PUBLICLY AVAILABLE SPECIFICATION

IEC PAS 60603-7-3

Pre-Standard

First edition
2004-11

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

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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

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The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft PAS	**Report on voting**
48B/1394/PAS	48B/1450/RVN

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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

1 General

1.1 Scope

This standard covers IEC 60603-7-3 connectors to be used up to 100 MHz when used with appropriate cables. These cables are specified in IEC 61156 and used in cabling systems specified in ISO/IEC 11801.

The connectors below are defined up to 100 MHz.

These connectors are intermateable, interoperable, and backward compatible with other IEC 60603-7 series connectors. While the definition of interoperable is being discussed within IEC, "interoperable" in this standard means the following: The fixed and the free connector are capable of interconnecting with any IEC 60603-7 series connector, and when they are interconnected, fully meet all requirements of the lower frequency IEC 60603-7 series standard.

1.2 Normative references

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

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-14, *Environmental testing – Part 2: Tests. Test N: Change of temperature*

IEC 60068-2-38, *Environmental testing – Part 2: Tests – Test Z/AD: Composite temperature/ humidity cyclic test*

IEC 60169-16, *Radio-frequency connectors – Part 16: R.F. 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 60352-2, *Solderless connections – Part 2: Solderless crimped connections – General requirements, test methods and practical guidance*

IEC 60352-3, *Solderless connections – Part 3: Solderless accessible insulation displacement connections – General requirements, test methods and practical guidance*

IEC 60352-4, *Solderless connections – Part 4: Solderless non-accessible insulation displacement connections– General requirements, test methods and practical guidance*

IEC 60352-5, *Solderless connections – Part 5: Press in connections – General requirements, test methods and practical guidance*

IEC 60352-6, *Solderless connections – Part 6: Insulation piercing connections – General requirements, test methods and practical guidance*

IEC 60352-7, *Solderless connections – Part 7: Spring clamp connections – General requirements, test methods and practical guidance*

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

IEC 60512-2, *Electromechanical components for electronic equipment, basic testing procedures and measuring methods – Part 2: General examination, electrical continuity and contact resistance tests, insulation tests and voltage stress tests*

IEC 60512-3, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 3: Current-carrying capacity tests*

IEC 60512-4, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 4: Dynamic stress tests*

IEC 60512-5:1992, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 5: Impact tests (free components), static load tests (fixed components), endurance tests and overload tests*

IEC 60512-8:1993, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 8: Connector tests (mechanical) and mechanical tests on contacts and terminations*

IEC 60512-9, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 9: Mechanical operation*

IEC 60512-11, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 11: Climatic tests*

IEC 60512-13-2, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 13-2: Mechanical operating tests – Insertion and withdrawal forces*

IEC 60512-15, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 15: Mechanical tests on contacts and terminations*

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60603-1, *Connectors for frequencies below 3 MHz for use with printed boards – Part 1: Generic specification – General requirements and guide for the preparation of detail specifications with assessed quality*

IEC 60807-1, *Rectangular connectors for frequencies below 3 MHz – Part 1: Generic specification – General requirements and guide for the preparation of detail specifications for connectors with assessed quality*

IEC 61076-1, *Connectors with assessed quality, for use in d.c., low-frequency analogue and in digital high speed data applications – Part 1: Generic specification*

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

ISO 11801 *Information technology – Generic cabling for customer premises*

ISO 1302, *Geometrical Product Specifications (GPS) – Indication of surface texture in technical product documentation*

ITU-T K20, *Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents*

ITU-T K44, *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation*

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

ITU-T 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*

2 Technical information

2.1 Terminology

The terminology used in and applicable to this specification is stated in 2.1 of IEC 61076-1. Some applicable terms are also covered in IEC 60512-1.

(For definitions of terms used, refer to IEC 60050-581.)

2.2 Interchangeability levels

2.2.1 General

The connectors described in this standard are intermateable, interoperable and backward compatible with all IEC 60603-7 series connectors.

2.2.2 Intermateability

Intermateability is ensured by applying the "GO" and "NO-GO" gauge requirements herein and adherence to dimensional requirements given herein.

2.2.3 Backward Compatibility

The backward compatibility requirement ensures that a plug or jack which is in compliance with this standard, mated with a jack or plug in compliance with any lower frequency IEC 60603-7 series connector, shall fully comply with the requirements of the lower frequency IEC 60603-7 series connector.

2.2.4 Interoperability

Interoperability of different IEC 60603-7-3 connectors is assured by compliance with all transmission requirements when the fixed connector is mated with a full range of "test" free connectors, or "test plugs", as described herein.

2.3 IEC type designation

Connectors, connector bodies and connectors with pre-inserted contacts according to this standard shall be designated by the following system:

IEC-PAS-60603-7-3 | L | N | L | L | L | N | N | N

Reference to this standard

Letters denoting connector type	
Fixed version	A
Free version	C

Number of contacts
8

Letters denoting type of contact	
Female	F
Male	M

Letters denoting type of termination	
Screw terminal	A
Spring-clamp	B
Crimp	C
Insulation displacement (IDC)	D
Insulation piercing	P
Solder	S
Press-in connection	T

	Letters denoting type of conductor accommodation or cable
A	Tinsel wire
B	Stranded wire
C	Solid wire
D	Tinsel or stranded
E	Stranded or solid wire
F	Tinsel, stranded or solid wire
G	Board mounted
X	Customer specific requirements for cables

	Number denoting contact finish
1	Gold, gold-alloy
2	Palladium/nickel

	Number denoting variant
1	(not used yet)

	Number denoting performance level (PL)
1	750 operations
2	2 500 operations

Note: "L" stands for letter
"N" stands for number

Example:

IEC-PAS 60603-7-3 A8FD-E11-1: Fixed connector having 8 female contacts with IDC termination for stranded and solid wire, gold plated, meeting performance level 1.

3 Common features and isometric view

3.1 Isometric view

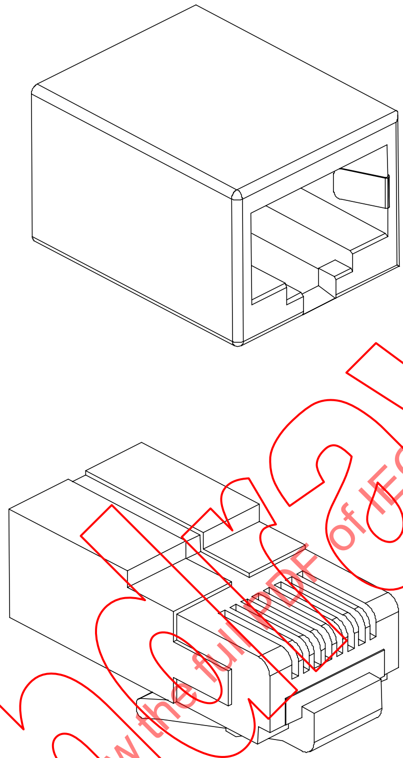


Figure 1

3.2 Mating information for connectors with cables attached

3.2.1 General

Dimensions are given in millimetres. Drawings are shown in third-angle projection. The shape of connectors may deviate from those shapes given in the following figures as long as the specified dimensions are not influenced.

3.2.2 Contacts

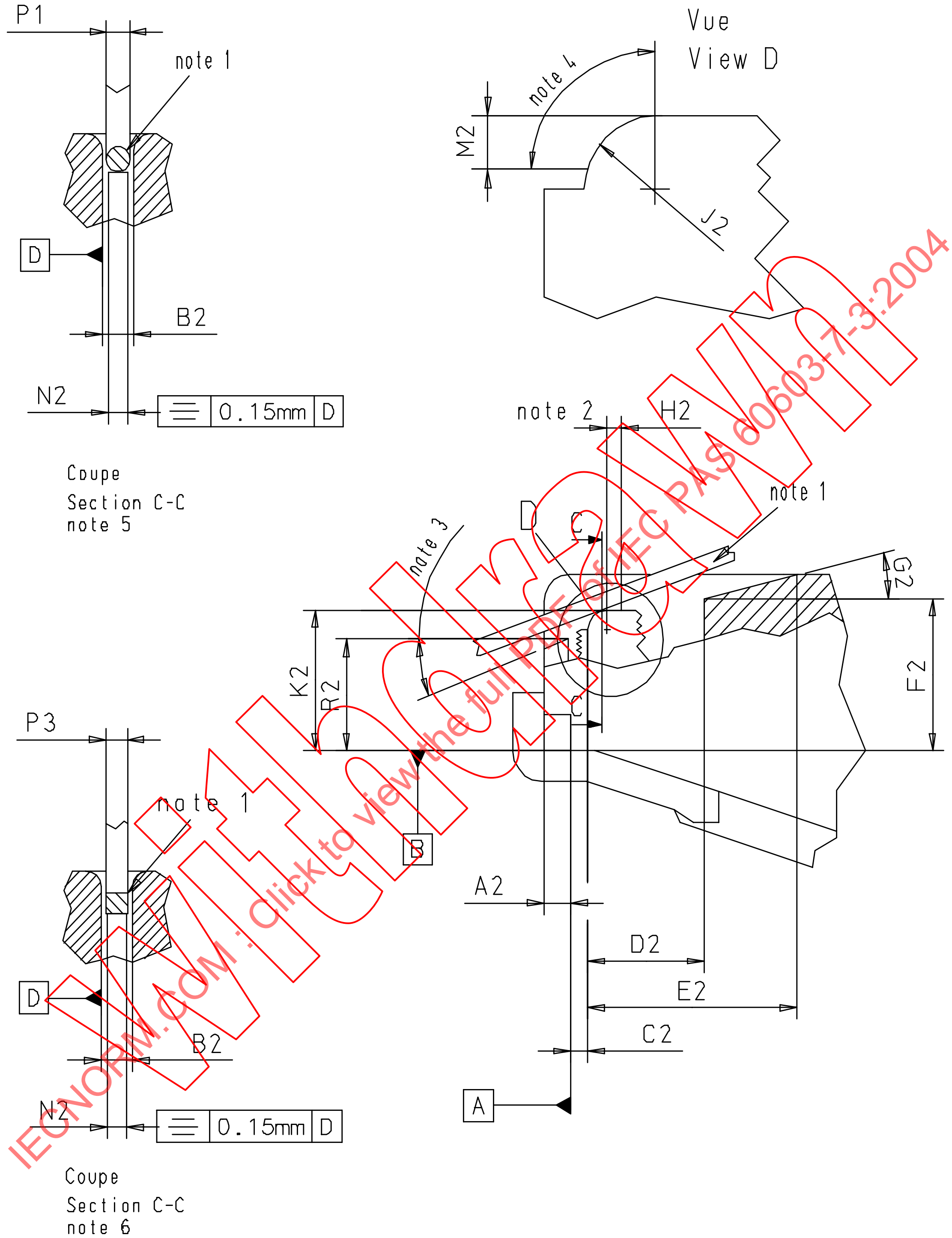


Figure 2 – Contact interface dimensions with terminated free connector

Notes:

1: Female contact of fixed connector

2: Burrs shall not project above top of contact in this area, since it may be a contact area

3: Optional angle

4: Preferred contact interface detail

5: Preferred contact configuration

6: Optional contact configuration

Table 1

Letter	Maximum mm	Minimum mm
A_2	1,45	0,89
B_2	0,61	0,51
C_2	0,46	0,03
D_2		2,79
E_2		4,11
F_2	6,22	
H_2		0,38
J_2	0,64	0,38
K_2	6,15	5,89
M_2		0,30
N_2		0,28
P_1	0,50	0,45
P_3	0,50	0,36
R_2	4,83	

Letter	Maximum
G_2	10°

Care shall be taken that the contacts of the fixed connector avoid interference with the plastic of the free connector.

3.2.3 Fixed connector

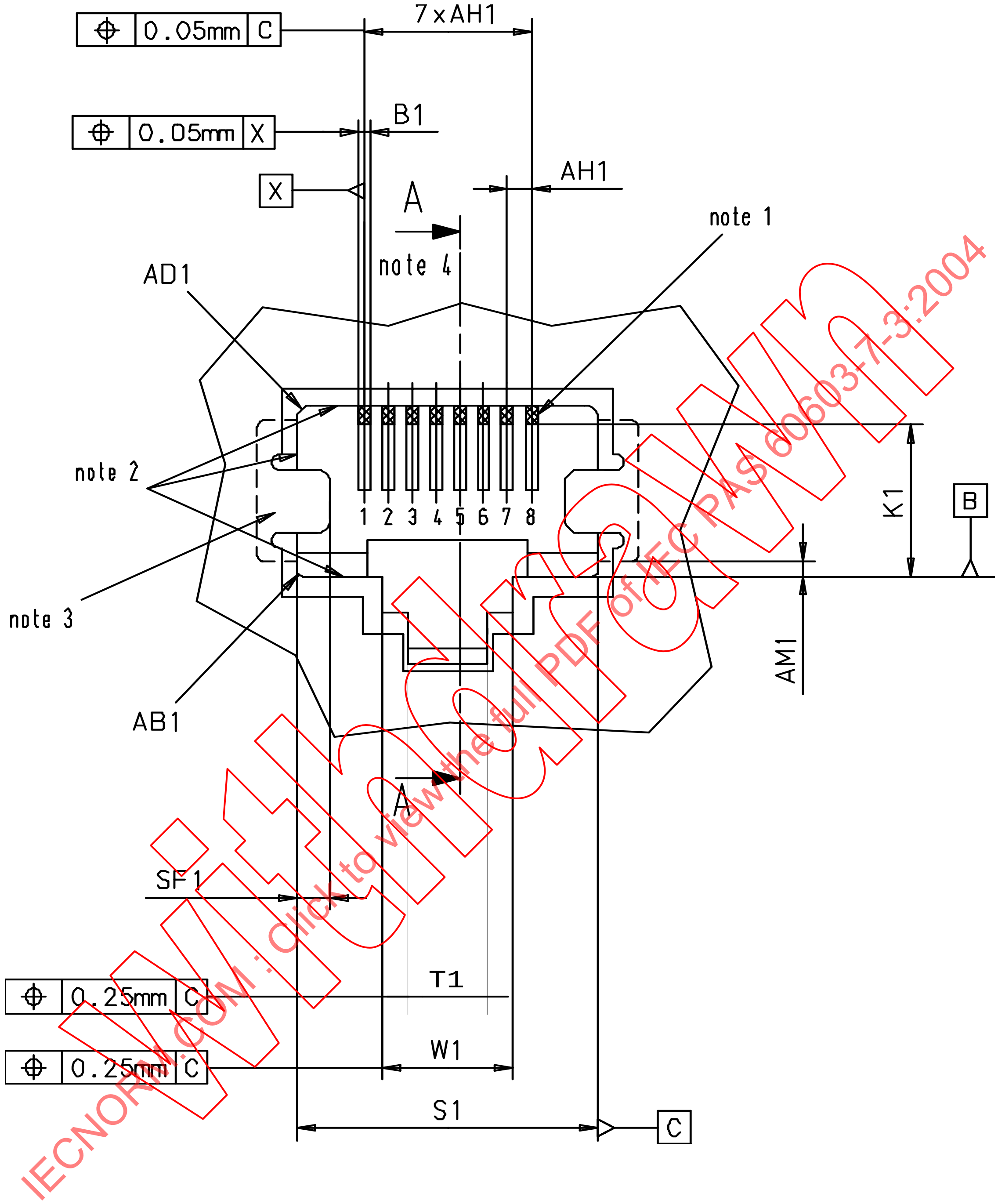


Figure 3a – View of contact zone

Note:

1: Contact zone: female contacts shall be completely within their individual contact zone in the area indicated

2: 0,15 mm maximum taper on both sides

3: Relief permitted on both sides

4: Section A – A: see figure 3b

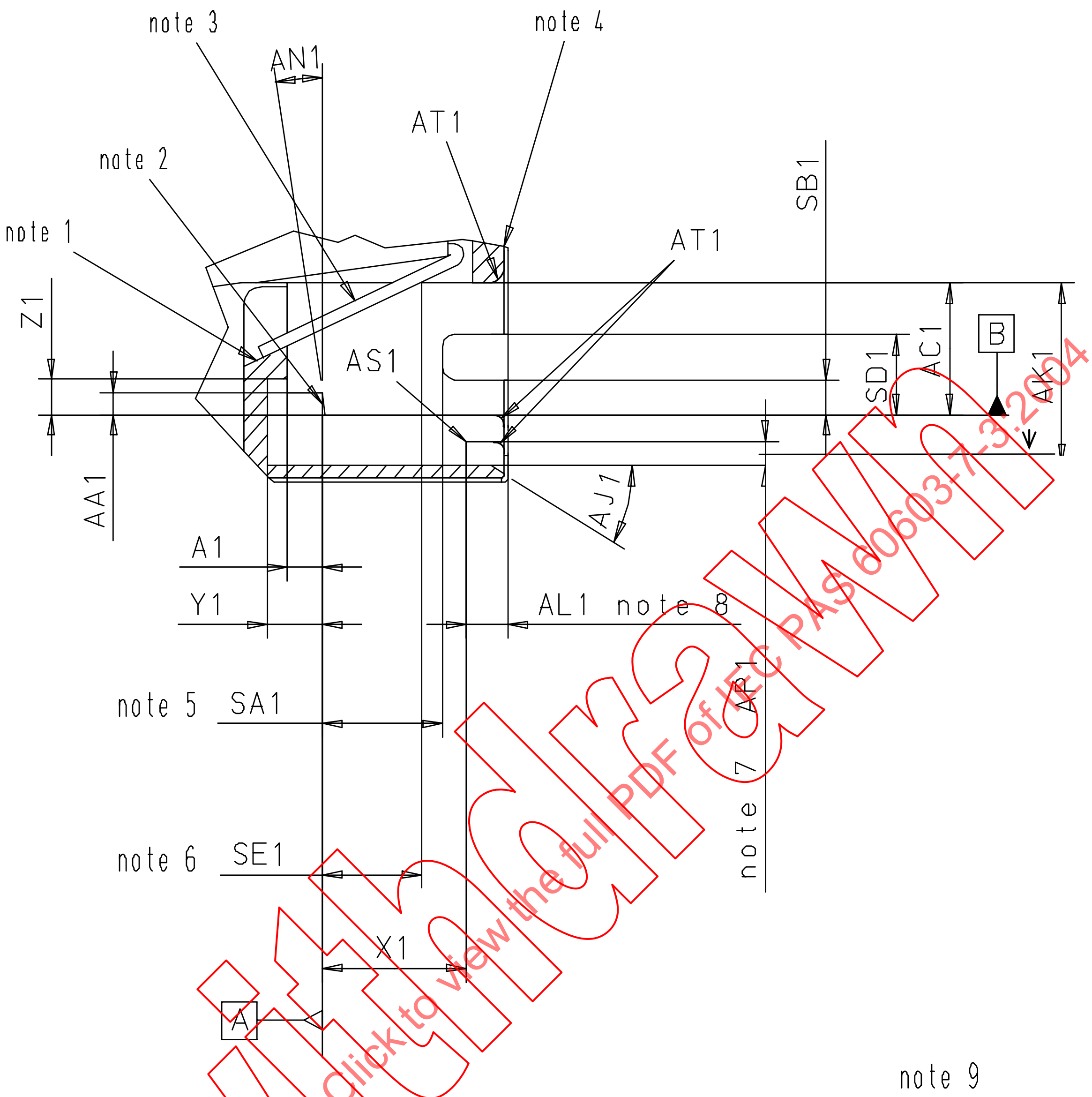


Figure 3b – Section A - A

Note:

1: Optional contact rest

2: Preferred free connector stop

3: Contacts shown at rest.
Contacts shall always be contained inside guide slots and shall move freely within their individual slots.

4: Surface need not be planar or coincident with the surface below the locking device as long as insertion, latching and unlatching of free connectors is not inhibited.

5: Dimension to point of mating contact

6: Maximum forward extension of contacts below surface AC1, to avoid contact with shields of free connectors. Applies in the mated state.

7: Flat surface

8: Projections beyond AL1 dimension shall not prevent finger access to free connector locking device

9: All internal corners in the connector cavity shall be 0,38 mm radius maximum unless otherwise specified.

Table 2

Letter	Maximum	Minimum	Nominal (ref)
	mm	mm	mm
A1		1,47	
B1	0,71		
K1	5,84		
S1	12,04	11,84	11,94
T1	4,19	3,94	
W1	6,38	6,22	
X1	6,86	6,68	
Y1		2,40	
Z1		2,08	
AA1	1,24		
AB1	0,38		
AC1	6,96	6,76	6,86
AD1	0,13		
AH1			1,02 TP [a)]
AK1	8,66	8,38	
AL1		1,40	
AM1		1,52	
AP1		1,27	
AS1	0,08		
AT1			0,76
SA1		5,31	
SB1		2,16	
SD1	4,90		
SE1	5,80		
SF1		[b)]	

a) TP indicates true position.

b) Care shall be taken that all screen contacts of the fixed connector always make contact with the screen contacts of the free connector in worst-case condition to ensure reliable performance

Letter	Maximum	Suggested minimum
AJ_1		15°
AN_1	3°30’	

3.2.4 Free connector (contacts not shown)

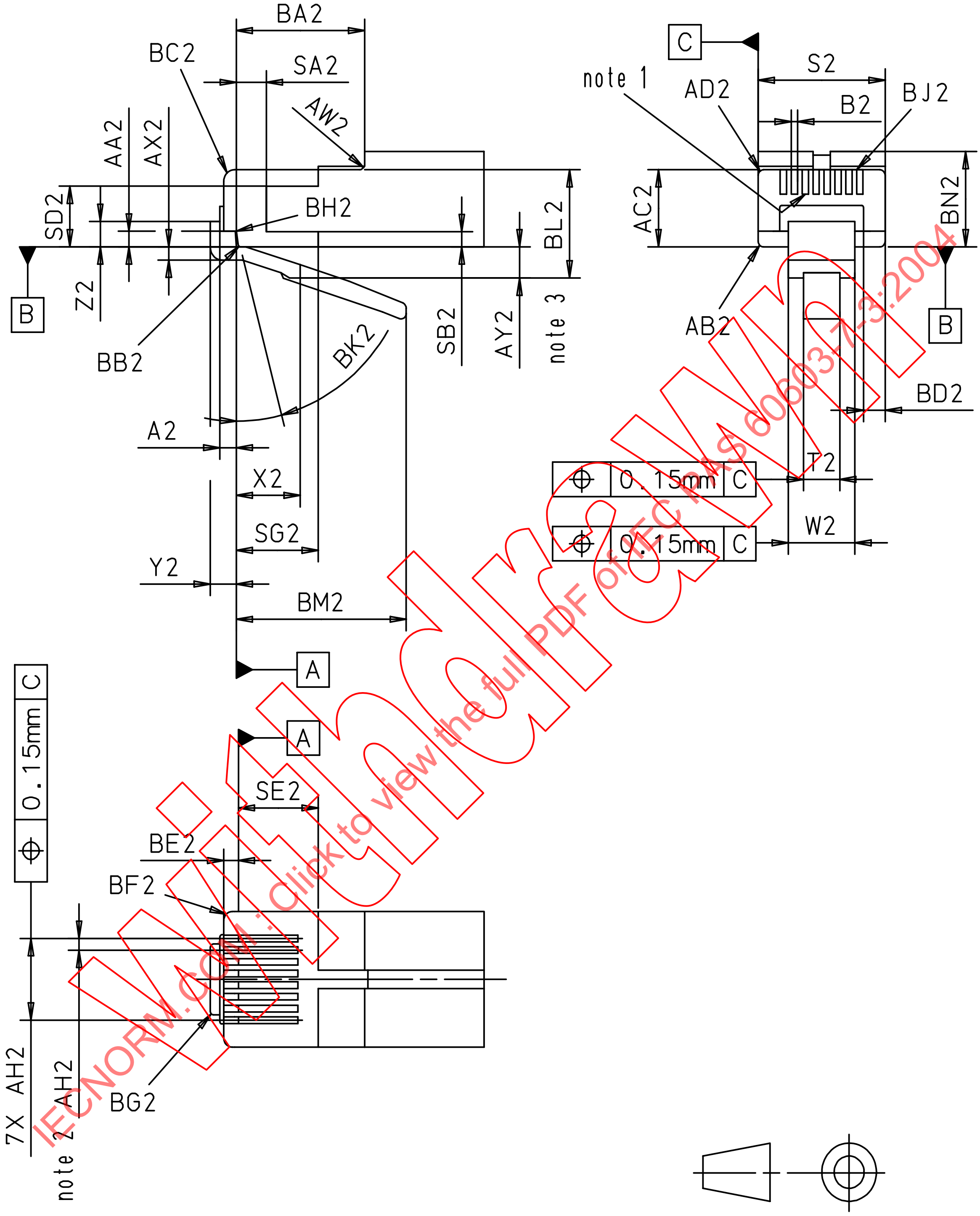


Figure 4

Note:

1: Full radius permitted on all slots

2: These dimensions apply to the locations of the contact slots

3: Applies with locking device depressed

Table 3

Letter	Maximum	Minimum	Nominal (ref)
	mm	mm	mm
A2	a)	a)	1,17
B2	a)	a)	0,56
S2	11,79	11,58	11,68
T2	3,38	3,12	
W2	6,17	6,02	
X2	6,02	5,77	
Y2	2,34		
Z2	2,06		
AA2		1,24	
AB2	0,64	0,38	
AC2	6,71	6,50	6,60
AD2	0,64	0,13	
AH2			1,02
AW2	0,51		
AX2	1,32		
AY2	2,87	2,67	
BA2		12,32	
BB2	1,14	0,38	
BC2	1,02	0,51	
BD2		0.51	
BE2	1,09		
BF2	0,64		
BG2	0,64	0,38	
BH2			0,13
BL2	8,36		
BM2	15,88	14,61	
BN2	9.24		
SA2	4,22		
SB2	1,66		
SD2		4.95	
SE2		6.85	
SG2		1,50 b)	

a) See table 1.

b) When this dimension is less than 6,85 mm (ffs), and the free connector is mated with an IEC 60603-7-7 fixed connector, utilizing switch option 1, there is a possibility that signal conductors 3,4,5,6 of the fixed connector may make contact with the screen of this free connector.

Letter	Maximum	Nominal (ref)
BJ2		Full radius
BK2	3°30'	

4 Cable terminations and internal connections – Fixed and free connectors

4.1 General

A connector may include multiple terminations between the cable termination and the separable contact interface. These may include press in connections of jack springs into PCBs, for example. All terminations shall meet the relevant termination requirements given in 4.2.

If a type of solderless termination is used which is not covered by any IEC specification, the supplier shall assure its reliability by performing similar tests, and demonstrating similar level of performance, to those in IEC 60352.

Free connectors are intended to be terminated to cable to provide connector and cable assemblies. The connector type designation provides basic terminations concerning the type of conductor (tinsel, stranded, solid) to which the conductor may be applied, and the type of connection used (solder, insulation displacement, etc.). Specific details concerning wire gauge size, type and thickness of conductor insulation, size and shape of cordage or cable jacket, etc., are not intended to be part of this specification. Minor variations in a free connector's interior details to accommodate differing wire gauge sizes, outer jackets, etc., do not require the generation of new free connector specifications.

If the connector is able to be used with multiple cable types, the manufacturer shall assure that all connection points comply with the relevant IEC standards with each of the cable types.

4.2 Termination Types

4.2.1 Solder terminations

ffs

4.2.2 Insulation displacement terminations

Shall conform to IEC 60352-3 or IEC 60352-4.

4.2.3 Crimp terminations

Shall conform to IEC 60352-2.

4.2.4 Insulation piercing terminations

Shall conform to IEC 60352-6.

4.2.5 Press-in connections (compliant pin (UC))

Shall conform to IEC 60352-5

4.2.6 Spring-clamp terminations

Shall conform to IEC 60352-7

4.2.7 Other types

In the case that a type of solderless termination is used which is not covered by any IEC specification and the supplier cannot demonstrate similar level of performance or there is no applicable IEC 60352 standard to be used as reverence, the supplier shall show conformance with the full durability test schedule in clause 7.7 for all possible variations of terminations, e.g. each cable construction type (screen construction types, wire construction (solid, flexible)) with which the connector is intended to be used.

5 Gauges

5.1 Fixed connectors

Gauges shall be made according to the following requirements:
Material: tool steel, hardened.
√ = Surface roughness, according to ISO 1302.
Ra = 0,25 μm max
A 0,01 mm wear tolerance shall be applied.
Clearance shall be provided for signal contacts and screen contacts (not shown on drawings).

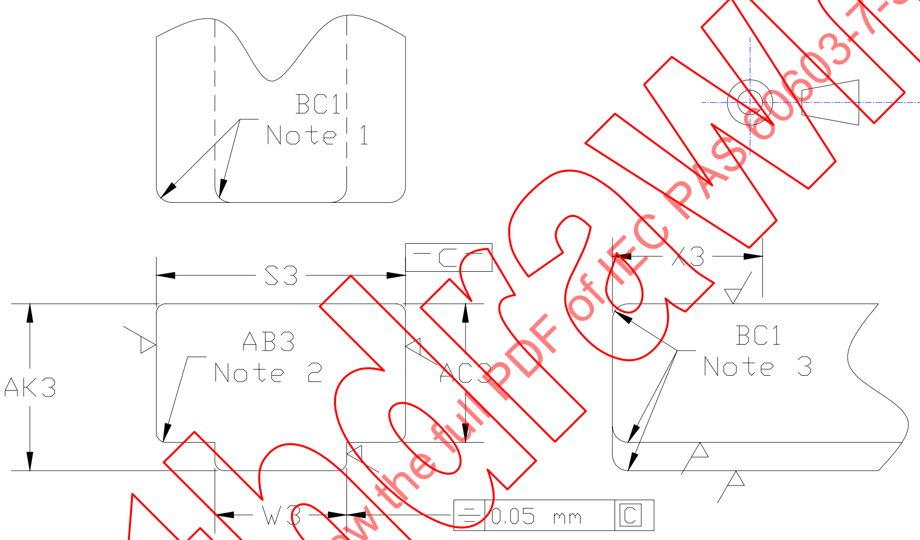


Figure 5 – "Go" gauge

Notes for figure 5	
1	Four places.
2	Six places.
3	All around.

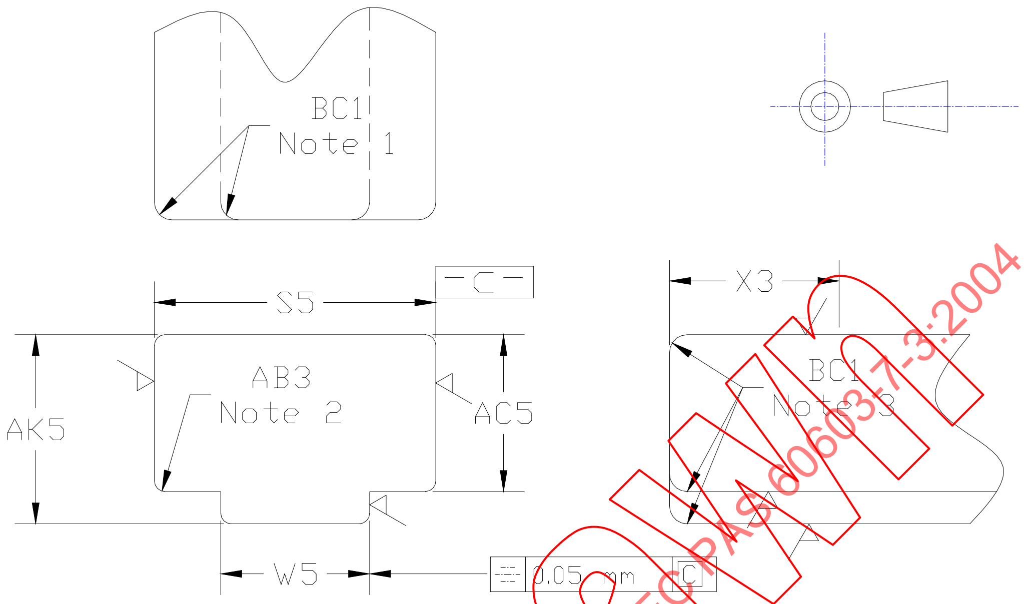


Figure 6A – "No-Go" gauge width

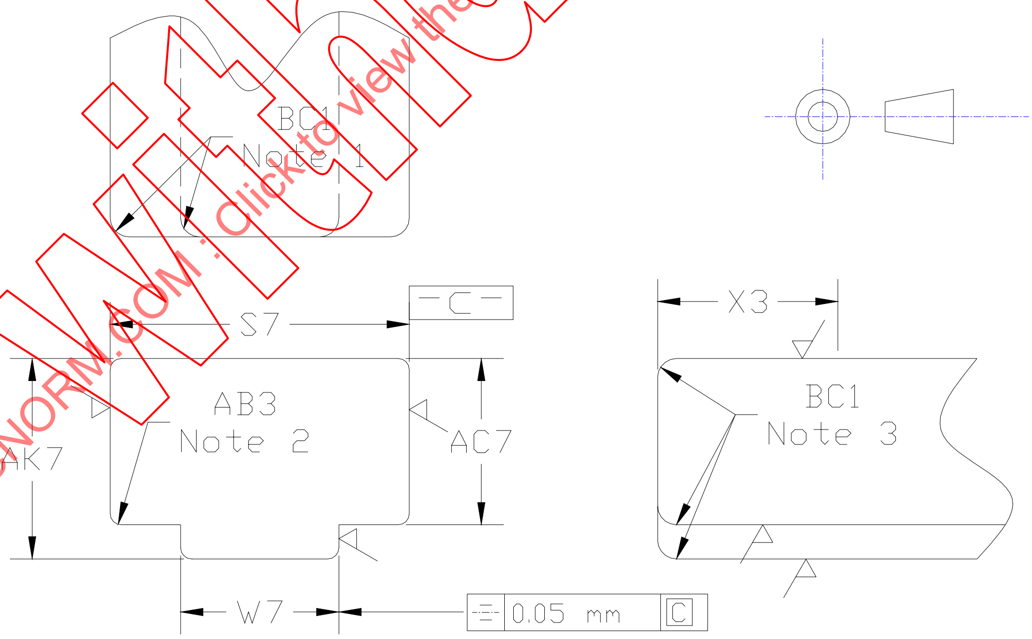


Figure 6B – "No-Go" gauge height

Table 4

Letter	Maximum	Minimum	Nominal (ref)
	mm	mm	mm
S_3	11,796	11,786	
S_5	12,050	12,040	
S_7	11,68	11,58	
X_3		10,16	
AB_3	0,51	0,389	0,450
AC_3	6,716	6,706	
AC_5	6,45	6,35	
AC_7	6,970	6,96	
BC_1	0,89	0,64	0,76
W_3	6,12	6,109	
W_5	6,38	6,365	
W_7	5,97	5,89	
AK_3	8,357	8,346	
AK_5	8,13	8,05	
AK_7	8,672	8,66	

5.2 Free connectors

Gauges shall be made according to the following requirements:
Material: tool steel, hardened.
$\sqrt{}$ = Surface roughness, according to ISO 1302
Ra = 0,25 µm max.
A 0,01 mm wear tolerance shall be applied.

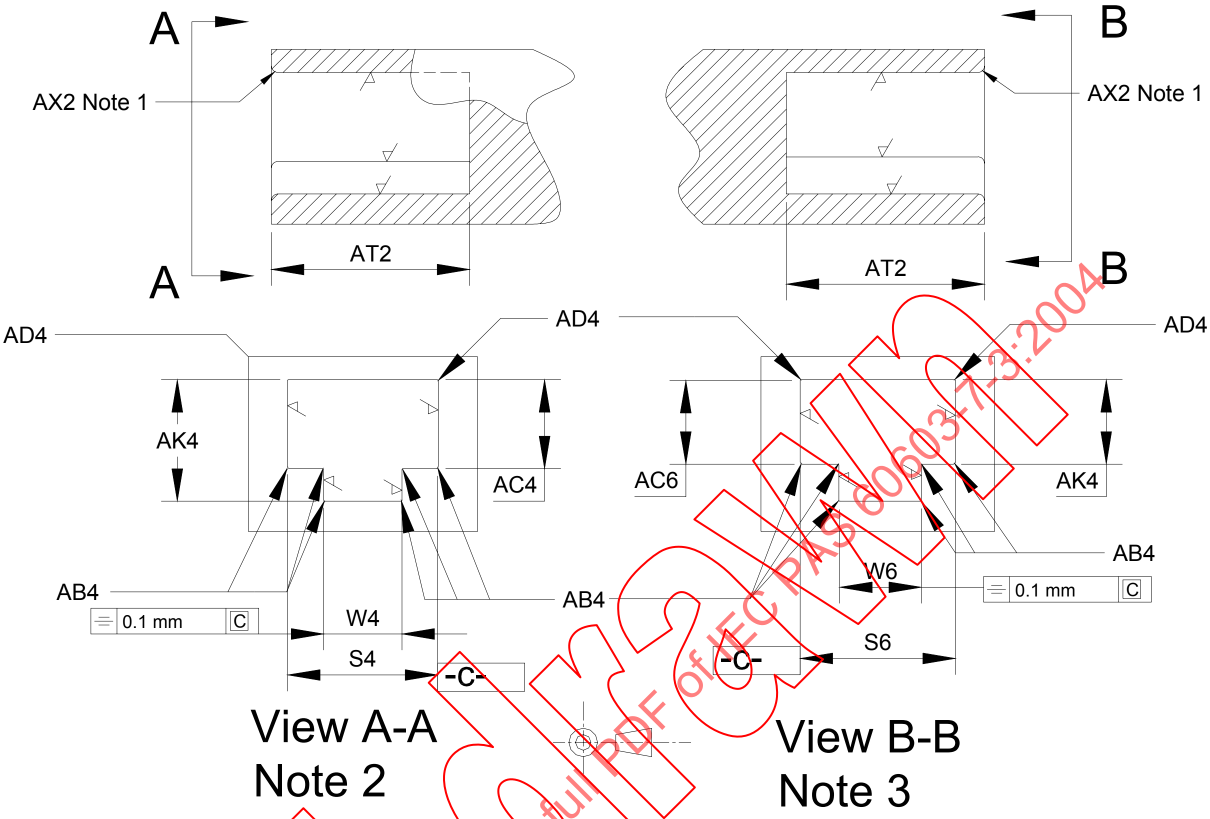


Figure 7 – "No-Go" gauges

Notes for figure 7	
1	All around.
2	Width gauge.
3	Height Gauge.

Table 5

Letter	Maximum	Minimum
	mm	mm
S_4	11,593	11,582
S_6	11,989	11,887
W_4	6,02	6,010
W_6	6,40	6,30
AB_4	0,38	0,0
AC_4	6,91	6,81
AC_6	6,512	6,502
AD_4	0,127	0,0
AK_4	9,42	9,32
at_2	15,29	15,19
AX_2	0,635	0,38

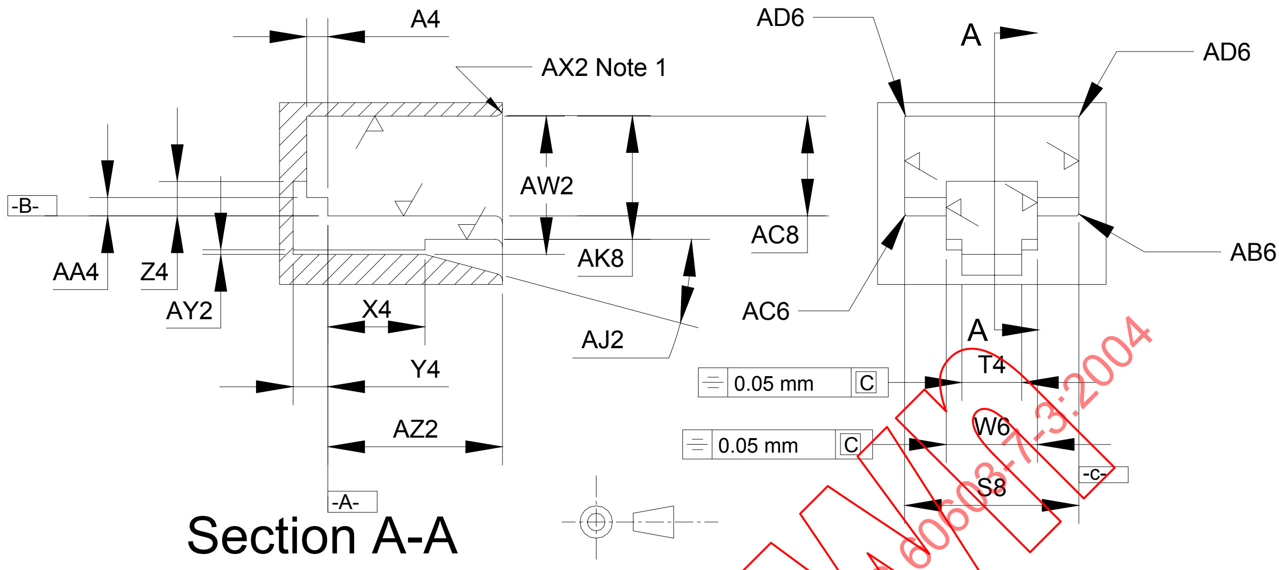


Figure 8 – "Go" gauge

Notes for figure 8	
1	All around.

Table 6

Letter	Maximum	Minimum
	mm	mm
A_4	1,448	1,438
S_8	11,847	11,836
T_4	4,115	4,013
W_6	6,198	6,187
X_4	6,604	6,594
Y_4	2,39	2,34
Z_4	2,39	2,29
AA_4	1,255	1,245
AB_6	0,38	0,0
AC_8	6,767	6,756
AD_6	0,13	0,0
AK_8	8,357	8,346
aw_2	9,42	9,32
ax_2	0,64	0,38
ay_2	0,305	0,295
az_2	11,91	11,81

Letter	Maximum	Minimum
AJ_2	16°	14°

6 Characteristics

6.1 General

Compliance to the test schedules is intended to ensure the reliability of all performance parameters, including transmission parameters, over the range of operating climatic conditions. Stable and compliant contact resistance is a good indication of the stability of transmission performance.

6.2 Pin and pair grouping assignment.

For those specifications for which pin and pair groupings are relevant, unless otherwise specified, the pin and pair grouping assignments shall be as shown in Figure 9.

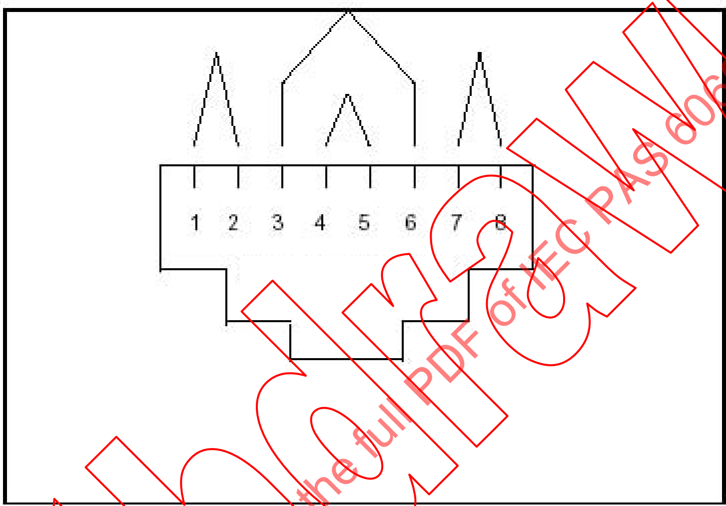


Figure 9 – Fixed connector pin and pair grouping assignment (front view of connector)

6.3 Classification into climatic category

The lowest and highest temperatures and the duration of the damp-heat, steady-state test should be selected from the preferred values stated in 2.2 of IEC 61076-1. The connectors are classified into climatic categories in accordance with the general rules given in IEC 60068-1. The following preferred temperature range and severity of the damp-heat steady-state test have been selected to comply with IEC 61156.

Table 7 – Climatic categories - selected values

Climatic category	Lower temperature °C	Upper temperature °C	Damp heat steady state Days
40/070/21	–40 °C	70 °C	21

6.4 Electrical

6.4.1 Creepage and clearance distances

The permissible operating voltages depend on the application and on the applicable or specified safety requirements.

Insulation coordination is not required for this connector; therefore, the creepage and clearance distances in IEC 60664-1 are reduced and covered by overall performance requirements.

Therefore, the creepage and clearance distances are given as operating characteristics of mated connectors.

In practice, reductions in creepage or clearance distances may occur due to the conductive pattern of the printed board or the wiring used and shall duly be taken into account.

Table 8

All dimensions in mm

Minimum distance between contacts and screen		Minimum distance between adjacent contacts	
Creepage	Clearance	Creepage	Clearance
1,40	0,51	0,36	0,36

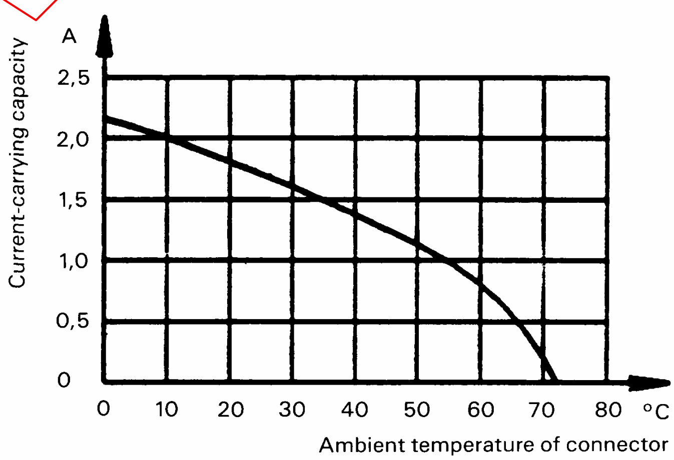
6.4.2 Voltage proof

Conditions: IEC 60512-4-1, Test 4a, Method A.
Standard atmospheric conditions,
Mated connectors,
All variants: 1 000 V d.c. or a.c. peak, contact-to-contact.
1 500 V d.c. or a.c. peak, contact to screen and test panel.

6.4.3 Current-carrying capacity

Conditions: IEC 60512-5-2, Test 5b.
All contacts, connected in series.

The current carrying capacity of each signal contact when connected in series of a connector in accordance with the requirements of 2.4 of IEC 61076-1 shall comply with the de-rating curve given in Figure 10.



NOTE 30° C maximum temperature rise when applying 0,75 Amps at 60° C.

Figure 10 – Connector de-rating curve

6.4.4 Mating cycles with power applied

6.4.4.1 Signal contacts, Resistive Load

Conditions: Annex M
Per electrical circuit (1 pair)
Breaking Voltage U_0 = 72V d.c.
Breaking Current I_0 = 175 mA (12,6 W switching power)
Number of cycles: PL1: 150 operations
PL2: 500 operations

The electrical characteristics of the signal contacts (i.e. contact resistance) shall not be degraded by this test.

6.4.4.2 Signal contacts, Reactive Load

Conditions: ffs

The electrical characteristics of the signal contacts (i.e. contact resistance) shall not be degraded by this test.

6.4.4.3 Screen contact, Resistive load

Conditions: Annex M
Breaking Voltage U_0 = 1 V d.c.
Breaking Current I_0 = 5 A (5 W switching power)
Number of cycles: PL1: 150 operations
PL2: 500 operations

The electrical characteristics of the screen contacts (i.e. contact resistance) shall not be degraded by this test.

6.4.5 Initial contact resistance between separable fixed and free connectors

Conditions: IEC 60512-2-1, Test 2a
Arrange according to 7.2
Mated connectors.
Measurement points: as specified in figure 11.
Signal contacts: 20 mΩ max.
Screen contact: 20 mΩ max.

6.4.6 Input to output d.c. resistance

Conditions :
IEC 60512-2, Test 2a
Mated connectors
Connection points: Cable termination to cable termination.
Signal contacts: 200 mΩ max.
Screen: 100 mΩ max.

6.4.7 Input to output d.c. resistance unbalance

Conditions:

IEC 60512-2-1 test 2a
Mated connectors
Connection points: Cable termination to cable termination.
Among all signal conductors, maximum difference between maximum and minimum
50 mΩ maximum

6.4.8 Insulation resistance

Conditions: IEC 60512-3-1, Test 3a.
Method A.
Mated connectors.
Test voltage: 100 V d.c.
Each contact and screen to all others: 500 MΩ min.

6.4.9 Transfer impedance

Conditions:

Annex I, Transfer Impedance
Mated connectors, terminated with each cable construction intended to be allowed for these connectors.
All Types: for $1 \leq f \leq 10$ $0{,}1 * f^{0{,}301}$ Ω
for $10 \leq f \leq 80$: $0{,}02 * f$ Ω
Where f is the frequency in MHz

6.5 Transmission characteristics

6.5.1 General

Category 5 performance level, respective to transmission characteristics, is determined according to specific test methods described in test group E. Category 5 transmission performance interoperability shall be demonstrated by testing the fixed connectors with the full range of free connectors or "test plugs" described in Annex C. Transmission performance backward compatibility shall be demonstrated by testing the fixed connectors with the full range of free connectors or "test plugs" described in IEC 60603-7-3. Interoperability and backward compatibility of free connectors shall be demonstrated by testing them against the limits in Annex C.

All transmission performance requirements apply between the reference planes specified in clause D.8.

6.5.2 Insertion loss

Conditions:

Annex E, Insertion loss
Mated connectors
All types: <0,04 (sqrt (f)) dB
Where f is the frequency in MHz.
Whenever the formula results in a value less than 0,1 dB, the requirement shall revert to 0,1 dB.

6.5.3 Return loss

Conditions:

Annex F
Mated connectors
All types: 60-20log (f) dB up to 100 MHz

Where f is the frequency in MHz.
Whenever the formula results in a value greater than 30 dB, the requirement shall revert to 30 dB.

6.5.4 Propagation delay

All types: < 2,5 ns
Propagation delay test does not need to be performed, since it is assumed that connectors comply by design.

6.5.5 Delay skew

All types: < 1,25 ns
Delay skew test does not need to be performed, since it is assumed that connectors comply by design.

6.5.6 NEXT loss

Conditions:

Annex G
Mated connectors, between all combinations of 2 pairs of contacts
All types: 83-20*log (f) dB up to 100 MHz
where f is the frequency in MHz.
Whenever the formula results in a value greater than 80 dB, the requirement shall revert to 80 dB.

6.5.7 Power sum NEXT loss (for information only)

Conditions:

Mated connectors, between each pair and all other pairs combined
All types: 80-20*log (f) dB up to 100 MHz
Where f is the frequency in MHz.

NOTE This characteristic is achieved by compliance to PP NEXT (6.5.6) and there is no necessity to test it.

6.5.8 FEXT Loss

Conditions:

Annex H
Mated connectors
All types: 75,1-20*log (f) dB up to 100 MHz
Where f is the frequency in MHz.
Whenever the formula results in a value greater than 65 dB, the requirement shall revert to 65 dB.

6.5.9 Power sum FEXT loss (for information only)

Conditions:

Mated connectors, between each pair and all other pairs combined
all types: 72,1-20*log (*f*) dB up to 100 MHz
Where *f* is the frequency in MHz.

NOTE This characteristic is achieved by compliance to PP FEXT (6.5.8) and there is no necessity to test it.

6.5.10 Transverse conversion loss

Conditions:

Annex J
Mated connectors
All types: 68-20*log(*f*) dB up to 100 MHz (ffs)
where *f* is the frequency in MHz.
Whenever the formula results in a value greater than 40 dB (ffs), the requirement shall revert to 40 dB.

6.5.11 Coupling attenuation

Conditions:

According to EN 50289-1-14
Mated connectors
All types: > 75-20 log(*f*) dB from >100 MHz to 1000 MHz
35 dB from 30 MHz to 100 MHz
Where *f* is the frequency in MHz

NOTE Coupling attenuation is assumed to be fulfilled when transverse conversion loss and transverse conversion transfer loss are met on the full bandwidth.

6.6 Mechanical

6.6.1 Mechanical operation

Conditions: IEC 60512-5, Test 9a.
Speed: 10 mm/s max.
Rest: 1 s min. (when mated and when unmated).
PL 1: 750 operations.
PL 2: 2 500 operations.

NOTE PL1 and PL2 are defined in section 2.2.

6.6.2 Effectiveness of connector coupling devices

Conditions: IEC 60512-8, Test 15f.
All types: 50 N for 60 s ± 5 s.

6.6.3 Insertion and withdrawal forces

Conditions:

IEC 60512-13-2, Test 13b
Speed: 10 mm/s maximum
All types, insertion and withdrawal: 30 N max.

7 Tests and test schedule

7.1 General

See clause 4 of IEC 61076-1.

This document states the test sequence (in accordance with this standard) and the number of specimens for each test sequence.

Individual variants may be submitted to type tests for approval of those particular variants.

It is permissible to limit the number of variants tested to a selection representative of the whole range for which approval is required (which may be less than the range covered by the detail specification), but each feature and characteristic shall be proved.

The connectors shall have been processed in a careful and workmanlike manner, in accordance with good current practice.

Unless otherwise specified, mated sets of connectors shall be tested. For contact resistance measurements, care shall be taken to keep a particular combination of connectors together during the complete test sequence, that is, when unmating is necessary for a certain test, the same connectors shall be mated for subsequent tests.

7.2 Arrangement for contact resistance test:

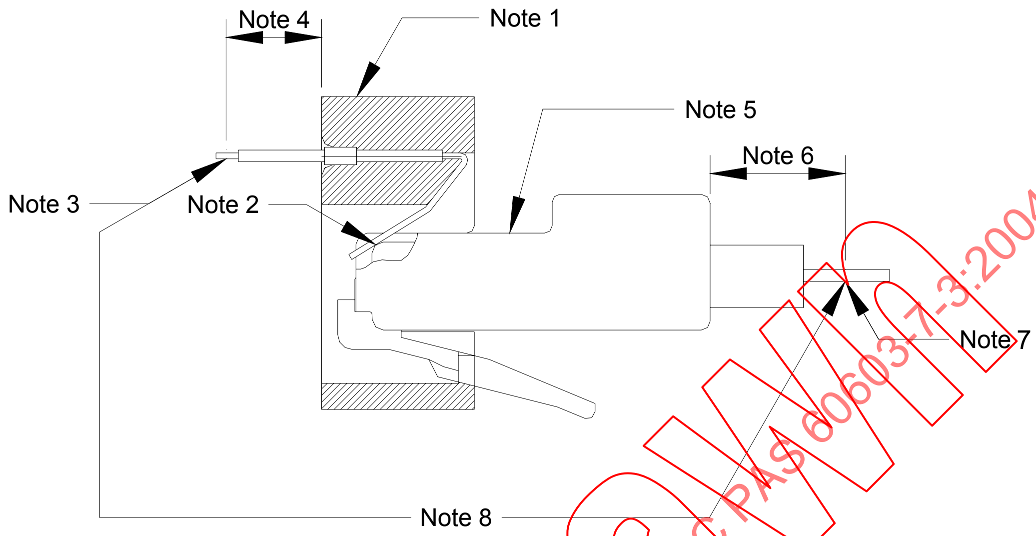


Figure 11 – Arrangement for contact resistance test

Notes for figure 11	
1	Fixed connector.
2	Point B
3	Point A
4	As short as practical (except for vibration test CP1 see clause 7.3).
5	Free connector.
6	As short as practical. (except for vibration test CP1 see clause 7.3).
7	Point C
8	Contact resistance measurement points.

Test procedure

a) Determine the bulk resistance of the fixed connector between points A and B of figure 11 by calculation or by measurement.

b) Determine the bulk resistance of the free connector between points B and C of figure 11 by calculation or by measurement.

c) Measure the total mated connector resistance between points A and C, following the requirements and procedures of IEC 60512-2, Test 2a.

d) Calculate the contact resistance by subtracting the sum of the bulk resistance of the fixed and free connectors from the total mated connector resistance.

Contact resistance = $R_{AC} - (R_{ABI} \pm R_{BCI})$

where I indicates initial value.

7.3 Arrangement for vibration test (test phase CP1)

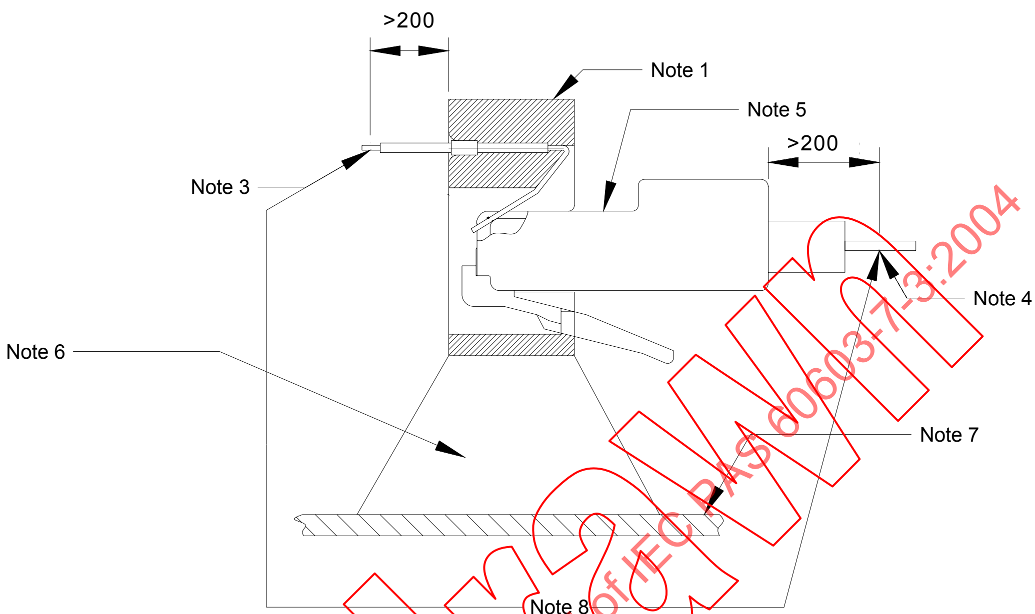


Figure 12 – Arrangement for vibration test

Notes for figure 12	
1	Fixed connector vibration feature.
3	Point A. Secure to the non-vibrating member.
4	Point C. Secure to the non-vibrating member.
5	Free Connector.
6	Fixed connector rigidly fixed to the mounting plate.
7	Mounting plate.
8	Contact resistance measurement point.

7.4 Test procedures and measuring methods

The test methods specified and given in the relevant standards are the preferred methods but not necessarily the only ones that can be used. In case of dispute, however, the specified method shall be used as the reference method.

Unless otherwise specified, all tests shall be carried out under standard atmospheric conditions for testing as specified in IEC 60068-1.

Where approval procedures are involved and alternative methods are employed, it is the responsibility of the manufacturer to satisfy the authority granting approval that any alternative methods which he may use give results equivalent to those obtained by the methods specified.

7.5 Preconditioning

Before the tests are made, the connectors shall be preconditioned under standard atmospheric conditions for testing as specified in IEC 60068-1 for a period of 24 h unless otherwise specified by the detail specification.

7.6 Wiring and mounting of specimens

7.6.1 Wiring

Wiring of these connectors shall take into account wire diameter of the cables defined in IEC 61156 parts 2, 3, 4, and 5 as applicable. Where wiring of test specimens is required, this specification contains information suitable to comply with the selected methods of test.

7.6.2 Mounting

When mounting is required in a test, unless otherwise specified, the connectors shall be rigidly mounted on a metal plate or to specified accessories, whichever is applicable, using the specified connection methods, fixing devices and panel cut-outs as laid down in this specification.

7.7 Test schedules

7.7.1 Basic (minimum) test schedule

Not applicable.

7.7.2 Full test schedule

The test parameters required shall not be less than those listed in 7.7.2.

The following tests specify the characteristics to be checked and the requirements to be fulfilled.

For a complete test sequence, a minimum of 62 specimens are needed. This equals 6 groups of 10, 1 + N groups of 1.

The groups of 10 are for test groups A, B, C, D, F and H.

One group of 1 shall be for transmission testing, group E. The N groups of 1 shall be for the “screen performance” testing, group G. The N stands for each cable screen construction type for which the connectors are intended to be used.

Test group G shall be performed N times with the specimens terminated with the different cable construction types for which the connectors are intended to be used.

7.7.2.1 Test group P preliminary

All specimens shall be subjected to the following tests. All the test group specimens shall be subjected to the preliminary group P tests in the following sequence.

The specimens shall then be divided into the appropriate number of groups. All connectors in each group shall undergo the following tests as described in the sequence given, required alteration of the sequence of tests or adding of new tests to verify additional connector characteristics.

Table 9 – Test group P

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
P 1	General examination	1		Visual examination	1a	There shall be no defects that would impair normal operation
				Examination of dimension and mass	1b	The dimensions shall comply with those specified in the detail specification
P 2	Polarization Not applicable.					
P 3	Contact resistance		Measurement points as in figure 11 All signal contacts and screen / specimens	Millivolt level method	2a	Contact resistance = 20 mΩ max
P 4			Test voltage 100 V ± 15 V d.c Method A Mated connectors	Insulation resistance	3a	500 MΩ min
P 5			Contact/contact: Method A Mated connectors	Voltage proof	4a	1 000 V d.c. or a.c. peak
			All contacts to screen: Method A Mated connectors			1 500 V d.c. or a.c. peak

7.7.2.2 Test group AP

Table 10 – Test group AP

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
AP 1	Insertion and withdrawal forces	13b	Connector locking device depressed			Insertion force 30 N max (ffs) Withdrawal force 30 N max (ffs)
AP 2	Effectiveness of connector coupling device	15f	Rate of load application 44,5 N/s max.			50 N for 60 s ± 5 s
AP 3	Rapid change of temperature	60068-2-14	–40°C to 70°C Mated connectors 25 cycles ι = 30 min Recovery time 2 h			
AP 4			Test voltage 100 V ± 15 V d.c. Method A Mated connectors	Insulation resistance	3a	500 MΩ min.
AP 5			Measurement points as in figure 11 All signal contacts and screen / specimens	Contact resistance	2a	20 mΩ max change from initial
AP 6			Contact/contact: Method A Mated connectors	Voltage proof	4a	1 000 V d.c. or a.c. peak
			All contacts to screen: Method A Mated connectors			1 500 V d.c. or a.c. peak
AP 7			Unmated connectors	Visual examination	1a	There shall be no defects that would impair normal operation
AP 8	Cyclic damp heat	60068-2-38	21 cycles low temperature 25 °C high temperature 65 °C cold subcycle –10 °C humidity 93 % Half of the samples in mated state Half of the samples in unmated state			
AP 9			Measurement points as in Figure 11 All signal contacts and screen/specimens	Contact resistance	2a	20 mΩ max change from initial for signal contacts. Input to output resistance 100 mΩ max for screen
AP 10	Insertion and withdrawal forces	13b	Connector locking device depressed			Insertion force 30 N max (ffs) Withdrawal force 30 N max (ffs)
AP 11	Effectiveness of connector coupling device	15f	Rate of load application 44,5 N/s (10 lbf/s) max.			50 N for 60 s ± 5 s
AP 12			Unmated connectors	Visual examination	1a	There shall be no defects that would impair normal operation
AP 13	Solderability		As applicable			
AP 14	Resistance to soldering heat		As applicable			
AP 15 See Note			Contact/contact: Method A Mated connectors	Voltage proof	4a	1 000 V d.c. or a.c. peak
			All contacts to screen: Method A Mated connectors			1 500 V d.c. or a.c. peak

NOTE Do not perform step AP 15 if solderability and resistance to soldering heat were not performed.

7.7.2.3 Test group BP

Table 11 – Test Group BP

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
BP 1	Locking device mechanical operations		2 N operations – see mechanical operations			See Annex B
BP 2	Mechanical operation	9a	N/2 operations – see mechanical operations. Speed 10 mm/s Rest 1 s (when mated and when unmated). Locking device inoperative			PL 1(N) = 750 PL 2(N) = 2 500
BP 3	Flowing mixed gas corrosion	11g	4 days Half of the samples in mated state Half of the samples in unmated state		11g	
BP 4			Measurement points as in figure 11 All signal contacts and screen / specimens	Contact resistance	2a	20 mΩ maximum change from initial for signal contacts. Input to output resistance 100 mΩ max for screen
BP 5	Mechanical operations	9a	N/2 operations see mechanical operations. Speed 10 mm/s. Rest 5 s (when unmated). Locking device inoperative			
BP 6			Measurement points as in figure 11 All signal contacts and screen / specimens	Contact resistance	2a	20 mΩ max. change from initial for signal contacts. Input to output resistance 100 mΩ max. for screen
BP 7			100 V ± 15 V d.c. Method A Mated connectors	Insulation resistance	3a	500 MΩ min.
BP 8			Contact/contact: Method A Mated connectors	Voltage proof	4a	1 000 V d.c. or a.c. peak
			All contacts screen: Method A Mated connectors			1 500 V d.c. or a.c. peak
BP 9				Visual examination	1a	There shall be no defects that would impair normal operation

7.7.2.4 Test group CP

Table 12 – Test group CP

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
CP 1	Vibration	6d	f = 10 – 500 Hz, Ampl. = 0,35 mm Accel.= 50 m/s^2 10 sweeps/axis Measurement points as in figure 12	Contact disturbance	2e	10 µs. maximum
CP 2			Measurement points as in figure 11 All signal contacts and screen/ specimens	Contact resistance	2a	No disturbance of plug and jack between vibration test and measurement 20 mΩ max. change from initial for signal contacts. Input to output resistance 100 mΩ max for screen
CP 3			Test voltage 100 V d.c. Method A Mated connectors	Insulation resistance	3a	500 MΩ Minimum
CP 4			Unmated connectors	Visual examination	1a	There shall be no defects that would impair normal operation

7.7.2.5 Test group DP

Table 13 – Test Group DP

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
DP 1	Electrical load and temperature	9b	500 h 70 °C Recovery period 2 h			0,5 A 5 connectors, no current 5 connectors
DP 2			Test voltage 100 V d.c. Method A Mated connectors	Insulation resistance	3a	500 MΩ Min.
DP 3			Contact/contact: Method A Mated connectors	Voltage proof	4a	1 000 V d.c. or a.c. peak
			All contacts to test panel: Method A Mated connectors			1 500 V d.c. or a.c. peak
DP 4			Unmated connectors	Visual examination	1a	There shall be no defects that would impair normal operation
DP 5			Measurement points as in figure 11 All signal contacts and screen/ specimens	Contact resistance	2a	20 mΩ max. change from initial for signal contacts. Input to output resistance 100 mΩ max for screen
DP 6	Mechanical gauging	Annex L	Both free and fixed connector			Passing Go / No Go test
DP 7	Gauging continuity	Annex A	All signal contacts and screen/ specimens	Contact disturbance	2e	10 µs max.

7.7.2.6 Test group EP

Table 14 – Test Group EP

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
EP1				Insertion loss	60512-25-2 and Annex E	$< 0{,}04\sqrt{f}$ rounded to superior 0,1 dB [d,f,g]
EP 2			All pairs, both directions (pair to pair)	NEXT loss	60512-25-1 and Annex G	83 – 20 log(f)[a,f,g]
EP 3			All pairs both directions	Return loss	60512-25-5 and Annex F	60 – 20 log(f)[b,f,g]
EP 4			All pairs, both directions (pair to pair)	FEXT loss	60512-25-1 and Annex H	75,1 – 20 log(f)[c,f,g]
EP 5				Transverse conversion loss	Annex J	68 – 20 log(f)[e,f,g]
EP 6	Input-to-Output resistance		Measurement points as defined in 6.4.6 All signal contacts and screen/ specimens	Millivolt level method	2a	Signal contact resistance = 200 mΩ maximum. Screen resistance = 100 mΩ maximum
EP 7	Resistance unbalance		Measurement points as defined in 6.4.7 All signal contacts specimens	Millivolt level method	2a	Unbalance resistance = 50 mΩ maximum

a) NEXT loss at frequencies that correspond to calculated values of greater than 80 dB shall revert to a minimum requirement of 80 dB.

b) Return loss at frequencies that correspond to calculated values of greater than 30 dB shall revert to a minimum requirement of 30 dB.

c) FEXT loss at frequencies that correspond to calculated values of greater than 65 dB shall revert to a minimum requirement of 65 dB.

d) Attenuation at frequencies that correspond to calculated values of less than 0,1 dB shall revert to a requirement of 0,1 dB max.

e) Transverse conversion loss at frequencies that correspond to calculated values of greater than 40 dB shall revert to a minimum requirement of 40 dB.

f) All transmission results shall report worst-case overall for the corresponding pair or pair combination after testing all the samples.

g) All measurements to be performed on mated connectors.

7.7.2.7 Test Group FP

Table 15 – Test Group FP

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
FP 1	Surge test	ITU-T K.20	Mated connectors, Table 2a /2b, Basic test level Tests 2.1.1a, 2.1.1b, 2.1.3, 2.2.1a and 2.3.1a			Test 2.1 and 2.2: Acceptance criteria A per ITU-T K.44, clause 9, Test 2.3: Acceptance criteria B per ITU-T K.44, clause 9,
FP 2			100 V ± 15 V d.c. Method A Mated connectors	Insulation resistance	3a	500 MΩ min.
FP 3			Unmated connectors	Visual examination	1a	There shall be no defects that would impair normal operation

7.7.2.8 Test Group GP

Table 16 – Test Group GP

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
GP 1	Switching under electrical load	Annex M	U_0 = 72 V/I_0 = 140 mA (signal contacts) U_0=1 V / I_0=5 A (screen contacts) PL1: 150 operations PL2: 500 operations	Contact resistance	2a	20 mΩ max change from initial for signal contacts. and screen

7.7.2.9 Test Group HP

Table 17 – Test Group HP

Test phase	Test			Measurement to be performed		
	Title	IEC 60512 Test No.	Severity or condition of test	Title	IEC 60512 Test No.	Requirements
HP 1	High temperature	9b	500 h 70°C Recovery period 2 h			
HP 2	Cyclic damp heat	60068-2-38	21 cycles, low temp. 25 °C, high temp. 65 °C, cold subcycle –10 °C, humidity >93 % Half of the samples in mated state Half of the samples in unmated state			
HP 3			Additional tests ffs			
HP 4				Transfer impedance	Annex I	For 1 ≤ f ≤ 10: 0,1*$f^{0,301}$ Ω For 10 ≤ f ≤ 100: 0,02*f Ω
HP 5				Coupling attenuation	EN 50289-1-14	[≥ 35 – 20 log (f/100)] dB from > 100 to 1 000 MHz

Annex A
(normative)

Gauging continuity procedure

A.1 Object

The object of this test is to check whether in worst-case conditions for the free connector the electrical continuity is guaranteed for signal contacts and screen.

A.2 Preparation of the specimens

A gauge according to figure A.1 should be applied to test the fixed connector specimen.

A.3 Test method

Apply to the test specimen and to the gauge a circuit according to IEC 60512-2-5-Test 2e. For each individual contact of the free connector and the screen, the test has to be repeated.

For the test of the signal contacts, the gauge shall be fully inserted and then be moved upwards until it stops against the plastic wall of the fixed connector.

For the test of the screen contact, the gauge shall be fully inserted and then be moved to both sides of the connector until it stops against the plastic wall of the fixed connector. This movement shall be repeated 3 times.

During this movement a forwards force of 20 N min. shall be applied as indicated by the arrow in figure A.2.

A.4 Final measurements

The fixed connector specimen will meet the requirements if no discontinuity >10 µs is monitored for each individual contact and the screen during movement and in end position.

A.5 Description of continuity gauge

The gauge shall be made according to the following specification:
Material: tool steel, hardened with suitable plating finish
Surface roughness: according to ISO 1302, Ra: 0,25 µm max.

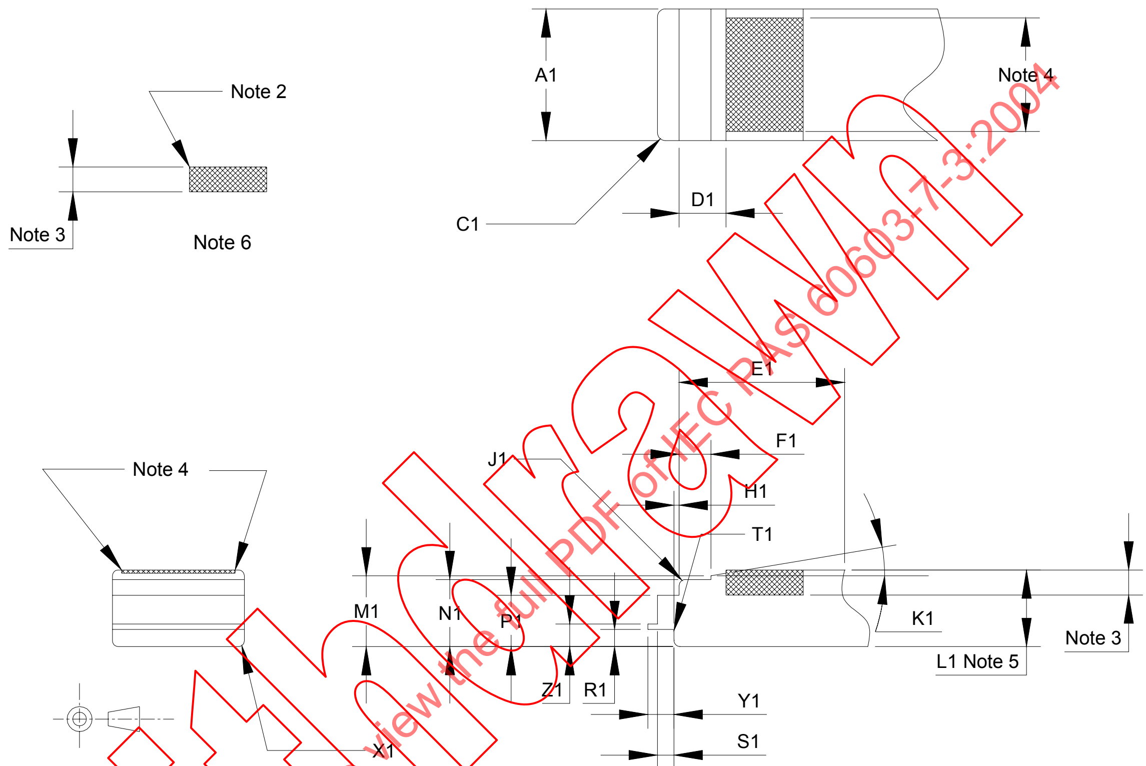


Figure A.1 – Gauge

Notes for figure A.1	
1	Sharp edge.
2	Insulation part
3	Final assembly height: 6,71 + 0,03 / – 0,01.
4	Edge of insulation part may not extend beyond radius of steel part.
5	Dimension to edge of insulation part.
6	Detail of insulation part.

Table A.1

Letter	Maximum	Minimum
	mm	mm
A_1	11,59	11,57
C_1	0,8	0,6
D_1	4,12	4,10
E_1		15,0
F_1	2,80	2,78
H_1	0,47	0,45
J_1	0,69	0,59
L_1	6,76	6,70
M_1	6,23	6,21
N_1	5,90	5,88
P_1	4,7	4,3
R_1	1,6	1,4
S_1	1,46	1,44
T_1	0,1	
X_1	0,6	0,4
Y_1		5,0

Letter	Maximum	Minimum
K_1	10°0’	9°0’

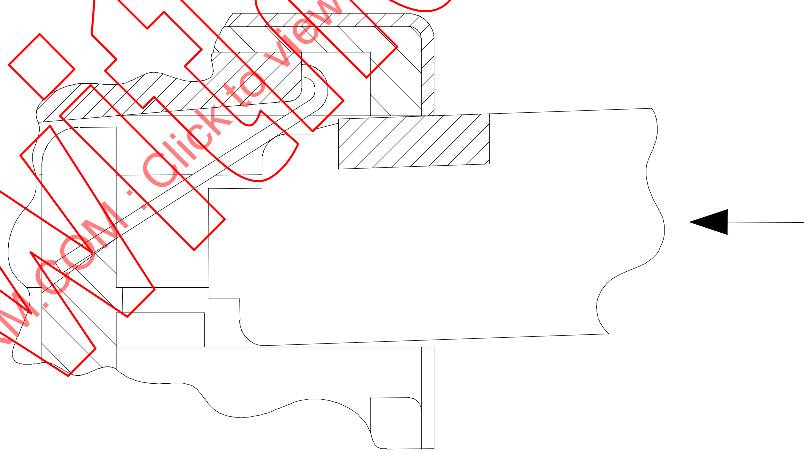


Figure A.2 – Gauge insertion

Annex B
(normative)

Locking device mechanical operation

B.1 Object

The object of this mechanical endurance test is to assess the operational limits of the locking device on the free connectors.

B.2 Preparation of the specimens

The specimen shall be prepared and mounted so that the locking device is readily accessible for application of the test. No other movement of the free connector shall be allowed.

B.3 Test method

The specimen shall be subjected to mechanical operational endurance tests of the number of cycles, as specified in table 11, group BP, test BP1.

The speed of the operation of the applied force to the locking device shall not exceed 20 cycles per minute.

The specimen shall be operated in the normal manner, and the locking device shall be depressed until it contacts the body of the free connector.

Mechanical aids which simulate normal operations may be used, provided that they do not introduce abnormal stresses.

B.4 Final measurements

After the specified number of operations, the specimens shall show no visual indication of fatigue or stress cracking of the locking device.

Annex C
(normative)

Test Plug Requirements

C.1 General

Test plugs shall be measured according to the procedure in sections C.8. They shall be measured mated to a reference jack as described in section C.5. For test plug NEXT measurements, the NEXT of the reference jack shall be subtracted. Use the values in table C.1 for the NEXT of the reference jack. Sections C.2-C.6 are for reference, and they specify how the NEXT of the reference jack was determined. However, section C.5.1 must be followed to select a reference jack. Also, these sections contain normative information to the extent that they are referenced by other sections of this standard.

When NEXT measurements are made, the test leads shall be mounted in a pyramid, channel, or other device to manage both their common and differential mode impedance.

C.2 De-embedding reference NEXT plug construction

Start with a cable complying with IEC 61156-2 category 5. From a pair that exhibits a return loss in excess of 35 dB from 1 to 100 MHz, cut four lengths of approximately 80 mm. Use of wire lengths of 81 mm will result in a plug length of approximately 75 mm, including the test leads. If the commonly available impedance management fixture is used, this will allow a small length of wire to be trimmed off to fit the plug on the fixture.

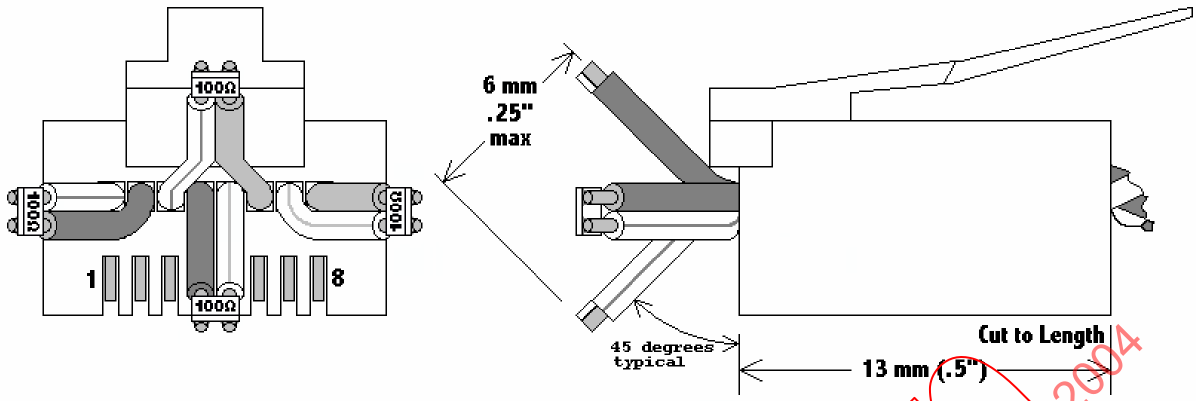
NOTE The port extension constants may be estimated by measuring the through delay of a 150 mm jumper, however, the data will have to be phase-corrected later, as specified in C.3.1.

Take a standard plug body that conforms to the dimensional requirements of IEC 60603-7 in which the 8 conductors are parallel and at the same height. Machine off the back end, where the strain relief is, so that the plug is 13 mm long from the nose where the contacts are to its back. Drill 8 conductor paths through the nose, so that the individual wires can be extended through the nose.

Untwist about 19 mm of one end of the four 81 mm long twisted pair wires. Strip off 1-2 mm of insulation from the untwisted end, so that 0603 package size resistors can be soldered there later. Place them in the plug, extending 6 mm beyond. The 3,6 pair will have to be split apart, but bend it back together as soon as practical after it exits from the nose. On the back end, insert pair 3,6 toward the locking tab from pair 4,5; later, it will be bent towards the locking tab, and pair 4,5 away from the locking tab.

Set the plug blades into the wires.

Arrange the conductors according to the following illustration.



NOTE The insulation of the twisted pairs are touching one another throughout their length.

Pair 3,6 is bent together as quickly as possible after it exits the plug nose.

Conductors 2 and 7 are bent away from conductors 3 and 6, respectively. This maximizes the distance and minimizes the coupling between loops 3,6 and 1,2, and 3,6 and 7,8.

The wires are bent at a 45° angle to the plug axis. This makes all the loops orthogonal and minimizes their coupling.

Conductors 3 and 6 are bent towards the locking tab, and conductors 4 and 5 are bent towards the blades.

Solder 0603 package size precision 100 Ω ± 0,1 % resistors to the wire tips as shown. The return loss of the resistor should be >40 dB from 1 MHz to 100 MHz. By using resistors as small as 0603, it will be unnecessary to spread the conductors of the twisted pairs apart.

Where the twisted pairs exit from the back of the plug body, bend them at a 45° angle, or any convenient angle, away from the plug axis. Bend pair 3,6 toward the plug tab, and pair 4,5 away form the plug tab. Stabilize the back of the plug with encapsulant.

C.3 Set-up and calibration

Since test plug characterization involves 3 measurements and subtractions between the measurements, it is necessary to take all 3 measurements at the same frequencies. It is therefore suggested that for test plug qualification, a linear sweep of 401 points from 1 to 401 MHz always be used.

Calibrate the network analyser using a full 2-port calibration. Use open, short, and load standards directly on the balun. For the through calibration, place the baluns back to back so as to maintain polarity, with a zero-length through standard. Alternatively, a non-zero length through may be used and its effects calibrated.

C.3.1 Port extension

The port extension function of the network analyser may be used to locate the reference plane of the test plug at the interface of the test plug and reference jack. Alternatively, real and imaginary data in volts/volt may be obtained from the network analyser, and the reference plane may be moved in post processing using a spreadsheet.

NOTE In the case of the reference plug, the port extensions cannot be determined during calibration, since there is no way to have the reference plug terminated open and short when the resistors are on it. Therefore, the suggested procedure cannot be used, and an alternate procedure, such as determining the plug delay after the fact and using a spreadsheet to adjust the phase of the data, must be used.

The time constant for the port extension shall be determined in the following manner.

A full 1-port calibration shall be performed to establish a reference plane location at the balun port. The settings of the network analyser shall be sufficient to achieve a maximum of ±5 ps of random variation. Recommended settings are as follows:

a) Measurement function is S_{11} delay.

b) Averaging 4× or higher.

c) Intermediate frequency bandwidth (IFBW) 300 Hz or less.

d) Set smoothing to 10 %.

C.3.1.1 Port Extension Measurements

a) With the test plug or reference plug connected to the test baluns, measure the S_{11} time delay determined with an open circuit at the plug ends at 50 MHz $(TD_{\text{open\_50MHz}})$ and 100 MHz $(TD_{\text{open\_100MHz}})$ for each pair.

b) Place a short on the plug. This short must connect the pins of the pair under test at the tip of the plug. Measure the S_{11} delay for each pair at 50 MHz $(TD_{\text{short\_50MHz}})$ and 100 MHz $(TD_{\text{short\_100MHz}})$ sequentially shorted in this manner.

c) Construct a spare plug. Measure the delay of this spare plug mated to the short jack. Then, solder across the blades of the spare plug and measure its shorted S_{11} delay. Calculate the delay of the shorting jack as the difference between these delays, with an allowance of 5 ps for the delay in the solder on adjacent pairs, and 15 ps on the split pair 36. Adjust the measured delays of the test or reference plug shorted by subtracting the delay of the shorting jack.

d) The time delay for each wire pair is determined by the average of the open and short circuit time delay measurements at 50 MHz and 100 MHz (four numbers averaged).

These time delay measurements represent round-trip time delays. The one-way time delay is one-half of the round trip S_{11} delay. For the purpose of NEXT loss measurements for each pair, the one-way time delays of the wire pairs involved in the measurement shall be used to set the port extension amount for each port as calculated in equation (C.1).

$$PortExtension = \frac{TD_{\text{open\_50MHz}} + TD_{\text{open\_100MHz}} + TD_{\text{short\_50MHz}} + TD_{\text{short\_100MHz}}}{8} \quad \text{(C.1)}$$

NOTE The time delay measurements are dependent on proximity to ground planes. The positioning of the wire pairs should remain as constant as possible during all measurements.

The measurement accuracy of this method is approximately 20 ps in a round trip measurement, corresponding to a one-way distance of approximately 2 mm (0,8 in).

When the test plug NEXT loss is measured, the appropriate port extensions shall be applied after calibration to align the tp-rj data and the TIA jack vector reference planes. This may be done by the following:

a) Turn the port extensions of the network analyser on.

b) Enter the calculated port extension constant for each port (1 and 2) of the network analyser.

C.4 De-embedding reference plug NEXT measurement

Measure the NEXT of the de-embedding reference plug on all 6 pair combinations. It is suggested that numerical conversions between real and imaginary and magnitude and phase be minimized, or avoided entirely, by taking data as real and imaginary.

Cut-off the resistors and the wires coming from the nose to the resistors.

C.5 De-embedding reference NEXT jack construction

Make a de-embedding reference jack as follows.

Start with Stewart part number SS-650810-A or equivalent inverse mounted PWB jack. Mount it on a PWB with 100 ohm traces leading to mounting places for resistors. Mount precision RF surface mount 100 Ohm ±0,1 % resistors on the jack PWB. Equivalent parts to the referenced jack may be used if the laboratory can demonstrate that they can achieve equivalent results.

C.5.1 De-embedding reference NEXT jack selection

The procedure described in this clause defines a figure of merit for the consistency of the reference jack. The reference jack used to measure test plugs shall be within the best 25 % of at least 20 reference jacks measured on all pair combinations. This will minimize the measurement variance due to the variance within this lot of jacks.

C.5.1.1 Measurement sampling plan

The de-embedding procedures specified in C.1-C.3 should be used to measure the reference jacks. The performance of a particular laboratory de-embedded reference jack shall be verified by determining the mated NEXT loss vector of multiple jack samples using one reference plug. A reference jack sample size of at least 20 pieces shall be measured.

The figure of merit shall be determined as follows:

1. Build a reference plug according to the instructions of C.1
2. For each pair combination, do the following:
   - 2.1 Measure real and imaginary NEXT of the mated reference plug and reference jack between 10 MHz and 100 MHz.
   - 2.2 Calculate the average of the mated reference plug and reference jack (RPRJ) real and imaginary parts for each frequency point.
   - 2.3 Discard all real data points for all of the jacks where the average real RPRJ is less than 316 uV/V.
   - 2.4 Discard all imaginary data points for all of the jacks where the average imaginary RPRJ is less than 316 uV/V
   - 2.5 Calculate the difference between each RPRJ and the average RPRJ. The real and imaginary differences shall be calculated separately.
   - 2.6 Normalize" the difference data by dividing each point by the frequency of measurement.
   - 2.7 Square the normalized data. Square the real and imaginary data separately.
   - 2.8 Sum all squared data over the frequency range.
3. Compile the results for all pair combinations.

   Sum the data for all pair combinations for each sample. This will yield a single number as a figure of merit for each reference jack.

The selected reference jacks shall be in the lowest 25 % of the sample set. The remaining jacks shall be discarded.

NOTE Whenever the magnitude of the NEXT is greater than 70 dB, the standard deviation should not be used to disqualify the reference jack.

C.6 De-embedding reference jack NEXT measurement

Use the same calibration, port extension, and impedance management as in reference plug measurement.

Measure the NEXT of the de-embedding reference plug and de-embedding reference jack mated together on all 6 pair combinations.

The jack vector is the difference between the de-embedding reference plug and de-embedding reference jack measurements.

C.7 Test plug construction

Trim the test plug leads so that the test plug fits on the impedance management fixture.

C.8 Test plug NEXT measurement

Use the same calibration procedure and impedance management as for reference plug measurement as given in C.2. To determine the port extension constants, measure the delay of the test plug on each pair.

Measure, as given in C.4, the NEXT of the test plug mated to the de-embedding reference jack on all 6 pair combinations.

The test plug NEXT is the difference between the test plug measurement and the jack vector.

Use the following values for the jack vector.

Table C.1 – Category 5 de-embedded real and imaginary reference jack vectors

Pair	**Re_J – Real coefficient of reference jack vector, (V/V) (f = frequency in MHz)**
3,6 – 4,5	$= 5{,}87 \cdot 10^{-11} \cdot f^3 + 2{,}02 \cdot 10^{-8} \cdot f^2 - 1{,}10 \cdot 10^{-6} \cdot f$
1,2 – 3,6	$= -1{,}72 \cdot 10^{-11} \cdot f^3 + 3{,}81 \cdot 10^{-8} \cdot f^2 - 3{,}89 \cdot 10^{-7} \cdot f$
3,6 – 7,8	$= 1{,}28 \cdot 10^{-13} \cdot f^4 - 2{,}63 \cdot 10^{-11} \cdot f^3 + 5{,}63 \cdot 10^{-8} \cdot f^2 - 3{,}62 \cdot 10^{-7} \cdot f$
1,2 – 4,5	$= 8{,}73 \cdot 10^{-8} \cdot f^2 + 3{,}07 \cdot 10^{-7} \cdot f$
4,5 – 7,8	$= 2{,}03 \cdot 10^{-11} \cdot f^3 + 5{,}08 \cdot 10^{-8} \cdot f^2 + 3{,}25 \cdot 10^{-7} \cdot f$
1,2 – 7,8	$= -2{,}51 \cdot 10^{-11} \cdot f^3 + 2{,}34 \cdot 10^{-8} \cdot f^2 - 2{,}23 \cdot 10^{-7} \cdot f$
	Im_J – Imaginary coefficient of reference jack vector, (V/V) (f = frequency in MHz)
3,6 – 4,5	$= 3{,}09 \cdot 10^{-11} \cdot f^3 + 1{,}77 \cdot 10^{-8} \cdot f^2 - 1{,}47 \cdot 10^{-6} \cdot f$
1,2 – 3,6	$= -1{,}09 \cdot 10^{-8} \cdot f^2 + 5{,}08 \cdot 10^{-6} \cdot f$
3,6 – 7,8	$= -1{,}86 \cdot 10^{-13} \cdot f^4 + 9{,}18 \cdot 10^{-11} \cdot f^3 - 9{,}32 \cdot 10^{-9} \cdot f^2 + 2{,}74 \cdot 10^{-5} \cdot f$
1,2 – 4,5	$= -2{,}68 \cdot 10^{-11} \cdot f^3 - 1{,}20 \cdot 10^{-8} \cdot f^2 + 6{,}82 \cdot 10^{-5} \cdot f$
4,5 – 7,8	$= -1{,}67 \cdot 10^{-13} \cdot f^4 + 8{,}58 \cdot 10^{-11} \cdot f^3 - 2{,}25 \cdot 10^{-8} \cdot f^2 + 4{,}96 \cdot 10^{-5} \cdot f$
1,2 – 7,8	$= 6{,}01 \cdot 10^{-14} \cdot f^4 - 4{,}58 \cdot 10^{-11} \cdot f^3 + 3{,}32 \cdot 10^{-10} \cdot f^2 + 9{,}12 \cdot 10^{-6} \cdot f$

NOTE The reference jack vector coefficients in table C.1 were derived from average measurements collected using a 4-balun test fixture set-up, incorporating impedance matching for the test leads, with common-mode terminations applied to all near-end pairs only.

C.9 Test plug NEXT requirements

For category 5, the following table of values applies:

Table C.2 – Test plug NEXT loss limits

Pair combination	Frequency range (MHz)	Total Range: Lower limit NEXT [d] (dB)	Total Range: Upper limit NEXT [c] (dB)	Phase [a), b)] (degrees)
3,6-4,5	10-100	34,4-20 log(*f*/100)	37,6-20log (*f*/100)	–90 ± 3*(*f*/100)
1,2-3,6	10-100	42-20 log(*f*/100)	50-20 log (*f*/100)	–90 ± 10*(*f*/100)
3,6-7,8	10-100	42-20 log(*f*/100)	50-20 log (*f*/100)	–90 ± 10*(*f*/100)
1,2-4,5	10-100	50-20 log(*f*/100)		Any phase
4,5-7,8	10-100	50-20 log(*f*/100)		Any phase
1,2-7,8	10-100	50-20 log(*f*/100)		Any phase

a) When the measured plug upper or lower NEXT limit is greater than 70 dB, the phase requirement does not apply.

b) Due to measurement accuracy considerations, phase measurement requirements below 50 MHz are specified for information only.

c) When upper limit NEXT calculations result in values greater than 70 dB, there shall be no upper limit for NEXT.

d) When lower limit NEXT calculations result in values greater than 70 dB, the lower limit NEXT shall revert to a limit of 70 dB.

A number of test plugs shall be measured with the de-embedding reference jack, until a complete set of test plugs, which includes the 9 worst cases from the table, is found. There are two worst cases for pair combinations 1,2-3,6; 3,6-4,5; and 3,6-7,8, and one worst case for pair combinations 1,2-4,5; 1,2-7,8; and 4,5-7,8. Each worst case plug shall perform at or outside the limit at 100 MHz. It is recommended that the slope deviation be minimized, and the number of dBs outside be minimized.

NOTE Slope variances from 20 dB/decade may be due to measurement anomalies. The pair combination 1,2-7,8 does not tend to follow 20 dB/decade slope. From 10-100 MHz, no test plug shall be below the lower limit at one frequency point and above the upper limit at another frequency point.

Modular connector performance on all pair combinations shall be qualified with the full range of test plugs. This means each pair combination of each modular connector will be tested with 2 worst case plugs representing the lower limit and upper limit NEXT requirement, on pair combinations 1,2-3,6; 3,6-4,5; and 3,6-7,8.

It is recommended that plugs which exhibit worst-case performance on one pair combination be within the limits on all other pair combinations. However, it will not be required to have 9 plugs if more than one worst-case condition is covered by a particular plug.

C.10 Connector NEXT testing

Fixed connector performance on all pair combinations shall be qualified with the full set of 9 test plugs specified in table C.2. With the exception of the upper and lower test plugs specified for the pair combination terminated on pins 3,6-4,5, mated fixed connector NEXT loss shall satisfy the requirements of 6.4.5. When mated to test plugs compliant with upper and lower test plug requirements specified for the pins terminated on pairs 3,6-4,5, mated fixed connector NEXT loss shall meet the values determined using equation (C.2).

$$NEXT_{\mathrm{conn}} \geq 92{,}5 - 20\log f \ dB \qquad \text{(C.2)}$$

C.11 Test plug FEXT loss test procedure – de-embedding method

For IEC 60603-7-3 connectors, there are no requirements for test plug FEXT.

C.12 Return Loss Reference Plug

Build a reference plug according to section C.2. Measure its return loss according to Annex F. Its return loss shall meet the requirements of table C.11.

Table C.11 – Return loss requirements for return loss reference plug

Pair Combination	Frequency range	Return Loss requirement dB
12, 45, and 78	1-100 MHz	≥35
36	1-100 MHz	≥30

C.13 Connector Return Loss Measurement Requirements

The fixed connector shall have its return loss verified with the return loss reference plug from section C.12, in both directions. .

Annex D
(normative)

General requirements for the measurement set-up

D.1 Test instrumentation

These electrical test procedures require the use of a vector network analyser. The analyser should have the capability of full two-ort calibrations. The analyser shall cover the frequency range of 1 MHz to 1 GHz at least.

At least 2 test baluns are required in order to perform measurements with balanced symmetrical signals. The requirements for the baluns are given in clause D.4.

Reference loads and cables are needed for the calibration of the set-up. Requirements for the reference loads and cables are given in clause D.5.1 and D.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 clause D.6.

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.

D.2 Coaxial cables and test leads for network analysers

Coaxial cable assemblies between the 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 Annex G).

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 category. Balanced test leads shall be limited to 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.

D.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.

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

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

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

D.4 Balun requirements

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

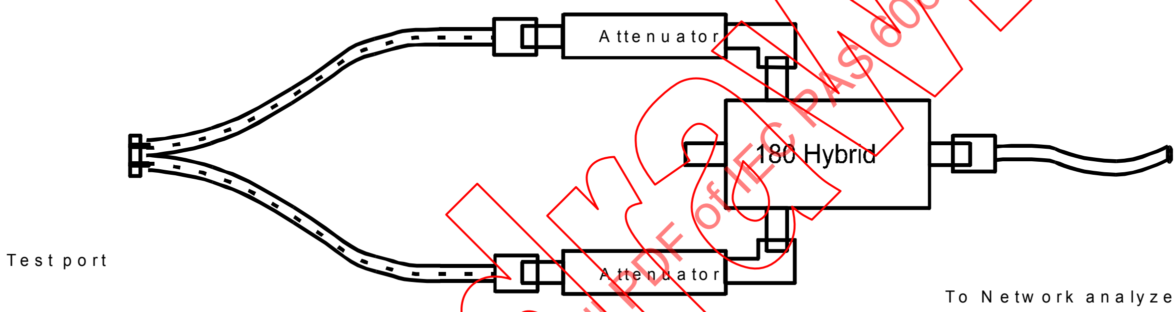


Figure D.1 – 180° hybrid used as a balun

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

All common-mode terminations and the housing of the baluns shall be terminated to one common-ground plane.

Table D.1 – Test balun performance characteristics

Parameter	Requirement at test frequencies up to 100 MHz
Impedance, Primary	Matched to applied network analyser
Impedance, Secondary	100 Ω
Insertion loss	10 dB max.
Return loss secondary	14 dB min.
Return loss common-mode with common-mode termination[a)]	10 dB min.
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 primary input terminal to common-mode terminal when secondary balanced terminal is terminated with 100 Ω.

c) Measured according to ITU-T G.117 and O.9).

NA Not applicable

D.5 D.5 Reference components for calibration

D.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 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 D.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, one 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.

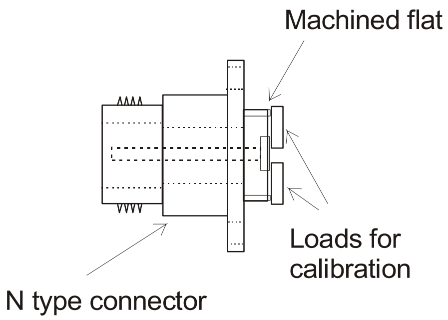


Figure D.2 – Calibration of reference loads

D.5.2 Reference cables for calibration

As a minimum, reference cable that is used to perform calibration of the test set-up shall satisfy the requirement of the same category according to IEC 61156 as the category 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 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 must be well prepared, so that the twisting is maintained up to the test ports

D.6 D.6 Termination loads for termination of conductor pairs

During measurement, 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 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 Ω ± 25 Ω.

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 – 10Log(f) where f is the frequency in megahertz[2]. 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 given in Annex K. For pairs connected to resistor loads, common-mode load is implemented by the Y configuration shown in figure D.3.

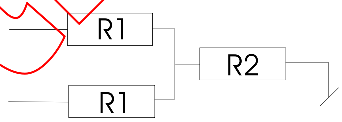


Figure D.3 – Resistor load

where

$$R_1 = \frac{R_{\text{dif}}}{2}$$

and

$$R_2 = R_{\text{com}} - \frac{R_{\text{dif}}}{4}$$

where

R_{dif} is the differential mode impedance (Ω);
R_{com} is the common-mode impedance (Ω).

---

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

[2] Return loss of terminations are measured with a network analyzer connected to one balun, which is calibrated (full one port calibration) using the reference loads (clause D.5.1).

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 common-mode termination points for all pairs shall be connected to the ground plane.

D.7 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.

D.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 maintained, whichever is farther from the connector; see figure D.4. This definition applies to both ends of the test specimen.

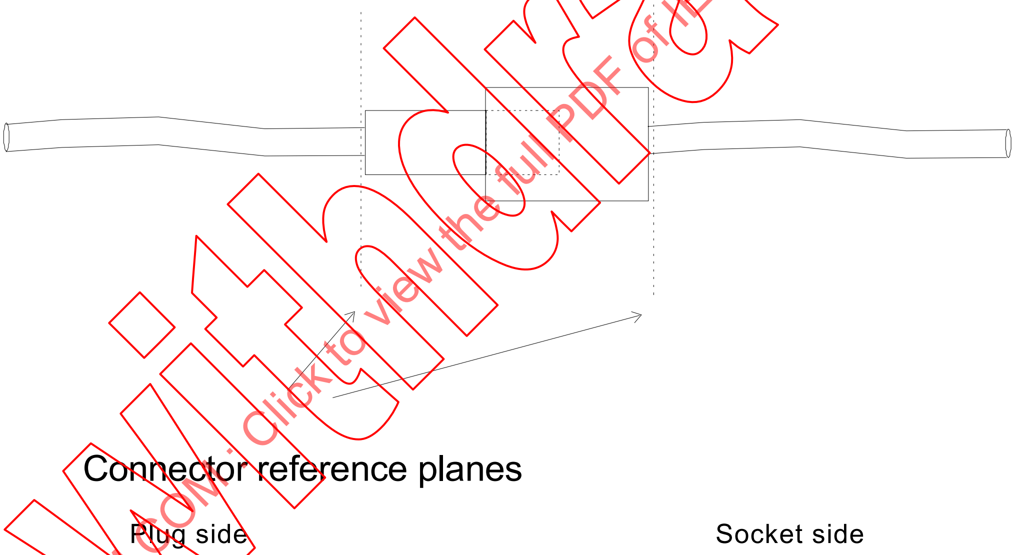


Figure D.4 – Definition of reference planes

Annex E
(normative)

Insertion loss

E.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.

E.2 Test method

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

E.3 Tests set-up

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

It is not necessary to terminate the unused pairs.

E.4 Procedure

E.4.1 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 performing the transmission calibration measurement. Then a maximum length of 7 cm reference cables are connected to the terminals of the two baluns (see figure E.1). The total length of these cables shall be equal to the length of the reference cable used for transmission calibrations. At the end of these reference cables the reflection calibrations are performed by applying open, short and load terminations.

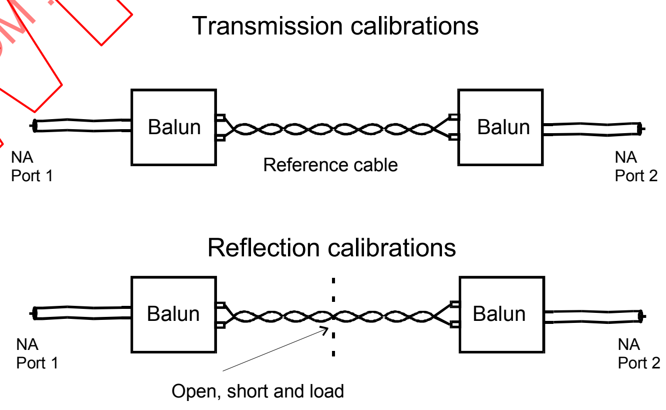


Figure E.1 – Calibration

3) Often referred to as Attenuation

E.4.2 Measurement

The test specimen shall be terminated with measurement cables at both ends (see Figure E.2). 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.

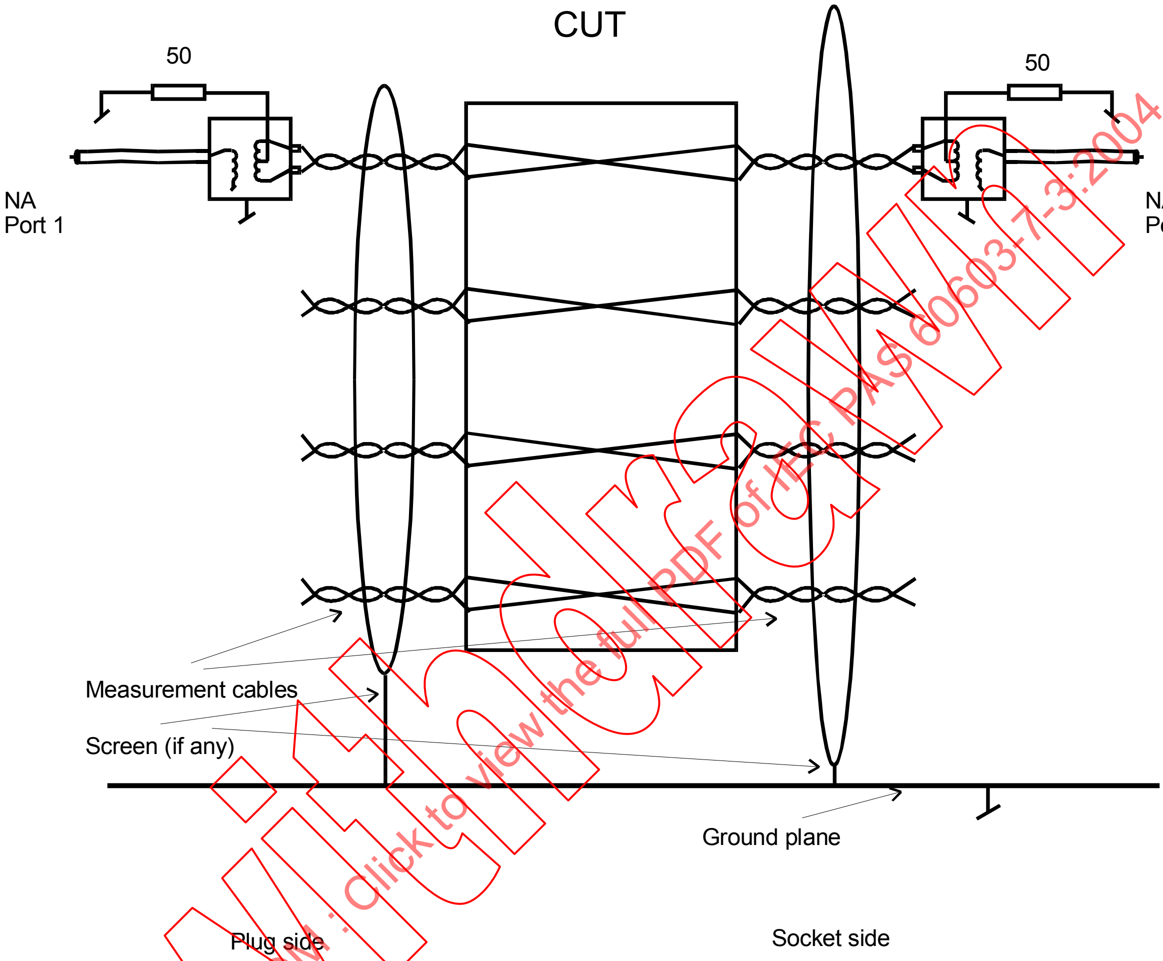


Figure E.2 – Measuring set-up

E.5 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.

E.6 Accuracy

The accuracy shall be within ±0,05 dB.

Annex F
(normative)

Return loss

F.1 Object

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

F.2 Test method

Return loss is measured by measuring the scattering parameters, S_{11} and S_{22} of all the conductor pairs.

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

F.3 Test set-up

The test set-up is as described in annex E

F.4 Procedure

F.4.1 Calibration

Calibration shall be performed as described in E.4.1

F.4.2 Measurement

The test specimen shall be terminated with measurement cables at both ends. The length of the 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. S_{11} and S_{22} measurements shall be carried out for each of the pairs.

F.5 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.

F.6 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 with measurements performed by a directional bridge with a directivity of 40 dB and 34 dB. The accuracy (uncertainty band) is tabled in table F.1 and F.2.

Table F.1 – Uncertainty band of return loss measurement at frequencies below 100 MHz

Measured RL	10	12	15	18	20	22	25	28	30
Lower uncertainty limit	–0,3	–0,3	–0,5	–0,7	–0,8	–1,0	–1,4	–1,9	–2,4
Higher uncertainty limit	+0,3	+0,4	+0,5	+0,7	+0,9	+1,2	+1,7	+2,5	+3,3

Table F.2 – Uncertainty band of return loss measurement at frequencies above 100 MHz

Measured RL	10	12	15	18	20	22	25	28	30
Lower uncertainty limit	–0,5	–0,7	–0,9	–1,3	–1,6	–1,9	–2,6	–3,5	–4,2
Higher uncertainty limit	+0,6	+0,7	+1,0	+1,3	+1,9	+2,5	+3,8	+6,0	+8,7

Example Let the measured RL be 20 dB. The true RL then lies in the band of 18,4 to 21,9 dB at frequencies above 100 MHz.

Annex G
(normative)

Near end cross talk

G.1 Object

The object of this test procedure is to measure the magnitude of the electric and magnetic coupling between driven (disturbing) and quiet (disturbed) pairs of a mated connector pair.

G.2 Test method

Near end crosstalk is evaluated by measuring the scattering parameters, S_{21}, of the possible conductor pair combinations at one end of the mated connector, while the other end of the pairs are terminated.

G.3 Test set-up

The test set-up consists of two baluns and a network analyser as defined in annex D. An illustration of the set-up, which also shows the termination principles, is shown in Figure G.1.

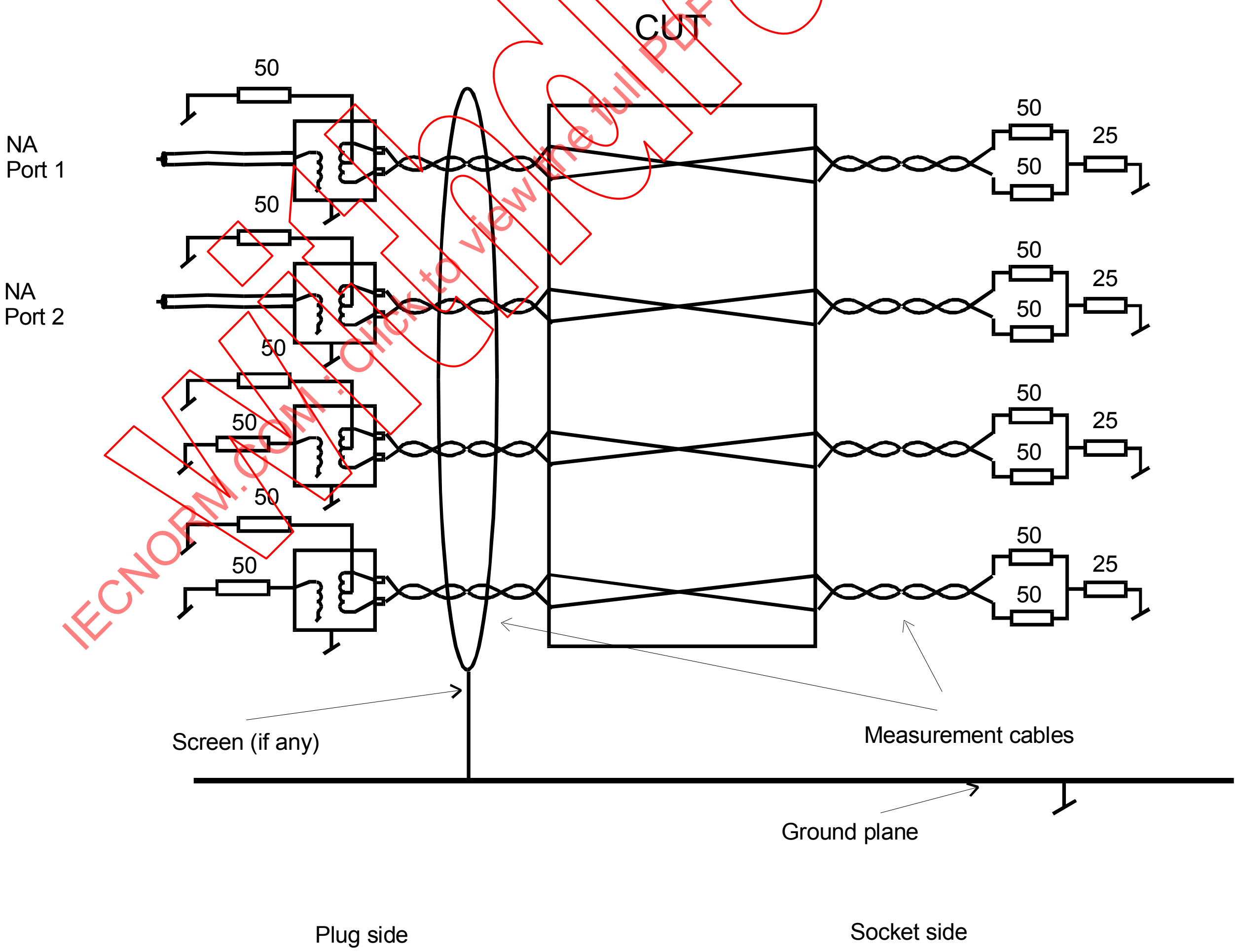


Figure G.1 – NEXT measurement differential and common-mode terminations

(Passive terminations may be either balun or resistor terminations)

G.4 Procedure

G.4.1 Calibration

A through calibration shall be applied as a minimum. Full two-port calibrations are recommended in order to enhance the measurement accuracy.

G.4.2 Establishment of noise floor

The noise floor of the set-up shall be measured. The level of the noise floor is determined by white noise, which may be reduced by increasing the test power and by reducing the bandwidth of the network analyser, and by residual crosstalk between the test baluns. The noise floor shall be measured by terminating the baluns with resistors and perform a S_{21} measurement. The noise floor shall be 20 dB lower than any specified limit for the crosstalk. If the measured value is closer to the noise floor than 10 dB, this shall be reported.

NOTE For high crosstalk values, it may be necessary to screen the terminating resistors.

G.4.3 Measurement

Connect the disturbing pair of the CUT to the signal source and the disturbed pair to the receiver port. Terminate according to Figure G.1. It is recommended that the socket be terminated with short separated pairs without jacket. Test all possible pair combinations[1)] and record the results.

The CUT shall be tested in the following configuration: with differential and common-mode terminations.

The measurements shall be performed from both ends of the mated connector. As a connector is a low-loss device near-end cross talk values from the two ends are nearly equal.

Differential and common-mode terminations shall be provided on at least one end of each pair, including the unused pairs. This may be the near or far end. Differential terminations shall be provided at both ends. Optionally, differential and common-mode terminations may be provided at both ends of all pairs, as shown in figure G.1.

G.5 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.

G.6 Accuracy

The accuracy shall be better than ±1 dB at measurements up to 60 dB and ±2 dB at measurements up to 85 dB.

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[1)] There are 6 different combinations of near-end crosstalk in a 4-pair connector from each side, which gives a total of 12 measurements for each kind of termination method.