



BSI Standards Publication

Connectors for electronic equipment — Tests and measurements

Part 27-100: Signal integrity tests up to 500 MHz on IEC 60603-7 series connectors — Tests 27a to 27g

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National foreword

This British Standard is the UK implementation of EN 60512-27-100:2012. It is identical to IEC 60512-27-100:2011.

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

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**Connectors for electronic equipment -
Tests and measurements -
Part 27-100: Signal integrity tests up to 500 MHz on IEC 60603-7 series
connectors -
Tests 27a to 27g
(IEC 60512-27-100:2011)**

Connecteurs pour équipements
électroniques -
Essais et mesures -
Partie 27-100: Essais d'intégrité des
signaux jusqu'à 500 MHz sur les
connecteurs de la série CEI 60603-7 -
Essais 27a à 27g
(CEI 60512-27-100:2011)

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Einrichtungen -
Mess- und Prüfverfahren -
Teil 27-100: Signalintegritätsprüfungen bis
500 MHz an Steckverbindern der Reihe
IEC 60603-7 -
Prüfungen 27a bis 27g
(IEC 60512-27-100:2011)

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Foreword

The text of document 48B/2262/FDIS, future edition 1 of IEC 60512-27-100, 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 approved by CENELEC as EN 60512-27-100:2012.

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

- | | |
|---------------|----------------------------------|
| IEC 60603-7-4 | NOTE Harmonized as EN 60603-7-4. |
| IEC 60603-7-5 | NOTE Harmonized as EN 60603-7-5. |

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

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

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-581	-	International Electrotechnical Vocabulary - Part 581: Electromechanical components for electronic equipment	-	-
IEC 60512-1	-	Connectors for electronic equipment - Tests and measurements - Part 1: General	EN 60512-1	-
IEC 60512-1-100	-	Connectors for electronic equipment - Tests and measurements - Part 1-100: General - Applicable publications	EN 60512-1-100	-
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	EN 60512-26-100	-
IEC 60603-7	Series	Connectors for electronic equipment	EN 60603-7	Series
IEC 60603-7	2008	Connectors for electronic equipment - Part 7: Detail specification for 8-way, unshielded, free and fixed connectors	EN 60603-7	2009
IEC 61076-1	-	Connectors for electronic equipment - Product requirements - Part 1: Generic specification	EN 61076-1	-
IEC 61156	Series	Multicore and symmetrical pair/quad cables for digital communications - Part 1: Generic specification	-	-
IEC 61169-16	-	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	-
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	-	-

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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

1 Scope and object

This part of IEC 60512 specifies the test methods for transmission performance for IEC 60603-7 series connectors up to 500 MHz. It is also suitable for testing lower frequency connectors if they meet the requirements of the detail specifications and of this standard.

The test methods provided here are:

- insertion loss, test 27a;
- return loss, test 27b;
- near-end crosstalk (NEXT) test 27c;
- far-end crosstalk (FEXT), test 27d;
- transverse conversion loss (TCL), test 27f;
- transverse conversion transfer loss (TCTL), test 27g;

For the transfer impedance (Z_t) 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 60512-1-100, *Connectors for electronic equipment – Tests and measurements – Part 1-100: General - Applicable publications*

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

IEC 60603-7, 2008: *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 61156 (all parts), *Multicore and symmetrical pair/quad cables for digital communications*

IEC 61169-16, *Radio-frequency connectors – Part 16: Sectional specification – 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*

3 Terms, definitions, acronyms and symbols

NOTE It should be noted that this document, although having a close relationship with corresponding documents, which use different terminology to that used in those documents.

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 as well as the following, apply.

3.1.1 Test Free Connector (TFC)

free connector, which is constructed such that it is a test artefact, is known as a Test Free Connector (TFC)

3.2 Acronyms

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

ACRF	Attenuation to crosstalk ratio, far-end
CM	Common mode
CMR	Common mode rejection
DM	Differential mode
DMCM	Differential mode plus common mode
DUT	Device under test
EIA	Electronic Industries Alliance
ELTCTL	Equal level transverse conversion transfer loss
FEXT	Far-end crosstalk
F/UTP	Foil (surrounding) unscreened twisted-pairs
ICEA	Insulated Cable Engineers Association
IDC	Insulation displacement connection
IPC	Insulation piercing connection
NEXT	Near-end crosstalk
OSB	Output signal balance
PSAACRF	Power sum attenuation to alien crosstalk ratio, far-end
PSACRF	Power sum attenuation to crosstalk ratio, far-end
PSANEXT	Power sum alien near-end crosstalk
PSFEXT	Power sum far-end crosstalk

PSNEXT	Power sum near-end crosstalk
RL	Return Loss
TCTL	Transverse conversion transfer loss
TFC	Test free connector
TIA	Telecommunications Industry Association
U/UTP	Unshielded twisted-pair
Z _t	Transfer impedance

3.3 Symbols

A	terminal of balun
<i>a</i>	insertion loss; equation coefficient
B	terminal of balun
<i>b</i>	equation coefficient
C	terminal of balun
D	terminal of balun
<i>f</i>	frequency
J	fixed connector; socket
<i>k</i>	equation coefficient
P	free connector
R _x	resistor
S _{xy}	normalized S-parameter
T _{xy}	T-parameter
<i>TD</i>	time delay
Z _t	transfer impedance
Ω	Ohms
%	percent
°	degree

4 Overall test arrangement

4.1 Test instrumentation

All test instrumentation shall be qualified for use over the frequency range of 1 MHz to 500 MHz.

These test procedures 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 500 MHz at least.

When used, at least two test baluns are required in order to perform measurements with balanced symmetrical signals. The requirements for the baluns are given in 4.4.

Optionally; multi-port network analyzers for balun-less test set-up may be used.

Reference loads and cables are needed for the calibration of the set-up. Requirements for the reference loads, and cables are given in 4.6.1 and 4.6.2 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 4.7.

An absorbing clamp and ferrite absorbers are needed for the coupling attenuation measurements. The requirements for these items are given in IEC 62153-4-12.

4.2 Coaxial cables and interconnect for network analysers

Lengths of coaxial cables used to connect the network analyser to the baluns shall be as short as possible. (It is recommended that they do not exceed 600 mm 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 Annex A).

Balanced interconnect and associated connecting hardware used to connect between the test equipment and the connector under test shall meet the requirements given in 4.9.2.

4.3 Measurement precautions

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

- Any measurement that is to be used in a de-embedding or re-embedding process, whether vector or matrix, shall have its phase adjusted to the free connector phase reference plane. Methods to do this are provided.
- Consistent and stable balun and resistor loads shall be used for each pair 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 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.

- The balance of the cables is 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.

4.4 Balun requirements

The baluns may be balun transformers or 180° hybrids with attenuators to improve matching if needed. Figure 1 shows such an arrangement.

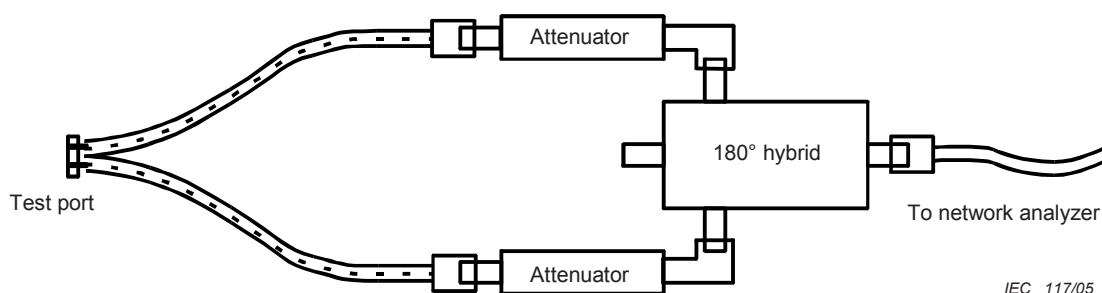


Figure 1 – Optional 180° hybrid used as a balun

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

Table 1 – Test balun performance characteristics

Parameter	Frequency (MHz)	Value
Impedance, primary ^a	$1 \leq f \leq 500$	50 Ω unbalanced
Impedance, secondary	$1 \leq f \leq 500$	100 Ω balanced
Insertion loss	$1 \leq f \leq 500$	2,0 dB maximum
Return loss, bi-directional ^b	$1 \leq f < 15$	12 dB minimum
	$15 \leq f \leq 500$	20 dB minimum
Return loss, CM ^b	$1 \leq f < 15$	15 dB minimum
	$15 \leq f < 400$	20 dB minimum
	$400 \leq f \leq 500$	15 dB minimum
Power rating	$1 \leq f \leq 500$	0,1 watt minimum
Longitudinal balance ^b	$1 \leq f < 100$	60 dB minimum
	$100 \leq f \leq 500$	50 dB minimum
Output signal balance ^b	$1 \leq f \leq 500$	50 dB minimum
CM rejection ^b	$1 \leq f \leq 500$	50 dB minimum
^a Primary impedance may differ, if necessary, to accommodate analyzer outputs other than 50 Ω . ^b Measured per ITU-T (formerly CCITT) Recommendation G.117 with the network analyzer calibrated using a 50 Ω load.		

4.5 Interfacing

For ease of interfacing to test fixtures, a pin and socket interface with dimensions as shown in informative Clause A.2 is recommended.

Figure 2 depicts the proper test configurations for qualifying test baluns to the requirements of this Standard.

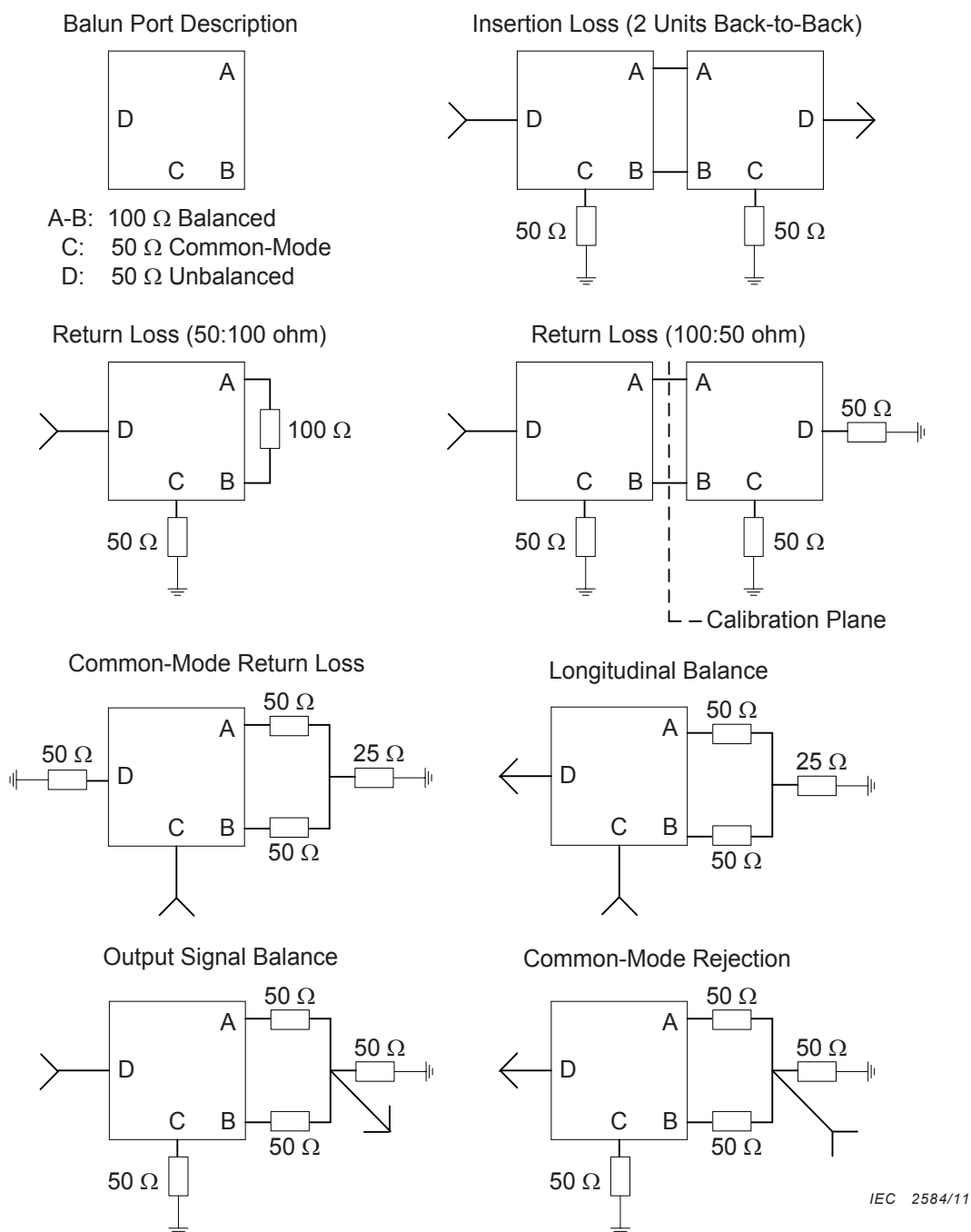


Figure 2 – Measurement configurations for test balun qualification

4.6 Reference components for calibration

4.6.1 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.

The reference load 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 N-type connector according to IEC 60169-16, meant for panel mounting.

which is machined flat on the back side (see Figure 3). 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.

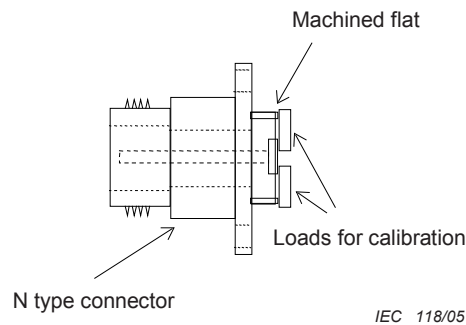


Figure 3 – Calibration of reference loads

4.6.2 Reference cables for calibration

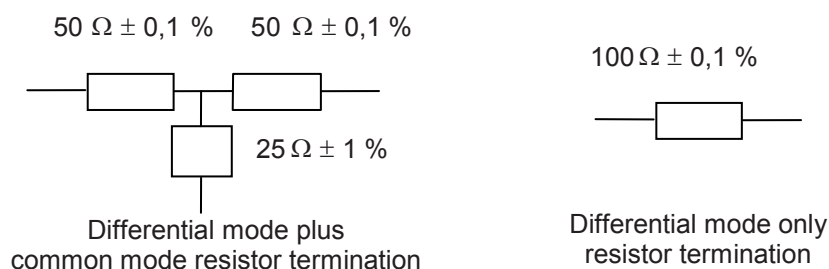
As a minimum, the reference cable that is used to perform the calibration of the test set-up shall satisfy the requirement of the same performance according to the IEC 61156 series as the performance of the connector. The reference cable shall be a length of horizontal cable for which the sheath is preserved. 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.

4.7 Termination loads for termination of conductor pairs

4.7.1 General

DM plus CM (DMCM) terminations, as shown in Figure 4 on the left, shall be used on all active pairs under test, except when measuring return loss, where DM only resistor terminations are recommended. DMCM resistor terminations shall be used on all inactive pairs and on the opposite ends of active pairs for NEXT loss and FEXT loss testing. Inactive pairs for return loss testing may be terminated with DM or DMCM resistor terminations. Balun terminations may be used on the far-end of all inactive pairs provided that their DM and CM return loss performance characteristics meet the minimum performance of the specified resistor networks.

4.7.2 Resistor terminations



IEC 2585/11

Figure 4 – Resistor termination networks

Small geometry chip resistors shall be used for the construction of resistor terminations. The two 50 Ω DM terminating resistors shall be matched to within 0,1 % at DC. The length of connections to impedance terminating resistors shall be minimized. Lead lengths of 2 mm or less are recommended.

4.7.3 Balun terminations

Baluns used for termination shall comply with the requirements of 4.4. The CM termination resistor applied to the CM port of the balun shall be 50 $\Omega \pm 1$ %.

4.7.4 Termination types

The performance of impedance matching resistor termination networks shall be verified by measuring the return loss of the termination at the calibration plane. For this measurement, a one port calibration is required using a traceable reference load. As described in 4.6.

The DM return loss of the load termination shall exceed $20-20\log(f/500)$. Calculations that result in return loss limit values greater than 40 dB shall revert to a requirement of 40 dB minimum. The CM return loss shall exceed 15 dB. The residual NEXT loss between any two impedance termination networks shall exceed the requirements of equation (1). Calculations that result in residual NEXT loss limit values greater than 90 dB shall revert to a requirement of 90 dB minimum.

$$NEXT_{\text{residual_term}} \geq 120 - 20 \cdot \log(f) \text{ dB.} \quad (1)$$

4.8 Termination of screens

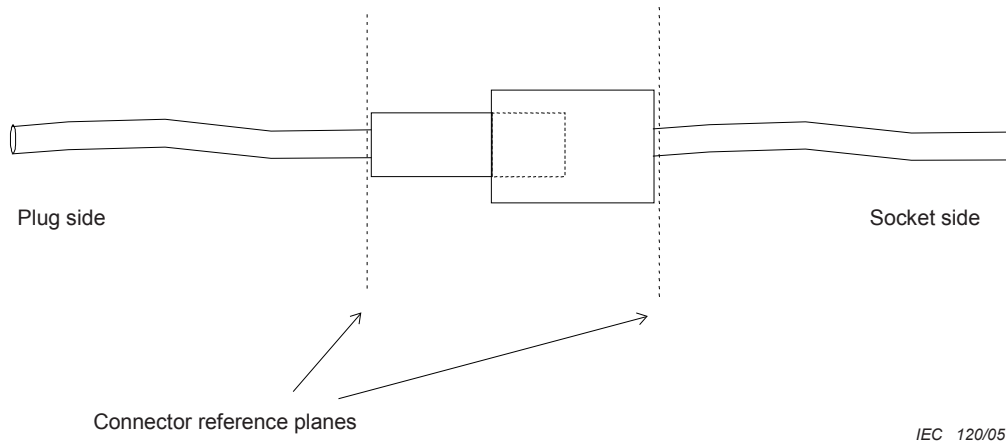
If the connector under test is screened, screened measurement cables shall be applied.

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

4.9 Test specimen and reference planes

4.9.1 General

The test specimen is a mated pair of relevant connectors. The connector 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 maintained, whichever is farther from the connector (see Figure 5). This definition applies to both ends of the test specimen. The fixed connector shall be terminated in accordance with the manufacturer's instructions and shall be compatible with the measurement test set up and fixtures.



IEC 120/05

Figure 5 – Definition of reference planes

4.9.2 Interconnections between device under test (DUT) and the calibration plane

4.9.2.1 General

Twisted-pair interconnect, printed circuits or other interconnections are used between the connector reference plane of the DUT and the calibration plane. It is necessary to control the characteristics of these interconnections to the best extent possible as they are beyond the calibration plane. These interconnections should be as short as practical and their CM and DM impedances shall be managed to minimize their effects on measurement. Refer to Annex A for additional information about test fixtures which may be used to facilitate impedance management. The return loss performance of the interconnections shall meet the requirements of Table 2. The insertion loss performance of the interconnections is assumed to be less than 0,1 dB over the frequency range from 1 MHz to 500 MHz.

It is recommended that all DUTs, including TFCs, have sockets with 2,5 mm spacing applied to the ends of their interconnects to facilitate a consistent interfacing with the baluns.

4.9.2.2 Impedance matching interconnect

When used, twisted-pair interconnect shall have 100 Ω nominal DM characteristic impedance. The twisted-pairs should not exhibit gaps between the conductors insulation. Interconnect shall be qualified for DM return loss. There are two different methods to obtain interconnect it may be obtained as individual twisted-pairs, or it may be part of a cable. If CM terminations are required, the interconnect shall be placed in an impedance managing system, as described in Annex A. The maximum length of the twisted-pair leads at each end of the DUT shall be 51 mm.

4.9.2.2.1 Individual twisted-pair interconnect

Twisted-pair interconnect may be obtained from discrete twisted-pair stock or removed from sheathed cable. Prior to attachment to the DUT, the return loss of each pair shall be tested. For this test, 100 mm lengths of twisted-pair shall be used. The interconnect shall be terminated across each pair with a precision 0,1% (e.g. a component known as a 0603 size or similar) chip resistor or similar chip resistor as described in 4.6.1. The resistor shall be attached directly to the conductors of the pair in such a way as to minimize the disturbance of the pair. Potential disturbances include gaps between the conductor insulation in the pair, melting insulation, and excess solder. When tested, the test leads shall be attached to the balun or DM test port using a test fixture yielding CM impedance stabilization. The twisted-pair leads are then trimmed for attachment to the device and the test fixtures. See Annex A for an appropriate test fixture. It is recommended to use the same load for both calibration and termination of the test lead during measurement.

4.9.2.2.2 Interconnect as part of cables

Interconnect may also be obtained from a section of twisted-pair cable where the four twisted-pair interconnect are maintained in the cable sheath. This method will most often be used with TFCs, cut from the ends of assembled cords, but can also be used with fixed connectors. Prior to attachment to the DUT, the return loss of the cable pairs (within the cable) shall be tested. For this test, a 100 mm length of cable shall be selected. Each twisted-pair of the cable end shall be DM terminated across each pair with precision 0,1 % (0603 size or similar) DM chip resistors as described in 4.6. The cable shall then be terminated to the DUT per manufacturer's instructions and trimmed for attachment to the measurement system. TFCs cut from assembled cords may be used if the return loss requirements of the cord cable, and of the assembled cord, are met, and the return loss requirements of TFCs per this standard in Table 10 are met.

4.9.2.3 Interconnection return loss requirements

The interconnection shall meet the requirements in Table 2 relative to the calibration resistor specified in 4.6.

Table 2 – Interconnection return loss

Frequency MHz	Return loss dB
$1 \leq f < 80$	40 dB
$80 \leq f \leq 500$	$78 - 20\log(f)$ dB

5 Connector measurement up to 500 MHz

5.1 General

The measurements described in this clause apply to a mated combination of a free connector and a fixed connector. Free connectors, or TFCs, for use in these tests, shall meet all the requirements of Clause 6.

5.2 Insertion loss, Test 27a

5.2.1 Object

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

5.2.2 Free connector for insertion loss

It is not necessary to qualify the free connector for insertion loss testing of the fixed connector.

5.2.3 Test method

Insertion loss (IL) is evaluated by measuring the scattering parameters, S_{21} , of each pair.

5.2.4 Test set-up

The test set-up consists of a network analyser and two baluns as defined in 4.4.

It is not necessary to terminate the pairs which are not under test.

5.2.5 Procedure

5.2.5.1 Calibration

A full 2-port calibration shall be performed at the calibration planes.

5.2.5.2 Measurement

The test specimen shall be terminated with measurement cables at both ends. The length of measurement cables shall be equal to the length of the reference cables used for reflection calibrations. The measurement cables shall be the cable types for which the connector is intended. An S_{21} measurement shall be performed. CM termination is required on the pair under test at least at one end. See Figure 6.

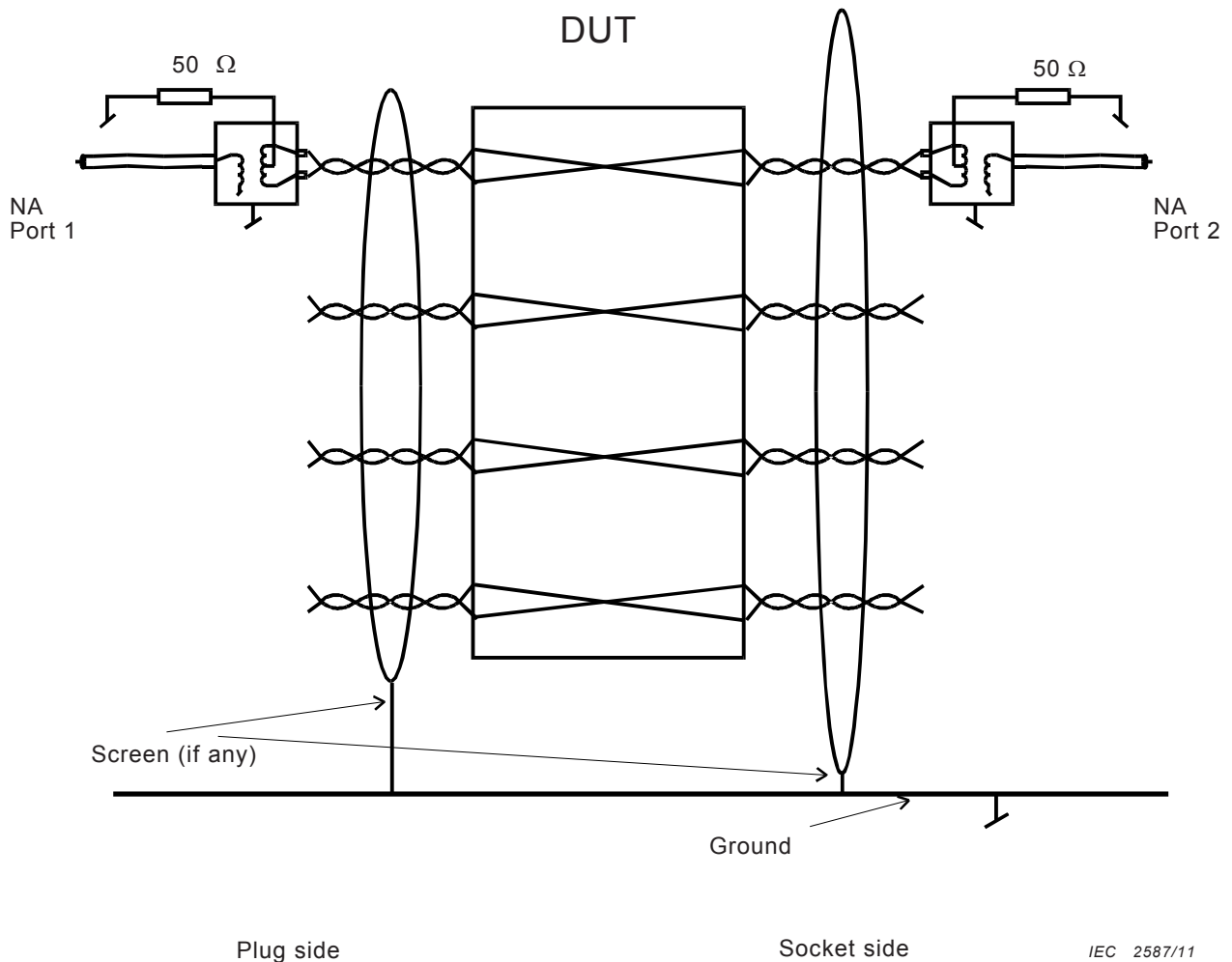


Figure 6 – Measuring set-up

Fixed connectors shall be measured with at least one free connector in at least one direction. There are no insertion loss requirements for free connectors. For improved accuracy, the insertion loss of the interconnections at each end of the mated connection may be subtracted from the measurement of the DUT.

5.2.6 Test report

The measured results shall be reported in graphical or table format with the specification limits shown on the graphs or in the table at the same frequencies as specified in the relevant detail specification. Results for all pairs shall be reported. It shall be explicitly noted if the measured results exceed the test limits.

5.2.7 Accuracy

The accuracy shall be within $\pm 0,05$ dB.

5.3 Return loss, Test 27b

5.3.1 Object

The object of this test is to measure the return loss (RL) of a mated connector pair at the two reference planes.

5.3.2 Free connector for return loss

Connecting hardware shall be tested in both directions for return loss using at least one free connector. This free connector shall satisfy the requirements of 6.4.4.

5.3.3 Test method

Return loss is measured by measuring the scattering parameters, S_{11} and S_{22} , of each pair.

NOTE As a connector is a low-loss device, the return loss of the two sides is nearly equal.

5.3.4 Test set-up

The test set-up is as described in Clause 4. DM only termination resistors are recommended and shall satisfy the requirements of 4.7.4. When possible, it is recommended to use the same resistor terminations as were used for instrument calibration as the far-end terminations. Interconnect (if used) shall be prepared and controlled per 4.9.2 and shall satisfy the requirements of 4.9.2.3.

5.3.5 Procedure

5.3.5.1 Calibration

A full one port, open, short, and load, calibration, shall be performed at the reference plane, as a minimum. A full two-port calibration is also acceptable. The calibration load shall meet the requirements of 4.7.4.

5.3.5.2 Measurement

S_{11} and S_{22} measurements shall be carried out for each of the pairs.

5.3.6 Test report

The measured results shall be reported in graphical or table format with the specification limits shown on the graphs or in the table at the same frequencies as specified in the relevant detail specification. Results for each pair shall be reported. It shall be explicitly noted if the measured results exceed the test limits.

5.3.7 Accuracy

The return loss of the load for calibration is verified to be greater than 46 dB up to 100 MHz and greater than 40 dB at higher frequencies. The uncertainty of the connection between the connector under test and the baluns is expected to deteriorate the return loss of the set-up (effectively the directional bridge implemented by the test set-up) by 6 dB. The accuracy of the return loss measurements is then equivalent to measurements performed by a directional bridge with a directivity of 40 dB and 34 dB. The accuracy (uncertainty band) is given in Tables 3 and 4.