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NETWORK SERVICES

# Guide to Structured

# Cabling

Networking

Standards

Cabling

Structured  
Cabling System

Installation  
& Testing

Other  
Standards

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# What is structured cabling?

**A** structured cabling system is the wiring network that carries all your data, voice, multimedia, security, VoIP, PoE, and even wireless connections throughout your building or campus. It includes everything from the data center to the desktop, including cabling, connecting hardware, equipment, telecommunications rooms, cable pathways, work areas, and even the jacks on the wallplate in your office.

## The importance of structured cabling.

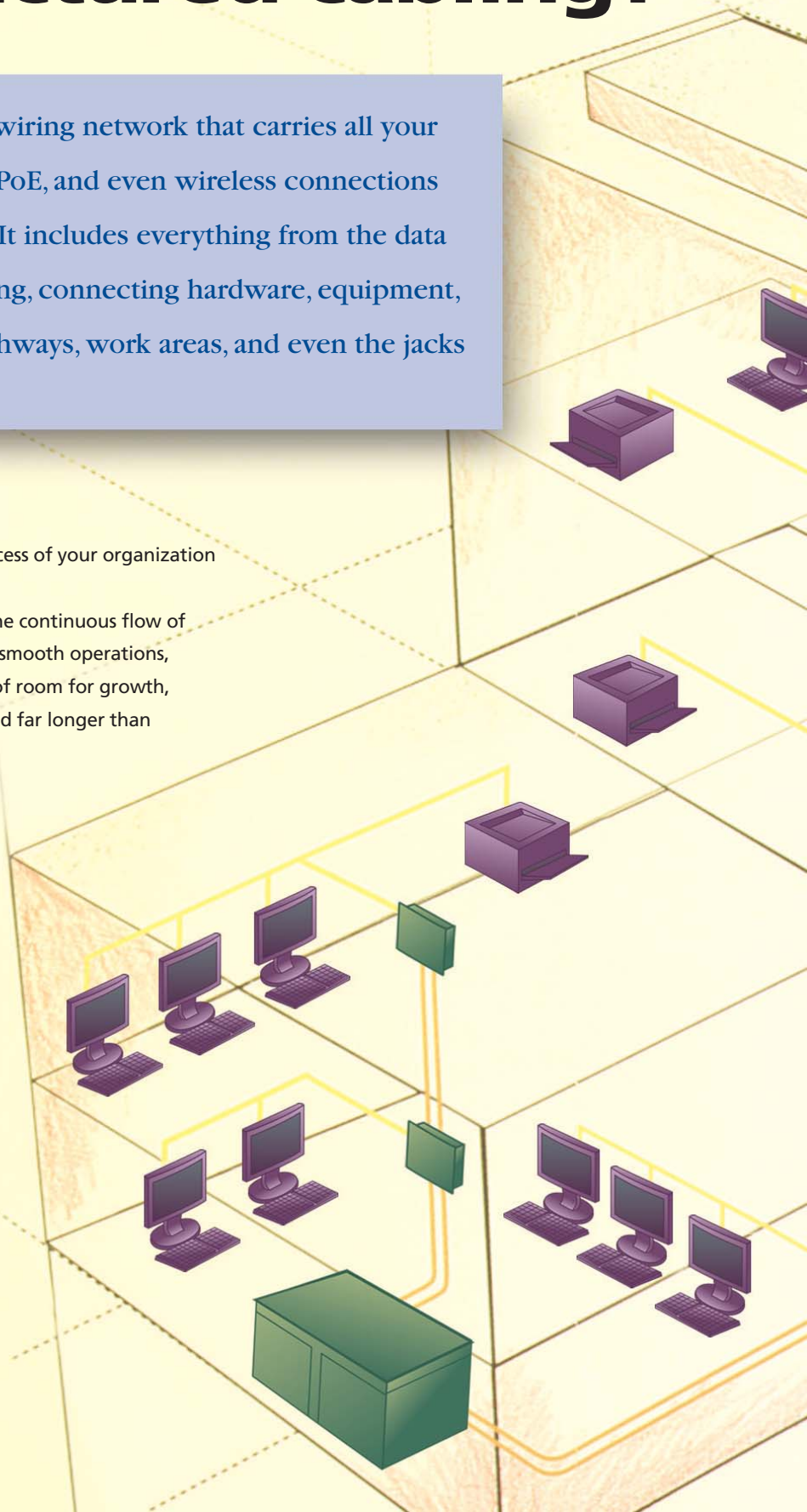
A structured cabling system is as important to the success of your organization as the people are who work in it.

A well-planned structured cabling system facilitates the continuous flow of information, enables the sharing of resources, promotes smooth operations, accommodates ever-changing technology, offers plenty of room for growth, and evolves with your organization. Plus, it will be around far longer than your current PC, server, and network switches.

In essence, a structured cabling system is the lifeblood of your organization. If done right, it will serve you well for years. If not, your organization's growth and bottom line can suffer.

The importance of structured cabling has increased right alongside the growth of LANs, MANs, and WANs. It started with individuals working on standalone PCs. It didn't take long to connect those PCs into workgroups and then to connect those workgroups to a server. One server became multiple servers. And the rest is history. Today's networks are complex systems running on technologies that no one could have imagined just 15 years ago.

This guide will provide an overview of the standards and practices that govern structured cabling systems. For expert advice on your new or upgraded structured cabling system, and for complete services ranging from design and products through installation and maintenance, call Black Box at 724-746-5500 or go to [blackbox.com](http://blackbox.com).





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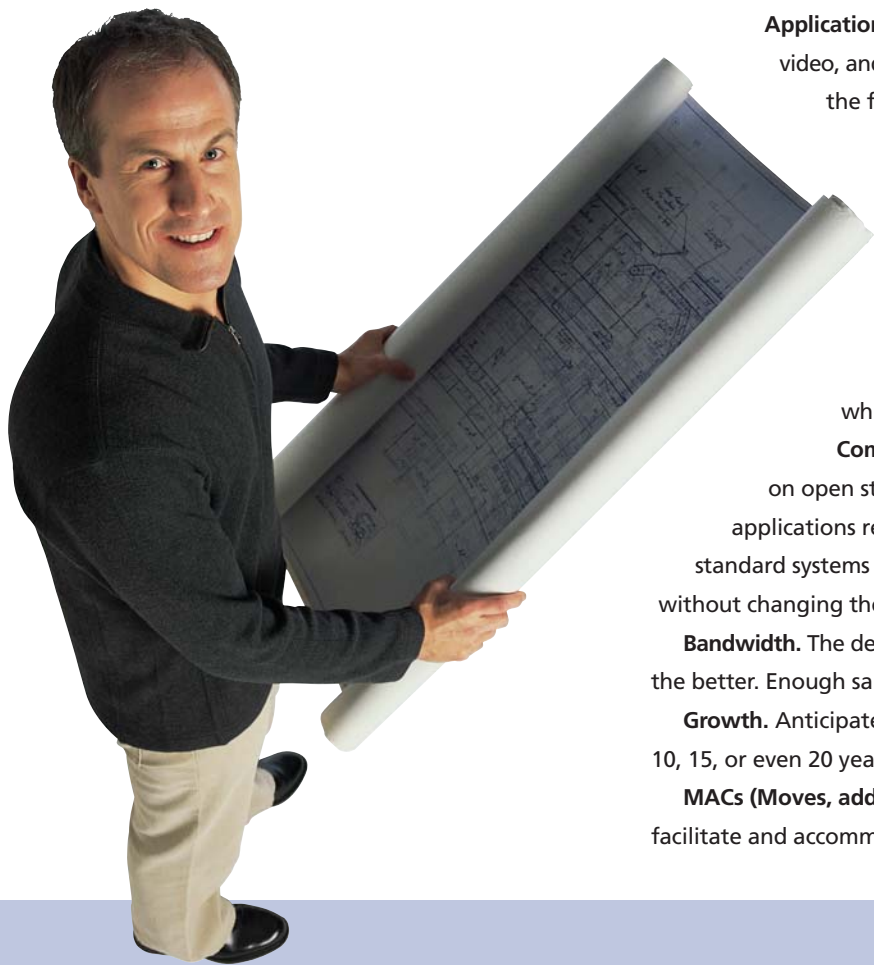
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# Planning your structured cabling



### The most important design considerations.

If you do nothing else, weigh these considerations carefully.

**Applications.** Your system should support data, voice, video, and multimedia applications now and well into the future. You should anticipate applications involving VoIP, PoE, wireless, and security.

**Life cycle.** Plan on a life span of 15–20 years, with 10 years as the minimum. Your cabling system should have the longest life cycle of any component in your network.

Compare that to a network switch, which has an average life span of five years.

**Compatibility.** Your system should be based on open standards and be able to support multiple applications regardless of the vendor. Modular, open-standard systems enable easy changes and easy expansion without changing the cabling and equipment.

**Bandwidth.** The demand for it just keeps growing. The more the better. Enough said.

**Growth.** Anticipate how many users you'll need to support 10, 15, or even 20 years down the road. See *Bandwidth* above.

**MACs (Moves, adds, and changes).** Your network should facilitate and accommodate frequent changes.

**A** structured cabling system that's smartly designed takes careful planning. Systems are more complex now than ever, and will get even more so as speed and bandwidth demands increase. The system you plan today will be supporting new and different applications for many years. Take your time, review everything, and get ready for the future. For guaranteed-for-life products, expert advice, and complete installation services, call Black Box.

# system

## Other important design considerations.

**Usage.** When planning a network, consider peak loads of all applications, usage patterns, type of traffic, and outlet density.

**Future technology.** In this business, change happens fast. See *Bandwidth* on the previous page.

**Location of users.** Where are users and how far are they from the network switches? Will a collapsed backbone work better? Centralized cabling? Zone cabling?

**Power over Ethernet.** Consider where you may need to run power over your data lines.

**Wireless access points.** Plan on complete coverage.

**VoIP.** Voice over Internet Protocol is fast becoming the network type of choice.

**Security.** Plan on current and emerging data, network, and physical security systems, including PoE and wireless applications.

**Regulations.** NEC. ANSI/TIA/EIA. State and local building codes. They exist for a reason so be sure to abide by them.

**Space.** Consider available space for data centers, equipment, telecommunications rooms, and cable runs. Factor in plenum runs, additional air ducts, sprinkler systems, suspended ceilings, etc.

**Physical conditions.** Consider any unusual physical constraints, such as power lines, EMI influences, seismic activity, industrial activity, even being below water level. For a listing of the Ingress Protection (IP) ratings, see [page 31](#).

**Media.** The type of cable you choose may depend on the applications, architecture, environment, and more.

**Redundancy.** Consider whether you need duplicate pathways to run redundant backbones for mission-critical applications.

**Site survey.** A comprehensive site survey should be done to identify users' equipment, locations, and regulations that require attention.

**Maintenance.** Who is going to do it, how often, and at what cost. Consider whether you're going to use in-house technicians or a contracted service.

**Warranties.** What do they cover? Most should cover the cabling components and the application the system was designed to support.

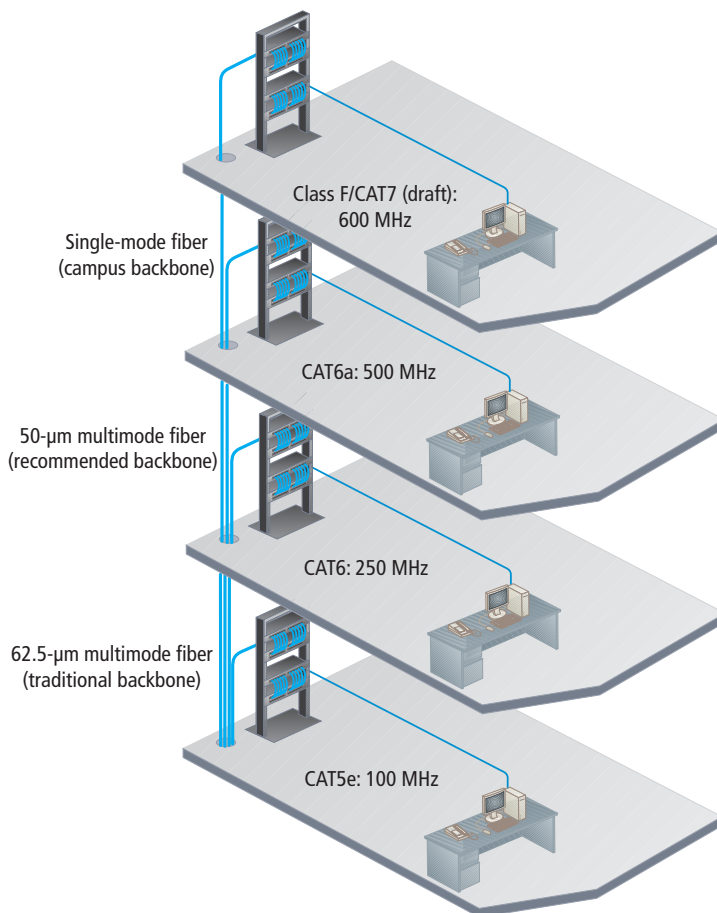
**Documentation.** Don't forget proper documentation, diagrams, labeling, color coding, and other administrative duties. Doing it right the first time will make your life a whole lot easier in the future.

## Last, but not least.

**Total cost of ownership.** This can be tricky. The lowest initial installation cost is not always the least expensive. You also have to factor in the cost of upgrades and recurring costs over the lifetime of the system. The greatest expenses after your original investment will be MACs and equipment upgrades. Plan on replacing your electronic equipment three to four times over the life of the cabling system. When all totaled, these ongoing costs can actually equal or exceed the cost of your original investment.

You also have to consider the quality of the installation. The lowest bid may not necessarily be the best. A well-planned and documented installation will more than pay for itself by lowering long-term maintenance, eliminating problems from poor workmanship, reducing downtime, and most importantly, giving you peace of mind.

## Structured Cabling System with Mixed Media



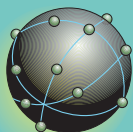
## Network applications (or the evolution of Ethernet)

Most likely, the network you use now and in the future will be some form of Ethernet. It's the most common network type, and it's the de facto standard in networking.

The original Ethernet networks (10BASE5 and 10BASE2) ran over coaxial cable. An upgrade, 10BASE-T, the first vendor-independent implementation of Ethernet, operated over unshielded twisted-pair cable at a then speedy 10 Mbps. As technology progressed, so did Ethernet—it went to 100BASE-TX, which runs at 100 Mbps and specifies a minimum of CAT5 cable, although CAT5e is more common.

### TECH TIP

**A short history of Ethernet** — Since 1985, when 10-Mbps Ethernet was first standardized, demand for bandwidth and speed has grown steadily alongside increasingly high-performance applications—thus the standardization of 100-Mbps Fast Ethernet in 1995; Gigabit Ethernet in 1998, and in the ratification of 10-Gigabit Ethernet in June 2002. Each step forward represents a tenfold increase in performance.



10-Gigabit Ethernet is a logical extension of previous Ethernet networks, which are the predominant technology for high-performance LANs.

Gigabit Ethernet (1 Gbps) was developed to handle backbone and server traffic, and is now also deployed to the desktop. When Gigabit Ethernet first appeared, fiber was crucial to running it effectively. Later the IEEE 802.3ab standard approved Gigabit Ethernet over Category 5 cable, although CAT5e or higher is the norm. Today, it is one of the most commonly installed networks.

10-Gigabit Ethernet (10-GbE) brings the familiarity and cost-effectiveness of Ethernet to high-performance networks with a speed ten times that of Gigabit Ethernet and a frequency of 500 MHz. It supports high-bandwidth applications, such as imaging and storage. 10-Gigabit Ethernet enables the construction of MANs and WANs that connect geographically dispersed LANs. Today, the most common application for 10-Gigabit Ethernet is as a backbone connecting high-speed LANs, server farms, and campuses.

10-GbE over fiber was ratified in 2002. An IEEE amendment in 2006, 802.3an, approved 10-GbE over twisted pair. The TIA/EIA-568-B.2.10 draft specifies transmission performance for Augmented Category 6 cable. The TSB-155 addresses existing Category 6 cabling for 10-GbE. It's emerging as the standard to wire for now. For more information on 10-GbE, see [page 11](#).

### Think fast.

When planning a network, think fast. Network technologies considered cutting edge only a few years ago are now becoming viable options for network upgrades. The shift is to Gigabit Ethernet, 10-GbE, SANs (storage area networks), and even 40+Gbps connections for enterprise and data center backbones.

### Other networks.

Other networks exist, but they're uncommon. Before the establishment of open-architecture, standards-based networks like Ethernet, proprietary networks, such as IBM® Token Ring, were the norm.

### Ethernet Standards

Network	Standard	IEEE	Cable	Speed	Distance
Ethernet	10BASE5, 2	802.3	Coaxial	10 Mbps	500 m/185 m
	10BASE-T	802.3i	CAT3	10 Mbps	100 m
	10BASE-F, -FB, FL, FP	802.3	Fiber	10 Mbps	2000 m/500 m
Fast Ethernet	100BASE-TX, T4	802.3u	CAT5	100 Mbps	100 m
	100BASE-FX	802.3u	MM Fiber	100 Mbps	400 m half-duplex, 2 km full-duplex
Gigabit Ethernet	1000BASE-T	802.3ab	CAT5e/CAT6	1000 Mbps	100 m
	1000BASE-LX	802.3z	MM, SM Fiber	1000 Mbps	550 m/5000 m
	1000BASE-SX	802.3z	MM Fiber	1000 Mbps	550 m
10-Gigabit Ethernet	10GBASE-SR, -LR, LX				
	-ER, -SW, -LW, -EW	802.3ae	MM, SM Fiber	10 Gbps	65 m to 40 km
	10GBASE-CX4	802.3ak	100-Ω Twinax	4 x 2.5 Gbps	15 m
	10GBASE-T	802.3an	UTP	10 Gbps	100 m



# Network topologies

There are three basic network topologies: star, ring, and bus.

## Star.

The star network features individual point-to-point cable runs radiating from a central equipment room, which can house a PBX in voice networks or switches in data networks. The advantage of a star network is that you can connect and disconnect equipment without disrupting the rest of the network. The star network facilitates smooth moves, adds, and changes. 10BASE-T and later versions of Ethernet use a star topology.

The TIA/EIA makes a few design recommendations for star topologies.

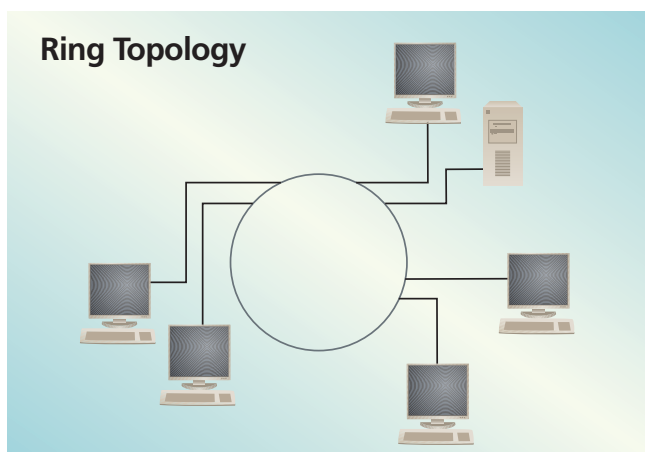
- There shall be no more than two hierarchical levels of backbone cross-connects.
- Bridged taps and splices shall not be installed.
- Proximity to sources of EMI shall be taken into account.
- Grounding should meet J-STD-607-A requirements.

*NOTE: The TIA/EIA has two basic categories of recommendations: mandatory and advisory. Mandatory criteria are designated by the word "shall." So if you see the word shall, pay attention. Advisory criteria are recommended, but not absolutely necessary.*

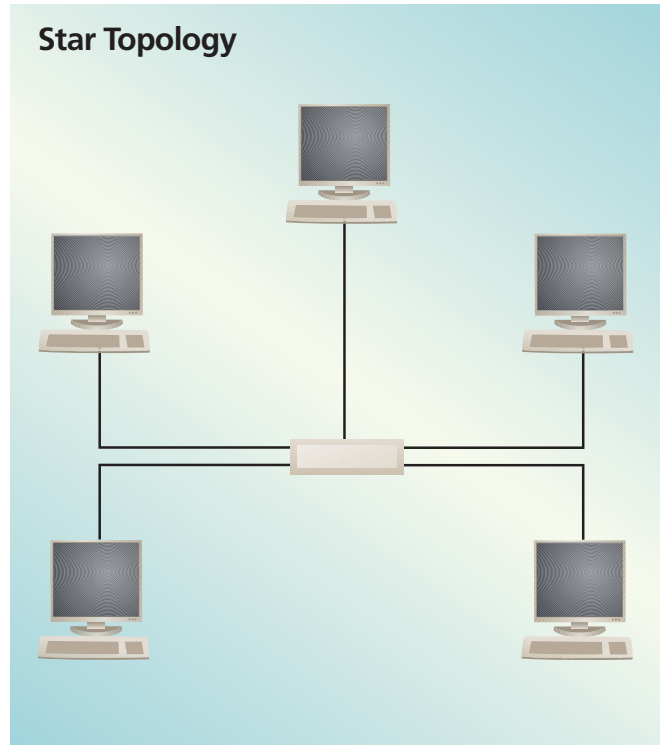
## Ring.

A ring topology links a series of devices in a continuous loop.

A ring is a simple network, but it has a few disadvantages. All the signals are passed from one device to the next until they reach the intended station.



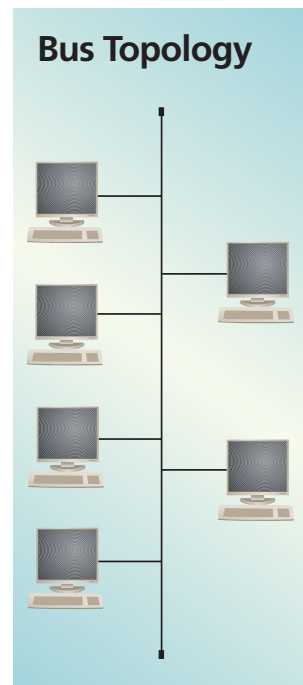
## Star Topology



## Bus.

A bus topology consists of one continuous cable, commonly called the backbone cable. Devices are connected along that cable, and information travels in a linear fashion along the entire length of the bus. Devices can be removed from the bus without disrupting the entire network. The original Ethernet topology was a bus.

## Bus Topology



## The importance of standards

The importance of standards in today's structured cabling systems can't be underestimated.

A standards-based system provides a generic base for building a communications infrastructure without compatibility worries.



Standards establish technical criteria and ensure uniform performance among network systems and components. They enable you to build modular networks that can easily accommodate new technologies, equipment, and users.

Before 1985, there were no structured cabling standards. Phone companies used their own cabling. Businesses generally used a vendor's proprietary system. Eventually, the Computer Communications Industry Association (CICIA) approached the Electronics Industries Alliance, formerly Association, (EIA) about developing cabling standards, which they did. Discussions centered around developing standards for voice, data, commercial, and residential cabling systems. (The TIA was formed in April 1988 after a merger of the United States

Telecommunications Suppliers Association and the Information and Telecommunications Technologies group of the EIA. Thus the TIA/EIA.)

In 1991, the TIA/EIA published its Commercial Building Telecommunications Wiring Standard, TIA/EIA-568. It was the first standard to define a generic telecommunications system

that would support a multiproduct, multivendor environment. It enabled wiring systems to be planned and installed without definite plans for telecommunications equipment installed later.

The standards committees meet and review standards every five years, and the issuance of TSB (Technical Service Bulletins) is on-going. The TIA/EIA has issued a number of standards covering everything from types of cabling, cabling installation, administration, and more. This guide covers the most relevant standards to commercial buildings.

### Standards organizations.

Today, there are a number of organizations developing standards related to cabling and communications.

**ANSI** (American National Standards Institute). This group coordinates and adopts national standards in the U.S.

**EIA** (Electronics Industries Alliance). Best known for developing cabling standards with the TIA, this trade organization is accredited by ANSI to help develop standards on electronics components, telecommunications, Internet security, and more.

**TIA** (Telecommunications Industry Association). Best known for developing cabling standards with the EIA, the TIA is the leading trade association for the information, communications, and entertainment technology industry. The TIA provides standards development and represents the communications sector of the Electronics Industries Alliance (EIA).

**ISO** (International Organization for Standardization). This group is the world's largest developer of standards and includes standards groups from member nations around the world.

**IEC** (International Electrotechnical Commission). This international standards organization prepares and publishes international standards for all electrical, electronic, and related technologies.

**IEEE** (Institute of Electrical and Electronics Engineers, Inc.). This international organization is a leading developer of industrial standards in a broad range of disciplines, including electric power, information technology, information assurance, and telecommunications. This group is known for its 802.3 committee, which sets the standards for Ethernet.

**BICSI** (Building Industry Consulting Service International, Inc.). This association supports the information transport systems (ITS) industry with information, education, and knowledge assessment.

**CSA** (Canadian Standards Association). Electrical and electronic goods in Canada must be CSA approved.



## Key standards.

### ANSI/TIA/EIA

The Commercial Building Telecommunications Cabling Standard is covered in ANSI/TIA/EIA-568-B.1, -B.2, and -B.3.

**ANSI/TIA/EIA-568-B.1:** Part 1: General Requirements. This standard covers the general requirements for planning, installing, and verifying structured cabling systems in commercial buildings. It also establishes performance parameters for cable channels and permanent link. One of the major changes in this document from the earlier version is that it recognizes CAT5e or higher cabling for the second data outlet.

**ANSI/TIA/EIA-568-B.2:** Part 2: Balanced Twisted-Pair Cabling Components. This standard discusses balanced twisted-pair cabling components and transmission requirements.

**ANSI/TIA/EIA-568-B.2-1:** Part 2, Addendum 1: 4-Pair, 100-Ohm Category 6 Transmission Performance. This standard specifies components and transmission requirements.

**ANSI/TIA/EIA-568-B.2-10 (Draft):** Augmented Category 6 Transmission Performance.

**TSB-155:** Characterizing Existing Category 6 Cabling to Support 10-Gigabit Ethernet.

**ANSI/TIA/EIA-568-B.3:** Optical Fiber Cabling Components Standard.

**ANSI/TIA/EIA-568-B.3-1:** Additional Transmission Performance Specifications for 50/125 Optical Fiber Cabling Systems.

**ANSI/TIA/EIA-569-B:** Commercial Building Standard for Pathways and Spaces.

**ANSI/TIA/EIA-570-A:** Residential Telecommunications Cabling Standard.

**ANSI/TIA/EIA-606-A:** Administration Standard for Telecommunications Infrastructure of Commercial Buildings.

**ANSI/TIA-607:** Commercial Building Grounding and Bonding Requirements for Telecommunications.

**ANSI/TIA/EIA-758:** Customer Owned Outside Plant.

**ANSI/TIA/EIA-862:** Building Automation Systems Standard for Commercial Buildings.

**ANSI/TIA/EIA-942:** Telecommunications Infrastructure Standard for Data Centers

**TSB-1005:** Telecommunications Infrastructure Standard for Industrial Premises

**TSB-162:** Telecommunications Cabling Guidelines for Wireless Access Points.

### ISO

**ISO 11801:2002:** Information Technology—Generic Cabling for Customer Premises.

**ISO/IEC 11801, 2nd Ed.:** Includes Class D, E, and F Cabling.

**ISO/IEC 11801, 2nd Ed. Amendment 1:** Covers Class E<sub>A</sub> and F<sub>A</sub>.\*

**ISO 11801 Class Ea, Edition 2.1:** 10-Gigabit over Copper.

**ISO/IEC TR 24704:** Information Technology—Customer Premises Cabling for Wireless Access Points.

\*NOTE: Class E<sub>A</sub> and F<sub>A</sub> are expected to be approved in Fall 2007.

### IEEE

**IEEE 802.3af:** Power over Ethernet. (PoE).

**IEEE 802.3at (draft):** Power over Ethernet Plus (PoE Plus).

**IEEE 802.11:** Wireless Networking.

**IEEE 802.3an:** 10GBASE-T 10 Gbps (1250 Mbps) Ethernet over Unshielded Twisted Pair (UTP).

### Other Standards and Regulations


**National Fire Protection Association:** National Electrical Code (NEC)

**Occupational Safety and Health Act of 1970**

**State and Local Building, Electrical, and Safety Codes and Ordinances**

Where to buy standards	
ANSI	212-642-4980 www.ansi.org
TIA/EIA	Global Engineering Documents 877-854-7179 (U.S. and Canada) www.ihs.com
ISO/IEC	Available from Global Engineering and ANSI in the U.S. and Canada Global Engineering Documents 877-854-7179 (U.S. and Canada) www.ihs.com ANSI www.ansi.org (U.S.)
ISO	Switzerland: +41 22 34 12 40
IEEE	800-701-4333 (U.S. and Canada) 732-981-0060 (Worldwide) www.ieee.org

## The importance of cable



**C**abling is one of the most important components of your network and is the most long-lived with an expected life span of 15–20 years. You'll most likely replace your network equipment three to four times over the life of the cabling system. Plan on cabling to be about 15% of your total network cost. And don't skimp on the cable or the installation. An investment in a high-quality cabling system is easily justified in reduced downtime, reduced maintenance, and better network performance. So think long-term and buy the best cable and installation services.

### Cabling considerations.

**Network application.** The type of network you plan to run will influence the cable you choose.

**Upgrades.** Anticipate changes and upgrades in equipment and applications.

**Life span.** Expect 10 years minimum and 20 years maximum.

**Distance.** Review the maximum distance between your network switches and the farthest desktop.

**Cable routing.** Consider bend radius and available space for running cables in the floor and ceiling.

**Fire risk.** Abide by all regulations.

**Existing cable.** Is there existing or abandoned cable that needs to be removed?

**EMI (electromagnetic interference).** Don't forget to check for it.

**Environment.** Any physical limitations that could affect your cable choice?

### Choosing cable.

When planning your cabling infrastructure, you have two basic choices: copper or fiber. Both offer superior data transmission. The decision on which one to use depends on your current network, your future networking needs, and your applications, including bandwidth, distances, environment, cost, and more.

Traditionally, copper was used in lower-speed, short-distance networks, and fiber was used in higher-speed, long-distance networks. But with the advent of copper cable running at 10-Gigabit rates, this maxim no longer holds true. You may even find a mixed network with a fiber backbone and copper horizontal cable to be an optimum solution.

## Copper cable

Some of the most obvious advantages copper offers is that it's less expensive than fiber cable and much easier to terminate in the field. Because copper is the most commonly installed cable, there is a vast selection of connecting hardware and networking devices, which are also less expensive than fiber equipment.

### Unshielded twisted pair (UTP).

**UTP.** This is the most widely used cable. Known as balanced twisted pair, UTP consists of twisted pairs (usually four) in a PVC or plenum jacket. When installing UTP cable, make sure you use trained technicians. Field terminations, bend radius, pulling tension, and cinching can all loosen pair twists and degrade performance. Also take note of any sources of EMI. Choose UTP for electrically quiet environments.

### Shielded twisted pair (STP, F/UTP, S/FTP, ScTP, S/STP).

Use shielded cable to extend distances and to minimize EMI. Sources of EMI, commonly referred to as noise, include elevator motors, fluorescent lights, generators, air conditioners, and printers, etc. In 10-GbE, shielded cable can also reduce ANEXT.

Shielded cable can be less balanced than UTP cable because of the shield. The metal sheaths in the cable need to be grounded to cancel the effect of EMI on the conductors. Shielded cable is also more expensive, less flexible, and can be more difficult to install than UTP cable. Most shielded cable is thicker than UTP, so it fills conduits quicker. Keep that in mind as you plan your cable pathways.

**STP.** This is twisted pair cabling with a shield. There are two common shields: foil sheaths and copper braids. Foil gives a 100% shield while a copper braid provides 85% to 95% coverage because of the holes in the braid. But, a braided shield offers *better* overall protection because it's denser than foil and absorbs more EMI. A braided shield also performs better at lower frequencies. Foil, being thinner, rejects less interference, but provides better protection over a wider range of frequencies. For these reasons, combination foil and braid shields are sometimes used for the best protection. Shields can surround all the twisted pairs and/or the individual twisted pairs.

**Foiled/Unshielded Twisted Pair (F/UTP).** Foil is the most basic cable shield. Cables with an overall foil shield surrounding all the pairs are called F/UTP. These may also be called FTP cables.

**Shielded Foiled Twisted Pair (S/FTP).** This cable features individual foil-shielded pairs and an outer shield, which can be braided or foil. It offers the best protection from external noise and ANEXT. This cable was traditionally called Screened Twisted Pair (ScTP). You may also see it listed as **S/STP**.

### Solid vs. stranded conductors.

Copper cable conductors can be solid or stranded, whether the cable is shielded or unshielded.

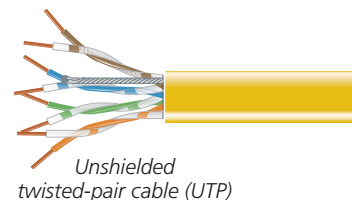
**Solid-conductor.** This cable is designed for both backbone and horizontal cable runs. Use it for runs between equipment rooms or from the telecommunications room to the wallplate. Solid cable shouldn't be bent, flexed, or twisted. Its attenuation is lower than that of stranded-conductor cable.

**Stranded-conductor.** This cable is used primarily as a patch cable between the outlet and desktop and between patching equipment. Stranded-conductor cable is more flexible than solid-core cable. However, attenuation is higher, so the total length of a stranded cable in your channel should be kept to 10 meters or less to reduce signal degradation.

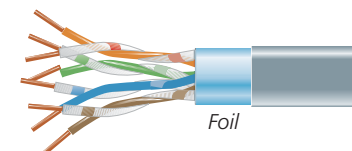
### PVC vs. plenum.

PVC cable features an outer polyvinyl chloride jacket that gives off toxic fumes when it burns. It's most commonly used between the wallplate and workstation. It can be used for horizontal and vertical runs, but only if the building features a contained ventilation system.

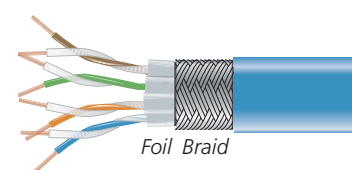
Plenum cable has a special coating, such as Teflon® FEP, which doesn't emit toxic fumes when it burns. A plenum is a space within the building designed for the movement of environmental air. In most office buildings, the space above the ceiling is used for the HVAC air return. If cable goes through that space, it must be "plenum-rated." LS0H (Low Smoke, Zero Halogen) is a type of plenum cable with a thermoplastic compound that reduces the amount of toxic and corrosive gases emitted during combustion.



Unshielded twisted-pair cable (UTP)



Foiled/unshielded twisted-pair cable (F/UTP)



Shielded/foiled twisted-pair cable (S/FTP)



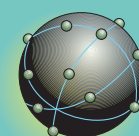
Solid conductor



Stranded conductor

### TECH TIP

**AWG — American Wire Gauge (AWG) is a classification system for the diameter of the conducting wire. The more a wire is drawn or sized, the smaller the diameter. For example, a 24-gauge wire is smaller than an 18-gauge wire.**





## Copper cable standards

As the need for increased bandwidth grows and applications continually get more complex, so does copper twisted-pair cable. Below are brief explanations of specifications for twisted-pair cabling and the applications for which each is best suited.

TIA/EIA-568B specifies several “categories” for both the components and the cable. The ISO/IEC specifies “categories” for the components and “classes” for the cabling.

### Cable categories.

**Category 3 (CAT3)** cable is rated for networks operating up to 16 Mbps. It is suitable for voice transmissions (not VoIP). ISO/IEC refers to the end-to-end channel as Class C.

**Category 4** cable is rated for transmission of 16 Mbps up to 100 meters. It is considered obsolete.

**Category 5 (CAT5)** cable was common for 100-Mbps LANs. It was ratified in 1991 and is now considered obsolete.

**Enhanced Category 5 (CAT5e/Class D)** cable, ratified in 1999, was designed to enable twisted-pair cabling to support full-duplex, 100-MHz applications such as 100BASE-TX and 1000BASE-T. CAT5e introduces stricter performance parameters such as Power-Sum Near-End Crosstalk (PS-NEXT), Equal-Level Far-End Crosstalk (EL-FEXT), and Power-Sum Equal-Level Far-End Crosstalk (PS-ELFEXT). It also introduces channel and component testing.

**Category 6 (CAT6/Class E)** cable easily handles Gigabit Ethernet (1000BASE-T) applications. It’s a 100-ohm cable with a frequency of 250 MHz. CAT6 has far more stringent performance parameters than CAT5e, and is characterized by channel, link, and component testing. In addition, CAT6 components must be backwards-

compatible with lower-level components. It’s important to note with CAT6, as with all categories, that all the components in a channel must be of the same level. If not, the channel will perform at the lowest level.

The TIA TSB-155: Characterizing Existing Category 6 Cabling to Support 10-Gb Ethernet, ISO/IEC 24750, and IEEE 802.3an all address 10GBASE-T over UTP cabling. They also address installation practices to mitigate Alien Crosstalk (ANEXT) though it is not a specified CAT6 measurement. CAT6 is also recommended for mid-span PoE applications. At the time of this publication (mid 2007), CAT6 cabling is the system of choice for new installations because of the increased headroom.

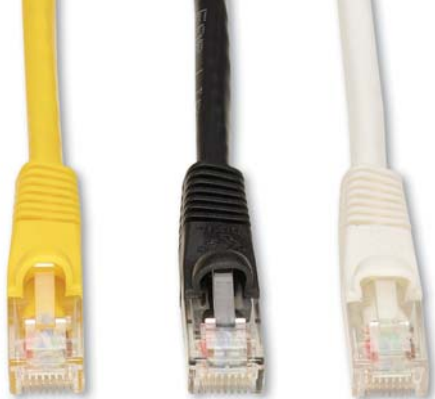
**Augmented Category 6 (CAT6a/Class E<sub>A</sub>)**, a relatively new standard, is designed to meet or exceed the requirements of 10-Gigabit Ethernet over copper at 100 meters. It extends the frequency range of CAT6 from 250 MHz to 500 MHz. Like CAT6, it includes an integrated set of channel, permanent link, and component requirements. It introduces an Alien Crosstalk (ANEXT) measurement for closely bundled “six around one” cable configurations. (For information on ANEXT, see [pages 28–29](#).) Both UTP and F/UTP cables can be used in CAT6a deployments. The F/UTP cable, though, virtually eliminates the problem of ANEXT.



Balanced Twisted-Pair Cable Specifications

	CAT5	CAT5e	CAT6	CAT6a	CAT7
Frequency	100 MHz	100 MHz	250 MHz	500 MHz	600 MHz
Attenuation (min. at 100 MHz)	22.0 dB	22.0 dB	19.8 dB	—	20.8 dB
Characteristic Impedance	100 ohms ± 15%	100 ohms ± 15%	100 ohms ± 15%	—	100 ohms ± 15%
NEXT (min. at 100 MHz)	32.3 dB	35.3 dB	44.3 dB	27.9 dB	62.1 dB
PS-NEXT (min. at 100 MHz)	—	32.3 dB	42.3 dB	—	59.1 dB
EL-FEXT (min. at 100 MHz)	—	23.8 dB	27.8 dB	9.3 dB	(not yet specified)
PS-ELFEXT (min. at 100 MHz)	—	20.8 dB	24.8 dB	—	(not yet specified)
PS-ANEXT (min. at 500 MHz)	—	—	—	49.5 dB	—
PS-AELFEXT (min. at 500 MHz)	16.0 dB	20.1 dB	20.1 dB	23.0 dB	14.1 dB
Return Loss (min. at 100 MHz)	16.0 dB	20.1 dB	20.1 dB	8.0 dB	14.1 dB
Delay Skew (max. per 100 m)	—	45 ns	45 ns	—	20 ns
Networks Supported	100BASE-TX	1000BASE-T	1000BASE-T	10GBASE-T	(not yet specified)

NOTE: The ISO currently has Class F<sub>A</sub> (Category 7a) requirements under development. They are based on Class F requirements and the Category 7 non-RJ style plug. They specify a bandwidth of 600 to 1000 MHz.



**Category 7/Class F** is only an ISO/IEC 11801:2002 standard and is not in a draft stage by the TIA. It's designed to meet or exceed the requirements of 10-Gigabit Ethernet. The standard specifies a frequency of 1–600 MHz over 100 meters of fully shielded twisted-pair cabling.

Category 7/Class F cable consists of four individually shielded pairs inside an overall shield. It's called Shielded/Foiled Twisted Pair (S/FTP) or Foiled/Foiled Twisted Pair (F/FTP). With both, each twisted pair is enclosed in foil. In S/FTP cable, the four pairs are encased in an overall metal braid. In F/FTP, the four pairs are encased in an overall foil shield.

The fully shielded cable virtually eliminates crosstalk between the pairs. In addition, the cables are noise resistant, making the Category 7/Class F system ideal for high EMI areas. It's well suited for applications where fiber optic cable would typically be used—but costs less.

Category 7/Class F cable can be terminated with two interface designs as specified in IEC 6063-7-7 and IEC 61076-3-104. One is an RJ-45 compatible GG-45 connector. The other is the more common TERA® connector launched in 1999.

**Category 7a/Class F<sub>A</sub>** is a pending ISO class based on the use of S/FTP cable to 1000 MHz.

## 10-GbE and twisted-pair cable.

The cabling industry is developing two different standards that can be used in 10-GbE applications. One is for use with Category 6 (CAT6) cable, and one is for Augmented Category 6 (CAT6a). These standards specify requirements for each component in the channel, such as cable and connecting hardware, as well as for the permanent link, and the channel.

**10-GbE using CAT6.** The first set of standards define cabling performance when using Category 6/Class E cabling for 10-GbE applications. The TIA/EIA version is the Technical Systems Bulletin 155 (TSB 155). ISO/IEC TR 24750 is a technical report that details measuring existing Class E systems.

No matter what the cable length is, CAT6 cable must meet 10-GbE electrical and ANEXT specifications up to 500 MHz. However, the CAT6 standard now specifies measurements only to 250 MHz, and it does not have an ANEXT requirement. There is no guarantee CAT6

Comparison of Categories and Classes				
Frequency	TIA (Components)	TIA (Cabling)	ISO (Components)	ISO (Cabling)
1-100 MHz	CAT5e	CAT5e	CAT5e	Class D
1-250 MHz	CAT6	CAT6	CAT6	Class E
1-500 MHz	CAT6a	CAT6a	CAT6a	Class E <sub>A</sub>
1-600 MHz	n/s	n/s	CAT7	Class F
1-1000 MHz	n/s	n/s	CAT7 <sub>A</sub>	Class F <sub>A</sub>

can support a 10-GbE system. But the TSB provides guidelines for ways to help mitigate ANEXT. One way to lessen or eliminate ANEXT altogether is to use shielded cable and equipment, such as F/UTP cable. Another way is to follow mitigating installation techniques, such as using non-adjacent patch panels, separating equipment cords, unbundling horizontal cabling, avoiding areas of high EMI, etc.

**10-GbE using CAT6a.** The second set of standards will define Augmented Category 6 (CAT6a) and Augmented Class E (Class E<sub>A</sub>) cabling. The newer, augmented cabling systems are designed to support 10-GbE over a 100-meter horizontal UTP channel.

The TIA/EIA version is in draft as of mid 2007 and will be published as ANSI/TIA/EIA-568B.2-AD10. It recognizes both UTP and STP CAT6a systems. It extends CAT6 electrical parameters such as NEXT, FEXT, return loss, insertion loss, and more to 500 MHz. It also specifies near- and far-end Alien Crosstalk (ANEXT, AFEXT) to 500 MHz. It also goes beyond IEEE 802.3an by establishing the electrical requirements for the permanent link and cabling components. The ISO Class E<sub>A</sub> standard will be published in a new edition of the 11801 standard.

10-GbE Cabling		
Cable	Standard	Link Segment Distances
CAT6/Class E		
Unshielded	TSB-155, ISO/IEC TR-24750	55 (37*) m to 100 m
Shielded	TSB-155, ISO/IEC TR-24750	55 (37*) m to 100 m
CAT6a/Class E <sub>A</sub>	TIA/EIA-568-B.21-AD10	100 m
Unshielded	ISO/IEC 11801 2.1	
Class F	ISO/IEC TR-24750	100 m
Shielded		

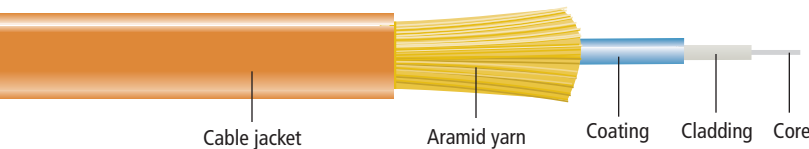
\* TSB-155 allows 37 meters in CAT6 installations without mitigation.

NOTE: For S/FTP and FIUTP cable, see [blackbox.com](http://blackbox.com).

## Fiber cable

Fiber optic technology uses light as an information carrier. The cable consists of a core, a single continuous strand of glass or plastic that's measured in microns ( $\mu$ ) by the size of its outer diameter. This is the pathway for light rays carrying data signals.

Fiber is the preferred cable for applications that require high bandwidth, long distances, and immunity to electrical interference. It's the most commonly installed backbone cable as well.



### The advantages of fiber.

**Greater bandwidth.** Because fiber provides far greater bandwidth than copper and has proven performance at rates up to 10 Gbps, it gives network designers future-proofing capabilities. Fiber can carry more information with greater fidelity than copper.

**Low attenuation and greater distance.** Because the fiber optic signal is made of light, very little signal loss occurs during transmission, and data can move at high speeds and greater distances. Fiber distances can range from 300 meters (984.2 ft.) to 40 kilometers (24.8 mi.), depending on the style of cable, wavelength, and network. (Fiber distances are usually measured in metric units.)

**Security.** Your data is safe with fiber. It doesn't radiate signals and is extremely difficult to tap. If the cable is tapped, it leaks light causing failures.

**Immunity.** Fiber provides extremely reliable data transmission. It's completely immune to many environmental factors that affect copper cable, such as EMI/RFI, crosstalk, impedance, and more. You can run fiber cable next to industrial equipment without worry. It's also less susceptible to temperature fluctuations than copper cable is.

**Design.** Fiber is lightweight, thin, and more durable than copper cable. It has pulling specifications that are up to 10 times greater than copper cable. Its small size makes it easier to handle, and it takes up less space in cabling ducts. Like copper, fiber is available with PVC and plenum jackets. Although fiber is more difficult to terminate than copper, advancements in connectors are making termination easier. And fiber is actually easier to test than copper cable.

**Costs.** Installation costs for fiber are higher than copper because of the skill needed for termination. Overall, fiber is more expensive than copper in the short run, but it may actually be less expensive in the long run. Fiber typically costs less to maintain, has less downtime, and requires less networking hardware.

### Multimode vs. single-mode

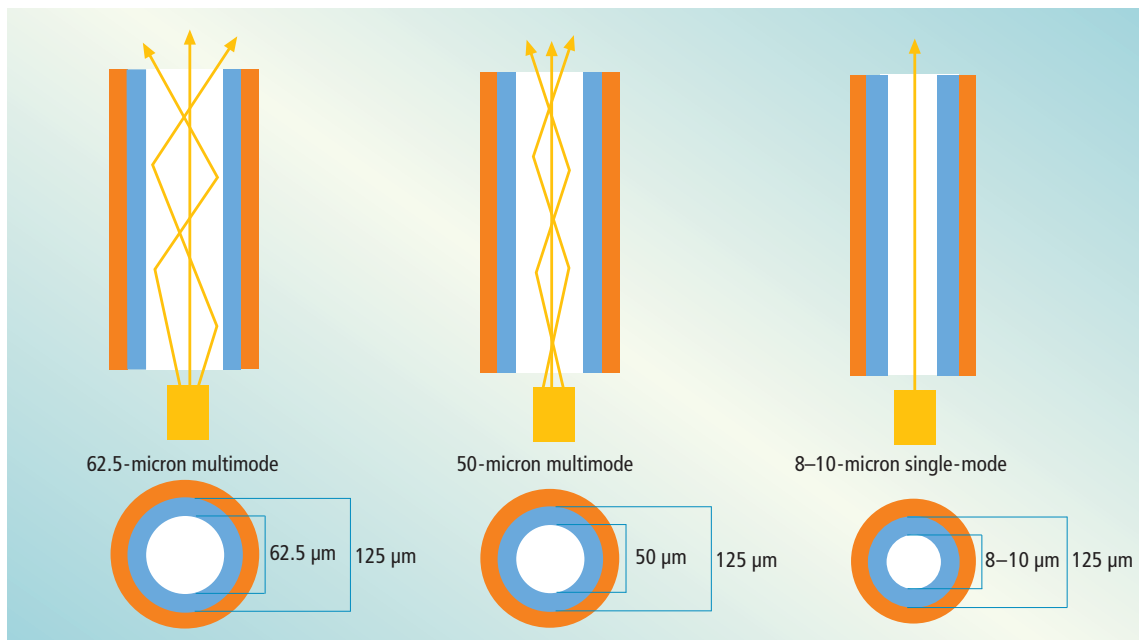
There are two types of fiber cable: multimode and single-mode. Most of the fiber cable used within a building is multimode. Single-mode cable, with its higher performance, is more commonly used in campus networks between buildings.

#### Multimode, 50- and 62.5-micron cable.

Multimode cable has a large-diameter core and multiple pathways of light. It comes in two core sizes: 50-micron and 62.5-micron.

Fiber Performance Standards					
Fiber Type	Wavelength	Attenuation (dB/km) Max.	Bandwidth (MHz/km)	Distance	
				Gigabit Ethernet	10-GbE
Multimode					
50-/125-Micron	850 nm	3.5	500	500 m	300 m
	1300 nm	1.5	500	500 m	300 m
62.5-/125-Micron	850 nm	3.5	160	220 m	300 m
	1300 nm	1.5	500	220 m	300 m
Single-Mode 8-10-/125-Micron					
Premises	1310 nm	1.0	—	2-5 km*	10 km*
	1550 nm	1.0	—	50-100 km*	40 km*
Outside Plant	1310 nm	0.5	—	2-5 km*	10 km*
	1550 nm	0.5	—	50-100 km*	40 km*





Multimode fiber cable can be used for most general data and voice applications. Both 50- and 62.5-micron cable feature the same cladding diameter of 125 microns, but 50-micron fiber cable features a smaller core (the light-carrying portion of the fiber). LED and laser light sources can also be used with both 50- and 62.5-micron cable.

The big difference between the two is that 50-micron cable provides longer link lengths and/or higher speeds, particularly in the 850-nm wavelength.

Although both can be used in the same way, 50-micron cable is recommended for backbone, horizontal, and intrabuilding connections, and should be considered for any new construction and installations. There is still a market for 62.5-micron multimode products though because many buildings already have multimode cable installed. *But it bears repeating: For new installations, use 50-micron cable.*

Multimode fiber cable is traditionally orange. 50-micron fiber cable that's optimized for 10-Gigabit applications is aqua.

**Single-mode, 8–10-micron cable.** Single-mode cable has a small 8–10-micron glass core and only one pathway of light. With only a single wavelength of light passing through its core, single-mode cable realigns the light toward the center of the core

instead of simply bouncing it off the edge of the core as multimode does.

Single-mode cable provides 50 times more distance than multimode cable. Consequently, single-mode cable is typically used in long-haul network connections spread out over extended areas, including cable television and campus backbone applications. Telcos use it for connections between switching offices.

Single-mode cable is traditionally yellow.

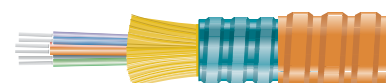
## Specialty fiber cable.

Depending on your application, you may want to use a specialty fiber cable.

To save money on innerducts and conduit, you can use a fiber cable with an aluminum interlocking armor covering an internal plenum jacket. It's flexible but extraordinarily strong so you can run this cable anywhere in your building.

If you need to run cable outdoors, consider an indoor/outdoor cable that can be pulled anywhere, between and within buildings. Because of its tough construction, it doesn't have to be terminated within 50 feet of the building entrance. Outdoor fiber cable is typically black.

Both cables are available at [blackbox.com](http://blackbox.com).



*An aluminum interlocking armor enables this fiber cable to be run anywhere indoors.*

*This tight-buffered cable can be run anywhere—indoors or out.*

## The structured cabling system

**A** structured cabling system, as defined by the TIA/EIA, consists of six subsections:

### 1 Horizontal Cabling

### 2 Backbone Cabling

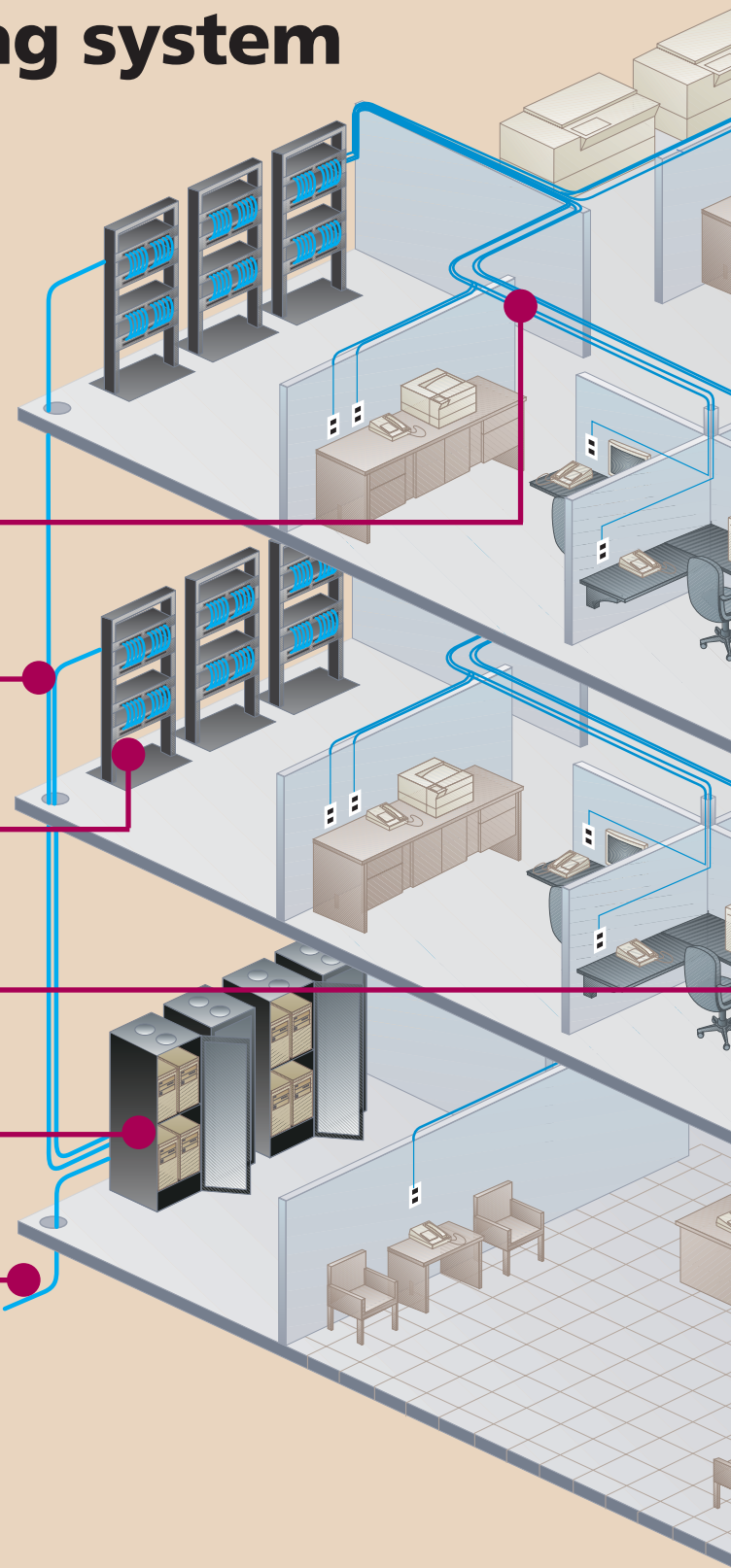
### 3 Telecommunications Room (TR)

### 4 Work Area (WA)

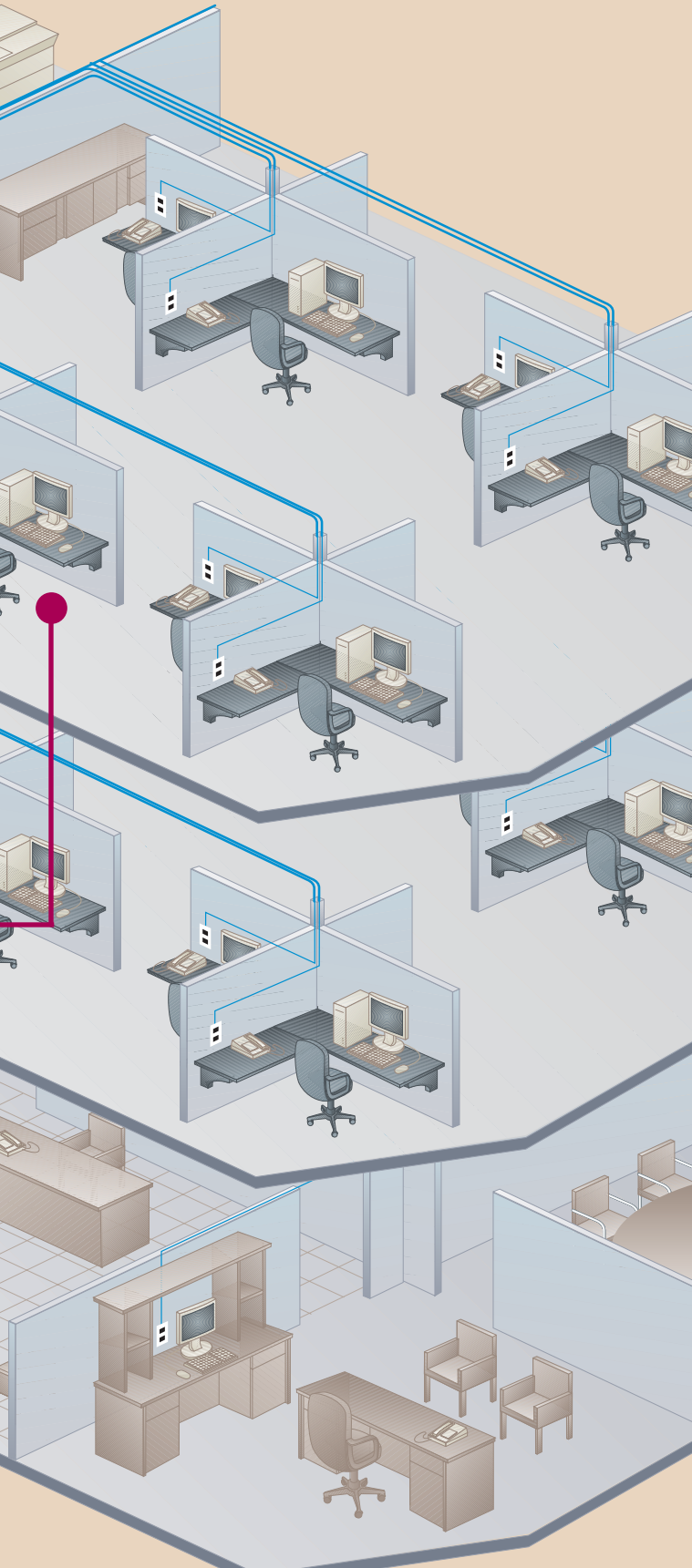
### 5 Equipment Room (ER)

### 6 Entrance Facility (EF)

*NOTE: This review is intended to present only the highlights of applicable TIA/EIA standards and is not to be considered a definitive resource for planning your system. For information on how you can get the complete standards, see [page 7](#).*



# Structured Cabling System



## Horizontal cabling.

The horizontal cabling system encompasses everything between the telecommunications room cross-connects to the telecommunications outlets in the work area. It's called horizontal because the cable typically runs horizontally above the ceiling or below the floor from the telecommunications room, which is usually on the same floor. For details, see [pages 16–18](#).

## Backbone cabling.

The backbone system encompasses all the cabling between telecommunications rooms, equipment rooms, entrance facilities, and between buildings. For details, see [pages 19–20](#).

## Telecommunications room.

The telecommunications room holds the termination equipment needed to connect the horizontal wiring to the backbone wiring. A building must contain at least one telecommunications room, and it should be on the floor it serves. For details, see [page 22](#).

## Work area.

The work area consists of all the components between the telecommunications outlet and the user's workstation equipment. For details, see [page 21](#).

## Equipment room.

The equipment room houses telecommunications systems, such as PBXs, servers, and the mechanical terminations. It's different than the telecommunications room because of the complexity of the components. An equipment room may take the place of a telecommunications room or it may be separate. For details, see [page 23](#).

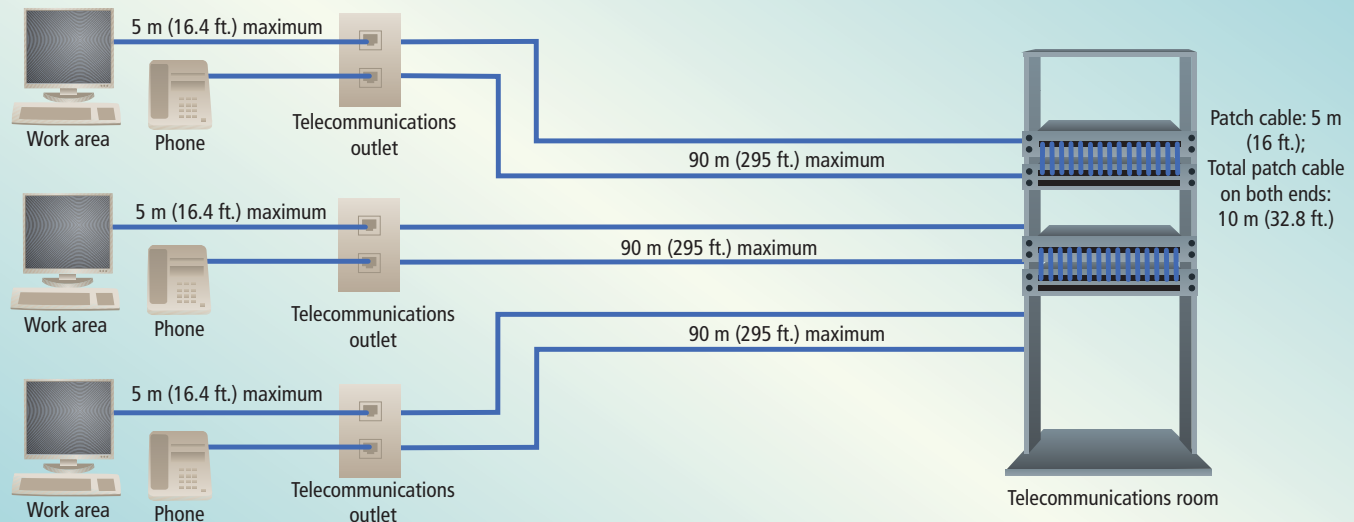
## Entrance facility.

The entrance facility is the point where the outdoor cable connects with the building's backbone cabling. This is usually the demarcation point between the service provider and the customer-owned systems. For details, see [page 23](#).



## Horizontal cabling

### Horizontal Cabling Distances



### Planning horizontal cabling.

The horizontal cabling system encompasses everything between the telecommunications room cross-connects to the outlets in the work area. It's specified in TIA/EIA-568-B.1 and includes:

- Horizontal cabling.
- Telecommunications outlets.
- Telecommunications connectors.
- Cross-connects.
- Patch cords.
- Consolidation point (if any).

Most of the cables in your building will be part of the horizontal cabling system. These can include your voice, data, multimedia, security, HVAC, PoE, wireless, and other systems.

After a building is constructed, the horizontal cabling system is subject to the most activity in terms of users, locations, changes in building layouts, and more. But the horizontal cable is much less accessible than the backbone cable. To change the horizontal cabling after installation can be very expensive, time-consuming, and disruptive. Plan carefully because the horizontal cabling is extremely important to the design and effectiveness of your cabling system.

### Horizontal cabling considerations.

**Change.** Plan for it. Accept the fact that after your system is up, most of the work will be MACs. You should be able to relocate users and equipment without changing the cable or disrupting users. Run cable to all areas of the building, even if they're vacant. When expansion occurs, you'll be ready.

**Maintenance.** Set up your system so that it facilitates on-going maintenance.

**Equipment.** Satisfy current network requirements, but consider future equipment changes, too.

**Applications.** Consider your current applications while planning for more bandwidth-intensive applications in the future.

**User work areas.** Don't be surprised if your organization decides to change its floor plan—frequently. Just be prepared.

**Keeping up appearances.** To maintain a neat office, horizontal cabling should never be visible. There are many installation methods, including raised access floor, conduit, cable trays, ceiling pathways, raceways, and perimeter pathways.

**Physical layouts.** Consider how and where you're going to run cable. Do you have enough space to

accommodate bend radius and fill ratios? What are fire and building code regulations? Are there physical barriers or environmental factors, such as seismic planning or water levels? You get the idea.

**Documentation.** Plan on thoroughly labeling and documenting all connections in the telecommunications room and at the workstation outlet.

**EMI.** Take into account any areas of high EMI, such as near elevators, motors, and other equipment.

## Horizontal topology.

The following are highlights of the TIA/EIA-568-B.1 specifications.

- The horizontal system shall (remember that “shall” means required) be installed in a star topology.
- Each work-area telecommunications outlet shall be connected to the horizontal cross-connect in the telecommunications room.
- The telecommunications room should be on the same floor as the work area.
- Bridge taps and splices shall not be installed for copper cable.
- No more than one transition point or consolidation point shall be installed. (The exception comes later.)
- Electrical components shall not be installed as part of the horizontal cabling. No application-specific components can go there either. They can go next to the outlets or cross-connects.
- A minimum of two telecommunications outlets shall be installed for each work area. One should be at least CAT3 or higher for voice. The other should be CAT5e or higher for data. You can add more if you want.

## Maximum horizontal distances.

- Horizontal run: 90 meters (295.3 ft.) from the telecommunications outlet to the horizontal cross-connect.
- Work-area patch cord: 5 meters (16.4 ft.).
- Total of work-area and cross-connect patch cords, equipment cables, jumpers, etc: 10 meters (32.8 ft.).

## Recognized media.

### Cables

You can use these cables individually or in combination.

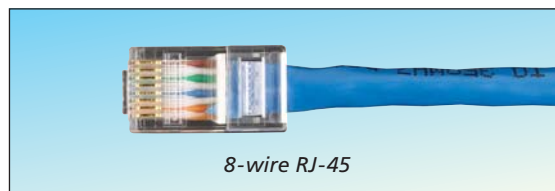
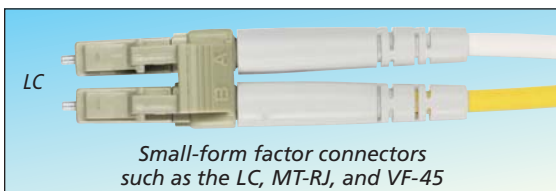
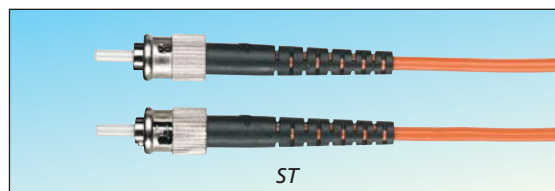
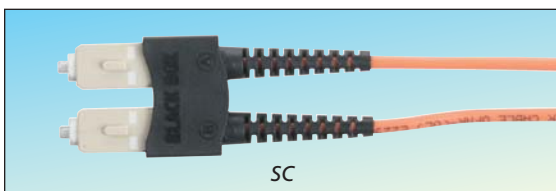
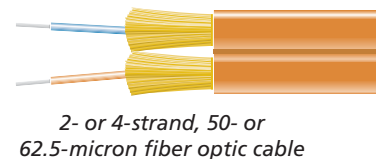
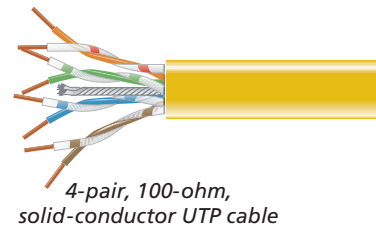
- 4-pair, 100-ohm UTP or ScTP cable (24 AWG, solid conductors) (EIA/TIA-568-B.2).
- 2-fiber (or more) 50- and 62.5-micron fiber optic cable (EIA/TIA-568-B.3).
- 150-ohm shielded twisted-pair cable is recognized, but not recommended.

Hybrid cables (multiple cable types in one sheath) are allowed, provided each individual cable is recognized and meets the transmission and color-coding requirements for that cable.

For copper horizontal runs, use solid-conductor cable. Use stranded conductor cable for the patch cords. Make sure your cables are marked with the correct performance category. And match performance categories of the channel equipment, such as jacks, patch cords, patch panels, etc. This ensures category performance.

### Connectors

- 8-position modular jack and plug with T568A or T568B pinning. See **page 21**.
- SC and ST® fiber connectors.
- Small form-factor fiber connectors.



## Open office cabling.

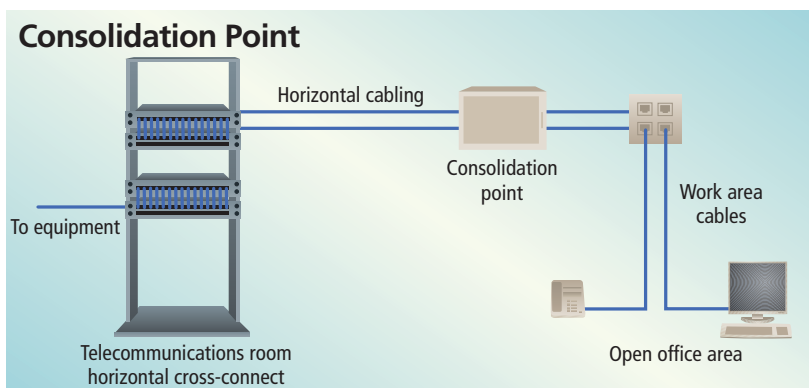
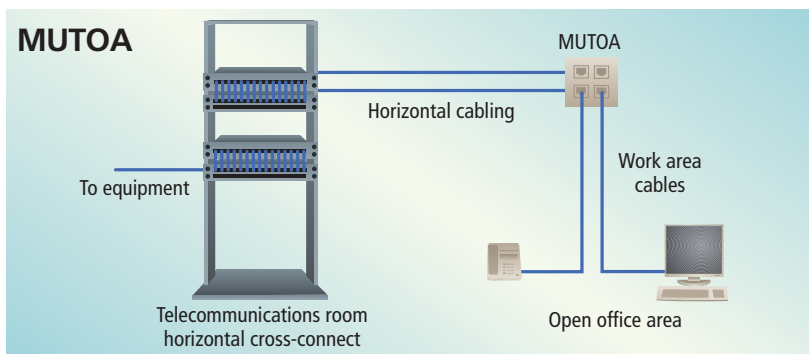
If you have an open office with lots of modular furniture and anticipate lots of MACs, the TIA has specified two horizontal cabling configurations for you: the MUTOA and the Consolidation Point. Both will enable you to keep your horizontal cabling intact when your open office layout is changed.

*Open office cabling is the only exception you'll find to the 5-meter rule for work area cables.*

**Open Office Horizontal Cabling Distances**

Horizontal Cable Length	Maximum Work Area Cable Length (24 AWG)	Work Area, Patch, and Equipment Cord Maximum Combined Length
90 m (295.3 ft.)	5 m (16.4 ft.)	10 m (32.8 ft.)
85 m (278.9 ft.)	9 m (29.5 ft.)	14 m (45.9 ft.)
80 m (262.5 ft.)	13 m (42.6 ft.)	18 m (59.1 ft.)
75 m (246.1 ft.)	17 m (55.7 ft.)	22 m (72.1 ft.)
70 m (229.6 ft.)	22 m (72.1 ft.)	27 m (88.6 ft.)

**NOTE:** The maximum length for a work area cable is 22 meters (72.1 ft). For fiber cable, any combination of horizontal, work area, patch, and equipment cables may not exceed 100 meters (328 ft).



## MUTOA (Multiuser Telecommunications Outlet Assembly).

The MUTOA enables the terminations of multiple horizontal cables in a common, permanent location, such as a column, wall, or permanent furniture, close to a cluster of work areas. Guidelines include:

- Locate multi-user telecommunications outlets in a permanent location.
- Multi-user telecommunications outlets shall not be installed in the ceiling.
- The maximum cable length is 20 meters (65.6 ft.).
- A maximum of 12 work areas can be served.
- Uniquely identify work area cables on each end.

## Consolidation point.

The Consolidation Point (CP) is a straight-through interconnection point in the horizontal cabling. It provides another option for open office cabling and is ideal for work areas that are frequently reconfigured, but not as frequently as a MUTOA.

Specifications include:

- Only one CP is allowed per horizontal run between the work area and telecommunications room. Cross-connection between the cables is not allowed.
- A CP should not be more than 15 meters (49.2 ft.) from the telecommunications room.
- A CP can serve a maximum of 12 work areas.

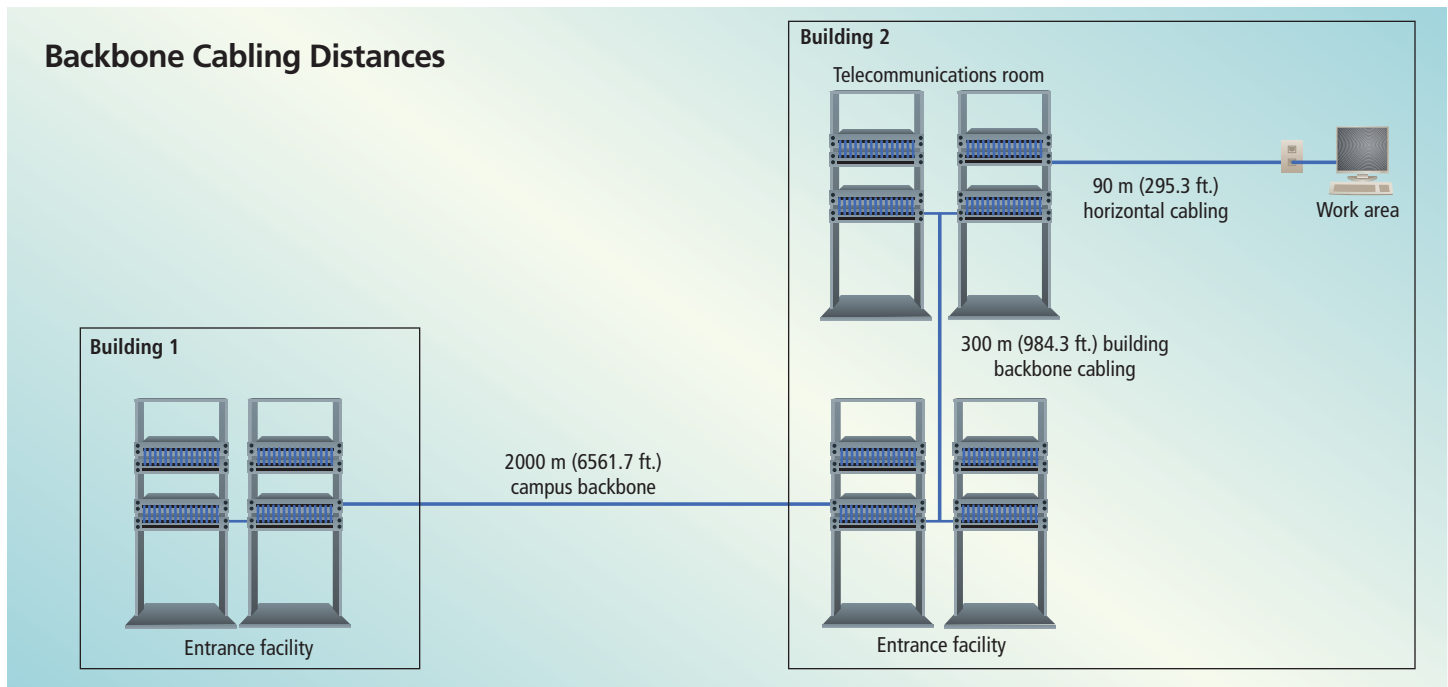
## Centralized fiber optic cabling.

Centralized fiber optic cabling, Annex A to the TIA/EIA-568-B.1, gives you recommendations for designing a fiber-to-the-desktop system. It centralizes the fiber electronics instead of using electronics on different floors. Recommendations include:

- To connect the fiber from the work area to the equipment room, you can use either a splice or interconnect in the telecommunications room.
- The distance for the total channel is 300 meters (984.3 ft.), including the horizontal, intrabuilding backbone, and patch cords.
- Fiber can be pulled through the telecommunications room. The distance is limited to 90 meters (295.3 ft.).
- Cable can be 50- or 62.5-micron fiber.
- Allow for slack and sufficient space for the addition and removal of cable, and conversion to a full cross-connect system.



## Backbone cabling



### Planning backbone cabling.

Backbone cabling provides the main information conduit connecting all your horizontal cabling within a building and between buildings. It's the inter-connection between telecommunication rooms, equipment rooms, and entrance facilities. In large organizations, you can connect multiple LANs with a high-speed backbone to create large service areas.

Backbone cabling is specified in TIA/EIA-568-B.1 and includes:

- Cabling
- Intermediate and main cross-connects
- Mechanical terminations
- Patch cords or jumpers for backbone-to-backbone connections

Another type of backbone is called a collapsed backbone. This is usually a short backbone that has a central router or switch interconnecting all the LAN segments in a given building.

The main requirement of any backbone is that it be able to support your current needs as well as future applications. When planning your backbone, take these factors into consideration.

**Performance and applications.** Plan on far more bandwidth than you think you'll ever need.

**Site size and user population.** Current size and future growth requirements must be considered. Plan your backbone to accommodate the maximum number of connections anticipated in all telecommunication rooms, equipment rooms, and entrance facilities. You may want to consider installing extra, unused copper or "dark" fiber cable for future needs.

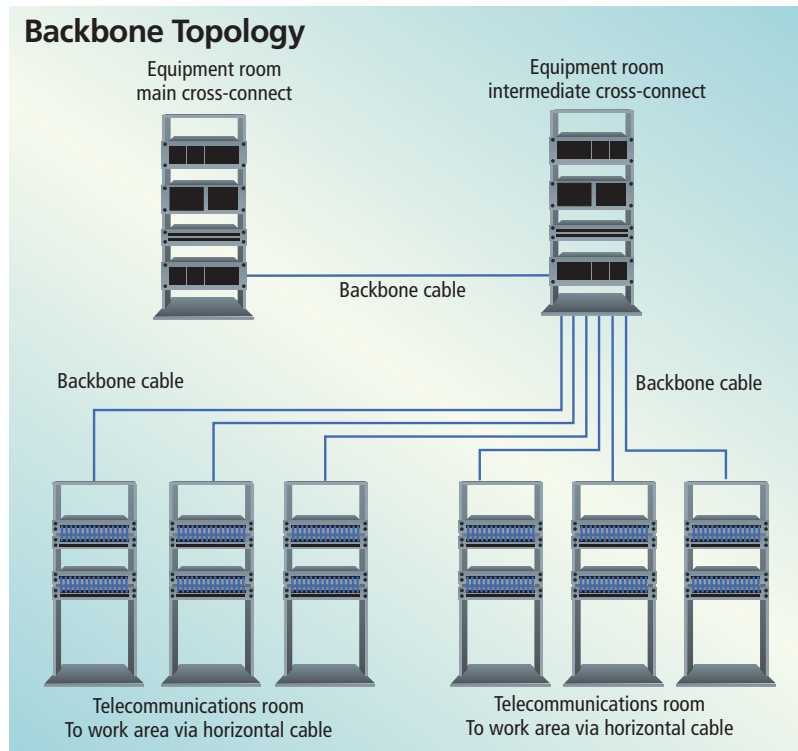
**Distance.** The distance you run your backbone will most likely determine the type(s) of cable you use.

**Redundancy and diverse path routing.** Consider diverse path routing for mission-critical systems. This consists of running redundant backbones in separate pathways far from each other. The redundant cables should never be run in the same conduit. Although they terminate at the same place, they will follow different routes to get there, such as on different sides of a building.

**Useful life.** Be aware of the minimum length of time the backbone cabling is expected to serve. Replacing backbone cable is inconvenient and expensive.

# Structured Cabling System

## Backbone Topology



### Physical environment.

- **EMI.** Install copper away from areas of EMI.
- **Physical plant systems.** Install away from a building's physical plant systems, such as electrical wiring, plumbing, and sprinklers. Do not install backbone cable in elevator shafts.
- **Environment.** Air spaces should be examined for dampness, which can corrode copper cable. In addition, take into account all pathway standards and requirements.
- **Fire resistance.** Pay attention to all fire regulations.
- **Security.** Make sure your backbone cable and all equipment and telecommunications rooms are inaccessible to unauthorized personnel.

### Backbone topology.

The recommended topology is a conventional hierarchical star where all the wiring radiates from

a central location called the main cross-connect. Each telecommunications room or equipment room is cabled to the main cross-connect either directly or via an intermediate cross-connect. A benefit of this topology is that it provides damage control. If a cable goes out, only that segment is involved. Others are unaffected. Here are some backbone cabling recommendations:

- The backbone system shall be installed in a hierarchical star topology.
- From the horizontal cross-connect, there shall be no more than one additional cross-connect to reach the main cross-connect.
- There should be no more than two levels of backbone cross-connects.
- There shall be no bridged taps and splitters.
- Make sure you meet all grounding requirements.

### Recognized media.

The cable you choose depends on your application and distance requirements. Fiber and copper cables have different characteristics that may make one more suitable for a particular application over the other. You may even use a combination of the two. For instance, you can use fiber to connect runs between buildings and for the vertical riser within a building. But you may decide to use copper for the second level backbone connecting the intermediate cross-connects to the horizontal cross-connects.

Recognized cables include:

- 4-pair, 100-ohm twisted-pair cable (TIA/EIA-568-B.2).
- 50- or 62.5-micron multimode fiber optic cable (TIA/EIA-568-B.3).
- Single-mode fiber optic cable (TIA/EIA-568-B.3).

### Maximum distances.

Backbone cable distances depend on the application as well as the cable used. For allowed distances, see the chart below .

Backbone Cabling Distances			
Media Type	Main Cross-Connect to Horizontal Cross-Connect	Main Cross-Connect to Intermediate Cross-Connect	Intermediate Cross-Connect to Horizontal Cross-Connect
100-ohm Copper	800 m (2624.7 ft.)	500 m (1640.4 ft.)	300 m (984.3 ft.)
Multimode Fiber	2000 m (6561.7 ft.)	1700 m (5577.4 ft.)	300 m (984.3 ft.)
Single-mode Fiber	3000 m (9842.5 ft.)	2700 m (8858.3 ft.)	300 m (984.3 ft.)

## Work area

The work area consists of all the components between the telecommunications outlet and the user's desktop workstation equipment. This covers:

- Telecommunications outlets, including wallplates, faceplates, surface-mount boxes, etc.
- Patch cables.
- Adapters, including connectors, and modular jacks.
- Workstation equipment, such as PCs, telephones, printers, etc. although they aren't included in the standard.

The work area should be well managed even though it is designed for frequent changes. There are a few specific recommendations in TIA/EIA-568-B.1:

- You should install a minimum of two telecommunications outlets in each work area.
  - The first outlet shall be a 100-ohm, 8-position modular jack, CAT3 or higher. It's very advisable to use CAT5e or higher.
  - The second outlet can be another 100-ohm, 8-position modular jack (minimum CAT5e or CAT6), or...
  - A 2-fiber, 62.5- or 50-micron fiber SC, ST, or other small-form factor duplex fiber connector.
- UTP wiring should follow T568A or T568B schemes. (See **right**.)
- The 4-pair UTP patch cable from the telecommunications outlet to the workstation equipment should be no more than 5 meters (16.4 ft.).

- Make sure the equipment cords, patch cables, and modular jacks all have the same performance rating.
- Follow standard installation practices and maintain proper pair twists, bend radius, etc.
- Use different pathways for electrical wiring and structured cabling.
- Estimate pathway capacity at 20–40% fill.
- Run an independent pathway to control centers, reception areas, and other high-activity spaces.
- An electrical outlet should be installed within 3 feet (9.1 m) and at the same height.

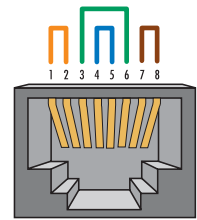
### T568A and T568B pinning.

There are two approved pinning methods: T568A and T568B. The T568A scheme is the one recognized and used by the U.S. government. The T568A pinning is also common in Canada and in other parts of the world.

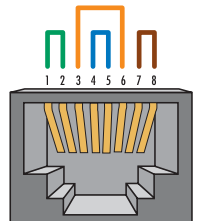
The T568B pinning is the one used by AT&T® and is the de facto standard in the U.S.

By the way, the T stands for termination, and not TIA as commonly thought.

Whichever scheme you choose, stick to it. All pin/pair assignments must conform to one standard or the other. Mixing the two can cause crossed pairs, which just doesn't work. In addition, you must follow established telecommunications cabling color schemes.



**T568B**



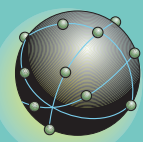
**T568A**



Wiring Color Codes				
Wire Color	Pair	Tip/Ring	T568A Jack Pin #	T568B Jack Pin #
White/Blue	1	Tip 1	5	5
Blue/White	1	Ring 1	4	4
White/Orange	2	Tip 2	3	1
Orange/White	2	Ring 2	6	2
White/Green	3	Tip 3	1	3
Green/White	3	Ring 3	2	6
White/Brown	4	Tip 4	7	7
Brown/White	4	Ring 4	8	8

## TECH TIP

*A cross-connect is the connection between horizontal cabling and backbone or equipment hardware. Connections made directly between equipment and the horizontal cable are called interconnects.*



## Telecommunications room

Formerly known as the telecommunications closet, the telecommunications room (TR) houses all the equipment associated with connecting the backbone wiring to the horizontal wiring. It includes:

- Intermediate cross-connects
- Main cross-connects
- Patch cords
- All connecting equipment

The telecommunications room can also house auxiliary equipment such as a PBX, security equipment, etc.

### Design specifications.

The telecommunications room is addressed in TIA/EIA-568-B.1. But you'll find the complete design and provisioning recommendations in TIA/EIA-569-B.

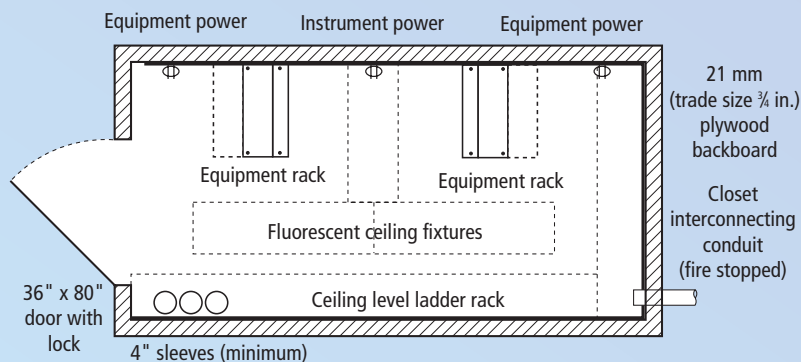
- If you're terminating less than 100 meters of cable, you can use an interconnection. As the number of connections grows, use cross-connects for better cable management.
- Place the telecommunications room as close as possible to the center of the floor.
- Do not share the telecommunications room with electrical equipment.

### Recommended Room Sizes

Floor Area		Room Size	
m <sup>2</sup>	ft. <sup>2</sup>	m	ft.
1000	10,763	3 x 3.4	10 x 11
800	8611	3 x 2.8	10 x 9
500	5381	3 x 2.2	10 x 7

- Depending on the size of the floor area, you should have at least one telecommunications room per floor. The recommendation is one TR per 10 m<sup>2</sup> (100 ft.<sup>2</sup>).
- If the floor area is greater than 1000 m<sup>2</sup> (10,763 ft.<sup>2</sup>), or if the distance to the work area exceeds 300 feet, there should be additional telecommunications rooms per floor.
- When there are multiple telecommunications rooms on a floor, interconnect them with at least one trade size 3 conduit.
- Specific room sizes are recommended based on floor-area size. These provide sufficient space for all connecting hardware, as well as enough room for technicians to work comfortably.
- Be aware of any seismic zone requirements.

### Typical Layout of a Telecommunications Room



### Requirements for the Telecommunications Room

- At least two walls must be covered in 2.6-meter (8.5-ft.) high, 200-mm (¾ in.) thick A-C plywood capable of supporting equipment.
- Do not install a false ceiling.
- Lighting should supply at least 500-foot candles (540 lux) of illumination.
- Walls, floor, and ceiling should be light colored to enhance lighting.
- HVAC equipment should provide continuous 24/7/365 service.
- Fire protection should be provided.
- The door should be at least 910-mm (35.8-in.) wide and 2000 millimeters (78.75 in.) high. It should be hinged, sliding, or removable, and have a lock.
- The minimum floor loading should be at least 2.4 kPa (50lb/ft<sup>2</sup>).
- Install at least two dedicated duplex electrical outlets on separate circuits. If necessary, additional duplex outlets can be placed at 1.8 meters (5.9 ft.) around the room.

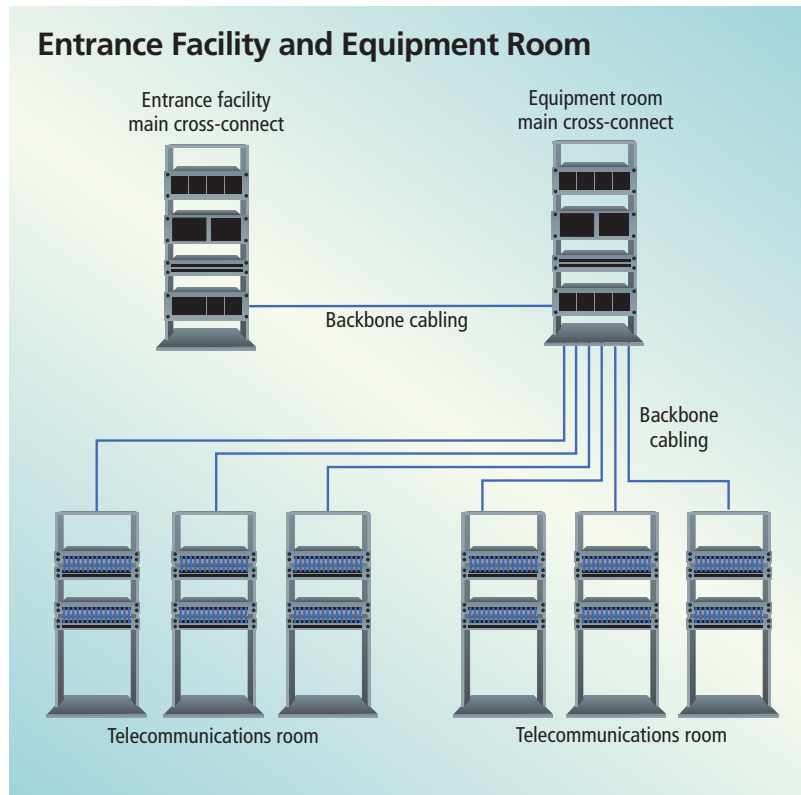


## Equipment room

The equipment room (ER) houses telecommunications systems, such as PBXs, servers, routers, switches, and other core electronic components as well as the mechanical terminations. It's different than the telecommunications room because of the complexity of the components. An equipment room may take the place of a telecommunications room or it may be separate. It can also function as the entrance facility. The equipment room is specified in TIA/EIA-568-B. Design recommendations are in TIA/EIA-569-B.

### Design considerations.

- Each building should contain at least one equipment room or telecommunications room.
- Only install equipment related to the telecommunications system.
- Consider future expansion when sizing and placing the equipment room.
- Design the door to accommodate the delivery of large enclosures and equipment. The door should be a minimum of 910 mm (35.8 in.) wide and 2000 mm (78.7 in.) high. A double door without a center post is best.
- The minimum ceiling height shall be 2.4 meters (7.8 ft.). No false ceilings either.
- The minimum recommended size is 14 m<sup>2</sup> (150.7 ft.<sup>2</sup>). The general rule is to allow 0.07 m<sup>2</sup> (0.75 ft.<sup>2</sup>) for every 10 m<sup>2</sup> (107.6 ft.<sup>2</sup>) of usable floor space.
- The room should have conditioned power and backup power.
- Protect against vibration, EMI, contaminants, and pollutants. The room should not be near mechanical rooms, electrical distribution panels, and wet/dirty areas.
- Take into account any water infiltration issues. Do not locate the room below water level.
- Like the telecommunications room, provide 24/7/365 HVAC. Temperature and humidity should be controlled.
- The lighting should be the same as the TR: 500 lux (50 foot candles).
- The floor loading should be a minimum of 4.8 kPa (100 lbf/ft<sup>2</sup>).



## Entrance facility

The entrance facility (EF) is the point where the outdoor plant cable connects with the building's backbone cabling. This is usually the demarcation point between the service provider and the customer-owned systems. The entrance facility is designated in TIA/EIA-568-B. Design recommendations are in TIA/EIA-569-B. It includes:

- Cables.
- Connecting hardware.
- Protection devices.

### Design considerations.

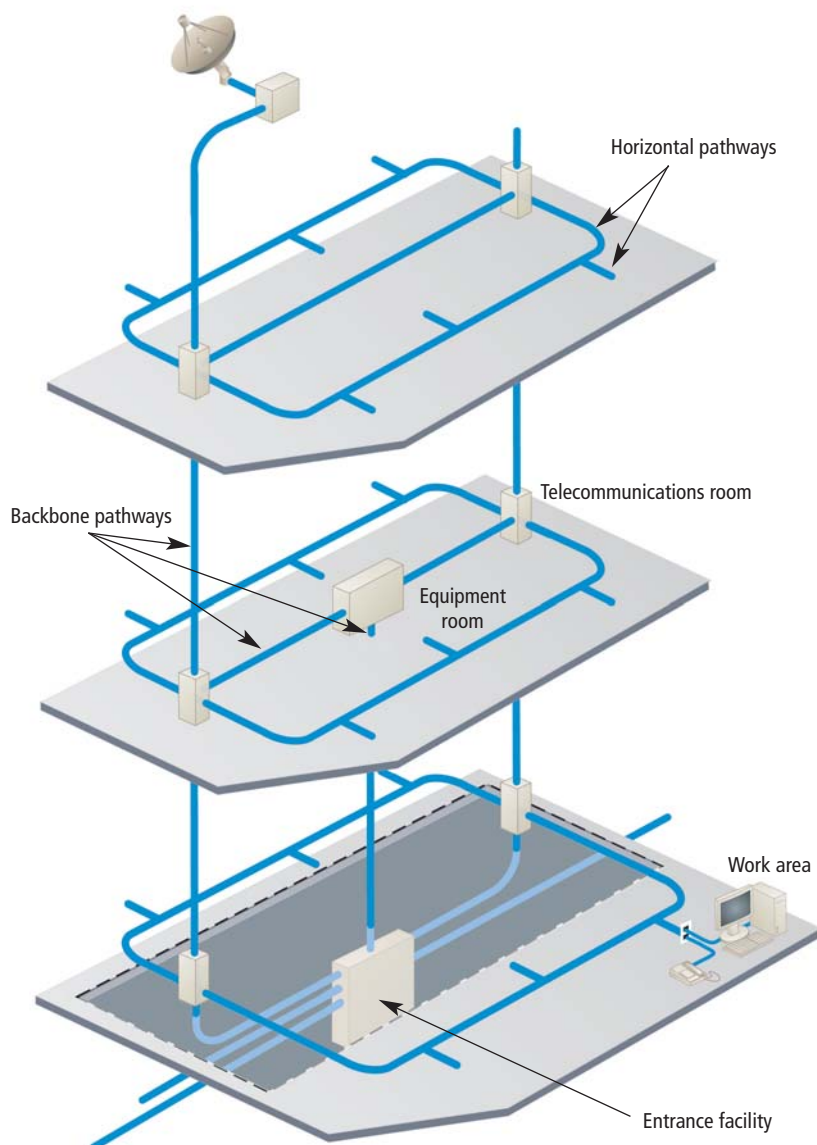
- The entrance facility may also house the backbone links to other buildings in a campus.
- Public network interface equipment and telecommunications equipment may be in the entrance facility.
- The location should be a dry area, near the vertical backbone pathways.
- The entrance facility should be provisioned as the telecommunications room is for environment, HVAC, lighting, doors, electrical power, etc.

## Pathways

Simply put, a pathway is the space in which cable runs from one area to another. The standard TIA/EIA-569-B: Commercial Building Standard for Telecommunications Pathways and Spaces defines different types of pathways, such as interbuilding, intrabuilding, horizontal, service entry, etc.

This discussion will cover intrabuilding backbone and horizontal pathways. Interbuilding and service entry pathways are beyond the scope of this guide.

### Building Pathways



### Intrabuilding backbone pathways.

Intrabuilding backbone pathways run vertically and horizontally between the entrance facilities, equipment room, and telecommunications room(s). They carry the backbone cable and can be conduit, sleeves, slots, or cable trays. Complete specifications for conduit, sleeves, trays, pull points, and more can be found in the TIA standard.

*NOTE: Make sure all pathways are firestopped. And, do not use elevator shafts as backbone pathways.*

**Vertical backbone pathways.** When designing a building, stack the telecommunications rooms vertically above one another on each floor. This provides for the easiest and most efficient backbone runs. The TRs should have a minimum of three 4-inch sleeves for floor areas of 5000 m<sup>2</sup> (58,819 ft.<sup>2</sup>). One sleeve is for the cable; the other two are spares.

**Horizontal backbone pathways.** If the TRs are not stacked vertically, use 4-inch conduit to connect them horizontally. You should have no more than two 90° bends between pull points. In addition, the fill should not exceed 40% for any run greater than two cables.

### Horizontal pathways.

As the name suggests, these pathways run horizontally between the telecommunications room and the work area. You can choose a number of different pathways, depending on your facility, office layout, and cable type. When choosing, keep in mind the pathway fill for current and future use, and allow enough room for growth.

### Pathway options.

**Underfloor duct.** These are a system of single- or dual-level, rectangular ducts embedded in concrete flooring that's at least 64-mm (2.5-in.) or 100-mm (3.9 in.) deep, respectively.

**Flush duct.** This is a single-level, rectangular duct embedded flush with the top level of a 25-mm (1-in.) concrete surface.

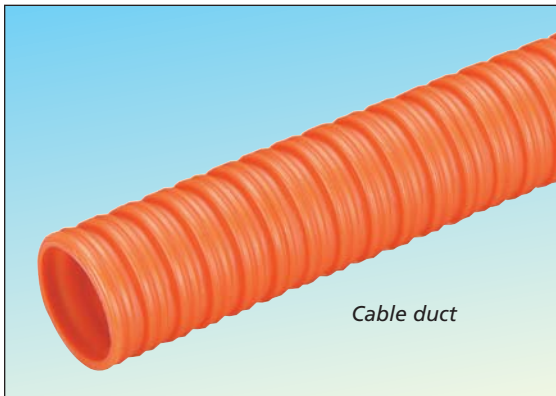
**Multichannel raceway.** Ducts have separate channels for running telecommunications and power cable. The raceways are designed to be buried in 75-mm (3-in.) reinforced concrete.

**Cellular floor.** These are preformed, steel-lined cells buried in 75-mm (3-in.) reinforced concrete. They come with preset fittings and large capacity header ducts.

**Trench duct.** This solid tray has compartments and a flat top, and is embedded flush with the concrete.

**Access floor.** This consists of modular floor panels supported by pedestals. It's commonly used in computer and equipment rooms.

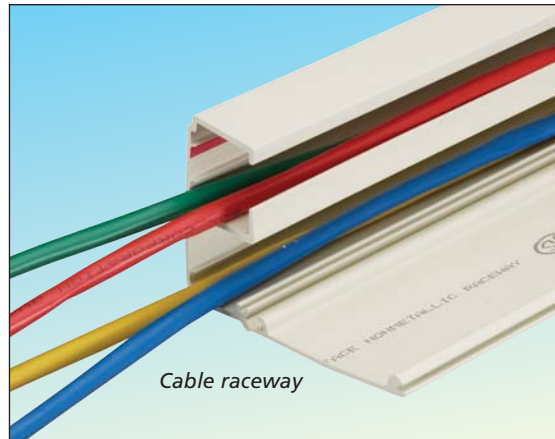
**Conduit.** There are different types of conduit: metallic tubing, rigid metal, and rigid PVC. Use conduit when your telecommunications outlets are considered permanent, device density is low, and future changes are not a consideration. Conduit must meet the appropriate electrical codes. It should not be longer than 30 meters (98.4 ft.) nor contain more than two 90-degree bends between pull points.



Cable duct

**Cable trays.** Options include prefabricated channel, ladder, solid bottom, ventilated, and wire trays. Trays can be located above or below the ceiling.

**Ceiling pathways.** This is one of the most popular methods of routing cable. Bundled cables run on J-hooks suspended above a plenum ceiling. The cables are then fanned out through the walls, support columns, or power poles to the work area outlet. *Cables must be supported and must not be run directly on the ceiling tiles.*



Cable raceway

**Perimeter raceways.** These include plastic or metal surface, recessed, multichannel, and molded raceways. Use them in areas where devices can be reached from the walls at convenient levels. Fill capacity should be no more than 20–40%, depending on the cable.

## Power considerations.

Make sure your telecommunications cables and power cables are separated. Also check your local codes. Some allow the two cables to be run in the same raceway (with a barrier), while others do not. Consider sources of EMI/RFI and be sure to use surge protection equipment.

## Other pathways.

Please refer to the standard for recommendations for work area and telecommunications outlet pathways.



Cable tray

## Cable installation practices

You can invest in the best cable and hardware, but if they're not installed properly, they won't work, or at least they won't work well. Protect your investment and follow the guidelines as outlined in TIA/EIA-568-B.1. The most important practices involve:

1. Cable pair twists.
2. Bend radius.
3. Tension.
4. Cinching.
5. Connecting hardware.

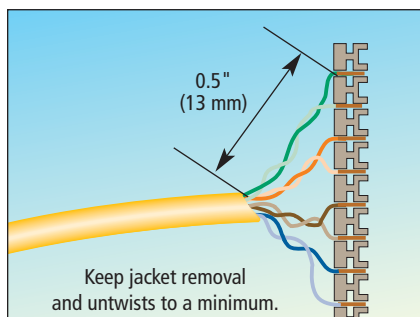
There are others, but if you do nothing else, mind these.

### Cable pair twists.

This is the most important guideline you can

follow for twisted-pair cable. The pair twists are responsible for much of cable's performance. If you lose the twists, you lose performance. Remember this.

When terminating CAT5e or higher, maintain pair twists to within 13 mm (0.5 in.) from the point of termination. And remove as little of the sheath as possible.



### Bend radius.

Next on your installation "to-do" list is bend radius. If you bend twisted-pair cable too much, you loosen the twists, and yes, lose performance. The following bend radii are under no-load conditions:

**UTP horizontal.** 4 times the cable diameter.

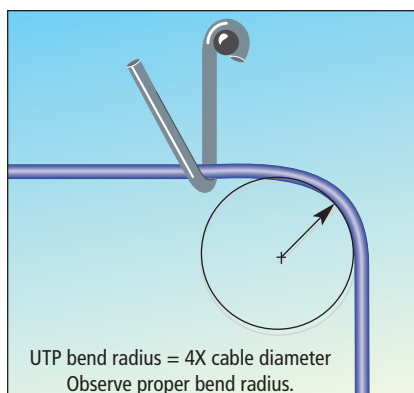
**Sctp horizontal.** 8 times the cable diameter.

**Multipair backbone.** 10 times the cable diameter.

**2- and 4-fiber horizontal.** Not less than 25 mm (0.98 in.).

**Fiber backbone:** Not less than 10 times the cable diameter, or as recommended by the manufacturer.

Even though there is no standard at this time for patch cable bend radius, be aware of that, too.



### Tension.

Too much tension will give you a headache.

**UTP.** To avoid stretching, pulling tension should not exceed 110 N (25 lb/ft.). Pulling too hard untwists the pairs, and you know what that does. Use supports and trays in cable runs to minimize sagging, which pulls on the pairs and degrades performance.

**2- and 4-fiber horizontal:** The maximum tensile load is 222 N (50 lb/ft.).

### Cinching.

Take care not to cinch cable bundles tightly, which causes stress and degrades performance. Tie cable bundles loosely. And never ever staple cables.

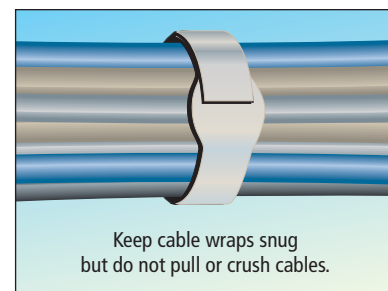
### Connecting hardware.

**Twisted pair.** It may seem obvious, but use connecting hardware of the same category or higher. The transmission of your components will always be the lowest category in the link. So, if you're using CAT6 cable, use CAT6 connectors.

**Fiber.** Fiber is much more difficult to terminate in the field than copper cable. If you have a poor fiber polish and alignment, you'll lose a great deal of performance. Rather than field polishing the termination, use pre-polished connectors.

### Miscellaneous considerations.

- Visually inspect the cable installation for proper terminations, bend radius, tension, etc.
- Don't uncoil UTP on a spool. It can cause kinks and NEXT failures. Rotate the spool instead.
- Plan for 12 inches of slack cable behind wall outlets for possible future reterminations.
- As always, avoid EMI. And don't run UTP cable over fluorescent lights, etc.





## Cable testing

Once you install your structured cabling infrastructure, you have to test its performance. Just because you bought the best materials and followed all the installation recommendations, it doesn't mean your system is going to work flawlessly. Transmission performance depends on a number of factors:

- Cable characteristics
- Connecting hardware
- Patch cords and cross-connect wiring
- Number of connections
- Installation practices

Specific performance requirements are listed in TIA/EIA-568-B.2 for balanced twisted-pair cable and TIA/EIA-568-B.3 for fiber optic cable.

### Field testing copper.

There are two ways to check a copper cabling system: channel tests and permanent link tests.

**Channel.** This provides the most reliable results for actual transmission performance. Channel tests are performed after all the telecommunications equipment is in place. The channel includes:

- Horizontal cable, up to 90 meters (295.3 ft.)
- Work area patch cord, up to 5 meters (16.4 ft.)
- Work area telecommunications outlet connector
- Optional consolidation point connection
- Two TR patch cord connections

The total length of the channel must not exceed 100 meters (328 ft.). The total length of equipment, patch, and work area cords must not exceed 10 meters (33 ft.).

Many manufacturers now have their channels pre-tested and verified by independent laboratories, such as ETL® Semko.

**Permanent link test.** This test provides installers and technicians with a method of verifying the performance of the permanently installed cable, minus any patch cord connections. It measures performance before any telecommunications room equipment or office furniture is installed, and is not as accurate as the channel test. The permanent link includes:

- Horizontal cable, up to 90 meters (295.3 ft.)
- Two connections, one at each end
- An optional consolidation point connection

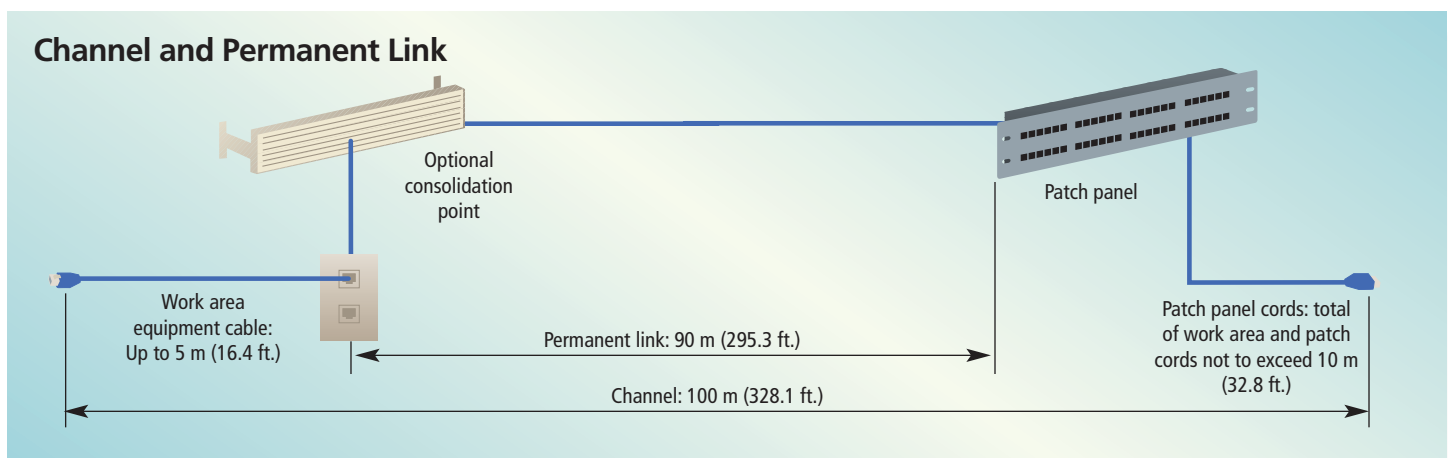
### Copper test parameters.

The primary copper test parameters are:

- Wire map
- Length
- Insertion loss
- Near-end crosstalk (NEXT)
- Power-sum near-end crosstalk (PS-NEXT)
- Equal-level far-end crosstalk (EL-FEXT)
- Power-sum equal-level far-end crosstalk (PS-ELFEXT)
- Return loss
- Propagation delay
- Delay skew

For explanations, see the Glossary on **pages 41–43**.

For more copper performance parameters and 10-GbE test information, see **pages 28–29**.



## Copper testers.

If all these tests seem a little overwhelming, they are. But there's help—professional technicians and professional-grade test equipment. Trained technicians know how to use the advanced Level III and IV equipment that automatically tests, calculates, and certifies your copper cable links in accordance with TIA and ISO standards. Level III equipment is designed for measurements to 250 MHz. Level IV testers certify accuracy up to 600 MHz. Manufacturers of test equipment are conforming to the changes in standards with firmware updates.

The results of the tests will tell you if your system meets all the applicable performance standards. If there are problems, the technicians and the

equipment can help isolate the problem. Better yet, the equipment saves all the test results for downloading and proper documentation.

## 10-GbE considerations.

In June 2006, the IEEE approved the standard for 10-Gbps Ethernet, or 10GBASE-T (10-GbE). 10-GbE transmission requires a bandwidth of 500 MHz. The industry is using two different cables for 10-GbE applications: Category 6 (CAT6) cable and Augmented Category 6 (CAT6a).

## Alien crosstalk.

Before discussing how to test CAT6 and CAT6a in 10-GbE, a definition of alien crosstalk is needed.

Alien crosstalk (ANEXT) is a critical measurement unique to 10-GbE systems. Crosstalk, measured in 10/100/1000BASE-T systems, is the mixing of signals between wire pairs within a cable. Alien crosstalk is the measurement of the signal coupling between wire pairs in different, adjacent cables.

The amount of ANEXT depends on a number of factors, including the proximity of adjacent cables and connectors, cable length, cable twist density, and EMI. Patch panels and connecting hardware are also affected by ANEXT.

With ANEXT, the affected cable is called the disturbed, or victim, cable. The surrounding cables are the disturbers.

## 10-GbE over CAT6.

CAT6 cable must meet 10-GbE electrical and ANEXT specifications up to 500 MHz. However, as of mid 2007, the CAT6 standard specifies measurements only to 250 MHz and does not specify an ANEXT requirement. There is no guarantee CAT6 can support a 10-GbE system. But the TIA TSB-155, ISO/IEC 24750, and IEEE 802.3an all characterize 10GBASE-T over UTP cabling.

The TSB provides guidelines for ways to help mitigate ANEXT. One way to lessen or completely eliminate ANEXT is to use shielded equipment and cables such as Black Box's S/FTP or F/UTP cables (see [blackbox.com](http://blackbox.com)). Another way is to follow mitigation guidelines, such as using non-adjacent patch panels, separating equipment cords, unbundling cabling, etc.

**Copper Performance Comparison at 100 MHz**

	CAT5e	CAT6	CAT6a	ISO Class F (CAT7)
<b>Standard</b>	TIA-568-B.2	TIA-568-B.2-1	TIA-568-B.2-10 draft	ISO/IEC 11180*
<b>Insertion Loss</b>				
Channel	24.0 dB	21.3 dB	20.8 dB	20.8 dB
Permanent Link	21.0 dB	18.6 dB	17.9 dB	17.7 dB
<b>NEXT</b>				
Channel	30.1 dB	39.9 dB	39.9 dB	62.9 dB
Permanent Link	32.3 dB	41.8 dB	41.8 dB	65.0 dB
<b>PS-NEXT</b>				
Channel	27.1 dB	37.1 dB	37.1 dB	59.9 dB
Permanent Link	29.3 dB	39.3 dB	39.3 dB	62.0 dB
<b>ELFEXT (ACRF*)</b>				
Channel	17.4 dB	23.3 dB	23.3 dB	44.4 dB
Permanent Link	18.6 dB	24.2 dB	24.2 dB	46.0 dB
<b>PS-ELFEXT (PSACR-F**)</b>				
Channel	14.4 dB	20.3 dB	20.3 dB	41.4 dB
Permanent Link	15.6 dB	21.2 dB	21.2 dB	43.0 dB
<b>Return Loss</b>				
Channel	10.0 dB	12.0 dB	14.0 dB	12.0 dB
Permanent Link	12.0 dB	14.0 dB	6.0 dB	14.0 dB
<b>PS-ANEXT</b>				
Channel	—	—	60.0 dB	—
Permanent Link	—	—	61.1 dB	—
<b>PS-AACRF</b>				
Channel	—	—	37.0 dB	—
Permanent Link	—	—	37.8 dB	—

\* ACRF (Attenuation to crosstalk ratio, far-end) is replacing ELFEXT in the CAT6a proposed draft.

\*\* PSACR-F (Power sum attenuation to crosstalk ratio, far end) is replacing PS-ELFEXT in the CAT6a proposed draft.

NOTE: PS-ANEXT (power sum alien near-end crosstalk) and PS-AACRF (power sum attenuation-to-alien crosstalk ratio, far-end) are new measurements.

## 10-GbE over CAT6a.

Augmented Category 6 (CAT6a) and Augmented Class E (Class E<sub>A</sub>) cabling are designed to support 10-GbE over a 100-meter horizontal channel.

The TIA/EIA-568B.2-AD10 (draft) extends CAT6 electrical parameters such as NEXT, FEXT, return loss, insertion loss, and more to 500 MHz. The CAT6a draft specifies near- and far-end alien crosstalk (ANEXT, AFEXT) to 500 MHz for closely bundled “six around one” cable configurations. It also goes beyond IEEE 802.3an by establishing the electrical requirements for the permanent link and cabling components. The ISO Class E<sub>A</sub> standard will be published in a new edition of the 11801 standard.

These standards specify requirements for each component in the channel, such as cable and connecting hardware, as well as for the permanent link and the channel.

## Testing 10-GbE.

Field certification for 10-GbE consists of two phases. The first is to certify the transmission capability and quality of each individual link. The 10-GbE test limits are identical to CAT6 and ISO 11801, but the frequency range is extended from 250 MHz to 500 MHz. The parameters are insertion loss, return loss, pair-to-pair near-end crosstalk (NEXT), power-sum NEXT, pair-to-pair equal-level far-end crosstalk (ELFEXT), Power-Sum ELFEXT (PS-ELFEXT), propagation delay, length, delay skew, and wire map.

The second phase is to field certify the cabling system for compliance with alien crosstalk (ANEXT) requirements, which are the between-channel parameters. This should include sample testing of some links in a bundle to verify compliance.

## Measuring ANEXT.

Typically in a laboratory, measuring power sum alien near-end crosstalk (PS-ANEXT) and power-sum alien far-end crosstalk (PS-AFEXT) is based on cables in a “six-around-one” configuration. The central cable is the victim cable, and all the adjacent cables are the disturbers. This test configuration provides a worst case scenario. A total of seven equal length links are connected to each other at previously defined

distances. Every circuit is measured against the other so there are 96 individual measurements.

At this point, it's not possible to test all wire-pair combinations in the field for ANEXT. One strategy is to use a sampling technique to select a limited number of links for testing. The chosen links should be those most likely to fail, such as the longest links, or shorter links with the shortest distance between connectors. Limit testing to links that are bundled together.

## Field testing fiber.

Compared to copper, fiber optic cable is relatively simple to test. Basically, you shine a light down the cable and measure how much arrives on the other end. That's attenuation, and it's the performance parameter used for fiber testing. Unfortunately, attenuation can be affected by the installation, but it's easily tested in the field.

The typical fiber test link includes:

- Fiber cable (horizontal or backbone, depending on application)
- Telecommunications outlet connector
- Consolidation points, if any

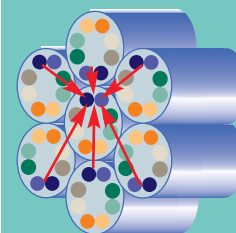
When testing fiber, each individual link segment in both the horizontal and backbone runs must be tested. Each segment is allowed a budget loss. Then, the total link insertion loss is the sum of the individual link segment losses.

The performance standards for fiber optic cable are listed in the chart on **page 12**.

## Fiber testers.

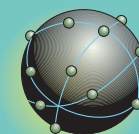
Don't worry about trying to test your fiber system yourself. Again, there are professional technicians who know how to use advanced fiber test equipment, which includes a power meter and a light source. Very advanced equipment can test different wavelengths, in both directions, eliminating a lot of legwork for either you or a professional technician. These testers, like their copper counterparts, automatically calculate all test results and save them for future downloading and documentation.

## TECH TIP



ANEXT

*In a six-around-one configuration with a disturbed, or victim, cable, alien crosstalk measures the crosstalk induced in a wire pair in the victim cable by wire pairs in adjacent cables. ANEXT can be mitigated or eliminated through the use of S/FTP or F/UTP cable.*



## Structured cabling administration

Following standard practices ensures current and future occupants of a building have all the information they need for smooth operations. Administrative record keeping is detailed in TIA/EIA-606-A: Administration Standard for Commercial Telecommunications Infrastructure. It specifies identification, labeling, and documentation for different components of the structured cabling system, including:

- Telecommunications pathways (horizontal and backbone)
- Telecommunications spaces (telecommunications rooms, work areas, equipment rooms, etc.)
- Connecting hardware and splices
- Cables
- Equipment
- Building(s)
- Grounding and bonding

### Classes of administration.

The TIA specifies four classes of administration based on the size and complexity of the infrastructure. It defines the requirements for identifiers, records, and labeling.

**Class 1: Single equipment room.** This is a building with a single equipment room and no backbone cabling.

- Telecommunications Space (TS) identifier
- Horizontal link identifier
- Telecommunications Main Grounding Busbar (TMGB)
- Telecommunications Grounding Busbar (TGB)

**Class 2: Single building, multiple telecommunications rooms.**

- Class 1 identifiers
- Building backbone identifier
- Building backbone pair or fiber identifier
- Firestopping location identifier
- Optional pathways identifiers

**Class 3: Campus with multiple buildings.**

- Class 2 identifiers
- Building identifier
- Campus backbone cable identifier
- Campus backbone pair or fiber identifier

Optional identifiers:

- Optional Class 2 identifiers
- Outside plant pathway element identifier
- Campus pathway or element identifier

Additional identifiers may be added.

**Class 4: Multisite/multicampus.**

- Class 3 identifiers.
- Campus or site identifier

Optional identifiers:

- Optional Class 3 identifiers
- Intercampus element identifier

Additional identifiers for mission-critical systems, WAN connections, large or multitenant buildings, pathways and spaces, and outside plant elements are optional, but recommended.

### Identification formats/labeling.

When identifying the elements in your system, you must create a unique alphanumeric code, or label, for each location, pathway, cable, and termination point. These codes link back to the corresponding record, which should contain all the information related to that component, including linkages.

The format of the code or label is not mandated by the standard, although it does list numerous examples. Whatever format you choose, it must be consistent, logical, and flexible.

The label itself must be easily readable and should withstand environmental conditions. The labels must be printed or produced mechanically.

### Color coding.

Color coding the termination fields is recommended to simplify system administration. A rule of thumb is that the labels identifying each end of a cable must be the same color.

Label Color Coding		
Color	Pantone Number	Element Identified
Orange	150C	Demarcation point (central-office termination)
Green	353C	Network connections on the customer side
Purple	264C	Common equipment
White		First-level backbone
Gray	422C	Second-level backbone
Blue	291C	Horizontal cabling terminations
Brown	465C	Interbuilding backbone
Yellow	101C	Auxiliary circuits
Red	184C	Key telephone systems



# Industrial environments

## Ethernet/Industrial Protocol.

The Ethernet/Industrial Protocol (Ethernet/IP) standard, usually called Industrial Ethernet, is an open standard. Industrial Ethernet adapts ordinary, off-the-shelf IEEE 802.3 Ethernet physical media to industrial applications. In addition, all the TIA/EIA 568-B.1, 568-B.2, and 568-B.3 standards apply in harsh environments.

## TIA/EIA 1005: Industrial Telecommunication Infrastructure.

The TIA TR-42.9 subcommittee is developing the TIA/EIA 1005 standard to address harsh environments. It defines the requirements for cabling, connectors, pathways, and spaces and will establish four environmental conditions with the acronym MICE:

- Mechanical (shock, vibration, impact, etc.)
- Ingress (contamination influx)
- Climate (temperature, humidity, UV exposure, etc.)
- Electromagnetic (conducted and radiated interference)

## Ingress Protection.

The Ingress Protection (IP) ratings, developed by the European Committee for Electrotechnical Standardization (CENELEC), specify the environmental protection equipment enclosures provide. It consists of two or three numbers: The first number refers to protection from solid objects or materials; the second number refers

to protection from liquids; and the third number, commonly omitted, refers to protection against mechanical impacts. For example, an IP67-rated connector is totally protected from dust and from the effects of immersion in 5.9 inches (15 cm) to 3.2 feet (1 m) of water for 30 minutes. Because office-grade RJ-45 connectors do not stand up in industrial environments, the Ethernet/IP standard calls for sealed industrial RJ-45 connectors that meet an IP67 standard.

## NEMA ratings.

The National Electrical Manufacturers' Association (NEMA) issues guidelines and ratings for an enclosure's level of protection against contaminants. Here are a few of the most common ratings:

**NEMA 3 and 3R** enclosures, for indoor and outdoor use, protect against falling dirt, windblown dust, rain, sleet, snow, and ice formation. NEMA 3R is identical to NEMA 3 except that it doesn't specify protection against windblown dust.

**NEMA 4 and 4X** enclosures, for indoor and outdoor use, protect against windblown dust and rain, splashing and hose-directed water, and ice formation. NEMA 4X goes further, specifying protection against corrosion caused by the elements.

**NEMA 12** enclosures, for indoor use, protect against falling dirt; circulating dust, lint, and fibers; dripping or splashing non-corrosive liquids; and oil and coolant seepage.

Ingress Protection Ratings		
First IP Number	Second IP Number	Third IP Number
0 No protection	0 No protection	0 No protection
1 Protection from solid foreign objects of 50 millimeters or greater	1 Protection from vertically falling drops of water and condensation	1 Protection from impact of 0.225 joules (150 grams falling from 15 cm)
2 Protection from solid objects up to 12 millimeters	2 Protection from direct sprays of water up to 15° from the vertical	2 Protection from impact of 0.375 joules (250 grams falling from 15 cm)
3 Protection from solid objects more than 2.5 millimeters	3 Protection from direct sprays of water up to 60° from the vertical	3 Protection from impact of 0.5 joules (250 grams falling from 20 cm)
4 Protection from solid objects more than 1 millimeter	4 Protection from splashing water from all directions	4 Protection from impact of 2.0 joules (500 grams falling from 40 cm)
5 Protected from dust, limited ingress	5 Protection from low-pressure water jets from all directions	5 Protection from impact of 6.0 joules (1.5 kilograms falling from 40 cm)
6 Totally protected from dust, dust tight	6 Protection from high-pressure water jets	6 Protection from impact of 20 joules (5 kilograms falling from 40 cm)
—	7 Protection from temporary immersion up to 1 meter	—
—	8 Protection from long periods of immersion under pressure	—

## Data center infrastructure

The data center is the building, or portion of a building, that houses computer rooms and support facilities. Traditionally, there were no design guidelines for data centers. That changed in 2005 with the ratification of TIA/EIA-942: Telecommunications Infrastructure Standards for Data Centers, which was developed to ensure uniformity in design and performance. It was created for data center designers who are early in the building development process. A good part of the standard involves facility specifications, functional areas, and equipment placement in a hierarchical star topology. The standard includes:

- Architecture
- Cabling infrastructure
- Pathways and spaces
- Redundancy
- Network design
- Topology
- Racks and cabinets
- Access
- Power
- Environmental design
- Fire protection
- Water intrusion
- Security
- Disaster avoidance/recovery
- Best practices

### Data center spaces.

When planning a data center, plan plenty of “white space” or empty space to accommodate future equipment. The basic elements of the data center include:

**Entrance Room(s).** It’s recommended that this be outside of the computer room for security.

**Main Distribution Area (MDA).** This is in a centrally located area to house the routers and switches. It includes the main cross-connect (MC), and may include a horizontal cross-connect.

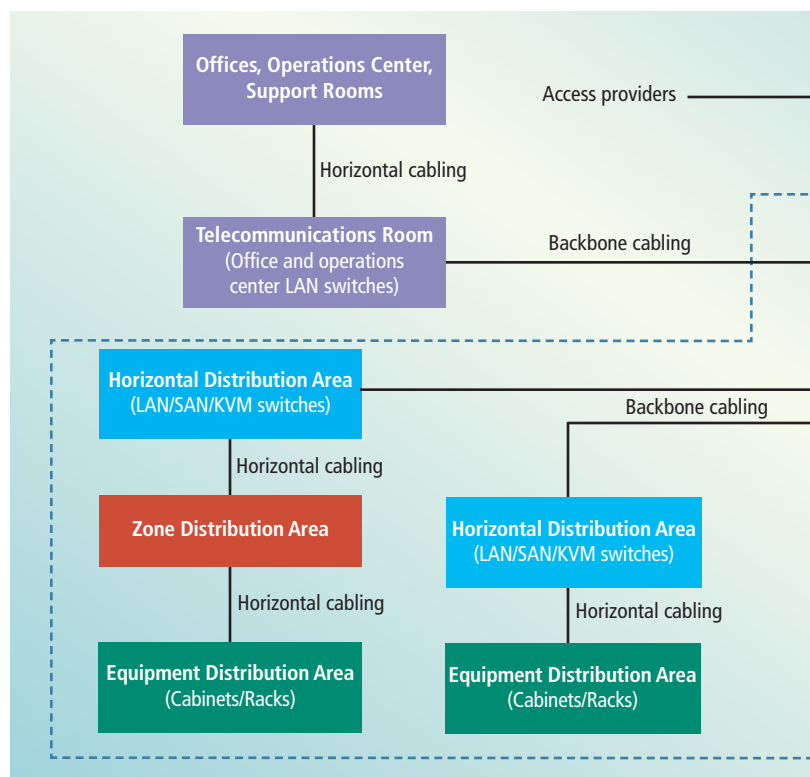
**Horizontal Distribution Areas (HDA).** There may be one or more HDAs, which serve as the distribution point for horizontal cabling. The HDA houses the horizontal cross-connects and active equipment, such as switches.

**Equipment Distribution Areas (EDA).** These are where the horizontal cables are terminated in patch panels. See “hot and cold aisles” on the facing page.

**Zone Distribution Area (ZDA).** This is an optional interconnection or consolidation point between the EDA and HDA for zone cabling.

**Backbone and Horizontal Cabling.**

**Equipment Distribution Area Outlet.**



## Recommended media.

Like the TIA/EIA-568-B standards, the TIA-942 recommends:

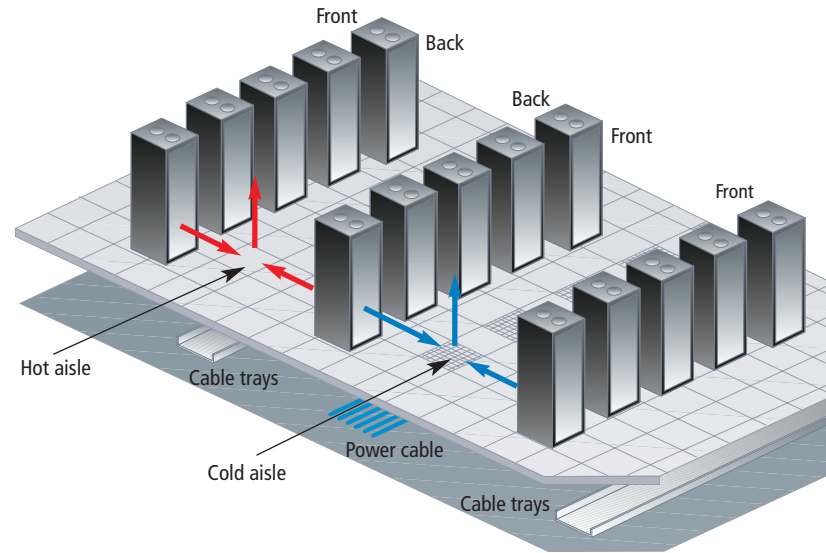
- 100-ohm twisted pair cable, Category 6. (At the time of this writing, Augmented Category 6 is still in draft form.)
- 50- and 62.5-micron multimode fiber optic cable.  
Laser-optimized 50-micron is recommended.
- Single-mode fiber optic cable
- 75-ohm coax cable

Each cable type is still governed by all the applicable requirements in TIA/EIA-568-B.2 and TIA/EIA-568-B.3.

## Data center pathways.

The standard lists many recommendations for cable management, such as each cable type must have separate racks and pathways. Power cables must be in separate pathways with a physical barrier. Abandoned cable should be removed. And large data centers should have access floor systems for running cable.

**Hot and Cold Aisles.** Cabinets and racks should be arranged in rows of alternating patterns with the fronts facing each other to create “hot and cold” aisles. Cold aisles are in front of the cabinets and racks. Hot aisles are behind the cabinets and racks where the hot equipment air is exhausted. In addition, there should be a minimum of 1 meter (3.3 ft.) of front space provided for equipment installation. A front clearance of 1.2 meters (3.9 ft.) is preferred.



A minimum space of 0.6 meters (2 ft.) is required for the rear clearance with 1 meter (3.3 ft.) preferred. For easy under-floor cable access, the cabinets and racks should be aligned with the floor tiles.

## Redundancy.

Crucial to the operation of any data center are fail-safe systems that enable continued operation despite catastrophic conditions. The standard includes four tiers of data center availability. The tiers are based on research from the Uptime Institute.

### Tier 1: Basic

- 99.671% availability
- Annual downtime: 28.8 hours
- Single path for power and cooling
- No redundant components

### Tier 2: Redundant Components

- 99.741% availability
- Annual downtime: 22 hours
- Single path for power and cooling
- Redundant components ( $N + 1$ )

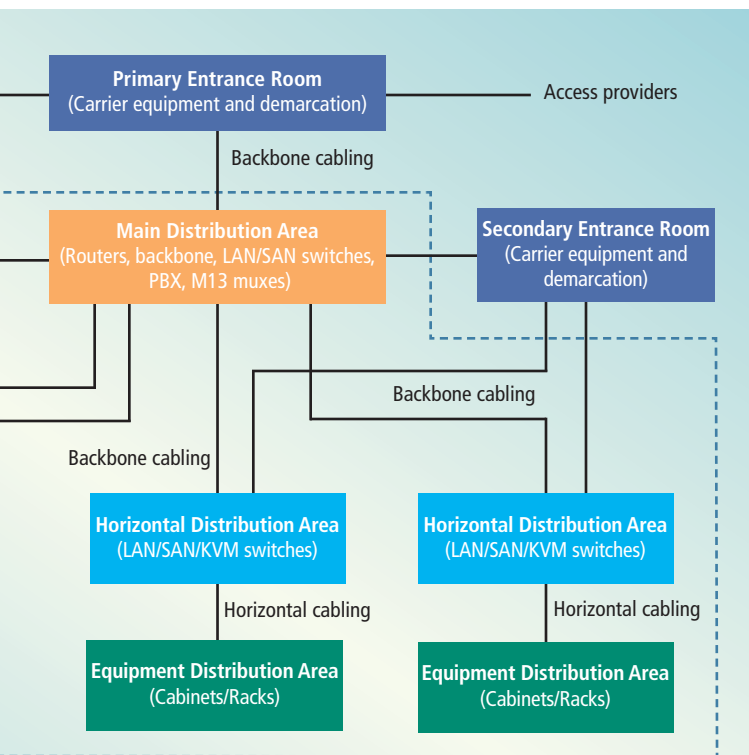
### Tier 3: Concurrently Maintainable

- 99.982% availability
- Annual downtime: 1.6 hours
- Multiple power and cooling paths
- Redundant components ( $N + 1$ )

### Tier 4: Fault Tolerant

- 99.995% availability
- Annual downtime: 0.4 hours
- Multiple power and cooling paths
- Redundant components  $2(N + 1)$

*NOTE:  $N$  indicates need or level of redundant components for each tier with  $N$  representing only the necessary system need.*



## Power over Ethernet (PoE)

### What is PoE?

Your twisted-pair Ethernet structured cabling system has another role to play—providing electrical power to low-wattage electrical devices.

Power over Ethernet (PoE) was ratified by the IEEE as the 802.3af-2003 standard. It defines the specifications for low-level power delivery—roughly 13 watts at 48 VDC—over four-pair CAT3 or CAT5 twisted-pair data cables to PoE devices. PoE is forward and backward compatible with other Ethernet protocols.

When planning your structured cabling system, consider PoE for powering widely distributed devices, such as VoIP telephones, wireless access points, IP cameras, video kiosks, and more.

### Advantages of PoE.

**Savings.** Because PoE operates across the UTP data cable, it eliminates the need to run both data and power lines to each network device. It also reduces the need for conduit, electrical wiring, and outlets.

**Flexibility.** PoE enables you to locate devices without worrying about the nearest electrical outlet. This is especially important for devices such as wireless access points or surveillance cameras that are often located in hard-to-reach areas.

**Reliability.** PoE increases reliability because it enables you to power remote devices using a centralized power source backed up by an uninterruptible power supply (UPS). So equipment, such as VoIP phones, will continue to work even if the power goes out.

### How does PoE work?

Ethernet cable consists of four twisted pairs. PoE sends power over these pairs to PoE-enabled devices. In one method, two pairs are used to transmit data, and the remaining two pairs are used for power. In the other method, power and data are sent over the same pair.

When the same pair is used for both power and data, the power and data transmissions don't interfere with each other. Because electricity and data function at opposite ends of the frequency spectrum, they can travel over the same cable.

### PoE devices.

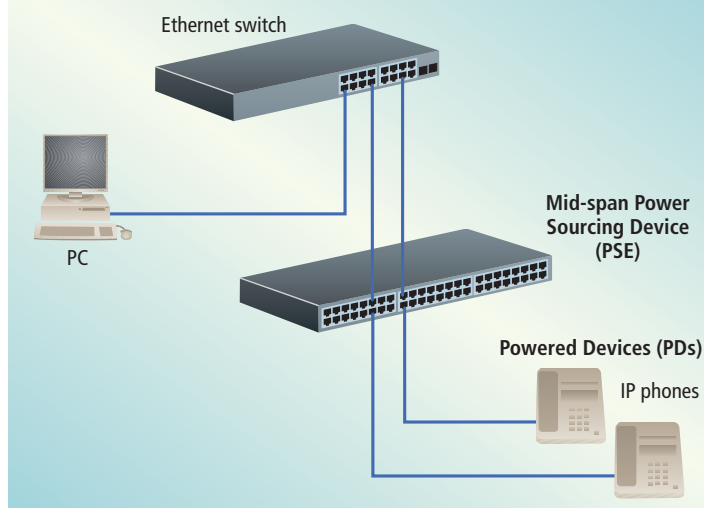
There are two types of PoE devices: Power Sourcing Equipment (PSE) and Powered Devices (PD).

PSEs provide power to PDs over the Ethernet cable.

The PD is the device that receives the power.

When connected to a network, a PSE discovers a PD and supplies 48 V and a maximum current of 350 mA. A minimum of about

### PoE Network



13 W is sent to each PD. That's enough to power PDs such as VoIP telephones, wireless access points, security cameras, building access systems, etc.

There are two types of PSE devices: end-span and mid-span.

An **end-span device** is often a PoE-enabled network switch that supplies power directly to the cable from each port.

A **mid-span device** is inserted between a non-PoE switch and the network, and supplies power to the PD. It offers the advantage of being able to add PoE to a network while using existing non-PoE equipment. There are also powered patch panels, which combine a patch panel and mid-span device.

A power injector, a pre-standard PSE, supplies power to a specific point on the network while the other network segments remain without power.

### IEEE 802.3at: PoE Plus.

In 2005, the IEEE began working on IEEE 802.3at, PoE Plus, a revision to the 802.3af standard. It's expected to be ratified in 2008. The major enhancements include:

- Operation over CAT5 and higher cable.
- Increasing power over all four pairs to a minimum of 30 watts up to 60 watts.
- Backwards compatibility with 802.3af.
- An active indication when an 802.3at PD is connected to an 802.3af PSE.
- Research mid-spans for 1000BASE-T.
- Research mid-spans and end-spans for 10-GbE.



# Wireless networking

To future-proof your network, you need to incorporate wireless technology into your structured cabling system. Plan on complete wireless coverage, which, oddly enough, means more cabling not less. It also means going through the alphabet soup of wireless networking and infrastructure standards.

## IEEE standards.

Some of the IEEE 802.11 standards are outlined below:

**IEEE 802.11.** Introduced in 1997, it supports speeds only up to 2 Mbps and two different methods of encoding—Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS)—leading to incompatibility between equipment.

**IEEE 802.11a** uses the 5.8-GHz band called U-NII (Unlicensed National Information Infrastructure) in the United States. It has a higher frequency and a larger bandwidth allotment than the 2.4-GHz band, and achieves speeds up to 54 Mbps.

**IEEE 802.11b.** This extension boosts wireless throughput from 2 Mbps up to 11 Mbps. It operates in the 2.4-GHz band, one of the most common. 802.11b can transmit up to 328 feet (100 m) under good conditions. It dropped FHSS in favor of DSSS.

**IEEE 802.11e.** Ratified in 2005, this standard defines Quality of Service (QoS) mechanisms for wireless. QoS makes it feasible to operate bandwidth-sensitive applications such as voice and video.

**IEEE 802.11g** is an extension of 802.11b and operates in the same 2.4-GHz band. It brings data rates up to 54 Mbps using Orthogonal Frequency-Division Multiplexing (OFDM) technology. 802.11g is backward compatible with 802.11b, and an 802.11b device can interface directly with an 802.11g access point.

**IEEE 802.11i** addresses many of the security concerns that come with a wireless network by adding Wi-Fi® Protected Access (WPA) and Robust Security Network (RSN) to 802.11a and 802.11b standards. It loses security if used with non-802.11i devices.

**IEEE 802.11n** is, as of mid 2007, not yet ratified. This high-speed wireless standard may achieve wireless throughput of up to 540 Mbps, although it's expected that a more typical data rate will be 200 Mbps. It will achieve these speeds by using a technique called Multiple-Input/Multiple-Output (MIMO). MIMO transmits multiple data streams simultaneously, increasing wireless capacity while also increasing network reliability and coverage.

## ISO/IEC TR 24704.

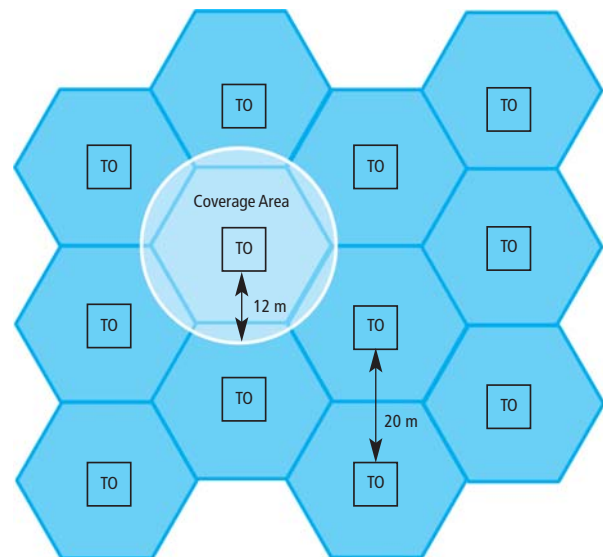
The ISO/IEC published the Technical Report 24704 in 2004 to address wireless connections not specified in ISO/IEC 11801. It addresses how to plan future wireless access point connections

that supplement existing copper and fiber networks. It provides guidelines on how to install the cabling prior to the wireless implementation, and covers:

- Minimum configuration, structure, and topology.
- Performance requirements.
- Coverage and location of telecommunications outlets.
- Interfaces to wireless access points.
- Power delivery.

TR 24704 recommends using a dense wireless cell structure, similar to a honeycomb pattern. Each cell has an operating radius of 12 meters (39.4 ft.), with one CAT5e (or higher) telecommunications outlet in the center of each cell. The recommended distance between outlets is 20 meters (65.6 ft.).

## TR 24704 Wireless Grid

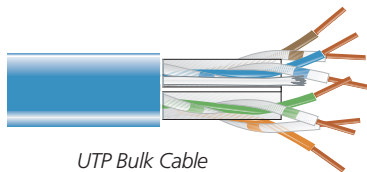


## TIA TSB-162.

The TIA addresses cabling for wireless networking in TSB-162: Telecommunications Cabling Guidelines for Wireless Access Points, published in 2006. Like TR 24704, it provides guidelines on topology, design, installation, and testing of wireless cabling infrastructure. All its cabling recommendations are in compliance with TIA/EIA-568-B.2 and TIA/EIA-569-B. It also addresses cabling between network and wireless equipment and the pathways.

The primary difference between the TSB and the ISO/IEC standard is the cell shape. The TIA recommends a square rather than hexagon shape. Both standards recommend dense prewiring and testing to make sure all possible areas are covered.

## Black Box Copper Channel Solutions



UTP Bulk Cable



Jacks



Wallplates



UTP Patch Cables

### Guaranteed-for-Life Copper Channel Solutions at a Glance\*

	CAT7 S/FTP	CAT6a F/UTP	CAT6a 10-Gigabit		CAT6	CAT5e
			High-Density	Standard		
Patch Cable	EVNSL71-80 Series	EVNSL6F-70 Series	EVNSL6A-70 Series	EVNSL6A Series	EVNSL670 Series	EVNSL80 Series
Bulk Cable	EYNC770A Series	EYN10G10FA Series	EYN10G10A Series		EYN870A-PB Series	EYN851A-PB Series
Patch Panels	JPM10GF16 Series	JPM10GF24 Series	JPM10G24		JPM612A-R5 Series	JPM902A-R4 Series
Jacks	FMC700 Series	FM10GFAN Series	FM10G2		FMT630-R2 Series	FMT920-R2 Series
Faceplates	WPC7453 Series	WPF459 Series	—		WPT454 Series	WPT454 Series
Wiring Blocks	—	—	—		JP061	JPT022-KIT

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

### CAT7 S/FTP Channel Solution

	Description	Colors	Length/Size	Codes*
Patch Cable	1.2-GHz; LS0H; PVC; Stranded; 1- or 4-pair; TERA® connectors.	White	1, 2, 3, 5 m	EVNSL71-80 Series
Bulk Cable	1000-MHz; Individually shielded pairs; Overall copper braid; Protects against ANEXT; Solid; PVC and plenum.	Blue	1000 ft.	EYNC770A Series
Patch Panels	10-Gigabit; High density; Shielded; 16- and 24-port.	Black	19", 1U	JPM10GF16 Series
Jacks	Fully shielded; Eliminates ANEXT; TERA outlet; Accepts 1-, 2-, and 4-Pair plugs; Quadrant design.	Metal	—	FMC700
Faceplates	Single-Gang; 1-, 2-, 3-, and 6-port.	Black	—	WPC7453 Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

### CAT6a F/UTP Channel Solution

	Description	Colors	Length/Size	Codes*
Patch Cable	Supports 10-GbE; Fully shielded; Meets or exceeds CAT6a specs; RJ-45; T568A/B; Stranded; LS0H; PVC.	Gray, Blue, White	1, 2, 3, 5 m	EVNSL6F Series
Bulk Cable	750-MHz; Supports 10-GbE; Foil shield; Prevents ANEXT; Solid; 4-pair; Central member; PVC and plenum.	Gray	1000 ft.	EN10G10FA Series
Patch Panels	10-Gigabit; High density; Shielded; 16- and 24-port.	Black	19", 1U	JPM10GF16 Series
Jacks	Fully shielded; Universal wiring; 4-pair; Angled, flat, or keystone.	Beige	—	FM10GFAN Series
Faceplates	2- and 4-port single-gang; 6-port dual-gang.	Black	—	WPF459 Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).



Patch Panels



Wiring Blocks

CAT6a Channel Solution				
	Description	Colors	Length/Size	Codes*
Patch Cables				
High-Density	Supports 10-GbE; High-density, data center design; Patent-pending push-pull boot fits standard RJ-45 openings; Low-profile for side-by-side stackability; RJ-45, T568B, Stranded, LS0H, PVC.	Gray, Blue, White	3, 5, 7, 10, 15, 20 ft.	EVNSL6A-70 Series
Standard	10-Gigabit; 625-MHz; ANEXT component compliant; PoE ready; RJ-45; T568B; Stranded.	Beige	3, 5, 7, 10, 15, 20 ft.	EVNSL6A Series
Bulk Cable	10-Gigabit; Foil shield; Prevents ANEXT; Solid; 4-pair; Central member; PVC and plenum.	Gray	1000 ft.	EN10G10FA Series
Patch Panels	10-Gigabit; High density; Shielded; 16- and 24-port.	Black	19", 1U	JPM10GF16 Series
Jacks	10-Gigabit; Fully shielded; Universal wiring; 4-pair; Angled, flat, or keystone	Beige	—	FM10GFAN Series
Faceplates	2- and 4-port single-gang; 6-port dual-gang.	Black	—	WPF459 Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

ETL®-Tested GigaTrue CAT6 Channel Solution				
	Description	Colors	Length/Size	Codes*
Patch Cable	GigaTrue® 550-MHz; 1000BASE-T; Molded boots; 24 AWG Stranded; RJ-45; 4-Pair, T568B; Straight Pinned; PVC.	11 Colors	3, 5, 6, 7, 10, 14, 20 ft.	EVNSL670 Series
Bulk Cable	GigaTrue 550-MHz; Exceeds CAT6; Solid; 4-pair; Cross-web design.	Gray, Blue, Yellow White, Green, Red	1000 ft.	EYN870A-PB Series
Patch Panels	350-MHz; 24-port, 1U; 48-port, 2U; 96-port, 4U.	Black	19"	JPM610A-R5 Series
Jacks	GigaTrue2; Universal wiring; Individual and 25-packs.	10 Colors	—	FMT630-R2 Series
Wiring Block	64-pair; Includes (1) wiring block, connecting blocks label holders, labels.	White	—	JP061
Wallplates**	1-, 2-, 3-, 4-, and 6-port single-gang; 9- and 12-port dual-gang.	Ivory, Office White, White	—	WPT454 Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

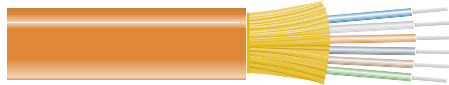
\*\* Wallplates are not part of the ETL-tested channel.

ETL-Tested GigaBase CAT5e Channel Solution				
	Description	Colors	Length/Size	Codes*
Patch Cable	GigaBase® 350-MHz; Snagless boots; 24 AWG.	11 Colors	14 lengths from 1 to 100 ft.	EVNSL80 Series
Bulk Cable	GigaBase 350-MHz; Exceeds CAT5e; Solid; 4-pair.	Gray, Blue, Yellow White, Green, Red	1000 ft.	EYN850A-PB Series
Patch Panels	350 MHz; Universal wiring; 24-port 1U, 48-port 2U, and 96-port 4U.	Black	19"	JPM902A-R4 Series
Jacks	GigaBase2; 100-MHz; Universal wiring.	10 Colors	—	FMT920-R2 Series
Wiring Block	50-pair; Includes (1) Type 110 wiring block, connecting blocks, label holders, and labels.	White	—	JP022-KIT
Wallplates**	1-, 2-, 3-, 4-, and 6-port single-gang; 9- and 12-port dual-gang.	Ivory, Office White, White	—	WPT454 Series

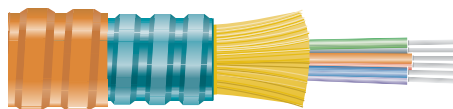
\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

\*\* Wallplates are not part of ETL-tested channel.

## Fiber Solutions



Bulk Fiber Optic Cable



Interlocking Armored Multimode Cable



Indoor/Outdoor Multimode Cable

### Guaranteed-for-Life Fiber Optic Bulk Cable

Type	Description	Length	Codes
<b>Tight-Buffered, Distribution-Style 62.5-Micron Multimode</b>	For intrabuilding backbone runs; Outer jacket; Aramid yarn.	Custom	EXP3006A, EXP3012A
<b>50-Micron Multimode</b>	Plenum; 6- and 12-fiber.	Custom	EXP35006A, EXP35012A
<b>Tight-Buffered, Interlocking Armored 62.5-Micron Multimode</b>	Cable is jacketed in aluminum interlocking armor with an internal PVC jacket; Cable can be run anywhere; No conduit needed; Flexible; Rodent resistant; 12-fiber; Plenum (OFCF).	Custom	EXP3012A
<b>Tight-Buffered, Indoor/Outdoor 62.5-Micron Multimode</b>	Cable can be pulled anywhere, indoors and outdoors, even beyond 50 feet of building entrance; Moisture-resistant; Water-blocking strength member; Resists fungus; UV stabilizer; 12-fiber; Plenum (OFNP).	Custom	EXP3012A

### Guaranteed-for-Life Fiber Optic Patch Cable

Type	Description	Length	Codes*
<b>Premium Ceramic Multimode 62.5-Micron</b>	Ceramic connectors provide low signal loss, high reliability, and a long life; Duplex and simplex; Riser and plenum; ST®, SC, LC, and MT-RJ connectors.	1, 2, 3, 5, 15, 20, 30 m** Custom	EFN110 Series
<b>Single-Mode Duplex 9-Micron</b>	Provides three times the bandwidth of multimode; Duplex; ST®, SC, LC, and MT-RJ connectors; PVC and plenum.	1, 2, 3, 5, 15, 20, 30 m** Custom	EFN310 Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

\*\* Plenum available only in 5-, 10-, 15-, and 30-meter lengths.

### Fiber Optic Connectors

Type	Description	Codes*
<b>Ceramic-Ferrule, Multimode and Single-Mode</b>	ST, SC, FC, and LC; 125-, 126-, and 127-μm diameters; 0.9, 2.0, and 3.0 boot openings; All in simplex; LC also in duplex.	FOT200 Series
<b>UV-Curable Multimode, Preassembled</b>	Glass insert; Reduced-piece part; Only three pieces to assemble: boot, strain relief, and connector body; ST and SC.	FO110–FO111
<b>Crimp-Lock Multimode</b>	Preradiused PC zirconia ceramic ferrule; No adhesive, setup, or electricity required; Press locking arm to close metal element; ST and SC.	FO120–FO121
<b>50-Micron</b>	Ceramic ferrules; ST, SC, LC, and MT-RJ.	FO041 Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

### Fiber Optic Enclosures

Type	Description	Codes*
<b>Fiber Wall Cabinets</b>	Low profile for limited-space areas; Open style holds 2- and 4-adapter panels; Lock style holds 4- and 12-adapter panels.	JPM400A Series
<b>Rackmount Fiber Cabinets</b>	2U and 3U high; Fit 19" and 23" racks; Hold 6-, 9-, 12-adapter panels.	JPM418A-R3 Series
<b>Rackmount Fiber Shelf</b>	1U high; Holds 3-adapter panel; Fits 19" or 23" cabinets and racks.	JPM407A-R3
<b>Preloaded Rackmount Fiber Panels</b>	Preloaded with 24 single-mode/multimode simplex ST adapters or 12 duplex single-mode/multimode SC adapters; 1U high; Fits 19" or 23" racks.	JPM370A JPM375A
<b>Adapter Panels</b>	Standard panels include ST, SC, LC, and MT-RJ connectors; High-density panels include ST, SC, and MT-RJ pairs; All snap into above hardware.	JPM404A-R2 Series JPM411A-R2 Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).





Cabinets



Cable Management



Patch Panels

## Cabinets and Racks

Standalone Cabinets, Full-Size Distribution Racks		
Type	Description	Codes*
Select™ Plus Cabinets	40" and 42" deep; 2200-lb. weight capacity; Mesh split rear door; Mesh or tempered glass front door; 15U, 38U, 42U high models; Many optional shelves and accessories.	RM2500A Series
Premier Aluminum Distribution Racks	1000-lb. weight capacity; 38U and 45U high models; 19" wide; Many optional shelves and cable managers.	RM155A Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

## Cable Management

Panels, Managers, Raceways, and Labeler		
Type	Description	Codes*
Patch Cable Management Panels	Rackmount panels for organizing cables; 1U and 2U; 19" wide.	37803-R2–37804-R2
Zero U-Height Cable Managers	Supports cable in front of the patch panel, freeing up rack space; Can be used with 1U, 2U, or 3U equipment; Fits all standard racks.	JPM500A-R2 Series
Media Track 6 and 8 Raceways	Nonmetallic surface cable raceways; Hold UTP, fiber optic, and electrical cables; Single- and dual-channel; Other raceways available.	JPT605-ADH, JPT805-ADH
Brother P-Touch 1000 Electronic Labeler	Creates professional, laminated labels; Prints up to two lines; Previews label text on screen; Auto setting adjusts text size.	PT1000

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

## Patch Panels

CAT5e and CAT6 Patch Panels		
Type	Description	Codes*
CAT5e and CAT6 Feed-Through Patch Panels	No punchdowns needed; Unique design features RJ-45 plugs on both sides of the panels; T568A and T568B wiring; Shielded and unshielded; 24-port 1U and 48-port 2U; 19" wide.	JPM808A-R2 Series JPM818A Series
CAT6 Protected Panels	Surge protected; Built-in, all-wire protection on each port; Fail-safe design; 12-, 24-, and 48-port; 1U and 2U; 19" wide.	JSM112A Series
CAT6 Feed-Through Protected Panels	Surge protection and feed-through design; Built-in, all-wire protection on each port; 32-port; 2U; 19" wide.	JPM812A

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).



## Networking and Wireless

Networking Switches, Wireless Access Points, Cabling, and Tools		
Type	Description	Codes*
L2 Managed Gigabit Ethernet Switches	8,16, or 24 1000BASE-TX copper and two dual-media SFP ports; Switch copper and fiber; Allocate bandwidth; Prioritize traffic.	LGB1001A Series
Pure Networking™ 802.11g Wireless Access Point with Switch	Transmit at 54 Mbps; Includes 4-port switch; IP sharing with NAT/NAPT; Includes security features.	LW6004A
400- and 600-Style Bulk Coax Cable	50-ohm coax cable for connecting wireless antennas.	CA400-REEL Series
Hyperlink 400- and 600-Style Cable	Low-loss coax cable for wireless connections.	CA3N010, CA6N100 Series
400- and 600-Style Connectors	N-Type connectors for wireless coax cable.	ANM-1406 Series
Wireless Cable Tools	Stripping, crimp, and tool kits for wireless coax cable.	HT-STRIP400 Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

## Installation and Test Kits

Copper Termination and Installation Kits, Copper and Fiber Test Kits		
Type	Description	Codes
CAT6 and CAT5e Termination and Installation Kits	Everything to terminate cable: tester, cable stripper, crimp tool, plugs, dies, and carrying case; Installation kits also include bulk cable.	FT490A, FT495A-R2 FT480A, FT475A
Validator NT	All-in-one UTP tester for certifying, identifying, configuring, and documenting a network.	NT955
CAT5/5e/6 LAN Performance Verifier	Verify UTP cables and hardware speeds; Level 1 and Level 2 certifications; Includes test units, cables, batteries, CD, and accessories.	TS580A
Power LAN CAT6 Certifier	Test and measure twisted-pair and coax basic and channel links.	TS200A, TS002A
Single-Mode and Multimode Test Kits	Measure power loss; Identify breaks and bends; Instantaneous readings; Upload results to a PC.	TS1400A, TS1500A

## Multimedia Presentations

Multimedia Cabling and Equipment		
Type	Description	Codes*
RapidRun™ Cable System	An audiovisual cabling system that can be terminated and reterminated in seconds; Snap on different connectors.	50712 Series
Premium VGA Video Extension Cable	Move VGA monitors up to 100 feet from a CPU; Triple shielded; HD15.	EVNPS05 Series
DVI Cable and Adapters	Supports digital transmissions.	EVNDVI01 Series
VGA Video Splitters	Connect two, four, or eight monitors to one PC; 350-MHz. Broadcast up to 210 feet.	AC1056A-2 Series
Digital Visual Interface (DVI) Splitters	Split DVI signals to two or four displays; Ideal for digital signage.	AC1031A-2, AC1031A-4
Multi DVI Extenders over Fiber	Send high-resolution DVI signals, stereo audio, and serial up to 10 kilometers over fiber; Use in harsh environments.	AC1080A Series

\* Only the first product code in a series is listed. Entire product descriptions can be found with these codes at [blackbox.com](http://blackbox.com).

**10BASE-T:** An Ethernet standard that uses twisted-wire pairs.

**10-GbE (10-Gigabit Ethernet):** The fastest Ethernet standard with a nominal data rate of 10 Gbps, ten times as fast as Gigabit Ethernet. Can be run over fiber or copper cable.

**100BASE-FX:** This Fast Ethernet standard (IEEE 802.3u) supports 100 Mbps, full-duplex data transmission over fiber optic cable.

**100BASE-T:** A high-speed version of Ethernet (IEEE 802.3). Also called Fast Ethernet, 100BASE-T transmits at 100 Mbps.

**100BASE-TX:** A popular implementation of the 100BASE-T Fast Ethernet standard. It specifies data transmission over two-pair (four-wire) Category 5 or higher unshielded twisted-pair (UTP) cable.

**1000BASE-LX:** A Gigabit Ethernet standard that defines data transmission over fiber optic cable using long-wavelength lasers, typically 1300 or 1310 nm. This standard is rated to operate at up to 2 kilometers over single-mode fiber or 550 meters over multimode fiber, although many manufacturers will guarantee longer distances.

**1000BASE-SX:** A Gigabit Ethernet standard defining data transmission over 850-nm fiber optic cable at distances of up to 220 m. Many manufacturers will guarantee longer transmission distances.

**1000BASE-T:** A Gigabit Ethernet standard that defines data transmission at 1000 Mbps over twisted-pair copper cable.

**1000BASE-X:** Describes Gigabit Ethernet transmission over fiber. Includes 1000BASE-LX and 1000BASE-SX.

**Access Point (AP):** A device that links wireless devices to a network. Also known as a base station or wireless access point (WAP).

**ACR:** Attenuation-to-Crosstalk Ratio. The ratio of the attenuated signal to NEXT. It's one factor in determining how far a signal can be transmitted in any given medium.

**Adapter:** A device that joins different kinds of connectors or interfaces.

**Address:**

- 1) The number of a specific memory or peripheral storage location.
- 2) The number assigned to a node on a network.

**Administration:** The process of identifying and documenting installed structured cabling.

**AFF (Above Finished Floor):** A common measurement used when specifying the mounting height of interior fixtures such as counters, cabinets, etc.

**AHJ (Authority Having Jurisdiction):** The local governmental agency that enforces building codes.

**Alarm:** Any message that alerts the user to a problem in equipment or data.

**Alien Crosstalk:** An unwanted signal introduced into wire pairs from adjacent cables.

**ANSI (American National Standards Institute):** This nonprofit organization oversees the development and accreditation of voluntary consensus standards for products, services, systems, and personnel in the U.S. It also coordinates U.S. standards with international standards.

**Architecture:**

- 1) The design of a computer system, which sets the standard for all devices that can connect to it and all the software that can run on it.
- 2) The design of a communications system, which includes the hardware, software, access methods, and protocols used.

**Attenuation:** The decrease of signal strength as it travels through a medium or interconnect. Attenuation is measured in decibels relative to a reference signal. Contrast with *Gain*.

**AWG (American Wire Gauge):** A method of measuring wire-conductor diameter. The number refers to the number of steps involved in drawing the wire. The more a wire is drawn or sized, the smaller the diameter will be. For example, 24 AWG wire is smaller than 19 AWG wire.

**Backboard:** A plywood panel mounted on the wall of

a telecommunications room. Used for mounting telecommunications equipment.

**Backbone:** A high-capacity network, conduit, or cable that links other lower-capacity networks together. It often uses the highest-speed transmission paths in the network and may also run the longest distance.

**Backbone Cabling:** Cabling between floors in a building or between buildings in a campus.

**Bandwidth:**

- 1) The transmission capacity of a computer channel, communications line, or bus.
- 2) The difference between the lowest and highest frequencies in a transmission signal.

**Barrier:** A partition that separates cables in a cable raceway.

**BAS (Building Automation System):** An integrated, intelligent network of devices that provides automated control of building systems such as entry, fire detection, and climate control.

**Baud:** A line's signaling rate, the switching speed, or number of frequency changes made per second. Often used loosely as a synonym for "bps."

**Bend Loss:** Increased attenuation in a fiber that results from the fiber being bent or from minute distortions within the fiber.

**Bend Radius:** A measurement of a cable's flexibility; the radius of the smallest circle you can form with the cable without damaging it.

**BNC Connector (Bayonet-Neill-Concelman):** A commonly used connector for coaxial cable. After insertion, the plug is turned, tightening the pins in the socket.

**Bonding:** The permanent connecting of conductors to a building grounding infrastructure.

**Broadband:** High-frequency data transmission, typically at least 1.5 Mbps over fiber or coax cable.

**Building Core:** A space within a building used for services such as electrical, plumbing, and elevators.

**Bus:** A common pathway, or channel, between multiple devices. In a bus topology, nodes are all connected to a single channel.

**Campus Area Network:** A network that includes buildings in a limited geographic area such as a college or corporate campus or an industrial park.

**Capacitance:** A buildup of voltage along the surface of a metal wire while it's conducting an electrical signal.

**Carrier:** An alternating current that oscillates at a fixed frequency and serves as a boundary or baseline signal over which information can be transmitted. Changes in the carrier signal's amplitude, frequency, or phase represent the actual data being transmitted.

**Category:** EIA/TIA-568 standards defining performance of UTP cable.

**Category 3:** UTP cable specified for voice and data applications at 16 MHz or 10 Mbps.

**Category 4:** UTP cable specified to 20 MHz or 16 Mbps. This category is now obsolete.

**Category 5:** UTP, connectors, and systems. Specified for voice and data applications to 100 MHz.

**Category 5e:** Also called Enhanced Category 5. This UTP standard supports voice and data applications to 100 MHz and is suitable for Fast Ethernet and Gigabit Ethernet applications.

**Category 6:** A UTP performance classification for twisted-pair cables, connectors, and systems. Specified up to 250 MHz for voice and data. Also known as Class E.

**Category 6a (CAT6a):** A 10-Gigabit over copper proposal of the CAT6 standard. Extends CAT6 electrical specifications from 250 MHz to 500 MHz. Also known as Class E<sub>A</sub>.

**Category 7 (Proposed):** Cables and connectors with transmission characteristics to 600 MHz. Unlike other cable categories, Category 7 cable has individually shielded pair cables. Also known as Class F.

**CATV (Community Antenna Television):** Cable television that uses one antenna or set of antennas to serve a group of subscribers.

**CCTV (Closed-Circuit Television):** A private TV system with a limited number of receivers.

**Ceiling Distribution:** Cabling installed in the space above a dropped ceiling.

**Centralized Fiber Optic Cabling:** A fiber structured cabling configuration where the backbone cable extends to the workstation. See *Collapsed Backbone*.

**Central Office:** The telephone switching facility that interconnects subscribers' telephone lines to the rest of the telephone system.

**Channel:** The end-to-end transmission path including the connecting equipment, patch cords, equipment cables, and cross-connect cords in the work area and telecommunications room. Contrast with *Permanent Link*.

**Churn (Change in User's Location):** The relocation of a user's work area in a building.

**Cladding:** In fiber optic cable, the outer layer on the fiber core. Cladding promotes the internal reflection of light and also serves as protection for the fiber core.

**Cleave:** A controlled break in an optical fiber intended to provide a perfect 90° endface for connection.

**Collapsed Backbone:** A wiring configuration that uses the backplane of a single switch rather than several switches linked together. See *Centralized Fiber Optic Cabling*.

**Conduit:** A pipe, usually metal, that contains data, voice, and electrical wiring.

**Connector:** Any plug, socket, or wire that links two devices together.

**Consolidation Point:** An interconnection device in the horizontal cabling that enables the cable to be split into two to support clusters in zone cabling.

**Core:** The center fiber of a fiber optic cable through which light is transmitted.

**Cross-Connect:** Hardware such as patch panels and punchdown blocks, used to connect two groups of cables.

**Cross-Pinned or Crossover Cable:** A configuration that enables two DTE or two DCE devices to communicate.

**Crosstalk:** Interference from an adjacent communication channel.

**Daisychain:** To connect devices in a series, one after the other, where the transmitted signals go to the first device, then to the second, and so on.

**Data Rate, Data Signaling Rate:** The data-transfer speed within the computer or between a peripheral and computer. The data-transmission speed in a network.

**Delay Skew:** The difference in propagation delay between the slowest and fastest pairs in a cable. Delay skew is caused by wires of different lengths within twisted-pair cable.

**Demarcation Point:** The point in a facility where the service provider cabling and the customer-owned cabling interconnect.

**Digital Loopback:** A technique for testing the digital processing circuitry of a communications device that can be initiated locally or remotely via a telecommunications circuit.

**Digital PBX (Digital Private Branch Exchange):** A modern PBX that uses digital methods for switching. (Older PBXs used analog methods.)

**Digital Service:** High-speed digital data-transmission services offered for lease by telecommunication-service providers including ISDN, Frame Relay, T1, and dedicated or switched 56-kbps transmission lines.

**Disaster Recovery:** A plan for duplicating computer operations after a catastrophe such as a fire or earthquake occurs. It includes routine off-site backup as well as procedures for activating necessary information systems in a new location.

**Dish:** A saucer-shaped (parabolic) antenna that receives—or transmits and receives—signals from a satellite.



**Distortion:** The unwanted changes in signal or signal shape that occur during transmission between two points.

**Distributed Architecture:**

- 1) LAN architecture that uses a shared communications medium such as bus or ring LANs.
- 2) Any computer system that uses shared access methods.

**Distribution Frame:** Also called a distribution block, it's a wallmounted structure for terminating telephone wiring. It's used for permanent wires from or at the telephone central office, where cross-connections are made to extensions.

**Download:** To transmit a file from one computer to another.

**Downtime:** The period during which computer or network resources are unavailable to users because of a system or component failure.

**Downward Compatible:** Also called backward compatible. Refers to hardware or software that is compatible with earlier versions.

**Drain Wire:** In a cable, an uninsulated conductor laid over the component, or components, in a foil-shield cable. Used as a ground connection.

**Drop:** A connection point between a communicating device and a communications network; a single connection (or node) on a multipoint line.

**Drop Cable:** A cable that connects the main network cable, or bus, and the data terminal equipment (DTE).

**DSL (Digital Subscriber Line):** A PSTN line that provides high bandwidth for short distances using copper cable.

**Duplex:** The ability of a device to simultaneously transmit and receive signals through a common cable.

**Duplex Cable:** A fiber optic cable with two fibers used for duplex transmission.

**Dynamic Routing:** A routing system that automatically adapts to network topology or traffic changes.

**EIA (Electronic Industries Association):** Founded in 1924 as the Radio Manufacturing Association, this membership organization sets standards for consumer products and electronic components. In 1988, it spun off its Information and Telecommunications Technology Group into a separate organization called the TIA. See TIA.

**EIA/TIA 568:** A wiring standard for commercial buildings supported by both the Electronic Industries Association and the Telecommunications Industry Association, as well as the American National Standards Institute.

**ELFEXT (Equal-Level Far-End Crosstalk):** The measure of unwanted electrical noise from a transmitter (near end) into a neighboring wire pair measured at the far end, relative to the received signal measured on the same pair.

**EMI/RFI (Electromagnetic Interference/Radio-Frequency Interference):** Radiation of electric and magnetic fields that interferes with signal transmission or reception.

**Enterprise Network:** A privately owned and maintained network connecting several key areas in a company. Contrast with WAN.

**Entity:** A manageable device on a network.

**Entrance Facility:** A room or space that supports the entry of inter- and intrabuilding cabling from outside service providers.

**Equalization:** Technique used to reduce distortion and compensate for signal loss (attenuation) over long-distance communication lines.

**Equipment Room:** An environmentally controlled room designed for housing network components, telecommunications equipment, and main cross-connections.

**Error Checking, Control, Detection, or Correction:** Testing for accurate data transmission over a communications network or internally within the computer system.

**Error Rate:** Used to measure the effectiveness of a communications channel, it's the ratio of the number of erroneous units of data to the total

number of units of data transmitted.

**Ethernet:** A local area network (LAN) developed by Xerox®, Digital Equipment Corp., and Intel (IEEE 802.3). Ethernet connects up to 1024 nodes at 10 Mbps over twisted-pair, coax, and fiber optic cable. When a station is ready to send, it transmits its data packets onto the network, which is common to all nodes. All stations "hear" the data. The station that matches the destination address in the packet responds, while the others do nothing. Ethernet is a data-link protocol and functions at the Physical and Data-Link levels of the OSI model (Layers 1 and 2).

**Ethernet Address:** A unique 48-bit number maintained by the IEEE and assigned to each Ethernet network adapter.

**Ethernet Meltdown:** Usually a result of misrouted packets, it's an event causing near or total saturation in Ethernet applications.

**F Connector:** A coaxial connector commonly used for video applications (CATV).

**Fallback:** The ability to default to an alternate line or device in case the primary unit fails.

**Ferrule:** The hollow cylindrical tip of a fiber optic connector that encloses the end of the fiber core.

**FEXT (Far-End Crosstalk):** Unwanted electrical noise from a transmitter (near end) into a neighboring wire pair measured at the far end.

**Fiber Loss:** The amount of signal attenuation in a fiber optic transmission.

**Fiber Optics:** A technology that uses light to carry digital information through small strands of glass.

**Fire-Rated Poke Through:** A cable entry suitable for penetration through fire-rated floors.

**Firewall:** A network node set up as a boundary to prevent traffic from one segment to cross over to another. Firewalls are used to improve network traffic, as well as for security purposes.

**Floor Box:** A metal box installed in the floor to serve as an outlet or interconnection.

**Flying Lead:** A lead that exits the back of the connector hood on the outside of the cable jacket. It's normally attached to the drain wire or shield and then connected to the chassis of the switch, modem, etc.

**Full-Duplex (FDX):** Simultaneous transmission of data in both directions at once.

**F/UTP (Foiled/Unshielded Twisted Pair):** A unshielded twisted-pair cable with an overall foil shield.

**Gain:** Increased signal power, usually the result of amplification. Contrast with Attenuation.

**Gigabit Ethernet:** An Ethernet standard for data transmission at 1 Gbps over copper or fiber.

**Ground:** An electrical connection or common conductor that, at some point, connects to the earth.

**Ground Fault:** The temporary current in the ground line, caused by a failing electrical component or interference from an external electrical source such as a thunderstorm.

**Ground Loop:** An unwanted ground current flowing back and forth between two devices that are grounded at two or more points.

**Half-Duplex (HDX):** The transmission of data in both directions, but only one direction at a time.

**Horizontal Cabling:** The cables and connectors that connect the telecommunications room to the work area. It includes the work area outlet, distribution cable, and the connecting hardware.

**Horizontal Cross-Connect:** Where the horizontal cabling joins to backbone cabling, usually in a patch panel.

**Hybrid Cable:** A single cable that incorporates different kinds of cable within the same sheath—fiber and UTP, for instance.

**Impedance:** The resistance to the flow of alternating current in a circuit.

**Impedance Match:** When the impedance of a component or circuit is equal to the internal impedance of the source. Ideally, impedances should match to minimize reflection and distortion.

**In-Band Signaling:** A transmission occurring in the frequency range normally used for data transmission.

**Insertion Loss:** A power loss that results from inserting a component into a previously continuous path or creating a splice in it.

**Inside Wiring:** In telephone deregulation, the customer's premise wiring; the wiring inside a building.

**Internet Telephony:** Generic term describing various methods of running voice calls over Internet Protocol (IP).

**Internetwork:** Networks connected by routers and other devices. This collection functions generally as a single network.

**Intranet:** A network connecting a related set of standard Internet protocols and files in HTML format with employees using Internet browsers in an organization's network and within the corporate firewalls.

**IOP (Interoperability):** Generic term describing functional compatibility. IOP is the ability of equipment from different manufacturers or implementations to operate together.

**ISP (Internet Service Provider):** A company that provides Internet access.

**Jacket:** A cable's protective insulated housing.

**LC:** A small, simplex fiber optic connector.

**Link:** A segment or transmission path between two points not including connecting equipment and patch cables. See *Permanent Link*.

**Local Area Network (LAN):** A data communications system confined to a limited geographic area, normally a single building or campus.

**Loopback:** A diagnostic test in which the transmitted signal is returned to the sending device after passing through all or part of a data communications link or network. A loopback test compares the returned signal with the transmitted signal.

**Loose-Tube Fiber Cable:** A fiber optic cable that has multiple fibers inside a loose jacket and is usually used outdoors. Many of these cables contain a gel to cushion the fibers. Contrast with *Tight-Buffered Fiber Cable*.

**MACs (Moves, Adds, Changes):** Administering and physically moving, adding, and changing components when users change locations in the network. Refers to data and voice networks.

**Main Cross-Connect (MC):** The cross-connect for first-level backbone, entrance, and equipment cables.

**MAN (Metropolitan-Area Network):** A communications network that covers a geographic area, such as a city or suburb.

**Media Management:** The ability to manage and the process of managing different transmission media used within the same network. It includes cable-performance monitoring, cable-break detection, and cable-routes planning.

**Microbend:** In fiber optics, a microscopic bend in a glass fiber that causes it to lose the signal.

**Mirroring:** A complete, redundant duplicate of a device including its programming and data, kept active, current, and on-line as a fault-tolerant backup system.

**Mission-Critical:** System resources whose failure could seriously impair the ability of the system to function.

**MT-RJ:** A small duplex fiber optic connector that resembles an RJ-45 connector.

**Multimode Fiber:** An optical fiber with a core diameter of 50 to 100 microns. Its core causes some distortion and provides less bandwidth than single-mode fiber.

**MUTOA (Multi-User Telecommunications Outlet Assembly):** A grouping of telecommunications outlets that serves several individual work areas.

**Network Architecture:** The design of a communications system, which includes the hardware, software, access methods, protocols, and the method of control.

**Network Topology:** The physical and logical arrangement of the links and nodes within a network.



**NEXT (Near-End Crosstalk):** Unwanted electrical noise from a transmitter (near end) into a neighboring wire pair measured at the near end.

**Noise:** Random electrical signals, generated by circuit components or by natural disturbances, that corrupt the data transmissions by introducing errors.

**Nominal Velocity of Propagation:** The ratio of signal speed to the velocity of light in a vacuum.

**Off-Premise Station:** A PBX station in a location separated from the main PBX.

**Off-site:** A location that is not in the building or campus being referred to.

**On-site:** A location that is in the building or on the campus being referred to.

**Open Office:** A floor space of offices separated by moveable furniture or partitions rather than walls.

**Optical Fiber:** Any filament or fiber, made of dielectric materials, that is used to transmit laser or LED-generated signals.

**OPX (Off-Premise Extensions):** A leased line from the telephone company that enables telephones at a distant location to operate as if they were directly connected to a local PBX.

**Outlet (Telecommunications):** A connector in a wall or partition that provides a connection point to power, phone, or network services.

**Patch Cord:** A short cable with a plug on each end that is used to make a cross-connection.

**Patch Panel:** A panel, usually rackmountable, that contains the connecting hardware to join multiple cables.

**Pathway:** An open or closed channel used for the routing of cables.

**PBX (Private Branch eXchange):** A device that provides private local voice switching and voice-related services within the private network.

**Permanent Link:** A segment or transmission path between two points not including connecting equipment and patch cable. Used for testing. See *Link*. Contrast with *Channel*.

**Plenum-Rated Cables:** Cables with low-smoke insulation approved by the National Electrical Code for installation in air spaces ("plenums").

**PoE (Power over Ethernet):** A technology in which electrical power and data are transmitted over standard twisted-pair cable in an Ethernet network. It's particularly useful for wireless access points, security cameras, and other devices where power is not readily accessible.

**Premise Cabling, Premise Wiring:** Existing cable or wiring installed in a building or campus.

**Propagation Delay:** The time it takes a signal to travel from one point to another over a transmission channel.

**PS-AACRF (Power Sum Attenuation to Crosstalk Ratio, Far End):** The sum of signal coupling from multiple pairs of disturbing pairs to a disturbed pair in another cable measured at the far-end and relative to the received signal level in the disturbed pair at the far-end. Formerly *PS-AELFEXT*.

**PS-ACR (Power Sum Attenuation to Crosstalk Ratio):** A sum derived by subtracting the attenuation (insertion loss) from the power sum near-end crosstalk.

**PS-AELFEXT (Power Sum Attenuation to Crosstalk Ratio, Far End):** See *PS-AACRF*.

**PS-AFEXT (Power Sum Alien Far-End Crosstalk):** The sum of signal coupling from multiple near-end disturbing cable pairs to a disturbed pair in a neighboring cable, measured at the far end.

**PS-ANEXT (Power Sum Alien Near-End Crosstalk):** The sum of signal coupling from multiple disturbing cable pairs to a disturbed pair in a neighboring cable, measured at the near end.

**PS-ELFEXT (Power Sum Equal-Level Far-End Crosstalk):** The sum of unwanted signals from multiple transmitters (near end) into a pair measured at the far end, and relative to the received signal level.

**PS-NEXT (Power Sum Near-End Crosstalk):** The sum of unwanted electrical noise from multiple transmitters (near end) into neighboring wire pairs measured at the near end.

**Pull Box:** A conduit or raceway box with an access cover to facilitate feeding cables around corners.

**Pulling Tension:** The amount of pull placed on a cable during installation. Measured in pounds.

**Punchdown Block:** A plastic block with contacts used for cross-connecting UTP Cable. Generally used with phone lines.

**Raceway:** An enclosed cable-distribution pathway.

**Rackmount:** Components that are built to fit in a metal frame that can be installed in a cabinet; usually 19" wide.

**Rack Unit:** A measurement of vertical rack space. One rack unit is equal to 1.75".

**Raised Floor:** A modular floor constructed over the building's floor to facilitate cabling and cooling.

**Return Loss:** The measure of a signal reflected back toward the transmitter as a result of impedance differences in the cabling.

**Reversed Pair:** A cable-termination error in which conductors are in the wrong order.

**RFI (Radio-Frequency Interference):** Interference with broadcast and data signals caused by radiation in the radio-frequency band of the electromagnetic spectrum.

**Riser Cable:** Backbone cable rated for vertical applications.

**RJ-11:** A wiring designation with 4- or 6-wire modular connectors; commonly used for standard telephone lines.

**RJ-45:** A wiring designation with 8-wire modular connectors.

**RJ-48C:** An 8-wire modular connector used for the DSX-1 interface.

**Roaming:** In wireless, the ability to move seamlessly from one access point coverage area to another with no loss in connectivity.

**SC:** A push-pull type single-channel fiber optic connector.

**Server:** A computer or processor that holds applications, files, or memory shared by users on a network.

**S/FTP (Shielded/Foiled Twisted Pair):** A twisted-pair cable with an overall shield and individual foiled twisted pairs.

**Single-Mode Fiber:** An optical fiber that transmits light only in a single optical path, achieving very high bandwidth over long distances.

**ST<sup>®</sup>:** A registered trademark for a bayonet-style, single-channel fiber optic connector invented by AT&T<sup>®</sup>.

**STP (Shielded Twisted Pair):** Cabling that consists of twisted pairs with a foil and/or braided shield to minimize EMI/RFI.

**Straight-Through Pinning:** Cable configuration that has connectors wired, pin for pin (Pin 1 to Pin 1, Pin 2 to Pin 2, etc.).

**Strain Relief:** Any means of relieving an installed cable of supporting its own weight.

**Structured Cabling System:** A planned, logical infrastructure of telecommunications cabling installed to industry standards.

**Surge Protector:** A device that protects computers from excessive voltage and current in the power line.

**T1:** A digital carrier facility used to transmit a DS-1 formatted digital signal at 1.544 Mbps that can be divided into 24 separate DS0 channels at either 56 or 64 kbps.

**Telecommunications Room:** The area that houses telecommunications equipment, cable terminations, and horizontal cross-connects. Usually serves one floor in a building. Formerly *Wiring Closet*.

**Terminal Block:** A junction point for multiple connections within a cable to be spliced or manipulated.

**Termination:** Placement of a connector on a cable or distribution panel.

**Terminator:** A device that provides termination for a signal line, or several signal lines, at the end of a cable.

**TIA (Telecommunications Industry Association):** Best known for developing cabling standards with the EIA, it's the leading trade association for the information, communications, and entertainment technology industry. The TIA provides standards development and represents the communications sector of the EIA. See *EIA*.

**Tight-Buffered Fiber Cable:** An indoor cable with multi-fibers, each of which has a 900-micron jacket. Contrast with *Loose-Tube Fiber Cable*.

**Twisted Pair:** A cable with pairs of two conductors twisted together.

**UTP (Unshielded Twisted Pair):** A cable with one or more pairs of twisted conductors bundled within the same outer PVC covering.

**VCSEL (Vertical Cavity Surface Emitting Laser):** A small laser used for emitting optical power for multimode fiber.

**VoIP (Voice over Internet Protocol):** Technology for transmitting voice conversations (telephone calls) over the Internet or any other data network using the Internet Protocol, such as a corporate Intranet. VoIP converts analog voice data into digital packets for transmission.

**VPN (Virtual Private Network):** A means of segmenting a network and prioritizing traffic of a selected set of users.

**WAN (Wide-Area Network):** A data communications network spread across a wide geographic area and incorporating a large number of users. Contrast with *Enterprise Network*.

**Wireless:** Communication of data, voice, and video signals over radio frequencies.

**Wireless Access Point (WAP):** A device that links wireless devices to a network. Also known as an access point (AP) or base station.

**Wireless Internet Service Provider (WISP):** An Internet provider that specializes in providing wireless Internet access, often in hotspots in public areas, such as airports.

**Wireless IP:** Wireless IP (Internet Protocol) is the packet protocol standard for sending wireless data over the Internet.

**Wireless LAN (WLAN):** A local area network that incorporates wireless transmission—usually using one of the 802.11 Ethernet standards—in place of cable. Wireless Ethernet standards, such as 802.11, differ from standard 802.3 wired Ethernet only at OSI Layers 1 and 2, making them interoperable with standard wired Ethernet.

**Wire Map:** A test that checks cable termination by identifying miswiring, such as shorts, continuity, split pairs, etc.

**Wiring Closet:** The area that houses telecommunications equipment, cable terminations, and horizontal cross-connects. Usually serves one floor in a building. An older term. Now *Telecommunications Room*.

**Work Area:** The cabling between the wall outlet and user equipment, such as PCs, printers, and phones.

**Xchange:** Often a term for the Central Office, it's a unit established by a common carrier to administer communications services in a specific geographical area, such as a city. It consists of one or more Central Offices as well as the equipment used.

**xDSL:** A term that encompasses a broad range of digital subscriber line (DSL) services. These DSL-based services, which operate over existing telephone lines, provide users with speeds significantly faster than those of 56-kbps analog modems.

**Zone Cabling:** The cabling from the horizontal cross-connect to an office area.

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**What's the maximum distance for horizontal cabling? What cable is approved for use with 10-Gigabit Ethernet? How are data centers supposed to be set up? Find out the answers to these and other questions in the *Guide to Structured Cabling*.**

This guide provides an overview of the standards and practices that govern the planning, installation, and testing of structured cabling systems. It reviews everything from network applications and cabling to the installation and testing of the system. Related standards, such as administration, harsh environments, data centers, PoE, and wireless networking, are reviewed as well.



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