Anixter Standards Reference Guide

Anixter: The Cabling System Experts

Anixter is a leading global supplier of communications and security products, electrical and electronic wire and cable, fasteners and other small components. We help our customers specify solutions and make informed purchasing decisions around technology, applications and relevant standards. Throughout the world, we provide innovative supply chain management services to reduce our customers' total cost of production and implementation.

Purpose of Industry Standards

By providing guidelines for installation, maintenance and testing to improve availability and reduce expenses associated with downtime, the telecommunications standards define cabling types, distances, connections, cable system architectures, cable termination standards, performance characteristics, installation and testing methods. The standards provide recommended best practices for the design and installation of cabling systems to support a wide variety of existing and future systems to extend the life span of the telecommunications infrastructure. A single common structured cabling system for all communications and security systems simplifies moves, adds and changes, maximizes system availability and extends the usability of a cabling system. By adhering to industry standards, industrial environments can expect to fully experience the benefits of structured cabling on overall performance.

Scope of this Guide

This document is meant as a reference that highlights the key points of the ANSI/TIA-568-C.0, ANSI/TIA-568-C.1, ANSI/TIA-568-C.2, ANSI/TIA-568-C.3, ANSI/TIA-569-B, ANSI/TIA-606-A, J-STD-607-A, ANSI/TIA-942, ANSI/TIA-1005, ISO 11801, ISO 11801 Class E_A, IEEE 802.3af, IEEE 802.3at, IEEE 802.3an, IEEE 802.3ba and IEEE 802.11 standards.

It is not intended as a substitute for the original documents. For further information on any topic in the guide, refer to the actual standard. See the section called "Reference Documents" for instructions on how to order a copy of the standard itself.

Abbreviation References

ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
CSA	Canadian Standards Association
EIA	Electronic Industries Alliance
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronics Engineers
ISO	International Organization for Standardization
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
TIA	Telecommunications Industry Association

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ANSI/TIA-568-C.0 Standard

Purpose of the ANSI/TIA-568-C.0 Standard

The ANSI/TIA-568-C.0 standard enables the planning and installation of a structured cabling system for all types of customer premises. It specifies a system that will support generic telecommunications cabling in a multiproduct, multimanufacturer environment. By serving as the foundation for premises telecommunications cabling infrastructure, the ANSI/TIA-568-C.0 standard provides additional requirements for other standards specific to the type of premises (e.g., ANSI/TIA-568-C.1 contains additional requirements applicable to commercial building cable).

The standard specifies requirements for generic telecommunications cabling, including:

- Cabling system structures
- Topologies and distances
- Installation, performance and testing
- Optical fiber transmission and test requirements.

This standard replaces ANSI/TIA/EIA-568-B.1 dated April 12, 2001, and its addenda. It incorporates and refines the technical content of ANSI/TIA/EIA-568-B.1-1 Addendum 1, 568-B.1-2 Addendum 2, 568-B.1-3 Addendum 3, 568-B.1-7 Addendum 7, TSB125, TSB140 and TSB153.

Section Contents

ANSI/TIA-568-C.0

Generic Telecommunications Cabling for Customer Premises

Telecommunications Cabling System Structure

General

Figure 1 shows a representative model of the functional elements of a generic cabling system for ANSI/TIA-568-C.0. In a typical commercial building where ANSI/TIA-568-C.1 applies, Distributor C represents the main cross-connect (MC), Distributor B represents the intermediate cross-connect (IC), Distributor A represents the horizontal cross-connect (HC), and the equipment outlet (EO) represents the telecommunications outlet and connector.

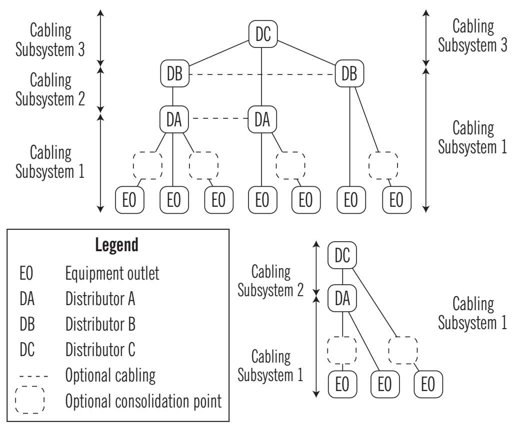

Figure 1 – Elements that comprise a generic cabling system

Topology

- Star topology
- No more than two distributors between Distributor C and an equipment outlet (EO)

Equipment Outlets (EOs)

Also called the work area (WA) in ANSI/TIA-568-C.1, equipment outlets are the outermost location to terminate the cable in a hierarchical star topology.

Distributors

Distributors provide a location for administration, reconfiguration, connection of equipment and testing. They can be either interconnections or cross-connections.

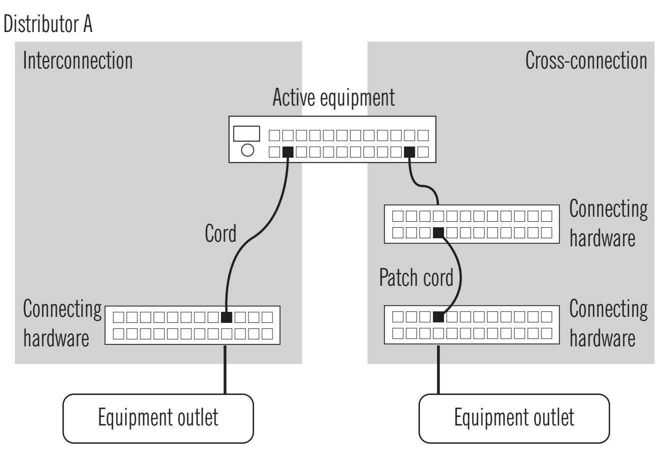

Figure 2 – Interconnections and cross-connections

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ANSI/TIA-568-C.0 Standard

Cabling Subsystem 1

- Provides a signal path between Distributor A, Distributor B or Distributor C and an EO (see Figure 1)
- Contains no more than one transition point or consolidation point
- Stipulates that splices shall not be installed as part of a balanced twisted-pair cabling subsystem and that splitters shall not be installed as part of optical fiber for Cabling Subsystem 1

Cabling Subsystem 2 and Cabling Subsystem 3

Cabling Subsystem 2 and Cabling Subsystem 3 provide signal paths between distributors (see Figure 1). The use of Distributor B is optional.

Recognized Cabling

The recognized media, which shall be used individually or in combination, are:

- 100-ohm balanced twisted-pair cabling
- Multimode optical fiber cabling
- Single-mode optical fiber cabling.

Cabling media other than those recognized above may be specified by the appropriate premises cabling standards.

Cabling Lengths

Cabling lengths are dependent upon the application and upon the specific media chosen (see following tables).

Cabling Lengths

Application	Media	Distance m (ft.)	Comments
Ethernet 10BASE-T	Category 3, 5e, 6, 6A	100 (328)	
Ethernet 100BASE-TX	Category 5e, 6, 6A	100 (328)	
Ethernet 1000BASE-T	Category 5e, 6, 6A	100 (328)	
Ethernet 10GBASE-T	Category 6A	100 (328)	
ASDL	Category 3, 5e, 6, 6A	5,000 (16,404)	1.5 Mbps to 9 Mbps
VDSL	Category 3, 5e, 6, 6A	5,000 (16,404)	1,500 m (4,900 ft.) for 12.9 Mbps; 300 m (1,000 ft.) for 52.8 Mbps
Analog Phone	Category 3, 5e, 6, 6A	800 (2,625)	
Fax	Category 3, 5e, 6, 6A	5,000 (16,404)	
ATM 25.6	Category 3, 5e, 6, 6A	100 (328)	
ATM 51.84	Category 3, 5e, 6, 6A	100 (328)	
ATM 155.52	Category 5e, 6, 6A	100 (328)	
ATM 1.2G	Category 6, 6A	100 (328)	
ISDN BRI	Category 3, 5e, 6, 6A	5,000 (16,404)	128 kbps
ISDN PRI	Category 3, 5e, 6, 6A	5,000 (16,404)	1.472 Mbps

Table 1 – Maximum supportable distances for balanced twisted-pair cabling by application, which includes horizontal and backbone cabling (application specific)

	Parameter	Multimode						Single-mode	
		62.5/125 μm TIA 492AAAA (OM1)		50/125 μm TIA 492AAAB (OM2)		850 nm laser-optimized 50/125 μm TIA 492AAAC (OM3)		TIA 492CAAA (OS1) TIA 492CAAB (OS2)	
Application	Nominal Wavelength (nm)	850	1,300	850	1,300	850	1,300	1,310	1,550
Ethernet 10/100BASE-SX	Channel attenuation (dB)	4.0	–	4.0	–	4.0	–	–	–
	Supportable distance m (ft.)	300 (984)	–	300 (984)	–	300 (984)	–	–	–
Ethernet 100BASE-FX	Channel attenuation (dB)	–	11.0	–	6.0	–	6.0	–	–
	Supportable distance m (ft.)	–	2,000 (6,850)	–	2,000 (6,850)	–	2,000 (6,850)	–	–
Ethernet 1000BASE-SX	Channel attenuation (dB)	2.6	–	3.6	–	4.5	–	–	–
	Supportable distance m (ft.)	275 (900)	–	550 (1,804)	–	800 (2,625)	–	–	–
Ethernet 1000BASE-LX	Channel attenuation (dB)	–	2.3	–	2.3	–	2.3	4.5	–
	Supportable distance m (ft.)	–	550 (1,804)	–	550 (1,804)	–	550 (1,804)	5,000 (16,405)	–
Ethernet 10GBASE-S	Channel attenuation (dB)	2.4	–	2.3	–	2.6	–	–	–
	Supportable distance m (ft.)	33 (108)	–	82 (269)	–	300 (984)	–	–	–
Ethernet 10GBASE-LX4	Channel attenuation (dB)	–	2.5	–	2.0	–	2.0	6.3	–
	Supportable distance m (ft.)	–	300 (984)	–	300 (984)	–	300 (984)	10,000 (32,810)	–
Ethernet 10GBASE-L	Channel attenuation (dB)	–	–	–	–	–	–	6.2	–
	Supportable distance m (ft.)	–	–	–	–	–	–	10,000 (32,810)	–
Ethernet 10GBASE-LRM	Channel attenuation (dB)	–	1.9	–	1.9	–	1.9	–	–
	Supportable distance m (ft.)	–	270 (720)	–	270 (720)	–	270 (720)	–	–
Fibre Channel 100-MX-SN-I (1062 Mbaud)	Channel attenuation (dB)	3.0	–	3.9	–	4.6	–	–	–
	Supportable distance m (ft.)	300 (984)	–	500 (1,640)	–	880 (2,822)	–	–	–

Table 2 – Maximum supportable distances and attenuation for optical fiber applications **(more on page 14.4)**

ANSI/TIA-568-C.0 Standard

	Parameter	Multimode						Single-mode	
		62.5/125 µm TIA 492AAAA (OM1)		50/125 µm TIA 492AAAB (OM2)		850 nm laser-optimized 50/125 µm TIA 492AAAC (OM3)		TIA 492CAAA (OS1) TIA 492CAAB (OS2)	
Application	**Nominal wavelength (nm)**	**850**	**1,300**	**850**	**1,300**	**850**	**1,300**	**1,310**	**1,550**
Fibre Channel 100-SM-LC-L (1062 Mbaud)	Channel attenuation (dB)	–	–	–	–	–	–	7.8	–
	Supportable distance m (ft.)	–	–	–	–	–	–	10,000 (32,810)	–
Fibre Channel 200-MX-SN-I (2125 Mbaud)	Channel attenuation (dB)	2.1	–	2.6	–	3.3	–	–	–
	Supportable distance m (ft.)	150 (492)	–	300 (984)	–	500 (1,640)	–	–	–
Fibre Channel 200-SM-LC-L (2125 Mbaud)	Channel attenuation (dB)	–	–	–	–	–	–	7.8	–
	Supportable distance m (ft.)	–	–	–	–	–	–	10,000 (32,810)	–
Fibre Channel 400-MX-SN-I (4250 Mbaud)	Channel attenuation (dB)	1.8	–	2.1	–	2.5	–	–	–
	Supportable distance m (ft.)	70 (230)	–	150 (492)	–	270 (886)	–	–	–
Fibre Channel 400-SM-LC-L (4250 Mbaud)	Channel attenuation (dB)	–	–	–	–	–	–	7.8	–
	Supportable distance m (ft.)	–	–	–	–	–	–	10,000 (32,810)	–
Fibre Channel 1200-MX-SN-I (10512 Mbaud)	Channel attenuation (dB)	2.4	–	2.2	–	2.6	–	–	–
	Supportable distance m (ft.)	33 (108)	–	82 (269)	–	300 (984)	–	–	–
Fibre Channel 1200-SM-LL-L (10512 Mbaud)	Channel attenuation (dB)	–	–	–	–	–	–	6.0	–
	Supportable distance m (ft.)	–	–	–	–	–	–	10,000 (32,810)	–
FDDI PMD ANSI X3.166	Channel attenuation (dB)	–	11.0	–	6.0	–	6.0	–	–
	Supportable distance m (ft.)	–	2,000 (6,560)	–	2,000 (6,560)	–	2,000 (6,560)	–	–
FDDI SMF-PMD ANSI X3.184	Channel attenuation (dB)	–	–	–	–	–	–	10.0	–
	Supportable distance m (ft.)	–	–	–	–	–	–	10,000 (32,810)	–

Table 3 – Maximum supportable distances and attenuation for optical fiber applications

Cabling Installation Requirements

- Cabling installations shall comply with the authority having jurisdiction (AHJ) and applicable regulations.
- Cable stress caused by suspended cable runs and tightly cinched bundles should be minimized.
- Cable bindings, which are used to tie multiple cables together, should be irregularly spaced and should be loosely fitted (easily moveable).

Balanced Twisted-Pair Cabling

Maximum Pulling Tension

- The pulling tension for a 4-pair balanced twisted-pair cable shall not exceed 110 N (25 pound-force) during installation.
- For multipair cable, manufacturers' pulling tension guidelines shall be followed.

Minimum Bend Radius

Cable

- The minimum inside bend radius, under no-load or load, for a 4-pair balanced twisted-pair cable shall be four times the cable diameter.
- The minimum bend radius, under no-load or load, for a multipair cable shall follow the manufacturer's guidelines.

Cord Cable

- The minimum inside bend radius for a 4-pair balanced twisted-pair cord cable shall be one times the cord cable diameter.

Cable Termination

- Cables should be terminated with connecting hardware of the same performance (Category) or higher.
- The Category of the installed link should be suitably marked and noted in the administrative records.
- The cable geometry shall be maintained as close as possible to the connecting hardware and its cable termination points.
- The maximum pair untwist for the balanced twisted-pair cable termination shall be in accordance with Table 4.

Pair Untwist Lengths

Category	Maximum Pair Untwist mm (in.)
3	75 (3)
5e	13 (0.5)
6	13 (0.5)
6A	13 (0.5)

Table 4 – Maximum supportable pair untwist length for Category cable termination

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ANSI/TIA-568-C.0 Standard

8-Position Modular Jack Pin-Pair Assignments

Pin-pair assignments shall be as shown in Figure 3 or, optionally, per Figure 4 if it is necessary to accommodate certain 8-pin cabling systems. The colors shown are associated with 4-pair cable.

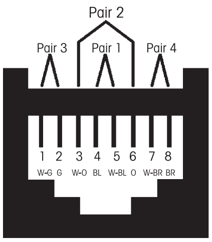


Figure 3 – Front view of 8-position jack pin-pair assignments (T568A)

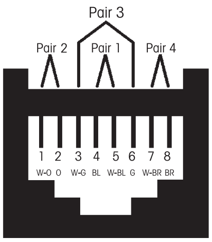


Figure 4 – Front view of optional 8-position jack pin-pair assignment (T568B)

Cords and Jumpers

Cross-connect jumpers and modular plug cords should be of the same Category or higher as the Category of the cabling to which they connect. It is recommended that modular cords be factory manufactured.

Grounding and Bonding Requirements for Screened Cabling

- The screen of screened twisted-pair (ScTP) cables shall be bonded to the telecommunications grounding busbar (TGB) or telecommunications main grounding busbar (TMGB).
- A voltage greater than 1 volt rms between the cable screen and the ground of the corresponding electrical outlet used to provide power to the equipment indicates improper grounding.

Optical Fiber Cabling

Minimum Bend Radius and Maximum Pulling Tension

Measured to the inside curvature, the bend radius is the minimum a cable can bend without any risk to kinking it, damaging it or shortening its life. The smaller the bend radius, the greater the material flexibility.

Minimum Bend Radius and Maximum Pulling Tension			
Cable Type and Installation Details	Maximum Tensile Load During Installation	Minimum Bend Radii While Subjected To Maximum Tensile Load (During Installation)	No Tensile Load (After Installation)
Inside Plant Cable with 2 or 4 Fibers Installed in Cabling Subsystem 1	220 N (50 lbf)	50 mm (2 in.)	25 mm (1 in.)
Inside Plant Cable with more than 4 Fibers	Per manufacturer	20 times the cable outside diameter	10 times the cable outside diameter
Indoor/Outdoor Cable with up to 12 Fibers	1335 N (300 lbf)	20 times the cable outside diameter	10 times the cable outside diameter
Indoor/Outdoor Cable with more than 12 Fibers	2670 N (600 lbf)	20 times the cable outside diameter	10 times the cable outside diameter
Outside Plant Cable	2670 N (600 lbf)	20 times the cable outside diameter	10 times the cable outside diameter
Drop Cable Installed by Pulling	1335 N (300 lbf)	20 times the cable outside diameter	10 times the cable outside diameter
Drop Cable Installed by Directly Buried, Trenched or Blown into Ducts	440 N (100 lbf)	20 times the cable outside diameter	10 times the cable outside diameter

Table 5 – Maximum and minimum pulling tension and bend radius for different cable types

Polarity

Transmit-to-receive polarity must be maintained throughout the cabling system. (Annex B of the full standard describes methods to do this.)

ANSI/TIA-568-C.1 Standard

Purpose of the ANSI/TIA-568-C.1 Standard

The ANSI/TIA-568-C.1 standard enables the planning and installation of a structured cabling system within a commercial building and in between commercial buildings within a campus environment. By supporting a multiproduct, multimanufacturer environment, the standard supports a wide range of different commercial applications (e.g., voice, data, text, video and images) and building sites with a geographic extent from 3,000 square meters (approximately 10,000 feet) up to 1,000,000 square meters (approximately 10,000,000 square feet) of office space and with a population of up to 50,000 users.

This standard replaces ANSI/TIA/EIA-568-B.1 dated April 12, 2001, and its addenda. It incorporates and refines the technical content of ANSI/TIA-B.1-4, Addendum 4, and ANSI/TIA-B.1-5, Addendum 5.

Significant Technical Changes from the Previous Edition

- Incorporates generic nomenclature found in ANSI/TIA-568-C.0, "Generic Telecommunications Cabling for Customer Premises"
- Includes Category 6 and Category 6A balanced 100-ohm cabling
- Includes 850-nm laser-optimized 50/125 μm multimode optical fiber cabling
- Includes telecommunications enclosures (TEs)
- Removes 150-ohm STP cabling
- Removes Category 5 cabling

Telecommunications Cabling System Structure

Establishes a structure for commercial building cabling based on the generic cabling system structure in ANSI/TIA-568-C.1

Figure 5 shows a model for a commercial building telecommunications cabling system. The elements of a commercial building telecommunications cabling system are:

a) Entrance facilities
b) Equipment rooms (space typically containing Distributor C, but may contain Distributor B)
c) Telecommunications room (space typically containing Distributor A, but may contain Distributor B and Distributor C) or, in some implementations, telecommunications enclosures (space containing Distributor A)
d) Backbone cabling (Cabling Subsystem 2 and Cabling Subsystem 3)
e) Horizontal cabling (Cabling Subsystem 1)
f) Work area (space containing the equipment outlet).

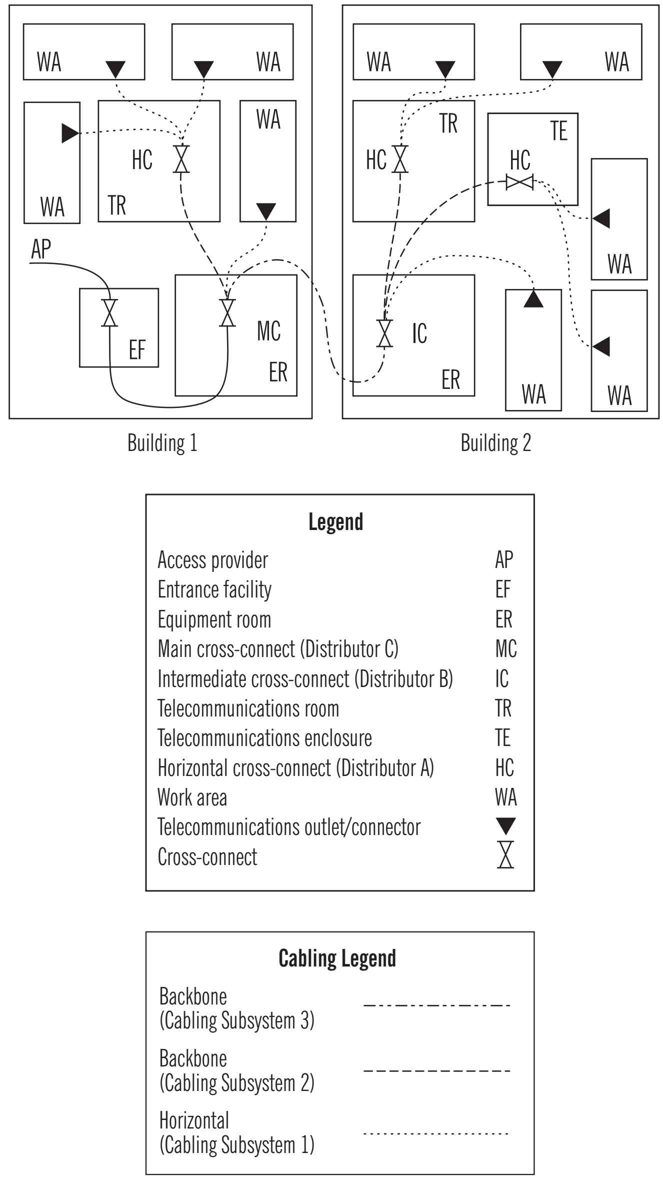


Figure 5 – Model for a commercial building telecommunications cabling system

ANSI/TIA-568-C.1 Standard

Section Contents

ANSI/TIA-568-C.1

Commercial Building Telecommunications Cabling Standard

Entrance Facilities

- Entrance facilities (EFs) contain the cables, network demarcation point(s), connecting hardware, protection devices and other equipment that connects to the access provider (AP) or private network cabling.
- Entrance facilities include connections between outside plant and inside building cabling.

Equipment Rooms

- Equipment rooms (ERs) are considered to be distinct from telecommunications rooms (TRs) and telecommunications enclosures (TEs) because of the nature or complexity of the equipment they contain. An ER may alternatively provide any or all of the functions of a TR or TE.
- The main cross-connect (MC, Distributor C) of a commercial building is located in an ER. Intermediate cross-connects (ICs, Distributor B), horizontal cross-connects (HCs, Distributor A), or both, of a commercial building may also be located in an ER.

Telecommunications Rooms (TRs) and Telecommunications Enclosures (TEs)

- Telecommunications rooms and enclosures provide a common access point for backbone and building pathways (see Figure 5) and cabling used for cross-connection.
- The horizontal cross-connect (HC, Distributor A) of a commercial building is located in a TR or TE. The main cross-connect (MC, Distributor C) and intermediate cross-connects (IC, Distributor B) of a commercial building may also be located in a TR. The TR and any TE should be located on the same floor as the work areas served.
- The telecommunications enclosure (TE) is intended to serve a smaller floor area than a TR and may be used in addition to the “minimum one TR per floor” rule.

Centralized Optical Fiber Cabling (see Figure 6)

- Centralized optical fiber cabling is designed as an alternative to the optical cross-connect located in the TR or TE in support of installing centralized electronics.
- It provides connections from work areas (WAs) to centralized cross-connects by allowing the use of pull-through cables and the use of an interconnect or splice in the TR or TE.
- The maximum allowed distance for a pull-through cable is 90 m (295 ft.).

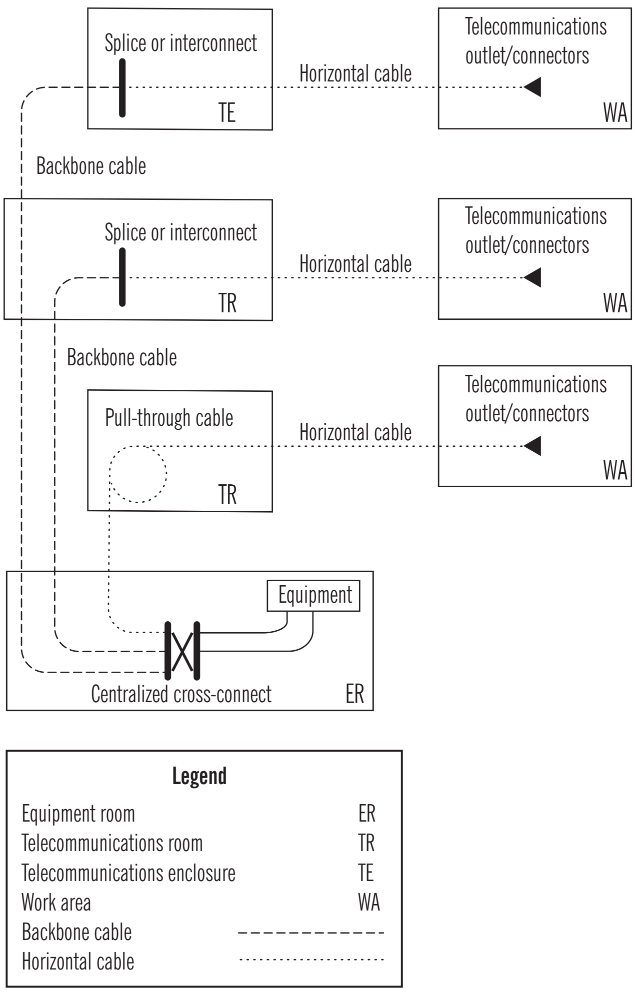


Figure 6 – Centralized optical fiber cabling

Backbone Cabling (Cabling Subsystems 2 and 3)

- Provides interconnections between entrance facilities (EFs), access provider (AP) spaces, service provider (SP) spaces, common equipment rooms (CERs), common telecommunications rooms (CTRs), equipment rooms (ERs), telecommunications rooms (TRs) and telecommunications enclosures (TEs) (see Figure 5)
- Ensures that the backbone cabling shall meet the requirements of ANSI/TIA-568-C.0 Cabling Subsystem 2 and Cabling Subsystem 3
- Uses a star topology (see Figure 7)
- Allows for no more than two hierarchical levels of cross-connects

Length and Maximum Distances

- Backbone cabling length extends from the termination of the media at the MC to an IC or HC.
- Cabling lengths are dependent on the application and the media chosen. They are found in the previous section covering ANSI/TIA-568-C.0 (see Tables 1, 2 and 3).
- The length of the cross-connect jumpers and patch cords in the MC or IC should not exceed 20 m (66 ft.).
- The length of the cord used to connect telecommunications equipment directly to the MC or IC should not exceed 30 m (98 ft.).

ANSI/TIA-568-C.1 Standard

Recognized Cabling

The recognized media, which shall be used individually or in combination, are:

- 100-ohm balanced twisted-pair cabling (Category 3, 5e, 6 or 6A)
- Multimode optical fiber cabling: 850-nm laser-optimized 50/125 µm is recommended; 62.5/125 µm and 50/125 µm are allowed
- Single-mode optical fiber cabling.

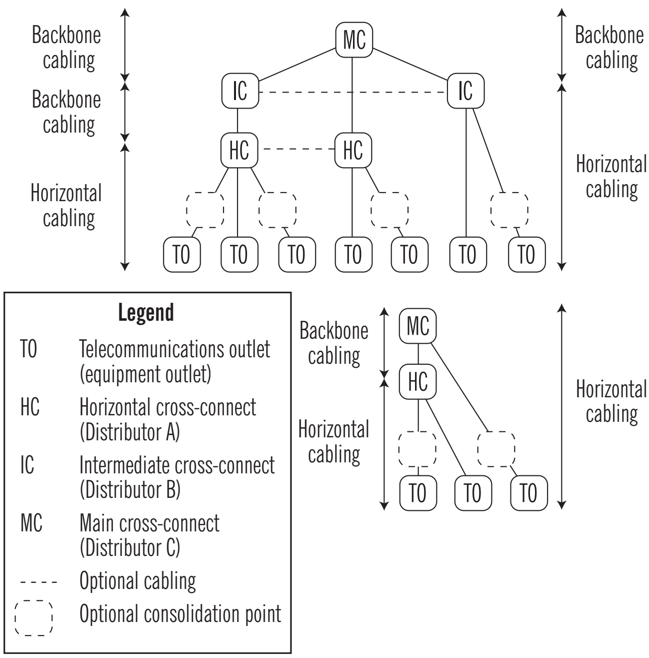


Figure 7 – Commercial building hierarchical star topology

Horizontal Cabling (Cabling Subsystem 1)

- Horizontal cabling (see Figure 8) includes horizontal cable, telecommunications outlets and connectors in the work area (WA); mechanical terminations and patch cords or jumpers located in a telecommunications room (TR) or telecommunications enclosure (TE); and may incorporate multiuser telecommunications outlet assemblies (MUTOAs) and consolidation points (CPs).
- A minimum of two permanent links shall be provided for each work area.
- Each 4-pair cable at the equipment outlet shall be terminated in an 8-position modular jack.
- Optical fibers at the equipment outlet shall be terminated to a duplex optical fiber outlet and connector.
- Horizontal cabling uses a star topology.
- The maximum horizontal cable length shall be 90 m (295 ft.), independent of media type. If a MUTOA is deployed, the maximum horizontal balanced twisted-pair copper cable length shall be reduced in accordance with Table 6 (page 14.9).
- The length of the cross-connect jumpers and patch cords that connect horizontal cabling with equipment or backbone cabling should not exceed 5 m (16 ft.).
- For each horizontal channel, the total length allowed for cords in the WA, plus patch cords or jumpers and equipment cords in the TR or TE, shall not exceed 10 m (33 ft.) unless a MUTOA is used.

Recognized Cabling

The recognized media, which shall be used individually or in combination, are:

- 4-pair 100-ohm unshielded or shielded twisted-pair cabling (Category 3, 5e, 6 or 6A)
- Multimode optical fiber cabling, 2 fiber (or higher count)
- Single-mode optical fiber cabling, 2 fiber (or higher count).

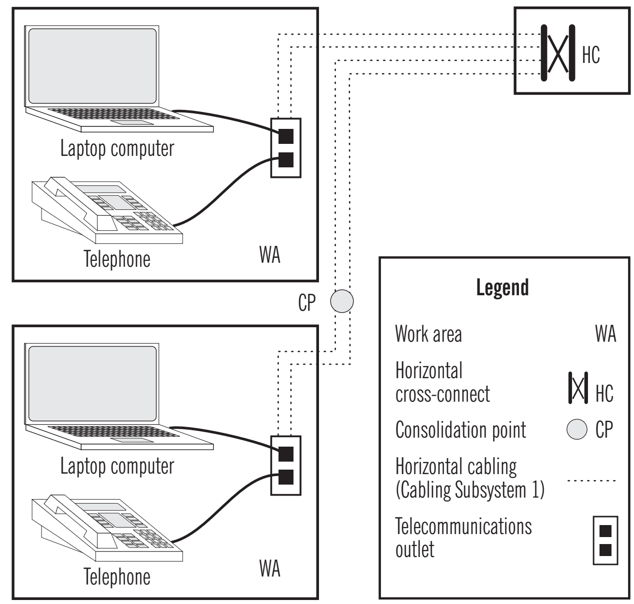


Figure 8 – Typical horizontal and work area cabling using star topology

Work Area

- The telecommunications outlet and connector shall meet the requirements of ANSI/TIA-568-C.0.
- The work area (WA) components extend from the telecommunications outlet/connector end of the horizontal cabling system to the WA equipment.
- When application-specific adapters are needed at the WA, they shall be external to the telecommunications outlet and connector.

ANSI/TIA-568-C.1 Standard

Open Office Cabling (MUTOA)

Open office design practices use multiuser telecommunications outlet assemblies (MUTOAs), consolidation points (CPs) or both to provide flexible layouts. MUTOAs allow horizontal cabling to remain intact when the open office plan is changed.

- WA cords originating from the MUTOA should be routed through WA pathways (e.g., furniture pathways).
- The WA cables shall be connected directly to workstation equipment without the use of any additional intermediate connections (see Figure 9).
- MUTOAs shall be located in fully accessible, permanent locations, such as building columns and permanent walls. They should not be located in ceiling spaces, obstructed areas or in furniture unless the furniture is secured to the building structure.

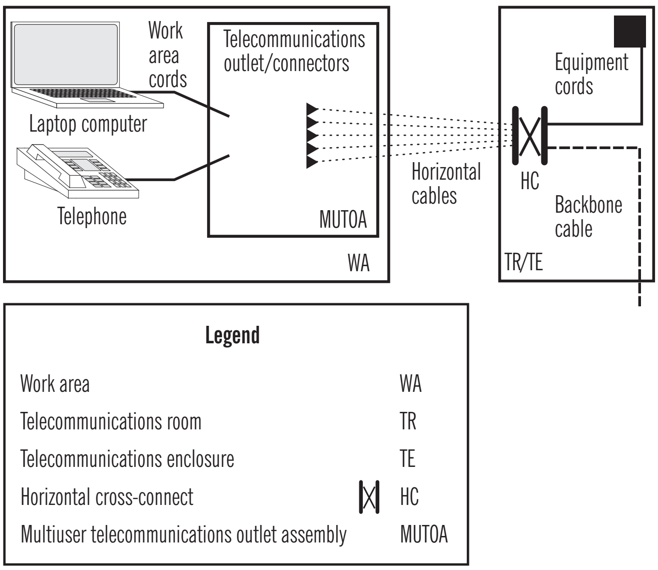


Figure 9 – Multiuser telecommunications outlet assembly (MUTOA) application

Maximum Work Area Cord Lengths

- Balanced twisted-pair WA cables: the maximum cord length used in the context of MUTOAs and open office furniture is as follows in Table 6.
- Optical fiber WA cords: the maximum horizontal cabling length is not affected by the deployment of a MUTOA.

Maximum Length of Horizontal Cables and Work Area Cords				
	24 AWG Cords		26 AWG Cords	
Length of horizontal cable	Maximum length of work area cord	Maximum combined length of work area cord, patch cords and equipment cord	Maximum length of work area cord	Maximum combined length of work area cord, patch cords and equipment cord
H m (ft.)	W m (ft.)	C m (ft.)	W m (ft.)	C m (ft.)
90 (295)	5 (16)	10 (33)	4 (13)	8 (26)
85 (279)	9 (30)	14 (46)	7 (23)	11 (35)
80 (262)	13 (44)	18 (59)	11 (35)	15 (49)
75 (246)	17 (57)	22 (72)	14 (46)	18 (59)
70 (230)	22 (72)	27 (89)	17 (56)	21 (70)

Table 6 – Maximum length of work area cord in relation to horizontal cable

Consolidation Point (CP)

The CP is an interconnection point within the horizontal cabling. It differs from the MUTOA in that a CP requires an additional connection for each horizontal cable run. It may be useful when reconfiguration is frequent, but not so frequent as to require the flexibility of a MUTOA (see Figure 10).

- The CP should be located at least 15 m (49 ft.) from the TR or TE.
- Cross-connections shall not be used at a CP.
- Each horizontal cable extending to the WA outlet from the CP shall be terminated to a telecommunications outlet/connector or MUTOA.
- CPs shall be located in fully accessible, permanent locations such as building columns and permanent walls. They should not be located in obstructed areas or in furniture unless the furniture is secured to the building structure.

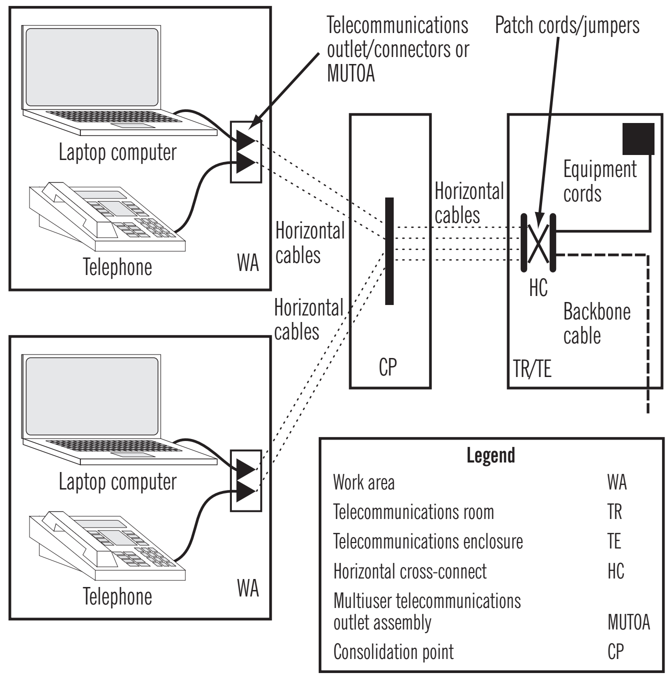


Figure 10 – Application of consolidation point

ANSI/TIA-568-C.2 Standard

Purpose of the ANSI/TIA-568-C.2 Standard

This standard includes component and cabling specifications as well as testing requirements for copper cabling, including Category 3, Category 5e, Category 6 and Category 6A. It recommends Category 5e to support 100 MHz applications. By using one laboratory test method to define all categories of connecting hardware, the standard introduces coupling attenuation parameters that are under study for characterizing radiated peak power generated by common-mode currents for screened cables. Balanced twisted-pair channel and permanent performance requirements were moved to this document.

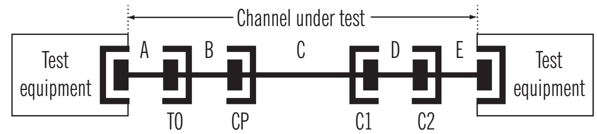
Section Contents

ANSI/TIA-568-C.2

Balanced Twisted-Pair Telecommunications Cabling and Components Standard

Channel and Permanent Link Test Configurations

For the purpose of testing twisted-pair cabling systems, the worst-case cabling channel configuration is assumed to contain a telecommunications outlet and connector, a transition point, 90 meters of twisted-pair cable, a cross-connect consisting of two blocks or panels and a total of 10 meters of patch cords. The figure below shows the relationship of these components.



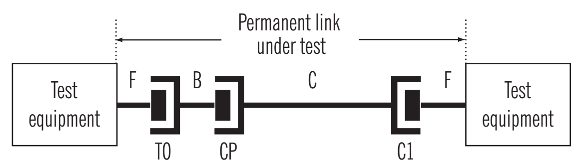
Legend

Cables and cords		Connecting hardware	
Work area cord	A	Telecommunications outlet/connector	TO
Optional consolidation point cabling	B	Optional consolidation point connector	CP
Horizontal cabling	C	Horizontal cross-connect or interconnect	C1, C2
Patch cord or jumper cable	D		
Telecommunications room equipment cord	E		

Maximum length	
B + C	90 m (295 ft.)
A + D + E	10 m (32.8 ft.)

Figure 11 – Channel test configuration

The permanent link test configuration includes the horizontal distribution cable, telecommunications outlet and connector or transition point and one horizontal cross-connect component including the mated connections. This is assumed to be the permanent part of a link. The channel is comprised of the permanent link plus cross-connect equipment, user equipment cord and cross-connect patch cable.



Legend

Cables and cords		Connecting hardware	
Test equipment cord	F	Telecommunications outlet/connector	TO
Optional consolidation point cabling	B	Optional consolidation point connector	CP
Horizontal cabling	C	Horizontal cross-connect or interconnect	C1

Maximum length	
B + C	90 m (295 ft.)

Figure 12 – Permanent link test configuration

ANSI/TIA-568-C.2 Standard

Definitions of Electrical Parameters

Return loss: A measure of the degree of impedance mismatch between two impedances. It is the ratio, expressed in decibels, of the amplitude of a reflected wave echo to the amplitude of the main wave at the junction of a transmission line and a terminating impedance.

Insertion loss: This term has replaced the term "attenuation" (ATTN). It is a measure of the decrease of signal strength as it travels down the media.

NEXT loss (near-end crosstalk): A measure of the unwanted signal coupling from a transmitter at the near-end into a neighboring (nonenergized) pair measured at the near-end.

PSNEXT loss (powersum near-end crosstalk): A computation of the unwanted signal coupling from multiple transmitters at the near-end into a neighboring (nonenergized) pair measured at the near-end.

FEXT loss (far-end crosstalk): A measure of the unwanted signal coupling from a transmitter at the near-end into a neighboring pair measured at the far-end.

ACRF (attenuation to crosstalk ratio, far-end) or ELFEXT (equal-level far-end crosstalk): A measure of the unwanted signal coupling from a transmitter at the near-end into a neighboring pair measured at the far-end, relative to the received signal level measured on that same pair.

PSFEXT loss (powersum far-end crosstalk): A computation of the unwanted signal coupling from multiple transmitters at the near-end into a neighboring pair measured at the far-end.

PSACRF (powersum attenuation to crosstalk ratio, far-end) or PSELFEXT (powersum equal-level far-end crosstalk): A computation of the unwanted signal coupling from multiple transmitters at the near-end into a neighboring pair measured at the far-end, relative to the received signal level measured on that same pair.

Propagation delay: The time needed for the transmission of signal to travel the length of a single pair.

Propagation delay skew: The difference between the propagation delay of any two pairs within the same cable sheath. Delay skew is caused primarily because twisted-pair cable is designed to have different twists per foot (lay lengths). Delay skew could cause data transmitted over one wire pair to arrive out of sync with data over another wire pair.

ANEXT loss (alien near-end crosstalk): A measure of signal coupling from a near-end disturbing pair into a disturbed pair of a neighboring cable or connector pair or part thereof, measured at the near-end.

PSANEXT loss (powersum alien near-end crosstalk): A computation of signal coupling from multiple near-end disturbing pairs into a disturbed pair of a neighboring channel, cable or connector pair or part thereof, measured at the near-end.

AFEXT loss (alien far-end crosstalk): A measure of signal coupling from a near-end disturbing pair into a disturbed pair of a neighboring cable or connector pair or part thereof, measured at the far-end.

PSAFEXT loss (powersum alien far-end crosstalk): A computation of signal coupling from multiple near-end disturbing channel pairs into a disturbed pair of a neighboring channel or part thereof, measured at the far-end.

PSAACRF (powersum alien attenuation to crosstalk ratio, far-end) or PSAELFEXT (powersum alien equal-level far-end crosstalk): A computation of signal coupling from multiple pairs of disturbing channels to a disturbed pair in another channel measured at the far-end and relative to the received signal level in the disturbed pair at the far-end.

Recognized Categories of Balanced Twisted-Pair Cabling and Components

As data transmission rates have increased, higher performance twisted-pair cabling has become a necessity. In addition, some means of classifying horizontal twisted-pair cables and connecting hardware by performance capability had to be established. These capabilities have been broken down to a series of categories. The following categories are currently recognized.

Category 3: Cables and connecting hardware with transmission parameters characterized up to 16 MHz

Category 5e: Cables and connecting hardware with transmission parameters characterized up to 100 MHz

Category 6: Cables and connecting hardware with transmission parameters characterized up to 250 MHz

Category 6A: Cables and connecting hardware with transmission parameters characterized up to 500 MHz. Additionally, requirements for alien crosstalk are specified in order to support 10GBASE-T transmission systems.

The following tables show the performance limits for channel, permanent link and twisted-pair cable for Category 3, Category 5e, Category 6 and Category 6A.

Channel Transmission Performance

The following tables reflect the various mitigating factors that need to be taken into consideration when calculating a channel's transmission performance.

Channel Return Loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	17.0	19.0	19.0
4.00	-	17.0	19.0	19.0
8.00	-	17.0	19.0	19.0
10.00	-	17.0	19.0	19.0
16.00	-	17.0	18.0	18.0
20.00	-	17.0	17.5	17.5
25.00	-	16.0	17.0	17.0
31.25	-	15.1	16.5	16.5
62.50	-	12.1	14.0	14.0
100.00	-	10.0	12.0	12.0
200.00	-	-	9.0	9.0
250.00	-	-	8.0	8.0
300.00	-	-	-	7.2
400.00	-	-	-	6.0
500.00	-	-	-	6.0

Table 7 – Minimum channel return loss

Channel Insertion Loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	3.0	2.2	2.1	2.3
4.00	6.5	4.5	4.0	4.2
8.00	9.8	6.3	5.7	5.8
10.00	11.2	7.1	6.3	6.5
16.00	14.9	9.1	8.0	8.2
20.00	-	10.2	9.0	9.2
25.00	-	11.4	10.1	10.2
31.25	-	12.9	11.4	11.5
62.50	-	18.6	16.5	16.4
100.00	-	24.0	21.3	20.9
200.00	-	-	31.5	30.1
250.00	-	-	35.9	33.9
300.00	-	-	-	37.4
400.00	-	-	-	43.7
500.00	-	-	-	49.3

Table 8 – Maximum channel insertion loss

ANSI/TIA-568-C.2 Standard

Channel NEXT Loss (Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	39.1	60.0	65.0	65.0
4.00	29.3	53.5	63.0	63.0
8.00	24.3	48.6	58.2	58.2
10.00	22.7	47.0	56.6	56.6
16.00	19.3	43.6	53.2	53.2
20.00	-	42.0	51.6	51.6
25.00	-	40.3	50.0	50.0
31.25	-	38.7	48.4	48.4
62.50	-	33.6	43.4	43.4
100.00	-	30.1	39.9	39.9
200.00	-	-	34.8	34.8
250.00	-	-	33.1	33.1
300.00	-	-	-	31.7
400.00	-	-	-	28.7
500.00	-	-	-	26.1

Table 9 – Minimum channel NEXT loss

Channel PSNEXT Loss (Powersum Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	57.0	62.0	62.0
4.00	-	50.5	60.5	60.5
8.00	-	45.6	55.6	55.6
10.00	-	44.0	54.0	54.0
16.00	-	40.6	50.6	50.6
20.00	-	39.0	49.0	49.0
25.00	-	37.3	47.3	47.3
31.25	-	35.7	45.7	45.7
62.50	-	30.6	40.6	40.6
100.00	-	27.1	37.1	37.1
200.00	-	-	31.9	31.9
250.00	-	-	30.2	30.2
300.00	-	-	-	28.8
400.00	-	-	-	25.8
500.00	-	-	-	23.2

Table 10 – Minimum channel PSNEXT loss

Channel ACRF (Attenuation to Crosstalk Ratio, Far-End) or ELFEXT (Equal-Level Far-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	57.4	63.3	63.3
4.00	-	45.4	51.2	51.2
8.00	-	39.3	45.2	45.2
10.00	-	37.4	43.3	43.3
16.00	-	33.3	39.2	39.2
20.00	-	31.4	37.2	37.2
25.00	-	29.4	35.3	35.3
31.25	-	27.5	33.4	33.4
62.50	-	21.5	27.3	27.3
100.00	-	17.4	23.3	23.3
200.00	-	-	17.2	17.2
250.00	-	-	15.3	15.3
300.00	-	-	-	13.7
400.00	-	-	-	11.2
500.00	-	-	-	9.3

Table 11 – Minimum channel ACRF

Channel PSACRF (Powersum Insertion Loss to Alien Crosstalk Ratio Far-End) or PSELFEXT (Powersum Equal-Level Far-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	54.4	60.3	60.3
4.00	-	42.4	48.2	48.2
8.00	-	36.3	42.2	42.2
10.00	-	34.4	40.3	40.3
16.00	-	30.3	36.2	36.2
20.00	-	28.4	34.2	34.2
25.00	-	26.4	32.3	32.3
31.25	-	24.5	30.4	30.4
62.50	-	18.5	24.3	24.3
100.00	-	14.4	20.3	20.3
200.00	-	-	14.2	14.2
250.00	-	-	12.3	12.3
300.00	-	-	-	10.7
400.00	-	-	-	8.2
500.00	-	-	-	6.3

Table 12 – Minimum channel PSACRF

Channel Propagation Delay Skew

Channel propagation delay skew shall be less than 50 ns for all frequencies from 1 MHz to the upper frequency limit of the Category. For field-testing channels, it is sufficient to test at 10 MHz only and channel propagation delay skew at 10 MHz shall not exceed 50 ns.

Channel Propagation Delay				
Frequency (MHz)	Category 3 (ns)	Category 5e (ns)	Category 6 (ns)	Category 6A (ns)
1.00	580	580	580	580
4.00	562	562	562	562
8.00	557	557	557	557
10.00	555	555	555	555
16.00	553	553	553	553
20.00	-	552	552	552
25.00	-	551	551	551
31.25	-	550	550	550
62.50	-	549	549	549
100.00	-	548	548	548
200.00	-	-	547	547
250.00	-	-	546	546
300.00	-	-	-	546
400.00	-	-	-	546
500.00	-	-	-	546

Table 13 – Maximum channel propagation delay

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ANSI/TIA-568-C.2 Standard

Channel PSANEXT Loss (Powersum Alien Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	-	-	67.0
4.00	-	-	-	67.0
8.00	-	-	-	67.0
10.00	-	-	-	67.0
16.00	-	-	-	67.0
20.00	-	-	-	67.0
25.00	-	-	-	66.0
31.25	-	-	-	65.1
62.50	-	-	-	62.0
100.00	-	-	-	60.0
200.00	-	-	-	55.5
250.00	-	-	-	54.0
300.00	-	-	-	52.8
400.00	-	-	-	51.0
500.00	-	-	-	49.5

Table 14 – Minimum channel PSANEXT loss

Channel PSAACRF (Powersum Insertion Loss to Alien Crosstalk Ratio Far-End) or PSAELFEXT (Powersum Alien Equal Level Far-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	-	-	67.0
4.00	-	-	-	65.0
8.00	-	-	-	58.9
10.00	-	-	-	57.0
16.00	-	-	-	52.9
20.00	-	-	-	51.0
25.00	-	-	-	49.0
31.25	-	-	-	47.1
62.50	-	-	-	47.1
100.00	-	-	-	37.0
200.00	-	-	-	31.0
250.00	-	-	-	29.0
300.00	-	-	-	27.5
400.00	-	-	-	25.0
500.00	-	-	-	23.0

Table 15 – Minimum channel PSAACRF loss

Augmented Category 6 Channel Requirements

Note: The requirements for ISO (the International Organization for Standardization) 11801 Class E_A are more demanding compared to the TIA Augmented Category 6 requirements. Anixter's Infrastructure Solutions Lab tests to the more stringent ISO 11801 standards.

ISO Compared to TIA		
Characteristics 500 MHz (dB)	ISO Class E_A	TIA Augumented Category 6
PSNEXT Loss	24.8 dB	23.2 dB
NEXT Loss	27.9 dB	26.1 dB
PSANEXT Loss	49.5 dB	49.5 dB
Return Loss	6.0 dB	6.0 dB
Insertion Loss	49.3 dB	49.3 dB
Referred to by IEEE	Yes	No

Table 16 – ISO versus TIA performance comparison

Note: See the IEEE 802.3an and ISO Class E_A section of this book for more information on 10 Gigabit cabling and protocol methods.

Permanent Link Transmission Performance

The tables below show the requirements intended for performance validation according to the specific cabling Category.

Permanent Link Return Loss				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	19.0	19.1	19.1
4.00	-	19.0	21.0	21.0
8.00	-	19.0	21.0	21.0
10.00	-	19.0	21.0	21.0
16.00	-	19.0	20.0	20.0
20.00	-	19.0	20.0	20.0
25.00	-	19.0	19.5	19.5
31.25	-	17.1	18.5	18.5
62.50	-	14.1	16.0	16.0
100.00	-	12.0	14.0	14.0
200.00	-	-	11.0	11.0
250.00	-	-	10.0	10.0
300.00	-	-	-	9.2
400.00	-	-	-	8.0
500.00	-	-	-	8.0

Table 17 – Minimum permanent link return loss

Permanent Link Insertion Loss				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	2.6	2.1	1.9	1.9
4.00	5.6	3.9	3.5	3.5
8.00	8.5	5.5	5.0	5.0
10.00	9.7	6.2	5.5	5.5
16.00	13.0	7.9	7.0	7.0
20.00	-	8.9	7.9	7.8
25.00	-	10.0	8.9	8.8
31.25	-	11.2	10.0	9.8
62.50	-	16.2	14.4	14.0
100.00	-	21.0	18.6	18.0
200.00	-	-	27.4	26.1
250.00	-	-	31.1	29.5
300.00	-	-	-	32.7
400.00	-	-	-	38.4
500.00	-	-	-	43.8

Table 18 – Maximum permanent link insertion loss

ANSI/TIA-568-C.2 Standard

Permanent Link NEXT Loss (Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	40.1	60.0	65.0	65.0
4.00	30.7	54.8	64.1	64.1
8.00	25.9	50.0	59.4	59.4
10.00	24.3	48.5	57.8	57.8
16.00	21.0	45.2	54.6	54.6
20.00	-	43.7	53.1	53.1
25.00	-	42.1	51.5	51.5
31.25	-	40.5	50.0	50.0
62.50	-	35.7	45.1	45.1
100.00	-	32.3	41.8	41.8
200.00	-	-	36.9	36.9
250.00	-	-	35.3	35.3
300.00	-	-	-	34.0
400.00	-	-	-	29.9
500.00	-	-	-	26.7

Table 19 – Minimum permanent link NEXT loss

Permanent Link PSNEXT Loss (Powersum Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	57.0	62.0	62.0
4.00	-	51.8	61.8	61.8
8.00	-	47.0	57.0	57.0
10.00	-	45.5	55.5	55.5
16.00	-	42.2	52.2	52.2
20.00	-	40.7	50.7	50.7
25.00	-	39.1	49.1	49.1
31.25	-	37.5	47.5	47.5
62.50	-	32.7	42.7	42.7
100.00	-	29.3	39.3	39.3
200.00	-	-	34.3	34.3
250.00	-	-	32.7	32.7
300.00	-	-	-	31.4
400.00	-	-	-	27.1
500.00	-	-	-	23.8

Table 20 – Minimum permanent link PSNEXT loss

Permanent Link ACRF (Attenuation to Crosstalk Ratio, Far-End) or ELFEXT (Equal-Level Far-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	58.6	64.2	64.2
4.00	-	46.6	52.1	52.1
8.00	-	40.6	46.1	46.1
10.00	-	38.6	44.2	44.2
16.00	-	34.5	40.1	40.1
20.00	-	32.6	38.2	38.2
25.00	-	30.7	36.2	36.2
31.25	-	28.7	34.3	34.3
62.50	-	22.7	28.3	28.3
100.00	-	18.6	24.2	24.2
200.00	-	-	18.2	18.2
250.00	-	-	16.2	16.2
300.00	-	-	-	14.6
400.00	-	-	-	12.1
500.00	-	-	-	10.2

Table 21 – Minimum permanent link ACRF

Permanent Link PSACRF (Powersum Insertion Loss to Alien Crosstalk Ratio Far-End) or PSELFEXT (Powersum Equal Level Far-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	55.6	61.2	61.2
4.00	-	43.6	49.1	49.1
8.00	-	37.5	43.1	43.1
10.00	-	35.6	41.2	41.2
16.00	-	31.5	37.1	37.1
20.00	-	29.6	35.2	35.2
25.00	-	27.7	33.2	33.2
31.25	-	25.7	31.3	31.3
62.50	-	19.7	25.3	25.3
100.00	-	15.6	21.2	21.2
200.00	-	-	15.2	15.2
250.00	-	-	13.2	13.2
300.00	-	-	-	11.6
400.00	-	-	-	9.1
500.00	-	-	-	7.2

Table 22 – Minimum permanent link PSACRF

Permanent Link Propagation Delay				
Frequency (MHz)	Category 3 (ns)	Category 5e (ns)	Category 6 (ns)	Category 6A (ns)
1.00	521	521	521	521
4.00	504	504	504	504
8.00	500	500	500	500
10.00	498	498	498	498
16.00	496	496	496	496
20.00	-	495	495	495
25.00	-	495	495	495
31.25	-	494	494	494
62.50	-	492	492	492
100.00	-	491	491	491
200.00	-	-	490	490
250.00	-	-	490	490
300.00	-	-	-	490
400.00	-	-	-	490
500.00	-	-	-	490

Table 23 – Maximum permanent link propagation delay

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ANSI/TIA-568-C.2 Standard

Permanent Link Propagation Delay Skew

Permanent link propagation delay skew shall be less than 44 ns for all frequencies from 1 MHz to the upper frequency limit of the Category. For field-testing channels, it is sufficient to test at 10 MHz only and permanent link propagation delay skew at 10 MHz shall not exceed 50 ns.

Permanent Link PSANEXT Loss (Powersum Alien Near-End Crosstalk)

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	-	-	67.0
4.00	-	-	-	67.0
8.00	-	-	-	67.0
10.00	-	-	-	67.0
16.00	-	-	-	67.0
20.00	-	-	-	67.0
25.00	-	-	-	66.0
31.25	-	-	-	65.1
62.50	-	-	-	62.0
100.00	-	-	-	60.0
200.00	-	-	-	55.5
250.00	-	-	-	54.0
300.00	-	-	-	52.8
400.00	-	-	-	51.0
500.00	-	-	-	49.5

Table 24 – Minimum permanent link PSANEXT loss

Permanent Link PSAACRF (Powersum Insertion Loss to Alien Crosstalk Ratio Far-End) or PSAELFEXT (Powersum Alien Equal-Level Far-End Crosstalk)

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	-	-	67.0
4.00	-	-	-	65.7
8.00	-	-	-	59.6
10.00	-	-	-	57.7
16.00	-	-	-	53.6
20.00	-	-	-	51.7
25.00	-	-	-	49.7
31.25	-	-	-	47.8
62.50	-	-	-	41.8
100.00	-	-	-	37.7
200.00	-	-	-	31.7
250.00	-	-	-	29.7
300.00	-	-	-	28.2
400.00	-	-	-	25.7
500.00	-	-	-	23.7

Table 25 – Minimum permanent link PSAACRF loss

Horizontal Cable Transmission Performance

The following tables show the performance specifications for horizontal cable transmission performance.

Horizontal Cable Return Loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	20.0	20.0	20.0
4.00	-	23.0	23.0	23.0
8.00	-	24.5	24.5	24.5
10.00	-	25.0	25.0	25.0
16.00	-	25.0	25.0	25.0
20.00	-	25.0	25.0	25.0
25.00	-	24.3	24.3	24.3
31.25	-	23.6	23.6	23.6
62.50	-	21.5	21.5	21.5
100.00	-	20.1	20.1	20.1
200.00	-	-	18.0	18.0
250.00	-	-	17.3	17.3
300.00	-	-	-	16.8
400.00	-	-	-	15.9
500.00	-	-	-	15.2

Table 26 – Minimum horizontal cable return loss

Horizontal Cable Insertion Loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
0.772	2.2	-	-	-
1.00	2.6	2.0	2.0	2.1
4.00	5.6	4.1	3.8	3.8
8.00	8.5	5.8	5.3	5.3
10.00	9.7	6.5	6.0	5.9
16.00	13.1	8.2	7.6	7.5
20.00	-	9.3	8.5	8.4
25.00	-	10.4	9.5	9.4
31.25	-	11.7	10.7	10.5
62.50	-	17.0	15.4	15.0
100.00	-	22.0	19.8	19.1
200.00	-	-	29.0	27.6
250.00	-	-	32.8	31.1
300.00	-	-	-	34.3
400.00	-	-	-	40.1
500.00	-	-	-	45.3

Table 27 – Maximum horizontal cable insertion loss

ANSI/TIA-568-C.2 Standard

Horizontal Cable NEXT Loss (Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
0.772	43.0	-	-	-
1.00	41.3	65.3	74.3	74.3
4.00	32.3	56.3	65.3	65.3
8.00	27.8	51.8	60.8	60.8
10.00	26.3	50.3	59.3	59.3
16.00	23.2	47.2	56.2	56.2
20.00	-	45.8	54.8	54.8
25.00	-	44.3	53.3	53.3
31.25	-	42.9	51.9	51.9
62.50	-	38.4	47.4	47.4
100.00	-	35.3	44.3	44.3
200.00	-	-	39.8	39.8
250.00	-	-	39.3	38.3
300.00	-	-	-	37.1
400.00	-	-	-	35.3
500.00	-	-	-	33.8

Table 28 – Minimum horizontal cable NEXT loss

Horizontal Cable PSNEXT Loss (Powersum Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	62.3	72.3	72.3
4.00	-	53.3	63.3	63.3
8.00	-	48.8	58.8	58.8
10.00	-	47.3	57.3	57.3
16.00	-	44.2	54.2	54.2
20.00	-	42.8	52.8	52.8
25.00	-	41.3	51.3	51.3
31.25	-	39.9	49.9	49.9
62.50	-	35.4	45.4	45.4
100.00	-	32.3	42.3	42.3
200.00	-	-	37.8	37.8
250.00	-	-	36.3	36.3
300.00	-	-	-	35.1
400.00	-	-	-	33.3
500.00	-	-	-	31.8

Table 29 – Minimum horizontal cable PSNEXT loss

Horizontal Cable ACRF (Attenuation to Crosstalk Ratio, Far-End) or ELFEXT (Equal-Level Far-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	63.8	67.8	67.8
4.00	-	51.8	55.8	55.8
8.00	-	45.7	49.7	49.7
10.00	-	43.8	47.8	47.8
16.00	-	39.7	43.7	43.7
20.00	-	37.8	41.8	41.8
25.00	-	35.8	39.8	39.8
31.25	-	33.9	37.9	37.9
62.50	-	27.9	31.9	31.9
100.00	-	23.8	27.8	27.8
200.00	-	-	21.8	21.8
250.00	-	-	19.8	19.8
300.00	-	-	-	18.3
400.00	-	-	-	15.8
500.00	-	-	-	13.8

Table 30 – Minimum horizontal cable ACRF

Horizontal Cable PSACRF (Powersum Insertion Loss to Alien Crosstalk Ratio Far-End) or PSELFEXT (Powersum Equal-Level Far-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	60.8	64.8	64.8
4.00	-	48.8	52.8	52.8
8.00	-	42.7	46.7	46.7
10.00	-	40.8	44.8	44.8
16.00	-	36.7	40.7	40.7
20.00	-	34.8	38.8	38.8
25.00	-	32.8	36.8	36.8
31.25	-	30.9	34.9	34.9
62.50	-	24.9	28.9	28.9
100.00	-	20.8	24.8	24.8
200.00	-	-	18.8	18.8
250.00	-	-	16.8	16.8
300.00	-	-	-	15.3
400.00	-	-	-	12.8
500.00	-	-	-	10.8

Table 31 – Minimum horizontal cable PSACRF

Horizontal Cable Propagation Delay Skew

Horizontal cable propagation delay skew shall be less than 45 ns/100 m for all frequencies from 1 MHz to the upper frequency limit of the Category.

Horizontal Cable Propagation Delay				
Frequency (MHz)	Category 3 (ns/100 m)	Category 5e (ns/100 m)	Category 6 (ns/100 m)	Category 6A (ns/100 m)
1.00	570	570	570	570
4.00	552	552	552	552
8.00	547	547	547	547
10.00	545	545	545	545
16.00	543	543	543	543
20.00	-	542	542	542
25.00	-	541	541	541
31.25	-	540	540	540
62.50	-	539	539	539
100.00	-	538	538	538
200.00	-	-	537	537
250.00	-	-	536	536
300.00	-	-	-	536
400.00	-	-	-	536
500.00	-	-	-	536

Table 32 – Maximum horizontal cable propagation delay

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ANSI/TIA-568-C.2 Standard

Horizontal Cable PSANEXT Loss (Powersum Alien Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	-	-	67.0
4.00	-	-	-	67.0
8.00	-	-	-	67.0
10.00	-	-	-	67.0
16.00	-	-	-	67.0
20.00	-	-	-	67.0
25.00	-	-	-	67.0
31.25	-	-	-	67.0
62.50	-	-	-	65.6
100.00	-	-	-	62.5
200.00	-	-	-	58.0
250.00	-	-	-	56.5
300.00	-	-	-	55.3
400.00	-	-	-	53.5
500.00	-	-	-	52.0

Table 33 – Minimum horizontal cable PSANEXT loss

Horizontal Cable PSAACRF (Powersum Insertion Loss to Alien Crosstalk Ratio Far-End) or PSAELFEXT (Powersum Alien Equal Level Far-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	-	-	67.0
4.00	-	-	-	66.2
8.00	-	-	-	60.1
10.00	-	-	-	58.2
16.00	-	-	-	54.1
20.00	-	-	-	52.2
25.00	-	-	-	50.2
31.25	-	-	-	48.3
62.50	-	-	-	42.3
100.00	-	-	-	38.2
200.00	-	-	-	32.2
250.00	-	-	-	30.2
300.00	-	-	-	28.7
400.00	-	-	-	26.2
500.00	-	-	-	24.2

Table 34 – Minimum horizontal cable PSAACRF loss

TIA Category 6 Versus Augmented Category 6				
	TIA Category 5e UTP	TIA Category 6 UTP	TIA Augmented Category 6 UTP	ISO Class E_A
Recognized by IEEE 802.3an	No	Yes	Yes	Yes
55 Meter Distance Support	No	Yes	Yes	Yes
100 Meter Distance Support	No	No	Yes	Yes
Extrapolated Test Limits for NEXT and PSNEXT to 500 MHz	No	No	No	Yes

Table 35 – IEEE 10GBASE-T application support

Note: This table compares current TIA Category 6 cabling with new TIA and ISO specifications for 10 Gigabit cabling. This table summarizes the various twisted-pair cabling options and their respective 10 Gigabit performance attributes as defined by the latest standards. Category 5e is not recognized as a viable cabling media to support 10 Gigabit transmission regardless of its installed cabling distance. Category 6 cabling will only support 10 Gigabit Ethernet at a maximum installed distance of 55 meters.

Bundled and Hybrid Cable

Bundled, wrapped or hybrid cables are allowed for use in horizontal cabling, provided that each individual cable type meets the TIA-568-C.2 transmission specifications and that the PSNEXT loss created by adjacent jacketed cables is 3 dB better than the normally allowed pair-to-pair NEXT for the cable type being tested. Color codes must follow individual cable standards to distinguish them from multipair twisted-pair backbone cabling.

Patch Cord Transmission Performance

Jumper and patch cord maximum length limitations:

20 m (66 ft.) in main cross-connect
20 m (66 ft.) in intermediate cross-connect
6 m (20 ft.) in telecommunications room
3 m (10 ft.) in the work area

Assembled patch cords: Insertion loss (attenuation): per 100 m (328 ft.) at 20° C = horizontal UTP cable insertion loss + 20 percent (due to stranded conductors) for all performance categories

Matrix of Backward Compatible Mated Component Performance					
		Category of Modular Connecting Hardware Performance			
		Category 3	Category 5e	Category 6	Category 6A
Modular Plug and Cord Performance	**Category 3**	Category 3	Category 3	Category 3	Category 3
	Category 5e	Category 3	Category 5e	Category 5e	Category 5e
	Category 6	Category 3	Category 5e	Category 6	Category 6
	Category 6A	Category 3	Category 5e	Category 6	Category 6A

Table 36 – The lowest rated component determines the rating of the permanent link or channel

Patch Cord Cable Construction

Stranded conductors for extended flex-life cables used for patch cords and cross-connect jumpers need to be of the same performance Category (or higher) as the horizontal cables they connect.

Patch Cord Return Loss				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	19.8	19.8	19.8
4.00	-	21.6	21.6	21.6
8.00	-	22.5	22.5	22.5
10.00	-	22.8	22.8	22.8
16.00	-	23.4	23.4	23.4
20.00	-	23.7	23.7	23.7
25.00	-	24.0	24.0	24.0
31.25	-	23.0	23.0	23.0
62.50	-	20.0	20.0	20.0
100.00	-	18.0	18.0	18.0
200.00	-	-	15.0	15.0
250.00	-	-	14.0	14.0
300.00	-	-	-	12.8
400.00	-	-	-	10.9
500.00	-	-	-	9.5

Table 37 – Minimum patch cord return loss

ANSI/TIA-568-C.2 Standard

2-Meter Patch Cord NEXT Loss (Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	65.0	65.0	65.0
4.00	-	65.0	65.0	65.0
8.00	-	60.6	65.0	65.0
10.00	-	58.7	65.0	65.0
16.00	-	54.7	62.0	62.0
20.00	-	52.8	60.1	60.1
25.00	-	50.9	58.1	58.2
31.25	-	49.0	56.2	56.3
62.50	-	43.2	50.4	50.4
100.00	-	39.3	46.4	46.4
200.00	-	-	40.6	40.7
250.00	-	-	38.8	38.9
300.00	-	-	-	36.2
400.00	-	-	-	31.9
500.00	-	-	-	28.4

Table 38 – Minimum 2-meter patch cord NEXT loss

5-Meter Patch Cord NEXT Loss (Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	65.0	65.0	65.0
4.00	-	64.5	65.0	65.0
8.00	-	58.6	65.0	65.0
10.00	-	56.7	64.5	64.5
16.00	-	52.8	60.5	60.5
20.00	-	50.9	58.6	58.7
25.00	-	49.1	56.8	56.8
31.25	-	47.2	54.9	54.9
62.50	-	41.6	49.2	49.2
100.00	-	37.8	45.3	45.4
200.00	-	-	39.8	39.9
250.00	-	-	38.1	38.1
300.00	-	-	-	35.9
400.00	-	-	-	32.1
500.00	-	-	-	29.0

Table 39 – Minimum 5-meter patch cord NEXT loss

10-Meter Patch Cord NEXT Loss (Near-End Crosstalk)				
Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	-	65.0	65.0	65.0
4.00	-	62.5	65.0	65.0
8.00	-	56.7	64.8	64.8
10.00	-	54.9	62.9	63.0
16.00	-	51.0	59.0	59.1
20.00	-	49.2	57.2	57.3
25.00	-	47.4	55.4	55.4
31.25	-	45.6	53.6	53.6
62.50	-	40.2	48.1	48.1
100.00	-	36.7	44.4	44.5
200.00	-	-	39.3	39.3
250.00	-	-	37.6	37.7
300.00	-	-	-	35.8
400.00	-	-	-	32.5
500.00	-	-	-	29.8

Table 40 – Minimum 10-meter patch cord NEXT loss

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ANSI/TIA-568-C.3 Standard

Purpose of the ANSI/TIA-568-C.3 Standard

The purpose of the ANSI/TIA-569-C.3 standard is to specify cable and component transmission performance requirements for premises optical fiber cabling. Although this standard is primarily intended to be used by manufacturers of optical cabling solutions, other groups such as end-users, designers and installers may also find it useful.

ANSI/TIA-568-C.3 Optical Fiber Cabling Components

Optical Fiber Cabling Systems				
Optical Fiber and Cable Type[2]	Wavelength (nm)	Maximum Attenuation (dB/km)	Minimum Overfilled Modal Bandwidth-Length Product (MHz • km)[1]	Minimum Effective Modal Bandwidth-Length Product (MHz • km)[1]
62.5/125 µm Multimode TIA 492AAAA (OM1)	850 1300	3.5 1.5	200 500	Not required Not required
50/125 µm Multimode TIA 492AAAB (OM2)	850 1300	3.5 1.5	500 500	Not required Not required
850-nm Laser-Optimized 50/125 µm Multimode TIA 492AAAC (OM3)	850 1300	3.5 1.5	1,500 500	2,000 Not required
Single-Mode Indoor-Outdoor TIA 492CAAA (OS1) TIA 492CAAB (OS2)[3]	1310 1550	0.5 0.5	- -	- -
Single-Mode Inside Plant TIA 492CAAA (OS1) TIA 492CAAB (OS2)[3]	1310 1550	1.0 1.0	- -	- -
Single-Mode Outside Plant TIA 492CAAA (OS1) TIA 492CAAB (OS2)[3]	1310 1550	0.5 0.5	- -	- -
NOTES				
1 – The bandwidth-length product, as measured by the fiber manufacturer, can be used to demonstrate compliance with this requirement.				
2 – The fiber designation (OM1, OM2, OM3, OS1 and OS2) corresponds to the designation of ISO/IEC 11801 or ISO/IEC 24702.				
3 – OS2 is commonly referred to as "low water peak" single-mode fiber and is characterized by having a low attenuation coefficient in the vicinity of 1383 nm.				

Table 41 – Optical fiber cable transmission performance parameters

Optical Fiber Bend Radius	
Fiber Type	Bend Radius
Small Inside Plant Cable (2–4 fibers)	1 in. (no load)
	2 in. (with load)
All Other Inside Plant Cable	10 x diameter (no load)
	15 x diameter (with load)
Outside Plant Cable	10 x diameter (no load)
	20 x diameter (with load)

Table 42 – Optical fiber bend radius

Outside plant cable must be water-blocked and have a minimum pull strength of 600 lb. (drop cable pull strength may be 300 lb.).

Optical Fiber Connector

No specified connector: 568SC and other duplex designs may be used in addition to the MPO or MTP array connectors.

Color Identification

Unless color coding is used for some other purpose, the connector strain relief and adapter housing should be identifiable by the following colors:

a) 850-nm laser-optimized 50/125 mm fiber – aqua
b) 50/125 mm fiber – black
c) 62.5/125 mm fiber – beige
d) Single-mode fiber – blue
e) Angled contact ferrule single-mode connectors – green

In addition, unless color coding is used for some other purpose, the connector plug body should be generically identified by the following colors, where possible:

a) Multimode – beige, black or aqua
b) Single-mode – blue
c) Angled contact ferrule single-mode connectors – green

Optical Fiber Telecommunications Outlet Required Features

- Capability to terminate minimum of two fibers into 568SC couplings or other duplex connection
- Means of securing fiber and maintaining minimum bend radius of 25 mm (1 in.)

Optical Fiber Splices, Fusion or Mechanical

Maximum insertion loss 0.3 dB

- Minimum return loss:
  - Multimode: 20 dB
  - Single-mode: 26 dB
  - Single-mode: 55 dB (analog CATV)

Optical Fiber Connector (mated pair)

- Maximum insertion loss 0.75 dB

Patch Cords

- Shall be dual fiber of the same type as the horizontal and backbone fiber
- Polarity shall be keyed duplex

For more information on Fibre Channel, download Anixter's Data Center Resource Guide at anixter.com/datacenterguide.

ANSI/TIA/EIA-569-B Standard

Purpose of the ANSI/TIA/EIA-569-B Standard

As the complexity of voice and data telecommunications has increased, standards have been established to ensure the operability, flexibility, manageability and longevity of these critical commercial support systems. Telecommunication systems now encompass voice, data and video transmission of business information, fire and security, audio, environmental and other intelligent building controls over media that include fiber optics, specialized copper data cabling, microwave and radio wave. This document concisely describes the architectural design elements of cabling pathways and dedicated rooms for telecommunications equipment.

A multitenant commercial building has a life expectancy of at least 50 years. Software, hardware and communications gear have a far shorter life span of one to five years. Moreover, in a multitenant environment, continuous moves, adds and changes are inevitable. Standards help to guide the design of current systems to ease future changes. By planning for the future, these standards intend to provide a generic structured cabling plant capable of running any voice or data application foreseeable in the next 10 to 15 years.

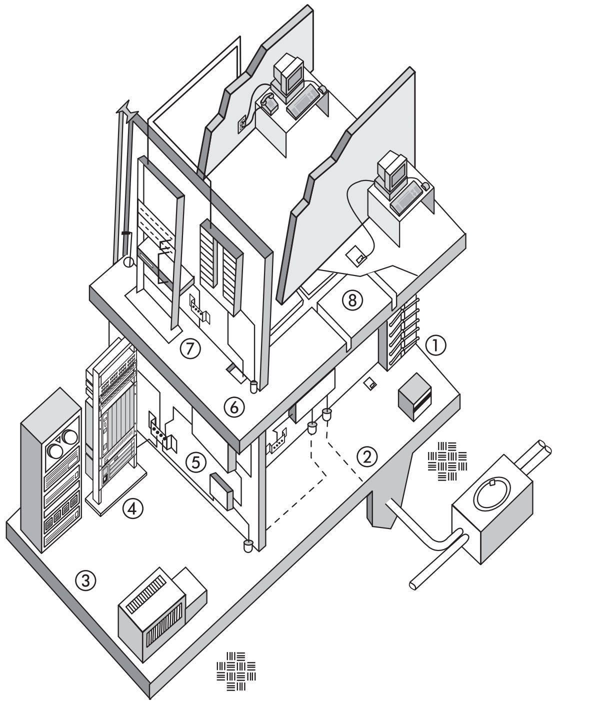
Abbreviations:

AWG	American Wire Gauge
V	Volts
A	Amps
kVA	Kilovolt ampere
V/m	Volts per meter

Section Contents

ANSI/TIA/EIA-569-B

Commercial Building Standard for Telecommunications Pathways and Spaces



1. Electric entrance	5. Voice equipment
2. Telco entrance	6. Telecommunications room
3. Telecommunications equipment room	7. Grounding and bonding
4. Data equipment	8. Underfloor system

Figure 13 – Pathways and spaces

ANSI/TIA/EIA-569-B Design Considerations

Entrance Facilities

Entrance facilities include the pathways for outside carrier services, interbuilding backbone, alternate entrance and antennae entrance. The entrance facilities consist of a termination field interfacing any outside cabling to the intrabuilding backbone cabling. The local telephone carrier is typically required to terminate cabling within 50 ft. of building penetration and to provide primary voltage protection.

In buildings larger than 20,000 usable sq. ft., a locked, dedicated, enclosed room is recommended. Beyond 70,000 sq. ft., a locked, dedicated room is required, with a plywood termination field provided on two walls.

In buildings up to 100,000 usable sq. ft., a wall-mounted termination field may serve as the entrance facility, using 3/4-in. plywood, 8 ft. high. Beyond 100,000 sq. ft., rack-mounted and free-standing frames may also be required. Minimum space requirements are given in Table 43 (page 14.21).

Service Entrance Pathways

For underground facilities, use a minimum 4-in. conduit or duct constructed of PVC type B, C or D, multiple plastic duct, galvanized steel or fiber glass with appropriate encasement. No more than two 90-degree manufactured bends are allowed (10 times the diameter). Drain slope should not be less than 12 in. per 100 ft. Recommended conduit fill varies, but should not exceed 40 percent for more than two cables. Maintenance holes (typically 3,500 lb./sq. in., concrete) must be equipped with sump, corrosion-protected pulling iron, cable racks, grounded ladder and only such power and light conductors as required for telecommunications support per NEC requirements.

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ANSI/TIA/EIA-569-B Standard

Entrance Room, Wall and Floor Space		
Gross Building Floor Space Served (ft.²/ m²)	Minimum Termination Wall Size Plywood Wall Field in. (mm)	Minimum Termination Floor Space Dimensions Free-Standing Floor Mounted Frame (ft.) mm
10,000/1000	8' high (2.4 m) x 39" (990 mm)	
20,000/2,000	8' high (2.4 m) x 42" (1,060 mm)	
40,000/4,000	8' high (2.4 m) x 68" (1,725 mm)	
50,000/5,000	8' high (2.4 m) x 90" (2,295 mm)	
60,000/6,000	8' high (2.4 m) x 96" (2,400 mm)	
80,000/8,000	8' high (2.4 m) x 120" (3,015 mm)	
100,000/10,000	8' high (2.4 m) x 144" (3,630 mm)	(12 x 6.5) 3,660 x 1,930
200,000/20,000		(12 x 9.0) 3,660 x 2,750
400,000/40,000		(12 x 13.0) 3,660 x 3,970
500,000/50,000		(12 x 15.5) 3,660 x 4,775
600,000/60,000		(12 x 18.5) 3,660 x 5,630
800,000/80,000		(12 x 22.5) 3,660 x 6,810
1,000,000/100,000		(12 x 27.5) 3,660 x 8,440

Table 43 – Recommended entrance room termination wall and floor space dimensions

Allow 1 sq. ft. (929 cm^2) of plywood wall mount for each 200 sq. ft. (19 m^2) area of floor space.

Equipment Room

An equipment room may house the main distribution frame, PBXs, secondary voltage protection, etc. The equipment room is often appended to the entrance facilities or a computer room to allow shared air conditioning, security, fire control, lighting and limited access.

Workstation Floor Space	
Number of Workstations	Equipment Room Floor Space ft.² (m²)
1–100	150 (14)
101–400	400 (38)
401–800	800 (74)
801–1,200	1,200 (111)

Table 44 – The floor space needed to accomodate workstations

Provide 0.75 $ft.^2$ (697 cm^2) of equipment room floor space for every 100 $ft.^2$ (9 m^2) of user workstation area.

Location

Typically, rooms should be located away from sources of electromagnetic interference (transformers, motors, X-ray, induction heaters, arc welders, radio and radar).

Perimeters

Typically, no false ceiling; all surfaces treated to reduce dust; walls and ceiling painted white or pastel to improve visibility.

Limited Access

Typically, single or double 36-in. x 80-in. lockable doors with no doorsills.

Other

Typically, no piping, ductwork, mechanical equipment or power cabling should be allowed to pass through the equipment room. No unrelated storage.

Ceiling Height

Minimum clear height in room shall be 8 ft. (2.4 m); the height between the finished floor and the lowest point should be 10 ft. (3 m) to accommodate tall racks and overhead raceways. False ceilings should not be installed.

HVAC

24 hours a day, 365 days a year, 64° F to 75° F, 30 to 55 percent humidity, positive pressure, with independent power from telecommunications equipment.

Lighting

Typically, 8.5 ft. high, providing 50 foot-candle at 3 ft. above floor.

Electrical

Typically, a minimum of two dedicated 15 A, 110 V AC duplex outlets on separate circuits is required. Convenience duplex outlets shall be placed at 6-ft. intervals around the perimeter. Emergency power should be considered and supplied if available.

Bonding and Grounding

Access shall be available to the bonding and grounding as specified in J-STD-607-A (see page 1209 of the office standards document or refer to page 14.27 of this guide).

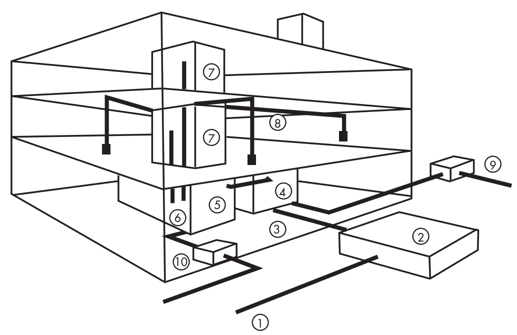
Dust

Less than 100 micrograms/cubic meter per 24 hour period.

Note: The term "typically" is applied here to indicate, where applicable, that these requirements also apply to other elements of the cabling system spaces. Lighting requirements, for instance, are largely identical for entrance facilities, equipment rooms and telecommunications rooms.

Intrabuilding Backbone Pathways

Within a building, the intrabuilding backbone pathways extend between the entrance facilities, equipment room and telecommunications rooms. Telecommunications rooms should be stacked vertically above each other on each floor and be provided with a minimum of three 4-in. sleeves (a stub of conduit through the floor) for less than 50,000 sq. ft. served. An equivalent 4-in. x 12-in. slot may be used in lieu of three sleeves. Firestopping is required. If rooms are not vertically aligned, then 4-in. horizontal conduit runs are required. Include no more than two 90 degree bends between pull points. Pulling iron or eyes embedded in the concrete for cable pulling is recommended. Fill should not exceed 40 percent for any run greater than two cables.



1. Telco conduit	6. Vertical backbone
2. Telco manhole	7. Telecommunications room
3. Entrance conduit	8. Horizontal cabling
4. Telco entrance facility	9. Interbuilding backbone
5. Telecommunications equipment room	10. Electrical entrance facility

Figure 14 – Backbone and horizontal pathways

ANSI/TIA/EIA-569-B Standard

Telecommunications Room

The telecommunications room on each floor is the junction between the backbone and horizontal pathways. It contains active voice and data telecommunications equipment, termination fields and cross-connect wiring. More than one telecommunications room per floor is required if distance to a work area exceeds 300 ft., or if floor area served exceeds 10,000 sq. ft. Recommended room sizing is 10 ft. x 11 ft. for each 10,000 sq. ft. area served. Power, lighting, air conditioning and limited access are typical. See requirements for equipment room. There are a minimum of three 4-in. firestopped backbone sleeves in the floor at the left side of a plywood termination field, which are ideally located near the door. A fire extinguisher is recommended.

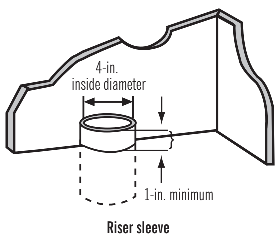


Figure 15 – Riser sleeve

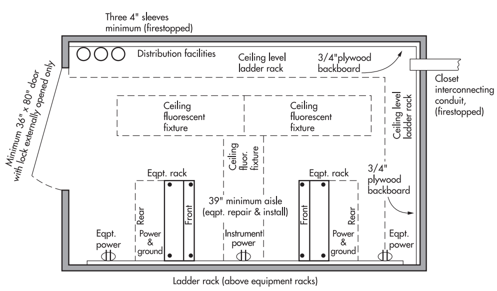


Figure 16 – Telecommunications room

Horizontal Pathways

Horizontal pathways extend between the telecommunications room and the work area. A variety of generic pathway options are described. Choice of pathway(s) is left to the discretion of the designer. The most commonly employed pathway consists of cable bundles run from the telecommunications room along J-hooks suspended above a plenum ceiling, which fan out once a work zone is reached. They then drop through interior walls or support columns or raceways, and terminate at an information outlet (I/O). Other options include the following.

Underfloor Duct
Single- or dual-level rectangular ducts embedded in greater than 2.5-in. (7 cm) concrete flooring.

Flushduct
Single-level rectangular duct embedded flush in greater than 1-in. (3 cm) concrete flooring.

Multichannel Raceway
Cellular raceway ducts capable of routing telecommunications and power cabling separately in greater than 3-in. (8 cm) reinforced concrete.

Cellular Floor
Preformed hollows or steel-lined cells are provided in concrete with header ducts from the telecommunications room arranged at right angles to the cells.

Trenchduct
A wide, solid tray, sometimes containing compartments and fitted with a flattop (with gaskets) along its entire length. It is embedded flush with the concrete finish.

Access Floor
Modular floor panels supported by pedestals, used in computer rooms and equipment rooms.

Plenum and Ceiling
Bundled cables, suspended above a false ceiling, fan out to drop through walls, power poles or along support columns to baseboard level.

Conduit
To be considered only when outlet locations are permanent, device density low and flexibility (future changes) are not required.

Cable Trays
Options include channel tray, ladder tray, solid bottom, ventilated and wireway.

Perimeter Pathways
Options include surface raceway, recessed, molding and multichannel (to carry separate power and lighting circuits).

Typically, size horizontal pathways by providing 1 sq. in. of cross-section area for every 100 sq. ft. of workspace area being served.

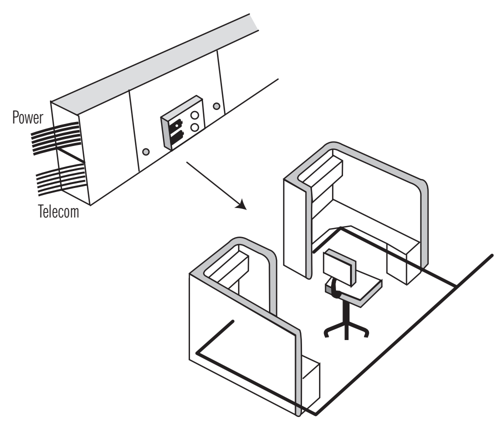


Figure 17 – Perimeter pathway and modular office path

Note: Typically, a pull box, splice box or pulling point is required for any constrained pathway where there are more than two 90 degree bends, a 180 degree reverse bend or length more than 100 ft.

A Variety of Horizontal Pathways

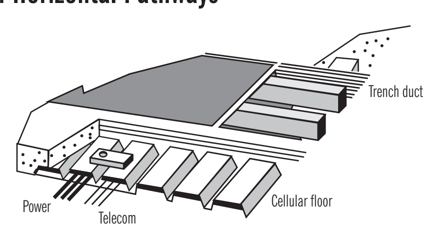


Figure 18 – Access floor

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ANSI/TIA/EIA-569-B Standard

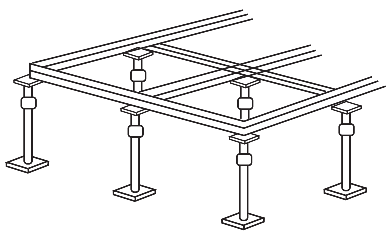

Figure 19 – Access floor

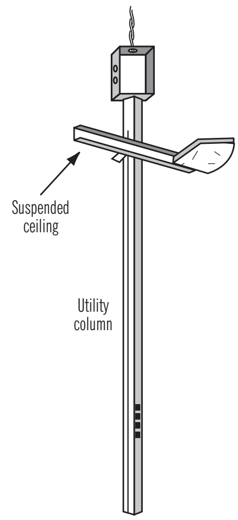

Figure 20 – Ceiling utility pole

Consolidation Points and MUTOAs

Consolidation points provide limited area connection access. Typically, a permanent flush wall, ceiling or support column-mounted panel serves modular furniture work areas. The panels must be unobstructed and fully accessible without moving fixtures, equipment or heavy furniture.

A multiuser telecommunication outlet assembly (MUTOA) is another methodology to reduce cabling moves, adds and changes in modular furniture settings. The user cord is directly connected to the MUTOA. A MUTOA location must be accessible and permanent and may not be mounted in ceiling spaces or under access flooring. Similarly, it cannot be mounted in furniture unless that furniture is permanently secured to the building structure.

For more descriptive information on distance limitations and purposes of consolidation points and MUTOAs, see ANSI/TIA-568-C.1.

Electromagnetic Interference

Voice and data telecommunications cabling should not be run adjacent and parallel to power cabling – even along short distances – unless one or both cable types are shielded and grounded. For low-voltage communication cables, a minimum 5-in. distance is required from any fluorescent lighting fixture or power line over 2 kVA and up to 24 in. from any power line over 5 kVA*. In general, telecommunications cabling is routed separately several feet away from power cabling. Similarly, telecommunications cabling is routed away from large motors, generators, induction heaters, arc welders, X-ray equipment and radio frequency, microwave or radar sources.

***Note:** Distance recommendations from (1990) ANSI/TIA/EIA-569 are reproduced here by popular request. For current recommendations, refer to NEC/NFPA 70, Article 800-52.

Firestops

Annex A of the standard discusses various types of packing used to re-establish the integrity of fire-rated structures when these barriers have been penetrated by cable. This section of the standard briefly discusses passive mechanical systems and nonmechanical systems such as putty, caulk, cements, intumescent sheets and strips, silicone foams and premanufactured pillows. The most common method is stuffing all apertures with ceramic or mineral wool and caulking both sides with fire-resistant putty. The information refers the designer to check manufacturer specifications and UL ratings against NFPA, ASTM and NEC codes.

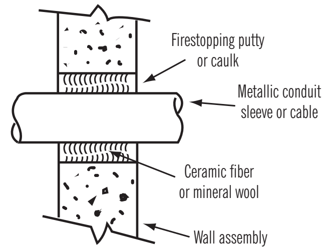

Figure 21 – Cross-section of typical firestop

ANSI/TIA/EIA-606-A Standard

Purpose of the ANSI/TIA/EIA-606-A Standard

Modern buildings require an effective telecommunications infrastructure to support the wide variety of services that rely on the electronic transport of information. Administration includes basic documentation and timely updating of drawings, labels and records. Administration should be synergistic with voice, data and video telecommunications, as well as with other building signal systems, including security, audio, alarms and energy management.

Administration can be accomplished with paper records, but in today's increasingly complex telecommunications environment, effective administration is enhanced by the use of computer-based systems.

A multitenant commercial building has a life expectancy of at least 50 years. Moreover, in a multitenant environment, continuous moves, adds and changes are inevitable.

Administrative record keeping plays an increasingly necessary role in the flexibility and management of frequent moves, adds and changes. This standard concisely describes the administrative record keeping elements of a modern structured cabling system.

Section Contents

ANSI/TIA/EIA-606-A

Administration Standard for Commercial Telecommunications Infrastructure

Elements of an Administration System

- Horizontal pathways and cabling
- Backbone pathways and cabling
- Telecommunications grounding and bonding
- Spaces (e.g., entrance facility, telecommunications room, equipment room)
- Firestopping

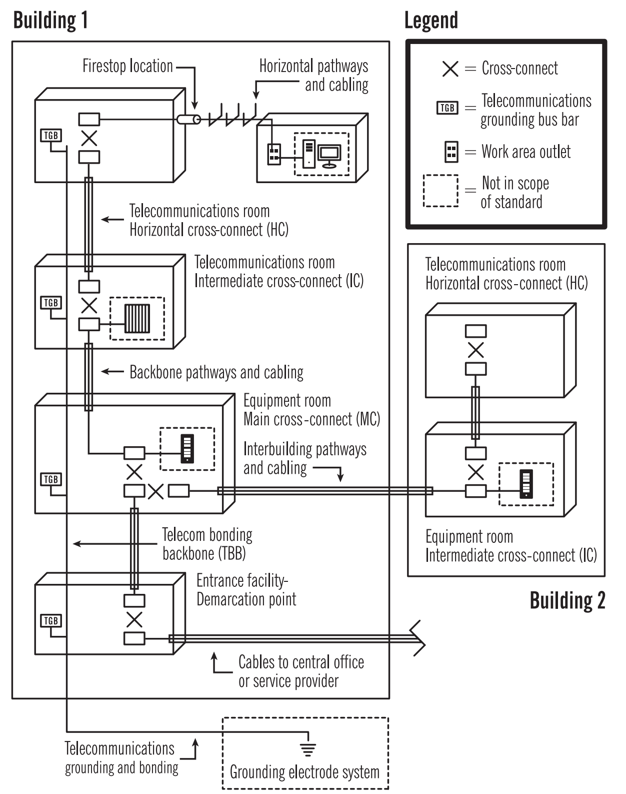

Figure 22 – A typical model for the infrastructure elements used in an administration system

Classes of Administration

Four classes of administration are specified in this standard to accommodate diverse degrees of complexity present in telecommunications infrastructure. Each class defines the administration requirements for identifiers, records and labeling. An administration system can be managed using a paper-based system, general-purpose spreadsheet software or special-purpose cable management software.

Classes of Administration

Identifier	Description of identifier	Class of administration 1	2	3	4
fs	Telecommunications space (TS)	R	R	R	R
fs-an	Horizontal link	R	R	R	R
fs-TGMB	Telecommunications main grounding busbar (TMGB)	R	R	R	R
fs-TGB	Telecommunications grounding busbar (TGB)	R	R	R	R
fs_1 /fs_2-n	Building backbone cabling		R	R	R
fs_1 /fs_2-n.d	Building backbone pair or optical fiber		R	R	R
f-FSLn(h)	Firestop location		R	R	R
[b_1-fs_1]/[b_2-fs_2]-n	Campus backbone cable			R	R
[b_1-fs_1]/[b_2-fs_2]-n/d	Campus backbone or optical fiber			R	R
b	Building			R	R
c	Campus or site				R

Table 45 – Identifier descriptions and classes of administration

Technical Information

ANSI/TIA/EIA-606-A Standard

Class 1 Administration

Class 1 addresses the administration requirements for a building or premise that is served by a single equipment room (ER).

The following infrastructure identifiers shall be required in Class 1 Administration when the corresponding elements are present:

- Telecommunications space (TS) identifier
- Horizontal link identifier
- Telecommunications main grounding busbar (TMGB)
- Telecommunications grounding busbar (TGB)

Class 1 Identifiers

Identifier	Description of identifier
f s	Numeric character(s) identifying the floor of the building occupied by the TS Alpha character(s) uniquely identifying the TS on floor f or the building area in which the space is located
fs	The TS identifier
a	One or two alpha characters uniquely identifying a single patch panel, a group of patch panels with sequentially numbered ports, or an IDC connector (punch-down block), or a group of IDC connectors, serving as part of the horizontal cross-connect
n	Two to four numeric characters designating the port on a patch panel, or the section of an IDC connector on which a four-pair horizontal cable is terminated in the TS
TMGB	Portion of an identifier designating a telecommunications main grounding busbar
TGB	Portion of an identifier designating a telecommunications grounding busbar

Table 46 – Class 1 identifiers

Class 2 Administration

Class 2 addresses the administration of infrastructure with one or more telecommunications spaces (TS) in a single building.

The following infrastructure identifiers shall be required in Class 2 Administration when the corresponding elements are present:

- Identifiers required in Class 1 Administration
- Building backbone cable identifier
- Building backbone pair or optical fiber identifier
- Firestopping location identifier

Class 2 Administration may also include pathway identifiers.

Class 2 Identifiers

Identifier	Description of identifier
fs_1	TS identifier for the space containing the termination of one end of the backbone cable
fs_2	TS identifier for the space containing the termination of the other end of the backbone cable
n	One or two alphanumeric characters identifying a single cable with one end terminated in the TS designated fs_1 and the other end terminated in the TS designated FS_2
fs_1/fs_2-n	A building backbone cable identifier
d	Two to four numeric characters identifying a single copper pair or a single optical fiber
FSL	An identifier referring to a firestopping location
h	One numeric character specifying the hour rating of a firestopping system

Table 47 – Class 2 identifiers

Class 3 Administration

Class 3 Administration addresses infrastructure with multiple buildings at a single site.

The following infrastructure identifiers shall be required in Class 3 Administration:

- Identifiers required in Class 2 Administration
- Building identifier
- Campus backbone cable identifier
- Campus backbone pair or optical fiber identifier

The following infrastructure identifiers are optional in Class 3 Administration:

- Identifiers optional in Class 2 Administration
- Outside plant pathway element identifier
- Campus pathway or element identifier

Additional identifiers may be added if desired.

Class 3 Identifiers

Identifier	Description of identifier
[b_1-fs_1]/[b_2-fs_2]-n	Campus backbone identifier
d	Two to four numeric characters identifying a single copper pair or a single optical fiber
b	One or more alphanumeric characters identifying a single building

Table 48 – Class 3 identifiers

Class 4 Administration

Class 4 Administration addresses infrastructure with multiple sites or campuses.

The following infrastructure identifiers shall be required in Class 4 Administration:

- Identifiers required in Class 3 Administration
- Campus or site identifier

The following infrastructure identifiers are optional in Class 4 Administration:

- Identifiers optional in Class 3 Administration
- Intercampus element identifier

Additional identifiers may be added if desired.

Class 4 Identifiers

Identifier	Description of identifier
c	One or more alphanumeric characters identifying a campus or a site

Table 49 – Class 4 identifiers

Identification Formats

A unique alphanumeric identification code is created for every location, pathway, cable and termination point. The standard includes these suggestions:

Alphanumeric Identification Code

Code	Description	Code	Description
BCxxx	Bonding conductor	HHxxx	Handhole
BCDxxx	Backbone conduit	ICxxx	Intermediate cross-connect
Cxxx	Cable	Jxxx	Jack
CBxxx	Backbone cable	MCxxx	Main cross-connect
CDxxx	Conduit	MHxxx	Manhole or maintenance hole
CTxxx	Cable tray	PBxxx	Pull box
ECxxx	Equipment (bonding) conductor	Sxxx	Splice
EFxxx	Entrance facility	SExxx	Service entrance
ERxxx	Equipment room	SLxxx	Sleeve
Fxxx	Fiber	TCxxx	Telecommunications closet
GBxxx	Grounding busbar	TGBxxx	Telecommunications grounding busbar
GCxxx	Grounding conductor	TMGB	Telecommunications main grounding busbar
		WAxxx	Work area

Table 50 – Alphanumeric identification codes

ANSI/TIA/EIA-606-A Standard

Identification Format Example

The actual format in the preceding chart is not mandated by the standard. However, the chosen format must be consistent and provide a unique identifier number for each system element. This method lends itself to organizing and updating multiple records by the use of powerful relational database (three-dimensional spreadsheet) programs.

Identification Example

J0001	Label for an information outlet jack
D306	Designation for a work area
3A-C17-005	Termination in closet 3A, column C, row 17, block position 005

Examples like those above (taken from the ANSI/TIA/EIA-606-A text and administrative labeling map) indicate the flexibility of conventions that can be established for purposes of naming. Logical naming conventions can also convey considerable additional information about other linkages. Further examples are included in the complete standard.

Summary of Record Elements

This table outlines the minimum required information and required linkages. Further information is optional. A multidimensional database or spreadsheet is helpful.

Documentation Requirements

	Record	Required Information	Required Linkages
Pathways and Spaces	Pathway	Pathway identification #	Cable records
		Pathway type	Space records
		Pathway fill	Pathway records
		Pathway load	Grounding records
	Space	Space identification #	Pathway records
		Space type	Cable records
		Grounding records	
Wiring	Cable	Cable identification #	Termination records
		Cable type	Splice records
		Unterminated pair #s	Pathway records
		Damaged pair #s	Grounding records
		Available pair #s	
	Termination Hardware	Termination hardware #s	Termination position records
		Termination hardware type	Space records
		Damaged position #s	Grounding records
	Termination Position	Termination position #	Cable records
		Termination position type	Other termination records
		User code	Termination hardware records
		Cable pair/condition #s	Space records
	Splice	Splice identification #	Cable records
		Splice type	Space records
Grounding	TMGB	TMGB identification #	Bonding conductor records
		Busbar type	Space records
		Grounding conductor #s	
		Resistance to earth	
		Date of measurement	
	Bonding	Bonding conductor ID#	Grounding busbar records
		Conductor type	Pathway records
	Conductor	Busbar identification #	
	TGB	Busbar identification #	Bonding conductor records
		Busbar type	Space records

Table 51 – Documentation requirements

Grounding and Bonding Administration

Telecommunications systems require a reliable electrical ground reference potential, provided by a dedicated grounding and bonding conductor network.

WARNING

IF THIS CLAMP OR CABLE IS LOOSE OR MUST BE REMOVED,
PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER.

Figure 23 – Sample label

Bonding conductor cabling shall be colored green or labeled appropriately with an alphanumeric identifier and warning label. Grounding records are similar to cable record format.

Grounding and Bonding Terms (with abbreviation):

TMGB	Telecommunications main grounding busbar
TBB	Telecommunications bonding backbone
TGB	Telecommunications grounding busbar
TBBIBC	Telecommunications bonding backbone interconnecting bonding conductor

Label Color Coding

Shown here are the color codes used for termination field labels.

Field Label Color Codes

Termination Type	Color	Comments
Demarcation Point	Orange	CO terminations
Network Connections	Green	Also aux. circuit terms.
Common Equipment	Purple	PBX, host, LANs, Mux
First-Level Backbone	White	MC-IC terminations
Second-Level Backbone	Gray	IC-TC terminations
Station	Blue	Horizontal cable terms.
Interbuilding Backbone	Brown	Campus cable terms.
Miscellaneous	Yellow	Aux., maint., security
Key Telephone Systems	Red	

Table 52 – Field label color codes

The abbreviation “terms.” is used in this example (for space considerations) to mean “terminations.”

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J-STD-607-A Standard

Purpose of the J-STD-607-A Standard

This standard specifies a uniform telecommunications grounding and bonding infrastructure that shall be followed within commercial buildings. Following the AT&T divestiture of 1984, the end-user became responsible for all premises cabling for voice and data. Advancements in voice communications and the convergence of voice and data communications led to increasingly complex interactive systems owned and maintained by the end-user. These systems require a reliable electrical ground-reference potential. Grounding by attachment to the nearest piece of iron pipe is no longer satisfactory to provide ground-reference for sophisticated active electronics systems.

Section Contents

J-STD-607-A

Commercial Building Grounding and Bonding Requirements for Telecommunications

Design Considerations

Solid copper grounding busbars (1/4 in. thick x 4 in. high x variable length) are installed with insulated standoffs in entrance facilities and the equipment room, as well as each telecommunications room (1/4 in. thick x 2 in. high x variable length is sufficient here). Each busbar is drilled with rows of holes according to NEMA standards, for attachment of bolted compression fittings.

Telecommunications equipment, frames, cabinets and voltage protectors are typically grounded to these busbars. Busbars are connected by a backbone of insulated, solid copper cable between all closets and rooms (minimum 6 AWG, 3/0 AWG recommended). This backbone is connected to a main grounding busbar in the telecommunications entrance facility, to an earth ground in the electrical entrance facility and to structural steel on each floor. Bonding conductor cabling must be colored green or labeled appropriately.

Abbreviations

- Telecommunications main grounding busbar (TMGB)
- Telecommunications bonding backbone (TBB)
- Telecommunications grounding busbar (TGB)
- Telecommunications bonding backbone interconnecting bonding conductor (TBBIBC)

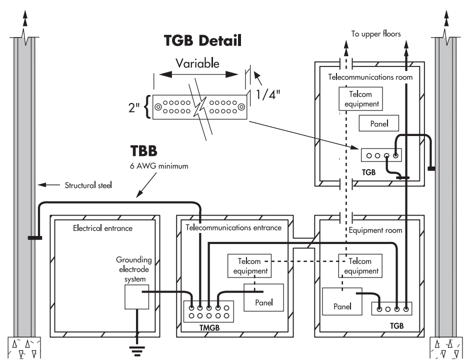

Figure 24 – Schematic of grounding/bonding network

Technical Information

ANSI/TIA/EIA-942 Standard

Purpose of the ANSI/TIA/EIA-942 Standard

Telecommunications Infrastructure Standard for Data Centers

The purpose of this standard is to provide requirements and guidelines for the design and installation of a data center or computer room. It is intended for designers who need a comprehensive understanding of the data center design including the facility planning, the cabling system and the network design. It facilitates the planning for data centers to occur earlier in the building development process (architectural, facilities and IT).

Data centers support a wide range of transmission protocols. Some of these protocols impose distance restrictions that are shorter than those imposed by this standard. When applying specific transmission protocols, consult standards, regulations, equipment manufacturers and system service suppliers for applicability, limitations and ancillary requirements. Consider consolidating standardized and proprietary cabling into a single structured cabling system.

The Standard specifies:

- Cabling design
- Network design
- Facilities design
- Informative annexes containing best practices and availability requirements
- Spaces
- Pathways
- Racks and cabinets.

Section Contents

ANSI/TIA/EIA-942

Telecommunications Infrastructure Standard for Data Centers

Data Center Cabling Infrastructure

The basic elements of a data center cabling system include the following:

- Horizontal cabling
- Backbone cabling
- Cross-connect in the entrance room or main distribution area
- Main cross-connect (MC) in the main distribution area
- Horizontal cross-connect (HC) in the telecommunications room, horizontal distribution area or main distribution area
- Zone outlet or consolidation point in the zone distribution area
- Outlet in the equipment distribution area

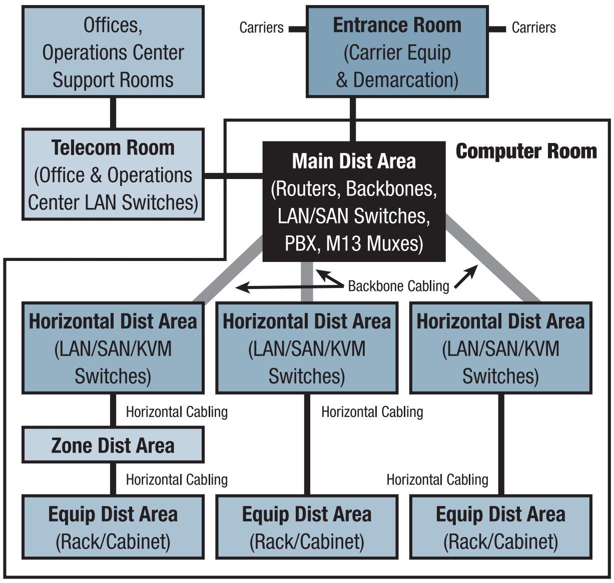

Figure 25 – Example of basic data center topology

Hot and Cold Aisles

Cabinets and racks shall be arranged in an alternating pattern, with the fronts of cabinets and racks facing each other in a row to create hot and cold aisles.

Cold aisles are in front of racks and cabinets. If there is an access floor, power distribution cables should be installed here under the access floor on the slab. Hot aisles are behind racks and cabinets. If there is an access floor, cable trays for telecommunications cabling should be located under the access floor in the hot aisles.

A minimum of 1 m (3 ft.) of front clearance shall be provided for installation of equipment. A front clearance of 1.2 m (4 ft.) is preferable to accommodate deeper equipment. A minimum of 0.6 m (2 ft.) of rear clearance shall be provided for service access at the rear of racks and cabinets. A rear clearance of 1 m (3 ft.) is preferable. Some equipment may require service clearances of greater than 1 m (3 ft.).

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ANSI/TIA/EIA-942 Standard

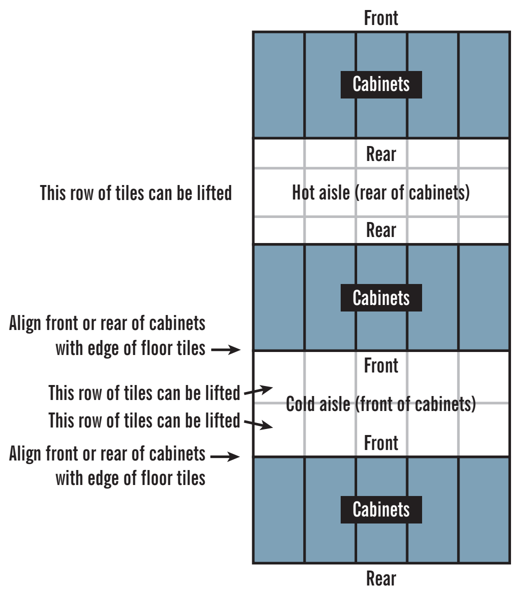

Figure 26 – Hot and cold aisles

Horizontal Cabling

The horizontal cabling is the portion of the telecommunications cabling system that extends from the mechanical termination in the equipment distribution area to either the horizontal cross-connect in the horizontal distribution area or the main cross-connect in the main distribution area. The horizontal cabling includes horizontal cables, mechanical terminations, and patch cords or jumpers. It may also include a zone outlet or a consolidation point in the zone distribution area.

The following partial listing of common services and systems should be considered when designing the horizontal cabling:

- Voice, modem and facsimile telecommunications service
- Premises switching equipment
- Computer and telecommunications management connections
- Keyboard/video/mouse (KVM) connections
- Data communications
- Wide area networks (WAN)
- Local area networks (LAN)
- Storage area networks (SAN)
- Other building signaling systems (building automation systems such as fire, security, power, HVAC, etc.)

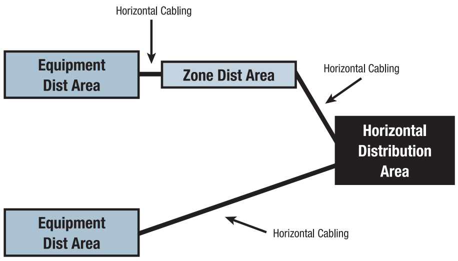

Figure 27 – Horizontal cabling using star topology

Maximum Equipment Area Cord Length				
	24 AWG UTP/24 ScTP Patch Cords		26 AWG ScTP Patch Cords	
Length of Horizontal Cable (H) m (ft.)	Maximum Length of Zone Area Cable (Z) m (ft.)	Maximum Combined Length of Zone Area Cables, Patch Cords and Equipment (C) m (ft.)	Maximum Length of Zone Area Cable (Z) m (ft.)	Maximum Combined Length of Zone Area Cables, Patch Cords and Equipment Cable (C) m (ft.)
90 (295)	5 (16)	10 (33)	4 (13)	8 (26)
85 (279)	9 (30)	14 (46)	7 (23)	11 (35)
80 (262)	13 (44)	18 (59)	11 (35)	15 (49)
75 (246)	17 (57)	22 (72)	14 (46)	18 (59)
70 (230)	22 (72)	27 (89)	17 (56)	21 (70)

Table 53 – Maximum length horizontal and equipment area cables

Backbone Cabling

The function of the backbone cabling is to provide connections between the main distribution area, the horizontal distribution area and entrance facilities in the data center cabling system. Backbone cabling consists of the backbone cables, main cross-connects, horizontal cross-connects, mechanical terminations and patch cord or jumpers used for backbone-to-backbone cross-connections.

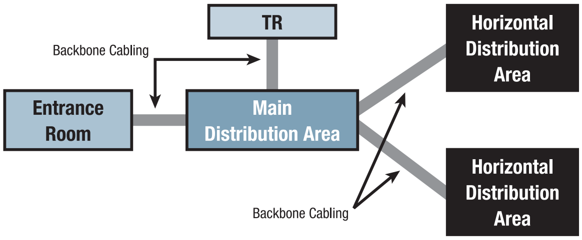

Figure 28 – Backbone cabling using star topology

ANSI/TIA/EIA-942 Standard

Recognized Cabling Media for Horizontal and Backbone Applications

Recognized cables, associated connecting hardware, jumpers, patch cords, equipment cords and zone area cords shall meet all applicable requirements specified in ANSI/TIA-568-C.2 and ANSI/TIA-568-C.3. *

- 100-ohm twisted-pair cable **
- Multimode optical fiber cable, either 62.5/125 μ or 50/125 μ, 50/125 μ 850-nm laser-optimized multimode fiber is recommended
- Single-mode optical fiber cable
- Recognized coaxial media: 75-ohm (734 and 735 type) coaxial cable (Telcordia Technologies GR-139-CORE) and coaxial connector (ANSI T1.404)

* Since publication of the ANSI/TIA/EIA-942 standard, the ANSI/TIA-568-C.2 and ANSI/TIA-568-C.3 standards supersede the referenced ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3 standards.

** Although not part of the currrent ANSI/TIA/EIA-942 Standard, best practices for data centers would include recommending Cat 6A twisted-pair cabling ANSI/TIA-568-C.1 and ANSI/TIA-568-C.2.

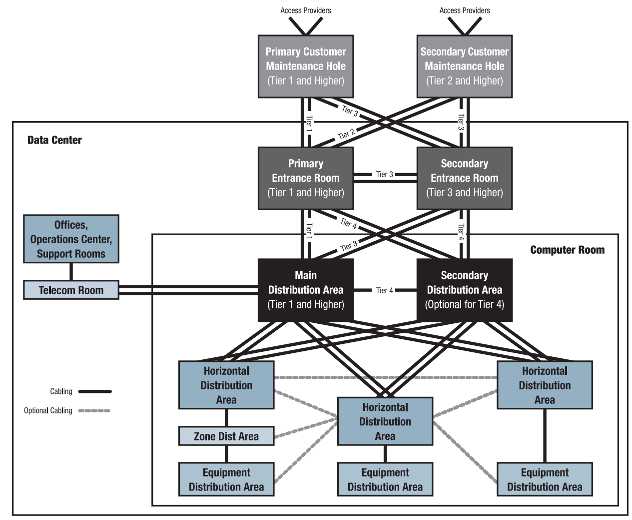

Figure 29 – Telecommunications infrastructure redundancy

Redundancy

Data centers that are equipped with diverse telecommunications facilities may be able to continue their function under catastrophic conditions that would otherwise interrupt the data center's telecommunications service. This standard includes four tiers relating to various levels of availability of the data center facility infrastructure. The tiers are related to research conducted by the Uptime Institute, which defines four tiers of performance as shown in the following table.

Providing redundant cross-connect areas and pathways that are physically separated can increase the reliability of the communications infrastructure. It is common for data centers to have multiple access providers that supply services, redundant routers, redundant core distribution and edge switches. Although this network topology provides a certain level of redundancy, the duplication in services and hardware alone does not ensure that single points of failure have been eliminated.

Tier Clarification				
	Tier I: Basic	Tier II: Redundant Components	Tier III: Concurrently Maintainable	Tier IV: Fault Tolerant
Number of Delivery paths	Only 1	Only 1	1 Active, 1 Passive	2 Active
Redundant Components	N	N+1	N+1	2 (N+1) S+S
Support Space to Raised Floor Ratio	20%	30%	80-90%	100%
Initial Watts/ft.	20-30	40-50	40-60	50-80
Ultimate Watts/ft.	20-30	40-50	100-150	150+
Raised Floor Height	12 in.	18 in.	30-36 in.	30-36 in.
Floor Loading Pounds/ft.	85	100	150	150+
Utility Voltage	208, 480	208, 480	12-15 kV	12-15 kV
Months to Implement	3	3-6	15-20	15-20
Year First Deployed	1965	1970	1985	1995
Construction $/ft. Raised Floor	$450	$600	$900	$1,100+
Annual IT Downtime Due to Site	28.8 hrs.	22.0 hrs.	1.6 hrs.	0.4 hrs.
Site Availability	99.671%	99.749%	99.982%	99.995%

Table 54 – Uptime Institute tier references

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ANSI/TIA-1005 Standard

Purpose of the ANSI/TIA-1005 Standard

This standard helps to enable the planning and installation of telecommunications cabling infrastructure within and between industrial buildings. In contrast to the ANSI/TIA-568-C series of wiring standards, which addresses commercial buildings, the central concept of this standard is the potential exposure to hostile environments in the industrial space. A prime design principle of this document is the special cabling system requirements for industrial operations.

Expected Usefulness:

- This standard is useful for those responsible for designing a telecommunications infrastructure to meet the requirements of an industrial environment.
- A working knowledge of this standard may prove beneficial in understanding problems associated with the unique aspects of industrial environments and applications.

The Standard's Specifics:

- Definition of structured cabling for commercial networks
- Definition of structured cabling for industrial networks
- The ANSI/TIA-1005 standard structure
- Industrial area concepts
- Recognized cables
- Recognized connectivity
- The automation outlet
- 2-pair cabling
- Multiconnect or Ethernet channels
- MICE

Terminology:

- **Automation island:** Area in proximity to the industrial machines
- **Automation outlet:** Where the generic telecommunications cabling ends and the automation-specific cabling begins
- **Device area:** Where system I/O interacts with control equipment
- **Industrial segment:** A point-to-point connection between two active industrial communications devices
- **MICE:** Mechanical, ingress, climate/chemical, electromechanical conditions

Increasing severity →

	Classes		
Mechanical	M_1	M_2	M_3
Ingress rating	I_1	I_2	I_3
Climatic	C_1	C_2	C_3
Electromagnetic	E_1	E_2	E_3

The MICE matrix defines environmental classes in three levels and four parameters.

Legend

$M_1I_1C_1E_1$ describes a worst-case environment according to ISO/IEC 11801

$M_2I_2C_2E_2$ describes a worst-case light industrial environment

$M_3I_3C_3E_3$ describes a worst-case industrial environment

Industrial Areas

Industrial premises cabling may traverse from the front office through the factory floor. The factory floor (see Figure 31) may include work areas and automation islands. Typically, industrial premises encompass environments that are much harsher when compared to commercial office environments. As such, additional performance requirements for industrial-premises telecommunications components must be considered.

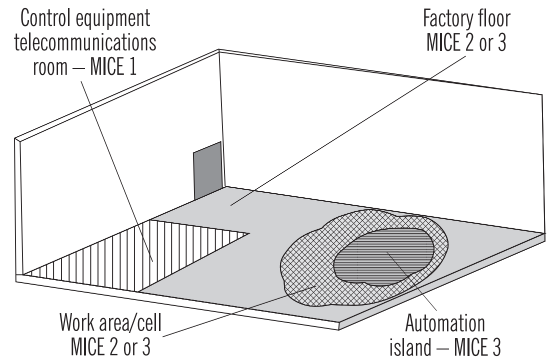

Figure 31 – Typical industrial environment

Control Equipment/Telecommunications Room

This area is equivalent to the MDC or IDC as defined in the ANSI/TIA-568-C.1. It is usually enclosed and protected from the factory environment and is located where the primary network interface equipment for the factory is housed.

Factory Floor Area

The factory floor is the space beyond the office in the manufacturing facility where the machines and work areas exist. These are typically high-traffic areas that require special consideration for the protection and placement of communications equipment. The factory floor environment is generally classified MICE 1 or higher.

Work Area

On a factory floor, the work area is where personnel interact with the telecommunications devices and industrial machines. Work areas often have more severe environments than the factory floor. It is important that the work area be properly designed for both occupants and control devices. The environment of the work area is generally classified MICE 1 or higher.

Automation Island Area

The automation island is the space on the factory floor in immediate proximity to or on the industrial machines and usually accompanies a work area. It is usually the most environmentally harsh area within the industrial premise. Accordingly, the automation island can often be identified as an area where humans are generally not present during machine cycling. In some cases, the automation island may extend into the work area. Components selected to be installed need to be compatible with the environment local to the components. The industrial machines require connectivity to machine control devices such as machine sensors, vision and general telecommunications devices. The environment of the automation island is generally classified MICE 3.

Anixter Standards Reference Guide

Telecommunications Infrastructure for Industrial Premises

Anixter's Standards Reference Guide for Telecommunications Infrastructure for Industrial Premises is an invaluable tool to help you plan and install telecommunications cabling infrastructure within and between industrial buildings. The ANSI/TIA-1005 standard address the potential exposure to hostile environments in the industrial space. In addition to the special cabling system requirements for industrial operations, including 2-pair cabling systems, the standard provides definitions for areas in the industrial space including automation islands, outlets and cables.

To request a copy, contact your local Anixter representative, or visit anixter.com/literature.

ISO, European and IEEE Standards

Purpose of the ISO/IEC 11801 Standard

The international standard provides users with an application-independent generic cabling system capable of supporting a wide range of applications. It provides users with a flexible cabling scheme, so modifications are both easy and economical. Building professionals (architects, for example) are given guidance on the accommodation of cabling at the initial stages of development.

The International Standard specifies a multimanufacturer cabling system that may be implemented with material from single and multiple sources and is related to:

- International standards for cabling components developed by committees in the IEC
- Standards for the installation and operation of information technology cabling as well as for testing of installed cabling
- Applications developed by technical committees of the IEC
- Planning and installation guides that take into account the needs of specific applications.

Generic cabling defined within this International Standard:

- Specifies a cabling structure supporting a wide variety of applications
- Specifies channel and link classes A, B, C, D and E, meeting the requirements of standardized applications
- Specifies channel and link classes E and F based on higher performance components to support future applications
- Specifies optical channel and link classes OF-300, OF-500 and OF-2000
- Involves component requirements and specifies cabling implementations that ensure performance of permanent links and channels that meet or exceed the requirements for cabling classes

The International Standard specifies a generic cabling system that is anticipated to have a usable life in excess of 10 years.

ISO 11801 Class E_A Standard

The requirements for ISO (the International Organization for Standardization) Class E_A are more demanding compared to the TIA/EIA Augmented Category 6 requirements. Anixter's Infrastructure Solutions Lab tests to the more stringent ISO standards.

ISO Compared to TIA		
Characteristics 500 MHz (dB)	ISO Class E_A	TIA Augmented Category 6
PSNEXT Loss	24.8 dB	23.2 dB
NEXT Loss	27.9 dB	26.1 dB
PSANEXT Loss	49.5 dB	49.5 dB
Return Loss	6.0 dB	6.0 dB
Insertion Loss	49.3 dB	49.3 dB
Referred to by IEEE	Yes	No

Table 55 – ISO Class E_A and TIA Category 6 performance comparison

TIA Category 6 versus Augmented Category 6 versus ISO Class E_A				
	TIA Category	TIA Category	TIA Augmented	ISO Class E_A
Recognized by IEEE 802.3an	No	Yes	Yes	Yes
55 Meter Distance Support	No	Yes	Yes	Yes
100 Meter Distance Support	No	No	Yes	Yes
Extrapolated Test Limits for NEXT and PSNEXT to 500 MHz	No	No	No	Yes

Table 56 – ISO and TIA 10GBASE-T media types

Table 56 summarizes the various UTP cabling options and their respective 10 Gigabit performance attributes as defined by the latest draft standards. Category 5e is not recognized as a viable cabling media to support 10 Gigabit transmission regardless of its installed cabling distance. Category 6 cabling will only support 10 Gigabit at a maximum installed distance of 55 meters.

Today, the only options for operating 10 Gigabit at 100 meters using RJ45 connectivity are the TIA Augmented Category 6 and ISO Class E_A standards. ISO's Class E_A system has superior NEXT and PSNEXT performance values when compared with the current TIA Augmented Category 6 standard.

IEEE 802.3af Power over Ethernet (PoE) Standard

The IEEE 802.3af specification calls for power source equipment (PSE) that operates at 48 volts of direct current. This guarantees 12.95 watts of power over unshielded twisted-pair cable to data terminal equipment (DTE) 100 meters away (the maximum distance supported by Ethernet). That's enough power to support IP phones, WLAN access points and many other DTE devices. Two PSE types are supported including Ethernet switches equipped with power supply modules called endspan devices and a special patch panel called a midspan device that sits between a legacy switch and powered equipment, injecting power to each connection.

IEEE 802.3at Power Over Ethernet+ (Plus) Standard

The IEEE 802.3at Power over Ethernet Plus amendment to the IEEE 802.3af standard offers improved power-management features and increases the amount of power to end devices. The new amendment will usher in new possibilities of powering devices through standard Category 5e, 6 and 6A cabling. It will allow many more devices, such as access control and video surveillance, to receive power over a twisted-pair cabling infrastructure.

The standard defines the technology for powering a wide range of devices up to 25 watts over existing Category 5e and above cables. The 802.3at standard states that 30 watts at a minimum are allocated at the port, so 24.6 watts are ensured at the end-device connector 100 meters away. It also allows for gigabit pass-through. PoE Plus represents a considerable upgrade over the existing PoE standard.

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ISO, European and IEEE Standards

IEEE 802.3an, Physical Layer and Management Parameters for 10 Gbps Operation Type 10GBASE-T

Describes the physical layer (PHY) for 10 Gigabit Ethernet transmission over twisted-pair copper cable.

IEEE 802.3an Standard		
Standard	Media	Distance
ISO Class F (Individual Shields)	S/FTP	100 m
ISO Class E_A	UTP	100 m
TIA Augmented Category 6	UTP	100 m
Shielded Category 6 (Overall Shield)	F/UTP, ScTP, STP	100 m
TIA Standard Category 6/ISO Class E	UTP	<55 m

Table 57 – Maximum 10GBASE-T cabling distances

ANSI/TIA-568-C.2 (Augmented Category 6) and ISO 11801 (Class E_A) cable specifications are based on IEEE cabling models. 100 meters over UTP is only guaranteed when using Augmented Category 6 or ISO Class E_A compliant cabling systems.

TIA-568-B.2-ad10 Augmented Category 6 or ISO 11801 Class E_A Cables

10 Gigabit Ethernet Channel Applications			
Application	10GBASE Fiber (802.3ae)	10GBASE-T	10GBASE-CX4 (802.3ak)
Data Center (Server Clustering)	Yes	Yes	Yes (<15 m)
Horizontal (In Building)	No	Yes	No
Vertical (Risers)	Yes	No	No
Campus/Metro	Yes	No	No

Table 58 – 10 Gigabit Ethernet applications and recommended protocols

In Table 58, the recommended application roadmaps for 10 Gigabit Ethernet cabling and protocol types have been provided. The choice of which media to use will revolve around three variables:

- Circuit distances
- Cost
- Active equipment interfaces (connectors)

10GBASE fiber will maintain traditional applications in backbones and risers and also in the data center for server clustering.

10GBASE-T copper will remain in the traditional areas of application (in horizontal building cabling but also in the data center between servers and clusters).

10GBASE-CX4 defines a multiconductor copper solution primarily designed to connect servers and switches over short distances.

IEEE 802.3ba Media Access Control Parameters, Physical Layers and Management Parameters for 40 Gbps and 100 Gbps Operation

The 802.3ba amendment to the IEEE 802.3-2008 standard defines Media Access Control (MAC) parameters, physical layer specifications and management parameters for the transfer of 802.3 frames at 40 Gbps and 100 Gbps. The updated amendment will facilitate the migration of 10 Gigabit Ethernet from the network core to the network edge by providing 40 Gbps and 100 Gbps data rates for backbone and backhaul applications to effectively remove the bandwidth bottleneck that exists in many corporate networks today. The following media types and distances are approved as part of the 802.3ba amendment:

40 Gigabit Ethernet		
Protocol	Media	Distance
40GBASE-CR4	Twinax	10 m
40GBASE-SR4	OM3 MMF	100 m
40GBASE-SR4	OM4 MMF	150 m
40GBASE-LR4	SMF	10 km

100 Gigabit Ethernet		
Protocol	Media	Distance
100GBASE-CR10	Twinax	10 m
100GBASE-SR10	OM3 MMF	100 m
100GBASE-SR10	OM4 MMF	150 m
100GBASE-LR4	SMF	10 km
100GBASE-ER4	SMF	40 km

Table 59 – 40 Gbps and 100 Gbps approved media types and distances

ISO, European and IEEE Standards

IEEE 802.11 Wireless Standard

IEEE 802.11, the Wi-Fi standard, denotes a set of wireless LAN/WLAN standards developed by working group 11 of the IEEE LAN/MAN standards committee (IEEE 802). The term 802.11x is also used to denote this set of standards and is not to be mistaken for any one of its elements. There is no single 802.11x standard.

802.11 details a wireless interface between devices to manage packet traffic (to avoid collisions, etc.). Some common specifications and their distinctive attributes include the following:

802.11a – Operates in the 5 GHz frequency range (5.125 to 5.85 GHz) with a maximum 54 Mbps signaling rate. The 5 GHz frequency band isn't as crowded as the 2.4 GHz frequency because it offers significantly more radio channels than the 802.11b and is used by fewer applications. It has a shorter range than 802.11g, is actually newer than 802.11b and is not compatible with 802.11b.

802.11b – Operates in the 2.4 GHz Industrial, Scientific and Medical (ISM) band (2.4 to 2.4835 GHz) and provides signaling rates of up to 11 Mbps. This is a commonly used frequency. Microwave ovens, cordless phones, medical and scientific equipment, as well as Bluetooth® devices, all work within the 2.4 GHz ISM band.

802.11e – Ratified by the IEEE in late September 2005, the 802.11e quality-of-service specification is designed to guarantee the quality of voice and video traffic. It will be particularly important for companies interested in using Wi-Fi phones.

802.11g – Similar to 802.11b, this standard supports signaling rates of up to 54 Mbps. It also operates in the heavily used 2.4 GHz ISM band but uses a different radio technology to boost overall throughput. Compatible with older 802.11b.

802.11i – Also sometimes called Wi-Fi Protected Access 2 (WPA 2), 802.11i was ratified in June 2004. WPA 2 supports the 128-bit-and-above Advanced Encryption Standard, along with 802.1x authentication and key management features.

802.11k – Passed in June 2008, the 802.11k Radio Resource Management Standard will provide measurement information for access points and switches to make wireless LANs run more efficiently. It may, for example, better distribute traffic loads across access points or allow dynamic adjustments of transmission power to minimize interference.

802.11n – Ratified in September 2009, 802.11n is a set of standards for wireless local area network (WLAN) communications, developed by the IEEE LAN/MAN Standards Committee (IEEE 802) in the 5 GHz and 2.4 GHz public spectrum bands. The proposed amendment improves upon the previous 802.11 standards by adding multiple-input multiple-output (MIMO) and many other newer features.

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Anixter Infrastructure Solutions Lab

The Anixter Infrastructure Solutions Lab

Anixter's Infrastructure Solutions Lab actively demonstrates the best practical technology solutions from best-in-class manufacturers in the area of enterprise cabling, video security and access control for our customers. Our mission for The Lab is simple—educate, demonstrate and evaluate.

- **Educate** customers on the latest industry standards and technologies
- **Demonstrate** the latest infrastructure product solutions available from our manufacturer partners
- **Evaluate** our network infrastructure and security solutions to ensure that our customers are selecting the right products for their specific needs

We are continually testing products in The Lab to ensure:

- Quality products are recommended and delivered to our customers
- Consistency of performance across product lines and within systems
- Interoperability of products and systems to ensure customers can integrate systems and follow the trend toward convergence.

Networking and security product testing at The Lab includes:

- Random performance testing of Anixter inventory to ensure quality of standards compliance
- Network throughput and interoperability testing
- Copper and fiber cabling compliance verification (TIA/EIA, ISO/IEC, IEEE)
- Customer proof of concept
- Power over Ethernet (PoE)
- Application testing
- 10 Gig Ethernet cabling testing
- Video over IP, video quality and bandwidth utilization
- Power over Ethernet capability and verification
- Digital compression image quality vs. analog technology testing
- Evaluation of analog and IP cameras, video management software evaluation, DVR, NDVR and NVR products.

THE LAB
ANIXTER'S INFRASTRUCTURE SOLUTIONS LAB

Anixter's Infrastructure Solutions Lab In Action

Challenge: Leading Pennsylvania University Explores Campuswide Rewiring Project
Anixter Infrastructure Solutions Lab Resolution: The Anixter Infrastructure Solutions Lab was called upon to help this university determine which copper cabling system would best meet its current and future information technology needs. The university had a variety of different copper cabling products installed in its network infrastructure: Category 3, Category 5 and some Category 5e. The Anixter Infrastructure Solutions Lab deployed computer applications that the university typically carried over its cabling infrastructure, including Lotus Notes, SAP and streaming video. Testing found that its current infrastructure was consistently dropping information, causing the network to operate slowly and inefficiently. This same traffic was sent over a Category 6 infrastructure with no degradation to the data. Armed with testing from the Anixter Infrastructure Solutions Lab, university IT professionals wrote cabling infrastructure specifications around a higher performing Category 6 system that better met the university's network performance needs.

Challenge: Major Railway Company Needs Video Surveillance to Monitor Switchyard
Anixter Infrastructure Solutions Lab Resolution: A railroad company wanted to use video surveillance to monitor yards as it assembled unit trains, but it had a big cabling challenge. Installing traditional cabling in the switchyard would have entailed major disruptions and expense for the customer. Instead, Anixter's Infrastructure Solutions Lab recommended a sophisticated wireless Internet video surveillance system that did not require cabling. Anixter was able to simulate the wireless Internet video surveillance solution in the Infrastructure Solutions Lab for the customer. The Infrastructure Solutions Lab also provided this customer with test results illustrating how much bandwidth the video solution would absorb on the customer's network as well as the video quality the customer could expect from the recommended system.

Challenge: National Insurance Company with Data Center Cabling Choice
Anixter Infrastructure Solutions Lab Resolution: The Anixter Infrastructure Solutions Lab assessed backbone cabling requirements based on the current and future bandwidth needs for this insurance provider. The Anixter Infrastructure Solutions Lab ran representative network traffic over 62.5-micron, 50-micron and laser-optimized 50-micron fiber (OM3) to ascertain which would best meet the company's needs. These tests were key in determining that the OM3 was the customer's best choice.

Anixter's 10 Gigabit Ethernet Cabling Testing

Anixter Infrastructure Solutions Lab is the only UL Certified lab to conduct rigorous, independent third-party testing of emerging 10 Gigabit cabling solutions. Anixter's 10 Gigabit cabling testing examines electrical characteristics such as insertion loss, return loss and crosstalk, but also looks at alien crosstalk (which is part of the Augmented Category 6 spec). To ensure the 10 Gigabit cabling solutions we sell meet the highest levels of performance and reliability, the Anixter Infrastructure Solutions Lab tests the toughest performance parameter, alien crosstalk, in the "worst case" scenario. Customers can rest assured that the cabling solutions Anixter sells will provide the network performance they require.

Technical Information

Reference Documents

Reference Documents for Further Information on Cabling Standards

IEEE 802.3ba (2010)
Media Access Control Parameters, Physical Layers and Management Parameters for 40 Gbps and 100 Gbps Operation

ANSI/TIA-568-C.0 (2009)
Generic Telecommunications Cabling for Customer Premises

ANSI/TIA-568-C.1 (2009)
Commercial Building Telecommunications Standard

ANSI/TIA-568-C.2 (2009)
Balanced Twisted-Pair Telecommunications Cabling and Component Standard

ANSI/TIA-568-C.3 (2009)
Optical Fiber Cabling Components

ANSI/TIA-1005 (2009)
Telecommunications Infrastructure for Industrial Premises

IEEE 802.3at (2009)
Power over Ethernet Plus

IEEE 802.3an (2006)
Physical Layer and Management Parameters for 10 Gbps Operation, Type 10GBASE-T

TIA/EIA-942 (2005)
Telecommunications Infrastructure Standard for Data Centers

ANSI/TIA/EIA-569-B (2004)........ (CSA T530)*
Commercial Building Standard for Telecommunications Pathways and Spaces

IEEE 802.3af (2003)
Power over Ethernet (PoE) Standard

ISO/IEC 11801 (2002)
Generic Cabling for Customer Premises

J-STD-607-A (2002)........ (CSA T527)*
Commercial Building Grounding/Bonding Requirements for Telecommunications

TIA/EIA-606-A (2002)........ (CSA T528)*
Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

TIA/EIA-570-A (1999)........ (CSA T525)*
Residential and Light Commercial Telecommunication Wiring Standard

TIA/EIA-758 (1999)
Customer-Owned Outside Plant Telecommunications Cabling Standard

IEEE 802.3-1998 (1998)
Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specification (also known as ANSI/IEEE Std 802.3-1998 or ISO 8802-3: 1990 (E))

IEEE 802.11
Wireless Standard

- **802.11n** (2009)
- **802.11k** (2008)
- **802.11e** (2005)
- **802.11i** (2004)
- **802.11a** (2003)
- **802.11b** (2003)
- **802.11g** (2003)

*Canadian Standards Association equivalent document

Obtaining Standards Documents

TIA/EIA documents may be purchased through Global Engineering Documents at 800.854.7179 or www.global.ihs.com. IEEE documents may be purchased through IEEE, P.O. Box 1331, Piscataway, NJ 08855 or www.ieee.org. CSA documents may be purchased through the Canadian Standards Association at www.csa.ca or by calling 416.747.4000.

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