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TECHNICAL SPECIFICATION

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Information technology – Generic cabling systems for customer premises – Part 9903: Matrix modelling of channels and links

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Information technology – Generic cabling systems for customer premises – Part 9903: Matrix modelling of channels and links

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INFORMATION TECHNOLOGY –
GENERIC CABLING SYSTEMS FOR CUSTOMER PREMISES –

Part 9903: Matrix modelling of channels and links

FOREWORD

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ISO/IEC TS 11801-9903 has been prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology. It is a Technical Specification.

This first edition of ISO/IEC TS 11801-9903 cancels and replaces ISO/IEC TR 11801-9903 published in 2015. This edition constitutes a technical revision.

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

a) the addition of further clarifications of the relations of parameters described in this edition and referenced analogous parameters in IEC TR 62152, e.g. operational attenuation versus operational transfer loss;
b) the introduction and description of the higher order M-parameters 8 × 8 matrix of mixed-mode parameters, which includes the 4 × 4 submatrix of 4-port differential-mode-to-differential-mode (DD) parameters, among three other submatrices of mixed-mode parameters;
c) Annex A, matrix conversion formulas, covers up to 16-port parameters matrices;
d) the expanded Annex B description of example calculations for channel and permanent link, and updated component parameter tables.

The list of all currently available parts of the ISO/IEC 11801 series, under the general title *Information technology – Generic cabling for customer premises*, can be found on the IEC and ISO web sites.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
JTC1-SC25/2959/DTS	JTC1-SC25/2993/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, available at www.iec.ch/members_experts/refdocs.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

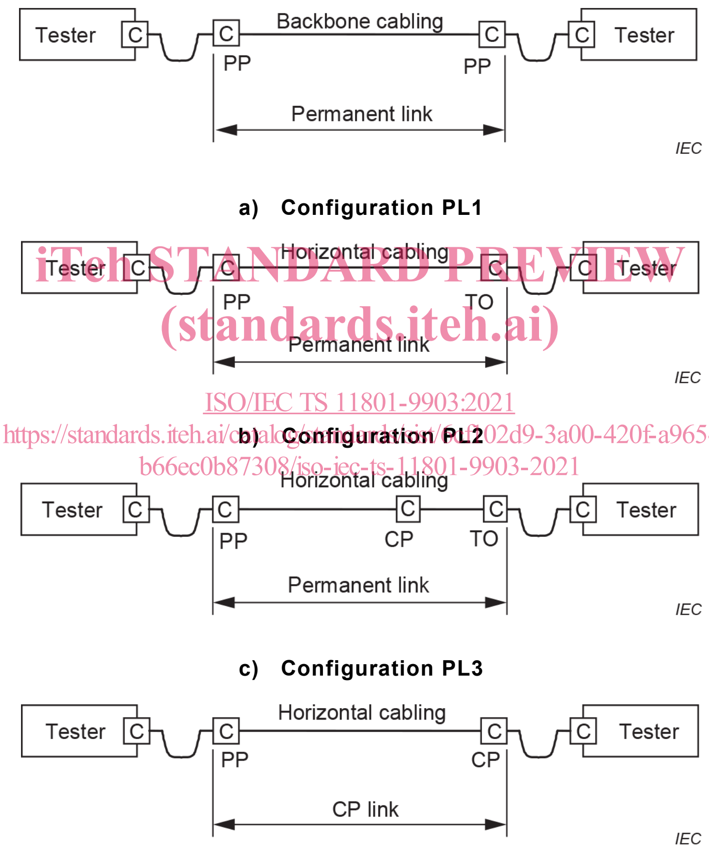
INTRODUCTION

The pass/fail limits for defined channel and permanent link cabling configurations have an implicit impact on the component limits for the cabling components used. The channel configurations and the link configurations are specified in ISO/IEC 11801-1:2017, Clause 6 and Clause 7, respectively.

The permanent link configurations, which represent the fixed portion of the cabling, have two possible topologies:

– a connection plus a segment of cable plus a connection (2-connector topology);
– a connection plus a segment of cable plus a connection plus another segment of cable plus another connection (3-connector topology).

The link configurations of ISO/IEC 11801-1 are shown in Figure 1.



a) **Configuration PL1**

b) **Configuration PL2**

c) **Configuration PL3**

d) **Configuration CP1**

Figure 1 – Link configurations of ISO/IEC 11801-1

This document includes models and assumptions, which support pass/fail limits for the channel and permanent link test configurations in ISO/IEC 11801-1. These are based on the performance requirements of cable and connecting hardware as specified in IEC standards.

This document provides reasonable assurance that a channel created by adding compliant patch cords to a previously certified permanent link will meet the applicable channel performance limits.

Over the years the frequencies of the classes increased, but the theory for calculating the limits stayed the same. Especially the higher order effects had to be considered and in the end only by doing a Monte Carlo calculation, assuming that not all components would be at the limit at the same time, allowed compliance to be proved.

The model uses two pairs for all calculations. The limits are equal for pairs or pair combinations but in reality measured values could be different. If results are required that need more pairs to be considered, then this calculation can be done based on the results from multiple two-pair calculations with appropriate inputs (worst case). An example of such a calculation is the power sum and average limit lines for four pairs.

Symmetry and additional contributions that result from unbalanced signals and differential-to-common and common-to-differential mode coupling are included in this document by increasing the matrix size.

For details on the naming of transmission parameters, see Clause 3 and Clause C.1.

INFORMATION TECHNOLOGY – GENERIC CABLING SYSTEMS FOR CUSTOMER PREMISES –

Part 9903: Matrix modelling of channels and links

1 Scope

This part of ISO/IEC 11801, which is a Technical Specification, establishes a matrix-model for formulating limits for mixed-mode parameters within and between two pairs of balanced cabling. This is for the purpose of supporting new, improved balanced cabling channel and link specifications.

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.

ISO/IEC 11801-1, *Information technology – Generic cabling for customer premises – Part 1: General requirements*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 11801-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
attenuation
diminishing of signal strength

Note 1 to entry: Details need to be added to indicate the exact usage.

3.1.2
connection
two mated connectors

EXAMPLE Jack and plug.

3.1.3
image attenuation
wave attenuation
attenuation when a two-port is terminated by its input and output characteristic impedances with no reflections at input and output

Note 1 to entry: The wave attenuation of cables is length scalable.

3.1.4
insertion loss
attenuation or loss caused by a two-port inserted into a system

3.1.5
insertion loss deviation
deviation of attenuation loss with regard to the wave attenuation due to mismatches or internal reflections

3.1.6
operational attenuation
ratio of the square root of the maximum available power wave vector emitted by the generator and the square root of the power wave vector absorbed by the load of the two-port

Note 1 to entry: The operational attenuation is not length scalable (see also C.3.1 and C.3.2).

Note 2 to entry: The operational attenuation is expressed in decibels (dB) and radians (rad).

3.1.7
passivity
property of an electrical system that the output power at all ports does not exceed the input power at all ports

3.1.8
unitarity
mathematical concept for matrices to define passivity

3.1.9
operational reflection
loss due to the reflection at a junction

Note 1 to entry: See also C.3.6.

3.2 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO/IEC 11801-1 and the following apply.

f	frequency (MHz)
RL	return loss limit (dB)
ρ	(rho) operational reflection transfer function, junction reflection coefficient
DRL	distributed return loss (dB)
IL	insertion loss limit (dB)
A	operational wave attenuation (Np)
A_{T}	operational wave transfer function (Np)
B	operational phase (rad)
B_{T}	operational phase transfer function (rad)
B_{RAND}	random phase (rad)
NEXT	operational near-end crosstalk loss limit (dB)
$\mathrm{NEXT}_{\mathrm{T}}$	operational near-end crosstalk transfer function (dB)
FEXT	operational far-end crosstalk loss limit (dB)
$\mathrm{FEXT}_{\mathrm{T}}$	operational far-end crosstalk transfer function (dB)

4 Matrix model

The model to be used is a concatenated matrix calculation as discussed in IEC TR 62152 [1][1] for a 2-port system. For a 2-pair balanced cabling calculation, a 4-port differential matrix as shown in Figure 2 shall be used.

The model assumes that all components are specified with S-parameters and these parameters are used then to fill an S-matrix for every cabling component.

To concatenate components these S-matrices are transformed into transmission T-matrices which can then be multiplied in the appropriate order to simulate the transmission characteristics of the concatenated components (for details see IEC TR 62152:2009, Annex C).

To evaluate the transmission performance of the modelled channel or permanent link, the calculated T-matrix of the cabling is transformed back into an S-matrix providing the expected transmission parameters of the cabling system.

The matrix calculation is done mathematically with S-parameters in amplitude and phase.

a) Measured S-parameters are usually known in amplitude and phase.
b) Parameter limit lines for components and for cabling are specified in amplitude only, usually in decibel. For modelling purposes these amplitudes shall be transformed into a linear value.
c) For the calculation of matrix terms representing limit lines, the phase is added as a random value to simulate power sum addition (see Clause 6).

5 Matrix definition

5.1 General

In Clause 5 only the part with the balanced components is described. For the unbalanced part see 8.2.

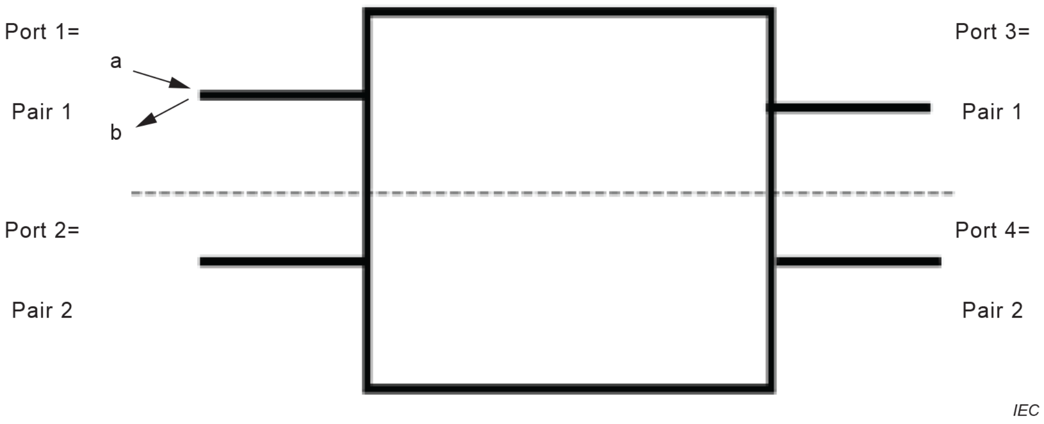
5.2 Quadriports

In IEC TR 62152 [1] voltage and currents of the input and output waves are specified for two ports. In Figure 2, Figure 3, Table 1, and Formula (1), the cabling specific notation needed for quadriports (two pairs) is detailed.

5.3 Matrix port definition for a two-pair system representative for modelling purposes

In Figure 2, a 4-port matrix is presented. The definition is one line per port per twisted pair.

1 Numbers in square brackets refer to the Bibliography.



Key

a designates a wave entering the quadriport

b designates a wave leaving the quadriport

Figure 2 – Matrix definition of a 4-port two twisted pair system

5.4 Operational scattering matrix

In Figure 3, the S-parameters for a source at port 2 are shown. For all definitions, see 5.5.

Key

Definition of S-parameters: $S_{\text{output, input}}$

S_{12} = operational near-end crosstalk transfer function (NEXT_T)

S_{22} = operational reflections coefficient (ρ)

S_{32} = operational far-end crosstalk transfer function (FEXT_T)

S_{42} = operational forward transfer function (A_T)

Figure 3 – Operational scattering parameters example from port 2

5.5 General naming convention

The naming convention for the four ports is given in Table 1.

Table 1 – All four ports operational scattering parameter definition

From Port 1:	From Port 2:	From Port 3:	From Port 4:
S_{21} NEXT_T	S_{12} NEXT_T	S_{43} NEXT_T	S_{34} NEXT_T
S_{11} ρ	S_{22} ρ	S_{33} ρ	S_{44} ρ
S_{41} FEXT_T	S_{32} FEXT_T	S_{23} FEXT_T	S_{14} FEXT_T
S_{31} A_T	S_{42} A_T	S_{13} A_T	S_{24} A_T

5.6 S-matrix

For each cabling component (for cables for each length and type involved, for connections for each type) an S-matrix needs to be developed, see Formula (1). The matrix numbering starts with 1 to be compatible with scattering parameters and generally used definitions (see 5.5) and IEC TR 62152.

$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix} \tag{1}$$

The following transmission parameters can be substituted into the matrix in Formula (1).

ρ: S_{11}, S_{22}, S_{33}, S_{44}

NEXT_T: S_{12}, S_{34}

FEXT_T: S_{14}, S_{23}

A_T: S_{13}, S_{24}

The equal scattering coefficient due to symmetrical nature of component parameters results in the set of equalities in Table 2.

Table 2 – Equal S-parameters for real components

Parameter	Equality	For pair number(s)
A_T	$S_{13} = S_{31}$	1
A_T	$S_{24} = S_{42}$	2
FEXT_T	$S_{14} = S_{41}$	1 and 2
FEXT_T	$S_{23} = S_{32}$	1 and 2
NEXT_T	$S_{21} = S_{12}$	1 and 2
NEXT_T	$S_{34} = S_{43}$	1 and 2

The equalities provided in Table 2 apply to the component scattering matrix in Formula (1).

5.7 Passivity

There is a general assumption that all transmission parameter loss values, e.g. NEXT and FEXT, are much less than one, in linear value, or much greater than 0, in dB.

At higher frequencies this needs to be taken care of. Otherwise, the output power at ports in total can be calculated as being higher than the input power.

This is defined as passivity and should be implemented. An example is shown in 5.8.