



Got Datacom Questions? ASK BO!

Bo Conrad knows the difference between theory and practice. He has been an integral contributor for TIA/EIA international datacomm standards committees and a VDV design consultant for Intel and Hewlett-Packard. He will answer your questions here in future issues of POWER OUTLET— e-mail questions to poweroutlet@rexelusa.com.

By D.A. “Bo” Conrad

Alphabet Soup – MHz, Mbps

Question

Please clear up my confusion about the difference between megaHertz (MHz) and megabits per second (MBPS).

The name of the cabling game is bandwidth! By definition, (optical) bandwidth is “a measure of the information carrying capacity” of a cabling system – the established performance criteria.

Bandwidth is a frequency domain measured in Hertz (Hz), or the number of cycles per second (CPS) of an analog or sinusoidal (sine) wave. Therefore, 1 KHz (one kilohertz) = 1,000 Hz or 1,000 CPS. And 1 MHz (one megaHertz) = 1,000,000 Hz, or 1 million CPS. And so it follows that 1GHz (one gigahertz) = 1,000,000,000 cycles per second, or 1 billion CPS.

Please remember that the rating and testing of a cabling system is measured in Hz! Cat 3 UTP is factory-rated to 16 MHz. Cat 5E and Cat 6 are rated to 100 MHz, with a maximum horizontal “basic or permanent link” distance of 90 meters or 295 feet.

UTP field testers perform attenuation and crosstalk measurements across multiple sweep frequencies from 1KHz to the maximum rating of the cable (for example, Cat 5E at 100 MHz).

Multi-mode fiber optics is factory-rated from a minimum 160

MHz/km to 500 MHz/km (1 km = one kilometer, or 3,281 feet), depending on the two operating wavelengths of 850 nm or 1300 nm. Single-mode fiber has theoretical unlimited bandwidth capability, as a direct function of the laser light source. The bandwidth (or its “rating”) is dependent on optical glass quality and varies

Here’s where some confusion may come into the picture: *Network applications are digital pulses or square waves measured in bits per second (bps)*. 64 kbps is 64,000 bps. 1 Mbps is 1 million bps. As you may know, the most common LAN application is Ethernet. You can translate 100BaseTX or 100BaseFX into 100 Mbps. Notice there is no mention of MHz or GHz.

Bandwidth is analogous to the *RPM of your racing car engine* (MHz) and LAN application speeds (Mbps) and the *output of your wheels*. If your tachometer reads 3,000 RPM, does this mean you are going 3,000 mph? Of course not!

Network performance is the same. The UTP Cat 5E cabling has a bandwidth rating of 100 MHz, yet achieves 1 Gbnet or 1 billion bits per second. How is this achieved? The “transmission” of the racing car or the network’s digital electronics encoding scheme sophistication determines how fast the car can go (Mbps). A “higher-performance” car or cabling rating allows Layer One, Two, and Three devices (see next question) to achieve higher digital data stream speeds.

And, like racing cars, networks are getting much faster!

No matter how professional the installation looks, it has to be able to support the network for which it was designed. Be aware that most customers – and unfortunately, many of their consultants who design and write the specifications – will not have the foggiest idea what you’re talking about.

However, you should be aware

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inversely with fiber length. A long fiber will have less bandwidth available for use than a shorter fiber per MHz/km. Field-testing fiber bandwidth is not a standard practice.

of the necessary steps to ensure that your Acceptance Test follows Acceptance Test Procedures to meet this goal.

What's An Ethernet Layer?

Question

My customer's information technology (IT) department keeps asking me if the cabling we installed will support Ethernet Layer One, Two, and Three devices on their network. What are they talking about? Why is it important to have a cabling system tested to be in "compliance" to the network's requirements?

First, realize that most IT network managers have no real concept of cabling. Their misperception is that Category 5 (Cat 5) is the universal standard, and fiber is too expensive.

However, many are beginning to realize the importance of having a properly designed and installed structured cabling system. Their concern is that when they plug in and hook up the network devices and the PCs, they will work without experiencing downtime – since 60-70% of the downtime is related to cabling! *This is your opportunity to educate your customer on the pros and cons of the different types of cabling media from Cat 3, 5, 5E and 6 through fiber.*

Alternatively, many cabling installers have little knowledge of networking. Once you have a firmer understanding of their network needs both – current and future – the proper cabling type choice solution can better come into focus.

However, the need for speed, or higher bandwidth requirements of these upper Layer devices that they are referring to, will most probably require the use of **both** fiber optics and Cat 5E or 6.

It is very important to know the prime objective or the desired local area network (LAN) application(s) when designing, installing, and testing a cabling installation. Let's start with a basic understanding of

networking terms. Remember, one purpose of standards is *interoperability* – the ability of different active and passive components, technologies (LANs, MANs, WANs, etc), and multiple manufacturers products to *work together*.

An organization – the International Standards Organization (ISO) – is the group that creates networking



standards that seek to achieve interoperability. Standards proposals are presented to ISO by worldwide members from the American National Standards Institute (ANSI) – representing the U.S. Other contributors

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are the International Electrotechnical Commission (IEC) for Europe, the CSA for Canada, and so forth.

You probably already have seen the ISO somewhere or other; because you've no doubt seen marketing material for one (or several) companies noting that they are "ISO 9000 Approved." This notes the company has in place an ISO-verified and -approved quality control system.

In 1984, the ISO established the Open Systems Interconnect (OSI)

model of networking. OSI is the foundation for the development of many networking communications standards. This model has seven-plus *zero-defined layers* for data communications. Goal of the ISO/OSI model is to match the capabilities of all components to ensure a reliable transmission. It takes into consideration:

- the strength and characteristics of the launched signal by the transmitter;
- the fidelity of the signal transmission through the fiber medium (the cabling plant); and
- the capability of the receiver to capture and decode the signal.

We will concentrate on just the first three layers and the related active equipment or hardware devices. Each layer serves a particular network function when sending a digital signal (for example, an e-mail).

Ethernet, as you may know, is the most commonly used LAN application. The standards committee for this LAN application is the Institute of Electrical and Electronic Engineers (IEEE); the Ethernet standard is designated IEEE 802.3X.

Layer One

Take a look at Table One. The bottom of this model, or Layer One (some will argue this is actually the "Zero" layer), is the "Transmission" layer. "Bits" of digital information are converted into a pattern of ones and zeros for transport across a medium. In networking application, *this* is where an active device such as a **hub** functions – it broadcasts a digital signal out to all those PCs (nodes) that are connected to it and the bandwidth is shared or equally divided.

Descriptions for Ethernet applications define the type and speed of the signal, plus the cabling medium. For example, "10BaseT" can be deconstructed as "10" for 10 Megabits per second (Mbps); "base" for a digital baseband signal; and "T" for Twisted-Pair.

However, this Layer One also includes all the passive components (requires no power to operate) in a structured cabling system – inclusive of unshielded twisted-pair (UTP) and an optical link segment. Most, if not all, voice-data-video (VDV) or

low-voltage manufacturers and contractors conduct business in this arena.

What standard is used for defining structured cabling? One in particular is ANSI/TIA/EIA 568B.3. EIA is the Electronics Industry Association; TIA is the Telecommunications Industry Association.

568B.3 defines an optical link *segment* as “. . . the cable, connectors, and splices (if present) between two optical fiber patch panels.” An optical fiber *link* is comprised of all multiple optical link segments inclusive of the backbone and horizontal cabling.

Traditionally, contractors installed and tested cabling systems to support only Layer One applications and related devices. The concentration was more on the horizontal cabling, with little regard to the devices connected to the backbone cabling.

So, at one time, the contractor’s job was: Install the cable and connectors, wall plates and patch panels; check for continuity – perhaps Cat 3 or 5 test parameters on UTP; hopefully document the installation and supply as-builts . . . and leave.

But not anymore.

With the customer’s “need for speed” (higher bandwidth) – along with lower attenuation or signal loss – we have seen an increase in the use of fiber optics. FO is being used not just by the service providers (outside plant or WAN /MAN applications), but into the building LAN’s backbone – and the horizontal, with fiber-to-the-desk (FTTD).

“Riser shafts” in high-rise buildings or “distribution” cabling in data centers and “co-los” (co-location facilities) are prime examples of networks with Layer One, Two, and Three active equipment and devices connected to the backbone.

What does this mean? Years ago, cabling/connector manufacturers recognized that the higher layers of the ISO/OSI Model of Networking and the related active equipment and hardware devices in

the backbone were driving the need for more speed. By establishing a firm foundation of products in the Layer One physical level, their products would be able to support a variety of applications and related networking devices – both at the workstation and in the backbone.

To better attract higher-end customers and develop product loyalty, they began offering 7-, then 10-, then 15-year – to lifetime – warranties! Note: Some may interpret this as proprietary, but it’s the name of the game!



Accurate testing had to follow this path.

What have VDV contractors been certifying for their customers these past years? It may have worked fine for older, lower-speed applications and Layer One devices. But will it handle the higher speed demands dictated from Layer Two and Three devices and equipment?

Layer Two

Layer Two of the ISO/OSI networking model is the “datalink” layer, which provides a reliable transfer of data (called “frames”) across the media (the cables). Other factors include physical addressing, network topology, error notification, and flow control.

An **Ethernet switch** is the most commonly used active equipment or device at this level. Instead of a broadcast shared signal like a Hub, it has a dedicated bandwidth path to each user that is connected to it.

Here are the most common

designations of an Ethernet switch: “10/100BaseTX” or “100BaseFX.” What this means: 10 megabits per second (Mbps) or “100” for 100 Mbps for the PC’s NIC cards; “base” for digital baseband signal; “T” on Twisted-Pair; and “F” on Fiber utilizing an “X” half-duplex signal.

Accordingly, a 100BaseTX application on UTP is tested to Cat 5 parameters. Fiber is tested by determining the attenuation or signal loss of the fiber link segment and is expressed in decibels (dB). A

100BaseFX device operating on 62.5/125um at 850 nm has a hefty budget loss of 11.0 dB at a maximum distance of 2,000 meters.

You probably have noticed that, in the Ethernet world, LAN application speeds – when comparing the horizontal to the backbone – jump by a factor of 10. For example, there have been 10 Mbps PCs (usually Pentium I and II) with 100 Mbps backbones. Today, 100 Mbps PCs (Pentium IIIs) are hooked up to 1,000 Mbps backbones. As you may know, 1,000 megabits is also called one **Gigabit** – one billion bits per second.

Bringing “Gignet” to the workstation (Pentium IVs) is helping drive the need for fiber in the horizontal or FTTD. A Gignet device is identified with a designation either 1000BaseT for UTP and 1000BaseSX and LX for fiber. The “S” designates the shorter and most price-desirable 850nm (nanometer) wavelength, and “L” stands for the longer 1300nm wavelength. Both operate on multimode fiber.

The UTP cable used to support 1000BaseT Gignet is Cat 5E – or the recently released Cat 6. These UTP testing parameters are found in the ANSI/TIA/EIA 568B.3 standard – which requires more detailed tests than Cat 5 for 100BaseTX.

This may be too technical, but reference ANSI/TIA/EIA 526-14A for testing multi-mode and 526-7A for single-mode fiber optics. *The attenuation or budget loss parameters tighten significantly* for Gignet, with a maximum budget loss of only 3.2db



at a maximum 220 meters or 7,218 feet on 62.5/125um 200 MHz/km multi-mode fiber, but 3.9 db at 550 meters or 18,046 ft. with 50/125um 500 MHz/km fibers using VCSEL light sources.

This is still significantly higher performance than UTP, and at comparable costs.

Layer Three

Layer Three of the ISO/OSI Model of Networking is the “Network” layer. It provides connectivity and the best path selection between the sending host and the receiving host.

In this level, segments sent from Layer Four are put into packets. The commonly used active equipment or device in Layer Three is an **Ethernet Router**. The driving force for higher speeds usually starts with Layer Three active equipment (routers) connected to the backbone and the MAN or WAN. By the way, MAN stands for Metropolitan Area Network, and WAN = Wide Area Network.

It takes another five to seven years of price migration (mostly related to the cost of the chips) down through Layer Two for a given piece of technology to finally become a price-competitive Layer One device to the workstation – the **network interface card (NIC)**. Albeit, the cabling and connectors in Layer One

must be able to support the desired application (usually Ethernet) and all related active equipment and devices in all three layers.

Whether it is a Layer Three router, a Layer Two switch, or a Layer One hub, the relative speeds are increasing! “Moore’s Law” states that we double the processing power of a chip every 18 months. If you take into consideration the networking technologies of tomorrow, these higher speed requirements will be applicable within the cable/connector manufacturer’s warranty timeframe.

Therefore, to best serve your customer, you had better ensure the cabling system is in “compliance” – but not only to ANSI/TIA/EIA 568B.3 and the cabling/connector manufacturer’s specifications. It also should comply with requirements of the customer’s network as dictated by IEEE 802.3X.

Thus, you can dispel the IT manager’s misperceptions by knowing the limitations of UTP and justifying the slightly added costs of incorporating fiber optics.

Listen carefully to your customer’s needs! Ensure that the structured cabling system that is designed, installed, tested and documented supports not only the customer’s desired LAN application for today and tomorrow, but all the associated Layer One, Two, and Three active equipment and devices.

Though Cat 5E and 6 satisfy today’s requirements in the horizontal, fiber must be considered in the backbone as well as the horizontal (or FTTD) to be “future-proof.”

Signal Transmission

Question

Please help me to understand the type of signal transmission.

Simplex means one-way-only, on one conductor or one fiber strand. It functions like a megaphone. A conventional simplex TX signal application is a video camera.

Half duplex means one-way both ways on two conductors or two fiber

strands. It functions like a two-way radio. TX transmit (“tip”) on one and RX receive (“ring”) on the other. Typical half-duplex signals applications are used in most fiber LAN Ethernets like 100BaseSX and LX and UTP Ethernets up to 100BaseTX, and phone lines.

Full duplex means TX and RX both ways *simultaneously* on one conductor or one fiber strand. This functions like a telephone conversation, and is also called multiplexing. Gigabit Ethernet (1000BaseT) requires splitting the signal along the *four pairs* with full duplex processing or multiplexing to achieve Gigabit transmission.

Fiber optics uses WDM wave divisional multiplexing and DWDM (Dense WDM) and is typically used by long distance carriers.

Acceptance Testing

Question

I have seen many references to “Acceptance Testing” in a number of articles and fiber optics technician textbooks. What is an “Acceptance Test?”

An Acceptance Test is performed to verify that the installed optical transmission link segment with all its passive components meets the established performance criteria for successful deployment of the network LAN application – whether it is for one or a combination of Layer One, Two, or Three related devices. This verification can be defined as an Acceptance Test.

By definition, a structured cabling (copper) system’s Acceptance Test is verifiable test documentation to determine if the transmission cable and components meet and/or is in compliance to an industry (or government) standard. The standard defines both: (1) the method of testing (or Acceptance Test Procedures); and (2) the “acceptable” range between minimum and/or maximum specifications.

Unfortunately, on the customer’s end, “unacceptable” testing generally isn’t realized

until their network system crashes.

Question

Would you please define the differences in the various fire-type terms used in fire stopping?

Fire Stopping Terms

“The fireman is standing in a fire zone with firewalls and the room is equipped with a fire alarm system. He/she is firestopping with fire stop around a fire shield containing plenum-rated cables penetrating a fireproof wall lined with fire-rated plywood coated with two coats of fire retardant paint to provide a fire resistant rating to meet city code. Give the tech a fiber break!”

Fire containment is an essential part of a professional cabling installer’s job. This includes installing the proper fire-rated cabling, firestop material applications, and the plywood in the closet.

I suggest taking a picture as documentation of your final firestop installation.

Let’s define the terms, as they each have distinct definitions. They also are typical questions you might find in taking your RCDD exam! Let’s make the fireman a volunteer, with his primary job serving as a professional VDV cabling technician.

A **fire zone** is a contained area completely enclosed by fire resistant walls, floors, and ceilings.

A **firewall** helps to prevent fire from spreading from one fire zone or area to another, and runs all the way from the structural floor to the structural ceiling (confusion may result from the fact that this term is also being used in computer and Internet security).

A **fire alarm system** provides a reasonable amount of safety by reducing the probability of injury or loss of life from fire, smoke, and heat in buildings by providing detection, suppression, and notification functions. (for example, sprinklers).

Firestopping is the actual *process* of installing specialty material(s)

into penetrations of fire-rated barriers to reestablish the integrity of the barrier. You cannot use the same construction material of the penetrated fire barrier or firewall (for example, mortar, cement, or “mud”) to obtain the same fire-rated integrity.

Firestop is the *material*, device, or assembly or parts used in an architectural barrier to prevent vertical or horizontal passage of flames, smoke, water, or gasses through the fire barrier. The two types are:

- “mechanical,” which consists of manufactured metal encased elastomeric components pre-sized to and shaped to fit around cable, pipes, conduit, and tubes; and
- “Non-mechanical,” which generally are pliable (for example, caulk, putty, sprays, etc.)

A **fire shield** is a material, device, or an assembly of parts used to prevent the propagation of flames from one cable system or pathway to an adjacent cable system or pathway – for example, between two cable trays.

Plenum-rated cable is usually (but not always) required by a locality’s municipal code for plenum-rated ceilings (air chambers) and raised-floor environments. The next lower fire rating is riser-rated, followed by general-rated; the lowest is, ironically, residential-rated. The National Electrical Code (NEC) allows a maximum 50 feet from the entry point of an outside-rated cable to be fire-rated inside the building (unless it is in rigid metallic conduit).

Penetration is further defined as “membrane” penetration through the outside surface of only one side of a fire-rated barrier (for example,

an electrical box); and “through” penetration penetrates both outside surfaces of a firewall (for example, conduit, cable tray, etc.)

Fireproof does not support the combustion of flames, even under accelerated conditions – including masonry, block, brick, concrete, and gypsum board. However, no material is entirely fireproof.

Fire-rated cable, doors, walls, or “materials” – including firestop itself – is based upon a fire resistance rating (see below).

Fire-retardant paint requires two coats over any telecommunications room’s plywood backboard. Check the local code, as water-based paint usually does not qualify.

Fire-resistant rating is the time in hours or fraction of hours that a material or assembly of materials will withstand the passage of flames and the transmission of heat when exposed to fire under specified conditions of test and performance criteria. For example, gypsum board’s fire-resistant rating is 30 minutes per 5/8ths-of-an-inch thickness.

City code or local code dictates over county, state, and federal codes (unless you are in a military base where they have their own set of codes). The local inspector’s responsibility is to be cognizant of these other codes – and, in particular, the NEC as adopted locally.

A **fire break** is not a 10-minute break for coffee, but a material, device, or assembly of parts installed in a cable system (but NOT at a cable penetration of a fire barrier or firewall but in-between) to prevent the spread of fire along a cable. ■

Table One. ISO Open Systems Interconnect Reference Model of Networking

Layer 7	Application	Network process to application	Data Stream – Software
Layer 6	Presentation	Data Representation	Data Stream – Software
Layer 5	Session	Inter-host communication	Data Stream – Software
Layer 4	Transport	End-to-end connections	Segments
Layer 3	Network	Addressing and best path	Packets – Routers
Layer 2	Datalink	Access to media	Frames – Switches
Layer 1	Network	Transmission	Bits – Hubs and cable and connectors