INTERNATIONAL STANDARD

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**Electric railway equipment –
Train bus –**

**Part 2:
Train communication network conformance testing**

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Commission Electrotechnique Internationale
International Electrotechnical Commission
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRIC RAILWAY EQUIPMENT – TRAIN BUS –

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61375-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This standard is to be read in conjunction with IEC 61375-1, second edition.

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

FDIS	Report on voting
9/1014/FDIS	9/1034/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 the ISO/IEC Directives, Part 2.

A list of all parts of IEC 61375 series, published under the general title *Electric railway equipment – Train bus* can be found on the IEC website.

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.

Following the decision of the committee, some parts of the text and some figures of this publication are copied from the IEC 61375-1 for keeping the maximum of clarity.

A bilingual version of this standard may be issued at a later date.

INTRODUCTION

TCN is an International Standard with the aim of defining interfaces so as to achieve plug-in compatibility:

a) between equipment located in different vehicles, and

b) between equipment and devices located within the same vehicle.

One of the key success factors for deployment of any technology is the standardisation and the ensuring interoperability among various implementations. To facilitate interoperability a conformance test should be implemented.

In this part of IEC 61375, the TCN hierarchical structure deals with two levels of busses:

a) the train bus called the Wire Train Bus (WTB);

b) the vehicle bus called the Multifunction Vehicle Bus (MVB).

No other busses are taken into consideration even though they are foreseen by IEC 61375-1, see the note below.

WTB and MVB share the same real-time protocols, which offer two communication services:

a) process variables, a distributed, real-time database, periodically refreshed through broadcasting;

b) messages, transmitted on demand either as:

   0. unicast messages (point-to-point) or/and

   1. multicast messages.

WTB and MVB share a common network management, which allows debugging, commissioning and maintenance over the network.

NOTE TCN states that several vehicle busses may apply, provided that such busses are able to provide the services of Real_Time Protocols. However, this part of IEC 61375 is focused on MVB as vehicle bus, even if the conformance test may apply to other busses, the exact conformance test should be derived upon.

This standard is structured into 7 clauses and 2 annexes.

The clauses and annexes are listed and briefly described in the Table 1.

Table 1 – Document structure

Clause/sections	Description
1. General	This clause describes the scope of this standard and introduces basic terms and abbreviations not reported in IEC 61375-1.
2. Conformance test: approach, requirements and boundaries	This clause is an overview of the methods of TCN implementation verification that are available to the developer and regulatory personnel.
	Supplies information concerning the ICS and IXITpPro-forma(s).
3. Conformance test of an MVB device	This clause covers all tests on MVB devices that are grouped by classes, from Class 0 up to Class 4. The main contents are:
	the MVB PICS and PIXIT;
	the MVB test suites;
	the MVB test procedures.
4. Conformance test of a WTB device	Contents: All tests on WTB are classified by nodes related to WTB itself and MVB only. The main contents are:
	the WTB PICS and PIXIT;
	the WTB test suites;
	the WTB test procedures.
5 Conformance test of RTP	This clause lists the tests covered in Clauses 3 and 4 fulfilling the real time protocol.
6. Conformance test of a WTB-equipped vehicle	This clause covers the Physical Layer while the Services given by the WTB node are covered by the previous clauses. Application profiles are covered by other bodies, like UIC for profile UIC 556.
7 Conformance test of NM	Partially covered by Clauses 3 and 4. Remaining parts are not covered.
Annex A – Test laboratory role and client role	This annex is normative.
Annex B – Test instrumentation and dedicated test bed	This annex is informative.

ELECTRIC RAILWAY EQUIPMENT – TRAIN BUS –

Part 2: Train communication network conformance testing

1 General

1.1 Scope

This part of IEC 61375 applies to all equipment and devices implemented according to IEC 61375-1, i.e. it covers the procedures to be applied to such equipment and devices when the conformance should be proven.

The applicability of this standard to a TCN implementation allows for individual conformance checking of the implementation itself and is a pre-requisite for further interoperability checking between different TCN implementations.

NOTE 1 For a definition of TCN implementation see 1.3.

1.2 Normative references

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

IEC 60571:*Electronic equipment used on rail vehicles*

IEC 60807, *Rectangular connectors for frequencies below 3 MHz*

IEC 61375-1: 2007, *Electric railway equipment – Train bus – Part 1: Train communication network*

ISO/IEC 9646-1:1994, *Information technology – Open Systems Interconnection – Conformance testing methodology and framework – Part 1: General concepts* (Also available as ITU-T Recommendation X.290 (1995))

ISO/IEC 9646-7:1994, *Information technology – Open Systems Interconnection –Conformance testing methodology and framework – Part 7: Implementation Conformance Statements* (Also available as ITU-T Recommendation X.296 (1995))

UIC 556, *Information transmission in trains (train bus)*

1.3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 9646-1 and IEC 61375-1 apply.

2 Conformance test: approach, requirements and boundaries

2.1 The approach

This standard specifies a general methodology for testing the conformance to the TCN protocol standard of products in which the standard is claimed to be implemented.

This standard is organised into clauses structured into different phases of the conformance testing process, these phases being characterised by the following roles:

a) the specification of abstract test suites for particular TCN protocols according to ISO/IEC 9646-1;
b) the derivation of executable test suites and associated testing tools according to ISO/IEC 9646-7;

Annex A specifies the rules on clients and laboratory specifying:

c) the role of a client of a test laboratory, having an implementation of TCN protocols to be tested;
d) the operation of conformance testing, culminating in the production of a conformance test report which gives the results in terms of the test suite(s) used and the relevant documentation produced.

In all clauses of this standard, the scope is limited in order to meet the following objectives:

e) to achieve an adequate level of confidence in the tests as a guide to conformance;
f) to achieve comparability between the results of the corresponding tests applied in different places at different times;
g) to facilitate communication between the parties responsible for the roles described above.

Each objective involves the framework for development of TCN test suites, as listed hereinafter:

h) how they should relate to the various types of conformance requirement;
i) the types of test to be standardised and the types not needing standardisation;
j) the criteria for selecting tests for inclusion in a conformance test suite;
k) the notation to be used for defining tests;
l) the structure of a test suite.

Certification, an administrative procedure which may follow conformance testing, is outside the scope of this standard.

Requirements for procurement and contracts are outside the scope of this standard.

2.1.1 Requirements

2.1.1.1 General

In the context of TCN, a real system is said to exhibit conformance if it complies with the requirements of applicable TCN standard clauses in its communication with a reference system, i.e. the tester.

A TCN standard is a set of interrelated clauses which, together, define behaviour of TCN systems in their communication. Conformance of an IUT will, therefore, be expressed at two levels, conformance to each individual clause, and conformance to the set of clauses.

The following clauses define the conformance requirements and classify them according to attributes and into feasible groups. Attributes and grouping are defined from the general point of view with reference to a TCN specification itself and from the IUT point of view. In the second case, the requirement shall be declared in the appropriate PICS and PIXIT.

2.1.1.2 Conformance requirements

The conformance requirements can be:

a) mandatory requirements: these are to be observed in all cases;
b) conditional requirements: these are to be observed if the conditions, set out in the clause, apply;

c) options: these can be selected to suit the implementation, provided that any requirements applicable to the option are observed.

TCN essential functionality are mandatory requirements; additional functionality can be either conditional or optional requirements.

Furthermore, conformance requirements in a Part can be stated:

d) positively: they state what shall be done;
e) negatively (prohibitions): they state what shall not be done.

Finally, conformance requirements fall into two groups:

f) static conformance requirements;
g) dynamic conformance requirements;

these are discussed in 2.1.1.3 and 2.1.1.4, respectively.

2.1.1.3 Static conformance requirements

To facilitate interoperability static conformance requirements define the allowed minimum capabilities of an implementation. These requirements may be at a broad level, such as the grouping of functional units and options into protocol classes, or at a detailed level, such as a range of values that have to be supported for specific parameters of timers.

Static conformance requirements and options in TCN parts can be of two varieties:

a) those which determine the capabilities to be included in the implementation of the particular protocol;
b) those which determine multi-layer dependencies, for example those which place constraints on the capabilities of the underlying layers of the system in which the protocol implementation resides. These are likely to be found in upper layer parts (e.g. network management vs real time protocols).

All capabilities not explicitly stated as static conformance requirements are to be regarded as optional.

2.1.1.4 Dynamic conformance requirements

Dynamic conformance requirements are all those requirements (and options) which determine what observable behaviour is permitted by the relevant TCN part in instances of communication. They form the bulk of each TCN protocol document. They define the set of allowable behaviours of an implementation or real system. This set defines the maximum capability that a conforming implementation or real system can have within the terms of the TCN protocol document.

A system exhibits dynamic conformance in an instance of communication if its behaviour is a member of the set of all behaviours permitted by the relevant TCN protocol part in a way which is consistent with the PICS.

2.1.1.4.1 A conforming system

A conforming system or implementation is one which is shown to satisfy both static and dynamic conformance requirements, consistent with the capabilities stated in the PICS, for each protocol declared in the system conformance statement.

2.1.1.4.2 Interoperability and conformance

The primary purpose of conformance testing is to increase the probability that different implementations are able to inter-operate.

Successful interoperability of two or more real open systems is more likely to be achieved if they all conform to the same subset of a TCN part, or to the same selection of TCN parts, than if they do not.

To prepare two or more systems to successfully inter-operate, it is recommended that a comparison is made of the system conformance statements and PICSs of these systems.

If there is more than one version of a relevant TCN part indicated in the PICSs, the differences between the versions need to be identified and their implications for consideration, including their use in combination with other parts.

While conformance is a necessary condition, it is not on its own a sufficient condition to guarantee interoperability capability. Even if two implementations conform to the same TCN protocol part, they may fail to interoperate because of factors outside the scope of this standard.

Trial interoperability is recommended to detect these factors. Further information to assist interoperability between two systems can be obtained by extending the PICS comparison to other relevant information, including test reports and PIXIT. The comparison can focus on:

a) additional mechanisms claimed to work around known ambiguities or deficiencies not yet corrected in the TCN standard or in peer real systems, for example solution of multi-layer problems;
b) selection of free options which are not taken into account in the static conformance requirements of the TCN parts;
c) the existence of timers not specified in the TCN parts and their associated values.

NOTE The comparison can be made between two individual systems, between two or more types of product, or, for the PICS comparison only, between two or more specifications for procurement, permissions to connect, etc.

2.1.2 Requirements declaration statements for an IUT

2.1.2.1 Protocol implementation conformance statement (PICS)

To evaluate the conformance of a particular implementation, it is necessary to have a statement of the capabilities and options which have been implemented, and any features which have been omitted, so that the implementation can be tested for conformance against relevant requirements, and against those requirements only. Such a statement is called a Protocol Implementation Conformance Statement (PICS).

In a PICS there should be a distinction between the following categories of information which it may contain:

a) information related to the mandatory, optional and conditional static conformance requirements of the protocol itself;
b) information related to the mandatory, optional and conditional static conformance requirements for multi-layer dependencies.

If a set of interrelated TCN protocol has been implemented in a system, a PICS is needed for each protocol. A system conformance statement will also be necessary, summarising all protocols in the system for each of which a distinct PICS is provided.

2.1.2.2 Protocol implementation extra information for testing (PIXIT)

In order to test a protocol implementation, the test laboratory will require information relating to the IUT and its testing environment in addition to that provided by the PICS. This *"Protocol*

Implementation eXtra Information for Testing" (PIXIT) will be provided by the client submitting the implementation for testing, as a result of consultation with the test laboratory.

The PIXIT may contain the following information:

a) information needed by the test laboratory in order to be able to run the appropriate test suite on the specific system (e.g. information related to the test method to be used to run the test cases, addressing information);
b) information already mentioned in the PICS and which needs to be made precise (e.g. a timer value range which is declared as a parameter in the PICS should be specified in the PIXIT);
c) information to help determine which capabilities stated in the PICS as being supported are testable and which are untestable;
d) other administrative matters (e.g. the IUT identifier, reference to the related PICS).

The PIXIT should not conflict with the appropriate PICS.

The abstract test suite specifier, test implementor and test laboratory will all contribute to the development of the PIXIT pro-forma.

2.2 Boundaries

2.2.1 General

Conformance testing as discussed in this standard is focused on testing for conformance to TCN clauses as they are specified in IEC 61375-1 (second edition).

In principle, the objective of conformance testing is to establish whether the implementation being tested conforms to the specification in the relevant clause. Practical limitations make it impossible to be exhaustive, and economic considerations may restrict testing still further.

Therefore, this standard distinguishes four types of testing, according to the extent to which they provide an indication of conformance:

a) basic interconnection tests, which provide *prima facie* evidence that an IUT conforms;
b) capability tests, which check that the observable capabilities of the IUT are in accordance with the static conformance requirements and the capabilities claimed in the PICS;
c) behaviour tests, which endeavour to provide testing which is as comprehensive as possible over the full range of dynamic conformance requirements within the capabilities of the IUT;
d) conformance resolution tests, which probe in depth the conformance of an IUT to particular requirements, to provide a definite yes/no answer and diagnostic information in relation to specific conformance issues; such tests are not covered by this standard.

Tests a), b), c) and d) are foreseen in A.6.3 of IEC 61375-1, and are described in detail by the following subclauses.

Relations to interoperability and performance are hereinafter considered and defined to clarify their boundaries.

2.2.2 Basic interconnection tests

Basic interconnection tests provide limited testing of an IUT to establish that there is sufficient conformance for interconnection to be possible, without trying to perform thorough testing.

2.2.2.1 Applicability of basic interconnection tests

Basic interconnection tests are appropriate:

a) for detecting severe cases of non-conformance;

b) as a preliminary filter before undertaking more costly tests;

c) to give a *prima facie* indication that an implementation which has passed full conformance tests in one environment still conforms in a new environment (e.g. before testing an (N)-implementation, to check that a tested (N – 1)-implementation has not undergone any severe change due to being linked to the (N)-implementation);

d) for use by users of implementations, to determine whether the implementations appear to be usable for communication with other conforming implementations, for example as a preliminary to data interchange.

Basic interconnection tests are inappropriate:

e) as a basis for claims of conformance by the supplier of an implementation;

f) as a means of arbitration to determine causes for communications failure.

Basic interconnection tests are standardised a subset of a conformance test suite (including capability and behaviour tests). They can be used on their own or together with a conformance test suite. The existence and execution of basic interconnection tests are optional.

2.2.3 Capability tests

Capability tests provide limited testing of each of the static conformance requirements in a Part, to ascertain what capabilities of the IUT can be observed and to check that those observable capabilities are valid with respect to the static conformance requirements and the PICS.

2.2.3.1 Applicability of capability tests

Capability tests are appropriate:

a) to check as far as possible the consistency of the PICS with the IUT;

b) as a preliminary filter before undertaking more in-depth and costly testing;

c) to check that the capabilities of the IUT are consistent with the static conformance requirements;

d) to enable efficient selection of behaviour tests to be made for a particular IUT;

e) when taken together with behaviour tests, as a basis for claims of conformance.

Capability tests are inappropriate:

f) on their own, as a basis for claims of conformance by the supplier of an implementation;

g) for testing in detail the behaviour associated with each capability which has been implemented or not implemented;

h) for resolution of problems experienced during live usage or where other tests indicate possible non-conformance even though the capability tests have been satisfied.

Capability tests are standardised within a conformance test suite. They can either be separated into their own test group(s) or merged with the behaviour tests.

2.2.4 Behaviour tests

Behaviour tests test an implementation as thoroughly as is practical, over the full range of dynamic conformance requirements specified in a Part. Since the number of possible combinations of events and timing of events is infinite, such testing cannot be exhaustive. There is a further limitation, namely that these tests are designed to be run collectively in a single test environment, so that any faults which are difficult or impossible to detect in that environment are likely to be missed. Therefore, it is possible that a non-conforming implementation passes the conformance test suite; one aim of the test suite design is to minimise the number of times that this occurs.

Behaviour tests with capability tests are the basis for the conformance assessment process.

Behaviour tests are inappropriate:

a) for resolution of problems experienced during live usage or where other tests indicate possible non-conformance even though the behaviour tests have been satisfied.

Behaviour tests are standardised as the bulk of a conformance test suite.

NOTE Behaviour tests include tests for valid behaviour by the IUT in response to valid, inopportune and syntactically invalid protocol behaviour by the real tester. This includes testing the rejection by the IUT of attempts to use features (capabilities) which are stated in the PICS as being not implemented. Thus, capability tests do not need to include tests for capabilities omitted from the PICS.

2.2.5 Conformance resolution tests

Conformance resolution tests provide diagnostic answers, as near to definitive as possible, to the resolution of whether an implementation satisfies particular requirements. Because of the problems of exhaustiveness, the definite answers are gained at the expense of confining tests to a narrow field.

The test architecture and test method will normally be chosen specifically for the requirements to be tested, and need not be ones that are generally useful for other requirements. They may even be ones that are regarded as being unacceptable for (standardised) abstract conformance test suites, for example involving implementation-specific methods using, say, the diagnostic and debugging facilities of the specific operating system.

The distinction between behaviour tests and conformance resolution tests may be illustrated by the case of an event such as a reset. The behaviour tests may include only a representative selection of conditions under which a reset might occur, and may fail to detect incorrect behaviour in other circumstances. The conformance resolution tests would be confined to conditions under which incorrect behaviour was already suspected to occur, and would confirm whether or not the suspicions were correct.

Conformance resolution tests are appropriate:

a) for providing a yes/no answer in a strictly confined and previously identified situation (e.g. during implementation development, to check whether a particular feature has been correctly implemented, or during operational use, to investigate the cause of problems);
b) as a means for identifying and offering resolutions for deficiencies in a current conformance test suite.

Conformance resolution tests are inappropriate

c) as a basis for judging whether or not an implementation conforms overall.

Conformance resolution tests are not standardised. As a by-product of conformance testing, errors and deficiencies in protocol parts may be identified.

2.2.6 Interpretation of clauses/subclauses and statements

The TCN described in IEC 61375-1 is subject to a sort of interpretation to translate some clauses/subclauses and requirements into realisable test suites. The complexity of most TCN protocols makes exhaustive testing impractical on both technical and economic grounds. To cope with a real implementation and extract from IEC 61375-1 all the relevant tests and some criteria were used. The criteria were grouped according to their characteristics:

a) imperatives;
b) illustrative;
c) directives;

d) options;

e) weak phrases.

The following subclauses describe the criteria.

2.2.6.1 Imperatives

Imperatives are those words and phrases commanding that something shall be provided and are classified as mandatory. They are:

a) **shall –** dictates the provision of a functional capability;

b) **must** or must not – establishes performance requirements or constraints;

c) **is required to** – is a specification statement written in the passive voice;

d) **are applicable** – includes, by reference, standards or other documentation as an addition to the requirements being specified;

e) **responsible for** – is a requirement written for architectures already defined. As an example, " In extended reply delay applications, the master is responsible for spacing the master frames so that the minimum time to transmit to a slave frame and the following master frame is greater than T_safe..";

f) **will** – is generally used to cite things that the operational or development environment are to provide to the capability being specified. For example, " If it was a strong master, it will signal its demoting to all nodes and it will remain in control of the bus as a weak master until a strong node is appointed";

g) **should** – when it is used, the specification statement is considered to be very weak. For example, " Devices supporting the message data capability should have a device address smaller than 256.".

Continuance

Phrases that follow an imperative and introduce the specification of requirements at a lower level, for a supplemental requirement count.

a) as follows,

b) below,

c) following,

d) in particular,

e) listed,

f) support.

Phrases that introduces temporal indication, that may lead to definite or indefinite actions, or enumerative that may lead to infinite test cases.

Table 2 – Continuance indication

	Statement	Example
1	for each	A PV_Set identifies a set of variables belonging to the same dataset, including for each variable the Memory_Address where it should be copied to (or from), and including for the whole dataset the Freshness_Time.)
2	while	While sending BD packets, the producer filters incoming BR packets and starts retransmission after insertion of a transmission pause (PAUSE_TMO in addition to the normal SEND_TMO)

The requirement containing temporal or enumerative is tested with a finite time or finite sample.

2.2.6.2 Illustrative

This is information within the requirements document. The data and information pointed to by illustrative strengthens the document's specification statements and whenever possible is used as sample category input for the test. Namely:

a) **figure;**

b) **table;**

c) **for example;**

d) **note**.

2.2.6.3 Options

Options is the category of words that give the developer latitude in satisfying the specification statements that contain them. This category clearly forms the basis for the option statements declaration into the PICS. However, those requirements containing such a category of words loosen the specification, increase the risk of non-interoperability, and widen the tests sets.

a) **can** (Example: Gateways with Bus_Administrator capability can synchronise the busses.);

b) **may** (Example: Class 5 devices may offer the Bus_Administrator capability.);

c) **optionally** (Example: The User_Programmable capability is optional.);

d) **exclusion** (Example: while the IUT is naming the nodes, one node responds to the naming frame but not to the status request, or sends a wrong naming response frame).

Options shall drive the PICS production.

2.2.6.4 Weak statements

Weak statements are apt to cause uncertainty leaving room for multiple interpretations, such wording provides a basis for expanding a requirement or adding future requirements. For the extent of testing, this category generates test with test cases chosen among a representative set of samples. However, by no means such sets fully represent all significant cases foreseen by the clause under test. They are:

Table 3 – Weak statements

Phrases with	Example
adequate	The transmitter and the receiver connector shall be *adequately* identified, preferably: • light grey for the transmitter; • dark grey for the receive.
be able to	The link layer as well as the application shall *be able to* access a port consistently, i.e. write or read all its data in one indivisible operation
be capable	A device with double-line attachment shall *be capable* of being attached to both a single-line or to a double-line EMD segment, as shown in Figure 56
effective	The entity which *effectively* accesses the objects in each layer is called the Layer Management Entity, or LME
normal	While sending BD packets, the producer filters incoming BR packets and starts retransmission after insertion of a transmission pause (PAUSE_TMO in addition to the *normal* SEND_TMO.
provide for	The Application Layer for Variables (AVI) shall *provide for* Cluster access the following primitives, illustrated in Figure 14 and specified in the following subclauses

2.2.7 Relation to interoperability

One of the aims of this conformance test is to lead to comparability and wide acceptance of test results produced by different testers, and thereby minimise the need for repeated conformance testing of the same system. Interoperability plays a principal role, since the conformance test is aimed to facilitate interoperability, it has been taken into account with the following domains:

Table 4 – Relation to interoperability

Application interoperability	the ability of TCN to provide a consistent implementation of the syntax and semantics of the data which are interchanged
Protocol interoperability	the ability of TCN to interchange PDUs via the communications platform
Service interoperability	the ability of TCN to support a subset of its intended services
User perceived interoperability	the ability of the service user (human, application, machine) to exchange information via the TCN

No provision is made in this standard to implement or recommend an interoperability test.

2.2.8 Relation to performance test

Performance attributes relate deeply on services given by the TCN, even though this conformance test does not intend to implement a performance test, nevertheless performance attributes were taken into account in the following way:

Table 5 – Relation to performance test

Speed	This performance attribute describes the time interval that is used to perform the function or the rate at which the function is performed. (The function may or may not be performed with the desired accuracy.). An example of speed attribute evaluation is: freshness time supervision test
Accuracy	This performance attribute describes the degree of correctness with which the function is performed, no matter if the function is or is not performed with the desired speed. An example of accuracy evaluation is: the receiver hysteresis test
Dependability	This performance attribute describes the degree of certainty (or surety) with which the function is performed regardless of speed or accuracy, but within a given observation interval. An example of dependability attribute evaluation is: Connection stability for the entire inauguration time

No provision is made in this standard to implement or recommend a performance test as it is defined by IEC 60571.

2.3 Conformance assessment process outline

2.3.1 General

The main feature of the conformance assessment process is a configuration of equipment allowing exchanges of information between the IUT and a real tester. These are controlled and observed by the real tester.

In a conceptual outline, conformance testing should include several steps, involving both static conformance reviews and live testing phases, culminating in the production of a test report which is as thorough as is practical.

These steps are:

- compilation of the PICS;
- compilation of the PIXIT;
- test selection and parameterisation;

- basic interconnection testing (optional);
- capability testing;
- behaviour testing;
- review and analysis of test results;
- synthesis, conclusions and conformance test report production.

2.3.2 Analysis of results, outcomes and verdicts

The observed outcome (of the test execution) is the series of events which have occurred during execution of a test case; it includes all input to and output from the IUT at the points of control and observation.

The foreseen outcomes are identified and defined by the abstract test case specification taken in conjunction with the protocol Part. For each test case, there may be one or more foreseen outcomes. Foreseen outcomes are defined primarily in abstract terms.

A verdict is a statement of pass, fail or inconclusive to be associated with every foreseen outcome in the abstract test suite specification.

The analysis of results is performed by comparing the observed outcomes with foreseen outcomes.

The verdict assigned to an observed outcome is that associated with the matching foreseen outcome. If the observed outcome is unforeseen then the abstract test suite specification will state what default verdict shall be assigned.

The means by which the comparison of the observed outcomes with the foreseen outcomes is made is outside the scope of this standard.

NOTE Amongst the possibilities are:

a) manual or automated comparison (or a mixture);

b) comparison at or after execution time;

c) translating the observed outcomes into abstract terms for comparison with the foreseen outcomes or translating the foreseen outcomes into the terms used to record the observed outcomes.

The verdict will be pass, fail or inconclusive:

d) pass means that the observed outcome satisfies the test purpose and is valid with respect to the relevant TCN Parts and with respect to the PICS;

e) fail means that the observed outcome is syntactically invalid or inopportune with respect to the relevant TCN Parts or the PICS;

f) inconclusive means that the observed outcome is valid with respect to the relevant TCN Parts but prevents the test purpose from being accomplished.

The verdict assigned to a particular outcome will depend on the test purpose and the validity of the observed protocol behaviour.

The verdicts made in respect of individual test cases will be synthesised into an overall summary for the IUT based on the test cases executed.

3 Conformance test of an MVB device

3.1 PICS

PICS pro-forma is a set of tables containing questions to be answered by an implementer, and limitations on the possible answers.

It contains two types of questions:

- questions to be answered by either "YES" or "NO", related to whether a clause (ranging from a macroscopic functional unit to a microscopic one) has been implemented or not. The allowed answers, which reflect the base specification, are documented in the PICS as requirement; the answers constitute the support;
- questions on numerical values implemented (for timers, for sizes of messages, for frequencies, etc.). The legitimate range of variation of this value, which reflects the base specification, is given in IEC 61375-1. The answers constitute the supported values.

3.1.1 Instructions for filling the PICS pro-forma

PICS are organised in tables. Columns in the tables are:

- Ref.
- Supported subclause
- Supported capability
- Requirement
- Implementation
- Parameter values

3.1.1.1 Abbreviations

The following abbreviations are used in this PICS pro-forma:

m: mandatory

n/a: not applicable

o: optional

c: conditional

d: default

Y: yes

N: no

3.1.1.2 Ref. column

This column is used for reference purposes inside the PICS

3.1.1.3 Supported subclause column

This column gives the mapping between IEC 61375-1 and the corresponding entry in the PICS.

3.1.1.4 Supported capability column

The capability is supported if the Implementation Under Test (IUT) is able to:

- generate the corresponding service parameters (either automatically or because the end user explicitly requires that capability);
- interpret, handle and when required make available to the end user the corresponding service parameter(s).

3.1.1.5 Requirement column

This column indicates the level of support required for conformance to IEC 61375-1.

The values are as follows:

m mandatory support is required;

o optional support is permitted for conformance to the IEC 61375-1. If implemented it must conform to the specifications and restrictions contained in the relevant clause. These restrictions may affect the optionality of other items;

c the item is conditional, the support of this item is subject to a predicate which is referenced in the note column;

n/a the item is not applicable.

If options are not supported the corresponding items shall be considered as not applicable.

3.1.1.6 Implementation column

This column shall be completed by the supplier or implementer of the IUT. The pro-forma has been designed so that the only entries required in its own column are:

Y: yes, the item has been implemented;

N: no, the item has not been implemented;

-: the item is not applicable.

In the PICS pro-forma tables, every leading item marked 'm' should be supported by the IUT. Sub-items marked 'm' should be supported if the corresponding leading feature is supported by the IUT.

3.1.1.7 Parameter values columns

3.1.1.7.1 Allowed min.

This column is already filled and indicates the minimum value for a parameter.

3.1.1.7.2 Default value

This column indicates the default value for a parameter. When IEC 61375-1 defines the default for the parameter, such a value is used as the entry in this column. When the standard recommends a range, the mean value is used.

3.1.1.7.3 Allowed max.

This column is already filled and indicates the maximum value for a parameter.

3.1.1.7.4 Implemented value

This column shall be completed by the supplier or implementer. The pro-forma has been designed so that the entry required is the implemented value. In case of multiple values, the default value shall be chosen.

3.1.2 PICS tables

3.1.2.1 Identification of PICS

The following table is intended to be filled in order to identify the pro-forma.

Ref. No.	Question	Response
1	Date of statement	
2	PICS serial number	

3.1.2.2 Identification of the implementation under test

The following table shall be filled in to identify the implementation under test.

Ref. No.	Question	Requirement	Response
1.	Implementation name	m	
2.	Version number	m	
3.	Special configuration	o	
4.	Power supply	m	
5.	Other information	o	

NOTES

1 Implementation name refers to the identifier of the IUT as indicated by the client. The specific conformance test shall be applied to the entity identified by the implementation name.

2 This is the version number of the IUT.

3 The special configuration should be indicated if PIXIT is provided for this IUT.

4 The power supply should be indicated the applicable power supply. The power supply is chosen amongst the values specified by EN 50155.

5 Other information the client considers relevant for IUT identification.

3.1.2.3 Identification of the IUT supplier and/or test laboratory client

The following table shall be filled in to identify the IUT supplier and the test laboratory client.

Ref. No.	Question	Requirement	Response
1.	Organisation name	m	
2.	Contact name(s)	m	
3.	Address:	m	
4.	Telephone number[1]	m	
5.	Fax number[1]	m	
6.	e-mail address[1]	m	
7.	Other information[1]	m	

[1] Fill in if the information is available.

3.1.2.4 Identification of the standard

The following table shall be filled in to identify the standard applied to the IUT for the conformance test.

Ref. No.	Question	Requirement	Response
1	Title	m	
2	Reference number	m	
3	Date of publication	m	
4	Version number	m	

3.1.2.5 Global statement of conformance

This table shall be filled in by the IUT supplier in the “Implementation” column

Ref. No.	Question	Requirement	Implementation
1	Are all mandatory capabilities implemented?	m	[ ]
NOTE Answering "No" to this subclause indicates non-conformance to the protocol specification. Non-supported mandatory capabilities are to be identified in the PICS, with an explanation of why the implementation is non-conforming.			

3.1.2.6 Device classes

This table shall be filled in by the IUT supplier in order to identify the device class of the IUT. An IUT implementing more than one class shall test each interface to determine to which class it belongs.

Ref. No.	Subclause	Capability	Implementation
1	3.2.2.2	Class 0	[ ]
2	3.2.2.3	Class 1	[ ]
3	3.2.2.4	Class 2	[ ]
4	3.2.2.5	Class 3	[ ]
5	3.2.2.6	Class 4	[ ]
6	3.2.2.7	Class 5	[ ]

3.1.2.7 Class 0

This table shall be filled in by the IUT supplier if the device class declared in the “Device classes” table is Class 0.

Ref. No.	Subclause)	Capability	Implementation
1	3.2.6.7	Active_Star_Coupler	[ ]
2	3.2.6.7 (refer to NOTE)	Star_coupler	[ ]
3	3.3.3	Repeater	[ ]
4	3.2.4.3.1	ESD backplane	[ ]
5	3.2.4.2.1	ESD cable	[ ]
6	3.2.5.2.1	EMD cable	[ ]

3.1.2.8 Class 1

This table shall be filled by the IUT supplier if the device class declared in the “Device classes” table is Class 1.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.2.3	Device status	m	[ ]
2	3.2.2.3	Process data	m	[ ]

3.1.2.9 Class 2

This table shall be filled in by the IUT supplier if the device class declared in the “Device classes” table is Class 2.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.2.4	Device status	m	[ ]
2	3.2.2.4	Process data	m	[ ]
3	3.2.2.4	Message data	m	[ ]
4	3.2.2.1	Network management (TNM)	m	[ ]

3.1.2.10 Class 3

This table shall be filled in by the IUT supplier if the device class declared in the “Device classes” table is Class 3.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.2.5	Device status	m	[ ]
2	3.2.2.5	Process data	m	[ ]
3	3.2.2.5	Message data	m	[ ]
4	3.2.2.5	User programmable	m	[ ]
5	3.2.2.1	Network management (TNM)	m	[ ]

3.1.2.11 Class 4

This table shall be filled in by the IUT supplier if the device class declared in the “Device classes” table is Class 4.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.2.6	Device status	m	[ ]
2	3.2.2.6	Process data	m	[ ]
3	3.2.2.6	Message data	m	[ ]
4	3.2.2.6	User programmable (TNM)	o	[ ]
5	3.2.2.6	Bus administrator	m	[ ]
6	3.2.2.1	Network management (TNM)	m	[ ]

3.1.2.12 Class 5

This table shall be filled in by the IUT supplier if the device class declared in the “Device classes” table is Class 5.

Note that the test of the TCN gateway is not covered by this standard due to incomplete specification in IEC 61375-1.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.2.7	Device status	m	[ ]
2	3.2.2.7	Process data	m	[ ]
3	3.2.2.7	Message data	m	[ ]
4	3.2.2.7	User programmable	o	[ ]
5	3.2.2.7	Bus administrator	o	[ ]
~~6~~	~~3.2.2.7~~	~~TCN gateway~~[2]	~~m~~	~~[ ]~~

3.1.2.13 Segment

This table shall be filled in by the IUT supplier to declare which type of bus segment the device is designed to be attached to.[2]

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.1.1	ESD	o	[ ]
~~2~~	~~3.2.1.1~~	~~OGF~~[3]	~~o~~	~~[ ]~~
3	3.2.1.1	EMD	o	[ ]
NOTE One of the given capabilities should be chosen and for the conformance test purpose, the chosen capability is considered mandatory (m).				

3.1.2.14 Redundancy

This table shall be filled by the IUT supplier to declare if the IUT implements the double-segment attachment and line redundancy.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.1.3	Physical redundancy media	o	[ ]

3.1.2.15 Redundancy configuration

This table shall be filled in by the IUT supplier if in the previous table, column “Implementation”, the implementation is Y.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.5.4.2	Is line A marked?	m	[ ]
2	3.2.5.4.2	Is line B marked?	m	[ ]

3.1.2.16 Device address

This table shall be filled in by the IUT supplier declaring the device address of the IUT as supplied for this test.

Ref. No.	Subclause	Capability	Requirement	Implementation value
1	3.5.1.1	Device_Address	m	

2 This test is purposely crossed out to make evidence that TCN gateway test is not covered.

3 This test is purposely crossed out to make evidence that OGF is not covered.

3.1.2.17 Timing general values

This table shall be filled in by the IUT supplier who shall declare the implementation values of the Timing General Values.

All boundaries are derived from the IEC 61375-1 and they refer to the ALLOWED range.

Ref. No.	Sub-clause	Capability	Require-ment	Allowed min.	Default value	Allowed max.	Implemen-tation
1	3.2.3.2 3.4.2.2	T_reply_max	m	T_reply_def = 42,7µs.	T_reply_def = 42,7µs.	T_reply_def = 66,6 µs.	
2	3.4.2.4.1	T_ignore	m	T_ignore = 1µs.	T_ignore = T_reply_def	T_ignore = 255 µs.	
3	3.4.2.5	T_alive	m	T_alive = 1,3 ms	T_alive = 1,3 ms	-	
4	3.4.2.4.1	T_safe	m	T_safe = T_reply_def	T_safe = T_reply_def	-	

3.1.2.18 Additional timing for Classes 4 and 5 only

This table shall be filled in by the IUT supplier who shall declare the implementation values of the scan rate value. The IUT supplier shall declare the tolerance, expressed as a percentage of the declared value. This table applies only to Class 4 and Class 5 devices.

Ref. No.	Subclause	Capability	Requirement	Default value	Implementation
1	3.6.4.3	Scan Rate	m	Scan Rate = 64 devices every 512,0 ms.	

3.1.2.19 Network manager agent services

This table shall be filled in by the IUT supplier who shall declare the network manager agent services implemented.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	5.4.2.4.2	WRITE_RESERVATION (03)	m	[ ]
2	5.4.3.1	READ_MVB_STATUS (10)	m	[ ]
3	5.4.3.3	READ_MVB_DEVICES (12)	m	[ ]

3.1.2.20 ESD section option

This subclause applies only if the response Y is given at the line referred to as 1 in 3.1.2.13. One of the given capabilities should be chosen and for the conformance test purpose the chosen capability is considered mandatory (m) .

Ref. No.	Subclause	Capability	Requirement	Implementation
1		Backplane bus used	o	[ ]
2		Cable used	o	[ ]

3.1.2.20.1 ESD backplane

This subclause applies only if the response Y is given at the line referred to as 1 in the tables of 3.1.2.20 and 3.1.2.7 reference 0.

Ref. No.	Subclause	Capability	Requirement	Allowed min.	Allowed max.	Implementation
1	3.2.4.3.1	Extension of a stub	c – 3.1.2.20 Ref. 1	-	10 cm.	[ ]
2	3.2.4.3.1	Pitch between adjacent taps	c – 3.1.2.20 Ref. 1	2,0 cm.	20 m.	[ ]

3.1.2.20.2 ESD cable

This subclause applies only if the response Y is given at the line referred to as 2 in the table of 3.1.2.20.

Ref. No.	Subclause	Capability	Requirement	Allowed min.	Allowed max.	Implementation
1	3.2.4.3.2	Equipotential wire	c – 3.1.2.20 Ref. 2	0,34 mm² (AWG 22)	0,56 mm² (AWG 20)	[ ]

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.4.3.1	Equipotential wire identification for LINE_A	c – 3.1.2.20 Ref. 2	[ ]
2	3.2.4.3.1	Equipotential wire identification for LINE_B	c – 3.1.2.20 Ref. 2	[ ]

3.1.2.20.2.1 ESD cable confectioned

Ref. No.	Clause	Capability	Requirement	Implementation
1	3.2.4.4	Shield connected to the casing of each connector	c – 3.1.2.20 Ref. 2	[ ]
2	3.2.4.4	Shield connected to the casing of each conductive connector	c – 3.1.2.20 Ref. 2	[ ]

3.1.2.20.3 ESD load

This subclause applies anyway if the response Y is given at the line referred to as 1 or 2 in the table of 3.1.2.20. This part is a declaration by the client, not subject to testing.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.4.6.2	Conform to ISO/IEC 8482 (RS-485).	m	[ ]

3.1.2.21 ESD connector

This table shall be filled in by the IUT supplier who shall declare how the connection to the ESD segment is implemented.

3.1.2.21.1 Cable side

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.4.5.2	Line_A 9-pin and LINE_B Sub-D 9 connectors using metric screws (IEC 60807)	m	[ ]
2	3.2.4.5.2	Connector_1 Cable female	m	[ ]
3	3.2.4.5.2	Connector_2 Cable male	m	[ ]
4	3.2.4.5.2	Shielding	m	[ ]
5	3.2.4.5.2	Conductive casing connected to the cable shield	m	[ ]
6	3.2.4.5.2	Makes an electrical contact with the receptacle when fastened	m	[ ]

3.1.2.22 Receptacle side

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.4.5.2	Line_A and Line_B use 9 pin Sub-D 9 receptacle called mVB-S1	m	[ ]
2	3.2.4.5.2	MVB-S1 receptacle has metric screws (IEC 60807)	m	[ ]
3	3.2.4.5.2	MVB-S1 receptacle male	m	[ ]
4	3.2.4.5.2	Line_A and Line_B use 9 pin Sub-D 9 receptacle called mVB-S2	m	[ ]
5	3.2.4.5.2	MVB-S2 receptacle has metric screws (IEC 60807)	m	[ ]
6	3.2.4.5.2	MVB-S2 receptacle female	m	[ ]
7	3.2.4.5.2	Shielding	m	[ ]
8	3.2.4.5.2	Conductive casing connected to the cable shield	m	[ ]
9	3.2.4.5.2	Makes an electrical contact with the receptacle when fastened	m	[ ]

3.1.2.23 EMD section

This subclause applies only if the response Y is given at the line referred to as item 3) in 3.1.2.13.

3.1.2.23.1 EMD cable

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.5.4.1	Shielded cable	m	[ ]
2	3.2.5.4.1	Jacketed cable	m	[ ]
3	3.2.5.4.1	Twisted pair	m	[ ]
4	3.2.5.4.2	Individual wires marked distinctly[4]	m	[ ]
5	3.2.5.4.2	Line A identified as: A.Data_P A.Data_N	m	[ ]
6	3.2.5.4.2	Line B identified as: B.Data_P B.Data_N	m	[ ]

4 The two pairs of wires may be geometrically laid out as a quadruple, in this case, diagonal wires should form one pair.

Ref. No.	Subclause	Capability	Requirement	Allowed min.	Allowed max.	Implementation
1	3.2.5.4.1	Cross-section wire	m	0,34 mm² (AWG 22)	0,56 mm² (AWG 20)	[ ]
2	3.2.5.4.1	Twist per meter		12	-	[ ]

Ref. No.	Subclause	Capability	Requirement	Value	Implementation
1	3.2.5.4.3	Impedance	m	Zw = 120,0 Ω (±10 %) between 0,5 BR and 2,0 BR	[ ]
2	3.2.5.4.4	Attenuation	m	Less than 15,0 dB/km at 1,0 BR	[ ]
3	3.2.5.4.4	Attenuation	m	Less than 20,0 dB/km at 2,0 BR	[ ]
4	3.2.5.4.5	Distributed capacitance	m	Less than 46 pF/m at 1,0 BR	[ ]
5	3.2.5.4.6	Capacitive unbalance to shield	m	Less than 1,5 pF/m at 1,0 BR	[ ]
6	3.2.5.4.7	Crosstalk	m	Great than 45,0 dB between 0,5 to 2,0 MHz	[ ]
7	3.2.5.4.8	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[ ]
8	3.2.5.4.8	Differential transfer impedance	m	Less than 2,0 mΩ/m at 20,0 MHz	[ ]
9	3.2.5.4.9	Continuity of wires	m	Less than 10,0 mΩ/m	[ ]

3.1.2.23.2 EMD line attachment

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.5.6.1	Passive tap attachment	m	[ ]
2	3.2.5.5.1	Shield continuity	m	[ ]
3	3.2.5.5.1	Case of device connected to receptacle	m	[ ]
4	3.2.5.5.1	Means to connect the shield to its device ground	m	[ ]
5	3.2.5.6.2	Double-line attachment	o	[ ]

Ref. No.	Subclause	Capability	Requirement	Allowed min.	Allowed max.	Implementation
1	3.2.5.6.1	Length of stub	m	-	10,0 cm	[ ]

3.1.2.23.3 EMD connector

The following cable side and receptacle side tables shall be filled by the IUT supplier who shall declare how the connection to the EMD segment is implemented.

3.1.2.23.3.1 Cable side

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.5.6.3	Line_A and Line_B are on 9-pin Sub-D9 connectors called Connector_1	m	[ ]
2	3.2.5.6.3	Connector_1 has metric screws (IEC 60807)	m	[ ]
3	3.2.5.6.3	Connector_1 male	m	[ ]
4	3.2.5.6.3	Line_A and Line_B are on 9-pin Sub-D9 connectors called Connector_2	m	[ ]
5	3.2.5.6.3	Connector_2 has metric screws (IEC 60807)	m	[ ]
6	3.2.5.6.3	Connector_2 female	m	[ ]
7	3.2.5.6.3	Shielding	m	[ ]
8	3.2.5.6.3	Conductive casing connected to the cable shield	m	[ ]
9	3.2.5.6.3	Makes an electrical contact with the receptacle when fastened	m	[ ]

Ref. No.	Subclause	Capability	Requirement	Value	Implementation
1	3.2.5.4.9	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[ ]

3.1.2.23.3.2 Receptacle side

Ref. No.	Subclause	Capability	Requirement	Implementation
1	3.2.5.6.3	Line_A and Line_B 9-pin Sub-D 9 receptacle called mVB-M1	m	[ ]
2	3.2.5.6.3	MVB-M1 has metric screws (IEC 60807)	m	[ ]
3	3.2.5.6.3	MVB-M1 is female	m	[ ]
4	3.2.5.6.3	Line_A and Line_B 9-pin Sub-D 9 receptacle called mVB-2	m	[ ]
5	3.2.5.6.3	MVB-M2 has metric screws (IEC 60807)	m	[ ]
6	3.2.5.6.3	MVB-M2 is male	m	[ ]
7	3.2.5.6.3	Shielding	m	[ ]
8	3.2.5.6.3	Conductive casing connected to the cable shield	m	[ ]
9	3.2.5.6.3	Makes an electrical contact with the receptacle when fastened	m	[ ]

Ref. No.	Subclause	Capability	Requirement	Value	Implementation
1	3.2.5.4.9	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[ ]

3.2 Test suites

This subclause specifies the test suites to be applied to an MVB device to assess its conformance. There are three main groups of test suites:

- basic interconnection tests;
- capability tests;
- behavioural tests.

The list of standard test instruments, test bed description and list of test application software, that shall be used during the MVB test suites, are reported in Annex B. Also, in Annex B are two proposed templates for test reporting.

Physical layer testing requires manipulation of signal amplitude and signal timing. To reduce the effort of adapting existing generators, either frame or telegram generators, or creating ad-hoc frame generators, the idea for testing the electrical part of the physical layer is to use a test equipment derived from a reference medium attachment unit followed by a waveshaper. The waveshaper samples the signal coming from the test equipment and generates the required conditions to stimulate the IUT.

The waveshaper shall sample the incoming bit sending out an outgoing bit:

a) with the amplitude changed as required by the test.
b) with the rise time changed as required by the test.
c) with the fall time changed as required by the test.
d) with the jitter as required by the test.

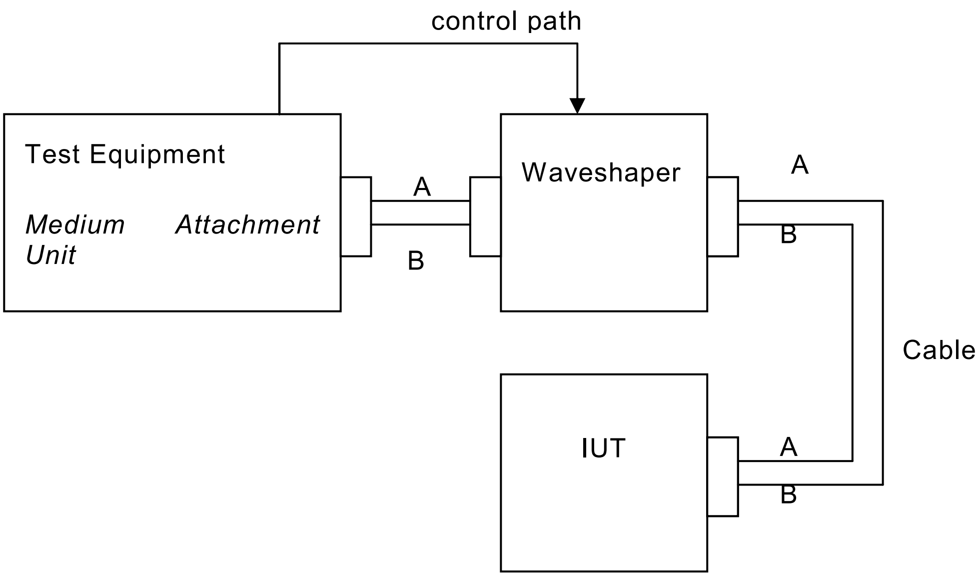


Figure 1 – Application of the waveshaper

3.2.1 Basic interconnection tests

The basic interconnection tests are a subset of the behavioural tests. The following two clauses list the relevant clauses of the behavioural test that constitutes the basic interconnection tests in the case of an MVB device using respectively ESD and EMD attachment.

3.2.1.1 ESD basic interconnection tests

The following table lists the relevant clause to be applied to the ESD basic interconnection tests.

Table 6 – ESD basic interconnection tests

Subclause to be applied	
3.2.4.1	ESD test layout
3.2.4.2	ESD identification
3.2.4.3.2	ESD connector
3.2.6.1.1	Requirements
3.2.6.1.2.1	Device status protocol
3.2.6.1.2.8	Capabilities field
3.2.7.1	Simple test

3.2.1.2 EMD basic interconnection tests

The following table lists the relevant clause to be applied to the EMD basic interconnection tests.

Table 7 – EMD basic interconnection tests

Subclause to be applied	
3.2.5.1.1	Resistance test
3.2.5.1.4	Measurement of the signal waveform during transmission
3.2.5.1.5	Receiver behaviour test
3.2.6.1.1	Requirements
3.2.6.1.2.1	Device status protocol
3.2.6.1.2.8	Capabilities field
3.2.7.1	Simple test

3.2.2 Capability tests

The capability tests consist of activities:

- to check the consistency of the PICS against the declared values into the PICS themselves, as a preliminary filter before undertaking more in-depth and costly testing;
- to check that the capabilities of the IUT are consistent with the static conformance requirements specified by this standard and IEC 61375-1;
- to enable efficient selection of behaviour tests to be made for a particular IUT;

when taken together with behaviour tests, as a basis for claims of conformance.

Refer to Clause A.3 for the role of the IUT supplier and the Laboratory test to be played in this activities.

3.2.3 Behavioural tests

The behavioural test suites are sub-divided into the following test sequences.

3.2.4 Electrical short distance medium

3.2.4.1 ESD test layout

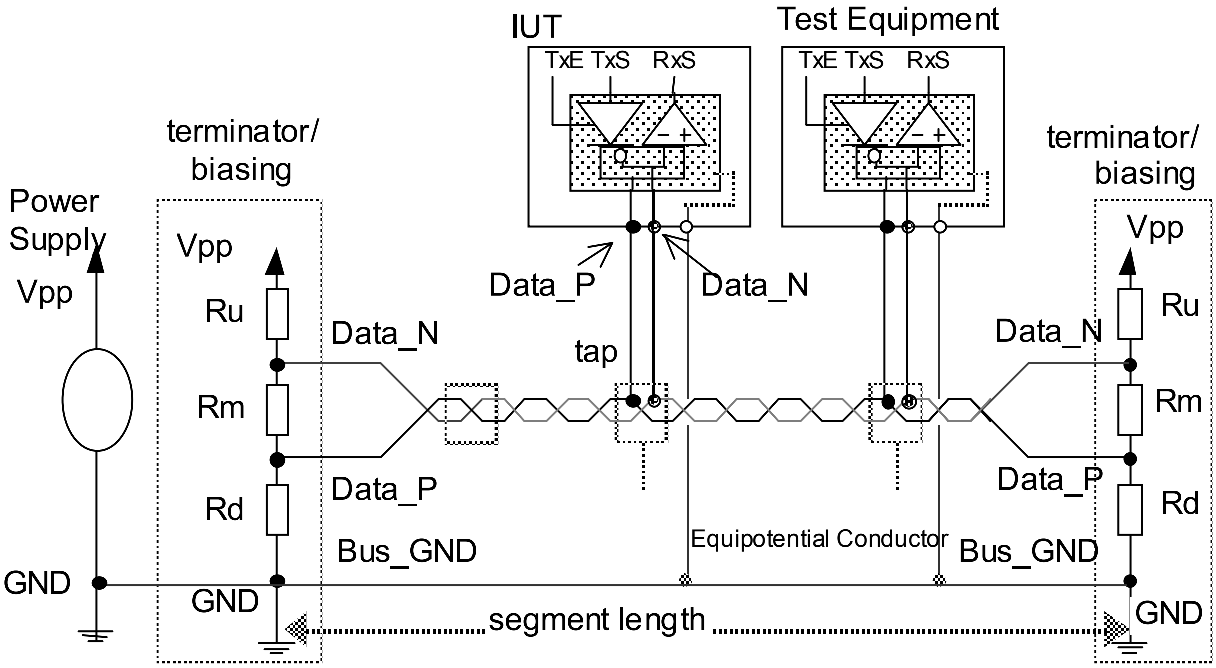
The ESD test layout consists of

a) two conductors carrying the serial data;

b) an equipotential conductor;

c) two terminators biasing at each end;

d) stubs to attach the devices participating on the network.



Components	Type	Value	Connections	Type	Value
Ru	Resistor	390 Ω 1 W	Vpp	Supply voltage	5,0 V 3,0 W
Rm	Resistor	150 Ω 1 W	GND	Reference voltage	0,0 V
Rd	Resistor	390 Ω 1 W			

Figure 2 – ESD test layout

3.2.4.2 ESD identification

ESD identification is to test the implementation of the requirement 3.2.4.2.1:

- verify that the two conductors of a line are named Data_P and Data_N;
- verify that the two conductors Data_P and Data_N are marked distinctly;
- verify that the equipotential conductor is named Bus_GND;
- verify that the equipotential conductor is marked distinctly.

3.2.4.3 ESD section specifications

3.2.4.3.1 ESD attachment backplane

This test is conditioned by 3.1.2.20.

Test the implementation of the requirement 3.2.4.5.1 of IEC 61375-1.

Verify that Line_A and/or Line_B through independent connection points, identified as shown in Figure 1 as:

- A.Data_P and A.Data_N; respectively;
- B.Data_P and B.Data_N.

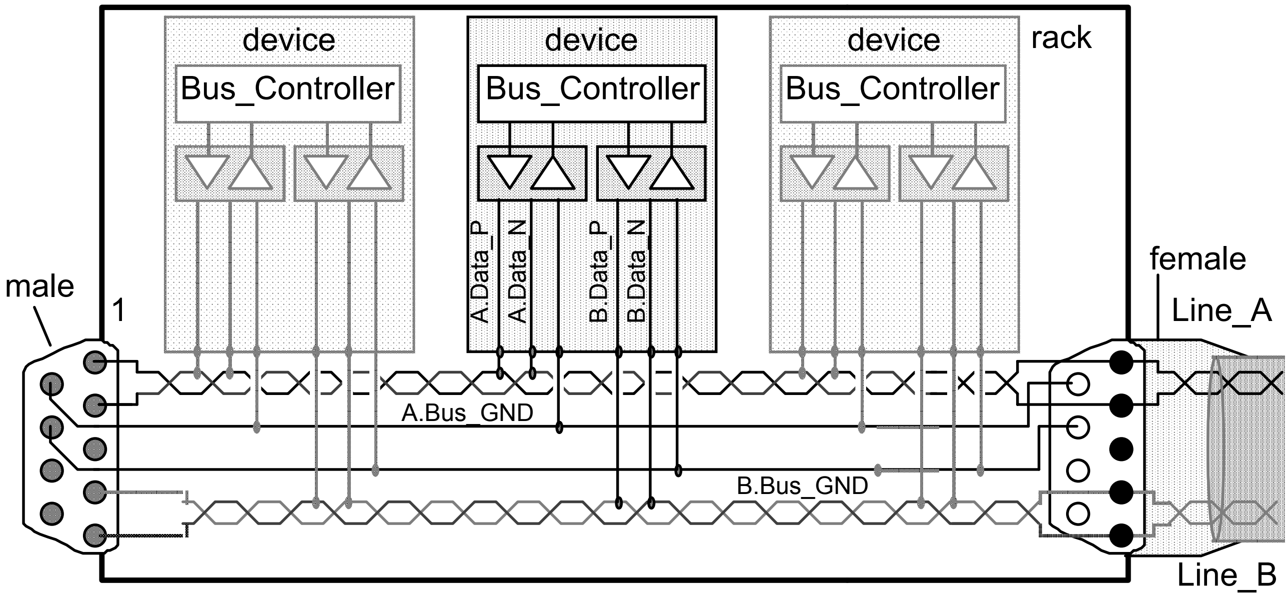


Figure 3 – ESD backplane section (double-line)

3.2.4.3.2 ESD connector

Test the implementation of the requirement 3.2.4.5.2 of IEC 61375-1. The requirement in item j) states a minimum source current of 70,0 mA and a maximum current of 300,0 mA. This test checks for these values as minimum and maximum. A first assessment with no load is applied, then the minimum current is tested, following which the maximum. To assess the maximum current limitation, the value of 350 mA exceeding the maximum current of 16,6 % is chosen. This value, even if arbitrary, is 3 times the tolerance of current and voltage specified in IEC 61375-1.

Calculation for the minimum current: 5 V / 70 mA = 71,42 Ω

Calculation for the maximum current: 5 V / 300 mA = 16,6 Ω

Calculation for the overcurrent: 5 V / 350 mA = 14,28 Ω

The loads chosen from the E96 standard table are respectively 71,5 Ω, 17,8 Ω, 14,3 Ω, the values fit near enough to the calculated values. Resistor power is chosen big enough to account for the derating.

a) the connectors shall have the polarity and arrangement shown in Figure 4;

b) measure 5,0 V ± 5 % as in the following table;

Table 8 – Measurement idle

Measurement points	Result
Pin 8 to Pin 6	5,0 V ± 5 %
Pin 9 to Pin 7	5,0 V ± 5 %

c) connect a load of 71,5 Ω 1 % 5 W between the couple of pins in the following table and measure the voltage across them. See item j) 3.2.4.5.2 of IEC 61375-1;

Table 9 – Measurement with load for minimum current

Measurement points	Result
Pin 8 to Pin 6	5,0 V ± 5 %
Pin 9 to Pin 7	5,0 V ± 5 %

d) connect a load of 17,8 Ω 1 % 5 W between the couple of pins in the following table and measure the voltage across them;

Table 10 – Measurement with load for maximum current

Measurement points	Result
Pin 8 to Pin 6	5,0 V ± 5 %
Pin 9 to Pin 7	5,0 V ± 5 %

e) connect a load of 14,3 Ω 1 % 5 W between the couple of pins in the following table and measure the voltage across them.

Table 11 – Measurement with load for overcurrent

Measurement points	Result
Pin 8 to Pin 6	± 50 mV
Pin 9 to Pin 7	± 50 mV

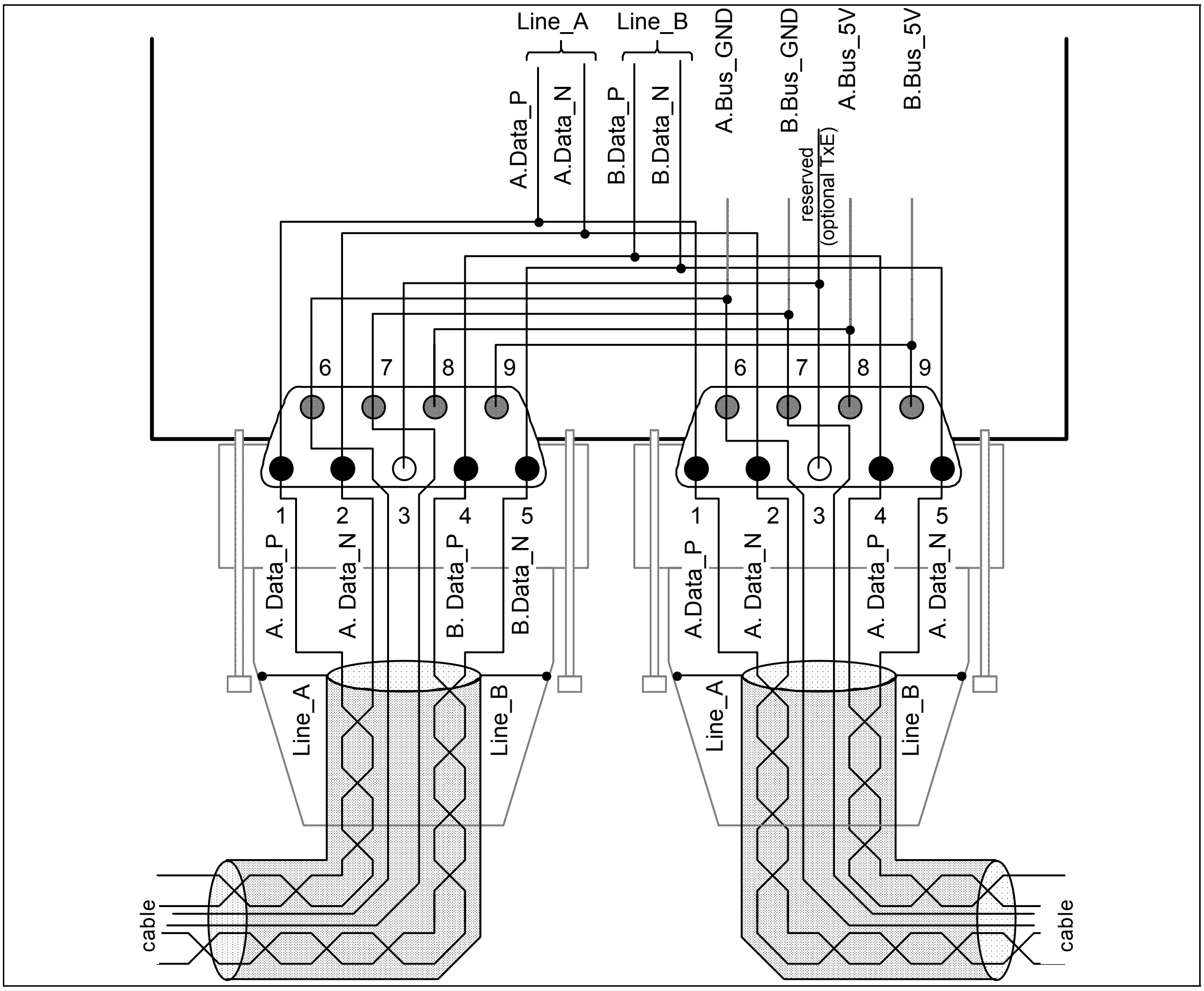


Figure 4 – ESD connector arrangement

Table 12 – Pin assignment for the ESD connector

1	A.Data_P, positive wire Line_A	6	A.Bus_GND, ground Line_A
2	A.Data_N, negative wire Line_A	7	B.Bus_GND, ground Line_B
3	TxE (optional)	8	A.Bus_5V, positive supply Line_A
4	B.Data_P, positive wire Line_B	9	B.Bus_5V, positive supply Line_B
5	B.Data_N, negative wire Line_B		

3.2.4.3.3 ESD connector of the terminator

Test the implementation of the requirement 3.2.4.5.3

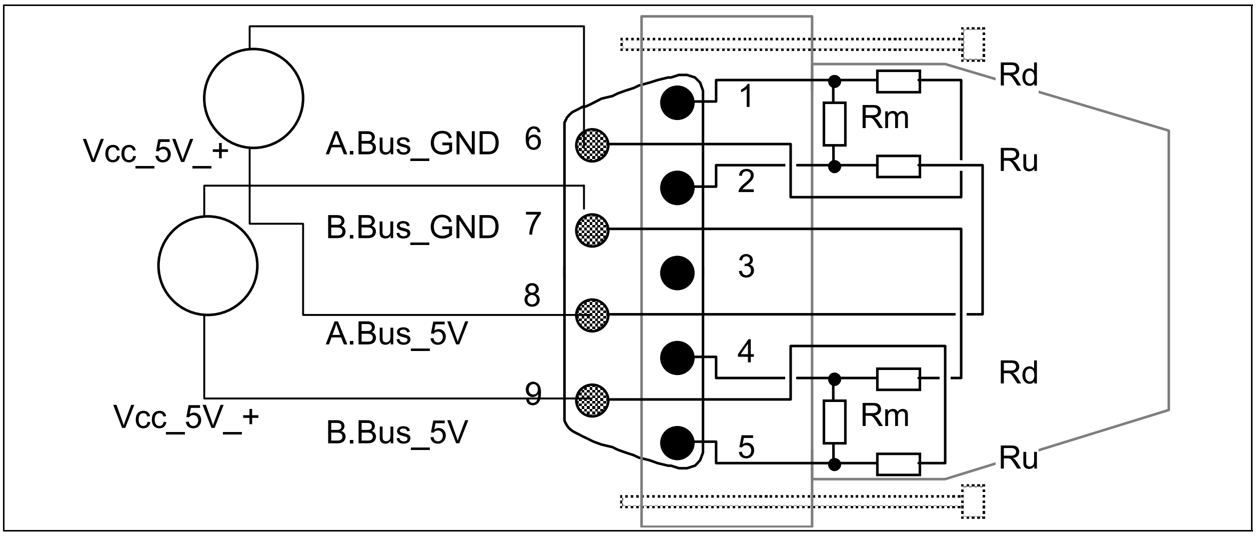


Figure 5 – ESD terminator connector test

The connector containing the terminator for ESD shall be tested as follows:

Connect a 5 V 1 W short-circuit protected power supply as in Figure 5

Measure the voltages as:

Table 13 – ESD measurements pin to pin

Measurement points	Result
Pin 6 to Pin 1	2 V ± 10 %
Pin 6 to Pin 2	4,7 V ± 10 %
Pin 7 to Pin 4	2 V ± 10 %
Pin 7 to Pin 5	4,7 V ± 10 %

3.2.4.4 ESD Line_Unit test

3.2.4.4.1 ESD conventions

a) The characteristics of each device are measured at the points where the line is attached to the device, Data_P, Data_N and Bus_GND.
b) When measuring a transmitter, the circuit of the receiver is the normal receiving state.
c) When measuring a receiver, the circuit of its transmitter is in a high impedance state.
d) If the device is attached through connectors, these are included into the measurement.

3.2.4.4.2 ESD signal waveform

Test the implementation of the requirement in 3.2.4.8.1 and 3.2.4.8.3

With the test setup described in Figure 6:

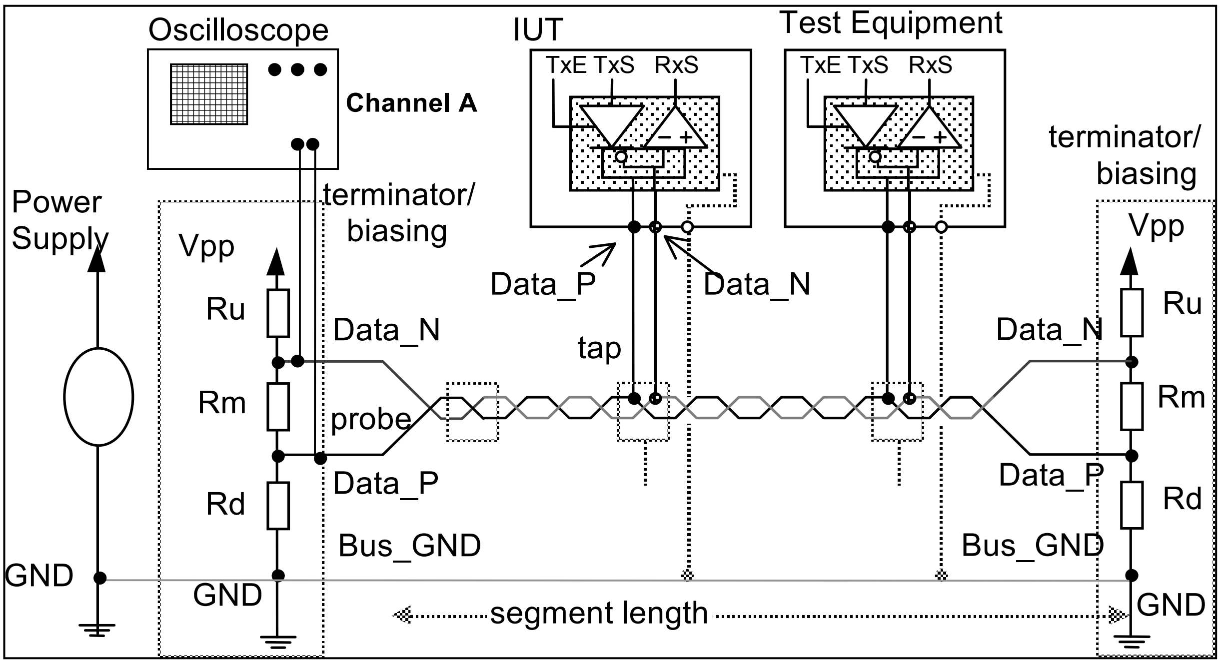


Figure 6 – ESD waveform measurement

a) Using the oscilloscope in single shot acquisition and the arrangement of Figure 6, acquire a frame from the IUT.

b) The rise time of the signal (10 % – 90 %) < 20,0 ns at 1,5 Mb/s.

c) The level of the transmitted frame shall be a differential voltage two active levels:

– HIGH, when the voltage difference (Data_P – Data_N) is within:+1,5 V < (U_p – U_n) < +5,0 V;

– LOW, when the voltage difference (Data_P – Data_N) is within: -1,5 V > (U_p – U_n) > -5,0 V.

d) The beginning level of transmitted frame shall be a differential voltage that is:

– LOW, for at least 0,125 µs ± 0,010 µs.

e) The end level of transmitted frame shall be a differential voltage that is:

– LOW state for at least 0,125 µs and at most 1,0 BT.

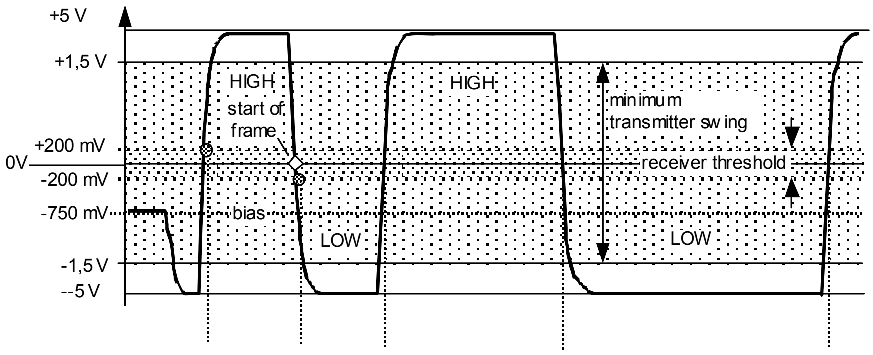


Figure 7 – Frame (ESD)

3.2.4.4.3 ESD transmitter jitter

Send at least 100 frames, the jitter between two consecutive edges between Start_Bit and End_Delimiter shall not exceed 10,0 ns.

Using the digital storage oscilloscope the jitter measurement is accumulated (long-term jitter). This is defined to be the deviation of a rising (or falling) edge "n" cycles after the first rising (or falling) edge. The digital phosphor oscilloscope can measure 100 cycles of an incoming frame sent by the IUT. The scope is set to delay by 100 µs (n × period of BT). This is the long-term jitter performance of the frame over 100 cycles or 66 us. The value specified for the jitter is ±10,0 ns, the measured peak-to-peak jitter shall not exceed 3 σ.

3.2.4.5 ESD receiver

3.2.4.5.1 Signal reception

This subclause tests the implementation of the requirement 3.2.4.9 of IEC 61375-1 and applies to its items a) and b). Item c) of 3.2.4.9 of IEC 61375-1 shall be guaranteed by the datasheet specification of the receiver and thus **not tested**.

The characteristics of the receiver are tested by applying a sequence of frames containing 256 random data bits in the data field, passed by a waveshape modifier. The waveshape modifier shall be able to

a) sample the incoming bit and sending out an outgoing bit with the amplitude changed as required by the test;
b) sample the incoming bit and sending out an outgoing bit with the rise time changed as required by the test;
c) sample the incoming bit and sending out an outgoing bit with the fall time changed as required by the test;
d) sample the incoming bit and sending out an outgoing bit with the jitter as required by the test:
   1) the amplitude of the outgoing signal from the waveshape modifier shall be set until the oscilloscope read a differential voltage of 250 mV p-p;
   2) verify that the IUT receives correctly all frames.

3.2.4.5.2 Input impedance

This subclause tests the implementation of the requirement in 3.2.5.7.2

The sequence is the following:

a) attach the test fixture and waveform generator as shown in Figure 8;
b) test both with the device not powered and with the device powered and not transmitting;
c) set the generator to produce a 150[5] kHz sinusoid at about 5 V p-p differential measured at Vi;
d) verify that the level is constant (±2 %) from 150 kHz to 1500 kHz;
e) measure Vo (p-p differential) with the generator set to 150 kHz;
f) Vo should be greater than Vi/2 V. This verifies that the differential input resistance is greater than 12 kΩ[6];
g) calculate the ratio Vo/Vi , if the ratio is ≥0,5 the test passes.

3.2.5 Electrical middle distance medium

3.2.5.1 Measurement of terminating resistors

3.2.5.1.1 Resistance test

This test is intended to check the requirement 3.2.5.3 of IEC 61375-1.

This is a pure resistance test of the terminating resistors of MVB lines A and B, with the IUT switched off.

The resistance shall have the following value: 120 Ω range ±10 %.

3.2.5.1.2 Inductance test

This test is intended to check the requirement 3.2.5.3 of IEC 61375-1.

The inductance test of the terminating resistors is executed by connecting a sine-wave generator to the IUT and measuring the phase displacement between current and voltage.

Optionally, the inductance can be measured with an LCR meter.

The maximum permissible phase displacement is 0,087 rad in a frequency range between 0,5 and 2,0 BR.

3.2.5.1.3 Measurement of insertion loss

This test is intended to check the requirement 3.2.5.7.1 of IEC 61375-1.

For this test, the measuring setup illustrated in Figure 8 is required.

One MVB connector of the IUT is connected to a terminating resistor via a 20 m MVB cable. The other MVB connector of the IUT is connected to a sine-wave generator (with an internal resistance Zt = 120 Ω) via a 20 m mVB cable. The amplitude of the signal output by the frequency generator is set to 4 V at the location of the voltmeter, without the IUT inserted.

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5 The lower frequency limit is 150 kHz.

6 12 kΩ is the specified minimum value of impedance.

The insertion loss is measured as the ratio between the voltage present at the location of the voltmeter in a setup without IUT with shorted cables (2 x 20 m MVB cable) (1)) and the voltage present with the IUT inserted (2)).

With the IUT switched off or in normal operation, the maximum permissible loss at frequencies between 0,5 BR and 2,0 BR is 0,15 dB.

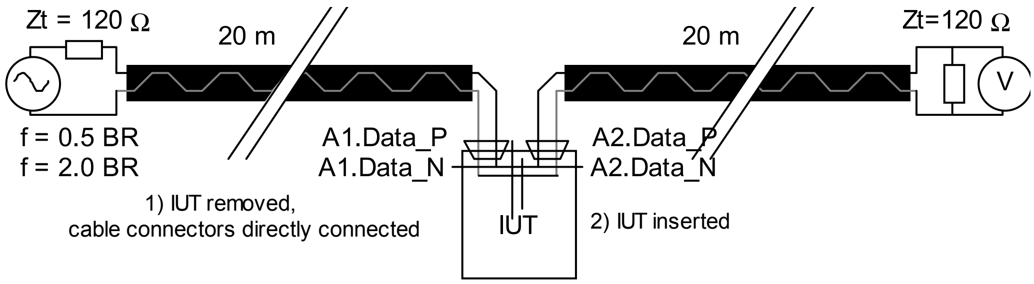

Figure 8 – Measurement of insertion loss

3.2.5.1.4 Measurement of the signal waveform during transmission

This test is intended to check the requirements 3.2.5.9.2 and 3.2.5.9.4 of IEC 61375-1.

The waveform of the signals from the IUT during transmission is measured in three setups.

Due to the data encoding, the transmitter generates pulses which are either one bit in length (1,0 BT), a half-bit in length (0,5 BT) or one-and-a-half bits in length (1,5 BT): the operator shall choose one of these three pulses to synchronize upon.

The IEC 61375-1 specifies three test fixtures for load and one additional for current limit.

- Heavy load test. The heavy test circuit shall be placed at the connection point of IUT (where Zt = 120 Ω). See Figure 9

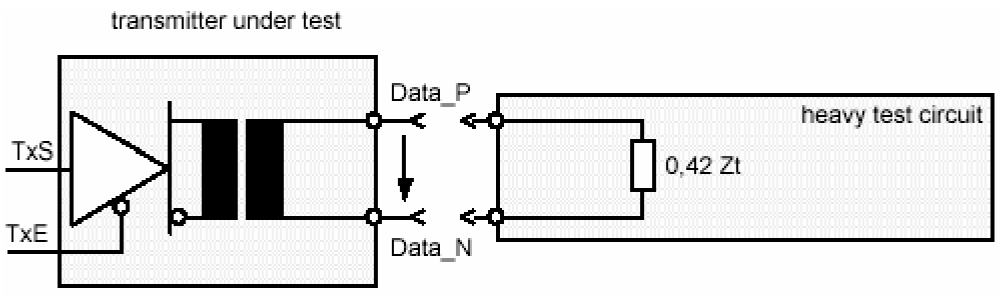

Figure 9 – EMD transmitter heavy load circuit

By sending a master frame F_CODE4 subscribed by the IUT as source port, the TE authorises the IUT to send a slave frame: the differential output signal from the IUT (slave frame) is measured at the IUT for channels A and B by means of an oscilloscope. The sourced frame from the IUT data bits are a sequence of

– first 64 bits at "1";
– the second 64 bits at "0";
– the third 64 bits with the sequence “10” repeated 32 times;
– the fourth 64 bits with the sequence “01” repeated 32 times.

According to the IEC 61375-1, it shall comply with Figure 11:

a) the signal shall have a voltage level of ±5,5 V max. and ±1,5 V min. symmetrically to the zero line (Figure 11);

b) the difference between the steady-state amplitudes of two successive pulses must not exceed 100 mV;

c) the slew rate of the output signal shall be more than 15 mV/ns within 0,100 µs of the zero-crossing (Figure 11);

d) The maximum jitter shall be limited to ±2 %. This jitter is defined as the actual time difference between Two signal voltage zeroes in reference to an ideal interval of one Bit Time (Figure 11);

e) The overshoot of the output signal, defined as the ratio of the maximum amplitude to the stationary amplitude shall not exceed 10 % of its stationary amplitude.

As an option, in order to improve signal quality, the transmitter may use a technique called Pre-Emphasis. In such a case, the transmitter shall comply with the herein above-listed requirements except requirement e) that is replyced by the following requirements:

f) the ratio of the Pre-Emphasis amplitude to the steady state amplitude shall be in the range from 165 % up to 235 %;

g) the duration of the Pre-Emphasis pulse, measured from the front edge of the waveform, shall be maximum 330 ns;

h) the difference between the positive and the negative stationary amplitude in two consecutive pulses shall not exceed 0,20 V.

The heavy load test fixture shall be disconnected. The light test circuit shall be placed at the connection point of IUT (where Zt = 120 Ω), and the operator shall verify the same previous items (a), b), c), d), e)) with the new test circuit (see Figure 10).

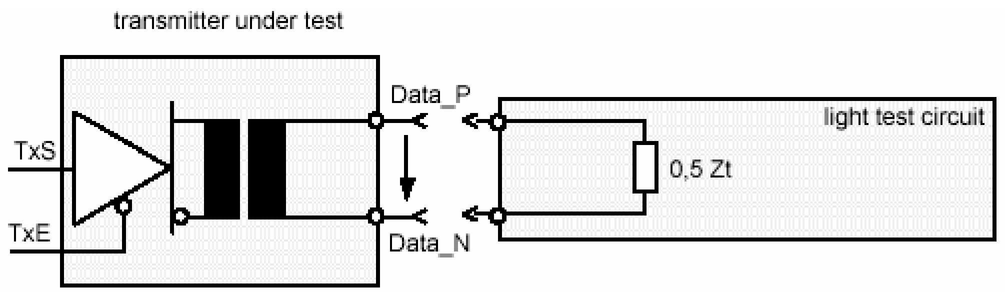

Figure 10 – EMD transmitter light test circuit

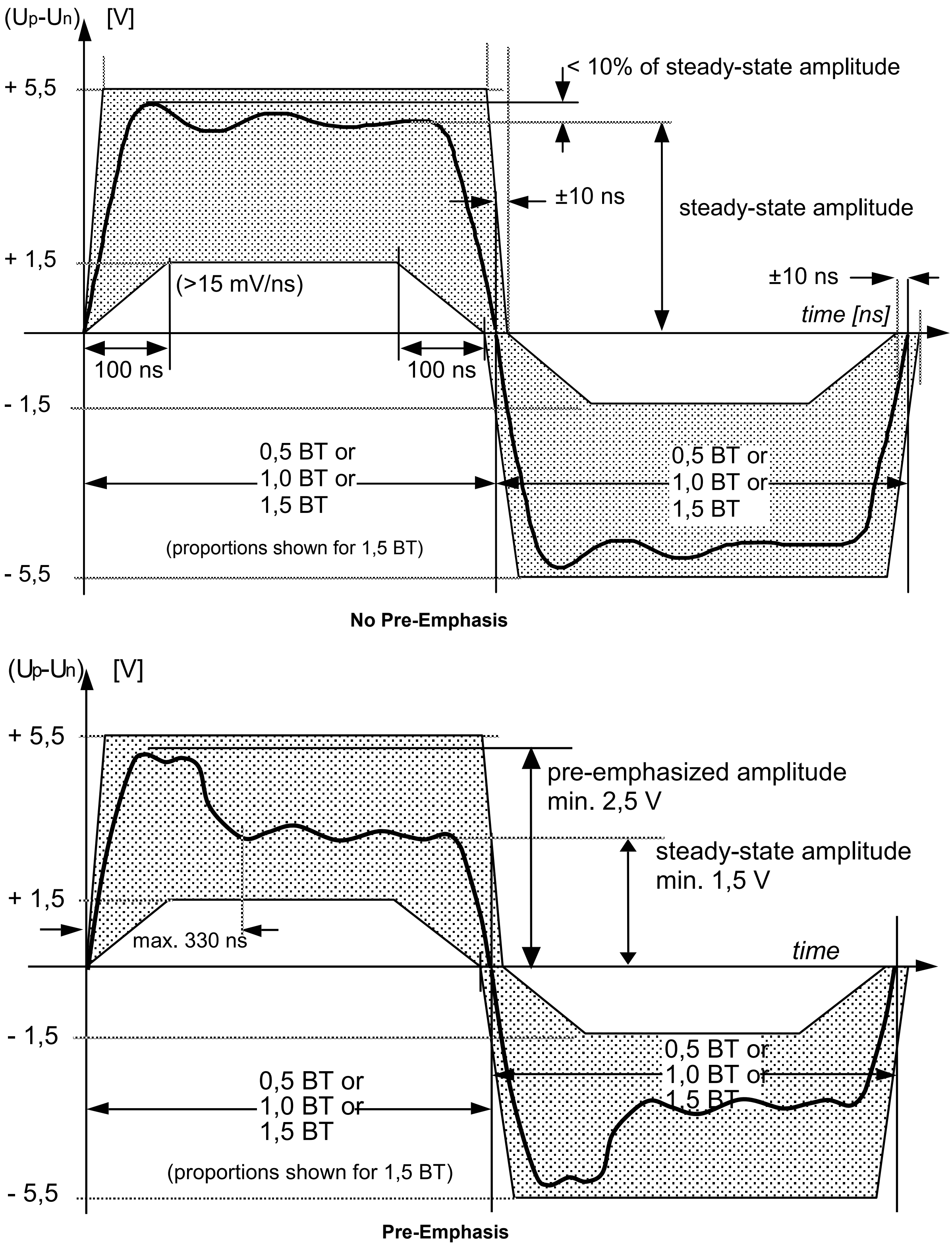

Figure 11 – Example of pulse waveform at EMD transmitter

The light test circuit shall be disconnected. The idling test circuit shall be placed at the connection point of IUT (see Figure 12).

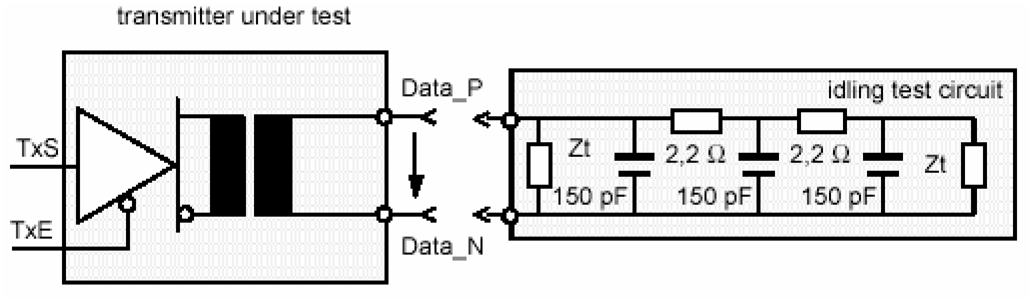

Figure 12 – EMD transmitter idling test circuit

The reply of IUT shall have the end delimiter with some characteristic:

the voltage must not exceed 200 mV (see Figure 13)

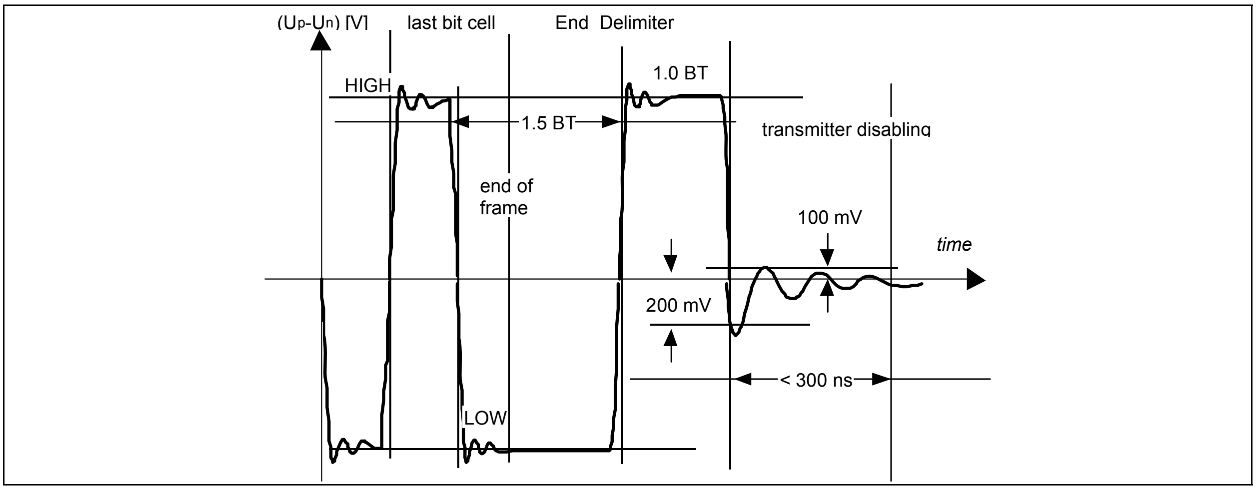

Figure 13 – Signal with end delimiter

The voltage must have dropped to less than 100 mV after 300 ns (see Figure 13);

The frame must be closed with a "NL" symbol followed by a "NH" symbol (see Figure 14 and Manchester or Bi-phase-L encoding);

The output signal amplitude shall be greater than 4,5 V before the transmitter is disabled;

These points are verifiable on the IUT for channels A and B by means of an oscilloscope.

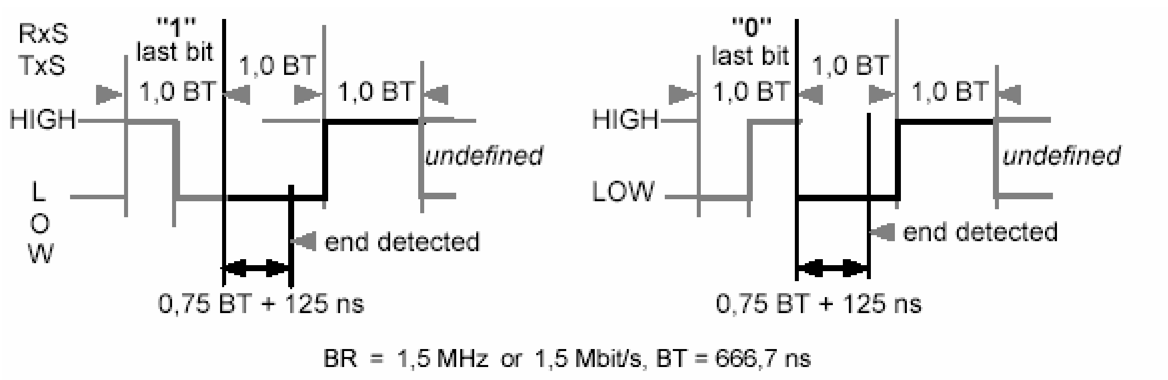

Figure 14 – Example of end delimiter for EMD medium

If the transmitter uses the pre-emphasis, the transmitter shall comply with the requirements a),b),c),d) and requirement e) which is replaced by the following requirements:

e) the ratio of the pre-emphasis amplitude to the steady state amplitude shall be in the range from 165 % up to 235 %;

g) the duration of the pre-emphasis pulse, measured from the front edge of the waveform, shall be 330 ns.

3.2.5.1.5 Receiver behaviour test threshold set to 200 mV

This test checks the requirement 3.2.5.10.1 of IEC 61375-1.

To test the receive behaviour of the IUT, it is necessary to find out at what maximum deviation of the received signal from the ideal signal the IUT can still correctly interpret the received data.

The IUT is connected to the TE via 20 m of MVB cable.

To generate such a non-ideal signal, the sender of the TE is provided with an additional attenuation resistor that reduces the amplitude of the master frames to 300 mV at the input of the IUT.

If the IUT has correctly received the master frame from the TE, it will acknowledge the reception by sending a slave frame. No slave frame may be lost.

3.2.5.1.6 Receiver behaviour test threshold set to 500 mV

This test checks the requirement 3.2.5.10.1 of IEC 61375-1 when the threshold of 500 mV is set.

To test the receiver behaviour of the IUT, it is necessary to find out at what maximum deviation of the received signal from the ideal signal the IUT can still correctly interpret the received data.

The IUT is connected to the TE via 20 m of MVB cable.

To generate such a non-ideal signal, the sender of the TE is provided with an additional attenuation resistor that reduces the amplitude of the master frames to 750 mV at the input of the IUT.

If the IUT has correctly received the master frame from the TE, it will acknowledge the reception by sending a slave frame. No slave frame may be lost.

3.2.6 Slave device status test suites

The slave device status test suite shall be executed in distinct phases depending of the capabilities of the IUT. The following phases are specified:

a) common test;

b) custom test;

c) specific class test.

Phase 1 covers the tests that are common to all devices irrespectively to the capabilities.

Phase 2 covers the tests to be applied to devices that require customised test method having lacks of capabilities or characteristics (as an example a class one device is able to sink ports but not to source ports, consequently it is not able to answer at application level to incoming test data).

Phase 3 covers the tests that are specific of a certain MVB class.

3.2.6.1 Common test

This test applies to Classes 1, 2, 3, 4 and 5.

This test does not apply to Class 0.

3.2.6.1.1 Requirements

The IUT requirements and the test equipment requirement are specified by the following subclauses.

3.2.6.1.1.1 IUT requirement

The IUT supplier shall define:

a) the physical address of the IUT;
b) physical redundant capability;
c) the T_ignore time of the device;
d) the capabilities of the device (class of device);
e) the configuration option to execute the automatic switchover when the device responds to a Device_Status_Response (LAT and ERD test). If the device is a class 1, this specification is not required [7];
f) the procedure to produce a malfunction the IUT or a fault outside of the device without effect on the communication (SDD test).
g) the procedure to force/unforce at least a Port of the IUT to the imposed value (FRC test). Not applicable to Class 1;
h) the procedure to set the IUT not operative without effect on the communication and the procedure to return the IUT operative (DNR test).

3.2.6.1.1.2 Test equipment requirement

The test equipment shall provide a Class 4 or higher MVB device (master device) with the capability to connect either or the single line (LINE_A or LINEB),

The test equipment shall provide a Class 2 or higher MVB device with a manager interface (MGI) to send a WRITE_RESERVATION request message to IUT (see SER test in this standard).

NOTE The two above-mentioned devices might be the same device (master and slave).

3.2.6.1.2 Common test execution procedure

Test clauses presented hereinafter contain questions asking for proof, the relevant clause specifies the test to prove the compliance to the question.

[7] NOTE: For class 1 devices, if a device responds to a Device_Status_Request with a Device_Status_Response (with RLD=0), the switchover is mandatory

3.2.6.1.2.1 Device status protocol

This test checks the requirement 3.6.4.2.of IEC 61375-1 summarised by the following question:

is a device replying with its Device_Status_Response ,when receiving a Master Frame with F_code = 15 (Device_Status_Request) and with its own address?

The test equipment shall send one or more Device_Status_Request.

The test passes if the IUT response is a Device_Status_Response (16 bits length response) for every Device_Status_Request.

The test shall be terminated when 10 Device_Status_Request are sent.

3.2.6.1.2.2 RLD and LAT

This test checks the requirements 3.6.4.1.2.4 and 3.6.4.1.2.4 of IEC 61375-1 summarised respectively by the following questions:

- is the RLD flag set if the Observed_Line is disturbed?
- is the LAT flag asserted if the master frame of this telegram was received over Line_A, and negated if it was received over Line_B?

Using a lay-out without physical layer redundancy, the test equipment shall send a sequence of Device_Status_Request and read the status of the LAT and RLD flags in the Device_Status_Response sent back by IUT.

The test passes if the RLD flag is always set to 1 and if the LAT flag is always set to the same value.

The test shall be terminated when 10 Device_Status_Request are sent.

Using a lay-out with physical layer redundancy, the test equipment shall send a sequence of Device_Status_Request with the following sequence of status of line connection.

a) At least a Device_Status_Request with either lines connected.
b) At least a Device_Status_Request with only line A connected.
c) At least a Device_Status_Request with either lines connected.
d) At least a Device_Status_Request with only line B connected.

For any step it shall execute the following check (the test pass if):

Step 1. All Device_Status_Responses in this step shall have RLD=0.

Step 2. All Device_Status_Responses in this step shall have the LAT=1 and the RLD=1.

Step 3. All Device_Status_Responses in this step shall have RLD=0. If the IUT is a class 1 device or if it has this configuration option set for the other class, the LAT bit shall change every time, or else it shall remain equal to 1.

Step 4. All Device_Status_Responses in this step shall have the LAT=0 and the RLD=1.

3.2.6.1.2.3 SDD

This test checks the requirement 3.6.4.1.2.4 of IEC 61375-1 summarised by the following question:

Is the SDD flag set by a device malfunction (for instance: ROM or RAM checksum error) or a fault outside of the device (for instance: damaged sensors) and reset when the fault is removed?

The test sequence is the following:

a) the tester shall execute the procedure to produce a malfunction of the IUT or a fault outside of the device without effect on the communication (see IUT requirement 6).

   The test passes if, for every Device_Status_Request sent by the test equipment, then the IUT Device_Status_Response contain the SDD flag equal to 1.

   The test shall be terminated when 10 Device_Status_Request are sent;

b) the tester shall execute the procedure to remove the malfunction of the IUT or the fault outside of the device (see IUT requirement 6).

   The test pass if, for every Device_Status_Request sent by the test equipment, then the IUT Device_Status_Response contains the SDD flag equal to 0.

   The test shall be terminated if 10 Device_Status_Request are sent.

3.2.6.1.2.4 ERD flag (option)

This test checks the requirements 3.4.2.4.2 and 3.6.4.1.2.4 of IEC 61375-1 summarised respectively by the following question:

Is the ERD flag asserted if T_ignore > T_reply_def, negated otherwise?

The test equipment shall send more Device_Status_Request and relate the status of the ERD flag in the Device_Status_Response sent back by IUT to the T_ignore defined by the IUT supplier.

(pass criteria are to be defined)

The test shall be terminated when 10 Device_Status_Request are sent.

3.2.6.1.2.5 FRC flag

This test checks the requirement 3.6.4.1.2.4 of IEC 61375-1 summarised by the following question:

Is the FRC flag asserted if any port has been forced to an imposed value and negated if all ports attached to the MVB are in the unforced state?

The test equipment shall send a sequence of Device_Status_Request and read the status of the FRC flag in the Device_Status_Response sent back by IUT.

If the IUT is a Class 1 device, the test is passed when the flag FRC is always 0

If the IUT is a class higher than 1, the test is passed when:

- the FRC flag is 1 if at least one port of the IUT is forced to an imposed value (see IUT requirement 7);
- the FRC flag is 0 if all ports of the IUT are unforced (see IUT requirement 7).

The test shall be terminated when 10 Device_Status_Request are sent.

3.2.6.1.2.6 DNR flag

This test checks the requirement 3.6.4.1.2.4 of IEC 61375-1 summarised by the following question:

Is the DNR flag asserted if the device is not operational (for instance application not running) but able to operate normally on the bus, and negated if the device is operational?

The test equipment shall send a sequence of Device_Status_Request and read the status of the FRC flag in the Device_Status_Response sent back by IUT.

The test is passed when:

- the flag is 1 if the IUT is not operational (see IUT requirement 8);
- the flag is 0 if the device is operational (see IUT requirement 8).

The test shall be terminated if 10 Device_Status_Request are sent.

3.2.6.1.2.7 SER flag

This test checks the requirement 3.6.4.1.2.4 of IEC 61375-1 summarised by the following question:

Is the SER flag set if the device has been reserved for exclusive use and reset when this exclusive use is lifted or timed-out?

If the IUT is a Class 1 device, the test equipment shall send a sequence of Device_Status_Request and read the status of the SER flag in the Device_Status_Response sent back by IUT. The test passes if the SER flag is always set to 0.

If the IUT is not a Class 1 device, the bus administrator of the test equipment shall send a sequence of Device_Status_Request to read the status of the SER flag in the Device_Status_ sent back by IUT. The Class 2 stimulator device of the test equipment shall send a WRITE_RESERVATION request message to IUT with COMMAND field set to RESERVE, and after enough time (e.g. 1 s) it shall send a WRITE_RESERVATION request message to IUT with COMMAND field set to KEEPREL. The test pass if the SER flag is set to 1 after the first command, and if it is set to 0 after the second command.

3.2.6.1.2.8 Capabilities field

This test checks the requirement 3.6.4.1.2.2 of IEC 61375-1 summarised by the following questions:

a) Is the SP bit set to "1" for special device and set to "0" for device with Device_Status and Process Data capability?
b) Is the BA bit set to "1" for no special device with bus administrator capability and set to «0» for no special device without bus administrator capability?
c) Is the GW bit set to "1" for no special device with gateway capability and set to «0» for no special device without gateway capability?
d) Is the MD bit set to "1" for no special device with message data capability and set to «0» for no special device without message data capability?

The test equipment shall send one or more Device_Status_Request and relate the status of the capabilities field (SP, BA, GW and MD flags) in the Device_Status_Response sent back by IUT to the capabilities of the device (class of device) defined by the manufacturer.

The test shall be terminated if 10 Device_Status_Request are sent.

3.2.6.2 Custom test

This test shall be executed using a stimulator supplied by the manufacturer of IUT. Only the data logger shall be supplied by the test laboratory to test the IUT.

3.2.6.2.1 IUT requirement

The physical address of the IUT is required.

3.2.6.2.2 Test equipment requirement

The test equipment is partly supplied by the IUT supplier and this part is a stimulator that shall be capable of sending to the IUT all sink process data present in the Periodic_List of the IUT (master frame + slave frame) using the correct period for any one. Using an input of the stimulator shall be possible to avoid a sending of at least a single port.

Periodically the stimulator shall send a Device_Status_Response to check the Device_Status_Response sent by the IUT.

The test equipment is completed by a second part supplied by the test laboratory. This part is a data logger that shall be capable of latching and displaying the Device_Status_Response sent by the IUT.

3.2.6.2.3 Custom test procedure

This test checks the requirement 3.6.4.1.2.4 of IEC 61375-1 summarised by the following question:

Is the SSD flag set when the sink time supervision of any port triggered and reset when all configured ports operated normally?

The test procedure is the following:

a) the stimulator shall send all sink process data published by the IUT using the correct period.

   The test passes if, for every Device_Status_Request sent by the stimulator, the IUT Device_Status_Response contains the SSD flag equal to 0.

   The test is terminated when 10 Device_Status_Request are sent;

b) the stimulator shall not send all sink process data of the IUT using the correct period, but at least a sink process data shall send in a time greater than the sink time supervision.

   The test passes if, for every Device_Status_Request sent by the stimulator, the IUT Device_Status_Response contains the SSD flag equal to 1.

   The test is terminated when 10 Device_Status_Request are sent.

3.2.6.3 Specific class test

This test checks the Class_specific field of the Device_Status_Response of the IUT,.

3.2.6.3.1 Class 1 device specific test

This test shall be applied to Class 1 IUT (no special device, no bus administrator capability, no Gateway capability, no message data capability).

The capabilities field is «0000».

3.2.6.3.1.1 IUT requirement

To run this test, the IUT supplier shall define the physical address of the IUT.

3.2.6.3.1.2 Test equipment requirement

The test equipment shall provide a MVB device with a bus administrator capability (master device).

3.2.6.3.1.3 Procedure

This test checks the requirement 3.6.4.1.2.3.1 of IEC 61375-1 that is summarised by the following questions:

Does a device of Class 1 response with the "specific" field set to "0000"?

The test equipment shall send several Device_Status_Request to the IUT and verify that the status of the «specific» field in the Device_Status_Response responded from the IUT is always «0000».

The test is terminated when 10 Device_Status_Request are sent.

3.2.6.3.2 Bus administrator specific test

This test shall be applied to the IUT if it is a bus administrator capability device, i.e. no special device, bus administrator capability, independent of gateway capability, independent of message data capability).

The test procedure is sub-divided into the following phases:

- ACT flag;
- AX1 and AX0 bits;
- MAS flag.

3.2.6.3.2.1 IUT requirement

Using this test, the IUT manufacturer shall define:

a) the physical address of the IUT;
b) Actualisation_Key of the Periodic List;
c) the procedure to set «configured» (in possession of a Bus_Configuration) and, optionally, the procedure to set «unconfigured» (only executes the Event_Round and the Devices_Scan) the MVB_Administrator object of the IUT.

3.2.6.3.2.2 Test equipment requirement

The test equipment shall provide a MVB device with bus administrator capability (master device) with modifiable Actualisation_Key.

Also the test equipment shall provide a data logger to read all Device_Status_Response sent from IUT.

It would be better if the two above-mentioned devices were the same device (master and slave).

3.2.6.3.2.3 AX1 and AX0 bits

This test checks the requirement 3.6.4.1.2.3.3 of IEC 61375-1 that is summarised by the following questions:

a) Does the AX1 bit correspond to the second least significant bit of the Actualisation_Key of the Periodic List?

b) Does the AX0 bit correspond to the least significant bit of the Actualisation_Key of the periodic list?

At start-up (bus inauguration) the test equipment shall take the mastership before the IUT (it may be necessary to turn on the test equipment before the IUT).

The bus administrator device of the test equipment shall send several Device_Status_Request to IUT and verify that the status of the AX0 and AX1 bits of the «specific» field in the Device_Status_Response match the last two least significant bits of the Actualisation_Key in the periodic list defined by the manufacturer of the IUT.

The test is terminated when 10 Device_Status_Request are sent.

3.2.6.3.2.4 ACT flag

This test checks the requirement 3.6.4.1.2.3.3 of IEC 61375-1 that is summarised by the following question:

Is the ACT Bit set to 1 if the device is actualised (in possession of a Bus_Configuration) and set to 0 if the device is not actualised (only executes the Event_Round and the Devices_Scan)?

At start-up (bus inauguration) the test equipment shall take the mastership before the IUT (may be necessary turn on the test equipment before the IUT).

Then the bus administrator device of the test equipment shall send a sequence of Device_Status_Request to IUT and verify that when the IUT is «configured» (see IUT requirement 3) the status of the ACT of the «specific» field in the Device_Status_Response is set to 1, and when the IUT is «unconfigured» (see IUT requirement 3) the status of the ACT is set to 0.

The test is terminated when 10 Device_Status_Request are sent.

3.2.6.3.2.5 MAS flag

This test checks the requirement 3.6.4.1.2.3.3 of IEC 61375-1 that is summarised by the following question:

Is the MAS Bit set to 1 if the device is the current master and set to 0 if the device is not the current master?

To execute this test, the bus administrator device of the test equipment shall use the same Actualisation_Key of IUT and IUT shall be «configured».

At start-up (bus inauguration) the test equipment shall take the mastership before the IUT (may be necessary to turn on the test equipment before the IUT).

In this status (phase 1) the bus administrator device of the test equipment shall send one or more Device_Status_Request to IUT.

Then the test equipment shall execute a mastership transfer procedure to set the IUT as master of the bus.

In this status (phase 2) the IUT shall send one or more Device_Status_Request to itself.

The test passes if during the phase 1 the MAS flag of Device_Status_Response of IUT is set to 0, and if during the phase 1 MAS flag of Device_Status_Response of IUT is set to 1.

The test is terminated when 10 Device_Status_Request are sent.

3.2.6.3.3 Gateway specific test

This test shall apply to IUT if it is a device with gateway capability (no special device, no bus administrator capability, gateway capability, independent of message data capability).

The other bus connect to IUT can be WTB bus or other bus (see gateway definition in 1.3.64 of IEC 61375-1), nevertheless they are not involved in this test.

The test procedure is sub-divided into the following phases:

- STD flag;
- DYD flag.

3.2.6.3.3.1 IUT requirement

In order to run this test, the IUT manufacturer shall define:

a) the physical address of the IUT;

b) the procedure to MVB bus of IUT in static disturbance status and the procedure to remove it and set back the IUT in normal condition;

c) the procedure to set MVB bus of IUT in dynamic disturbance status and the procedure to remove it and set back the IUT in normal condition.

3.2.6.3.3.2 Test equipment requirement

The test equipment shall provide a MVB device with bus administrator capability (master device).

3.2.6.3.3.3 STD flag

This test checks the requirement 3.6.4.1.2.3.4 of IEC 61375-1 that is summarised by the following question:

Is the STD bit set to "1" to indicates a static disturbance (remote bus down)?

The test sequence is the following:

a) the test shall execute the procedure to set the remote bus of the IUT in static disturbance state (see IUT requirement 2).

   The test passes if, for every Device_Status_Request sent by the test equipment, the IUT Device_Status_Response contains the STD flag of the «specific» field equal to 1;

b) the test shall execute the procedure to remove the static disturbance state from remote bus of the IUT (see IUT requirement 2).

   The test passes if, for every Device_Status_Request sent by the test equipment, the IUT Device_Status_Response contains the STD flag of the «specific» field equal to 0.

3.2.6.3.4 DYD flag

This test is intended to check the requirement 3.6.4.1.2.3.4 of IEC 61375-1 that is summarised by the following question:

Is the DYD bit set to "1" to indicate a dynamic disturbance (e.g. train inauguration)?

a) The test shall execute the procedure to set the remote bus of IUT in dynamic disturbance state (see IUT requirement 3).

   The test pass if, for every Device_Status_Request sent by the test equipment, the IUT Device_Status_Response contains the DYD flag of the «specific» field equal to 1.

b) The test shall execute the procedure to remove the dynamic disturbance state from the remote bus of the IUT (see IUT requirement 3).

   The test passes if, for every Device_Status_Request sent by the test equipment, the IUT Device_Status_Response contains the DYD flag of the «specific» field equal to 0.

3.2.7 Process data test suites

To make easier the testing of process data capability without sacrificing the coverage, some confidence tests shall be applied to the IUT. A confidence test is not exhaustive nor fully covering all the possible cases referred to specification, nevertheless it gives the confidence that coverage is high enough to assure conformance. The use of confidence tests take some advantages: fast execution, low cost, reduction error during test.

The following test suites are implemented:

a) simple test;
b) high coverage test;
c) custom test.

The simple test is intended for Class 1 devices without computing capability, nevertheless it may be applied on the upper classes of MVB devices.

The high coverage test is intended exclusively for MVB devices with computing capability.

The custom test is intended for MVB device implementation on which the simple test and the high coverage test cannot run owing to implementation characteristics even though they are according to the IEC 61375-1.

3.2.7.1 Simple test

This test is intended to execute check on MVB Class 1 IUT that are implemented without computing capability.

The IUT shall provide a sink process data (test sink process data) and a source process data (test source process data) that are not necessarily dedicated to test purposes only.

When the IUT receives the sink process data, it puts a single bit in a register; when the IUT sends the source process data, it retrieves the previous received and written value and sends it.

The use of a test register is asking for extra hardware on the device, nevertheless, in some cases, the same register can be used for application purposes or for other tests (e.g. for physical layer test).

Figure 15 describes an example of test hardware implementation.

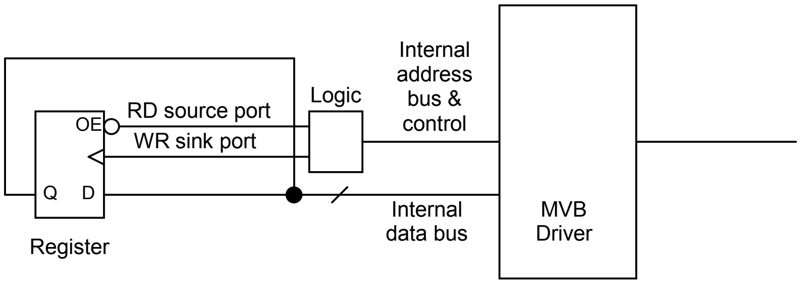

Figure 15 – Example of test hardware implementation

If a process data is managed by means of different functions from the ones used for test process data in the same layer, this process data is considered not tested.

3.2.7.1.1 IUT requirement

In order to run this test, the IUT manufacturer shall define:

- the logical address of sink process data;
- the logical address of source process data;
- the size of sink and source process data, they shall have the same size;
- the position of the test bit in sink process data with the mask of the other bits that shall remain fixed during the test;
- the position of the test bit in source process data;
- the maximum setup time of the register (to define the minimum time from Process_Data_Response of sink process data to Process_Data_Request of source process data). It shall be lower than 511 ms;
- the list of all other source process data (application source process data);
- the mean and the procedure to invalidate the test source process data (the source process data with the test bit).

Hereinafter, an example of IUT requirements is given

- sink process data address = 3368;
- source process data address = 3360;
- size of either process data = 16 bits (FC = 0);
- mask of sink process data = 0111 1111 0000 x000 (the test bit is BIT3, the others bit are fixed);
- position of test bit in source process data = BIT5;
- maximum setup time of the register = 2 ms;
- application source process data = 25 (128 bits), 26 (64 bits);
- invalidate command = connect to GND the sleep signal field interface.

3.2.7.1.2 Test equipment requirement

The test equipment shall provide a Class 4 or higher MVB device (master device).

The periodic list of the bus administrator shall include two programmable process data (two for every size type). For every process data, the address and the poll period shall be programmable.

Furthermore, the test equipment shall provide a Class 1 or higher MVB device with local intelligence (slave device).

This device shall be capable of publishing a programmable (address and size) source process data.

It is possible that the two above-mentioned devices are the same device (master and slave).

No extra requirements, offered by the test equipment, can be requested by the manufacturer of the IUT (e.g. the use of application process data in the periodic list). All the means needed to set up the IUT in the testing mode shall be prepared by the manufacturer of the IUT.

3.2.7.1.3 Procedure

For each test sink process data subscribed by the IUT, a source process data published by the test equipment shall exist. For each test source process data published by the IUT, a sink process data subscribed by the test equipment shall exist.

If not differently specified, a «write sink process data» is a sequence of a Process_Data_Request with size and address specified by the test sink process data of the IUT, and the corresponding Process_Data_Response sent by test equipment.

If not differently specified, a «read source process data request» is a Process_Data_Request with size and address specified by the test source process data of the IUT.

The test sequence is the following:

a) the test equipment shall send a sequence of «write sink process data» and «read source process data request» (spaced out by the declared setup time) and compare the test bit in the send Frame_Data (that can be different to the previous Frame_Data sent) with the test bit in the Frame_Data eventually responds from the IUT.

   The Frame_Data of «write sink process data» shall contain the fixed part as specified in mask of sink process data by the manufacturer of IUT, and the test bit that can change every cycle.

   The test passes if the IUT response is a correct size slave frame for every «read source process data request» and if the test bit in Frame_Data of these responses is equal to the test bit in Frame_Data sent by the test equipment.

   This test step is finished when 10 cycles are over;

b) the test equipment shall send a sequence of «write sink process data» and «read source process data request» (spaced out by the declared setup time) using, for the «write sink process data», different size within those declared in the specific sink process data, and compare the test bit in the Frame_Data send (that shall be different to the previous Frame_Data sent) with the test bit in the Frame_Data response from the IUT.

   The test passes if the IUT response is a correct size slave frame for every «read source process data request» and if the test bit Frame_Data of these responses is the same as the previous one in the Frame_Data received.

   This test step is finished when 10 cycles are over;

c) the test equipment executes the procedure to invalidate the source process data on the IUT, it shall send a sequence of «write sink process data» and «read source process data request» (spaced out by the declared setup time).

   The test passes if the IUT response is a correct size slave frame with Frame_Data set to invalid data irrespectively to the value of the test bit in the Frame_Data sent by the test equipment.

   This test step is finished when 10 cycles are over;

d) the test equipment shall send the Process_Data_Request of the complementary set of the list of all source ports (test source process data + application source process data). The source process data not provided by the IUT shall be requested in all sizes (five Process_Data_Request), the source process data provided by the IUT shall be requested in all other sizes (four Process_Data_Request).

   The test passes if the IUT never responds (no slave frame).

   This test step is finished when 10 cycles are over.

NOTE To run this test, the Class 1 device with computing capability, that is part of the test equipment, is passive disabled (no source port shall be published). Consequently, the bus administrator of the test equipment uses an appropriate periodic list that ceases to poll the disabled device. Specific software, loaded into the test equipment, executes the Process_Data_Request described in the test.

The coverage of the test is hereinafter stated.

Step 1 of this procedure covers the check of the requirements 3.5.4.1.1, 3.5.4.1.4 and 3.5.4.1.5 of IEC 61375-1. The indivisibility property of the internal buffer of the IUT is not checked.

Step 2 covers the check that the device is able to “not accept a slave frame if the F_code indicates a frame length different from the configured length for that logical address” as it is required by 3.5.4.1.5 of IEC 61375-1.

Step 3 checks the requirements 3.5.4.1.4 of IEC 61375-1.

Step 4 of the procedure checks the requirements 3.5.4.1.4 of IEC 61375-1.

The requirement in 3.5.4.1.5 specified as “ a sink buffer shall provide means to indicate how long ago it was updated” is not verified by this test.

All tests shall verify at a minimum one size type sink process data and one size type source process data.

3.2.7.2 High coverage test

This test is applicable to Classes 2, 3, 4 and 5.

The IUT shall provide five sink process data (test sink process data) and five source process data (test source process data) that are not necessarily dedicated to test purposes only.

Each one of five test sink process data and the five test source process data shall represent a different size type of process data (FC=0 .. FC=4).

At application layer, every time the IUT receives a test sink process data, the value written in its port shall be copied in the port of the corresponding (with the same size) test source process data.

The use of these test process data may require a specific test application code on the device.

The test application code shall use the same accessing functions that are used by the application code loaded into the device when the conformity is claimed and declared by the IUT supplier in real implementation.

3.2.7.2.1 IUT requirement

In order to run this test, the IUT manufacturer shall define:

a) the logical address of the five test sink process data;
b) the logical address of the five test source process data;
c) the maximum setup time of the source port (to define the minimum time from Process_Data_Response of sink process data to Process_Data_Request of the corresponseing source process data). It shall be lower than 511 ms;
d) the list of all other source process data (application source process data);
e) the means and the procedure to invalidate all test source process data (invalidate command);
f) the means and the procedure to indicate how long ago the sink process data was updated (refresh timer indicator) and the minimum and maximum period to use in the test to point them out (refresh test time).

Hereinafter, an example of an IUT requirement is given:

- sink process data address = 1 (16 bits), 2 (32 bits), 3 (64 bits), 4 (128 bits), 5 (256 bits);
- source process data address = 6 (16 bits), 7 (32 bits), 8 (64 bits), 9 (128 bits), 10 (256 bits);
- maximum setup time of the source port = 0,5 ms for all test source port;
- application source process data = 25 (128 bits), 26 (64 bits);
- invalidate command = Invalidate_Port(address) from service interface of the IUT;
- refresh timer indicator and refresh test time = service interface of IUT (command Get_Refresh_Time_Port(address)) with a period from 5 s to 1 min.

3.2.7.2.2 Test equipment requirement

The test equipment shall provide a Class 4 or higher MVB device (master device).

The periodic list of bus administrator shall include ten programmable process data (two for every size type). The address and the poll period of each process data shall be programmable.

Furthermore, the test equipment shall provide a Class 1 or higher MVB device with local intelligence (slave device).

This device shall be capable of publishing a programmable (address and size) source process data.

It is possible that the two above-mentioned devices are the same device (master and slave).

No extra requirements, offered by the test equipment, can be requested by the manufacturer of the IUT (e.g. the use of application process data in the periodic list). All the means needed to set up the IUT in the testing mode shall be prepared by the manufacturer of the IUT.

3.2.7.2.3 Procedure

For each test sink process data subscribed by IUT, a source process data published by test equipment shall exist.

For each test source process data published by the IUT, a sink process data subscribed by the test equipment shall exist.

If not differently specified, a «write sink process data» is a sequence of

- a Process_Data_Request, with size and address specified by the test sink process data of the IUT as defined in the relevant PIXIT, generated by the BA of the test equipment;
- the corresponding Process_Data_Response sent by the test equipment source process data.

If not differently specified, a «read source process data request» is a Process_Data_Request with size and address specified by the test source process data of the IUT as defined in the relevant Pixit and generated by the BA of the test equipment.

3.2.7.2.3.1 Port cycle time

To test the process data capability, some characteristics about the port cycle time used shall be explained:

The cycle_1024 constitutes all the Periodic_List.
The basic period is equal to 1 ms.
The Split_List, which contains the number of master frames to be sent in each basic period, is set to 1 in every index: in every basic period only one port is polled.

F_code and Address identify the port:

- the four most significant bits of the 16-bit word represent the F_code;
- the least significant 12 bits represent the address.

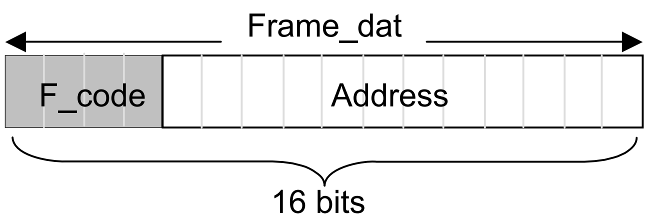

Figure 16 – F_code + Address

Conventional representation:

F_code+Address → Port_x

Port_1	**Sink port_1**
Port_2	**Sink port_2**
Port_3	**Sink port_3**
Port_4	**Sink port_4**
Port_5	**Sink port_5**
Port_6	**Source port_1**
Port_7	**Source port_2**
Port_8	**Source port_3**
Port_9	**Source port_4**
Port_10	**Source port_5**

The structure of a general cycle_1024 shall be the following:

Array of 1024 elements

1	**Port_x**
2	**Port_y**
3	**Port_z**
…	…
…	…
…	…
…	…
1024	**Port_y**

The structure of cycle_1024 in this specific case shall be the following:

Array of 1024 elements

1	**Port_1**
2	**Port_2**
3	**Port_3**
4	**Port_4**
5	**Port_5**
6	**0**
7	**0**
8	**0**
9	**Port_6**
10	**Port_7**
11	**Port_8**
12	**Port_9**
13	**Port_10**
14	**0**
15	**0**
16	**0**
17	**Port_1**
18	**Port_2**
19	**Port_3**
20	**Port_4**
21	**Port_5**
22	**0**
23	**0**
24	**0**
25	**Port_6**
26	**Port_7**
27	**Port_8**
28	**Port_9**
29	**Port_10**
30	**0**
31	**0**
32	**0**
…	…
…	…
…	…
1009	**Port_1**
1010	**Port_2**
1011	**Port_3**
1012	**Port_4**
1013	**Port_5**
1014	**0**

1015	**0**
1016	**0**
1017	**Port_6**
1018	**Port_7**
1019	**Port_8**
1020	**Port_9**
1021	**Port_10**
1022	**0**
1023	**0**
1024	**0**

The port address '0' represents non-existing address polling.

The cycle_1024 is completed in 1,024 s.

A cycle_16 should be enough to poll the 10 ports declared, but the need to execute other tests with more than 16 ports to poll suggests a longer cycle (cycle_1024), but with the same effects for the 10 ports declared:

the hypothetical cycle_16 that composes the first 16 elements of cycle_1024, shall be repeated to cover the 1024 elements of cycle_1024.

Example:

The IUT has declared the following sink/source port:

F_code	Address	Type
0	10	Sink
1	11	Sink
2	12	Sink
3	13	Sink
4	14	Sink
0	15	Source
1	16	Source
2	17	Source
3	18	Source
4	19	Source

The hexadecimal representation becomes:

Port_1	**0x000A**
Port_2	**0x100B**
Port_3	**0x200C**
Port_4	**0x300D**
Port_5	**0x400E**
Port_6	**0x000F**
Port_7	**0x1010**
Port_8	**0x2011**
Port_9	**0x3012**
Port_10	**0x4013**

The corresponding cycle_1024 is the following:

1	**0x000A**
2	**0x100B**
3	**0x200C**
4	**0x300D**
5	**0x400E**
6	**0**
7	**0**
8	**0**
9	**0x000F**
10	**0x1010**
11	**0x2011**
12	**0x3012**
13	**0x4013**
14	**0**
15	**0**
16	**0**
17	**0x000A**
18	**0x100B**
19	**0x200C**
20	**0x300D**
21	**0x400E**
22	**0**
23	**0**
24	**0**
25	**0x000F**
26	**0x1010**
27	**0x2011**
28	**0x3012**
29	**0x4013**
30	**0**
31	**0**
32	**0**
…	…
…	…
…	…
1009	**0x000A**
1010	**0x100B**
1011	**0x200C**
1012	**0x300D**
1013	**0x400E**
1014	**0**
1015	**0**
1016	**0**
1017	**0x000F**
1018	**0x1010**
1019	**0x2011**
1020	**0x3012**
1021	**0x4013**
1022	**0**
1023	**0**
1024	**0**

3.2.7.2.3.2 Steps

For each sink-source process data couple, the test equipment shall execute the following tests:

a) the test equipment shall send a sequence of «write sink process data» and «read source process data request» (spaced out by the declared setup time) and compare the sent Frame_Data (that shall be different to the previous Frame_Data sent) with the Frame_Data eventually responding from the IUT.

   The test passes if the IUT response is a correct size slave frame for each «read source process data request» and if all Frame_Data of these responses are equal to the corresponding Frame_Data sent by the test equipment.

   This test step is finished when 10 cycles are over;

b) the test equipment shall send a sequence of «write sink process data» and «read source process data request» (spaced out by the declared setup time) using, for the «write sink process data», different size[8] from that declared in the specific sink process data, and compare the Frame_Data send (that shall be different to the previous Frame_Data sent) with the previous Frame_Data of the same source process data response from the IUT.

   The test passes if the IUT response with a correct size slave frame for every «read source process data request» and if all Frame_Data of these responses are the same as that of previous Frame_Data received.

   This test step is finished when 10 cycles are over;

c) the test equipment shall execute on the IUT the procedure to invalidate the source process data.

   The test equipment shall send a sequence of «write sink process data» and «read source process data request» (spaced out by the declared setup time).

   The test passes if the IUT response is a correct size slave frame with Frame_Data set to invalid data irrespectively to the value of the test bit in the Frame_Data sent by the test equipment.

   This test step is finished when 10 cycles are over;

d) the test equipment shall send a sequence of «write sink process data» using the minimum refresh test time period and then using the maximum refresh test time period.

   The test passes if, during the test, the indicator of update port timer display an appropriate value for every refresh test time period.

   This test step is finished when 10 cycles are over;

e) the test equipment shall send the Process_Data_Request of the complementary set of the list of all source port (test source process data + application source process data). The source process data not provided in the IUT shall be requesedt in all sizes (five Process_Data_Request), the source process data provided in the IUT shall be requested in all other sizes (four Process_Data_Request).

The test passes if the IUT never responds (no slave frame).

This test step is finished when 10 cycles are over.

The test is now stopped, and the tester shall wait for the exhaustion of the maximum refresh test time period.

The coverage of the test is stated hereinafter.

Step 1 of this procedure covers the check of the requirements 3.5.4.1.1, 3.5.4.1.4 and 3.5.4.1.5 of IEC 61375-1. The indivisibility property of the internal buffer of the IUT is not checked.

Step 2 covers the check that the device is able to “not accept a slave frame if the F_code inicates a frame length different from the configured length for that logical address” as it is required by 3.5.4.1.5 of IEC 61375-1.

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8 If the “Write sink process data” declared by the IUT has F_code=1, the test foresees 4 written using the same address but the other four F_code (0,2,3,4)

Step 3 checks the requirements 3.5.4.1.4 of IEC 61375-1.

Step 4 of the procedure checks the requirements 3.5.4.1.4 of IEC 61375-1.

The requirement of 3.5.4.1.5 specified as " a sink buffer shall provide means to indicate how long ago it was updated" is verified by this test provided by the means of the IUT to communicate the maximum refresh test time period timeout.

3.2.7.3 Custom test

This test is provided to execute a check on an MVB device where the simple test or high coverage test cannot be executed. For this check, the test equipment and the test procedure shall be provided by the manufacturer of the IUT; they shall be implemented according to the constraints and guidelines stated into the following subclauses.

The test laboratory is in charge of executing the test and report the result only.

3.2.7.3.1 Process data identification

Each process data of the IUT involved in the test shall be declared as the following:

a) mnemonic identifier;

b) size;

c) logical address;

d) type (sink, source, bidirectional).

3.2.7.3.2 Process data sample

Each process data of the IUT involved in the test shall be characterised by the following testability attribute:

a) minimum and maximum frequency of process data poll;

b) other access constraints (status of device, sequence with other sink process data, etc.).

All process data shall be divided into subgroups with the same peculiarity. A sample of each subgroup of process data shall be submitted for test.

3.2.7.3.3 Test conditions of process data

In devices that are submitted to custom test, some bits of the IUT process data ports may not be exposed.

In order to run the test, the facilities to read or to force such ports shall be provided by the IUT supplier in the relevant PIXIT.

The conditions and the sequence of change of the ports shall be described by the IUT supplier in details.

3.2.7.4 Test procedure

For every process data sample, the test procedure shall be according to the following framework:

a) identify the process data;

b) describe the group of the process data sample;

c) describe the test conditions;

d) describe the test bed;

e) describe the operation sequence;

f) describe the pass criteria (with reference of the PICS).

3.2.7.4.1 Test execution

The following two subclauses list the subclauses of IEC 61375-1 and the relevant questions that the test shall check.

3.2.7.4.1.1 Source process data

The implementation of test shall address the following IEC 61375-1 requirements declared at the beginning of the next sentences:

3.5.4.1.1 of IEC 61375-1– Does the slave which sources the process data corresponding to the identifier in the Process Data_Request respond with a Process Data_Response?

3.5.4.1.4 of IEC 61375-1 – Is the IUT device sourcing process data reading the contents of its source buffer and sending it in one indivisible operation in the slave frame?

3.5.4.1.4 of IEC 61375-1 – Does the IUT device not respond if the F_code of the Process Data_Request indicates a frame length different from the configured length for that Logical_Address?

3.5.4.1.4 of IEC 61375-1 – Does the source buffer of the IUT device provide means to be overwritten with “0” to invalidate its data?

3.2.7.4.1.2 Sink process data

The implementation of test shall be such that the following IEC 61375-1 requirements declared at the beginning of each of the next sentences are addressed:

3.5.4.1.5 of IEC 61375-1 – Is the IUT device, when sinking process data, storing the frame in the corresponding buffer (port), overwriting the previous contents of that buffer in one indivisible operation with the contents of the frame received over the bus?

3.5.4.1.5 of IEC 61375-1 – Is the IUT device, when sinking process data, not accepting a slave frame if the F_code indicates a frame length different from the configured length for that Logical_Address?

3.5.4.1.5 of IEC 61375-1 – Does the sink buffer of the IUT device provide means to indicate how long ago it was updated?

3.2.8 Slave message data capability test suite

To make easier the test of message data capability, a standard test shall be applied to the IUT. As already weighed up in process data capability, the use of a standard test has some advantage: fast execution, low cost, reduced error during test, defined test covering.

The following test type can be implemented:

a) standard test (on a device with a dedicated function test);

b) custom test (other).

3.2.8.1 Standard test

For the purpose of the test, this model considers only two devices participating in the communication. Figure 17 shows the concept of message data testing, the figure shows two participating devices and three non-participating devices.

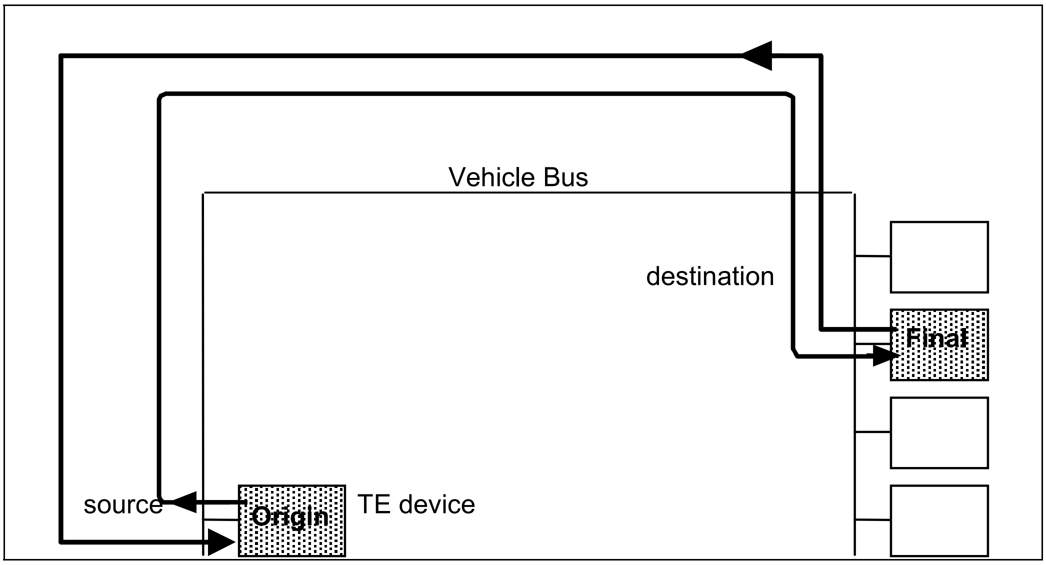

Figure 17 – Concept of message data testing

The following general conventions are applied:

a) test sink message: is a message data that will be received and processed by the IUT;
b) test source message: is a message data that will be sent by the IUT;
c) in the IUT shall exist memory regions, each consisting of a number of identical, consecutive items, which size is an integral multiple of one octet, each octet having an address. The alignment is as follows:
   - if the item size is 1, the memory region may begin at an odd or an even address;
   - if the item size is 2, the memory region shall begin at an even address;
   - if the item size is 4, the memory region shall begin at an address divisible by 4.

The message data process involves the TE as caller-originator and the IUT as replier. Figure 18 shows the model.

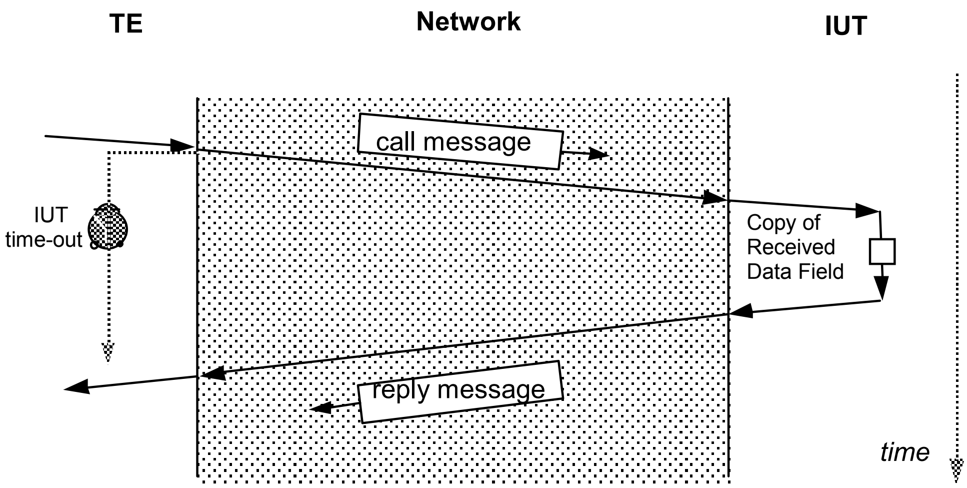

Figure 18 – Model of the relation between TE and IUT for message data testing

The complete test model is shown in Figure 19, here the TE asks the IUT to become the caller. The TE originates a message call, the IUT receives it and copies the data part of the data field in a call message for the TE. The TE receives the message and copies the data field again replying to the IUT. The IUT receives the reply message from the TE and copies the data field replying to the TE. An IUT timeout is set by the TE against the IUT and a TE timeout is set by the IUT against the TE.

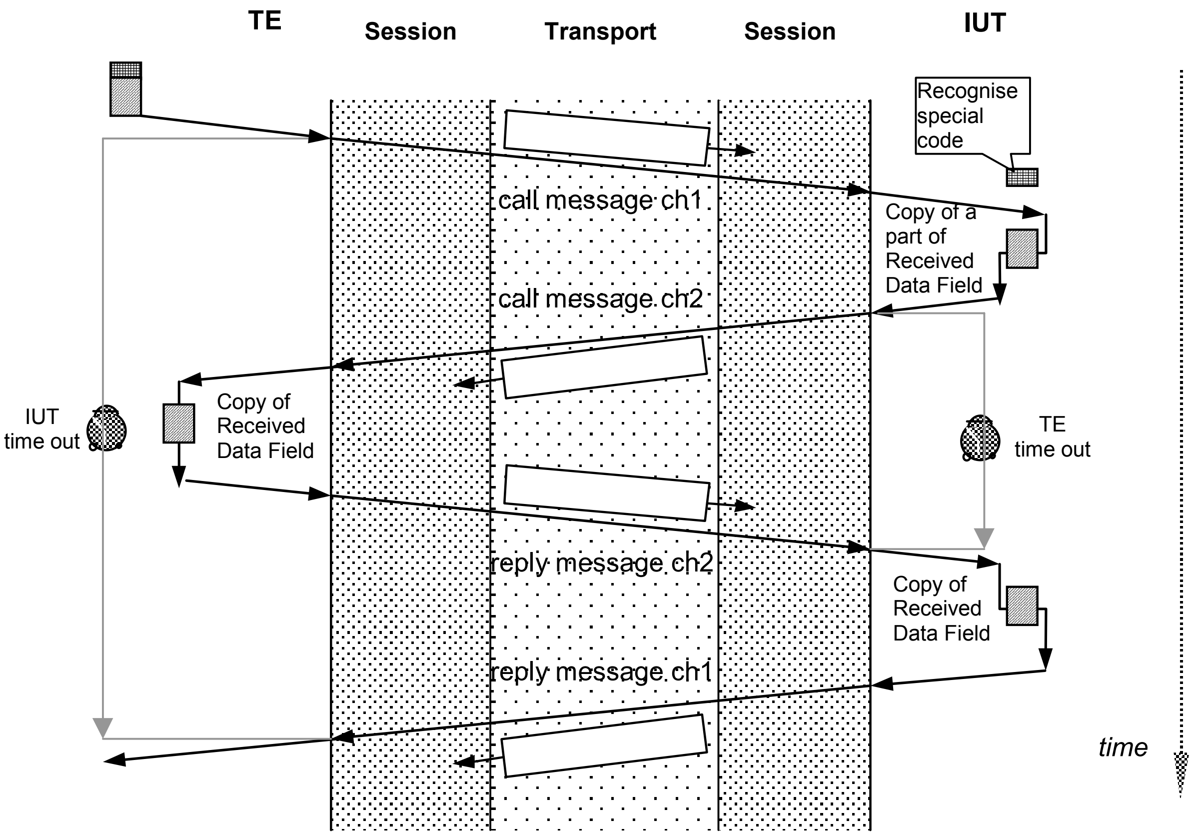

Figure 19 – Relation between TE and IUT in case of test of IUT as caller

The transport layer operates with the seven packet types illustrated in Figure 20. The field dt_data is used mostly.

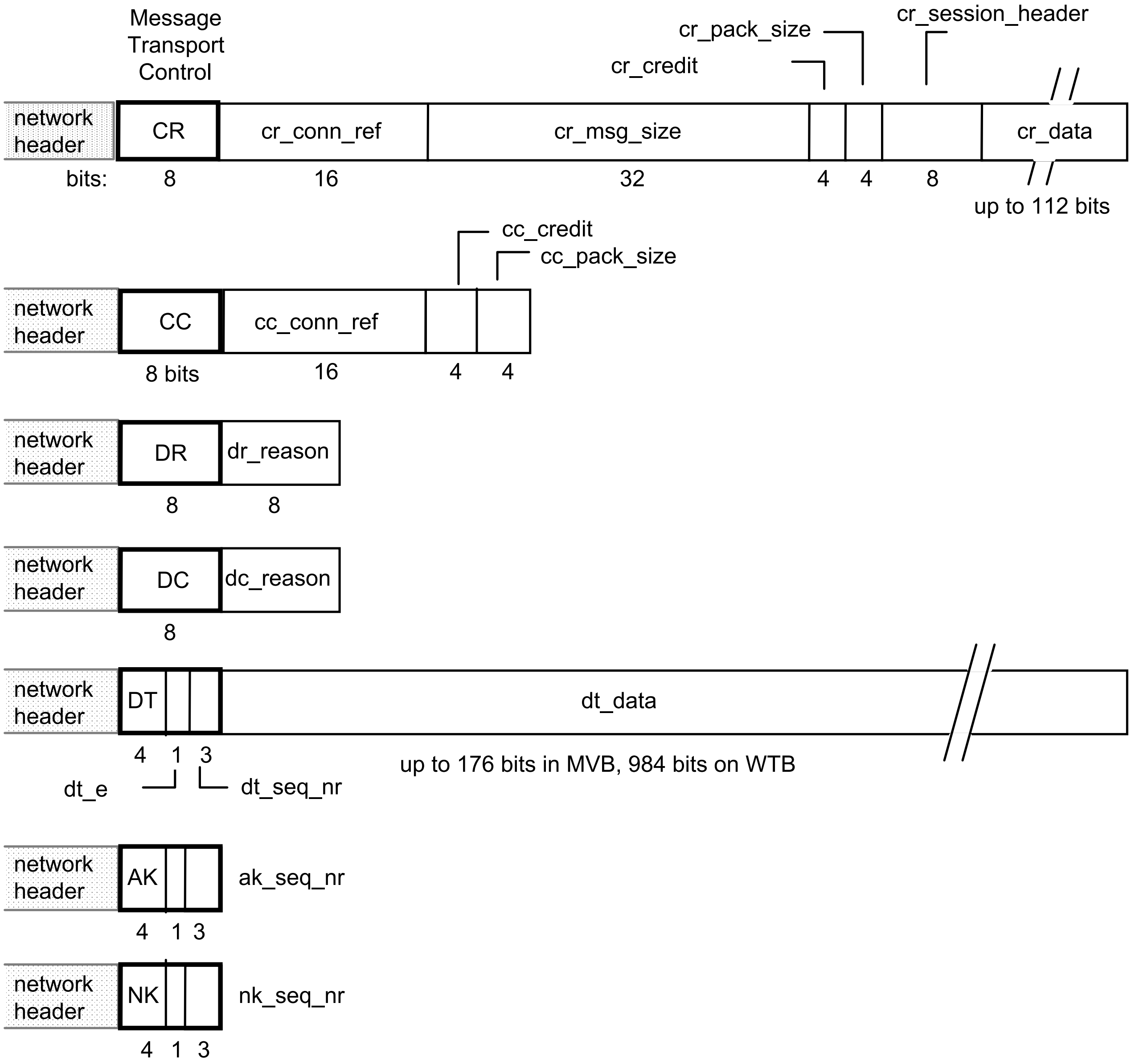

Figure 20 – Packet formats (transport layer body)

3.2.8.2 IUT checks

The IUT shall:

copy the dt_data a specific message data received by the dt_data of the reply message (tests the IUT as replier).

It shall check if the first byte of dt_data of received message is 0x83, in this case it shall use the next four bytes of dt_data as AM_ADDRESS of its reply. The IUT shall use the remaining data as the dt_data of this reply message; when the IUT receives the reply to this message, it can send the reply of the first received message using the same dt_data of the reply from TE as the dt_data of its reply to the first message.

Figure 18 describes the test procedure used when the first byte of the dt_data of the received message is not equal to 0x83. Figure 19 describes the test procedure used when the first byte of the dt_data of the received message is equal to 0x83.

Figure 21 describes the flowchart that shall be implemented in the IUT to execute the test. Timeout is not shown in the flow chart, but shall be implemented accordingly.

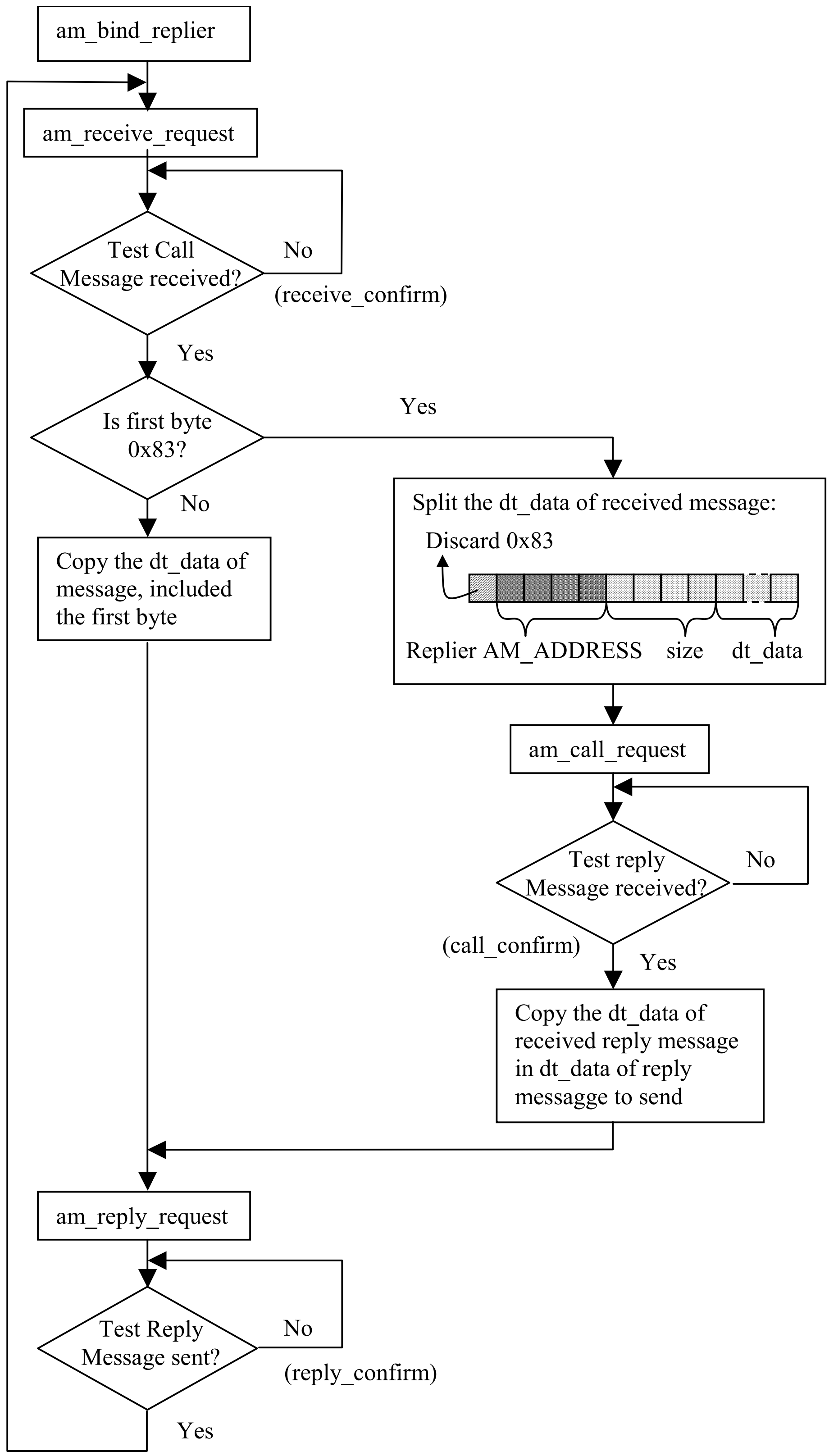

Figure 21 – Test message task of IUT

3.2.8.2.1 IUT requirements

The IUT shall define:

a) link layer parameters;
b) the network layer parameters;
c) the transport layer parameter;
d) the session layer parameter.

3.2.8.2.1.1 Link layer parameters

The following information shall be specified:

MSG_1 The physical address of the IUT[9]

MSG_2 The priority event implemented for the event phase in sporadic phase:

Table 14 – Event poll strategy

event_poll_strategy	
NOEVENTS (‘0000’H),	no event polling
HIPRIONLY (‘4000’H),	high priority events only
LOPRIONLY (‘8000’H),	low priority events only
HILOPRIO (‘C000’H)	high and low priority events

3.2.8.2.1.2 The network layer parameters

The following information shall be specified:

MSG_3 The final function of the test sink message (test replier function)

MSG_4 The origin function of the test sink message (test replier function)

MSG_5 The final function of the test source message (test caller function)

MSG_6 The origin function of the test source message (only if the final function is used in the client’s application program)

MSG_7 The station_id of the device

MSG_8 The maximum length of a message (see cr_msg_size in 2.3.6.5 of IEC 61375-1, and Figure 20). This value shall be the lowest value of the max send and max receive messages. This parameter is required by the network and by the upper layer, this value can be different for different layers; the maximum length of a message is the smallest of these.

MSG_9 The timeout for replying to the received message in a single call case (see IUT timeout in Figure 18)

MSG_10 The timeout for replying to the received message in a double call case (see IUT timeout in Figure 19).

MSG_11 The timeout for replying the received message in TNM services.

[9] The “Physical Address” is the “Device Address” on MVB

MSG_12 For the Group_Directory, management shall be defined if the Group_Directory exists (multicast) or does not exist (single cast only) or it is fixed. If the Group_Directory exists, it shall be defined if it is up/downloadable by means of the network management or by means of service interface or either.

MSG_13 For the Function_Directory, management shall be defined if the Function_Directory does not exist, if it is fixed, if it is up/downloadable by means of the network management or by means of the service interface or either.

MSG_14 For the Station_Directory, management shall be defined if the Station_Directory does not exist (simple routing), if it is fixed, if it is up/downloadable by means of network management or by means of service interface or either.

MSG_15 For an IUT as node shall be defined the Node_Directory management and if the Node_Directory is fixed or if it is up/downloadable by means of network management

MSG_16 For an IUT as node shall be defined the node address if the IUT is a node in a train bus with fixed composition.

3.2.8.2.1.3 The transport layer parameter (optional)

The following information shall be specified:

MSG_17 The multicast transport protocol implementation.

3.2.8.2.1.4 The session layer parameter

The following information shall be specified:

MSG_18 The topo_counter value.

3.2.8.2.1.5 Example of IUT requirements data gathering

The physical address of the IUT = 14

The startup station address = The same as the physical address = 14

The final function of the function test sink message = 93

The origin function of the function test sink message = 80

The final function of the function test source message = The same origin function as the function test sink message = 80

The origin function of the function test source message = The same final function of the function test sink message = 93

The final station of the station test sink message = 252 (as recommended)

3.2.8.2.1.6 IUT test application

The IUT shall send to the final function of the source message the same message received by the final function of the test sink message. This operation shall be executed in less than 1 s.

The source device (SD) of a received message shall be used as the DD (destination device) of the message replied.

If the DD of the received message is the broadcast address then the IUT shall reply the same message to the broadcast address.

3.2.8.2.1.7 General IUT requirement

The following information shall be specified:

MSG_19 The test equipment waiting time to execute another call_request to the same replier (is identified as caller timeout), after having executed the call_confirm (receive the reply),.

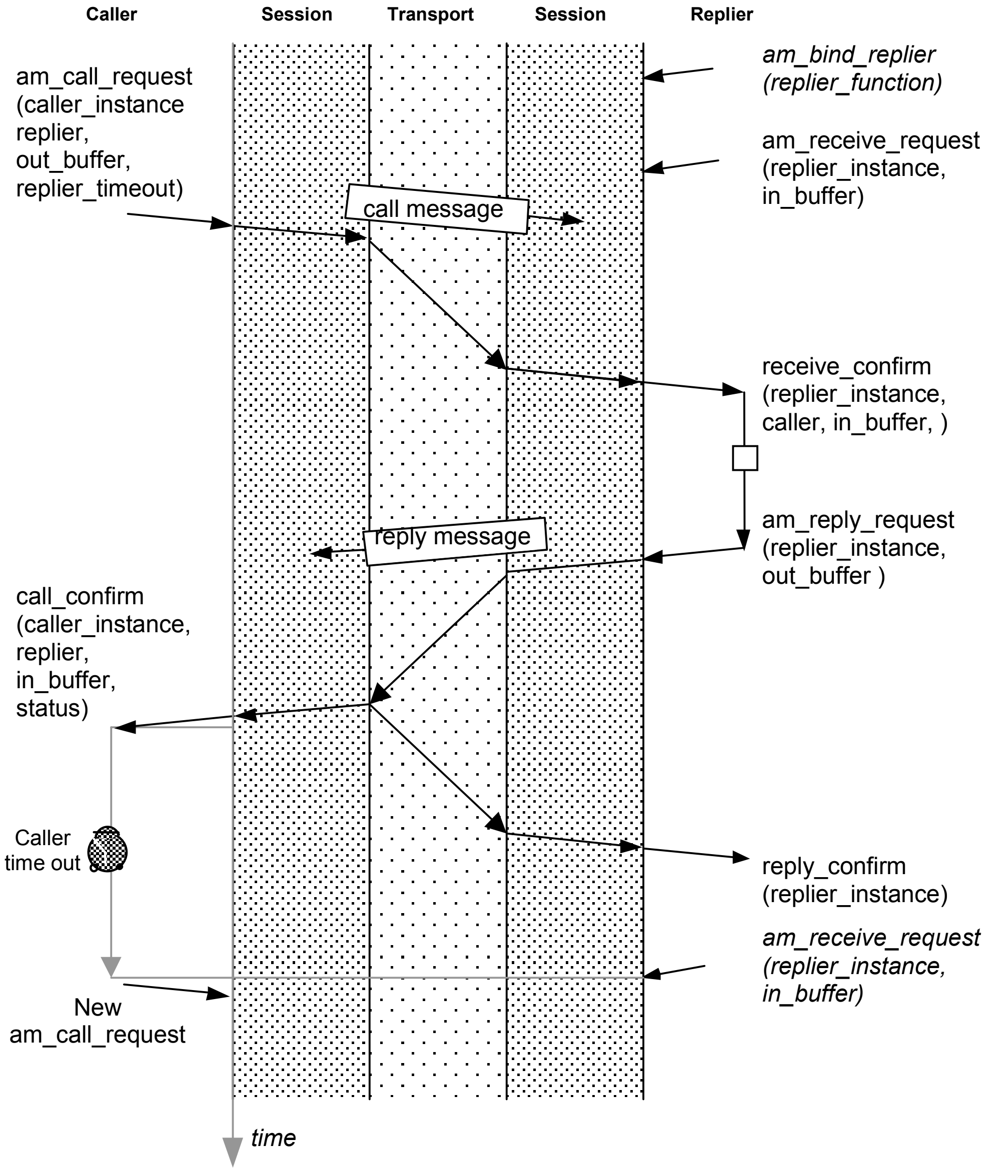

Figure 22 – Caller timeout identification[10]

MSG_20 The IUT agent shall implement the following services:

- Read_Station_Status
- Read_Station_Inventory

10 IEC 61375-1, 2.3.10.2.1 shows an interaction diagram. It is recommended that the user take care of the delay times.

MSG_21 Every time the IUT receives a message to the final station (see requirement MSG_1) of the type station test sink message (osu=1), it shall reply to the origin station the same received message. This operation shall be executed in less than 1 s. The source device (SD) of the received message shall be used as the DD (destination device) of the replied message.
If the DD of the received message is the broadcast address then the IUT shall reply the same message to broadcast address.

MSG_22 Every time IUT receives a function test sink message (osu=0), from the origin function (see requirement MSG_4) to the final function (see requirement MSG_3), it shall reply the same message using the origin function (see requirement MSG_6) as the final function (see requirement MSG_5) of the function test source message (osu=0). This operation shall be executed in less than 1 s. The source device (SD) of the received message shall be used as the DD (destination device) of the replied message.
If the DD of the received message is the broadcast address then the IUT shall reply the same message to the broadcast address.

MSG_23 One memory region with at least 16 bytes, that shall be, during the test, reserved and exclusively available for test purposes. The memory region shall be defined with its address.

MSG_24 A memory area (domain) where the test equipment can execute the Download_Segment using test data. Shall be defined the base_address, the domain_size (e.g. the sectors size of a flash EEPROM) and an invalid domain_size (e.g. in a Flash with 64*1024 byte sectors, the 80*1024 byte can be an invalid size).

MSG_25 Shall be defined if the domain can be erased.

MSG_26 Shall be defined if the domain can be written.

MSG_27 Shall be defined a memory area where the test equipment cannot execute the Download_Segment using test data. Only the base_address is required.

MSG_28 The data segments to download in the domain area defined in MSG_24. Every segment shall be characterised with segment_base_address, segment_size and segment_values (including its checksum).

MSG_29 The same first segment described in MSG_28 but with the wrong checksum.

MSG_30 The same first segment described in MSG_28 but with only a segment_value different (including the eventually correct checksum).

MSG_31 Shall be defined if is provided with the means and the procedure to cause an INFO event used as entry of the journal object.

MSG_32 Shall be defined if is provided with the means and the procedure to cause a WARNING event used as an entry of journal object. Shall be defined if is provided with the means and the procedure to cause an ERROR event used as an entry of the journal object

3.2.8.2.2 Test equipment requirement

TE_1 The test equipment shall provide a Class 2 or higher MVB device (message data capability device) implementing at the application layer a task that sends test messages to the IUT and receives reply messages from it.

TE_2 Test equipment shall provide a Class 4 or higher MVB device to execute the bus administrator function to permit the messages transfer.

It is recommended that the two above-mentioned classes reside on the same device.

3.2.8.2.3 Procedure

The following paragraphs describe the test procedure.

Table 15 – Abbreviations

Abbreviations	
FN	Final Node
FF	Final Function
FS	Final Station
fgi	Final Group or Individual
fsu	Final Station or Function
ON	Origin Node
OF	Origin Function
OS	Origin Station
osu	Origin Station or Function
ogi	Origin Group or Individual
DC	Don't Care

3.2.8.2.3.1 Addressing type used

The following table shows the different addressing modes used for specific test steps of the procedure.

For every test message sent from the test equipment, the IUT replies with a corresponding reply message.

Table 16 – Addressing type

Addr.	Test message (from TE)								Reply message (from IUT)							
Type	Fsu	Fgi	FN	FF/FS	osu	Ogi	ON	OF/OS	Fsu	Fgi	FN	FF/FS	osu	ogi	ON	OF/OS
1.	1	0	0	253 [0]	1	0	0	254 [0]	1	0	0	254 [0]	1	0	0	253 [0]
2.	1	1	0	Req. MSG_3	1	1	0	Req. MSG_4	1	1	0	Req. MSG_5	1	1	0	Req. MSG_6
3.	0	0	0	Req. MSG_3	0	0	0	Req. MSG_4	0	0	0	Req. MSG_5	0	0	0	Req. MSG_6

[a] Is the AM_AGENT_FCT value

[b] Is the AM_MANAGER_FCT value

[c] Is the AM_UNKNOWN value

[d] The original Station_Id (Req. MSG_7).

[e] The value read using the READ_STATION_INVENTORY service (it shall be the same as [0]).

[f] A group address defined in the fixed (see requirement MSG_12) or downloaded group directory.

[g] The final node and the origin node shall be defined by test equipment supplier.

[h] The final Station_Id of the transit packet

[i] The origin Station_Id of the transit packet

[j] The same value of ON in test message from TE.

3.2.8.2.3.1.1 Preamble

During this test, the test equipment shall be:

- enabled to receive a message from the origin function of the test source message (see requirement MSG_6) of the IUT (see requirement MSG_1) to its final function of the test source message (requirement MSG_5 as replier_function of am_bind_replier);
- enabled to receive a message from the origin station of the test source message (manager of the IUT) of the IUT (see requirement MSG_1) to its final station of the test source message (agent of TE).

If not differently specified, a «function test call message» is an application layer message sent by the test equipment using:

- • the origin function of the function test sink message (see requirement MSG_4);
- • the final function of the test sink message (see requirement MSG_3);
- • the IUT physical address as destination device (see requirement MSG_1).

If high and low priority events (see requirement MSG_2 and 3.8.3.2 of IEC 61375-1) are used by the IUT, all tests shall be repeated for both priorities. The bus administrator shall apply the different priority Event_Request only for the IUT; for the other slave (Class 2 or upper device of test equipment) the priority used for Event_Request shall be the same for all steps.

3.2.8.2.3.1.2 Test steps

The step sequence described in this subclause is organised so as to verify the individual functions depending on the object available or already tested in previous steps.

The functions may be verified in a single step, or in a single sequence of steps, or in different sequences of steps.

The following list describes the functions and the step (in parentheses) where they are verified.

a) Function message (steps 16, 17, 18, 19, 23)
b) Station service of TNM (steps 1, 2, 3, 4, 5, 6, 7, 8, 66)
c) Messages service of TNM (steps 10, 11, 12, 13, 14, 20, 21, 22)
d) Domain services of TNM (steps 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 39, 40, 42, 43, 44, 47, 48, 49, 50, 51)
e) Clocks services of TNM (steps 52, 53, 54)
f) Journal services of TNM (steps 55, 60, 61, 62)
g) Equipment services of TNM (step 63)

If not differently specified, in this paragraph all call/reply shall be executed using the addressing type 1 described in Table 16.

3.2.8.2.3.1.3 Station services

1. The test equipment shall send a “Call_Read_Station_Status” (see 5.4.2.1 of IEC 61375-1) to the IUT. The TE shall receive the “Reply_Read_Station_Status” from the IUT before the timeout specified on MSG_11. The “Reply_Read_Station_Status” sent from the IUT, shall contain the same device address defined in point MSG_1, the IUT Station_Status and the bus_id over which the agent received the call.
2. The test equipment shall send a “Call_Read_Station_Inventory” (see 5.4.2.3 of IEC 61375-1) to the IUT. The TE shall receive the “Reply_Read_Station_Inventory” from the IUT before the timeout specified on MSG_11. The “Reply_Read_Station_Inventory” sent from the IUT shall contain the Station_Id defined in MSG_7, the IUT Station_Status, and at least a bit of Link_Set set to 1 (link MVB active). [11]
3. If supported by the IUT (see step 2), the test equipment shall send a “Call_Write_Station_Reservation” (see 5.4.2.4 of IEC 61375-1) to the IUT using command = 1 (reservation), a manager_id (Application_Address), access_type = 0 (WRITEREQ), the reservation_time_out = 3600. In this test, the IUT shall reply with a “Reply_Write_Station_Reservation”, before the timeout specified on MSG_11, with the same manager_id sent in “Call_Write_Station_Reservation”. After having received the reply, the IUT shall verify that the bit SER of device status of the IUT is 1.
4. If supported by the IUT (see step 2), the test equipment shall send a “Call_Write_Station_Reservation” (see 5.4.2.4 of IEC 61375-1) to the IUT using command = 1 (reservation), a manager_id not equal to manager_id sent in step 3, access_type = 0 (WRITEREQ), reservation_time_out = 3600. In this test, the IUT shall reject the request (time_out reply or “Reply_Write_Station_Reservation” with the manager_id sent in step 3).
5. If supported by the IUT (see step 2), the test equipment shall send a “Call_Write_Station_Reservation” (see 5.4.2.4 of IEC 61375-1) to the IUT using command = 1 (reservation a manager_id not equal to manager_id sent in step 3, access_type = 1 (OVERRIDE), a reservation_time_out = 1. In this test, the IUT shall reply with a “Reply_Write_Station_Reservation”, before the timeout specified on MSG_11, with the manager_id sent in “Call_Write_Station_Reservation” of this step.

   The test equipment shall not send any message to the IUT for 2 s (wait reservation_time_out).
6. If supported by the IUT (see step 2), the test equipment shall send a “Call_Write_Station_Reservation” (see 5.4.2.4 of IEC 61375-1) to IUT using command = 1 (reservation), the Original_manager_id (Application_Address), access_type = 0 (WRITEREQ), reservation_time_out = 3600. In this test, the IUT shall reply with a “Reply_Write_Station_Reservation”, before the timeout specified on MSG_11, with the manager_id sent in “Call_Write_Station_Reservation” of this step.
7. If supported by the IUT (see step 2), the test equipment shall send a “Call_Write_Station_Control” (see 5.4.2.2 of IEC 61375-1) to the IUT using RST = 0, the

11 The Service_Set field of the Reply_Read_Station_Inventory should be used by the TE to execute or skip the subsequent steps

test Station_Id shall be the complement of the origin value read in step 2, Station_Name containing the “*MVB CONFORMANCE MESSAGEDATA TEST*” string. In this test, the IUT shall reply with a “Reply_Write_Station_Control”, before the timeout specified on MSG_11, with the device address defined in point MSG_1 and the bus_id read in step 1.

8. If step 7 was successfully executed, the test equipment shall send a “Call_Read_Station_Inventory” (see 5.4.2.3 of IEC 61375-1) to the IUT with test Station_Id set in step 7. In this tes, the IUT shall reply with a “Reply_Read_Station_Inventory”, before the timeout specified on MSG_11, with the test Station_Id and the Station_Name set in step 7 and the IUT Station_Status. The TE shall verify the Station_Status comparing it with the value of MVB device_status.
9. If supported by the IUT (see step 2), the test equipment shall execute a WRITE_STATION_CONTROL to restore the original Station_Id and the Station_Name read in step 2.

3.2.8.2.3.1.4 Messages services

10. If supported by the IUT (see step 2), the test equipment shall execute a “Call_Read_Function_Directory” (see 5.4.6.3 of IEC 61375-1) to IUT. In this test, the IUT shall reply with a “Reply_Read_Function_Directory”, before the timeout specified on MSG_11, including the original function_list.
11. If supported by the IUT (see step 2 and requirement MSG_13), the test equipment shall execute a “Call_Write_Function_Directory” (see 5.4.6.4 of IEC 61375-1) to the IUT using the test function directory defined in Table 17.

Table 17 – Test function directory

Function	Final station
MSG_3	MSG_7
MSG_6	MSG_7
MSG_4	Station_id of TE_1
MSG_5	Station_id of TE_1

In this test, the IUT shall reply with a “Reply_Write_Function_Directory” before the timeout specified on MSG_11. If the WRITE_FUNCION_DIRECTORY is not supported but is possible to download the Function_Directory using the service interface, the manufacturer of the IUT shall execute this operation in this step.

12. If supported by the IUT (see step 2), the test equipment shall execute a “Call_Read_Function_Directory” (see 5.4.6.3 of IEC 61375-1) to the IUT. In this test, the IUT shall reply with a “Reply_Read_Function_Directory” before the timeout specified on MSG_11 including the function_list written in step 11.
13. If supported by the IUT (see step 2), the test equipment shall execute a “Call_Read_Station_Directory” (see 5.4.6.5 of IEC 61375-1) to the IUT. In this test, the IUT shall reply with a “Reply_Read_Station_Directory” before the timeout specified on MSG_11 including the original station_list.
14. If supported (see step 2 and requirement MSG_14), the test equipment shall execute a “Call_Write_Station_Directory” (see 5.4.6.6 of IEC 61375-1) to the IUT using the test station directory defined in Table 18.

Table 18 – Test station directory

Final station	Next station	Bus id	Device address
MSG_7	MSG_7	Read in step 1.	MSG_1
MSG_7	MSG_7	Read in step 1.	MSG_1
Station_id of TE_1	Station_id of TE_1	Read in step 1.	Device address of TE_1
Station_id of TE_1	Station_id of TE_1	Read in step 1.	Device address of TE_1

In this test, the IUT shall reply with a "Reply_Write_Station_Directory" before the timeout specified on MSG_11. If the WRITE_STATION_DIRECTORY is not supported but is possible to download the Station_Directory using the service interface, the manufacturer of the IUT shall execute this operation in this step.

15. If supported by the IUT (see step 2), the test equipment shall execute a "Call_Read_Station_Directory" (see 5.4.6.5 of IEC 61375-1) to IUT. In this test, the IUT shall reply with a "Reply_Read_Station_Directory" before the timeout specified on MSG_11 including station directory defined in Table 18.
16. The TE shall send a «function test call message» with a one byte of dt_data data (see cr_msg_size in 2.3.6.5 of IEC 61375-1) to the IUT. The IUT shall copy the received dt_data into the corresponding reply dt_data field. The IUT shall reply to the TE. The TE shall receive the IUT reply message carrying the received dt_data field before the timeout specified on MSG_9. This test shall be executed using the addressing 3 described in Table 16. This test shall be repeated putting in dt_data each value contained in the following list: 0x00, 0x55, 0xAA, 0xFF.
17. The test equipment shall send a «function test call message» to the IUT, with the maximum length of dt_data as declared in MSG_8. The IUT shall copy the received dt_data into the corresponding reply dt_data field. The IUT shall reply to the TE. The TE shall receive the IUT reply message carrying the received dt_data field before the timeout specified on MSG_9. The dt_data field shall contain: 0x00, 0x01, 0x02 … 0xFE, 0xFF, 0x00 … until the maximum length is reached. This test shall be executed using the addressing type 3 described in Table 16.
18. The test equipment shall send a "function test call message" to the IUT, with the dt_data built in this way:

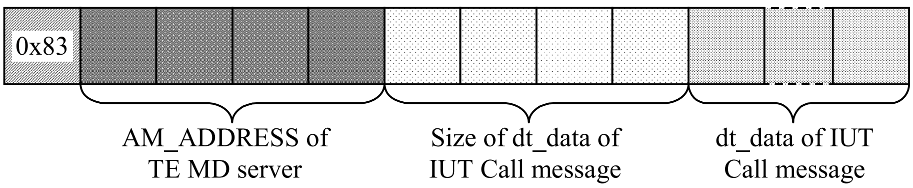

Figure 23 – Nesting address with 0x83

- the 1st byte (0x83 value) is the code to identify the reply procedure in the test message task of the IUT (see Figure 21);
- the 2nd to 5th bytes identify the destination address of the call message of the IUT;

Table 19 – Nesting address

2nd	0	0	0
3rd	MSG_5		
4th	Station_id of TE_1		
5th	0	0	0

- the 6nd to 9th bytes identified the size of the dt_data of the IUT call message;
- the remaining data (10th to Nth) shall be used as the dt_data of the IUT call message.

The IUT shall encode the message and send its call massage. When the TE will produce the reply using the dt_data of the call of the IUT. When the IUT receives the reply, it copies the dt_data to the reply of the first message to the TE as described in Figure 21. The TE shall receive the IUT reply message carrying the received dt_data field before the timeout specified on MSG_10 This test shall be executed using the addressing type described in Table 16. In this test the dt_data of IUT call message shall be only a byte. This test shall be repeated putting in the dt_data of each value contained in the following list: 0x00, 0x55, 0xAA, 0xFF.

19. The test equipment shall repeat test 18 using the same parameters for the first nine bytes filling the dt_data field with the following sequence: 0x00, 0x01, 0x02 … 0xFE, 0xFF, 0x00 … until the maximum length is reached.
20. If supported by the IUT (see footnote to step 2 and requirement MSG_12), the test equipment shall send a “Call_Read_Group_Directory” (see 5.4.6.7 of IEC 61375-1) to IUT. In this test the IUT shall reply with a “Reply_Read_Group_Directory”, before the timeout specified on MSG_11, with the original Group_Directory.
21. If supported by the IUT (see footnote to step 2 and requirement MSG_12), the test equipment shall send a “Call_Write_Group_Directory” (see 5.4.6.8 of IEC 61375-1) to IUT with at least a group where the IUT is a member. The TE shall receive the “Reply_Write_Group_Directory” before the timeout specified on MSG_11. If the WRITE_GROUP_DIRECTORY is not supported but is possible to download the Group_Directory using the service interface, the client of IUT shall execute this operation in this step.
22. If supported by the IUT (see footnote to step 2 and requirement MSG_12) and if step 21 was executed, the test equipment shall send a “Call_Read_Group_Directory” (see 5.4.6.7 of IEC 61375-1) to the IUT. In this test, the IUT shall reply with a “Reply_Read_Group_Directory” before the timeout specified on MSG_11 and with the Group_Directory written in step 21.
23. If the IUT is a member of a Group (step 21 executed or fixed Group_Directory is provided), the test equipment shall send a “function test call message” to the IUT, using the addressing type 2 described in Table 16, with at least one byte of dt_data (see cr_msg_size in 2.3.6.5 of IEC 61375-1). The IUT shall reply the same dt_data of the call message as dt_data of the corresponding reply message. The TE shall receive the IUT reply message carrying the received dt_data field before the timeout specified on MSG_9.

    If supported by the IUT (see requirement MSG_17), this test shall be executed using the multicast transport protocol.
24. If supported by the IUT (see step 2), the test equipment shall execute a WRITE_GROUP_DIRECTORY to restore the original group_list read in step 20. If the WRITE_GROUP_DIRECTORY is not supported but it is possible to download the Group_Directory using the service interface, the manufacturer of IUT shall execute this operation to restore the original Group_Directory read in step 20.

3.2.8.2.3.1.5 Domain services

The following steps apply to MVB Class 3 or Class 4 devices.

25. If supported by the IUT (see footnote to step 2), the test equipment shall execute a “Call_Read_Memory” (see 5.4.7.1.2 of IEC 61375-1) to a single memory region (nr_regions = 1) of the IUT with base_address of MSG_23, item_size = 1 and nr_items = 16. In this test, the IUT shall reply with “Reply_Read_Memory” before the timeout specified on MSG_11 including the values in the memory region (see requirement MSG_23).

26. If supported by the IUT (see footnote to step 2), the test equipment shall execute the sequence of services type described inTable 20. For every “Call_Write_Memory” (see 5.4.7.2.2 of IEC 61375-1) writing values into a single memory region (nr_regions = 1), the IUT shall reply with a “Reply_Write_Memory”, before the timeout specified on MSG_11. For every “Call_Read_Memory” (see 5.4.7.1.2 of IEC 61375-1) reading single memory region (nr_regions = 1), the IUT shall reply with a “Reply_Read_Memory” before the timeout specified on MSG_11.

Table 20 – Read_Memory and Write_Memory sequence

N°	*Service type*	*Size*	*Offset as to base_address*	*nr_items*	*Address* 0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
1	**W**	**4**	**0**	**4**	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
2	**R**	**2**	**0**	**8**	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
3	**W**	**2**	**2**	**6**			FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF		
4	**R**	**4**	**0**	**4**	00	00	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	00	00
5	**W**	**4**	**4**	**2**					54	55	56	57	58	59	5A	5B				
6	**R**	**1**	**0**	**16**	00	00	FF	FF	54	55	56	57	58	59	5A	5B	FF	FF	00	00
7	**W**	**1**	**5**	**4**					FF	65	66	67	68	00						
8	**R**	**1**	**4**	**6**					54	65	66	67	68	59						
9	**W**	**1**	**7**	**3**							FF	77	78	79						
12	**R**	**1**	**6**	**5**							66	77	78	79	5A	XX				
13	**W**	**1**	**8**	**3**									88	89	8A	00				
14	**R**	**1**	**7**	**5**							XX	77	88	89	8A	5B	XX			
15	**W**	**1**	**6**	**4**							96	97	98	99						
16	**R**	**1**	**5**	**7**					XX	65	96	97	98	99	8A	5B				

- The WRITE_MEMORY service is identified by W into *Service type* field.
- The READ_MEMORY service is identified by R into *Service type* field.
- The item_size is identified in *Size* field.
- The base_address is the sum of value defined in MSG_23 and value identified in *Offset as to base_address* field.
- The nr_items is identified in *nr_items* field.
- Every "Reply_Read_Memory" shall contain the values shown in *address* fields at the corresponding addresses (XX = don't care).
- The sequence has been produced to ensure the highest coverage for this test.

27. If supported by the IUT (see footnote to step 2), the test equipment shall execute a "Call_Write_Memory" (see 5.4.7.2.2 of IEC 61375-1) to two memory regions (nr_regions = 2) of the IUT with base_address of MSG_23 for the first regions and the same base address add to 8 for the second region. For every region, the item_size = 1 and nr_items = 8. The first region_value_list shall contain the sequence 0x00..0x07, the second region_value_list shall contain the sequence 0x08..0x0F. In this test, the IUT shall reply with a "Reply_Write_Memory" before the timeout specified on MSG_11.
28. If supported by the IUT (see footnote to step 2) and if step 27 was be successfully executed, the test equipment shall execute a "Call_Read_Memory" (see 5.4.7.1.2 of IEC 61375-1) to two memory regions (nr_regions = 2) of IUT with base_address of MSG_23 for the first regions and the same base address add to 8 for the second region. For every region, the item_size = 1 and nr_items = 8. In this test, the IUT shall reply with "Reply_Read_Memory" before the timeout specified on MSG_11 with two memory regions (nr_regions = 2) including, for every region, nr_octets=8 and the same region_value_lists writen in step 27.
29. If supported by the IUT (see footnote to step 2), the test equipment shall execute a WRITE_MEMORY (see 5.4.7.2.2 of IEC 61375-1) to the IUT with base_address = 0, item_size = 1 and nr_items = 16 to restore the values read in the step 25.
30. If supported by the IUT (see footnote to step 2), the test equipment shall execute a "Call_Write_Download_Setup"(see 5.4.7.3.2 of IEC 61375-1) to the IUT with download command = 0 (DNLD_PREPARE). The IUT shall reply with a "Reply_Write_Download_Setup " with setup_result = 0 (DOMAIN_OK) before the timeout specified on MSG_11.

31. If supported by the IUT (see footnote to step 2) and if the requirement MSG_25 is defined, the test equipment shall execute a “Call_Write_Download_Setup” (see 5.4.7.3.2 of IEC 61375-1) to the IUT with download command = 1 (DNLD_CHECK_ONLY), nr_domains = 1, and the base_address defined in MSG_25. The IUT shall reply with a “Reply_Write_Download_Setup” with setup_result = 1 (DOMAIN_BAD_BASE_ADDR) before the timeout specified on MSG_11.
32. If supported by the IUT (see footnote to step 2) and if the requirement MSG_24 is defined, the test equipment shall execute a “Call_Write_Download_Setup” (see 5.4.7.3.2 of IEC 61375-1) to the IUT with download command = 1 (DNLD_CHECK_ONLY), nr_domains = 1, the base_address and the not valid domain_size defined in MSG_24. The IUT shall reply with a “Reply_Write_Download_Setup” with setup_result = 2 (DOMAIN_BAD_SIZE) before the timeout specified on MSG_11.
33. If supported by the IUT (see footnote to step 2) and if the requirement MSG_24 is defined, the test equipment shall execute a “Call_Write_Download_Setup” (see 5.4.7.3.2 of IEC 61375-1) to the IUT with download command = 2 (DNLD_START_NOERASE), download_setup_time = 16, nr_domains = 1, the base_address and the domain_size defined in MSG_24. The IUT shall reply with a “Reply_Write_Download_Setup” before the timeout specified on MSG_11, according to requirement MSG_1, , with setup_result = 4 (DOMAIN_WRITE_ERR) if the domain may not be written or with setup_result = 0 (DOMAIN_OK) if the domain may be written.
34. If supported by the IUT (see footnote to step 2) and if the requirement MSG_24 is defined, and if the setup_result of the step 33 is 4 (DOMAIN_WRITE_ERR), the test equipment shall execute a “Call_Write_Download_Setup” (see 5.4.7.3.2 of IEC 61375-1) to the IUT with download command = 2 (DNLD_START_ERASE), download_setup_time = 16, nr_domains = 1, the base_address and the domain_size defined in MSG_24. The IUT shall reply with a “Reply_Write_Download_Setup” before the timeout specified on MSG_11, with setup_result = 0 (DOMAIN_OK).
35. If supported by the IUT (see footnote to step 2) and if step 34 or step 33 was executed with setup_result = 0 and if the requirement MSG_29 is defined, the test equipment shall execute a “Call_Write_Download_Segment” (see 5.4.7.4.2 of IEC 61375-1) to the IUT with domain_id = 0 and the segment parameters defined in MSG_29. The IUT shall reply with a “Reply_Write_Download_Segment” before the timeout specified on MSG_11.
36. If supported by the IUT (see footnote to step 2) and if step 35 was executed the test equipment shall execute a “Call_Write_Download_Setup” with download command = 2 (DNLD_TERMINATE_NOBOOT). The IUT shall reply with a “Reply_Write_Download_Setup” before the timeout specified on MSG_11, with setup_result = 5 (DOMAIN_BAD_CHECKSUM).
37. If supported by the IUT (see footnote to step 2), the test equipment shall repeat step 30.
38. If supported by the IUT (see footnote to step 2) and if the requirement MSG_28 is defined, the test equipment shall repeat the step 33 or step 34 that has the reply setup_result = 0.
39. If supported by the IUT (see footnot to step 2) and if step 38 was executed the test equipment shall execute the sequence of “Call_Write_Download_Segment” (see 5.4.7.4.2 of IEC 61375-1) to the IUT with domain_id = 0 and the segment parameters defined in MSG_28. For every “Call_Write_Download_Segment” the IUT shall reply with a “Reply_Write_Download_Segment” before the timeout specified on MSG_11.
40. If supported by the IUT (see footnote to step 2) and if step 39 was successfully executed the test equipment shall execute a “Call_Write_Download_Setup” with download command = 2 (DNLD_TERMINATE_NOBOOT). The IUT shall reply with a “Reply_Write_Download_Setup” before the timeout specified on MSG_11, with setup_result = 0 (DOMAIN_OK).
41. If supported by the IUT (see footnote to step 2), the test equipment shall repeat the step 30.
42. If supported by the IUT (see footnote to step 2) and if step 40 was successfully executed the test equipment shall execute a “Call_Write_Download_Setup” with download command = 6 (DNLD_VERIFY), download_setup_time = 16, nr_domains = 1, the base_address and the domain_size defined in MSG_24. The IUT shall reply with a

"Reply_Write_Download_Setup" before the timeout specified on MSG_11, with setup_result = 0 (DOMAIN_OK).

43. If supported by the IUT (see footnote to step 2) and if step 42 was successfully executed the test equipment shall repeat step 39.
44. If supported by the IUT (see footnote to step 2) and if step 43 was successfully executed the test equipment shall execute a "Call_Write_Download_Setup" with download command = 2 (DNLD_TERMINATE_NOBOOT). The IUT shall reply with a "Reply_Write_ Download_Setup" before the timeout specified on MSG_11, with setup_result = 0 (DOMAIN_OK).
45. If supported by the IUT (see footnote to step 2), and if step 44 was successfully executed the test equipment shall repeat step 30.
46. If supported by the IUT (see footnote to step 2) and if step 44 was successfully executed the test equipment shall repeat step 42.
47. If supported by the IUT (see footnote to step 2) and if step 46 was successfully executed the test equipment shall repeat step 39 but replacing the first segment of sequence with segment define in MSG_30.
48. If supported by the IUT (see footnote to step 2) and if step 47 was successfully executed the test equipment shall execute a "Call_Write_Download_Setup" with download command = 2 (DNLD_TERMINATE_NOBOOT). The IUT shall reply with a "Reply_Write_Download_ Setup" before the timeout specified on MSG_11, with setup_result = 4 (DOMAIN_WRITE_ERR).
49. If supported by the IUT (see footnote to step 2) and if the requirement MSG_28 is defined, the test equipment shall repeat step 33 or step 34 that have the reply setup_result = 0, but using download_time_out = 1 s.
50. If supported by the IUT (see footnote to step 2) and if step 49 was successfully executed the test equipment shall repeat step 39, but waiting from the call_comfirm of the first "Reply_Write_Download_Segment" of the sequence, to next call_request of the second "Call_Write_Download_Segmen" of the sequence 3 s.
51. If supported by the IUT (see footnote to step 2) and if step 50 was successfully executed the test equipment shall execute a "Call_Write_Download_Setup" with download command = 2 (DNLD_TERMINATE_NOBOOT). The IUT shall reply with a "Reply_Write_ Download_Setup" before the timeout specified on MSG_11, with setup_result = 0 (DOMAIN_WRITE_ERR).

3.2.8.2.3.1.6 Clock services

52. If supported by the IUT (see footnote to step 2), the test equipment shall execute a "Call_Read_Clock" (see 5.4.9.1.2 of IEC 61375-1) to the IUT. The IUT shall reply with a "Reply_Read_Clock" before the timeout specified on MSG_11 with original time_date in seconds and ticks.
53. If supported by the IUT (see footnote to step 2), the test equipment shall execute a "Call_Write_Clock" (see 5.4.9.2.2 of IEC 61375-1) to the IUT with time_date in seconds and ticks, these two parameters shall be different from the values read in step 52. The IUT shall reply with a "Reply_Write_Clock" before the timeout specified on MSG_11.
54. If supported by the IUT (see footnote to step 2) and if step 53 was successfully executed, the test equipment shall execute a "Call_Read_Clock" (see 5.4.9.1.2 of IEC 61375-1) to IUT. The IUT shall reply before the timeout specified on MSG_11 with a "Reply_Read_Clock" with time_date equal or greater than the value written in step 53. The difference between the write value and the read value shall be lower or equal to the value calculated between the sending to the receiving time of the test equipment.

3.2.8.2.3.1.7 Journal services

55. If supported by the IUT (see footnote to step 2), the test equipment shall execute a "Call_Read_Journal" (see 5.4.10.1.2 of IEC 61375-1) to the IUT with number_entries = 1. The IUT shall reply with a "Reply_Read_Journal" before the timeout specified on MSG_11.

If the number_entries is 1, the test equipment saves the event time_stamp to identify the start point of events search in the next steps.

56. If supported by the IUT (see footnote to step 2), the test equipment shall execute a WRITE_CLOCK to synchronise the reference time of IUT with the reference time of test equipment
57. If provided in MSG_31 the test equipment shall execute the procedure to cause the INFO event and then wait 5 s.
58. If provided in MSG_32 the test equipment shall execute the procedure to cause the WARNING event and then wait 10 s.
59. If provided in MSG_32 the test equipment shall execute the procedure to cause the ERROR event and then wait 10 s.
60. If supported by the IUT (see footnote to step 2), the test equipment shall execute a “Call_Read_Journal” (see 5.4.10.1.2 of IEC 61375-1) to the IUT with number_entries = 2. The IUT shall reply with a “Reply_Read_Journal” before the timeout specified on MSG_11, with the last two entries just caused (WARNING and ERROR) with the relevant time_stamp.
61. If supported by the IUT (see footnote to step 2), the test equipment shall execute a “Call_Read_Journal” (see 5.4.10.1.2 of IEC 61375-1) to the IUT with number_entries = 255. The IUT shall reply with a “Reply_Read_Journal” before the timeout specified on MSG_11, with the three entries just caused (INFO and WARNING and ERROR) with the relevant time_stamp.
62. If supported by the IUT (see footnote to step 2), the test equipment shall execute a “Call_Read_Journal” (see 5.4.10.1.2 of IEC 61375-1) to the IUT with number_entries = 1. The IUT shall reply with a “Reply_Read_Journal” before the timeout specified on MSG_11, with the last entry just caused (ERROR) with the relevant time_stamp.

3.2.8.2.3.1.8 Equipment services

63. If supported by the IUT (see footnote to step 2), the test equipment shall execute a “Call_Read_Equipment” (see 5.4.11.1.2 of IEC 61375-1) to IUT. The IUT shall reply with a “Reply_Read_Equipment” before the timeout specified on MSG_11.

3.2.8.2.3.1.9 Restore

64. If supported by the IUT (see step 2) and if step 14 was executed, the test equipment shall execute a WRITE_ STATION_DIRECTORY to restore the original station_list read in step 13. If the WRITE_STATION_DIRECTORY is not supported but is possible to download the Station_Directory using the service interface, the manufacturer of IUT shall execute this operation to restore the original station_list read in step 13.
65. If supported by the IUT (see step 2) and if step 11 was executed, the test equipment shall execute a WRITE_FUNCTION_DIRECTORY to restore the original function_list read in step 10. If the WRITE_FUNCTION_DIRECTORY is not supported but it is possible to download the Function_Directory using the service interface, the manufacturer of the IUT shall execute this operation to restore the original station_list read in step 10.
66. The test equipment shall send a “Call_Write_Station_Reservation” (see 5.4.2.4 of IEC 61375-1) to the IUT using command = 2 (release and keep changes), the Original_manager_id (Application_Address), access_type = 0 (WRITEREQ). In this test, the IUT shall reply with a “Reply_Write_Station_Reservation”, from the IUT before the timeout specified on MSG_11. After having received the reply, the IUT shall verify that the bit SER of device status of IUT is 0.

3.2.9 MVB repeater conformance tests

This subclause describes the tests that will check the conformity of the repeater to requirements listed in 3.3.3.1 of IEC 61375-1.

The repeater consists of two nearly identical halves, each one corresponding to one of the redundant lines (A and B). The tests specified in this subclause refer to the configuration where the repeater is between single-line segments, see the following figure. The configuration where the repeater is applied as a redundant medium is an option and is not treated.

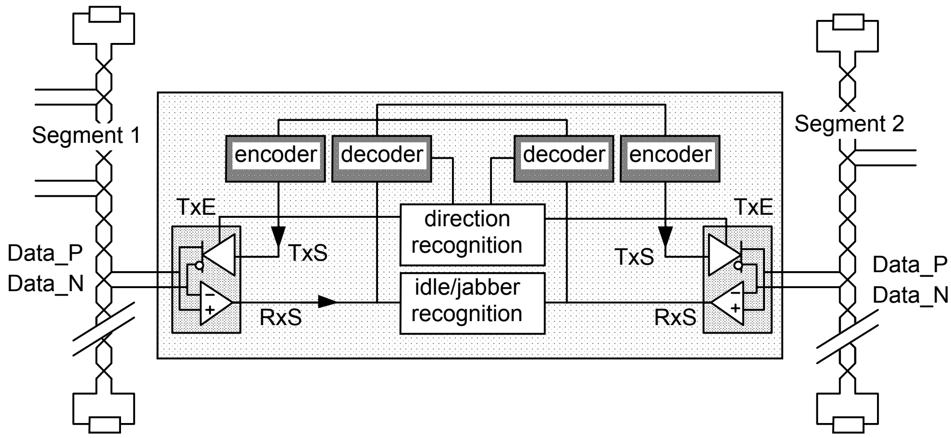

Figure 24 – Block diagram of a line

The test bed shall include a test equipment that is required to generate the frames that the IUT shall receive, a measuring and monitoring unit that is required in order to monitor the frames on the line and to measure some parameters relevant to the MVB traffic and control units that are MVB nodes attached to the bus in order to simulate equipment other that the IUT. Refer to Annex B.

3.2.9.1 EMD – MVB repeater test 1

This test is to check the requirements specified in items a) b) d) and f) of 3.3.3.1 of IEC 61375-1 in case of no time overlapping between frames on segment 1 and segment 2.

The test equipment shall transmit telegrams constituted by a master frame and the corresponding slave frame, treated as a whole, with slave frames of all possible lengths and fixed data subset, through both segments. Frame spacing shall be large enough to avoid frame overlapping. The repeater will forward each frame through the opposite bus segment.

The measuring and monitoring unit shall:

- check if the frames are correctly repeated (items a) and c) of 3.3.3.1);
- measure the delays introduced by the repeater for each frame (item f) of 3.3.3.1) and the pulse distortion at the output (item d) of 3.3.3.1).

3.2.9.1.1 Test bed requirements

The IUT is connected to the test equipment and the measuring and monitoring unit by both segments as shown in the test bed configuration MRTB1 described in B.1.2.1.

3.2.9.1.2 Test sequence

The initial condition of the device is the following: device powered and ready.

The test is performed through the following steps, repeating the sequence for each segments:

Step 1 The TE sends telegrams with well-calculated delays between segment 1 and segment 2 in order to check the capability of the repeater to recognise the initial direction.

Step 2 The monitoring and measuring unit checks if the frames are correctly forwarded, according to 3.3.3.1.a), from the initial direction to the opposite direction and if the forwarded frames are regenerated transparently according to 3.3.3.1.

Step 3 The monitoring and measuring unit checks that the measured delays are of at most 3,0 µs (3.3.3.1.f).

Step 4 The monitoring and measuring unit checks that pulse distortion at the output is less than 10,0 ns.

At the end of the sequence the IUT shall be restored into its operational state.

3.2.9.1.3 Verdict criteria

The test is passed if Step 2, Step 3 and Step 4 are all passed. Any other behaviour means that the IUT fails.

3.2.9.2 MVB repeater test 2

This test aims to check the requirements specified in item a) of 3.3.3.1 of IEC 61375-1: in case of time overlapping between frames on segment 1 and segment 2.

The test equipment shall transmit alternately a telegram formed by a master frame (MF-1) and a slave frame (SF-1) of 64 data bits through segment 1, and a telegram formed by a master frame (MF-2) and a slave frame (SF-2) of 16 bits through segment 2.

The frame spacing between SF-1 and MF-2 will vary from 0,7 µs (end delimiter of one frame and start delimiter of the other frame overlapped), to 5,7 µs (see Figure 25).

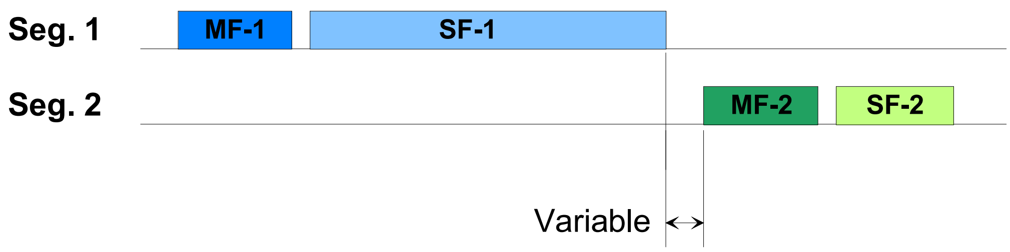

Figure 25 – Frames in test RP-1.2

All the other spacing times shall be large enough. Inter-frame spacing is counted from the middle edge of the last bit to the transition of the start bit of the preamble.

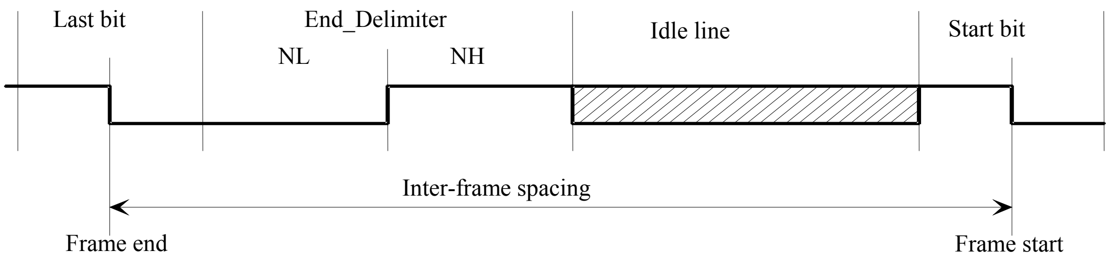

Figure 26 – Inter-frame spacing

As specified in item a) of 3.3.3.1 of IEC 61375-1, the repeater shall not change the transmission direction until the signal received remains stable for 2,0 µs. According to this, and even if overlapping occurs, SF-1 should be transmitted completely and without any distortion. MF-2 should be transmitted correctly only in case this frame is received after segment 1 has remained stable for 2,0 µs. In other cases, it is not expected that the repeater will transmit it properly.

It must be checked if SF-1 is always completely transmitted, and which inter-frame spacing values cause that MF-2 is transmitted properly.

3.2.9.2.1 Test bed requirements

The IUT is connected to the test equipment and the measuring and monitoring unit by both segments as shown in the test bed configuration MRTB1 described in B.1.2.1.

3.2.9.2.2 Test sequence

The initial condition of the device is the following: device powered and ready.

The test is performed through the following steps, repeating the sequence for each segments:

Step 1 The test equipment transmits alternately a master frame and a slave frame of 64 bits to segment 1, and a master frame and a slave frame of 16 bits to segment 2. The spacing between the slave frame of segment 1 and the master frame of segment 2 is varied between 0,7 µs and 5,7 µs by steps of 0,1 µs .

Step 2 Check that SF-1 is always correctly transmitted.

Step 3 Check that MF-2 is transmitted properly only when this frame is received by the repeater after segment 1 having remained stable for 2,0 µs.

At the end of the sequence the IUT shall be forced into its operational state.

3.2.9.2.3 Verdict criteria

The test is passed if Step 2 and Step 3 are all passed. Any other behaviour means that the IUT fails.

3.2.9.3 MVB repeater test 3

This test is to check the requirements specified in 3.3.3.1.b) of the IEC 61375-1, so the capability of the repeater to accept pulse distortion at the input of less than ±0,125 µs is measured.

This test is executed with three different distortion values generated by the test equipment and applied to the IUT:

±0,83 µs

±0,104 µs

±0,125 µs

For each distortion value, frames of all possible lengths are fed through both segments. Inter-frame spacing will be large enough to avoid overlapping. The repeater shall accept the distortion, regenerate the frame and forward it to the opposite segment.

The following picture shows a master frame without distortion (below), and the same frame distorted (above).

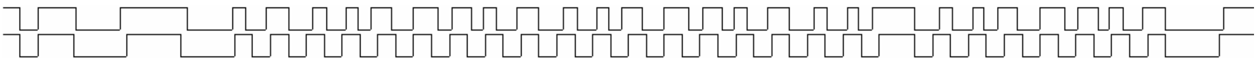

Figure 27 – Pulse distortion

This distortion is in the limit of what the repeater should accept. Depending on the moment when the transition of the start bit occurs in reference to the checking of the repeater, the repeater could consider this frame as incorrect. If it rejects some frames, the percentage of incorrect frames will be measured.

Finally, the test is executed with one out of three frames that shall have an out-of-place transition (see Figure 28).

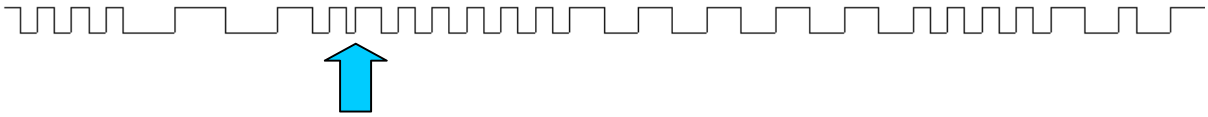

Figure 28 – Frame with out-of-place transition

The repeater shall detect this condition and shall consider that a collision has taken place in the segment it was listening to, and transmit the frame without regenerating it.

3.2.9.3.1 Test bed requirements

The IUT is connected to the test equipment and the measuring and monitoring unit by both segments as shown in the test bed configuration MRTB1 described in B.1.2.1.

3.2.9.3.2 Test sequence

The initial condition of the device is the following: device powered and ready.

The test is performed through the following steps, repeating the sequence for each segment:

Step 1 The test equipment transmits frames with a pulse distortion of ± 0,83µs.

Step 2 Check that the IUT accepts this distortion, regenerates the frame and forwards it to the opposite segment.

Step 3 The test equipment transmits frames with a pulse distortion of ± 0,104 µs.

Step 4 Check that the IUT accepts this distortion, regenerates the frame and forwards it to the opposite segment.

Step 5 The test equipment transmit frames with a pulse distortion of ±0,125 µs.

Step 6 Measure the percentage of incorrect frames.

Step 7 The test equipment transmits one out of three frames with an out-of-frame transition.

Step 8 Check that the IUT detects this failure and transmits the frame without regenerating it.

At the end of the sequence the IUT shall be forced into its operational state.

3.2.9.3.3 Verdict criteria

The test is passed if the checks of Step 2, Step 8 and Step 8 are all passed. Any other behaviour means that the IUT fails.

Comment: The test must be repeated for telegrams with slave frames of all possible lengths.

3.2.9.4 MVB repeater test 4

This test is to check the requirements specified in item g) of 3.3.3.1 of IEC 61375-1.

The test equipment will transmit a telegram formed by a master frame and a slave frame of 256 data bits. Inter-frame spacing will vary from 1,5 µs (this is the case when an end delimiter of one frame and the start bit of the other frame are overlapped), to 6,83 µs. Other spacing timing has no constraints so it may be large enough.

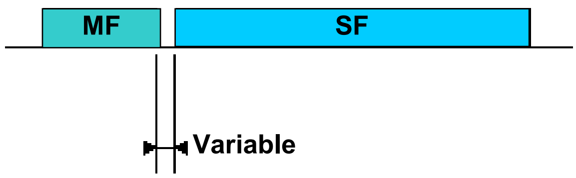

Figure 29 – Frames in test RP-1.4

The repeater's behaviour shall be checked for different values of inter-frame spacing:

- inter-frame spacing < 2 µs: the repeater is not expected to transmit properly frames that come so close one after another;
- inter-frame spacing between 2 µs and 4 µs: the repeater shall delay the transmission of the second frame (item g)) of 3.3.3.1);
- inter-frame spacing > 4 µs: the repeater shall transmit the second frame without any delay.

3.2.9.4.1 Test bed requirements

The IUT is connected to the test equipment and the measuring and monitoring unit by both segments as shown in the test bed configuration MRTB1 described in B.1.2.1.

3.2.9.4.2 Test sequence

The initial condition of the device is the following: device powered and ready.

The test is performed through the following steps, repeating the sequence for each segment:

Step 1 The test equipment transmits a telegram formed by a master frame and a slave frame of 256 bits. Inter-frame spacing is set to 1,5 µs.

Step 2 For inter-frame spacing <2 µs, check that the IUT does not transmit these frames properly.

Step 3 For inter-frame spacing between 2 µs and 4 µs, check that the IUT delays the transmission of the second frame according to 3.3.3.1.g).

Step 4 For inter-frame spacing >4 µs, check that the IUT transmits the second frame without any delay.

Repeat the sequence increasing the inter-frame spacing by 0,03 µs until the value of 6,83 µs.

At the end of the sequence, the IUT shall be forced into its operational state.

3.2.9.4.3 Verdict criteria

The test is passed if Step 2, Step 3 and Step 4 are all passed. Any other behaviour means that the IUT fails.

3.2.9.5 MVB repeater test 5

This test is to check the requirements specified in item h) of 3.3.3.1 of IEC 61375-1. According to this subclause, a repeater shall recognise and isolate a segment in which a continuous transmitter is active for a time longer than a timeout T_jabber_all.

Inter-frame spacing has no constraints so it may be large enough.

The repeater shall transmit the master frames and shall cut the slave frames that exceed the T_jabber_all time.

3.2.9.5.1 Test bed requirements

The IUT is connected to the test equipment and the measuring and monitoring unit by both segments as shown in the test bed configuration MRTB1 described in B.1.2.1.

The test equipment shall be capable of transmitting the following sequence of frames alternatively on segment 1 and segment 2:

- good master frame;
- too long slave frame, with a good slave start delimiter;
- good master frame;
- too long slave frame, without start delimiter.

3.2.9.5.2 Test sequence

The initial condition of the device is the following: device powered and ready.

The test is performed through the following steps:

Step 1 The test equipment shall transmit the following sequence listed in 3.2.9.5.1.

Step 2 The measuring and monitoring unit shall check that the IUT forwards the master frames and cuts the frames that exceed the T_jabber_all time out.

The sequence is executed three times per segment.

At the end of the sequence the IUT shall be forced into its operational state.

3.2.9.5.3 Verdict criteria

The test is passed if Step 2 is always passed . Any other behaviour means that the IUT fails.

Comment: T_jabber_all is equal to 228,7 µs (see 3.3.3.1 h)) of IEC 61375-1).

3.2.9.6 MVB repeater test 6

This test is to check the requirements specified in item e) of 3.3.3.1 of IEC 61375-1.

3.2.9.6.1 Test bed requirements

The repeater shall be tested in a network environment where some MVB devices, called control units, and a bus administrator are present in order to assure that it does not affect the communication between them and in order to check its behaviour in case of collision.

Refer to the test bed configuration MRTB2 described in B.1.2.1.

The test bed generates the following types of data:

- **periodic data**: the presence of the repeater does not alter the network behaviour regarding the process data transmission, although it introduces a little delay (~1 µs) in the transmission of the frames;

- **sporadic data**: the presence of the repeater in the network may substantially change the Event_Search process. The following behaviour is expected.

Due to the delay introduced by the repeater, the General_Event_Request will be received by the CU-1 slightly before that of the CU-2. As a consequence, when both CUs want to participate in the Event_Round, CU-1 will respond with its Event_Identifier_Response before the CU-2 does.

The repeater will receive the Event_Identifier_Response of the CU-1 in segment 1 before the Event_Identifier_Response of the CU-2 in segment 2, and will forward it to segment 2 ignoring what it receives through this segment.

This will cause a collision in segment 2 while a unique frame is being transmitted through segment 1, the Event_Identifier_Response of CU-1 (3.3.3.1.e)). The BA will receive this frame and assume that there is only one device that wants to report an event, the CU-1.

The BA will be able to detect that CU-2 wants to send an event when at the end of the Event_Round the BA sends again a General_Event_Request { NOT new round, answer now}, since CU-1 will not respond.

3.2.9.6.1.1 BA configuration

The following subclauses report the configuration and setup of the bus administrator module and control unit modules participating in the test bed.

- *Device Address: 0x001*
- *Periodic Data:*

Table 21 – Configuration of periodic data in BA

Logical address (hex)	F_code (hex)	Period (ms)
0x001	0	8
0x002	0	8
0x003	1	8
0x004	1	8
0x005	2	8
0x006	2	8
0x007	3	8
0x008	3	8
0x009	4	8
0x00A	4	8

3.2.9.6.1.2 CU-1 configuration

- *Device Address: 0x0AA*
- *Periodic Data: Freshness Supervision*[12]*: 2 ms*

Table 22 – Configuration of periodic ports in CU-1

Logical address (hex)	F_code (hex)	Type	Data (hex)	STS limit (ms)
0x001	0	Source	00AA	
0x002	0	Sink		12
0x003	1	Source	00AA	
0x004	1	Sink		12
0x005	2	Source	00AA	
0x006	2	Sink		12
0x007	3	Source	00AA	
0x008	3	Sink		12
0x009	4	Source	00AA	
0x00A	4	Sink		12

The CU-1 will write the specified data to the ports defined as source ports for this device. The freshness time and the STS (Sink Time Supervisor) have been estimated so that the device is able to detect an error if a port is not refreshed because of a non-received frame.

- *Non-periodic data:*

The device will send the following message:

Source device: 0x0AA   Destination device: 0x00F

Origin function: 1   Final function: 2

Data size: 256 bytes (all words 0x0F0F)

The device shall not wait for an answer. When the message transmission ends it will be sent again.

3.2.9.6.1.3 CU-2 configuration

- *Device Address: 0x550*
- *Periodic Data:*

Freshness Supervision: 2 ms

12 Basic cycle.

Table 23 – Configuration of periodic ports in CU-2

Logical address (hex)	F_code (hex)	Subscription	Data (hex)	STS limit (ms)
0x001	0	Sink		12
0x002	0	Source	5050	
0x003	1	Sink		12
0x004	1	Source	5050	
0x005	2	Sink		12
0x006	2	Source	5050	
0x007	3	Sink		12
0x008	3	Source	5050	
0x009	4	Sink		12
0x00A	4	Source	5050	

The CU-1 will write the specified data to the ports defined as source ports for this device. The freshness time and the STS (Sink Time Supervisor) have been estimated so that the device is able to detect an error if a port is not refreshed because of a non-received frame.

- *Non-periodic data:*

The device will send the following message:

Source device: 0x550 *Destination device*: 0x0FF

Origin function: 1 *Final function*: 3

Data size: 256 bytes (all words 0x00FF)

The device shall not wait for an answer. When the message transmission ends it will be sent again.

3.2.9.6.2 Test sequence

The initial condition of the device is the following: device powered and ready.

The test is performed through the following steps:

Step 1 Check that the CU-1 responds to the General_Event_Request sent by the BA with its Event_Identifier_response before the CU-2 response.

Step 2 Check that a collision occurs in segment 2 and only the Event_Identifier_ Response of the CU-1 is transmitted through segment 1.

Step 3 Check that the CU-1 does not answer when the BA sends a General_Event_Request {NOT new round, answer now} at the end of the Event_Round.

At the end of the sequence, the IUT shall be forced into its operational state.

3.2.9.6.3 Verdict criteria

The test is passed if Step 1, Step 2 and Step 3 are performed properly. Any other behaviour means that the IUT fails.

4 Conformance test of a WTB node, WTB trunk cable, WTB jumper cables, WTB extension cables

4.1 PICS

PICS pro-forma is a set of tables containing questions to be answered by an implementer, and limitations on the possible answers.

It contains two types of questions:

- questions to be answered by either "YES" or "NO", related to whether a clause (ranging from a macroscopic functional unit to a microscopic) has been implemented or not. The allowed answers, which reflect the base specification, are documented in the PICS as requirement; the answers constitute the support;
- questions on numerical values implemented (for timers, for sizes of messages, for frequencies, etc.). The legitimate range of variation of this value, which reflects the base specification, is given in IEC 61375-1. The answers constitute the supported values.

4.1.1 Instructions for filling the PICS pro-forma

PICS are organised in tables. Columns in the tables are:

- Ref.
- Supported subclause
- Supported capability
- Requirement
- Question
- Response
- Implementation
- Parameter values

4.1.1.1 Abbreviations

The following abbreviations are used in this PICS proforma:

m: mandatory

n/a: not applicable

o: optional

c: conditional

d: default

Y: yes

N: no

4.1.1.2 Ref. column

This column is used for reference purposes inside the PICS.

4.1.1.3 Supported subclause column

This column gives the mapping between the IEC 61375-1 and the corresponding entry in the PICS.

4.1.1.4 Supported capability column

This column highlights the unitary capability of the subclause which is concerned.

The answer of "Y" in implementation column means that the Implementation Under Test (IUT) is able to:

- generate the corresponding service parameters (either automatically or because the end user explicitly requires that capability);·
- interpret, handle and when required to make available to the end user the corresponding service parameter(s);

When the answer is "N", this does not mean that the corresponding service parameters are not implemented but the conformity test is requested by the user.

4.1.1.5 Requirement column

This column indicates the level of support required for conformance to IEC 61375-1.

The values are as follows:

m mandatory support is required;

o optional support is permitted for conformance to the IEC 61375-1. If implemented, it must conform to the specifications and restrictions contained in the relevant subclause. These restrictions may affect the optionality of other items;

c the item is conditional, the support of this item is subject to a predicate which is referenced in the note column;

n/a the item is not applicable.

If options are not supported the corresponding items shall be considered as not applicable.

4.1.1.6 Implementation column

This column shall be completed by the supplier or implementer of the IUT. The pro-forma has been designed so that the only entries required in its own column are:

Y: yes, the item has been implemented;

N: no, the item has not been implemented;

-: the item is not applicable.

In the PICS pro-forma tables, every leading items marked 'm' should be supported by the IUT. Sub-items marked 'm' should be supported if the corresponding leading feature is supported by the IUT.

4.1.1.7 Parameter values columns

4.1.1.7.1 Allowed min.

This column is already filled in and indicates the minimum value for a parameter.

4.1.1.7.2 Default value

This column indicates the default value for a parameter. When IEC 61375-1 defines the default for the parameter, such a value is used as an entry in this column. When the standard recommends a range the mean value is used.

4.1.1.7.3 Allowed max.

This column is already filled in and indicates the maximum value for a parameter.

4.1.1.7.4 Implemented value

This column shall be completed by the supplier or implementer. The pro-forma has been designed so that the entry required is the implemented value. In case of multiple values, the default value shall be chosen.

4.1.2 PICS tables

4.1.2.1 Identification of PICS

The following table is intended to be filled in in order to identify the pro-forma.

Ref. No.	Question	Response
1	Date of statement	
2	PICS serial number	

4.1.2.2 Identification of the implementation under test

The following table shall be filled in to identify the implementation under test.

Ref. No.	Question	Requirement	Response
1	Implementation name	m	
2	Version number	m	
3	Special configuration	o	
4	Power supply voltage	m	
5	Power supply current	m	
6	Other information	o	

NOTE 1 Implementation name refers to the identifier of the IUT as indicated by the client. The specific conformance test is applied to the entity identified by the implementation name.

NOTE 2 This is the version number of the IUT. When a version number is defined for an IUT, no subsystem which composes it can progress without a change of this figure (the architecture is frozen and constitutes a configuration).

NOTE 3 Indicated if PIXIT is provided for this IUT.

NOTE 4 Indicated the applicable power supply voltage. Power supply voltage is chosen amongst the values specified by EN 50155.

NOTE 5 Indicated the applicable maximum power supply current. Power supply current is chosen amongst the values specified by EN 50155.

NOTE 6 Other information the client considers relevant for IUT identification.

4.1.2.3 Identification of the IUT supplier and/or test laboratory client

The following table shall be filled in to identify the IUT supplier and the test laboratory client.

If the IUT supplier and the test laboratory client are not the same entity, the PICS shall be agreed between the supplier and the test laboratory client.

Ref. No.	Question	Requirement	Response
1	Organisation name	m	
2	Contact name(s)	m	
3	Address:	m	
4	Telephone number	m	
5	Fax number	m	
6	e-mail address	m	
7	Other information	m	

4.1.2.4 Identification of the standards

The following table shall be filled in to identify the Standards applied to the IUT for the conformance test.

Ref.No.	Question	Response
1	Specification document title	
2	Specification document IEC reference number	
3	Specification document date of publication	
4	Specification document version number	
5	Conformance document title	
6	Conformance document number	
7	Conformance document date of publication	
8	Conformance document version number	

4.1.2.5 Global statement of conformance

This table shall be filled by the IUT supplier in the "Implementation" column

Ref. No.	Question	Requirement	Implementation
1	Are all mandatory capabilities implemented?	m	[ ]

NOTE Answering "No" to this section indicates non-conformance to the protocol specification. Non-supported mandatory capabilities are to be identified in the PICS, with an explanation of why the implementation is non-conforming.

4.1.2.6 Level of testing

This table shall be filled by the IUT supplier in order to identify the IUT.

Ref. No.	Subclause	Capability	Implementation
1	4.2.1.4 – 4.2.1.5	Vehicle	[ ]
2	4.2.1.3	Node	[ ]
3	4.2.1.1	Trunk cable	[ ]
4	4.2.1.1	Jumper cables	[ ]
5	4.2.1.1	Extension cables	[ ]

4.1.2.7 Node capability

This table shall be filled in by the IUT supplier only in case that the response Y is filled at reference 2 in the table of 4.1.2.6.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	4.2.2.1	Intermediate node	m	[ ]
2	4.2.2.1	End node	m	[ ]
3	4.2.2.1	When intermediate node, only one of its transceivers enabled	m	[ ]
4	4.2.2.1	When end node able to communicate over both its bus sections independently	m	[ ]
5	4.2.2.1	When intermediate node establishes electrical continuity between Direction_1 and Direction_2	m	[ ]
6	4.2.2.1	When end node terminates electrically the bus sections of Direction_1 through a terminator	m	[ ]
7	4.2.2.1	When end node terminates electrically the bus sections of Direction_2 through a terminator	m	[ ]
8	4.7.1.2	Strong node [13]	o	[ ]
9	4.7.1.2	Weak node [14]	o	[ ]
10	4.7.1.2	Slave node [1]	o	[ ]

4.1.2.8 Redundancy

This table shall be filled in by the IUT supplier in order to declare if line redundancy is implemented or not.

Ref. No.	Subclause	Capability	Requirement	Implementation
1	4.2.2.2	Physical redundancy	o	[ ]
2	4.2.2.2	UIC node	o	[ ]

4.1.2.8.1 Redundancy configuration

This table shall be filled in by the IUT supplier only in case that the response Y is filled in at reference 1 in the table of 4.1.2.8

Ref. No.	Subclause	Capability	Requirement	Implementation
1	4.2.2.2	Is line A marked as LINE_A?	m	[ ]
2	4.2.2.2	Is line B marked as LINE_B?	m	[ ]
3	4.2.2.2	Are LINE_A and LINE_B identically configured respectively Direction_1 and Direction_2?	m	[ ]

4.1.2.9 Signalling

Ref. No.	Subclause	Capability	Requirement	Value	Implementation
1	4.2.2.3.1	Speed	m	1,0 Mbit/s ± 0,01 %,	[ ]
2	4.2.2.3.1	Coding	m	Manchester	[ ]
3	4.2.2.3.1	Frequency	m	1,0 MHz	[ ]

[13] At least one option is chosen.

[14] At least one option is chosen.

4.1.2.9.1 Cable

Ref. No.	Subclause	Capability	Requirement	Implementation
1	4.2.2.4.1	Shielded cable	m	[ ]
2	4.2.2.4.1	Jacketed cable	m	[ ]
3	4.2.2.4.1	Twisted pair	m	[ ]
4	4.2.2.4.2	Idividual wires identified as X,Y	m	[ ]
5	4.2.2.4.2	Shield wires identified as S	m	[ ]

4.1.2.9.1.1 Trunk cable

This table shall be filled in by the IUT supplier only in case that the response Y is filled in at reference 3 in the table of 4.1.2.6

Ref. No.	Subclause	Capability	Requirement	Value	Implementation
1	4.2.2.4.3	Impedance	m	Zw = 120,0 Ω (±10 %)	[ ]
2	4.2.2.4.1	Twist per meter	m	12	[ ]
3	4.2.2.4.4	Attenuation	m	Less than 10,0 dB/km at 1,0 MHz	[ ]
4	4.2.2.4.4	Attenuation	m	Less than 14,0 dB/km at 2,0 MHz	[ ]
5	4.2.2.4.5	Distributed capacitance	m	Less than 65 pF/m at 1,0 MHz	[ ]
6	4.2.2.4.6	Capacitive unbalance to shield	m	Less than 1,5 pF/m at 1,0 MHz	[ ]
7	4.2.2.4.8	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[ ]
8	4.2.2.4.8	Differential transfer impedance	m	Less than 2,0 mΩ/m at 20,0 MHz	[ ]

4.1.2.9.1.2 Jumper cable

This table shall be filled in by the IUT supplier only in case that the response Y is filled in at reference 4 in the table of 4.1.2.6

Ref. No.	Subclause	Capability	Requirement	Value	Implementation
1	4.2.2.4.3	Impedance	m	Zw = 120,0 Ω (±10 %)	[ ]
2	4.2.2.4.1	Twist per meter	m	12	[ ]
3	4.2.2.4.4	Attenuation	m	Less than 10,0 dB/km at 1,0 MHz	[ ]
4	4.2.2.4.4	Attenuation	m	Less than 14,0 dB/km at 2,0 MHz	[ ]
5	4.2.2.4.5	Distributed capacitance	m	Less than 65 pF/m at 1,0 MHz	[ ]
6	4.2.2.4.6	Capacitive unbalance to shield	m	Less than 1,5 pF/m at 1,0 MHz	[ ]
7	4.2.2.4.8	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[ ]
8	4.2.2.4.8	Differential transfer impedance	m	Less than 2,0 mΩ/m at 20,0 MHz	[ ]

4.1.2.9.1.3 Extension cable

This table shall be filled in by the IUT supplier only in case that the response Y is filled in at reference 5 in the table of 4.1.2.6

Ref.No.	Subclause	Capability	Requirement	Value	Implementation
1	4.2.2.4.3	Impedance	m	Zw = 120,0 Ω (±10 %)	[ ]
2	4.2.2.4.1	Twist per meter	m	12	[ ]
3	4.2.2.4.1	Cross-section	m	Less than 0,56 mm^2	[ ]
4	4.2.2.4.4	Attenuation	m	Less than 10,0 dB/km at 1,0 MHz	[ ]
5	4.2.2.4.5	Distributed capacitance	m	Less than 65 pF/m at 1,0 MHz	[ ]
6	4.2.2.4.6	Capacitive unbalance to shield	m	Less than 1,5 pF/m at 1,0 MHz	[ ]
7	4.2.2.4.7	Crosstalk	m	Great than 55,0 dB between 0,5 to 2,0 MHz	[ ]
8	4.2.2.4.8	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[ ]
9	4.2.2.4.8	Differential transfer impedance	m	Less than 2,0 mΩ/m at 20,0 MHz	[ ]

4.1.2.9.2 Connectors

These tables shall be filled in by the IUT supplier only in case that the response Y is filled in at reference 2 in the table of 4.1.2.6. The conformance of connectors is mandatory when interoperability is required.

4.1.2.9.2.1 Front panel layout

Ref. No.	Subclause	Capability	Requirement	Implementation
1	4.2.3.4	Vertical	o	[ ]
2	4.2.3.4	Horizzontal	o	[ ]
NOTE One option shall be chosen.				

4.1.2.9.2.2 Arrangement

Ref. No.	Subclause	Capability	Requirement	Implementation
1	4.2.3.4	A1 male is the upper	c Ref. 1 of 4.1.2.9.2.1	[ ]
2	4.2.3.4	A1 male is leftmost	c Ref. 2 of 4.1.2.9.2.1	[ ]

4.1.2.9.2.3 Layout and type

Ref. No.	Subclause	Capability	Requirement	Value	Implementation
1	4.2.3.4	Line_A Direction_1	m	9-pin Sub-D 9 connectors using metric screws (IEC 60807)	[ ]
2	4.2.3.4	Line_A Direction_2	m	9-pin Sub-D 9 connectors using metric screws (IEC 60807)	[ ]
3	4.2.3.4	Line_A Direction_1	m	Male	[ ]
4	4.2.3.4	Line_A Direction_2	m	Female	[ ]
5	4.2.3.4	Line_B Direction_1	m	9-pin Sub-D 9 connectors using metric screws (IEC 60807)	[ ]
6	4.2.3.4	Line_B Direction_2	m	9-pin Sub-D 9 connectors using metric screws (IEC 60807)	[ ]
7	4.2.3.4	Line_B Direction_1	m	male	[ ]
8	4.2.3.4	Line_B Direction_2	m	female	[ ]
9	4.2.3.4	Shielding	m	-	[ ]
10	4.2.2.4.8	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[ ]
11	4.2.2.4.8	Differential transfer impedance between two pins	m	Less than 2,0 mΩ/m at 20,0 MHz (refer to IEC 60096-1)	[ ]
12	4.2.3.4	Conductive casing connected to the cable shield	m	-	[ ]
13	4.2.3.4	Makes an electrical contact with the receptacle when fastened	m	-	[ ]
14	4.2.2.4.9	Continuity resistance	m	Less than 10,0 mΩ/m	[ ]
15	4.2.3.4	Label on Line_A Direction_1	m	A1	[ ]
16	4.2.3.4	Label on Line_A Direction_2	m	A2	[ ]
17	4.2.3.4	Label on Line_B Direction_1	m	B1	[ ]
18	4.2.3.4	Label on Line_B Direction_2	m	B2	[ ]

4.1.2.10 Switches type

Ref.No.	Clause	Capability	Requirement	Implementation
1	4.2.5.3	Solid state [15]	o	[ ]
2	4.2.5.3	Mechanical [15]	o	[ ]

[15] One option must be chosen.

4.1.2.11 Switches

Ref. No.	Subclause	Capability	Requirement	Value	Implementation
1	4.2.5.3	Isolation	m	Greater than or equal to 500,0 Vrms	[ ]
2	4.2.5.3	Initial contact resistance	m	Less than 0,050 Ω	[ ]
3	4.2.5.3	Contact resistance after 10^7 cycles	m	Less than 0,100 Ω	[ ]
4	4.2.5.3	Switch time	m	Less than 10,0 ms, including bounce time	[ ]

4.1.3 Basic interconnection tests

They are a subset of the behavioural tests.

4.1.4 Capability tests

The capability tests consist of activities:

- to check as far as possible the consistency of the PICS against the declared values into the PICS themselves, as a preliminary filter before undertaking more in-depth and costly testing;
- to check that the capabilities of the IUT are consistent with the static conformance requirements specified by this standard and the IEC 61375-1;
- to enable efficient selection of behaviour tests to be made for a particular IUT;

when taken together with behaviour tests, as a basis for claims of conformance.

Refer to Clause A.1 for the role of the IUT supplier (the client) and the laboratory test to be played in this activities.

4.1.5 Behaviour tests

4.1.5.1 Physical test

4.1.5.1.1 Characteristic impedance

This refers to the requirement of 4.2.2.4.3.

The IUT shall present a differential characteristic impedance of Zw = 120,0 Ω (±10 %) measured with a sinusoidal signal at a frequency between 0,5 BR and 2,0 BR.

The measuring method is the open-short measurements.

a) The IUT shall be at least 100 m of cable[16].
b) The Test Equipment TE shall be able to measure the reflection coefficient of a transmission line.
c) The TE shall have a balanced output impedance.
d) The TEt's output impedance is denoted as Z_{TE}.

Measure the refection coefficient of the IUT at 1 MHz having one extremity of the IUT opened and denote the measured value as ρ_o.

[16] A length of less than 100 m may cause measurement inaccuracies.

Measure the the refection coefficient of the IUT at 1 MHz having one extremity of the IUT short-circuited (the short circuit shall be made directly soldering together the twisted wires) and denote the measured value as ρ_s.

Compute the: $Zopen = Z_{TE} \cdot \frac{1+\rho_o}{1-\rho_o}$

Compute the: $Zshort = Z_{TE} \cdot \frac{1+\rho_s}{1-\rho_s}$

Compute the: $Zc = \sqrt{Zopen \cdot Zshort}$

4.1.5.1.2 Shield quality

This referes to the requirement of 4.2.2.4.8.

Transfer impedance is a fundamental value of a shield's performance. Transfer impedance relates a current on one surface of the shield to the voltage drop generated by this current on the opposite surface of the shield. This value depends solely on the shield construction.

Transfer Impedance is defined as:

$Zt = (1 / I_o) \times (dV / dx)$

where

I_o is a longitudinal disturbing current generated on one surface (either the inner or the outer surface) of the shield, and

dV/dx is the longitudinal voltage per unit length, generated by I_o, appearing on the opposite surface of the shield.

Transfer impedance test data shall be obtained with a terminated triaxial test fixture. IEC 60096-1 describes the test fixture applicable to WTB cable. The test cable centre conductor and the shield form an inner transmission system, with the shield and the outer concentric tube forming an outer transmission system.

The outer system is driven by a generator and creates a current Io on the outer surface of the shield. This current causes a voltage difference on the opposite surface shown as V1, and V2 over a length of shield *X*. This generates signals in the test cable which can be related to the transfer impedance value of the shield.

4.1.5.1.3 Insertion losses of a line unit

This refers to the requirements of 4.2.5.2.1 and 4.2.5.2.3.

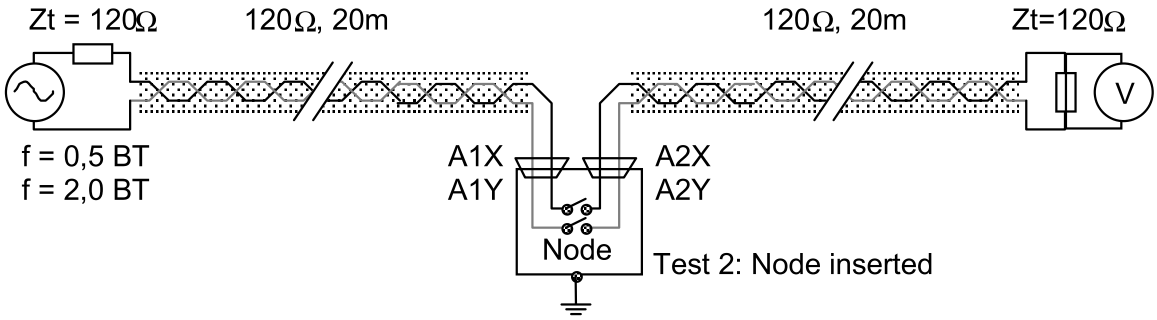

Figure 30 – Insertion loss measurement

The sinusoidal signal of a generator (of internal impedance = Zt) is applied through 20,0 m of cable to the points A1X and A1Y and measured by a voltmeter (connected in parallel with an impedance Zt) at the extremity of other 20,0 m of cable attached to the points A2X and A2Y.

4.1.5.1.3.1 Insertion loss in intermediate setting

The generator shall be able to produce:

a) sinusoidal signal of 2 BR 4 V peak to peak;

b) sinusoidal signal of 1 BR 4 V peak to peak.

The IUT shall be:

a) in intermediate setting (Kb closed, Kt1 and Kt2 open);

b) The transceivers of the IUT shall be disabled (in high impedance).

Procedure:

Set to 4,0 Vpp the generator. Measure the reference r.m.s. level present on the full length of cable. This level sets the 0 dB value, 0DV, 0 %. The reference level shall be measured with the cable alone. Than if the r.m.s. value of the cable itself is 0 dB the insertion loss due to the MAU is a negative gain (loss). As soon as the reference is established, the cable shall be opened and attached to the MAU. This procedure shall be repeated any time when performing the subsequent measures.

The measured attenuation shall be:

– less than 0,3 dB between 0,5 BR and 1,0 BR;

– less than 0,4 dB up to 2,0 BR.

The IUT shall be:

– not powered (switched off).

Procedure

Set the generator to 4,0 Vpp. Measure the reference r.m.s. level present on the full length of cable. This level sets the 0 dB value, 0DV, 0 %. The reference level shall be measured with the cable alone. Then, if the r.m.s. value of the cable itself is 0 dB the insertion loss due to the MAU is a negative gain (loss). As soon as the reference is established, the cable shall be opened and attached to the MAU. This procedure shall be repeated any time when performing the subsequent measures.

The measured attenuation shall be:

– less than 0,3 dB between 0,5 BR and 1,0 BR;

– less than 0,4 dB up to 2,0 BR.

4.1.5.1.3.2 Input resistance in intermediate setting

Use a d.c. voltage generator 48 Vdc 10 % and set the current limit at 10 mA.

The IUT shall be:

in intermediate setting (Kb closed, Kt1 and Kt2 open):

The measured current shall not exceed 48 µA.

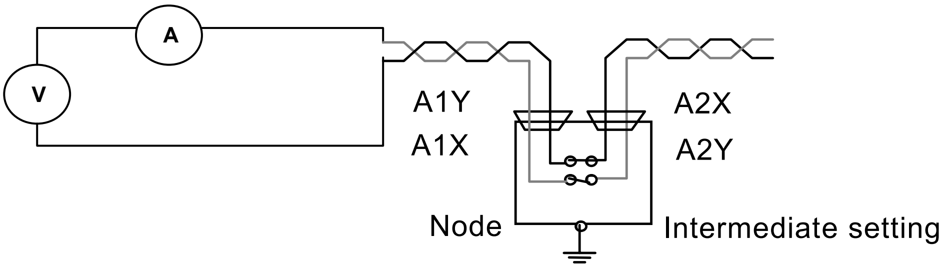

Figure 31 – Measurement of the input resistance

Do the measure for

1. A1X – A1Y
2. A2X – A2Y

4.1.5.1.4 End setting

This refers to the requirement of 4.2.5.2.2.

The characteristic impedance of the IUT being measured can be calculated from the height of the step reflected from the transition between the TDR system and the $Z_{EndNode}$ IUT.

Measure the height of the incident wave sent by the TDR and measure the height of the reflected wave.

Compute the: $Z_{EndNode} = Z_{TDR} \cdot \dfrac{Heigth\_incident + Height\_reflected}{Height\_incident - Heigth\_reflected}$

$Z_{EndNode}$ shall be 120 Ω ±10 %

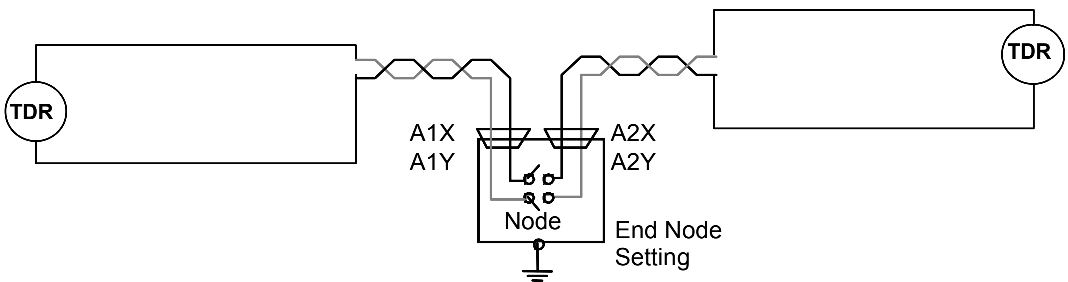

Figure 32 – End setting measurement setup 1

4.1.5.1.4.1 End setting attenuation

A line unit in the end setting shall attenuate by more than 55,0 dB a signal applied between A1X and A1Y and measured between A2X and A2Y or vice-versa. IEC 61375-1 does not declare any test signal, so to identify the end setting losses measured, as indicated in the standard, it is better to refer to it as crosstalk on the same segment between uncoupled vehicles. This measure is mainly influenced by the highest harmonics still present on the signal. To measure it, a square wave of 1,0 BR is used under the followings conditions:

a) square wave of 1,0 BR 4 V r.m.s. 22,5 ns leading and trailing edge;

b) square wave 1,0 BR 4 V r.m.s. 254 ns leading and trailing edge.

Set the IUT as end node.

Set the condition 1.

Tune the generator until the voltage given in a) is 4 V r.m.s..

Measure the voltage given in b)

Compute the ratio: $V_{Att} = 20 \cdot \log\left(\frac{Va}{Vb}\right)$

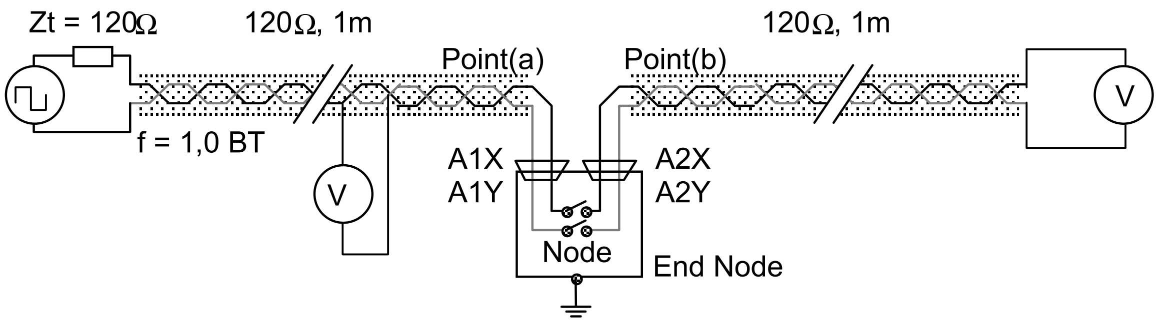

Figure 33 – End setting measurement setup 2

The ratio shall be more than 55,0 dB

4.1.5.1.5 Switches

This refers to the requirement of 4.2.5.3.

4.1.5.1.5.1 Initial contact resistance

The contact resistance is defined as:

electrical resistance between the relay load terminals while the respective contact is closed. The resistance can be obtained out of the ratio of the voltage drop across the relay and the load current (Ohm´s law). Due to slight contact corrosion, the contact voltage drop can be higher (up to 250 mV) for small load currents. For loads in the ampere range, the current locally generates heat evaporating the cover layer (fritting) and reducing the resistance.

The resistance shall be measured. The resistance to be measured is a low 0,050 Ω. A four and a half digit DMM may have 1/100 Ω, resolution but the resistance of the connecting leads, the contact resistance where the leads plug into the meter and where the leads clip to the unknown is significant compared to the unknown. Moreover, this contact resistance is quite variable so you cannot connect the leads together and subtract that reading from the unknown reading.

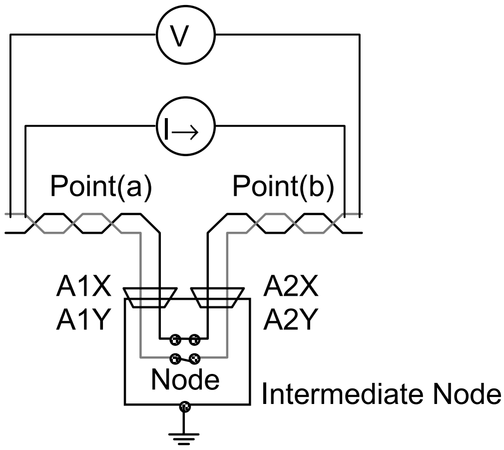

Figure 34 – Switches measurement setup 1

The circuit of a four wire system is shown in the figure. The horizontal twisted-cable-wires represent the parasitic resistances. In the inner loop, the current source maintains a constant current regardless of how much resistance is in the loop. (Within practical limits.) Because the voltmeter is connected to the unknown through its own leads, it measures only the voltage across the unknown. The voltmeter has its own parasitic resistances, but because the input resistance of the voltmeter is high, these small series resistances have no significant effect on the reading. This measurement method is used whenever the impedance of a circuit is very low.

The exact determination of the contact resistance cannot be reasonably achieved without accessing the internal parts of the IUT. For that reason, the resistance shall be measured using the test fixture of the following picture, and evaluated by comparison with a reference value.

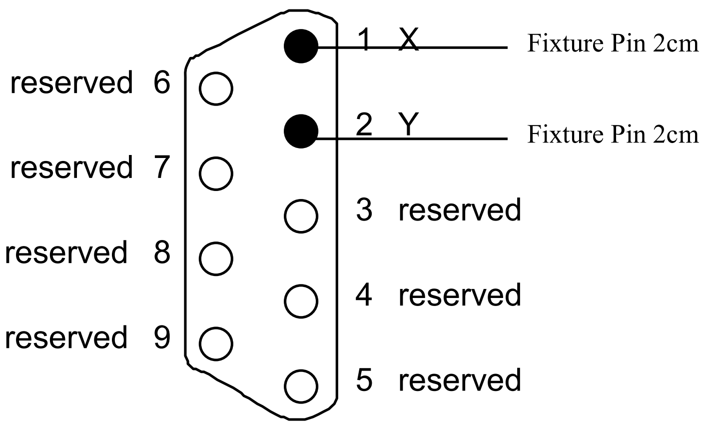

Figure 35 – Direct attachment switches measurements Fixture 1

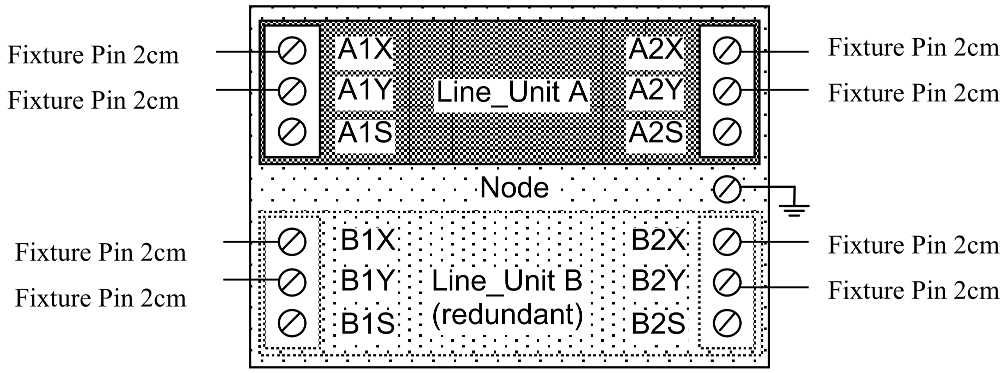

Figure 36 – Indirect attachment switches measurements Fixture 1

Values between pins:

Table 24 – WTB pin to pin measurement

Measurement points	**Expected value** **Ω**
A1_pin_1 and A2_pin_1	Max 0,07
A1_pin_2 and A2_pin_2	Max 0,07
B1_pin_1 and B2_pin_1	Max 0,07
B1_pin_2 and B2_pin_2	Max 0,07

4.1.5.1.6 Transceiver

This referes to the requirement of 4.2.6.

Unless otherwise specified, the following default measuring conditions hold:

a) the characteristics of a transceiver are measured at the X and Y points where the cable sections are attached to the node;

b) all voltages are measured as differential voltage between X and Y, (Ux – Uy);

c) when measuring a transmitter, the circuit of the receiver is in the normal receiving state. When measuring a receiver, the circuit of the transmitter is in a high impedance state;

d) all resistor values are ±1 %, all capacitor values are ±10 %.

4.1.5.1.6.1 Transmitter

4.1.5.1.6.1.1 Test circuit for transmitter

To approximate the loading of the transmitter with a cable and nodes, four test circuits are specified:

a) the light test circuit simulates an open line (as in a node in end setting). The value of the total resistive load is equal to that of the terminator;

b) the heavy test circuit simulates a fully loaded bus. The value of the total resistive load is equal to 0,42 of that of the terminator;

c) the idling test circuit simulates a cable of 860,0 m without resistive loads. The capacitors have a value of 1,3 nF ± 10 % each, the resistors a value of 27,0 Ω ± 1 % each;

d) the short test circuit simulates a line failure. It consists only of a current measurement circuit;

These circuits are shown in the next figure.

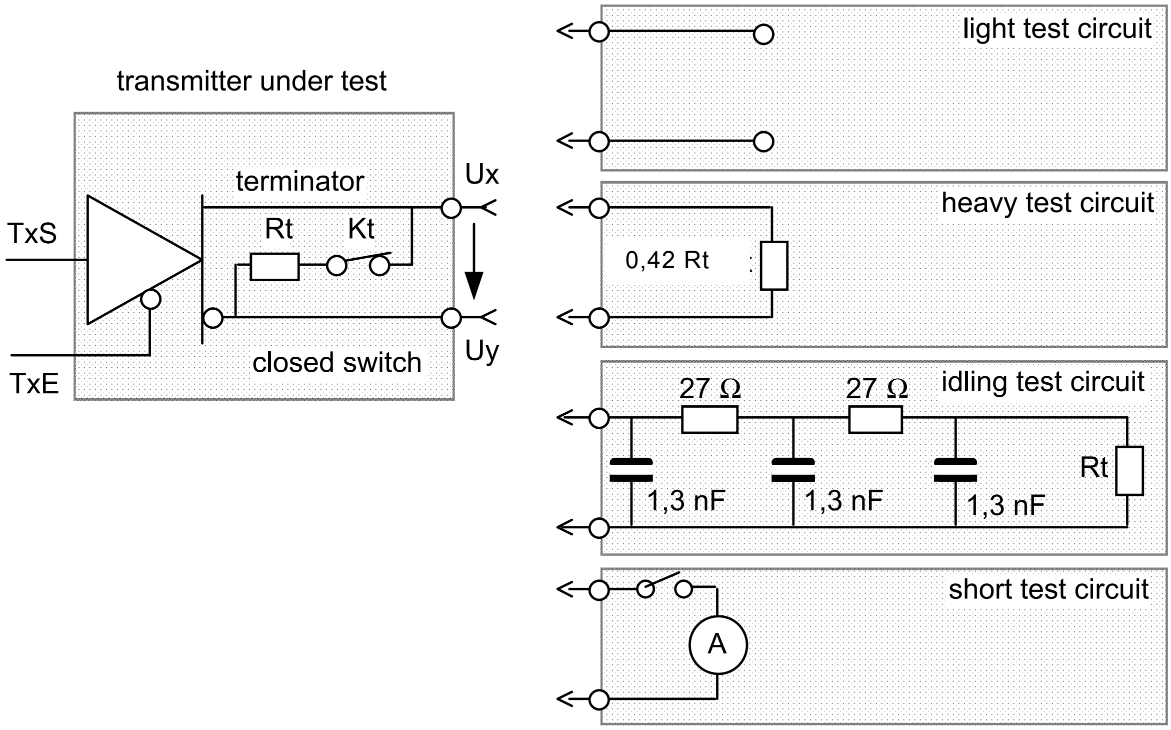

Figure 37 – Transmitter fixtures

e) the measurement is made with the node in end setting (Kb open, Kt closed);

f) the terminator of the line unit is considered in the test circuit specification.

4.1.5.1.6.1.2 Transmitter output signal

When connected to either the heavy and the light test circuit defined in 4.1.5.1.6.1.1 the transmitter shall comply with the following specifications, as shown in Figure 38:

a) the output signal shall be alternatively positive and negative;

b) the amplitude of the output signal shall be at least ±3,0 V with the heavy test circuit and at most ±7,0 V with the light test circuit;

c) the peak amplitude is defined as the maximum amplitude of the output signal. The signal shall not drop by more than 20 % from this peak amplitude until 0,100 μs from the next expected zero-transition; The ringing of the amplitude during this time, relative to the average voltage drop, shall not exceed 5 % of the peak value;

d) the slew rate of the output signal shall be less than 0,20 V/ns at any time and more than 0,03 V/ns within 100,0 ns of the zero-crossing;

e) the overshoot of the output signal, defined as the ratio of the maximum amplitude to the stationary amplitude shall not exceed 10 % of its stationary amplitude;

f) the edge distortion of the output signal, defined as the time difference between the idealised and the actual zero crossing, shall not exceed ±2 % of one bit time.

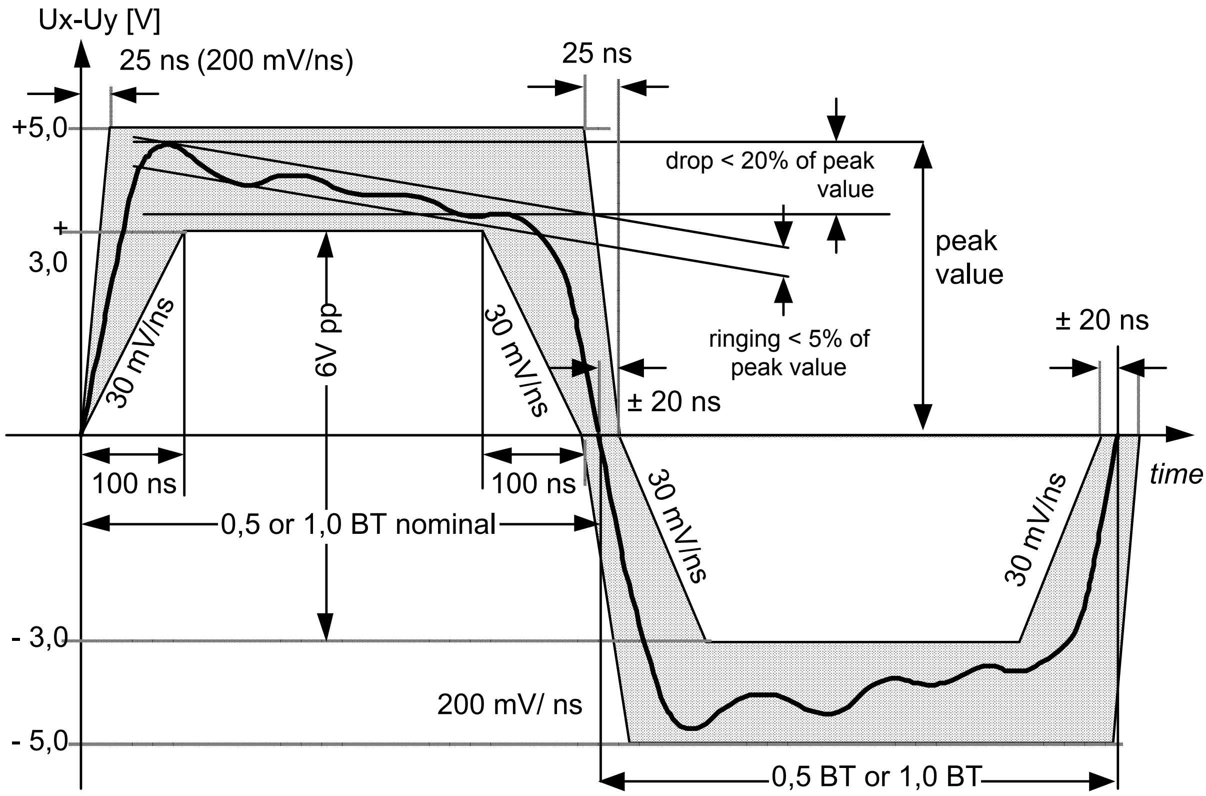

Figure 38 – Transmitter output signal

4.1.5.1.6.1.3 Transmitter noise

The measurement shall be performed either in:

a) intermediate;

b) end setting.

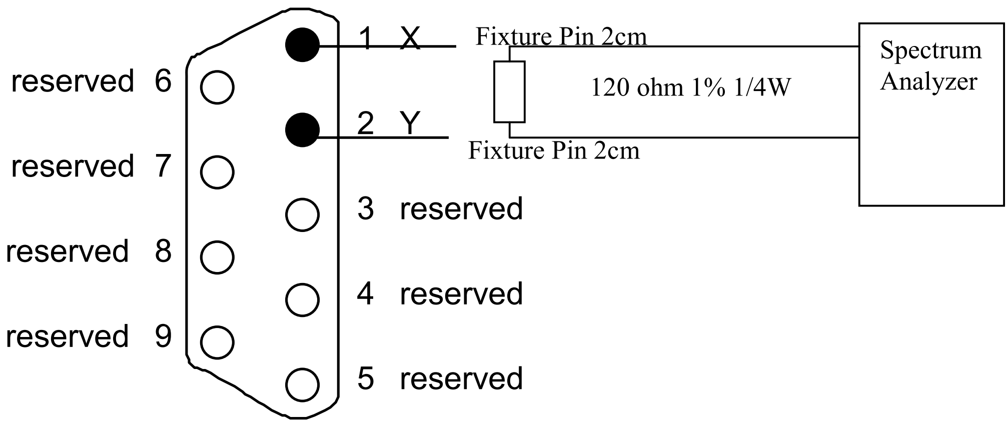

Figure 39 – Intermediate transmitted noise test fixture

The test fixture for the intermediate node shall be applied and noise generated by a transmitter which is not transmitting shall not exceed a value of 5,0 mV r.m.s. over the frequency range 1,0 kHz to 4,0 BR.

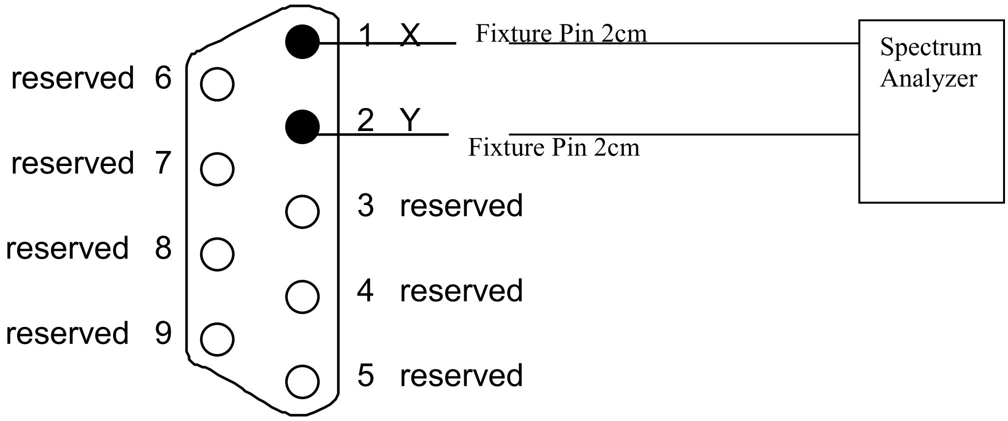

Figure 40 – End node transmitted noise test fixture

4.1.5.1.6.1.4 Transmitter end of frame

The end of frame produced by the transmitter shall be tested under the following conditions:

a) the transmitter transmits the longest possible frame;

b) the Frame_Data bits are a pseudo-random sequence of ‘1’ and ‘0’ symbols;

c) the frame is closed with the end delimiter symbol;

d) the transmitter drives the idling test circuit;

e) the average differential amplitude is greater than 4,5 V before the transmitter is disabled.

Under these conditions, the output signal shall remain within the following limits, as shown in Figure 41:

1) 100,0 ns after the last negative-to-positive transition and for 2,0 BT ± 100 ns, the output signal shall remain above 0,300 V;

2) within 3,0 BT after the last negative-to-positive transition, the output signal shall fall below 1,100 V;

3) within 20,0 µs, starting when the output signal first reaches 1,100 V, the output signal amplitude shall not exceed 0,100 V;

4) within 64,0 µs, starting when the output signal first reaches 1,100 V, the output signal amplitude shall not exceed 0,025 V.

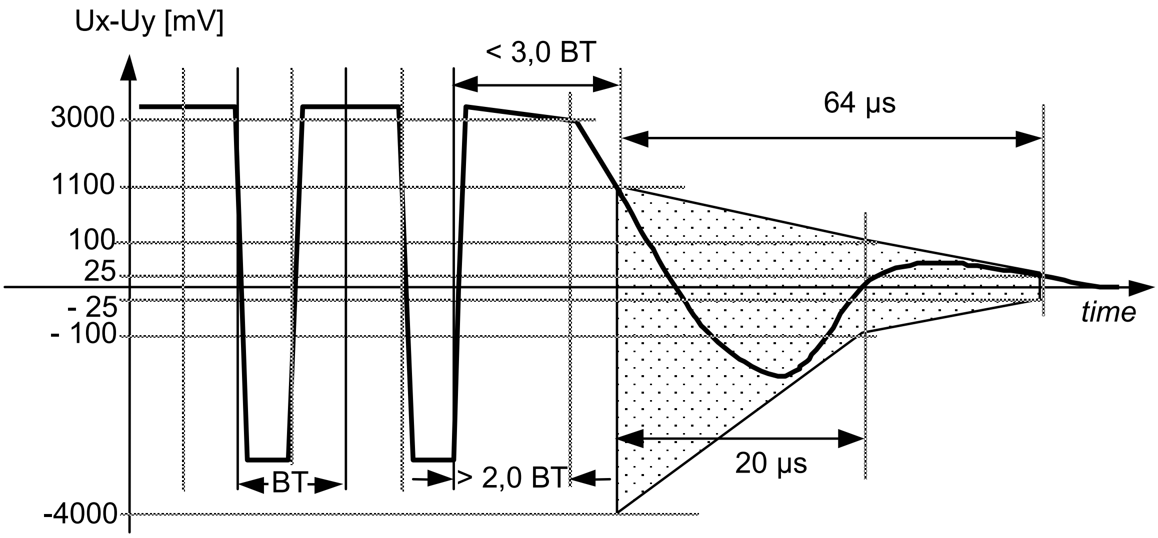

Figure 41 – Signal and idling at transmitter

4.1.5.1.6.1.5 Transmitter fault tolerance

A transmitter shall tolerate the application of the short test circuit at the connection point until thermal stability is reached

A transmitter shall resume normal operation after the short test circuit is removed.

Conditions

a) Transmitter enabled;

b) Transmitter not enabled.

Instruments

a) Oscilloscope 100 Mhz bandwidth;

b) Current probe 20 Mhz bandwidth;

c) Short-circuit current load 7 RF resistors of as specified in the following table:

Table 25 – Fault tolerance parameters

Resistance	Power (watts)	Frequency	Capacitance
50,1 Ω	20 Hz	DC – 2G	0,75 pf

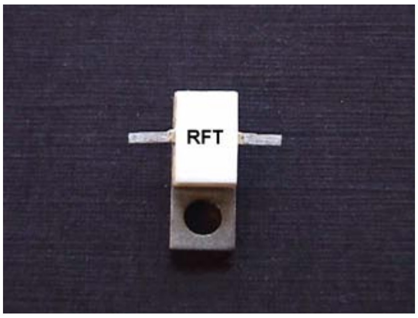

Figure 42 – RF resistor example

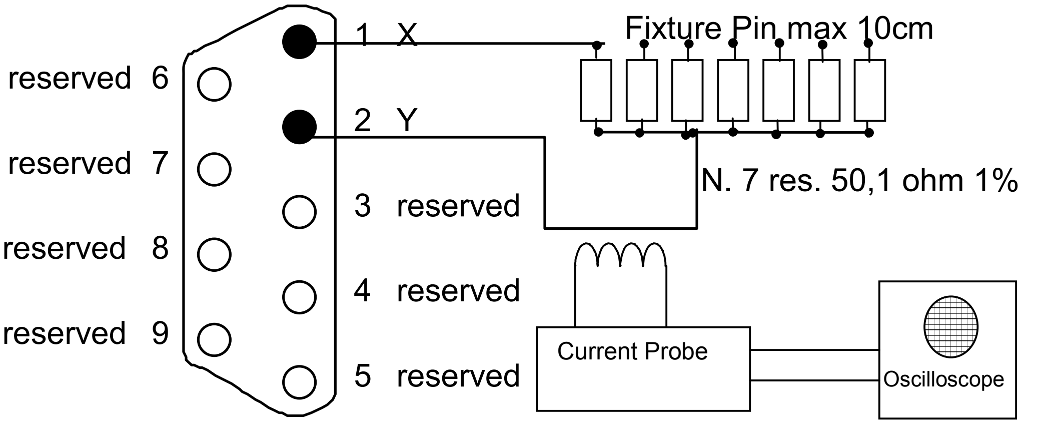

Figure 43 – Short-circuit test Fixture 1

Set condition1 (transmitter enabled).

Applying the Fixture 1 for 1 (one) h, the maximum r.m.s. current measured by the current probe shall not exceed 1 A ± 10 %.

When removing the fixture, the transmitter shall resume its previous operational status.

Set condition2 (transmitter not enabled).

Applying the Fixture 1 for 1 (one) h, the maximum r.m.s. current measured by the current probe shall not exceed 1 A ± 10 %.

When removing the fixture, the transmitter shall resume its previous operational status.

4.1.5.1.6.1.6 Transmitter anti-jabber

This functionality that is specified by 4.2.6.2.6 of IEC 61375-1 is impossible to be verified because it should be necessary to generate an error condition inside the IUT TCN software or hardware.

This functionality is requested only to be declared in the PICS if it is implemented or not.

4.1.5.1.6.2 Receiver specifications

This refers to test requirements of 4.2.6.6.3, 4.2.6.6.4, 4.2.6.6.5 and 4.2.6.6.6:

The characteristics of a receiver are tested by applying a sequence of frames containing 1024 random data bits in the data field, passed by a waveshape modifier. The waveshape modifier shall be able to

a) sample the incoming bit and send out an outgoing bit with the amplitude changed as required by the test;
b) sample the incoming bit and send out an outgoing bit with the rise time changed as required by the test;
c) sample the incoming bit and send out an outgoing bit with the fall time changed as required by the test;
d) sample the incoming bit and send out an outgoing bit with the jitter as required by the test.

The test shall be performed with the configuration Fixture 1.

The test shall be performed with the configuration Fixture 2.

The waveshape modifier shall be set with

1) the signal remaining above 0,300 V for a time period that starts after 100,0 ns of the preceding zero-crossing and that lasts at least (0,5 BT – 350,0 ns), respectively (1,0 BT – 0,350 µs);
2) its peak amplitude 5,00 V;
3) jitter less than 0,05BT.

The TE shall be a node able to act as strong master.

The TE shall inaugurate the IUT.

The TE shall interrogate every basic period the IUT, inserting the proper Presence_Frame every 3 basic periods.

The IUT shall respond on each interrogation and shall maintain the network inaugurated.

The waveshape modifier shall be set with

4) the signal remaining above 0,300 V for a time period that starts after 100,0 ns of the preceding zero-crossing and that lasts at least (0,5 BT – 350,0 ns), respectively (1,0 BT – 0,350 µs);
5) its peak amplitude 0,330 V;
6) jitter less than 0,05BT.

The IUT shall respond on each interrogation and shall maintain the network inaugurated.

The waveshape modifier shall be set with

7) the signal remaining above 0,300 V for a time period that starts after 100,0 ns of the preceding zero-crossing and that lasts at least (0,5 BT – 350,0 ns), respectively (1,0 BT – 0,350 µs);
8) its peak amplitude 5,00 V;
9) jitter more than 0,08BT and less than 0,1BT.

The IUT shall respond on each interrogation and shall maintain the network inaugurated.

The waveshape modifier shall be set with

10) the signal remaining above 0,300 V for a time period that starts after 100,0 ns of the preceding zero-crossing and that lasts at least (0,5 BT – 350,0 ns), respectively (1,0 BT – 0,350 µs);

11) its peak amplitude 0,330 V;

12) more than 0,08BT and less than 0,1BT.

The waveshape modifier shall be set with

13) the signal remaining above 0,050 V and the slope of the test signal will exceed 2,0 mV/ns for a time period that starts after 100,0 ns of the preceding zero;

14) its peak amplitude 0,330 V;

15) jitter less than 0,05BT.

The IUT shall not respond on each interrogation and shall not hold the inauguration.

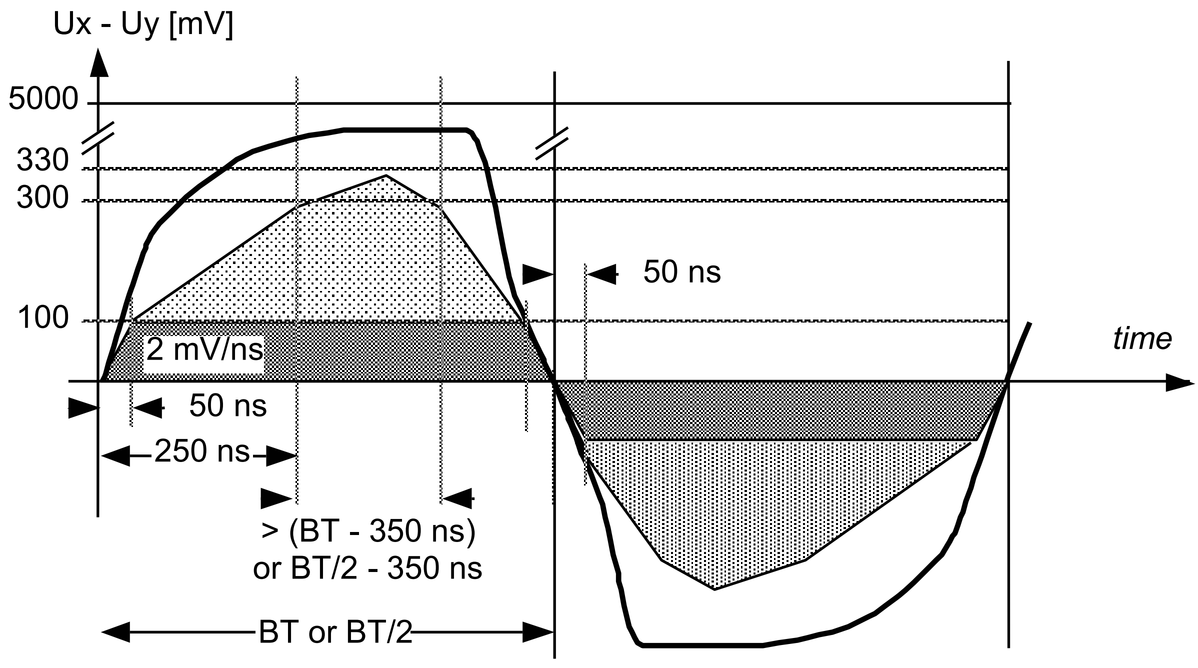

Figure 44 – Receiver signal envelope

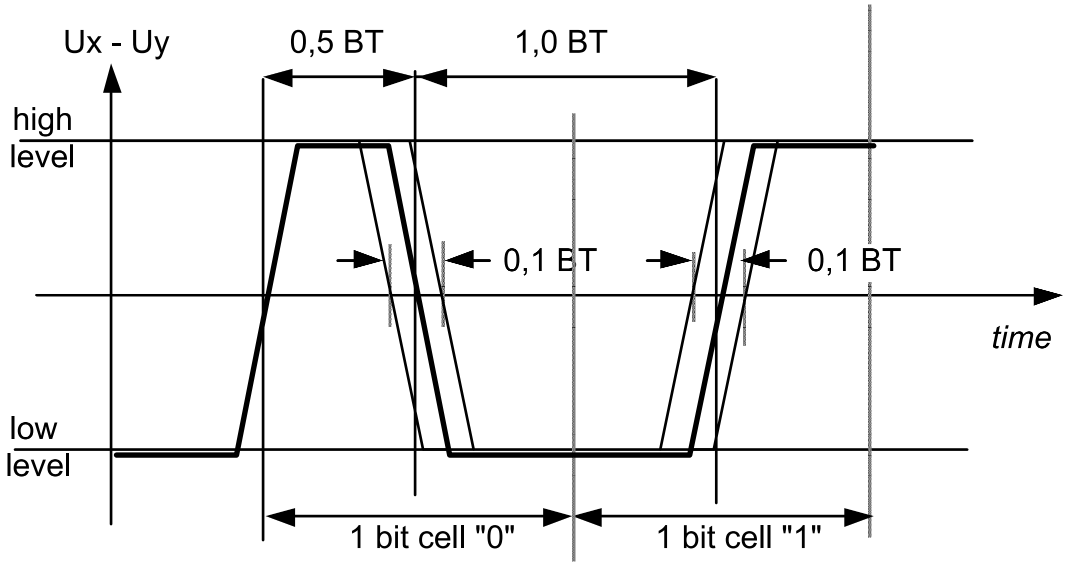

Figure 45 – Receiver edge distortion

4.1.5.1.6.3 Receiver noise rejection

The characteristics of a receiver are tested by applying a sequence of frames containing 1024 random data bits in the data field, passed by a waveshape modifier. The waveshape modifier shall be able to

a) sample the incoming bit and send out an outgoing bit with the amplitude changed as required by the test;
b) sample the incoming bit and send out an outgoing bit with the rise time changed as required by the test;
c) sample the incoming bit and send out an outgoing bit with the fall time changed as required by the test;
d) sample the incoming bit and send out an outgoing bit with the jitter as required by the test.

The test shall be performed with the configuration Fixture 1.

The test shall be performed with the configuration Fixture 2.

The waveshape modifier shall be set with

1) the signal remaining above 0,300 V for a time period that starts after 100,0 ns of the preceding zero-crossing and that lasts at least (0,5 BT – 350,0 ns), respectively (1,0 BT – 0,350 μs);
2) its peak amplitude 5,00 V;
3) jitter less than 0,05BT.

The TE shall be a node able to act as strong master.

The TE shall inaugurate the IUT.

The TE shall interrogate every basic period the IUT, inserting the proper Presence_Frame every 3 basic periods.

The IUT shall respond on each interrogation and shall maintain the network inaugurated.

Set a common-mode sinusoidal signal applied between casing and both data wires with an amplitude of 4,000 V r.m.s. and repeat the following test for 10 values as in the following table:

Table 26 – Frequency sinusoidal signal

Frequency Hz
65
1000
10 000
100 000
1 000 000
1 500 000

The waveshape modifier shall be set with

1) the signal remaining above 0,300 V for a time period that starts after 100,0 ns of the preceding zero-crossing and that lasts at least (0,5 BT – 350,0 ns), respectively (1,0 BT – 0,350 µs);
2) its peak amplitude 0,700 V;
3) jitter more than 0,08 BT and less than 0,1 BT.

The IUT shall respond on each interrogation and shall maintain the network inaugurated for 1 (one) h.

Set an additive quasi-white Gaussian noise (applied between X and Y) distributed over a bandwidth of 1,0 kHz to 4,0 MHz at an amplitude of 0,140 V r.m.s..

The IUT shall respond on each interrogation and shall maintain the network inaugurated for 1 (one) h.

4.1.6 Link layer interface

4.1.6.1 General description

The WTB link layer is a complex state machine – testing its functions requires many test cases to check all internal states and the state transitions. The guidelines for conformance testing, described in Annex B of IEC 61375-1, recommends a black box approach to test the TCN stack for conformity, this recommendation is followed by the testing approach described hereinafter.

4.1.6.2 WTB IUT

According to 1.6.6.1, 1.6.6.4 and 1.6.6.5 of IEC 61375-1, a WTB device shall include the RTP with messages services and the TNM with the agent function.

The simplest WTB device shall consist of these three communication modules:

a) WTB-LLC. WTB Link Layer Control.

b) RTP. Real Time Protocol.

c) TNM (Agent). TCN Network Management Agent.

To become a WTB IUT the device shall implement

– WTA. (WTB test application) see 4.1.6.3

The WTB IUT is modelled as a black box.

The WTB IUT for the purpose of testing shall expose only two external interfaces:

a) WTB medium attachment connectors as specified in 4.2.3 of IEC 61375-1.

b) the power control interface to control the power-up and power-down.

The medium attachment connectors are required to test the protocol.

The power control interface is required during the test execution to switch-on and switch-off the WTB IUT.

The client shall provide this external interface according with the test bed definition.

The client shall declare, in the appropriate PICS, the maximum time required for switch-on and switch-off the WTB IUT.

4.1.6.3 WTB test application

The IEC 61375-1 does not specify the application layer, so a specific simple test application is required to drive the WTB device communication layers. In this standard, the WTB test application is also called WTA.

The WTB test application is a simple state machine that controls the WTB-LL. It implements the stimuli and read the results required by the test cases. According to the WTB-LL some configuration data shall be supplied before the WTB-LL enters in regular operation state.

4.1.6.4 Procedures required for WTB device configurations

Precondition: WTB-LL configuration and initial node strength shall be supplied to the WTB device before the TCN inauguration.

Rationale: the WTB-LL configuration and its initial node strength cannot be supplied through the TNM agent, because the TNM requires the full functionality of RTP, and the RTP requires the WTB-LL state set in regular operation (see 4.8.4.2.2 of IEC 61375-1).

Procedures:

The procedures required for WTB device configurations listed in 4.8.4.x are:

- ls_t_Configure. This procedure sets up the basic **WTB-LL configuration** parameter;
- ls_t_SetSlave, ls_t_SetWeak, ls_t_SetStrong. These procedures define the **initial node strength**.

NOTE The required data to configure the IUT may be embedded into the WTA or passed via the configuration database.

The ls_t_report procedure defined in 4.8.4.3 shall be subscribed by the WTA in order to react to the WTB-LL events. See 4.8.4.6.4 Type_Configuration used by ls_t_Configure procedure.

The WTA shall implement a counter for each event listed in 4.8.4.3.2. When the WTB-LL calls for the ls_t_report procedure with the specific event code, the WTA shall increment the appropriate counter and then execute the requested code.

The event counters shall be reset to zero at power up.

A TNM SIF_code shall be implemented to read these counters.

4.1.6.5 WTB test bed

The test bed consists of a set of devices listed below.

- N.1 host computer
- N.1 mVB class 1 relay switch box
- N.2 WTB/MVB reference gateway named probe devices with WTA
- N.1 mVB device with the bus administrator capability
- N.30 WTB reference devices with WTA

4.1.6.6 Host computer

The host computer may be a standard personal computer with a wide diffusion operating system and a man machine interface. The host computer shall have the capability to download the test report on an appropriate media. An MVB device shall be included in order to let the test bed communicate with all WTB devices trough the probe devices. The RTP protocol and TNM services shall be used to send stimuli end to get results.

4.1.6.7 Relay switch box

The relay switch box may be implemented with a Class 1 MVB device.

There are two defined kinds of relays:

a) N.8 WTB relays to switch the WTB communication lines. These relays are used to simulate the coupling and uncoupling of WTB nodes and also for redundancy tests. Each relay shall have two contact signals for a single WTB line. Relay specification shall be as recommended by IEC 61375-1, 4.2.5.3, the following figure shows an example of a logic diagram of one single switch.

b) N.9 relay to control the WTB reference devices power interfaces and the IUT. The power switches usage is defined in the test suite definition. The relays shall be used to command switch-on and switch-off of the IUT. Contact rating shall be appropriate for the IUT.

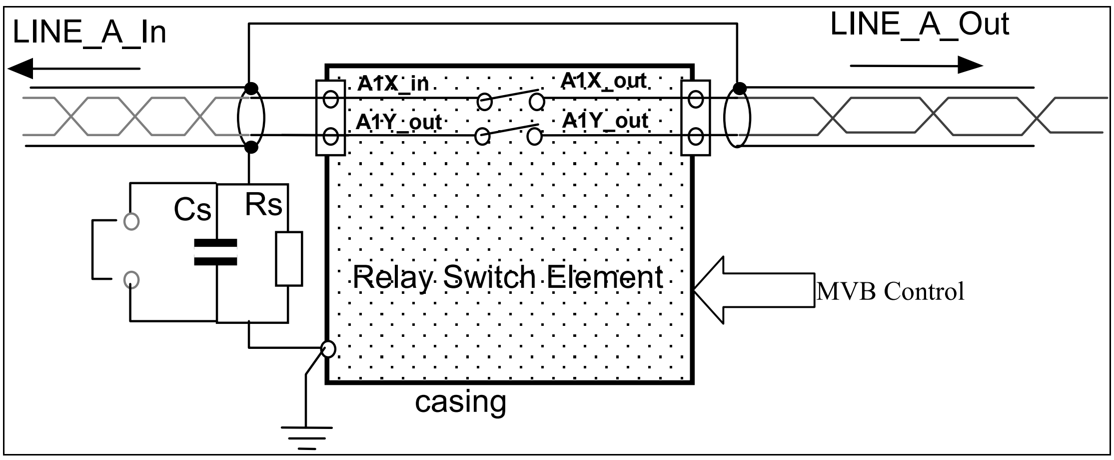

Figure 46 – Example of relay switch logic diagram for line A

4.1.6.8 MVB bus administrator

The test bed shall include an MVB device with the bus administrator capability in order to run the MVB segment. It may reside on the MVB device installed on the host computer or on the probe devices.

4.1.6.9 Reference devices

The test bed shall include 30 WTB devices implementing the WTA.

4.1.6.10 Probe devices

The test bed shall include 2 special WTB reference devices with the gateway capability for the MVB bus. The host computer is directly connected to the probe devices on the MVB network and trough the RTP routing to the other 30 WTB devices. The TNM services are used to inject stimuli to and read result from all WTB devices.

4.1.6.11 WTB data logger

A WTB data logger shall be used to perform some measures of the WTB-LL telegrams on the WTB network. The data logger is part of the test bed.

4.1.6.12 WTB devices configuration

The configuration parameters according to 4.8.4.6.4 of IEC 61375-1 shall be set to default value with the exceptions listed in the following table.

Table 27 – WTB devices configuration

Parameter	Value
node_frame_size	128
node_period	2= 4BP = 100msec
sink_port_count	31

NOTE 1 The node_frame_size and the node_period are both fields of the Type_NodeDescriptor structure defined in 4.8.4.6.3 of IEC 61375-1.

NOTE 2 The sink_port_count is set to 31 in order to allow the maximum number of WTB devices participating in the network. The total number of WTB devices is 32: 1 sink, and 31 sources.

The initial node strength shall be “weak”. This means that the ls_t_SetWeak procedure shall be invoked by the WTA just after the WTB-LL configuration.

4.1.6.13 TNM agent services

The TNM agent defined in Clause 5 of IEC 61375-1 shall be extended in order to let the test bed stimuli injection results be retrieved.

The IUT and reference implementation devices shall implement these TNM services.

Table 28 – TNM agent services

SIF_code	Service name	Procedures involved
20	READ_WTB_STATUS	ls_t_GetStatus ls_t_GetStatistics
21	WRITE_WTB_CONTROL	ls_t_CancelSleep ls_t_SetSleep ls_t_Allow ls_t_Inhibit ls_t_Remove ls_t_Slave ls_t_Weak ls_t_Strong ls_t_Configure (*) ls_t_ChgNodeDesc (**) ls_t_ChgUserReport (**) ls_t_ChgInauguration_Data (**)
22	READ_WTB_NODES	ls_t_GetWTBNodes
24	READ_TOPOGRAPHY	ls_t_GetTopography ls_t_GetInaug_data
32	READ_VARIABLES	
33	WRITE_FORCE_VARIABLES	

NOTE 1 The write_wtb_control code is defined as a bitset16, but only one procedure can be invoked per time. It is better to define a subcode for the procedure instead of bitset16.

NOTE 2 (*) The WTB configuration procedure requires a Type_Configuration argument. Two possibilities are envisaged: a) in case of missing argument the previous argument is used and, b) after the command the Type_Configuration structure is defined. In this case, the embedded parameters such as ls_t_report are not used.

NOTE 3 (**) The ls_t_ChgNodeDesc and ls_t_ChgUserReport and ls_t_ChgInauguration_Data have to be implemented in order to add stimuli.

NOTE 4 The read_variables and write_force_variables are used to access to WTB traffic store trough RTP and LPI interface. The following limitations are applied to simplify the WTA implementation: a) the bus_id should be always 1 to address the WTB traffic store; b) the port_address should be a valid WTB address 1..63, the value 0 may be used for the node itself to address the source port; c) the var_type is 15 and var_size is 63 to define and array of 128 octets; d) the var_offset is 0 to address the beginning of the dataset; e) the check_offset is 65535 for undefined check variable.

NOTE 5 The READ_WTB_EVENT_COUNTERS should be implemented to check events. According to 4.8.4.3.2 of IEC 61375-1 an array of 16-bits counters for each event should be reported on a reply telegram.

4.1.6.14 Test suites

On a WTB network, the number of involved devices and their position on the network are relevant for several test cases. The WTB device positions on the WTB network are called P01 to P32.

The WTB orientation is set according to this schema:

- P01,P02,P07,P08 have orientation 1-2;
- P03,P04,P05,P06 have orientation 2-1;
- the nodes P09 to P16 have the same orientation of P01 to P08;
- the nodes P17 to P32 have the same orientation of P01 to P16;
- the P01 direction 1 and P32 direction 2 lines are not connected.

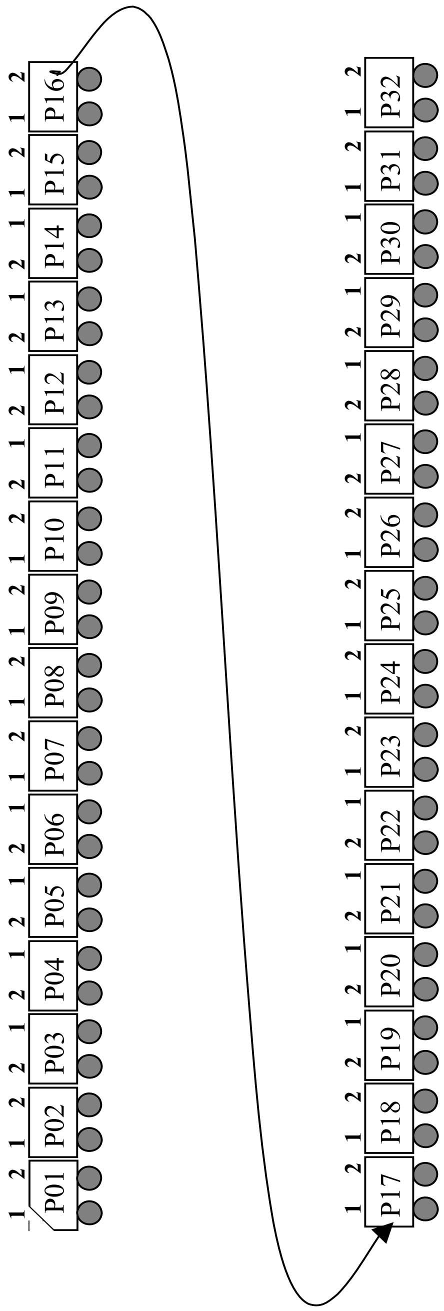

Figure 47 – WTB orientation

The power switch is attached to these WTB devices:

Power switch identifier	Device position
PS1	P01
PS2	P02
PS3	P03..P08
PS4	P09
PS5	P10
PS6	P11
PS7	P12.. P30
PS8	P31
PS9	P32

The WTB line switch assignment is the following:

Line switch identifier	Position	WTB line
LS1	P01	A2
LS2	P01	B2
LS3	P10	A1
LS4	P10	B1
LS5	P10	A2
LS6	P10	B2
LS7	P32	A1
LS8	P32	B1

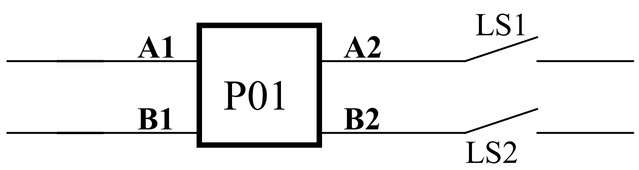

Figure 48 – Line switch identification in position P01

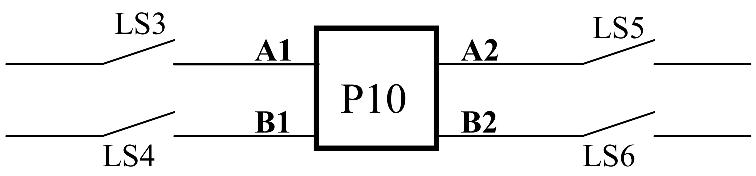

Figure 49 – Line switch identification in position P10

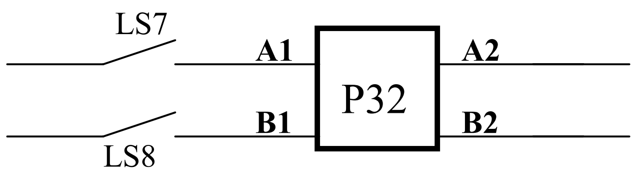

Figure 50 – Line switch identification in position P32

The table shown above describes all test suites:

Table 29 – Test suite

Test suite identifier	IUT	Probe_1	Probe_2
TTS1	P01	P02	P32
TTS2	P32	P01	P31
TTS3	P10	P09	P11

The WTB data logger position is defined on test cases definitions.

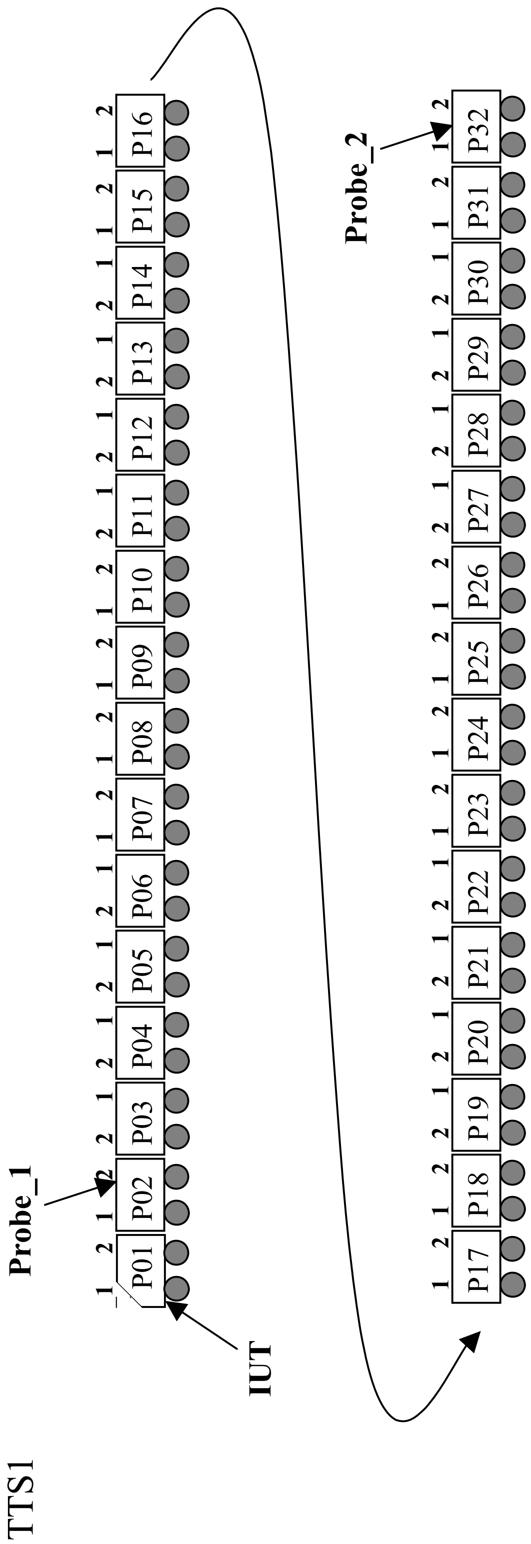

Figure 51 – Test suite identifier TTS1

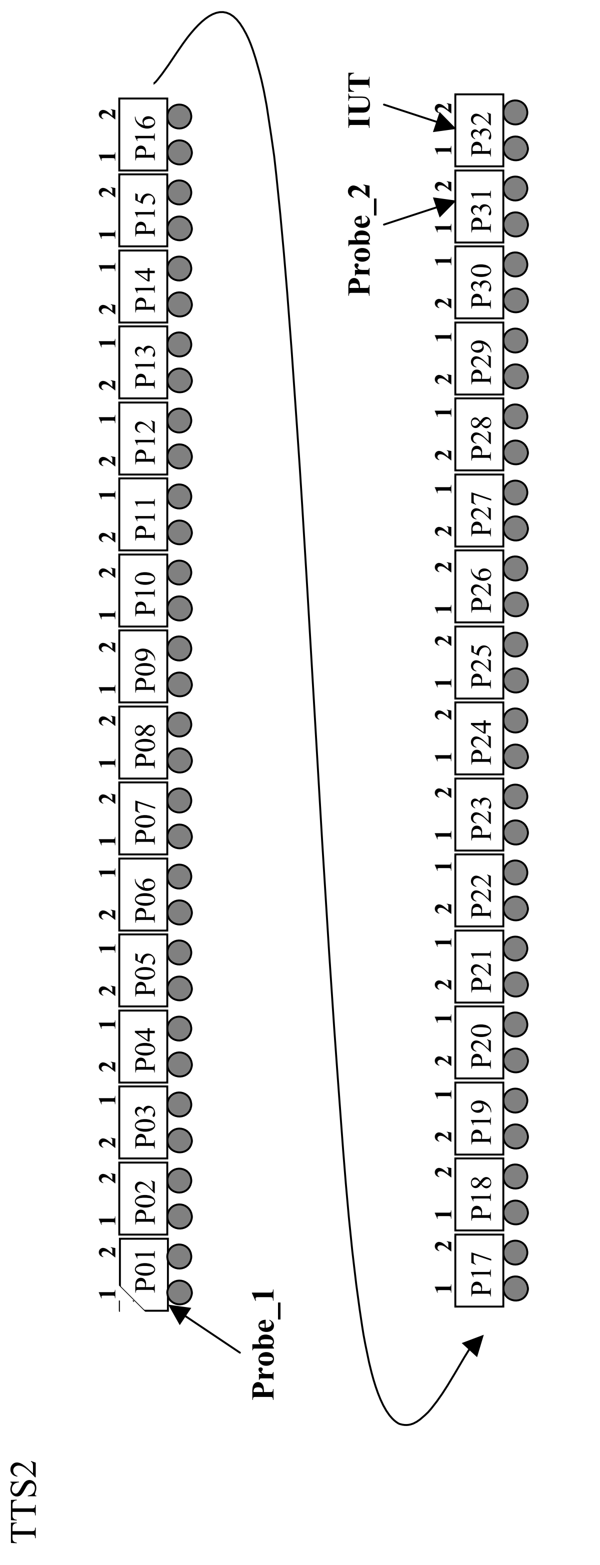

Figure 52 – Test suite identifier TTS2

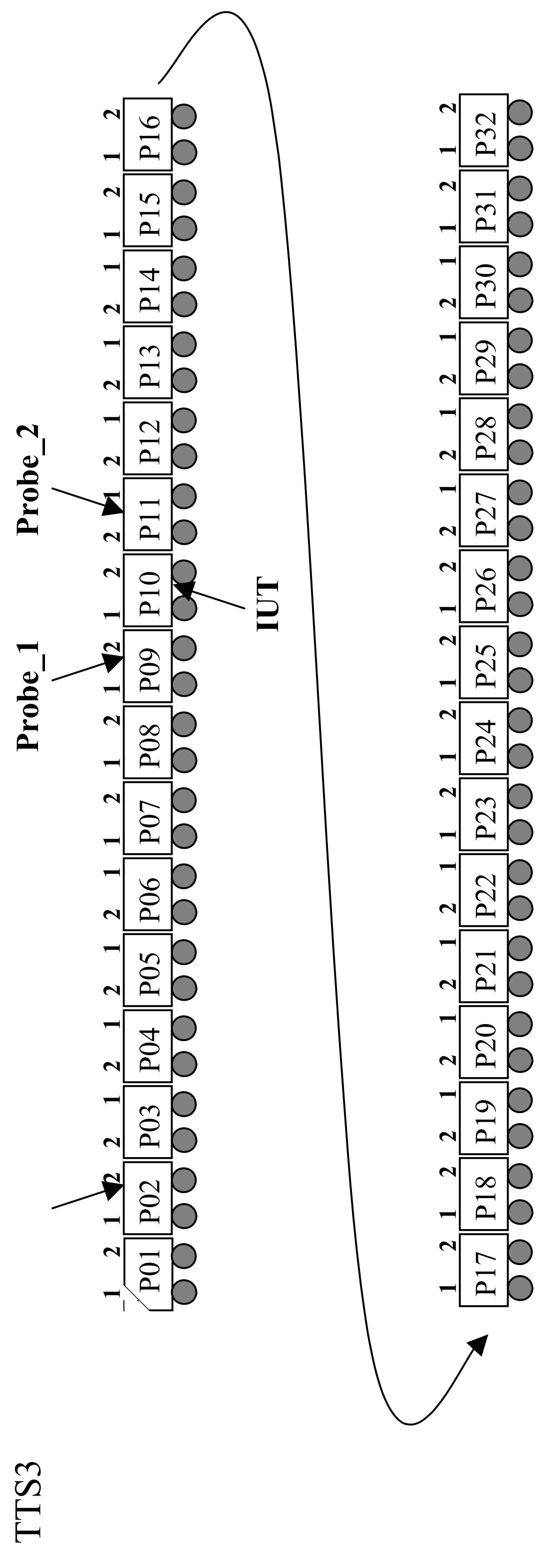

Figure 53 – Test suite identifier TTS3

4.1.6.15 IUT positions

The IUT position is relevant for different test cases. The position P01 is used to check the end setting position for a maximum network length (32 nodes). The position P32 is similar to P01 but the main direction is different. The position P10 is about 1/3 position of a full-length network and can be used for different test cases.

4.1.7 The test cases

Several test cases are specified in order to verify the correct behaviour of the IUT id different conditions. For each test case, the suite and the table containing the test steps with actions and expected results are specified.

All stimuli are performed trough the TNM with the commands:

- WRITE_WTB_CONTROL (to invoke the LSI procedures);
- WRITE_FORCE_VARIABLES (to write the export dataset for process data traffic).

Other stimuli are supplied trough the relay switch box to control:

- the power of the IUT and reference devices;
- the WTB line switch to simulate coupling and line failure.

The results are retrieved through the TNM with the commands:

- READ_WTB_STATUS (to get the WTB-LL status and statistics);
- READ_WTB_NODES (to get the node report and user report of all nodes),
- READ_TOPOGRAPHY (to get the topography and the inauguration data);
- READ_VARIABLES (to get the sink datasets of all nodes for process data traffic);
- READ_WTB_EVENT_COUNTER (to check about the WTB-LL events).

The frame spacing timing shall be measured for each of the test cases specified in 4.1.7.1 to 4.1.7.9 and from 4.1.7.11 to 4.1.7.14 of this standard. The measured value shall be compliant with 4.4.2.4 of IEC 61375-1.

4.1.7.1 Node strength

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10,P11,P32	• inauguration with four nodes • master position is random
2	ls_t_SetStrong P10	• new topography • optionally new inauguration • P10 strong master
3	ls_t_SetStrong P11	• two separate networks: P09,P10 and P11,P32. • the Master Conflict is stable, so the LR_MASTER_CONFLICT is reported only once, the according counter does not count
4	ls_t_SetWeak P11	• coupling of two compositions • P11,P32 lose, P10,P11 win • P10 is the strong master • the LR_MASTER_CONFLICT event counter of P10 stops increments

Step	Action	Expected result
5	Is_t_SetWeak P10	• new topography • no inauguration • P10 is the weak master
6	Is_t_SetSlave P10	• demotion of P10 • master position is random
7	Power off P09,P11,P32	• network disruption • no traffic; using of data logger to check • P10 does not perform detection
8	Power on P11, P32	• inauguration of P10,P11,P32 • P10 is the slave
10	Is_t_Remove P10	• P10 is removed from the network. • inauguration with P11,P32

4.1.7.2 Change of user report

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10	• inauguration
2	Ls_t_SetStrong P09	• P09 is the strong master
3	Is_t_ChgUserReport P09	• user to master
4	Is_t_ChgUserReport P10	• user to master
5	Is_t_SetSlave P09	• P10 is master
6	Is_t_ChgUserReport P09	• user to master
7	Is_t_ChgUserReport P10	• user to master

4.1.7.3 Change of node descriptor

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10	• inauguration
2	Is_t_SetStrong P09	• P09 is the strong master
3	Is_t_ChgNodeDesc P09	• new topography
4	Is_t_ChgNodeDesc P10	• new topography
5	Is_t_SetSlave P09	• P10 is the master
6	Is_t_ChgNodeDesc P09	• new topography
7	Is_t_ChgNodeDesc P10	• new topography

4.1.7.4 Change of inauguration data

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10	• Inauguration
2	ls_t_SetStrong P09	• P09 is strong master
3	ls_t_ChgInauguration_Data P09	• No change
4	ls_t_ChgNodeDesc P09	• New topography
5	ls_t_ChgInauguration_Data P10	• No change
6	ls_t_ChgNodeDesc P10	• New topography
7	ls_t_SetSlave P09	• P10 is master
8	ls_t_ChgInauguration_Data P09	• No change
9	ls_t_ChgNodeDesc P09	• New topography
10	ls_t_ChgInauguration_Data P10	• No change
11	ls_t_ChgNodeDesc P10	• New topography

4.1.7.5 Inauguration inhibit lengthening

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10,P11	• inauguration
2	ls_t_SetStrong P10	• P10 is the strong master
3	ls_t_Inhibit P09	• network inhibited
4	Power up P32	• no inauguration
5	ls_t_Inhibit P11	• network inhibited
6	ls_t_Allow P09	• network inhibited
7	ls_t_Inhibit P10	• network inhibited
8	ls_t_Allow P11	• network inhibited
9	ls_t_Allow P10	• new inauguration

4.1.7.6 Sleep state

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10,P11,32	• inauguration
2	ls_t_SetStrong P10	• P10 is the strong master
3	ls_t_SetSleep P09	• sleep request on node P09 reported on WTB status
4	ls_t_SetSleep P10	• sleep request on node P10 reported on WTB status

Step	Action	Expected result
5	Is_t_SetSleep P11	• sleep request on node P11 reported on WTB status
6	Is_t_CancelSleep P09	• sleep request removed on node P11 reported on WTB status
7	Is_t_SetSleep P32	• sleep request for node P32 reported on WTB status
8	Is_t_SetSleep P09	• all nodes enter in sleep state: no WTB traffic
9	Power off / power on P09	• new inauguration

4.1.7.7 Fast insertion

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10,P11,32	• inauguration
2	Is_t_SetStrong P10	• P10 is the strong master
3	Power off P11	• P11 does not communicate • topography does not change
4	Power on P11	• no inauguration • new topography due to reintegration of P11
5	Ls_t_SetSlave P10	• new inauguration • P10 is the slave
6	Power off P10	• P10 does not communicate • topography does not change
7	Power on P10	• no inauguration • new topography due to reintegration of P10

4.1.7.8 Late insertion

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10,P11,P32	• inauguration
2	Is_t_SetStrong P10	• P10 is the strong master
3	Power off P11	• P10 does not communicate
4	Power off / power on P09	• new inauguration due to end node lost • network with P09,P10,P32
5	Is_t_Inhibit P09	• inauguration inhibited
6	Power on P11	• topography does not change
7	Is_t_Allow P09	• new inauguration with P09,P10,P11,P32

4.1.7.9 Process data

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10,P11,32	• inauguration
2	ls_t_SetStrong P10	• P10 is the strong master
3	Write Process Data pattern	• export and import of process data
4	ls_t_Remove P11	• check about sink time supervision of node P11
5	Power off all nodes	
6	Power up P09,P10,P11,32	• inauguration
7	ls_t_SetStrong P11	• P11 is the strong master
8	Write Process Data pattern	• export and import of process data
9	ls_t_Remove P10	• check about sink time supervision of node P10

4.1.7.10 Individual period

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up all nodes	• inauguration
2	ls_t_SetStrong P10	• P10 is the strong master
3	ls_t_ChgNodeDesc P01..P32 node_period=3	• new topography • check the LR_POLL_LIST_OVR event counter (expect no overflow)
4	ls_t_ChgNodeDesc P01..P32 node_period=2	• new topography • check the LR_POLL_LIST_OVR event counter (expect overflow)
5	ls_t_ChgNodeDesc P10..P32 node_period=3 P10..P32 node_frame_size=40	• new topography • check the LR_POLL_LIST_OVR event counter (expect no overflow)

NOTE The step 5 requires the correct limit calculation.

4.1.7.11 Coupling of two compositions

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up all nodes	• inauguration
2	Ls_t_SetStrong / ls_t_SetWeak P01	• P01 is master
3	Open LS5 and LS6	• inauguration of two network • network #1: P01..P10; P01 is master (10 nodes) • network #2: P11..P32 (21 nodes)
4	Ls_t_SetStrong / ls_t_SetWeak P32	• P32 is the master of network #2
5	Close LS5 and LS6	• coupling of two network • P32 is the master (the longer former network wins, its master become the master of the new network)

Step	Action	Expected result
6	Ls_t_SetStrong / ls_t_SetWeak P10	• P10 is the master
7	Open LS5 and LS6	• inauguration of two networks • network #1: P01..P10; P10 are masters • network #2: P11..P32
8	Ls_t_SetStrong / ls_t_SetWeak P32	• P32 is the master of network #2
9	Close LS5 and LS6	• coupling of two networks • P32 is the master
10	Power off P12..P30	•
11	Ls_t_SetStrong / ls_t_SetWeak P01	• P01 is the master
12	Open LS5 and LS6	• inauguration of two networks • network #1: P01..P10; P01 are masters • network #2: P11,P31,P32
13	Ls_t_SetStrong / ls_t_SetWeak P32	• P32 is the master of network #2
14	Close LS5 and LS6	• coupling of two networks • P01 is the master
15	Ls_t_SetStrong / ls_t_SetWeak P10	• P10 is the master
16	Open LS5 and LS6	• inauguration of two networks • network #1: P01..P10; P10 are masters • network #2: P11,P31,P32
17	Ls_t_SetStrong / ls_t_SetWeak P32	• P32 is the master of network #2
18	Close LS5 and LS6	• coupling of two networks • P10 is the master

4.1.7.12 Inauguration time IUT intermediate

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up all nodes	• inauguration
2	ls_t_SetStrong/ls_t_SetWeak P10	• P10 is the master
3	Power off P01	• inauguration (end node lost) • P10 master • using of data logger to measure inauguration time
4	Power on P01	• inauguration (lengthening) • P10 master • using of data logger to measure inauguration time

4.1.7.13 Inauguration time IUT end setting main direction 2

Setup: TTS1

Test sequence

Step	Action	Expected result
1	Power up all nodes	• inauguration
2	Is_t_SetStrong/Is_t_SetWeak P01	• P01 is the master
3	Power off P32	• inauguration (end node lost) • P01 master • using of data logger to measure inauguration time
4	Power on P32	• inauguration (lengthening) • P01 master • using of data logger to measure inauguration time

4.1.7.14 Inauguration time IUT end setting main direction 1

Setup: TTS2

Test sequence

Step	Action	Expected result
1	Power up all nodes	• inauguration
2	Is_t_SetStrong/Is_t_SetWeak P32	• P32 is the master
3	Power off P01	• inauguration (end node lost) • P32 is the master • using of data logger to measure inauguration time
4	Power on P01	• inauguration (lengthening) • P32 is the master • using of data logger to measure inauguration time

4.1.7.15 Failure of the master node

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10,P11,P32	• inauguration with four nodes • master position is random
2	Is_t_ SetStrong P11	• new topography • optionally new inauguration • P11 is the strong master
3	Is_t_ SetWeak P10	• no change
4	Is_t_ SetSlave P01	• no change
5	Is_t_ SetSlave P32	• no change
6	Power off P11	• new topography • new inauguration • P10 is the master

4.1.7.16 Line redundancy during regular operation

Setup: TTS3

Test sequence

Step	Action	Expected result
1	Power up P09,P10,P11,P32	• inauguration with four nodes • master position is random
2	Is_t_ SetStrong P11	• new topography • optionally new inauguration • P11 is the strong master
3	Open LS3	• Master_Report dma shall be set to 1
4	Close LS3	• Master_Report dma shall be set to 0
5	Open LS4	• Master_Report dmb shall be set 1
6	Close LS4	• Master_Report dmb shall be set to 0
7	Open LS5	• Master_Report dma shall be set to 1
8	Close LS5	• Master_Report dma shall be set to 0
9	Open LS6	• Master_Report dmb shall be set to 1
10	Close LS6	• Master_Report dmb shall be set to 0
11	Wait 5s	• no changes
12	Repeat steps 3…10 for 1h	• inauguration shall never take place (robustness test)

4.1.7.17 Line redundancy during inauguration

Setup: TTS1

Test sequence

Step	Action	Expected result
1	Power up all nodes	• inauguration • master position is random
2	Is_t_ SetStrong P11	• new topography • optionally new inauguration • P11 is the strong master
3	Power off P01	• end node lost • inauguration
4	Open LS1	• no change
5	Power on P01	• inauguration • P01 is the end node
6	Power off P01	• end node lost • inauguration
7	Close LS1	• no change
8	Open LS2	• no change
9	Power on P01	• inauguration • P01 is end node
10	Open LS1	• end node lost • inauguration

4.1.7.18 Measurement of basic period

Setup: TTS1

Test sequence

Step	Action	Expected result
1	Power up P01, P02	• No change
2	ls_t_SetStrong P01	• P01 is master
3	ls_t_ChgNodeDesc P01, P02 node_period=0	• New topography • Use of data logger to measure basic period. Expected value shall be: 25 ms ± 1 ms

4.1.7.19 WTB link layer procedures

The following table lists the WTB link layer procedures that are used to implement the test application.

Table 30 – WTB link layer procedures

Procedure	Subclause in IEC 61375-1	IEC 61375-1
ls_t_Report(…)	4.8.4.3	WTA Implemented
ls_t_Init()	4.8.4.4	WTA Implemented
ls_t_Reset()	4.8.4.5	5.4.4.2
ls_t_Configure(…)	4.8.4.6	5.4.4.2 TNM extension for parameters
ls_t_SetSlave()	4.8.4.7	5.4.4.2
ls_t_SetWeak()	4.8.4.8	5.4.4.2
ls_t_SetStrong()	4.8.4.9	5.4.4.2
ls_t_StartNaming()	4.8.4.10	5.4.4.2
ls_t_Remove()	4.8.4.11	5.4.4.2
ls_t_Inhibit()	4.8.4.12	5.4.4.2
ls_t_Allow()	4.8.4.13	5.4.4.2
ls_t_SetSleep()	4.8.4.14	5.4.4.2
ls_t_CancelSleep()	4.8.4.15	5.4.4.2
ls_t_GetStatus(…)	4.8.4.16	5.4.4.1
ls_t_GetWTBNodes(…)	4.8.4.17	5.4.4.3
ls_t_GetTopography(…)	4.8.4.18	5.4.4.4
ls_t_ChgNodeDesc(…)	4.8.4.19	TNM extension
ls_t_ChgUserReport(…)	4.8.4.20	TNM extension
ls_t_ChgInauguration_Data(…)	4.8.4.21	TNM extension
ls_t_GetStatistics(…)	4.8.4.22	5.4.4.1
ls_t_GetInaug_Data(…)	4.8.4.23	WTA implemented

5 Conformance test of RTP

Conforming to the concept stated in the guidelines to conformance testing in Annex B of IEC 61375-1 that ask for a black box testing, the RTP are tested by MVB and WTB tests that involve the usage of the RTP themselves.

No exposed interface between the RTP and the link layer protocol is foreseen so the herein above method is the only one feasible.

RTP is designed to operate with concurrent access of shared resources creating contentions. Non-conformance and its manifestation in communication failure may not appear or can appear unconnected. Contentions and races can run successfully for long periods, or for a number of different executions, and then fail during a slightly different execution sequence. According to Holzmann (see bibliography) "It is virtually impossible to exhaustively test all possible behaviours of an unknown implementation by simply probing it and observing its responses. There is always a possibility that some untried sequence of probes would reveal a new behaviour that is unacceptable. The specific test suite selected for a conformance test of this type, therefore, is always a small selection of the infinite set of all possible test suites." This conformance test will be limited to a bounded set of values.

Basic requirements for testing the protocol are:

a) number of possible process data type is finite;
b) reponse time of the protocol is finite;
c) stable conditions in which the IUT is waiting for a new input signal exists;
d) status property exists: when a ‘‘status’’ message is received, the IUT responds with an output message that uniquely identifies its current state;

All basic requirements listed are owned by MVB.

5.1 Ports and Traffic_Store

Refer to 2.2.2.2.1 of IEC 61375-1.

a) The number of ports for Process_Data communication is tested by the test 3.2.7
b) Access a port consistently in one indivisible operation is tested by the test of 3.2.7
c) Ports belonging to the same link layer belong to the same Traffic_Store tested by the test of 3.2.7.
d) A port identified within a Traffic_Store by its Port_Address is tested by the test of 3.2.7.
e) A Traffic_Store identified within a device by its Traffic_Store_Id is tested by the test of 3.2.7.

The shared memory structure, cannot be directly tested due to unavailability explicit standardised synchronisation between application and network. To improve the confidence test of 3.2.7.2 which can be accessed simultaneously by the application and the network shall be left running for 6 h.

If the IUT passes these tests, it is capable of reproducing the behaviour of the specification IEC 613751-1, but it remains unknown if the IUT may go into a set of states that produces erroneous behaviour.

5.2 Dataset consistency

Refer to 2.2.2.2.2 of IEC 61375-1.

a) Each port contains exactly one dataset tested by the test of 3.2.7.
b) A dataset produced by only one publisher application tested by the test of 3.2.7.
c) Only one source port with a given Port_Address on a bus is tested by the test of 3.2.7
d) The link layers transmit the contents of a source port within a limited time to the sink ports subscribed to the same Port_Address and provide consistency of transmitted source port, tested by the test of 3.2.7

5.2.1 Error handling

Refer to 2.2.2.2.3 of IEC 61375-1.

Listed below are undefined fields in a dataset overwritten with ‘1’ not tested.

a) if the link layer detects that a transmission error occurred;
b) if the link layer detects that its pubisher application does not supply correct data;
c) if the link layer detects that its pubisher application does not supply timely data.

The link layer shall overwrite the whole port with ‘0’ and is tested by the test of 3.2.7.

5.2.2 Freshness supervision

Refer to 2.2.2.2.4 of IEC 61375-1.

a) Each sink port Freshness_Timer is tested by the test of 3.2.7
b) Freshness_Timer retrieved in an indivisible operation and is tested by the test of 3.2.7.
c) The resolution of Freshness_Timer shorter or equal to 16 ms is tested by the test of 3.2.7.
d) The range of Freshness_Timer not tested.

5.2.3 Synchronisation dataset

Refer to 2.2.2.2.5 of IEC 61375-1.

Not tested.

5.2.4 Dataset polling

Refer to 2.2.2.2.6 of IEC 61375-1.

Not tested in this standard.

5.2.5 Dataset, port and logical address

Refer to 2.2.2.2.7.1 of IEC 61375-1

Not tested

5.2.6 Traffic_Store Identifier

Refer to 2.2.2.2.7.3 of IEC 61375-1.

Traffic_Store_Id tested by the test of 3.2.8.2.3.1.3 verifies only that it is different from the value 1 (WTB).

The maximum number of Traffic_Stores supported is not tested.

5.3 Port_Address

Refer to 2.2.2.2.8 of IEC 61375-1.

The Port_Address is one of 4096 ports within the Traffic_Store selected by Traffic_Store_Id. It is limited to the test address given to the IUT for conformance testing and is tested by the test of 3.2.7.

5.4 Link_Process_Data_Interface primitives

Refer to 2.2.2.3 of IEC 61375-1.

Primitives may vary in implementation, the black box testing is not able to assess the direct compliance, only expected behaviour can be checked by the test of 3.2.7.

5.5 Messages services and protocols

Refer to 2.3 of IEC 61375-1.

Tested by 3.2.8 of this standard.

6 Conformance test of a WTB-equipped vehicle

6.1 General

The conformance at TCN level of a vehicle is a fundamental pre-requisite for interoperability of vehicles equipped with TCN.

The scope of this clause is to specify the tests necessary to assure the TCN conformance of a WTB equipped vehicle. These tests can be performed independently by the application tests or can be integrated in the application tests, as preliminary tests, common for all application profiles.

TCN conformance is the necessary pre-requisite to assure the interoperability among different vehicles, but it is not able to guarantee it because other pre-requisites have to be satisfied at application level.

That is why both tests (TCN conformance and application) are necessary to allow the interoperability among vehicles from different railway manufacturers and operators.

The instrument used for the test is the coach tester, specified in the Annex B.

6.2 PICS

PICS pro-forma is a set of tables containing questions to be answered by an implementer, and limitations on the possible answers.

It contains two types of questions:

- questions to be answered by either "YES" or "NO", related to whether a clause (ranging from a macroscopic functional unit to a microscopic) has been implemented or not. The allowed answers, which reflect the base specification, are documented in the PICS as Requirement; the answers constitute the support;
- questions on numerical values implemented (for timers, for sizes of messages, for frequencies, etc.). The legitimate range of variation of this value, which reflects the base specification, is given in IEC 61375-1. The answer constitutes the supported values.

6.2.1 Instructions for filling the PICS pro-forma

PICS are organised into tables. Columns in the tables are:

- Ref. No.;
- Question, related to a characteristic or a supported capability;
- Response, answer to the question;

- Note, to be filled in to give more explanations about the answer. In the document, it is used to give explanations about the meaning of the question and/or a possible answer.

6.2.2 Abbreviations

The following abbreviations are used in this PICS pro-forma:

Y: yes

N: no

d: default

n/a: not applicable

6.2.3 PICS tables

6.2.3.1 Identification of PICS

The following table is intended to be filled in, in order to identify the pro-forma.

Ref. No.	Question	Response
1	Date of statement	
2	PICS serial number	

6.2.3.2 Identification of WTB vehicle under test

The following table is intended to be filled in, in order to identify the Vehicle Under Test (VUT).

Ref. No.	Question	Response	Note
1	Vehicle identification number		*UIC code number or other internal code used by the operator*
2	Manufacturer name		
4	Number of active nodes on the vehicle		
5	Number of not-active nodes on the vehicle		*E.g. if there are nodes with a cold redundancy configuration*
6	Node redundancy capability		*Possible answers: [Y] or [N]*
7	Line redundancy capability		*Possible answers: [Y] or [N]*
8	Trunk cable		*Possible answers: [Y] or [N]* *IEC 61375-1 –. 4.2.1.1*
9	Jumper cable		*Possible answers: [Y] or [N]* *IEC 61375-1 – 4.2.1.1*
10	Extension cable		*Possible answers: [Y] or [N]* *IEC 61375-1 – 4.2.1.1*

6.2.3.3 Identification of vehicle WTB node

The following table is intended to be filled in, in order to identify the WTB nodes that are aboard on the VUT. If the VUT is equipped with more than one node (see 4.2.3.2), the following table shall be filled in for each node.

Ref. No.	Question	Response	Note
1	Node number		*Identification code by the manufacturer or operator*
2	Node manufacturer		*Name of the manufacturer*
3	Node application		*Reference to a standard or other specification, e.g. UIC 556*
4	Process data default value		*Process data default contents to be sent by the tester in order to initialise the vehicle functions. Information to be provided if required in order to implement the test properly.*
5	Message data capability and testability		*Detailed information about thr MD that have to be given in order to properly implement the test on the tester*
6	Node conformance certificate		*If the device has been tested by an internal or external laboratory, it is the certificate number of the test*
7	Node SW version		*Reference to a standard or other specification, e.g. WTB_LL IEC 61375-1, UIC Mapping Server 13th version*
8	Node type		*Possible answers:* *[SM] Strong Master* *[WM] Weak Master* *[PS} Permanent Slave* *They can be more than one, specify in this cell how they can be selected*

Identification of vehicle trunk cable

The following table is intended to be filled in, in order to identify the trunk cable (see IEC 61375-1, 4.2.1.1) that is on board the VUT. It includes the connections on the two extremities of the cable.

Ref. No.	Question	Response	Note
1	Cable code		*Identification code by the manufacturer or operator*
2	Cable manufacturer		*Name of the manufacturer*
3	Cable shape and section		*E.g. 2 x 0,75 mm^2 shielded*
4	Cable length		*From end to end*
6	Cable conformance certificate		*If the cable has been tested by an internal or external laboratory, it is the certificate number of the test*
7	Cable end connections		*Connectors or screw terminals*

If the trunk cable on a vehicle is divided into different sections, one table shall be filled in for each section.

6.2.3.4 Identification of vehicle jumper cable

The following table is intended to be filled in, in order to identify the jumper cable (see IEC 61375-1, 4.2.1.1) that is on board the VUT. It includes the connections on the two extremities of the cable.

Ref. No.	Question	Response	Note
1	Cable code		*Identification code by the manufacturer or operator*
2	Cable manufacturer		*Name of the manufacturer*
3	Cable shape and section		*E.g. 2 x 0,75 mm^2 shielded + 16 x 1 mm^2 shielded*
4	Cable length		*From end to end*
5	Cable standard		*E.g. UIC 558*
6	Cable conformance certificate		*If the cable has been tested by an internal or external laboratory, it is the certificate number of the test*
7	Cable end connections		*Connectors or screw terminals*

If the jumper cable on a vehicle is divided into different sections, one table shall be filled in for each section.

6.2.3.5 Identification of vehicle extension cable

The following table is intended to be filled in, in order to identify the extension cable (see IEC 61375-1, 4.2.1.1) that is on board the VUT. It includes the connections on the two extremities of the cable.

Ref. No.	Question	Response	Note
1	Cable code		*Identification code by the manufacturer or operator*
2	Cable manufacturer		*Name of the manufacturer*
3	Cable shape and section		*E.g. 4 x 0,5 mm^2 shielded*
4	Cable length		*From end to end*
6	Cable conformance certificate		*If the cable has been tested by an internal or external laboratory, it is the certificate number of the test*
7	Cable end connections		*Connectors or screw terminals*

If the extension cable on a vehicle is divided into different sections, one table shall be filled in for each section.

6.3 Test suites

The TCN conformance tests are supposed to be performed on a single vehicle (or trainset) equipped with one WTB active node and the WTB line(s) physically available on both ends of the vehicle under test.

No intervention on board, by decoupling and coupling device connectors, is admitted.

Besides, vehicle equipped with external MVB connectors at the two ends cannot be tested by using them. The access to MVB devices on board the vehicle can be done by WTB/MVB gateway only.

The devices and subsystems that constitute the vehicle have to be individually tested at device level and the related test certificate, mentioned in the PICS, have to be available on request.

In any case, the PICS described in 6.2 and properly filled in, are able to prepare the test suites for the different test levels.

There are three test levels:

– basic interconnection tests;
– capability tests;
– behaviour tests.

The tests here considered are basic interconnection tests, even if some of them are able to verify also some capabilities (like the error transmission frame) and the methodology requires a behaviour test and analysis for some test clauses.

In the following specification, the difference among the three levels is not mentioned.

The tests are given in the two subclauses below:

a) physical interface;
b WTB link layer capabilities.

Any further tests are not considered for the following reasons:

– connector tests have to be carried out at application level, because the external vehicle connectors are defined by the application (e.g. UIC leaflets);
– insertion tests related to the single vehicle are included in the physical interface tests;
– the MVB interoperability test is not relevant at vehicle level (it is not strictly necessary that a WTB vehicle is equipped with MVB bus);
– application profile is out of the scope of TCN conformance and requires a specific application test (e.g. UIC test at vehicle level, by using a vehicle simulator).

In order to perform the tests, a special instrument called “coach tester” shall be used. It includes all necessary test devices for the different test steps.

6.3.1 Physical interface tests

The tests are performed at vehicle level, independently from the layout of the internal cabling and connection. All the items included in the physical layer (cables, connectors, devices) should be in conformance with the TCN standard IEC 61375-1, but in any case the scope of the present tests is to check the characteristics of the whole physical layer by some tests and measurements.

The check shall be performed without detaching any connectors on the board vehicle, but only by the connection of the tester to the end connectors at the two vehicle ends. According to the TCN standard (see 4.2.1.4 of IEC 61375-1), it is assumed that the WTB node on the vehicle is connected by direction 1 line to the vehicle end “1” and by direction 2 line to the vehicle end “2”.

The WTB line can be in the single configuration (line A only) or in the redundant configuration (lines A and B).

The tests are divided into the following cases:

a) d.c. tests
b) a.c. tests

During the execution of all physical interface tests, the active devices (normally the WTB node) have to be switched off.

6.3.2 DC test: line resistance

6.3.2.1 Single line

These tests verify the line resistance in two different cases.

They are carried out on the WTB end connectors, making a short cut or leaving without a connection the poles belonging to the same line at one side of the coach.

On the other end of the line, with a DMM, the resistance of the line will be measured.

It is recommended to perform the test with a 4-wire resistance measurement, because the value to be measured is of low-resistance.

The test will pass if:

- the measured resistance will be less than 2 Ω if the short circuit is present

(see 4.2.2.4.1. IEC 61375-1) or

- the measured resistance will be more than 1 MΩ if the open-circuit is present

(see 4.2.5.1 IEC 61375-1).

6.3.2.2 Double line

If a double line is present these tests will be performed on both lines (A and B).

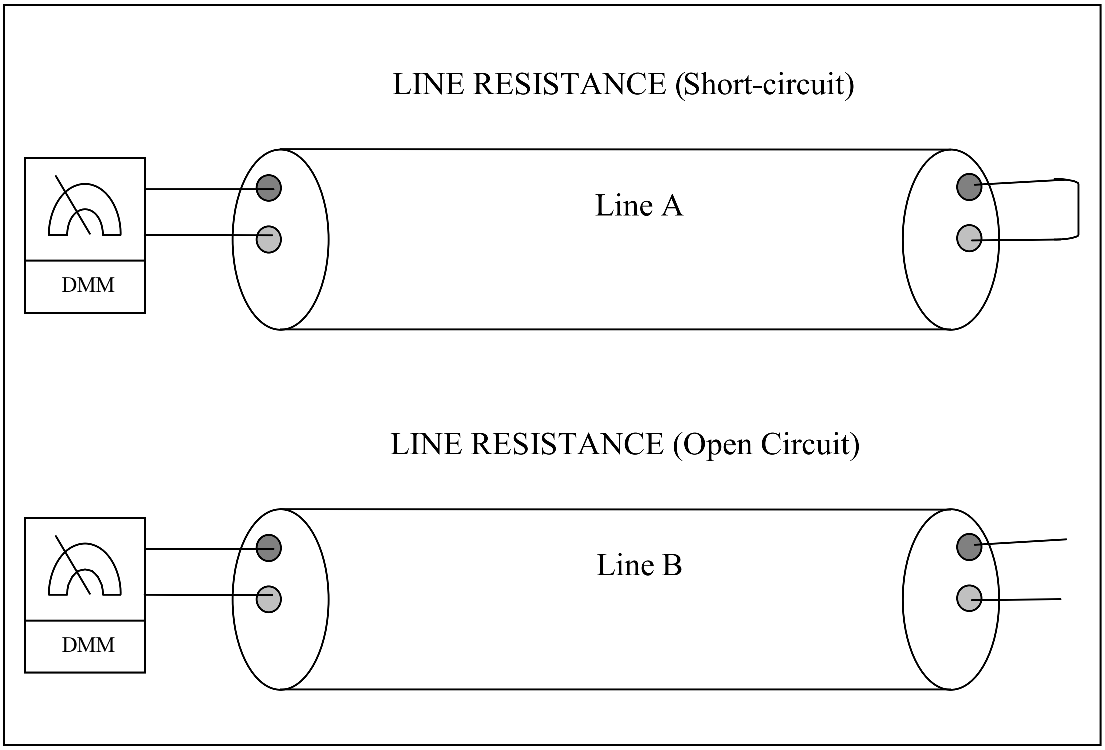

Figure 54 – Line resistance

6.3.2.3 AC test1: crosstalk

This test is carried out only if the double line is present and the two pairs of wires are in the same cable in some parts of the vehicle (see 4.2.2.4.7, IEC 61375-1]).

1st test

On WTB end connectors, side 1, lines A and B terminating resistors (120 Ω ± 10 %) are connected. On side 2, line B only shall be terminated with another resistor (120 Ω ± 10 %)

On side 2, the instruments are connected in the following way:

- *sine wave generator with an internal resistance Zt = 120 Ω to line A.*

  It shall be set to:

Amplitude	*4 Vpp*
Frequency	*0,5 – 1 – 2 MHz*

- *oscilloscope on side 1, line B. Measure the voltage and check that the rejection value limit of 55 dB is not reached.*

This value, keeping the coach train length in mind, is near 7 mV.

2nd test

Repeat the 1st test exchanging the connection of sine wave generator (now to line B) with its terminating resistor and oscilloscope (now to line A).

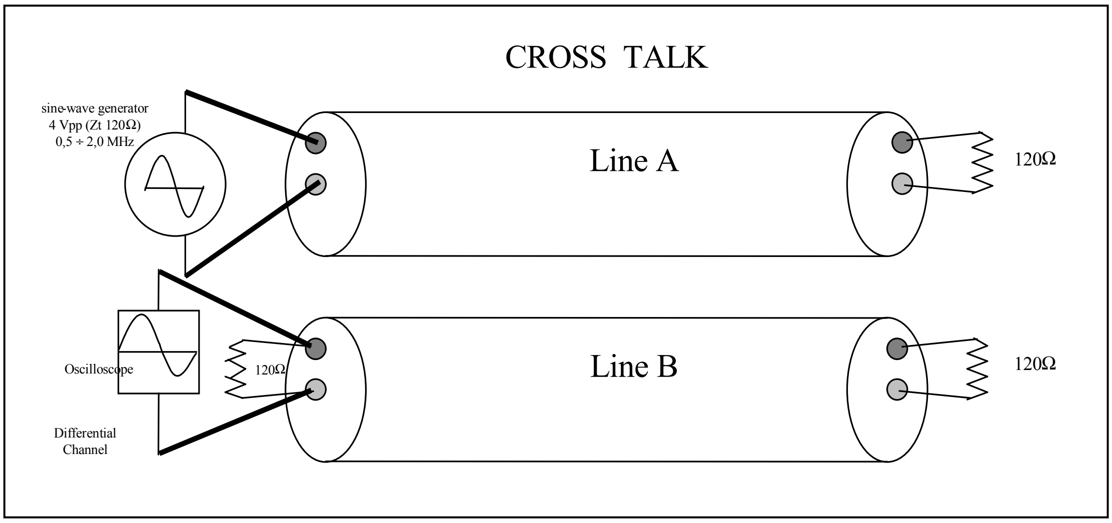

Figure 55 – Crosstalk

6.3.2.4 AC test2: propagation delay and attenuation

These tests are carried out only where the double line is present (see IEC 61375-1, 4.2.2.3.2 Delay; and 4.2.1.5 Attenuation).

1st test

On WTB end connectors, side 1, lines A and B are connected together. On side 2, line B only shall be terminated with a resistor (120 Ω ± 10 %).

On side 1, the instruments are connected in the following way:

- *sine wave generator with an internal resistance Zt = 120 Ω to line A.*

It shall be set to:

Amplitude 4 Vpp

Frequency0.5 – 1 – 2 MHz

- *oscilloscope differential channel 1 on side 1 of line A, and the differential channel 2 on side 1 of line B.*

By comparing the signal read at the side of line A and on the other side of line B the propagation delay and the attenuation can be obtained.

2nd test

Repeat the 1st test exchanging the connection of sine wave generator (now to line B) with its terminating resistor and oscilloscope (now to line A).

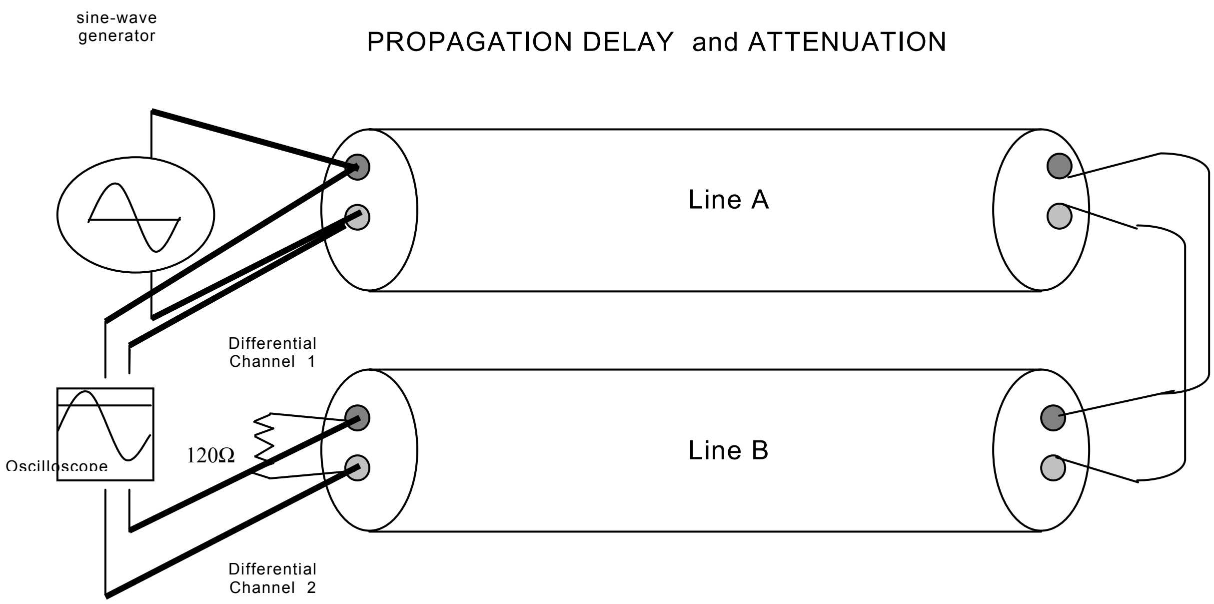

Figure 56 – Propagation delay and attenuation

6.3.3 WTB Link_layer capabilities

6.3.3.1 Test bed preparation

The tests at WTB level are functional tests. They shall be performed with the coach tester, that includes two reference nodes and can be connected to the vehicle on one end or at the same time on both ends.

From PICS, some important information is available about the vehicle node, especially its SW version (at TCN and application level) and the default value of the sink process variables expected by the vehicle WTB node. The coach tester nodes shall be configured with a SW that is compatible with a TCN stack of the vehicle node and, if the vehicle application requires it, also with the application SW.

The tests are performed with the WTB node of the vehicle powered up. The vehicle is connected by the end connectors to the coach tester, according to the sequence of coupling and decoupling described in the different test steps.

The vehicle node is configured according to its capabilities and, during the test, it shall be possible to select all provided functions.

6.3.3.2 Inauguration test

The inauguration test is performed between the vehicle node (without any SW modification) and one node in the coach tester, connected through the WTB connector(s) on one end.

If the vehicle has a redundant line configuration (A and B), both lines have to be connected to the coach tester.

In any case, the tests are repeated on both ends of the vehicle.

On the end side not connected to the network, the presence of detect frames shall be checked, with an oscilloscope or with an analyser.

The possible vehicle node types are declared in the PICS. The following test cases shall be checked, if available:

- if the VUT node is a weak master, the coach tester commands the following test cases:
  a) coach tester node type: permanent slave, the inauguration ends with the VUT node as a network master;
  b) coach tester node type: strong master, the inauguration ends with the coach tester node as a network master;
  c) coach tester node type: weak master, the inauguration ends with one of the nodes as a network master;
- if the VUT node is a strong master, the coach tester commands the following test cases:
  a) coach tester node type: permanent slave, the inauguration ends with the VUT node as a network master;
  b) coach tester node type: strong master, the inauguration is not completed in 2 s (and it will not be able to be completed at all) and a master conflict occurs. It shall be detected and shown;
  c) coach tester node type: weak master, the inauguration ends with the VUT node as a network master;
- if the VUT node is a permanent slave, the coach tester commands the following test cases:
  a) coach tester node type: permanent slave, no inauguration occurs (time-limit: 2 s for test purposes, but it never occurs under this configuration), no detect frames are found;
  b) coach tester node type: weak or strong master, the inauguration ends with the coach tester node as a network strong master.

The tests are performed between the vehicle and the coach tester, configured in a different node type for each test phase, according to the list.

The different test steps perform some inaugurations under different conditions, to check the right function. They shall be driven by the coach tester, through the HMI, where the results are shown.

Before starting the test, the node shall be active, in powered up state (not in sleep mode). Its node type (strong master, weak master, permanent slave) shall be set.

- Test with vehicle node type “weak master”.

Before plugging the coachtTester node, check that on the connector(s) on both ends of the vehicle the detect frames are found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ± 4,0 ms) shallo be seen on the WTB lines A and B.

The coach tester node is configured as a permanent slave. Plug WTB lines (A and B) of the vehicle (end 1) with the corresponding ones of the tester (DIR1). An inauguration occurs and shall be completed within 1 s. If not, after 2 s, a timeout shall lock the test and send to the HMI an error message, otherwise the final result of the inauguration shall be:

- the vehicle node is the master (TCN address = 01);
- the coach tester node address is 63;
- the network consists of 2 nodes;
- the inauguration phase is completed in the time range 25 ms – 1 s;
- on the connector(s) on end 2 the detect frames shall be found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ± 4,0 ms) shall be seen on the WTB lines A and B.

Then the coach tester is configured as a strong master. This causes a new inauguration, that shall be completed within 1 s. If not, after 2 s, a timeout shall lock the test and send to the HMI an error message, otherwise the final result of the inauguration shall be:

- the vehicle node is the slave (TCN address = 63);
- its orientation is opposite to the master (M=2);
- the coach tester node address is 01;
- the network consists of 2 nodes;
- the inauguration phase is completed in the time range 25 ms – 1 s;
- on the connector(s) on end 2 the detect frames shall be found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ±4,0 ms) shall be seen on the WTB lines A and B.

At last, the coach tester is configured as a weak master. A new inauguration occurs, it shall be completed within 1 s. If not, after 2 s, a timeout shall lock the test and send to the HMI an error message, otherwise the final result of the inauguration shows:

- the network consists of 2 nodes;
- the inauguration phase is completed in the time range 25 ms – 1 s;
- on the connector(s) on end 2 the detect frames have to be found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ±4,0 ms) have to be seen on the WTB linse A and B;
- the TCN address of the vehicle node can be 01 or 63. If 63, the orientation is opposite to the master (M=2).

The same test shall be repeated with lines A and B of the vehicle (End 2) plugged with the tester (always DIR1). The results are the following:

coach tester configuration: permanent slave.

- The vehicle node is the master (TCN address = 01).
- The Coach Tester node address is 02.
- The network consists of 2 nodes.
- The inauguration phase is completed in the time range 25 ms – 1 s.
- On the connector(s) on end 1 the Detect Frames have to be found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ±4,0 ms) have to be seen on WTB line A and B.

Coach tester configuration: strong master:

- the vehicle node is the slave (TCN address = 63);
- its orientation is like the master (M=1);

- the coach tester node address is 01;
- the network consists of 2 nodes;
- the inauguration phase is completed in the time range 25 ms – 1 s;
- on the connector(s) on end 1 the detect frames shall be found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ±4,0 ms) shall be seen on the WTB lines A and B.

Coach tester configuration: weak master:

- the network consists of 2 nodes;
- the inauguration phase is completed in the time range 25 ms – 1 s;
- on the connector(s) on end 1 the detect frames shall be found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ±4,0 ms) shall be seen on the WTB lines A and B;
- the TCN address of the vehicle node can be 01 or 63. If 63, the orientation is like the master (M=1).

- Test with vehicle node type "strong master".

Before plugging in the coach tester node, check that on the connector(s) on both ends of the vehicle the detect frames are found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ±4,0 ms) shall be seen on the WTB lines A and B.

The coach tester node is configured as a permanent slave. The actions and the results are the same as for the weak master vehicle node.

Then the coach tester is configured as a strong master. An inauguration of a network with two strong masters cannot occur and a master conflict shall be detected by the coach tester and shown on the HMI. After 2 s, a timeout stops the inauguration operation without a positive conclusion.

At last, the coach tester is configured as a weak master. An inauguration occurs and shall be completed within 1 s. If not, after 2 s, a timeout shall lock the test and send to the HMI an error message, otherwise the final result of the inauguration shall be:

- the vehicle node is the master (TCN address = 01);
- the coach tester node address is 63;
- the network consists of 2 nodes;
- the inauguration phase is completed in the time range 25 ms – 1 s;
- on the connector(s) on end 2, the detect frames shall be found. Pulse sequences of approximately 50 µs every 25 ms (with a tolerance of ±4,0 ms) shall be seen on the WTB lines A and B.

The same test has to repeated with lines A and B of the vehicle (end 2) plugged with the tester (always DIR1). The results are the following:

coach tester configuration: permanent slave. The actions and the results are the same as the weak master vehicle node.

Coach tester configuration: strong master. An inauguration of a network with two strong masters cannot occur and a master conflict shall be detected by the coach tester and shown on the HMI. After 2s, a timeout stops the inauguration operation without a positive conclusion.

Coach tester configuration: weak master. The actions and the results are the same as for the weak master vehicle node.

- Test with vehicle node type “permanent slave”.

Before plugging in the coach tester node, check that on the connector(s) on both ends of the vehicle, the detect frames are not found.

The coach tester node is configured as a permanent slave. Plug WTB lines (A and B) of the vehicle (end 1) with the corresponding ones of the tester (DIR1). No inauguration occurs and after 2 s, a timeout shall stop the test and alerts the HMI that the inauguration has not occurred.

Then, the coach tester node is configured as a strong or weak master. That causes an inauguration, that shall be completed within 1 s. If not, after 2 s a timeout shall lock the test and send to the HMI an error message, otherwise, the final result of the inauguration shall be:

– the vehicle node is the slave (TCN address = 63);
– its orientation is opposite to the master (M=2);
– the coach tester node address is 01;
– the network consists of 2 nodes;
– the inauguration phase is completed in the time range 25 ms – 1 s;
– on the connector(s) on end 2, the detect frames shall be found. Pulse sequences of approximately 50 μs every 25 ms (with a tolerance of ±4,0 ms) shall be seen on the WTB lines A and B.

The same test shall be repeated with lines A and B of the vehicle (end 2) plugged with the tester (always DIR1). The results are the following:

coach tester configuration: permanent slave. The actions and the results are the same as the connection to vehicle end 1.

coach tester configuration: strong or weak master. This causes an inauguration, that shall be completed within 1 s. If not, after 2 s, a timeout shall lock the test and send to the HMI an error message, otherwise, the final result of the inauguration shall be:

– the vehicle node is the slave (TCN address = 02);
– its orientation is opposite to the master (M=1);
– the coach tester node address is 01;
– the network consists of 2 nodes;
– the inauguration phase is completed in the time range 25 ms – 1 s;
– on the connector(s) on end 2 the detect frames shall be found. Pulse sequences of approximately 50 μs every 25 ms (with a tolerance of ±4,0 ms) shall be seen on the WTB lines A and B.

- Inauguration test – vehicle node as intermediate node.

This test requires both coach tester nodes. They shall be configured as weak master. The coach tester node 1 is connected with its DIR1 to end 2 of the vehicle. The coach tester node 2 is connected with its DIR2 to end 1 of the vehicle. The configuration of the network is the following:

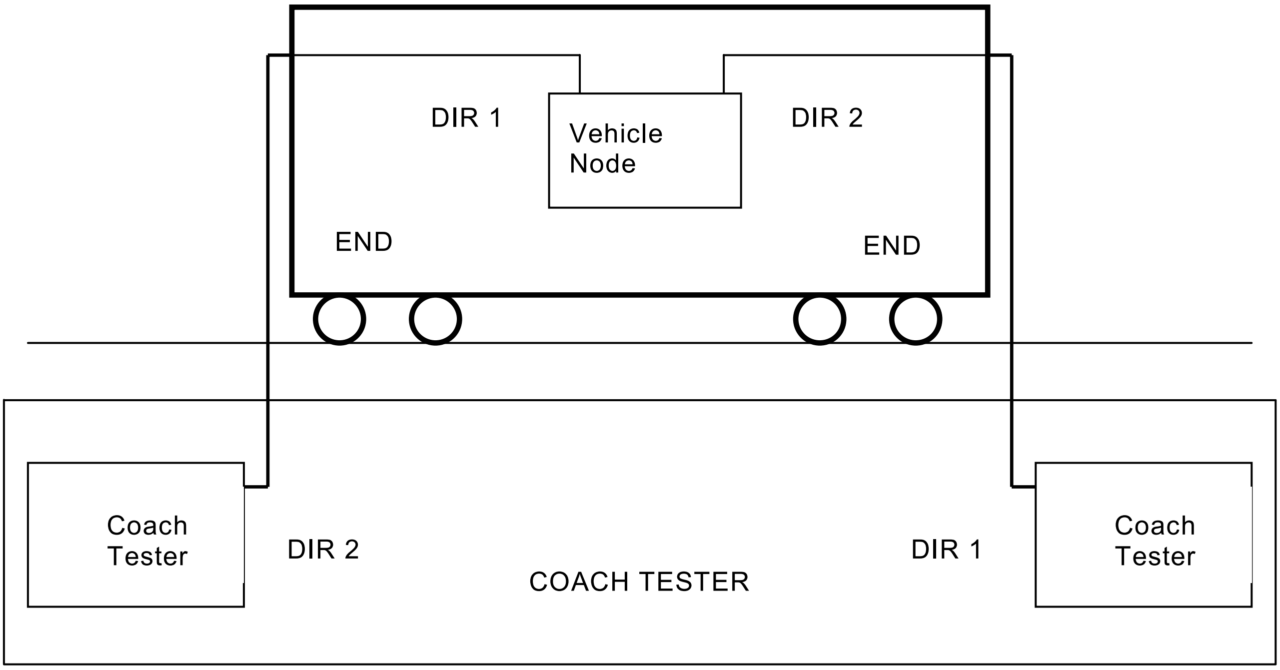

Figure 57 – Coach tester nodes

As initial state, the coach tester nodes and the vehicle node have completed the start-up phase before the plugging of the external connectors.

When the connection between coach tester node 1 and end 2 of the vehicle is performed, a network with 2 nodes is inaugurated. One node is the master, the other one is the slave. The vehicle node is in end node state.

When the connection between coach tester node 2 and end 1 of the vehicle is performed, a new inauguration occurs. The network consists of three nodes, one is the master and the other two are slaves.

About the results of the inauguration, they shall be in compliance with the TCN standard. In particular, the following parameters shall be checked:

– the orientation of all three nodes is 01;
– the TCN address of the master is 01. If coach tester node 1 is the master, the vehicle node has the TCN address = 63. If the coach tester node 2 is the master, the vehicle node TCN address is 02;
– switch off the vehicle node, without decoupling it from the other two nodes. If the vehicle node is not the network master, no inauguration occurs. Switch on the vehicle node, no inauguration occurs, the TCN address of the nodes remains unchanged.

If the vehicle node is the network master, when it is switched off a new inauguration occurs, and one of the two coach tester nodes becomes the new network master.

In all cases, the inauguration time lasts not less than 25 ms and not more than 1 s. The results of each test step shall be shown through the HMI within 2 s from the start of the single step. A timeout shall be provided to alert the HMI if a test has not reached an end.

6.3.3.3 Regular operation test

The TCN standard requires some tests on 3 million of transmitted frames (see 4.2.6.3.3 to 4.2.6.3.6).

With a basic period of 25 ms (in a network with two nodes only, it is possible to obtain an individual period equal to the basic period), the transmission of 3 000 000 frames takes a long time (75 000 s, that means more than 20 h).

The correctness of the data received by the VUT node is unknown out of the node itself (the statistic data, defined in 4.8.4.22.2 of IEC 61375-1 are available to the application on the same node).

As a consequence, the test can be performed in the following way:

– the coach tester is set to strong master node type;
– after the inauguration of the network with VUT and coach tester, a regular operation phase of 75 000 s is set up. In that time, every 25 ms the master sends a master call to the VUT node and it replies with its data port;
– the coach tester node checks that in the same time no inauguration occurs and that the timeouts_count (4.8.4.22.2 of IEC 61375-1) does not overflow the threshold of “3” errors;
– if the VUT node receives an erroneous frame, it does not answer properly (or it does not at all) and it can be checked by the coach tester node.

This test lasts very long (more than 20 h). As a basic test, a faster test can be used, but it gives only a general overview of the proper regular operation. It requires that a test SW at application level is included in the tester.

This test SW should be able to check the freshness of data sent through WTB by the vehicle node, when the network consisting of 2 nodes (vehicle node and coach tester) is inaugurated and working in regular operation. It should give the maximum time between two close data refresh. From the theoretical point of view, this refresh time should be 25 ms, but due to the not-synchronisation between TCN stack and application, this time could be doubled.

The test should last at least 10 min, the network should be stable (without new inauguration in the meantime) and the maximum value of the refresh counter should not exceed 50 ms.

6.3.3.4 WTB line redundancy switch over

This test is applicable to redundant line configuration (WTB lines A and B).

The transmitted frames have to be available on both lines; in reception, the best quality line is considered “trusted”, the other one “observed”. All tests have to be performed with WTB segment between vehicle and coach tester working with line A trusted (and B observed) and repeated with line B trusted (and A observed).

The coach tester shall be configured as a strong master. In the initial state, the network is working with the WTB lines both connected properly. The following steps shall be performed:

a) check that the transmission skew of the electrical signals on lines A and B is less than 32,0 µs;
b) then, it sends frames on line A only. It becomes the trusted line for the VUT. The operation is correct if the VUT reply is correct;

c) then, the tester switches the transmission from line A to line B only (an intermediate state of A and B working is necessary, but it shall be as short as possible, less than 32 µs). The VUT reply will not affect from the operational point of view (the switchover from line A to line B for the VUT shall not cause any error);

d) the test continues with lines A and B both working properly, then the test shall be repeated as before, but exchanging A and B, by sending frame at first on line B only, then on line A only and then on lines A and B. The VUT replies will remain unaffected.

In this test, the use of a protocol analyser could help the real measurement of the phenomena. If it is not available, the test is done without a precise verification of the switchover timing.

6.3.4 Data test storage

The specified tests do not require the storage of the data, nevertheless, this capability can be very useful, especially in the investigation phase when a fault occurs.

Data can be logged and stored in two different ways:

– by the coach tester node under operation, for example by capturing the different data received during the different test steps;

– by a second node in the coach tester, connected on the WTB between the vehicle and the coach tester operating node. This second node should work as a simple “listener” and, as a consequence, not participating in the activity on the WTB. Its configuration should be with line relays closed.

Data should be stored under the conditions required by the HMI. The elaboration and visualization of the stored data shall be performed off line.

6.4 MVB interoperability test

It is not considered, because the vehicle is considered as a black box accessible by the WTB only.

6.5 Application profile

The application profile test is beyond the scope of the TCN conformance test and is not considered.

6.6 Several nodes on the vehicle

This standard considers the application of the conformance procedures as for a single node, the same profile is replicated for the other nodes installed in the vehicle. Application profile (e.g. UIC 556) tests are beyond the scope of this conformance test and are not considered.

7 Conformance test of NM

From the survey done by the PT61375-2 no network management services are implemented in real TCN devices except user customised services like upload and download of node supervisor data base and upload and download of executable object code.

Following this situation, no reason to develop NM test suites exist for the time being.

Annex A
(normative)

Test laboratory role and client role

A.1 Test laboratory and client role

A.1.1 General

The test laboratory is responsible for conducting the conformance assessment of the TCN implementation at the request of a client. Typically, test laboratories are:

a) organisations developing or supplying TCN implementations. In this case, they are called first-party test laboratories and belong to a TCN manufacture/supplier;

b) organisations willing to verify TCN implementations themselves before using them. In this case ,they are called second-party test laboratories and belong to a TCN user;

c) organisations, independent of suppliers or users of TCN implementations, whose business is the testing of such implementations. In this case, they are called third-party test laboratories.

The client is responsible for the conformance statements accompanying the IUT and for the configuration of the IUT itself. Typically, clients are:

d) implementers or suppliers of TCN IUT who are applying for their own implementations to be tested;

e) procurers of those implementations, or any other interested party.

The applicability of this standard is independent of the relationship between the client and the implementation so the client is referred throughout this standard as the IUT supplier.

A.1.2 Overview

The purpose of this annex is to specify the role, relating to both the test laboratory and the client, with reference to the conformance assessment process that is divided into three phases:

a) preparation for testing;
b) test operation;
c) production of test reports.

The laboratory role, that is specified by the following subclauses of this annex, is applicable equally to those test laboratories which are affiliated to suppliers or procurers, and those which are independent.

The following are outside the scope of this annex:

a) the production of diagnostic trace information, additional to that in the conformance log, for the results of testing performed by the test laboratory, and its supply to the client;
b) aspects of test laboratory operations which are not specific to testing implementations of TCN protocols;
c) accreditation of test laboratories.

A.2 Preparation for testing

This preparatory phase is performed through the execution of the following steps:

a) general administrative steps;

b) agreement on test methods and selection of test suites;

c) exchange of documentation for conformance assessment;

d) preparation of the IUT and the MOT (mean of test) for the testing configuration that results from the choice of step number 2.

During the preparation phase and, generally, during the conformance assessment process, technical issues may arise, because of incompatibility between the characteristics of the IUT and those of the test equipment and test methods provided by the test laboratory. There are no general requirements concerning procedures for the resolution of such technical issues. However, should differences be discovered between the conformance testing standard and the protocol standard, the protocol standard shall have precedence in problem resolution.

A.2.1 General administrative steps

The general administrative steps are:

- the application form and the provision of information about the IUT by the IUT supplier;
- the provision of documents, describing the general policy, terms and conditions to be followed during test operations, by the test laboratory.

A.2.2 Agreement on test methods and selection of test suites

The agreement is based on the exchange of checklists (IUT supplier checklist and test laboratory checklist) and the successive review of such a checklist in order to reach a basic agreement on the test methods and the selection of the test suites. This is a preliminary activity that is completed by the further activities indicated in Clause A.2.

A.2.2.1 Test laboratory role

The test laboratory shall review the IUT supplier checklist and shall determine if the test laboratory offers a testing service which is applicable to the client's proposed IUT. The test laboratory shall evaluate the client's choice of test suites in the proposed IUT (see A.2.2.2 of this annex) and shall select the corresponding reference standardised test suites to be used in the conformance assessment process.

For each test suite, the test laboratory shall identify the test equipment and test methods that will be used.

A.2.2.2 IUT supplier role

The IUT supplier shall review the test laboratory checklist and shall make the choice of which test methods are to be used for test suites in the proposed IUT in accordance with the claims for IUT testability and the testing service offered by the test laboratory.

A.2.3 Exchange of documentation for conformance assessment

After the test laboratory and IUT supplier have agreed on the definition of the IUT and on the test suites and test methods to be used during the conformance assessment, they exchange detailed information about the IUT. This information resides in documents related to test preparation: the PICS, PIXIT and any other relevant documents such as identification data for the IUT and the description of the implementation of hardware and software means for testing.

A.2.3.1 PICS

A.2.3.1.1 Test laboratory role

There is no requirement of the test laboratory for the provision of PICS for use by the client. However, the test laboratory may provide copies of the relevant PICS if necessary.

A.2.3.1.2 IUT supplier role

The IUT supplier shall provide a PICS for each TCN standardised device which is implemented in the IUT and for which conformance is to be tested.

The IUT supplier shall complete the relevant PICS. The requirements for the provision of PICS information are stated in this standard.

A.2.3.2 PIXIT

The role and scope of the PIXIT is to give requirements and further guidance on the structure and implementation of the IUT and the means of testing.

A.2.3.2.1 Test laboratory role

The test laboratory shall produce a PIXIT for each standardised test suite for which testing is offered.

A.2.3.2.2 IUT supplier role

The IUT supplier shall provide a PIXIT for each standardised test suite to be used for testing, by completing the relevant PIXIT provided by the test laboratory with the information relevant to the IUT.

A.2.3.3 Any relevant documents

The relevant documents, provided by the IUT supplier, contain the following information as a minimum:

– information related to both the IUT and IUT supplier:

- administrative information to identify the client, in case that supplementary information is considered useful by the IUT supplier in addition to that included into the clauses that report respectively the PICS called identification of the IUT supplier and identification of the implementation under test;

Further more, it may be useful to provide a description of the means for testing provided by the IUT supplier and the test equipment used by the test laboratory.

A.2.3.4 Preparation of the IUT and the MOT

This activity consists in the test bed setup where the IUT and the test equipment are connected together.

A.2.3.4.1 Test laboratory role and IUT supplier role

The test laboratory operator and the IUT supplier operator shall co-operate in the activity of physical connection between the test equipment and the IUT. Some technical issues may arise like physical interface problems, in such a case an agreement shall be found between the test laboratory and the IUT supplier in order to solve such problems.

A.3 Test operation

This operational phase is performed through the execution of the following steps:

a) static conformance review;
b) selection of test cases and test parameterisation;
3. test campaign.

A.3.1 Static conformance review

During the static conformance review, the PICS and any other relevant documentation supplied by the IUT supplier shall be submitted for review.

A.3.1.1 Test laboratory role

The test laboratory shall:

- verify that the PICS are self-consistent;
- verify that the PICS are consistent with the static conformance requirements specified in this standard and in the IEC 61375-1 to which the IUT is claimed to conform. As a minimum, the following checks shall be made for consistency between the PICS and the static conformance requirements:
  – for each item which is indicated as mandatory in the status column, check that the item is indicated as supported;
  – for each item which is indicated as optional and from which a defined subset are supported, check that the indications of support are consistent with the requirement;
- verify the consistency of the information presented in the PIXIT and in any other relevant documents submitted by the IUT supplier;
- inform the client of the results of the static conformance review before continuing with the conformance assessment process.

A.3.1.2 IUT supplier role

The client shall review the results of the static conformance review performed by the test laboratory.

A.3.2 Selection of test cases and test parameterisation

The selection of test cases and test parameterisation consist in:

- selection of all those test cases appropriate for the IUT, based on the information in the PICS, PIXIT and any other relevant documents submitted by the IUT supplier, in accordance with the requirements of its reference standardised test suites of this document.

A.3.2.1 Test laboratory role

A.3.2.1.1 Test cases selection

The test laboratory shall select the following test cases provided that they are testable according to the PICS, PIXIT and any other relevant documents submitted by the IUT supplier:

- all capability test cases for mandatory capabilities;
- all capability test cases for optional or conditional capabilities that are present in the IUT according to the PICS;
- all behaviour test cases for mandatory capabilities;

- all behaviour test cases that are consistent with the optional or conditional capabilities that are present in the IUT according to the PICS.

A.3.2.1.2 Test cases parameterisation

After the selection of all test cases, the information provided in the PIXIT and in any other relevant document shall be used to determine the appropriate values for each parameter in those test cases, in accordance with the documentation of the means of testing and with the requirements of its reference standardised test suites. The resulting parameterised executable test suite is then ready to be executed on the IUT.

Examples of types of parameterisation are:

- values of network addresses;
- values of counters;
- values of timers;

This list is not exhaustive.

A.3.2.2 IUT supplier role

A.3.2.2.1 Test cases selection

For the test selection, further to providing the PICS, PIXIT and any other relevant documents, the IUT supplier shall inform the test laboratory whether or not basic interconnection testing should be performed during the test campaign.

A.3.2.2.2 Test cases parameterisation

There are no requirements of the client during test parameterisation.

A.3.3 Test campaign

A test campaign is the process of executing the selected and parameterised test suites for a particular IUT and producing information required for the conformance log.

A.3.3.1 Test laboratory role

During the test campaign, the test laboratory shall execute all the test cases relevant to the selected test suites and establish for each test case, which one of the following results applies:

a) pass verdict;
b) fail verdict;
c) inconclusive verdict;
d) test case error;
e) executable test case error;
f) abnormal test case termination.

For each test case that produced a fail verdict, the test laboratory shall assess whether the verdict was associated with an unidentified test event in the test case. If this is not the case, the test laboratory shall record the fail verdict for this test case in the protocol report. If this is the case, the test laboratory shall determine whether there is a test case error, that is, whether the event which matched the unidentified test event was valid according to the protocol and should have been defined in the test case. If so, the test laboratory shall indicate in the protocol report that the test case was “not run” together with the reason why.

For each test case that produced an inconclusive verdict, the test laboratory shall re-run the test case at least once. If a pass or fail verdict is produced during a subsequent execution, that verdict shall be recorded in the protocol report. If an inconclusive verdict is produced during subsequent execution(s) of the test case and the test case behaviour is the same as in previous executions, the inconclusive verdict shall be recorded in the protocol report.

For each test case that has a test case error, the test laboratory shall indicate in the protocol report that the test case was “not run” together with the reason why.

For each test case that produced either an executable test case error or an abnormal test case termination result, the test laboratory shall re-run the test case. If the same result is produced, the test laboratory shall indicate in the protocol report that the test case was “not run” together with the reason why.

A.3.3.2 IUT supplier role

The client shall ensure that the IUT and, if required, an IUT operator are available throughout the agreed test campaign period. The client shall co-operate with the test laboratory to make any changes to the IUT or its environment which are required in order to enable execution of all the test cases and shall review the documentation of such changes.

There are no requirements on the client concerning analysis of verdict assignments. However, during the test campaign, the client may request a re-run of any test case that produced a fail verdict, if not satisfied that the test case correctly diagnosed an error in the IUT.

A.4 Production of test reports

This culminating phase is performed through the execution of the following steps:

a) IUT conformance test report;

b) protocol conformance test report;

The report listed at line 1 shall be produced by the test laboratory while the test report listed at line 2 shall be produced in case that it is requested by the IUT supplier.

A.4.1 IUT conformance test report

IUT conformance test report provides a summary of the results of the conformance testing performed on the supplier's IUT.

A.4.1.1 Test laboratory role

The test laboratory shall produce the report using a pro-forma that includes:

- the list of reference standardised test suites against which testing has been carried out, together with their dates of publication of this standard;
- eventually, details of any amendments or addenda with which the IUT is claimed to conform;
- a brief explanation of the nature of the TCN testing and in particular that there is no guarantee that the IUT that has passed all the tests will inter-operate with other real TCN systems;
- clear and unambiguous statements if non-conformance has been demonstrated in any of the test cases, or if any areas of concern have been observed;
- recording of the agreement between the test laboratory and the client on the definition of what part(s) of the system, that is/are submitted to the TCN testing, is/are considered to be the IUT during testing.

The report shall be made available to the client by the test laboratory at the end of the conformance assessment process.

A.4.1.2 IUT supplier role

There are no requirements on the client role during the production of the report.

The client should review the report and, in the case of disagreement with the test laboratory over its content, should supply comments to be filed, as an annex, on the report itself.

A.4.2 Protocol conformance test report

At the client's request, the test laboratory shall provide an accompanying documentation for each test suites and test case for which conformance testing has been carried out during this conformance assessment process.

A.4.2.1 Test laboratory role

The test laboratory shall produce the report using a pro-forma that includes:

- a list of the test suites and test cases which were selected;
- a list of the test suites for which corresponding executable test cases were run to completion during the test campaign;
- the verdicts assigned to those test cases that were run to completion;
- observations (if any) made by the test laboratory during the test campaign;
- a list of test cases which are selected but reported as being “not run” They include those which produced a test case error or an abnormal test case termination;
- conformance logs on paper or on magnetic support readable for the IUT supplier.

A.4.2.2 IUT supplier role

The client shall inform the test laboratory whether or not the protocol conformance test report and the associated conformance logs are to be provided.

The client should review the report and, in the case of disagreement with the test laboratory over its content, should supply comments to be filed, as an annex, on the report itself.

Annex B
(informative)

Test instrumentation and dedicated test bed

B.1 Test instrumentation

B.1.1 Standard instrumentation

B.1.1.1 MVB test suites standard instrumentation

The standard instruments for test suites shall be chosen by the laboratory according to the specifications given by the relevant clause of this standard. All standard instruments used, type, brand, and primary characteristics shall be listed and reported on the specific IUT's report. All tolerances, precisions, accuracies, repeatability, stability of the standard instruments shall be better than or equal to those specified by the relevant tested clause.

B.1.2 Test bed architecture

The test bed is implemented by the relevant testing train configuration that shall support the following manipulations in the testing train configuration itself:

- testing of an MVB device;
- testing of a WTB device;
- coupling and uncoupling of WTB devices;
- turning on and off of nodes;
- redundancy switching over.

Furthermore, it is necessary to attach the TCN test equipment to the relevant node that shall perform the action as it is specified in the test sequence.

The TCN test equipment and a line monitor, when necessary, are needed in order to log the results of the action and check them for the qualitative and quantitative aspects.

It is not required that the IUT and the reference node, when necessary, have exposed interfaces dedicated to the purpose of the test, the existing WTB and MVB interfaces are sufficient and the TCN tester is believed to be normally attached to the MVB interface of the relevant TCN gateway that causes the action or, when the MVB or the WTB bus is not used by the node, to the application interface of the node itself.

The monitoring and logging of the results are performed by instrumentation devices attached to the WTB and/or MVB interface (may be the TCN test equipment itself that provides such capabilities).

Nevertheless, if the node provides a service interface, this interface may be used to provide the logging data to a PC unit.

In order to reduce the testing cost and the total duration of the testing, a full automation of the testing sequences is suggested but not required.

The advantage of full automation consists also in reducing the human errors and in obtaining an automatic print-out of the results and checks.

The main areas to be automated are:

- the coupling and uncoupling of the WTB connection between the nodes of the testing train configuration in order to control by means of the TCN equipmen,t the shortening and the lengthening of the configuration;
- the power on and off of the WTB nodes in order to control by means of the TCN equipment the simulation of the node failure and node re-insertion;
- the power on and off of the MVB device in order to control by means of the TCN equipment the simulation of the device failure and its re-insertion;
- the switch-over of the redundant MVB line in order to control in a precise and simultaneous way the taking over of the redundant line;
- the switch-over of the redundant node in order to control in a precise and simultaneous way the taking over of the redundant node;
- the test sequencing and reporting.

The architecture is depicted in the following figure, shows the stimulus, monitoring and logging of the results that is performed by instrumentation devices attached to the WTB and/or MVB interface. A testing application program, very simple and loaded into the IUT, shall interact and respond to the stimulus sent by the instrumentation.

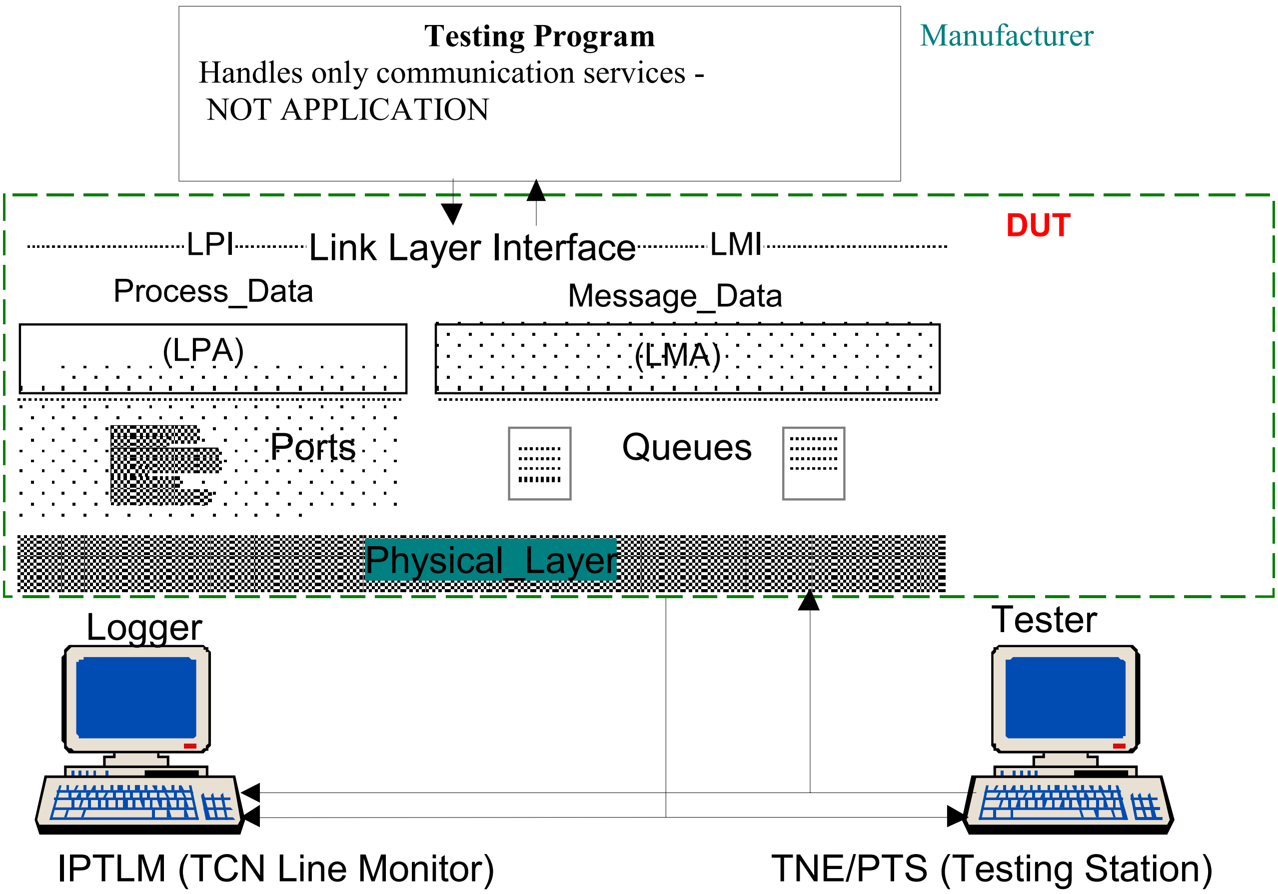

Figure B.1 – Hardware test bed architecture

B.1.2.1 MVB repeater test bed configuration

The following figures show the test bed configurations for MVB repeater testing.

The test bed configuration MRTB1 is shown in the following figure.

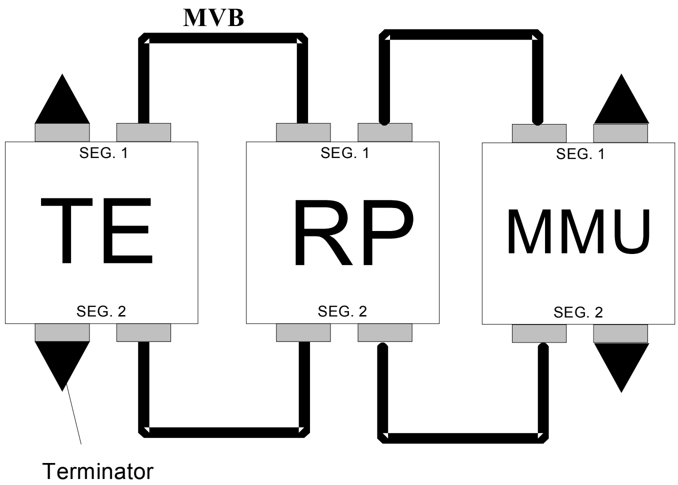

Figure B.2 – Test bed configuration MRTB1

The test equipment shall be able to:

- generate good and faulty master and slave frames on both lines A and B;
- control timing of frames in order to generate any required timing for test purposes.

The test bed configuration MRTB2 is shown in following figure.

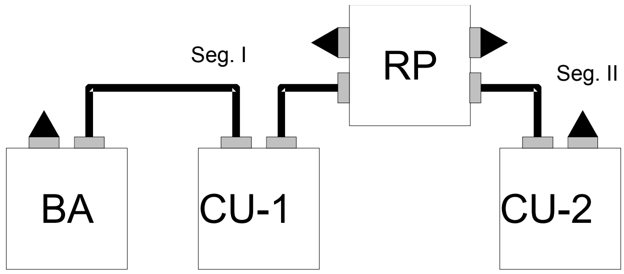

Figure B.3 – Test bed configuration MRTB2

Because the aim of this test bed is to analyse the influence of the repeater on the communication between MVB devices, a monitoring and measuring unit will be connected to both segments to check the expected test results. The position of the monitoring and measuring unit is the one that is suitable to read the frames seen by the bus administrator and by the control unit 2.

B.1.3 Coach tester specification

B.1.3.1 General information

The coach tester is equipped with two WTB nodes. These nodes have been previously submitted to a TCN conformance device test.

The tester includes a PC, suitable to control the different test steps and show the results. Where required, it is able to elaborate the received data and give further details (as diagram, statistics, etc.) in a friendly way. It can perform a post-elaboration (off line) of the collected data.

The communication between WTB node and PC is realised through an internal bus; the use of MVB is strongly recommended. A serial link between the two entities can be added, if useful.

It is recommended that the tester includes also the measure instruments (like oscilloscope, signal generators, resistance meter) necessary to perform the test of the physical layer.

If some constraints coming from the customer (especially regarding the size and the weight) make this integration not possible, it is recommended to include at least the basic required functionalities and use traditional instruments to perform other measurements.

B.1.3.2 Coach tester architecture

The coach tester is based on a Human Machine Interface (HMI),it may be a PC, that is loaded with the test application software. As shown in the following figure, the coach tester includes two nodes that are connected together by the MVB and are controlled by the HMI through the MVB itself. It is suggested that the HMI is able to control the measuring instruments too.

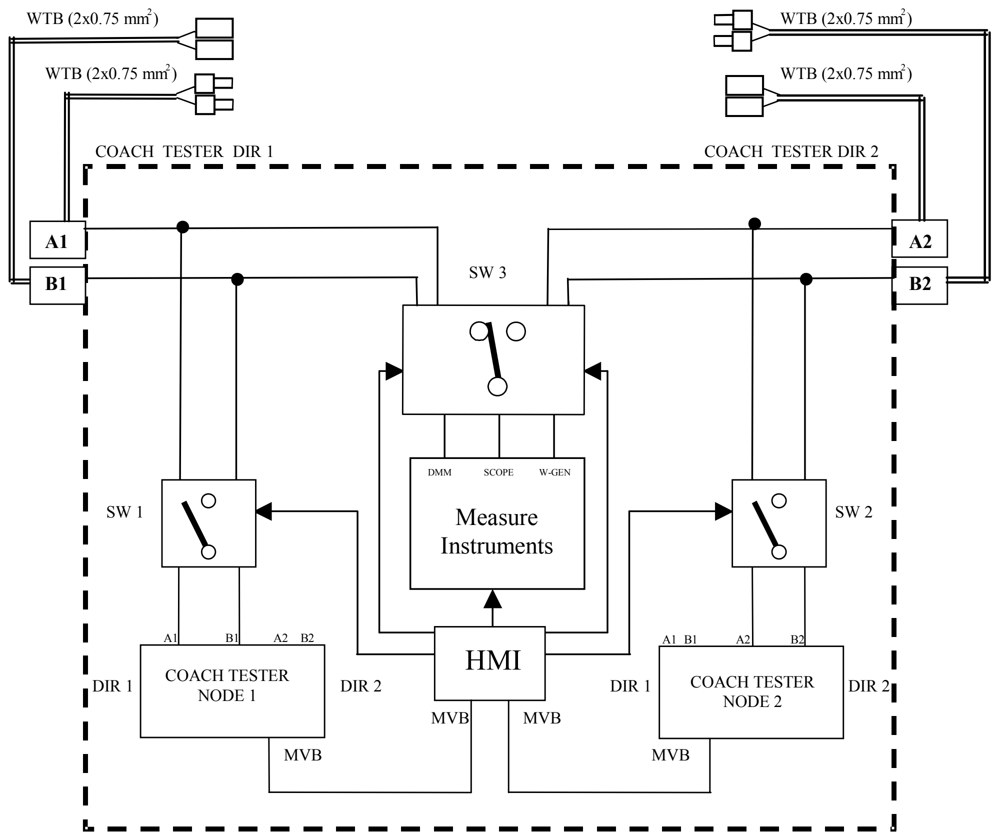

Figure B.4 – Coach tester architecture

The measuring instruments can be connected to the A1/B1 connectors or to the A2/B2 connectors, so that there is the possibility to perform physical measurements on one VUT end when the other one is connected to a coach tester node.

Different test steps are driven through a user friendly HMI.

B.1.4 Physical tests

During the execution of the physical tests, the vehicle node shall not be powered (its power supply is in electrical off state).

Physical tests are performed according to the specification (see 6.3), by remote control from a computer (HMI) with an HMI on the measuring instruments.

A dedicated software will be present and running in the PC to carry on the tests.

Switches SW1 and SW2 are open. In this way, the coach tester nodes are not connected to respective WTB connectors.

Switch SW3 connects WTB connectors to measuring instruments.

For the r*esistance line test* they are DMM and oscilloscope, but for the *crosstalk test* they are wave generator and oscilloscope.

In particular:

- In the ***resistance line test***

  Setting up the connections on WTB:

  Short cut test

  Left side: DMM

  Right side: a short cut between the line

  Opened test

  Left side: DMM

  Right side: the line is left opened

The PC commands the DMM to start and the measurement is captured.

The s*hort cut test* will pass if the measured resistance is less than 2 Ω.

The o*pened test* will pass if the measured resistance is more than 1 MΩ.

- In the ***crosstalk test***

  Setting up the connections on WTB:

  Line A

  Left side sine-wave generator (4 Vpp, Zt = 120 Ω, 0,5 to 2,0 MHz)

  Right side a 120 Ω resistor.

  Line B

  Left side a 120 Ω resistor and the oscilloscope with two channels connected across the resistor.

  Right side a 120 Ω resistor.

At first, the control will be on the waveform generator to make the sine-wave generator sending a (sinusoidal) waveform at frequencies 0,5 BR and 2 BR (for WTB these values are 0,5 MHz and 2 MHz) into left side of line A.

Afterwards, the remote control will verify on the left side of line B by the oscilloscope that the rejection value is less than 55 dB.

The *crosstalk test* to be complete, should be carried out changing line A with line B and performing all steps described above.

The c*rosstalk test* will pass if the rejection value is less than 55 dB (the maximum read voltage is near 7 mV)

In the ***propagation delay and attenuation tests***

Setting up the connections on WTB:

Line A

Left side: sine–wave generator (4 Vpp, Zt = 120 Ω, 0,5 to 2,0 MHz)

Channel 1 of the oscilloscope.

Right side: a connection to the right side of line B

Line B

Left side: Channel 2 of the oscilloscope.

a 120 Ω resistor.

Right side: a connection to the right side of line A

At first, the control will be on the waveform generator to make the sine-wave generator send a (sinusoidal) waveform at frequency 0,5 BR and 2 BR (for WTB these values are 0,5 MHz and 2 MHz) into the left side of line A.

Afterwards, the remote control will make the oscilloscope capture the signal present on the left side of line A (channel 1) and the signal present at the end (left side) of line B (channel B).

The propagation delay and attenuation values can be calculated automatically.

The maximum value of this delay depends on the vehicle. In the standard, it is fixed at 60 µs, with the maximum length of the bus (860 m), with nodes and WTB repeaters (if included). For a single vehicle the following formula should be applied:

$$T_{pd} = L \times 6,0 + R \times T_{rd}$$

where

T_{pd} is the propagation delay time [in nanoseconds];

L is the length of WTB line (A+B) on the VUT, trunk cable, extension boxes and jumper cables included. The length must be expressed in metres;

R is the number of WTB repeaters on the VUT;

T_{rd} is the repeater delay time introduced by each repeater.

The p*ropagation delay test* will pass if the delay value is less than the T_{pd} value calculated above.

The a*ttenuation test* will pass if the read attenuation is less than the maximum attenuation allocated to a vehicle (0,5 dB).

B.1.4.1 Functional tests

B.1.4.1.1 WTB Link _layer capabilities

These tests are performed with the WTB node of the vehicle powered up.

There are three tests:

a) inauguration;

b) regular operation;

c) WTB line redundancy switch over.

B.1.4.1.1.1 Inauguration

The coach tester node type (permanent slave, strong master, weak master) is selectable by the HMI. The coach tester nodes (DIR1 and DIR2) can be connected to the vehicle ends according to the different test steps.

For example the test with the vehicle node type weak master, can be done in the following way:

To check the presence of the detect frames on both VUT end connectors, plug A1 B1 coach tester connectors to the VUT end1. Through HMI we have to drive the measuring instruments (oscilloscope) to A1 B1 and read the results. The same operation should be repeated on VUT end2.

Then the HMI has to configure coach tester node1 to permanent slave and connect its Dir1 to A1 B1.

Plug A1 B1 coach tester to VUT end1 and perform the inauguration. HMI will show when the results will start and a timer will count the time elapsed between this event and its conclusion. The conclusion event will be noticed by a signal push-up in the coach tester node. With the HMI the information in the topography can be read.

With this connection on the coach tester node, the part on the right of the topography will be:

63	**01**
Coach tester node	Vehicle node

In the same way, the other inauguration test steps can be performed.

B.1.4.1.1.2 Regular operation

The connection between vehicle and coach tester is performed between one end of the connector vehicle and A1/B1 of the coach tester.

The configuration of the coach tester is shown in the following figure.

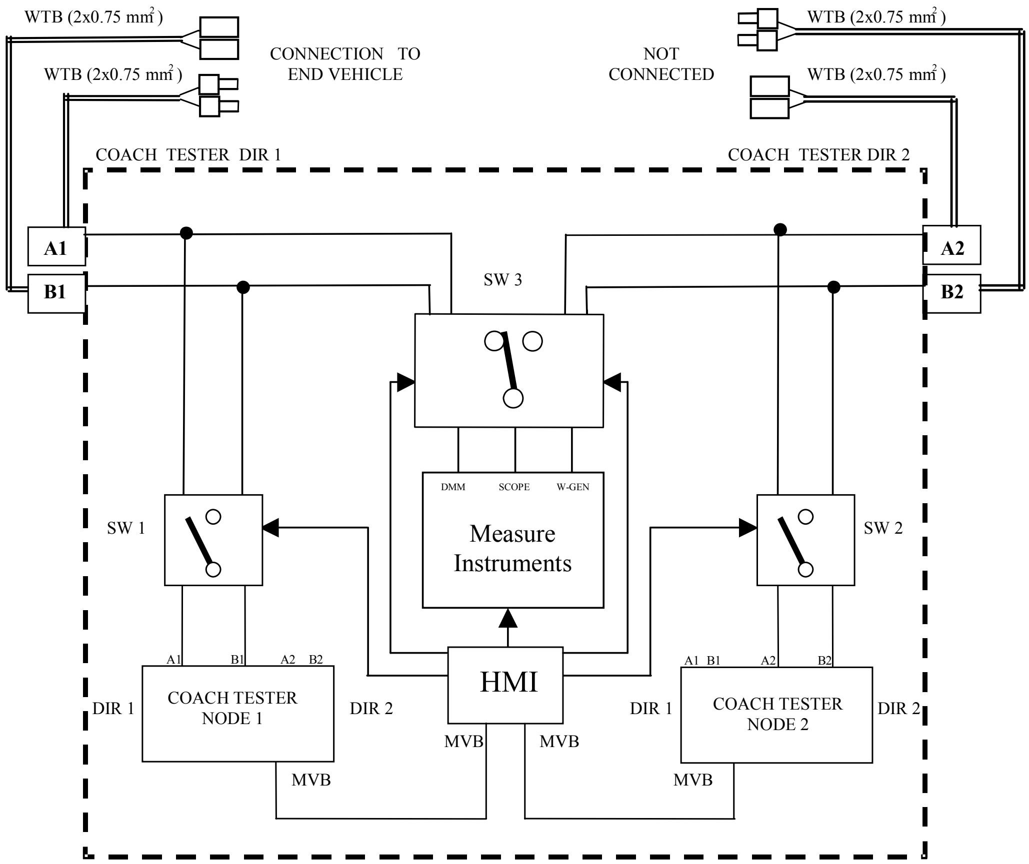

Figure B.5 – Configuration of the coach tester

The coach tester node is the master, the vehicle node is the slave.

The coach tester WTB data port (128 bytes) are set in a default mode. If not specified by the PICS, the default mode is defined as all 128 bytes to 00.

The HMI can read the WTB data port coming from the vehicle node and shows the 128 bytes in hexadecimal byte format.

The user checks on the HMI the counter value and the 128 bytes WTB data. Information about their quality is carried out investigating refresh counter values.

The same test should be repeated setting the vehicle node as master and the coach tester as slave.

The positions of the switches are SW1 and SW2 closed. In this case, coach tester nodes are connected to WTB connectors. SW3 is switched in a way that there are not connections between measuring instruments and lines Ax / Bx.

The principal steps of this test are described below:

- after the inauguration, HMI starts the test with a regular operation phase of 75 000 s, making the start to its counter;
- after this, it continuously checks that no inauguration occurs;

- every 25 ms, the coach tester sends a master call to the VUT. If the VUT does not reply after a short time a fail occurs and a counter (timeout_count) in the coach tester will be upgraded;
- the test finishes when 75 000 s elapses. It will be considered PASSED if timeout_count does not overflow the threshold of '3' errors.

B.1.4.1.1.3 WTB line redundancy switch-over

The coach tester should be equipped with measuring instruments able to carry on tests described in 4.3.2.4.

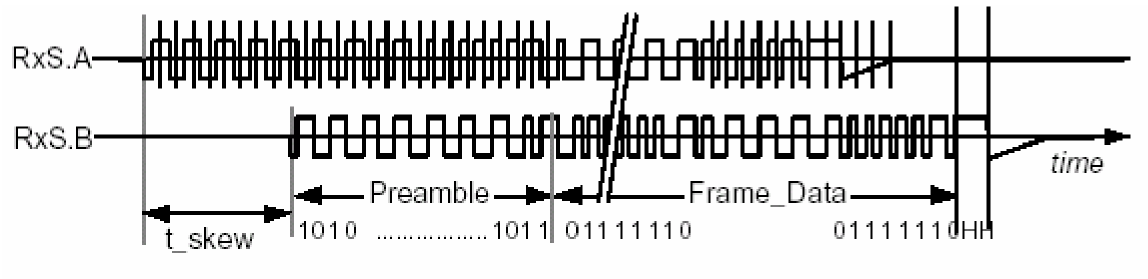

Figure B.6 – WTB line redundancy switch-over

In particular:

- it is able to capture and recognize frames coming from the vehicle node and verify that the skew ('*t_skew*') between the two signals present on Line_A and Line_B is less than ±32,0 μs;
- it is able to drive with the HMI carrying out the following tests:
- master frames sent by the coach tester node on one line only.
- the check of the correctness of the slave reply sent by the vehicle and displayed on the HMI.

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