

BS EN 60512-26-100:2008+A1:2011



BSI Standards Publication

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

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

raising standards worldwide™



National foreword

This British Standard is the UK implementation of EN 60512-26-100:2008+A1:2011. It is identical to IEC 60512-26-100:2008, incorporating amendment 1:2011. It supersedes BS EN 60512-26-100:2008, which will be withdrawn on 18 April 2014.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee EPL/48, Electromechanical components and mechanical structures for electronic equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This standard cancels and replaces the Annexes of BS EN 60603-7-x documents dealing with transmission characteristics for interoperability and backward compatibility that were previously found in some BS EN 60603-7 standards. This standard is to be read in conjunction with BS EN 60512-1:2001 and BS EN 60512-1-100:2006 which explain the structure of the IEC 60512 series.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© BSI 2011

ISBN 978 0 580 69143 0

ICS 31.220.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2009

Amendments/corrigenda issued since publication

Date	Text affected
30 June 2011	Implementation of IEC amendment 1:2011, with CENELEC endorsement A1:2011

**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 60512-26-100:2008)**

Connecteurs
pour équipements électroniques -
Essais et mesures -
Partie 26-100: Montage de mesure,
dispositifs d'essai et de référence
et mesures pour les connecteurs
conformes à la CEI 60603-7 -
Essais 26a à 26g
(CEI 60512-26-100:2008)

Steckverbinder
für elektronische Einrichtungen -
Mess- und Prüfverfahren -
Teil 26-100: Messaufbau,
Prüf- und Referenzanordnung
und Messverfahren für Steckverbinder
nach IEC 60603-7 -
Prüfungen 26a bis 26g
(IEC 60512-26-100:2008)

This European Standard was approved by CENELEC on 2008-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 48B/1892/FDIS, future edition 1 of IEC 60512-26-100, prepared by SC 48B, Connectors, of IEC TC 48, Electromechanical components and mechanical structures for electronic equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60512-26-100 on 2008-10-01.

This European Standard cancels and replaces the annexes of EN 60603-7-x documents dealing with transmission characteristics for interoperability and backward compatibility.

This standard is to be read in conjunction with EN 60512-1 and EN 60512-1-100 which explains the structure of the EN 60512 series.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2009-07-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2011-10-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60512-26-100:2008 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068-1	NOTE Harmonized as EN 60068-1:1994 (not modified).
IEC 60512-25	NOTE Harmonized in EN 60512-25 series (not modified).

Foreword to amendment A1

The text of document 48B/2065/CDV, future amendment 1 to IEC 60512-26-100:2008, prepared by SC 48B, Connectors, of IEC TC 48, Electromechanical components and mechanical structures for electronic equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60512-26-100:2008 on 2011-04-18.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

- latest date by which the amendment has to be
implemented at national level by publication of
an identical national standard or by endorsement (dop) 2012-01-18
- latest date by which the national standards conflicting
with the amendment have to be withdrawn (dow) 2014-04-18

Endorsement notice

The text of amendment 1:2011 to the International Standard IEC 60512-26-100:2008 was approved by CENELEC as an amendment to the European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

NOTE 1 When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Where a standard cited below belongs to the EN 50000 series, the European Standard applies instead of the relevant International Standard.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
-	-	Communication cables - Specifications for test methods - Part 1-14: Electrical test methods - Coupling attenuation or screening attenuation of connecting hardware	EN 50289-1-14	- ¹⁾
IEC 60169-15	- ¹⁾	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	- ¹⁾	Connectors for electronic equipment - Tests and measurements - Part 1: General	EN 60512-1	2001 ²⁾
IEC 60512-1-100	- ¹⁾	Connectors for electronic equipment - Tests and measurements - Part 1-100: General - Applicable publications	EN 60512-1-100	2006 ²⁾
IEC 60603-7	- ¹⁾	Connectors for electronic equipment - Part 7: Detail specification for 8-way, unshielded, free and fixed connectors	EN 60603-7	200X ³⁾
IEC 60603-7-2	- ¹⁾	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	EN 60603-7-2	200X ³⁾
IEC 60603-7-3	- ¹⁾	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	EN 60603-7-3	200X ³⁾
IEC 60603-7-4	2005	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	EN 60603-7-4	2005
IEC 60603-7-5	2007	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	EN 60603-7-5	200X ³⁾

¹⁾ Undated reference.

²⁾ Valid edition at date of issue.

³⁾ To be ratified.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61156	Series	Multicore and symmetrical pair/quad cables for digital communications	-	-
IEC 61169-16	- ¹⁾	Radio-frequency connectors - Part 16: Sectional specification - RF coaxial connectors with inner diameter of outer conductor 7 mm (0,276 in) with screw coupling - Characteristics impedance 50 ohms (75 ohms) (type N)	EN 61169-16	2007 ²⁾
ISO/IEC 11801	2002	Information technology - Generic cabling for customer premises	EN 50173-1 ⁴⁾ and EN 50173-2 ⁵⁾	2007 2007
ITU-T Recommendation G.117	- ¹⁾	Transmission aspects of unbalance about earth	-	-
ITU-T Recommendation O.9	- ¹⁾	Measuring arrangements to assess the degree of unbalance about earth	-	-

⁴⁾ The title of EN 50173-1 is: *Information technology - Generic cabling systems – Part 1: General requirements.*

⁵⁾ The title of EN 50173-2 is: *Information technology - Generic cabling systems – Part 2: Office premises.*

CONTENTS

INTRODUCTION.....	9
1 Scope.....	10
2 Normative reference	10
3 General requirements for measurement setup	11
3.1 Test instrumentation.....	11
3.2 Coaxial cables and test leads for network analysers.....	11
3.3 Measurement precautions	11
3.4 Balun requirements	12
3.5 Reference components for calibrations.....	13
3.5.1 Reference loads for calibration	13
3.5.2 Reference cables for calibration	13
3.6 Termination loads for termination of conductor pairs	13
3.7 Termination of screens	14
3.8 Test specimen and reference planes	14
3.9 Termination of balun with low return loss for common mode	15
3.9.1 General	15
3.9.2 Centre tap connected to ground.....	15
3.9.3 Centre tap open.....	15
4 Connector measurement up to 250 MHz.....	16
4.1 Insertion loss (IL), Test 26a.....	16
4.1.1 Object	16
4.1.2 Free connector for insertion loss.....	16
4.1.3 Test method	16
4.1.4 Test set-up	16
4.1.5 Procedure.....	16
4.1.6 Test report.....	18
4.1.7 Accuracy	18
4.2 Return loss (RL), Test 26b	18
4.2.1 Object	18
4.2.2 Free connector for return loss.....	18
4.2.3 Test method	18
4.2.4 Test set-up	18
4.2.5 Procedure.....	18
4.2.6 Test report.....	18
4.2.7 Accuracy	18
4.3 Near-end crosstalk (NEXT), Test 26c	19
4.3.1 Object	19
4.3.2 Fixed and free connector combinations to be tested	19
4.3.3 Test method	19
4.3.4 Test set-up	19
4.3.5 Procedure.....	20
4.3.6 Test report.....	21
4.3.7 Accuracy	21
4.4 Far-end crosstalk (FEXT), Test 26d.....	21
4.4.1 Object	21

4.4.2	Fixed and free connector combinations to be tested	21
4.4.3	Test method	21
4.4.4	Test set-up	21
4.4.5	Procedure.....	22
4.4.6	Test report.....	23
4.4.7	Accuracy	23
4.5	Transfer impedance (Z_T), Test 26e	23
4.5.1	Object	23
4.5.2	Test method	23
4.5.3	Definitions	23
4.5.4	Test set-up	24
4.5.5	Procedure.....	27
4.5.6	Test report.....	28
4.5.7	Accuracy	28
4.6	Transverse Conversion Loss (TCL), Test 26f.....	29
4.6.1	Object	29
4.6.2	Test method	29
4.6.3	Test set-up	29
4.6.4	Procedure.....	29
4.6.5	Test report.....	30
4.6.6	Accuracy	30
4.7	Transverse Conversion Transfer Loss (TCTL), Test 26g.....	30
4.7.1	Object	30
4.7.2	Test method	30
4.7.3	Test set-up	31
4.7.4	Procedure.....	31
4.7.5	Test report.....	31
4.7.6	Accuracy	32
5	Construction and qualification of test plugs.....	32
5.1	De-embedding near-end crosstalk (NEXT) test plug	32
5.1.1	Set-up and calibration of reference plug	32
5.1.2	Test plug construction	33
5.1.3	Test plug NEXT measurement	34
5.1.4	Test plug NEXT requirements	35
5.1.5	Test plug balance	37
5.2	Far-end crosstalk (FEXT) test plug	38
5.2.1	General	38
5.2.2	Test plug FEXT measurement – de-embedding method	39
5.2.3	Test plug FEXT measurement – direct method	39
5.2.4	FEXT test plug requirements	40
5.3	Return loss test plug	40
6	Reference plug and jack construction and measurement – the basics of the de-embedding test method	40
6.1	De-embedding near-end crosstalk (NEXT) reference plug and jack	40
6.1.1	Reference plug construction	40
6.1.2	Return loss reference plug.....	41
6.1.3	Set-up and calibration of reference plug	42
6.1.4	De-embedding reference plug NEXT measurement.....	42
6.1.5	Delay adjustment in lieu of port extension.....	

6.2	De-embedding near-end crosstalk (NEXT) reference jack.....	42
6.2.1	Reference jack construction.....	42
6.2.2	De-embedding reference jack NEXT measurement.....	44
6.2.3	Differential mode jack vector	44
6.3	Determining reference jack FEXT vector	44
6.3.1	FEXT reference plug details	44
6.3.2	FEXT reference jack assembly	47
6.3.3	De-embedding reference jack FEXT assembly measurement.....	48
Annex A (informative) Example test fixtures in support		49
Bibliography.....		55
Figure 1 – Optional 180° hybrid used instead of a balun		12
Figure 2 – Example of calibration of reference loads.....		13
Figure 3 – Resistor load.....		14
Figure 4 – Definition of reference planes.....		15
Figure 5 – Balanced attenuator for balun centre tap grounded		15
Figure 6 – Balanced attenuator for balun centre tap open		16
Figure 7 – Calibration		17
Figure 8 – Measuring set-up		17
Figure 9 – NEXT measurement for differential and common mode terminations		20
Figure 10 – FEXT measurement for differential and common mode terminations.....		22
Figure 11 – Preparation of test specimen.....		24
Figure 12 – Triaxial test set-up		25
Figure 13 – Impedance matching for $R_1 < 50 \Omega$		26
Figure 14 – Impedance matching for $R_1 > 50 \Omega$		27
Figure 15 – TCL measurement.....		29
Figure 16 – TCTL measurement.....		31
Figure 17 – Back-to-back through calibration (for more information see Annex A).....		32
Figure 18 – Mated test plug/direct fixture test configuration		39
Figure 19 – De-embedding reference plug		41
Figure 20 – De-embedding reference jack.....		43
Figure 21 – De-embedding reference FEXT plug without sockets.....		44
Figure 22 – De-embedding reference FEXT plug with sockets.....		45
Figure 23 – Reference FEXT plug mated to PWB.....		45
Figure 24 – Reference FEXT plug-test lead position		46
Figure 25 – Reference FEXT plug assembly		46
Figure 26 – Test leads connected to de-embedded reference jack/PWB assembly.....		48
Figure 27 – Reference FEXT plug mated to reference jack/PWB assembly		48
Figure A.1 – TH13KIT test head interface with baluns attached		49
Figure A.2 – Alternative to item 3.1 in Table A.2		51
Figure A.3 – Pyramid test setup for shielded connectors.....		51
Figure A.4 – Exploded assembly of the coaxial termination reference test head.....		53
Figure A.5 – Detailed view of the coaxial termination reference test-head interface		53

Table 1 – Test balun performance characteristics	12
Table 2 – Uncertainty band of return loss measurement at frequencies below 100 MHz	19
Table 3 – Uncertainty band of return loss measurement at frequencies above 100 MHz.....	19
Table 4 – De-embedded NEXT real and imaginary reference jack vectors.....	34
Table 5 – Differential mode reference jack vectors.....	35
Table 6 – Test plug NEXT loss limits for connectors specified up to 100 MHz according to IEC 60603-7-2 or IEC 60603-7-3.....	36
Table 7 – Test plug NEXT loss limits for connectors specified up to 250 MHz according to IEC 60603-7-4 or IEC 60603-7-5.....	37
Table 8 – Test-plug differential and differential with common-mode consistency	38
Table 9 – Test plug FEXT requirements – De-embedding method	40
Table 10 – Return loss requirements for return loss reference plug.....	42
Table A.1 – Coaxial termination reference head component list	49
Table A.2 – Coaxial termination reference head, additional parts	50
Table A.3 – Coaxial termination reference head component list	52

INTRODUCTION

Detail specifications for 8-way, free and fixed connectors such as IEC 60603-7-4:2005 and IEC 60603-7-5:2007 define measurement setup, test and reference arrangements and measurements for interoperability and backward compatibility tests for connectors according IEC 60603-7 up to 250 MHz for insertion loss (IL), near end crosstalk (NEXT), far end crosstalk (FEXT), return loss (RL) and balance (transverse conversion loss, TCL, and transverse conversion transfer loss, TCTL) as well as the de-embedding method to qualify the fixed (outlet) connector.

This standard keeps the technical content of the test methods specified in the annexes C to J as specified in IEC 60603-7-4:2005 and annexes C to K as specified in IEC 60603-7-5:2007, but it structures and harmonizes the measurements for better readability. This standard is intended to be referenced by the future second editions of IEC 60603-7-x and the future first editions of IEC 60603-7-xy (under preparation). This standard is intended to be referenced by IEC 60603-7-x Edition 2.0 and IEC 60603-7-xy Edition 1.0 standards (under preparation) and may be referenced for all IEC standards with 60603-7 interface.

IEC 60516-26-100: Connectors for electronic equipment – Tests and measurements – Part 26-100, consists of the following clauses:

- Clause 3: General requirements for measurement setup
- Clause 4: Connector measurement up to 250 MHz

NOTE 1 Clauses 3 and 4 define the measurement procedures to qualify the outlet

- Clause 5: Construction and qualification of test plugs

NOTE 2 The wiring of the plug has an effect on the mated connector performance. Extensive measurements show that NEXT and FEXT are affected in a particular way so that the properties of the test plug must be controlled. To ensure adequate performance for the outlet over the expected range of different plug wiring, it shall be tested with a set of up to 12 test plugs with different NEXT performances. The outlet complies with the NEXT requirements of the standard only if all the combinations comply with their requirements for near end crosstalk. FEXT is handled in a similar way, but only one test plug is required. Clause 5 describes the construction and qualification of test plugs. Test plugs are used in the laboratory as long as possible to avoid the costly procedure to find new test plugs.

- Clause 6: Reference jack construction and measurement – the basics of the de-embedding test method

NOTE 3 Clause 6 describes the preparation and measurements of the reference plugs and jacks as a basis of the de-embedding test method.

The test methods provided here are:

- insertion loss, test 26a;
- return loss, test 26b;
- near-end crosstalk (NEXT), test 26c;
- far-end crosstalk (FEXT), test 26d;
- transfer impedance (Z_T), test 26e;
- transverse conversion loss (TCL), test 26f;
- transverse conversion transfer loss (TCTL), test 26g.

For the coupling attenuation, see EN 50289-1-14.

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

1 Scope

This part of IEC 60512 specifies the test and measurements and the related measurement setup and reference arrangements for interoperability and backward compatibility tests for the development and qualification of 8-way, free and fixed connectors for data transmission.

2 Normative reference

The following referenced documents are indispensable for the application 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 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: General*

IEC 60512-1-100, *Connectors for electronic equipment – Tests and measurements – Part 1-100: General – Applicable publications*

IEC 60603-7, *Connectors for frequencies below 3 MHz for use with printed boards – Part 7: Detail specification for connectors, 8-way, including fixed and free connectors with common mating features, with assessed quality*

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 transmissions with frequencies up to 100 MHz*

IEC 60603-7-4:2005, *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 60603-7-5:2007, *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 61156 (all parts), *Multicore and symmetrical pair/quad cables for digital communications*

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)*

ISO 11801:2002, *Information technology – Generic cabling for customer premises*

ITU-T Recommendation G.117, *Transmission aspects of unbalance about earth*

ITU-T Recommendation O.9, *Measuring arrangements to assess the degree of unbalance about earth*

EN 50289-1-14, *Communication cables – Specification for test methods – Part 1-14: Electrical test methods – Coupling attenuation or screening attenuation of connecting hardware*

3 General requirements for measurement setup

3.1 Test instrumentation

These electrical test procedures require the use of a vector network analyser. The analyser shall have be capable of full 2-port calibrations. The analyser shall cover the frequency range of 1 MHz to 1 GHz at least.

At least two test baluns are required in order to perform measurements with balanced symmetrical signals. The requirements for the baluns are given in 3.4.

Reference loads and cables are needed for the calibration of the set-up. Requirements for the reference loads and cables are given in 3.5.1 and 3.5.2 respectively.

Termination loads are needed for termination of pairs, used and unused, which are not terminated by the test baluns. Requirements for the termination loads are given in 3.9.

An absorbing clamp and ferrite absorbers are needed for the coupling attenuation measurements. The requirements for these items are given in EN 50289-1-14.

3.2 Coaxial cables and test leads for network analysers

Coaxial cable assemblies between network analyser and baluns should be as short as possible. (It is recommended that they do not exceed 60 cm each.)

The baluns shall be electrically bonded to a common ground plane. For crosstalk measurements, a test fixture may be used, in order to reduce residual crosstalk (see 3.9 and Annex A).

Balanced test leads and associated connecting hardware to connect between the test equipment and the connector under test shall be taken from components that meet or exceed the requirements for the relevant class of balanced cabling performance according to ISO/IEC 11801. Balanced test leads shall be limited to a maximum of 7 cm between each balun and the reference plane of the connector under test. Pairs shall remain twisted from the baluns to where connections are made. The impedance of the test leads from the DUT (Device Under Test) to the baluns shall be managed, as far as possible, for both differential and common modes. This can be done by mounting the test leads in a pyramid, channel, or other device.

3.3 Measurement precautions

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

- a) Consistent and stable balun and resistor loads shall be used for each pair 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 terminations (baluns or 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 is 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 detail for both the measurement equipment and the procedures.
- f) All common mode terminations and the housing of the baluns shall be terminated to one common ground plane.

3.4 Balun requirements

The baluns may be balun transformers or 180° hybrids with attenuators to improve matching if needed (see Figure 1).

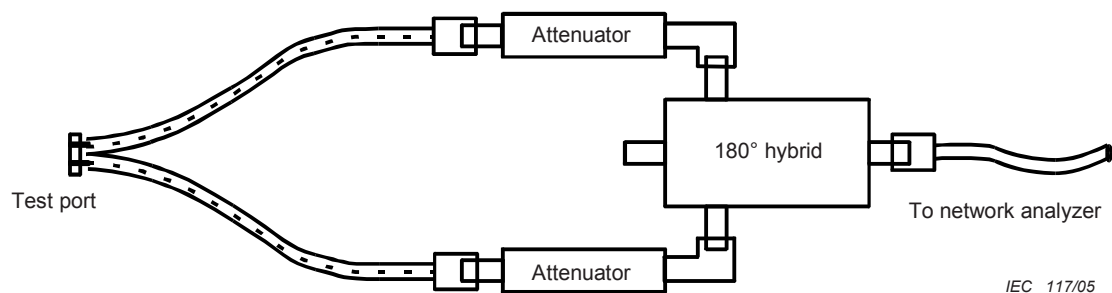


Figure 1 – Optional 180° hybrid used instead of a balun

The specifications for the baluns apply for the whole frequency range for which they are used. Baluns shall be shielded and shall comply with the specifications listed in Table 1.

Table 1 – Test balun performance characteristics

Parameter	Requirement at test frequencies up to 250 MHz
Impedance, primary	Matched to applied network analyser
Impedance, secondary	100 Ω
Insertion loss	10 dB maximum
Return loss secondary	14 dB minimum
Return loss common mode with common mode termination ^{a)}	10 dB minimum
Return loss common mode without common mode termination ^{a)}	1 dB maximum
Longitudinal balance ^{b)}	50 dB
Common mode rejection ^{c)}	50 dB
Output signal balance ^{c)}	50 dB
Power rating	0,1 W
^{a)} Measured by connecting the balanced output terminals together and measuring the return loss. The nominal primary impedance shall terminate the primary input terminal. ^{b)} Applicable for baluns, which are used for balance measurements. Measured from the primary input terminal to the common mode terminal when the secondary balanced terminal is terminated with 100 Ω . ^{c)} Measured according to ITU-T Recommendations G.117 and O.9 (formerly CCITT recommendations).	

3.5 Reference components for calibrations

3.5.1 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 at the reference plane.

The reference load e.g. chip resistors shall be calibrated against a calibration reference, which shall be a 50 Ω load, traceable to an international reference standard. Two 100 Ω reference loads in parallel shall be calibrated against the calibration reference. The reference loads for calibration shall be placed in an appropriate connector, e.g. N-type connector according to IEC 61169-16 or SMA connector according to IEC 60169-15, meant for panel mounting, which is machined flat on the back side (see Figure 2). The loads shall be fixed to the flat side of the connector, distributed evenly around the centre conductor. A network analyser shall be calibrated, 1-port full calibration, with the calibration reference. Thereafter, the return loss of the reference loads 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.

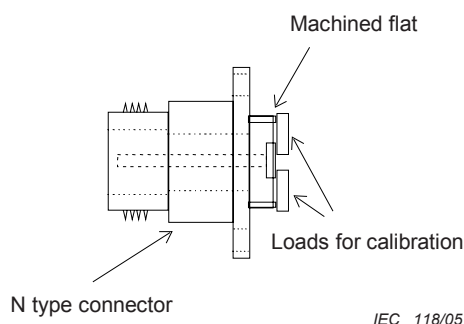


Figure 2 – Example of calibration of reference loads

3.5.2 Reference cables for calibration

As a minimum, the reference cable that is used to perform the calibration of the test set-up shall satisfy the requirement of the same class of balanced cabling performance according to ISO/IEC 11801 according to the IEC 61156 series as the class of the connector. The reference cable shall be a length of horizontal cable for which the sheath is preserved. One of the pairs of the reference cable is used for the calibrations. The total length of the reference cable shall be according to the length of the measurement cables as outlined in the calibration procedures for the various tests. Both ends of the reference cable shall be well prepared, so that the twisting is maintained up to the test ports.

3.6 Termination loads for termination of conductor pairs

During measurement, the conductor pairs of the measurement cables for the connector under test shall be terminated according to the specified test set-up with impedance matching loads. For the pairs under test, this is provided by the test instrumentation at one or both ends. For pairs not under test or not connected to test instrumentation, resistor loads or terminated baluns shall be applied. For differential mode only terminations, only resistor loads are allowed.¹

The nominal differential mode impedance of the termination shall be 100 Ω . The nominal common mode impedance shall be 50 $\Omega \pm 25 \Omega$.

¹ Unpredictable stray capacitances in baluns cause resonances at high frequencies, if they are used as terminations, when the common-mode terminal is open.

NOTE The exact value of the common-mode impedance is not critical for most measurements. Normally, a value of 75 Ω is used for unscreened connectors while a value of 25 Ω is used for screened connectors.

Resistor loads shall use resistors specified for ± 1 % accuracy at d.c. and have a return loss greater than $40 - 10\log(f)$ where f is the frequency in megahertz². For pairs connected to a balun, common-mode load is implemented by applying a load at the common-mode terminal (centre tap) of the balun. The impedance of the load is equal to the common-mode impedance. For a balun without a common-mode terminal (centre tap is not accessible), the requirement for common-mode return loss shall be complied with by inserting a balanced attenuator between the balun and the connector pair. Guidance on how this is done is shown in 3.9. For pairs connected to resistor loads, common-mode load is implemented by the Y configuration shown in Figure 3.

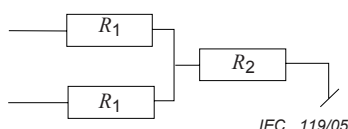


Figure 3 – Resistor load

where:

$$R_1 = \frac{R_{\text{dif}}}{2} \quad (1)$$

and

$$R_2 = R_{\text{com}} - \frac{R_{\text{dif}}}{4} \quad (2)$$

where:

R_{dif} is the differential mode impedance (Ω);

R_{com} is the common mode impedance (Ω).

The two resistors R_1 shall be matched to within 0,5 %. The termination shall be implemented at a small printed circuit board with surface mount resistors. The layout for the resistors R_1 shall be symmetrical.

The commonmode termination points for all pairs shall be connected to the ground plane.

3.7 Termination of screens

If the connector under test is screened, screened measurement cables shall be applied. (Individually screened twisted pairs (STP) are recommended.)

The screen or screens of these cables shall be fixed to the ground plane as close as possible to the measurement baluns.

If a pyramid test setup is used, the screen of each pair shall in contact with the grooves of the pyramid and connected as close as possible to the baluns on the mounting plate.

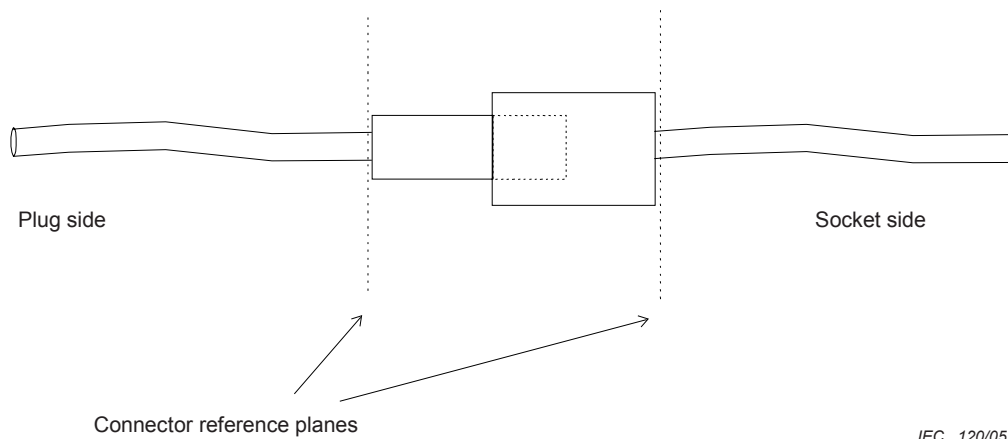
Care shall be taken to maintain a tight fit of the individual pair foil, if present, around the twisted pairs.

3.8 Test specimen and reference planes

The test specimen is a mated pair of relevant connectors. The electrical reference plane for the test specimen is the point at which the cable sheath enters the connector (the back end of the connector) or the point at which the internal geometry of the cable is no longer

² Return loss of terminations are measured with a network analyser connected to one balun, which is calibrated (full 1-port calibration) using the reference loads (see 3.5.1).

maintained, whichever is farther from the connector (see Figure 4). This definition applies to both ends of the test specimen.



IEC 120/05

Figure 4 – Definition of reference planes

3.9 Termination of balun with low return loss for common mode

3.9.1 General

If the available balun does not provide a common-mode termination (centre tap is either connected to ground or open), a balanced resistor attenuator shall be applied in order to provide the required return loss. The attenuator shall be implemented at a small printed board mounted with SMD resistors. There are two cases: one for the centre tap connected to ground and one for the centre tap open.

3.9.2 Centre tap connected to ground

A diagram of the attenuator is shown in Figure 5. The nominal attenuation is 10 dB and the calculated common-mode impedance is 26 Ω .

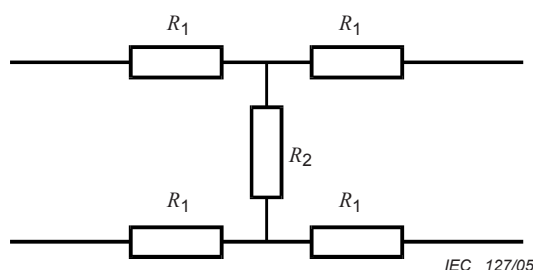


Figure 5 – Balanced attenuator for balun centre tap grounded

where: $R_1 = 26 \Omega$

and $R_2 = 70 \Omega$

3.9.3 Centre tap open

A diagram of the attenuator is shown in Figure 6. The nominal attenuation is 5 dB and the calculated common-mode impedance is 48 Ω .

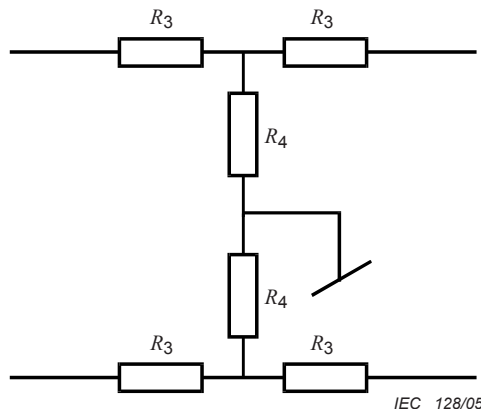


Figure 6 – Balanced attenuator for balun centre tap open

where: $R_3 = 14 \, \Omega$

and $R_4 = 82 \, \Omega$

NOTE Resistor values are nominal. The nearest standard values may be chosen.

4 Connector measurement up to 250 MHz

4.1 Insertion loss³ (IL), Test 26a

4.1.1 Object

The object of this test is to measure the insertion loss, which is defined as the additional attenuation that is provided by a pair of mated connectors inserted in a communication cable.

4.1.2 Free connector for insertion loss

It is not necessary to qualify the free connector for insertion loss testing of the fixed connector; it is assumed that the influence of different free connectors to the insertion loss is marginal. In case of conflict, the centre test plug should be used.

4.1.3 Test method

Insertion loss is evaluated by measuring the scattering parameters, S_{21} , of all the conductor pairs.

4.1.4 Test set-up

The test set-up consists of a network analyser and two baluns as defined in 3.1.

It is not necessary to terminate the unused pairs.

4.1.5 Procedure

4.1.5.1 Calibration

A full 2-port calibration shall be performed at the reference plane. This is performed by applying a maximum length of 14 cm reference cable between the terminals of the baluns and carrying out the transmission calibration measurement. Then maximum lengths of 7 cm reference cables are connected to the terminals of the two baluns (see Figure 7). The total length of these cables shall be equal to the length of the reference cable used for

³ Often referred to as attenuation.