IEC 60512-28-100

Edition 2.0 2019-11

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

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CONTENTS

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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

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International Standard 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.

This second edition cancels and replaces the first edition, issued in 2013, and constitutes a technical revision.

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

- The title is revised from 1 000 MHz to 2 000 MHz to reflect the range of frequencies which may be tested.
- All tables and requirements have been revised up to 2 000 MHz.

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

FDIS	Report on voting
48B/2756/FDIS	48B/2766/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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

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

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- withdrawn,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

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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

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, IEC 61076-1, IEC 61076-2, and IEC 61076-3 standards for connecting hardware applications up to 2 000 MHz. It is also suitable for testing lower frequency connectors, however, the test methodology specified in the detail specification for any given connector remains the reference conformance test for that connector. The above 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:

– transfer impedance (Z_T), see IEC 60512-26-100, test 26e.
– for coupling attenuation (a_C), see IEC 62153-4-12.

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 60169-15, *Radio-frequency connectors – Part 15: R.F. coaxial connectors with inner diameter of outer conductor 4,13 mm (0.163 in) with screw coupling – Characteristic impedance 50 ohms (Type SMA)*

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 arrangement 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 PAS 60512-27-200, *Connecteurs 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 60603-7-1, *Connectors for electronic equipment – Part 7-1: Detail specification for 8-way, shielded, free and fixed connectors*

IEC 60603-7-2, *Connectors for electronic equipment – Part 7-2: Detail specification for 8-way, unshielded, free and fixed connectors, for data transmissions with frequencies up to 100 MHz*

IEC 60603-7-3, *Connectors for electronic equipment – Part 7-3: Detail specification for 8-way, shielded, free and fixed connectors, for data transmission with frequencies up to 100 MHz*

IEC 60603-7-4, *Connectors for electronic equipment – Part 7-4: Detail specification for 8-way, unshielded, free and fixed connectors, for data transmissions with frequencies up to 250 MHz*

IEC 60603-7-5, *Connectors for electronic equipment – Part 7-5: Detail specification for 8-way, shielded, free and fixed connectors, for data transmissions with frequencies up to 250 MHz*

IEC 60603-7-7, *Connectors for electronic equipment – Part 7-7: Detail specification for 8-way, shielded, free and fixed connectors for data transmission with frequencies up to 600 MHz*

IEC 60603-7-41, *Connectors for electronic equipment – Part 7-41: Detail specification for 8-way, unshielded, free and fixed connectors, for data transmissions with frequencies up to 500 MHz*

IEC 60603-7-51, *Connectors for electronic equipment – Part 7-51: Detail specification for 8-way, shielded, free and fixed connectors, for data transmissions with frequencies up to 500 MHz*

IEC 60603-7-71, *Connectors for electronic equipment – Part 7-71: Detail specification for 8-way, shielded, free and fixed connectors, for data transmission with frequencies up to 1 000 MHz*

IEC 60603-7-81, *Connectors for electronic equipment – Part 7-81: Detail specification for 8-way, shielded, free and fixed connectors, for data transmissions with frequencies up to 2 000 MHz*

IEC 60603-7-82, *Connectors for electronic equipment – Part 7-82: Detail specification for 8-way, 12 contacts, shielded, free and fixed connectors, for data transmission with frequencies up to 2 000 MHz*

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

IEC 61076-2, *Connectors for electronic equipment – Product requirements – Part 2: Sectional specification for circular connectors*

IEC 61076-2-109, *Connectors for electronic equipment – Product requirements – Part 2-109: Circular connectors – Detail specification for connectors with M 12 x 1 screw-locking, for data transmission frequencies up to 500 MHz*

IEC 61076-3, *Connectors for electronic equipment – Product requirements – Part 3: Rectangular connectors – Sectional 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 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 61156-9, *Multicore and symmetrical pair/quad cables for digital communications – Part 9: Cables for channels with transmission characteristics up to 2 GHz – Sectional specification*

IEC 61156-10:2016, *Multicore and symmetrical pair/quad cables for digital communications – Part 10: Cables for cords with transmission characteristics up to 2 GHz – 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 11801-1:2017, *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 and IEC 61076-3-110, 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 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>
parameters or measurements containing differential mode, common mode, and intermodal S-matrices

3.2 Abbreviated terms

a_C	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
NA	network analyzer
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 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, IEC 60603-7-1, IEC 61076-2, 61076-3 and other standards for connecting hardware and their sectional specifications, with signal integrity specifications up to 2 000 MHz; such connector standards include IEC 60603-7-81, IEC 60603-7-82, IEC 61076-3-110, IEC 61076-3-104, and IEC 61076-2-109, which are used with twisted-pair cables having 100 Ω nominal differential characteristic impedance.

The test methods and procedures specified herein are referenced by connector standards for connecting hardware typically used with twisted-pair cables having 100 Ω nominal differential characteristic impedance, which are specified in accordance with IEC 61156-1 cable standards and its sectional specifications up to 2 000 MHz, e.g. IEC 61156-9 and IEC 61156-10.

4.2 Test instrumentation

4.2.1 General

All test instrumentation shall be capable of performing measurements over the frequency range of 1 MHz to 2 000 MHz.

4.2.2 Vector network analyser

The test procedures hereby described require the use of a vector network analyzer. The analyzer shall have the capability of full 2-port calibrations. The analyzer shall cover the frequency range of 1 MHz to 2 000 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 or responses, ensuring that intermodal parameters can be measured without reconnection.

A 16-port network analyzer shall be used to measure all combinations of a 4-pair device without external switching, however the network analyzer 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 analyzer will involve successive repositioning of the measurement port in order to measure any given parameter.

A 4-port network analyzer 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.

4.2.3 RF switching unit

In order to minimise 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 network analyzer, and results are processed either by internal analysis within the network analyzer 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 set-up. 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 network analyzer. 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.

- Consistent and stable resistor loads 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.
- 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.
- 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.
- The sensitivity to set-up variations for these measurements at high frequencies demands attention to details for both the measurement equipment and the procedures.
- The test setup has to be grounded appropriately.

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). For a device with 4 terminals, a diagram is given in Figure 1.

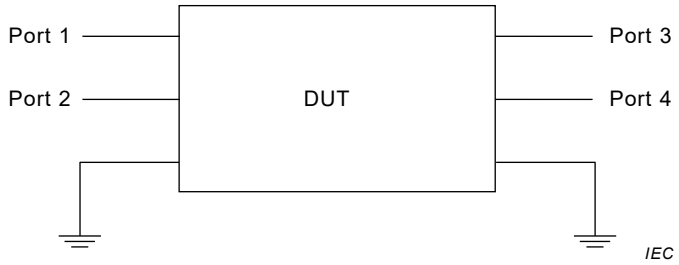

Figure 1 – Diagram of a single ended 4-port device

The 4-port device in Figure 1 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.

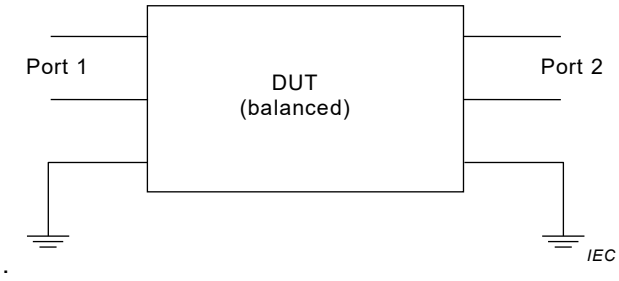

Figure 2 – Diagram of a balanced 2-port device

The device is characterised 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 are given in Table 1.