BS EN 50173-1:2011

BSI Standards Publication

Information technology — Generic cabling systems

Part 1: General requirements

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 50173-1:2011. It supersedes BS EN 50173-1:2007+A1:2009 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee TCT/7, Telecommunications - Installation requirements.

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

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

ISBN 978 0 580 69185 0

ICS 33.040.50

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 July 2011.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 50173-1

May 2011

ICS 33.040.50

English version

Information technology - Generic cabling systems - Part 1: General requirements

Technologies de l'information - Systèmes de câblage générique - Partie 1: Exigences générales

Informationstechnik - Anwendungsneutrale Kommunikationskabelanlagen - Teil 1: Allgemeine Anforderungen

This European Standard was approved by CENELEC on 2011-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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

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

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 50173-1:2011 E

Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 215, *Electrotechnical aspects of telecommunication equipment*. This 3rd edition of EN 50173-1 replaces the text of EN 50173-1:2007, EN 50173-1:2007/A1:2009 and consolidates these two standards with the text of EN 50173-1:2007/FprAB:2010 for the convenience of the user of the standard.

The text of draft amendment EN 50173-1:2007/FprAB was submitted to the Formal Vote and was approved by CENELEC to amend EN 50173-1:2007 on 2011-04-01.

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

The following dates were fixed:

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

The previous editions of European Standards EN 50173:1995 and EN 50173-1:2002 have been developed to enable the application-independent cabling to support ICT applications in office premises. Their basic principles, however, are applicable to other types of applications and in other types of premises.

TC 215 has decided to establish relevant European Standards which address the specific requirements of these premises. In order to point out the commonalities of these cabling design standards, these ENs are published as individual parts of the series EN 50173, thus also acknowledging that standards users recognize the designation “EN 50173” as a synonym for generic cabling design.

At the time of publication of this European Standard, series EN 50173 comprises the following standards:

- EN 50173-1 Information technology – Generic cabling systems – Part 1: General requirements
- EN 50173-2 Information technology – Generic cabling systems – Part 2: Office premises
- EN 50173-3 Information technology – Generic cabling systems – Part 3: Industrial premises
- EN 50173-4 Information technology – Generic cabling systems – Part 4: Homes
- EN 50173-5 Information technology – Generic cabling systems – Part 5: Data centres

This edition of EN 50173-1:

a) contains a change of electromagnetic parameters in the MICE classification (Table 3);

b) introduces new component Categories 6_A and 7_A in accordance with the channel Classes E_A and F_A defined in EN 50173-1:2007/A1:2009;

c) modifies insertion loss requirements for coaxial channels;

d) modifies optical fibre Class OF-100 media and defines a new cabled optical fibre Category OM4;

e) amends and modifies connecting hardware requirements, defines both a new interface for 2 optical fibres and for 12 and 24 fibres;

f) introduces limits for additional parameters in Annexes A, B and D.2;

g) revises D.3 regarding test requirements for mechanical and environmental performance of connecting hardware;

h) updates Annex F “Supported applications”;

i) introduces a new normative Annex I “Test procedures to assess conformance with EN 50173 standards”;

j) amends various other subclauses, tables and figures.

Contents

Figures

Tables

Introduction

This European Standard contains general requirements in support of the other standards in the EN 50173 series.

It should be noted that generic cabling is a passive system and cannot be tested for EMC compliance individually. Application-specific equipment, designed for one or more cabling media, is required to meet relevant EMC standards on those media. Care should be taken that the installation of any of those media in a cabling system does not degrade the characteristics of the system. The installation methods of EN 50174 series should be used to minimise the effect of electromagnetic disturbances. For EMC requirements of BCT cabling see EN 50083-8.

Series EN 50174 and EN 50310 specify requirements for earthing and equipotential bonding.

Figure 1 and Table 1 show the schematic and contextual relationships between the standards produced by TC 215 for information technology cabling, namely:

1) this and other parts of the EN 50173 series;
2) application dependent cabling design (e.g. EN 50098 series);
3) installation (EN 50174 series);
4) testing of installed cabling (EN 50346);
5) equipotential bonding requirements (EN 50310).

In addition, a number of Technical Reports have been developed to support or extend the application of these standards, including:

– CLC/TR 50173-99-1, *Cabling guidelines in support of 10 GBASE-T*;
– CLC/TR 50173-99-2, *Information technology – Implementation of BCT applications using cabling in accordance with EN 50173-4*.

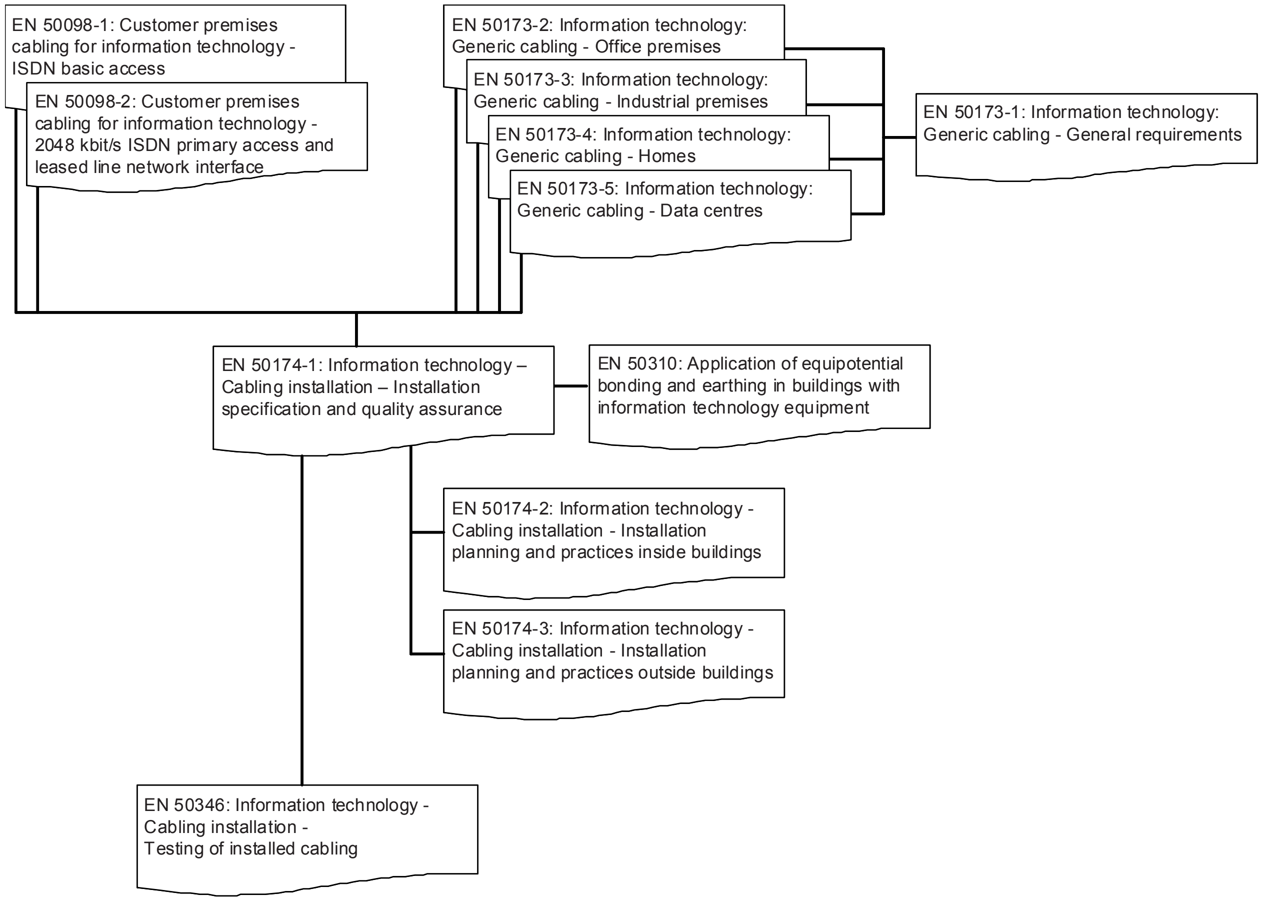


Figure 1 – Schematic relationship between the EN 50173 series and other relevant standards

Table 1 – Contextual relationship between EN 50173 series and other standards relevant for information technology cabling systems

Building design phase	Generic cabling design phase	Specification phase	Installation phase	Operation phase
EN 50310	**EN 50173 series except EN 50173-4**	**EN 50174-1**		**EN 50174-1**
6. Bonding networks	4: Structure 5: Channel performance 7: Cable requirements 8: Connecting hardware requirements 9: Requirements for cords and jumpers A: Link performance limits	4 Requirements for specifying installations of information technology cabling 5: Requirements for installers of information technology cabling		4: Requirements for specifying installations of information technology cabling
		Planning phase		
	and EN 50173-4	**EN 50174-2**	**EN 50174-2**	
	4 and 5: Structure 6: Channel performance 8: Cable requirements 9: Connecting hardware requirements 10: Requirements for cords and jumpers A: Link performance limits	4: Requirements for planning installations of information technology cabling 6: Segregation of metallic information technology cabling and power supply cabling 7: Electricity distribution systems and lightning protection **and EN 50174-3** **and (for equipotential bonding) EN 50310**	5: Requirements for the installation of information technology cabling 6: Segregation of metallic information technology cabling and power supply cabling 8: Office (commercial) premises 9: Industrial premises 10: Homes 11: Data centres **and EN 50174-3** **and (for equipotential bonding) EN 50310** **and EN 50346** 4: General requirements 5: Test parameters for balanced cabling 6: Test parameters for optical fibre cabling	

1 Scope and conformance

1.1 Scope

This European Standard specifies:

a) the structure and configuration of the backbone cabling subsystems of generic cabling systems within the types of premises defined by the other standards in the EN 50173 series;

b) channel performance requirements in support of the standards in the EN 50173 series;

c) link performance requirements in support of the standards in the EN 50173 series;

d) backbone cabling reference implementations in support of the standards in the EN 50173 series;

e) component performance requirements in support of the standards in the EN 50173 series.

Safety (electrical safety and protection, optical power, fire, etc.) and electromagnetic compatibility (EMC) requirements are outside the scope of this European Standard and are covered by other standards and regulations. However, information given in this European Standard may be of assistance in meeting these standards and regulations.

1.2 Conformance

This European Standard does not contain specific conformance requirements. The other standards in the EN 50173 series incorporate the requirements of this standard as part of their individual conformance requirements.

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.

EN 50083 (series), *Cable networks for television signals, sound signals and interactive services*

NOTE EN 50083 series is gradually replaced by EN 60728 series.

EN 50117-1, *Coaxial cables – Part 1: Generic specification*

EN 50117-4-1, *Coaxial cables – Part 4-1: Sectional specification for cables for BCT cabling in accordance with EN 50173 – Indoor drop cables for systems operating at 5 MHz – 3 000 MHz*

EN 50174-1:2009, *Information technology – Cabling installation – Part 1: Installation specification and quality assurance*

EN 50174-2, *Information technology – Cabling installation – Part 2: Installation planning and practices inside buildings*

EN 50174-3, *Information technology – Cabling installation – Part 3: Installation planning and practices outside buildings*

EN 50288-1, *Multi-element metallic cables used in analogue and digital communication and control – Part 1: Generic specification*

EN 50288-2-1, *Multi-element metallic cables used in analogue and digital communication and control – Part 2-1: Sectional specification for screened cables characterized up to 100 MHz – Horizontal and building backbone cables*

EN 50288-2-2, *Multi-element metallic cables used in analogue and digital communication and control – Part 2-2: Sectional specification for screened cables characterized up to 100 MHz – Work area and patch cord cables*

EN 50288-3-1, *Multi-element metallic cables used in analogue and digital communication and control – Part 3-1: Sectional specification for unscreened cables characterized up to 100 MHz – Horizontal and building backbone cables*

EN 50288-3-2, *Multi-element metallic cables used in analogue and digital communication and control – Part 3-2: Sectional specification for unscreened cables characterized up to 100 MHz – Work area and patch cord cables*

EN 50288-4-1, *Multi-element metallic cables used in analogue and digital communication and control – Part 4-1: Sectional specification for screened cables characterised up to 600 MHz – Horizontal and building backbone cables*

EN 50288-4-2, *Multi-element metallic cables used in analogue and digital communication and control – Part 4-2: Sectional specification for screened cables characterised up to 600 MHz – Work area and patch cord cables*

EN 50288-5-1, *Multi-element metallic cables used in analogue and digital communication and control – Part 5-1: Sectional specification for screened cables characterized up to 250 MHz – Horizontal and building backbone cables*

EN 50288-5-2, *Multi-element metallic cables used in analogue and digital communication and control – Part 5-2: Sectional specification for screened cables characterized up to 250 MHz – Work area and patch cord cables*

EN 50288-6-1, *Multi-element metallic cables used in analogue and digital communication and control – Part 6-1: Sectional specification for unscreened cables characterized up to 250 MHz – Horizontal and building backbone cables*

EN 50288-6-2, *Multi-element metallic cables used in analogue and digital communication and control – Part 6-2: Sectional specification for unscreened cables characterized up to 250 MHz – Work area and patch cord cables*

EN 50288-9-1 [1)], *Multi-element metallic cables used in analogue and digital communications and control – Part 9-1: Sectional specification for screened cables characterised up to 1 000 MHz, to be used in horizontal floor and building backbone wiring for information technology generic cabling systems*

EN 50288-9-2 [1)], *Multi-element metallic cables used in analogue and digital communications and control – Part 9-2: Sectional specification for screened cables characterised up to 1 000 MHz – Work area and patch cord cables*

EN 50288-10-1 [1)], *Multi-element metallic cables used in analogue and digital communication and control – Part 10-1: Sectional specification for screened cables characterised up to 500 MHz – Horizontal floor and building backbone cables*

EN 50288-10-2 [1)], *Multi-element metallic cables used in analogue and digital communication and control – Part 10-2: Sectional specification for screened cables characterized up to 500 MHz – Work area and patch cord cables*

EN 50288-11-1 [1)], *Multi-element metallic cables used in analogue and digital communication and control – Part 11: Sectional specification for unscreened cables characterised up to 500 MHz – Horizontal floor and building backbone cables*

---

1) At draft stage.

EN 50288-11-2 [2)], *Multi-element metallic cables used in analogue and digital communication and control – Part 13-2: Sectional specification for unscreened cables characterized up to 500 MHz – Work area and patch cord cables*

EN 50289-1-2, *Communication cables – Specifications for test methods – Part 1-2: Electrical test methods – D.C. resistance*

EN 50289-1-5:2001, *Communication cables – Specifications for test methods – Part 1-5: Electrical test methods – Capacitance*

EN 50289-1-6, *Communication cables – Specifications for test methods – Part 1-6: Electrical test methods – Electromagnetic performance*

EN 50289-1-8, *Communication cables – Specifications for test methods – Part 1-8: Electrical test methods – Attenuation*

EN 50289-1-9, *Communication cables – Specifications for test methods – Part 1-9: Electrical test methods – Attenuation unbalance (Longitudinal conversion loss, longitudinal conversion transfer loss)*

EN 50289-1-11, *Communication cables – Specifications for test methods – Part 1-11: Electrical test methods – Characteristic impedance, input impedance, return loss*

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

EN 50289-3-9:2001, *Communication cables – Specifications for test methods – Part 3-9: Mechanical test methods – Bending tests*

EN 50346, *Information technology – Cabling installation – Testing of installed cabling*

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

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

EN 60352-2, *Solderless connections – Part 2: Crimped connections – General requirements, test methods and practical guidance (IEC 60352-2)*

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

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

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

EN 60352-6, *Solderless connections – Part 6: Solderless insulation piercing connections – General requirements, test methods and practical guidance (IEC 60352-6:1997)*

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

[2)] At draft stage.

EN 60352-8, *Solderless connections – Part 8: Compression mount connections – General requirements, test methods and practical guidance (IEC 60352-8)*

EN 60512-2-1:2002, *Connectors for electronic equipment – Tests and measurements – Part 2-1: Electrical continuity and contact resistance tests – Test 2a: Contact resistance – Millivolt level method (IEC 60512-2-1:2002)*

EN 60512-3-1:2002, *Connectors for electronic equipment – Tests and measurements – Part 3-1: Insulation tests – Test 3a: Insulation resistance (IEC 60512-3-1:2002)*

EN 60512-4-1:2003, *Connectors for electronic equipment – Tests and measurements – Part 4-1: Voltage stress tests – Test 4a: Voltage proof (IEC 60512-4-1:2003)*

EN 60512-4-2, *Connectors for electronic equipment – Tests and measurements – Part 4-2: Voltage stress tests – Test 4b: Partial discharge (IEC 60512-4-2)*

EN 60512-5-2:2002, *Connectors for electronic equipment – Tests and measurements – Part 5-2: Current-carrying capacity tests – Test 5b: Current-temperature derating (IEC 60512-5-2:2002)*

EN 60512-6-2, *Connectors for electronic equipment – Tests and measurements – Part 6-2: Dynamic stress tests – Test 6b: Bump (IEC 60512-6-2)*

EN 60512-6-3, *Connectors for electronic equipment – Tests and measurements – Part 6-3: Dynamic stress tests - Test 6c: Shock (IEC 60512-6-3)*

EN 60512-6-4, *Connectors for electronic equipment – Tests and measurements – Part 6-4: Dynamic stress tests – Test 6d: Vibration (sinusoidal) (IEC 60512-6-4)*

EN 60512-11-4, *Connectors for electronic equipment – Tests and measurements – Part 11-4: Climatic tests – Test 11d: Rapid change of temperature (IEC 60512-11-4)*

EN 60512-11-7, *Connectors for electronic equipment – Tests and measurements – Part 11-7: Climatic tests – Test 11g: Flowing mixed gas corrosion test (IEC 60512-11-7)*

EN 60512-11-9, *Connectors for electronic equipment – Tests and measurements – Part 11-9: Climatic tests – Test 11i: Dry heat (IEC 60512-11-9)*

EN 60512-11-10, *Connectors for electronic equipment – Tests and measurements – Part 11-10: Climatic tests – Test 11j: Cold (IEC 60512-11-10)*

EN 60512-11-12, *Connectors for electronic equipment – Tests and measurements – Part 11-12: Climatic tests – Test 11m: Damp heat, cyclic (IEC 60512-11-12)*

EN 60512-16-4, *Connectors for electronic equipment – Tests and measurements – Part 16-4: Mechanical tests on contacts and terminations - Test 16d: Tensile strength (crimped connections) (IEC 60512-16-4:2008)*

EN 60512-17-2, *Connectors for electronic equipment – Tests and measurements – Part 17-2: Cable clamping tests - Test 17b: Cable clamp resistance to cable rotation (IEC 60512-17-2:2011)*

EN 60512-17-4, *Connectors for electronic equipment – Tests and measurements – Part 17-4: Cable clamping tests - Test 17d: Cable clamp resistance to cable torsion (IEC 60512-17-4:2010)*

EN 60512-19-3, *Connectors for electronic equipment – Tests and measurements – Part 19-3: Chemical resistance tests – Section 3: Test 19c – Fluid resistance (IEC 60512-19-3)*

EN 60512-23-3, *Connectors for electronic equipment – Tests and measurements – Part 23-3: Test 23c: Shielding effectiveness of connectors and accessories (IEC 60512-23-3)*

EN 60512-25-1, *Connectors for electronic equipment – Tests and measurements – Part 25-1: Test 25a – Crosstalk ratio (IEC 60512-25-1)*

EN 60512-25-2, *Connectors for electronic equipment – Tests and measurements – Part 25-2: Test 25b – Attenuation/insertion loss (IEC 60512-25-2)*

EN 60512-25-4, *Connectors for electronic equipment – Tests and measurements – Part 25-4: Test 25d – Propagation delay (IEC 60512-25-4)*

EN 60512-25-5, *Connectors for electronic equipment – Tests and measurements – Part 25-5: Test 25e – Return loss (IEC 60512-25-5)*

EN 60512-25-9, *Connectors for electronic equipment – Tests and measurements – Part 25-9: Signal integrity tests – Test 25i – Alien crosstalk (IEC 60512-25-9)*

EN 60512-26-100:2008, *Connectors for electronic equipment – Tests and measurements – Part 26-100: Measurement setup, test and reference arrangements and measurements for connectors according to IEC 60603-7 – Tests 26a to 26g (IEC 60512-26-100:2008)*

EN 60529, *Degrees of protection provided by enclosures (IP code) (IEC 60529)*

EN 60603-7:2009, *Connectors for electronic equipment – Part 7: Detail specification for 8-way, unshielded, free and fixed connectors (IEC 60603-7:2008)*

EN 60603-7-1, *Connectors for electronic equipment – Part 7-1: Detail specification for 8-way, shielded, free and fixed connectors (IEC 60603-7-1)*

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

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

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

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

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

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

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

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

EN 60793-1-20, *Optical fibres – Part 1-20: Measurement methods and test procedures – Fibre geometry (IEC 60793-1-20)*

EN 60793-1-40, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation (IEC 60793-1-40)*

EN 60793-1-41, *Optical fibres – Part 1-41: Measurement methods and test procedures – Bandwidth (IEC 60793-1-41)*

EN 60793-1-44, *Optical fibres – Part 1-44: Measurement methods and test procedures – Cut-off wavelength (IEC 60793-1-44)*

EN 60793-1-49, *Optical fibres – Part 1-49: Measurement methods and test procedures – Differential mode delay (IEC 60793-1-49)*

EN 60793-2, *Optical fibres – Part 2: Product specifications – General (IEC 60793-2)*

EN 60793-2-10:2011, *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres (IEC 60793-2-10:2011)*

EN 60793-2-30:2009, *Optical fibres – Part 2-30: Product specifications – Sectional specification for category A3 multimode fibres (IEC 60793-2-30:2007)*

EN 60793-2-40:2011, *Optical fibres – Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres (IEC 60793-2-40:2009)*

EN 60793-2-50:2008*, Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres (IEC 60793-2-50:2008)*

EN 60794-1-1, *Optical fibre cables – Part 1-1: Generic specification – General (IEC 60794-1-1)*

EN 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures (IEC 60794-1-2)*

EN 60794-2, *Optical fibre cables – Part 2 : Indoor optical fibre cables – Sectional specification (IEC 60794-2)*

EN 60794-3, *Optical fibre cables – Part 3: Sectional specification – Outdoor cables (IEC 60794-3)*

EN 60811-1-1:1995, *Insulating and sheathing of electric cables – Common test methods – Part 1: General application – Section 1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties (IEC 60811-1-1:1993)*

EN 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (IEC 60825-2)*

EN 60966-2-4, *Radio frequency and coaxial cable assemblies – Part 2-4: Detail specification for cable assemblies for radio and TV receivers – Frequency range 0 to 3000 MHz, IEC 61169-2 connectors (IEC 60966-2-4)*

EN 60966-2-5, *Radio frequency and coaxial cable assemblies – Part 2-5: Detail specification for cable assemblies for radio and TV receivers – Frequency range 0 to 1 000 MHz, IEC 61169-2 connectors (IEC 60966-2-5)*

EN 60966-2-6, *Radio frequency and coaxial cable assemblies – Part 2-6: Detail specification for cable assemblies for radio and TV receivers – Frequency range 0 to 3 000 MHz, IEC 61169-24 connectors (IEC 60966-2-6)*

EN 61073-1, *Mechanical splices and fusion splice protectors for optical fibres and cables – Part 1: Generic specification (IEC 61073-1)*

EN 61076-2-101, *Connectors for electronic equipment – Part 2-101: Circular connectors – Detail specification for circular connectors M8 with screw- or snap-locking, M12 with screw-locking for low voltage applications (IEC 61076-2-101)*

EN 61076-3-104:2006, *Connectors for electronic equipment – Product requirements – Part 3-104: – Detail specification for 8-way, shielded free and fixed connectors, for data transmissions with frequencies up to 1 000 MHz minimum (IEC 61076-3-104:2006)*

EN 61076-3-110, *Connectors for electronic equipment - Product requirements - Part 3-110: Rectangular connectors - Detail specification for shielded, free and fixed connectors for data transmission with frequencies up to 1 000 MHz (IEC 61076-3-110)*

EN 61169-1, *Radio-frequency connectors – Part 1: Generic specification – General requirements and measuring methods (IEC 61169-1)*

EN 61169-2, *Radio-frequency connectors – Part 2: Sectional specification – Radio frequency coaxial connectors of type 9,52 (IEC 61169-2)*

EN 61169-24, *Radio-frequency connectors – Part 24: Sectional specification – Radio frequency coaxial connectors with screw coupling, typically for use in 75 ohm cable distribution systems (type F) (IEC 61169-24)*

EN 61300-2-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-1: Tests – Vibrations (sinusoidal) (IEC 61300-2-1)*

EN 61300-2-2, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-2: Tests – Mating durability (IEC 61300-2-2)*

EN 61300-2-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Tests – Fibre/cable retention (IEC 61300-2-4)*

EN 61300-2-5, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-5: Tests – Torsion/twist (IEC 61300-2-5)*

EN 61300-2-6, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-6: Tests – Tensile strength of coupling mechanism (IEC 61300-2-6)*

EN 61300-2-9, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-9: Tests – Shock (IEC 61300-2-9)*

EN 61300-2-12, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-12: Tests – Impact (IEC 61300-2-12)*

EN 61300-2-17, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-17: Tests – Cold (IEC 61300-2-17)*

EN 61300-2-18, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-18: Tests – Dry heat – High temperature endurance (IEC 61300-2-18)*

EN 61300-2-19, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-19: Tests – Damp heat (steady state) (IEC 61300-2-19)*

EN 61300-2-22, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-22: Tests – Change of temperature (IEC 61300-2-22)*

EN 61300-2-30, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-30: Tests – Solar radiation (IEC 61300-2-30)*

EN 61300-2-34, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-34: Tests – Resistance to solvents and contaminating fluids (IEC 61300-2-34)*

EN 61300-2-42, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-42: Tests – Static side load for connectors (IEC 61300-2-42)*

EN 61300-2-44, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-44: Tests – Flexing of the strain relief of fibre optic devices (IEC 61300-2-44)*

EN 61300-2-46*, Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-46: Tests – Damp heat cyclic (IEC 61300-2-46)*

EN 61300-3-6, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-6: Examinations and measurements – Return loss (IEC 61300-3-6)*

EN 61300-3-34, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-34: Examinations and measurements – Attenuation of random mated connectors (IEC 61300-3-34)*

EN 61935-2, *Specification for the testing of balanced and coaxial information technology cabling – Part 2: Cords as specified in ISO/IEC 11801 and related standards (IEC 61935-2)*

EN 62012-1, *Multicore and symmetrical pair/quad cables for digital communications to be used in harsh environments – Part 1: Generic specification (IEC 62012-1)*

IEC 61156-1:2007*, Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61156-5-1, *Multicore and symmetrical pair/quad cables for digital communications – Part 5-1: Symmetrical pair/quad cables with transmission characteristics up to 1000 MHz – Horizontal floor wiring – Blank detail specification*

IEC 61156-6-1, *Multicore and symmetrical pair/quad cables for digital communications – Part 6-1: Symmetrical pair/quad cables with transmission characteristics up to 1000 MHz – Work area wiring – Blank detail specification*

IEC 61156-7, *Multicore and symmetrical pair/quad cables for digital communications – Part 7: Symmetrical pair cables with transmission characteristics up to 1 200 MHz – Sectional specification for digital and analog communication cables*

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document and the other standards in the EN 50173 series, the following terms and definitions apply.

3.1.1
administration
methodology defining the documentation requirements of a cabling system and its containment, the labelling of functional elements and the process by which moves, additions and changes are recorded

3.1.2
alien (exogenous) crosstalk
signal coupling from a disturbing pair of a channel to a disturbed pair of another channel

NOTE This also applies to the signal coupling from a disturbing pair within a permanent link or component, used to create a channel, to a disturbed pair within a permanent link or component, used to create another channel.

3.1.3
alien (exogenous) far-end crosstalk loss (AFEXT)
signal isolation between a disturbing pair of a channel and a disturbed pair of another channel, measured at the far-end

NOTE This also applies to the measurement of the signal isolation between a disturbing pair within a permanent link or component, used to create a channel, and a disturbed pair within a permanent link or component, used to create another channel.

3.1.4
alien (exogenous) near-end crosstalk loss (ANEXT)
signal isolation between a disturbing pair of a channel and a disturbed pair of another channel, measured at the near-end

NOTE This also applies to the measurement of the signal isolation between a disturbing pair within a permanent link or component, used to create a channel, and a disturbed pair within a permanent link or component, used to create another channel.

3.1.5
application
system, with its associated transmission method that is supported by telecommunications cabling

3.1.6
attenuation to alien (exogenous) crosstalk ratio at the far-end (AACR-F)
difference, in dB, between the alien far-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbed pair in another channel

NOTE This also applies to the calculation using the alien far-end crosstalk loss from a disturbing pair within a permanent link or component, used to create a channel, and the insertion loss of a disturbed pair within a permanent link or component, used to create another channel.

3.1.7
attenuation to alien (exogenous) crosstalk ratio at the near-end (AACR-N)
difference, in dB, between the alien near-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbed pair in another channel

NOTE This also applies to the calculation using the alien near-end crosstalk loss from a disturbing pair within a permanent link or component, used to create a channel, and the insertion loss of a disturbed pair within a permanent link or component, used to create another channel.

3.1.8
attenuation to crosstalk ratio at the far-end (ACR-F)
difference, in dB, between the far-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbed pair of the same channel

NOTE This also applies to the calculation using the far-end crosstalk loss from a disturbing pair within a permanent link or component, used to create a channel, and the insertion loss of a disturbed pair within the permanent link or component, of the same channel.

3.1.9
attenuation to crosstalk ratio at the near-end (ACR-N)
difference, in dB, between the near-end crosstalk loss from a disturbing pair of a channel and the insertion loss of a disturbed pair of the same channel

NOTE This also applies to the calculation using the near-end crosstalk loss from a disturbing pair within a permanent link or component, used to create a channel, and the insertion loss of a disturbed pair within the permanent link or component, of the same channel.

3.1.10
average alien (exogenous) near-end crosstalk loss
calculated average of the alien near-end crosstalk loss of the pairs of a disturbed channel

NOTE This also applies to the calculation using the pairs within a permanent link, used to create a channel.

3.1.11
average power sum alien (exogenous) near-end crosstalk loss
calculated average of the power sum alien near-end crosstalk loss of the pairs of a disturbed channel

NOTE This also applies to the calculation using the pairs within a permanent link used to create a channel.

3.1.12
average power sum attenuation to alien (exogenous) crosstalk ratio far-end
calculated average of the power sum attenuation to alien crosstalk ratio at the far-end of the pairs of a disturbed channel

NOTE This also applies to the calculation using the pairs within a permanent link used to create a channel.

3.1.13
balanced cable
cable consisting of one or more symmetrical metallic cable elements (twisted pairs or quads)

3.1.14
broadcast and communication technologies
group of applications using the HF band (3 MHz to 30 MHz), the VHF band (30 MHz to 300 MHz) and the UHF band (300 MHz to 3 000 MHz) for transmission of sound radio, TV and two-way data services, as well as for in-home inter-networking

3.1.15
building backbone cable
cable that connects the building distributor to a floor distributor

NOTE Building backbone cables may also connect floor distributors in the same building.

3.1.16
building distributor
distributor in which the building backbone cable(s) terminate(s) and at which connections to the campus backbone cable(s) may be made

3.1.17
building entrance facility
facility that provides all necessary mechanical and electrical services for the entry of telecommunications cables into a building and which may allow for transition from external to internal cable

3.1.18
cable
assembly of one or more cable units of the same type and Category in an overall sheath

NOTE It may include an overall screen.

3.1.19
cabled optical fibre Category
system of defining requirements for the cabled optical fibre performance within optical fibre channels and links (also referred to as performance codes in those standards developed by IEC SC 86A to support premises cabling)

3.1.20
cable element
smallest construction unit in a cable

NOTE 1 A cable element may have a screen.

NOTE 2 A pair, a quad, a single isolated lead with coaxial screen and a single optical fibre are examples of a cable element.

3.1.21
cable unit
single assembly of one or more cable elements usually of the same type or Category

NOTE A cable unit may have a screen.

3.1.22
cabling
system of telecommunications cables, cords and connecting hardware that supports the operation of information technology equipment

3.1.23
campus
premises containing one or more buildings

3.1.24
campus backbone cable
cable that connects the campus distributor to the building distributor(s)

NOTE Campus backbone cables may also interconnect building distributors.

3.1.25
campus distributor
distributor from which the campus backbone cabling emanates

3.1.26
channel
any transmission path comprising passive cabling components between application-specific equipment or between application-specific equipment and an external network interface

NOTE Differing definitions of the term “channel” as given in other standards (such as series EN 50083) are not applicable in series EN 50173.

3.1.27
coaxial cable
cable the transmission line of which is in the form of two coaxial conductors (unbalanced cable)

3.1.28
connection
mated device or combination of devices including terminations used to connect cables or cable elements to other cables, cable elements or application specific equipment

3.1.29
commands, controls and communications in buildings
group of applications such as appliance control and building control

3.1.30
cord
cable unit or element with a minimum of one termination

3.1.31
cross-connect
method of connecting a cabling subsystem to equipment (or another cabling subsystem) by the use of a patch cord or jumper

3.1.32
distributor
term used for the functions of a collection of components (for example, patch panels, patch cords) used to connect cables

3.1.33
equipment cord
cord connecting equipment to a distributor

3.1.34
equipment interface
point at which application-specific equipment can be connected to the generic cabling or network access cabling

3.1.35
equipment room
room dedicated for housing distributors and application-specific equipment

3.1.36
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

[195-01-10 of IEC 60050-195:1998]

3.1.37
external network interface
termination point providing external network demarcation

3.1.38
floor distributor
distributor used to make connections between the building backbone cabling subsystem, cabling subsystems specified in other standards in the EN 50173 series and active equipment

NOTE See telecommunications room.

3.1.39
functional performance
level of transmission performance able to support an intended Class of applications

3.1.40
generic cabling
structured telecommunications cabling system, capable of supporting a wide range of applications

NOTE 1 Application-specific hardware is not a part of generic cabling.

NOTE 2 Generic cabling can be installed without prior knowledge of the required applications.

3.1.41
hybrid cable
assembly of two or more different types or Categories of cables or cable units covered by an overall sheath

NOTE It may be covered by an overall screen.

3.1.42
information and communication technologies
group of applications using information and communications (telecommunications) technologies

3.1.43
information technology
telecommunications
branch of technology concerned with the transmission, emission and reception of signs, signals, writing, images and sounds; that is, information of any nature by cable, radio, optical or other electromagnetic systems

NOTE The term telecommunications has no legal meaning when used in this document.

3.1.44
interconnect
method of connecting a cabling subsystem to equipment (or another cabling subsystem) without the use of a patch cord or jumper

3.1.45
jumper
cable, cable unit or cable element without connectors used to make a connection on a cross-connect

3.1.46
keying
mechanical feature of a connector system that guarantees correct orientation of a connection or prevents the connection to a jack or optical fibre adapter of the same type intended for another purpose

3.1.47
link
transmission path between two specified test interfaces of generic cabling

3.1.48
MICE classification
classification system that describes the environment conditions that are local to a channel based upon the following factors: mechanical (M), ingress (I), climatic and chemical (C) and electromagnetic (E)

3.1.49
multi-unit cable
balanced cable containing more than four pairs

3.1.50
network access cable
cable connecting the external network interfaces to a generic cabling distributor

3.1.51
operating temperature
temperature of the cabling, once a steady state has been reached, combining ambient temperature with any increase due to the application being supported

3.1.52
optical fibre cable (or optical cable)
cable comprising one or more optical fibre cable elements

3.1.53
optical fibre duplex adapter
mechanical device designed to align and join two optical fibre duplex connectors

3.1.54
optical fibre duplex connector
mechanical termination device designed to transfer optical power between two pairs of optical fibres

3.1.55
pair
twisted pair or one side circuit (two diametrically facing conductors) in a star quad

3.1.56
patch cord
cord used to establish connections on a patch panel

3.1.57
patch panel
cross-connect designed to accommodate the use of patch cords

NOTE It facilitates administration for moves and changes.

3.1.58
permanent link
transmission path between any two test interfaces within a cabling subsystem link including the connecting hardware at each end

NOTE Premises-specific definitions are found in other standards in the EN 50173 series.

3.1.59
power sum alien (exogenous) far-end crosstalk loss (PSAFEXT)
power sum of the signal isolation between multiple disturbing pairs of one or more channels and a disturbed pair of another channel, measured at the far-end

NOTE This also applies to the calculation using the multiple disturbing pairs within one or more permanent links or components and a disturbed pair within a permanent link or component, used to create another channel.

3.1.60
power sum alien (exogenous) near-end crosstalk loss (PSANEXT)
power sum of the signal isolation between multiple disturbing pairs of one or more channels and a disturbed pair of another channel, measured at the near-end

NOTE This also applies to the calculation using the multiple disturbing pairs within one or more permanent links or components and a disturbed pair within a permanent link or component, used to create another channel.

3.1.61
power sum attenuation to alien (exogenous) crosstalk ratio at the far-end (PSAACR-F)
difference, in dB, between the power sum alien far-end crosstalk loss from multiple disturbing pairs of one or more channels and the insertion loss of a disturbed pair in another channel

NOTE This also applies to the calculation using the multiple disturbing pairs within one or more permanent links or components and the insertion loss of a disturbed pair within a permanent link or component, used to create another channel.

3.1.62
power sum attenuation to alien (exogenous) crosstalk ratio at the near-end (PSAACR-N)
difference, in dB, between the power sum alien near-end crosstalk loss from multiple disturbing pairs of one or more channels and the insertion loss of a disturbed pair in another channel

NOTE This also applies to the calculation using the multiple disturbing pairs within one or more permanent links or components and the insertion loss of a disturbed pair within a permanent link or component, used to create another channel.

3.1.63
power sum attenuation to crosstalk ratio at the far-end (PSACR-F)
difference, in dB, between the power sum far-end crosstalk loss from multiple disturbing pairs of a channel and the insertion loss of a disturbed pair in the same channel

NOTE This also applies to the calculation using the multiple disturbing pairs within one or more permanent links or components, used to create a channel, and the insertion loss of a disturbed pair within a permanent link or component, of the same channel.

3.1.64
power sum attenuation to crosstalk ratio at the near-end (PSACR-N)
difference, in dB, between the power sum near-end crosstalk loss from multiple disturbing pairs of a channel and the insertion loss of a disturbed pair in the same channel

NOTE This also applies to the calculation using the multiple disturbing pairs within one or more permanent links or components, used to create a channel, and the insertion loss of a disturbed pair within a permanent link or component, of the same channel.

3.1.65
requirement met by design
requirement that does not require testing and where conformance may be achieved either by selection of appropriate components and their installation techniques or by conformance of a related parameter

3.1.66
screened cable
assembly of two or more balanced twisted pair cable elements or one or more quad cable elements where each element is individually screened and/or the elements are contained within an overall screen

3.1.67
screened cabling
system of telecommunications cables, cords and connecting hardware each of which contains screens and within which the screens are interconnected

3.1.68
small form factor connector
optical fibre connector designed to accommodate two or more optical fibres with at least the same mounting density as balanced cabling interfaces in accordance with EN 60603-7 series

3.1.69
splice
joining of conductors or fibres, generally from separate cables

3.1.70
star quad
cable element which comprises four insulated conductors twisted together

NOTE 1 Two diametrically facing conductors form a transmission pair.

NOTE 2 Cables containing star quads can be used interchangeably with cables consisting of pairs, provided the electrical characteristics meet the same specifications.

NOTE 3 Often, the term quad is used instead of star quad.

3.1.71
telecommunications room
enclosed space for housing telecommunications equipment, cable terminations, and cross-connect cabling

3.1.72
test interface
point at which test equipment can be connected to the generic cabling

3.1.73
twisted pair
cable element that consists of two insulated conductors twisted together in a determined fashion to form a balanced transmission line

3.1.74
unscreened cable
balanced cable without any screens

3.2 Abbreviations

For the purposes of this document and the other standards in the EN 50173 series, the following abbreviations apply.

AACR-F	Attenuation to alien (exogenous) crosstalk ratio at the far-end
AC	Alternating current
ACR-N	Attenuation to crosstalk ratio at the near-end
ACR-F	Attenuation to crosstalk ratio at the far-end

AFEXT	Alien (exogenous) far-end crosstalk loss
ANEXT	Alien (exogenous) near-end crosstalk loss
APC	Angled physical contact
ATM	Asynchronous transfer mode
α	Insertion loss
α_{avg}	Average insertion loss
BCT	Broadcast and Communications Technologies
BD	Building distributor
c	Velocity of propagation in free space
C	Connection
CCCB	Controls, Commands and Communications in Buildings
CD	Campus distributor
CSMA/CD	Carrier sense multiple access with collision detection
DAB	Digital Audio Broadcast
DVB	Digital Video Broadcast
DVB-C	Digital Video Broadcast, cabled
DVB-S	Digital Video Broadcast, satellite
DVB-T	Digital Video Broadcast, terrestrial
d.c., DC	Direct current
EI	Equipment interface
ELTCTL	Equal level transverse conversion transfer loss
EMC	Electromagnetic compatibility
EQP	Transmission equipment
FC	Fibre Channel
FD	Floor distributor
FDDI	Fibre distributed data interface
FEXT	Far-end crosstalk loss
ffs	For further study
FOIRL	Fibre optic inter-repeater link
HF	High frequency
ICT	Information and Communication Technologies
IDC	Insulation displacement connection
IPC	Insulation piercing connection
ISDN	Integrated services digital network
LAN	Local area network
MICE	Mechanical, Ingress, Climatic and chemical, Environmental
N/A	Not applicable
NEXT	Near-end crosstalk loss
PBX	Private branch exchange
PC	Physical contact
PMD	Physical Layer Medium Dependent
PP	Patch panel
PSACR-N	Power sum attenuation to crosstalk ratio at the near-end

PSAACR-F	Power sum attenuation to alien (exogenous) crosstalk ratio at the far-end
PSAACR-F_{avg}	Average power sum attenuation to alien (exogenous) crosstalk ratio at the far-end
PSACR-F	Power sum attenuation to crosstalk ratio at the far-end
PSAFEXT	Power sum alien (exogenous) far-end crosstalk loss
$PSAFEXT_{norm}$	Normalised power sum alien (exogenous) far-end crosstalk loss
PSANEXT	Power sum alien (exogenous) near-end crosstalk loss
$PSANEXT_{avg}$	Average power sum alien (exogenous) near-end crosstalk loss
PSFEXT	Power sum far-end crosstalk loss
PSNEXT	Power sum near-end crosstalk loss
SC	Subscriber connector
TCL	Transverse conversion loss
TI	Test interface
TP	Twisted pair
TV	Television
UHF	Ultra high frequency
VHF	Very high frequency

4 Structure of generic cabling

4.1 General

This clause identifies the backbone functional elements of generic cabling, independent of the type of premises within which the cabling is installed, describes how they are connected together to form backbone cabling subsystems and identifies the interfaces at which application-specific components are connected by the generic cabling. Channels, created by connecting application-specific cabling components to the generic cabling, are used to support applications. Applications listed in Annex F are supported by connecting active equipment at the telecommunications outlets and the distributors.

Each type of premises contains additional functional elements.

4.2 Backbone functional elements

The backbone functional elements of generic cabling to support ICT applications are as follows:

a) campus distributor (CD);
b) campus backbone cable;
c) building distributor (BD);
d) building backbone cable;
e) floor distributor (FD).

Groups of these functional elements are connected together to form backbone cabling subsystems (see 4.3).

4.3 General structure and hierarchy of backbone cabling subsystems

Generic cabling systems contain up to two types of backbone cabling subsystems: campus backbone and building backbone. The cabling subsystems are connected together to create a generic cabling system with a structure as shown in Figure 2. The composition of the subsystems is described in 4.4.1 and 4.4.2. The functional elements of the cabling subsystems are interconnected to form a basic hierarchical topology as shown in Figure 3. Where the functions of distributors are combined the cabling subsystems linking them are not required.

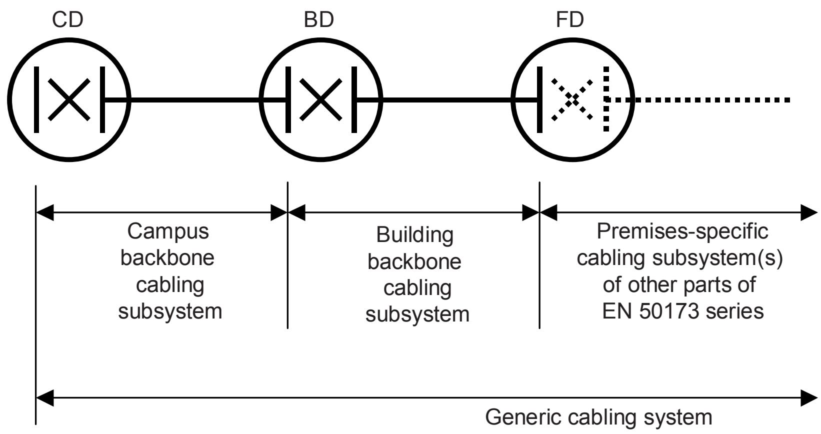
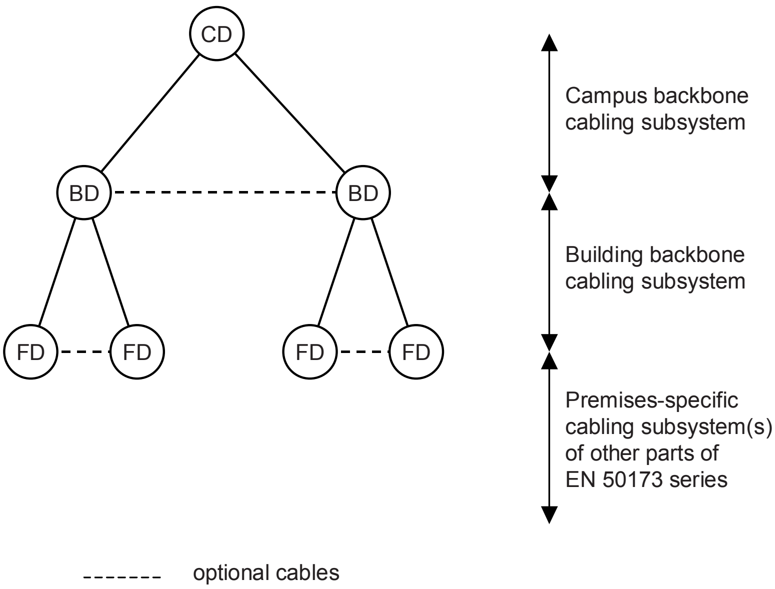


Figure 2 – Structure of generic cabling



NOTE Data centre cabling in accordance with EN 50173-5 may be connected to any of the distributors.

Figure 3 – Hierarchical structure of generic cabling

Connections between cabling subsystems are either active, requiring application-specific equipment, or passive. Connection to application-specific equipment adopts either an interconnect or a cross-connect approach (see Figure 4). Passive connections between cabling subsystems adopt either a cross-connect approach, by way of either patch cords or jumpers, or an interconnect approach.

4.4 Cabling subsystems

4.4.1 Campus backbone cabling subsystem

The campus backbone cabling subsystem extends from the campus distributor to the building distributor(s) connected to it usually located in separate buildings. When present, the subsystem includes:

a) the campus backbone cables including any cabling components within the building entrance facilities;

b) the mechanical termination of the campus backbone cables at both the campus and building distributors together with associated patch cords and/or jumpers at the CD.

Although equipment cords are used to connect the transmission equipment to the cabling subsystem, they are not considered part of the cabling subsystem because they are application-specific.

The campus backbone cabling may provide direct connection between building distributors. When provided this cabling shall be in addition to that required for the basic hierarchical topology.

4.4.2 Building backbone cabling subsystem

The building backbone cabling subsystem extends from building distributor to the floor distributors connected to it. When present, the subsystem includes:

a) the building backbone cables;
b) the mechanical termination of the building backbone cables at both the building and floor distributors together with associated patch cords and/or jumpers at the BD.

Although equipment cords are used to connect the transmission equipment to the cabling subsystem, they are not considered part of the cabling subsystem because they are application-specific.

The building backbone cabling may provide direct connection between floor distributors. When provided this cabling shall be for redundancy and in addition to those required for the basic hierarchical topology.

4.4.3 Design objectives

It is generally not possible or economically viable to install backbone cabling for the entire life of the generic cabling system. Instead, the design may be based on current or foreseeable application requirements. Such short-term selection criteria are often appropriate for building backbone cabling where there is good physical access to pathways for future changes.

The selection of campus backbone cabling may require a longer term approach than that adopted for the building backbone, particularly if access to pathways is more limited.

4.5 Accommodation of functional elements

4.5.1 Distributors in the EN 50173 series of standards

The requirements for the accommodation of distributors are specified in EN 50174-2.

4.5.2 Campus, building and floor distributors

Campus, building and floor distributors are typically located in equipment rooms or telecommunications rooms.

A telecommunications room should provide all the facilities (space, power, environmental control etc.) for passive components, active devices, and external network interfaces housed within it. Each telecommunications room should have direct access to the backbone.

An equipment room is an area within a building where telecommunications equipment is housed and may or may not contain distributors. Equipment rooms are treated differently from telecommunications rooms because of the nature or complexity of the equipment (e.g. PBXs or extensive computer installations). More than one distributor may be located in an equipment room. If a telecommunications space houses more than one distributor it should be considered an equipment room.

4.5.3 Cables

Backbone cables are routed using pathways. A variety of cable management systems can be used to support the cables within the pathways including ducts, conduits and tray. Requirements for the pathways and the cable management systems within them are provided in the EN 50174 series of standards.

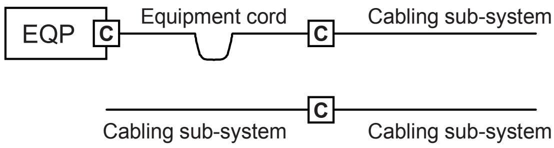
4.6 Equipment Interfaces and test interfaces for backbone cabling

Equipment interfaces to generic cabling are located at the ends of each backbone cabling subsystem.

Campus, building and floor distributors may have an equipment interface to an external service at any port, and may use either interconnects or cross-connects (see Figure 4). Figure 5 shows the potential equipment interfaces to the backbone cabling subsystems.

Test interfaces to generic cabling are located at the ends of each backbone cabling subsystem. Figure 5 shows the potential test interfaces to the backbone cabling subsystems.

a) interconnect model



b) crossconnect model

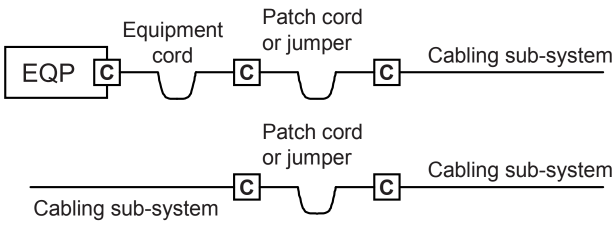


Figure 4 – Interconnect and cross-connect models

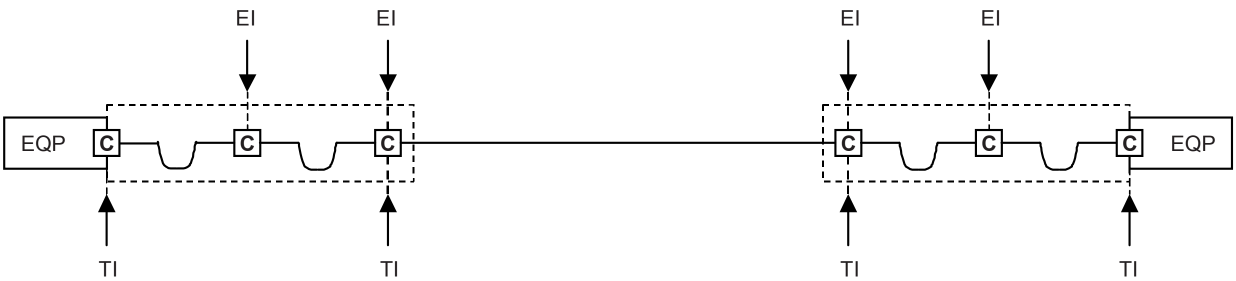


Figure 5 – Test and equipment interfaces for backbone cabling

4.7 Dimensioning and configuring

4.7.1 External network interface

Connections to external networks for the provision of services (e.g. public telecommunications) are made at external network interfaces. The location of external network interfaces, if present, and the facilities which shall be provided may be regulated by national, regional, and local regulations. If the external network interface is not connected directly to a generic cabling interface the performance of the network access cabling should be taken into account and should be considered as part of the initial design and implementation of customer applications. The type of cross-connect and the network access cable may be governed by national regulations, in which case they shall be taken account of in the design of the generic cabling.

4.7.2 Building entrance facilities

Building entrance facilities are required whenever campus backbone, public and private network cables (including antennae) enter buildings and a transition is made to internal cables. It comprises an entrance point at a building wall and the pathway leading to the campus or building distributor. Local regulations may require special facilities where the external cables are terminated. At this termination point, a change from external to internal cable can take place.

5 Channel performance

5.1 Environmental performance

5.1.1 General

The environmental performance specifications of channels are classified to cover the different conditions under which channels are required to operate in the types of premises defined in the other standards of the EN 50173 series.

The local conditions, to which the cabling components within the channel are exposed, shall be used to determine the applicable environmental classification(s) of this clause. With regard to temperature the local environment is considered to be the operating temperature of the cabling.

The environmental classifications described in this clause shall be used for the selection of:

a) components and/or protection afforded to them;
b) installation techniques to be applied to the channel in order to provide protection against extreme environments.

It is possible for the different locations within a channel to be subject to different environmental conditions. The local environment along the channel shall be classified accordingly. For each M, I, C, or E group, the classification of a given environment shall be determined by the most demanding parameter within the M, I, C or E group. However, the selection of components shall be based on the specific demands of each of the parameters within the M, I, C, or E group, which may be less demanding than the overall classification of the group.

5.1.2 Environmental classifications

Table 2 lists the environmental classifications for channels. The details of the environmental classifications are set out in Table 3.

Generally, it is possible to classify a channel environment by using any combination of the MICE designations, e.g. $M_2I_1C_3E_1$. However, certain environments (e.g. nuclear, chemical, fire, explosive, damage risk from animals, salt mist) demand additional requirements beyond those of this clause. Further details on specific environments are shown in Annex G.

Table 2 – Channel environments

Parameter	Environmental class		
	1	**2**	**3**
Mechanical rating	M_1	M_2	M_3
Ingress rating	I_1	I_2	I_3
Climatic and chemical rating	C_1	C_2	C_3
Electromagnetic rating	E_1	E_2	E_3

The requirements of a given classification cover the requirements of a lower classification, i.e. channels designed to operate under environmental conditions defined by M_2 shall continue to operate under environmental conditions defined by M_1.

The parameters of the environmental classifications are defined in Table 3.

Table 3 – Details of Environmental Classification

Mechanical	**M_1**	**M_2**	**M_3**
Shock/bump [a]			
Peak acceleration	40 m/s^2	100 m/s^2	250 m/s^2
Vibration			
Displacement amplitude (2 Hz to 9 Hz)	1,5 mm	7,0 mm	15,0 mm
Acceleration amplitude (9 Hz to 500 Hz)	5 m/s^2	20 m/s^2	50 m/s^2
Tensile force	See Note 1	See Note 1	See Note 1
Crush	45 N over 25 mm (linear) min.	1 100 N over 150 mm (linear) min.	2 200 N over 150 mm (linear) min.
Impact	1 J	10 J	30 J
Bending, flexing and torsion	See Note 1	See Note 1	See Note 1
Ingress	**I_1**	**I_2**	**I_3**
Particulate ingress (max. diameter)	12,5 mm	0,05 mm	0,05 mm
Immersion	None	Intermittent liquid jet ≤ 12,5 l/min ≥ 6,3 mm jet > 2,5 m distance	Intermittent liquid jet ≤ 12,5 l/min ≥ 6,3 mm jet > 2,5 m distance and immersion (≤1 m for ≤ 30 min)
Climatic and chemical	**C_1**	**C_2**	**C_3**
Ambient temperature	- 10 °C to + 60 °C	- 25 °C to + 70 °C	- 40 °C to + 70 °C
Rate of change of temperature	0,1 °C/min	1,0 °C/min	3,0 °C/min
Humidity	5 % to 85 % (non-condensing)	5 % to 95 % (condensing)	5 % to 95 % (condensing)
Solar radiation	700 W/m^2	1 120 W/m^2	1 120 W/m^2
Liquid pollution Contaminants	Concentration x 10^{-6}	Concentration x 10^{-6}	Concentration x 10^{-6}
Sodium chloride (salt/sea water)	0	< 0,3	< 0,3
Oil (dry-air concentration)	0	< 0,005	< 0,5
Sodium stearate (soap)	None	> 5 × 10^4 aqueous non-gelling	> 5 × 10^4 aqueous gelling
Detergent	None	ffs	ffs
Conductive materials in solution	None	Temporary	Present
Gaseous pollution Contaminants	Mean/Peak (Concentration × 10^{-6})	Mean/Peak (Concentration × 10^{-6})	Mean/Peak (Concentration × 10^{-6})
Hydrogen sulphide	< 0,003 / < 0,01	< 0,05 / < 0,5	< 10 / < 50
Sulphur dioxide	< 0,01 / < 0,03	< 0,1 / < 0,3	< 5 / < 15
Sulphur trioxide (ffs)	< 0,01 / < 0,03	< 0,1 / < 0,3	< 5 / < 15
Chlorine wet (>50% humidity)	< 0,000 5 / < 0,001	< 0,005 / < 0,03	< 0,05 / < 0,3
Chlorine dry (<50% humidity)	< 0,002 / < 0,01	< 0,02 / < 0,1	< 0,2 / < 1,0
Hydrogen chloride	- / < 0,06	< 0,06 / < 0,3	< 0,6 / 3,0
Hydrogen fluoride	< 0,001 / < 0,005	< 0,01 / < 0,05	< 0,1 / < 1,0
Ammonia	< 1 / < 5	< 10 / < 50	< 50 / < 250
Oxides of Nitrogen	< 0,05 / < 0,1	< 0,5 / < 1	< 5 / < 10
Ozone	< 0,002 / < 0,005	< 0,025 / < 0,05	< 0,1 / < 1

Table 3 – Details of Environmental Classification *(continued)*

Electromagnetic	**E_1**	**E_2**	**E_3**
Electrostatic discharge – Contact (0,667 μC)	4 kV	4 kV	4 kV
Electrostatic discharge – Air (0,132 μC)	8 kV	8 kV	8 kV
Radiated radio frequency, amplitude modulated (RF – AM)	3 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz	3 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz	10 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz
Conducted radio frequency (RF)	3 V at 150 kHz to 80 MHz	3 V at 150 kHz to 80 MHz	10 V at 150 kHz to 80 MHz
Electrical fast transient/Burst (EFT/B) AC mains power including the protective earth	1 000 V	1 000 V	2 000 V
Electrical fast transient/Burst (EFT/B) I/O (signal/data/control)	500 V	500 V	1 000 V
Surge (transient ground potential difference) - signal, line to earth	500 V	1 000 V	1 000 V
Magnetic Field (50/60 Hz)	1 A/m	3 A/m	30 A/m
Magnetic Field (60 Hz to 20 000 Hz)	ffs	ffs	ffs
[a] The repetitive nature of the shock experienced by the channel shall be taken into account.			
NOTE 1 This aspect of environmental classification is installation-specific and should be considered in association with EN 50174-2 and the appropriate component specification.			

5.2 Transmission performance

5.2.1 General

The required transmission performance Class of this clause shall be met for all environmental classifications specified for the channel.

5.2.2 Balanced cabling channel performance

5.2.2.1 General

This standard specifies the following classes for balanced cabling:

a) Class A: specified up to 0,1 MHz;

b) Class B: specified up to 1 MHz;

c) Class C: specified up to 16 MHz;

d) Class D: specified up to 100 MHz;

e) Class E: specified up to 250 MHz;

f) Class E_A: specified up to 500 MHz;

g) Class F: specified up to 600 MHz;

h) Class F_A: specified up to 1 000 MHz.

A Class A channel is specified so that it will provide the minimum transmission performance to support Class A applications. Similarly, Class B, C, D, E, E_A, F and F_A channels provide the transmission performance to support Class B, C, D, E, E_A, F and F_A applications respectively. Channels of a given class will support all applications of a lower class. Class A is regarded as the lowest class.

This standard specifies the following additional Classes for balanced cabling in support of specific types of transmission system described in other standards in the EN 50173 series:

i) Class CCCB: specified up to 0,1 MHz;

j) Class BCT-B specified up to 1 000 MHz.

The channels specified in 5.2.2 are not guaranteed to support the simultaneous transmission of different applications, of the same or different application Classes of Annex F, within a cable or at an interface to the generic cabling. The sharing of components by applications (to, for example, maximise the capacity of cable management systems) may require additional performance requirements to be applied. These requirements are not included in this standard.

The insertion loss performance of BCT-B cabling is further subdivided into three sub-Classes, L, M and H. These sub-Classes have identical performance requirements for all other transmission parameters.

The parameters specified in this subclause apply to channels with screened or unscreened cable elements, with or without an overall screen, unless explicitly stated otherwise.

The nominal impedance of channels is 100 Ω. This is achieved by suitable design, and appropriate choice of cabling components (irrespective of their nominal impedance).

5.2.2.2 Return loss

The variation of the input impedance of a channel is characterised by the return loss. The return loss parameter is applicable to Classes C, D, E, E_A, F, F_A and BCT-B only. The return loss for each pair of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 4. The limits shown in Table 5 are derived from the formulae at key frequencies only.

When required, the return loss shall be measured according to EN 50346. Terminations of 100 Ω shall be connected to the cabling elements under test at the remote end of the channel. The return loss requirements shall be met at both ends of the cabling.

Table 4 – Formulae for return loss limits for a channel

Class	**Frequency** MHz	**Minimum return loss** dB
C	$1 \leq f \leq 16$	15,0
D	$1 \leq f < 20$	17,0
	$20 \leq f \leq 100$	$30 - 10 \times \lg f$
E	$1 \leq f < 10$	19,0
	$10 \leq f < 40$	$24 - 5 \times \lg f$
	$40 \leq f \leq 250$	$32 - 10 \times \lg f$
E_A	$1 \leq f < 10$	19,0
	$10 \leq f < 40$	$24 - 5 \times \lg f$
	$40 \leq f < 398,1$	$32 - 10 \times \lg f$
	$398,1 \leq f \leq 500$	6,0
F	$1 \leq f < 10$	19,0
	$10 \leq f < 40$	$24 - 5 \times \lg f$
	$40 \leq f < 251,2$	$32 - 10 \times \lg f$
	$251,2 \leq f \leq 600$	8,0
F_A	$1 \leq f < 10$	19,0
	$10 \leq f < 40$	$24 - 5 \times \lg f$
	$40 \leq f < 251,2$	$32 - 10 \times \lg f$
	$251,2 \leq f < 631$	8,0
	$631 \leq f \leq 1\,000$	$36 - 10 \times \lg f$
BCT-B	$4 \leq f < 10$	19,0
	$10 \leq f < 100$	$24 - 5 \times \lg f$
	$100 \leq f < 251,2$	$29 - 7,5 \times \lg f$
	$251,2 \leq f < 600$	$17,2 - 2,6 \times \lg f$
	$600 \leq f \leq 1\,000$	$35 - 9 \times \lg f$

Table 5 – Return loss limits for a channel at key frequencies

Frequency MHz	Minimum return loss dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class C	N/A	15,0	15,0	N/A	N/A	N/A	N/A	N/A
Class D	N/A	17,0	17,0	10,0	N/A	N/A	N/A	N/A
Class E	N/A	19,0	18,0	12,0	8,0	N/A	N/A	N/A
Class E_A	N/A	19,0	18,0	12,0	8,0	6,0	N/A	N/A
Class F	N/A	19,0	18,0	12,0	8,0	8,0	8,0	N/A
Class F_A	N/A	19,0	18,0	12,0	8,0	8,0	8,0	6,0
Class BCT-B	N/A	19,0	18,0	14,0	11,0	10,2	10,0	8,0

Values of return loss at frequencies for which the measured channel insertion loss is below 3,0 dB are for information only.

5.2.2.3 Insertion loss

The insertion loss α for each pair of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 6. The limits shown in Table 7 are derived from the formulae at key frequencies only.

When required, the insertion loss of the channel shall be measured according to EN 50346.

Table 6 – Formulae for insertion loss limits for a channel

Class	Frequency MHz	Maximum insertion loss dB
A	$f = 0,1$	16,0
B	$f = 0,1$	5,5
	$f = 1$	5,8
C	$1 \leq f \leq 16$	$1,05 \times \left(3,23 \times \sqrt{f}\right) + 4 \times 0,2$
D	$1 \leq f \leq 100$	$1,05 \times \left(1,910\,8 \times \sqrt{f} + 0,022\,2 \times f + 0,2/\sqrt{f}\right) + 4 \times 0,04 \times \sqrt{f}$, 4,0 min.
E	$1 \leq f \leq 250$	$1,05 \times \left(1,82 \times \sqrt{f} + 0,016\,9 \times f + 0,25/\sqrt{f}\right) + 4 \times 0,02 \times \sqrt{f}$, 4,0 min.
E_A	$1 \leq f \leq 500$	$1,05 \times \left(1,82 \times \sqrt{f} + 0,009\,1 \times f + 0,25/\sqrt{f}\right) + 4 \times 0,02 \times \sqrt{f}$, 4,0 min.
F	$1 \leq f \leq 600$	$1,05 \times \left(1,8 \times \sqrt{f} + 0,01 \times f + 0,2/\sqrt{f}\right) + 4 \times 0,02 \times \sqrt{f}$, 4,0 min.
F_A	$1 \leq f \leq 1\,000$	$1,05 \times \left(1,8 \times \sqrt{f} + 0,005 \times f + 0,25/\sqrt{f}\right) + 4 \times 0,02 \times \sqrt{f}$, 4,0 min.
CCCB	$f = 0,1$	4,0
BCT-B-L	$1 \leq f \leq 1\,000$	$0,132 \times \left(1,645 \times \sqrt{f} + 0,01 \times f + 0,25/\sqrt{f}\right) + 2 \times 0,02 \times \sqrt{f}$, 2,0 min.
BCT-B-M	$1 \leq f \leq 1\,000$	$0,264 \times \left(1,645 \times \sqrt{f} + 0,01 \times f + 0,25/\sqrt{f}\right) + 2 \times 0,02 \times \sqrt{f}$, 2,0 min.
BCT-B-H	$1 \leq f \leq 1\,000$	$0,514 \times \left(1,645 \times \sqrt{f} + 0,01 \times f + 0,25/\sqrt{f}\right) + 2 \times 0,02 \times \sqrt{f}$, 2,0 min.
NOTE The slope (difference in attenuation) between 47 MHz and 862 MHz is critical for BCT- B applications. See F.1 for additional information regarding supported applications.		

Table 7 – Insertion loss limits for a channel at key frequencies

Frequency MHz	Maximum insertion loss dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class A	16,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class B	5,5	5,8	N/A	N/A	N/A	N/A	N/A	N/A
Class C	N/A	4,2	14,4	N/A	N/A	N/A	N/A	N/A
Class D	N/A	4,0	9,1	24,0	N/A	N/A	N/A	N/A
Class E	N/A	4,0	8,3	21,7	35,9	N/A	N/A	N/A
Class E_A	N/A	4,0	8,2	20,9	33,9	49,3	N/A	N/A
Class F	N/A	4,0	8,1	20,8	33,8	49,3	54,6	N/A
Class F_A	N/A	4,0	8,0	20,3	32,5	46,7	51,4	67,6
Class CCCB	4,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class BCT-B-L	N/A	2,0	2,0	2,7	4,4	6,4	7,1	9,5
Class BCT-B-M	N/A	2,0	2,0	5,0	8,2	11,9	13,2	17,6
Class BCT-B-H	N/A	2,0	3,7	9,4	15,3	22,4	24,8	33,2

5.2.2.4 Near-end crosstalk loss (NEXT)

5.2.2.4.1 Pair-to-pair NEXT (NEXT)

The pair-to-pair NEXT parameter is applicable to Classes A to F_A. The pair-to-pair NEXT α_{NEXT} for each pair combination of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 8. The limits shown in Table 9 are derived from the formulae at key frequencies only.

When required, the NEXT shall be measured according to EN 50346. The NEXT requirements shall be met at both ends of the cabling.

Table 8 – Formulae for NEXT limits for a channel

Class	Frequency MHz	Minimum NEXT dB
A	$f = 0{,}1$	27,0
B	$0{,}1 \le f \le 1$	$25 - 15 \times \lg f$
C	$1 \le f \le 16$	$39{,}1 - 16{,}4 \times \lg f$
D	$1 \le f \le 100$	$-20 \times \lg\left(10^{\frac{65{,}3 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{83 - 20 \times \lg f}{-20}}\right)$, 65,0 max.
E	$1 \le f \le 250$	$-20 \times \lg\left(10^{\frac{74{,}3 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{94 - 20 \times \lg f}{-20}}\right)$, 65,0 max.
E_A [a, c]	$1 \le f \le 500$	$-20 \times \lg\left(10^{\frac{74{,}3 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{94 - 20 \times \lg f}{-20}}\right)$, 65,0 max.
F	$1 \le f \le 600$	$-20 \times \lg\left(10^{\frac{102{,}4 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{102{,}4 - 15 \times \lg f}{-20}}\right)$, 65,0 max.
F_A [b, c]	$1 \le f \le 1\,000$	$-20 \times \lg\left(10^{\frac{105{,}4 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{116{,}3 - 20 \times \lg f}{-20}}\right)$, 65,0 max.

a Where the channel insertion loss at 450 MHz is less than 12 dB, the requirement is reduced by $1{,}4((f - 450)/50)$ for $f \ge 450$ MHz.

b Where the channel insertion loss at 900 MHz is less than 17 dB, the requirement is reduced by $2{,}8((f - 900)/100)$ for $f \ge 900$ MHz.

c The terms in the formulae are not intended to imply component performance.

Table 9 – NEXT limits for a channel at key frequencies

Frequency MHz	Minimum NEXT dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class A	27,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class B	40,0	25,0	N/A	N/A	N/A	N/A	N/A	N/A
Class C	N/A	39,1	19,4	N/A	N/A	N/A	N/A	N/A
Class D	N/A	63,3	43,6	30,1	N/A	N/A	N/A	N/A
Class E	N/A	65,0	53,2	39,9	33,1	N/A	N/A	N/A
Class E_A	N/A	65,0	53,2	39,9	33,1	27,9	N/A	N/A
Class F	N/A	65,0	65,0	62,9	56,9	52,4	51,2	N/A
Class F_A	N/A	65,0	65,0	65,0	59,1	53,6	52,1	47,9

Values of NEXT at frequencies for which the measured channel insertion loss is below 4,0 dB are for information only.

5.2.2.4.2 Power Sum NEXT (PSNEXT)

The PSNEXT parameter is applicable to Classes D, E, E_A, F and F_A only. The PSNEXT α_{PSNEXT} for each pair of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 10. The limits shown in Table 11 are derived from the formulae at key frequencies only.

The PSNEXT requirements shall be met at both ends of the cabling.

PSNEXT of pair k, $\alpha_{PSNEXT}(k)$, is computed from pair-to-pair NEXT $\alpha_{NEXT}(i,k)$ of the adjacent pairs i, i = 1...n, as follows:

$$\alpha_{PSNEXT}(k) = -10 \times \lg \sum_{i=1, i \neq k}^{n} 10^{-0,1 \times \alpha_{NEXT}(i,k)} \qquad (1)$$

where $\alpha_{NEXT}(i,k)$ is the pair-to-pair NEXT of pair k to adjacent pair i in dB.

Table 10 – Formulae for PSNEXT limits for a channel

Class	**Frequency** MHz	**Minimum PSNEXT** dB
D	$1 \leq f \leq 100$	$-20 \times \lg\left(10^{\frac{62,3 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{80 - 20 \times \lg f}{-20}}\right)$, 62,0 max.
E	$1 \leq f \leq 250$	$-20 \times \lg\left(10^{\frac{72,3 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{90 - 20 \times \lg f}{-20}}\right)$, 62,0 max.
E_A [a, c]	$1 \leq f \leq 500$	$-20 \times \lg\left(10^{\frac{72,3 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{90 - 20 \times \lg f}{-20}}\right)$, 62,0 max.
F	$1 \leq f \leq 600$	$-20 \times \lg\left(10^{\frac{99,4 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{99,4 - 15 \times \lg f}{-20}}\right)$, 62,0 max.
F_A [b, c]	$1 \leq f \leq 1\,000$	$-20 \times \lg\left(10^{\frac{102,4 - 15 \times \lg f}{-20}} + 2 \times 10^{\frac{113,3 - 20 \times \lg f}{-20}}\right)$, 62,0 max.

a Where the channel insertion loss at 450 MHz is less than 12 dB, the requirement is reduced by $1,4((f - 450)/50)$ for $f \geq 450$ MHz.

b Where the channel insertion loss at 900 MHz is less than 17 dB, the requirement is reduced by $2,8((f - 900)/100)$ for $f \geq 900$ MHz.

c The terms in the formulae are not intended to imply component performance.

Table 11 – PSNEXT limits for a channel at key frequencies

Frequency MHz	**Minimum PSNEXT** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	60,3	40,6	27,1	N/A	N/A	N/A	N/A
Class E	N/A	62,0	50,6	37,1	30,2	N/A	N/A	N/A
Class E_A	N/A	62,0	50,6	37,1	30,2	24,8	N/A	N/A
Class F	N/A	62,0	62,0	59,9	53,9	49,4	48,2	N/A
Class F_A	N/A	62,0	62,0	62,0	56,1	50,6	49,1	44,9

Values of PSNEXT at frequencies for which the measured channel insertion loss is below 4,0 dB are for information only.

5.2.2.5 Attenuation to crosstalk ratio at the near-end (ACR-N)

NOTE ACR-N replaces, and is equivalent to, ACR of previous editions of this standard.

5.2.2.5.1 Pair-to-pair ACR-N

ACR-N of pairs i and k, $\alpha_{ACR\text{-}N}(i,k)$, is computed from pair-to-pair NEXT $\alpha_{NEXT}(i,k)$ and insertion loss $\alpha(i)$ of pair i as follows:

$$\alpha_{ACR\text{-}N}(i,k) = \alpha_{NEXT}(i,k) - \alpha(i) \quad (2)$$

where

i is the number of the disturbing pair;

k is the number of the disturbed pair;

$\alpha_{NEXT}(i,k)$ is the pair-to-pair NEXT of pair k to adjacent pair i, in dB. The NEXT shall be measured according to EN 50346 in dB;

$\alpha(i)$ is the insertion loss of pair i, when measured according to EN 50346, in dB.

The ACR-N parameter is applicable to Classes D, E, E_A, F and F_A only. The ACR-N for each pair combination of a channel shall meet the limits computed according to Equation (2), to one decimal place, using the relevant formulae of Table 6 and Table 8. The limits shown in Table 12 are derived with Equation (2) at key frequencies only.

The ACR-N requirements shall be met at both ends of the cabling.

Table 12 – ACR-N limits for a channel at key frequencies

	Minimum ACR-N dB							
Frequency MHz	**0,1**	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	59,3	34,5	6,1	N/A	N/A	N/A	N/A
Class E	N/A	61,0	44,9	18,2	-2,8	N/A	N/A	N/A
Class E_A	N/A	61,0	45,0	19,0	-0,8	-21,4	N/A	N/A
Class F	N/A	61,0	56,9	42,1	23,1	3,1	-3,4	N/A
Class F_A	N/A	61,0	57,0	44,7	23,1	6,9	0,7	-19,6

5.2.2.5.2 Power sum ACR-N (PSACR-N)

PSACR-N of pair k, $\alpha_{PSACR\text{-}N}(k)$, is computed from PSNEXT $\alpha_{PSNEXT}(k)$ and insertion loss $\alpha(k)$ of pair k as follows:

$$\alpha_{PSACR\text{-}N}(k) = \alpha_{PSNEXT}(k) - \alpha(k) \quad (3)$$

where

k is the number of disturbed pair;

$\alpha_{PSNEXT}(k)$ is the PSNEXT of pair k in dB;

$\alpha(k)$ is the insertion loss of pair k in dB when measured according to EN 50346.

The PSACR-N parameter is applicable to Classes D, E, E_A, F and F_A. The PSACR-N for each pair of a channel shall meet the limits computed according to Equation (3), to one decimal place, using the relevant formulae of Table 6 and Table 10. The limits shown in Table 13 are derived with Equation (3) at key frequencies only.

The PSACR-N requirements shall be met at both ends of the cabling.

Table 13 – PSACR-N limits for a channel at key frequencies

Frequency MHz	**Minimum PSACR-N** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	56,3	31,5	3,1	N/A	N/A	N/A	N/A
Class E	N/A	58,0	42,3	15,4	– 5,8	N/A	N/A	N/A
Class E_A	N/A	58,0	42,4	16,2	– 3,7	– 24,5	N/A	N/A
Class F	N/A	58,0	53,9	39,1	20.1	0,1	– 6,4	N/A
Class F_A	N/A	58,0	54,0	41,7	23,7	3,9	– 2,3	– 22,6

5.2.2.6 Attenuation to crosstalk ratio at the far-end (ACR-F)

NOTE ACR-F replaces, and differs from, ELFEXT of previous editions of this standard.

5.2.2.6.1 Pair-to-pair ACR-F

The ACR-F parameter is applicable to Classes D, E, E_A, F and F_A only.

ACR-$F_{i,k}$ of pairs i and k, $\alpha_{ACR\text{-}F}(i,k)$, is computed as follows:

$$\alpha_{ACR\text{-}F}(i,k) = \alpha_{FEXT}(i,k) - \alpha(k) \text{ [dB]} \tag{4}$$

where

i is the number of the disturbing pair;

k is the number of the disturbed pair;

$\alpha_{FEXT}(i,k)$ is the far-end crosstalk loss coupled from disturbing pair i into disturbed pair k. When required, it shall be measured according to EN 50346;

$\alpha(k)$ is the insertion loss of pair k. When required, it shall be measured according to EN 50346.

The ACR-F for each pair combination of a channel shall meet the limits computed, to one decimal place, using the equations of Table 14. The limits shown in Table 15 are derived from the equations at key frequencies.

Table 14 – Formulae for ACR-F limits for a channel

Class	**Frequency** MHz	**Minimum ACR-F** dB
D	$1 \le f \le 100$	$-20\times\lg\left(10^{\frac{63{,}8-20\times\lg f}{-20}}+4\times 10^{\frac{75{,}1-20\times\lg f}{-20}}\right)$
E	$1 \le f \le 250$	$-20\times\lg\left(10^{\frac{67{,}8-20\times\lg f}{-20}}+4\times 10^{\frac{83{,}1-20\times\lg f}{-20}}\right)$
E_A	$1 \le f \le 500$	$-20\times\lg\left(10^{\frac{67{,}8-20\times\lg f}{-20}}+4\times 10^{\frac{83{,}1-20\times\lg f}{-20}}\right)$
F	$1 \le f \le 600$	$-20\times\lg\left(10^{\frac{94-20\times\lg f}{-20}}+4\times 10^{\frac{90-15\times\lg f}{-20}}\right)$, 65,0 max.
F_A	$1 \le f \le 1\,000$	$-20\times\lg\left(10^{\frac{95{,}3-20\times\lg f}{-20}}+4\times 10^{\frac{103{,}9-20\times\lg f}{-20}}\right)$, 65,0 max.
NOTE ACR-F values at frequencies that correspond to measured FEXT values of greater than 70,0 dB are for information only.		

Table 15 – ACR-F limits for a channel at key frequencies

Frequency MHz	**Minimum ACR-F** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	57,4	33,3	17,4	N/A	N/A	N/A	N/A
Class E	N/A	63,3	39,2	23,3	15,3	N/A	N/A	N/A
Class E_A	N/A	63,3	39,2	23,3	15,3	9,3	N/A	N/A
Class F	N/A	65,0	57,5	44,4	37,8	32,6	31,3	N/A
Class F_A	N/A	65,0	63,3	47,4	39,4	33,4	31,8	27,4

5.2.2.6.2 Power sum ACR-F (PSACR-F)

The PSACR-F parameter is applicable to Classes D, E, E_A, F and F_A only.

PSACR-F of pair k, $\alpha_{PSACR\text{-}F}(k)$, is computed as follows:

$$\alpha_{PSACR\text{-}F}(k) = -10\times\lg\left[\sum_{i=1,i\neq k}^{n} 10^{\frac{-\alpha_{FEXT}(i,k)}{10}}\right] - \alpha(k)\ \text{[dB]} \qquad (5)$$

where

- i is the number of the disturbing pair;
- k is the number of the disturbed pair;
- n is the total number of pairs;
- $\alpha_{FEXT}(i,k)$ is the far-end crosstalk loss coupled from disturbing pair i into disturbed pair k. When required, it shall be measured according to EN 50346;
- $\alpha(k)$ is the insertion loss of pair k. When required, it shall be measured according to EN 50346.

The PSACR-F for each pair of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 16. The limits shown in Table 17 are derived from the formulae at key frequencies.

Table 16 – Formulae for PSACR-F limits for a channel

Class	**Frequency** MHz	**Minimum PSACR-F** dB
D	$1 \le f \le 100$	$-20 \times \lg\left(10^{\frac{60{,}8-20\times\lg f}{-20}} + 4\times 10^{\frac{72{,}1-20\times\lg f}{-20}}\right)$
E	$1 \le f \le 250$	$-20 \times \lg\left(10^{\frac{64{,}8-20\times\lg f}{-20}} + 4\times 10^{\frac{80{,}1-20\times\lg f}{-20}}\right)$
E_A	$1 \le f \le 500$	$-20 \times \lg\left(10^{\frac{64{,}8-20\times\lg f}{-20}} + 4\times 10^{\frac{80{,}1-20\times\lg f}{-20}}\right)$
F	$1 \le f \le 600$	$-20 \times \lg\left(10^{\frac{91-20\times\lg f}{-20}} + 4\times 10^{\frac{87-15\times\lg f}{-20}}\right)$, 62,0 max.
F_A	$1 \le f \le 1\,000$	$-20 \times \lg\left(10^{\frac{92{,}3-20\times\lg f}{-20}} + 4\times 10^{\frac{100{,}9-20\times\lg f}{-20}}\right)$ 62,0 max.
NOTE PSACR-F values at frequencies that correspond to measured FEXT values of greater than 70,0 dB are for information only.		

Table 17 – PSACR-F limits for a channel at key frequencies

Frequency MHz	**Minimum PSACR-F** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	54,4	30,3	14,4	N/A	N/A	N/A	N/A
Class E	N/A	60,3	36,2	20,3	12,3	N/A	N/A	N/A
Class E_A	N/A	60,3	36,2	20,3	12,3	6,3	N/A	N/A
Class F	N/A	62,0	54,5	41,4	34,8	29,6	28,3	N/A
Class F_A	N/A	62,0	60,3	44,4	36,4	30,4	28,8	24,4

5.2.2.7 Direct current (d.c.) loop resistance

The d.c. loop resistance for each pair of a channel shall meet the limits given in Table 18. When required, the d.c. loop resistance shall be measured according to EN 50346.

Table 18 – d.c. loop resistance limits for a channel

Class	Maximum d.c. loop resistance Ω
A	560,0
B	170,0
C	40,0
D	25,0
E	25,0
E_A	25,0
F	25,0
F_A	25,0
CCCB	8,0 [a]

[a] Applications that only deliver power over the channel may allow up to 10 Ω.

5.2.2.8 Direct current (d.c.) resistance unbalance

The d.c. resistance unbalance between the two conductors within each pair of a channel shall meet the limits given in Table 19. This shall be achieved by design.

Table 19 – d.c. loop resistance unbalance limits for a channel

Class	Maximum d.c. resistance unbalance [a]
A	3,0 %
B	3,0 %
C	3,0 %
D	3,0 %
E	3,0 %
E_A	3,0 %
F	3,0 %
F_A	3,0 %
CCCB	3,0 % [b]

[a] Subject to a minimum measured value of 200 mΩ.

[b] Where channels are required to provide power feeding this value shall be reduced to 1,5 %.

5.2.2.9 Direct current (d.c.) power feeding

Channels of Classes D, E, E_A, F and F_A shall be as per Table 20.

Table 20 – Minimum current carrying capacity

Minimum current carrying capacity A	**Operating temperature *t*** °C
0,300	$t \leq (T_R\text{-}10)$
0,175	$(T_R\text{-}10) < t \leq T_R$
T_R The lowest specified operating temperature (maximum) of the components comprising the cabling subsystem.	

Channels of Class CCCB shall be designed to support a current of DC 0,7 A (via conductors used in parallel or conductors with appropriate current carrying capacity) for all temperatures at which the cabling is intended to be used and shall provide a minimum power capacity of DC 15 W.

Channels of Class CCCB shall be designed to support a minimum fault current carrying capacity of DC 1 A (DC 3 A where power is fed by conductors used in parallel or conductors with appropriate current carrying capacity).

Relevant application standards and manufacturers‘ instructions shall be consulted with reference to safety aspects of power feeding.

NOTE See ISO/IEC TR 29125 for information on current carrying capacity in respect of applications using remote power supplied over balanced cabling.

Care shall be taken when using multi-unit or bundled cables due to the possible rise of temperature within the cabling components that may degrade channel performance.

5.2.2.10 Dielectric withstand

The channels of Classes D, E, E_A, F, F_A and CCCB shall have a minimum dielectric withstand of DC 1 000 V conductor-to-conductor and DC 1 000 V conductor-to-screen or conductor to earth, if a screen is not present. This requirement shall be met by design.

5.2.2.11 Propagation Delay

The propagation delay parameter is applicable to Classes A to F_A, CCCB and BCT-B. The propagation delay for each pair of a channel shall meet the limits computed, to three decimal places, using the formulae of Table 21. The limits shown in Table 22 are derived from the formulae at key frequencies only.

When required, the propagation delay shall be measured according to EN 50346.

Table 21 – Formulae for propagation delay limits for a channel

Class	**Frequency** MHz	**Maximum propagation delay** µs
A	$f = 0{,}1$	20,000
B	$0{,}1 \leq f \leq 1$	5,000
C	$1 \leq f \leq 16$	$0{,}534 + 0{,}036/\sqrt{f} + 4 \times 0{,}002\,5$
D	$1 \leq f \leq 100$	$0{,}534 + 0{,}036/\sqrt{f} + 4 \times 0{,}002\,5$
E	$1 \leq f \leq 250$	$0{,}534 + 0{,}036/\sqrt{f} + 4 \times 0{,}002\,5$
E_A	$1 \leq f \leq 500$	$0{,}534 + 0{,}036/\sqrt{f} + 4 \times 0{,}002\,5$
F	$1 \leq f \leq 600$	$0{,}534 + 0{,}036/\sqrt{f} + 4 \times 0{,}002\,5$
F_A	$1 \leq f \leq 1\,000$	$0{,}534 + 0{,}036/\sqrt{f} + 4 \times 0{,}002\,5$
CCCB	$f = 0{,}1$	1,000
BCT-B	$1 \leq f \leq 1\,000$	$0{,}534 + 0{,}036/\sqrt{f} + 4 \times 0{,}002\,5$

Table 22 – Propagation delay limits for a channel at key frequencies

Frequency MHz	**Maximum propagation delay** µs							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class A	20,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class B	5,000	5,000	N/A	N/A	N/A	N/A	N/A	N/A
Class C	N/A	0,580	0,553	N/A	N/A	N/A	N/A	N/A
Class D	N/A	0,580	0,553	0,548	N/A	N/A	N/A	N/A
Class E	N/A	0,580	0,553	0,548	0,546	N/A	N/A	N/A
Class E_A	N/A	0,580	0,553	0,548	0,546	0,546	N/A	N/A
Class F	N/A	0,580	0,553	0,548	0,546	0,546	0,545	N/A
Class F_A	N/A	0,580	0,553	0,548	0,546	0,546	0,545	0,545
Class CCCB	1,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class BCT-B	N/A	0,580	0,553	0,548	0,546	0,546	0,545	0,545

5.2.2.12 Delay Skew

The delay skew parameter is applicable to Classes D, E, E_A, F and F_A only. The delay skew between all pairs of a channel shall meet the limits computed, to three decimal places, using the formulae of Table 23.

When required, the delay skew shall be calculated according to EN 50346.

Table 23 – Delay skew limits for a channel

Class	Maximum delay skew µs
D	0,050 [a, c]
E	0,050 [a, c]
E_A	0,050 [a, c]
F	0,030 [b, c]
F_A	0,030 [b, c]

[a] Calculation is based upon 0,045 + 4 × 0,001 25.

[b] Calculation is based upon 0,025 + 4 × 0,001 25.

[c] Delay skew of any given installed cabling channel shall not vary by more than 0,010 µs within this requirement, due to effects such as the daily temperature variation.

5.2.2.13 Transverse conversion loss (TCL)

The TCL parameter is applicable to Classes A to F_A and BCT-B.

The TCL of each pair of a channel constructed of unscreened cabling components that is subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 24. The limits shown in Table 25 are derived from the formulae at key frequencies only.

Table 24 – Formulae for TCL limits for an unscreened cabling channel

Class	**Frequency** MHz	**MICE classification (electromagnetic)**		
		E_1	**E_2**	**E_3**
		Minimum TCL dB		
A	0,1	30	30	30
B	f = 0,1	45	45	45
	f = 1	20	20	20
C	$1 \le f \le 16$	$30 - 5 \times \lg f$	$30 - 5 \times \lg f$	$30 - 5 \times \lg f$
D	$1 \le f < 30$	$53 - 15 \times \lg f$, 40 max.	$63 - 15 \times \lg f$, 40 max.	$73 - 15 \times \lg f$, 40 max.
	$30 \le f \le 100$	$60{,}3 - 20 \times \lg f$	$70{,}3 - 20 \times \lg f$, 40 max.	$80{,}3 - 20 \times \lg f$, 40 max.
E	$1 \le f < 30$	$53 - 15 \times \lg f$, 40 max.	$63 - 15 \times \lg f$, 40 max.	$73 - 15 \times \lg f$, 40 max.
	$30 \le f \le 250$	$60{,}3 - 20 \times \lg f$	$70{,}3 - 20 \times \lg f$, 40 max.	$80{,}3 - 20 \times \lg f$, 40 max.
E_A	$1 \le f < 30$	$53 - 15 \times \lg f$, 40 max.	$63 - 15 \times \lg f$, 40 max.	$73 - 15 \times \lg f$, 40 max.
	$30 \le f \le 500$	$60{,}3 - 20 \times \lg f$	$70{,}3 - 20 \times \lg f$, 40 max.	$80{,}3 - 20 \times \lg f$, 40 max.
F	$1 \le f < 30$	$53 - 15 \times \lg f$, 40 max.	$63 - 15 \times \lg f$, 40 max.	$73 - 15 \times \lg f$, 40 max.
	$30 \le f \le 600$	$60{,}3 - 20 \times \lg f$	$70{,}3 - 20 \times \lg f$, 40 max.	$80{,}3 - 20 \times \lg f$, 40 max.
F_A	$1 \le f < 30$	$53 - 15 \times \lg f$, 40 max.	$63 - 15 \times \lg f$, 40 max.	$73 - 15 \times \lg f$, 40 max.
	$30 \le f \le 1\,000$	$60{,}3 - 20 \times \lg f$	$70{,}3 - 20 \times \lg f$, 40 max.	$80{,}3 - 20 \times \lg f$, 40 max.
BCT-B	$1 \le f < 30$	$53 - 15 \times \lg f$, 40 max.	$63 - 15 \times \lg f$, 40 max.	$73 - 15 \times \lg f$, 40 max.
	$30 \le f \le 1\,000$	$60{,}3 - 20 \times \lg f$	$70{,}3 - 20 \times \lg f$, 40 max.	$80{,}3 - 20 \times \lg f$, 40 max.
NOTE Values above 100 MHz are for information only.				

Table 25 – TCL limits for an unscreened cabling channel at key frequencies

Frequency MHz		Minimum TCL dB							
		0,1	1,0	16,0	100,0	250,0	500,0	600,0	1 000,0
Class A	E_1	30,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	E_2	30,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	E_3	30,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class B	E_1	45,0	20,0	N/A	N/A	N/A	N/A	N/A	N/A
	E_2	45,0	20,0	N/A	N/A	N/A	N/A	N/A	N/A
	E_3	45,0	20,0	N/A	N/A	N/A	N/A	N/A	N/A
Class C	E_1	N/A	30,0	24,0	N/A	N/A	N/A	N/A	N/A
	E_2	N/A	30,0	24,0	N/A	N/A	N/A	N/A	N/A
	E_3	N/A	30,0	24,0	N/A	N/A	N/A	N/A	N/A
Class D	E_1	N/A	40,0	34,9	20,3	N/A	N/A	N/A	N/A
	E_2	N/A	40,0	40,0	30,3	N/A	N/A	N/A	N/A
	E_3	N/A	40,0	40,0	40,0	N/A	N/A	N/A	N/A
Class E	E_1	N/A	40,0	34,9	20,3	12,3	N/A	N/A	N/A
	E_2	N/A	40,0	40,0	30,3	22,3	N/A	N/A	N/A
	E_3	N/A	40,0	40,0	40,0	32,3	N/A	N/A	N/A
Class E_A	E_1	N/A	40,0	34,9	20,3	12,3	6,4	N/A	N/A
	E_2	N/A	40,0	40,0	30,3	22,3	16,4	N/A	N/A
	E_3	N/A	40,0	40,0	40,0	32,3	26,4	N/A	N/A
Class F	E_1	N/A	40,0	34,9	20,3	12,3	6,4	4,7	N/A
	E_2	N/A	40,0	40,0	30,3	22,3	16,4	14,7	N/A
	E_3	N/A	40,0	40,0	40,0	32,3	26,4	24,7	N/A
Class F_A	E_1	N/A	40,0	34,9	20,3	12,3	6,4	4,7	0,3
	E_2	N/A	40,0	40,0	30,3	22,3	16,4	14,7	10,3
	E_3	N/A	40,0	40,0	40,0	32,3	26,4	24,7	20,3
Class BCT-B	E_1	N/A	40,0	34,9	20,3	12,3	6,4	4,7	0,3
	E_2	N/A	40,0	40,0	30,3	22,3	16,4	14,7	10,3
	E_3	N/A	40,0	40,0	40,0	32,3	26,4	24,7	20,3
NOTE Values above 100 MHz are for information only.									

The TCL of each pair of a channel constructed of screened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The TCL requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware.

The measurement procedure of TCL for installed cabling is under development. TCL of a sample installation may be assessed by laboratory measurements of representative samples of channels assembled using the components, connector termination practices and installation practices in question. The laboratory testing of TCL is performed using EN 50289-X.

5.2.2.14 Equal level transverse conversion transfer loss (ELTCTL)

The ELTCTL parameter is applicable to Classes D, E, E_A, F, F_A and BCT-B only.

The ELTCTL of each pair of a channel constructed of unscreened cabling components that is subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 26. The limits shown in Table 27 are derived from the formulae at key frequencies only.

The ELTCTL of each pair of a channel constructed of screened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

Table 26 – Formulae for ELTCTL limits for an unscreened cabling channel

Class	**Frequency** MHz	**MICE classification (electromagnetic)**		
		E_1	**E_2**	**E_3**
		Minimum ELTCTL dB		
D, E and F	$1 \leq f \leq 30$	$30 - 20 \times \lg f$	$40 - 20 \times \lg f$	$50 - 20 \times \lg f$, 40 max.
E_A	$1 \leq f \leq 30$	$30 - 20 \times \lg f$	$40 - 20 \times \lg f$	$50 - 20 \times \lg f$, 40 max.
F_A	$1 \leq f \leq 30$	$30 - 20 \times \lg f$	$40 - 20 \times \lg f$	$50 - 20 \times \lg f$, 40 max.
BCT-B	$1 \leq f \leq 30$	$30 - 20 \times \lg f$	$40 - 20 \times \lg f$	$50 - 20 \times \lg f$, 40 max.

Table 27 – ELTCTL limits for an unscreened cabling channel at key frequencies

Frequency MHz		**Minimum ELTCTL** dB		
		1,0	**16,0**	**30,0**
Class D	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5
Class E	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5
Class E_A	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5
Class F	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5
Class F_A	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5
Class BCT-B	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5

The ELTCTL requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware.

The measurement procedure of ELTCTL for installed cabling is under development. ELTCTL of a sample installation may be assessed by laboratory measurements of representative samples of channels assembled using the components, connector termination practices and installation practices in question. The laboratory testing of ELTCTL is performed using EN 50289-X.

5.2.2.15 Coupling attenuation

The coupling attenuation parameter is applicable to Classes D, E, E_A, F, F_A and BCT-B only.

The coupling attenuation of each pair of a channel constructed of unscreened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The coupling attenuation of each pair of a channel constructed of screened cabling components that is intended to be subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 28. The limits shown in Table 29 are derived from the formulae at key frequencies only.

Table 28 – Formulae for coupling attenuation limits for a screened cabling channel

Class	**Frequency** MHz	**MICE classification (electromagnetic)**		
		E_1	**E_2**	**E_3**
		Minimum coupling attenuation dB		
D	$30 \leq f \leq 100$	40	50	60
E	$30 \leq f \leq 250$	$80 - 20 \times \lg f$, 40 max.	$90 - 20 \times \lg f$, 50 max.	$100 - 20 \times \lg f$, 60 max.
E_A	$30 \leq f \leq 500$	$80 - 20 \times \lg f$, 40 max.	$90 - 20 \times \lg f$, 50 max.	$100 - 20 \times \lg f$, 60 max.
F	$30 \leq f \leq 600$	$80 - 20 \times \lg f$, 40 max.	$90 - 20 \times \lg f$, 50 max.	$100 - 20 \times \lg f$, 60 max.
F_A	$30 \leq f \leq 1\,000$	$80 - 20 \times \lg f$, 40 max.	$90 - 20 \times \lg f$, 50 max.	$100 - 20 \times \lg f$, 60 max.
BCT-B	$30 \leq f \leq 1\,000$	$80 - 20 \times \lg f$, 40 max.	$90 - 20 \times \lg f$, 50 max.	$100 - 20 \times \lg f$, 60 max.

Table 29 – Coupling attenuation limits for a screened cabling channel at key frequencies

Frequency MHz		**Minimum coupling attenuation** dB					
		30,0	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	E_1	40,0	40,0	N/A	N/A	N/A	N/A
	E_2	50,0	50,0	N/A	N/A	N/A	N/A
	E_3	60,0	60,0	N/A	N/A	N/A	N/A
Class E	E_1	40,0	40,0	32,0	N/A	N/A	N/A
	E_2	50,0	50,0	42,0	N/A	N/A	N/A
	E_3	60,0	60,0	52,0	N/A	N/A	N/A
Class E_A	E_1	40,0	40,0	32,0	26,0	N/A	N/A
	E_2	50,0	50,0	42,0	36,0	N/A	N/A
	E_3	60,0	60,0	52,0	46,0	N/A	N/A
Class F	E_1	40,0	40,0	32,0	26,0	24,4	N/A
	E_2	50,0	50,0	42,0	36,0	34,4	N/A
	E_3	60,0	60,0	52,0	46,0	44,4	N/A
Class F_A	E_1	40,0	40,0	32,0	26,0	24,4	20,0
	E_2	50,0	50,0	42,0	36,0	34,4	30,0
	E_3	60,0	60,0	52,0	46,0	44,4	40,0
Class BCT-B	E_1	40,0	40,0	32,0	26,0	24,4	20,0
	E_2	50,0	50,0	42,0	36,0	34,4	30,0
	E_3	60,0	60,0	52,0	46,0	44,4	40,0

The coupling attenuation requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware.

The measurement procedure of coupling attenuation for installed cabling is under development. Coupling attenuation of a sample installation may be assessed by laboratory measurements of representative samples of channels assembled using the components, connector termination practices and installation practices in question. The laboratory testing of coupling attenuation is performed using EN 50289-1-6.

5.2.2.16 Alien NEXT (ANEXT)

5.2.2.16.1 Power sum alien NEXT (PSANEXT)

The PSANEXT parameter is applicable to Classes E_A, F and F_A only.

NOTE For information on PSANEXT performance of Class E systems, see CLC/TR 50173-99-1.

The PSANEXT of pair k, $\alpha_{PSANEXT}(k)$, is computed as follows:

$$\alpha_{PSANEXT}(k) = -10 \times \lg\left[\sum_{l=1}^{N}\sum_{i=1}^{n} 10^{\frac{-\alpha_{ANEXT}(l,i,k)}{10}}\right] \text{ [dB]} \qquad (6)$$

where

k is the number of the disturbed pair in the disturbed channel;

i is the number of the disturbing pair in the disturbing channel l;

l is the number of the disturbing channel;

N is the number of disturbing channels;

n is the number of disturbing pairs in disturbing channel l;

$\alpha_{ANEXT}(l,i,k)$ is the ANEXT between pair i of disturbing channel l and pair k of the disturbed channel.

The PSANEXT of each pair of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 30. The limits shown in Table 31 are derived from the formulae at key frequencies only.

When required, the ANEXT shall be measured according to EN 50346.

The PSANEXT requirements shall be met at both ends of the cabling.

PSANEXT of Class E_A and F channels is met by design if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

PSANEXT of Class F_A channels is met by design if the coupling attenuation is at least 25 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

Table 30 – Formulae for PSANEXT limits for a channel

Class	**Frequency** MHz	**Minimum PSANEXT** dB
E_A	$1 \leq f < 100$	$80 - 10 \times \lg f$, 67 max.
	$100 \leq f \leq 500$ [a]	$90 - 15 \times \lg f$
F	$1 \leq f < 100$	$80 - 10 \times \lg f$, 67 max.
	$100 \leq f \leq 600$ [a]	$90 - 15 \times \lg f$
F_A	$1 \leq f < 100$	$95 - 10 \times \lg f$, 67 max.
	$100 \leq f \leq 1\,000$	$105 - 15 \times \lg f$, 67 max.

[a] If the average insertion loss of all disturbed pairs at 100 MHz, $\alpha_{100MHz,avg}$, is less than 7 dB subtract

$$\text{minimum}\left\{7 \times \frac{f-100}{400} \times \frac{7-\alpha_{100MHz,avg}}{\alpha_{100MHz,avg}}, 6 \times \frac{f-100}{400}\right\}$$

where

f is the frequency in megahertz;

$$\alpha_{100MHz,avg} = \frac{1}{4}\sum_{i=1}^{4}\alpha_{100MHz,i};$$

$\alpha_{100MHz,i}$ is the insertion loss of pair i at 100 MHz.

Table 31 – PSANEXT limits for a channel at key frequencies

Frequency MHz	**Minimum PSANEXT** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class E_A	N/A	67,0	67,0	60,0	54,0	49,5	N/A	N/A
Class F	N/A	67,0	67,0	60,0	54,0	49,5	48,3	N/A
Class F_A	N/A	67,0	67,0	67,0	67,0	64,5	63,3	60,0

5.2.2.16.2 Average power sum alien NEXT (PSANEXT$_{avg}$)

The PSANEXT$_{avg}$ parameter is applicable to Classes E_A and F only. Adequate PSANEXT$_{avg}$ performance for Class F_A channels is achieved by conformance with the PSANEXT requirements of Table 30.

The PSANEXT$_{avg}$ of the pairs of Class E_A and F channels shall meet the limits computed, to one decimal place, using the formulae of Table 32. The limits shown in Table 33 are derived from the formulae at key frequencies only.

The PSANEXT$_{avg}$ of a channel, $\alpha_{PSANEXT,avg}$, is computed as follows:

$$\alpha_{PSANEXT,avg} = \frac{1}{n} \times \lg\left[\sum_{k=1}^{n} \alpha_{PSANEXT}(k)\right] \text{ [dB]} \qquad (7)$$

where

k is the number of the disturbed pair in the disturbed channel;

n is the number of disturbing pairs in disturbing channel;

$\alpha_{PSANEXT(k)}$ is the PSANEXT of pair k of the disturbed channel.

The PSANEXT$_{avg}$ requirements shall be met at both ends of the cabling.

PSANEXT$_{avg}$ of Class E_A and F channels is met by design if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table 28(electromagnetic environmental classification E_1).

Table 32 – Formulae for PSANEXT$_{avg}$ limits for a channel

Class	Frequency MHz	Minimum PSANEXT$_{avg}$ dB
E_A	$1 \le f < 100$	$82,25 - 10 \times \lg f$, 67 max
	$100 \le f \le 500$ [a]	$92,25 - 15 \times \lg f$
F	$1 \le f < 100$	$82,25 - 10 \times \lg f$, 67 max
	$100 \le f \le 600$ [a]	$92,25 - 15 \times \lg f$

[a] If the average insertion loss of all disturbed pairs at 100 MHz, $\alpha_{100MHz,avg}$, is less than 7 dB subtract

$$\text{minimum}\left\{7 \times \frac{f - 100}{400} \times \frac{7 - \alpha_{100MHz,avg}}{\alpha_{100MHz,avg}}, 6 \times \frac{f - 100}{400}\right\}$$

where

f is the frequency in megahertz;

$\alpha_{100MHz,avg} = \frac{1}{4}\sum_{i=1}^{4}\alpha_{100MHz,i}$;

$\alpha_{100MHz,i}$ is the insertion loss of pair i at 100 MHz.

Table 33 – PSANEXT$_{avg}$ limits for a channel at key frequencies

Frequency MHz	Minimum PSANEXT$_{avg}$ dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class E_A	N/A	67,0	67,0	62,3	56,3	51,8	N/A	N/A
Class F	N/A	67,0	67,0	62,3	56,3	51,8	50,6	N/A

5.2.2.17 Alien ACR-F (AACR-F)

5.2.2.17.1 Power sum alien ACR-F (PSAACR-F)

The PSAACR-F parameter is applicable to Classes E_A, F and F_A only. PSANEXT of Class F is considered to be as good as the PSAACR-F of Class E_A.

NOTE For information on PSAACR-F performance of Class E systems, see CLC/TR 50173-99-1.

The PSAACR-F of each pair of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 34. The limits shown in Table 35 are derived from the formulae at key frequencies only.

When required, the PSAACR-F shall be computed according to 5.2.2.17.3.1. The PSAACR-F requirements shall be met at both ends of the cabling.

PSAACR-F of Class E_A and F channels is met by design if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

PSAACR-F of Class F_A channels is met by design if the coupling attenuation is at least 25 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

The PSAACR-F of a channel, $\alpha_{PSAACR\text{-}F}(k)$, is computed as follows:

$$\alpha_{PSAACR\text{-}F}(k) = \alpha_{PSAFEXT}(k) - \alpha(k) \text{ [dB]} \quad (8)$$

where

$\alpha(k)$ is the insertion loss of pair k in the disturbed channel;

$\alpha_{PSAFEXT}(k)$ is the power sum alien far-end crosstalk loss of pair k of the disturbed channel (see 5.2.2.17.3).

Table 34 – Formulae for PSAACR-F limits for a channel

Class	**Frequency** MHz	**Minimum PSAACR-F** dB [a]
E_A	$1 \le f \le 500$	$77 - 20 \times \lg f$, 67 max.
F	$1 \le f \le 600$	$77 - 20 \times \lg f$, 67 max.
F_A	$1 \le f \le 1\,000$	$92 - 20 \times \lg f$, 67 max.
[a] PSAACR-F at frequencies that correspond to calculated PSAFEXT values of greater than 67,0 dB or $102 - 15 \times \lg f$ dB shall be for information only.		

Table 35 – PSAACR-F limits for a channel at key frequencies

Frequency MHz	**Minimum PSAACR-F** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class E_A	N/A	67,0	52,9	37,0	29,0	23,0	N/A	N/A
Class F	N/A	67,0	52,9	37,0	29,0	23,0	21,4	N/A
Class F_A	N/A	67,0	67,0	52,0	44,0	38,0	36,4	32,0

5.2.2.17.2 Average power sum alien ACR-F (PSAACR-F$_{avg}$)

The PSAACR-F$_{avg}$ parameter is applicable to Classes E_A and F only. Adequate PSAACR-F$_{avg}$ performance for Class F_A channels is achieved by conformance with the PSAACR-F requirements of Table 34.

The PSAACR-F$_{avg}$ of the pairs of Class E_A and F channels shall meet the limits computed, to one decimal place, using the formulae of Table 36. The limits shown in Table 37 are derived from the formulae at key frequencies only.

The PSAACR-F$_{avg}$ of a channel, $\alpha_{PSAACR\text{-}F,avg}$, is computed as follows:

$$\alpha_{PSAACR\text{-}F,avg} = \frac{1}{n} \times \lg\left[\sum_{k=1}^{n} \alpha_{PSAACR\text{-}F}(k)\right] \quad (9)$$

where

k is the number of the disturbed pair in the disturbed channel;

n is the number of disturbing pairs in disturbing channel;

$\alpha_{PSAACR\text{-}F}(k)$ is the PSAACR-F of pair k of the disturbed channel in dB.

The PSAACR-F$_{avg}$ requirements shall be met at both ends of the cabling.

PSAACR-F$_{avg}$ of Class E_A and F channels is met by design if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

Table 36 – Formulae for PSAACR-F_{avg} limits for a channel

Class	Frequency MHz	Minimum PSAACR-F_{avg} dB [a]
E_A	$1 \leq f \leq 500$	$81 - 20 \times \lg f$, 67 max.
F	$1 \leq f \leq 600$	$81 - 20 \times \lg f$, 67 max.

[a] PSAACR-F_{avg} at frequencies that correspond to calculated PSAFEXT values of greater than 67,0 dB or $102 - 15 \times \lg f$ dB shall be for information only.

Table 37 – PSAACR-F_{avg} limits for a channel at key frequencies

Frequency MHz	Minimum PSAACR-F_{avg} dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class E_A	N/A	67,0	56,9	41,0	33,0	27,0	N/A	N/A
Class F	N/A	67,0	56,9	41,0	33,0	27,0	25,4	N/A

5.2.2.17.3 PSAACR-F computation

5.2.2.17.3.1 General

PSAACR-F is computed using the alien far-end crosstalk loss (AFEXT) parameter together with the insertion losses of disturbing and disturbed channels.

Two computation methods are detailed in 5.2.2.17.3.2 and 5.2.2.17.3.3.

Method 1 (see 5.2.2.17.3.2) is applicable to:

- Class E_A and F channels (unscreened);
- Class E_A and F channels (screened) that have coupling attenuation less than 10 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

Method 2 (see 5.2.2.17.3.3) is applicable to:

- Class F_A channels (unscreened);
- Class F_A channels (screened) that have coupling attenuation less than 25 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

5.2.2.17.3.2 Method 1

The measured pair-to-pair AFEXT values of a pair k in a disturbed channel from the disturbing channel l are normalized by the difference of the insertion losses of disturbing and disturbed channels.

AFEXT$_{norm}$, $\alpha_{AFEXT,norm}(l,i,k)$, is computed from Equations (10) to (13).

If

$$\alpha(k) - \alpha(l,i) > 0 \qquad (10)$$

then

$$\alpha_{AFEXT,norm}(l,i,k) = \alpha_{AFEXT}(l,i,k) - \alpha(l,i) - \alpha(k) - 10 \times \lg\left(\frac{\alpha(k)}{\alpha(l,i)}\right) \qquad (11)$$

If

$$\alpha(k) - \alpha(l,i) < 0 \quad (12)$$

then

$$\alpha_{AFEXT,norm}(l,i,k) = \alpha_{AFEXT}(l,i,k) \quad (13)$$

where

k	is the number of the disturbed pair in the disturbed channel;
i	is the number of the disturbing pair in the disturbing channel l;
l	is the number of the disturbing channel;
$\alpha_{AFEXT}(l,i,k)$	is the AFEXT between pair i of disturbing channel l and pair k of the disturbed channel in dB;
$\alpha(k)$	is the measured insertion loss of pair k in the disturbed channel in dB;
$\alpha(l,i)$	is the measured insertion loss of pair i in the disturbing channel l in dB.

The PSAFEXT is determined according to Equation (14).

$$\alpha_{PSAFEXT}(k) = -10 \times \lg\left[\sum_{l=1}^{N}\sum_{i=1}^{n} 10^{\frac{-\alpha_{AFEXT,norm}(l,i,k)}{10}}\right] \quad (14)$$

where

k	is the number of the disturbed pair in the disturbed channel;
i	is the number of the disturbing pair in the disturbing channel l;
l	is the number of the disturbing channel;
N	is the number of disturbing channels;
n	is the number of disturbing pairs in disturbing channel l.

5.2.2.17.3.3 Method 2

The PSAFEXT of pair k, $\alpha_{PSAFEXT}(k)$, is computed as follows:

$$\alpha_{PSAFEXT}(k) = -10 \times \lg\left[\sum_{l=1}^{N}\sum_{i=1}^{n} 10^{\frac{-\alpha_{AFEXT}(l,i,k)}{10}}\right] \quad (15)$$

where

k	is the number of the disturbed pair in the disturbed channel;
i	is the number of the disturbing pair in the disturbing channel l;
l	is the number of the disturbing channel;
N	is the number of disturbing channels;
n	is the number of disturbing pairs in disturbing channel l;
$\alpha_{AFEXT}(l,i,k)$	is the AFEXT between pair i of disturbing channel l and pair k of the disturbed channel in dB.

5.2.2.18 Capacitance

Capacitance parameters are applicable to Class CCCB.

The mutual capacitance of a pair within a channel shall be in the range 2,0 nF (ffs) to 20 nF when measured at 1 kHz in accordance with EN 50289-1-5.

The capacitance unbalance between all pairs of a channel shall not exceed 75 pF when measured at 1 kHz in accordance with EN 50289-1-5.

The capacitance unbalance to earth of a channel shall not exceed 450 pF when measured at 1 kHz in accordance with EN 50289-1-5.

5.2.3 Coaxial cabling channel performance

5.2.3.1 General

This standard specifies the following Class for coaxial cabling:

Class BCT-C: specified up to 3 000 MHz.

The insertion loss performance of BCT-C cabling is further subdivided into three sub-Classes, L, M and H. These sub-Classes have identical performance requirements for all other transmission parameters.

The nominal impedance of channels is 75 Ω. This is achieved by suitable design, and appropriate choice of cabling components.

5.2.3.2 Return loss

The variation of the input impedance of a channel is characterized by the return loss. The return loss of a channel shall meet the limits given in Table 38.

When required, the return loss shall be measured according to EN 50289-1-11. The return loss requirements shall be met at both ends of the cabling.

Table 38 – Return loss limits for a Class BCT-C channel

Frequency MHz	**Minimum return loss** dB
$5 \leq f < 470$	18,0
$470 \leq f < 1\ 000$	16,0
$1\ 000 \leq f \leq 3\ 000$	10,0

5.2.3.3 Insertion loss

The insertion loss of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 39. The limits shown in Table 40 are derived from the formulae at key frequencies only.

When required, the insertion loss of the channel shall be measured according to ffs.

Table 39 – Formulae for insertion loss limits for a channel

Class	Frequency MHz	Maximum insertion loss dB
BCT-C-L	$1 \le f < 100$	$(0{,}3+0{,}05)\times\left(0{,}625\times\sqrt{f}+0{,}0001\times f\right)+2\times(0{,}0001\times f)$, 2,0 min
	$100 \le f \le 3\ 000$	$(0{,}3+0{,}05)\times\left(0{,}597\times\sqrt{f}+0{,}0026\times f\right)+2\times(0{,}0001\times f)$
BCT-C-M	$1 \le f < 100$	$(0{,}69+0{,}05)\times\left(0{,}625\times\sqrt{f}+0{,}0001\times f\right)+2\times(0{,}0001\times f)$, 2,0 min
	$100 \le f \le 3\ 000$	$(0{,}69+0{,}05)\times\left(0{,}597\times\sqrt{f}+0{,}0026\times f\right)+2\times(0{,}0001\times f)$
BCT-C-H	$1 \le f < 100$	$(0{,}96+0{,}05)\times\left(0{,}625\times\sqrt{f}+0{,}0001\times f\right)+2\times(0{,}0001\times f)$, 2,0 min
	$100 \le f \le 3\ 000$	$(0{,}96+0{,}05)\times\left(0{,}597\times\sqrt{f}+0{,}0026\times f\right)+2\times(0{,}0001\times f)$
NOTE The slope (difference in attenuation) between 47 MHz and 862 MHz is critical for BCT-B applications. See F.2 for additional information regarding supported applications.		

Table 40 – Insertion loss limits for a channel at key frequencies

	Maximum insertion loss dB							
Frequency MHz	**5,0**	**10,0**	**100,0**	**200,0**	**600,0**	**1 000,0**	**2 400,0**	**3 000,0**
Class BCT-C-L	2,0	2,0	2,2	3,2	5,8	7,7	12,9	14,8
Class BCT-C-M	2,0	2,0	4,7	6,7	12,1	16,1	26,7	30,6
Class BCT-C-H	2,0	2,0	6,3	9,1	16,5	21,9	36,3	41,5

5.2.3.4 Direct current (d.c.) loop resistance

The d.c. loop resistance of a channel shall meet the limits given in Table 41. This shall be achieved by design.

Table 41 – d.c. loop resistance limits for a channel

Class	Maximum d.c. loop resistance Ω
BCT-C	5,0

5.2.3.5 Direct current (d.c.) power feeding

BCT-C channels shall be designed to support a current of DC 0,5 A for all temperatures at which the cabling is intended to be used.

Relevant application standards and manufacturers' instructions shall be consulted with reference to safety aspects of power feeding.

Care shall be taken when using multi-unit or bundled cables due to the possible rise of temperature within the cabling components that may degrade channel performance.

5.2.3.6 Operating voltage

BCT-C channels shall support an operating voltage of DC 72 V for all temperatures at which the cabling is intended to be used. This shall be achieved by design.

5.2.3.7 Screening attenuation

Screening attenuation shall meet the limits given in Table 42 and shall be achieved by the appropriate choice of cables and connections.

Table 42 – Screening attenuation limits for a channel

Frequency MHz	**Minimum screening attenuation** dB	
	EMC Class A	**EMC Class B**
30 ≤ f < 300	85,0	75,0
300 ≤ f < 470	80,0	75,0
470 ≤ f < 1 000	75,0	65,0
1 000 ≤ f ≤ 3 000	55,0	50,0
NOTE EMC Class A and EMC Class B limits are in line with EN 50083-2:2006, Table 10.		

5.2.4 Optical fibre cabling channel performance

5.2.4.1 General

This standard specifies the following Classes of optical fibre cabling:

a) Class OF-25 channels support applications listed in Annex F using plastic optical fibre cable in accordance with 7.7.2 to a minimum of 25 m;

b) Class OF-50 channels support applications listed in Annex F using plastic optical fibre cable in accordance with 7.7.2 to a minimum of 50 m;

c) Class OF-100 channels support applications listed in Annex F to a minimum of 100 m using:

   1) cabled multimode all-silica optical fibre in accordance with 7.7.1.1;

   2) cabled plastic optical fibre in accordance with 7.7.2;

   3) cabled plastic clad silica optical fibre in accordance with 7.7.3;

d) Class OF-200 channels support applications listed in Annex F using plastic optical fibre cable in accordance with 7.7.2 or plastic clad silica optical fibre cables in accordance with 7.7.3 to a minimum of 200 m;

e) Class OF-300 channels support applications listed in Annex F using all-silica optical fibre cables in accordance with 7.7.1 to a minimum of 300 m;

f) Class OF-500 channels support applications listed in Annex F using all-silica optical fibre cables in accordance with 7.7.1 to a minimum of 500 m;

g) Class OF-2000 channels support applications listed in Annex F using all-silica optical fibre cables in accordance with 7.7.1 to a minimum of 2 000 m;

h) Class OF-5000 channels support applications listed in Annex F using all-silica optical fibre cable in accordance with 7.7.1.3 to a minimum of 5 000 m;

i) Class OF-10000 channels support applications listed in Annex F using all-silica optical fibre cable in accordance with 7.7.1.3 to a minimum of 10 000 m.

A given Class of optical fibre cabling channel is specified so that it will support that Class of application when constructed from the appropriate Category of cabled optical fibres as detailed in F.3.

The requirements for the wavelength multiplexing and de-multiplexing components will be found in the application standards. There are no special requirements for generic cabling concerning wavelength multiplexing. All application-specific hardware for wavelength multiplexing is installed internal to, or associated with, transmission and/or terminal equipment, both of which are outside the scope of this standard.

5.2.4.2 Channel attenuation

The attenuation of channels constructed using the relevant cable Categories of 7.7 shall meet the limits given in Table 43.

The attenuation of a channel shall be measured according to EN 50346.

The test methods have been developed for conventional optical fibre connection systems comprising two plugs and an adaptor. In some cases the methods are not appropriate for Small Form Factor connectors that comprise a plug and socket.

The attenuation of channels at a specified wavelength shall not exceed the sum of the specified attenuation values for the components at that wavelength (where the attenuation of a length of optical fibre cable is calculated from its attenuation coefficient multiplied by its length).

Table 43 – Attenuation limits for optical fibre cabling channels

Class	Cabled optical fibre Category	Maximum channel attenuation dB				
		Multimode			Single-mode	
		650 nm	850 nm	1 300 nm	1 310 nm	1 550 nm
OF-25	OP1[a]	7,5	–	–	–	–
OF-50	OP1[a]	12,0	–	–	–	–
OF-100	OP2	13,0	6,3	6,3	–	–
	OH1	–	4,0	–	–	–
	OM1, OM2, OM3, OM4	–	1,85	1,65	–	–
OF-200	OP2	23,0	9.6	9,6	–	–
	OH1	–	5,0	–	–	–
OF-300	OM1, OM2, OM3, OM4, OS1, OS2	–	2,55	1,95	1,80	1,80
OF-500	OM1, OM2, OM3, OM4, OS1, OS2	–	3,25	2,25	2,00	2,00
OF-2000	OM1, OM2, OM3, OM4, OS1, OS2	–	8,50	4,50	3,50	3,50
OF-5000	OS2	–	–	–	4,00	4,00
OF-10000	OS2	–	–	–	6,00	6,00

[a] The modal conditions under which the measurement is made are ffs.

5.2.4.3 Assumptions regarding total connecting hardware attenuation within channels

5.2.4.3.1 OF-25, OF-50, OF-100 and OF-200 channels using cabled optical fibres of Categories OP1, OP2 or OH1

The values in Table 43 are based on a total allocation of 3,0 dB for connections. Additional connectors and splices may be used provided that the channel requirements of the application are met.

5.2.4.3.2 OF-100 channels using cabled optical fibres of Categories OM1, OM2, OM3 or OM4

The values in Table 43 are based on a total allocation of 1,5 dB for connections. Additional connectors and splices may be used provided that the channel requirements of the application are met.

5.2.4.3.3 OF-300, OF-500 and OF-2000

The values in Table 43 are based on a total allocation of 1,5 dB for connections. Additional connectors and splices may be used provided that the channel requirements of the application are met.

5.2.4.3.4 OF-5000 and OF-10000

The values in Table 43 are based on a total allocation of 2,0 dB for connections. Additional connectors and splices may be used provided that the channel requirements of the application are met.

5.2.4.4 Propagation delay

For some applications, knowledge of the delay, and hence the length, of fibre channels is required. Propagation delay can be calculated from cable performance (see 7.7.2).

5.2.4.5 Delay skew

The delay skew parameter is only applicable to Class OF-100 using all-silica optical fibre. The delay skew between all optical fibres comprising a channel shall not exceed 80 ns.

NOTE This requirement is met by design if all the optical fibres providing a channel are contained within a single cable.

6 Reference implementations for backbone cabling

6.1 General

This clause describes implementations of generic backbone cabling that utilise components referenced in Clauses 7, 8 and 9. These reference implementations meet the requirements of Clause 4 and, when installed in accordance with EN 50174 series of standards, meet the channel transmission performance requirements of 5.2 when subjected to the relevant environmental classifications of 5.1.

To ensure the integrity of the environmental performance of the cabling components, compatibility between cabling components shall be assured by design and in accordance with EN 50174-1.

6.2 Balanced cabling

6.2.1 General

Balanced cabling components referenced in Clauses 7, 8 and 9 are defined in terms of Category. In the reference implementations of this clause, the components used in each cabling channel shall have the same nominal characteristic impedance in accordance with 7.3.

The implementations are based on component performance at 20 °C. The effect of temperature on the performance of cables shall be taken into account as shown in Table 43.

6.2.2 Component choice

The selection of balanced cabling components will be determined by the channel lengths required and the Class of applications to be supported. Refer to F.1 for guidance.

6.2.3 Dimensions

Figure 6 shows the model used to correlate cabling dimensions specified in this clause with the channel specifications in Clause 5. The backbone channel shown (either building or campus) contains a cross-connect at both ends. This represents the worst-case configuration for a backbone channel.

NOTE 1 Reference implementations for Class E_A and F_A channels are to be provided in a further amendment of this European Standard.

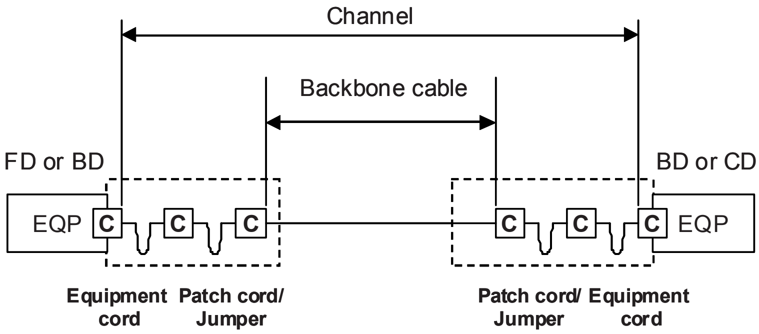


Figure 6 – Backbone cabling model

The channel includes cords comprising patch and equipment cords. For the purposes of this subclause, jumpers used in place of patch cords are treated as cords.

In Table 44 it is assumed that:

a) the flexible cable within these cords has a higher insertion loss specification than that used in the fixed backbone cable;

b) the cables within all these cords in the channel have a common insertion loss specification.

In order to accommodate the higher insertion loss of stranded cables used for cords, the length of the cables used within a channel of a given Class (see Clause 5) shall be determined by the equations shown in Table 44.

When four connections are used in a channel, the physical length of the backbone cable should be at least 15 m.

NOTE 2 Channel and permanent link performance requirements are based on assumptions regarding the minimum length and insertion loss of cords.

The maximum length of the fixed backbone cable will depend on the total length of cords to be supported within a channel. The maximum lengths of cords shall be fixed for distributors and during the operation of the installed cabling, a management system should be implemented to ensure that the cords used to create the channel conform with these design limits.

Table 44 – Backbone channel length equations

Component Category	Implementation equations [a]			
	Class A	**Class B**	**Class C**	**Class D**
5	2 000	B = 250 – $F \times X$	B = 170 – $F \times X$	B = 105 – $F \times X$
6	2 000	B = 260 – $F \times X$	B = 185 – $F \times X$	B = 111 – $F \times X$
6_A	2 000	B = 260 – $F \times X$	B = 189 – $F \times X$	B = 114 – $F \times X$
7	2 000	B = 260 – $F \times X$	B = 190 – $F \times X$	B = 115 – $F \times X$
7_A	2 000	B = 260 – $F \times X$	B = 192 – $F \times X$	B = 117 – $F \times X$
	Class E	**Class E_A**	**Class F**	**Class F_A**
5	–	–	–	–
6	B = 105 – 3[b] – $F \times X$	–	–	–
6_A	B = 108 – 3[b] – $F \times X$	B = 105 – 3[b] – $F \times X$	–	–
7	B = 109 – 3[b] – $F \times X$	B = 107 – 3[b] – $F \times X$	B = 105 – 3[b] – $F \times X$	–
7_A	B = 111 – 3[b] – $F \times X$	B = 110 – 3[b] – $F \times X$	B = 110 – 3[b] – $F \times X$	B = 105 – 3[b] – $F \times X$

B length of the fixed backbone cable (m)

F combined length of patch cords, jumpers and equipment cords (m)

X ratio of flexible cable insertion loss (dB/m) to fixed network access cable insertion loss (dB/m) – see Clause 9

[a] Applications limited by propagation delay or skew may not be supported if channel lengths exceed 100 m.

[b] This length reduction is to provide an allocated margin to accommodate insertion loss deviation.

Where channels contain a different number of connections than in the model shown in Figure 4, the fixed cable length shall be reduced (where more connections exist) or may be increased (where fewer connections exist) by 2 m per connection for Category 5 cabling and 1 m per connection for Category 6, 6_A, 7 and 7_A components. Additionally, the NEXT, Return Loss and ACR-F performance should be verified.

For operating temperatures above 20 °C, B should be reduced by 0,2 % per degree Celsius for screened cables and 0,4 % per degree Celsius (20 °C to 40 °C) and 0,6 % per degree Celsius (> 40 °C to 60 °C) for unscreened cables. Manufacturers'/suppliers' information shall be consulted where the intended operating temperature exceeds 60 °C.

6.3 Coaxial cabling

See EN 50083 series.

6.4 Optical fibre cabling

6.4.1 General

Optical fibre components are referenced in Clauses 7, 8 and 9. The optical fibres are defined in terms of physical construction (core/cladding diameter) and their transmission performance Category within a cable. Within the reference implementations of this clause, the optical fibres used in each cabling channel shall have the same physical construction specification and the cabled optical fibres shall be of the same Category.

When more than one physical construction or cabled optical fibre Category is used in a cabling subsystem the cabling shall be marked to allow each cabling type to be clearly identified.

6.4.2 Component choice

The selection of optical fibre components shall be determined by the channel lengths required and the applications to be supported. Refer to Annex F for guidance.

6.4.3 Dimensions

The model of Figure 4 is applicable to backbone optical fibre cabling. It should be noted that the connection systems used to terminate fixed optical cabling may contain mated connections and splices (permanent or re-useable) and that cross-connects may comprise re-useable splices.

In order to accommodate differing quantities of mated connections and splices of the cables used within a channel of a given Class (see Clause 5), the total length of the channel length shall be determined by the equations shown in Table 45.

Table 45 – Channel length equations for optical fibre cabling

Cabled optical fibre Category	Class	Implementation equations		
		Wavelength		Maximum length m
Multimode		850 nm	1 300 nm	
OM1/OM2/ OM3/OM4	OF-100	$L = 535 - 214 \times x - 90 \times y$	$L = 1\ 100 - 500 \times x - 200 \times y$	100
	OF-300	$L = 735 - 214 \times x - 90 \times y$	$L = 1300 - 500 \times x - 200 \times y$	300
	OF-500	$L = 935 - 214 \times x - 90 \times y$	$L = 1500 - 500 \times x - 200 \times y$	500
	OF-2000	$L = 2435 - 214 \times x - 90 \times y$	$L = 3000 - 500 \times x - 200 \times y$	2 000
Single-mode		1310 nm	1550 nm	
OS1	OF-300	$L = 1800 - 750 \times x - 300 \times y$	$L = 1800 - 750 \times x - 300 \times y$	300
	OF-500	$L = 2000 - 750 \times x - 300 \times y$	$L = 2000 - 750 \times x - 300 \times y$	500
	OF-2000	$L = 3500 - 750 \times x - 300 \times y$	$L = 3500 - 750 \times x - 300 \times y$	2 000
OS2	OF-300	$L = 4500 - 1875 \times x - 750 \times y$	$L = 4500 - 1875 \times x - 750 \times y$	300
	OF-500	$L = 5000 - 1875 \times x - 750 \times y$	$L = 5000 - 1875 \times x - 750 \times y$	500
	OF-2000	$L = 8750 - 1875 \times x - 750 \times y$	$L = 8750 - 1875 \times x - 750 \times y$	2 000
	OF-5000	$L = 10000 - 1875 \times x - 750 \times y$	$L = 10000 - 1875 \times x - 750 \times y$	5 000
	OF-10000	$L = 15000 - 1875 \times x - 750 \times y$	$L = 15000 - 1875 \times x - 750 \times y$	10 000
L = the length of the channel (m) x = total number of mated connections in the channel y = total number of splices in the channel				

Additional connections may be used if the maximum channel insertion loss (or optical power budget, as applicable) of the application allows (see Annex F).

7 Cable requirements

7.1 General

This clause defines the minimum requirements for.

a) cables installed within generic cabling subsystems as specified within the reference implementations specified in the standards in the EN 50173 series;

b) flexible balanced cables to be assembled as cords as specified in Clause 9 and as specified within the reference implementations specified in the standards in the EN 50173 series;

c) balanced cables or cable elements to be used as jumpers.

Balanced cables shall meet the generic specification EN 50288-1 and the sectional specifications as defined in 7.3 and 7.4.

Coaxial cables shall meet the generic specification EN 50117-1 and the additional requirements defined in 7.6.

Optical fibre cables shall meet the generic specification EN 60794-1-1 and the sectional specifications as defined in 7.7.

For the purposes of the reference implementations specified in this, and in other parts of the EN 50173 series of standards, it is assumed that all cable elements within a cable are of the same performance Category.

7.2 Operating environment

For each M, I, C or E group, the classification of a given environment shall be determined by the most demanding parameter within the M, I, C or E group. However, the selection of components shall be based on the specific demands of each of the parameters within the M, I, C or E group, which may be less demanding than the overall classification of the group.

In general, conformance to the limits and test methods specified by this clause, and product specifications referenced in it, for individual transmission parameters cannot be considered to provide assurance of performance when simultaneously subjected to the full range of environmental conditions of a given environmental classification.

It is assumed that if a channel is constructed entirely of components meeting requirements based on a $M_1I_1C_1E_1$ classification according to the reference implementations of Clause 6 then the required channel transmission performance is achieved in a $M_1I_1C_1E_1$ environment based upon a statistical approach of performance modelling.

The maintenance of functional performance under specific combinations of environmental conditions within a given environmental classification of Table 3 should be indicated by the supplier. Agreement shall be reached between customer and supplier that the product maintains functional performance when subjected to specific combinations of environmental conditions.

7.3 Balanced cables of Categories 5, 6, 6_A, 7, 7_A and BCT-B

7.3.1 Basic performance requirements

Both mechanical and electrical requirements of cables meeting the minimum requirements to support the transmission performance classes A to F_A and BCT-B specified in Clause 5 are given in the generic specification EN 50288-1 and the relevant sectional and associated blank detail specifications detailed in Table 46.

Table 46 – Balanced cable standards

Cable category	Applicable standard for solid cables	Applicable standard for flexible cables
5	EN 50288-2-1 EN 50288-3-1	EN 50288-2-2 EN 50288-3-2
6	EN 50288-5-1 EN 50288-6-1	EN 50288-5-2 EN 50288-6-2
6_A	EN 50288-10-1 EN 50288-11-1	EN 50288-10-2 EN 50288-11-2
7	EN 50288-4-1	EN 50288-4-2
7_A	EN 50288-9-1	EN 50288-9-2
BCT-B	IEC 61156-7	IEC 61156-7

NOTE Specifications for Categories 6_A and 7_A meeting the requirements of this clause are in development at the time of publication of this standard.

Detail specifications based upon the blank detail specifications EN 50288-X-Y-Z shall be used to specify cable performance requirements under the environmental classifications of Table 3. Table 47 shows the elements of Table 3 that are not covered by these blank detail specifications and which have to be specified separately.

Table 47 – Environmental performance specifications for balanced cables (in addition to blank detail specifications of Table 46) [a]

Mechanical	M_1	M_2	M_3	Reference
Bending	As required	As required	As required	EN 62012-1
Flexing (flexible cables)	As required	As required	As required	EN 62012-1
Torsion (flexible cables)	As required	As required	As required	EN 62012-1
Climatic and chemical	C_1	C_2	C_3	
Solar radiation	N/A	ffs	ffs	
Oil resistance	As required	As required	As required	EN 62012-1

[a] Cables shall maintain mechanical and electrical performance during exposure to the relevant environmental conditions described in Table 3.

NOTE Although not contained in Table 3 “weld spatter” may also be considered during the development of a detail specification.

7.3.2 Additional performance requirements of Category BCT-B cables

The insertion loss/100 m of BCT-B cables shall meet the requirements of IEC 61156-7 from 1 MHz to 1 000 MHz.

The coupling attenuation of BCT-B cables shall meet the limits given in Table 48.

Table 48 – Coupling attenuation limits for Category BCT-B cables

Frequency MHz	**Minimum coupling attenuation** dB	
	EMC Class A	**EMC Class B**
30 ≤ *f* < 300	85,0	75,0
300 ≤ *f* < 470	80,0	75,0
470 ≤ *f* ≤ 1 000	75,0	75,0
NOTE EMC Class A and EMC Class B limits are in line with EN 50083-2:2006, Table 10.		

7.4 Other balanced cables

Cables of Category CCCB shall meet the electrical and mechanical requirements of Table 49 and Table 50 respectively.

Table 49 – Electrical performance requirements for Category CCCB cable [a, b]

No	**Cable characteristics**		**Cable performance**		**Test method**
	Electrical Characteristics (at all operating temperatures)	**Frequency** kHz	**Power feeding**	**Information transfer including cable sharing**	
a)	Mutual capacitance	*f* = 1	N/A	≤ 90 nF/km	EN 50289-1-5
b)	Maximum d.c. loop resistance	d.c.	75 Ω/km	150 Ω/km	EN 50289-1-2
c)	Maximum d.c. resistance unbalance	d.c.	1,5 %	1,5 %	EN 50289-1-2
d)	Current carrying capacity per conductor	d.c.	0,75 A	N/A	To be met by design
e)	Operating voltage	d.c.	72 V	72 V	To be met by design
f)	Maximum attenuation	*f* = 100	N/A	2 dB/100 m	EN 50289-1-8
g)	Capacitance unbalance between pairs	*f* = 1	N/A	500 pF/km	IEC 61156-1:2007, 6.2.6
h)	Capacitance unbalance to earth	*f* = 1	N/A	3 000 pF/km	EN 50289-1-5:2001, 4.3.3
i)	Maximum group delay	*f* = 100	N/A	5,5 µs/km	IEC 61156-1:2007, 6.3.1
j)	Minimum near end unbalance attenuation	*f* = 100	N/A	40 dB	EN 50289-1-9

[a] The same pair may be used for power feeding and information transfer.

[b] Operating temperatures normally are in the range of – 20 °C to + 60 °C.

Table 50 – Mechanical performance requirements for Category CCCB cable

No	Cable Characteristics	Cable performance	Test Method
a)	Diameter of conductor	0,65 mm to 1,0 [a] mm	EN 60811-1-1:1995, 8.1
b)	Diameter over insulated conductor [b]	≤ 1,6 mm	EN 60811-1-1:1995, 8.1
c)	Number of conductors in a cable element	2 per pair 4 per quad	Visual
d)	Screen around cable element [c]	Optional	Visual
e)	Number of cable elements in a unit	≥ 1 pairs	Visual
		≥ 1 quads	Visual
f)	Screen around cable unit [c]	Optional	Visual
g)	Number of cable units in a cable	≥ 1	Visual
h)	Screen around cable core [c]	Optional	Visual
i)	Outer diameter of cable [d, e]	≤ 20 mm	EN 60811-1-1:1995, 8.2
j)	Temperature range [f]	Installation: 0 °C to + 50 °C Operation: – 20 °C to + 60°C	To be met by design
k)	Minimum bending radius for pulling during installation	8 times outer cable diameter	EN 50289-3-9:2001, 8
l)	Minimum bending radius installed	4 times outer cable diameter	To be met by design
m)	Fire rating	According to IEC 61156-1:2007, 6.5.16, unless otherwise in accordance with national or local regulation	As applicable
n)	Colour coding [g]	As required by local regulations or customer, preferably EN 60708	To be met by design
o)	Cable marking	As required by local regulations or national specifications	To be met by design

[a] Conductor diameters above 0,8 mm may not be compatible with all connecting hardware.

[b] Diameters of the insulated conductor up to 1,6 mm may be used if they meet all other performance requirements. These cables may not be compatible with all connecting hardware.

[c] If it is intended to use cables with screening, care shall be taken that the connecting hardware is properly designed to terminate the screen.

[d] Should be minimised to make best use of duct and cross-connect capacity.

[e] In case of under carpet cable the value is not applicable.

[f] For certain applications (e.g. pre-cabling buildings in cold climate) a cable with a lower temperature bending performance of – 30 °C may be required.

[g] For cables with fewer cable elements than those specified by EN 60708, pair colours should be consistent with all pairs or quads specified starting from 1 up to the number of elements in the cable.

7.5 Hybrid and multi-unit cables

Cables required to meet this subclause shall also meet the transmission requirements for the corresponding cable Category and type given in 7.3. Additionally, the PSNEXT between all non-fibre recognised cable units or elements shall be 3 dB better than the specified pair-to-pair NEXT required at all specified frequencies according to 7.3 for the same Category.

7.6 Coaxial cables

Cables of Category BCT-C shall meet the electrical and mechanical requirements of Table 51 and Table 52 respectively when subjected to the applicable environmental conditions. See EN 50117-4-1 for specifications of cables that meet such requirements.

Table 51 – Electrical performance requirements for Category BCT-C cable

No	Electrical Characteristics	Frequency MHz	Requirement
a)	Mean Characteristic impedance	$f = 100$	$(75 \pm 3)\ \Omega$
b)	Minimum return loss (RL) on 100 m cable	$5 \leq f < 470$	20 dB
		$470 \leq f < 1\ 000$	18 dB
		$1\ 000 \leq f \leq 3\ 000$	12 dB (ffs)
c)	Maximum attenuation	$1 \leq f < 100$	$0{,}625 \times \sqrt{f} + 0{,}0001 \times f$ dB/100 m
		$100 \leq f \leq 3\ 000$	$0{,}597 \times \sqrt{f} + 0{,}0026 \times f$ dB/100 m
	Informative values at key frequencies	$f = 5$	4,0 dB/100 m
		$f = 10$	4,0 dB/100 m
		$f = 100$	6,3 dB/100 m
		$f = 200$	9,0 dB/100 m
		$f = 600$	16,2 dB/100 m
		$f = 1\ 000$	21,5 dB/100 m
		$f = 2\ 400$	35,5 dB/100 m
		$f = 3\ 000$	40,5 dB/100 m
d)	Maximum (d.c.) loop resistance	d.c.	9 Ω/100 m
e)	d.c. current carrying capacity	d.c.	0,5 A
f)	Operating voltage	d.c.	72 V
g)	Power capacity	d.c.	ffs
h)	Velocity ratio		>66 %
i)	Minimum screening attenuation (EMC Class A)	$30 \leq f < 1\ 000$	85 dB/100 m
		$1\ 000 \leq f \leq 3\ 000$	ffs
	Minimum screening attenuation (EMC Class B)	$30 \leq f < 1\ 000$	75 dB/100 m
		$1\ 000 \leq f \leq 3\ 000$	ffs
j)	Maximum transfer impedance	$f = 5$	7 mΩ/m
		$f = 30$	1,2 mΩ/m
NOTE EMC Class A and EMC Class B limits are in line with EN 50083-2:2006, Table 10.			

Table 52 – Mechanical performance requirements for Category BCT-C cable

No	Cable characteristics	Value
a)	Diameter of inner conductor [a]	0,6 mm to 1,2 mm
b)	Diameter over dielectric [a]	3 mm to 6 mm
c)	Outer diameter of outer conductor	3,5 mm to 6,5 mm
d)	Number of coaxial cable elements in a cable	≥ 1
e)	Outer diameter of cable [b]	≤ 11 mm
f)	Temperature range [c]	installation: 0 °C to + 50 °C operation: - 20 °C to + 60 °C
g)	Minimum bending radius for pulling during installation	10 times outer cable diameter
h)	Minimum bending radius installed	4 times outer cable diameter
i)	Cable marking	as required

[a] Conductor diameters below 0,6 mm and above 1,2 mm may not be compatible with all connecting hardware. The two measured values using the IEC method shall be averaged and then compared to the limit for compliance verification.

[b] Should be minimised to make best use of duct and cross-connect capacity. In case of under carpet cable the value is not applicable.

[c] For certain applications (e.g. precabling buildings in cold climate) a cable with a lower temperature bending performance of – 30 °C may be required.

7.7 Optical fibre cables

7.7.1 All-silica optical fibre cables

7.7.1.1 Cabled multimode optical fibres of Category OM1, OM2 and OM3 and OM4

The optical fibre used to produce cabled optical fibre Category OM1 and OM2 shall be a multimode, graded-index optical fibre waveguide with nominal 50/125 µm or 62,5/125 µm core/cladding diameter and numerical aperture complying with EN 60793-2-10:2011, optical fibre A1a or fibre A1b, respectively.

The optical fibre used to produce cabled optical fibre Category OM3 shall be a multimode, graded-index optical fibre waveguide with nominal 50/125 µm core/cladding diameter and numerical aperture complying with EN 60793-2-10:2011, optical fibre A1a.2.

The optical fibre used to produce cabled optical fibre Category OM4 shall be a multimode, graded-index optical fibre waveguide with nominal 50/125 µm core/cladding diameter and numerical aperture complying with EN 60793-2-10:2011, optical fibre A1a.3.

Each cabled optical fibre of a given Category shall meet the performance requirements of Table 53 as appropriate in conjunction with a completed optical fibre cable detail specification based upon those within EN 60794 series, as appropriate.

Table 53 – Cabled multimode optical fibre performance requirements

Category	Maximum attenuation [a] (dB/km)		Minimum modal bandwidth [b] MHz × km		
			Overfilled launch		Application-specific bandwidth (See NOTE)
	850 nm	1 300 nm	850 nm	1 300 nm	850 nm
OM1	3,5	1,5	200	500	not specified
OM2	3,5	1,5	500	500	not specified
OM3	3,5	1,5	1 500	500	2 000
OM4	3,5	1,5	3 500	500	4 700

[a] The cabled optical fibre attenuation shall be measured in accordance with EN 60793-1-40.

[b] Modal bandwidth requirements apply to the optical fibre used to produce the relevant cabled optical fibre Category and are assured by the parameters and test methods specified in EN 60793-2-10. Optical fibres that meet only the overfilled launch modal bandwidth may not support some applications specified in Annex F.

NOTE This bandwidth is based on application-specific implementation of the EMB_C requirements of EN 60793-2-10.

Detail specifications based upon the blank detail specifications within the series EN 60794 shall be used to specify cable performance requirements under the environmental classifications of Table 3. Table 54 shows the elements of Table 3 that are not covered by these blank detail specifications and which have to be specified separately.

Table 54 – Environmental performance specifications for optical fibre cables (in addition to series EN 60794) [a, b]

Mechanical	M_1	M_2	M_3	Reference
Bending	As required	As required	As required	EN 60794-1-2
Flexing	As required	As required	As required	EN 60794-1-2
Torsion	As required	As required	As required	EN 60794-1-2
Climatic and chemical	C_1	C_2	C_3	
Solar radiation	N/A	ffs	ffs	ffs
Oil resistance	As required	As required	As required	EN 60794-1-2

[a] Cables shall maintain mechanical and optical performance during exposure to the relevant environmental conditions described in Table 3.

[b] Any optical fibre cables containing metallic elements shall be subjected to the voltage proof test applied to balanced cables.

NOTE Although not contained in Table 3 “weld spatter” may also be considered during the development of a detail specification.

7.7.1.2 Cabled single-mode optical fibres of Category OS1

The optical fibre used to produce cabled optical fibre of Category OS1 shall comply with EN 60793-2-50:2008, fibre B1.3 or B6_a.

NOTE The values for total connecting hardware attenuation in channels (see clause 5) are based on the assumption that the optical fibres in the channel are of the same type (i.e. B1.3 or B6_a).

Each cabled optical fibre shall meet the performance requirements of Table 55.

Detail specifications based upon the blank detail specifications within the EN 60794 series, as appropriate, shall be used to specify cable performance requirements under the environmental classifications of Table 3. Table 54 shows the elements of Table 3 that are not covered by these blank detail specifications and which have to be specified separately.

Table 55– Cabled single-mode optical fibre performance requirements (Category OS1)

Wavelength [a] nm	**Maximum attenuation** [b] dB/km
1 310	1,0
1 383	1,0
1 550	1,0

[a] The cut-off wavelength shall be less than 1 260 nm when measured in accordance with EN 60793-1-44.

[b] The cabled optical fibre attenuation shall be measured in accordance with EN 60793-1-40.

7.7.1.3 Cabled single-mode optical fibres of Category OS2

The optical fibre used to produce cabled optical fibre of Category OS2 shall comply with EN 60793-2-50:2008, fibre B1.3 or B6_a. Each cabled optical fibre shall meet the performance requirements of Table 56.

Detail specifications based upon the blank detail specifications within the EN 60794 series, as appropriate, shall be used to specify cable performance requirements under the environmental classifications of Table 3. Table 54 shows the elements of Table 3 that are not covered by these blank detail specifications and which have to be specified separately.

Table 56 – Cabled single-mode optical fibre performance requirements (Category OS2)

Wavelength [a] nm	**Maximum attenuation** [b] dB/km
1 310	0,4
1 383	0,4
1 550	0,4

[a] The cut-off wavelength shall be less than 1 260 nm when measured in accordance with EN 60793-1-44.

[b] The cabled optical fibre attenuation shall be measured in accordance with EN 60793-1-40.

7.7.2 Plastic optical fibre cables

The optical fibre used to produce cabled optical fibre of Category OP1 shall be multimode, plastic optical fibre with a nominal cladding diameter of 1 000 µm in accordance with EN 60793-2-40:2011, fibre A4a.2. Each cabled optical fibre of Category OP1 shall meet the performance requirements of Table 57 when subject to the applicable environmental classification of Table 3.

The optical fibre used to produce cabled optical fibre of Category OP2 shall be multimode, plastic optical fibre with a nominal cladding diameter of 490 µm in accordance with EN 60793-2-40:2011, fibre A4g. Each cabled optical fibre of Category OP2 shall meet the performance requirements of Table 57 when subject to the applicable environmental classification of Table 3.

Table 57 – Cabled plastic and plastic clad silica optical fibre performance requirements

Category	Maximum attenuation [a] dB/km (see NOTE 1)			Minimum modal bandwidth MHz x km (see NOTE 1,2)		
	650 nm	850 nm	1 300 nm	650 nm	850 nm	1 300 nm
OP1 (see NOTE 3)	180	N/A	N/A	4	N/A	N/A
OP2	100	33	33	80	188	188
OH1	ffs	10	ffs	ffs	5	ffs

[a] The cabled optical fibre attenuation shall be measured in accordance with EN 60793-1-40.

NOTE 1 Although the attenuation and the modal bandwidth values are quoted in dB/km and MHz × km respectively, the qualification measurement may be undertaken using 100 m lengths.

NOTE 2 Modal bandwidth requirements apply to the optical fibre used to produce the relevant cabled optical fibre Category and are assured by the parameters and test methods specified in EN 60793-2-40.

NOTE 3 Launch condition: Numerical Aperture = 0,3 as specified in EN 60793-2-40.

7.7.3 Plastic clad silica optical fibre cables

The optical fibre used to produce cabled optical fibre of Category OH1 shall be multimode optical fibre waveguide with nominal 200/230 μm core/cladding diameter complying with EN 60793-2-30:2009, fibre A3c. Each cabled optical fibre of Category OH1 shall meet the performance requirements of Table 57 when subject to the applicable environmental classification of Table 3.

7.7.4 Propagation delay

For all fibre Categories defined in Table 53, Table 55 and Table 56 a conservative conversion value for unit propagation delay of 5,00 ns/m (0,667 $\times$ c) may be used. This value can be used to calculate channel delay without verification.

7.7.5 Marking

The Category of the optical fibre(s) within the cable shall be marked upon the cable sheath.

8 Connecting hardware requirements

8.1 General requirements

8.1.1 Overview

This clause defines the minimum requirements for connecting hardware installed within generic cabling sub-systems as specified within the reference implementations specified in the standards in the EN 50173 series.

For the purposes of this clause, connecting hardware (sometimes referred to as a connection) is considered to consist of a device or a combination of devices used to connect cables or cable elements. Unless stated otherwise, this standard specifies the minimum performance of mated connectors as part of a channel. Performance requirements do not include the effects of cross-connect jumpers or patch cords. Requirements for balanced cords are provided in Clause 9.

It shall be possible to protect connecting hardware in a non-mated state to meet the stated environmental classification of Clause 5. Such protection may take the form of blind inserts, protective caps or overall enclosures of the connection or connections.

Where a protective housing prevents the identification of the connecting hardware type, the protective housing shall be suitably marked or colour coded.

NOTE This clause does not address requirements for media adapters or other devices with passive or active electronic circuitry (for example, impedance matching transformers, terminating resistors, LAN equipment, filters and protection devices) whose main purpose is to serve a specific application or to provide compliance with other rules and regulations. When required, such devices are not considered to be part of the cabling and may have significant detrimental effects on network performance. Therefore, it is important that their compatibility with the cabling system and active equipment be considered before use.

8.1.2 Location

Connecting hardware is installed:

a) in a campus distributor permitting connections to building backbone and campus backbone cabling and equipment (if provided);

b) in a building distributor permitting connections to the backbone cabling and equipment (if provided);

c) in a floor distributor providing the cross-connections and permitting connections to equipment (if provided);

d) at other locations as specified in other standards of the EN 50173 series;

e) in the building entrance facility (BEF).

8.1.3 Design

In addition to its primary purpose, the connecting hardware should be designed to provide:

a) a means to identify cabling for installation and administration as described in EN 50174-1;
b) a means to permit orderly cable management;
c) a means of access to monitor or test cabling and active equipment;
d) protection against physical damage and ingress of contaminants that may affect performance;
e) a termination density that is space efficient, but that also provides ease of both cable management and ongoing administration of the cabling system;
f) a means to accommodate screening and grounding requirements, when applicable.

8.1.4 Operating environment

8.1.4.1 General

For each M, I, C or E group, the classification of a given environment shall be determined by the most demanding parameter within an M, I, C or E group. However, the selection of components shall be based on the specific demands of each of the parameters within the M, I, C or E group, which may be less demanding than the overall classification of the environment.

In general, conformance to the limits and test methods specified by this clause, and product specifications referenced in it, for individual transmission parameters cannot be considered to provide assurance of performance when simultaneously subjected to the full range of environmental conditions of a given environmental classification.

It is assumed that if a channel is constructed entirely of components meeting requirements based on a $M_1I_1C_1E_1$ classification according to the reference implementations of Clause 6 then the required channel transmission performance is achieved in a $M_1I_1C_1E_1$ environment based upon a statistical approach of performance modelling.

The maintenance of functional performance under specific combinations of environmental conditions within a given environmental classification of Table 3 should be indicated by the supplier. Agreement shall be reached between customer and supplier that the product maintains functional performance when subjected to specific combinations of environmental conditions.

8.1.4.2 Connecting hardware for balanced cabling

Connecting hardware for balanced cabling shall meet the mechanical and transmission performance requirements of 8.2 and 8.3 as appropriate in conjunction with the performance requirements detailed in Table 58 for the relevant environmental classifications of Table 3.

Table 58 – Environmental performance specifications for balanced cabling connecting hardware

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Bump	[a]	[a]	[a]	EN 60512-6-2
Shock	[a]	[a]	[a]	EN 60512-6-3
Vibration sinusoidal	[a]	[a]	[a]	EN 60512-6-4
Tensile strength, free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	EN 60512-16-4
Cable clamp resistance to cable torsion	[b]	[b]	[b]	EN 60512-17-4
Cable clamp resistance to rotation	[b]	[b]	[b]	EN 60512-17-2
Ingress	**I_1**	**I_2**	**I_3**	
Particulate	IP 2X	IP 6X	IP 6X	EN 60529
Liquid / Immersion	IP X0	IP X5	IP X5 and X7	EN 60529
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Ambient temperature	[a]	[a]	[a]	EN 60512-11-9 and EN 60512-11-10
Rapid change of temperature	[a]	[a]	[a]	EN 60512-11-4
Solar radiation	[a]	[a]	[a]	ffs
Damp heat cyclic	[a]	[a]	[a]	EN 60512-11-12
Fluid resistance	[a]	[a]	[a]	EN 60512-19-3
Flowing mixed gas corrosion test	[a]	[a]	[a]	EN 60512-11-7
Electromagnetic	**E_1**	**E_2**	**E_3**	
Shielding effectiveness	[a]	[a]	[a]	EN 60512-23-3, and EN 60512-4-2 for partial discharge
Radio Frequency	[a]	[a]	[a]	EN 60512-23-3
Voltage proof	[a]	[a]	[a]	EN 60512-4-1

[a] Connecting hardware shall maintain functional performance during exposure to the relevant environmental conditions described in Table 3.

[b] Connecting hardware shall maintain functional performance during exposure to the relevant environmental conditions.

NOTE Although not contained in Table 3 “weld spatter” may also be considered during the development of a detail specification.

8.1.4.3 Connecting hardware for coaxial cabling

Connecting hardware for coaxial cabling shall meet the mechanical and transmission performance requirements of 8.4 in conjunction with the performance requirements detailed in Table 59 for the relevant environmental classifications of Table 3.

Table 59 – Environmental performance specifications for coaxial cabling connecting hardware

Mechanical	M_1	M_2	M_3	Reference
Bump	[a]	[a]	[a]	
Shock	[a]	[a]	[a]	
Vibration sinusoidal	[a]	[a]	[a]	
Tensile strength, free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	
Cable clamp resistance to cable torsion	[b]	[b]	[b]	
Cable clamp resistance to rotation	[b]	[b]	[b]	
Ingress	I_1	I_2	I_3	
Particulate	IP 2X	IP 6X	IP 6X	EN 60529
Liquid / Immersion	IP X0	IP X5	IP X5 and X7	EN 60529
Climatic and chemical	C_1	C_2	C_3	
Ambient temperature	[a]	[a]	[a]	
Rapid change of temperature	[a]	[a]	[a]	
Solar radiation	[a]	[a]	[a]	
Damp heat cyclic	[a]	[a]	[a]	
Fluid resistance	[a]	[a]	[a]	
Flowing mixed gas corrosion test	[a]	[a]	[a]	
Electromagnetic	E_1	E_2	E_3	
Shielding effectiveness	[a]	[a]	[a]	
Radio Frequency	[a]	[a]	[a]	
Voltage proof	[a]	[a]	[a]	

[a] Connecting hardware shall maintain functional performance during exposure to the relevant environmental conditions described in Table 3.

[b] Connecting hardware shall maintain functional performance during exposure to the relevant environmental conditions.

NOTE Although not contained in Table 3 “weld spatter” may also be considered during the development of a detail specification.

8.1.4.4 Connecting hardware for optical fibre cabling

Connecting hardware for optical fibre cabling shall meet the mechanical and transmission performance requirements of 8.5 in conjunction with the performance requirements detailed in Table 60 for the relevant environmental classifications of Table 3.

Table 60 – Environmental performance specifications for optical fibre cabling connecting hardware

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Bump	[a]	[a]	[a]	
Shock	[a]	[a]	[a]	EN 61300-2-9
Vibration sinusoidal	[a]	[a]	[a]	EN 61300-2-1
Tensile strength, free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	EN 61300-2-4
Cable clamp resistance to cable torsion	[b]	[b]	[b]	EN 61300-2-5
Cable clamp resistance to rotation	[b]	[b]	[b]	EN 61300-2-44
Ingress	**I_1**	**I_2**	**I_3**	
Particulate	IP 2X	IP 6X	IP 6X	
Liquid / Immersion	IP X0	IP X5	IP X5 and X7	
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Ambient temperature	[a]	[a]	[a]	EN 61300-2-18
Rapid change of temperature	[a]	[a]	[a]	EN 61300-2-22
Solar radiation	[a]	[a]	[a]	EN 61300-2-30
Damp heat cyclic	[a]	[a]	[a]	EN 61300-2-46
Fluid resistance	[a]	[a]	[a]	EN 61300-2-34
Flowing mixed gas corrosion test	[a]	[a]	[a]	

[a] Connecting hardware shall maintain functional performance during exposure to the relevant environmental conditions described in Table 3.

[b] Connecting hardware shall maintain functional performance during exposure to the relevant environmental conditions.

NOTE Although not contained in Table 3 "weld spatter" may also be considered during the development of a detail specification.

8.1.5 Mounting

Connecting hardware shall be designed to provide flexibility for mounting in closures as described in EN 50174-1.

8.1.6 Installation practices

Installation practices should be in accordance with EN 50174-1, EN 50174-2 and EN 50174-3.

8.1.7 Marking and colour coding

In order to maintain consistent and correct point-to-point connections, provision shall be made to ensure that terminations are properly located with respect to connector positions and their corresponding cable elements. Such provision may include the use of colours, alphanumeric identifiers or other means designed to ensure that cables are connected in a consistent manner throughout the system. See EN 50174-1 for further information.

8.2 Category 5, 6, 6_A, 7, 7_A and BCT-B connecting hardware for balanced cabling

8.2.1 General requirements

The following requirements apply to all connecting hardware used to provide electrical connections with balanced cables described in 7.3. When connecting hardware used to directly terminate cable elements is of the solderless connection type, e.g. insulation displacement connection (IDC), it shall meet the requirements of D.3.2. In addition to the requirements of this subclause, connecting hardware used with screened cabling shall be in full compliance with the applicable requirements of series EN 50174.

Assurance should be sought from suppliers that the combinations of components within connecting hardware are able to meet the electrical and mechanical requirements of this clause.

8.2.2 Performance marking

Connecting hardware intended for use with balanced cabling should be marked to designate transmission performance at the discretion of the manufacturer. The markings, if any, shall be visible during installation.

NOTE Performance markings are in addition to, and do not replace, other markings specified in 8.1.7, EN 50174-1 or those required by local codes or regulations.

8.2.3 Mechanical characteristics

Connecting hardware intended for use with balanced cabling shall meet the requirements of Table 61.

Table 61 – Mechanical characteristics of connecting hardware intended for use with balanced cabling of Category 5, 6, 6_A, 7, 7_A and BCT-B

No	Characteristic	Requirement	Reference
a)	Cable termination compatibility		
	Nominal conductor diameter	0,5 mm to 0,65 mm [a]	
	Conductor type	Solid	EN 50288-X-2 or EN 50288-X-1
		Stranded	EN 50288-X-2
	Nominal diameter of insulated conductor Category 5, Category 6 and Category 6_A Category 7, Category 7_A and Category BCT-B	 0,7 mm to 1,4 mm [b, c] 0,7 mm to 1,6 mm	EN 60811-1-1:1995, 8.1
	Number of conductors	≥ 2×n (n = 1,2,3, ...)	Visual inspection
	Cable outer diameter fixed connector free connector	 ≤ 20 mm ≤ 9 mm [d]	EN 60811-1-1:1995, 8.2
	Means to connect screen	EN 50174-2 [e]	
b)	Mechanical operation (durability)		
	Cable termination Non-reusable IDC Reusable IDC Non-reusable IPC	 1 ≥ 20 1	 EN 60352-3 and EN 60352-4 EN 60352-3 and EN 60352-4 EN 60352-6
	Jumper termination (cycles)	≥ 200 [f]	EN 60352-3 and EN 60352-4
	Interfaces (cycles) EN 60603-7 series EN 61076-3-104 EN 61076-2-101 other	 ≥ 750 (level PL1 of EN 60603-7) [g] ≥ 750 ≥ 750 ≥ 200	 EN 60603-7:2009, 6.6.1 Clauses 6 and 7 of EN 61076-3-104 EN 61076-2-101 Annex D

[a] Nominal conductor diameters described in EN 50288-X-Y (see 7.3.1) allow conductor diameters ranging from 0,4 mm to 0,8 mm, connecting hardware described in this clause is limited to 0,4 mm to 0,55 mm for free connectors (plugs) and 0,5 mm to 0,65 mm for fixed connectors (jacks or punch down blocks).

[b] Use of the modular free connector specified in EN 60603-7-X is typically limited to cables having insulated conductor diameters in the range of 0,8 mm to 1,0 mm.

[c] Because it is not required for connecting hardware to be compatible with cables outside of this range, special care shall be taken to ensure compatibility between cables with insulated conductor diameters as high as 1,6 mm (when used) and the connecting hardware they are used with.

[d] Use of the modular free connector specified in EN 60603-7-X is typically limited to cables having outside diameters in the range of 5 mm to 8 mm.

[e] If it is intended to use screened cabling, care should be taken that the cross-connect is designed to terminate the screening. Note that there may be a difference between cross-connects designed to terminate balanced cables with overall screens only, as opposed to cables having both individually screened elements and an overall screen.

[f] This durability requirement is only applicable to connections designed for more than a single termination operation (for example, those that are used to administer cabling system changes).

[g] Mating and unmating under load is ffs.

8.2.4 Electrical characteristics

8.2.4.1 General

Connecting hardware complying with the mechanical requirements of the referenced EN specifications of Table 61 shall comply with all the requirements of the relevant part of the referenced standard for the relevant Category. Other connecting hardware shall comply with all the electrical characteristics specified in

Annex D for the relevant Category. Connecting hardware shall be tested with each cable impedance that it is intended to support.

Free and fixed connectors (plugs and sockets) that are intermateable shall be backward compatible with those of different performance Categories. Backward compatibility means that mated connections with free and fixed connectors from different Categories shall meet all requirements for the lower Category component. See Table 62 for a matrix of mated modular connector performance that is representative of backward compatible connectivity.

Table 62 – Backwards compatibility matrix

Modular plug/cord	Modular connector Category				
	Category 5	**Category 6**	**Category 6_A**	**Category 7**	**Category 7_A**
Category 5	Category 5	Category 5	Category 5	Category 5	Category 5
Category 6	Category 5	Category 6	Category 6	Category 6	Category 6
Category 6_A	Category 5	Category 6	Category 6_A	Category 6_A	Category 6_A
Category 7	Category 5	Category 6	Category 6_A	Category 7	Category 7
Category 7_A	Category 5	Category 6	Category 6_A	Category 7	Category 7_A

8.2.4.2 Enhanced requirements for specific permanent links

Certain standards in the EN 50173 series support permanent links of Configuration C (see Figure A.1). The creation of such permanent links of the Class F_A performance specified in Annex A and in which the cables either side of connection Y are in accordance with EN 50288-9-1 requires the connecting hardware at connection Y to have minimum NEXT and PSNEXT performance 6 dB better than that specified for Category 7_A in Annex D.

NOTE 1 The 6 dB increment applies at 1 000 MHz and is provided by additional NEXT and PSNEXT performance of $27 \times \lg (f/600)$ between 600 MHz and 1 000 MHz.

NOTE 2 Calculations suggest that the 6 dB does not provide adequate NEXT and PSNEXT performance for all cabling configurations. The application of one or more of the following measures will further improve performance:

a) connecting hardware at connection Y (see Figure A.1) with incremental performance of greater than that of NOTE 1;
b) cables between connections X and Y of higher insertion loss specification than that in the fixed cable link;
c) connecting hardware at other places than connection Y (see Figure A.1) with NEXT and PSNEXT performance between 600 MHz and 1 000 MHz in excess of that specified for Category 7_A.

8.3 Category CCCB connecting hardware for balanced cabling

8.3.1 General requirements

The following requirements apply to all connecting hardware used to provide electrical connections with balanced cables described in 7.4. When connecting hardware used to directly terminate cable elements is of the solderless connection type, e.g. insulation displacement connection (IDC), it shall meet the requirements of D.3.2. In addition to the requirements of this subclause, connecting hardware used with screened cabling shall be in compliance with the applicable requirements of series EN 50174.

Assurance should be sought from suppliers that the combinations of components within connecting hardware are able to meet the electrical and mechanical requirements of this clause.

8.3.2 Performance marking

Connecting hardware intended for use with balanced cabling should be marked to designate transmission performance at the discretion of the manufacturer. The markings, if any, shall be visible during installation.

NOTE Performance markings are in addition to, and do not replace, other markings specified in 8.1.7, EN 50174-1 or those required by local codes or regulations.

8.3.3 Mechanical characteristics

Connecting hardware intended for use with balanced cabling shall meet the requirements of Table 63.

Table 63 – Mechanical characteristics of connecting hardware intended for use with balanced cabling of Category CCCB

No	Characteristic	Requirement	Reference
a)	Cable termination compatibility		
	Nominal conductor diameter	0,65 mm to 1,0 mm	--
	Conductor type	solid	--
		Stranded	--
	Nominal diameter of insulated conductor	0,7 mm to 1,6	EN 60811-1-1:1995, 8.1
	Number of conductors	≥ 2 × n (n = 1,2,3, ...)	Visual inspection
	Cable outer diameter fixed connector free connector	 ≤ 20 mm ≤ 9 mm [a]	EN 60811-1-1:1995, 8.2
	Means to connect screen	EN 50174-2 [b]	
b)	Mechanical operation (durability)		
	Cable termination Non-reusable IDC Reusable IDC Non-reusable IPC	 1 ≥ 20 1	 EN 60352-3 and EN 60352-4 EN 60352-3 and EN 60352-4 EN 60352-6
	Jumper termination (cycles)	≥ 200 [c]	EN 60352-3 and EN 60352-4
	CO type interface (cycle)	≥ 750 (level PL1 of EN 60603-7) [d]	EN 60603-7:2009, 6.6.1
	other interface (cycles)	≥ 200 (see Annex D)	EN 60352-6

[a] Use of the modular plug connector specified in EN 60603-7-X is typically limited to cables having outside diameters in the range of 5 mm to 8 mm. Flat/oval cables with equivalent cross-sectional area are acceptable.

[b] If it is intended to use screened cabling, care should be taken that the cross-connect is designed to terminate the screening. Note that there may be a difference between cross-connects designed to terminate balanced cables with overall screens only, as opposed to cables having both individually screened elements and an overall screen.

[c] This durability requirement is only applicable to connections designed for more than a single termination operation (for example, those that are used to administer cabling system changes).

[d] Mating and unmating under load is ffs.

8.3.4 Electrical characteristics

Connecting hardware shall meet the requirements of Table 64. Connecting hardware shall be tested with each cable impedance that it is intended to support.

Table 64 – Electrical performance of connecting hardware of Category CCCB

No	Electrical Characteristics	Frequency kHz	Connecting hardware performance	Test Method
a)	Return loss (minimum)	$f = 100$	30,0 dB	EN 60512-25-5
b)	Insertion loss (maximum)	$f = 100$	0,1 dB	EN 60512-25-2
c)	NEXT (minimum)	$f = 100$	80,0 dB	EN 60512-2-1 (balance)
d)	FEXT (minimum)	$f = 100$	65,0 dB	EN 60512-2-1
e)	Input to output resistance (maximum) [a]	d.c.	100 μΩ	EN 60512-2-1:2002, Test 2a
f)	Current carrying capacity (minimum) [b]	d.c.	0,7 A	EN 60512-5-2:2002, Test 5b
g)	Propagation delay (maximum)	$f = 100$	1,0 ns	EN 60512-25-4
h)	Insulation resistance (minimum)	d.c.	100 MΩ	EN 60512-3-1:2002 Test 3a Method C, DC 500 V
i)	Voltage proof Conductor to conductor Conductor to test panel	 d.c. d.c.	 1 000 V 1 500 V	EN 60512-4-1:2003, Test 4a

[a] Input to output resistance is a separate measurement from the contact resistance measurements required in EN 60603-7. Input to output resistance is measured to determine the connector's ability to transmit direct current and low frequency signals. Contact resistance measurements are used to determine the reliability and stability of individual electrical connections. These requirements are applicable to each conductor and to the screen, when present.

[b] Applicable to each conductor for an ambient temperature of 60 ºC. Sample preparation shall be as specified in the applicable document.

8.4 Category BCT-C connecting hardware for coaxial cabling

8.4.1 General requirements

The following requirements apply to all connecting hardware used to provide electrical connections with coaxial cables of Category BCT-C described in 7.6.

In addition to the requirements of this subclause, connecting hardware used with screened cabling shall be in full compliance with the applicable requirements of series EN 50174.

Assurance should be sought from suppliers that the combinations of components within connecting hardware are able to meet the electrical and mechanical requirements of this clause.

8.4.2 Performance marking

Connecting hardware intended for use with coaxial cabling should be marked to designate transmission performance at the discretion of the manufacturer. The markings, if any, shall be visible during installation.

NOTE Performance markings are in addition to, and do not replace, other markings specified in 8.1.7, EN 50174-1 or those required by local codes or regulations.

8.4.3 Electrical characteristics

8.4.3.1 Return loss

The return loss of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table 65. The limits shown in Table 66 are derived from the formulae at key frequencies only.

Table 65 – Formulae for return loss limits for BCT-C connecting hardware

Category	Frequency MHz	Minimum return loss dB
BCT-C	$1 \leq f < 2\,000$	23,0
	$2\,000 \leq f \leq 3\,000$	$23 - 39,75 \times \lg\left(f/2000\right)$, 30,0 max.

Table 66 – Return loss limits for BCT-C connecting hardware at key frequencies

Frequency MHz	Minimum return loss dB	Component and test standard
5,0	23,0	EN 61169-2 EN 61169-24
10,0	23,0	
100,0	23,0	
200,0	23,0	
1 000,0	23,0	
2 000,0	23,0	
2 400,0	19,9	
3 000,0	16,0	

8.4.3.2 Insertion loss

The insertion loss of connecting hardware shall meet the limits computed, to two decimal places, using the formulae of Table 67 The limits shown in Table 68 are derived from the formulae at key frequencies only.

Table 67 – Formulae for insertion loss limits for BCT-C connecting hardware

Category	Frequency MHz	Maximum insertion loss dB
BCT-C	$1 \leq f \leq 3\,000$	$0{,}0001 \times f$, 0,10 min.

Table 68 – Insertion loss limits for BCT-C connecting hardware at key frequencies

Frequency MHz	Maximum insertion loss dB	Component and test standard
5,0	0,10	EN 61169-2 EN 61169-24
10,0	0,10	
100,0	0,10	
200,0	0,10	
1 000,0	0,10	
2 000,0	0,20	
2 400,0	0,24	
3 000,0	0,30	

8.4.3.3 Current carrying capacity

The current carrying capacity of connecting hardware shall exceed 0,500 A when measured in accordance with EN 61169-1. The requirements are applicable to each conductor including the screen and for an ambient temperature of 60 °C.

8.4.3.4 Screening attenuation

The screening attenuation shall meet the limits given in Table 69.

Table 69 – Screening attenuation limits for BCT-C connecting hardware

Frequency MHz	**Minimum screening attenuation** dB		**Test standard**
	EMC Class A	**EMC Class B**	
$30 \leq f < 300$	85,0	75,0	EN 50289-1-14
$300 \leq f < 470$	80,0	75,0	
$470 \leq f \leq 1\,000$	75,0	65,0	
$1\,000 \leq f < 3\,000$	55,0	N/A	
NOTE EMC Class A and EMC Class B limits are in line with EN 50083-2:2006, Table 10.			

8.5 Optical fibre connecting hardware

8.5.1 All-silica optical fibre

8.5.1.1 General requirements

The requirements of 8.5.1.2 and 8.5.1.3 apply to all connecting hardware used to provide connections between optical fibre cables described in 7.7.1. These requirements apply to the connecting hardware for any cabling subsystem in the EN 50173 series of standards. Additionally, all optical ports shall comply with the safety requirements of EN 60825-2.

8.5.1.2 Marking and colour coding

Consistent coding of connectors and adapters, for example by colour, should be used to identify connections between:

a) different cabled multimode optical fibre types;

b) incompatible single-mode connecting hardware (e.g. blue for connectors with physical contact (PC) ferrules and green for connectors with angled physical contact (APC) ferrules).

In addition, keying and the identification of optical fibre positions may be used to ensure that correct polarity is maintained.

These markings are in addition to, and do not replace, other markings specified in EN 50174-1 or those required by local codes or regulations.

NOTE The following colour codes apply to IEC 60874-19-1 SC duplex connectors but may also be used for other connector types:

a) multimode 50 μm and 62,5 μm: Beige or black;

b) single-mode PC: Blue;

c) single-mode APC: Green.

8.5.1.3 Mechanical and optical characteristics

Optical fibre connecting hardware shall meet the requirements of Table 70.

The choice of connecting hardware is open to all types of optical fibre connectors standardized by IEC or CENELEC. When high density is an important consideration then small form factor connectors are recommended.

However, where detail specifications produced by IEC or CENELEC in accordance with requirements of Table 70 a) do not exist then assurance should be sought from suppliers that the combinations of components within connecting hardware are able to meet the optical and mechanical requirements of this clause.

Table 70 – Mechanical and optical characteristics of all-silica optical fibre connecting hardware

No	Characteristic		Requirement	Reference
a)	Optical performance characteristics			
	Maximum attenuation	connectors	0,5 dB for 95 % of matings 0,75 dB for 100 % of matings	EN 61300-3-34
		splice	0,3 dB	EN 61073-1
	Minimum return loss	multimode	20 dB	EN 61300-3-6
		single-mode	35 dB	EN 61300-3-6
b)	Physical characteristics			
	Cable termination compatibility			
	Nominal cladding diameter (μm)		125	EN 60793-1-20
	Nominal buffer diameter (μm)		-	EN 60794-1-1
	Cable outer diameter (μm)		-	EN 60794-1-1
c)	Mechanical characteristics			
	Mechanical endurance (durability) cycles		≥ 500 (see NOTE 1)	EN 61300-2-2
	Strength of coupling mechanism		40 N 1 min (see NOTE 1)	EN 61300-2-6
	Cable pulling		50 N 1 min (see NOTE 2)	EN 61300-2-4
	Connector side pull		5 N 1 min (see NOTE 1)	EN 61300-2-42
d)	Environmental performance requirements			
	Cold		- 10 °C, 96 h (see NOTE 1)	EN 61300-2-17
	Dry Heat		60 °C, 96 h (see NOTE 1)	EN 61300-2-18
	Damp heat (steady state)		40 °C 93 % RH, 96 h (see NOTE 1)	EN 61300-2-19
	Impact		1,5 m, 5 times (see NOTE 3)	EN 61300-2-12
	Vibration		10 Hz to 55 Hz, 0,75 mm, 30 min at each of 3 directions (see NOTE 1)	EN 61300-2-1
	Change of temperature test		+ 60 °C/- 10 °C , rate 1 °C/min, 30 min at extremes, 5 cycles (see NOTE 1)	EN 61300-2-22

NOTE 1 Max. change during test < 0,2 dB, initial and final attenuation < 0,75 dB.

NOTE 2 Initial and final attenuation < 0,75 dB.

NOTE 3 Max. change during test < 0,5 dB, initial and final attenuation < 0,75 dB.

8.5.2 Plastic optical fibre

8.5.2.1 General requirements

The requirements of 8.5.2.2 and 8.5.2.3 apply to all connecting hardware used to provide connections between plastic optical fibre cables described in 7.7.2. These requirements apply to the connecting hardware for any cabling subsystem in the EN 50173 series of standards. Additionally, all optical ports shall comply with the safety requirements of EN 60825-2.

8.5.2.2 Marking and colour coding

Correct coding of connectors and adapters, for example by colour, should be used to ensure that mating of different fibre types does not occur. In addition, keying and the identification of fibre positions may be used to ensure that correct polarity is maintained for duplex links.

These markings are in addition to, and do not replace, other markings specified in EN 50174-1, or those required by local codes or regulations.

8.5.2.3 Mechanical and optical characteristics

The insertion loss of a mated connection shall not exceed 1,5 dB when measured in accordance with EN 61300-3-34. The modal conditions under which the measurement is made are ffs.

8.5.3 Plastic clad silica optical fibre

8.5.3.1 General requirements

The requirements of 8.5.3.2 and 8.5.3.3 apply to all connecting hardware used to provide connections between plastic clad silica optical fibre cables described in 7.7.3. These requirements apply to the connecting hardware for any cabling subsystem in the EN 50173 series of standards. Additionally, all optical ports shall comply with the safety requirements of EN 60825-2.

8.5.3.2 Marking and colour coding

See 8.5.2.2.

8.5.3.3 Mechanical and optical characteristics

See 8.5.2.3.

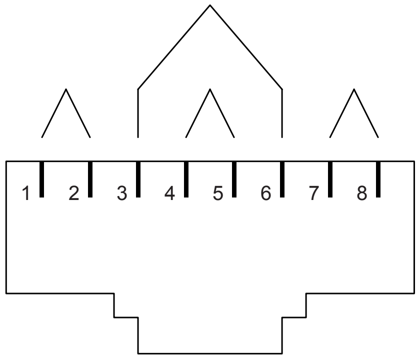
8.6 Connecting hardware in accordance with EN 60603-7 series

Where other standards in the EN 50173 series specify the use of connecting hardware in accordance with the EN 60603-7 series, they shall be as referenced in Table 71.

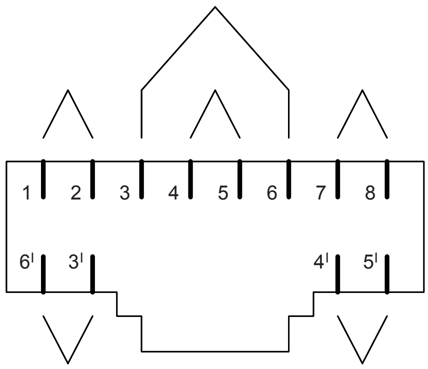
Table 71 – EN 60603-7 series connecting hardware

Category	Standard
Category 5 unscreened	EN 60603-7-2
Category 5 screened	EN 60603-7-3
Category 6 unscreened	EN 60603-7-4
Category 6 screened	EN 60603-7-5
Category 6_A unscreened	EN 60603-7-41
Category 6_A screened	EN 60603-7-51
Category 7	EN 60603-7-7
Category 7_A screened	EN 60603-7-71

The pin grouping and pair assignments shall be as shown in Figure 7.



a) EN 60603-7 series interfaces except for EN 60603-7-7 and EN 60603-7-71



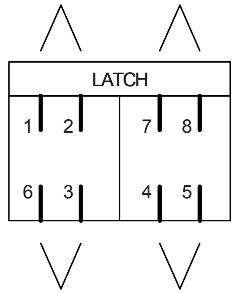
NOTE The pin designations 3^{I}, 4^{I}, 5^{I} and 6^{I} for Categories 7, 7_{A} and BCT-B correspond to 3, 4, 5, and 6 for Categories 5, 6 and 6_{A}.

b) EN 60603-7-7 and EN 60603-7-71 interfaces

Figure 7 – Pin grouping and pair assignments for EN 60603-7 series connecting hardware (front view of connector)

8.7 Connecting hardware in accordance with EN 61076-3-104

The pin grouping and pair assignments shall be as shown in Figure 8.



NOTE The pin designations correspond to those of EN 60603-7 series interfaces.

Figure 8 – Pin grouping and pair assignments for EN 61076-3-104 connecting hardware (front view of connector)

8.8 Connecting hardware in accordance with EN 61076-2-101 (Type D, 4 poles)

The pin grouping and pair assignments shall be as shown in Figure 9.

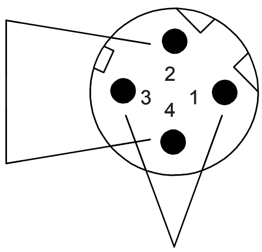


Figure 9 – Four position jack pin and pair grouping assignments for EN 61076-2-101 connecting hardware (front view of connector)

8.9 Connecting hardware for two optical fibres

The optical fibre assignments shall be as shown in Figure 10 (see EN 50174-1:2009, Annex B, for further information regarding polarity maintenance).

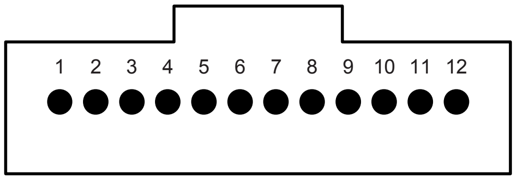
a) Front view of fixed connector (duplex adapter)

b) Front view of free connector

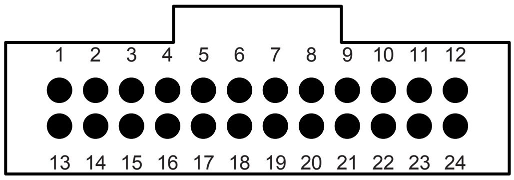
Figure 10 – Optical fibre assignments for connecting hardware for two optical fibres

8.10 Connecting hardware for more than two optical fibres

The optical fibre assignments shall be as shown in Figure 11 (see EN 50174-1:2009, Annex B, for further information regarding polarity maintenance).



a) 12-fibre interface



b) 24-fibre interface

Figure 11 – Optical fibre assignments for connecting hardware for 12 and 24 optical fibres (front view of fixed or free connector)

9 Requirements for cords and jumpers

9.1 General

The performance of channels is dependent upon the performance of cords and jumper cables. The moves, additions and changes made using cords and jumpers represent a greater risk to operational channel performance than that of fixed installed cables.

This clause defines the requirements for terminated cables used as part of generic cabling channels. Jumpers shall be in accordance with the requirements of Clause 7.

The use of cables and connecting hardware suitable for use when subject to certain environmental conditions does not automatically assure that the cord meets the applicable transmission performance of this clause when subjected to those environment conditions.

9.2 Operating environment

For each M, I, C or E group, the classification of a given environment shall be determined by the most demanding parameter within the M, I, C or E group. However, the selection of components shall be based on the specific demands of each of the parameters within the M, I, C or E group, which may be less demanding than the overall classification of the group.

In general, conformance to the limits and test methods specified by this clause, and product specifications referenced in it, for individual transmission parameters cannot be considered to provide assurance of performance when simultaneously subjected to the full range of environmental conditions of a given environmental classification.

It is assumed that if a channel is constructed entirely of components meeting requirements based on a $M_1I_1C_1E_1$ classification according to the reference implementations of Clause 6 then the required channel transmission performance is achieved in a $M_1I_1C_1E_1$ environment based upon a statistical approach of performance modelling.

The maintenance of functional performance under specific combinations of environmental conditions within a given environmental classification of Table 3 should be indicated by the supplier. Agreement shall be reached between customer and supplier that the product maintains functional performance when subjected to specific combinations of environmental conditions.

9.3 Balanced cords

9.3.1 General

This subclause specifies the minimum requirements for balanced cords used to create channels specified in the standards in the EN 50173 series.

A cord shall be assembled using cables in accordance with 7.3.

Connections used shall meet the requirements of Clause 8 with the exception of the equipment connectors used on cords that lie outside the scope of this standard.

Where cords are not pre-manufactured:

a) the cable shall be fitted to the connections following the procedures and using the tools specified by the manufacturers of the connections;
b) where screened cables and connections are used, the cable screen shall be connected according to the connection manufacturers' instructions.

The connections and the interconnected pin assignment shall be in accordance with the intended use of the cord and shall be a logical extension to the cabling interface(s) to which it is to be connected.

9.3.2 Cable insertion loss

Most EN 60603-7 connecting hardware are limited to maximum insulated conductor diameters of 1,02 mm. For cables containing stranded conductors the insulated conductor diameter influences the maximum conductor diameter for a given cable construction which in turn affects the insertion loss of the cable.

The maximum insertion loss ratio of flexible cables in accordance with 7.3, defined as their insertion loss (dB/100 m) compared to that of installation cables, is 1,5. However, cable constructions having insertion loss ratios below 1,5 are supported by the reference implementation rules of standards in the EN 50173 series.

The maintenance of channel performance requires that flexible cables of the correct insertion loss ratio shall be used as defined by the implementation rules.

9.3.3 Identification

Each cord shall be identified to indicate:

a) the length;
b) the design insertion loss ratio of the cable;
c) the Category of cable;
d) wire-map status where a direct pin-pin relationship does not exist (i.e. cross-over cords).

9.3.4 Environmental performance requirements for patch cords

Detail specifications based upon the blank detail specification EN 61935-2-X shall be used to specify cord performance requirements under the environmental classifications of Table 3. Table 72 shows the elements of Table 3 that are not covered by these blank detail specifications and which have to be specified separately.

Table 72 – Environmental performance specifications for balanced cords (in addition to EN 61935-2-X)

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Tensile strength, free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	
Cable clamp resistance to cable torsion	[a]	[a]	[a]	
Cable clamp resistance to rotation	[a]	[a]	[a]	
Bending and flexing	[a]	[a]	[a]	
ffs				
Ingress	**I_1**	**I_2**	**I_3**	
ffs				
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Oil resistance	As required	As required	As required	
ffs				
Electromagnetic	**E_1**	**E_2**	**E_3**	
ffs				
[a] Cords shall maintain functional performance during exposure to the relevant environmental conditions described in Table 3.				
NOTE Although not contained in Table 3 “weld spatter” may also be considered during the development of a detail specification.				

9.3.5 Electrical performance requirements for patch cords

9.3.5.1 Return loss

Cords shall meet the return loss requirements specified in Table 73 with an accuracy of one decimal place when measured in accordance with EN 61935-2.

Table 73 – Return loss requirements for cords

Category	**Frequency** MHz	**Minimum return loss** dB
5	$1 \leq f < 25$	$19{,}8 + 3 \times \lg f$
	$25 \leq f \leq 100$	$38 - 10 \times \lg f$
6	$1 \leq f < 25$	$19{,}8 + 3 \times \lg f$
	$25 \leq f \leq 250$	$38 - 10 \times \lg f$
6_A	$1 \leq f < 25$	$19{,}8 + 3 \times \lg f$
	$25 \leq f < 250$	$38 - 10 \times \lg f$
	$250 \leq f \leq 500$	$14 - 15 \times \lg\left(\frac{f}{250}\right)$
7	$1 \leq f < 25$	$19{,}8 + 3 \times \lg f$
	$25 \leq f \leq 600$	$38 - 10 \times \lg f$
7_A	$1 \leq f < 25$	$19{,}8 + 3 \times \lg f$
	$25 \leq f \leq 1\,000$	$38 - 10 \times \lg f$, 10,0 min.
NOTE Return loss values below 4 MHz are for information only.		

9.3.5.2 Near-end crosstalk loss (NEXT)

Cords shall meet the requirements calculated according to equation (16) when measured in accordance with EN 61935-2.

$$\alpha_{NEXT,cord}(L) = -10 \times \lg\left(10^{\frac{-\alpha_{NEXT,con}}{10}} + 10^{\left(\frac{-\alpha_{NEXT,cab} - 2\times\alpha_{con}}{10}\right)}\right) - RFEXT \quad (16)$$

where

$\alpha_{NEXT,cord}(L)$	is the NEXT of the entire cord in dB;
$\alpha_{NEXT,con}$	is the NEXT of the connectors in dB;
$\alpha_{NEXT,cab}$	is the NEXT of the cable itself in dB;
α_{con}	is the insertion loss of one connector in dB;
$RFEXT$	is the reflected FEXT.

The NEXT of the connectors is determined by Equation (17):

$$\alpha_{NEXT,con} = -20 \times \lg\left(10^{\frac{-\alpha_{NEXT,local}}{20}} + 10^{\left(\frac{-\alpha_{NEXT,remote} - 2\times(\alpha_L + \alpha_{con})}{20}\right)}\right) \quad (17)$$

where

$\alpha_{NEXT,local}$	is the NEXT of the connector at the local end of the cord in dB;
$\alpha_{NEXT,remote}$	is the NEXT of the connector at the remote end of the cord in dB;
α_L	is the length corrected insertion loss of the cable in dB;
α_{con}	is the insertion loss of the connector in dB.

The length corrected insertion loss of the cable is given by Equation (18):

$$\alpha_L = \alpha_{cab} \times \frac{L}{100} \quad (18)$$

where

L	is the length of the cable in the cord;
α_{cab}	is the insertion loss of 100 m of the cable used for the cord.

The length corrected NEXT of the cable of the cord is given by Equation (19):

$$\alpha_{NEXT,cab}(L) = \alpha_{NEXT,cab} - 10 \times \lg\left(\frac{1 - 10^{\frac{-\alpha_L}{5}}}{1 - 10^{\frac{-\alpha_{cab}}{5}}}\right) \quad (19)$$

Calculations yielding NEXT limits in excess of 65 dB shall revert to a limit of 65 dB.

Requirements for cords of Category 5, 6, 6_A, 7 and 7_A are calculated using the variables shown in Table 74. Table 75, Table 76 and Table 77 contain informative values of NEXT at key frequencies for different lengths of cords.

Table 74 – Component performance formulae used to derive limits for cord NEXT

	Category	Variable	Value [a] dB	
	5	α_{con}	0	
	Other	$\alpha_{NEXT,local} = \alpha_{NEXT,remote}$	0,5	
Cable	**5**	α_{cab}	$1{,}5 \times (1{,}9108 \times \sqrt{f} + 0{,}0222 \times f + 0{,}2/\sqrt{f})$	
		$\alpha_{NEXT,cab}$	$65{,}3 - 15 \times \lg(f)$	
	6	α_{cab}	$1{,}5 \times (1{,}82 \times \sqrt{f} + 0{,}0169 \times f + 0{,}25/\sqrt{f})$	
		$\alpha_{NEXT,cab}$	$74{,}3 - 15 \times \lg(f)$	
	6_A	α_{cab}	$1{,}5 \times (1{,}82 \times \sqrt{f} + 0{,}0091 \times f + 0{,}25/\sqrt{f})$	
		$\alpha_{NEXT,cab}$	$74{,}3 - 15 \times \lg(f)$	
	7	α_{cab}	$1{,}5 \times (1{,}80 \times \sqrt{f} + 0{,}01 \times f + 0{,}2/\sqrt{f})$	
		$\alpha_{NEXT,cab}$	$102{,}4 - 15 \times \lg(f)$	
	7_A	α_{cab}	$1{,}5 \times (1{,}8 \times \sqrt{f} + 0{,}005 \times f + 0{,}25/\sqrt{f})$	
		$\alpha_{NEXT,cab}$	$105{,}4 - 15 \times \lg(f)$	
Connecting hardware	**5**	α_{con}	$0{,}04 \times \sqrt{f}$	
		$\alpha_{NEXT,local} = \alpha_{NEXT,remote}$	$87 - 20 \times \lg(f)$	
	6	α_{con}	$0{,}02 \times \sqrt{f}$	
		$\alpha_{NEXT,local} = \alpha_{NEXT,remote}$	$94 - 20 \times \lg(f)$	
	6_A	α_{con}	$0{,}02 \times \sqrt{f}$	
		$\alpha_{NEXT,local} = \alpha_{NEXT,remote}$	≤ 250 MHz	$94 - 20 \times \lg(f)$
			> 250 MHz	$46{,}04 - 30 \times \lg(f/250)$
	7	α_{con}	$0{,}02 \times \sqrt{f}$	
		$\alpha_{NEXT,local} = \alpha_{NEXT,remote}$	$102{,}4 - 15 \times \lg(f)$	
	7_A	α_{con}	$0{,}02 \times \sqrt{f}$	
		$\alpha_{NEXT,local} = \alpha_{NEXT,remote}$	≤ 600 MHz	$116{,}3 - 20 \times \lg(f)$
			> 600 MHz	$60{,}73 - 40 \times \lg(f/600)$

[a] All equations apply from 1 MHz to the upper frequency of the category unless otherwise indicated.

Table 75 – Minimum NEXT for 2 m cords at key frequencies

Frequency MHz	Minimum NEXT (2 m cords) dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Category 5	N/A	65,0	54,2	39,0	N/A	N/A	N/A	N/A
Category 6	N/A	65,0	61,6	46,2	38,7	N/A	N/A	N/A
Category 6_A	N/A	65,0	61,6	46,2	38,7	31,0	N/A	N/A
Category 7	N/A	65,0	65,0	65,0	60,7	56,5	55,4	N/A
Category 7_A	N/A	65,0	65,0	65,0	62,6	57,1	55,6	47,4

Table 76 – Minimum NEXT for 5 m cords at key frequencies

Frequency MHz	Minimum NEXT (5 m cords) dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Category 5	N/A	65,0	52,1	37,4	N/A	N/A	N/A	N/A
Category 6	N/A	65,0	60,0	45,1	38,0	N/A	N/A	N/A
Category 6_A	N/A	65,0	60,0	45,1	38,0	31,3	N/A	N/A
Category 7	N/A	65,0	65,0	65,0	61,2	57,2	56,2	N/A
Category 7_A	N/A	65,0	65,0	65,0	63,3	58,0	56,7	48,9

Table 77 – Minimum NEXT for 10 m cords at key frequencies

Frequency MHz	Minimum NEXT (10 m cords) dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Category 5	N/A	65,0	50,4	36,4	N/A	N/A	N/A	N/A
Category 6	N/A	65,0	58,4	44,2	37,6	N/A	N/A	N/A
Category 6_A	N/A	65,0	58,5	44,2	37,6	31,7	N/A	N/A
Category 7	N/A	65,0	65,0	65,0	61,9	58,0	57,0	N/A
Category 7_A	N/A	65,0	65,0	65,0	64,1	59,1	57,8	50,2

9.4 Coaxial cords

Cords shall be in accordance with EN 60966-2-4, EN 60966-2-5 or EN 60966-2-6.

9.5 Optical fibre cords

9.5.1 General requirements

This subclause specifies the minimum requirements for optical fibre cords used to create channels specified in the standards in the EN 50173 series.

A cord shall be assembled using cables in accordance with 7.7.

Connections used shall meet the requirements of Clause 8 with the exception of the equipment connectors used on cords that lie outside the scope of this standard.

Where cords are not pre-manufactured, the cable shall be fitted to the connections following the procedures and using the tools specified by the manufacturers of the connections.

The connections and the means of maintaining polarity shall be in accordance with the intended use of the cord and shall be a logical extension to the cabling interface(s) to which it is to be connected.

9.5.2 Identification

Each cord shall be identified to indicate:

a) the length;
b) the core diameter;
c) the Category of cable;
d) the port-map status where a direct port to port relationship does not exist (i.e. cross-over cords).

9.5.3 Environmental performance requirements for patch cords

Detail specifications based upon the blank detail specification EN 61753-X shall be used to specify cord performance requirements under the environmental classifications of Table 3. Table 78 shows the elements of Table 3 that are not covered by these blank detail specifications and which have to be specified separately.

Table 78 – Environmental performance specifications for optical fibre cords (in addition to EN 61753-X)

Mechanical	M_1	M_2	M_3	Reference
Tensile strength, free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	
Cable clamp resistance to cable torsion	[a]	[a]	[a]	
Cable clamp resistance to rotation	[a]	[a]	[a]	
Bending and flexing	[a]	[a]	[a]	
ffs				
Ingress	I_1	I_2	I_3	
ffs				
Climatic and chemical	C_1	C_2	C_3	
Oil resistance	As required	As required	As required	
ffs				
Electromagnetic	E_1	E_2	E_3	
ffs				
[a] Cords shall maintain functional performance during exposure to the relevant environmental conditions described in Table 3.				
NOTE Although not contained in Table 3 “weld spatter” may also be considered during the development of a detail specification.				

9.5.4 All-silica optical fibre cords

Optical fibre cables used for cords shall meet the generic specification EN 60794-1-1, the test methods EN 60794-1-2 and the sectional specifications as defined in 7.7.1.

Connecting hardware used shall meet the requirements of Clause 8 with the exception of the equipment connectors on cords that lie outside the scope of this standard. The cable shall be fitted to the connections following the procedures and using the tools specified by the manufacturers of the connections. The connecting hardware and the means of maintaining polarity within the cord shall be in accordance with the intended use of the cord and shall be a logical extension to the cabling interface(s) to which it is to be connected.

9.5.5 Plastic optical fibre cords

ffs

9.5.6 Plastic clad silica optical fibre cords

ffs

Annex A
(normative)

Link performance limits

A.1 Balanced cabling

A.1.1 General

This annex contains performance requirement formulae for permanent links and sub-links as shown in Figure A.1.

The cabling under test in Configurations A and B is termed the permanent link and may be either in the backbone or in the premises-specific cabling subsystems defined in the other standards within the EN 50173 series. The designation of interface X is dependent upon the applicable cabling subsystem.

The cabling under test in Configuration C may be found in the premises-specific cabling subsystems defined in the other standards within the EN 50173 series and is also termed the permanent link. The Configuration C permanent link comprises a fixed cabling element and a cord. The designation of interfaces X and Y is dependent upon the applicable cabling subsystem. Measurements made for this configuration are invalid if the cord is changed.

The cabling under test in Configuration D is the fixed cabling element of the permanent link in Configuration C. The name applied to this link is defined in the premises-specific cabling subsystems defined in the other standards within the EN 50173 series. The difference between the links of Configurations C and D (and the associated link specifications) is that the Configuration D link is assumed to be extended, in the future, to a Configuration C link by the addition of cabling components.

In all configurations the test configuration reference plane of a link is within the test cord cable next to, and including, the test cord connection which mates to the termination point of the link under test.

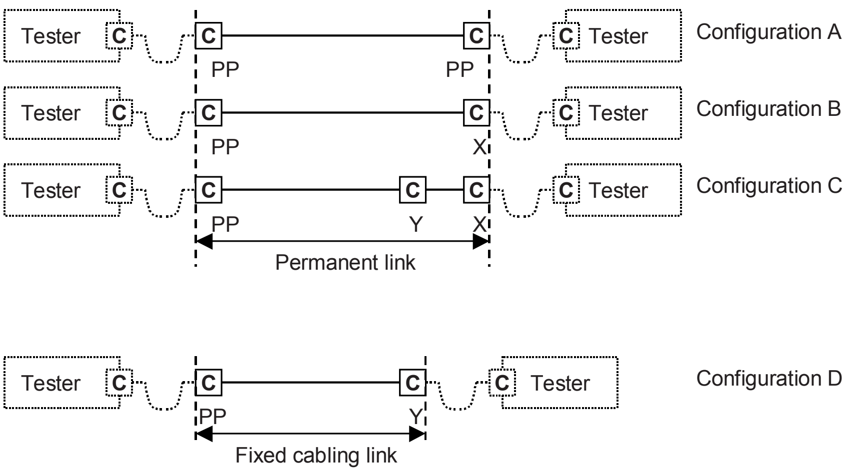


Figure A.1 – Link options

This clause contains performance requirement formulae for installed balanced cabling links. Annex B contains values derived from the formulae at key frequencies for permanent links and is for information only.

The parameters specified in this Annex apply to balanced links with screened or unscreened cable elements, with or without an overall screen, unless explicitly stated otherwise.

The nominal impedance of links is 100 Ω. This is achieved by suitable design, and appropriate choice of cabling components (irrespective of their nominal impedance). The link performance specification of the relevant Class shall be met for all temperatures at which the cabling is intended to operate.

Consideration should be given to measuring performance at worst case temperatures, or calculating worst case performance based on measurements made at other temperatures.

NOTE The term "attenuation" is used in A.1.2 and A.3 since it is common usage within the cabling industry. However, the correct term is insertion loss which includes the effect of impedance variations both with and between the cabling components in the link.

A.1.2 Link limits

A.1.2.1 Return loss

The return loss of each pair of the link shall meet the limits computed, to one decimal place, using the formulae of Table A.1. The return loss shall be measured according to 5.2.2.2.

Table A.1 – Formulae for return loss limits for a link

Class	Frequency MHz	Minimum return loss dB
C	$1 \leq f \leq 16$	15,0
D	$1 \leq f < 20$	19,0
	$20 \leq f \leq 100$	$32 - 10 \times \lg f$
E	$1 \leq f < 10$	21,0
	$10 \leq f < 40$	$26 - 5 \times \lg f$
	$40 \leq f \leq 250$	$34 - 10 \times \lg f$
E_A	$1 \leq f < 10$	21,0
	$10 \leq f < 40$	$26 - 5 \times \lg f$
	$40 \leq f < 398{,}1$	$34 - 10 \times \lg f$
	$398{,}1 \leq f \leq 500$	8,0
F	$1 \leq f < 10$	21,0
	$10 \leq f < 40$	$26 - 5 \times \lg f$
	$40 \leq f < 251{,}2$	$34 - 10 \times \lg f$
	$251{,}2 \leq f \leq 600$	10,0
F_A	$1 \leq f < 10$	21,0
	$10 \leq f < 40$	$26 - 5 \times \lg f$
	$40 \leq f < 251{,}2$	$34 - 10 \times \lg f$
	$251{,}2 \leq f < 631$	10,0
	$631 \leq f \leq 1\,000$	$38 - 10 \times \lg f$
BCT-B	$4 \leq f < 10$	21,0
	$10 \leq f < 100$	$27{,}6 - 6{,}3 \times \lg f$
	$100 \leq f < 251{,}2$	$25 - 5 \times \lg f$
	$251{,}2 \leq f < 600$	$25{,}7 - 5{,}3 \times \lg f$
	$600 \leq f \leq 1\,000$	$36 - 9 \times \lg f$

For all configurations of Figure A.1, values of return loss at frequencies for which the measured insertion loss is below 3,0 dB are for information only.

A.1.2.2 Insertion loss

Where the maximum lengths of channel components to be added to the link are unknown, the insertion loss of each pair of the link shall meet the limits computed, to one decimal place, using the formulae of Table A.2. See 5.2.2.3 for details of measurement.

Table A.2 – Formulae for insertion loss limits for a link

Class	**Frequency** MHz	**Maximum insertion loss** dB
A	f = 0,1	16,0
B	f = 0,1	5,5
	f = 1	5,8
C	$1 \leq f \leq 16$	$0{,}9\times\left(3{,}23\sqrt{f}\right)+3\times 0{,}2$
D	$1 \leq f \leq 100$	$(L/100)\times\left(1{,}9108\times\sqrt{f}+0{,}0222\times f+0{,}2/\sqrt{f}\right)+n\times 0{,}04\times\sqrt{f}$, 4,0 min.
E	$1 \leq f \leq 250$	$(L/100)\times\left(1{,}82\times\sqrt{f}+0{,}0169\times f+0{,}25/\sqrt{f}\right)+n\times 0{,}02\times\sqrt{f}$, 4,0 min.
E_A	$1 \leq f \leq 500$	$(L/100)\times\left(1{,}82\times\sqrt{f}+0{,}0091\times f+0{,}25/\sqrt{f}\right)+n\times 0{,}02\times\sqrt{f}$, 4,0 min.
F	$1 \leq f \leq 600$	$(L/100)\times\left(1{,}8\times\sqrt{f}+0{,}01\times f+0{,}2/\sqrt{f}\right)+n\times 0{,}02\times\sqrt{f}$, 4,0 min.
F_A	$1 \leq f \leq 1\,000$	$(L/100)\times\left(1{,}8\times\sqrt{f}+0{,}005\times f+0{,}25/\sqrt{f}\right)+n\times 0{,}02\times\sqrt{f}$
CCCB	f = 0,1	4,0
BCT-B-L	$1 \leq f \leq 1\,000$	$(L/100)\times\left(1{,}645\times\sqrt{f}+0{,}01\times f+0{,}25/\sqrt{f}\right)+n\times 0{,}02\times\sqrt{f}$, 2,0 min.
BCT-B-M		
BCT-B-H		

where $L = L_{FC} + L_C \times Y$;

L_{FC} is the length of fixed cable (m);

L_C is the length of Configuration C cord (where present) (m);

Y is the ratio of Configuration C cord cable insertion loss (dB/m) to fixed cable insertion loss (dB/m) (see Clause 9);

n is the number of connection (n = 2 for Configurations A, B and D, n = 3 for Configuration C).

Configurations A, B, C and D refer to the configurations shown in A.1.

Where the maximum lengths of channel components to be added to the link are known and specified for the cabling, the margin between the measured value of insertion loss of the link and the channel limits of Table 6 shall exceed the total insertion loss of:

a) the specified maximum lengths of cords used to create the channel;

b) the specified maximum lengths of any additional cables and connections, where appropriate, used to create the channel.

A.1.2.3 Near end crosstalk loss (NEXT)

A.1.2.3.1 Pair-to-pair NEXT

The NEXT between each pair combination of the link shall meet the limits computed, to one decimal place, using the formulae of Table A.3. The NEXT shall be measured according to 5.2.2.4.1.

Table A.3 – Formulae for NEXT limits for a link

Class	Frequency MHz	Minimum NEXT[a] dB
A	$f = 0,1$	27,0
B	$0,1 \le f \le 1$	$25,0 - 15 \times \lg f$
C	$1 \le f \le 16$	$40,1 - 15,8 \times \lg f$
D	$1 \le f \le 100$	$-20 \times \lg\left(10^{\frac{65,3 - 15 \times \lg f}{-20}} + 10^{\frac{83 - 20 \times \lg f}{-20}}\right)$, 60,0 max.
E	$1 \le f \le 250$	$-20 \times \lg\left(10^{\frac{74,3 - 15 \times \lg f}{-20}} + 10^{\frac{94 - 20 \times \lg f}{-20}}\right)$, 65,0 max.
E_A	$1 \le f < 300$	$-20 \times \lg\left(10^{\frac{74,3 - 15 \times \lg f}{-20}} + 10^{\frac{94 - 20 \times \lg f}{-20}}\right)$, 65,0 max.
	$300 \le f \le 500$	$87,46 - 21,57 \times \lg f$ [b, c]
F	$1 \le f \le 600$	$-20 \times \lg\left(10^{\frac{102,4 - 15 \times \lg f}{-20}} + 10^{\frac{102,4 - 15 \times \lg f}{-20}}\right)$, 65,0 max.
F_A [d]	$1 \le f < 600$	$106,1 - 18,5 \times \lg f$, 65,0 max.
	$600 \le f \le 1\,000$	$124,85 - 25,25 \times \lg f$ [e, f]

[a] The terms in the equations are not intended to imply component performance.

[b] For Configuration C, this equation is 102,22 – 27,54 lg f.

[c] For Configurations A, B or D, where the permanent link insertion loss at 450 MHz is less than 12 dB, the requirement is educed by 1,4((f – 450)/50) for $f \ge 450$ MHz.

[d] When using connecting hardware with enhanced performance at connection Y (see Figure A.1 and 8.2.4.2), Configuration D requirements do not apply, and the Configuration C permanent link is the means of conformance.

[e] For Configuration C, this equation is 139,7 – 30,6 lg f.

[f] For Configurations A, B or D, where the permanent link insertion loss at 450 MHz is less than 17 dB, the requirement is reduced by 2,8((f – 900)/100) for $f \ge 900$ MHz.

Configurations A, B, C and D refer to the configurations shown in A.1.

Values of NEXT at frequencies for which the measured link attenuation is below 4,0 dB are for information only.

A.1.2.3.2 Power sum NEXT (PSNEXT)

The PSNEXT for each pair of the link shall meet or exceed the limits computed, to one decimal place, using the formulae of Table A.4. The PSNEXT shall be measured according to 5.2.2.4.2.

Table A.4 – Formulae for PSNEXT limits for a link

Class	**Frequency** MHz	**Minimum PSNEXT** [a] dB
D	$1 \le f \le 100$	$-20\times\lg\left(10^{\frac{62{,}3-15\times\lg f}{-20}}+10^{\frac{80-20\times\lg f}{-20}}\right)$, 57,0 max.
E	$1 \le f \le 250$	$-20\times\lg\left(10^{\frac{72{,}3-15\times\lg f}{-20}}+10^{\frac{90-20\times\lg f}{-20}}\right)$, 62,0 max.
E_A	$1 \le f < 300$	$-20\times\lg\left(10^{\frac{74{,}3-15\times\lg f}{-20}}+10^{\frac{94-20\times\lg f}{-20}}\right)$, 65,0 max.
	$300 \le f \le 500$	$87{,}46-21{,}57\times\lg f$ [b, c]
F	$1 \le f \le 600$	$-20\times\lg\left(10^{\frac{99{,}4-15\times\lg f}{-20}}+10^{\frac{99{,}4-15\times\lg f}{-20}}\right)$, 62,0 max.
F_A [d]	$1 \le f < 600$	$103{,}1-18{,}5\times\lg f$, 62,0 max.
	$600 \le f \le 1\,000$	$121{,}85-25{,}25\times\lg f$ [e, f]

[a] The terms in the equations are not intended to imply component performance.

[b] For Configuration C, this equation is $104{,}65 - 29{,}57 \times \lg f$.

[c] For Configurations A, B or D, where the permanent link insertion loss at 450 MHz is less than 12 dB, the requirement is reduced by $1{,}4((f - 450)/50)$ for $f \ge 450$ MHz.

[d] When using connecting hardware with enhanced performance at connection Y (see Figure A.1 and 8.2.4.2), Configuration D requirements do not apply, and the Configuration C permanent link is the means of conformance.

[e] For Configuration C, this equation is $136{,}7 - 30{,}6 \times \lg f$.

[f] For Configurations A, B or D, where the permanent link insertion loss at 450 MHz is less than 17 dB, the requirement is reduced by $2{,}8((f - 900)/100)$ for $f \ge 900$ MHz.

Configurations A, B, C and D refer to the configurations shown in A.1.

Values of PSNEXT at frequencies for which the measured link attenuation is below 4,0 dB are for information only.

A.1.2.4 Attenuation to crosstalk loss ratio at the near-end (ACR-N)

A.1.2.4.1 Pair-to-pair ACR-N

The ACR-N for each pair combination of the link shall meet the limits calculated from the relevant NEXT and insertion loss formulae.

A.1.2.4.2 Power sum ACR-N (PSACR-N)

The PSACR-N for all pairs of the link shall meet the limits calculated from the relevant PSNEXT and insertion loss formulae.

A.1.2.5 Attenuation to crosstalk loss ratio at the far-end (ACR-F)

A.1.2.5.1 Pair-to-pair ACR-F

The ACR-F for each pair combination of the link shall meet the limits computed, to one decimal place, using the formulae of Table A.5. The ACR-F shall be measured according to 5.2.2.6.1.

Table A.5 – Formulae for ACR-F limits for a link

Class	**Frequency** MHz	**Minimum ACR-F** [a, b] dB
D	$1 \leq f \leq 100$	$-20\times\lg\left(10^{\frac{63{,}8-20\times\lg f}{-20}}+n\times10^{\frac{75{,}1-20\times\lg f}{-20}}\right)$
E	$1 \leq f \leq 250$	$-20\times\lg\left(10^{\frac{67{,}8-20\lg f}{-20}}+n\times10^{\frac{83{,}1-20\times\lg f}{-20}}\right)$
E_A	$1 \leq f \leq 500$	$-20\times\lg\left(10^{\frac{67{,}8-20\lg f}{-20}}+n\times10^{\frac{83{,}1-20\times\lg f}{-20}}\right)$
F	$1 \leq f \leq 600$	$-20\times\lg\left(10^{\frac{94-20\times\lg f}{-20}}+n\times10^{\frac{90-15\times\lg f}{-20}}\right)$, 65,0 max.
F_A	$1 \leq f \leq 1\,000$	$-20\times\lg\left(10^{\frac{95{,}3-20\times\lg f}{-20}}+n\times10^{\frac{103{,}9-20\times\lg f}{-20}}\right)$, 65,0 max.
where	n = 2 for Configurations A, B and D shown in A.1; n = 3 for Configuration C shown in A.1.	

[a] The terms in the equations are not intended to imply component performance.

[b] ACR-F values at frequencies that correspond to measured FEXT values of greater than 70,0 dB are for information only.

A.1.2.5.2 Power sum ACR-F (PSACR-F)

The PSACR-F for each pair of the link shall meet the limits computed, to one decimal place, using the formulae of Table A.6. The PSACR-F shall be measured according to 5.2.2.6.2.

Table A.6 – Formulae for PSACR-F limits for a link

Class	**Frequency** MHz	**Minimum PSACR-F** [a, b] dB
D	$1 \leq f \leq 100$	$-20 \times \lg\left(10^{\frac{60,8 - 20 \times \lg f}{-20}} + n \times 10^{\frac{72,1 - 20 \times \lg f}{-20}}\right)$
E	$1 \leq f \leq 250$	$-20 \times \lg\left(10^{\frac{64,8 - 20 \times \lg f}{-20}} + n \times 10^{\frac{80,1 - 20 \times \lg f}{-20}}\right)$
E_A	$1 \leq f \leq 500$	$-20 \times \lg\left(10^{\frac{64,8 - 20 \times \lg f}{-20}} + n \times 10^{\frac{80,1 - 20 \times \lg f}{-20}}\right)$
F	$1 \leq f \leq 600$	$-20 \times \lg\left(10^{\frac{91 - 20 \times \lg f}{-20}} + n \times 10^{\frac{87 - 15 \times \lg f}{-20}}\right)$, 62,0 max.
F_A	$1 \leq f \leq 1\,000$	$-20 \times \lg\left(10^{\frac{92,3 - 20 \times \lg f}{-20}} + n \times 10^{\frac{100,9 - 20 \times \lg f}{-20}}\right)$, 62,0 max.

where n = 2 for Configurations A, B and D shown in A.1;
n = 3 for Configuration C shown in A.1.

[a] The terms in the equations are not intended to imply component performance.

[b] PSACR-F values at frequencies that correspond to measured FEXT values of greater than 70,0 dB are for information only.

A.1.2.6 Direct current (d.c.) loop resistance

Where the maximum lengths of channel components to be added to the link are unknown, the d.c. loop resistance of each pair of the link shall be less than the values given in Table A.7 for each Class of application. See 5.2.2.7 for details of measurement.

Table A.7 – Direct current (d.c.) loop resistance limits for a link

Class	Maximum d.c. loop resistance Ω
A	530
B	140
C	34
D	$(L/100) \times 22 + n \times 0,4$
E	$(L/100) \times 22 + n \times 0,4$
E_A	$(L/100) \times 22 + n \times 0,4$
F	$(L/100) \times 22 + n \times 0,4$
F_A	$(L/100) \times 22 + n \times 0,4$
CCCB	8,0
where	$L = L_{FC} + L_C \times Y$; L_{FC} is the length of fixed cable (m); L_C is the length of Configuration C cord (where present) (m); Y is the ratio of Configuration C cord cable insertion loss (dB/m) to fixed cable insertion loss (dB/m) (see Clause 9); n = 2 for Configurations A, B and D; n = 3 for Configuration C.
Configurations A, B, C and D refer to the configurations shown in A.1.	

Where the maximum lengths of channel components to be added to the link are known and specified for the cabling, the margin between the measured value of d.c. loop resistance of the link and the channel limits of Table 18 shall exceed the total d.c. loop resistance of:

a) the specified maximum lengths of cords used to create the channel;

b) the specified maximum lengths of any additional cables and connections, where appropriate, used to create the channel.

This requirement is considered to be met if the equivalent requirements of A.1.2.2 (insertion loss) and A.1.2.9 (delay skew) are also met.

A.1.2.7 Direct current (d.c.) resistance unbalance

The d.c. resistance unbalance between the two conductors within each pair of a link shall meet the limits given in Table A.8. See 5.2.2.8 for details of measurement.

Table A.8 – d.c. resistance unbalance limits for a link

Class	Maximum d.c. resistance unbalance [a] %
A	3,0 %
B	3,0 %
C	3,0 %
D	3,0 %
E	3,0 %
E_A	3,0 %
F	3,0 %
F_A	3,0 %
CCCB	3,0 %[b]

[a] Subject to a minimum measured value of 150 mΩ

[b] Where channels are required to provide power feeding this value shall be reduced to 1,5 %.

A.1.2.8 Propagation delay

Where the maximum lengths of channel components to be added to the link are unknown, the maximum propagation delay of each pair in the link shall not exceed the limits computed, to three decimal places, using the formulae of Table A.9. See 5.2.2.11 for details of measurement.

Where the maximum lengths of channel components to be added to the link are known and specified for the cabling, the margin between the measured value propagation delay of the link and the channel limits of Table 20 shall exceed the total propagation delay of:

a) the specified maximum lengths of cords used to create the channel;

b) the specified maximum lengths of any additional cables and connections, where appropriate, used to create the channel.

This requirement is considered to be met if the equivalent requirements of A.1.2.2 (insertion loss) and A.1.2.9 (delay skew) are also met.

Table A.9 – Propagation delay formulae for a link

Class	**Frequency** MHz	**Maximum propagation delay** µs
A	$f = 0,1$	19,400
B	$0,1 \leq f \leq 1$	4,400
C	$1 \leq f \leq 16$	$(L/100) \times \left(0,534 + 0,036/\sqrt{f}\right) + n \times 0,0025$
D	$1 \leq f \leq 100$	$(L/100) \times \left(0,534 + 0,036/\sqrt{f}\right) + n \times 0,0025$
E	$1 \leq f \leq 250$	$(L/100) \times \left(0,534 + 0,036/\sqrt{f}\right) + n \times 0,0025$
E_A	$1 \leq f \leq 500$	$(L/100) \times \left(0,534 + 0,036/\sqrt{f}\right) + n \times 0,0025$
F	$1 \leq f \leq 600$	$(L/100) \times \left(0,534 + 0,036/\sqrt{f}\right) + n \times 0,0025$
F_A	$1 \leq f \leq 1\,000$	$(L/100) \times \left(0,534 + 0,036/\sqrt{f}\right) + n \times 0,0025$
CCCB	$f = 0,1$	1,000
BCT-B	$1 \leq f \leq 1\,000$	$(L/100) \times \left(0,534 + 0,036/\sqrt{f}\right) + n \times 0,0025$
where $L = L_{FC} + L_C$; L_{FC} is the length of fixed cable (m); L_C is the length of Configuration C cord (where present) (m); n = 2 for Configurations A, B and D; n = 3 for Configuration C.		
Configurations A, B, C and D refer to the configurations shown in A.1.		

A.1.2.9 Delay skew

Where the maximum lengths of channel components to be added to the link are unknown, the maximum delay skew between the pairs in the link shall not exceed the limits computed, to three decimal places, using the formulae of Table A.10. See 5.2.2.12 for details of measurement.

Table A.10 – Delay skew formulae for a link

Class	Maximum delay skew µs
C	$(L/100)\times 0{,}045 + n\times 0{,}001\,25$
D	$(L/100)\times 0{,}045 + n\times 0{,}001\,25$
E	$(L/100)\times 0{,}045 + n\times 0{,}001\,25$
E_A	$(L/100)\times 0{,}045 + n\times 0{,}001\,25$
F	$(L/100)\times 0{,}025 + n\times 0{,}001\,25$
F_A	$(L/100)\times 0{,}045 + n\times 0{,}001\,25$
where	$L = L_{FC} + L_C$; L_{FC} length of fixed cable (m); L_C length of Configuration C cord (where present) (m); n = 2 for Configurations A, B and D; n = 3 for Configuration C.
Configurations A, B, C and D refer to the configurations shown in A.1.	

Where the maximum lengths of channel components to be added to the link are known and specified for the cabling, the margin between the measured value of delay skew of the link and the channel limits of Table 22 shall exceed the total delay skew of:

a) the specified maximum lengths of cords used to create the channel;

b) the specified maximum lengths of any additional cables and connections, where appropriate, used to create the channel.

A.1.2.10 Transverse conversion loss (TCL)

The TCL of each pair of a link constructed of unscreened cabling components that is subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 24 (ffs).

The TCL of each pair of a link constructed of screened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The TCL requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware.

A.1.2.11 Equal level transverse conversion transfer loss (ELTCTL)

The ELTCTL of each pair of a link constructed of unscreened cabling components that is subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 26 (ffs).

The ELTCTL of each pair of a link constructed of screened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The ELTCTL requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware.

A.1.2.12 Coupling attenuation

The coupling attenuation of each pair of a link constructed of screened cabling components that is subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 28 (ffs).

The coupling attenuation of each pair of a link constructed of unscreened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The coupling attenuation requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware.

A.1.2.13 Alien NEXT (ANEXT)

A.1.2.13.1 Power sum alien NEXT (PSANEXT)

The PSANEXT of each pair of a link shall meet the limits computed, to one decimal place, using the formulae of Table A.11. The ANEXT shall be measured according to 5.2.2.16.1.

The PSANEXT requirements of Classes E_A and F in Table A.11 are met by design if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

The PSANEXT requirements of Class F_A in Table A.11 are met by design if the coupling attenuation is at least 25 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

Table A.11 – Formulae for PSANEXT limits for a link

Class	Frequency MHz	Minimum PSANEXT dB
E_A	$1 \le f < 100$	$80 - 10 \times \lg f$, 67 max.
	$100 \le f \le 500$ [a]	$90 - 15 \times \lg f$
F	$1 \le f < 100$	$80 - 10 \times \lg f$, 67 max.
	$100 \le f \le 600$ [a]	$90 - 15 \times \lg f$
F_A	$1 \le f < 100$	$95 - 10 \times \lg f$, 67 max.
	$100 \le f \le 1\,000$	$105 - 15 \times \lg f$, 67 max.

[a] If the average insertion loss of all disturbed pairs at 100 MHz, $\alpha_{100MHz,avg}$, is less than 7 dB subtract

$$\text{minimum}\left\{7 \times \frac{f-100}{400} \times \frac{7-\alpha_{100MHz,avg}}{\alpha_{100MHz,avg}}, 6 \times \frac{f-100}{400}\right\}$$

where

f is the frequency in megahertz;

$\alpha_{100MHz,avg} = \frac{1}{4}\sum_{i=1}^{4}\alpha_{100MHz,i}$;

$\alpha_{100MHz,i}$ is the insertion loss of pair i at 100 MHz.

A.1.2.13.2 Average power sum alien NEXT ($PSANEXT_{avg}$)

The parameter $PSANEXT_{avg}$ is applicable to Classes E_A and F only. Adequate $PSANEXT_{avg}$ performance for Class F_A links is achieved by conformance with the PSANEXT requirements of A.1.2.13.1.

The $PSANEXT_{avg}$ of each pair of a link shall meet the limits computed, to one decimal place, using the formulae of Table A.12. The $PSANEXT_{avg}$ shall be computed according to 5.2.2.16.2.

$PSANEXT_{avg}$ of Classes E_A and F is met by design if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

Table A.12 – Formulae for $PSANEXT_{avg}$ limits for a link

Class	Frequency MHz	Minimum $PSANEXT_{avg}$ dB
E_A	$1 \leq f < 100$	$82{,}25 - 10 \times \lg f$, 67 max.
	$100 \leq f \leq 500$ [a]	$92{,}25 - 15 \times \lg f$
F	$1 \leq f < 100$	$82{,}25 - 10 \times \lg f$, 67 max.
	$100 \leq f \leq 600$[a]	$92{,}25 - 15 \times \lg f$

a If the average insertion loss of all disturbed pairs at 100 MHz, $\alpha_{100MHz,avg}$, is less than 7 dB subtract

$$\text{minimum} \left\{ 7 \times \frac{f - 100}{400} \times \frac{7 - \alpha_{100MHz,avg}}{\alpha_{100MHz,avg}}, 6 \times \frac{f - 100}{400} \right\}$$

where

f is the frequency in megahertz;

$\alpha_{100MHz,avg} = \frac{1}{4}\sum_{i=1}^{4}\alpha_{100MHz,i}$;

$\alpha_{100MHz,i}$ is the insertion loss of pair i at 100 MHz.

A.1.2.14 Alien ACR-F (AACR-F)

A.1.2.14.1 Power sum alien ACR-F (PSAACR-F)

The PSAACR-F of each pair of a link shall meet the limits computed, to one decimal place, using the formulae of Table A.13. The AFEXT and insertion loss shall be measured according to 5.2.2.17.1.

PSAACR-F of Class E_A and F is met by design if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

PSAACR-F of Class F_A is met by design if the coupling attenuation is at least 25 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

Table A.13 – Formulae for PSAACR-F limits for a link

Class	Frequency MHz	Minimum PSAACR-F dB [a]
E_A	$1 \leq f \leq 500$	$77 - 20 \times \lg f$, 67 max.
F	$1 \leq f \leq 600$	$77 - 20 \times \lg f$, 67 max.
F_A	$1 \leq f \leq 1\,000$	$92 - 20 \times \lg f$, 67 max.

[a] PSAACR-F at frequencies that correspond to calculated PSAFEXT values of greater than 67,0 dB or $102 - 15 \times \lg f$ dB shall be for information only.

A.1.2.14.2 Average power sum alien ACR-F (PSAACR-F_{avg})

The parameter PSAACR-F_{avg} is applicable to Classes E_A and F only. Adequate PSAACR-F_{avg} performance for Class F_A links is achieved by conformance with the PSAACR-F requirements of A.1.2.14.1.

The PSAACR-F_{avg} of each pair of a link shall meet the limits computed, to one decimal place, using the formulae of Table A.14. The PSAACR-F_{avg} shall be computed according to 5.2.2.17.2.

PSAACR-F_{avg} of Classes E_A and F is met by design if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table 28 (electromagnetic environmental classification E_1).

Table A.14 – Formulae for PSAACR-F_{avg} limits for a link

Class	Frequency MHz	Minimum PSAACR-F_{avg} dB [a]
E_A	$1 \leq f \leq 500$	$81 - 20 \times \lg f$, 67 max.
F	$1 \leq f \leq 600$	$81 - 20 \times \lg f$, 67 max.

[a] PSAACR-F_{avg} at frequencies that correspond to calculated PSAFEXT values of greater than 67,0 dB or $102 - 15 \times \lg f$ dB shall be for information only.

A.2 Coaxial cabling – Insertion loss

The insertion loss of each coaxial permanent link shall meet the limits computed, to one decimal place, using the formulae of Table A.15. Details of measurement are ffs.

Table A.15 – Formulae for insertion loss limits for a link

Class	Frequency MHz	Maximum insertion loss dB
BCT-C-L	$1 \le f < 100$	$0{,}3\times\left(0{,}625\times\sqrt{f}+0{,}0001\times f\right)+2\times\left(0{,}0001\times f\right)$, 2,0 min.
	$100 \le f \le 3\ 000$	$0{,}3\times\left(0{,}597\times\sqrt{f}+0{,}0026\times f\right)+2\times\left(0{,}0001\times f\right)$
BCT-C-M	$1 \le f < 100$	$0{,}69\times\left(0{,}625\times\sqrt{f}+0{,}0001\times f\right)+2\times\left(0{,}0001\times f\right)$, 2,0 min.
	$100 \le f \le 3\ 000$	$0{,}69\times\left(0{,}597\times\sqrt{f}+0{,}0026\times f\right)+2\times\left(0{,}0001\times f\right)$
BCT-C-H	$1 \le f < 100$	$0{,}96\times\left(0{,}625\times\sqrt{f}+0{,}0001\times f\right)+2\times\left(0{,}0001\times f\right)$, 2,0 min.
	$100 \le f \le 3\ 000$	$0{,}96\times\left(0{,}597\times\sqrt{f}+0{,}0026\times f\right)+2\times\left(0{,}0001\times f\right)$
NOTE The slope (difference in attenuation) between 47 MHz and 862 MHz is critical for BCT-C applications. See F.2 and CLC/TR 50173-99-2 for additional information regarding supported applications.		

A.3 Optical fibre cabling

A.3.1 All-silica optical fibre cabling

The attenuation of a link at a specified wavelength shall not exceed the sum of the specified attenuation values for the cabling components at that wavelength (where the attenuation of a length of optical fibre cable is calculated from its attenuation coefficient multiplied by its length).

Measurements made shall be consistent with the design values of cable length and cabling materials used.

The attenuation of a link shall be measured according to EN 50346.

NOTE The test methods have been developed for conventional optical fibre connection systems comprising two plugs and an adaptor. in some cases the methods are not appropriate for Small Form Factor connectors that comprise a plug and socket.

A.3.2 Plastic optical fibre cabling

ffs

A.3.3 Plastic clad silica optical fibre cabling

ffs

Annex B
(informative)

Permanent link performance limits for maximum implementations (balanced and coaxial cabling)

B.1 Balanced cabling

B.1.1 General

The values shown in Tables B.1 to B.11 are derived from the formulae in Annex A at key frequencies.

For Classes A to F_A, the values of L, Y and n are: L = 90, Y = 1 and n = 3. These conditions do not provide the most stringent values based on the requirements of Annex A.

For Classes BCT-B-L, BCT-B-M and BCT-B-H, the values of L are: $L = 7{,}8$, $L = 21$ and $L = 46$ respectively and n = 2 (Configuration C is not considered).

B.1.2 Performance limits

B.1.2.1 Return loss

Table B.1 – Return loss limits for a permanent link at key frequencies

Frequency MHz	Minimum return loss dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class C	N/A	15,0	15,0	N/A	N/A	N/A	N/A	N/A
Class D	N/A	19,0	19,0	12,0	N/A	N/A	N/A	N/A
Class E	N/A	21,0	20,0	14,0	10,0	N/A	N/A	N/A
Class E_A	N/A	21,0	20,0	14,0	10,0	8,0	N/A	N/A
Class F	N/A	21,0	20,0	14,0	10,0	10,0	N/A	N/A
Class F_A	N/A	21,0	20,0	14,0	10,0	10,0	10,0	8,0
Class BCT-B	N/A	21,0	20,0	15,0	13,0	11,4	11,0	9,0

B.1.2.2 Insertion loss

Table B.2 – Insertion loss limits for a permanent link at key frequencies

Frequency MHz	**Maximum insertion loss** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class A	16,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class B	5,5	5,8	N/A	N/A	N/A	N/A	N/A	N/A
Class C	N/A	4,2	12,2	N/A	N/A	N/A	N/A	N/A
Class D	N/A	4,0	7,7	20,4	N/A	N/A	N/A	N/A
Class E	N/A	4,0	7,1	18,5	30,7	N/A	N/A	N/A
Class E_A	N/A	4,0	7,0	17,8	28,9	42,1	N/A	N/A
Class F	N/A	4,0	6,9	17,7	28,8	42,1	46,6	N/A
Class F_A	N/A	4,0	6,8	17,3	27,7	39,8	43,9	57,6
Class CCCB	4,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class BCT-B-L	N/A	2,0	2,0	2,0	2,9	4,4	4,6	6,1
Class BCT-B-M	N/A	2,0	2,0	4,1	6,6	9,7	10,7	14,3
Class BCT-B-H	N/A	2,0	3,3	8,4	13,8	20.1	22,3	29,8

B.1.2.3 Pair-to-pair NEXT

Table B.3 – NEXT limits for a permanent link at key frequencies

Frequency MHz	**Minimum NEXT** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class A	27,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class B	40,0	25,0	N/A	N/A	N/A	N/A	N/A	N/A
Class C	N/A	40,1	21,1	N/A	N/A	N/A	N/A	N/A
Class D	N/A	60,0	45,2	32,3	N/A	N/A	N/A	N/A
Class E	N/A	65,0	54,6	41,8	35,3	N/A	N/A	N/A
Class E_A	N/A	65,0	54,6	41,8	35,3	29,2 (27,9 [a])	N/A	N/A
Class F	N/A	65,0	65,0	65,0	60,4	55,9	54,7	N/A
Class F_A	N/A	65,0	65,0	65,0	61,7	56,1	54,7	49,1 (47,9 [a])
[a] Value applicable to Configuration C shown in A.1.								

B.1.2.4 Power sum NEXT

Table B.4 – PSNEXT limits for a permanent link at key frequencies

Frequency MHz	Minimum PSNEXT dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	57,0	42,2	29,3	N/A	N/A	N/A	N/A
Class E	N/A	62,0	52,2	39,3	32,7	N/A	N/A	N/A
Class E_A	N/A	62,0	52,2	39,3	32,7	26,4 (24,8 [a])	N/A	N/A
Class F	N/A	62,0	62,0	62,0	57,4	52,9	51,7	N/A
Class F_A	N/A	62,0	62,0	62,0	58,7	53,1	51,7	46,1 (44,9 [a])

[a] Value applicable to Configuration C shown in A.1.

B.1.2.5 Pair-to-pair ACR-N

Table B.5 – ACR-N limits for a permanent link at key frequencies

Frequency MHz	Minimum ACR-N dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	56,0	37,5	11,9	N/A	N/A	N/A	N/A
Class E	N/A	61,0	47,5	23,3	4,7	N/A	N/A	N/A
Class E_A	N/A	61,0	47,6	24,0	6,4	- 12,9 (- 14,2 [a])	N/A	N/A
Class F	N/A	61,0	58,1	47,3	31,6	13,8	8,1	N/A
Class F_A	N/A	61,0	58,2	47,7	34,0	16,4	10,8	- 8,5 (- 9,7 [a])

[a] Value applicable to Configuration C shown in A.1.

B.1.2.6 Power sum ACR-N (PSACR-N)

Table B.6 – PSACR-N limits for a permanent link at key frequencies

Frequency MHz	Minimum PSACR-N dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	53,0	34,5	8,9	N/A	N/A	N/A	N/A
Class E	N/A	58,0	45,1	20,8	2,0	N/A	N/A	N/A
Class E_A	N/A	58,0	45,2	21,5	3,8	- 15,7 (- 16,3 [a])	N/A	N/A
Class F	N/A	58,0	55,1	44,3	28,6	10,8	5,1	N/A
Class F_A	N/A	58,0	55,2	44,7	31,0	13,4	7,8	- 11,5 (- 12,7 [a])

[a] Value applicable to Configuration C shown in A.1.

B.1.2.7 Pair-to-pair ACR-F

Table B.7 – ACR-F limits for a permanent link at key frequencies

Frequency MHz	Minimum ACR-F dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	58,6	34,5	18,6	N/A	N/A	N/A	N/A
Class E	N/A	64,2	40,1	24,2	16,2	N/A	N/A	N/A
Class E_A	N/A	64,2	40,1	24,2	16,2	10,2	N/A	N/A
Class F	N/A	65,0	57,5	46,0	39,2	34,0	32,6	N/A
Class F_A	N/A	65,0	64,7	48,8	40,8	34,8	33,2	28,8

B.1.2.8 Power sum ACR-F (PSACR-F)

Table B.8 – PSACR-F limits for a permanent link at key frequencies

Frequency MHz	Minimum PSACR-F dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class D	N/A	55,6	31,5	15,6	N/A	N/A	N/A	N/A
Class E	N/A	61,2	37,1	21,2	13,2	N/A	N/A	N/A
Class E_A	N/A	61,2	37,1	21,2	13,2	7,2	N/A	N/A
Class F	N/A	62,0	56,3	43,0	36,2	31,0	29,6	N/A
Class F_A	N/A	62,0	61,7	45,8	37,8	31,8	30,2	25,8

B.1.2.9 Direct current (d.c.) loop resistance

Table B.9 – Direct current (d.c.) loop resistance limits for a permanent link

Class	Maximum d.c. loop resistance Ω
A	530,0
B	140,0
C	34,0
D	21,0
E	21,0
E_A	21,0
F	21,0
F_A	21,0
CCCB	8,0

B.1.2.10 Direct current (d.c.) resistance unbalance

Table B.10 – d.c. resistance unbalance limits for a permanent link at key frequencies

Class	Maximum d.c. resistance unbalance
A	3,0 %, 150 mΩ min.
B	3,0 %, 150 mΩ min.
C	3,0 %, 150 mΩ min.
D	3,0 %, 150 mΩ min.
E	3,0 %, 150 mΩ min.
E_A	3,0 %, 150 mΩ min.
F	3,0 %, 150 mΩ min.
F_A	3,0 %, 150 mΩ min.
CCCB	3,0 %, 150 mΩ min. [a]

[a] Where channels are required to provide power feeding this value shall be reduced to 1,5 %, subject to a minimum of 150 mΩ.

B.1.2.11 Propagation delay

Table B.11 – Propagation delay limits for a permanent link at key frequencies

Frequency MHz	Maximum propagation delay µs							
	0,1	1,0	16,0	100,0	250,0	500,0	600,0	1 000,0
Class A	19,400	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class B	4,400	4,400	N/A	N/A	N/A	N/A	N/A	N/A
Class C	N/A	0,521	0,496	N/A	N/A	N/A	N/A	N/A
Class D	N/A	0,521	0,496	0,491	N/A	N/A	N/A	N/A
Class E	N/A	0,521	0,496	0,491	0,490	N/A	N/A	N/A
Class E_A	N/A	0,521	0,496	0,491	0,490	0,490	N/A	N/A
Class F	N/A	0,521	0,496	0,491	0,490	0,490	0,489	N/A
Class F_A	N/A	0,521	0,496	0,491	0,490	0,490	0,489	0,489
Class CCCB	1,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Class BCT-B	N/A	0,521	0,496	0,491	0,490	0,489	0,489	0,489

B.1.2.12 Delay skew

Table B.12 – Delay skew limits for a permanent link

Class	Maximum delay skew µs
D	0,044
E	0,044
E_A	0,044
F	0,026
F_A	0,026

B.1.2.13 TCL

See Table 25 (ffs).

B.1.2.14 ELTCTL

See Table 27 (ffs).

B.1.2.15 Coupling attenuation

See Table 29 (ffs).

B.1.2.16 Power sum alien NEXT (PSANEXT)

Table B.13 – PSANEXT limits for a permanent link at key frequencies

Frequency MHz	**Minimum PSANEXT** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class E_A	N/A	67,0	67,0	60,0	54,0	49,5	N/A	N/A
Class F	N/A	67,0	67,0	60,0	54,0	49,5	48,3	N/A
Class F_A	N/A	67,0	67,0	67,0	67,0	64,5	63,3	60,0

B.1.2.17 Average power sum alien NEXT ($PSANEXT_{avg}$)

Table B.14 – $PSANEXT_{avg}$ limits for a permanent link at key frequencies

Frequency MHz	**Minimum $PSANEXT_{avg}$** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class E_A	N/A	67,0	67,0	62,3	56,3	51,8	N/A	N/A
Class F	N/A	67,0	67,0	62,3	56,3	51,8	50,6	N/A

B.1.2.18 Power sum alien ACR-F (PSAACR-F)

Table B.15 – PSAACR-F limits for a permanent link at key frequencies

Frequency MHz	**Minimum PSAACR-F** dB							
	0,1	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class E_A	N/A	67,0	52,9	37,0	29,0	23,0	N/A	N/A
Class F	N/A	67,0	52,9	37,0	29,0	23,0	21,4	N/A
Class F_A	N/A	67,0	67,0	52,0	44,0	38,0	36,4	32,0

B.1.2.19 Average power sum alien ACR-F (PSAACR-F_{avg})

Table B.16 – PSAACR-F_{avg} limits for a permanent link at key frequencies

	Minimum PSAACR-F_{avg} dB							
Frequency MHz	**0,1**	**1,0**	**16,0**	**100,0**	**250,0**	**500,0**	**600,0**	**1 000,0**
Class E_A	N/A	67,0	56,9	41,0	33,0	27,0	N/A	N/A
Class F	N/A	67,0	56,9	41,0	33,0	27,0	25,4	N/A

B.2 Coaxial cabling – Performance limits – Insertion loss

Table B.17 – Insertion loss limits for a permanent link at key frequencies

	Maximum insertion loss dB							
Frequency MHz	**5,0**	**10,0**	**100,0**	**200,0**	**600,0**	**1 000,0**	**2 400,0**	**3 000,0**
Class BCT-C-L	2,0	2,0	2,0	2,7	5,0	6,6	11,1	12,7
Class BCT-C-M	2,0	2,0	4,3	6,2	11,3	15,0	25,0	28,5
Class BCT-C-H	2,0	2,0	6,0	8,6	15,7	20,8	34,5	39,5

Annex C
Void

Annex D
(normative)

Electrical, mechanical and environmental requirements of balanced connecting hardware

D.1 Introduction

This annex provides performance requirements for connecting hardware that is not covered by a specific IEC or CENELEC standard or covered by a specific IEC or CENELEC standard but not referenced in Clause 8.

D.2 Electrical performance of Category 5, 6, 6_A, 7 and 7_A and BCT-B connecting hardware

D.2.1 Return loss

The return loss of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.1. The limits shown in Table D.2 are derived from the formulae at key frequencies only.

Table D.1 – Formulae for return loss limits for connecting hardware

Category	**Frequency** MHz	**Minimum return loss** dB
5	$1 \leq f \leq 100$	$60 - 20 \times \lg f$, 30,0 max.
6	$1 \leq f \leq 250$	$64 - 20 \times \lg f$, 30,0 max.
6_A	$1 \leq f \leq 500$	$68 - 20 \times \lg f$, 30,0 max.
7	$1 \leq f \leq 600$	$68 - 20 \times \lg f$, 30,0 max.
7_A	$1 \leq f \leq 1\,000$	$68 - 20 \times \lg f$, 30,0 max.
BCT-B	$1 \leq f \leq 1\,000$	$68 - 20 \times \lg f$, 30,0 max.

Table D.2 – Minimum return loss for connecting hardware at key frequencies

Frequency MHz	**Minimum return loss** dB						**Component or test standard**
	Category 5	**Category 6**	**Category 6_A**	**Category 7**	**Category 7_A**	**Category BCT-B**	
1,0	30,0	30,0	30,0	30,0	30,0	30,0	EN 60512-25-5
16,0	30,0	30,0	30,0	30,0	30,0	30,0	
100,0	20,0	24,0	24,0	24,0	24,0	24,0	
250,0	N/A	16,0	16,0	16,0	16,0	16,0	
500,0	N/A	N/A	14,0	14,0	14,0	14,0	
600,0	N/A	N/A	N/A	12,4	12,4	12,4	
1 000,0	N/A	N/A	N/A	N/A	8,0	8,0	

D.2.2 Insertion loss

The insertion loss of connecting hardware shall not exceed the limits computed, to two decimal places, using the formulae of Table D.3. The limits shown in Table D.4 are derived from the formulae at key frequencies only.

Table D.3 – Formulae for insertion loss limits for connecting hardware

Category	**Frequency** MHz	**Maximum insertion loss** dB
5	$1 \leq f \leq 100$	$0{,}04 \times \sqrt{f}$, 0,10 min.
6	$1 \leq f \leq 250$	$0{,}02 \times \sqrt{f}$, 0,10 min.
6_A	$1 \leq f \leq 500$	$0{,}02 \times \sqrt{f}$, 0,10 min.
7	$1 \leq f \leq 600$	$0{,}02 \times \sqrt{f}$, 0,10 min.
7_A	$1 \leq f \leq 1\,000$	$0{,}02 \times \sqrt{f}$, 0,10 min.
BCT-B	$1 \leq f \leq 1\,000$	$0{,}02 \times \sqrt{f}$, 0,10 min.

Table D.4 – Maximum insertion loss for connecting hardware at key frequencies

Frequency MHz	**Maximum insertion loss** dB						**Component or test standard**
	Category 5	**Category 6**	**Category 6_A**	**Category 7**	**Category 7_A**	**Category BCT-B**	
1,0	0,10	0,10	0,10	0,10	0,10	0,10	EN 60512-25-2
16,0	0,16	0,10	0,10	0,10	0,10	0,10	
100,0	0,40	0,20	0,20	0,20	0,20	0,20	
250,0	N/A	0,32	0,32	0,32	0,32	0,32	
500,0	N/A	N/A	0,45	0,45	0,45	0,45	
600,0	N/A	N/A	N/A	0,49	0,49	0,49	
1 000,0	N/A	N/A	N/A	N/A	0,63	0,63	

D.2.3 NEXT

The NEXT of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.5. The limits shown in Table D.6 are derived from the formulae at key frequencies only.

Table D.5 – Formulae for NEXT limits for connecting hardware

Category	**Frequency** MHz	**Minimum NEXT** dB
5	$1 \le f \le 100$	$83 - 20 \times \lg f$, 75,0 max.
6	$1 \le f \le 250$	$94 - 20 \times \lg f$, 75,0 max.
6_A	$1 \le f < 250$	$94 - 20 \times \lg f$, 75,0 max.
	$250 \le f \le 500$	$46{,}04 - 30 \times \lg(f/250)$
7	$1 \le f \le 600$	$102{,}4 - 15 \times \lg f$, 75,0 max.
7_A	$1 \le f < 600$	$116{,}3 - 20 \times \lg f$, 75,0 max.
	$600 \le f \le 1\,000$	$60{,}73 - 40 \times \lg(f/600)$

Table D.6 – Minimum NEXT for connecting hardware at key frequencies

Frequency MHz	**Minimum NEXT** dB					**Component or test standard**
	Category 5	**Category 6**	**Category 6_A**	**Category 7**	**Category 7_A**	
1,0	75,0	75,0	75,0	75,0	75,0	EN 60512-25-1
16,0	58,9	69,9	69,9	75,0	75,0	
100,0	43,0	54,0	54,0	72,4	75,0	
250,0	N/A	46,0	46,0	66,4	68,3	
500,0	N/A	N/A	37,0	62,3	62,3	
600,0	N/A	N/A	N/A	60,7	60,7	
1 000,0	N/A	N/A	N/A	N/A	51,9	

D.2.4 PSNEXT

The PSNEXT of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.7. The limits shown in Table D.8 are derived from the formulae at key frequencies only.

Table D.7 – Formulae for PSNEXT limits for connecting hardware

Category	**Frequency** MHz	**Minimum PSNEXT** dB
5	$1 \le f \le 100$	$80 - 20 \times \lg f$, 72,0 max.
6	$1 \le f \le 250$	$90 - 20 \times \lg f$, 72,0 max.
6_A	$1 \le f < 250$	$90 - 20 \times \lg f$, 72,0 max.
	$250 \le f \le 500$	$42{,}04 - 30 \times \lg(f/250)$
7	$1 \le f \le 600$	$99{,}4 - 15 \times \lg f$, 72,0 max.
7_A	$1 \le f < 600$	$113{,}3 - 20 \times \lg f$, 72,0 max.
	$600 \le f \le 1\,000$	$57{,}73 - 40 \times \lg(f/600)$

Table D.8 – Minimum PSNEXT for connecting hardware at key frequencies

Frequency MHz	Minimum PSNEXT dB					Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	
1,0	72,0	72,0	72,0	72,0	72,0	EN 60512-25-1
16,0	55,9	65,9	65,9	72,0	72,0	
100,0	40,0	50,0	50,0	69,4	72,0	
250,0	N/A	42,0	42,0	63,4	65,3	
500,0	N/A	N/A	33,0	58,9	59,3	
600,0	N/A	N/A	N/A	57,7	57,7	
1 000,0	N/A	N/A	N/A	N/A	48,9	

D.2.5 FEXT

The FEXT of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.9. The limits shown in Table D.10 are derived from the formulae at key frequencies only.

NOTE For connectors, the difference between FEXT and ACR-F is minimal. Therefore, connector FEXT requirements are used to model ACR-F performance for channels.

Table D.9 – Formulae for FEXT limits for connecting hardware

Category	Frequency MHz	Minimum FEXT dB
5	$1 \leq f \leq 100$	$75{,}1 - 20 \times \lg f$, 75,0 max.
6	$1 \leq f \leq 250$	$83{,}1 - 20 \times \lg f$, 75,0 max.
6_A	$1 \leq f \leq 500$	$83{,}1 - 20 \times \lg f$, 75,0 max.
7	$1 \leq f \leq 600$	$90 - 15 \times \lg f$, 75,0 max.
7_A	$1 \leq f \leq 1\,000$	$103{,}9 - 20 \times \lg f$, 75,0 max.

Table D.10 – Minimum FEXT for connecting hardware at key frequencies

Frequency MHz	Minimum FEXT dB					Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	
1,0	75,0	75,0	75,0	75,0	75,0	EN 60512-25-1
16,0	51,0	59,0	59,0	71,9	75,0	
100,0	35,1	43,1	43,1	60,0	63,9	
250,0	N/A	35,1	35,1	54,0	55,9	
500,0	N/A	N/A	29,1	49,5	49,9	
600,0	N/A	N/A	N/A	48,3	48,3	
1 000,0	N/A	N/A	N/A	N/A	43,9	

D.2.6 PSFEXT

The PSFEXT of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.11. The limits shown in Table D.12 are derived from the formulae at key frequencies only.

NOTE For connectors, the difference between PSFEXT and PSACR-F is minimal. Therefore, connector PSFEXT requirements are used to model PSACR-F performance for channels.

Table D.11 – Formulae for PSFEXT limits for connecting hardware

Category	**Frequency** MHz	**Minimum PSFEXT** dB
5	$1 \leq f \leq 100$	$72{,}1 - 20 \times \lg f$, 62,0 max.
6	$1 \leq f \leq 250$	$80{,}1 - 20 \times \lg f$, 62,0 max.
6_A	$1 \leq f \leq 500$	$80{,}1 - 20 \times \lg f$, 72,0 max.
7	$1 \leq f \leq 600$	$87 - 15 \times \lg f$, 62,0 max.
7_A	$1 \leq f \leq 1\,000$	$100{,}9 - 20 \times \lg f$, 72,0 max.

Table D.12 – Minimum PSFEXT for connecting hardware at key frequencies

Frequency MHz	**Minimum PSFEXT** dB					**Component or test standard**
	Category 5	**Category 6**	**Category 6_A**	**Category 7**	**Category 7_A**	
1,0	72,0	72,0	72,0	72,0	72,0	EN 60512-25-1
16,0	48,0	56,0	56,0	68,9	72,0	
100,0	32,1	40,1	40,1	57,0	60,9	
250,0	N/A	32,1	32,1	51,0	52,9	
500,0	N/A	N/A	26,1	46,5	46,9	
600,0	N/A	N/A	N/A	45,3	45,3	
1 000,0	N/A	N/A	N/A	N/A	40,9	

D.2.7 Propagation delay

The propagation delay of connecting hardware shall not exceed the limits of Table D.13.

Table D.13 – Limits for propagation delay for connecting hardware

Category	**Frequency** MHz	**Maximum propagation delay** µs	**Component or test standard**
5	$1 \leq f \leq 100$	0,002 5	EN 60512-25-4
6	$1 \leq f \leq 250$	0,002 5	
6_A	$1 \leq f \leq 500$	0,002 5	
7	$1 \leq f \leq 600$	0,002 5	
7_A	$1 \leq f \leq 1\,000$	0,002 5	
BCT-B	$1 \leq f \leq 1\,000$	0,002 5	

D.2.8 Delay skew

The delay skew of connecting hardware shall not exceed the limits of Table D.14.

Table D.14 – Limits for delay skew for connecting hardware

Category	Frequency MHz	Maximum delay skew µs	Component or test standard
5	$1 \leq f \leq 100$	0,001 25	EN 60512-25-4
6	$1 \leq f \leq 250$	0,001 25	
6_A	$1 \leq f \leq 500$	0,001 25	
7	$1 \leq f \leq 600$	0,001 25	
7_A	$1 \leq f \leq 1\,000$	0,001 25	

D.2.9 Input to output resistance

Input to output resistance is a separate measurement from the contact resistance measurements required in EN 60603-7 series. Input to output resistance is measured from cable termination to cable termination to determine the connector's ability to transmit direct current and low frequency signals. Contact resistance measurements are used to determine the reliability and stability of individual electrical connections. These requirements are applicable to each conductor and to the screen, when present.

The input to output resistance of connecting hardware shall not exceed the limits of Table D.15.

Table D.15 – Maximum input to output resistance

Frequency MHz	Maximum input to output resistance mΩ						Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	Category BCT-B	
d.c.	200	200	200	200	200	200	EN 60512-2-1:2002, Test 2a

D.2.10 Input to output resistance unbalance

The input/output resistance unbalance of connecting hardware shall not exceed the limits of Table D.16.

Table D.16 – Maximum input to output resistance unbalance

Frequency MHz	Maximum input to output resistance unbalance mΩ						Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	Category BCT-B	
d.c.	50	50	50	50	50	50	EN 60512-2-1:2002, Test 2a

D.2.11 Current carrying capacity

The current carrying capacity of connecting hardware shall meet the limits of Table D.17. The requirements are applicable to each conductor including the screen, if present, and for an ambient temperature of 60 °C. The sample preparation shall be as specified in EN 60603-7 series.

Table D.17 – Minimum current carrying capacity

Frequency MHz	Minimum current capacity per conductor [a, b] A						Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	Category BCT-B	
d.c.	0,75	0,75	0,75	0,75	0,75	0,75	EN 60512-5-2:2002, Test 5b

[a] Applicable for an ambient temperature of 60 °C.

[b] Applicable to each conductor including the screen (if present).

D.2.12 Transfer impedance

The transfer impedance of screened connecting hardware shall meet the limits computed, to two decimal places, using the formulae of Table D.18. The limits shown in Table D.19 are derived from the formulae at key frequencies only.

Table D.18 – Formulae for transfer impedance for connecting hardware

Category	Frequency MHz	Maximum transfer impedance Ω
5	$1 \leq f \leq 10$	$0{,}1 \times f^{0{,}3}$
	$10 < f \leq 80$	$0{,}02 \times f$
6	$1 \leq f \leq 10$	$0{,}1 \times f^{0{,}3}$
	$10 < f \leq 80$	$0{,}02 \times f$
6_A	$1 \leq f \leq 10$	$0{,}1 \times f^{0{,}3}$
	$10 < f \leq 80$	$0{,}02 \times f$
7	$1 \leq f \leq 10$	$0{,}05 \times f^{0{,}3}$
	$10 < f \leq 80$	$0{,}01 \times f$
7_A	$1 \leq f \leq 10$	$0{,}05 \times f^{0{,}3}$
	$10 < f \leq 80$	$0{,}01 \times f$
BCT-B	$1 \leq f \leq 10$	$0{,}05 \times f^{0{,}3}$
	$10 < f \leq 80$	$0{,}01 \times f$

Table D.19 – Maximum transfer impedance for connecting hardware at key frequencies

Frequency MHz	Maximum transfer impedance Ω						Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	Category BCT-B	
1,0	0,10	0,10	0,10	0,05	0,05	0,05	EN 60512-26-100:2008, Test 26e
16,0	0,32	0,32	0,32	0,16	0,16	0,16	
80,0	1,60	1,60	1,60	0,80	0,80	0,80	

D.2.13 Unbalance attenuation

D.2.13.1 Transverse conversion loss (TCL)

The transverse conversion loss (TCL) of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.20. The limits shown in Table D.21 are derived from the formulae at key frequencies only.

Table D.20 – Formulae for Transverse Conversion Loss (TCL) limits for connecting hardware

Category	**Frequency** MHz	**Minimum TCL** dB
5	$1 \leq f \leq 100$	$66 - 20 \times \lg f$, 50,0 max.
6	$1 \leq f \leq 250$	$68 - 20 \times \lg f$, 50,0 max.
6_A	$1 \leq f \leq 500$	$68 - 20 \times \lg f$, 50,0 max.
7	$1 \leq f \leq 600$	$68 - 20 \times \lg f$, 50,0 max.
7_A	$1 \leq f \leq 1\,000$	$68 - 20 \times \lg f$, 50,0 max.
BCT-B	$1 \leq f \leq 1\,000$	$68 - 20 \times \lg f$, 50,0 max.

Table D.21 – Minimum TCL for connecting hardware at key frequencies

Frequency MHz	**Minimum TCL** dB						**Component or test standard**
	Category 5	**Category 6**	**Category 6_A**	**Category 7**	**Category 7_A**	**Category BCT-B**	
1,0	50,0	50,0	50,0	50,0	50,0	50,0	ITU-T O.9
16,0	41,9	43,9	43,9	43,9	43,9	43,9	
100,0	26,0	28,0	28,0	28,0	28,0	28,0	
250,0	N/A	20,0	20,0	20,0	20,0	20,0	
500,0	N/A	N/A	14,0	14,0	14,0	14,0	
600,0	N/A	N/A	N/A	12,4	12,4	12,4	
1 000,0	N/A	N/A	N/A	N/A	8,0	8,0	

D.2.13.2 Transverse conversion transfer loss (TCTL)

The transverse conversion transfer loss (TCTL) of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.22. The limits shown in Table D.23 are derived from the formulae at key frequencies only.

Table D.22 – Formulae for Transverse Conversion Transfer Loss (TCTL) limits for connecting hardware

Category	**Frequency** MHz	**Minimum TCTL** dB
5	$1 \leq f \leq 100$	$66 - 20 \times \lg f$, 50,0 max.
6	$1 \leq f \leq 250$	$68 - 20 \times \lg f$, 50,0 max.
6_A	$1 \leq f \leq 500$	$68 - 20 \times \lg f$, 50,0 max.
7	$1 \leq f \leq 600$	$68 - 20 \times \lg f$, 50,0 max.
7_A	$1 \leq f \leq 1\,000$	$68 - 20 \times \lg f$, 50,0 max.
BCT-B	$1 \leq f \leq 1\,000$	$68 - 20 \times \lg f$, 50,0 max.

Table D.23 – Minimum TCTL for connecting hardware at key frequencies

Frequency MHz	**Minimum TCTL** dB						**Component or test standard**
	Category 5	**Category 6**	**Category 6_A**	**Category 7**	**Category 7_A**	**Category BCT-B**	
1,0	50,0	50,0	50,0	50,0	50,0	50,0	ITU-T O.9
16,0	41,9	43,9	43,9	43,9	43,9	43,9	
100,0	26,0	28,0	28,0	28,0	28,0	28,0	
250,0	N/A	20,0	20,0	20,0	20,0	20,0	
500,0	N/A	N/A	14,0	14,0	14,0	14,0	
600,0	N/A	N/A	N/A	12,4	12,4	12,4	
1 000,0	N/A	N/A	N/A	N/A	8,0	8,0	

D.2.14 Coupling attenuation

The coupling attenuation of screened connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.24. The limits shown in Table D.25 are derived from the formulae at key frequencies only.

Table D.24 – Formulae for coupling attenuation limits for connecting hardware

Category	Frequency MHz	Minimum coupling attenuation dB	
5	$30 \leq f \leq 100$	$85 - 20 \times \lg f$, 45,0 max.	
6	$30 \leq f \leq 250$	$85 - 20 \times \lg f$, 45,0 max.	
6_A	$30 \leq f \leq 500$	$85 - 20 \times \lg f$, 45,0 max.	
7	$30 \leq f \leq 600$	$85 - 20 \times \lg f$, 45,0 max.	
7_A	$30 \leq f \leq 1\,000$	$85 - 20 \times \lg f$, 45,0 max.	
		EMC Class A	**EMC Class B**
BCT-B	$30 \leq f < 300$	85,0	75,0
	$300 \leq f < 470$	80,0	75,0
	$470 \leq f \leq 1\,000$	75,0	65,0
NOTE EMC Class A and EMC Class B limits are in line with EN 50083-2:2006, Table 10.			

Table D.25 – Minimum coupling attenuation for connecting hardware at key frequencies

Frequency MHz	Minimum coupling attenuation dB						Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	Category BCT-B	
1,0	45,0	45,0	45,0	45,0	45,0	See Table D.24	EN 50289-1-14
16,0	45,0	45,0	45,0	45,0	45,0		
100,0	45,0	45,0	45,0	45,0	45,0		
250,0	N/A	37,0	37,0	37,0	37,0		
500,0	N/A	N/A	31,0	31,0	31,0		
600,0	N/A	N/A	N/A	29,4	29,4		
1 000,0	N/A	N/A	N/A	N/A	25,0		
NOTE The applicability of this test standard at frequencies above 250 MHz is for information only.							

D.2.15 Insulation resistance

The insulation resistance of connecting hardware shall exceed the limits of Table D.26.

Table D.26 – Minimum insulation resistance

Frequency MHz	Minimum insulation resistance MΩ						Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	Category BCT-B	
d.c.	100	100	100	100	100	100	EN 60512-3-1:2002, Test 3a, Method C, DC 500 V

D.2.16 Voltage proof

The voltage proof of connecting hardware shall exceed the limits of Table D.27.

Table D.27 – Minimum d.c. voltage proof

	Minimum d.c. voltage proof V						Component or test standard
	Category 5	Category 6	Category 6_A	Category 7	Category 7_A	Category BCT-B	
Conductor to conductor	1 000	1 000	1 000	1 000	1 000	1 000	EN 60512-4-1:2003, Test 4a
Conductor to test panel (and screen, if present)	1 500	1 500	1 500	1 500	1 500	1 500	

D.2.17 Power sum alien NEXT (PSANEXT)

The power sum alien NEXT (PSANEXT) of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.28. The limits shown in Table D.29 are derived from the formulae at key frequencies only.

The PSANEXT requirements for Category 6_A and 7 in Table D.28 are met by design for screened connecting hardware if the coupling attenuation is at least 10 dB better than the minimum requirements specified in Table D.24.

The PSANEXT requirements for Category 7_A in Table D.28 are met by design for screened connecting hardware if the coupling attenuation is at least 25 dB better than the minimum requirements specified in Table D.24.

Table D.28 – Formulae for PSANEXT limits for connecting hardware

Category	Frequency MHz	Minimum PSANEXT dB
6_A	$1 \leq f \leq 500$	$110{,}5 - 20 \times \lg f$, 72,0 max.
7	$1 \leq f \leq 600$	$110{,}5 - 20 \times \lg f$, 72,0 max..
7_A	$1 \leq f \leq 1\,000$	$125{,}5 - 20 \times \lg f$, 72,0 max.

Table D.29 – Minimum PSANEXT for connecting hardware at key frequencies

Frequency MHz	Minimum PSANEXT dB			Component or test standard
	Category 6_A	Category 7	Category 7_A	
1,0	72,0	72,0	72,0	EN 60512-25-9 [a]
16,0	72,0	72,0	72,0	
100,0	70,5	70,5	72,0	
250,0	62,5	62,5	72,0	
500,0	56,5	56,5	71,5	
600,0	N/A	54,9	69,9	
1 000,0	N/A	N/A	65,5	

[a] The test standard does not specify a fixed relationship between adjacent connecting hardware. Manufacturers' instructions shall be applied for installed configurations.

D.2.18 Power sum alien FEXT (PSAFEXT)

The power sum alien FEXT (PSAFEXT) of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table D.30. The limits shown in Table D.31 are derived from the formulae at key frequencies only.

NOTE For connectors, the difference between PSAFEXT and PSAACR-F is minimal. Therefore, connector PSAFEXT requirements are used to model PSAACR-F performance for links and channels.

Table D.30 – Formulae for PSAFEXT limits for connecting hardware

Category	**Frequency** MHz	**Minimum PSAFEXT** dB
6_A	$1 \le f \le 500$	$107 - 20 \times \lg f$, 72,0 max.
7	$1 \le f \le 600$	$107 - 20 \times \lg f$, 72,0 max.
7_A	$1 \le f \le 1\,000$	$122 - 20 \times \lg f$, 72,0 max.

Table D.31 – Minimum PSAFEXT for connecting hardware at key frequencies

Frequency MHz	**Minimum PSAFEXT** dB			**Component or test standard**
	Category 6$_A$	**Category 7**	**Category 7$_A$**	
1,0	72,0	72,0	72,0	EN 60512-25-9 [a]
16,0	72,0	72,0	72,0	
100,0	67,0	67,0	72,0	
250,0	59,0	59,0	72,0	
500,0	53,0	53,0	68,0	
600,0	N/A	51,4	66,4	
1 000,0	N/A	N/A	62,0	

[a] The test standard does not specify a fixed relationship between adjacent connecting hardware. Manufacturers' instructions shall be applied for installed configurations.

D.3 Mechanical and environmental performance

D.3.1 Introduction

The mechanical and environmental performance of connecting hardware is vital to the cabling system. Changes in contact resistance because of operational and environmental stress can negatively affect the transmission characteristics of the cabling system. Product acceptance testing is accomplished by subjecting the product to a number of mechanical and environmental conditions and measuring any resistance deviations at prescribed intervals and after completion of each conditioning sequence. In addition, the product shall not show evidence of degradation with respect to the ease of mechanical termination, safety or other functional attributes during or after environmental conditioning.

Connecting hardware often contains a combination of solderless connections and a separable contact interface (free connector/fixed connector interface). All connections shall be tested. Where a combination of connections and/or separable contact interfaces are tested together, care should be taken to ensure the use of the most stringent test schedule as the test schedules vary by type of connection.

This annex provides mechanical connection performance requirements for connections that are not covered by a specific EN or IEC connector standard. It is intended to replace the specifications in this annex by reference to EN or IEC standards, as they become available.

NOTE Connection interfaces that conform to the mechanical and environmental performance requirements of EN 60603-7 (unscreened) or EN 60603-7-1 (screened) comply with this annex as these documents specify appropriate tests. Connection interfaces that are covered by European/international standards other than the EN 60603-7 series shall comply with at least the equivalent mechanical and environmental performance requirements specified in this annex.

D.3.2 Solderless connections

To ensure reliable solderless terminations of balanced cable with insulated conductors, and to ensure reliable solderless connections between component parts within connecting hardware, solderless connections shall meet the requirements of the applicable standards specified in Table D.32.

Table D.32 – Standards for solderless connections

Connection type	Standard
Crimped connection	EN 60352-2
Accessible IDC	EN 60352-3
Non-accessible IDC	EN 60352-4
Press-in connection	EN 60352-5
IPC	EN 60352-6
Spring clamp connection	EN 60352-7
Compression mount	EN 60352-8

The default criteria and conditions in the relevant standards in Table D.32 apply, except as specified in the remainder of this clause.

The maximum initial contact resistance for an insulation displacement connection shall be 2,5 mΩ and the maximum change in contact resistance during and after conditioning shall be 5 mΩ from the initial value.

The following test conditions are specified, as detailed by the type test requirements of EN 60352 series of standards:

a) vibration test severity: 10 Hz to 500 Hz;
b) low temperature (LCT): – 40 °C;
c) electrical load and temperature, test current: DC 1 A.

D.3.3 Free and fixed connectors (modular plugs and jacks)

Free and fixed connectors (modular plugs and jacks) shall comply with the reliability requirements of the applicable standard specified in Table D.33.

Table D.33 – Standards for free and fixed connectors (modular plugs and jacks)

Category and type	Standard
Category 3, unscreened	EN 60603-7
Category 3, screened	EN 60603-7-1
Category 5, unscreened	EN 60603-7-2
Category 5, screened	EN 60603-7-3
Category 6, unscreened	EN 60603-7-4
Category 6, screened	EN 60603-7-5
Category 6_A, unscreened	EN 60603-7-41
Category 6_A, screened	EN 60603-7-51
Category 7, screened	EN 60603-7-7
Category 7_A, screened	EN 60603-7-71, EN 61076-3-104 or EN 61076-3-110 as appropriate

The default criteria and conditions in the relevant standards in Table D.33 apply, except as specified in the remainder of this clause.

The number of mating cycles (insertions and withdrawals) for free and fixed connectors (modular plugs and jacks), and the number of conductor re-terminations per solderless connection shall comply with the specifications in Table D.34.

Table D.34 – Free and fixed connectors (modular plugs and jacks) operations matrix

Connecting hardware type	Insertion and withdrawal, and conductor re-termination, operations	Minimum number of operations
Free connector (modular plug)	Insertion/withdrawal with fixed connector (modular socket)	750
	Cable re-termination	0
Fixed connector (modular jack)	Insertion/withdrawal with free connector (modular plug)	750
	Cable re-termination	20 [a, b]

[a] Unless not intended for re-termination, in which case this value equals 0.

[b] The range of conductor size and type shall be in accordance with the manufacturer's instructions.

Between terminations, the solderless connection should be inspected for debris. Any extraneous material should be removed.

D.3.4 Other connecting hardware

Examples of other connecting hardware include:

a) cross-connect blocks and plugs;

b) pin and socket connectors.

The reliability of connecting hardware, other than free and fixed connectors (modular plugs and jacks) shall be demonstrated by complying with the applicable requirements of the standards specified in Table D.35. The connecting hardware shall be terminated, mounted, and operated in accordance with the manufacturer's instructions for use. A minimum of 100 individual electrical contact paths (e.g. connecting hardware, input to output) shall be tested without failure.

The following tests shall be as per the manufacturer's specification:

1) examination of dimensions and mass;
2) insertion and withdrawal force requirements;
3) effectiveness of any connector coupling device requirements;
4) gauging and gauging continuity requirements;
5) arrangement for contact resistance test;
6) arrangement for vibration (dynamic stress) test.

Table D.35 – Reference for reliability testing of other connecting hardware

Category and type	Standard	
All Categories, unscreened	EN 60603-7	Clause 6 and Clause 7 [a]
All Categories, screened	EN 60603-7-1	

[a] Excluding subclauses addressing pin and pair grouping assignment, creepage and clearance distances, transmission characteristics, transfer impedance, and test group EP (transmission testing).

The default criteria and conditions in the relevant standards in Table D.35 apply, unless otherwise specified in this clause.

The number of mating cycles (insertions and withdrawals) for other connecting hardware, and the number of conductor re-terminations per solderless connection shall comply with the specifications in Table D.36.

Table D.36 – Other connecting hardware operations matrix

Connecting hardware type	Insertion and withdrawal, and conductor re-termination, operations	Minimum number of operations
Other connecting hardware "free connector (plug)"	Insertion/withdrawal operations with "fixed connector (socket)"	200
	Cable re-termination	0
Other connecting hardware "fixed connector (socket)"	Insertion/withdrawal operations with "free connector (plug)"	200
	Cable re-termination	20 [a, b]
	Jumper re-termination	200

[a] Unless not intended for re-termination, in which case this value equals 0.

[b] The range of conductor size and type shall be in accordance with the manufacturer's instructions.

Between terminations, the solderless connection should be inspected for debris. Any extraneous material should be removed.

Annex E
(informative)

Electromagnetic characteristics of balanced cabling

Cabling consists of passive components and can therefore only be verified for conformance with EMC standards (such as EN 55022 and EN 55024) together with attached application-specific equipment. However, electromagnetic characteristics of a network installation are influenced by parameters, which characterise the balance and/or screening properties of the cabling.

Balance is characterised by unbalance attenuation, which is the ratio between the unwanted common mode signal power, which arises due to imperfections such as asymmetry in the cabling system, and the injected differential mode signal power. This common mode signal causes radiation and affects immunity. Unbalance attenuation is characterised for components, including cables and connections. Limits for unbalance attenuation are also given for cabling. Unbalance attenuation test methods for components are well established for frequencies up to 100 MHz.

Screening effectiveness is characterised for components. At low frequencies up to about 30 MHz transfer impedance is used for this parameter. Transfer impedance is the quotient of the longitudinal voltage measured on the secondary side of the screen to the current in the screen, caused by a primary inducing circuit. This unwanted current causes radiation and affects immunity. At higher frequencies screening effectiveness is characterised by screening attenuation, which is the ratio between the common mode signal in the conductors enclosed in the screen and the radiated signal outside the screen.

Balance and screening effectiveness properties may be combined in one parameter, coupling attenuation, which is the ratio between the wanted signal power and the unwanted radiated power from the cabling. Coupling attenuation is normally measured from 30 MHz to 1 000 MHz.

Coupling attenuation can be applied to screened and unscreened elements.

Test methods and requirements for components have been developed.

Characterisation of coupling attenuation for cabling is for further study. Use of components with good electromagnetic characteristics, the use of screened or unscreened components throughout a system, and installation according to manufacturers' instructions, will help to achieve good electromagnetic characteristics of the cabling.

The electromagnetic characteristics of the components used within balanced cabling referenced in this standard, may be used for guidance, when application specific electronic equipment is constructed and tested for compliance with EMC standards. The relationship between the requirements of EMC standards and the installed component characteristics is a subject for further study.

Annex F
(informative)

Supported applications

F.1 Supported applications for balanced cabling

Balanced cabling specified in this European Standard is intended to support the applications detailed in this annex. It is not an exhaustive list and other applications not listed may also be supported.

Balanced cabling applications are correlated to channel performance Classes specified in Clause 5 of this standard. Generic cabling has been designed to support optical and electrically balanced transmission.

Table F.1 contains:

a) established and emerging ICT applications defined by international specifications (e.g. ISO/IEC standards, ITU Recommendations, IEEE 802 standards and IP/MPLS Forum [formerly ATM Forum] specifications);

b) established and emerging BCT applications defined by CLC/TC 209 and IEC/TC 100, respectively. The cabling configurations detailed in CLC/TR 50173-99-2 allow:

   1) BCT-B-L permanent links of Annex A to support these applications without any slope compensation;

   2) BCT-B-M permanent links to support these applications with a 6 dB slope compensation;

   3) BCT-B-H permanent links to support these applications only where specific transmission engineering has been applied.

Applications supported by generic balanced cabling listed in Table F.1 use the pin assignment recorded in Table F.2. This mapping relates the modular connector pinning specified by each application standard to the channel performance Classes specified in Clause 5 of this standard.

F.2 Supported applications for coaxial cabling

Coaxial cabling specified in this European Standard is intended to support the applications detailed in this annex. It is not an exhaustive list and other applications not listed may also be supported.

Coaxial cabling applications are correlated to BCT-C channel performance Classes specified in Clause 5 of this standard.

Table F.3 contains established and emerging BCT applications defined by CLC TC 209 and IEC/TC 100, respectively. The cabling configurations detailed in CLC/TR 50173-99-2 allow:

– BCT-C-L channels to support these applications without any slope compensation;

– BCT-C-M channels to support these applications with a 6 dB slope compensation;

– BCT-C-H channels to support these applications only where specific transmission engineering has been applied.

F.3 Supported applications for optical fibre cabling

Optical fibre cabling specified in this European Standard is intended to support the applications detailed in this annex; other applications not listed may also be supported.

Optical fibre cabling applications are correlated to channel performance Classes specified in Clause 5 of this standard.

Table F.4 contains detailed information on the maximum channel lengths supported by generic applications for each recognised all-silica multimode optical fibre. Table F.5 contains detailed information on the maximum channel lengths supported by generic applications for each recognised single-mode optical fibre.

Table F.6 and Table F.7 contain detailed information on the maximum channel lengths supported by data centre applications.

Table F.8, Table F.9 and Table F.10 contain detailed information of the longest channel lengths supported by process monitoring and control applications for each recognised all-silica multimode optical fibre, all-silica single-mode optical fibre and plastic optical fibre respectively.

Table F.1 – Supported ICT and BCT applications using balanced cabling

Application	Specification Reference	Date	Additional Name
Class A (defined up to 100 kHz)			
PBX	National Requirements		
V.11	ITU-T V.11	1996	
X.21	ITU-T X.21	1992	
Class B (defined up to 1 MHz)			
S_0-Bus (extended)	ITU-T I.430	1993	ISDN Basic Access (Physical Layer)
S_0 Point-to-Point	ITU-T I.430	1993	ISDN Basic Access (Physical Layer)
S_0 Star	EN 50098-1:1998/A1 (ITU-T I.430)	2002	
S_1/S_2	ITU-T I.431	1993	ISDN Primary Access (Physical Layer)
Class C (defined up to 16 MHz)			
CSMA/CD 10BASE-T [a]	IEEE 802.3	2005	Ethernet: IEEE 802.3i
Token Ring 4 Mbit/s	IEEE 802.5	1998	
ATM LAN 25,60 Mbit/s	IP/MPLS Forum af-phy-0040.000	1995	ATM-25/Category 3
ATM LAN 51,84 Mbit/s	IP/MPLS Forum af-phy-0018.000	1994	ATM-52/Category 3
ATM LAN 155,52 Mbit/s	IP/MPLS Forum af-phy-0047.000	1995	ATM-155/Category 3
Class D (defined up to 100 MHz)			
Token Ring 16 Mbit/s	IEEE 802.5	1998	
CSMA/CD 100BASE-TX [b]	IEEE 802.3 clause 25	2005	Fast Ethernet IEEE 802.3u
Token Ring 100 Mbit/s	IEEE 802.5t	2000	High Speed Token Ring
CSMA/CD 1000BASE-T [b]	IEEE 802.3 clause 40	2005	Gigabit Ethernet, IEEE 802.3ab
ATM LAN 155,52 Mbit/s	IP/MPLS Forum af-phy-0015.000	1994	ATM-155/Category 5
Fibre Channel 1Gb/s	INCITS 435	2007	Twisted pair Fibre Channel 1G
PoE	IEEE 802.3at Type 1	2009	Power over Ethernet
PoE-*plus*	IEEE 802.3at Type 2	2009	Power over Ethernet Plus
Firewire 100 Mbit/s	IEEE 1394b	1999	Firewire/Category 5
Class E (defined up to 250 MHz)			
ATM LAN 1,2 Gbit/s	IP/MPLS Forum af-phy-0162.000	2001	ATM-1200/Category 6
Class E_A (defined up to 500 MHz)			
10GBASE-T	IEEE 802.3an	2006	10 Gigabit Ethernet
Class F (defined up to 600 MHz)			
Fibre Channel 2Gb/s	INCITS 435	2007	Twisted pair Fibre Channel 2G
Fibre Channel 4Gb/s	INCITS 435	2007	Twisted pair Fibre Channel 4G
FC-100-DF-EL-S	ISO/IEC 14165-114	2005	FA-FC-100-DF-EL-S
Class BCT-B (defined up to 1.000 MHz)			
Analogue TV	ITU-R BT.470-6	(2006)	EN 60728-1 (PAL-x, SECAM-y)
Analogue Radio	ITU-R BS.412-9		EN 60728-1 (FM Radio)
DVB-T	ITU-RP.1546		EN 60728-1 (DVB-T, T-DAB)
Digital TV	EN 300 429	1998	EN 60728-1 (DVB-C)
Digital TV	EN 300 744	2004	EN 60728-1 (DVB-T)
Digital Radio	EN 300 401	2001	EN 60728-1 (DAB)
Digital Radio	EN 300 429	1998	EN 60728-1 (DVB-C)
Data streaming	EN 300 429	1998	EN 60728-1 (DVB-C)

[a] Class D channel performance is required to support power feeding of IEEE 802.3at Type 2. Class D channel performance is recommended to support power feeding of IEEE 802.3at Type 1.

[b] Including support for power feeding of IEEE 802.3at Type 1 and Type 2 systems.

Table F.2 – Modular connector pin assignment for ICT applications

Application	Pins 1 & 2	Pins 3 & 6	Pins 4 & 5	Pins 7 & 8
Supported Applications				
PBX	Class A [a]	Class A [a]	Class A	Class A [a]
X.21		Class A	Class A	
V.11		Class A	Class A	
S_0-Bus (extended)	[b]	Class B	Class B	[b]
S_0 Point-to-Point	[b]	Class B	Class B	[b]
S_1/S_2	Class B	[c]	Class B	[b]
S_0 Star	[b]	Class B	Class B	[b]
CSMA/CD 10BASE-T	Class C	Class C		
Token Ring 4 Mbit/s		Class C	Class C	
ATM-25,60 Category 3	Class C			Class C
ATM-51,84 Category 3	Class C			Class C
ATM-155,52 Category 3	Class C			Class C
Token Ring 16 Mbit/s		Class D	Class D	
Token Ring 100 Mbit/s		Class D	Class D	
ATM-155,52 Category 5	Class D			Class D
CSMA/CD 100BASE-TX	Class D	Class D		
CSMA/CD 1000BASE-T	Class D	Class D	Class D	Class D
Fibre Channel 1Gb/s	Class D	Class D	Class D	Class D
Firewire 100 Mbit/s	Class D			Class D
PoE	Class D	Class D	Class D	Class D
PoE-*plus*	Class D	Class D	Class D	Class D
10GBASE-T	Class E	Class E	Class E	Class E
10GBASE-T	Class E_A	Class E_A	Class E_A	Class E_A
ATM-1200 Category 6	Class E	Class E	Class E	Class E
Fibre Channel 2 Gb/s	Class F	Class F	Class F	Class F
Fibre Channel 4 Gb/s	Class F	Class F	Class F	Class F
10GBASE-T	Class F	Class F	Class F	Class F
FC-100-DF-EL-S [d]	Class F	Class F	Class F	Class F
FC-100-DF-EL-S [e]	Class F			Class F

[a] Option dependent on supplier.
[b] Optional power sources.
[c] Option for continuity of cable screen.
[d] Type 1 interface.
[e] Type 2 interface.

Table F.3 – Supported BCT applications using coaxial cabling

Application	Specification Reference	Date	Interface standard
Analogue TV	ITU-R BT.470-6		EN 60728-1 (PAL-x, SECAM-y)
Analogue Radio	ITU-R BS.412-9		EN 60728-1 (FM Radio)
DVB-T	ITU-R P.1546		EN 60728-1 (DVB-T, T-DAB)
Digital TV	EN 300429	1998	EN 60728-1 (DVB-C)
Digital TV	EN 300421	1997	EN 60728-1 (DVB-S)
Digital TV	EN 300744	2004	EN 60728-1 (DVB-T)
Digital Radio	EN 300401	2001	EN 60728-1 (DAB)
Digital Radio	EN 300429	1998	EN 60728-1 (DVB-C)
Data streaming	EN 300429	1998	EN 60728-1 (DVB-C)

Table F.4 – Supported generic ICT applications and maximum channel lengths with all-silica multimode fibres

Network Application	λ nm	Core dia µm	OM1			OM2			OM3/OM4		
			CIL[a] dB	L[b] m	Class	CIL[a] dB	L[b] m	Class	CIL[a] dB	L[b] m	Class
IEEE 802.3: FOIRL	850	50	3,3	514	OF-500	3,3	514	OF-500	3,3	514	OF-500
		62,5	9,0	1 000	OF-500	9,0	1 000	OF-500	–	–	–
IEEE 802.3: 10BASE-FL, FP & FB	850	50	6,8	1 514	OF-500	6,8	1 514	OF-500	6,8	1 514	OF-500
		62,5	12,5	2 000	OF-2000	12,5	2 000	OF-2000	–	–	–
ISO/IEC TR 11802-4: Token Ring (4 and 16 Mbit/s)	850	50	8,0	1 857	OF-500	8,0	1 857	OF-500	8,0	1 857	OF-500
		62,5	13,0	2 000	OF-2000	13,0	2 000	OF-2000	–	–	–
ATM at 51,84 Mbit/s	1 300	50	5,3	2 000	OF-2000	5,3	2 000	OF-2000	5,3	2 000	OF-2000
		62,5	10,0	2 000	OF-2000	10,0	2 000	OF-2000	–	–	–
ATM at 155,52 Mbit/s	850	50	7,2	1 000	OF-500	7,2	1 000	OF-500	7,2	1 000	OF-500
		62,5	7,2	1 000	OF-500	7,2	1 000	OF-500	–	-	–
	1 300	50	5,3	2 000	OF-2000	5,3	2 000	OF-2000	5,3	2 000	OF-2000
		62,5	10,0	2 000	OF-2000	10,0	2 000	OF-2000	–	–	–
ATM at 622,08 Mbit/s [c]	850	50	4,0	300	OF-300	4,0	300	OF-300	4,0	300	OF-300
		62,5	4,0	300	OF-300	4,0	300	OF-300	–	–	–
	1 300	50	2,0	330	OF-300	2,0	330	OF-300	2,0	330	OF-300
		62,5	6,0	500	OF-500	6,0	500	OF-500	–	–	–
DIS 14165-111: Fibre Channel (FC-PH) at 133 Mbit/s	1 300	50	–	–	–	–	–	–	–	–	–
		62,5	6,0	1 500	OF-500	6,0	1 500	OF-500	6,0	1500	OF-500
DIS 14165-111: Fibre Channel (FC-PH) at 266 Mbit/s	850	50	12,0	2 000	OF-2000	12,0	2 000	OF-2000	12,0	2 000	OF-2000
		62,5	12,0	700	OF-500	12,0	700	OF-500			
	1 300	50	5,5	2 000	OF-2000	5,5	2 000	OF-2000	5,5	2 000	OF-2000
		62,5	6,0	1 500	OF-500	6,0	1 500	OF-500			
DIS 14165-111: Fibre Channel (FC-PH) at 531 Mbit/s	850	50	8,0	1 000	OF-500	8,0	1 000	OF-500	8,0	1 000	OF-500
		62,5	8,0	350	OF-300	8,0	350	OF-300			
DIS 14165-111: Fibre Channel (FC-PH) at 1 062 Mbit/s [c]	850	50	4,0	500	OF-500	4,0	500	OF-500	4,0	500	OF-500
		62,5	4,0	300	OF-300	4,0	300	OF-300			
1 Gbit/s FC (1,062 5 GBd) [c]	850	50	–	–	–	3,85	500	OF-500	2,62	500	OF-500
		62,5	3,0	300	OF-300	–	–	–	–	–	–
2 Gbit/s FC (2,125 GBd) [c]	850	50	2,10	150	OF-100	2,62	300	OF-300	3,31	300	OF-300
4 Gbit/s FC (4,25 GBd) [c]	850	50	–	–	–	–	–	–	2,28 [d]	380 [d]	OF-300
			–	–	–	–	–	–	3,02 [e]	420 [e]	OF-300
8 Gbit/s FC (8,5 GBd) [c]	850	50	–	–	–	1,68	50	-	2,19 [d]	150 [d]	OF-100
			–	–	–	–	–	–	2,22 [e]	190 [e]	OF-100
16 Gbit/s FC (14,025 GBd)	850	50	–	–	–	1,63	35	–	1,95 [d]	100 [d]	OF-100
			–	–	–	–	–	–	1,97 [e]	125 [e]	OF-100
IEEE 802.3: 1000BASE-SX [c]	850	50	–	–	–	3,56	550	OF-500	3,56	550	OF-500
		62,5	2,6	275	OF-100	–	–	–	–	–	–
IEEE 802.3: 1000BASE-LX [c]	1 300	50	2,35	550	OF-500	2,35	550	OF-500	2,35	550	OF-500
		62,5	2,35	550	OF-500	2,35	550	OF-500	–	–	–
ISO/IEC 9314-3: FDDI PMD	1 300	50	6,3	2 000	OF-2000	6,3	2 000	OF-2000	6,3	2 000	OF-2000
		62,5	11,0	2 000	OF-2000	11,0	2 000	OF-2000	–	–	–
IEEE 802.3: 100BASE-FX	1 300	50	6,3	2 000	OF-2000	6,3	2 000	OF-2000	6,3	2 000	OF-2000
		62,5	11,0	2 000	OF-2000	11,0	2 000	OF-2000	–	–	–
IEEE 802.3: 10GBASE-SR/SW	850	50	–	–	–	1,80	82	–	2,60	300	OF-300
		62,5	1,60	32	–	–	–	–	–	–	–

Table F.4 – Supported generic ICT applications and maximum channel lengths with all-silica multimode fibres (*continued*)

Network Application	λ nm	Core dia µm	OM1			OM2			OM3/OM4		
			CIL[a] dB	*L*[b] m	Class	CIL[a] dB	*L*[b] m	Class	CIL[a] dB	*L*[b] m	Class
IEEE 802.3: 10GBASE-LX4 [c]	1 300	50	2,0	300	OF-300	2,0	300	OF-300	2,0	300	OF-300
		62,5	2,0	300	OF-300	2,0	300	OF-300	–	–	–
IEEE 802.3: 40GBASE-SR4 [c]	850	50 [d]	–	–	–	–	–	–	1,90 [d]	100 [d]	OF-100
		50 [e]							1,50 [f]	150 [f]	OF-100
IEEE 802.3: 100GBASE-SR10 [c]	850	50 [d]	–	–	–	–	–	–	1,90 [d]	100 [d]	OF-100
		50 [e]							1,50 [f]	150 [f]	OF-100

[a] CIL is the maximum channel insertion loss (or optical power budget, as applicable) as defined in the application standard.

[b] *L* is the lower of:
– the maximum channel length specified in the application standard;
– a calculated length from the CIL with 1,5 dB allocated to connecting hardware.

[c] A bandwidth limited application at the channel length shown. The use of lower attenuation components to produce channels exceeding the length shown cannot be recommended.

[d] For cabled optical fibre of Category OM3.

[e] For cabled optical fibre of Category OM4.

[f] For cabled optical fibre of Category OM4 (subject to a maximum total connecting hardware loss of 1,0 dB).

Table F.5 – Supported generic ICT applications and maximum channel lengths with all-silica single-mode fibres

Network Application	λ nm	OS1			OS2		
		CIL[a] dB	*L*[b] m	Class	CIL[a] dB	*L*[b] m	Class
ATM at 51,84 Mbit/s	1 310	10,0	2 000	OF-2000	10,0	20 000	OF-10000
ATM at 155,52 Mbit/s	1 310	7,0	2 000	OF-2000	7,0	12 500	OF-10000
ATM at 622,08 Mbit/s	1 310	7,0	2 000	OF-2000	7,0	12 500	OF-10000
DIS 14165-111: Fibre Channel (FC-PH) at 266 Mbit/s	1 310	6,0	2 000	OF-2000	6,0	10 000	OF-10000
DIS 14165-111: Fibre Channel (FC-PH) at 531 Mbit/s	1 310	14,0	2 000	OF-2000	14,0	30 000	OF-10000
DIS 14165-111: Fibre Channel (FC-PH) at 1 062 Mbit/s	1 310	6,0	2 000	OF-2000	6,0	10 000	OF-10000
1 Gbit/s FC (1,0625 GBd) [c]	1 310	7,8	5 800	OF-2000	7,8	10 000	OF-10000
2 Gbit/s FC (2,125 GBd) [c]	1 310	7,8	5 800	OF-2000	7,8	10 000	OF-10000
4 Gbit/s FC (4,25 GBd) [c]	1 310	7,8	2 400	OF-2000	7,8	10 000	OF-2000
8 Gbit/s FC (8,5 GBd) [c]	1 310	6,4	4 400	OF-2000	6,4	10 000	OF-10000
16 Gbit/s FC (14,025 GBd)	1 310	6,4	4 400	OF-2000	6,4	10 000	OF-10000
IEEE 802.3ae: 1000BASE-LX [c]	1 310	4,56	2 560	OF-2000	4,56	5 000	OF-5000
ISO/IEC 9314-4: FDDI SMF-PMD [c]	1 310	10,0	2 000	OF-2000	10,0	20 000	OF-10000
IEEE 802.3: 10GBASE-LX4 [c]	1 310	6,2	4 200	OF-2000	6,2	10 000	OF-10000
IEEE 802.3: 10GBASE-LR/LW [c]	1 310	6,2	4 200	OF-2000	6,2	10 000	OF-10000
IEEE 802.3: 10GBASE-ER/EW [c]	1 550	10,9	8 900	OF-2000	10,9	22 250	OF-10000
IEEE 802.3: 40GBASE-LR4	1 310	6,7	4 700	OF-2000	6,7	10 000	OF-10000
IEEE 802.3: 100GBASE-LR4	1 310	8,3	6 300	OF-2000	8,3	10 000	OF-10000
IEEE 802.3: 100GBASE-ER4	1 550	18,0	16 000	OF-10000	18,0	40 000	OF-10000

[a] CIL is the maximum channel insertion loss (or optical power budget, as applicable) as defined in the application standard.

[b] *L* is the lower of:
– the maximum channel length specified in the application standard;
– a calculated length from the CIL with 2,0 dB allocated to connecting hardware.

[c] A bandwidth limited application at the channel length shown. The use of lower attenuation components to produce channels exceeding the length shown cannot be recommended.

Table F.6 – Supported data centre applications and maximum channel lengths with all-silica multimode fibres

Network Application	λ nm	Core dia µm	OM1			OM2			OM3		
			CIL[a] dB	L[b] m	Class	CIL[a] dB	L[b] m	Class	CIL[a] dB	L[b] m	Class
ESCON (SBCON) at 200 Mbit/s	1 300	50	8,0	2 000	OF-2000	8,0	2 000	OF-2000	8,0	2 000	OF-2000
		62,5	8,0	2 000	OF-2000	8,0	2 000	OF-2000	–	–	–
SYSPLEX TIMER (ETR/CLO) at 16 Mbit/s	1 300	50	8,0	2 000	OF-2000	8,0	2 000	OF-2000	8,0	2 000	OF-2000
		62,5	8,0	2 000	OF-2000	8,0	2 000	OF-2000	–	–	–
FICON (SX) 1,06 Gbit/s [c]	850	50	–	–	–	3,88	500	OF-500	3,88	500	OF-500
		62,5	2,8	250	OF-250	–	–	–	–	–	–
FICON Express2 (SX) 2,1 Gbit/s [c]	850	50				2,78	300	OF-300	2,78	300	OF-300
		62,5	3,0	300	OF-300						
FICON Express4 (SX) 4 Gbit/s [c]	850	50	2,1	55	OF-50	–	–	–	–	–	–
		62,5	–	–	–	2,26	150	OF-100	2,26	150	OF-100
FICON (LX) 1,06 Gbit/s [c]	1 300	50	5,0	550	OF-500	5,0	550	OF-500	5,0	550	OF-500
		62,5	5,0	550	OF-500	5,0	550	OF-500	–	–	–
COUPLING LINK (ISC) at 531 Mbit/s	850	50	8,0	1 000	OF-500	8,0	1 000	OF-500	8,0	1 000	OF-500
		–	–	–	–	–	–	–	–	–	–
COUPLING LINK (ISC) at 1,06 Gbit/ s [c]	850	50	5,0	550	OF-500	5,0	550	OF-500	5,0	550	OF-500
		–	–	–	–	–	–	–	–	–	–

[a] CIL is the maximum channel insertion loss (or optical power budget, as applicable) as defined in the application standard.

[b] L is the lower of:

- the maximum channel length specified in the application standard;
- a calculated length from the CIL with 2,0 dB allocated to connecting hardware.

[c] A bandwidth limited application at the channel length shown. The use of lower attenuation components to produce channels exceeding the length shown cannot be recommended.

Table F.7 – Supported data centre applications and maximum channel lengths with single-mode fibres

Network Application	λ nm	OS1			OS2		
		CIL[a] dB	L[b] m	Class	CIL[a] dB	L[b] m	Class
ESCON (SBCON) at 200 Mbit/s	1 310	14,0	2 000	OF-2000	14,0	20 000	OF-10000
FICON (LX) 1,06 Gbit/s [c]	1 310	7,0	2 000	OF-2000	7,0	10 000	OF-10000
FICON Express2 (SX) 2,1 Gbit/s [c]	1 310	7,0	2 000	OF-2000	7,0	10 000	OF-10000
FICON Express4 (SX) 4 Gbit/s [c]	1 310	7,0	2 000	OF-2000	7,0	10 000	OF-10000
COUPLING LINK (ISC) at 1,06 Gbit/s [c]	1 310	7,0	2 000	OF-2000	7,0	10 000	OF-10000
COUPLING LINK (ISC) at 2,1 Gbit/s	1 310	7,0	2 000	OF-2000	7,0	10 000	OF-10000

[a] CIL is the maximum channel insertion loss (or optical power budget, as applicable) as defined in the application standard.

[b] L is the lower of:

- the maximum channel length specified in the application standard;
- a calculated length from the CIL with 2,0 dB allocated to connecting hardware.

[c] A bandwidth limited application at the channel length shown. The use of lower attenuation components to produce channels exceeding the length shown cannot be recommended.

Table F.8 –Supported process monitoring and control applications and maximum channel lengths with all-silica multimode optical fibres

Network Application	λ nm	Core dia µm	OM1			OM2			OM3		
			CIL[a] dB	*L*[b] m	Class	CIL[a] dB	*L*[b] m	Class	CIL[a] dB	*L*[b] m	Class
ControlNET	1 300	50	6,5	1 514	OF-500	6,5	1 514	OF-500	6,5	1 514	OF-500
		62,5	11,3	6 533	OF-2000	11,3	6 533	OF-2000			

[a] CIL is the maximum channel insertion loss (or optical power budget, as applicable) as defined in the application standard.

[b] *L* is the lower of:

- the maximum channel length specified in the application standard;
- a calculated length from the CIL with 1,5 dB allocated to connecting hardware.

Table F.9 – Supported process monitoring and control applications and maximum channel lengths with all-silica single-mode optical fibres

Network Application	λ nm	OS1			OS2		
		CIL[a] dB	*L*[b] m	Class	CIL[a] dB	*L*[b] m	Class
ControlNET	1 310	10,0	8 000	OF-5000	10,0	20 000	OF-5000

[a] CIL is the maximum channel insertion loss (or optical power budget, as applicable) as defined in the application standard.

[b] *L* is the lower of:

- the maximum channel length specified in the application standard;
- a calculated length from the CIL with 2,0 dB allocated to connecting hardware.

Table F.10 – Supported process monitoring and control applications and maximum channel lengths with plastic and plastic clad silica optical fibres

Network Application	λ nm	OP1			OP2			OH1		
		CIL [a] dB	*L* [b] m	Class	CIL [a] dB	*L* [b] m	Class	CIL[a] dB	*L* [b] m	Class
Profibus v2.0 July 1999	650	9,0	25	OF-25	–	–	–	–	–	–
Profibus (enhanced) v2.0 July 1999	650	14,0	50	OF-50	–	–	–	–	–	–
Interbus-S August 2000	650	17,2	50	OF-50	–	–	–	–	–	–

[a] CIL is the maximum channel insertion loss (or optical power budget, as applicable) as defined in the application standard.

[b] *L* is the lower of either:

- the maximum channel length specified in the application standard; or
- a calculated length from the CIL with 3,0 dB allocated to connecting hardware.

Annex G
(informative)

Introduction to environmental classification

G.1 General

This annex provides information on the development and application of the environmental classification system introduced in Clause 5 of this standard.

G.2 The application of environmental classification

G.2.1 MICE

The term MICE relates to the classification of the environment local to the cabling channel. There are four primary environmental criteria used to classify an environment:

a) the M element, defining the mechanical characteristics of the environment;

b) the I element, defining the ingress protection characteristics of the environment;

c) the C element, defining the climatic and chemical characteristics of the environment;

d) the E element, defining the electromagnetic characteristics of the environment.

Each of the four primary environmental criteria are further divided into specific parameters and levels for those parameters. The MICE classification for a given location is therefore defined as $M_aI_bC_cE_d$ where a, b, c and d are the individual sub-classifications for the M, I, C and E criteria respectively.

The suffices for the four primary environmental criteria are either 1, 2 or 3. For example, the most benign environment is described as $M_1I_1C_1E_1$ whereas the most harsh environment within the scope of this standard would be defined as $M_3I_3C_3E_3$.

G.2.2 The channel environment

The applicable MICE classification may vary along the length of the cabling channel. In the example of industrial premises shown in Figure G.1, the ingress protection characteristics of the environment in the automation area and at the automation island are different to, and more severe than, those characteristics on the factory floor or in the telecommunications room.

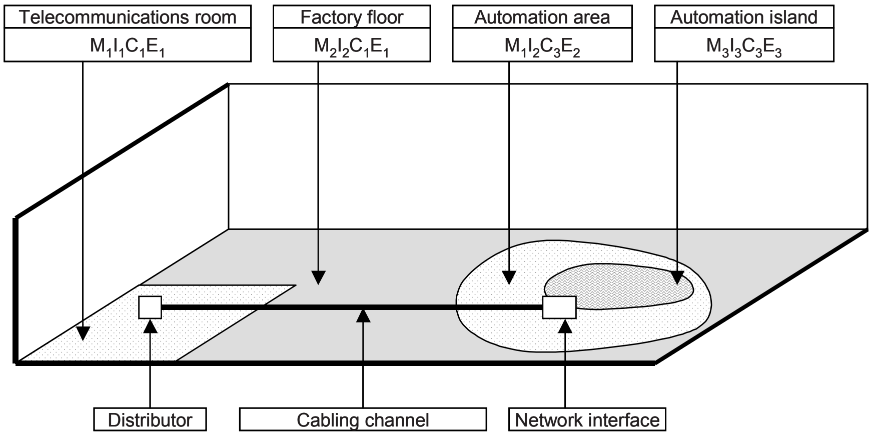


Figure G.1 − Variation of the environment along a cabling channel

The environment to be classified is that local to the cabling. Where no environmental protection is provided to the cabling, the classification of the local environment is also that of the overall environment at that location.

However, where technical or economic restrictions preclude the use of components compatible with the overall environment, mitigation or isolation techniques may be applied to modify the environment local to the channel in order to allow appropriate components to be installed.

The mitigation or isolation techniques typically involve the use of alternative pathways and/or pathway systems as shown in Figure G.2.

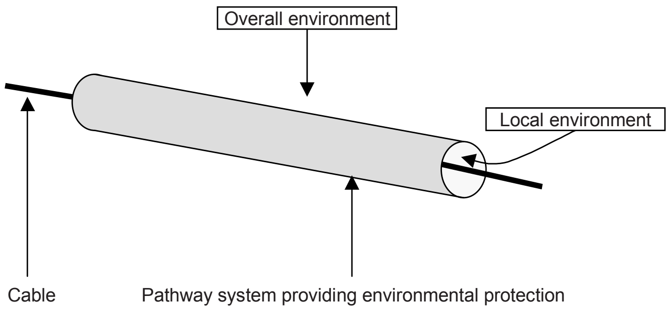


Figure G.2 − The local environment

G.2.3 Component selection

The components used within a channel should be selected to be compatible with the MICE classification of the channel at the point where the components are to be installed.

Table 3 shows the parameters used to classify the local environment under the M, I, C or E criteria. While the classification of an environment is determined by the most demanding parameter within each criteria group, the selection of components may reflect the specific demands of all the parameters within the group – including those that may be less demanding than the overall classification of the environment.

G.3 The MICE system

The MICE concept is provided for the use of designers and planners to allow the specification of components to be purchased or protection (mitigation or isolation) required respectively.

Table 3 is not a basis for testing the local environment and neither is it a series of environmental criteria for the testing of components used within those environments. However the limits describing the $M_aI_bC_cE_d$ classification system are in many cases based upon existing standards.

Tables G.1, G.2, G.3, G.4 and G.5 and the text following each Table show the derivation of the boundaries used in Table 3.

Table G.1 – Derivation of boundaries for mechanical criteria in Table 3

Mechanical	M_1	M_2	M_3
Shock/bump			
Peak acceleration	40 m/s^2	100 m/s^2	250 m/s^2
Vibration			
Displacement amplitude (2 Hz to 9 Hz)	1,5 mm	7,0 mm	15,0 mm
Acceleration amplitude (9 Hz to 500 Hz)	5 m/s^2	20 m/s^2	50 m/s^2
Shock/bump/vibration (source material)	EN 60721-3-3:1995, Class 3M2	< EN 60721-3-3:1995 Class 3M6	EN 60721-3-3:1995 Class 3M8
Crush	45 N over 25 mm (linear) min.	1 100 N over 150 mm (linear) min.	2 200 N over 150 mm (linear) min.
Impact	1 J	10 J	30 J

From EN 60721-3-3:

Class 3M1 applies to locations with insignificant vibration and shock.

In addition to the conditions covered by Class 3M1, Class 3M2 applies to locations with vibration of low significance (products mounted on light structures subject to negligible vibration).

In addition to the conditions covered by Class 3M5, Class 3M6 applies to locations where the level of vibration is high (e.g. close to heavy machines).

In addition to the conditions covered by Class 3M7, Class 3M8 applies to locations where the level of vibration is extremely high (e.g. products mounted on power hammers).

Table G.2 – Derivation of boundaries for ingress protection criteria in Table 3

Ingress	I_1	I_2	I_3
Particulate ingress (diameter max)	12,5 mm	50 µm	50 µm
Immersion	None	Intermittent liquid jet ≤ 12,5 l/min ≥ 6,3 mm jet > 2,5 m distance	Intermittent liquid jet ≤ 12,5 l/min ≥ 6,3 mm jet > 2,5 m distance and immersion (≤ 1 m for ≤ 30 min)

Table G.3 – Derivation of boundaries for climatic and chemical criteria in Table 3

Climatic	C_1	C_2	C_3
Ambient temperature	– 10 °C to + 60 °C	– 25 °C to + 70 °C	– 40 °C to + 70 °C
	EN 50173-1	EN 60721-3-3:1995, Class 3K8H	EN 60721-3-3:1995, Class 3K7
Rate of change of temperature	0,1 °C/ min	1,0 °C/min	3,0 °C/min
	EN 60721-3-3:1995, Class 3K1	EN 60721-3-3:1995, Class 3K7	EN 61131-2
Humidity	5 % to 85 % (non-condensing)	5 % to 95 % (condensing)	5 % to 95 % (condensing)
	EN 60721-3-3:1995, Class 3K3	EN 60721-3-3:1995, Class 3K4	EN 60721-3-3:1995, Class 3K5
Solar radiation	700 W/m^2	1 120 W/m^2	1 120 W/m^2
	EN 60721-3-3:1995, Class 3K3 – 3K6	EN 60721-3-3:1995, Class 3K7. EN 60068-2-5:1999 contains a table covering wavelengths from UV to IR that totals 1 120 W/m^2.	

From EN 60721-3-3:

Class 3K1 applies to fully air-conditioned enclosed locations. Air temperature and humidity control is used continuously to maintain the required conditions. Installed products may be exposed to attenuated solar radiation and to movements of surrounding air due to draughts from the air-conditioning system. They are not subjected to heat radiation, condensed water, precipitation, water from sources other than rain, or formation of ice. These conditions may be found in room of such construction that a confined range of temperature and humidity may be maintained.

In addition to the conditions covered by Class 3K1, Class 3K2 applies to continuously temperature-controlled enclosed locations. Humidity is not controlled. Heating, cooling or humidification is used where necessary to maintain the required conditions, especially where there is a large difference between them and the open air-climate. Installed products may be exposed to solar radiation and to heat radiation. They may be subject to movements of surrounding air due to draughts in buildings. These conditions may be found in manned offices, workshops, and other rooms for special applications.

In addition to the conditions covered by Class 3K2, Class 3K3 applies to continuously temperature-controlled enclosed locations. Humidity is not controlled. Heating or cooling is used where necessary to maintain the required conditions, especially where there is a large difference between them and the open air-climate. These conditions may be found in normal living or working areas e.g. living rooms, rooms for general use (theatres, restaurantsm etc.), offices, shops, workshops for electronic assemblies and other electro-technical products, telecommunications centres, storage rooms for valuable and sensitive products.

In addition to the conditions covered by Class 3K3, Class 3K4 applies to temperature-controlled enclosed locations with a wide range of relative humidity. Humidity is not controlled. Installed products may be subject to condensed water and to water from sources other than rain. These conditions may be found in certain living or working areasm e.g. kitchens, bathrooms, workshops with processes producing high humidity, certain cellars, ordinary storage rooms, stables, garages. For the more humid open-air climates they may also be found in living rooms and rooms for general use.

In addition to the conditions covered by Class 3K4, Class 3K5 applies to enclosed locations having neither temperature or humidity control. Heating may be used to raise low temperatures, especially where there is a large difference between them and the open air-climate. Product may be subject to the formation of ice. These conditions may be found in some entrances and staircases of buildings, garages, cellars, certain workshops, buildings in factories and industrial process plants, certain telecommunications buildings, ordinary storage rooms for frost-resistant products, farm buildingsm etc.

In addition to the conditions covered by Class 3K4, Class 3K6, Class 3K7 and Class 3K8H apply to weather-protected locations having neither temperature or humidity control. The locations may have openings to the open-air. The climatic conditions may be affected by the open-air climate and the type of building. Installed products may be exposed to solar radiation. They may also be subject to wind-driven precipitation including snow. These conditions may be found in some entrances of buildings, some garages, in sheds, shacks, lofts, telephone booths, buildings in factories and industrial process plants, unattended equipment stations, unattended buildings for telecommunications purposes, ordinary storage rooms for frost-resistant products, farm buildings, etc.

Table G.4 – Derivation of boundaries chemical criteria in Table 3

Chemical	C_1	C_2	C_3
Liquid pollution Contaminants	Concentration × 10^{-6}	Concentration × 10^{-6}	Concentration × 10^{-6}
Sodium chloride (salt/sea water)	0	< 0,3	< 0,3
	EN 60721-1		
Oil (dry-air concentration)	0	< 0,005	< 0,5
Sodium stearate (soap)	None	5 × 10^4 aqueous non-gelling	> 5 × 10^4 aqueous gelling
Detergent	None	ffs	ffs
Conductive materials in solution	None	Temporary	Present
Gaseous pollution Contaminants	Mean/Peak (Concentration × 10^{-6})	Mean/Peak (Concentration × 10^{-6})	Mean/Peak (Concentration × 10^{-6})
Hydrogen sulphide	< 0,003 / < 0,01	< 0,05 / < 0,5	< 10 / < 50
	The limits are taken from EN 60654-4:1997 for the environmental descriptions Class 1, 2 and 3. They are within the same region as those in EN 60721-3-3:1995, A.1, for the environmental descriptions 3C1, 3C2 and 3C4. NOTE For comparison the values in EN 60721-3-3:1995, A.1, have been converted from mg.cm^{-3} using the STP density = 1,539.		
Sulphur dioxide	< 0,01 / < 0,03	< 0,1 / < 0,3	< 5 / < 10
	The limits are taken from EN 60654-4:1997 for the environmental descriptions Class 1, 2 and 3, with the exception of Class 3 (max < 15). They are identical to the environmental descriptions EN 60721-3-3:1995, A.1, for the environmental descriptions 3C1 and 3C2 and within the same region for the environmental description 3C4 (mean < 4,5, max. < 14). NOTE for comparison the values in EN 60721-3-3:1995, A.1, have been converted from mg.cm^{-3} using the STP density = 2,927.		
Sulphur trioxide (ffs)	< 0,01 / < 0,03	< 0,1 / < 0,3	< 5 / < 15
	There are no limits in EN 60654-4:19987 or EN 60721-3-3.		
Chlorine wet (> 50 % humidity)	< 0,000 5 / < 0,001	< 0,005 / < 0,03	< 0,05 / < 0,3
	The limits are taken from EN 60654-4:1997 for the environmental descriptions Class 1, 2 and 3. There are no limits in EN 60721-3-3.		
Chlorine dry (< 50 % humidity)	< 0,002 / < 0,01	< 0,02 / < 0,1	< 0,2 / < 1,0
	The limits are taken from EN 60654-4:1997 for the environmental descriptions Class 1, 2 and 3. They are within the same region as those in EN 60721-3-3:1995, A.1, for the environmental descriptions 3C1, 3C2 and 3C4. NOTE For comparison the values in EN 60721-3-3:1995, A.1, have converted from mg.cm^{-3} using the STP density = 3,124.		
Hydrogen chloride	– / < 0,06	< 0,06 / < 0,3	< 0,6 / 3,0
	There are no limits in EN 60654-4:1997. The limits are taken from EN 60721-3-3:1995 for the environmental descriptions 3C1, 3C2 and 3C4. NOTE For comparison the values in EN 60721-3-3:1995, A.1, have converted from mg.cm^{-3} using the STP density = 1,639.		
Hydrogen fluoride	< 0,001 / < 0,005	< 0,01 / < 0,05	< 0,1 / < 1,0
	The limits are taken from EN 60654-4:1997 for the environmental descriptions Class 1, 2 and 3. They are within the same region as those in EN 60721-3-3:1995, A.1, for the environmental descriptions 3C1, 3C2 and 3C4. NOTE For comparison the values in EN 60721-3-3:1995, A.1, have been converted from mg.cm^{-3} using the STP density = 0,901.		
Ammonia	< 1 / < 5	< 10 / < 50	< 50 / < 250
	The limits are taken from EN 60654-4:1997 for the environmental descriptions Class 1, 2 and 3. They are within the same region as those in EN 60721-3-3:1995, A.1, for the environmental descriptions 3C2, 3C3 and 3C4. NOTE: For comparison the values in EN 60721-3-3:1995, A.1, have been converted from mg.cm^{-3} using the STP density = 0,771.		
Oxides of Nitrogen	< 0,05 / < 0,1	< 0,5 / < 1	< 5 / < 10
	The limits are taken from EN 60654-4:1997 for the environmental descriptions Class 1, 2 and 3. They are within the same region as those in EN 60721-3-3:1995, A.1, for the environmental descriptions 3C1, 3C2 and 3C4. NOTE For comparison the values in EN 60721-3-3:1995, A.1, have been converted from mg.cm^{-3} using the STP density = 1,350 (averaged on NO, NO_2 and NO_3).		
Ozone	< 0,002 / < 0,005	< 0,025 / < 0,05	< 0,1 / < 1
	The limits are taken from EN 60654-4:1997 for the environmental descriptions Class 1, 2 and 3. They are within the same region as those in EN 60721-3-3:1995, A.1, for the environmental descriptions 3C2, 3C3 and 3C4. NOTE for comparison the values in EN 60721-3-3:1995, A.1, have been converted from mg.cm^{-3} using the STP density = 2,144.		

From EN 60654-4:1987:

Class 1: Environments sufficiently well controlled so that corrosion is not a factor in determining corrosion.

Class 2: Environments where the affects of corrosion are measurable and may be a factor in determining equipment reliability.

Class 3: Environments where there is a high probability that corrosive attack will occur.

From EN 60721-3-3:

Class 3C1R applies to locations with stringently monitored and controlled atmosphere (clean room category).

In addition to the conditions covered by Class 3C1L, Class 3C1R applies to locations where the atmosphere is continuously controlled.

In addition to the conditions covered by Class 3C1R, Class 3C1 applies to locations in rural and some urban areas with low industrial activities and moderate traffic. Increased contamination in urban areas in winter due to heating methods. Salt mist may be present in sheltered locations of coastal areas.

In addition to the conditions covered by Class 3C1, Class 3C2 applies to locations with normal levels of contaminants experienced in urban areas with scattered industrial activities or heavy traffic.

In addition to the conditions covered by Class 3C2, Class 3C3 applies to locations in the immediate neighbourhood of industrial sources with chemical emissions.

In addition to the conditions covered by Class 3C3, Class 3C4 applies to locations within industrial process plants. Emissions of chemical pollutants in high concentrations may occur.

Table G.5 – Derivation of boundaries for electromagnetic criteria in Table 3

Electromagnetic	E_1	E_2	E_3
Electrostatic discharge – Contact (0,667 μC)	4 kV	4 kV	4 kV
Electrostatic discharge – Air (0,132 μC)	8 kV	8 kV	8 kV
	EN 61000-6-1/EN 61326		
Radiated radio frequency, amplitude modulated (RF – AM)	3 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz	3 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz	10 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz
	IEC/TS 61000-2-5		
Conducted radio frequency (RF)	3 V at 150 kHz to 80 MHz	3 V at 150 kHz to 80 MHz	10 V at 150 kHz to 80 MHz
	EN 61000-6-1/EN 61326		EN 61000-6-2/EN 61326
Electrical fast transient/burst, EFT/B (signal line)	AC 500 V	AC 1 000 V	AC 1 000 V
	EN 61000-6-1	IEC/TS 61000-2-5/EN 61131-2	EN 61326:1997, Table A.1
Surge (transient ground potential difference) - signal, line to earth	500 V	1 000 V	2 000 V
	EN 61000-6-2		
Magnetic Field (50/60 Hz)	1 A/m	3 A/m	30 A/m
		EN 61000-6-1	EN 61000-6-2/EN 61326
Magnetic Field (60 Hz to 20 000 Hz)	ffs	ffs	ffs

G.4 Guidance with respect to environmental classification

G.4.1 Mechanical environment

ffs

G.4.2 Ingress protection environment

ffs

G.4.3 Climatic and chemical environment

ffs

G.4.4 Electromagnetic environment

Within industrial premises electromagnetic noise may be present over a wide range of frequencies. In addition, there is a range of noise coupling mechanisms. Figure G.3 is provided as guidance in determining the frequency range of common noise generating devices that may be found in industrial premises.

The grey bars in Figure G.3 indicate the extension of the frequency range caused by the third harmonic.

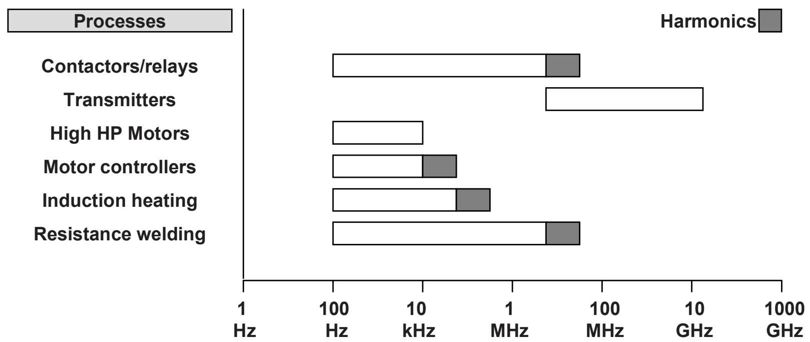


Figure G.3 − Noise Ranges of Common Industrial Machine Devices

The level of the interfering noise is dependent on two factors:

a) distance;

b) magnitude of the generating device.

Table G.6 indicates the coupling mechanism for each of the interfering devices and provides assistance to designer, installer and troubleshooting personnel in mitigating or correcting for noise interference.

For example, in an environment where a relay contactor is found to cause interference, the mechanism for noise ingress is coupling through adjacent lines (EFT). To correct this situation, additional separation should be provided to reduce the magnitude of coupling.

Table G.6 – Coupling mechanisms for common noise sources

Noise Generating Device	Noise	Coupling mechanism
Electric Motors	Surge and electrical fast transient (EFT)	Local Ground, Conducted
Drive Controllers	Conducted and Surge	Local Ground, Conducted
Relays and Contactors	EFT	Radiated, Conducted
Welding	EFT, Induction	Radiated Magnetic
RF Induction Welding	Radio Frequency	Radiated, Conducted
Material handling (paper/textile)	Electrostatic discharge (ESD)	Radiated
Heating	EFT	Local Ground, Conducted, Radiated
Induction Heating	EFT, Magnetic	Local Ground, Conducted, Radiated
Radio Communications	Radio Frequency	Radiated

Annex H
(informative)

Acronyms for balanced cables

There is a great variety of cable constructions and a number of systems to describe these constructions in a shortened form. These abbreviations have been used to describe the difference in construction, as well the difference in impedance. Since such acronyms are used in many commercial documents and have never been clearly specified by a standard, the same term could mean different kinds of constructions in different context.

The intention of this annex is to clarify this situation and give guidance on how to use abbreviations for the main constructions used for communication cables. This document uses the words balanced cable, unscreened/screened cable and unscreened/screened cable element for the cable constructions described in this annex.

To reduce confusion a more systematic naming is specified in Figure H.1. It is understood that cable names based on this schema only describe the types of constructions and not any transmission characteristics such as impedance.

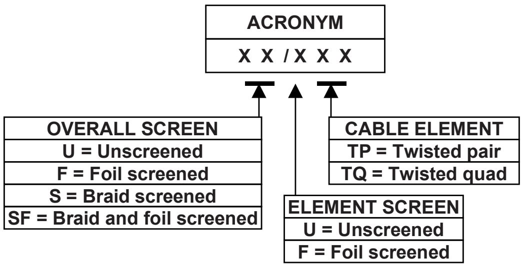


Figure H.1 – Balanced cable naming schema

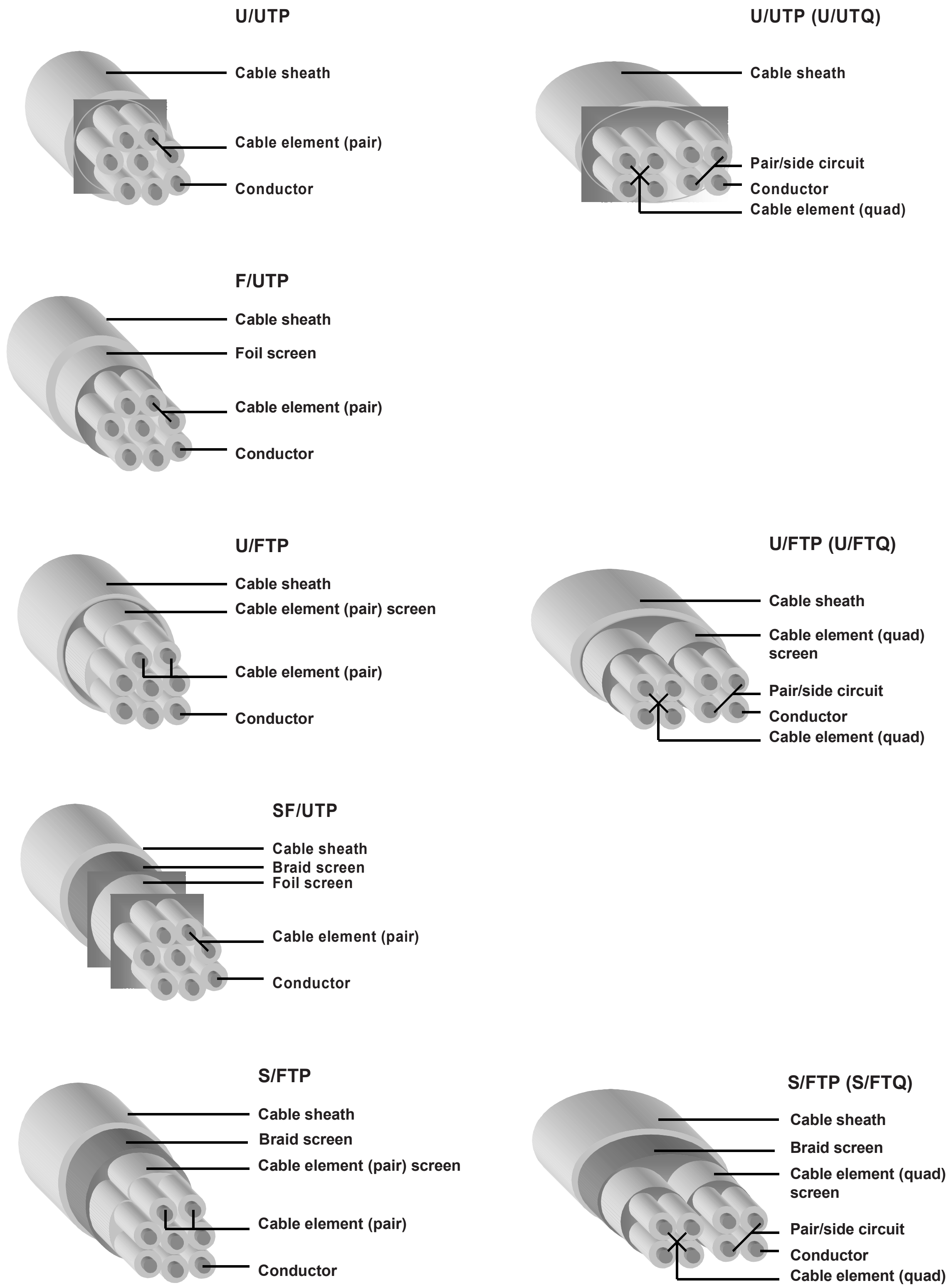
EXAMPLES

a) SF/UTP Overall braid and foil screened cable with unscreened balanced cable elements;

b) S/FTP Overall braid screened cable with foil screened balanced cable elements;

c) U/UTP Unscreened cable with unscreened balanced cable elements.

Figure H.2 illustrates cable constructions and their names based on this schema.



NOTE The letter P is sometimes replaced by Q to denote a quad cable element construction.

Figure H.2 – Balanced cable construction types

Annex I
(normative)

Testing procedures to assess conformance with EN 50173 standards

I.1 General

This annex contains requirements and recommendations for testing of channels and links in order to determine their conformance to the EN 50173 series of standards.

I.2 Channel and link performance testing

I.2.1 General

Performance testing can be undertaken either:

a) in a laboratory, where channels or links contain specific cabling components in a specific implementation; or

b) in the field, after installation, using field test equipment.

This testing is independent from any requirements for acceptance testing contained within an installation specification as in EN 50174-1.

There are two kinds of conformance testing:

1) Reference conformance testing

   This testing is performed on a sample of installed cabling in a laboratory where an assessment against the conformance criteria of the applicable EN 50173 standard is required. The assessment documentation shall include details of the number of channels or links tested, test evaluation criteria, supplier's declarations and certification, laboratory accreditation and calibration certification, etc. This testing is also known as type testing.

   This testing can also be used for:

   i) the comparison of measurements performed with laboratory and field test instruments;

   ii) assessing cabling models in a laboratory environment;

   iii) assessing parameters that cannot be tested in an installation.

2) Installation conformance testing

   This testing is performed on a complete installation of cabling in the field where an assessment against the conformance criteria of the applicable EN 50173 standard is required.

Conformance testing of both types is often performed by independent or third party organisations in order to give greater guarantees of compliance.

I.2.2 Testing balanced cabling channels and links

Testing to determine conformance with the transmission performance requirements is not a requirement of the EN 50173 series of standards. Testing should be performed in the following cases:

a) links or channels with lengths exceeding, or having more components than, those specified in reference implementations of the applicable EN 50173 standard;

b) links containing cables or connecting hardware with transmission performance lower than those described in the relevant component clauses of the applicable EN 50173 standard;

c) channels containing cables, connecting hardware or cords with transmission performance lower than those described in the relevant component clauses of the applicable EN 50173 standard;

d) channels created by adding more than one cord to either end of links meeting the requirements of the applicable EN 50173 standard;

e) evaluation of a channel to determine its capacity to support a certain group of applications;

f) confirmation of performance of cabling designed in accordance with the reference implementations of the standard using cables, connecting hardware and cords in accordance with relevant component clauses of the applicable EN 50173 standard.

The test procedures for balanced cabling channels and links are specified in EN 50346.

I.2.3 Testing optical fibre cabling channels and links

Testing to determine conformance with the transmission performance is not a requirement of the EN 50173 series of standards. Testing should be performed in the following cases:

a) evaluation of cabling to determine its ability to support a certain group of applications;

b) confirmation of performance of cabling designed in accordance with the reference implementations of the standard using cables, connecting hardware and cords in accordance with relevant component clauses of the applicable EN 50173 standard.

The test procedures for optical fibre cabling channels and links are specified in EN 50346.

I.2.4 Channel and link test schedules

NOTE If field test equipment is not available for certain testing transmission parameters, or for certain frequency ranges, laboratory test equipment can be used. Laboratory test equipment is generally not practical for testing certain transmission parameters where access to both ends of the installed cabling is required at the same time.

A test regime for each of the two kinds of conformance testing (see I.2.1) is defined for each transmission parameter. The test regime for balanced cabling reference conformance and installation conformance testing is shown in Table I.1. The test regime for optical fibre cabling reference conformance and installation conformance testing is shown in Table I.2.

Table I.1 – Test regime for reference conformance and installation conformance to EN 50173 series standards − Balanced cabling

Transmission parameter [a]	Reference conformance testing	Installation conformance testing
Return loss	N	N
Insertion loss	N	N
Pair-to-pair NEXT	N	N
PS NEXT	C	C
Pair-to-pair ACR-N	C	C
PS ACR-N	C	C
Pair-to-pair ACR-F	N	N
PSACR-F	C	C
Direct current (d.c.) loop resistance	C	C
Direct current (d.c.) resistance unbalance	N	I
Propagation delay	N	N
Delay skew	C	C
Unbalance attenuation, near-end (TCL)	N	I
Unbalance attenuation, far-end (ELTCTL)	N	I
Coupling attenuation	N	I
PSANEXT	N	N_S
$PSANEXT_{avg}$	C	C
PSAACR-F	N	N_S
$PSAACR\text{-}F_{avg}$	C	C
Wire-map	N	N
Continuity: - Signal conductors - Screen conductors (if present) - Short circuits - Open circuits	N	N
Length [b]	I	I

C = Calculated value
I = Informative (optional) testing
N = Normative (100 %) testing, if not met by design
N_S = Normative (sampled) testing, if not met by design. The sample size to be tested should be in accordance with EN 50174-1:2009/A1:2011.

[a] Only those parameters specified for each Class of cabling need to be tested as required in Clause 5 and Annex A.

[b] Length is not a pass/fail criterion.

Table I.2 – Test regime for reference conformance and installation conformance to EN 50173 series standards − Optical fibre cabling

Transmission parameter	Reference conformance testing	Installation conformance testing
Attenuation	N	N
Propagation delay [a]	I	I
Polarity	N	N
Length	N	N
I = Informative (optional) testing N = Normative (100 %) testing		
[a] Not a pass/fail criterion.		

Bibliography

CLC/TR 50173-99-1, *Cabling guidelines in support of 10 GBASE-T*

CLC/TR 50173-99-2, *Information technology – Implementation of BCT applications using cabling in accordance with EN 50173-4*

EN 50083-2:2006, *Cable networks for television signals, sound signals and interactive services – Part 2: Electromagnetic compatibility for equipment*

EN 50083-7, *Cable networks for television signals, sound signals and interactive services – Part 7: System performance*

EN 50098-1:1998 + A1:2002, *Customer premises cabling for Information Technology – Part 1: ISDN basic access*

EN 50098-2, *Customer premises cabling for Information Technology – Part 2: 2 048 kbit/s ISDN primary access and leased line network interface*

EN 50173-2, *Information technology – Generic cabling systems – Part 2: Office premises*

EN 50173-3, *Information technology – Generic cabling systems – Part 3: Industrial premises*

EN 50173-4, *Information technology – Generic cabling systems – Part 4: Homes*

EN 50173-5, *Information technology – Generic cabling systems – Part 5: Data centres*

EN 50310, *Application of equipotential bonding and earthing in buildings with information technology equipment*

EN 55022, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement (IEC/CISPR 22:1997, modified)*

EN 55024, *Information technology equipment – Immunity characteristics – Limits and methods of measurement (IEC/CISPR 24:1997, modified)*

EN 60068-1:1994, *Environmental testing – Part 1: General and guidance (IEC 60068-1:1988 + A1:1992)*

EN 60068-2-5:1999, *Environmental testing – Part 2: Tests – Test Sa: Simulated solar radiation at ground level (IEC 60068-2-5:1975)*

EN 60654-4:1997, *Operating conditions for industrial-process measurement and control equipment – Part 4: Corrosive and erosive influences (IEC 60654-4:1987)*

EN 60708, *Low-frequency cables with polyolefin insulation and moisture barrier polyolefin sheath (IEC 60708:2005)*

EN 60721-1, *Classification of environmental conditions – Part 1: Environmental parameters and their severities (IEC 60721-1:1990 + A1:1992)*

EN 60721-3-3:1995, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weather protected locations (IEC 60721-3-3:1994)*

EN 60728-1:2008, *Cable networks for television signals, sound signals and interactive services – Part 1: System performance of forward paths (IEC 60728-1:2007)*

EN 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments (IEC 61000-6-1:1997, modified)*

EN 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments (IEC 61000-6-2:1999, modified)*

EN 61131-2, *Programmable controllers – Part 2: Equipment requirements and tests (IEC 61131-2:2003)*

EN 61326:1997, *Electrical equipment for measurement, control and laboratory use – EMC requirements (IEC 61326:1997)*

EN 300 401, *Radio broadcasting systems – Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers*

EN 300 421, *Digital Video Broadcasting (DVB) – Framing structure, channel coding and modulation for 11/12 GHz satellite services*

EN 300 429, *Digital Video Broadcasting (DVB) – Framing structure, channel coding and modulation for cable systems*

EN 300 744, *Digital Video Broadcasting (DVB) – Framing structure, channel coding and modulation for digital terrestrial television*

IEC 60050-195:1998, *International Electrotechnical Vocabulary – Part 195: Earthing and protection against electric shock*

IEC 60874-19-1, *Fibre optic interconnecting devices and passive components – Connectors for optical fibres and cables – Part 19-1: Fibre optic patch cord connector type SC-PC (floating duplex) standard terminated on multimode fibre type A1a, A1b – Detail specification*

IEC/TS 61000-2-5, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 5: Classification of electromagnetic environments*

ISO/IEC 9314-3, *Information processing systems – Fibre distributed Data Interface (FDDI) – Part 3: Physical Layer Medium Dependent (PMD)*

ISO/IEC 9314-4, *Information technology – Fibre distributed data interface (FDDI) – Part 4: Single-mode fibre physical layer medium dependent (SMF-PMD)*

ISO/IEC 14165-114, *Information technology – Fibre Channel – Part 114: 100 MB/s Balanced Copper Physical Interface (FC-100-DF-EL-S)*

ISO/IEC TR 11802-4, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks - Technical reports and guidelines – Part 4: Token ring access method and physical layer specifications – Fibre optic attachment*

ISO/IEC/TR 29125, *Telecommunications cabling requirements for remote powering of terminal equipment*

IEEE Std 802.3, *IEEE Standard for Information technology – Telecommunications and information exchange between systems-Local and metropolitan area networks – Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*

IEEE Std 802.5, *IEEE Standard for Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 5: Token Ring Access Method and Physical Layer Specification* (ISO/IEC 8802-5)

IEEE Std 1394b, *IEEE Standard for a High-Performance Serial Bus*

INCITS 435, *Information technology – Fibre Channel BaseT (FC-BaseT)*

ITU-T Recommendation I.430, *Basic user-network interface; Layer 1 specification*

ITU-T Recommendation I.431, *Primary rate user-network interface; Layer 1 specification*

ITU-T Recommendation V.11, *Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s*

ITU-T Recommendation X.21, *Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for synchronous operation on public data networks*

ITU-R Recommendation BT.470-6, *Conventional television systems*

ITU-R Recommendation BS.412-9, *Planning standards for terrestrial FM sound broadcasting at VHF*

ITU-R Recommendation P.1546, *Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz*

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK