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Industrial communication networks – Fieldbus specifications – Part 4-16: Data-link layer protocol specification – Type 16 elements

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-16: Data-link layer protocol specification – Type 16 elements

FOREWORD

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NOTE Use of some of the associated protocol types is restricted by their intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in Type combinations as specified explicitly in the IEC 61784 series. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

International Standard IEC 61158-4-16 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This first edition and its companion parts of the IEC 61158-4 subseries cancel and replace IEC 61158-4:2003. This edition of this part constitutes a technical addition. This publication, together with its companion parts for Type 16, also partially replaces IEC 61491:2002 which is at present being revised. IEC 61491 will be issued as a technical report.

This edition of IEC 61158-4 includes the following significant changes from the previous edition:

a) deletion of the former Type 6 fieldbus, and the placeholder for a Type 5 fieldbus data link layer, for lack of market relevance;

b) addition of new types of fieldbuses;

c) division of this part into multiple parts numbered -4-1, -4-2, …, -4-19.

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

FDIS	Report on voting
65C/474/FDIS	65C/485/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.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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:

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

NOTE The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

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

INTRODUCTION

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/TR 61158-1.

The data-link protocol provides the data-link service by making use of the services available from the physical layer. 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 data-link entities (DLEs) at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

a) as a guide for implementors and designers;

b) for use in the testing and procurement of equipment;

c) as part of an agreement for the admittance of systems into the open systems environment;

d) as a refinement to the understanding of time-critical communications within OSI.

This standard is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this standard together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-16: Data-link layer protocol specification – Type 16 elements

1 Scope

1.1 General

The data-link layer provides basic time-critical messaging communications between devices in an automation environment.

This protocol provides communication opportunities to all participating data-link entities

a) in a synchronously-starting cyclic manner, according to a pre-established schedule, and
b) in a cyclic or acyclic asynchronous manner, as requested each cycle by each of those data-link entities.

Thus this protocol can be characterized as one which provides cyclic and acyclic access asynchronously but with a synchronous restart of each cycle.

1.2 Specifications

This standard specifies

a) procedures for the timely transfer of data and control information from one data-link user entity to a peer user entity, and among the data-link entities forming the distributed data-link service provider;
b) the structure of the fieldbus DLPDUs used for the transfer of data and control information by the protocol of this standard, and their representation as physical interface data units.

1.3 Procedures

The procedures are defined in terms of

a) the interactions between peer DL-entities (DLEs) through the exchange of fieldbus DLPDUs;
b) the interactions between a DL-service (DLS) provider and a DLS-user in the same system through the exchange of DLS primitives;
c) the interactions between a DLS-provider and a Ph-service provider in the same system through the exchange of Ph-service primitives.

1.4 Applicability

These procedures are applicable to instances of communication between systems which support time-critical communications services within the data-link layer of the OSI or fieldbus reference models, and which require the ability to interconnect in an open systems interconnection environment.

Profiles provide a simple multi-attribute means of summarizing an implementation's capabilities, and thus its applicability to various time-critical communications needs.

1.5 Conformance

This standard also specifies conformance requirements for systems implementing these procedures. This part of this standard does not contain tests to demonstrate compliance with such requirements.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61158-2 (Ed.4.0), *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-3-16, *Industrial communication networks – Fieldbus specifications - Part 3-16: Data-link layer service definition – Type 16 elements*

IEC 61800-7-20x (all subparts), *Adjustable speed electrical power drive systems – Part 7-20x: Generic interface and use of profiles for power drive systems – Profile type x specification*[1]

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

ISO/IEC 7498-3, *Information technology – Open Systems Interconnection – Part 3: Basic Reference Model: Naming and addressing*

ISO/IEC 10731, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

ISO/IEC 13239, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures*

ITU X.25, *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit*

3 Terms, definitions, symbols, abbreviations and conventions

For the purposes of this document, the following terms, definitions, symbols, abbreviations and conventions apply.

3.1 Reference model terms and definitions

This standard is based in part on the concepts developed in ISO/IEC 7498-1 and ISO/IEC 7498-3, and makes use of the following terms defined therein:

3.1.1 DL-address [7498-3]

3.1.2 DL-address-mapping [7498-1]

3.1.3 called-DL-address [7498-3]

3.1.4 calling-DL-address [7498-3]

3.1.5 centralized multi-end-point-connection [7498-1]

3.1.6 DL-connection [7498-1]

3.1.7 DL-connection-end-point [7498-1]

[1] At present, these subparts are IEC 61800-7-201, 7-202, 7-203 and 7-204.

3.1.8 DL-connection-end-point-identifier [7498-1]

3.1.9 DL-connection-mode transmission [7498-1]

3.1.10 DL-connectionless-mode transmission [7498-1]

3.1.11 correspondent (N)-entities [7498-1]
correspondent DL-entities (N=2)
correspondent Ph-entities (N=1)

3.1.12 DL-duplex-transmission [7498-1]

3.1.13 (N)-entity [7498-1]
DL-entity (N=2)
Ph-entity (N=1)

3.1.14 DL-facility [7498-1]

3.1.15 flow control [7498-1]

3.1.16 (N)-layer [7498-1]
DL-layer (N=2)
Ph-layer (N=1)

3.1.17 layer-management [7498-1]

3.1.18 DL-local-view [7498-3]

3.1.19 DL-name [7498-3]

3.1.20 naming-(addressing)-domain [7498-3]

3.1.21 peer-entities [7498-1]

3.1.22 primitive name [7498-3]

3.1.23 DL-protocol [7498-1]

3.1.24 DL-protocol-connection-identifier [7498-1]

3.1.25 DL-protocol-data-unit [7498-1]

3.1.26 DL-relay [7498-1]

3.1.27 reset [7498-1]

3.1.28 responding-DL-address [7498-3]

3.1.29 routing [7498-1]

3.1.30 segmenting [7498-1]

3.1.31 (N)-service [7498-1]
DL-service (N=2)
Ph-service (N=1)

3.1.32 (N)-service-access-point [7498-1]
DL-service-access-point (N=2)
Ph-service-access-point (N=1)

3.1.33 DL-service-access-point-address [7498-3]

3.1.34 DL-service-connection-identifier [7498-1]

3.1.35 DL-service-data-unit [7498-1]

3.1.36 DL-simplex-transmission [7498-1]

3.1.37 DL-subsystem [7498-1]

3.1.38 systems-management [7498-1]

3.1.39 DL-user-data [7498-1]

3.2 Service convention terms and definitions

This standard also makes use of the following terms defined in ISO/IEC 10731 as they apply to the data-link layer:

3.2.1 acceptor

3.2.2 asymmetrical service

3.2.3 confirm (primitive);
requestor.deliver (primitive)

3.2.4 deliver (primitive)

3.2.5 DL-confirmed-facility

3.2.6 DL-facility

3.2.7 DL-local-view

3.2.8 DL-mandatory-facility

3.2.9 DL-non-confirmed-facility

3.2.10 DL-provider-initiated-facility

3.2.11 DL-provider-optional-facility

3.2.12 DL-service-primitive;
primitive

3.2.13 DL-service-provider

3.2.14 DL-service-user

3.2.15 DL-user-optional-facility

3.2.16 indication (primitive);
acceptor.deliver (primitive)

3.2.17 multi-peer

3.2.18 request (primitive);
requestor.submit (primitive)

3.2.19 requestor

3.2.20 response (primitive);
acceptor.submit (primitive)

3.2.21 submit (primitive)

3.2.22 symmetrical service

3.3 Other terms and definitions

3.3.1
acknowledge telegram (AT)
telegram, in which each slave inserts its data

3.3.2
broadcast
transmission to all devices in a network without any acknowledgment by the receivers

3.3.3
communication cycle
fixed time period between two master synchronization telegrams in which real-time telegrams are transmitted in the RT channel and non real-time telegrams are transmitted in the IP channel

3.3.4
control unit
control device (e.g., a PLC as specified in the IEC 61131 standard family)

3.3.5
control word
two adjacent octets inside the master data telegram containing commands for the addressed device

3.3.6
cycle time
duration of a communication cycle

3.3.7
cyclic communication
periodic exchange of telegrams

3.3.8
cyclic data
part of a telegram, which does not change its meaning during cyclic operation of the network

3.3.9
cyclic operation
operation in which devices in the communication network are addressed and queried one after the other at fixed, constant time intervals

3.3.10
data exchange
demand dependent, non cyclic transmission (service channel), whereas transmission of information occurs upon master request

3.3.11
delimiter, telegram delimiter
beginning and ending identifiers of a telegram (eight bits: 01111110_B)

3.3.12
device
a slave in the communication network, (e.g., a power drive system as defined in the IEC 61800 standard family, I/O stations as defined in the IEC 61131 standard family)

3.3.13
device address field
address field (eight bits) containing the address of the device

3.3.14
device status
four adjacent octets inside the acknowledge telegram containing status information for each device

3.3.15
DLE station identifier
network address assigned to a DLE

3.3.16
DLE station slot
unit (granularity of one) of position dependent mapping (for cyclic data field) of which a DLE may occupy one or more, delineated by the range beginning at the DLE station identifier with a length equal to the configured number of occupied slots

3.3.17
DL-segment, link, local link
single DL-subnetwork in which any of the connected DLEs may communicate directly, without any intervening DL-relaying, whenever all of those DLEs that are participating in an instance of communication are simultaneously attentive to the DL-subnetwork during the period(s) of attempted communication

3.3.18
DLSAP
distinctive point at which DL-services are provided by a single DL-entity to a single higher-layer entity

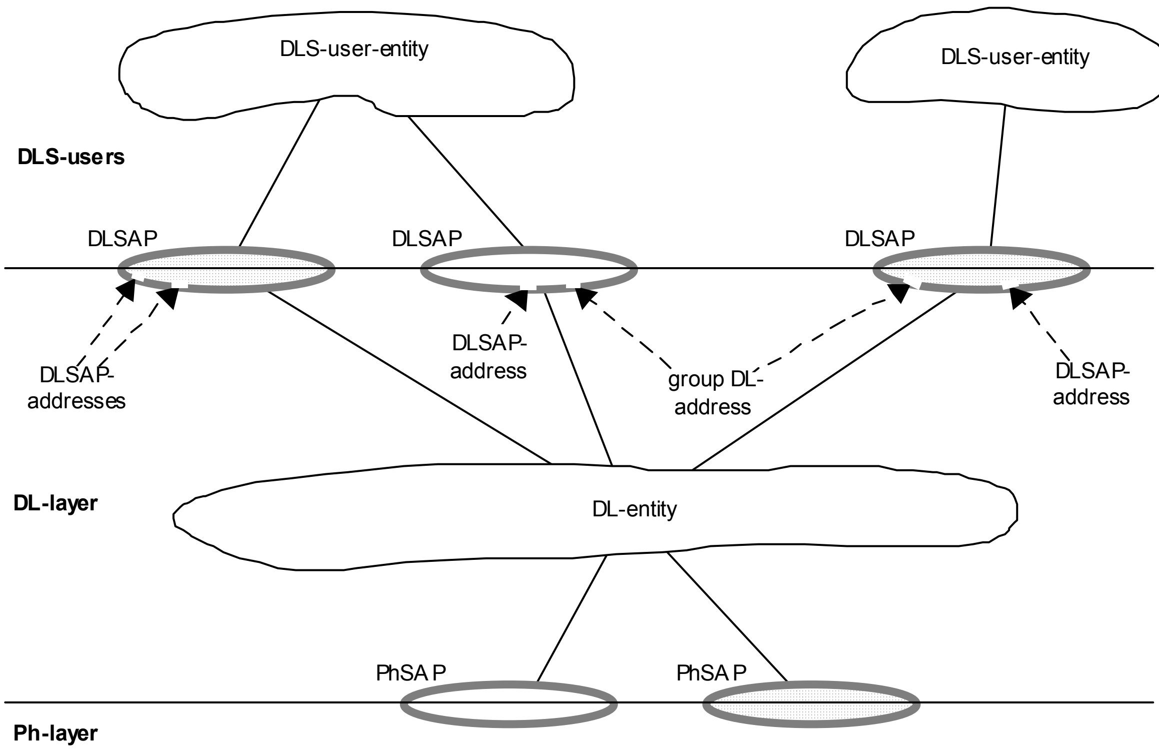
NOTE This definition, derived from ISO/IEC 7498-1, is repeated here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses.

3.3.19
DL(SAP)-address
either an individual DLSAP-address, designating a single DLSAP of a single DLS-user, or a group DL-address potentially designating multiple DLSAPs, each of a single DLS-user

NOTE This terminology is chosen because ISO/IEC 7498-3 does not permit the use of the term DLSAP-address to designate more than a single DLSAP at a single DLS-user.

3.3.20
(individual) DLSAP-address
DL-address that designates only one DLSAP within the extended link

NOTE A single DL-entity may have multiple DLSAP-addresses associated with a single DLSAP. (See Figure 1.)



NOTE 1 DLSAPs and PhSAPs are depicted as ovals spanning the boundary between two adjacent layers.

NOTE 2 DL-addresses are depicted as designating small gaps (points of access) in the DLL portion of a DLSAP.

NOTE 3 A single DL-entity may have multiple DLSAP-addresses and group DL-addresses associated with a single DLSAP.

Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses

3.3.21
element
part of IDNs – each IDN has 7 elements, whereas each one has a specific meaning (e.g., number, name, data)

3.3.22
extended link
DL-subnetwork, consisting of the maximal set of links interconnected by DL-relays, sharing a single DL-name (DL-address) space, in which any of the connected DL-entities may communicate, one with another, either directly or with the assistance of one or more of those intervening DL-relay entities

NOTE An extended link may be composed of just a single link.

3.3.23
frame
denigrated synonym for DLPDU

3.3.24
frame check sequence (FCS)
check character sequence consists of a given number of bits (e.g., 16, 32) which is generated by means of a cyclic redundancy check (CRC) character polynomial in accordance with ITU-T X.25

3.3.25
group DL-address
DL-address that potentially designates more than one DLSAP within the extended link. A single DL-entity may have multiple group DL-addresses associated with a single DLSAP. A single DL-entity also may have a single group DL-address associated with more than one DLSAP

3.3.26
hot plug
possibility to open the communication network and insert or remove slaves while the network is still in real-time operation

3.3.27
identification number (IDN)
designation of operating data under which a data block is preserved with its attribute, name, unit, minimum and maximum input values, and the data

3.3.28
master
node, which assigns the other nodes (i.e., slaves) the right to transmit

3.3.29
master data telegram (MDT)
telegram, in which the master inserts its data

3.3.30
master DLE
DLE that performs the functions of network master

3.3.31
master synchronization telegram (MST)
telegram, or part of a telegram, in which the master inserts a time synchronization signal

3.3.32
node
single DL-entity as it appears on one local link

3.3.33
PDS enable
command to close the feedback loop(s) of a power drive system

3.3.34
PDS on
command that the power stage of a power drive system can be activated

3.3.35
physical layer
first layer of the ISO-OSI reference model

3.3.36
protocol
convention about the data formats, time sequences, and error correction in the data exchange of communication systems

3.3.37
real-time data
part of the telegram that does not change its meaning during cyclic operation of the interface

3.3.38
receiving DLS-user
DL-service user that acts as a recipient of DL-user-data

NOTE A DL-service user can be concurrently both a sending and receiving DLS-user.

3.3.39
S-0-nnnn
designation of IDNs

3.3.40
sending DLS-user
DL-service user that acts as a source of DL-user-data

3.3.41
service channel (SVC)
non real-time transmission of information upon master request during RT channel

3.3.42
status word
two adjacent octets inside the acknowledge telegram containing status information of a device

3.3.43
slave
node, which is assigned the right to transmit by the master

3.3.44
slave DLE
DLE that performs the functions of network slave

3.3.45
station
node

3.3.46
telegram
DLPDU

3.3.47
topology
physical network architecture with respect to the connection between the stations of the communication system

3.4 Abbreviations

3.4.1 AHS service transport handshake of the device (acknowledge HS)

3.4.2 ASCII American Standard Code for Information Interchange

3.4.3 AT acknowledge telegram

3.4.4 BOF begin of frame

3.4.5 C1D class 1 diagnostic

3.4.6 C2D class 2 diagnostic

3.4.7 C3D class 3 diagnostic

3.4.8 CA procedure command acknowledgment

3.4.9 CC cross communication between participants

3.4.10 CP communication phase

3.4.11 CPS communication phase switching

3.4.12 CRC cyclic redundancy check

3.4.13 DL- Data-link layer (as a prefix)

3.4.14 DLC DL-connection

3.4.15 DLCEP DL-connection-end-point

3.4.16 DLE DL-entity (the local active instance of the data-link layer)

3.4.17 DLL DL-layer

3.4.18 DLPCI DL-protocol-control-information

3.4.19 DLPDU DL-protocol-data-unit

3.4.20 DLM DL-management

3.4.21 DLME DL-management Entity (the local active instance of DL-management)

3.4.22 DLMS DL-management Service

3.4.23 DLS DL-service

3.4.24 DLSAP DL-service-access-point

3.4.25 DLSDU DL-service-data-unit

3.4.26 EOF end of frame

3.4.27 FCS frame check sequence

3.4.28 FIFO First-in first-out (queuing method)

3.4.29 HS service channel handshake (see AHS and MHS)

3.4.30 IDN Identification Number

3.4.31 LSB least significant bit

3.4.32 Mbit/s megabit per second

3.4.33 MDT master data telegram

3.4.34 MDT MST type 19 header in MDT

3.4.35 MHS service transport handshake of the master

3.4.36 MST master synchronization telegram

3.4.37 OSI Open systems interconnection

3.4.38 PDS power drive system (see IEC 61800 standard family)

3.4.39 Ph- Physical layer (as a prefix)

3.4.40 PhE Ph-entity (the local active instance of the physical layer)

3.4.41 PhL Ph-layer

3.4.42 QoS Quality of service

3.4.43 RE Resource element

3.4.44 RTC Real-time channel

3.4.45 SERCOS serial real-time communication system interface

3.4.46 SI Sub Index

3.4.47 SVC Service channel

3.5 Symbols

3.5.1 ADR device address (1 ≤ ADR ≤ 254) adjusted directly on the device e.g., using a selector switch

3.5.2 INFO service channel information

3.5.3 J_{t2} jitter in t_2

3.5.4 J_{tscyc} jitter in t_{Scyc}

3.5.5 MDT0 master data telegram with synchronization data that the slaves evaluates

3.5.6 n_{min} shut-off velocity in the PDS after C1D error

3.5.7 SLKN slave identification parameter, slave arrangement

3.5.8 SVC service channel

3.5.9 t_1 AT transmission starting time

3.5.10 $t_{1.m}$ AT transmission starting time with data record m of slave XX

3.5.11 t_{1min} shortest AT transmission starting time

3.5.12 $t_{1min.m}$ shortest AT transmission starting time with data record m of slave XX after receiving the MST

3.5.13 t_2 MDT transmission starting time

3.5.14 t_3 command value valid time

3.5.15 t_5 minimum feedback processing time

3.5.16 t_{ATAT} transmit to transmit recovery time in a slave with several slaves

3.5.17 t_{ATMT} transmit/receive transmission time

3.5.18 $t_{ATMT.M}$ transmit/receive transmission time which slave M needs between transmitting its AT and being prepared for receiving an MDT

3.5.19 t_{ATRP} maximum transition time in a slave to switch from transmitting an AT to repeater function

3.5.20 t_{MTSG} command value processing time

3.5.21 t_{MTSY} receive to receive recovery time in a slave

3.5.22 $t_{MTSY.K}$ recovery time of the last slave after the reception of an MDT to switch over for receiving the next MST (the last slave is the one which is served with data record K)

3.5.23 t_{Ncyc} control unit cycle time

3.5.24 t_{RPAT} maximum transition time in a slave to switch from the repeater function to the transmitter function for the AT

3.5.25 t_{Scyc} communication cycle time

3.5.26 XX address of a device

3.6 DLPDU IDN concept

All data classes that are handled by Type 16 networks have been assigned identification numbers (IDNs). They include real-time data (commands and feedback values), parameters, and procedures. Several IDNs relate to the application and are defined in their relevant standards (e.g., IEC 61800-7-20x for Power Drive Systems).

Refer to Annex A for additional information.

4 DL-protocol overview

Type 16 profile provides a highly optimized means of interchanging fixed-length real-time data and variable-length segmented messages between a single master device and a set of slave devices, interconnected in a ring topology. The exchange of real-time data is totally synchronous by configuration and is unaffected by the messaging traffic.

The device addresses are set by the user, for example, using a selector. Additional devices may be added whenever required, even during operation, without affecting the address selections, which already exist. The determination of the number, identity and characteristics of each device may be configured or may be detected automatically at start-up.

Slave interfaces shall be used to connect the devices to the network. At the physical layer, a slave represents the connection of one or more devices to the network. Logically, one slave with several devices shall act the same as several slaves with one device each.

There are two classes of Type 16 DLE:

e) master DLE;

f) slave DLE.

Only the master DLE is able to initiate the cyclic transmission.

All Type 16 data exchange between the master and the slaves shall take place using defined telegrams. There shall be three sub types of telegrams.

- Master synchronization telegram (MST). MSTs shall be broadcasted by the master at the beginning of a transmission cycle for synchronizing all slaves. They do not transmit any data.
- Master data telegram (MDT). MDTs shall be broadcasted by the master once during each cycle for transmitting its data to all slaves (e.g. command values).
- Device telegrams (AT). ATs shall be sent by each slave once during each cycle for transmitting its data to the master (e.g. feedback values).

Type 16 networks shall not be used for transmitting any other telegrams.

Each device data record in the MDT or AT shall contain a fixed and a configurable part. The fixed part of the data record shall always be present, while the structure of the configurable part of the data record shall be determined for every device by initialization parameters, according to its operation mode and the desired data volume.

5 Basic DLPDU structure

5.1 Overview

5.1.1 General Type 16 telegram structure

Type 16 networks use specific DLPDUs for transporting Type 16 data.

The structure of the DLPDU depends on the telegram type (MST, MDT and AT) and the specific communication phase (CP0-CP6).

The general structure of Type 16 telegrams is shown in Table 1.

Table 1 – General telegram structure

Frame part	Data field	Data type	Value/description
Type 16 telegrams	BOF	OCTET[1]	Telegram delimiter
	ADR	OCTET[1]	Address field
	Data field	OCTET[j × x]	Configurable length
	FCS	OCTET[2]	Frame check sequence
	EOF	OCTET[1]	Telegram delimiter

The administrative segment of the telegram (BOF, ADR, FCS, and (EOF) is required for the transmission of any telegram. The master shall either address telegrams to a specific target or use a broadcast address to transmit messages to all devices concurrently. Slave telegrams (ATs) shall contain the source address.

The User application data shall contain specific information and be handled differently according to the three telegram types and the status of the interface.

5.1.2 BOF telegram delimiter (beginning of frame)

The BOF delimiter shall indicate the start of the telegram. Table 2 shows the content of the field.

Table 2 – BOF field

Bit no,	Value	Description
7	0	Fix value
6-1	1	Fix value
0	0	Fix value

5.1.3 ADR address field

The address field shall be as specified in Table 3.

Table 3 – Device address field

Bit no,	Value	Description
7-0		Device address
	0	Logical device removal
	1 - 254	Device addresses for operation
	255	Reserved

The device address ADR shall be in the range 0 ≤ ADR ≤ 255. It shall be set by the user on the device, for example, using a selector. Each device shall then have its own address ADR. The addresses of all devices that are connected to the same slave shall be in a row.

Any device address in the range 1 ≤ ADR ≤ 254 shall be allocated to not more than one device.

The device address ADR = 0 may be allocated to any number of devices. Devices with such an address shall not generate any telegrams except during network initialization. This makes it possible to remove devices logically from the communication (e.g., for testing purposes).

The device address ADR = 255 shall be reserved.

5.1.4 FCS frame check sequence

A cyclic redundancy check (CRC) shall be used by the transmit and receive algorithms to generate a CRC value for the FCS field. The frame check sequence (FCS) field shall contain a 2 octet (16-bit) cyclic redundancy check (CRC) value. This value shall be computed as a function of the contents of the address and data fields. The FCS shall be generated by the transmitter. The encoding shall be defined as specified in ISO/IEC 13239.

Table 4 – FCS field

Bit no,	Value	Description
15-0		Calculated CRC

5.1.5 EOF telegram delimiter (end of frame)

The EOF delimiter shall indicate the end of a Type 16 telegram. Its content is the same as the BOF telegram delimiter (see Table 2).

5.1.6 Data field

The data field shall be structured according to the three telegram types and the status of the interface (initialization). All transmitted data is allowed to have arbitrary bit sequences of length j × 8 bits.

5.2 MST DLPDU

In the MST, the data field shall only indicate the operation status of the interface and shall be structured as shown in Table 5.

Table 5 – Master synchronization telegram structure

Frame part	Data field	Data type	Value/description
Master data field	INFO	OCTET[1]	Operation status

The INFO field in a MST shall indicate the operation status of the interface. Table 6 shows the content of the field.

Table 6 – MST INFO field

Bit no,	Value	Meaning
7-3	0	Fix value
2-0		Operation status of the interface
	000_B	CP0 (master attempts to close the ring)
	001_B	CP1 (address and device identification)
	010_B	CP2 (parameter mode)
	011_B	CP3 (cyclic parameter mode)
	100_B	Reserved
	101_B	CP4 (cyclic operation)
	010_B	CP5 (file download)
	111_B	CP6 (file upload)

5.3 MDT DLPDU

5.3.1 Introduction

5.3.1.1 General MDT telegram structure

Except during initialization, the MDT shall be handled as a broadcast telegram to save time. The data field of the MDT shall be divided into as many data records as there are slaves serviced by the master (see Table 7). The MDT shall contain all the data records which are cyclically sent to all connected slaves by the master.

Table 7 – Data fields of the master data telegram

Frame part	Data field	Data type	Value/description
MDT real-time data field	Real-time data slave #1	OCTET[see Table 8]	
	Real-time data slave #2	OCTET[see Table 8]	
	…		(And so on for slaves #3 to #(K-1).)
	Real-time data slave #K	OCTET[see Table 8]	

Individual data records may have different lengths. During initialization, every data record shall be assigned to its respective device depending upon its address ADR.

They shall remain constant during normal operation, and can be modified only by reinitializing the system, if the configuration requires it.

Each device shall have its own real-time data field as specified in Table 8.

Table 8 – Master real-time data (for each device)

Frame part	Data Field	Data Type	Value/Description
Real-time data slave #k	Control	OCTET[2]	
	Master service INFO	OCTET[see 5.3.1.3]	
	Configurable real-time data	OCTET[see 5.3.4]	

5.3.1.2 Control k – control word for device XX

Table 9 describes the control word as it shall be.

Table 9 – Control word description (DLL)

Bit no,	Value	Control word description
15-11		Reserved for application profile (e.g. IEC 61800-7-20x)
10		Reserved for application layer (IEC 61158-6-16)
9-8		Reserved for application profile (e.g. IEC 61800-7-20x)
7-6		Reserved for application layer (IEC 61158-6-16)
5-3		Data block element
	000	Service channel not active, close service channel or break a transmission in progress
	001	IDN of the operation data. The service channel is closed for the previous IDN and opened for a new IDN
	010	Name of operation data
	011	Attribute of operation data
	100	Unit of the operation data
	101	Minimum input value
	110	Maximum input value
	111	Operation data
2		Bit last transmission
	0	Transmission in progress
	1	Last transmission
1		R/W (read/write)
	0	Read service INFO
	1	Write service INFO
0		MHS (master handshake bit)
	toggle	Service transport handshake of the master

5.3.1.3 Master service INFO k

The length of this field shall be adjusted by the telegram type (S-0-0015) for CP3 and CP4. It shall be 2, 4, 6 or 8 octets long in CP3 and CP4, programmable by telegram type (S-0-0015). It shall always be 2 octets long in CP1 and CP2.

The master service INFO field shall be the container for the non-cyclic data exchange from master to device XX which takes place in steps in special data fields of the telegram.

Figure 2 describes the master service info field as it shall be.

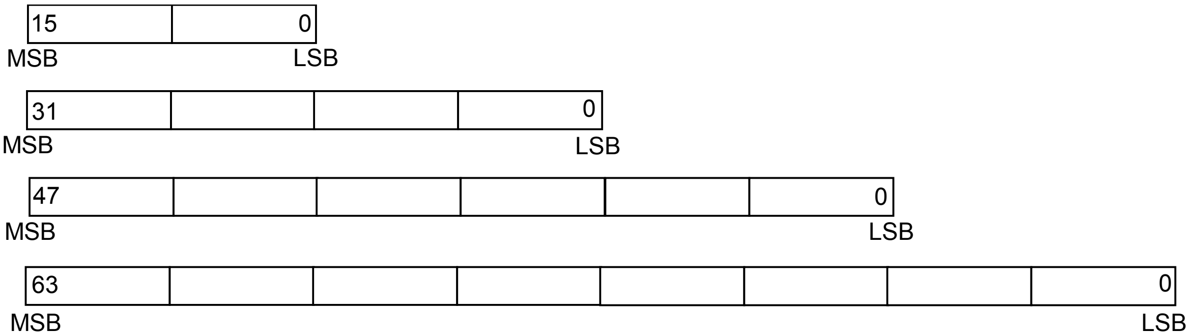


Figure 2 – Master service INFO field k

5.3.2 CP1 and CP2

Device specific identification MDTs (ID request telegrams) shall be used to request the device addresses. Their structure is shown in Table 10.

Table 10 – Structure of the ID request telegram in CP1

Frame part	Data field	Data type	Value/description
Master data field = ID request telegram in CP1	Control	OCTET[2]	0x0001
	Master service INFO	OCTET[2]	

The addressed device shall respond by sending the identification AT (ID acknowledge telegram).

Telegrams in CP2 shall have the same structure as in CP1, but the contents of master service INFO shall now be valid.

5.3.3 CP3

The configurable real-time data field of the MDT shall be used for transmitting individual real-time data to any device. Only element 7 of the data block, configured with a length of two, four or eight octets shall be used. The telegram type parameter S-0-0015 shall determine which operation data is included in the configurable real-time data field of the MDT. The appropriate operation data for standard telegrams shall be defined by this parameter. The structure of the application telegram shall be determined by the configuration list labeled S-0-0024.

The MDT shall be structured as shown in Figure 3. The data field of the MDT shall have as many data records as there are devices which are serviced by the master. Individual data records may vary in length. The assignment of a data record to a device with address XX shall take place during initialization via IDN S-0-0009.

Only the fixed part of the data records shall be used. The configurable part of the data records does not care, but it shall have the number of octets required for cyclical operation. The positions of the fixed part of the data records relevant to the individual devices shall have been transmitted during CP2 with the corresponding communication parameters.

In the control word of the MDT, bit 10 (control unit synchronization bit) shall be valid from CP3 on. This bit shall be set to 0 during phases 0 to 2. In CP3, the control unit shall start the interpolation cycle and keep it steady. Bit 10 of the control word in the MDT shall be inverted with each interpolation cycle.

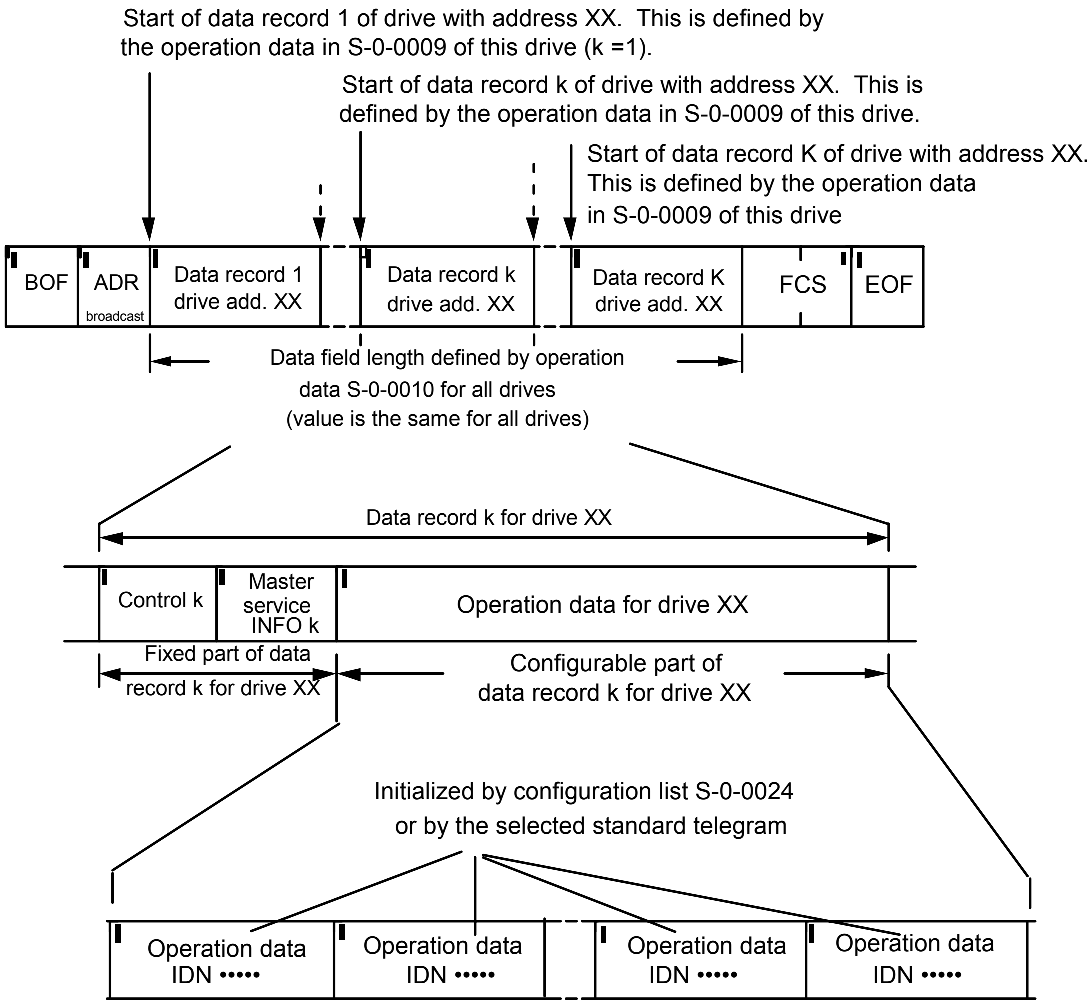


Figure 3 – Structure of the master data telegram

5.3.4 CP4

The MDT shall be structured as shown in Figure 3. The configurable parts of the data records shall be filled with command values which shall have been determined by the parameters transmitted during CP2. The positions of the fixed part of the data records relevant to the individual devices shall have been transmitted during CP2 with the corresponding communication parameters.

5.3.5 CP5

5.3.5.1 CP5 master data description

Table 11 shows the form of the Master Data Telegram for CP5.

Table 11 – Structure of MDT in CP5

Frame part	Data field	Data type	Value/description
Master data field MDT in CP5	Control	OCTET[2]	Unused
	Master service INFO	OCTET[2]	Unused
	Data Record	OCTET[see Table 12]	

The Control Word and the Master Service INFO shall be unused in CP5. The Data Record for the CP5 MDT shall be as specified in Table 12. The File Block size shall be set by the transmission rate as shown in Table 13.

Table 12 – Structure of Data Record in MDT in CP5

Frame part	Data field	Data type	Value/description
Data Record	U/D Control	OCTET[4]	
	File Block Index	OCTET[4]	
	File Block	OCTET[see Table 13}	

Table 13 – File block size in CP5

Transmission rate (Mbit/s)	File block size (octets)	MDT length (octets)	AT length (octets)
2	128	140	12
4	256	268	12
8	512	524	12
16	1024	1036	12

5.3.5.2 U/D control word in CP5

Table 14 defines the bits for the U/D Control Word in the CP5 MDT.

Table 14 – U/D control word in CP5

Bit 31	Value	Meaning
	0	Type 16 interface defined file types
	1	User defined file types
30 - 16		File type identification number
15 - 3		(Reserved)
2		Enable
	0	No file block transfer requested U/D Control word = 0x0001 U/D Status word = 0x0001
	1	File block transfer requested
1		Final Block
	0	Not last block of file transfer
	1	Final block of file transfer
0		U/D Handshake
	toggle	U/D Handshake of master

Before a file transfer may begin, the enable bit, bit 2 in the U/D Control word, shall be set low and the U/D Handshake bit, bit 0 in the U/D Control word shall be set high. If the slave handshake bit matches the master handshake bit, file transfers may begin. File transfers shall be initiated as follows:

- Step 1: Set the File Block Index to 0x0000.
- Step 2: Set the data to be transferred to the MDT File Block Data field.

- Step 3: Set the file type identification number to the File Type Qualifier and File Type Identification Number bits to the file type to be sent.
- Step 4: Set the Enable bit true.
- Step 5: Toggle U/D Handshake bit.

The master shall not change the MDT until the slave has toggled the U/D Handshake bit in the AT to match that of the MDT. If the slave has not toggled the U/D Handshake bit within 10 communication cycles, a fault in the slave shall be assumed.

When the slave toggles the U/D Handshake bit to match that of the master, the slave may also set the U/D Busy bit in the AT indicating that it is processing the data file block being transferred. Only the U/D Handshake bit in the U/D Status word shall be valid while the U/D Busy bit is set. When the slave has completed transfer of the data block and verified the file type and block number, it shall return the File Type Qualifier, File Type Identification Number, set error bits as appropriate and clear the U/D Busy bit in the AT. The master shall not initiate a new data transfer to the same slave until the U/D Handshake bit in that slave AT matches that of the master and the U/D Busy bit is 0.

Subsequent data blocs may be sent by incrementing the file block index of step 1 above and repeating steps 2 through 5. In the event the slave returns an error condition on receipt of any file block, the master may repeat the same file block by leaving the File Block Index unchanged.

The Final Block bit shall be set true when transferring the last block in a series of data transfers. This bit may be used in the slave to complete the file transfer process. This process is not part of this specification.

5.3.5.3 File block index and file block in CP5 (MDT)

A file can be divided into File Blocs that can be downloaded to a slave one File Block at a time. The contents of a file, use and placement of the file by the slave are dependent upon manufacturer implementation. The File Block Index shall be used to indicate which File Block is being transmitted. File blocs shall normally be sent sequentially beginning with File Block 0 and incrementing the block number until the entire file has been sent.

5.3.6 CP6

5.3.6.1 Introduction

Table 15 shows the form of the Master Data Telegram for CP6.

Table 15 – Structure of MDT in CP6

Frame part	Data field	Data type	Value/description
Master data field MDT in CP6	Control	OCTET[2]	Unused
	Master service INFO	OCTET[2]	Unused
	Data Record	OCTET[see Table 16]	

The Control Word and the Master Service INFO shall be unused in CP6. The Data Record for the CP6 MDT shall be as specifies in Table 16.

Table 16 – Structure of data record field in MDT in CP6

Frame part	Data field	Data type	Value/description
Data Record	U/D Control	OCTET[4]	
	File Block Index	OCTET[4]	

5.3.6.2 U/D control word in CP6

Table 17 defines the bits for the U/D Control word in the CP6 MDT.

Table 17 – U/D control word in CP6

Bits	Value	Meaning
31		File type qualifier
	0	Type 16 specific file types
	1	User defined file types
30 - 16		File type identification number
15 - 3		(Reserved)
2		Enable
	0	No file block transfer requested U/D Control word = 0x0001 U/D Status word = 0x0001
	1	File block transfer requested
1		(Reserved)
0		U/D Handshake
	toggle	U/D Handshake of master

Before a file transfer can begin, the enable bit, bit 2 in the U/D Control word, shall be set low and the U/D Handshake bit, bit 0 in the U/D Control word shall be set high. If the slave handshake bit matches the master handshake bit, file transfers shall begin. File transfers shall be initiated following these steps:

- Step 1: Set the File Block Index to 0x0000.
- Step 2: Set the file type number to the File Type Qualifier and File Type Identification Number bits to the file type to be sent.
- Step 3: Set the Enable bit true.
- Step 4: Toggle the U/D Handshake bit.

The slave shall respond by setting the U/D Busy bit true and toggling the U/D Handshake bit in the U/D Status word of the AT.

NOTE It is not necessary for the slave to set the U/D Busy bit true if it can respond with the requested data within the 10 communication cycle period allowed for the U/D Handshake bit to toggle.

After toggling the U/D Handshake bit, the slave shall verify the file type and block number and respond by setting the file type to the File Type bits and the block index number to the File Block Index field respectively, and by setting or clearing the File Transfer Error bit, and place data as appropriate in the Data Block field of the AT. Finally, the slave shall clear the U/D Busy bit in the U/D Status word to tell the master that the data is now valid. Only the U/D Handshake in the U/D Status word is valid when the U/D Busy bit is true. The master shall not initiate a new data transfer until the U/D Handshake bit in the slave AT matches that of the master and the U/D Busy bit is 0.

Subsequent data blocs shall be requested by incrementing the file block index of step 1 above and repeating steps 2 through 4. To transfer the entire file, this process shall be repeated until an error is reported or until the Final Block bit in the AT is set true.

In the event the slave returns an error condition on receipt of any file block, the master may request the same file block by leaving the File Block Index unchanged.

5.3.6.3 File block index in CP6 (MDT)

A file can be divided into File Blocs that can be uploaded from a slave one File Block at a time. The contents of a file, use and placement of the file by the slave are dependent upon manufacturer implementation. The File Block Index shall be used to indicate which File Block is to be uploaded. File blocs shall normally be requested sequentially beginning with File Block 0 and incrementing the block number until the entire file has been received as indicated by the Final Block bit in the AT.

5.4 AT DLPDU

5.4.1 Introduction

5.4.1.1 General AT telegram structure

In the AT, the data field shall have only one data record, which shall be sent from the device to the control unit cyclically, see Table 18. The data records of individual ATs shall be as specified in Table 19.

Table 18 – Data field of the acknowledge telegram

Frame part	Data field	Data type	Value/description
Acknowledge telegram	Real-time data slave #m	OCTET[see Table 19]	

Table 19– AT real-time data (for each device)

Frame part	Data field	Data type	Value/description
Real-time data slave #m	Device m status	OCTET[2]	
	Device m service INFO	OCTET[see 5.4.1.3]	
	Configurable real-time data	OCTET[see 5.4.4]	

5.4.1.2 Status m – status word of device XX

Table 20 describes the status word as it shall be.

Table 20 – Status word description (DLL)

Bit no,	Value	Meaning
15-8		Reserved for the application profile (e.g., IEC 61800-7-20x)
7-6		Reserved for application layer (IEC 61158-5)
5		Procedure command change bit
	0	No change in procedure command acknowledgement
	1	Changing procedure command acknowledgment
4		Reserved
3		Status command value processing
	0	Device ignores the command values
3	1	Device follows the command values
2		SVC error
	0	No error
	1	Error in SVC, error message in SVC INFO
1		Busy
	0	Step finished, slave ready for new step
	1	Step in process, new step not allowed
0		AHS
	toggle	SVC transport handshake of the slave (toggle bit)

5.4.1.3 Device service INFO m

The device service INFO field shall be 2, 4, 6 or 8 octets long in CP3 and CP4. In CP1 and CP2, it shall always be 2 octets long. The length shall be adjusted by the telegram type (S-0-0015) for CP3 and CP4.

The device service INFO field shall be the container for the non-cyclic data exchange from device XX to master which takes place in steps in special data fields of the telegram.

Figure 4 describes the device service info field as it shall be.

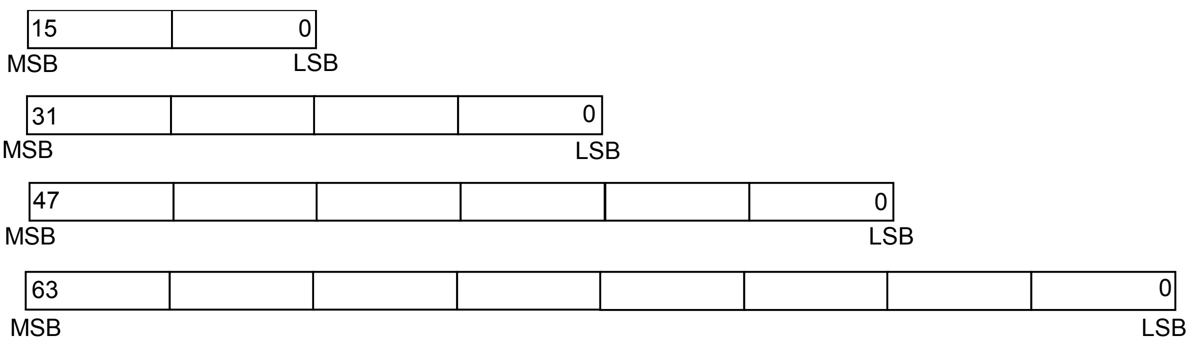


Figure 4 – Device service INFO field m

5.4.2 CP1 and CP2

In CP1 the addressed device shall respond by sending the identification AT (ID acknowledge telegram) as shown in Table 21.

Table 21 – Structure of the ID acknowledge telegram in CP1

Frame part	Data field	Data type	Value/description
AT data field ID acknowledge telegram in CP1	Status	OCTET[2]	
	Device service INFO	OCTET[2]	

Master service INFO (2 octets) and device service INFO (2 octets) shall be part of the ID request and ID acknowledge telegrams, but their content shall have no meaning during CP1.

Telegrams in CP2 shall have the same structure as in CP1, but the contents of the device service INFO shall now be valid.

5.4.3 CP3

The AT shall be structured as shown in Table 18 and Table 19. Only the fixed part of the data record shall be used. The configurable part of the data record does not care, but it shall have the number of octets required for cyclical operation.

The configurable real-time data field of the AT shall be used for transmitting individual real-time data to any device. Only operation data configured in two, four or eight octet length shall be used. The telegram type parameter S-0-0015 shall determine which operation data is included in the configurable real-time data field of the AT. The appropriate operation data for standard telegrams shall be defined by this parameter. The structure of the application telegram shall be determined by the configuration list labeled S-0-0016.

The structure of the telegram, which depends upon the application, shall be determined by the configuration list labeled S-0-0016.

Table 22 – Structure of the operation data of device m in acknowledge telegram

Frame part	Data field	Data type	Value/description
Device m Configurable real-time data	Operation data IDN …	OCTET[depending upon IDN]	Number and length of operation data shall be as configured in IDN list S-0-0016 or by the selected standard telegram.
	Operation data IDN …	OCTET[depending upon IDN]	
	Operation data IDN …	OCTET[depending upon IDN]	
	…		
	Operation data IDN …	OCTET[depending upon IDN]	

5.4.4 CP4

The AT shall be structured as in CP3 except that the configurable part of the data record shall be filled with actual values which shall be determined by the parameters transmitted in CP2.

5.4.5 CP5

5.4.5.1 Introduction

Table 23 show the form of the acknowledge telegram (AT) for CP5.

Table 23 – Structure of AT in CP5

Frame part	Data field	Data type	Value/description
AT data field AT in CP5	Status	OCTET[2]	unused
	Device INFO	OCTET[2]	unused
	Data Record	OCTET[see Table 24]	

The Status Word and the Device Service INFO shall be unused in CP5. The Data Record for the CP5 AT shall contain a 4 octet U/D Status word and a 4 octet File Block Index (see Table 23).

Table 24 – Structure of data record in AT in CP5

Frame part	Data field	Data type	Value/description
Data Record	U/D Status	OCTET[4]	
	File Block Index	OCTET[4]	

5.4.5.2 U/D status word in CP5

Table 25 defines the bits for the U/D Status word in the CP5 AT.

Table 25 – U/D status word in CP5

Bits	Value	Meaning
31		File type qualifier
	0	Type 16 specific file types
	1	User defined file types
30 - 16		File type identification number
15 - 4		(Reserved)
3		File transfer error
	0	No error
	1	Download error, error message in file block index in AT
2		U/D Busy
	0	Slave completed previous request
	1	Previous request accepted and in progress
1		Final Block
	0	Acknowledge: not last block of file transfer
	1	Acknowledge: final block of file transfer
0		U/D Handshake
	toggle	U/D Handshake of slave

If the slave sees a U/D Handshake bit in the MDT change from matching that of the slave AT to not matching and the Enable bit is set in the MDT, the slave shall save the type number sent in the File Type Qualifier and File Type fields, the block index number sent in the File Block Index field, and the data in the Data Block. If further processing of the file type, file block and data are necessary, the slave shall set the U/D Busy bit true and then toggle the U/D Handshake bit in the U/D Status word of the AT to indicate it has received the data and is processing it. The U/D Handshake bit in the AT shall be set to match that of the MDT in less than or equal to 10 communication cycles or the master will assume a fault has occurred. The slave shall save all data in the MDT before toggling the U/D Handshake bit in the U/D Status Word.

The slave shall then verify that the File Type Qualifier, File Type, File Block Index and data from the MDT are valid. If no error is found, the data transferred shall be applied as appropriate in the slave. When the slave has completed processing the file data, the file type number and data block number shall be returned in the File Type bits and File Block Index fields of the AT respectively. Clearing the U/D Busy bit shall notify the master that the operation is complete, and that the File Type, File Block Number and the File transfer error bit in the AT are valid and the slave is free to accept more data.

If the Final Block bit was set in the MDT the slave shall take appropriate action for the final block of data transfer in the slave. This action is not part of this specification.

If either the file type number or the file block number are invalid or the data field contains unexpected or erroneous data, the slave shall set the File transfer error bit true and place a 32 bit error code in the File Block Number field in the AT. Error codes are defined in Table 26.

5.4.5.3 File block index in CP5 (AT)

Before the slave toggles the U/D Handshake bit in the AT to match the MDT and sets the U/D Busy bit to 0, it shall set the File Block Index field to the value of the File Type Qualifier and File Block Index received in the MDT. The master can use this value to verify the correct block is being transferred.

If an error occurs, the slave shall replace the File Block Index with a 32 bit error code. The Table 26 defines the error message in the File Block Index in the CP5 AT.

Table 26 – File block index in CP5

Bits	Value	Meaning
31 -16		User defined error message
15 - 4		(Reserved)
3		File checksum error
	0	No error
	1	Error
2		File type error
	0	No error
	1	File type not supported
1		File block data error
	0	No error
	1	Data transferred not valid
0		File block index error
	0	No error
	1	Invalid file block index number

5.4.5.4 U/D control word and U/D status word handshaking in CP5

Figure 5 shows the functional relationship between the Enable and U/D Handshake bits in the CP5 MDT and the U/D Busy and the U/D Handshake bit in the CP5 AT.

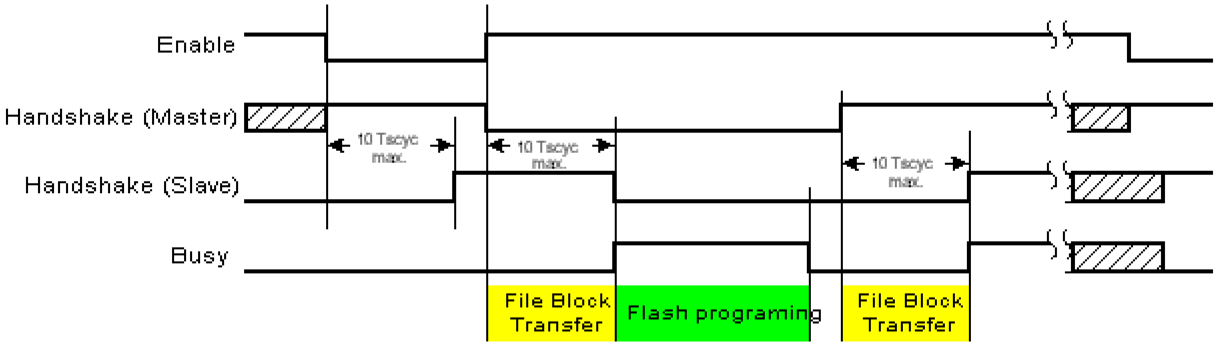


Figure 5 – Timing of U/D bits in CP5

5.4.6 CP6

5.4.6.1 Introduction

Table 27 shows the form of the acknowledge telegram (AT) for CP6.

Table 27 – Structure of AT in CP6

Frame part	Data field	Data type	Value/description
AT data field AT in CP6	Status	OCTET[2]	Unused
	Device INFO	OCTET[2]	Unused
	Data Record	OCTET[see Table 29]	

The Status Word and the Device Service INFO shall be unused in CP6. The Data Record for the CP6 AT shall be as specified in Table 28. The File Block size shall be set by the transmission rate as shown in Table 29.

Table 28 – Structure of data record in AT in CP6

Frame part	Data field	Data type	Value/description
Data Record	U/D Status	OCTET[4]	
	File Block Index	OCTET[4]	
	File Block	OCTET[see Table 29]	

Table 29 – File block size in CP6

Transmission rate (Mbit/s)	File block size (octets)	MDT length (octets)	AT length (octets)
2	128	12	140
4	256	12	268
8	512	12	524
16	1 024	12	1 036

5.4.6.2 U/D status word in CP6

The Table 30 defines the bits for the U/D Status Word in the CP6 AT.

Table 30 – U/D status word in CP6

Bits	Value	Meaning
31		File type qualifier
	0	Type 16 specific file types
	1	User defined file types
30 - 16		File type identification number
15 - 4		(Reserved)
3		File transfer error
	0	No error
	1	Upload error, error message in file block index in AT
2		U/D Busy
	0	Slave completed previous request
	1	Previous request accepted and in progress
1		Final Block
	0	Not last block of file being transferred
	1	Final block of file being transferred
0		U/D Handshake
	toggle	U/D Handshake of slave

If the slave sees a U/D Handshake bit in the MDT change from matching that of the slave AT to not matching and the Enable bit is set in the MDT, the slave shall save the type number sent in the File Type Qualifier and File Type fields and the block index number sent in the File Block Index field. If the file type number and the block index are supported by the slave, the slave shall fill the Data Block field with the requested data and toggle the U/D Handshake bit in the AT to match that of the MDT. If the time required to fill the data field exceeds 10 communication cycles, the slave shall set the U/D Busy bit and toggle the U/D Handshake bit before attempting to fill the data field. When the data field is updated, the slave shall then set the U/D Busy bit to 0 to signal the master that the data is now valid. In either case, the U/D Handshake bit in the AT shall be set to match that of the MDT in 10 or less communication cycles or the master will assume a fault has occurred.

The slave shall set the Final Block bit in the U/D Status word to indicate the final block of the file. Definition of Final File block is not part of this specification.

If either the file type number or the file block number is invalid, the slave shall set the File Transfer Error bit in the AT as appropriate and place a 32 bit error code in the File Block Number field in the AT. Error codes are defined in Table 31.

The master shall only read data in the U/D Status word and the Data field if the U/D Handshake bit matches that of the master and the U/D Busy bit is 0.

5.4.6.3 File block index and file block in CP6 (AT)

Before the slave toggles the U/D Handshake bit in the AT to match the MDT and sets the U/D Busy bit to 0, it shall set the File Block Index field to the value of the File Type Qualifier and File Block Index received in the MDT. The master can use this value to verify the correct block is being transferred.

If an error occurred, the slave shall replace the File Block Index with a 32 bit error code. The Table 31 defines the error message in the File Block Index in the CP6 AT.

Table 31 – File block index in CP6

Bits	Value	Meaning
31 -16		User defined error message
15 - 3		(Reserved)
2		File type error
	0	No error
	1	File type not supported
1		(Reserved)
0		File block index error
	0	No error
	1	Invalid file block index number

5.4.6.4 U/D control word and U/D status word handshaking in CP6

Figure 6 shows the functional relationship between the Enable and U/D Handshake bits in the CP6 MDT and the U/D Busy and the U/D Handshake bit in the CP6 AT.

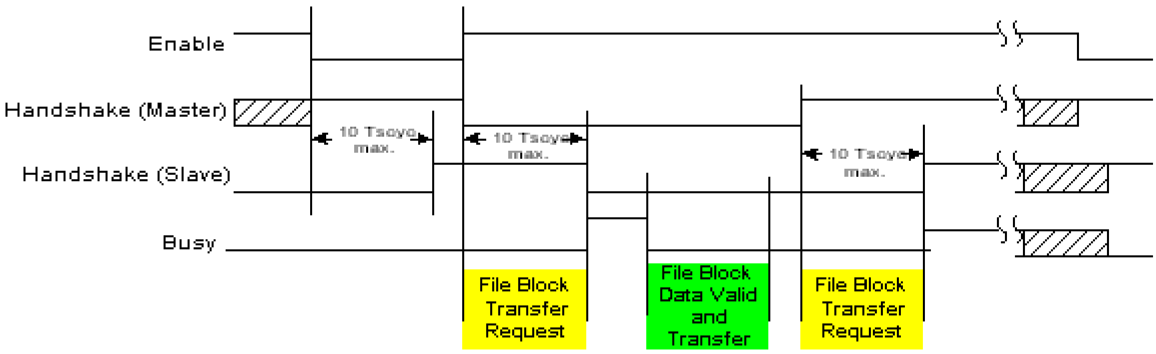


Figure 6 – Timing of U/D bits in CP6

6 Network management methods

6.1 Overview

DL-management procedures are functionally processed in response to DL-management service requests submitted by the DL-user and events caused by the network.

6.2 Enable and disable cyclic communication

6.2.1 Introduction

Upon an Initiate_cyclic_communication (ICC) request by the DL user in the master device the so-called phase upshift is initiated.

A Notify_cyclic_communication (NCC) indication is generated for the DL user in the slave device if the phase upshift has been successfully completed.

Upon a Disable_cyclic_communication (DCC) request by the DL user in the master device the so-called phase downshift is initiated.

A Notify_cyclic_communication_disabled (NCCD) indication is generated for the DL user in the slave device if the cyclic communication has been disabled.

A Notify_error (NER) indication is generated for the DL user in a master and a slave device if an error has occurred in the cyclic communication.

6.2.2 Communication phases (CP)

6.2.2.1 Introduction

Initialization shall be divided into five communication phases (CPs):

- network initialization shall always begin with CP0;
- CP0 and CP1 shall be used for recognizing the participating devices;
- in CP2, the timing and data structure of the protocols for normal operation shall be prepared;
- in CP3, the station synchronization and the cyclic data transmission shall be operational;
- in CP4, the initialization process shall be over and the network shall be in normal operation. CP4 shall be similar to CP3 as far as communication is concerned, but valid application-specific data shall be transmitted.

It shall also be possible to enter CP0 from any higher phase. It shall not be possible to enter other phases except when leaving the previous one in ascending order.

The master shall initiate a specific CP by setting the INFO octet of the MST (see 5.2). The slaves shall follow accordingly. Only in the case of a communication error shall the slaves switch to CP0.

6.2.2.2 Communication phase 0 (CP0)

6.2.2.2.1 General

After all slaves in the network have been powered up, and after internal checks are error-free, all slaves shall be operating in repeater mode only. The master shall send MSTs and monitor its receiver for receipt in order to verify network closure.

During CP0, the master shall only send the MSTs. The slaves shall not send any telegram.

6.2.2.2.2 Leaving CP0

The master shall wait for its MST to be received. As soon as the master has received its own MSTs back for at least 10 successive cycles, which means that the network is closed and that all the slaves in the network are in the repeater mode, the master shall initiate CP1.

If this procedure cannot be achieved within the time set by the master, the master shall remain in CP0 and generate a message. The scope of the message and at what point it has to be activated is a function of the control unit.

If CP0 is initiated as a response to a previous communication error, a routine in the master may be used to cause an automatic advance routine to CP2 with the possibility of error diagnostics, as specified by its manufacturer or depending upon configuration.

6.2.2.3 Communication phase 1 (CP1)

In CP1, any data exchange during one cycle shall only be possible between the master and one device. CP1 shall be used for recognizing the devices connected to the network. To do so, the master shall address each device specifically with the device address. The device shall answer to a MDT which is addressed to it by sending an AT in the next cycle.

The required addresses shall be storable in the control unit to verify that all devices are present as required by the configuration. It shall also be possible to find all devices in the network by calling all allowed device addresses and waiting for an answer. The master may compare the detected device addresses with the device addresses that it is expecting to find, and then evaluate deviations (e.g., generate an error message).

The address XX = 0 shall not be used in the inquiry. Devices that are not participating in the communication shall use this address as their address (see 5.1.3). Devices that are not being addressed in CP1 and whose address is not 0 shall behave like devices with the address 0. No device shall react in CP1 when address 0 or 255 is queried.

6.2.2.4 Operational sequence in phase 1 (CP1)

6.2.2.4.1 General

At the beginning of CP1, it is not certain that the physical slave is ready to receive the MDT. It might happen that a slave's repeater operates (the network is closed) but start-up routines are still being processed internally. Thus a particular device address might have to be queried several times. The master shall begin with the lowest address in the network or uses any other strategy, depending upon configuration, and shall expect a response within the HS timeout (see **9.3**).

The master shall repeat this request until the addressed device acknowledges or until the HS timeout. If a device does not respond, it is recommended that it be addressed again after some time is elapsed.

6.2.2.4.2 Leaving CP1

After the master has identified the devices on the network and no error has occurred, the MST INFO field shall be used to initiate CP2.

If the device identification time is exceeded or deviations to the stored device addresses are detected, the initialization shall not be continued. The control unit shall evaluate deviations (e.g., generate an error message).

6.2.2.5 Communication phase 2 (CP2)

6.2.2.5.1 General

During CP2, the devices shall be addressed specifically by their addresses. For CP2 and higher phases, they shall support complete service channel functionality.

As a minimum, the communication parameters transmission starting times and transfer timeslots required for CP3 and CP4 and the parameters for determining the length and the contents of the MDT and ATs shall be transmitted to the devices. The slave shows in “IDN-list of operation data for CP2” which data in CP2 shall be transferred (see S-0-0018).

The entire information exchange shall take place via the mechanisms of the service channel. The reliability of transmission is guaranteed by the MHS and AHS bits as well as the HS timeout. Further parameter exchanges can take place in CP2 or CP3. No device shall react in CP2 if the addresses 0 or 255 are queried.

6.2.2.5.2 Leaving CP2

The transition from CP2 to CP3 shall be performed according to the following procedure.

a) The master shall activate the procedure command “CP3 transition check” as defined in S-0-0127.
b) The slave shall then determine the validity of the parameters for CP3.
c) The slave shall acknowledge the procedure command positively (e.g., “Procedure command executed correctly”).

d) After the positive procedure command acknowledgment, the master shall delete the procedure command in the slave.

e) The master shall then switch to CP3.

If the slave is not yet ready to switch over (e.g., the parameters required for CP3 have not yet been completely calculated), the slave shall set the procedure command acknowledgment “procedure command not yet executed”.

If there are additional invalid parameters still present after the procedure command has been processed, the slave shall respond with the procedure command acknowledgment “Error, procedure command execution impossible”. In this case, the master shall remain in CP2 and, depending on its capabilities, try to set again the parameters identified as invalid or to send an error message to allow further initialization by means of an operator intervention. If a fault occurs, the slave shall save the IDNs of the invalid data into the “IDN-list of invalid operation data for CP2” (see S-0-0021).

After the master has transmitted further parameters (depending on S-0-0021) to the slave in CP2, the procedure command “CP 3 transition check” shall be activated once more.

The validity check of the parameters by the slave shall refer only to general criteria (e.g., minimum, maximum). It shall not recognize if all parameters that have been transmitted by the master are correct with respect to the master data and the total installation. This means that even if a slave acknowledges the “CP3 transition check” positively, there can be incorrect communication parameters with respect to the total installation which can lead to a disruption of the communication.

If CP2 was attained by an automatic advance routine after an error, this error shall be corrected first before a transition to CP3 can take place.

Depending upon configuration the master may also switch to CP0 in case of communication error or human intervention (e.g., the operator).

6.2.2.6 Communication phase 3 (CP3)

6.2.2.6.1 General

In the first cycle CP3, it shall not be necessary to send an AT.

Starting with CP3, the exchange of data shall be done via the telegrams defined for CP4. Also the timeslots for cyclic operation shall be used. The MDT shall be sent with the broadcast address.

During CP3, the parameters for the devices shall be set by means of the service channel. The slave shall show in “IDN-list of operation data for CP3” which data in CP3 needs to be transferred (see S-0-0019). Transmission reliability for the service channel shall be guaranteed by the MHS and AHS-bits as well as the HS timeout.

6.2.2.6.2 Leaving CP3

The transition from CP3 to CP4 shall be performed according to the following procedure.

a) The master shall activate the procedure command “CP4 transition check” as defined in S-0-0128.

b) The slave shall then determine the validity of the parameters for CP4.

c) Afterwards, the slave shall complete the processing of the parameters that are required for operating the slave.

d) The slave shall then activate the synchronization.

e) And finally, the slave shall acknowledge the procedure command positively (e.g., “procedure command executed correctly”).

f) After receiving the positive procedure command acknowledgment, the master shall delete the procedure command in the slave.

g) The master shall then switch to CP4.

If the slave is not yet ready to switch over (e.g., the parameters required for operating the slave have not yet been completely calculated), it shall set the procedure command acknowledgment – “procedure command not yet executed”.

If there are additional invalid parameters still present after the procedure command has been processed, the slave shall respond with the procedure command acknowledgment “Error, procedure command execution impossible”. In this case, the master shall remain in CP3 and, depending on the capabilities of the master, try to re-establish the parameters identified as invalid or send an error message indicating that human intervention (e.g., operator) is required. In a faulty case, the slave shall save the IDNs of the invalid data into the “IDN-list of invalid operation data for CP3” (see S-0-0022).

After the master has transmitted further parameters (depending on S-0-0022) to the slave in CP3, the procedure command “CP 4 transition check” shall to be activated once more.

Depending upon configuration the master can also switch to CP0 in case of communication errors or human intervention (e.g., the operator).

6.2.2.7 Communication phase 4 (CP4) – end of initialization

6.2.2.7.1 General

Upon switching to CP4 the initialization is complete.

6.2.2.7.2 Leaving communication phase 4 (CP4)

The only possibility of leaving CP4 shall be a return to CP0. The reason for this can be communication faults or human intervention (e.g., operator). Any slave which recognizes CP0 shall shut down itself in the best possible manner. The method of shutting down the slaves is part of the application profiles (e.g., IEC 61800-7-20x).

6.2.2.7.3 Switching to communication phase 0 (CP0)

When switching the control unit from communication phase 3 or 4 (CP3/4) to communication phase 0 (CP0), after switching, within two communication cycles, MST shall be sent with phase 0 by the control unit. If this is not the case, the devices shall recognize MST-failure in the CP3 or CP4. The first MST of the CP0 shall be in the raster of the communication cycle time.

Figure 7 shows the three possible cases that are as follow:

- **Case 1**: If the master changes over within 1 communication cycle time and sends MST with phase 0 immediately, without interruption, then the slave does not see any MST failure and shall therefore not recognize any MST error.
- **Case 2**: If the master needs more time and changes over within 2 communication cycle times, then one MST is missing before the master resumes sending MSTs with phase 0. The slave notices one MST failure, but shall not recognize any double MST failure.
- **Case 3 - Error**: If the master needs further more time and changes over within ≥ 3 communication cycle times, then ≥ 2 MST are missing before the master resumes sending MSTs with phase 0. The slave shall recognize a double MST failure and generate an error of class 1 diagnostics.

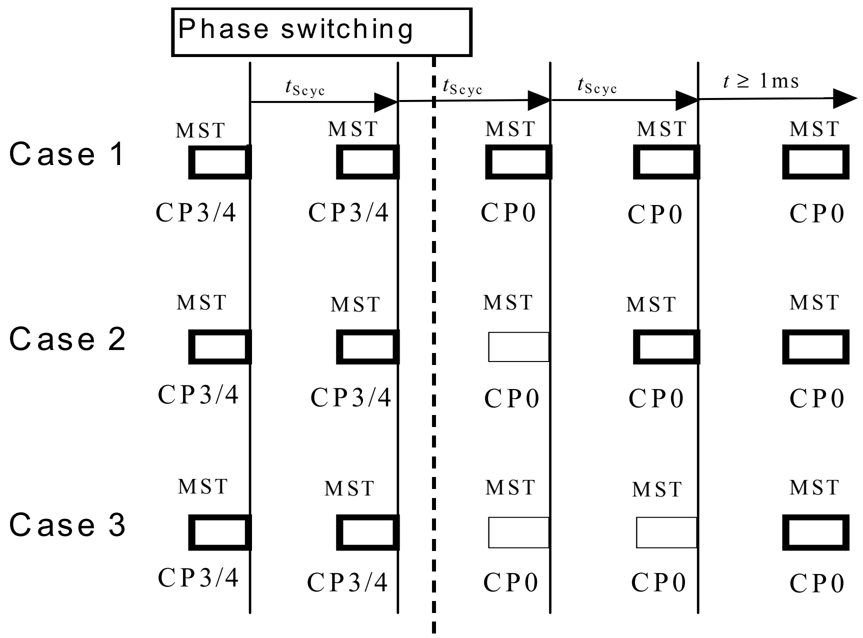


Figure 7 – Switching to CP0

6.3 File transfer

A network shall provide for specific methods for the download and upload of files to and from a slave, as specified in this subclause. During the download process, a binary data file of arbitrary length shall be transferred from the master to the slave. During upload, binary data shall be recovered from the slave.

File lengths, file contents, how the file is to be used, and where the file is to be located in the device's memory space is not part of this specification. A file may contain a header defining how the file is to be used (file type, size, location, etc.). The specification of a header is left to the manufacturer. This means that files are not necessarily interchangeable between slaves of different manufacturers.

Two additional communication phases shall be used:

- phase 5 (CP5), which shall be used to download files and is characterized by a large file block in the MDT;
- phase 6 (CP6), which shall be used to upload files and is characterized by a large file block in the AT.

Phases 5 and 6 shall only be reached from CP0. Figure 8 shows the allowed communication phase transitions. The communication phase can be returned to CP0 from any phase.

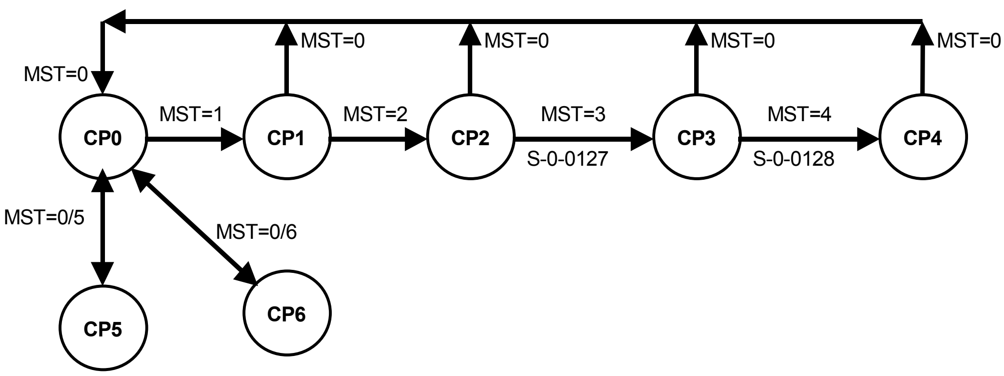


Figure 8 – Phase transitions

In CP5, data exchange in any one cycle shall be possible only between the master and one slave. CP5 shall be used for the download of files to slaves. To do so, the master shall transmit an MDT with a specific slave address. The slave shall respond by transmitting its status in an AT. The master can identify a slave by checking the address field in the AT.

The addresses XX = 0 and XX = 255 shall not be used in the transmission of the MDT. No slave shall react in CP5 if address 0 or 255 is used in the transmission of the MDT.

When leaving communication phase 5 (CP5 to CP0 transition) it is anticipated that some slaves will not be able to advance from CP0 to CP1 following CP5 download. Should this be the case, the slave shall report an error if the CP0 to CP1 transition is attempted. In addition, operation manuals for the slave shall detail the required procedure for returning the slave to normal operation.

CP6 data exchange in any one cycle shall be possible only between the master and one slave. CP6 shall be used to upload of files from slaves. To do so, the master shall transmit an MDT with a specific slave address. The slave shall respond by transmitting its status in an AT. The master can identify a slave by checking the address field in the AT.

The addresses XX = 0 and X = 255 shall not be used in the transmission of the MDT. No slave shall react in CP6 if address 0 or 255 is used in the transmission of the MDT.

6.4 Status procedures

Upon a Get_Device_Status (GDS) request by the DL user in the master device the status word of the specified device is returned to the DL user.

Upon a Set_Device_Status (GDS) request by the DL user in the master device the control word of the specified device is set.

Upon a Get_Network_Status (GNS) request by the DL user in the master device the status of the network is returned to the DL user.

7 Data transmission methods

7.1 Overview

Data transmission methods are the means by which a DLE performs its functions and affects the behavior of the DL-protocol. Methods are initiated, executed and terminated under the control of invoked services, as specified in the Type 18 DL-service

7.2 SVC

7.2.1 Introduction

7.2.1.1 SVC handling

Acyclic data is exchanged between a master and a slave device upon a Read (RD) request initiated by the DL user in a master device.

Acyclic data is exchanged between a master and a slave device upon a Read (RD) request initiated by the DL user in a master device.

In addition to the cyclic transmission of data, Type 16 shall provide the ability to transmit non-cyclic data. To transmit this data, the device service INFO field shall be reserved for the service channel in the MDT (see 5.3.1.3) and in the AT (see 5.4.1.3). Special control and status bits in the control word of the MDT or the status word of the AT shall be used to control execution in the service channel. Therefore, the master shall be able to support a separate service channel for every connected device.

With a SVC transmission, the following operations shall be possible:

- initialization of the Type 16 communication;
- transmission of all elements of a data block;
- transmission of procedure commands;
- changing limit values on demand;
- changing control loop parameters on demand;
- obtaining detailed status messages from a device;
- diagnostic functions;

Any SVC transmission shall always be initiated and controlled by the master. The operations, “read element” or “write element”, shall be from the perspective of the master. All operations shall always relate to the last transmitted IDN.

The service channel shall be initialized during CP1 and be functional for the remainder of the communication phases.

The SVC transport of operation data or of a procedure command shall be handled via a predetermined handling and proceeding sequence (see Figure 9 and Figure 10) for individual actions. The master shall follow strictly the outline of these diagrams.

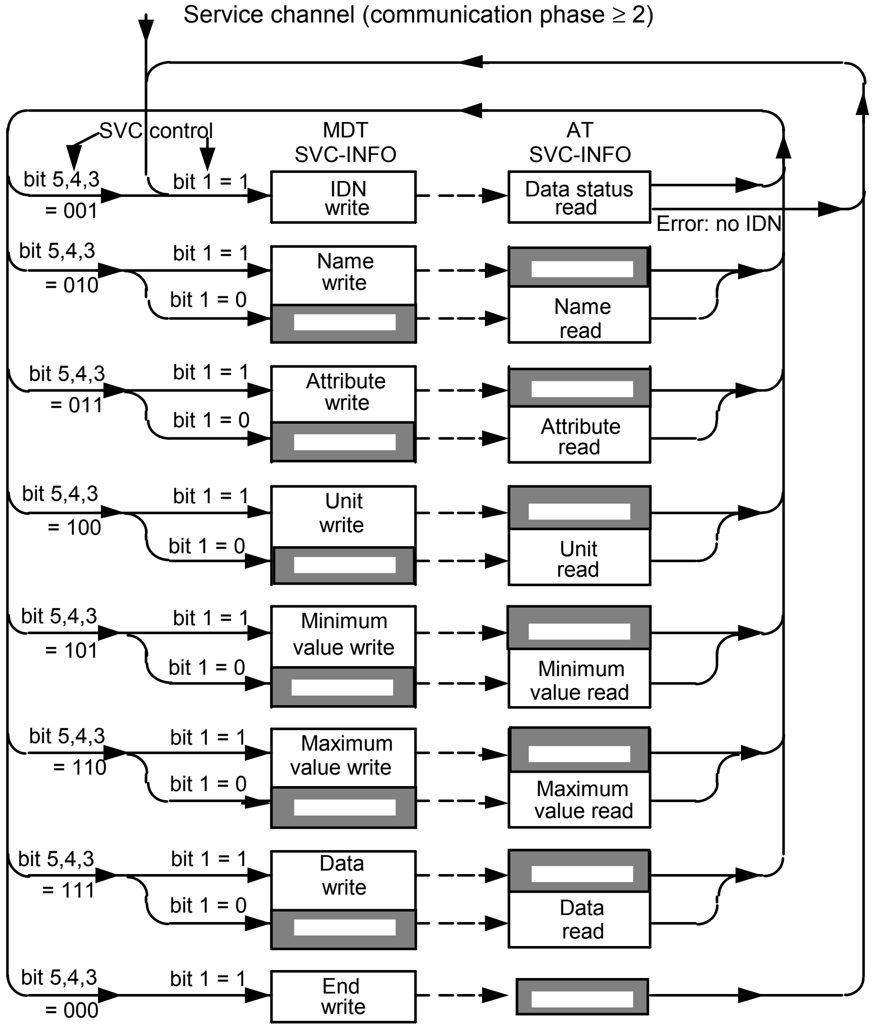


Figure 9 – Service channel handling diagram

7.2.1.2 Selection of IDN

The transmission shall start with the opening of the service channel by sending the IDN of the data block (SVC control, bits 5, 4, 3 = 001, element 1). The slave shall respond by writing the IDN with the data status or the procedure command acknowledgment.

7.2.1.3 Selection of data block element

During the next step, the master shall indicate which elements of the data block shall be processed. For this purpose, the master shall set bits 5, 4 and 3 accordingly in the SVC control.

7.2.1.4 Read/Write

Following this, the master shall indicate in bit 1 whether the element will be read or written to. While writing, the SVC INFO field of the MDT shall be filled with the appropriate data for the slave (contents of the AT SVC INFO field are invalid). If reading is selected, the slave shall insert the appropriate data in the SVC INFO field of the AT (contents of the SVC INFO field of the MDT are invalid).

7.2.1.5 Transmission steps

Depending on the length of the data block elements which need to be transmitted and of the length of the SVC INFO field, several steps shall be performed. Every step shall transport four octets of data.

Table 32 shows the necessary steps for the individual elements of a data block.

Table 32 – List of IDNs element and step numbers

Element number	Description	Requirement	Number of steps	
1	IDN	Mandatory	1	
2	Name	Optional	1 to 16	
3	Attribute	Mandatory	1	
4	Unit	Optional	1 to 4	
5	Minimum input value	Optional	1or 2	
6	Maximum input value	Optional	1or 2	
7	Operation data	Mandatory	Fixed length:	1 or 2
			Variable length:	1 to 16 384
Closing the service channel			1	

The master shall indicate in bit 2 of the SVC control a transmission in progress (bit 2 = 0) or the transmission of the last 4 octets (bit 2 = 1). A transport with just one step shall immediately be set by the master as the last transmission (bit 2 = 1).

The error messages “element transmission too short” or “element transmission too long” shall be executed by the slave only if the length of the actual transmitted element is not in coincidence with the states of bit 2 in the SVC control.

7.2.1.6 End of transmission

The SVC transmission of operation data or a procedure command shall end with the transmission of the IDN for the next operation data or procedure command.

7.2.1.7 Changing of data block element

Changing the data block element shall be possible without an error message only if the following bits have the status given in Table 33.

Table 33 – Condition for modifying data block elements

Information	SVC control bit	SVC status bit	bit value
Transmission in progress	bit 2		0
Handshake bits equal	bit 0	bit 0	MHS = AHS
Busy		bit 1	0
SVC valid		bit 3	1

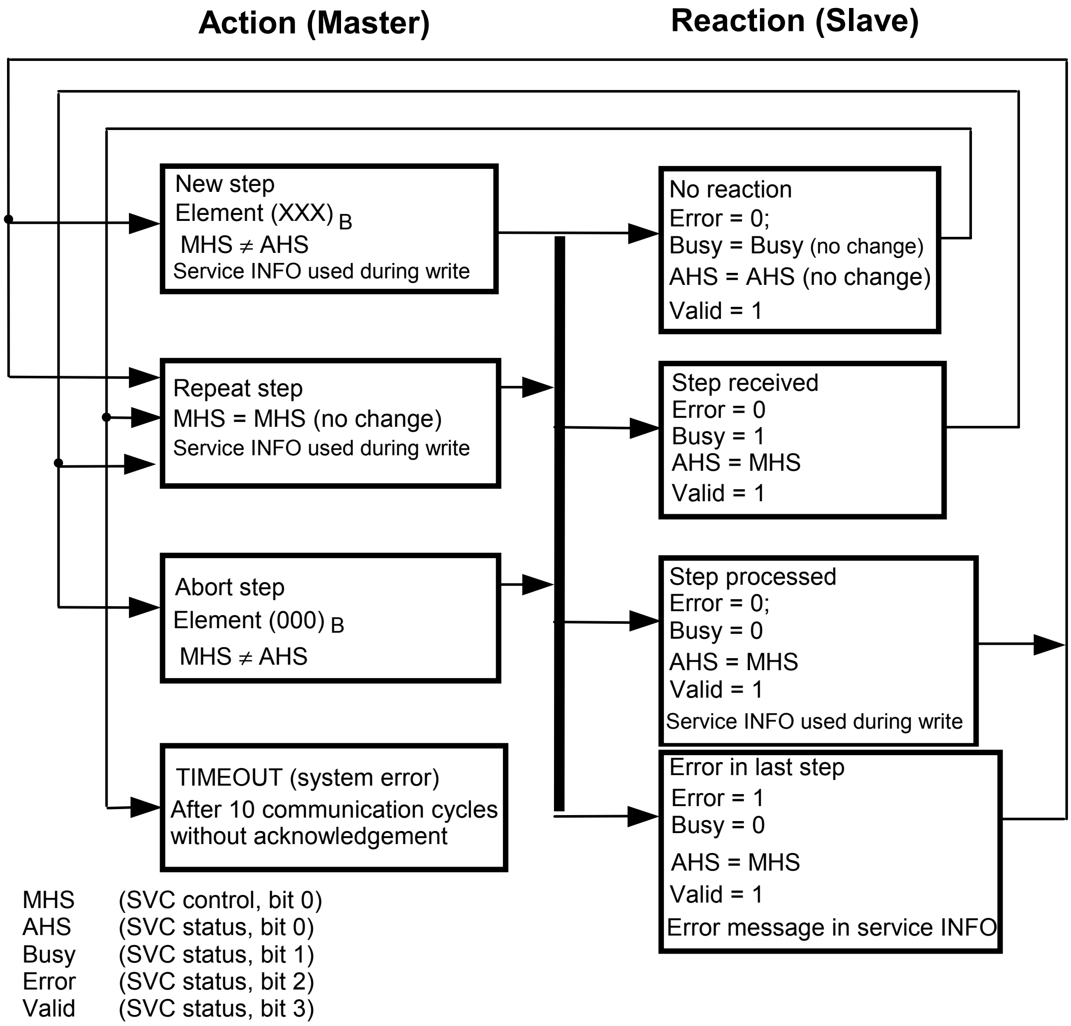


Figure 10 – Communication step proceeding diagram

7.2.1.8 SVC valid

The slave shall set "SVC valid" (SVC status, bit 3) to 1 (valid) as soon as it has finished handling the required service channel action. It shall set it back to 0 (not valid) if it is unable to handle the master's demand (MHS ≠ AHS). In a ring topology, the slave may handle the SVC enquiries either on the primary or on the secondary channel, depending on configuration. In a line topology, the slave shall handle the SVC enquiries only on one channel (primary or secondary) as required by the master.

The master shall evaluate the slave's SVC answer only if it reads "SVC valid" (SVC status, bit 3). It shall not evaluate it if "SVC valid" = 0 (invalid). The master shall scan the SVC in the primary or secondary depending on the topology.

The time-out of SVC valid is the same as HS time-out (see 7.2.1.9).

7.2.1.9 Handshake bits

During SVC transmissions, the transport of every step shall be secured by two service transport handshake bits. These shall be the bits 0 in the SVC control (MHS) and in the SVC status (AHS).

For every new step during the transmission, the master shall toggle the MHS-bit. The slave shall recognize by the toggled MHS-bit that a new step needs to be executed. After the slave has received the required step and secured it for processing, it shall proceed to set its AHS-bit equal to the MHS-bit. By comparing the MHS-bit with the AHS-bit, the master and the slaves shall always be able to recognize the actual transport status during SVC transmission. See Table 34.

Table 34 – SVC channel evaluation

Master's perspective	AHS bit = MHS bit (SVC valid = 1)	The step was received by the slave and secured, slave starts processing. The master shall wait for processing acknowledgment (busy = 0, bit 1 in the SVC status)
	AHS bit ≠ MHS bit or SVC valid = 0	The steps were not yet received or secured by the slave. The master shall repeat the last step
Slave's perspective	MHS bit = AHS bit	The master does not require a new step, slave repeats the last step
	Master MHS-bit ≠ slave AHS-bit	The master requests a new step

The service transport handshake bits shall enable the slaves and the master to insert "wait cycles" during the transmission, e.g.:

- if more than one cycle will be required for receiving or transmitting a step;
- if a new step has not been recognized due to an error during the transmission;
- if the master does not issue any new steps at this time.

During every "wait cycle", the master or the slave shall transmit the data of the previous communication cycle into the SVC INFO field.

After a maximum of 10 communication cycles, the master shall set a "time-out" condition if the slave does not acknowledge the proper reception of a step by matching its AHS-bit or if the valid bit is 0.

7.2.1.10 Busy bit

The slave shall be able to control any SVC transmission through the busy bit. The busy bit shall indicate that the slave is processing or just finishing the requested step at this time. Not until the slave sends the processing acknowledgement (busy bit = 0) shall the master be allowed to start the next step. The busy bit shall allow the slave to prevent the master from forcing the steps on the slave too quickly.

Type 19 does not specify any "time-out" parameter for the processing acknowledgment (busy) of the slave. After some time, depending upon configuration, the master shall be able to interrupt a step which was not acknowledged by the slave, by closing the service channel.

7.2.1.11 List transfer via the service channel

With this function, the control unit shall be able to divide the transport of parameters of large variable length into several smaller ones. It shall also be possible to transfer only elements of the lists without having to transfer the whole list. It shall thus be possible to interrupt a current transfer in order to send prior data via the service channel. After that, the control unit shall be able to resume the earlier transfer at the exact point where it had been interrupted. When accessing the list segment, the slave shall check for plausibility. In case of an error, the slave shall signal "invalid indirect addressing" (0x700B) via the service channel. This functionality shall use the parameters listed in Table 35.

Table 35 – IDN for list transfer

IDN	Description
S-0-0394	List IDN
S-0-0395	List index
S-0-0396	Number of list elements
S-0-0397	List segment

7.2.2 Service channel initialization

In CP1, each service channel shall start with the following status:

- the MHS-bit in the MDT and the AHS-bit in the AT shall be set to 1;
- the SVC valid shall be set to 1. All other bits in SVC control or SVC status shall be set to 0;
- all bits in the SVC INFO fields are invalid.

Starting with CP2, the SVC INFO fields in the MDT and the AT shall become valid. This implies that the master and a slave servicing several devices shall freeze the status of the service channel before switching from one device to another. When addressing this device again at a later time, the master shall be set to this frozen status.

7.2.3 Procedure command control and acknowledgment

7.2.3.1 General

A procedure command function shall always prompt a procedure command control from the master to the slave and a procedure command acknowledgment from a slave to the master. The procedure command control shall be element 7 of the data block (element 7 is always represented as a bit list for procedure commands). See Table 36.

Procedure command control shall allow procedure commands to be

- set;
- enabled for execution;
- interrupted during execution;
- cancelled.

The slave shall acknowledge the transmission of a procedure command from the master via the service channel with its AHS-bit, the busy bit and the SVC valid in its SVC status.

Table 36 – Procedure command control

Bit no,	Value	Description
15-2		Reserved
1		
	0	Interrupt procedure command execution
	1	Enable procedure command execution
0		
	0	Cancel procedure command
	1	Set procedure command

When starting the initializing (CP0), all procedure commands inside the master shall be disabled and then the procedure command control shall be updated appropriately internally in the master.

The procedure command acknowledgment shall be part of the data status (see Table 37).

In order to receive a procedure command acknowledgment, the master shall write the IDN of the procedure command via the service channel.

When acknowledging a procedure command, the slave shall indicate the actual status of the procedure command as given in Table 37. Bits 0 and 1 of the procedure command acknowledgment shall simply be copies of the procedure command control and indicate the actual status of the procedure command.

The procedure commands shall be treated as non-real-time data in the Slave.

If the master activates a procedure command, it can take several communication cycles until the slave generates the corresponding procedure command acknowledgment. Therefore it is recommended that the master scans the procedure command acknowledgment as shown in Table 37.

Table 37 – Procedure command acknowledgment (data status)

Bit no,	Value	Description
15-9		Reserved
8		
	0	Operation data is valid
	1	Operation data is invalid
7-4		Reserved
3		
	0	No procedure command error
	1	Error, procedure command execution is impossible
2		
	0	Procedure command executed correctly
	1	Procedure command not yet executed
1		
	0	Procedure command execution is interrupted
	1	Procedure command execution is enabled
0		
	0	Procedure command is not yet set
	1	Procedure command is set

With the beginning of initialization (CP0), all procedure commands within the slave shall be disabled and then the procedure command acknowledgment shall be updated appropriately internally in the slave.

7.2.3.2 Procedure command change bit

In order to inform the master of the end of a procedure command being executed in the slave, a procedure command change bit shall be reserved in the device status (bit 5).

Only the following changes in the procedure command acknowledgment shall set the procedure command change bit:

- procedure command executed correctly (positive acknowledgment, bit 2 changes from 1 to 0);
- error, procedure command execution impossible (negative acknowledgment, bit 3 changes from 0 to 1).

The procedure command change bit shall not indicate any other change of the procedure command acknowledgment (e.g., an interrupt).

The master shall read the data status by writing the IDN of the procedure command and check the procedure command acknowledgment contained therein. This indicates whether the procedure command was executed positively or negatively.

At negative procedure command acknowledgment, it is recommended that the master reads the diagnosis (if desired) before the procedure command is cancelled.

If a procedure command is cancelled by the master, all the effects of the procedure command on the procedure command change bit in the slave shall be cancelled as well. If the master has activated several procedure commands concurrently, all resulting procedure command acknowledgments shall be checked after setting the procedure command change bit in order to determine which procedure command caused the change.

As a rule, the master shall cancel a procedure command after it has been processed, irrespective of whether it was acknowledged positively or negatively.

A procedure command shall be cancelled by setting bit 0 in the procedure command control to 0. This shall be independent from the actual procedure command execution state.

The state machine Figure 11 describes the allowed state changes for procedure commands.

For procedure command control (CC), only the 0x00 through 0x03 values shall be allowed. If the value is invalid, the slave shall generate the error message “invalid data” in the SVC INFO.

A state change to “procedure command not set” (CA = 0x00), shall only be possible by canceling the procedure command.

If more than one procedure command execution is active and the “procedure command change bit” is set by more than one procedure command, this bit shall be reset in the device status when all procedure commands which had set the bit are cancelled.

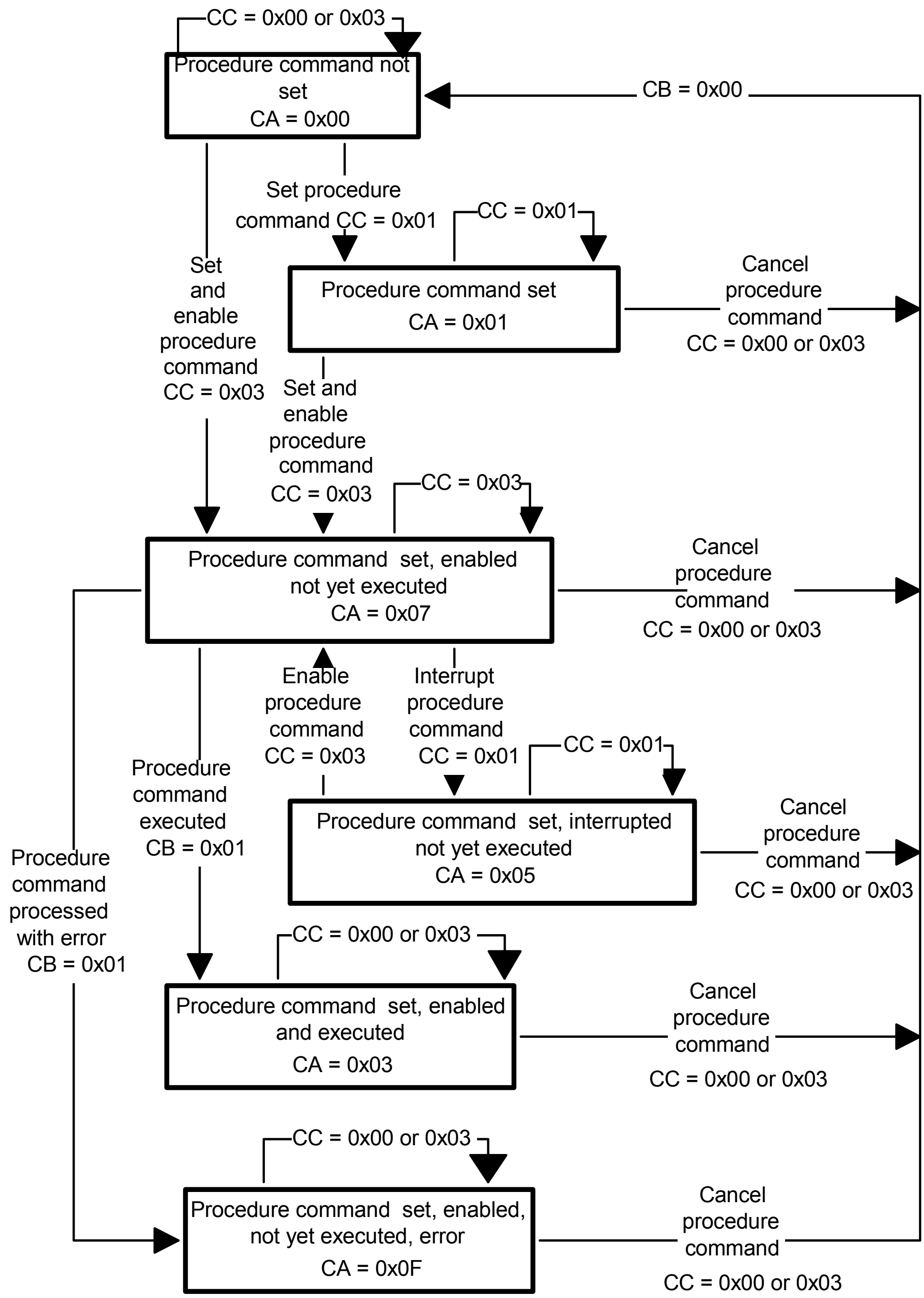


Figure 11 – State machine for procedure command execution

Figure 12 shows the sequence of procedure command handling that shall be met by the master.

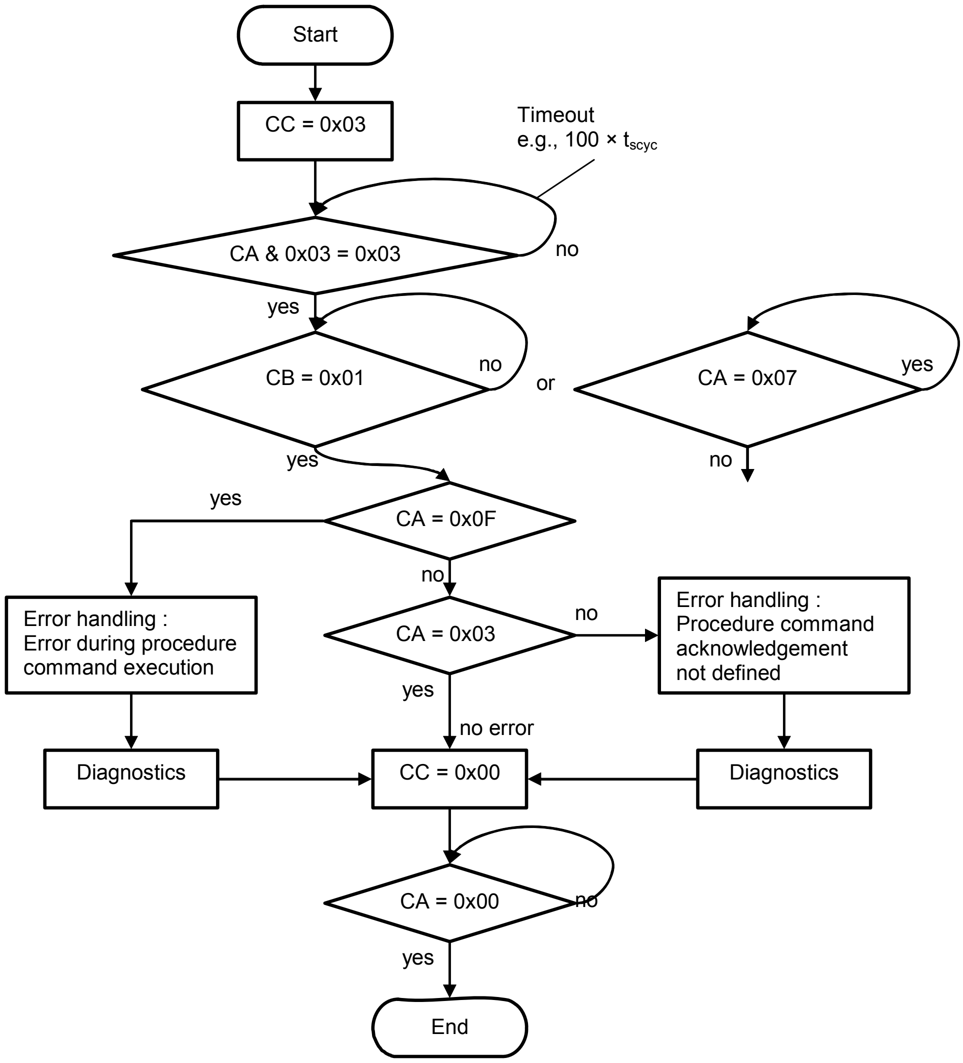


Figure 12 – Interaction of procedure command control and acknowledgement

7.2.3.3 Procedure command execution

In the following Figure 13, Figure 14 and Figure 15, the interactions between the master and the slave are represented, including procedure command executions with or without interruption and procedure command executions with error messages.

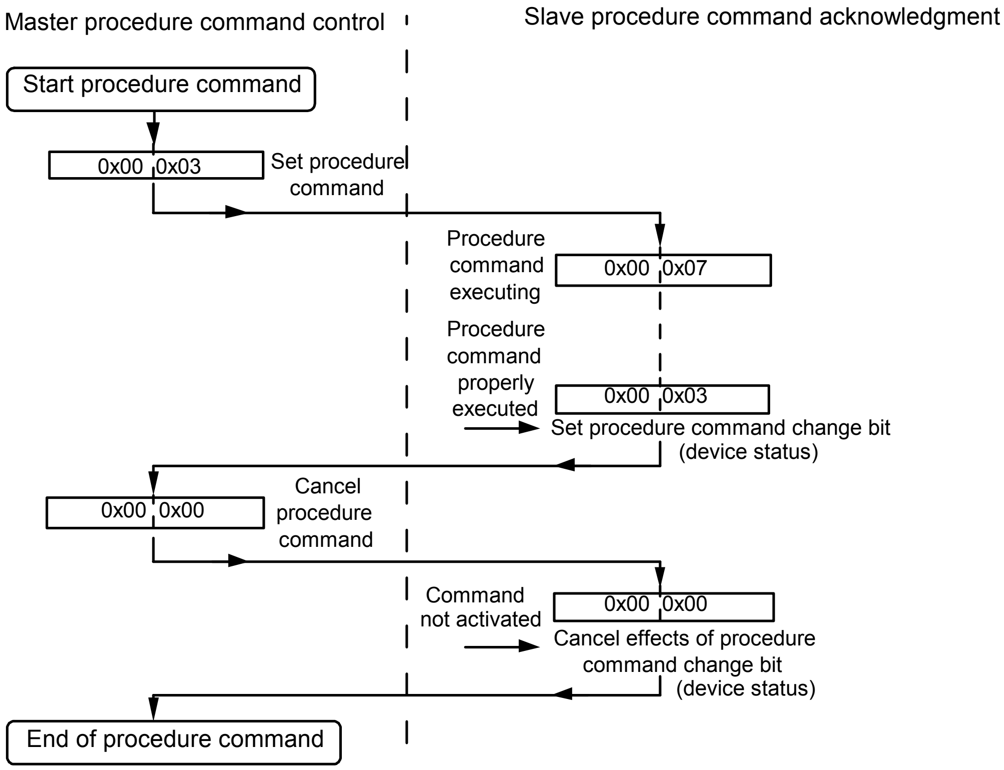


Figure 13 – Procedure command execution without interrupt

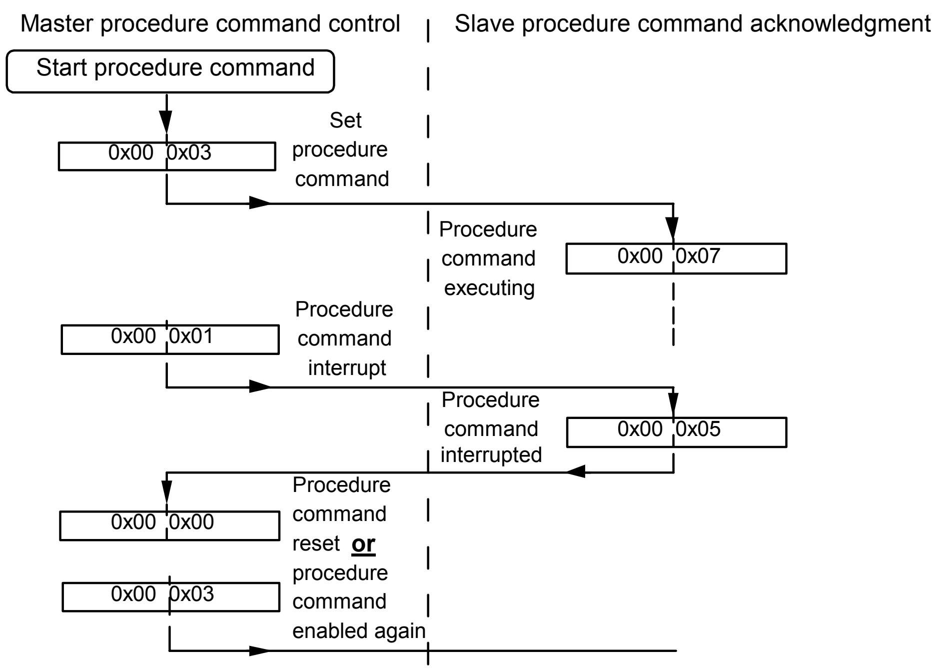


Figure 14 – Procedure command execution with interrupt

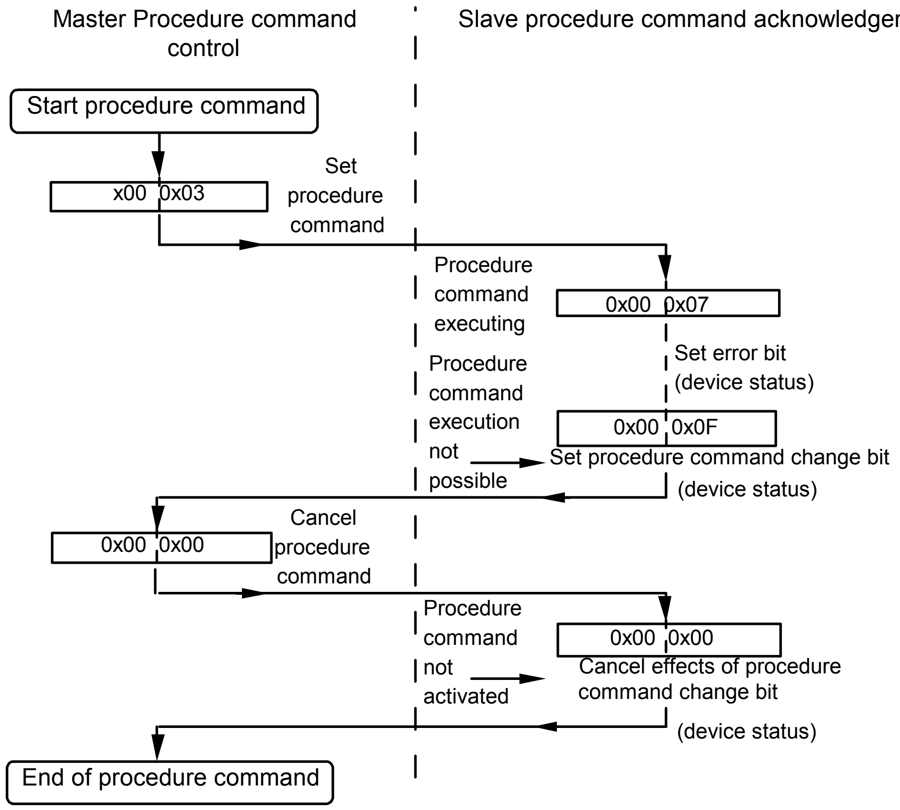


Figure 15 – Procedure command execution with error message

7.2.3.4 Procedure command functions via the service channel

In the Type 16 interface, procedure command functions shall be transmittable through the service channel. A procedure command is considered as a special type of non-cyclic data which, when transmitted through the service channel, invokes fixed functional processes in both the slaves and the master. These processes can take up some time. Hence, a procedure command shall only cause a functional process to start. After a procedure command has started its function, the service channel shall become available again immediately for the transmission of non-cyclic data or for more procedure commands.

Contrary to non-cyclic data transmission, whose proceeding shall be finished with the last transmitted step, the end of a procedure command during a lengthy procedure command execution shall be indicated by the procedure command change bit (bit 5 in the AT status word). The master shall also be able to interrupt a procedure command during its execution which is not possible for non-cyclic data transmission.

Every procedure command shall have been assigned an IDN and an appropriate data block. Not all elements of the data block are defined, however, and other elements have a predetermined form. Procedure commands are described in more detail in IEC 61800-7-20x.

7.3 RTC

7.3.1 Introduction

Cyclic data is exchanged between all devices in a Type 16 network in communication phase 4 according to the configuration given by the Initiate_cyclic_communication request (see 4.2).

7.3.2 Read_Cyclic (RDC)

Cyclic data is read by a DL user using the Read_Cyclic (RDC) request.

7.3.3 Write (WRC)

Cyclic data is written by a DL user using the Write_Cyclic (WRC) request. The cyclic data is transmitted in the next communication cycle of the Type 16 network.

7.3.4 Notify_Cyclic_Data (NCD)

Upon reception of a DLPDU of Type MDT0-MST the DL generates a Notify_Cyclic_Data (NCD) indication for the DL user.

8 DL management

8.1 Overview

The order of bit transmission of the address and data fields shall be low-order bit first (e.g., the first bit of the sequence number that is transmitted shall have the weight 2^0). If two octets make up a 16-bit word or if four octets form a 32-bit word, the lowest-valued octet shall always be transferred first.

If there are several operation data in the configurable part of the data record, then the LSB of the low octet of the first operation data shall be sent first.

The frame check sequence shall be transmitted to the line commencing with the bit of the coefficient with the highest term (X^{15}).

8.2 Access to PhL

8.2.1 Introduction

A synchronous error-free media access control shall be used. Telegrams shall be exchanged in fixed communication cycles. The master shall start the communication cycle strictly equidistant with the communication cycle time t_{Scyc}, by transmitting the master synchronization telegram (MST).

This MST shall be transmitted as a broadcast telegram to all stations and reach all slaves simultaneously, not taking into account the time delay of the ring. The MST is especially short, since it only has information about the status of the network in its data field. The content of the data field shall remain constant during the same communication phase so that bit-stuffing does not cause jitter at the end of the telegram.

The acknowledge telegram is called AT_m, if m represents the number of the transmission timeslot for the associated device XX (m = 1, 2 ... M; M = the number of devices in the network). The transmission timeslot describes the time interval within which a slave is allowed to transmit an AT from one of its connected devices. The beginning of the mth AT transmission timeslot shall follow $t_{1.m}$ after the end of the MST. This timeslot shall be stored by the device (slave) as an IDN (i.e. in a variable slave memory which can be read or written to by the master).

The sequence of timeslots shall determine the timing of the ATs, which shall be independent of the physical order of the ring as well as the defined device address. The master shall be the recipient of the ATs. Slave units positioned between the master and the transmitting slave shall transmit the telegrams by means of its repeater function.

The MDT shall be sent out at time t_2 after the end of the MST after all ATs have been sent within a communication cycle. All devices shall be receivers of the MDT. The next cycle shall start with the transmitting of the next MST.

From now on, “beginning of frame” (telegram), BOF, shall be the signal edge point which marks the leading binary 0 of the opening delimiter. Similarly, end of frame (telegram), EOF, shall be the signal edge point of the last binary 0 of the closing delimiter.

8.2.2 Cycle times

The communication cycle time, t_{Scyc}, shall have one of the following values:

t_{Scyc} = 62,5 µs, 125 µs, 250 µs to 65 ms (in 250 µs increments)

This cycle time is allowed to have some jitter. The jitter describes the deviations from the t_{Scyc} value in the distance between the ends of two MSTs. J_{tScyc} is determined shown in Table 38.

Table 38 – Allowed jitter

Jitter MST	2 Mbit/s and 4 Mbit/s	8 Mbit/s and 16 Mbit/s
J_{tScyc}	min {5 µs; 0,005 × t_{Scyc}} + 4 × t_{BIT}	1 µs

Therefore, the actual time interval between the end of an MST and the end of the j^th^ following MST shall have a minimum value of

j x tScyc × 0,9999× JtScyc (j = 1, 2, 3, ...)

and a maximum value of:

j x tScyc × 1,0001 + JtScyc (j = 1, 2, 3, ...)

NOTE j is an ordinary integer and not related to the abbreviations.

The factors 0,999 9 or 1,000 1 take into account the deviation of the communication cycle time t_{Scyc}, compared to the accuracy of the usual crystal oscillators ($\pm 10^{-4}$). Note that the jitter shall not accumulate over several periods (i.e. the average value shall be zero).

8.2.3 Medium access

8.2.3.1 General

Figure 16 shows the medium access during CP3 and CP4 (cyclic operation). The medium access during CP0 - CP2, which are used during initialization, is given in the following subclauses.

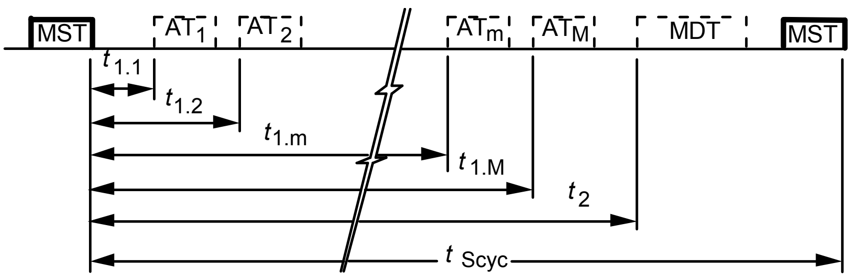


Figure 16 – Access to the transfer medium

Medium access is specified by time parameters which shall follow specific limits. Some times are allowed to have a certain amount of jitter.

8.2.3.2 Timing diagram for CP0

During CP0, the master shall only send the MST and the fill signal (see IEC 61158-2, 30.3.2.2).

The communication cycle time shall be preset by the master with $t_{Scyc} \geq 1$ ms (see Figure 17).

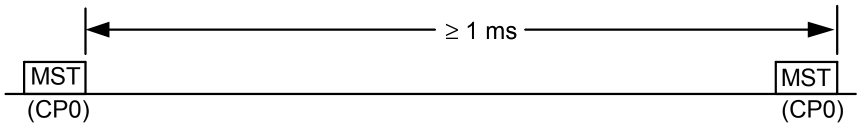


Figure 17 – Timing diagram for CP0

8.2.3.3 Timing diagram for CP1 and CP2

The communication cycle time shall be preset by the master with $t_{Scyc} \geq 1$ ms. The telegram transmission starting times during CP1 and CP2 are shown in Figure 18.

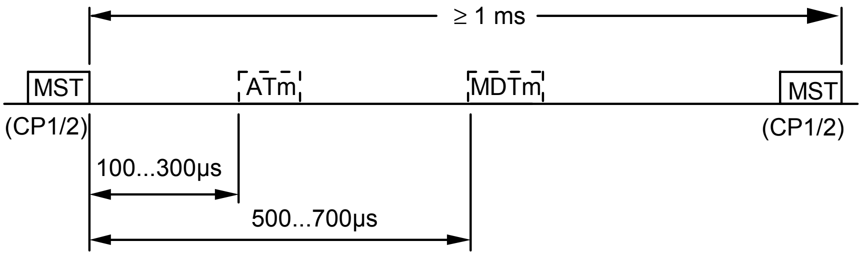


Figure 18 – Telegram transmission starting times of CP1 and CP2

An AT shall be sent by a slave only if the MDT, which was received before the last MST, was directed at its own address.

8.2.3.4 Timing diagram for CP3

Telegram transmission starting times are specified by the parameters which shall have been transmitted during CP2 and correspond to the timeslots for cyclical operation.

8.2.3.5 Timing diagram for CP4

During cyclic operation all telegrams shall be transmitted in predetermined timeslots. All timing shall be in reference to the end of the MST. The appropriate timing shall be established for every device during CP2.

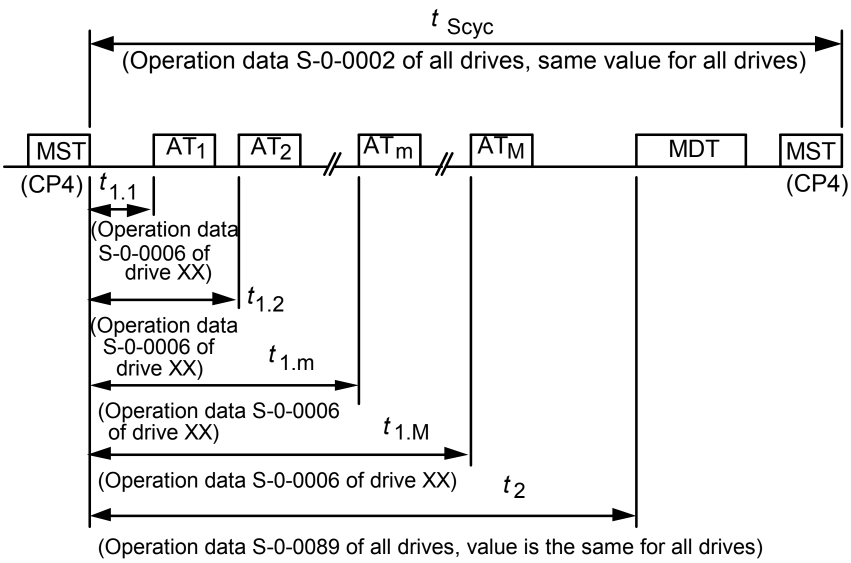


Figure 19 – Timing diagram for cyclic operation

During the initialization phase, the master shall inquire about some time parameters from the slaves (see 8.2.4). With this information, it is possible to calculate a collision-free distribution of transmission timeslots for the telegrams within the communication cycles.

The master shall proceed to transmit the AT transmission starting time, $t_{1.m}$, for all connected devices to each slave as well as the transmission starting time of the MDT t_2. These starting times of the transmitting timeslots for the telegrams are defined next. Jitter has been incorporated in $t_{1.m}$ and t_2:

- t_2 – MDT transmission starting time: this is the nominal time interval between the end of the MST and the beginning of the MDT during CP3 and CP4. The master shall store this time interval in an IDN in the devices.
- J_{t2} – Jitter in t_2: this is the maximum deviation of the beginning of the MDT. It is the allowed deviation of the time interval t_2. J_{t2} is determined as shown in Table 39.

Table 39 – Jitter in t_2

Jitter MDT	2 Mbit/s and 4 Mbit/s	8 Mbit/s and 16 Mbit/s
J_{t2}	min. {5 µs; 0,005 × t_{Scyc}} + 4 × t_{BIT}	1 µs

The actual time interval between the end of a MST and the beginning of a MDT shall lie between t_2 - J_{t2} and t_2 + J_{t2}.

- t_1 – AT transmission starting time: this is the nominal time interval between the end of the MST and the beginning of the AT. Every device shall have its determined $t_{1.m}$. This parameter shall have been determined by the master and be stored in the associated device as an IDN.
- J_{t1} – Jitter in t_1: this is the maximum deviation of the beginning of the AT. It is the allowed deviation of the time interval t_1. J_{t1} is determined as shown in Table 40:

Table 40 – Jitter in t_1

Jitter AT	2 Mbit/s and 4 Mbit/s	8 Mbit/s and 16 Mbit/s
J_{t1}	min. {5 µs; 0,005 × t_{Scyc}} + 4 × t_{BIT}	1 µs

The actual time interval between the end of a MST and the beginning of an AT_m shall lie between $t_{1.m}$ - J_{t1} and $t_{1.m}$ + J_{t1}.

Figure 16 shows the starting times of the transmission timeslots.

8.2.3.6 Timing diagram for CP5

The communication cycle time is preset by the master so that t_{Scyc} ≥ 1 000 µs. The Telegram Transmission Starting Times during CP5 are shown in Figure 20.

In order to provide sufficient time for data transmission, it is necessary to use Telegram Transmission Start Times that are different from the Telegram Transmission Start Times of CP1.

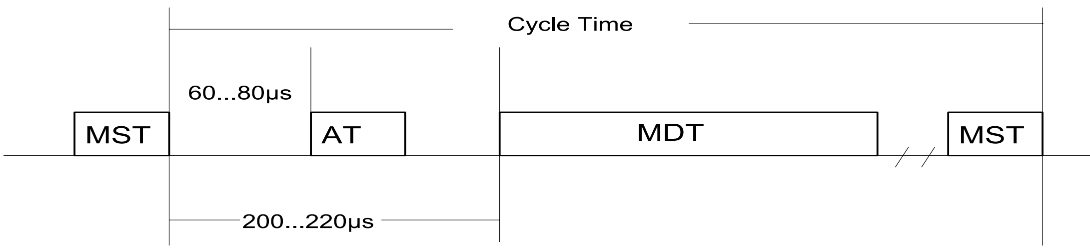


Figure 20 – Telegram transmission times in CP5

8.2.3.7 Timing diagram for CP6

The communication cycle time shall be preset by the master so that t_{Scyc} ≥ 1000 µs. The Telegram Transmission Starting Times during CP6 are shown in Figure 21.

In order to provide sufficient time for data transmission, it is necessary to use Telegram Transmission Start Times that are different from the Telegram Transmission Start Times of CP1.

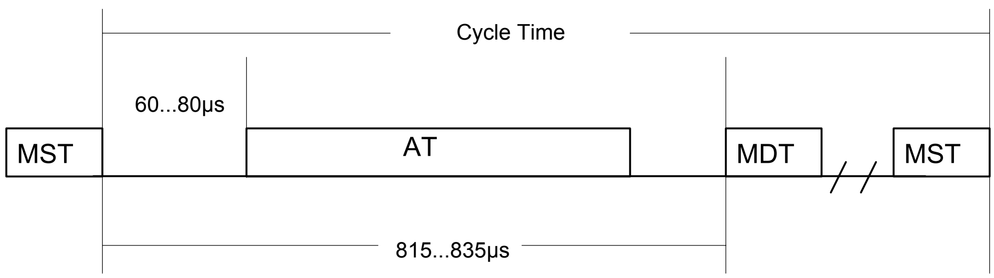


Figure 21 – Telegram transmission times in CP6

8.2.4 Time parameters

The following time parameters are characteristic values of slaves. They shall be requested by the master from every slave during initialization, excluding the values for t_{ATRP} and t_{RPAT}.

- t_{1min} – Shortest AT transmission starting time. $t_{1min.m}$ shall be the minimum time after the MST that device XX with data record m can transmit its AT. This parameter shall be stored in all devices as an IDN.
- t_{ATRP} – Maximum transition time of a slave to switch from transmitting the AT to the repeater function. This time interval shall not exceed 4 × t_{BIT}
- t_{RPAT} – Maximum transition time of a slave to switch from repeater function to transmit the AT. This time interval shall not exceed 2 × t_{BIT}
- $t_{ATMT.M}$ – Transmit/receive transition time in the device M (ADR XX) to switch from transmitting an AT to the ready state for receiving the MDT. This parameter shall be stored in all devices as an IDN.
- $t_{MTSY.K}$ – Receive to receive recovery time needed by the slave which is served with data record K in order to be ready to receive the MST from the end of the MDT. This parameter shall be stored in all devices as an IDN.
- t_{ATAT} – Transmit to transmit recovery time needed by a slave with several devices, in order to transmit another acknowledge telegram after the end of a acknowledge telegram. The actual time required may be exceeded by J_{t1}. This parameter shall be stored as an IDN in all devices which belong to the same slave. Otherwise, such an IDN shall not be available.

The minimum distance to be maintained between the end of one AT and the following telegram shall be determined from the following parameters:

- t_{ATRP}, where another AT follows the current AT which is not sent by the same slave;
- t_{ATAT}, where another AT follows the current AT which is sent by the same slave;
- t_{ATMT}, where the MDT follows the AT.

These defined time parameters are shown in Figure 22.

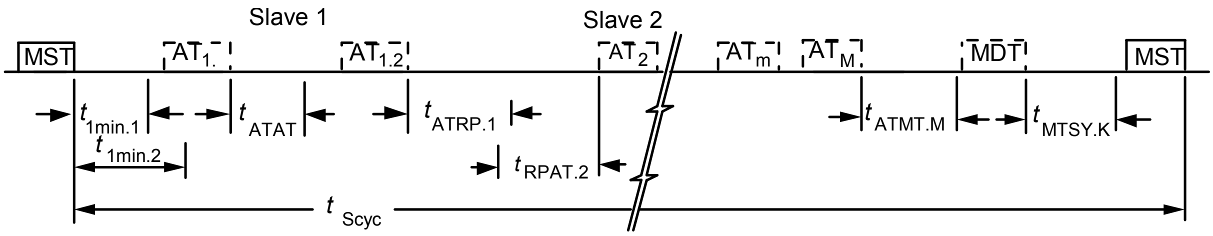


Figure 22 – Required time intervals between telegrams

9 Error handling and monitoring

9.1 Invalid telegrams

A telegram shall be invalid if any of the following faults occur or any combination hereof:

a) it is not properly bounded by delimiters at the beginning and at the end;

b) if the bit sequence enclosed by the delimiters does not correspond to the length defined during initialization (e.g. shorter than 32 bits).

c) the CRC check is not correct;

d) the telegram does not arrive within the defined time tolerance limits.

Additionally, an MST shall be invalid if the INFO octet does not indicate a valid communication phase.

Invalid telegrams shall be ignored by the receiver.

Telegrams ending with seven or more sequential binary 1's instead of the defined delimiter shall be ignored by the receiver.

9.2 Response to MDT and AT telegram failure

If a telegram failure occurs, the master and the slave shall respond as follows:

a) the synchronization of the interface shall be maintained;

b) several counters (internal) shall be incremented for missing telegrams;

In addition, a slave shall not send its AT if it has not received the MST in the previous cycle.

The application profile may specify additional response (e.g., on the basis of the last correct command values, a power device system shall calculate internal command values to replace the missing telegram, as specified in IEC 61800-7-3, annex D).

Table 41 shows the error patterns for all communication phases if two successive MSTs fail:

Table 41 – Loss or failure of master synchronization telegram (MST)

CP	Reaction in master	Reaction in the slave
0	The master registers the network as open. The network is closed only after the master has received a defined number of successive MSTs without any errors. This is the pre-condition for operating in CP1	None
1	None. Beginning with CP1, the master no longer performs monitoring of the MST	None
2	None	None
3	None	The slave automatically returns to CP0 and waits for the MST of CP0. The device sets the “communication error bit” in C1D (see S-0-0011)
4	None	The slave automatically returns to CP0 and waits for the MST of CP0. In addition, all its connected and running devices are shut-down in the best possible way. The devices set the “communication error bit” in C1D (see S-0-0011)
NOTE Monitoring, see 9.8.		

Table 42 shows the error patterns for all CPs if the slave registers two successive MDT failures:

Table 42 – Failure of master data telegrams (MDT)

CP	Reaction in master 1)	Reaction in the slave 2)
0		None
1		None
2		None
3		None
4		In CP4, the failure of two successive MDTs will result in the best possible shut-down of those devices that are controlled by the slave. The slave returns to CP0 and waits for the MST of CP0. The devices set the “communication error bit” in C1D (see S-0-0011)

1) Reaction in the master: no reaction in any CP. The master will react indirectly to the behavior of the device.

2) Monitoring, see9.8.

Table 43 shows the error patterns for all CPs if the master registers two successive AT failures.

Table 43 – Failure of acknowledge telegrams (AT)

CP	Reaction in master 4)	Reaction in the slave 4)
1	The master responds by indicating on the display that a device is missing 1) 5)	None 3)
2	The master returns to CP0 and attempts to close the network 5)	None 3)
3	The master returns to CP0 and attempts to close the network 2)	None 3)
4	The master responds where applicable, with an error handling procedure stored in the control unit, and then returns to CP0 and attempts to close the network 2)	None 3)

1) The master registers a device has failed according to the specifications in 9.1.

2) Error pattern: failure of two successive ATs of the same address. (The first cycle in CP3 does not need an AT. Therefore this missing AT is not counted.)

3) Reaction in the device: the devices react indirectly to the reset to CP0.

4) Monitoring, see 9.9.

5) A failure of AT will be recognized by the master if during handshake timeout no response of the addressed device was received.

9.3 Reaction to handshake timeout

A handshake (HS) timeout shall occur if any addressed device does not acknowledge its AHS-bit in the Status word after 10 communication cycles in CP2 to CP4. During CP1, a device shall be registered as not present if the AHS-bit has not been set to a logical 1 within the maximum device identification time (see Table 44).

Table 44 – Reaction to handshake timeout

CP	Reaction in master	Reaction in the slave
2-4	Error message is sent to the operator. The master responds with an error handling procedure that may be stored in the control unit and then switches back to CP0	No response possible

9.4 Service channel error messages

Should an error occur in the transport mechanism of the service channel (e.g. if the lengths of the operation data differ between the master and the device, or vice versa, or if the IDN is undefined), the slave shall announce it by setting the error bit (bit 2) in the status word and by writing an error code into the service INFO field of its AT.

The slave shall be allowed to report an error message only if a new processing step is issued by the master, which is in any of following cases:

- MHS-bit ≠ AHS-bit (step not yet secured);
- busy bit = 1 (step still in process).

If the device recognizes an error, it shall ignore the actual step, interrupt and acknowledge by

- setting the AHS-bit equal to the MHS-bit (if not already acknowledged in a previous cycle);
- setting the error bit to 1 (SVC status, bit 2);
- setting the busy bit to 0;
- setting the SVC valid to 1.

If the master intends to repeat the transmission of an element after an error message, the lowest-valued octet of the element shall be transmitted first.

All possible SVC error messages are shown in Table 45.

Table 45 – Error messages

Error code	Description/meaning
0x0nnn	**General error**
0x0000	No error in the service channel
0x0001	Service channel not open
0x0009	Invalid access to closing the service channel
0x1nnn	**Element 1 (Ident number)**
0x1001	No IDN
0x1009	Invalid access to element 1
0x2nnn	**Element 2 (Name)**
0x2001	No name
0x2002	Name transmission too short
0x2003	Name transmission too long
0x2004	Name cannot be changed (read only)
0x2005	Name is write-protected at this time
0x3nnn	**Element 3 (Attribute)**
0x3002	Attribute transmission too short
0x3003	Attribute transmission too long
0x3004	Attribute cannot be changed (read only)
0x3005	Attribute is write-protected at this time
0x4nnn	**Element 4 (Unit)**
0x4001	No units
0x4002	Unit transmission too short
0x4003	Unit transmission too long

Error code	Description/meaning
0x4004	Unit cannot be changed (read only)
0x4005	Unit is write-protected at this time
0x5nnn	**Element 5 (Minimum input value)**
0x5001	No minimum input value
0x5002	Minimum input value transmission too short
0x5003	Minimum input value transmission too long
0x5004	Minimum input value cannot be changed (read only)
0x5005	Minimum input value is write-protected at this time
0x6nnn	**Element 6 (Maximum input value)**
0x6001	No maximum input value
0x6002	Maximum input value transmission too short
0x6003	Maximum input value transmission too long
0x6004	Maximum input value cannot be changed (read only)
0x6005	Maximum input value is write-protected at this time
0x7nnn	**Element 7 (Operation data)**
0x7002	Operation data transmission too short
0x7003	Operation data transmission too long
0x7004	Operation data cannot be changed (read only)
0x7005	Operation data is write-protected at this time (e.g. communication phase)
0x7006	Operation data is smaller than the minimum input value
0x7007	Operation data is greater than the maximum input value
0x7008	Invalid operation data: Configured IDN will not be supported, invalid bit number or bit combination
0x7009	Operation data write protected by a password
0x700A	Operation data is write protected, it is configured cyclically. (IDN is configured in the MDT or AT. Therefore writing via the service channel is not allowed).
0x700B	Invalid indirect addressing: (e.g., data container, list handling)
0x700C	Operation data is write protected, due to other settings. (e.g. parameter, operation mode, PDS enable, PDS on etc.)
0x700D	Reserved
0x700E	Reserved
0x700F	Reserved
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Procedure command at this time not executable (e.g. in this phase the procedure command can not be activated).
0x7013	Procedure command not executable (invalid or false parameters)
NOTE All other codes are reserved.	

9.5 Reaction to error messages in the service channel

A valid error message for the master is present in the service channel if the device sets bit 2 in the device status word to logical 1 and the AHS-bit of the device equals the MHS-bit of the master control word (see Table 46).

Table 46 – Reaction to error message

CP	Reaction in master	Reaction in the slave
2-4	Display of an error message	The step currently being processed is interrupted, the busy bit (bit 1 – status word) is set to 0

9.6 Error counters in the master and the slave

Error counters 1 in the master shall count successive MST failures in CP0 and successive AT failures starting in CP3. There shall be one MST counter 1 and different AT counters 1 for each device. If one of these counters has the value 2, the master shall return to CP0 and the system shall only be able to restart by means of a new initialization (see Table 47).

Table 47 – States of error counters 1 in the master for MST and AT failures

Event	Reaction in the master
Telegram failure according to 9.1	Error counters 1 (MST, AT) increments by 1
Telegram valid received	Error counters 1 (MST, AT) resets to 0
Error counters 1 (MST, AT) ≥ 2	Master returns to CP0

Error counter 1 (for MST-failures in the devices) shall count successive MST-failures in CP3 and CP4. If the MST-counter 1 of a device has the value 2, the appropriate slave shall return to CP0 and wait for the MST of CP0. (During CP4, all its connected and running devices shall be shut-down in the best possible way.) The device shall set the communication error bit in C1D (see Table 48).

Table 48 – States of error counter 1 in the devices for MST-failures in CP3 and CP4

Event	Reaction in the slave
MST failure according to 9.1	Error counter 1 (MST) increments by 1
MST valid received	Error counter 1 (MST) resets to 0
Error counter 1 (MST) ≥ 2	Slave returns to CP0, sets communication error bit in C1D, and waits until the master reinitializes the network

Error counter 1 for MDT-failures in the devices shall count successive MDT-failures in CP4. If the MDT counter of a device has the value 2, the appropriate slave shall return to CP0 and wait for the MST of CP0. All its connected and running devices shall be shut-down in the best possible way. The device shall set the communication error bit in C1D (see Table 49.)

Table 49 – States of error counter 1 in the devices for MDT-failures in CP4

Event	Reaction in the slave
MDT failure according to 9.1	Error counter 1 (MDT) increments by 1
MDT valid received	Error counter 1 (MDT) resets to 0
Error counter 1 (MDT) ≥ 2	Slave returns to CP0, sets communication error bit in C1D, and waits until the master reinitializes the network

The master shall have an AT error counter 2 for each device which shall count independently. If more than two consecutive ATs are invalid, the invalid ATs over two shall not be counted. The counters shall be reset to 0 during the transition from CP2 to CP3 and incremented in CP3 and CP4 to a maximum value of 2^{16}–1, 0xFFFF. There shall be different counters for each device. The counters for AT-failures shall be readable in the master for certification (see Table 50).

Table 50 – States of error counters 2 in the master for AT-failures

CP	Event	Reaction in the master
0, 1, 2	AT failure according to 9.1	Error counter 2 (AT) does not change
	AT valid received	Error counter 2 (AT) does not change
	Transition from CP2 to CP3	Error counter 2 (AT) resets to 0
3, 4	AT failure according to 9.1	Error counter 2 (AT) increments by 1
	AT valid received	Error counter 2 (AT) does not change
	Error counter 2 (AT) = 0xFFFF	Error counter 2 (AT) does not change and stops incrementing

Error counter 2 (for MST-failures in the devices) shall count all MST-failures in CP3 and CP4. If more than two consecutive MSTs are invalid, the invalid MSTs over two shall not be counted. This MST error counter shall have the IDN S-0-0028 in every device and the master from CP2 on shall be able to read and reset it (see Table 51). The maximum value for this counter shall be 0xFFFF.

Table 51 – States of error counter 2 in the devices for MST-failures

CP	Event	Reaction in the slave
0, 1, 2	MST failure according to 9.1	Error counter 2 (MST) does not change
	MST valid received	Error counter 2 (MST) does not change
	Transition from CP2 to CP3	Error counter 2 (MST) resets to 0
3, 4	MST failure according to 9.1	Error counter 2 (MST) increments by 1
	MST valid received	Error counter 2 (MST) does not change
	Error counter 2 (MST) = 0xFFFF	Error counter 2 (MST) does not change and stops incrementing

Error counter 2 for MDT-failures in the device shall count all MDT-failures in CP4. If more than two consecutive MDTs are invalid, the invalid MDTs over 2 shall not be counted. This MDT error counter shall have the IDN S-0-0029 in every device and the master from CP2 on shall be able to read and reset it (see Table 52). The maximum value for this counter shall be 0xFFFF.

Table 52 – States of error counter 2 in the devices for MDT-failures

CP	Event	Reaction in the slave
0, 1, 2	MST failure according to 9.1	Error counter 2 (MDT) does not change
	MDT valid received	Error counter 2 (MDT) does not change
	Transition from CP2 to CP3	Error counter 2 (MDT) resets to 0
3, 4	MDT failure according to 9.1	Error counter 2 (MDT) increments by 1
	MDT valid received	Error counter 2 (MDT) does not change
	Error counter 2 (MDT) = 0xFFFF	Error counter 2 (MDT) does not change and stops incrementing

9.7 Error effects on communication phases

9.7.1 Ascending communication phases

The sequence of communication phases shall be maintained in ascending order (0, 1, ..., 4). If this sequence is not maintained, the slave shall return to CP0. The communication error bit shall be set in C1D.

9.7.2 Descending communication phases

A change of the CPs in descending order shall only be accomplished through CP0. The progression from CP0 shall be accomplished in accordance with 6.2.2.

If the master switches from a higher CP to a lower CP other than CP0, the slave shall then immediately return to CP0 and wait for the MST of CP0 from the master. The communication error bit shall then be set in C1D.

9.8 Monitoring in the master

Monitoring in the master shall be done according to Table 53.

Table 53 – Master monitoring

Communication Phase	CP0	CP1	CP2	CP3	CP4
MST monitoring with:					
CRC checking	X	–	–	–	–
Telegram length checking	X	–	–	–	–
MDT monitoring with:					
CRC checking	–	–	–	–	–
Telegram length checking	–	–	–	–	–
AT monitoring with:					
CRC checking	–	X	X	X	X
Telegram length checking	–	X	X	X	X
Timing check	–	X	X	X	X
Error counters 1 (count successive telegram failures, maximum value = 2)					
Count of MST failures	X	–	–	–	–
Count of MDT failures	–	–	–	–	–
Count of AT failures	–	–	–	X	X
Error counters 2 (count all telegram failures, maximum value = 2^{16}– 1)					
MST error counter (S-0-0028)	–	–	–	–	–
MDT error counter (S-0-0029)	–	–	–	–	–
Count of AT failures	–	–	–	X	X
NOTE X = monitoring/checking is necessary; – = monitoring/checking is not necessary.					

9.9 Monitoring in the slave

Monitoring in the slave shall be done according to Table 54.

Table 54 – Slave monitoring

Communication Phase	CP0	CP1	CP2	CP3	CP4
MST monitoring with:					
CRC checking	X	X	X	X	X
Telegram length checking	X	X	X	X	X
INFO–octet	X	X	X	X	X
Timing check	–	–	–	X	X
MDT monitoring with:					
CRC checking	–	X	X	X	X
Telegram length checking	–	X	X	X	X
Timing check	–	X	X	X	X
AT monitoring with:					
CRC checking	–	–	–	–	–
Telegram length checking	–	–	–	–	–
Error counters 1 (count successive telegram failures, maximum value = 2)					
Count of MST failures	–	–	–	X	X
Count of MDT failures	–	–	–	–	X
Count of AT failures	–	–	–	–	–
Error counters 2 (count all telegram failures, maximum value = 2^{16}– 1)					
MST error counter (S-0-0028)	–	–	–	X	X
MDT error counter (S-0-0029)	–	–	–	–	X
Count of AT failures	–	–	–	–	–
NOTE X = monitoring/checking is necessary; – = monitoring/checking is not necessary.					

Annex A
(normative)
–
IDN – Identification numbers

A.1 IDN specification

A.1.1 Introduction

All operation data shall be assigned IDNs.

Every IDN shall have an underlying data block. Data blocs shall be used in different data types to supply additional information, which is required to allow the display and input of data and the use of universal routines by means of the control terminal.

This additional information is necessary for handling arbitrary slave-related data. With this information, anonymous operation data can be interpreted by the control unit.

The data block structure shall be as shown in Table . In a data block, elements 1, 3, and 7 shall be mandatory and always present. Elements 2, 4, 5, and 6 are optional and may be supported depending on configuration. Elements 5 and 6 are mandatory for cycle time parameters (S-0-0001, S-0-0002) only. The appropriate elements of the data blocks shall be selected via the service channel control bits in the control word.

Table A.1 – Data block structure

Element No.	Description	Requirement
1	IDN	mandatory
2	Name	optional
3	Attribute	mandatory
4	Unit	optional
5	Minimum input value	optional
6	Maximum input value	optional
7	Operation data	mandatory
NOTE Elements 5 and 6 are mandatory for cycle time parameters (S-0-0001, S-0-0002).		

A.1.2 Element 1: structure of IDN

If written and read via the service channels, the appropriate data shall be addressed by means of the IDNs. Beyond that, operation data within the configurable part of the data records of the AT and MDT shall be as defined by means of the IDNs.

IDN numbering shall have a range of 2^{16}, which shall be subdivided as follow:

a) two ranges shall be available for standard IDNs and manufacturer-specific IDNs. Manufacturer-specific IDNs are out of the scope of standardization;
b) every range shall be subdivided into eight parameter sets;
c) each set shall thus have up to 4 095 IDNs.

IDNs shall be transferred in telegrams as 16-bit binary numbers.

NOTE 1 As an example, S–2–00005 is the standard IDN for “Minimum feedback processing time (t_5)” in parameter set 2.

NOTE 2 Operation data which are not included in standard data but which are required for a specific function of the product shall be specified by the appropriate manufacturer in the product data record. Example: P-3-1234.

Table A.2 and Figure A.1 describe the structure of IDNs.

Table A.2 – IDN structure

Bit no,	Value	Description
15		
	0	Standard data (normative)
	1	Product data (determined by manufacturer)
14-12		
	000-111	Parameter set 0 – 7
11-0		
	0000-4095	Data block number

X	–	X	–	XXXX
S – Standard data P – Product data		Parameter set		Data block number

Figure A.1 – General IDN structure

A.1.3 Element 2: name of operation data

The name shall consist of 64 octets maximum. It shall have two length specifications of two octets each and a character string of maximum 60 ASCII characters (60 octets). Octets 1 and 2 of the name shall specify the length of the programmed text in octets. Octets 3 and 4 of the name shall indicate the maximum number of characters available for text in a slave if the name is changeable. Text longer than that specified by these octets cannot be stored in the slaves. Length specifications of the initial four octets shall be coded for hexadecimal digits. Figure A.2 shows the IDN name structure.

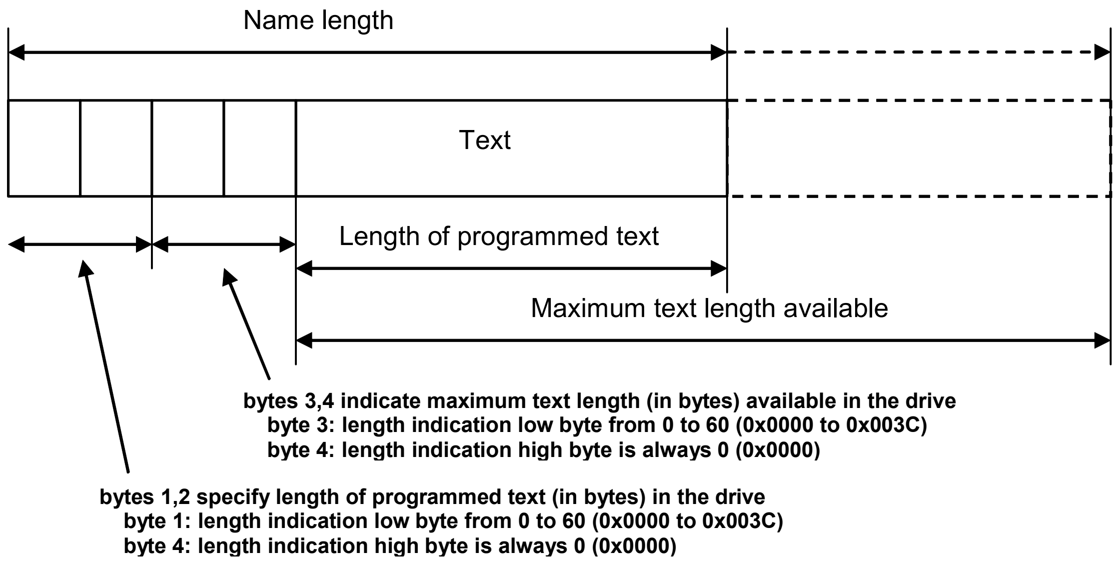


Figure A.2 – IDN name structure

It is recommended to program text length in even numbers since the service channel can only transfer words.

If the programmed text has a length of 0, only the two length indications shall be transmitted. Octets 1 and 2 shall then contain the value 0.

Reading: In order to complete a read command in the service channel, the master shall require octets 1 and 2. Octets 3 and 4 shall only be read by the master to prevent writing text which is too long.

Writing: When writing a name, the master shall set octets 1 and 2 according to the length of the programmed text. The text shall not be longer than specified in octets 3 and 4. During writing the slave shall ignore octets 3 and 4 and insert its available length during reading.

A.1.4 Element 3: attribute of operation data

Every data block shall have an attribute which allows for an intelligible representation of various operation data by means of universal routines. The attribute shall contain all information which is needed to display operation data intelligibly. The attribute makes it possible to convert the transferred operation data into intelligible display data and vice versa. The conversion shall have no impact on the data itself. If data needs to be scaled, specific scaling parameters shall be supplied. Every scaling modification needs a change in the attributes of the affected data. See Table A.3.

Table A.3 – Element 3 of IDNs

Bit No.	Value	Description
31		Reserved
30		Write protected in CP4
	0	Operation data is writeable
	1	Operation data is write protected
29		Write protected in CP3
	0	Operation data is writeable
	1	Operation data is write protected
28		Write protected in CP2
	0	Operation data is writeable
	1	Operation data is write protected
27-24		Decimal point: Places after the decimal point indicate the position of the decimal point for the display and input of appropriate operation data. This is additional display information. Decimal point = 0, for data type "floating-point number"
	0000 to 1111	No place to 15 places after decimal point (maximum)
23		Reserved
22-20		Data type and display format. Data type and display format are used to convert the operation data and the minimum and maximum input value to the correct display format
	000	Data type: Binary number Display format: Binary
	001	Data type: Unsigned integer Display format: Unsigned decimal
	010	Data type: Integer Display format: Signed decimal
	011	Data type: Unsigned integer Display format: Hexadecimal
	100	Data type: Extended character set Display format: Text (ASCII)
	101	Data type: Unsigned integer

Bit No.	Value	Description
		Display format: IDN
	110	Data type: Floating-point number Display format: Signed decimal with exponent (float) Single or double precision, according to ANSI/IEEE 752-1995
	111	Reserved
19		Function of operation data: The function of operation data indicates that this operation data is used to call up procedure command functions in a slave
	0	Operation data or parameter
	1	Procedure command
18-16		Data length: Data length is required so that the control unit is able to complete service channel data transfers correctly
	000	Reserved
	001	Operation data is two octets long
	010	Operation data is four octets long
	011	Operation data is eight octets long
	100	Variable length with one-octet data strings
	101	Variable length with two-octet data strings
	110	Variable length with four-octet data strings
	111	Variable length with eight-octet data strings
15-0		Conversion factor: the conversion factor is an unsigned integer used to convert numeric data to display format. The conversion factor shall be set to a value of 1 when it is not needed for data display (e.g., for binary display, character string or floating-point number)

The display formats and data length shall have any of the valid combinations ("yes" marked) in Table A.4.

Table A.4 – Valid combinations of the display formats

Data length	Binary	Unsigned decimal	Signed decimal	Hex	Text	IDN	Float
2 octet	yes	yes	yes	yes		yes	
4 octet	yes	yes	yes	yes			yes
8 octet	yes	yes	yes	yes			yes
1 octet list					yes		
2 octet list	yes	yes	yes	yes		yes	
4 octet list	yes	yes	yes	yes			yes
8 octet list	yes	yes	yes	yes			yes

A.1.5 **Element 4: operation data unit**

This unit element shall consist of 16 octets maximum. It shall have two length specifications of two octets each, and an ASCII character string of 12 characters maximum (12 octets). Octets 1 and 2 of the unit shall specify the length in the programmed text in octets. Octets 3 and 4 of the unit shall indicate the maximum number of characters available for text in a slave if it is changeable. Text longer than that specified by these octets may not be stored in the slaves. Length specifications of the initial four octets shall be coded for hexadecimal digits. Operation data shall not have any unit if the data type is either a binary number or an ASCII. See Figure A.3.

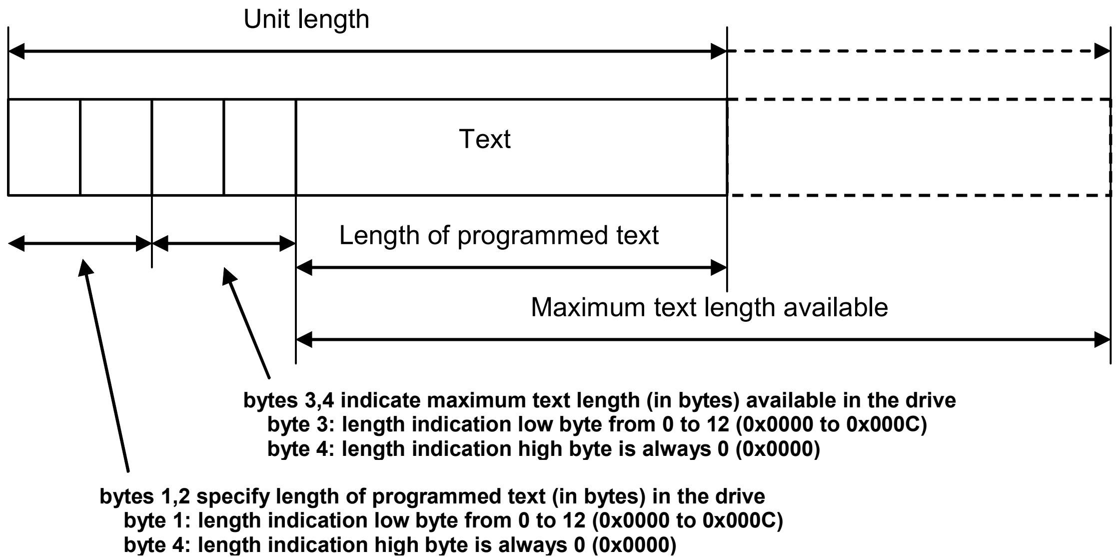


Figure A.3 – IDN data unit structure

It is recommended to program text length in even numbers since the service channel can only transfer words.

If the programmed text has the length 0 only the two length indications shall be transmitted. Octets 1 and 2 shall then contain the value 0.

Reading: In order to complete a read command in the service channel, octets 1 and 2 shall be required by the master. Octets 3 and 4 shall only be read by the master to prevent writing text which is too long.

Writing: When writing a unit, the master shall set octets 1 and 2 according to the length of the programmed text. The text shall not be longer than specified in octets 3 and 4. During writing the slave shall ignore octets 3 and 4 and insert its available length during reading.

A.1.6 Element 5: minimum input value of IDN operation data

The IDN minimum input value shall be the smallest numerical value for the operation data which the slave is able to process and have the same length as operation data.

If, in a write request, the value for the operation data is lower than the minimum input value, the operation data shall not be changed.

The operation data shall have no minimum input values if a binary number or an ASCII character string is used or if the operation data is of variable length.

The minimum input value shall be displayed like the operation data.

A.1.7 Element 6: maximum input value of IDN operation data

The IDN maximum input value shall be the largest numerical value for the operation data which the slave the slave is able to process and have the same length as operation data.

If, in a write request for the operation data, the maximum input value is exceeded, the operation data shall have changed.

The operation data shall have no maximum input value if a binary number or ASCII character string is used or if the operation data is of variable length.

The maximum input value shall be displayed like the operation data.

A.1.8 Element 7: IDN operation data

The IDN operation data length shall have any one of following values:

- fixed length with two octets;
- fixed length with four octets;
- fixed length with eight octets;
- variable length up to 65 532 octets.

Length specifications for the variable length only shall be coded in the initial four octets for hexadecimal digits.

Structure of operation data with variable length shall be as shown in Figure A.4.

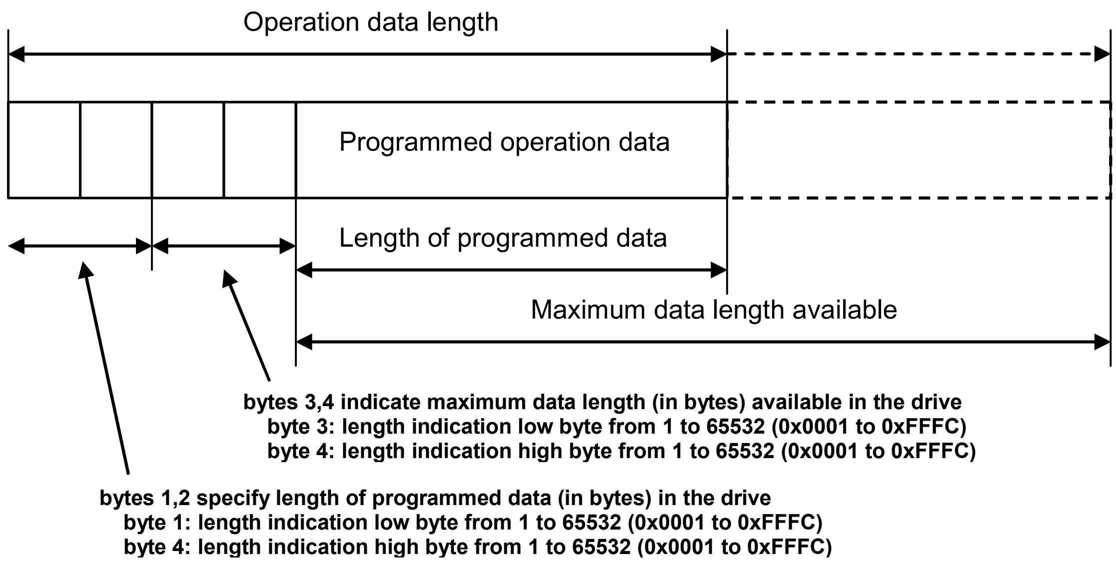


Figure A.4 – Structure of IDN operation data with variable length

IDN operation data with variable length shall consist of length indicators in the initial four octets, followed by the programmed operation data.

Files or tables shall be loaded from the control unit to the slaves or vice versa by means of the transfer of operation data with variable length (e.g., the IDN-list of all operation data in a slave).

It is recommended to program the length of the operation data in an even number of octets since the service channel can only transfer words.

If the operation data has the length 0, only the two length indications shall be transmitted. Octets 1 and 2 shall then contain the value 0.

Reading: In order to complete a read command in the service channel correctly, the master shall require octets 1 and 2. Octets 3 and 4 shall only be read by the master to prevent writing operation data which is too long.

Writing: When writing operation data, the master shall set octets 1 and 2 according to the length of the programmed data. The data shall not be longer than specified in octets 3 and 4.

During writing, the slave shall ignore octets 3 and 4 and insert its available length during reading.

NOTE Figure A.5 shows the structure of an IDN list as an example.

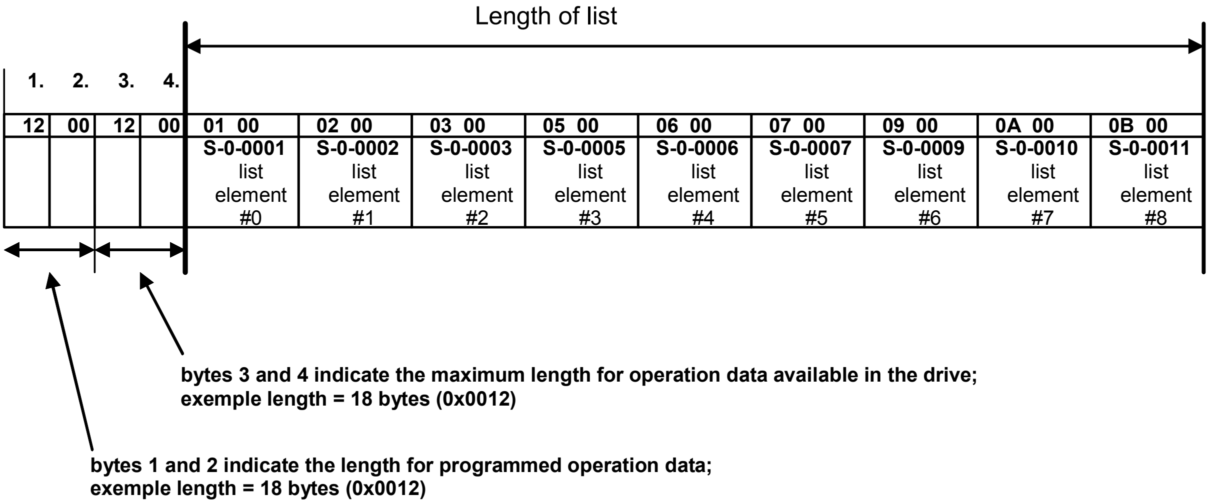


Figure A.5 – Example of the structure of an IDN-list

A.1.9 Data status

The content of "data status" shall be related to the entire data block. "Data status" shall contain conditions which change dynamically. When opening the service channel via an IDN, the current data status shall be transferred automatically to the master. This enables the control unit to respond to procedure command acknowledgments during transmission of a procedure command. The data status (procedure command acknowledgment) shall be reset by the device during every renewed initialization.

Bits 0-3 shall only be present for procedure commands (procedure command acknowledgment).

Changes in the procedure command acknowledgment by:

- bit 2: procedure command executed correctly (1 → 0 = positive acknowledgment), or
- bit 3: procedure command execution is impossible (0 → 1 = negative acknowledgment) shall lead to setting the Procedure command change bit in the status word of the device.

Bit 8 shall be set by the device if the data block is recognized as invalid, such as if the data memory is checked for data loss and a checksum error is set.

The structure of the data status is shown in Table A.5.

Table A.5 – Data status structure

Bits	Value	Meaning
15-9		(Reserved)
8		
	0	Operation data is valid
	1	Operation data is invalid
7-4		(Reserved)
3		
	0	No procedure command error
	1	Error, procedure command execution is impossible
2		
	0	Procedure command executed correctly
	1	Procedure command not yet executed
1		
	0	Procedure command execution interrupted in the device
	1	Procedure command execution enabled in the device
0		
	0	Procedure command not yet set in the device by the master
	1	Procedure command set in the device

A.2 Identification numbers in numerical orders

Table A.6 lists the IDNs which are related to communication. Their detailed description appears in A.3.

Application-specific data content is specified in other relevant standards, e.g., IEC 61800-7-20x.

Table A.6 – Communication related IDN list that are relevant for Type 16

IDN (No.)	Name
S-0-0001	Control unit cycle time (t_{Ncyc})
S-0-0002	Communication cycle time (t_{Scyc})
S-0-0003	Shortest AT transmission starting time (t_{1min})
S-0-0004	Transmit/receive transition time (t_{ATMT})
S-0-0006	AT transmission starting time (t_1)
S-0-0008	Command value valid time (t_3)
S-0-0009	Position of data record in MDT
S-0-0010	Length of MDT
S-0-0011	Class 1 diagnostic (C1D)
S-0-0014	Interface status
S-0-0015	Telegram type
S-0-0016	Configuration list of AT
S-0-0018	IDN list of operation data for CP2
S-0-0019	IDN-list of operation data for CP3

IDN (No.)	Name
S-0-0021	IDN-list of invalid operation data for CP2
S-0-0022	IDN-list of invalid operation data for CP3
S-0-0024	Configuration list of MDT
S-0-0028	MST error counter
S-0-0029	MDT error counter
S-0-0087	Transmit to transmit recovery time (t_{ATAT})
S-0-0088	Receive to receive recovery time (t_{MTSY})
S-0-0089	MDT transmission starting time (t_2)
S-0-0090	Command value proceeding time (t_{MTSG})
S-0-0096	Diagnostic message
S-0-0097	Mask class 2 diagnostic
S-0-0098	Mask class 3 diagnostic
S-0-0127	CP3 transition check
S-0-0128	CP4 transition check
S-0-0134	Master control word
S-0-0135	Device status word
S-0-0143	Type 16 version
S-0-0185	Length of the configurable data record in the AT
S-0-0186	Length of the configurable data record in the MDT
S-0-0187	IDN-list of configurable data in the AT
S-0-0188	IDN-list of configurable data in the MDT
S-0-0301	Allocation of real-time control bit 1
S-0-0303	Allocation of real-time control bit 2
S-0-0305	Allocation of real-time status bit 1
S-0-0307	Allocation of real-time status bit 2
S-0-0394	List IDN
S-0-0395	List index
S-0-0396	Number of list elements
S-0-0397	List segment
S-0-0413	Bit number allocation of real-time control bit 1
S-0-0414	Bit number allocation of real-time control bit 2
S-0-0415	Bit number allocation of real-time status bit 1
S-0-0416	Bit number allocation of real-time status bit 2
NOTE All other IDN numbers are reserved	

A.3 Detailed specification of communication-related IDNs

A.3.1 IDN S-0-0001 Control unit cycle time (t_{Ncyc})

A.1.1.1 Attributes

Table A.7 shows the possible attributes for this IDN.

Table A.7 – Attributes for IDN S-0-0001

Attribute	Value
Name	Control unit cycle time (t_{Ncyc})
Version	
Length	2
Display Format	unsigned decimal
Min. input value	62
Max. input value	65 000
Scaling/resolution	1
Unit	µs

A.1.1.2 Description

The control unit cycle time defines the cyclic intervals during which the control unit makes new command values available. The control unit cycle time shall be transferred from the master to the slave during CP2 and becomes active in the slave during CP3. The control unit cycle time should be an integer multiple of the communication cycle time.

$t_{Ncyc} = t_{Scyc} \times n$ [n =1, 2, 3, 4...]

Min./max. input values are mandatory.

A.3.2 IDN S-0-0002 Communication cycle time

A.3.2.1 Attributes

Table A.8 shows the possible attributes for this IDN.

Table A.8 – Attributes for IDN S-0-0002

Attribute	Value
Name	Communication cycle time (t_{Scyc})
Version	
Length	2
Display Format	unsigned decimal
Min. input value	62
Max. input value	65 000
Scaling/resolution	1
Unit	µs

A.3.2.2 Description

This IDN shall indicate the communication cycle time of the interface defines the intervals during which the cyclic data are transferred. The communication cycle time is defined as 62,5 µs, 125 µs, 250 µs, ..., up to 65 000 µs in steps of 250 µs. The communication cycle time shall be transferred from the master to the slave during CP2 and becomes active in both during CP3.

Min/max input values are mandatory.

A.3.3 IDN S-0-0003 Shortest AT transmission starting time (t_{1min})

A.3.3.1 Attributes

Table A.9 shows the possible attributes for this IDN.

Table A.9 – Attributes for IDN S-0-0003

Attribute	Value
Name	Shortest AT transmission starting time (t_{1min})
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	µs

A.3.3.2 Description

This IDN shall indicate the time requirement of the slaves between the end of the reception of the MST and the start of transmission of the AT. This time interval, required by the slave, depends on the selected telegram type. The time t_{1min} is read by the master during CP2 in order to calculate the time of transfer of AT transmission starting time, t_1 (S-0-0006).

A.3.4 IDN S-0-0004 Transmit/receive transition time (t_{ATMT})

A.3.4.1 Attributes

Table A.10 shows the possible attributes for this IDN.

Table A.10 – Attributes for IDN S-0-0004

Attribute	Value
Name	Transmit/receive transition time (t_{ATMT})
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	µs

A.3.4.2 Description

This IDN shall indicate the time required by the slave to switch from transmitting the AT to receiving the MDT. The transition time for transmit/receive is read by the master during CP2 in order to calculate correctly the MDT transmission starting time t_2 (S-0-0089).

A.3.5 IDN S-0-0006 AT transmission starting time (t_1)

A.3.5.1 Attributes

Table A.11 shows the possible attributes for this IDN.

Table A.11 – Attributes for IDN S-0-0006

Attribute	Value
Name	AT transmission starting time (t_1)
Version	
Length	2
Display Format	unsigned decimal
Min. input value	t_{1min}
Max. input value	t_{Scyc}
Scaling/resolution	1
Unit	µs

A.3.5.2 Description

The AT transmission starting time determines when the slave sends its AT during CP3 and CP4, following the MST. This parameter is transferred by the master to the slave during CP2. The time of transfer of the AT shall be set greater than or equal to the shortest AT transmission starting time (S-0-0003). $t_1 \geq t_{1min}$.

A.3.6 IDN S-0-0008 Command value valid time (t_3)

A.3.6.1 Attributes

Table A.12 shows the possible attributes for this IDN.

Table A.12 – Attributes for IDN S-0-0008

Attribute	Value
Name	Command value valid time (t_3)
Version	
Length	2
Display Format	unsigned decimal
Min. input value	0
Max. input value	t_{Scyc}
Scaling/resolution	1
Unit	µs

A.3.6.2 Description

t_3 determines the time at which the device is allowed to access the new command values after the completion of a MST. In this way the master provides the command value valid time for command values among all coordinated devices. The device activates the command value valid time during CP3.

A.3.7 IDN S-0-0009 Position of data record in MDT

A.3.7.1 Attributes

Table A.13 shows the possible attributes for this IDN.

Table A.13 – Attributes for IDN S-0-0009

Attribute	Value
Name	Position of data record in MDT
Version	
Length	2
Display Format	unsigned decimal
Min. input value	1 (one device)
Max. input value	65 531
Scaling/resolution	1
Unit	

A.3.7.2 Description

This IDN shall indicate the position of a data record of the device in a MDT, expressed as a octet position. It starts with 0x01 for the initial data octet after the address field within the MDT. Every device is informed by the master during CP2 of the beginning address of the data record of the device in the MDT. The position of a data record in the MDT becomes active during CP3 in the master and slave.

A.3.8 IDN S-0-0010 Length of MDT

A.3.8.1 Attributes

Table A.14 shows the possible attributes for this IDN.

Table A.14 – Attributes for IDN S-0-0010

Attribute	Value
Name	Length of MDT
Version	
Length	2
Display Format	unsigned decimal
Min. input value	4 (one device)
Max. input value	65 534 (number of octets of 254 devices)
Scaling/resolution	1
Unit	

A.3.8.2 Description

The length of the MDT, expressed in octets, includes data records for all devices. Each device is informed by the master during CP2 of the length of the MDT. It becomes active in the master and slave during CP3.

A.3.9 IDN S-0-0011 Class 1 diagnostic (C1D)

A.3.9.1 Attributes

Table A.15 shows the possible attributes for this IDN.

Table A.15 – Attributes for IDN S-0-0011

Attribute	Value
Name	Class 1 diagnostic (C1D)
Version	
Length	2
Display Format	binary
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.9.2 Description

This IDN shall indicate the device shut-down error

A device error situation of C1D leads to the following:

d) A best case deceleration followed by torque release at n_{min}.

e) The device shut-down error bit for C1D is set to '1' in the device status (bit 13). The error bit is reset to '0' by the device only when no errors of C1D exists and after the command 'reset class 1 diagnostic' (S-0-0099) has been received by the device via the service channel.

Table A.16 shows the interpretation of C1D.

Table A.16 – Structure of C1D

Bit No.	Value	Meaning
0	0 = no error 1 = error	overload shut-down (see S-0-0114)
1		amplifier over temperature shut-down (see S-0-0203)
2		motor over temperature shut-down (see S-0-0204)
3		cooling error shut-down (see S-0-0205)
4		control voltage error
5		feedback error
6		error in the "commutation“ system
7		over current error
8		over voltage error
9		under voltage error
10		power supply phase error
11		excessive position deviation (see S-0-0159)
12		communication error (see S-0-0014)
13		over travel limit is exceeded (shut-down) (see S-0-0049, S-0-0050)
14		reserved
15		manufacturer-specific error (see S-0-0129)

A.3.10 IDN S-0-0014 Interface status

A.3.10.1 Attributes

Table A.17 shows the possible attributes for this IDN.

Table A.17 – Attributes for IDN S-0-0014

Attribute	Value
Name	Interface status
Version	
Length	2
Display Format	binary
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.10.2 Description

A communication error is set in C1D (see S-0-0011) if the interface status is set by an error. The setting of bits 2–0 does not signify an error. If there are no communication errors present, the actual communication phase is contained in the interface status. If a communication error has occurred, the error and the CP at the time of the error will be stored. The device cancels a communication error and resets to '0' only if the error at the interface has been eliminated and on receiving the command 'reset class 1 diagnostic' (see S-0-0099) via the service channel.

Table A.18 shows the structure of interface status.

Table A.18 – Structure of interface status

Bit No.	Value	Meaning
2-0	000_B to 111_B	communication phase (same as bit 2-0 in MST INFO field, see 5.2, Table 6)
3	0 = no error 1 = error	MST failure
4		MDT failure
5		invalid phase (phase > 4)
6		error during phase upshift (invalid sequence)
7		error during phase downshift (not to phase 0)
8		phase switching without ready acknowledge
9		switching to uninitialized operation mode
10		devices with the same address in the ring
11		IPO-SYNC error
12		reserved
13		reserved
14		reserved
15		reserved

A.3.11 IDN S-0-0015 Telegram type

A.3.11.1 Attributes

Table A.19 shows the possible attributes for this IDN.

Table A.19 – Attributes for IDN S-0-0015

Attribute	Value
Name	Telegram type
Version	
Length	2
Display Format	binary
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.11.2 Description

The telegram type allows selection between standard telegrams and application telegrams (bits 2-0). The position feedback 1 or 2 is programmed in bit 3. The extension of the service channel is programmed in the telegram type in bit 8 – 11. The extended service channel is only active in CP3 and CP4. In CP2 the service channel stays unchanged (2 octets).

Table A.20 shows bit assignments for IDN S-0-0015.

Table A.20 – Structure of telegram type parameter

Bits	Value	Description
4-0	0 0000	Standard telegram – 0
	0 0001	Standard telegram – 1
	0 0010	Standard telegram – 2
	x x011	Standard telegram – 3
	x x100	Standard telegram – 4
	x x101	Standard telegram – 5
	0 0110	Standard telegram – 6
	0 0111	Application telegram (see S-0-0016, S-0-0024)
3	0	Position feedback value 1 (motor feedback)
	1	Position feedback value 2 (external feedback)
4	0	Configured position feedback value
	1	Active position feedback value
7-5		Reserved
9-8		Length of MDT service channel
	00	2 octets, Master service INFO (Standard, CP2/3/4)
	01	4 octets, Master service INFO (CP3/4)
	10	6 octets, Master service INFO (CP3/4)
	11	8 octets, Master service INFO (CP3/4)
11-10		Length of AT service channel
	00	2 octets, Device service INFO (Standard, CP2/3/4)
	01	4 octets, Device service INFO (CP3/4)
	10	6 octets, Device service INFO (CP3/4)
	11	8 octets, Device service INFO (CP3/4)
15-12		Reserved

A.3.12 IDN S-0-0016 Configuration list of AT

A.3.12.1 Attributes

Table A.21 shows the possible attributes for this IDN.

Table A.21 – Attributes for IDN S-0-0016

Attribute	Value
Name	Configuration list of AT
Version	
Length	2, variable
Display Format	IDN
Min input value	
Max input value	
Scaling/resolution	1
Unit	

A.3.12.2 Description

This IDN list contains the IDNs whose operation data will be transmitted cyclically in the AT in an application telegram. The device needs to support this list only if it allows the application telegram in its telegram type parameter (see S-0-0015). Only operation data which are present in the "IDN list of configurable data in the AT" (S-0-0187) are allowed as cyclic data.

A.3.13 IDN S-0-0018 IDN-list of operation data for CP2

A.3.13.1 Attributes

Table A.22 shows the possible attributes for this IDN.

Table A.22 – Attributes for IDN S-0-0018

Attribute	Value
Name	IDN list of operation data for CP2
Version	
Length	2, variable
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.13.2 Description

IDNs of all operation data needed for CP2 are stored in this IDN-list and must be transferred during CP2. Processing this list is required before switching to CP3.

A.3.14 IDN S-0-0019 IDN-list of operation data for CP3

A.3.14.1 Attributes

Table A.23 shows the possible attributes for this IDN.

Table A.23 – Attributes for IDN S-0-0019

Attribute	Value
Name	IDN-list of operation data for CP3
Version	
Length	2, variable
Display Format	
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.14.2 Description

IDNs of all operation data needed for CP3 are stored in this IDN-list and must be transferred during CP3. Processing this list is required before switching to CP4.

A.3.15 IDN S-0-0021 IDN-list of invalid operation data for CP2

A.3.15.1 Attributes

Table A.24 shows the possible attributes for this IDN.

Table A.24 – Attributes for IDN S-0-0021

Attribute	Value
Name	IDN-list of invalid operation data for CP2
Version	
Length	2, variable
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.15.2 Description

IDNs which are in the list "IDN-list of operation data for CP2" (S-0-0018) and which are considered invalid by the device prior to switchover from CP2 to CP3 are stored in this IDN-list (see S-0-0127).

Case 1: procedure command S-0-0127 is performed correctly; the IDN-list (S-0-0021) contains no IDNs.

Case 2: procedure command S-0-0127 results in an error; the IDN-list (S-0-0021) contains all IDNs of invalid operation data.

A.3.16 IDN S-0-0022 IDN-list of invalid operation data for CP3

A.3.16.1 Attributes

Table A.25 shows the possible attributes for this IDN.

Table A.25 – Attributes for IDN S-0-0022

Attribute	Value
Name	IDN-list of invalid operation data for CP3
Version	
Length	2, variable
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.16.2 Description

IDNs which are in the list "IDN-list of operation data for CP3" (S-0-0019) and which are considered invalid by the device prior to switchover from CP3 to CP4 are stored in this IDN-list (see S-0-0128).

Case 1: Procedure command S-0-0128 is performed correctly; the IDN-list (S-0-0022) contains no IDNs.

Case 2: Procedure command S-0-0128 results in an error; the IDN-list (S-0-0022) contains all IDNs of invalid operation data.

A.3.17 IDN S-0-0024 Configuration list of MDT

A.3.17.1 Attributes

Table A.26 shows the possible attributes for this IDN.

Table A.26 – Attributes for IDN S-0-0024

Attribute	Value
Name	Configuration list of MDT
Version	
Length	2, variable
Display Format	
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.17.2 Description

This IDN list contains the IDNs whose operation data will be transmitted cyclically in the MDT in an application telegram. The device needs to support this list only when it allows the application telegram in its telegram type parameter (see S-0-0015). Only operation data which are present in the "IDN-list of configurable data in the MDT" (S-0-0188) are allowed as cyclic data.

A.3.18 IDN S-0-0028 MST error counter

A.3.18.1 Attributes

Table A.27 shows the possible attributes for this IDN.

Table A.27 – Attributes for IDN S-0-0028

Attribute	Value
Name	MST error counter
Version	
Length	2
Display Format	
0	62
Max. input value	65 535
Scaling/resolution	1
Unit	

A.3.18.2 Description

The MST error counter counts all invalid MST's in communication phases 3 and 4. In cases where more than two consecutive MSTs are invalid, the invalid MSTs over two are not counted. The MST error counter counts to a maximum of $2^{16} – 1$. This means that, if a value of 65 535 is set in the counter, there may have been a noisy transmission over a long period of time.

A.3.19 IDN S-0-0029 MDT error counter

A.3.19.1 Attributes

Table A.28 shows the possible attributes for this IDN.

Table A.28 – Attributes for IDN S-0-0029

Attribute	Value
Name	MDT error counter
Version	
Length	2
Display Format	
Min. input value	0
Max. input value	65 535
Scaling/resolution	1
Unit	

A.3.19.2 Description

The MDT error counter counts all invalid MDTs in communication phase 4. In cases where more than two consecutive MDTs are invalid, the invalid MDTs over two are not counted. The MDT error counter counts to a maximum of $2^{16} – 1$. This means that, if a value of 65 535 is set in the counter, there may have been a noisy transmission over a long period of time.

A.3.20 IDN S-0-0087 Transmit to transmit recovery time (t_{ATAT})

A.3.20.1 Attributes

Table A.29 shows the possible attributes for this IDN.

Table A.29 – Attributes for IDN S-0-0087

Attribute	Value
Name	Transmit to transmit recovery time (t_{ATAT})
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	µs

A.3.20.2 Description

This IDN shall define the time required between two ATs when sent by the same slave. This parameter is not used for slaves with a single device. The transmit to transmit recovery time is read by the master during CP2 in order to correctly calculate the AT transmission starting time t_1 (S-0-0006).

A.3.21 IDN S-0-0088 Receive to receive recovery time (t_{MTSY})

A.3.21.1 Attributes

Table A.30 shows the possible attributes for this IDN.

Table A.30 – Attributes for IDN S-0-0088

Attribute	Value
Name	Receive to receive recovery time (t_{MTSY})
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	µs

A.3.21.2 Description

This IDN shall define the recovery time of the slave after reception of a MDT to switch over to receive the next MST. The master reads this time during CP2 to ensure that the interval will be sufficient between the end of the MDT and the beginning of the MST.

A.3.22 IDN S-0-0089 MDT transmission starting time (t_2)

A.3.22.1 Attributes

Table A.31 shows the possible attributes for this IDN.

Table A.31 – Attributes for IDN S-0-0089

Attribute	Value
Name	MDT transmission starting time (t_2)
Version	
Length	2
Display Format	unsigned decimal
Min. input value	0
Max. input value	t_{Scyc}
Scaling/resolution	1
Unit	µs

A.3.22.2 Description

The MDT transmission starting time determines when the master shall send its MDT during CP3 and CP4, following the MST. This parameter is transferred by the master to the slave during CP2 and becomes active during CP3.

A.3.23 IDN S-0-0090 Command value proceeding time (t_{MTSG})

A.3.23.1 Attributes

Table A.32 shows the possible attributes for this IDN.

Table A.32 – Attributes for IDN S-0-0090

Attribute	Value
Name	Command value proceeding time (t_{MTSG})
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	µs

A.3.23.2 Description

This IDN shall define the time required by the slave to make command values available for a device after receipt of a MDT. This time is read by the master during CP2 in order to correctly calculate the command value valid time t_3 (S-0-0008). The command value proceeding time depends on the telegram type.

A.3.24 IDN S-0-0096 Slave arrangement (SLKN)

A.3.24.1 Attributes

Table A.33 shows the possible attributes for this IDN.

Table A.33 – Attributes for IDN S-0-0096

Attribute	Value
Name	Slave arrangement (SLKN)
Version	
Length	2
Display Format	hexadecimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	µs

A.3.24.2 Description

During initialization, the master needs to recognize which physical slaves and their associated devices are present in order to optimize the automatic timeslot computation. The master can request this information from the devices during CP2. By this entry the master recognizes other devices which belong to the same physical slave. Valid device addresses are all decimal values from 1 to 254, in accordance with hexadecimal values 0x01 through 0xFE.

Table A.34 shows details of legal values.

Table A.34 – Structure of SLKN

Bit range	Device address	Use
15 – 8	Intrinsic device address	The device enters its own address here
7 – 0	Next device address	The next higher device address of the device serviced by the slave is entered in ascending order here. If the actual device on the physical slave is one with the highest address, then the slave enters the lowest available device address here. If the slave services only one device, then the 'intrinsic device address' is entered here

Example in Figure A.6 shows a slave with three devices (device addresses 3, 5, 8).

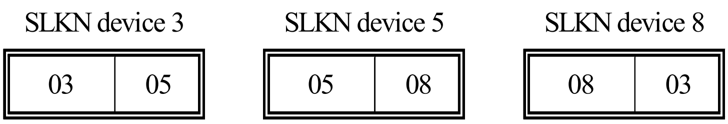


Figure A.6 – SLKN example

A.3.25 IDN S-0-0097 Mask class 2 diagnostic

A.3.25.1 Attributes

Table A.35 shows the possible attributes for this IDN.

Table A.35 – Attributes for IDN S-0-0097

Attribute	Value
Name	Mask class 2 diagnostic
Version	
Length	2
Display Format	binary
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.25.2 Description

Using this mask, warnings in class 2 diagnostic can be masked with respect to their effect on the change bit in drive status. When changing masked warnings, the change bit for class 2 diagnostic is not set in the drive status. The mask does not affect the operation data of class 2 diagnostic (see S-0-0012).

Table A.36 shows details of the legal values.

Table A.36 – Structure of Mask C2D

Bit	Value	Meaning
15 – 0		
	all 0s	masked warning
	all 1a	unmasked warning

A.3.26 IDN S-0-0098 Mask class 3 diagnostic

A.3.26.1 Attributes

Table A.37 shows the possible attributes for this IDN.

Table A.37 – Attributes for IDN S-0-0098

Attribute	Value
Name	Mask class 3 diagnostic
Version	
Length	2
Display Format	binary
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.26.2 Description

Using this mask, condition flags in C3D can be masked with respect to their effect on the change bit in drive status (see Table A.38). When masked condition flags change, the change bit for C3D is not set in the drive status. The mask does not affect the operation data of C3D (see S-0-0013).

Table A.38 – Structure of Mask C3D

Bit	Value	Meaning
15 – 0		
	all 0s	masked condition flag
	all 1a	unmasked condition flag

A.3.27 IDN S-0-0127 CP3 transition check

A.3.27.1 Attributes

Table A.39 shows the possible attributes for this IDN.

Table A.39 – Attributes for IDN S-0-0127

Attribute	Value
Name	CP3 transition check
Version	
Length	2
Display Format	Binary
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.27.2 Description

The master uses this procedure command to instruct the slave to check that all necessary parameters have been transferred for CP3. Otherwise, this procedure command results in an error (see S-0-0021). After the procedure command is performed correctly, the control unit has to cancel the procedure command. The control unit can then activate CP3 in the MST.

A.3.28 IDN S-0-0128 CP4 transition check

A.3.28.1 Attributes

Table A.40 shows the possible attributes for this IDN.

Table A.40 – Attributes for IDN S-0-0128

Attribute	Value
Name	CP4 transition check
Version	
Length	2
Display Format	binary
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.28.2 Description

The master uses this procedure command to instruct the slave to check that all necessary parameters have been transferred for CP4. Otherwise, this procedure command results in an error (see S-0-0022). After the procedure command is performed correctly, the control unit has to cancel the procedure command. The control unit can then activate CP4 in the MST.

A.3.29 IDN S-0-0134 Master control word

A.3.29.1 Attributes

Table A.41 shows the possible attributes for this IDN.

Table A.41 – Attributes for IDN S-0-0134

Attribute	Value
Name	Master control word
Version	
Length	2
Display Format	binary
Mi.n input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.29.2 Description

This IDN shall enable the display of the master control word on the control unit screen, via the service channel. (This can be useful during start-up and error recovery.)

A.3.30 IDN S-0-0135 Drive status word

A.3.30.1 Attributes

Table A.42 shows the possible attributes for this IDN.

Table A.42 – Attributes for IDN S-0-0135

Attribute	Value
Name	Drive status word
Version	
Length	2
Display Format	binary
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.30.2 Description

This IDN shall enable the display of the drive status word on the control unit screen, via the service channel. (This can be useful during start-up and error recovery.)

A.3.31 IDN S-0-0143 Type 16 version

A.3.31.1 Attributes

Table A.43 shows the possible attributes for this IDN.

Table A.43 – Attributes for IDN S-0-0143

Attribute	Value
Name	Type 16 version
Version	
Length	1, variable
Display Format	text
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.31.2 Description

The operation data contains the version of the Type 16 specification. A version number is linked to every update. If only one of the changed or new functions of the device is supported, then the corresponding version number must be shown. Only changes or modifications of the basic functions of Type 16 influence the version number.

- Basic functions:
- Data block structure
- Service channel functions (Error messages, sequence, length, ...)
- Structure of control word and status word
- Error handling
- Phase switching sequence
- Telegram structure
- Topology
- Physical layer
- Procedure command sequence

Table A.44 shows the specification of each version.

Table A.44 – Structure of Type 16 version

Version	Specification
V01.01	Specification 1990 (old standard telegrams)
V01.02	IEC 61491 / EN 61491 (1st edition)
V01.03	Update 98
V02.01	Specification Type 16 (Edition 2002)
V02.03	Specification Type 16 V2.3 (2003)

A.3.32 IDN S-0-0185 Length of the configurable data record in the AT

A.3.32.1 Attributes

Table A.45 shows the possible attributes for this IDN.

Table A.45 – Attributes for IDN S-0-0185

Attribute	Value
Name	Length of the configurable data record in the AT
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	octet

A.3.32.2 Description

The device indicates the maximum length in octets which can be processed in the configurable data record of the AT in the operation data of this IDN. The device needs to support this IDN only if it allows the application telegram in its telegram type parameter (see S-0-0015).

A.3.33 IDN S-0-0186 Length of the configurable data record in the MDT

A.3.33.1 Attributes

Table A.46 shows the possible attributes for this IDN.

Table A.46 – Attributes for IDN S-0-0186

Attribute	Value
Name	Length of the configurable data record in the MDT
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	octet

A.3.33.2 Description

The device indicates the maximum length in octets which can be processed in the configurable data record of the MDT in the operation data of this IDN. The device needs to support this IDN only if it allows the application telegram in its telegram type parameter (see S-0-0015).

A.3.34 IDN S-0-0187 IDN-list of configurable data in the AT

A.3.34.1 Attributes

Table A.47 shows the possible attributes for this IDN.

Table A.47 – Attributes for IDN S-0-0187

Attribute	Value
Name	IDN-list of configurable data in the AT
Version	
Length	2, variable
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.34.2 Description

This list consists of the IDNs of operation data which can be processed by the device cyclically as feedback values. The device needs to support this list only if it allows the application telegram in its telegram type parameter (see S-0-0015).

A.3.35 IDN S-0-0188 IDN-list of configurable data in the MDT

A.3.35.1 Attributes

Table A.48 shows the possible attributes for this IDN.

Table A.48 – Attributes for IDN S-0-0188

Attribute	Value
Name	IDN-list of configurable data in the MDT
Version	
Length	2, variable
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.35.2 Description

This list consists of the IDNs of operation data which can be processed by the device cyclically as command values. The device needs to support this list only if it allows the application telegram in its telegram type parameter (see S-0-0015).

A.3.36 IDN S-0-0301 Allocation of real-time control bit 1

A.3.36.1 Attributes

Table A.49 shows the possible attributes for this IDN.

Table A.49 – Attributes for IDN S-0-0301

Attribute	Value
Name	Allocation of real-time control bit 1
Version	
Length	2
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.36.2 Description

In order to assign a signal to the real-time control bit 1, the IDN of the signal is written to the operation data allocation for real-time control bit 1. After the allocation of IDN and bit number (see S-0-0413), the assigned signal appears in the real-time control bit 1. If the S-0-0413 of the drive is not supported, the bit 0 of the IDN is configured automatically.

A.3.37 IDN S-0-0303 Allocation of real-time control bit 2

A.3.37.1 Attributes

Table A.50 shows the possible attributes for this IDN.

Table A.50 – Attributes for IDN S-0-0303

Attribute	Value
Name	Allocation of real-time control bit 2
Version	
Length	2
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.37.2 Description

In order to assign a signal to the real-time control bit 2, the IDN of the signal is written to the operation data allocation for real-time control bit 2. After the allocation of IDN and bit number (see S-0-0414), the assigned signal appears in the real-time control bit 2. If the S-0-0414 of the drive is not supported, the bit 0 of the IDN is configured automatically.

A.3.38 IDN S-0-0305 Allocation of real-time status bit 1

A.3.38.1 Attributes

Table A.51 shows the possible attributes for this IDN.

Table A.51 – Attributes for IDN S-0-0305

Attribute	Value
Name	Allocation of real-time status bit 1
Version	
Length	2
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.38.2 Description

In order to assign a signal to the real-time status bit 1, the IDN of the signal is written to the operation data allocation for real-time status bit 1. After the allocation of IDN and bit number (see S-0-0415), the assigned signal appears in the real-time status bit 1. If the S-0-0415 of the drive is not supported, the bit 0 of the IDN is configured automatically.

A.3.39 IDN S-0-0307 Allocation of real-time status bit 2

A.3.39.1 Attributes

Table A.52 shows the possible attributes for this IDN.

Table A.52 – Attributes for IDN S-0-0307

Attribute	Value
Name	Allocation of real-time status bit 2
Version	
Length	2
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.39.2 Description

In order to assign a signal to the real-time status bit 2, the IDN of the signal is written to the operation data allocation for real-time status bit 2. After the allocation of IDN and bit number (see S-0-0416), the assigned signal appears in the real-time status bit 2. If the S-0-0416 of the drive is not supported, the bit 0 of the IDN is configured automatically.

A.3.40 IDN S-0-0394 List IDN

A.3.40.1 Attributes

Table A.53 shows the possible attributes for this IDN.

Table A.53 – Attributes for IDN S-0-0394

Attribute	Value
Name	List IDN
Version	
Length	2
Display Format	IDN
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.40.2 Description

The identification number of an operation data with variable length must be set into the List IDN. After this, access to the list elements of the operation data via "List index" (S-0-0395) and "number of list elements" (S-0-0396) is possible.

A.3.41 IDN S-0-0395 List index

A.3.41.1 Attributes

Table A.54 shows the possible attributes for this IDN.

Table A.54 – Attributes for IDN S-0-0395

Attribute	Value
Name	List index
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.41.2 Description

The list index specifies the starting address inside the list. With list index = 0, the first list element is accessed after the lengths indication. The list index is always programmed according to the list elements.

List index = 0 ➔ 1. List element (1, 2, 4 or 8 octet long)

List index = 1 ➔ 2. List element (1, 2, 4 or 8 octet long)

A.3.42 IDN S-0-0396 Number of list elements

A.3.42.1 Attributes

Table A.55 shows the possible attributes for this IDN.

Table A.55 – Attributes for IDN S-0-0396

Attribute	Value
Name	Number of list elements
Version	
Length	2
Display Format	unsigned decimal
Min. input value	
Max. input value	
Scaling/resolution	1
Unit	

A.3.42.2 Description

The IDN specifies how many list elements beginning at the list index are written or read via the list segment.

A.3.43 IDN S-0-0397 List segment

A.3.43.1 Attributes

Table A.56 shows the possible attributes for this IDN.

Table A.56 – Attributes for IDN S-0-0397

Attribute	Value
Name	List segment
Version	
Length	1, 2, 4 or 8
Display Format	like configured data
Min. input value	
Max. input value	
Scaling/resolution	1, or scaling like configured data
Unit	

A.3.43.2 Description

In the list segment the data are transmitted, which are selected by list IDN, list index and number of list elements.

In order to show the list segment, the device can choose between minimal requirement and maximal requirement.

Minimal requirement of list segment:

Herewith the list segment is shown hexadecimal and without unit.

Attribute: Data type and display format are set on hexadecimal (Bit 22-20 = 011).

Unit: not present

Maximal requirement of lists segment:

Herewith the list segment is shown with the data block of the programmed list. In this way the values in the list segment is shown exactly as with his own identification number.

A.3.44 IDN S-0-0413 Bit number allocation of real-time control bit 1

A.3.44.1 Attributes

Table A.57 shows the possible attributes for this IDN.

Table A.57 – Attributes for IDN S-0-0413

Attribute	Value
Name	Bit number allocation of real-time control bit 1
Version	
Length	2
Display Format	unsigned decimal (bit number)
Min. input value	0
Max. input value	63
Scaling/resolution	1
Unit	

A.3.44.2 Description

This identification number contains the bit number of the operation data assigned in the S-0-0301. The bit assigned by S-0-0301 and bit number (S-0-0413) is copied into the real- time control bit 1.

A.3.45 IDN S-0-0414 Bit number allocation of real-time control bit 2

A.3.45.1 Attributes

Table A.58 shows the possible attributes for this IDN.

Table A.58 – Attributes for IDN S-0-0414

Attribute	Value
Name	Bit number allocation of real-time control bit 2
Version	
Length	2
Display Format	unsigned decimal (bit number)
Min. input value	0
Max. input value	63
Scaling/resolution	1
Unit	

A.3.45.2 Description

This identification number contains the bit number of the operation data assigned in the S-0-0303. The bit assigned by S-0-0303 and bit number (S-0-0414) is copied into the real- time control bit 2.

A.3.46 IDN S-0-0415 Bit number allocation of real-time status bit 1

A.3.46.1 Attributes

Table A.59 shows the possible attributes for this IDN.

Table A.59 – Attributes for IDN S-0-0415

Attribute	Value
Name	Bit number allocation of real-time status bit 1
Version	
Length	2
Display Format	unsigned decimal (bit number)
Min. input value	0
Max. input value	63
Scaling/resolution	1
Unit	

A.3.46.2 Description

This identification number contains the bit number of the operation data assigned in the S-0-0305. The bit assigned by S-0-0305 and bit number (S-0-0415) is copied into the real- time status bit 1.

A.3.47 IDN S-0-0416 Bit number allocation of real-time status bit 2

A.3.47.1 Attributes

Table A.60 shows the possible attributes for this IDN.

Table A.60 – Attributes for IDN S-0-0416

Attribute	Value
Name	Bit number allocation of real-time status bit 2
Version	
Length	2
Display Format	unsigned decimal (bit number)
Min. input value	0
Max. input value	63
Scaling/resolution	1
Unit	

A.3.47.2 Description

This identification number contains the bit number of the operation data assigned in the S-0-0307. The bit assigned by S-0-0307 and bit number (S-0-0416) is copied into the real- time status bit 2.

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