

Principles of Unshielded vs. Shielded Network Cabling

Scope

With both the TIA 568-B.2-10 and IEEE 802.3an standards addressing the role of Augmented Category 6 pushing the frequency of network cabling to 500 MHz and introducing the effect of Alien Crosstalk, the discussion of unshielded vs. shielded cables has come into the spotlight. The purpose of this paper is to provide information about both types of cabling and their applications.

UTP Fundamentals

The acronym UTP stands for unshielded twisted pair and it represents the majority of network cabling that is in place today. The UTP cable starts out with two insulated conductors that are then twisted together to form a pair. Typically four pairs are then formed into a cable core, usually with all pairs employing different twist lengths. One reason for the twisting of the conductors is to reduce the effect of crosstalk or unwanted signal coupling between the pairs of the cable core. This is pair to pair crosstalk. Another less obvious reason for twisting the conductors into a pair is to provide good balance between the two conductors that make up the pair.

A balanced twisted pair is defined by Bicsi as, “a multi conductor cable comprised of two or more copper conductors twisted in a manner designed to cancel electrical interference.” The cancellation of electrical interference takes place by using the pair’s “physical symmetry” or balance. The conductors of the pair should be made identical to each other and twisted at the same rate over the length of the cable. When this occurs the current of each conductor flows in equal magnitude but in opposite directions. This allows for the unwanted coupled noise from each conductor to be cancelled out when they reach the receiver. The pairs are able to withstand Common Mode noise due to this balance and also prevent it from being converted into Differential Mode noise. Both Common Mode and Differential Mode noise may distort the transmitted signals of a given pair or cable and lead to logic errors inside equipment.

The greater the balance between the conductors of a pair the greater the reduction in radiated EMI (electromagnetic interference) transferred from the pair. Improved balance will also lower the noise coupling from external sources of EMI and RFI (radio frequency interference) to the pair. To achieve good balance the primary rule of thumb is that the larger the number of twists per foot that are applied to a pair the better that pair’s

balance will be. This is due to the ability of a tightly twisted pair to maintain better geometric stability than a longer, loosely twisted pair. For example the typical pair lay of a Category 3 cable (1.5” to 4.0”) will deform easier vs. the lay of Category 6A (0.250” to 0.500”) cables being made today. UTP cable employing tightly twisted and well balanced pairs in conjunction with the overall cable design is very effective at minimizing Pair to Pair Crosstalk as well as Alien Crosstalk in most standard working environments. Alien Crosstalk is unwanted signal coupling from pairs between adjacent cables.

UTP Pros and Cons

Most modern technologies and computer applications are designed using a type of 4 pair communication cable platform for transporting all types of information, from voice and data to video. This is true not only in commercial business applications and retail environments but also in today’s households. UTP cabling will continue to grow in these areas due to several factors:

- **Cost** – UTP cables and their components (cable, connectivity and active devices) are less costly than shielded cables and their components or fiber optic solutions.
- **Flexibility and size** – The size of most UTP cables are smaller than their shielded counterparts or other alternatives such as coaxial cables and they are more flexible providing a tighter bend radius
 - UTP - 4X the cable O.D.
 - F/UTP - 8X the cable O.D.
- **Ease of installation** – UTP cables are very familiar to most installers reducing installation time and there is no additional time required to ground the shield (Lower project cost due to fewer installation hours required).
- **Applications** – UTP can run applications from analog telephony to 10G.
- **UTP 10GBASE-T**
- **UTP 10 Gig** provides effective immunity to Alien Crosstalk and is not dependant on grounding issues.

Shielded Cable Fundamentals

There are several types of shielding options and most of these have recently had their trade designations changed. Most people are familiar with the acronyms FTP and ScTP but may have had different ideas as to what each type means. The new current nomenclature is:

- **F/UTP** refers to a cable core consisting of unshielded twisted pairs that are under an overall wrap (longitudinal or spiral) of an aluminum/mylar shield. (Foil over unshielded twisted pair F/UTP)
- **S/FTP** refers to a cable core where all the pairs in the core are individually shielded with an aluminum/mylar shield and then a braided shield is applied over the core. (Braid shield over foil wrapped twisted pairs)
- **SF/UTP** refers to a cable core consisting of unshielded twisted pairs that are under an overall wrap (longitudinal or spiral) of an aluminum/mylar shield that is then covered with a braided shield. (Screen and Foil over unshielded twisted pair)

A shielded cable is generally constructed in the same way as a UTP cable except there is a type of metallic protection element covering either the individual pairs of a cable, the entire cable core or both. This metallic protection element is generally composed of a foil wrap or braided wire design using aluminum or copper.

A shielded cable would be preferred in areas where significant external noise (EMI, RFI) exists or there is the potential for a significant amount of external interference along the cable's pathway where adequate separation between these noise sources and the cable is not attainable. These areas would include, but are not limited to, things such as large dc motors, power lines (2.5Kv or higher), appliances, broadcast equipment, heaters, and fluorescent lights. The added protection of the shield does not allow the external interference to migrate into the cable and works in conjunction with the internal pair lay and balance to reduce EMI effects on the cable core to outside influences.

Foil shields typically are the most popular type of shield used today. They are a low cost, effective means of blocking EMI and RFI in extreme environments. It provides 100% continuous coverage over the core or the pairs, is lightweight and best suited for higher frequency protection. A drawback of foil shields is that they may crack under flexing conditions.

Braided shields are typically found alone in cables that require low frequency noise protection or in conjunction with a FTP core where added

protection is needed at very low and high frequency extremes, as found in an ISO IEC Class F, sometimes referred to as Category 7 cable. Braided shields are better designed to withstand flexing without damage.

Grounding

Regardless of what type of shielded solution is used in the network cabling, the shield **MUST** be grounded properly at both ends to ensure its effectiveness. If a shield is not properly grounded, it can act like an antenna and capture the ambient EMI/RFI, transferring it onto the cable. Also, any additional resistance due to poorly installed shield or damage to the shield can allow the conductors to pick up noise interference (ANEXT) from other cables in close proximity.

Most shielded cables today contain a drain wire in the cable design that runs continuously along the cable length and is in constant contact with the shield. The drain wire is added to ease the procedure of grounding the shield during installation and is usually made of bare or tinned copper for the best conductivity.

Shielded Cable Pros and Cons

Some important factors to consider for a shielded cabling system include:

- The cabling and the connectivity required are more costly than UTP.
- Additional labor is required for installation due to the required grounding.
- Poor grounding can lead to an antennae effect, creating testing and performance issues.
- Shielding in most cases results in a larger cable O.D. (not so for Category 6A). A larger cable results in fewer available cables in pathways; larger pathways will increase project costs.
- Shielding of a cable does not ensure that Alien crosstalk testing will pass or that it will support Category 6A applications.
- Shielded Category 6A cable must still be tested for Alien crosstalk based on the IEEE and TIA standards.
- A shielded cable is very effective at reducing EMI and RFI in noisy environments.

All of these factors should be taken into account and discussed with the appropriate parties to ensure the most suitable cabling system is chosen for each application.