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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Connectors for electronic equipment – Tests and measurements – Part 28-100: Signal integrity tests up to 1 000 MHz on IEC 60603-7 and IEC 61076-3 series connectors – Tests 28a to 28g

Connecteurs pour équipements électroniques – Essais et mesures – Partie 28-100: Essais d'intégrité des signaux jusqu'à 1 000 MHz sur les connecteurs des séries CEI 60603-7 et CEI 61076-3 – Essais 28a à 28g

IEC 60512-28-100:2013

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CONNECTORS FOR ELECTRONIC EQUIPMENT – TESTS AND MEASUREMENTS –

Part 28-100: Signal integrity tests up to 1 000 MHz on IEC 60603-7 and IEC 61076-3 series connectors – Tests 28a to 28g

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International Standard IEC 60512-28-100 has been prepared by subcommittee 48B: Connectors, of IEC technical committee 48: Electromechanical components and mechanical structures for electronic equipment.

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

FDIS	Report on voting
48B/2322/FDIS	48B/2332/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 60512 series, under the general title *Connectors for electronic equipment – Tests and measurements*, 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- withdrawn,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.

CONNECTORS FOR ELECTRONIC EQUIPMENT – TESTS AND MEASUREMENTS –

Part 28-100: Signal integrity tests up to 1 000 MHz on IEC 60603-7 and IEC 61076-3 series connectors – Tests 28a to 28g

1 Scope

This part of IEC 60512 specifies the test methods for transmission performance for IEC 60603-7 and IEC 61076-3 series connectors up to 1 000 MHz. It is also suitable for testing lower frequency connectors, however the test methodology specified in the detailed specification for any given connector remains the reference conformance test for that connector.

The test methods provided here are:

– insertion loss, test 28a;
– return loss, test 28b;
– near-end crosstalk (NEXT) test 28c;
– far-end crosstalk (FEXT), test 28d;
– transverse conversion loss (TCL), test 28f;
– transverse conversion transfer loss (TCTL), test 28g.

For the transfer impedance (ZT) test, see IEC 60512-26-100, test 26e.

For the coupling attenuation, see IEC 62153-4-12.

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 60050-581, *International Electrotechnical Vocabulary (IEV) – Part 581: Electromechanical components for electronic equipment*

IEC 60512-1, *Connectors for electronic equipment – Tests and measurements – Part 1: General*

IEC 60512-26-100:2008, *Connectors for electronic equipment – Tests and measurements – Part 26-100: Measurement setup, test and reference arrangement and measurements for connectors according to IEC 60603-7 – Tests 26a to 26g*

IEC 60603-7 (all parts), *Connectors for electronic equipment*

IEC 61076-1, *Connectors for electronic equipment – Product requirements – Part 1: Generic specification*

IEC 61076-3-104, *Connectors for electronic equipment – Product requirements – Part 3-104: Detail specification for 8-way, shielded free and fixed connectors for data transmissions with frequencies up to 1 000 MHz*

IEC 61076-3-110, *Connectors for electronic equipment – Product requirements – Part 3-110: Detail specification for shielded, free and fixed connectors for data transmission with frequencies up to 1 000 MHz*

IEC 61156 (all parts), *Multicore and symmetrical pair/quad cables for digital communications*

IEC 61156-6, *Multicore and symmetrical pair/quad cables for digital communications – Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Sectional specification*

IEC 61169-16, *Radio-frequency connectors – Part 16: RF coaxial connectors with inner diameter of outer conductor 7 mm (0,276 in) with screw coupling – Characteristic impedance 50 ohms (75 ohms) (Type N)*

IEC 62153-4-12, *Metallic communication cable test methods – Part 4-12: Electromagnetic compatibility (EMC) – Coupling attenuation or screening attenuation of connecting hardware – Absorbing clamp method*

ISO/IEC 11801, *Information technology – Generic cabling for customer premises*

3 Terms, definitions and acronyms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 60050(581), IEC 61076-1, IEC 60512-1, IEC 60603-7, IEC 61076-3-104 and IEC 61076-3-110 as well as the following, apply.

3.1.1
mixed mode (parameter or measurement)
parameters or measurements containing differential mode, common mode, and intermodal S-matrices

3.1.2
intermodal (parameter or measurement)
a parameter or measurement that either sources on the common mode and measures on the differential mode or, sources on the differential mode and measures on the common mode

3.2 Acronyms

For ease of reference acronyms used in this document are given below.

CM	common mode
DM	differential mode
DUT	device under test
FEXT	far-end crosstalk loss
IEC	International Electrotechnical Commission
LCL	longitudinal conversion loss
LCTL	longitudinal conversion transfer loss
NEXT	near-end crosstalk loss
TCL	transverse conversion loss

TCTL transverse conversion transfer loss

SE single ended

Z_T transfer impedance

4 Overall test arrangement

4.1 Test instrumentation

All test instrumentation shall be capable of performing measurements over the frequency range of 1 MHz to 1 000 MHz.

The test procedures hereby described require the use of a vector network analyser. The analyser should have the capability of full 2-port calibrations. The analyser shall cover the frequency range of 1 MHz to 1 000 MHz at least.

Measurements are to be taken using a mixed mode test set-up, which is often referred to as an unbalanced, modal decomposition or balun-less setup. This allows measurements of balanced devices without use of an RF balun in the signal path.

Such a configuration also allows testing with either a common or differential mode stimulus and responses, ensuring that intermodal parameters can be measured without reconnection.

A 16 port network analyser is required to measure all combinations of a 4 pair device without external switching, however the network analyser shall have a minimum of 2 ports (including one bi-directional port) to enable the data to be collated and calculated.

It should be noted that the use of a 2 port analyser will involve successive repositioning of the measurement port in order to measure any given parameter.

A 4 port network analyser is recommended as a practical minimum number of ports, as this will allow the measurement of the full 16 term mixed mode S-parameter matrix on a given pair combination without switching or reconnection in one direction.

In order to minimise the reconnection of the DUT for each pair combination the use of an RF switching unit is also recommended.

Each conductor of the pair or pair combination under test shall be connected to a separate port of the network analyser, and results are processed either by internal analysis within the network analyser or by an external application.

Reference loads and through connections are needed for the calibration of the set-up. Requirements for the reference loads are given in 4.8. Termination loads are needed for termination of pairs, used and unused, which are not terminated by the network analyser. Requirements for the termination loads are given in 4.7 and 4.10.

4.2 Measurement precautions

To ensure a high degree of reliability for transmission measurements, the following precautions are required.

a) Consistent and stable resistor loads shall be used throughout the test sequence.

b) Cable and adapter discontinuities, as introduced by physical flexing, sharp bends and restraints shall be avoided before, during and after the tests.

c) Consistent test methodology and termination resistors shall be used at all stages of transmission performance qualifications.

The relative spacing of conductors in the pairs shall be preserved throughout the tests to the greatest extent possible.

d) The balance of the cables shall be maintained to the greatest extent possible by consistent conductor lengths and pair twisting to the point of load.

e) The sensitivity to set-up variations for these measurements at high frequencies demands attention to details for both the measurement equipment and the procedures.

4.3 Mixed mode S-parameter nomenclature

The test methods specified in this standard are based on a balun-less test setup in which all terminals of a device under test are measured and characterized as single ended (SE) ports, i.e. signals (RF voltages and currents) are defined relative to a common ground. For a device with 4 terminals, a diagram is given in Figure 1.

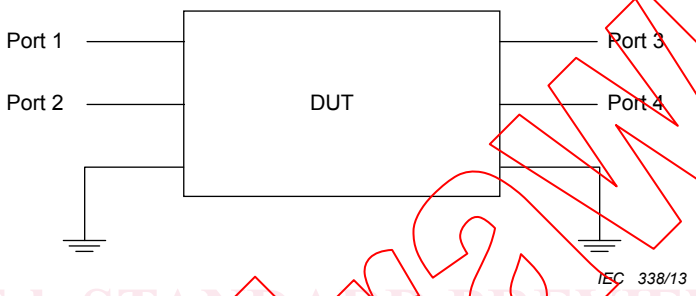


Figure 1 – Diagram of a single ended 4 port device

The 4 port device in Figure 1 is characterized by the 16 term SE S-matrix given in Formula 1, in which the S-parameter S_{ba} expresses the relation between a single ended response on port "b" resulting from a single ended stimulus on port "a".

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

For a balanced device, each port is considered to consist of a pair of terminals (= a balanced port) as opposed to the SE ports defined above, see Figure 2.

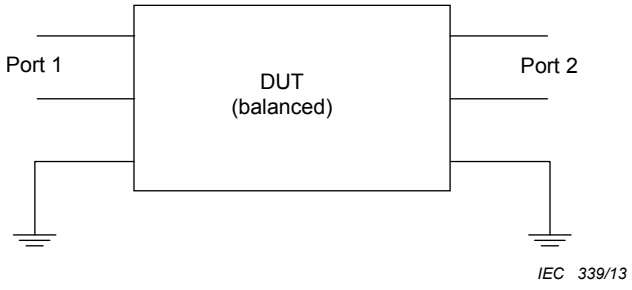


Figure 2 – Diagram of a balanced 2 port device

In order to characterize the balanced device, both the differential mode and the common mode signals on each balanced port shall be considered. The device can be characterized by a mixed mode S-matrix that includes all combinations of modes and ports, e.g. the mixed mode S-parameter S_{DC21} that expresses the relation between a differential mode response on

port 2 resulting from a common mode stimulus on port 1. Using this nomenclature, the full set of mixed mode S-parameters for a 2-port can be presented as in Table 1.

Table 1 – Mixed mode S-parameter nomenclature

		Differential mode stimulus		Common mode stimulus	
		Port 1	Port 2	Port 1	Port 2
Differential mode response	Port 1	S_{DD11}	S_{DD12}	S_{DC11}	S_{DC12}
	Port 2	S_{DD21}	S_{DD22}	S_{DC21}	S_{DC22}
Common mode response	Port 1	S_{CD11}	S_{CD12}	S_{CC11}	S_{CC12}
	Port 2	S_{CD21}	S_{CD22}	S_{CC21}	S_{CC22}

A 4 terminal device can be represented both as a 4 port SE device as in Figure 1 characterized by a single ended S-matrix (Formula 1) and as a 2 port balanced device as in Figure 2 characterized by a mixed mode S-matrix (Table 1). As applying a SE signal to a port is mathematically equivalent to applying superposed differential and common mode signals, the SE and the mixed mode characterizations of the device are interrelated. The conversion from SE to mixed mode S-parameters is given in Annex A. Making use of this conversion, the mixed mode S-parameters may be derived from the measured SE S-matrix.

4.4 Coaxial cables and interconnect for network analysers

Assuming that the characteristic impedance of the network analyser is 50 Ω, coaxial cables used to interconnect the network analyser, switching matrix and the test fixture shall be of 50 Ω characteristic impedance and of low transfer impedance (double screen or more).

These coaxial cables should be as short as possible. (It is recommended that they do not exceed 1 000 mm each.)

The screens of each cable shall be electrically bonded to a common ground plane.

To optimize dynamic range, the total interconnecting cable insertion loss should be less than 3 dB at 1 000 MHz.

4.5 Requirements for switching matrices

Switches (if used) shall be of a minimum of 2x4 configuration, although a switch with a higher number of ports (e.g. 2x8, 1x16) is recommended as this can allow more complete or even total measurement of the DUT without reconnection or moving the DUT. When such switching is used, it shall be constructed such that each port be configurable as either input, output or 50 Ω termination. All inactive ports of the switch shall be terminated with a 50 Ω impedance load.

The switch shall be capable of swapping the ports of the network analyser in a paired fashion to correctly connect to each conductor of the DUT transmission pair.

The switch should be constructed to minimise the different path lengths for each signal path of the pair.

The switch shall comply to the minimum switch performance recommendations given by Table 2.

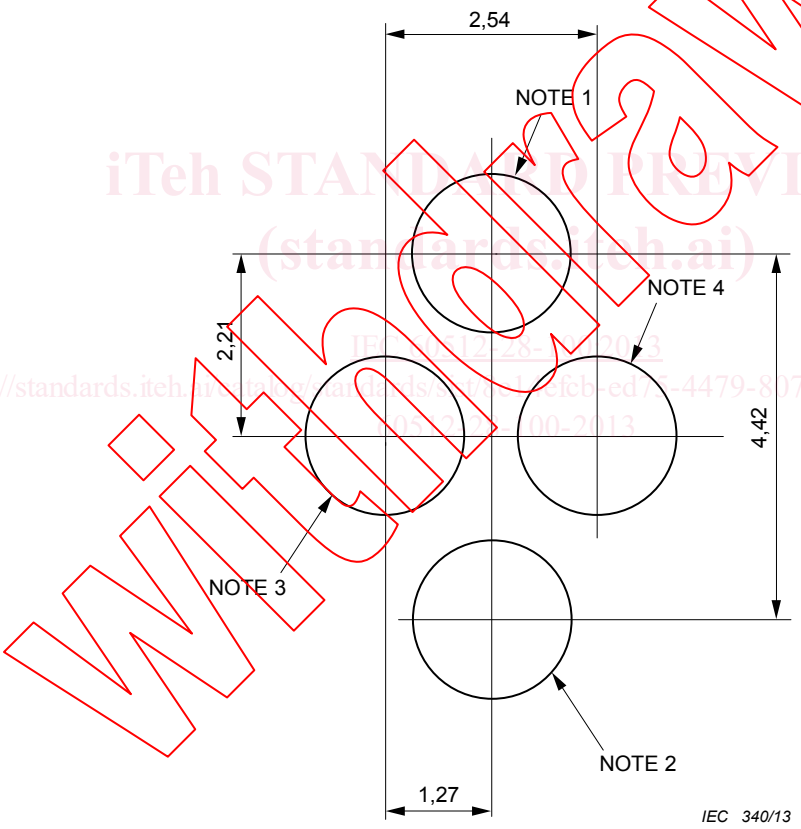
Table 2 – Switch performance recommendations

Parameter	Frequency MHz	Requirement up to 1 000 MHz
Insertion loss (dB)	1 ≤ f ≤ 1 000)	≤ 0,5 dB
Return loss (dB)		≥68-20log(*f*) dB 40 dB max 24 dB min
Crosstalk (dB)		≥ 95 dB

4.6 Test fixture requirements

For ease of interfacing to test fixtures, a pin and fixed connector interface with dimensions as shown in Figure 3 is recommended. Information concerning examples of fixed connectors that may be used for this interface is given in Annex B.

Dimensions in millimeters



NOTE 1 Ground

NOTE 2 Ground

NOTE 3 First conductor in a pair

NOTE 4 Second conductor in a pair

Figure 3 – Test interface pattern

Test fixtures shall meet the requirements of Table 3 when tested using appropriate resistor terminations at the DUT interface fixed connectors of the fixture after the network analyser has been calibrated at the end of the coaxial cables intended to interface to the fixture.

Table 3 – Test fixture requirements

Parameter	Frequency MHz	Requirement up to 1 000 MHz
SE Port (50 Ω) return loss (dB)	1 ≤ f ≤ 1 000	≥72-20log(*f*) dB 40 dB max
DM port (100 Ω) return loss (dB)		≥78-20log(*f*) dB 40 dB max
CM port (100 Ω) return loss (dB)		≥68-20log(*f*) dB 35 dB max
SE (50 Ω) Port to Port Isolation NEXT and FEXT		≥114-20log(*f*) dB 75 dB max
DM (100 Ω) Port to Port Isolation NEXT and FEXT pair to pair		≥130-20log(*f*) dB 94 dB max
DM (100 Ω) insertion loss		< 0,5 dB
TCL LCL		≥100-20log(*f*) dB 70 dB max
TCTL LCTL		≥90-20log(*f*) dB 50 dB max

4.7 Requirements for termination performance at calibration plane

Termination performance at the calibration plane shall meet the requirements of Table 4.

Table 4 – Requirements for terminations at calibration plane

Parameter	Frequency MHz	Requirement up to 1 000 MHz
SE Port (50 Ω) return loss (dB)	1 ≤ f ≤ 1 000	≥74-20log(*f*) dB 40 dB max
DM port (100 Ω) return loss (dB)		≥74-20log(*f*) dB 40 dB max
DM Port to Port residual NEXT		≥130-20log(*f*) dB 94 dB max

4.8 Reference loads for calibration

To perform a one or two-port calibration of the test equipment, a short circuit, an open circuit and a reference load are required. These devices shall be used to obtain a calibration.

The reference load shall be calibrated against a calibration reference, which shall be a 50 Ω load, traceable to an international reference standard. One 50 Ω reference load shall be calibrated against the calibration reference. The reference load for calibration shall be placed in an N-type connector according to IEC 61169-16, meant for panel mounting, which is machined flat on the back side, see Figure 4.

The load shall be fixed to the flat side of the connector. A network analyser shall be calibrated, 1-port full calibration, with the calibration reference. Thereafter, the return loss of the reference load for calibration shall be measured. The verified return loss shall be >46 dB at frequencies up to 100 MHz and >40 dB at frequencies above 100 MHz and up to the limit for which the measurements are to be carried out.