

INTERNATIONAL STANDARD

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**Electronic railway equipment – Train communication network (TCN) –
Part 2-2: Wire Train Bus conformance testing**

**Matériel électronique ferroviaire – Réseau embarqué de train (TCN) –
Partie 2-2: Bus de Train Filaire – Essais de conformité**



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**Matériel électronique ferroviaire – Réseau embarqué de train (TCN) –
Partie 2-2: Bus de Train Filare – Essais de conformité**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRONIC RAILWAY EQUIPMENT –
TRAIN COMMUNICATION NETWORK (TCN) –****Part 2-2: Wire Train Bus conformance testing**

FOREWORD

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International Standard IEC 61375-2-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This first edition cancels the clauses of IEC 61375-2, first edition, published in 2007, relevant to the specification of WTB conformance testing and constitutes a technical revision.

It was prepared taking into account IEC 61375-2-1, first edition.

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

FDIS	Report on voting
9/1643/FDIS	9/1667/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, under the general title *Electronic railway equipment – Train communication network (TCN)*, can be found on the IEC website.

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

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- withdrawn,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

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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 consists, and
- b) between equipment and devices located within the same consist.

One of the key success factors for the deployment of any technology is the standardisation and 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 the train bus called the Wire Train Bus (WTB).

No other busses are taken into consideration even though they are foreseen by IEC 61375.

WTB has real-time protocols, which offer two communication services:

- c) process variables, a distributed, real-time database, periodically refreshed through broadcasting;
- d) messages, transmitted on demand either as:
 - 0. unicast messages (point-to-point) or/and
 - 1. multicast messages.

WTB has a network management, which allows debugging, commissioning and maintenance over the network.

This standard is structured into 8 clauses and 2 annexes.

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

Table 1 – Document structure

Clause	Description
1 Scope	This clause describes the scope of this standard..
2 Normative references	This clause lists the normative references.
3 Terms and definitions, abbreviations, conventions	This clause introduces basic terms and abbreviations not reported in IEC 61375-2-1.
4 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).
5 Conformance test of a WTB node, WTB trunk cable, WTB jumper cables, WTB extension cables	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.
6 Conformance test of RTP	This clause lists the tests covered in Clauses 3 and 4 fulfilling the real time protocol.
7 Conformance test of a WTB-equipped consist	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 communication profile as described in UIC CODE 556.
8 Conformance test of NM	Partially covered by Clauses 3 and 4. Remaining parts are not covered.
Annex A – Test laboratory and client role	This annex is normative.
Annex B – Test suites standard instrumentation	This annex is informative.

ELECTRONIC RAILWAY EQUIPMENT – TRAIN COMMUNICATION NETWORK (TCN) –

Part 2-2: Wire Train Bus conformance testing

1 Scope

This part of IEC 61375 applies to all equipment and devices implemented according to IEC 61375-2-1, 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 For a definition of TCN implementation see IEC 61375-2-1, 1.3.

2 Normative references

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

IEC 60571: *Electronic equipment used on rail vehicles*

IEC 60807(all parts), *Rectangular connectors for frequencies below 3 MHz*

IEC 61375-2-1: *Electronic railway equipment – Train Communication Network (TCN) – Part 2-1: Wire Train Bus (WTB)*

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

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 CODE 556, *Information transmission in the train (train-bus)*

3 Terms and definitions, abbreviations, conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 9646-1 and IEC 61375-2-1 apply.

3.2 Abbreviations

AVI	Application Variables Interface, the definition of the Process Variable services
BR	Bit Rate, the rate of data throughput on the medium expressed in bits per second (bit/s) or in hertz (Hz), whichever is appropriate
BT	Bit Time, the duration of the transmission of one bit, expressed in μ s
CUT	Consist under Test
DMM	Digital Multi Meter
ITU	International Telecommunication Union, the international standardisation body for telecommunications based in Geneva
IUT	Implementation Under Test
IEC	International Electrotechnical Commission, Geneva
ISO	International Standard Organisation, Geneva
LLC	Logical Link Control, a sub-layer within the Link Layer ruling the data exchange
LME	Layer Management Entity, the entity in charge of supervising a layer on behalf of Network Management
MAU	Medium Attachment Unit, the part of a Node which interfaces electrically to the bus and which provides/accepts binary logic signals
MOT	Mean of Test
MVB	Multifunction Vehicle Bus, a Consist network
MS	Mapping Server, defined in UIC CODE 556
OSI	Open System Interconnection, a universal communication model defined in the ISO/IEC 7498
PCTR	Protocol Conformance Test Report, defined in ISO/IEC 9646
PICS	Protocol Implementation Conformance Statement, defined in ISO/IEC 9646
PIXIT	Protocol Implementation Extra Information for Testing
RTP	Real-Time Protocols, the common communication protocols for process data and message data
TCN	Train Communication Network, a set of communicating consist and Train Busses
TDR	Time Domain Reflectometry, tool for analyzing single-ended and differential transmission lines
TNM	Train Network Management
UIC	International Union of Railways , the international railways operators association
WTB	Wire Train Bus

4 Conformance test: approach, requirements and boundaries

4.1 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.

4.1.1 Requirements

4.1.1.1 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.

4.1.1.2 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 4.1.1.3 and 4.1.1.4, respectively.

4.1.1.3 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.

4.1.1.4 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.

4.1.1.4.1 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.

4.1.1.4.2 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.

4.1.2 Requirements declaration statements for an IUT

4.1.2.1 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.

4.1.2.2 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.

4.2 Boundaries

4.2.1 General

Conformance testing as discussed in this standard is focused on testing for conformance to TCN clauses as they are specified in IEC 61375-2-1.

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.

The tests a), b), c) and d) are described in detail by the following subclauses.

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

4.2.2 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.

4.2.2.1 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.

4.2.3 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.

4.2.3.1 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.

4.2.4 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.

4.2.5 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.

4.2.6 Interpretation of clauses/subclauses and statements

The TCN described in IEC 61375-2-1 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 61375-2-1 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.

4.2.6.1 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: establishes performance requirements or constraints;
- c) is required: is a specification statement written in the passive voice;
- d) is 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.

- h) as follows,
- i) below,
- j) following,
- k) in particular,
- l) listed,
- m) support.

Phrases that introduces temporal indication, that may lead to definite or indefinite actions, or enumerative that may lead to infinite test cases. For examples see Table 2:

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.

4.2.6.2 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) example;
- d) note.

4.2.6.3 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.

4.2.6.4 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 listed in Table 3:

Table 3 – Weak statements

Phrases with	Example
adequate	The transmitter and the receiver connector shall be <i>adequately</i> identified, preferably: • light grey for the transmitter; • dark grey for the receive.
be able to	The link layer as well as the application shall <i>be able to</i> 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 <i>be capable</i> of being attached to both a single-line or to a double-line segment
effective	The entity which <i>effectively</i> 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 <i>normal</i> SEND_TMO.
provide for	The Application Layer for Variables (AVI) shall <i>provide for</i> Cluster access the following primitives, ...

4.2.7 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 in Table 4:

Table 4 – Relation to interoperability

Domain	Description
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.

4.2.8 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 in Table 5:

Table 5 – Relation to performance test

Performance attribute	Description
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.

4.3 Conformance assessment process outline

4.3.1 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.

4.3.2 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.

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

5.1 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 61375-2-1. The answers constitute the supported values.

5.1.1 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

5.1.1.1 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

5.1.1.2 Ref. column

This column is used for reference purposes inside the PICS.

5.1.1.3 Supported subclause column

This column gives the mapping between the IEC 61375-2-1 and the corresponding entry in the PICS.

5.1.1.4 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.

5.1.1.5 Requirement column

This column indicates the level of support required for conformance to IEC 61375-2-1.

The values are as follows:

m mandatory support is required;

o optional support is permitted for conformance to the IEC 61375-2-1. If implemented, it shall 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.

5.1.1.6 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.

5.1.1.7 Parameter values columns

5.1.1.7.1 Allowed min.

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

5.1.1.7.2 Default value

This column indicates the default value for a parameter. When IEC 61375-2-1 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.

5.1.1.7.3 Allowed max.

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

5.1.1.7.4 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.

5.1.2 PICS tables

5.1.2.1 Identification of PICS

The following Table 6 is intended to be filled in in order to identify the PICS pro-forma.

Table 6 – PICS pro-forma identification

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

5.1.2.2 Identification of the implementation under test

The following Table 7 shall be filled in to identify the implementation under test.

Table 7 – PICS pro-forma 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 Indicates the applicable power supply voltage. Power supply voltage is chosen amongst the values specified by IEC 60571.

NOTE 5 Indicates the applicable maximum power supply current. Power supply current is chosen amongst the values specified by IEC 60571.

NOTE 6 Other information the client considers relevant for IUT identification.

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

The following Table 8 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.

Table 8 – PICS pro-forma IUT supplier and/or 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	

5.1.2.4 Identification of the standards

The following Table 9 shall be filled in to identify the Standards applied to the IUT for the conformance test.

Table 9 – PICS pro-forma identification of the standards

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	

5.1.2.5 Global statement of conformance

Table 10 shall be filled by the IUT supplier in the “Implementation” column.

Table 10 – PICS pro-forma global statement of conformance

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.

5.1.2.6 Level of testing

Table 11 shall be filled by the IUT supplier in order to identify the IUT.

Table 11 – PICS pro-forma level of testing

Ref. No.	IEC 61375-2-1 Subclause	Capability	Implementation
1	4.1.4 – 2.1.5	Consist	[]
2	4.1.3	Node	[]
3	4.1.1	Trunk cable	[]
4	4.1.1	Jumper cables	[]
5	4.1.1	Extension cables	[]

5.1.2.7 Node capability

Table 12 shall be filled in by the IUT supplier only in case that the response Y is filled at reference 2 in the table of 5.1.2.6.

Table 12 – PICS pro-forma node capability

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Implementation
1	4.2.1	Intermediate node	m	[]
2	4.2.1	End node	m	[]
3	4.2.1	When intermediate node, only one of its transceivers enabled	m	[]
4	4.2.1	When end node able to communicate over both its bus sections independently	m	[]
5	4.2.1	When intermediate node establishes electrical continuity between Direction_1 and Direction_2	m	[]
6	4.2.1	When end node terminates electrically the bus sections of Direction_1 through a terminator	m	[]
7	4.2.1	When end node terminates electrically the bus sections of Direction_2 through a terminator	m	[]
8	5.5.1.2	Strong node ¹	o	[]
9	5.5.1.2	Weak node ²	o	[]
10	5.5.1.2	Slave node	o	[]

5.1.2.8 Redundancy

Table 13 shall be filled in by the IUT supplier in order to declare if line redundancy is implemented or not.

Table 13 – PICS pro-forma redundancy

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Implementation
1	4.2.2	Physical redundancy	o	[]
2	4.2.2	UIC node	o	[]

5.1.2.8.1 Redundancy configuration

Table 14 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 5.1.2.8

Table 14 – PICS pro-forma redundancy configuration

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Implementation
1	4.2.2	Is line A marked as LINE_A?	m	[]
2	4.2.2	Is line B marked as LINE_B?	m	[]
3	4.2.2	Are LINE_A and LINE_B identically configured respectively Direction_1 and Direction_2?	m	[]

¹ At least one option is chosen.

² At least one option is chosen.

5.1.2.9 Signalling

Table 15 shall be filled in by the IUT supplier in order to declare signalling characteristics.

Table 15 – PICS pro-forma signalling

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Value	Implementation
1	4.2.3.1	Speed	m	1,0 Mbit/s $\pm$ 0,01 %,	[]
2	4.2.3.1	Coding	m	Manchester	[]
3	4.2.3.1	Frequency	m	1,0 MHz	[]

5.1.2.9.1 Cable

Table 16 shall be filled in by the IUT supplier in order to declare cable characteristics.

Table 16 – PICS pro-forma cable

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Implementation
1	4.2.4.1	Shielded cable	m	[]
2	4.2.4.1	Jacketed cable	m	[]
3	4.2.4.1	Twisted pair	m	[]
4	4.2.4.2	Individual wires identified as X,Y	m	[]
5	4.2.4.2	Shield wires identified as S	m	[]

5.1.2.9.1.1 Trunk cable

Table 17 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 5.1.2.6

Table 17 – PICS pro-forma trunk cable

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Value	Implementation
1	4.2.4.3	Impedance	m	$Z_w = 120,0 \Omega (\pm 10 \%)$	[]
2	4.2.4.1	Twist per metre	m	12	[]
3	4.2.4.4	Attenuation	m	Less than 10,0 dB/km at 1,0 MHz	[]
4	4.2.4.4	Attenuation	m	Less than 14,0 dB/km at 2,0 MHz	[]
5	4.2.4.5	Distributed capacitance	m	Less than 65 pF/m at 1,0 MHz	[]
6	4.2.4.6	Capacitive unbalance to shield	m	Less than 1,5 pF/m at 1,0 MHz	[]
7	4.2.4.8	Transfer impedance	m	Less than 20,0 m Ω /m at 20,0 MHz	[]
8	4.2.4.8	Differential transfer impedance	m	Less than 2,0 m Ω /m at 20,0 MHz	[]

5.1.2.9.1.2 Jumper cable

Table 18 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 5.1.2.6

Table 18 – PICS pro-forma jumper cable

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Value	Implementation
1	4.2.4.3	Impedance	m	$Z_w = 120,0 \Omega (\pm 10 \%)$	[]
2	4.2.4.1	Twist per metre	m	12	[]
3	4.2.4.4	Attenuation	m	Less than 10,0 dB/km at 1,0 MHz	[]
4	4.2.4.4	Attenuation	m	Less than 14,0 dB/km at 2,0 MHz	[]
5	4.2.4.5	Distributed capacitance	m	Less than 65 pF/m at 1,0 MHz	[]
6	4.2.4.6	Capacitive unbalance to shield	m	Less than 1,5 pF/m at 1,0 MHz	[]
7	4.2.4.8	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[]
8	4.2.4.8	Differential transfer impedance	m	Less than 2,0 mΩ/m at 20,0 MHz	[]

5.1.2.9.1.3 Extension cable

Table 19 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 5.1.2.6

Table 19 – PICS pro-forma extension cable

Ref.No.	IEC 61375-2-1 Subclause	Capability	Requirement	Value	Implementation
1	4.2.4.3	Impedance	m	$Z_w = 120,0 \Omega (\pm 10 \%)$	[]
2	4.2.4.1	Twist per metre	m	12	[]
3	4.2.4.1	Cross-section	m	Less than 0,56 mm ²	[]
4	4.2.4.4	Attenuation	m	Less than 10,0 dB/km at 1,0 MHz	[]
5	4.2.4.5	Distributed capacitance	m	Less than 65 pF/m at 1,0 MHz	[]
6	4.2.4.6	Capacitive unbalance to shield	m	Less than 1,5 pF/m at 1,0 MHz	[]
7	4.2.4.7	Crosstalk	m	Greater than 55,0 dB between 0,5 to 2,0 MHz	[]
8	4.2.4.8	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[]
9	4.2.4.8	Differential transfer impedance	m	Less than 2,0 mΩ/m at 20,0 MHz	[]

5.1.2.9.2 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 5.1.2.6. The conformance of connectors is mandatory when interoperability is required.

5.1.2.9.2.1 Front panel layout

Table 20 shall be filled in by the IUT supplier in order to declare front panel layout characteristics.

Table 20 – PICS pro-forma front panel layout

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Implementation
1	4.3.4	Vertical	o	[]
2	4.3.4	Horizzontal	o	[]
NOTE One option shall be chosen.				

5.1.2.9.2.2 Arrangement

Table 21 shall be filled in by the IUT supplier in order to declare connector arrangement characteristics.

Table 21 – PICS pro-forma connector arrangement

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Implementation
1	4.3.4	A1 male is the upper	c Ref. 1 of 5.1.2.9.2.1	[]
2	4.3.4	A1 male is leftmost	c Ref. 2 of 5.1.2.9.2.1	[]

5.1.2.9.2.3 Layout and type

Table 22 shall be filled in by the IUT supplier in order to declare connector layout and type characteristics.

Table 22 – PICS pro-forma connector layout and type

Ref. No.	IEC 61375-2-1 Subclause	Capability	Requirement	Value	Implementation
1	4.3.4	Line_A Direction_1	m	9-pin Sub-D 9 connectors using metric screws (IEC 60807)	[]
2	4.3.4	Line_A Direction_2	m	9-pin Sub-D 9 connectors using metric screws (IEC 60807)	[]
3	4.3.4	Line_A Direction_1	m	Male	[]
4	4.3.4	Line_A Direction_2	m	Female	[]
5	4.3.4	Line_B Direction_1	m	9-pin Sub-D 9 connectors using metric screws (IEC 60807)	[]
6	4.3.4	Line_B Direction_2	m	9-pin Sub-D 9 connectors using metric screws (IEC 60807)	[]
7	4.3.4	Line_B Direction_1	m	male	[]
8	4.3.4	Line_B Direction_2	m	female	[]
9	4.3.4	Shielding	m	-	[]
10	4.2.4.8	Transfer impedance	m	Less than 20,0 mΩ/m at 20,0 MHz	[]
11	4.2.4.8	Differential transfer impedance between two pins	m	Less than 2,0 mΩ/m at 20,0 MHz	[]
12	4.3.4	Conductive casing connected to the cable shield	m	-	[]
13	4.3.4	Makes an electrical contact with the receptacle when fastened	m	-	[]
14	4.2.4.9	Continuity resistance	m	Less than 10,0 mΩ/m	[]
15	4.3.4	Label on Line_A Direction_1	m	A1	[]
16	4.3.4	Label on Line_A Direction_2	m	A2	[]
17	4.3.4	Label on Line_B Direction_1	m	B1	[]
18	4.3.4	Label on Line_B Direction_2	m	B2	[]

5.1.2.10 Switches type

Table 23 shall be filled in by the IUT supplier in order to declare switches type characteristics.

Table 23 – PICS pro-forma switches type

<u>Ref.No.</u>	<u>IEC 61375-2-1 Clause</u>	<u>Capability</u>	<u>Requirement</u>	<u>Implementation</u>
<u>1</u>	<u>4.5.3</u>	<u>Solid state</u> ³	<u>0</u>	[1]
<u>2</u>	<u>4.5.3</u>	<u>Mechanical</u> ³	<u>0</u>	[1]

5.1.2.11 Switches

Table 24 shall be filled in by the IUT supplier in order to declare switches characteristics.

Table 24 – PICS pro-forma switches

<u>Ref. No.</u>	<u>IEC 61375-2-1 Subclause</u>	<u>Capability</u>	<u>Requirement</u>	<u>Value</u>	<u>Implementation</u>
1	4.5.3	Isolation	m	Greater than or equal to 500,0 Vr.m.s.	[]
2	4.5.3	Initial contact resistance	m	Less than 0,050 Ω	[]
3	4.5.3	Contact resistance after 10 ⁷ cycles	m	Less than 0,100 Ω	[]
4	4.5.3	Switch time	m	Less than 10,0 ms, including bounce time	[]

5.1.3 Basic interconnection tests

They are a subset of the behavioural tests.

5.1.4 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 IEC 61375-2-1;
- 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 in these activities.

5.1.5 Behaviour tests

5.1.5.1 Physical test

5.1.5.1.1 Characteristic impedance

This refers to the requirement of 2.2.4.3 of IEC 61375-2-1.

The IUT shall present a differential characteristic impedance of $Z_w = 120,0 \Omega (\pm 10 \%)$ measured with a sinusoidal signal at a frequency between 0,5 BR and 2,0 BR.

³ One option shall be chosen.

The measuring method is the open-short measurements.

- a) The IUT shall be at least 100 m of cable⁴.
- 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 TE's output impedance is denoted as Z_{TE} .

Measure the reflection coefficient of the IUT at 1 MHz having one extremity of the IUT opened and denote the measured value as ρ_o .

Measure the reflection 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: $Z_{open} = Z_{TE} \cdot \frac{1 + \rho_o}{1 - \rho_o}$

Compute the: $Z_{short} = Z_{TE} \cdot \frac{1 + \rho_s}{1 - \rho_s}$

Compute the: $Z_c = \sqrt{Z_{open} \cdot Z_{short}}$

5.1.5.1.2 Shield quality

This refers to the requirement of 4.2.4.8 of IEC 61375-2-1.

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:

$$Z_t = (1 / I_o) \times (dV / dx)$$

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. 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 I_o 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.

5.1.5.1.3 Insertion losses of a line unit

This refers to the requirements of 4.5.2.1 and 4.5.2.3 of IEC 61375-2-1.

Figure 1 shows the setup for measurement of insertion loss of a line unit.

⁴ A length of less than 100 m may cause measurement inaccuracies.

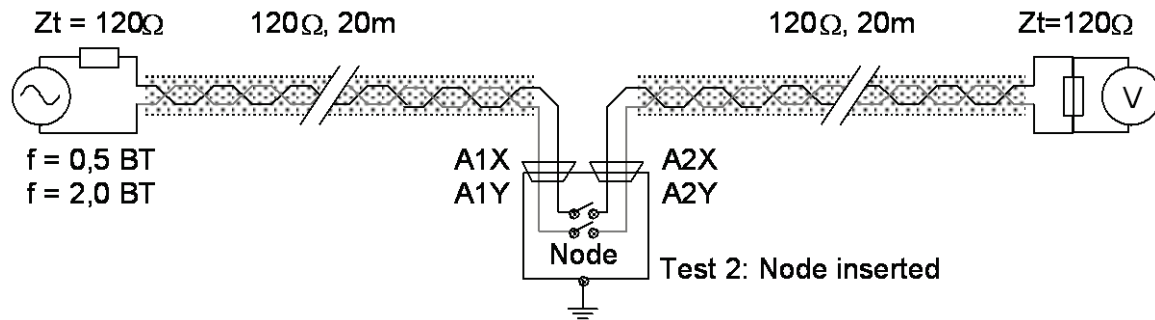


Figure 1 – Insertion loss measurement

The sinusoidal signal of a generator (of internal impedance = Z_t) 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 Z_t) at the extremity of other 20,0 m of cable attached to the points A2X and A2Y.

5.1.5.1.3.1 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:

- c) in intermediate setting (K_b closed, K_{t1} and K_{t2} open);
- d) The transceivers of the IUT shall be disabled (in high impedance).

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.

The IUT shall be:

- not powered (switched off).

5.1.5.1.3.2 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 (K_b closed, K_{t1} and K_{t2} open):

The measured current shall not exceed 48 μ A.

Figure 2 shows the setup for measurement of input resistance in intermediate setting

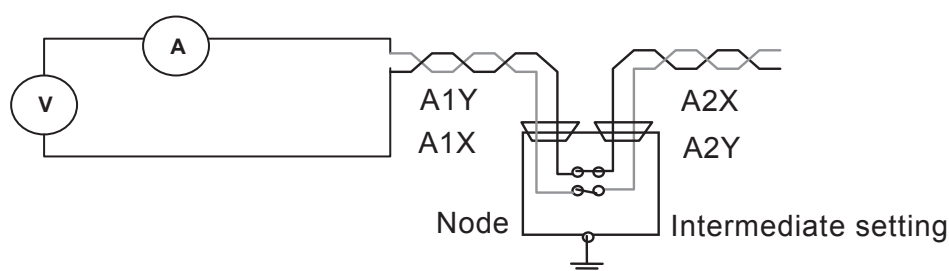


Figure 2 – Measurement of the input resistance

Do the measure for

a) A1X – A1Y

b) A2X – A2Y

5.1.5.1.4 End setting

This refers to the requirement of 4.5.2.2 of IEC 61375-2-1.

The characteristic impedance of the IUT being measured can be calculated from the height of the step reflected from the transition between the TDR (Time Domain Reflectometry) 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.

$$\text{Compute the: } Z_{\text{EndNode}} = Z_{\text{TDR}} \cdot \frac{\text{Height}_{\text{incident}} + \text{Height}_{\text{reflected}}}{\text{Height}_{\text{incident}} - \text{Height}_{\text{reflected}}}$$

Z_{EndNode} shall be $120 \, \Omega \pm 10 \, \%$

Figure 3 shows the setup for measurement of input resistance in end setting.

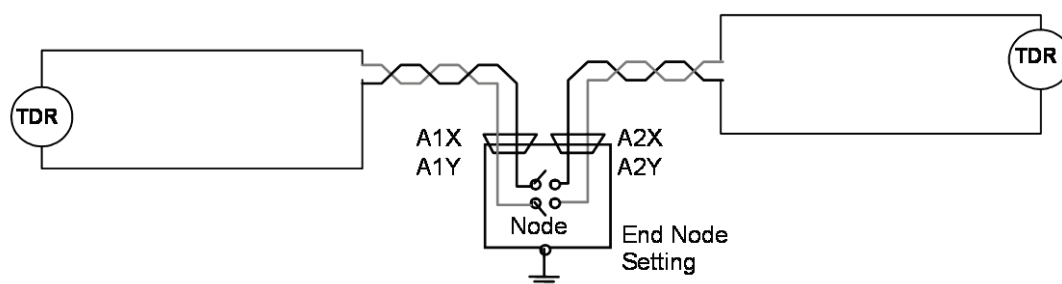


Figure 3 – End setting measurement setup 1

5.1.5.1.4.1 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 61375-2-1 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 consists. 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 a).

Tune the generator until the voltage given in a) is 4 V r.m.s.

Measure the voltage given in b).

Compute the ratio: $V_{Att} = 20 \cdot \log\left(\frac{V_a}{V_b}\right)$

Figure 4 shows the setup for measurement of attenuation in end setting.

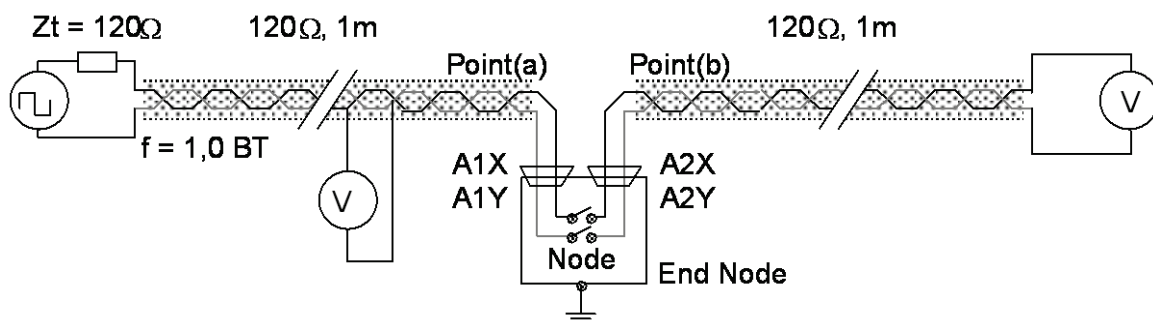


Figure 4 – End setting measurement setup 2

The ratio shall be more than 55,0 dB.

5.1.5.1.5 Switches

This refers to the requirement of 4.5.3 of IEC 61375-2-1.

5.1.5.1.5.1 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 (Digital Multi Meter) 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 5 shows the setup for measurement of switches.

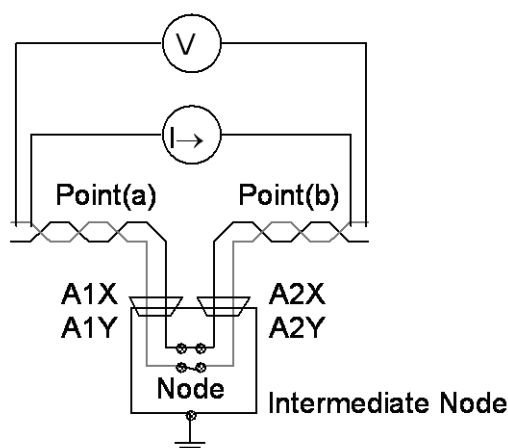


Figure 5 – Switches measurement setup 1

The circuit of a four wire system is shown in the Figure 5. 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 6 shows the setup of fixture for measurement of indirect attachment of switches.

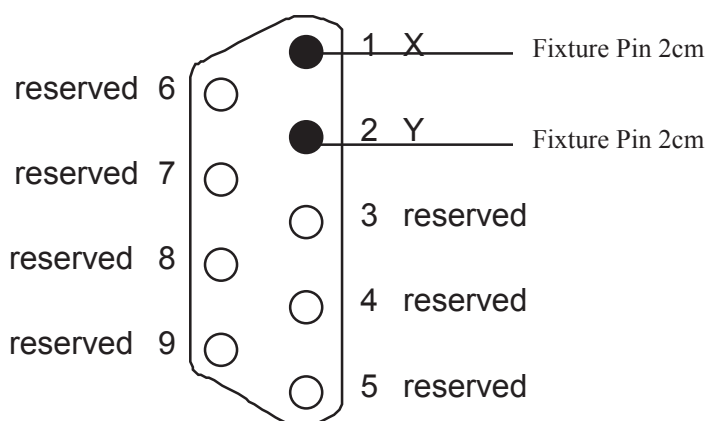


Figure 6 – Indirect attachment switches measurements fixture 1

Figure 7 shows the setup of fixture for measurement of direct attachment of switches.

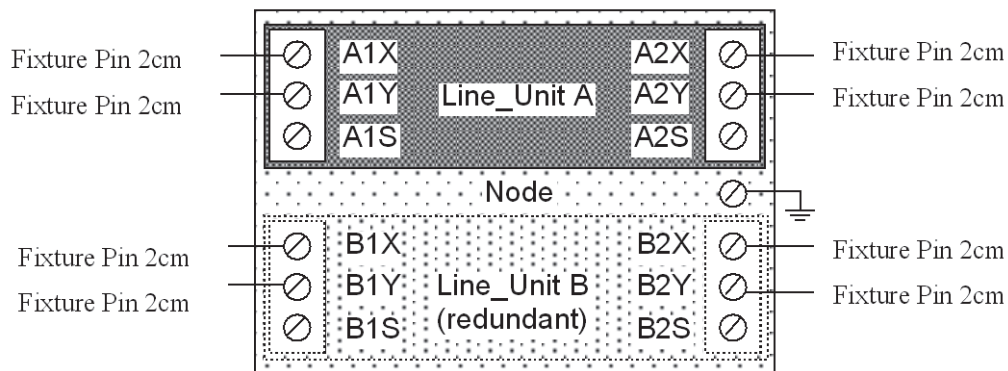


Figure 7 – Direct attachment switches measurements fixture 1

Values between pins (Table 25 – WTB pin to pin measurement):

Table 25 – 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

5.1.5.1.6 Transceiver

This refers to the requirement of 4.6 of IEC 61375-2-1.

Unless otherwise specified, the following default measuring conditions hold:

- the characteristics of a transceiver are measured at the X and Y points where the cable sections are attached to the node;
- all voltages are measured as differential voltage between X and Y, ($U_x - U_y$);
- 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;
- all resistor values are $\pm 1\%$, all capacitor values are $\pm 10\%$.

5.1.5.1.6.1 Transmitter

5.1.5.1.6.1.1 Test circuit for transmitter

To approximate the loading of the transmitter with a cable and nodes, four test circuits are specified:

- 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;
- 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;
- the idling test circuit simulates a cable of 860,0 m without resistive loads. The capacitors have a value of 1,3 nF $\pm 10\%$ each, the resistors a value of 27,0 $\Omega \pm 1\%$ each;
- the short test circuit simulates a line failure. It consists only of a current measurement circuit;

These circuits are shown in Figure 8.

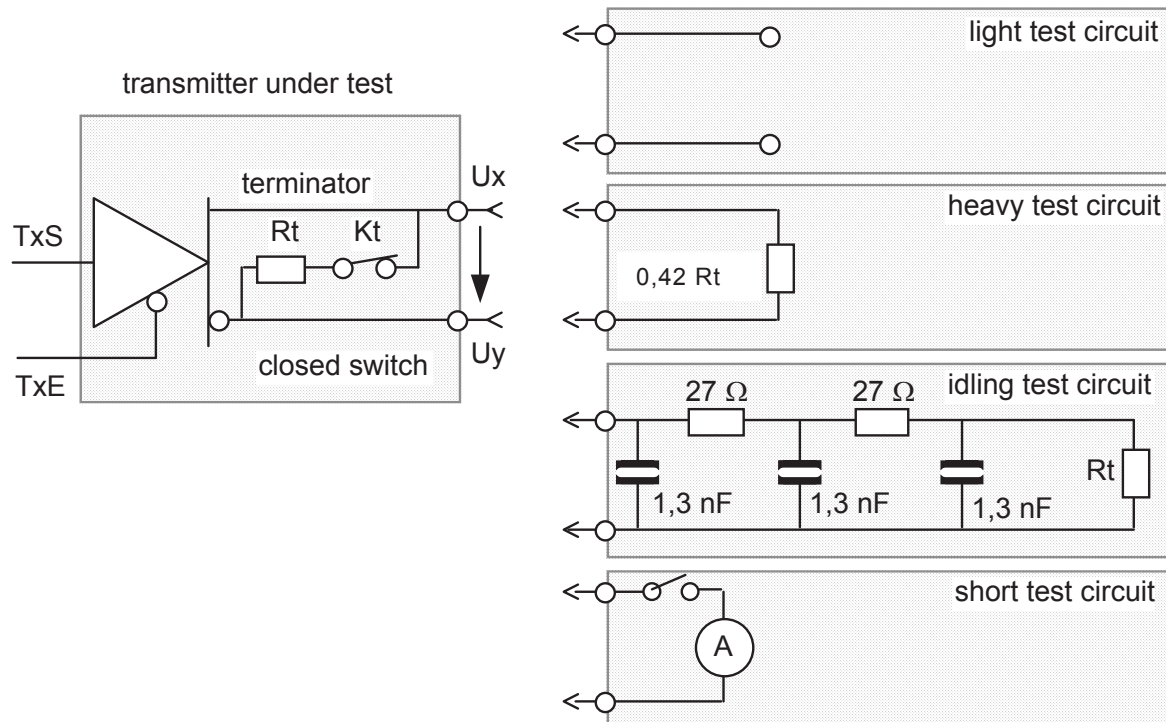


Figure 8 – Transmitter fixtures

- 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.

5.1.5.1.6.1.2 Transmitter output signal

When connected to either the heavy and the light test circuit defined in 5.1.5.1.6.1.1 the transmitter shall comply with the following specifications, as shown in Figure 9:

- a) the output signal shall be alternatively positive and negative;
- b) the amplitude of the output signal shall be at least $\pm 3,0$ V with the heavy test circuit and at most $\pm 7,0$ 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 $0,100 \mu\text{s}$ 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 $0,20 \text{ V/ns}$ at any time and more than $0,03 \text{ V/ns}$ within $100,0 \text{ ns}$ 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.

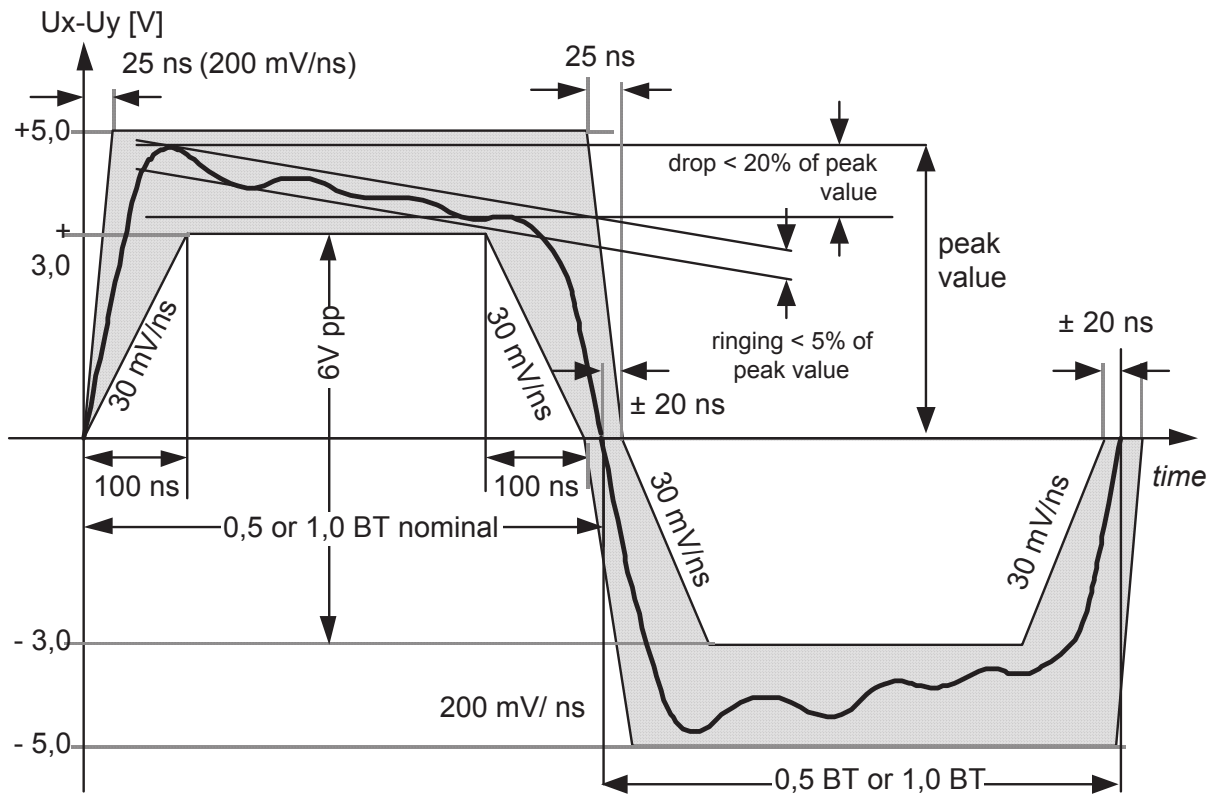


Figure 9 – Transmitter output signal

5.1.5.1.6.1.3 Transmitter noise

The measurement shall be performed either in:

- a) intermediate; or
- b) end setting.

Figure 10 shows the setup of fixture for intermediate transmitted noise test.

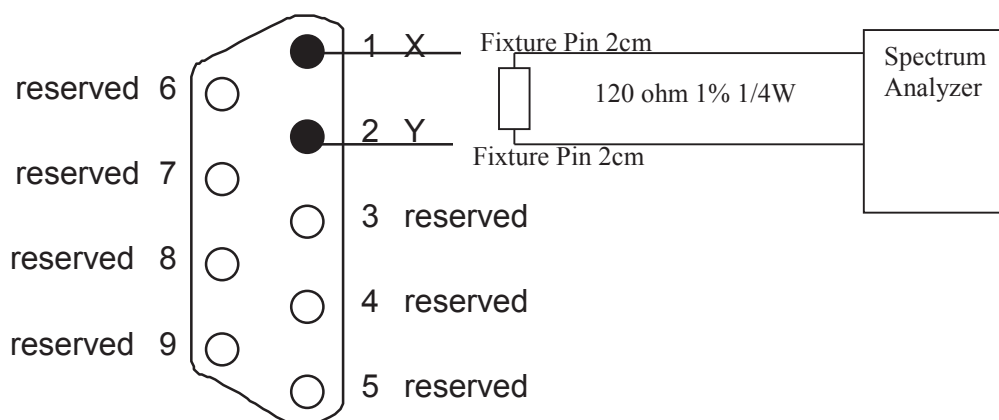


Figure 10 – Intermediate transmitted noise test fixture

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 11 shows the setup of fixture for end node transmitted noise test.

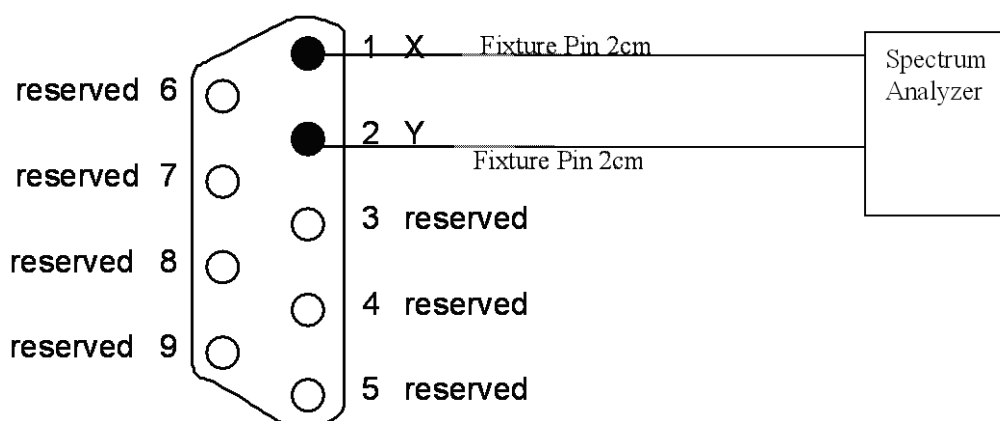


Figure 11 – End node transmitted noise test fixture

5.1.5.1.6.1.4 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 12:

- 1) 100,0 ns after the last negative-to-positive transition and for $2,0 \text{ BT} \pm 100 \text{ ns}$, 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.

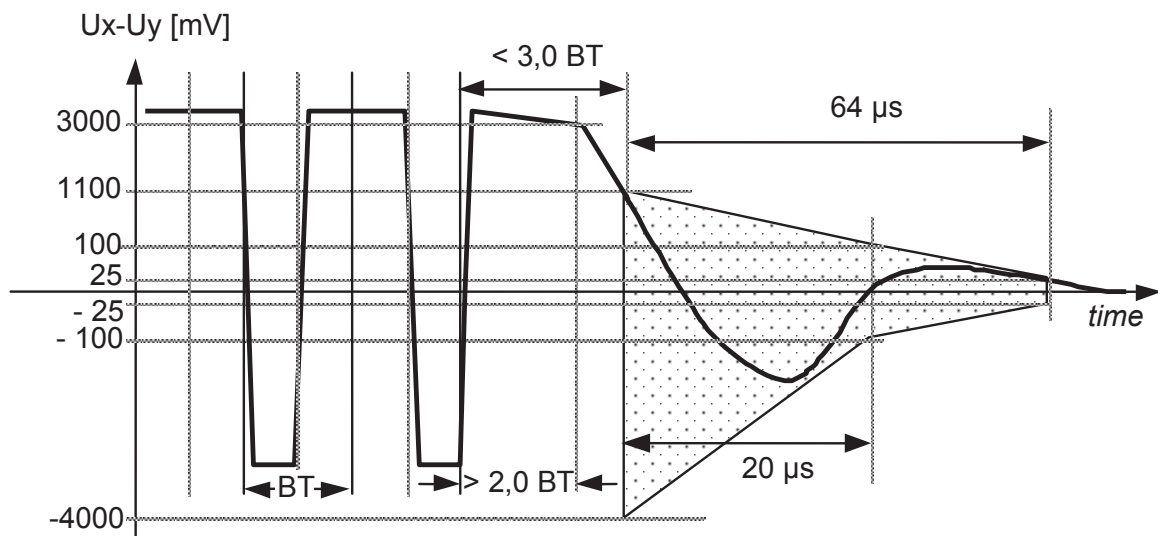


Figure 12 – Signal and idling at transmitter

5.1.5.1.6.1.5 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

- Transmitter enabled;
- Transmitter not enabled.

Instruments

- c) Oscilloscope 100 MHz bandwidth;
- d) Current probe 20 MHz bandwidth;
- e) Short-circuit current load 7 RF resistors as specified in the following Table 26:

Table 26 – Fault tolerance parameters

Resistance	Power (W)	Frequency	Capacitance
50,1	20	DC – 2MHz	0,75 pF

Figure 13 shows an example of a RF resistor.

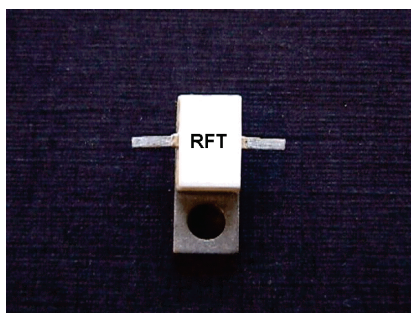


Figure 13 – RF resistor example

Figure 14 shows the setup of fixture for the short circuit test.

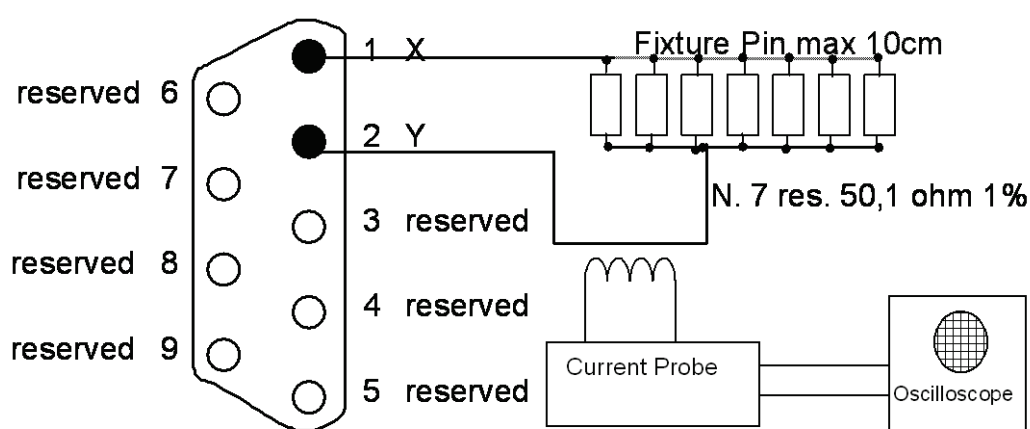


Figure 14 – Short-circuit test fixture 1

Set condition a) (transmitter enabled).

Applying the fixture 1 for 1 (one) h, the maximum r.m.s. current measured by the current probe shall not exceed $1\text{ A} \pm 10\%$.

When removing the fixture, the transmitter shall resume its previous operational status.

Set condition b) (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 $1\text{ A} \pm 10\%$.

When removing the fixture, the transmitter shall resume its previous operational status.

5.1.5.1.6.1.6 Transmitter anti-jabber

This functionality that is specified by 4.6.2.6 of IEC 61375-2-1 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.

5.1.5.1.6.2 Receiver specifications

This refers to test requirements of 4.6.3.3, 4.6.3.4, 4.6.3.5 and 4.6.3.6 of IEC 61375-2-1, the receiver shall comply with the following specifications, as shown in Figure 15 and Figure 16:

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 of 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 $(0,5 \text{ BT} - 350,0 \text{ ns})$, respectively $(1,0 \text{ BT} - 0,350 \text{ s})$;
- 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.

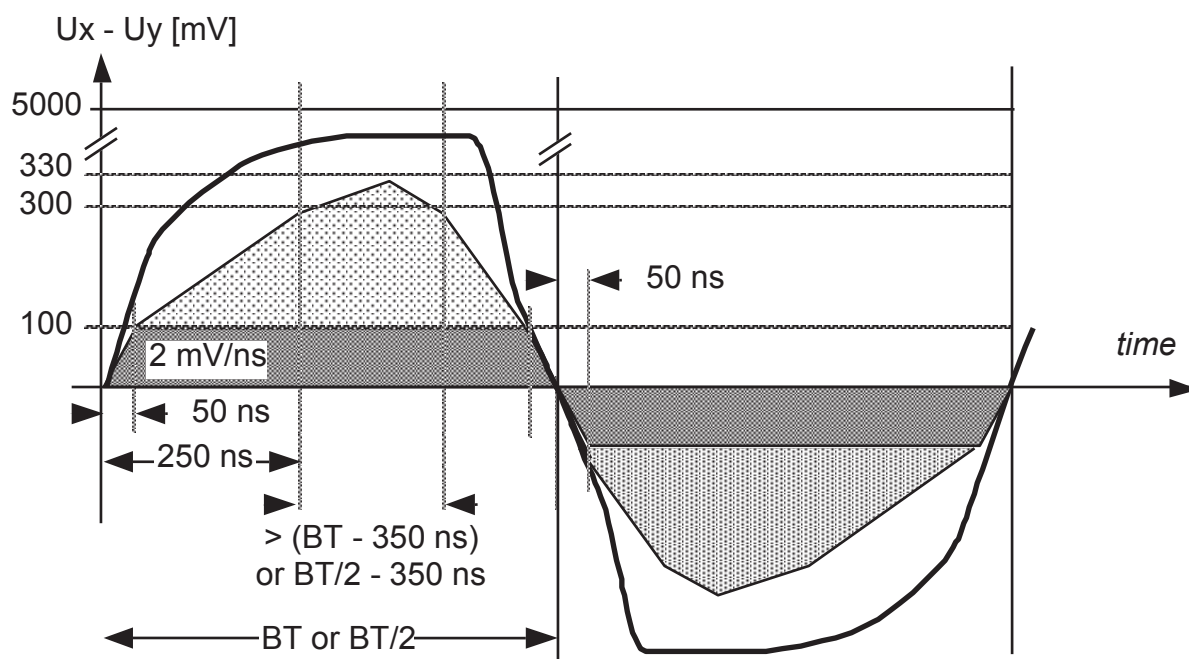


Figure 15 – Receiver signal envelope

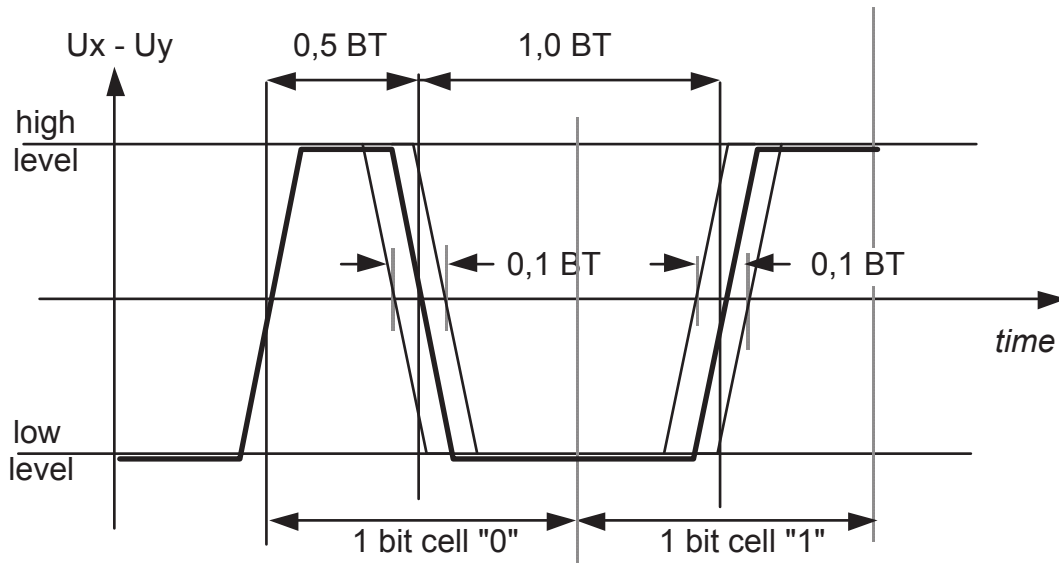


Figure 16 – Receiver edge distortion

5.1.5.1.6.3 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

- sample the incoming bit and send out an outgoing bit with the amplitude changed as required by the test;
- sample the incoming bit and send out an outgoing bit with the rise time changed as required by the test;
- sample the incoming bit and send out an outgoing bit with the fall time changed as required by the test;
- 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

- 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);
- its peak amplitude 5,00 V;
- 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 of 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 27:

Table 27 – Frequency sinusoidal signal

Frequency Hz
65
1000
10 000
100 000
1 000 000
1 500 000

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 0,700 V;
- 6) 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.

5.1.6 Link layer interface

5.1.6.1 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. This part of IEC 61375 recommends a black box approach to test the TCN stack for conformity, this recommendation is followed by the testing approach described hereinafter.

5.1.6.2 WTB IUT

A WTB device shall include the RTP with messages services and the TNM with the agent function. A WTB device shall also include a Mapping Server according to UIC CODE 556, which computes the WTB topography based on the information exchange during states 'TEACHING_MASTER' 5.5.4.8.7 of IEC 61375-2-1 and 'LEARNING_SLAVE' 5.5.4.9.3 of IEC 61375-2-1.

The simplest WTB device shall consist of these four communication modules:

- a) WTB-LLC. WTB Link Layer Control.
- b) RTP. Real Time Protocol.
- c) TNM (Agent). TCN Network Management Agent.
- d) MS. Mapping Server.

The WTB IUT is modelled as a black box.

The WTB IUT for the purpose of testing shall expose only two external interfaces:

- e) WTB medium attachment connectors as specified in 4.3 of IEC 61375-2-1.
- f) 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.

5.1.6.3 Procedures required for WTB device configurations

The IEC 61375-2-1 does not specify the application layer. But for a defined precondition of the specified test cases a proper WTB device initialization is necessary. This initialization can be part of the Mapping Server according to UIC CODE 556. The configuration parameters shall be supplied in a configuration database.

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 5.6.4.2.2 of IEC 61375-2-1).

Procedures:

The procedures required for WTB device configurations listed in 5.6.4.6 and 5.6.4.7 of IEC 61375-2-1 are:

- Is_t_Configure. This procedure sets up the basic **WTB-LL configuration** parameter;
- Is_t_SetSlave, Is_t_SetWeak, Is_t_SetStrong. These procedures define the **initial node strength**.

The required data to configure the IUT shall be passed via the configuration database for regular operation.

The Is_t_report procedure defined in 5.6.4.3 of IEC 61375-2-1 shall be subscribed by the Mapping Server in order to react to the WTB-LL events. See 5.6.4.6.4 of IEC 61375-2-1 Type_Configuration used by Is_t_Configure procedure.

5.1.6.4 WTB test bed

The test bed consists of a set of devices listed below.

- N.1 host computer
- N.1 relay switch box, e.g. controlled by MVB class 1 access
- N.2 WTB/consist network reference gateway named probe devices
- N.1 MVB device with the bus administrator capability, if MVB is used
- N.30 WTB reference devices