Chapter 10: Twisted-Pair Cabling Standards and Performance Requirements

As is the case for the other aspects of data communications, cabling standards are important in order to foster a competitive market for products that do what they are supposed to do. Cabling standards also give test equipment vendors the basis on which to build test products.

Twisted-pair cabling is the most frequently used Ethernet LAN medium. This chapter focuses on twisted-pair cabling requirements and the tests that you must perform to check whether your cable conforms to these requirements. Tests for fiber optic cable are discussed briefly at the end of the chapter.

Cable testing equipment, which is an essential part of a LAN technician's arsenal, can check out the performance parameters that are described in this chapter.

Cabling Standards Bodies

The body that rules United States cabling standards is the Telecommunications Industry Association (TIA) whose parent organization is the Electronic Industries Alliance (EIA). Cabling requirements are described in the *TIA/EIA-568A Commercial Building Telecommunications Cabling Standard,* first published in 1991. This standard has been updated on a regular basis.

A Canadian equivalent of this U.S. standard is called *CSA T529*. The ISO/IEC 11801 standards are followed in Europe and in many other parts of the world. These standards are based partly on TIA/EIA specifications and partly on standards that reflect special European conditions.

A number of organizations influence cabling standards, including the IEEE 803 committee, the ATM Forum, and the Comite Europeen de Normalisation Electrotechnique (CENELEC), among others.

TIA/EIA Categories

The focal point of the standards activity is to define various categories of cabling that are matched to the needs of different applications. A *category number* is a standard rating that is applied to an entire cabling system, which in addition to cable runs, includes outlets, patch cords, panels, connectors, and cross-connect blocks. Rating and testing all of the components of a system makes a lot more sense than focusing only on the cable.

Note - ISO/IEC and CENELEC use some terminology that differs from the TIA/EIA language. As with TIA/EIA, connectors and cables are rated by category number. However, ISO/IEC and CENELEC use alphabetical c*lass values* to grade link performance. Class C corresponds to TIA/EIA Category 3 performance, Class D to Category 5, Class E to Category 6, and Class F to Category 7.

Engineers keep reaching for higher capacities for twisted-pair systems, and recently there has been a flurry of work on new cable categories. At the time of writing, seven categories of twisted-pair cable exist, numbered 1, 2, 3, 4, 5, 5E, and 6; discussion of a Category 7 standard already has started as well. A higher number corresponds to better quality cable. The current installed base consists almost entirely of Category 5, 5E, and 3 cable.

Each category above 1 specifies a guaranteed bandwidth measured in megahertz (MHz) that a cable must be capable of transmitting in a dependable manner. (The cable may, in fact, support a higher bandwidth.)

No simple formula maps bandwidth, which is measured as a range of frequencies, into bits per second. Again and again, a clever new transmission technology has raised the number of bits per second that could be sent across a cable with a specified bandwidth.

Note - It is important to think of a category as a standard that you test for, not just as a set of products that you buy. A botched installation can turn the best cable and components into worthless junk. It doesn't take much to botch it—loosening the twists on a cable when adding a connector, pulling the cable with too much force (more than 25 pounds), positioning the cable close to a source of interference such as electric power cables or fluorescent lights, creating too sharp a bend, twisting the cable, or causing a kink.

An entire cable plant must be certified by testing *after* it is installed.

- Category 1 sometimes is referred to as "barbed wire," so you should not expect much from it.
- Category 2 is an improved version that primarily carries digital voice and connects to digital PBX switches.
- Category 3 cable is used in many 10BASE-T LANs. It is made up of two or more pairs of copper wires with each wire wrapped in insulation.
- Category 4 is similar to Category 3, but the quality of the cable and components is somewhat better.
- Category 5 cable is a popular data grade. The quality of the cable and components is better than that of Category 4, and the wires are more tightly wound. Although 100Mbps and Gigabit Ethernet can run on Category 5 UTP cable, problems arise if the entire cable system is not of sufficiently high quality.
- Category 5E was introduced to define the tests that assure that a cable system is capable of supporting Gigabit Ethernet. Some existing Category 5 cable plants have been reclassified as Category 5E after testing.
- At the time of writing, the Category 6 standard still had draft status. However, vendors already sell cables, components, and testers that meet the current draft specifications. Category 6 cable must support a bandwidth of up to 250MHz across 100 meters. It was designed with backward

compatibility in mind, so a RJ-45 style connector still is used. Although the components are compatible with Category 5, they must pass tests that require a higher level of quality.

- Category 7, which is aimed at very high transmission capacities, is expected to be a big departure from the other cabling standards. Each twisted–pair segment is shielded, and the cable as a whole also is wrapped in shielding. This cable would be stiff and heavy, and it might turn out to be more costly than optical fiber. Optical fiber can carry far more information than even the best twisted–pair cable.

Note - Most of the copper cable that is sold today is Category 5 or better. Vendors already offer cable that exceeds the performance levels that are targets for Category 6.

While some organizations are moving quickly to install high-performance cable, quite a few sites continue to use Category 3 or thin coaxial cable for their LANs. There still is a small market for Category 3 cable.

The characteristics of each category are summarized briefly in Table 10.1.

Table 10.1 UTP Categories

Category	Bandwidth	Description
1	—	Meets the minimum requirements for plain old telephone service (POTS).
2	—	Sometimes is used for digital PBX or ISDN connections.
3	16MHz	Meets the requirements of 10BASE-T Ethernet, 4Mbps Token Ring, and 100BASE-T4 (as well as voice).
4	20MHz	Meets the requirements of 10BASE-T Ethernet and 16Mbps Token Ring.
5	100MHz	Meets the requirements of 100Mbps Ethernet and, if it passes certification tests, 1000Mbps Ethernet. Also used for CDDI (FDDI over copper).
5E	100MHz	Meets the requirements of 100Mbps and 1000Mbps Ethernet. Category 5E stands for Enhanced Category 5. The cable has passed specified performance tests, and the RJ-45 connector components have been tested and matched to the requirements of high-speed transmission.
6	250MHz	Currently a draft standard, aimed at 1000Mbps and above. The cable must pass more tests than Category 5E. The RJ-45 connector form is used, but the components satisfy extra performance requirements. Components must be carefully matched.
7	600MHz to 1200MHz	Currently a draft standard, aimed at 1000Mbps and above. Shielded screened twisted-pair cable is used. Each pair is individually shielded. A new connector form is used.

Wire Features

The wire used for a long run of twisted-pair cable is a solid copper cylinder. For Category 1-5E, 100-ohm wire is used. Another feature of the wire is that its diameter is standardized. However, the diameter is reported indirectly, using an inverted measurement called the *American Wire Gauge* (AWG). The AWG value is the inverse of the thickness (in inches) of a wire. For example, the diameter of 24-AWG wire is 1/24 inch. Note that thicker wire has a smaller AWG value.

Category 1-5E LAN cable is predominantly 24 AWG (although 22 AWG was specified as acceptable in the standards). A bigger diameter (such as 23 AWG) might be used for Category 6.

Patch cords, which are used in work areas and wiring closets, need to be flexible. The wire in a patch cord is made up of many thin strands, which makes it far easier to bend. A solid wire cable does not bend easily, fatigues when it is bent, and can be damaged by a bend with too tight a radius.

Cabling Layouts

A typical cabling layout was described in Chapter 6, "The Ethernet 10Mbps Physical Layer." This layout, which conforms to ANSI/TIA/EIA 568-A, specifies a total of 10 meters for equipment cords and patch cords, and a 90-meter cable run between the office telecommunications outlet and cross-connect panels in the wiring closet. An additional detail was added in Chapter 9, "Gigabit Ethernet Physical Layer." A horizontal run can include a *transition point*, which is a location where flat undercarpet cabling connects to round cabling. (See Figure 9.6.)

There are a couple of other cabling layout options (which are specified in ANSI/TIA/EIA TSB 75). One incorporates a *multiuser telecommunications outlet* (MUTO). Up to 24 work area cables (each as long as 20 meters) can run directly from office equipment to a MUTO. The MUTO must be within 70 meters of the wiring closet. Because the MUTO replaces a work area jack, it does not add a connection point to the cable path. However, it often is used to gather pairs together into a 25-pair cable (which should not be done with Gigabit Ethernet).

The other option, called a *consolidation point*, introduces an extra connector into the horizontal run. The horizontal cabling that leads from the telecom outlet to the wiring closet consists of two sections that meet at the consolidation point. The maximum combined length of the two horizontal cable sections is 90 meters.

Up to 24 horizontal cables can meet at a consolidation point. (To compensate for the extra connector, the work area cable must be restricted to a maximum length of 3 meters.) Because this arrangement adds an extra connection point, it can cause problems if used with Gigabit Ethernet connections.

Unshielded Twisted-Pair Cabling Performance Parameters

Cabling performance parameters are not mysterious. They are symptoms that enable you to track down flaws that can distort and ruin the signal on twisted-pair cable. For example:

- The signal might be getting too faint as it traverses the cable.
- The copper wires in a pair might not be twisted tightly all along the cable. This prevents the positive and negative signals in a pair from balancing out and creates an electromagnetic field. This electromagnetic field induces false signals on neighboring cables and may corrupt data transmission.

- Flaws in the cable structure might be causing part of the signal to be reflected back to the source, resulting in problems there.

Expressing performance characteristics as measurable quantities makes it possible to set cable quality standards and use cable-testing equipment to detect faults.

Parameters for All Ethernet LANs

Some basic TIA/EIA test requirements must be satisfied for all twisted-pair cables used for Ethernet LANs. These basic requirements set acceptable levels for the following:

- **Attenuation—**The proportion of power that is lost as a signal traverses a cable. Attenuation is measured in decibels (dB).

- **Near end crosstalk (NEXT)—**The distortion of a weak incoming signal by a strong outgoing signal on a neighboring wire pair. NEXT is measured in decibels.

- **Impedance—**A measure of the opposition to the flow of electricity down the wire. Irregularities in the impedance of a cable, or interconnecting two cables that have different impedance ratings, causes part of an out-going signal to be reflected back. Impedance is measured in ohms.

A checkup on the health of a cable plant also includes *wiremap testing*. This procedure checks the following for every conductor in a cable:

- Proper pin termination at each end

- Continuity to the remote end

- Crossed pairs or reversed pairs

- Shorts between two or more conductors

- Split pairs (that is, the wires of two different pairs are cross-connected)

The 802.3 specification defines some further wiring constraints needed to assure that Ethernet will function correctly. It specifies maximum values for the following:

- Cable length

- Jitter (that is, variation in the interval between signal transitions)

- Propagation delay

Parameters for High-Speed LANs

Not surprisingly, more stringent requirements must be applied to cable that is used to carry data at gigabit speeds.

Also, a new factor arises for 1000BASE-T Ethernet. 1000BASE-T transmission occurs simultaneously across four twisted pairs. The fact that data is being transmitted at high frequencies across four neighboring wire pairs instead of two creates the potential for severe crosstalk problems.

This led to the establishment of a slew of new parameter definitions and tests. The parameters include

- Far end crosstalk (FEXT)
- Equal level far end crosstalk (ELFEXT)
- Power sum near end crosstalk (PSNEXT)
- Worst pair-to-pair ELFEXT
- Power sum ELFEXT
- Attenuation to crosstalk ratio (ACR)
- Delay skew
- Return loss

Note - Category 5 cable is qualified for use at high speeds by testing that the values of these parameters lie within specified bounds. Currently, the same set of parameters is used to qualify Category 6 cable, but the quality requirements are more stringent.

Parameter Descriptions

Both basic and high-speed performance parameters are described in deeper detail in the sections that follow.

Jitter

At each transmission speed, there is a fixed time interval during which a bit is transmitted. A bit is represented as a variation in the signal sent across a cable—for example, by changing a voltage from high to low or from low to high.

Jitter is a deviation in the periodic interval at which signal transitions occur. Transmission standards set limits on jitter. For example, when tested, a 10BASE-T cable should not exhibit more than 5 nanoseconds of jitter.

Attenuation and Decibels

Attenuation measures the amount of power loss of the electrical signal when it travels through a cable. It is calculated in logarithmic units called decibels (dB). The formula is shown here:

Attenuation = 10 $\log^{10}$(Power-out/Power-in) dB

Note that if the far end power (the power-out) is 1/10 of the original power (the power-in), the attenuation is

$$10 \log_{10}(1/10) = 10 \log_{10}(10^{-1}) = 10\ (-1) = -10\text{dB}$$

If the far end power is 1/100 of the power-in, the attenuation is

$$10 \log_{10}(1/100) = 10 \log_{10}(10^{-2}) = 10\ (-2) = -20\text{dB}$$

The farther a signal travels, the more it attenuates. Thus, attenuation depends on the cable length. Standards documents handle this by stating the value for a specific length (such as per kilometer).

Because the power-out at the far end always is less than the power-in, the attenuation always is negative. The minus sign often is omitted in documents that set attenuation levels. For example, in the statement "Standard 568-A limits attenuation in a Category 5 system to 24dB for a 100MHz signal," it is understood that the measurement actually is –24dB. Note that this means that smaller measurements are good news—they indicate less attenuation.

The attenuation across a cable actually is different at each frequency level. Higher frequencies experience more attenuation.

Note - Temperature and cable diameter also have an effect on attenuation. Attenuation increases as the temperature goes up. Enlarging the diameter of a cable decreases attenuation. This is the reason that a bigger diameter than 24 AWG might be used for Category 6 cable.

Near End Crosstalk

A strong signal transmitted from a station can distort a weak data signal arriving at the station on an adjacent pair of wires. This happens because current flowing through a wire creates an electromagnetic field that induces signals on adjacent wires.

The amount of distortion is measured in decibels and is called the near end crosstalk (NEXT). More precisely, the near end crosstalk is the amount of energy transferred to a weak incoming signal from a strong outgoing signal on an adjacent wire. This amount increases as the frequency level of the transmission increases.

Recall that the same signal is sent across both of the wires in a pair, but with reverse polarity. Twisting the wires tightly causes the two electromagnetic fields to cancel one another. A strong NEXT effect is a symptom that the wires are not twisted properly.

Measuring NEXT

The effect of crosstalk is measured by transmitting a specified signal level on a transmit pair. The near end crosstalk is the proportion of that signal that is transferred to the local receive pair. Figure 10.1 illustrates NEXT. In the figure, a strong outgoing signal induces a NEXT signal on a neighboring pair that could badly distort the weak incoming signal.

Figure 10.1
A strong outgoing signal inducing NEXT on a neighboring pair.

NEXT is measured in decibels. You want the NEXT measurement to be small—a small proportion translates to a large negative dB value. As was the case for attenuation, the negative sign commonly is dropped in documentation. For example, the statement "The amount of NEXT between pairs in a four-pair cable should be at least 60dB for a 10MHz link" means that it should be –60dB or less.

NEXT levels are improved by using wire pairs that have been tightly twisted. A certain amount of untwisting is bound to happen near a terminating plug. It is important to make sure that the wires are not untwisted for more than 1/2 inch from the termination point. The use of high-grade plugs and jacks also helps. NEXT is affected by the frequency of the signal and increases as the frequency increases.

Some of the vendors that manufacture high-performance cables conforming to Category 6 performance levels isolate the four pairs from one another using separators called *splines*. Figure 10.2 illustrates one implementation of splines in a sheath containing four twisted pairs. These splines maintain interpair spacing, even when the cable is bent more sharply than it should be. The use of splines reduces near end crosstalk, attenuation, and far end crosstalk.

Figure 10.2
Separating twisted pairs within a four-pair cable.

Far End Crosstalk

Far end crosstalk (FEXT) is the amount of energy transferred to an outgoing signal by an incoming signal on an adjacent wire. Maintaining tight twists and using good connectors at the receive end prevents the FEXT level from getting out of bounds.

Figure 10.3 illustrates FEXT. In the figure, the incoming signal has been attenuated by its trip along the cable, but it still might be capable of inducing noise on an adjacent cable.

Figure 10.3
A weak incoming signal inducing FEXT on a neighboring pair.

Measuring FEXT and Computing ELFEXT

Like NEXT, FEXT is measured by transmitting a specified signal level on a transmit pair. The proportion of the signal that is transferred to the transmit pair at the far end then is measured in decibels.

However, this measurement must be adjusted to make it meaningful. The strength of a signal decreases due to attenuation as the signal travels down a length of cable. Thus, the FEXT value depends on the length of the cable and the amount of attenuation.

FEXT is turned into a meaningful measurement by subtracting the attenuation. The result is called the *equal level far end crosstalk* (ELFEXT):

ELFEXT = FEXT – attenuation

ELFEXT is independent of length and measures a characteristic of a cable product.

PSNEXT, PSELFEXT, and Worst Pair-to-Pair ELFEXT

Four-pair cables are used for 100-BASE-T4 and 1000BASE-T transmission. Every pair causes crosstalk on the three other neighboring pairs. Thus, for pairs A, B, C, and D, the following is true:

- B, C, and D cause near and far end crosstalk on A.
- A, C, and D cause near and far end crosstalk on B.
- A, B, and D cause near and far end crosstalk on C.
- A, B, and C cause near and far end crosstalk on D.

This adds up to a long list of 24 crosstalk measurements. Some combined measurements have been defined to pare the list into a smaller set of numbers that can be used to evaluate a cable:

- Power sum near end crosstalk (PSNEXT)
- Power sum equal level far end crosstalk (PSELFEXT)
- Worst pair-to-pair equal level far end crosstalk

The *power sum near end crosstalk* (PSNEXT) is the sum of the NEXT effects on a pair by the other three pairs. For example, the PSNEXT for pair A is the sum of the near end crosstalk values caused by B, C, and D. There is a separate PSNEXT value for each of the four pairs.

Similarly, there is a separate *power sum equal level far end crosstalk* (PSELFEXT) value for each of the four pairs. The PSELFEXT is the sum of the equal level far end crosstalk (ELFEXT) effects on a pair by the other three pairs. For example, the PSELFEXT for pair A is the sum of the equal level far end crosstalk values caused by B, C, and D.

Finally, the *worst pair-to-pair equal level far end crosstalk* is the biggest ELFEXT effect of one pair on another.

Attenuation to Crosstalk Ratio

The *attenuation to crosstalk ratio* (ACR) is a measurement of the signal to noise ratio at the receive end of a pair. This measurement is expressed in decibels. If the signal is stronger than the noise, the ACR is positive. Bigger ACR values correspond to better signals.

The ACR measurement actually is equivalent to the ELFEXT and can be converted into an ELFEXT value.

Structural Return Loss and Return Loss

If a wire's structure is not uniform, its impedance varies along its length. Changes in impedance cause a signal sent down the wire to lose strength because part of the signal is reflected back to its origin. *Structural return loss* (SRL) is a measure of this loss, expressed in decibels.

Return loss is a measure of the relative amount of a signal that is reflected back to its source. It is related to the uniformity of a cable relative to a given target value for its impedance—100 ohms, in the case of twisted–pair cabling.

Propagation Delay and Time Domain Reflectometry

Recall that the *propagation delay* is the amount of time that it takes a signal to travel from one end of a wire to the other end. Obviously, this depends on the length of the wire and the speed at which electrons travel through the wire.

The propagation delay for a particular type of cable can be computed from a rating called the *nominal velocity of propagation* (NVP). The NVP is the transmission speed along a wire relative to the speed of light in a vacuum. It is expressed as a percentage of the speed of light.

Having a standardized and pretested NVP for a cable enables a network technician to locate a cable fault using a *Time Domain Reflectometry* (TDR) test device. Before testing a cable, the user enters the cable's rated NVP into the device. On command, the test device emits a signal. If there is a fault such as an open cable, short circuit, or bad connection, all or part of the signal pulse will be reflected back.

The test device can estimate the distance to the fault based on the velocity of the signal and the amount of time that elapses between sending the pulse and receiving the reflected signal. TDR tools exist for both coax and twisted-pair cable.

Delay Skew

1000BASE-TX transmits signals across four pairs concurrently. The multiple incoming signals must be synchronized so that they can be recombined into the original signal. A receiver can cope with slight variations in delay, but if too large a difference exists between the propagation times of the pairs, communication will fail.

The *delay skew* is the difference between the propagation delays of the slowest and fastest pairs.

Managing Twisted–Pair Cabling

Changing from coaxial cable to twisted-pair cable did more than rationalize the cabling layout of Ethernet LANs. It improved LAN reliability, availability, and manageability.

A coax bus is vulnerable to cable or connector flaws that can shut down or degrade the performance of the entire LAN. These flaws have always been hard to track down.

Faults still happen in twisted-pair LANs, but the effect of a fault is limited. A cable failure between a hub or switch port and a station affects only that station. Link integrity tests detect a cable failure very quickly. Using an SNMP management station or checking LED lights can pinpoint a trouble spot.

A fault on a link between hubs or bridges temporarily can segment the LAN into two pieces, but each part still can continue to function on its own.

Test Tools

A cable test tool is the LAN technician's best friend. There are basically two types of test tools:

- Continuity/cable testers
- Certification tools

Bulky test devices once were the norm, but now handheld equipment that meets high-quality standards is available.

Continuity/Cable Tester

Called a continuity tester by some vendors and a cable tester by others, these devices offer a helping hand to a someone who is installing a cable in an office or trying to track down a cable fault. The device

- Calculates the total cable length from the office to the hub or switch in the wiring closet
- Performs wiremap tests to verify continuity to the remote end; to check for crossed, reversed, or split pairs; and to make sure that there are no shorts
- Performs TDR tests

Many test products include the components needed to perform a *tone test*. To do this, a *tone test set* is attached to one end of a cable and generates a tone that is transmitted onto a wire. When a separate piece of equipment called a *probe* is placed near a bundle of wires, it can detect which wire in the bundle carries the tone.

Tone test equipment makes it possible to match one end of a cable located in an office to the other end in a wiring closet. It is a valuable tool for installations, for moves and changes, and for tracing faulty wires.

Certification Tool

A certification tool is a high-end tester that can determine whether installed cables meet TIA Category 5, 5E, or proposed Category 6 or 7 requirements. The tool checks the performance parameters automatically.

A product usually also includes the capabilities of a continuity/cable tester as well as optional kits, such as fiber optic test components.

Note - Certification tools differ in their level of accuracy. In fact, standards have been set for the accuracy of their measurements.

The least accurate devices are rated as Level I testers. Level II testers attain a higher degree of accuracy.

Level II-E testers also can calculate quantities such as PSNEXT and ELFEXT needed to qualify Category 5E cables, and Level III testers can check out Category 6 cables.

The Scope of a Test

There are two scopes for tests: *channel* or *permanent link* (also called a *basic link*). These are illustrated in the upper part of Figure 10.4:

- A channel includes all of the cabling system components between a station and a hub or a switch in a wiring closet. It includes up to 90 meters of horizontal cabling, a work area patch cord plugged into an outlet, and cross-connects or interconnects in the wiring closet.
- A permanent link excludes the patch cords. It includes the horizontal cabling and the connectors at each end of the horizontal cabling.

Note - The horizontal cabling portion might include a transition point or a consolidation point.

The lower part of Figure 10.4 shows the components that are included in a channel test. The systems at the ends of the channel have been replaced with test equipment.

Figure 10.4
Testing a channel or a permanent link.

Testing Fiber Optic Cable

An understanding of fiber optic cable testing requires more background information than can be included in this book. This section provides a brief discussion of a few of the factors that are involved in testing fiber optic cable.

First of all, there is one boon. Crosstalk, a worrisome problem for twisted-pair media, does not occur for fiber optic media.

Some of the items that must be tested for fiber optic media include:

- **Source optical power—**If the source power is inadequate, information transfer could be error prone or could fail.
- **Signal attenuation—**Most attenuation is caused by scattering of light due to bouncing off the cladding or bouncing off atoms in the glass. Some attenuation is caused by absorption of light by dopants added to the glass. (A dopant is an impurity intentionally added to an optical medium to change its optical properties.) The light then is converted to heat.
- **Wavelength measurement—**Data must be transmitted using specified wavelengths. Less scattering occurs for long wavelengths, so greater cable lengths can be supported with long wavelengths.
- **Cable continuity—**The light used to transmit data is invisible. A cable continuity check is carried out by shining a harmless visible light onto the fiber. This makes bends and breaks visible if the sheath has torn.

Note - A user should not look into a fiber optic cable while a laser is actively transmitting. Laser energy is high, and exposure to a laser beam can cause blindness.

Cable faults can be located using an optical time-domain reflectometer (OTDR). An OTDR also can measure the amount of light that is being scattered back to the source. However, OTDRs are costly and usually are used only for long- distance single-mode fiber links. A simplified product called a *fault finder* can be used for LANs.

Summary Points

- U.S. cabling standards are published by the Telecommunications Industry Association (TIA) and the Electronic Industries Association (EIA). ISO/IEC standards are used in other parts of the world.
- A category number is a standard rating that is applied to an entire cabling system, which in addition to cable runs, includes outlets, patch cords, panels, connectors, and cross-connect blocks.
- There are seven currently defined categories of unshielded twisted-pair cable, numbered 1, 2, 3, 4, 5, 5E, and 6. A higher number corresponds to better-quality cable.
- Most of the installed base of cable is Category 5 or Category 3. Category 5E and 6 are appropriate for gigabit speeds.
- An American Wire Gauge (AWG) value is the inverse of the thickness (in inches) of a wire. Category 1-5E LAN cable is predominantly 24 AWG.

- All data cable must be tested for impedance, attenuation, and near end crosstalk (NEXT). High-speed LAN cable is checked for equal level far end crosstalk (ELFEXT), power sum near end crosstalk (PSNEXT), worst pair-to-pair ELFEXT, delay skew, and return loss.
- Wiremap testing checks pin termination, continuity, crossed or reverse pairs, shorts, and split pairs.
- A Time Domain Reflectometry test device is used to locate cable faults.
- A continuity and cable tester can calculate cable length, perform wiremap tests, and perform TDR tests. The product usually includes tone test equipment.
- A certification tool is a high-end tester that can determine whether installed cables meet TIA Category 5, 5E, or proposed Category 6 or 7 requirements.
- Fiber optic cable measurements include source optical power, signal attenuation, wavelength measurement, and cable continuity.

References

Copper and fiber cabling performance guidelines are specified in ANSI/TIA/EIA-568, "Commercial Building Telecommunications Cabling Standard," 2000.

Guidelines for field testing Category 3, 4, and 5 UTP cabling can be found in TIA/EIA Technical Service Bulletin 67 (TSB-67), "Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems," 1995.

Return loss and ELFEXT link performance parameters are specified in TIA/EIA-TSB-95, "Additional Transmission Performance Guidelines for 4-Pair 100 Ohm Category 5 Cabling," 1999.

Other documents that may be of interest include

- TIA/EIA-569. "Commercial Building Standard for Telecommunications Pathways and Spaces." 1998.
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