INSTALLATION POCKET REFERENCE GUIDE

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THE ANIXTER DIFFERENCE

At Anixter, we help build, connect, power and protect valuable assets and critical infrastructures. From enterprise networks to industrial support and supplies to video surveillance applications and electric power transmission and distribution, we offer full-line solutions – and intelligence – that create reliable, resilient systems that can sustain your business and community.

Through our unmatched global distribution network, supply chain management expertise and technical know-how, we drive efficiency and effectiveness to benefit your bottom line.

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INTRODUCTION

From Product Selection to Installation

Even the best product will fail to perform if it's not installed correctly. Making sure a product is installed correctly the first time means that you won't have to lose time troubleshooting and fixing an installation. Using best practices helps to make sure that once an installation is completed, it performs to everyone's expectations.

In this easy-to-use pocket guide, we've gathered the best tips, practices and techniques to properly install cabling infrastructure and related products. We also cover the key aspects and standards of twisted-pair, coaxial and fiber cable and connectors so you not only have the right skills to complete the job but also the underlying knowledge that makes these systems work.

This guide is a product of years of field experience from Anixter's engineers and is continuously updated to reflect the latest practical and standards developments in the industry.

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1. STANDARDS REFERENCE DOCUMENTS

SECTION 1: STANDARDS REFERENCE DOCUMENTS

Standards Reference Documents

Telecommunications standards provide recommended best practices for the design and installation of cabling systems to support a wide variety of existing and future systems to extend the life span of the telecommunications infrastructure.

Table 1.1 Standards Reference Documents

Standard	Description
TIA-568.0-D	Generic Telecommunications Cabling for Customer Premises
TIA-568.1-D	Commercial Building Telecommunications Cabling Standard
TIA-568.2-D	Balanced Twisted-Pair Telecommunications Cabling and Components Standard
TIA-568.3-D	Optical Fiber Cabling Components
TIA-569-D	Telecommunications Pathways and Spaces
TIA-606-C	Administration Standard for Telecommunications Infrastructure
TIA-607-C	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-942-B	Telecommunications Infrastructure Standard for Data Centers
IEEE 802.3af	This standard specifies data terminal equipment (DTE) power via media dependent interface (MDI). The specification calls for power source equipment that operates at 48 volts of direct current for 12.95 watts of power over unshielded twisted-pair cable to data terminal equipment 100 meters away.

Continued on next page >>

Standard	Description
IEEE 802.3an	This standard specifies physical layer and management parameters for 10 Gbps operation, type 10GBASE-T and 10 Gigabit Ethernet over twisted-pair cabling.
IEEE 802.3at	This amendment to the 802.3af standard offers improved power-management features. Increased power to end devices and new possibilities of powering devices through standard Category 5e, 6 and 6A cabling. The new IEEE 802.3at Power over Ethernet+ (Plus) standard increases the current, voltage and wattage available over balanced 100-ohm twisted-pair cabling systems. The standard defines the technology for powering a wide range of powered devices up to 25 watts over existing Category 5e and above cables. The 802.3at standard states that 30 watts at a minimum are allocated at the port, so 24.6 watts are ensured at the end device connector 100 meters away.
IEEE 802.3ba	This standard defines Media Access Control (MAC) parameters, physical layer specifications and management parameters for the transfer of 802.3 frames at 40 Gbps and 100 Gbps. The amendment facilitates the migration of 10 GB Ethernet from the network core to the edge by providing 40 Gbps and 100 Gbps data rates for backbone and backhaul applications to remove bandwidth bottlenecks that exists in many corporate networks today.
IEEE 802.3bm	Physical Layer specifications and management parameters for 40 Gb/s operation over single-mode fiber (40GBASE-ER4) and for 100 Gb/s operation over multimode fiber (100GBASE-SR4) are added by this amendment. This amendment also specifies a four-lane variant of the 100 Gigabit Attachment Unit Interface (CAUI-4) and optional Energy Efficient Ethernet (EEE) for 40 Gb/s and 100 Gb/s operation over fiber optic cables.

Standard	Description
IEEE 802.3bq	This amendment to IEEE Std 802.3-2015 specifies new Physical Coding Sublayer (PCS) interfaces and new Physical Medium Attachment (PMA) sublayer interfaces for 25 Gb/s Ethernet and 40 Gb/s Ethernet. 25GBASE-T and 40GBASE-T specify LAN interconnects for up to 30 m of balanced twisted-pair structured cabling, for 25 Gb/s and 40 Gb/s, respectively.
IEEE 802.3bz	Ethernet Media Access Control (MAC) parameters, Physical Layer specifications, and management objects for the transfer of Ethernet format frames at 2.5 Gb/s and 5 Gb/s over balanced twisted-pair transmission media used in structured cabling are defined in this amendment to IEEE Std 802.3-2015.
IEEE 802.3bs	This amendment includes IEEE 802.3 Media Access Control (MAC) parameters, Physical Layer specifications, and management parameters for the transfer of IEEE 802.3 format frames at 200 Gb/s and 400 Gb/s.
IEEE 802.11	This standard specifies wireless LAN Access Control (MAC) and physical layer (PHY) specifications. The standard denotes a set of wireless LAN/WLAN specifications developed by working group 11 of the IEEE LAN/WAN standards committee (IEEE 802).

Abbreviation References

Table 1.2 Abbreviation References

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

Obtaining Standards Documents

TIA documents may be purchased through Global Engineering Documents at 1.800.854.7179 or **global.ihs.com.** IEEE documents may be purchased through IEEE, P.O. Box 1331, Piscataway, NJ 08855 or **ieee.org**. CSA documents may be purchased through the Canadian Standards Association at **csa.ca** or by calling 1.416.747.4000.

Some material in this publication is reproduced from standards publications, which are copyrighted by the Telecommunications Industry Association (TIA).

This handbook was prepared by Anixter Inc., which is not affiliated with the Telecommunications Industry Association or the Electronic Industries Alliance. TIA is not responsible for the content of this publication.

For direct assistance in interpreting telecommunications standards, consider contacting a Registered Communications Distribution Designer (RCDD) certified by the Building Industry Consulting Service International (BICSI) at 1.800.242.7405 or **bicsi.org**.

Additional Resources

Anixter provides a wide variety of resources, including our Standards Reference Guides. These documents (shown below) highlight the key points of industry standards to improve availability and reduce expenses by defining cabling types, distances, connections, system architectures, termination standards, performance characteristics, and installation and testing methods.

Standards Reference Guide

Standards Reference Guide
Telecommunications Infrastructure for Industrial Premises

To download these guides visit **anixter.com/standards.**

For additional information, visit the Technical Resources page of **anixter.com**.

Anixter also has a collection of resources that provide you with the right products for your specific applications. These include the Electrical and Electronic Wire & Cable Products catalog, the Wire and Cable Technical Information Handbook, the Communications Products catalog and the Security Solutions catalog.

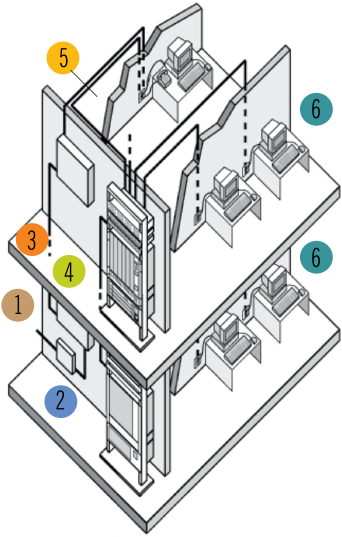
Contact your local Anixter sales representative, call 1.800.ANIXTER or go to **anixter.com/literature** for more information.

2. BUILDING SUBSYSTEMS

SECTION 2: BUILDING SUBSYSTEMS

The Six Subsystems of a Structured Cabling System

Note: This portion of the reference guide is based on two standards titled TIA-568.0-D (Generic Telecommunications Cabling for Customer Premises), which is used for generic infrastructures, and TIA-568.1-D (Commercial Building Telecommunications Cabling Standard [see p. 6]), which is more commonly used with typical commercial building infrastructures. These two standards are fully consistent with each other regarding the telecommunications infrastructure topology. However, they occasionally use different terms for the same system components. In this reference guide when different terms exist between the two standards for the same component, the more common 568.1-D version will be used first, followed by the 568.0-D (generic version) in square parentheses. Example: work area (WA) [equipment outlet (EO)].



Subsystems Key

1. Entrance Facilities
2. Equipment Room
3. Backbone Cabling
4. Telecommunications Room and Enclosure
5. Horizontal Cabling
6. Work Area

Figure 2.1—Six Subsystems of a Structured Cabling System

1. Entrance Facilities (EF) Entrance facilities contain the cables, network demarcation point(s), connecting hardware, protection devices and other equipment that connect to the access provider (AP) or private network cabling. It includes connections between outside plant and inside building cabling.

2. Equipment Room (ER) The environmentally controlled centralized space for telecommunications equipment is usually more complex than a telecommunications room (TR) or telecommunications enclosure (TE). It usually houses the main cross-connect (MC) [Distributor C] and may also contain the intermediate cross-connects (ICs) [Distributor B], horizontal cross-connects (HCs) [Distributor A], or both.

3. Backbone Cabling The backbone cabling provides interconnection between telecommunications rooms, equipment rooms, access provider (AP) spaces and entrance facilities. There are two subsystems defined for backbone cabling:

- Cabling Subsystem 2—Backbone cabling between the horizontal cross-connect (HC) [Distributor A (DA)] and the intermediate cross-connect (IC) [Distributor B (DB)]
- Cabling Subsystem 3—Backbone cabling between an intermediate cross-connect (IC) [Distributor B (DB)] and the main cross-connect (MC) [Distributor C (DC)]

Recognized cabling:

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

(See **Tables 2.2 and 2.3** on the following pages for maximum supportable distances for copper and fiber backbones.)

4. Telecommunications Room (TR) and Telecommunications Enclosure (TE)

A TR or TE houses the terminations of horizontal and backbone cables to connecting hardware including any jumpers or patch cords. It may also contain the IC or MC for different portions of the backbone cabling system. The TR or TE also provides a controlled environment to house telecommunications equipment, connecting hardware and splice closures serving a portion of the building.

The use of a telecommunications enclosure (TE) is for a specific implementation and not a general case. It is intended to serve a smaller floor area than a TR and may be used in addition to the minimum "one TR per floor" rule.

5. Horizontal Cabling—(Cabling Subsystem 1) The horizontal cabling system extends from the work area's telecommunications information outlet to the telecommunications room (TR) or telecommunications enclosure (TE). It includes horizontal cable, mechanical terminations, jumpers and patch cords located in the TR or TE and may incorporate multiuser telecommunications outlet assemblies (MUTOAs) and consolidation points (CPs). The maximum horizontal cable length shall be 90 m (295 ft.), independent of media type. If a MUTOA is deployed, the maximum horizontal balanced twisted-pair copper cable length shall be reduced in accordance with **Table 2.4.**

Recognized cabling:

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

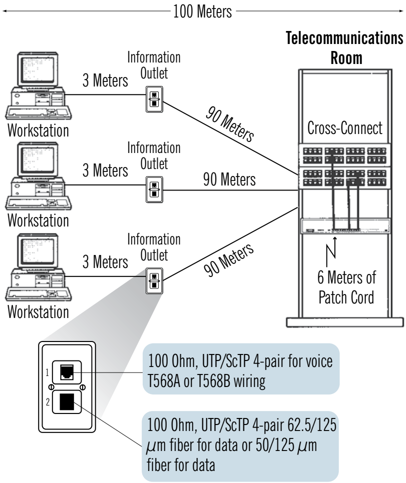


Figure 2.2—Horizontal Cable Maximum Distances and Information Outlets

6. Work Area (WA) Work area (WA) components extend from the telecommunications outlet/connector end of the horizontal cabling system to the WA equipment. A minimum of two telecommunications outlets (permanent links) should be provided for each work area. Multiuser telecommunications outlet assemblies (MUTOAs), if used, are part of the WA.

(**See Table 2.4** for the maximum length of horizontal cables and work area cords.)

Table 2.1—Work Area Components

Equipment	Components
Station equipment	Computers, data terminals, telephones, etc.
Patch cables	Modular cords, PC adapter cables, fiber jumpers, etc.
Adapters	Converters, baluns, etc. (Must be external to telecommunications outlet)

Maximum Cabling Distances

Maximum supportable distances for balanced twisted-pair cabling by application. Includes horizontal and backbone cabling (application specific).

Table 2.2 —Cabling Distances for Horizontal and Backbone Cabling and Work Area Cord

Application	Media	Distance m (ft.)	Comments
Ethernet 10BASE-T	Category 3, 5e, 6, 6A	100 (328)	
Ethernet 100BASE-TX	Category 5e, 6, 6A	100 (328)	
Ethernet 1000BASE-T	Category 5e, 6, 6A	100 (328)	
Ethernet 10GBASE-T	Category 6A	100 (328)	
IEEE Std 802.3™ Type 1 PoE	Category 5e, 6, 6A	100 (328)	
IEEE Std 802.3™ Type 2 PoE	Category 5e, 6, 6A	100 (328)	
IEEE Std 802.3™ Type 3 PoE	Category 5e, 6, 6A	100 (328)	Under Development
IEEE Std 802.3™ Type 4 PoE	Category 5e, 6, 6A	100 (328)	Under Development
ADSL	Category 3, 5e, 6, 6A	5,000 (16,404)	1.5 Mbps to 9 Mbps
VDSL	Category 3, 5e, 6, 6A	5,000 (16,404)	1,500 m (4,900 ft.) for 12.9 Mbps, 300 m (1,000 ft.) for 52.8 Mbps
Analog phone	Category 3, 5e, 6, 6A	800 (2,625)	
Fax	Category 3, 5e, 6, 6A	5,000 (16,404)	
ATM 25.6	Category 3, 5e, 6, 6A	100 (328)	
ATM 51.84	Category 3, 5e, 6, 6A	100 (328)	
ATM 155.52	Category 5e, 6, 6A	100 (328)	
ATM 1.2G	Category 6, 6A	100 (328)	
ISDN BRI	Category 3, 5e, 6, 6A	5,000 (16,404)	128 kbps
ISDN PRI	Category 3, 5e, 6, 6A	5,000 (16,404)	1.472 Mbps

Table 2.3—Maximum Supportable Distances and Attenuation for Optical Fiber Applications

		Multimode								Single-mode	
		62.5/125 µm TIA 492AAAA (OM1)		50/125 µm TIA 492AAAB (OM2)		850 nm laser-optimized 50/125 µm TIA AAAC (OM3)		850 nm laser-optimized 50/125 µm TIA 492AAAD (OM4)		TIA 492CAAA (OS1) TIA 492CAAB (OS2)	
Application	**Parameter Nominal Wavelength (nm)**	**850**	**1300**	**850**	**1300**	**850**	**1300**	**850**	**1300**	**1310**	**1550**
Ethernet 10/100BASE-SX	Channel attenuation (dB)	4.0	-	4.0	-	4.0	-	4.0	-	-	-
	Supportable distance m (ft.)	300 (984)	-	300 (984)	-	300 (984)	-	300 (984)	-	-	-
Ethernet 100BASE-FX	Channel attenuation (dB)	-	11.0	-	6.0	-	6.0	-	6.0	-	-
	Supportable distance m (ft.)	-	2,000 (6,560)	-	2,000 (6,560)	-	2,000 (6,560)	-	2,000 (6,560)	-	-
Ethernet 1000BASE-SX	Channel attenuation (dB)	2.6	-	3.6	-	4.5	-	4.5	-	-	-
	Supportable distance m (ft.)	275 (900)	-	550 (1,804)	-	800 (2,625)	-	800 (2,625)	-	-	-
Ethernet 1000BASE-LX	Channel attenuation (dB)	-	2.3	-	2.3	-	2.3	-	2.3	4.5	-
	Supportable distance m (ft.)	-	550 (1,804)	-	550 (1,804)	-	550 (1,804)	-	550 (1,804)	5,000	-
Ethernet 10GBASE-S	Channel attenuation (dB)	2.4	-	2.3	-	2.6	-	2.9	-	-	-
	Supportable distance m (ft.)	33 (108)	-	82 (269)	-	300 (984)	-	400 (1312)	-	-	-

Table 2.3—Maximum Supportable Distances and Attenuation for Optical Fiber Applications (continued)

		62.5/125 µm TIA 492AAAA (OM1)		50/125 µm TIA 492AAAB (OM2)		850 nm laser-optimized 50/125 µm TIA AAAC (OM3)		850 nm laser-optimized 50/125 µm TIA 492AAAD (OM4)		TIA 492CAAA (OS1) TIA 492CAAB (OS2)	
Application	**Parameter Nominal Wavelength (nm)**	**850**	**1300**	**850**	**1300**	**850**	**1300**	**850**	**1300**	**1310**	**1550**
Ethernet 10GBASE-LX4	Channel attenuation (dB)	-	2.5	-	2.0	-	2.0	2.0	-	6.3	-
	Supportable distance m (ft.)	-	300 (984)	-	300 (984)	-	300 (984)	300 (984)	-	10,000 (32,810)	-
Ethernet 10GBASE-LRM	Channel attenuation (dB)	-	1.9	-	1.9	-	1.9		1.9	6.2	-
	Supportable distance m (ft.)	-	220 (720)	-	220 (720)	-	220 (720)		220 (720)	10,000 (32,810)	-
Ethernet 40GBASE-SR4	Channel attenuation (dB)	-	-	-	-	1.9	-	1.5	-	-	-
	Supportable distance m (ft.)	-	-	-	-	100 (328)	-	150 (492)	-	-	-
Ethernet 100GBASE-SR4	Channel attenuation (dB)	-	-	-	-	1.9	-	1.9	-	-	-
	Supportable distance m (ft.)	-	-	-	-	70 (230)	-	100 (328)	-	-	-
Ethernet 100GBASE-SR20	Channel attenuation (dB)	-	-	-	-	1.9	-	1.5	-	-	-
	Supportable distance m (ft.)	-	-	-	-	100 (328)	-	150 (492)	-	-	-
1G Fibre Channel 100-MX-SN-I	Channel attenuation (dB)	3.0	-	3.9	-	4.6	-	4.6	-	-	-
	Supportable distance m (ft.)	300 (984)	-	500 (1,640)	-	860 (2,822)	-	860 (2,822)	-	-	-

Table 2.3—Maximum Supportable Distances and Attenuation for Optical Fiber Applications (continued)

		62.5/125 µm TIA 492AAAA (OM1)		50/125 µm TIA 492AAAB (OM2)		850 nm laser-optimized 50/125 µm TIA AAAC (OM3)		850 nm laser-optimized 50/125 µm TIA 492AAAD (OM4)		TIA 492CAAA (OS1) TIA 492CAAB (OS2)	
Application	**Parameter Nominal Wavelength (nm)**	**850**	**1300**	**850**	**1300**	**850**	**1300**	**850**	**1300**	**1310**	**1550**
2G Fibre Channel 200-SM-MX-SN-I	Channel attenuation (dB)	2.1	-	2.6	-	3.3	-	3.3	-	-	-
	Supportable distance m (ft.)	150 (492)	-	300 (984)	-	500 (1,640)	-	500 (1,640)	-	-	
Fibre Channel 200-SM-LC-L	Channel attenuation (dB)	-	-	-	-	-	-	-	-	7.8	-
	Supportable distance m (ft.)	-	-	-	-	-	-	-	-	10,000 (32,810)	-
4G Fibre Channel 400-MX-SN	Channel attenuation (dB)	1.8	-	2.1	-	2.9	-	3.0	-	-	-
	Supportable distance m (ft.)	70 (230)	-	150 9492)	-	380 (886)	-	400 (1312)	-	-	-
Fibre Channel 400-SM-LC-L	Channel attenuation (dB)	-	-	-	-	-	-	-	-	7.8	-
	Supportable distance m (ft.)	-	-	-	-	-	-	-	-	10,000 (32,810)	-
8G Fibre Channel 800-MX-SN	Channel attenuation (dB)	1.6	-	1.7	-	2.0	-	2.2	-	-	-
	Supportable distance m (ft.)	21 (69)	-	50 (164)	-	150 (492)	-	190 (624)	-	-	-

Table 2.3—Maximum Supportable Distances and Attenuation for Optical Fiber Applications (continued)

		62.5/125 µm TIA 492AAAA (OM1)		50/125 µm TIA 492AAAB (OM2)		850 nm laser-optimized 50/125 µm TIA AAAC (OM3)		850 nm laser-optimized 50/125 µm TIA 492AAAD (OM4)		TIA 492CAAA (OS1) TIA 492CAAB (OS2)	
Application	**Parameter Nominal Wavelength (nm)**	**850**	**1300**	**850**	**1300**	**850**	**1300**	**850**	**1300**	**1310**	**1550**
8G Fibre Channel 800-MX-SA	Channel attenuation (dB)	1.6	-	1.9	-	2.6	-	2.2	-	-	-
	Supportable distance m (ft.)	40 (131)	-	100 (328)	-	300 (984)	-	300 (984)	-	-	-
10G Fibre Channel 1200-MX-SN-1	Channel attenuation (dB)	2.4	-	2.2	-	2.6	-	2.9	-	-	-
	Supportable distance m (ft.)	33 (108)	-	82 (269)	-	300 (984)	-	400 (1312)	-	-	-
16G Fibre Channel 1600-MX-SN	Channel attenuation (dB)	-	-	1.6	-	1.9	-	2.0	-	-	-
	Supportable distance m (ft.)	-	-	35 (115)	-	100 (328)	-	125 (410)	-	-	-
16G Fibre Channel 3200-MX-SN-S 3200-MX-SN-S1	Channel attenuation (dB)	-	-	2.0	-	1.9	-	1.9	-	-	-
	Supportable distance m (ft.)	-	-	20 (66)	-	70 (230)	-	100 (328)	-	-	-
Fibre Channel 1200-SM-LL-L (10,512 Mbaud)	Channel attenuation (dB)	-	-	-	-	-	-	-	-	6.0	-
	Supportable distance m (ft.)	-	-	-	-	-	-	-	-	10,000 (32,810)	-
FDDI PMD ANSI X3.166	Channel attenuation (dB)	-	11.0	-	6.0	-	6.0	-	6.0	-	-
	Supportable distance m (ft.)	-	2,000 (6,560)	-	2,000 (6,560)	-	2,000 (6,560)	-	2,000 (6,560)	-	-
FDDI SMF-PMD ANSI X3.184	Channel attenuation (dB)	-	-	-	-	-	-	-	-	10.0	-
	Supportable distance m (ft.)	-	-	-	-	-	-	-	-	10,000 (32,810)	-

Table 2.4—Maximum Length of Horizontal Cable and Work Area Cords

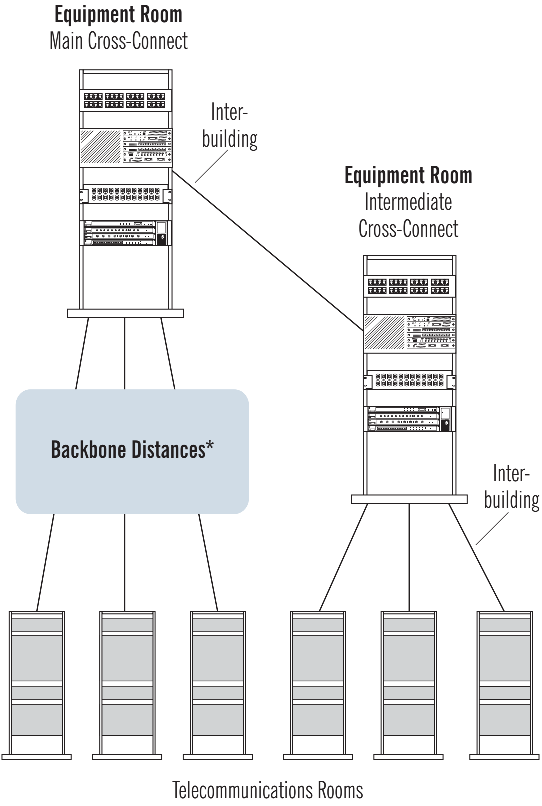
	24 AWG Cords		26 AWG Cords	
Length of Horizontal Cable m (ft.)	**Max. Length of Work Area Cord m (ft.)**	**Max. Combined Length of Work Area Cord, Patch Cords and Equipment Cord m (ft.)**	**Max. Length of Work Area Cord m (ft.)**	**Max. Combined Length of Work Area Cord, Patch Cords and Equipment Cord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

Star Wiring

Cabling shall be installed in a hierarchal star topology. There shall be no more than two cross-connects [Distributors] between the main cross-connect (MC) [Distributor C] and the work area (WA) [equipment outlet–EO].

Figure 2.3—Star Topology Diagram

*** Note:** Please refer to **Tables 2.2 and 2.3** (on previous pages) for maximum distances based on media type and application.



3. TWISTED-PAIR CABLE

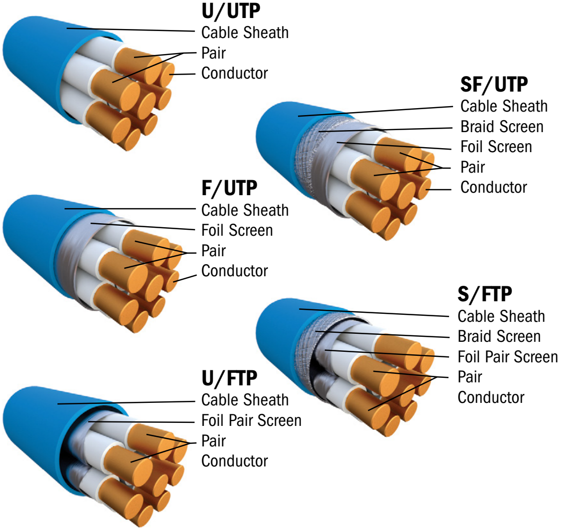
SECTION 3: TWISTED-PAIR CABLE

Twisted-Pair Cable

Twisted-pair cable consists of two insulated copper wires twisted around each other with neighboring pairs in a bundle typically having different twist lengths, between 5 and 15 cm, to reduce crosstalk or electromagnetic induction.

The conductor insulation and overall jacketing of the cable can utilize various shielded or unshielded elements. The ISO/IEC 11801 cable designations are noted in the following figures.

8-conductor/4-pair twisted-pair cable is generally used in horizontal applications from telecommunication closets to a workstation or desk. A multipair twisted-pair cable is generally used in intra- or inter-building backbones.



Guide to understand twisted-pair cabling types abbreviations

- Balanced element — TP = Twisted pair
- Element screen
  - U = Unscreened
  - F = Foil screened
- Overall screen
  - F = Foil screened
  - S = Braid screen
  - SF = Braid and foil screen

Figure 3.1—Twisted-Pair Cabling Types

Twisted-Pair Wiring Color-Code Chart

The 25-pair color code is used to identify individual conductors of multiconductor twisted-pair cabling used primarily in backbone applications. The colors are applied to the insulation that covers each conductor. The first color is chosen from one group of five colors and the other from a second group of five colors, giving 25 combinations of two colors.

Table 3.1—Twisted-Pair Wiring Color-Code Chart

Color Codes		2nd Color									
		Blue		Orange		Green		Brown		Slate	
Wire No. in Pair		1	2	1	2	1	2	1	2	1	2
1st Color	White	1		2		3		4		5	
	Red	6		7		8		9		10	
	Black	11		12		13		14		15	
	Yellow	16		17		18		19		20	
	Violet	21		22		23		24		25	

Pair No.	1st Wire	2nd Wire	Pair No.	1st Wire	2nd Wire
1	White	Blue	14	Black	Brown
2	White	Orange	15	Black	Slate
3	White	Green	16	Yellow	Blue
4	White	Brown	17	Yellow	Orange
5	White	Slate	18	Yellow	Green
6	Red	Blue	19	Yellow	Brown
7	Red	Orange	20	Yellow	Slate
8	Red	Green	21	Violet	Blue
9	Red	Brown	22	Violet	Orange
10	Red	Slate	23	Violet	Green
11	Black	Blue	24	Violet	Brown
12	Black	Orange	25	Violet	Slate
13	Black	Green			

Figure 3.2—Twisted-Pair Color-Code Chart

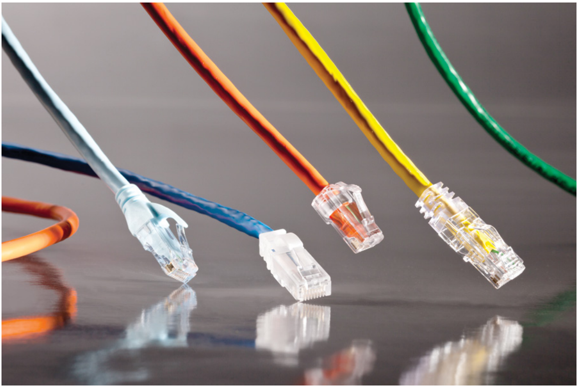
The Difference Between Cat 5e, Cat 6 and Cat 6A Performance Levels

When supporting Ethernet applications for twisted-pair cabling, the guidelines below shall be considered. Different applications may require different cabling performance levels to achieve desired distance requirements.

For example, 10 Gigabit Ethernet at 100 meters will require TIA Augmented Cat 6 or ISO E_A cabling.

Table 3.2—TIA Cat 5e Versus TIA Cat 6 Versus TIA Augmented Cat 6 Versus ISO Class E_A

Data Rate	Cat 5e	Cat 6	Augmented Cat 6	Class E_A
10 Mbps	Yes	Yes	Yes	Yes
100 Mbps	Yes	Yes	Yes	Yes
1 Gbps	Yes	Yes	Yes	Yes
10 Gbps (55 m)	No	Yes	Yes	Yes
10 Gbps (100 m)	No	No	Yes	Yes



Bend Radius

It is important not to change the geometry of the cable. Bend radius is the maximum arc into which a cable can be looped before its data transmission is impaired.

The minimum bend radius for UTP and F/UTP cable is four times the cable diameter. The bend radius for multipair cable should follow the manufacturer's guidelines. The minimum bend radius for cord cable (patch cord) is one times the cord cable diameter.

When you bend a cable too much, you separate the pairs within the jacketing, which can result in performance degradation. Cables are manufactured very carefully. There is a specific twist scheme/pair lay within the jacketing of the cable. Bending it too much will disturb the benefits of the cable's manufacturing.

Exceeding the bend radius could kink or crimp the copper, causing signal reflections.

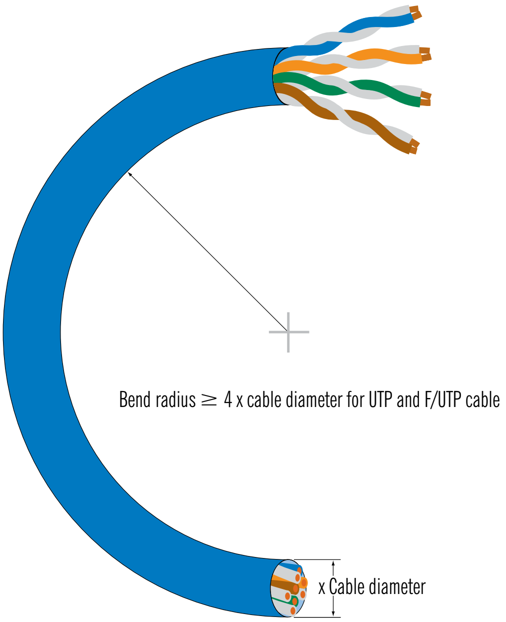


Figure 3.3—Minimum Bend Radius UTP and F/UTP Cable

Twisted-Pair Connectors

A registered jack (RJ) is a standardized physical network interface for connecting telecommunications or data equipment. The physical connectors that registered jacks use are mainly of the modular connector and 50-pin miniature ribbon connector types. The most common twisted-pair connector is an 8-position, 8-contact (8P8C) modular plug and jack commonly referred to as an RJ45 connector.

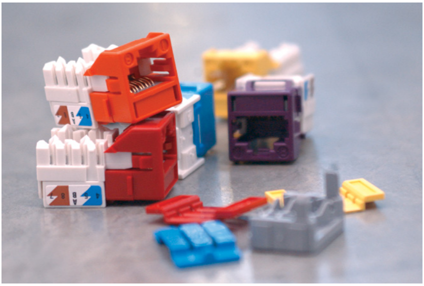


Figure 3.4—Twisted-Pair Connectors

RJ45

- An 8-pin/8-position plug or jack is commonly used to connect computers onto Ethernet-based local area networks (LAN).
- Two wiring schemes—T568A and T568B—are used to terminate the twisted-pair cable onto the connector interface.

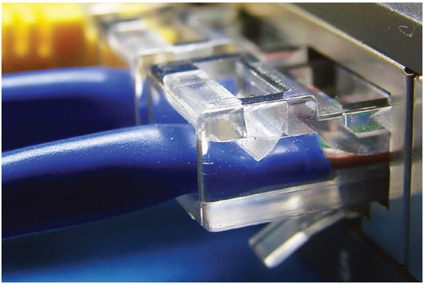


Figure 3.5—RJ45

GG45

- GG45 is a connector for high-speed Category 7 (S/FTP) cabling systems.
- It was standardized in 2001 as IEC 60603-7-7.

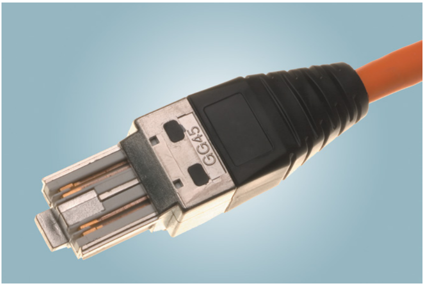


Figure 3.6—GG45

RJ21

- A modular connector using 50 conductors is usually used to implement a 25-line (or less) telephone connection.
- High-performance versions of the connector can support Category 5e transmission levels.

Figure 3.7—RJ21

Testing

Verification of the transmission performance of the installed cabling system is recommended by the TIA 568-2-D standard. The primary field test parameters for twisted-pair cabling systems include:

- Impedance or return loss
- Attenuation or insertion loss
- Near-end crosstalk
- Power-sum crosstalk
- Attenuation-to-crosstalk ratio
- Far-end crosstalk
- Propagation delay and delay skew
- Noise.

Wire mapping is the most basic and obvious test for any twisted-pair cable installation. A proper wire-mapping tester can detect any of the following faults:

- Open pair
- Shorted pair
- Short between pairs
- Reversed pairs
- Crossed pairs

STEP-BY-STEP: TWISTED-PAIR CABLE PREPARATION AND CONNECTOR TERMINATION

The following steps will guide you through the preparation and termination process for UTP cable. Following these guidelines will help give you the optimum performance from the twisted-pair cabling.

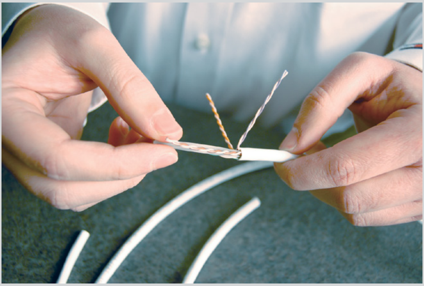
Step 1: The tools you will need:

- Jacket stripper
- Punch-down tool (not shown)
- Wire cutters (not shown)

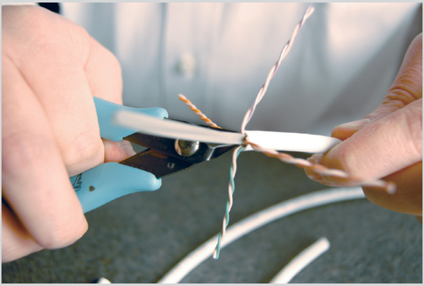
Step 2: Insert cable into stripping tool to the desired strip length. Strip off only as much cable jacket needed to properly terminate the pairs (1 to 1½ inches should be sufficient to terminate pairs).

Step 3: Holding the cable near the tool, rotate the tool around the cable several times.

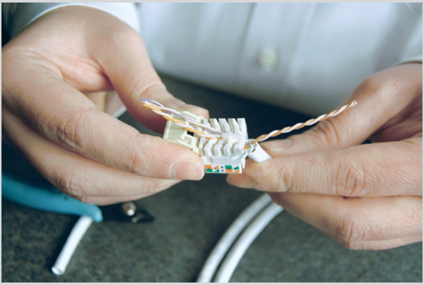
Step 4: Slightly bend the outer jacket and manually remove the cut piece or slide the cut outer jacket with the stripper.



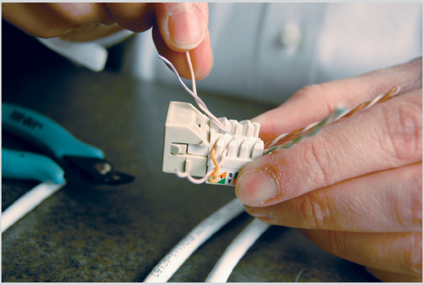
Step 5: Bend each pair in one direction to expose the rip cord, binder or cross-web filler on the cable.



Step 6: Remove the rip cord, binder or cross-web filler if they are present on the cable, leaving only the twisted pairs of wire. The cross-web filler should be cut as flush as possible to the jacket.



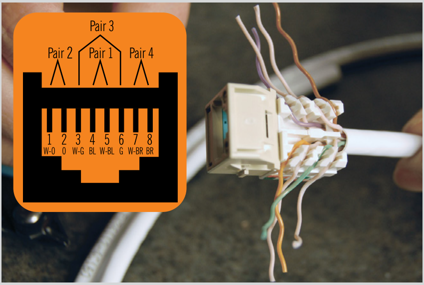
Step 7: Determine the wiring scheme and properly align all four cables accordingly on the jack. Keep the cable jacket as close to the connector as possible. Always use connectors, wall plates and patch panels that are compatible (same rating or higher) with the grade of the cable used.



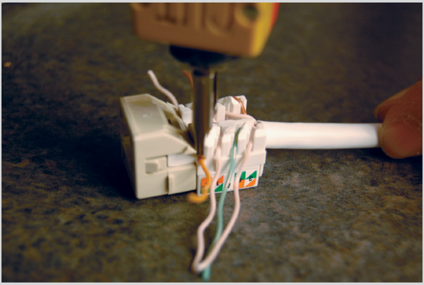
Step 8: Preserve the wire pair twists as close as possible to the point of termination. When connecting jacks and plugs, do not untwist the cable more than 0.5 inches for Category 5e, 6 and 6A cable.

Helpful Hint:

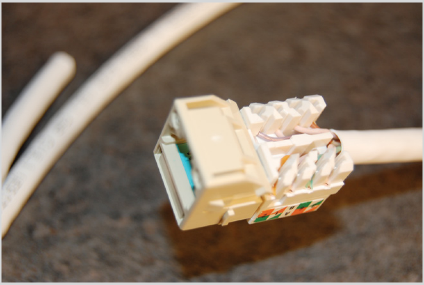
- **A half of an inch of an untwisted wire pair results in 1.5 dB of near-end crosstalk.**



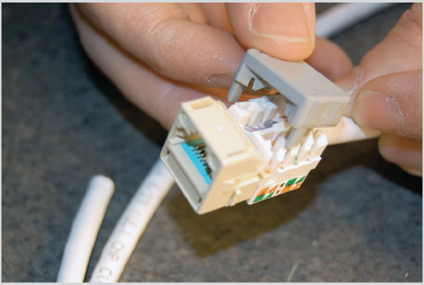
Step 9: Insert wires down into IDC terminal slots to position them before punching down. Maintain the twist. To "future-proof" an installation, terminate all four pairs. The picture above shows an outlet being wired to the T568B wiring scheme.



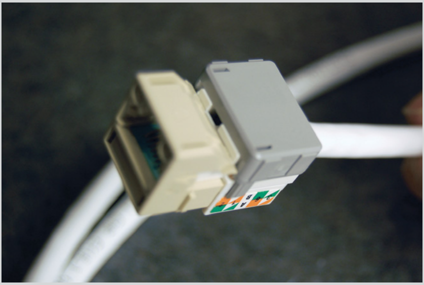
Step 10: When using a punch-down tool, make sure the tool is straight before punching down on the connector. Make sure the cut-side of the tool is facing outward.



Step 11: Inspect the connector to verify that the wires are fully engaged in the IDC terminals and they are cut properly.



Step 12: Place a dust cover on the jack for protection.



Step 13: This is how your assembled jack should look.

4. COAXIAL CABLE

SECTION 4: COAXIAL CABLE

Coaxial Cable

Coaxial cable is a two-conductor electronic cable that is used as the transmission medium for a variety of applications such as analog baseband video (closed circuit television [CCTV]), RF broadband video (such as cable television [CATV] and satellite) and for some data, radio and antenna applications. It is constructed to provide protection against outside signal interference.

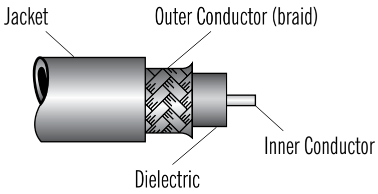


Figure 4.1—Flexible Coax

Coaxial Cable Wiring Descriptions—CCTV and CATV

CCTV operates in a lower frequency range than CATV and requires different cable constructions. Be sure that the cable used is chosen accordingly. The primary differences are based on the frequency range differences as shown below **(see Figure 4.2)**.

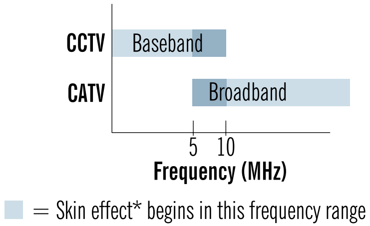


Figure 4.2—CATV and CCTV Frequency Ranges

* **Note:** Skin effect is the tendency of alternating current, as its frequency increases, to travel only on the surface of a conductor. In copper-clad steel coax, the high-frequency signal travels only on the copper “skin.”

Table 4.1—Conductor Types

Type	Description
CCTV	Solid bare copper Stranded bare copper (for pan tilt, zoom)
CATV	Solid/stranded bare copper Copper-covered steel
Precision Digital	Solid bare copper

Table 4.2—Shield Types

Type	Description
CCTV	95 percent bare copper braid
CATV	65–95 percent aluminum braid plus one or more aluminum shields
Precision Digital	85–95 percent tinned copper braid plus one or more foil shields

CATV requires a foil shield to contain high-frequency noise in order to comply with FCC regulations. CATV sometimes uses copper-covered steel. Because of this conductor type, care should be given to not damage cutters when handling the steel in CATV coax.

Table 4.3—Coaxial Cable Construction Types

Type	Description
Miniature Coax 75 ohm—usually used in CCTV headends and for precision analog and digital video applications such as component video or audio.	Single or bundled (multiple unit) coax construction from 23–30 AWG with either a tinned or bare solid copper conductor or a stranded conductor. Shielding is a 90–95 percent braid with a foil shield.
RG-59—inexpensive 75-ohm cable used for flexibility, small size and shorter run lengths available in numerous varieties.	CCTV: #20 AWG solid copper conductor, 95 percent coverage bare copper braid shield CATV: #20 AWG copper-covered steel conductor, numerous foil and braid shields available
RG-6—mid-cost longer run-length capability than RG-59 that is often used in distribution of video signals in commercial buildings and CATV applications.	CCTV: #18 AWG solid copper conductor, 95 percent coverage bare copper braid shield CATV: #18 AWG copper-covered steel conductor, numerous foil and braid shields available
RG-11—higher cost used in long run-length, low-attenuation applications where larger size is acceptable.	CCTV: #14 AWG solid copper conductor, 95 percent coverage bare copper braid shield CATV: #14 AWG copper-covered steel conductor, numerous foil and braid shields available

Note: This is not a complete list. It covers the most common types of 75-ohm coaxial cables. The installation methods outlined in the guide are common practice for many types of coaxial cables.

Coaxial Connectors

Coaxial connectors are components attached to the end of a coaxial cable that connect with an audio, video, data or other device to prevent interference and damage.

Figure 4.3—Coaxial Connectors

- Coaxial connectors are designed to maintain the coaxial shielding.
- Connectors included in this designation are the widely used F and BNC connectors.

BNC Connector

- They are the most common connector for CCTV (baseband) coax cables.
- 50-ohm connectors are rated to 4 GHz.
- 75-ohm, 4 GHz connectors are available to meet the demands of 75-ohm coax cables.
- They are commonly used in distributed video applications.

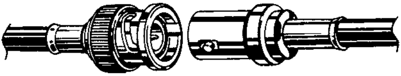


Figure 4.4—BNC Connector

These are common on all CCTV (baseband) cables; not just miniature cables.

F Connector

- The 75-ohm, screw-threaded couplers are used with RG-59, RG-6 and RG-11 type coaxial cables.
- It is standard for cable television systems.
- It is simple and economical to install.
- It meets the specifications of CATV/MATV systems.
- A single crimp on the attached ferrule terminates the connector.

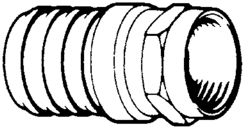


Figure 4.5—F Series Coax Connector

Bend Radius

Current military coaxial standards do not specify bend radius; however, various manufacturers do provide guidance. Check with manufacturers for specifics.

Special care should be taken when pulling a coaxial cable around bends. Using too much force or too tight of a bend can deform the dielectric and cause a drop in transmission performance.

Testing

Testing coax performance includes the following:

- Impedance anomaly
- Return loss
- Attenuation or insertion loss
- Signal level

Note: Use a signal strength meter to verify that the right signal level is available (check installed length and possible damage). Contact your Anixter sales representative to learn more about tools available for testing coax.

Table 4.4—Typical Maximum Length

RG-59		RG-6	RG-11
CCTV	750–1,000 ft.	1,000–1,500 ft.	1,500–3,000 ft.

Range depends on cable and connector performance, environment, signal frequency, and transmission and reception equipment.

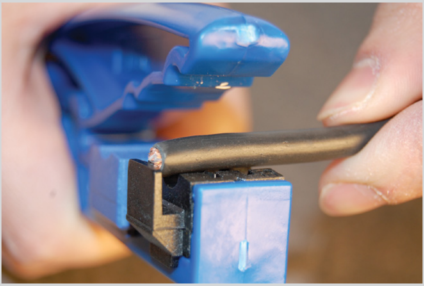
STEP-BY-STEP: COAXIAL CABLE PREPARATION AND COMPRESSION CONNECTOR TERMINATION

The following steps will guide you through the preparation and termination process for coaxial cable with compression connectors. Following these guidelines will help make sure that you receive the optimum performance from the coaxial cable.

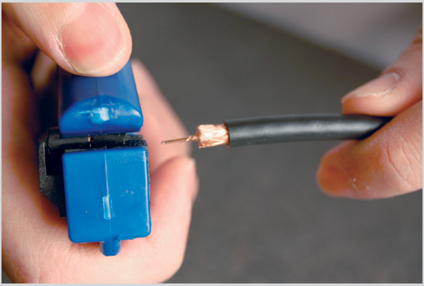
Step 1: The tools you will need:

- Compression tool
- Cable stripper
- Compression connectors

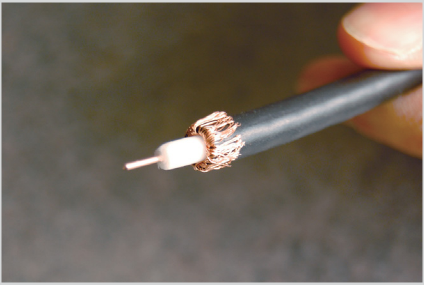
- **To order these tools, call your local Anixter sales representative or request a quote using Anixter's online catalog at anixter.com/catalog.**



Step 2: Adjust the blades of the stripper to expose ¼ inch of the conductor and ¼ inch of the insulation. Insert the coax cable into the strip cartridge to the adjusted length.

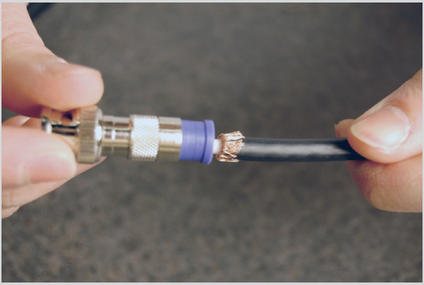


Step 3: Holding the cable near the tool, rotate the cutter around the cable (three to five full turns) to score the jacket and cut through the insulation. Be sure the braid is cut (you can hear when the wires of the braid have all been cut). Then flex the jacket to separate and slide it off to expose the center conductor.



Step 4: Flare and bend back the remaining outer braid onto the cable outer jacket. Make sure to remove any stray or loose braids. Stray or loose braids can cause shorts if they touch the center conductor. Verify that the center conductor and the insulation are not nicked or scored.

- **When handling cables with multiple braids, such as quad-shield, refer to the manufacturer's literature for proper braid handling techniques.**



Step 5: Insert the sleeve ferrule and BNC body onto the coaxial cable. Firmly push the cable as far as possible or until ⅛ inch of the center conductor is protruding from the connector.

- **Make sure the connector is fully seated and the white dielectric material is firmly pushed against the inner stop of the connector. You can see this by looking into the open end of some connectors.**

Step 6: Insert the cable and connector into the crimping device, making sure that it is positioned firmly. Squeeze the crimper handle tightly. Use a ratcheting tool that does not release until the proper crimping displacement has been applied for the specific cabling and connector type. Once the tool releases after the final "click," the crimp should be complete.

Step 7: Inspect the connection making sure no braiding is exposed and that the connector is firmly attached to the cable.

5. FIBER OPTIC CABLES

SECTION 5: FIBER OPTIC CABLES

Fiber optic cables consist of a central core that carries light and an outer cladding that completes the guiding structure. There are two basic fiber types: single-mode and multimode.

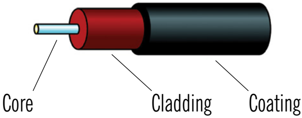


Figure 5.1—Fiber Optic Cable

Single-Mode

- Core diameter of 8 to 10 microns
- Normally used for long-distance requirements and high-bandwidth applications
- Does not bounce light off the surrounding cladding as it travels

Multimode

- Allows more than one mode of light to travel through the cable
- Typical wavelengths of 850 and 1350 nanometers (nm)
- Normally used in LAN applications

Multimode Fiber Optic Cable Types

Multimode 62.5-micron fiber:

- 62.5-micron core diameter
- 125-micron cladding diameter

Multimode 50-micron fiber:

- 50-micron core diameter
- 125-micron cladding diameter
- Increased bandwidth with smaller size
- Greater bandwidth with laser-optimized 50-micron fiber

Figure 5.2—Fiber Types and Sizes

Fiber Optic Connectors

Figure 5.3—ST has a bayonet mount and a long cylindrical ferrule to hold the fiber. It is commonly used in building applications.

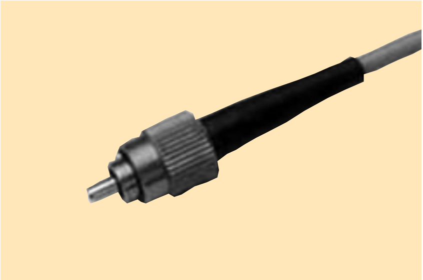


Figure 5.4—FC has a 2.5 mm ferrule tip with screw-on mechanism. It is keyed to prevent tip rotation and damage to the mated fiber. It is are typically used for single-mode applications.

Figure 5.5—SC is a snap-in connector that latches with a simple push-pull motion that is available in a duplex configuration. It is commonly used in building applications.

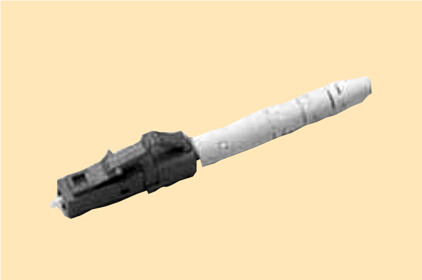


Figure 5.6—LC is a small form factor (SFF) connector that uses a 1.25 mm ferrule, is half the size of the ST, and is a standard ceramic ferrule connector that provides good performance. It is highly favored for single-mode and is easily terminated with any adhesive. It is commonly used in building applications.

Figure 5.7—MT-RJ is a small form factor (SFF) duplex connector with both fibers in a single polymer ferrule that uses pins for alignment, has male and female versions, and field terminates only by prepolished and splice methods. It is commonly used in building applications.

Figure 5.8—MTP/MPP is a high-density multifiber connector used with ribbon fiber cables and is an improvement as compared to the original MPO (multifiber push-on) connector.

MTP connectors house up to 12 and sometimes more optical fibers in a single ferrule.

Applications include horizontal zone cabling, high-density backbones, data centers and industrial operations.

Attachment Methods

There are several different attachment methods for installing fiber connectors like those shown on the previous few pages. Below are descriptions of each attachment method along with an explanation of the pros and cons of each.

Table 5.1—Attachment Methods—Pros and Cons

Fiber Optics Attachment Method	Pros	Cons
Heat-cure style—epoxy	Cost effective	Long termination time (typically 15 minutes) Long cure time (typically 30 minutes)
Quick-cure style—UV-cure	Faster install than heat-cured 99 percent yield	Requires a UV light source Requires a special ferrule with glass capillary Limited resistance to environmental extremes
Quick-cure style—Anaerobic	Faster install than heat-cured 99 percent yield	Short shelf life
Nonadhesive—Mechanical grip or crimp	Speedy install No curing involved	Polishing still required
Nonadhesive—No-cure, no-polish	Faster install No epoxy, no polish	Higher cost Special tools required

Bend Radius

It is important not to change the geometry of the cable. Changing the geometry of the cable can negatively impact the transmission performance. Bend radius is the maximum arc into which a cable can be looped before its data transmission is impaired. The minimum bend radius for optical fiber cable is 10 times the diameter.

Table 5.2—Optical Fiber Bend Radius

Fiber Type	Bend Radius
Small inside plant cable (2–4 fibers)	1 in. (no load) 2 in. (with load)
All other inside plant cable	10 x diameter (no load) 20 x diameter (with load)
Outside plant cable	10 x diameter (no load) 20 x diameter (with load)

Testing

Figure 5.9—Fiber Optic Cable Tester

Attenuation is the parameter most frequently measured and includes the attenuation of the cable as well as that of attached connectors. Attenuation testing is done with an optical loss test set (OLTS). Cable attenuation can be caused by microbending, poorly installed connectors, the presence of dirt on the end-face of a connector, excessive mechanical force on the cable or, of course, a broken fiber.

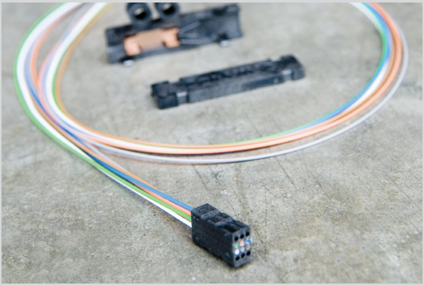
There are two tiers of optical field testing defined in the standards:

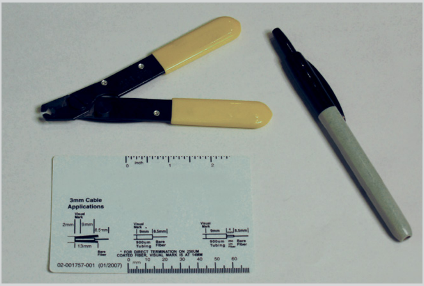
- Tier 1: Mandatory—Tests attenuation and verifies cable length and polarity
- Tier 2: Optional—Includes the Tier 1 tests plus an optical time domain reflectometer (OTDR) trace

STEP-BY-STEP: FIBER OPTIC CABLE PREPARATION AND CONNECTOR TERMINATION

The following steps will guide you through the preparation and termination process for a no epoxy, no polish fiber optic SC connector. Following these guidelines will help make sure that you receive the optimum performance from the fiber optic cable.

There are numerous other methods for terminating fiber optic connectors. **See Table 5.1 on page 52** for all the attachment methods.

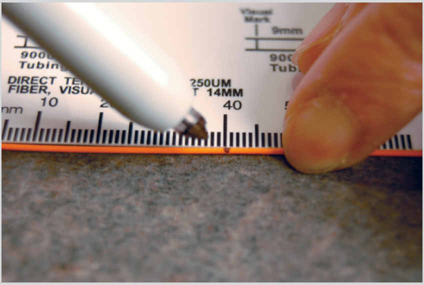




Step 1: The tools you will need:

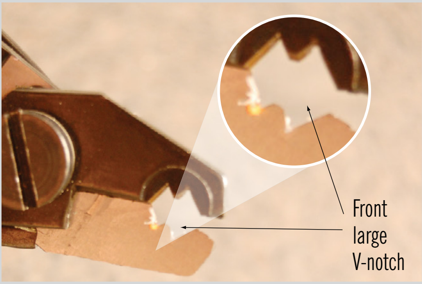
- Fiber stripper
- Ruler
- Marker

- **To order these tools, call your local Anixter sales representative or request a quote using Anixter's online catalog at anixter.com/catalog.**



Step 2: Measure from the end of the fiber to 40 mm and mark the cable.

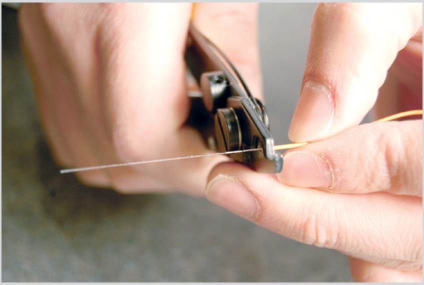
Step 3: Slide the strain-relief boot onto the cable.



Step 4: Make sure the stripper's cutting face is clean. Use the front, large V-notch on the cable stripper to remove the 900-micron tight buffer.

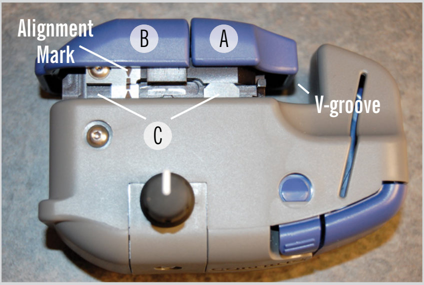
Step 5: Carefully clamp down on the cable halfway down from the mark you made.

Step 6: Keeping the pressure light, carefully slide the jacket off of the fiber. Be careful to avoid breaking the fragile glass fiber. Repeat step to remove the remaining 20 mm of jacket.



Step 7: Carefully remove any of the leftover 250-micron coating (notice the white film on the fiber) using the smaller, back V-notch on the tool.

Step 8: Clean the bare fiber with two passes of a fiber wipe dampened with fiber optic cleaning fluid. Do not touch the bare fiber after cleaning it.



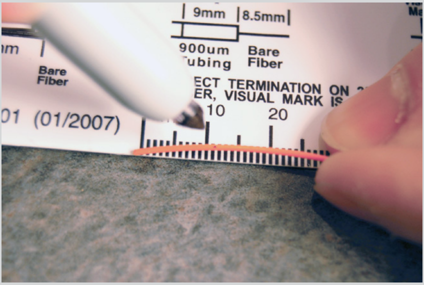
Step 9: Make sure that both clamps (C) are clean and free of fiber. Squeeze buttons A and B at the same time to open clamps.

Step 10: Place fiber in the slot so the bare fiber is in the V-groove, the buffer or coating is aligned with the alignment mark, and the fiber rests under the tab. Fully release button B then button A. Make sure both the bare and coated fiber is secured by the clamps.

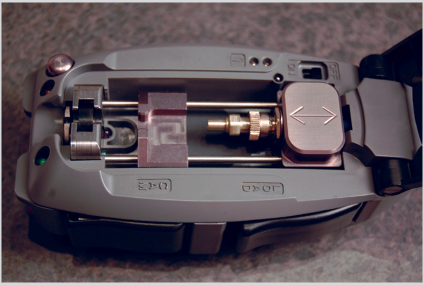
Step 11: Slowly turn the knob 360 degrees to cut the fiber.

Step 12: Squeeze button A, remove the scrap fiber and place it in the scrap fiber bin.

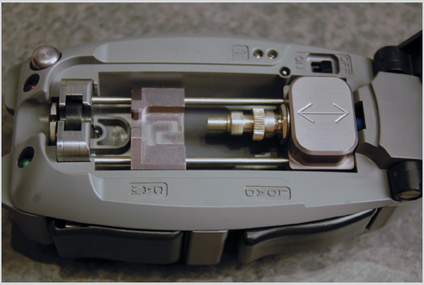
Step 13: While holding onto the fiber, squeeze button B and remove the cleaved fiber.



Step 14: Measure and mark an additional 11 mm on the fiber jacket.

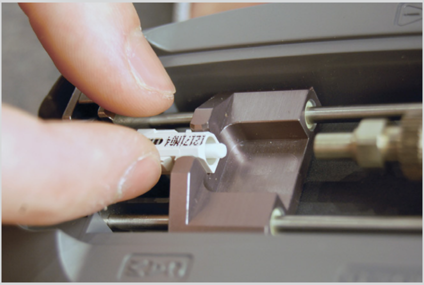


Step 15: Make sure the components are in the starting position. If not, slide the VFL coupler back toward the cover hinge until it locks. Verify the load button is released and the connector cradle is against the travel stop. Depress the reset button to return the wrench to the start position.



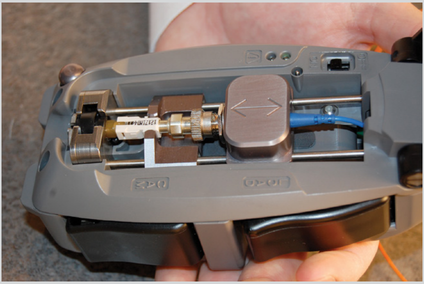
Step 16: Make sure the correct ferrule adapter is installed. Switch the power on. If the power light flashes or does not glow, the batteries need to be replaced.

Step 17: Remove the dust cap from connector and squeeze the load button to move the connector cradle away from the wrench.



Step 18: With the connector oriented up, load the connector into the tool by inserting it (lead-in tube first), into the wrench.

Slowly release the load button while guiding the connector into the connector cradle.



Step 19: Slide the VFL coupler down until the ferrule adapter is seated on the connector.

Step 20: Close the cover and check for the error light. If the error light remains off, there are no problems.

Insert the cleaved fiber into the back of the lead-in tube. Insert the fiber until you feel it firmly stop against the fiber stub. The visual mark should be within 2 mm of the lead-in tube.

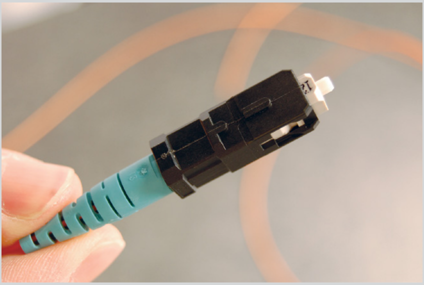
While maintaining enough inward pressure, squeeze the CAM button in until it locks. Check the termination lights. If the green light is illuminated, the termination was successful. If the red light is illuminated, press the reset button, remove the fiber and repeat the termination process.

Step 21: Turn the crimp knob 180 degrees in either direction to crimp and lock the connector into the fiber.

Step 22: Open the cover and slide the VFL coupler back into its starting position. Slightly squeeze the button to remove the connector.

Make sure the clear ferrule dust cap is installed. Slide the boot up the back of the connector until it reaches the cam.

Step 23: Install the outer shroud by lining up the date code with the key-side of the outer shroud. Using the boot, push the assembly into the outer shroud until it snaps into place.



Step 24: The fiber connector is completed.

6. CONDUIT FILL RECOMMENDATIONS

SECTION 6: CONDUIT FILL RECOMMENDATIONS

Conduit Fill Recommendations

Conduit fill states the maximum amount of space that the installed cables should occupy in a given size conduit expressed as a percentage of the interior volume.

When designing a conduit run, consider not only the cable being installed now but also the likelihood of having to add cables in the future.

Table 6.1 (right) makes recommendations for the maximum cable sizes to be installed in conduit.

- Clearance should be ¼ inch at minimum and up to 1 inch for large cable installations or installations involving numerous bends.
- When calculating clearance, make sure all cable diameters are equal.
- Do not exceed recommended conduit fill requirements.
- Typical OD for twisted-pair cabling is 0.25 to 0.35 inch.

Examples of conduit fill based on sample sizing of cables are listed below.

Table 6.1—Conduit Fill Recommendations

		Sample Cable Outside Diameters (mm [in.])					
Conduit Inside Diameter mm (in.)	**Trade Size**	**4.5 (0.15)**	**5 (0.19)**	**6 (0.23)**	**7 (0.27)**	**8 (0.31)**	**9 (0.35)**
21 (0.82)	3/4	11	7	5	3	3	2
27 (1.04)	1	18	11	8	6	4	3
35 (1.38)	1-1/4	30	19	13	10	8	6
41 (1.61)	1-1/2	41	26	18	13	10	8
50 (2.06)	2	68	43	30	22	17	13
63 (2.46)	2-1/2	96	62	43	31	24	19
75 (3.06)	3	149	95	66	49	37	29
91 (3.54)	3-1/2	199	127	88	65	50	39
100 (4.02)	4	255	163	113	83	64	50

Note: The calculations used in **Table 6.1** to determine cable fill are based on a 40 percent initial fill factor assuming straight runs with no degrees of bend. These conduit sizes are typical in the United States and Canada and may vary in other countries. The metric trade designators and imperial trade sizes are not literal conversions of metric to imperial sizes. Fire and smoke stop assemblies may require different fill ratios.

Reference: BICSI 2008 Telecommunications Distribution Methods Manual.

7. ADMINISTRATION

SECTION 7: ADMINISTRATION

Administration

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

Administrative record keeping plays an increasingly necessary role in the flexibility and management of frequent moves, adds and changes. The TIA-606-C standard concisely describes the administrative record keeping elements of a modern structured cabling system.

Elements of an Administration System per the TIA-606-C Standard

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

Classes of Administration

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

Class 1 Administration

Class 1 Administration addresses the administration requirements for a building or premise that is served by a single equipment room (ER). The following infrastructure identifiers shall be required in Class 1 Administration when the corresponding elements are present:

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

Class 2 Administration

Class 2 Administration addresses the administration of infrastructure with one or more telecommunications spaces (TS) in a single building. The following infrastructure identifiers shall be required in Class 2 Administration when the corresponding elements are present:

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

Class 2 Administration may additionally include pathway identifiers.

Class 3 Administration

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

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

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

The following infrastructure identifiers are optional in Class 3 Administration:

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

Additional identifiers may be added if desired.

Class 4 Administration

Class 4 Administration addresses infrastructure with multiple sites or campuses. The following infrastructure identifiers shall be required in Class 4 Administration:

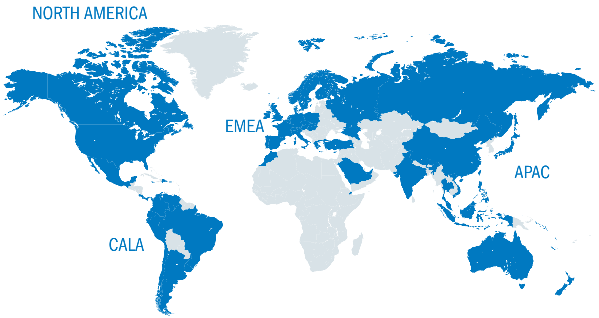
- Identifiers required in Class 3 Administration
- Campus or site identifier

The following infrastructure identifiers are optional in Class 4 Administration:

- Identifiers optional in Class 3 Administration
- Intercampus element identifier

Additional identifiers may be added if desired.

8. ABOUT ANIXTER



GLOBAL REACH. LOCAL ADVANTAGE.

With Anixter, you get a true local partner around the world. No other distributor of our kind can claim an in-country presence in approximately 50 countries and in over 300 cities.

We do business in more than 35 currencies and 30 languages, which means we are uniquely positioned to help facilitate your project in the local environment, reduce risks and keep costs down.

SECTION 8: ABOUT ANIXTER

CORPORATE SNAPSHOT

FOUNDED **1957**

OVER **9,400 EMPLOYEES**

OVER **$8.8 BILLION IN SALES**

APPROXIMATELY **50 COUNTRIES**

IN OVER **300 CITIES**

OVER **100,000** CUSTOMERS

NEARLY **600,000 PRODUCTS**

OVER **$1 BILLION** INVENTORY

FORTUNE **500** COMPANY

STOCK SYMBOL **AXE**

Our Products

Our products are used around the world to:

BUILD

- Automation
- Electrical/electronic wire and cable
- Gear, controls, transformers, power generation
- Indoor/outdoor lighting

CONNECT

- Broadcast and professional A/V
- Cabling and connectivity infrastructure
- Data center infrastructure
- Power
- Wireless

POWER

- Generation, transmission and distribution
- MRO supplies
- Outdoor lighting
- Smart grid infrastructure

PROTECT

- Access control
- Electrified door hardware
- Emergency telephones
- Fire and life safety
- Intrusion detection
- Mass notification
- Mechanical door hardware
- Sound, paging and intercom
- Video surveillance

Our Technical Expertise

Across the world, Anixter has more than 2,700 highly trained specialists with years of experience specifying products and solutions for a variety of industries. This dedication to technical expertise makes Anixter a company customers can depend on to keep informed of the latest products, applications, industry trends, standards and emerging technologies.

Our technical expertise includes:

Technology Support Services

Our specialized group of industry experts assist our customers to deliver standards-compliant technology solutions that respond to change, drive innovation and deliver value. Utilizing our global technical resources, we bring you the right technology support when and where you need it. We build technology teams that meet your specific needs.

Industry Certificates, Association Participation and Standards Development

Our engineers actively participate in industry associations, standards bodies and obtain key certifications in order to recommend the right solution to meet your needs.

Associations and Committee Memberships

- Telecommunications Industry Association (TIA)
- International Organization for Standardization (ISO)
- Institute of Electrical & Electronics Engineers (IEEE)
- ONVIF
- Building Industry Consulting Services International (BICSI)
- Security Industry Association (SIA)
- Control Systems Integrators Association (CSIA)
- Association for Passive Optical LAN (APOLAN)
- InfoComm International
- Sports Video Group (SVG)
- National Electrical Manufacturers Association (NEMA)

- National Association of Electrical Distributors (NAED)
- Edison Electric Institute (EEI)
- National Rural Electric Cooperative Association (NRECA)
- American Public Power Association (APPA)

Technical Certifications

- ASIS CPP (Certified Protection Professional)
- More than 90 Registered BICSI RCDDs (Registered Communications Distribution Designer)
- PSPs (Physical Security Professional Certification)
- CCNAs (Cisco Certified Network Associate)
- BICSI DCDC (Data Center Design Consultant)
- DC Professional DCP (Data Center Practitioner)
- DC Professional DCS (Data Center Specialist)
- ASIS PSP (Physical Security Professional)
- ALOA CRL (Certified Registered Locksmith)
- BICSI NTS (Network Technology Systems)
- InfoComm CTS (Certified Technology Specialist)
- iBwave Level 1 & 2 Design

Anixter University

Anixter University™ is the educational initiative of Anixter. Courses are tailored to suit our customers' learning requirements, and feature a comprehensive array of technical and standards-based information delivered in a straightforward, unbiased way.

Learn more at **anixter.com/technology**

The Anixter Infrastructure Solutions Lab℠

Anixter's Infrastructure Solutions Lab℠ is at the center of a worldwide collection of labs that research, test and evaluate products to help customers meet their application challenges. This world-class research and educational center encompasses more than 4,000 square feet where Anixter's technical experts push the boundaries of technology, products and solutions.

Our mission for the Lab is simple – educate, demonstrate and evaluate.

- Educate customers on the latest industry standards and technologies
- Demonstrate the latest infrastructure and security product solutions available from our manufacturer partners

- Evaluate our network infrastructure and security solutions to make sure that our customers are selecting the right products for their specific needs

We are continually testing products in The Lab to establish that:

- Quality products are recommended and delivered to our customers
- Performance across product lines and within systems is consistent
- Products and systems recommended to customers can be integrated and follow the trend toward convergence.

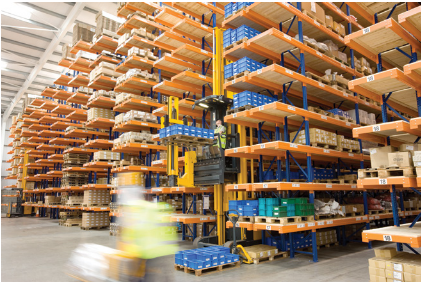
Register for a Lab visit or take a video tour: **anixter.com/lab**

Supply Chain Solutions

The foundation of an efficient deployment is having a fundamental distribution network that leverages an extensive product inventory with coordinated deliveries. Fundamental distribution services should include:

- The ability to view and allocate inventory in any warehouse in a global network
- A significant investment in a diverse breadth of inventory
- IT systems that provide customers real-time information
- Predictable (e.g., next-day ground service) delivery times to help plan even the most complicated of projects
- Product selection and specification assistance
- Packaging and configuration of products to streamline installation.

Anixter takes fundamental distribution a step further by applying supply chain best practices to assist with the realities of technology deployments.



Deployment Services

Any activities that take your focus away from installation and implementation for your customer introduces risk for your business and can have an impact on overall project success.

Anixter's Supply Chain Solutions help simplify and address the material management challenges at the job site(s).

Supply Chain Solutions from Anixter can:

- Simplify on-site storage requirements
- Improve speed of deployment
- Reduce damaged, lost or stolen materials at the job site
- Reduce packaging waste at the construction site
- Minimize will calls, go backs and setup time
- Increase productivity
- Decrease total cost of deployment.

TECHNOLOGY ALLIANCE PARTNERS

From enterprise data centers to security infrastructure to in-building wireless and beyond, Anixter recommends and provides solutions that connect the world's most important information. Delivered directly and through partners, these solutions help today's data-intensive organizations operate more efficiently and maximize the business value of their infrastructures. As a provider of leading-edge solutions, Anixter recognizes the benefits that a joint technology partnership can bring to its customers. That's why Anixter has created the Technology Alliance Partner program with the mission of building long-term partnerships that enable us to deliver comprehensive and proven best-of-breed technology solutions.

Learn more about our Technology Alliance Partner program at anixter.com/techalliance.

Association and Committee Memberships

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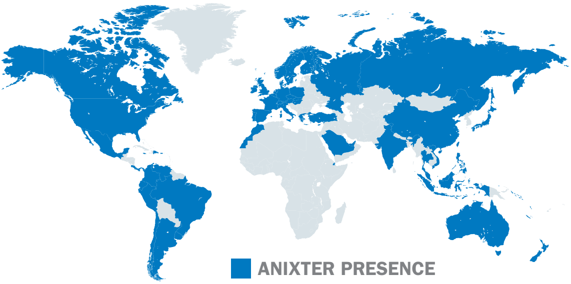

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