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To the Members of:

Technical Committee TCT/7

SUBJECT: CENELEC VOTE FINAL DRAFT PR EN 50173-1 INFORMATION TECHNOLOGY -GENERIC CABLING SYSTEMS PART 1:GENERAL REQUIREMENTS AND OFFICE AREAS. UK CLOSE DATE 9 SEPTEMBER 2002

Please find attached the final draft for prEN 50173-1 Information technology -Generic cabling systems Part 1:General requirements and office areas.

Please note that the UK close date is **9 September 2002.**

Yours sincerely

Sharon Sinatra
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DISC
Secretary to TCT/7

FINAL DRAFT
prEN 50173-1

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Information technology - Generic cabling systems
Part 1: General requirements and office areas

Technologies de l'information - Systèmes génériques de câblage
Partie 1: Spécification générale et environnement de bureaux

Informationstechnik - Anwendungsneutrale Kommunikationskabelanlagen
Teil 1: Allgemeine Anforderungen und Bürobereiche

This draft European Standard is submitted to CENELEC members for formal vote.
Deadline for CENELEC: 2002-09-13

It has been drawn up by Technical Committee CENELEC TC 215.

If this draft becomes a European Standard, 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.

This draft European Standard was established by CENELEC 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, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

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CENELEC

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

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Foreword

This draft European Standard has been prepared by Technical Committee CENELEC/TC 215 „Electrotechnical aspects of telecommunication equipment" under the framework of the Mandates M/212 on „Telecommunication cables and cabling systems" and M/239 on „Air traffic management equipment and systems".

It is submitted to the Formal Vote.

The following dates are proposed:

- latest date by which the existence of the EN has to be announced at national level	(doa)	dor + 6 months
- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	dor + 12 months
- latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	dor + 12 months (to be confirmed or modified when voting)

This European Standard supersedes both EN 50173:1995 and EN 50173:1995/A1:2000.

Annexes designated “normative” are a part of this standard. Annexes designated “informative” are for information only. In this standard, Annexes A and D are normative, Annexes B, C, E, F and G are informative.

To ease the commenting of this draft line numbers have been included; they will be suppressed in the final document.

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Introduction

Within premises, the importance of the information technology cabling infrastructure is similar to that of other fundamental building utilities such as heating, lighting and mains power. As with other utilities, interruptions to service can have serious impact. Poor quality of service due to lack of design foresight, use of inappropriate components, incorrect installation, poor administration or inadequate support can threaten an organisation's effectiveness.

Historically, the cabling within a premises comprised both application-specific and multipurpose networks. The previous edition of this standard enabled a controlled migration to generic cabling and the reduction in the use of application-specific cabling. The subsequent growth of generic cabling designed in accordance with EN 50173 has supported the development of high data rate applications based upon a defined cabling model. This edition, EN 50173-1, has been revised to reflect these increasing demands.

This European Standard provides:

a) users with an application independent generic cabling system and an open market for cabling components;

b) users with a flexible cabling scheme such that modifications are both easy and economical;

c) building professionals (for example, architects) with guidance allowing the accommodation of cabling before specific requirements are known; i.e., in the initial planning either for construction or refurbishment;

d) industry and standardisation bodies with a cabling system which supports current products and provides a basis for future product development and applications standardisation.

This European Standard specifies multi-vendor cabling, and is related to:

- standards for cabling components developed by Technical Committees of CENELEC and/or IEC;
- standards for the quality assurance and installation of information technology cabling (series EN 50174) and testing of installed cabling (EN 50346);
- applications developed by the subcommittees of ISO/IEC JTC 1 and study groups of ITU-T..

The applications listed in Annex E have been analysed to determine the requirements for a generic cabling system. These requirements, together with statistics concerning premises geography from different countries and the models described in Clause 6, have been used to develop the requirements for cabling components and to stipulate their arrangement into cabling systems. As a result, generic cabling defined within this European Standard is targeted at, but not limited to, the general office environment.

It is anticipated that the generic cabling system meeting the minimum requirements of this European Standard will have a life expectancy in excess of ten years.

Figure 1 shows the relationships between the standards produced by TC 215 for information technology cabling, namely this generic cabling design standard, cabling installation standards (EN 50174 series), testing of installed cabling (EN 50346) and equipotential bonding requirements (EN 50310).

Building design phase	**Generic cabling design phase**	**Planning phase**	**Implementation phase**	**Operation phase**
EN 50310 5.2: Common bonding network (CBN) within a building 6.3: AC distribution system and bonding of the protective conductor (TN-S)	EN 50173-1 4: Topology 5: Channel performance 7: Cable requirements 8: Connecting hardware requirements 9: Requirements for cords A.1: Link performance limits	EN 50174-1 4: Specification considerations 5: Quality assurance 7: Cabling administration **and** EN 50174-2 4: Safety requirements 5: General installation practices for metallic and optical fibre cabling 6: Additional installation practice for metallic cabling 7: Additional installation practice for optical fibre cabling **and** EN 50174-3 **and** **(for equipotential bonding)** EN 50310 5.2: Common bonding network (CBN) within a building 6.3: AC distribution system and bonding of the protective conductor (TN-S)	EN 50174-1 6: Documentation 7: Cabling administration **and** EN 50174-2 4: Safety requirements 5: General installation practices for metallic and optical fibre cabling 6: Additional installation practice for metallic cabling 7: Additional installation practice for optical fibre cabling **and** EN 50174-3 **and** **(for equipotential bonding)** EN 50310 5.2: Common bonding network (CBN) within a building 6.3: AC distribution system and bonding of the protective conductor (TN-S) **and** EN 50346 4: General requirements 5: Test parameters for balanced cabling 6: Test parameters for optical fibre cabling	EN 50174-1 5: Quality assurance 7: Cabling administration 8: Repair and maintenance

Figure 1 – Relationship between EN 50173-1 and other standards relevant for information technology cabling systems

1 Scope and conformance

1.1 Scope

This European Standard specifies generic cabling for use within premises which may comprise single or multiple buildings on a campus. It covers balanced cabling and optical fibre cabling.

The standard is optimised for premises in which the maximum distance over which telecommunications services have to be distributed is 2 000 m. The principles of this European Standard may also be applied to larger installations.

Cabling defined by this standard supports a wide range of services including voice, data, text, image and video.

This European Standard specifies:

a) the structure and configuration for generic cabling;

b) cabling performance requirements;

c) implementation options.

Safety (electrical safety and protection, 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

For a cabling system to conform to this European Standard:

a) the structure and configuration shall conform to the requirements of Clause 4;

b) the interfaces to the cabling at the telecommunications outlet shall conform to the requirements of Clause 8 with respect to mating interfaces and performance;

c) connecting hardware at other places in the cabling structure shall meet the performance requirements specified in Clause 8;

d) the performance of channels shall conform to the requirements of Clause 5;

e) local regulations concerning safety shall be met.

The performance of balanced channels shall meet the requirements specified in Clause 5 This shall be achieved by one of the following:

- a channel design and implementation ensuring that the prescribed channel performance class of Clause 5 is met;

- attachment of appropriate components to a link design meeting the prescribed performance class of Annex A. Channel performance shall be assured where a channel is created by adding more than one cord to either end of a link meeting the requirements of Annex A;

- using the reference implementations of Clause 6 and compatible cabling components conforming to the requirements of Clauses 7, 8 and 9, based upon a statistical approach of performance modelling.

Test methods to ensure conformance with the channel and link requirements of Clause 5 and Annex A respectively are specified in EN 50346. The treatment of measured results that fail to meet the requirements of this clause, or lie within the relevant measurement accuracy, shall be clearly documented within a quality plan as described in EN 50174-1.

Installation and administration of cabling in accordance with this European standard should be undertaken in accordance with the EN 50174 series of standards.

This standard does not specify which tests and sampling levels should be adopted. The test parameters to be measured and the sampling levels to be applied for a particular installation should be defined in the installation specification and quality plans for that installation prepared in accordance with EN 50174-1.

Specifications marked "ffs" (for further study) are preliminary and are not required for conformance to this European Standard.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EDITORIAL NOTE: To be updated before publication

EN 50174-1, *Information technology - Cabling installation – Part 1: Specification and quality assurance.*

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

EN 50174-3 [1)], *Information technology - Cabling system installation – Part 3: Installation planning and practices external to buildings.*

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

EN 50288-2-1 [2)], *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 [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 [2)], *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 [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 [2)], *Multi-element metallic cables used in analogue and digital communication and control – Part 4-1: Sectional specification for screened cables characterized up to 600 MHz – Horizontal and building backbone cables.*

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

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1) At draft stage (CEN/CENELEC enquiry).

2) Approved for Unique Acceptance Procedure (UAP) by CLC/SC 46XC.

EN 50288-5-1 [2)], *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 [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 [2)], *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 [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 50289-1-6, *Communication cables - Specifications for test methods – Part 1-6: Electrical test methods – Electromagnetic performance.*

EN 50310, *Application of equipotential bonding and earthing in buildings with information technology equipment.*

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 60068-2-14:1984 + A1:1986).*

EN 60068-2-38, *Environmental testing - Part 2: Tests - Test Z/AD: Composite temperature/humidity cyclic test (IEC 60068-2-38:1999).*

EN 60352-3, *Solderless connections – Part 3: Solderless accessible insulation displacement connections - General requirements, test methods and practical guidance (IEC 60352-3:1993).*

EN 60352-4, *Solderless connections - Part 4: Solderless non-accessible insulation displacement connections - General requirements, test methods and practical guidance (IEC 60352-4:1994).*

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

EN 60512-25-1, *Connectors for electronic equipment - Tests and measurements - Part 25-1: Test 25a – Crosstalk ratio (IEC 60512-25-1:2001).*

EN 60512-25-2, *Electromechanical components for electronic equipment – Basic testing procedures and measuring methods - Part 25-2: High speed electronics tests – Test 25b Attenuation/insertion loss (IEC 60512-25-2:2002).*

EN 60512-25-3, *Connectors for electronic equipment - Tests and measurements - Part 25-3: Test 25c - Rise time degradation (IEC 60512-25-3:2001).*

EN 60512-25-4, *Connectors for electronic equipment - Tests and measurements - Part 25-4: Test 25d – Propagation delay (IEC 60512-25-4:2001).*

EN 60512-25-5 [3)], *Connectors for electronic equipment - Tests and measurements - Part 25-5: Test 25e – Return loss (IEC 60512-25-5:200x).*

EN 60603-7, *Connectors for frequencies below 3 MHz for use with printed boards – Part 7: Detail specification for connectors, 8 way, including fixed and free connectors with common mating features (IEC 60603-7:1996).*

EN 60603-7-2 [3)], *Connectors for use in d.c. low frequency analogue and in digital high speed data applications – Part 7-2: Detail specification for 8 way connectors, with assessed quality, including fixed and free connectors with common mounting features; test methods and related requirements for use at frequencies up to 100 MHz.*

EN 60603-7-3 [3)], *Connectors for use in d.c. low frequency analogue and in digital high speed data applications – Part 7-3:*

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2) Approved for Unique Acceptance Procedure (UAP) by CLC/SC 46XC.

3) In preparation by IEC/SC 48B.

EN 60603-7-4 [3)], *Connectors for use in d.c. low frequency analogue and in digital high speed data applications – Part 7-4: Connectors for electronic equipment: Detail specification for an 8 way connector with performance up to 250 MHz.*

EN 60603-7-5 [3)], *Connectors for use in d.c. low frequency analogue and in digital high speed data applications – Part 7-5:*

EN 60603-7-7, *Connectors for use in d.c. low frequency analogue and in digital high speed data applications – Part 7-7: 8 way connectors for frequencies up to 600 MHz [Category 7 Detail Specification] (IEC 60603-7-7:2002).*

EN 60793-1-40, *Optical fibres - Part 1-40: Measurement methods and test procedures – Attenuation (IEC 60793-1-40:2001).*

EN 60793-1-41, *Optical fibres - Part 1-41: Measurement methods and test procedures - Bandwidth (IEC 60793-1-41:2001).*

EN 60793-1-44, *Optical fibres - Part 1-44: Measurement methods and test procedures - Cut-off wavelength (IEC 60793-1-44:2001).*

EN 60793-1-49, *Optical fibres - Part 1-49: Measurement methods and test procedures - Differential mode delay (IEC 60793-1-49:200X).*

EN 60793-2-10, *Optical fibres - Part 2-10: Product specifications - Sectional specification for category A1 multimode fibres (IEC 60793-2-10:2002).*

EN 60793-2-50, *Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres(IEC 60793-2-50:2002).*

EN 60794-1-1, *Optical fibre cables - Part 1-1: Generic specification – General (IEC 60794-1-1:1999).*

EN 60794-1-2, *Optical fibre cables - Part 1-2: Generic specification - Basic optical cable test procedures (IEC 60794-1-2:1999).*

EN 60794-3, *Optical fibre cables – Part 3: Telecommunication cables - Sectional specification (IEC 60794-3:1998).*

EN 60811-1-1, *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 60825-2:2000).*

EN 61073-1, *Mechanical splices and fusion splice protectors for optical fibres and cables - Part 1: Generic specification (IEC 61073-1:2000).*

EN 61280-4-2, *Fibre optic communication subsystem basic test procedures – Part 4-2: Fibre optic cable plant - Single-mode fibre optic cable plant attenuation (IEC 61280-4-2:1999).*

EN 61300-2-1, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 2-1: Tests - Vibrations (sinusoidal) (IEC 61300-2-1:1995).*

EN 61300-2-2, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 2-2: Tests - Mating durability (IEC 61300-2-2:1995).*

EN 61300-2-4, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 2-4: Tests - Fibre/cable retention (IEC 61300-2-4:1995).*

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 61300-2-6:1995).*

EN 61300-2-12, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 2-12: Tests - Impact (IEC 61300-2-12:1995).*

EN 61300-2-17, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 2-17: Tests - Cold (IEC 61300-2-17:1995).*

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 61300-2-18:1995).*

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 61300-2-19:1995).*

EN 61300-2-22, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 2-22: Tests - Change of temperature (IEC 61300-2-22:1995).*

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 61300-2-42:1998).*

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 61300-3-6:1997).*

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 61300-3-34:1997).*

EN 61935-2 [4], *Generic cabling systems - Specification for the testing of balanced communication cabling in accordance with ISO/IEC 11801 - Part 2: Patch cords and work area cabling (IEC 61935-2:200X).*

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

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

IEC 60793-2, *Optical fibres – Part 2: Product specifications.*

IEC 60794-2, *Optical fibre cables – Part 2: Product specifications.*

IEC 60874-19-1, *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 61073-1, *Splices for optical fibres and cables – Part 1: Generic specification - Hardware and accessories.*

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this European Standard the following 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
application
system, with its associated transmission method that is supported by telecommunications cabling

3.1.3
balanced cable
cable consisting of one or more symmetrical metallic cable elements (twisted pairs or quads)

3.1.4
building backbone cable
cable that connects the building distributor to a floor distributor. Building backbone cables may also connect floor distributors in the same building

3.1.5
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

[4] In preparation by IEC/SC 46A.

3.1.6
building entrance facility
facility that provides all necessary mechanical and electrical services, that complies with all relevant regulations, for the entry of telecommunications cables into a building

3.1.7
cable
assembly of one or more cable units of the same type and category in an overall sheath. It may include an overall screen

3.1.8
cable element
smallest construction unit in a cable. A cable element may have a screen

NOTE A pair, a quad and a single fibre are examples of a cable element.

3.1.9
cable unit
single assembly of one or more cable elements usually of the same type or category. The cable unit may have a screen

3.1.10
cabling
system of telecommunications cables, cords and connecting hardware that supports the operation of information technology equipment

3.1.11
campus
premises containing one or more buildings

3.1.12
campus backbone cable
cable that connects the campus distributor to the building distributor(s). Campus backbone cables may also interconnect building distributors

3.1.13
campus distributor
distributor from which the campus backbone cabling emanates

3.1.14
channel
end to end transmission path connecting any two pieces of application-specific equipment. Equipment cords and work area cords are included in the channel

3.1.15
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

3.1.16
consolidation point
connection point in the horizontal cabling subsystem between a floor distributor and a telecommunications outlet

3.1.17
consolidation point cable
CP cable
cable connecting a consolidation point to a telecommunications outlet

3.1.18
consolidation point link
CP link
transmission path between a consolidation point and the interface at the other end of the fixed horizontal cable including the connecting hardware at each end

3.1.19
cord
cable unit or element with a minimum of one termination

3.1.20
cross-connect
a method of connecting a cabling subsystem to equipment (or another cabling subsystem) by the use of a patch cord or jumper

3.1.21
distributor
term used for the functions of a collection of components (for example, patch panels, patch cords) used to connect cables

3.1.22
equipment cord
cord connecting equipment to a distributor

3.1.23
equipment interface
point at which application-specific equipment can be connected to the generic cabling

3.1.24
equipment room
room dedicated for housing distributors and application-specific equipment

3.1.25
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality
[195-01-10 of IEC 60050-195:1998]

3.1.26
external network interface
point of demarcation between external and private network

NOTE In many cases the external network interface is the point of connection between the network provider's facilities and the customer premises cabling

3.1.27
fixed horizontal cable
cable connecting the floor distributor to either the telecommunications outlet or the consolidation point (if present)

3.1.28
floor distributor
distributor used to make connections between the horizontal cable, other cabling subsystems and active equipment (see telecommunications room)

3.1.29
generic cabling
structured telecommunications cabling system, capable of supporting a wide range of applications. Application-specific hardware is not a part of generic cabling

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

3.1.30
horizontal cable
cable connecting the floor distributor to the telecommunications outlet(s) or Consolidation Point(s)

3.1.31
hybrid cable
assembly of two or more different types or Categories of cables or cable units covered by an overall sheath. It may be covered by an overall screen

3.1.32
individual work area
minimum building space which would be reserved for an occupant

3.1.33
interconnect
method of connecting a cabling subsystem to equipment (or another cabling subsystem) without the use of a patch cord or jumper

3.1.34
jumper
cable, cable unit or cable element without connectors used to make a connection on a cross-connect

3.1.35
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

3.1.36
link
transmission path between any two interfaces of generic cabling. It excludes equipment cords and work area cords

3.1.37
multi-unit cable
balanced cable containing more than four pairs

3.1.38
optical fibre cable (or optical cable)
cable comprising one or more optical fibre cable elements

3.1.39
optical fibre duplex adapter
mechanical device designed to align and join two duplex connectors

3.1.40
optical fibre duplex connector
mechanical termination device designed to transfer optical power between two pairs of optical fibres

3.1.41
pair
twisted pair or one side circuit (two diametrically facing conductors) in a star quad

3.1.42
patch cord
cord used to establish connections on a patch panel

3.1.43
patch panel
cross-connect designed to accommodate the use of patch cords

NOTE It facilitates administration for moves and changes

3.1.44
permanent link
transmission path between two or – if a consolidation point is present in the cabling - three mated interfaces of generic cabling, excluding equipment cords, work area cords and cross-connections, but including the connecting hardware at each end

3.1.45
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

3.1.46
screened cabling
system of telecommunications cables, cords and connecting hardware each of which contains screens and within which the screens are interconnected

3.1.47
small form factor connector
optical fibre connector designed to accomodate two or more optical fibres with at least the same mounting density as the connectors used for balanced cabling

3.1.48
splice
joining of conductors or fibres, generally from separate cables

3.1.49
star quad
cable element which comprises four insulated conductors twisted together. Two diametrically facing conductors form a transmission pair

NOTE 1 Cables containing star quads can be used interchangeably with cables consisting of pairs, provided the electrical characteristics meet the same specifications

NOTE 2 Often, the term quad is used instead of star quad

3.1.50
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

3.1.51
telecommunications room
enclosed space for housing telecommunications equipment, cable terminations, and cross-connect cabling. The telecommunications room is a recognized cross-connect point between the backbone and horizontal cabling subsystems

3.1.52
terminal equipment
application-specific equipment located in the work area

3.1.53
telecommunications outlet
fixed connecting device where the horizontal cable terminates. The telecommunications outlet provides the interface to the work area cabling

3.1.54
test interface
point at which test equipment can be connected to the generic cabling

3.1.55
twisted pair
cable element that consists of two insulated conductors twisted together in a determined fashion to form a balanced transmission line

3.1.56
unscreened cable
balanced cable without any screens

3.1.57
work area
building space where the occupants interact with telecommunications terminal equipment

3.1.58
work area cord
cord connecting the telecommunications outlet to the terminal equipment

3.2 Abbreviations

ACR	Attenuation to crosstalk ratio
ATM	Asynchronous transfer mode
BD	Building distributor
c	Velocity of propagation in free space
C	Connection
CC	Cross-connect
CD	Campus distributor
CP	Consolidation point
CSMA/CD	Carrier sense multiple access with collision detection
d.c.	Direct current
EI	Equipment interface
ELFEXT	Equal level far end crosstalk loss
EMC	Electromagnetic compatibility
EQP	Equipment

FD	Floor distributor
FDDI	Fibre distributed data interface
FEXT	Far-end crosstalk loss
ffs	For further study
FOIRL	Fibre optic inter-repeater link
IDC	Insulation displacement connection
IPC	Insulation piercing connection
ISDN	Integrated services digital network
IT	Information technology
LAN	Local area network
LCL	Longitudinal conversion loss
LCTL	Longitudinal conversion transfer loss
MUTO	Multi-user telecommunications outlet
N/A	Not applicable
NEXT	Near-end crosstalk loss
OE EQP	Opto-electronic equipment
PBX	Private branch exchange
PC	Physical contact
PMD	Physical Layer Medium Dependent
PP	Patch panel
PSACR	Power sum attenuation to crosstalk ratio
PSFEXT	Power sum far-end crosstalk loss
PSELFEXT	Power sum equal level far end crosstalk loss
PSNEXT	Power sum near-end crosstalk loss
S	Splice
SC	Subscriber connector
SC-D	Duplex SC connector
TCL	Transfer conversion loss
TE	Terminal equipment
TI	Test interface
TO	Telecommunications outlet
TP-PMD	Twisted Pair Physical Layer Medium Dependent

4 Structure of the generic cabling system

4.1 General

This Clause identifies the functional elements of generic cabling, describes how they are connected together to form 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.

4.2 Functional elements

The functional elements of generic cabling are as follows:

a) campus distributor (CD);

b) campus backbone cable;

c) building distributor (BD);

d) building backbone cable;

e) floor distributor (FD);

f) horizontal cable;

g) consolidation point (CP);

h) consolidation point cable (CP cable);

i) multi-user TO assembly;

j) telecommunications outlet (TO).

Groups of these functional elements are connected together to form cabling subsystems.

4.3 General structure and hierarchy

Generic cabling systems contain three cabling subsystems: campus backbone, building backbone and horizontal cabling. 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, 4.4.2 and 4.4.3. 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 (see 4.7.1) the intermediate cabling subsystem(s) are not required.

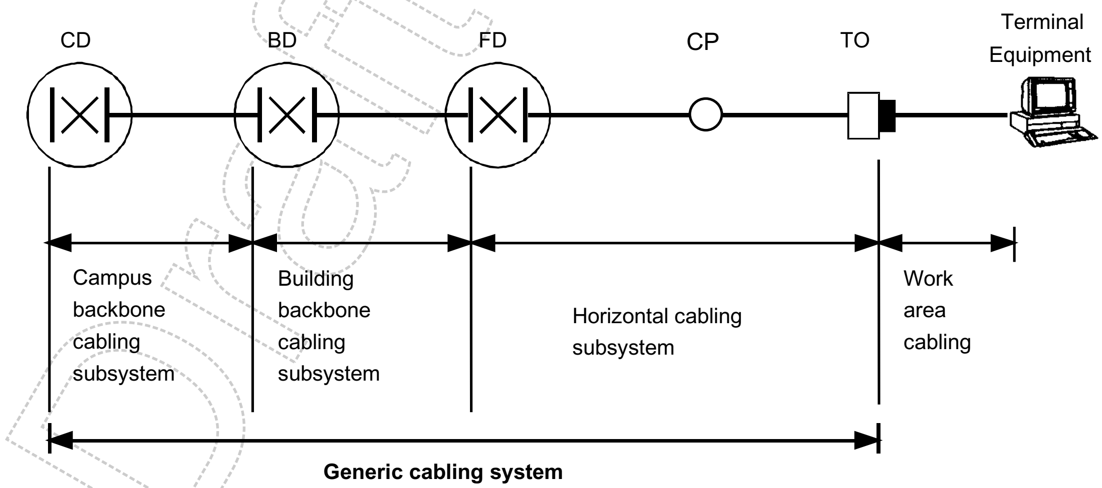


Figure 2 - Structure of generic cabling

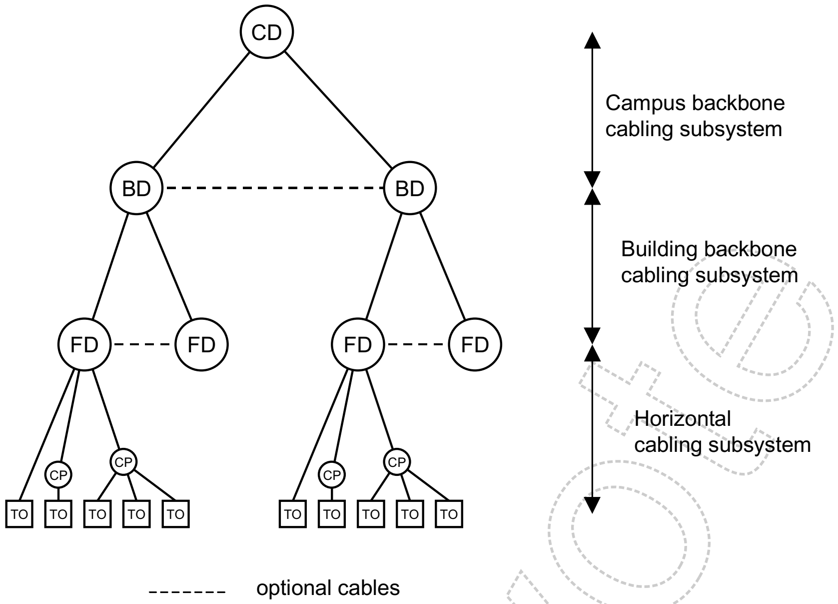


Figure 3 – Hierarchical structure of generic cabling

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 6). Passive connections between cabling subsystems adopt either a cross-connect approach, by way of either patch cords or jumpers, or an interconnect approach.

Centralized cabling structures as shown in Figure 4 combine backbone and horizontal channels. The channels are provided by passive connections in the distributors. The connections are achieved by using either cross-connections or interconnections. In addition, for centralised optical fibre cabling, it is possible to create connections at the distributors using splices although this reduces the ability of the cabling to support re-configuration.

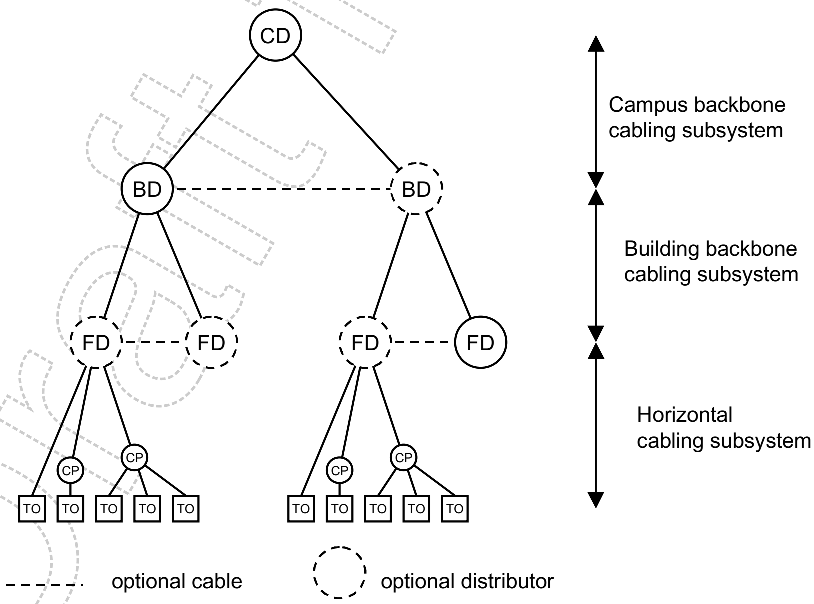


Figure 4 – Structures for centralized generic cabling

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) 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 including the connections (e.g. of the interconnect or cross-connect) 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. Where the building distributor does not exist, the campus backbone cabling subsystem extends from the campus distributor to the floor distributor.

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

A building backbone cabling subsystem extends from building distributor(s) to the floor distributor(s). When present, the subsystem includes:

a) the building backbone cables;

b) the mechanical termination of the building backbone cables including the connections (e.g. of the interconnect or cross-connect) 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 back-up and in addition to those required for the basic hierarchical topology.

4.4.3 Horizontal cabling subsystem

The horizontal cabling subsystem extends from a floor distributor to the telecommunications outlet(s) connected to it. The subsystem includes:

a) the horizontal cables;

b) the mechanical termination of the horizontal cables including the connections (e.g. of the interconnect or cross-connect) at the telecommunications outlet and the floor distributor together with associated patch cords and/or jumpers at the FD;

c) a consolidation point (optional);

d) the telecommunications outlets.

Although work area and equipment cords are used to connect terminal and transmission equipment, respectively, to the cabling subsystem, they are not considered part of the cabling subsystem because they are application-specific. Horizontal cables shall be continuous from the floor distributor to the telecommunications outlets unless a consolidation point is installed (see 4.7.6).

4.4.4 Design objectives

Horizontal cabling should be designed to support the broadest set of existing and emerging applications and therefore provide the longest operational life. This will minimize disruption and the high cost of recabling in the work area.

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

Figure 5 shows an example of how the functional elements are accommodated in a building.

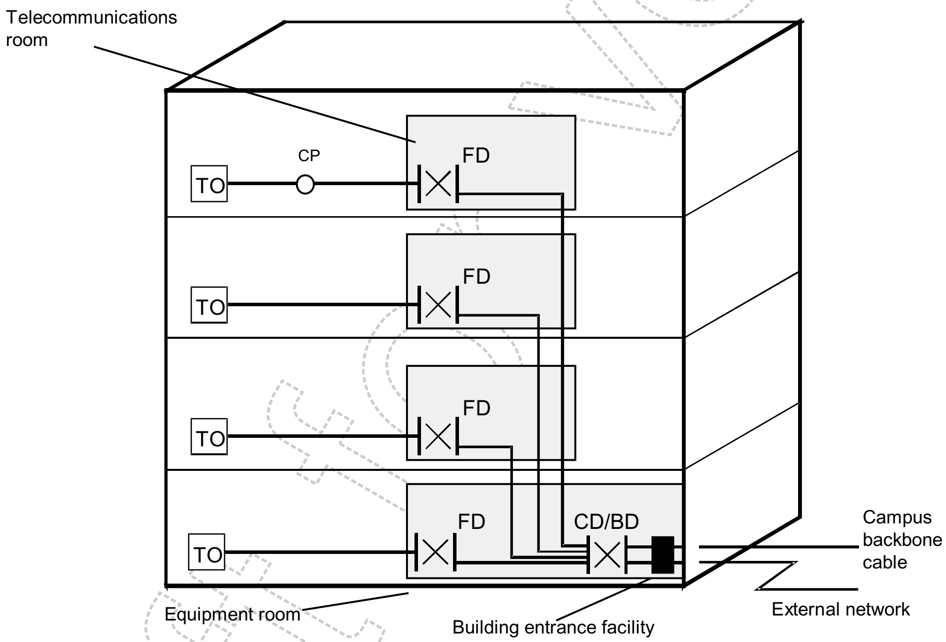


Figure 5 - Accommodation of functional elements

Distributors are typically located in equipment rooms or telecommunications rooms. The requirements for the accommodation of distributors are specified in EN 50174-1.

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.

Telecommunications outlets are located in the work area, depending on the design of the building.

4.6 Interfaces

4.6.1 Equipment interfaces and test interfaces

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

Any distributor may have an equipment interface to an external service at any port, and may use either interconnects or cross-connects (see Figure 6). A consolidation point does not provide an equipment interface to the generic cabling system. Figure 7 shows the potential equipment interfaces to the horizontal and backbone cabling subsystems.

Test interfaces to generic cabling are located at the ends of each subsystem and at consolidation points, where present. Figure 7 shows the potential test interfaces to the horizontal and backbone cabling subsystems.

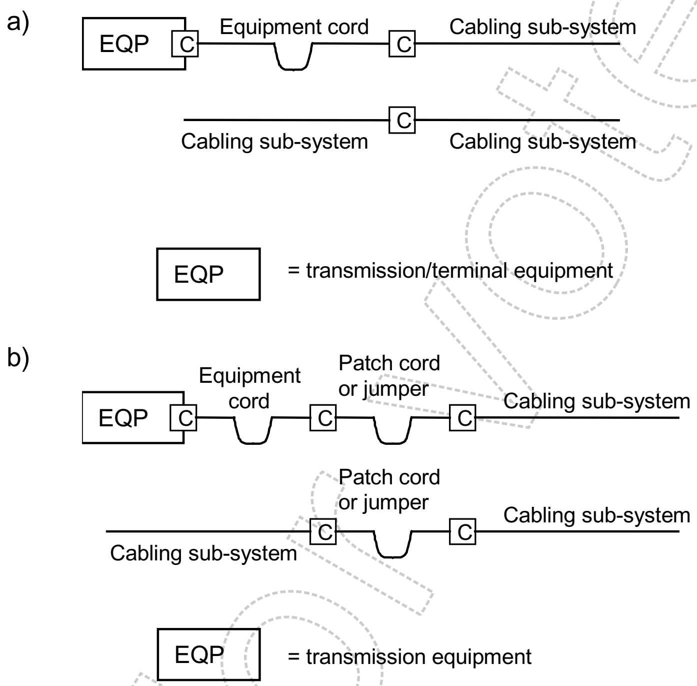


Figure 6- Interconnect and cross-connect models
a) interconnect model
b) crossconnect model

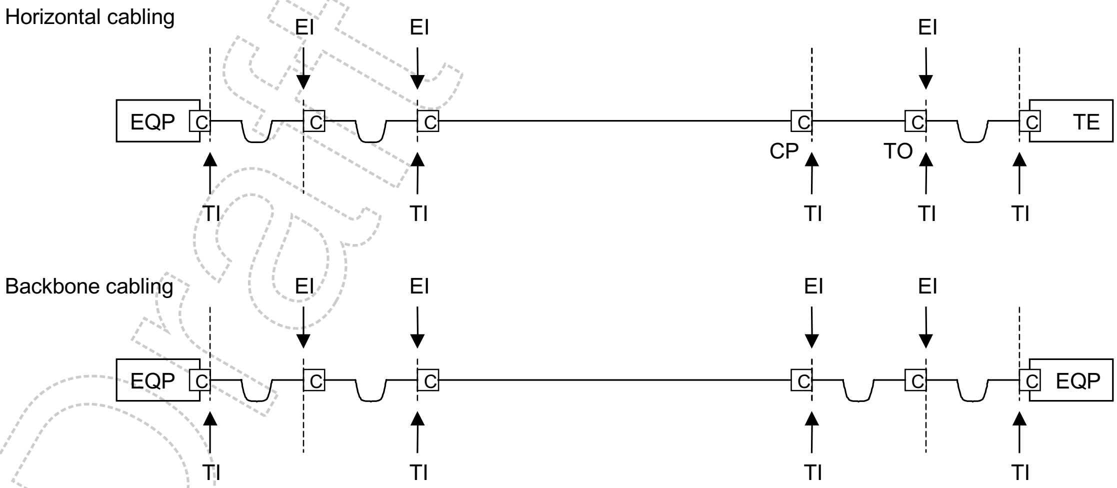


Figure 7 - Test and equipment interfaces

4.6.2 Channels and links

The transmission performance of generic cabling between specific test interfaces is detailed in Clause 5 in terms of the channel and Annex A for links.

The channel is the transmission path between IT equipment such as a LAN hub (EQP in Figure 6) and the terminal equipment. A typical channel would consist of the horizontal subsystem together with work area and equipment cords. For longer reach services the channel would be formed by the connection of two or more subsystems (including work area cords and/or equipment cords). It is important that the generic cabling channel is designed to meet the required class of performance for the applications that are to be run. For the purposes of testing, the channel excludes the connections at the application-specific equipment.

A link is the transmission path between two test interfaces. Links may be tested either during commissioning or for the detection of faults that are suspected in the cabling. The link includes the connections at the ends of the cabling link under test.

4.6.3 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 cabling between the external network interface and the generic cabling interface 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 cable may be governed by national regulations,which then shall be considered in planning the generic cabling.

4.7 Dimensioning and configuring

4.7.1 Distributors

The number and type of subsystems that are included in a generic cabling implementation depends upon the geography and size of the campus or building, and upon the strategy of the user. Usually there would be one campus distributor per campus, one building distributor per building, and one floor distributor per floor. If the premises comprise only a single building which is small enough to be served by a single building distributor, there is no need for a campus backbone cabling subsystem. Similarly larger buildings may be served by multiple building distributors interconnected via a campus distributor.

The design of the floor distributor shall ensure that the lengths of patch cords, jumpers and equipment cords are minimised and administration should ensure that the design lengths are maintained during operation.

Distributors should be located such that the resulting cable lengths are consistent with the channel performance requirements of Clause 5. For the implementations described in Clause 6, using the components of Clauses 7, 8 and 9, the maximum channel lengths in Table 1 shall be observed. In the case of the reference implementations described in Clause 6, distributors shall be located to ensure that the channel lengths in Table 1 are not exceeded.

However, not all applications are supported over the maximum lengths shown in Table 1 using a single cable type. Table 22, Table 23 and Table 24 in Clause 6 indicate that the support of specific applications over installed channels may require a mix of cabling media and performance specifications.

Table 1 - Maximum channel lengths for reference implementations

Channel	Length m
Horizontal	100
Horizontal + building backbone + campus backbone	2 000
NOTE In some implementations of the horizontal cabling subsystem in Clause 5, the FD may not support TOs up to the maximum distance shown.	

There should be a minimum of one floor distributor for every 1 000 m^2 of floor space reserved for offices. A minimum of one floor distributor should be provided for every floor. If a floor is sparsely populated (e.g. a lobby), it is permissible to serve this floor from the floor distributor located on an adjacent floor.

If a floor area extends beyond 1 000 m^2, additional floor distributors may need to be installed to more effectively service the work area.

The functions of multiple distributors may be combined.

Figure 8 shows an example of generic cabling. The building in the foreground shows each distributor housed separately. The building in the background shows that the functions of a floor distributor and the building distributor have been combined into a single distributor.

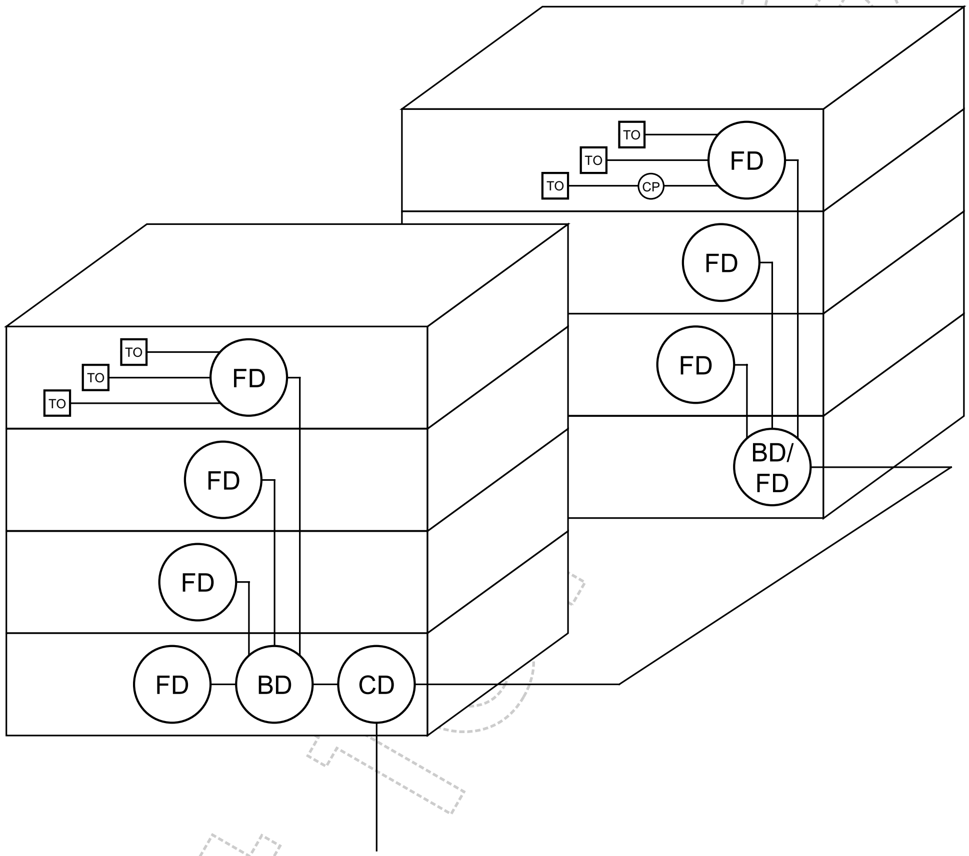


Figure 8 - Example of a generic cabling system with combined BD and FD

In certain circumstances, for example for security or reliability reasons, redundancy may be built into a cabling design. Figure 9 is a schematic showing one of many possible examples of the connection of functional elements within the structured framework to provide such protection against failure in one or more parts of the cabling infrastructure. This might form the basis for the design of generic cabling for a building, providing some protection against such hazards as fire damage or the failure of the external network feeder cable.

4.7.2 Cables

Cable types used in the reference implementations of Clause 6 are given in Clause 7. Hardware for connecting cables shall only provide direct onward attachment for each conductor and shall not provide any contact between more than one incoming or outgoing conductor (e.g. bridge taps shall not be used).

4.7.3 Work area cords and equipment cords

The work area cord connects the telecommunications outlet to the terminal equipment. Equipment cords connect transmission equipment to the generic cabling at distributors. Both are non-permanent and can be application-specific. Assumptions have been made concerning the length and the transmission performance of these cords; the assumptions are identified when relevant.

The performance contribution of these cords shall be taken into account in the design of the channel. Clause 6 provides guidance on cord lengths for reference implementations of generic cabling.

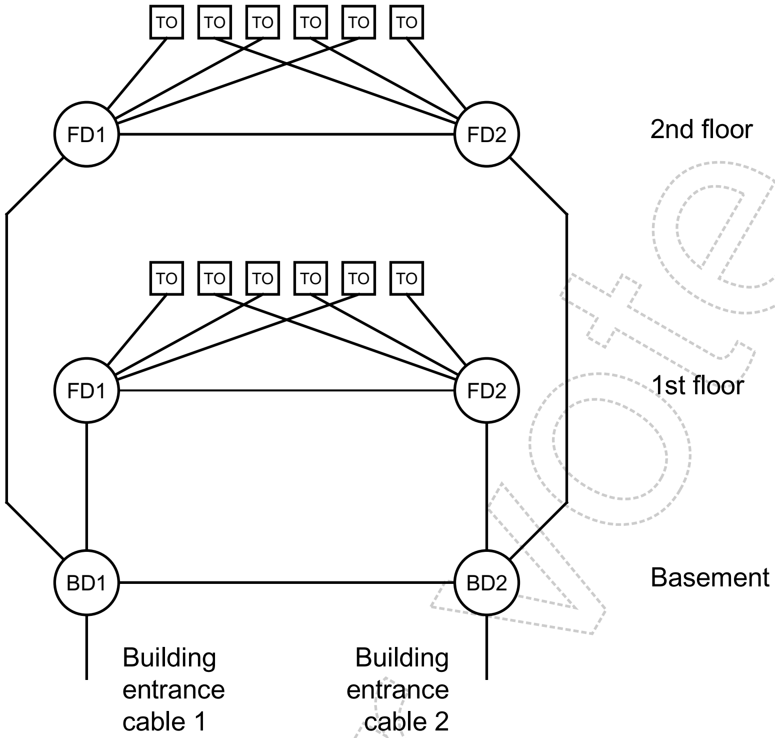


Figure 9 - Connection of functional elements providing redundancy

4.7.4 Patch cords and jumpers

Patch cords and jumpers are used within cross-connect implementations at distributors. The performance contribution of these cords shall be taken into account in the design of the channel. Clause 6 provides guidance on cord/jumper lengths for reference implementations of generic cabling.

4.7.5 Telecommunications outlet (TO)

4.7.5.1 General requirements

The design of generic cabling should provide for telecommunications outlets to be installed throughout the usable floor space. A high density of telecommunications outlets will enhance the ability of the cabling to accommodate changes. Telecommunications outlets may be presented singly, or in groups.

a) each individual work area shall be served by a minimum of two TOs;

b) the first outlet should be for four pair balanced cable terminated in accordance with 8.2.5;

c) the second outlet may be for two optical fibres terminated in accordance with 8.3 or four pair balanced cable terminated in accordance with 8.2.5 as required;

d) each telecommunications outlet shall have a permanent means of identification that is visible to the user;

e) devices such as baluns and impedance matching adapters, if used, shall be external to the outlet.

Two pairs per TO may be used as an alternative to four pairs, however this requires pair reassignment and will not support some applications (see Annex E).

Care should be taken that the initial pair assignment and all subsequent changes are recorded (see EN 50174-1 for details of recommended administration schemes). Pair reassignment by means of inserts is allowed.

4.7.5.2 Single user TO assembly

In a general implementation of generic cabling, one assembly of TOs serves a single work area. In this case, one of the implementation options shown in Figure 11 (for balanced cabling) and Figure 13 (for optical fibre cabling) of Clause 6 shall be used and the assembly of TOs shall be known as a single user TO assembly.

Where the single user TO assembly is used

a) the TO assembly should be located in user-accessible locations;

b) the performance contribution of work area cords, patch cords, jumpers and equipment cords shall be taken into account to ensure that the channel requirements of Clause 5 are met.

4.7.5.3 Multi-user TO assembly

In an open office environment, a single assembly of TOs may be used to serve more than one work area. One of the implementation options shown in Figure 11 (for balanced cabling) and Figure 13 (for optical fibre cabling) of Clause 6 shall be used and the assembly of TOs shall be known as a multi-user TO assembly.

In addition, where the multi-user TO assembly is used:

a) a multi-user TO assembly shall be located in an open work area so that each furniture cluster is served by at least one multi-user TO assembly;

b) a multi-user TO assembly should be limited to serving a maximum of twelve work areas;

c) a multi-user TO assembly should be located in user accessible, permanent locations;

d) a multi-user TO assembly shall not be installed in ceiling spaces or any obstructed areas;

e) the performance contribution of work area cords, patch cords, jumpers and equipment cords shall be taken into account to ensure that the channel requirements of Clause 5 are met;

f) the length of the work area cord should be limited to ensure cable management in the work area.

4.7.6 Consolidation point

The installation of a consolidation point in the horizontal cabling between the floor distributor and the telecommunications outlet may be useful in an open office environment where the flexibility of relocating TOs in the work area is required. One consolidation point is permitted between a FD and any TO. The consolidation point shall only contain passive connections.

In addition, where a consolidation point is used:

a) the consolidation point shall be located so that each work area group is served by at least one consolidation point;

b) the consolidation point should be limited to serving a maximum of twelve work areas;

c) a consolidation point should be located in accessible permanent locations such as ceiling voids and under floors;

d) for balanced cabling, the effect of multiple connections in close proximity on transmission performance should be taken into consideration when planning the cable lengths between the floor distributor and the consolidation point;

e) a consolidation point has labelling and documentation requirements and shall be covered in the cabling administration system.

4.7.7 Telecommunications rooms and equipment rooms

A telecommunications room should provide all the facilities (space, power, environmental control etc.) for passive components, active devices, and public 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.

4.7.8 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.

4.8 Electromagnetic compatibility

Premises cabling is a passive system and cannot be tested for EMC compliance individually. Application-specific equipment which is designed for one or more 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.

4.9 Earthing and equipotential bonding

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

5 Channel performance

5.1 General

This Clause specifies the minimum channel performance of generic cabling. The performance of the cabling is specified for individual channels for two different media types (balanced cable and optical fibre). The channel performance specifications for balanced cabling are separated into Classes that allow for the transmission of the applications in Annex E. In the case of cable sharing, additional requirements shall be taken into account for balanced cabling. The additional crosstalk requirements are specified in 7.3.

The channel performance requirements described in this Clause shall be used for the design and may be used for verification of any implementation of this European standard. Where required the test methods defined or referenced by this Clause shall apply. In addition, these requirements can be used for application development and troubleshooting. The channel 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.

The channel specifications in this Clause allow for the transmission of defined Classes of applications over distances other than those of Clause 6, and/or using media and components with different transmission performance than those of Clauses 7, 8 and 9.

Link performance requirements are specified in Annex A.

5.2 Layout of channels

The performance of a channel is specified at and between connections to active equipment. The channel comprises only passive sections of cable, connections, work area cords, equipment cords, patch cords and jumpers. The performance contribution of active equipment connections is not taken into account.

Application support depends on channel performance only, which in turn depends on cable length, number of connections, the performance of the components and the installation practices used.

Channels are implemented using:

– horizontal cabling only;

– building backbone cabling only;

– campus backbone cabling only;

– combinations of the above.

Equivalent channel performance can be achieved over greater lengths by the use of fewer connections or by using components with higher performance.

Figure 10 shows an example of terminal equipment in the work area connected to transmission equipment using two channels, an optical fibre channel and a balanced cabling channel. The optical fibre and balanced cabling channels are connected together using an optical fibre to balanced copper cable converter. There are four channel interfaces; one at each end of the balanced channel, and one at each end of the optical fibre channel.

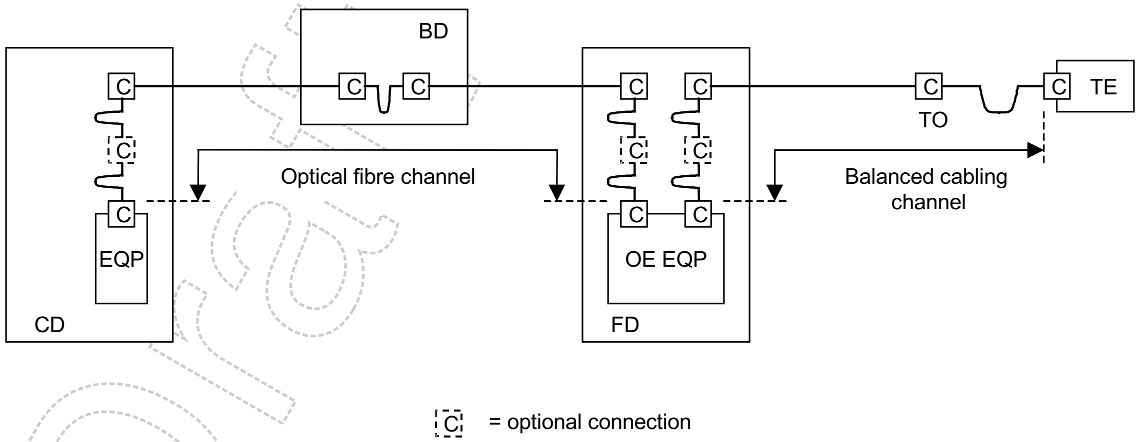


Figure 10 - Example of a system showing the location of cabling interfaces

5.3 Classification of balanced cabling channels

This standard specifies the following classes for balanced cabling.

Class A is specified up to 100 kHz.

Class B is specified up to 1 MHz.

Class C is specified up to 16 MHz.

Class D is specified up to 100 MHz.

Class E is specified up to 250 MHz.

Class F is specified up to 600 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 and F channels provide the transmission performance to support Class B, C, D, E and F applications respectively. Channels of a given class will support all applications of a lower class. Class A is regarded as the lowest class.

Horizontal cabling shall be installed to provide a minimum of Class D performance. Annex E lists known applications by class.

5.4 Balanced cabling channel performance

5.4.1 General

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).

NOTE The term “attenuation” is used in 5.4.3, 5.4.4, 5.4.5, 5.4.6, 5.4.7, 5.4.12 and 5.4.13 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 channel.

5.4.2 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 and F only. The return loss for each pair of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 2. The limits shown in Table 3 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 2 - 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
	$20 \leq f \leq 100$	30-10log(f)
E	$1 \leq f < 10$	19,0
	$10 \leq f < 40$	24-5log(f)
	$40 \leq f \leq 250$	32-10log(f)
F	$1 \leq f < 10$	19,0
	$10 \leq f < 40$	24-5log(f)
	$40 \leq f < 251,2$	32-10log(f)
	$251,2 \leq f \leq 600$	8,0

Table 3 - Return loss limits for a channel at key frequencies

Frequency MHz	**Minimum return loss** dB			
	Class C	**Class D**	**Class E**	**Class F**
1,0	15,0	17,0	19,0	19,0
16,0	15,0	17,0	18,0	18,0
100,0	N/A	10,0	12,0	12,0
250,0	N/A	N/A	8,0	8,0
600,0	N/A	N/A	N/A	8,0

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

5.4.3 Attenuation / Insertion loss

The attenuation α for each pair of a channel measured as insertion loss shall not exceed 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 attenuation of the channel shall be measured according to EN 50346.

Table 4 - Formulae for attenuation limits for a channel

Class	Frequency MHz	Maximum attenuation dB
A	$f = 0,1$	16,0
B	$f = 0,1$	5,5
	$f = 1$	5,8
C	$1 \le f \le 16$	$1,05 \bullet \left(3,23\sqrt{f}\right) + 4 \bullet 0,2$
D	$1 \le f \le 100$	$1,05 \bullet \left(1,9108\sqrt{f} + 0,0222 \bullet f + 0,2/\sqrt{f}\right) + 4 \bullet 0,04 \bullet \sqrt{f}$, 4,0 min
E	$1 \le f \le 250$	$1,05 \bullet \left(1,82\sqrt{f} + 0,0169 \bullet f + 0,25/\sqrt{f}\right) + 4 \bullet 0,02 \bullet \sqrt{f}$, 4,0 min
F	$1 \le f \le 600$	$1,05 \bullet \left(1,8\sqrt{f} + 0,01 \bullet f + 0,2/\sqrt{f}\right) + 4 \bullet 0,02 \bullet \sqrt{f}$, 4,0 min

Table 5 - Attenuation limits for a channel at key frequencies

Frequency MHz	Maximum attenuation dB					
	Class A	Class B	Class C	Class D	Class E	Class F
0,1	16,0	5,5	N/A	N/A	N/A	N/A
1,0	N/A	5,8	4,2	4,0	4,0	4,0
16,0	N/A	N/A	14,4	9,1	8,3	8,1
100,0	N/A	N/A	N/A	24,0	21,7	20,8
250,0	N/A	N/A	N/A	N/A	35,9	33,8
600,0	N/A	N/A	N/A	N/A	N/A	54,6

5.4.4 Near-end crosstalk loss (NEXT)

5.4.4.1 Pair-to-pair NEXT

The pair-to-pair NEXT α_{NEXT} between each pair combination 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 NEXT shall be measured according to EN 50346. The NEXT requirements shall be met at both ends of the cabling.

Table 6 - Formulae for NEXT limits for a channel

Class	**Frequency** MHz	**Minimum NEXT** dB
A	$f = 0,1$	27,0
B	$0,1 \leq f \leq 1$	25,0-15*log(f)
C	$1 \leq f \leq 16$	39,1-16,4*log(f)
D	$1 \leq f \leq 100$	$-20\log\left(10^{\frac{65,3-15\log(f)}{-20}} + 2 \bullet 10^{\frac{83-20\log(f)}{-20}}\right)$, 60,0 max.
E	$1 \leq f \leq 250$	$-20\log\left(10^{\frac{74,3-15\log(f)}{-20}} + 2 \bullet 10^{\frac{94-20\log(f)}{-20}}\right)$, 65,0 max
F	$1 \leq f \leq 600$	$-20\log\left(10^{\frac{102,4-15\log(f)}{-20}} + 2 \bullet 10^{\frac{102,4-15\log(f)}{-20}}\right)$, 65,0 max.

Table 7 - NEXT limits for a channel at key frequencies

Frequency MHz	**Minimum NEXT** dB					
	Class A	**Class B**	**Class C**	**Class D**	**Class E**	**Class F**
0,1	27,0	40,0	N/A	N/A	N/A	N/A
1,0	N/A	25,0	39,1	60,0	65,0	65,0
16,0	N/A	N/A	19,4	43,6	53,2	65,0
100,0	N/A	N/A	N/A	30,1	39,9	62,9
250,0	N/A	N/A	N/A	N/A	33,1	56,9
600,0	N/A	N/A	N/A	N/A	N/A	51,2

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

5.4.4.2 Power Sum NEXT (PSNEXT)

The PSNEXT parameter is applicable to Classes D, E and F only. The PSNEXT for each pair 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.

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:

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

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

Table 8 - Formulae for PSNEXT limits for a channel

Class	Frequency MHz	Minimum PSNEXT dB
D	$1 \le f \le 100$	$-20\log\left(10^{\frac{62,3 - 15\log(f)}{-20}} + 2 \bullet 10^{\frac{80 - 20\log(f)}{-20}}\right)$, 57,0 max.
E	$1 \le f \le 250$	$-20\log\left(10^{\frac{72,3 - 15\log(f)}{-20}} + 2 \bullet 10^{\frac{90 - 20\log(f)}{-20}}\right)$, 62,0 max
F	$1 \le f \le 600$	$-20\log\left(10^{\frac{99,4 - 15\log(f)}{-20}} + 2 \bullet 10^{\frac{99,4 - 15\log(f)}{-20}}\right)$, 62,0 max.

Table 9 - PSNEXT limits for a channel at key frequencies

Frequency MHz	Minimum PSNEXT dB		
	Class D	Class E	Class F
0,1	N/A	N/A	N/A
1,0	57,0	62,0	62,0
16,0	40,6	50,6	62,0
100,0	27,1	37,1	59,9
250,0	N/A	30,2	53,9
600,0	N/A	N/A	48,2

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

5.4.5 Attenuation to crosstalk loss ratio (ACR)

5.4.5.1 Pair-to-pair ACR

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

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

where $\alpha_{NEXT}(i,k)$ 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 attenuation of pair i, when measured according to EN 50346, in dB.

The ACR 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 Tables 4 and 6. The limits shown in Table 10 are derived with equation (2) at key frequencies only.

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

Table 10 - ACR limits for a channel at key frequencies

Frequency MHz	Minimum ACR dB		
	Class D	Class E	Class F
0,1	N/A	N/A	N/A
1,0	56,0	61,0	61,0
16,0	34,5	44,9	56,9
100,0	6,1	18,2	42,1
250,0	N/A	-2,8	23,1
600,0	N/A	N/A	-3,4

5.4.5.2 Power sum ACR (PSACR)

PSACR of pair k, $\alpha_{PSACR}(k)$, is computed from PSNEXT $\alpha_{PSNEXT}(k)$ and attenuation $\alpha(k)$ of pair k as follows:

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

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

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

The PSACR parameter is applicable to Classes D, E and F only. The PSACR for each pair of a channel shall meet the limits computed according to equation (3), to one decimal place, using the relevant formulae of Tables 4 and 8. The limits shown in Table 11 are derived with equation (3) at key frequencies only.

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

Table 11 - PSACR limits for a channel at key frequencies

Frequency MHz	Minimum PSACR dB		
	Class D	Class E	Class F
0,1	N/A	N/A	N/A
1,0	53,0	58,0	58,0
16,0	31,5	42,3	53,9
100,0	3,1	15,4	39,1
250,0	N/A	-5,8	20,1
600,0	N/A	N/A	-6,4

5.4.6 ELFEXT

5.4.6.1 Pair-to-pair ELFEXT

The ELFEXT parameter is applicable to Classes D, E and F only.

ELFEXT of pairs i and k, $\alpha_{ELFEXT}(i,k)$, is computed from pair-to-pair FEXT $\alpha_{FEXT}(i,k)$ and attenuation $\alpha(k)$ of pair k as follows:

$$\alpha_{ELFEXT}(i,k) = \alpha_{FEXT}(i,k) - \alpha(k) \quad (4)$$

where i is the number of the disturbed pair.

k is the number of the disturbing pair.

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

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

The ELFEXT for each pair combination of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 12. The limits shown in Table 13 are derived from the formulae at key frequencies only.

Table 12 - Formulae for ELFEXT limits for a channel

Class	**Frequency** MHz	**Minimum ELFEXT** dB
D	$1 \leq f \leq 100$	$-20\log\left(10^{\frac{63{,}8 - 20\log(f)}{-20}} + 4 \bullet 10^{\frac{75{,}1 - 20\log(f)}{-20}}\right)$
E	$1 \leq f \leq 250$	$-20\log\left(10^{\frac{67{,}8 - 20\log(f)}{-20}} + 4 \bullet 10^{\frac{83{,}1 - 20\log(f)}{-20}}\right)$
F	$1 \leq f \leq 600$	$-20\log\left(10^{\frac{94 - 20\log(f)}{-20}} + 4 \bullet 10^{\frac{90 - 15\log(f)}{-20}}\right)$, 65,0 max.
NOTE ELFEXT values at frequencies that correspond to measured FEXT values of greater than 70,0 dB are for information only.		

Table 13 - ELFEXT limits for a channel at key frequencies

Frequency MHz	**Minimum ELFEXT** dB		
	Class D	**Class E**	**Class F**
0,1	N/A	N/A	N/A
1,0	57,4	63,3	65,0
16,0	33,3	39,2	57,5
100,0	17,4	23,3	44,4
250,0	N/A	15,3	37,8
600,0	N/A	N/A	31,3

5.4.6.2 Power sum ELFEXT (PSELFEXT)

The PSELFEXT parameter is applicable to Classes D, E and F only. The PSELFEXT for each pair of a channel shall meet the limits computed, to one decimal place, using the formulae of Table 14. The limits shown in Table 15 are derived from the formulae at key frequencies only.

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

$$\alpha_{PSELFEXT}(k) = -10\log\sum_{i=1\, i\neq k}^{n} 10^{-0,1\alpha_{ELFEXT}(i,k)} \tag{5}$$

where $\alpha_{ELFEXT}(i,k)$ is the pair-to-pair ELFEXT of pair k to adjacent pair i

Table 14 - Formulae for PSELFEXT limits for a channel

Class	**Frequency** MHz	**Minimum PSELFEXT** dB
D	$1 \leq f \leq 100$	$-20\log\left(10^{\frac{60,8-20\log(f)}{-20}} + 4 \bullet 10^{\frac{72,1-20\log(f)}{-20}}\right)$
E	$1 \leq f \leq 250$	$-20\log\left(10^{\frac{64,8-20\log(f)}{-20}} + 4 \bullet 10^{\frac{80,1-20\log(f)}{-20}}\right)$
F	$1 \leq f \leq 600$	$-20\log\left(10^{\frac{91-20\log(f)}{-20}} + 4 \bullet 10^{\frac{87-15\log(f)}{-20}}\right)$, 62,0 max.

NOTE PSELFEXT values at frequencies that correspond to measured FEXT values of greater than 70,0 dB are for information only.

Table 15 - PSELFEXT limits for a channel at key frequencies

Frequency MHz	**Minimum PSELFEXT** dB		
	Class D	**Class E**	**Class F**
0,1	N/A	N/A	N/A
1,0	54,4	60,3	62,0
16,0	30,3	36,2	54,5
100,0	14,4	20,3	41,4
250,0	N/A	12,3	34,8
600,0	N/A	N/A	28,3

5.4.7 Direct current (d.c.) loop resistance

The d.c. loop resistance for each pair of a channel shall be less than the values given in Table 16 for each Class of application. When required, the d.c. loop resistance shall be measured according to EN 50346.

Table 16 - Maximum d.c. loop resistance values for a channel

Maximum d.c. loop resistance Ω					
Class A	**Class B**	**Class C**	**Class D**	**Class E**	**Class F**
560	170	40	25	25	25

5.4.8 Direct current (d.c.) resistance unbalance

The d.c. resistance unbalance between the two conductors within each pair of a channel shall not exceed 3 % for all classes. This shall be achieved by design.

5.4.9 Direct current (d.c.) power feeding

Channels of Classes D, E and F shall be designed to support a current of DC 0,175 A per conductor for all temperatures at which the cabling is intended to be used.

Channels of Classes D, E and F shall be designed to support an operating voltage of DC 72 V between any conductors 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.

5.4.10 Operating voltage

The channels of Classes D, E and F shall support an operating voltage of DC 72 V between any conductors for all temperatures at which the cabling is intended to be used. This shall be achieved by design.

5.4.11 Propagation Delay

The propagation delay for each pair of a channel, measured – when required - according to EN 50346, shall be less than the limits computed using the formulae, to three decimal places, of Table 17. The limits shown in Table 18 are derived from the formulae at key frequencies only.

Table 17 - 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	$1 \leq f \leq 16$	$0,534 + 0,036 / \sqrt{f} + 4 \bullet 0,0025$
D	$1 \leq f \leq 100$	$0,534 + 0,036 / \sqrt{f} + 4 \bullet 0,0025$
E	$1 \leq f \leq 250$	$0,534 + 0,036 / \sqrt{f} + 4 \bullet 0,0025$
F	$1 \leq f \leq 600$	$0,534 + 0,036 / \sqrt{f} + 4 \bullet 0,0025$

Table 18 - Propagation delay limits for a channel at key frequencies

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

5.4.12 Delay Skew

The delay skew parameter is applicable to Classes C, D, E and F only. The delay skew between all pairs of a channel, measured – when required - according to EN 50346, shall be less than the limits computed using the equations, to three decimal places, of Table 19.

Table 19 - Delay skew limits for a channel

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

a Calculation is based upon 0,045 + 4*0,001 25
b Calculation is based upon 0,025 + 4*0,001 25

5.4.13 Unbalance attenuation

Unbalance attenuation, near end, (LCL) shall be achieved by the appropriate choice of cables and connections. Unbalance attenuation, near end, (LCL) for the channel shall exceed the values given in Table 20.

Table 20 - Maximum unbalance attenuation, near end

Cabling Class	Applicable frequency (range) MHz	Limit dB
A	$f = 0,1$	30
B	0,1 and 1	45 at 0,1 MHz, 20 at 1 MHz
C	$1 \leq f \leq 16$	30 - 5 log f (ffs)
D	$1 \leq f \leq 100$ [a]	ffs
E	$1 \leq f \leq 250$ [a]	ffs
F	$1 \leq f \leq 600$ [a]	ffs

a Measurement of this parameter above 80 MHz is not well established (i.e. limits are ffs).

5.4.14 Coupling attenuation

The measurement 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.

5.5 Classification of optical fibre cabling channels

5.5.1 General

This standard specifies the following classes for optical fibre cabling:

a) class OF-300 channels support applications listed in Annex E over the optical fibre Categories referenced in Clause 7 to a minimum of 300 m;

b) class OF-500 channels support applications listed in Annex E over the optical fibre Categories referenced in Clause 7 to a minimum of 500 m;

c) class OF-2000 channels support applications listed in Annex E over the optical fibre Categories referenced in Clause 7 to a minimum of 2 000 m.

The performance requirements for optical fibre channels assume that each optical fibre channel employs a single optical wavelength in one transmission window only.

Application standards employing wavelength multiplexing are not yet available for listing in Annex E.

There are no special requirements for generic cabling concerning wavelength multiplexing. The requirements for the wavelength multiplexing and de-multiplexing components will be found in the application standards. All application-specific hardware for wavelength multiplexing is installed in the equipment area and in the work area, both of which are outside the scope of this standard.

5.5.2 Channel Attenuation

The channel attenuation shall not exceed the values shown in Table 21. The values are based on an allocation of 1,5 dB for connections.

The attenuation of a channel shall be measured according to

a) Annex A.3.2 (Method 1) of EN 50346:2002, for multimode optical fibre,

b) method 1.C of EN 61280-4-2:1999, for singlemode optical fibre.

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.

Table 21 - Optical fibre channel attenuation limits

Class	Maximum channel attenuation dB			
	Multimode		Singlemode	
	850 nm	1300 nm	1310 nm	1550 nm
OF-300	2,55	1,95	1,80	1,80
OF-500	3,25	2,25	2,00	2,00
OF-2000	8,50	4,50	3,50	3,50

5.5.3 Propagation delay

For some applications, knowledge of the delay of fibre channels is important to ensure compliance with end-to-end delay requirements of complex networks consisting of multiple cascaded channels. For this reason, it is important to know the lengths of the optical fibre channels. It is possible to calculate propagation delay based on cable performance (see Clause 7).

6 Reference implementations

6.1 General

This clause describes implementations of generic 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, comply with the channel performance requirements of Clause 5.

6.2 Balanced cabling

6.2.1 Assumptions

Balanced cabling components referenced in Clauses 7, 8 and 9 are defined in terms of impedance and Category. In the reference implementations of this clause, the components used in each cabling channel shall meet the following requirements:

a) the balanced cables within a Class A, B and C channel shall have a common nominal characteristic impedance of 100 Ω or 120 Ω;

b) the balanced cables within a Class D, E and F channel shall have a common nominal characteristic impedance of 100 Ω.

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 22 and Table 23.

6.2.2 Horizontal cabling

6.2.2.1 Component choice

The selection of balanced cabling components will be determined by the class of applications to be supported by the cabling. Refer to Annex E for guidance.

Using the models of 6.2.2.2:

a) Category 5 components provide Class D balanced cabling performance;

b) Category 6 components provide Class E balanced cabling performance;

c) Category 7 components provide Class F balanced cabling performance.

Cables and connections of different categories may be mixed within a channel however the resultant cabling performance will be determined by the category of the lowest performing component.

6.2.2.2 Dimensions

Figure 11 shows the models used to correlate horizontal cabling dimensions specified in this clause with the channel specifications in Clause 5.

Figure 11a shows a channel containing only an interconnect and a TO or MUTO.

Figure 11b contains an additional connection as a cross-connect. In both cases the fixed horizontal cable connects the FD to the TO. The channel includes cords comprising patch, equipment and work area cords. For the purposes of this subclause, jumpers used in place of patch cords are treated as cords.

Figure 11c shows a channel containing an interconnect, a CP and a telecommunications outlet. Figure 11d contains an additional connection as a cross-connect. In both cases the fixed horizontal cable connects the FD to the CP. The channel includes cords comprising patch, equipment and work area cords. For the purposes of this subclause, jumpers used in place of patch cords are treated as cords.

In addition to the cords, the channels shown in Figure 11c and Figure 11d contain a CP cable. The attenuation specification for the CP cable may differ from that of both the fixed horizontal cable and the flexible cables. The channel of Figure 11d is recognized as the maximum implementation used to define the channel performance limits of Clause 5.

In order to accommodate cables used for work area cords, CP cables, patch cords, jumpers and equipment cords with different attenuation specifications, the length of the cables used within a channel shall be determined by the equations shown in Table 22.

In Table 22 it is assumed that

1) the flexible cable within these cords has a higher attenuation specification than that used in the fixed horizontal cable (see Clause 9),

2) the cables within these cords in the channel have a common attenuation specification.

Table 22 - Horizontal channel equations

Model	Figure	Model equations		
		Class D	Class E	Class F
Interconnect – TO	11a	H = 109 - FX	H = 107 – 3[a] - FX	H = 107 – 2[a] - FX
Cross-connect – TO	11b	H = 107 - FX	H = 106 – 3[a] - FX	H = 106 – 3[a] - FX
Interconnect - CP –TO	11c	H = 107 - FX - CY	H = 106 – 3[a] - FX – CY	H = 106 – 3[a] - FX – CY
Cross-connect - CP – TO	11d	H = 105 - FX - CY	H = 105 – 3[a] - FX - CY	H = 105 – 3[a] - FX - CY

H maximum length of the fixed horizontal cable (m)

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

C length of the CP cable (m)

X ratio of flexible cable attenuation (dB/m) to fixed horizontal cable attenuation (dB/m) - see Clause 9

Y ratio of CP cable attenuation (dB/m) to fixed horizontal cable attenuation (dB/m) - see Clause 9

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

For operating temperatures above 20 °C, H should be reduced by 0,2% per °C for screened cables and 0,4% per °C (20 °C to 40 °C) and 0,6% per °C (>40 °C to 60 °C) for unscreened cables.

The following general restrictions apply:

– the physical length of the channel shall not exceed 100 m;

– the physical length of the fixed horizontal cable shall not exceed 90 m and may be less depending on the length of CP cables and cords used and the number of connections;

– where a multi-user TO assembly is used, the length of the work area cord should not exceed 20 m;

– when used, a CP should be located at least 15 m from the floor distributor in order to reduce the effect of multiple connections in close proximity on NEXT and return loss;

– the length of patch cords or jumpers should not exceed 5 m.

The maximum length of the fixed horizontal cable will depend on the total length of CP cables and cords to be supported within a channel. During the operation of the installed cabling, a management system should be implemented to ensure that the cords and, where appropriate, the CP cables used to create the channel conform with the design rules for the floor, building or installation.

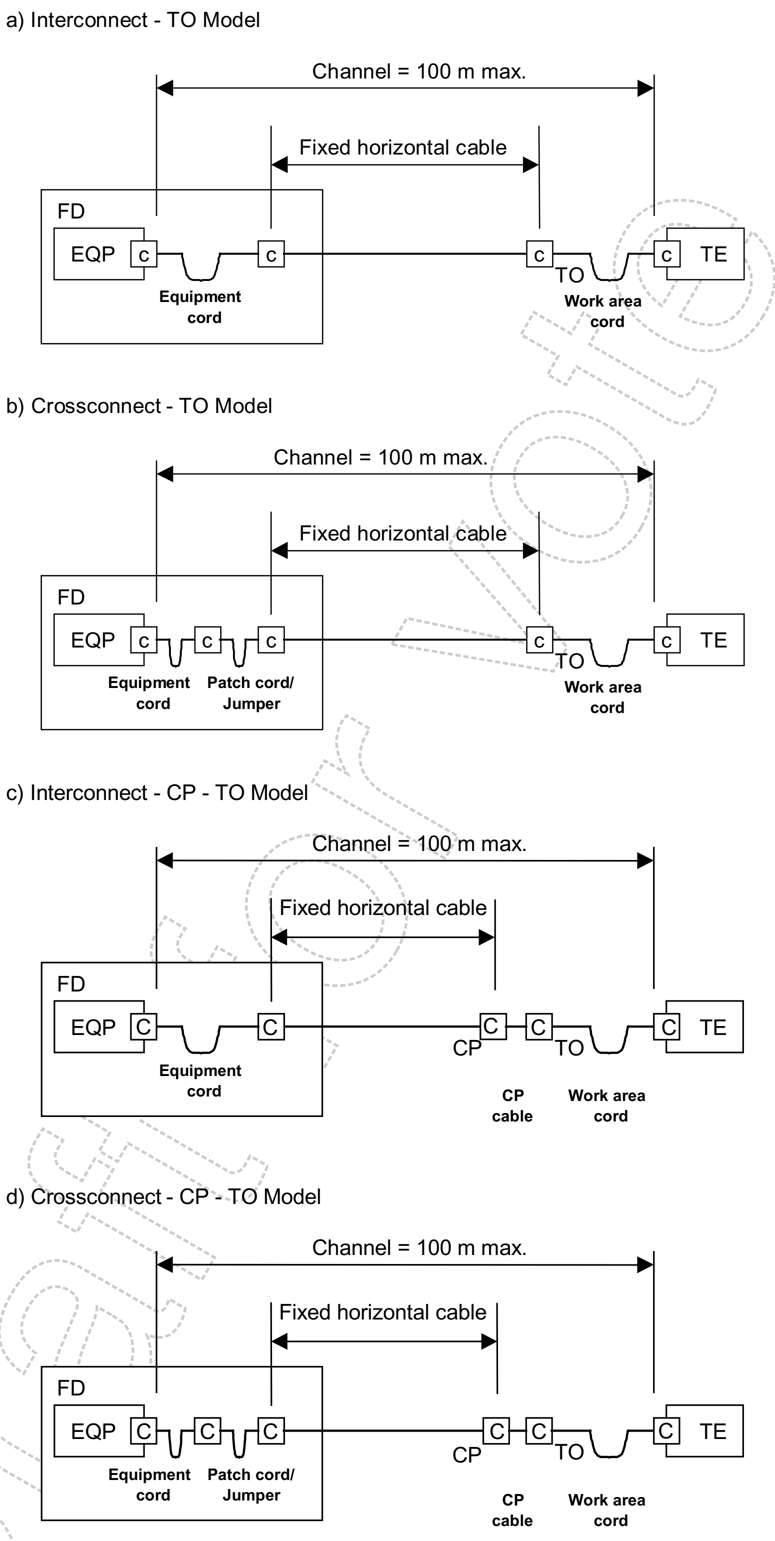


Figure 11 - Horizontal cabling models

6.2.3 Backbone cabling

6.2.3.1 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 Annex E for guidance.

6.2.3.2 Dimensions

Figure 12 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.

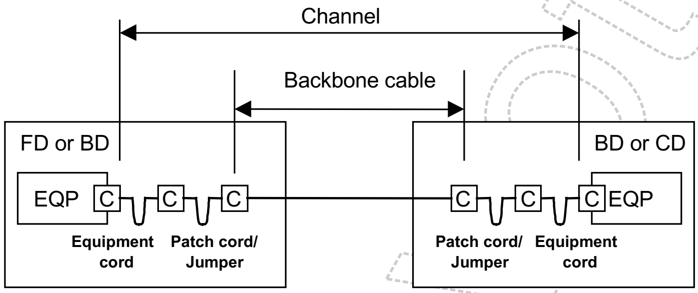


Figure 12 - Backbone cabling model

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

In Table 23 it is assumed that

a) the flexible cable within these cords has a higher attenuation specification than that used in the fixed backbone cable,

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

In order to accommodate the higher attenuation 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 23.

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

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 23 - Backbone channel equations

Component Category	Class [a]					
	A	B	C	D	E	F
5	2000	B = 250 - FX	B = 170 - FX	B = 105 - FX	-	-
6	2000	B = 260 - FX	B = 185 - FX	B = 111 - FX	B = 105 – 3[b]- FX	
7	2000	B = 260 - FX	B = 190 - FX	B = 115 - FX	B = 107 – 3[b] - FX	B = 105 – 3[b]- FX

B length of the fixed backbone cable (m)

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

X ratio of flexible cable attenuation (dB/m) to fixed backbone cable attenuation (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 8, 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 and 7 components. Additionally, the NEXT, Return Loss and ELFEXT performance should be verified.

For operating temperatures above 20 °C, B should be reduced by 0,2 % per °C for screened cables and 0,4 % per °C (20 °C to 40 °C) and 0,6 % per °C (>40 °C to 60 °C) for unscreened cables.

6.3 Optical fibre cabling

6.3.1 Assumptions

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 Category. Within the reference implementations of this clause, the optical fibres used in each cabling channel shall have the same physical construction specification and be of the same Category.

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

6.3.2 Component choice

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

6.3.3 Optical fibre channel lengths

The models of Figure 11 and Figure 12 are applicable to horizontal and backbone optical fibre cabling respectively. 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.

The delivery of optical fibre to the TO would not generally require transmission equipment at the FD (unless the design of optical fibre in the backbone cabling subsystem differed from that in the horizontal cabling subsystem). This allows the creation of a combined backbone/horizontal channel as shown in Figure 13. The three diagrams show a patched channel, a spliced channel and a direct channel (which does not require the use of a FD). Patched and spliced channel designs are also applicable to combined campus/building backbone channels and it is possible to consider a combined campus/building/horizontal channel.

The use of permanently spliced and direct channels as a means of reducing channel attenuation and/or centralizing the distribution of applications is also a reduction in the overall flexibility of generic cabling.

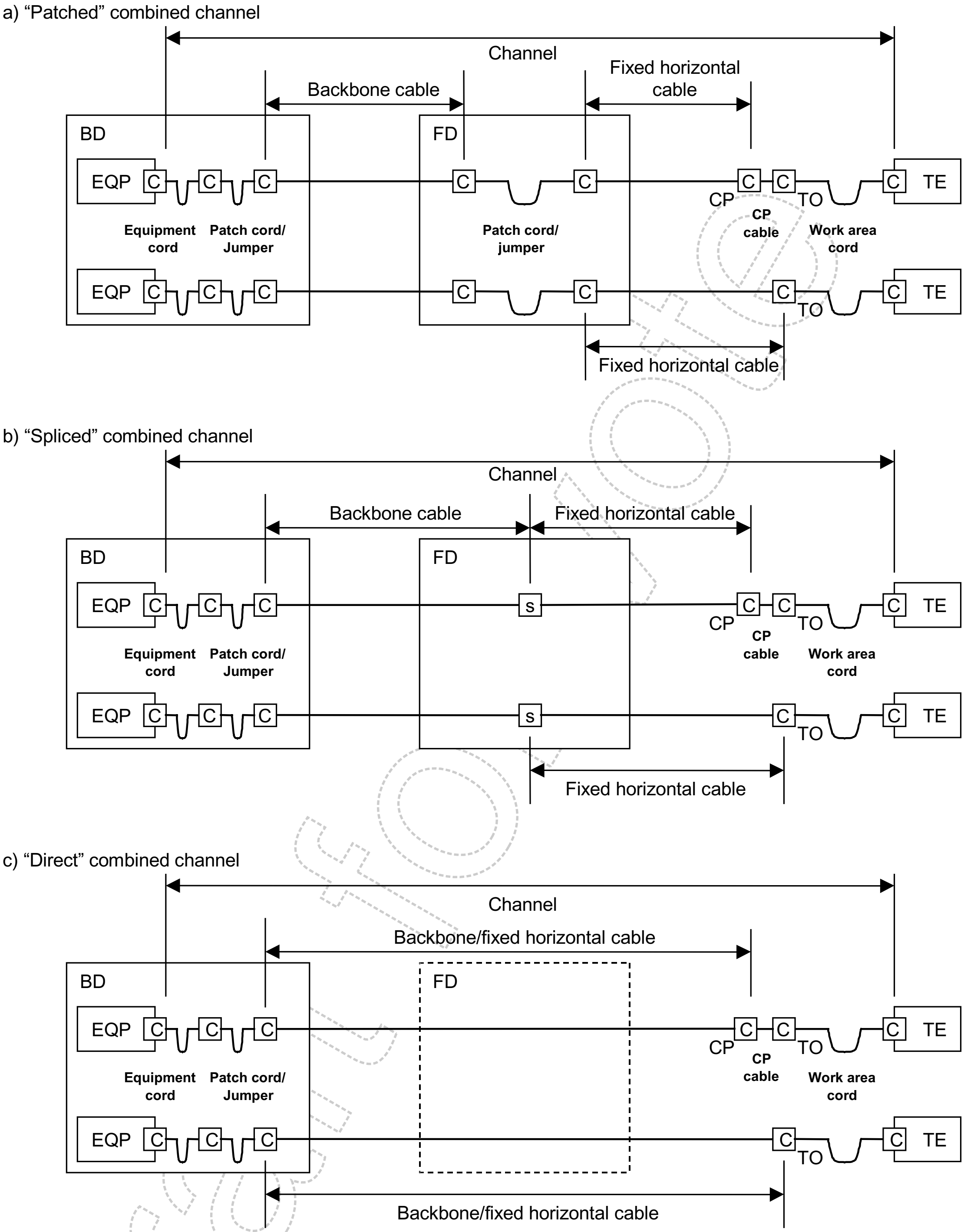


Figure 13 - Combined optical fibre backbone/horizontal channels

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 24.

NOTE The equations of Table 24 may not support the implementation of all the channel configurations shown in Figure 13.

Table 24 - Optical fibre channel parameters

Optical fibre type	Class	Implementation equations [a]		Maximum length m
Multimode		**850 nm**	**1300 nm**	
Cable Category OM1/OM2/OM3	OF-300	L = 735-145x-90y	L = 1300-330x-200y	300
	OF-500	L = 935-145x-90y	L = 1500-330x-200y	500
	OF-2000	L = 2435-145x-90y	L = 3000-330x-200y	2 000
Singlemode		**1310 nm**	**1550 nm**	
OS1	OF-300	L = 1800-500x-300y	L = 1800-500x-300y	300
	OF-500	L = 2000-500x-300y	L = 2000-500x-300y	500
	OF-2000	L = 3500-500x-300y	L = 3500-500x-300y	2 000

L length of the channel (m)

x total number of mated connections in the channel

y total number of splices in the channel

[a] These equations assume 0,5 dB attenuation per mated connection (as for a two connection system only 0,25 % would exceed that value)

Additional connections/splices may be used if the optical power budget of the application allows (see Annex E).

7 Cable requirements

7.1 General

This clause defines the minimum requirements for

a) cables installed in the horizontal and backbone cabling subsystems specified in Clause 4 and used in the reference implementations of Clause 6,

b) balanced cables or cable elements to be used as jumpers,

c) flexible balanced cables to be assembled as cords as specified in Clause 9 and used in the reference implementations of Clause 6.

Balanced cables shall meet the generic specification EN 50288-1 and the sectional specifications as defined in 7.2.

Optical fibre cables shall meet the generic specification EN 60794-1-1 and the sectional specifications as defined in 7.4.

7.2 Balanced cables

7.2.1 Basic performance requirements

Both mechanical and electrical requirements are given in the generic specification EN 50288-1 and the relevant sectional specifications (see Table 25) and cover the minimum requirements to meet the performance classes specified in Clause 5.

Table 25 indicates the applicable standards for balanced cables.

Table 25 - Balanced cable standards

Cable category	Applicable standard for solid cables	Applicable standard for flexible cables
5	prEN 50288-2-1:200X prEN 50288-3-1:200X	prEN 50288-2-2:200X prEN 50288-3-2:200X
6	prEN 50288-5-1:200X prEN 50288-6-1:200X	prEN 50288-5-2:200X prEN 50288-6-2:200X
7	prEN 50288-4-1:200X	prEN 50288-4-2:200X

7.2.2 Additional performance requirements

The equations contained within the specifications listed in Table 25 that define the requirements for return loss are normative requirements of this European standard.

7.3 Hybrid and multi-unit cables, and cables connected to more than one telecommunications outlet

Examples of the types of cables that are covered by this subclause include hybrid cables, multi-unit cables and any cable connected to more than one telecommunications outlet (either directly or through a consolidation point).

Cables required to meet this subclause shall also meet the transmission requirements for the corresponding cable category and type given in 7.2. 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 7.2 for the same category.

7.4 Optical fibre cables

7.4.1 Multimode optical fibre cables

The optical fibre shall be multimode, graded-index optical fibre waveguide with nominal 50/125 µm or 62,5/125 µm core/cladding diameter complying with A1a or A1b optical fibre, respectively, of EN 60793-2-10:2002.

Each optical fibre in the cable shall meet the performance requirements of Table 26. Both attenuation and modal bandwidth-distance product shall be measured in accordance with EN 60793-1-40 and EN 60793-1-41 respectively.

Table 26 - Multimode optical fibre cable performance requirements

Category	Maximum attenuation (dB/km)		Minimum modal bandwidth MHz.km		
			Overfilled launch		Effective laser launch [a]
	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 [b]	3,5	1,5	1 500	500	2 000

[a] Effective laser launch bandwidth is assured using differential mode delay (DMD) as specified in draft EN 60793-1-49. Optical fibres that meet only the overfilled launch modal bandwidth may not support some applications listed in Annex E.

[b] OM3 can only be realized with 50/125 µm fibres.

The mechanical and environmental requirements for indoor and outdoor optical fibre cables are defined in accordance with EN 60794-1-1, EN 60794-1-2, IEC 60794-2 and EN 60794-3.

7.4.2 Singlemode optical fibre cables

The optical fibre shall comply with B1 fibre of EN 60793-2-50:2002.

Each optical fibre in the cable shall have an attenuation as defined in Table 27. The attenuation shall be measured in accordance with EN 60793-1-40.

Table 27 - Singlemode optical fibre cable (Category OS1) performance requirements

Wavelength nm	**Maximum attenuation** dB/km
1 310	1,0
1 550	1,0

The cut-off wavelength of singlemode optical fibre cables shall be less than 1 260 nm when measured in accordance with EN 60793-1-44.

The mechanical and environmental requirements for indoor and outdoor optical fibre cables are defined in accordance with EN 60794-1-1, EN 60794-1-2, IEC 60794-2 and EN 60794-3.

7.4.3 Propagation delay

For all fibre categories defined in Tables 26 and 27 a conservative conversion value for unit propagation delay of 5,00 ns/m (0,667 c) may be used. This value can be used to calculate channel delay without verification.

7.4.4 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 provides guidelines and requirements for connecting hardware used with generic cabling. 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 otherwise specified, this standard specifies the minimum performance of mated connectors as part of a permanent link or channel. These requirements apply to individual connectors which include telecommunications outlets, patch panels, consolidation point connectors, splices and cross-connects. Performance requirements do not include the effects of cross-connect jumpers or patch cords. Requirements for balanced cords are provided in Clause 9.

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 between backbone and horizontal cabling and permitting connections to equipment (if provided);

d) at the horizontal cabling consolidation point (if provided);

e) at the telecommunications outlet;

f) 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 cable management and ongoing administration of the cabling system;

f) a means to accommodate screening and grounding requirements, when applicable.

This European standard specifies the types of connecting hardware to be used at the Telecommunications Outlet. It is possible to use alternative connecting hardware at other locations provided that it meets the relevant requirements of this clause.

8.1.4 Operating environment

The performance of the connecting hardware shall be maintained over the temperature range -10 °C to 60 °C.

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 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 Clause 7. 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 series EN 60352. 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 8.1.6, 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 28.

Table 28 - Mechanical characteristics of connecting hardware intended for use with balanced cabling

	Characteristic	Requirement	Reference
a)	Cable termination compatibility		
	Nominal conductor diameter	0,5 mm to 0,65 mm [1]	--
	Conductor type	solid	EN 50288-X-2 or EN 50288-X-1
	Conductor type	stranded	EN 50288-X-2
	Nominal diameter of insulated conductor Category 5 and Category 6 Category 7	 0,7 mm to 1,4 mm [2] [3] 0,7 mm to 1,6 mm	8.1 of EN 60811-1-1:1995
	Number of conductors (TO)	8	visual inspection
	Number of conductors (other)	≥ 2*n (n = 1,2,3, ...)	
	Cable outer diameter outlet plug	 ≤ 20 mm ≤ 9 mm [4]	8.2 of EN 60811-1-1:1995
	Means to connect screen	EN 50174-2 [5]	
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 [6]	EN 60352-3 and EN 60352-4
	TO type interface (cycle)	≥ 750 (level PL1 of EN 60603-7) [7]	Clauses 6 and 7 of EN 60603-7:1996
	other interface (cycles)	≥ 200 (see Annex D)	EN 60352-6

1) Nominal conductor diameters described in EN 50288-X-Y 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 plugs and 0,5 mm to 0,65 mm for jacks or punch down blocks.

2) Use of the modular plug 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.

3) 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.

4) 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.

5) 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.

6) 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).

7) Mating and unmating under load is ffs.

8.2.4 Electrical characteristics

8.2.4.1 General

Connecting hardware intended for use with balanced cabling shall meet the corresponding performance requirements of 8.2.4.2 to 8.2.4.16. Connecting hardware shall be tested with each cable impedance that it is intended to support. When connectors complying with the mechanical requirements of EN 60603-7 are used, the connectors shall comply with all requirements of the relevant parts of EN 60603-7 for the relevant category.

Plugs and sockets that are intermateable shall be backward compatible with those of different performance categories. Backward compatibility means that mated connections with plugs and sockets from different categories shall meet all requirements for the lower category component. See Table 29 for a matrix of mated modular connector performance that is representative of backward compatible connectivity.

Table 29 - Backwards compatibility matrix

Modular plug/cord	Modular connector (TO) Category		
	Category 5	**Category 6**	**Category 7**
Category 5	Category 5	Category 5	Category 5
Category 6	Category 5	Category 6	Category 6
Category 7	Category 5	Category 6	Category 7

8.2.4.2 Return loss

The return loss of connecting hardware 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.

Table 30 - Formulae for return loss limits for connecting hardware

Category	**Frequency** MHz	**Minimum return loss** dB
5	$1 \leq f \leq 100$	$60 - 20 \bullet \log(f)$, 30,0 max.
6	$1 \leq f \leq 250$	$64 - 20 \bullet \log(f)$, 30,0 max.
7	$1 \leq f \leq 600$	$68 - 20 \bullet \log(f)$, 30,0 max.

Table 31 - Minimum return loss

Frequency MHz	**Minimum return loss** dB			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
1,0	30,0	30,0	30,0	EN 60512-25-5
16,0	30,0	30,0	30,0	
100,0	20,0	24,0	24,0	
250,0	N/A	16,0	16,0	
600,0	N/A	N/A	12,4	

8.2.4.3 Attenuation / insertion loss

The attenuation of connecting hardware measured as insertion loss shall not exceed the limits computed, to two decimal places, using the formulae of Table 32. The limits shown in Table 33 are derived from the formulae at key frequencies only.

Table 32 - Formulae for attenuation limits for connecting hardware

Category	Frequency MHz	Maximum attenuation/insertion loss dB
5	$1 \leq f \leq 100$	$0{,}04\sqrt{f}$, 0,10 min.
6	$1 \leq f \leq 250$	$0{,}02\sqrt{f}$, 0,10 min.
7	$1 \leq f \leq 600$	$0{,}02\sqrt{f}$, 0,10 min.

Table 33 - Maximum attenuation (insertion loss)

Frequency MHz	Maximum attenuation (insertion loss) dB			Component or test standard
	Category 5	Category 6	Category 7	
1,0	0,10	0,10	0,10	EN 60512-25-2
16,0	0,16	0,10	0,10	
100,0	0,40	0,20	0,20	
250,0	N/A	0,32	0,32	
600,0	N/A	N/A	0,49	

8.2.4.4 NEXT

The NEXT of connecting hardware 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.

Table 34 – Formulae for NEXT limits for connecting hardware

Category	Frequency MHz	Minimum NEXT dB
5	$1 \leq f \leq 100$	$83 - 20 \bullet \log(f)$, 80,0 max.
6	$1 \leq f \leq 250$	$94 - 20 \bullet \log(f)$, 80,0 max.
7	$1 \leq f \leq 600$	$102{,}4 - 15 \bullet \log(f)$, 80,0 max.

Table 35 - Minimum NEXT

Frequency MHz	Minimum NEXT dB			Component or test standard
	Category 5	Category 6	Category 7	
1,0	80,0	80,0	80,0	EN 60512-25-1
16,0	58,9	69,9	80,0	
100,0	43,0	54,0	72,4	
250,0	N/A	46,0	66,4	
600,0	N/A	N/A	60,8	

8.2.4.5 PSNEXT

The PSNEXT of connecting hardware 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.

Table 36 - Formulae for PS NEXT limits for connecting hardware

Category	**Frequency** MHz	**Minimum PSNEXT** dB
5	$1 \leq f \leq 100$	80 – 20•log(*f*), 77,0 max.
6	$1 \leq f \leq 250$	90 – 20•log(*f*), 77,0 max.
7	$1 \leq f \leq 600$	99,4 - 15•log(*f*), 77,0 max.

Table 37 - Minimum PSNEXT

Frequency MHz	**Minimum PSNEXT** dB			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
1,0	75,9	77,0	77,0	EN 60512-25-1
16,0	55,9	65,9	77,0	
100,0	40,0	50,0	69,4	
250,0	N/A	42,0	63,4	
600,0	N/A	N/A	57,8	

8.2.4.6 FEXT

The FEXT of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table 38. The limits shown in Table 39 are derived from the formulae at key frequencies only.

NOTE For connectors, the difference between FEXT and ELFEXT is minimal. Therefore, connector FEXT requirements are used to model ELFEXT performance for channels.

Table 38- Formulae for FEXT limits for connecting hardware

Category	**Frequency** MHz	**Minimum FEXT** dB
5	$1 \leq f \leq 100$	75,1 – 20•log(*f*), 65,0 max.
6	$1 \leq f \leq 250$	83,1 – 20•log(*f*), 65,0 max.
7	$1 \leq f \leq 600$	90 - 15•log(*f*), 65,0 max.

Table 39 - Minimum FEXT

Frequency MHz	Minimum FEXT dB			Component or test standard
	Category 5	**Category 6**	**Category 7**	
1,0	65,0	65,0	65,0	EN 60512-25-1
16,0	51,0	59,0	65,0	
100,0	35,1	43,1	60,0	
250,0	N/A	35,1	54,0	
600,0	N/A	N/A	48,3	

8.2.4.7 PSFEXT

The PSFEXT of connecting hardware shall meet the limits computed, to one decimal place, using the formulae of Table 40. The limits shown in Table 41 are derived from the formulae at key frequencies only.

NOTE For connectors, the difference between PSFEXT and PSELFEXT is minimal. Therefore, connector PSFEXT requirements are used to model PSELFEXT performance for channels.

Table 40 - Formulae for PSFEXT limits for connecting hardware

Category	Frequency MHz	Minimum PSFEXT dB
5	$1 \leq f \leq 100$	72,1 – 20•log(f), 62,0 max.
6	$1 \leq f \leq 250$	80,1 – 20•log(f), 62,0 max.
7	$1 \leq f \leq 600$	87 – 15•log(f), 62,0 max.

Table 41 - Minimum PSFEXT

Frequency MHz	Minimum PSFEXT dB			Component or test standard
	Category 5	**Category 6**	**Category 7**	
1,0	62,0	62,0	62,0	EN 60512-25-1
16,0	48,0	56,0	62,0	
100,0	32,1	40,1	57,0	
250,0	N/A	32,1	51,0	
600,0	N/A	N/A	45,3	

8.2.4.8 Propagation delay

The propagation delay of connecting hardware shall not exceed the limits of Table 42.

Table 42 - Formulae 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	
7	$1 \leq f \leq 600$	0,002 5	

8.2.4.9 Delay skew

The delay skew of connecting hardware shall not exceed the limits of Table 43.

Table 43 - Formulae 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	
7	$1 \leq f \leq 600$	0,001 25	

8.2.4.10 Input to output resistance

Input to output resistance is a separate measurement from the contact resistance measurements required in EN 60603-7. 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/output resistance of connecting hardware shall not exceed the limits of Table 44.

Table 44 – Maximum input to output resistance

Frequency MHz	**Maximum input to output resistance** mΩ			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
d.c.	200	200	200	Test 2a of EN 60512-2:1985

8.2.4.11 Input to output resistance unbalance

The input/output resistance unbalance of connecting hardware shall not exceed the limits of Table 45.

Table 45 – Maximum input to output resistance unbalance

Frequency MHz	**Maximum input to output resistance unbalance** mΩ			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
d.c.	50	50	50	Test 2a of EN 60512-2:1985

8.2.4.12 Current carrying capacity

The current carrying capacity of connecting hardware shall meet the limits of Table 46. 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.

Table 46 - Minimum current carrying capacity

Frequency MHz	**Minimum current capacity per conductor** A			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
d.c.	0,75	0,75	0,75	Test 5b of IEC 60512-3:1976

8.2.4.13 Transfer impedance

The transfer impedance of connecting hardware shall meet the limits computed, to two decimal places, using the formulae of Table 47. The limits shown in Table 48 are derived from the formulae at key frequencies only.

Table 47 - Formulae for transfer impedance for connecting hardware

Category	**Frequency** MHz	**Maximum transfer impedance** Ω
5	$1 \leq f \leq 10$	$0,1 \bullet f^{0,3}$
	$10 < f \leq 30$	$0,02 \bullet f$
6	$1 \leq f \leq 10$	$0,1 \bullet f^{0,3}$
	$10 < f \leq 30$	$0,02 \bullet f$
7	$1 \leq f \leq 10$	$0,05 \bullet f^{0,3}$
	$10 < f \leq 30$	$0,01 \bullet f$

Table 48 - Maximum transfer impedance

Frequency MHz	**Maximum transfer impedance** Ω			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
1,0	0,10	0,10	0,05	EN 60512-25-5
16,0	0,32	0,32	0,16	
30,0	0,60	0,60	0,30	
100,0	N/A	N/A	N/A	
250,0	N/A	N/A	N/A	
600,0	N/A	N/A	N/A	

8.2.4.14 Unbalance attenuation

Unbalance attenuation, near end, (LCL) shall meet the limits computed, to two decimal places, using the formulae of Table 49. The limits shown in Table 50 are derived from the formulae at key frequencies only.

Table 49 - Formulae for Transverse Conversion Loss (TCL) limits for connecting hardware

Category	**Frequency** MHz	**Minimum TCL** dB
5	$1 \leq f \leq 100$	66 – 20•log(f), 60,00 max.
6	$1 \leq f \leq 250$	66 – 20•log(f), 60,00 max.
7	$1 \leq f \leq 600$	66 – 20•log(f), 60,00 max.

Table 50 - Minimum TCL

Frequency MHz	**Minimum balance** dB			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
1,0	60,0	60,0	60,0	Annex K of EN 60603-7-7 :2002
16,0	41,9	41,9	41,9	
100,0	26,0	26,0	26,0	
250,0	N/A	18,0	18,0	
600,0	N/A	N/A	10,4	
NOTE This test method is applicable to all connecting hardware.				

8.2.4.15 Insulation resistance

The insulation resistance of connecting hardware shall exceed the limits of Table 51.

Table 51 – Minimum insulation resistance

Frequency MHz	**Minimum insulation resistance** MΩ			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
d.c.	100	100	100	Test 3a, Method C of EN 60512-2:1985 at DC 500 V

8.2.4.16 Voltage proof

The voltage proof of connecting hardware shall exceed the limits of Table 52.

Table 52 – Minimum d.c. voltage proof

Characteristic	**Minimum d.c. voltage proof** V			**Component or test standard**
	Category 5	**Category 6**	**Category 7**	
Conductor to conductor	1 000	1 000	1 000	Test 4a of EN 60512-2:1985
Conductor to test panel	1 500	1 500	1 500	

8.2.5 Environmental characteristics

8.2.5.1 Connecting hardware of the type used at the telecommunications outlet

See the EN 60603-7 series of standards.

8.2.5.2 Other types of connecting hardware

See Annex D.

8.2.6 Telecommunications outlet requirements

Pin and pair grouping assignments shall be as shown in Figure 14

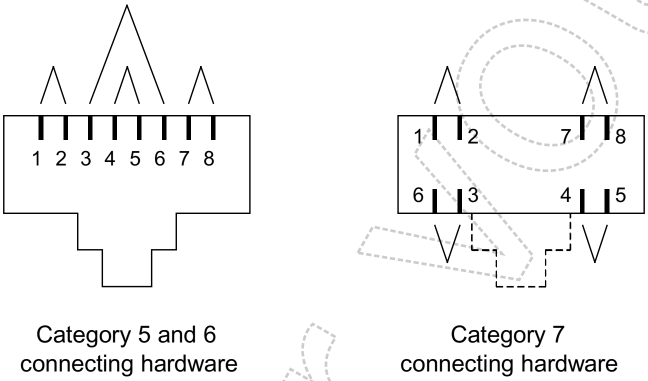


Figure 14 - Eight position jack pin and pair grouping assignments (front view of connector)

Pair rearrangement at the telecommunications outlet should not involve modification of the horizontal cable terminations. If pair rearrangement is used at the telecommunications outlet, the configuration of the outlet terminations shall be clearly identified.

NOTE When two physically similar cabling links are used in the same installation (for example, different performance categories and cables with different nominal impedance) special precautions are required to ensure that they are properly identified

8.2.7 Physical dimensions

The requirements for the physical dimensions of connecting hardware at the telecommunications outlet are summarized in Table 53.

Table 53 – Connecting hardware requirements at the telecommunications outlet

Characteristic	Requirement	Component or test standard
Category 5 unscreened	Mating dimensions and gauging	EN 60603-7-2
Category 5 screened	Mating dimensions and gauging	EN 60603-7-3
Category 6 unscreened	Mating dimensions and gauging	EN 60603-7-4
Category 6 screened	Mating dimensions and gauging	EN 60603-7-5
Category 7	Mating dimensions and gauging	EN 60603-7-7 [a]
[a] In installations where other factors, such as Home Entertainment and Multimedia (HEM, see EN 50173-3) applications take preference over backward compatibility offered with EN 60603-7-7, also the interface specified in IEC/PAS 61076-3-104/Ed.1 (48B/1167/PAS) may be used.		

8.3 Optical fibre connecting hardware

8.3.1 General requirements

The requirements of 8.3.2 to 8.3.5 apply to all connecting hardware used to provide connections between optical fibre cables described in Clause 7. These requirements apply to the connecting hardware for both horizontal and backbone cabling. Additionally, all optical ports shall comply with the requirements of EN 60825-2.

8.3.2 Marking and colour coding

Coding of connectors and adapters, for example by colour, should be used to prevent accidential connection of different fibre types (i.e. singlemode, 50/125 µm or 62,5/125 µm multimode) and/or fibre categories. Consistent polarisation of duplex optical fibre connections shall be maintained throughout the cabling system by means of physical keying, administration (i.e. labelling) or both. Also, keying and the identification of fibre positions may be used to ensure that correct polarity is maintained for duplex links.

The following colour code applies for IEC 60874-19-1 SC Duplex connectors:

Multimode:	beige or black
Singlemode (physical contact):	blue
Singlemode (angled physical contact):	green

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.

8.3.3 Mechanical and optical characteristics

Optical fibre connecting hardware shall meet the requirements of Table 54.

8.3.4 Telecommunications outlet requirements

The optical fibre cables in the work area shall be connected to the horizontal cabling with a duplex SC connector (SC-D) which meets the requirements of detail specification IEC 60874-19-1. The optical fibre connectors shall meet the requirements of 8.3.3.

8.3.5 Requirements for areas other than the telecommunications outlet

The optical fibre connectors used shall meet the requirements of 8.3.3, with exception of the physical dimensions as described in Table 54 b1).

In areas other than the work area, the choice of connecting hardware is open to all types of optical fibre connectors standardized by IEC. When high density is an important consideration for the Campus Distributor (CD), Building Distributor (BD), Floor Distributor (FD), or Consolidation Point (CP), then Small Form Factor connector designs that accommodate at least two fibres within the footprint of an EN 60603-7 connector are recommended.

However, where detail specifications produced by IEC or CENELEC in accordance with requirements of Table 54 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 54 - Mechanical and optical characteristics of optical fibre connecting hardware

	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	Method 1 of EN 61300-3-6:1997
		singlemode	35 dB	Method 1 or 2 of EN 61300-3-6:1997
b)	Physical characteristics			
b1)	Physical dimensions (only at telecommunications outlet for multimode optical fibre)		Mating dimensions and gauging	IEC 60874-19-1 (SC-D)
b2)	Cable termination compatibility			
	Nominal cladding diameter (µm)		125	4.1.1.4 (A1a, A1b) and 5.1.4 (B1) of IEC 60793-2:1998
	Nominal buffer diameter (µm)		-	6.1 of IEC 60794-2:1989
	Cable outer diameter (µm)		-	6.1 of IEC 60794-2:1989
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 1deg/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

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 represents a greater risk to operational channel performance than that of installed horizontal or backbone cables.

This clause defines the requirements for terminated cables used as work area cords, CP cords, equipment cords and patch cords within horizontal and backbone cabling. Jumpers shall be in accordance with the requirements of Clause 7.

9.2 Balanced cords

9.2.1 General

This subclause specifies the minimum requirements for balanced cords used to form the horizontal and backbone channels specified in Clause 4.

A cord shall be assembled in accordance with 7.2.

Work area cords shall only be assembled using flexible cables of stranded construction as defined in 7.2.

Connections used shall meet the requirements of Clause 8 with the exception of the equipment connectors used on work area and equipment 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. Where screened cables and connections are used, the cable screen shall be connected according to the connections manufacturers' instruction.

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.

9.2.2 Cable attenuation

The maximum insulated conductor diameter for use within modular plugs according to EN 60603-7 is 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 attenuation of the cable.

The maximum attenuation ratio of flexible cables in accordance with 7.2, defined as their attenuation / insertion loss (dB/100 m) compared to that of installation cables, is 1,5. However, cable constructions having attenuation ratios below 1,5 are supported by the reference implementation rules of Clause 6.

The maintenance of channel performance requires that flexible cables of the correct attenuation ratio shall be used as defined by the implementation rules.

9.2.3 Electrical performance requirements for patch cords

9.2.3.1 Insertion loss

Insertion loss measurements of cords shall not exceed the insertion loss requirements of the connection at each end, plus the insertion loss requirement for the cable, scaled for length. The insertion loss performance is achieved by design.

9.2.3.2 Return loss

Cords shall meet the return loss requirements specified in Table 55 when measured in accordance with EN 61935-2.

Table 55 – Return loss requirements for cords

Category	Frequency MHz	Minimum return loss dB
5	$4 \le f < 25$	$19{,}8+3 \bullet \log f$
	$25 \le f \le 100$	$38-10 \bullet \log f$
6	$4 \le f < 25$	$19{,}8+3 \bullet \log f$
	$25 \le f \le 250$	$38-10 \bullet \log f$
7	$4 \le f < 25$	$19{,}8+3 \bullet \log f$
	$25 \le f \le 600$	$38-10 \bullet \log f$

9.2.3.3 Near-end crosstalk loss (NEXT)

The cords for Category 5 shall meet the requirements calculated according to equation (6) when measured in accordance with EN 61935-2.

$$\alpha_{NEXT,cord}(L) = 10\log_{10}\left(10^{\frac{-\alpha_{NEXT,con}}{10}} + 10^{\left(\frac{-\alpha_{NEXT,cab}+2\cdot\alpha_{con}}{10}\right)}\right) + RSXT \qquad (6)$$

where

$\alpha_{NEXT,cord}(L)$ NEXT of the entire cord in dB

$\alpha_{NEXT,con}$ NEXT of the connectors in dB

$\alpha_{NEXT,cab}$ NEXT of the cable itself in dB

α_{con} attenuation of one connector in dB

$RSXT$ reflected signal crosstalk ($RSXT$ = 0 dB for Category 5 cords, $RSXT$ = 0,5 dB for Category 6 and Category 7 cords)

The NEXT of the connectors is determined by equation (7):

$$\alpha_{NEXT,con} = -20\cdot\log_{10}\left(10^{\frac{-\alpha_{NEXT,local}}{20}} + 10^{\left(\frac{-\alpha_{NEXT,remote}+2\cdot(\alpha_L+\alpha_{con})}{20}\right)}\right) \qquad (7)$$

where

$\alpha_{NEXT,local}$ NEXT of the connector at the local end of the cord in dB

$\alpha_{NEXT,remote}$ NEXT of the connector at the remote end of the cord in dB

α_L length corrected attenuation of the cable in dB

α_{con} attenuation of the connector in dB

The length corrected attenuation of the cable is given by equation (8):

$$\alpha_L = \alpha_{cab} \cdot \frac{L}{100} \tag{8}$$

where

L length of the cable in the cord

α_{cab} attenuation of 100 m of the cable used for the cord

The frequency dependence of NEXT, if the anchor value at 100 MHz is known, is given by equation (9):

$$\alpha_{NEXT,local} = \alpha_{NEXT,remote} = \alpha_{NEXT,con}(100) - 20 \cdot \log_{10}\left(\frac{f}{100}\right) \tag{9}$$

where

$\alpha_{NEXT,con}(100)$ NEXT of the connector in dB at 100 MHz

The length corrected NEXT of the cable of the cord is given by equation (10):

$$\alpha_{NEXT,cab}(L) = \alpha_{NEXT,cab} - 10 \cdot \log_{10}\left(\frac{1-10^{-\frac{\alpha_L}{5}}}{1-10^{-\frac{\alpha_{cab}}{5}}}\right) \tag{10}$$

Calculations yielding NEXT limits in excess of 65 dB shall revert to a limit of 65 dB.

Requirements for Category 6 and 7 cords are for further study. Table 56 lists informative NEXT values at key frequencies for different lengths of the cords.

Table 56 - Informative values of NEXT at key frequencies for Category 5, 6 and 7 cords

Frequency MHz	**NEXT for cord of Category** dB								
	5			**6**			**7**		
	Length			**Length**			**Length**		
	2 m	5 m	10 m	2 m	5 m	10 m	2 m	5 m	10 m
1	65,0	65,0	65,0	65,0	65,0	65,0	65,0	65,0	65,0
16	50,3	49,5	48,7	61,6	60,0	58,5	65,0	65,0	65,0
100	35,0	34,7	34,5	46,2	45,0	44,2	65,0	65,0	65,0
250	N/A			38,6	37,9	37,6	60,7	61,2	61,9
600				N/A			55,4	56,2	57,0

For the commonly available Category 5 test head the anchor value at 100 MHz is:

$$\alpha_{NEXT,con}(100) = 41{,}0 \text{ dB} \tag{11}$$

9.2.4 Identification

Each cord shall be identified to indicate:

a) length;

b) the design attenuation ratio of the cable;

c) category of cable;

d) wire-map status where a direct pin-pin relationship does not exist (i.e. cross-over cords).

9.3 Optical fibre cords

This subclause specifies the minimum requirements for optical fibre cords used to form the horizontal and backbone cabling channels specified in Clause 4.

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 7.4.

Connecting hardware used shall meet the requirements of Clause 8 with the exception of the equipment connectors used on work area and equipment 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.

Annex A

(normative)

Link performance limits

A.1 General

This annex contains performance requirement formulae for permanent links and CP links as shown in Figure A.1.

The cabling under test in Configurations A, B and C is termed the permanent link:

a) Configurations A and B comprise fixed cabling only.

b) Configuration C comprises fixed cabling and a CP cord. Measurements made for this configuration are invalid if the CP cord is changed.

The cabling under test in Configuration D contains fixed cabling only and is termed the CP link.

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.

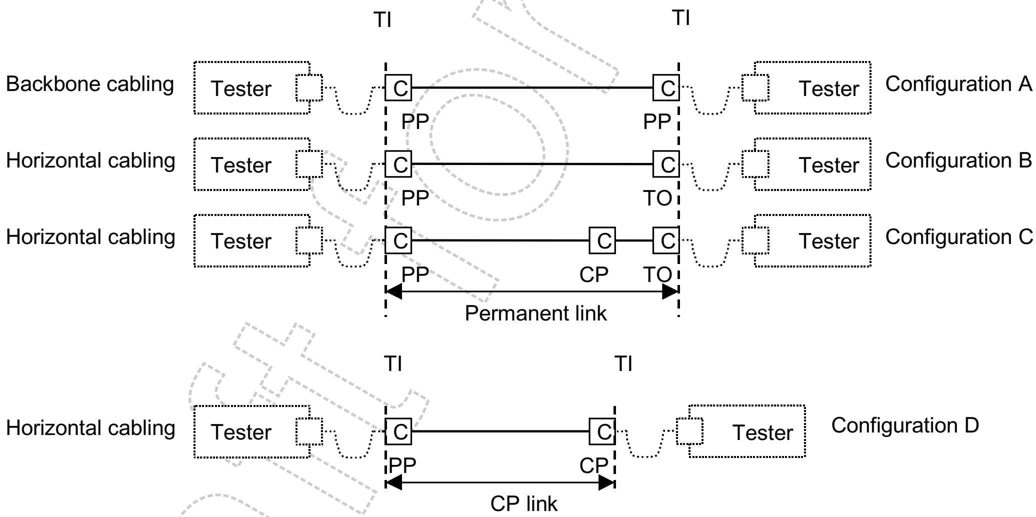


Figure A.1 - Link options

A.2 Balanced cabling

A.2.1 General

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 permanent links and CP 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.2.2 and A.2.3 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.2.2 Link limits

A.2.2.1 Return loss

The return loss of each pair of the link shall meet or exceed the limits computed, to one decimal place, using the formulae of Table A.1. The return loss shall be measured according to 5.4.2.

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
	$20 \leq f \leq 100$	$32 - 10 \bullet \log(f)$
E	$1 \leq f < 10$	21,0
	$10 \leq f < 40$	$26 - 5 \bullet \log(f)$
	$40 \leq f \leq 250$	$34 - 10\log(f)$
F	$1 \leq f < 10$	21,0
	$10 \leq f < 40$	$26 - 5 \bullet \log(f)$
	$40 \leq f < 251,2$	$34 - 10 \bullet \log(f)$
	$251,2 \leq f \leq 600$	10,0

For all configurations of Figure A.1, values of return loss at frequencies for which the measured attenuation is below 3,0 dB are for information only.

A.2.2.2 Attenuation / Insertion loss

Where the maximum lengths of channel components to be added to the link are unknown, the attenuation of each pair of the link shall not exceed the limits computed, to one decimal place, using the formulae of Table A.2. See 5.4.3 for details of measurement.

Table A.2 - Formulae for attenuation limits for a link

Link Class	**Frequency** MHz	**Maximum attenuation** dB
A	f = 0,1	16,0
B	f = 0,1	5,5
	f = 1	5,8
C	$1 \le f \le 16$	$0{,}9 \bullet \left(3{,}23\sqrt{f}\right) + 3 \bullet 0{,}2$
D	$1 \le f \le 100$	$\left(L/100\right) \bullet \left(1{,}9108\sqrt{f} + 0{,}0222 * f + 0{,}2/\sqrt{f}\right) + n \bullet 0{,}04 \bullet \sqrt{f}$, 4,0 min.
E	$1 \le f \le 250$	$\left(L/100\right) \bullet \left(1{,}82\sqrt{f} + 0{,}0169 \bullet f + 0{,}25/\sqrt{f}\right) + n \bullet 0{,}02 \bullet \sqrt{f}$, 4,0 min.
F	$1 \le f \le 600$	$\left(L/100\right) \bullet \left(1{,}8\sqrt{f} + 0{,}01 \bullet f + 0{,}2/\sqrt{f}\right) + n \bullet 0{,}02 \bullet \sqrt{f}$, 4,0 min.

Where $L = L_{FC} + L_{CP} \bullet Y$

L_{FC} length of fixed cable (m)

L_{CP} length of CP cord (where present) (m)

Y ratio of CP cable attenuation (dB/m) to fixed horizontal cable attenuation (dB/m) (see Clause 9)

n = 2 for Configurations A, B and D

n = 3 for Configuration C

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 attenuation/insertion loss of the link and the channel limits of Table 4 shall exceed the total attenuation/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.2.2.3 NEXT

A.2.2.3.1 Pair-to-pair NEXT

The NEXT between each pair combination of the link shall meet or exceed the limits computed, to one decimal place, using the formulae of Table A.3. The NEXT shall be measured according to 5.4.4.1.

Table A.3 - Formulae for NEXT limits for a link

Link Class	**Frequency** MHz	**Minimum NEXT** dB
A	$f \leq 0,1$	27,0
B	$0,1 \leq f \leq 1$	25,0-15•log(f)
C	$1 \leq f \leq 16$	40,1-15,8•log(f)
D	$1 \leq f \leq 100$	$-20\log\left(10^{\frac{65,3-15\log(f)}{-20}}+10^{\frac{83-20\log(f)}{-20}}\right)$, 60,0 max.
E	$1 \leq f \leq 250$	$-20\log\left(10^{\frac{74,3-15\log(f)}{-20}}+10^{\frac{94-20\log(f)}{-20}}\right)$, 65,0 max
F	$1 \leq f \leq 600$	$-20\log\left(10^{\frac{102,4-15\log(f)}{-20}}+10^{\frac{102,4-15\log(f)}{-20}}\right)$, 65,0 max.

Values of NEXT at frequencies for which the measured link attenuation is below 4,0 dB are for information only.

A.2.2.3.2 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 5.4.4.2.

Table A.4 - Formulae for PSNEXT limits for a link

Link Class	**Frequency** MHz	**Minimum PSNEXT** dB
D	$1 \leq f \leq 100$	$-20\log\left(10^{\frac{62,3-15\log(f)}{-20}}+10^{\frac{80-20\log(f)}{-20}}\right)$, 57,0 max.
E	$1 \leq f \leq 250$	$-20\log\left(10^{\frac{72,3-15\log(f)}{-20}}+10^{\frac{90-20\log(f)}{-20}}\right)$, 62,0 max
F	$1 \leq f \leq 600$	$-20\log\left(10^{\frac{99,4-15\log(f)}{-20}}+10^{\frac{99,4-15\log(f)}{-20}}\right)$, 62,0 max.

Values of PSNEXT at frequencies for which the measured link attenuation is below 4,0 dB are for information only.

A.2.2.4 Attenuation to crosstalk loss ratio (ACR)

A.2.2.4.1 Pair-to-pair ACR

The ACR for each pair combination of the link shall meet or exceed the limits calculated from the relevant NEXT and attenuation/insertion loss formulae.

A.2.2.4.2 Power sum ACR (PSACR)

The PSACR for each pair combination of the link shall meet or exceed the limits calculated from the relevant PSNEXT and attenuation/insertion loss formulae.

A.2.2.5 ELFEXT

A.2.2.5.1 Pair-to-pair ELFEXT

The ELFEXT for each pair of the link shall meet or exceed the limits computed, to one decimal place, using the formulae of Table A.5. The ELFEXT shall be measured according to 5.4.6.1.

Table A.5 - Formulae for ELFEXT limits for a link

Class	**Frequency** MHz	**Minimum ELFEXT** dB
D	$1 \le f \le 100$	$-20\log\left(10^{\frac{63,8-20\log(f)}{-20}} + n \bullet 10^{\frac{75,1-20\log(f)}{-20}}\right)$
E	$1 \le f \le 250$	$-20\log\left(10^{\frac{67,8-20\log(f)}{-20}} + n \bullet 10^{\frac{83,1-20\log(f)}{-20}}\right)$
F	$1 \le f \le 600$	$-20\log\left(10^{\frac{94-20\log(f)}{-20}} + n \bullet 10^{\frac{90-15\log(f)}{-20}}\right)$, 65,0 max.
Where	n = 2 for Configurations A, B and D n = 3 for Configuration C	

A.2.2.5.2 Power sum ELFEXT (PSELFEXT)

The PSELFEXT for each pair of the link shall meet or exceed the limits computed, to one decimal place, using the formulae of Table A.6. The PSELFEXT shall be measured according to 5.4.6.2.

Table A.6 - Formulae for PSELFEXT limits for a link

Class	Frequency MHz	Minimum PSELFEXT dB
D	$1 \le f \le 100$	$-20\log\left(10^{\frac{60{,}8 - 20\log(f)}{-20}} + n \bullet 10^{\frac{72{,}1 - 20\log(f)}{-20}}\right)$
E	$1 \le f \le 250$	$-20\log\left(10^{\frac{64{,}8 - 20\log(f)}{-20}} + n \bullet 10^{\frac{80{,}1 - 20\log(f)}{-20}}\right)$
F	$1 \le f \le 600$	$-20\log\left(10^{\frac{91 - 20\log(f)}{-20}} + n \bullet 10^{\frac{87 - 15\log(f)}{-20}}\right)$, 62,0 max.
Where	n = 2 for Configurations A, B and D n = 3 for Configuration C	

A.2.2.6 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 5.4.7 for details of measurement.

Table A.7 – Direct current (d.c.) loop resistance limits for a link

Link Class	Maximum d.c. loop resistance Ω
A	530
B	140
C	34
D	$(L/100)\bullet 22 + n\bullet 0{,}4$
E	$(L/100)\bullet 22 + n\bullet 0{,}4$
F	$(L/100)\bullet 22 + n\bullet 0{,}4$
Where	$L = L_{FC} + L_{CP}\bullet Y$ L_{FC} length of fixed cable (m) L_{CP} length of CP cord (where present) (m) Y ratio of CP cable attenuation (dB/m) to fixed horizontal cable attenuation (dB/m) (see Clause 9) n = 2 for Configurations A, B and D n = 3 for Configuration C

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 16 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.2.2.2 (attenuation/insertion loss) and A.2.2.9 (delay skew) are also met.

A.2.2.7 Direct current (d.c.) resistance unbalance

The d.c. resistance unbalance of the conductors within a pair shall not exceed 3 %.

A.2.2.8 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.8. See 5.4.10 for details of measurement.

Table A.8 - Propagation delay formulae for a link

Link Class	**Frequency** MHz	**Maximum propagation delay** µs
A	$f = 0{,}1$	19,400
B	$f \leq 1$	4,400
C	$1 \leq f \leq 16$	$(L/100) \bullet \left(0{,}534 + 0{,}036/\sqrt{f}\right) + n \bullet 0{,}0025$
D	$1 \leq f \leq 100$	$(L/100) \bullet \left(0{,}534 + 0{,}036/\sqrt{f}\right) + n \bullet 0{,}0025$
E	$1 \leq f \leq 250$	$(L/100) \bullet \left(0{,}534 + 0{,}036/\sqrt{f}\right) + n \bullet 0{,}0025$
F	$1 \leq f \leq 600$	$(L/100) \bullet \left(0{,}534 + 0{,}036/\sqrt{f}\right) + n \bullet 0{,}0025$
Where	$L = L_{FC} + L_{CP} \bullet Y$ L_{FC} length of fixed cable (m) L_{CP} length of CP cord (where present) (m) Y ratio of CP cable attenuation (dB/m) to fixed horizontal cable attenuation (dB/m) (see Clause 9) n = 2 for Configurations A, B and D n = 3 for Configuration C	

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 17 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.2.2.2 (attenuation/insertion loss) and A.2.2.9 (delay skew) are also met.

A.2.2.9 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.9. See 5.4.11 for details of measurement.

Table A.9 - Delay skew formulae for a link

Link Class	Frequency MHz	Maximum delay skew µs
C	$1 \le f \le 16$	$(L/100) \bullet 0{,}045 + n \bullet 0{,}001\ 25$
D	$1 \le f \le 100$	$(L/100) \bullet 0{,}045 + n \bullet 0{,}001\ 25$
E	$1 \le f \le 250$	$(L/100) \bullet 0{,}045 + n \bullet 0{,}001\ 25$
F	$1 \le f \le 600$	$(L/100) \bullet 0{,}045 + n \bullet 0{,}001\ 25$
Where	$L = L_{FC} + L_{CP}$ L_{FC} length of fixed cable (m) L_{CP} length of CP cord (where present) (m) n = 2 for Configurations A, B and D n = 3 for Configuration C	

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 19 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.3 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

a) Annex A.3.2 (Method 1) of EN 50346:2002 for multimode optical fibre,

b) method 1.A of EN 61280-4-2:1999 for singlemode optical fibre.

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.

Annex B

(informative)

Permanent link performance limits for maximum implementation

B.1 General

The values shown in Tables B.1 to B.12 are derived from the formulae in Annex A at key frequencies.

Where relevant, the values of L, Y and n are: L = 90, Y = 1 and n = 3.

B.2 Performance limits

B.2.1 Return loss

Table B.1 - Return loss limits for a permanent link at key frequencies

Frequency MHz	**Minimum return loss** dB			
	Class C	**Class D**	**Class E**	**Class F**
1,0	15,0	19,0	21,0	21,0
16,0	15,0	19,0	20,0	20,0
100,0	N/A	12,0	14,0	14,0
250,0	N/A	N/A	10,0	10,0
600,0	N/A	N/A	N/A	10,0

B.2.2 Attenuation / insertion loss

Table B.2 - Attenuation limits for a permanent link at key frequencies

Frequency MHz	**Maximum attenuation** dB					
	Class A	**Class B**	**Class C**	**Class D**	**Class E**	**Class F**
0,1	16,0	5,5	N/A	N/A	N/A	N/A
1,0	N/A	5,8	4,0	4,0	4,0	4,0
16,0	N/A	N/A	12,2	7,7	7,1	6,9
100,0	N/A	N/A	N/A	20,4	18,5	17,7
250,0	N/A	N/A	N/A	N/A	30,7	28,8
600,0	N/A	N/A	N/A	N/A	N/A	46,6

B.2.3 Near end crosstalk loss

Table B.3 - NEXT limits for a permanent link at key frequencies

Frequency MHz	Minimum NEXT dB					
	Class A	Class B	Class C	Class D	Class E	Class F
0,1	27,0	40,0	N/A	N/A	N/A	N/A
1,0	N/A	25,0	40,1	60,0	65,0	65,0
16,0	N/A	N/A	21,1	45,2	54,6	65,0
100,0	N/A	N/A	N/A	32,3	41,8	65,0
250,0	N/A	N/A	N/A	N/A	35,3	60,4
600,0	N/A	N/A	N/A	N/A	N/A	54,7

B.2.4 Power sum NEXT

Table B.4 - PSNEXT limits for a permanent link at key frequencies

Frequency MHz	Minimum PSNEXT dB		
	Class D	Class E	Class F
1,0	57,0	62,0	62,0
16,0	42,2	52,2	62,0
100,0	29,3	39,3	62,0
250,0	N/A	32,7	57,4
600,0	N/A	N/A	51,7

B.2.5 Attenuation to crosstalk ratio

Table B.5 - ACR limits for a permanent link at key frequencies

Frequency MHz	Minimum ACR dB		
	Class D	Class E	Class F
1,0	56,0	61,0	61,0
16,0	37,5	47,5	58,1
100,0	11,9	23,3	47,3
250,0	N/A	4,7	31,6
600,0	N/A	N/A	8,1

B.2.6 Power sum ACR

Table B.6 - PSACR limits for a permanent link at key frequencies

Frequency MHz	**Minimum PSACR** dB		
	Class D	**Class E**	**Class F**
1,0	53,0	58,0	58,0
16,0	34,5	45,1	55,1
100,0	8,9	20,8	44,3
250,0	N/A	2,0	28,6
600,0	N/A	N/A	5,1

B.2.7 ELFEXT

Table B.7 - ELFEXT limits for a permanent link at key frequencies

Frequency MHz	**Minimum ELFEXT** dB		
	Class D	**Class E**	**Class F**
1,0	58,6	64,2	65,0
16,0	34,5	40,1	59,3
100,0	18,6	24,2	46,0
250,0	N/A	16,2	39,2
600,0	N/A	N/A	32,6

B.2.8 Power sum ELFEXT

Table B.8 - PSELFEXT limits for a permanent link at key frequencies

Frequency MHz	**Minimum PSELFEXT** dB		
	Class D	**Class E**	**Class F**
1,0	55,6	61,2	62,0
16,0	31,5	37,1	56,3
100,0	15,6	21,2	43,0
250,0	N/A	13,2	36,2
600,0	N/A	N/A	29,6

B.2.9 Direct current (d.c.) loop resistance

Table B.9 – Direct current (d.c.) loop resistance limits for a permanent link at key frequencies

Maximum d.c. loop resistance Ω					
Link Class A	**Link Class B**	**Link Class C**	**Link Class D**	**Link Class E**	**Link Class F**
530	140	34	21	21	21

B.2.10 Direct current (d.c.) resistance unbalance

The d.c. resistance unbalance of the conductors within a pair shall not exceed 3 %.

B.2.11 Propagation delay

Table B.10 - Propagation delay limits for a permanent link at key frequencies

Frequency MHz	**Maximum propagation delay** µs					
	Class A	**Class B**	**Class C**	**Class D**	**Class E**	**Class F**
0,1	19,400	4,400	N/A	N/A	N/A	N/A
1,0	N/A	4,400	0,521	0,521	0,521	0,521
16,0	N/A	N/A	0,496	0,496	0,496	0,496
100,0	N/A	N/A	N/A	0,491	0,491	0,491
250,0	N/A	N/A	N/A	N/A	0,490	0,490
600,0	N/A	N/A	N/A	N/A	N/A	0,489

B.2.12 Delay skew

Table B.11 - Delay skew limits for a permanent link at key frequencies

Link Class	**Frequency** MHz	**Maximum delay skew** µs
C	$1 \leq f \leq 16$	0,044
D	$1 \leq f \leq 100$	0,044
E	$1 \leq f \leq 250$	0,044
F	$1 \leq f \leq 600$	0,026

Annex C

(informative)

Class F channel and permanent link with two connections

Most class F channels and permanent links are implemented with two connections only.

The performance limits for balanced cabling channels given in this annex supplement Table 10 and Table 11 in 5.4.5; they are derived from the component performance limits of clause 7 and clause 8 assuming the channel is composed of 90 m of solid conductor cable, 10 m of cord(s) and two connections (see Figure C.1).

The performance limits for balanced cabling permanent links given in this annex supplement A.2.2.4; they are derived from the component performance limits of clause 7 and clause 8 assuming the permanent link is composed of 90 m of solid conductor cable and two connections (see Figure C.1).

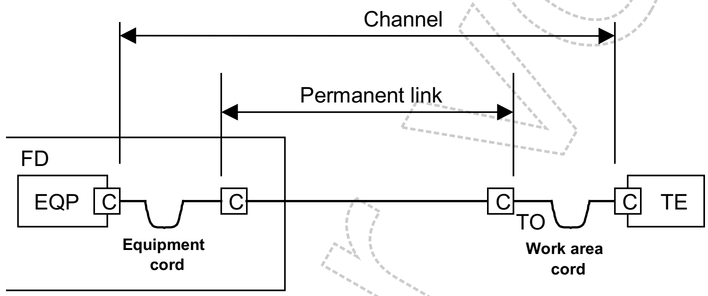


Figure C.1 – Two connection channel and permanent link

The ACR of each pair combination of a channel and of a permanent link are given in Table C.1.

The PSACR of each pair of a channel and of a permanent link are also given in Table C.1.

Table C.1 - ACR and PSACR values for 2 connection class F channels and permanent links at key frequencies

Frequency MHz	**Channel**		**Permanent link**	
	Minimum ACR dB	**Minimum PSACR** dB	**Minimum ACR** dB	**Minimum PSACR** dB
1,0	61,0	58,0	61,0	58,0
16,0	57,1	54,1	58,2	55,2
100,0	44,6	41,6	47,5	44,5
250,0	27,3	24,3	31,9	28,9
600,0	1,1	-1,9	8,6	5,6

Annex D

(normative)

Mechanical and environmental performance testing of balanced cabling connecting hardware of types other than those used at the TO

D.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 life 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 at any time during or after environmental conditioning.

To ensure that all connecting hardware for balanced cabling systems will perform reliably under field installation conditions, it shall be capable of maintaining reliable connections throughout the series of environmental conditioning and testing illustrated in Table D.2 to Table D.5. Products under test shall be mounted and connected in accordance with manufacturer's guidelines. Unless otherwise specified, tests should be carried out under standard atmospheric conditions in accordance with 5.3.1 of EN 60068-1.

NOTE This annex provides mechanical connection performance requirements for connections that are not covered by a specific IEC or CENELEC connector standard. It is intended to replace the specifications in this annex by reference to European standards, as they become available.

D.2 Test requirements

D.2.1 General

This test schedule shows all tests and the order in which they shall be carried out, as well as the requirements to be met.

Unless otherwise specified, connecting hardware shall be tested in the mated or terminated state. Care shall be taken to keep a particular combination of connecting hardware together during the complete test sequence. That is, when unmating is necessary for a certain test, the same connecting hardware shall be mated for the subsequent tests.

Hereinafter, mated/terminated connecting hardware is called the "specimen".

For each group, a minimum of 10 product samples shall be used to compile data for supporting a conclusion that pass criteria are satisfied.

D.2.2 Initial test measurements

All specimens shall be subjected to the measurements and sequence shown in Table D.1.

Table D.1 - Test group P

Test phase	Test			Measurement to be performed		
	Title	EN 60512 Test No.	Severity or condition of test	Title	EN 60512 Test No.	Requirements
P 1	General examination	1		Visual examination	1a	There shall be no defects that would impair normal operation
				Examination of dimensions and mass	1b	The dimensions shall comply with those specified in the detail specification
P 2	Polarization (if applicable)					
P 3	Contact resistance		All signal contacts and screen / specimens (bulk resistance subtracted)	Millivolt level method	2a	Contact resistance ≤ 20 mΩ
P 4			Test voltage DC (100 V ± 15 V) Method A Mated or terminated connectors	Insulation resistance	3a	≥ 500 MΩ
P 5			Contact/contact Method A Mated or terminated connectors	Voltage proof	4a	DC 1 000 V or AC 1 000 V (peak)
			All contacts to screen: Method A Mated or terminated connectors			DC 1 500 V or AC 1 500 V (peak)

D.2.3 Environmental and mechanical performance

The specimens shall be divided into four groups: group A, group B, group C and group D. Connecting hardware in each group shall undergo the tests specified in the relevant group.

Table D.2 - Test group AP

Test phase	Test: Title	Test: EN 60512 Test No.	Test: Severity or condition of test	Measurement to be performed: Title	Measurement to be performed: EN 60512 Test No.	Measurement to be performed: Requirements
AP 1	Insertion and withdrawal forces (two piece connectors)	13b	Connector locking device depressed (if applicable)			As per manufacturer's specifications
AP 2	Effectiveness of connector coupling device (if applicable)	15f	Rate of load application ≤ 44,5 N/s			As per manufacturer's specifications
AP 3	Rapid change of temperature	EN 60068 -2-14	-40°C to 70°C Mated or terminated connectors 25 cycles, t = 30 min Recovery time 2 h			
AP 4			Test voltage DC (100 V ± 15 V), Method A Mated or terminated connectors	Insulation resistance	3a	≥ 500 MΩ
AP 5			All signal contacts and screen / specimens (bulk resistance subtracted)	Contact resistance	2a	≤ 20 mΩ change from initial
AP 6			Contact/contact: Method A Mated or terminated connectors	Voltage proof	4a	DC 1 000 V or AC 1 000 V (peak)
			All contacts to screen: Method A: Mated or terminated connectors			DC 1 500 V or AC 1 000 V (peak)
AP 7			Unmated or unterminated connectors	Visual examination	1a	There shall be no defects that would impair normal operation
AP 8	Cyclic damp heat	EN 60068 -2-38	21 cycles low temperature 25 °C, high temperature 65 °C cold subcycle –10 °C, humidity 93 % Half of the samples in mated or terminated state Half of the samples in unmated or unterminated state			
AP 9			All signal contacts and screen / specimens (bulk resistance subtracted)	Contact resistance	2a	≤ 20 mΩ change from initial
AP 10	Insertion and withdrawal forces (two piece connectors)	13b	Connector locking device depressed (if applicable)			As per manufacturer's specification
AP 11	Effectiveness of connector coupling device (if applicable)	15f	Rate of load application ≤ 44,5 N/s			As per manufacturer's specification
AP 12			Unmated or unterminated connectors	Visual examination	1a	There shall be no defects that would impair normal operation

Table D.3 - Test group BP

Test phase	Test			Measurement to be performed		
	Title	EN 60512 Test No.	Severity or condition of test	Title	EN 60512 Test No.	Requirements
BP 1	Locking device mechanical operations (if applicable)		Mechanical operations			As per manufacturer's specification, but equivalent to N = 200 insertions and withdrawals
BP 2	Mechanical operations	9a	N/2 operations Speed 10 mm/s Rest 5 s (two piece connectors). Locking device inoperative			N = 200
BP 3	Flowing mixed gas corrosion	11-7	4 days Half of the samples in mated or terminated state Half of the samples in unmated or unterminated state			Mixture of gases: SO_2 = (0,5 ± 0,1) 10^{-6} (V/V) H_2S = (0,1 ± 0,02) 10^{-6} (V/V) Temperature: (25 ± 2) °C Relative humidity: (75 ± 3) %
BP 4			All signal contacts and screen / specimens (bulk resistance subtracted)	Contact resistance	2a	≤ 20 mΩ change from initial
BP 5	Mechanical operations	9a	N/2 operations Speed 10 mm/s. Rest 5 s (two piece connectors). Locking device inoperative			
BP 6			All signal contacts and screen / specimens	Contact resistance	2a	≤ 20 mΩ change from initial
BP 7			DC (100 V ± 15 V) Method A Mated or terminated connectors	Insulation resistance	3a	≥ 500 MΩ
BP 8			Contact/contact: Method A, Mated or terminated connectors	Voltage proof	4a	DC 1 000 V or AC 1 000 V (peak)
			All contacts to screen: Method A, Mated or terminated connectors			DC 1 500 V or AC 1 000 V (peak)
BP 9				Visual examination	1a	There shall be no defects that would impair normal operation

Table D.4 - Test group CP

Test phase	Test			Measurement to be performed		
	Title	EN 60512 Test No.	Severity or condition of test	Title	EN 60512 Test No.	Requirements
CP 1	Vibration	11c	Measurement points as per manufacturer's specification	Contact disturbance	2e	≤ 10 µs
CP 2			Test voltage DC 100 V Method A Mated or terminated connectors	Insulation resistance	3a	≥ 500 MΩ
CP 3			All signal contacts and screen / specimens (bulk resistance subtracted)	Contact resistance	2a	≤ 20 mΩ change from initial
CP 4			Unmated or unterminated connectors	Visual examination	1a	There shall be no defects that would impair normal operation

Table D.5 - Test group DP

Test phase	Test			Measurement to be performed		
	Title	EN 60512 Test No.	Severity or condition of test	Title	EN 60512 Test No.	Requirements
DP 1	Electrical load and temperature	9b	5 connectors 500 h 70°C Recovery period 2 h			0,5 A, 5 connectors No current, 5 connectors
DP 2			Test voltage DC 100 V Method A Mated or terminated connectors	Insulation resistance	3a	≥ 500 MΩ
DP 3			Contact/contact: Method A Mated or terminated connectors	Voltage proof	4a	DC 1 000 V or AC 1 000 V (peak)
			All contacts to screen: Method A Mated or terminated connectors			DC 1 500 V or AC 1 500 V (peak)
DP 4			Unmated or unterminated connectors	Visual examination	1a	There shall be no defects that would impair normal operation
DP 5			All signal contacts and screen / specimens (bulk resistance subtracted)	Contact resistance	1a	≤ 20 mΩ change from initial

Annex E

(informative)

Supported Applications

E.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 be supported too.

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. Applications using unbalanced transmission are outside the scope of this standard.

Table E.1 contains established and emerging applications defined by international specifications (e.g. ISO/IEC standards, ITU Recommendations, IEEE 802 standards and ATM Forum specifications).

Applications supported by generic balanced cabling listed in Table E.1 use the pin assignment recorded in Table E.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.

E.2 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 E.3 contains established and emerging applications defined by international specifications (e.g. ISO/IEC standards, ITU Recommendations, IEEE 802 standards and ATM Forum specifications).

Details of application support are provided for each optical fibre category included in Clause 7. For multimode optical fibre, the optical fibre Classes specified for each application are based upon the greatest channel length specified in the relevant application standard independent of optical fibre design (i.e. 50/125µm or 62,5/125µm). Table E.4 and Table E.5 contain additional information concerning maximum channel lengths for 50 µm and 62,5 µm multimode optical fibres and singlemode optical fibres.

Table E.1 - Supported applications using balanced cabling

Application	Specification Reference	Date	Additional Name
Class A (defined up to 100 kHz)			
PBX	National Requirements		
X.21	ITU-T Rec. X.21	1994	
V.11	ITU-T Rec. X.21	1994	
Class B (defined up to 1 MHz)			
S_0-Bus (extended)	ITU-T Rec. I.430	1993	ISDN Basic Access (Physical Layer)
S_0 Point-to-Point	ITU-T Rec. I.430	1993	ISDN Basic Access (Physical Layer)
S_1/S_2	ITU-T Rec. I.431	1993	ISDN Primary Access (Physical Layer)
CSMA/CD 1BASE5	ISO/IEC 8802-3	1996	Star LAN
Class C (defined up to 16 MHz)			
CSMA/CD 10Base-T	ISO/IEC 8802-3	1996	Ethernet
CSMA/CD 100BASE-T4	ISO/IEC 8802-3	1997	Fast Ethernet
CSMA/CD 100BASE-T2	ISO/IEC 8802-3	1997	Fast Ethernet
Token Ring 4 Mbit/s	ISO/IEC 8802-5	1998	
ISLAN	ISO/IEC 8802-9	1996	Integrated Services LAN
ISLAN16-T	ISO/IEC 8802-9 DAM 1	1997	Isochronous Ethernet
Demand Priority	ISO/IEC 8802-12	1998	VGAnyLAN ™
ATM LAN 25,60 Mbit/s	ATM Forum af-phy-0040.000	1995	ATM-25/Category 3
ATM LAN 51,84 Mbit/s	ATM Forum af-phy-0018.000	1994	ATM-52/Category 3
ATM LAN 155,52 Mbit/s	ATM Forum af-phy-0047.000	1995	ATM-155/Category 3
Class D (defined up to 100 MHz)			
CSMA/CD 100BASE-TX	ISO/IEC 8802-3	1997	Fast Ethernet
Token Ring 100 Mbit/s	ISO/IEC 8802-5t	1999	High Speed Token Ring
CSMA/CD 1000BASE-T	ISO/IEC 8802-3	1999	Gigabit Ethernet
Token Ring 16 Mbit/s	ISO/IEC 8802-5	1998	
TP-PMD	ISO/IEC FCD 9314-10	2000	Twisted-Pair Physical Medium Dependent
ATM LAN 155,52 Mbit/s	ATM Forum af-phy-0015.000	1994	ATM-155/Category 5
Class E (defined up to 250 MHz)			
ATM LAN 1,2 Gbit/s	ATM Forum af-phy-0162.000	2001	ATM-1200/Category 6
Class F (defined up to 600 MHz)			
FC-100-TP	ISO/IEC 14165-114		

Table E.2 - Modular connector pin assignment for 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]
CSMA/CD 1BASE5	Class B	Class B		
CSMA/CD 10BASE-T	Class C	Class C		
CSMA/CD 100BASE-T4	Class C	Class C	Class C	Class C
CSMA/CD 100BASE-T2	Class C	Class C		
Token Ring 4 Mbit/s		Class C	Class C	
ISLAN	Class C	Class C		[b]
Demand Priority	Class C	Class C	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	
TP-PMD	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
ATM-1200 Category 6	Class E	Class E	Class E	Class E
FC-100-TP	Class F			Class F

[a] Option dependent on supplier.

[b] Optional power sources.

[c] Option for continuity of cable screen.

Table E.3 - Supported applications using optical fibre cabling

Network Application	Maximum channel insertion loss dB			EN 50173 Channel supported on							
	Multimode [a]	Multimode [a]	Singlemode	OM1 optical fibre		OM2 optical fibre		OM3 optical fibre		OS1 optical fibre	
	850 nm	1300 nm	1310 nm	850 nm	1300 nm	850 nm	1300 nm	850 nm	1300 nm	1310 nm	1550 nm
ISO/IEC 8802-3: FOIRL	9,0 (3,3)	-	-	OF-500		OF-500		OF-500			
ISO/IEC 8802-3: 10BASE-FL, FP & FB	12,5 (6,8)	-	-	OF-2000		OF-2000		OF-2000			
ISO/IEC TR 11802-4: 4 & 16 Mbit/s Token Ring	13,0 (8,0)	-	-	OF-2000		OF-2000		OF-2000			
ISO/IEC 8802-12: Demand Priority	7,5 (2,8)	7,0 (2,3)	-	OF-500	OF-2000	OF-500	OF-2000	OF-500	OF-2000		
ATM at 52 Mbit/s [b]	NA	10,0 (5,3)	10,0		OF-2000		OF-2000		OF-2000	OF-2000	
ATM at 155 Mbit/s [b]	7,2	10,0 (5,3)	7,0	OF-500	OF-2000	OF-500	OF-2000	OF-500	OF-2000	OF-2000	
ATM at 622 Mbit/s [b, c]	4,0	6,0 (2,0)	7,0	OF-300	OF-500	OF-300	OF-500	OF-300	OF-500	OF-2000	
DIS 14165-111: Fibre Channel (FC-PH) at 133 Mbit/s	NA	6,0			OF-2000		OF-2000		OF-2000		
DIS 14165-111: Fibre Channel (FC-PH) at 266 Mbit/s [b]	12,0	6,0 (5,5)	6,0	OF-2000	OF-2000	OF-2000	OF-2000	OF-2000	OF-2000	OF-2000	
DIS 14165-111: Fibre Channel (FC-PH) at 531 Mbit/s [b]	8,0	-	14,0	OF-500		OF-500		OF-500		OF-2000	
DIS 14165-111: Fibre Channel (FC-PH) at 1062 Mbit/s [b, c]	4,0	-	6,0	OF-300		OF-500		OF-500		OF-2000	
ISO/IEC 8802-3: 1000BASE-SX [c]	2,6 (3,56)	-	-	[d]		OF-500		OF-500			
ISO/IEC 8802-3: 1000BASE-LX [b, c]	-	2,35	4,56		OF-500		OF-500		OF-500	OF-2000	
ISO/IEC 9314-9: FDDI LCF-PMD	-	7,0 (2,0)	-		OF-500		OF-500		OF-500		
ISO/IEC 9314-3: FDDI PMD	-	11,0 (6,0)	-		OF-2000		OF-2000		OF-2000		
ISO/IEC 9314-4: FDDI SMF-PMD [b]	-	-	10,0							OF-2000	
ISO/IEC 8802-3: 100BASE-FX		11,0 (6,0)	-		OF-2000		OF-2000		OF-2000		
IEEE 802.3: 10GBASE-LX4 [e]	2,0	2,0	6,2		OF-300		OF-300		OF-300	OF-2000	
IEEE 802.3: 10GBASE-ER/EW [b, e]			10,9								OF-2000
IEEE 802.3: 10GBASE-SR/SW [e]	1,60 (OM1, 62,5 µm) 1,80 (OM2, 50 µm) 2,60 (OM3)							OF-300			
IEEE 802.3: 10GBASE-LR/LW [b, e]	-		6,2							OF-2000	

[a] The values apply to both 50/125 µm and 62,5/125 µm fibres; where figures differ, the values in parenthesis apply to 50/125 µm fibre.
[b] The channel length on singlemode optical fibre may be longer but lies outside the scope of this standard. See the relevant application standard for details.
[c] A bandwidth-limited application at the channel lengths shown. The use of lower attenuation components to produce channels exceeding the values shown cannot be recommended.
[d] See Table E.4.
[e] Application under development

1971 **Table E.4 - Maximum channel lengths supported by optical fibre applications with multimode fibres**

Application	Nominal transmission wavelength	Maximum channel length m	
	nm	50 µm fibre [a]	62,5 µm fibre [b]
ISO/IEC 8802-3: FOIRL	850	514	1 000
ISO/IEC 8802-3: 10BASE-FL & FB	850	1 514	2 000
ISO/IEC TR 11802-4: 4 & 16 Mbit/s Token Ring	850	1 857	2 000
ISO/IEC 8802-12: Demand Priority	850	371	500
ATM at 155 Mbit/s [c]	850	1 000	1 000
ATM at 622 Mbit/s [c]	850	300	300
DIS 14165-111: Fibre Channel (FC-PH) at 266 Mbit/s	850	2 000	700
DIS 14165-111: Fibre Channel (FC-PH) at 531 Mbit/s	850	1 000	350
DIS 14165-111: Fibre Channel (FC-PH) at 1 062 Mbit/s [c]	850	500	300
ISO/IEC 8802-3: 1000BASE-SX [c]	850	550	275
ISO/IEC 9314-9: FDDI LCF-PMD	1 300	500	500
EN ISO/IEC 9314-3: FDDI PMD	1 300	2 000	2 000
ISO/IEC 8802-3: 100BASE-FX	1 300	2 000	2 000
IEEE 802.5t: 100 Mbit/s Token Ring	1 300	2 000	2 000
ISO/IEC 8802-12: Demand Priority	1 300	533	2 000
ATM at 52 Mbit/s	1 300	2 000	2 000
ATM at 155 Mbit/s	1 300	2 000	2 000
ATM at 622 Mbit/s	1 300	330	500
DIS 14165-111: Fibre Channel (FC-PH) at 133 Mbit/s	1 300	Not supported	1 500
DIS 14165-111: Fibre Channel (FC-PH) at 266 Mbit/s	1 300	2 000	1 500
ISO/IEC 8802-3: 1000BASE-LX [c]	1 300	550	550

[a] Maximum attenuation per km (850 nm / 1 300 nm): 3,5 dB / 1,5 dB;
minimum modal bandwidth (850 nm / 1 300 nm): 500 MHzkm / 500 MHzkm

b) Maximum attenuation per km (850 nm / 1 300 nm): 3,5 dB / 1,5 dB;
minimum modal bandwidth (850 nm / 1 300 nm): 200 MHzkm / 500 MHzkm

[c] These applications are bandwidth limited at the channel lengths shown. The use of lower attenuation components to produce channels exceeding the values shown cannot be recommended.

Table E.5 - Maximum channel lengths supported by optical fibre applications with singlemode fibres

Application	Nominal transmission wavelength nm	Maximum channel length [a)] m
ISO/IEC 9314-4: FDDI SMF-PMD	1 310	2 000
ATM at 52 Mbit/s	1 310	2 000
ATM at 155 Mbit/s	1 310	2 000
ATM at 622 Mbit/s	1 310	2 000
DIS 14165-111: Fibre Channel (FC-PH) at 266 Mbit/s	1 310	2 000
DIS 14165-111: Fibre Channel (FC-PH) at 531 Mbit/s	1 310	2 000
DIS 14165-111: Fibre Channel (FC-PH) at 1 062 Mbit/s	1 310	2 000
ISO/IEC 8802-3: 1000BASE-LX	1 310	2 000

[a] Maximum attenuation per km (1310 nm / 1 550 nm): 0,5 dB / 1,5 dB

Annex F

(informative)

Electromagnetic characteristics

Cabling consists of passive components and can therefore only be verified for conformance with 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 referenced in this standard, may be used for guidance, when application specific electronic equipment is constructed and tested for compliance with EN 55022 and EN 55024. The relationship between the requirements of the latter EMC standards and these characteristics is a subject for further study.

Annex G

(informative)

Changes from earlier editions of this European Standard

G.1 General

This European standard contains performance requirements for both components and installed cabling. These requirements differ from those of the earlier edition of this standard, EN 50173:1995, and those of the amendment to that edition, EN 50173:1995/A1:2000.

This informative annex contains a historical record of these changes and provides a reference to the requirements of the earlier editions and amendments of this standard.

The 1st edition of this standard, EN 50173:1995, contained requirements for:

– Classes A, B, C and D of installed balanced cabling links;

– 100 Ω (Category 3 and 5) cabling components;

– 120 Ω (Category 3 and 5) cabling components;

– 150 Ω cabling components.

The amendment, EN 50173:1995/A1:2000, contained revisions to the requirements for installed cabling links and specified the requirements for channels (see G.2) but did not include changes to the component requirements.

This European standard contains a revision of the requirements for cabling components. For balanced cabling, Category 3 (100 Ω and 120 Ω) and 150 Ω cabling components have been removed and Category 6 and 7 requirements have been included. For optical fibre cabling, Category OM1, OM2 OM3 and OS1 have been introduced.

This European standard also contains further modifications to the requirements for installed balanced cabling; these are described in G.2 and G.3.

References to this European standard should specifically differentiate the relevant requirements and classifications from those of EN 50173:1995 and EN 50173:1995/A1:2000 by explicitly referencing EN 50173-1:2002.

G.2 Cabling structure

This European standard limits the maximum combined channel (campus backbone, building backbone and horizontal) length to 2 000 m. This is consistent with:

a) the scope of the standard;

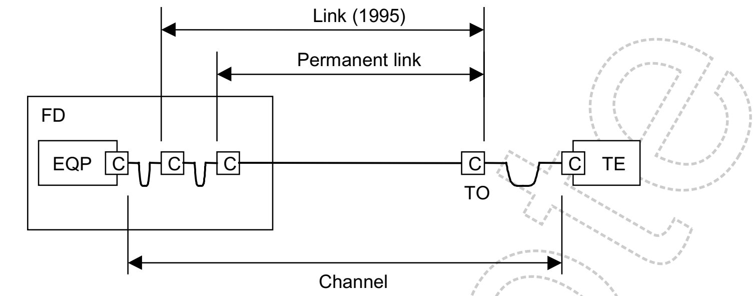
b) the intention of delivering optical fibre solution to the desk using OF-2000 channel (see Clause 6);

c) the maximum supported length of many optical fibre applications.

Figures G.1 and G.2 show the installed cabling performance reference points used in EN 50173:1995 and EN 50173:1995/A1:2000.

EN 50173:1995 specified limits for the link as defined in Figures G.1 and G.2. The link, shown in the figures as “Link (1995)” was defined as the channel excluding the cable within the equipment cords.

EN 50173:1995/A1:2000 re-defined the reference points as “permanent link” and “channel”. The permanent link was defined as the fixed installation including the connecting hardware at each end.



NOTE EN 50173:1995 and EN 50173:1995/A1:2000 did not support the concept of the consolidation point

Figure G.1 - Horizontal cabling model

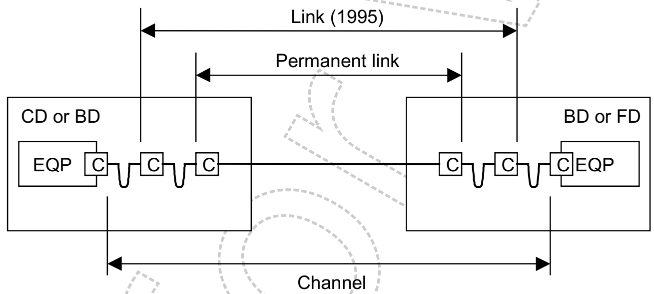


Figure G.2 - Backbone cabling model

In all Tables in this annex the abbreviations L, PL and C refer to the performance limits for the Classes of “links”, “permanent links” and “channels” respectively.

G.3 Installed balanced cabling requirements

Tables G.1 to G.7 show the requirements for parameters included in both EN 50173:1995 and EN 50173:1995/A1:2000. Component performance requirements for these parameters, included in EN 50173:1995, were not changed in EN 50173:1995/A1:2000.

Tables G.8 and G.9 show the requirements for parameters included only in EN 50173:1995/A1:2000. The component performance requirements for these parameters were not specified in EN 50173:1995/A1:2000.

The use of components of EN 50173:1995 does not imply conformance with the requirements of Tables G.8 and G.9.

Table G.1 - Maximum attenuation

Frequency MHz	**Maximum attenuation** dB											
	Class A			Class B			Class C			Class D		
	L	PL	C	L	PL	C	L	PL	C	L	PL	C
0,1	16,0	16,0	16,0	5,5	5,5	5,5	N/A	N/A	N/A	N/A	N/A	N/A
1,0	N/A	N/A	N/A	5,8	5,8	5,8	3,7	3,1	4,2	2,5	2,1	2,5
4,0	N/A	N/A	N/A	N/A	N/A	N/A	6,6	5,8	7,3	4,8	4,1	4,5
10,0	N/A	N/A	N/A	N/A	N/A	N/A	10,7	9,6	11,5	7,5	6,1	7,0
16,0	N/A	N/A	N/A	N/A	N/A	N/A	14	12,6	14,9	9,4	7,8	9,2
20,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10,5	8,7	10,3
31,25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13,1	11,0	12,8
62,5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18,4	16,0	18,5
100,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23,2	20,6	24,0

NOTE The maximum attenuation for Class D specified in EN 50173:1995 could only be exploited within the limits given by the minima specified for NEXT and ACR.

Table G.2 - Minimum NEXT

Frequency MHz	**Minimum NEXT** dB											
	Class A			Class B			Class C			Class D		
	L	PL	C	L	PL	C	L	PL	C	L	PL	C
0,1	27,0	27,0	27,0	40,0	40,0	40,0	N/A	N/A	N/A	N/A	N/A	N/A
1,0	N/A	N/A	N/A	25,0	25,0	25,0	39,0	40,1	39,1	54,0	61,2	60,3
4,0	N/A	N/A	N/A	N/A	N/A	N/A	29,0	30,7	29,3	45,0	51,8	50,6
10,0	N/A	N/A	N/A	N/A	N/A	N/A	23,0	24,3	22,7	39,0	45,5	44,0
16,0	N/A	N/A	N/A	N/A	N/A	N/A	19,0	21,0	19,3	36,0	42.3	40,6
20,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35,0	40,7	39,0
31,25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32,0	37,6	35,7
62,5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27,0	32,7	30,6
100,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24,0	29,3	27,1

NOTE The minimum NEXT for Class D specified in EN 50173:1995 could only be exploited within the limits given by the maxima specified for attenuation and ACR.

Table G.3 - Minimum ACR

Frequency MHz	Minimum ACR dB											
	Class A			Class B			Class C			Class D		
	L	PL	C	L	PL	C	L	PL	C	L	PL	C
0,1	11,0	11,0	11,0	34,5	34,5	34,5	-	-	-	-	-	-
1,0	N/A	N/A	N/A	19,2	19,2	19,2	35,3	37,0	34,9	-	59,1	57,8
4,0	N/A	N/A	N/A	N/A	N/A	N/A	22,4	24,9	22,0	40,0	47,7	46,1
10,0	N/A	N/A	N/A	N/A	N/A	N/A	12,3	14,7	11,2	35,0	39,4	37,0
16,0	N/A	N/A	N/A	N/A	N/A	N/A	5,0	8,4	4,4	30,0	34,5	31,4
20,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28,0	32,0	28,7
31,25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23,0	26,6	22,9
62,5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13,0	16,7	12,1
100,0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,0	8,7	3,1

NOTE The ACR for Class D specified in EN 50173:1995 provided some head room for trade-off between NEXT and attenuation.

Table G.4 - Minimum Return loss

Frequency MHz	Minimum Return loss dB					
	Class C			Class D		
	L	PL	C	L	PL	C
$1 \leq f < 10$	18,0 (ffs)	15,0	15,0	18,0 (ffs)	17,0	17,0
$10 \leq f \leq 16$	15,0 (ffs)	15,0	15,0	15,0 (ffs)	17,0	17,0
$16 \leq f < 20$	N/A	N/A	N/A	15,0 (ffs)	17,0	17,0
$20 \leq f \leq 100$	N/A	N/A	N/A	10,0 (ffs)	17-7log(f/20)	17-10log(f/20)

NOTE The return loss requirements of EN 50173:1995 and EN 50173:1995/A1:2000 demand that the links, permanent links and channels under test be terminated with an impedance equal to that of the design impedance of the cabling (100 Ω, 120 Ω or 150 Ω as applicable). The test methods referred to in EN 50173-1 require that cabling be terminated with an impedance of 100 Ω only.

Table G.5 - Minimum LCL/LCTL

Frequency MHz	Minimum LCL/LCTL dB											
	Class A			Class B			Class C			Class D		
	L	PL	C	L	PL	C	L	PL	C	L	PL	C
0,1	30	-	30	45	-	45	35	-	45	40	-	45
1,0	N/A	-	N/A	20	-	20	30	-	30	40	-	40
4,0	N/A	-	N/A	N/A	-	N/A	ffs	-	ffs	ffs	-	ffs
10,0	N/A	-	N/A	N/A	-	N/A	25	-	25	30	-	30
16,0	N/A	-	N/A	N/A	-	N/A	ffs	-	ffs	ffs	-	ffs
20,0	N/A	-	N/A	N/A	-	N/A	ffs	-	ffs	ffs	-	ffs
100,0	N/A	-	N/A	N/A	-	N/A	N/A	-	N/A	ffs	-	ffs

Table G.6 - Maximum Delay

Frequency MHz	**Maximum Delay** µs											
	Class A			Class B			Class C			Class D		
	L	PL	C	L	PL	C	L	PL	C	L	PL	C
0,1	20,0 at 0,01 MHz	0,9	20*	5,0 at 1 MHz	-	-	1,0 at 10 MHz	-	-	1,0 at 30 MHz	-	-
1		N/A	N/A		0,9	5*		0,486+ 0,036/ $\sqrt{f}$	0,544 + 0,036 /$\sqrt{f}$		0,486+ 0,036/ $\sqrt{f}$	0,544+ 0,036/ $\sqrt{f}$
1 ≤ *f* ≤ 16		N/A	N/A		N/A	N/A						
1 ≤ *f* ≤ 100		N/A	N/A		N/A	N/A		NA	NA			

* the maximum delay within a horizontal channel = 1,0 µs

Table G.7 - Maximum d.c. loop resistance

Maximum d.c. loop resistance Ω											
Class A			Class B			Class C			Class D		
L	PL	C	L	PL	C	L	PL	C	L	PL	C
560	560	560	170	170	170	40	40	40	40	40	40

Table G.8 – Class D Power sum values

Frequency MHz	**PSNEXT** dB		**PSACR** dB		**ELFEXT** dB		**PSELFEXT** dB	
	PL	C	PL	C	PL	C	PL	C
1,0	58,2	57,3	56,1	54,8	59,6	57,0	57,0	54,4
4,0	48,8	47,6	44,7	43,1	47,6	45,0	45,0	42,6
10,0	42,5	41,0	36,4	34,0	39,6	37,0	37,0	34,4
16,0	39,3	37,6	31,5	28,4	35,5	32,9	32,9	30,3
20,0	37,7	36,0	29,0	25,7	33,6	31,0	31,0	28,4
31,25	34,6	32,7	23,6	19,9	29,7	27,0	27,1	24,5
62,5	29,7	27,6	13,7	9,1	23,7	21,1	21,1	18,5
100,0	26,3	24,1	5,7	0,1	19,6	17,0	17,0	14,4

Table G.9 - Delay skew

Frequency MHz	**Delay skew** µs							
	Class A		Class B		Class C		Class D	
	PL	C	PL	C	PL	C	PL	C
1 ≤ *f* ≤ 16	N/A	N/A	N/A	N/A	0,043	0,050	0,043	0,050
1 ≤ *f* ≤ 100	N/A	N/A	N/A	N/A	0,043	0,050	0,043	0,050
NOTE Limits for delay skew were not included in EN 50173:1995.								

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[6] In preparation by ISO/IEC JTC 1/SC 25.