INTERNATIONAL STANDARD

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Information technology – Generic cabling for customer premises

Technologies de l'information – Câblage générique des locaux d'utilisateurs

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialised system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75% of the national bodies casting a vote.

International Standard ISO/IEC 11801 was prepared by the Joint Technical Committee ISO/IEC JTC 1/SC 25, Interconnection of Information Technology Equipment.

This International Standard has taken into account requirements specified in application standards listed in annex G. It refers to International Standards for components and test methods whenever an appropriate International Standard was available.

Annexes A, B and C form an integral part of this International Standard.
Annexes D, E, F, G, H and J are for information only.

Introduction

Within customer premises, the importance of the 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. Appropriate use of this International Standard will enable a controlled migration to generic cabling. Certain circumstances may warrant the introduction of application specific cabling; these instances should be minimised.

This International 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; that is, in the initial planning either for construction or refurbishment;

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

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

a) International Standards for cabling components developed by committees of the IEC; for example, copper cables IEC/TC 46[1), copper connectors IEC/TC 48, optical fibre cables and connectors IEC/TC 86;

b) applications developed by the sub-committees of ISO/IEC JTC 1[2) and study groups of ITU-T[3): for example, LANs: ISO/IEC JTC 1/SC 6 and SC 25/WG 4[4); ISDN: ITU-T SG 13[5);

c) planning and installation guides for the implementation and use of generic cabling systems;

The applications listed in annex G 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 model described in 6.1.1, 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 International Standard is targeted at, but not limited to, the general office environment.

It is anticipated that the generic cabling system defined by this International Standard will have a life expectancy in excess of 10 years.

1) International Electrotechnical Commission - Technical Committee 46
2) International Organization for Standardization/International Electrotechnical Commission - Joint Technical Committee 1
3) International Telecommunication Union - Telecommunications
4) Subcommittee 25 - Working Group 4
5) Study Group 13

INTERNATIONAL STANDARD

Information technology –

Generic cabling for customer premises

1 Scope

International Standard ISO/IEC 11801 specifies generic cabling for use within commercial premises, which may comprise single or multiple buildings on a campus.

The International Standard is optimised for premises having a geographical span of up to 3 000 m, with up to 1 000 000 m^2 of office space, and a population between 50 and 50 000 persons. It is recommended that the principles of this International Standard be applied to installations that do not fall within this range.

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

This International Standard specifies:

a) the structure and minimum configuration for generic cabling[1],

b) implementation requirements,

c) performance requirements for individual cabling links and

d) conformance requirements and verification procedures.

Although safety (electrical, fire, etc.) and Electromagnetic Compatibility (EMC) requirements are outside the scope of this International Standard, and may be covered by other standards and regulations, information given in this International Standard may be of assistance in meeting these requirements.

1) Cables and cords used to connect application specific equipment to the generic cabling system are outside of the scope of this International Standard. Since they have significant effect on the transmission characteristics of the channel, assumptions and guidance are provided on their performance and length.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of ISO/IEC 11801. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 68-1:1988,	Basic environmental testing procedures – Environmental testing – Part 1: General and guidance
IEC 68-2-2:1974,	Basic environmental testing procedures – Part 2: Tests – Tests B: Dry heat
IEC 68-2-6:1982,	Basic environmental testing procedures – Part 2: Tests – Tests Fc and guidance: Vibration (sinusoidal)
IEC 68-2-14:1984,	Basic environmental testing procedures – Part 2: Tests – Test N: Change of temperature
IEC 68-2-38:1974,	Basic environmental testing procedures – Part 2: Tests – Test Z/AD: Composite temperature/humidity cyclic test
IEC 68-2-60 TTD:1990,	Basic environmental testing procedures – Part 2: Tests – Test Ke: Corrosion tests in artificial atmosphere at very low concentration of polluting gas(es) [Technical Trend Document]
IEC 96-1:1986,	Radio-frequency cables – Part 1: General requirements and measuring methods
IEC 189-1:1986,	Low-frequency cables and wires with p.v.c. insulation and p.v.c. sheath – Part 1: General test and measuring methods
IEC 227-2:1979,	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods
IEC 512-1:1994,	Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 1: General
IEC 512-2:1985,	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 Amendment 1 (1988)
IEC 603-7:1990,	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 708-1:1981,	Low-frequency cables with polyolefin insulation and moisture barrier polyolefin sheath – Part 1: General design details and requirements
IEC 793-1:1992,	Optical fibres – Part 1: Generic specification
IEC 793-2:1992,	Optical fibres – Part 2: Product specifications

IEC 794-1:1993,	Optical fibre cables – Part 1: Generic specification
IEC 794-2:1989,	Optical fibre cables – Part 2: Product specifications
IEC 807-8:1992,	Rectangular connectors for frequencies below 3 MHz – Part 8: Detailed specification for connectors, four signal contacts and earthing contacts for cable screen
IEC 811-1-1:1993,	Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties
IEC 874-1:1993,	Connectors for optical fibres and cables – Part 1: Generic specification
IEC 874-10:1992,	Connectors for optical fibres and cables – Part 10: Sectional specification for fibre optic connector – Type BFOC/2,5
IEC 874-14:1993,	Connectors for optical fibres and cables – Part 14: Sectional specification for fibre optic connector – Type SC
IEC 1073-1:1994,	Splices for optical fibres and cables – Part 1: Generic specification – Hardware and accessories
IEC 1156-1:1994,	Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification
ISO/IEC 8802-5:1992,	Information technology – Local and metropolitan area networks – Part 5: Token ring access method and physical layer specifications
CISPR 22:1993,	Limits and methods of measurement of radio disturbance characteristics of information technology equipment.
ITU-T Rec. G.117:1988,	Transmission aspects of unbalance about earth (definitions and methods)
ITU-T Rec. G.650:1993,	Transmission media characteristics. Definition and test methods for the relevant parameters of single-mode fibres
ITU-T Rec. G.651:1993,	Characteristics of a 50/125 µm multimode graded index optical fibre cable
ITU-T Rec. G.652:1993,	Characteristics of a single-mode optical fibre cable
ITU-T Rec. O.9:1988,	Measuring arrangements to assess the degree of unbalance about earth

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this International Standard, the following definitions are applicable.

3.1.1 **application:** A system, with its associated transmission method which is supported by telecommunications cabling.

3.1.2 **balanced cable:** A cable consisting of one or more metallic symmetrical cable elements (twisted pairs or quads).

3.1.3 **building backbone cable:** A cable that connects the building distributor to a floor distributor. Building backbone cables may also connect floor distributors in the same building.

3.1.4 **building distributor:** A distributor in which the building backbone cable(s) terminate(s) and at which connections to the campus backbone cable(s) may be made.

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

3.1.6 **cable:** An assembly of one or more cable units of the same type and category in an overall sheath. It may include an overall shield.

3.1.7 **cable element:** The smallest construction unit (for example pair, quad, or single fibre) in a cable. A cable element may have a shield.

3.1.8 **cable unit:** A single assembly of one or more cable elements of the same type or category. The cable unit may have a shield.

NOTE - A binder group is an example of a cable unit.

3.1.9 **cabling:** A system of telecommunications cables, cords, and connecting hardware that can support the connection of information technology equipment.

3.1.10 **campus:** A premises containing one or more buildings.

3.1.11 **campus backbone cable:** A cable that connects the campus distributor to the building distributor(s). Campus backbone cables may also connect building distributors directly.

3.1.12 **campus distributor:** The distributor from which the campus backbone cabling emanates.

3.1.13 **channel:** The end-to-end transmission path connecting any two pieces of application specific equipment. Equipment and work area cables are included in the channel.

3.1.14 **cross-connect:** A facility enabling the termination of cable elements and their connection, primarily by means of patch cords or jumpers.

3.1.15 **distributor:** The term used for the functions of a collection of components (such as, patch panels, patch cords) used to connect cables.

3.1.16 **equipment cable:** A cable connecting equipment to a distributor.

3.1.17 **equipment room:** A room dedicated to housing distributors and application specific equipment.

3.1.18 **floor distributor:** The distributor used to connect between the horizontal cable and other cabling subsystems or equipment. (See telecommunications closet).

3.1.19 **generic cabling:** A structured telecommunications cabling system, capable of supporting a wide range of applications. Generic cabling can be installed without prior knowledge of the required applications. Application specific hardware is not a part of generic cabling.

3.1.20 **horizontal cable:** A cable connecting the floor distributor to the telecommunications outlet(s).

3.1.21 **hybrid cable:** An assembly of two or more different types of cable units, cables or categories covered by an overall sheath. It may be covered by an overall shield.

3.1.22 **individual work area:** The minimum building space which would be reserved for an occupant.

3.1.23 **interconnect:** A location at which equipment cables are terminated and connected to the cabling subsystems without using a patch cord or jumper.

3.1.24 **interface:** A point at which connections are made to the generic cabling.

3.1.25 **jumper:** A cable unit or cable element without connectors, used to make a connection on a cross-connect.

3.1.26 **keying:** A mechanical feature of a connector system, which 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.

3.1.27 **link:** The transmission path between any two interfaces of generic cabling. It excludes equipment and work area cables.

3.1.28 **optical fibre cable (or optical cable):** A cable comprising one or more optical fibre cable elements.

3.1.29 **optical fibre duplex adapter:** A mechanical device designed to align and join two duplex connectors.

3.1.30 **optical fibre duplex connector:** A mechanical termination device designed to transfer optical power between two pairs of optical fibres.

3.1.31 **pair:** A twisted pair or one side circuit (two diametrically facing conductors) in a star quad.

3.1.32 **patch cord:** Flexible cable unit or element with connector(s), used to establish connections on a patch panel.

3.1.33 **patch panel:** A cross-connect designed to accommodate the use of patch cords. It facilitates administration for moves and changes.

3.1.34 **public network interface:** A point of demarcation between public and private network. In many cases the public network interface is the point of connection between the network provider's facilities and the customer premises cabling.

3.1.35 **quad:** See star quad.

3.1.36 **side circuit:** See pair.

3.1.37 **shielded cables:** An assembly of two or more balanced twisted pair cable elements, or one or more quad cable elements, wrapped by an overall screen or shield contained within a common sheath or tube.

3.1.38 **shielded twisted pair cables:** An electrically conducting cable comprising one or more elements, each of which is individually shielded. There may be an overall shield, in which case the cable is referred to as a shielded twisted pair cable with an overall shield.

3.1.39 **splice:** A joining of conductors and fibres, generally from separate sheaths.

3.1.40 **star quad:** A cable element which comprises four insulated conductors twisted together. Two diametrically facing conductors form a transmission pair.

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

3.1.41 **telecommunications:** A 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. The term telecommunications has no legal meaning when used in this International Standard.

3.1.42 **telecommunications closet:** An enclosed space for housing telecommunications equipment, cable terminations, and cross-connect cabling. The telecommunications closet is a recognized cross-connect point between the backbone and horizontal cabling subsystems.

3.1.43 **telecommunications outlet:** A fixed connecting device where the horizontal cable terminates. The telecommunications outlet provides the interface to the work area cabling.

3.1.44 **transition point:** A location in the horizontal cabling where a change of cable form takes place; for example flat cable connects to round cable or cables with differing numbers of elements are joined.

3.1.45 **twisted pair:** A cable element which consists of two insulated conductors twisted together in a regular fashion to form a balanced transmission line.

3.1.46 **unshielded twisted pair cable:** An electrically conducting cable comprising one or more pairs none of which is shielded. There may be an overall shield, in which case the cable is referred to as unshielded twisted pair with an overall shield.

3.1.47 **work area:** A building space where the occupants interact with telecommunications terminal equipment.

3.1.48 **work area cable:** A cable connecting the telecommunications outlet to the terminal equipment.

3.2 Abbreviations

a.c.	alternating current
ACR	Attenuation to Crosstalk Ratio
BD	Building Distributor
BEF	Building Entrance Facilities
BFOC	Bayonet Fibre Optic Connector
B-ISDN	Broadband ISDN
BRI	Basic Rate ISDN
CD	Campus Distributor
c	speed of light
CISPR	International Special Committee on Radio Interference
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
d.c.	direct current
DCE	Data Circuit Terminating Equipment
DTE	Data Terminal Equipment
DUT	Device Under Test
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ER	Equipment Room
FD	Floor Distributor
FDDI	Fibre Distributed Data Interface
f.f.s.	for further study
FOIRL	Fibre Optic Inter-Repeater Link
FWHM	Full Width Half Maximum
IC	Integrated Circuit
IDC	Insulation Displacement Connection
IEC	International Electrotechnical Commission
ISDN	Integrated Services Digital Network
ISO	International Organisation for Standardization
ITU-T	International Telecommunication Union - Telecommunication Standardization Bureau (formerly CCITT)
JTC	Joint Technical Committee
LAN	Local Area Network
LCL	Longitudinal Conversion Loss
LCTL	Longitudinal Conversion Transfer Loss
N/A	Not Applicable
N-BNC	N type to BNC Convertor
NEXT	Near End Crosstalk
OTDR	Optical Time Domain Reflectometer
PBX	Private Branch Exchange
PDAM	Proposed Draft Amendment
PMD	Physical Layer Medium Dependent
PVC	Polyvinyl chloride
SC	Subscriber Connector (Optical fibre connector)
SC-D	Duplex SC connector
STI	Surface Transfer Impedance
TC	Telecommunications Closet
TDR	Time Domain Reflectometer
TO	Telecommunications Outlet
TP	Transition Point

4 Conformance

For a cabling installation to conform to this International Standard the following applies.

a) The configuration shall conform to the requirements outlined in clause 5.

b) The interfaces to the cabling shall conform to the requirements of clause 9.

c) The entire system shall be composed of links that meet the necessary level of performance specified in clause 7. This shall be achieved by installing components which meet the requirements of clauses 8 and 9, according to the design parameters of clause 6, or by a system design and implementation ensuring that the prescribed performance class of clause 7, and the reliability requirements of clause 9, are met.

d) System administration shall meet the requirements of clause 11.

e) Local regulations concerning safety and EMC shall be met.

The link performance specified in clause 7 is in accordance with clause 6. The link performance is met when components specified in clauses 8 and 9 are installed in a workmanlike manner and in accordance with supplier's and designer's instructions, over distances not exceeding those specified in clause 6. It is not required to test the transmission characteristics of the link in that case.

Conformance testing to the specifications of clause 7 should be used in the following cases:

a) the design of links with lengths exceeding those specified in clause 6;

b) the design of links using components different from those described in clauses 8 and 9;

c) the evaluation of installed cabling to determine its capacity to support a certain group of applications;

d) performance verification, as required, of an installed system designed in accordance with clauses 6, 8 and 9.

Specifications marked "f.f.s." (for further study) are preliminary specifications, and are not required for conformance to this International Standard.

5 Structure of the generic cabling system

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 interconnected by the generic cabling. General requirements for implementing generic cabling are also provided.

Applications are supported by connecting equipment to the telecommunications outlets and distributors. The components used to make this connection do not form part of generic cabling.

5.1 Structure

5.1.1 Functional elements

The functional elements of generic cabling are as follows:

Campus Distributor	[CD]
Campus Backbone Cable	
Building Distributor	[BD]
Building Backbone Cable	
Floor Distributor	[FD]
Horizontal Cable	
Transition Point (optional)	[TP]
Telecommunications Outlet	[TO]

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

5.1.2 Cabling subsystems

Generic cabling contains three cabling subsystems: campus backbone, building backbone and horizontal cabling. The composition of the subsystems are described in 5.1.3, 5.1.4 and 5.1.5. The cabling subsystems are connected together to create a generic cabling structure as shown in figure 1. The distributors provide the means to configure the cabling to support different topologies like bus, star and ring.

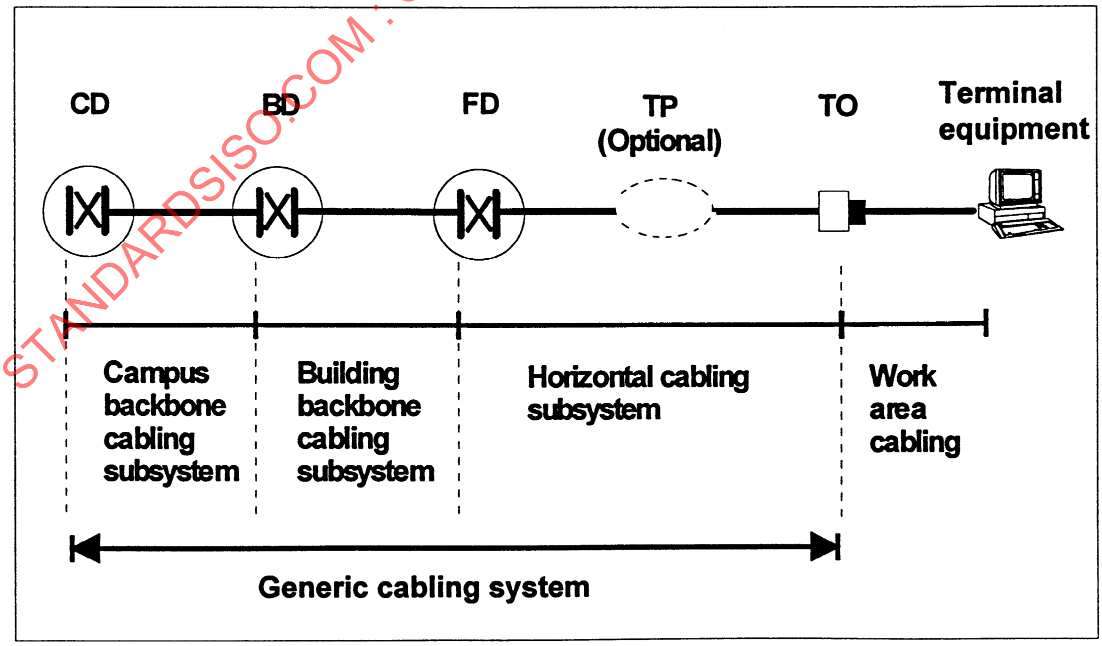


Figure 1 - Structure of generic cabling

5.1.3 Campus backbone cabling subsystem

The campus backbone cabling subsystem extends from the CD to the BD(s) usually located in separate buildings. When present, it includes the campus backbone cables, the mechanical termination of the campus backbone cables (at both the CD and BD(s)) and the cross-connections at the CD. The campus backbone cable may also interconnect BD(s).

5.1.4 Building backbone cabling subsystem

A building backbone cabling subsystem extends from BD(s) to the FD(s). The subsystem includes the building backbone cables, the mechanical termination of the building backbone cables (at both the BD(s) and FD(s)) and the cross-connects at the BD. The building backbone cables shall not contain TPs; copper backbone cables should not contain splices.

5.1.5 Horizontal cabling subsystem

The horizontal cabling subsystem extends from FD(s) to the TO(s). The subsystem includes the horizontal cables, the mechanical termination of the horizontal cables at the FD, the cross-connections at the FD and the TOs.

Horizontal cables should be continuous from the FD to the TOs. If necessary, one TP is permitted between an FD and any TO. The transmission characteristics of the horizontal cabling shall be maintained. The incoming and outgoing pairs and fibres at the TP shall be connected so that a 1:1 correspondence is maintained. All cable elements at the TP shall be mechanically terminated. The TP shall not be used as a point of administration (that is, not used as a cross-connect), and application specific equipment shall not be located there. The TP may only contain passive connecting hardware. Refer to 8.3 for restrictions on the use of multi-unit cables.

5.1.6 Work area cabling

The work area cabling connects the TO to the terminal equipment. It is non-permanent and application specific and therefore lies outside the scope of this International Standard. Assumptions have been made concerning the length and the transmission performance of the work area cable; these assumptions are identified when relevant.

5.2 Overall structure

The generic cabling is a hierarchical star structure which may take the form shown in figure 2. 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. For example, in a campus having only one building the primary distribution point is the BD, and there is no need for a campus backbone cabling subsystem. On the other hand, one large building may be treated as a campus, with a campus backbone subsystem and several BDs. Further information on the application of the cabling structure is given in D.3 of annex D.

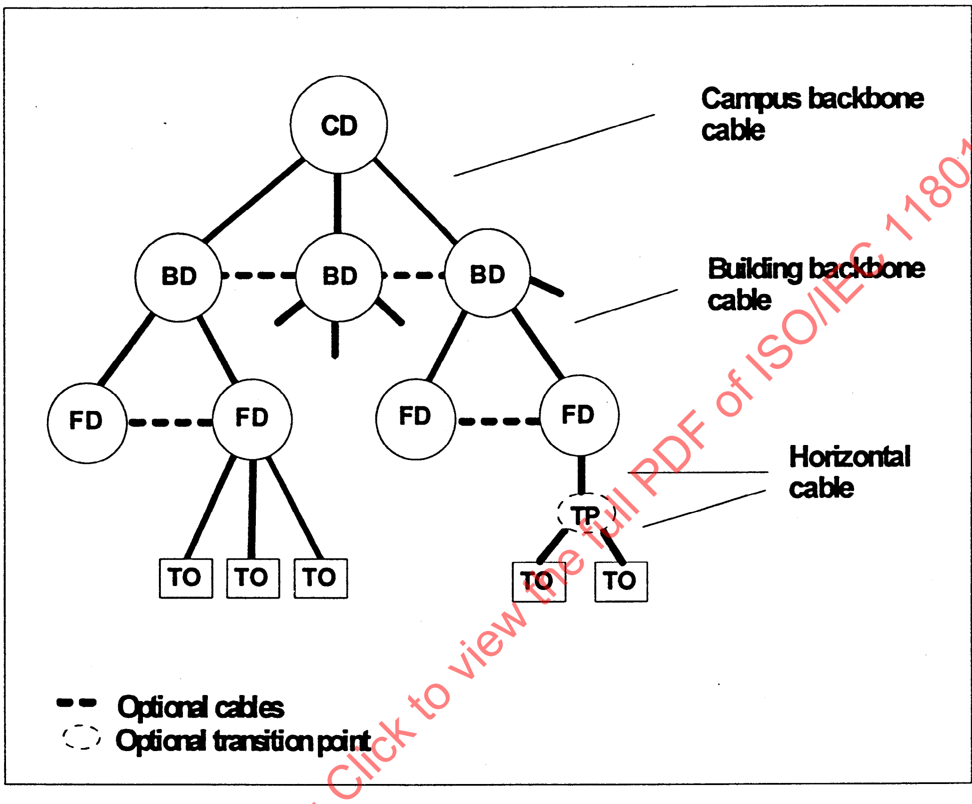


Figure 2 - Inter-relationship of functional elements

Cables shall be installed between adjacent levels in the structure. This forms a hierarchical star as shown in figure 2, and provides the high degree of flexibility needed to accommodate a variety of applications. Annex D details how to configure various networks within the boundaries of the hierarchical star topology. These topologies are established by the interconnection of the cable elements at cross-connects, and at the application specific equipment.

For some applications, additional direct connections between FDs or BDs are desirable and are permitted. The building backbone cable may also interconnect FDs. However, such connections shall be in addition to those required for the basic hierarchical star topology.

The functions of multiple distributors may be combined. Figure 3 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 the BD and FD have been combined into a single distributor.

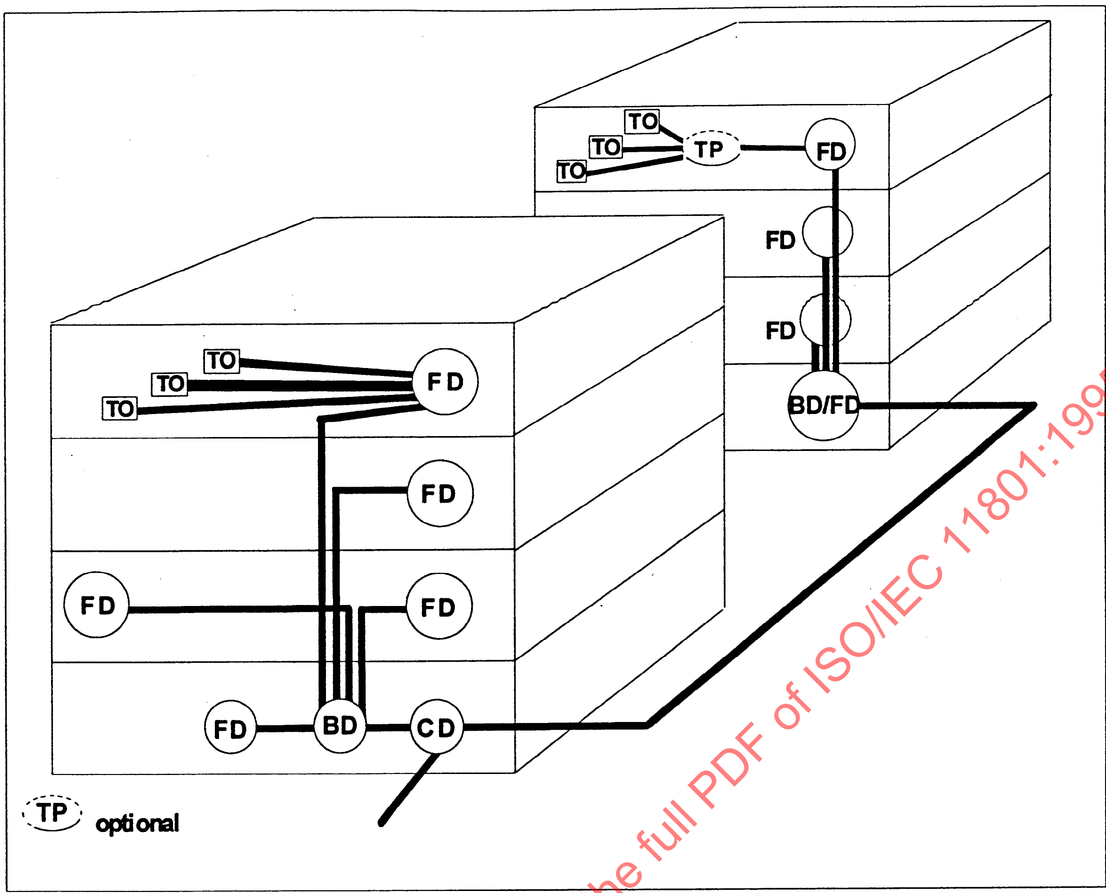


Figure 3 - Example of the generic cabling system

Information about additional cabling for fault tolerance can be found in annex D.

5.3 Location of distributors

Distributors are located in equipment rooms (ER) or telecommunications closets (TC). Figure 4 shows how the functional elements are typically accommodated in a building.

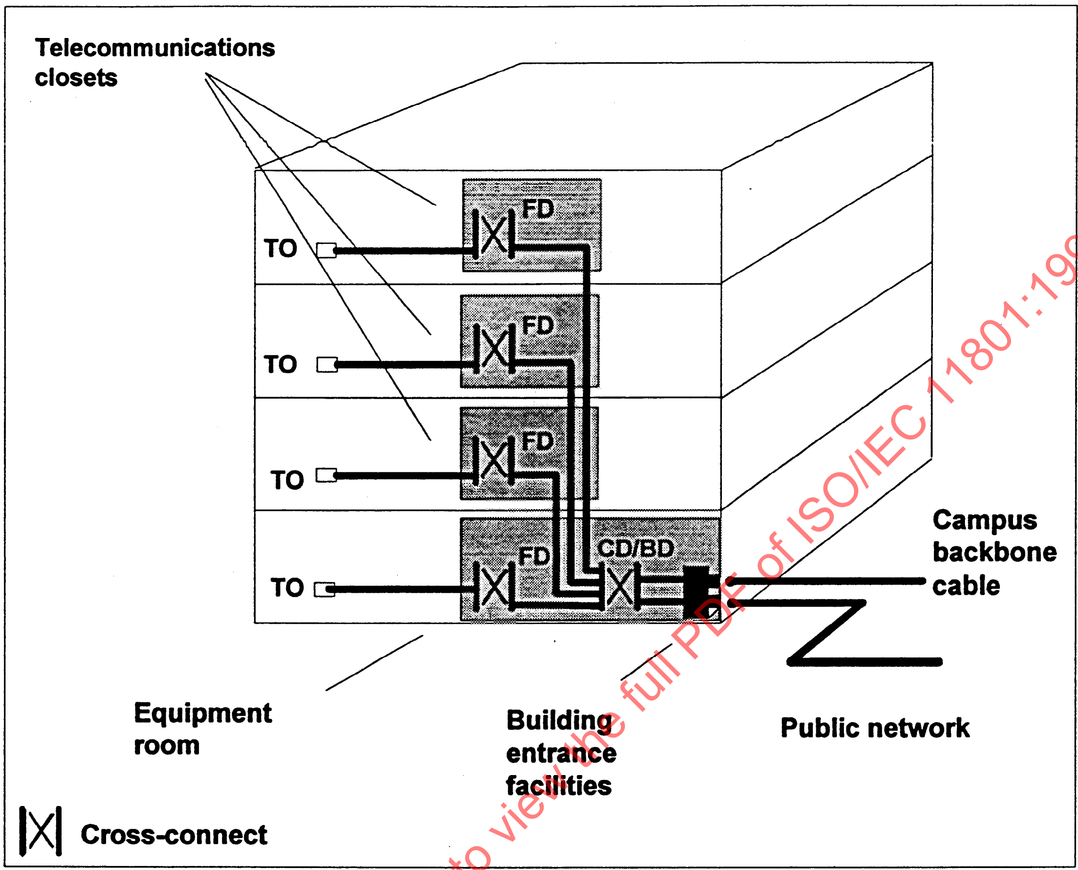


Figure 4 - Typical accommodation of functional elements

Cables are placed in appropriate pathways which may take a variety of forms including ducts, tunnels, cable trays, etc.

5.4 Interfaces to the generic cabling system

Interfaces to generic cabling are located at the ends of each subsystem. Application specific equipment can be connected at these points. Figure 5 shows potential interfaces at the distributors and TO. Any distributor may have an interface to an external services cable, and may use either interconnects or cross-connects.

The distance from external services to the CD can be significant. The performance of the cable between these points should be considered as part of the initial design and implementation of customer applications.

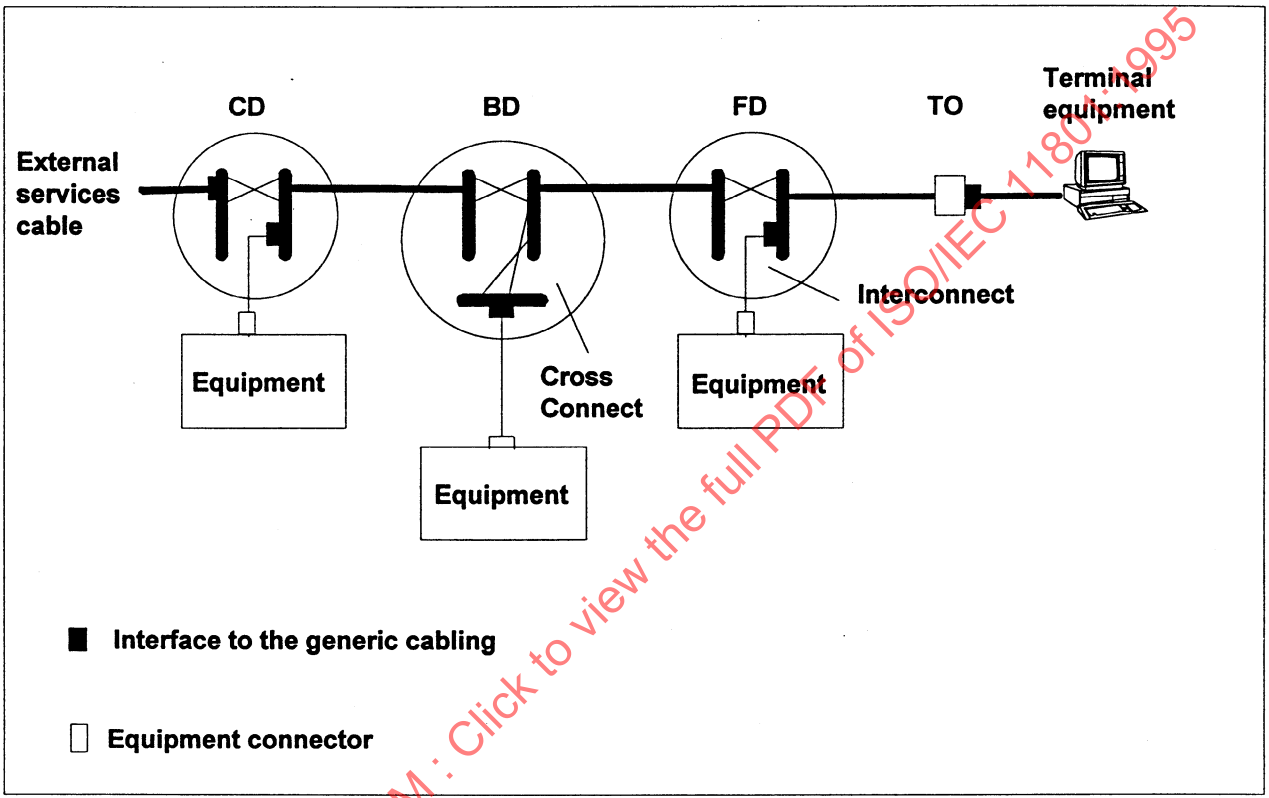


Figure 5 - Potential interfaces to generic cabling

5.4.1 Public network interface

Connections to the public network for the provision of public telecommunications services are made at the public network interface. The location of the public network interface, if present, and the facilities which must be provided may be regulated by national, regional, and local regulations. If the public network interface is not connected directly to a generic cabling interface the performance of the intermediate cabling should be taken into account. The type of cross-connect and the intermediate cable may be governed by national regulations. These regulations should be considered in planning the generic cabling.

5.5 Dimensioning and configuring

5.5.1 Floor distributor

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

5.5.2 Preferred cable types for pre-cabling and recommended use

Table 1 gives general guidelines regarding the use of different media in a particular subsystem for pre-cabling.

Table 1 - Recommended media for pre-cabling

Subsystem	Media Type	Recommended Use
Horizontal	Balanced cables	Voice and data (see tables G.4 and G.5) [1]
	Optical fibre	Data (see tables G.4 and G.5) [1]
Building backbone	Balanced cables	Voice and low to medium speed data
	Optical fibre	Medium to high speed data
Campus backbone	Optical fibre	For most applications - by using optical fibre - ground potential differences and other sources of interference may be overcome
	Balanced cables	As needed [2]

NOTES

1) Under certain conditions, (for example, environmental conditions, security concerns, etc.), installation of optical fibre in the horizontal cabling subsystem should be considered.

2) Balanced cables can be used in the campus backbone cabling subsystem in cases when the bandwidth of optical fibre is not required, for example PBX lines.

5.5.3 Telecommunications outlets

TOs are located on the wall, floor, or elsewhere in the work area, depending on the design of the building. The design of generic cabling should provide for TOs to be installed in readily accessible locations throughout the usable floor space. A high density of TOs will enhance the flexibility of the cabling to accommodate changes. In many countries two TOs are provided to serve a maximum of 10 m^2 of usable floor space.

TOs may be presented singly, or in groups, but each work area shall be served by a minimum of two.

A minimum of one TO served by 100 Ω or 120 Ω cable shall be provided at each work area[1] (100 Ω preferred). Other TOs shall be supported by either balanced cable or by fibre optical cable. When a TO is supported by balanced cable, 2 pairs[2] or 4 pairs shall be provided at each TO; all pairs shall be terminated. If less than four pairs are provided, the outlet shall be clearly marked[3]. Emerging balanced cable applications may be limited by differential delay of pairs that serve a single telecommunications outlet. See clause 9 for TO specifications that correspond to each of the cables listed above.

Outlets shall be marked with a permanent label that is visible to the user. Care should be taken that the initial pair assignment, and all subsequent changes, are recorded (see clause 10). Devices such as baluns and impedance matching adapters, if used, shall be external to the outlet. Pair reassignment by means of inserts is allowed.

1) When the greatest flexibility is desired, four pair or two quad cable should be used (see Annex G).
2) Installation of 2 pairs not capable of forming class D links may limit the applications supported.
3) See annex G for number and performance of pairs needed for different applications and their pin assignment.

5.5.4 Telecommunications closets and equipment rooms

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

An ER is an area within a building where telecommunications equipment is housed and may or may not contain distributors. ERs are treated differently from TCs 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 ER. If a telecommunications space houses more than one distributor it should be considered an ER.

5.5.5 Building entrance facilities

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

5.6 Electromagnetic compatibility

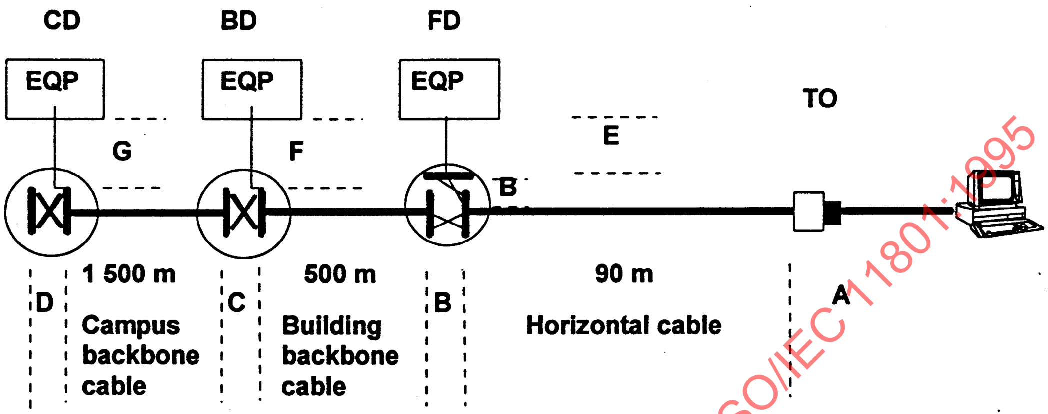
Where applicable, International Standards on electromagnetic emissions and immunity (such as CISPR 22), and local regulations shall be taken into account. Premises cabling is considered as a passive system and cannot be tested for EMC compliance individually. The active equipment which is designed for one specific medium is required to meet relevant EMC standards on this medium.

5.7 Earthing and bonding

Earthing shall meet the requirements mandated by the relevant authorities. Where compatible with required electrical codes, the earthing instructions and requirements of the equipment manufacturers should also be followed.

6 Implementation

This clause specifies a cabling design that, when properly installed, conforms to the requirements of this International Standard. The design should be applicable to the majority of installations. Maximum lengths are defined for the horizontal and backbone cabling subsystems (see figure 6).



A + B + E = < 10 m - combined length of work area cable, equipment cable and patch cord (or jumper) in the horizontal subsystem
C and D = < 20 m - patch cord (or jumper) in the BD or CD
F and G = < 30 m - equipment cable in the BD or CD

Note that all lengths are mechanical lengths

EQP = application specific equipment

NOTES

1 See annex C for further information on flexible cables.
2 The 10 m (A + B + E) and 30 m (F and G) lengths are strongly recommended, but are of an advisory nature, because they include equipment cables which are outside the scope of this International Standard.

Figure 6 - Maximum cable lengths

The requirements for the cabling components to be used within this clause can be found in clause 8 (for cables) and clause 9 (for connecting hardware). Balanced cables of 100 Ω and 120 Ω characteristic impedance and the connecting hardware for these cables are specified by categories of increasing performance. The transmission characteristics of category 3, 4 and 5 components are specified up to 16 MHz, 20 MHz, and 100 MHz respectively.

Cables and connecting hardware of different categories may be mixed within a subsystem and/or the cabling link, but the transmission of the link will be determined by the category of the least performing component.

Cables of different nominal characteristic impedances shall not be mixed within a cabling link. Optical fibres of different core diameters shall not be mixed within a cabling link.

Multiple appearances of the same conductor or conductors continuing past the point of termination (bridged taps) shall not exist as part of the cabling system.

6.1 Horizontal cabling

6.1.1 Horizontal distances

The maximum horizontal cable length shall be 90 m independent of medium (figure 7). This is the cable length from the mechanical termination of the cable in the FD to the TO in the work area.

In establishing maximum length, a total mechanical length of 10 m is allowed for work area cables, patch cords or jumpers, and equipment cables in any horizontal segment. Equipment cables that meet or have better performance characteristics than patch cord requirements are strongly recommended because they may be required to meet the performance requirements of applications intended to run on these cables. This mechanical length may be assigned differently according to need, but should be consistent throughout the premises. The FD jumper or patch cord lengths shall not exceed 5 m.

NOTE - See clause 9 and annex C for specifications on patch cords, other flexible cables and the relationship between mechanical and electrical lengths.

Figure 7a shows the model (cable lengths and connectors) used to correlate the horizontal cabling specifications of clause 6 with the link performance specifications in clause 7. For that purpose the horizontal copper cabling consists of 90 m of fixed and 5 m of flexible cable (which are together electrically equivalent to 97,5 m of cable as defined in clause 8) and three connections of the same category (as specified in clause 9). Note that the optional transition point is not included in this model; if the transition point is used, the transmission characteristics of the 90 m maximum horizontal cable shall be maintained. It has been necessary to make assumptions about the work area and equipment cables, which are part of the end-to-end channel specifications, but are not included in the generic cabling. It is assumed that the combined electrical length (in terms of clause 8) of equipment and work area cable is equivalent to 7,5 m of cable as defined in clause 8. This difference between mechanical and electrical length is necessitated by the attenuation requirements for flexible cables specified in annex C.

The model used to correlate the optical fibre horizontal cabling differs from figure 7a in that it contains a connection and a splice at each end of the subsystem.

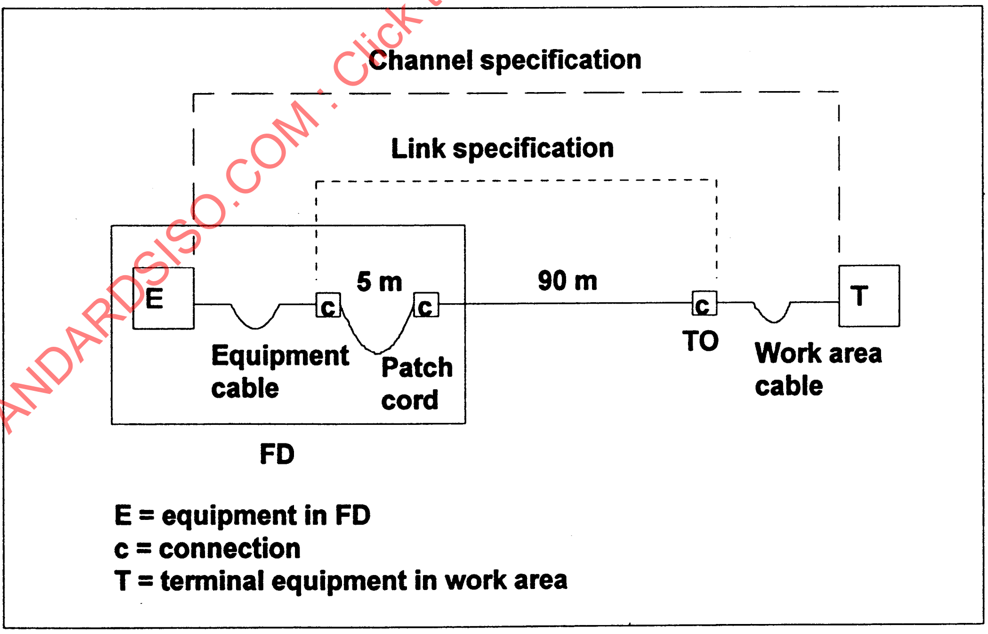


Figure 7a - Horizontal cabling model - copper

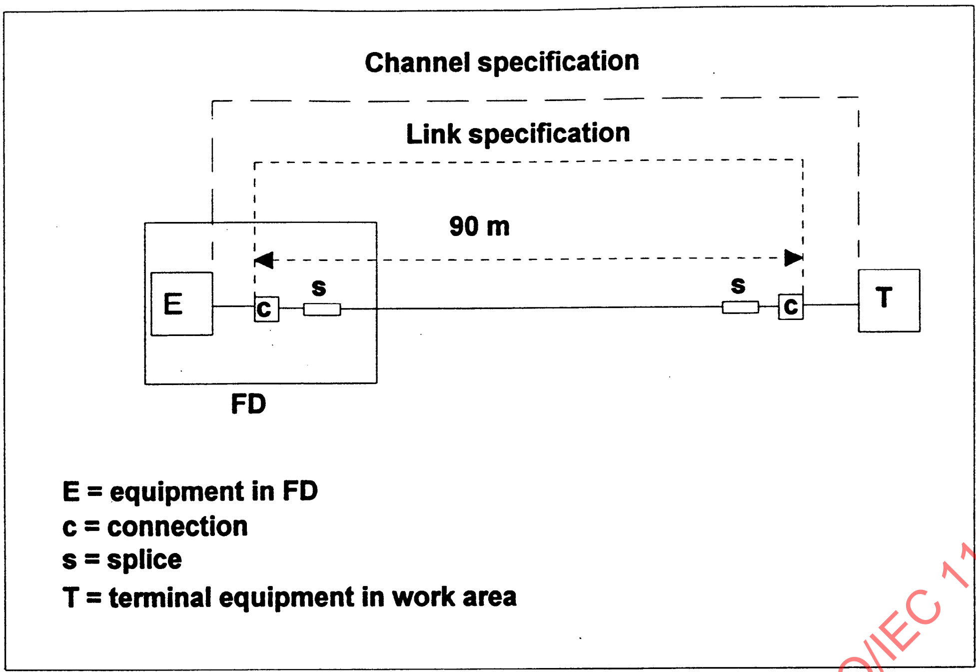


Figure 7b - Horizontal cabling model - fibre

Figure 7 - Horizontal cabling models for copper and fibre

6.1.2 Choosing cable types

The following cable types are recommended for use in the horizontal cabling subsystem:

Preferred:

a) 100 Ω balanced cable - (see 8.1).

b) 62,5/125 µm multimode optical fibres - (see 8.4).

Alternative:

a) 120 Ω balanced cable - (see 8.1).

b) 150 Ω balanced cable - (see 8.2).

c) 50/125 µm multimode optical fibres - (see 8.4).

The performance characteristics for the horizontal cable types, associated connecting hardware and cross-connects are described in clauses 8 and 9.

Hybrid and multi-unit cables that meet the requirements of 8.3 may be used in the horizontal cabling subsystem for serving more than one TO.

If shields or grounded metallic parts are present, refer to clause 10.

6.1.3 Configuring TOs

The two TOs in a work area corresponding to the minimum configuration of clause 5 are configured as follows.

a) One telecommunications outlet shall be supported by balanced cable category 3 or higher according to 8.1.

b) A second telecommunications outlet shall be supported either by balanced cable of category 5, according to 8.1, a balanced cable according to 8.2, or an optical fibre cable according to 8.3.

NOTE - See 9.2.5, 9.3.5 and 9.4.5 for TO requirements that correspond to each of the cables listed above.

A typical horizontal and work area cabling scenario is represented in figure 8.

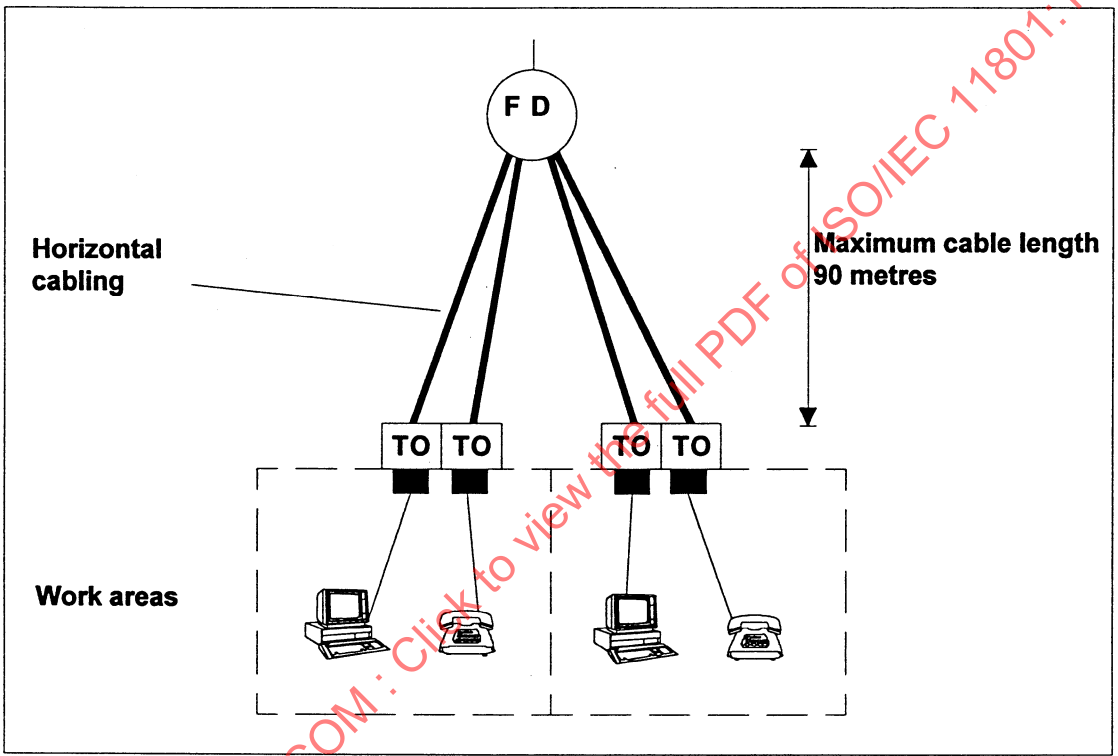


Figure 8 - Typical horizontal and work area cabling

6.2 Backbone cabling

6.2.1 Physical topology

There shall be no more than two hierarchical levels of cross-connects in the backbone cabling to limit signal degradation for passive systems and to simplify administration in keeping track of cables and connections. No more than one cross-connect shall be passed through to reach the CD when starting from a FD.

A single backbone cabling cross-connect may meet the cross-connect needs of the entire backbone subsystem. Backbone cabling cross-connects may be located in telecommunications closets or equipment rooms. See annex D for guidance on accommodating ring, bus, tree, etc. configurations within the hierarchical star.

The star topology is applicable to the cable elements of the transmission medium, such as individual fibres or pairs. Depending on the physical characteristics of a site, cable elements that are terminated at different locations may be part of the same cable over a portion of the distance, or may use individual cables over the entire distance. Hybrid and multi-unit cables that meet the requirements of 8.3 may be used in the backbone cabling subsystem.

An example of the backbone star topology is given in figure 9.

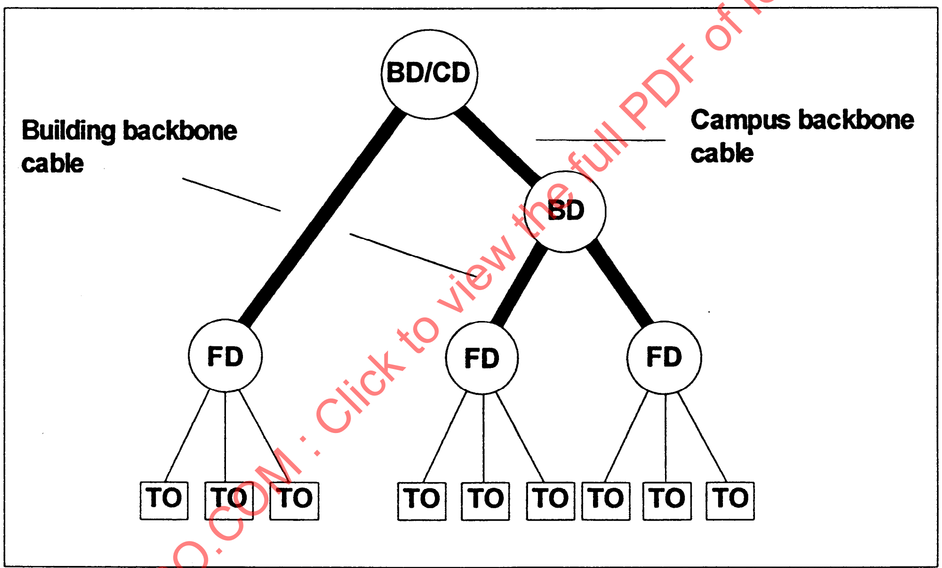


Figure 9 - Backbone star topology

6.2.2 Choosing cable types

This International Standard specifies five transmission media; more than one of these five general types may be present in the backbone cabling. The five media are:

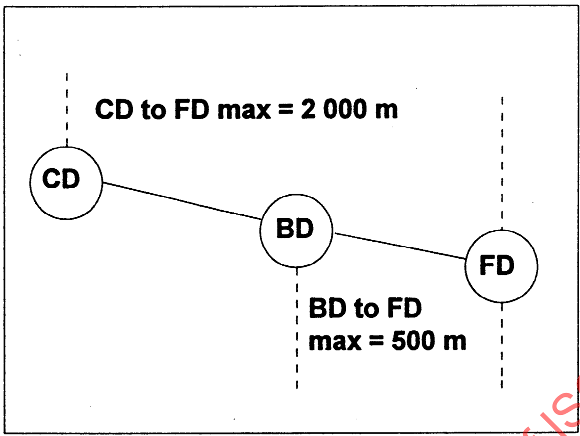
- multimode and singlemode optical fibre cable (see 8.4 and 8.5 respectively). The 62,5/125 µm multimode fibre is preferred;
- 100 Ω, 120 Ω or 150 Ω balanced cable (see 8.1 and 8.2 respectively). The 100 Ω cable is preferred. All high speed applications on copper shall be limited to horizontal distances as specified in 6.1.1.

If shields or grounded metallic parts are present, refer to clause 10.

6.2.3 Backbone cabling distances

6.2.3.1 Floor distributor to building/campus distributor

The maximum backbone distance between the CD and the associated distributor in the telecommunications closet shall comply with figure 10. Installations that exceed these distance limits may be divided into areas, each of which can be supported by backbone cabling, thus satisfying the distance requirements of this clause.



NOTE - These maximum distances are not applicable for all combinations of cabling media and applications. It is recommended that equipment manufacturers, applications standards, and system providers be consulted before selecting a backbone medium. See also table 2.

Figure 10 - Maximum backbone distances

The distance between the CD and FD shall not exceed 2 000 m. The distance between the BD and FD shall not exceed 500 m. The 2 000 m maximum distance from the CD to the FD may be extended when using singlemode optical fibre cabling. While it is recognized that the capabilities of singlemode fibre may allow for end-to-end distances of up to 60 km, CD to FD distances greater than 3 km are considered beyond the scope of this International Standard. Note, however, that the infrastructure shall conform to the structural requirements in clause 5.

In the BD and CD, jumper and patch cord lengths should not exceed 20 m. Lengths in excess of 20 m shall be deducted from the maximum permissible backbone cable length.

6.2.3.2 External services

External services (for example, broadcast services received by antennae) may enter a campus or building at locations remote from a distributor. The distance between these external service entry points and the distributor to which the services are connected shall be considered in determining maximum cable lengths. Regulatory policies within the jurisdiction which relate to the location of the network interface, if any, will also influence this distance. When applicable, the length and diameter of the media used shall be recorded, and should be made available to the service provider upon request.

6.2.3.3 Connections to telecommunications equipment

Cables that connect telecommunications equipment, such as a PBX, directly to a CD or BD have been assumed not to exceed 30 m in length. If longer cables are used, the backbone distances should be reduced accordingly.

7 Link specifications

This clause defines the performance requirements of installed generic cabling. The performance of the cabling is specified for individual links and for two different media types (balanced cables and optical fibre). A tutorial on the material in this clause is provided in annex F.

The design rules of clause 6 can be used to create generic cabling links containing components specified in clauses 8 and 9. The link 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 8 and 9.

The performance requirements described in this clause may be used as verification tests for any implementation of this International Standard, using the test methods defined, or referred to, by this clause. Additionally, they can be used for qualification of existing cabling, diagnosis at the cabling link level, and as the basis for an alternative implementation.

Care should be exercised in the interpretation of any results obtained from alternative test methods or practices. When needed, correlation factors should be identified and applied.

The performance of a cabling link is specified at and between interfaces to the link. The cabling comprises only passive sections of cable, connecting hardware, and patch cords. Active and passive application specific hardware is not addressed by this International Standard. Figure 11 shows an example of terminal equipment in the work area connected to a host using two links; an optical fibre link and a balanced cable link. The two links are connected together using an optical fibre to balanced cable converter. There are four link interfaces; one at each end of the copper link, and one at each end of the optical fibre link.

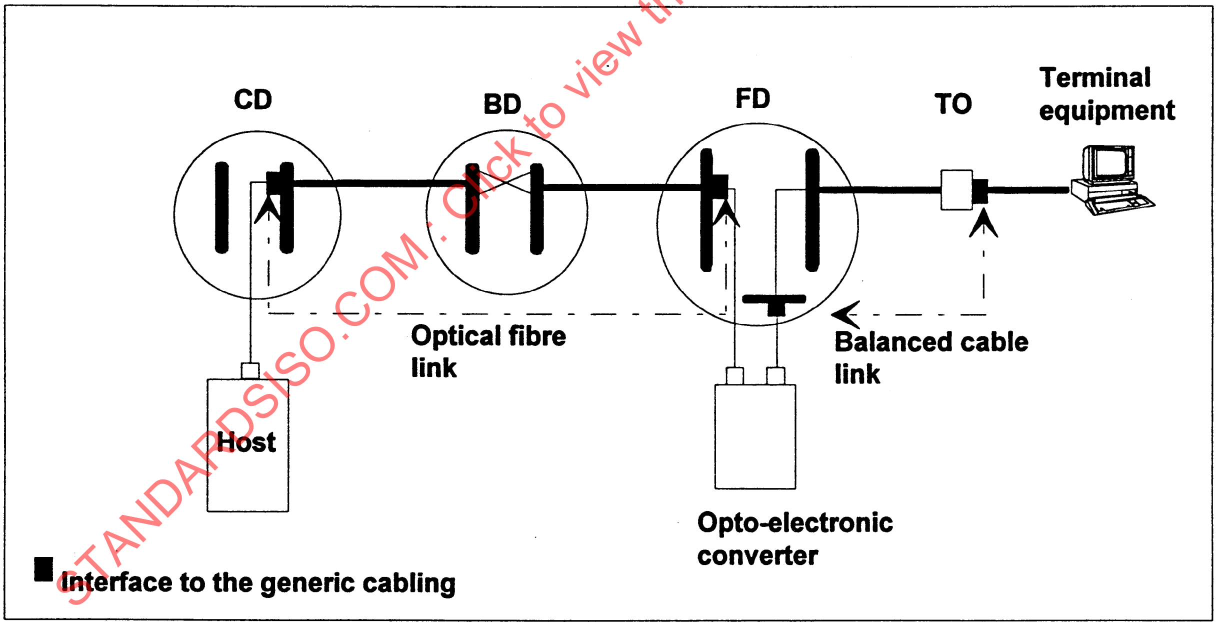


Figure 11 - Example of a system showing the location of cabling interfaces and extent of associated links

Interfaces to the cabling are at each end of a link. Interfaces to the cabling are specified at the TO and at any point where application specific equipment is connected to the cabling; the work area and equipment cabling are not included in the link.

The link performance requirements specified in this clause shall be met at each interface specified for each medium. It is not necessary to measure every parameter specified in this clause as conformance may also be proved by suitable design.

Link performance specifications shall be met for all temperatures at which the cabling is intended to operate. Performance testing may be carried out at ambient temperature, but there shall be adequate margins to account for temperature dependence of cabling components as per manufacturer's specifications. The effects of ageing should also be taken into account. In particular, consideration should be given to measuring performance at worst case temperatures, or calculating worst case performance based on measurements made at other temperatures.

7.1 Classification of applications and links

7.1.1 Application classification

Five application classes for cabling have been identified for the purposes of this International Standard. This ensures that the limiting requirements of one system do not unduly restrict other systems.

The application classes are:

Class A — applications include speech band and low frequency applications. Copper cabling links supporting class A applications are specified up to 100 kHz.

Class B — applications include medium bit rate data applications. Copper cabling links supporting class B applications are specified up to 1 MHz.

Class C — applications include high bit rate data applications. Copper cabling links supporting class C applications are specified up to 16 MHz.

Class D — applications include very high bit rate data applications. Copper cabling links supporting class D applications are specified up to 100 MHz.

Optical class — applications include high and very high bit rate data applications. Optical fibre cabling links are specified at 10 MHz and above. Bandwidth is generally not a limiting factor in the customer's premises.

Annex G gives examples of applications that fall within the various classes.

7.1.2 Link classification

Generic cabling, when configured to support particular applications, comprises one or more links.

For copper cabling links, a class A link is specified so that it will provide the minimum transmission performance to support class A applications. Similarly, class B, C and D links provide the transmission performance to support class B, C and D applications respectively. Links of a given class will support all applications of a lower class. Class A is regarded as the lowest class.

Optical parameters are specified for singlemode and multimode optical fibre links. For optical fibre cabling links, the link is specified so that the minimum transmission performance is supported for applications specified at 10 MHz and above.

Class C and D links correspond to full implementations of category 3 and category 5 horizontal cabling subsystems respectively, as specified in 6.1.

Table 2 relates the link classes to the cabling categories of clauses 8 and 9. This table indicates the channel length over which the various applications may be supported.

The distances presented are based on crosstalk loss (for copper cables), bandwidth (for optical fibre cables), and attenuation limits for various classes. Other characteristics of applications, for example propagation delay, may further limit these distances.

Table 2 - Channel lengths achievable with different categories and types of cabling

Medium	Channel length				
	Class A	Class B	Class C	Class D	Optical class
Category 3 balanced cable (8.1)	2 km	200 m	100 m [1)]	-	-
Category 4 balanced cable (8.1)	3 km	260 m	150 m [3)]	-	-
Category 5 balanced cable (8.1)	3 km	260 m	160 m [3)]	100 m [1)]	-
150 Ω balanced cable (8.2)	3 km	400 m	250 m [3)]	150 m [3)]	-
Multimode optical fibre (8.4)	N/A	N/A	N/A	N/A	2 km
Singlemode optical fibre (8.5)	N/A	N/A	N/A	N/A	3 km [2)]

NOTES

1) The 100 m distance includes a total allowance of 10 m of flexible cable for patch cords / jumpers, work area and equipment connections. Link specifications are consistent with 90 m horizontal cable, 7,5 m electrical length of patch cable and three connectors of the same category. Support for applications is assumed, provided that no more than an additional 7,5 m electrical length of combined work and equipment area cable is used (see figure 7).

2) 3 km is a limit defined by the scope of the International Standard and not a medium limitation.

3) For distances greater than 100 m of balanced cable in the horizontal cabling subsystem, the applicable application standards should be consulted.

Consideration should be given, when specifying and designing cabling, to the possible future connection of cabling subsystems to form longer links. The performance of these longer links will be lower than that of any of the individual subsystem links from which they are constructed. Measurement of links should be made initially, upon installation of each cabling subsystem. Testing of combined subsystems should be performed as required by the application.

7.2 Balanced cabling links

The parameters specified in this subclause apply to cabling links with shielded or unshielded cable elements, with or without an overall shield, unless explicitly stated otherwise. Unless stated otherwise, outline test configurations for all measurements on balanced cabling are given in annex A. Specialised test instruments are required for high frequency field measurements on balanced cabling. The maximum application frequencies are based on required link characteristics, and are not indicated by the maximum specified frequency for the cabling.

7.2.1 Characteristic impedance

The nominal differential characteristic impedance of a cabling link shall be 100 Ω, 120 Ω, or 150 Ω at frequencies between 1 MHz and the highest specified frequency for the cabling class.

The tolerance of the characteristic impedance in a given link shall not exceed the chosen nominal impedance by more than ±15 Ω (f.f.s.) from 1 MHz up to the highest specified frequency for that class.

The variation of the characteristic impedance of a cabling link is characterised by the return loss. The nominal characteristic impedance of cables used in a cabling link shall be in accordance with the requirements of clause 8.

The measurement of these values on installed cabling systems is under study. Verification of the characteristic impedance of cabling links should be made by a suitable design, and the appropriate choice of cables and connecting hardware.

7.2.2 Return loss

The return loss of the cabling, measured at any interface, shall meet or exceed the values shown in table 3. The remote end of the link should be terminated with a resistor of value equal to the nominal impedance of the cabling during the test.

Table 3 - Minimum return loss at each cabling interface

Frequency MHz	Minimum return loss dB	
	Class C	Class D
1 ≤ f ≤ 10	18 (f.f.s.)	18 (f.f.s.)
10 ≤ f ≤ 16	15 (f.f.s.)	15 (f.f.s.)
16 ≤ f ≤ 20	.N/A	15 (f.f.s.)
20 ≤ f ≤ 100	N/A	10 (f.f.s.)

7.2.3 Attenuation

The attenuation of a link shall not exceed the values shown in table 4, and shall be consistent with the design values of cable length and cabling materials used. The attenuation of the link shall be measured according to 3.3.2 of IEC 1156-1, except that the measured attenuation shall not be scaled to a standard length. For class D links, the ACR requirements in 7.2.5 may require lower attenuation than that shown in table 4. Class D links should comprise cables which closely follow the square root of frequency attenuation characteristic above 1 MHz.

The values in table 4 are based on the requirements of the applications listed in annex G.

Table 4 - Maximum attenuation values

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

For attenuation measurements that include equipment and work area cables on both ends of a cabling link, the values in table 4 should not be exceeded by more than the attenuation of the equipment and work area cables used.

7.2.4 Near-end crosstalk loss

The near-end crosstalk loss of a link shall meet or exceed the values shown in table 5, and shall be consistent with the design values of cable length and cabling materials used. The crosstalk loss shall be measured according to 3.3.4 of IEC 1156-1 except that the measured near-end crosstalk loss shall not be adjusted for length. The NEXT shall be measured from both ends of the cabling segment to allow a correct evaluation of the cabling link. See also A.1.1. For class D links, the ACR in 7.2.5 may require better near-end crosstalk loss performance than that shown in table 5.

The values in table 5 are based on the near-end crosstalk loss requirements of the applications listed in annex G.

Table 5 - Minimum NEXT loss

Frequency MHz	Minimum crosstalk loss dB			
	Class A	Class B	Class C	Class D
0,1	27	40	N/A	N/A
1,0	N/A	25	39	54
4,0	N/A	N/A	29	45
10,0	N/A	N/A	23	39
16,0	N/A	N/A	19	36
20,0	N/A	N/A	N/A	35
31,25	N/A	N/A	N/A	32
62,5	N/A	N/A	N/A	27
100,0	N/A	N/A	N/A	24

For NEXT loss measurements that include equipment and work area cables on both ends of a cabling link, the NEXT loss in table 5 should be met. Equipment connectors are not accounted for in this table and may contribute to additional crosstalk degradation.

Crosstalk is not the only source of noise in a transmission system. An assumption has been made that noise from all other sources is at least 10 dB less than the crosstalk noise power at all application frequencies of interest.

7.2.5 Attenuation to crosstalk loss ratio

This is the difference between the crosstalk loss and the attenuation of the link in dB. It is related to, but distinct from, the signal to crosstalk ratio (SCR) which accommodates the transmit and receive signal levels of an application. By applying the requirements of 7.2.3, 7.2.4 and 7.2.5, the transmission requirements of the applications listed in annex G will be met. The ACR of a link is calculated by:

$$ACR(dB) = a_N(dB) - a(dB)$$

where:

- ACR is the attenuation to crosstalk loss ratio
- a_N is the crosstalk loss, measured between any two pairs of a link. The crosstalk attenuation shall be measured according to 3.3.4 of IEC 1156-1, except that the measured crosstalk shall not be adjusted for length.
- a is the attenuation of the link when measured according to 3.3.2 of IEC 1156-1, except that the measured attenuation shall not be scaled to a standard length.

The ACR is based on the most severe requirements of the applications listed in annex G. The ACR for links of class A, B and C is identical to the values which can be calculated directly from the attenuation and crosstalk loss values shown in tables 4 and 5 respectively. For class D links, the ACR is more demanding than the direct calculation from tables 4 and 5. For class D links, the ACR shall be better than the limits shown in table 6. This provides some flexibility in the choice of cabling components, allowing some limited trade-offs between attenuation (cable length) and crosstalk performance of the cabling.

Table 6 - Minimum ACR values

Frequency MHz	Minimum ACR dB Class D
1,0	-
4,0	40
10,0	35
16,0	30
20,0	28
31,25	23
62,5	13
100,0	4

For ACR calculations that include equipment and work area cables on both ends of a link, the ACR values in table 6 should not be degraded by more than the attenuation of the equipment and work area cables used.

7.2.6 DC resistance

The loop resistance of pairs shall be less than the values given in table 7 for each class of application. These figures are derived from application requirements. The d.c. loop resistance shall be measured according to 5.1 of IEC 189-1. A short circuit is applied at the remote end of the pair and the loop resistance is measured at the near end. The measured value should be consistent with the length and diameter of the conductors used in the cable.

Table 7 - Maximum d.c. loop resistance

Link class	Class A	Class B	Class C	Class D
Maximum loop resistance Ω	560	170	40	40

7.2.7 Propagation delay

The propagation delay, measured as shown in annex A, shall be less than the limits given in table 8. These limits are derived from system requirements. Any measured or calculated values should be consistent with the lengths and materials used in the cabling.

Table 8 - Maximum propagation delay

Measurement Frequency MHz	Class	Delay µs
0,01	A	20,0
1	B	5,0
10	C	1,0
30	D	1,0

The maximum propagation delay in the horizontal cabling subsystem shall not exceed 1 µs.

7.2.8 Longitudinal to differential conversion loss (balance)

The longitudinal conversion loss, measured as LCL and as LCTL according to ITU-T Recommendation G.117, should exceed the values shown in table 9.

Table 9 - Longitudinal to differential conversion loss

Frequency MHz	Minimum longitudinal to differential conversion loss dB			
	Class A	Class B	Class C	Class D
0,1	30	45	35	40
1,0	N/A	20	30	40
4,0	N/A	N/A	f.f.s.	f.f.s.
10,0	N/A	N/A	25	30
16,0	N/A	N/A	f.f.s.	f.f.s.
20,0	N/A	N/A	f.f.s.	f.f.s.
100,0	N/A	N/A	N/A	f.f.s.

The measurement of these values on installed systems is not yet well established. It is sufficient to verify the values by design.

7.2.9 Transfer impedance of shield

This parameter applies to shielded cabling only. The measurement of transfer impedance for installed cabling is not well developed. Connector termination practices may be verified by laboratory measurements of representative samples of short lengths of terminated cable. The transfer impedance requirements for shielded cables and connectors in clauses 8 and 9 should be applied. See clause 10 for guidance on the use of shielded cabling.

7.3 Optical fibre links

The performance requirements for optical fibre links assume that each optical fibre link employs a single optical wavelength in one transmission window only. Application standards employing wavelength multiplexing are not yet available for listing in annex G. All application specific hardware for wavelength multiplexing is installed in the equipment area and in the work area, which both are outside the scope of this International Standard. The requirements for the wavelength multiplexing and demultiplexing components will be found in the application standards. There are no special requirements for generic cabling concerning wavelength multiplexing.

The performance requirements of singlemode and multimode optical fibre links are considered in this subclause.

Unless otherwise stated, test procedures are described in annex A.

7.3.1 Optical attenuation

The maximum attenuation (insertion loss) shall not exceed the values specified in table 10 in the wavelength windows specified in table 11. In addition, the attenuation of optical links that comprise multiple cabling subsystems (for example, horizontal plus backbone) shall not exceed 11 dB for 62,5/125 μm and 8/125 μm optical fibre (other fibre types may be subject to further restrictions) at the nominal operating wavelengths.

The attenuation values given in table 10 have been calculated for optical fibre links in each cabling subsystem, assuming a worst case installation philosophy of a connector and a splice at each end of each subsystem.

Table 10 - Attenuation of fibre optic cabling subsystems

Cabling subsystem	Link length [1)] m	Attenuation dB			
		Singlemode		Multimode	
		1 310 nm	1 550 nm	850 nm	1 300 nm
Horizontal	100	2,2	2,2	2,5	2,2
Building backbone	500	2,7	2,7	3,9	2,6
Campus backbone	1 500	3,6	3,6	7,4	3,6

Care should be taken with short optical links to ensure that optical power carried in the fibre cladding does not overload the receiver.

Table 11 - Wavelength windows for multimode fibre optic cabling

Nominal wavelength nm	Lower limit nm	Upper limit nm	Reference test wavelength nm	Max. spectral width FWHM nm
850	790	910	850	50
1 300	1 285	1 330	1 300	150

1) The link lengths given here are the maximum distances achievable using fibre optic components meeting the minimum requirements of 8.4, 8.5 and 9.4.
Different link lengths could be achieved if other fibre optic components were used.

Table 12 - Wavelength windows for singlemode fibre optic cabling

Nominal wavelength nm	Lower limit nm	Upper limit nm	Reference test wavelength nm	Max. spectral width FWHM nm
1 310	1 288	1 339	1 310	10
1 550	1 525	1 575	1 550	10

7.3.2 Multimode modal bandwidth

For multimode optical fibre links the optical modal bandwidth shall exceed the minimum values shown in table 13.

Table 13 - Minimum optical modal bandwidth

Wavelength nm	Minimum bandwidth MHz
850	100
1 300	250

The dispersion of the fibre used in the optical link shall be measured in accordance with the test methods described in IEC 793-1. See table 2 for achievable distances.

7.3.3 Return loss

The optical return loss of any interface of an optical link shall exceed the values shown in table 14.

Table 14 - Minimum optical return loss

Multimode		Singlemode	
850 nm	1 300 nm	1 310 nm	1 550 nm
20 dB	20 dB	26 dB	26 dB

7.3.4 Propagation delay

Some applications may impose limits for the maximum propagation delay.

8 Cable requirements

This clause provides the requirements for the cable for the horizontal and backbone cabling subsystems. For additional requirements regarding flexible balanced cables, see annex C.

NOTE - It is intended to supplement the requirements of this clause by reference to International Standards as these become available. At the time this International Standard was approved the following documents were available from IEC SC 46C: DIS 1156-2, DIS 1156-2-1, DIS 1156-3, DIS 1156-3-1, DIS 1156-4, DIS 1156-4-1.

All cables shall meet the applicable safety requirements as specified by the relevant local authorities. This clause provides essential mechanical and transmission characteristics for each medium. Due to inherent limitations of some telecommunications services, the use of cables described below to support applications other than those listed in annex G may not always result in acceptable service performance. The user is advised to consult standards associated with the planned service or equipment in order to determine any specific limitation.

In the following tables, the requirements for attenuation and NEXT loss are given for discrete frequencies only. They have to be fulfilled, however, for all intermediate frequencies. Requirements at intermediate frequencies are derived by linear interpolation between two specified frequencies on a semi-logarithmic (NEXT loss) or logarithmic (attenuation) scale.

The requirements of this clause are provided for the cable as measured by the manufacturer. It is assumed that these characteristics do not change significantly for cables installed according to manufacturer's instructions and operating at 20 °C.

8.1 General requirements for 100 Ω and 120 Ω balanced cable

The mechanical and electrical requirements given in table 15 and table 16 shall be met by both 100 Ω and 120 Ω cables. For additional electrical requirements, see 8.1.1 (100 Ω) and 8.1.2 (120 Ω).

Table 15 - Mechanical characteristics of 100 Ω and 120 Ω balanced cables

Cable characteristics		Units	Subsystem		Test method
1	Mechanical characteristics		Backbone	Horizontal	
1.1	Diameter of conductor [1]	mm	0,4 to 0,65		f.f.s.
1.2	Diameter over insulated conductor [2]	mm	≤ 1,4		8.3 of IEC 811-1-1
1.3	Number of conductors in a cable element	per pair / per quad	2 / 4		
1.4	Shield around cable element [3]		Optional. Refer to clause 10		
1.5	Number of cable	pairs	≥ 4	2, 4, n (n > 4)	
	elements in a unit [4]	quads	≥ 2	1, 2, n (n > 2)	
1.6	Shield around cable unit [3]		Optional		
1.7	Number of cable units in a cable		≥ 1[4]		
1.8	Shield around cable [3]		Optional. Refer to clause 9		
1.9	Outer diameter of cable [5]	mm	≤ 90	≤ 20	8.3 of IEC 811-1-1
1.10	Temperature range without mechanical degradation [6]	°C	installation: 0 to +50 operation: -20 to +60		f.f.s.
1.11	Minimum bending radius for pulling during installation		8 times outer cable diameter		IEC 227-2
1.12	Minimum bending radius installed		6 (f.f.s.) times outer cable diameter	4 (f.f.s.) times outer cable diameter	f.f.s.
1.13	Pulling strength [7]	N/mm^2 x Cu_{min}	≥ 50		10 of IEC 794-1
1.14	Fire rating		as required by local regulation preferably IEC 332-3 (f.f.s.)		f.f.s.
1.15	Colour coding [8]		as required by local regulations preferably IEC 708-1		
1.16	Cable marking		as required by local regulations or national specifications		

NOTES

1) Conductor diameters below 0,5 mm may not be compatible with all connecting hardware.

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

3) If it is intended to use cables with shielding, care shall be taken that the connecting hardware is properly designed to terminate the shielding.

4) Care has to be taken to meet the NEXT requirements given in clause 8.3.

5) Should be minimized to make best use of duct and crossconnect capacity (see clause 9). In case of under carpet cable the value is not applicable.

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

7) This is an indication for cable performance, installation needs are for further study. This results in a maximum pulling force of 50 N/mm^2 times copper conductor cross-section, excluding shields if present.

8) For cables with fewer cable elements than those specified by IEC 708, pair colours should be consistent with all pairs or quads specified starting from 1 up to the number of elements in the cable.

The following electrical characteristics are given for 20 °C. They may degrade with changing temperature. Some commonly used insulation materials may result in a non-linearly dependence of electrical characteristics on temperature. Thus, especially for temperatures above 40 °C, special insulation materials may be necessary.

Table 16 - Electrical characteristics of 100 Ω and 120 Ω balanced cables

Cable characteristics				Cable category			Test method
2	Electrical characteristics at 20 °C	Units	MHz	3	4	5	
2.1	Maximum d.c. loop resistance	Ω/100 m	d.c.	19,2 [1]	19,2 [1]	19,2 [1]	5.1 of IEC 189-1
2.2	Nominal phase velocity of propagation		1 10 100	0,4 c 0,6 c N/A	0,6 c 0,6 c N/A	0,65 c 0,65 c 0,65 c	f.f.s.
2.3	Minimum near end crosstalk loss [2]	dB at 100 m cable length	0,772	43	58	64	f.f.s.
			1	41	56	62	
			4	32	47	53	
			10	26	41	47	
			16	23	38	44	
			20	N/A	36	42 [3]	
			31,25	N/A	N/A	40 [3]	
			62,5	N/A	N/A	35 [3]	
			100	N/A	N/A	32 [3]	
2.4	Maximum resistance unbalance	%	d.c.	3	3	3	f.f.s.
2.5	Minimum longitudinal conversion loss	dB	0,064	N/A	43 (f.f.s.)	43 (f.f.s.)	ITU-T O.9
2.6	Maximum capacitance unbalance pair to ground	pF/km	0,0008 or 0,001	3 400	3 400	3 400	28 of IEC 708-1 or 5.5 of IEC 189-1
2.7	Maximum transfer impedance only applicable when shields are present	mΩ/m	1	50 (f.f.s.)	50 (f.f.s.)	50 (f.f.s.)	A.5.2 of IEC 96-1
			10	100 (f.f.s.)	100 (f.f.s.)	100 (f.f.s.)	
			100	N/A	N/A	f.f.s.	
2.8	Minimum d.c. insulation resistance	MΩ km	d.c.	150	150	150	5.3 of IEC 189-1
2.9	Dielectric strength cond/cond.and cond/shield		d.c. or	1 kV, 1 min or 2,5 kV, 2 s			5.2 of IEC 189-1
			a.c.	700 V, 1 min or 1,7 kV, 2 s			
2.10	Minimum structural return loss	dB at 100 m cable length	1 to <10	12 (f.f.s.)	21 (f.f.s.)	23 (f.f.s.)	f.f.s.
			10 to <16	10 (f.f.s.)	19 (f.f.s.)	23 (f.f.s.)	
			16 to <20	N/A	18 (f.f.s.)	23 (f.f.s.)	
			20 to 100	N/A	N/A	23-10log (f/20) (f.f.s.)	

NOTES

1) If all other values are fulfilled, the maximum d.c. loop resistance may be as high as 30 Ω /100 m.

2) Unless otherwise specified, cable NEXT loss performance shall be characterized using "worst case pair combination" testing. See 8.3 for additional NEXT requirements for balanced cables.

3) Alternatively, 100 Ω cables with characteristics that fall within the range of values provided in table 18 can generally be used.