10 Gigabit Ethernet

Comparing Shielded and Unshielded Structured Cabling Systems For 10GBASE-T Applications

White Paper

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Introduction

The IEEE 802.3an-2006 standard for 10GBASE-T operation was ratified in June 2006. It defines an application standard for 10 Gb/s data transmission over copper twisted pair cabling of up to 100 meters reach, and allows use of both unshielded twisted pair (UTP) and shielded twisted pair (STP) copper cabling systems. This white paper compares the benefits of installing UTP or STP cabling systems for 10GBASE-T applications so users can choose the appropriate cabling investment for maximum long-term network performance.

IEEE 802.3an-2006 10GBASE-T Standard

UTP and STP cabling systems must meet the same fundamental parameters in order to support 10GBASE-T applications, including suppression of alien crosstalk (cable-to-cable coupling) and channel specifications up to 500 MHz. IEEE 802.3an-2006 addresses both Augmented Category 6 UTP, Category 6 STP, and Category 6 UTP cabling. Although the 10GBASE-T specification primarily addresses Augmented Category 6 cabling, it also includes provisions for installed Category 6. Traditionally, Category 6 cabling has been specified and tested up to 250 MHz, and will achieve 10 Gigabit Ethernet (10 GbE) compliance to the link distances listed in Table 1 (55 meters or 55-100 meters) only when the cabling meets internal channel specifications as well as alien crosstalk specifications up to 500 MHz as defined in TIA Technical Bulletin TSB-155. Typically a Category 6 solution only allows for 37 meters without mitigation, as specified in TSB-155.

Table 1. 10GBASE-T cabling types and distance (from IEEE 802.3an-2006 Table 55-12)

Cabling	Supported Link Segment Distances	Cabling References
Class E/Category 6, unscreened	55 to 100 m*	ISO/TEC TR-24750 / TIA/EIA TSB-155
Class E/Category 6, unscreened	55 m*	ISO/TEC TR-24750 / TIA/EIA TSB-155
Class E/Category 6, screened	100 m	ISO/TEC TR-24750 / TIA/EIA TSB-155
Class F, screened	100 m	ISO/TEC TR-24750
Class E_A / Augmented Category 6, unscreened	100 m	ISO/IEC 11801 Ed 2.1 / TIA/EIA-568-B.2-AD10

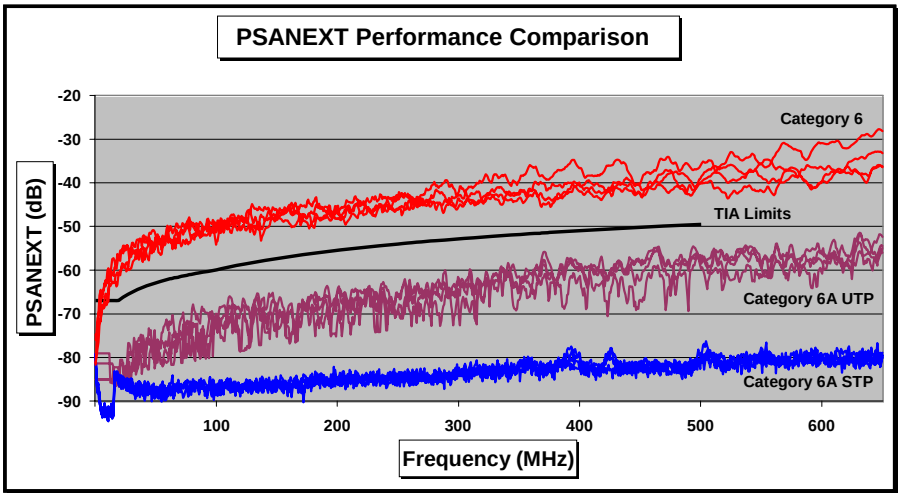
* Actual allowable length may be shorter in typical Category 6 installations without mitigation (37 meters) as specified in TSB-155.

Alien Crosstalk

In 10GBASE-T applications, the noise source that most limits the ability to transmit 10 GbE over copper cabling is alien crosstalk. Because the 10GBASE-T receiver cannot detect and compensate for noise from adjacent channels, this effect must be suppressed within the cabling system to ensure reliable data transmission. This noise is measured as Power Sum Alien Near-End Crosstalk (PSANEXT) and as Power Sum Alien Attenuation to Crosstalk Ratio at the Far-End (PSAACRF). Both TIA-EIA-568-B.2-10 and TSB-155 require that crosstalk be measured in a 6-around-1 cabling configuration that takes into account the worst-case effect on a center cable with six cables tightly bundled around it.

In Augmented Category 6 UTP cabling, *PANDUIT* Laboratories designed innovative features to reduce alien crosstalk into both the cable, such as increased separation between cables and tighter twist rates; and the connectors, such as crosstalk suppression within the printed circuit boards. These enhancements help the system comply with TIA/EIA standard PSANEXT and PSAACRF specifications for achieving 100 meters reach. A Category 6 UTP system that does not incorporate the improvements of Augmented Category 6 will not meet the alien crosstalk limits required for 100 meters of 10GBASE-T transmission (see Figure 1).

Figure 1. 100-Meter Channel PSANEXT Performance Characteristics



For properly installed and bonded STP cabling, foil screens within the cable prevent signals from coupling, which reduces alien crosstalk well below required performance levels. This impact is similar whether the cable is comprised of individual shields around each pair, as in U/FTP and S/STP cables, or of a single foil around all pairs, as in F/UTP cables. Testing performed by *PANDUIT* Laboratories indicates that STP cabling systems provide significant margin over the IEEE 802.3an-2006 specifications for 10GBASE-T PSANEXT (see Figure 1) and PSAACRF, resulting in enhanced alien crosstalk performance. Due to the increased suppression of ANEXT and AACRF by STP cable, the need for cumbersome and time-consuming field-testing of alien crosstalk is eliminated.

Shielded Cable

When choosing a shielded cable type, there are several different options to consider. The diagrams below show the three major categories of shielded cables.

- Screened unshielded twisted pair cable includes an overall foil around the pairs
- Shielded twisted pair cable includes a shield around each individual pair
- Screened shielded twisted pair cable includes an overall shield, or braid, around all pairs with an additional foil around each individual shield

Each of these cables offer benefits and drawbacks. Cable designs that include a single foil around all pairs, such as F/UTP, sufficiently reduce alien crosstalk between cables in a channel, although *PANDUIT* Laboratories has found that the influence of the overall shield makes it more difficult to meet internal performance requirements as frequencies increase for 10GBASE-T transmission.

With an U/FTP cable design, each individual pair includes a shield. This design provides superior Alien NEXT performance, internal NEXT, ELFEXT and Return Loss, as there is no source of crosstalk between pairs since the pairs are individually shielded. U/FTP typically costs more than F/UTP cable due to the individually shielded pairs.

An S/FTP cable design incorporates a single foil/braid around all pairs and an additional foil around each individual pairs. This design also delivers superior Alien NEXT performance and offers the benefit of superior structural integrity; reduced low frequency external interference to ensure exceptional cable performance at all swept frequency levels. This cable is typically larger to allow for the dual shields and are cumbersome to terminate, resulting in more difficult cable management.

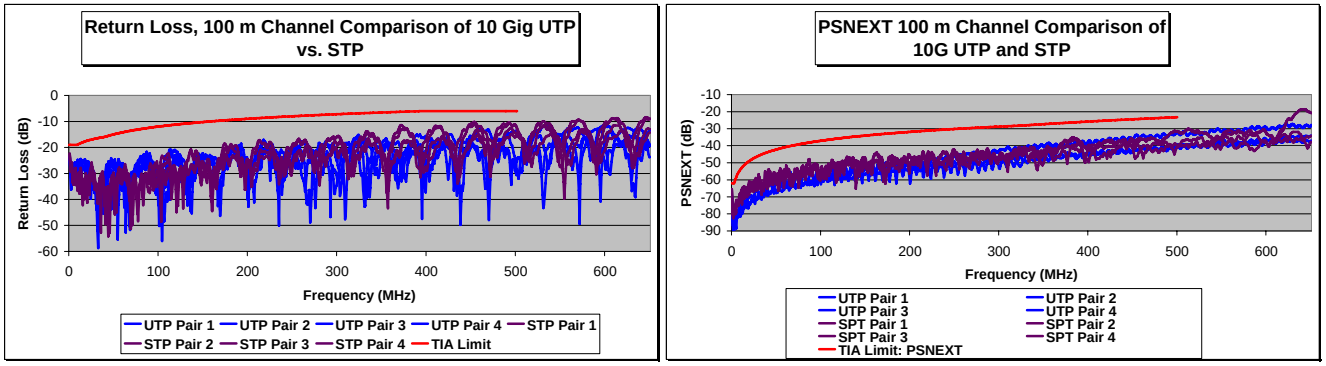
EMI and RFI Performance

In addition to providing superior alien crosstalk performance, the *PANDUIT*® *TX6*™ *10GIG*™ Shielded Copper Cabling System is excellent at suppressing electromagnetic interference (EMI) and radio frequency interference (RFI). EMI/RFI can degrade network performance and can emanate from common devices such as WLANs, cellular phones, TV broadcasting, or radios. A properly grounded STP cabling system gives a high level of immunity against EMI/RFI emissions and should be used in noisy environments or locations where equipment is particularly sensitive to EMI.

Internal Channel Performance

While STP cabling systems offer superior alien crosstalk performance, both STP and UTP cabling systems have comparable electrical performance for internal noise and crosstalk within a channel. Since the internal electrical performance is dominated by the connector performance at high frequencies, STP and UTP copper cabling systems behave nearly the same for these parameters as they both use similar connectivity designs. Figure 2 shows the very similar performance levels between STP and UTP cabling for return loss and near-end crosstalk.

Figure 2. Comparison of *TX6™ 10GIG™* Performance of Internal Channel Return Loss and Power Sum Near-End Crosstalk



How Differences in Patch Cord Length Affect Channel Length

Historically in twisted pair cabling, STP cable diameter has been larger than UTP cable to accommodate the foil shield. In order to meet alien crosstalk requirements of Category 6A UTP cabling, larger diameter cable is necessary to control the geometry between pairs within and between cables. These design changes for UTP cable has caused the cable diameter to increase, surpassing typical STP Category 6A cabling.

The cable size differential between 10GBASE-T compliant UTP and STP cabling is even more dramatic on patch cords. Since STP patch cords are completely shielded against ANEXT, STP patch cords use smaller stranded conductors allowing easier cable management. As with horizontal cable, addressing alien crosstalk and controlling pair geometry has resulted in larger conductors and cable diameter for UTP patch cords.

The larger conductors of the UTP patch cords results in a stronger signal with a de-rating of 20%, compared to a 50% de-rating of STP patch cords. This difference in de-rating needs to be taken into account when designing channels requiring longer than 8 meters of patch cords.

Per the TIA/EIA 568-B standard, the maximum length of horizontal cable is defined as: H = 102 – C (1+D)

Where: H = the maximum length of the horizontal cable
C = the combined length of the equipment cables, work area cords, and patch cords
D = de-rating factor for patch cables (UTP- 20%, STP – 50%)

For example, using the equation above, the maximum length of horizontal cable for a channel where the total length of patch cable is 15 meters is equal to 84 meters for UTP cabling and 79.5 meters for STP cabling.

UTP Channel Example

H = 102 – C (1+D)
H = 100
C = 15
D = 20%

H = 102 – 15 (1+0.20)
H = 84

STP Channel Example

H = 102 – C (1+D)
H = 100
C = 15
D = 50%

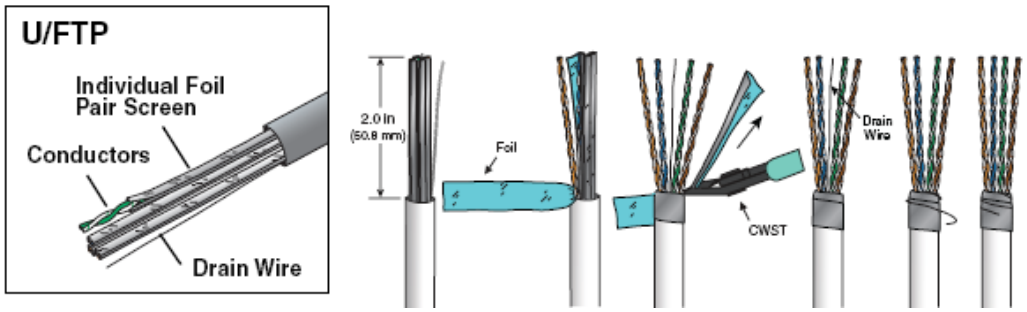
H = 102 – 15 (1+0.50)
H = 79.5

Termination and Installation

Although STP cabling systems have superior alien crosstalk and EMI/RFI suppression, installers, contractors, and IT managers in many markets are not familiar with proper termination and installation of STP cabling. Installation time may take longer for STP cabling over UTP.

For the *PANDUIT* termination methodology, both UTP and STP jack modules are identical, except for cable preparation. As shown in Figure 3, the foil and drain wire in an STP cable must be pulled back and twisted around the cable end prior to terminating in order to make a continuous connection for effective grounding. Since these foils need to be peeled back and unused foils trimmed, additional time is required to complete each termination. On average, it takes approximately 30 seconds more time to terminate a *PANDUIT* STP Jack Module over an UTP Jack Module.

Figure 3. Cable preparation for termination of *PANDUIT TX6™ 10GIG™* Shielded Copper Cabling System



Bonding and Grounding Requirements

Today, as most 10GBASE-T compliant copper cabling is installed in data centers, it becomes essential to implement proper structured grounding processes in order to protect personnel and expensive equipment. The overall integrity of the bonding and grounding system in the facility must be sound in order to realize the full performance benefits of the system. *PANDUIT* can provide assistance to ensure proper bonding and grounding for STP and UTP installations.

For UTP systems, cabling connectivity does not require complete system bonding, but careful attention must be given to the integrity of the grounding of the patch panels and racks to the common grounding point in order to protect the infrastructure. For STP systems, the additional step of bonding cable to the connectivity components is essential to ensure proper performance. The *PANDUIT TX6™ 10GIG™* Shielded Copper Cabling System has been designed for consistent seamless bonding when used with the *PANDUIT STRUCTUREDGROUND™* Grounding Solutions. The components essentially are self-grounding with minimal additional cost.

The Importance of Proper Grounding for STP Cabling Systems

For 10GBASE-T data transmission, an STP cabling system has some key electrical characteristics to consider when planning a new installation for 10 GbE traffic. When using an STP cabling system, attention needs to be given to the implementation of the power and grounding system that the copper data cable system resides in. If the power or cabling system is not properly designed and/or installed, transients or an electrical potential difference could result in a spike or ground loop, which would likely cause data rate errors. Since 10GBASE-T applications are very sensitive to noise, potential differences in electrical grounds can cause bit-error-rates high enough to effect 10 GbE traffic. Therefore, up front design and installation are very important for the power and grounding system to ensure date rate integrity. If there are data transmission issues within a STP cabling data network, an audit should be performed to check for proper bonding and grounding as well as the overall design of the power and ground system.

The *PANDUIT* Laboratories recommendation for bonding a cabling solution is provided in Figure 4 below. In summary:

Step1. Cable preparation and termination to jack module

- Remove outer cable jacket and prepare foil, braid, or drain wire to be bonded to the jack module
- Establish a metal-to-metal bond between the shielded cable and shielded jack module (360 degree conductive cover offers the best protection)

Step 2. Bond the jack module to the patch panel

- Establish metal-to-metal contact points between the jack module and the patch panel
- Alternatively, establish a metal-to-metal bond between the jack module and the rack/cabinet with wire straps

Step 3. Bond the patch panel to the rack/cabinet

- Establish metal-to-metal contact points between the patch panel and rack
- Since most patch panels and/or racks are powered painted, thread-forming screws should be used to remove paint from the thread holes of the equipment mounting rails as it is installed. The screw heads or washers should also have serrations to remove paint from the patch panel during installation

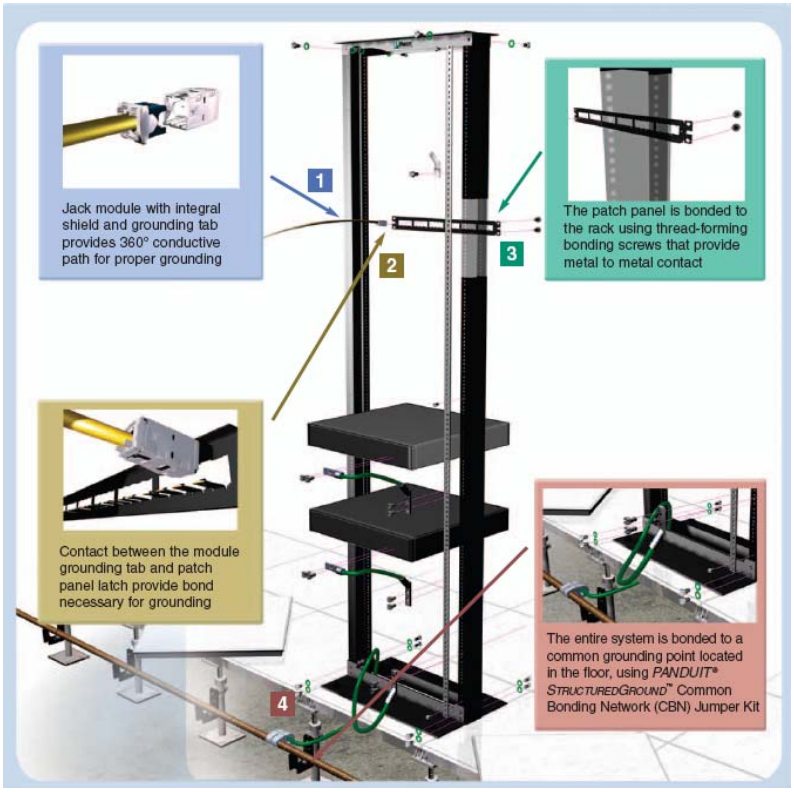
Step 4. Bond the rack/cabinet to the common bonding network

- Rack rails of rack or cabinet are to be bonded to the ground structure on that floor through the main grounding bar or via a mesh common bonding network (MCBN)
- It is not recommended to “daisy-chain” racks together with bonding straps as it creates a single point of failure for an entire lineup and it routes currents directly through racks

In addition to properly bonding and grounding the structured cabling system, it is also important to construct the equipment-bonding network to minimize any electrical potential differences. Recommendations include:

- Bonding equipment to racks/cabinets
- Bonding each rack/cabinet to the telecommunications main grounding busbar-TMGB (may be done via a mesh common bonding network)
- Bonding the TMGB to the serving electrical panel in the room

Figure 4. *PANDUIT* Seamless 4-Step Bonding Process



Finally, during installation, a frequently asked question is whether the installer should bond one-end or both-ends of a cable link. With only one-end of a cable link bonded, the risk of a ground current loop is eliminated. When both-ends of the link are bonded, there is the potential for a ground current loop if there is an electrical potential ground difference between the two ends of the channel (i.e., having the cable shield be the only metallic connection between different AC power services.) The benefit though of bonding both-ends of the link is increased levels of protection against external Alien NEXT, EMI, and RFI noises. Therefore, to ensure maximum electrical performance in data center and telecommunication room applications, *PANDUIT* Laboratories recommends that both-ends of the cable link be bonded provided:

- Any multiple serving AC power systems are intersystem bonded to reduce any ground voltage differences (as required by the NEC)
- Shielded cable channels are contained in the same building

For workstation applications, it is recommended that the cable link be bonded only through the normal process in the telecommunication room and through the patch cord at the workstation, which provides the proper path to ground via the computer's AC power plug.

Economics

To make UTP cabling components 10GBASE-T compliant, several robust design features such as filler material, larger cable, sophisticated twists and strand schemes have been incorporated into the solution. These enhanced cable design features have made the cost delta between an UTP and STP 10GBASE-T cabling system close to parity (pricing differences depend on the cable flame rating and the particular network channel configuration).

During installation, an STP solution will take longer to terminate jack modules and properly bond the structured cabling system. Therefore, it is expected that installation costs will add a little more to overall installed cost. On the other hand, the overall installed cost savings of a UTP cabling system will depend on the percentage of field-testing for alien crosstalk required by the end-user, which can take anywhere from 20 to 40 minutes per link.

Summary

With the exception of some countries in Western Europe, the cable of choice throughout the world for structured copper cabling installations has been UTP. The IEEE 10GBASE-T specification, which defines 10 GbE transmission over copper twisted pair, permits both UTP and STP copper cabling systems. There are advantages and disadvantages to using either type (see Table 2).

The main advantage of using a STP cabling system is the dramatic suppression of alien crosstalk. The containment of this noise helps ensure better signal integrity than can be achieved with a UTP cabling system. The main advantages of UTP cabling are that it is simpler to install, quicker to terminate, and less expensive than STP cabling based on product and installation costs. Also, within most regions, installers and contractors are more familiar with UTP cabling, including its proper installation. For many markets, a learning curve for STP cabling installations still remains.

While proper bonding and grounding methods should always be followed, in practice there is often more confusion on how to do this with STP cabling and how much additional cost will be incurred to meet these requirements. Also, attention to proper grounding beyond the cabling itself to the electrical systems must be implemented to eliminate the possibility of ground loops. If the power cabling system is not properly designed and/or installed, an electrical potential difference could result between the two ends of an STP cabling link. This electrical potential difference could result in a ground loop, which would likely cause data rate errors. Thus, the overall integrity of the power and grounding system is very important to ensure 10GBASE-T performance. This becomes less of an issue with UTP because UTP cabling systems are not closed ground loops.

In conclusion, if performance is the key driver at a site, it is recommended that an STP cabling system be installed, due to STP's superior performance at suppressing alien crosstalk for 10GBASE-T application, and/or eliminating the need to perform time-consuming field-testing for alien crosstalk. If a user has concerns about bonding and grounding practices within its network, maintaining the integrity and continuity of the STP and grounded system over the lifespan of the cabling system, and/or wants the lowest cost 10GBASE-T system, it is recommended that a UTP cabling system be installed.

Table 2. Comparison of STP and UTP 10 GbE Compliant Cabling

Advantages of STP	Advantages of UTP
• Excellent alien crosstalk suppression (> 20 dB PS ANEXT headroom over the standard) • Field testing for alien crosstalk not necessary due to superior headroom margin over the 10GBASE-T standard (estimated time savings of 20-40 minutes per individual link) • Excellent immunity from devices that emanate EMI and RFI noise such as WLAN's, cellular phones, TV broadcasting or radios • Increased patch cord cable manageability due to smaller cable (0.23 in. STP vs. 0.29 in. UTP)	• Installers and contractors are more comfortable installing UTP over STP systems which may lead to lower installation quotes • Additional step of bonding cable to connectivity components is not required, no potential ground loop concerns • No cable preparation required when terminating jacks, less installation time (Shielded jack termination takes 50% longer than UTP) • Lower product and installation cost • UTP and STP patch cables have channel de-rating of 20% and 50% respectively, which allows for longer channel length in UTP installation when using more than 8 meters of patch cords

About *PANDUIT*

PANDUIT is a leading, world-class developer and provider of innovative networking and electrical solutions. For more than 50 years, *PANDUIT* has engineered and manufactured end-to-end solutions that assist our customers in the deployment of the latest technologies. Our global expertise and strong industry relationships make *PANDUIT* a valuable and trusted partner dedicated to delivering technology-driven solutions and unmatched service. Through our commitment to innovation, quality and service, *PANDUIT* creates competitive advantages to earn customer preference.