IEC 60512-28-100

Edition 3.0 2024-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Connectors for electrical and electronic equipment – Tests and measurements – Part 28-100: Signal integrity tests up to 2 000 MHz – Tests 28a to 28g

Connecteurs pour équipements électriques et électroniques – Essais et mesures – Partie 28-100: Essais d'intégrité des signaux jusqu'à 2 000 MHz – Essais 28a à 28g

IEC 60512-28-100:2024-08(en-fr)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Connectors for electrical and electronic equipment – Tests and measurements – Part 28-100: Signal integrity tests up to 2 000 MHz – Tests 28a to 28g

FOREWORD

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IEC 60512-28-100 has been prepared by subcommittee 48B: Electrical connectors, of IEC technical committee 48: Electrical connectors and mechanical structures for electrical and electronic equipment. It is an International Standard.

This third edition cancels and replaces the second edition, published in 2019. This edition constitutes a technical revision.

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

a) The frequency range has been modified to start at 0,1 MHz instead of 1 MHz, to include single-pair connectors.

b) All tables and requirements have been revised down to 0,1 MHz, and partially improved to reduce the impact of the test fixture.

c) Formulae to calculate the S-parameters from single-ended parameters have been added.

d) A note was added for those parameters which are not applicable to single-pair connectors.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
48B/3109/FDIS	48B/3112/RVD

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

The language used for the development of this International Standard is English.

A list of all parts in the IEC 60512 series, published under the general title Connectors for electrical and electronic equipment, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

Connectors for electrical and electronic equipment – Tests and measurements – Part 28-100: Signal integrity tests up to 2 000 MHz – Tests 28a to 28g

1 Scope

This part of IEC 60512 specifies the test methods for signal integrity and transmission performance for connectors specified in respective parts of IEC 60603-7 [1], IEC 61076-1 [2], IEC 61076-2 [3], IEC 61076-3 [4] and IEC 63171 [5] series of standards for connecting hardware applications from 0,1 MHz up to 2 000 MHz, with reference to this document.

NOTE This document is also suitable for testing signal integrity and transmission performance of connectors up to a lower value of maximum frequency; however, the test methodology specified in the detail specification for any given connector remains the reference conformance test for that connector.

The list of connector series of standards does not preclude referencing this document in other connector manufacturer's specifications or published standards.

Test procedures provided herein 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.

Other test procedures referenced herein are:

– shield transfer impedance (Z_T), see IEC 60512-26-100, test 26e.
– coupling attenuation (a_C), see IEC 62153-4-7 and IEC 62153-4-12.
– low frequency coupling attenuation (a_{CLF}) see IEC 62153-4-7 and IEC 62153-4-15.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 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: Generic specification*

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

IEC 60512-27-100, *Connectors for electronic equipment – Tests and measurements – Part 27-100: Signal integrity tests up to 500 MHz on 60603-7 series connectors – Tests 27a to 27g*

IEC 60512-27-200, *Connectors for electrical and electronic equipment – Tests and measurements – Part 27-200: Additional specifications for signal integrity tests up to 2 000 MHz on IEC 60603-7 series connectors – Tests 27a to 27g*

IEC 60512-29-100, *Connectors for electronic equipment – Tests and measurements – Part 29-100: Signal integrity tests up to 500 MHz on M12 style connectors – Tests 29a to 29g*

IEC 60603-7, *Connectors for electronic equipment – Part 7: Detail specification for 8-way, unshielded, free and fixed connectors*

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

IEC 61076-3-104, *Connectors for electrical and electronic equipment – Product requirements – Part 3-104: Detail specification for 8-way, shielded free and fixed connectors for data transmissions with frequencies up to 2 000 MHz*

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

IEC 61156-1, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61169-15, *Radio-frequency connectors – Part 15: Sectional specification – RF coaxial connectors with inner diameter of outer conductor 4,13 mm (0,163 in) with threaded coupling – Characteristic impedance 50 Ω (type SMA)*

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 62153-4-6, *Metallic cables and other passive components test methods – Part 4-6: Electromagnetic compatibility (EMC) – Surface transfer impedance – Line injection method*

IEC 62153-4-7, *Metallic cables and other passive components test methods – Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring of transfer impedance Z_T and screening attenuation a_S or coupling attenuation a_C of connectors and assemblies – Triaxial tube in tube method*

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*

IEC 62153-4-15, *Metallic cables and other passive components test methods – Part 4-15: Electromagnetic compatibility (EMC) – Test method for measuring transfer impedance and screening attenuation – or coupling attenuation with triaxial cell*

IEC 63171, *Connectors for electrical and electronic equipment – Shielded or unshielded free and fixed connectors for balanced single-pair data transmission with current-carrying capacity – General requirements and tests*

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

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 60050-581, IEC 61076-1, IEC 60512-1, IEC 60603-7, IEC 61076-3-104, IEC 61076-3-110, IEC 61156-1 and IEC 63171, and the following apply.

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

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

3.1 Terms and definitions

3.1.1
intermodal
<parameter or measurement> 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

3.1.2
mixed mode
<parameter or measurement> parameter or measurement containing differential mode, common mode, and intermodal S-matrices

3.1.3
interconnection
cable assembly made of a cable terminated by two connectors

EXAMPLE: A connection between a VNA, switching matrix or test fixture

3.2 Abbreviated terms

a_C	coupling attenuation
a_{CLF}	Low frequency coupling attenuation
CM	common mode
DM	differential mode
DUT	device under test
FEXT	far-end crosstalk loss
LCL	longitudinal conversion loss
LCTL	longitudinal conversion transfer loss
NEXT	near-end crosstalk loss
RF	radio frequency
RL_{CM}	return loss, common mode
RL_{DM}	return loss, differential mode
SE	single-ended
TCL	transverse conversion loss
TCTL	transverse conversion transfer loss
VNA	vector network analyser

Z_T transfer impedance

4 Overall test arrangement

4.1 General

This document specifies test methods and procedures for connectors.

The test methods and procedures for signal integrity and transmission performance specified herein are referenced by connector standards, specified in IEC 60603-7 [1], IEC 61076-1 [2], IEC 61076-2 [3], IEC 61076-3 [4], IEC 63171 [5] series of standards and other standards for connecting hardware and their sectional specifications, with signal integrity specifications from 0,1 MHz up to 2 000 MHz; such connector standards include IEC 60603-7-81 [6], IEC 60603-7-82 [7], IEC 61076-3-110 [8], IEC 61076-3-104 [9], and IEC 61076-2-109 [10]. They are used with twisted-pair or quad cables having 100 Ω nominal differential characteristic impedance, which are specified in accordance with IEC 61156 (all parts) [11] and its sectional specifications covering at least the frequency range supported by the connecting hardware.

4.2 Test instrumentation

4.2.1 General

All test instrumentation shall be capable of performing measurements over the frequency range of 0,1 MHz to 2 000 MHz or at least the frequency range of the connector under test.

4.2.2 Vector network analyser

The VNA shall have a minimum of two ports (including one bi-directional port) to enable the data to be collated and calculated.

A 4-port VNA 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 or pair combination without switching or reconnection, as shown in Figure 6, Figure 7, Figure 8 and Figure 9.

The use of a 2-port VNA will involve successive repositioning of the measurement port in order to measure any given parameter. For single-pair connectors a 4-port VNA is recommended to be used to measure all S-parameter combinations to avoid external switching. For 4-pair devices, a 16-port VNA is recommended to be used to measure all S-parameter combinations to avoid external switching.

4.2.3 RF switching unit

In order to minimize the reconnection of the DUT for each pair combination the use of a 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 VNA, and results are processed either by internal analysis within the VNA or by an external application.

4.2.4 Reference loads and termination loads

Reference loads and through connections shall be utilised for the calibration of the setup. Requirements for the reference loads shall be as given in 4.9. Termination loads shall be utilised for termination of pairs, used and unused, which are not terminated by the VNA. Requirements for the termination loads shall be as given in 4.11.

Loads used for calibration shall be paired as explained in Annex E to ensure good symmetry at the calibration plane.

4.3 Measurement precautions

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

- Resistors with a tolerance of ±0,1 % shall be used throughout the test sequence.
- Cable and adapter discontinuities, as introduced by physical flexing, sharp bends and restraints shall be avoided before, during and after the tests.
- Standardised test methodology and termination resistors shall be used at all stages of transmission performance qualifications.
- The balance of the cables shall be maintained to the greatest extent possible by ensuring same conductor lengths and pair twisting to the point of load.
- The relative spacing of conductors in the pairs shall be preserved throughout the tests to the greatest extent possible.
- The sensitivity to setup variations for these measurements at high frequencies demands attention to details for both the measurement equipment and the procedures.
- The test setup shall be appropriately earthed (bonded).

4.4 Mixed mode S-parameter nomenclature

The test methods specified in this document are based on a balunless test setup in which all terminals of a device under test are measured and characterised as single-ended (SE) ports, i.e. signals (RF voltages and currents) shall be defined relative to a common earth (ground) plane. For a device with four terminals, a diagram is given in Figure 1.

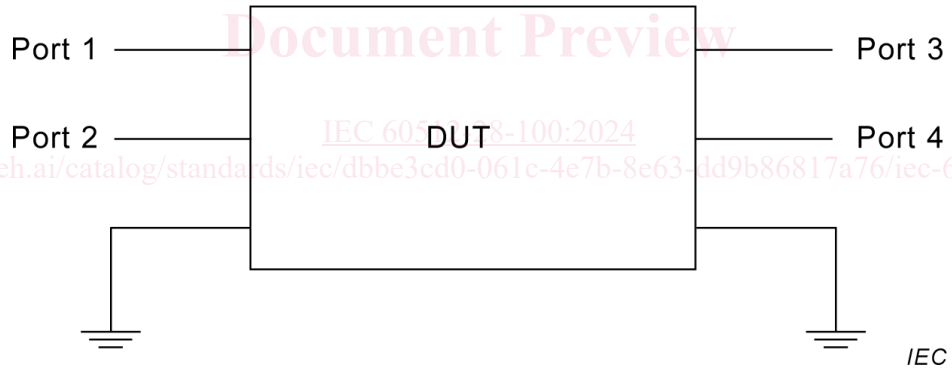

Figure 1 – Diagram of a single-ended 4-port device

The 4-port device in Figure 1 shall be characterised 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”.

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

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