Les étapes suivantes doivent être réalisées à la suite de l'émission par la DLE d'une demande PH-DATA **END-OF-ACTIVITY**:

a) transférer le paquet réservé à la sous-couche MAC.

9.6.3.3 Réception

9.6.3.3.1 START-OF-ACTIVITY

A la suite de la réception d'un paquet de la sous-couche MAC, émettre une indication PH-DATA de classe **START-OF-ACTIVITY**. Le paramètre de données correspondant doit détenir le premier octet du paquet reçu. La valeur du paramètre d'état correspondant doit être établie sur SUCCESS (Succès).

9.6.3.3.2 DATA

Les données suivantes dans le paquet reçu doivent entraîner l'émission par la MDS d'indications PH-DATA de classe **DATA**. Les paramètres de données correspondants doivent détenir les valeurs reçues. La valeur des paramètres d'état correspondants doit indiquer SUCCESS.

9.7 *Vide*

NOTE Dans la présente édition, le Paragraphe 9.7 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

9.8 Type 8: MDS: Supports câblés et optiques

9.8.1 Fonction

La MDS (sous-couche dépendante du support) échange des séquences PhSDU via l'interface MIS-MDS, comme décrit en 6.5 et transmet la PhPDU via l'interface MDS-MAU comme décrit à l'Article 9. La MDS code et décode la PhSDU, ajoute et retire la trame de transmission (en-tête et bit d'arrêt) des sous-séquences de PhSDU à émettre et à recevoir, elle synchronise l'interface MIS-MDS avec l'interface MDS-MAU et avec les PhPDU ainsi qu'avec les fonctions temporelles et émet directement une PhPDU entre les MAU via l'interface MDS-MAU (couplage MAU).

La MDS peut être constituée de plusieurs canaux. La PhPDU doit générer un canal de la MDS correspondant aux séquences de PhSDU transmises via l'interface MIS-MDS et code les séquences de PhSDU en conséquence. En revanche, ce canal doit reconnaître le format de la PhPDU reçue et transmet à la MIS la séquence de PhSDU décodée via l'interface MIS-MDS. Tous les autres canaux sont utilisés pour transférer directement une PhSDU entre deux MAUs.

Le canal de la MDS d'un esclave qui a une interface avec la MIS doit avoir la relation suivante entre les sens de transmission et de réception: Si le signal RTS de l'interface MIS-MDS est à 0, le contenu du DI est transmis sur le signal DO de l'interface MDS-MAU avec un temps de retard d'exactement un temps binaire. Si RTS est à 1, DO est couplé à TxD (applicable uniquement lorsqu'il n'y a aucun couplage MDS).

Dans la MDS d'un maître, il est possible qu'une séquence de 8 PhSDU soit d'abord mise en tampon et ensuite une PhPDU de séquence de données ou de séquence de contrôle correspondante est générée.

9.8.2 Formats de PhPDU

La MDS peut reconnaître et générer les formats de PhPDU suivants: **PhPDU de séquence de données**, **PhPDU de séquence de contrôle**, **PhPDU d'état** et **PhPDU de réinitialisation**.

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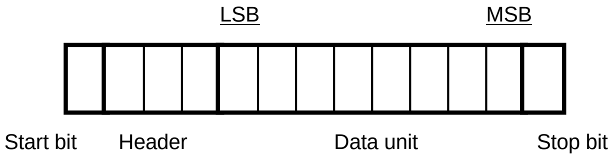
9.8.2.1 PhPDU de séquence de données

La MDS génère la PhPDU de séquence de données en ajoutant un bit de départ, un en-tête et un bit d'arrêt à l'unité de données. L'unité de données proprement dite est constituée de huit PhSDU qui, en tant que séquence PhSDU, ont été transmises comme partie de la DLPDU de séquence de données via l'interface MIS-MDS, au moyen du service de transmission de messages. La Figure 37 illustre la structure de la PhPDU de séquence de données.



Légende

Anglais	Français
Start bit	Bit de départ
Header	En-tête
Data Unit	Unité de données
Stop bit	Bit d'arrêt

Figure 37 – PhPDU de séquence de données

La PhPDU de séquence de données ainsi générée est transmise de gauche à droite, via l'interface MDS-MAU dans l'ordre suivant: bit de départ, en-tête, unité de données, bit d'arrêt. Les PhSDU de l'unité de données sont transmises via l'interface MDS-MAU dans l'ordre dans lequel elles ont été émises à travers l'interface MIS-MDS.

Conformément à la Figure 37, une PhPDU de séquence de données est reçue de gauche à droite et dans l'ordre suivant: bit de départ, en-tête, unité de données, bit d'arrêt. La MDS retire le bit de départ, le bit d'arrêt et l'en-tête et transmet à la MIS la séquence de PhSDU contenue dans l'unité de données avec le service de réception de messages, comme partie d'une DLPDU de séquence de données, par l'intermédiaire de l'interface MIS-MDS. L'émission commence par la première PhSDU qui suit l'en-tête et se termine par la dernière PhSDU avant le bit d'arrêt.

NOTE 1 Chaque PhPDU de séquence de données commence par un bit de départ et se termine par un bit d'arrêt.

NOTE 2 Une DLPDU de séquence de données est transmise par une séquence de PhPDU de séquence de données.

La structure de l'en-tête dans une PhPDU de séquence de données est présentée à la Figure 38.

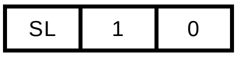


Figure 38 – Structure de l'en-tête dans une PhPDU de séquence de données

L'en-tête de la PhPDU de séquence de données est émis et reçu de gauche à droite, via l'interface MDS-MAU, en commençant par le bit SL.

Pour qu'une PhPDU de séquence de données soit envoyée, le symbole logique à transférer dans le bit SL équivaut à l'état logique inversé du signal TxSL de l'interface MIS-MDS au moment où la PhPDU de séquence de données est à transmettre à la MAU via l'interface MDS-MAU (voir le Tableau 36):

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Tableau 36 – Attribution du bit SL et du signal TxSL

Signal TxSL	Bit SL
Niveau logique 1	0
Niveau logique 0	1

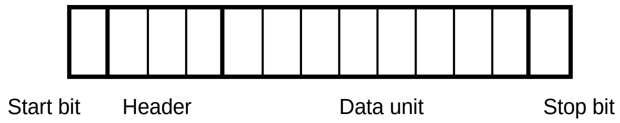
Pour une PhPDU de séquence de données reçue, l'état logique du signal RxSL de l'interface MIS-MDS équivaut au symbole logique inversé qui est transmis dans le bit SL (voir le Tableau 37).

Tableau 37 – Attribution du bit SL et du signal RxSL

Bit SL	Signal RxSL
0	Niveau logique 1
1	Niveau logique 0

9.8.2.2 PhPDU de séquence de contrôle

La MDS génère la PhPDU de séquence de contrôle en ajoutant un bit de départ, un en-tête et un bit d'arrêt à l'unité de données. L'unité de données proprement dite est constituée de huit PhSDU qui ont été transmises en tant que séquence PhSDU au moyen du service de transmission de messages, comme partie de la DLPDU de séquence de contrôle via l'interface MIS-MDS. La Figure 39 illustre la structure de la PhPDU de séquence de contrôle.



Légende

Anglais	Français
Start bit	Bit de départ
Header	En-tête
Data Unit	Unité de données
Stop bit	Bit d'arrêt

Figure 39 – PhPDU de séquence de contrôle

Une PhPDU de séquence de contrôle ainsi générée est transmise de gauche à droite, via l'interface MDS-MAU dans l'ordre suivant: bit de départ, en-tête, unité de données, bit d'arrêt. Les PhSDU de l'unité de données sont transmises via l'interface MDS-MAU dans l'ordre dans lequel elles ont été émises à travers l'interface MIS-MDS.

Une PhPDU de séquence de contrôle est reçue, conformément à la Figure 39, de gauche à droite et dans l'ordre suivant: bit de départ, en-tête, unité de données, bit d'arrêt. La MDS retire le bit de départ, le bit d'arrêt et l'en-tête et transmet à la MIS la séquence de PhSDU contenue dans l'unité de données avec le service de réception de messages, comme partie d'une DLPDU de séquence de contrôle, par l'intermédiaire de l'interface MIS-MDS. L'émission commence par la première PhSDU qui suit l'en-tête et se termine par la dernière PhSDU avant le bit d'arrêt.

NOTE 1 Chaque PhPDU de séquence de contrôle commence par le bit de départ et se termine par le bit d'arrêt.

NOTE 2 Une DLPDU de séquence de contrôle est transmise avec une série de quatre PhPDU de séquence de contrôle.

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La structure de l'en-tête dans une PhPDU de séquence de contrôle est présentée à la Figure 40.

SL	0	0

Figure 40 – Structure de l'en-tête dans une PhPDU de séquence de contrôle

L'en-tête de la PhPDU de séquence de contrôle est émis et reçu de gauche à droite, via l'interface MDS-MAU, en commençant par le bit SL.

Pour qu'une PhPDU de séquence de contrôle soit envoyée, le symbole logique à transférer dans le bit SL équivaut à l'état logique inversé du signal TxSL de l'interface MIS-MDS au moment où la PhPDU de séquence de contrôle est à transmettre à la MAU via l'interface MDS-MAU (voir Tableau 38):

Tableau 38 – Attribution du bit SL et du signal TxSL

Signal TxSL	Bit SL
Niveau logique 1	0
Niveau logique 0	1

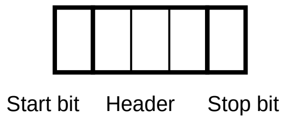
Pour une PhPDU de séquence de contrôle reçue, l'état logique du signal RxSL de l'interface MIS-MDS équivaut au symbole logique inversé qui est transmis dans le bit SL (voir Tableau 39).

Tableau 39 – Attribution du bit SL et du signal RxSL

Bit SL	Signal RxSL
0	Niveau logique 1
1	Niveau logique 0

9.8.2.3 PhPDU d'état

La PhPDU d'état qui est formée par la MDS est constituée d'un bit de départ, de l'en-tête et d'un bit d'arrêt. La structure de la PhPDU d'état est présentée à la Figure 41.



Légende

Anglais	Français
Start bit	Bit de départ
Header	En-tête
Stop bit	Bit d'arrêt

Figure 41 – Structure de la PhPDU d'état

La PhPDU d'état est émise et reçue de gauche à droite, via l'interface MDS-MAU, en commençant par le bit de départ, suivi par l'en-tête et se terminant par le bit d'arrêt.

La structure de l'en-tête d'une PhPDU d'état est présentée à la Figure 42.

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SL	0/1	1

Figure 42 – Structure de l'en-tête dans une PhPDU d'état

Conformément à la Figure 42, l'en-tête est émis et reçu de gauche à droite, via l'interface MDS-MAU, en commençant par le bit SL. L'état du bit qui suit le bit SL n'est pas défini et peut prendre les valeurs "0" ou "1".

Pour qu'une PhPDU d'état soit envoyée, le symbole logique à transférer dans le bit SL équivaut à l'état logique inversé des signaux TxSL de l'interface MIS-MDS au moment où la PhPDU d'état est à transmettre à la MAU via l'interface MDS-MAU (voir Tableau 40).

Tableau 40 – Attribution du bit SL et du signal TxSL

Signal TxSL	Bit SL
Niveau logique 1	0
Niveau logique 0	1

Pour une PhPDU de séquence de contrôle reçue, l'état logique du signal RxSL de l'interface MIS-MDS équivaut au symbole logique inversé qui est transmis dans le bit SL (voir Tableau 41).

Tableau 41 – Attribution du bit SL et du signal RxSL

Bit SL	Signal RxSL
0	Niveau logique 1
1	Niveau logique 0

Chaque PhPDU d'état commence par un bit de départ et se termine par un bit d'arrêt.

Si aucune des séquences de PhSDU n'est transmise à la MDS via l'interface MIS-MDS, la MDS commence automatiquement à émettre des PhPDU d'état successives. Des états de repos peuvent être générés entre deux PhPDU d'état successives. L'émission des PhPDU d'état se termine de manière synchrone avec le message dès que la première PhSDU d'une PhPDU de séquence de données ou de séquence de contrôle a été transmise de la MIS à la MDS.

Les PhPDU d'état sont transmises après une PhPDU de réinitialisation si aucune PhPDU de séquence de contrôle ou de séquence de données n'est à émettre.

NOTE La réception d'une PhPDU d'état ne modifie pas l'état logique du signal RxCR de l'interface MIS-MDS.

9.8.2.4 PhPDU d'état d'activité du support

La PhPDU d'état d'activité du support qui est formée par la MDS est constituée d'un bit de départ, de l'en-tête et d'un bit d'arrêt. La structure de la PhPDU d'état d'activité du support est présentée à la Figure 43.

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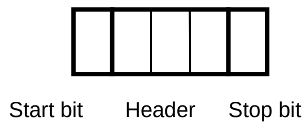

Légende

Anglais	Français
Start bit	Bit de départ
Header	En-tête
Stop bit	Bit d'arrêt

Figure 43 – Structure de la PhPDU d'état d'activité du support

La structure de l'en-tête d'une PhPDU d'état d'activité du support est présentée à la Figure 44.

1	1	1

Figure 44 – Structure de l'en-tête d'une PhPDU d'état d'activité du support

Conformément à la Figure 44, l'en-tête est émis et reçu de gauche à droite, via l'interface MDS-MAU. La PhPDU d'état d'activité du support n'est transmise via une MAU passive de départ (mode de rebouclage = désactivé) que si la Gestion systèmes établit la variable "sélection de données" = activé.

9.8.2.5 Codage et décodage

Le codage et le décodage sont effectués conformément aux règles du Tableau 42.

Tableau 42 – Règles de codage et de décodage

Bit de symbole logique	Codage DO, DI
1	Niveau haut
0	Niveau bas

Les niveaux haut et bas doivent être prélevés du début d'un bit pendant la durée d'un temps binaire.

NOTE 1 Pour le codage, les symboles logiques sont convertis en l'état correspondant du signal DO de l'interface MDS-MAU.

NOTE 2 Pour le décodage, l'état du signal DI de l'interface MDS-MAU est converti en symbole logique correspondant.

9.8.2.6 Bit de départ

Le bit de départ correspond au symbole logique "1".

La MDS doit synchroniser son horloge de réception avec le début des bits de départ (low-high transitions).

9.8.2.7 Bit d'arrêt

Le bit d'arrêt correspond au symbole logique "0".

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NOTE La MDS ne peut synchroniser son horloge de réception sur un bit de départ nouvel arrivant qu'après un bit d'arrêt (low-high transitions).

9.8.3 Etats de repos

L'émetteur du maître bus peut générer des états de repos au cours des transitions des PhPDU d'état en PhPDU de séquence de données ou en PhPDU de séquence de contrôle. Les états de repos ont toujours un low-level sur DO. La longueur maximale des états de repos ne doit pas dépasser 26 temps binaires. Les règles de décodage pour les états de repos reconnus sur le support sont données dans le Tableau 43.

Tableau 43 – Règles de décodage pour les états de repos

Etat de repos	Etat RxCR	Décodage DI
Data_Idle	Niveau logique 0	Niveau bas
CRC_Idle	Niveau logique 1	Niveau bas
CRC_Status_Idle	Niveau logique 1	Niveau bas

9.8.4 PhPDU de réinitialisation

9.8.4.1 Structure de la PhPDU de réinitialisation

La PhPDU de réinitialisation transmet les symboles logiques "réinitialisation courte" ou "réinitialisation longue". La Figure 45 illustre la structure de la PhPDU de réinitialisation.

0	0	0	0	0	0		…….		0	0	0	0	0	0

Réinitialisation courte ou réinitialisation longue

Figure 45 – PhPDU de réinitialisation

NOTE Les symboles "réinitialisation courte" et "réinitialisation longue" ne diffèrent qu'en termes de durée de transmission d'un low-level par les signaux DO ou DI de l'interface MDS-MAU.

9.8.4.2 Codage et décodage

Les règles de codage de la PhPDU de réinitialisation sont données dans le Tableau 44 et le Tableau 45.

Tableau 44 – Règles de codage de la PhPDU de réinitialisation

Symbole logique	Intervalle de temps	Codage DO
Réinitialisation courte du bus	2 ms $\leq T_{Rst} <$ 25,6 ms	Niveau bas
Réinitialisation longue du bus	$T_{Rst} \geq$ 25,6 ms	Niveau bas

Tableau 45 – Règles de décodage de la PhPDU de réinitialisation

DI	Intervalle de temps	Symbole logique
Niveau bas	2 ms $\leq T_{Rst} <$ 25,6 ms	Réinitialisation courte du bus
Niveau bas	$T_{Rst} \geq$ 25,6 ms	Réinitialisation longue du bus

NOTE 1 Une PhPDU de réinitialisation se termine par le bit de départ d'une PhPDU de séquence de données, d'une PhPDU de séquence de contrôle ou d'une PhPDU d'état.

NOTE 2 Au cours du codage, les symboles logiques sont convertis en l'état correspondant du signal DO de l'interface MDS-MAU pendant le temps T_{Rst}.

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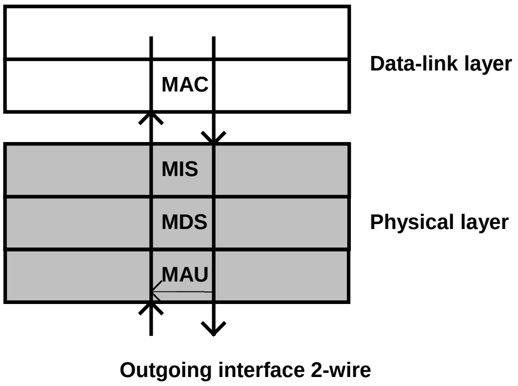
NOTE 3 Au cours du décodage, pendant le temps T_{Rst}, l'état du signal DI de l'interface MDS-MAU est converti en symbole logique correspondant.

Les temps donnés dans le Tableau 44 et Tableau 45 ne s'appliquent pas à l'émetteur du maître. Pour l'émetteur du maître du bus, la PhPDU de réinitialisation correspondante doit générer sur demande du service RO, conformément aux définitions spécifiées dans les variables PhL "durée de réinitialisation courte du bus" et "durée de réinitialisation longue du bus".

NOTE 4 Les règles de codage pour la PhPDU de réinitialisation s'appliquent uniquement à un couplage MDS dans la MIS.

9.8.5 Couplage des MAU

Lorsque des MAU du même type ont des paires couplées, chaque PhPDU ainsi que tous les états au repos sont transmis sans aucune modification entre deux MAU. La Figure 46, la Figure 47 et la Figure 48 présentent des configurations possibles des appareils de bus lorsque le support câblé à 2 conducteurs est utilisé.



Légende

Anglais	Français
Data Link Layer	Couche de liaison de données
Physical Layer	Couche physique
Outgoing Interface 2-wire	Interface de départ, à 2 conducteurs

Figure 46 – Configuration d'un maître

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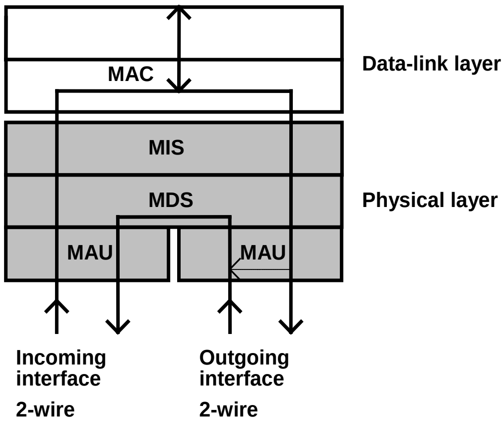
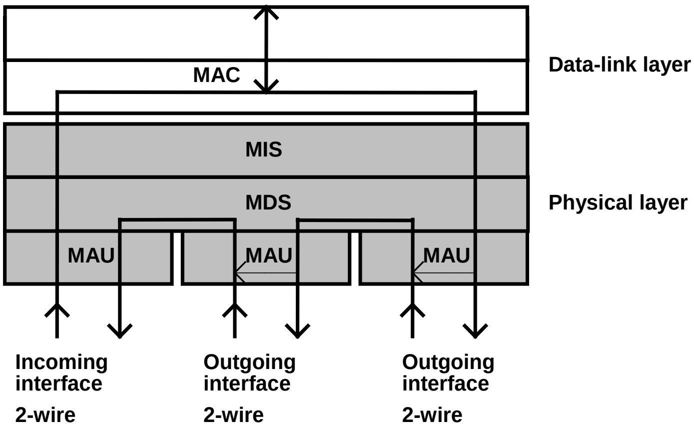


Légende

Anglais	Français
Data Link Layer	Couche de liaison de données
Physical Layer	Couche physique
Incoming Interface 2-wire	Interface d'arrivée, à 2 conducteurs
Outgoing Interface 2-wire	Interface de départ, à 2 conducteurs

Figure 47 – Configuration d'un esclave



Légende

Anglais	Français
Data Link Layer	Couche de liaison de données
Physical Layer	Couche physique
Incoming Interface 2-wire	Interface d'arrivée, à 2 conducteurs
Outgoing Interface 2-wire	Interface de départ, à 2 conducteurs

Figure 48 – Configuration d'un coupleur de bus

Lorsque deux MAU sont directement couplées, des répéteurs transparents au code peuvent être utilisés pour la régénération temporelle.

9.9 Type 12: MDS: Supports câblés

9.9.1 PhPDU

La MDS doit produire la PhPDU présentée à la Figure 49 en ajoutant des délimiteurs et des séquences de repos minimales pour encadrer la séquence série de PhSDU (bits) transférée depuis la DIS par l'intermédiaire de l'interface ETTD-DCE. La séquence de transmission doit

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aller de gauche à droite comme présenté à la Figure 49, c'est-à-dire le SOF en premier lieu, suivi par la séquence de PhSDU et finalement EOF.

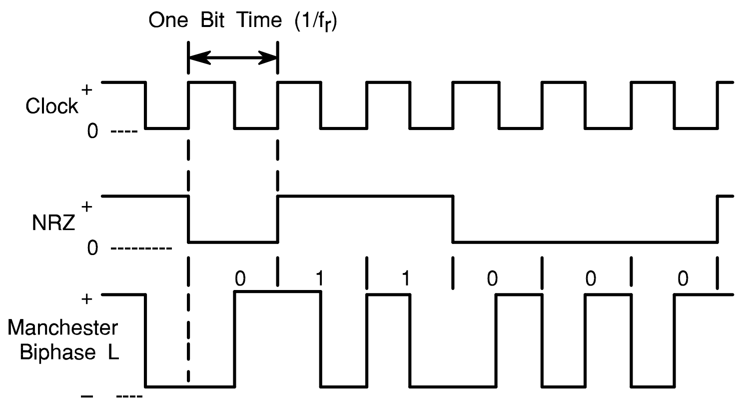
repos	SOF	SEQUENCE DE PhSDU	EOF	repos

Figure 49 – Unité de données de protocole

En revanche, la MDS doit retirer le repos, SOF et EOF d'une PhPDU reçue pour générer une séquence série correspondante de PhSDU. Si une unité de données non binaires est détectée dans la séquence de PhSDU reçue, la MDS doit immédiatement arrêter de transférer les PhSDU à la DIS, la MDS doit rendre compte d'une erreur et doit indiquer la fin de l'activité à la DIS au moment où elle a lieu.

9.9.2 Codage et décodage

Les unités de données doivent être codées par la MDS pour application à la MAU en utilisant le code présenté à la Figure 50 (Manchester Biphase L). Les règles de codage formelles sont données à la Figure 51 et dans le Tableau 46.



Légende

Anglais	Français
One Bit Time	Un temps binaire
Clock	Horloge
Manchester Biphase L	Manchester Biphase L

Figure 50 – Codage et décodage PhSDU

NOTE La Figure 50 est incluse à des fins d'explication et n'implique aucune mise en œuvre spécifique.

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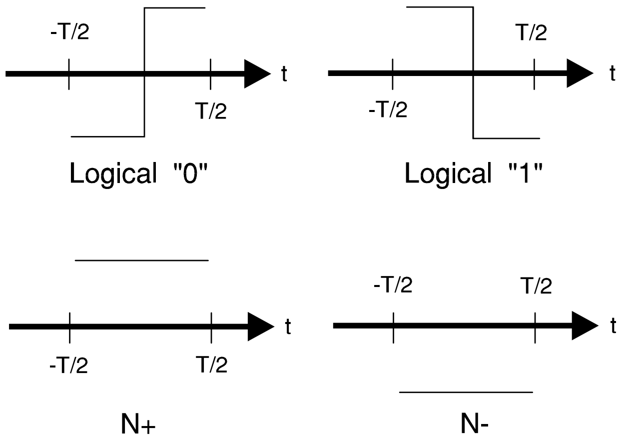

Légende

Anglais	Français
Logical “0”	Niveau logique “0”
Logical “1”	Niveau logique “1”

Figure 51 – Règles de codage Manchester

Tableau 46 – Règles de codage Manchester

Symboles	Codage
1(ONE)	Hi–Lo transition (à mi-bit)
0 (ZERO)	Lo–Hi transition (à mi-bit)
N+ (NON-DATA PLUS)	Hi (Pas de transition)
N– (NON-DATA MINUS)	Lo (Pas de transition)
NOTE On peut voir que les symboles de données (1 et 0, acheminés par des PhSDU) sont codés pour contenir toujours une transition à mi-bit. Les symboles non données (N+ et N–) sont codés de façon à ce qu'il n'y ait jamais de transition à mi-bit.	

Le décodage doit normalement correspondre à l'opposé du codage. A la réception, la MDS doit vérifier que chaque symbole est codé conformément à la Figure 51 et au Tableau 46 et doit détecter les erreurs suivantes:

a) code Manchester invalide;
b) erreurs de glissement d'un demi-bit;
c) défaut d'alignement de EOF (le nombre de bits n'est pas un multiple de 8).

Toute erreur de ce type doit être notifiée comme:

indication PH-DATA (class=END-W-ERROR, data=error).

9.9.3 Détection de polarité

Il n'y a pas de détection automatique de la polarité du signal reçu codé Manchester Biphase L.

9.9.4 SOF

La séquence de symboles suivante, présentée de gauche à droite, dans l'ordre de transmission, doit précéder immédiatement la séquence de PhSDU pour délimiter le début d'une trame:

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0, N+

La MDS ne doit accepter un train de signaux reçus comme une PhPDU qu'après avoir vérifié cette séquence et doit retirer cette séquence avant de transférer la séquence de PhSDU à la DIS.

9.9.5 EOF

La séquence de symboles suivante, présentée de gauche à droite, dans l'ordre de transmission, doit immédiatement suivre la séquence de PhSDU pour délimiter la fin d'une trame:

N–, 0

La MDS doit retirer cette séquence de la PhPDU avant de transférer la séquence de PhSDU à la DIS. La MDS doit rendre compte à l'entité DLL correspondante des éventuelles trames reçues via le support lorsque ces trames ne comprennent pas cette séquence dans les 1535 octets à compter du début de la trame (à partir de la fin de SOF) sous la forme:

Indication PH-DATA (class=END-W-ERROR, data=frame_too_long).

La MDS doit rendre compte à l'entité DLL associée, via la DIS correspondante, des éventuelles trames reçues par l'intermédiaire du support si celles-ci ont un délimiteur de fin qui n'est pas placé à une frontière d'octet, sous la forme:

Indication PH-DATA (class=END-W-ERROR, data=alignment_error).

9.9.6 Repos

Pour synchroniser les temps binaires, une séquence de repos doit être envoyée si aucune PhSDU ou SOF/EOF n'est transmise:

0

Une séquence Repos est toujours alignée sur les bits.

NOTE Une série de 1 dans une PhSDU peut être interprétée comme repos. Les symboles "0" suivants ou EOF réajusteront la détection de bit élémentaire.

9.9.7 Synchronisation

Après activation et réception d'un nombre suffisant de signaux, le récepteur doit détecter et rendre compte des erreurs de glissement d'un demi-bit.

NOTE 1 Cette spécification de synchronisation autorise la perte de 4 bits du préambule.

Après SOF, les erreurs de glissement d'un demi-bit doivent être notifiées sous la forme:

Indication PH-DATA (class=END-W-ERROR, data=half_bit_slip_error).

NOTE 2 Les erreurs de glissement d'un demi-bit peuvent être détectées comme une instabilité excessive (gigue) de bit élémentaire et/ou une variation excessive de la période binaire.

9.9.8 Intervalle (Gap) entre trames

Après émission d'une PhPDU, il doit y avoir une période minimale au cours de laquelle l'émission suivante ne doit pas commencer. Pendant cette même période minimale, après réception d'une PhPDU, l'entité PhL de réception doit ignorer toute signalisation reçue. Une entité MDS doit établir une période minimale post-émission de 92 temps binaires nominaux (96 avec SOF, EOF). La période peut être étendue mais non réduite par la Gestion systèmes.

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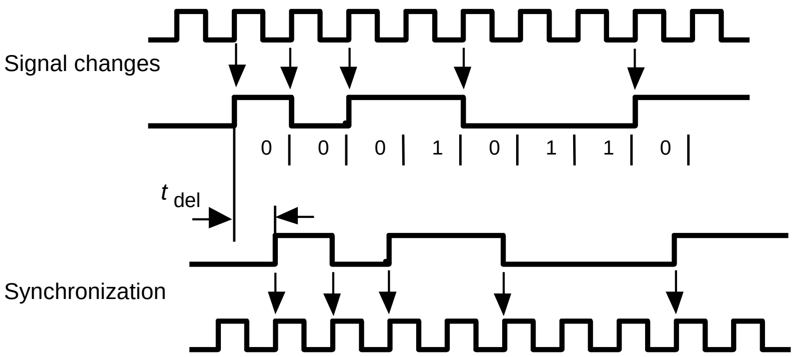
9.10 Type 16: MDS: Supports optiques

9.10.1 Règles de codage des données

Les signaux sur les lignes de transmission doivent être codés NRZI. Les variations des signaux sont uniquement possibles en synchronisation avec l'horloge de transmission. A chaque fois qu'un "0" est transmis, le signal doit modifier son état en synchronisation avec l'horloge de transmission, tandis qu'il doit rester inchangé lorsqu'un "1" est émis.

L'émetteur doit s'assurer, par une méthode appropriée (c'est-à-dire insertion binaire) qu'un nombre suffisant de zéros est présent dans le train binaire transmis. Cela engendre des variations supplémentaires du signal. De cette manière, on crée des conditions qui rendent possible l'extraction d'une horloge de réception à partir du signal reçu. L'horloge de réception récupérée doit également avoir une position de phase fixe par rapport à l'horloge de l'émetteur. L'horloge doit pouvoir être récupérée au moyen d'une boucle numérique à verrouillage de phase (DPLL) qui doit être synchronisée sur la variation du signal reçu transformé en signal électrique. Figure 52 d) donne un exemple de signal codé NRZI. Par conséquent, l'horloge de transmission fournit la configuration de synchronisation du système par l'intermédiaire des changements d'états (transitions) du signal.



Légende

Anglais	Français
Signal changes	Variations des signaux
Synchronization	Synchronisation
a) Transmitting clock	a) Horloge de transmission
b) Transmitted NRZI-coded signal	b) Signal codé NRZI émis
c) Bit sequence	c) Séquence binaire
d) Received NRZI-coded signal	d) Signal codé NRZI reçu
e) Receiving clock	e) Horloge de réception

Figure 52 – Exemple de signal codé en NRZI

9.10.2 Télégrammes et caractères de remplissage

Au niveau physique, il suffit de savoir qu'un télégramme doit commencer et se terminer par la séquence binaire 0111 1110. Cette séquence binaire est également connue sous le nom de délimiteur. En raison de l'insertion binaire, cette séquence binaire ne peut pas se produire à l'intérieur du télégramme.

D'autres zones du télégramme appartiennent à des couches de protocole supérieures et sont discutées ailleurs.

Lorsqu'une unité ne place pas son propre télégramme sur le réseau, deux possibilités se présentent:

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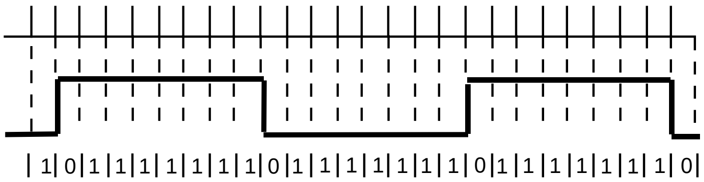
a) le maître doit émettre un signal dit "de remplissage" (bits de remplissage) entre ses propres télégrammes. Il doit être composé d'une séquence de un "0" binaire et de 7 "1" binaires (c'est-à-dire 0111 1111). Ceci génère un signal de remplissage symétrique dont la période est égale à 16 fois la période de l'horloge de transmission, en raison du codage NRZI (voir Figure 53);

b) entre ses propres télégrammes, un esclave doit transmettre, avec l'horloge locale synchronisée, des signaux reçus, régénérés physiquement (mode répéteur).

Pendant la transition d'un télégramme à un signal de remplissage (maître) ou d'un télégramme au mode répéteur (esclave), les variations du signal doivent suivre la configuration de l'impulsion d'horloge en cours.



Légende

Anglais	Français
a) Transmitting clock, symbolic	a) Horloge de transmission symbolique
b) Fill signal	b) Signal de remplissage
c) Bit sequence	c) Séquence binaire

Figure 53 – Signal de remplissage

NOTE En raison de l'insertion binaire et de a), l'esclave situé physiquement en premier sur le réseau est capable, à tout instant, de déduire son horloge locale à partir de son signal reçu. En raison de b), c'est également le cas pour toutes les unités suivantes, et ainsi de suite jusqu'au récepteur du maître. De cette manière, les boucles numériques à verrouillage de phase, qui sont en fin de compte utilisées pour obtenir l'horloge locale, restent verrouillées, empêchant ainsi une perte de temps liée à la synchronisation avant le début du message proprement dit.

9.11 Type 18: MDS: Supports câblés

9.11.1 Vue d'ensemble

La MDS de type 18 doit pouvoir détecter le lancement et l'achèvement ultérieur d'une réception de données; les moyens utilisés pour cela ne relèvent pas du domaine d'application de la présente spécification.

9.11.2 Emission

La transmission de données commence dès réception d'une demande PH-DATA (START-OF-ACTIVITY) provenant de l'utilisateur DL. Cette demande est traduite par la MDS en une affirmation de signal TRANSMIT-ENABLE, avec la valeur spécifiée dans le champ de DATA à transmettre sur le TRANSMIT-SIGNAL.

La MDS doit émettre une confirmation (SUCCESS) PH-DATA et doit recevoir la demande PH-DATA (DATA) suivante avant l'expiration du compteur de temps binaire de débit en bauds de la MDS. La confirmation (SUCCESS) PH-DATA qui en résulte ne se produit qu'après réaction à cette demande. De cette manière, le compteur de temps de débit en bauds de la MDS peut réguler le débit de données.

Sur réception d'une demande PH-DATA (END-OF-ACTIVITY) de la part de l'utilisateur DL, la MDS achève l'émission en cours et conclut par une infirmation du signal TRANSMIT-ENABLE.

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9.11.3 Réception

Sur réception d'une activité de données, la MDS émet une indication PH-DATA (START-OF-ACTIVITY) avec la valeur de DATA reçue. Chaque donnée suivante reçue donne lieu à une indication PH-DATA (DATA) avec la valeur de DATA reçue. Une fois terminée la réception des données, la MDS émet une indication PH-DATA (END-OF-ACTIVITY) à l'utilisateur DL.

9.12 Type 24: MDS: Câble à paire torsadée

9.12.1 Généralités

La sous-couche dépendante du support (MDS) fait partie de l'équipement de transmission de données (DCE). Elle communique des bits codés par le biais de l'interface MDS-MAU spécifiée en 10.8.

9.12.2 Précision d’horloge

Les spécifications temporelles de la signalisation PhL doivent être telles que définies dans le Tableau 47.

Tableau 47 – Caractéristiques temporelles de la MDS

Spécification	Limites / caractéristiques	Commentaires
Débit binaire	10 Mbit/s ± CA	Egalement appelé débit de DL-symbol, données ‘zéro’ ou ‘un’
Temps binaire	100 ns ± CA	Egalement appelé durée de DL-symbol, données ‘zéro’ ou ‘un’
Durée de symbole PhL	50 ns ± CA	Egalement appelé durée de Ph-symbol, voir les règles de codage de données
Précision d’horloge (CA, de l'anglais Clock Accuracy)	± 100 µHz/Hz max.	Tenant compte de la température ainsi que de la stabilité à long et à court termes

9.12.3 Régénération de données

Les signaux à l'interface DLL-PhL doivent être synchronisés sur le débit binaire local, comme présenté dans le Tableau 47. Chaque application PhL doit prévoir un mécanisme de régénération des données qui récupère ou reconstruit les données reçues à partir du support approprié, de manière à satisfaire aux exigences de temporisation du Tableau 47. Lorsque la synchronisation des données a été atteinte par la MDS, l'Indication de PH-LOCK doit être "vrai".

Une partie de la trame des données reçue peut être perdue ou ignorée lors du processus d'obtention de la synchronisation des données. La spécification de temporisation des données présentée dans le Tableau 47 doit être atteinte avant le commencement de l'indicateur de début.

9.12.4 Règles de codage des données

Les DL-symbols présents à l'interface DLL-PhL doivent être codés en Ph-symbols appropriés comme indiqué dans le Tableau 48 et la Figure 54. Les symboles ZERO et ONE doivent être codés en Ph-symbols qui représentent les règles de codage de données Manchester Biphase L, comme indiqué dans le Tableau 48. La forme d'onde de tension du signal (provenant de la MAU) est présentée sous forme idéalisée à la Figure 54 de manière à fournir un exemple des règles de codage de données du Tableau 48.

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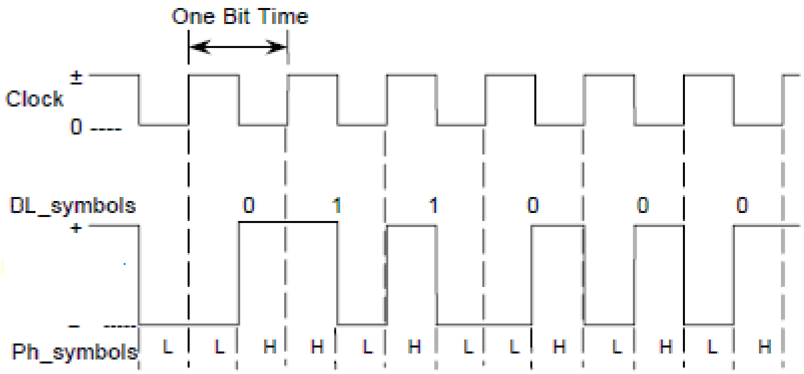
Tableau 48 – Règles de codage des données MDS

Bits de données (nom commun)	Représentation de symbole DL	Codé en symbole Ph	Codé Manchester
données 'zéro'	(ZERO) ou {0}	{L,H}	0
données 'un'	ONE ou {1}	{H,L}	1



Légende

Anglais	Français
One Bit Time	Un temps binaire
Clock	Horloge

Figure 54 – Symboles codés Manchester

10 Interface MDS – MAU

10.1 Généralités

La MAU (unité de liaison au support) est une partie optionnellement séparée d'un élément de communication qui relie le support directement ou par l'intermédiaire de composants passifs. (Voir Figure 1.) Pour des variantes de signalisation électrique, la MAU est l'émetteur-récepteur qui fournit le changement de niveau et la forme d'onde des signaux émis et reçus. L'interface MDS – MAU relie la MAU à la MDS. Les services sont définis comme des signaux physiques afin de faciliter l'éventuelle exposition facultative de cette interface. Les paragraphes ci-après spécifient pour chaque type l'ensemble minimal de services exigés au niveau de l'interface MDS – MAU. Pour les services de gestion, voir l'Article 6.

NOTE Un certain nombre d'interfaces MDS – MAU différentes sont spécifiées, sur la base des pratiques industrielles en la matière.

10.2 Type 1: Interface MDS – MAU: Supports câblés et optiques

10.2.1 Services

Si l'interface MDS – MAU est exposée, elle doit prendre en charge au moins l'ensemble des services exigés indiqués dans le Tableau 49 et spécifiés en 10.2.2.

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Tableau 49 – Ensemble minimal de services à l'interface MDS – MAU

Service	Abréviation	Sens
Exigé:		
Signal de transmission	TxS	Vers la MAU
Signal de réception	RxS	De la MAU
Activation de transmission	TxE	Vers la MAU
Facultatif		
Activation du rebouclage	LbE	Vers la MAU

10.2.2 Spécifications de services

10.2.2.1 Signal de transmission (TxS)

Le service de signal de transmission (TxS) doit transférer à la MAU la séquence de signaux PhPDU codée à travers l'interface MDS – MAU, la séquence doit être transmise sur le support si TxE (activation de l'émission) est mis au niveau logique "1" (niveau haut).

10.2.2.2 Signal de réception (RxS)

Le service de signal de réception (RxS) doit transférer à la MDS la séquence de signaux PhPDU codée ou un silence, à travers l'interface MAU – MDS. Le signal RxS doit renvoyer en écho le signal transmis via TxS en recevant simultanément les émissions en provenance du support.

10.2.2.3 Activation de l'émission (TxE)

Le service TxE (activation de l'émission) doit fournir à la MDS la fonction qui permet d'activer la MAU pour qu'elle émette. TxE doit être mis au niveau "1" logique (niveau haut) au début de l'émission du préambule puis au niveau "0" logique (niveau bas) après que le dernier bit du délimiteur de fin ait été transmis.

Si des supports redondants sont utilisés et si la méthode de mise en œuvre de la redondance est de recevoir sur tous les canaux mais de ne transmettre que sur un seul, le canal (câble) qui est en cours d'utilisation pour la transmission doit être sélectionné en mettant son signal TxE au "1" logique (niveau haut). Tous les canaux qui ne sont pas en cours d'utilisation pour la transmission doivent être désactivés en établissant le signal TxE au "0" logique (niveau bas).

10.2.2.4 Activation du rebouclage (LbE)

Si le service facultatif LbE (activation du rebouclage) présenté dans le Tableau 49 est utilisé, il doit désactiver l'étage de sortie finale du circuit de transmission de la MAU, connecter la sortie de l'étage précédent du circuit de transmission de la MAU au circuit de réception de la MAU et déconnecter le circuit de réception de la MAU du support. L'état du service activation du rebouclage ne doit pas être modifié pendant que la MAU émet ou reçoit.

NOTE Ce service de confirmation n'a qu'une importance locale et permet à un appareil de vérifier par des essais l'intégrité et la fonctionnalité des circuits de la PhL, à l'exception du support.

10.2.3 Caractéristiques des signaux

Les caractéristiques temporelles doivent être compatibles avec celles spécifiées dans les exigences de la présente norme pour la MDS correspondante.

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Si l'interface MDS – MAU est exposée, elle doit fonctionner avec des niveaux de signaux numériques, comme présenté dans le Tableau 50. Les deux côtés de l'interface doivent fonctionner à la même valeur de V_{DD}.

Tableau 50 – Niveaux de signaux pour une interface MDS – MAU exposée

Symbole	Paramètre	Conditions	Limites	Unités	Remarques
V_{OL}	Tension de sortie de low-level maximale	I_{out} = ±100 μA	0,1	V	Voir la Note 1
		I_{out} = +1,6 mA	0,4	V	
V_{OH}	Tension de sortie de high-level minimale	I_{out} = ±100 μA	V_{DD} – 0,1	V	Voir la Note 1
		I_{out} = -0,8 mA	V_{DD} – 0,8	V	Voir la Note 2
V_{IL}	Tension d'entrée de low-level maximale		0,2 V_{DD}	V	
V_{IH}	Tension d'entrée de high-level minimale		0,7 V_{DD}	V	Voir la Note 3

NOTE 1 Donne la capacité d'entraîner deux charges CMOS typiques.

NOTE 2 La compatibilité d'une entrée CMOS avec une sortie TTL nécessite une résistance de polarisation de l'entrée du signal vers V_{DD}.

NOTE 3 La compatibilité d'une sortie CMOS pour 3,0 V ≤ V_{DD}≤ 5,5 V. La compatibilité d'une sortie TTL (4,75 V ≤ V_{DD}≤ 5,25 V) nécessite une résistance de polarisation de l'entrée du signal vers V_{DD}.

10.2.4 Mode de communication

A cette interface, le mode de communication doit permettre une émission et une réception simultanées.

10.2.5 Caractéristiques temporelles

L'interface MDS – MAU doit fonctionner correctement à un débit binaire de PhSDU compris entre 1 kbit/s et 1,1 fois le débit binaire MAU déclaré le plus élevé.

NOTE Les débits binaires disponibles dans une mise en œuvre donnée sont fournis dans la déclaration de conformité de mise en œuvre du protocole (PICS).

10.3 *Vide*

NOTE Dans la présente édition, le Paragraphe 10.3 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

10.4 Type 2: Interface MDS – MAU: Supports câblés et optiques

10.4.1 Interface MDS-MAU: Généralités

10.4.1.1 Conformité

Un nœud peut inclure n'importe quelle (ou plusieurs) variante de PhL mais, pour chaque variante de PhL mise en œuvre, l'interface de support appropriée doit être fournie.

L'interface MDS-MAU peut ne pas être exposée lors de la mise en œuvre d'une quelconque variante de PhL. Cette interface peut être interne au nœud et peut être interne à un appareil à semi-conducteur. Cependant, si une conformité à l'interface MDS-MAU est revendiquée, la mise en œuvre doit satisfaire aux exigences de 10.4.

10.4.1.2 Délai du support à l'interface MDS-MAU

Pour toutes les applications conformes à l'interface MDS-MAU, le délai de réception du support à l'interface MDS-MAU doit être inférieur à 200 ns et le délai de transmission de l'interface MDS-MAU au support doit être inférieur à 200 ns.

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10.4.2 Interface MDS-MAU: support à câble coaxial de 5 Mbit/s en mode tension

10.4.2.1 Définitions des signaux

Le Paragraphe 10.4.2 énumère les signaux définis pour l'interface MDS-MAU à support à câble coaxial de 5 Mbit/s en mode tension, comme présenté dans le Tableau 51.

Tableau 51 – Définitions de l'interface MDS-MAU: support à câble coaxial de 5 Mbit/s en mode tension

TXDATAOUT	TXDATABAR	NETENABLE	RXDATA	RXCARRIER	Symbole Ph
x	x	0	indéfini	0	Pas de transmission MAU_FRAME_REQUEST=faux
0	0	1	indéfini	0	Pas de transmission MAU_FRAME_REQUEST=faux
1	0	1	1	1	H
0	1	1	0	0	L
1	1	1	-	-	Non autorisé, l'émetteur peut être endommagé

10.4.2.2 TxDataOut

TXDATAOUT doit être "vrai" pour représenter le high-level (H) à partir de la MAU et doit être "faux" pour représenter le low-level (L), comme présenté dans le Tableau 51. TXDATAOUT doit être "faux" lorsqu'aucune donnée de symbole Ph n'est à transmettre (MAU_FRAME_REQUEST = false).

10.4.2.3 TxDataBar

TXDATABAR doit être "vrai" pour représenter le low-level (L) à partir de la MAU et doit être "faux" pour représenter le high-level (H), comme présenté dans le Tableau 51. TXDATABAR doit être "faux" lorsqu'aucune donnée de symbole Ph n'est à transmettre (MAU_FRAME_REQUEST = false).

10.4.2.4 NetEnable

NETENABLE doit être "vrai" pour permettre à la MAU d'émettre les données de Ph-symbol TXDATAOUT et TXDATABAR sur le support à câble coaxial. NETENABLE sur "faux" doit empêcher la transmission de données de Ph-symbol TXDATAOUT et TXDATABAR, comme présenté dans le Tableau 51.

10.4.2.5 RxData

RxData doit représenter les Ph-symbols (H ou L) bruts, déformés et non synchronisés, tels que récupérés du support à câble coaxial. Ce signal doit être "vrai" ou "faux" selon les exigences du Tableau 90. Après récupération des données et resynchronisation pour répondre aux exigences de temporisation de la MDS (du Tableau 34), ces Ph-symbols doivent être décodés en M_symbols appropriés de la MDS, comme présenté dans le Tableau 35.

10.4.2.6 RxCarrier

RxCarrier doit être "vrai" lorsque le niveau du signal sur le support à câble coaxial dépasse la tension du seuil de détection de porteuse, comme présenté dans le Tableau 91; dans le cas contraire, il doit être "faux". Ce signal doit être utilisé pour générer l'indication de Ph-CARRIER à l'interface DLL-PhL définie en 5.3.5.

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10.4.3 Support optique 5 Mbit/s d'interface MDS – MAU

10.4.3.1 Définitions des signaux

Le Paragraphe 10.4.3 énumère les signaux définis pour l'interface MDS – MAU à support à fibre optique de 5 Mbit/s, comme présenté dans le Tableau 52.

Tableau 52 – Support à fibre optique 5 Mbit/s d'interface MDS – MAU

TXDATAOUT	NETENABLE	RXDATA	RXCARRIER	Symbole Ph
Sans effet	0	0	0	L (bas) ou ‘lumière inactive’
1	1	1	1	H (haut) ou ‘lumière active’
0	1	0	0	L (bas) ou ‘lumière inactive’

10.4.3.2 TxDataOut

TXDATAOUT doit être "vrai" pour représenter le high-level (H) à partir de la MAU et doit être "faux" pour représenter le low-level (L), comme présenté dans le Tableau 98. Un signal "vrai" doit être représenté sur le support à fibre optique comme ‘lumière active’. Un signal "faux" doit être représenté sur le support à fibre optique comme ‘lumière inactive’. Les exigences de niveau de transmission de la fibre qui définissent ‘lumière active’ (ou puissance couplée, PT on) et ‘lumière inactive’ (ou puissance couplée, PT off) doivent être telles que définies en 19.6.

10.4.3.3 NetEnable

NETENABLE doit être "vrai" pour indiquer que la sous-couche MDS a des Ph-symbol valides à transmettre sur le support à fibre optique. NETENABLE doit permettre à la MAU d'émettre des niveaux de lumière TXDATAOUT sur le support à fibre optique. NETENABLE sur "faux" doit empêcher l'émission de signaux TXDATAOUT, comme présenté dans le Tableau 52.

10.4.3.4 RxData

RXDATA doit représenter les Ph-symbols (H ou L) bruts, déformés et non synchronisés, tels que récupérés du support à fibre optique. Ce signal doit être "vrai" lorsque le niveau de lumière sur le support satisfait aux exigences de ‘lumière active’ définies en 19.6; autrement ce signal doit être "faux". Après récupération des données et resynchronisation pour répondre aux exigences de temporisation de la MDS (du Tableau 34), ces Ph-symbols doivent être décodés en M_symbols appropriés PLS_DATA_INDICATION, comme présenté dans le Tableau 35. RXDATA doit indiquer "faux" si le support est défectueux, manquant ou si l'alimentation est retirée de l'extrémité émission de la fibre.

10.4.3.5 RxCarrier

RXCARRIER doit être "vrai" lorsque le niveau de lumière sur le support satisfait aux exigences de ‘lumière active’ définies en 19.6; autrement ce signal doit être "faux". Ce signal doit être directement utilisé pour générer l'indication PLS_CARRIER_INDICATION à l'interface DLL-PhL. Si l'émetteur-récepteur à fibre optique ne prend pas en charge un mécanisme d'indication de porteuse, ce signal d'interface doit être connecté au signal d'interface RXDATA. RXCARRIER doit indiquer "faux" si le support est défectueux, manquant ou si l'alimentation est retirée de l'extrémité émission de la fibre.

10.4.4 Port d'accès au réseau (NAP) de l'interface MDS – MAU

Les signaux suivants doivent être exigés pour l'interface MDS-MAU du port NAP:

a) /TxPTC doit être "faux" pour représenter le high-level (H) des données de transmission à partir de la MAU, et doit être "vrai" pour représenter le low-level (L);

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b) /RxPTC doit être "faux" pour représenter le high-level (H) des données de réception à partir de la MDS, et doit être "vrai" pour représenter le low-level (L). Ce signal doit être "vrai" si le support NAP est retiré, défectueux, en court-circuit ou si l'émetteur d'origine est désactivé.

10.5 Type 3: Interface MDS – MAU: Supports câblés et optiques

10.5.1 Transmission synchrone

L'interface MDS-MAU spécifiée pour le Type 1 doit être utilisée (voir 10.2).

10.5.2 Transmission asynchrone

On doit utiliser, en lieu et place de l'interface MDS-MAU décrite en 10.2, l'interface DL-Ph pour la transmission asynchrone (voir 5.1 et 5.4.2).

10.6 Type 8: Interface MDS – MAU: Supports câblés et optiques

10.6.1 Aperçu des services

L'interface MDS-MAU met à disposition des services permettant de connecter la MDS à une MAU correspondante. Les services sont définis comme des signaux logiques que la sous-couche MAU convertit directement en signaux physiques (voir le Tableau 53).

Tableau 53 – Services de l'interface MDS-MAU

Service	Mnémonique	Sens
Données sortantes	DO	De la MDS
Données entrantes	DI	De la MAU
Connecteur de bus	BC	De la MAU
Activation du rebouclage	LbE	De la MDS
Sélection de données	DS	De la MDS
Activité du support	MA	De la MDS
NOTE Les services connecteur de bus, activation du rebouclage, sélection de données et activité du support sont uniquement pris en charge par la MAU d'une interface de départ.		

10.6.2 Description des services

10.6.2.1 Données sortantes (DO)

Ce service transmet la PhPDU de la MDS à la MAU.

10.6.2.2 Données entrantes (DI)

Ce service transmet la PhPDU de la MAU à la MDS.

10.6.2.3 Connecteur de bus (BC)

Ce service indique à une MDS si le support de transmission est connecté à la MAU d'une interface de départ. Si le support de transmission n'est pas connecté à la MAU d'une interface de départ, la Gestion systèmes doit, pour cette MAU, déconnecter le circuit de réception du support au moyen du service activation du rebouclage (LbE) et connecter le circuit de transmission au circuit de réception.

NOTE 1 Le service connecteur de bus est uniquement pris en charge par la MAU d'une interface de départ. Il n'est pas lié aux autres services de l'interface MDS-MAU.

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NOTE 2 Il s'agit d'un service de gestion local qui indique si un autre appareil de bus est connecté à l'interface de départ de la MAU, ce qui permet à la Gestion systèmes de fermer ou d'ouvrir l'anneau de transmission au moyen du service d'activation du rebouclage.

NOTE 3 La détection d'un autre appareil de bus connecté est réalisée par un signal qui est conduit par l'intermédiaire d'un pont dans le connecteur du câble de départ (voir la définition du câble).

10.6.2.4 Activation du rebouclage (LbE)

Ce service permet à la Gestion systèmes de désaccoupler le circuit de réception du support de transmission pour une MAU d'interface de départ et de connecter le circuit de transmission au circuit d'entrée.

NOTE 1 Le service activation du rebouclage est uniquement pris en charge par la MAU d'une interface de départ et n'est pas lié aux autres services de l'interface MDS-MAU.

NOTE 2 Il s'agit d'un service de gestion local qui permet à la Gestion systèmes de fermer l'anneau de transmission si aucun autre esclave de bus n'est connecté à la MAU d'une interface de départ.

10.6.2.5 Activité du support (MA)

Ce service émet une PhPDU d'état spécial de la MDS à la MAU si l'anneau actif a été désaccouplé du support et si les circuits de transmission et de réception ont été connectés mais une activité contrôlée doit être générée sur le support.

NOTE 1 Ce service est utilisé par un esclave uniquement.

NOTE 2 Le service activité du support est uniquement pris en charge par la MAU d'une interface de départ et n'a aucune relation temporelle avec les autres services de l'interface MDS-MAU.

10.6.2.6 Sélection de données (DS)

La Gestion systèmes utilise ce service pour émettre sur le support désaccouplé d'une MAU de départ soit une PhPDU de réinitialisation soit, au moyen du service activité du support, certaines PhPDU d'état.

NOTE 1 Ce service est utilisé par un esclave uniquement.

NOTE 2 Le service sélection des données est uniquement pris en charge par la MAU d'une interface de départ et n'est pas lié aux autres services de l'interface MDS-MAU.

10.6.3 Réponse temporelle

La MDS doit pouvoir décoder clairement un bit ayant une instabilité du signal binaire, comme spécifié dans la Figure 55. La variation de l'horloge d'échantillonnage doit s'inscrire dans une plage de ± 0,1 %.

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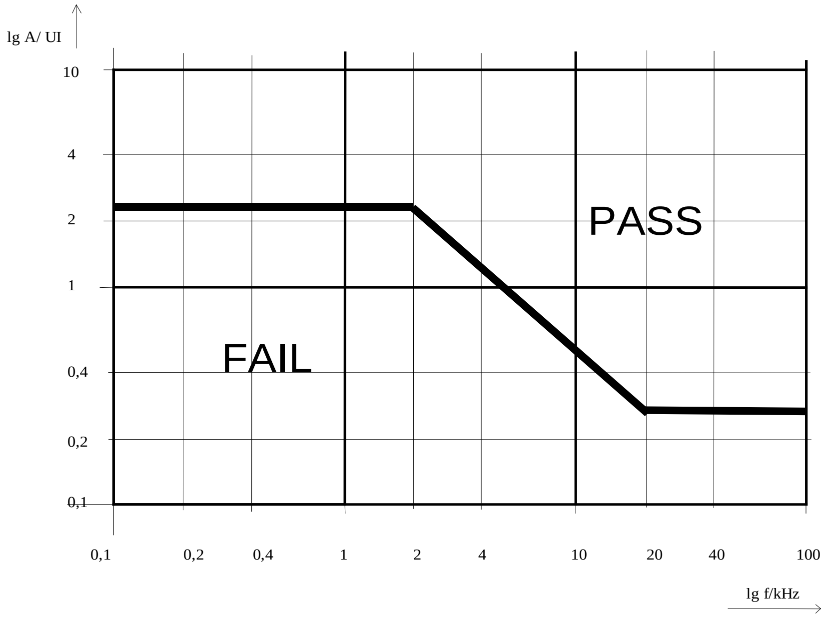

Légende

Anglais	Français
FAIL	ECHEC
PASS	REUSSITE

Figure 55 – Tolérance à l'instabilité (gigue)

10.6.4 Mode de transmission

L'interface MDS-MAU doit permettre une émission et une réception simultanées et indépendantes.

10.7 Type 18: Interface MDS – MAU: Supports câblés

10.7.1 Généralités

La granularité des PhPDU échangées au niveau de l'interface MAU est d'un bit.

10.7.2 Services

Si l'interface MAU est exposée, elle doit prendre en charge au moins l'ensemble des services exigés indiqués dans le Tableau 54 et spécifiés en 10.7.3.

Tableau 54 – Ensemble minimal de services à l'interface MAU

Service	Abréviation	Sens
Signal de transmission	TxS	Vers la MAU
Signal de réception	RxS	De la MAU
Activation de transmission	TxE	Vers la MAU

10.7.3 Spécifications de services

10.7.3.1 Signal de transmission (TxS)

Le service de signal de transmission (TxS) doit transférer la séquence de signaux PhPDU codée à travers l'interface vers la MAU, où la séquence doit être transmise sur le support si TxE (activation de l'émission) est mis au niveau logique "1" (niveau haut).

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10.7.3.2 Signal de réception (RxS)

Le service de signal de réception (RxS) doit transférer la séquence de signaux PhPDU codée ou un silence, à travers l'interface vers la MDS. Le signal RxS doit renvoyer en écho le signal transmis via TxS en recevant simultanément les émissions en provenance du support.

10.7.3.3 Activation de l'émission (TxE)

Le service TxE (activation de l'émission) doit fournir la fonction qui permet d'activer la MAU pour qu'elle émette. TxE doit être mis au niveau "1" logique (niveau haut) au début de l'émission du préambule puis au niveau "0" logique (niveau bas) après que le dernier bit du délimiteur de fin a été transmis.

10.7.4 Caractéristiques des signaux

Si l'interface MAU est exposée, elle doit fonctionner avec des niveaux de signaux numériques, comme présenté dans le Tableau 55. Les deux côtés de l'interface doivent fonctionner à la même valeur de V_{DD}.

Tableau 55 – Niveaux de signaux pour une interface MAU exposée

Symbole	Paramètre	Conditions	Limites	Unités	Remarques
V_{OL}	Tension de sortie de low-level maximale	I_{out} = ±100 µA	0,1	V	Voir la Note 1
		I_{out} = +1,6 mA	0,4	V	
V_{OH}	Tension de sortie de high-level minimale	I_{out} = ±100 µA	V_{DD} – 0,1	V	Voir la Note 1
		I_{out} = –0,8 mA	V_{DD} – 0,8	V	Voir la Note 2
V_{IL}	Tension d'entrée de low-level maximale		0,2 V_{DD}	V	
V_{IH}	Tension d'entrée de high-level minimale		0,7 V_{DD}	V	Voir la Note 3

NOTE 1 Donne la capacité d'entraîner deux charges CMOS typiques.

NOTE 2 La compatibilité d'une entrée CMOS avec une sortie TTL nécessite une résistance de polarisation de l'entrée du signal vers V_{DD}.

NOTE 3 Compatible avec une sortie CMOS pour 3,0 V ≤ V_{DD}≤ 5,5 V. La compatibilité avec une sortie TTL (4,75 V ≤ V_{DD}≤ 5,25 V) nécessite une résistance de polarisation de l'entrée du signal vers V_{DD}.

10.7.5 Mode de communication

A cette interface, le mode de communication doit permettre une émission et une réception simultanées.

10.7.6 Caractéristiques temporelles

L'interface MAU doit fonctionner correctement à un débit binaire de PhSDU compris entre 1 kbit/s et 1,1 fois le débit binaire MAU déclaré le plus élevé. La précision de la fréquence de synchronisation doit être autour de 150 µHz/Hz du taux spécifié.

10.8 Type 24: Interface MDS – MAU: Support câblé à paire torsadée

10.8.1 Aperçu du service

Si l'interface MDS – MAU est exposée, elle doit prendre en charge au moins l'ensemble des services exigés indiqués dans le Tableau 56 et spécifiés en 10.8.2.

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Tableau 56 – Services minimum de l'interface MDS-MAU

Désignation du signal	Mnémonique	Sens
Signal de transmission	TxS	Vers la MAU
Activation de transmission	TxE	Vers la MAU
Signal de réception	RxS	De la MAU

10.8.2 Description des services

10.8.2.1 Signal de transmission (TxS)

Ce service transmet la PhPDU de la MDS à la MAU; la transmission doit être effectuée sur le support si TxE (activation de l'émission) est mis au niveau "1" logique (niveau haut).

10.8.2.2 Activation de l'émission (TxE)

Le service TxE (activation de l'émission) doit fournir à la MDS la fonction qui permet d'activer la MAU pour qu'elle émette. TxE doit être mis au niveau "1" logique (niveau haut) par la MDS, immédiatement avant que l'émission ne commence, et au niveau "0" logique (niveau bas) après que l'émission s'est achevée.

10.8.2.3 Signal de réception (RxS)

Ce service transmet la PhPDU de la MAU à la MDS.

10.8.2.4 Caractéristiques des signaux

Si l'interface MDS – MAU est exposée, elle doit fonctionner avec des niveaux de signaux numériques, comme présenté dans le Tableau 57. Les deux côtés de l'interface doivent fonctionner à la même valeur de V_{DD}.

Tableau 57 – Niveaux de signaux pour une interface MDS-MAU exposée (V_{DD}=5V)

Symbole	Paramètre	Conditions	limites	Unités	Remarques
V_{OL}	Tension de sortie de low-level maximale	Iout = ±100 µA	0,1	V	Voir la Note 1
V_{OH}	Tension de sortie de high-level minimale	Iout = ±100 µA Iout = –0,8 mA	V_{DD}–0,1 V_{DD}–0,8	V	Voir la Note 2
V_{IL}	Tension d'entrée de low-level maximale		0,2V_{DD}	V	
V_{IH}	Tension d'entrée de high-level minimale		0,7V_{DD}	V	Voir la Note 3

NOTE 1 Donne la capacité d'entraîner deux charges CMOS typiques.

NOTE 2 La compatibilité d'une entrée CMOS avec une sortie TTL nécessite une résistance de polarisation de l'entrée du signal vers V_{DD}.

NOTE 3 Compatible avec une sortie CMOS pour 3,0 V ≤ V_{DD} ≤ 5,5 V. La compatibilité avec une sortie TTL

(4,75 V ≤ V_{DD} ≤ 5,25 V) nécessite une résistance de polarisation de l'entrée du signal vers V_{DD}.

10.8.2.5 Caractéristiques temporelles

Les caractéristiques temporelles doivent être compatibles avec celles spécifiées dans les exigences de la présente norme pour la MDS correspondante. L'interface MDS – MAU doit fonctionner correctement à un débit binaire de PhSDU de 10 Mbit/s.

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11 Types 1 et 7: Unité de liaison au support: mode tension, topologie de bus linéaire, support câblé à paire torsadée 150 Ω

11.1 Généralités

NOTE Ces exigences applicables à la MAU ne sont pas spécifiquement destinées à faciliter les options de distribution de l'alimentation par le biais des conducteurs de signaux et à permettre la certification de la sécurité intrinsèque.

Le support réseau est constitué d'un câble à paire torsadée blindé. Indépendamment de la topologie, tous les appareils connectés, sauf éventuellement l'appareil de transmission, présentent une impédance élevée pour éviter une surcharge importante du réseau. Des formes d'onde trapézoïdales sont utilisées pour réduire les émissions électromagnétiques et la distorsion des signaux.

Une topologie de bus linéaire est prise en charge, comme le sont également certaines topologies acycliques à dérivations. Un réseau comporte un câble de ligne principale, disposant de terminaisons à ses extrémités.

11.2 Grandeurs dépendantes du débit binaire

Six débits binaires sont définis pour une MAU (unité de liaison au support) à paire torsadée en mode tension. Une MAU donnée doit prendre en charge au moins un de ces débits binaires.

Le Tableau 58 indique les débits binaires pris en charge et définit les symboles relatifs aux grandeurs dépendantes du débit binaire utilisés tout au long de l'Article 11.

Tableau 58 – Grandeurs dépendantes du débit binaire de réseaux en mode tension

Grandeur		Symbole	Unité	Valeur					
Débit binaire nominal		BR	Mbit/s	0,031 25	1	2,5	5	10	25
Ecart maximal par rapport à BR		ΔBR		0,2 %	0,01 %				
Durée binaire nominale		T_{bit}	µs	32	1,0	0,4	0,2	0,1	0,04
Ecart maximal par rapport à T_{bit}		ΔT_{bit}	–	0,9 µs	0,025 %				
Fréquences de signalisation	Nominale pour une répétition de bit	f_r	MHz	0,031 25	1	2,5	5	10	25
	Nominale minimale = 0,25 f_r	f_{min}	MHz	0,007 8	0,25	0,625	1,25	2,5	6,25
	Nominale maximale = 1,25 f_r	f_{max}	MHz	0,039	1,25	3,125	6,25	12,5	31,25
Nombre maximal d'appareils		N_{max}		32				16	
Distance maximale entre appareils		L_{max}	m	4 000	750	500	400	200	100
Affaiblissement maximal entre appareils		A_{max}	dB	15	17	18			
Distorsion d'affaiblissement maximale entre appareils		AD_{max}	dB	8		10			
Distorsion de désadaptation maximale entre appareils		MD_{max}	dB	0,2			0,4	0,6	
Temps de croissance ou de décroissance de signal maximal		T_{rf}	ns	8 000	200	80	40	20	8
Espacement maximal des coupleurs pour former une grappe		CS_{max}	m	4		2	1	0,5	0,25
Impédance d'entrée minimale d'un appareil		Din_{min}	kΩ	8			4	2	1
Sortie maximale d'émetteur passif		QTO_{max}	mV eff.	1	5	10	20	40	80
Fréquence maximale pour la mesure de QTO_{max}		f_{QTOmax}	MHz	0,1	4 f_r				

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Le débit binaire moyen doit être BR ±ΔBR, moyenné sur une trame ayant une longueur minimale de 16 octets. Le temps binaire instantané doit être T_{bit}±ΔT_{bit}.

11.3 Spécifications du réseau

11.3.1 Composants

Une MAU en mode tension fonctionne sur un réseau constitué des composants suivants:

a) un câble à paire torsadée;

b) des appareils (comportant au moins un élément de communication);

c) des connecteurs;

d) des coupleurs;

e) des terminateurs.

11.3.2 Topologies

Une MAU câblée doit fonctionner sur un réseau de topologie de bus linéaire nominalement acyclique, constitué d'une ligne principale, terminée à chaque extrémité comme spécifié en 11.8.5 et à laquelle des éléments de communication sont connectés par l'intermédiaire de coupleurs. Chaque élément de communication doit être connecté en parallèle au câble de ligne principale.

NOTE Le coupleur et l'élément de communication sont en général intégrés dans un appareil.

Des répéteurs actifs peuvent être utilisés pour constituer des dérivations ou étendre la longueur de la ligne principale au-delà d'un segment unique si cela est autorisé par les règles de configuration du réseau. Les dérivations doivent être considérées comme des segments, et peuvent rendre le bus non linéaire. Les cycles (boucles fermées) ne sont jamais autorisés.

11.3.3 Règles de configuration du réseau

Une MAU qui revendique la conformité à l'Article 11 doit satisfaire aux exigences de l'Article 11 lorsqu'elle est utilisée sur un réseau qui satisfait aux présentes règles.

Règle 1: Un bus de terrain doit être capable d'assurer la communication entre deux et N_{max} appareils, fonctionnant tous au même débit binaire.

NOTE 1 Cette règle n'exclut pas l'utilisation d'un nombre d'appareils supérieur à N_{max} dans un système installé.

Règle 2: Un segment de bus de terrain à pleine charge (comportant le nombre maximal d'appareils connectés) doit avoir une longueur totale de câble, y compris les dérivations, entre deux appareils quelconques, allant jusqu'à L_{max}.

NOTE 2 Cette longueur maximale du câble est une exigence de conformité à l'Article 11, mais n'exclut pas l'utilisation de longueurs supérieures dans un système installé.

Règle 3: Le nombre total de régénérations de forme d'onde par des répéteurs et des coupleurs actifs entre deux appareils quelconques dépend de la mise en œuvre du répéteur concerné.

NOTE 3 Ce nombre total était limité à quatre dans les éditions précédentes de la présente norme.

Règle 4: Le délai maximal de propagation entre deux appareils quelconques ne doit pas dépasser 40 T_{bit}. Pour que le réseau fonctionne efficacement, il convient que cette partie du temps de retournement de tout appareil du réseau, générée par une PhE entre la fin d'une trame reçue et le début d'une trame émise contenant une réponse immédiate associée, ne dépasse pas 30 temps binaires, dont il convient qu'au maximum 2 temps binaires soient dus à la MAU.

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NOTE 4 Sachant qu'il n'est pas obligatoire d'exposer l'interface DLL – PhL ou l'interface MDS – MAU, cette partie du temps de retournement d'un appareil de bus de terrain due à la PhL ou à la MAU n'est pas spécifiée et donc non disponible pour des essais de conformité.

Règle 5: Le bus de terrain doit pouvoir continuer à fonctionner lorsqu'un appareil y est connecté ou déconnecté. Les erreurs de données générées lors de la connexion ou de la déconnexion doivent être détectées.

Règle 6: Pour un bus de terrain qui n'est pas alimenté par l'intermédiaire de conducteurs de signaux, la défaillance unique de tout élément de communication (y compris un court circuit mais à l'exception des bavardages) ne doit pas interférer avec les transactions entre d'autres éléments de communication pendant plus de 1 ms.

Règle 7: Dans des systèmes polarisés, les paires de conducteurs du support doivent être distinctement repérées de manière à identifier de manière unique chaque conducteur individuel. Une polarisation homogène doit être maintenue en tout point de raccordement.

Règle 8: La dégradation des caractéristiques électriques du signal, entre deux appareils quelconques, due à l'affaiblissement, à la distorsion d'affaiblissement et à la distorsion de désadaptation doit être limitée aux valeurs indiquées ci-dessous.

a) Affaiblissement du signal: La configuration du bus (la longueur de ligne principale, le nombre d'appareils, et les éventuels appareils d'adaptation) doit être telle que l'affaiblissement entre deux appareils quelconques, à une fréquence f_r, ne doit pas dépasser A_{max};

b) Distorsion d'affaiblissement: La configuration du bus (les longueurs de la ligne principale et des lignes secondaires ainsi que le nombre d'appareils) doit être telle qu'entre deux appareils quelconques:

   $0 \leq$ [Affaiblissement (f_{max}) – Affaiblissement (f_{min})] $\leq AD_{max}$

   L'affaiblissement doit être monotonique, non décroissant, pour toutes les fréquences de f_{min} à f_{max};

c) Distorsion de désadaptation: La désadaptation (due à un effet quelconque) sur le bus, en tout point sur la ligne principale et dans la bande de fréquence f_{min} à f_{max}, doit être:

   $|Z - Z_{fr}| / |Z + Z_{fr}| \leq MD_{max}$

   où Z_{fr} est l'impédance caractéristique du câble de ligne principale à la fréquence f_r et Z est la combinaison parallèle de Z_{fr} et de l'impédance de charge au niveau du coupleur.

   NOTE 5 Cette règle permet de réduire les restrictions, en termes de longueurs de la ligne principale et des lignes secondaires ainsi qu'en termes de nombre d'appareils, etc. en ne spécifiant que des limites de transmission imposées par des combinaisons de ces facteurs. Il est possible d'utiliser différentes combinaisons en fonction des besoins de l'application.

   NOTE 6 En général, la cause d'une désadaptation importante est la concentration de plusieurs coupleurs sur une courte longueur de ligne principale.

   Si la distance entre deux coupleurs consécutifs est inférieure à CS_{max}, le temps de propagation entre ces deux coupleurs est inférieur à T_{rf} et la concentration apparaît comme un seul élément désadapté, induisant des réflexions importantes des transitions de signaux.

Une concentration de coupleurs dont la distance entre deux coupleurs consécutifs est inférieure à CS_{max} est définie comme une grappe. Afin de satisfaire à la règle 8c lorsque des appareils ayant une impédance d'entrée de valeur minimale Din_{min} et des lignes secondaires de longueur zéro sont utilisés, il est recommandé qu'une grappe ne comprenne pas plus de 4 coupleurs.

L'utilisation d'appareils ayant une impédance d'entrée notablement plus élevée que la valeur minimale Din_{min} permet d'utiliser des grappes constituées d'un plus grand nombre de coupleurs. L'utilisation de lignes secondaires de longueur non égale à zéro pourrait exiger que les grappes soient constituées de moins de 4 coupleurs.

NOTE 7 Il est possible de réduire la désadaptation due à une grappe de la manière suivante:

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– en utilisant des coupleurs multivoies actifs,

– en insérant des appareils d'adaptation (atténuateurs passifs) de chaque côté de la grappe tout en se conformant à la Règle 8.

Règle 9: Les règles suivantes doivent s'appliquer aux systèmes mis en œuvre avec des supports redondants:

a) chaque canal (câble) doit satisfaire aux règles de configuration du réseau;

b) il ne doit pas y avoir de segment non redondant entre deux segments redondants;

c) les répéteurs doivent également être redondants;

d) si les appareils du système sont configurés (par la Gestion systèmes) pour émettre sur plusieurs canaux simultanément, la différence de délai de propagation entre deux appareils quelconques sur deux canaux quelconques ne doit pas dépasser cinq temps binaires;

   Cette période peut être étendue mais non réduite par la Gestion systèmes, comme indiqué dans le Tableau 7 (voir 6.2.2.2 et 9.2.9).

e) les numéros de canaux et leur association aux supports de transmission physiques doivent être maintenus de manière cohérente sur l'ensemble des bus de terrain, c'est-à-dire que les canaux 1, 2, 3... en provenance de la Gestion systèmes doivent toujours être connectés aux canaux physiques 1, 2, 3...;

11.3.4 Règles de distribution de l'alimentation pour la configuration du réseau

Le blindage du câble ne doit pas être utilisé comme conducteur de l'alimentation.

11.4 Spécification du circuit de transmission de la MAU

11.4.1 Récapitulatif

Les Tableau 59 à Tableau 61 résument les exigences applicables à la MAU.

Tableau 59 – Récapitulatif de la spécification du niveau de transmission de la MAU

Caractéristiques du niveau de transmission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 56)	**Limites**
Niveau de sortie (crête à crête, voir la Figure 57) Avec charge d'essai (0,5 de Z_o nominale du câble de ligne principale à la fréquence f_r)	5,5 V à 9,0 V 75 Ω± 1 %
Différence d'amplitude positive et négative maximale (biais de la signalisation) telle qu'illustrée à la Figure 58	± 0,45 V
Niveau de sortie, un terminateur retiré (crête à crête) avec charge d'essai (impédance nominale du câble de ligne principale à f_r)	5,5 V à 11,0 V 150 Ω± 1 %
Niveau maximal de sortie; circuit ouvert (crête à crête)	5,5 V à 30,0 V
Distorsion maximale du signal de sortie; c'est-à-dire surtension, suroscillation et statisme (voir la Figure 57)	±10 %
Sortie d'émetteur passif, c'est-à-dire bruit de l'émetteur (mesuré sur la bande de fréquence de 1 kHz à f_{QTOmax})	≤ QTO_{max} (eff)

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Tableau 60 – Récapitulatif de la spécification de la synchronisation de l'émission de la MAU pour un fonctionnement à 31,25 kbit/s

Caractéristiques de synchronisation de l'émission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 56)	Limites
Débit binaire de transmission	BR ±ΔBR
Temps binaire instantané	$T_{bit} \pm \Delta T_{bit}$
Temps de croissance et de décroissance (10 % à 90 % du signal crête à crête, voir la Figure 57)	≤ 25 % T_{bit}
Taux de dérive (en tout point de 10 % à 90 % du signal crête à crête)	≤ 0,2 V/µs
Instabilité de bit élémentaire maximale émise (écart du point de passage par zéro, (voir la Figure 58)	± 2,5 % T_{bit}
Délai d'activation/désactivation de transmission (c'est-à-dire durée pendant laquelle la forme d'onde de sortie peut ne pas satisfaire aux exigences de transmission)	≤ 2,0 T_{bit}

Tableau 61 – Récapitulatif de la spécification de la synchronisation de l'émission de la MAU pour un fonctionnement ≥ 1 Mbit/s

Caractéristiques de synchronisation de l'émission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 56)	Limites
Débit binaire de transmission	BR ±ΔBR
Temps binaire instantané	$T_{bit} \pm \Delta T_{bit}$
Temps de croissance et de décroissance (10 % à 90 % du signal crête à crête, voir la Figure 57)	≤ 20 % T_{bit}
Taux de dérive (en tout point de 10 % à 90 % du signal crête à crête)	≤ 100 V/µs × ($f_{r/MHz}$)
Instabilité de bit élémentaire maximale émise (écart du point de passage par zéro, (voir la Figure 58)	± 2,5 % T_{bit}
Délai d'activation/désactivation de transmission (c'est-à-dire durée pendant laquelle la forme d'onde de sortie peut ne pas satisfaire aux exigences de transmission)	≤ 2,0 T_{bit}

11.4.2 Configuration d'essai de la MAU

La Figure 56 illustre la configuration qui doit être utilisée pour les essais de MAU:

- Tension de signal en mode différentiel: $V_d = V_a – V_b$
- Résistance de la charge d'essai R = 75 Ω (0,5 impédance nominale du câble de ligne principale à f_r) et C = 0,15 µF, sauf spécification contraire dans une exigence particulière.
- Borne "+" des données raccordée à la borne "+" de l'alimentation et borne "-" des données raccordée à la borne "-" de l'alimentation.

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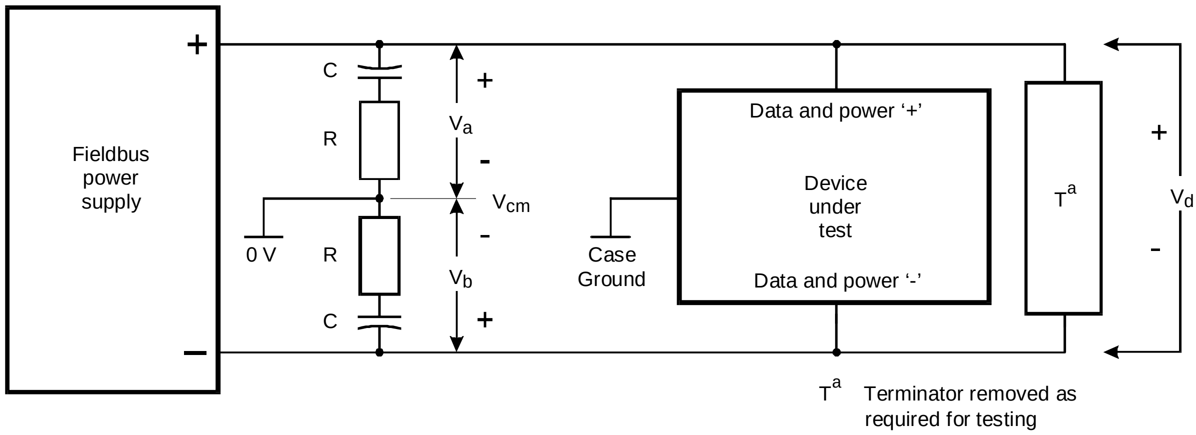


Légende

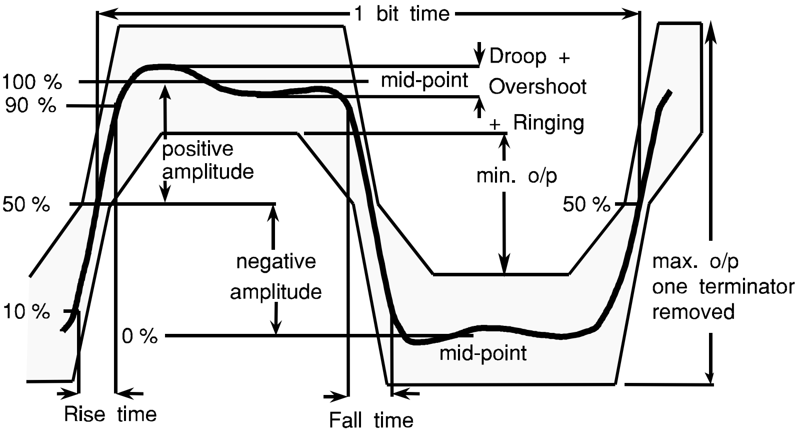
Anglais	Français
Fieldbus power supply	Alimentation du bus de terrain
Case ground	Masse du boîtier
Data and power “+”	Données et alim “+”
Device under test	Appareil en essai
Data and power “-”	Données et alim “-”
Terminator removed as required for testing	Terminateur retiré selon les exigences d'essai

Figure 56 – Configuration d'essai du circuit de transmission

11.4.3 Exigences de niveau de sortie de la MAU

La Figure 57 décrit la forme de sortie du signal compte tenu des exigences de niveau de sortie en tension de la paire torsadée.

NOTE La Figure 57 présente un exemple de la composante alternative d'un cycle de forme d'onde de bus de terrain, illustrant certains éléments-clés de la spécification du circuit de transmission. Seules les tensions des signaux sont indiquées; ce schéma ne tient aucunement compte des tensions d'alimentation.



Légende

Anglais	Français
1 bit time	1 temps binaire
Positive amplitude	Amplitude positive
Negative amplitude	Amplitude négative
Rise time	Temps de croissance
Fall time	Temps de décroissance

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Anglais	Français
Mid-point	Point médian
Droop + Overshoot Ringing	Statisme + suroscillation de dépassement
Min. o/p	Min. o/p
Max. o/p one terminator removed	Max. o/p un terminateur retiré

Figure 57 – Forme d'onde de sortie

Le circuit de transmission de la MAU doit être conforme aux exigences de niveau de sortie suivantes, toutes les amplitudes étant mesurées au point médian estimé entre toute crête ou creux en haut et en bas de la forme d'onde ("point médian" dans la Figure 57):

a) la tension de sortie sur la charge d'essai après élévation/abaissement par le transformateur (le cas échéant), doit être comprise entre 5,5 V et 9,0 V crête à crête avec une résistance de charge de 75 Ω± 1 % ("min. o/p" dans la Figure 57);

b) la tension de sortie au niveau de la ligne principale ou aux bornes de transmission, avec une résistance de charge de 150 Ω± 1 % (c'est-à-dire l'un des terminateurs de la ligne principale étant retiré) doit être comprise entre 5,5 V et 11,0 V crête à crête ("max. o/p un terminateur retiré" dans la Figure 57);

c) la tension de sortie au niveau de la ligne principale ou aux bornes de transmission, avec toute charge comprenant un circuit ouvert, doit être comprise entre 5,5 V et 30,0 V crête à crête. Aux fins de l'essai, un circuit ouvert doit être défini comme étant une charge ayant une résistance de 100 kΩ en parallèle avec une capacité de 15 pF;

d) au cours d'une émission, un appareil donné ne doit pas subir de défaillance permanente lorsqu'une résistance de charge de ≤1 Ω est appliquée pendant 1 s;

e) la différence entre amplitude positive et amplitude négative, mesurée comme présenté dans la Figure 57, ne doit pas dépasser ±0,45 V crête;

f) le bruit en sortie d'une MAU en réception ou non alimentée ne doit pas dépasser QTO_{max} eff., mesuré de manière différentielle sur la bande de fréquence de 1 kHz à f_{QTOmax}, en référence à la ligne principale;

g) la tension différentielle sur la charge d'essai doit donner une modification monotonique de la tension, entre 10 % et 90 % de la valeur crête à crête. Par la suite, la tension du signal ne doit pas varier de plus de ±10 % de la valeur crête à crête jusqu'à ce que la transition suivante ait lieu. Cette variation admissible doit inclure toutes les formes de distorsion de signal de sortie, c'est-à-dire la surtension, la suroscillation et le statisme.

11.4.4 Exigences de synchronisation des sorties de la MAU

11.4.4.1 Exigences communes de synchronisation des sorties pour tous les débits de données

Le circuit de transmission d'une MAU doit être conforme aux exigences suivantes de synchronisation des sorties:

a) l'instabilité de bit élémentaire émise ne doit pas dépasser ΔT_{bit} par rapport au point de passage par zéro idéal, mesuré en fonction du point de passage par zéro précédent (voir Figure 58);

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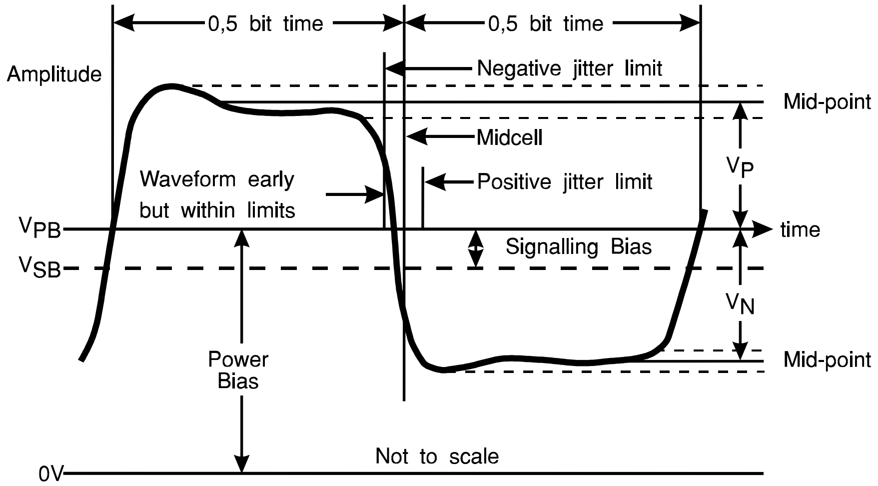

Légende

Anglais	Français
0,5 bit time	0,5 temps binaire
Amplitude	Amplitude
Negative Jitter Limit	Limite d'instabilité négative
Mid-point	Point médian
Waveform early but within limits	Forme d'onde précoce mais dans les limites
Mid-cell	à mi-cellule (bit élémentaire)
Positive Jitter Limit	Limite d'instabilité positive
Signalling Bias	Biais de la signalisation
Time	Temps
Power Bias	Biais de l'alimentation
Mid-point	Point médian
Not to scale	Non à l'échelle

Figure 58 – Instabilité de bit élémentaire émis et reçu (écart du point de passage par zéro)

b) le circuit de transmission doit s'activer, ce qui signifie que le signal doit monter d'un niveau inférieur au bruit de sortie maximal du circuit de transmission, comme spécifié en 11.4.3 f), jusqu'au niveau de pleine puissance, en moins de 2,0 T_{bit}. La forme d'onde correspondant au troisième temps binaire et au-delà, doit être telle que spécifiée dans la Figure 57;

c) le circuit de transmission doit se désactiver, ce qui signifie que le signal doit tomber depuis le niveau de pleine puissance jusqu'à un niveau inférieur au bruit de sortie maximal du circuit de transmission, comme spécifié en 11.4.3 f), en moins de 2,0 T_{bit}. La durée nécessaire pour que le circuit de transmission revienne à son impédance d'état "non actif" ne doit pas dépasser 4,0 T_{bit}. Aux fins des essais, les exigences doivent être satisfaites dans la configuration d'essai du circuit de transmission de la Figure 56, avec la capacité équivalente d'une longueur de câble maximale entre les bornes de l'appareil en essai.

NOTE Cette exigence permet de s'assurer que la capacité de la ligne a été pleinement déchargée lors de la transition du circuit de transmission de l'état actif à l'état passif.

11.4.4.2 Exigences supplémentaires de synchronisation des sorties pour un fonctionnement à 31,25 kbit/s

Le circuit de transmission de la MAU doit être conforme aux exigences supplémentaires suivantes de synchronisation des sorties:

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a) les temps de croissance et de décroissance, mesurés de 10 % à 90 % de l'amplitude du signal crête à crête, ne doivent pas dépasser 0,25 T_{bit} (voir la Figure 57);

b) le taux de dérive, mesuré en tout point dans une plage de 10 % à 90 % de l'amplitude du signal crête à crête, ne doit pas dépasser 0,2 V/µs (voir la Figure 57).

NOTE Les exigences a) et b) génèrent une forme d'onde trapézoïdale à la sortie du circuit de transmission. L'exigence b) limite le niveau des émissions de perturbation qui peuvent être couplées aux circuits adjacents, etc. L'exigence b) est calculée à partir de la formule suivante:

taux de dérive max. = 2 × taux de dérive min. = $2 \times 0{,}8\ V_o / 0{,}25\ T_{bit} = 6{,}4 \times V_o / T_{bit}$,
où V_o est la tension de sortie maximale crête à crête (9,0 V) avec une charge normalisée.

11.4.4.3 Exigences supplémentaires de synchronisation des sorties pour un fonctionnement ≥ 1 Mbit/s

Le circuit de transmission de la MAU doit être conforme aux exigences supplémentaires suivantes de synchronisation des sorties:

a) les temps de croissance et de décroissance, mesurés de 10 % à 90 % de l'amplitude du signal crête à crête, ne doivent pas dépasser 0,2 T_{bit} (voir la Figure 57);

b) le taux de dérive, mesuré en tout point dans une plage de 10 % à 90 % de l'amplitude du signal crête à crête, ne doit pas dépasser 100 V/µs × ($f_{r/MHz}$) (voir la Figure 57).

NOTE Les exigences a) et b) génèrent une forme d'onde trapézoïdale à la sortie du circuit de transmission. L'exigence b) limite le niveau des émissions de perturbation qui peuvent être couplées aux circuits adjacents, etc. L'exigence b) est calculée à partir de la formule suivante:

taux de dérive max. = 36 × taux de dérive min. = $3 \times 0{,}8\ V_o / 0{,}2\ T_{bit} = 12 \times V_o / T_{bit}$,
où V_o est la tension de sortie maximale crête à crête (9,0 V) avec une charge normalisée.

11.4.5 Polarité du signal

Pour un appareil alimenté par le bus, la borne “+” des données, doit être connectée à la borne “+” de l'alimentation et la borne “–” des données doit être connectée à la borne “–” de l'alimentation. Voir la Figure 56.

Lorsque l'émission est activée, une transition du haut vers le bas du signal codé Manchester doit entraîner une transition du haut vers le bas de la tension V_d sur le bus. Une transition du bas vers le haut du signal codé Manchester doit entraîner une transition du bas vers le haut de la tension V_d sur le bus. La polarité du signal est définie dans la Figure 59.

Pendant la réception, une transition du haut vers le bas de la tension V_d sur le bus, doit entraîner une transition du haut vers le bas du signal codé Manchester. Une transition du bas vers le haut de la tension V_d sur le bus doit entraîner une transition du bas vers le haut du signal codé Manchester.

NOTE 1 Le codage Manchester est défini en 9.2.2.

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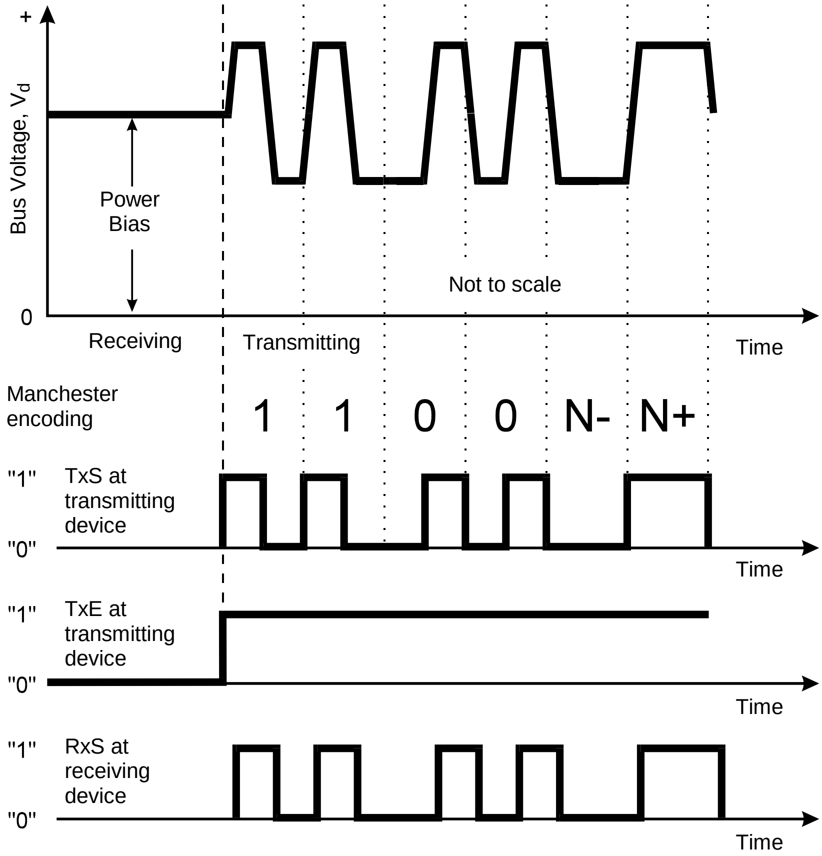

Légende

Anglais	Français
Bus voltage, Vd	Tension de bus, Vd
Power bias	Biais de l'alimentation
Receiving	Réception
Transmitting	Emission
Not to scale	Non à l'échelle
Time	Temps
Manchester encoding	codage Manchester
TxS at transmitting device	TxS au niveau de l'appareil de transmission
TxE at transmitting device	TxE au niveau de l'appareil de transmission
RxS at receiving device	RxS au niveau de l'appareil de réception

Figure 59 – Polarité du signal

NOTE 2 La forme d'onde de la Figure 59 donne un exemple des symboles “1”, “0”, “N+” et “N-”. Cette forme d'onde ne représente pas une PhPDU réelle. Voir 9.2.2 pour les règles de codage.

NOTE 3 Les formes d'onde TxS et RxS de la Figure 59 sont indéterminées au cours de la période de temps marquée "réception".

NOTE 4 Les signaux à l'interface MDS-MAU sont définis à l'Article 10. Les signaux TxS, TxE et RxS de la Figure 59 sont uniquement accessibles si l'interface MDS-MAU est exposée.

11.5 Spécification du circuit de réception de la MAU

11.5.1 Récapitulatif

Le Tableau 62 résume la spécification.

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Tableau 62 – Récapitulatif de la spécification du circuit de réception de la MAU

Caractéristiques du circuit de réception (valeurs en référence à la ligne principale)	Limites
Impédance d'entrée, mesurée sur la gamme de fréquences f_{min} à f_{max}	≥8 kΩ
Sensibilité; signal min. crête à crête dont l'acceptation est exigée (voir la Figure 60)	700 mV
Suppression du bruit; bruit max. crête à crête dont le rejet est exigé (voir la Figure 60)	280 mV
Instabilité de bit élémentaire maximale reçue (écart du point de passage par zéro, (voir la Figure 57)	±0,10 T_{bit}

11.5.2 Impédance d'entrée

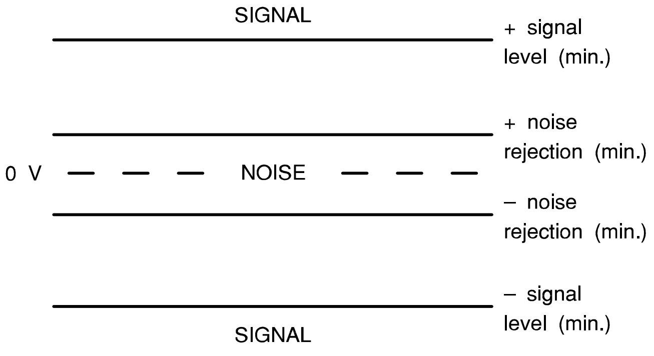
L'impédance d'entrée différentielle du circuit de réception d'une MAU ne doit pas être inférieure à Din_{min} sur la gamme de fréquences f_{min} à f_{max}. Cette exigence doit être satisfaite à l'état hors tension et sous tension (sans émission) ainsi que pendant la transition entre ces états. Cette impédance doit être mesurée aux bornes de l'élément de communication en utilisant une onde sinusoïdale d'une amplitude de signal supérieure au seuil de sensibilité du récepteur et inférieure à 9,0 V crête à crête.

NOTE L'exigence d'une impédance d'entrée ≥Din_{min} pendant la mise sous tension et hors tension peut être satisfaite par désactivation automatique de l'émetteur au cours de ces périodes.

11.5.3 Sensibilité du récepteur et suppression du bruit

Un circuit de réception de MAU doit être capable de recevoir un signal d'entrée d'une amplitude d'au moins 700 mV crête à crête, y compris la surtension et l'oscillation (voir "niveau du signal" ainsi que "amplitude positive" et "amplitude négative" dans la Figure 60).

Le circuit de réception de MAU ne doit pas répondre à un signal d'entrée d'amplitude crête à crête non supérieur à 280 mV (voir "suppression du bruit" dans la Figure 60).



Légende

Anglais	Français
SIGNAL	Signal
signal level (min.)	Niveau du signal (min.)
NOISE	Bruit
noise rejection (min.)	suppression du bruit (min.)

Figure 60 – Sensibilité du récepteur et suppression du bruit

11.5.4 Instabilité de bit élémentaire reçu

Le circuit de réception doit accepter un signal codé Manchester émis conformément à 11.2 et à 11.4. En outre, le récepteur doit fonctionner correctement à des signaux ayant des

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variations temporelles, entre deux points adjacents quelconques de transition des signaux (passage par zéro) d'au maximum ±0,10 T_{bit}. Voir la Figure 58.

NOTE 1 Cette spécification n'exclut pas l'utilisation de récepteurs dont les performances sont supérieures à la présente spécification.

NOTE 2 En fonction de la configuration du symbole, la durée nominale entre passages par zéro peut être de 0,5 T_{bit} ou 1,0 T_{bit}.

NOTE 3 Il n'y a aucune exigence quant au rejet d'un signal donné ayant une valeur de variation temporelle spécifiée. Le récepteur rend compte d'une erreur lorsque l'instabilité du bit élémentaire reçu dépasse l'aptitude du récepteur à décoder la signalisation de manière fiable.

11.5.5 Susceptibilité au brouillage et taux d'erreurs

Lorsqu'un bus de terrain fonctionne dans divers environnements de bruit normalisés, il convient que la probabilité qu'une unité de données utilisateur de couche Application contienne une erreur non détectée, du fait du fonctionnement des entités physiques et DLL d'acheminement, soit inférieure à 1 sur 10^{12} (1 erreur en 20 années à 1 600 messages/s).

Un élément de communication est considéré conforme à cette exigence théorique lorsqu'il satisfait aux exigences suivantes de susceptibilité au brouillage. Ces exigences sont spécifiées sur la base d'un taux d'erreur de trame détecté obtenu en utilisant un rapport d'erreurs détectées/non détectées de 10^6.

NOTE 1 Il convient que cela soit facilement réalisable au moyen d'une séquence de contrôle de trame de 16 bits au niveau de la DLL.

Un élément de communication qui inclut une MAU, utilisant des trames contenant 64 bits de données utilisateur aléatoires, à un débit de trame maximal et avec des signaux dune amplitude de 1,4 V crête à crête, ne doit pas produire plus de trois erreurs de trame détectées sur 3×10^6 trames pendant son fonctionnement en présence d'une tension en mode commun ou de bruit gaussien comme décrit ci-après:

a) un signal sinusoïdal en mode commun à toute fréquence de 63 Hz à 2 f_r, d'une amplitude de 4 V eff. et de 47 Hz à 63 Hz avec une amplitude de 250 V eff.;
b) un signal c.c. en mode commun de ±10 V;
c) un bruit blanc gaussien différentiel additionnel dans la bande de fréquence de 1 kHz à 4 f_r, avec une densité de bruit de 30 $\mu V/\sqrt{Hz}$ eff.

NOTE 2 Les valeurs spécifiées pour la tension en mode commun et le bruit gaussien correspondent à des essais de conformité de circuit de réception avec des charges symétriques et ne sont pas représentatives d'une quelconque pratique d'installation de système.

Un élément de communication qui inclut une MAU, utilisant des trames contenant 64 bits de données utilisateur aléatoires, à une moyenne de 1 600 messages/s, avec des signaux d'une amplitude de 1,4 V crête à crête, ne doit pas produire plus de six erreurs de trame détectées sur 100 000 trames, lorsqu'il est utilisé dans des environnements de perturbations électromagnétiques ou électriques comme décrit ci-après:

1) champ électromagnétique de 10 V/m, comme spécifié dans la CEI 61000-4-3 au niveau de sévérité 3;
2) transitoires électriques rapides, comme spécifié dans la CEI 61000-4-4 au niveau de sévérité 3.

Le taux d'erreur spécifié ci-dessus doit également être réalisé après, mais non pendant le fonctionnement dans les environnements de bruit suivants:

i) décharge électrostatique de 8 kV sur une structure métallique exposée, comme spécifié dans la CEI 61000-4-2, au niveau de sévérité 3. Si l'appareil subit une perte temporaire de fonctions ou de performances suite à cet essai, il doit récupérer de cette perte éventuelle sans intervention de l'opérateur, dans les 3 s qui suivent la fin de l'essai;

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ii) essais de perturbation à haute fréquence, comme spécifié dans la CEI 60255-22-1:1988, classe III de tension d'essai (2,5 kV et 1 kV de valeurs crêtes de la première demi-alternance, respectivement en mode longitudinal et transversal). Si l'appareil subit une perte temporaire de fonctions ou de performances du fait de cet essai, il doit récupérer de cette perte éventuelle sans intervention de l'opérateur, dans les 3 s qui suivent la fin de l'essai.

11.6 Inhibition du bavardage

La MAU doit comporter une capacité d'interruption automatique pour empêcher les signaux émis d'atteindre le support. Le matériel dans la MAU (sans message extérieur autre que la détection des signaux de sortie ou de fuite par la fonction de transmission) doit fournir une fenêtre d'une durée comprise entre 5 000 T_{bit} et 15 000 T_{bit} au cours de laquelle une trame normale peut être émise. Si la longueur de trame dépasse cette durée, la fonction d'inhibition du bavardage doit empêcher d'autres signaux en sortie d'atteindre le support et doit désactiver l'écho sur la ligne RxS (voir 10.2.2.2) pour indiquer à la MDS la détection de bavardage.

Pour un débit binaire de 31,25 kbit/s, la MAU doit réinitialiser la fonction d'interruption automatique après une période de 3 s ± 50 %.

NOTE 1 Ceci inhibe le trafic sur le bus pendant au maximum 8 % (≈ 1/12,5) du temps disponible.

Pour un débit binaire de 1 Mbit/s ou plus, la MAU doit réinitialiser la fonction d'interruption automatique après une période de 500 000 T_{bit}± 50 %.

NOTE 2 Ceci inhibe le trafic sur le bus pendant au maximum 3 % (≈ 1/32) du temps disponible.

11.7 Distribution de l'alimentation

11.7.1 Vue d'ensemble

Les MAU en mode tension fonctionnant à un débit binaire de ≤ 2,5 Mbit/s peuvent, au choix, recevoir leur alimentation par l'intermédiaire de conducteurs de signaux ou être alimentées séparément. Les MAU en mode tension fonctionnant à un débit binaire de > 2,5 Mbit/s sont alimentées séparément. Un appareil à alimentation séparée peut être connecté à un bus de terrain alimenté.

Pour faciliter le renvoi aux textes correspondants, les exigences de 11.7 pour les appareils alimentés par le réseau et les alimentations du réseau sont respectivement résumées dans le Tableau 63 et dans le Tableau 64.

Tableau 63 – Caractéristiques des appareils alimentés par le réseau

Caractéristiques des appareils alimentés par le réseau	Limites		
	31,25 kbit/s	1 Mbit/s	> 1 Mbit/s
Taux de variation maximal du courant passif (pas de transmission);	1 mA/µs	0,05 mA/µs	0,1 mA/µs
Tension de fonctionnement	9,0 V à 32,0 V c.c.		
Tension de tenue minimale, quelle que soit la polarité, sans dommages	35 V		

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Tableau 64 – Exigences d'alimentation réseau

Exigences d'alimentation réseau	Limites
Tension de sortie	≤ 32 V c.c.
Ondulation de sortie et bruit	Voir la Figure 61
Impédance de sortie, mesurée sur la gamme de fréquences f_{min}à f_{max}	≥Din_{min}

11.7.2 Tension d'alimentation

Un appareil de bus de terrain revendiquant la conformité à l'Article 11 doit pouvoir fonctionner dans une plage de tension de 9 V à 32 V c.c. entre les deux conducteurs, y compris l'ondulation. L'appareil doit supporter sans aucun dommage une tension minimale de ±35 V c.c.

Un appareil de bus de terrain qui revendique la conformité à l'Article 11 doit satisfaire aux exigences de l'Article 11 lorsqu'il est alimenté par une source ayant les spécifications suivantes:

a) La tension de sortie maximale de l'alimentation doit être de 32 V c.c., y compris l'ondulation.

   Il convient que la tension de l'alimentation ajoutée à la tension de sortie de l'émetteur en circuit ouvert soit inférieure à la limite spécifiée par l'organisme de réglementation local pour la mise en œuvre particulière.

b) L'impédance de sortie de l'alimentation doit être ≥8 kΩ sur la gamme de fréquences f_{min} à f_{max}.

c) Les exigences de claquage de l'isolation du circuit de signaux et du circuit de distribution de l'alimentation par rapport à la masse et par rapport à l'autre circuit doivent être conformes à la CEI 61131-2.

   La tension d'essai équivalente est à appliquer entre circuits isolés indépendants ou entre circuits isolés et parties conductrices accessibles. Pour des circuits de tension nominale ≤50 V c.c. ou efficace, les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 444 V eff., 635 V c.c. et 635 V crête. Pour des circuits de tension nominale comprise entre 150 V et 300 V eff., les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 2 260 V eff., 3 175 V c.c. et 3 175 V crête.

d) Lorsqu'une source donnée alimente deux ou plusieurs segments, l'impédance de l'isolation de chaque segment doit être partagée à ±10 % entre les deux conducteurs de signaux du segment.

11.7.3 Alimentation par l'intermédiaire de conducteurs de signaux

Un appareil de bus de terrain revendiquant la conformité à l'Article 11, qui est alimenté via les conducteurs de signaux, doit satisfaire aux exigences de l'Article 11 lorsqu'il fonctionne à des valeurs maximales d'ondulation et de bruit de l'alimentation, de la manière suivante:

a) 30 mV crête à crête sur la gamme de fréquences f_{min}à f_{max};
b) 2 V crête à crête sur la gamme de fréquences de 47 Hz à 63 Hz;
c) 300 mV crête à crête à des fréquences supérieures à 12,5 f_r, jusqu'à une fréquence maximale de 50 MHz;
d) des niveaux à des fréquences intermédiaires généralement conformes à la Figure 61, qui donnent le niveau et les fréquences pour une alimentation via des conducteurs de signaux.

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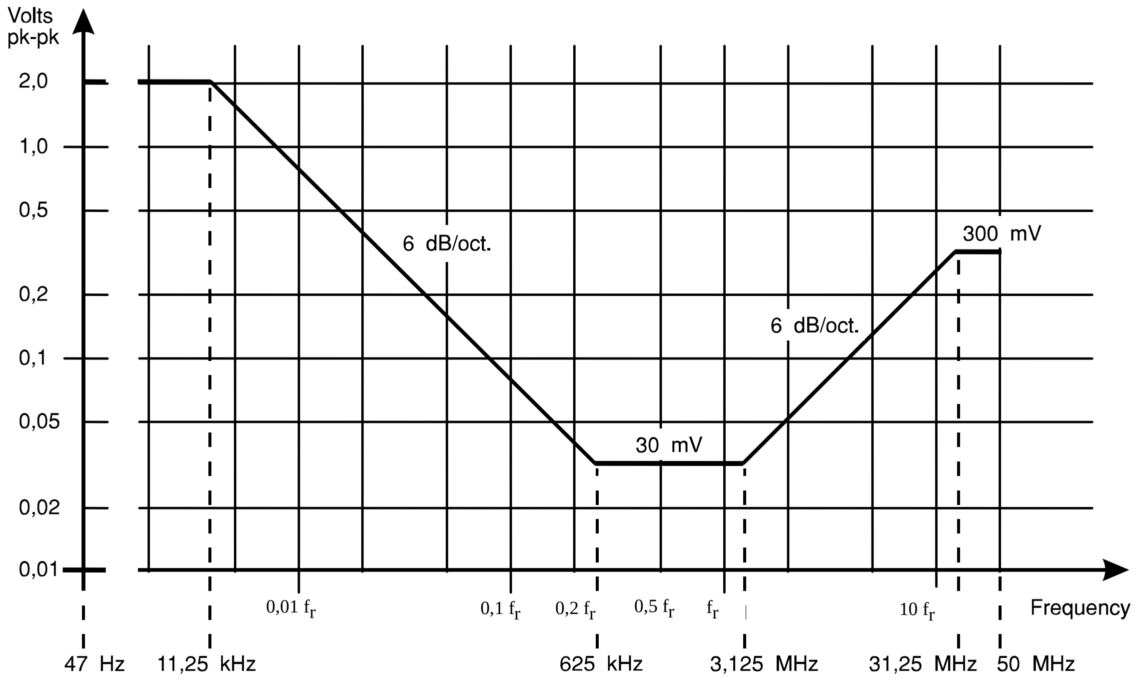

Légende

Anglais	Français
Volts pk-pk	Volts, crête à crête
Frequency	Fréquence

Figure 61 – Ondulation et bruit de l'alimentation

L’appareil doit avoir un taux de variation maximal du courant passif, à l'état de non émission, de 0,1 mA/µs.

NOTE Cette exigence limite les effets des transitoires d'alimentation sur les signaux.

11.7.4 Alimentation séparée à partir des conducteurs de signaux

NOTE La distribution de l'alimentation pour des appareils de bus de terrain non alimentés par le bus s'effectue au moyen de conducteurs séparés fournissant l'énergie à des alimentations locales ou des régulateurs. Il est possible que ces conducteurs soient contenus dans un câble séparé ou dans le même câble que les conducteurs de signaux.

Un appareil de bus de terrain alimenté séparément, revendiquant la conformité à l'Article 11, ne doit pas prélever plus de 100 µ en courant continu des conducteurs de signaux et ne doit pas fournir plus de 100 µA en courant continu aux conducteurs de signaux, lorsqu'il n'y a pas de transmission.

11.7.5 Isolation électrique

Tous les appareils de bus de terrain, alimentés séparément ou par l'intermédiaire des conducteurs de signaux, doivent assurer une isolation basse fréquence entre la masse et le câble de ligne principale du bus de terrain.

NOTE 1 Ceci peut être réalisé en isolant l'ensemble de l’appareil de la masse au moyen d'un transformateur, d'un optocoupleur ou de tout autre organe d'isolation entre le câble de ligne principale et l’appareil.

Une alimentation et un élément de communication combinés ne doivent pas nécessiter d'isolation électrique.

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Pour les installations électriques disposant de mises à la terre différentes, l'impédance d'isolation mesurée entre le blindage du câble de bus de terrain et la masse de l'appareil de bus de terrain doit être supérieure à 250 kΩ à toutes les fréquences inférieures à 63 Hz.

L'isolation doit être contournée par une capacité à des fréquences élevées, de façon à ce que l'impédance mesurée entre le blindage du câble du bus de terrain et la masse de l'appareil de bus de terrain soit inférieure à 15 Ω entre 3 MHz et 100 MHz.

NOTE 2 La capacité entre la masse et le blindage du câble de ligne principale nécessaire pour satisfaire à ces exigences peut prendre toute valeur comprise entre 3,5 nF et 10,6 nF.

Pour des installations électriques disposant d'une masse commune, conformément à la CEI 60364-4-41 et à la CEI 60364-5-54, le blindage du câble de bus de terrain et la masse de l'appareil de bus de terrain peuvent être directement connectés.

La capacité dissymétrique maximale par rapport à la masse de toute borne d'entrée d'un appareil ne doit pas dépasser 250 pF.

Les exigences de claquage de l'isolation du circuit de signaux et du circuit de distribution de l'alimentation par rapport à la masse et par rapport à l'autre circuit doivent être conformes à la CEI 61131-2.

NOTE 3 La tension d'essai équivalente est appliquée entre circuits isolés indépendants ou entre circuits isolés et parties conductrices accessibles. Pour des circuits alimentés à partir d'une source de tension assignée de ≤50 V c.c. ou efficace, les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 444 V eff., 635 V c.c. et 635 V crête. Pour un appareil alimenté à partir d'une source de tension assignée comprise entre 150 V et 300 V eff., les tensions d'essai équivalentes au niveau de la mer correspondent à des tensions d'essais de choc de 2 260 V eff., 3 175 V c.c. et 3 175 V crête.

11.8 Spécifications du support

11.8.1 Connecteur

Si des connecteurs de câbles sont utilisés, ils doivent être conformes à la présente norme (voir l'Annexe A). Des techniques de terminaison sur le terrain, comme par exemple les bornes à vis ou à lames ainsi que les terminaisons permanentes (épissures), peuvent également être utilisées.

11.8.2 Câble d'essai normalisé

Le câble utilisé pour les essais d'appareils de bus de terrain avec une MAU de 150 Ω en mode tension, destinés à vérifier la conformité aux exigences de l'Article 11, doit être un câble unique à paire torsadée, à blindage global, conforme aux exigences minimales suivantes, à une température de 25 °C:

a) Z_O = 150 Ω± 10 % dans la gamme de fréquences de 0,25 f_r à 1,25 f_r;
b) affaiblissement maximal à une fréquence de 25 f_r à 1,25 f_r, comme spécifié dans le Tableau 65;
c) déséquilibre capacitif maximal par rapport au blindage = 1,5 nF/km
d) résistance maximale en courant continu (par conducteur) = 57,1 Ω/km;
e) aire de la section des conducteurs (dimension des fils) = 0,33 mm^2, valeur nominale;
f) résistivité minimale entre chaque conducteur et le blindage = 16 GΩ km;
g) la couverture minimale du blindage doit être de 95 %.

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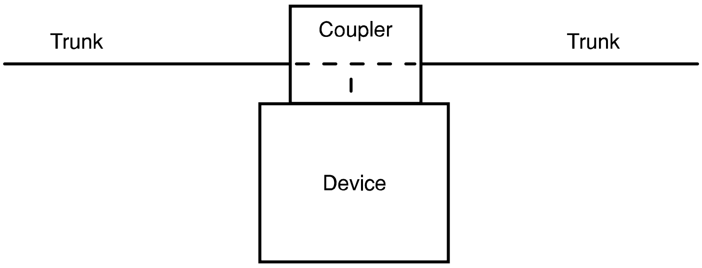
Tableau 65 – Limites d'affaiblissement du câble d'essai

Débit binaire	Affaiblissement maximal à	
	$0{,}25\ f_r$	$1{,}25\ f_r$
31,25 kbit/s	1,5 dB	3 dB
1 Mbit/s	6,5 dB	13 dB
2,5 Mbit/s	10 B	20 dB
5 Mbit/s	13 dB	26 dB
10 Mbit/s	17 dB	37 dB
25 Mbit/s	26 dB	60 dB

La spécification ci-dessus concerne les essais de conformité d'une MAU. D'autres types de câbles peuvent être utilisés dans les installations réelles (voir l'Annexe B). Les câbles à spécifications améliorées peuvent permettre de plus grandes longueurs de lignes principales ou une meilleure immunité aux perturbations ou encore il peut être exigé qu'ils satisfassent à des conditions d'environnement ou d'installation. En revanche, les câbles ayant des spécifications inférieures peuvent être utilisés, sous réserve d'une limitation des longueurs utilisées, tant pour les lignes principales que secondaires, auxquels s'ajoute une éventuelle non-conformité aux exigences de susceptibilité aux perturbations radioélectriques (RFI) et électromagnétiques (EMI).

11.8.3 Coupleur

Le coupleur, comme illustré dans la Figure 62, doit fournir un ou plusieurs points de connexion à la ligne principale. Il est en général intégré à un appareil de bus de terrain.



Légende

Anglais	Français
Trunk	Ligne principale
Coupler	Coupleur
Device	Dispositif

Figure 62 – Coupleur de bus de terrain

Un coupleur passif peut inclure un ou tous les éléments facultatifs décrits ci-dessous:

a) un transformateur assurant l'isolation galvanique et la transformation de l'impédance entre la ligne principale et l’appareil;

b) des connecteurs facilitant le branchement à la ligne principale.

Les coupleurs actifs qui nécessitent une alimentation externe, comportent des composantes d'amplification et de réémission des signaux. Le niveau de transmission et les exigences de synchronisation doivent être conformes à 11.4.

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11.8.4 Epissures

NOTE Une épissure est toute partie du réseau dans laquelle l'impédance caractéristique du câble de réseau n'est pas maintenue. Ceci peut être dû à la séparation des conducteurs du câble, au retrait de blindage du câble, au changement de calibre ou de type de fil, à la fixation à des barrettes à bornes, etc. Une définition pratique d'une épissure est par conséquent toute partie du réseau qui n'est pas une longueur continue du support spécifié.

La continuité de tous les conducteurs du câble doit être maintenue dans une épissure.

11.8.5 Terminateur

Un terminateur doit être placé aux deux extrémités du câble de ligne principale et connecté d'un conducteur de signal à l'autre. Il ne doit y avoir aucune connexion entre terminateur et blindage du câble.

Pour les besoins de l'essai, en utilisant le câble spécifié en 11.8.2, le terminateur doit avoir une valeur d'impédance de 150 Ω± 2 % sur la gamme de fréquences globale de 625 kHz à 31,25 MHz.

NOTE Dans des applications pratiques, la valeur choisie serait environ égale à la valeur de l'impédance caractéristique moyenne du câble aux fréquences pertinentes afin de réduire le plus possible les réflexions de la ligne de transmission.

Le courant continu de fuite à travers le terminateur ne doit pas dépasser 100 μA. Le terminateur doit être non polarisé.

11.8.6 Règles de blindage

Pour une entière conformité aux exigences d'immunité au bruit de 11.5.3, l'intégrité du blindage doit être assurée sur toute la longueur du câblage, dans les connecteurs et dans les coupleurs, de la manière suivante:

a) la couverture du blindage doit être supérieure à 95 % de la longueur totale du câble;
b) le blindage doit couvrir complètement les circuits électriques des connecteurs, des coupleurs et des épissures.

NOTE Toute dérogation à ces règles de blindage peut dégrader l'immunité au bruit.

11.8.7 Règles de mise à la masse (mise à la terre)

NOTE Mise à la masse (à la terre) signifie une connexion permanente à la terre par l'intermédiaire d'une impédance suffisamment basse et ayant un courant admissible suffisant pour prévenir un amorçage en tension qui pourrait entraîner des risques excessifs pour le matériel connecté ou les personnes.

Les lignes de tension zéro (commun) peuvent être reliées à la masse lorsqu'elles sont galvaniquement isolées de la ligne principale du bus de terrain.

Les appareils de bus de terrain doivent fonctionner conformément aux exigences de l'Article 11, le point médian d'un terminateur ou d'un coupleur inductif étant directement connecté à la masse.

Les appareils de bus de terrain ne doivent pas raccorder l'un des conducteurs de la paire torsadée à la masse, quel que soit le point du réseau. Les signaux doivent être appliqués et préservés de manière différentielle sur l'ensemble du réseau.

Il est habituel dans la pratique de mettre effectivement à la masse le blindage du câble de ligne principale de bus de terrain (le cas échéant) en un point sur la longueur du câble. De ce fait, il convient que les appareils de bus de terrain permettent une isolation c.c. du blindage du câble par rapport à la masse.

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La pratique courante est également de raccorder les conducteurs de signaux à la masse de manière symétrique, au même point, en utilisant par exemple la prise médiane d'un terminateur ou d'un transformateur de couplage.

Pour des systèmes alimentés par le bus, il convient que la mise à la masse du blindage et des conducteurs de signaux équilibrés soit proche de l'unité d'alimentation. On peut avoir un couplage capacitif entre le blindage ou les conducteurs de signaux équilibrés et la mise à la masse locale de l'appareil pour une meilleure immunité aux interférences électromagnétiques.

11.8.8 Code de couleur des câbles

Il convient que le choix des couleurs de câble tienne compte des pratiques régionales.

En Amérique du Nord, il convient d'attribuer les couleurs des conducteurs intérieurs du câble et de la gaine extérieure (enveloppe) du câble, comme spécifié dans le Tableau 66.

Tableau 66 – Code de couleur recommandé pour les câbles en Amérique du Nord

Couleur des conducteurs intérieurs	
Conducteur intérieur '+' (tension positive)	Orange ou rouge/orange/marron, à l'extrémité du spectre
Conducteur intérieur '-' (tension négative)	Bleu ou bleu/violet, à l'extrémité du spectre
Conducteur du blindage (qui peut être relié à la terre)	Nu, incolore ou vert
Couleur de la gaine extérieure (enveloppe)	
Règles de construction d'usage général	Orange
Règles de construction non incendiaire	Bande orange/bleue
Règles de construction en sécurité intrinsèque (IS)	Bande bleue ou bleue/orange ou bande bleue/noire

12 Types 1 et 3: Unité de liaison au support: 31,25 kbit/s, mode tension avec option basse puissance, topologie bus et arborescente, support câblé 100 Ω

NOTE Le Type 3 utilise cette MAU uniquement pour la transmission synchrone.

12.1 Généralités

La MAU 31,25 kbit/s en mode tension de 100 Ω fournit simultanément l'accès à un réseau de communication et à un réseau de distribution d'énergie optionnel. Les appareils raccordés au réseau communiquent par l'intermédiaire du support et peuvent ou non être alimentés par ce support. Si l'alimentation s'effectue par le bus, elle est distribuée en tension directe et en courant continu et des signaux de communication sont superposés sur l'alimentation c.c. Dans les applications de sécurité intrinsèque, la puissance disponible peut limiter le nombre d'appareils.

Le support du réseau est constitué d'un câble d'une seule paire, qui est en général mais pas toujours, une paire torsadée. Indépendamment de la topologie, tous les appareils connectés, sauf éventuellement l'appareil de transmission, présentent une impédance élevée pour éviter une surcharge importante du réseau. Les formes d'onde trapézoïdales sont utilisées pour réduire les émissions électromagnétiques.

Des topologies en bus et arborescentes sont prises en charge. Quelle que soit la topologie, un réseau comporte un câble de ligne principale disposant de terminaisons à ses extrémités. Dans la topologie de bus linéaire, les lignes secondaires sont réparties sur la longueur de la ligne principale. Dans la topologie arborescente, les lignes secondaires sont concentrées à une extrémité de la ligne principale. Une ligne secondaire peut connecter plusieurs appareils au réseau et le nombre maximal d'appareils sur une ligne secondaire donnée dépend de la longueur de cette ligne.

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A fréquence industrielle (c.c.), les appareils apparaissent pour le réseau comme des absorbeurs de courant avec un taux de variation limité du courant d'alimentation prélevé du support. Ceci permet d'éviter que les modifications transitoires du courant de charge n'interfèrent avec les signaux de communication.

L'Article 12 spécifie une option à faible puissance qui permet de réduire le courant prélevé du réseau par les appareils lorsqu'ils ne sont pas en émission.

Pour réduire les oscillations et les suroscillations sur le réseau, l'impédance de l'alimentation est spécifiée en fonction de l'impédance du terminateur de bus, de façon à ce que la réactance totale du réseau soit réduite au minimum sur la gamme de fréquences de 50 Hz à 39 kHz.

12.2 Débit binaire de transmission

Le débit binaire moyen, BR, doit être de 31,25 kbit/s ± 0,2 %, moyenné sur une trame ayant une longueur minimale de 16 octets. Le temps binaire instantané, T_{bit}, doit être de 32 µs ± 0,9 µs.

12.3 Spécifications du réseau

12.3.1 Composants

Une MAU fonctionne sur un réseau constitué des composants suivants:

a) un câble à conducteurs;

b) des appareils (comportant au moins un élément de communication);

c) des coupleurs;

d) des terminateurs.

Le réseau peut inclure les composants optionnels suivants:

e) des connecteurs;

f) des alimentations;

g) des appareils qui comprennent les alimentations;

h) des barrières de sécurité intrinsèque.

12.3.2 Topologies

Une MAU câblée doit fonctionner sur un réseau de topologie de bus linéaire ou arborescente nominalement acyclique constituée d'une ligne principale, terminée à chaque extrémité comme spécifié en 12.8.5 et à laquelle des éléments de communication sont connectés par l'intermédiaire de coupleurs et de lignes secondaires. Une topologie arborescente dont tous les éléments de communication sont placés aux extrémités de la ligne principale est considérée comme un cas particulier de bus aux fins de l'Article 12. Chaque élément de communication doit être connecté en parallèle au câble de ligne principale.

Le coupleur et l'élément de communication peuvent être intégrés en un appareil (c'est-à-dire une ligne secondaire de longueur zéro). Plusieurs éléments de communication peuvent être connectés à la ligne principale en un point donné, en utilisant un coupleur multivoies. Un coupleur actif peut être utilisé pour étendre une ligne secondaire sur une longueur qui nécessite une terminaison afin d'éviter les réflexions et distorsions. Des répéteurs actifs peuvent être utilisés pour étendre la longueur de la ligne principale au-delà d'un segment unique si cela est autorisé par les règles de configuration du réseau. Les dérivations doivent être considérées comme des segments, et peuvent rendre le bus non linéaire. Les cycles (boucles fermées) ne sont jamais autorisés.

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12.3.3 Règles de configuration du réseau

Une MAU qui revendique la conformité à l'Article 12 doit satisfaire aux exigences de l'Article 12 lorsqu'elle est utilisée sur un réseau qui satisfait aux présentes règles.

Règle 1: Un bus de terrain doit être capable d'assurer la communication entre les nombres d'appareils indiqués ci-après, fonctionnant tous au même débit binaire:

a) pour un bus de terrain non IS sans alimentation par les conducteurs de signaux: entre deux et 32 appareils;
b) pour un bus non IS avec alimentation par l'intermédiaire de conducteurs de signaux: entre deux et le nombre d'appareils qui peuvent être alimentés par l'intermédiaire des conducteurs de signaux, en supposant qu'un minimum de 120 mA (au total) doit être mis à la disposition des appareils à l'extrémité distante de l'alimentation et en sachant que la communication avec un appareil à l'extrémité de l'alimentation consomme 10 mA;
c) pour un bus de terrain IS: entre deux et le nombre d'appareils qui peuvent être alimentés par l'intermédiaire des conducteurs de signaux, en supposant qu'au minimum 40 mA (au total) doivent être mis à la disposition des appareils dans la zone dangereuse.

NOTE 1 Cette règle n'exclut pas l'utilisation d'un nombre d'appareils supérieur à celui spécifié dans un système installé. Etant donné que la consommation d'énergie de l'appareil n'est pas spécifiée, le nombre d'appareils alimentés par le bus ne peut pas être spécifié.
Le point b) suppose que la tension minimale d'alimentation est de 20 V c.c.
Le point c) suppose que la barrière IS fonctionne avec une sortie de 19 V c.c.

Règle 2: Un segment de bus de terrain à pleine charge (comportant le nombre maximal d'appareils connectés) doit avoir une longueur totale de câble, y compris les lignes secondaires, entre deux appareils quelconques, allant jusqu'à 1 900 m.

NOTE 2 Cette longueur maximale du câble est une exigence de conformité à l'Article 12, mais n'exclut pas l'utilisation de longueurs supérieures dans un système installé.

Règle 3: Le nombre total de régénérations de forme d'onde par des répéteurs et des coupleurs actifs entre deux appareils quelconques dépend de la mise en œuvre du répéteur concerné.

NOTE 3 Ce nombre total était limité à quatre dans les éditions précédentes de la présente norme.

Règle 4: Le délai maximal de propagation entre deux appareils quelconques ne doit pas dépasser 20 T_{bit}.

Pour que le réseau fonctionne efficacement, il convient que cette partie du temps de retournement de tout appareil du réseau, générée par une PhE entre la fin d'une trame reçue et le début d'une trame émise contenant une réponse immédiate associée, ne dépasse pas 30 temps binaires, dont il convient qu'au maximum 2 temps binaires soient dus à la MAU.

NOTE 4 Sachant qu'il n'est pas obligatoire d'exposer l'interface DLL – PhL ou l'interface MDS – MAU, cette partie du temps de retournement d'un appareil de bus de terrain due à la PhL ou à la MAU n'est pas spécifiée et donc non disponible pour des essais de conformité.

Règle 5: Le bus de terrain doit pouvoir continuer à fonctionner lorsqu'un appareil y est connecté ou déconnecté. Les erreurs de données générées lors de la connexion ou de la déconnexion doivent être détectées.

Règle 6: La défaillance d'un quelconque élément de communication ou d'une ligne secondaire (à l'exception d'un court circuit, d'une faible impédance ou d'un bavardage) ne doit pas interférer avec des transactions entre d'autres éléments de communication pendant plus de 1 ms.

Règle 7: Dans des systèmes polarisés, les paires de conducteurs du support doivent être distinctement repérées de manière à identifier de manière unique chaque conducteur individuel. Une polarisation homogène doit être maintenue en tout point de raccordement.

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Règle 8: La dégradation des caractéristiques électriques du signal, entre deux appareils quelconques, due à l'affaiblissement, à la distorsion d'affaiblissement et à la distorsion de désadaptation doit être limitée aux valeurs indiquées ci-dessous.

a) Affaiblissement du signal: La configuration du bus (les longueurs de la ligne principale et des lignes secondaires ainsi que le nombre d'appareils, les barrières IS, les sectionneurs galvaniques, et les éventuels appareils d'adaptation) doit être telle que l'affaiblissement entre deux appareils quelconques, à une fréquence f_r (31,25 kHz), ne doit pas dépasser 10,5 dB.

b) Distorsion d'affaiblissement: La configuration du bus (longueurs de ligne principale et de lignes secondaires, nombre d'appareils, barrières IS et sectionneurs galvaniques) doit être telle qu'entre deux appareils quelconques:

   0≤[Affaiblissement (1,25 f_r) – Affaiblissement (0,25 f_r)]≤6 dB

   L'affaiblissement doit être monotonique, non décroissant pour toutes les fréquences de 0,25 f_rà 1,25 f_r(7,8 kHz à 39 kHz).

c) Distorsion de désadaptation: La désadaptation (due à n'importe quel effet, y compris une ligne secondaire en circuit ouvert de longueur maximale) sur le bus doit être telle qu'en tout point sur la ligne principale dans la bande de fréquence comprise entre 0,25 f_rà 1,25 f_r(7,8 kHz à 39 kHz):

   $|Z – Zfr| / |Z + Zfr| \leq 0,2$

   où Z_{fr}est l'impédance du câble de ligne principale à la fréquence f_r(31,25 kHz) et Z est la combinaison parallèle de Z_{fr}et de l'impédance de charge au niveau du coupleur.

La concentration des coupleurs doit être inférieure à 15 pour 250 m.

NOTE 5 Cette règle permet de réduire les restrictions, en termes de longueurs de la ligne principale et des lignes secondaires ainsi qu'en termes de nombre d'appareils, etc. en ne spécifiant que des limites de transmission imposées par des combinaisons de ces facteurs. Il est possible d'utiliser différentes combinaisons en fonction des besoins de l'application.

Règle 9: Les règles suivantes doivent s'appliquer aux systèmes mis en œuvre avec des supports redondants:

a) chaque canal (câble) doit satisfaire aux règles de configuration du réseau;

b) il ne doit pas y avoir de segment non redondant entre deux segments redondants;

c) les répéteurs doivent également être redondants;

d) si les appareils du système sont configurés (par la Gestion systèmes) pour émettre sur plusieurs canaux simultanément, la différence de délai de propagation entre deux appareils quelconques sur deux canaux quelconques ne doit pas dépasser cinq temps binaires;

   Cette période peut être étendue mais non réduite par la Gestion systèmes, comme indiqué dans le Tableau 4 (voir 6.2.2.2 et 9.2.9).

e) les numéros de canaux et leur association aux supports de transmission physiques doivent être maintenus de manière cohérente sur l'ensemble des bus de terrain, c'est-à-dire que les canaux 1, 2, 3… en provenance de la gestion systèmes doivent toujours être connectés aux canaux physiques 1, 2, 3…;

Règle 10: Pour un segment de bus de terrain alimenté par le bus, la tension mise à la disposition de tous les appareils, y compris l'ondulation et la composante continue de la chute de tension due à la signalisation, doit s'inscrire dans une plage de 9,0 V à 32,0 V c.c.

NOTE 6 La composante continue de la chute de tension due à la signalisation dépend de la configuration du réseau. La composante continue est due à la variation en échelon du courant de l'appareil à travers la résistance du réseau (résistance du câble, résistance de la barrière IS, etc.).

12.3.4 Règles de distribution de l'alimentation pour la configuration du réseau

Voir 11.3.4.

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12.4 Spécification du circuit de transmission de la MAU

12.4.1 Récapitulatif

Pour faciliter le renvoi aux textes correspondants, les exigences définies en 12.2 et 12.4 sont résumées dans le Tableau 67 et dans le Tableau 68.

Tableau 67 – Récapitulatif de la spécification du niveau de transmission de la MAU

Caractéristiques du niveau de transmission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 56)	Limites
Niveau de sortie (crête à crête, voir la Figure 57) Avec charge d'essai (0,5 de l'impédance nominale du câble de ligne principale à une fréquence f_r de 31,25 kHz)	0,75 V à 1 V 50 Ω± 1 %
Différence d'amplitude positive et négative maximale (biais de la signalisation) telle qu'illustrée à la Figure 58	± 50 mV
Niveau de sortie; un terminateur retiré (crête à crête) avec charge d'essai (impédance nominale du câble de ligne principale à $f_r$de 31,25 kHz)	0,75 V à 2,0 V 100 Ω± 1 %
Niveau maximal de sortie; circuit ouvert (crête à crête)	35 V
Distorsion maximale du signal de sortie; c'est-à-dire surtension, suroscillation et statisme (voir la Figure 57)	±10 %
Sortie d'émetteur passif, c'est-à-dire bruit de l'émetteur (mesuré sur la bande de fréquence de 1 kHz à 100 kHz)	≤1 mV (eff.)

Tableau 68 – Récapitulatif de la spécification de synchronisation de transmission de la MAU

Caractéristiques de synchronisation de l'émission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 56)	Limites pour 31,25 kbit/s (alimentation par le bus et/ou IS)
Débit binaire de transmission	31,25 kbit/s ± 0,2 %
Temps binaire instantané	32 μs ± 0,9 μs
Temps de croissance et de décroissance (10 % à 90 % du signal crête à crête, voir la Figure 57)	≤ 25 % T_{bit}
Taux de dérive (en tout point de 10 % à 90 % du signal crête à crête)	≤0,2 V/μs
Instabilité de bit élémentaire maximale émise (écart du point de passage par zéro, voir la Figure 58)	± 2,5 % T_{bit}
Délai d'activation/désactivation de transmission (c'est-à-dire durée pendant laquelle la forme d'onde de sortie peut ne pas satisfaire aux exigences de transmission)	≤ 2,0 T_{bit}

12.4.2 Configuration d'essai de la MAU

La Figure 56 illustre la configuration qui doit être utilisée pour les essais de MAU.

Tension de signal en mode différentiel: $V_d = V_a – V_b$.

Sauf spécification contraire dans une exigence particulière, la résistance de la charge d'essai R = 50 Ω (0,5 de l'impédance nominale du câble de ligne principale à une fréquence $f_r$de 31,25 kHz) et C = 2 μF (2 × la capacité d'un terminateur).

Borne "+" des données raccordée à la borne "+" de l'alimentation et borne "-" des données raccordée à la borne "-" de l'alimentation.

NOTE Voir 12.7 concernant la spécification de l'alimentation et 12.8.5 concernant la spécification du terminateur.

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12.4.3 Exigences de niveau de sortie de la MAU

La Figure 57 décrit la forme de sortie du signal compte tenu des exigences de niveau de sortie en tension de la paire torsadée.

NOTE 1 La Figure 57 présente un exemple de la composante alternative d'un cycle de forme d'onde de bus de terrain, illustrant certains éléments-clés de la spécification du circuit de transmission. Seules les tensions des signaux sont indiquées; ce schéma ne tient aucunement compte des tensions d'alimentation.

Le circuit de transmission de la MAU doit être conforme aux exigences de niveau de sortie suivantes, toutes les amplitudes étant mesurées au point médian estimé entre toute crête ou creux en haut et en bas de la forme d'onde ("point médian" dans la Figure 57):

a) la tension de sortie sur la charge d'essai après élévation/abaissement par le transformateur (le cas échéant), doit être comprise entre 0,75 V et 1,0 V crête à crête avec une résistance de charge de 50 Ω± 1 % ("min o/p" dans la Figure 57);

b) la tension de sortie au niveau de la ligne principale ou aux bornes de transmission, avec une résistance de charge de 100 Ω± 1 % (c'est-à-dire l'un des terminateurs de la ligne principale étant retiré) doit être comprise entre 0,75 V et 2,0 V crête à crête ("max. o/p un terminateur retiré" dans la Figure 57);

c) la tension de sortie au niveau de la ligne principale ou aux bornes de transmission, avec toute charge comprenant un circuit ouvert, ne doit pas dépasser 35 V quelle que soit la polarité. Aux fins de l'essai, un circuit ouvert doit être défini comme étant une charge ayant une résistance de 100 kΩ en parallèle avec une capacité de 15 pF;

d) au cours d'une émission, un appareil donné ne doit pas subir de défaillance permanente lorsqu'une résistance de charge de ≤1 Ω est appliquée pendant 1 s;

e) la différence entre amplitude positive et amplitude négative, mesurée comme présenté dans la Figure 57, ne doit pas dépasser ±50 mV crête;

f) le bruit en sortie d'une MAU en réception ou non alimentée ne doit pas dépasser 1 mV eff., mesuré de manière différentielle sur une bande de fréquence de 1 kHz à 100 kHz, en référence à la ligne principale;

g) la tension différentielle sur la charge d'essai doit donner une modification monotonique de la tension, entre 10 % et 90 % de la valeur crête à crête. Par la suite, la tension du signal ne doit pas varier de plus de ±10 % de la valeur crête à crête jusqu'à ce que la transition suivante ait lieu. Cette variation admissible doit inclure toutes les formes de distorsion de signal de sortie, c'est-à-dire la surtension, la suroscillation et le statisme.

NOTE 2 En cours de transmission, la tension de sortie présente aux bornes de l’appareil peut augmenter de manière substantielle par rapport à celle spécifiée dans le Paragraphe 12.4.3 g), mais toujours dans les limites spécifiées en 12.4.3 c), du fait des effets combinés de l'impédance série de l’appareil, du câble de ligne secondaire et de tout appareil de protection du bus, comme décrit en 12.8.3 c).

12.4.4 Exigences de synchronisation des sorties

Le circuit de transmission d'une MAU doit être conforme aux exigences suivantes de synchronisation des sorties:

a) l'instabilité de bit élémentaire émise ne doit pas dépasser ±0,025 T_{bit} par rapport au point de passage par zéro idéal, mesuré en fonction du point de passage par zéro précédent (voir la Figure 58);

b) le circuit de transmission doit s'activer, ce qui signifie que le signal doit monter d'un niveau inférieur au bruit de sortie maximal du circuit de transmission, comme spécifié en 12.4.3 f), jusqu'au niveau de pleine puissance, en moins de 2,0 T_{bit}. La forme d'onde correspondant au troisième temps binaire et au-delà, doit être telle que spécifiée dans la Figure 57;

c) le circuit de transmission doit se désactiver, ce qui signifie que le signal doit tomber depuis le niveau de pleine puissance jusqu'à un niveau inférieur au bruit de sortie maximal du circuit de transmission, comme spécifié en 12.4.3 f), en moins de 2,0 T_{bit}. La durée nécessaire pour que le circuit de transmission revienne à son impédance d'état "non actif" ne doit pas dépasser 4 T_{bit}. Aux fins des essais, les exigences doivent être satisfaites

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dans la configuration d'essai du circuit de transmission de 12.4.2, avec la capacité équivalente d'une longueur de câble maximale entre les bornes de l'appareil en essai.

NOTE 1 Cette exigence permet de s'assurer que la capacité de la ligne a été pleinement déchargée lors de la transition du circuit de transmission de l'état actif à l'état passif.

d) les temps de croissance et de décroissance, mesurés de 10 % à 90 % de l'amplitude du signal crête à crête, ne doivent pas dépasser 0,25 T_{bit} (voir la Figure 57);

e) le taux de dérive, mesuré en tout point dans une plage de 10 % à 90 % de l'amplitude du signal crête à crête, ne doit pas dépasser 0,2 V/µs (voir la Figure 57).

NOTE 2 Les exigences d) et e) génèrent une forme d'onde trapézoïdale à la sortie du circuit de transmission. L'exigence d) limite le niveau des émissions de perturbation qui peuvent être couplées aux circuits adjacents, etc. L'exigence d) est calculée à partir de la formule suivante:

taux de dérive max. = 2 × taux de dérive min. = $2 \times 0{,}8\ V_o / 0{,}25\ T_{bit} = 6{,}4 \times V_o / T_{bit}$,
où V_o est la tension de sortie maximale crête à crête (1,0 V) avec une charge normalisée.

12.4.5 Polarité du signal

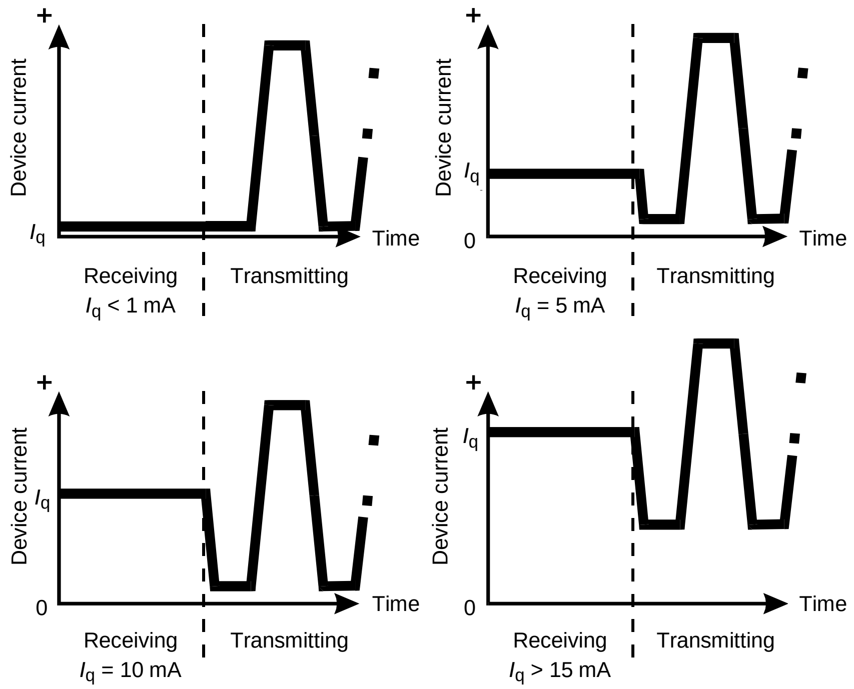
Voir 11.4.5.

12.4.6 Transition de la réception à l'émission

Lorsqu'un appareil commence à émettre, la forme d'onde de sortie doit immédiatement satisfaire aux exigences de 12.4.3.

NOTE Il n'y a aucune exigence pour le passage du courant de l'appareil de sa valeur de réception à sa valeur de transmission.

La Figure 63 présente quatre exemples de différentes valeurs du courant passif de l'appareil.



NOTE Cette figure est incluse dans la présente norme à des fins d'explication et n'implique aucune mise en œuvre spécifique.

Anglais	Français
Device current	Courant de l'appareil
Receiving	Réception
Transmitting	Emission
Time	Temps

Figure 63 – Transition de la réception à l'émission

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12.5 Spécification du circuit de réception de la MAU

12.5.1 Récapitulatif

Le Tableau 69 résume la spécification.

Tableau 69 – Récapitulatif de la spécification du circuit de réception de la MAU

Caractéristiques du circuit de réception (valeurs en référence à la ligne principale)	Limites (alimentation par le bus et/ou IS)
Impédance d'entrée, mesurée sur la gamme de fréquences 0,25 f_r à 1,25 f_r	≥ 3 kΩ
Sensibilité; signal min. crête à crête dont l'acceptation est exigée (voir la Figure 60)	150 mV
Suppression du bruit; bruit max. crête à crête dont le rejet est exigé (voir la Figure 60)	75 mV
Instabilité de bit élémentaire maximale reçue (écart du point de passage par zéro, voir la Figure 57)	±0,10 T_{bit}

12.5.2 Impédance d'entrée

L'impédance d'entrée différentielle d'un circuit de réception de MAU ne doit pas être inférieure à 3 kΩ sur la gamme de fréquences de 0,25 f_r à 1,25 f_r (7,8 kHz à 39 kHz). Cette exigence doit s'appliquer après une période de démarrage de 20 ms suite à la connexion au réseau ou à la mise sous tension du réseau. Les appareils alimentés séparément et les appareils alimentés par le réseau qui peuvent être mis hors tension lorsqu'ils sont connectés au réseau, doivent satisfaire aux exigences en état sous tension et hors tension ainsi que lors des transitions entre ces états. Cette impédance doit être mesurée aux bornes de l'élément de communication en utilisant une onde sinusoïdale d'une amplitude de signal supérieure au seuil de sensibilité du récepteur et inférieure à 2,0 V crête à crête.

NOTE 1 L'exigence d'une impédance d'entrée de ≥3 kΩ pendant la mise sous tension et hors tension peut être satisfaite par désactivation automatique de l'émetteur au cours de ces périodes.

NOTE 2 Il est possible que les appareils disposant de circuits électroniques de déconnexion en cas de défaut aient des impédances inférieures à la valeur spécifiée dans des conditions de défaut.

12.5.3 Sensibilité du récepteur et suppression du bruit

Un circuit de réception de MAU doit être capable de recevoir un signal d'entrée d'une amplitude d'au moins 150 mV crête à crête, y compris la surtension et l'oscillation (voir "niveau du signal" ainsi que "amplitude positive" et "amplitude négative" dans la Figure 60).

Le circuit de réception de MAU ne doit pas répondre à un signal d'entrée d'amplitude crête à crête non supérieur à 75 mV (voir "suppression du bruit" dans la Figure 60).

12.5.4 Instabilité de bit élémentaire reçu

Le circuit de réception doit accepter un signal codé Manchester émis conformément à 12.2 et à 12.4. En outre, le récepteur doit fonctionner correctement à des signaux ayant des variations temporelles, entre deux points adjacents quelconques de transition des signaux (passage par zéro) d'au maximum ±0,10 T_{bit}. Voir la Figure 58.

NOTE 1 Cette spécification n'exclut pas l'utilisation de récepteurs dont les performances sont supérieures à la présente spécification.

NOTE 2 En fonction de la configuration du symbole, la durée nominale entre passages par zéro peut être d'un-demi temps binaire ou d'un temps binaire.

NOTE 3 Il n'y a aucune exigence quant au rejet d'un signal donné ayant une valeur de variation temporelle spécifiée. Le récepteur rend compte d'une erreur lorsque l'instabilité du bit élémentaire reçu dépasse l'aptitude du récepteur à décoder la signalisation de manière fiable.

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12.5.5 Susceptibilité au brouillage et taux d'erreurs

Lorsque le bus de terrain fonctionne dans divers environnements de bruit normalisés, il convient que la probabilité qu'une unité de données utilisateur de couche Application contienne une erreur non détectée, du fait du fonctionnement des entités physiques et DLL d'acheminement, soit inférieure à 1 sur 6×10^9 (1 erreur en 20 années à 10 messages/s).

Un élément de communication est considéré conforme à cette exigence théorique lorsqu'il satisfait aux exigences suivantes de susceptibilité au brouillage. Ces exigences sont spécifiées sur la base d'un taux d'erreur de trame détecté obtenu en utilisant un rapport d'erreurs détectées/non détectées de 10^6.

NOTE 1 Cela est facilement réalisable au moyen d'une séquence de contrôle de trame de 16 bits au niveau de la DLL.

Un élément de communication qui inclut une MAU, utilisant des trames contenant 32 bits de données utilisateur aléatoires, à un débit de trame maximal et avec des signaux d'une amplitude de 375 mV crête à crête, ne doit pas produire plus de 10 erreurs de trame détectées sur 60 000 trames pendant son fonctionnement en présence d'une tension en mode commun ou de bruit gaussien comme décrit ci-après:

a) un signal sinusoïdal en mode commun à toute fréquence de 63 Hz à 2 MHz, d'une amplitude de 4 V eff. et de 47 Hz à 63 Hz avec une amplitude de 250 V eff.;

b) un signal c.c. en mode commun de ±10 V;

c) un bruit blanc gaussien différentiel additionnel dans la bande de fréquence de 1 kHz à 100 kHz, avec une densité de bruit de 70 $\mu V/\sqrt{Hz}$ eff.

NOTE 2 Les valeurs spécifiées pour la tension en mode commun et le bruit gaussien correspondent à des essais de conformité de circuit de réception avec des charges symétriques et ne sont pas représentatives d'une quelconque pratique d'installation de système.

Un élément de communication qui inclut une MAU, utilisant des trames contenant 32 bits de données utilisateur aléatoires, à une moyenne de 10 messages/s, avec des signaux d'une amplitude de 375 mV crête à crête, ne doit pas produire plus de 10 erreurs de trame détectées sur 1 000 trames, lorsqu'il est utilisé dans des environnements de perturbations électromagnétiques ou électriques comme décrit ci-après:

1) champ électromagnétique de 10 V/m, comme spécifié dans la CEI 61000-4-3 au niveau de sévérité 3;

2) transitoires électriques rapides, comme spécifié dans la CEI 61000-4-4 au niveau de sévérité 3.

Le taux d'erreur spécifié ci-dessus doit également être réalisé après, mais non pendant le fonctionnement dans les environnements de bruit suivants:

i) décharge électrostatique de 8 kV sur une structure métallique exposée, comme spécifié dans la CEI 61000-4-2, au niveau de sévérité 3. Si l'appareil subit une perte temporaire de fonctions ou de performances suite à cet essai, il doit récupérer de cette perte éventuelle sans intervention de l'opérateur, dans les 3 s qui suivent la fin de l'essai;

ii) essais de perturbation à haute fréquence, comme spécifié dans la CEI 60255-22-1:1988, Annexe E, classe III de tension d'essai (2,5 kV et 1 kV de valeurs crêtes de la première demi-alternance, respectivement en mode longitudinal et transversal). Si l'appareil subit une perte temporaire de fonctions ou de performances du fait de cet essai, il doit récupérer de cette perte éventuelle sans intervention de l'opérateur, dans les 3 s qui suivent la fin de l'essai.

12.6 Inhibition du bavardage

La MAU doit comporter une capacité d'interruption automatique pour empêcher les signaux émis d'atteindre le support. Le matériel dans la MAU (sans message extérieur autre que la détection des signaux de sortie ou de fuite par la fonction de transmission) doit fournir une

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fenêtre d'une durée comprise entre 120 ms et 240 ms au cours de laquelle une trame normale peut être émise. Si la longueur de trame dépasse cette durée, la fonction d'inhibition du bavardage doit empêcher d'autres signaux en sortie d'atteindre le support et doit désactiver l'écho sur la ligne RxS (voir 10.2.2.2) pour indiquer à la MDS la détection de bavardage.

La MAU doit réinitialiser la fonction d'interruption automatique après une période de 3,0 s ± 50 %.

NOTE Ceci inhibe le trafic sur le bus pendant au maximum 16 % (≈ 240 ms / 1,5 s) du temps disponible.

12.7 Distribution de l'alimentation

12.7.1 Généralités

Un appareil peut recevoir son alimentation par l'intermédiaire des conducteurs de signaux ou peut être alimenté de manière séparée.

Un appareil peut être certifié comme étant de sécurité intrinsèque quelle que soit la méthode d'alimentation.

NOTE La présente norme n'inclut pas d'exigences pour la certification IS mais cherche à exclure des conditions ou situations qui pourraient empêcher la certification IS.

Un appareil à alimentation séparée peut être connecté à un bus de terrain alimenté.

Pour faciliter le renvoi aux textes correspondants, les exigences de 12.7 pour les appareils alimentés par le réseau et les alimentations du réseau sont respectivement résumées dans le Tableau 70 et dans le Tableau 71.

Tableau 70 – Caractéristiques des appareils alimentés par le réseau

Caractéristiques des appareils alimentés par le réseau	Limites pour 31,25 kbit/s
Tension de fonctionnement	9,0 V à 32,0 V c.c.
Tension de tenue minimale, quelle que soit la polarité, sans dommages	35 V
Taux de variation maximal du courant passif (pas de transmission); cette exigence ne s'applique pas au cours des 20 premières ms après connexion de l'appareil à un réseau opérationnel ou dans les 20 premières ms après mise sous tension du réseau.	1,0 mA/ms [a, b]
Courant maximal; cette exigence s'applique au cours de l'intervalle de temps de 500 µs à 20 ms après connexion de l'appareil à un réseau opérationnel ou 500 µs à 20 ms après mise sous tension du réseau (voir note)	Courant passif assigné plus 20 mA

[a] Les 500 premières µs sont exclues pour permettre le chargement des filtres RFI et autres capacités de l'appareil. La spécification du taux de variation s'applique au bout de 20 ms.

[b] Il convient que le courant maximal au cours de ces 500 premières µs ne soit pas supérieur à deux fois le courant maximal spécifié ci-dessus, afin de réduire les effets d'appels de courant sur les autres composantes du réseau de bus de terrain connecté.

NOTE 1 Ces exclusions permettent de générer un "délestage" au niveau des appareils alimentés par la même source au cours de cet intervalle d'exclusion.

NOTE 2 Ces exclusions peuvent augmenter de manière substantielle les exigences en courant de l'alimentation au cours de l'intervalle d'exclusion qui a lieu immédiatement après mise sous tension du segment PhL.

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Tableau 71 – Exigences d'alimentation réseau

Exigences d'alimentation réseau [a]	Limites pour 31,25 kbit/s
Tension de sortie, non IS	≤ 32 V c.c.
Tension de sortie, IS	En fonction des caractéristiques assignées de la barrière
Ondulation de sortie et bruit	Voir la Figure 64
Impédance de sortie	Voir 12.7.4
[a] Il convient que les alimentations soient conçues de manière à tenir compte du courant de choc lors de la connexion de l'appareil ou à la mise sous tension, comme défini en Tableau 70.	

12.7.2 Tension d'alimentation

Un appareil de bus de terrain revendiquant la conformité à l'Article 12 doit pouvoir fonctionner dans une plage de tension de 9 V à 32 V c.c. entre les deux conducteurs, y compris l'ondulation. L'appareil doit supporter sans aucun dommage une tension minimale de ±35 V c.c.

12.7.3 Alimentation par l'intermédiaire de conducteurs de signaux

Un appareil de bus de terrain qui revendique la conformité à l'Article 12 doit satisfaire aux exigences de l'Article 12 lorsqu'il est alimenté par une source ayant les spécifications suivantes:

a) La tension de sortie maximale de l'alimentation, pour des réseaux non IS, doit être de 32 V c.c., y compris l'ondulation.

NOTE 1 Pour des systèmes IS, la tension de service peut être limitée par les exigences de certification. Dans ce cas, l'alimentation sera placée dans la zone de sécurité et sa tension de sortie sera atténuée par une barrière de sécurité ou composante équivalente.

b) Les exigences de claquage de l'isolation du circuit de signaux et du circuit de distribution de l'alimentation par rapport à la masse et par rapport à l'autre circuit doivent être conformes à la CEI 61131-2.

NOTE 2 Voir 11.7.5, Note 3.

c) Lorsqu'une source donnée alimente deux ou plusieurs segments, l'impédance de l'isolation de chaque segment doit être partagée à ±10 % entre les deux conducteurs de signaux du segment.

Un appareil de bus de terrain revendiquant la conformité à l'Article 12 qui est alimenté via les conducteurs de signaux doit satisfaire aux exigences de l'Article 12 lorsqu'il fonctionne à des valeurs maximales d'ondulation et de bruit de l'alimentation, de la manière suivante:

d) 16 mV crête à crête sur la gamme de fréquences de 0,25 f_r à 1,25 f_r(7,8 kHz à 39 kHz);

e) 2,0 V crête à crête sur la gamme de fréquences de 47 Hz à 63 Hz pour des applications non IS;

f) 0,2 V crête à crête sur la gamme de fréquences de 47 Hz à 625 Hz pour des applications IS;

g) 1,6 V crête à crête à des fréquences supérieures à 125 f_r, jusqu'à une fréquence maximale de 25 MHz;

h) des niveaux, à des fréquences intermédiaires, généralement conformes à la Figure 64.

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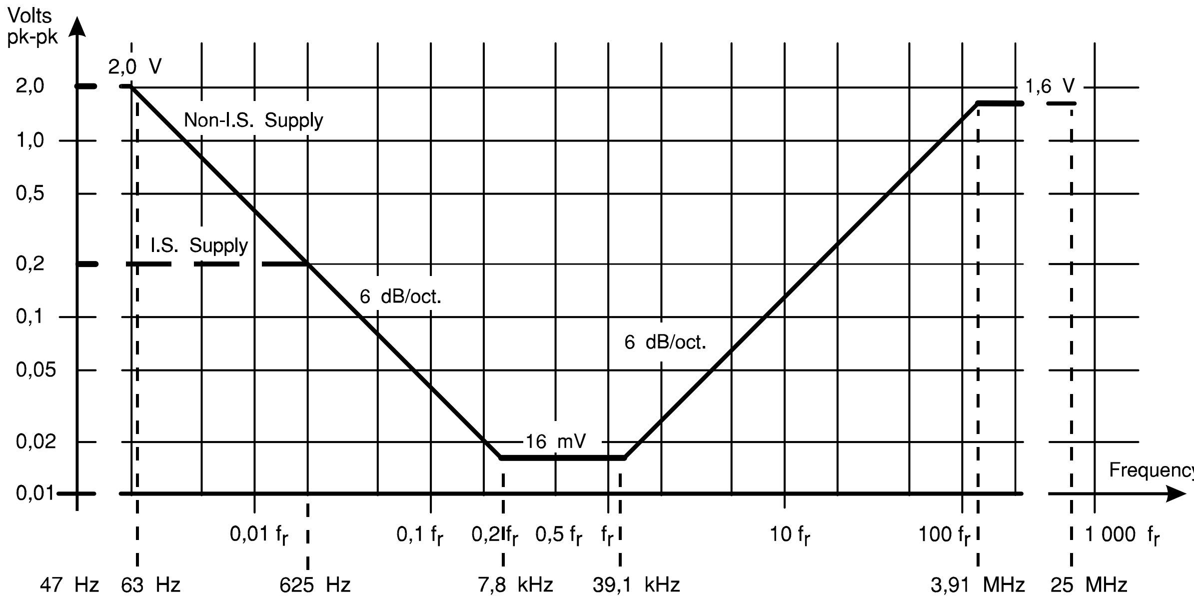

Légende

Anglais	Français
Volts pk-pk	Volts, crête à crête
Non IS supply	Alimentation non IS
IS supply	Alimentation IS
Frequency	Fréquence

Figure 64 – Ondulation et bruit de l'alimentation

Un appareil de bus de terrain qui revendique la conformité à l'Article 12 et qui est alimenté par les conducteurs de signaux, doit présenter un taux maximal de variation du courant prélevé du réseau de 1 mA/ms. Cette exigence ne s'applique pas:

1) en cours de transmission,
2) au cours des 20 premières ms après connexion de l’appareil à un réseau opérationnel,
3) au cours des 20 premières ms après mise sous tension du réseau, ou
4) lors de la déconnexion du réseau ou de la mise hors tension du réseau.

Un appareil doit porter un marquage indiquant son courant passif assigné. Un appareil ne doit pas prélever du réseau plus de 20 mA au-dessus de son courant assigné au cours de l'intervalle de temps de 500 µs à 20 ms après connexion de l’appareil à un réseau opérationnel ou 500 µs à 20 ms après mise sous tension du réseau.

NOTE 3 Les 500 premières µs sont exclues pour permettre le chargement des filtres RFI et autres capacités dans l’appareil. La spécification du taux de variation s'applique au bout de 20 ms.

Il convient que le courant maximal au cours de ces 500 premières µs ne soit pas supérieur à deux fois le courant maximal spécifié ci-dessus, afin de réduire les effets d'appels de courant sur les autres composantes du réseau de bus de terrain connecté.

NOTE 4 Ces exclusions permettent de générer un "délestage" au niveau des appareils alimentés par la même source au cours de cet intervalle d'exclusion.

NOTE 5 Ces exclusions peuvent augmenter de manière substantielle les exigences en courant de l'alimentation au cours de l'intervalle d'exclusion qui a lieu immédiatement après la mise sous tension du segment PhL.

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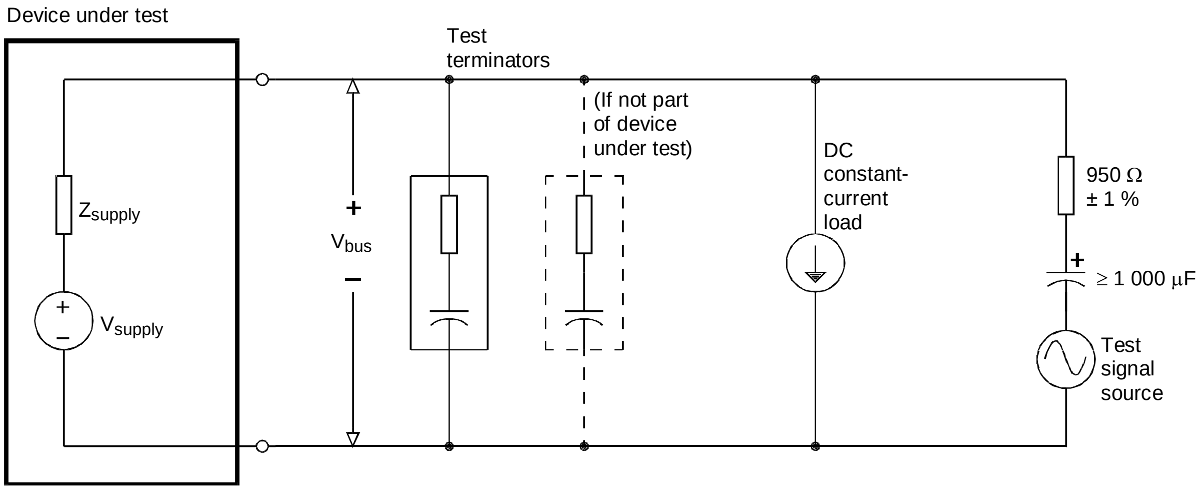
12.7.4 Impédance d'alimentation

L'alimentation utilisée pour fournir de l'énergie aux conducteurs de signaux doit être conforme aux valeurs d'impédance spécifiées en 12.7.4.1, 12.7.4.2, ou 12.7.4.3.

Il convient que les alimentations soient conçues de manière à tenir compte du courant de choc lors de la connexion de l'appareil ou à la mise sous tension, comme défini en 12.7.3.

12.7.4.1 Impédance des alimentations à sortie unique

L'impédance des alimentations à sortie unique doit être mesurée au moyen du circuit d'essai de la Figure 65.



Légende

Anglais	Français
Device under test	Appareil en essai
Z supply	Z alimentation
V supply	V alimentation
V bus	V bus
Test terminators	Terminateurs d'essai
(if not part of device under test)	(s'il ne fait pas partie de l'appareil en essai)
DC constant-current load	Charge de courant constant c.c.
Test signal source	Source de signal d'essai

Figure 65 – Circuit d'essai pour des alimentations à sortie unique

Les terminateurs d'essai présentés dans la Figure 65 doivent chacun avoir une valeur de 100 Ω± 1 % en série, avec 1 µF ± 5 %. Deux terminateurs d'essai doivent être utilisés dans le circuit d'essai si l'alimentation soumise à l'essai ne comporte pas un terminateur interne. Si l'alimentation soumise à l'essai comporte un terminateur interne qui est toujours connecté, un seul terminateur d'essai doit être utilisé dans le circuit d'essai. Si l'alimentation soumise à l'essai comporte un terminateur interne qui peut être facultativement connecté au circuit, l'alimentation doit être soumise à l'essai a) avec le terminateur interne et un terminateur d'essai, et b) avec deux terminateurs d'essai et pas de terminateur interne.

S'il est prévu d'utiliser l'alimentation avec un réseau externe à détermination de l'impédance (par exemple cela pourrait être le cas d'alimentations conçues pour être utilisées en redondance), l'alimentation doit être soumise à l'essai avec le réseau externe connecté.

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L'alimentation doit être soumise à l'essai à 20 %, 50 % et 80 % de son courant de sortie assigné (ou 20 mA, la valeur la plus grande étant retenue), avec application d'une charge à courant continu constante ayant une conformité d'au moins 1 mA/V (c'est-à-dire une impédance de $\geq$1 kΩ).

L'alimentation doit être soumise à l'essai en surveillant la tension continue du bus, $V_{BUS,}$ tout en appliquant une onde sinusoïdale de 10 V_{pk-pk} à partir d'une source de signal d'essai, à travers une résistance de 950 $\Omega \pm$ 1 % et un condensateur de couplage d'au moins 1 000 μF.

La tension alternative du bus mesurée, V_{BUS}, doit être conforme aux valeurs suivantes.

a) **Pour des alimentations non IS conçues pour fournir l'énergie à des barrières IS:** V_{BUS} doit être comprise entre 0,40 V_{pk-pk} et 0,60 V_{pk-pk} à toute fréquence de 50 Hz à 39 kHz.

b) **Pour des alimentations IS ainsi que pour des alimentations non IS qui ne sont pas destinées à fournir de l'énergie à des barrières IS:** V_{BUS} doit être comprise entre 0,40 V_{pk-pk} et 0,60 V_{pk-pk}, pour des fréquences de 3 kHz à 39 kHz, et elle ne doit pas croître ou décroître à un taux supérieur à 20 dB par décade, à toute fréquence de 50 Hz à 3 kHz.

NOTE Il est acceptable que les fonctions de l'alimentation et du terminateur soient combinées, à condition que la combinaison résultante soit électriquement équivalente aux appareils indépendants qui satisfont aux exigences de l'Article 12 et si les règles de configuration du réseau de 12.3 sont respectées.

Les alimentations qui ne sont pas conçues pour fournir de l'énergie à des barrières IS doivent porter un marquage indiquant "Ne pas utiliser avec des barrières IS".

12.7.4.2 Distribution de l'alimentation par l'intermédiaire d'une barrière IS

L'impédance de sortie de barrières de sécurité intrinsèque doit être définie en termes de caractéristiques en fonction de la fréquence lorsque la barrière est connectée au circuit d'essai de la Figure 66.

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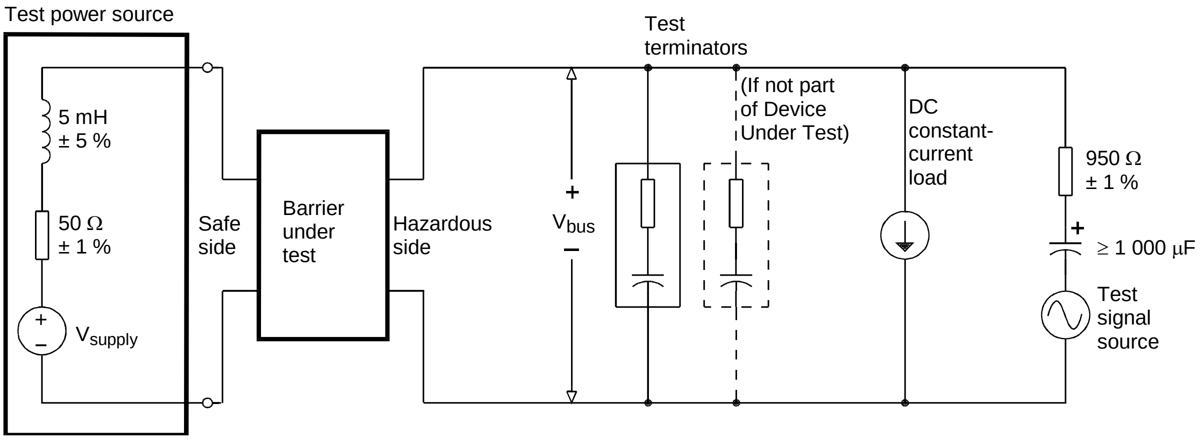

Légende

Anglais	Français
Test power source	Source d'alimentation d'essai
V supply	V alimentation
Safe side	Côté sûr
Barrier under test	Barrière en essai
Hazardous side	Côté dangereux
V bus	V bus
Test terminators	Terminateurs d'essai
(if not part of device under test)	(s'il ne fait pas partie de l'appareil en essai)
DC constant-current load	Charge de courant constant c.c.
Test signal source	Source de signal d'essai

Figure 66 – Circuit d'essai pour distribution de l'alimentation par l'intermédiaire d'une barrière IS

La source d'alimentation d'essai présentée à la Figure 66 est constituée d'une source de tension continue de faible impédance en série avec 5 mH ± 5 % et 50 Ω± 1 %. Les terminateurs d'essai doivent avoir chacun une valeur de 100 Ω± 1 % en série, avec 1 µF ± 5 %. Si la barrière comporte un terminateur interne, elle doit être soumise aux essais avec un terminateur d'essai. Dans le cas contraire, la barrière doit être soumise aux essais avec deux terminateurs d'essai.

La barrière doit être soumise à l'essai à 20 %, 50 % et 80 % de son courant de sortie assigné (ou 20 mA, la valeur la plus grande étant retenue), avec application d'une charge à courant continu constante ayant une conformité d'au moins 1 mA/V (c'est-à-dire une impédance de ≥1 kΩ).

La barrière doit être soumise à l'essai en surveillant la tension du bus, $V_{BUS,}$ tout en appliquant une onde sinusoïdale de 10 V_{pk-pk} à partir d'une source de signal d'essai, à travers une résistance de 950 Ω± 1 % et un condensateur de couplage d'au moins 1 000 µF.

La tension alternative du bus V_{BUS} mesurée du côté dangereux de la barrière doit être comprise entre 0,40 V_{pk-pk} et 0,60 V_{pk-pk}, pour des fréquences de 3 kHz à 39 kHz, et elle ne doit pas croître ou décroître à un taux supérieur à 20 dB par décade à toute fréquence de 50 Hz à 3 kHz.

NOTE Il est acceptable que les fonctions de l'alimentation, de la barrière IS et du terminateur soient combinées de diverses manières, à condition que la combinaison obtenue soit électriquement équivalente aux appareils indépendants qui satisfont aux exigences de l'Article 12 et si les règles de configuration du réseau de 12.3 sont respectées.

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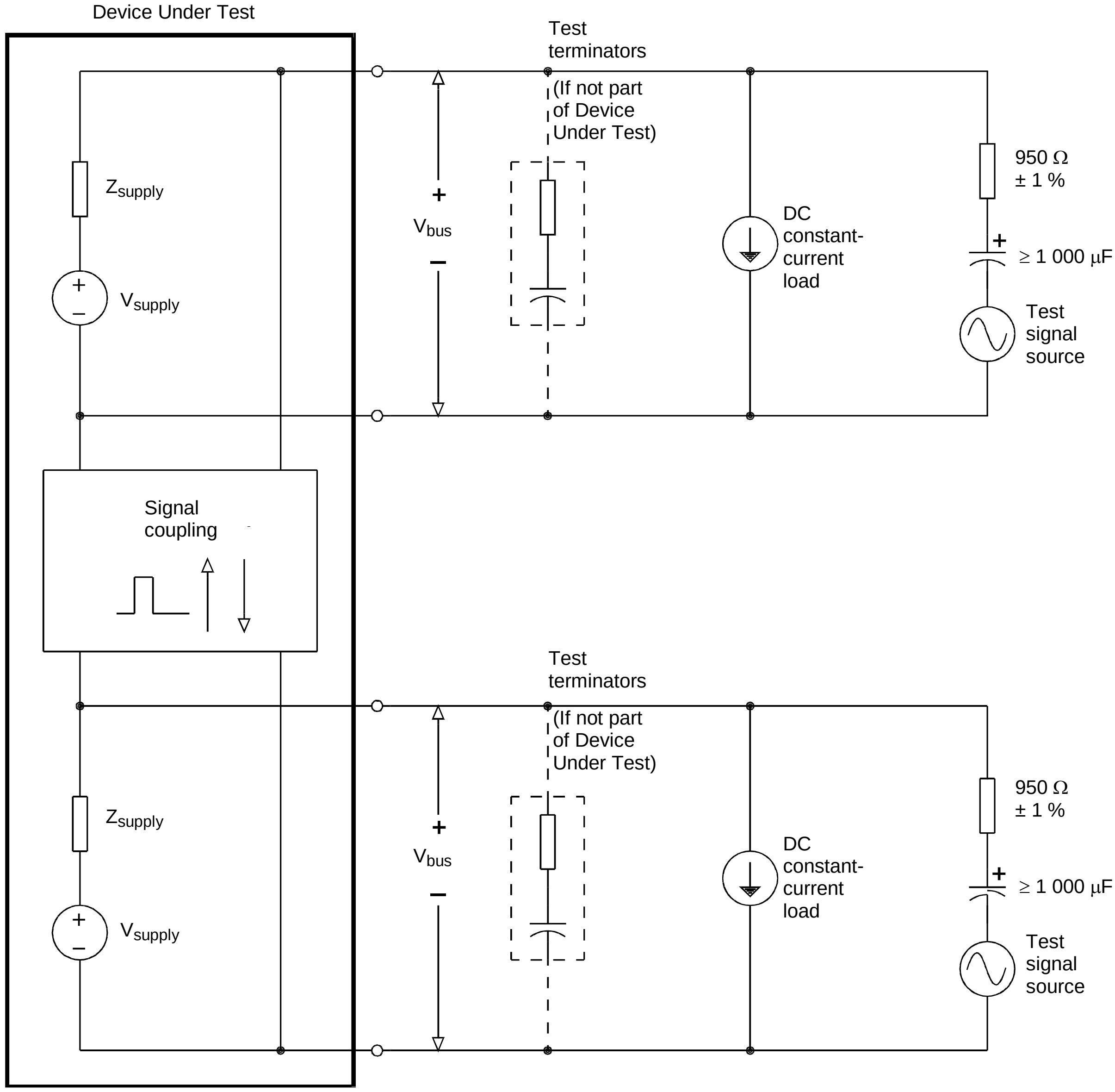
12.7.4.3 Impédance des alimentations à sorties multiples avec couplage du signal entre sorties

NOTE 1 Le Paragraphe 12.7.4.3 est applicable aux sectionneurs galvaniques, aux coupleurs actifs et aux autres appareils munis de plusieurs ports d'alimentation et de signaux.

Pour des alimentations à sorties multiples avec couplage du signal de communication du bus de terrain entre sorties, l'impédance d'alimentation doit être mesurée au moyen du circuit d'essai de la Figure 67.



Légende

Anglais	Français
Device under test	Appareil en essai
Z supply	Z alimentation
V supply	V alimentation
V bus	V bus
Test terminators	Terminateurs d'essai
(if not part of device under test)	(s'il ne fait pas partie de l'appareil en essai)
DC constant-current load	Charge de courant constant c.c.

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Anglais	Français
Test signal source	Source de signal d'essai
Signal coupling	Couplage du signal

Figure 67 – Circuit d'essai pour des alimentations à sorties multiples avec couplage du signal

Les terminateurs d'essai présentés dans la Figure 67 doivent chacun avoir une valeur de 100 Ω± 1 % en série, avec 1 μF ± 5 %. Deux terminateurs d'essai doivent être utilisés dans le circuit d'essai si l'appareil soumis à l'essai ne comporte pas un terminateur interne. Si l'appareil soumis à l'essai comporte un terminateur interne qui est toujours connecté, un seul terminateur d'essai doit être utilisé dans le circuit d'essai. Si l'appareil soumis à l'essai comporte un terminateur interne qui peut être facultativement connecté au circuit, l'appareil doit être soumis à l'essai a) avec le terminateur interne et un terminateur d'essai, et b) avec deux terminateurs d'essai et pas de terminateur interne.

S'il est prévu d'utiliser l'appareil soumis à l'essai avec un réseau externe à détermination de l'impédance (par exemple cela pourrait être le cas d'alimentations conçues pour être utilisées en redondance), l'alimentation doit être soumise à l'essai avec le réseau externe connecté.

L'appareil doit être soumis à l'essai à 20 %, 50 % et 80 % de son courant de sortie assigné (ou 20 mA, la valeur la plus grande étant retenue) à chaque sortie, avec application d'une charge à courant continu constante ayant une conformité d'au moins 1 mA/V (c'est-à-dire une impédance de ≥1 kΩ).

La tension alternative du bus mesurée, V_{BUS}, doit être comprise entre 0,40 V_{pk-pk} et 0,60 V_{pk-pk}, pour des fréquences de 3 kHz à 39 kHz, et elle ne doit pas croître ou décroître à un taux supérieur à 20 dB par décade, à toute fréquence de 50 Hz à 3 kHz.

NOTE 2 Il est acceptable que les fonctions de l'alimentation, du sectionneur ou du coupleur et du terminateur soient combinées de diverses manières, à condition que l'impédance de la combinaison obtenue soit équivalente à l'impédance parallèle d'appareils indépendants qui satisfont aux exigences de l'Article 12 et si les règles de configuration du réseau de 12.3 sont respectées.

12.7.5 Alimentation séparée à partir des conducteurs de signaux

NOTE La distribution de l'alimentation pour des appareils de bus de terrain non alimentés par le bus s'effectue au moyen de conducteurs séparés fournissant l'énergie à des alimentations locales, des régulateurs ou des barrières de sécurité. La certification IS peut exiger que ces conducteurs soient dans un câble séparé de celui des conducteurs de signaux et peut également imposer des exigences de niveau de courant plus strictes que celles qui sont spécifiées.

Un appareil de bus de terrain alimenté séparément ne doit pas prélever des conducteurs de signaux plus de 10 mA en courant continu et ne doit pas fournir plus de 100 μA en courant continu aux conducteurs de signaux, lorsqu'il n'y a pas de transmission. Un appareil doit porter un marquage indiquant son courant passif assigné prélevé du réseau.

12.7.6 Isolation électrique

Tous les appareils de bus de terrain, alimentés séparément ou par l'intermédiaire des conducteurs de signaux, doivent assurer une isolation basse fréquence entre la masse et le câble de ligne principale du bus de terrain.

NOTE 1 Ceci peut être réalisé en isolant l'ensemble de l'appareil de la masse au moyen d'un transformateur, d'un optocoupleur ou de tout autre organe d'isolation entre le câble de ligne principale et l'appareil.

Une alimentation et un élément de communication combinés ne doivent pas nécessiter d'isolation électrique.

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Pour les câbles blindés, l'impédance d'isolation mesurée entre le blindage du câble de bus de terrain et la masse de l'appareil de bus de terrain doit être supérieure à 250 kΩ à toutes les fréquences inférieures à 63 Hz.

La capacité dissymétrique maximale par rapport à la masse de toute borne d'entrée d'un appareil ne doit pas dépasser 250 pF.

Les exigences de claquage de l'isolation du circuit de signaux et du circuit de distribution de l'alimentation par rapport à la masse et par rapport à l'autre circuit doivent être conformes à la CEI 61131-2.

NOTE 2 Voir 11.7.5, Note 3.

12.8 Spécifications du support

12.8.1 Connecteur

Les éventuels connecteurs de câbles doivent être conformes à la présente norme (pour la transmission synchrone de Type 1, voir l'Annexe A et pour la transmission synchrone de Type 3, voir l'Annexe I). Des techniques de terminaison sur le terrain, comme par exemple les bornes à vis ou à lames ainsi que les terminaisons permanentes, peuvent également être utilisées.

12.8.2 Câble d'essai normalisé

Le câble utilisé pour les essais d'appareils de bus de terrain revendiquant la conformité aux exigences de l'Article 12, doit être un câble unique à paire torsadée, à blindage global, conforme aux exigences minimales suivantes, à une température de 25 °C:

a) impédance à une fréquence f_r (31,25 kHz) = 100 Ω ± 20 %;
b) affaiblissement maximal à une fréquence de 1,25 f_r (39 kHz) = 3,0 dB/km;
c) déséquilibre capacitif maximal par rapport au blindage = 4 nF/km, soumis à l'essai au moyen d'un échantillon d'une longueur minimale de 30 m;
d) résistance maximale en courant continu (par conducteur) = 24 Ω/km;
e) variation du délai maximal de propagation à une fréquence de 0,25 f_r à 1,25 f_r = 1,7 µs/km;
f) aire de la section des conducteurs (dimension des fils) = 0,8 mm^2, valeur nominale;
g) la couverture minimale du blindage doit être de 90 %.

La spécification ci-dessus concerne les essais de conformité d'une MAU. D'autres types de câbles peuvent être utilisés dans les installations réelles. (Voir Annexe B.) Les câbles à spécifications améliorées peuvent permettre de plus grandes longueurs de lignes principales ou une meilleure immunité aux perturbations ou encore il peut être exigé qu'ils satisfassent à des conditions d'environnement ou d'installation. En revanche, les câbles ayant des spécifications inférieures peuvent être utilisés, sous réserve d'une limitation des longueurs utilisées, tant pour les lignes principales que secondaires, auxquels s'ajoute une éventuelle non-conformité aux exigences de susceptibilité aux perturbations radioélectriques (RFI) et électromagnétiques (EMI).

Pour des applications de sécurité intrinsèque, il convient que le rapport inductance/résistance (L/R) soit inférieur à la limite spécifiée par l'organisme de réglementation local pour la mise en œuvre particulière.

12.8.3 Coupleur

Le coupleur doit fournir un ou plusieurs point(s) de connexion à la ligne principale. Il peut être intégré à l'appareil de bus de terrain, auquel cas il n'y a pas de ligne secondaire. Dans le cas contraire, il dispose d'au moins trois points d'accès comme présenté dans la Figure 68: un pour la ligne secondaire et un pour chaque côté de la ligne principale.

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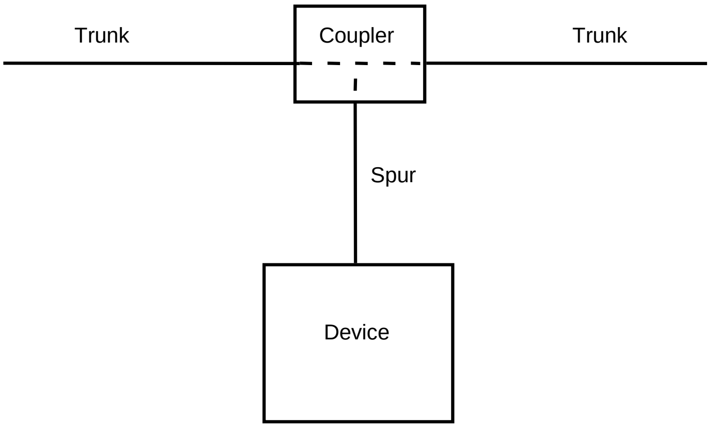


Légende

Anglais	Français
Trunk	Ligne principale
Coupler	Coupleur
Spur	Ligne secondaire
Device	Dispositif

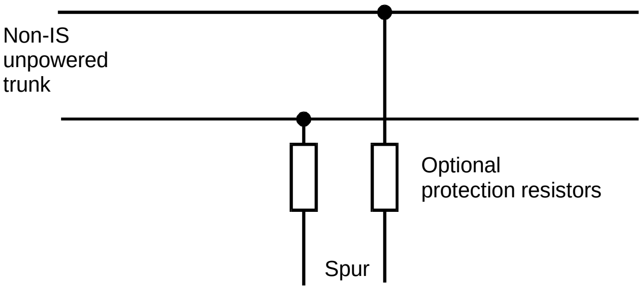
Figure 68 – Coupleur de bus de terrain

Un coupleur passif peut inclure un ou tous les éléments facultatifs décrits ci-dessous:

a) un transformateur assurant l'isolation galvanique et la transformation de l'impédance entre la ligne principale et la ligne secondaire;

b) des connecteurs facilitant le branchement à la ligne secondaire et/ou à la ligne principale.

c) des résistances de protection, comme illustré dans la Figure 69, pour protéger le trafic sur le bus entre d'autres appareils, des effets d'une ligne secondaire en court-circuit sur une ligne principale non alimentée et non de sécurité intrinsèque.



Légende

Anglais	Français
Non-IS unpowered trunk	Ligne principale non alimentée et non IS
Spur	Ligne secondaire
Optional protection resistors	Résistances de protection facultatives

Figure 69 – Résistances de protection

NOTE Ces résistances série augmentent de manière inhérente la tension aux bornes de l'appareil lorsqu'il est en émission. Ceci affecte la tension aux bornes de réception des appareils électriquement “voisins”. Voir 12.4.3 pour la tension de tenue maximale exigée de tous ces appareils.

Les coupleurs actifs qui nécessitent une alimentation externe, comportent des composantes d'amplification et de réémission des signaux. Le niveau de transmission et les exigences de synchronisation doivent être conformes à 12.3.

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12.8.4 Epissures

NOTE 1 Une épissure est toute partie du réseau dans laquelle l'impédance caractéristique du câble de réseau n'est pas maintenue. Ceci peut être dû à la séparation des conducteurs du câble, au retrait de blindage du câble, au changement de calibre ou de type de fil, à la connexion de lignes secondaires, à la fixation à des barrettes à bornes, etc. Une définition pratique d'une épissure est par conséquent toute partie du réseau qui n'est pas une longueur continue du support spécifié.

Pour des réseaux d'une longueur de câblage totale (ligne principale et lignes secondaires) supérieure à 400 m, la somme des longueurs de toutes les épissures ne doit pas dépasser 2,0 % de la longueur totale du câble. Pour des longueurs de câblage de 400 m ou moins, la somme des longueurs de toutes les épissures ne doit pas dépasser 8 m.

NOTE 2 Cette spécification est motivée par le fait qu'il est nécessaire de préserver la qualité de transmission en exigeant que le réseau soit presque entièrement constitué du support spécifié.

La continuité de tous les conducteurs du câble doit être maintenue dans une épissure.

12.8.5 Terminateur

Un terminateur doit être placé aux deux extrémités du câble de ligne principale et connecté d'un conducteur de signal à l'autre. Il ne doit y avoir aucune connexion entre terminateur et blindage du câble.

La valeur de l'impédance du terminateur doit être de 100 Ω – 2 Ω/+ 6 Ω sur la gamme de fréquences de 0,25 f_r à 1,25 f_r (7,8 kHz à 39 kHz). L'impédance du terminateur doit être équivalente à une résistance en série de 100 Ω avec une capacité de 1,0 μF. Les tolérances maximales des composants doivent être de 100 Ω ± 2 Ω et 1,0 μF ± 0,2 μF.

NOTE 1 Cette valeur d'impédance correspond approximativement à la valeur moyenne de l'impédance caractéristique du câble, pour les câbles appropriés, aux fréquences pertinentes, et elle est choisie pour réduire autant que possible les réflexions de la ligne de transmission.

Il convient que les composants du terminateur soient choisis de manière à satisfaire aux valeurs spécifiées sur la plage de température indiquée et pendant toute la durée de vie et de fonctionnement de l'installation. Il est recommandé que les caractéristiques assignées des composants à 25 °C soient de 100 Ω ± 1 Ω et 1 μF ± 0,1 μF.

Le courant continu de fuite à travers le terminateur ne doit pas dépasser 100 μA. Le terminateur doit être non polarisé.

Tous les terminateurs utilisés pour les applications IS doivent être conformes aux exigences d'isolation (lignes de fuite et distances d'isolement) en fonction de l'homologation IS requise. L'homologation IS ne doit pas être exigée pour des terminateurs destinés à des applications non IS.

NOTE 2 Il est acceptable que les fonctions de l'alimentation, de la barrière de sécurité et du terminateur soient combinées de diverses manières, à condition que l'impédance de la combinaison obtenue soit équivalente à l'impédance parallèle d'appareils indépendants qui satisfont aux exigences de l'Article 12 et si les règles de configuration du réseau de 12.3.3 sont respectées.

12.8.6 Règles de blindage

Lorsque la conformité aux exigences d'immunité au bruit de 12.5 est à réaliser au moyen d'un blindage, il est nécessaire d'assurer l'intégrité du blindage sur toute la longueur du câblage, dans les connecteurs et dans les coupleurs. Les règles suivantes peuvent aider au respect de ces exigences, mais ne constituent pas en soi une exigence:

a) il convient que le câble soit blindé sur plus de 90 % de sa longueur totale;
b) il convient que le blindage couvre complètement les circuits électriques des connecteurs, des coupleurs et des épissures.

NOTE 1 Toute dérogation à ces règles de blindage peut dégrader l'immunité au bruit.

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NOTE 2 Du fait des longueurs d'onde importantes, en général, les éventuelles ruptures de la couverture du blindage sur 25 cm à peu près au niveau des connecteurs, des coupleurs et des épissures, y compris les points de fixation des lignes secondaires, ne poseront pas de problèmes, à condition que la continuité du blindage soit maintenue.

NOTE 3 Les enveloppes de connecteurs, de coupleurs et d'épissures utilisant des boîtes de jonction métalliques peuvent assurer un blindage de protection contre les sources de bruit hors de la boîte de jonction.

12.8.7 Règles de mise à la masse (mise à la terre)

NOTE Mise à la masse (à la terre) signifie une connexion permanente à la terre par l'intermédiaire d'une impédance suffisamment basse et ayant un courant admissible suffisant pour prévenir un amorçage en tension qui pourrait entraîner des risques excessifs pour le matériel connecté ou les personnes.

Les appareils de bus de terrain doivent fonctionner conformément aux exigences de l'Article 12, le point médian d'un terminateur ou d'un coupleur inductif étant directement connecté à la masse.

Les appareils de bus de terrain ne doivent pas raccorder l'un des conducteurs de la paire torsadée à la masse quel que soit le point du réseau. Les signaux doivent être appliqués et préservés de manière différentielle sur l'ensemble du réseau. Les lignes de tension zéro (commun) peuvent être reliées à la masse lorsqu'elles sont galvaniquement isolées de la ligne principale du bus de terrain.

Il est habituel dans la pratique de mettre effectivement à la masse le blindage du câble de ligne principale de bus de terrain (le cas échéant) en un point sur la longueur du câble. De ce fait, il convient que les appareils de bus de terrain permettent une isolation c.c. du blindage du câble par rapport à la masse.

La pratique courante est également de raccorder les conducteurs de signaux à la masse de manière symétrique, au même point, en utilisant par exemple la prise médiane d'un terminateur ou d'un transformateur de couplage.

Pour des systèmes alimentés par le bus, il convient que la mise à la masse du blindage et des conducteurs de signaux équilibrés soit proche de l'unité d'alimentation.

Pour les systèmes IS, il convient que la mise à la masse soit effectuée au niveau de la connexion à la terre de la barrière de sécurité.

On peut, sous réserve de conformité aux exigences IS, avoir un couplage capacitif entre le blindage ou les conducteurs de signaux équilibrés et la mise à la masse locale de l'appareil pour une meilleure immunité aux interférences électromagnétiques.

12.8.8 Code de couleur des câbles

Voir 11.8.8.

Si les pratiques locales, telles que celles spécifiées en 11.8.8, le permettent, il est recommandé d'utiliser les couleurs de câble suivantes pour les systèmes de Type 3, comme présenté dans le Tableau 72.

Tableau 72 – Spécification des couleurs de câbles pour le Type 3

Paramètres du câble	Couleur
Couleur de gaine non IS	Noire
Couleur de gaine IS	Bande bleue ou bleue/noire
Couleur du conducteur intérieur du câble A (PA-)	Verte
Couleur du conducteur intérieur du câble B (PA+)	Rouge

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12.9 Sécurité intrinsèque

12.9.1 Généralités

La présente norme n'a pas pour ambition d'énumérer les exigences grâce auxquelles un équipement peut être certifié comme étant de sécurité intrinsèque et n'exige pas non plus que l'équipement soit de sécurité intrinsèque. Elle cherche plutôt à exclure les conditions ou situations qui pourraient empêcher la certification IS.

12.9.2 Barrière de sécurité intrinsèque

L'impédance de la barrière doit être supérieure à 460 Ω, à toute fréquence dans une plage de 0,25 f_r à 1,25 f_r (7,8 kHz à 39 kHz). La spécification de l'impédance de la barrière IS doit s'appliquer à toutes les barrières utilisées comme parties de PhL, qu'elles soient installées comme un élément séparé de matériel de réseau ou intégrées dans une carte d'alimentation. L'impédance de la barrière doit être mesurée entre les bornes des deux côtés de la barrière. L'impédance de la barrière doit être mesurée avec l'alimentation réseau réglée à la tension de service assignée (et non la tension de sécurité) de la barrière.

NOTE Il est acceptable que les fonctions de l'alimentation, de la barrière de sécurité et du terminateur soient combinées de diverses manières, à condition que l'impédance de la combinaison obtenue soit équivalente à l'impédance parallèle d'appareils indépendants qui satisfont aux exigences de l'Article 12 et si les règles de configuration du réseau de 12.3.3 sont respectées.

A la tension de service assignée de la barrière et à toute fréquence dans une gamme de 0,25 f_r à 1,25 f_r (7,8 kHz à 39 kHz), la capacité mesurée à la borne positive du réseau "+" (côté dangereux) et la masse ne doit pas s'écarter de plus de 250 pF par rapport à la capacité mesurée entre la borne négative du réseau "-" (côté dangereux) et la masse.

12.9.3 Mise en place de barrières et de terminateurs

Une barrière doit être séparée du terminateur le plus proche d'au maximum 100 m de câble.

12.10 Sectionneurs galvaniques

Les caractéristiques de communication des sectionneurs galvaniques utilisés sur le bus de terrain doivent satisfaire aux spécifications données en 12.4, 12.5 et 12.9. Les sectionneurs galvaniques alimentant les appareils de bus de terrain doivent également satisfaire aux spécifications d'alimentation de 12.7.

13 Type 1: Unité de liaison au support: mode courant, support câblé à paire torsadée

13.1 Généralités

La MAU en mode courant de 1,0 kbit/s fournit simultanément l'accès à un réseau de communication et à un réseau de distribution d'énergie. Les appareils raccordés au réseau communiquent par l'intermédiaire du support et peuvent ou non être alimentés par ce support. L'alimentation est distribuée comme un courant alternatif constant. Les signaux de communication sont superposés à l'alimentation en c.a.

Le support réseau est constitué d'un câble à paire torsadée blindé.

Des formes d'onde trapézoïdales sont utilisées pour réduire les émissions électromagnétiques et la distorsion des signaux.

Dans les applications de sécurité intrinsèque, la puissance disponible peut limiter le nombre d'appareils.

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Les appareils sont connectés en série sur le bus tandis que dans les variantes en mode tension, les appareils sont connectés au bus en parallèle.

13.2 Débit binaire de transmission

Le débit binaire moyen, BR± ΔBR, doit être de 1,0 Mbit/s ± 0,01 %, moyenné sur une trame ayant une longueur minimale de 16 octets. Le temps binaire instantané, $T_{bit} \pm \Delta T_{bit}$, doit être de 1,0 μs ± 0,025 μs.

13.3 Spécifications du réseau

13.3.1 Composants

Une MAU fonctionne sur un réseau constitué des composants suivants:

a) un câble;
b) des terminateurs;
c) des coupleurs;
d) des appareils (comportant au moins un élément de communication);

Un réseau filaire en mode courant peut en outre inclure les composants suivants:

e) des connecteurs;
f) des alimentations;
g) des appareils qui comprennent les alimentations;
h) des barrières de sécurité intrinsèque.

Le support réseau est constitué d'un câble à paire torsadée blindé. Indépendamment de la topologie, tous les appareils connectés, sauf éventuellement l'appareil de transmission, présentent une faible impédance pour éviter une surcharge importante du réseau.

13.3.2 Topologies

Une MAU câblée doit fonctionner sur un réseau de topologie de bus linéaire constitué d'une ligne principale, terminée à chaque extrémité comme spécifié en 13.8.5 et à laquelle des éléments de communication sont connectés par l'intermédiaire de coupleurs et de lignes secondaires.

Le coupleur et l'élément de communication peuvent être intégrés en un appareil (c'est-à-dire une ligne secondaire de longueur zéro).

Une topologie arborescente dont tous les éléments de communication sont placés aux extrémités de la ligne principale est considérée comme un cas particulier de bus aux fins de l'Article 13.

Plusieurs éléments de communication peuvent être connectés à la ligne principale en un point donné, en utilisant un coupleur multivoies. Un coupleur actif peut être utilisé pour étendre une ligne secondaire sur une longueur qui nécessite une terminaison afin d'éviter les réflexions et distorsions. Des répéteurs actifs peuvent être utilisés pour étendre la longueur de la ligne principale au-delà d'un segment unique si cela est autorisé par les règles de configuration du réseau.

13.3.3 Règles de configuration du réseau

Une MAU qui revendique la conformité à l'Article 13 doit satisfaire aux exigences de l'Article 13 lorsqu'elle est utilisée sur un réseau qui satisfait aux présentes règles.

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Règle 1: Un bus de terrain doit être capable de prendre en charge la communication d'un nombre d'appareils compris entre deux et 32, fonctionnant tous au même débit binaire, qu'il s'agisse d'un bus alimenté ou non alimenté et dans une zone dangereuse utilisant des barrières distribuées.

NOTE 1 L'utilisation d'une barrière unique dans la zone de sécurité peut limiter le nombre d'appareils dans une zone dangereuse.

NOTE 2 Cette règle n'exclut pas l'utilisation d'un nombre d'appareils supérieur à celui spécifié dans un système installé. Le nombre d'appareils a été calculé en supposant qu'un appareil alimenté par le bus prélève 100 mW.

Règle 2: Un segment de bus de terrain à pleine charge (comportant le nombre maximal d'appareils connectés) en mode courant doit avoir une longueur totale de câble, entre deux appareils quelconques, allant jusqu'à 750 m.

NOTE 3 Cette longueur maximale du câble de 750 m est l'exigence de conformité à l'Article 13 mais n'exclut pas l'utilisation de longueurs supérieures dans un système installé.

Règle 3: Le nombre total de régénérations de forme d'onde par des répéteurs et des coupleurs actifs entre deux appareils quelconques dépend de la mise en œuvre du répéteur concerné.

NOTE 4 Ce nombre total était limité à quatre dans les éditions précédentes de la présente norme.

Règle 4: Le délai maximal de propagation entre deux appareils quelconques ne doit pas dépasser 40 T_{bit}.

Pour que le réseau fonctionne efficacement, il convient que cette partie du temps de retournement de tout appareil du réseau, générée par une PhE entre la fin d'une trame reçue et le début d'une trame émise contenant une réponse immédiate associée, ne dépasse pas 5 temps binaires, dont il convient qu'au maximum 2 temps binaires soient dus à la MAU.

NOTE 5 Sachant qu'il n'est pas obligatoire d'exposer l'interface DLL – PhL ou l'interface MDS – MAU, cette partie du temps de retournement d'un appareil de bus de terrain due à la PhL ou à la MAU n'est pas spécifiée et donc non disponible pour des essais de conformité.

Règle 5: Le bus de terrain doit pouvoir continuer à fonctionner lorsqu'un appareil y est connecté ou déconnecté. Les erreurs de données générées lors de la connexion ou de la déconnexion doivent être détectées.

Règle 6: La défaillance de tout élément de communication ou de ligne secondaire (y compris un court circuit, ou un circuit ouvert mais à l'exception des bavardages) ne doit pas interférer avec les transactions entre d'autres éléments de communication pendant plus de 1 ms.

Règle 7: Le réseau ne doit pas être sensible à la polarité, avec ou sans énergie injectée sur la ligne.

Règle 8: La dégradation des caractéristiques électriques du signal, entre deux appareils quelconques, due à l'affaiblissement, à la distorsion d'affaiblissement et à la désadaptation doit être limitée aux valeurs indiquées ci-dessous.

a) Affaiblissement du signal: L'affaiblissement du signal dû à chaque appareil ne doit pas dépasser 0,2 dB. La configuration du bus (longueurs de la ligne principale et des lignes secondaires, nombre d'appareils, barrières IS, sectionneurs galvaniques et éventuels appareils d'adaptation) doit être telle que l'affaiblissement entre deux appareils quelconques, à la fréquence correspondant au débit binaire, ne doit pas dépasser 16 dB.

b) Distorsion d'affaiblissement: La configuration du bus (les longueurs de la ligne principale et des lignes secondaires ainsi que le nombre d'appareils) doit être telle qu'entre deux appareils quelconques:

   [Affaiblissement (1,25 f_r) – Affaiblissement (0,25 f_r)] ≤ 6 dB

   Affaiblissement (1,25 f_r) ≥ Affaiblissement (0,25 f_r)

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où f_r est la fréquence correspondant au débit binaire. L'affaiblissement doit être monotonique pour toutes les fréquences de 0,25 f_rà 1,25 f_r (250 kHz à 1,25 MHz).

c) Distorsion de désadaptation: La désadaptation (due à des lignes secondaires ou à tout autre effet, y compris une ligne secondaire de longueur maximale en circuit ouvert) sur le bus doit être telle qu'en tout point sur la ligne principale, dans la bande de fréquence comprise entre 0,25 f_r et 1,25 f_r(250 kHz à 1,25 MHz):

$$|Z – Zfr| / |Z + Zfr| \leq 0,2$$

où

Z_o est l'impédance caractéristique du câble de ligne principale;

Z est la combinaison parallèle de Z_o et de l'impédance de charge au niveau du coupleur.

NOTE 6 Cette règle permet de réduire les restrictions, en termes de longueurs de la ligne principale et des lignes secondaires ainsi qu'en termes de nombre d'appareils, etc. en ne spécifiant que des limites de transmission imposées par des combinaisons de ces facteurs. Il est possible d'utiliser différentes combinaisons en fonction des besoins de l'application.

Règle 9: Les règles suivantes doivent s'appliquer aux systèmes mis en œuvre avec des supports redondants:

a) chaque canal (câble) doit satisfaire aux règles de configuration du réseau;

b) il ne doit pas y avoir de segment non redondant entre deux segments redondants;

c) les répéteurs doivent également être redondants;

d) si le système est configuré (par la Gestion systèmes) pour émettre sur plusieurs canaux simultanément, la différence de délai de propagation entre deux appareils quelconques sur deux canaux quelconques ne doit pas dépasser cinq temps binaires;

e) les numéros de canaux doivent être maintenus sur l'ensemble des bus de terrain, c'est-à-dire que les canaux 1, 2, 3... en provenance de la Gestion systèmes doivent toujours être connectés aux canaux physiques 1, 2, 3...

13.3.4 Règles de distribution de l'alimentation pour la configuration du réseau

Voir 11.3.4.

13.4 Spécification du circuit de transmission de la MAU

Les exigences de 13.4 sont résumées dans le Tableau 73 et dans le Tableau 74.

Tableau 73 – Récapitulatif de la spécification du niveau de transmission de la MAU

Caractéristiques du niveau de transmission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 70)	Limites (alimentation par le bus et/ou IS)
Niveau de sortie (crête à crête, voir la Figure 57) Avec charge d'essai (>2 × de Z_o nominale du câble de ligne principale)	≥2,5 V 320 Ω± 1 %
Différence d'amplitude positive et négative maximale (biais de la signalisation) telle qu'illustrée dans la Figure 58	±0,2 V
Niveau de sortie; circuit ouvert (crête à crête)	≤4,0 V
Distorsion maximale du signal de sortie; c'est-à-dire surtension, suroscillation et statisme (voir la Figure 57)	±10 %
Sortie d'émetteur passif, c'est-à-dire bruit de l'émetteur (mesuré sur la bande de fréquence de 1 kHz à 4 MHz)	≤1 mV (eff.)

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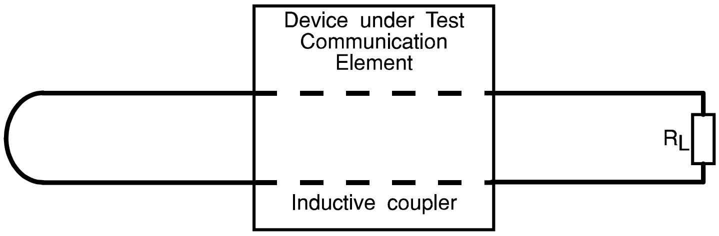
Tableau 74 – Récapitulatif de la spécification de synchronisation de transmission de la MAU

Caractéristiques de synchronisation de l'émission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 70)	Limites (alimentation par le bus et/ou IS)
Débit binaire de transmission	1 Mbit/s ± 0,01 %
Temps binaire instantané	1 µs ± 0,025 µs
Temps de croissance et de décroissance (10 % à 90 % du signal crête à crête, voir la Figure 57)	≤ 20 % T_{bit}
Taux de dérive (en tout point de 10 % à 90 % du signal crête à crête)	≤40,0 V/µs
Instabilité de bit élémentaire maximale émise (écart du point de passage par zéro, voir la Figure 58)	± 2,5 % T_{bit}
Délai d'activation/désactivation de transmission (c'est-à-dire durée pendant laquelle la forme d'onde de sortie peut ne pas satisfaire aux exigences de transmission)	≤ 2,0 T_{bit}

13.4.1 Configuration d'essai

La Figure 70 illustre la configuration qui doit être utilisée pour les essais.



Légende

Anglais	Français
Device Under test communication element	Dispositif à l'essai Elément de communication
Inductive coupler	Coupleur inductif

Figure 70 – Configuration d'essai d'une MAU en mode courant

La configuration d'essai de l'Article 13 doit être comme présentée dans la Figure 70 sauf spécification contraire dans une exigence particulière.

NOTE Résistance de la charge d'essai R = 320 Ω (deux fois la valeur Z_o maximale du câble) la sortie étant chargée par une boucle série de la ligne principale.

13.4.2 Exigences de niveau de sortie

NOTE La Figure 57 présente un exemple de cycle de forme d'onde de bus de terrain, illustrant certains éléments-clés de la spécification du circuit de transmission. Seules les tensions des signaux sont indiquées; ce schéma ne tient aucunement compte des tensions d'alimentation.

Un circuit de transmission de MAU en mode courant doit être conforme aux exigences de niveau de sortie suivantes, toutes les amplitudes étant mesurées au point médian estimé entre toute crête ou creux en haut et en bas de la forme d'onde ("point médian" dans la Figure 57):

a) la tension de sortie sur la charge d'essai après élévation/abaissement par le transformateur ne doit pas être inférieure à 2,5 V crête à crête avec une résistance de charge de 320 Ω± 1 % ("sortie min" dans la Figure 57);

b) la tension de sortie au niveau de la ligne principale ou aux bornes de transmission, avec toute charge comprenant un circuit ouvert, ne doit pas dépasser 4,0 V crête à crête ("max.

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o/c ligne principale" dans la Figure 57). Aux fins de l'essai, un circuit ouvert doit être défini comme étant une charge ayant une résistance de 100 kΩ en parallèle avec une capacité de 15 pF;

c) au cours d'une émission, un appareil donné ne doit pas subir de défaillance permanente lorsqu'une résistance de charge de ≤1 Ω est appliquée pendant 1 s;

d) la différence entre amplitude positive et amplitude négative, mesurée comme présenté dans la Figure 57, ne doit pas dépasser ±0,2 V crête;

e) le bruit en sortie d'une MAU en mode courant qui est en réception ou non alimentée ne doit pas dépasser 1 mV eff., mesuré de manière différentielle sur la bande de fréquence de 1 kHz à 4 MHz, en référence à la ligne principale;

f) la tension différentielle sur la charge d'essai doit donner une modification monotonique de la tension, entre 10 % et 90 % de la valeur crête à crête. Par la suite, la tension du signal ne doit pas varier de plus de ±10 % de la valeur crête à crête jusqu'à ce que la transition suivante ait lieu. Cette variation admissible doit inclure toutes les formes de distorsion de signal de sortie, c'est-à-dire la surtension, la suroscillation et le statisme.

13.4.3 Exigences de synchronisation des sorties

Le circuit de transmission d'une MAU en mode courant doit être conforme aux exigences suivantes de synchronisation des sorties:

a) les temps de croissance et de décroissance, mesurés de 10 % à 90 % de l'amplitude du signal crête à crête, ne doivent pas dépasser 0,2 T_{bit} (voir la Figure 57);

b) le taux de dérive, mesuré en tout point dans une plage de 10 % à 90 % de l'amplitude du signal crête à crête, ne doit pas dépasser 40 V/µs (voir la Figure 57).

NOTE 1 Les exigences a) et b) génèrent une forme d'onde trapézoïdale à la sortie du circuit de transmission. L'exigence b) limite le niveau des émissions de perturbation qui peuvent être couplées aux circuits adjacents, etc. L'exigence b) est calculée à partir de la formule suivante:

$$\text{Taux de dérive max} = 3 \times \text{taux de dérive min} = 3 \times 0{,}8\ V_o / 0{,}2\ T = 12 \times V_o / T_{bit},$$

où V_o est une estimation de la tension de sortie maximale crête à crête avec une charge normalisée (3,3 V).

c) l'instabilité de bit élémentaire émise ne doit pas dépasser ±0,025 du temps binaire nominal par rapport au point de passage par zéro idéal, mesuré en fonction du point de passage par zéro précédent (voir la Figure 71);

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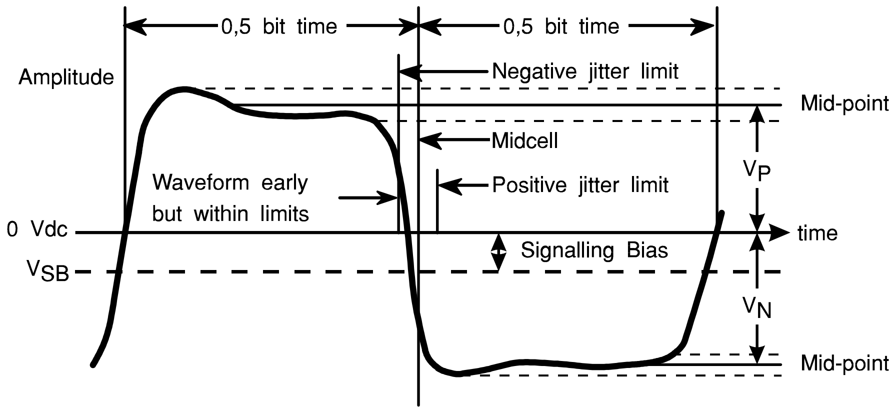

Légende

Anglais	Français
0,5 bit time	0,5 temps binaire
Amplitude	Amplitude
Negative Jitter Limit	Limite d'instabilité négative
Mid-point	Point médian
Waveform early but within limits	Forme d'onde précoce mais dans les limites
Midcell	à mi cellule (bit élémentaire)
Positive Jitter Limit	Limite d'instabilité positive
Signalling Bias	Biais de la signalisation
Time	Temps

Figure 71 – Instabilité de bit élémentaire émis et reçu (écart du point de passage par zéro)

d) le circuit de transmission doit s'activer, ce qui signifie que le signal doit monter d'un niveau inférieur au bruit de sortie maximal du circuit de transmission, comme spécifié en 13.4.2 e), jusqu'au niveau de pleine puissance, en moins de 2,0 T_{bit}. La forme d'onde correspondant au troisième temps binaire et au-delà, doit être telle que spécifiée dans d'autres paragraphes de 13.4;

e) le circuit de transmission doit se désactiver, ce qui signifie que le signal doit tomber, en moins de 2,0 T_{bit}, du niveau de pleine puissance à un niveau inférieur au bruit de sortie maximal du circuit de transmission, comme spécifié en 13.4.2 e). La durée nécessaire pour que le circuit de transmission revienne à son impédance d'état "non actif" ne doit pas dépasser 4,0 T_{bit}. Aux fins des essais, les exigences doivent être satisfaites dans la configuration d'essai du circuit de transmission de 13.4.1, avec la capacité équivalente d'une longueur de câble maximale entre les bornes de l'appareil en essai.

NOTE 2 Cette exigence permet de s'assurer que la capacité de la ligne a été pleinement déchargée lors de la transition du circuit de transmission de l'état actif à l'état passif.

13.5 Spécification du circuit de réception de la MAU

13.5.1 Généralités

Pour faciliter le renvoi aux textes correspondants, les exigences définies en 13.4 sont résumées dans le Tableau 75.

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Tableau 75 – Récapitulatif de la spécification du circuit de réception

Caractéristiques du circuit de réception (valeurs en référence à la ligne principale)	Limites (alimentation par le bus et/ou IS)
Impédance d'entrée, mesurée sur la gamme de fréquences 0,25 f_rà 1,25 f_r	≤2,5 Ω
Sensibilité; signal min. crête à crête dont l'acceptation est exigée (voir la Figure 60)	1,3 Ma
Suppression du bruit; bruit max. crête à crête dont le rejet est exigé (voir la Figure 60)	0,8 Ma
Instabilité de bit élémentaire maximale reçue (écart du point de passage par zéro, (voir la Figure 71)	±0,10 T_{bit}

13.5.2 Impédance d'entrée

L'impédance d'entrée différentielle d'un circuit de réception de MAU en mode courant ne doit pas dépasser 2,5 Ω en série avec la phase sur la gamme de fréquences de 0,25 f_rà 1,25 f_r (250 kHz à 1,25 MHz). Cette exigence doit être satisfaite à l'état hors tension et sous tension (sans émission) ainsi que pendant la transition entre ces états. L'impédance doit être mesurée au niveau du coupleur inductif au moyen d'une forme d'onde de courant sinusoïdale d'une amplitude de signal supérieure au seuil de sensibilité du récepteur et inférieure à 20 mA crête à crête.

NOTE L'exigence d'une impédance d'entrée ≤2,5 Ω pendant la mise sous tension et hors tension peut être satisfaite par désactivation automatique de l'émetteur au cours de ces périodes.

13.5.3 Sensibilité du récepteur et suppression du bruit

Un circuit de réception de MAU doit être capable de recevoir un signal d'entrée de 1,3 mA crête à crête à 20,0 mA crête à crête, y compris la surtension et l'oscillation (voir "niveau du signal" ainsi que "amplitude positive" et "amplitude négative" dans la Figure 57).

Le circuit de réception de MAU ne doit pas répondre à un signal d'entrée ayant une amplitude crête à crête de courant de ligne ne dépassant pas 0,8 mA (voir "suppression du bruit" dans la Figure 60).

13.5.4 Instabilité de bit élémentaire reçu

Le circuit de réception doit accepter un signal codé Manchester émis conformément à 13.2 et à 13.4. En outre, le récepteur doit fonctionner correctement à des signaux ayant des variations temporelles, entre deux points adjacents quelconques de transition des signaux (passage par zéro) d'au maximum ±0,10 Tbit. Voir la Figure 71.

NOTE 1 Cette spécification n'exclut pas l'utilisation de récepteurs dont les performances sont supérieures à la présente spécification.

NOTE 2 En fonction de la configuration du symbole, la durée nominale entre passages par zéro est d'un demi temps binaire ou d'un temps binaire.

NOTE 3 Il n'y a aucune exigence quant au rejet d'un signal donné ayant une valeur de variation temporelle spécifiée. Le récepteur rend compte d'une erreur lorsque l'instabilité du bit élémentaire reçu dépasse l'aptitude du récepteur à décoder la signalisation de manière fiable.

13.5.5 Susceptibilité au brouillage et taux d'erreurs

Lorsque le bus de terrain fonctionne dans divers environnements de bruit normalisés, il convient que la probabilité qu'une unité de données utilisateur de couche Application contienne une erreur non détectée, du fait du fonctionnement des entités physiques et DLL d'acheminement, soit inférieure à 1 sur 10^{12} (1 erreur en 20 années à 1 600 messages/s).

Un élément de communication est considéré conforme à cette exigence théorique lorsqu'il satisfait aux exigences suivantes de susceptibilité au brouillage. Ces exigences sont

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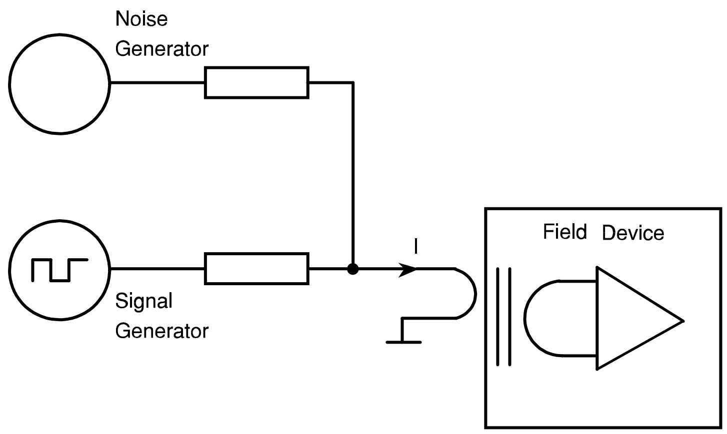
spécifiées sur la base d'un taux d'erreur de trame détecté obtenu en utilisant un rapport d'erreurs détectées/non détectées de 10^6.

NOTE 1 Ceci est facilement réalisable au moyen d'une séquence de contrôle de trame de 16 bits au niveau de la DLL.

Un élément de communication qui inclut une MAU en mode courant, utilisant des trames contenant 64 bits de données utilisateur aléatoires, à un débit de trame maximal et avec des signaux dune amplitude de 4,0 mA crête à crête, ne doit pas produire plus de trois erreurs de trame détectées sur 3×10^6 trames pendant son fonctionnement en présence d'une tension en mode commun ou de bruit gaussien comme décrit ci-après:

a) un signal sinusoïdal en mode commun à toute fréquence de 63 Hz à 2 MHz, d'une amplitude de 4 V eff. et de 47 Hz à 63 Hz avec une amplitude de 250 V eff.;
b) un signal c.c. en mode commun de ±10 V;
c) un bruit blanc gaussien différentiel additionnel dans la bande de fréquence de 1 kHz à 4 MHz, avec une densité de bruit de 0,09 μA/√Hz eff. en utilisant le circuit d'essai de la Figure 72.

NOTE 2 Les valeurs spécifiées pour la tension en mode commun et le bruit gaussien correspondent à des essais de conformité de circuit de réception avec des charges symétriques et ne sont pas représentatives d'une quelconque pratique d'installation de système.



Légende

Anglais	Français
Noise generator	Générateur de bruit
Signal generator	Générateur de signaux
Field device	Dispositif de terrain

Figure 72 – Circuit d’essai du bruit d'une MAU en mode courant

Un élément de communication qui inclut une MAU en mode courant, utilisant des trames contenant 64 bits de données utilisateur aléatoires, à une moyenne de 1 600 messages/s, avec des signaux d'une amplitude de 4,0 mA crête à crête, ne doit pas produire plus de six erreurs de trame détectées sur 100 000 trames, lorsqu'il est utilisé dans des environnements de perturbations électromagnétiques ou électriques comme décrit ci-après:

1) champ électromagnétique de 10 V/m, comme spécifié dans la CEI 61000-4-3 au niveau de sévérité 3;
2) transitoires électriques rapides, comme spécifié dans la CEI 61000-4-4 au niveau de sévérité 3.

Le taux d'erreur spécifié ci-dessus doit également être réalisé après, mais non pendant le fonctionnement dans les environnements de bruit suivants:

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i) décharge électrostatique de 8 kV sur une structure métallique exposée, comme spécifié dans la CEI 61000-4-2, au niveau de sévérité 3. Si l'appareil subit une perte temporaire de fonctions ou de performances suite à cet essai, il doit récupérer de cette perte éventuelle sans intervention de l'opérateur, dans les 3 s qui suivent la fin de l'essai;

ii) essais de perturbation à haute fréquence, comme spécifié dans la CEI 60255-22-1:1988, classe III de tension d'essai (2,5 kV et 1 kV de valeurs crêtes de la première demi-alternance, respectivement en mode longitudinal et transversal). Si l'appareil subit une perte temporaire de fonctions ou de performances du fait de cet essai, il doit récupérer de cette perte éventuelle sans intervention de l'opérateur, dans les 3 s qui suivent la fin de l'essai.

13.6 Inhibition du bavardage

La MAU doit comporter une capacité d'interruption automatique pour empêcher les signaux émis d'atteindre le support. Le matériel dans la MAU (sans message extérieur autre que la détection des signaux de sortie ou de fuite par la fonction de transmission) doit fournir une fenêtre d'une durée comprise entre 5 ms et 15 ms au cours de laquelle une trame normale peut être émise. Si la longueur de trame dépasse cette durée, la fonction d'inhibition du bavardage doit empêcher d'autres signaux en sortie d'atteindre le support et doit désactiver l'écho sur la ligne RxS (voir 10.2.2.2) pour indiquer à la MDS la détection de bavardage.

La MAU doit réinitialiser la fonction d'interruption automatique après une période de 500 ms ± 50 %.

NOTE Ceci inhibe le trafic sur le bus pendant au maximum 6 % (= 15/250) du temps disponible.

13.7 Distribution de l'alimentation

13.7.1 Généralités

Un appareil peut, en option, recevoir son alimentation par l'intermédiaire des conducteurs de signaux ou être alimenté de manière séparée.

Un appareil peut être certifié comme étant de sécurité intrinsèque quelle que soit la méthode d'alimentation.

La présente norme n'inclut pas d'exigences pour la certification IS mais cherche à exclure des conditions ou situations qui pourraient empêcher la certification IS.

Un appareil à alimentation séparée peut être connecté à un bus de terrain alimenté.

Pour faciliter le renvoi aux textes correspondants, les exigences définies en 13.7 sont résumées dans le Tableau 76.

Tableau 76 – Exigences d'alimentation réseau

Exigences d'alimentation réseau	Limites
Courant de sortie	50 mA à 200 mA eff.
Fréquence de sortie	16 kHz ± 0,5 %
Tension de sortie maximale, IS	En fonction des caractéristiques assignées de la barrière
Taux d'harmoniques du courant d'alimentation	≤ 0,2 %
Impédance d'entrée, mesurée sur la gamme de fréquences 0,25 f_r à 1,25 f_r	≤ 5 Ω

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13.7.2 Alimentation par l'intermédiaire de conducteurs de signaux

Un appareil doit fonctionner sur une plage de courant constante de 50 mA à 200 mA.

NOTE La tension de sortie de l'alimentation dépend des pertes dues au câble et de la puissance consommée par chaque appareil.

Un appareil de bus de terrain peut être conçu pour consommer une ou plusieurs charges normalisées. Une charge normalisée est égale à 100 mW.

La tension de sortie en circuit ouvert de l'alimentation doit être inférieure à la limite spécifiée par l'organisme de réglementation local pour la mise en œuvre particulière. L'impédance de sortie de l'alimentation doit être ≤5 Ω sur la gamme de fréquences de 0,25 f_r à 1,25 f_r (250 kHz à 1,25 MHz).

La fuite de tension dans le coupleur de signaux doit être inférieure à 0,1 V à une fréquence de 16 kHz.

La fuite de tension dans les terminaisons doit être inférieure à 0,3 V à une fréquence de 16 kHz.

La forme d'onde d'alimentation doit être une sinusoïde pure d'une fréquence de 16 kHz ± 0,5 % et ayant un taux d'harmoniques maximal de 0,2 %.

L'appareil ne doit pas introduire, dans la ligne principale, de composantes harmoniques de la fréquence industrielle supérieure à 1,0 mV crête à crête entre phases.

13.7.3 Alimentation séparée des signaux

NOTE La distribution de l'alimentation pour des appareils de bus de terrain non alimentés par le bus s'effectue au moyen de conducteurs séparés fournissant l'énergie à des alimentations locales, des régulateurs ou des barrières de sécurité. La certification IS peut exiger que ces conducteurs soient dans un câble séparé de celui des conducteurs de signaux et peut également imposer des exigences de niveau de courant plus strictes que celles qui sont spécifiées.

Un appareil de bus de terrain alimenté séparément, revendiquant la conformité à l'Article 13 ne doit pas provoquer de chute de tension supérieure à 1 mV eff, à la fréquence industrielle sur les conducteurs de signaux, et ne doit pas fournir un courant de plus de 100 µA eff aux conducteurs de signaux, lorsqu'il n'y a pas de transmission.

13.7.4 Isolation électrique

Tous les appareils de bus de terrain, alimentés séparément ou par l'intermédiaire des conducteurs de signaux, doivent assurer une isolation basse fréquence entre la masse et le câble de ligne principale du bus de terrain.

NOTE 1 Ceci est possible en utilisant un coupleur inductif ayant une isolation suffisante, en isolant l'ensemble de l'appareil de la masse ou au moyen d'un transformateur, d'un optocoupleur ou de tout autre organe d'isolation entre le câble de ligne principale et l'appareil.

Une alimentation et un élément de communication combinés ne doivent pas nécessiter d'isolation électrique.

L'impédance d'isolation mesurée entre le blindage du câble de bus de terrain et la masse de l'appareil de bus de terrain doit être supérieure à 250 kΩ à toutes les fréquences inférieures à 63 Hz.

L'isolation doit être contournée par une capacité à des fréquences élevées, de façon à ce que l'impédance mesurée entre le blindage du câble du bus de terrain et la masse de l'appareil de bus de terrain soit inférieure à 15 Ω entre 3 MHz et 30 MHz.

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NOTE 2 La capacité entre la masse et le blindage du câble de ligne principale nécessaire pour satisfaire à ces exigences peut prendre toute valeur comprise entre 3,5 nF et 10,6 nF.

La capacité dissymétrique maximale par rapport à la masse de toute borne d'entrée d'un appareil ne doit pas dépasser 250 pF.

Les exigences de claquage de l'isolation du circuit de signaux et du circuit de distribution de l'alimentation par rapport à la masse et par rapport à l'autre circuit doivent être conformes à la CEI 61131-2.

La tension d'essai équivalente est à appliquer entre circuits isolés indépendants ou entre circuits isolés et parties conductrices accessibles.

NOTE 3 Pour des circuits de tension nominale ≤ 50 V c.c. ou efficace, les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 444 V eff., 635 V c.c. et 635 V crête. Pour des circuits de tension nominale comprise entre 150 V et 300 V eff., les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 2260 V eff., 3175 V c.c. et 3175 V crête.

13.8 Spécifications du support

13.8.1 Connecteur

Si des connecteurs de câbles sont utilisés, ils doivent être conformes à la norme de bus de terrain correspondante de la CEI (voir l'Annexe A). Des techniques de terminaison sur le terrain, comme par exemple les bornes à vis ou à lames ainsi que les terminaisons permanentes, peuvent également être utilisées.

13.8.2 Câble d'essai normalisé

Le câble utilisé pour les essais d’appareils de bus de terrain avec une MAU en mode courant, destinés à vérifier la conformité aux exigences de l'Article 13, doit être un câble unique à paire torsadée, à blindage global, conforme aux exigences minimales suivantes, à une température de 25 °C:

a) Z_0 à une fréquence de 0,25 f_r (250 kHz) = 150 Ω± 10 %;

b) Z_0 à une fréquence de 1,25 f_r (1,25 MHz) = 150 Ω± 10 %;

c) affaiblissement maximal à une fréquence de 0,25 f_r (250 kHz) = 6,5 dB/km;

d) affaiblissement maximal à une fréquence de 1,25 f_r (1,25 MHz) = 13 dB/km;

e) déséquilibre capacitif maximal par rapport au blindage = 1,5 nF/km

f) résistance maximale en courant continu (par conducteur) = 57,1 Ω/km;

g) aire de la section des conducteurs (dimension des fils) = 0,33 mm^2, valeur nominale;

h) résistivité minimale entre chaque conducteur et le blindage = 16 GΩ/km;

i) la couverture minimale du blindage doit être de 95 %.

La spécification ci-dessus concerne les essais de conformité d'une MAU. D'autres types de câbles peuvent être utilisés dans les installations réelles. (Voir l'Annexe B.) Les câbles à spécifications améliorées peuvent permettre l'utilisation de longueurs de ligne principale plus importantes et/ou une meilleure immunité aux perturbations. En revanche, les câbles ayant des spécifications inférieures peuvent être utilisés, sous réserve d'une limitation des longueurs utilisées, tant pour les lignes principales que secondaires, auxquels s'ajoute une éventuelle non-conformité aux exigences de susceptibilité aux perturbations radioélectriques (RFI) et électromagnétiques (EMI).

Pour des applications de sécurité intrinsèque, il convient que le rapport inductance/résistance (L/R) soit inférieur à la limite spécifiée par l'organisme de réglementation local pour la mise en œuvre particulière.

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13.8.3 Coupleur

Un coupleur inductif connecte un appareil ou une ligne secondaire à la ligne principale. Il assure l'échange des signaux de données avec l'appareil et peut transférer l'alimentation à l'appareil. Le câble de ligne principale fonctionne comme une spire primaire unique du transformateur du coupleur inductif. On peut admettre les options suivantes:

a) le couplage peut être réalisé sans violation de l'isolation du câble;
b) le coupleur inductif peut être utilisé comme connecteur;
c) un élément de barrière IS peut être inclus comme partie intégrante du coupleur inductif.

Le coupleur doit faire partie intégrante de la MAU si l'appareil est connecté à la ligne principale. L'impédance d'entrée du coupleur doit avoir une valeur maximale de 2,5 Ω en série avec la phase.

13.8.4 Epissures

NOTE Une épissure est toute partie du réseau dans laquelle l'impédance caractéristique du câble de réseau n'est pas maintenue. Ceci peut être dû à la séparation des conducteurs du câble, au retrait de blindage du câble, au changement de calibre ou de type de fil, à la connexion de lignes secondaires, etc. Une définition pratique d'une épissure est par conséquent toute partie du réseau qui n'est pas une longueur continue du support spécifié.

La continuité de tous les conducteurs du câble doit être maintenue dans une épissure.

13.8.5 Terminateur

Un terminateur doit être placé aux deux extrémités du câble de ligne principale et connecté d'un conducteur de signal à l'autre. Il ne doit y avoir aucune connexion entre terminateur et blindage du câble.

Pour les besoins de l'essai, en utilisant le câble spécifié en 13.8.2, le terminateur doit avoir une valeur d'impédance de 120 Ω± 2 % sur la gamme de fréquences de 0,25 f_r à 1,25 f_r(250 kHz à 1,25 MHz).

NOTE 1 La valeur de la résistance du terminateur a été choisie pour être inférieure à la valeur de l'impédance caractéristique du câble d'essai car les appareils en mode courant ajoutent des impédances série au terminateur. La valeur a été choisie pour réduire les réflexions de la ligne de transmission pour un bus de terrain comportant 2 à 32 appareils.

NOTE 2 Dans des applications pratiques, lorsque l'alimentation est fournie via les conducteurs de signaux, le terminateur serait contourné aux fréquences industrielles afin de réduire les pertes de puissance.

Le courant continu de fuite à travers le terminateur ne doit pas dépasser 100 μA. Le terminateur doit être non polarisé.

Tous les terminateurs utilisés pour les applications IS doivent être conformes aux exigences d'isolation (lignes de fuite et distances d'isolement) en fonction de l'homologation IS requise. L'homologation IS ne doit pas être exigée pour des terminateurs destinés à des applications non IS.

13.8.6 Règles de blindage

Pour une entière conformité aux exigences d'immunité au bruit de 13.5, l'intégrité du blindage doit être assurée sur toute la longueur du câblage, dans les connecteurs et dans les coupleurs, de la manière suivante:

a) la couverture du blindage doit être supérieure à 95 % de la longueur totale du câble;
b) le blindage doit couvrir complètement les circuits électriques des connecteurs, des coupleurs et des épissures.

NOTE Toute dérogation à ces règles de blindage peut dégrader l'immunité au bruit.

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13.8.7 Règles de mise à la masse

NOTE Mise à la masse signifie une connexion permanente à la terre par l'intermédiaire d'une impédance suffisamment basse et ayant un courant admissible suffisant pour prévenir un amorçage en tension qui pourrait entraîner des risques excessifs pour le matériel connecté ou les personnes.

Les lignes de tension zéro (commun) peuvent être reliées à la masse lorsqu'elles sont galvaniquement isolées de la ligne principale du bus de terrain.

Les appareils de bus de terrain doivent fonctionner conformément aux exigences de l'Article 13, le point médian d'un terminateur ou d'un coupleur inductif étant directement connecté à la masse.

Les appareils de bus de terrain ne doivent pas raccorder l'un des conducteurs de la paire torsadée à la masse, quel que soit le point du réseau. Les signaux doivent être appliqués et préservés de manière différentielle sur l'ensemble du réseau.

Il est habituel dans la pratique de mettre effectivement à la masse le blindage du câble de ligne principale de bus de terrain (le cas échéant) en un point sur la longueur du câble. De ce fait, il convient que les appareils de bus de terrain permettent une isolation c.c. du blindage du câble par rapport à la masse.

Pour des systèmes alimentés par le bus, il convient que la mise à la masse du blindage et des conducteurs de signaux équilibrés soit proche de l'unité d'alimentation.

Pour les systèmes IS, il convient que la mise à la masse soit effectuée au niveau de la connexion à la terre de la barrière de sécurité. On peut, sous réserve de conformité aux exigences IS, avoir un couplage capacitif entre le blindage ou les conducteurs de signaux équilibrés et la mise à la terre locale de l’appareil pour une meilleure immunité aux interférences électromagnétiques.

13.8.8 Code de couleur des câbles

Voir 11.8.8.

14 Type 1: Unité de liaison au support: mode courant (1 A), support câblé à paire torsadée

14.1 Généralités

Une MAU en mode courant de 1,0 Mbit/s fournit simultanément l'accès à un réseau de communication et à un réseau de distribution d'énergie ayant une capacité d'alimentation étendue. Les appareils raccordés au réseau communiquent par l'intermédiaire du support et peuvent ou non être alimentés par ce support. L'alimentation est distribuée comme un courant alternatif constant d'une fréquence bien inférieure à la fréquence des signaux. Les signaux de communication sont superposés à l'alimentation en c.a.

Le support réseau est constitué d'un câble à paire torsadée blindé.

Dans des applications de zone dangereuse, un bus non IS peut disposer de barrières IS intégrées aux appareils connectés, ce qui permet d'augmenter le nombre d’appareils autorisés dans la zone dangereuse sur une configuration de barrière unique.

Les appareils sont connectés en série sur le bus tandis que dans les variantes en mode tension, les appareils sont connectés au bus en parallèle.

14.2 Débit binaire de transmission

Voir 13.2.

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14.3 Spécifications du réseau

14.3.1 Composants

Une MAU fonctionne sur un réseau constitué des composants suivants:

a) câble;
b) terminateurs;
c) des coupleurs;
d) montages pour coupleurs;
e) appareils (comportant au moins un élément de communication);

Un réseau filaire en mode courant peut en outre inclure les composants suivants:

f) des connecteurs;
g) des alimentations;
h) des appareils qui comprennent les alimentations;
i) des barrières de sécurité intrinsèque (IS).

Le support réseau est constitué d'un câble à paire torsadée blindé. Indépendamment de la topologie, tous les appareils connectés, sauf éventuellement l'appareil de transmission, présentent une faible impédance pour éviter une surcharge importante du réseau.

Un montage de coupleur est un élément du réseau qui permet de connecter un coupleur au support réseau. Il peut être considéré comme un enroulement primaire de transformateur (coupleur inductif) et, en tant que tel, il a des caractéristiques électriques qui affectent le réseau.

14.3.2 Topologies

Une MAU câblée doit fonctionner sur un réseau de topologie de bus linéaire constitué d'une ligne principale, terminée à chaque extrémité comme spécifiée en 14.8.5 et à laquelle des éléments de communication sont connectés par l'intermédiaire de coupleurs.

Le coupleur et l'élément de communication peuvent être intégrés en un appareil (comme par exemple une ligne secondaire de longueur zéro).

Plusieurs éléments de communication peuvent être connectés à la ligne principale en un point donné, en utilisant un coupleur multivoies. Un coupleur actif peut être utilisé pour étendre une ligne secondaire sur une longueur qui nécessite une terminaison afin d'éviter les réflexions et distorsions. Des répéteurs actifs peuvent être utilisés pour étendre la longueur de la ligne principale au-delà d'un segment unique si cela est autorisé par les règles de configuration du réseau.

14.3.3 Règles de configuration du réseau

Une MAU qui revendique la conformité à l'Article 14 doit satisfaire aux exigences de l'Article 14 lorsqu'elle est utilisée sur un réseau qui satisfait aux présentes règles.

Règle 1: Un bus de terrain doit être capable de prendre en charge la communication d'un nombre d'appareils compris entre deux et trente, fonctionnant tous au même débit binaire, qu'il s'agisse d'un bus alimenté ou non alimenté et dans une zone dangereuse utilisant des barrières distribuées.

NOTE 1 Cette règle n'exclut pas l'utilisation d'un nombre d'appareils supérieur à celui spécifié dans un système installé. Le nombre d'appareils a été calculé en supposant qu'un appareil alimenté par le bus prélève 1,0 W.

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Règle 2: Un segment de bus de terrain à pleine charge (comportant le nombre maximal d'appareils connectés) en mode courant doit avoir une longueur totale de câble, entre deux appareils quelconques, allant jusqu'à 400 m.

NOTE 2 Cette longueur maximale du câble de 400 m est l'exigence de conformité à l'Article 14 mais n'exclut pas l'utilisation de longueurs supérieures dans un système installé.

Règle 3: Le nombre total de régénérations de forme d'onde par des répéteurs et des coupleurs actifs entre deux appareils quelconques dépend de la mise en œuvre du répéteur concerné.

NOTE 3 Ce nombre total était limité à cinq dans les éditions précédentes de la présente norme.

Règle 4: Le délai maximal de propagation entre deux appareils quelconques ne doit pas dépasser 40 Tbit.

Pour que le réseau fonctionne efficacement, il convient que cette partie du temps de retournement de tout appareil du réseau, générée par une PhE entre la fin d'une trame reçue et le début d'une trame émise contenant une réponse immédiate associée, ne dépasse pas cinq temps binaires, dont il convient qu'au maximum deux temps binaires soient dus à la MAU.

NOTE 4 Sachant qu'il n'est pas obligatoire d'exposer l'interface DLL – PhL ou l'interface MDS – MAU, cette partie du temps de retournement d'un appareil de bus de terrain due à la PhL ou à la MAU n'est pas spécifiée et donc non disponible pour des essais de conformité.

Règle 5: Le bus de terrain doit pouvoir continuer à fonctionner lorsqu'un appareil y est connecté ou déconnecté. Les erreurs de données générées lors de la connexion ou de la déconnexion doivent être détectées.

Règle 6: La défaillance de tout élément de communication ou de ligne secondaire (y compris un court circuit, ou un circuit ouvert mais à l'exception des bavardages) ne doit pas interférer avec les transactions entre d'autres éléments de communication pendant plus de 1 ms.

Règle 7: Le réseau ne doit pas être sensible à la polarité, avec ou sans énergie injectée sur la ligne.

Règle 8: La dégradation des caractéristiques électriques du signal, entre deux appareils quelconques, due à l'affaiblissement, à la distorsion d'affaiblissement et à la désadaptation doit être limitée aux valeurs indiquées ci-dessous.

a) Affaiblissement du signal: l'affaiblissement du signal dû à chaque appareil ne doit pas dépasser 0,35 dB. L'affaiblissement du signal dû à chaque montage de coupleur, qu'il soit plein ou vide, ne doit pas dépasser 0,6 dB. La configuration du bus (longueurs de la ligne principale et des lignes secondaires, nombre d'appareils, barrières IS, sectionneurs galvaniques et éventuels appareils d'adaptation) doit être telle que l'affaiblissement entre deux appareils quelconques, à la fréquence correspondant au débit binaire, ne doit pas dépasser 10 dB.

   NOTE 5 L'affaiblissement du signal dû à un appareil est calculé avec un câble d'une impédance caractéristique de 80 Ω. Si un câble d'impédance plus faible est utilisé, l'affaiblissement par appareil augmentera.

   Il sera exigé que les appareils soient connectés au bus au moyen d'un montage pour atteindre le nombre maximal d'appareils connectés.

b) Distorsion d'affaiblissement: La configuration du bus (les longueurs de la ligne principale et des lignes secondaires ainsi que le nombre d'appareils) doit être telle qu'entre deux appareils quelconques:

   [Affaiblissement (1,25 f_r) – Affaiblissement (0,25 f_r)] ≤ 6 dB

   Affaiblissement (1,25 f_r) ≥ Affaiblissement (0,25 f_r)

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où f_r est la fréquence correspondant au débit binaire. L'affaiblissement doit être monotonique pour toutes les fréquences de 0,25 f_r à 1,25 f_r (250 kHz à 1,25 MHz).

c) Distorsion de désadaptation: La désadaptation (due à des lignes secondaires ou à tout autre effet, y compris une ligne secondaire de longueur maximale en circuit ouvert) sur le bus doit être telle qu'en tout point sur la ligne principale, dans la bande de fréquence comprise entre 0,25 f_r et 1,25 f_r (250 kHz à 1,25 MHz):

$$|Z - Z_{fr}| / |Z + Z_{fr}| \leq 0,2$$

où

Z_o est l'impédance caractéristique du câble de ligne principale;

Z est la combinaison série de Z_o et de l'impédance de charge au niveau du coupleur.

NOTE 6 Cette règle permet de réduire les restrictions, en termes de longueurs de la ligne principale et des lignes secondaires ainsi qu'en termes de nombre d'appareils, etc. en ne spécifiant que des limites de transmission imposées par des combinaisons de ces facteurs. Il est possible d'utiliser différentes combinaisons en fonction des besoins de l'application.

Règle 9: Les règles suivantes doivent s'appliquer aux systèmes mis en œuvre avec des supports redondants:

a) chaque canal (câble) doit satisfaire aux règles de configuration du réseau;

b) il ne doit pas y avoir de segment non redondant entre deux segments redondants;

c) les répéteurs doivent également être redondants;

d) si le système est configuré (par la Gestion systèmes) pour émettre sur plusieurs canaux simultanément, la différence de délai de propagation entre deux appareils quelconques sur deux canaux quelconques ne doit pas dépasser cinq temps binaires;

NOTE 7 Ce délai est égal à la valeur par défaut de la dérive du signal entre canaux (voir 9.2.9). La différence de temps de propagation peut être plus importante si le paramètre de dérive du signal entre canaux est établi de manière à correspondre à cette différence.

e) les numéros de canaux doivent être maintenus sur l'ensemble des bus de terrain, c'est-à-dire que les canaux 1, 2, 3... en provenance de la gestion système doivent toujours être connectés aux canaux physiques 1, 2, 3...

14.3.4 Règles de distribution de l'alimentation pour la configuration du réseau

Voir 11.3.4.

14.4 Spécification du circuit de transmission de la MAU

Les exigences de 14.4 sont résumées dans le Tableau 77 et dans le Tableau 78.

Tableau 77 – Récapitulatif de la spécification du niveau de transmission de la MAU en mode courant

Caractéristiques du niveau de transmission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 70)	Limites (alimentation par le bus et/ou IS)
Niveau de sortie (crête à crête, voir la Figure 57) Avec charge d'essai (>2 × de Z_o nominale du câble de ligne principale)	≥2,25 V 160 Ω± 1 %
Distorsion maximale du signal de sortie; c'est-à-dire surtension, suroscillation et statisme (voir la Figure 57)	±10 %
Sortie d'émetteur passif, c'est-à-dire le bruit de l'émetteur (mesuré sur la bande de fréquence de 1 kHz à 4 MHz)	≤1 mV (eff.)

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Tableau 78 – Récapitulatif de la spécification de la synchronisation de l'émission de la MAU en mode courant

Caractéristiques du niveau de transmission, valeurs en référence à la ligne principale (mais mesurées en utilisant la charge d'essai présentée dans la Figure 70)	Limites (alimentation par le bus et/ou IS)
Débit binaire de transmission	1 Mbit/s ± 0,01 %
Temps binaire instantané	1 µs ± 0,025 µs
Temps de croissance et de décroissance (10 % à 90 % du signal crête à crête, voir la Figure 57)	≤ 20 % T_{bit}
Taux de dérive (en tout point de 10 % à 90 % du signal crête à crête)	≤200,0 V/µs
Instabilité de bit élémentaire maximale émise (écart du point de passage par zéro, voir la Figure 73)	± 2,5 % T_{bit}
Le délai d'activation/désactivation de transmission (c'est-à-dire la durée pendant laquelle la forme d'onde de sortie peut ne pas satisfaire aux exigences de transmission)	≤ 2,0 T_{bit}

14.4.1 Configuration

La Figure 70 illustre la configuration qui doit être utilisée pour les essais.

La configuration d'essai de l'Article 14 doit être comme présentée dans la Figure 70 sauf spécification contraire dans une exigence particulière.

NOTE Résistance de la charge d'essai R_L = 160 Ω ± 1 %, la sortie étant chargée par une boucle série de la ligne principale.

14.4.2 Exigences de niveau de sortie

NOTE La Figure 57 présente un exemple de cycle de forme d'onde de bus de terrain, illustrant certains éléments-clés de la spécification du circuit de transmission. Seules les tensions des signaux sont indiquées; ce schéma ne tient aucunement compte des tensions d'alimentation.

Un circuit de transmission de MAU en mode courant doit être conforme aux exigences de niveau de sortie suivantes, toutes les amplitudes étant mesurées au point médian estimé entre toute crête ou creux en haut et en bas de la forme d'onde ("point médian" dans la Figure 57):

a) la tension de sortie sur la charge d'essai après élévation/abaissement par le transformateur ne doit pas être inférieure à 2,25 V crête à crête avec une résistance de charge de 160 Ω ± 1 % (“min. o/p” dans la Figure 57);
b) au cours d'une émission, un appareil donné ne doit pas subir de défaillance permanente lorsqu'une résistance de charge de ≤1 Ω est appliquée pendant 1 s;
c) le bruit en sortie d'une MAU en mode courant qui est en réception ou non alimentée ne doit pas dépasser 1 mV (efficace), mesuré de manière différentielle sur la bande de fréquence de 100 kHz à 4 MHz, en référence à la ligne principale;
d) la tension différentielle sur la charge d'essai doit donner une modification monotonique de la tension, entre 10 % et 90 % de la valeur crête à crête. Par la suite, la tension du signal ne doit pas varier de plus de ±10 % de la valeur crête à crête jusqu'à ce que la transition suivante ait lieu. Cette variation admissible doit inclure toutes les formes de distorsion de signal de sortie, telles que la surtension, la suroscillation et le statisme.

14.4.3 Exigences de synchronisation des sorties

Le circuit de transmission de MAU doit être conforme aux exigences suivantes de synchronisation des sorties:

a) les temps de croissance et de décroissance, mesurés de 10 % à 90 % de l'amplitude du signal crête à crête, ne doivent pas dépasser 0,2 (voir la Figure 57);

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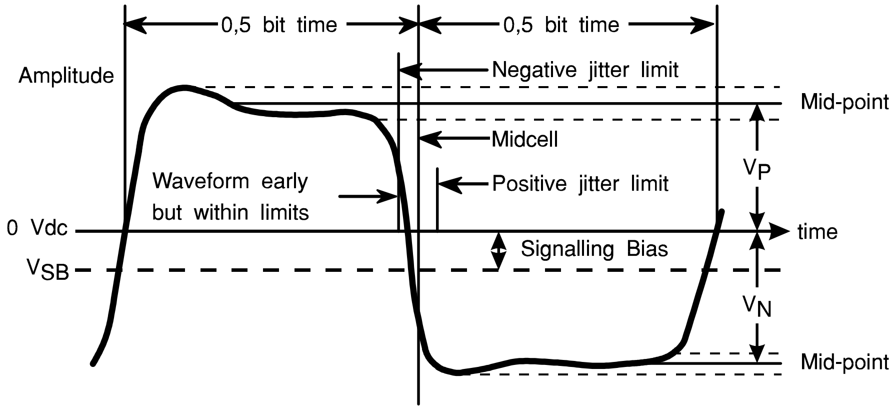
b) le taux de dérive, mesuré en tout point dans une plage de 10 % à 90 % de l'amplitude du signal crête à crête, ne doit pas dépasser 200,0 V/µs (voir la Figure 57).

L'instabilité de bit élémentaire émise ne doit pas dépasser ±0,025 Tbit par rapport au point de passage par zéro idéal, mesuré en fonction du point de passage par zéro précédent (voir la Figure 73);



Légende

Anglais	Français
0,5 bit time	0,5 temps binaire
Amplitude	Amplitude
Negative Jitter Limit	Limite d'instabilité négative
Mid-point	Point médian
Waveform early but within limits	Forme d'onde précoce mais dans les limites
Midcell	à mi cellule (bit élémentaire)
Positive Jitter Limit	Limite d'instabilité positive
Signalling Bias	Biais de la signalisation
Time	Temps

Figure 73 – Instabilité de bit élémentaire émis et reçu (écart du point de passage par zéro)

d) le circuit de transmission doit s'activer, ce qui signifie que le signal doit monter d'un niveau inférieur au bruit de sortie maximal du circuit de transmission, comme spécifié en 14.4.2 c), jusqu'au niveau de pleine puissance, en moins de 2,0 Tbit. La forme d'onde correspondant au troisième temps binaire et au-delà, doit être telle que spécifiée dans d'autres paragraphes de 14.4;

e) le circuit de transmission doit se désactiver, ce qui signifie que le signal doit tomber, en moins de 2,0 Tbit, du niveau de pleine puissance à un niveau inférieur au bruit de sortie maximal du circuit de transmission, comme spécifié en 14.4.2 c). La durée nécessaire pour que le circuit de transmission revienne à son impédance d'état "non actif" ne doit pas dépasser 4,0 Tbit. Aux fins des essais, cette exigence doit être satisfaite dans la configuration d'essai du circuit de transmission décrite en 14.4.1.

NOTE Cette exigence permet de s'assurer que la capacité de la ligne a été pleinement déchargée lors de la transition du circuit de transmission de l'état actif à l'état passif.

14.5 Spécification du circuit de réception de la MAU

14.5.1 Généralités

Les exigences de 14.5 sont résumées dans le Tableau 79.

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L'impédance d'entrée du circuit de réception peut être inductive. Pour éviter que la partie résistive de l'impédance devienne trop élevée, l'impédance d'entrée totale maximale et la résistance d'entrée maximale sont spécifiées dans le Tableau 79.

Tableau 79 – Récapitulatif de la spécification du circuit de réception de la MAU en mode courant

Caractéristiques du circuit de réception (valeurs en référence à la ligne principale)	Limites en mode courant (alimentation par le bus et/ou IS)
Résistance d'entrée, mesurée sur la gamme de fréquences 0,25 f_r à 1,25 f_r (250 kHz à 1,25 MHz)	≤0,5 Ω
Sensibilité; signal min. crête à crête dont l'acceptation est exigée (voir la Figure 60)	4,0 mA
Suppression du bruit; bruit max. crête à crête dont le rejet est exigé (voir la Figure 60)	2,0 mA
Instabilité de bit élémentaire maximale reçue (écart du point de passage par zéro, (voir la Figure 71)	±0,10 T_{bit}
Impédance d'entrée, mesurée sur la gamme de fréquences 0,25 f_rà 1,25 f_r (250 kHz à 1,25 MHz)	≤4,0 Ω

14.5.2 Impédance d'entrée

La résistance d'entrée différentielle d'un circuit de réception de MAU en mode courant ne doit pas dépasser 0,5 Ω, et l'impédance d'entrée différentielle d'un circuit de réception de MAU en mode courant ne doit pas dépasser 4,0 Ω en série avec la phase sur la fréquence de 0,25 f_r à 1,25 f_r (250 kHz à 1,25 MHz). Cette exigence doit être satisfaite à l'état hors tension et sous tension (sans émission), ainsi que pendant la transition entre ces états. L'impédance doit être mesurée au niveau du coupleur inductif, au moyen d'une forme d'onde de courant sinusoïdale d'une amplitude de signal supérieure au seuil de sensibilité du récepteur et inférieure à 20 mA crête à crête.

14.5.3 Sensibilité du récepteur et suppression du bruit

Un circuit de réception de MAU doit être capable de recevoir un signal d'entrée de 4,0 mA crête à crête à 20,0 mA crête à crête, y compris la surtension et l'oscillation (voir "niveau du signal" ainsi que "amplitude positive" et "amplitude négative" dans la Figure 57).

Le circuit de réception de MAU ne doit pas répondre à un signal d'entrée ayant une amplitude crête à crête de courant de ligne ne dépassant pas 2,0 mA (voir "suppression du bruit" dans la Figure 60).

14.5.4 Instabilité de bit élémentaire reçu

Le circuit de réception doit accepter un signal codé Manchester émis conformément à 14.2 et à 14.4. En outre, le récepteur doit fonctionner correctement à des signaux ayant des variations temporelles, entre deux points adjacents quelconques de transition des signaux (passage par zéro) d'au maximum ±0,10 Tbit. Voir Figure 73.

NOTE 1 Cette spécification n'exclut pas l'utilisation de récepteurs dont les performances sont supérieures à la présente spécification.

En fonction de la configuration du symbole, la durée nominale entre passages par zéro peut être d'un demi temps binaire ou d'un temps binaire.

NOTE 2 Il n'y a aucune exigence quant au rejet d'un signal donné ayant une valeur de variation temporelle spécifiée. Le récepteur rend compte d'une erreur lorsque l'instabilité de bit élémentaire reçue excède l'aptitude du récepteur à décoder la signalisation de manière fiable.

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14.5.5 Susceptibilité au brouillage et taux d'erreurs

Voir 13.5.5.

14.6 Inhibition du bavardage

Voir 13.6.

14.7 Distribution de l'alimentation

14.7.1 Généralités

Un appareil peut, en option, recevoir son alimentation par l'intermédiaire des conducteurs de signaux ou être alimenté de manière séparée.

Un appareil peut être certifié comme étant de sécurité intrinsèque quelle que soit la méthode d'alimentation.

NOTE 1 La présente norme n'inclut pas d'exigences pour la certification de la sécurité intrinsèque mais cherche à exclure des conditions ou situations qui pourraient empêcher la certification de la sécurité intrinsèque.

Un appareil à alimentation séparée peut être connecté à un bus de terrain alimenté.

NOTE 2 Pour faciliter le renvoi aux textes correspondants, les exigences définies en 14.7 sont résumées dans le Tableau 80.

Tableau 80 – Exigences d'alimentation réseau

Exigences d'alimentation réseau	Limites
Courant de sortie	1,0 A eff. ± 5 %
Fréquence de sortie	16 kHz ± 0,5 %
Taux d'harmoniques et bruit du courant d'alimentation	Voir Figure 74
Impédance de sortie, mesurée sur la gamme de fréquences 0,25 f_r à 1,25 f_r (250 kHz à 1,25 MHz)	≤5 Ω

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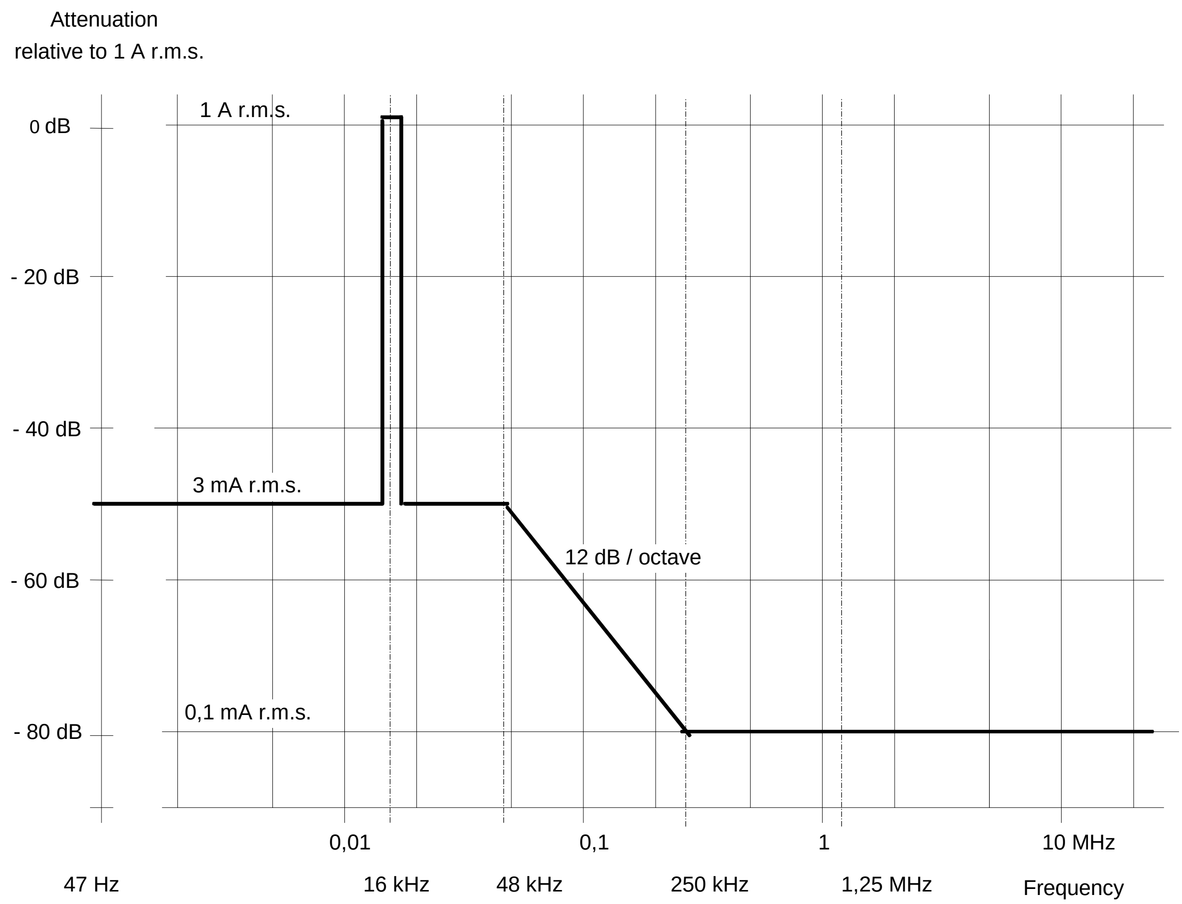

Légende

Anglais	Français
Attenuation relative to 1 Ar.m.s	Affaiblissement pour 1 A eff.
Ar.ms	A eff.
Frequency	Fréquence

Figure 74 – Taux d'harmoniques et bruit de l'alimentation

14.7.2 Alimentation par l'intermédiaire de conducteurs de signaux

Un appareil de bus de terrain qui revendique la conformité à l'Article 14 et qui est alimenté via les conducteurs de signaux doit satisfaire aux exigences de l'Article 14 lorsqu'il est alimenté par une source ayant les spécifications suivantes.

a) Le courant de sortie de l'alimentation doit être de 1,0 A eff. ± 5 %.

NOTE 1 La tension de sortie de l'alimentation dépend des pertes dues au câble et de la puissance consommée par chaque appareil.

Un appareil de bus de terrain peut être conçu pour consommer une ou plusieurs charges normalisées. Une charge normalisée est égale à 1,0 W.

NOTE 2 La tension de sortie en circuit ouvert de l'alimentation sera inférieure à la limite spécifiée par l'organisme de réglementation local pour la mise en œuvre particulière.

b) L'impédance de sortie de l'alimentation doit être ≤5 Ω sur la gamme de fréquences de 0,25 f_r à 1,25 f_r (250 kHz à 1,25 MHz).

c) La forme d'onde de l'alimentation doit être une sinusoïde dont la fréquence ainsi que le taux d'harmoniques maximal et le bruit sont les suivants:

1) 0,1 mA eff. sur la gamme de fréquences de 0,25 f_r à 1,25 f_r (250 kHz à 1,25 MHz);

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2) 3,0 mA eff. sur la gamme de fréquences de 47 Hz à 48 kHz, à l'exception de 16 kHz ± 0,5 %;

3) des niveaux, à d'autres fréquences, conformément à la Figure 74.

L'appareil ne doit pas introduire, dans la ligne principale, de composantes harmoniques de la fréquence industrielle supérieure à 15μA eff.

14.7.3 Alimentation séparée des signaux

NOTE La distribution de l'alimentation pour des appareils de bus de terrain non alimentés par le bus s'effectue au moyen de conducteurs séparés fournissant l'énergie à des alimentations locales, des régulateurs ou des barrières de sécurité. La certification IS peut exiger que ces conducteurs soient dans un câble séparé de celui des conducteurs de signaux et peut également imposer des exigences de niveau de courant plus strictes que celles qui sont spécifiées.

Un appareil de bus de terrain alimenté séparément, revendiquant la conformité à l'Article 14 ne doit pas provoquer de chute de tension supérieure à 200 mV eff, à la fréquence industrielle sur les conducteurs de signaux, et ne doit pas fournir un courant de plus de 100 μA eff aux conducteurs de signaux, lorsqu'il n'y a pas de transmission.

14.7.4 Isolation électrique

Voir 13.7.4.

14.8 Spécifications du support

14.8.1 Connecteur

Voir 13.8.1.

14.8.2 Câble d'essai normalisé

Le câble utilisé pour les essais d'appareils de bus de terrain avec une MAU en mode courant, destinés à vérifier la conformité aux exigences de l'Article 14, doit être un câble unique à paire torsadée, à blindage global, conforme aux exigences minimales suivantes, à une température de 25 °C:

a) Z_0 à une fréquence de 0,25 f_r (250 kHz) = 80 Ω ± 10 %;

b) Z_0 à une fréquence de 1,25 f_r (1,25 MHz) = ± 10 %;

c) affaiblissement maximal à une fréquence 0,25 f_r (250 kHz) = 11,0 dB/km;

d) affaiblissement maximal à une fréquence 1,25 f_r (1,25 MHz) = 20,0 dB/km;

e) résistance maximale en courant continu (par conducteur) = 15,0 Ω/km;

f) aire de la section des conducteurs (dimension des fils) = 1,5 mm^2 valeur nominale.

La spécification ci-dessus concerne les essais de conformité d'une MAU. D'autres types de câbles peuvent être utilisés dans les installations réelles. (Voir Annexe B.) Les câbles à spécifications améliorées peuvent permettre l'utilisation de longueurs de ligne principale plus importantes et/ou une meilleure immunité aux perturbations. En revanche, les câbles ayant des spécifications inférieures peuvent être utilisés, sous réserve d'une limitation des longueurs utilisées, tant pour les lignes principales que secondaires, auxquels s'ajoute une éventuelle non-conformité aux exigences de susceptibilité aux perturbations radioélectriques (RFI) et électromagnétiques (EMI).

14.8.3 Coupleur

Voir 13.8.3.

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14.8.4 Epissures

Voir 13.8.4.

14.8.5 Terminateur

Un terminateur doit être placé aux deux extrémités du câble de ligne principale et connecté d'un conducteur de signal à l'autre. Il ne doit y avoir aucune connexion entre terminateur et blindage du câble.

Pour les besoins de l'essai, en utilisant le câble spécifié en 14.8.2, le terminateur doit avoir une valeur d'impédance de ± 2 % sur la gamme de fréquences de 0,25 f_r à 1,25 f_r (250 kHz à 1,25 MHz).

La fuite de tension dans les terminaisons doit être inférieure à 0,3 V à une fréquence de 16 kHz.

NOTE Dans des applications pratiques, lorsque l'alimentation est fournie via les conducteurs de signaux, le terminateur serait contourné aux fréquences industrielles afin de réduire les pertes de puissance.

Le terminateur doit être non polarisé.

Tous les terminateurs utilisés pour des atmosphères explosibles doivent satisfaire à des exigences conformes aux documents d'homologation requis.

14.8.6 Règles de blindage

Pour être pleinement conforme aux exigences d'immunité au bruit du 14.5, l'intégrité du blindage doit être assurée sur toute la longueur du câblage, dans les connecteurs et dans les coupleurs, de la manière suivante:

a) la couverture du blindage doit être supérieure à 95 % de la longueur totale du câble;
b) le blindage doit couvrir complètement les circuits électriques des connecteurs, des coupleurs et des épissures.

NOTE Toute dérogation à ces règles de blindage peut dégrader l'immunité au bruit.

14.8.7 Règles de mise à la masse

Voir 13.8.7.

14.8.8 Code de couleur des câbles

Voir 11.8.8.

15 Types 1 et 7: Unité de liaison au support: supports à fibre optique double

15.1 Généralités

Le support réseau est constitué d'une paire de guides d'onde à fibre optique assurant la bidirectionnalité par séparation des fibres pour chaque sens de propagation du signal. Ces supports sont connus sous l'appellation générale de chemin optique élémentaire.

Dans tous les réseaux comportant plusieurs appareils, les guides d'onde à fibre optique qui acheminent les signaux en provenance des appareils sont associés à un coupleur en étoile, actif ou passif, qui rediffuse sur tous les guides d’onde acheminant des signaux aux appareils. Une liaison point à point entre une paire d’appareils utilisant un seul chemin optique élémentaire est également possible.

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Ces fibres optiques doubles sont connectées au CPIC d'un appareil de bus de terrain. Le système de transmission à fibre optique est en soi de sécurité intrinsèque.

15.2 Grandeurs dépendantes du débit binaire

Il est défini six débits binaires pour une MAU (Unité de liaison au support) de supports de réseau à fibre optique double, constitués d'une paire de guides d'onde à fibre optique unidirectionnels. Une MAU donnée doit prendre en charge au moins un de ces débits binaires. Le Tableau 81 indique les débits binaires pris en charge et définit les symboles relatifs aux grandeurs dépendantes du débit binaire utilisés tout au long de 15.2:

Tableau 81 – Grandeurs dépendantes du débit binaire de réseaux à fibre optique double à grande vitesse (≥1 Mbit/s)

Grandeur	Symbole	Unité	Valeur					
Débit binaire nominal	BR	Mbit/s	0,031 25	1	2,5	5	10	25
Ecart maximal par rapport à BR	ΔBR		0,2 %	0,01 %				
Durée binaire nominale	T_{bit}	μs	32,0	1,0	0,4	0,2	0,1	0,04
Ecart maximal par rapport à T_{bit}	ΔT_{bit}	–	0,025 %	0,015 %				
Délai maximal de propagation	PD_{max}	T_{bit}	20	40				

Le débit binaire moyen doit être BR ± ΔBR, moyenné sur une trame ayant une longueur minimale de 16 octets. Le temps binaire instantané doit être Tbit ± ΔTbit.

15.3 Spécifications du réseau

15.3.1 Composants

Une MAU à fibre optique fonctionne sur un réseau constitué des composants suivants:

a) câble optique;

b) des appareils (comportant au moins un élément de communication);

c) des connecteurs;

d) des étoiles passives optiques;

e) des étoiles actives optiques.

15.3.2 Topologies

Une MAU à fibre optique doit fonctionner sur un réseau à topologie en étoile ou sur un réseau point à point. Les appareils sont connectés aux étoiles optiques ou aux appareils homologues par des chemins optiques élémentaires. Les étoiles optiques sont interconnectées par des chemins optiques élémentaires.

15.3.3 Règles de configuration du réseau

Une MAU qui revendique la conformité à l'Article 15 doit satisfaire aux exigences de l'Article 15 lorsqu'elle est utilisée sur un réseau qui satisfait aux présentes règles.

Règle 1: Tous les appareils du réseau fonctionnent au même débit binaire.

Règle 2: Il ne doit pas y avoir plus de quatre étoiles actives optiques entre deux appareils quelconques.

Règle 3: Le délai maximal de propagation entre deux appareils quelconques ne doit pas dépasser les valeurs indiquées au Tableau 81.

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Pour que le réseau fonctionne efficacement, il convient que cette partie du temps de retournement de tout appareil du réseau, générée par une PhE entre la fin d'une trame reçue et le début d'une trame émise contenant une réponse immédiate associée, ne dépasse pas cinq temps binaires, dont il convient qu'au maximum deux temps binaires soient dus à la MAU.

NOTE Sachant qu'il n'est pas obligatoire d'exposer l'interface DLL – PhL ou l'interface MDS – MAU, cette partie du temps de retournement d'un appareil de bus de terrain due à la PhL ou à la MAU n'est pas spécifiée et donc non disponible pour des essais de conformité.

Règle 4: Le bus de terrain doit pouvoir fonctionner en continu lorsqu'un appareil y est connecté ou déconnecté. Les erreurs de données générées lors de la connexion ou de la déconnexion doivent être détectées.

Règle 5: Le réseau doit être acyclique, avec un seul chemin entre deux appareils quelconques.

Règle 6: Les règles suivantes doivent s'appliquer aux systèmes mis en œuvre avec des supports redondants:

a) chaque canal doit satisfaire aux règles de configuration du réseau;
b) il ne doit pas y avoir de segment ou d'équipement non redondant entre deux segments redondants;
c) si les appareils du système sont configurés (par la Gestion systèmes) pour émettre sur plusieurs canaux simultanément, la différence de délai de propagation entre deux appareils quelconques sur deux canaux quelconques ne doit pas dépasser cinq temps binaires;
d) les numéros de canaux et leur association aux supports de transmission physiques doivent être maintenus de manière cohérente sur l'ensemble des bus de terrain, c'est-à-dire que les canaux 1, 2, 3, … en provenance de la gestion système doivent toujours être connectés aux canaux physiques 1, 2, 3, …

15.4 Spécifications du circuit de transmission de la MAU

NOTE Pour faciliter le renvoi aux textes correspondants, les exigences définies en 15.4 sont résumées dans les Tableau 82 et Tableau 83.

15.4.1 Configuration d'essai

Le niveau de sortie ainsi que les spécifications de spectre et de synchronisation sont mesurés à l'extrémité d'une fibre d'essai normalisée de 1 m connectée au CPIC.

15.4.2 Spécification du niveau de sortie

Un circuit de transmission de MAU à fibre optique doit être conforme au niveau de sortie et aux exigences spectrales suivantes. Le niveau et les caractéristiques spectrales sont mesurés à une température de 25 °C. Le niveau de sortie est la puissance d'injection effective d'un niveau élevé. Le niveau de sortie est spécifié dans le Tableau 82.

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Tableau 82 – Récapitulatif de la spécification du niveau de transmission et des caractéristiques spectrales

Niveau de transmission et caractéristiques spectrales (valeurs en référence au CPIC avec fibre d'essai normalisée)	Limites, avec une fibre de 62,5/125 μm
Longueur d'onde de transmission crête (λp)	(850 ± 30) nm
Longueur d'onde type de demi-intensité (Δλ)	≤50 nm
High-level de la puissance d'injection effective	(–11,5 ± 1,5) dBm
Dépassement de transitions	≤15 % de la puissance effective
rapport d'extinction	≥20:1

15.4.3 Spécification de synchronisation des sorties

Un circuit de transmission de MAU à fibre optique doit être conforme aux exigences suivantes de synchronisation des sorties (Voir la Figure 75). Les caractéristiques de synchronisation sont mesurées à une température de 25 °C. La spécification de synchronisation des sorties est présentée dans le Tableau 83.

Tableau 83 – Récapitulatif de la spécification de synchronisation de transmission

Caractéristiques de synchronisation de transmission (valeurs en référence au CPIC avec fibre d'essai normalisée)	Limites
Débit binaire de transmission	BR ±ΔBR
Temps binaire instantané	$T_{bit} \pm \Delta T_{bit}$
Temps de croissance et de décroissance (10 % à 90 % du signal crête à crête)	≤ 2,0 % T_{bit}
Différence entre les temps de croissance et de décroissance	≤ 0,5 % T_{bit}
Instabilité maximale de bit élémentaire émis	± 2,0 % T_{bit}

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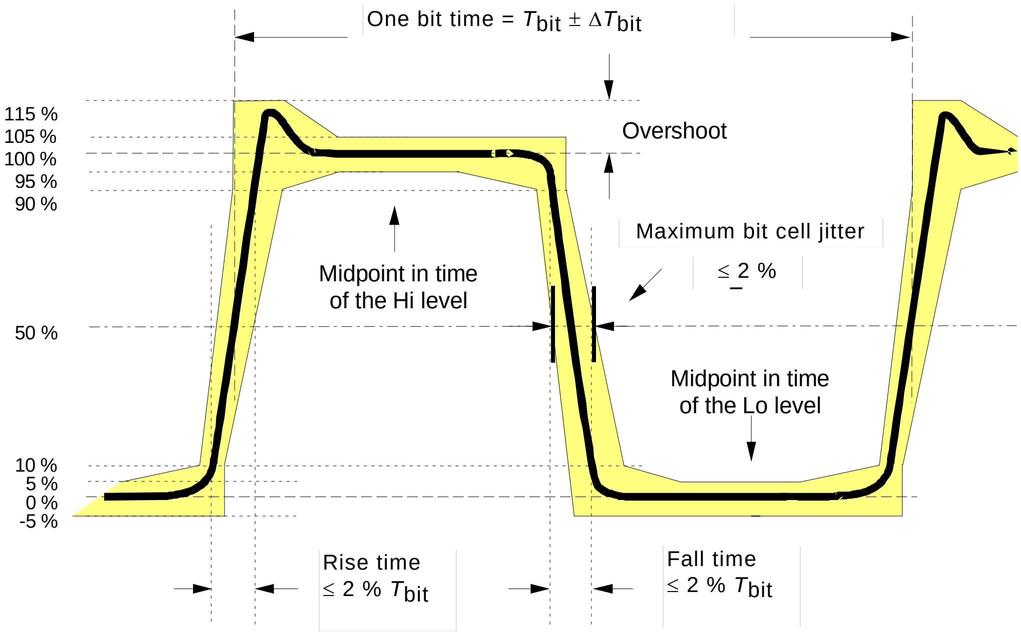

Légende

Anglais	Français
One bit time	Un temps binaire
Overshoot	Suroscillation
Midpoint in time of the Hi level	Point médian dans la durée du niveau Haut
Maximum bit cell jitter	Instabilité maximale de bit élémentaire
Midpoint in time of the Lo level	Point médian dans la durée du niveau Bas
Rise point	Point de croissance
Fall time	Temps de décroissance
Note: 0% effective power is the Lo level state power level	Note: 0% de puissance effective correspond au niveau de puissance à l'état bas
100% effective power is the Hi level state power level	100% de puissance effective correspond au niveau de puissance à l'état haut

Figure 75 – Modèle de forme d'onde optique

15.5 Spécifications du circuit de réception de la MAU

15.5.1 Généralités

Les exigences de 15.5 sont résumées dans le Tableau 84.

Tableau 84 – Récapitulatif de la spécification du circuit de réception

Caractéristiques du circuit de réception (valeurs en référence au CPIC avec fibre d'essai normalisée)	Limites	
	Système à faible sensibilité	Système à sensibilité élevée
Domaine de fonctionnement du récepteur	–30,0 dBm à –10,0 dBm	–40,0 dBm à –20,0 dBm
Instabilité maximale de bit élémentaire reçu	±14 % Tbit	

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15.5.2 Domaine de fonctionnement du récepteur

La plage de sensibilité spécifiée pour le récepteur est la suivante

a) puissance effective de –30,0 dBm à –10,0 dBm pour une faible sensibilité;
b) puissance effective de –40,0 dBm à –20,0 dBm pour une sensibilité élevée.

15.5.3 Instabilité maximale de bit élémentaire reçu

Le circuit de réception doit accepter un signal codé Manchester émis conformément au 15.4. En outre, le récepteur doit accepter des signaux ayant des variations temporelles, entre deux points adjacents quelconques de transition des signaux (passage par 50 %) d'au maximum ±14,0 % Tbit.

NOTE Ceci n'exclut pas l'utilisation de récepteurs ayant des performances supérieures à la présente spécification mais conformes aux tolérances relatives à l'instabilité de bit élémentaire reçue de la MDS (voir 9.2.6).

En fonction de la configuration du symbole, la durée nominale entre passages par 50 % peut être de 1,0 Tbit ou 0,5 Tbit.

15.5.4 Susceptibilité au brouillage et taux d'erreurs

15.5.4.1 Basse vitesse (31,25 kbit/s)

Lorsque le bus de terrain fonctionne dans divers environnements de bruit normalisés, il convient que la probabilité qu'une unité de données utilisateur de couche Application contienne une erreur non détectée, du fait du fonctionnement des entités physiques et DLL d'acheminement, soit inférieure à 1 sur 6×10^9 (une erreur en 20 années à 10 messages/s).

Un élément de communication est considéré conforme à cette exigence théorique lorsqu'il satisfait aux exigences suivantes de susceptibilité au brouillage. Ces exigences sont spécifiées sur la base d'un taux d'erreur de trame détecté obtenu en utilisant un rapport d'erreurs détectées/non détectées de 10^6.

Un élément de communication qui inclut une MAU à fibre optique fonctionnant à 31,25 kbit/s et utilisant des trames de 32 bits de données utilisateur aléatoires, à une moyenne de 10 messages/s, avec des signaux de –25 dBm, ne doit pas produire plus de dix erreurs de trame détectées sur 60 000 trames, lorsqu'il est utilisé dans des environnements de perturbations électromagnétiques ou électriques comme décrit ci-après:

a) champ électromagnétique de 10 V/m, comme spécifié dans la CEI 61000-4-3 au niveau de sévérité 3;
b) transitoires électriques rapides, comme spécifié dans la CEI 61000-4-4 au niveau de sévérité 3.

15.5.4.2 Vitesse élevée (≥1 Mbit/s)

Lorsque le bus de terrain fonctionne dans divers environnements de bruit normalisés, il convient que la probabilité qu'une unité de données utilisateur de couche Application contienne une erreur non détectée, du fait du fonctionnement des entités physiques et DLL d'acheminement, soit inférieure à 1 sur 10^{12} (une erreur en 20 années à 1 600 messages/s).

Un élément de communication est considéré conforme à cette exigence théorique lorsqu'il satisfait aux exigences suivantes de susceptibilité au brouillage. Ces exigences sont spécifiées sur la base d'un taux d'erreur de trame détecté obtenu en utilisant un rapport d'erreurs détectées/non détectées de 10^6.

Un élément de communication qui inclut une MAU à fibre optique fonctionnant à ≥1 Mbit/s et utilisant des trames de 64 bits de données utilisateur aléatoires, à une moyenne de 1 600 messages/s, avec des signaux de –25 dBm, ne doit pas produire plus de six erreurs de trame

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détectées sur 100 000 trames, lorsqu'il est utilisé dans des environnements de perturbations électromagnétiques ou électriques comme décrit ci-après:

a) champ électromagnétique de 10 V/m, comme spécifié dans la CEI 61000-4-3 au niveau de sévérité 3;
b) transitoires électriques rapides, comme spécifié dans la CEI 61000-4-4 au niveau de sévérité 3.

15.5.4.3 Commune

Les taux d'erreur spécifiés doivent également être réalisés après, mais non pendant le fonctionnement dans les environnements de bruit suivants:

a) décharge électrique de 8 kV sur une structure métallique exposée, comme spécifié dans la CEI 61000-4-2, au niveau de sévérité 3. Si l’appareil subit une perte temporaire de fonctions ou de performances à la suite de cet essai, il doit récupérer de cette perte éventuelle sans intervention de l'opérateur, dans les 3 s qui suivent la fin de l'essai;
b) essais de perturbation à haute fréquence, comme spécifié en 3.1 de la CEI 60255-22-1:1988 (classe III de tension d'essai 2,5 kV et 1 kV de valeurs crêtes de la première demi-alternance, respectivement en mode longitudinal et transversal). Si l’appareil subit une perte temporaire de fonctions ou de performances du fait de cet essai, il doit récupérer de cette perte éventuelle sans intervention de l'opérateur, dans les 3 s qui suivent la fin de l'essai.

15.6 Inhibition du bavardage

La MAU doit comporter une capacité d'interruption automatique pour empêcher les signaux émis d'atteindre le support. Le matériel dans la MAU (sans message extérieur autre que la détection des signaux de sortie ou de fuite par la fonction de transmission) doit fournir une fenêtre d'une durée comprise entre 3 750 Tbit et 7 500 Tbit au cours de laquelle une trame normale peut être émise. Si la longueur de trame dépasse cette durée, la fonction d'inhibition du bavardage doit empêcher d'autres signaux en sortie d'atteindre le support et doit désactiver l'écho sur la ligne RxS (voir 10.2.2.2) pour indiquer à la MDS la détection de bavardage.

Pour un débit binaire de 31,25 kbit/s, la MAU doit réinitialiser la fonction d'interruption automatique après une période de 3 s ± 50 %.

NOTE 1 Ceci inhibe le trafic sur le bus pendant au maximum 8 % (≈ 1/12,5) du temps disponible.

Pour un débit binaire de 1 Mbit/s ou plus, la MAU doit réinitialiser la fonction d'interruption automatique après une période de 500 000 Tbit ± 50 %.

NOTE 2 Ceci inhibe le trafic sur le bus pendant au maximum 3 % (≈ 1/32) du temps disponible.

15.7 Spécifications du support

15.7.1 Connecteur

Si des connecteurs de câbles sont utilisés, ils doivent être conformes à la présente norme (voir l'Annexe A). Des terminaisons permanentes (épissures) peuvent également être utilisées.

15.7.2 Fibre d'essai normalisée

Le câble utilisé pour les essais d’appareils de bus de terrain ou d'étoiles actives optiques avec une MAU à fibre optique, destiné à vérifier la conformité aux exigences de l'Article 15, doit être un câble à fibre optique d'une longueur de 1 m comportant deux guides d'onde à fibre de silice. Les caractéristiques de ces guides d’onde doivent être compatibles avec la CEI 60793 [type de fibre: A1b (62,5/125 μm)] pour ce qui concerne:

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– le diamètre du cœur(µm): 62,5 ± 3
– le diamètre de la gaine (µm): 125 ± 3
– la concentricité cœur/gaine (%): ≤6
– la non-circularité du cœur (%): ≤6
– la non-circularité de la gaine (%): ≤2
– le diamètre extérieur du revêtement primaire (µm): 250 ± 15
– l'ouverture numérique: 0,275 ± 0,015
– l'affaiblissement pour 850 nm (dB/km): ≤3,0
– la largeur de bande pour 850 nm (MHz x km): ≥200

D'autres types de fibres d'essai peuvent être utilisés.

NOTE L'Annexe E décrit un fonctionnement avec utilisation d'une fibre d'essai alternative de 50 µm ou 100 µm.

15.7.3 Etoile passive optique

NOTE Pour de plus amples informations, voir l'Annexe C.

15.7.4 Etoile active optique

15.7.4.1 Définition

Un appareil ou un module optoélectronique dans un système de communication à fibre optique qui reçoit un signal l'amplifie et le retransmet (la resynchronisation est facultative).

15.7.4.2 En service

Trois types de liaisons doivent être pris en compte.

a) La liaison entre deux étoiles actives optiques

Toute trame provenant directement d'une étoile active optique qui atteint un accès optique d'une autre étoile active optique est retransmise sans retour d'information (l'accès qui reçoit la trame ne retransmet pas cette trame).

b) La liaison entre une étoile active optique et un appareil de bus de terrain

Toute trame en provenance d'une étoile active optique qui atteint un appareil de bus de terrain est reçue et non retransmise. Toute trame provenant d'un appareil de bus de terrain qui atteint une étoile active optique est retransmise sans retour d'information.

c) La liaison entre une étoile passive optique et une étoile active optique

Toute trame provenant d'une étoile passive optique qui atteint une étoile active optique est retransmise sans retour d'information. De par sa conception, une étoile passive reflète toutes les trames. Une étoile active optique ne doit pas réémettre les signaux de retour d'information d'une étoile passive optique.

Fonctions régénératrices

Une étoile active optique rétablit les signaux à des niveaux de puissance de transmission normalisés. Les caractéristiques de synchronisation (gigue) peuvent ou non être régénérées; cette fonction est facultative.

15.7.4.3 Caractéristiques de transmission et de réception

Les caractéristiques suivantes sont indiquées:

a) Caractéristiques de niveau

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Les spécifications de niveau de transmission et de réception sont identiques à celles d'une MAU à fibre optique (15.4.2 et 15.5.2). Le niveau et les caractéristiques spectrales sont mesurés à une température de 25 °C. Ces spécifications sont résumées dans le Tableau 85.

Tableau 85 – Spécifications du niveau de transmission et de réception et des caractéristiques spectrales d'une étoile active optique

Niveau de transmission et caractéristiques spectrales (valeurs en référence au CPIC avec fibre d'essai normalisée)	Limites, avec une fibre de 62,5/125 μm	
Longueur d'onde de transmission crête (λp)	(850 ± 30) nm	
Longueur d'onde type de demi-intensité (Δλ)	≤ 50 nm	
rapport d'extinction	≥20:1	
High-level de la puissance d'injection effective	(–11,5 ± 1,5) dBm	
Domaine de fonctionnement du récepteur (puissance effective)	Système à faible sensibilité	Système à sensibilité élevée
	–30,0 dBm à –10,0 dBm	–40,0 dBm à –20,0 dBm

b) Caractéristiques temporelles

Les spécifications de synchronisation de transmission et de réception d'une étoile active optique concernent (voir Tableau 86):

– les temps de croissance et de décroissance du signal émis;
– la déformation temporelle des signaux, due à une étoile active optique.

Les caractéristiques de synchronisation sont mesurées à une température de 25 °C. Pour des étoiles actives optiques qui ont une fonction de régénération de la synchronisation, les caractéristiques de synchronisation sont identiques à celles d'une MAU à fibre optique.

Tableau 86 – Caractéristiques de synchronisation d'une étoile active optique

Caractéristiques temporelles (valeurs en référence au CPIC)	Limites
Temps de croissance et de décroissance des signaux émis (10 % à 90 %du signal crête à crête)	≤2 % Tbit
Déformation temporelle maximale entre accès d'entrée optiques et accès de sortie optiques (voir la Note 1)	±3 % Tbit
Temps de propagation d'un bit de données entre un accès d'entrée optique et tout accès de sortie pour une étoile active ayant une fonction de régénération de la synchronisation (voir la NOTE 2).	≤2 Tbit
Instabilité de bit élémentaire maximale émise pour une étoile active optique avec fonction de régénération de la synchronisation (voir Note 2).	±2,0 % Tbit
NOTE 1 La déformation temporelle due à une étoile active optique est la différence temporelle de largeur d'un même bit physique, configuration binaire, forme d'onde ou autre terme approprié. NOTE 2 Uniquement pour des étoiles actives optiques ayant une fonction de régénération de la synchronisation.	

16 Type 1: Unité de liaison au support: support optique monofibre 31,25 kbit/s

16.1 Généralités

Le support réseau est constitué d'un ensemble de guides d'onde bidirectionnels monofibre, chaque guide étant appelé chemin optique élémentaire.

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Dans tous les réseaux comportant plusieurs appareils, les guides d'onde à fibre optique qui acheminent les signaux en provenance des appareils sont associés à un coupleur en étoile réflectif passif, d'où tous les signaux sont retransmis sur tous les guides d'onde à fibre optique vers les appareils. Une liaison point à point entre une paire d'appareils utilisant un seul chemin optique élémentaire est également possible.

Ces monofibres bidirectionnelles sont connectées au CPIC d'un appareil de bus de terrain. Le système de transmission à fibre optique est en soi de sécurité intrinsèque.

16.2 Débit binaire de transmission

Le débit binaire de transmission, BR ± ΔBR, doit être 31,25 kbit/s ± 0,2 %, moyenné sur une trame ayant une longueur minimale de 16 octets. Le temps binaire instantané, Tbit ± ΔTbit, doit être de 32 µs ± 0,025 %.

16.3 Spécifications du réseau

16.3.1 Composants

Voir 15.3.1.

16.3.2 Topologies

Voir 15.3.2.

16.3.3 Règles de configuration du réseau

Une MAU qui revendique la conformité à l'Article 16 doit satisfaire aux exigences de l'Article 16 lorsqu'elle est utilisée sur un réseau qui satisfait aux présentes règles.

Les règles sont identiques à 15.3.3, à l'exception de ce qui suit.

16.4 Spécifications du circuit de transmission de la MAU

NOTE Pour faciliter le renvoi aux textes correspondants, les exigences définies en 16.4 sont résumées dans les Tableau 87 et Tableau 83.

16.4.1 Configuration d'essai

Voir 15.4.1.

16.4.2 Spécification du niveau de sortie

Un circuit de transmission de MAU à fibre optique doit être conforme au niveau de sortie et aux exigences spectrales suivantes. Le niveau et les caractéristiques spectrales sont mesurés à une température de 25 °C. Le niveau de sortie est la puissance d'injection effective d'un niveau élevé. Le niveau de sortie est spécifié dans le Tableau 87.

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Tableau 87 – Récapitulatif de la spécification du niveau de transmission et des caractéristiques spectrales

Niveau de transmission et caractéristiques spectrales (valeurs en référence au CPIC avec fibre d'essai normalisée)	Limites pour 31,25 kbit/s (fibre 100/140 μm)
Longueur d'onde de transmission crête (λp)	(850 ± 30) nm
Longueur d'onde type de demi-intensité (Δλ)	≤50 nm
High-level de la puissance d'injection effective	(–13,5 ± 1,0) dBm
Dépassement de transitions	≤15 % de la puissance effective
rapport d'extinction	≥20:1

16.4.3 Spécification de synchronisation des sorties

Un circuit de transmission de MAU à fibre optique doit être conforme aux exigences suivantes de synchronisation des sorties (Voir la Figure 75). Les caractéristiques de synchronisation sont mesurées à une température de 25 °C. La spécification de synchronisation des sorties est présentée dans le Tableau 83.

16.5 Spécifications du circuit de réception de la MAU

16.5.1 Généralités

Les exigences du 16.5 sont résumées dans le Tableau 84, qui concerne cependant la fibre d'essai normalisée 100/140 μm de l'Article 16.

16.5.2 Domaine de fonctionnement du récepteur

La plage de sensibilité spécifiée pour le récepteur est la suivante

a) puissance effective de –30,0 dBm à –12,5 dBm pour une faible sensibilité;

b) puissance effective de –40,0 dBm à –20,0 dBm pour une sensibilité élevée.

16.5.3 Instabilité maximale de bit élémentaire reçu

Voir 15.5.3.

16.5.4 Susceptibilité au brouillage et taux d'erreurs

Voir 15.5.4.1 et 15.5.4.3.

16.6 Inhibition du bavardage

L'exigence est identique au 15.6, à l'exception de ce qui suit.

La MAU doit réinitialiser la fonction d'interruption automatique après une période de 3 s ± 50 %.

NOTE Ceci inhibe le trafic sur le bus pendant au maximum 8 % (≈1/12,5) du temps disponible.

16.7 Spécifications du support

16.7.1 Connecteur

Voir 15.7.1.

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16.7.2 Fibre d'essai normalisée

Guide d'onde à fibre de silice dont les caractéristiques nominales sont compatibles avec la CEI 60793 [type de fibre: A1d (100/140 μm)].

Le câble utilisé pour les essais d'appareils de bus de terrain ou d'étoiles actives optiques avec une MAU à fibre optique, destiné à vérifier la conformité aux exigences de l'Article 16, doit être un câble à fibre optique d'une longueur de 1 m comportant un guide d'onde à fibre optique et ayant les caractéristiques suivantes:

– le diamètre du cœur(μm): 100 ± 5
– le diamètre de la gaine (μm): 140 ± 4
– la concentricité cœur/gaine (%): ≤6
– la non-circularité du cœur (%): ≤6
– la non-circularité de la gaine (%): ≤4
– l'ouverture numérique: 0,26 ± 0,03
– l'affaiblissement pour 850 nm (dB/km): ≤4,0
– la largeur de bande pour 850 nm (MHz x km): ≥100

D'autres types de fibres d'essai peuvent être utilisés.

NOTE L'Annexe E décrit un fonctionnement avec utilisation de fibres d'essai alternatives de 50 μm ou 62,5 μm.

16.7.3 Etoile passive optique

NOTE Pour de plus amples informations, voir l'Annexe C.

16.7.4 Etoile active optique

16.7.4.1 Définition

Le Paragraphe 15.7.4.1 s'applique.

16.7.4.2 En service

Le Paragraphe 15.7.4.2 s'applique.

16.7.4.3 Caractéristiques de transmission et de réception

16.7.4.3.1 Caractéristiques de niveau

Les spécifications de niveau de transmission et de réception sont identiques à celles d'une MAU à fibre optique (voir 16.4.2 et 16.5.2). Le niveau et les caractéristiques spectrales sont mesurés à une température de 25 °C. Ces spécifications sont résumées dans le Tableau 88.

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Tableau 88 – Spécifications du niveau de transmission et de réception et des caractéristiques spectrales d'une étoile active optique

Niveau de transmission et caractéristiques spectrales (valeurs en référence au CPIC avec fibre d'essai normalisée)	Limites, avec une fibre de 100/140 µm	
Longueur d'onde de transmission crête (λp)	(850 ± 30) nm	
Longueur d'onde type de demi-intensité (Δλ)	≤50 nm	
rapport d'extinction	≥20:1	
High-level de la puissance d'injection effective	(–13,5 ± 1,0) dBm	
Domaine de fonctionnement du récepteur (puissance effective)	Système à faible sensibilité	Système à sensibilité élevée
	–30,0 dBm à –12,5 dBm	–40,0 dBm à –20,0 dBm

16.7.4.3.2 Caractéristiques temporelles

Les caractéristiques de synchronisation du 15.7.4.3 s'appliquent.

17 *Vide*

NOTE Dans la présente édition, l'Article 17 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

18 Type 2: Unité de liaison au support: Support à câble coaxial, de 5 Mbit/s, en mode tension

18.1 Généralités

Une seule méthode de connexion est spécifiée pour le support câblé coaxial de 5 Mbit/s en mode tension. D'autres méthodes peuvent être utilisées, mais elles doivent être conformes aux mêmes caractéristiques de signalisation et de performance. Si la méthode de connexion à support câblé coaxial spécifiée est utilisée, elle doit intégrer un couplage par transformateur au niveau du nœud et il doit être utilisé une prise passive pour connexion au support. La prise doit inclure une ligne secondaire de 1 m.

La variante de PhL à câble coaxial de 5 Mbit/s en mode tension, doit être connectée au support câblé coaxial avec des segments de réseaux allant jusqu'à 1 km de long et comprenant jusqu'à 48 nœuds (voir 18.5).

NOTE La couche physique peut être mise en œuvre de manière à permettre une certification pour un fonctionnement dans des atmosphères explosives sans sacrifier la distance ou réduire le nombre de nœuds. La présente norme n'inclut pas d'exigences pour la certification de la sécurité intrinsèque mais cherche à exclure des conditions ou situations qui pourraient empêcher la certification de la sécurité intrinsèque.

La MAU doit comprendre un émetteur-récepteur, un transformateur et un connecteur comme illustré à la Figure 76. L'émetteur-récepteur doit utiliser les signaux définis dans l'interface MDS-MAU pour générer ceux qui sont nécessaires pour piloter le transformateur. La connexion au support doit être effectuée par l'intermédiaire de connecteurs BNC ou TNC, comme spécifié en Annexe F. L'isolation de la masse doit être assurée par l'intermédiaire du transformateur, comme spécifié en 18.3.

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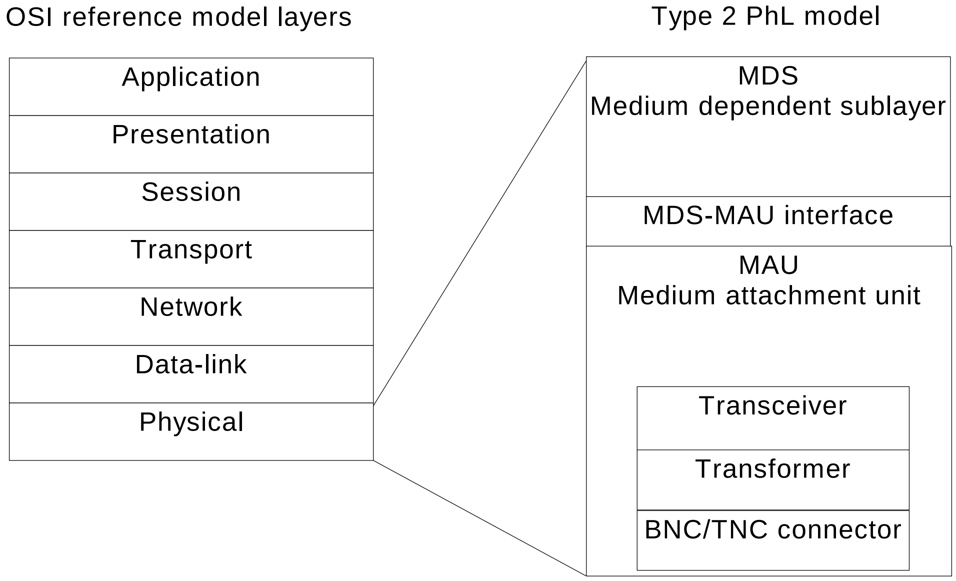

Légende

Anglais	Français
OSI reference model layers	Couches du modèle de référence OSI
Application	Application
Presentation	Présentation
Session	Session
Transport	Transport
Network	Réseau
Data-Link	Liaison de données
Physical	Physique,
Type 2 PhL model	Modèle de PhL de Type 2
MDS Medium Dependent Sublayer	MDS: Sous-couche dépendante du support
MDS-MAU interface	Interface MDS – MAU
MAU Medium Attachment Unit	MAU: Unité de liaison au Support
Transceiver	Emetteur-récepteur
Transformer	Transformateur
BNC/TNC Connector	Connecteur BNC/TNC

Figure 76 – Composantes de la variante de PhL à câble coaxial de 5 Mbit/s en mode tension

18.2 Emetteur-récepteur: support à câble coaxial de 5 Mbit/s en mode tension

Lorsqu'il est utilisé un support à câble coaxial de 5 Mbit/s en mode tension, un émetteur-récepteur à câble coaxial doit être utilisé pour émettre et recevoir des signaux L (bas) et H (haut). La partie émettrice de l'émetteur-récepteur doit obtenir de l'interface MDS-MAU des signaux de transmission représentant des symboles H et L. Elle doit émettre sur le câble, via le transformateur d'isolation, un signal à extrémité unique et isolé à la masse. Le complément de cette fonction doit être réalisé dans le récepteur qui doit fournir à l'interface MDS-MAU les indications RXDATA et RXCARRIER.

Un synoptique fonctionnel décrivant les composantes de la sous-couche MAU est présenté à la Figure 77.

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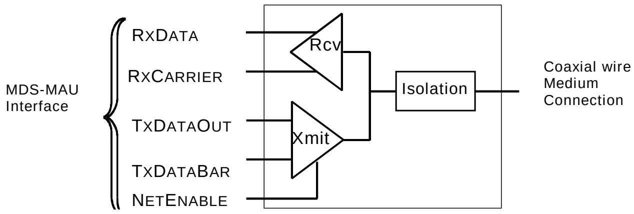
NOTE 1 La Figure H.3 présente un exemple d'émetteur-récepteur redondant et la Figure H.4 un exemple d'émetteur-récepteur à un seul canal.



NOTE Ensemble, les blocs marqués Xmit et Isolation représentent l'émetteur.

Légende

Anglais	Français
MDS-MAU Interface	Interface MDS – MAU
Rcv	Récept.
Xmit	Emiss.
Isolation	Isolation
Coaxial wire Medium connection	Connexion du support à câble coaxial

Figure 77 – Synoptique de MAU à câble coaxial

La Figure 78 illustre un schéma fonctionnel simplifié de l'émetteur.

NOTE 2 Pour plus de détails, se reporter aux schémas donnés pour exemple à la Figure H.3 et à la Figure H.4.

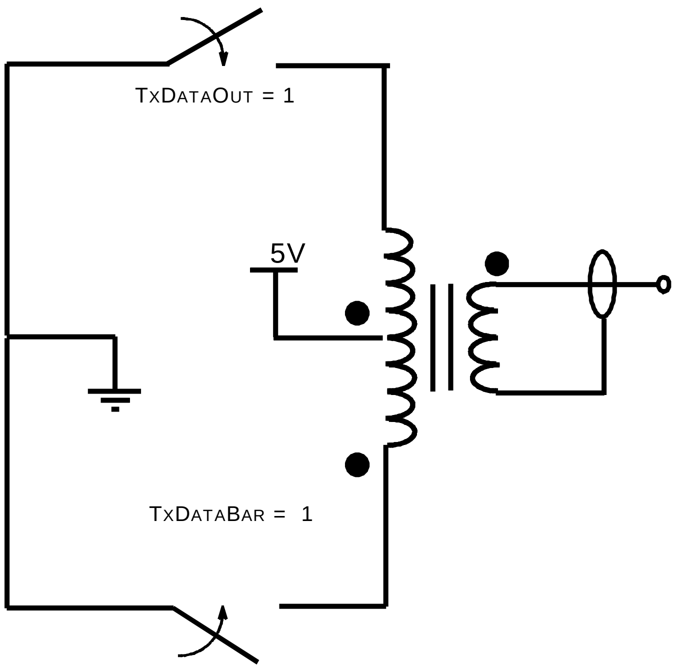


Figure 78 – Emetteur de MAU à câble coaxial

Trois signaux doivent être disponibles à l'interface MDS-MAU pour contrôler l'émission sur le support: TXDATAOUT, TXDATABAR et NETENABLE. Ces trois signaux de transmission, lorsqu'ils sont connectés à l'émetteur-récepteur, doivent définir les symboles physiques présents sur le câble. La relation entre ces lignes de demande de l'émetteur-récepteur et les signaux sur le support, doit être telle que spécifiée dans le Tableau 89.

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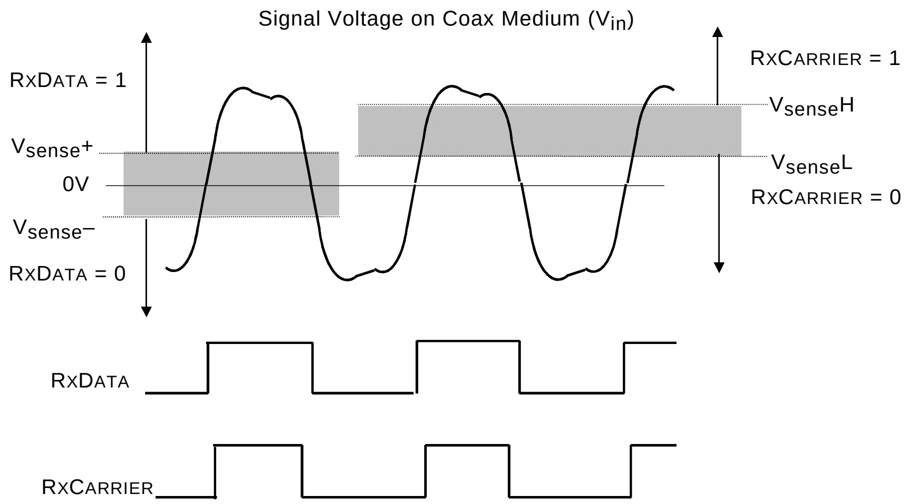
Tableau 89 – Définition des lignes de commande de transmission – Support de câble coaxial de 5 Mbit/s en mode tension

TxDataOut	TxDataBar	NetEnable	Symbole physique	Signal sur le support
sans effet (x)	sans effet (x)	faux (0)	aucun	Emetteur non actif, voir Tableau 92.
faux (0)	faux (0)	vrai (1)	aucun	Emetteur non actif, voir Tableau 92.
vrai (1)	faux (0)	vrai (1)	H	tension + (positive), voir Tableau 92.
faux (0)	vrai (1)	vrai (1)	L	- tension (négative), voir Tableau 92.
vrai (1)	vrai (1)	vrai (1)	non autorisé (voir note)	non autorisé (voir note)
NOTE Cet état peut endommager les circuits de l'émetteur.				



NOTE Les parties grisées ci-dessus ne sont pas définies.

Légende

Anglais	Français
Signal voltage on coaxial medium (Vin)	Tension du signal sur support à câble coaxial (Vin)

Figure 79 – Fonctionnement du récepteur avec MAU à câble coaxial

Deux signaux d'indication doivent être fournis au niveau de l'interface MDS-MAU à partir de la MAU, avec RxData et RxCarrier, comme présenté dans le Tableau 89. La relation entre la tension du signal sur le câble et ces deux signaux pour les seuils nominaux, doit être telle que présentée dans le Tableau 90 et le Tableau 91. Les valeurs indiquées dans le Tableau 90 et dans le Tableau 91 sont définies dans le Tableau 93. Le niveau d'entrée (V_{in}), comme illustré à la Figure 79, doit être défini comme étant la tension mesurée entre le conducteur central du câble coaxial et le blindage du câble coaxial. Toutes les polarités doivent être définies en termes de tension sur le conducteur central du câble coaxial (V_{in}+ ou V_{in}–), en référence au blindage du câble coaxial.

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Tableau 90 – Définitions des sorties de données du récepteur: support à câble coaxial de 5 Mbit/s en mode tension

Niveau d'entrée au support	RxData	Commentaires
V_{in} est plus positif que la limite positive de sensibilité des données (V_{sense}+)	vrai (1)	Voir Tableau 93
V_{in} est plus négatif que la limite négative de sensibilité des données (V_{sense}–)	faux (0)	Voir Tableau 93
V_{in} se trouve entre les limites de sensibilité négative et positive des données	indéfini	Tient compte de l'hystérésis et de la tolérance

Tableau 91 – Définitions des sorties de porteuses du récepteur: support à câble coaxial de 5 Mbit/s en mode tension

Niveau d'entrée au support	RxCarrier	Commentaires
V_{in} est plus positif que la limite haute de sensibilité de la porteuse (V_{sense}H)	vrai (1)	Voir Tableau 93
V_{in} est inférieur à la limite basse (ou négative) de sensibilité de la porteuse (V_{sense}L)	faux (0)	Voir Tableau 93
V_{in} se trouve entre les limites haute et basse de sensibilité de la porteuse	indéfini	Tient compte de l'hystérésis et de la tolérance

L'interface du support doit être conforme aux exigences données dans le Tableau 92, le Tableau 93 et le Tableau 94.

Tableau 92 – Interface du support à câble coaxial – Spécifications de transmission

Spécification	Limites / caractéristiques	Commentaires
Niveau de transmission (niveau Tx) crête à crête	8,2 V ± 1,3 V [a, b, c]	Voir Figure 80
Asymétrie du niveau de transmission (entre 0 et 1)	< 450 mV max [b, d]	
Distorsion du signal de transmission (surtension, statisme, suroscillation)	± 10 % [a, e]	Voir Figure 80
Instabilité de transmission totale (gigue Tx)	< 5 ns	Voir Figure 80
Impédance de sortie de l'émetteur	20 Ω max	
Niveau de bruit maximal de l'émetteur à l'arrêt	5 mV max [a]	
Temps depuis NetEnable "faux" au niveau de bruit d'émetteur "non actif"	400 ns [a]	
Limite de dérive	1 V/ns max [a]	Voir Figure 80
Limite de croissance/décroissance (10 % à 90 % du signal crête à crête)	30 ns max [a]	Voir Figure 80

[a] Il doit s'agir d'une tension crête à crête mesurée sur une charge de 37,5 Ω de 0 MHz à 20 MHz.

[b] Le niveau de transmission doit être mesuré au point médian estimé entre toute crête ou creux, tant à la partie supérieure qu'à la partie inférieure de la forme d'onde.

[c] Ce niveau doit être inférieur de 0,5 V lorsqu'il est mesuré dans un diagramme en œil relatif au pilotage d'une prise pour un signal minimal de 6,4 V (crête à crête).

[d] Cette valeur doit être mesurée comme la différence absolue entre la valeur absolue du niveau de transmission pour 1 (tension +) et la valeur absolue du niveau de transmission pour 0 (tension –), mesurée sur une charge de 37,5 Ω de 0 MHz à 20 MHz.

[e] Les niveaux doivent être calculés en fonction de la tension de transmission réelle mesurée.

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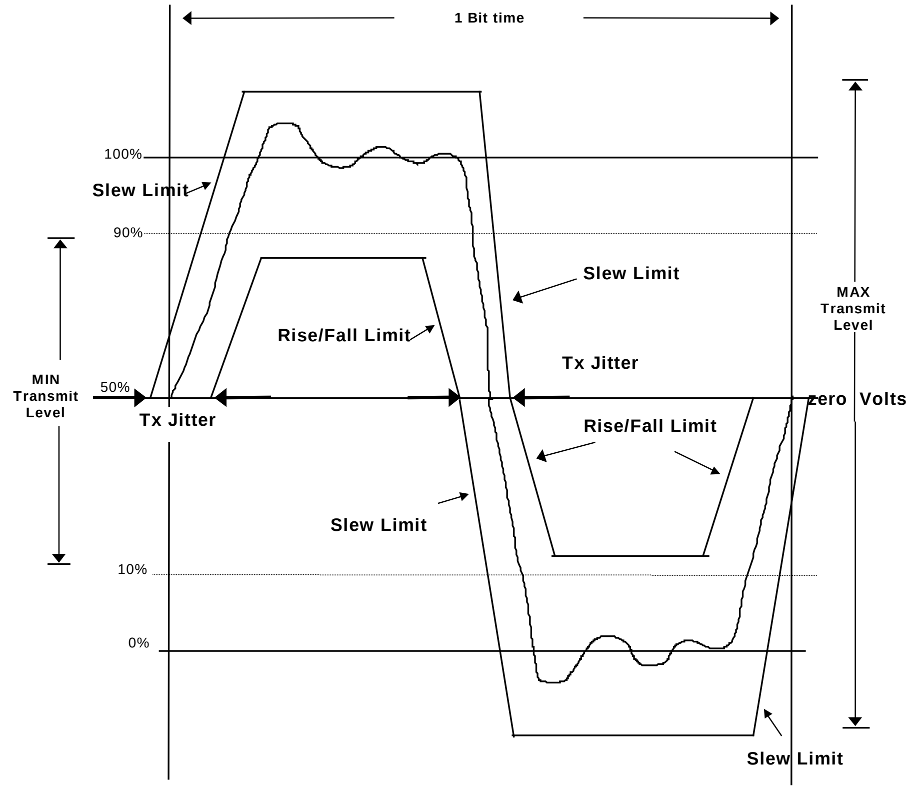

Légende

Anglais	Français
1 Bit time	1 temps binaire
Slew limit	Limite de dérive
Min transmit level	Niveau de transmission min.
Tx Jitter	Instabilité Tx
Rise/Fall limit	Limite de croissance/décroissance
Max transmit level	Niveau de transmission max.
Zero volts	Zéro volts

Figure 80 – Masque de transmission de MAU à câble coaxial

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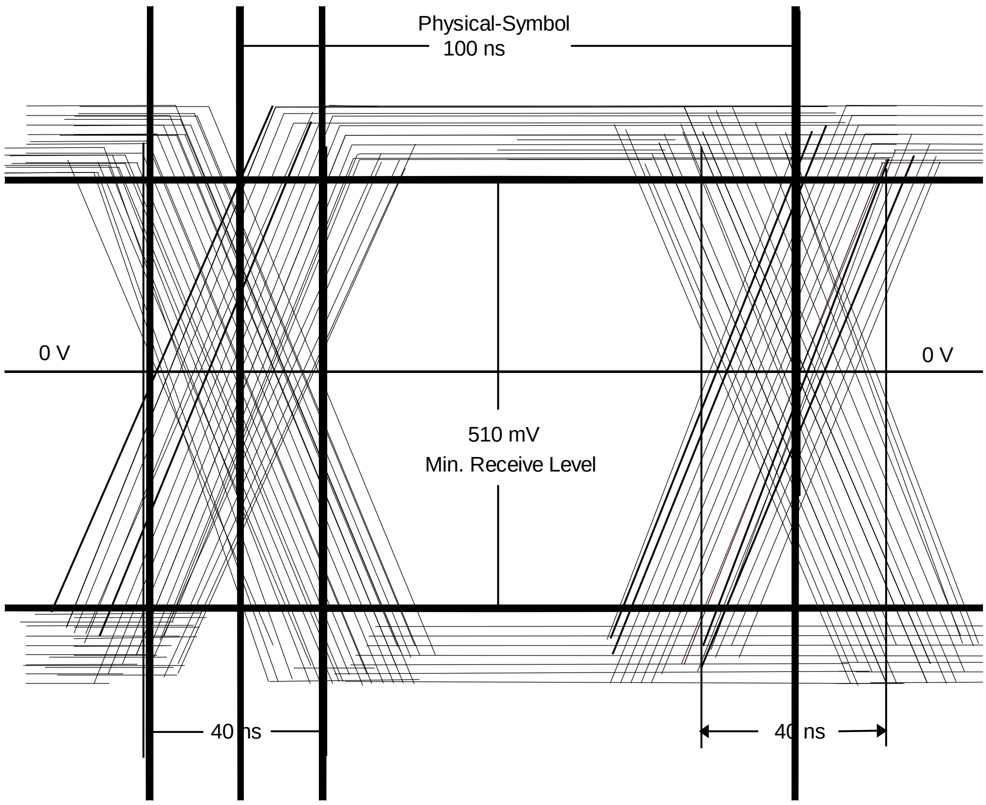
Tableau 93 – Interface du support à câble coaxial – Réception

Spécifications	Limites / caractéristiques	Commentaires
Niveau minimal du signal de réception (crête à crête)	510 mV	Dans le diagramme en œil de la Figure 81
Tension de seuil de données	zero V	Les limites négatives et positives de sensibilité tiennent compte de l'hystérésis et de la tolérance
Limites négatives de sensibilité des données (V_{sense-})	–140 mV	Tient compte de l'hystérésis et de la tolérance
Limites positives de sensibilité des données (V_{sense+})	+140 mV	Tient compte de l'hystérésis et de la tolérance
Limite basse de sensibilité de la porteuse (V_{senseL})	+ 23 mV	Tient compte de l'hystérésis et de la tolérance
Limite haute de sensibilité de la porteuse (V_{senseH})	+ 255 mV	Tient compte de l'hystérésis et de la tolérance
Instabilité du modèle de signal `RxData` (crête à crête) pour V_{in}> 510 mV	< 40 ns	Dans le diagramme en œil de la Figure 81 doit être "vrai" si V_{in}> niveau minimal du signal de réception



Légende

Anglais	Français
Physical symbol	Symbole physique
Min. receive level	Niveau de réception min.

Figure 81 – Masque de réception de MAU à câble coaxial

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Tableau 94 – Interface du support à câble coaxial – Aspects généraux

Spécification	Limites / caractéristiques	Commentaires
Couplage	Couplage par transformateur	Masse isolée
Isolation à 0 Hz	500 kΩ min [a]	Le blindage doit être couplé par R/C à la terre locale
Impédance d'entrée (Emission non active)	0,2 dB de perte due à la prise	(Voir Figure 85) Alternative au modèle d'impédance
Modèle d'impédance (Emission non active)		Alternative à l'impédance d'entrée
Inductance série	0,56 μH ± 20 % [b]	Mise sous tension
Inductance parallèle	425 μH ± 20 % [b]	Mise sous tension
Capacité parallèle	50 pF max [b] 55 pF max [b]	Sous tension Hors tension
Résistance parallèle	3,9 kΩ± 20 % [b] 3,4 kΩ± 20 % [b]	Sous tension Hors tension
Connecteur	BNC ou TNC	Voir Annexe F pour plus d'informations

[a] La valeur minimale du condensateur doit être de 0,01 μF/500 V. Cette exigence s'applique à toutes les interfaces de supports connectés au réseau.

[b] Toutes les impédances spécifiées doivent être satisfaites, l'émetteur étant à l'état non actif et avec mise sous tension ou hors-tension, comme indiqué. Toutes les impédances spécifiées doivent être satisfaites sur l'ensemble de la plage dynamique du récepteur, du niveau de réception minimal au niveau de transmission maximal.

NOTE 3 Un exemple de conception de référence pour un émetteur-récepteur avec MAU à câble coaxial de 5 Mbit/s en mode tension est présenté en H.1.1.

18.3 Transformateur pour support à câble coaxial de 5 Mbit/s en mode tension

NOTE 1 Le transformateur assure le couplage des signaux de transmission et de réception vers et en provenance du support. Une caractéristique importante du transformateur est qu'il assure l'isolation galvanique ou l'isolation à la terre entre nœuds. Ceci prévient des tensions en mode commun importantes dues aux différences de tension par rapport à la masse entre nœuds. Le transformateur évite également les boucles de masse importantes qui peuvent être sensibles au couplage magnétique à basse fréquence.

La Figure 82 illustre la représentation schématique du transformateur.

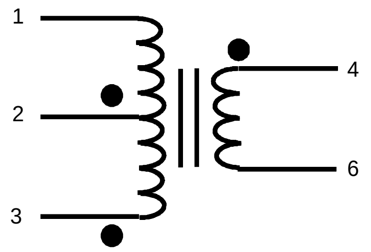

Figure 82 – Schéma du transformateur

Les transformateurs de couplage doivent être conformes aux exigences spécifiées dans le Tableau 95.

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Tableau 95 – Spécifications électriques transformateur support à câble coaxial de 5 Mbit/s en mode tension

Spécifications	Min.	Type	Max.
Inductance (mesurée à 40 kHz et 100 mV)	350 μH	750 μH	
Capacité d'enroulement (mesurée à 10 MHz)	16,0 pF	24,8 pF	29,5 Pf
Résistance parallèle (pertes dans le fer)	8,0 kΩ	9,1 kΩ	11,2 kΩ
Inductance de fuite	255 nH	441 nH	625 nH
isolation galvanique (à 47-63 Hz, inférieure à 1,0 mA)	500 $V_{eff.}$ pendant 60 s 600 V_{rms} pendant 1 s		
Fréquence de résonance	1,0 MHz	1,4 MHz	1,8 MHz

L'inductance de fuite doit être mesurée entre les broches 1 et 2, les broches 4 et 6 étant reliées ensemble. L'isolation galvanique doit être mesurée au moyen des broches 1, 2 et 3 reliées ensemble et les broches 4 et 6 reliées ensemble. L'isolation galvanique exigée doit être satisfaite de la broche 1 à la broche 4, de la broche 1 au noyau et de la broche 4 au noyau. Toutes les autres mesures doivent être effectuées entre les broches 4 et 6, la broche 2 étant reliée à la masse de l'instrument.

NOTE 2 Un exemple de conception de référence pour un transformateur de MAU à câble coaxial de 5 Mbit/s en mode tension est présenté en H.1.2.

18.4 Connecteur de support à câble coaxial de 5 Mbit/s en mode tension

Le connecteur utilisé sur un nœud donné doit être une prise jack de type BNC ou TNC, conformément aux exigences de la présente norme (voir l'Annexe F).

18.5 Topologie pour un support à câble coaxial de 5 Mbit/s en mode tension

Un segment doit être constitué d'une architecture ligne principale–ligne secondaire. La ligne principale doit être réalisée en câble coaxial et doit être terminée aux deux extrémités par une résistance de 75 Ω ± 5 %.

NOTE 1 Ceci permet de limiter les réflexions des signaux émis aux extrémités du câble de ligne principale.

Les nœuds doivent être connectés au réseau par des câbles de dérivation. Les câbles de dérivation doivent être connectés à la ligne principale au moyen de prises spécifiées. Ces prises doivent comprendre des circuits passifs permettant la connexion à la ligne principale tout en réduisant les réflexions dues aux charges de connexion.

Les nœuds connectés à un réseau à commande déterministe ne doivent pas terminer directement à la masse le blindage du câble de dérivation. La terminaison du blindage doit être réalisée conformément au Tableau 94. Pour terminer correctement le blindage de chaque câble de dérivation, on doit utiliser une résistance connectée en parallèle à un condensateur de 0,01 μF. La R/C en parallèle doit être connectée du blindage à la masse.

Un exemple de topologie est présenté à la Figure 83.

NOTE 2 Dans cet exemple, deux segments sont connectés par un répéteur pour constituer une liaison à sept nœuds.

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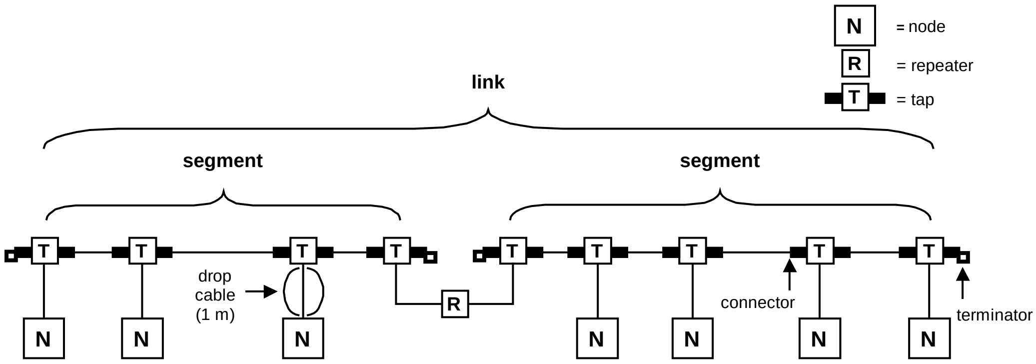

Légende

Anglais	Français
N = node	N = nœud
R = repeater	R = répéteur
T = tap	T = prise
Link	Liaison
Segment	Segment
Drop cable (1 m)	Câble de dérivation (1 m)
Connector	Connecteur
Terminator	Terminateur

Figure 83 – Exemple de topologie de câble coaxial de 5 Mbit/s en mode tension

Les limites de cette topologie sont présentées à la Figure 84. On peut connecter jusqu'à 48 nœuds à un segment d'une longueur allant jusqu'à 1 km, comme illustré à la Figure 84. Le compromis entre distance et nombre de nœuds est illustré à la Figure 84. S'il est requis une combinaison de nœuds et de distances qui dépasse les limites du segment, on doit utiliser un appareil répéteur de PhL (voir l'Annexe G). Pour ce qui concerne le support, un appareil répéteur de PhL doit être semblable, du point de vue électrique et mécanique, à un nœud. L'appareil répéteur de PhL doit nécessiter une prise pour chaque segment auquel il est connecté et il peut par conséquent être connecté n'importe où sur chaque segment. Les répéteurs ne doivent pas être placés de sorte à nécessiter plusieurs connexions entre segments.

Toute topologie qui prend en charge un chemin unique entre deux entités PhL quelconques doit pouvoir être mise en œuvre. Les trajectoires multiples entre des entités PhL ne doivent pas être autorisées par une application qui revendique la conformité à l'Article 18.

Cette variante de PhL peut être associée à d'autres variantes de PhL sur le même nœud, ou sur des nœuds différents, en utilisant la RM (machine répéteur) et/ou des appareils répéteurs de PhL (Voir l'Annexe G).

NOTE 3 Pour plus d'informations sur les répéteurs, voir l'Annexe G.

NOTE 4 Ces limites reposent sur les spécifications de câblage de 18.7.1.

La Figure 84 doit s'appliquer lorsqu'il est utilisé des prises comme spécifié en 18.6 et le câble coaxial de ligne principale, comme spécifié dans le Tableau 97. Les câbles ayant des caractéristiques d'affaiblissement autres que celles données dans le Tableau 97 peuvent être utilisés si un multiplicateur de longueur de segment approprié est mis en œuvre conformément à la Figure 84.

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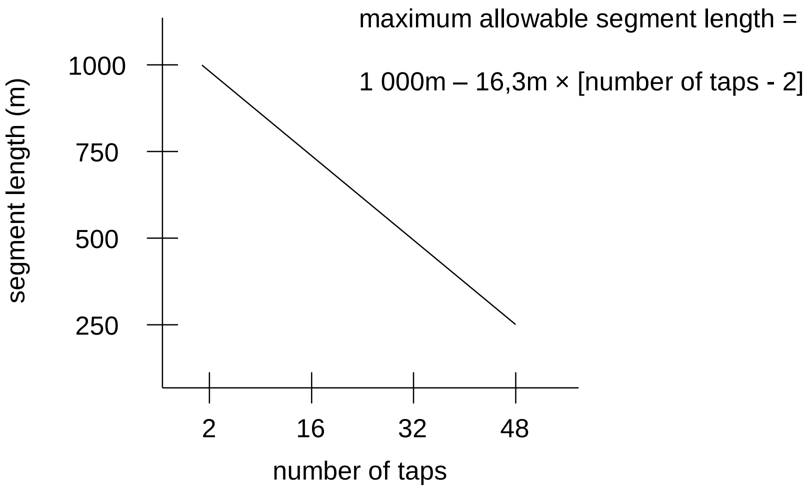

Légende

Anglais	Français
Segment length (m)	Longueur de segment (m)
Maximum allowable segment length	Longueur de segment maximale admissible
Number of taps	Nombre de prises

Figure 84 – Limites de topologie d'un support à câble coaxial

18.6 Prises pour un support à câble coaxial de 5 Mbit/s en mode tension

18.6.1 Description

La prise doit comporter des circuits passifs qui compensent les surcharges supplémentaires du nœud connecté.

NOTE 1 De cette manière, on obtient une perte de transmission moindre plutôt qu'une discontinuité de l'impédance et par conséquent une réflexion sur la ligne principale pour chaque nœud.

Une prise doit être utilisée pour tous les nœuds qui satisfont à la méthode de connexion spécifiée du support à câble coaxial.

NOTE 2 Un exemple de conception de référence pour un émetteur-récepteur avec MAU à câble coaxial de 5 Mbit/s en mode tension est présenté en H.1.3.

18.6.2 Exigences

La variante de prise normalisée doit permettre des connexions au moyen de prises jack BNC au niveau de la ligne principale et d'une fiche BNC au niveau du nœud; la variante de prise étanche IP67 doit permettre des connexions de prise jack TNC au niveau de la ligne principale et d'une fiche TNC ou BNC au niveau du nœud, conformément aux exigences de la présente norme (voir l'Annexe F). Un câble de ligne secondaire de 1 m de longueur, du type spécifié, doit être utilisé dans la prise si une compensation correcte du câble de ligne secondaire doit être obtenue.

NOTE 1 Les exigences électriques de la prise sont définies par les caractéristiques émises et reflétées telles que perçues par la ligne principale lorsque le port de la prise est correctement connecté par la ligne secondaire requise et une charge équivalente au nœud. Bien que la prise dispose de trois accès, elle peut être perçue comme un appareil à deux accès lorsqu'elle est configurée de cette manière. Le terme "charge équivalente au nœud" signifie une charge qui représente l'impédance nominale d'un nœud. Une charge équivalente au nœud peut être constituée à partir de composants discrets à condition que la charge équivalente remplisse l'ensemble des exigences de l'Article 18.

Les exigences de transmission et de réflexion doivent être telles que présentées à la Figure 85. Les paramètres de dispersion (S11, S22, S12 et S21) doivent être utilisés pour définir les

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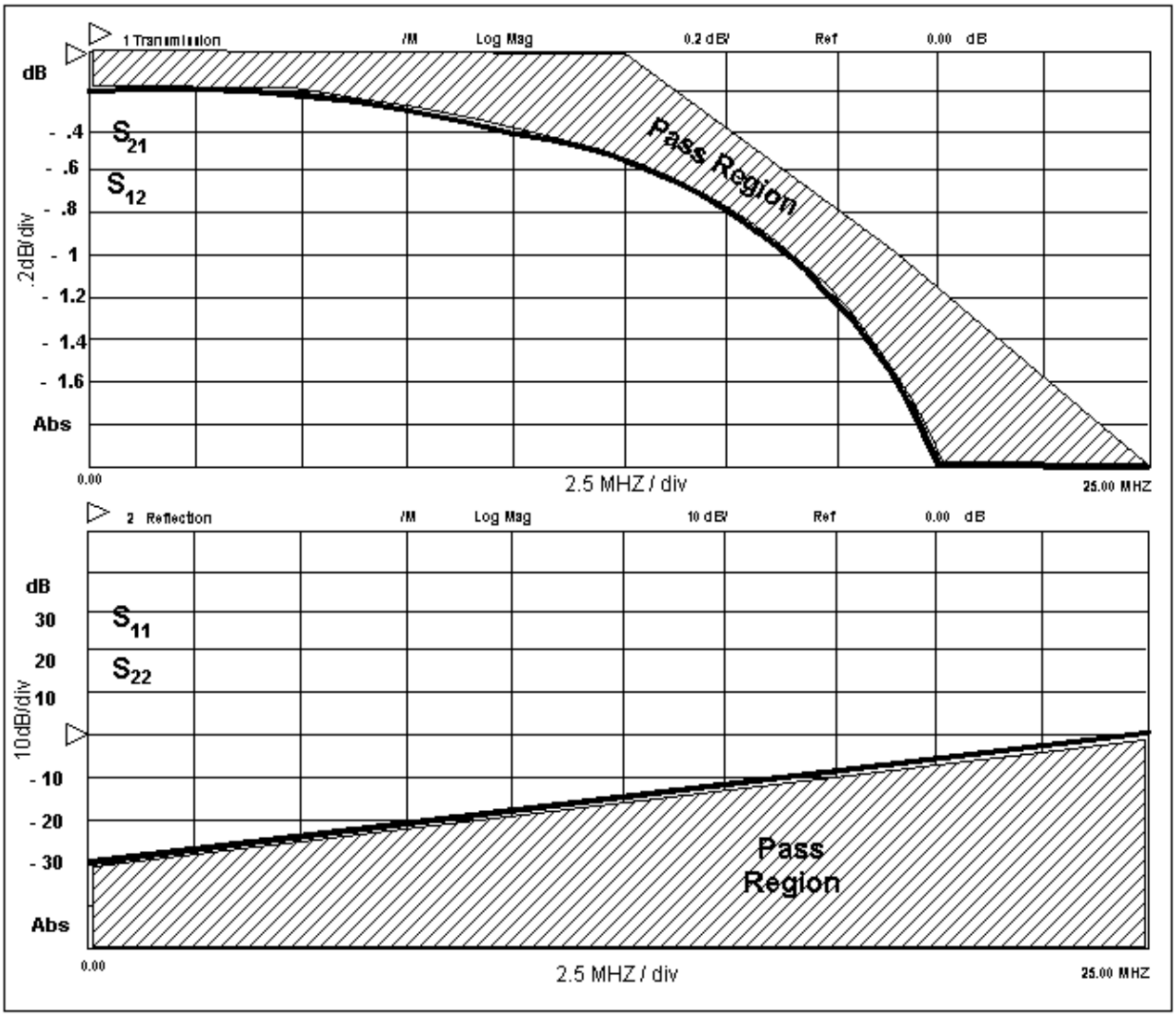
exigences électriques de la prise. S11 et S22 doivent être utilisés pour définir les caractéristiques de réflexion du connecteur de ligne principale d'une prise lorsque la ligne secondaire est terminée par une charge équivalente au nœud et que l'autre connecteur de ligne principale est terminé par un terminateur de ligne principale (75 Ω± 5 %). S12 et S21 doivent être utilisés pour définir les caractéristiques de transmission de la prise d'un connecteur de ligne principale à l'autre, le câble de dérivation étant terminé par une charge équivalente au nœud. Les caractéristiques de transmission et de réflexion de toutes les prises doivent s'inscrire dans la zone d'acceptation définie à la Figure 85.

NOTE 2 La prise est un appareil réciproque (S11=S22, S12=S21), de sorte que l'orientation des ports de ligne principale est arbitraire.



Légende

Anglais	Français
1 Transmission	1 Emission
Log mag	Log mag
Pass region	Zone d'acceptation
Reflection	Réflexion

Figure 85 – Caractéristiques électriques d'une prise de support à câble coaxial

18.6.3 Ligne secondaire

Le câble de ligne secondaire doit être conforme aux limites et caractéristiques indiquées dans le Tableau 96.

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Tableau 96 – Spécifications du câble coaxial de ligne secondaire

Spécifications	Limites / caractéristiques
Blindage	Blindage à double tresse, chaque tresse ayant une couverture de 95 %
Impédance	75 Ω ± 3 Ω
retard	4,1 ns/m ± 0,1 ns/m
Affaiblissement (dB/100 m) à	
1 MHz	1,25
5 MHz	3,01
10 MHz	4,33
25 MHz	6,89
50 MHz	10,1
Affaiblissement de réflexion de régularité	23 dB au moins, de 5 MHz à 50 MHz
Résistance en courant continu du conducteur	92 Ω/km nominal
Résistance en courant continu du blindage	10,5 Ω/km nominal
Capacité nominale	54,13 pF/m

18.7 Ligne principale pour un support à câble coaxial de 5 Mbit/s en mode tension

18.7.1 Câble de ligne principale

Le câble de ligne principale doit satisfaire aux spécifications du Tableau 97.

Tableau 97 – Spécifications du câble coaxial de ligne principale

Spécifications	Limites / caractéristiques
Blindage	Blindage quadruple
Impédance	75 Ω ± 3 Ω
Retard	4,1 ns/m ± 0,1 ns/m
Affaiblissement (dB/100 m) à	
1 MHz	1,15
2 MHz	1,25
5 MHz	1,48
10 MHz	1,94
20 MHz	2,82
50 MHz	4,49
Affaiblissement de réflexion de régularité	23 dB au moins, de 5 MHz à 50 MHz
Résistance en courant continu du conducteur	92 Ω/km nominal
Résistance en courant continu du blindage	24 Ω/km nominal
Capacité nominale	53,15 pF/m

Le câble de ligne secondaire spécifié dans le Tableau 96 peut également être utilisé comme câble de ligne principale sur des longueurs limitées (jusqu'à 10 m par segment).

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18.7.2 Connecteurs

La connexion à la ligne principale doit utiliser une fiche BNC ou TNC, conformément aux exigences de la présente norme (voir l'Annexe F).

19 Type 2: Unité de liaison au support: support optique 5 Mbit/s

19.1 Généralités

NOTE 1 L'Article 19 spécifie la variante de support optique et de PhL. Des informations importantes concernant la conception de la connexion de la PhL sont fournies.

NOTE 2 La méthode de connexion du support à fibre optique définit trois variantes de supports à fibre optique et de PhL. La première variante concerne les supports à fibre optique et PhL exigés pour un système de courte portée, pour des distances (nominales) allant jusqu'à 300 m, la seconde variante concerne des supports à fibre optique et PhL exigés pour un système de moyenne portée, pour des distances (nominales) allant jusqu'à 7 km et la dernière variante concerne des supports à fibre optique et PhL exigés pour un système de longue portée, pour des distances (nominales) allant jusqu'à 20 km.

La méthode de connexion du support à fibre optique doit comporter une topologie point à point ou annulaire en transmission bidirectionnelle simultanée, utilisant un émetteur et un récepteur à chaque extrémité d'une paire de fibres.

Pour toutes les variantes, les méthodes de connexion du support à fibre optique doivent être définies comme étant soit une liaison point à point, soit une topologie annulaire. La liaison point à point doit relier des nœuds d'extrémité entre eux, des nœuds d'extrémité et des appareils répéteurs de PhL ou des répéteurs de PhL entre eux. La topologie annulaire doit connecter entre eux deux ou plusieurs nœuds ou appareils qui utilisent la machine répéteur d'anneau (RRM), décrite en Annexe G. Le passage entre support et topologies doit exiger l'utilisation d’appareils répéteurs de PhL. La mise en œuvre doit utiliser soit un concentrateur actif, une étoile active ou un anneau actif. Un concentrateur actif ou une étoile active doivent comprendre au minimum deux ports d'accès.

NOTE 3 La couche physique peut être mise en œuvre de manière à permettre une certification pour un fonctionnement dans des atmosphères explosives sans sacrifier la distance ou réduire le nombre de nœuds. La présente norme n'inclut pas d'exigences pour la certification de la sécurité intrinsèque mais cherche à exclure des conditions ou situations qui pourraient empêcher la certification de la sécurité intrinsèque.

La MAU à support à fibre optique doit comprendre l'émetteur-récepteur à fibre optique et le connecteur à fibre optique. L'émetteur-récepteur doit utiliser les signaux définis dans l'interface MDS-MAU pour générer ceux qui sont nécessaires pour piloter l'émetteur-récepteur. La connexion au support doit être effectuée par l'intermédiaire de connecteurs à fibre optique.

19.2 Emetteur-récepteur de support optique de 5 Mbit/s,

Pour prendre en charge un support à fibre optique, un émetteur à fibre optique doit émettre et recevoir de la MDS des signaux L (bas) et H (haut). La partie émetteur de l'émetteur-récepteur doit obtenir des signaux de transmission de l'interface MDS-MAU, représentant les symboles H et L, et émet, au moyen d'un émetteur-récepteur directement couplé, des signaux ‘lumière active’ (pour H) ou ‘lumière inactive’ (pour L). Ceci signifie que l'émetteur-récepteur doit être capable d'émettre et de recevoir la signalisation PhL à des fréquences allant de zéro (pas de transitions de symbole Ph) à 10 MHz minimum.

NOTE Les émetteurs-récepteurs directement couplés sont nécessaires, car les sous-couches MDS et MAU, telles que spécifiées, ne permettent pas l'insertion et la suppression d'une séquence de repos lorsqu'il n'y a pas de données L ou H à envoyer, c'est-à-dire au cours des périodes où il n'y a aucune activité de symbole Ph.

Cette fonction doit être complétée dans le récepteur, qui doit fournir les indications RXDATA et RXCARRIER à l'interface MDS-MAU, comme présenté à la Figure 86, qui est un synoptique fonctionnel décrivant les composants de la MAU.

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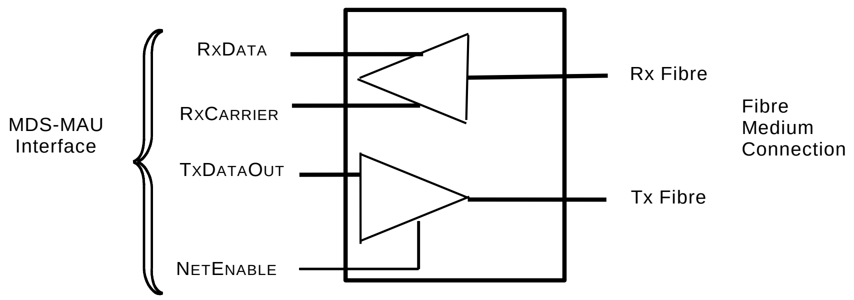

Légende

Anglais	Français
MDS-MAU interface	Interface MDS – MAU
Rx Fibre	Fibre Rx
Tx Fibre	Fibre Tx
Fibre medium connection	Connexion de support à fibre optique

Figure 86 – Synoptique de MAU 5 Mbit/s, support à fibre optique

Les signaux de transmission doivent être tels que présentés dans le Tableau 98.

Tableau 98 – Définitions des lignes de commande de transmission, support à fibre optique de 5 Mbit/s

TxDataOut	NetEnable	Symbole physique	Signal sur support à fibre optique
sans effet (x)	faux (0)	sans effet (x)	lumière éteinte
faux (0)	vrai (1)	L	lumière éteinte
vrai (1)	vrai (1)	H	lumière active

Les limites de transmission et de réception de l'interface à fibre optique doivent être conformes au Tableau 99.

Tableau 99 – Interface de support à fibre optique de 5,0 Mbit/s

Spécification	Limites / caractéristiques	Commentaires
Instabilité du modèle d'entrée	40 ns crête à crête max.	Mesurée sur RxData
Instabilité totale en émission	< 5 ns crête à crête	

19.3 Topologie support optique de 5 Mbit/s

La topologie des supports définis pour une variante de connexion de support à fibre optique, doit être une liaison point à point ou une topologie annulaire. La topologie point à point doit être utilisée entre deux entités PhL quelconques conformes aux exigences de l'Article 19 et qui n'utilisent pas la RRM. La topologie annulaire doit être utilisée entre deux entités PhL quelconques conformes aux exigences de l'Article 19 qui utilisent la RRM (voir l'Annexe G). Le passage entre ces deux topologies doit nécessiter l'utilisation d'un répéteur PhL ou de tout appareil utilisant la fonction RRM et une PhL de répéteur. Dans les deux cas, les nœuds et les répéteurs doivent pouvoir être connectés en cascade, à condition que chaque liaison soit conforme aux exigences du présent Article 19. Le temps total de propagation du signal doit être utilisé pour le calcul de la durée de créneau, comme décrit dans la CEI 61158-4-2.

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Toute topologie qui prend en charge un chemin unique entre deux entités PhL quelconques doit pouvoir être mise en œuvre. Les trajectoires multiples entre des entités PhL ne doivent pas être autorisées par une application qui revendique la conformité de l'Article 19.

Cette variante de PhL peut être associée à d'autres variantes de PhL sur le même nœud, ou sur des nœuds différents, en utilisant la RM (machine répéteur) et/ou des appareils répéteurs de PhL (Voir l'Annexe G).

19.4 Fibre optique de ligne principale de support de 5 Mbit/s

La fibre optique de la ligne principale doit satisfaire aux exigences spécifiées en 19.6 pour la variante correspondante de PhL à fibre optique.

19.5 Connecteurs de ligne principale de support à fibre optique de 5 Mbit/s

Les connecteurs de ligne principale doivent être conformes aux exigences de la présente norme (voir l'Annexe F) pour les différentes variantes de PhL à fibre optique.

19.6 Spécifications de fibre optique de support de 5 Mbit/s

Les caractéristiques des signaux pour les supports à fibre optique et la variante de PhL correspondante, à 25 ºC, doivent être telles que présentées dans les Tableau 100, Tableau 101 et Tableau 102.

Tableau 100 – Spécification des signaux de support à fibre optique de 5 Mbit/s, de courte portée

Spécifications	Min.	Nominale	Max.
Fibre			
Distance	0 m	300 m	
Affaiblissement de la fibre à λ		6 dB/km	
Technologie de fibre optique	à saut d'indice, silice gainée en dur (HCS)		
Cœur/gaine	200/230 μm		
Ouverture numérique	0,5		
Système			
BER	10^{-9}		
Bilan de puissance	3,9 dB	9,5 dB	
Émetteur			
Longueur d'onde λ	640 nm	650 nm	660 nm
Largeur spectrale	21 nm		
Puissance couplée, $P_{T\ on}$ (lumière émission active)	–16,1 dBm, crête	–12,5 dBm, crête	–8,5 dBm, crête
Puissance couplée, $P_{T\ off}$(lumière émission inactive)			–44 dBm, crête
Temps de croissance optique T_{rise}			
Temps de décroissance optique T_{fall}			
Récepteur			
$P_{R\ MIN}$ (lumière réception active)		–25 dBm, crête	–23 dBm, crête
$P_{R\ MAX}$ (lumière réception active)	–1,0 dBm	+3,0 dBm	
Distorsion de la largeur d'impulsion			30 ns

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Tableau 101 – Spécification des signaux de support à fibre optique de 5 Mbit/s, de moyenne portée

Spécifications	Min.	Nominale	Max.
Fibre			
Distance	0 m	7 km	
Affaiblissement de la fibre à λ		1,5 dB/km	
Technologie de fibre optique	à gradient d'indice, multimodale		
Cœur/gaine	62,5/125 µm		
Ouverture numérique	0,275		
Système			
BER	10^{-9}		
Bilan de puissance	11,3 dB	16,4 dB	
Émetteur			
Longueur d'onde λ	1 270 nm	1 300 nm	1 370 nm
Largeur spectrale		130 nm	185 nm
Puissance couplée, $P_{T\ on}$ (lumière émission active)	–15,5 dBm, crête	–13,5 dBm, crête	–12,0 dBm, crête
Puissance couplée, $P_{T\ off}$(lumière émission inactive)			–40 dBm, crête
Temps de croissance optique T_{rise}		1,8 ns	4,0 ns
Temps de décroissance optique T_{fall}		2,2 ns	4,0 ns
Récepteur			
$P_{R\ MIN}$ (lumière réception active)	–33,5 dBm, crête	–31,8 dBm, crête	–28,8 dBm, crête
$P_{R\ MAX}$ (lumière réception active)			
Distorsion de la largeur d'impulsion			2 ns

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Tableau 102 – Spécification des signaux de support à fibre optique de 5 Mbit/s, de longue portée

Spécifications	Min.	Nominale	Max.
Fibre			
Distance			20 km
Affaiblissement de la fibre à λ		0,5 dB/km	
Technologie de fibre optique	à gradient d'indice, unimodale		
Cœur/gaine	10/125 µm		
Ouverture numérique	0,1		
Système			
BER	10^{-9}		
Bilan de puissance	10 dB		
Émetteur			
Longueur d'onde λ	1 270 nm	1 300 nm	1 370 nm
Largeur spectrale		70 nm	
Puissance couplée, $P_{T\ on}$ (lumière émission active)	–18 dBm, crête	–15 dBm, crête	–10 dBm, crête
Puissance couplée, $P_{T\ off}$(lumière émission inactive)			–40 dBm crête
Temps de croissance optique T_{rise}		2 ns	4,0 ns
Temps de décroissance optique T_{fall}		2,2 ns	4,0 ns
Récepteur			
$P_{R\ MIN}$ (lumière réception active)		–32 dBm, crête	–30 dBm, crête
$P_{R\ MAX}$ (lumière réception Active)	–10 dBm		
Distorsion de la largeur d'impulsion			2 ns

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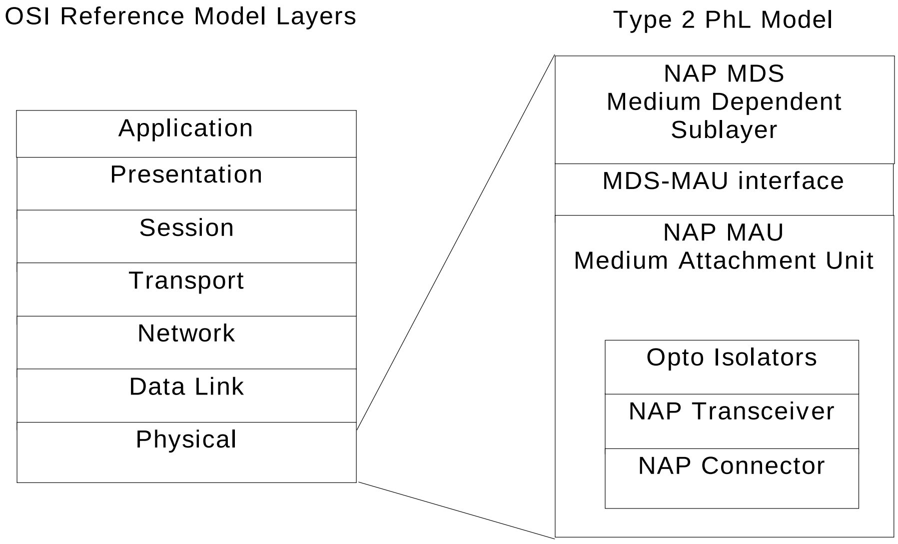
20 Type 2: Unité de liaison au support: Port d'accès au réseau (NAP)

20.1 Généralités

La Figure 87 montre l'emplacement de la PhL du port d'accès au réseau (NAP) et du support dans le modèle de référence ISO/OSI.



Légende

Anglais	Français
OSI reference model layers	Couches du modèle de référence OSI
Application	Application
Presentation	Présentation
Session	Session
Transport	Transport
Network	Réseau
Data link	Liaison de données
Physical	Physique
Type 2 PhL model	Modèle de PhL de Type 2
NAP MDS Medium dependent sublayer	NAP MDS: Sous-couche dépendante du support
MDS-MAU interface	Interface MDS – MAU
NAP MAU Medium Attachment Unit	NAP MAU: Unité de liaison au Support
Opto Isolators	Isolateurs optiques
NAP transceiver	Emetteur-récepteur NAP
NAP connector	Connecteur NAP

Figure 87 – Modèle de référence NAP

La connexion locale à un ordinateur (de bureau ou portable) à un appareil de programmation portatif ou toute autre connexion temporaire au réseau, doit être effectuée par l'intermédiaire de l'émetteur-récepteur NAP en utilisant le protocole et les débits de données spécifiés pour la ligne principale. L'émetteur-récepteur NAP doit obtenir une ligne de transmission unique de l'interface MDS-MAU, envoyer des données et en recevoir d'un autre nœud à l'autre extrémité du câble NAP et fournir une seule ligne de réception en retour vers l'interface MDS-MAU.

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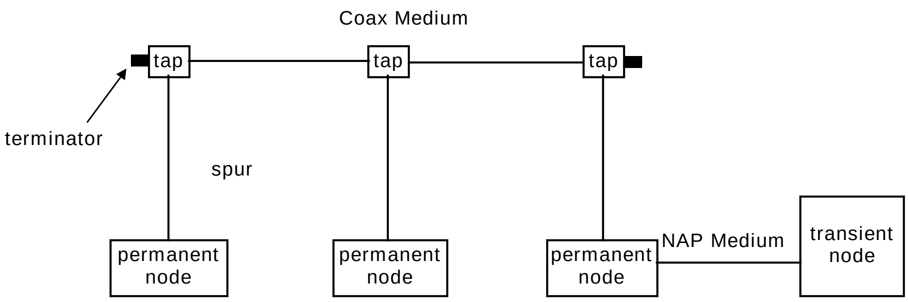
S'agissant de lignes uniques, aucune représentation de l'activation/désactivation de la porteuse ne doit être présente. A tout moment, ces signaux doivent être soit un "zéro" logique soit un "un" logique. Le support doit à tout instant être piloté par la ligne de transmission unique.

La PhL du NAP doit prendre en charge une connexion point à point entre deux nœuds. Il ne doit pas y avoir une topologie de liaison multipoints prenant en charge plus de deux nœuds.

Toute topologie qui prend en charge un chemin unique entre deux entités PhL quelconques doit pouvoir être mise en œuvre. Les trajectoires multiples entre des entités PhL ne doivent pas être autorisées par une application qui revendique la conformité de l'Article 20.

Un nœud, dont la connexion principale à la liaison s'effectue par le biais de la variante de PhL du NAP, doit être considéré comme un nœud réseau transitoire. Un nœud, dont la connexion principale à la liaison s'effectue via une autre variante de PhL, doit être considéré comme un nœud de réseau permanent. Un nœud transitoire doit communiquer avec un autre nœud transitoire ou permanent en utilisant le support NAP. Le nœud permanent doit utiliser la fonctionnalité machine répéteur (RM) (voir l'Annexe G) contenue dans la DLL de ce nœud pour permettre au nœud transitoire de communiquer avec d'autres nœuds permanents, comme illustré à la Figure 88. Un nœud permanent doit fonctionner comme un nœud transitoire lorsqu'aucun support PhL n'est connecté, comme présenté à la Figure 88.



Légende

Anglais	Français
Terminator	Terminateur
Tap	Prise
Spur	Ligne secondaire
Permanent node	Nœud permanent
Coax medium	Support à câble coax
Nap medium	NAP Support
Transient node	Nœud transitoire

Figure 88 – Exemples de nœuds transitoires et permanents

Cette variante de PhL peut être associée à d'autres variantes de PhL sur le même nœud, ou sur des nœuds différents, en utilisant la RM (machine répéteur) et/ou des appareils répéteurs de PhL (Voir l'Annexe G).

20.2 Signalisation

Les exigences de signalisation pour le port NAP doivent être telles que présentées au Tableau 103.

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Tableau 103 – Exigences du NAP

Spécification d'interface NAP	Spécification de conception	Commentaires
Interface NAP – Généralités		
Couplage	CC	Isolateur optique exigé pour la programmation des nœuds
Configuration de la liaison	Deux, paire RS-422 unidirectionnelle	Une Rx, une Tx
Connecteur	RJ-45 blindé	Voir Annexe F
Terminaison	100 Ω interne, uniquement sur /RxPTC	
NAP – Emission		
Niveau de sortie au niveau du support NAP avec/TxPTC = vrai	2,5 V min.	Mesuré entre Tx_H et broche GND REF, avec une charge de réception NAPΩ connectée de 100 (voir Tableau F.2)
Niveau de sortie au niveau du support NAP avec/TxPTC = faux	2,5 V min.	Mesuré entre Tx_L et broche GND REF, avec une charge de réception NAPΩ connectée de 100 (voir Tableau F.2)
Niveau de sortie au niveau du support NAP avec/TxPTC = vrai	0,5 V max.	mesuré entre Tx_L et broche GND REF, avec une charge de réception NAPΩ connectée de 100 (voir Tableau F.2)
Niveau de sortie au niveau du support NAP avec/TxPTC = faux	0,5 V max.	mesuré entre Tx_H et broche GND REF, avec une charge de réception NAPΩ connectée de 100 (voir Tableau F.2)
Niveau de sortie au niveau du support NAP avec/TxPTC = données	4,0 V min.	(Tx_H – Tx_L) mesuré de crête à crête, avec une chargeΩde 100 (voir Tableau F.2)
Instabilité totale en émission	± 5 ns max.	
Terminaison	Aucune	
NAP – Réception		
Niveau de réception au niveau du support NAP avec/TxPTC= données	2,5 V min.	(Rx_H – Rx_L) mesuré de crête à crête (Voir le Tableau F.2)
Instabilité en réception	`± 15 ns max.	
Terminaison	100 Ω ± 10 %	Entre lignes différentielles
Signal de réception de défauts	/RxPTC= vrai	Si le support est déconnecté, en court-circuit, si le récepteur est hors-tension ou désactivé, /RxPTC doit être "vrai"

20.3 Emetteur-récepteur

Le synoptique de la MAU du NAP à la Figure 89 représente les applications isolées et non isolées. Le NAP isolé doit être utilisé sur des nœuds transitoires. L'isolation optique doit être assurée pour éviter que des courants de boucle de masse ne circulent entre nœuds ayant des potentiels de terre différents. L'isolation optique ne doit pas être exigée si le nœud est autoalimenté et qu'il n'est pas mis à la masse. Le NAP non isolé doit être utilisé sur des nœuds permanents.

NOTE 1 Un nœud transitoire est défini comme étant un nœud ayant une connexion principale et ordinaire au réseau par l'intermédiaire du NAP d'un autre nœud. Ceci comprend, de manière non limitative, des cartes d'interface informatiques, des nœuds de configuration ainsi que d'autres nœuds qui sont des connexions transitoires ou temporaires au réseau.

NOTE 2 Un nœud permanent est défini comme étant un nœud ayant une connexion principale et ordinaire au réseau par l'intermédiaire d'une PhL autre que le NAP. Ceci comprend, de manière non limitative: les automates programmables, les adaptateurs de châssis E/S, les appareils de commande, les robots, les soudeuses et autres nœuds qui sont connectés au réseau de manière quasi-permanente.

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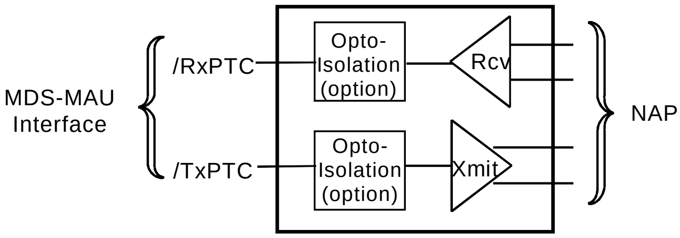
Si un nœud peut être utilisé à la fois comme nœud transitoire et permanent, il doit inclure une isolation optique dans la conception du NAP (à moins qu'il ne soit autoalimenté et qu'il ne puisse pas être mis à la terre).



Légende

Anglais	Français
MDS-MAU interface	Interface MDS – MAU
Opto Isolation (option)	Isolation optique (facultative)
Rcv	Récept.
Opto Isolation (option)	Isolation optique (facultative)
X (mit)	Emiss.

Figure 89 – Emetteur-récepteur NAP

NOTE 3 Un exemple de modèle de référence d'une MAU de port d'accès au réseau est présenté à l'Article H.2.

20.4 Connecteur

Le connecteur utilisé aux deux extrémités d'une connexion NAP doit être du type RJ-45 à 8 broches, blindé, comme spécifié dans l'Annexe F.

20.5 Câble

Le câble NAP doit contenir 8 conducteurs et un blindage global. Le blindage doit être conçu de manière à réduire les perturbations électromagnétiques. Les broches du connecteur du câble doivent être telles que présentés dans le Tableau F.2.

Sachant que le connecteur du NAP et les connexions des broches sont identiques pour les nœuds transitoires et permanents, le câble doit être conçu de manière à permettre les connexions correctes des données de transmission et de réception. Ceci doit être obtenu en inversant la connexion à une extrémité du câble NAP, comme présenté à la Figure 90.

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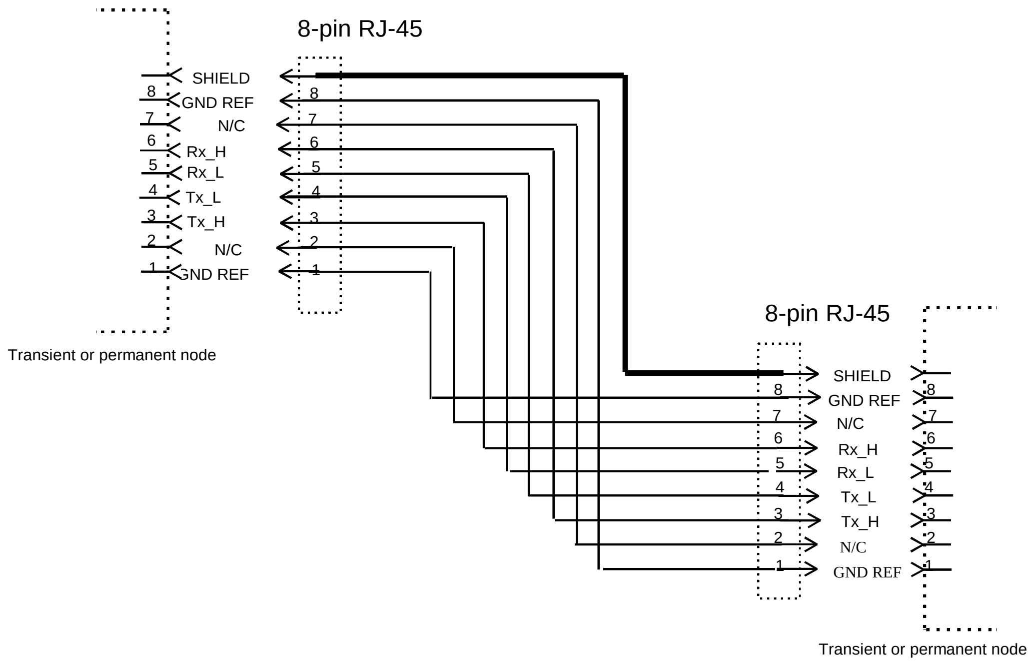

NOTE Les connecteurs du câble NAP sont montés de façon à ce que les lignes de signaux soient inversées pour permettre une connexion correcte. De cette manière, l'équipement utilise la même configuration de broches indépendamment de la fonction.

Légende

Anglais	Français
8-Pin RJ-45	RJ-45 à 8 broches
Shield	Blindage
GND REF	REF MASSE
Transient or permanent node	Nœud transitoire ou permanent

Figure 90 – Câble de NAP

Le câble de NAP doit satisfaire aux exigences suivantes:

a) caractéristiques des paires de lignes = 100Ω;
b) résistance (à 0 Hz) = 0,122 Ω/m;
c) calibre du fil = 26 (7 brins, diamètre 0,16 mm);
d) conducteurs = 8 plus blindage global;
e) longueur maximale du câble = 10 m.

21 Type 3: Unité de liaison au support: Transmission synchrone, 31,25 kbit/s, mode tension, support câblé

21.1 Généralités

La MAU 31,25 kbit/s en mode tension fournit simultanément l'accès à un réseau de communication et à un réseau de distribution d'énergie optionnel. Les appareils raccordés au réseau communiquent par l'intermédiaire du support et peuvent ou non être alimentés par ce support. Si l'alimentation s'effectue par le bus, elle est distribuée en tension directe et en courant continu et des signaux de communication sont superposés sur l'alimentation c.c. Dans les applications de sécurité intrinsèque, la puissance disponible peut limiter le nombre d'appareils.

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Le support réseau est constitué d'un câble à paire torsadée. Indépendamment de la topologie, tous les appareils connectés, sauf éventuellement l'appareil de transmission, présentent une haute impédance pour éviter une surcharge importante du réseau. Les formes d'onde trapézoïdales sont utilisées pour réduire les émissions électromagnétiques.

Des topologies en bus et arborescentes sont prises en charge. Quelle que soit la topologie, un réseau comporte un câble de ligne principale disposant de terminaisons aux deux extrémités. Dans la topologie de bus linéaire, les lignes secondaires sont réparties sur la longueur de la ligne principale. Dans la topologie arborescente, les lignes secondaires sont concentrées à une extrémité de la ligne principale. Une ligne secondaire peut connecter plusieurs appareils au réseau et le nombre d'appareils sur une ligne secondaire donnée dépend de la longueur de cette ligne.

A fréquence industrielle (c.c.), les appareils apparaissent pour le réseau comme des absorbeurs de courant avec un taux de variation limité du courant d'alimentation prélevé du support. Ceci permet d'éviter que les modifications transitoires du courant de charge n'interfèrent avec les signaux de communication.

21.2 Débit binaire de transmission

Voir 12.2.

21.3 Spécifications du réseau

21.3.1 Composants

Le Paragraphe 12.3.1 s'applique.

Lors de la sélection des différentes composantes, il faut s'assurer qu'elles satisfont toutes aux exigences du modèle FISCO. Seules les composantes identifiées comme étant du matériel électrique de sécurité intrinsèque ou du matériel électrique associé, conformément à la CEI 60079-11, peuvent être installées sur des segments de bus de terrain de sécurité intrinsèque. Pour satisfaire aux exigences de 12.2.5.1 de la CEI 60079-14, les valeurs admissibles des paramètres d'entrée U_I, I_I et P_I d'un matériel de sécurité intrinsèque (par exemple des appareils de terrain) ne doivent pas être inférieures aux valeurs maximales certifiées des paramètres de sortie U_0, I_0 et P_0 de l'appareil d'alimentation correspondant. Des restrictions supplémentaires, applicables aux composantes individuelles (par exemple limitation de la puissance d'alimentation ≤ 1,2 W) doivent être également prises en compte.

Le Tableau 104 énumère les combinaisons possibles d'appareils de différentes catégories de systèmes.

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Tableau 104 – Combinaison d’appareils de différentes catégories

Protection du segment de bus contre l'explosion	Protection de l’appareil d'alimentation contre l'explosion	Protection de l’appareil de terrain contre l'explosion					
		EEx ia			EEx ib		
		IIC	IIB	IIC/IIB	IIC	IIB	IIC/IIB
EEx ia IIC (Groupe IIC)	[EEx ia] IIC	x		x			
EEx ia IIB	[EEx ia] IIB	x	x	x			
(Groupe IIB)	[EEx ia] IIC	x	x	x			
EEx ib IIC	[EEx ib] IIC	x		x	x		X
(Groupe IIC)	[EEx ia] IIC	x		x	x		X
	[EEx ib] IIB	(x)[1)]	x	x	(x)[1)]	x	X
EEx ib IIB	[EEx ib] IIC	x	x	x	x	x	X
(Groupe IIC)	[EEx ia] IIB	(x)[1)]	x	x	(x)[1)]	x	X
	[EEx ia] IIC	x	x	x	x	x	X

1) Ces combinaisons sont possibles en théorie, mais elles ne sont pas pertinentes en pratique, car les appareils de terrain peuvent être certifiés pour le groupe IIC et pour le groupe IIB également (voir la colonne IIC/IIB).

Quelle que soit la combinaison choisie, on doit s'assurer que les valeurs maximales absolues des caractéristiques assignées d'entrée de l’appareil de terrain correspondent aux caractéristiques de sortie de l’appareil d'alimentation:

$U_I \geq U_O$

$I_I \geq I_O$

$P_I \geq P_O$

Des appareils alimentés par le bus et des appareils alimentés localement sur un bus de terrain de sécurité intrinsèque peuvent être connectés si les appareils alimentés localement sont munis d'une isolation appropriée conforme à la CEI 60079-11.

Bien que la connexion d'une station de bus de terrain (par exemple un appareil de terrain, un terminal portatif et un coupleur pour le maître du bus) avec inversion des pôles n'affecte pas la fonctionnalité des autres appareils connectés au bus de terrain, une station de bus installée de manière incorrecte et qui n'est pas équipée d'une détection automatique de la polarité ne sera pas alimentée en énergie ou ne pourra pas émettre et recevoir. Les stations disposant d'une détection automatique de polarité fonctionnent correctement quelle que soit l'attribution des bornes d'entrée aux conducteurs.

21.3.2 Topologies

Une MAU câblée doit fonctionner sur un réseau de topologie de bus linéaire constitué d'une ligne principale, terminée à chaque extrémité comme spécifiée en 21.8.5 et à laquelle des éléments de communication sont connectés par l'intermédiaire de coupleurs et de lignes secondaires.

Le coupleur et l'élément de communication peuvent être intégrés en un appareil (c'est-à-dire une ligne secondaire de longueur zéro).

Une topologie arborescente dont tous les éléments de communication sont placés aux extrémités de la ligne principale est considérée comme un cas particulier de bus aux fins de l'Article 21.

Plusieurs éléments de communication peuvent être connectés à la ligne principale en un point donné, en utilisant un coupleur multivoies. Un coupleur actif peut être utilisé pour étendre une ligne secondaire sur une longueur qui nécessite une terminaison afin d'éviter les réflexions et

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distorsions. Des répéteurs actifs peuvent être utilisés pour étendre la longueur de la ligne principale au-delà d'un segment unique si cela est autorisé par les règles de configuration du réseau.

21.3.3 Règles de configuration du réseau

Une MAU de 31,25 kbit/s en mode tension doit satisfaire aux exigences de l'Article 21 lorsqu'elle est utilisée sur un réseau qui satisfait aux présentes règles.

Règle 1: Un bus de terrain doit être capable d'assurer la communication entre les nombres d'appareils indiqués ci-après, fonctionnant tous au même débit binaire:

a) pour un bus de terrain non IS sans alimentation par les conducteurs de signaux: entre deux et 32 appareils;
b) pour un bus non IS avec alimentation par l'intermédiaire de conducteurs de signaux: entre deux et le nombre d'appareils qui peuvent être alimentés par l'intermédiaire des conducteurs de signaux, en supposant qu'un minimum de 120 mA doit être mis à la disposition des appareils à l'extrémité distante de l'alimentation et en sachant que la communication avec un appareil à l'extrémité de l'alimentation consomme 10 mA;
c) pour un bus de terrain IS: entre deux et le nombre d'appareils qui peuvent être alimentés par l'intermédiaire des conducteurs de signaux, en supposant qu'au minimum 40 mA doivent être mis à la disposition des appareils dans la zone dangereuse.

NOTE 1 La règle 1 n'exclut pas l'utilisation d'un nombre d'appareils supérieur à celui spécifié dans un système installé. Etant donné que la consommation d'énergie de l'appareil n'est pas spécifiée, le nombre d'appareils alimentés par le bus ne peut pas être spécifié. Le point b) suppose que la tension minimale d'alimentation est de 20 V c.c. Le point c) suppose que la barrière IS fonctionne avec une sortie de 19 V c.c.

Règle 2: La longueur totale de câble entre deux appareils quelconques, y compris les lignes secondaires, d'un segment de bus de terrain de 31,25 kbit/s en mode tension, à pleine charge (comportant le nombre maximal d'appareils connectés) doit être de 1900 m au maximum.

NOTE 2 Cette longueur maximale du câble de 1 900 m est l'exigence de conformité à l'Article 21, mais n'exclut pas l'utilisation de longueurs supérieures dans un système installé.

Règle 3: Le nombre total de régénérations de forme d'onde par des répéteurs et des coupleurs actifs entre deux appareils quelconques ne doit pas être supérieur à quatre.

Règle 4: Le délai maximal de propagation entre deux appareils quelconques ne doit pas dépasser 20 Tbit.

Pour que le réseau fonctionne efficacement, il convient que cette partie du temps de retournement de tout appareil du réseau, générée par une PhE entre la fin d'une trame reçue et le début d'une trame émise contenant une réponse immédiate associée, ne dépasse pas 5 temps binaires, dont il convient qu'au maximum 2 temps binaires soient dus à la MAU.

NOTE 3 Sachant qu'il n'est pas obligatoire d'exposer l'interface DLL – PhL ou l'interface MDS – MAU, cette partie du temps de retournement d'un appareil de bus de terrain due à la PhL ou à la MAU n'est pas spécifiée et donc non disponible pour des essais de conformité.

Règle 5: Le bus de terrain doit pouvoir continuer à fonctionner lorsqu'un appareil y est connecté ou déconnecté. Les erreurs de données générées lors de la connexion ou de la déconnexion doivent être détectées.

Règle 6: La défaillance d'un quelconque élément de communication ou d'une ligne secondaire (à l'exception d'un court circuit, d'une faible impédance ou d'un bavardage) ne doit pas interférer avec des transactions entre d'autres éléments de communication pendant plus de 1 ms.

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Règle 7: Dans des systèmes polarisés, les paires torsadées du support doivent être distinctement repérées de manière à identifier de manière unique chaque conducteur individuel. La polarisation doit être maintenue en tout point de raccordement.

Règle 8: La dégradation des caractéristiques électriques du signal, entre deux appareils quelconques, due à l'affaiblissement, à la distorsion d'affaiblissement et à la désadaptation doit être limitée aux valeurs indiquées ci-dessous.

a) Affaiblissement du signal: La configuration du bus (longueurs de la ligne principale et des lignes secondaires, nombre d'appareils, barrières IS, sectionneurs galvaniques et éventuels appareils d'adaptation) doit être telle que l'affaiblissement entre deux appareils quelconques, à la fréquence correspondant au débit binaire, ne doit pas dépasser 10,5 dB.

b) Distorsion d'affaiblissement: La configuration du bus (longueurs de ligne principale et de lignes secondaires, nombre d'appareils, barrières IS et sectionneurs galvaniques) doit être telle qu'entre deux appareils quelconques:

   [Affaiblissement (1,25 f_r) – Affaiblissement (0,25 f_r)] ≤ 6 dB

   Affaiblissement (1,25 f_r) ≥ Affaiblissement (0,25 f_r)

   où f_r est la fréquence correspondant au débit binaire. L'affaiblissement doit être monotonique pour toutes les fréquences de 0,25 f_r à 1,25 f_r(7,8 kHz à 39 kHz).

c) Distorsion de désadaptation: La désadaptation (due à des lignes secondaires ou à tout autre effet, y compris une ligne secondaire de longueur maximale en circuit ouvert) sur le bus doit être telle qu'en tout point sur la ligne principale, dans la bande de fréquence comprise de 0,25 f_r à 1,25 f_r(7,8 kHz à 39 kHz):

   $|Z – Zfr| / |Z + Zfr| \leq 0,2$

   où $Z_o$est l'impédance caractéristique du câble de ligne principale et Z est la combinaison parallèle de Z_o et de l'impédance de charge au niveau du coupleur.

La concentration des coupleurs doit être inférieure à 15 pour 250 m.

NOTE 4 La règle 8 permet de réduire les restrictions, en termes de longueurs de la ligne principale et des lignes secondaires ainsi qu'en termes de nombre d'appareils, etc. en ne spécifiant que des limites de transmission imposées par des combinaisons de ces facteurs. Il est possible d'utiliser différentes combinaisons en fonction des besoins de l'application.

Règle 9: Les règles suivantes doivent s'appliquer aux systèmes mis en œuvre avec des supports redondants:

a) chaque canal (câble) doit satisfaire aux règles de configuration du réseau;
b) il ne doit pas y avoir de segment non redondant entre deux segments redondants;
c) les répéteurs doivent également être redondants;
d) si le système est configuré (par la Gestion systèmes) pour émettre sur plusieurs canaux simultanément, la différence de délai de propagation entre deux appareils quelconques sur deux canaux quelconques ne doit pas dépasser cinq temps binaires;
e) les numéros de canaux doivent être maintenus sur l'ensemble des bus de terrain, c'est-à-dire que les canaux 1, 2, 3… en provenance de la gestion système doivent toujours être connectés aux canaux physiques 1, 2, 3…

21.3.4 Règles de distribution de l'alimentation pour la configuration du réseau

Voir 12.3.4.

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21.4 Spécification du circuit de transmission pour la MAU 31,25 kbit/s en mode tension

21.4.1 Récapitulatif

Pour faciliter le renvoi aux textes correspondants, les exigences définies en 21.2 et 21.4 sont résumées dans le Tableau 67 et le Tableau 68 (voir 12.4.1).

21.4.2 Configuration d'essai

La Figure 56 (voir 11.4.2) illustre la configuration qui doit être utilisée pour les essais de MAU.

Tension de signal en mode différentiel: $V_d = V_a - V_b$.

Résistance de la charge d'essai R = 50 Ω (Z_0 du câble 0,5) et C = 10 μF, sauf spécification contraire dans une exigence particulière.

21.4.3 Impédance

Pour les interfaces du bus (c'est-à-dire la MAU – unité de liaison au support) des appareils de terrain et des éléments d'accouplement ainsi que pour les alimentations, 11.4 exige que l'impédance d'entrée (peut être mesurée à partir de la ligne de bus) dans la gamme de fréquences des signaux (7,8 kHz à 39 kHz) ne descende pas sous une valeur minimale en fonctionnement normal. A l'exception des premières 10 ms qui suivent la connexion d'un appareil de terrain à une alimentation, cette exigence s'applique à tous les aspects du fonctionnement. Le Tableau 105 donne les impédances d'entrée des interfaces de bus et des alimentations.

Tableau 105 – Impédances d'entrée des interfaces de bus et des alimentations

	Impédance	Plage de tensions	Plage de courants
Interface de bus (par exemple, appareil de terrain)	≥ 3 kΩ	9 V à 32 V	Pour le courant de service
Alimentation de bus de sécurité intrinsèque	≥ 400 Ω	Pour une tension de service	0 à I_{max}
Alimentation de bus non de sécurité intrinsèque	≥ 3 kΩ	Pour une tension de service	0 à I_{max}

L'impédance d'entrée de l'interface de bus doit être mesurée avec un signal sinusoïdal dont l'amplitude doit être supérieure à la sensibilité du récepteur et toujours inférieure à 2 Vss.

NOTE Aucun signal de mesure n'est défini pour l'alimentation.

L'impédance de l'appareil de terrain et de l'alimentation doivent être déterminées en utilisant le circuit de mesure présenté à la Figure 91.

L'impédance X de l'appareil à l'essai est calculée à partir du rapport des deux tensions U_D et U_R.

$$X = R_M \times \frac{U_D}{U_R}$$

Les deux tensions mesurées représentent des valeurs complexes dont le déphasage est inclus dans le résultat. Si U_R est utilisée comme référence:

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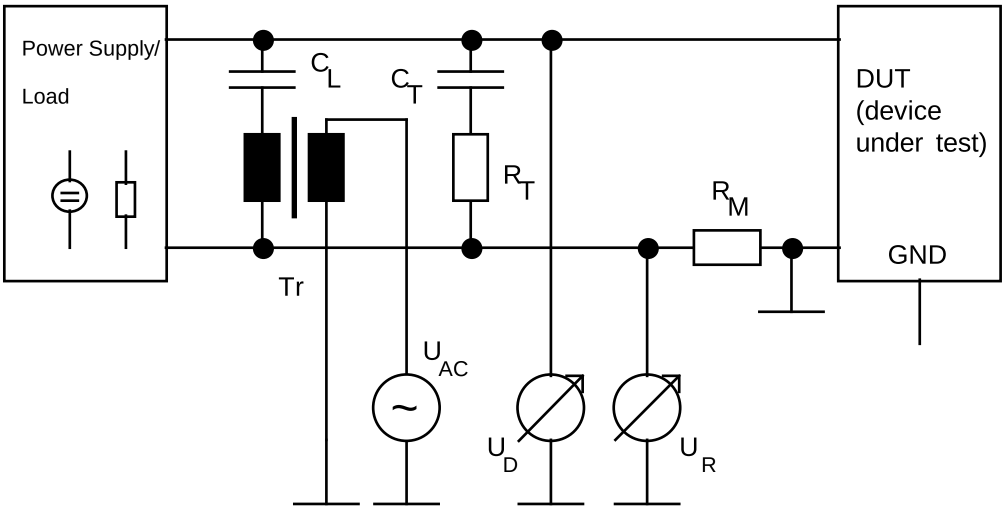
$$X = R_M \times \frac{|U_D|}{|U_R|} \times e^{j\varphi}$$

où

φ est le décalage angulaire $\varphi(U_D)$- $\varphi(U_R)$

Ceci réduit la mesure de l'impédance à une mesure du rapport des deux tensions et à une mesure du déphasage.



Légende

Anglais	Français
Power Supply/Load	Alimentation /charge
DUT (device under test)	DUT (appareil en essai)

Figure 91 – Schéma de principe de la mesure de l'impédance

Exemple

CL = CT = 2 μF, RT = RM = 100 Ω

Le décalage angulaire peut également être négatif. Dans ce cas, l'objet à mesurer représente une charge négative qui donne une amplification plutôt qu'une atténuation. Elle peut être omise (elle a même des effets positifs) pour la gamme de fréquences des signaux de 7,9 kHz à 39 kHz tant que |X| demeure dans la plage spécifiée.

NOTE Il n'y a aucune spécification concernant l'impédance. N'importe quelle valeur faible est possible. Si elle est associée à des conditions de circuit extérieur défavorables (par exemple de longues lignes d'adaptation), une impédance négative peut créer un circuit oscillant non atténué qui transforme le système de bus en un oscillateur même si l'objet à mesurer demeure stable dans le circuit de mesure.

Les sources d'erreurs suivantes peuvent affecter le résultat de la mesure de l'impédance.

a) Distorsions non linéaires. Correction: Utiliser une méthode de mesure sélective en fréquence (c'est-à-dire évaluer uniquement l'onde fondamentale) et surveiller le signal de mesure au moyen d'un oscillographe.

b) Asymétries du montage de mesure. Correction: Utiliser un transformateur symétrique Tr et éviter les capacités de mise à la masse. Laisser ouverte toute connexion à la masse de l'objet d'essai (due par exemple au filtre CEM) lors de la mesure de l'impédance.

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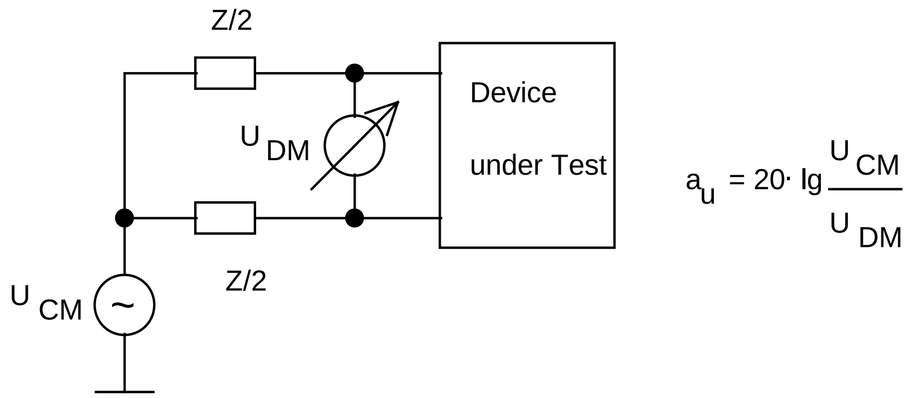
c) Signaux de bruit générés par l'objet d'essai. Correction: Mesurer le bruit de fond. Il doit être ≤ 1 mV_{eff} (mesuré à 50 Ω). Si cette condition est remplie, on peut ne pas tenir compte de l'effet sur la mesure de l'impédance.

21.4.4 Symétrie

Toutes les interfaces du bus doivent être isolées de la terre. La capacité dissymétrique entre les deux bornes de bus et la terre ne doit pas dépasser 250 pF. Ceci est également exigé pour les barrières et les alimentations.

A condition que l'impédance entre chacune des deux bornes de bus et la terre ne comporte qu'une composante capacitive, la mesure des deux capacités de terre effectives et le calcul de la différence peuvent déterminer l'asymétrie. Des composantes inductives significatives sont présentes, notamment lorsqu'il est utilisé des interfaces de bus qui ne sont pas de sécurité intrinsèque et qui peuvent être couplées au bus par l'intermédiaire d'un transformateur. Même lorsqu'il est utilisé des éléments de couplage qui ne comportent pas des composantes d'inductivité, le comportement inductif dû à des effets parasites peut être détecté, notamment aux fréquences supérieures. Au mieux, on peut supposer uniquement une asymétrie purement capacitive dans une gamme de fréquences limitée. De ce fait, il est recommandé de déterminer le rapport de réjection en mode commun (CMRR) comme défini dans la Figure 92 pour évaluer les caractéristiques de symétrie.



Légende

Anglais	Français
Device Under Test	Appareil en essai

Figure 92 – Définition du CMRR

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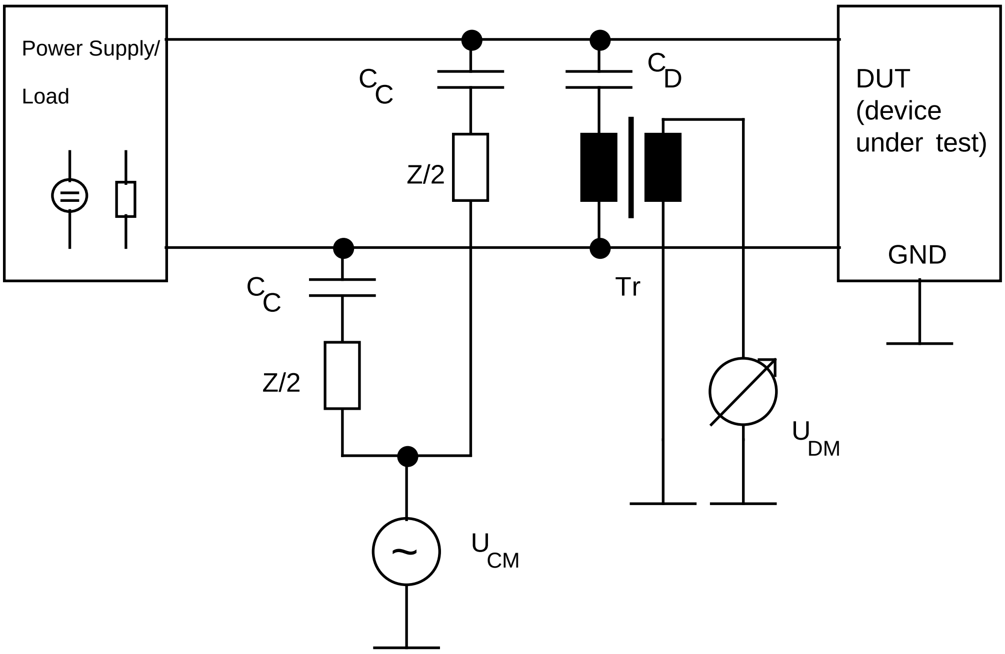

Légende

Anglais	Français
Power Supply/Load	Alimentation /charge
DUT (device under test)	DUT (appareil en essai)
GND	MASSE

Figure 93 – Schéma de principe de mesure du CMRR

Exemple

$C_C = C_D = 2\ \mu F$, $Z/2 = 25\ \Omega \pm 0,1\ \%$.

L'appareil de terrain, la barrière ou l'alimentation doit satisfaire au CARR exigé dans le Tableau 106. En ce qui concerne la capacité dissymétrique, le CARR doit être plus élevé que les valeurs énumérées dans le Tableau 106. Le CARR de l'instrument de mesure (par exemple comme illustré à la Figure 93) sans l'appareil en essai (DUT – Device under test) doit être d'au moins 10 dB supérieur aux valeurs indiquées.

Tableau 106 – CARR exigé

Fréquence	kHz	≤ 40	120	400	1 200
CARR	dB	≥ 50	≥ 40	≥ 30	≥ 20

21.4.5 Exigences de niveau de sortie

Voir 12.4.3.

21.4.6 Exigences de synchronisation des sorties

Voir 12.4.4.

21.4.7 Polarité du signal

Voir 11.4.5.

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21.5 Spécification du circuit de réception pour la MAU 31,25 kbit/s en mode tension

Voir 12.5.

21.6 Inhibition du bavardage

Voir 12.6.

21.7 Distribution de l'alimentation

21.7.1 Généralités

Un appareil peut, en option, recevoir son alimentation par l'intermédiaire des conducteurs de signaux ou être alimenté de manière séparée.

Un appareil peut être certifié comme étant de sécurité intrinsèque quelle que soit la méthode d'alimentation.

NOTE La présente norme n'inclut pas d'exigences pour la certification IS mais cherche à exclure des conditions ou situations qui pourraient empêcher la certification IS.

Un appareil à alimentation séparée peut être connecté à un bus de terrain alimenté.

Pour faciliter le renvoi aux textes correspondants, les exigences définies en 21.7 sont résumées dans les Tableau 107 et Tableau 108.

Tableau 107 – Caractéristiques des appareils alimentés par le réseau pour la MAU de 31,25 kbit/s en mode tension

Caractéristiques des appareils alimentés par le réseau	Limites pour 31,25 kbit/s
Tension de fonctionnement	9,0 V c.c. à 32,0 V c.c.
Tension de tenue minimale, quelle que soit la polarité, sans dommages	35 V
Le taux de variation maximal du courant passif (pas de transmission); cette exigence ne s'applique pas au cours des premières 10 ms après connexion de l'appareil à un réseau opérationnel ou dans les premières 10 ms après mise sous tension du réseau.	1,0 mA/ms
Courant maximal; cette exigence s'applique au cours de l'intervalle de temps de 100 µs à 10 ms après connexion de l'appareil à un réseau opérationnel ou 100 µs à 10 ms après mise sous tension du réseau (voir note)	Courant passif assigné plus 10 mA
NOTE Les premières 100 µs sont exclues pour permettre le chargement des filtres RFI et autres capacités de l'appareil. La spécification du taux de variation s'applique au bout de 10 ms.	

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Tableau 108 – Exigences d'alimentation réseau pour la MAU de 31,25 kbit/s en mode tension

Exigences d'alimentation réseau	Limites pour 31,25 kbit/s
Tension de sortie, non IS	≤ 32 V d.c.
Tension de sortie, IS	En fonction des caractéristiques assignées de la barrière
Ondulation de sortie et bruit	Voir Figure 94
Impédance de sortie non IS, mesurée sur la gamme de fréquences 0,25 f_rà 1,25 f_r	≥3 kΩ
Impédance de sortie IS, mesurée sur la gamme de fréquences 0,25 f_rà 1,25 f_r	≥400 Ω (Voir la note)
NOTE L'alimentation IS est supposée comprendre une barrière IS.	

21.7.2 Tension d'alimentation

Un appareil de bus de terrain qui comprend une MAU de 31,25 kbit/s en mode tension, doit pouvoir fonctionner dans une plage de tension de 9 V à 32 V c.c. entre les deux conducteurs, y compris l'ondulation. L'appareil doit supporter sans aucun dommage une tension minimale de ±35 V c.c.

NOTE 1 Pour des systèmes IS, la tension de service est éventuellement limitée par les exigences de certification. Dans ce cas, l'alimentation sera placée dans la zone de sécurité et sa tension de sortie sera atténuée par une barrière de sécurité ou composante équivalente.

Un appareil de bus de terrain qui comprend une MAU de 31,25 kbit/s en mode tension doit satisfaire aux exigences de l'Article 21 lorsqu'il est alimenté par une source ayant les spécifications suivantes:

a) La tension de sortie maximale de l'alimentation, pour des réseaux non IS, doit être de 32 V c.c., y compris l'ondulation.

b) L'impédance de sortie de l'alimentation, pour des réseaux non IS, doit être ≥3 kΩ sur la gamme de fréquence de 0,25 f_rà 1,25 f_r (7,8 kHz à 39 kHz). Cette exigence ne s'applique pas dans les 10 ms après connexion ou retrait d'un appareil de terrain.

c) L'impédance de sortie d'une alimentation IS doit être ≤400 Ω sur la gamme de fréquences de 0,25 f_r à 1,25 f_r (7,8 kHz à 39 kHz).

NOTE 2 L'alimentation IS est supposée comprendre une barrière IS.

d) Les exigences de claquage de l'isolation du circuit de signaux et du circuit de distribution de l'alimentation par rapport à la masse et par rapport à l'autre circuit doivent être conformes à la CEI 61131-2.

   La tension d'essai équivalente est à appliquer entre circuits isolés indépendants ou entre circuits isolés et parties conductrices accessibles.

NOTE 3 Pour des circuits de tension nominale ≤ 50 V c.c. ou efficace, les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 444 V eff., 635 V c.c. et 635 V crête. Pour des circuits de tension nominale comprise entre 150 V eff. et 300 V eff., les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 2 260 V eff., 3 175 V c.c. et 3 175 V crête.

21.7.3 Alimentation par l'intermédiaire de conducteurs de signaux

Un appareil de bus de terrain qui comprend une MAU de 31,25 kbit/s en mode tension et qui est alimenté via les conducteurs de signaux doit satisfaire aux exigences de l'Article 21 lorsqu'il fonctionne à des valeurs maximales d'ondulation et de bruit de l'alimentation, de la manière suivante:

a) 16 mV crête à crête sur la gamme de fréquences de 0,25 f_rà 1,25 f_r(7,8 kHz à 39 kHz);

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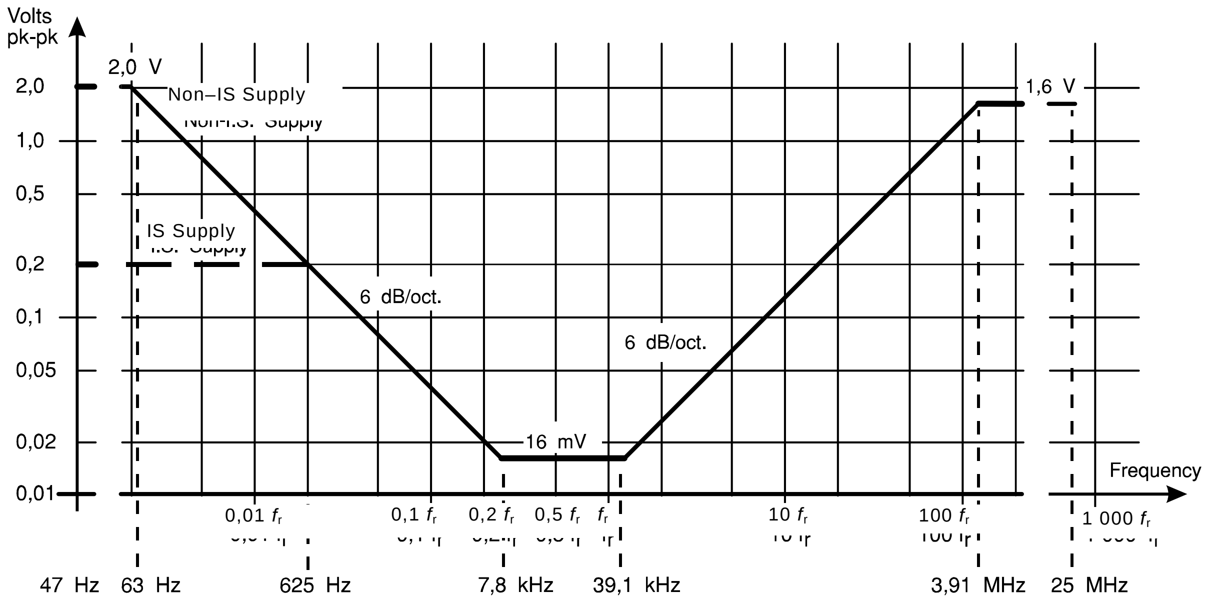
b) 2,0 V crête à crête sur la gamme de fréquences de 47 Hz à 63 Hz pour des applications non IS;

c) 0,2 V crête à crête sur la gamme de fréquences de 47 Hz à 625 Hz pour des applications IS;

d) 1,6 V crête à crête à des fréquences supérieures à 125 f_r, jusqu'à une fréquence maximale de 25 MHz;

e) des niveaux, à des fréquences intermédiaires, généralement conformes à la Figure 94.



Légende

Anglais	Français
Volts pk-pk	Volts, crête à crête
Non IS Supply	Alimentation non IS
IS supply	Alimentation IS
Frequency	Fréquence

Figure 94 – Ondulation et bruit de l'alimentation

Un appareil de bus de terrain qui comprend une MAU de 31,25 kbit/s en mode tension et qui est alimenté via les conducteurs de signaux doit présenter un taux maximal de variation du courant prélevé du réseau de 1 mA/ms. Cette exigence ne s'applique pas:

- pendant l'émission;
- au cours des premières 10 ms après connexion de l'appareil à un réseau opérationnel,
- au cours des premières 10 ms après mise sous tension du réseau;
- lors de la déconnexion du réseau ou de la mise hors tension du réseau.

Un appareil doit porter un marquage indiquant son courant passif assigné. Un appareil ne doit pas prélever du réseau plus de 10 mA au-dessus de son courant assigné au cours de l'intervalle de temps de 100 µs à 10 ms après connexion de l'appareil à un réseau opérationnel ou 100 µs à 10 ms après mise sous tension du réseau.

NOTE Les premières 100 µs sont exclues pour permettre le chargement des filtres RFI et autres capacités dans l'appareil. La spécification du taux de variation s'applique au bout de 10 ms.

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21.7.4 Isolation électrique

Tous les appareils de bus de terrain utilisant un support câblé, qu'ils soient alimentés séparément ou par l'intermédiaire des conducteurs de signaux, doivent assurer une isolation basse fréquence entre la masse et le câble de ligne principale du bus de terrain.

NOTE 1 Ceci est possible en isolant l'ensemble de l'appareil de la masse ou au moyen d'un transformateur, d'un optocoupleur ou de tout autre organe d'isolation entre le câble de ligne principale et l'appareil.

Une alimentation et un élément de communication combinés ne doivent pas nécessiter d'isolation électrique.

Pour les câbles blindés, l'impédance d'isolation mesurée entre le blindage du câble de bus de terrain et la masse de l'appareil de bus de terrain doit être supérieure à 250 kΩ à toutes les fréquences inférieures à 63 Hz.

La capacité dissymétrique maximale par rapport à la masse de toute borne d'entrée d'un appareil ne doit pas dépasser 250 pF.

Les exigences de claquage de l'isolation du circuit de signaux et du circuit de distribution de l'alimentation par rapport à la masse et par rapport à l'autre circuit doivent être conformes à la CEI 61131-2.

La tension d'essai équivalente est à appliquer entre circuits isolés indépendants ou entre circuits isolés et parties conductrices accessibles.

NOTE 2 Pour des circuits de tension nominale ≤ 50 V c.c. ou efficace, les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 444 V eff., 635 V c.c. et 635 V crête. Pour des circuits de tension nominale comprise entre 150 V eff. et 300 V eff., les tensions d'essai équivalentes au niveau de la mer correspondent à des essais de choc de 2 260 V eff., 3 175 V c.c. et 3 175 V crête.

21.8 Spécifications du support

21.8.1 Connecteur

Le connecteur est spécifié à l'Article I.1.

21.8.2 Câble d'essai normalisé

Le câble utilisé pour les essais d'appareils de bus de terrain avec une MAU de 31,25 kbit/s en mode tension, destinés à vérifier la conformité aux exigences de l'Article 21 doit être un câble unique à paire torsadée, à blindage global, conforme aux exigences minimales suivantes, à une température de 25 °C:

a) Z_o à f_r(31,25 kHz) = 100 Ω ± 20 Ω;

b) affaiblissement maximal à une fréquence 1,25 f_r(39 kHz) = 3,0 dB/km;

c) déséquilibre capacitif maximal par rapport au blindage = 2 nF/km;

d) résistance maximale en courant continu (par conducteur) = 24 Ω/km;

e) variation du délai maximal de propagation à une fréquence de 0,25 f_r à 1,25 f_r= 1,7 µs/km;

f) aire de la section des conducteurs (dimension des fils) = 0,8 mm^2, valeur nominale;

g) la couverture minimale du blindage doit être de 90 %.

La spécification ci-dessus concerne les essais de conformité d'une MAU. D'autres types de câbles peuvent être utilisés dans les installations réelles. (Voir Annexe B.) Les câbles à spécifications améliorées peuvent permettre l'utilisation de longueurs de ligne principale plus importantes et/ou une meilleure immunité aux perturbations. En revanche, les câbles ayant des spécifications inférieures peuvent être utilisés, sous réserve d'une limitation des longueurs utilisées, tant pour les lignes principales que secondaires, auxquels s'ajoute une

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éventuelle non-conformité aux exigences de susceptibilité aux perturbations radioélectriques (RFI) et électromagnétiques (EMI).

Pour les applications de sécurité intrinsèque, il convient de respecter des exigences particulières, telles que spécifiées par les normes de sécurité intrinsèque pertinentes, par exemple la CEI 60079-11 et la CEI 60079-25.

21.8.3 Coupleur

Voir 12.8.3.

21.8.4 Epissures

Voir 12.8.4.

21.8.5 Terminateur

Un terminateur doit être placé aux deux extrémités du câble de ligne principale et connecté d'un conducteur de signal à l'autre. Il ne doit y avoir aucune connexion entre terminateur et blindage du câble.

La valeur de l'impédance du terminateur doit être de 100 Ω ± 2 Ω sur la gamme de fréquences de 0,25 f_r à 1,25 f_r (7,8 kHz à 39 kHz).

NOTE 1 Cette valeur correspond approximativement à la valeur moyenne de l'impédance caractéristique du câble, pour les câbles appropriés, aux fréquences pertinentes, et elle est choisie pour réduire autant que possible les réflexions de la ligne de transmission.

Le courant continu de fuite à travers le terminateur ne doit pas dépasser 100 μA. Le terminateur doit être non polarisé.

Tous les terminateurs utilisés pour les applications IS doivent être conformes aux exigences d'isolation (lignes de fuite et distances d'isolement) en fonction de l'homologation IS requise. L'homologation IS ne doit pas être exigée pour des terminateurs destinés à des applications non IS.

NOTE 2 Il est acceptable que les fonctions de l'alimentation, de la barrière de sécurité et du terminateur soient combinées de diverses manières, à condition que l'impédance de la combinaison obtenue soit équivalente à l'impédance parallèle d'appareils indépendants qui satisfont aux exigences de l'Article 21 et si les règles de configuration du réseau de 21.3.3 sont respectées.

21.8.6 Règles de blindage

Voir 12.8.6.

21.8.7 Règles de mise à la masse

NOTE Mise à la masse signifie une connexion permanente à la terre par l'intermédiaire d'une impédance suffisamment basse et ayant un courant admissible suffisant pour prévenir un amorçage en tension qui pourrait entraîner des risques excessifs pour le matériel connecté ou les personnes. Les lignes de tension zéro (commun) peuvent être reliées à la masse lorsqu'elles sont galvaniquement isolées de la ligne principale du bus de terrain.

Les appareils de bus de terrain doivent fonctionner conformément aux exigences de l'Article 21, le point médian d'un terminateur ou d'un coupleur inductif étant directement connecté à la masse.

Les appareils de bus de terrain ne doivent pas raccorder l'un des conducteurs de la paire torsadée à la masse quel que soit le point du réseau. Les signaux doivent être appliqués et préservés de manière différentielle sur l'ensemble du réseau.

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Il est meilleur, dans la pratique, de mettre effectivement à la masse le blindage du câble de ligne principale de bus de terrain (le cas échéant) en plusieurs points sur la longueur du câble. Il convient néanmoins que les appareils de bus de terrain permettent une isolation c.c. du blindage du câble par rapport à la masse.

La pratique courante est également de raccorder les conducteurs de signaux à la masse de manière symétrique, en un point central de mise à la masse, en utilisant par exemple la prise centrale d'un terminateur ou d'un transformateur de couplage. Pour des systèmes alimentés par le bus, il convient que la mise à la masse du blindage et des conducteurs de signaux équilibrés soit proche de l'unité d'alimentation. Pour les systèmes IS, il convient que la mise à la masse soit conforme aux normes de sécurité intrinsèque correspondantes, par exemple la CEI 60079-11 et la CEI 60079-25.

21.8.8 Couleurs du câblage

Voir 12.8.8.

21.9 Sécurité intrinsèque

21.9.1 Généralités

La présente norme n'a pas pour ambition d'énumérer les exigences grâce auxquelles un équipement peut être certifié comme étant de sécurité intrinsèque et n'exige pas non plus que l'équipement soit de sécurité intrinsèque. Elle cherche plutôt à exclure les conditions ou situations qui pourraient empêcher la certification IS.

21.9.2 Barrière de sécurité intrinsèque

L'impédance de la barrière doit être supérieure à 460 Ω, à toute fréquence dans une plage de 0,25 f_r à 1,25 f_r (7,8 kHz à 39 kHz). La spécification de l'impédance de la barrière IS doit s'appliquer à toutes les barrières utilisées comme parties de PhL, qu'elles soient installées comme un élément séparé de matériel de réseau ou intégrées dans une carte d'alimentation. L'impédance de la barrière doit être mesurée entre les bornes des deux côtés de la barrière. L'impédance de la barrière doit être mesurée avec l'alimentation réseau réglée à la tension de service assignée (et non la tension de sécurité) de la barrière.

NOTE Il est acceptable que les fonctions de l'alimentation, de la barrière de sécurité et du terminateur soient combinées de diverses manières, à condition que l'impédance de la combinaison obtenue soit équivalente à l'impédance parallèle d'appareils indépendants qui satisfont aux exigences de l'Article 21 et si les règles de configuration du réseau de 21.3.3 sont respectées.

A la tension de service assignée de la barrière et à toute fréquence dans une gamme de 0,25 f_r à 1,25 f_r(7,8 kHz à 39 kHz), la capacité mesurée entre la borne positive du réseau "+" (côté dangereux) et la masse ne doit pas s'écarter de plus de 250 pF par rapport à la capacité mesurée entre la borne négative du réseau "–" (côté dangereux) et la masse.

21.9.3 Mise en place de barrières et de terminateurs

Une barrière doit être séparée du terminateur le plus proche d'au maximum 100 m de câble.

NOTE La barrière peut apparaître comme une impédance en dérivation de valeur aussi faible que 460Ω aux signalisations de fréquences. La résistance du terminateur est suffisamment basse pour que, lorsqu''elle est mise en parallèle avec l'impédance de la barrière, l'impédance résultante soit presque totalement résistive (non réactive).

21.10 Sectionneurs galvaniques

Les caractéristiques de communication des sectionneurs galvaniques utilisés sur le bus de terrain doivent satisfaire aux spécifications données en 21.9.

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21.11 Eléments de couplage

21.11.1 Généralités

Les éléments de couplage sont utilisés pour connecter différents segments de Type 3 à la même PhL ou à une PhL différente.

A l'exception des niveaux de signaux, le présent document ne décrit pas les caractéristiques exigées d'un élément de couplage. En d'autres termes, il incombe au planificateur de système de s'assurer que la norme relative aux "Règles de configuration du réseau" est respectée lorsque des éléments de couplage sont utilisés. Les spécifications suivantes sont importantes.

- Retard maximal du signal;
- Ecart maximal par rapport au passage par zéro du signal nominal (instabilité du signal).

Deux types d'éléments de couplage peuvent être utilisés:

- des répéteurs MBP-IS;
- des coupleurs de signaux MBP-IS/RS 485.

21.11.2 Répéteur MBP-IS

Un répéteur MBP-IS est connecté à deux segments MBP-IS. Il dispose d'une MAU sur chaque segment et d'une isolation galvanique entre les deux MAU. Les caractéristiques électriques présentées dans le Tableau 109 sont obligatoires pour les deux interfaces de bus de terrain. Les exigences concernant la MAU de l'Article 12 et de 21.1 à 21.10 s'appliquent également aux répéteurs.

Tableau 109 – Caractéristiques électriques des interfaces de bus de terrain

Paramètre	Valeurs	Paragraphe de la présente Norme
Codage du signal	Manchester II	9.2.2
Délimiteur de début	1, N+, N-, 1, 0, N-, N+, 0 (Note 1)	9.2.4
Délimiteur de fin	1, N+, N-,N+, N-,1, 0, 1 (Note 1)	9.2.5
Préambule	1, 0, 1, 0, 1, 0, 1, 0	9.2.6
Débit de transmission de données	31,25 kbit/s ± 0,2 %	21.2
Niveau de sortie (crête à crête)	0,75 V à 1 V	21.4.5
Différence max. entre amplitudes de transmission positive et négative	± 50 Mv	21.4.5
Distorsion max. du signal de transmission (surtension, suroscillation et statisme)	± 10 %	21.4.5
Bruit de l'émetteur	1 mV (eff) (Note 2)	21.4.5
Impédance de sortie	≥ 3 kΩ (Note 3)	21.7.1
Tension de fonctionnement	9 V à 32 V (Note 4)	21.7.1
Rapport de réjection en mode commun (CMRR)	≥ 50 dB (Note 5)	
Courant de fuite (Note 6)	50 µA	

NOTES

1 N+ et N- sont des symboles non données.

2 Dans la gamme de fréquences de 1 kHz à 100 kHz.

3 Dans la gamme de fréquences de 7,8 kHz à 39 kHz.

4 Plage de tensions de fonctionnement. Peut être limitée de 9 V à 17,5 V ou de 9 V à 24 V pour des appareils de sécurité intrinsèque.

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5 Correspond à une capacité dissymétrique de 250 pF à une fréquence de 39 kHz.

6 Uniquement pour sécurité intrinsèque.

Des répéteurs connectés à des segments de bus de sécurité intrinsèque doivent être certifiés comme matériel de sécurité intrinsèque. Le certificat doit inclure une déclaration stipulant que les appareils sont conformes au modèle FISCO. Les spécifications de la CEI 60079-11 doivent être respectées pour ce qui concerne l'isolation galvanique.

Pour pouvoir déterminer la conformité aux règles de configuration du réseau du 21.3.3, le planificateur de système nécessite des informations concernant le retard du signal dû aux répéteurs et l'écart maximal par rapport au passage par zéro du signal nominal (c'est-à-dire l'instabilité du signal). Ces informations doivent être indiquées dans la fiche technique.

Un répéteur peut être associé à une alimentation et à des terminateurs de lignes.

21.11.3 Coupleur de signaux MBP-IS/RS 485

Un coupleur de signaux RS 485 MBP-IS connecte un segment MBP-IS à un segment RS 485. Il dispose d'une MAU sur chaque segment, d'une isolation galvanique entre les deux MAU et d'un codage/décodage Manchester.

Les caractéristiques électriques présentées dans le Tableau 109 sont obligatoires pour l'interface MBP-IS. Les exigences concernant la MAU de l'Article 12 et de 21.1 à 21.10 sont également applicables. L'Article 22 s'applique à la conception de l'interface de bus RS 485.

Des coupleurs de signaux connectés à des segments de bus de sécurité intrinsèque doivent être certifiés comme matériel de sécurité intrinsèque. Le certificat doit inclure une déclaration stipulant que les appareils sont conformes au modèle FISCO. Les spécifications de la CEI 60079-11 doivent être respectées pour ce qui concerne l'isolation galvanique (voir 21.10).

Pour pouvoir déterminer la conformité aux règles de configuration du réseau du 21.3.3, le planificateur de système nécessite des informations concernant le retard du signal dû aux répéteurs et l'écart maximal par rapport au passage par zéro du signal nominal (c'est-à-dire l'instabilité du signal). Ces informations doivent être indiquées dans la fiche technique du coupleur de signaux.

Un coupleur de signaux peut être associé à une alimentation et à un terminateur de bus.

NOTE Un tel appareil est généralement appelé coupleur de segment.

21.12 Alimentation électrique

21.12.1 Généralités

Une alimentation doit être connectée au bus pour fournir de l'énergie aux appareils de terrain. La tension d'alimentation dépend des exigences de l'application particulière.

L'alimentation d'un bus de sécurité intrinsèque peut être fournie soit par une alimentation à sortie de sécurité intrinsèque, soit par une alimentation qui n'est pas de sécurité intrinsèque complétée par une barrière.

Pour éviter tout effet sur l'émission des données, les caractéristiques électriques de l'Article 21 de la présente norme, énumérées dans le Tableau 110, sont obligatoires pour toutes les alimentations.

Les bornes de sortie d'une alimentation doivent être clairement marquées "+" et "-".

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Même si une alimentation isolée par rapport à la terre n'est pas spécifiquement exigée, une mise à la masse asymétrique des conducteurs du câble de bus n'est pas admise. Il est essentiel que toute connexion entre les conducteurs et la terre soit symétrique. Pour plus de détails, voir 21.8.7.

Tableau 110 – Caractéristiques électriques des alimentations

	Non de sécurité intrinsèque	Sécurité intrinsèque, IIC FISCO [a]	Sécurité intrinsèque, IIB FISCO [a]	Sécurité intrinsèque, IIC barrière linéaire [b]
Selon modèle FISCO	non	Oui	oui	
Tension max. d'alimentation en c.c. U_0	≤ 32 V	≤ 17,5 V	≤ 17,5 V	≤ 24 V
Courant max. de court-circuit en c.c. I_0		≤ 360 mA	≤ 380 mA [g]	≤ 250 mA
Puissance de sortie max. P_0		≤ 2,52 W	≤ 5,32 W	≤ 1,2 W
Ondulation, bruit	≤ 16 mV[c]	≤ 16 mV[c]	≤ 16 mV[c]	≤ 16 mV[c]
Impédance de sortie [g]	≥3 k Ω[c d]	≥ 400 Ω[c d]	≥ 400 Ω[c d]	≥ 400 Ω[c d e]
Ondulation, bruit	≤ 16 mV[c]			
Affaiblissement par asymétrie	≥ 50 dB[f]			≥ 50 dB[e f]

[a] Alimentation à caractéristique rectangulaire ou trapézoïdale, conformément au modèle FISCO.

[b] Alimentation ou barrière à caractéristique linéaire.

[c] Dans la gamme de fréquences de 7,8 kHz à 39 kHz. Autrement, voir la Figure 94.

[d] Avec terminateur de ligne intégré: 100 Ω± 2 %. Il est recommandé de munir chaque alimentation d'une résistance de terminaison.

[e] Y compris une barrière si nécessaire.

[f] Aucune spécification obligatoire dans la présente norme, mais exigé du point de vue fonctionnel.

[g] La limite de courant résulte d'une caractéristique rectangulaire.

Les alimentations utilisées pour fournir de l'énergie aux appareils de terrain situés dans des zones explosibles doivent être certifiées en tant que matériel associé de sécurité intrinsèque destiné à une utilisation dans des lieux dangereux.

21.12.2 Alimentation non de sécurité intrinsèque

Les alimentations qui ne sont pas de sécurité intrinsèque doivent avoir les caractéristiques techniques définies dans le Tableau 110.

Les alimentations qui ne sont pas de sécurité intrinsèque peuvent être utilisées avec une barrière homologuée pour fournir de l'énergie à un bus de sécurité intrinsèque.

21.12.3 Alimentation de sécurité intrinsèque

Pour alimenter des appareils de terrain dans des zones explosibles, une alimentation à sortie de sécurité intrinsèque peut être connectée au bus en lieu et place d'une combinaison d'alimentation non de sécurité intrinsèque et de barrière. Cet appareil est en général placé à l'extérieur de la zone dangereuse, dans la salle de commande. Il s'agit de ce qu'on appelle, au sens de la CEI 60079-11, le matériel associé car, même s'il n'est pas protégé contre l'explosion proprement dite, il génère effectivement un circuit électrique de sécurité intrinsèque qui mène à la zone explosible.

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Outre les exigences de l'Article 21, notamment dans le Tableau 110, des alimentations de sécurité intrinsèque doivent satisfaire aux exigences de sécurité établies dans la CEI 60079-14 et dans la CEI 60079-11.

Si l'alimentation est placée dans la zone dangereuse, un type de protection normalisée supplémentaire doit être prévu (par exemple, installation dans un boîtier de protection de type “à enveloppe antidéflagrante d").

Des alimentations de sécurité intrinsèque peuvent faire partie d'autres composantes de bus de terrain (par exemple des coupleurs de segments, voir 21.11).

Le modèle FISCO repose sur une tension continue assignée de 13,5 V. Les courbes d'inflammation des alimentations à caractéristique rectangulaire indiquent que la puissance maximale admissible diminue considérablement si la tension augmente. D'autre part, une alimentation basse tension peut ne pas convenir à cause de la chute de tension due à la ligne de transmission. Par conséquent, la tension de 13,5 V semble être un compromis acceptable.

Du fait des tolérances et afin de disposer d'une marge d'amplitude du signal, la tension de sortie maximale U_0 d'un appareil d'alimentation doit être supérieure à la tension de sortie assignée. L'amplitude du signal est ≤ 1 V_{PP}; par conséquent une marge de 0,5 V est nécessaire. Si on suppose que les tolérances sont ≤ 1 V, le calcul donne une tension de sortie maximale garantie U_0 = 15 V. Le courant de sortie maximal admissible (courant de court circuit), en fonction du groupe de gaz, peut être extrait des courbes d'inflammation disponibles ou peut être déduit à partir d'essais d'inflammation. Dans le groupe IIC, le courant de sortie admissible est I_0 = 128 mA. D'autres combinaisons tension/courant, conformes au FISCO, peuvent être sélectionnées.

La conception et la mise en œuvre de tensions relatives à la sécurité et de limiteurs du courant dépendent de la catégorie choisie de circuit de sécurité intrinsèque (“ia“ ou “ib“). Les valeurs maximales des paramètres de sortie doivent satisfaire aux exigences du FISCO.

Un certificat de contrôle doit être obtenu pour l'alimentation du bus en tant que "matériel associé", au sens de la CEI 60079-11. Ce certificat doit déclarer que l'alimentation est conforme au modèle FISCO.

Outre les données habituelles (c'est-à-dire les valeurs maximales des paramètres de sortie), le certificat peut également contenir des spécifications fondamentales applicables à la configuration de bus de terrain admissible.

NOTE En général, les valeurs limites d'inductance La et de capacité Ca externes maximales admissibles ne sont pas exigées. Si ces valeurs avaient été incluses, elles donneraient l'impression que La et Ca sont présents dans le circuit de sécurité intrinsèque en tant qu'inductivité et capacité non protégées, ce qui n'est pas le cas pour le modèle FISCO. Le câble n'est pas considéré ici comme une inductivité et une capacité concentrées tant que les paramètres du système demeurent dans la plage des limites définies du modèle FISCO.

21.12.4 Alimentation de catégorie "ib"

NOTE 1 Etant donné qu'il convient que le circuit du courant de sortie de l'alimentation ait une résistance interne faible en courant continu, l'utilisation de l'alimentation avec un régulateur de tension et une commande de courant active (c'est-à-dire une limitation électronique du courant) vient à l'esprit. Par exemple, il est possible d'obtenir une résistance interne ≥ 400 Ω dans la gamme de fréquences des signaux conformément au Tableau 110 en utilisant par exemple une contre-réaction en fonction de la fréquence.

La courbe de sortie caractéristique idéale d'une alimentation (c'est-à-dire la caractéristique courant/tension) est rectangulaire (voir la Figure 95). Lorsque le courant de sortie augmente, la tension de sortie reste constante jusqu'à ce que le courant atteigne certaines limites. La CEI 60079-11 permet d'utiliser une telle solution dans l'hypothèse où il est établi une limitation redondante du courant et de la tension, ainsi qu'une isolation galvanique (facultative) fiable par rapport aux circuits électriques qui ne sont pas de sécurité intrinsèque.

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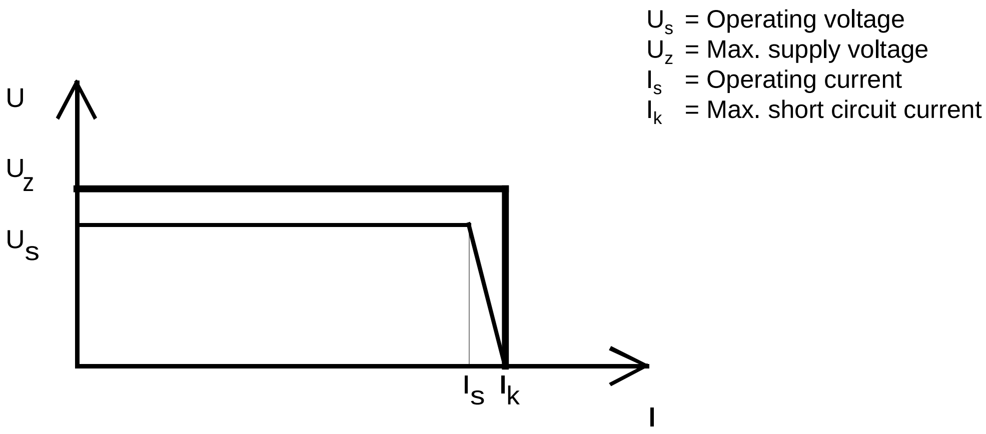


Légende

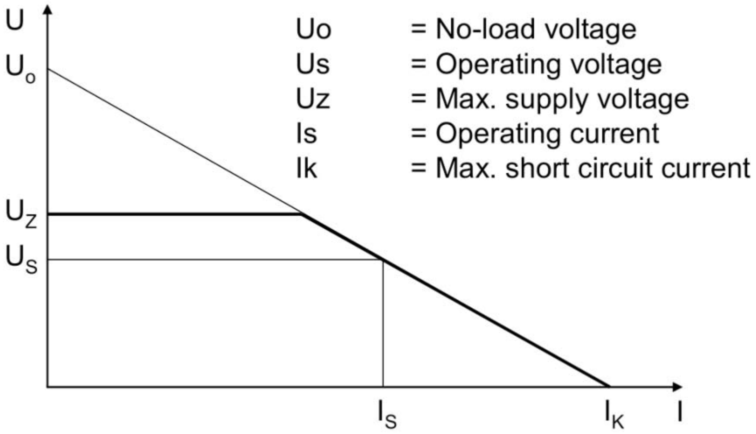
Anglais	Français
Us = Operating voltage	Us = Tension de service
Uz = Max. supply voltage	Uz = Tension max. d'alimentation
Is = Operating current	Is = Courant de service
Ik = Max. short circuit current	Ik = Courant max. de court-circuit

Figure 95 – Courbe de sortie caractéristique d'une alimentation de catégorie EEx ib

NOTE 2 Une tension de 13,5 V en courant continu semble réaliste, sachant que des tensions plus élevées pourraient restreindre la puissance disponible. Les courbes de limite d'explosivité pour des sources ayant des courbes caractéristiques de sortie carrées montrent que la puissance admissible décroît de manière significative lorsque la tension augmente.

21.12.5 Alimentation de catégorie "ia"

Les alimentations disposant d'une limitation électronique de courant doivent être certifiées conformément à la CEI 60079-11 pour la catégorie "ib".



Légende

Anglais	Français
Uo = Non load voltage	Uo = Tension hors charge
Us = Operating voltage	Us = Tension de service
Uz = Max. supply voltage	Uz = Tension max. d'alimentation
Is = Operating current	Is = Courant de service
Ik = Max. short circuit current	Ik = Courant max. de court-circuit

Figure 96 – Courbe de sortie caractéristique d'une alimentation de catégorie EEx ia

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L'alimentation ia doit être conforme au modèle FISCO. Le courant de sortie maximal IK de la Figure 95 correspond au courant IZul (à U = Uz) de la Figure 96.

Exemple

Un exemple d'alimentation appropriée pour la catégorie "ia" comporte les éléments de sécurité suivants: Source de tension Uo = 34 V, résistance fixe R = 158 Ω, et diodes Zener UZD = 15 V (valeur maximale). Un tel circuit a une courbe de sortie caractéristique trapézoïdale, comme présenté à la Figure 96. Les valeurs opérationnelles approchées qui peuvent être obtenues pour l'alimentation sont énumérées ci-dessous.

U = 13,5 V

I = 120 mA

P = 1,7 W

$$P_{v\,max} = \frac{U_0^2}{R_v} = 7,32\ W$$

NOTE 1 Ainsi, les valeurs opérationnelles sont comparables à celles du concept "ib" avec limitation électronique du courant. Ceci présente cependant un inconvénient: l'exigence d'une contrainte thermique relativement élevée de la résistance série et la perte de puissance de la résistance série qui est toujours présente dans des conditions opérationnelles.

Si l'on applique un facteur de sécurité de 1,5, la puissance dissipée admissible de la résistance doit être de 11 W.

NOTE 2 L'utilisation de deux résistances en série peut aider à pallier ce problème.

La puissance dissipée maximale des diodes Zener est de 1,8 W.

$$P_{v\,max} = \frac{U_o - U_z}{R_v} \times 15\ V = \frac{34\ V - 15\ V}{158\ \Omega} \times 15\ V = 1,8\ W$$

En tenant compte du facteur de sécurité, les diodes Zener doivent permettre une puissance dissipée maximale de 2,7 W.

NOTE 3 L'utilisation de deux diodes série est également possible dans ce cas.

La CEI 60079-14 et la CEI 60079-11 s'appliquent.

21.12.6 Retour de puissance

A l'exception d'une alimentation par segment, le modèle FISCO ne permet pas à des appareils connectés au bus de terrain de sécurité intrinsèque de retourner l'alimentation vers le bus de terrain, même en cas de court-circuit sur la ligne de bus de terrain. Ceci est en général assuré en connectant en série deux (pour la catégorie EEx ib) ou trois (pour la catégorie EEx ia) diodes au silicium ou Schottky dans le circuit électrique d'entrée. L'appareil de terrain est conforme au modèle FISCO lorsque le courant de fuite de ces diodes (jusqu'à la valeur maximale de tension inverse dans la plage de températures admissible) ne dépasse pas 50 μ A. Ici, outre un facteur de sécurité, les spécifications des fabricants de diodes (c'est-à-dire les valeurs types des fiches techniques) s'appliquent également.

La décision finale concernant ces mesures incombe à l'autorité de certification qui réalise les essais de sécurité et la certification de l'appareil de terrain particulier.

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22 Type 3: Unité de liaison au support: transmission asynchrone, support câblé

22.1 Unité de liaison au support non IS

22.1.1 Caractéristiques

Cette spécification de MAU décrit une transmission sur ligne symétrique correspondant à la norme TIA/EIA RS-485-A de l'ANSI. Les terminateurs, placés aux deux extrémités du câble à paire torsadée permettent à la PhL de prendre notamment en charge des vitesses de transmission plus élevées. La longueur maximale du câble est de 1200 m pour des débits de données de ≤ 93,75 kbit/s. Pour un débit de 1500 kbit/s, la longueur maximale du câble est réduite à 70 m pour le type B et à 200 m pour le type A. Pour un débit de 12 Mbit/s, elle est de 100 m (câble de type A uniquement, voir 22.1.2.2).

Le codage binaire NRZ est associé à la signalisation TIA/EIARS-485-A de l'ANSI avec pour objectif des coupleurs de ligne à faible coût qui peuvent ou non isoler la station de la ligne (isolation galvanique); des terminateurs de ligne sont exigés, notamment pour les débits de données les plus élevés (jusqu'à 12 Mbit/s).

Les caractéristiques exigées sont présentées dans le Tableau 111.

Tableau 111 – Caractéristiques de MAU non de sécurité intrinsèque

Caractéristique	Contraintes
Topologie:	Bus linéaire, terminé aux deux extrémités, lignes d'adaptation ≤ 0,3 m, pas de branchements; voir la note La longueur totale de la ligne inclut la somme des longueurs de lignes d'adaptation.
Support:	Concernant le câble à paire torsadée blindé recommandé, voir les "Spécifications du support"
Longueur de ligne:[a]	≤ 1200 m, en fonction du débit de données et du type de câble
Nombre de stations:[a]	32 (stations maître, stations esclave ou répéteurs)
Débits de données:	9,6 / 19,2 / 45,45 / 93,75 / 187,5 / 500 / 1500 / 3000 / 6000 / 12000 kbit/s, d'autres débits de données peuvent être pris en charge.
[a] Le répéteur étend les caractéristiques, voir le Tableau 112.	
NOTE Contrairement aux recommandations de la norme TIA/EIA RS-485-A de l'ANSI, il est meilleur dans la pratique de permettre des lignes d'adaptation plus longues si la valeur totale des capacités de toutes les lignes d'adaptation (Cstges) ne dépasse pas les valeurs suivantes: 0,05 nF à 3, 6 et 12 Mbit/s. 0,2 nF à 1,5 Mbit/s. 0,6 nF à 500 kbit/s. 1,5 nF à 187,5 kbit/s. 3,0 nF à 93,75 kbit/s. 15 nF à 9,6 et 19,2 kbit/s.	

La longueur de la ligne et le nombre de stations connectées peuvent être augmentés si des répéteurs sont utilisés. Au maximum 3 répéteurs peuvent être utilisés entre deux stations. Si le débit de données est ≤ 93,75 kbit/s et si les sections liées constituent une chaîne (topologie en bus linéaire, pas d'étoile active, par exemple, comme dans la Figure 97) et si l'on suppose une aire de la section du conducteur de 0,22 mm^2, la topologie maximale admissible est telle que présentée dans le Tableau 112.

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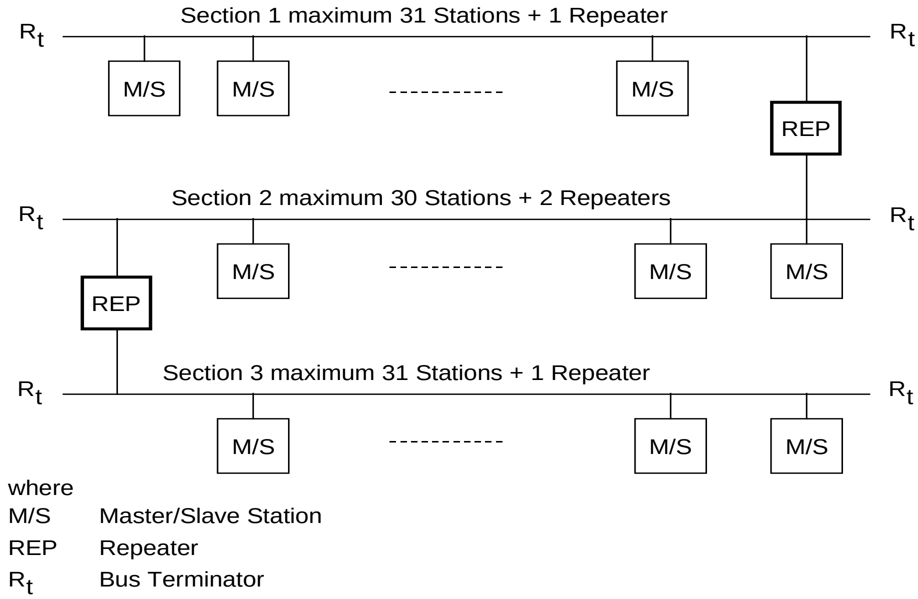
Tableau 112 – Caractéristiques avec utilisation de répéteurs

Nombre de répéteurs	Caractéristique	Contraintes
1	Longueur de ligne	< 2,4 km
	Nombre de stations	62 (stations maître, stations esclave ou répéteurs)
2	Longueur de ligne	< 3,6 km
	Nombre de stations	92 (stations maître, stations esclave ou répéteurs), voir la Figure 97
3	Longueur de ligne	< 4,8 km
	Nombre de stations	122 (stations maître, stations esclave ou répéteurs)



Légende

Anglais	Français
Section 1 maximum 31 stations + 1 repeater	Section 1, au maximum 31 stations + 1 répéteur
Section 2 maximum 30 stations + 2 repeaters	Section 2, au maximum 30 stations + 2 répéteurs
Section 3 maximum 31 stations + 1 repeater	Section 3, au maximum 31 stations + 1 répéteur
Where	Où
M/S Master/Slave station	M/S= Station maître/esclave
REP Repeater	REP: Répéteur
Rt Bus Terminator	Rt: Terminateur de bus

Figure 97 – Répéteur en topologie en bus linéaire

Dans une topologie arborescente, comme dans la Figure 98, plus de 3 répéteurs peuvent être utilisés et plus de 122 stations peuvent être connectées, par exemple 5 répéteurs et 127 stations. Une zone étendue peut être couverte grâce à cette topologie, par exemple une longueur de 4,8 km à un débit de données inférieur à 93,75 kbit/s et une aire de section de conducteur de 0,22 mm^2.

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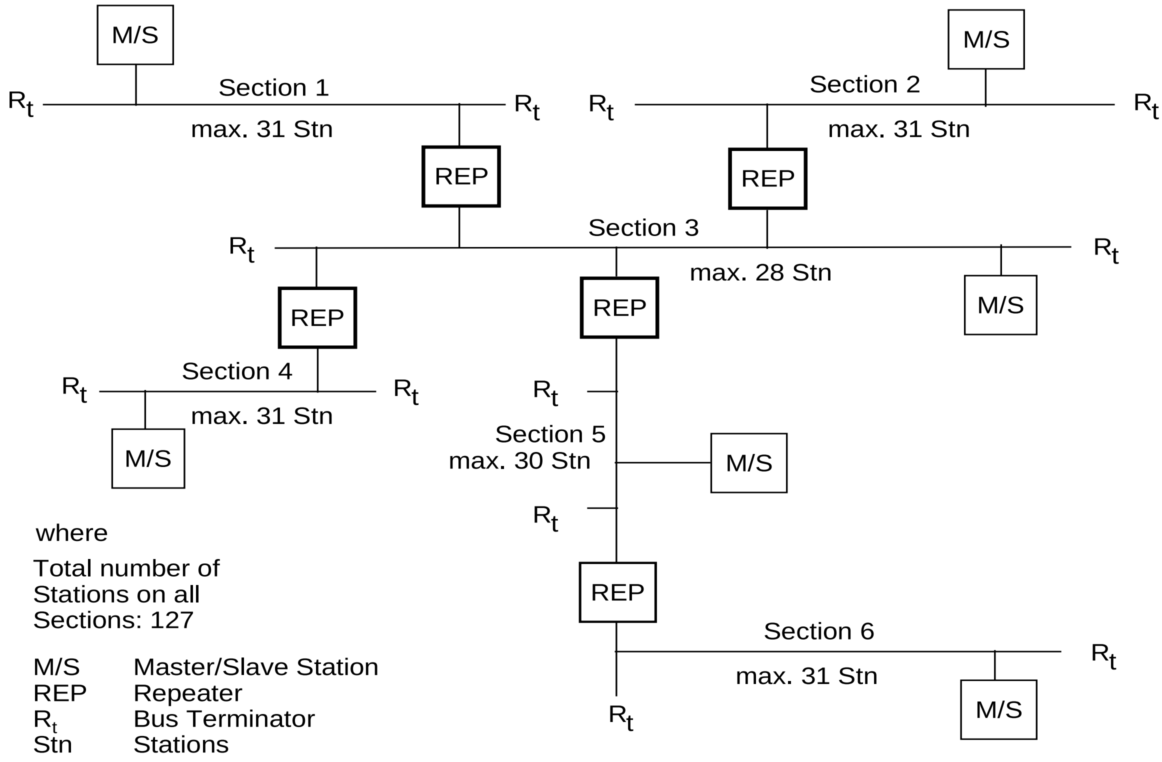

Anglais	Français
Section 1	Section 1
Max. 31 Stn	31 stations max.
Section 2	Section 2
Section 3	Section 3
Max. 28 Stn	28 Stations max.
Section 4	Section 4
Section 5	Section 5
Max. 30 Stn	30 Stations max.
Section 6	Section 6
Max 31 Stn	max. 31 Stations
Where	Où
Total number of stations on all sections: 127	Nombre total de stations sur toutes les sections: 127
M/S Master/Slave	M/S= Maître/Esclave
REP Repeater	REP: Répéteur
Rt Bus terminator	Rt: Terminateur de bus
Stn Stations	Stn = Stations

Figure 98 – Répéteur en topologie arborescente

22.1.2 Spécifications du support

22.1.2.1 Connecteur

Le connecteur est spécifié en I.2.1.

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22.1.2.2 Câble

Le support de bus est un câble à paire torsadée blindé. Le blindage permet d'améliorer la compatibilité électromagnétique (CEM). Des paires torsadées non blindées peuvent être utilisées en l'absence de perturbations électromagnétiques (EMI) sévères.

L'impédance caractéristique du câble doit être dans une plage comprise entre 100 Ω et 220 Ω; il convient que la capacité du câble (entre conducteurs) soit inférieure à 60 pF/m et il convient que l'aire de la section du conducteur soit supérieure ou égale à 0,22 mm^2. Des critères de sélection du câblage sont donnés dans l'annexe de la norme TIA/EIA RS-485-A de l'ANSI.

Deux types de câbles sont définis, comme spécifié dans le Tableau 113.

Tableau 113 – Spécifications du câblage

Paramètres du câble	Type A	Type B
Impédance	135 Ω à 165 Ω (f = 3 à 20 MHz)	100 Ω à 130 Ω (f > 100 kHz)
Capacité	< 30 pF/m	< 60 pF/m
Résistance	< 110 Ω/km	non spécifiée
Aire de la section du conducteur	≥ 0,34 mm^2	≥ 0,22 mm^2
Couleur de gaine non IS	Violette	Non spécifié
Couleur du conducteur intérieur du câble A (RxD/TxD-N)	Verte	Non spécifié
Couleur du conducteur intérieur du câble B (RxD/TxD-P)	Rouge	Non spécifié

Le Tableau 114 présente la longueur maximale du câble de type A et du câble de type B pour les différentes vitesses de transmission.

Tableau 114 – Longueur maximale du câble pour les différentes vitesses de transmission

Point	Unité	Valeur								
Débit de données	kbit/s	9,6	19,2	93,75	187,5	500	1500	3000	6000	12000
Câble de type A	m	1200	1200	1200	1000	400	200	100	100	100
Câble de type B	m	1 200	1 200	1 200	600	200	70	Non admissible		

Pour des débits de données inférieurs ou égaux à 1500 kbit/s, la somme des longueurs de lignes d'adaptation (les capacités totales de toutes les lignes d'adaptation (Cstges)) est spécifiée en 22.1. Par exemple, à 1500 kbit/s, la longueur maximale d'une ligne d'adaptation pour le type de câble A est 6,6 m.

A des débits de données de 3 Mbit/s et plus, les capacités totales de toutes les lignes d'adaptation doivent être inférieures à 0,05 nF. Par conséquent, pour le câble de type A, la longueur totale de ligne d'adaptation est de 1,6 m. A ce débit, l'impédance doit être intégrée dans le câblage pour éviter les réflexions.

L'exemple suivant (Figure 99) illustre l'intégration des inductances L1 à L4 dans le connecteur.

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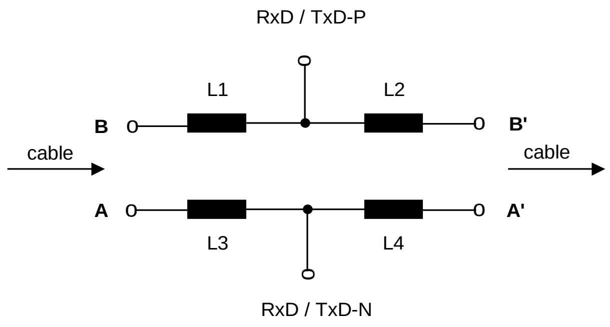


Légende

Anglais	Français
Cable	Câble

Figure 99 – Exemple d'un connecteur avec inductance intégrée

Pour des câbles de type A, les inductances L1 à L4 doivent avoir une valeur de 110 nH ±22 nH avec la contrainte suivante:

La résistance entre A et A' ainsi qu'entre B et B' doit être ≤ 0,35 Ω.

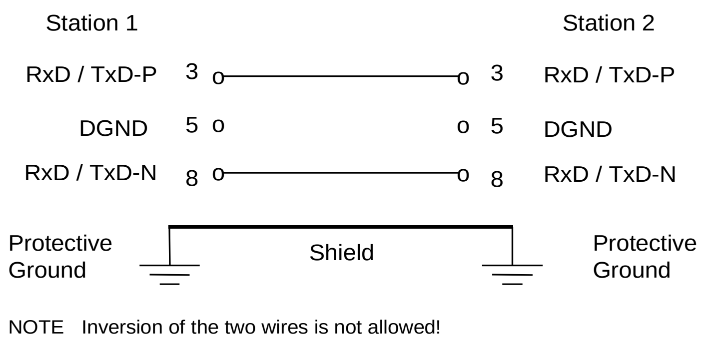
La capacité type de chaque station connectée (connecteur, câble pour émetteurs-récepteurs de la norme TIA/EIA RS-485-A de l'ANSI, émetteurs-récepteurs proprement dits et autres composantes) doit être: 15 à 25 pF.

NOTE 1 Le calcul de l'inductance comprend la contribution de la station connectée. En cas de débranchement de ces connecteurs, des réflexions dues au câblage peuvent apparaître et entraîner des distorsions sur le bus.

La dépendance du débit de données admissible sur l'extension de la liaison locale (distance maximale entre deux stations) est illustrée dans la Figure 2-A.1 de la norme TIA/EIA-422-B de l'ANSI (également incluse dans le V.11 de l'UIT-T).

NOTE 2 Les recommandations concernant la longueur de la ligne supposent un affaiblissement maximal du signal de 6 dB. L'expérience montre que les distances sont éventuellement doublées s'il est utilisé des conducteurs ayant une aire de la section égale à ≥ 0,5 mm^2.

Le câblage minimal entre deux stations est présenté à la Figure 100.



Légende

Anglais	Français
Station	Station
Protective ground	Terre de protection
Shield	Blindage
Note: Inversion of the two wires is not allowed!	Note: L'inversion de deux conducteurs n'est pas admise!

Figure 100 – Câblage d'interconnexion

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Le câblage illustré à la Figure 100 permet d'obtenir une tension en mode commun entre deux stations (c'est-à-dire la différence de potentiel entre les masses de protection) d'au maximum ± 7 V. S'il est souhaité une tension en mode commun supérieure, un conducteur de compensation doit être placé entre les points de mise à la masse.

22.1.2.3 Règles de mise à la masse et de blindage

S'il est utilisé un câble à paire torsadée blindé, il est recommandé de connecter le blindage à la terre de protection aux deux extrémités du câble, au moyen de connexions à faible impédance (c'est-à-dire à faible inductance). Ceci est nécessaire pour obtenir une compatibilité électromagnétique raisonnable.

Il convient de préférence de réaliser les branchements entre le blindage du câble et la terre de protection (par exemple le boîtier métallique de la station) par l'intermédiaire des boîtiers métalliques et des vis de fixation métalliques des connecteurs sub-D. Si cette connexion n'est pas réalisable, la broche 1 des connecteurs peut être utilisée.

22.1.2.4 Terminateur de bus

Le câblage de bus de Type A et de Type B doit être terminé aux deux extrémités par les résistances R_{tA} et R_{tB} respectivement. La résistance de terminaison R_t, spécifiée dans la norme TIA/EIA RS-485-A de l'ANSI doit être complétée par une résistance de polarisation à la masse R_d (connectée à la masse des données DGND) et par une résistance de polarisation à l'alimentation R_u (connectée au Plus de la tension VP), comme illustrée à la Figure 101. Ce complément force la tension en mode différentiel (c'est-à-dire la tension entre les conducteurs) à une valeur bien définie, lorsque aucune station n'émet (au cours des périodes de repos).

Chaque station qui termine la ligne (en association avec un terminateur de bus) doit mettre à disposition le Plus de la tension (par exemple + 5 V ± 0,25 V) au niveau de la broche 6 du connecteur de bus.

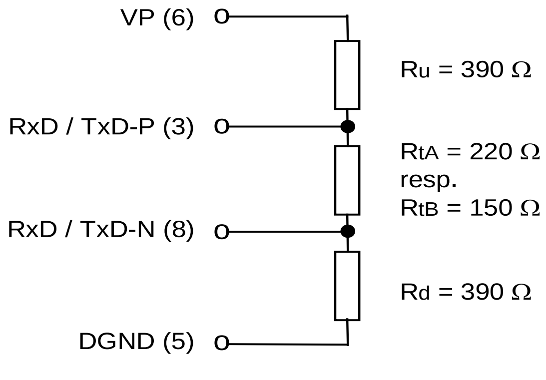

Figure 101 – Terminateur de bus

En supposant une tension d'alimentation de +5 V ±0,25 V, les valeurs de résistance suivantes sont recommandées:

R_{tA} = 220 Ω±4,4 Ω, min. 1/4 W;

R_{tB} = 150 Ω±3 Ω, min. 1/4 W;

R_u = R_d = 390 Ω±7,8 Ω, min. 1/4 W

La source qui alimente la broche 6 (VP) doit pouvoir livrer un courant d'au moins 10 mA dans les limites spécifiées de tolérances de tension.

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On peut combiner les deux types de câbles et résistances de terminaisons du câblage, comme décrit ci-dessus. Cependant, la longueur maximale de la ligne doit être réduite à la moitié de la valeur fixée ci-dessus si la terminaison de la ligne et l'impédance de la ligne ne sont pas en correspondance.

22.1.3 Méthode de transmission

22.1.3.1 Codage binaire

Les données codées NRZ (non-return-to-zero) en provenance de la DLL sont transmises par l'intermédiaire d'un câble à paire torsadée. Un "1" binaire (DL_symbol = "UN") est représenté par une tension différentielle positive constante entre la broche 3 (RxD/TxD-P) et la broche 8 (RxD/TxD-N) du connecteur de bus; un "0" binaire (DL_symbol = "ZERO") est représenté par une tension différentielle négative constante.

22.1.3.2 Commande de l'émetteur-récepteur

Lorsqu'une station n'est pas en émission, la sortie de l'émetteur doit être désactivée (DL_symbol = "SILENCE"); elle doit présenter une impédance élevée par rapport à la ligne. Au cours des périodes de repos, c'est-à-dire lorsqu'aucune donnée n'est transmise par une quelconque station, le signal de la ligne de réception doit représenter une valeur binaire "1" (DL_symbol = "UN"). Par conséquent, le terminateur de bus doit forcer la tension différentielle entre les broches 3 et 8 du connecteur à l'état positif lorsque tous les émetteurs sont désactivés. Les récepteurs de la ligne doivent toujours être activés et par conséquent au cours de la période de repos, le signal binaire "1" est reçu par toutes les stations.

22.2 Unité de liaison au support de sécurité intrinsèque

22.2.1 Caractéristiques

Cette spécification de MAU décrit une MAU de protection contre l'explosion de type Ex i, conformément à la CEI 60079-11 et à la CEI 60079-25, sur la base d'une transmission sur ligne symétrique correspondant à la norme TIA/EIA RS-485-A de l'ANSI. Les terminateurs, placés aux deux extrémités du câble à paire torsadée permettent à la PhL de prendre notamment en charge des vitesses de transmission plus élevées. La longueur maximale du câble est de 1200 m pour des débits de données de ≤ 93,75 kbit/s. Pour la vitesse maximale de transmission de 1500 kbit/s, la longueur maximale du câble est réduite à 200 m. Seul le câble de type A, voir 22.2.2.2, doit être utilisé avec cette MAU.

Le codage binaire NRZ est associé à la signalisation de la norme TIA/EIA RS-485-A de l'ANSI qui cible les coupleurs de ligne de moindre coût. Des terminateurs de ligne sont exigés.

Dans tous les appareils connectés aux bus de terrain, le circuit d'interface du bus doit être galvaniquement isolé de tous les autres circuits électriques. Les distances de séparation et les tensions d'isolement entre circuits de sécurité intrinsèque et/ou circuits non de sécurité intrinsèque doivent satisfaire aux normes applicables (par exemple la CEI 60079-11).

Les caractéristiques exigées sont présentées dans le Tableau 118.

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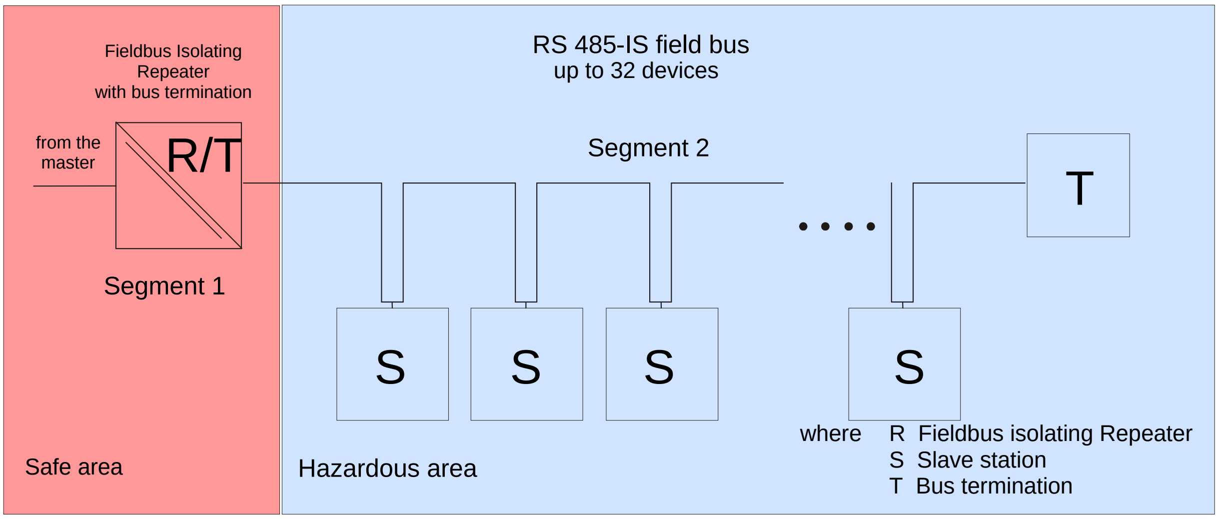
Tableau 115 – Caractéristiques de sécurité intrinsèque

Caractéristique	Contraintes
Topologie	Bus linéaire, terminé aux deux extrémités, lignes d'adaptation ≤ 0,3 m, pas de branchements
Support	Concernant le câble à paire torsadée blindé recommandé, voir les "Spécifications du support"
Longueur de ligne:	≤ 1200 m, en fonction du débit de données
Nombre de stations:	32 (stations maîtres, stations esclaves ou répéteurs d'isolation de bus de terrain et en outre 2 terminateurs de bus externes)
Débits de données	9,6 / 19,2 / 45,45 / 93,75 / 187,5 / 500 / 1500 kbit/s

La structure linéaire, présentée à la Figure 102, permet la mise en place de points de connexion sur le segment de bus de terrain semblable à l'installation des circuits d'alimentation. Il convient que le câble de bus de terrain soit bouclé à travers les appareils de terrain individuels afin d'éviter les lignes d'adaptation.

Un répéteur d'isolation de bus de terrain ou un appareil comparable constitue normalement le début d'un segment de bus de terrain de sécurité intrinsèque. Ce répéteur d'isolation de bus de terrain connecte un segment de bus de terrain qui n'est pas de sécurité intrinsèque avec le segment de bus de terrain de sécurité intrinsèque et assure simultanément une isolation galvanique fiable entre les deux. Le segment de bus de terrain de sécurité intrinsèque est terminé aux deux extrémités par une terminaison de bus active. Jusqu'à 32 éléments de bus (appareils de terrain, répéteurs d'isolation de bus de terrain, terminateurs de bus externes, etc.) peuvent être disposés sur le segment de bus de terrain. Ces éléments du bus sont connectés à un segment de bus de terrain en système électrique flottant (sans retour à la terre).



Légende

Anglais	Français
Fieldbus isolating repeater with bus termination	Répéteur d'isolation de bus de terrain avec terminaison de bus
from the master	en provenance du maître
RS 485-IS field bus up to 32 devices	bus de terrain RS 485 IS jusqu'à 32 appareils
segment	segment
safe area	zone sûre
hazardous area	zone dangereuse

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Anglais	Français
where	où
fieldbus isolating repeater	répéteur d'isolation de bus de terrain
Slave station	Station esclave
Bus Termination	terminaison de bus

Figure 102 – Structure linéaire d'un segment de sécurité intrinsèque

La Figure 103 illustre un exemple de montage et la segmentation d'un système de bus de terrain avec répéteurs d'isolation de bus de terrain. Les segments 2 et 3 de bus de terrain sont de sécurité intrinsèque. Le répéteur d'isolation de bus de terrain, entre les segments de sécurité intrinsèque 2 et 3 doit maintenir l'isolation galvanique. Le nombre de répéteurs qui peuvent être connectés en cascade dépend de la distorsion du signal et du retard de signal (attention aux spécifications du fabricant).

Le segment 3 de la Figure 103 commence par un répéteur d'isolation de bus de terrain au milieu du segment 3. La terminaison de bus est assurée à une extrémité au moyen d'une terminaison de bus active et à l'autre extrémité au moyen d'un autre répéteur d'isolation de bus de terrain qui ouvre le segment 4 dans la zone de sécurité.

Les terminaisons de bus d'un segment de bus de terrain peuvent être localisées dans un répéteur d'isolation de bus de terrain, dans un appareil de terrain, dans une terminaison de bus active (en tant qu'appareil autonome) ou dans un connecteur alimenté à partir d'un répéteur d'isolation de bus de terrain ou d'un appareil de terrain.

Le répéteur entre les segments 2 et 3 de la Figure 103 doit être installé soit à l'extérieur de la zone dangereuse, soit comme matériel associé. L'installation dans la zone dangereuse exige des mesures de protection supplémentaires contre l'explosion (par exemple Ex e, Ex d, Ex I, etc., conformément à la CEI 60079-0).

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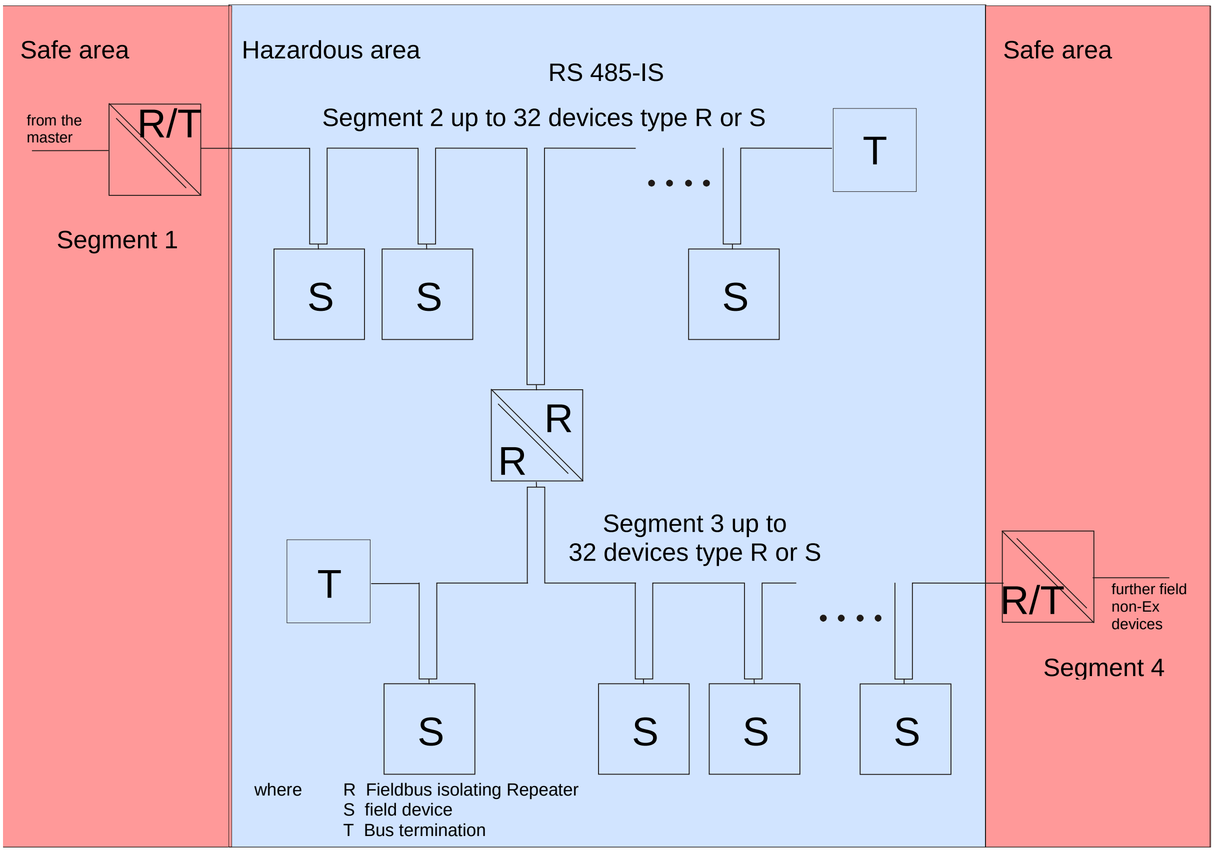

Légende

Anglais	Français
segment 2 up to 32 devices type R or S	segment 2 jusqu'à 32 appareils type R ou S
from the master	en provenance du maître
segment 3 up to 32 devices type R or S	segment 3 jusqu'à 32 appareils type R ou S
further field non Ex devices	autres appareils de terrain non Ex
segment	Segment
safe area	zone sûre
hazardous area	zone dangereuse
where	Où
fieldbus isolating repeater	répéteur d'isolation de bus de terrain
field device	appareil de terrain
Bus Termination	terminaison de bus

Figure 103 – Exemple de topologie étendue par des répéteurs

22.2.2 Spécifications du support

22.2.2.1 Connecteur

Le connecteur est spécifié en I.2.2.

22.2.2.2 Câble

Le Tableau 116 présente les paramètres spécifiés du câble compte tenu de la fonction et de la sécurité intrinsèque.

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Tableau 116 – Spécification du câble (liée à la fonction et à la sécurité)

Paramètres du câble	Câble de type A[a]	Valeurs limites de sécurité
Impédance d'onde (Ω)	135 à 165 à une fréquence de 3 MHz à 20 MHz	Non applicable
Capacité de service (nF/km)	≤ 30	Non applicable
Diamètre du conducteur (mm)	> 0,64	> 0,1 par fil pour un conducteur toronné à brins fins [b] > 0,35[c]
Aire de la section de l'âme (mm²)	> 0,34	> 0,096 2[c]
Résistance de boucle (Ω/km)	≤ 110	Non applicable
Rapport L/R (µH/Ω)	≤ 15	≤ 15 pour la température ambiante la plus basse (voir la note)
Couleur de gaine IS	Bleu clair	Si la couleur est utilisée pour le marquage
Couleur du conducteur intérieur du câble A (RxD/TxD-N)	Verte	
Couleur du conducteur intérieur du câble B (RxD/TxD-P)	Rouge	

a Conformément à la CEI 60079-14. Le câble doit satisfaire aux exigences correspondantes.

b Conformément à la CEI 60079-14. Les extrémités des conducteurs toronnés à brins fins doivent être protégées contre la séparation des brins élémentaires, par exemple au moyen de cosses de câbles ou de manchons d'extrémité.

c Cette valeur minimale s'applique à une température ambiante maximale de 40 °C et à la classe de température T6 pour une valeur totale du courant dans le câble de bus de terrain de 4,8 A maximum. Selon la CEI 60079-11, les informations concernant le courant admissible à d'autres températures ambiantes doivent être déduites des exigences existantes. Dans le cas de la RS 485-IS, le courant maximal dans le câble de bus de terrain est de 4,8 A. Ceci nécessite une section de conducteur de ≥ 0,096 2 mm2 (diamètre: ≥ 0,35 mm) pour un câble utilisé en classe T6 et pour une température ambiante maximale de 40 °C. La température de surface admissible du câble ne doit pas dépasser 80 °C dans le cas de T6, et de ce fait, l'échauffement maximal est de 40 K pour 4,8 A et la section de conducteur spécifiée ci-dessus. Pour des câbles déployés en classe T4 et des températures ambiantes supérieures à 40 °C, la somme de la température ambiante et de l'échauffement du câble ne doit pas dépasser 130 °C pour un courant de 4,8 A. En tout état de cause, l'isolation du câble doit convenir aux températures maximales prévues pour le câble.

NOTE Le câble de type A satisfait à cette exigence pour une température ambiante supérieure à –40 °C.

Le Tableau 117 présente la longueur de câble maximale admissible en fonction des vitesses de transmission.

Tableau 117 – Longueur maximale du câble pour les différentes vitesses de transmission

Point	Unité	Valeur					
Débit de données	kbit/s	9,6	19,2	93,75	187,5	500	1 500
Câble de type A	m	1 200	1 200	1 200	1 000	400	200

22.2.2.3 Règles de mise à la masse et de blindage

NOTE Mise à la masse signifie une connexion permanente à la terre par l'intermédiaire d'une impédance suffisamment basse et ayant un courant admissible suffisant pour prévenir un amorçage en tension qui pourrait entraîner des risques excessifs pour le matériel connecté ou les personnes.

Les lignes de tension zéro (commun) peuvent être reliées à la masse lorsqu'elles sont galvaniquement isolées de la ligne principale du bus de terrain.

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Les appareils de bus de terrain ne doivent pas raccorder l'un des conducteurs de la paire torsadée à la masse quel que soit le point du réseau. Les signaux doivent être appliqués et préservés de manière différentielle sur l'ensemble du réseau.

Il convient que les appareils de bus de terrain permettent une isolation c.c. du blindage du câble par rapport à la masse.

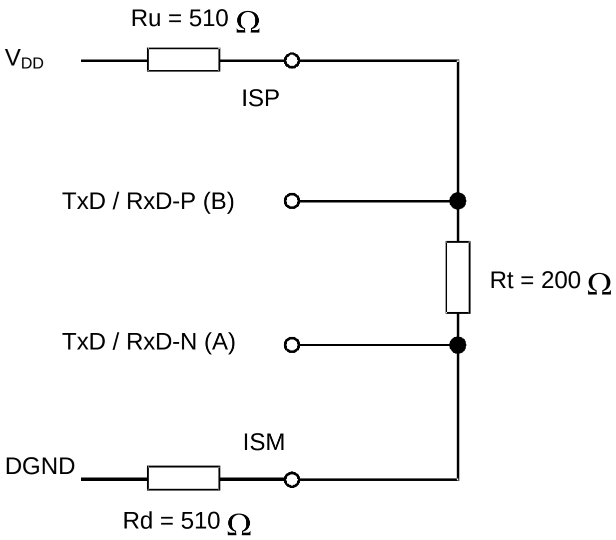
Pour des installations de sécurité intrinsèque, la mise à la masse doit être conforme à la CEI 60079-14.

Pour ce qui concerne le blindage, voir 12.8.6.

22.2.2.4 Terminateur de bus

Le câble de bus de Type A doit être terminé aux deux extrémités par la résistances R_t. La résistance de terminaison R_t, spécifiée dans la norme TIA/EIA RS-485-A de l'ANSI doit être complétée par une résistance de polarisation à la masse R_d (connectée à la masse des données ISGND) et par une résistance de polarisation à l'alimentation R_u (connectée au Plus de la terminaison de bus ISP), comme illustrée à la Figure 104. Ce complément force la tension en mode différentiel (c'est-à-dire la tension entre les conducteurs) à une valeur bien définie, lorsqu'aucune station n'émet (au cours des périodes de repos).

La terminaison de cette spécification de MAU pour le type de protection contre l'explosion Ex i diffère de la spécification de la MAU qui n'est pas de sécurité intrinsèque de par la modification des caractéristiques électriques. Dans ce contexte, les valeurs de résistance de la terminaison de bus (voir la Figure 104) et la disposition modifiée de la terminaison de bus (voir I.2.2) doivent faire l'objet d'une attention particulière lorsque ces éléments sont intégrés dans des appareils de communication ou des connecteurs à fiche.



Chaque station qui termine la ligne (en association avec un terminateur de bus) doit mettre à disposition une tension d'alimentation interne U+ de + 3,3 V ± 5 %.

Figure 104 – Terminateur de bus

22.2.3 Méthode de transmission

22.2.3.1 Codage binaire

Voir 22.1.3.1.

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22.2.3.2 Commande de l'émetteur-récepteur

Voir 22.1.3.2.

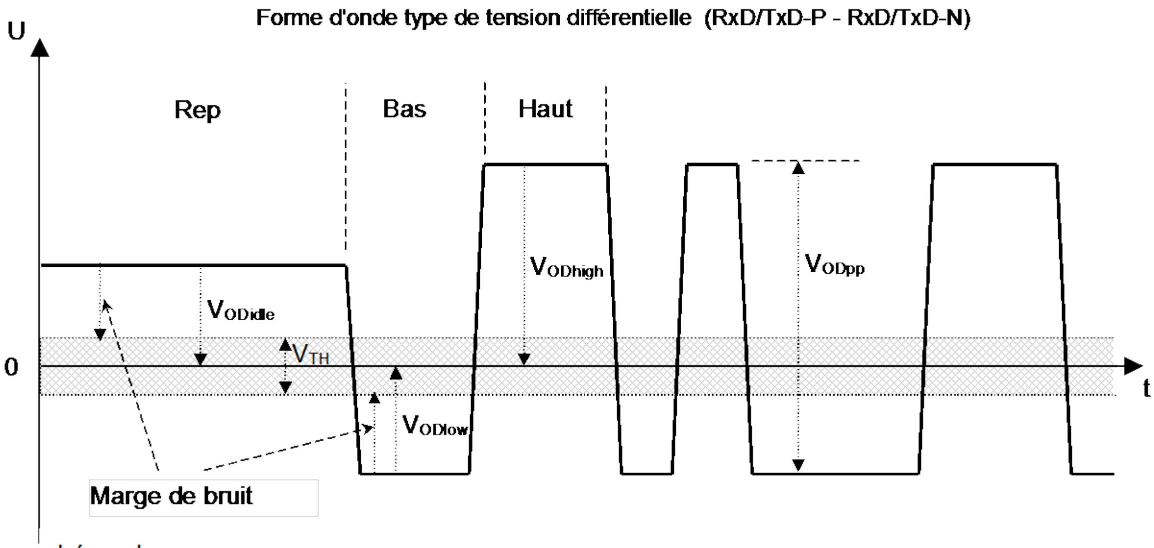
22.2.3.3 Caractéristiques des signaux

22.2.3.3.1 Spécification des signaux

La Figure 105 illustre une forme d'onde de tension type sur le bus de terrain de sécurité intrinsèque. Il est défini trois phases au cours desquelles des niveaux de signal caractéristiques sont générés sur le bus:

– état de repos avec V_{ODidle}
– phase basse avec V_{ODlow}
– phase haute avec V_{ODhigh}

La marge de bruit joue un rôle crucial dans la définition des niveaux de signal. La marge de bruit d'un niveau du signal est toujours la différence entre la tension correspondant à ce niveau et la tension de seuil. La tension de seuil U_{TH} est un attribut du récepteur dans la norme TIA/EIA-485-A de l'ANSI; elle est définie dans la plage de ±0,2 V. Pour une transmission de données fiable, la marge de bruit doit être aussi grande que possible. Dans le cas d'une MAU pour bus de terrain de sécurité intrinsèque, une marge de bruit minimale de 0,2 V doit être assurée dans les conditions "les plus défavorables".



Légende
V_{ODidle} = tension différentielle à l'état de repos (pas d'émetteur actif)
V_{ODlow} = tension différentielle en phase basse
V_{ODhigh} = tension différentielle en phase haute
V_{ODpp} = niveau de pleine puissance (crête à crête)
V_{TH} = tension de seuil du récepteur (±0,2V selon TIA/EIA-485-A de l'ANSI)

Figure 105 – Forme d'onde de la tension différentielle

Les paramètres définis dans le Tableau 118 sont obligatoires pour les appareils de communication.

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Tableau 118 – Caractéristiques électriques de l'interface de sécurité intrinsèque

Paramètre	Description	Valeur	Remarque
Niveau de repos minimal	V_{ODidle} [V]	0,50	Applicable uniquement à des appareils ayant une terminaison de bus intégrée ou raccordable.
Niveau de transmission sur la connexion du bus (crête à crête)	V_{ODss} [V]	≥ 2,7	Pour la configuration de bus la plus défavorable et une charge maximale sur l'émetteur.
Niveau de transmission positif et négatif sur la connexion du bus	V_{ODhigh} [V]	≥ 1,5	Pour la configuration de bus la plus défavorable et une charge maximale sur l'émetteur.
	V_{ODlow} [V]	≤– 1,1	
Niveau du signal à l'entrée du récepteur	V_{IDhigh} [V]	≥ 0,8	Pour la configuration de bus la plus défavorable
	V_{Idlow} [V]	≤– 0,4	
Vitesses de transmission de données	kbit/s	9,6; 19,2; 45,45; 93,75; 187,5; 500; 1 500	Un appareil de terrain peut être conçu avec une vitesse limitée de transmission de données
Impédance d'entrée (récepteur)	R_{IN} [kOhm] C_{IN} [pF] L_{IN}	≥ 12 ≤ 40 ≈ 0	Pour un appareil alimenté ou non alimenté
Tension d'alimentation circuit d'attaque RS 485 et terminaison de bus	V_{DD} [V]	3,3 ±5 %	

22.2.3.3.2 Circuits d'essai

22.2.3.3.2.1 Généralités

L'objectif de ces mesures est de vérifier les niveaux de signal exigés par le Tableau 118. Il convient d'effectuer des mesures statiques à basse vitesse de transmission de données de sorte que les réactances existantes, telles que les capacités d'entrée, n'influencent pas les résultats de mesure. En outre, le câble de bus est remplacé par une résistance équivalente correspondant à la résistance de boucle pour la longueur maximale du câble de bus.

NOTE Seules les mesures qui sont spécifiques à l'interface de sécurité intrinsèque sont décrites dans les présentes.

Par ailleurs, il convient de s'assurer de la conformité à la norme TIA/EIA RS-485-A de l'ANSI.

22.2.3.3.2.2 Mesure du niveau au repos

Cette mesure détermine les caractéristiques de la résistance de terminaison. De ce fait, cette mesure doit uniquement être effectuée sur des appareils en essai qui sont soit équipés d'une terminaison de bus voir la Figure 106, soit fournissent une alimentation à une terminaison de bus externe (les connexions ISM et ISP sont réalisées) (voir la Figure 107).

Il convient que les composants supplémentaires ainsi que les commutateurs et résistances soient directement connectés aux bornes du DUT (à une distance de 5 cm à 15 cm). Lorsqu'on doit utiliser un câble de connexion, la longueur du câble ne doit pas dépasser 1 m.

La mesure est effectuée en deux étapes:

Etape 1: la tension en circuit ouvert V1 est mesurée; elle doit être supérieure aux valeurs spécifiées sur la ligne 1 du Tableau 118.

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Etape 2: la tension V2 est mesurée en conditions de charge (charge de 330 Ω). V2 doit être dans une plage spécifiée (0,65·V1 ≤ V2≤ 0,72· V1). Ceci garantit une valeur de la résistance de terminaison dans une plage de 130 Ω à 180 Ω.

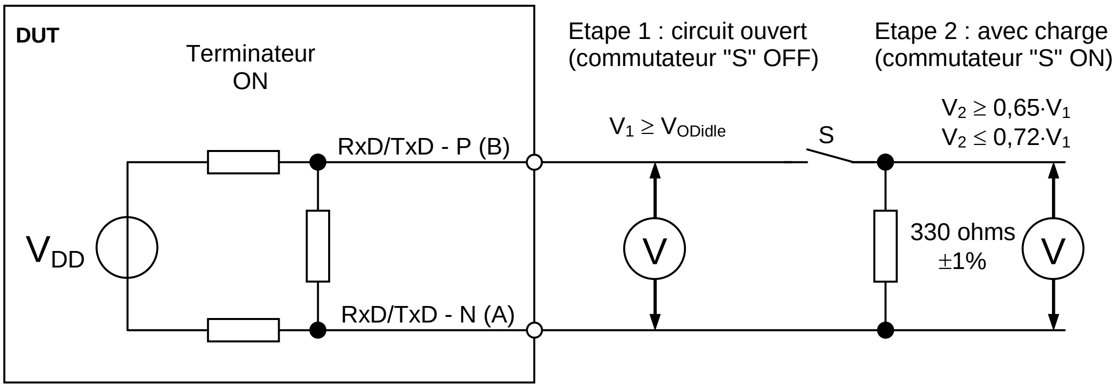

Figure 106 – Montage d'essai pour la mesure du niveau de repos d'appareils à résistance de terminaison intégrée

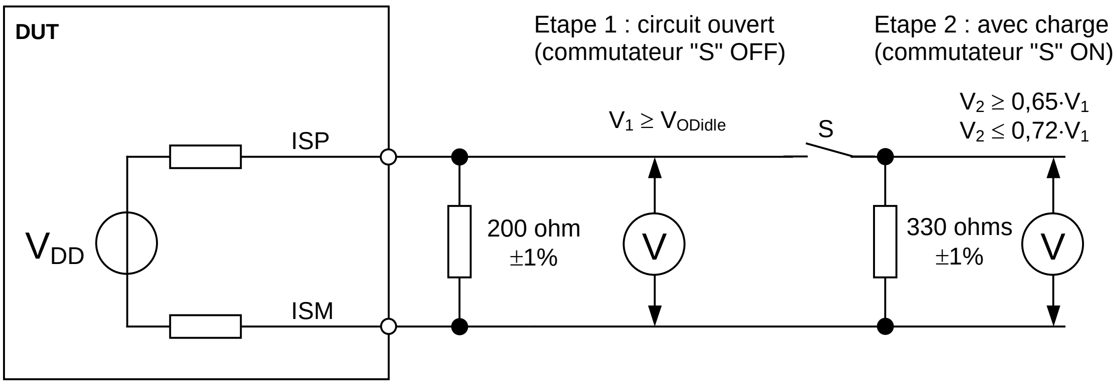

Figure 107 – Montage d'essai pour la mesure du niveau de repos d'appareils à résistance de terminaison raccordable

22.2.3.3.2.3 Mesure des niveaux de signal

Pour le montage de mesure ci-dessous, un répéteur d'isolation du bus de terrain conforme doit être employé pour la connexion au système maître. Au cours de l'essai, le bus de terrain de sécurité intrinsèque doit être terminé aux deux extrémités conformément à 22.2.2.4. Si la terminaison de bus n'est pas intégrée à l'appareil en essai, une terminaison de bus externe conforme doit être utilisée.

Pour mesurer les signaux sur le bus de terrain de sécurité intrinsèque sans influences externes, il est nécessaire de connecter un oscilloscope isolé électriquement (par exemple un appareil portatif alimenté par batterie).

Il convient que les composants supplémentaires ainsi que la résistance et le réseau de résistance soient connectés sur une longueur aussi courte que possible aux bornes du DUT et au répéteur d'isolation du bus de terrain. Lorsqu'on doit utiliser un câble de connexion, la longueur du câblage ne doit pas dépasser 2 m. L'oscilloscope peut être connecté à toute borne appropriée en fonction du montage.

La mesure présentée à la Figure 108 détermine le niveau de transmission sur les connexions de l'émetteur et pour une charge la plus défavorable. C'est le cas d'une longueur de câble de

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bus de terrain égale à zéro. Dans ce cas, le courant de sortie de l'émetteur et par conséquent la charge sont au maximum. Les valeurs assignées pour le niveau de transmission sont présentées sur les lignes 2 et 3 du Tableau 118.

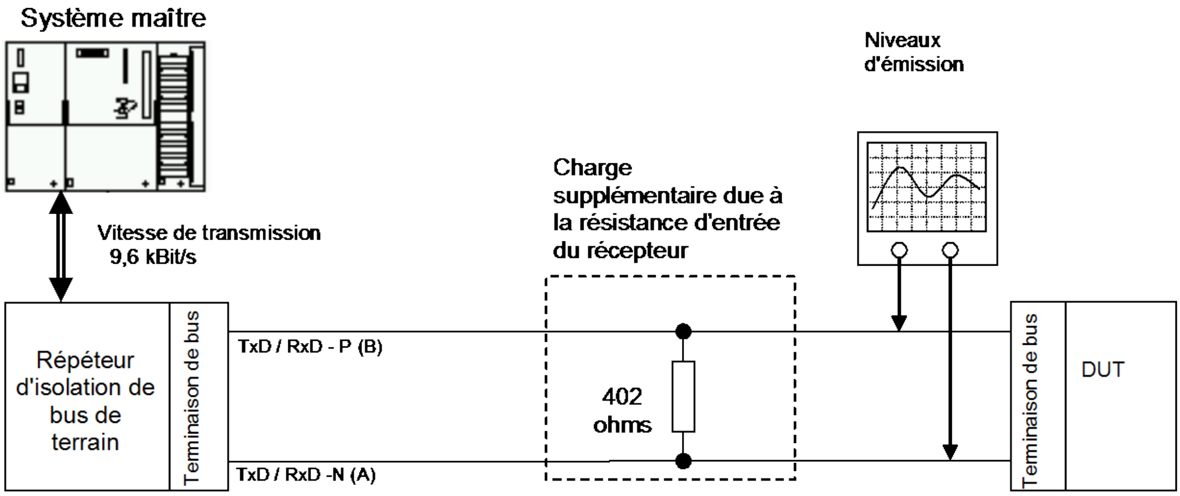

Figure 108 – Montage d'essai pour la mesure des niveaux de transmission

La mesure illustrée à la Figure 109 tente de vérifier la capacité de l'émetteur à générer un niveau suffisant pour chaque récepteur et dans des conditions de charge la plus défavorable. Pour une longueur maximale de câble de bus de terrain de 1 200 m et une charge supplémentaire, ceci est le cas approximativement au niveau du milieu du câble. Les valeurs des mesures doivent satisfaire aux exigences de la ligne 4 du Tableau 118.

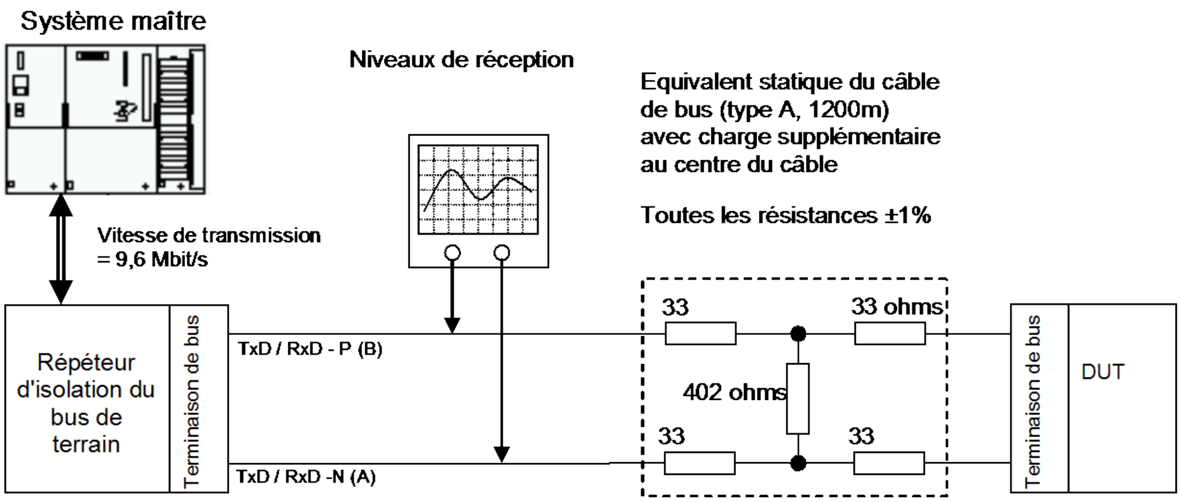

Figure 109 – Montage d'essai pour la mesure du niveau de réception

22.2.4 Sécurité intrinsèque

22.2.4.1 Généralités

La présente norme n'a pas pour ambition d'énumérer les exigences grâce auxquelles un équipement peut être certifié comme étant de sécurité intrinsèque et n'exige pas non plus que l'équipement soit de sécurité intrinsèque. Elle cherche plutôt à exclure les conditions ou situations qui pourraient empêcher la certification de la sécurité intrinsèque.

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22.2.4.2 Modèle de bus de terrain de sécurité intrinsèque

Le bus de terrain de sécurité intrinsèque repose sur un modèle dans lequel tous les appareils sont actifs. Tous les appareils sont alimentés de l'extérieur et peuvent fournir de l'énergie au bus de terrain. Dans un circuit de sécurité intrinsèque, uniquement une quantité maximale d'énergie peut être admise compte tenu des inductances et des capacités existantes. La quantité maximale d'énergie est décrite par les courbes d'inflammation.

NOTE Le bus de terrain de sécurité intrinsèque repose sur l'analyse effectuée par le PTB (Physikalisch-Technische Bundesanstalt). PTB-Mitteilungen, 113 Jahrgang, Heft 2/2003, Die Bewertung der Zündfähigkeit eigensicherer Stromkreise anhand eines Rechenverfahrens. Abschnitt: Der eigensichere RS 485 Feldbus als Anwendungsbeispiel.

Un montage du modèle de base du bus de terrain est illustré à la Figure 110. Un répéteur d'isolation de bus de terrain est (généralement) placé dans la zone non dangereuse pour assurer en toute sécurité la séparation entre le segment de bus de sécurité intrinsèque et le segment de bus qui n'est pas de sécurité intrinsèque. D'autres appareils de communication connectés se trouvent dans la zone dangereuse. Le câble de bus est terminé aux deux extrémités par une terminaison de bus externe active ou par une terminaison de bus intégrée dans un appareil de terrain. Tous les appareils de communication sont alimentés par des sources de tension externes et possèdent les moyens de limiter en toute sécurité le courant et la tension présents sur le bus.

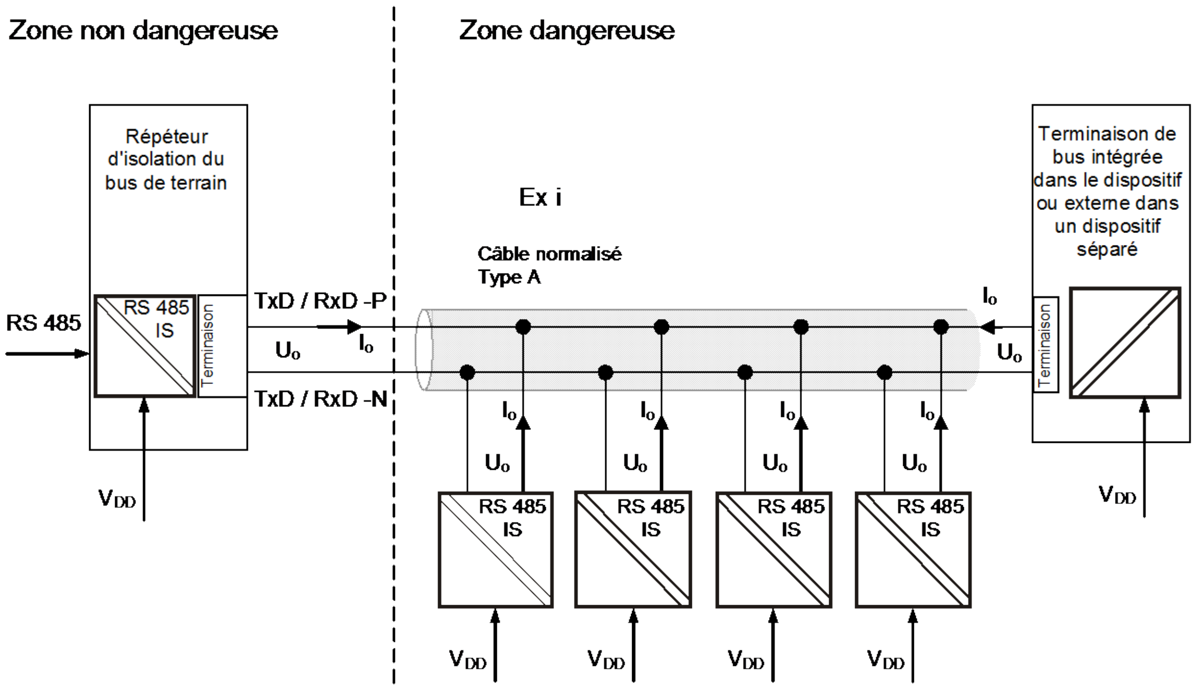

Figure 110 – Modèle de bus de terrain de sécurité intrinsèque

Dans certaines circonstances, les appareils installés dans la zone dangereuse doivent être protégés par des mesures de protection supplémentaires contre l'explosion (par exemple Ex e, d ou m, conformément à la CEI 60079-0).

22.2.4.3 Modèle d'appareil de communication

La Figure 111 illustre un schéma de circuit de l'interface RS 485-IS. Cette interface est constituée de composants d'isolation galvanique et de limitation de la tension et du courant, ainsi que d'un émetteur-récepteur RS 485.

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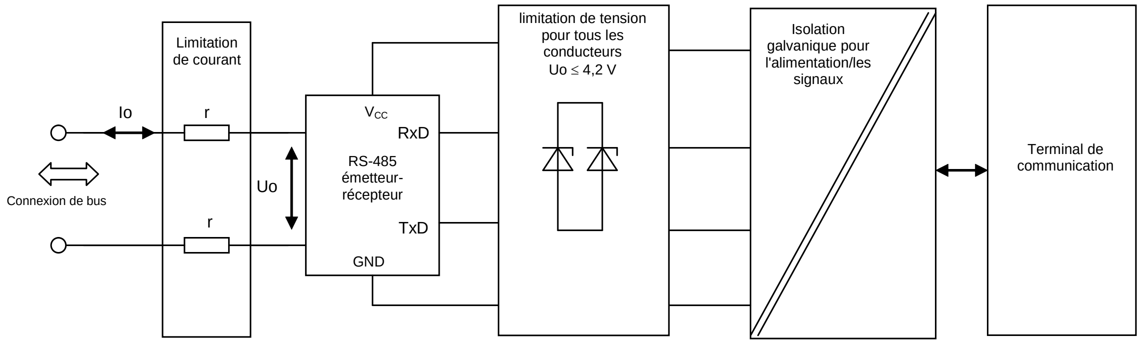

Figure 111 – Modèle d'appareil de communication de sécurité intrinsèque

Pour se conformer à la limite donnée pour U_o dans le Tableau 119, toutes les connexions à l'interface de bus (lignes d'alimentation et de données) doivent être limitées au moyen de composants de limitation de la tension appropriés. Dans ce contexte, les tolérances et les valeurs maximales de puissance assignée des composants doivent être prises en compte. Dans certaines circonstances, il convient d'intégrer au terminal de communication / à l'alimentation des mesures appropriées de limitation de puissance.

Dans tous les appareils connectés aux bus de terrain de sécurité intrinsèque, le circuit d'interface du bus doit être galvaniquement isolé de tous les autres circuits électriques.

Les distances de séparation et les tensions d'isolement entre circuits de sécurité intrinsèque et/ou circuits non de sécurité intrinsèque, doivent satisfaire aux exigences de la CEI 60079-11.

NOTE La limitation du courant est déterminée par la tension de sortie maximale et la somme des résistances internes. Les résistances internes sont constituées par les résistances série des lignes de données RxD/TxD-N et RxD/TxD-P ainsi que par les résistances série Ru et Rd pour l'alimentation du terminateur de bus.

Dans ce contexte, les tolérances et les valeurs assignées de puissance des résistances doivent également être prises en compte. La CEI 60079-11 fournit les exigences détaillées applicables aux composants de limitation du courant et de la tension.

22.2.4.4 Valeurs maximales de sécurité

Le Tableau 119 présente les paramètres de sécurité pertinents ainsi que leurs valeurs pour l'ensemble du système de bus de terrain.

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Tableau 119 – Valeurs maximales de sécurité

Paramètre	Description	Valeur	Remarque
Système de bus			
Tension d'entrée maximale	U_I [V]	|±4,2|	
Courant d'entrée maximal	I_I [A]	4,8	Le circuit a une caractéristique linéaire Rs = Uo/Io
Rapport maximal inductance / résistance (voir la note)	L'/R' [µH/Ω]	15	Pour l'ensemble de la plage de températures de service du système de bus
Nombre d'appareils	N_{TN}	≤ 32	Un appareil de terrain peut être conçu avec une vitesse limitée de transmission de données
Dispositif de communication			
Tension de sortie maximale	Uo [V]	|±4,2|	
Courant de sortie maximal	Io [mA]	149	Courant total des conducteurs A, B et alimentation de terminaison de bus
Tension d'entrée maximale	U_I [V]	|±4,2|	
Inductance interne maximale	L_I [H]	0	Aucune inductance concentrée ne peut être tolérée le long du bus de terrain
Capacité interne maximale	C_I [nF]	N/A	Non significatif pour la sécurité
Terminaison de bus active externe			
Tension de sortie maximale	Uo [V]	|±4,2|	
Courant de sortie maximal	Io [mA]	16	
Tension d'entrée maximale	U_I [V]	|±4,2|	
Inductance interne maximale	L_I [H]	0	Aucune inductance concentrée ne peut être tolérée le long du bus de terrain
Capacité interne maximale	C_I [nF]	N/A	Non significatif pour la sécurité
NOTE Pour une tension inférieure à 10 V, la capacité du câble ne génère pas de danger supplémentaire. Cependant, pour des raisons fonctionnelles, la capacité du câble de bus est limitée à C' < 40 nF/km.			

Pour des raisons fonctionnelles, il convient de subdiviser de manière symétrique la résistance de limitation du courant.

22.2.4.5 Répéteur d'isolation du bus de terrain

Pour créer ou connecter des segments de bus de terrain de sécurité intrinsèque, il est nécessaire d'utiliser des répéteurs d'isolation de bus de terrain (voir la Figure 102 et la Figure 103). Les interfaces du bus de terrain de sécurité intrinsèque de ces appareils doivent également être mises en œuvre conformément à la présente spécification de MAU. On doit notamment tenir compte, du point de vue de la sécurité, des données de sécurité maximale (voir 22.2.4.4) et de l'isolation galvanique par rapport à tous les autres circuits (voir 22.2.1).

Le répéteur d'isolation de bus de terrain doit être conçu comme matériel associé. Si des répéteurs d'isolation de bus de terrain doivent être installés dans la zone dangereuse, des mesures supplémentaires de protection contre l'explosion sont nécessaires.

23 Type 3: Unité de liaison au support: transmission asynchrone, support optique

23.1 Caractéristiques techniques de la transmission de données sur fibre optique

Le Tableau 120 présente les caractéristiques techniques d'une transmission de données sur fibre optique.

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Tableau 120 – Caractéristiques techniques

Point	Description
Support de transmission	Câble à fibre optique (FOC) en quartz ou en plastique
Caractéristiques	– Large gamme, indépendante de la vitesse de transmission – Insensibilité aux perturbations électromagnétiques – Isolation galvanique entre les nœuds connectés – Connexion non réactive – même aux applications existantes – Configuration des composantes optiques avec des composantes normalisées et économiques
Structure du réseau	Topologies en étoile, en anneau, linéaires et mixtes (arborescentes) Connexion à des segments du réseau électrique
Composants de réseau	Coupleur en étoile actif Répéteur } avec ou sans resynchronisation Convertisseur électro-optique
Débits de données	9,6 kbit/s; 19,2 kbit/s; 45,45 kbit/s; 93,75 kbit/s; 187,5 kbit/s; 500 kbit/s; 1,5 Mbit/s; 3 Mbit/s; 6 Mbit/s; 12 Mbit/s
Portée du réseau et nombre de nœuds	En fonction du nombre et du type de composants réseau utilisés EXEMPLE 1: Segment de réseau avec 1 coupleur en étoile actif et un câble à fibre optique en silice (multimodale): – 3 400 m (indépendant du nombre de nœuds). EXEMPLE 2: Segment de réseau avec 1 coupleur en étoile actif et un câble à fibre optique en plastique: – 88 m (indépendant du nombre de nœuds). NOTE Il est possible d'augmenter les portées et le nombre de nœuds en reliant des segments de réseau.

La Figure 112 illustre la MAU à fibre optique à côté d'une MAU de la norme TIA/EIA RS-485-A de l'ANSI. Ceci signifie que la MAU à fibre optique doit être connectée à une DLL sur une interface DL-Ph de la même manière qu'une MAU de la norme TIA/EIA RS-485-A de l'ANSI. L'interface mentionnée est décrite en 5.4.2.

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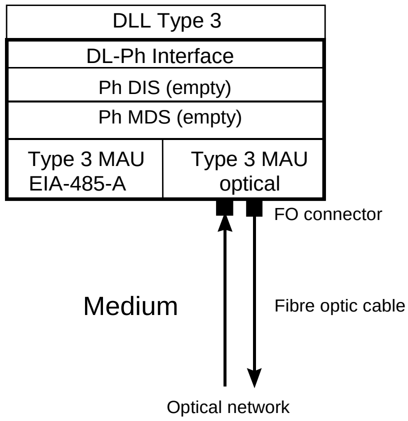

Légende

Anglais	Français
DLL Type 3	DLL de type 3
DL-PH Interface	Interface DL – Ph
Ph – DIS (empty)	Ph – DIS (vide)
Ph – MDS (empty)	Ph – MDS (vide)
Type 3 MAU EIA – 485 A	MAU de type 3 selon EIA – 485 A
Type 3 MAU optical	MAU à fibre optique de type 3
FO Connector	Connecteur FO
Medium	Support
Fibre optic Cable	Câble à fibre optique
Optical network	Réseau optique

Figure 112 – Connexion au réseau optique

23.2 Caractéristiques de base d'un support de transmission de données sur fibre optique

Un support de transmission de données sur fibre optique est caractérisé par:

- une insensibilité aux perturbations électromagnétiques, c'est-à-dire:
  a) l'absence de diaphonie entre différentes lignes de signaux sur fibre optique,
  b) l'immunité aux injections de perturbations en provenance et vers des lignes électriques,
  c) l'immunité aux perturbations de champs électromagnétiques qui peuvent apparaître, par exemple, lors de la commutation de charges électriques importantes.
- une isolation galvanique entre les nœuds connectés, c'est-à-dire:
  a) l'absence de courants d'égalisation entre des potentiels de terre différents
  b) aucune mesure particulière de protection contre la foudre n'est nécessaire pour la liaison de transmission.
- La possibilité d'utiliser des pontages en fibre optique sur de grandes distances et à des vitesses de transmission élevées.
- L'installation simple et économique de réseaux plus courts à base de fibres plastiques.
- Un faible poids.
- L'absence de toute corrosion.

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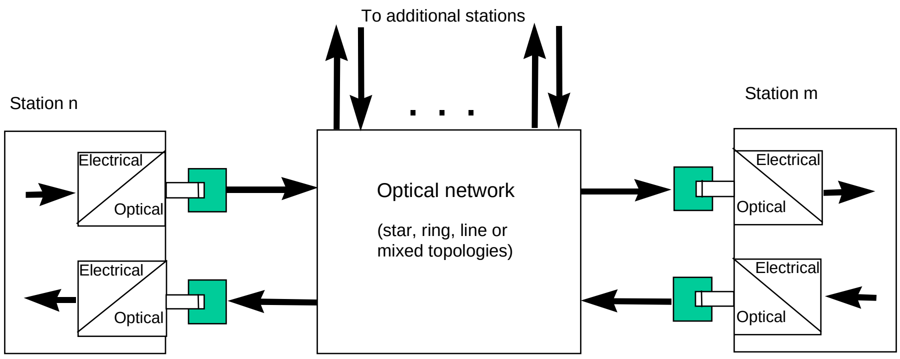
– Un câblage simplifié et normalisé des bâtiments au moyen de fibres de référence identiques pour de nombreuses normes de communication.

23.3 Réseau optique

Le convertisseur électro-optique qui assure l'interface entre la partie électrique de la MAU et un support de réseau optique est une composante importante de la MAU à fibre optique d'un nœud.

Un émetteur optique convertit des signaux électriques en signaux optiques et les injecte dans le support à fibre optique. En sens inverse, un récepteur optique convertit les signaux optiques reçus du support à fibre optique en signaux électriques.

La Figure 113 présente la structure de principe d'un réseau optique.



Légende

Anglais	Français
To additional stations	Vers des stations supplémentaires
Station n	Station n
Electrical / optical	Electrique / optique
Optical network (star, ring, line or mixed topologies)	Réseau optique (topologies en étoile, en anneau, linéaires et mixtes)
Station m	Station m

Figure 113 – Structure de principe d'un réseau optique

Il est spécifié, pour chaque type de fibre, un convertisseur électro-optique ayant un bilan spécifique de niveau de signal, tenant compte des différences physiques entre fibres en silice et fibres en matière plastique.

L'utilisateur peut “consommer” le bilan de niveau de signal comme un affaiblissement sur la liaison optique.

23.4 Liaison optique normalisée

La liaison optique normalisée est une construction théorique utilisée pour spécifier la gamme admissible de niveaux de signal et de distorsion de signal, voir la Figure 114.

A partir de la liaison optique normalisée, on peut calculer des topologies de réseau de toute complexité. La liaison optique normalisée est constituée de

– un convertisseur électro-optique (émetteur) qui convertit un signal électrique en signal optique s'inscrivant dans les limites admissibles spécifiées par le modèle de signal (voir la Figure 115);

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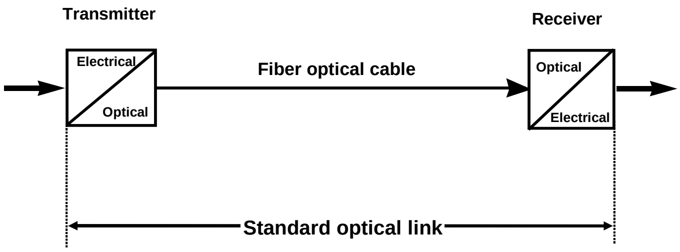
– une liaison optique passive constituée d'un câble à fibre optique et caractérisée par un affaiblissement d'amplitude et une distorsion de synchronisation des signaux;
– un convertisseur électro-optique (récepteur) qui détecte le signal optique reçu, comme décrit en 23.7.3, et le convertit en un signal électrique dont les caractéristiques sont spécifiées en 23.8.



Légende

Anglais	Français
Transmitter	Emetteur
Electrical / optical	Electrique / optique
Fiber optical cable	Câble à fibre optique
Standard optical link	Liaison optique normalisée
Receiver	Récepteur
Optical / electrical	Optique / électrique

Figure 114 – Définition d'une liaison optique normalisée

23.5 Structures de réseaux construits à partir d'une combinaison de liaisons optiques normalisées

Selon la définition ci-dessus, une liaison optique normalisée constitue une connexion d’une extrémité à l’autre. Des liaisons optiques normalisées peuvent être interconnectées (en chaîne) pour constituer des réseaux complexes par interconnexion des interfaces électriques. Les règles de chaînage sont spécifiées en 23.8.3.

L'utilisateur peut ainsi spécifier la structure du réseau en sélectionnant la distribution de signaux qui répond au mieux aux exigences du système à mettre en réseau.

Les topologies suivantes sont prises en charge: en étoile, en anneau ou linéaires ainsi qu'une combinaison de ces topologies, de manière à constituer une topologie mixte. Le couplage de segments optiques et électriques du réseau (telles que la MAU de la norme TIA/EIA RS-485-A de l'ANSI) est possible et acceptable.

23.6 Codage binaire

Le codage binaire NR (non retour à zéro) à partir de la DLL est représenté par des signaux optiques, comme défini ci-après:

– binaire "1" (DL_symbol = "UN") signifie: pas de lumière sur le FOC,
– binaire "0" (DL_symbol = "ZERO") signifie: lumière sur le FOC.

L'état de repos (DL_symbol = "SILENCE") prend l'état binaire “1”, c'est-à-dire: pas de lumière.

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23.7 Niveau de signal optique

23.7.1 Généralités

Compte tenu des différences physiques entre fibres silice et plastique, un bilan de niveau spécifique est applicable aux deux types de fibres.

23.7.2 Caractéristiques des émetteurs optiques

La puissance de transmission est spécifiée en dBm.

Les niveaux spécifiés sont définis à l'extrémité d'un câble à fibre optique silice d'une longueur de 1 m ou d'un câble à fibre optique plastique de 0,5 m de longueur; ces niveaux sont mesurés sur une grande surface de détecteur. Les modes de gaine ne doivent pas être inclus dans la valeur mesurée. Le câble à fibre optique doit être connecté à l'émetteur au moyen du connecteur spécifié en 23.10. En d'autres termes, l'affaiblissement du connecteur au niveau de l'émetteur optique, est inclus dans la valeur mesurée.

Les tolérances de niveaux des signaux sont applicables sur l'ensemble de la plage de températures de service (température ambiante de l'élément émetteur).

Toutes les valeurs spécifiées du Tableau 121 au Tableau 124 ci-dessous sont fondées sur la forme du signal de transmission spécifié par le modèle de signal de la Figure 115. Les termes techniques utilisés dans le tableau (longueur d'onde de crête, etc.) sont définis dans la CEI 60050-731.

Tableau 121 – Caractéristiques des émetteurs optiques pour fibre silice multimodale

Grandeur	Valeur	Unité
Longueur d'onde de crête	790 à 910	nm
Largeur spectrale	≤ 75	nm
Température de service	0 à 70	°C
Fibre d'essai (à gradient d'indice) (voir la note)	62,5/125	μm
NA (ouverture numérique de la fibre d'essai)	0,275 ± 0,015	
$P_{Smax“0“}$ (puissance de réception max. pour "0" binaire)	–10	dBm
$P_{Smin“0“}$ (puissance de réception min. pour "0" binaire)	–15	dBm
$P_{Smax“1“}$ (puissance de réception max. pour "1" binaire)	–40	dBm
P_{Sost} (dépassement max., puissance de transmission pour "0" binaire)	–8,8	dBm
NOTE Fibre d'essai comme spécifié dans la CEI 60793, Type A1b.		

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Tableau 122 – Caractéristiques des émetteurs optiques pour fibre silice unimodale

Grandeur	Valeur	Unité
Longueur d'onde de crête	1260 à 1380	nm
Largeur spectrale	≤ 120	nm
Température de service	0 à 70	°C
Fibre d'essai (à gradient d'indice) (voir la note)	9/125	µm
NA (ouverture numérique de la fibre d'essai)	0,113 ± 0,02	
$P_{Smax“0“}$ (puissance de transmission max. pour "0" binaire)	–10	dBm
$P_{Smin“0“}$ (puissance de transmission min. pour "0" binaire)	–20	dBm
$P_{Smax“1“}$ (puissance de transmission max. pour "1" binaire)	–40	dBm
P_{Sost} (dépassement max., puissance tx pour "0")	–8,8	dBm
NOTE Fibre d'essai comme spécifié dans la CEI 60793, Type B1.1, B3.		

Tableau 123 – Caractéristiques des émetteurs optiques pour fibre plastique

Grandeur	Valeur		Unité
Longueur d'onde de crête	640 à 675		nm
Largeur spectrale	≤ 35		nm
Température de service	0 à 70		°C
Fibre d'essai (à gradient d'indice) (voir Note)	980/1000		µm
NA (ouverture numérique de la fibre d'essai)	0,5 ± 0,15		
Niveau de puissance de transmission	Normalisé	Amélioré	
$P_{Smax“0“}$ (puissance de transmission max. pour "0" binaire)	-5,0	0	dBm
$P_{Smin“0“}$ (puissance de transmission min. pour "0" binaire)	-11	-6	dBm
$P_{Smax“1“}$ (puissance de transmission max. pour "1" binaire)	-42	-42	dBm
P_{Sost} (dépassement max., puissance de transmission pour "0" binaire)	-4,3	2,3	dBm
NOTE Fibre d'essai comme spécifié dans la CEI 60793, Type A4a.			

Tableau 124 – Caractéristiques des émetteurs optiques pour fibre silice 200/230 µm

Grandeur	Valeur	Unité
Longueur d'onde de crête	640 à 675	nm
Largeur spectrale	≤ 35	nm
Température de service	0 à 70	°C
Fibre d'essai (à saut d'indice) (voir la Note)	200/230	µm
NA (ouverture numérique de la fibre d'essai)	0,37 ± 0,02	
$P_{Smax“0“}$ (puissance de transmission max. pour "0" binaire)	–8	dBm
$P_{Smin“0“}$ (puissance de transmission min. pour "0" binaire)	–17	dBm
$P_{Smax“1“}$ (puissance de transmission max. pour "1" binaire)	–44	dBm
P_{Sost} (dépassement max., puissance de transmission pour "0" binaire)	–6,8	dBm
NOTE Fibre d'essai de la CEI 60793, Type A3c: NA = 0,4 ± 0,04.		

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23.7.3 Caractéristiques des récepteurs optiques

La sensibilité d'entrée des récepteurs est également spécifiée en dBm voir Tableau 125 à Tableau 128. La sensibilité d'entrée est mesurée à l'extrémité d'une fibre de référence spécifiée sur une grande surface de détecteur. Les modes de gaine ne doivent pas être inclus dans la valeur mesurée.

Les tolérances de niveau de signal sont applicables sur l'ensemble de la plage de températures de service (température ambiante de l'élément de réception). Ces tolérances doivent être maintenues sur l'ensemble de la durée de vie spécifiée de l'élément de réception. La forme du signal de réception repose sur la forme du signal de transmission présentée dans le modèle de signal de la Figure 115.

Le récepteur doit tolérer un certain taux de dépassement du signal d'entrée au début de l'impulsion binaire "0". Cependant, le récepteur ne doit pas exiger un taux de dépassement donné pour, par exemple, maintenir une distorsion du signal exigée.

Tableau 125 – Caractéristiques des récepteurs optiques pour fibre silice multimodale

Grandeur	Valeur	Unité
Longueur d'onde de crête	790 à 910	nm
Température de service	0 à 70	°C
$P_{Emax“0“}$ (puissance de réception max. pour "0" binaire)	–10	dBm
$P_{Emin“0“}$ (puissance de réception min. pour "0" binaire)	–24	dBm
$P_{Emax“1“}$ (puissance de réception max. pour “1“ binaire)	–42	dBm

Tableau 126 – Caractéristiques des récepteurs optiques pour fibre silice unimodale

Grandeur	Valeur	Unité
Longueur d'onde de crête	1260 à 1380	nm
Température de service	0 à 70	°C
$P_{Emax“0“}$ (puissance de réception max. pour "0" binaire)	–10	dBm
$P_{Emin“0“}$ (puissance de réception min. pour "0" binaire)	–27	dBm
$P_{Emax“1“}$ (puissance de réception max. pour "1" binaire)	–40	dBm

Tableau 127 – Caractéristiques des récepteurs optiques pour fibre plastique

Grandeur	Valeur		Unité
Longueur d'onde de crête	640 à 675		nm
Température de service	0 à 70		°C
Récepteur pour niveau de performance tx	Normalisé	Amélioré	
$P_{Emax“0“}$ (max. (puissance de réception max pour "0" binaire)	–5	0	dBm
$P_{Emin“0“}$ (puissance de réception min. pour "0" binaire)	–20		dBm
$P_{Emax“1“}$ (puissance de réception max. pour "1" binaire)	–42		dBm

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Tableau 128 – Caractéristiques des émetteurs optiques pour fibre silice 200/230 μmf

Grandeur	Valeur	Unité
Longueur d'onde de crête	640 à 675	nm
Température de service	0 à 70	°C
$P_{Emax“0“}$ (puissance de réception max. pour "0" binaire)	-8	dBm
$P_{Emin“0“}$ (puissance de réception min. pour "0" binaire)	-22	dBm
$P_{Emax“1“}$ (puissance de réception max. pour "1" binaire)	-44	dBm

23.8 Distorsion temporelle des signaux

23.8.1 Généralités

Les paragraphes suivants décrivent la distorsion des signaux due à chacun des éléments de la liaison de transmission.

Les signaux numériques électriques sont toujours évalués à l'intersection avec l'amplitude de signal de 50 %.

23.8.2 Forme de signal à l'entrée électrique de l'émetteur optique

La distorsion de signal admissible à l'entrée électrique de l'émetteur optique d'une station ou d'une composante avec resynchronisation est présentée dans le Tableau 129.

Tableau 129 – Distorsion de signal admissible à l'entrée électrique de l'émetteur optique

Signal	Limites des débits de données < 1,5 Mbit/s	Limites des débits de données ≥ 1,5 Mbit/s (Note 1)
t_{BIT} (Note 2)	1/ Data_rate × (1 ± 0,3 %)	1/ Data_rate × (1 ± 0,03 %)
t_{SBIT} (uniquement pour le bit d'arrêt) (Note 3)	t_{BIT} × (1 ± 6,25 %)	

NOTE 1 Il s'agit du débit de données nominal spécifié dans le Tableau 120.

NOTE 2 t_{BIT} est la durée qui s'écoule pendant l'émission d'un bit. Elle est équivalente à la valeur inverse de la vitesse de transmission.

NOTE 3 t_{SBIT} est la tolérance étendue pour la durée de bit admissible sur le réseau optique qui s'applique exclusivement au bit d'arrêt émis. Cette extension de la tolérance permet aux répéteurs avec resynchronisation de compenser les écarts entre horloges de réception et de transmission.

23.8.3 Distorsion de signal due à l'émetteur optique

Pour satisfaire aux exigences spécifiées, le signal de transmission de l'émetteur optique doit s'inscrire dans la partie grisée du modèle de signal de la Figure 115 et se conformer aux paramètres donnés dans le Tableau 130.

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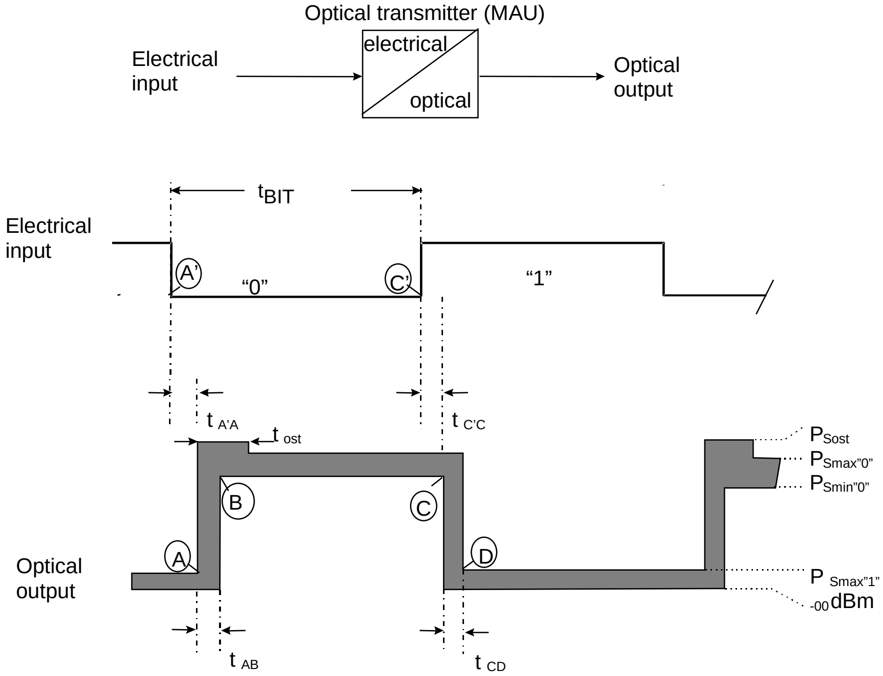

où

t_{ost} = la durée maximale pendant laquelle la puissance de transmission optique maximale peut être dépassée dynamiquement.

t_{AB} = le front montant du signal optique doit passer par $P_{Smax“1“}$ à $P_{Smin“0“}$ au cours de cette période.

T_{cd} = le front descendant du signal optique doit passer par $P_{Smin“0“}$à $P_{Smax“1“}$ au cours de cette période.

$t_{A’A}$ = le retard du signal de plus courte durée, dû au convertisseur électro-optique pour un changement de niveau de "1" à "0" (front optique montant).

$t_{C’C}$ = le retard du signal de plus courte durée, dû au convertisseur électro-optique pour un changement de niveau de "0" à "1" (front optique descendant).

Légende

Anglais	Français
Optical transmitter (MAU)	Emetteur optique (MAU)
Electrical input	Entrée électrique
Electrical / optical	Electrique / optique
Optical output	Sortie optique

Figure 115 – Modèle de signal pour l'émetteur optique

L'émetteur optique doit satisfaire aux spécifications du modèle à ≤1,5 Mbit/s et 3 Mbit/s à 12 Mbit/s, comme présenté dans le Tableau 130.

Tableau 130 – Distorsion de signal admissible due à l'émetteur optique

Temps	≤ 1,5 Mbit/s	3 Mbit/s à 12 Mbit/s	Unité
t_{ost}	200	20	Ns
t_{AB}	40	25	Ns
t_{CD}	95	25	Ns
$t_{A’A} – t_{C’C}$	65	5	Ns

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23.8.4 Distorsion du signal due au récepteur optique

La distorsion maximale du signal de sortie électrique du récepteur, en comparaison au signal d'entrée optique, est spécifiée dans le Tableau 131. Ceci s'applique à l'ensemble de la plage de niveaux d'entrée, spécifiée en 23.7.3.

Tableau 131 – Distorsion de signal admissible due au récepteur optique

Temps	≤ 1,5 Mbit/s	3 Mbit/s à 12 Mbit/s	Unité
$t_{dis“0“}$ (voir la note)	-20 à 95	-25 à 25	ns
NOTE $t_{dis“0“}$ décrit les limites admissibles de distorsion de durée binaire pour un bit "0".			

23.8.5 Influence des éléments de couplage sur le signal

Les éléments de couplage, tels que des coupleurs en étoile actifs, des convertisseurs ou des répéteurs de MAU à fibre optique de la norme TIA/EIA RS-485-A de l'ANSI, comportent une logique interne qui affecte le signal propagé au-delà de l'influence due au convertisseur électro-optique décrite ci-dessus.

L'effet maximal doit s'inscrire dans les limites spécifiées dans le Tableau 132:

Tableau 132 – Influence admissible des circuits électroniques internes d'un élément de couplage sur le signal

Temps	≤ 1,5 Mbit/s	3 Mbit/s à 12 Mbit/s	Unité
t_{log} (voir la Note 1)	-0 à 10	-0 à 10	ns
t_{delay} (voir la note 2)	≤ 3 t_{BIT}	≤ 8 t_{BIT}	ns
NOTE 1 t_{log} décrit la distorsion maximale du signal admissible due à la logique interne d'un élément de couplage (par exemple un coupleur en étoile actif) sans aucune resynchronisation. Ce facteur est pertinent lors du chaînage de liaisons optiques normalisées et figure déjà dans le Tableau 133. NOTE 2 t_{delay} décrit le retard de signal maximal admissible entre n'importe quelle entrée et sortie lors du passage à travers un élément de couplage (par exemple un coupleur en étoile actif).			

23.8.6 Chaînage de liaisons optiques normalisées

Si le réseau est constitué de liaisons optiques normalisées connectées en série (chaînage), la somme des distorsions de chaque liaison individuelle ne doit pas dépasser la distorsion de durée binaire globale admissible d'une interface de nœud, égale à 25 % (≤ 1,5 Mbit/s) ou 30 % (12 Mbit/s).

Sachant que les distorsions des convertisseurs électro-optiques représentent des valeurs absolues, elles augmentent de plus en plus à des vitesses élevées de transmission des données.

Si des liaisons optiques normalisées sont chaînées sans un appareil de resynchronisation, le nombre maximal de liaisons, calculé entre deux nœuds et/ou éléments de resynchronisation, ne doit pas dépasser les valeurs présentées dans le Tableau 133.

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Tableau 133 – Possibilité de chaînage maximale de liaisons optiques normalisées sans resynchronisation

Débit de données	Nombre de liaisons en série (≤1,5 Mbit/s, voir la note 1)	Nombre de liaisons en série (3 Mbit/s à 12 Mbit/s, voir la Note 2)
12 Mbit/s	–	1
6 Mbit/s	–	2
3 Mbit/s	–	4
1,5 Mbit/s	1	8
500 kbit/s	3	24
187,5 kbit/s	8	64
93,75 kbit/s	16	128
45,45 kbit/s	33	264
19,2 kbit/s	78	625
9,6 kbit/s	156	1250

NOTE 1 Dispositifs conçus pour des vitesses maximales de transmission des données de 1,5 Mbit/s.

NOTE 2 Dispositifs conçus pour des vitesses maximales de transmission des données de 12 Mbit/s.

Il est possible de réaliser tout degré de chaînage requis si les éléments de couplage rétablissent la synchronisation entre les liaisons optiques (resynchronisation).

23.9 Taux d'erreurs sur les bits

Il peut y avoir un taux maximal d'erreurs sur les bits (BER) de 10^{-9} à la sortie électrique d'une liaison optique normalisée.

23.10 Connecteurs pour câble à fibre optique

Les connecteurs sont spécifiés en I.2.2.

23.11 Redondance dans des réseaux de transmission optique

Une liaison optique redondante, analogue à la technologie de transmission électrique de Type 3 est également possible. Le principe fonctionnel est décrit en Annexe J.

24 Type 4: Unité de liaison au support: RS-485

24.1 Généralités

La MAU RS-485 peut être utilisée pour connecter jusqu'à 125 appareils de bus de terrain sur le même câble. La longueur peut atteindre 1 200 m et le débit en bauds peut être de 9 600, 19 200, 38 400 ou 76 800.

24.2 Aperçu des services

L'interface MDS-MAU met à disposition des services permettant de connecter la MDS à une MAU correspondante. Les services TxS et RxS sont définis comme des signaux logiques que la sous-couche MAU convertit directement en signaux physiques. Le service TxE est défini comme un signal logique utilisé en interne dans la MAU. Les services de l'interface MDS-MAU RS-485 sont présentés dans le Tableau 134.

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Tableau 134 – Services de l'interface MDS-MAU, RS-485, de Type 4

Désignation du signal	Mnémonique	Sens
Signal de transmission	TxS	Vers la MAU
Activation de transmission	TxE	Vers la MAU
Signal de réception	RxS	De la MAU

24.3 Description des services

24.3.1 Signal de transmission (TxS)

Ce service transmet la PhPDU de la MDS à la MAU; la transmission doit être effectuée sur le support si TxE (activation de l'émission) est mis au niveau "1" logique (niveau haut).

24.3.2 Activation de l'émission (TxE)

Le service TxE (activation de l'émission) doit fournir à la MDS la fonction qui permet d'activer la MAU pour qu'elle émette. TxE doit être mis au niveau "1" logique (niveau haut) par la MDS, immédiatement avant que l'émission ne commence, et au "0" logique (niveau bas) au minimum 3 et au maximum 10 périodes binaires après que l'émission s'est achevée.

24.3.3 Signal de réception (RxS)

Ce service transmet la PhPDU de la MAU à la MDS.

24.4 Réseau

24.4.1 Généralités

Cette MAU fonctionne sur un réseau constitué des composants suivants:

– câble;

– des connecteurs;

– appareils (comportant au moins un élément de communication).

24.4.2 Topologie

Cette MAU doit fonctionner dans une structure de bus organisée comme un anneau physique sans terminaison. Jusqu'à 125 appareils de bus de terrain sont connectés directement ou via des lignes d'adaptation d'une longueur maximale de 2 m. La longueur totale du câble ne doit pas dépasser 1 200 m.

24.5 Spécification électrique

Les niveaux de tension de l'émetteur et du récepteur peuvent être extraits de la norme TIA/EIA-485-A de l'ANSI.

24.6 Réponse temporelle

La réponse temporelle de l'émetteur et du récepteur peut également être extraite de la norme TIA/EIA-485-A de l'ANSI.

24.7 Interface avec le support de transmission

Un circuit recommandé pour le couplage au support de transmission est présenté à la Figure 116.

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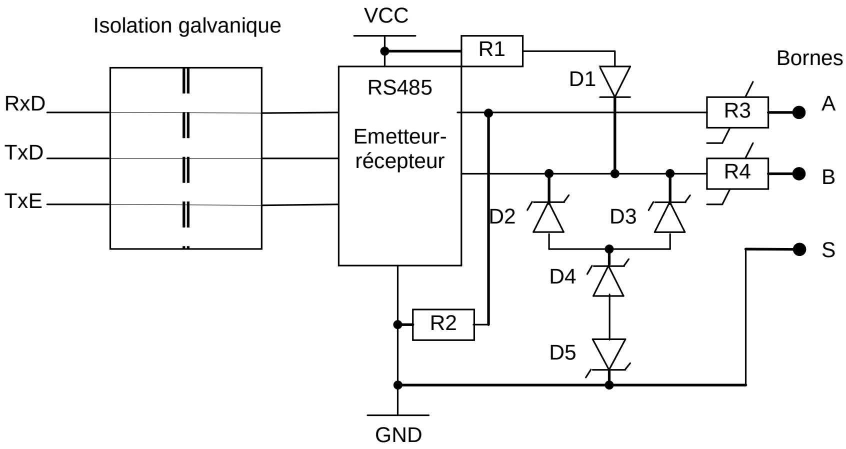

Valeurs des composants:

R1, R2	15 kΩ
R3, R4	PTC, max 13 Ω; Courant de maintien 100 mA
D1	100 mA Petite diode de signal
D2, D3, D4, D5	3.9 V / 1 W Diode régulatrice de tension

Figure 116 – Circuit d'interface recommandé

24.8 Spécification du support de transmission

24.8.1 Connecteurs de câble

En général, les appareils de bus de terrain sont munis de bornes à vis repérées A, B et S pour le blindage.

24.8.2 Câble

Un câble à paire torsadée blindé avec des conducteurs d'une section minimale de 0,22 mm^2 et d'une impédance caractéristique de 100 Ω à 120 Ω.

25 *Vide*

NOTE Dans la présente édition, l'Article 25 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

26 *Vide*

NOTE Dans la présente édition, l'Article 26 est destiné à maintenir la numérotation des articles et éviter la rupture avec des normes nationales et multinationales ainsi que des documents de consortiums existants qui renvoient à l'édition précédente.

27 Type 8: Unité de liaison au support: support câblé à paire torsadée

27.1 Signaux de MAU

Une MAU d'interface de départ et d'arrivée est présentée à la Figure 117 et à la Figure 118.

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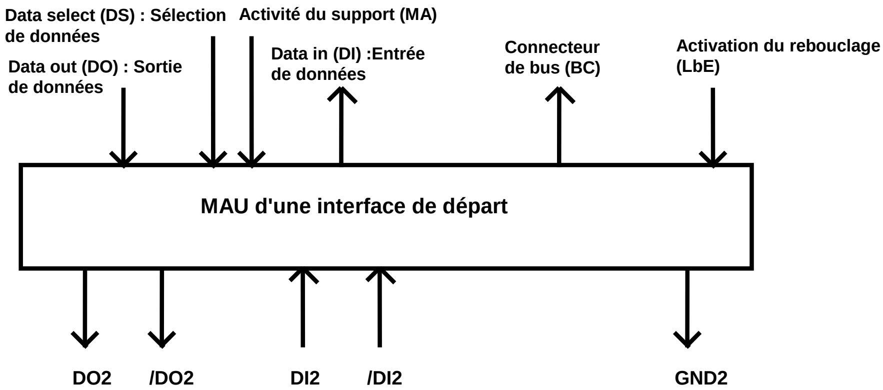

Figure 117 – MAU d'une interface de départ

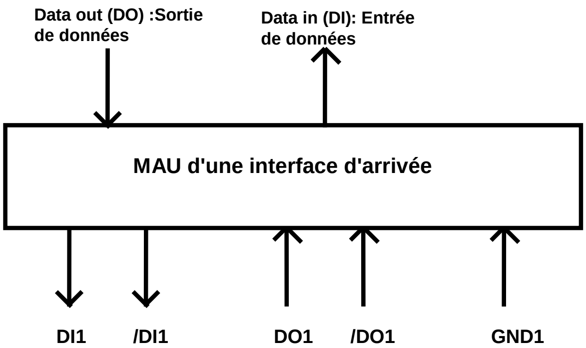

Figure 118 – MAU d'une interface d'arrivée

27.2 Grandeurs dépendantes du débit binaire de transmission

Quatre débits binaires sont définis pour une MAU (unité de liaison au support) à paire torsadée. Une MAU donnée doit prendre en charge au moins un de ces débits binaires. Le Tableau 135 définit les débits binaires et les grandeurs qui dépendent du débit binaire.

Tableau 135 – Grandeurs dépendantes du débit binaire pour une MAU de support câblé à paire torsadée

Grandeur	Valeur				Unité
Débit binaire nominal (voir la note)	0,5	2	8	16	Mbit/s
Ecart maximal par rapport au débit binaire	± 0,1 %	± 0,1 %	± 0,1 %	± 0,1 %	—
Durée binaire nominale (T)	2000	500	125	62,5	ns
Longueur minimale de bus distant	0	0	0	0	m
Longueur maximale de bus distant	400	150	125	100	m
Instabilité maximale de bit élémentaire émis	± 240	± 60	± 15	± 7,5	ns
NOTE Débit binaire moyen de transmission pour 13 bits.					

27.3 Réseau

27.3.1 Généralités

Une MAU de support câblé à paire torsadée fonctionne sur un réseau constitué des composants suivants:

– câble;

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– des connecteurs;
– isolation électrique;
– appareils (comportant au moins un élément de communication).

27.3.2 Topologie

La MAU de support câblé à paire torsadée doit fonctionner sur un bus distant avec un autre appareil. Une liaison de bus distant (voir la Figure 119) est constituée de deux connexions point à point. Les connexions sont unidirectionnelles. Ainsi, chaque MAU dispose d'un émetteur et d'un récepteur.

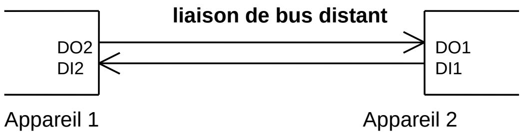

Figure 119 – Liaison de bus distant

Pour un débit binaire donné (voir le Tableau 135), une liaison de bus distant doit avoir une longueur comprise entre 0 et la longueur maximale.

27.4 Spécification électrique

Les niveaux de tension de l'émetteur et du récepteur doivent être extraits de la norme TIA/EIA-422-B de l'ANSI.

27.5 Réponse temporelle

Les niveaux de tension de l'émetteur et du récepteur doivent être extraits de la norme TIA/EIA-422-B de l'ANSI.

27.6 Interface avec le support de transmission

27.6.1 Généralités

Le couplage du support de transmission est réalisé par le biais d'une interface d'arrivée (facultative) et d'une ou de plusieurs interfaces de départ qui sont indépendantes du support (voir la Figure 120).

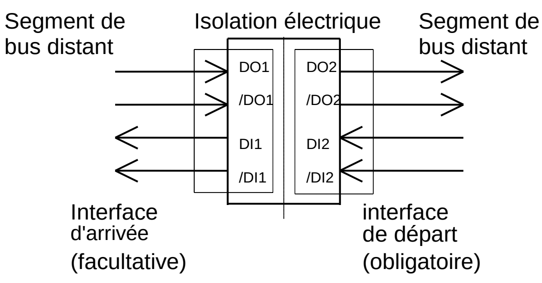

Figure 120 – Interface avec le support de transmission

27.6.2 Interface d'arrivée

L'interface d'arrivée est constituée de cinq lignes de signaux (voir le Tableau 136) pour la connexion au réseau. Ces lignes de signaux nécessitent d'être électriquement isolées de l'appareil. La tension d'isolation doit être ≥500 V (tension continue).

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Tableau 136 – Signaux d'interface d'arrivée

Nom abrégé	Nom
DO1	Ligne de données de réception +
/DO1	Ligne de données de réception -
DI1	Ligne de données de transmission +
/DI1	Ligne de données de transmission -
GND1	ligne de masse

27.6.3 interface de départ

L'interface de départ est constituée de cinq lignes de signaux (voir le Tableau 137) pour la connexion au réseau.

Tableau 137 – Signaux d'interface de départ

Nom abrégé	Nom
DO2	Ligne de données de transmission +
/DO2	Ligne de données de transmission -
DI2	Ligne de données de réception +
/DI2	Ligne de données de réception -
GND2	ligne de masse

27.7 Spécification du support de transmission

27.7.1 Connecteurs de câble

Si des connecteurs subminiatures D à 9 contacts sont utilisés, l'affectation des contacts doit être normalisée (voir M.1.1).

Les éléments de terminaison de terrain, tels que les bornes à vis de serrage ou de type plat ainsi que les connecteurs fixes, peuvent également être utilisés. Dans ce cas, il convient d'utiliser l'affectation des contacts de connecteur donnée en M.1.2.

27.7.2 Câble

Un câble blindé avec deux paires torsadées doit être utilisé comme câble de bus. Le blindage est destiné à améliorer la compatibilité électromagnétique (CEM). Il convient que le câble de bus distant soit au moins conforme aux exigences du Tableau 138.

Tableau 138 – Caractéristiques du câble de bus distant

Grandeur caractéristique (20 °C)	Valeur	Méthode d'essai
Nombre de conducteurs (paires torsadées)	3 x 2, paire torsadée	
Section	Min. 0,20 mm^2	
Résistance en courant continu du conducteur /100 m	Max. 9,6 Ω	CEI 60189-1, 8.1
Impédance caractéristique	120Ω± 20 %à une fréquence f = 0,064 MHz 100 Ω± 15 Ωà une fréquence f > 1 MHz	CEI 61156-1, 6.3.1
Rigidité diélectrique – Entre conducteurs – Conducteur/blindage	 1 $kV_{efficace}$, 1 min 1 $kV_{efficace}$, 1 min	CEI 60189-1, 8,2

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Résistance d'isolement (après essai de rigidité diélectrique)	Min 150 MΩ pour un câble d'une longueur de 1 km	CEI 60189-1, 8,3
Impédance de transfert maximale – à 30 MHz	 250 mΩ/m	
Capacité mutuelle (à 800 Hz)	Max. 60 nF pour un câble d'une longueur de 1 km	CEI 60189-1, 8,4
Perte de paradiaphonie (NEXT) min. pour un câble de 100 m – à 0,772 MHz – à 1 MHz – à 2 MHz – à 4 MHz – à 8 MHz – à 10 MHz – à 16 MHz – à 20 MHz	 61 dB 59 dB 55 dB 50 dB 46 dB 44 dB 41 dB 40 dB	CEI 61156-1, 6.3.5
Affaiblissement max. pour un câble de 100 m – à 0,256 MHz – à 0,772 MHz – à 1 MHz – à 4 MHz – à 10 MHz – à 16 MHz – à 20 MHz	 1,5 dB 2,4 dB 2,7 dB 5,2 dB 8,4 dB 11,2 dB 11,9 dB	CEI 61156-1, 6.3.3.

La Figure 121 illustre le câblage minimal avec un blindage entre deux appareils de communication.

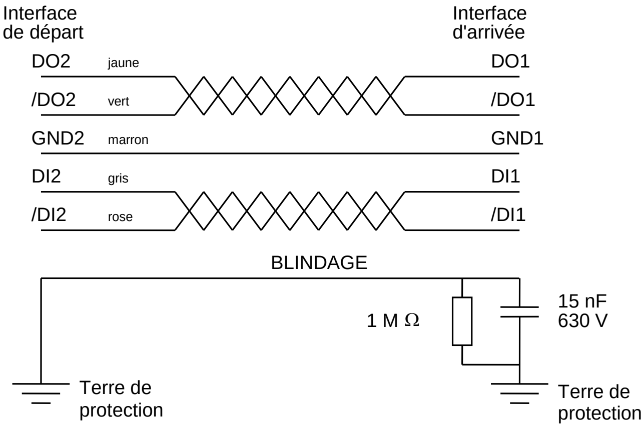

Figure 121 – Câblage

27.7.3 Résistance terminale

La paire du câble de la ligne de réception est à connecter à un réseau de résistance (voir la Figure 122) directement avant le récepteur de la MAU. Le circuit peut être utilisé pour la polarisation de la MAU, afin de détecter un circuit ouvert ou un court-circuit sur le conducteur. La résistance équivalente qui en résulte doit être d'au moins 100 Ω.

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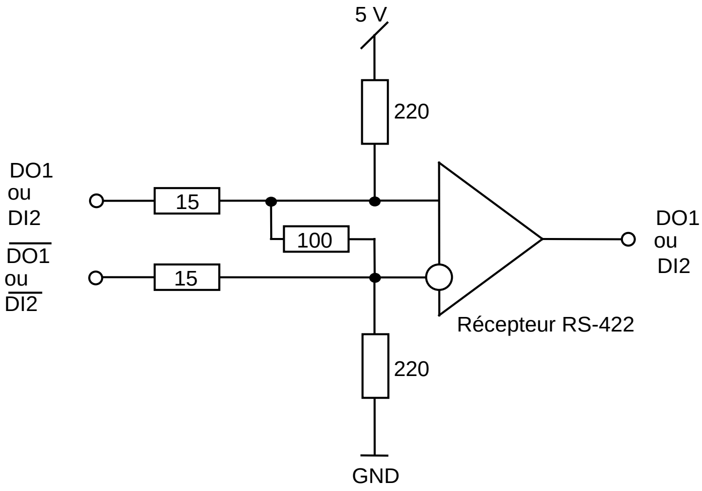

Figure 122 – Réseau de résistances terminales

28 Type 8: Unité de liaison au support: Supports optiques

28.1 Généralités

L'Article 28 a pour but de fournir les spécifications opérationnelles et optiques de la MAU à fibre optique en mode duplex.

Le câble de bus distant à fibre optique est constitué d'une paire de guides d'onde à fibre optique (voir la Figure 123) assurant la bidirectionnalité par utilisation d'une fibre séparée pour chaque sens de propagation du signal. Ces fibres optiques doubles sont connectées au CPIC d'un appareil de réseau.

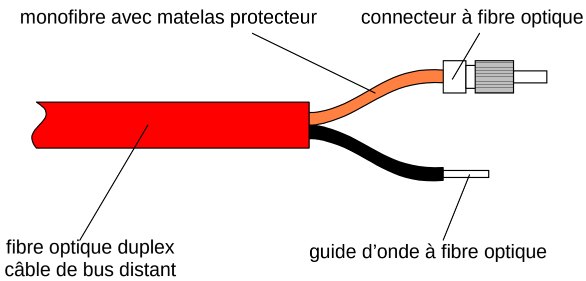

Figure 123 – Câble de bus distant à fibre optique

Deux types de fibres optiques sont pris en charge:

– la fibre optique polymère;
– la fibre de silice gainée de plastique.

28.2 Grandeurs dépendantes du débit binaire de transmission

Quatre débits binaires sont définis pour une MAU (unité de liaison au support) à fibre optique. Une MAU donnée doit prendre en charge au moins un de ces débits binaires. Le Tableau 139 définit les débits binaires et les grandeurs qui dépendent du débit binaire.

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Tableau 139 – Grandeurs dépendantes du débit binaire de MAU à fibre optique

Caractéristiques de synchronisation de transmission	Valeur				Unité
Débit binaire nominal	0,5	2	8	16	Mbit/s
Ecart maximal par rapport au débit binaire	± 0,1 %	± 0,1 %	± 0,1 %	± 0,1 %	
Durée binaire nominale (T)	2000	500	125	62,5	ns

28.3 Topologie du réseau

Une MAU à fibre optique fonctionne sur un réseau constitué des composants suivants:

– câble optique;

– des connecteurs;

– des appareils (comportant au moins un élément de communication).

Une MAU à fibre optique doit fonctionner sur un bus distant avec un autre appareil. Une liaison de bus distant (voir la Figure 124) est constituée de deux connexions point à point. Les connexions sont unidirectionnelles. Ainsi, chaque MAU dispose d'un émetteur à fibre optique et d'un récepteur à fibre optique.

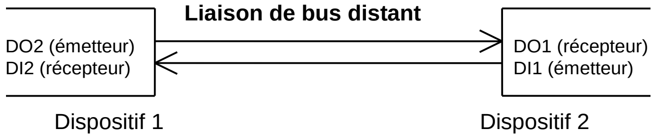

Figure 124 – Liaison de bus distant à fibre optique

La longueur du câble doit s'inscrire dans la plage spécifiée dans le Tableau 140.

Tableau 140 – Longueur du câble à fibre optique de bus distant

Type de fibre	Longueur minimale	Longueur maximale
Fibre optique polymère	1 m	50 m (voir [a] [b]))
Fibre de silice gainée de plastique	1 m	300 m (voir [a] [b]))

[a] Ceci n'exclut pas des distances plus longues entre appareils, lorsqu'on utilise par exemple des circuits de réception ayant une sensibilité minimale du récepteur optique plus faible que celle spécifiée en 28.5.2.

[b] La longueur maximale peut être réduite s'il est utilisé des câbles spéciaux ayant un affaiblissement supérieur à celui des câbles normalisés spécifiés en 28.6.2.

28.4 Spécifications du circuit de transmission

28.4.1 Règles de codage des données

Le codage NRZ est spécifié pour la transmission optique en se conformant aux règles de codage données dans le Tableau 141.

Tableau 141 – Règles de codage

Bit de symbole logique	Codage
1	Faible niveau de sortie optique
0	Haut niveau de sortie optique

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En cas d'absence d'activité du bus, un état de repos de niveau "0" logique doit être utilisé.

28.4.2 Configuration d'essai

Le niveau de sortie ainsi que les spécifications de spectre et de synchronisation sont mesurés à l'extrémité d'une fibre d'essai normalisée (comme spécifié en 28.6.4) connectée au CPIC.

Les exigences de 28.4 sont résumées dans le Tableau 142 et dans le Tableau 139.

28.4.3 Spécification du niveau de sortie

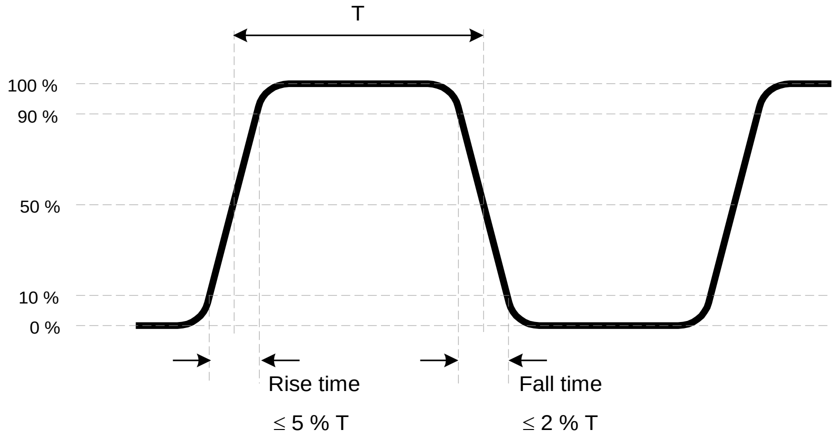
Un circuit de transmission de MAU à fibre optique doit être conforme au niveau de sortie et aux exigences spectrales suivantes. Le niveau spécifié et les caractéristiques spectrales doivent être maintenus sur l'ensemble de la plage de températures spécifiée pour l'appareil de réseau. Le niveau de sortie est la puissance d'injection effective de niveau "0" logique. Le niveau de sortie est spécifié dans le Tableau 142.

Tableau 142 – Récapitulatif des spécifications de niveau de transmission et de caractéristiques spectrales d'une MAU à fibre optique

Niveau de transmission et caractéristiques spectrales (valeurs en référence au CPIC avec fibre d'essai normalisée)	Fibre optique polymère (fibre 980/1 000 μm)		Fibre de silice gainée de plastique (fibre 200/230 μm)
Longueur d'onde de transmission crête maximale (λp)	660 nm	520 nm	660 nm
Largeur spectrale type à mi-crête (Δλ)	< 30 nm		< 30 nm
Niveau maximal de sortie	–2,0 dBm		–8 dBm
Niveau de sortie minimal	–6,2 dBm		–16,9 dBm
Puissance d'injection effective maximale d'un niveau "1" logique	–43 dBm	–41 dBm	–45 dBm
NOTE Pour la spécification de la fibre d'essai normalisée, voir 28.6.4.			

28.4.4 Spécification de synchronisation des sorties

Un circuit de transmission de MAU à fibre optique doit être conforme aux exigences suivantes de synchronisation des sorties (Voir la Figure 125). Les caractéristiques de synchronisation doivent être maintenues sur l'ensemble de la plage de températures spécifiée pour l'appareil de réseau.



Légende

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Anglais	Français
Rise time	Temps de croissance
Fall time	Temps de décroissance

Figure 125 – Modèle de forme d'onde optique pour une MAU à fibre optique

NOTE 1 Pour faciliter le renvoi aux textes correspondants, les exigences définies en 28.4.4 sont résumées dans le Tableau 139.

NOTE 2 Une puissance effective de 0 % correspondant à l'état bas (niveau "1" logique) de la puissance de sortie optique.

NOTE 3 Une puissance effective de 100 % correspondant à l'état haut (niveau "0" logique) de la puissance de sortie optique.

Le temps de croissance, le temps de décroissance et l'instabilité de bit élémentaire doivent être choisis de manière à ce que les spécifications de synchronisation de la sortie électrique du circuit de réception de la MAU à fibre optique données dans le Tableau 143 demeurent conformes.

28.5 Spécifications du circuit de réception

28.5.1 Règles de décodage

Les règles de décodage définies dans le Tableau 141 doivent être utilisées.

28.5.2 Domaine de fonctionnement du récepteur à fibre optique

Un circuit de réception de MAU à fibre optique doit avoir la sensibilité minimale de récepteur optique définie dans le Tableau 143 sur l'ensemble de la plage de températures spécifiée pour l’appareil de réseau. La puissance optique maximale pour le niveau "0" logique, mesurée au moyen de la fibre d'essai normalisée spécifié en 28.6.4, d'un circuit de réception de MAU à fibre optique ne doit pas dépasser la valeur définie dans le Tableau 143.

Le circuit de réception à fibre optique utilisé pour des systèmes à 0,5 Mbit/s et 2 Mbit/s doit être capable de détecter un train binaire 01010 après un état de repos d'une durée de 200 ms au cours duquel la réduction du second niveau "0" logique peut atteindre 65 % par rapport aux autres. Cette capacité doit être maintenue sur l'ensemble du domaine de fonctionnement du récepteur à fibre optique.

28.5.3 Instabilité maximale de bit élémentaire reçu

Le circuit de réception doit accepter un signal codé NRZ émis conformément au 28.4. En outre, le récepteur à fibre optique doit accepter des signaux ayant une variation temporelle, entre deux points adjacents quelconques de transition des signaux (passage par 50 %), de ± 25 %.

Les exigences de 28.5 sont résumées dans le Tableau 143.

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Tableau 143 – Récapitulatif de la spécification du circuit de réception de MAU à fibre optique

Caractéristiques du circuit de réception (valeurs en référence au CPIC)	Fibre optique polymère (fibre 980/1 000 μm)	Fibre de silice gainée de plastique (fibre 200/230 μm)
Sensibilité minimale du récepteur optique	≤ –21,6 dBm	≤ –23 dBm
Puissance optique maximale pour un niveau "0" logique	–2,0 dBm	–8 dBm
Instabilité maximale de bit élémentaire reçu	± 25 % du temps binaire nominal	± 25 % du temps binaire nominal

28.6 Spécification du support de transmission

28.6.1 Connecteur

Si des connecteurs de câbles sont utilisés, ils doivent être conformes à la spécification donnée à l'Article M.2.

28.6.2 Spécification du câble à fibre optique: câble à fibre optique polymère

28.6.2.1 Généralités

Un câble à fibre optique polymère à tracé fixe pour des installations intérieures doit être compatible avec les spécifications suivantes. Les câbles à fibre optique spéciaux utilisés pour des environnements spécifiques ou des applications physiques particulières, comme par exemple lorsqu'une flexibilité élevée du câble est essentielle, peuvent déroger aux spécifications suivantes en ce qui concerne l'affaiblissement du câble.

28.6.2.2 Guide d'onde à fibre optique

Un guide d'onde à fibre optique de câble à fibre optique polymère pour une MAU à fibre optique de réseau doit satisfaire aux exigences suivantes du Tableau 144.

Tableau 144 – Spécification du guide d'onde à fibre optique

Paramètre	Valeur
Diamètre de cœur	(980 ± 60) μm
Diamètre de gaine	(1 000 ± 60) μm
Non-circularité de la gaine	≤ 6 %
Matériau du cœur	Polyméthacrylate de méthyle (PMMA)
Ouverture numérique	0,47 ± 0,03
Profil d'indice (de réfraction)	Saut d'indice
Largeur de bande à 660 nm	≥ 10 MHz × 100 m
Affaiblissement à 650 nm (monochromatique)	≤ 160 dB/km
Affaiblissement à 660 nm (mesuré avec DEL et longueur de câble de 50 m)	≤ 230 dB/km

28.6.2.3 Monofibre

Une monofibre de câble à fibre optique polymère pour une MAU à fibre optique doit être conforme aux exigences suivantes du Tableau 145.

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Tableau 145 – Spécification d'une monofibre

Paramètre	Valeur
Matelas protecteur	Polyamide (PA)
Couleur de matelas protecteur	Noire ou orange
Diamètre extérieur	2,20 mm ± 0,07 mm
Rayon minimal de courbure à long terme	30 mm

28.6.2.4 Gaine de câble et propriétés mécaniques du câble

Il convient que la gaine de câble à fibre optique polymère d'une MAU à fibre optique soit conforme aux exigences suivantes du Tableau 146.

Tableau 146 – Spécification de la gaine de câble et propriétés mécaniques du câble

Paramètre	Valeur
Matériau de la gaine	Polyuréthane (PUR)
Couleur de gaine	Rouge
Eléments serre-câbles	non-métalliques
Marquage	Longueur de déploiement en m, date de production
Plage de températures (en fonctionnement)	-20 °C à +70 °C
Rayon minimal de courbure à long terme	≤ 65 mm
Résistance maximale à la traction à long terme	≥ 100 N
Pression latérale maximale à long terme	≥ 20 N/cm

28.6.2.5 Propriétés du matériau du câble

Il convient que le câble à fibre optique polymère d'une MAU à fibre optique ait les propriétés supplémentaires de matériaux données ci-dessous dans le Tableau 147.

Tableau 147 – Autres propriétés supplémentaires recommandées du matériau du câble

Paramètre	Valeur
Résistance à l’huile	Huile ASTM N°. 2, 100 °C, CEI 60811-2-1
Exempt d'halogène	CEI 60754-2
Résistance à l'ozone	CEI 60811-2-1
Résistance aux UV	ISO 4892-1
Résistance à l'abrasion	CEI 60794-1-2, méthode E2A 5 000 cycles au minimum, pointe d'acier de 1 mm de rayon, 500 g
NOTE Selon l'application, d'autres propriétés des matériaux peuvent également être exigées, comme par exemple l'absence de toute substance affectant les performances de mouillage de la peinture (essai au chloroforme).	

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28.6.3 Spécification du câble à fibre optique: câble à fibre de silice gainée de plastique

28.6.3.1 Généralités

Un câble à fibre optique en silice gainée de plastique à tracé fixe pour des installations intérieures doit être compatible avec les spécifications suivantes. Les câbles à fibre de silice gainée de plastique spéciaux utilisés pour des applications dans des environnements particuliers, tels que les câbles d'extérieur, peuvent déroger aux spécifications suivantes en ce qui concerne l'affaiblissement du câble.

28.6.3.2 Guide d'onde à fibre optique

Un guide d'onde à fibre optique de câble à fibre de silice gainée de plastique pour une MAU à fibre optique de réseau doit satisfaire aux exigences suivantes du Tableau 148.

Tableau 148 – Spécification du guide d'onde à fibre optique

Paramètre	Valeur
Diamètre de cœur	(200 ± 8) µm
Diamètre de gaine	(230 ± 10) µm
Non-circularité de la gaine	≤ 6 %
Ouverture numérique	0,40 ± 0,04
Profil d'indice (de réfraction)	Saut d'indice
Largeur de bande à 650 nm	≥ 17 MHz × km
Affaiblissement à 650 nm	≤ 10 dB/km

28.6.3.3 Monofibre

Une monofibre d'un câble à fibre optique en silice gainée de plastique pour une MAU à fibre optique doit être conforme aux exigences suivantes du Tableau 149.

Tableau 149 – Spécification d'une monofibre

Paramètre	Valeur
Matelas protecteur	Matériau FRNC (retardateur de flammes et non corrosif)
Couleur de matelas protecteur	Rouge ou verte
Diamètre extérieur	2,2 mm ou 2,9 mm
Rayon minimal de courbure à long terme	30 mm

28.6.3.4 Gaine de câble et propriétés mécaniques du câble

Il convient que la gaine d'un câble à fibre optique de silice gainée de plastique pour une MAU à fibre optique soit conforme aux exigences suivantes du Tableau 150.

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Tableau 150 – Spécification de la gaine de câble et propriétés mécaniques du câble

Paramètre	Valeur
Couleur de gaine	Rouge
Eléments serre-câbles	non-métalliques
Marquage	Longueur de déploiement (m); date de production
Plage de températures (en fonctionnement)	–20 °C à +70 °C
Rayon minimal de courbure à long terme	≤ 50 mm
Résistance maximale à la traction à long terme	≥ 200 N
Pression latérale maximale à long terme	≥ 100 N/cm

28.6.3.5 Propriétés du matériau du câble

Il convient que le câble à fibre optique de silice gainée de plastique pour une MAU à fibre optique ait d'autres propriétés supplémentaires de matériaux données dans le Tableau 147.

28.6.4 Fibre d'essai normalisée

Le câble utilisé pour les essais d’appareils de réseau avec une MAU à fibre optique, destiné à vérifier la conformité aux exigences de l’Article 28, doit être un câble ayant un ou plusieurs guides d'onde à fibre optique dont les caractéristiques sont présentées dans le Tableau 151.

Tableau 151 – Spécification de la fibre d'essai normalisée pour une MAU à fibre optique

Paramètre	Fibre optique polymère (fibre 980/1 000 μm)	Fibre de silice gainée de plastique (fibre 200/230 μm)
Longueur	1 m	1 m
Diamètre de cœur	(980 ± 60) μm	(200 ± 8) μm
Diamètre de gaine	(1 000 ± 60) μm	(230 ± 10) μm
Non-circularité de la gaine	≤ 6 %	≤ 6 %
Ouverture numérique	0,47 ± 0,03	0,40 ± 0,04
Largeur de bande à 660 nm	≥ 10 MHz × 100 m	≥ 17 MHz × 1 km
Affaiblissement à 660 nm (monochromatique)	≤ 160 dB/km	≤ 10 dB/km
Diamètre du matelas protecteur	2,2 mm	2,9 mm
Affaiblissement d'insertion (voir la note)	1,5 dB à 2,0 dB	1,0 dB à 1,5 dB
NOTE Mesuré conformément à la CEI 61300-3-4 (procédure B).		

29 Type 12: Unité de liaison au support: support électrique

29.1 Caractéristiques électriques

Cette spécification de MAU décrit une transmission unidirectionnelle sur ligne symétrique via une paire de conducteurs correspondant à la norme TIA/EIA RS-644-A de l'ANSI. Un terminateur, placé à l'extrémité de réception du conducteur, permet à la PhL de prendre notamment en charge des vitesses de transmission plus élevées. Il convient que la longueur maximale du conducteur ne dépasse pas 20 m. La méthode de transmission proposée s'ajoute aux technologies de l'ISO/CEI 8802-3 connues sous la désignation 100BASE-TX et 100BASE-FX. Son principal objet est la connexion d’appareils dans une armoire de commande. Il assume ainsi une masse de signalisation commune.

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Le codage binaire Manchester est associé à la signalisation TIA/EIA-644-A de l'ANSI avec pour objectif des coupleurs de ligne à faible coût qui ne peuvent pas isoler la station de la ligne (isolation galvanique); un terminateur de ligne est requis (la valeur de résistance recommandée est de 100 Ω).

La topologie prise en charge est constituée d'une paire de conducteurs avec précisément un émetteur et un récepteur sur une paire unique.

Une connexion est constituée de deux paires de conducteurs qui relient précisément deux ETTD.

Le terme conducteur fait référence à un support pouvant transmettre des signaux conformément à la norme TIA/EIA-644-A de l'ANSI, sur la longueur spécifiée. Une déclaration de conformité du fabricant de l'appareil doit spécifier ces paramètres.

29.2 Spécifications du support

29.2.1 Connecteur

Aucun connecteur n'est spécifié pour ce support. Une déclaration de conformité du fabricant de l'appareil doit spécifier les capacités de connexion.

29.2.2 Fil

Le support est une paire de conducteurs. Le blindage peut être utilisé pour améliorer la compatibilité électromagnétique (CEM). Des conducteurs non blindés peuvent être utilisés en l'absence de perturbations électromagnétiques (EMI) sévères.

Il convient que l'impédance caractéristique Z_O de la paire de conducteurs se situe dans une plage comprise entre 80 et 120 Ω et il convient que la capacité du câble (entre conducteurs) soit inférieure à 60 pF/m. Il convient que les critères de choix des conducteurs reposent sur les lignes directrices de mise en œuvre de la norme TIA/EIA-644-A de l'ANSI, notamment pour le fond de panier et l'interconnexion des cartes de circuit imprimé.

NOTE En supposant une tension de sortie en mode commun d'environ 1,2 V, il est possible de modéliser la résistance de sortie par deux résistances en série de 50 Ω dont la prise centrale est réglée à 1,2 V. Ceci donne une correspondance avec une impédance caractéristique d'une trace de carte de circuit imprimé type (Z_O) de 50 Ω et réduit les réflexions.

Il convient que la paire de conducteurs soit de conception symétrique (conducteurs de même longueur, étroitement corrélés et ayant une distance identique par rapport au signal de masse). Deux paires de conducteurs doivent avoir la même longueur. Une dérive inférieure à 2 ns est acceptable.

29.3 Méthode de transmission

29.3.1 Codage binaire

Les données codées Manchester en provenance de la DLL sont transmises par l'intermédiaire d'une paire de conducteurs. Un binaire "1" (N+ ou première moitié du DL_symbol = “UN” ou seconde moitié du DL_symbol = “ZERO”) est représenté par une valeur constante de tension différentielle positive sur TxS/RxS et un binaire "0" (N- ou première moitié du DL_symbol = "ZERO" or ou seconde moitié du DL_symbol = “UN”) par une valeur constante de tension différentielle négative sur TxS/RxS.

29.3.2 Représentation des signaux dans la norme TIA/EIA-644-A de l'ANSI

TxS sera représenté par OUT+ et OUT- selon les termes de la norme TIA/EIA-644-A de l'ANSI. Au niveau de la norme TIA/EIA-644-A de l'ANSI, les entrées RxS seront désignées IN+ et IN-.

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NOTE Si l'on suppose un courant de sortie de 3,5 mA et une tension en mode commun d'environ 1,2 V, la différence de tension nominale entre OUT+ et OUT- est de 350 mV (dans une plage comprise entre 247 mV et 454 mV). Une tension différentielle de 100 mV est nécessaire pour détecter un signal.

30 Type 16: Unité de liaison au support: support à fibre optique de 2, 4, 8 et 16 Mbit/s

30.1 Structure des lignes de transmission

La structure de la ligne de transmission optique est illustrée à la Figure 126.

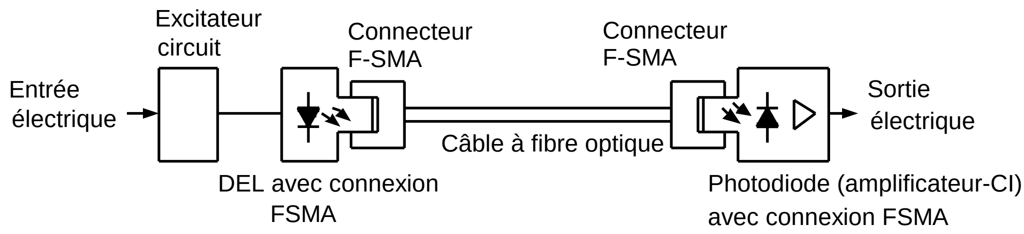

Figure 126 – Ligne de transmission optique

Le circuit d'attaque de la DEL émettrice doit être activé par une impulsion électrique. La DEL à haute performance (émetteur) doit émettre une lumière d'une longueur d'onde de 650 nm. La puissance de transmission doit être modifiable entre “faible affaiblissement” et “affaiblissement élevé”, au moyen d'un commutateur manuel.

Le câble à fibre optique doit être réalisé en matière plastique ou en verre (silice) et avoir un profil à saut d'indice ou à gradient d'indice. Les câbles à fibre optique et les cœurs peuvent être utilisés en fonction de l'application. L'affaiblissement qui a lieu sur la ligne de transmission est dû au câble à fibre optique et éventuellement à d'autres couplages. Ces couplages supplémentaires peuvent devenir nécessaires lorsqu'il s'agit par exemple de passer à travers un mur. Les facteurs qui contribuent à l'affaiblissement sur la ligne de transmission sont expliqués de manière plus détaillée à l'Article O.2.

NOTE En ce qui concerne les matériaux de fibre optique actuellement utilisés, l'affaiblissement est d'environ 220 dB/km pour le plastique et 6 dB/km pour le verre.

La composante récepteur doit être composée d'une photodiode et d'un circuit d'amplificateur intégré.

Il doit être possible d'inverser le signal lors du passage par un esclave (c’est-à-dire, un signal “lumière active” à l'entrée optique de l'esclave ne doit pas nécessairement donner lieu à un signal “lumière active” à la sortie optique).

30.2 Caractéristiques de durée de la transmission binaire

30.2.1 Introduction

La distance entre les fronts montant et descendant du signal optique est spécifiée au 30.2. Un front est une variation de niveau entre les niveaux optiques faibles et les niveaux optiques élevés. La spécification est fondée sur une enveloppe qui a été définie pour le signal optique. Tout signal optique de sortie d'un émetteur doit, à tout moment, demeurer dans cette enveloppe spécifique.

En outre, les caractéristiques de traitement entre l'entrée optique et la sortie optique de l'esclave sont spécifiées. Un esclave doit être synchronisé sur l'horloge de transmission du train binaire arrivant dans son entrée optique. Bien que l'horloge de transmission d'un esclave puisse être différente de l'horloge à son entrée pendant une courte durée, il est nécessaire que l'esclave soit synchronisé sur l'horloge prédéterminée (par exemple au moyen de la

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boucle à verrouillage de phase). De ce fait, il est exigé par définition que tous les terminaux reliés au réseau émettent la même impulsion moyenne d'horloge de transmission. En d'autres termes, tous les terminaux doivent utiliser l'impulsion de l'horloge de transmission du maître.

L'esclave doit être synchronisé sur l'horloge de transmission au niveau de son entrée optique par des fronts des signaux “lumière active” (fronts montants).

30.2.2 Maître et esclave en mode d'essai

30.2.2.1 Introduction

Le Paragraphe 30.2.2 spécifie les caractéristiques de traitement à la sortie optique du maître, alors que le maître fonctionne en mode normal et en mode d'essai.

Il doit être possible d'activer le mode d'essai de l'extérieur par des moyens spéciaux (par exemple en appuyant sur une touche). Le maître et l'esclave doivent être pouvoir émettre un signal lumineux continu, ainsi qu'un train binaire de zéro à la sortie optique, sans la présence d'un signal d'entrée.

30.2.2.2 Mode d'essai de signal lumineux continu

Un signal lumineux continu implique un état logique haut sans variation de niveau à la sortie optique. Ce mode est uniquement requis pour le maître. L'esclave peut générer un signal lumineux continu, selon qu'un signal lumineux continu arrive ou non à l'entrée optique. Du fait de sa fonction de répéteur, l'esclave doit pouvoir renvoyer à sa sortie optique la lumière qu'il reçoit (ou l'absence de lumière) au niveau de son entrée optique.

L'inversion du signal optique par l'esclave doit être possible.

30.2.2.3 Mode d'essai de train binaire de zéro

Le mode d'essai de train binaire de zéro implique que l'émetteur doit transmettre des zéros consécutifs qui, fondés sur le code NRZI, donnent lieu à des variations continues de niveau dans la configuration de signaux de l'horloge de transmission (on aboutit ainsi à un signal de 1 MHz pour un débit de données de 2 Mbit/s). Un esclave doit utiliser son horloge interne pour synchroniser l'horloge de transmission à son signal de sortie optique. Aucun réglage de l’horloge ne peut être effectué au niveau de la sortie optique (par exemple en raison de la boucle à verrouillage de phase, $\rightarrow t_{cad}$) et seule une instabilité du signal optique répartie de manière statistique peut être tolérée. Cette exigence est importante car elle permet au système d'isoler et de séparer le bruit lié à l'instabilité du signal ($\rightarrow J_{noise}$) résultant d'éventuels ajustements de l’horloge dus à la boucle à verrouillage de phase ($\rightarrow t_{cad}$); cette exigence sera discutée ultérieurement dans le texte. L'écart de forme des courbes des signaux optiques générés lorsque le système se trouve en mode d'essai de train binaire de zéro, par rapport aux courbes de signaux générés en fonctionnement normal, n'est pas admis au voisinage des fronts montant et descendant (par exemple des temps de montée et de descente différents, des amplitudes excessives différentes pendant le mode d'essai). De manière plus spécifique, on doit utiliser, en mode d'essai de train binaire de zéro, le même circuit d'attaque que celui qui est utilisé en mode normal.

Les paramètres suivants doivent être utilisés pour spécifier le signal optique de sortie du maître et de l'esclave (voir la Figure 127 et la Figure 128):

t_r: Il s'agit de la temporisation entre les points 1 et 2 (= 1-1' ou 2-2'). Il doit correspondre à la limite supérieure du temps requis pour que le signal optique passe de P_{TmaxL} à P_{TminH} sur le front montant. Ce temps ne correspond pas au temps de croissance de l'émetteur dont la fiche technique indique qu'il est compris entre 10 % et 90 % du signal optique.

t_f: Il s'agit de la temporisation entre les points 3 et 4 (= 3-3' ou 4-4'). Il doit correspondre à la limite supérieure du temps requis pour que le signal optique passe de P_{TminH} à P_{TmaxL} sur le

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front descendant. Ce temps ne correspond pas au temps de décroissance de l'émetteur dont la fiche technique indique qu'il est compris entre 10 % et 90 % du signal optique.

NOTE Voir la remarque ci-dessous concernant t_r et t_f.

t_{os}: Ce paramètre indique la durée pendant laquelle la puissance de transmission optique maximale peut être dépassée dynamiquement. Cet intervalle de temps doit commencer à l'instant ① (voir la Figure 127).

t_{BIT}: Il s'agit de la moyenne arithmétique (mesurée sur plusieurs secondes) de la période d'horloge de transmission (durée d'un bit élémentaire) par le maître (qui n'est pas en mode d'essai) et elle doit correspondre à la valeur inverse du débit de données. La durée nominale doit être décrite par t_{BITnom}. t_{BIT} doit être mesurée entre fronts du même sens (= 2 $\times t_{BIT}$) à des niveaux de puissance optique de $0{,}5 \times P_{TminH} \pm$ 20 %. t_{BIT} doit être considérée comme constante dans le domaine des secondes. Seules des fluctuations dues au bruit peuvent être admises. Une durée de mesure relativement longue de t_{BIT} garantit un effet négligeable des écarts à court terme de retards entre fronts (instabilité $\rightarrow J_{noise}$). De ce fait t_{BIT} doit décrire la durée entre les points 1 et 3 ainsi que la durée entre les points 3 et 5 (qui doit correspondre au point 1 de la période suivante) (voir la Figure 127).

$t_{BITtest}$: Il s'agit de la moyenne arithmétique (mesurée sur plusieurs secondes) de la période d'horloge de transmission (durée d'un bit élémentaire) du maître ou de l'esclave en mode d'essai de train binaire de zéro. Toutes les mesures et propriétés de $t_{BITtest}$ doivent correspondre à t_{BIT}.

J_{noise}: Ce paramètre décrit l'instabilité du signal optique. Il doit exprimer l'écart purement statistique de la distance entre les deux fronts, en comparaison avec la valeur de $t_{BITtest}$ mesurée sur un intervalle de temps long. J_{noise} doit être obtenu en superposant les signaux de plusieurs périodes (par exemple sur un oscilloscope) de sorte qu'ils arrivent ensemble à un seul niveau de puissance optique (par exemple, P_{TmaxL} sur le front montant ou descendant). L'instabilité du signal optique est ensuite déterminée par la largeur des signaux optiques superposés (ce qui donne une valeur temporelle). Cette largeur ne doit pas dépasser la valeur J_{noise} dans la zone de puissance entre P_{TmaxL} et P_{TminH} et inversement. Cette définition limite l'instabilité des signaux optiques et de ce fait que les formes des courbes de signaux doivent être reproductibles dans la zone de puissance entre P_{TmaxL} et P_{TminH}, et inversement.

Les temps t_r et t_f ne sont pas pleinement disponibles en tant que temps de croissance et de décroissance. En raison du caractère non symétrique du cycle de MARCHE/ARRET (ON/OFF) du circuit d'attaque (cycle de service, délai de propagation), le front descendant peut être temporellement déphasé par rapport au front montant, ce qui donne une différence résiduelle pour $t_{BITtest}$. Dans ce cas, le high-level peut être prolongé d'un intervalle de temps donné et le low-level peut être écourté du même intervalle de temps. Cet intervalle de prolongation/réduction n'est pas considéré faire partie de l'intervalle de temps de croissance et de décroissance. Le signal, auquel s'ajoute J_{noise}, doit en outre s'inscrire totalement dans l'enveloppe; en d'autres termes, l'instabilité doit être prise en compte pour les durées t_r et t_f.

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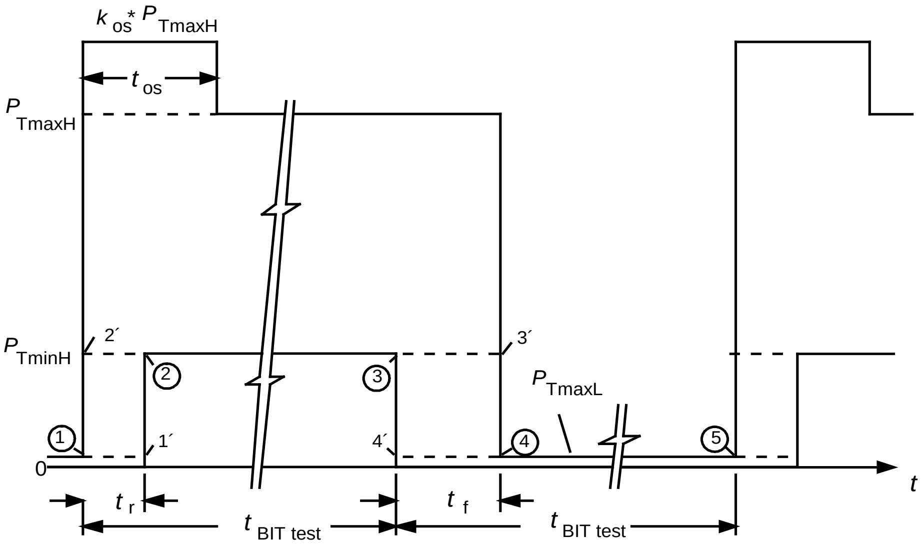

Figure 127 – Enveloppe de signal optique

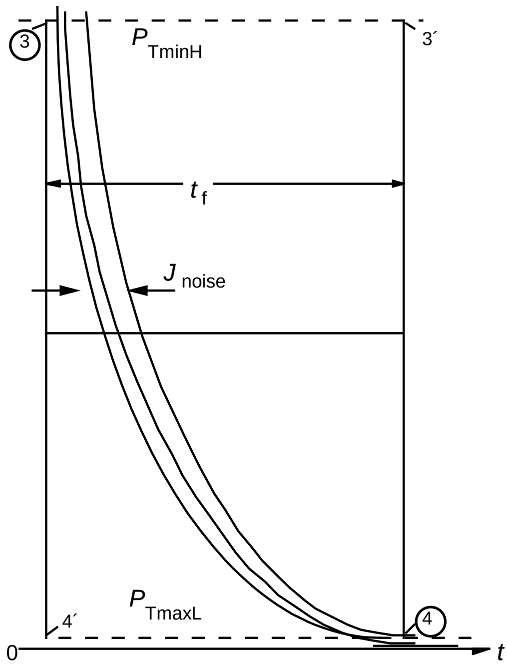

Figure 128 –Affichage de l'instabilité (J_{noise})

30.2.3 Débit de données

Le débit de données est le débit en bauds mesuré à la sortie optique du maître. Sa valeur nominale doit être 2 Mbit/s, 4 Mbit/s, 8 Mbit/s ou 16 Mbit/s. La valeur mesurée peut dévier de ±0,01 %. Le débit de données est une moyenne temporelle mesurée sur plusieurs secondes. Les performances à court terme (domaine des nanosecondes) peuvent légèrement fluctuer et sont spécifiées par l'intermédiaire de J_{noise} (voir le Tableau 153).

Le Tableau 152 spécifie les débits de données qui doivent être pris en charge par le Type 16 et la manière dont le débit en bauds doit être choisi, pour les deux classes de performance désignées CP16/1 et CP16/2.

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Tableau 152 – Prise en charge de la vitesse de transmission

Classe de performance	CP16/1	CP16/2
2 Mbit/s	Obligatoire	Obligatoire
4 Mbit/s	Facultatif	Facultatif
8 Mbit/s	Non	Facultatif
16 Mbit/s	Non	Facultatif
Débit en bauds	Réglage manuel (par exemple un commutateur)	Réglage manuel (par exemple un commutateur), ou reconnaissance automatique du débit en bauds

Tableau 153 – Paramètres des données de transmission

Vitesse de transmission (débit de données)	Temps binaires			
	2 Mbit/s ± 0,2 kbit/s	4 Mbit/s ± 0,4 kbit/s	8 Mbit/s ± 0,8 kbit/s	16 Mbit/s ± 1,6 kbit/s
t_{BIT} [ns]	500 ± 0,05	250 ± 0,025	125 ± 0,012 5	62,5 ± 0,006 25
t_{BITnom} [ns]	500	250	125	62,5
$t_{BITtest}$ [ns]	500 ± 0,05	250 ± 0,025	125 ± 0,012 5	62,5 ± 0,006 25
Fréquence de données (max.)	1 MHz	2 MHz	4 MHz	8 MHz
Durées pour les formes de courbes				
t_{os} [ns]	200	100	50	25
t_r [ns]	100	40	20	10
t_f [ns]	150	110	25	15
Instabilité [ns]	$0 \leq J_{noise} \leq 10$	$0 \leq J_{noise} \leq 10$	$0 \leq J_{noise} \leq 5$	$0 \leq J_{noise} \leq 5$

30.2.4 Caractéristiques d'entrée-sortie de l'esclave

30.2.4.1 Généralités

Le Paragraphe 30.2.4 spécifie les caractéristiques d'entrée-sortie de synchronisation de l'esclave. Un esclave doit recevoir, à son entrée optique, un signal avec une horloge donnée. La valeur moyenne de cette horloge est égale à l'horloge de transmission du maître. A long terme, un esclave doit être synchronisé sur cette horloge (en évaluant l'un des fronts montants ou descendants).

L'esclave doit générer sa propre horloge locale. Cette horloge locale doit être utilisée pour recevoir et émettre des données. L'horloge locale d'un esclave doit s'exécuter librement entre les fronts de synchronisation du train binaire entrant. Pendant la synchronisation, l'esclave doit procéder au réglage des phases de l'horloge locale (boucle à verrouillage de phase). Ces caractéristiques fonctionnelles peuvent être observées à la sortie optique parce que la durée du high-level ou bas est raccourcie ou allongée par rapport à la durée binaire moyenne (t_{BIT}). La durée de raccourcissement ou d'allongement doit être appelée temps de réglage de l'horloge t_{cad}.

Le temps de réglage de l'horloge ne doit pas dépasser une valeur spécifique (t_{cadmax}). En outre, le temps maximal de réglage de l'horloge utilisé ($t_{cadreal}$) de chaque esclave doit être spécifié par le fabricant (par exemple t_{BIT}/16).

Le signal optique doit passer par la gamme P_{TmaxL} – P_{TminH} de l'enveloppe, et inversement, toujours dans la même position (en tenant compte de J_{noise}). L'enveloppe peut être décalée

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sur le signal optique (en raison des temps courts de croissance et de décroissance), mais cet éventuel décalage ne doit pas être considéré comme un “surcroît” de réglage de l'horloge.

Un esclave doit pouvoir recevoir correctement des signaux si son temps de réglage d'horloge est inférieur ou égal au temps maximal de réglage de l'horloge, $t_{cadreal}$, utilisé dans cet esclave. Si les esclaves se trouvent physiquement dans l'anneau dans une séquence ascendante $t_{cadreal}$, le système doit s'assurer que des conditions de réception correctes sont établies pour tous les esclaves. Le récepteur du maître, qui constitue le dernier élément de l'anneau, doit pouvoir traiter le temps de réglage maximal admissible de l'horloge t_{cadmax}.

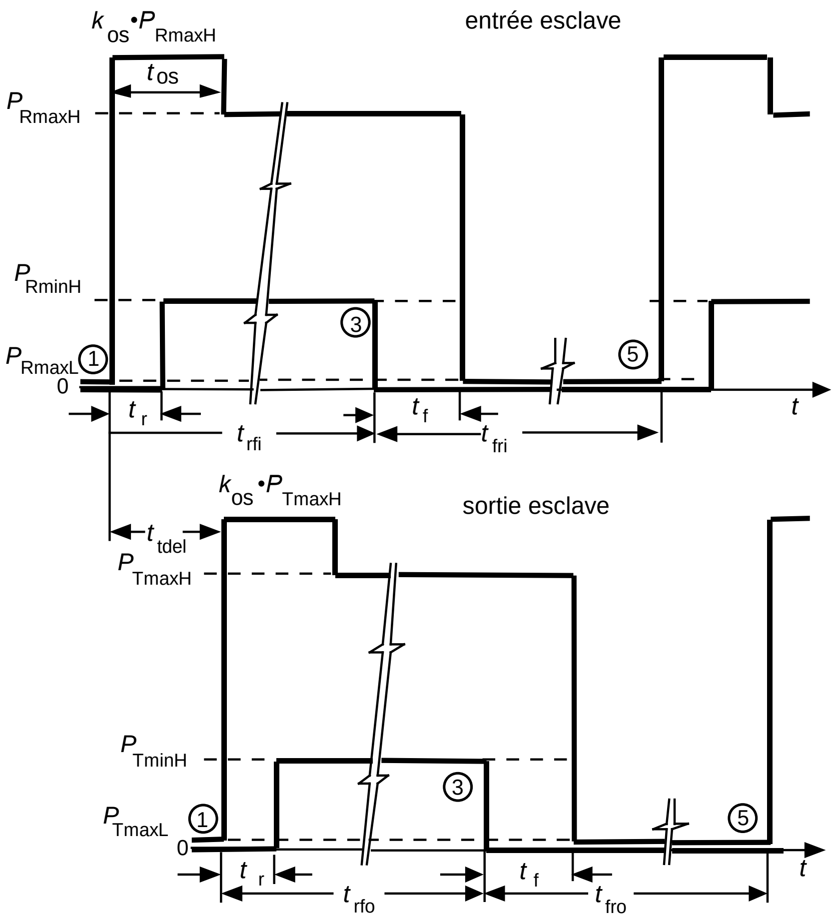

Figure 129 – Caractéristiques d'entrée/sortie d'un esclave

Outre le temps de réglage de l’horloge décrit précédemment, il doit être spécifié un temps minimal de réglage de l’horloge (t_{cadmin}). Chaque esclave doit pouvoir traiter des données si l'horloge a été réglée par t_{cadmin} à son entrée. Les caractéristiques d'entrée et de sortie d'un esclave sont spécifiées par les paramètres suivants.

t_{rfi}: il s'agit du temps entre les points 1 et 3 de la Figure 129, sur l'entrée du récepteur.

t_{fri}: il s'agit du temps entre les points 3 et 5 de la Figure 129, sur l'entrée du récepteur.

$t_{cadreal}$: Il s'agit du temps maximal de réglage de l’horloge (raccourcissement ou allongement d'un niveau) qu'un esclave génère à sa sortie optique. Cette valeur doit être spécifiée par le fabricant. L'esclave doit aussi pouvoir traiter correctement ce temps maximal de réglage de l’horloge à son entrée, dans les limites acceptables du taux spécifié d'erreurs sur les bits.

t_{cadmin}: il s'agit du temps de réglage minimal de l’horloge qu'un esclave doit pouvoir traiter correctement, dans les limites acceptables du taux spécifié d'erreurs sur les bits.

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t_{cadmax}: il s'agit de la limite supérieure pour $t_{cadreal}$; elle décrit également le temps maximal de réglage de l'horloge que le maître doit pouvoir traiter correctement dans les limites acceptables du taux spécifié d'erreurs sur les bits.

t_{rfo}: il s'agit du temps entre les points 1 et 3 de la Figure 129, à la sortie de l'émetteur.

t_{fro}: il s'agit du temps entre les points 3 et 5 de la Figure 129, à la sortie de l'émetteur.

t_{del}: il s'agit du retard de l'enveloppe entre l'entrée et la sortie optiques, mesuré au niveau de l'esclave (voir la Figure 129). Ce paramètre décrit le retard du signal optique (temps d'exécution) à travers un esclave en mode répéteur (voir également le Tableau 158). Le retard doit être mesuré entre le front "lumière active" à l'entrée optique et le front correspondant du signal lumineux à la sortie optique (pour des esclaves sans inversion de signal, il s'agit du front "lumière active"; pour les esclaves à inversion, il s'agit du front du signal "lumière inactive").

t_{del}-optique: retard maximal dans les éléments électro-optiques du récepteur et de l'émetteur.

t_{del}-électrique: retard maximal d'acheminement du signal électrique à travers l'esclave (en utilisant par exemple un ASIC).

Un récepteur doit disposer d'un signal d'entrée tel que défini par les cas a) ou b) du Tableau 154. Le passage entre les cas a) et b) n'est pas admis. Ainsi, le temps de réglage de l'horloge écourtera ou allongera uniquement le high-level ou uniquement le niveau bas.

Tableau 154 – Signaux d'entrée possibles de l'esclave

Cas	t_{rfi}	T_{fri}
a)	$i \times t_{BIT} - t_{cadreal} \leq t_{rfi} \leq i \times t_{BIT} + t_{cadreal}$	$j \times t_{BIT}$
b)	$i \times t_{BIT}$	$j \times t_{BIT} - t_{cadreal} \leq t_{rfi} \leq j \times t_{BIT} + t_{cadreal}$

NOTE 1 i et j sont des chiffres ordinaires; i ne correspond pas à la séquence de réseaux donnée dans les abréviations.

NOTE 2 En fonctionnement normal, i = 1 à 8 et j = 1 à 8, de sorte que I + j = 2 à 16. Lors du passage d'un télégramme à un signal de remplissage et inversement, i = 1 à 12 et j = 1 à 12, mais I + j = 2 à 20.

L'esclave doit pouvoir effectuer les tâches suivantes au moyen de ces signaux d'entrée spécifiques:

a) recevoir et traiter correctement des données, dans les limites acceptables du taux d'erreurs sur les bits;
b) générer des signaux de sortie valides.

Des signaux de sortie valides doivent avoir une synchronisation de signal conforme aux limites spécifiées et être générés conformément au cas c) ou d) du Tableau 155. L'esclave doit pouvoir écourter ou d'allonger uniquement le high-level ou uniquement le low-level sur le réglage de l'horloge. Le passage de l'un à l'autre n'est pas admis.

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Tableau 155 – Signaux de sortie possibles de l'esclave

Cas	t_{rfo}	T_{fro}
c)	m × t_{BIT} – $t_{cadreal} \leq t_{rfo} \leq$ m × t_{BIT} + $t_{cadreal}$	n × t_{BIT}
d)	m × t_{BIT}	n × t_{BIT} – $t_{cadreal} \leq t_{rfo} \leq$ n × t_{BIT} + $t_{cadreal}$
NOTE m et n sont des chiffres ordinaires. Ils ne correspondent pas à ceux dont l'explication est donnée dans les abréviations.		

Quatre cas (présentés dans le Tableau 156) doivent être distingués pour les valeurs admissibles de m et n:

Tableau 156 – Signaux de sortie valides de l'esclave

Etat / esclave	Esclave sans inversion de signal		Esclave avec inversion de signal	
Répéteur	**i = m; j = n**		**i = n; j = m**	
L'esclave transmet son propre télégramme	Fonctionnement normal i, j = 8 m, n= 1 .. 8 m + n = 2 .. 16	Lors d'une commutation entre signal de remplissage et télégramme (1 .. 12) (2 .. 20)	Fonctionnement normal i, j = 8 m, n= 1 .. 8 m + n = 2 .. 16	Lors d'une commutation entre signal de remplissage et télégramme (1 .. 12) (2 .. 20)
NOTE Les nombres entre parenthèses représentent des valeurs pouvant apparaître lors d'une commutation entre signal de remplissage et télégramme.				

30.2.4.2 Réglage d'horloge

Les valeurs limites de temps de réglage de l'horloge sont spécifiées dans le Tableau 157.

Tableau 157 – Spécifications des temps de réglage de l'horloge

Temps	Valeur
T_{cadmin}	= t_{BITnom} / 64
T_{cadmax}	= t_{BITnom} / 11
$T_{cadreal}$	$0 \leq t_{cadreal} \leq t_{cadmax}$

30.2.4.3 Retard de signal dû à l'esclave

Le retard de signal dû à l'esclave (en mode répéteur) est spécifié comme dans le Tableau 158.

Tableau 158 – Retard du signal optique dans un esclave

Débit en bauds	t_{del}-max	t_{del}-électrique	t_{del}-optique:
2 Mbit/s	750 ns	400 ns	350 ns
4 Mbit/s	375 ns	200 ns	175 ns
8 Mbit/s	250 ns	100 ns	150 ns
16 Mbit/s	200 ns	50 ns	150 ns

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30.2.5 Forme d'onde idéale

La forme d'onde idéale est caractérisée par des changements d'état du signal optique. Le signal optique est remplacé par des ondes rectangulaires d'égale hauteur et à temps de croissance et de décroissance infiniment courts. Le changement d'état (front) de la forme d'onde idéale (rectangle) est défini à la sortie de l'émetteur comme l'instant où la puissance optique est 0,5 × P_{TminH} ± 20 %. Les deux niveaux de seuil (faible affaiblissement et affaiblissement élevé) doivent toujours s'inscrire dans l'intervalle P_{TmaxL} et P_{TminH}.

Tous les temps ultérieurs doivent être mesurés entre les zones de changement d'état définies ci-dessus.

30.3 Connexion à la fibre optique

30.3.1 Introduction

Le Paragraphe 30.3 décrit de manière détaillée les connexions du maître et de l'esclave à la fibre optique ainsi que leur interaction.

Le Tableau 159 présente l'ensemble des fonctions de base qui doivent être réalisées par une connexion.

Tableau 159 – Fonctions de base de la connexion

Fonction à exécuter par →		Maître	Esclave
1	Récupérer l'horloge à partir du signal reçu	x	X
2	Régénérer et transmettre le signal reçu		X
3	Transmettre 0111 1111 comme signal de remplissage	x	
4	Transmettre son propre télégramme	x	X
5	Assurer une transition à correction de phase et exempte de pointes d'impulsion entre numéros	4 → 3 3 → 4	4 → 2 2 → 4

30.3.2 Connexion du maître

30.3.2.1 Fonction

La Figure 130 illustre les fonctions dont doit disposer une connexion de maître.

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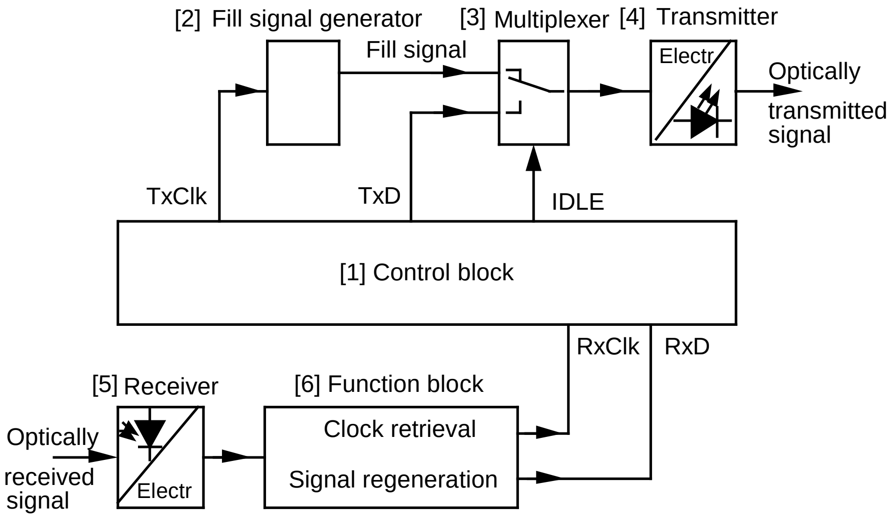

Légende

Anglais	Français
[2] Fill signal generator	[2] Générateur de signaux de remplissage
[3] Multiplexer	[3] Multiplexeur
[4] Transmitter	[4] Emetteur
Fill signal	Signal de remplissage
Electr	Electr.
Optically transmitted signal	Signal émis par voie optique
Idle	Repos
[1] Control Block	[1] Bloc de commande
[5] Receiver	[5] Récepteur
[6] Function block	[6] Bloc de fonction
Optically received signal	Signal reçu par voie optique
Clock retrieval	Récupération de l'horloge
Signal regeneration	Régénération du signal

Figure 130 – Fonctions de connexion d'un maître

Le bloc de commande – [1] à la Figure 130 – doit construire des télégrammes à envoyer conformément à la Figure 130 et les convertir en un signal codé NRZI. Lors de la réception d'un télégramme, le bloc de commande du maître doit reconnaître le télégramme codé NRZI et régénéré en message destiné au maître, en se fondant sur ses délimiteurs de télégramme et sur le champ d'adresse. En outre, le bloc de commande [1] doit vérifier le télégramme et ne transmettre que des champs de données corrects à l'unité de traitement des signaux.

A l'exception du codage/décodage NRZI et de la génération/identification des délimiteurs de télégramme, les fonctions ci-dessus seront discutées ultérieurement avec des couches de protocoles supérieures.

30.3.2.2 Génération d'un signal de remplissage

Conformément à la Figure 130, le bloc de commande [1] doit générer l'horloge de transmission (TxClk) pour le maître. Celle-ci doit être envoyée au générateur de signaux de remplissage – [2] dans la Figure 130– où le signal de remplissage est généré conformément à 9.10.2 et à la Figure 53.

Lorsque le maître est en train d'émettre le signal de remplissage (REPOS = 1), le signal doit atteindre le convertisseur électro-optique [4] en passant par le commutateur [3]. Le

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commutateur doit fonctionner de façon à ce qu'une modification du signal à sa sortie coïncide toujours avec le profil de l'horloge de transmission. De cette manière, les terminaux suivants peuvent utiliser des boucles à verrouillage de phase pour récupérer l'horloge. Ainsi, ils peuvent toujours être synchronisés sur l'horloge de transmission du maître.

Le bloc de fonction [6] sera discuté en 30.3.3.

30.3.2.3 Commutation entre signal de remplissage et délimiteurs de télégramme

Lors des transitions du signal de remplissage 0111 1111 aux délimiteurs de messages:

a) il doit être possible d'interrompre la chaîne binaire 0111 1111 en tout point;

b) il doit être possible d'insérer jusqu'à deux bits (de transition) arbitraires xx (par exemple pour simplifier la mise en œuvre).

Toutes les modifications des signaux générés de cette manière doivent cependant être synchronisées sur l'horloge de transmission.

La Figure 131 illustre quelques exemples de configurations de signaux de transmission valides au cours des transitions entre signal de remplissage en télégramme à envoyer, les bits occasionnellement insérés (de transition) étant grisés.

Comme le montre la Figure 131, il peut être généré des séquences binaires ayant plusieurs délimiteurs. Le récepteur doit pouvoir 'identifier le signal à double ligne mis en valeur comme le délimiteur de télégramme de tête.

Au cours de la transition des délimiteurs de télégrammes vers les signaux de remplissage, c'est-à-dire après la séquence binaire 01111110_B (délimiteur):

a) on peut insérer jusqu'à quatre bits arbitraires de transition;

b) suivis par une commutation vers un point arbitraire de la séquence binaire 0111 1111 (bits de remplissage).

Toutes les variations de signal générées doivent être synchronisées sur l'horloge de transmission. Figure 132 illustre quelques exemples. Les bits (de transition) occasionnellement insérés sont grisés. On peut voir apparaître plusieurs délimiteurs. Un récepteur doit pouvoir identifier le premier délimiteur comme un délimiteur d'encadrement de télégramme.

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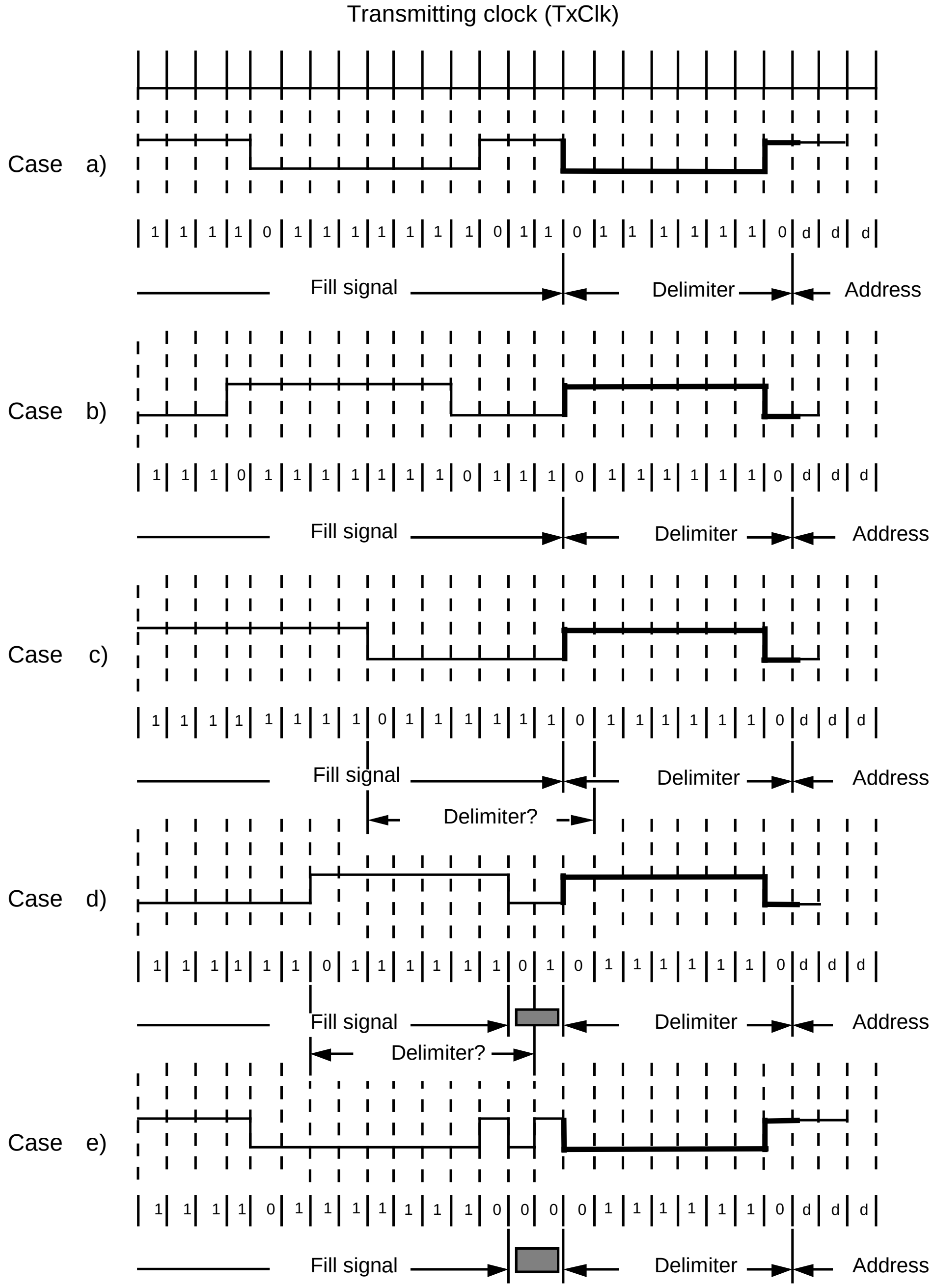

Légende

Anglais	Français
Transmitting clock (TxClk)	Horloge de transmission(TxClk)
Case	Cas
Delimiter	Délimiteur
Address	Adresse
Fill signal	Signal de remplissage

Figure 131 – Signaux de transmission valides pendant les transitions de signal de remplissage à délimiteurs de message

Dans la Figure 132, le cas e) est identifié par le fait que deux fronts successifs et de sens opposés doivent être séparés par un nombre maximal de 12 cycles d'horloge de transmission (t_{BIT}) et que deux fronts successifs de même sens doivent être séparés par un nombre maximal de 20 cycles d'horloge de transmission (t_{BIT}). Ceci est important pour le fonctionnement correct d'une DPLL.

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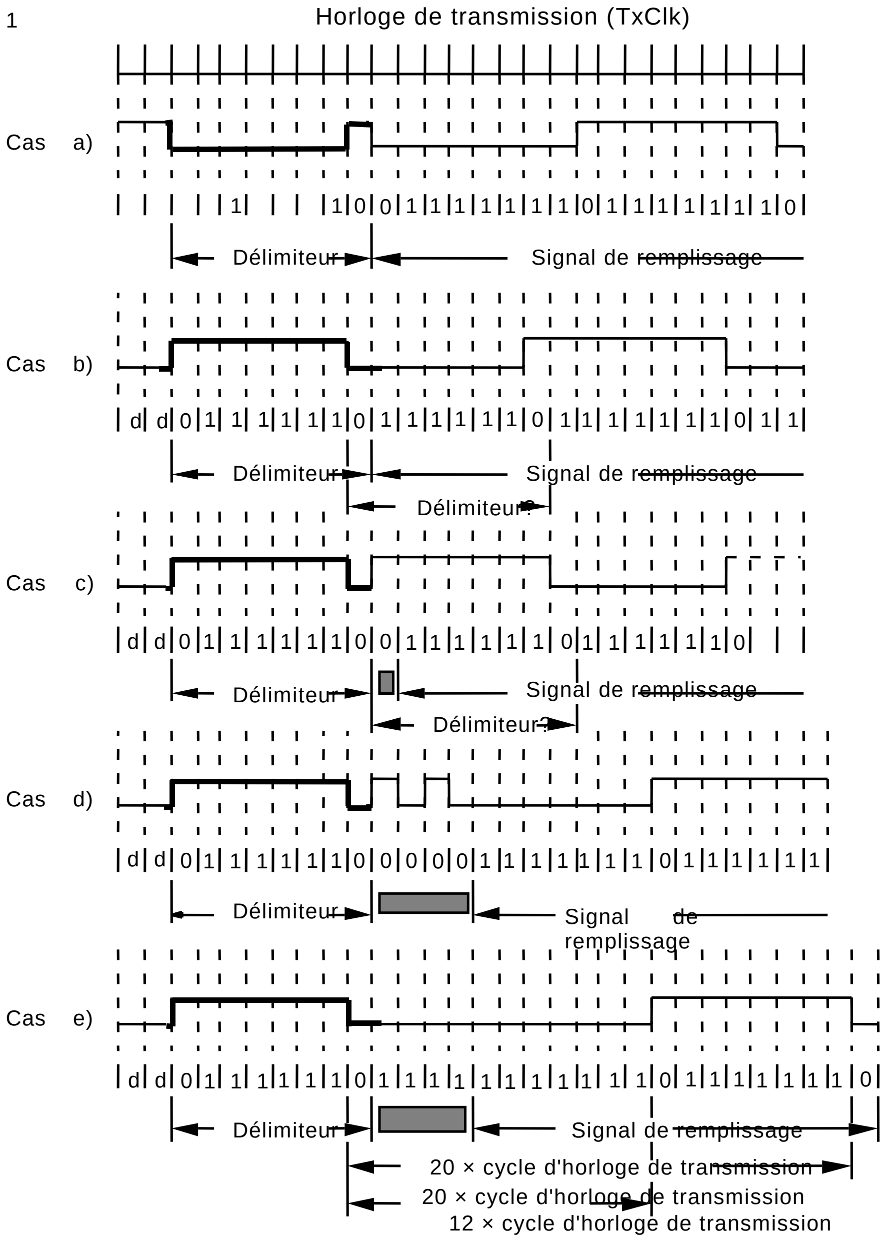

Figure 132 – Signaux de transmission valides pendant les transitions de délimiteurs de télégramme à signal de remplissage

30.3.3 Connexion de l'esclave

La Figure 133 illustre les fonctions dont doit disposer une connexion d'esclave.

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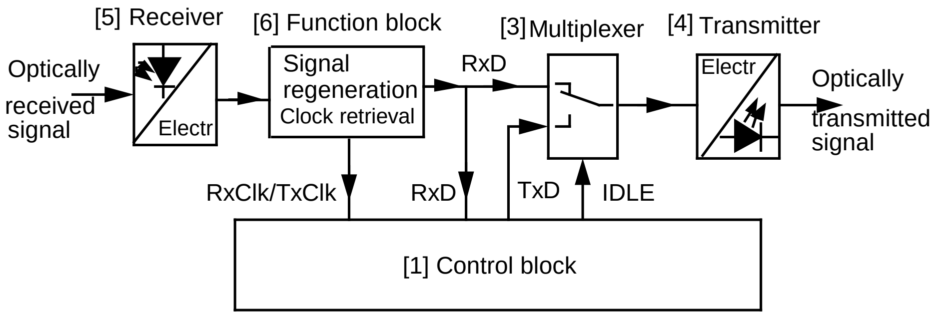

Légende

Anglais	Français
[1] Control Block	[1] Bloc de commande
[3] Multiplexer	[3] Multiplexeur
[4] Transmitter	[4] Emetteur
Electr	Electr
Optically transmitted signal	Signal émis par voie optique
Idle	Repos
[5] Receiver	[5] Récepteur
Optically received signal	Signal reçu par voie optique
[6] Function block	[6] Bloc de fonction
Clock retrieval	Récupération de l’horloge
Signal regeneration	Régénération du signal

Figure 133 – Fonctions de connexion d'un esclave

Le bloc de fonction [6] remplit les tâches suivantes:

a) Récupérer l'horloge du signal électrique reçu (récupération d'horloge, éventuellement avec la DPLL). L'horloge récupérée en [6] doit être utilisée comme horloge de transmission et de réception pour [1] (pour le maître, les horloges de transmission et de réception sont des signaux différents);

b) Régénérer le signal reçu, on doit s’assurer que toute variation du signal se produit en synchronisation avec l'horloge récupérée en a). S'il n'est pas nécessaire que l'esclave envoie son propre télégramme, le signal reçu et régénéré doit être émis (fonction de répéteur, REPOS =1).

Le multiplexeur [3] doit agir conformément aux paramètres de transition décrits en 30.3.2.3.

Alimentation:

Afin d'exécuter toutes les fonctions mentionnées ci-dessus, les composants électroniques doivent continuer à fonctionner (par exemple pendant le démarrage et le diagnostic), même si l'alimentation des appareils associés est coupée. Les esclaves doivent pouvoir au moins régénérer le flux de données et fonctionner en tant que répéteurs en transmettant les données.

30.3.4 Interactions des connexions

La Figure 134 illustre l'interaction de la connexion de deux esclaves sur un réseau. On suppose que l'esclave 1 est en train de transmettre un télégramme au maître. Le multiplexeur [3] dans le maître doit passer le signal de remplissage de sorte que le bloc de fonction [6] de l'esclave 1 puisse récupérer l'horloge. Le multiplexeur [3] de l'esclave 2 doit passer au maître le signal régénéré qu'il a reçu (c'est-à-dire, le télégramme de l'esclave 1). Le maître doit à son tour récupérer l'horloge du récepteur du signal reçu au moyen de son bloc de fonction [6].

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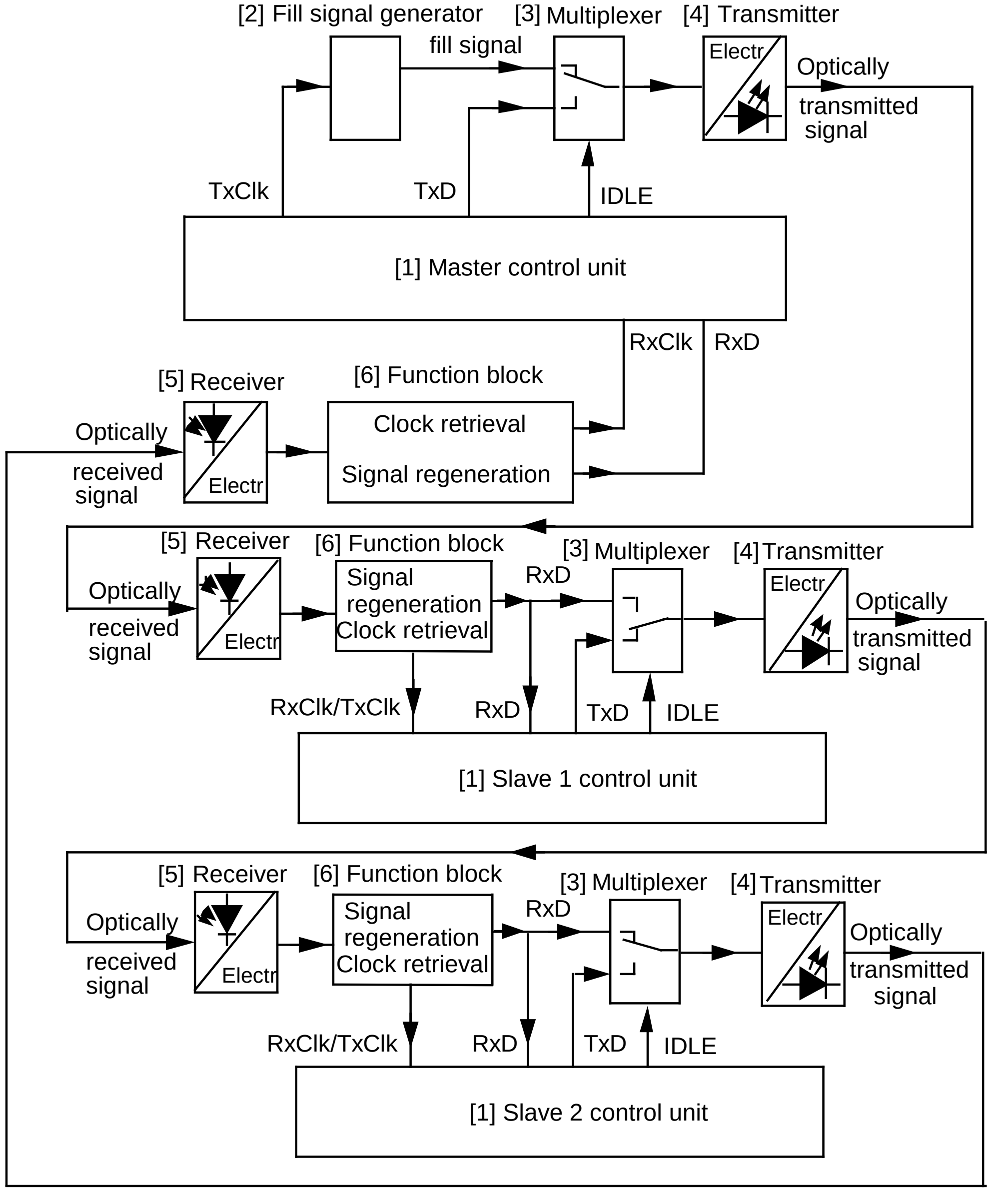
Les trois boucles à verrouillage de phase de la Figure 134 doivent être à tout moment synchronisées. Cette synchronisation doit toujours être maintenue, même si une transition [3] est activée. Lors de la commutation [3], il est important d'éviter tout front de signal non conforme à la configuration de l'horloge.



Légende

Anglais	Français
[2] Fill signal generator	[2] Générateur de signaux de remplissage
[3] Multiplexer	[3] Multiplexeur
[4] Transmitter	[4] Emetteur
Fill signal	Signal de remplissage
Electr	Electr
Optically transmitted signal	Signal émis par voie optique
Idle	Repos
[1] Master control unit	[1] Unité de commande Maître
[5] Receiver	[5] Récepteur
Optically received signal	Signal reçu par voie optique
Electr	Electr
[6] Function block	[6] Bloc de fonction

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Anglais	Français
Clock retrieval	Récupération de l’horloge
Signal regeneration	Régénération du signal
[1] Slave 1 control unit	[1] Unité de commande Esclave 1
[1] Slave 2 control unit	[1] Unité de commande Esclave 2

Figure 134 – Réseau avec deux esclaves

31 Type 18: Unité de liaison au support: support de base

31.1 Généralités

La PhL-B de Type 18 utilise une MAU conforme aux interconnexions multipoints par paire torsadée de l'ISO/CEI 8482, désignée par l'abréviation TPMI dans la suite de l'Article 31; il s'agit d'une variante de la TIA/EIA-485-A de l'ANSI.

Les exigences suivantes s'ajoutent à celles des TPMI:

- spécifications de codage du signal de données
- charge du signal de bus MAU
- exigences d'acheminement du signal
- spécifications des supports
  - descriptions des topologies
  - spécifications des câbles
  - spécifications des terminaisons de lignes de transmission
- connecteurs de câbles de dérivation et de point d'extrémité
- circuits d'interface recommandés

Le bus PhL-B de Type 18 résultant peut prendre en charge des débits binaires allant jusqu'à 10 Mbit/s et des distances de transmission allant jusqu'à 1,2 km.

NOTE Dans tout l'Article 31, le terme *station* désigne un appareil de réseau et il est utilisé pour assurer l'homogénéité avec la DLL et l'AL de Type 18 qui définissent divers types de stations.

31.2 Codage du signal de données

La PhL-B de Type 18 spécifie le codage de signaux de données en NRZI (non retour à zéro inversé) comme défini dans l'ISO/CEI 9314-1. En conséquence, une transition Marque-Espace ou une transition Espace-Marque représente un niveau logique un de la PhPDU; et une absence de transition (Marque-Marque ou Espace-Espace) représente un niveau logique zéro de la PhPDU.

31.3 Chargement du signal

La mise en œuvre d'un élément de communication de MAU de PhL-B de Type 18 exige l'utilisation d’appareils émetteurs-récepteurs qui ne doivent pas dépasser 0,5 charge unitaire (UL). Ainsi, le nombre maximal d’appareils connectés est de 64.

31.4 Exigences d'acheminement du signal

Le câblage minimal entre appareils communiquants est présenté à la Figure 135.

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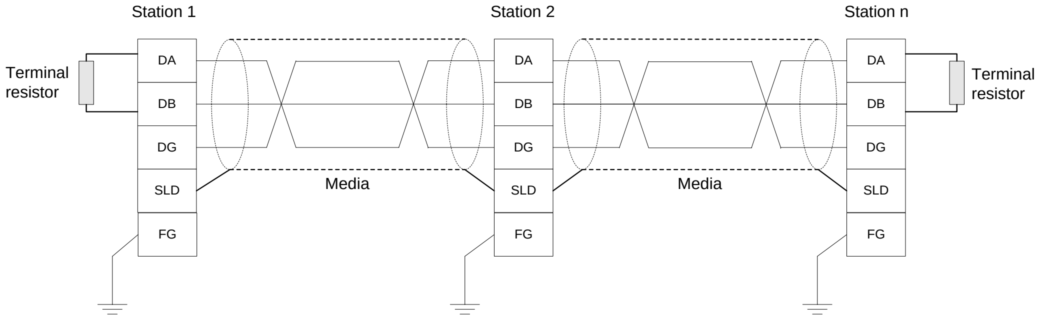


Légende

Anglais	Français
Terminal resistor	Résistance terminale
Media	Supports

Figure 135 – Câblage minimal d'interconnexion

Il est recommandé de connecter le blindage (SLD) à la masse de référence du bus de terrain (FG) aux deux extrémités du câble de ligne principale par l'intermédiaire de connexions à faible impédance (c'est-à-dire à faible inductance). Ceci est nécessaire pour obtenir une compatibilité électromagnétique raisonnable.

31.5 Supports

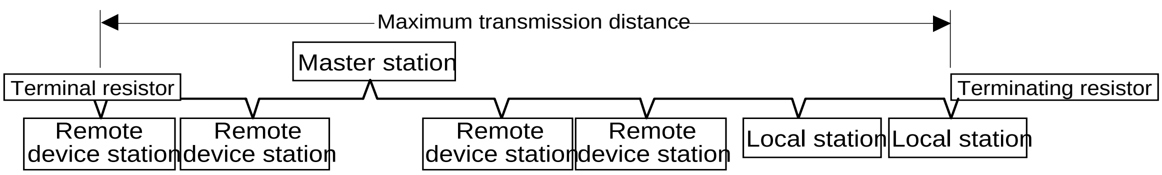
31.5.1 Généralités

Le support de chaque segment de bus (ligne principale) et de lignes secondaires (branchements) est un câble à paire torsadée blindé. Le blindage permet d'améliorer la compatibilité électromagnétique (CEM).

31.5.2 Topologie

31.5.2.1 Topologie de transfert

Un câble dédié est configuré avec un connecteur de type transfert pour chaque appareil, comme illustré à la Figure 136.



Légende

Anglais	Français
Maximum transmission distance	Distance maximale de transmission
Terminal resistor	Résistance terminale
Master station	Station maître
Terminating resistor	Résistance de terminaison
Remote device station	Station d’appareil distant
Local station	Station locale

Figure 136 – Topologie de câble dédiée

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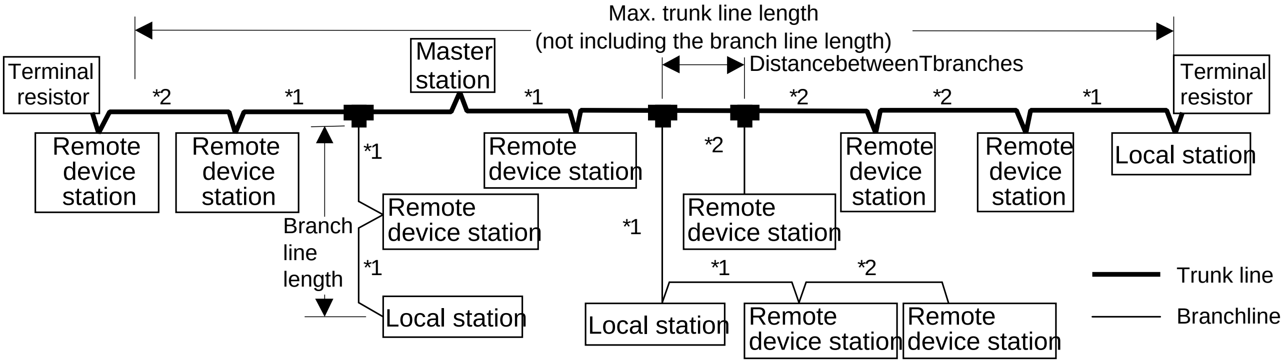
31.5.2.2 Topologie en T

Une topologie en T est configurée avec des connecteurs T utilisés comme coupleurs pour fournir des points de connexion des nœuds aux lignes secondaires (branchements), comme présenté à la Figure 137.



Légende

Anglais	Français
Max. trunk line length (not including the branch line length)	Longueur max. de ligne principale (non compris la longueur des lignes de dérivation)
Terminal resistor	Résistance terminale
Master station	Station maître
Remote device station	Station d'appareil distant
Branch line length	Longueur des lignes de dérivation
Local station	Station locale
Trunk line	Ligne principale
Branch line	Ligne de dérivation

Figure 137 – Topologie en T

31.5.2.3 Exigences de la topologie

31.5.2.3.1 Topologie de transfert

La longueur maximale du câble, en fonction du débit binaire, est spécifiée dans le Tableau 160. La distance minimale de câblage entre appareils est de 20 cm.

Tableau 160 – Limites de la topologie de transfert

Débit binaire kbit/s	**Longueur max. de câble** m
10 000	100
5 000	160
2 500	400
625	900
156	1 200

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31.5.2.3.2 Topologie en T

La topologie en T accepte uniquement des débits binaires de 156 kbit/s, 625 kbit/s. Les longueurs maximales de câble (en fonction du débit binaire) et autres limites de la topologie, sont spécifiées dans le Tableau 161. La Figure 137 décrit les composantes de bus référencés.

Tableau 161 – Limites de la topologie en T

Paramètre		Valeur	Commentaire
Longueur max. de ligne principale	625 kbit/s	100 m	
	156 kbit/s	500 m	
Longueur max. de dérivation	625 kbit/s	50 cm	Longueur de câble par dérivation (ligne secondaire)
	156 kbit/s	200 cm	
Longueur max. de l'ensemble des dérivations		8 m	Longueur totale de toutes les lignes de dérivation combinées
Distance max. entre dérivations en T		Aucune limite	Cette distance est mesurée sur la ligne principale
Nombre max. de stations connectées par dérivation		6	
Distance min. à la station maître		2 m	Voir ***1** à la Figure 137. Ce paramètre est réduit à 1 m pour des systèmes configurés sans stations locales ou stations à appareils intelligents.
Distance min. entre stations		30 cm	Voir ***2** à la Figure 137.
NOTE Les types de stations (par exemple station maître) sont définis dans la DLL et l'AP de Type 18.			

31.5.3 Spécifications du câblage de signaux

Le câble à paire torsadée à 3 conducteurs de support PhL-B de Type 18 est spécifié en R.1.

31.5.4 Terminaison de supports

Le segment de ligne principale doit être terminé à chaque extrémité par son impédance caractéristique. Les exigences pour ces deux résistances de terminaison de la ligne de transmission sont spécifiées dans le Tableau 162.

Tableau 162 – Exigences applicables aux résistances de terminaison

Paramètre	Valeur
Résistance	110 Ω
Puissance	0,5 W
Tolérance	<5 %

31.6 Connecteurs de câbles de dérivation et de point d'extrémités

Il n'est spécifié aucun connecteur physique pour utilisation avec la PhL-B de Type 18.

Le connecteur doit être du type à compression par vis; chaque borne pouvant recevoir deux conducteurs du type spécifié pour le câblage des supports. Il est également exigé qu'un nombre suffisant de bornes soit prévu pour l'ensemble des cinq points de connexion ou, comme autre variante, qu'il y ait quatre points de connexion avec un point de connexion séparé pour le circuit FG.

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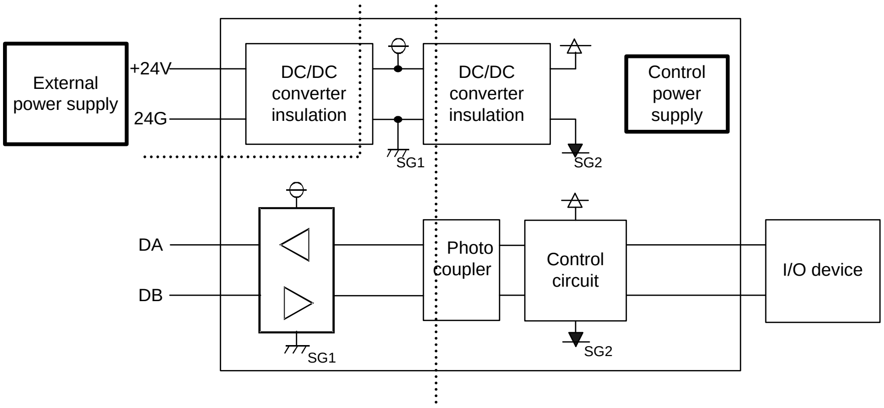
Il est recommandé d'utiliser des connecteurs en deux parties pour le débranchement en ligne des appareils. Il est par ailleurs recommandé que l'ingénieur d'application envisage des associations et des consortiums appropriés entre partenaires industriels pour les solutions de connecteurs communément utilisées dans le secteur d'application ciblé. Pour les références à ces spécifications et à d'autres spécifications apparentées, voir la série de normes CEI 61784.

31.7 Circuits recommandés de MAU de PhL-B de Type 18

L'isolation galvanique de l'élément de communication n'est pas exigée mais elle est recommandée et fortement encouragée pour des performances stables. Il est au minimum recommandé que l'élément de communication soit configuré avec une isolation galvanique comme illustré à la Figure 138. Il est par ailleurs recommandé que l'élément d'entrée/sortie soit configuré avec sa propre isolation galvanique comme illustré à la Figure 139.



Légende

Anglais	Français
External power supply	Alimentation externe
DC/DC converter insulation	Isolation de convertisseur c.c./c.c.
Control power supply	Alimentation de commande
Photo coupler	Photocoupleur
Control circuit	Circuit de commande
I/O device	Dispositif E/S

Figure 138 – Isolation des éléments de communication

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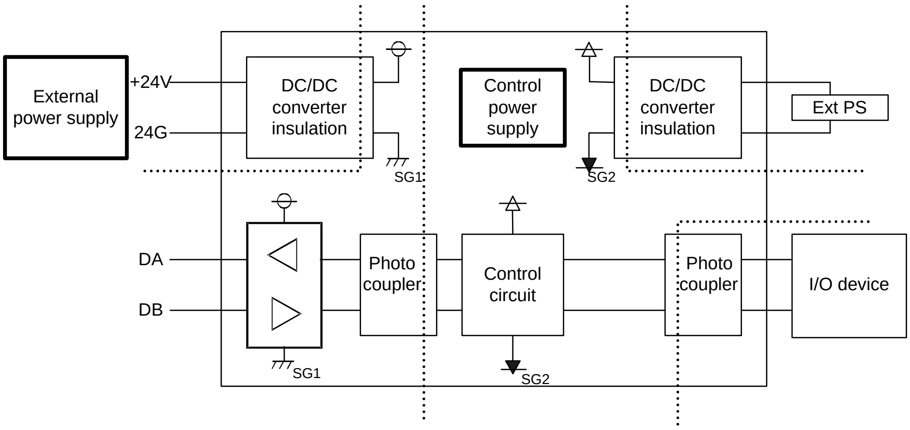

Légende

Anglais	Français
External power supply	Alimentation externe
DC/DC converter insulation	Isolation de convertisseur c.c./c.c.
Control power supply	Alimentation de commande
Ext PS	Alim. ext.
Photo coupler	Photocoupleur
Control circuit	Circuit de commande
I/O device	Dispositif E/S

Figure 139 – Isolation des éléments E/S et de communication

32 Type 18: Unité de liaison au support: support alimenté

32.1 Généralités

La PhL-P de Type 18 utilise une MAU conforme aux interconnexions multipoints par paire torsadée de l'ISO/CEI 8482, désignée par l'abréviation TPMI dans la suite de l'Article 32; il s'agit d'une variante de la TIA/EIA-485-A de l'ANSI.

Les exigences suivantes s'ajoutent à celles des TPMI:

- spécifications de codage du signal de données
- charge du signal de bus MAU
- exigences d'acheminement du signal
- spécifications des supports
  - descriptions des topologies
  - spécifications des câbles
  - spécifications des terminaisons de lignes de transmission
- connecteurs de câbles de dérivation et de point d'extrémité
- distribution de l'alimentation intégrée
- circuits d'interface recommandés

Le bus PhL-P de Type 18 résultant peut prendre en charge des débits binaires allant jusqu'à 2,5 Mbit/s et des distances de transmission allant jusqu'à 500 m.

NOTE Dans le présent Article 32, le terme *station* désigne un appareil de réseau et il est utilisé pour assurer l'homogénéité avec la DLL et l'AL de Type 18 qui définissent divers types de stations.

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32.2 Codage du signal de données

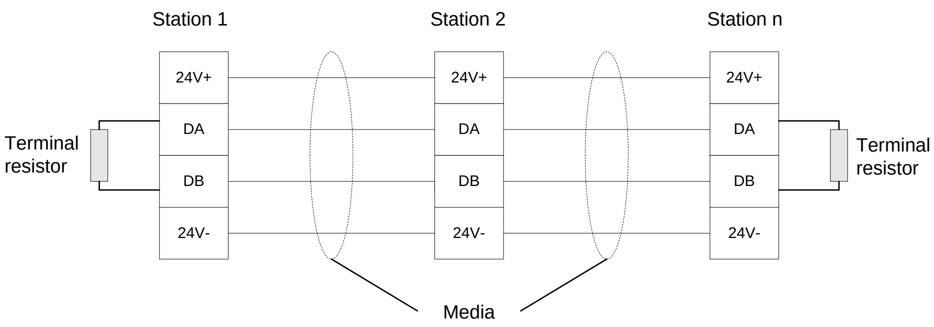
La PhL-U de Type 18 spécifie le codage de signaux de données en NRZI (non retour à zéro inversé) comme défini dans l'ISO/CEI 9314-1. En conséquence, une transition Marque-Espace ou une transition Espace-Marque représente un niveau logique un de la PhPDU; et une absence de transition (Marque-Marque ou Espace-Espace) représente un niveau logique zéro de la PhPDU.

32.3 Chargement du signal

La mise en œuvre d'un élément de communication de MAU de PhL-U de Type 18 exige l'utilisation d’appareils émetteurs-récepteurs qui ne doivent pas dépasser 0,5 charge unitaire (UL). Ainsi, le nombre maximal d’appareils de nœuds connectés est de 64.

32.4 Exigences d'acheminement du signal

Le câblage minimal entre deux appareils communiquant est présenté à la Figure 140.



Légende

Anglais	Français
Terminal resistor	Résistance terminale
Media	Supports

Figure 140 – Câblage minimal d'interconnexion

32.5 Supports

32.5.1 Généralités

Le support de chaque segment de bus (lignes principales) et de lignes secondaires (branchements) est un câble non blindé à 4 conducteurs. Les configurations de câbles spécifiées sont des câbles plats et des câbles ronds avec des conducteurs assurant à la fois la communication et la distribution de l'alimentation intégrée.

32.5.2 Topologie

32.5.2.1 Généralités

La Figure 141 illustre un exemple de configuration de câble plat avec distribution de l'alimentation intégrée. Le bus comporte une ligne principale et peut inclure des lignes secondaires (branchements).

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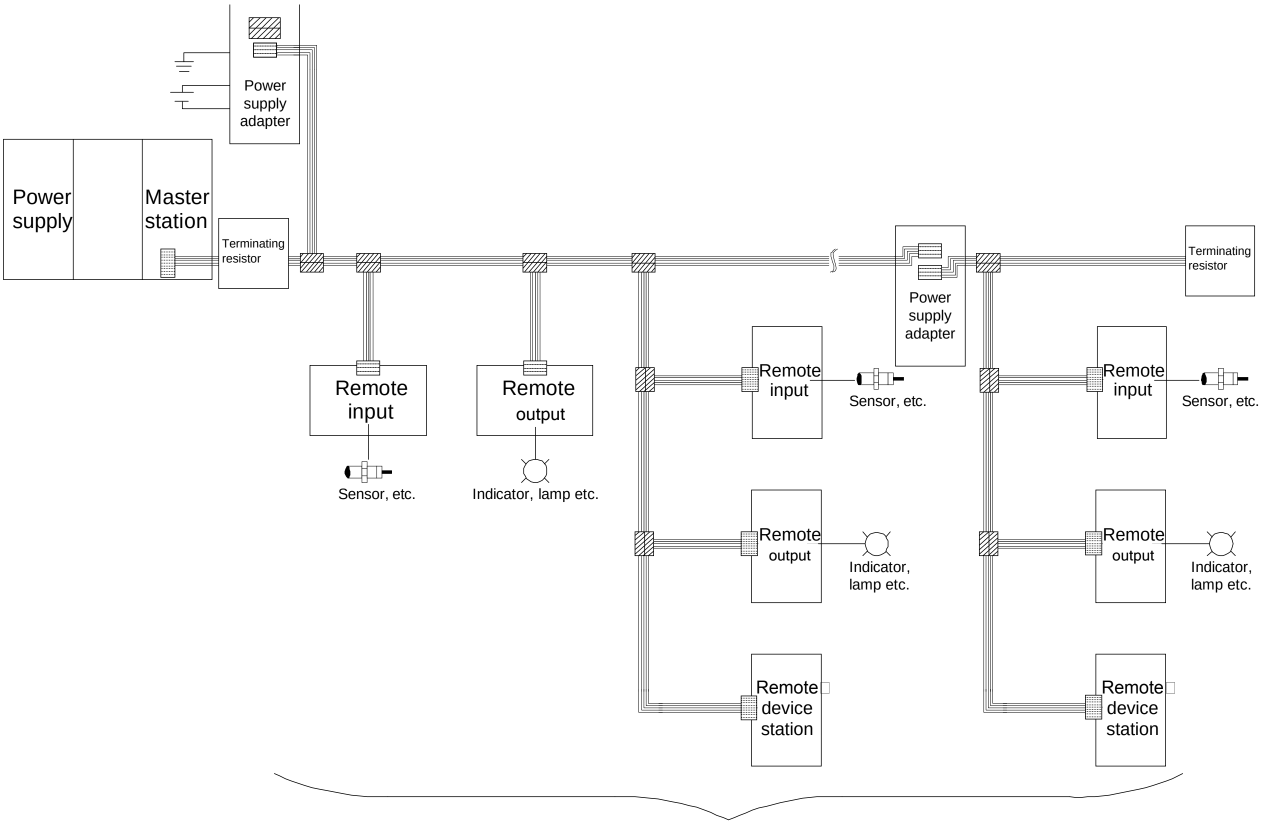

Légende

Anglais	Français
Power supply adapter	Adaptateur d'alimentation
Power supply	Alimentation
Master station	Station maître
Terminating resistor	Résistance de terminaison
Remote input	Entrée distante
Remote output	Sortie distante
Sensor, etc.	Capteur, etc.
Indicator lamp, etc.	Voyant, etc.
Remote device station	Station d'appareil distant
Slave stations maximum number is 64	Le nombre maximal de stations esclaves est de 64

Figure 141 – Topologie de câble plat

32.5.2.2 Topologie de transfert

Un câble dédié est configuré avec un connecteur de type transfert pour chaque appareil, comme illustré à la Figure 142.

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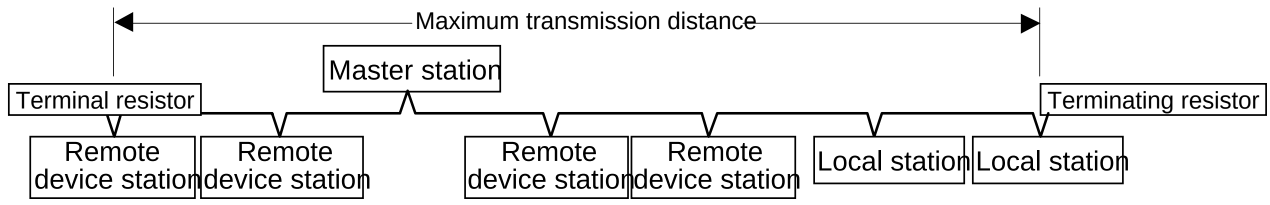


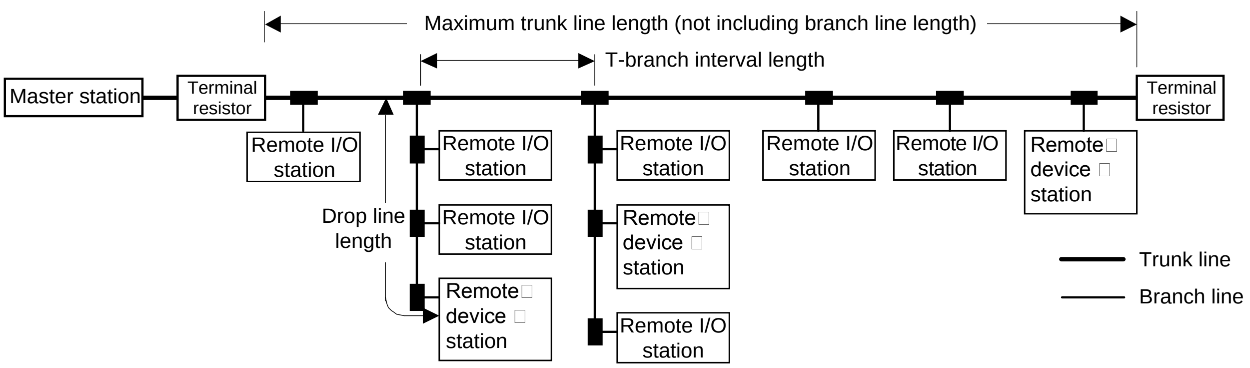
Légende

Anglais	Français
Maximum transmission distance	Distance maximale de transmission
Terminal resistor	Résistance terminale
Master station	Station maître
Remote device station	Station d'appareil distant
Local station	Station locale

Figure 142 – Topologie de câble dédiée

32.5.2.3 Topologie en T

Un exemple de topologie en T est illustré à la Figure 143. On peut combiner différents types de câbles sur le réseau, mais le câblage utilisé doit demeurer homogène pour une dérivation ou un segment de ligne principale donné.



Légende

Anglais	Français
Maximum trunk line length (not including branch line length)	Longueur maximale de ligne principale (non compris la longueur des lignes de dérivation)
T-branch interval length	Longueur d'intervalle entre dérivations en T
Master station	Station maître
Terminal resistor	Résistance terminale
Remote I/O station	Station E/S distante
Drop line length	Longueur des lignes de dérivation
Remote device station	Station d'appareil distant
Trunk line	Ligne principale
Branch line	Ligne de dérivation

Figure 143 – Topologie en T

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32.5.3 Exigences de la topologie

32.5.3.1 Topologie de transfert

La longueur maximale du câble, en fonction du débit binaire, est spécifiée dans le Tableau 163.

Tableau 163 – Limites de la topologie de transfert

Débit binaire kbit/s	**Longueur max. de câble** m
2 500	35
625	100
156	500

32.5.3.2 Topologie en T

La mise en œuvre de la topologie PhL-P de Type 18 est limitée par le fait que le segment de ligne principale doit être construit en utilisant uniquement un type de câble (plat, rond préférentiel ou variante de rond). De la même manière, chaque dérivation (ligne secondaire) doit être homogène, c'est-à-dire constituée d'un seul type de câble. Cependant, les types de câbles de dérivation peuvent ne pas correspondre au type du câble de ligne principale ou à celui d'autres dérivations sur le bus de segment PhL.

La topologie en T accepte uniquement des débits binaires de 156 kbit/s, 625 kbit/s et 2,5 Mbit/s.

Les longueurs maximales de câble (en fonction du débit binaire) et autres limites de la topologie, sont spécifiées dans le Tableau 164.

Tableau 164 – Limites de la topologie en T

Paramètre	**Valeur**			**Commentaire**
	156 kbit/s	**625 kbit/s**	**2 500 kbit/s**	
Longueur max. de segment de ligne principale	500 m	100 m	35 m	Ne comprenant pas la longueur de la ligne de dérivation
Longueur max. de dérivation	60 m	16 m	4 m	Longueur de câble par dérivation (ligne secondaire)
Longueur max. de l'ensemble des dérivations	200 m	50 m	15 m	Longueur totale de toutes les lignes de dérivation combinées
Longueur max. de câble entre appareils connectés	500 m	100 m	35 m	
Longueur max. de câble entre dérivations en T	Aucune limite			Cette distance est mesurée sur la ligne principale
Nombre max. d'appareils connectés par dérivation	8			

32.5.4 Spécifications du câblage de signaux

32.5.4.1 Câble plat

Le câble plat non blindé à 4 conducteurs de support PhL-P de Type 18 est spécifié en R.2.1.

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32.5.4.2 Câble rond – préférentiel

Le type préférentiel de câble rond non blindé à 4 conducteurs pour le support PhL-P de Type 18 est spécifié en R.2.2. Ce type de câble est également appelé cordon VCTF.

32.5.4.3 Câble rond – variante

La variante de câble rond non blindé à 4 conducteurs pour le support PhL-P de Type 18 est spécifié en R.2.3.

32.5.5 Terminaison de supports

Le segment de ligne principale doit être terminé à chaque extrémité par son impédance caractéristique. Les exigences pour ces deux résistances de terminaison de la ligne de transmission sont spécifiées dans le Tableau 165 pour les câbles plats et dans le Tableau 166 pour les câbles ronds.

Tableau 165 – Exigences applicables aux résistances de terminaison – câble plat

Paramètre	Valeur
Résistance	680 Ω
Puissance	0,5 W
Tolérance	<10 %

Tableau 166 – Exigences applicables aux résistances de terminaison – câble rond

Paramètre	Valeur
Résistance	680 Ω
Puissance	0,5 W
Tolérance	<10 %

32.6 Connecteurs de câbles de dérivation et de point d'extrémité

32.6.1 Connecteur d’appareil

Les dimensions exigées du connecteur d’appareil PhL-P de Type 18 sont spécifiées en Q.2.

32.6.2 Connecteur de câble plat

Les dimensions exigées du connecteur de câble plat PhL-P de Type 18 sont spécifiées en Q.3.

32.6.3 Connecteur de câble rond

Les dimensions exigées du connecteur de câble rond PhL-P de Type 18 sont spécifiées en Q.4. Ce connecteur est applicable aux deux modèles de câbles ronds PhL-P de type 18.

32.6.4 Variante de connecteur de câble rond

Les dimensions exigées de la variante de connecteur de câble rond PhL-P de Type 18 sont spécifiées en Q.5.

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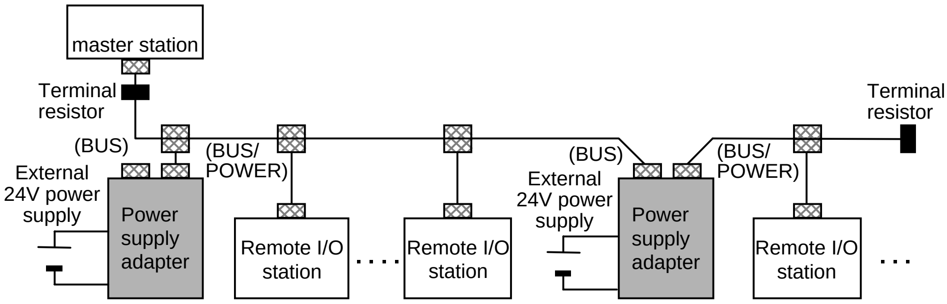
32.6.5 Coupleur de dérivation en T

Il n'y a pas de dimensions exigées pour le coupleur de dérivation en T PhL-P de Type 18. Tout bornier approprié disponible sur le marché peut être utilisé.

32.7 Distribution de l'alimentation intégrée

32.7.1 Généralités

La PhL-P de Type 18 comporte des spécifications pour la distribution de l'alimentation intégrée au réseau. La composante alimentation d'un segment PhL peut être soit un système de distribution d'énergie individuel interconnecté ou subdivisé en plusieurs segments d'attribution de l'alimentation. L'exemple du synoptique de la Figure 144 présente un segment PhL avec deux segments d'attribution de l'alimentation.



Légende

Anglais	Français
Master station	Station maître
Terminal resistor	Résistance terminale
(BUS)	(BUS)
External 24 V power supply	Alimentation externe 24 V
Power supply adapter	Adaptateur d'alimentation
(BUS/POWER)	(BUS/ALIMENTATION)
Remote I/O station	Station E/S distante

Figure 144 – Distribution de l'alimentation de PhL-P de Type 18

32.7.2 Source d'alimentation

Les appareils d'alimentation doivent être utilisés avec deux connecteurs de bus qui assurent une connectivité de transfert aux signaux de données mais tirent leur alimentation d'un connecteur uniquement. Le schéma de la Figure 145 présente l'interconnexion de la source d'alimentation.

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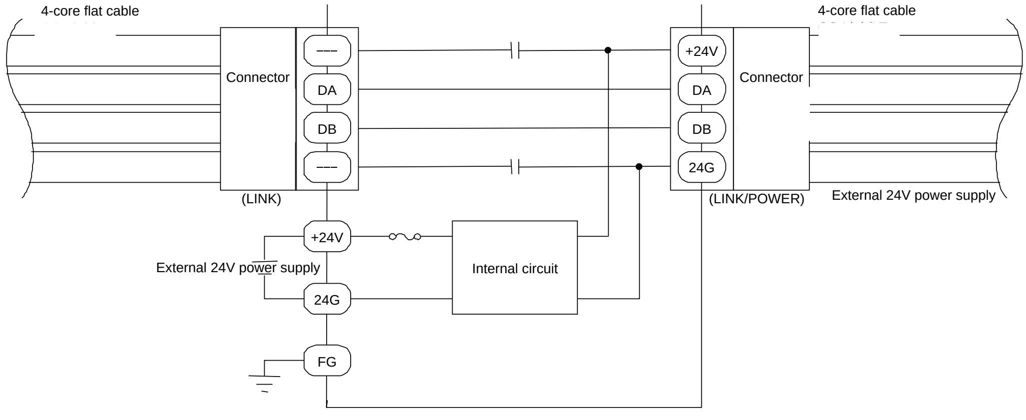

Légende

Anglais	Français
4-core flat cable	Câble plat à 4 conducteurs
Connector	Connecteur
(LINK)	(Liaison)
External 24 V power supply	Alimentation externe 24 V
Internal circuit	Circuit interne
Connector	Connecteur
(LINK/POWER)	(LIAISON/ALIMENTATION)

Figure 145 – Distribution de l'alimentation de PhL-P de Type 18

L'alimentation 24 V pour la PhL-P de Type 18 doit être conforme aux spécifications du Tableau 167.

Tableau 167 – Spécification de l'alimentation en 24 V

Paramètre	Spécification
Tension de service max.	28,8 V
Tension de service min.	20,4 V
Courant max.	5 A
Isolation – alimentation / signaux de données	500 V eff.
Protection contre les surtensions inverses	95 V
Tolérance aux courants de choc	Tension de sortie comprise entre 19,2 V et 30,0 V pour ±5 A/ impulsion de 1 mS

32.7.3 Charge d'alimentation

Chaque appareil connecté au bus PhL-P de Type 18 qui consomme également de l'énergie doit satisfaire aux exigences spécifiées dans le Tableau 168.

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Tableau 168 – Spécifications de consommation d'énergie de l'alimentation en 24 V

Paramètre	Spécification
Tension de service max.	30,0 V
Tension de service min.	19,2 V
Courant max.	5 A [a]
Courant de démarrage	1,33 fois le courant de service [b]
Protection contre le courant inverse	aucun dommage subi par l'appareil ou le réseau dû à une inversion de polarité

[a] Pour des transmissions à pleine distance, la consommation de courant doit être limitée à 0,1 A par appareil.

[b] Ceci n'inclut pas le courant d'appel nécessaire au chargement de condensateurs de découplage des entrées. Lorsque ces condensateurs sont utilisés, il est nécessaire de limiter les valeurs globales du courant d'appel de façon à ce que l'alimentation du bus ne chute pas sous 19,2 V pendant plus de 1 ms lorsqu'un appareil est branché à un réseau opérationnel.

Les spécifications concernant le courant de démarrage et le courant d'appel (Tableau 168, Note 2) nécessitent d'être respectées pour la prise en charge d'appareils connectables à chaud, c'est-à-dire des appareils qui peuvent être branchés ou débranchés d'un réseau opérationnel sans endommager le réseau ou les appareils.

Le filtrage du circuit d'entrée d'alimentation et sa protection contre les inversions de polarité sont également exigés pour un fonctionnement stable aux débits binaires les plus élevés. Les paramètres de filtrage ne sont pas spécifiés. Un circuit type de filtrage et de protection est présenté à la Figure 146 avec repérage des composantes critiques.

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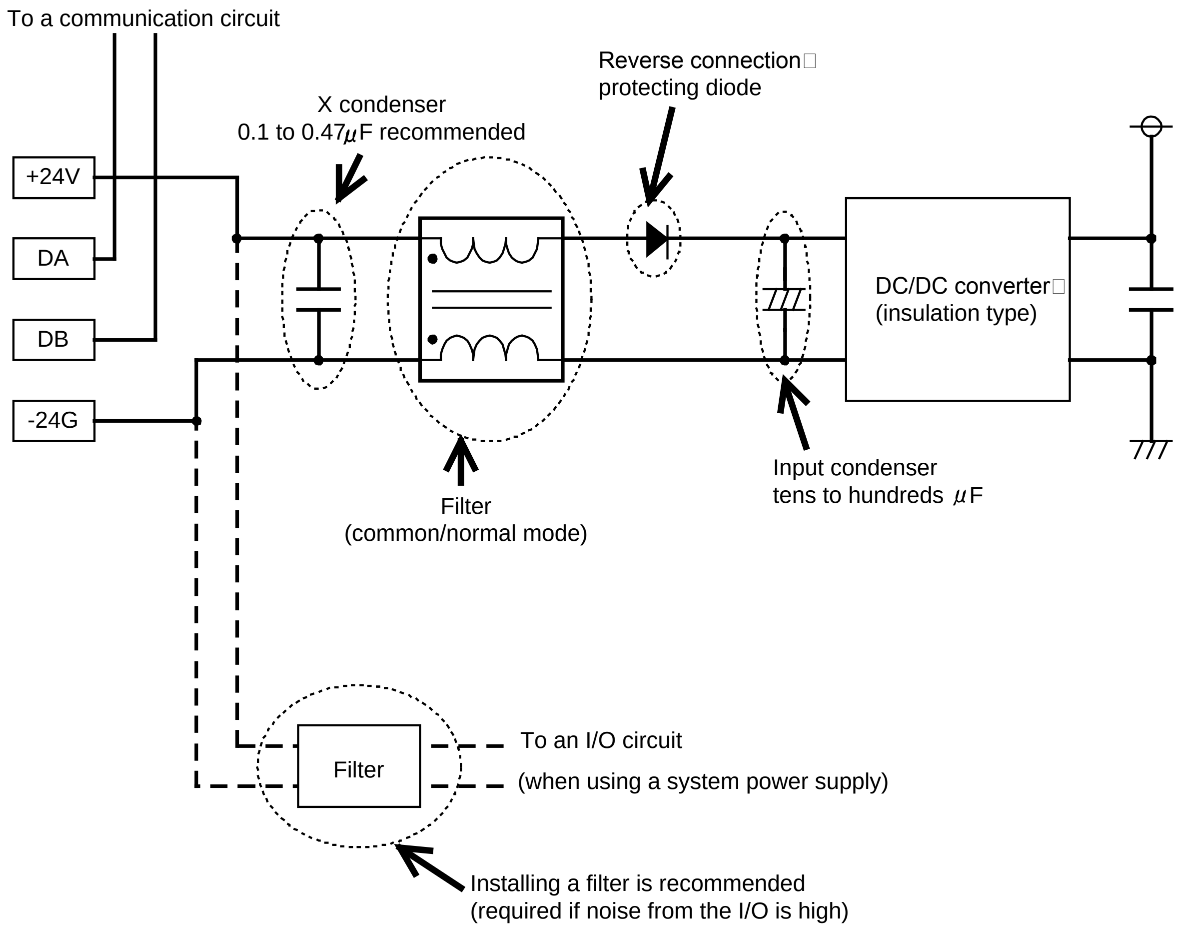

Légende

Anglais	Français
To a communication circuit	Vers un circuit de communication
X condenser 0.1 to 0.47 uf recommended	X condensateur 0,1 à 0,47 μF recommandé
Reverse connection protecting diode	Diode de protection contre l'inversion des connexions
DC/DC converter (insulation type)	Convertisseur c.c./c.c. (du type à isolation)
Filter (common/normal mode)	Filtre (mode commun/normal)
Input condenser tens to hundreds	Condensateur d'entrée, dizaines en centaines
Filter to an I/O circuit (when using a system power supply)	Filtre vers un circuit E/S (lorsqu'il est utilisé une alimentation système)
Installing a filter is recommended (required if noise from the I/O is high)	L'installation d'un filtre est recommandée (exigé si le bruit de l'E/S est élevé)

Figure 146 – Filtrage et protection de l'alimentation de PhL-P de Type 18

32.8 Circuits recommandés de MAU de PhL-P de Type 18

32.8.1 Généralités

Les schémas de circuit de 32.8.2 et de 32.8.3 sont fournis à titre d'information.

32.8.2 Isolation galvanique des éléments de communication

L'isolation galvanique de l'élément de communication n'est pas exigée mais elle est recommandée et fortement encouragée pour des performances stables. Il est au minimum recommandé que l'élément de communication soit configuré avec une isolation galvanique

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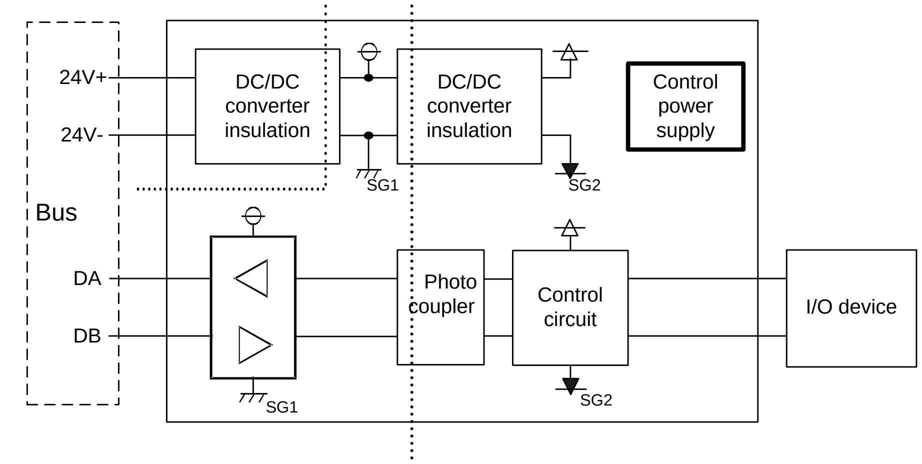
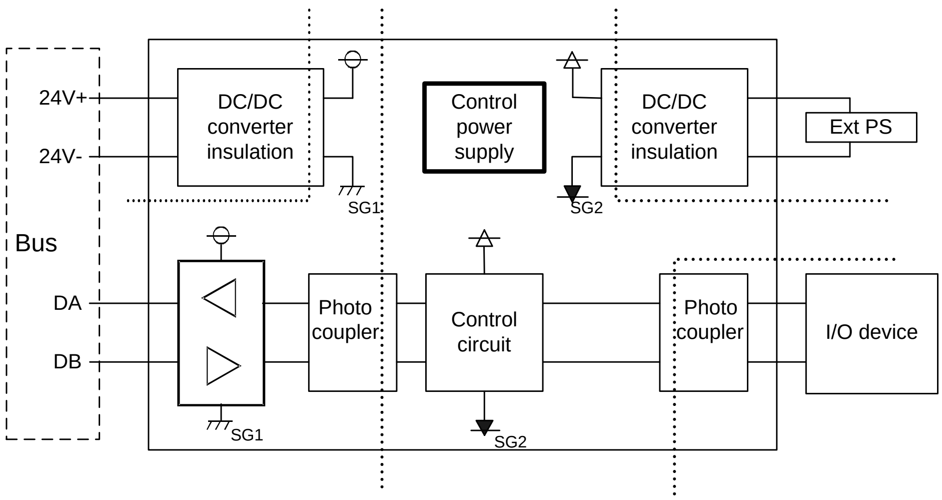
comme illustré à la Figure 147. Il est par ailleurs recommandé que l'élément d'entrée/sortie soit configuré avec sa propre isolation galvanique comme illustré à la Figure 148.



Légende

Anglais	Français
Bus	Bus
DC/DC converter insulation	Isolation de convertisseur c.c./c.c.
Control power supply	Alimentation de commande
Photo coupler	Photocoupleur
Control circuit	Circuit de commande
I/O device	Dispositif E/S

Figure 147 – Isolation des éléments de communication



Légende

Anglais	Français
Bus	Bus
DC/DC converter insulation	Isolation de convertisseur c.c./c.c.
Control power supply	Alimentation de commande
Ext PS	Alim. ext.
Photo coupler	Photocoupleur
Control circuit	Circuit de commande
I/O device	Dispositif E/S

Figure 148 – Isolation des éléments E/S et de communication

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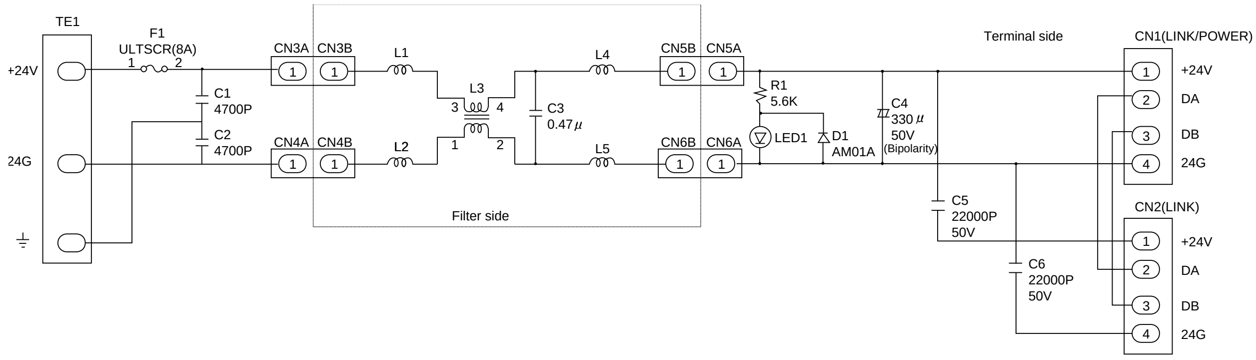
32.8.3 Puissance

Un circuit de conditionnement complet de l'alimentation est illustré à la Figure 149. Ce schéma est fourni pour information et peut servir de guide pour une mise en œuvre recommandée des composantes d'alimentation de PhL-P de Type 18.



Légende

Anglais	Français
Filter side	Côté filtre
(Bipolarity)	(Bipolarité)
Terminal side	Côté bornier
(LINK POWER)	(LIAISON/ALIMENTATION)
(LINK)	(Liaison)

Figure 149 – Circuit d'alimentation de PhL-P

33 Type 24: Unité de liaison au support: support câblé à paire torsadée

33.1 Généralités

Cette spécification de MAU décrit une transmission sur ligne symétrique correspondant à la norme TIA/EIA RS-485-A de l'ANSI. La longueur maximale du câble et de 50 m et le débit de données est de 10 Mbit/s. Des terminateurs sont placés aux deux extrémités du câble à paire torsadée. L'émetteur-récepteur de MAU est isolé de la ligne de transmission par une isolation galvanique à l'aide d'un transformateur. Les caractéristiques de la MAU sont résumées au Tableau 169.

Tableau 169 – Récapitulatif de la MAU

Caractéristique	Contraintes
Topologie	Bus linéaire, terminé aux deux extrémités, pas de branchements
Support	Câble en paire torsadée blindé, voir 33.4
Longueur de ligne	≤ 50 m
Nombre d'appareils	17(Longueur de ligne ≤ 30 m) 16(Longueur de ligne >30 m et 50 m)
Débit de données	10 Mbit/s

33.2 Réseau

33.2.1 Composant

Cette MAU fonctionne sur un réseau constitué des composants suivants:

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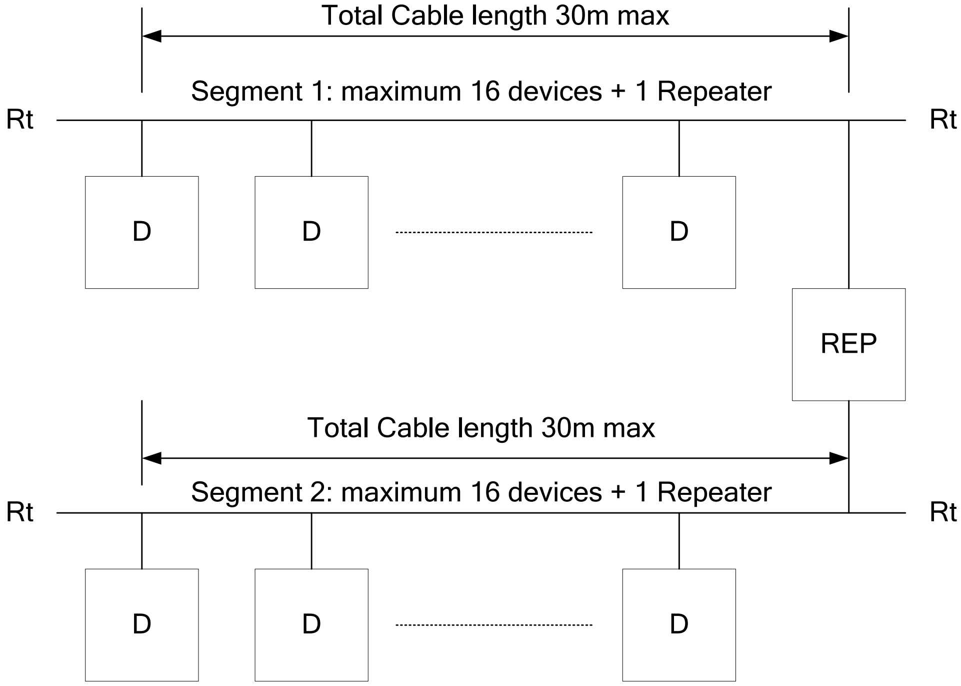
– un câble;

– des connecteurs;

– des appareils (comportant au moins un élément de communication).

33.2.2 Topologie

Cette MAU doit fonctionner dans une topologie de bus linéaire avec des terminateurs aux deux extrémités. Jusqu'à 17 appareils de bus de terrain sont connectés directement. La longueur totale du câble ne doit pas dépasser 50 m. Le nombre maximal d'appareils connectés varie en fonction de la longueur comme indiqué dans le Tableau 169. La longueur de la ligne et le nombre d'appareils peuvent être augmentés en utilisant un répéteur. Un seul répéteur peut être utilisé. La Figure 150 montre un exemple de réseau élargi qui utilisent un répéteur.



Légende

D Appareil

REP Répéteur

Rt Terminateur de bus

Légende

Anglais	Français
Total Cable length 30m max	Longueur de câblage totale 30 m max
Segment 1: maximum 16 devices + 1 Repeater	Segment 1: au maximum 16 appareils + 1 répéteur
Total Cable length 30m max	Longueur de câblage totale 30 m max
Segment 2: maximum 16 devices + 1 Repeater	Segment 2: au maximum 16 appareils + 1 répéteur

Figure 150 – Réseau élargi de type 24 qui utilise un répéteur

33.3 Spécification électrique

Les niveaux de tension de la sortie de l'émetteur et de l'entrée du récepteur sont conformes à la norme TIA/EIA-485-A de l'ANSI. La sortie de l'émetteur et l'entrée du récepteur sont isolées galvaniquement par un transformateur d'impulsions.

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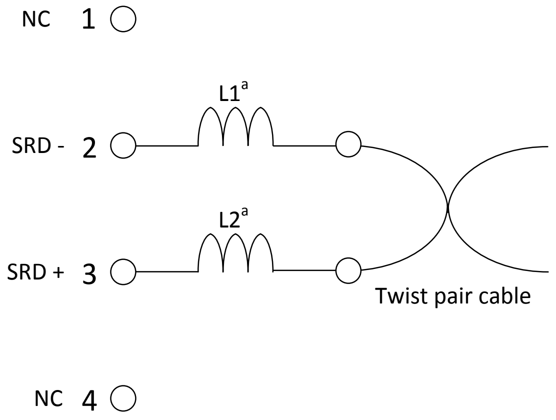
33.4 Spécifications du support

33.4.1 Connecteur

Le connecteur est spécifié à l'Article S.2. Pour prendre l'adaptation d'impédance avec la ligne de transmission, l'inducteur de 100 nH doit être monté dans le connecteur côté câble tel qu'indiqué à la Figure 151.



[a] L1, L2: 100 nH ±5 %

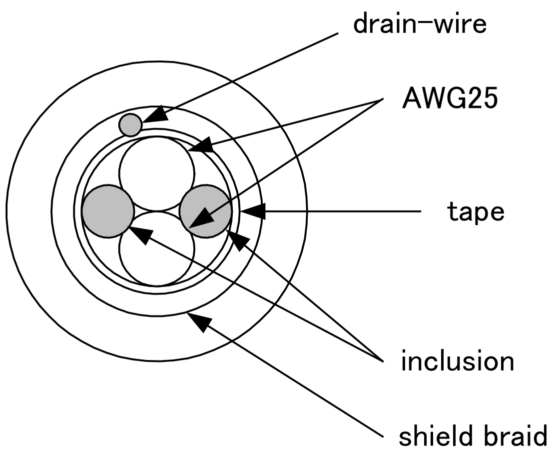
Légende

Anglais	Français
Twist pair cable	Câble paire torsadé

Figure 151 – Connecteur avec inducteur

33.4.2 Câble

Le support de bus est un câble à paire torsadée blindé. Le blindage permet d'améliorer la compatibilité électromagnétique (CEM). La structure et la spécification du câble sont indiquées respectivement à la Figure 152 et dans le Tableau 170.



Légende

Anglais	Français
Drain-wire	Conducteur d'évacuation
Tape	Bande
Inclusion	Inclusion
Shield braid	Blindage tressé

Figure 152 – Structure de câble

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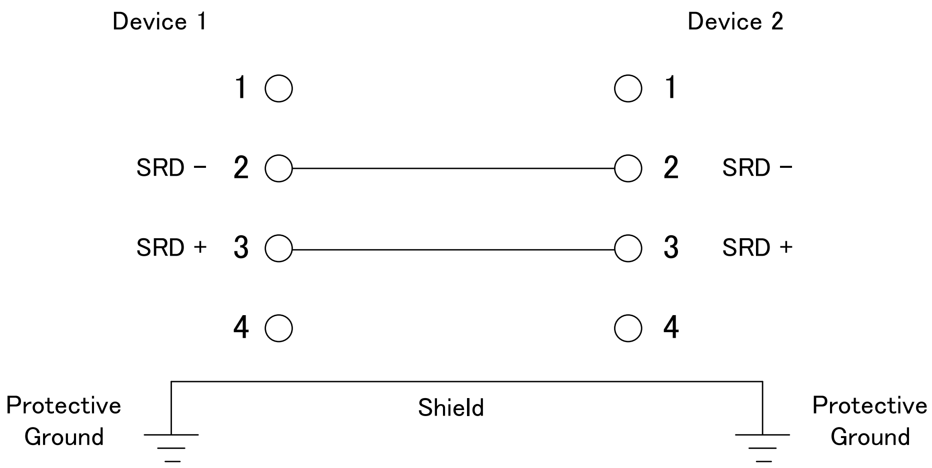
Tableau 170 – Spécifications du câblage

Caractéristique	Contraintes
Diamètre extérieur	4,8±0,2 mm
Conducteur	Cuivre étamé recuit
Résistance électrique du conducteur	≤ 114,4 Ω/km
Tension de tenue	CA 1000 V, 1 min
Résistance d'isolement	≥ 100 MΩ/km
Impédance	130 Ω
Capacité	110 nF/km
Atténuation	40 dB/km (à 4 MHz) 60 dB/km (à 10 MHz)
Code couleur	Noir / Rouge

Le câblage entre deux appareils est présenté à la Figure 153.



Légende

Anglais	Français
Device 1	Appareil 1
Device 2	Appareil 2
Protective ground	Terre de protection
Shield	Blindage

L'inversion des deux conducteurs SRD– et SRD+ n'est pas admise.

Figure 153 – Câblage d'interconnexion

Le câblage illustré à la Figure 153 permet d'obtenir une tension en mode commun entre deux appareils (c'est-à-dire la différence de potentiel entre les masses de protection) d'au maximum 7 V. S'il est souhaité une tension en mode commun supérieure, un conducteur de compensation doit être placé entre les points de mise à la masse.

33.4.3 Règles de mise à la masse et de blindage

Il est recommandé de connecter le blindage à la terre de protection aux deux extrémités du câble par l'intermédiaire de connexions à faible impédance (c'est-à-dire à faible inductance). Ceci est nécessaire pour obtenir une compatibilité électromagnétique raisonnable.

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Il convient de préférence de réaliser les branchements entre le blindage du câble et la terre de protection (par exemple le boîtier métallique de l'appareil) par l'intermédiaire des boîtiers métalliques des connecteurs.

33.4.4 Terminateur de bus

Le câble de bus doit être terminé aux deux extrémités par la résistances Rt. La valeur du terminateur doit être 130 Ω ± 5% (1/2 W min.), tel qu'illustré à la Figure 154.

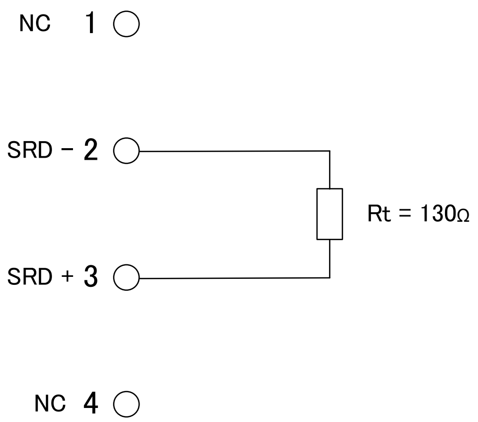

Figure 154 – Terminateur de bus

33.5 Méthode de transmission

33.5.1 Codage binaire

Les données codées Manchester en provenance de la MDS sont transmises par l'intermédiaire d'un câble à paire torsadée. On obtient un signal différentiel de la ligne de transmission à partir de la broche 2 (SRD-) et de la broche 3 (SRD+) du connecteur de bus.

Quand il est Faible et que ce dernier est Elevé, la première moitié du bit d'un signal différentiel devient un "1" binaire (DL_symbol = "ONE"). Quand il est Elevé et que ce dernier est Faible, la première moitié du bit devient un "0" binaire (DL_symbol = "ZERO").

33.5.2 Commande de l'émetteur-récepteur

L'émetteur-récepteur de la MAU de Type 24 doit être conforme aux spécifications de l'émetteur et du récepteur représentées dans le Tableau 171 et dans le Tableau 172. D'autres spécifications non répertoriées dans les présents tableaux doivent être conformes à la norme TIA/EIA-485-A de l'ANSI.

Tableau 171 – Spécifications de l'émetteur

Spécification	Limites / caractéristiques
Courant élevé du courant de sortie de niveau élevé, IOH	-100 mA min.
Courant faible du courant de sortie de niveau faible, IOL	100 mA min.

Tableau 172 – Spécifications du récepteur

Spécification	Limites / caractéristiques
Tension de seuil d'entrée de sens positif	-10 mV max.
Tension de seuil d'entrée de sens négatif	-200 mV min.

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Lorsqu'un appareil n'est pas en émission, la sortie de l'émetteur doit être désactivée et présenter une impédance élevée par rapport à la ligne. Au cours des périodes de repos, c'est-à-dire lorsqu'aucune donnée n'est transmise par un quelconque appareil, le signal de la ligne de réception doit représenter une valeur binaire "1". Le niveau de tension du signal différentiel reçu pendant les périodes de repos est de 0 V. Par conséquent, la tension de seuil du récepteur doit être inférieure à 0 V. tel qu'indiqué dans le Tableau 172 pour que le récepteur représente une valeur binaire "1". Le signal reçu doit également être conforme au diagramme en œil de la Figure 155.

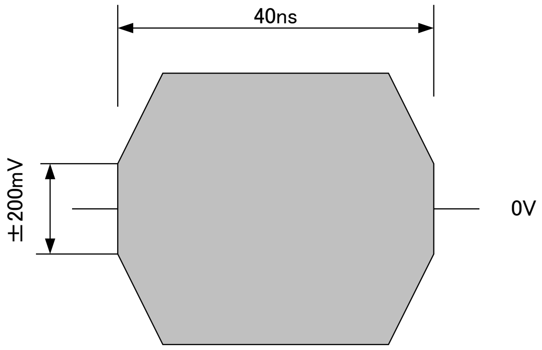
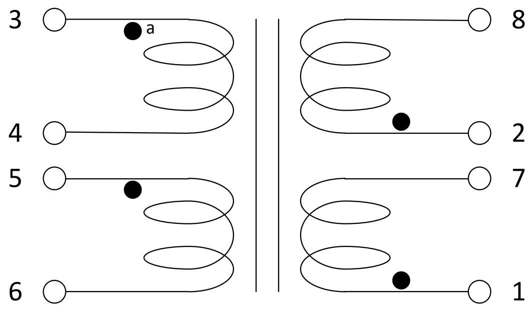


Figure 155 – Diagramme en œil

33.5.3 Transformateur

Pour une isolation galvanique entre le support et la MAU, un transformateur d'impulsions indiqué à la Figure 156 et dans le Tableau 173 doit être utilisé.



[a] signe: même pôle

Figure 156 – Schéma du transformateur

Tableau 173 – Spécifications du transformateur

Point	Spécification	NOTE
Fréquence de réponse	2/4/10M MHz	
Inductance	0,5 mH min	L (1-8) (2-7 court) 10 kHz 0,1 v
Rapport de transformation	(2-8):(1-7) = 1:1 (2-8):(3-4) = 1:2 (2-8):(5-6) = 1:2	
Résistance en courant continu	600 mΩ (1-8) 300 mΩ (4-3)	(2-7 court) (4-6 court et 3-5 court)
Inductance de fuite	400 nH max.	L (1-8) (2-7 court et 3-6-4-5 court)
Capacité	12 pF max.	(1-2 court et 3-5 court)
Perte d'insertion	0,5 dB max.	(3-4) à (1-8) (2-7 court, 4-6 court et 3-5 court) 50 Ω: 2 MHz ~ 10 MHz
Résistance d'isolement	100 MΩ min.	CA 500 V

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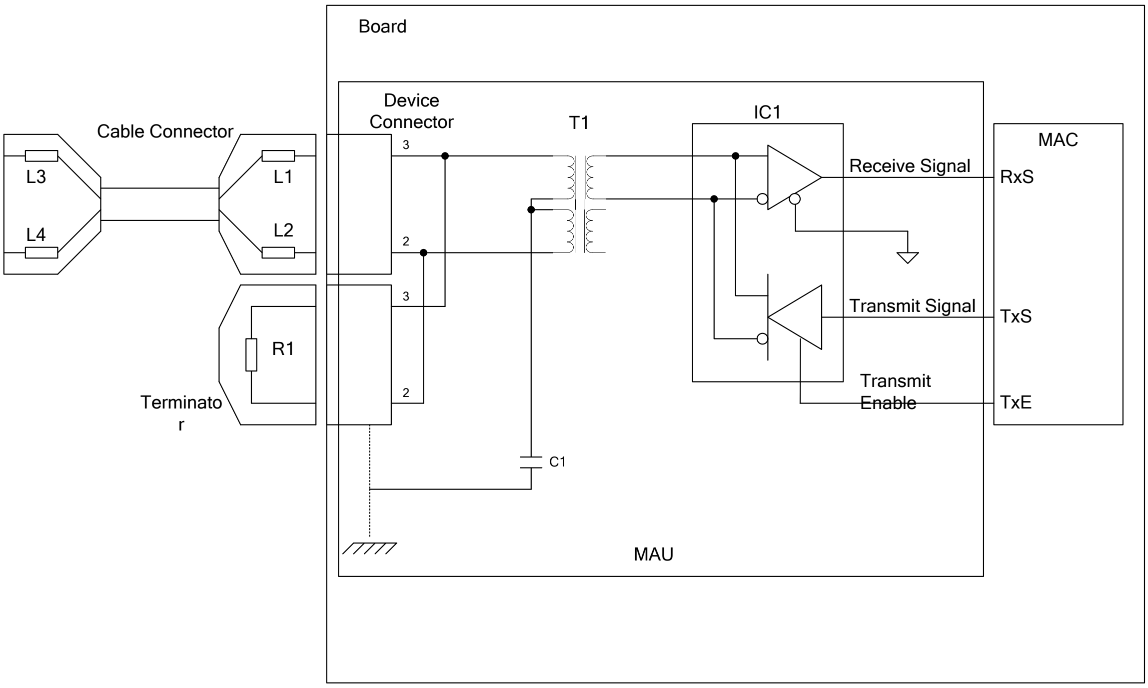
33.5.4 Exigence de niveau de sortie

Se reporter à la norme TIA/EIA-485-A de l'ANSI pour les niveaux de tension de l'émission et de la réception.

33.5.5 Interface avec le support de transmission

Le circuit recommandé de la MAU de type 24 est représenté à la Figure 157.



Légende

IC1:	Emetteur-récepteur IC
T1:	transformateur d'isolation
R1:	130 Ω ±5%, 1/2 W
C1:	1 000 pF, 1 kV
L1, L2, L3, L4:	100 nH ± 5 %

Légende

Anglais	Français
Board	Carte
Cable Connector	Connecteur de câble
Device Connector	Connecteur d'appareil
Terminator	Terminateur
Receive Signal	Signal de réception
Transmit Signal	Signal de transmission
Transmit Enable	Activation de l'émission

Figure 157 – Circuit MAU recommandé

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34 Type 20: Unité de liaison au support: support FSK

34.1 Vue d'ensemble

Le protocole de signalisation numérique de la présente norme utilise une modulation par déplacement de fréquence (FSK) à phase continue binaire de de 1 200 bit/s pour superposer des communications numériques sur une boucle de courant de 4 mA à 20 mA. Les appareils de communication envoient un signal soit en modulant le courant soit en alimentant en tension; toutes les signalisations apparaissent en tant que tension lorsqu'elles sont détectées à basse impédance. Une modulation par déplacement de fréquence à phase continue nécessite que l'angle de phase du repère (1 200 Hz = 1 binaire) et que l'espace (2 200 Hz = 0 binaire) restent continus aux limites binaires de 1 200 Hz tel que représenté à la Figure 158.

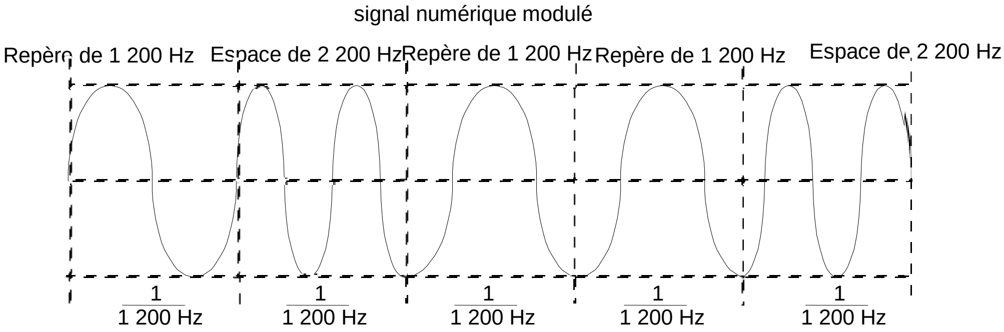

Figure 158 – Modulation par déplacement de fréquence à phase continue

L'appareil qui module le courant apparaît en tant qu'impédance élevée à travers le support, plusieurs appareils de ce type pouvant ainsi être connectés en parallèle. L'appareil qui fournit le signal de tension a une faible impédance en série. Bon nombre de ces appareils utilisent également du courant pour envoyer ou recevoir un signal analogique. La fréquence et l'amplitude du signal numérique sont telles qu'elles ne perturbent pas le signal analogique. La présente norme spécifie le signal analogique de sorte qu'il ne perturbe pas le signal numérique. L'appareil peut également utiliser de l'énergie du support en utilisant un signal analogique.

La présente norme spécifie également des appareils qui n'utilisent pas de signal analogique ou numérique. Ces appareils sont par exemple l'alimentation et la barrière.

34.2 PhPDU

34.2.1 Structure de PhPDU

La structure d'une PhPDU est illustrée à la Figure 159. La PhSDU est la séquence d'octets Ph-user-data d'une primitive PH-DATA. Le préambule est une séquence d'octets "0xFF" hexadécimaux.

Figure 159 – Structure de la PhPDU

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34.2.2 Emission PhPDU

34.2.2.1 Emission de caractères

A réception de la primitive de demande PH-START, la PhE doit envoyer au moins cinq (5) et au plus vingt (20) caractères de préambule. Le nombre de caractères de préambule est un paramètre configurable. Après la transmission du dernier préambule, la PhE doit fournir une confirmation PH-START. La PhE doit émettre des octets PhSDU lorsqu'elle est reçue en provenance de l'utilisateur PhS. Les caractères formant une PhPDU doivent être transmis dans un seul flux contigu.

NOTE Les 5 caractères du préambule laissent suffisamment de temps pour évaluer une porteuse, former le circuit du modem et pour autoriser l'appareil d'écoute à commencer la réception de la PhPDU.

Bien que le nombre maximal d'octets de préambule soit 20, le nombre d'octets pour le préambule a une incidence sur la performance du système. Dans des applications d'acquisition de données, la transmission de longues séquences de préambule peut être avoir des conséquences néfastes. En conséquence, l'émission d'un nombre excessif de caractères de préambule est fortement déconseillée.

34.2.2.2 Format de caractère

Chaque caractère doit être émis de manière asynchrone et être constitué de onze bits. Ces caractères sont, par ordre de transmission, un bit de départ, huit bits de données (d'abord le bit de poids le plus faible), un bit de parité impaire et un bit d'arrêt comme illustré à la Figure 160. Il ne doit y avoir pas plus qu'un bit de repos (c'est-à-dire des bits d'arrêt supplémentaires) entre des caractères consécutifs. Les caractères consécutifs dans une PhPDU doivent avoir un espacement entre les caractères d'intervention de moins d'un (1) délai de caractère.

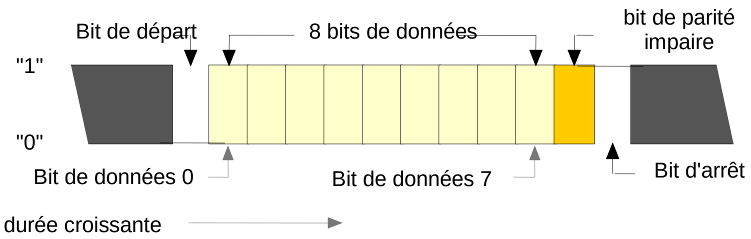

Figure 160 – Format de caractère

NOTE A 1 200 bit/s, l'émission d'un caractère dure 9,167 ms. Ce temps est le délai de caractère pour la Couche physique FSK.

34.2.3 Réception de PhPDU

Après détection de la porteuse, le récepteur de la PhE doit rechercher des caractères de préambule et se synchroniser avec les bits de départ et d'arrêt. Dès réception de deux caractères de préambule sans erreur, il doit fournir une indication PH-START. Il équivaut à une détection de porteuse.

Pendant la réception des caractères PhSDU, le récepteur doit vérifier la valeur exacte du bit de parité. Si une erreur quelconque est détectée, la PhE doit fournir une indication PH-DATA avec un état des erreurs.

Si la PhE détecte l'absence d'activité du support, elle doit fournir une primitive indication PH-END. L'activité du support est déduite d'un niveau de signal supérieur à celui des niveaux de suppression du bruit spécifiés en 34.6 et dans le Tableau 176.

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Si l'espacement entre deux caractères reçus est égal ou supérieur à un (1) délai de caractère, la PhE doit alors fournir une indication PH-DATA avec un état d'erreurs de réception de données discontinu.

34.2.4 Longueur de préambule

La longueur de préambule dans une PhPDU d'un appareil maître à esclave est spécifiée dans la demande DL-DATA-EXCHANGE (DL-ECHANGE DE DONNEES) – voir CEI 61158-3-20. La longueur de préambule dans une PhPDU de l'appareil esclave à maître est affectée comme un paramètre tel que défini dans la CEI 61158-3-20.

34.3 Types d'appareils

34.3.1 Généralités

Les appareils sont classés en fonction des deux critères suivants:

– Impédance d'entrée ou de sortie et
– Connexion au réseau.

Tous les appareils ont des paramètres selon leur type. Ces paramètres sont également définis en 34.3.2, 34.3.3 et 34.3.4.

34.3.2 Type d'impédance

34.3.2.1 Généralités

Tous les appareils sont classés selon l'un des deux types en fonction de leur impédance d'entrée ou de sortie dans une bande de fréquence numérique. Un appareil à faible impédance a un élément de signalisation qui est destiné à recevoir un signal de courant analogique ou à servir d'appareil maître pour un réseau multipoints. Un appareil à impédance élevée régule le courant en tant que signal analogique ou dans un réseau multipoints fixe son signal analogique à une valeur fixe.

34.3.2.2 Appareil à faible impédance

L'appareil à faible impédance doit avoir une impédance de 230 Ω à 600 Ω dans la bande de fréquence numérique. La variation de l'impédance sur la bande de fréquence étendue doit se situer dans une marge de ± 3 dB de sa valeur au centre de la bande de fréquence numérique.

NOTE 1 La limite de la variation d'impédance empêche une distorsion excessive de signal.

NOTE 2 Tout appareil qui reçoit le signal de courant analogique tel qu'un appareil de contrôleur d'entrée analogique ou une grille d'entraînement a une faible impédance d'entrée de sorte qu'il soit possible d'utiliser une tension de CC inférieure pour alimenter l'appareil qui envoie le signal de courant analogique. Il est impossible pour un appareil de ce type d'avoir une haute impédance dans la bande de fréquence numérique.

NOTE 3 L'appareil à l'extrémité basse de la plage d'impédance limite l'utilisation de résistance parallèle connectée au réseau. L'appareil à l'extrémité haute de la plage d'impédance limite la capacité totale du câble.

34.3.2.3 Appareil à haute impédance

L'appareil à haute impédance doit avoir une impédance de 600 Ω dans la bande de fréquence numérique.

Il convient qu'un appareil à haute impédance soit destiné à avoir une impédance aussi haute que possible dans les limites d'autres contraintes de conception.

NOTE Pour une application de réseau multipoints, l'impédance totale connectée au support est une combinaison parallèle d'impédance d'entrée de tous les appareils connectés au support.

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34.3.3 Type de connexion

34.3.3.1 Généralités

Un appareil doit être classé comme ayant l'un des types suivants de connexion au réseau:

1) Entrée de courant,
2) sortie de courant,
3) Entrée de tension,
4) Sortie de tension,
5) Secondaire,
6) Emetteur analogique,
7) Organe de commande,
8) Non isolé en courant continu, ou
9) Isolé en courant continu.

Un appareil peut présenter plusieurs caractéristiques parmi ces types de connexions. Il convient que le fabricant identifie les types de connexion pour lesquels l'appareil peut être configuré.

34.3.3.2 Entrée courant

Un appareil qui utilise une résistance pour mesure le signal de courant analogique est défini comme un appareil avec une connexion d'entrée de courant. La résistance de détection de courant peut soit être interne à l'appareil soit être connecté de manière externe. Dans un cas comme dans l'autre, la résistance de détection est considérée comme faisant partie de l'appareil, l'impédance d'un appareil d'entrée de courant devant être indiquée pour inclure cette résistance.

Les appareils d'entrée de courant peuvent comporter l'alimentation du réseau et fournir à la boucle une alimentation en courant continu. Si l'appareil peut utiliser une plage de valeurs de résistance de détection, au lieu d'une valeur fixe, les paramètres de l'appareil doivent alors être spécifiés en fonction de la valeur de résistance du capteur.

NOTE Les appareils d'entrée de courant ont une faible impédance et ne sont généralement pas isolés de la masse. L'exemple le plus courant d'un appareil d'entrée de courant est la connexion du contrôleur pour une boucle d'entrée analogique (une boucle avec un émetteur commun de 4 mA à 20 mA comme appareil de terrain).

34.3.3.3 Sortie de courant

Un appareil qui fournit le courant en tant que signal analogique est défini comme un appareil avec une connexion de sortie de courant. L'appareil de sortie de courant peut inclure l'alimentation du réseau et fournir à la boucle une alimentation en courant continu. Sinon, il peut être connecté en série avec une alimentation externe et ne contrôler que le courant de la boucle.

NOTE L'appareil de sortie de courant a une haute impédance. Ces appareils ne sont généralement pas isolés de la masse. On peut citer comme exemples d'appareil de sortie de courant la connexion du régulateur pour une boucle de sortie analogique (une boucle avec un organe de commande ou un positionneur commun de 4 mA à 20 mA comme appareil de terrain) ou un appareil de terrain alimenté séparément qui alimente la boucle en courant plutôt que de l'absorber de la boucle.

34.3.3.4 Entrée de tension

Un appareil qui mesure le signal d'entrée de courant est défini comme un appareil avec une connexion d'entrée de tension. Un appareil de ce type doit avoir une haute impédance d'entrée. Un appareil d'entrée de tension ne fournit pas à la boucle d'alimentation en courant continu, et peut ou peut ne pas être isolé de la masse.

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NOTE Une haute impédance d'entrée est nécessaire afin que la résistance dans la boucle du câble n'introduise pas une erreur dans le signal de tension. On peut citer comme exemples d'appareil d'entrée de tension la connexion du contrôleur pour une boucle d'entrée analogique où le signal analogique est une tension (par exemple, un émetteur de sortie de tension) ou un appareil de sortie alimenté séparément qui accepte la tension comme son signal d'entrée analogique plutôt que du courant.

34.3.3.5 Sortie de tension

Un appareil qui fournit le signal de sortie de tension est défini comme un appareil avec une connexion de sortie de tension. Un appareil de ce type doit avoir une faible impédance dans la gamme de fréquence numérique. Un appareil de sortie de tension ne fournit pas à la boucle d'alimentation en courant continu, et peut ou peut ne pas être isolé de la masse.

NOTE Une faible impédance de sortie est nécessaire afin que la résistance dans la boucle du câble n'introduise pas une erreur dans le signal de tension. Un émetteur de sortie de tension à 3 conducteurs constitue l'exemple le plus courant d'appareil de sortie de tension. Un contrôleur destiné à commander un appareil de terrain alimenté séparément en constitue un autre exemple. Un réseau avec une signalisation de tension analogique ne peut pas porter une alimentation en C.c. puisque cela entraîne une chute de tension dans le câblage de la boucle et une erreur inacceptable dans la signal analogique.

34.3.3.6 Secondaire

Un appareil qui a une connexion amovible, qui n'est pas nécessaire pour une communication sur le réseau et qui n'est raccordé que temporairement est défini comme un appareil secondaire. Un appareil secondaire doit avoir une haute impédance et être isolé en c.c. de la boucle de courant.

Il convient que l'analyse du réseau pour une longueur de câble maximale comporte l'appareil secondaire.

NOTE L'exemple le plus courant d'appareil secondaire est le terminal tenu dans la main.

34.3.3.7 Emetteur analogique

Un appareil qui extrait du courant continu de la boucle et fait varier la quantité de courant extraite comme moyen de signalisation analogique est défini comme un émetteur analogique. L'appareil peut utiliser le courant continu comme source d'alimentation ou peut être alimenté séparément.

NOTE L'émetteur analogique a une haute impédance et est généralement du courant continu isolé de la terre. On peut citer comme exemples de type d'émetteur analogique des émetteurs à 2 conducteurs ou des émetteurs alimentés séparément avec une interface de boucle qui tire du courant continu de la boucle.

34.3.3.8 Organe de commande

Un appareil qui tire du courant continu de la boucle à une valeur déterminée par l'appareil d'alimentation en courant est défini comme un organe de commande. L'appareil peut utiliser le courant continu comme source d'alimentation ou peut être alimenté séparément.

NOTE L'organe de commande a une faible impédance et est généralement du courant continu isolé de la terre. Les exemples les plus courants d'organes de commande sont les appareils à deux conducteurs qui reçoivent un signal analogique par l'intermédiaire d'un courant de boucle de 4 mA à 20 mA fourni par un contrôleur.

34.3.3.9 Non isolé en courant continu

Un appareil qui tire une valeur constante de courant continu de la boucle et n'utilise pas de signal analogique est comme un appareil Non isolé en courant continu. L'appareil peut utiliser le courant continu comme source d'alimentation ou peut être alimenté séparément. Il utilise un signal numérique pour la communication.

NOTE L'appareil non isolé en courant continu a une haute impédance et est généralement isolé en courant continu de la terre. Un émetteur de sortie à 2 conducteurs constitue l'exemple le plus courant de ce type d'appareil lorsqu'il est en mode .de courant fixe.

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34.3.3.10 Isolé en courant continu

Un appareil qui ne tire pas de courant continu de la boucle et n'utilise pas de signal analogique est comme un appareil isolé en courant continu. L'appareil a une alimentation séparée. Il utilise un signal numérique pour la communication.

NOTE L'appareil isolé en courant continu a une haute impédance. il est possible que les appareils de bus isolés en courant continu existent sur une boucle quelconque, y compris sur des boucles ayant une signalisation analogique, puisqu'elle n'a pas d'incidence sur le signal analogique. Un réseau est éventuellement construit avec tous appareils de ce type, autrement dit, avec des boucles n'ayant absolument aucune circulation de courant.

34.3.4 Paramètres de l'appareil

Un ou plusieurs paramètres définis dans le présent Tableau 174 s'appliquent à un appareil en fonction de son impédance et de son type de connexion.

Tableau 174 – Paramètres de l'appareil

Type d'appareil	Paramètre
Isolé en courant continu de la terre	Rtt minimal et Ctt maximal dans les conditions les plus défavorable d'un réseau non équilibré
Non isolé en courant continu de la terre	Rtt minimal et Ctt maximal tels que normalement connectés et une description de la référence de la terre
Appareil qui tire le courant continu de la boucle	La quantité de courant tiré et la tension minimale au niveau du terminal de l'appareil qui est nécessaire pour que l'appareil fonctionne
Appareil qui alimente la boucle en courant continu	Les valeurs minimale et maximale du courant alimenté et de la tension , et la tension de charge maximale à laquelle l'appareil peut fonctionner
L'appareil qui produit un signal analogique	Les valeurs minimale et maximale du courant alimenté et la tension minimale au niveau du terminal de l'appareil qui est nécessaire pour que l'appareil fonctionne
Appareil à faible impédance	Amplitudes d'impédance minimale et maximale dans la gamme de fréquence numérique

Les valeurs des paramètres applicables doivent être spécifiées par le fabricant de l'appareil.

34.4 Règles de configuration du réseau

Un appareil doit satisfaire aux exigences de la présente norme lorsqu'il est utilisé sur un réseau qui satisfait aux présentes règles.

Règle 1: Le réseau a au moins un appareil à faible impédance. L'impédance parallèle combinée de tous les appareils connectés doit se situer dans une plage comprise entre 170 Ω et 600 Ω.

NOTE 1 Le réseau peut avoir plusieurs appareils à faible impédance tant que l'impédance parallèle totale se situe dans la plage spécifiée ci-dessus.

Règle 2: Le réseau n'a qu'un seul appareil de signalisation analogique.

NOTE 2 Plus d'un appareil de signalisation analogique dans un réseau provoque une interférence entre les deux signaux analogiques, le rendant ainsi inefficace.

Règle 3: Un appareil secondaire est raccordé au réseau.

Règle 4: Un réseau point à point avec un maître primaire.

Règle 5: Le câble pour un réseau point à point a une capacité de 150 pF par mètre, une résistance de 0,05 Ω par mètre, la longueur de 1 200 m et une capacité d'appareil totale – C_{dev} de tous les appareils de 5 000 pF.

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NOTE 3 La longueur du câble est l'exigence pour l'essai de conformité mais n'exclut pas l'utilisation de longueurs supérieures dans un système installé.

Règle 6: L'appareil indiqué pour un réseau multipoints raccordé à un réseau avec 16 appareils

NOTE 4 Cette limite a été déduite par les calculs de bruit. Cette règle n'exclut pas l'utilisation d'un nombre d'appareils supérieur à celui spécifié dans un réseau installé. Le nombre maximal d'appareils connectés à un réseau dépend de la longueur du câble, de l'environnement de bruit et de la disponibilité de l'alimentation en courant continu nécessaire au niveau de la borne de l'appareil.

Règle 7: Le câble pour un réseau point à point a une capacité de 400 pF par mètre, une résistance de 0,0368 Ω par mètre, la longueur de 500 m et une capacité d'appareil totale – C_{dev} de tous les appareils de 25 000 pF.

NOTE 5 La longueur du câble est l'exigence pour l'essai de conformité mais n'exclut pas l'utilisation de longueurs supérieures dans un réseau installé.

Les règles de configuration du réseau sont pour l'essai de conformité d'un appareil. Le réseau peut être installé avec plusieurs topologies. L'Article T.1 présente quelques-unes de ces topologies.

Les lignes directrices pour les longueurs de câble sont données en T.2.

34.5 Spécifications de l'émetteur numérique

34.5.1 Configuration d'essai

La Figure 161 illustre la configuration qui doit être utilisée pour les essais. La Figure 161 (a), ‘Emetteur analogique’ est un exemple d'appareil soumis à un essai. A la Figure 161 (b) soit la ‘Sortie de courant’ soit l'‘Organe de commande’ peut être l'appareil soumis à un essai. La configuration d'essai doit être similaire pour un appareil soumis à un essai des autres types définis en 34.3.3. Tous les appareils doivent être soumis à un essai en utilisant cette configuration d'essai et des paramètres d'émetteur numérique doivent être mesurés sur toute la charge d'essai.

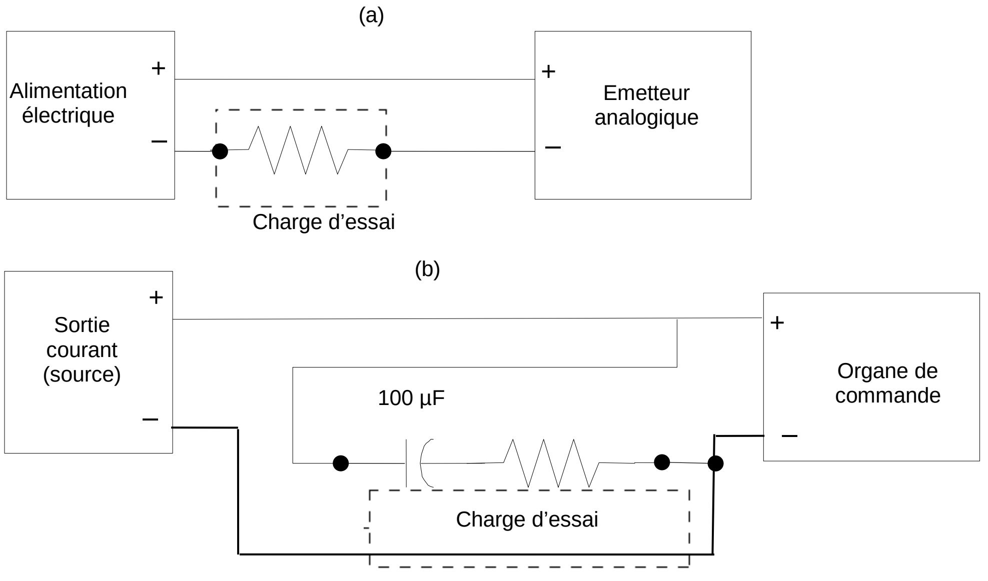

Figure 161 – Configuration de l'essai de transmission

Dans certains cas, il est nécessaire d'empêcher le courant continu de circuler à travers la charge d'essai. Quand cela est nécessaire, il convient de placer en série un condensateur de

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verrouillage en c.c. de 100 microfarads avec la charge d'essai tel que représenté à la Figure 161 (b).

Dans le cas d'un appareil de signalisation analogique tel qu'un émetteur analogique ou un appareil de sortie de courant, la charge d’essai peut aussi servir d'impédance de détection de courant.

La valeur de la partie de la résistance de la charge d’essai doit être:

– 1 000 Ω pour un appareil à faible impédance, et
– 500 Ω pour un appareil à haute impédance.

34.5.2 Débit binaire et modulation

Le débit binaire doit être de 1 200 bit/s ± 1%. L'appareil doit soit moduler le courant extrait soit appliquer la tension sur le support. Tous les signaux apparaissent comme de la tension lorsqu'ils sont détectés sur une charge à faible impédance. La technique de modulation doit être une modulation par déplacement de fréquence à phase continue, c'est-à-dire que l'angle de phase du repère et l'Espace doivent rester continus aux limites binaires. La fréquence du Repère (logique 1) doit être de 1 200 Hz ± 1%; la fréquence pour l'Espace (logique 0) doit être de 2 200 Hz ± 1%.

34.5.3 Amplitude

La Figure 162 présente un exemple de la composante alternative d'un cycle des formes d'onde Repère et Espace, illustrant quelques points clés des spécifications du circuit de transmission. Seules les tensions des signaux sont indiquées; ce schéma ne tient aucunement compte des tensions d'alimentation. Les limites d'amplitude de transmission sont résumées dans le Tableau 175.

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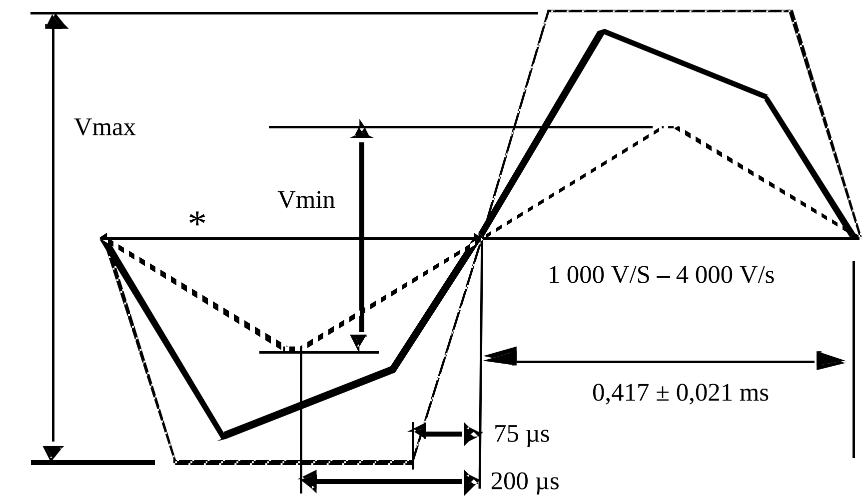
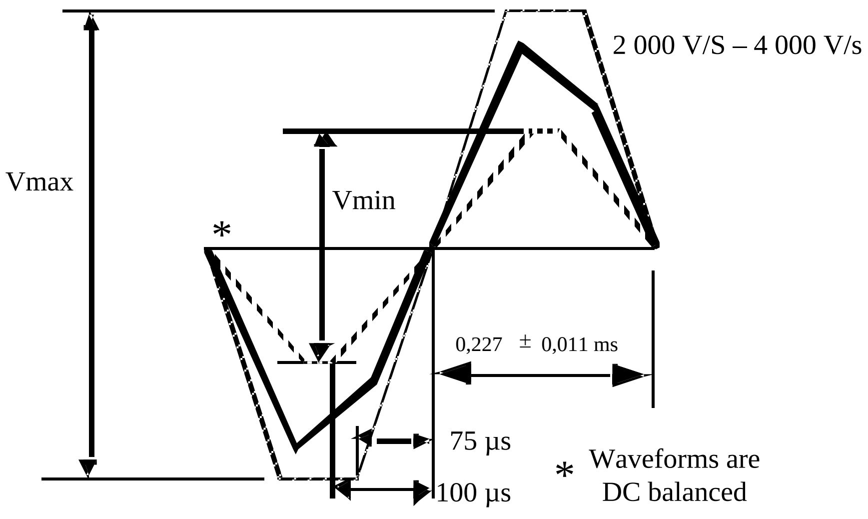


1 200 Hz transmit waveform limits



2 200 Hz transmit waveform limits

Légende

Anglais	Français
1200 Hz transmit waveform limits	Limites de la forme d'onde de transmission de 1200 Hz
Waveforms are DC balanced	Les formes d'onde sont symétriques au c.c.
2200 Hz transmit waveform limits	Limites de la forme d'onde de transmission de 2200 Hz

Figure 162 – Forme d'onde de transmission

Tableau 175 – Limites d'amplitude de transmission

Impédance de l'appareil	Vmin – Niveau minimal crête à crête	Vmax – niveau maximal crête à crête	Charge d'essai
Faible	400 Mv	800 mV	1 000 Ω ± 1%
Elevée	400 Mv	600.mV (voir texte)	500 Ω ± 1%

La tension de sortie d'un appareil à faible impédance doit être comprise entre 400 mV et 800 mV de crête à crête, avec une résistance de charge de 1 000 Ω ± 1%.

La tension de sortie d'un appareil à haute impédance doit être

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a) Soit, entre 400 mV et 600 mV crête à crête, avec une résistance de charge de 500 Ω ± 1 %,

b) Soit entre 400 mV et 800 mV crête à crête, avec une résistance de charge de 500 Ω ± 1 % et inférieur ou égale à 800 mV crête à crête avec une résistance de charge de 1 000 Ω ± 1 %.

34.5.4 Synchronisation

Tel qu'illustré à la Figure 162, la forme d'onde de transmission d'un appareil doit être conforme à la synchronisation suivante.

a) Les temps de croissance et de décroissance, mesurés d'une crête à la crête suivante doivent être supérieurs ou égaux à 150 µs.

b) Les temps de croissance et de décroissance, mesurés d'une crête à la crête suivante pour le Repère doivent être inférieurs ou égaux à 400 µs.

c) Les temps de croissance et de décroissance, mesurés d'une crête à la crête suivante pour l'Espace doivent être inférieurs ou égaux à 200 µs.

d) Le taux de dérive pour le Repère doit être compris entre 1 000 V/s et 4 000 V/s.

e) Le taux de dérive pour l'Espace doit être compris entre 2 000 V/s et 4 000 V/s.

Tel qu'illustré à la Figure 163, à la Figure 164 et à la Figure 165, la porteuse doit être conforme à la synchronisation suivante.

f) Temps de démarrage de la porteuse

Le circuit de transmission doit s'activer, ce qui signifie que le signal doit monter d'un niveau passif au niveau de transmission minimal requis spécifié en 34.5.3, en moins de cinq (5) temps binaires nominaux.

g) Temps d'arrêt de la porteuse

Après l'émission du dernier bit, le circuit de transmission doit se désactiver, ce qui signifie que le signal doit descendre en dessous du niveau de réception minimal requis spécifié en 34.6, en moins de trois (3) temps binaires nominaux.

NOTE 1 Le niveau de réception minimal requis est de 120 mV crête à crête.

h) Temps de décroissance de la porteuse

Après l'émission du dernier bit, le circuit de transmission doit se désactiver, et le signal doit descendre en dessous du niveau de bruit maximal acceptable spécifié en 34.6, en moins de six (6) temps binaires nominaux.

Le niveau de bruit maximal acceptable est de 80 mV crête à crête.

NOTE 2 Les spécifications de temps de démarrage, d'arrêt et de décroissance de la porteuse sont telles qu'il maintient l'interférence par rapport au signal analogique à un niveau acceptable. Ces synchronisations sont telles que lorsqu'on fait passer la forme d'onde du signal analogique, utilisant une charge d'essai de 250 Ω, à travers un filtre passe-bas à 2 pôles de 25 Hz, la sortie du filtre n'excède à aucun moment 10 mV. La réponse en amplitude de ce filtre est la même que celle du spectre du signal analogique spécifié en 34.7.1.

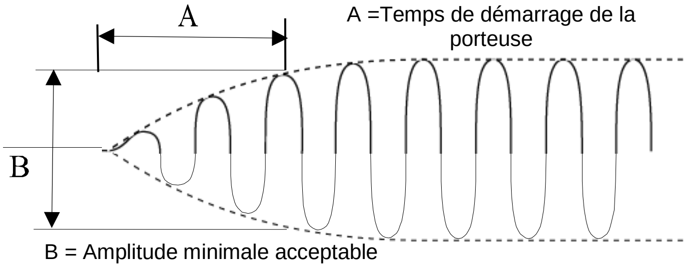

Figure 163 – Temps de démarrage de la porteuse

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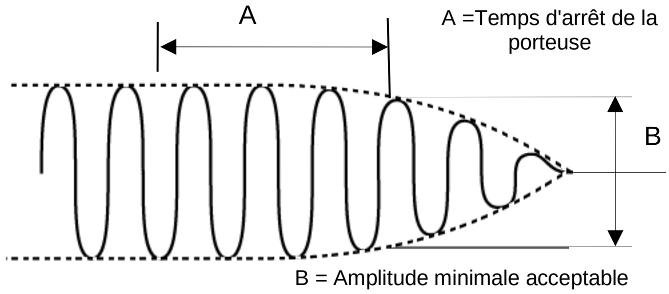


Figure 164 – Temps d'arrêt de la porteuse

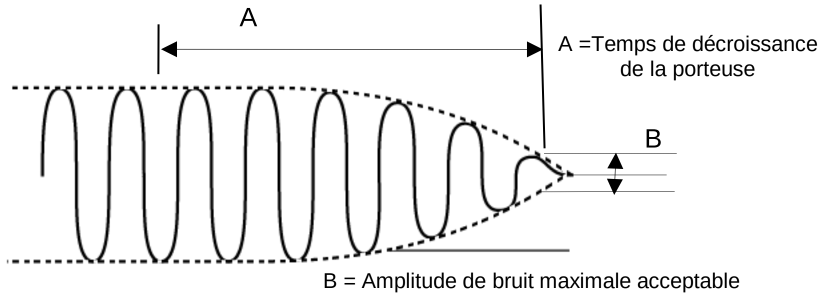
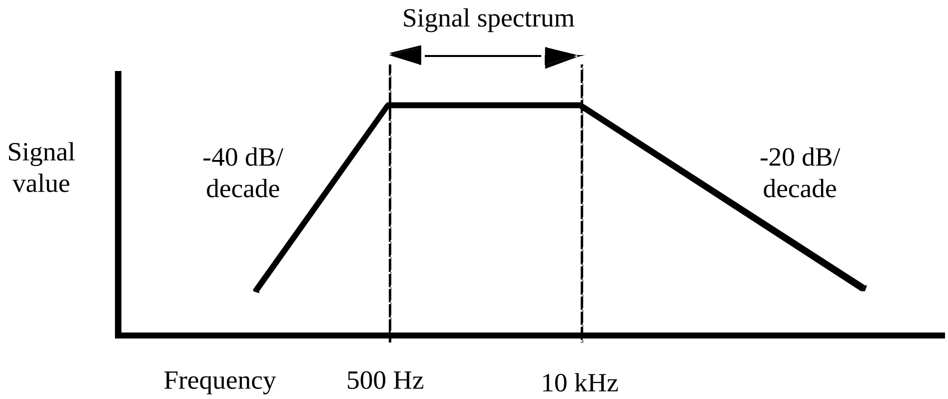


Figure 165 – Temps de décroissance de la porteuse

34.5.5 Spectre de signal numérique

Le spectre de signalisation numérique est défini comme les fréquences allant de 500 Hz à 10 kHz telles que définies en 3.12.13 et illustrées à la Figure 166. Il décroit à une vitesse de 40 dB par décade au-dessous de 500 Hz et de 20 dB par décade au-dessus de 10 kHz.



Légende

Anglais	Français
Signal spectrum	Spectre du signal
Signal value	Valeur du signal
-40 dB/ decade	-40 dB/ décade
-20 dB/decade	-20 dB/décade
Frequency	Fréquence

Figure 166 – Spectre de signal numérique

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NOTE Il n'y a pas d'essai de conformité pour le spectre de signal numérique. Si l'appareil est conforme à la synchronisation spécifiée en 34.5.4, alors le spectre devrait être tel que représenté.

34.6 Spécifications du récepteur numérique

Les spécifications du récepteur numérique sont résumées dans le Tableau 176. La Figure 167 montre les exigences pour la tolérance des interférences.

Tableau 176 – Spécifications du récepteur numérique

Paramètres du circuit du récepteur	Condition d'essai	Limites
Sensibilité – signal minimum crête-à crête dont l'acceptation est exigée		120 mV
Suppression du bruit –signal maximum crête à crête dont le rejet est exigé		80 mV
Signal maximum crête à crête dont l'acceptation est exigée	Appareil à haute impédance soumis à un essai	1 500 mV
Signal maximum crête à crête dont l'acceptation est exigée	Appareil à faible impédance soumis à un essai	800 mV
Taux d'erreurs maximal	Niveau de signal de 200 mV crête à crête, bruit Gaussien ajouté de densité constante de 163 microvolts/racine Hz sur la gamme de fréquence étendue, séquence binaire pseudo-aléatoire	1 sur (10 000 bits)
Interférences en mode commun dans la bande avec aucune dégradation des performances du récepteur – voir note	Bande de Fréquence étendue, c'est-à-dire 500 Hz à 10 kHz	200 mV crête à crête
Interférences en mode normal dans la bande avec aucune dégradation des performances du récepteur	Bande de Fréquence étendue, c'est-à-dire 500 Hz à 10 kHz	55 mV crête à crête
Interférences en mode commun sous la bande avec aucune dégradation des performances du récepteur – voir note	47 Hz à 500 Hz	2 V crête à crête
Interférences en mode normal hors bande avec aucune dégradation des performances du récepteur	0 Hz à 500 Hz 10 kHz à 1 MHz	Voir la Figure 167
NOTE Les exigences du mode commun ne s'appliquent qu'aux appareils qui ont tous des entrées flottantes par rapport à la terre.		

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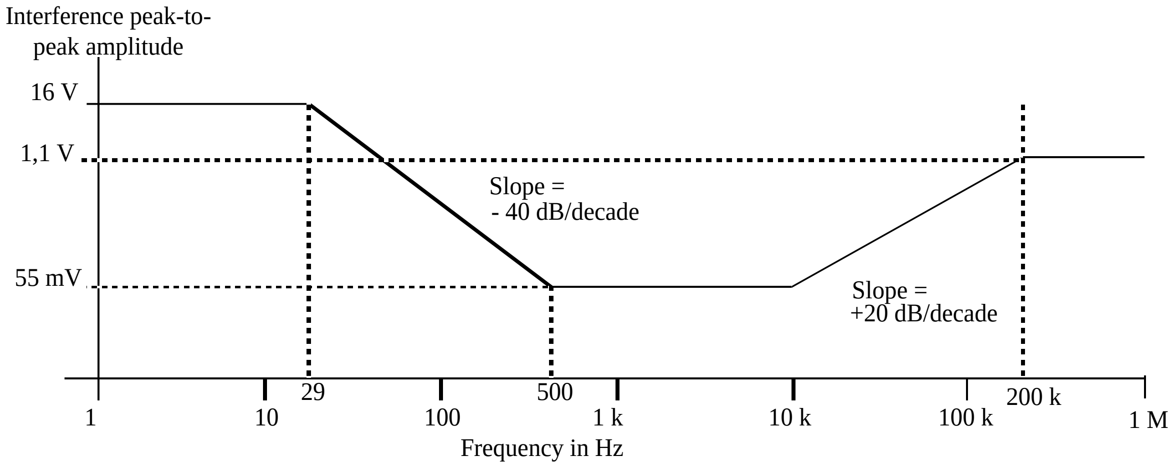

Légende

Anglais	Français
Interference peak-to-peak amplitude	Interférence d'amplitude crête à crête
Slope = -40 dB/decade	Pente = -40 dB/décade
Slope = +20 dB/decade	Pente = +20 dB/décade
Frequency in Hz	Fréquence en Hz

Figure 167 – Interférences du récepteur numérique

Le circuit de réception doit être capable de recevoir un signal d'entrée d'une amplitude d'au moins 120 mV crête à crête, y compris la surtension et l'oscillation. Le circuit de réception ne doit pas répondre à un signal d'entrée d'amplitude crête à crête non supérieur à 80 mV. Le récepteur doit fonctionner sans erreurs, avec le niveau de signal d'entrée crête à crête suivant:

– 1 500 mV à l'entrée de l'appareil à haute impédance,
– 800 mV à l'entrée de l'appareil à faible impédance.

Le récepteur doit fonctionner sans dégradation de ses performances (pas plus d'une erreur sur 10 000 bits) en présence d'une tension en mode commun ou d'interférences comme suit:

a) un signal sinusoïdal en mode commun d'une fréquence quelconque comprise entre 500 Hz et 10 kHz avec une amplitude de 200 mV crête à crête;
b) un signal sinusoïdal en mode normal d'une fréquence quelconque comprise entre 500 Hz et 10 kHz avec une amplitude de 55 mV crête à crête;
c) un signal sinusoïdal en mode commun d'une fréquence quelconque comprise entre 47 Hz et 500 Hz avec une amplitude de 2 V crête à crête;
d) une interférence de signal sinusoïdal en mode normal d'une fréquence quelconque en-dessous de 29 Hz avec une amplitude de 16 V crête à crête;
e) et spécifié pour quelques fréquences ci-dessous:
   – à 63 Hz, 3,52 V crête à crête,
   – à 125 Hz, 880 mV crête à crête,
   – à 250 Hz, 220 mV crête à crête.

NOTE L'interférence due au signal analogique pour un appareil à faible impédance est une impédance x 16 mA. La valeur maximale de cette impédance est de 600 Ω. En conséquence, l'interférence maximale due au signal analogique au-dessus de zéro jusqu'à 25 Hz est de 9,6 V.

Le récepteur avec un signal d'entrée de 200 mV crête à crête et une séquence binaire pseudo-aléatoire ne doit pas produire plus d'une erreur de trame détecté sur 10 000 bits

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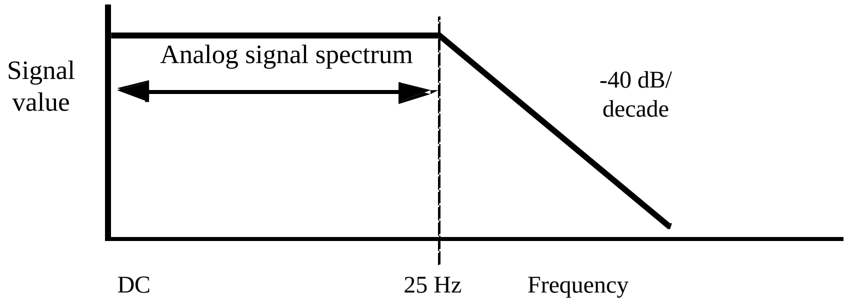
pendant son fonctionnement en présence de bruit gaussien d'une densité constante de 163 microvolts/racine Hz au-dessus de la bande de fréquence étendue.

34.7 Signalisation analogique

34.7.1 Spectre de signal analogique

Le spectre de signal analogique est défini comme les fréquences de courant continu à 25 Hz décroissant à une vitesse de 40 dB par décade au-dessus de 25 Hz.



Légende

Anglais	Français
Signal value	Valeur du signal
Analog signal spectrum	Spectre du signal analogique
-40 dB/ decade	-40 dB/ décade
Frequency	Fréquence

Figure 168 – Spectre de signal analogique

L'appareil qui produit un signal analogique doit être conforme au spectre de fréquences représenté à la Figure 168.

NOTE Cette spécification ne définit pas un type de signal analogique et des valeurs de signal, mais elle définit le spectre de fréquences. Ceci est réalisé de façon à ce que le signal analogique ne perturbe pas le signal numérique défini dans la présente spécification. Le signal analogique est la sortie de courant ou de tension.

34.7.2 Interférences par rapport au signal numérique

Les modifications du signal analogique doivent être telles que lorsqu'on applique un signal analogique à une charge de 500 Ω ± 1% pour un appareil à haute impédance ou une charge de 1 000 Ω ± 1% pour un appareil à faible impédance, et qu'il est filtré à travers le filtre d'essai numérique, la tension de crête instantanée au niveau de la sortie du filtre doit être inférieure ou égale à 15 mV.

Le filtre d'essai numérique est un filtre passe-bas Butterworth avec une bande passante de 500 Hz à 10 kHz, raccordement de second ordre au-dessous de 500 Hz, et raccordement de premier ordre au-dessus de 10 kHz.

NOTE 1 Cette spécification est telle que le signal analogique généré par un appareil de signalisation analogique (c'est-à-dire un émetteur analogique ou un appareil de sortie de courant) ne perturbe pas le signal numérique.

NOTE 2 Le filtre d'essai numérique a la même réponse en amplitude que le spectre de signal numérique spécifié en 34.5.5.

Il convient que les appareils d'entrée analogique, tels que les entrées de courant et les organes de commande filtrent le signal analogique avec un filtre passe-bas dans les limites du spectre de signalisation analogique définies ci-dessus, pour éviter des interférences en provenance du signal numérique.

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34.8 Impédance de l'appareil

34.8.1 Appareil à haute impédance

Il convient que l'appareil à haute impédance ait une impédance aussi élevée que possible. Les valeurs recommandées mesurées au-dessus de la bande de fréquence numérique sont représentées dans le Tableau 177. Il convient que l'appareil autoalimenté et alimenté par bus ait la haute impédance recommandée.

Tableau 177 – Caractéristiques des appareils à haute impédance

Paramètre	Condition d'essai	Valeur
Capacité pour un appareil équivalent – C_{dev}	Pas de transmission en cours	5 000 pF max.
Résistance d'appareil équivalent – R_{dev}	Pas de transmission en cours	100 kΩ min.

Les appareils polarisés doivent présenter la même impédance élevée ou une impédance supérieure lorsqu'ils sont connectés sur la tension de polarité inversée comme lorsqu'il est connecté avec la tension de polarité correcte. L'appareil autoalimenté doit présenter la même impédance élevée ou une impédance supérieure lorsqu'il n'est pas alimenté comme lorsqu'il est alimenté.

34.8.2 Appareil à faible impédance

L'appareil à faible impédance doit avoir l'impédance comme décrit dans le Tableau 178.

Tableau 178 – Caractéristiques des appareils à faible impédance

Paramètre	Condition d'essai	Limites
Impédance borne à borne – Z_{tt}	Pas de transmission en cours	230 Ω à 600 Ω
Impédance borne à borne – Z_{tt}	Transmission en cours	230 Ω à 600 Ω

L'impédance de borne à borne, sans inclure la résistance de détection de courant, mesurée au-dessus de la bande de fréquence numérique doit être:

– dans la plage comprise entre 230 Ω et 600 Ω lorsqu'aucune émission n'est en cours,

– L'impédance au-dessus de la bande de fréquence étendue, dans une marge qui se situe entre ± 3 dB de la valeur mesurée au-dessus de la bande de fréquence numérique.

– dans la plage de 230 Ω à 600 Ω lorsqu'une transmission est en cours et inférieure ou égale à la valeur mesurée lorsqu'aucune émission n'est en cours.

L'impédance doit être mesurée sans utiliser la charge d'essai tel que spécifié en 34.5.3.

34.8.3 Appareil secondaire

L'appareil secondaire doit avoir l'impédance comme décrit dans le Tableau 179.

Tableau 179 – Caractéristiques des appareils secondaires

Paramètre	Condition d'essai	Limites
Impédance borne à borne – Z_{tt}	Pas de transmission en cours	5 kΩ min.
Résistance borne à borne – R_{tt}	Transmission en cours	Voir texte ci-dessous
Capacité de borne à terre – C_{tg}	Toutes les conditions	250 pF max.
Résistance de borne à terre – R_{tg}		100 kΩ min.

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L'impédance borne à borne de l'appareil secondaire mesurée au-dessus de la bande de fréquence numérique doit être:

– lorsqu'aucune transmission n'est en cours, un minimum de 5 kΩ,
– lorsqu'une transmission est en cours, inférieure ou égale à la valeur mesurée lorsqu'aucune transmission n'est en cours.

La capacité borne à terre de l'appareil secondaire mesurée au-dessus de la bande de fréquence numérique doit être inférieure ou égale à 250 pF.

La résistance borne à terre de l'appareil secondaire mesurée au-dessus de la bande de fréquence numérique doit être supérieure ou égale à 100 kΩ.

Les appareils polarisés doivent présenter la même impédance élevée ou une impédance supérieure lorsqu'ils sont connectés sur la tension de polarité inversée comme lorsqu'il est connecté avec la tension de polarité correcte.

34.9 Interférences par rapport au signal analogique et numérique

34.9.1 Connexion ou déconnexion des appareils secondaires

Lorsqu'un appareil secondaire est connecté au réseau ou déconnecté de celui-ci, les transitoires sur le support doivent être tels que

– la valeur de crête est inférieure ou égale au courant du signal analogique de 160 uA (1 % de la fourchette) moyennée sur 10 ms,
– les interférences sur le signal numérique doivent satisfaire aux exigences de 34.7.2.

34.9.2 Connexion cyclique

Quand une faible impédance est connectée au réseau ou déconnecté de celui-ci, les transitoires sur le support doivent être tels que

– la valeur de crête est inférieure ou égale au courant du signal analogique de 160 uA (1 % de la fourchette) moyennée sur 10 ms,
– les interférences sur le signal numérique doivent satisfaire aux exigences de 34.7.2.

34.9.3 Sortie pendant le silence

Pendant le silence, la tension de sortie de l'appareil, moyennée sur 1 s ou plus, doit contenir moins de 2,2 mV efficace de bruit à large bande ou corrélé combiné dans la bande de fréquence étendue tel que représenté ci-dessous à la Figure 169. Pour des appareils pouvant supporter une signalisation analogique, cette exigence doit s'appliquer pendant qu'il est réglé pour produire un courant de sortie analogique constant.

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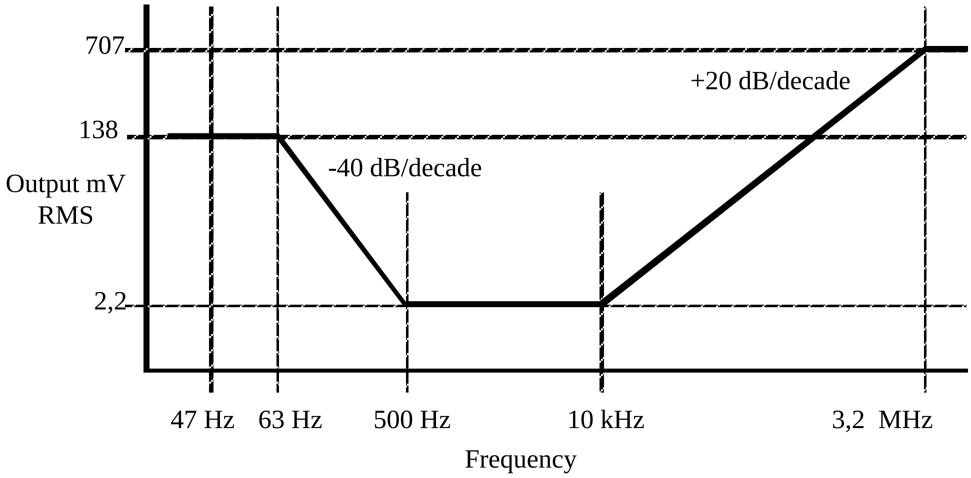

Légende

Anglais	Français
+20 dB/decade	+20 dB/décade
Output mV RMS	Sortie mV eff.
-40 dB/decade	-40 dB/décade
Frequency	Fréquence

Figure 169 – Sortie pendant le silence

NOTE Le bruit sinusoïdal crête-à crête est égal à la valeur de 2,8 x la valeur efficace. Le bruit blanc crête-à crête est environ égal à 6 x la valeur efficace.

34.10 Appareils ne communiquant pas

34.10.1 Alimentation réseau

L'alimentation réseau fournit au réseau une alimentation en CC. Si l'alimentation est destinée à être utilisée avec des fusibles externes ou des résistances externes de limite de courant, l'alimentation doit être soumise à un essai avec ces composants externes. Les exigences d'alimentation du réseau sont indiquées dans le Tableau 180 et à la Figure 170.

Tableau 180 – Caractéristiques d'alimentation du réseau

Paramètre	Condition d'essai	Limites
Ondulation	47 Hz à 63 Hz à toutes les charges assignées	138 mV valeurs efficaces max.
Ondulation	94 Hz à 126 Hz à toutes les charges assignées	35 mV valeurs efficaces max.
Bruit	Bande de fréquence étendue à toutes les charges assignées	2,2 mV valeurs efficaces max.
Bruit	Hors de la fréquence étendue à toutes les charges assignées	Voir Figure 170
Amplitude d'impédance	Bande de fréquence étendue à toutes les charges assignées	10 Ω max.

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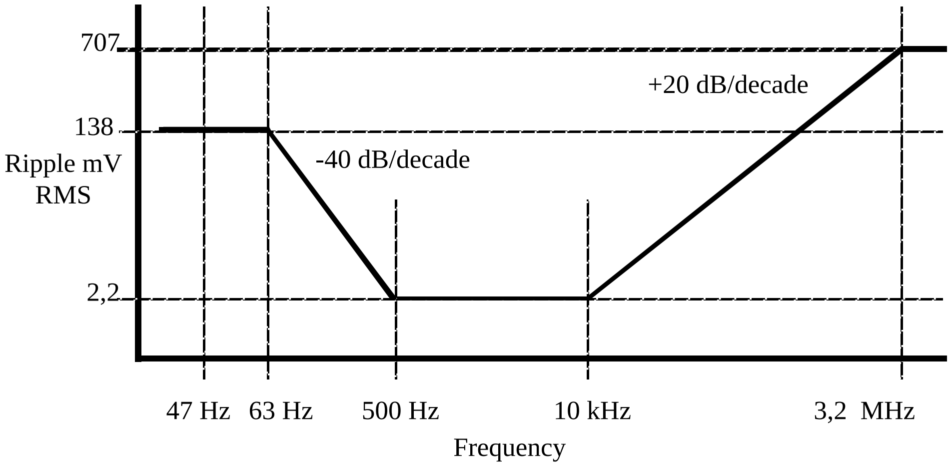

Légende

Anglais	Français
+20 dB/decade	+20 dB/décade
Ripple mV RMS	Ondulation mV eff.
-40 dB/decade	-40 dB/décade
Frequency	Fréquence

Figure 170 – Ondulation de l'alimentation réseau

NOTE Le bruit sinusoïdal crête à crête est égal à 2,8 x la valeur efficace. Le bruit blanc crête à crête est environ égal à 6 x la valeur efficace.

Pour des applications de sécurité intrinsèque, il convient que la tension et la barrière d'alimentation du réseau soient sélectionnées et fonctionnent de telle sorte qu'une tension en courant alternatif atteignant 1,4 volts de crête à crête puisse être superposée sur le courant continu du côté dangereux (réseau) de la barrière.

La connexion de l'alimentation du réseau est représentée à la Figure T.28. Les recommandations en matière de mise à la terre et de blindage sont indiquées en T.4.

34.10.2 Barrière

La barrière est caractérisée par son impédance, l'affaiblissement et la distorsion de retard du signal numérique lorsqu'il passe à travers la barrière.

L'impédance de sortie de barrières de sécurité intrinsèque doit être définie en termes de caractéristiques en fonction de la fréquence lorsque la barrière est connectée au circuit d'essai de la Figure 171, de la Figure 172 et de la Figure 173. La partie réelle de l'impédance mesurée doit être comprise entre 230 Ω et 600 Ω. La partie imaginaire de l'impédance mesurée doit être compris entre (-350) Ω et 350 Ω. Les fréquences d'essai doivent être:

– 200 Hz, 500 Hz, 950 Hz, 1,6 kHz, 2,5 kHz, 5,0 kHz et 10,0 kHz pour les barrières spécifiées à utiliser avec l'appareil à faible impédance.
– 500 Hz, 950 Hz, 1,6 kHz, 2,5 kHz, 5,0 kHz, 10,0 kHz, 20 kHz et 50 kHz pour les barrières spécifiées à utiliser avec l'appareil à haute impédance.

La distorsion d'affaiblissement et de retard du signal numérique doit également être mesurée lorsqu'elle est connectée dans des circuits d'essai de la Figure 171, de la Figure 172 et de la Figure 173. Les exigences sont résumées dans le Tableau 181.

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Tableau 181 – Caractéristiques de la barrière

Paramètre	Condition d'essai	Limites
Tension de sortie provenant du côté dangereux vers le côté sûr	Figure 171, fréquences lors des essais	185 mVpp min. 800 mVpp max.
Tension de sortie provenant du côté dangereux vers le côté sûr	Figure 172, fréquences lors des essais	135 mVpp min. 400 mVpp max.
Tension de sortie provenant du côté sûr vers le côté dangereux	Figure 173, fréquences lors des essais	270 mVpp min. 400 mVpp max.
distorsion de retard	Bande de fréquences numérique	50 µs max.

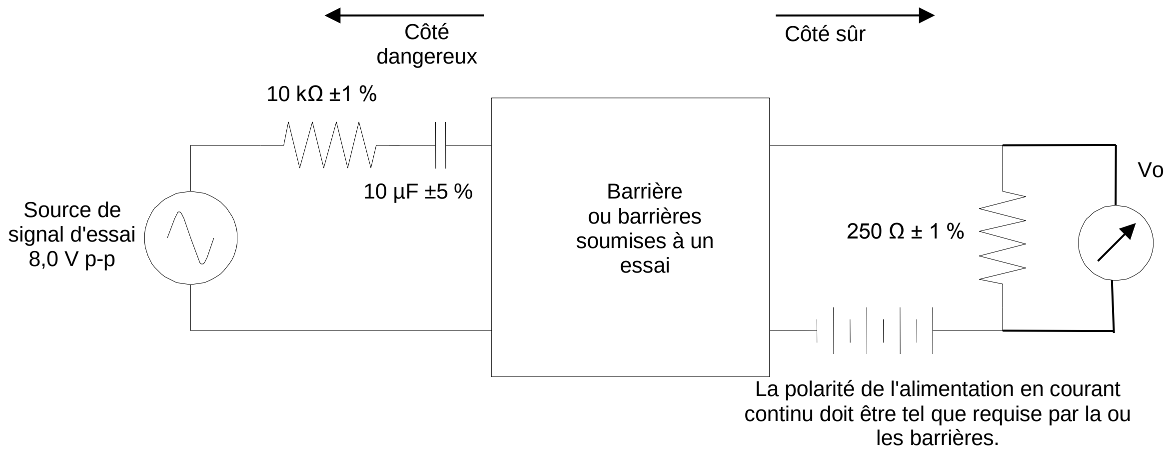

Figure 171 – Circuit d'essai de barrière A

Pour l'essai indiqué à la Figure 171, la source de signal d'essai doit être réglée sur 8,0 V crête à crête sur le côté dangereux et la sortie doit être mesurée sur toute la résistance de 250 Ω ±1 % sur le côté sûr. La tension de sortie doit être comprise entre 185 mV et 800 mV crête à crête aux fréquences d'essai.

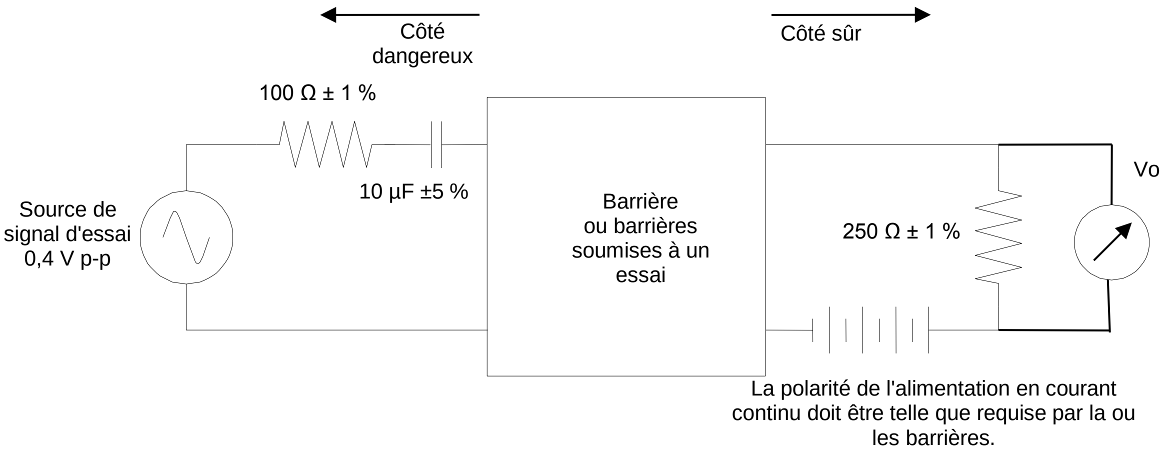

Figure 172 – Circuit d'essai de barrière B

Pour l'essai indiqué à la Figure 172, la source de signal d'essai doit être réglée sur 0,4 V crête à crête sur le côté dangereux et la sortie doit être mesurée sur toute la résistance de

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250 Ω ±1 % sur le côté sûr. La tension de sortie doit être comprise entre 135 mV et 400 mV crête à crête aux fréquences d'essai.

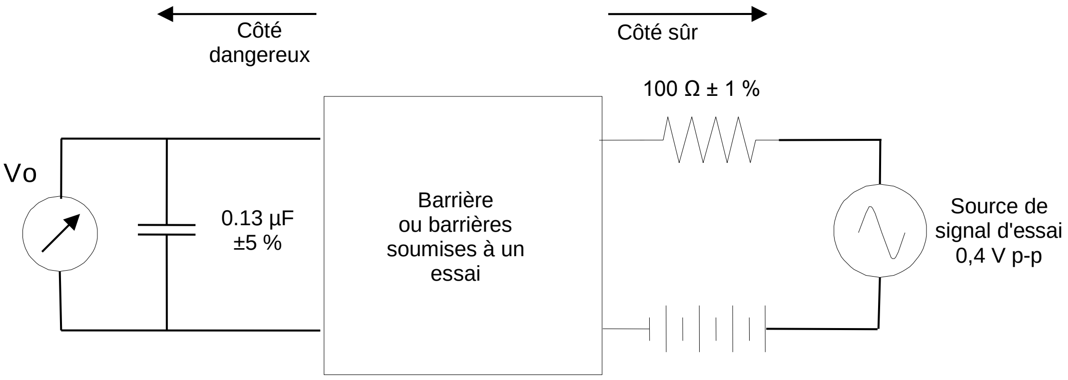

Figure 173 – Circuit d'essai de barrière C

Pour l'essai indiqué à la Figure 173, la source de signal d'essai doit être réglée sur 0,4 V crête à crête sur le côté sûr et la sortie doit être mesurée sur tout le condensateur de 0,13 µF ± 5 % sur le côté dangereux. La tension de sortie doit être comprise entre 270 mV et 400 mV crête à crête aux fréquences d'essai.

La connexion de l'alimentation du réseau et des barrières est représentée à la Figure T.28.

34.10.3 Matériel divers

Le matériel divers est connecté en série sur un appareil de terrain ou en parallèle avec des appareils de terrain selon sa fonction. Le matériel divers ne doit pas être raccordé en série avec une alimentation réseau de telle sorte qu'il devienne un élément commun à deux ou plusieurs réseaux partageant la même alimentation. Le matériel divers ne doit pas être raccordé entre le réseau et la masse. Les exigences sont résumées dans le Tableau 182. Certaines des caractéristiques comme décrites en Tableau 183 sont fournies à titre de recommandations mais ne sont pas requises pour la conformité à la présente norme.

NOTE 1 Les limites de paramètre recommandées sont spécifiées afin que les réseaux puissent être mis en application à l'aide de longueurs de câbles supérieures.

Tableau 182 – Caractéristiques requises du matériel divers

Paramètre	Condition d'essai	Limites
Résistance à la terre	Bande de fréquences étendue	100 kΩ min.
Relais à dérivée de matériel raccordé en série	Bande de fréquences étendue	±5 Ω par ms max.
Relais à dérivée de matériel raccordé en série en parallèle	Bande de fréquences étendue	±5 kΩ par ms max.
Interférence ou bruit à large bande ou corrélés	Bande de fréquences étendue, charge de 500 Ω	2,2 mV eff. max. en moyenne sur 1 s ou plus

NOTE 2 Il est possible qu'un réseau accueille plus d'un composant de matériel divers sous réserve que les caractéristiques électriques des appareils combinés soient compris dans les limites indiquées dans le Tableau 183.

Le matériel divers doit faire l'objet d'essai d'impédance dans la bande de fréquences étendue. Sa résistance à la terre utilisée doit être d'au moins 100 kΩ. Si le matériel est destiné à être raccordé en série avec un appareil de terrain, il convient alors que son impédance soit

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inférieure ou égale à 100 Ω et la vitesse de variation de son impédance doit être inférieure ou égale à ±5 Ω par ms. Si le matériel est destiné à être raccordé en parallèle avec des appareils de terrain, il convient alors que son impédance soit supérieure ou égale à 10 kΩ et la vitesse de variation de son impédance doit être inférieure ou égale à ±5 kΩ par ms. Il convient que la capacité à la masse soit inférieure ou égale à 1 000 pF. L'interférence ou le bruit à large bande ou corrélés doit être inférieur ou égale à 2,2 mV eff. avec une charge de 500 Ω, pour les valeurs moyennes durant 1s ou plus.

Tableau 183 – Caractéristiques recommandées du matériel divers

Paramètre	Condition d'essai	Limites
Capacité à la masse	Bande de fréquences étendue	1 000 pF max.
Impédance de matériel raccordé en série	Bande de fréquences étendue	100 Ω max.
Impédance de matériel raccordé en parallèle	Bande de fréquences étendue	10 kΩ min.

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Annexe A
(normative)

Type 1: Spécifications des connecteurs

A.1 Connecteur interne pour support câblé

Un connecteur de bus de terrain qui se trouve à l'intérieur de l'enveloppe de l'appareil de bus de terrain et qui, par conséquent, ne nécessite aucune protection contre l'environnement électromagnétique et physique, doit être spécifié comme un connecteur interne. Un connecteur interne doit satisfaire aux exigences fonctionnelles suivantes:

a) marqué distinctement afin d'éviter l'inversion des conducteurs;

b) auto-verrouillage avec une force d'extraction minimale de 50 N une fois verrouillé;

c) l'installation sur le terrain au moyen d'outils manuels doit être possible;

d) le côté fixe (appareil) doit disposer de languettes mâles de 4,8 mm × 0,8 mm avec orifice, comme illustré à la Figure A.1, dans le Tableau A.1 et comme spécifié dans la CEI 61210;

e) chaque conducteur du câble doit être terminé par un connecteur femelle à verrouillage disposant d'un manchon d'isolation ou d'un boîtier;

f) le connecteur femelle avec manchon d'isolation ou boîtier doit entrer dans un orifice d'un diamètre de 9,5 mm.

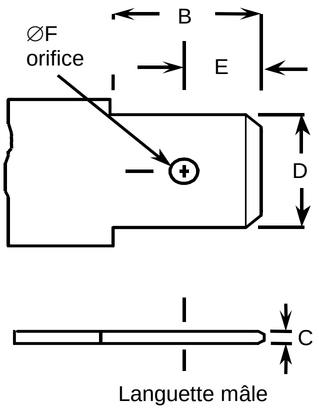

Figure A.1 – Connecteur de bus de terrain interne

Tableau A.1 – Dimensions de connecteur interne

Languette de 4,8 mm (0,187 in)				
	Millimètres		Pouces	
	Max.	Min.	Max.	Min.
B	6,5	6,2	0,256	0,244
C	0,84	0,77	0,033	0,030
D	4,9	4,7	0,193	0,185
E	3,4	3,0	0,134	0,117
∅ F	1,5	1,3	0,060	0,050

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A.2 Connecteurs externes pour support de transmission à base de câbles

Un connecteur de bus de terrain qui se trouve à l'extérieur de l'enveloppe de l'appareil de bus de terrain et qui nécessite par conséquent une protection contre l'environnement électromagnétique et physique, doit être spécifié comme un connecteur externe.

Il est spécifié deux connecteurs externes en fonction de l'environnement d'installation.

A.2.1 Connecteur externe pour environnements industriels rigoureux

Un connecteur externe pour des environnements externes rigoureux doit satisfaire aux exigences fonctionnelles suivantes:

a) polarisé de manière à éviter l'inversion des conducteurs, à l'état branché et débranché;
b) disponible avec étanchéité conformément à la CEI 60529: IP65 lorsqu'il est accouplé ou muni de bouchons de protection;
c) le côté libre (câble) doit disposer d'un serre-câble qui fixe le câble mais ne soumet pas les conducteurs à des contraintes dommageables;
d) les conducteurs doivent être entièrement entourés d'un boîtier conducteur qui maintient la continuité électrique du blindage;
e) le boîtier conducteur du côté libre (câble) doit être recouvert de matériau isolant;
f) le boîtier conducteur du côté fixe (appareil) doit être isolé de sa surface de montage;
g) le côté fixe (appareil) doit assurer une connexion au blindage, autre que le boîtier;
h) les contacts doivent accepter des dimensions des fils de 0,20 mm^2 à 0,64 mm^2;
i) muni d'un auto-verrouillage pour éviter toute déconnexion en cas de sollicitation du câble;
j) muni de quatre contacts (deux pour les signaux et deux pour l'alimentation);
k) disponible avec des conducteurs sertis;
l) fourni avec des contacts mâles du côté fixe (appareil);
m) un connecteur de câble à broches mâles doit permettre une connexion en ligne;
n) la rigidité diélectrique entre contacts et boîtier, ainsi qu'entre boîtier et terre, doit être au moins égale à la rigidité diélectrique spécifiée sous isolation pour la MAU correspondante;
o) les contacts doivent être attribués aux fonctions, comme présenté dans le Tableau A.2 et dans la Figure A.2;
p) les dimensions des connecteurs (faces d'accouplement) doivent être telles qu'illustrées dans la Figure A.3, la Figure A.4 et la Figure A.5.

Tableau A.2 – Affectation des contacts du connecteur externe pour environnements industriels rigoureux

Numéro de contact	Fonction
A	DATA + avec l'option alim +
B	DATA – avec l'option alim –
C	Réservé pour l'option alim +
D	Réservé pour l'option alim –

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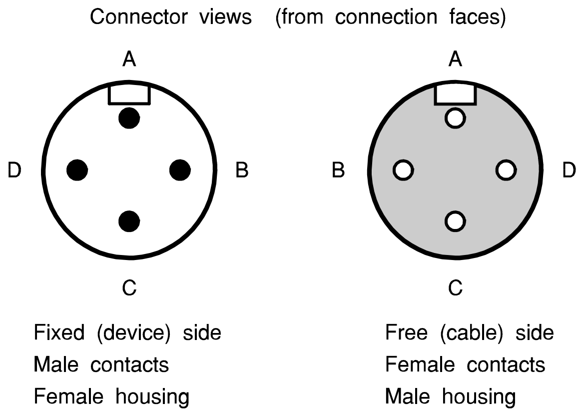

Légende

Anglais	Français
Connector views (from connection faces)	Vues de face des connecteurs
Fixed (device) side	Côté fixe (appareil)
Male contacts	Contacts mâles
Female housing	Boîtier femelle
Free (cable) side	Côté libre (câble)
Female contacts	Contacts femelles
Male housing	Boîtier mâle

Figure A.2 – Désignation des contacts du connecteur externe pour environnements industriels rigoureux

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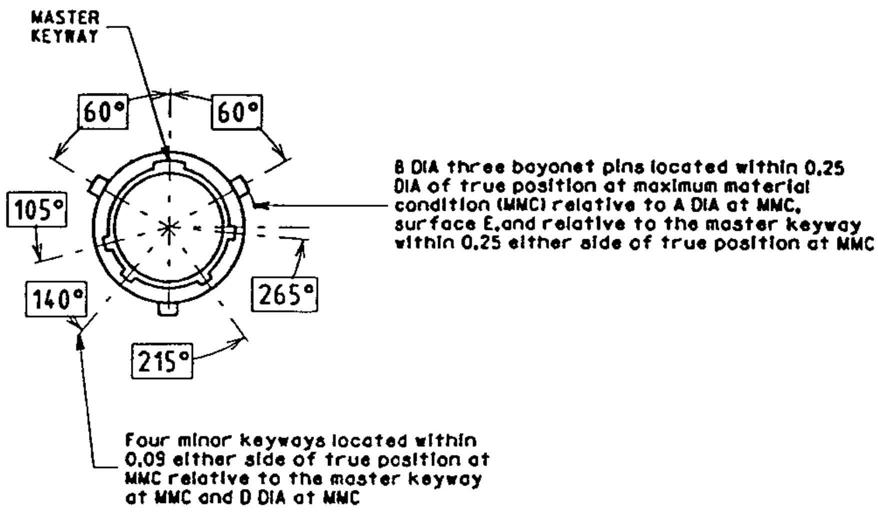
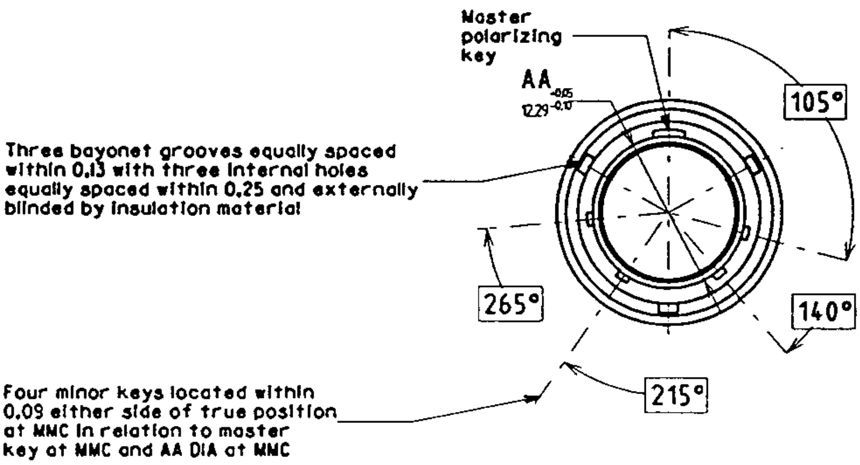


RECEPTACLE KEYWAYS AND BAYONET PINS



PLUG KEYS AND BAYONET GROOVES

Légende

Anglais	Français
Master Keyway	Rampe principale
8 DIA three bayonet pins located within 0.25 DIA of true position at maximum material condition (MMC) relative to A DIA at MMC surface E, and relative to the master keyway within 0.25 either side of true position at MMC	Trois ergots de diamètre 8 placés à un diamètre de 0,25 par rapport à la position vraie à l'état au maximum de matière (MMC) par rapport au diamètre A de la surface E à l'état MMC, et par rapport à la rampe principale à 0,25 des deux côtés de la position vraie à l'état MMC
Four minor keyways located within 0.09 either side of true position at MMC relative to the master keyway at MMC and D (0???) DIA at MMC	Quatre rampes secondaires placées à 0,09 des deux côtés de la position vraie à l'état MMC par rapport à la rampe principale à l'état MMC et par rapport au diamètre D à l'état MMC
RECEPTACLE KEYWAYS AND BAYONET PINS	RAMPES ET ERGOTS DE LA PRISE
Master polarizing key	Clavette de polarité (détrompeur) principale
Three bayonet grooves equally spaced within 0,13 with three internal holes equally spaced within 0,25 and externally blinded by insulation material	Trois rainures à baïonnette équidistantes à 0,13 près, avec trois orifices internes équidistants à 0,25 près et blindés extérieurement par un matériau isolant
Four minor keys located within 0.09 either side of true position at MMC in relation to master key at MMC and AA DIA at MMC	Quatre clavettes secondaires placées à 0,09 des deux côtés de la position vraie à l'état MMC par rapport à la clavette principale à l'état MMC et par rapport au diamètre AA à l'état MMC
PLUG KEYS AND BAYONET GROOVES	CLAVETTES ET RAINURES A BAIONNETTE DE FICHE

Figure A.3 – Rampes, clavettes, ergots et rainures de connecteur externe de bus de terrain

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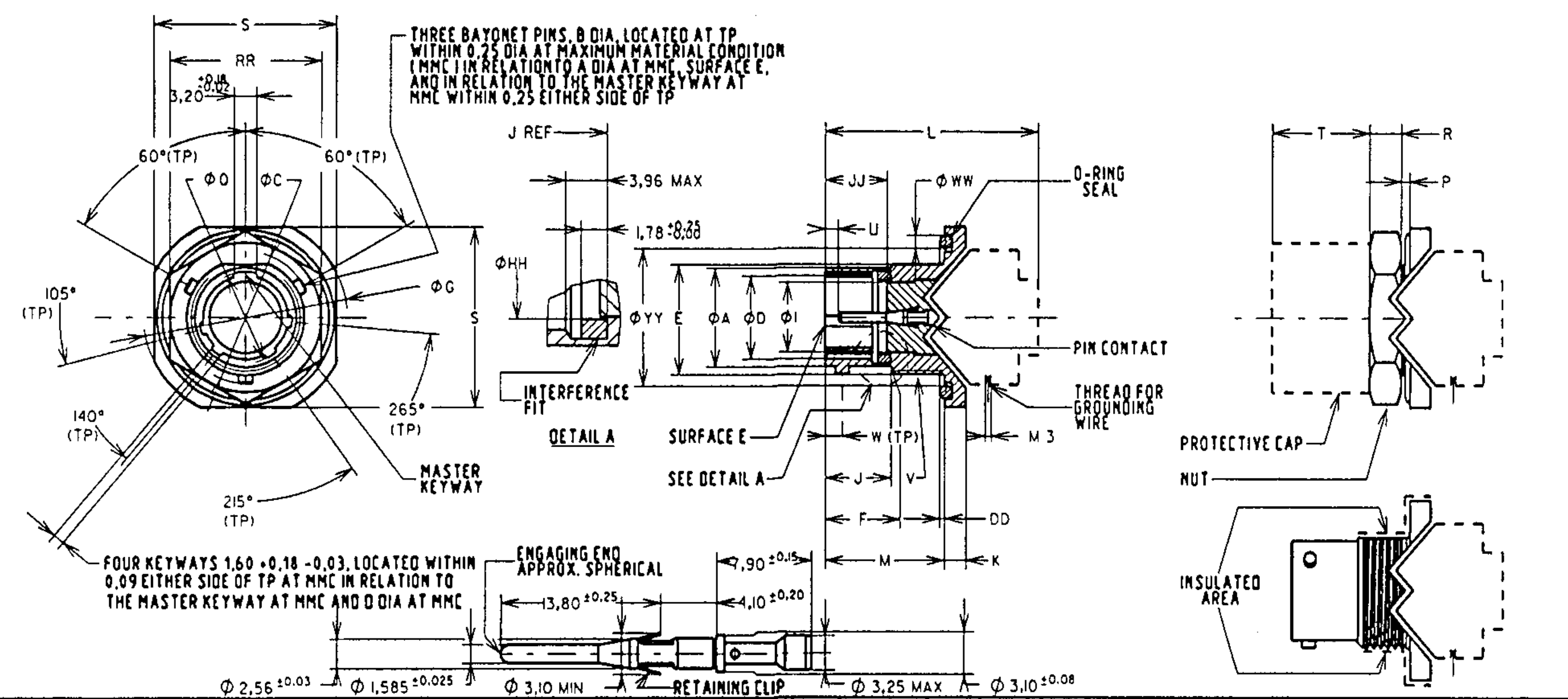


SIZE	ΦA	ΦB	ΦC	ΦD	E	F	ΦG	ΦI	J	JJ	K	L	M	P PANEL THK REF MIN	P PANEL THK REF MAX	ΦO	R	RR	S	T	U	V	W	ΦWW	ΦYY
	+0,03 -0,12 EXT. DIA.	+0,15 -0,05 BAY PIN	+0,00 -0,04 OVER BAY PINS	+0,13 -0,02 INT.DIA	+0,00 -0,25 MTG FLAT	MIN MTG THD LOC	+0,00 -0,82 ACROSS FLANGE COR	MAX INSERT	±0,25 PACK ING LOC	+0,00 -0,50 PIN INSERT LOC	± 0,51 THK MTG FLANGE	MAX OVER-ALL LENGTH	+0,79 -0,00 MTG FLANGE LOC			+0,13 -0,15 OVER KEY-WAYS	+0,25 -1,79 NUT THK	±0,43 HEXAGON DIM	MAX LENGTH SIDE	MAX PROTEC-TIVE CAP LENGTH	+0,25 -0,51 PIN CONTACT LOC	CLASS 2A MOUNT-ING THREAD	(TP) BAY PIN LOC	±0,08 O-RING CROSS SECTION	±0,15 O-RING SEAL INT.DIA.
10	14,98	1,98	17,27	12,44	16,64	9,75	30,55	10,55	9,70	9,40	2,97	39,30	17,55	1,57	3,17	13,71	4,52	22,22	27,38	15,30	2,16	11/16-24	2,54	1,78	20,35

NOTE 1 Dimensions are in millimetres

NOTE 2 True position (TP) tolerances

NOTE 3 Typical material: shell - aluminium alloy

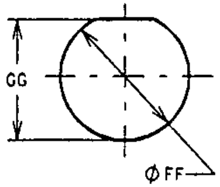
bayonet pins (ΦB) - stainless, passivated

nut - glass filled thermoplastic

NOTE 4 Nut: thread size: 11/16 - 24 UNEF - 2B

Slot dimension shall provide sufficient clearance for mounting on applicable receptacle

Slots shall be 120° apart



PANEL MTG DIMS REF
REFERENCE DIMENSIONS

SIZE	DD	ΦHH			ΦFF	GG
	±0,28 O-RING PROTEC-TION	MAX INT.DIA. GASKET			+0,25 -0,13 PANEL MTG HOLE	+0,25 -0,13 PANEL FLAT LOC
10	0,58	11,60			17,71	16,89

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Légende

Anglais	Français
Three bayonet pins 8 DIA located at TP within 0.25 DIA at maximum material condition (MMC) in relation to a DIA at MMC surface E and in relation to the master keyway at MMC within 0.25 either side of TP	Trois ergots de diamètre 8 placés par rapport à la position vraie (TP), à un diamètre de 0,25 à l'état au maximum de matière (MMC) par rapport au diamètre A de la surface E à l'état MMC et par rapport à la rampe principale à l'état MMC, à 0,25 des deux côtés de TP
Interference fit	Ajustement serré
0-ring seal	Joint torique
Pin contact	Broche de contact
Master keyway	Rampe principale
Detail A	Détail A
Surface E	Surface E
See detail A	Voir détail A
Thread for grounding wire	Filetage pour conducteur de mise à la masse
Protective cap	capot de protection
Nut	ECROU
Four keyways 1.60 . 0.18 – 0.03 located within 0.09 either side of TP at MMC in relation to the master keyway at MMC and D DIA at MMC	Quatre rampes 1,60 , 0,18 – 0,03 placées à 0,09 des deux côtés de TP à l'état MMC par rapport à la rampe principale à l'état MMC et par rapport au diamètre D à l'état MMC
Engaging end approx. spherical	Extrémité d'accouplement approximativement sphérique
Insulated area	Partie isolée
Retaining clip	clip de connexion
Size	Dimension
Ext. Dia	Dia. ext.
Bay pin	Ergot
Over bay pins	Sur ergots
Int. Dia	Dia. int.
MTG flat	Méplat de montage
Min MTG THD loc	Emplac. de filetage min
Across flange cor	Ame entre brides
Max insert	Insertion max.
Pack ing loc	Emplac. Garniture
Pin insert loc	Emplac. d'insertion broche
THK MTG flange	Epaisseur bride de montage
Max over-all length	Longueur globale max.
MTG flange loc	Emplac. bride de montage
Panel THK ref	Epaisseur réf. panneau
Over keyways	Sur rampes
Nut THK	Epaisseur écrou
Hexagon Dim	Dim. hexagon.
Max length side	Côté longueur max.
Max protective cap length	Longueur max. de capot de protection
Pin contact loc	Emplac. broche de contact
Mounting thread	Filetage de montage
(TP) Bay Pin loc	Emplac. Ergot (pos. vraie)
0-ring cross section	Section du joint torique

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Anglais	Français
0-ring seal int. Dia	Dia. int. du joint torique
Note 1: Dimension are in millimeters	Note 1: Dimensions en millimètres
Note 2: True position (TP) tolerances	Note 2: Tolérances de position vraie (TP)
Note 3: Typical materials shell – aluminium alloy	Note 3: Matériaux types du boîtier: alliage d'aluminium
Bayonet pins () – Stainless, passivated nut – glass filled thermoplastic	Ergots (dia. 8.): acier inox. passivé Ecrou – thermoplastique renforcé à la fibre de verre
Note 4: Nut: threaded size	Note 4: Ecrou: Dimension du filetage
Slot dimension shall provide sufficient clearance for mounting on applicable receptacle	La dimension des rainures doit prévoir un dégagement suffisant pour permettre le montage sur la prise correspondante.
Slots shall be 120° apart	Les rainures doivent être espacées à 120°
Panel MTG	Montage panneau
DIMS REF	REF DIM
Reference dimensions	Dimensions de référence
0-ring protection	Protection joint torique
Max Int Dia Gasket	Dia. int. max. du joint d'étanchéité
Panel MTG hole	Orifice de montage du panneau
Panel flat loc	Emplac. méplat du panneau

Figure A.4 – Dimensions d'accouplabilité de connecteur externe de bus de terrain

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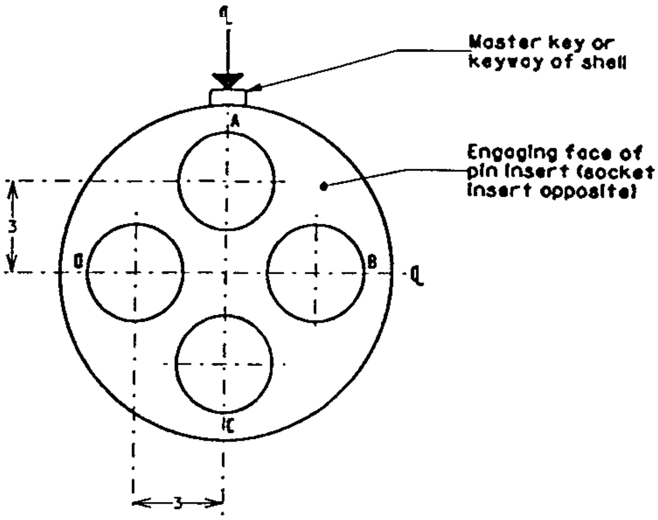

Dimension du boîtier	Nombre de contacts	Dimension des contacts
10	4	16

NOTE Les dimensions sont en millimètres.

Légende

Anglais	Français
Master key or keyway of shell	Clavette principale ou rampe du boîtier
Engaging face of pin insert (socket insert opposite)	Face d'accouplement d'insertion de la broche (insertion dans le contact femelle du côté opposé)

La disposition de l'isolant est illustrée en position normale dans le boîtier, la cavité A étant en face de la clavette principale ou de la rampe du boîtier. Seule cette "position normale" doit être utilisée.

Les quatre clavettes ou rampes (MMC) et l'isolant doivent être situés à 0,09 des deux côtés de (TP) par rapport à la clavette ou rampe principale (MMC) et doivent être DD ou ID (MMC).

Figure A.5 – Disposition des contacts du connecteur externe de bus de terrain

A.2.2 Connecteur externe pour environnements industriels typiques

Un connecteur pour des environnements industriels typiques doit satisfaire aux exigences fonctionnelles suivantes:

a) polarisé de manière à éviter l'inversion des conducteurs, à l'état branché et débranché;
b) entièrement entouré d'un boîtier conducteur;
c) muni de contacts mâles du côté fixe (appareil), et de bornes femelles filetées à verrouillage par vis (filetage 4-40 NC-2B);
d) muni de contacts femelles du côté libre (câble), et de vis de blocage (filetage 4-40 NC-2A);
e) muni de neuf contacts (deux pour les signaux, deux pour l'alimentation, et cinq réservés);
f) les contacts doivent être attribués aux fonctions, comme présenté dans la Figure A.6 et dans le Tableau A.3;
g) les dimensions du connecteur (face d'accouplement) doivent être comme présentées dans la Figure A.7 et la Figure A.8, dans le Tableau A.4 et le Tableau A.5, ainsi que comme spécifié dans la CEI 60807-3.

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Tableau A.3 – Affectation des contacts du connecteur externe pour environnements industriels typiques

Numéro de contact	Fonction
1	Réservée
2	Réservée
3	Réservée
4	Réservée
5	Réservée
6	DATA + avec l'option alim +
7	DATA – avec l'option alim –
8	Réservé pour l'option alim +
9	Réservé pour l'option alim –

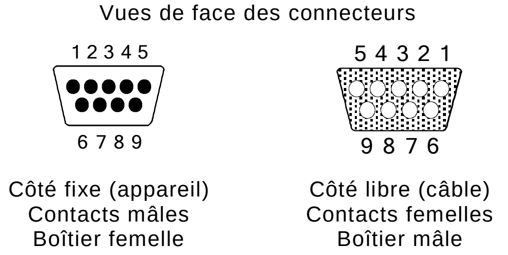

Figure A.6 – Désignation des contacts du connecteur externe pour environnements industriels typiques

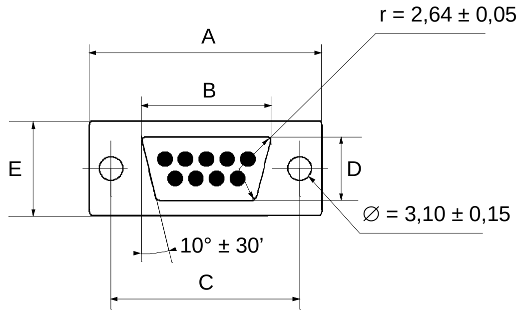

Figure A.7 – Connecteur externe du côté fixe (appareil) pour environnements industriels typiques: dimensions

Tableau A.4 – Dimensions du connecteur du côté fixe (appareil)

Connecteur du côté fixe (appareil) (contacts mâles, boîtier femelle)				
	Millimètres		Pouces	
	Max.	Min.	Max.	Min.
A	31,19	30,43	1,23	1,20
B	17,04	16,79	0,67	0,66
C	25,12	24,87	0,99	0,98
D	8,48	8,23	0,33	0,32
E	12,93	12,17	0,51	0,48

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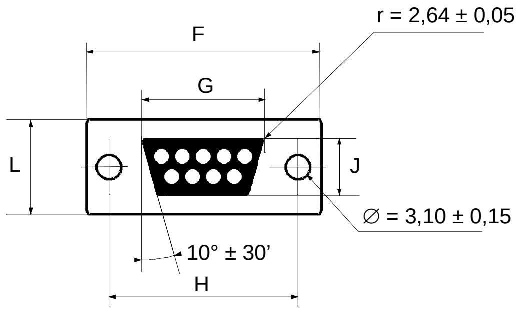

Figure A.8 – Connecteur externe du côté libre (câble) pour environnements industriels typiques: dimensions

Tableau A.5 – Dimensions du connecteur du côté libre (câble)

Connecteur du côté libre (câble) (contacts femelles, boîtier mâle)				
	Millimètres		**Pouces**	
	Max.	Min.	Max.	Min.
F	31,19	30,43	1,23	1,20
G	16,46	16,21	0,65	0,64
H	25,12	24,87	0,99	0,98
J	8,03	7,77	0,32	0,31
L	12,93	12,17	0,51	0,48

A.3 Connecteurs externes pour support optique

Un connecteur de bus de terrain qui se trouve à l'extérieur de l'enveloppe de l'appareil de bus de terrain et qui nécessite par conséquent une protection contre l'environnement électromagnétique et physique, doit être spécifié comme un connecteur externe.

Il est spécifié deux types de connecteurs externes en fonction de l'environnement d'installation.

A.3.1 Connecteur externe pour environnements industriels typiques

A.3.1.1 Connecteur externe pour environnements industriels typiques (1)

Pour l'interface CPIC au niveau d'un appareil de bus de terrain, d'une étoile active optique ou d'une étoile passive optique, le connecteur utilisé doit être compatible avec le connecteur présenté dans la Figure A.9 et dans le Tableau A.6. (Voir CEI 61754-13.)

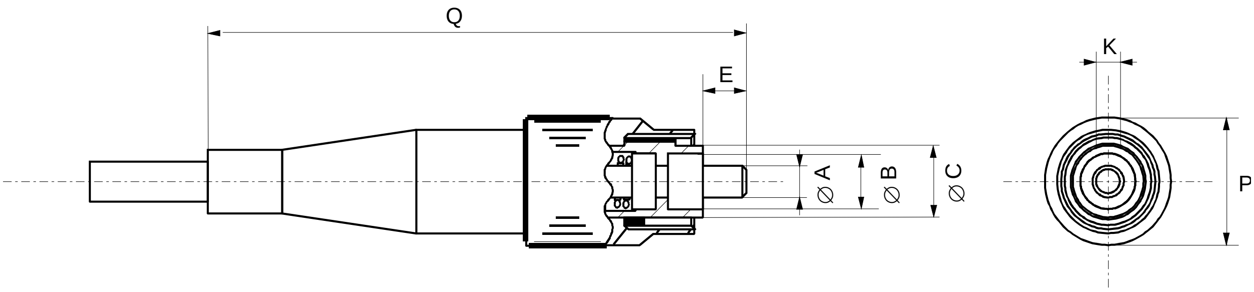

Figure A.9 – Connecteur optique pour environnements industriels typiques (connecteur FC)

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Tableau A.6 – Dimensions de connecteur

Référence	Millimètres	
	Min.	Max.
∅ A	2,498	2,500
∅ B	4,40	4,42
∅ C	5,95	6,00
E	3,75	4,05
K	1,85	2,14
P	–	10,5
Q	–	45

A.3.1.2 Connecteur externe pour environnements industriels typiques (2)

Pour l'interface CPIC au niveau d'un appareil de bus de terrain, d'une étoile active optique ou d'une étoile passive optique, le connecteur utilisé doit être compatible avec le connecteur présenté dans la Figure A.10.

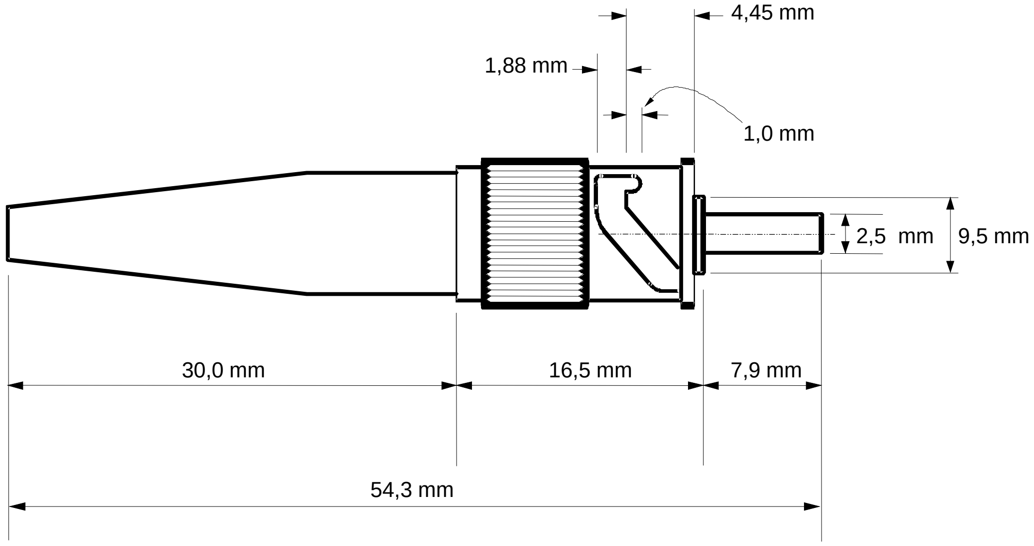

Figure A.10 – Connecteur optique pour environnements industriels typiques (connecteur ST)

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Annexe B
(informative)

Types 1 et 3: Spécification du câblage et longueurs de lignes principales et de lignes secondaires pour la MAU de 31,25 kbit/s en mode tension

B.1 Description et spécifications du câblage

Le câble de bus de terrain préférentiel est spécifié en 12.8.2 pour les essais de conformité; il est appelé câble de bus de terrain de type A.

NOTE 1 Ce câble sera probablement utilisé dans de nouvelles installations.

D'autres types de câbles peuvent être utilisés pour les bus de terrain dans le cadre d'activités autres que les essais de conformité. La variante de câble de bus de terrain préférentiel est un câble à paire torsadée multiple à blindage global; il est appelé ci-après câble de bus de terrain de type B.

NOTE 2 Ce câble sera probablement utilisé dans de nouvelles installations ainsi que dans des installations remises à niveau lorsque des bus de terrain multiples sont déployés dans la même zone de l'usine de l'utilisateur.

Un autre câble de bus de terrain de moindre préférence est un câble à paire torsadée simple ou multiple sans aucun blindage; il est appelé ci-après câble de bus de terrain de type C. Le câble de bus de terrain le moins recommandé est un câble à conducteurs multiples sans paires torsadées mais à blindage global; il est appelé ci-après câble de bus de terrain de type D.

NOTE 3 Les câbles de type C et D seront principalement utilisés pour la réhabilitation d'installations existantes. Ils seront affectés par certaines limitations en termes de longueurs de bus de terrain et de rapports signal/bruit; les câbles de type A et B ne souffrent pas de ces carences. De ce fait, l'utilisation des câbles de type C et D est exclue dans certaines applications.

Les spécifications de câbles typiques pour une température de 25 °C sont énumérées dans le Tableau B.1.

Tableau B.1 – Spécifications du câblage typique

Paramètre	Conditions	Type B	Type C	Type D
Impédance, Ω	f_r (31,25 kHz)	100 ± 30	Non spécifié	Non spécifié
Résistance max. en courant continu, Ω/km	Par conducteur	56	132	20
Affaiblissement max., dB/km	1,25 f_r (39 kHz)	5,0	8,0	8,0
Aire nominale de section des conducteurs, mm^2 (dimension des fils)		0,32	0,13	1,25
Déséquilibre capacitif max., nF/km	≥30 m de longueur	6	Non spécifié	Non spécifié

B.2 Longueurs de lignes principales et de lignes secondaires typiques

Si l'on utilise les règles de configuration du réseau spécifiées en 12.3.3, les longueurs maximales pour les câbles de type B, C et D, y compris toutes les lignes secondaires, seront en général les suivantes:

– type B – 1 200 m;
– type C – 400 m;
– type D – 200 m.

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NOTE Ces principes généraux ne remplacement pas les règles de configuration du réseau données en 12.3.3.

Les longueurs de lignes secondaires admissibles pour une topologie en bus ou arborescente, dépendent du nombre d'éléments de communication présents sur le bus de terrain. Le Tableau B.2 établit des nombres recommandés d'éléments de communication en fonction de la longueur de ligne secondaire. Les longueurs maximales des lignes secondaires sont identiques pour les câbles de type A, B, C et D. Le tableau suppose un élément de communication par ligne secondaire. Lorsqu'une ligne secondaire avec un coupleur de ligne principale passif comporte plusieurs éléments de communication, il convient que la longueur de cette ligne secondaire soit réduite de 30 m par élément de communication. Sachant que la longueur maximale totale recommandée de la ligne secondaire totale est de 120 m, il convient que le nombre maximal d'éléments de communication par ligne secondaire soit de quatre.

Tableau B.2 – Longueurs maximales de ligne secondaire recommandées en fonction du nombre d'éléments de communication

Nombre total d'éléments de communication	**Longueur maximale recommandée de ligne secondaire** m
25 à 32	0
19 à 24	30
15 à 18	60
13 à 14	90
1 à 12	120

Il convient de considérer comme des épissures les lignes secondaires d'une longueur inférieure à 1 m.

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Annexe C
(informative)

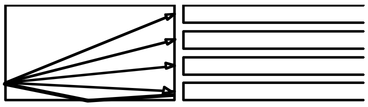
Types 1 et 7: Etoiles passives optiques

C.1 Définition

Un appareil passif dans lequel le signal en provenance des fibres optiques d'entrée est réparti sur un plus grand nombre de fibres optiques de sortie (les fibres optiques d'entrée et de sortie peuvent être les mêmes).

a) Etoile passive optique réflective

Un appareil destiné à réfléchir une entrée de puissance optique au niveau de tout port de sortie (voir la Figure C.1). Cet appareil peut uniquement être utilisé avec une MAU en mode monofibre.



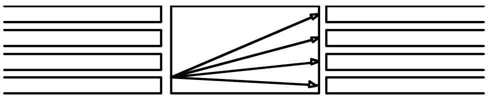
Légende

Anglais	Français
Input / output link 1	Liaison 1 d'entrée/sortie
Input / output link 2	Liaison 2 d'entrée/sortie
Input / output link 3	Liaison 3 d'entrée/sortie
Input / output link 4	Liaison 4 d'entrée/sortie

Figure C.1 – Exemple d'étoile passive optique réflective

b) Etoile passive optique transmissive

Un appareil destiné à diviser l'entrée de puissance optique au niveau de tout port de sortie (voir la Figure C.2). Cet appareil permet une diffusion des informations dans une seule direction. Il ne peut être utilisé qu'avec une MAU en mode fibre optique double.



Légende

Anglais	Français
Input link 1	Liaison d'entrée 1
Input link 2	Liaison d'entrée 2
Input link 3	Liaison d'entrée 3
Input link 4	Liaison d'entrée 4
Output link 1	Liaison de sortie 1
Output link 2	Liaison de sortie 2
Output link 3	Liaison de sortie 3
Output link 4	Liaison de sortie 4

Figure C.2 – Exemple d'étoile passive optique transmissive

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C.2 Exemples d'affaiblissement

Pour une longueur d'onde incluse entre 700 nm et 900 nm, le Tableau C.1 donne un exemple des affaiblissements minimal et maximal d'une étoile passive optique (ces spécifications sont également disponibles pour une fibre 62,5/125 ou 100/140).

Tableau C.1 – Récapitulatif de spécifications d'une étoile passive optique: exemple

700 nm $\leq \lambda_p \leq$ 900 nm	Etoile 4/4	Etoile 8/8	Etoile 16/16	Etoile 32/32	Unité
Affaiblissement min.	–6,0	–9,0	–12,0	–16,0	dB
Affaiblissement max.	–9,0	–12,0	–16,0	–20,0	dB

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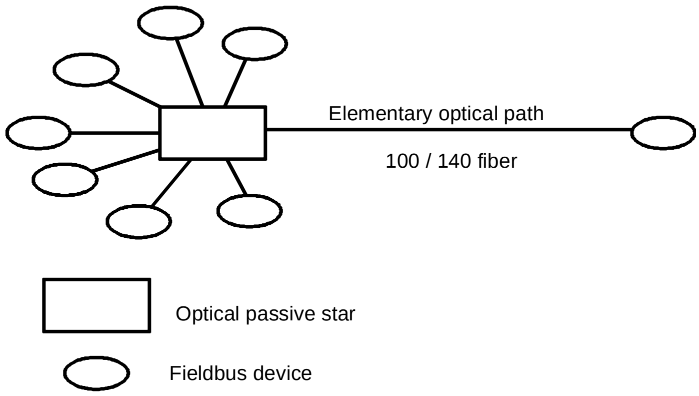
Annexe D
(informative)

Types 1 et 7: Topologie en étoile

D.1 Exemples de topologie

L'Article D.1 illustre certaines topologies de réseau qui peuvent être construites conformément à la présente norme. Ce qui ne signifie pas que ce sont les seules topologies possibles.

La dimension physique d'un réseau, en termes de longueur géographique et de nombre d'appareils de bus de terrain requis, aura un impact important sur le choix de la topologie du réseau. Lorsqu'un nombre limité d'appareils de bus de terrain est requis, il peut être utilisé presque n'importe quelle topologie. La Figure D.1 illustre une topologie possible.



Anglais	Français
Elementary optical path	Chemin optique élémentaire
100 / 140 fiber	Fibre 100 / 140
Optical passive star	Etoile passive optique
Fieldbus device	Appareil de bus de terrain

Figure D.1 – Exemple de topologie en étoile avec une MAU à fibre optique de 31,25 kbit/s en mode monofibre

Pour des configurations qui nécessitent un grand nombre d'appareils de bus de terrain situés en des lieux géographiques distants les uns des autres, une topologie multiétoile peut être nécessaire. Grâce aux topologies de ce type, on peut atteindre des nombres très importants d'appareils communiquants (voir la Figure D.2).

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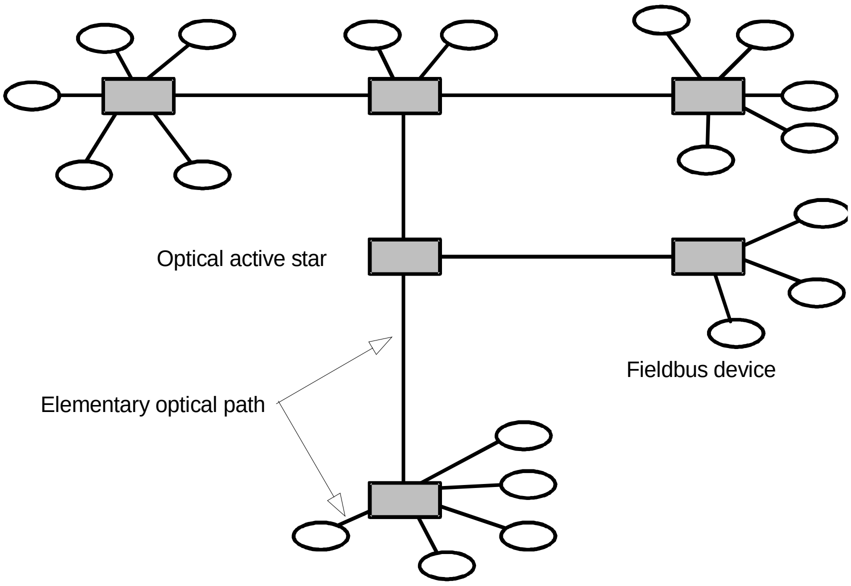

Légende

Anglais	Français
Optical active star	Etoile active optique
Elementary optical path	Chemin optique élémentaire
Fieldbus device	Appareil de bus de terrain

Figure D.2 – Topologie multiétoile avec une MAU à fibre optique

D.2 Bilan de puissance optique

Un bilan de puissance optique permet d'anticiper la distribution des différents affaiblissements et pertes du signal optique sur une liaison optique donnée.

On peut, à partir des niveaux de puissance d'injection effective de l'émetteur et du domaine de fonctionnement du récepteur, établir les longueurs minimale et maximale de la liaison.

Deux cas sont envisagés.

– Cas de puissance minimale: il correspond à la puissance minimale d'injection effective de l'émetteur, à des pertes maximales, à des pénalités maximales et à une marge système maximale ainsi qu'à la limite inférieure de domaine de fonctionnement du récepteur. Ce cas donne la longueur maximale garantie.
– Cas de puissance maximale: il correspond à la puissance maximale d'injection effective de l'émetteur, à des pertes minimales, à des pénalités minimales et à une marge système minimale ainsi qu'à la limite supérieure de domaine de fonctionnement du récepteur. Ce cas donne la longueur minimale garantie.

Deux exemples sont fournis. Le premier correspond à la topologie illustrée à la Figure D.1 et le second à celle de la Figure D.2.

D.2.1 Topologie en étoile passive (MAU à fibre optique de 31,25 kbit/s, en mode monofibre)

Dans cet exemple, la transmission entre des modems à faible sensibilité est prise en compte. Le Tableau D.1 résume les spécifications de la topologie en étoile passive.

Les paramètres à prendre en compte sont les suivants:

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– affaiblissement typique d'une fibre 100/140: 4,0 dB/km
– affaiblissement d'une étoile passive optique 8/8: 9,0 dBm à 12,0 dB
– puissance d'injection effective (fibre 100/140 μm): –14,5 dBm à –12,5 dBm
– domaine de fonctionnement du récepteur de sensibilité élevée: –40,0 dBm à –20,0 dBm

Tableau D.1 – Topologie en étoile passive

Paramètres	Max.	Min.	Unités
Domaine de fonctionnement du récepteur (sensibilité élevée)	–40,0	–20,0	dBm
Puissance d'injection effective	–14,5	–12,5	dBm
Caractéristiques dynamiques de toutes les pertes et affaiblissements	25,5	7,5	dB
Marge système	3,0	0,0	dB
Pertes dues aux deux connecteurs	2,0	0,0	dB
Etoile passive optique réflective (8/8)	12,0	9,0	dB
Affaiblissements max. et min. dus à la fibre	8,5	–	dB
Longueur de fibre entre modems (affaiblissement dû à la fibre: 4,0 dB/km)	2 125	0	m

D.2.2 Topologie en étoile active (MAU à fibre optique)

Dans cet exemple, la transmission entre des modems à faible sensibilité est prise en compte. Le Tableau D.2 résume les spécifications de la topologie en étoile passive.

Les paramètres à prendre en compte sont les suivants:

– affaiblissement typique d'une fibre 62,5/125: 3,0 dB/km
– émetteur (puissance d'injection effective): (–11,5 ± 1,5) dBm
– récepteur de faible sensibilité (domaine de fonctionnement du récepteur): (–30,0 to –10,0) dBm.

Tableau D.2 – Topologie en étoile active

Paramètres	Max.	Min.	Unité
Domaine de fonctionnement du récepteur (sensibilité élevée) Puissance d'injection effective de l'émetteur	–30,0 –13,0	–10,0 –10,0	dBm dBm
Caractéristiques dynamiques de toutes les pertes et affaiblissements	17,0	0,0	dB
Marge système Pertes dues aux deux connecteurs Affaiblissements max. et min. dus à la fibre	3,0 2,0 12,0	0,0 0,0 0,0	dB dB dB
Longueur de fibre entre modems (affaiblissement dû à la fibre: 3,0 dB/km)	4 000	0	m

D.3 Mixte, avec supports câblés

La combinaison des supports câblé et optique est réalisée au moyen d'un convertisseur électro-optique. Cet élément présente un ou plusieurs accès à support câblé et un ou plusieurs accès optiques. Chaque accès, qu'il soit câblé ou optique, doit respecter les spécifications de circuits de transmission et de réception.

Cet élément régénère le signal à son niveau de puissance optique nominale ou à son niveau électrique et lui redonne ses caractéristiques de synchronisation nominales (instabilité, temps de croissance et de décroissance, taux de dérive, etc.).

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Deux exemples sont illustrés à la Figure D.3 et à la Figure D.4.

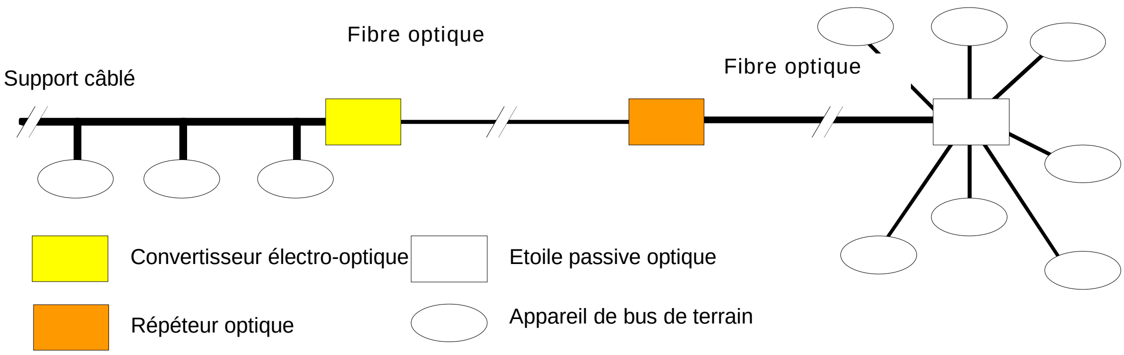
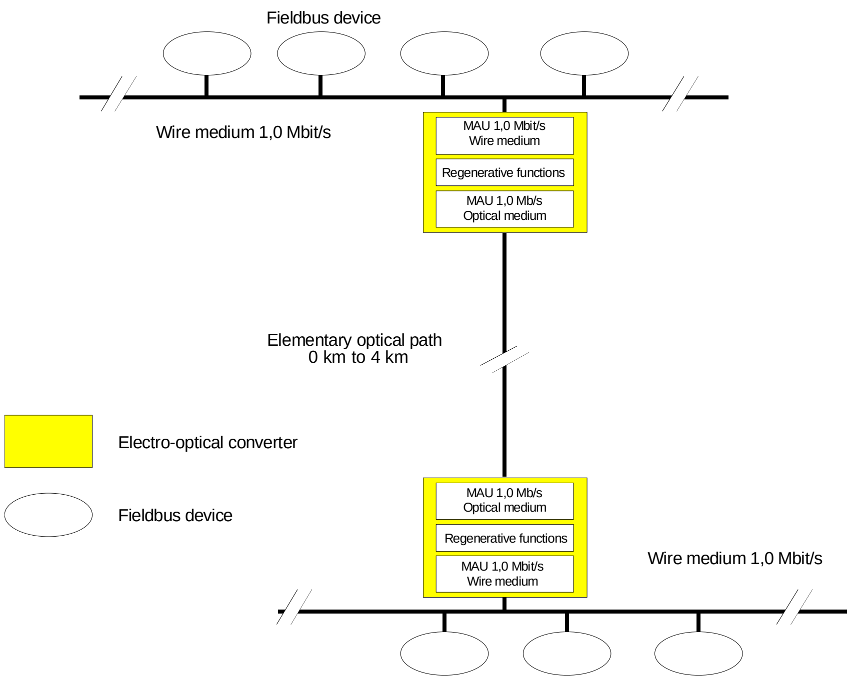


Figure D.3 – Exemple de combinaison de supports câblé et optique pour un débit binaire de 31,25 kbit/s



Légende

Anglais	Français
Fieldbus device	Appareil de bus de terrain
Wire medium 1,0 Mbit/s	Support câblé de 1,0 Mbit/s
MAU 1,0 Mbit/s	MAU de 1,0 Mbit/s
Wire medium	Support câblé
Regenerative functions	Fonctions régénératrices
Optical medium	Support optique
Elementary optical path	Chemin optique élémentaire
0 km to 4 km	0 km à 4 km
Electro-optical converter	Convertisseur électro-optique

Figure D.4 – Exemple de combinaison de supports câblé et optique

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Annexe E
(informative)

Type 1: Autres fibres

E.1 Variantes de fibres en mode fibre double

On peut utiliser des fibres autres que la fibre A1d spécifiée comme fibre d'essai normalisée. Les niveaux de puissance d'injection effective diffèrent en fonction des caractéristiques de ces fibres. D'autre part, les domaines de fonctionnement des récepteurs, pour des sensibilités faibles et élevées, sont identiques.

Le Tableau E.1 permet de comparer ces différentes fibres.

Tableau E.1 – Variantes de fibres en mode fibre double

Paramètres	Paragraphe	Norme d'essai de fibre spécifiée	Autre fibre spécifiée	Autre fibre spécifiée
Fibre	15.7.2	A1b (62,5/125)	A1a (50/125)	A1d (100/140)
Puissance d'injection effective	15.4.2	(–11,5 ± 1,5) dBm	(–14,5 ± 1,5) dBm	(–7,5 ± 1,0) dBm
Domaine de fonctionnement du récepteur – faible sensibilité	15.5.2	–30,0 dBm à –10,0 dBm	–30,0 dBm à –10,0 dBm	–30,0 dBm à –10,0 dBm
Domaine de fonctionnement du récepteur – sensibilité élevée	15.5.2	–40,0 dBm à –20,0 dBm	–40,0 dBm à –20,0 dBm	–40,0 dBm à –20,0 dBm

E.2 Variantes de fibres en mode monofibre

On peut utiliser des fibres autres que la fibre A1d spécifiée comme fibre d'essai normalisée. Les niveaux de puissance d'injection effective diffèrent en fonction des caractéristiques de ces fibres. D'autre part, les domaines de fonctionnement des récepteurs, pour des sensibilités faibles et élevées, sont identiques.

Le Tableau E.2 permet de comparer ces différentes fibres.

Tableau E.2 – Variantes de fibres en mode monofibre

Paramètres	Paragraphe	Norme d'essai de fibre spécifiée	Autre fibre spécifiée	Autre fibre spécifiée
Fibre	16.7.2	A1d (100/140)	A1a (50/125)	A1b (62,5/125)
Puissance d'injection effective	16.4.2	(–13,5 ± 1,0) dBm	(–21,0 ± 1,0) dBm	(–17,5 ± 1,0) dBm
Domaine de fonctionnement du récepteur – faible sensibilité	16.5.2	–30,0 dBm à –12,5 dBm	–30,0 dBm à –12,5 dBm	–30,0 dBm à –12,5 dBm
Domaine de fonctionnement du récepteur – sensibilité élevée	16.5.2	–40,0 dBm à –20,0 dBm	–40,0 dBm à –20,0 dBm	–40,0 dBm à –20,0 dBm

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Annexe F
(normative)

Type 2: Spécifications des connecteurs

F.1 Connecteur pour support à câble coaxial

La connexion au support coaxial doit être effectuée au moyen de connecteurs à fiche et à prise jack de type BNC (voir la CEI 61169-8:2007, Annexe A, variante 75 Ω) ou TNC (voir la CEI 60169-17, variante 75 Ω.

La variante TNC doit être étanche, conformément au degré de protection minimal IP67. Lorsque l'étanchéité est exigée, le nœud doit également satisfaire aux exigences IP67.

NOTE Il est possible de réaliser l'étanchéité jusqu'au degré IP65 avec le type BNC,.

L'impédance caractéristique doit être comprise entre 45 Ω et 80 Ω.

Le contact du conducteur central doit être plaqué conformément à l'une des spécifications suivantes:

a) 0,75 placage or d'au minimum 0,75 μm sur nickel d'au minimum 1,25 μm sur métal de base;
b) 0,05 μm à 0,2 μm d'éclat or sur 1,25 μm minimum de nickel palladium sur 1,25 μm minimum de nickel sur métal de base.

F.2 Connecteur pour support optique

F.2.1 Exigences générales

Les connecteurs pour support optique doivent satisfaire aux exigences spécifiées dans le Tableau F.1.

Tableau F.1 – Exigences des connecteurs

Spécification	Courte portée	Moyenne et longue portée
Perte d'insertion du connecteur (valeur nominale)	1,5 dB	1,0 dB

F.2.2 Connecteur pour support optique de courte portée

Cette variante doit utiliser un connecteur en deux parties, constitué d'un connecteur à broches (comme spécifié à la Figure F.1) et d'un fût à sertir qui permet de fixer le câble au connecteur à broches (comme spécifié à la Figure F.2).

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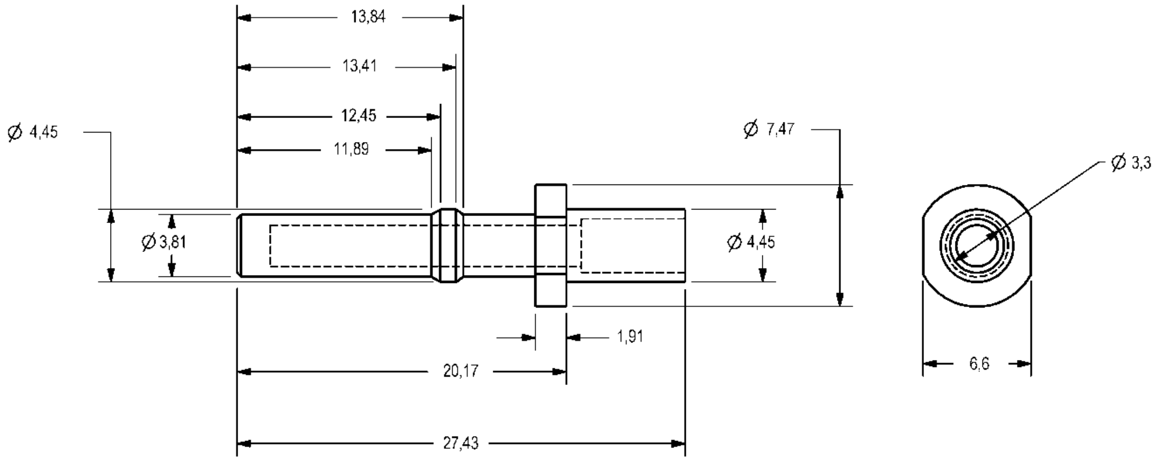
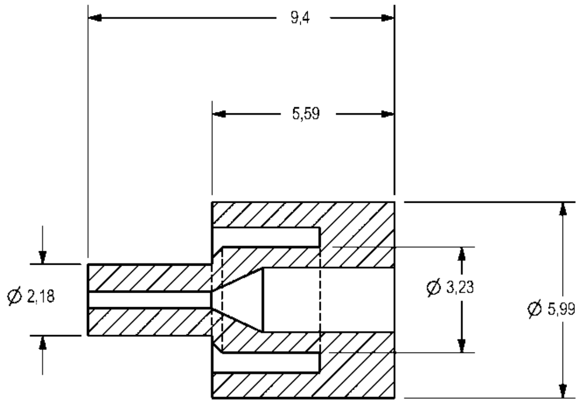


NOTE Les dimensions sont en millimètres.

Figure F.1 – Connecteur à broches pour support optique de courte portée



NOTE Les dimensions sont en millimètres.

Figure F.2 – Fût à sertir pour support optique de courte portée

F.2.3 Connecteur pour support optique de moyenne et longue portée

Ces variantes doivent utiliser un connecteur de type ST, comme spécifié dans la CEI 61754-2.

F.3 Connecteur pour support NAP

Le connecteur utilisé aux deux extrémités d'une connexion NAP doit être du type RJ-45 à 8 broches, blindé (voir la CEI 60603-7-4).

Les broches du connecteur NAP doivent être telles que présentées dans le Tableau F.2. Cette définition des contacts doit s'appliquer aux deux extrémités du câble. Le connecteur doit être installé sur le câble de manière à satisfaire aux exigences illustrées à la Figure 90.

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Tableau F.2 – Définition des broches du connecteur NAP

Numéro de contact	Désignation du signal
1	REF MASSE
2	N/C (non connectée)
3	Tx_H
4	Tx_L
5	Rx_L
6	Rx_H
7	N/C (non connectée)
8	REF MASSE

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Annexe G
(normative)

Type 2: Sous-couches de machine répéteur (RM, RRM) et PhL redondantes

G.1 Généralités

Un appareil répéteur de PhL (en bus ou en anneau) doit être utilisé pour augmenter les longueurs de ligne principale et le nombre de nœuds en connectant des longueurs entières et/ou des sections de supports pleinement chargées. Les répéteurs peuvent également être utilisés pour connecter entre elles des variantes de PhL différentes, par exemple à fibre optique et à câble coaxial. En outre, un appareil de répéteur d'anneau doit prendre en charge la redondance du support grâce à l'utilisation d'une topologie annulaire.

Les appareils répéteurs doivent être conformes à l'ensemble des articles applicables concernant la sous-couche MAU et l'interface MDS-MAU. Un appareil répéteur de bus PhL doit être constitué de deux (ou plus) interfaces PhL complètes (MDS/MAU, en provenance d'un modèle identique ou de variantes différentes) connectées ensemble par une sous-couche de machine répéteur (RM). Un appareil répéteur d'anneau de PhL doit être constitué de deux ou plusieurs interfaces PhL complètes connectées ensemble par une sous-couche de machine répéteur d'anneau (RRM).

Un répéteur de PhL (en bus ou en anneau) peut ne pas avoir un MAC ID (identifiant de contrôleur d'accès au support). Un appareil répéteur de PhL n'est pas la source de trafic du réseau et ne doit pas prendre en charge de couches au-dessus des sous-couches RM ou RRM. En revanche, il doit uniquement être responsable de la retransmission du trafic du réseau du segment à un ou à plusieurs autres segments et de la mise en œuvre correcte de la sous-couche RM ou RRM.

De manière facultative, un nœud peut inclure la fonctionnalité de sous-couche RM ou RRM comme partie de cette sous-couche MAC de nœud, pour permettre à un nœud de réseau de fonctionner à la fois comme nœud de réseau et comme répéteur entre des variantes de PhL. Ce type de nœud doit être considéré comme un nœud de réseau et doit avoir un identifiant MAC ID.

Un nœud qui prend en charge des variantes de PhL multiples et une sous-couche RM doit fonctionner à la fois comme un nœud (c'est-à-dire la source du trafic de réseau) avec des entités PhL redondantes (voir G.3) et comme un appareil répéteur de bus PhL. Un nœud qui prend en charge des variantes de PhL multiples et une sous-couche RRM doit fonctionner à la fois comme un nœud et comme un appareil de répéteur d'anneau PhL.

G.2 Sous-couche RM (machine répéteur)

G.2.1 Exigences

La Figure G.1 illustre le modèle de référence d'un appareil répéteur de bus PhL.

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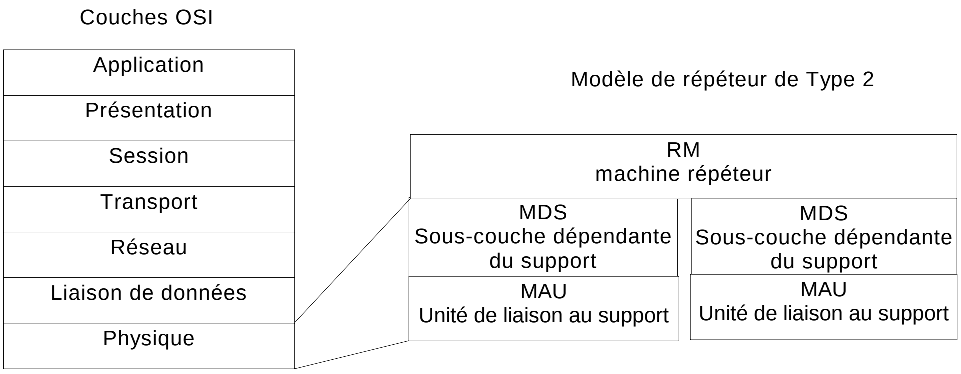

Figure G.1 – Modèle de référence d'appareil répéteur PhL

Chacune des deux (ou plus) entités PhL connectées à la sous-couche RM doit satisfaire aux spécifications applicables à une variante de PhL donnée.

Une sous-couche RM doit être utilisée comme connexion entre des segments pour constituer une liaison, comme illustré à la Figure 83. Tout identifiant MAC ID utilisé sur une variante de PhL connectée à une autre variante de PhL au moyen de la sous-couche RM doit être unique car les deux côtés partagent une liaison commune.

La sous-couche RM doit être complètement transparente au trafic du réseau. Tous les symboles MAC valides entre les délimiteurs de début et de fin (compris) reçus par une entité PhL dans la RM doivent être transmis sans aucune modification à tous les autres pour transmission. Le préambule doit être régénéré par la sous-couche RM pour corriger les éventuelles anomalies introduites par la MDS ou la MAU. La régénération du préambule doit recréer le préambule original de 16 M-symbols consécutifs {1} et peut introduire jusqu'à 4 M-symbol consécutifs supplémentaires {1}. Après retransmission du délimiteur de fin, la sous-couche RM peut introduire jusqu'à 4 M-symbols consécutifs supplémentaires de n'importe quelle valeur.

La RM doit avoir une sous-couche en semi-duplex. Une seule entité PhL connectée à la RM doit recevoir des données à un moment donné tandis que toutes les autres entités PhL retransmettent les données reçues.

La sous-couche RM ne doit pas être la cause de collisions sur un support quelconque. A tout moment, une seule entité PhL doit être sélectionnée pour la réception, tandis que toutes les autres doivent être sélectionnées pour la transmission. L'entité PhL sélectionnée pour la réception doit reposer sur l'état de l'indication PLS_CARRIER_INDICATION en provenance de l'entité PhL qui est la première à indiquer PLS_CARRIER_INDICATION (vrai). Toutes les autres entités PhL connectées à la sous-couche RM doivent être établies sur "émission", tandis que l'entité PhL reçoit l'indication PLS_CARRIER_INDICATION (vrai) et PLS_FRAME_INDICATION (vrai). Pendant la période de sélection de cette entité PhL pour la réception, toute indication PLS_CARRIER_INDICATION (vrai) en provenance des autres entités PhL doit être ignorée. Une nouvelle entité PhL doit être sélectionnée pour la réception une fois terminée la trame précédente (PLS_FRAME_INDICATION= faux).

La sous-couche RM doit être conçue pour réduire au minimum la durée du retard qui est ajouté à la retransmission de l'indication PLS_DATA_INDICATION. Le retard de la sous-couche RM doit être défini comme étant la période entre la fin du délimiteur de début reçu à la fin du délimiteur de début retransmis, tel que mesuré au niveau de l'interface MDS-MAU. Tout retard ajouté à la sous-couche RM doit être inclus dans le calcul de la durée de créneau utilisée par la sous-couche MAC. La durée totale du retard qui est ajouté par la sous-couche RM doit être mise à la disposition des outils de configuration du réseau et des utilisateurs.

NOTE Tout retard dans la sous-couche RM réduit le nombre total de supports qui peut être pris en charge ainsi que l'efficacité du réseau en augmentant la durée de créneau requise par le protocole (voir CEI 61158-4-2).

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La sous-couche RM doit être conçue de manière à reconstruire les données telles que transmises à partir du nœud d'origine. Cette exigence doit permettre la mise en cascade (en série) d'un nombre illimité de répéteurs sans aucune distorsion ajoutée par les répéteurs aux données initiales. La seule limite au nombre total de sous-couches RM qui peuvent être mises en cascade doit être la possibilité de réglage de la durée de créneau pour compenser la durée totale du retard sur le support. La durée de créneau maximale est définie dans le protocole DLL (voir CEI 61158-4-2).

G.2.2 **Diagramme d'états de sous-couche RM** (informative)

NOTE Le Paragraphe G.2.2 décrit un exemple de mise en œuvre. Il ne comporte aucune exigence normative.

La sous-couche RM est constituée de deux diagrammes d’états interconnectés. Le premier diagramme détermine le canal qui est en réception, tandis que les autres sont en émission. Le second diagramme contrôle le moment où le canal en émission envoie des données.

Le premier diagramme d’états comprend un état par canal à arbitrer. Lorsque le second diagramme d’états est à l'état de repos et que l'indication PLS_CARRIER_INDICATION arrive sur l'un des canaux, ce diagramme d’états passe à l'état correspondant à l'indication. Si le second diagramme est dans un état quelconque autre que l'état de repos, il est verrouillé et ne bouge pas, indépendamment de l'indication PLS_CARRIER_INDICATION. Les premières arrivées simultanées de deux ou plusieurs indications PLS_CARRIER_INDICATION ne sont pas une condition de fonctionnement normal de la PhL et ces transitions d'état du diagramme ne sont pas spécifiées.

Le second diagramme d’états comprend quatre états: RM_IDLE (RM repos), RM_CARRIER (RM porteuse), RM_FRAME (RM trame) et RM_WAIT (RM attente). Si la sous-couche MAC du nœud est en transmission de données, il convient que la RM soit forcée à l'état RM_WAIT:

– l'état RM_Idle indique qu'il n'y a aucune activité sur un quelconque canal. Lorsque l'indication pls_carrier_indication est "faux" pour tous les canaux, l'automate passe à l'état RM_Idle. La présence de l'indication pls_carrier_indication sur un canal donné fait passer l'automate à l'état RM_Carrier. En l'état RM_Idle, la demande pls_frame_request sur tous les canaux est "faux". Les premières arrivées simultanées de deux ou plusieurs indications pls_carrier_indication ne sont pas une condition de fonctionnement normal du réseau et il convient que l'automate passe à l'état RM_Wait;
– l'état RM_Carrier indique une activité de réception, mais la sous-couche MDS n'a pas encore réalisé le verrouillage (pls_lock_indication = faux). Il convient que cet état active la demande pls_frame_request sur tous les canaux, à l'exception de celui indiqué par le premier automate comme étant le canal en réception. La demande pls_data_request est un préambule. Si la régénération du préambule n'est pas utilisée, cet automate sert de paramètre fictif pour verrouiller le premier automate et l'empêcher de changer d'état. La présence de l'indication pls_lock_indication sur le canal sélectionné par le premier automate force l'automate à passer à l'état RM_Frame;
– l'état RM_Frame indique la répétition active de données. Cet état active la demande pls_frame_request sur tous les canaux, à l'exception de celui indiqué par le premier automate comme étant le canal en réception. Il déplace les M-symbols de l'entité PhL de réception aux canaux de transmission; l'indication pls_data_indication => pls_data_request. Au moment où le délimiteur de début des données répétées est transmis, au moins 16 M-symbols de préambule nécessitent d'avoir déjà été envoyés. La perte de l'indication pls_lock_indication sur le canal sélectionné par le premier automate force l'automate à passer à l'état RM_Wait;
– l'état RM_Wait indique la période de fermeture des données répétées. Il empêche les deux diagrammes d’états de passer à tout autre état afin de prévenir la répétition d'échos et de bruit de fin de paquets. L'automate demeure à l'état RM_Wait jusqu'à ce que l'indication pls_carrier_indication soit "faux" pour tous les canaux et que le temps de suppression ait expiré (voir le protocole DLL, CEI 61158-4-2). A ce moment-là, l'automate passe à l'état RM_Idle. En l'état RM_Wait, la demande pls_frame_request sur tous les canaux est "faux".

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L'indication PLS_FRAME_INDICATION du canal qui reçoit n'est pas directement utilisée par les machines répéteurs. Indirectement, il convient que la condition qui a donné lieu à la fin de trame force également la récupération de l'horloge de réception pour déverrouillage immédiat (PLS_LOCK_INDICATION = faux) afin d'éliminer la répétition du bruit après répétition du délimiteur de fin.

Si l'indication pls_lock_indication n'est pas maintenue ou si un délimiteur de début valide n'est pas détecté, ceci indique probablement une trame de données corrompue ou une salve de bruit sur le support. Il convient que la RM soit conçue pour réduire au minimum la possibilité de répétition d'une trame corrompue ou de bruit.

G.3 PhL redondante

La Figure G.2 illustre un modèle de référence de nœud contenant des entités MDS et MAU multiples permettant de réaliser la redondance de la PhL.

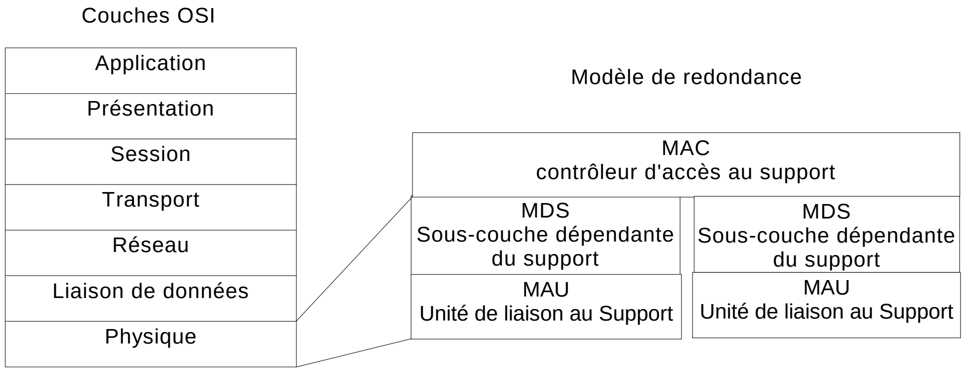

Figure G.2 – Modèle de référence pour la redondance

NOTE 1 Le modèle de base est très similaire à celui utilisé pour les appareils répéteurs de la couche physique spécifiés en G.2.

Les entités PhL redondantes (‘canaux’) dans un nœud simple doivent à tout moment émettre les mêmes informations sur tous les canaux. Les demandes PLS_FRAME_REQUEST et PLS_DATA_REQUEST doivent être communes à tous les canaux redondants.

Les indications PLS_DATA_INDICATION, PLS_CARRIER_INDICATION, PLS_FRAME_INDICATION, PLS_LOCK_INDICATION et PLS_STATUS_INDICATION doivent être indépendantes pour chaque canal. Certains nœuds peuvent, à tout moment, écouter sur un canal donné tandis que d'autres écoutent sur l'autre canal. Etant donné que les deux canaux sont considérés indépendants et identiques, aucun ne doit être considéré comme principal ou préférentiel même s'ils sont généralement appelés canal A et canal B.

NOTE 2 La sous-couche MAC sur chaque nœud détermine le canal à sélectionner pour utilisation par les couches supérieures du nœud concerné. Cette détermination est effectuée de manière indépendante sur chaque nœud.

Les mêmes données étant transmises sur les deux canaux, les mêmes données doivent également être reçues sur les deux canaux. Si l'indication PLS_FRAME_INDICATION d'un canal n'est pas encore "vrai" pour une trame MAC lorsque l'indication PLS_STATUS_INDICATION de l'autre canal indique "Normal", une erreur doit être déclarée sur le canal qui n'a pas détecté la trame MAC. Puisque la trame MAC la plus petite contient 64 Ph-symbols de la fin du délimiteur de début à la fin du délimiteur de fin, les deux canaux doivent être conçus et installés de façon à ce que l'écart temporel d'arrivée de trame MAC au niveau de la DLL soit ≤ 64 durées de symbole Ph.

NOTE 3 Si un canal détecte une trame normale et que l'autre canal ne la détecte pas, la DLL monte DLL_EV_ERRA ou DLL_EV_ERRB (voir CEI 61158-4-2).

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Dans l'exemple d'un nœud avec entités PhL redondantes et un NAP, illustré à la Figure G.3, la sous-couche MAC doit prendre en charge la fonctionnalité de sous-couche RM pour permettre aux données présentes sur le canal sélectionné d'être retransmises sur le port NAP. En même temps, les données reçues sur le port NAP doivent être transmises sur les deux canaux redondants. Toute donnée provenant de ce nœud doit être transmise sur les deux canaux redondants et sur le NAP simultanément.

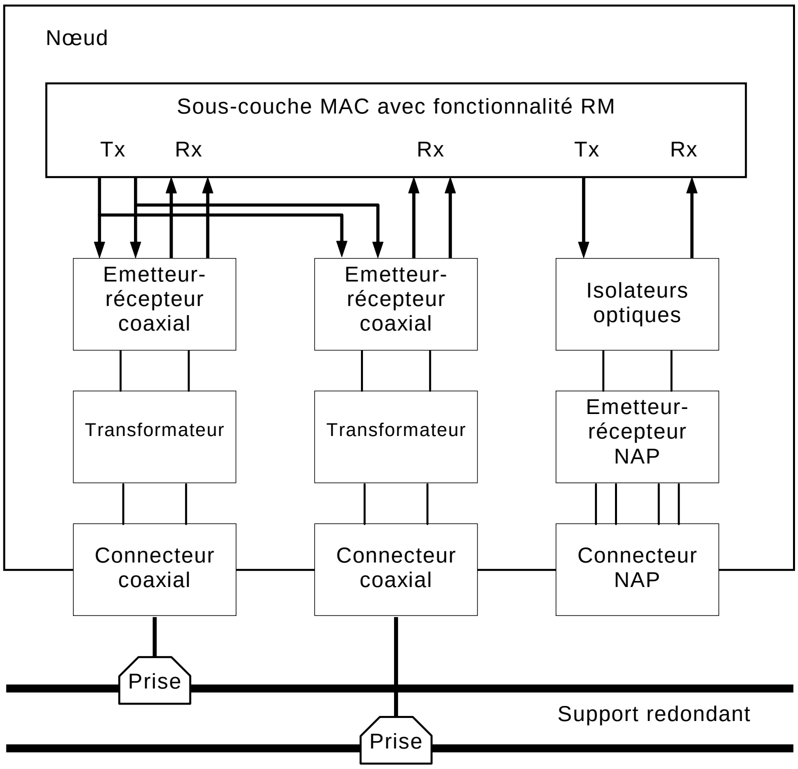

Figure G.3 – Synoptique illustrant le support coaxial redondant et le NAP

G.4 Sous-couche RRM (machine répéteur d'anneau)

G.4.1 Exigences

La RRM doit être au minimum un commutateur à trois ports à base de paquets (voir la Figure G.4). Le port 1, l'accès principal, doit voir chaque paquet de données une fois seulement et peut être utilisé comme interface avec des segments réseau point à point ou avec un nœud. Les deux accès secondaires, le port 2 et le port 3, doivent être de valeur égale et doivent participer à la topologie annulaire. La RRM doit décider de quel port répéter les paquets de données et doit empêcher les paquets de données de tourner indéfiniment sur l'anneau.

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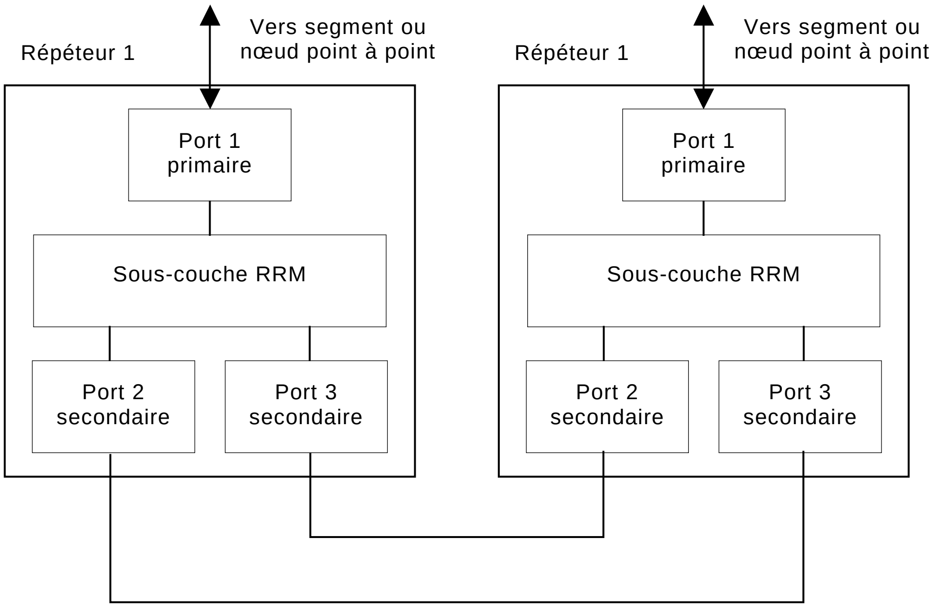

NOTE Si une connexion échoue, l'autre peut encore être active.

Figure G.4 – Synoptique illustrant les répéteurs d'anneau

G.4.2 Fonctionnement de la sous-couche RRM

G.4.2.1 Exigences applicables à la RRM

Pour la prise en charge du fonctionnement de la RRM, les ports de chaque répéteur d'anneau doivent satisfaire aux exigences suivantes:

a) Les ports secondaires de chaque répéteur doivent pouvoir envoyer et recevoir des données simultanément. Chaque port secondaire doit être indépendant de l'autre port et doit également pouvoir fonctionner en mode duplex avec un récepteur et un émetteur séparés pour chaque port.

b) La RRM doit avoir la capacité de détecter la durée de créneau du réseau, soit en déchiffrant le paquet modérateur, soit en surveillant l'activité du réseau ou par quelque autre moyen.

c) Chaque port secondaire doit disposer de son propre compteur de piles de port à fibre optique, appelé `fps_portx`, où x est le numéro du port.

La RRM doit commencer à fonctionner à l'état de repos lorsqu'il n'y a aucune activité réseau; les compteurs `fps_port2` et `fps_port3` étant tous deux à zéro.

G.4.2.2 Segmentation des ports

Le processus de segmentation doit être utilisé par la RRM pour réinitialiser les compteurs à des fins de synchronisation. A la mise sous tension, les ports 2 et 3 doivent commencer en mode segmentation. Les ports doivent revenir au mode segmentation à chaque fois qu'une communication est perdue entre des ports à fibre optique de répéteurs connectés adjacents. Un port en mode segmentation doit bloquer tous les messages en provenance des autres ports au sein du même module/nœud. Par ailleurs, un port en mode segmentation ne doit pas rediffuser les trames de segmentation provenant des autres ports au sein du même module.

NOTE Par exemple, un nœud passera en mode segmentation à la mise sous tension lorsqu'un câble à fibre optique est déconnecté de l'un des ports à fibre optique ou lorsque le trafic s'arrête pendant une seconde ou plus.

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En outre, la RRM doit forcer le mode segmentation à chaque fois que la RRM détecte que les compteurs ne sont plus synchronisés avec le trafic. La synchronisation/resynchronisation des compteurs peut être réalisée en déterminant les frontières du NUT correct.

Un nœud doit passer en mode segmentation dans les conditions suivantes:

– à la mise sous tension,
– si un écho de message n'est pas reçu d'un nœud connecté adjacent,
– si une liaison à fibre optique entre deux ports est silencieuse pendant plus d'une seconde, ce qui indique l'absence de trafic (repos).

Cette méthode utilise deux trames de segmentation particulières pour acquérir la synchronisation du compteur. Les trames de segmentation sont constituées de M_symbols, comme défini en 5.3.2. Les trames de segmentation sont utilisées pour l'établissement de liaisons RRM au cours du processus de segmentation.

Pendant la segmentation, le port concerné diffusera comme requête, un préambule de 32 M-symbols consécutifs {1}, comme illustré à la Figure G.5. Un port connecté à un port diffusant 32 M-symbols consécutifs {1} en mode segmentation doit répondre dès qu'il entend ce préambule par une séquence (préambule de 16 symboles M, délimiteur de début, préambule de 16 symboles M), comme illustré à la Figure G.6. Un module qui émet un préambule et sollicite une réponse doit être à l'écoute d'une séquence (préambule, délimiteur de début, préambule). Dès qu'il entend une réponse, il doit ensuite réinitialiser les compteurs fps_portx correspondants et passer du mode port en segmentation au mode port actif. Cette commutation du port ne doit s'effectuer qu'au cours d'une frontière de NUT (temps de silence). Le processus de segmentation doit être utilisé par la RRM pour réinitialiser les compteurs à des fins de synchronisation. Un port en mode segmentation diffusant des requêtes doit poursuivre jusqu'à réception d'une réponse d'un nœud connecté. Une fois la réponse reçue et pendant le temps de silence NUT, le port peut être mis en service pour émission de paquets de données.

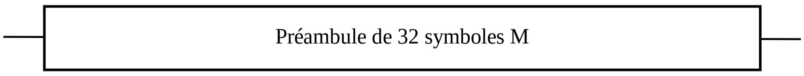

Figure G.5 – Requête de segmentation

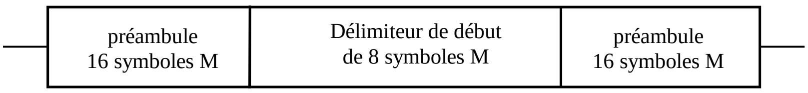

Figure G.6 – Réponse de segmentation

G.4.2.3 Principes de fonctionnement

Le port qui voit en premier l'activité du réseau doit définir la destination vers laquelle les données doivent être répétées. Si le port 2 voit l'activité du réseau en premier, les données doivent être répétées du port 2 vers le port 1 et le port 3 (voir la description détaillée en G.4.2.4). De la même manière, si le port 1 voit l'activité du réseau en premier, les données doivent être répétées du port 1 vers le port 2 et le port 3 (voir la description détaillée en G.4.2.5). Les ports 2 et 3 sont égaux, de sorte que le comportement de la RRM, lorsque le port 2 voit l'activité en premier, doit être identique à son comportement lorsque le port 3 voit l'activité en premier.

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Pour un fonctionnement correct à la mise sous tension et pour récupérer suite à une défaillance des supports, la RRM nécessite une temporisation sans aucune activité de réseau, égale à la durée de créneau.

NOTE 1 Il peut être nécessaire que SMAX soit réglé sur un nombre supérieur au nombre réel de nœuds sur le réseau pour obtenir cette temporisation. Cette méthode garantira au moins un temps de silence par NUT. Des temps de silence multiples par NUT ne posent aucun problème.

NOTE 2 La RRM ne stocke pas des parties de la trame pour déterminer si les échos sont réellement le même paquet de données que celui qui a été envoyé. L'ordre des paquets de données est garanti par la DLL de Type 2 qui spécifie que les nœuds sont émis séquentiellement. Il n'y a pas de risques de détérioration de l'ordre des trames diffusées en écho à moins qu'il n'y ait dysfonctionnement de supports ou de modules. Une trame peut être perdue au moment où il y a dysfonctionnement d'un support. Cependant, le réseau continuera à fonctionner normalement étant donné que l'autre trajectoire de message existe encore.

NOTE 3 La valeur maximale de `fps_portx` peut être calculée de la manière suivante. La longueur de paquet de données la plus courte possible est de 56 bits ou 11,2 μs. Le temps minimal entre trames est le temps de retournement du nœud de 11,2 μs. A une distance maximale de 22,5 km entre les répéteurs, il ne peut pas y avoir plus de 10 paquets de données se déplaçant entre des modules voisins.

Le diagramme d'états du commutateur principal correspondant, pour le fonctionnement de la RRM, est présenté en G.4.2.6.

G.4.2.4 Fonctionnement de la RRM lorsque le port 2 (ou le port 3) est actif en premier

Dans le cas où le port 2 est actif en premier, le fonctionnement de la RRM doit être le suivant.

Le Port 2 reçoit le paquet de données. Etant donné que `fps_port2` est zéro, la RRM doit répéter les données vers le port 1, le port 2 et le port 3 et doit incrémenter `fps_port3`.

NOTE 1 Les données sont répétées en sortie du port de réception, le port 2, car la RRM voisine attend cette répétition. Cette action génère un paquet en écho.

La RRM doit ensuite attendre:

1) L'activité du réseau sur le port 1.
   Voir le comportement résultant en G.4.2.5.
2) Nouvelle activité du réseau sur le port 2.
   La RRM doit simplement se comporter comme elle le faisait précédemment.

   NOTE 2 Ceci nécessite que `fps_port3` soit autorisé à avoir une valeur supérieure à un et inférieure à 11, étant donné que la temporisation la plus défavorable aura eu lieu avant que `fps_port3` n'atteigne 11 (voir le cas 4 ci-dessous).
3) Réception d'un paquet de données sur le port 3.
   Il convient que le paquet de données soit l'écho du paquet initialement émis du port 3 et renvoyé par le module voisin. Sur réception de ce paquet, `fps_port3` doit être décrémenté et la RRM doit retourner à l'état de repos initial. La réception de ce paquet de données ne doit pas provoquer la répétition du paquet par la RRM vers les ports 1 et 2.

   NOTE 3 Ceci est dû au fait que le compteur `fps_port3` n'est pas à zéro, ce qui indique à la RRM que le paquet reçu est un écho et non un nouveau paquet de données. Par ce mécanisme, la RRM empêche les paquets de tourner indéfiniment sur l'anneau.
4) Une temporisation sans aucune activité réseau, égale à la durée de créneau, a alors lieu.
   Dans ce cas, le module voisin n'a pas envoyé le paquet de données transmis à partir du port 3. Ceci peut être dû à un dysfonctionnement du module ou à une défaillance des supports. Dans ce cas, `fps_port2` et `fps_port3` doivent être remis à zéro.

Les ports 2 et 3 sont égaux, de sorte que le comportement de la RRM, lorsque le port 3 voit l'activité en premier, doit être identique à son comportement lorsque le port 2 voit l'activité en premier (dans la séquence ci-dessus, le rôle des ports 2 et 3 doit être inversé).

Le diagramme d'états correspondant au port 2 (et 3) est présenté en G.4.2.6.

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G.4.2.5 Fonctionnement de la RRM lorsque le port 1 est actif en premier

Dans le cas où le port 1 est actif en premier, le fonctionnement de la RRM doit être le suivant.

Le Port 1 reçoit le paquet de données. La RMM doit répéter ce paquet en l'émettant à partir des ports 2 et 3. Lorsque les ports 2 et 3 émettent ce paquet de données, ils doivent tous deux incrémenter leurs compteurs `fps_portx` respectifs.

La RRM doit ensuite attendre:

a) L'activité du réseau sur le port 1.
La RRM doit simplement se comporter comme elle le faisait précédemment, en émettant notamment le paquet à partir du port 2 et du port 3 et incrémenter `fps_port2` et `fps_port3`.

b) L'activité du réseau sur le port 2 ou le port 3.
Semblable au cas 3 en G.4.2.4: dans cette situation, il convient que le paquet de données suivant reçu par le port 2 ou le port 3 soit un écho provenant d'un module voisin. A la réception de ce paquet de données, le port doit décrémenter son compteur fps_portx. Il ne doit pas répéter les paquets envoyés en écho.

c) Une temporisation sans aucune activité réseau, égale à la durée de créneau, a alors lieu.
Ici encore, ceci signifie que des échos n'ont pas été reçus (pour quelque raison que ce soit). Dans ce cas, `fps_port2` et `fps_port3` doivent être remis à zéro.

Le diagramme d'états correspondant au port 1 est présenté en G.4.2.6.

G.4.2.6 Diagrammes d'états

La Figure G.7 illustre le diagramme d'états du commutateur principal correspondant pour le fonctionnement de la RRM.

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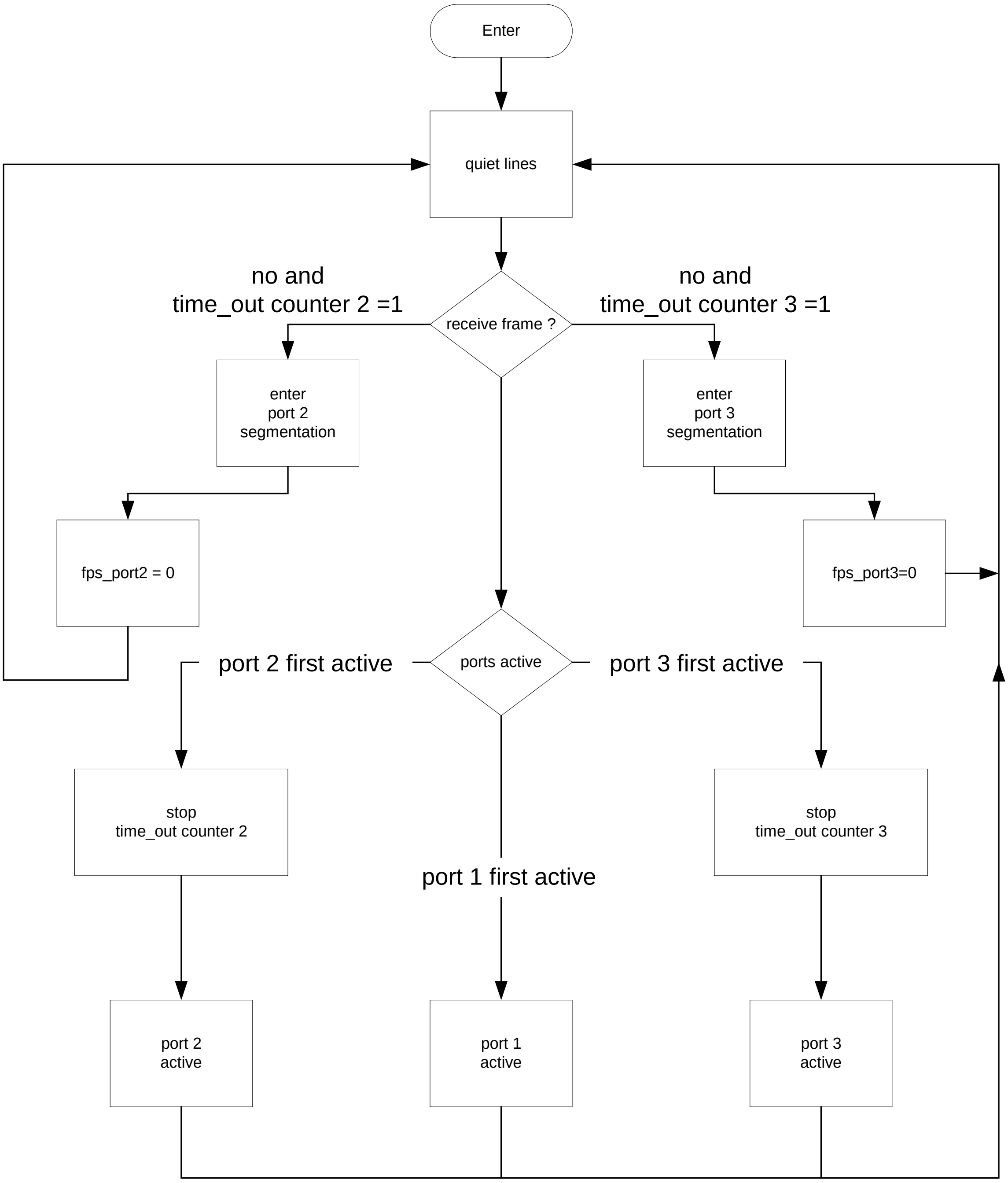

Légende

Anglais	Français
Enter	Entrer
Quiet lines	Lignes silencieuses
No and time_out counter 2 = 1	Non et compteur de temps imparti 2 = 1
Enter port 2 segmentation	Entrer en mode segmentation port 2
Receive frame ?	Recevoir trame ?
No and time_out counter 3 = 1	Non et compteur de temps imparti 3 = 1
Enter port 3 segmentation	Entrer en mode segmentation port 3
Port 2 first active	Port 2 actif en premier
Ports active	Ports actifs
Port 3 first active	Port 3 actif en premier

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Anglais	Français
Stop time_out counter 2	Arrêter compteur de temps imparti 2
Port 1 first active	Port 1 actif en premier
Stop time_out counter 3	Arrêter compteur de temps imparti 3
Port 2 active	Port 2 actif
Port 1 active	Port 1 actif
Port 3 active	Port 3 actif

Figure G.7 – Diagramme d'états du commutateur principal

La Figure G.8 illustre le comportement de la RRM lorsque le port 1 est actif en premier.

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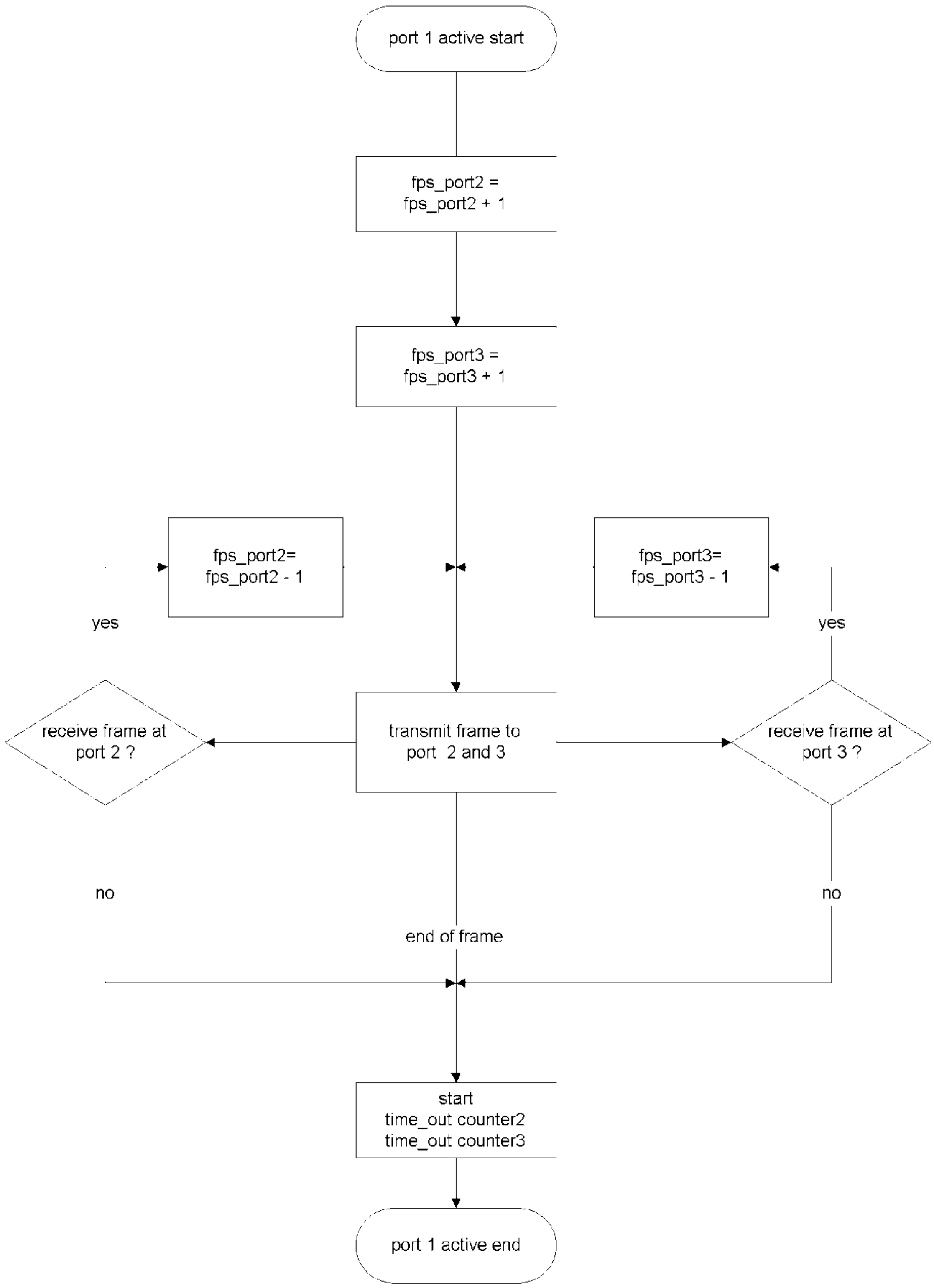

Légende

Anglais	Français
Port 1 active start	Début de Port 1 actif
yes	Oui
Receive port at frame 2 ?	Recevoir trame au port 2 ?
Transmit port to frame 2 and 3	Emettre trame vers ports 2 et 3
yes	Oui
Receive port at frame 3 ?	Recevoir trame au port 3 ?

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Anglais	Français
no	Non
End of frame	Fin de trame
no	Non
Start	Démarrer
Time_out counter 2	Compteur de temps imparti 2
Time_out counter 3	Compteur de temps imparti 3
Port 1 active end	Fin de Port 1 actif

Figure G.8 – Le port 1 voit l'activité du réseau en premier

La Figure G.5 illustre le comportement de la RRM lorsque le port 2 est actif en premier. Le comportement de la RRM lorsque le port 3 est actif en premier doit être identique en intervertissant "2" et "3" dans la Figure G.9.

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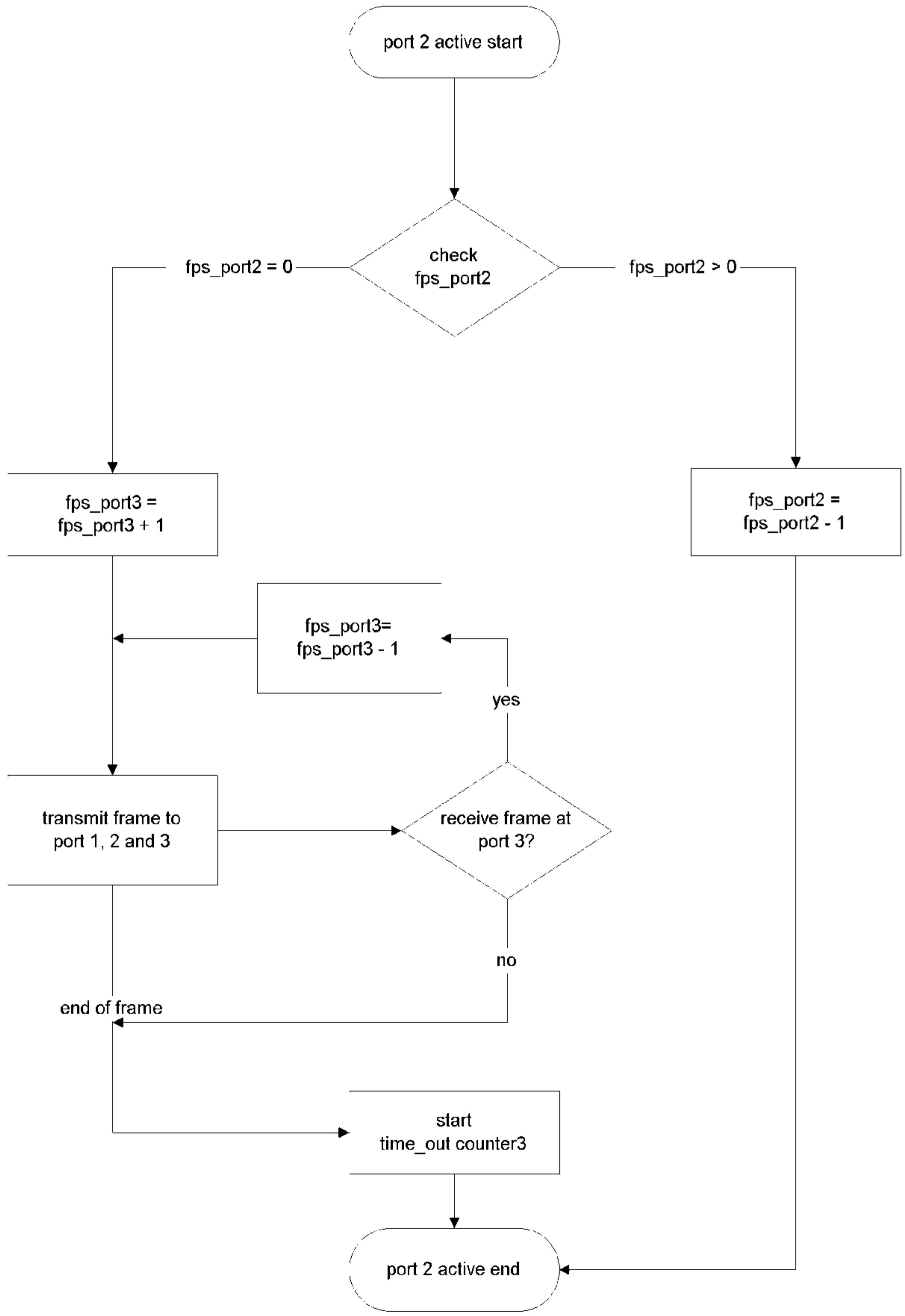

Légende

Anglais	Français
Port 2 active start	Début de Port 2 actif
Check fps_port 2	Vérifier fps_port 2
yes	Oui
Transmit frame to port 1, 2 and 3	Emettre trame vers ports 1, 2 et 3
Receive frame at port 3 ?	Recevoir trame au port 3 ?
End of frame	Fin de trame
no	Non

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Anglais	Français
Start time_out counter 3	Démarrer compteur de temps imparti 3
Port 2 active end	Fin de Port 2 actif

Figure G.9 – Le port 2 voit l'activité du réseau en premier

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Annexe H
(informative)

Type 2: Exemples de conceptions de référence

H.1 MAU: support à câble coaxial de 5 Mbit/s en mode tension

H.1.1 Exemple de modèle de référence d'un émetteur-récepteur

L'émetteur, illustré à la Figure H.3 et à la Figure H.4, est constitué d'une paire de préémetteurs en technologie MOS complémentaire (CMOS), d'une paire d'émetteurs à transistor et du transformateur. Les diodes Schottky série et les diodes de protection contre les surtensions sont traitées plus loin en H.1.

Le préémetteur est un 74AC08. Cet appareil permet de combiner des données et active des signaux; il fournit l'attaque base (excitateur de base) pour le transistor d'attaque.

Le circuit d'attaque du transistor utilise une paire de transistors MMBT2369. Il s'agit de commutateurs à grande vitesse choisis pour leurs facteurs de performance élevés, tels que

- courant du collecteur d'au moins 150 mA;
- caractéristiques de commutation rapides, en général supérieures à 10 ns;
- SOT-23 de dimension réduite;
- faible V_{ce} sat à une I_c d'environ 0,5 V;
- faible capacité nominale de sortie de 4,0 pF.

Les résistances série de base définissent l'attaque base requise et les résistances shunt de base réduisent la durée hors-tension. Les condensateurs de base assurent une limitation du taux de dérive qui améliore légèrement les émissions rayonnées.

Le transformateur (1:1:1) assure le couplage du signal de transmission au support. Chaque côté de la paire de circuits d'attaque commande un côté du transformateur à prise médiane, de sorte que le circuit d'attaque fonctionne en configuration symétrique. La tension présentée de chaque côté du circuit d'attaque est typiquement de 4,2 V (à V_{cc}= 5 V) et de 4,7 V au maximum (à V_{cc}= 5,5 V). Ceci correspond à un courant de sortie crête du circuit d'attaque (dans une résistance de 37,5 Ω) d'environ 110 mA en moyenne et d'environ 125 mA au maximum. Le courant total d'alimentation crête, y compris l'attaque base, est d'environ 140 mA.

Par conception, les circuits du récepteur sont simples. La complexité résulte du contrôle des seuils de détection. La Figure H.1 est un schéma simplifié représentant uniquement les composants importants du détecteur RXDATA.

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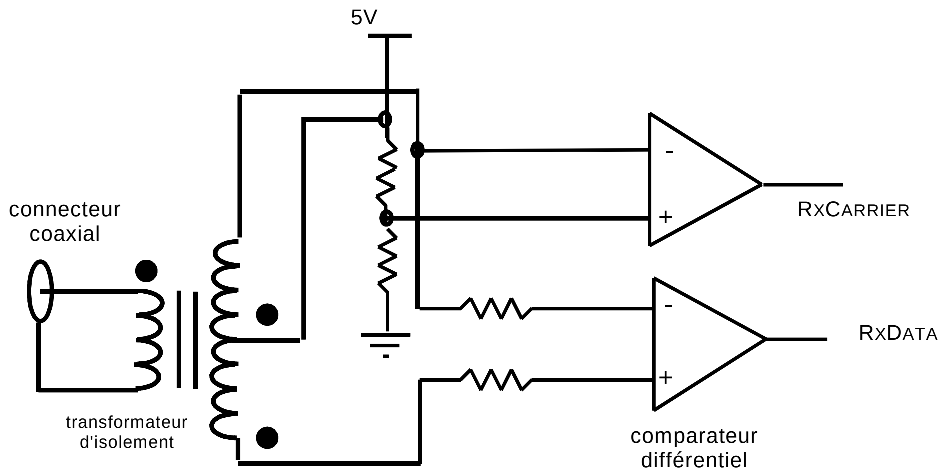

Figure H.1 – Détecteur RIxData de MAU à câble coaxial

L'exemple de détecteur utilise un 26LS32A (récepteur quadruple) sélectionné pour son impédance d'entrée élevée. De nombreux appareils de cette classe offrent une impédance d'entrée minimale spécifiée de 6 kΩ, tandis qu'un fournisseur offre une spécification de 12 kΩ au minimum. Un écrantage particulier est exigé pour cette partie, dans le modèle de référence, pour permettre une amélioration de la sensibilité sur une plus petite gamme en mode commun. Les spécifications les plus importantes pour cet appareil sont les suivantes:

a) impédance d'entrée élevée (elle doit être élevée pour répondre aux exigences d'impédance d'entrée du nœud): 15 kΩ en moyenne, 12 kΩ au minimum;
b) faibles tensions de seuil, dans le cas le plus défavorable: ± 100 mV sur une gamme en mode commun de 0 V à 5,5 V;
c) plage de températures de 0 °C à 85 °C;
d) simple alimentation en 5 V;
e) tolérance d'alimentation de ±10 %
f) suffisamment rapide pour traiter le débit binaire 5 Mbit/s codé Manchester.

Pour le détecteur Rx illustré à la Figure H.1 et pour les schémas de principe de la Figure H.3 et de la Figure H.4, le Tableau H.1 montre les niveaux de tension d'entrée pour la transition de RxData et RxCarrier.

Tableau H.1 – Définition des sorties du récepteur à câble coaxial de 5 Mbit/s en mode tension

Tension d'entrée au niveau du support	RxData	RxCarrier
V_{in}<–140 mV	faux (0)	faux (0)
–140 mV < V_{in}< 23 mV	indéfini	faux (0)
23 mV < V_{in}< 140 mV	indéfini	indéfini
140 mV < V_{in}< 255 mV	vrai (1)	indéfini
255 mV < V_{in}	vrai (1)	vrai (1)

Les résistances série sur l'entrée au 26LS32A ont des valeurs différentes pour compenser le décalage du seuil dû aux résistances de sécurité intrinsèque du récepteur 26LS32A.

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La détection de porteuse utilise un autre récepteur du 26LS32A. Il est effectué une comparaison locale du signal d'entrée à un seuil c.c, comme illustré dans le schéma simplifié de la Figure H.2.

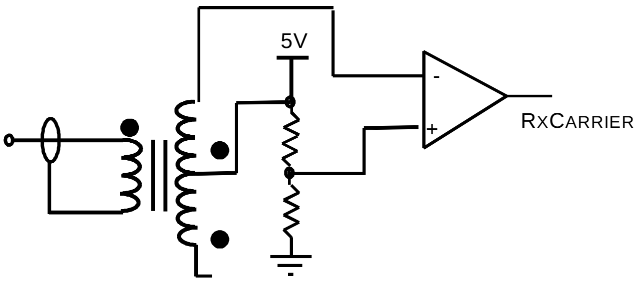

Figure H.2 – Détection RXCARRIER de MAU à câble coaxial

Le signal RXCARRIER est tout à fait similaire au signal RXDATA à des niveaux de signaux élevés. A des bas niveaux de signaux, ils sont également similaires, sauf que les largeurs d'impulsions "un" de RXCARRIER sont plus étroites que celles de RxData. Lorsqu'aucun signal n'est présent, la sortie de RXCARRIER est toujours à l'état bas, contrairement à RxData, qui est indéfini et qui peut changer d'état en fonction du bruit.

La Figure H.3 présente un exemple d'émetteur-récepteur redondant et la Figure H.4 un exemple d'émetteur-récepteur à un seul canal.

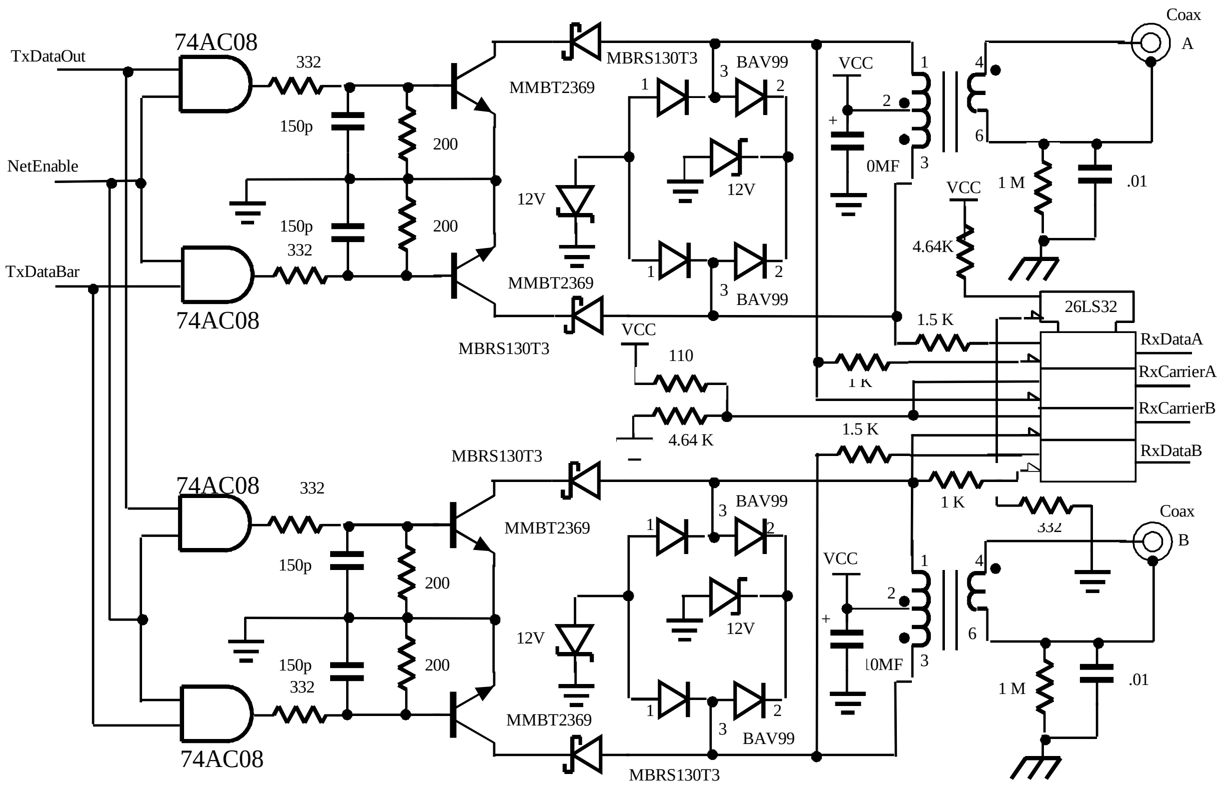

Figure H.3 – Emetteur-récepteur redondant de MAU à câble coaxial

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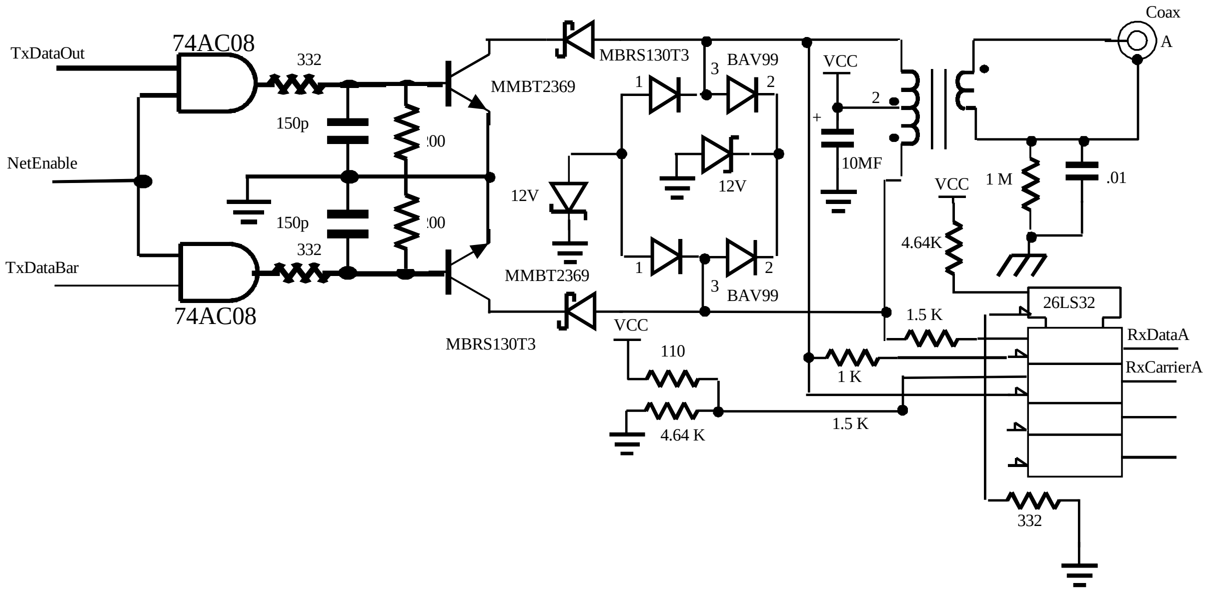

Figure H.4 – Emetteur-récepteur à un seul canal de MAU à câble coaxial

H.1.2 Exemple de modèle de référence d'un transformateur

Le noyau est conforme au type EP-7 de la CEI 61596, sans entrefer, avec une valeur minimale Al = 1 100 nH par spire^2. La séquence de construction des enroulements est la suivante:

a) enroulement 1 entre les broches 3 et 2: diamètre de 0,127 mm, 18 spires;

b) ruban de 1 mil.;

c) enroulement 2 entre les broches 2 et 1: diamètre de 0,127 mm, 18 spires;

d) ruban de 1 mil.;

e) enroulement 3 entre les broches 4 et 6: diamètre de 0,127 mm, 18 spires;

f) circuit extérieur.

H.1.3 Exemple de modèle de référence d'une prise

Un modèle de prise est donné pour exemple à la Figure H.5. L'autotransformateur (T1) est bobiné sur un noyau torique Ferronics 11-720B. L'enroulement est constitué de 18 spires bifilaires, d'un seul brin, avec un chevauchement minimal de fil de bobinage de 0,254 mm de diamètre en poly-nylon lourd.

Les caractéristiques électriques mesurées sont présentées dans le Tableau H.2.

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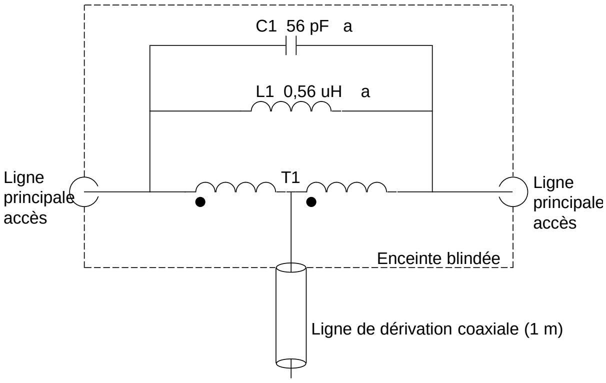
Tableau H.2 – Spécifications de tore bobiné de support à câble coaxial

Paramètre	Valeur
Inductance de fuite	75 μH à 300 kHz
Inductance d'aimantation	890 μH à 300 kHz
Capacité d'enroulement	20 pF à 25 MHz
Résistance de perte de l'enroulement	0,1 Ω à 300 kHz
Résistance de perte du noyau (pertes dans le fer)	16 kΩ à 1,3 MHz



[a] Les valeurs présentées sont nominales. Il convient d'ajuster les valeurs réelles de manière à satisfaire aux exigences des paramètres de dispersion décrits en Figure 85.

Figure H.5 – Prise de support à câble coaxial

H.2 Port d'accès au réseau (NAP)

La conception des circuits NAP de nœuds, illustrée dans le schéma de la Figure H.6, est relativement simple. Il est utilisé un simple ensemble émetteur et récepteur. Le récepteur a une tension de décalage interne ajoutée qui produit un état de données zéro dans les conditions de défaut (support retiré, court-circuit, etc.) énumérées dans les exigences du Tableau 103. La polarité du signal de réception est haute pour un état de données zéro. Des émetteurs et des récepteurs RS-422 différentiels sont utilisés pour améliorer la suppression du bruit.

Des diodes à polarisation inverse sont prévues sur des lignes de transmission du NAP pour assurer la protection contre les décharges électrostatiques.

Pour l'option support à fibre optique, les circuits NAP sont identiques. Les émetteurs-récepteurs de support à câble coaxial sont simplement remplacés par des émetteurs-récepteurs à fibre optique.

Le schéma d'un nœud permanent non isolé utilise un émetteur-récepteur similaire à celui illustré à la Figure H.6.

Comme dans le nœud, il est utilisé un émetteur / récepteur unique pour les données. Le même circuit de décalage est utilisé pour garantir des niveaux corrects de déconnexion et de mise hors-tension. En outre, les mêmes diodes de protection de l'émetteur sont utilisées.

Pour un nœud transitoire qui tire son énergie d'une source mise à la masse, il est utilisé des isolateurs optiques. Le modèle présenté à la Figure H.7 illustre la manière dont les isolateurs optiques et un convertisseur c.c-c.c peuvent être utilisés pour alimenter l'isolation à la masse requise.

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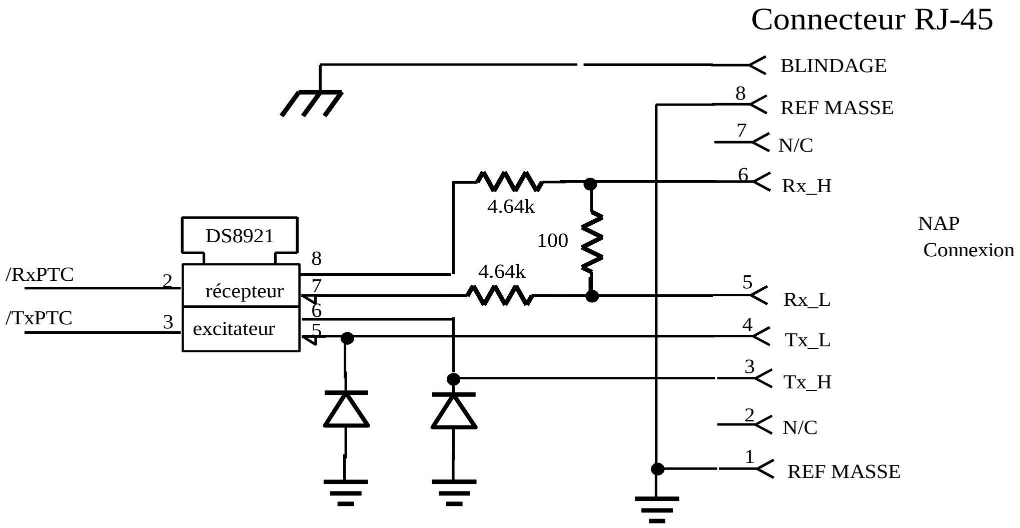

Figure H.6 – Émetteur-récepteur NAP non isolé

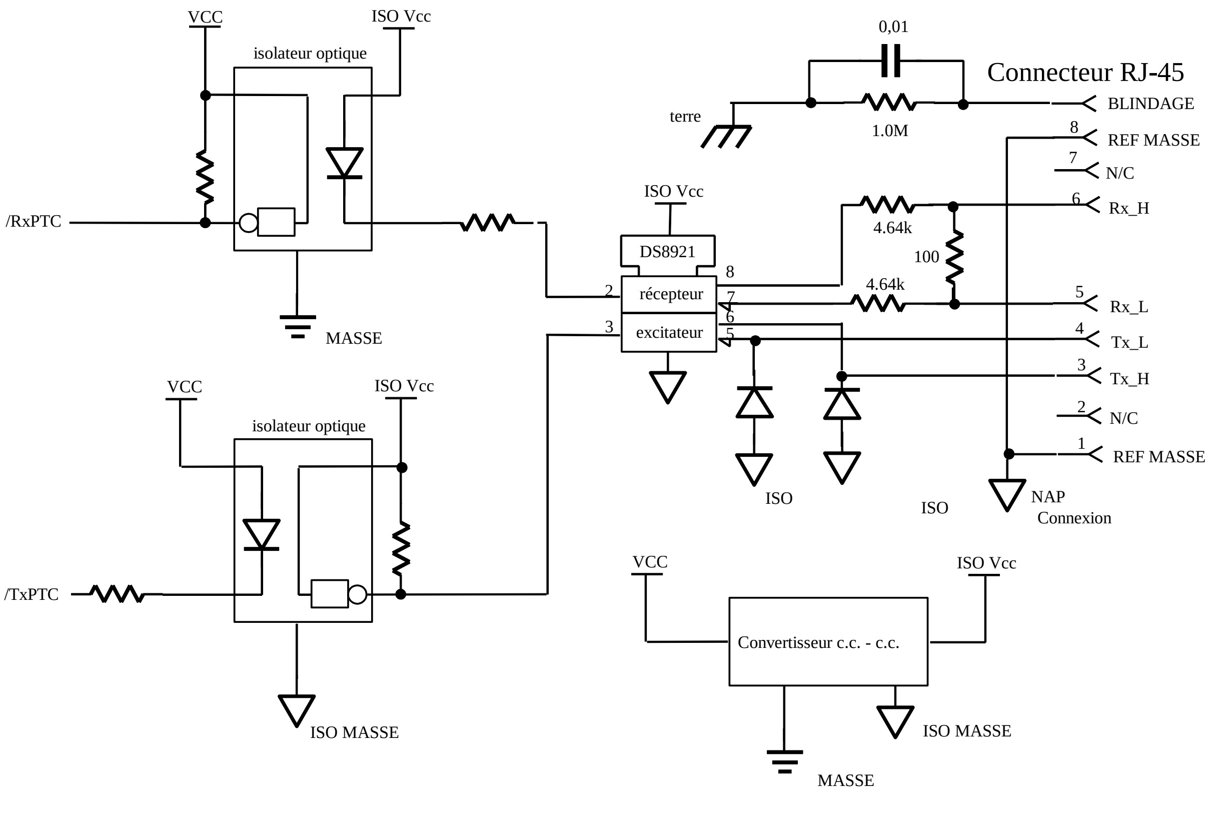

Figure H.7 – Émetteur-récepteur NAP isolé

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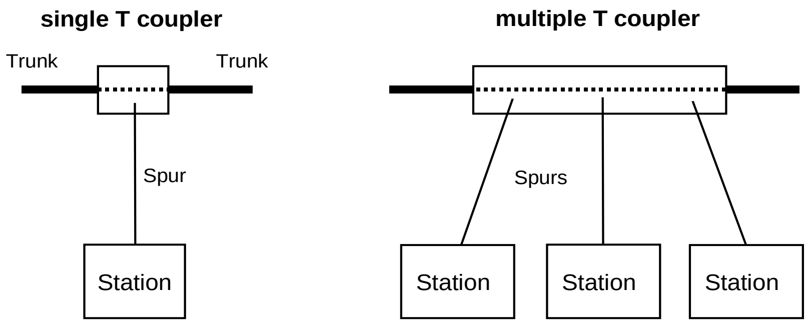
Annexe I
(normative)

Type 3: Spécifications des connecteurs

I.1 Connecteur pour transmission synchrone

I.1.1 Généralités

Il peut s'agir d'une topologie arborescente, linéaire ou d'une combinaison des deux. Les coupleurs en T connectent les stations (par exemple d'appareils de terrain) au câble de bus; ils doivent avoir un degré de protection IP 65. Le coupleur en T peut être simple ou multiple (voir la Figure I.1). La fonction du coupleur en T peut également être intégrée dans la station.



Légende

Anglais	Français
Single T coupler	Coupleur en T simple
Trunk	Ligne principale
Spur	Ligne secondaire
Station	Station
Multiple T coupler	Coupleur en T multiple
Spurs	Lignes secondaires

Figure I.1 – Schéma du coupleur de station

I.1.2 Affectation des broches d'un connecteur circulaire M12

Les contacts du connecteur circulaire M12 doivent être attribués aux fonctions présentées dans le Tableau I.1 et dans la Figure I.2.

Tableau I.1 –– Affectation des contacts du connecteur externe pour environnements industriels rigoureux

Numéro de contact	Fonction
1	Données + avec l'option alim +
2	non connecté
3	Données – avec l'option alim –
4	non connecté
Filetage	Blindage

Le blindage doit être concentrique autour du filetage. Le potentiel du blindage doit être transmis par l'intermédiaire du filetage. Les appareils de type 3 existants dont la broche 4 est

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connectée, sont également conformes à la présente Norme internationale. Pour les nouveaux appareils, la broche 4 ne doit pas être utilisée. Les câbles de type 3 préassemblés existants dont la broche 4 est connectée, sont également conformes à la présente Norme internationale. Pour les nouveaux câbles, la broche 4 ne doit pas être connectée.

Le connecteur circulaire M12 et le connecteur femelle doivent avoir un degré de protection IP 65 ou supérieur.

Les contacts mâles et femelles doivent être conçus de façon à maintenir les caractéristiques de transmission même dans une atmosphère corrosive, par exemple un environnement chimique.

L'orifice central de la fiche femelle ne doit pas être utilisé du fait de l'augmentation des lignes de fuite et des distances dans l'air dans des atmosphères explosibles (voir la Figure I.2).

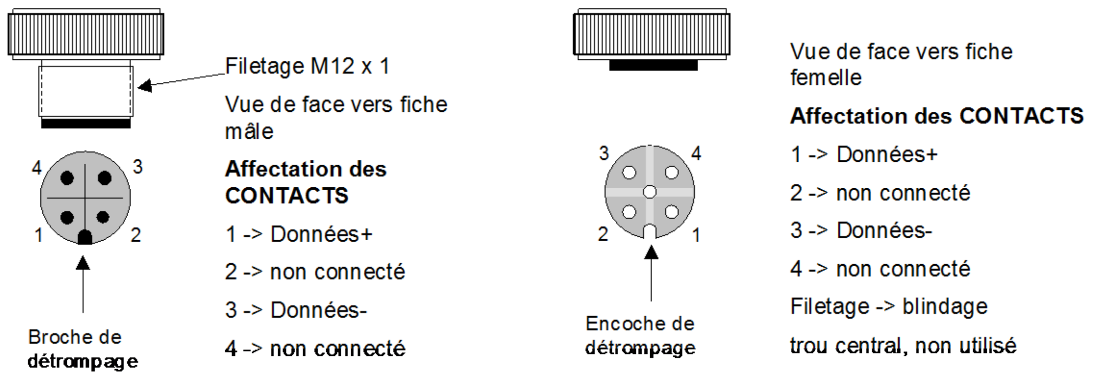

Figure I.2 – Affectation des broches des connecteurs mâles et femelles CEI 60947-5-2 (codage A)

I.1.3 Connexion entre un coupleur en T et une station

Les coupleurs en T et les stations sont connectés au moyen d'un connecteur circulaire blindé M12. Le coupleur en T peut être directement connecté à la station ou à une dérivation d'un connecteur M12 blindé.

Il faut toujours s'assurer que le blindage du câble de bus est appliqué sur une surface importante, conformément aux recommandations de mise à la masse (pour la mise à la masse et le blindage, voir 21.8.6 et 21.8.7).

Des techniques de terminaison sur le terrain, comme par exemple les bornes à vis ou à lames ainsi que les terminaisons permanentes, peuvent également être utilisées.

I.2 Connecteur pour transmission asynchrone

I.2.1 Connecteur pour transmission asynchrone sans sécurité intrinsèque

Chaque station est connectée au support au moyen d'un connecteur sub-D à 9 contacts. Le côté femelle du connecteur se trouve sur la station, tandis que le côté mâle est monté sur le câble de bus.

Les caractéristiques mécaniques et électriques sont spécifiées dans la CEI 60807-3.

Il convient d'utiliser de préférence un boîtier de connecteur métallique. Lorsqu'elles sont assemblées, il convient que les deux parties du connecteur soient solidarisées par des vis conductrices. Il convient de réaliser la connexion entre les sections de câble et les stations au moyen de coupleurs en T intégrant trois connecteurs sub-D à 9 contacts (deux connecteurs

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mâles et un connecteur femelle). Ces coupleurs en T permettent la déconnexion ou le remplacement de stations sans avoir à couper le câble et à interrompre le fonctionnement (déconnexion en ligne).

L'affectation des broches des connecteurs est présentée dans le Tableau I.2 et dans la Figure I.3.

Tableau I.2 – Désignations des contacts

Numéro de contact	Réf. RS-485	Désignation du signal	Signification
1		BLINDAGE (voir les notes 1, 2)	Blindage, terre de protection
2		M24V (voir note 1)	Tension de sortie–24 V
3	**B/B'**	RxD / TxD-P	Réception/transmission données P
4		CNTR-P (voir note 1)	Commande P
5	**C/C'**	DGND	masse de référence des données
6		VP	Plus de la tension
7		P24V (voir note 1)	Tension de sortie + 24 V
8	**A/A'**	RxD / TxD-N	Réception/transmission données N
9		CNTR-N (voir note 1)	Commande N
NOTE 1 Signaux facultatifs. NOTE 2 Connexion non recommandée.			

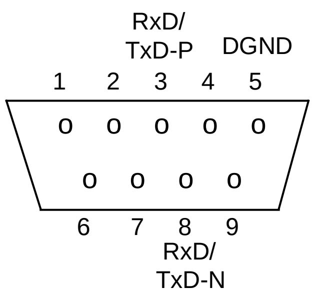

Figure I.3 – Configuration des contacts de connecteurs, vue de face du connecteur mâle et vue arrière du connecteur femelle, respectivement

La masse de référence des données, connectée au contact 5, et le plus de la tension, connecté au contact 6, alimentent le terminateur de bus.

Les signaux de commande CNTR-P et CNTR-N, connectés aux contacts 4 et 9, assurent la commande du sens lorsque des répéteurs sans fonction d'auto-commande sont utilisés. Il est recommandé d'utiliser les signaux de la norme TIA/EIA-485-A de l'ANSI. Pour des appareils simples, le signal CNTR-P peut être un signal TTL (1 charge TTL) et le signal CNTR-N peut être mis à la masse (DGND). La définition des signaux n'est pas du domaine de la présente norme.

La tension de sortie 24 V, conformément à la CEI 61131-2, dans le Tableau 6, permet de connecter des tableaux de commande ou des appareils de service sans alimentation intégrée. Si un appareil dispose d'une tension de sortie de 24 V, il doit accepter une charge de courant allant jusqu'à 100 mA.

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I.2.2 Connecteur pour transmission asynchrone de sécurité intrinsèque

I.2.2.1 Technique de connexion IP20

Pour les caractéristiques mécaniques et électriques, voir I.2.1.

L'affectation des broches des connecteurs est présentée dans le Tableau I.3.

Tableau I.3 – Désignations des contacts

Numéro de contact	Réf. RS-485	Désignation du signal	Signification
1		BLINDAGE (voir note 1)	Blindage
2		NC	(Non connecté)
3	**B**	RxD / TxD-P	Réception/transmission données P
4		NC	(Non connecté)
5		ISM (voir note 2)	Moins de la terminaison de bus
6		ISP (voir note 2)	Plus de la terminaison de bus
7		NC	(Non connecté)
8	**A**	RxD / TxD-N	Réception/transmission données N
9		NC	(Non connecté)
NOTE 1 Signal facultatif dont la connexion n'est pas recommandée.			
NOTE 2 Limitation du courant de signal par des résistances.			

Le terminateur de bus est alimenté par ISM, connecté au contact 5 et par ISP, connecté au contact 6.

Les inductances série dans les lignes de données, présentes dans les connecteurs qui ne sont pas de sécurité intrinsèque, ne doivent pas être utilisées. Le câblage allant de l'entrée du bus à la sortie du bus dans le connecteur doit être conçu pour un courant maximal de 4,8 A. Le piège vers l'appareil de communication (conducteurs A, B, ISM et ISP) doit être conçu pour le courant d'entrée maximal de 2 x Io (~300 mA) Les valeurs correctes de conception du connecteur (largeurs de pistes, distances de séparation, etc.) doivent être conformes à la CEI 60079-11.

Les distances de séparation entre les conducteurs A, B, ISM et ISP, depuis le piège du connecteur jusqu'aux résistances de limitation du courant dans l'appareil de communication, doivent être infaillibles conformément à la CEI 60079-11.

I.2.2.2 Technique de connexion IP65

Le connecteur M-12 à 4 contacts, conforme à la CEI 60947-5-2, est utilisé pour des systèmes de bus de terrain dans des environnements industriels extrêmes. Seuls des connecteurs blindés peuvent être utilisés. Les connecteurs comportent une clé mécanique (codage B). L'affectation des broches des connecteurs est présentée dans le Tableau I.4.

Tableau I.4 – Désignations des contacts

Numéro de contact	Réf. RS-485	Désignation du signal	Signification
1		ISP (voir la note)	Plus de la terminaison de bus
2	**A**	RxD / TxD-N	Réception/transmission données N
3		ISM (voir la note)	Moins de la terminaison de bus
4	**B**	RxD / TxD-P	Réception/transmission données P
Raccord fileté		BLINDAGE	Blindage
NOTE Limitation du courant de signal par des résistances.			

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Le terminateur de bus est alimenté par ISM, connecté au contact 3 et par ISP, connecté au contact 1.

Les inductances série dans les lignes de données, présentes dans les connecteurs qui ne sont pas de sécurité intrinsèque, ne doivent pas être utilisées. Les contacts du connecteur doivent être conçus pour un courant maximal de 4,8 A.

Le connecteur de l'appareil de terrain doit être du type M12 femelle, comme illustré à la Figure I.4.

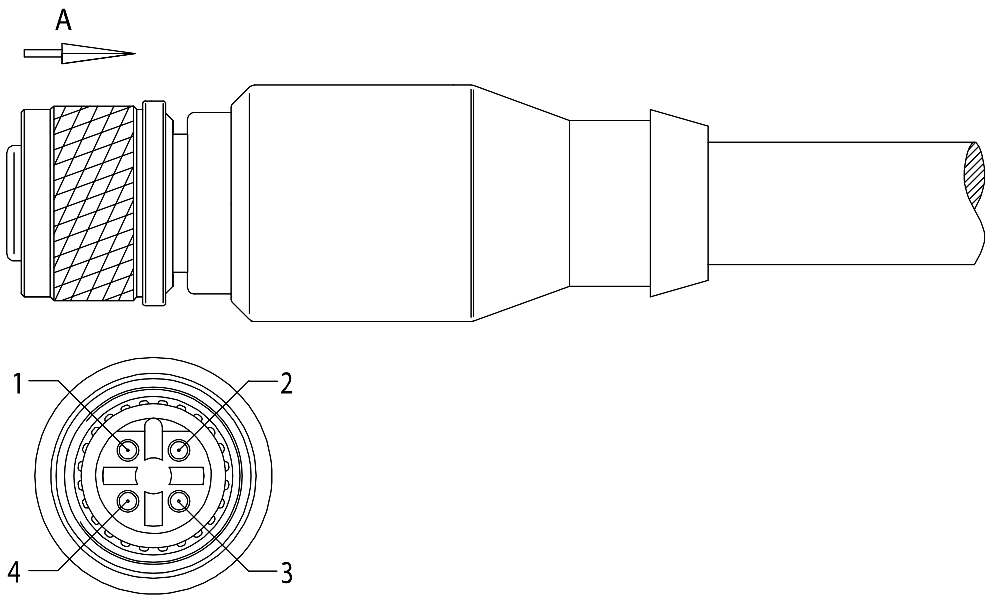

Figure I.4 – Configuration des contacts du connecteur, vue de face du connecteur M12 femelle

Les connecteurs du côté câble doivent être du type M12 mâle, comme illustré à la Figure I.5.

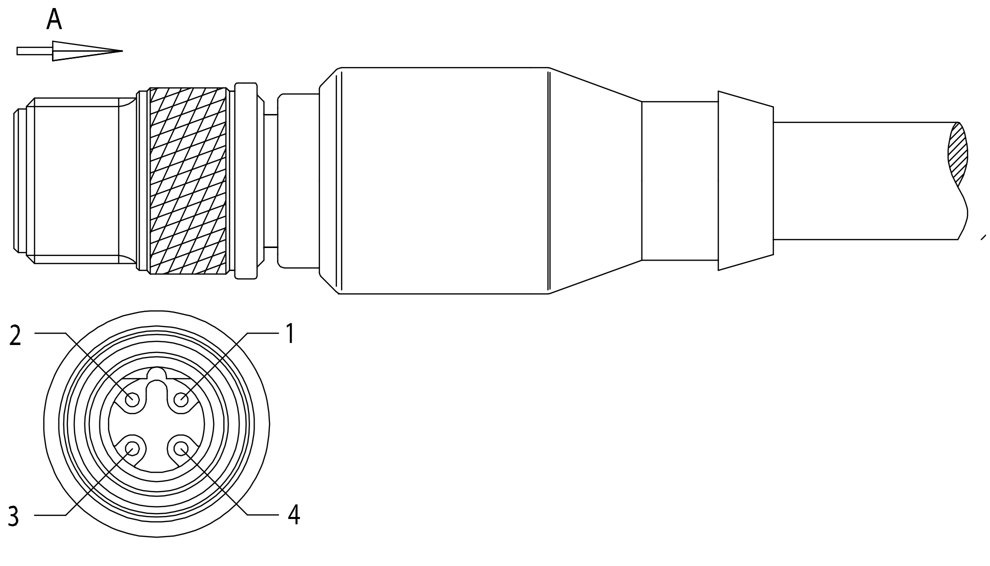

Figure I.5 – Configuration des contacts du connecteur, vue de face du connecteur M12 mâle

La topologie du bus de terrain est de structure linéaire. Les jonctions (coupleurs en T), comme illustrées à la Figure I.6, permettent de connecter les appareils individuels au câble

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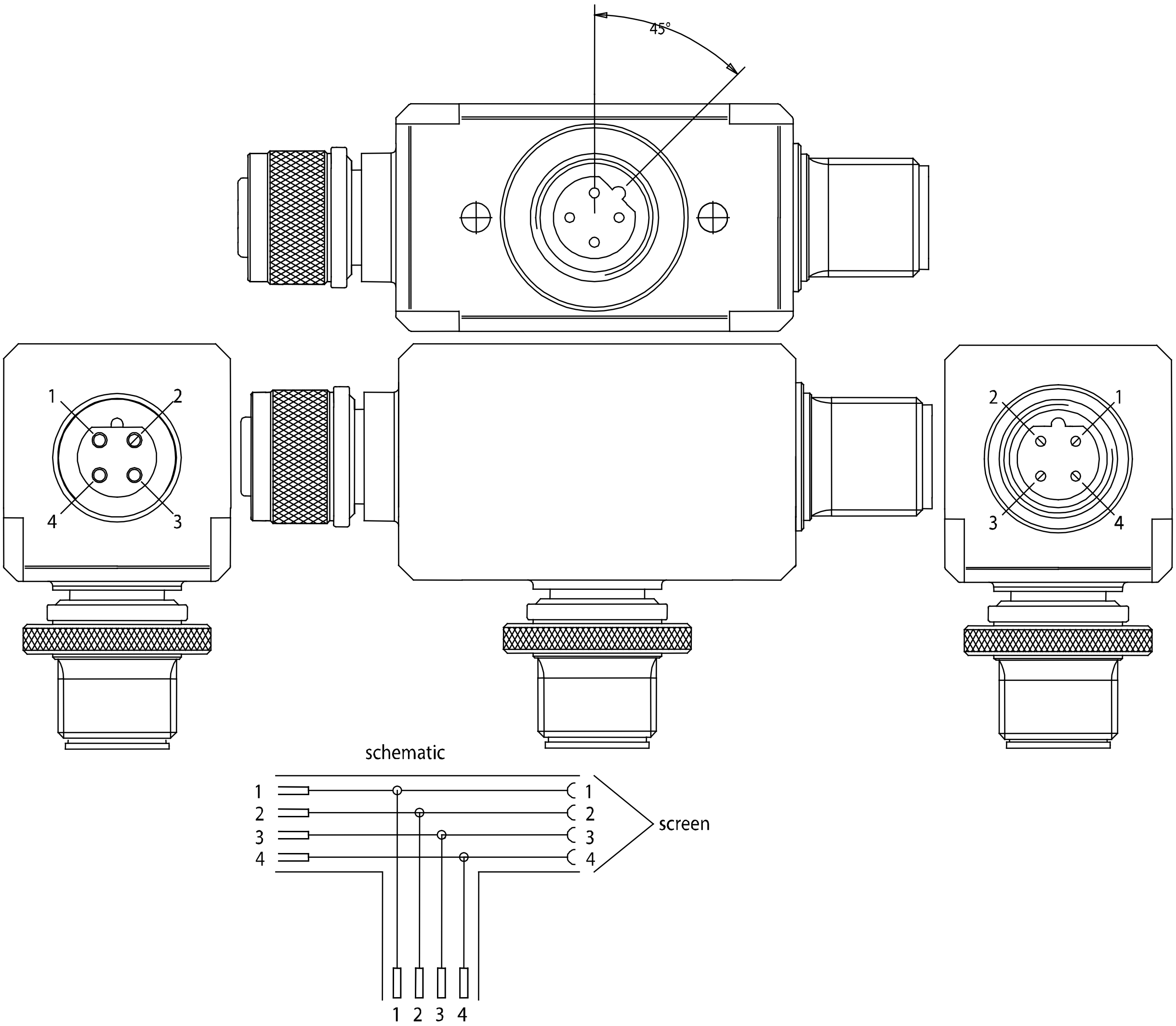
de ligne principale. Il convient que la longueur des lignes d'adaptation soit aussi courte que possible. Les inductances série ne doivent pas être utilisées dans les lignes de données.

Le coupleur en T doit être uniforme et concentrique tout le long jusqu'à l'écrou taraudé (raccord fileté); (connecteurs métalliques et similaires).

La tension d'alimentation fournie par les appareils pour exciter la résistance de terminaison doit être acheminée par le coupleur en T.



Légende

Anglais	Français
Schematic	Représentation schématique
Screen	Ecran

Figure I.6 – Coupleur en T M12

La Figure I.7 illustre la configuration des contacts et un schéma de la terminaison de bus M12.

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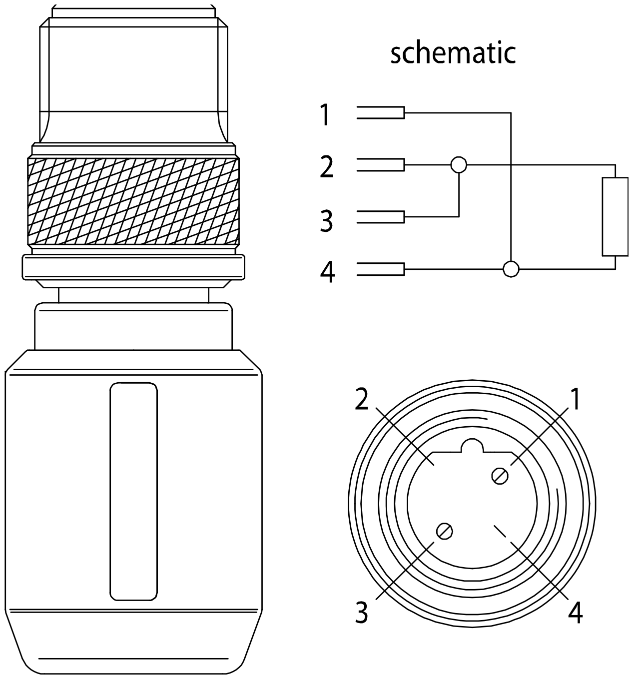

Légende

Anglais	Français
schematic	Représentation schématique

Figure I.7 – Terminaison de bus M12

I.2.2.3 Technique de connexion terminale

La connexion terminale doit fournir les signaux A, B, ISM et ISP. La désignation doit correspondre au nom du signal. Comme autre solution, si une terminaison de bus interne est disponible, on peut fournir uniquement les signaux A et B. L'appareil de communication doit assurer une connexion appropriée du blindage du câble.

Le câblage allant de l'entrée du bus à la sortie du bus dans la terminaison doit être conçu pour un courant maximal de 4,8 A.

I.3 Connecteurs pour câble à fibre optique

I.3.1 Connecteurs pour câble à fibre optique en silice (longueur d'onde de 850 nm et 1 300 nm)

Les câbles à fibre optique en silice sont connectés ou interconnectés au moyen de connecteurs de type BFOC/2.5 conformément à la CEI 61754-2.

NOTE Les contacts de jonction bout à bout des fibres, appelés contacts physiques (PC), réduisent l'affaiblissement et la réflexion des connexions fibre à fibre.

I.3.2 Connecteurs pour câble à fibre optique en matière plastique et silice (longueur d'onde de 660 nm)

Les câbles à fibre optique en matière plastique sont de préférence connectés ou interconnectés au moyen de connecteurs de type BFOC/2.5.

Il est admis d'utiliser d'autres éléments de connexion s'ils sont compatibles avec la fibre de référence en matière plastique 980/1 000 μm ou la fibre en verre (silice) 200/230 μm.

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Annexe J
(normative)

Type 3: Redondance de PhL et support

L'utilisation d'une PhL redondante améliore la fiabilité du bus de terrain. Lorsqu'elle est mise en œuvre, la PhL redondante comporte deux supports installés séparément (câble de bus "a" et câble de bus "b") ainsi que deux MAU (unités de liaison au support) complètes par station. Le principe de l'architecture redondante est illustré à la Figure J.1.

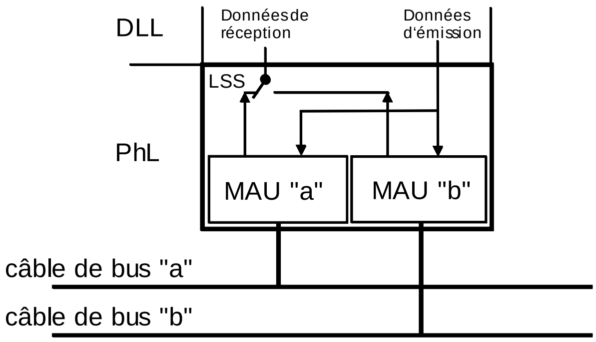

Figure J.1 – Redondance de PhL et support

Le principe de base, illustré à la Figure J.1, suppose que les données sont envoyées simultanément par les deux MAU (émetteurs-récepteurs) sur les deux supports (câble de bus "a" et câble de bus "b"). Par contre, chaque station reçoit d'un seul support (soit le câble de bus "a", soit le câble de bus "b"). Le canal de réception est sélectionné au moyen d'un sélecteur de ligne (LSS), placé entre les deux MAU et la DLL. Le sélecteur de ligne est commandé par la Gestion Ph. Pour cela, la MAC (commande d'accès au support physique) de chaque DLL de station surveille l'activité du support et fournit les informations correspondantes à la Gestion DL (voir dans la CEI 61158-3-3 – DLMS Event and Get Value service) indépendamment de toute autre station. Les principales conditions de commutation pour les maîtres et les esclaves sont les suivantes:

– deux ou plusieurs trames invalides successives sont reçues; invalide signifie que des trames ayant un format invalide, un bit de parité invalide ou une séquence de contrôle de trame invalide, sont détectées;
– le temporisateur de délai imparti T_{TO} expire (voir CEI 61158-4-3, 5.5);
– no Syn. Le temps T_{SYN} (c'est-à-dire ligne au repos pendant au moins T_{SYN}) a été détecté au cours d'un temps d'intervalle de synchronisation T_{SYNI} (voir CEI 61158-4-3, 5.5).

NOTE 1 En fonction de l'exécution, d'autres conditions de commutation peuvent être choisies.

La sélection du canal de réception "a" (principal) ou "b" (de remplacement) est notifiée à la Gestion Ph; voir 6.3. La Gestion Ph fournit alors cette information à l'utilisateur PHMS via l'interface de gestion.

NOTE 2 Il n'y a pas de canal de réception préférentiel une fois terminée l'initialisation du système.

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Annexe K
(normative)

Type 3: Topologie de réseau optique

K.1 Flux de signaux dans un réseau optique

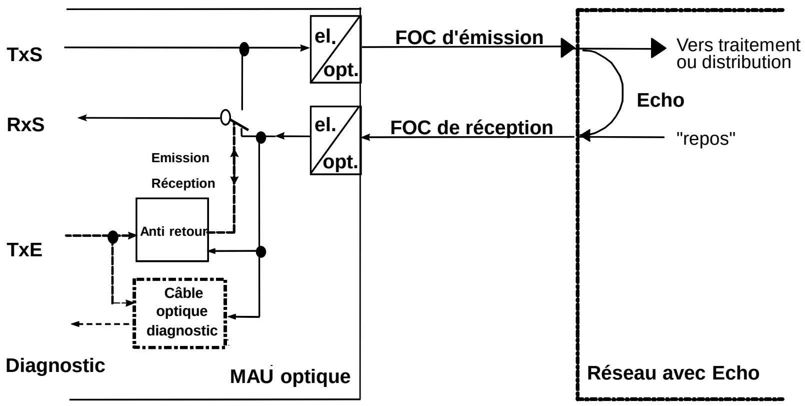
K.1.1 Généralités

La responsabilité des connexions aux stations maître ou esclave ou aux éléments de couplage, tels que les coupleurs en étoile, les répéteurs, etc., incombe à l'utilisateur. Cependant, il doit s'assurer de la compatibilité des diverses interfaces entre elles.

L'Article K.1 décrit les MAU (unités de liaison au support) à fibre optique permettant de connecter un réseau à fibre optique avec ou sans écho.

K.1.2 Connexion à un réseau avec écho

Après un certain temps, la MAU à fibre optique reçoit du réseau son propre signal en écho. La détection du signal en écho peut être utilisée pour confirmer l'état de la connexion physique à la MAU à fibre optique à l'autre extrémité de la ligne (voir la Figure K.1).



Légende :
FOC = câble à fibre optique
TxE = Activation de l'émission
TxS = Signal d'émission
RxS = Signal de réception
MAU = Unité de liaison au Support

Figure K.1 – MAU à fibre optique dans un réseau avec écho

L'écho est renvoyé avec un retard égal à deux fois le retard du signal à l'élément de couplage (par exemple un coupleur en étoile) qui génère l'écho. Dans une structure en anneau, le retard correspond à un cycle d'anneau. Le retard du signal de réception, qui n'existe pas dans des réseaux de transmission asynchrone, ne doit pas générer des défauts de fonctionnement ou des messages d'erreurs. La MAU à fibre optique émettrice doit retirer le signal d'écho du réseau. Le signal d'écho ne doit pas être renvoyé au réseau par l'émetteur et ne doit pas entraîner de duplication du message en tant que “nouveau” message dans un appareil de terrain.

K.1.3 Connexion à un réseau sans écho

Dans un tel réseau, la MAU à fibre optique ne reçoit pas du réseau son propre signal de transmission en écho. La ligne de réception demeure au repos pendant la procédure de

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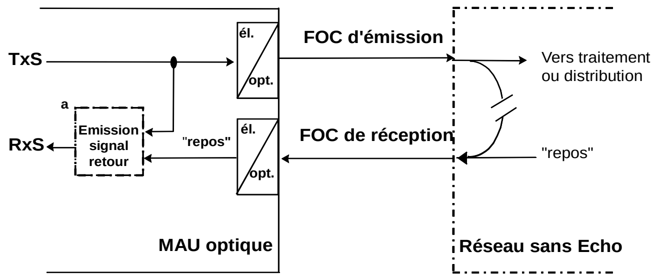
transmission, comme illustré à la Figure K.2. Aucune information n'est disponible quant à l'état de la liaison.



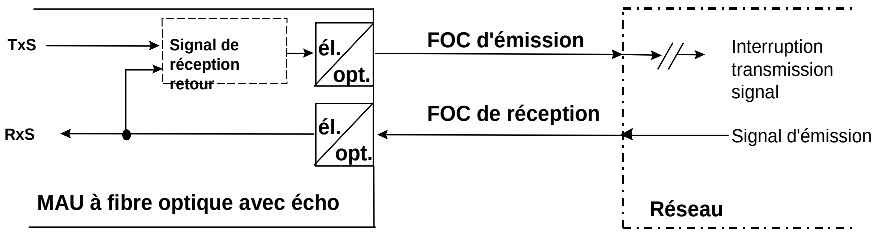
Légende :
FOC = câble à fibre optique
TxS = Signal d'émission
RxS = Signal de réception
MAU = Unité de liaison au Support
[a] obligatoire pour le maître

Figure K.2 – MAU à fibre optique dans un réseau sans écho

Les maîtres doivent localement satisfaire aux exigences d'acquittement du jeton avec, par exemple, un retour matériel (émulation) du signal de transmission.

K.1.4 MAU à fibre optique avec fonction d'écho

Une MAU à fibre optique avec fonction d'écho renvoie le signal reçu à une porte d'entrée à la ligne de retour correspondante, comme illustré à la Figure K.3. Ceci permet à une MAU à fibre optique appropriée, à l'autre extrémité de la ligne à fibre optique, de vérifier son propre message en surveillant l'écho.



Légende :
FOC = câble à fibre optique
TxS = Signal d'émission
RxS = Signal de réception
MAU = Unité de liaison au Support

Figure K.3 – MAU à fibre optique avec écho renvoyé par retour électrique interne du signal de réception

K.1.5 MAU à fibre optique sans fonction d'écho

Une MAU à fibre optique sans fonction d'écho ne renvoie pas le signal reçu à une porte d'entrée à la ligne de retour correspondante. La sortie reste au niveau de repos (voir la Figure K.4).

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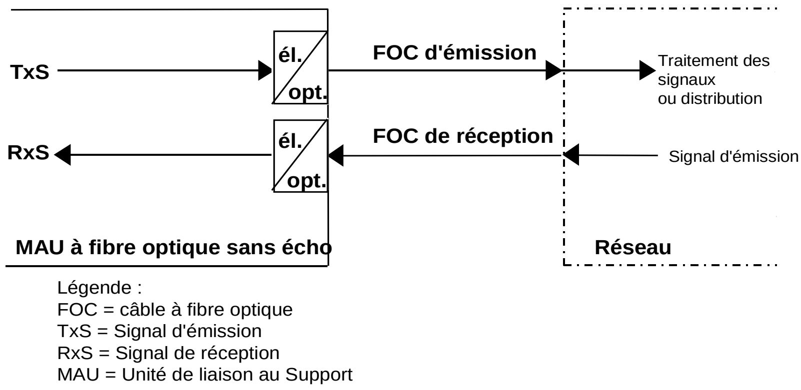

Figure K.4 – MAU à fibre optique sans fonction d'écho

K.1.6 Exemples de topologie

K.1.6.1 Généralités

Le Paragraphe K.1.6 illustre certaines topologies de réseau qui peuvent être construites conformément à la présente norme. Ce qui ne signifie pas que ce sont les seules topologies possibles.

K.1.6.2 Topologie en étoile

La distribution centralisée des signaux, au moyen de coupleurs en étoile actifs, donne une structure du réseau optique en étoile dont l'élément central est le coupleur en étoile actif (voir la Figure K.5).

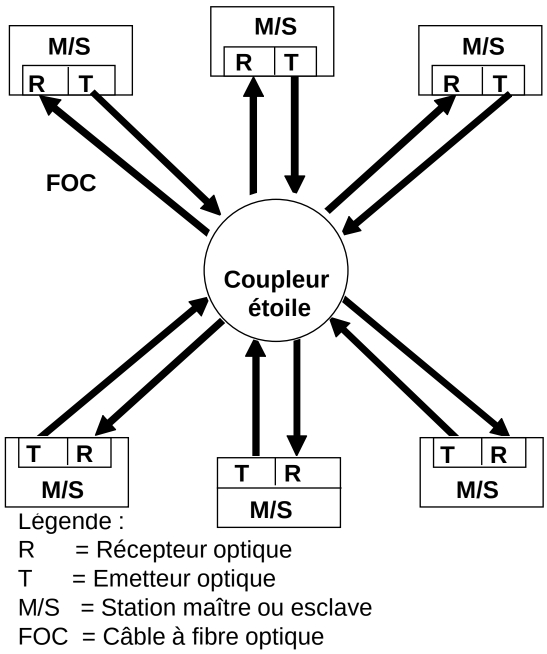

Figure K.5 – Réseau optique à topologie en étoile

Le coupleur en étoile actif est utilisé dans les réseaux optiques comme distributeur central des signaux avec restauration du niveau du signal. La régénération de la synchronisation (resynchronisation) du signal est disponible en option. Le coupleur en étoile actif nécessite

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une alimentation électrique. Le coupleur en étoile actif convertit les signaux optiques reçus à une entrée donnée en signaux électriques. Le traitement interne des signaux est effectué électriquement. Des convertisseurs électro-optiques placés aux portes de sortie transmettent un signal optique.

K.1.6.3 Topologie annulaire

Une structure en anneau, comme illustrée à la Figure K.6, exige dans la station des mesures de commande supplémentaires. Une station de transmission (maître/esclave) doit logiquement interrompre l'anneau et maintenir l'interruption après la fin du télégramme jusqu'à ce qu'il ait circulé une fois autour de l'anneau et qu'il ait été renvoyé à la station de transmission, où il est rejeté.

Dans les stations en mode réception, le signal reçu doit être ressorti du côté émission.

Les stations doivent disposer d'une protection qui évite que l'anneau ne devienne un anneau statiquement fermé. Ce problème peut apparaître si, par exemple, une pointe d'impulsion de défaut apparaît au cours d'une phase "repos”.

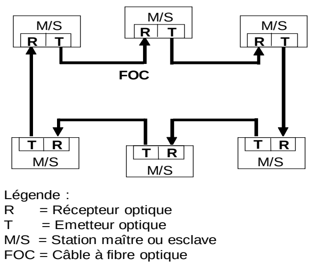

Figure K.6 – Réseau optique à topologie annulaire

K.1.6.4 Topologie en bus

La topologie en bus est constituée de coupleurs en étoile de type 3x3 ou de stations à interfaces optiques intégrées (voir la Figure K.7).

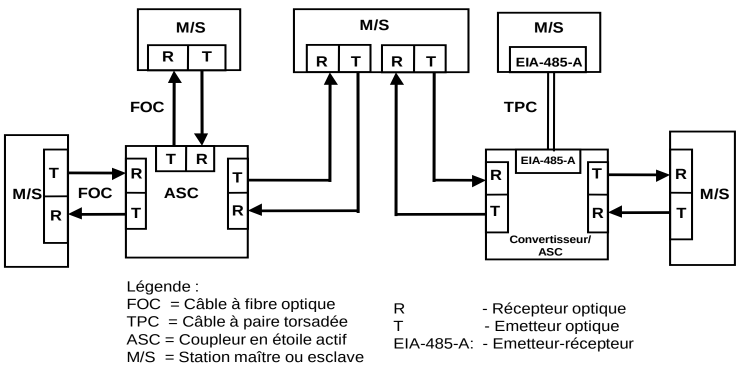

Figure K.7 – Réseau optique à topologie en bus

K.1.6.5 Topologie arborescente

Plusieurs coupleurs en étoile actifs peuvent être combinés pour construire des réseaux avec une structure arborescente, comme illustré à la Figure K.8.

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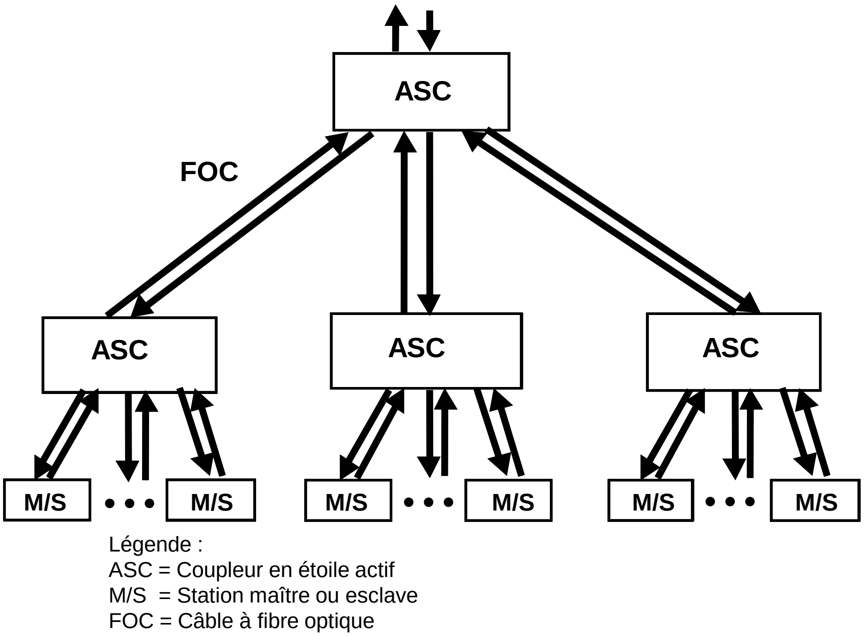

Figure K.8 – Structure arborescente construite à partir d'une combinaison de structures en étoile

K.1.6.6 Convertisseur de fibre optique selon la norme TIA/EIA-485-A de l'ANSI

Un convertisseur à fibre optique selon la norme TIA/EIA-485-A de l'ANSI est utilisé pour connecter une station ou un sous-réseau reposant sur la technologie de la norme TIA/EIA-485-A de l'ANSI, à un segment de réseau optique ou à une station maître/esclave optique.

Un exemple d'application du convertisseur à fibre optique de la norme TIA/EIA-485-A de l'ANSI est illustré à la Figure K.9.

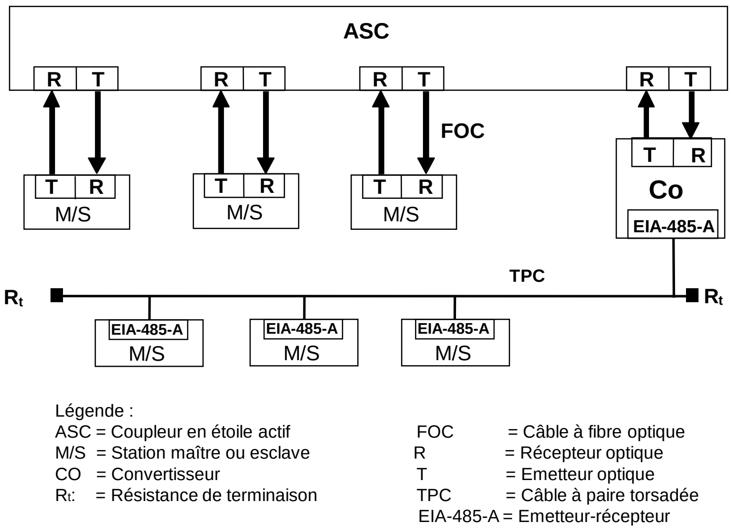

Figure K.9 – Exemple d'application d'un convertisseur à fibre optique de la norme TIA/EIA-485-A de l'ANSI

Ce convertisseur à fibre optique de la norme TIA/EIA-485-A de l'ANSI peut également être mis en œuvre en interne dans un coupleur en étoile actif modulaire.

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K.1.7 Bilan de puissance optique

K.1.7.1 Généralités

Un bilan de niveau de signal optique spécifique à la fibre est disponible entre deux nœuds et la consommation peut s'effectuer sous forme d'affaiblissement sur la liaison optique.

Des calculs de bilan spécifiques peuvent être effectués sur la base des spécifications fournies par le fabricant correspondant.

Le bilan de niveau de signal fait référence à la différence entre la puissance de sortie de l'émetteur optique et la puissance d'entrée exigée par un récepteur optique pour la détection d'un signal exempt d'erreur. L'affaiblissement global doit se trouver entre les bilans de niveau correspondant à la surcharge et à la sensibilité.

Le paragraphe K.1.7 donne des exemples de portées de réseaux qui peuvent être mises en œuvre avec divers types de fibres et de niveaux de puissance de transmission.

K.1.7.2 Conditions restrictives

Les conditions restrictives suivantes doivent être prises en compte pour l'interprétation des tableaux et les dimensionnements des liaisons optiques.

K.1.7.2.1 Ouverture numérique (NA)

Ouverture numérique (se reporter à la CEI 60793-2 pour la description).

K.1.7.2.2 Puissance de sortie

La puissance de sortie est le niveau de puissance dans la fibre, spécifié pour un signal “0” sur l'ensemble de la plage de températures, compte tenu de la diffusion de l'échantillon et des pertes dues à la connexion de la fibre au niveau de l'émetteur (élément de connecteur).

K.1.7.2.3 Limites du récepteur

Ces valeurs identifient la plage de signaux acceptable (plage dynamique) pour un signal “0” (“lumière” ACTIVE); “surcharge” fait référence au niveau de signal le plus élevé acceptable (= “lumière” la plus brillante) et “sensibilité” fait référence au niveau de signal le plus bas. Le fait de sortir de la plage dynamique n'entraîne pas nécessairement l'interruption du transfert de données, mais augmente l'écart de synchronisation du signal au-delà des limites spécifiées, ce qui accroît la probabilité d'erreurs de transmission.

K.1.7.2.4 Bilan de niveau

Le bilan de niveau est la plage dynamique qui résulte de la combinaison émetteur/récepteur spécifiée. Le taux d’erreur sur les bits (BER) est de $<10^{-9}$ dans ces limites.

K.1.7.2.5 Affaiblissement global

L'affaiblissement global fait référence à l'affaiblissement minimal requis pour une protection contre les surcharges du récepteur ou à l'affaiblissement maximal admissible pour utiliser l'ensemble de la sensibilité du récepteur.

L'affaiblissement global est constitué de:

- l'affaiblissement dû à la fibre, pour un câble à fibre optique;
- les pertes de couplage pour les connecteurs insérés et les épissures, le cas échéant;
- une marge système.

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K.1.7.2.6 Réserve système

La réserve système tient compte de la perte de puissance de sortie de l'élément de transmission, due au vieillissement. L'espérance de vie d'un élément émetteur est en général définie par la durée de la chute de l'émission émise de 3 dB par rapport à la valeur correspondant à un élément neuf.

Pour la détermination de l'immunité d'un récepteur aux surcharges, on suppose que cette "réserve système" n'a pas été consommée.

K.1.7.2.7 Affaiblissement de la fibre

L'affaiblissement de la fibre fait référence à l'affaiblissement maximal admissible ou à l'affaiblissement minimal exigé du câble à fibre optique.

K.1.7.2.8 Affaiblissement spécifique de la fibre

L'affaiblissement spécifique de la fibre est l'affaiblissement maximal ou minimal du câble à fibre optique par unité de longueur. Il dépend de la longueur d'onde de la lumière.

Les valeurs d'affaiblissement des fibres ne sont pas stipulées dans les spécifications et doivent être tirées des fiches techniques des fibres correspondantes. Les valeurs dans les tableaux sont des valeurs moyennes fondées sur l'expérience.

La longueur d'onde crête de la lumière émise se décale en fonction de la température de service de l'élément émetteur. Le décalage de longueur d'onde doit être pris en compte pour la détermination des valeurs limites d'affaiblissement spécifique de la fibre.

K.1.7.2.9 Longueur de la fibre

La longueur de la fibre est calculée en divisant la partie de l'affaiblissement global due à l'affaiblissement de la fibre par l'affaiblissement spécifique de la fibre.

K.1.7.3 Fibre silice multimodale 62,5/125 μm

Le niveau de puissance de transmission est choisi de façon à ce que la longueur minimale de la liaison optique soit de 0 m, ce qui signifie qu'une surcharge du récepteur ne peut pas avoir lieu avec une fibre 62,5/125 μm. Un exemple de calcul du bilan de niveau pour cette fibre de référence est donné dans le Tableau K.1.

Tableau K.1 – Exemple de calcul de bilan de liaison pour une fibre silice multimodale 62,5/125 μm

Bilan pour une liaison normalisée en fibre de silice multimodale 62,5/125 μm (profil à gradient d'indice) NA = 0,275			
Puissance de sortie de l'émetteur	–20 … –15		dBm
Limites du récepteur	**Surcharge**	**Sensibilité**	
	–10	–24	dBm
Bilan de niveau	0	9	dB
Affaiblissement global	0	9	dB
Réserve système	0	3	dB
Affaiblissement de la fibre	0	6	dB
Affaiblissement spécifique de la fibre	2,5	3,5	dB/km
Longueur de la fibre	min.	max. 1700	m

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K.1.7.4 Fibre silice unimodale 9/125µm

Ce type de fibre a été inclus pour pouvoir mettre en œuvre des liaisons optiques plus longues.

Le niveau de puissance de transmission est choisi de façon à ce que la longueur minimale de la liaison optique soit de 0 m, ce qui signifie qu'une surcharge du récepteur ne peut pas avoir lieu avec une fibre 9/125 µm.

Le Tableau K.2 présente des valeurs types observées dans la pratique et ne représente pas les spécifications.

Tableau K.2 – Exemple de calcul de bilan de liaison pour une fibre silice unimodale 9/125 µm

Bilan d'une liaison normalisée en fibre de silice unimodale 9/ 125 µm (profil à saut d'indice) NA = 0,13			
Puissance de sortie de l'émetteur	–20 … –10		dBm
Limites du récepteur	**Surcharge**	**Sensibilité**	
	–10	–27	dBm
Bilan de niveau	0	7	dB
Affaiblissement global	0	7	dB
Réserve système	0	2	dB
Affaiblissement de la fibre	0	5	dB
Affaiblissement spécifique de la fibre	0,3	0,5	dB/km
Longueur de la fibre	min.	max. 10 000	m

K.1.7.5 Fibre plastique multimodale 980/1 000 µm

Du fait de son diamètre important, la fibre en plastique est moins exigeante en termes de tolérances mécaniques au cours de l'installation. D'une manière générale, ceci permet de réduire les coûts d'installation.

Cependant, du fait de son affaiblissement de la fibre beaucoup plus élevé par rapport à la fibre silice, la fibre en plastique ne convient généralement qu'à des liaisons optiques relativement courtes. La gamme de longueurs d'onde du signal optique est choisie de manière à correspondre à l'affaiblissement minimal de la matière plastique. Un exemple numérique de bilan de niveau est donné dans le Tableau K.3.

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Tableau K.3 – Exemple de calcul de bilan de liaison pour une fibre plastique multimodale 980/1 000 μm

Bilan pour une liaison normalisée en fibre plastique 980/1000 μm (profil à saut d'indice) NA = 0,47					
Puissance de sortie de l'émetteur	**Normalisé**		**Amélioré**		
Puissance de sortie	–11 … – 5,5		–6 … 0		dBm
Limites du récepteur	**Surcharge**	**Sensibilité**	**Surcharge**	**Sensibilité**	
	–5,0	–20,0	0	–20,0	dBm
Bilan de niveau	-0,5	9,0	0	14,0	dB
Affaiblissement global	0	9,0	0	14,0	dB
Réserve système	0	3,0	0	3,0	dB
Affaiblissement de la fibre	0	6,0	0	11,0	dB
Affaiblissement spécifique de la fibre	0,15	0,25(voir note)	0,15	0,25(voir note)	dB/m
Longueur de la fibre	min. 0	max. 24	min. 0	max. 44	m
NOTE Augmentation de l'affaiblissement due au matériau de la fibre et décalage de la longueur d'onde dû aux variations de la température dans l'élément émetteur.					

K.1.7.6 Fibre silice multimodale 200/230 μm

Ce type de fibre a été inclus pour pouvoir mettre en œuvre de liaisons optiques plus longues. L'exemple numérique de bilan de niveau est donné dans le Tableau K.4.

Tableau K.4 – Exemple de calcul de bilan de niveau pour une fibre silice multimodale 200/230 μm

Bilan pour une liaison normalisée en fibre optique 200/230 μm (profil à saut d'indice) NA = 0,37			
Puissance de sortie de l'émetteur	– 16,0 à –8,0		dBm
Limites du récepteur	**Surcharge**	**Sensibilité**	
	–8,0	–22,0	dBm
Bilan de niveau	0	6,0	dB
Affaiblissement global	0	6,0	dB
Réserve système	0	3,0	dB
Affaiblissement de la fibre	0	3,0	dB
Affaiblissement spécifique de la fibre	5	10	dB/km
Longueur de la fibre	min. 0	max. 300	m

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Annexe L
(informative)

Type 3: Exemples de modèles de référence pour une transmission asynchrone, sur support câblé de sécurité intrinsèque

L.1 Terminaison de bus dans l'appareil de communication

Dans cette version, la terminaison de bus est déjà réalisée dans l'appareil au moyen des résistances Rt, Ru et Rd, comme illustré à la Figure L.1. L'activation est obtenue au moyen du commutateur S1 pour l'appareil installé à l'extrémité du segment de bus.

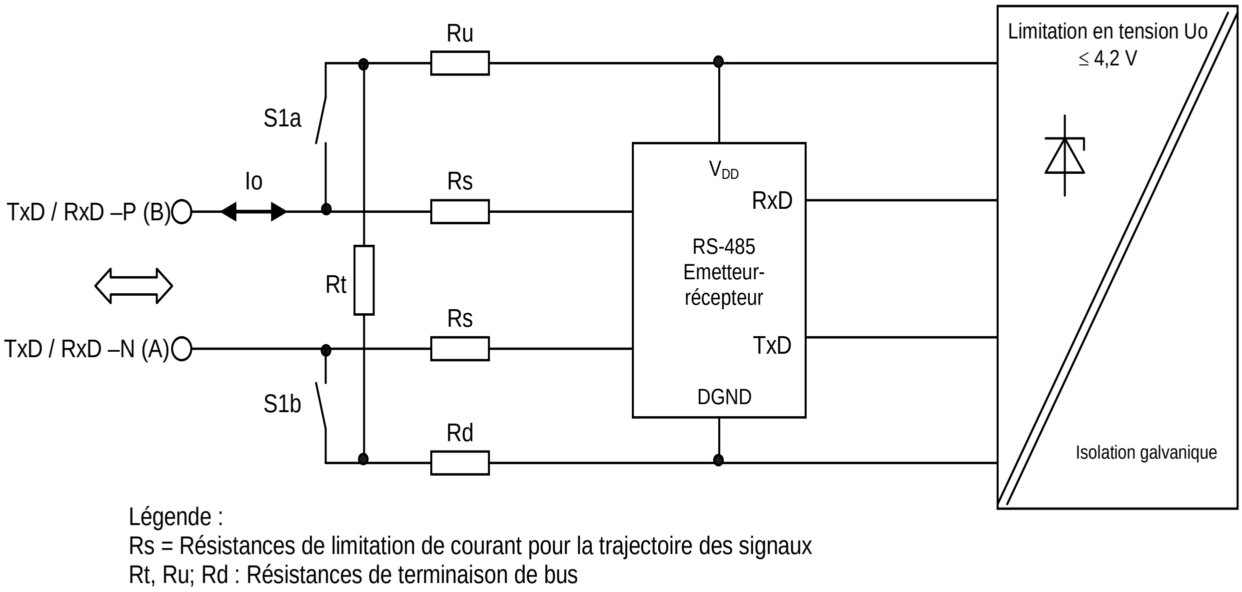

Figure L.1 – Terminaison de bus intégrée à l'appareil de communication

Lors de la détermination du courant de sortie maximal Io, il doit être noté que, du fait du commutateur S1, la résistance R3 est connectée en parallèle à R1 et la résistance R4 est connectée en parallèle à R2.

Ici, on doit également se conformer aux valeurs limites relatives à la sécurité, comme décrit dans le document "PTB-Mitteilungen, 113 Jahrgang, Heft 2/2003, Die Bewertung der Zündfähigkeit eigensicherer Stromkreise anhand eines Rechenverfahrens. Abschnitt: Der eigensichere RS 485 Feldbus als Anwendungsbeispiel".

Pour la conception des composantes et distances de séparation exigées, les dispositions de la norme pertinente applicable doivent être satisfaites (par exemple la CEI 60079-11).

L.2 Terminaison de bus dans le connecteur

Dans cette version, la terminaison de bus est réalisée dans le connecteur, comme illustré à la Figure L.2. Pour cela, les appareils de communication doivent fournir l'alimentation appropriée. L'activation est obtenue au moyen du commutateur S1 pour les appareils installés à l'extrémité concernée du segment de bus.

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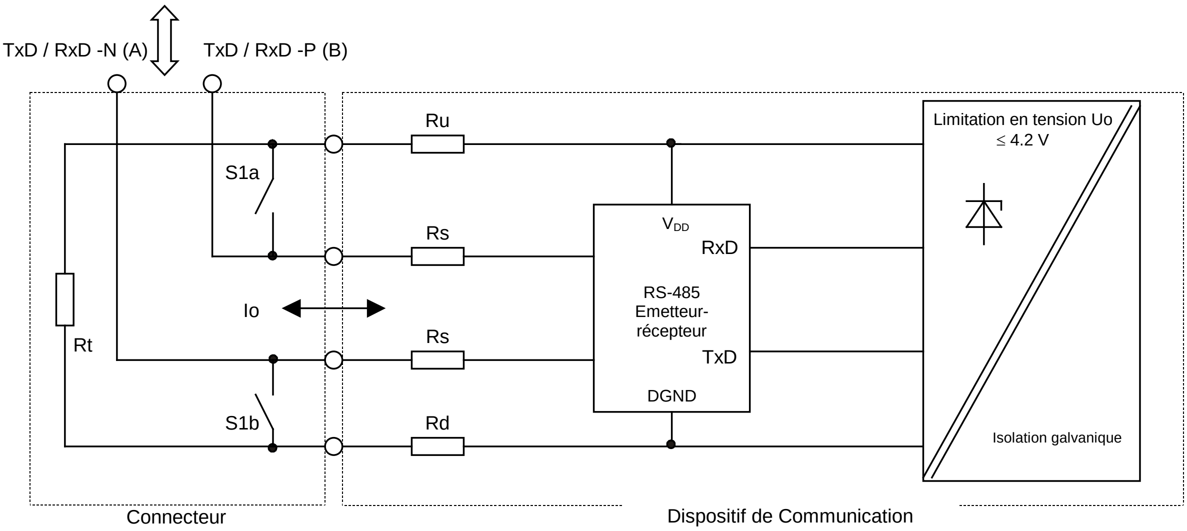


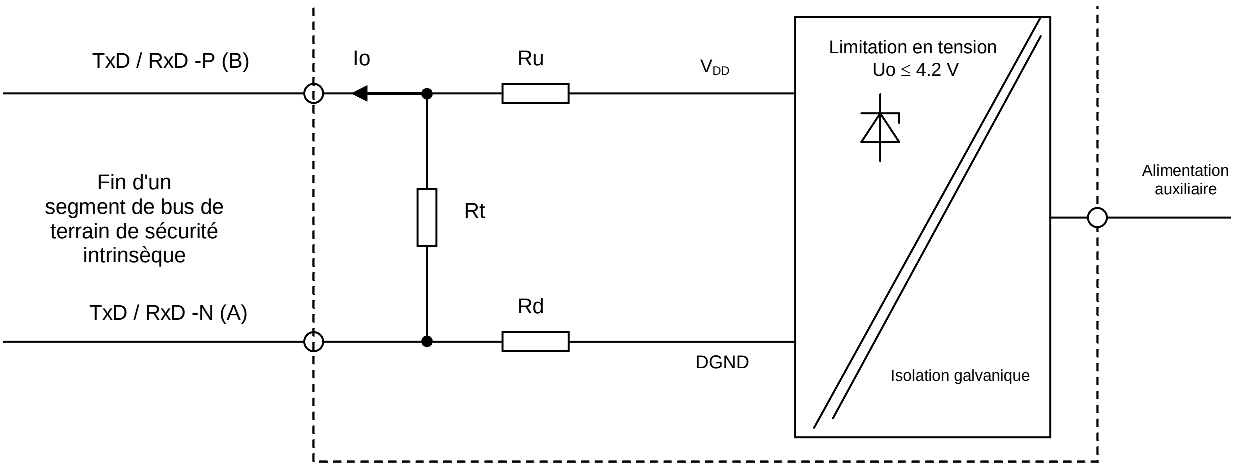
Légende :
Rs : Résistances de limitation de courant pour la trajectoire des signaux
R3, R4; R5 : Résistances de terminaison de bus

Figure L.2 – Terminaison de bus dans le connecteur

L.3 Terminaison de bus externe

L'alimentation auxiliaire doit être galvaniquement isolée du circuit de bus de terrain, comme illustré à la Figure 110. Ceci est décrit de manière détaillée en 22.2.4.3.

Dans cette version, la terminaison de bus est réalisée en externe dans un appareil distinct, comme illustré à la Figure L.3.



Légende :
Rt, Ru; Rd : Résistances de terminaison de bus

Figure L.3 – Terminaison de bus externe

L'alimentation auxiliaire doit être galvaniquement isolée du circuit de bus de terrain.

Les résistances Ru et Rd sont significatives pour le calcul du courant de sortie maximal I_o. Dans ce contexte, on doit également se conformer aux valeurs limites relatives à la sécurité pour des terminaisons de bus externes. Pour la conception des composantes et distances de séparation nécessaires, la norme pertinente doit être appliquée (par exemple la CEI 60079-11).

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Annexe M
(normative)

Type 8: Spécifications des connecteurs

M.1 Connecteurs externes pour support câblé

M.1.1 Affectation des contacts du connecteur subminiature D

L'affectation des contacts du connecteur est illustrée à la Figure M.1, à la Figure M.2 et au Tableau M.1.

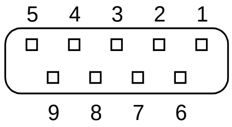

Figure M.1 – Connecteur subminiature D femelle à 9 contacts, interface de départ du côté appareil

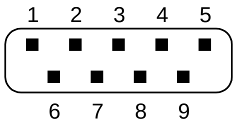

Figure M.2 – Connecteur subminiature D mâle à 9 contacts, interface d'arrivée du côté appareil

Tableau M.1 – Affectation des contacts du connecteur subminiature D à 9 contacts

Numéro de contact	Ligne de signal
1	DO
2	DI
3	GND
4	–
5	–
6	/DO
7	/DI
8	–
9	–

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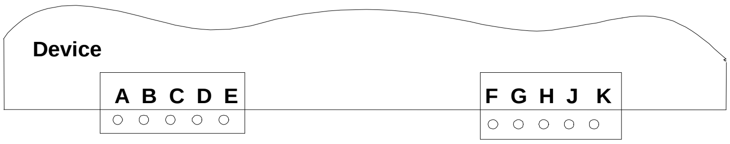
M.1.2 Affectation des contacts du connecteur terminal

La Figure M.3 illustre la position du connecteur terminal du côté appareil; les affectations de contacts du connecteur terminal sont présentées dans le Tableau M.2.



Légende

Anglais	Français
Device	Appareil

Figure M.3 – Connecteur terminal du côté appareil

Tableau M.2 – Affectation des contacts du connecteur terminal

Interface d'arrivée			Interface de départ	
Broche	**Normalisé**		**Broche**	**Normalisé**
A	/DO1		F	/DO2
B	DO1		G	DO2
C	/DI1		H	/DI2
D	DI1		J	DI2
E	GND1		K	GND

Une borne distincte doit être prévue pour la mise à la terre de protection.

Il convient d'observer l'ordre des points terminaux.

M.2 Connecteurs externes pour support à fibre optique

Un connecteur de réseau qui se trouve à l'extérieur de l'enveloppe de l'appareil et qui nécessite par conséquent une protection contre l'environnement électromagnétique, chimique et physique, doit être spécifié comme un connecteur externe.

Si un degré de protection IP20 ou moins est utilisé pour un appareil ayant une MAU à fibre optique, il convient que le connecteur utilisé pour le CPIC du côté appareil soit compatible, du point de vue mécanique, avec un connecteur de type F-SMA, comme spécifié dans la CEI 61754-22. La férule d'un connecteur optique F-SMA pour une fibre optique polymère (980/1 000 μm) est illustrée à la Figure M.4.

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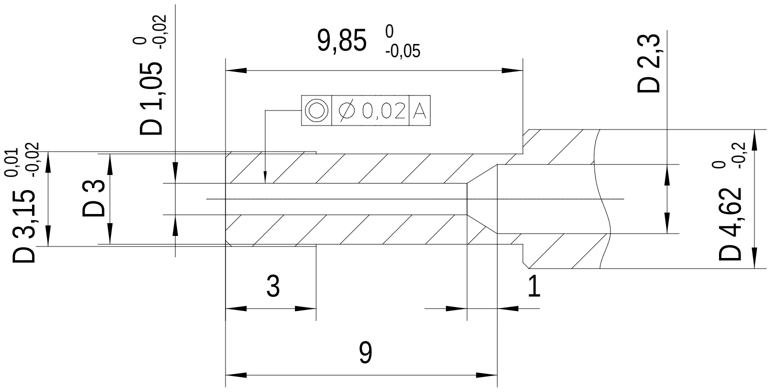

NOTE Toutes les mesures sont en millimètres.

Figure M.4 – Férule d'un connecteur optique F-SMA pour fibre optique polymère (980/1 000 μm)

M.3 Connecteurs externes hybrides utilisés dans des applications IP65

Si un connecteur hybride pour des applications d'un degré de protection IP65 ou supérieur est utilisé pour l'appareil ayant une MAU à fibre optique, il convient que ce connecteur utilisé pour le CPIC du côté appareil soit tel qu'illustré à la Figure M.5 et à la Figure M.6 et que ses dimensions soient telles que spécifiées dans le Tableau M.3.

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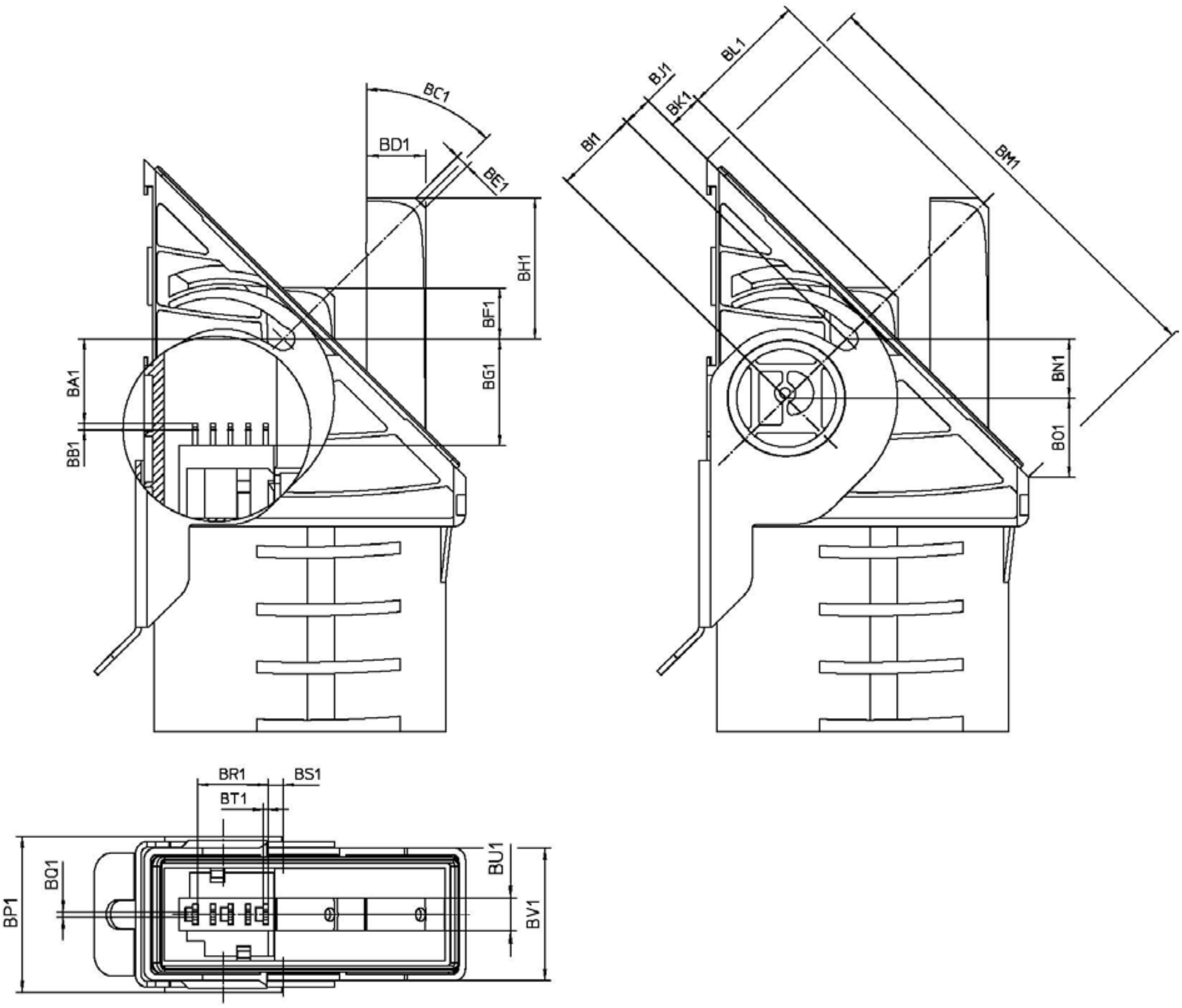

Figure M.5 – Boîtier de connecteur hybride à fibre optique de type 8

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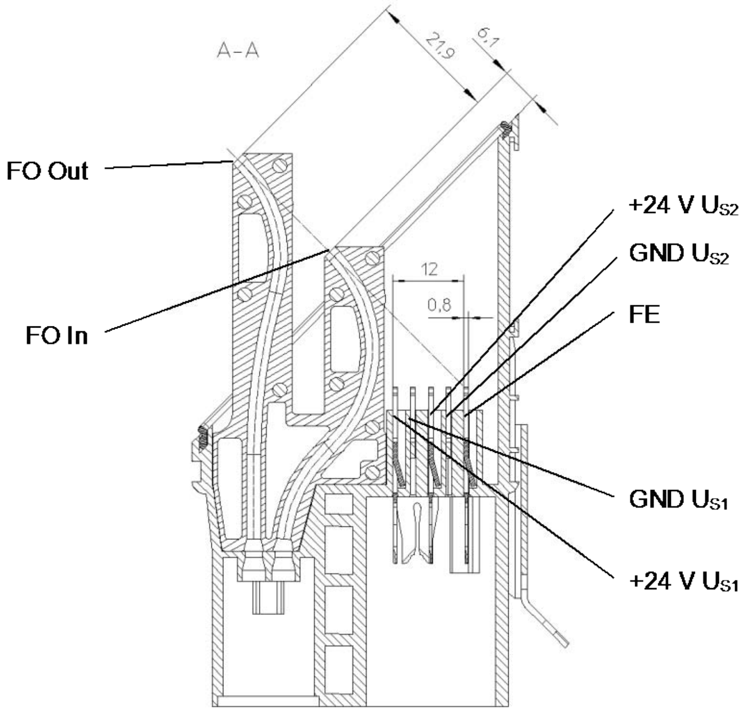

Légende:

U_{S1} = Alimentation du capteur et du module de bus

U_{S2} = Alimentation de l'organe de commande

FO in = Connexion à l'émetteur à FO

FO out= Connexion au récepteur à FO

Figure M.6 – Affectation des contacts de connecteur hybride à fibre optique de type 8

Il convient que les contacts électriques d'alimentation puissent supporter un courant maximal en continu de 16 A à une tension de 24 V.

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Tableau M.3 – Dimensions de connecteur hybride à fibre optique de type 8

Référence	Max. mm	Min. mm	Nominale mm
BA1	14,9	14,5	14,7
BB1	1,2	1	1,1
BC1	45,5	44,5	45
BD1	10,2	9,8	10
BE1	2,5	2,3	2,4
BF1	9	8,6	8,8
BG1	18,7	18,3	18,5
BH1	24,5	24,1	24,3
BI1	14,7	14,3	14,5
BJ1	5,3	5,1	5,2
BK1	6,3	5,9	6,1
BL1	22,1	21,7	21,9
BM1	78	77,6	77,8
BN1	10,45	10,05	10,25
BO1	13,85	13,45	13,65
BP1	27,2	26,8	27
BQ1	0,95	0,75	0,85
BR1	12,2	11,8	12
BS1	2,7	2,5	2,6
BT1	0,9	0,7	0,8
BU1	5,7	5,5	5,6
BV1	23,2	22,8	23

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Annexe N
(normative)

Type 16: Spécifications des connecteurs

Les connecteurs pour câbles à fibres optiques doivent

- satisfaire à la norme F-SMA (voir la CEI 61754-22);
- être d'un niveau de qualité d'au moins 5;
- avoir un anneau de connecteur métallique.

Les composants de l'émetteur et du récepteur doivent être intégrés dans des boîtiers opaques.

En outre, il convient que les câbles à fibre optique disposent d'un serre-câble permettant de soulager les contraintes.

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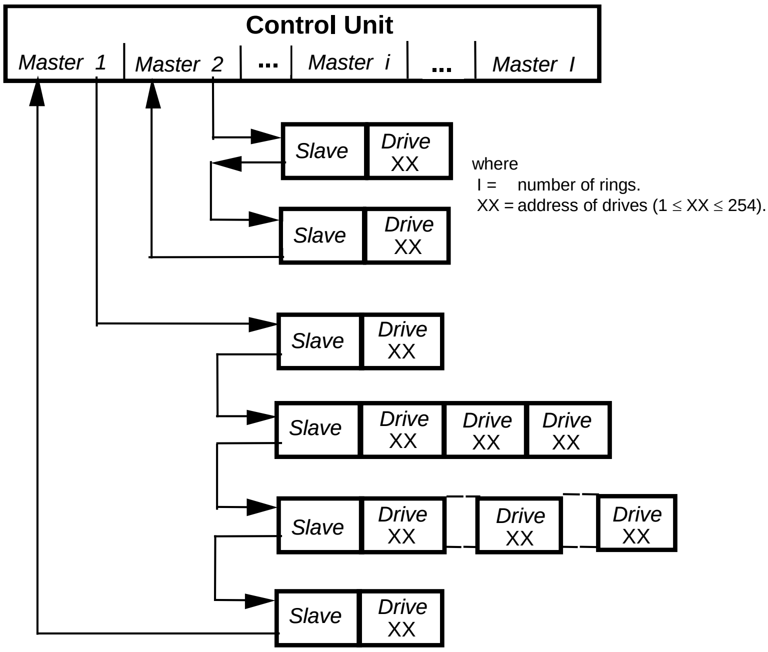
Annexe O
(normative)

Type 16: Topologie de réseau optique

O.1 Topologie

La topologie doit être constituée de lignes de transmission optiques point à point et d'abonnés. Une ligne de transmission doit être constituée de câbles à fibres optiques, sans aucun branchement optique. La transmission ne doit s'effectuer que dans une seule direction. Le maître et les esclaves font partie du réseau (abonnés).

La Figure O.1 illustre la structure connectée à l'unité de commande et aux appareils. En fonction des besoins de l'application, l'unité de commande peut homologuer un ou plusieurs maîtres. Un maître doit gérer un réseau uniquement sur la couche physique ainsi que dans les couches de protocole surjacentes. Des esclaves doivent être utilisés pour connecter les appareils au réseau à fibre optique. Sur la couche physique, un esclave peut représenter la connexion d'un ou plusieurs appareils au réseau à fibre optique. Logiquement, un esclave à plusieurs appareils doit agir de la même manière que plusieurs esclaves ayant chacun un appareil. Bien que les esclaves soient physiquement connectés les uns aux autres par l'intermédiaire du réseau à fibre optique, toutes les transmissions d'informations s'effectuent directement entre le maître et les esclaves. Une topologie en étoile est créée si chaque maître n'a qu'un seul esclave connecté.



Légende

Anglais	Français
Control unit	Unité de commande
Master	Maître
Slave	Esclave
Drive XX	Circuit d'attaque XX
Where	Où
I = number of rings	I = nombre d'anneaux
XX = address of drives	XX = adresses des circuits d'attaque

Figure O.1 – Topologie

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La disposition physique des esclaves sur le réseau doit être indépendante de l'adresse de l'appareil établie pour l'esclave et indépendante de la séquence de synchronisation de transmission de télégrammes d'acquittement (AT).

NOTE Le nombre d'appareils sur un réseau est M = K. La séquence des AT est libellée 1, 2, ..., M et la séquence d'enregistrement de données d'appareil dans le MDT est libellée 1, 2, ... K.

Des interfaces de type CP16/1 et CP16/2 déterminent les éventuels échanges d'informations au sein d'un réseau. Toute interaction entre réseaux est contrôlée par l'unité de commande et ne relève pas du domaine d'application de la présente spécification.

O.2 Bilan de puissance optique

O.2.1 Signaux optiques sur la ligne de transmission

Les niveaux de puissance optique sur la ligne de transmission sont exprimés par deux unités, en dB_m ou μW, corrélées de la manière suivante:

– niveau [dBm] = 10 × log (niveau [μW] / 1 000 μW):
– niveau [μW] = 10 niveau [dBm] / 10 dBm × 1 000 μW.

Les signaux optiques décrits dans le Tableau O.1, le Tableau O.2 et le Tableau O.4 pour l'émetteur, le récepteur et la ligne de transmission sont mesurés avec un câble à fibre optique plastique (POF) ayant un diamètre de cœur de 1 mm et une longueur de 1 m ou avec un câble à fibre silice (HCS) ayant un diamètre de 200 μm et une longueur de 1 m, comme spécifié dans le Tableau O.3.

Les niveaux optiques et les fronts (changements d'états) le long de la ligne de transmission sont spécifiés à l'aide des paramètres suivants:

a) P_{TmaxL}, puissance de transmission maximale à un niveau optiquement faible. Si le signal optique tombe en dessous de ce niveau, il est à un état logique bas;
b) P_{TminH}, puissance de transmission minimale à un niveau optiquement élevé. Si le signal optique dépasse ce niveau, il est à un état logique haut;
c) P_{TmaxH}, puissance de transmission maximale à un niveau optiquement élevé. Les signaux stationnaires ne doivent jamais dépasser cette limite. Cependant, un front montant de signal optique peut dépasser dynamiquement la limite supérieure du niveau optiquement élevé. Cela permet d'accentuer le front montant du signal (en réduisant le temps de croissance). L'amplitude et la durée du niveau du signal de dépassement sont limitées;
d) k_{os}, facteur de dépassement de la puissance optique. Ce paramètre indique le facteur auquel la puissance de transmission optique maximale peut être dépassée dynamiquement. Le dépassement de niveau de puissance n'est admissible que lors d'un changement d'état optique, de bas à haut, (front montant du signal).

NOTE PRxxx est utilisé pour exprimer le PTxxx équivalent d'un récepteur.

Le signal optique doit passer de P_{TmaxL} à P_{TminH} de manière monotonique (ce qui signifie que le bruit du signal est inférieur à 100 nW = –40 dB_m). Par conséquent, le niveau logique haut entre P_{RmaxL} et P_{RminH}, peut être reconnu avec certitude sans générer d'autres changements de niveau des signaux.

O.2.2 Spécifications de l'émetteur

Sauf indication contraire, les présentes spécifications doivent être valides sur l'ensemble de la plage de températures comprises entre 0 °C et +70 °C.

Un émetteur doit être conforme aux spécifications données dans le Tableau O.1.

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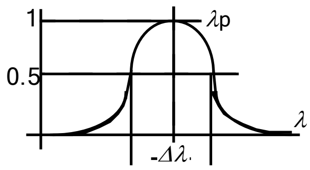
Tableau O.1 – Spécifications de l'émetteur

Position	**Affaiblissement à 650 nm**		
Type de fibre	**POF**		**HCS**
Puissance de transmission optique	**Faible**	**Elevée**	**Elevée**
P_{TmaxL}	–31,2 dBm	–28,2 dBm	–33,2 dBm
	0,75 µW	1,5 µW	0,5 µW
P_{TminH}	–10,5 dBm	–7,5 dBm	–18 dBm
	90 µW	180 µW	16 µW
P_{TmaxH}	–5,5 dBm	–3,5 dBm	–10 dBm
	280 µW	450 µW	100 µW
Longueur d'onde de la diode émettrice			
Longueur d'onde de crête	λ_{pk} = 640 nm à 675 nm		
Largeur de bande spectrale	$\Delta\lambda \leq$ 30 nm (25 °C)		
Spectre optique			
k_{os}	120 %		
Plage de températures	0 °C à 70 °C		
NOTE Toutes les données correspondent à λ_{pk} (représenté par λ_p dans la courbe insérée ci-dessus).			

O.2.3 Spécifications du récepteur

Sauf indication contraire, les présentes spécifications sont valides sur l'ensemble de la plage de températures comprises entre 0 °C et +70 °C.

Pour traiter correctement les données, le récepteur doit satisfaire aux exigences du Tableau O.2. La largeur de bande du câble à fibre optique étant relativement étendue, la distorsion des signaux optiques est insignifiante.

Tableau O.2 – Spécifications du récepteur

Longueur d'onde	**650 nm**	
Type de fibre	**Fibre plastique POF**	**Fibre silice HCS**
P_{RmaxL}	–31,2 dBm	–33,2 dBm
	0,75 µW	0,5 µW
P_{RminH}	–20 dBm	–22 dBm
	10 µW	6,3 µW
P_{RmaxH}	–5 dBm	–7 dBm
	316 µW	200 µW
Puissance dynamique (P_{RmaxH} à P_{RminH})	15 dB	
Taux d'erreurs sur les bits	$\leq 10^{-9}$	
Plage de températures	0 °C à 70 °C	
NOTE Toutes les données correspondent à λ_{pk}		

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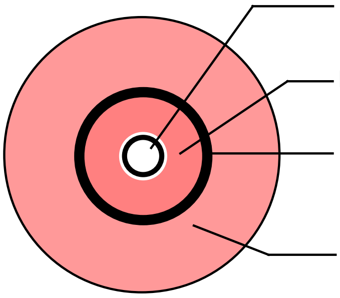
O.2.4 Câble à fibre optique

Le câble à fibre optique peut être en matière plastique ou en verre (silice) et avoir un profil à saut d'indice ou à gradient d'indice. Un exemple est illustré à la Figure O.2 et défini dans le Tableau O.3.



Légende

Anglais	Français
Optic core with cladding	Cœur optique avec gaine
PVC Inner sheath	Gaine intérieure en PVC
Stress release made of armid fibres	Serre-câble en fibre aramide
Outer sheath made of PUR or PVC (special mixture for use in manufacturing environments, etc.)	Gaine extérieure en PUR ou PVC (mélange particulier pour usage dans des environnements de fabrication, etc.)

Figure O.2 – Structure d'un câble unipolaire (exemple)

Tableau O.3 – Spécifications des câbles (exemple)

	Fibre plastique POF	Fibre silice HCS
Diamètre de cœur	980 µm	200 µm
Diamètre de gaine	1 000 µm	230 µm
Ouverture numérique	0,47	0,37
Largeur de bande	≥5 MHz × 1 km	≥10 MHz × 1 km

O.2.5 Données système relatives au trajet de transmission optique

Les niveaux de puissance optique sont illustrés à la Figure O.3 et doivent être conformes aux valeurs du Tableau O.4.

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Tableau O.4 – Données système de la ligne de transmission optique à 650 nm

Type de fibre		POF		HCS
Puissance de transmission optique (voir 30.1)		**Faible**	**Elevée**	**Elevée**
Puissance de transmission	P_{TmaxL}	–31,2 dBm	–28,2 dBm	–33,2 dBm
		0,75 μW	1,5 μW	0,5 μW
	P_{TminH}	–10,5 dBm	–7,5 dBm	–18 dBm
		90 μW	180 μW	16 μW
	P_{TmaxH}	–5,5 dBm	–3,5 dBm	–10 dBm
		280 μW	450 μW	100 μW
Puissance reçue	P_{RmaxL}	–31,2 dBm		
		0,75 μW		
	P_{RminH}	–20 dBm		
		10 μW		
	P_{RmaxH}	–5 dBm		
		315 μW		
	Puissance dynamique (P_{RmaxH} à P_{RminH})	15 dB		
Valeur système	P_{TminH} à P_{RminH}	9,5 dB	12,5 dB	4 dB
Réserve système (y compris la durée de vie de la diode émettrice)		≥ 5,1 dB		≥ 2 dB
Affaiblissement de ligne (valeur système – réserve système)		≤ 4,4 dB	≤ 7,4 dB	≤ 2 dB
Affaiblissement du câble de mesure (typique)		0,2 dB/m	0,2 dB/m	10 dB/km
Longueur du câble		≤ 22 m	≤ 37 m	≤ 200 m
Vitesse de transmission (NRZI)		2 Mbit/s, 4 Mbit/s, 8 Mbit/s et 16 Mbit/s		
Taux d'erreurs sur les bits		≤ 10^{-9}		
Plage de températures		0 °C à 70 °C		

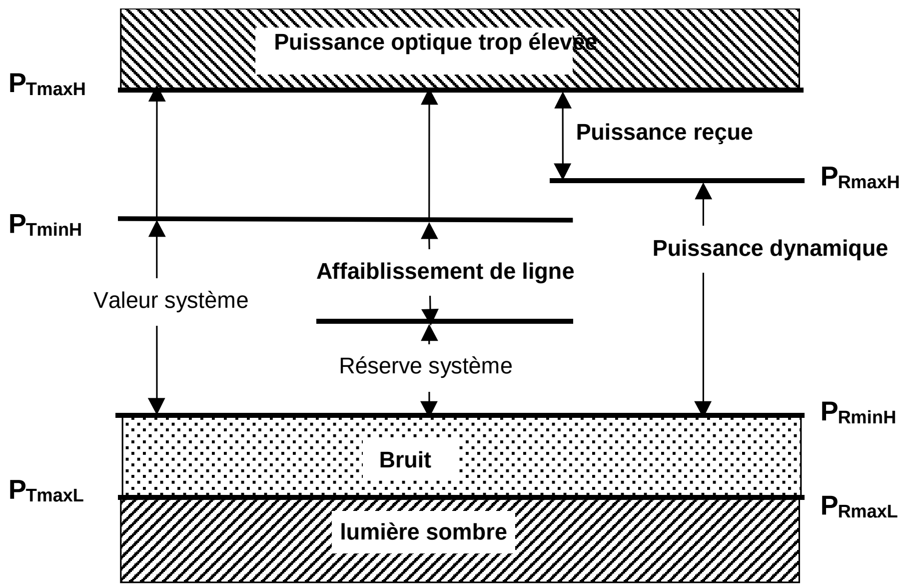

Figure O.3 – Niveaux de puissance optique

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Annexe P
(informative)

Type 16: Exemple de modèle de référence

P.1 Principes fonctionnels du circuit répéteur

La Figure P.1 illustre un exemple d'application de la fonction de régénération de signal, à partir du circuit répéteur. La fonction principale de ce circuit consiste à récupérer l'horloge RCLK du signal d'entrée IN, codé NRZI. Cela peut être effectué, par exemple, au moyen d'une boucle numérique à verrouillage de phase (DPLL). En outre, en prélevant le signal d'entrée IN à des intervalles convenables, on peut générer un signal de réception régénéré RxD. Le signal codé NRZI est particulièrement utile dans la structure du réseau.

Le circuit se compose de huit bascules et d'un circuit VN à logique combinatoire. Les bascules sont pilotées par une horloge ordinaire CX. Ce signal d'horloge est généré par un oscillateur piézo-électrique dont la fréquence est égale à 16 fois la fréquence du débit de données qui est de 32 MHz pour une vitesse de transmission de 2 Mbit/s.

Il est également possible d'utiliser des DPLL présentant des fréquences d'échantillonnage différentes. Pour remplir la condition ci-après, il est nécessaire de prévoir une fréquence d'échantillonnage au moins égale à 12 fois la fréquence du débit de données:

$$0 \le t_{cadreal} \le \frac{t_{bitnom}}{11}$$

La bascule 1 est utilisée pour la synchronisation initiale du signal d'entrée. La bascule 2 est utilisée pour la détection des fronts; si IN1 = 1 et IN2 = 0, ceci signifie toujours qu'un front positif a été détecté. Les bascules 5 à 8 sont utilisées conjointement au circuit à logique combinatoire pour implémenter un diagramme d’états.

Le diagramme d'états de la Figure P.2 illustre le comportement de la boucle DPLL. Les états Z = 0 à Z = 15 correspondent aux valeurs binaires fournies par les signaux de sortie des bascules 5 à 8.

En fonction du numéro d'état (Z = 0 ... 15) au cours duquel E (événement: front "lumière active" détecté) ou E* (événement: pas de front "lumière active" détecté) est détecté, la DPLL réagit en répétant ou en ignorant un état. Si E est trouvé à l'état Z = 0, la DPLL ne répète pas ou ignore l'état (ce qui signifie que la DPLL est synchronisée). Les signaux d'entrée ne sont pas prélevés au niveau de la moyenne théorique de l'élément binaire, mais dans leur position déphasée. Cela permet au système de fonctionner même en présence de signaux présentant une distorsion relativement importante. Pendant le passage de Z = 3 à Z = 4, RCLK = 1 est sélectionné. Pendant le passage de Z = 10 ou Z = 11 à Z = 12 et de Z = 11 à Z = 13, RCLK = 0 est sélectionné et le signal de sortie RxD est égal au signal synchronisé d'entrée IN1.

La Figure P.3 illustre la synchronisation des divers signaux.

De manière générale, la distorsion du signal est principalement due à la conversion électrique en optique et inversement. La Figure P.3 illustre la configuration théorique idéale du signal IN1 ainsi que sa forme caractéristique en présence de puissances de transmission minimale et maximale. On suppose le transfert d'une série de zéros codés NRZI, ce qui correspond à un signal rectangulaire de période 2 × tBIT.

L'augmentation de la puissance de transmission finit par surexciter le récepteur. Le niveau de signal électrique correspondant au signal optique "lumière active" demeure au niveau de la sortie du récepteur plus longtemps que le signal électrique généré à l'entrée de l'émetteur.

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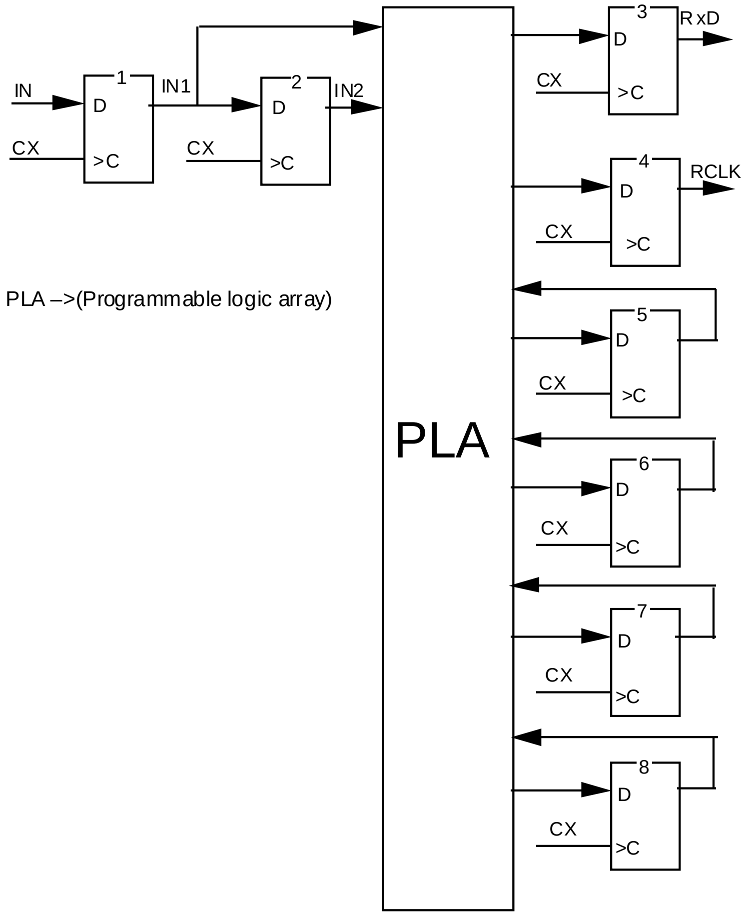
Dans la mesure où le signal IN1 n'est pas symétrique, il est utile de synchroniser la boucle à verrouillage de phase sur un seul front de signal. A cette fin, le front du signal "lumière active" semble plus stable. Selon les conditions physiques qui prévalent (c'est-à-dire récepteur inversé ou non inversé), on peut utiliser le front positif ou le front négatif comme signal d'entrée de la DPLL.



Légende

Anglais	Français
PLA (Programmable logic array)	PLA (Réseau logique programmable)

Figure P.1 – Exemple d'application d'une DPLL

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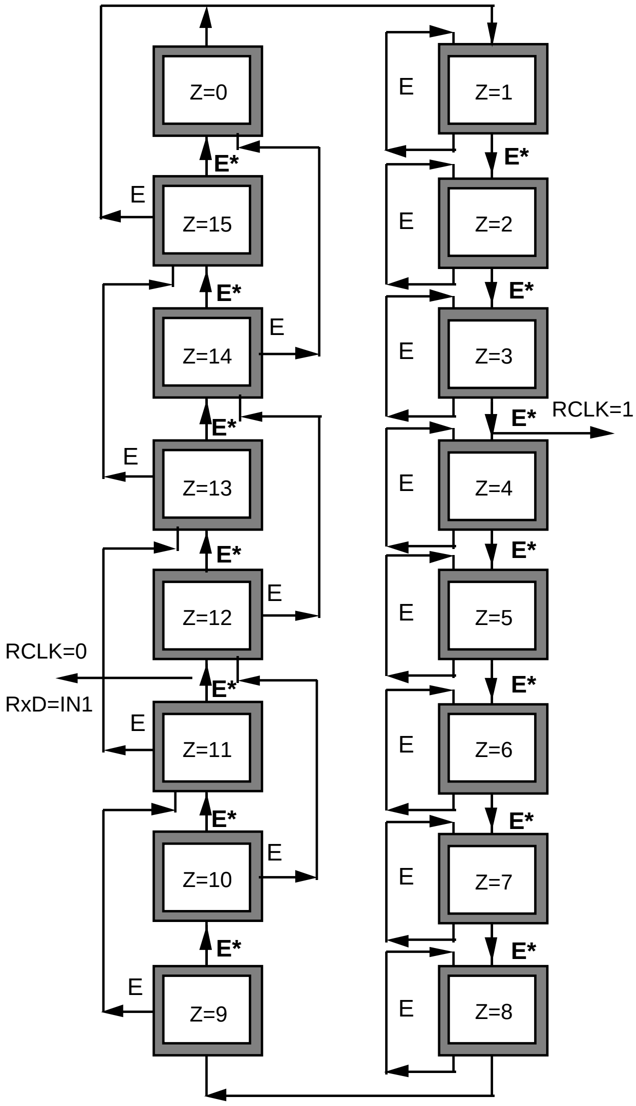

Légende:

E = événement de détection d'un front “lumière active”

E* = événement de non détection d'un front “lumière active”.

Figure P.2 – Diagrammes d'états de boucle DPLL

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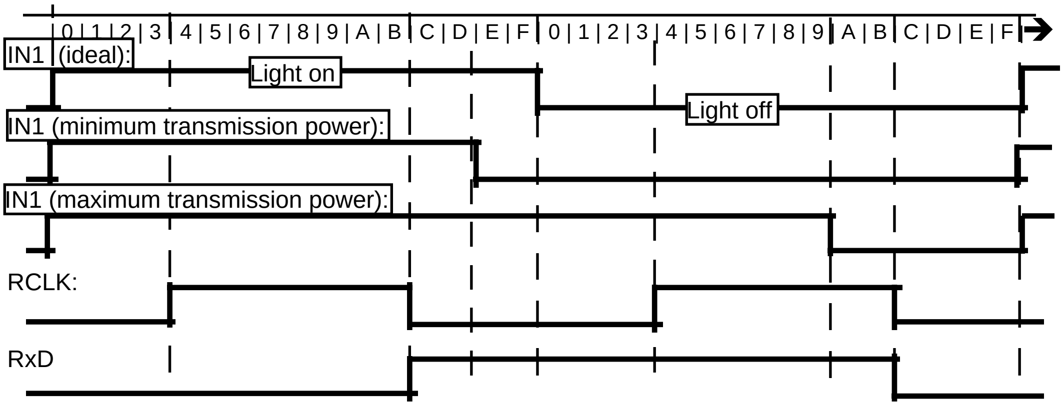

Légende

Anglais	Français
IN1 (ideal):	IN1 (idéal):
Light ON	Lumière ACTIVE
Light OFF	Lumière INACTIVE
IN1 (minimum transmission power)	IN1 (Puissance de transmission minimale)
IN1 (maximum transmission power)	IN1 (Puissance de transmission maximale)

Figure P.3 – Synchronisation de boucle DPLL

P.2 Affaiblissement sur la ligne de transmission

L'Article P.2 présente les facteurs qui contribuent à un affaiblissement sur la ligne de transmission.

Il est spécifié deux niveaux d'affaiblissement maximal admissible sur la ligne. Un émetteur peut être commuté pour exciter une ligne de transmission en mode “affaiblissement bas” ou “affaiblissement élevé”. Cela permet de réduire les effets de l'importante plage d'affaiblissement (0 dB à 7,4 dB).

Les facteurs suivants contribuent à l'affaiblissement:

- le câble à fibre optique
- d'éventuels couplages supplémentaires (par exemple des traversées murales)

Les couplages supplémentaires n'incluent pas l'affaiblissement induit par les connecteurs F-SMA sur la sortie de l'émetteur et sur l'entrée du récepteur.

Il convient de régler l'émetteur sur “affaiblissement bas” pour des lignes de transmission courtes sans couplages supplémentaires (par exemple, un affaiblissement de 2 dB sur la ligne de transmission), alors que le réglage “affaiblissement élevé” est sélectionné pour des lignes de transmission longues munies de couplages supplémentaires (par exemple, un affaiblissement de 7 dB sur la ligne de transmission). Lors de la conception de la ligne de transmission, on doit veiller à ce que l'affaiblissement maximal sur la ligne de transmission ne dépasse pas les niveaux de puissance définis par l'affaiblissement bas et l'affaiblissement élevé; en d'autres termes le niveau de puissance de transmission doit en fin de compte être adapté à l'affaiblissement prévu sur la ligne.

L'affaiblissement dû aux couplages est souvent spécifié dans les fiches techniques des connecteurs. La détermination de l'affaiblissement dû au câble à fibre optique ne peut pas être déterminée aussi simplement. Cela réside dans le fait que l'affaiblissement spécifique du câble à fibre optique n'est pas constant sur la gamme de longueurs d'ondes spécifiée. Par exemple, un câble ayant un affaiblissement spécifié de 220 dB/km peut, en fait, avoir cette

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valeur assignée pour une gamme étroite de longueurs d'ondes, située autour de 650 nm. La valeur assignée de cet affaiblissement spécifique peut facilement croître au delà de 350 dB/km (à des longueurs d'ondes comprises entre environ 635 nm et 680 nm).

Si l'on considère que la longueur d'onde émise par la diode émettrice se déplace vers des longueurs d'ondes plus importantes en fonction de l'élévation de la température (λp et $\Delta\lambda$ augmentent), des portions significatives de la lumière émise sont affaiblies en raison du câble à fibre optique.

Pour déterminer l'affaiblissement exact dû au câble à fibre optique, le produit de l'affaiblissement et de l'énergie lumineuse rayonnée doit être intégré sur toute la longueur d'onde.

Un câble à fibre optique de 30 m de long et ayant un affaiblissement caractéristique de 220 dB/km, peut présenter un intervalle d'affaiblissement de 6 dB à 9 dB sur toute la plage de températures comprise entre 0 °C et +55 °C (dû au décalage de longueur d'onde).

L'assemblage constitue un autre facteur d'incertitude concernant l'affaiblissement sur la ligne de transmission. Une fiche correctement installée et polie présente un affaiblissement induit très faible par rapport à une fiche mal montée.

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Annexe Q
(normative)

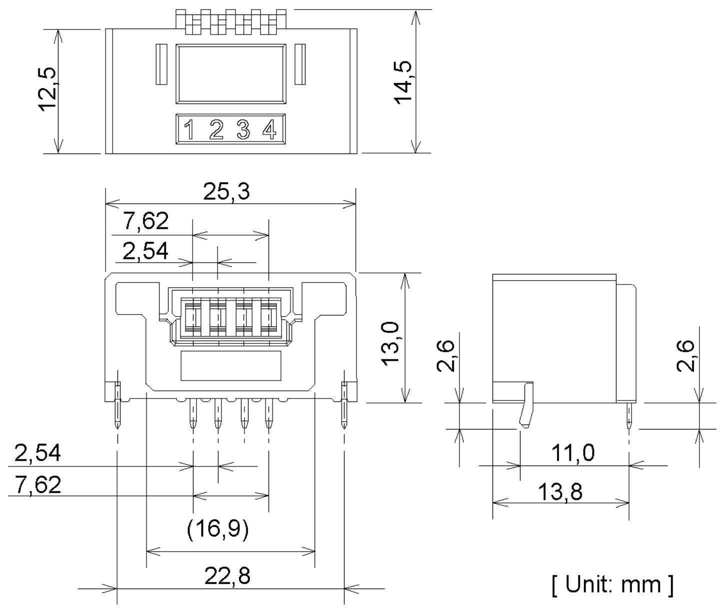
Type 18: Spécifications des connecteurs

Q.1 Vue d'ensemble

Seule la PhL-P de type 18 définit des connecteurs spécifiques.

Q.2 Connecteur d’appareil

Les dimensions requises d'un connecteur d’appareil de PhL-P de type 18 sont illustrées à la Figure Q.1 pour un connecteur à montage en angle droit, et à la Figure Q.2 pour un connecteur monté directement sur carte.



Légende

Anglais	Français
[Unit: mm]	[Unité: mm]

Figure Q.1 – Connecteur d’appareil PhL-P monté en angle droit

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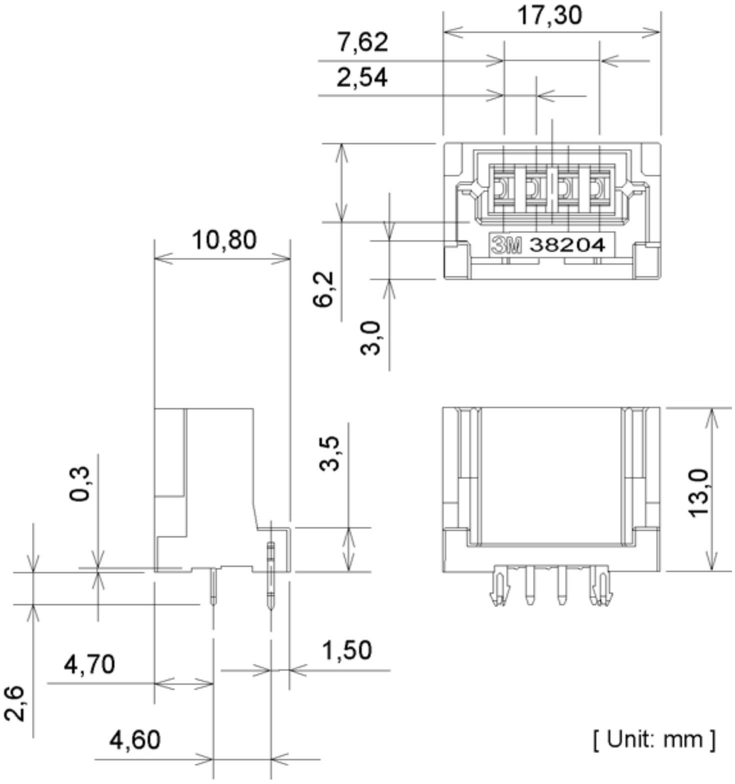

Légende

Anglais	Français
[Unit: mm]	[Unité: mm]

Figure Q.2 – Connecteur d'appareil PhL-P monté directement

Q.3 Connecteur de câble plat

Les dimensions exigées du connecteur de câble plat de PhL-P de Type 18 sont illustrées à la Figure Q.3 et à la Figure Q.4.

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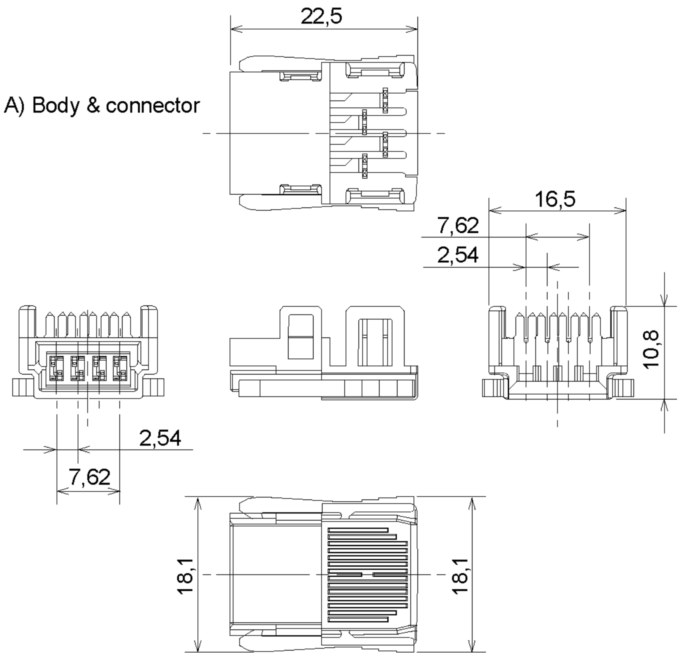
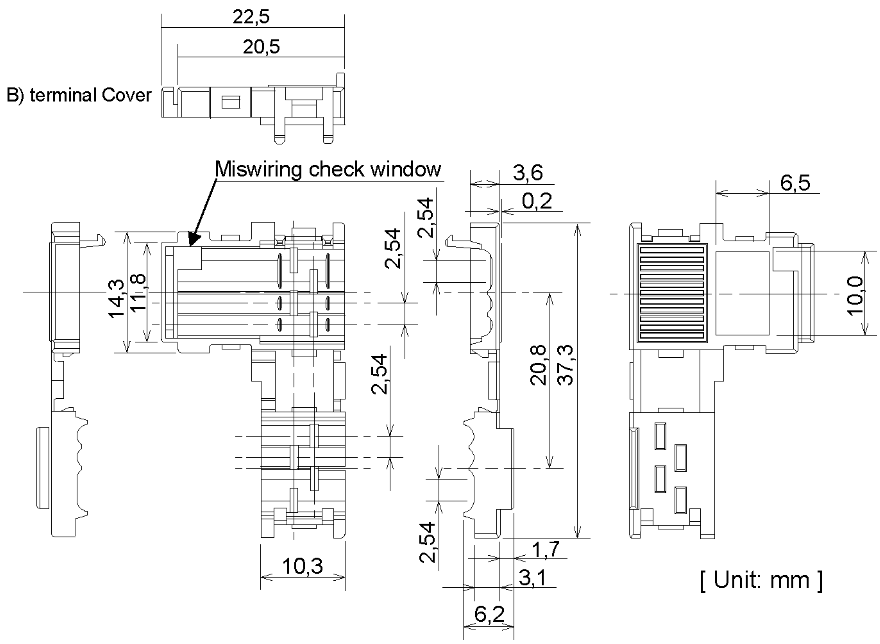


Légende

Anglais	Français
A) Body and connector	A) Corps et connecteur

Figure Q.3 – Connecteur de câble plat PhL-P et capot de borne – corps et connecteur



Légende

Anglais	Français
B) Terminal cover	B) Capot de borne
Miswiring check window	Fenêtre de vérification d'erreur de câblage
[Unit: mm]	[Unité: mm]

Figure Q.4 – Connecteur de câble plat PhL-P et capot de borne – capot de borne

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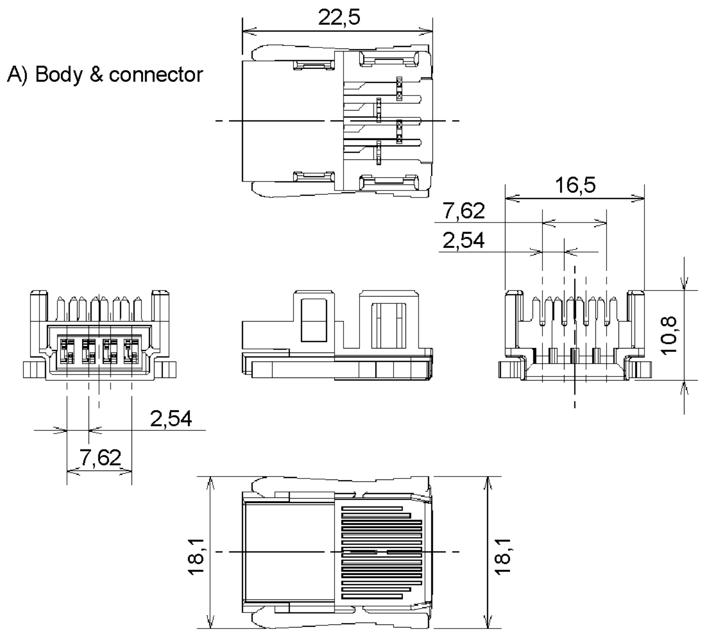
Q.4 Connecteur de câble rond

Les dimensions exigées du connecteur de câble rond de PhL-P de Type 18 sont illustrées à la Figure Q.5 et à la Figure Q.6. Ce connecteur est applicable aux deux modèles de câbles ronds PhL-P de type 18.



Légende

Anglais	Français
A) Body and connector	A) Corps et connecteur

Figure Q.5 – Corps de connecteur de câble rond de PhL-P de Type 18

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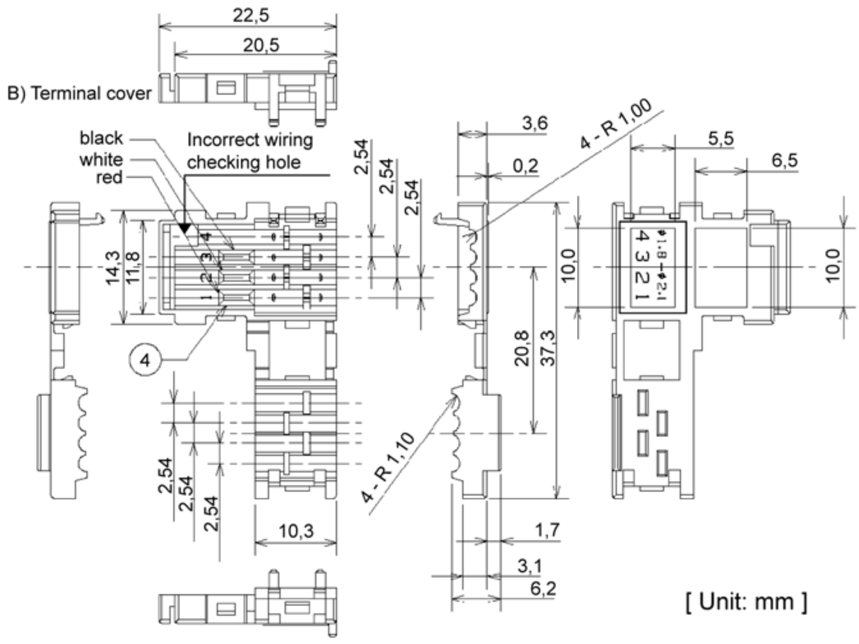

Légende

Anglais	Français
B) Terminal cover	B) Capot de borne
black	Noire
white	Blanche
red	Rouge
Incorrect wiring checking hole	Trou de contrôle de câblage Incorrect
[Unit: mm]	[Unité: mm]

Figure Q.6 – Capot de borne de connecteur de câble rond de PhL-P de Type 18

Q.5 Variante de connecteur de câble rond

Les dimensions exigées de la variante de connecteur de câble rond PhL-P de Type 18 sont illustrées à la Figure Q.7 et à la Figure Q.8.

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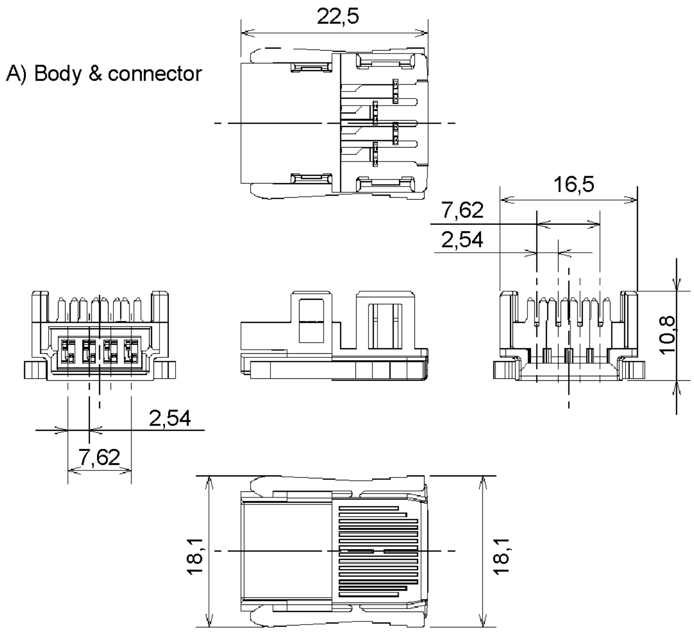

Légende

Anglais	Français
A) Body and connector	A) Corps et connecteur

Figure Q.7 – Variante de corps et connecteur de câble rond PhL-P de Type 18

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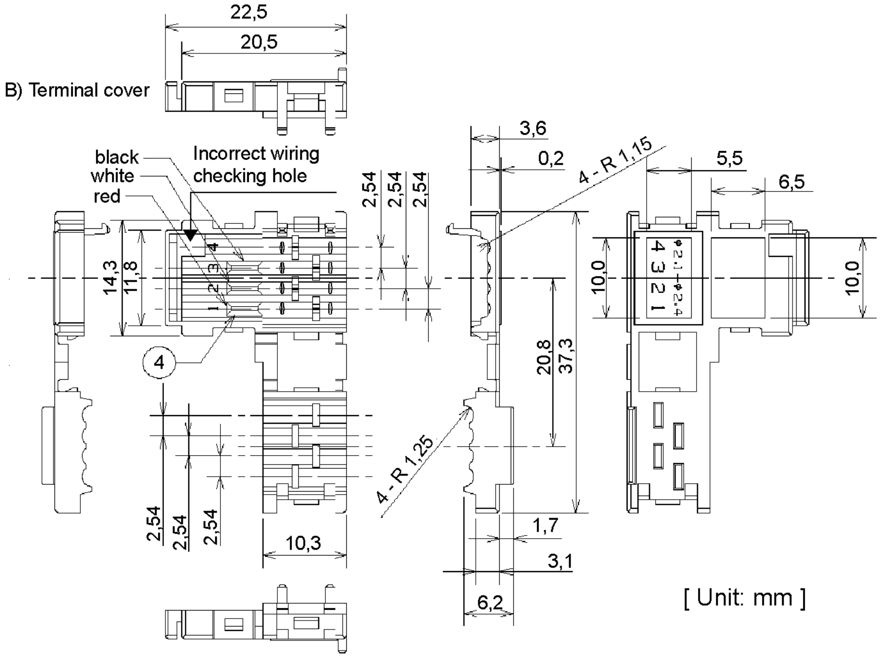

Légende

Anglais	Français
B) Terminal cover	B) Capot de borne
black	Noire
white	Blanche
red	Rouge
Incorrect wiring checking hole	Trou de contrôle de câblage Incorrect
[Unit: mm]	[Unité: mm]

Figure Q.8 – Capot de borne de variante de connecteur de câble rond de PhL-P de Type 18

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Annexe R
(normative)

Type 18: Spécifications du câblage des supports

R.1 Câble de PhL-B de Type 18

Le câble à paire torsadée à 3 conducteurs de support PhL-B de Type 18 est spécifié dans le Tableau R.1.

Tableau R.1 – Spécifications du câblage de PhL-B

Point		Spécifications
Type de câble		Câble torsadé blindé
Diamètre extérieur		8,0 mm ou moins
Nombre de conducteurs		3
Dimension du conducteur		20 AWG
Dimension de l'isolation		0,55 mm à 0,80 mm
Ligne d'évacuation		20 lignes/0,18 mm ou 24 lignes/0,18 mm Insérer séparément ou en faisceau entre le faisceau du câble de mise à la terre et le ruban en aluminium.
Résistance du conducteur (20°C)		37,8 Ω/km au maximum
Résistance d'isolation		10 000 MΩ/km au minimum
Tension de tenue diélectrique		500 V c.c. 1 min
Capacité électrostatique (1 kHz)		60 nF/km au maximum
Impédance caractéristique	1 MHz	110 ± 15 Ω
	5 MHz	110 ± 6 Ω
Affaiblissement (20 °C)	1 MHz	1,6 dB/100 m au maximum
	5 MHz	3,5 dB/100 m au maximum
Section	Ligne d'évacuation torsadée	Voir Figure R.1
	Ligne d'évacuation non torsadée	Voir Figure R.2

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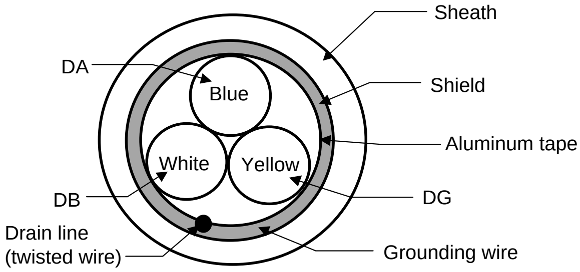
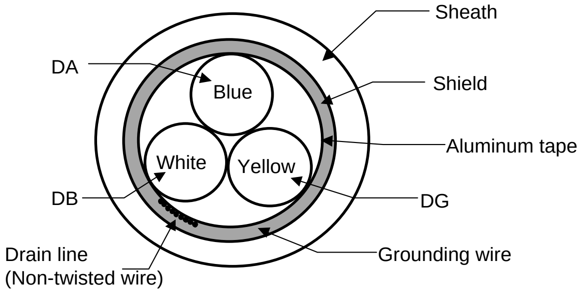


Légende

Anglais	Français
Blue	Bleue
White	Blanche
Yellow	Jaune
Sheath	Gaine
Shield	Blindage
Aluminum tape	Bande en aluminium
Grounding wire	Conducteur de mise à la masse
Drain line (twisted wire)	Ligne d'évacuation (conducteur torsadé)

Figure R.1 – Section transversale de câble PhL-B – Ligne d'évacuation torsadée



Légende

Anglais	Français
Blue	Bleue
White	Blanche
Yellow	Jaune
Sheath	Gaine
Shield	Blindage
Aluminum tape	Bande en aluminium
Grounding wire	Conducteur de mise à la masse
Drain line (non twisted wire)	Ligne d'évacuation (conducteur non torsadé)

Figure R.2 – Section transversale de câble PhL-B – Ligne d'évacuation non-torsadée

R.2 Câble PhL-P de Type 18

R.2.1 Câble plat

Le câble plat non blindé à 4 conducteurs de support PhL-P de Type 18 est spécifié dans le Tableau R.2.

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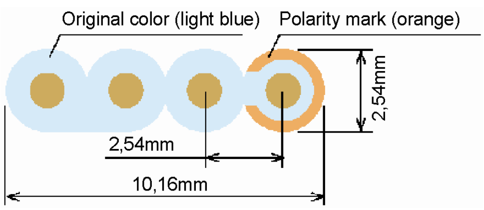
Tableau R.2 – Spécifications du câble plat de PhL-P

Point		Unité	Spécification	
Type de câble		-	Câble plat	
Nombre de conducteurs		-	4	
Conducteur	Matière	-	Fil de cuivre étamé, recuit (torsadage global)	
	AWG	-	18	
	Construction	Lignes/mm	43/0,16, 34/0,18, 30/0,18	
	Encombrement normalisé	mm	1,20 à 1,21	
	Pas entre lignes torsadées	mm	24,9 au maximum	
Matière isolante	Matière	-	Résine souple	
	Epaisseur normalisée	mm	0,66 à 0,67	
	Encombrement (petits axes × grands axes)	mm	2,54 ± 0,15×10,16 ± 0,40	
	Pas entre lignes	mm	2,54 ± 0,10	
Résistance du conducteur (à 20 °C)		Ω/km	23,4 au maximum	
Résistance d'isolation (à 20 °C)		MΩ/km	10 au moins	
Tension de tenue		-	500 V c.a., 1 min	
Impédance caractéristique (valeur de référence)		Ω	1 MHz	130 ± 25
			2 MHz	
Affaiblissement (valeur de référence)		dB/100 m	1 MHz	3,04 au maximum
			2 MHz	4,83 au maximum
Capacité électrostatique (valeur de référence)		nF/km	1 kHz	55 au maximum
Section transversale – avec clé (recommandé)		–	Voir Figure R.3	
Section transversale – sans clé		-	Voir Figure R.4	
Marquage de polarité		-	Voir Figure R.5	



Légende

Anglais	Français
Original color (light blue)	Couleur initiale (bleu clair)
Polarity mark (orange)	Repère de polarité (orange)

Figure R.3 – Section transversale de câble plat PhL-P – avec clé

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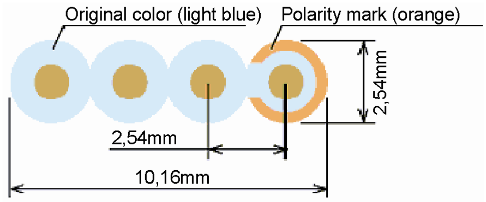

Légende

Anglais	Français
Original color (light blue)	Couleur initiale (bleu clair)
Polarity mark (orange)	Repère de polarité (orange)

Figure R.4 – Section transversale de câble plat PhL-P – sans clé

Légende

Anglais	Français
33 cm or less	33 cm au maximum

Figure R.5 – Marquage de la polarité de câble plat de PhL-P

R.2.2 Câble rond – préférentiel

Le type préférentiel de câble rond non blindé à 4 conducteurs pour le support PhL-P de Type 18 est spécifié dans le Tableau R.3. Ce type de câble est également appelé cordon VCTF.

Tableau R.3 – Spécifications du câble rond de PhL-P – type préférentiel

Point		Unité	Spécification
Type de câble		–	Câble rond à gaine en chlorure de polyvinyle
Nombre de conducteurs		–	4
Conducteur	Aire nominale de la section du conducteur	mm^2	0,75
	Nombre de conducteurs/diamètre d'un conducteur	conducteur/mm	30/0,18
	Diamètre extérieur	mm	1,1
Isolant	Epaisseur	mm	0,6
	Diamètre extérieur (environ)	mm	2,3
Gaine	Epaisseur	mm	1,0
	Diamètre extérieur de finition (environ)	mm	7,6
Résistance du conducteur (à 20°C)		Ω/km	25,1
Section		-	Voir Figure R.6

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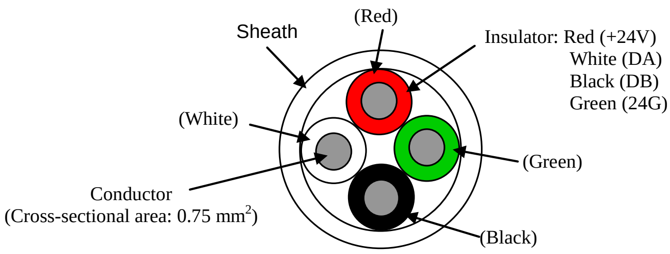

Légende

Anglais	Français
Conductor (cross-sectional area: 0,75 mm^2)	Conducteur (aire de la section: 0,75 mm^2)
(White)	(Blanc)
Sheath	Gaine
(Red)	(Rouge)
Insulator	Isolant
Red (+ 24V)	Rouge (+ 24V)
White (DA)	Blanc (DA)
Black (BD)	Noir (BD)
Green (24 G)	Vert (24 G)
(Green)	(Vert)
(Black)	(Noir)

Figure R.6 – Câble rond – préférentiel; section

R.2.3 Câble rond – variante

La variante de câble rond non blindé à 4 conducteurs pour le support PhL-P de Type 18 est spécifiée dans le Tableau R.4.

Tableau R.4 – Spécifications du câble rond de PhL-P – variante

Point		Unité	Spécification	
Nombre de conducteurs		-	4	
Conducteur	Aire de la section	mm^2	0,75	
Isolant	Diamètre extérieur	mm	1,8 à 2,4	
Résistance du conducteur (à 20 °C)		Ω/km	35 au maximum	
Résistance du conducteur (à 20 °C) (valeur de référence)		MΩ/km	5 au moins	
Tension de tenue (valeur de référence)		-	500 V c.a., 1 min	
Impédance caractéristique (valeur de référence)		Ω	1 MHz	90 ± 30
			2 MHz	
Chute de niveau en décibels (valeur de référence)		db/100 m	1 MHz	4 au maximum
			2 MHz	5 au maximum
Capacité électrique (valeur de référence)		nF/km	1 MHz	100 au maximum
Section		-	Voir Figure R.7	

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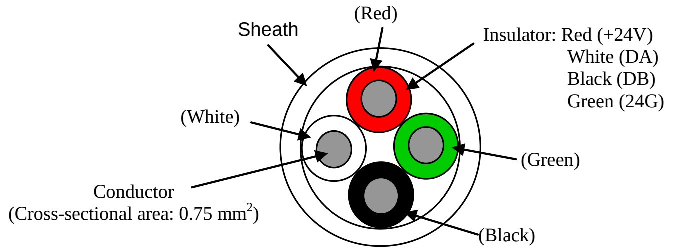

Légende

Anglais	Français
Conductor (cross-sectional area: 0,75 mm^2)	Conducteur (aire de la section: 0,75 mm^2)
(White)	(Blanc)
Sheath	Gaine
(Red)	(Rouge)
Insulator	Isolant
Red (+ 24V)	Rouge (+ 24V)
White (DA)	Blanc (DA)
Black (BD)	Noir (BD)
Green (24 G)	Vert (24 G)
(Green)	(Vert)
(Black)	(Noir)

Figure R.7 – Câble rond – variante; section

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Annexe S
(normative)

Type 24: Spécifications des connecteurs

S.1 Vue d'ensemble

La présente annexe en spécifie les deux types de connecteurs suivants en fonction du support.

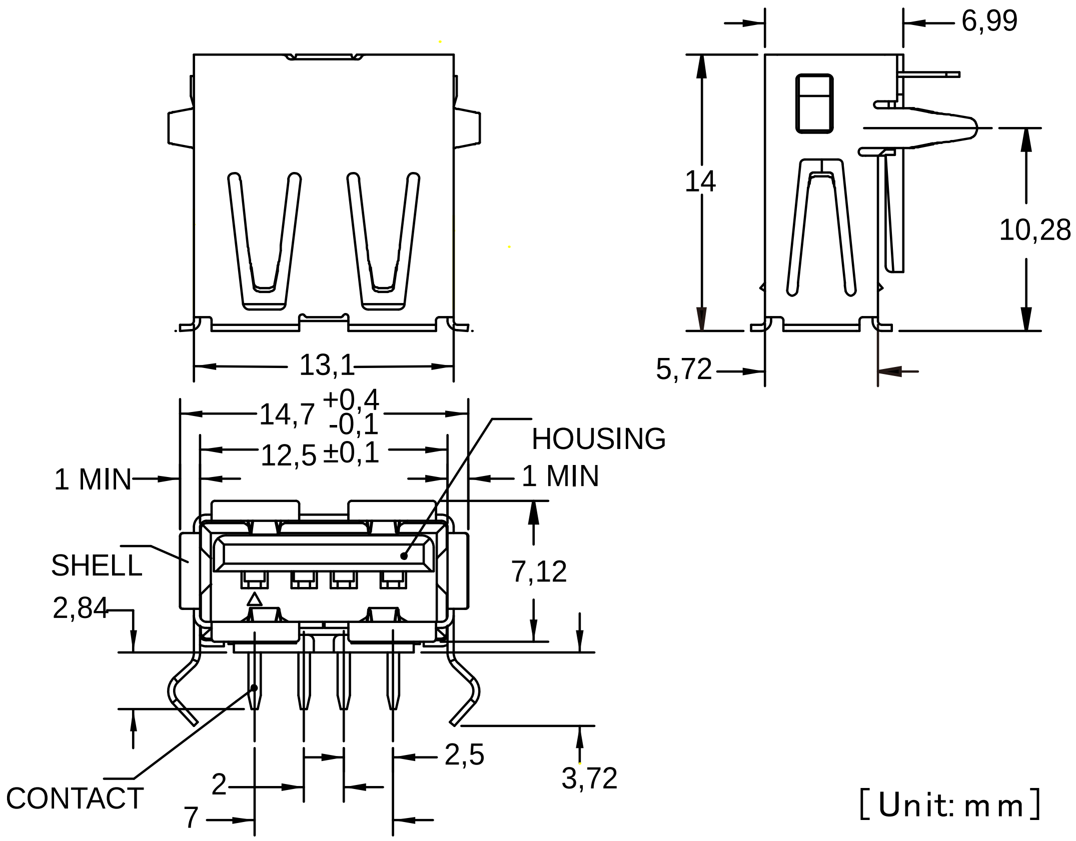
Connecteur de type 24-1 pour support câblé à paire torsadée;

Connecteur de type 24-2 pour support Ethernet.

S.2 Connecteur de type 24-1

S.2.1 Connecteur d’appareil de type 24-1

Les dimensions du connecteur d’appareil de type 24-1 (1 ligne) sont représentées à la Figure S.1.



Légende

Anglais	Français
HOUSING	BOITIER
SHELL	BOITIER
CONTACT	CONTACT
Unit: mm	Unité: mm

Figure S.1 – Dimensions du connecteur d’appareil de type 24-1 (1 ligne)

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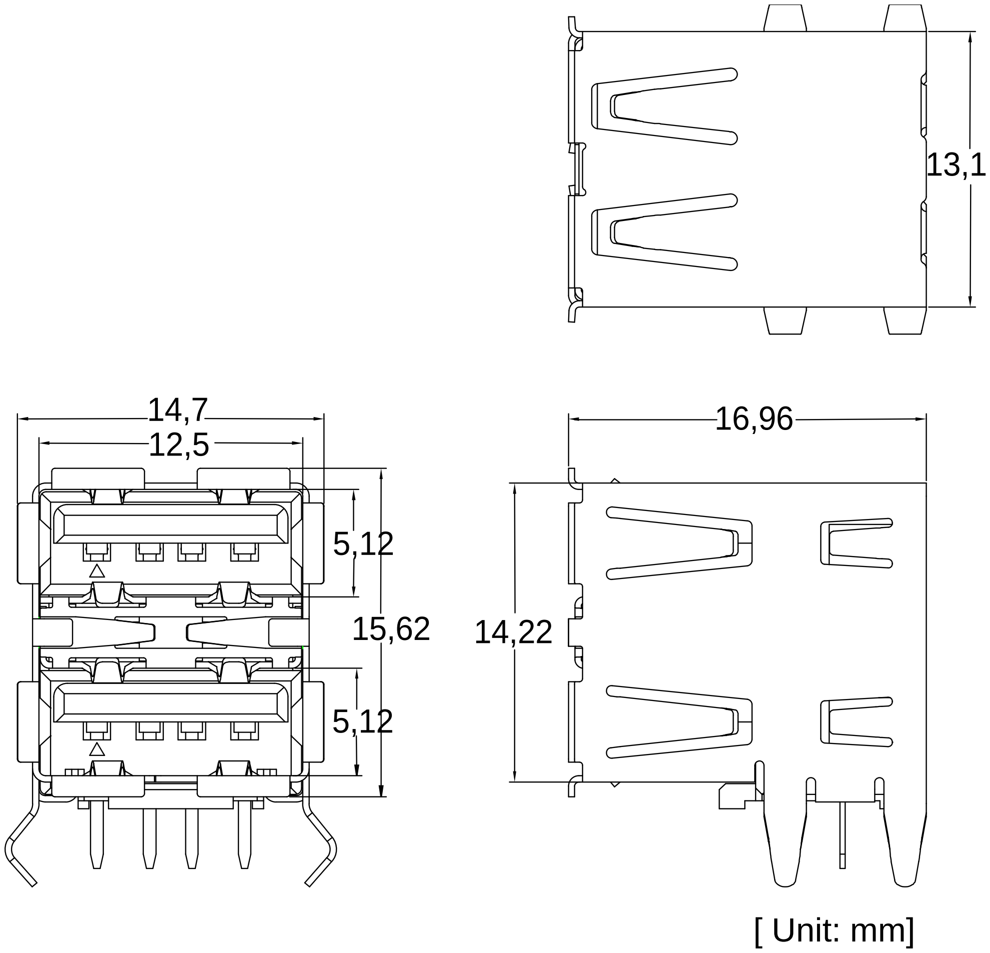
Les dimensions du connecteur d'appareil de type 24-1 (2 lignes) sont représentées à la Figure S.2.



Légende

Anglais	Français
Unit: mm	Unité: mm

Figure S.2 – Dimensions du connecteur d'appareil de type 24-1 (2 lignes)

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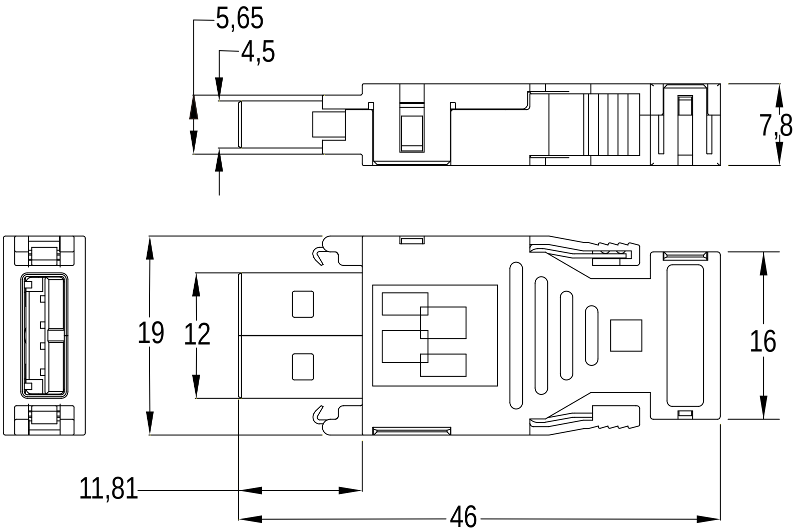
S.2.2 Connecteur de câble de type 24-1

Les dimensions du connecteur de câble de type 24-1 sont représentées à la Figure S.3.



Anglais	Français
Unit: mm	Unité: mm

Figure S.3 – Dimensions du connecteur de câble de type 24-1

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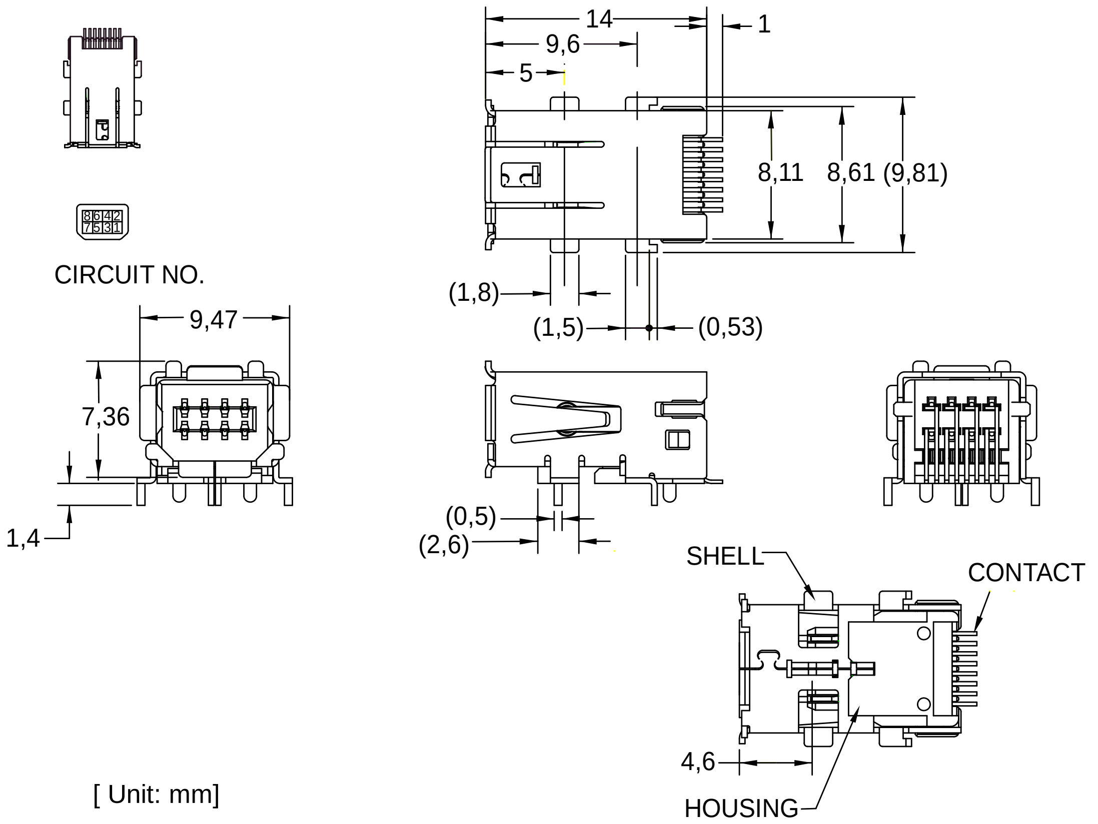
S.3 Connecteur de type 24-2

S.3.1 Connecteur d’appareil de type 24-2

Les dimensions du connecteur d’appareil de type 24-2 sont représentées à la Figure S.4.



Légende

Anglais	Français
CIRCUIT NO.	N° DU CIRCUIT
HOUSING	BOITIER
SHELL	BOITIER
CONTACT	CONTACT
Unit: mm	Unité: mm

Figure S.4 – Dimensions du connecteur d’appareil de type 24-2

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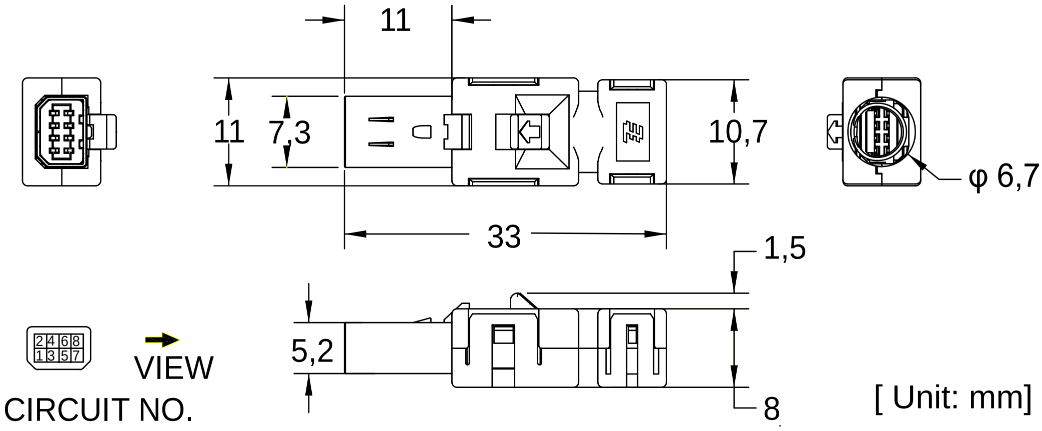
S.3.2 Connecteur de câble de type 24-2

Les dimensions du connecteur de câble de type 24-2 sont représentées à la Figure S.5.



Légende

Anglais	Français
CIRCUIT NO.	N° DU CIRCUIT
VIEW	VUE
Unit: mm	Unité: mm

Figure S.5 – Dimensions du connecteur de câble de type 24-2

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Annexe T
(informative)

Type 20: Topologie du réseau, caractéristiques et longueurs de câbles, distribution de l'alimentation par l'intermédiaire de barrières, et blindage et mise à la terre

T.1 Exemples de topologie

T.1.1 Généralités

Les appareils qui se conforment à la présente norme peuvent être utilisés dans des réseaux avec diverses typologies. La présente annexe en fournit certains exemples.

T.1.2 Réseau d'entrée courant point à point

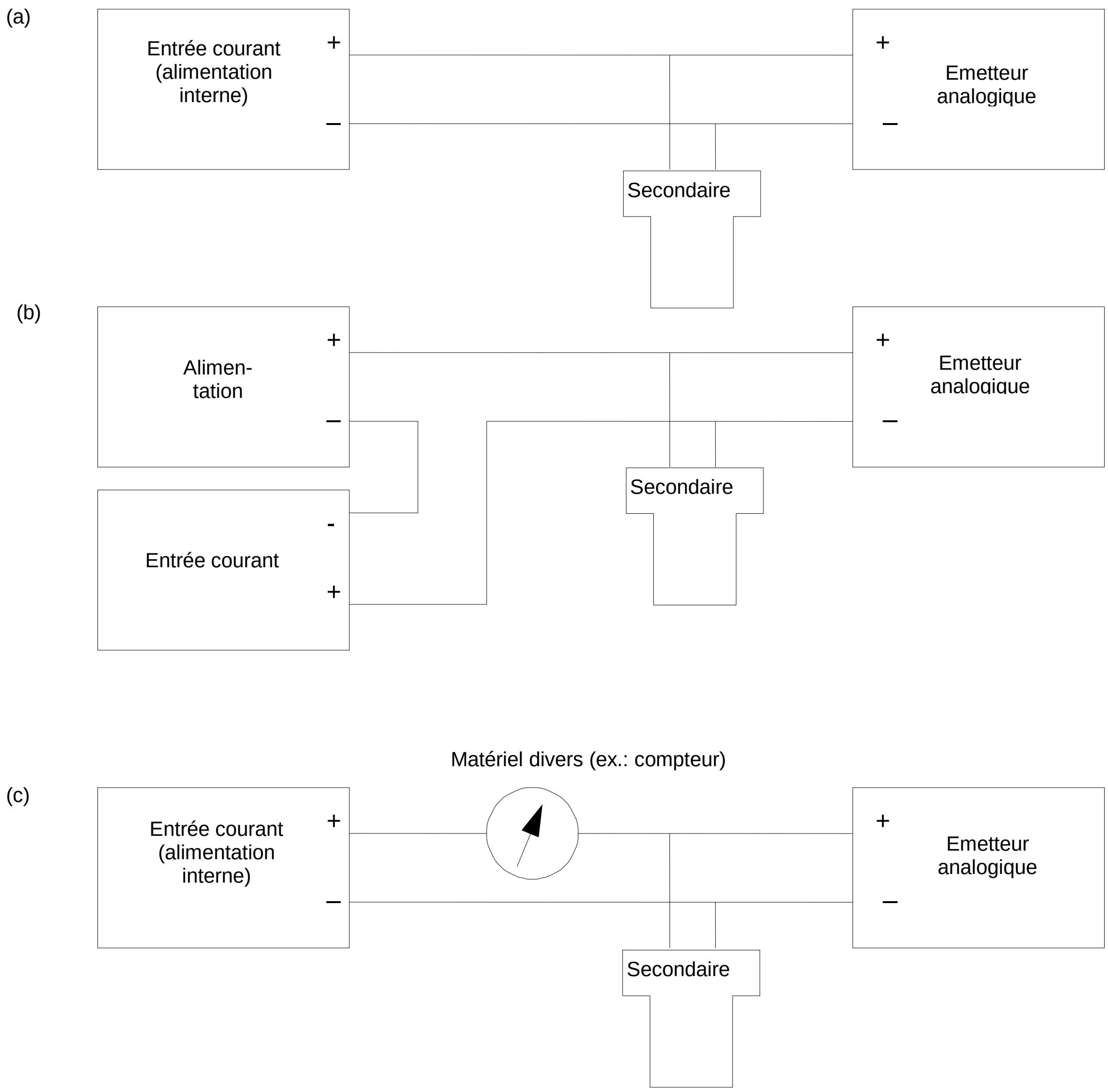

Figure T.1 – Réseau d'entrée courant point à point

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La Figure T.1 représente un réseau avec un émetteur analogique, un appareil d'entrée courant et un appareil secondaire – voir 34.3.3 les types de connexion. L'appareil d'entrée courant dans la Figure T.1 (a) et la Figure T.1 (c) possède une alimentation interne pour le réseau. La topologie de la Figure T.1 (b) utilise une alimentation distincte. Il peut y avoir une autre entité (compteur) sur le réseau comme illustré à la Figure T.1 (c), parce qu'il présente une faible impédance en série avec le câble.

T.1.3 Réseau de sortie courant point à point

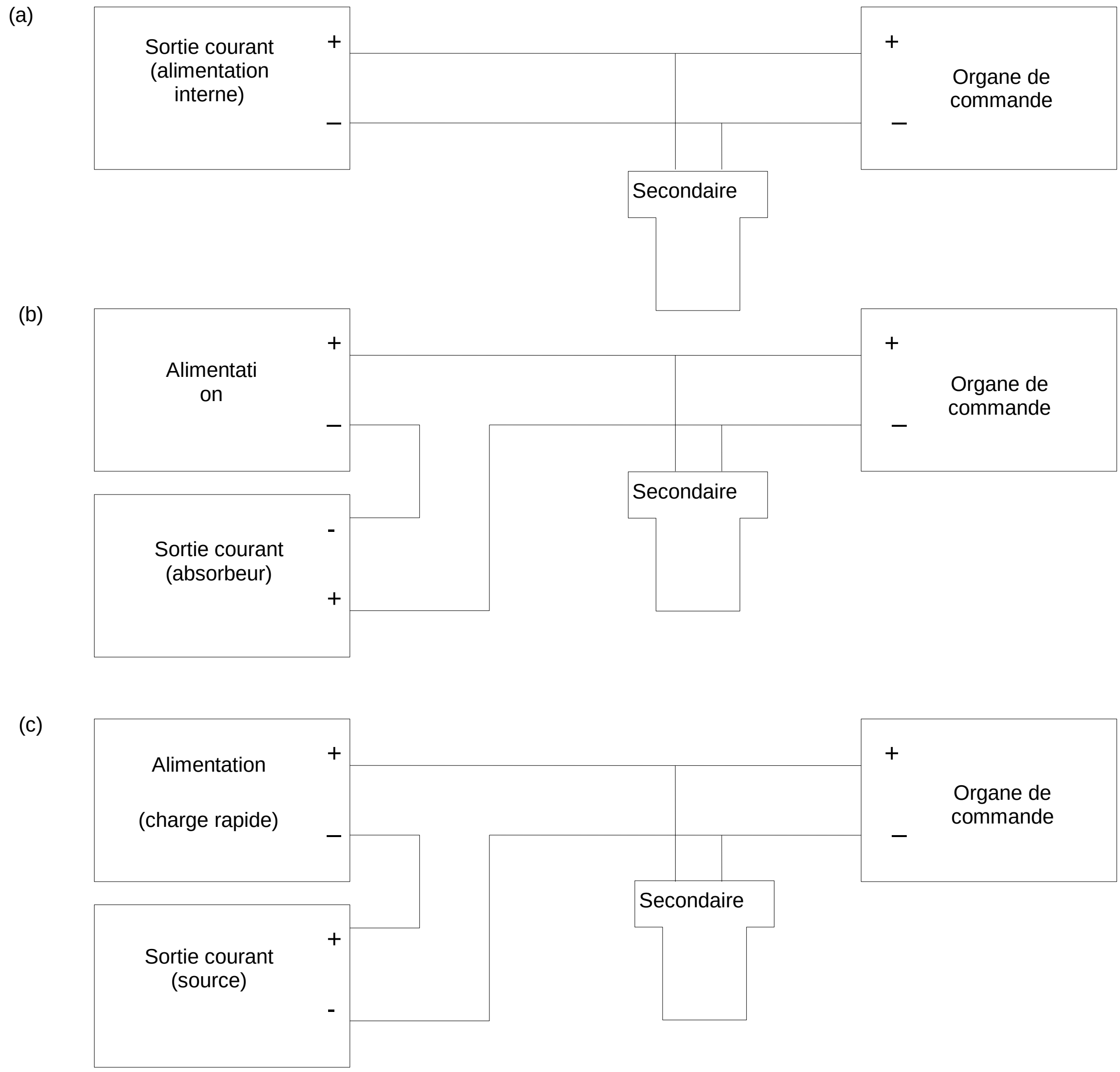

Figure T.2 – Réseau de sortie courant point à point

La Figure T.2 représente un réseau avec un organe de commande, un appareil de sortie courant et un appareil secondaire – voir 34.3.3 les types de connexion. L'appareil de sortie courant dans la Figure T.2 (a) possède une alimentation interne pour le réseau.

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T.1.4 Réseau multipoints

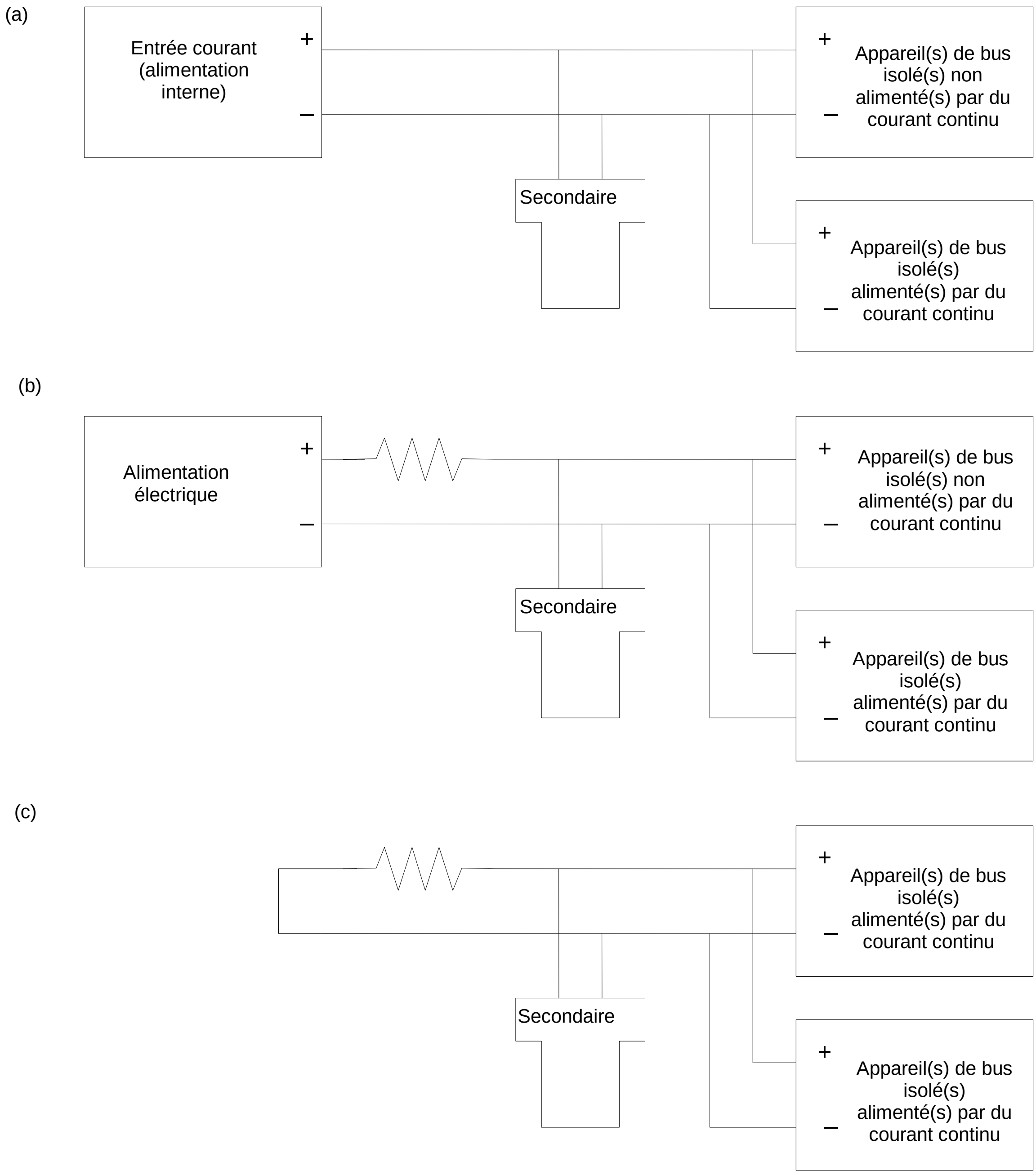

Figure T.3 – Réseau multipoints

La Figure T.3 représente un réseau multipoints avec deux esclaves. Comme illustré à la Figure T.3 (b) et (c), il n'est pas nécessaire de connecter un quelconque appareil d'entrée courant. En revanche, une résistance avec détection de courant doit être présente sur le réseau. L'alimentation est requise uniquement si le réseau possède au moins un appareil qui extrait du courant continu.

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T.1.5 Réseau multipoints avec signalisation analogique

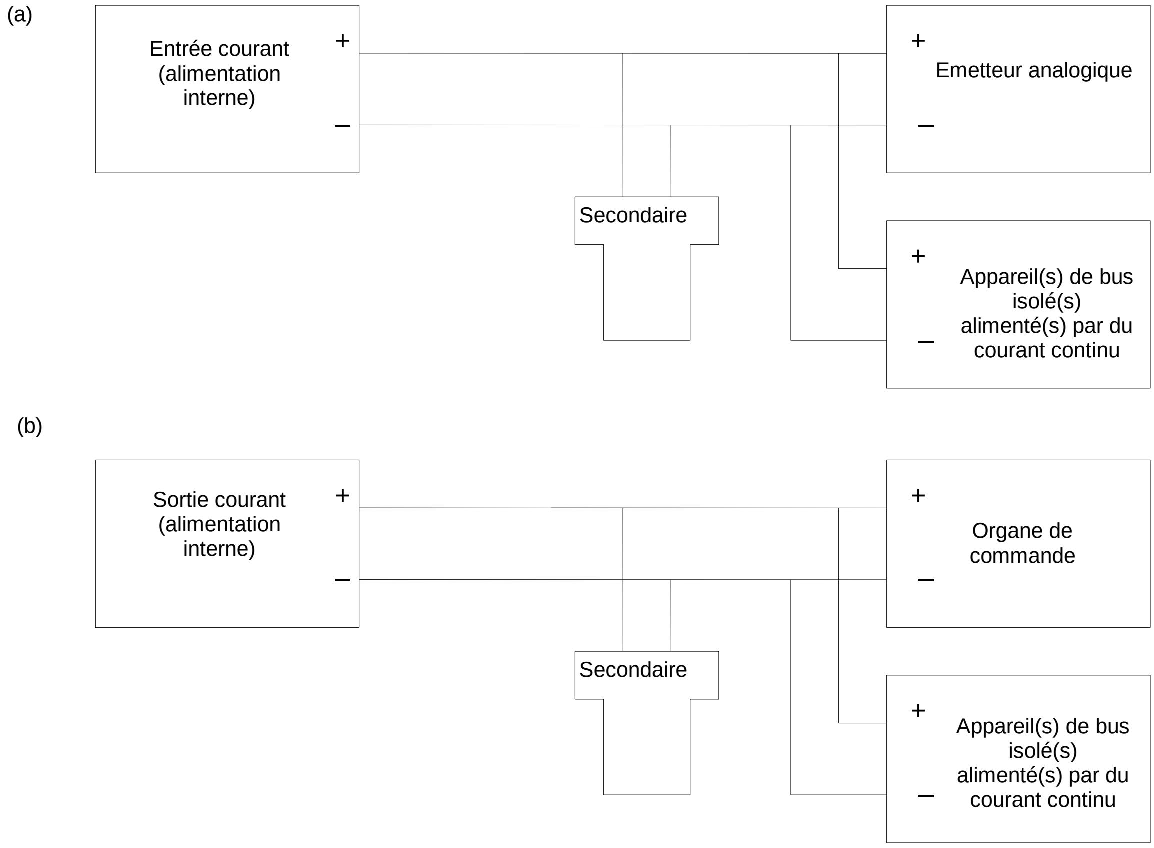

Figure T.4 – Réseau multipoints avec signalisation analogique

La Figure T.4 représente un réseau multipoints avec un esclave qui utilise une signalisation analogique et un esclave qui n'en utilise pas. Un appareil d'entrée courant doit être connecté pour un émetteur analogique comme illustré à la Figure T.4 (a), ou un appareil de sortie courant pour l'organe de commande.

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T.1.6 Réseau connecté en série

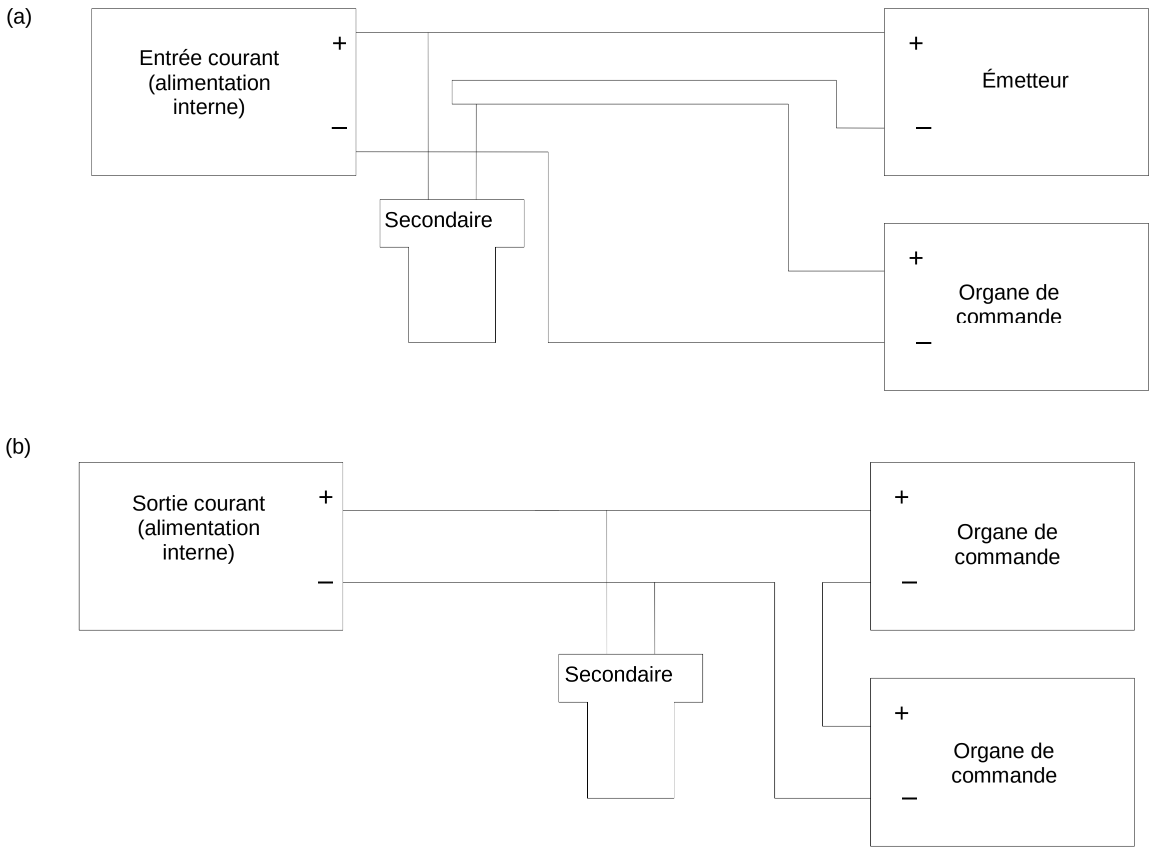

Figure T.5 – Réseau 1 connecté en série

La Figure T.5 représente un réseau connecté en série avec deux esclaves, un appareil secondaire et un appareil d'entrée courant ou de sortie courant. L'appareil secondaire est à connecter à l'appareil à impédance élevée comme illustré à la Figure T.5 (a). Si le réseau ne possède pas d'appareil à impédance élevée comme illustré à la Figure T.5 (b), l'appareil secondaire est à connecter à l'appareil de sortie courant. Si cette règle n'est pas respectée, la communication avec tous les appareils n'est pas possible.

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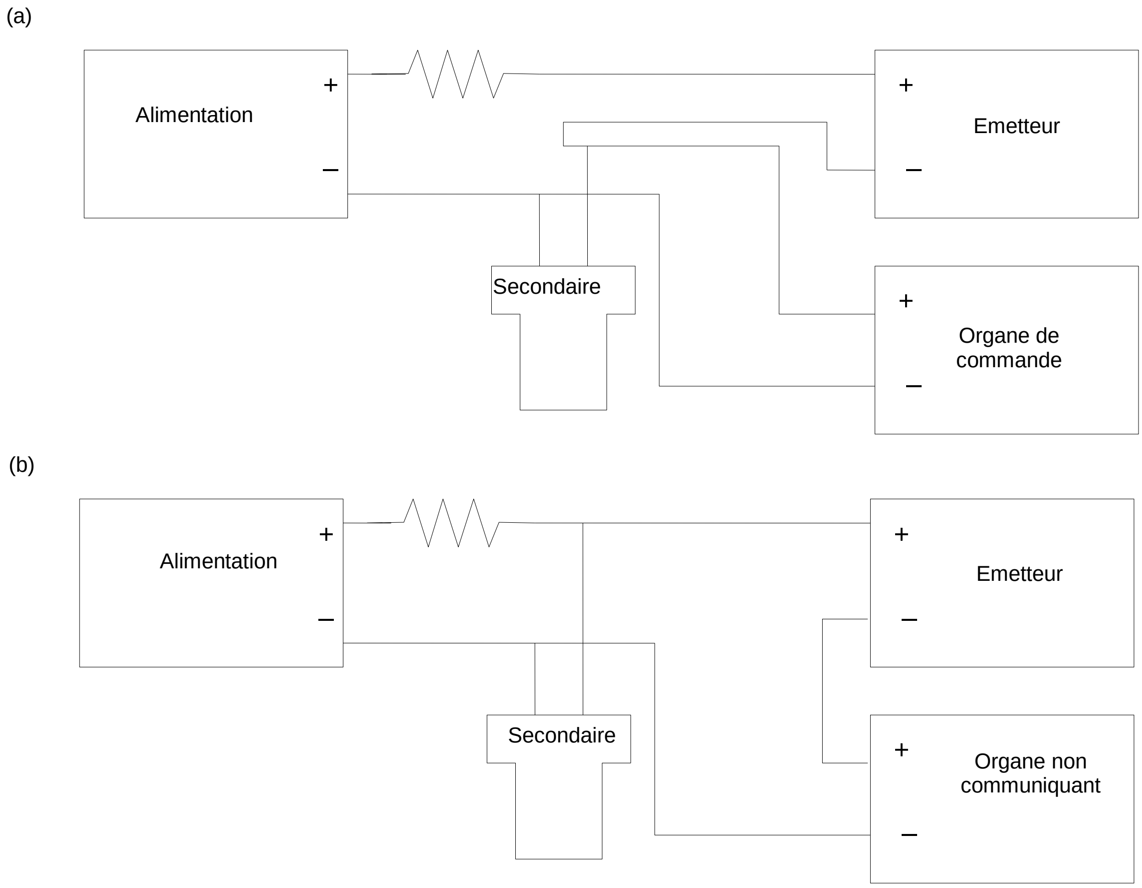

Figure T.6 – Réseau 2 connecté en série

La Figure T.6 représente un réseau connecté en série avec deux esclaves, un appareil secondaire et aucun appareil d'entrée courant ou de sortie courant. L'appareil secondaire est à connecter à l'un des appareils. Si cette règle n'est pas respectée, la communication avec tous les appareils n'est pas possible. On peut connecter un appareil ne communiquant pas, comme illustré à la Figure T.6 (b).

L'organe de commande communiquant dans tous les réseaux connectés en série est un appareil à faible impédance. Pour obtenir la longueur de câble la plus grande, il est nécessaire de faire correspondre son impédance à l'impédance de l'autre appareil à faible impédance dans le réseau – la résistance de détection en série ou l'appareil d'entrée courant ou de sortie courant.

T.2 Description et spécifications du câblage

T.2.1 Généralités

Le câble préférentiel est un câble à paire torsadée simple ou multiple à blindage global. Un câble à paire simple ou multiple peut être combiné dans un réseau donné à condition que tous les appareils à une extrémité (généralement l'extrémité de la salle de commande) du câble à paire multiple partagent une masse de châssis ou un blindage commun, et que le blindage global soit connecté à cette masse. Il convient qu'un câble non-blindé soit utilisé uniquement si l'on sait que le bruit ambiant ou la diaphonie est suffisamment bas pour conserver le taux d'erreurs de communication en-dessous de la limite acceptable. Les dimensions minimales préférentielles des conducteurs sont les suivantes:

- Longueur totale de câble jusqu'à 1 500 m – 0,51 mm de diamètre,
  NOTE 1 Cette valeur est identique à un fil 24 AWG.
- Longueur totale de câble supérieure à 1 500 m – 0,81 mm de diamètre
  NOTE 2 Cette valeur est identique à un fil 20 AWG.

T.2.2 Longueur de câble à paire simple

T.2.2.1 Paramètres

La longueur de câble maximale pour un réseau dépend des caractéristiques des appareils connectés au réseau ainsi que des caractéristiques du câble à utiliser. Pour toutes les estimations de longueurs de câbles, les paramètres définis dans le Tableau T.1 sont requis.

Tableau T.1 – Paramètres d'appareils et de câbles

Symbole	Nom de paramètre	Description du paramètre
$\sum C_{dev}$	Capacité d'appareil parallèle	Somme des valeurs de capacité d'appareil parallèle (C_{dev}) de tous les appareils connectés
$\sum R_{dev}$	Résistance d'appareil parallèle	Combinaison parallèle des valeurs de résistance d'appareil parallèle (R_{dev}) de tous les appareils connectés
R_{ser}	Impédance série diverse	Somme des impédances maximales sur une plage de fréquences comprises entre 500 Hz et 10 kHz, de tous les appareils connectés en série entre deux appareils communiquant
C_{cbl}	Capacité linéique de câble	Capacité d'un conducteur à tous les autres conducteurs (y compris le blindage s'ils sont blindés)
R_{cbl}	Capacité linéique de résistance de câble	Résistance des deux conducteurs en série

T.2.2.2 Mode opératoire

Déterminer les valeurs de paramètres définies en T.2.2.1. C_{dev} et R_{dev} sont fournis par le fabricant de l'appareil. Généralement, il existe un seul appareil à faible impédance dans le réseau, par exemple l'appareil d'entrée courant dans une boucle d'émetteur analogique, et il influe sur la valeur de $\sum R_{dev}$. L'effet d'un appareil à impédance élevée connecté au réseau est habituellement négligeable dans le calcul de $\sum R_{dev}$. Par conséquent, la valeur R_{dev} de l'appareil simple à faible impédance peut être utilisée pour la valeur de résistance de l'appareil parallèle. Une boucle type de sécurité non-intrinsèque ne présente pas une impédance série diverse. Les barrières IS passives et les indicateurs de courant constituent des exemples des appareils série. Les topologies série, telles que les appareils de terrain avec une capacité PID ou les appareils actionneurs à plage fractionnée, sont analysées en traitant l'un des appareils de terrain comme une résistance série diverse tout en analysant le réseau pour l'autre. Les valeurs de C_{cbl} et R_{cbl} sont fournies par le fabricant du câble. Une fois que les valeurs des paramètres sont connues, les graphiques représentés aux Figure T.7 à Figure T.27 sont utilisés pour connaître la longueur de câble maximale qui peut être utilisée. Il peut être nécessaire d'interpoler les valeurs dans les graphiques pour connaître les valeurs de paramètres réelles.

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La Figure T.7 représente la longueur de câble maximale qui peut être utilisée pour un réseau avec un appareil esclave et une résistance de détection en série 250 Ω. Un réseau idéal possède un appareil dominant à faible impédance de 250 Ω, des appareils à impédance élevée de 100 kΩ ou plus et un câble avec une faible capacitance.

La Figure T.8, la Figure T.9, la Figure T.10 et la Figure T.11 représentent la capacité de câble admissible totale pour un réseau contenant des appareils multiples et aucune impédance série diverse. La longueur de câble maximale peut être calculée à partir de la valeur de capacité de câble admissible. La Figure T.12, la Figure T.13, la Figure T.14 et la Figure T.15 représentent la capacité de câble admissible totale pour un réseau contenant des appareils multiples et diverses valeurs d'impédance série pour un câble dont le rapport capacité/résistance est de 1 000. La Figure T.16, la Figure T.17, la Figure T.18 et la Figure T.19 représentent la capacité de câble admissible totale pour un réseau contenant des appareils multiples et diverses valeurs d'impédance série pour un câble dont le rapport capacité/résistance est de 2 000. La Figure T.20, la Figure T.21, la Figure T.22 et la Figure T.23 représentent la capacité de câble admissible totale pour un réseau contenant des appareils multiples et diverses valeurs d'impédance série pour un câble dont le rapport capacité/résistance est de 5 000. La Figure T.24, la Figure T.25, la Figure T.26 et la Figure T.27 représentent la capacité de câble admissible totale pour un réseau contenant des appareils multiples et diverses valeurs d'impédance série pour un câble dont le rapport capacité/résistance est de 10 000.

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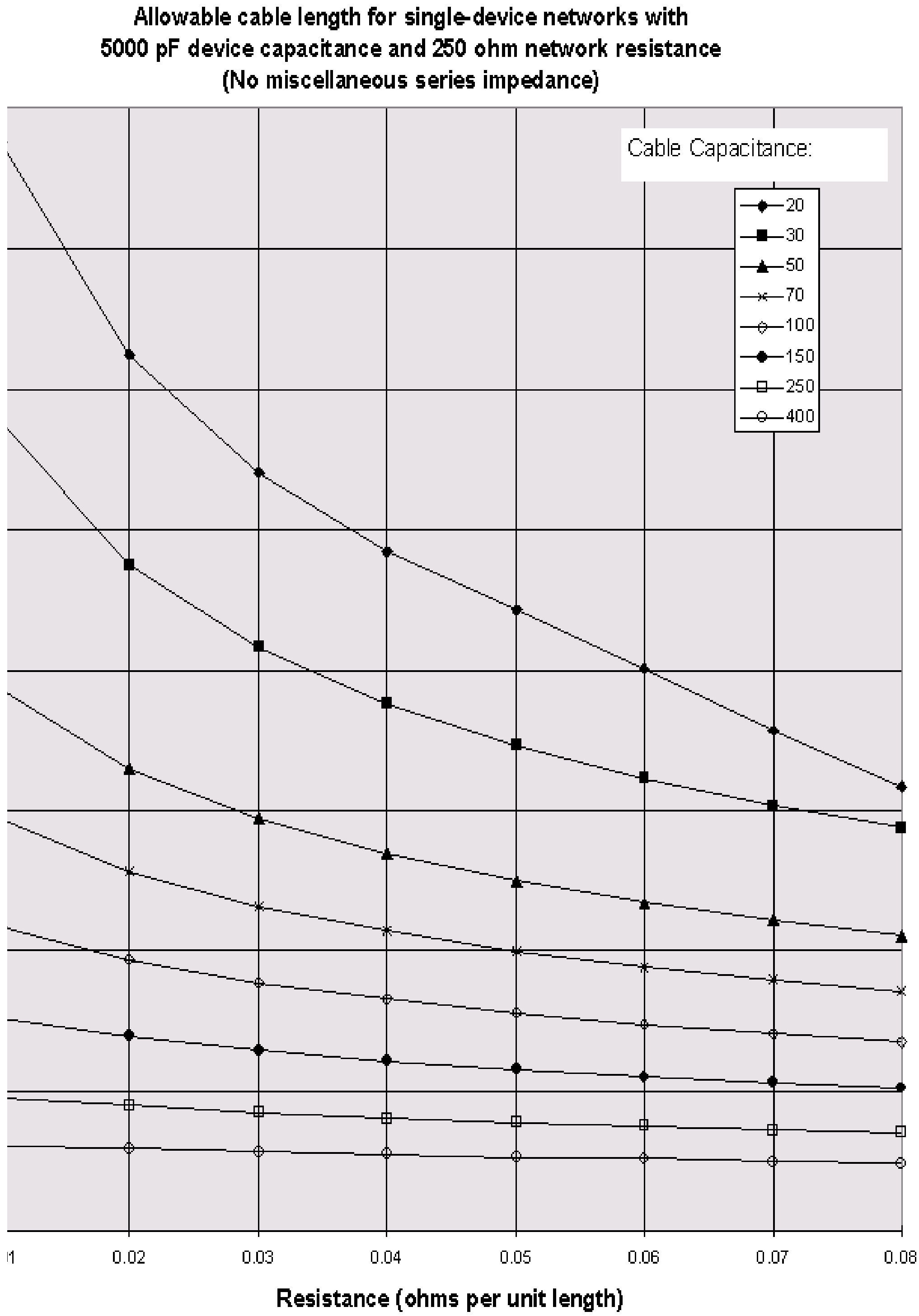

Légende

Anglais	Français
Allowable cable length for single-device networks with 5000 pF device capacitance and 250 ohm network resistance (No miscellaneous series impedance)	Longueur de câble admissible pour des réseaux à appareil unique avec une capacité d'appareil de 5000 pF et une résistance de réseau de 250 ohm (aucune impédance en série)
Length (same units as parameters)	Longueur (unités identiques aux paramètres)
Resistance (ohms per unit length)	Résistance (ohms par unité de longueur)
Cable Capacitance	Capacité du câble

Figure T.7 – Longueur de câble pour un réseau unique d'appareils esclaves

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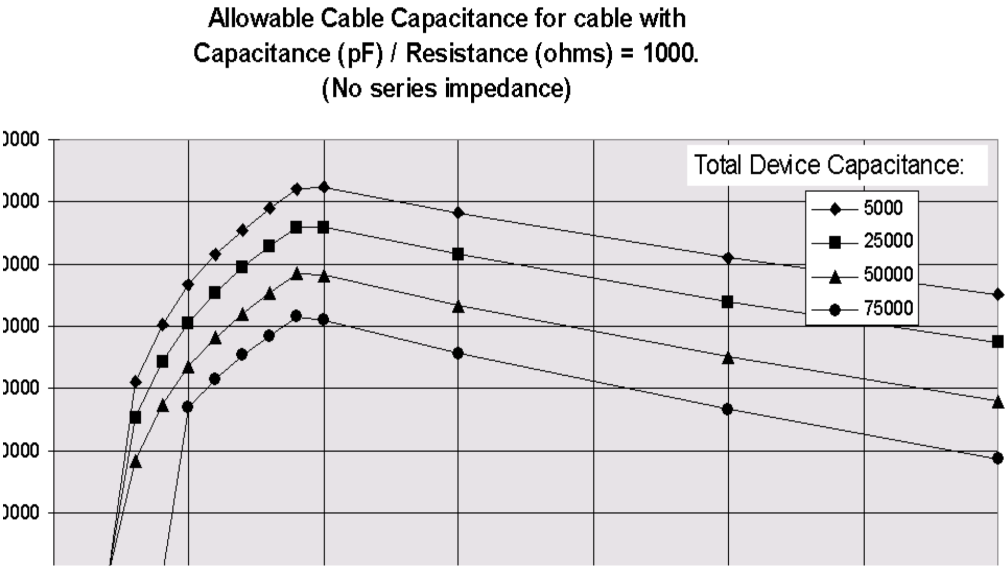

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 1000. (No series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 1000. (aucune impédance en série)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.8 – Capacité de câble pour C_{cbl}/R_{cbl}=1 000

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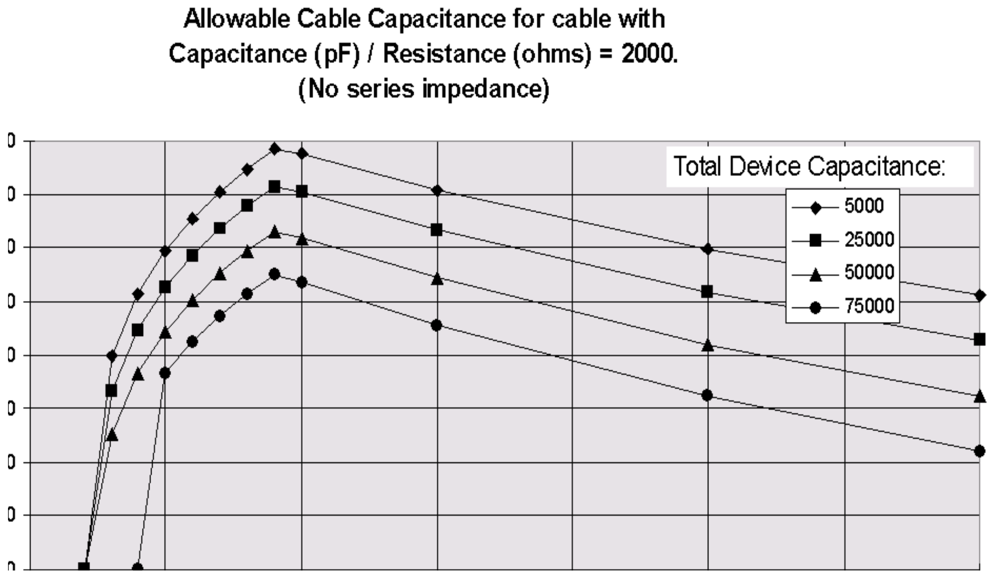

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 2000. (No series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 2000. (aucune impédance en série)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.9 – Capacité de câble pour C_{cbl}/R_{cbl}=2 000

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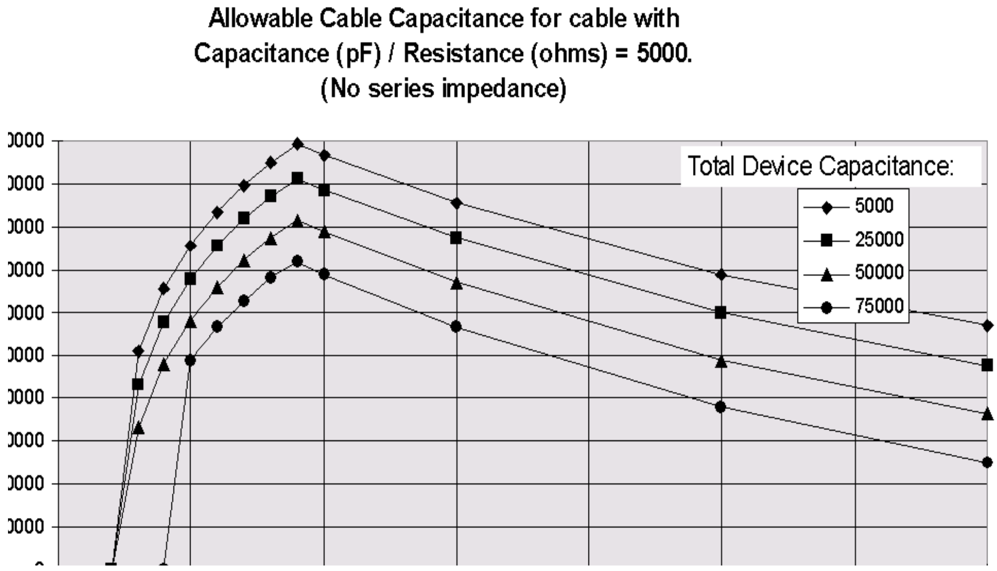

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 5000. (No series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 5000. (aucune impédance en série)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.10 – Capacité de câble pour C_{cbl}/R_{cbl}=5 000

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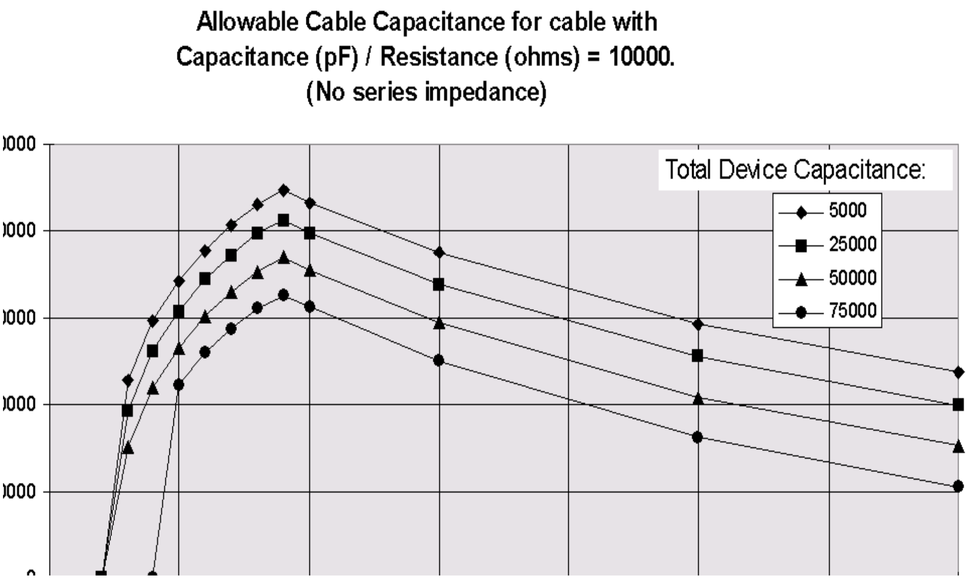

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 10 000. (No series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 10 000. (aucune impédance en série)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.11 – Capacité de câble pour C_{cbl}/R_{cbl}=10 000

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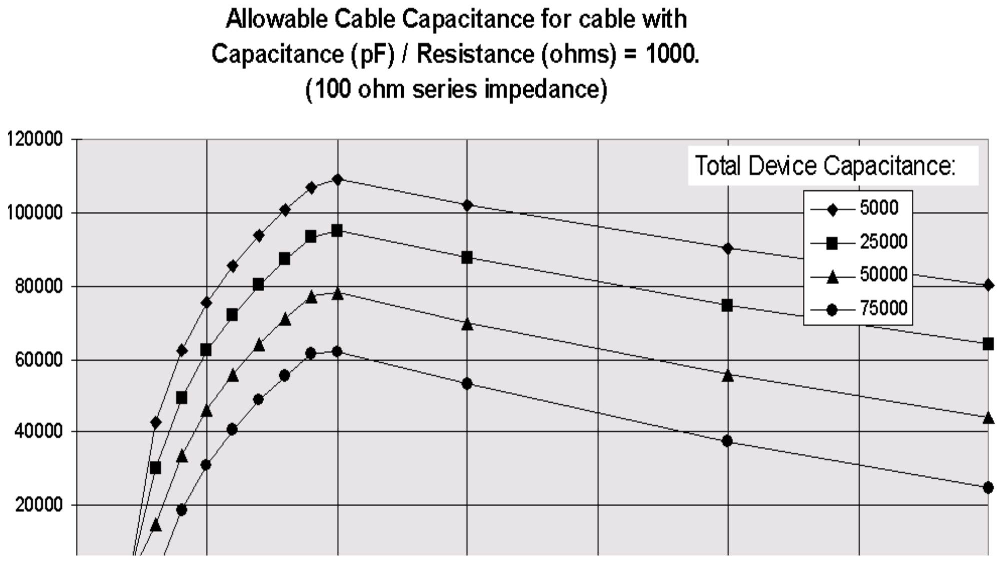

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 1000. (100 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 1000. (impédance en série de 100 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.12 – Capacité de câble pour C_{cbl}/R_{cbl}=1 000, résistance série de 100 Ω

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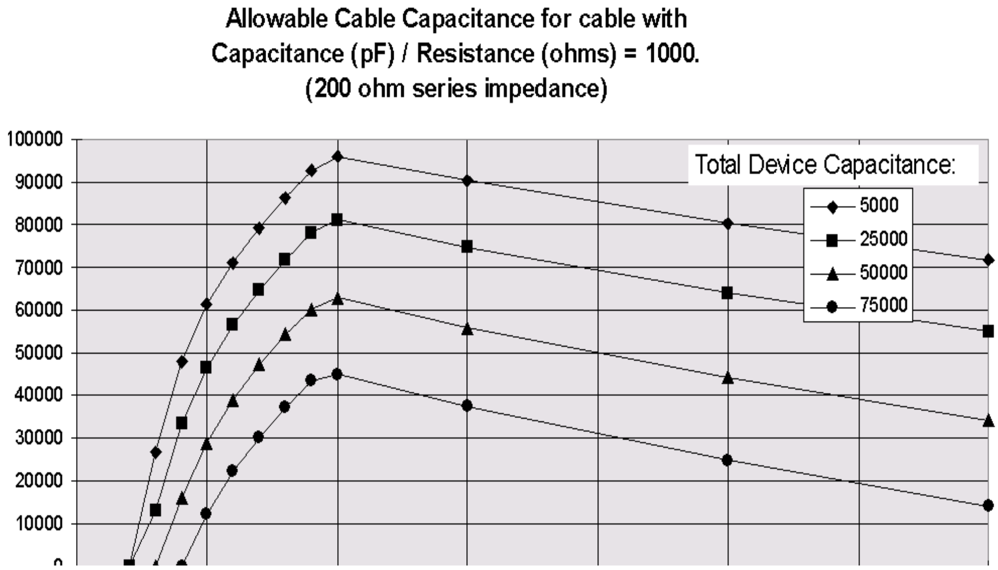

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 1000. (200 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 1000. (impédance en série de 200 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.13 – Capacité de câble pour C_{cbl}/R_{cbl}=1 000, résistance série de 200 Ω

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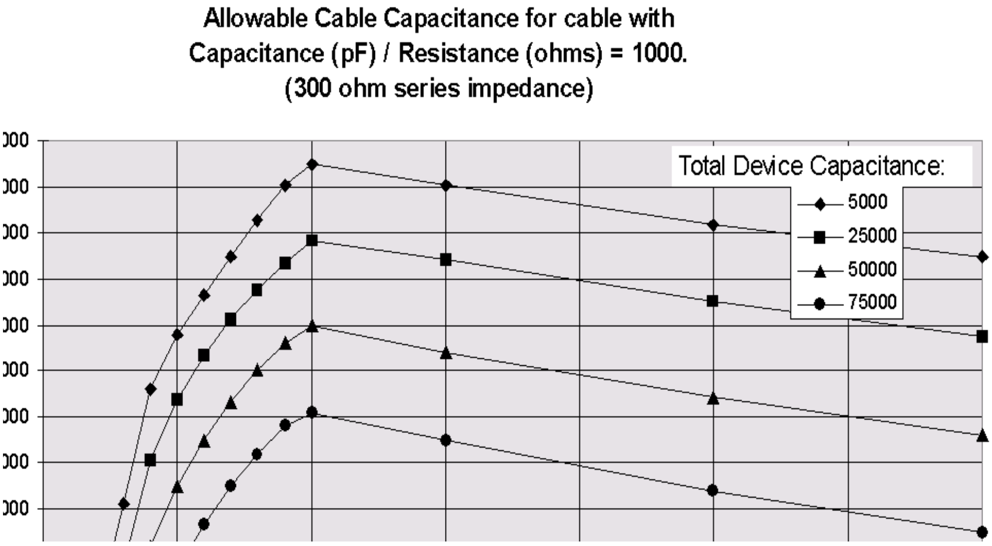

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 1000. (300 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 1000. (impédance en série de 300 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.14 – Capacité de câble pour C_{cbl}/R_{cbl}=1 000, résistance série de 300 Ω

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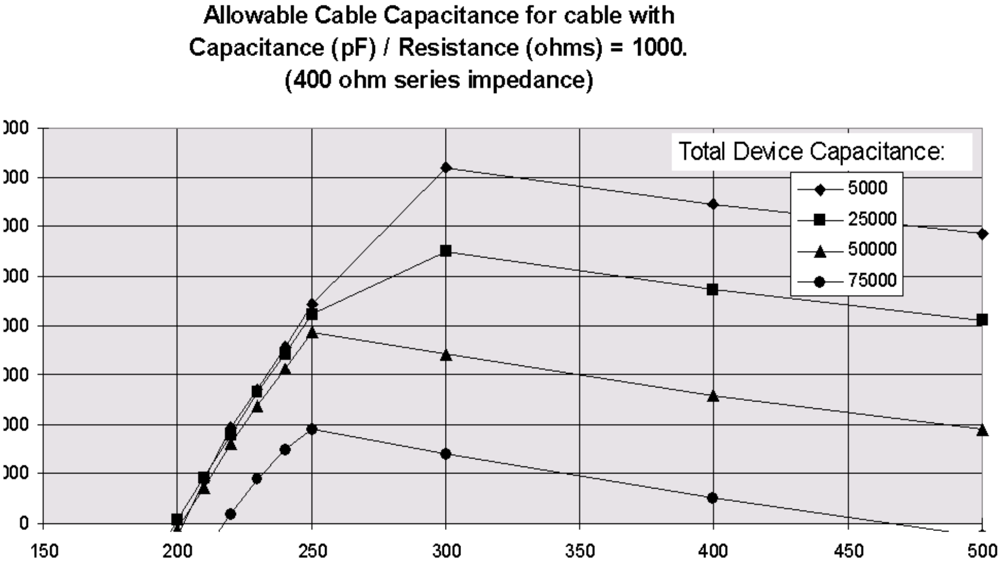

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 1000. (400 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 1000. (impédance en série de 400 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.15 – Capacité de câble pour C_{cbl}/R_{cbl}=1 000, résistance série de 400 Ω

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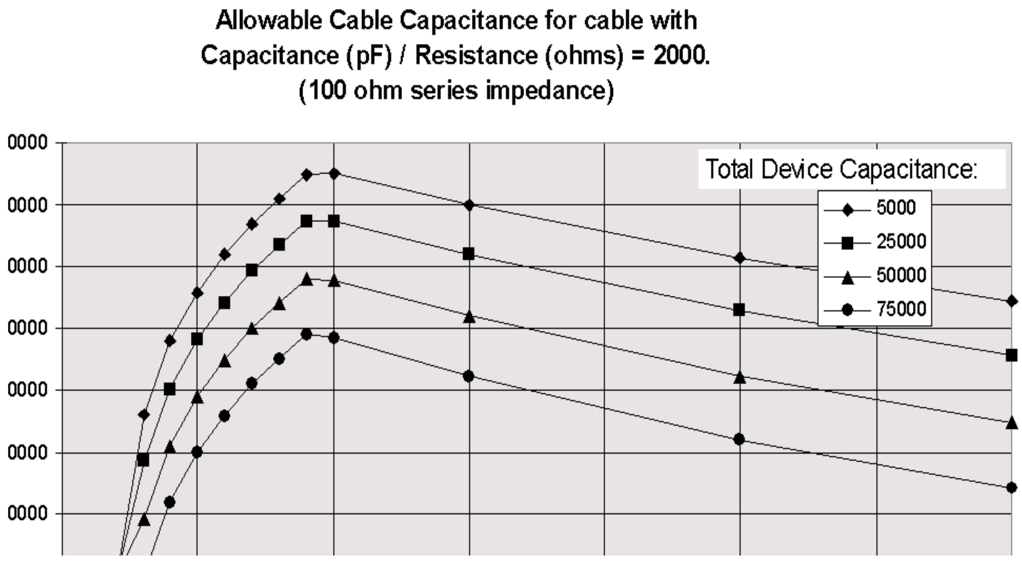

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 2000. (100 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 2000. (impédance en série de 100 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.16 – Capacité de câble pour C_{cbl}/R_{cbl}=2 000, résistance série de 100 Ω

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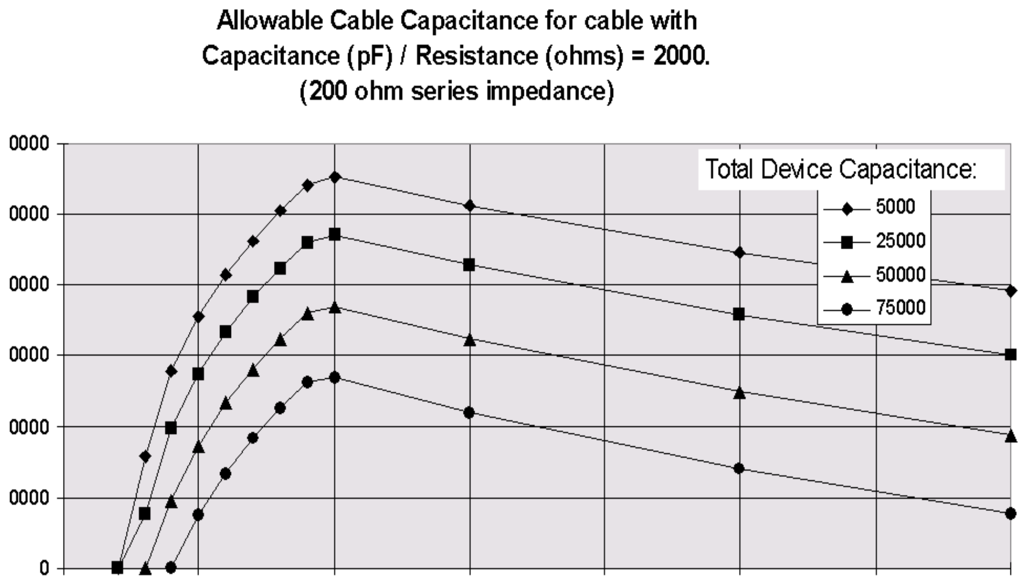

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Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 2000. (200 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 2000. (impédance en série de 200 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.17 – Capacité de câble pour C_{cbl}/R_{cbl}=2 000, résistance série de 200 Ω

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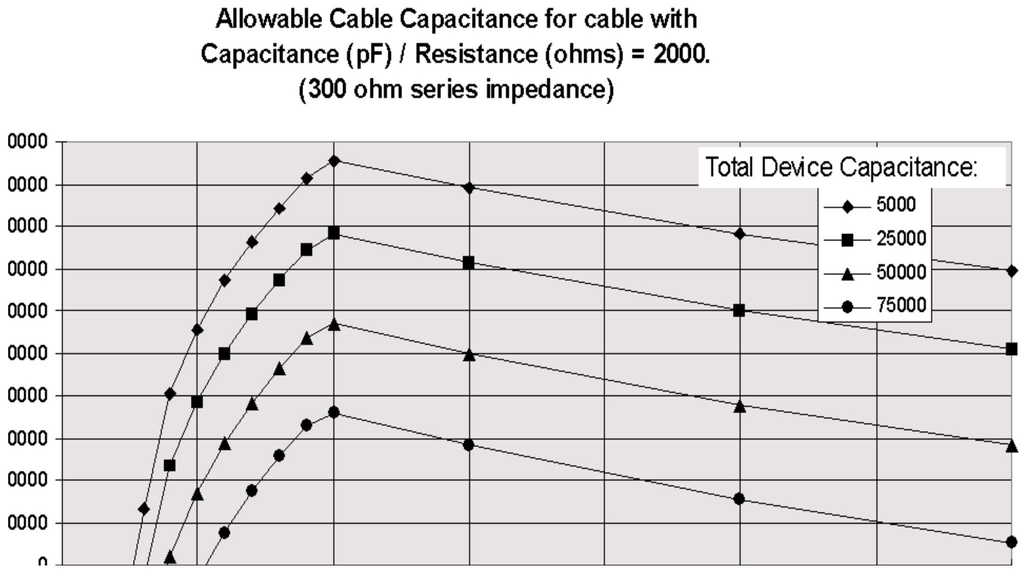

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Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 2000. (300 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 2000. (impédance en série de 300 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.18 – Capacité de câble pour C_{cbl}/R_{cbl}=2 000, résistance série de 300 Ω

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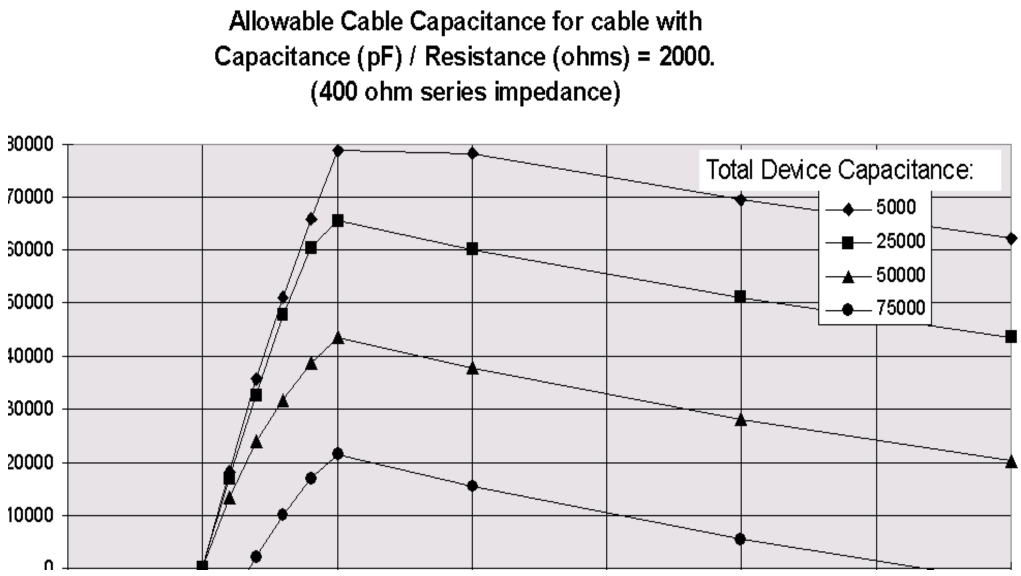

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 2000. (400 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 2000. (impédance en série de 400 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.19 – Capacité de câble pour C_{cbl}/R_{cbl}=2 000, résistance série de 400 Ω

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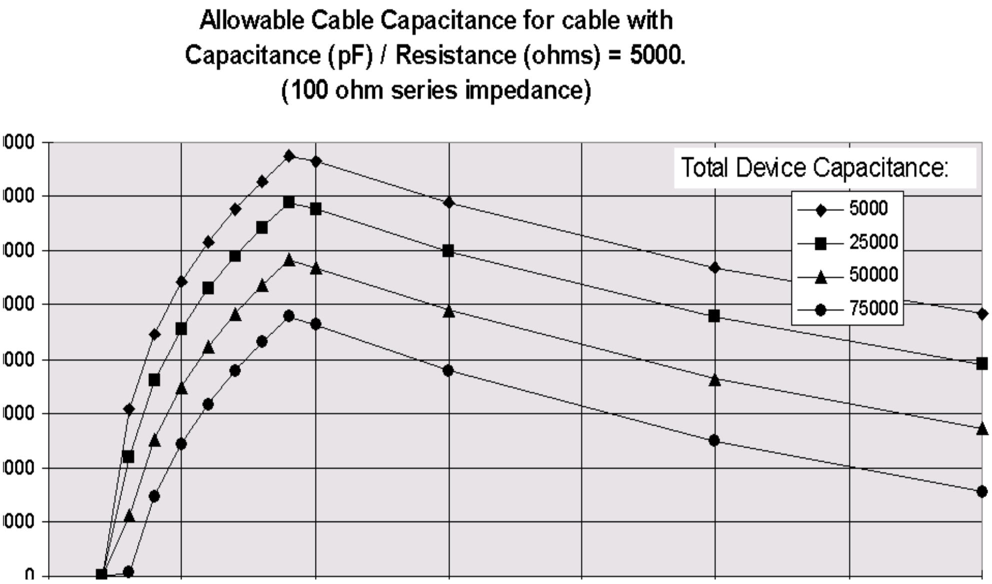

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 5000. (100 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 5000. (impédance en série de 100 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.20 – Capacité de câble pour C_{cbl}/R_{cbl}=5000, résistance série de 100 Ω

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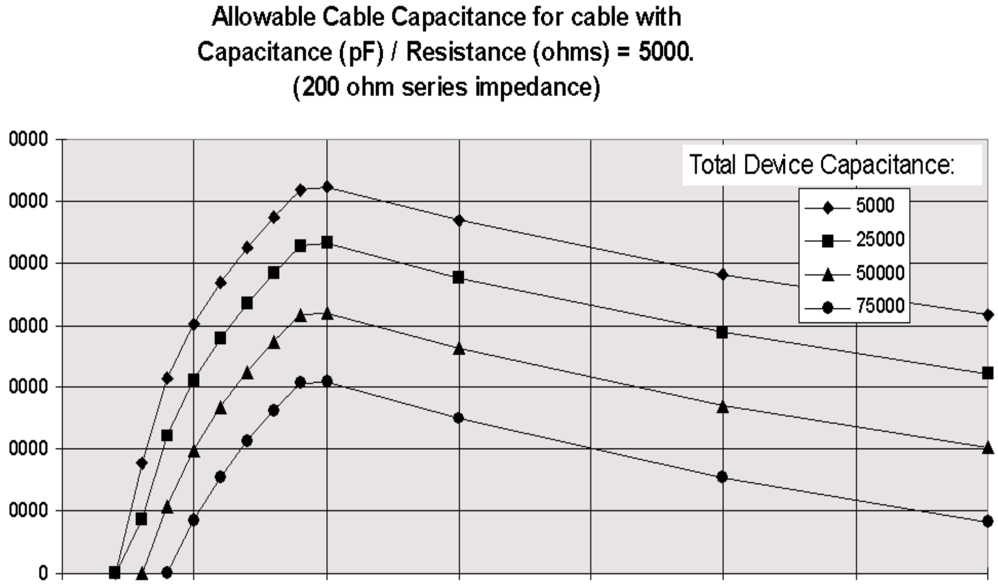

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 5000. (200 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 5000. (impédance en série de 200 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.21 – Capacité de câble pour C_{cbl}/R_{cbl}=5 000, résistance série de 200 Ω

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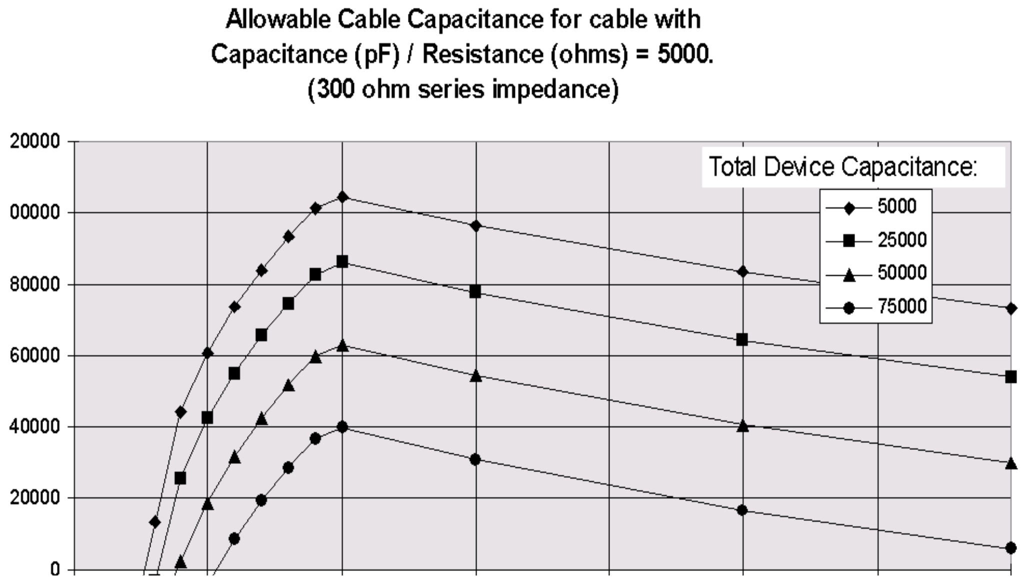

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 5000. (300 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 5000. (impédance en série de 300 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.22 – Capacité de câble pour C_{cbl}/R_{cbl}=5 000, résistance série de 300 Ω

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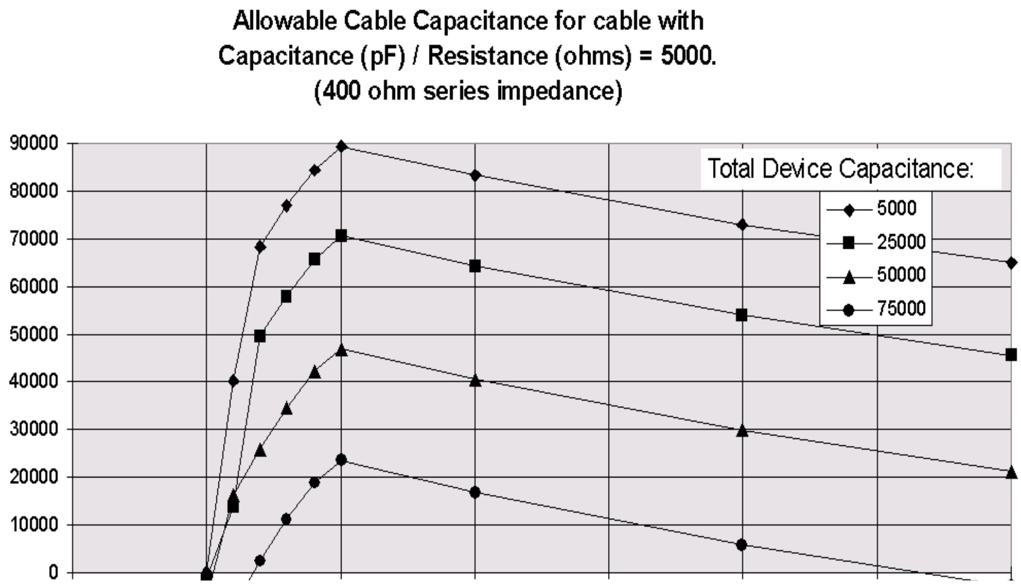

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 5000. (400 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 5000. (impédance en série de 400 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.23 – Capacité de câble pour C_{cbl}/R_{cbl}=5 000, résistance série de 400 Ω

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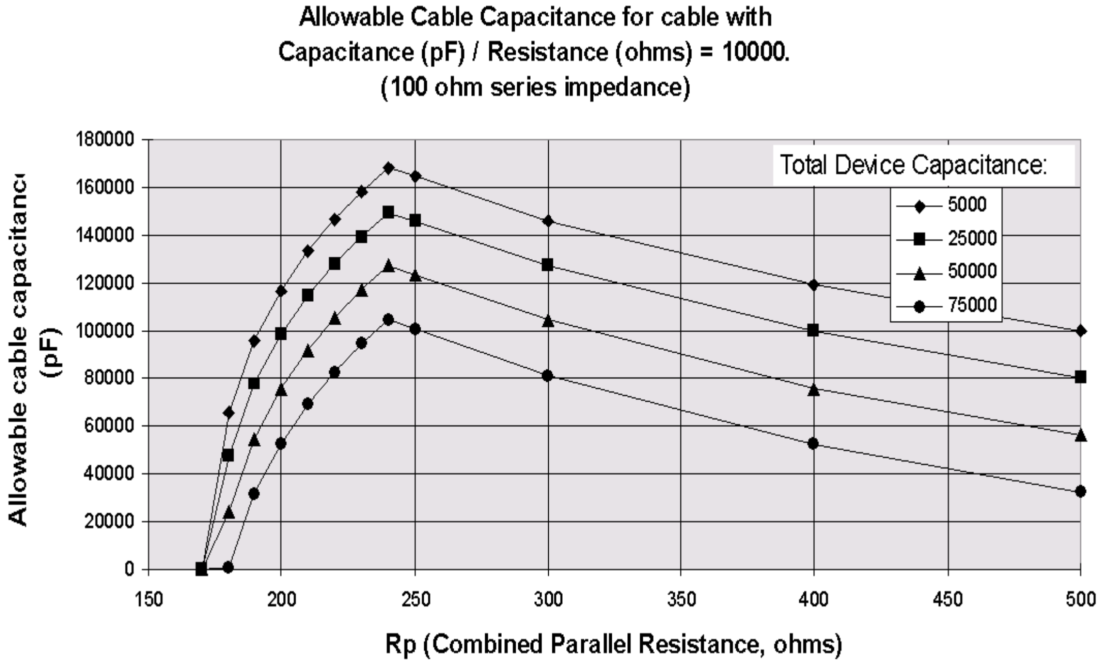

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 10 000. (100 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 10 000. (impédance en série de 100 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.24 – Capacité de câble pour C_{cbl}/R_{cbl}=10 000, résistance série de 100 Ω

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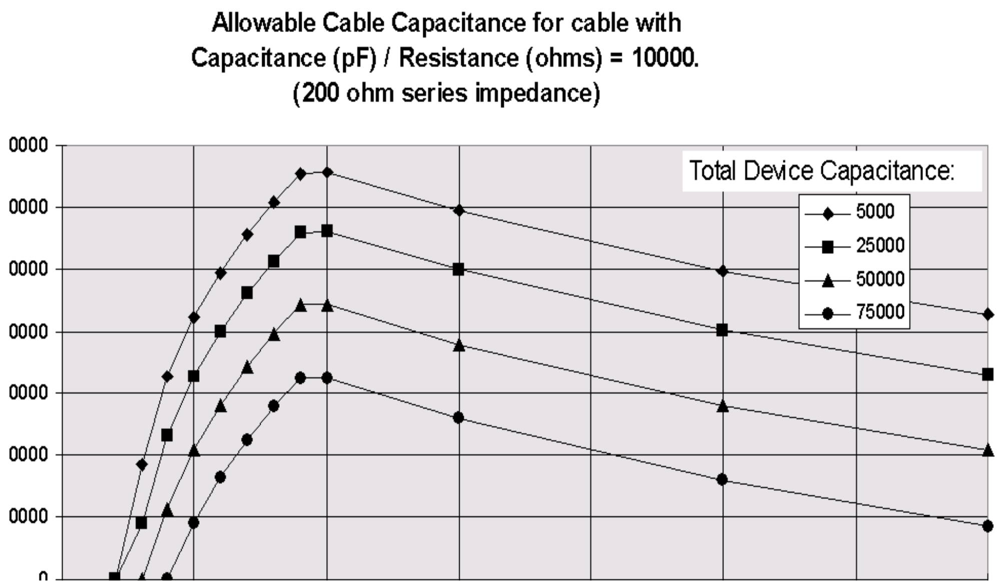

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 10 000. (200 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 10 000. (impédance en série de 200 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.25 – Capacité de câble pour C_{cbl}/R_{cbl}=10 000, résistance série de 200 Ω

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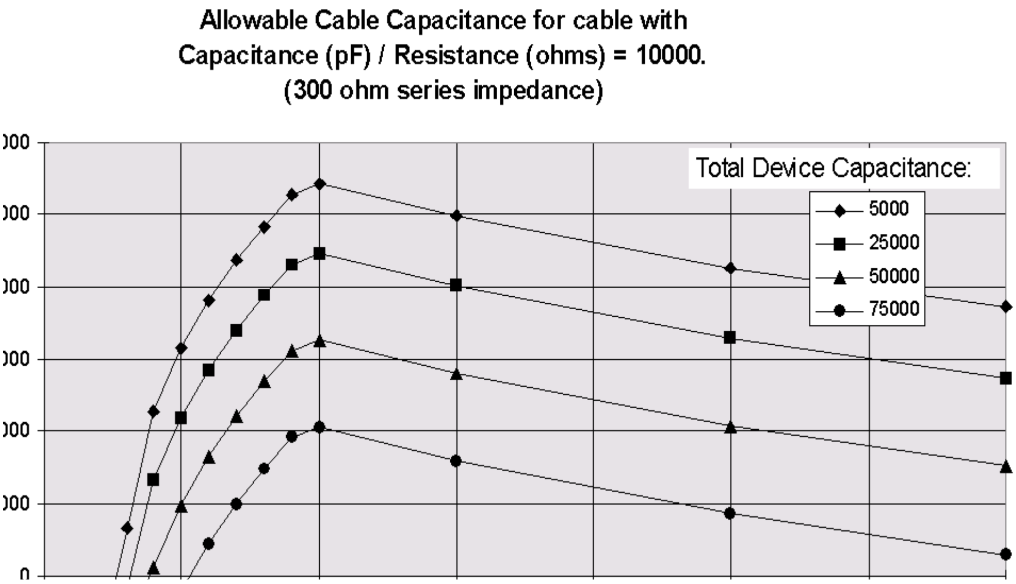

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 10 000. (300 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 10 000. (impédance en série de 300 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.26 – Capacité de câble pour C_{cbl}/R_{cbl}=10 000, résistance série de 300 Ω

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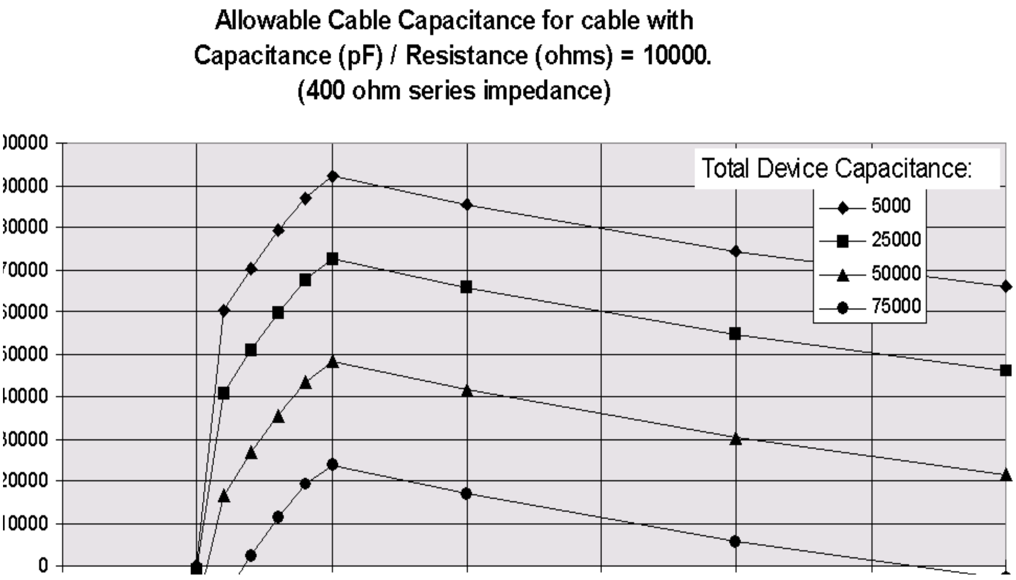

Légende

Anglais	Français
Allowable Cable Capacitance for cable with Capacitance (pF) / Resistance (ohms) = 10 000. (400 ohm series impedance)	Capacité du câble admissible pour une Capacité (pF) / Résistance (ohms) = 10 000. (impédance en série de 400 ohm)
Allowable cable capacitance	Capacité du câble admissible
Total Device Capacitance	Capacité totale de l'appareil
Rp (Combined Parallel Resistance, ohms)	Rp (Résistance parallèle combinée)

Figure T.27 – Capacité de câble pour C_{cbl}/R_{cbl}=10 000, résistance série de 400 Ω

T.2.2.3 Exemple de calcul de longueurs de câbles

T.2.2.3.1 Exemple 1

Le réseau présente:

- Un appareil unique avec une capacité C_{dev} = 5 000 pF,
- Une résistance d'appareil parallèle $\sum R_{dev}$ = 250 Ω,
- Une capacité de câble C_{cbl} = 150 pF/m,
- Une résistance de câble R_{cbl} = 0,05 Ω /m
  NOTE Cette valeur est identique à celle d'un fil 22 AWG.

Utiliser la Figure T.7 pour interpoler C_{cbl} = 150 pF/unité de longueur. La longueur de câble maximale est de 1 200 m.

T.2.2.3.2 Exemple 2

Le réseau présente:

- Trois appareils avec une capacité C_{dev} = 5 000 pF, 10 000 pF et 10 000 pF,
- Ces trois appareils chacun avec une résistance $\sum R_{dev}$ = 100 Ω,
- Un appareil à faible impédance où R_{dev} = 250 Ω,
- Pas d'appareil série,

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- Une capacité de câble C_{cbl} = 400 pF/m, et
- Une résistance de câble R_{cbl} = 0,0368 Ω/m (fil de 0,800 mm).

Par conséquent, les paramètres calculés sont les suivants:

- Capacité d'appareil parallèle $\sum C_{dev}$ = 5 000 + 10 000 + 10 000 = 25 000 pF,
- Résistance d'appareil parallèle $\sum R_{dev}$ = 250 Ω,
- Impédance série R_{ser} = 0,
- Câble C_{cbl}/R_{cbl} = 400 / 0,0368 = 10 869.

Le rapport capacité/résistance du câble est arrondi à la valeur la plus proche de 10 000. A l'aide de la Figure T.11, la capacité de câble admissible est de 200 000 pF. La longueur de câble maximale est calculée en divisant la capacité de câble admissible par la capacité par unité de longueur du câble. Dans cet exemple, la longueur de câble maximale admissible est de (200 000 pF) / (400 pF/m) = 500 m.

T.2.2.3.3 Exemple 3

Le réseau présente:

- Trois appareils avec une capacité C_{dev} = 5 000 pF, 10 000 pF et 10 000 pF,
- Ces trois appareils chacun avec une résistance $\sum R_{dev}$ = 100 Ω,
- Un appareil à faible impédance où R_{dev} = 250 Ω,
- Un appareil série avec une résistance de 100 Ω
- Une capacité de câble C_{cbl} = 400 pF/m et
- Une résistance de câble R_{cbl} = 0,0368 Ω/m (fil de 0,800 mm).

Ainsi, le réseau est le même qu'en T.2.2.3.2, à l'exception du fait qu'un appareil série a été ajouté. Par conséquent, les paramètres calculés sont les suivants:

- Capacité d'appareil parallèle $\sum C_{dev}$ = 5 000 + 10 000 + 10 000 = 25 000 pF,
- Résistance d'appareil parallèle $\sum R_{dev}$ = 250 Ω,
- Impédance série R_{ser} = 100 Ω,
- Câble C_{cbl}/R_{cbl} = 400 / 0,0368 = 10 869.

Le rapport capacité/résistance du câble est arrondi à la valeur la plus proche de 10 000. A l'aide de la Figure T.24, la capacité de câble admissible est de 145 000 pF. La longueur de câble maximale est calculée en divisant la capacité de câble admissible par la capacité par unité de longueur du câble. Dans cet exemple, la longueur de câble maximale admissible est de (145 000 pF) / (400 pF/m) = 362,5 m.

T.2.3 Longueur de câble à paire multiple

Si un câble à paire multiple est utilisé avec un câble à paire simple pour former un réseau, la longueur totale du câble dans ce réseau est déterminée comme la plus petite des valeurs suivantes:

1) 1 500 m,
2) La longueur telle que déterminée à l'aide de la procédure de T.2.2.2 pour un câble à paire simple et
3) La longueur telle que déterminée à l'aide de la procédure de T.2.2.2 pour un câble à paire simple utilisant la plus haute valeur de résistance parallèle du réseau pour tous les réseaux utilisant les autres câbles dans le câble à paire multiple

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T.3 Distribution de l'alimentation par l'intermédiaire de barrières

L'alimentation électrique du réseau est habituellement située au niveau de l'appareil d'entrée courant et peut être branchée comme illustré à la Figure T.28. Celle-ci représente des configurations sans barrière (Figure T.28 a)), avec deux barrières (Figure T.28 b)) et une barrière (Figure T.28 c)).

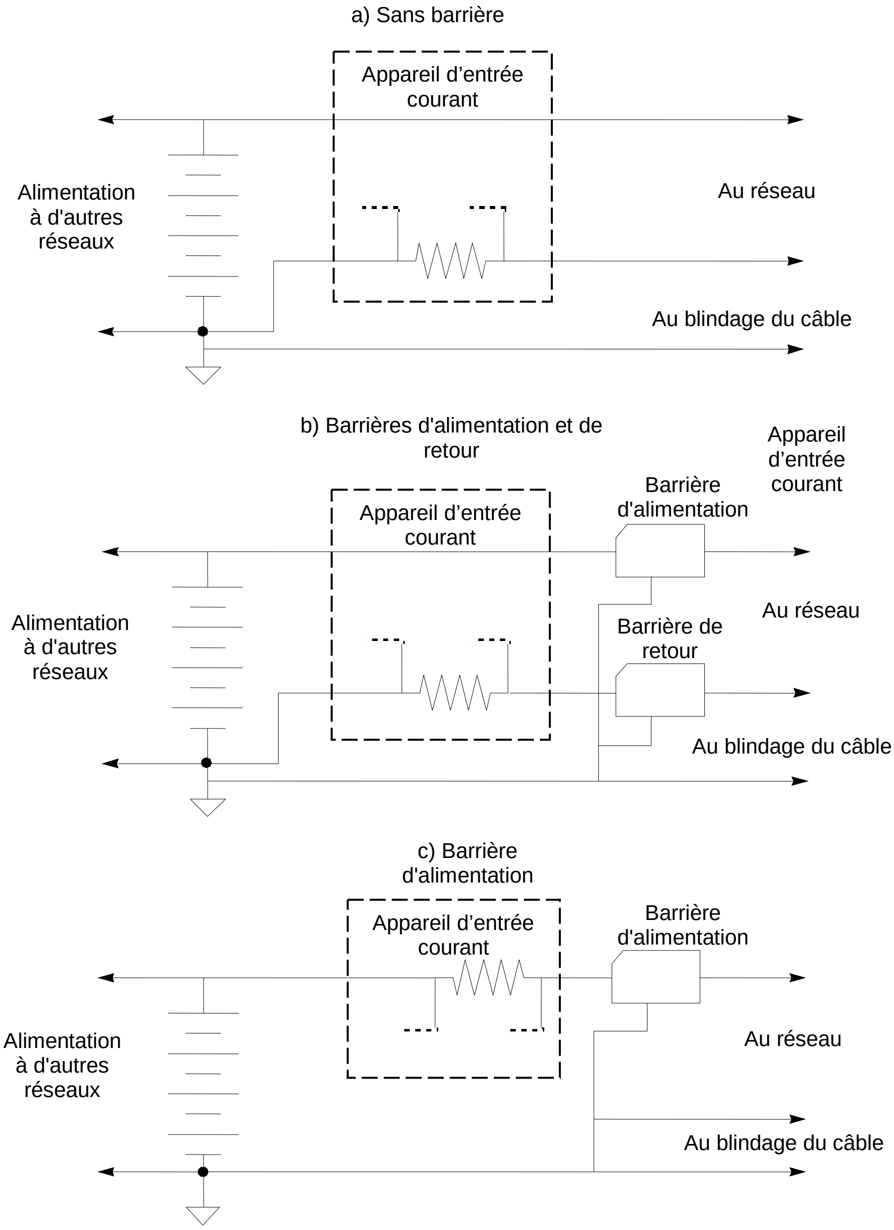

Figure T.28 – Connexions d'alimentation réseau

Si aucune alimentation réseau n'est utilisée, il convient de la remplacer par un réseau d'impédance ne dépassant pas l'impédance d'alimentation électrique autorisée spécifiée en 34.10.1. Une alimentation réseau unique peut alimenter plusieurs réseaux, à condition qu'elle soit connectée à plusieurs réseaux comme illustré à la Figure T.28.

Un appareil devant être alimenté par des sources autres que le réseau peut l'être par des paires torsadées dans le même câble à paire multiple qui porte les paires de signaux, à condition que la variation de consommation de courant de ces appareils se situe dans la limite spécifiée en 34.7.2.

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T.4 Blindage et mise à la terre

La présente annexe représente les schémas de mise à la terre préférentiels. Il convient que le blindage du câble soit mis à la terre en un seul point. Cela est habituellement effectué dans la salle de commande au niveau ou à proximité de la source d'alimentation de la boucle. Cependant, la connexion à la terre peut également avoir lieu dans un boîtier de raccordement ou à un autre emplacement adapté dans la zone de terrain. Il faut veiller à éviter une connexion accidentelle entre des objets métalliques mis à la terre et le blindage.

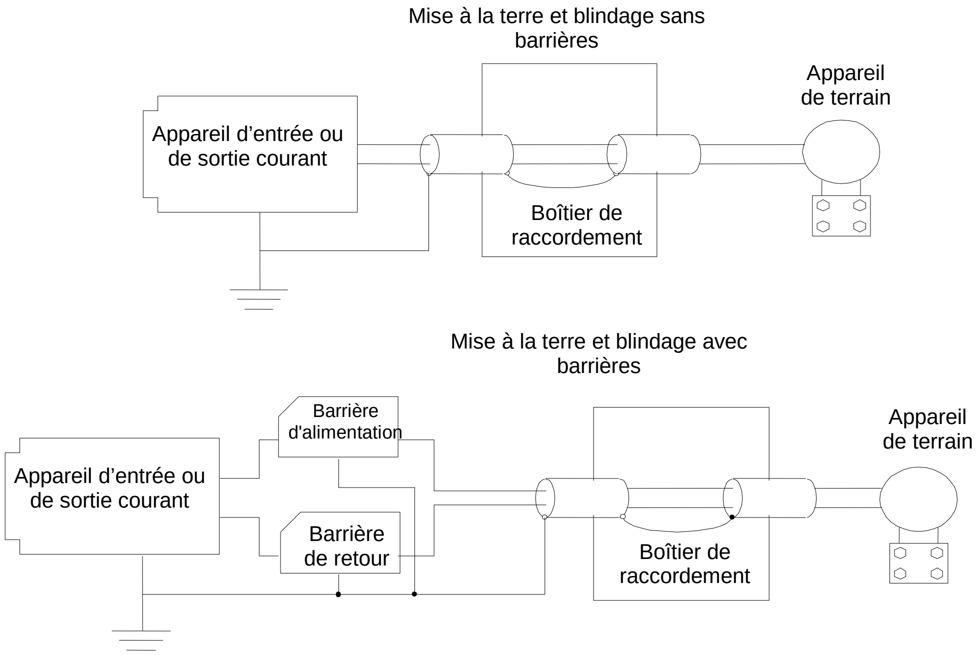

Figure T.29 – Mise à la terre et blindage

Il convient que plusieurs réseaux partageant une connexion commune soient mis à la terre au niveau du maître principal ou du contrôleur analogique correspondant.

Un blindage de câble est habituellement laissé ouvert (non connecté) au niveau d'un appareil de terrain. Autrement, le blindage peut être connecté au boîtier de l'appareil de terrain ou au blindage interne entourant les circuits de l'appareil, dans l'une des conditions suivantes:

a) le boîtier de l'appareil ou le blindage interne est isolé de la terre, ou

b) la connexion du blindage à la terre est le seul point dans le réseau auquel le blindage est mis à la terre.

Pour les raccordements qui ne sont pas situés au niveau d'un élément de signalisation, les blindages de tous les câbles acheminés au raccordement sont habituellement connectés. Pour entourer autrement le câblage exposé, les blindages de câbles peuvent être connectés aux boîtiers de raccordement et aux panneaux de câblage, si les boîtiers de raccordement ou les panneaux sont isolés de la terre ou si la connexion à la terre est le seul point auquel le blindage du réseau est mis à la terre.

D'autres dispositions en matière de mise à la terre et de blindage peuvent être utilisées si le couplage et le brouillage électromagnétique n'interfèrent pas avec la signalisation numérique.

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Bibliographie

NOTE 1 Toutes les parties de la série CEI 61158, ainsi que la CEI 61784-1 et la CEI 61784-2 font l'objet d'une maintenance simultanée. Les références croisées à ces documents dans le texte se rapportent par conséquent aux éditions datées dans la présente bibliographie.

NOTE 2 Une liste des documents pertinents publiés par des consortiums associés à l'élaboration de certaines des normes de bus de terrain de la série CEI 61158 est fournie dans la bibliographie de la CEI 61158-1.

CEI 60079-0, *Atmosphères explosives – Partie 0: Matériel – Exigences générales*

CEI 60227-5, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension assignée au plus égale à 450/750 V – Partie 5: Câbles souples*

CEI 60875-1, *Dispositifs d'interconnexion et composants passifs à fibres optiques – Dispositifs de couplage pour fibres optiques ne dépendant pas de la longueur d'onde – Partie 1: Spécification générique*

CEI 60947-5-2, *Appareillage à basse tension – Partie 5-2: Appareils et éléments de commutation pour circuits de commande – Détecteurs de proximité*

CEI 61158 (toutes les parties), *Réseaux de communication industriels – Spécifications des bus de terrain*

CEI 61158-1:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 1: Présentation et lignes directrices des séries CEI 61158 et CEI 61784*

CEI 61158-4-1:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-1: Spécification du protocole de la couche liaison de données – Éléments de type 1*

CEI 61158-4-4:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-4: Spécification du protocole de la couche liaison de données – Éléments de type 4*

CEI 61158-4-7:2007, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-7: Spécification du protocole de la couche liaison de données – Éléments de type 7*

CEI 61158-4-8:2007, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-8: Spécification du protocole de la couche liaison de données – Éléments de type 8*

CEI 61158-4-12:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-12: Spécification du protocole de la couche liaison de données – Éléments de type 12*

CEI 61158-4-16:2007, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-16: Spécification du protocole de la couche liaison de données – Éléments de type 16*

CEI 61158-4-18:2010, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-18: Spécification du protocole de la couche liaison de données – Éléments de type 18*

CEI 61158-4-20:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-18: Spécification du protocole de la couche liaison de données – Éléments de type 20*

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CEI 61158-4-24:2014, *Réseaux de communication industriels – Spécifications des bus de terrain – Partie 4-18: Spécification du protocole de la couche liaison de données – Éléments de type 24*

CEI 61300-3-4, *Dispositifs d'interconnexion et composants passifs à fibres optiques – Méthodes fondamentales d'essais et de mesures – Partie 3-4: Examens et mesures – Affaiblissement*

CEI/TR 61491, *Equipement électrique des machines industrielles – Liaison des données sérielles pour communications en temps réel entre unités de commande et dispositifs d'entraînement*

CEI 61596, *Noyaux EP en oxydes magnétiques et pièces associées utilisés dans les inductances et transformateurs – Dimensions*

CEI 61784-1, *Réseaux de communication industriels – Profils – Partie 1: Profils de bus de terrain*

CEI 61784-2, *Réseaux de communication industriels – Profils – Partie 2: Profils de bus de terrain supplémentaires pour les réseaux en temps réel basés sur l'ISO/CEI 8802-3*

ISO/CEI 8886:1996, *Technologies de l'information – Interconnexion de systèmes ouverts (OSI) – Définition du service de liaison de données*

ISO/CEI 10022:1996, *Technologies de l'information – Interconnexion de systèmes ouverts (OSI) – Définition du service physique*

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IEEE Std 100, *The IEEE Standard Dictionary of Electrical and Electronics Terms*

PTB-Mitteilungen, 113 Jahrgang, Heft 2/2003, *Die Bewertung der Zündfähigkeit eigensicherer Stromkreise anhand eines Rechenverfahrens*

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