WHITE PAPER

SCREENED OR UNSCREENED CABLING – WHICH IS BEST FOR THE DATA CENTRE?!

In this white paper, Dr Alan Flatman compares the use of screened vs. unscreened cabling in the data centre from operational, commercial and strategic viewpoints. The main focus will be the support of 10G and a risk assessment of marginally compliant cabling.

Background

To screen or not to screen? That has been a key question for many years and a debate I have followed and taken part in as a professional engineer. As a past "disciple" of UTP cabling, I am now convinced that screened cabling is the best way forward for speeds greater than 1G, especially in environments containing large clusters of high speed links such as the data centre. I arrived at this conclusion after my involvement in the development of 10GBASE-T, and I will explain why.

10GBASE-T Robustness

10GBASE-T uses 4-pair transmission and is designed to support 100m of Cat 6_A or Cat 7 cabling. 10 Gbit/s data rate is achieved by transmitting 2.5 Gbit/s over each pair, as shown in figure 1.

Significant levels of suppression are provided for internal crosstalk noise (NEXT, FEXT) and return loss (signal echo) in the cabling; this is accomplished by Digital Signal Processing (DSP) which has access to the source of each disturbance. Due to the high spectral bandwidth of 10GBASE-T signals (400 MHz), there is significantly more crosstalk from adjacent cables than we had with 1000BASE-T (which has only 80 MHz signal bandwidth). Unfortunately, it is not possible to suppress *alien crosstalk*, as DSP cannot access sources of this disturbance (as they are in separate links).

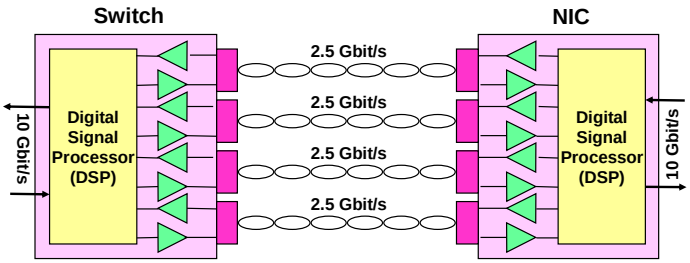
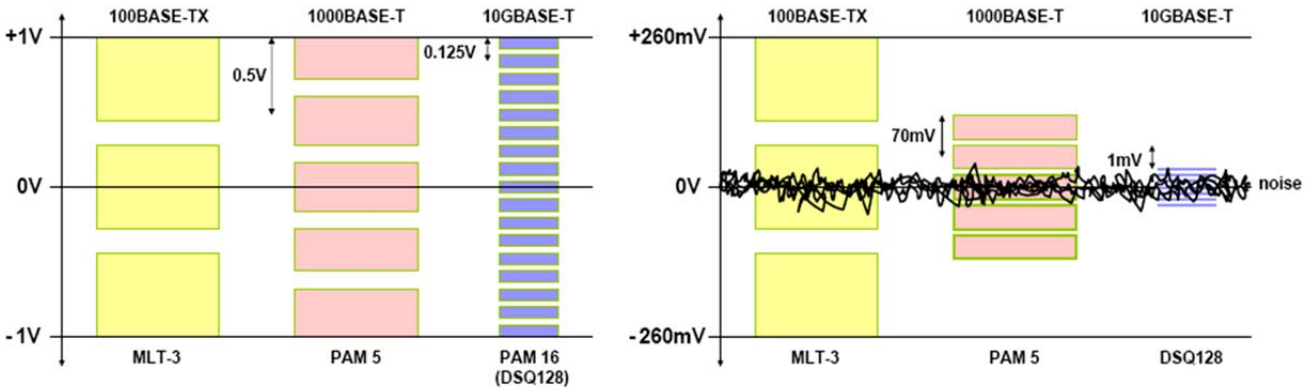


Figure 1: 4-pair full-duplex transmission used by 10GBASE-T

10GBASE-T uses 16-level signalling (DSQ128) in each pair, compared with 5-level signalling (PAM-5) for 1000BASE-T and 3-level signalling (MLT-3) for 100BASE-TX. A comparison of transmit and receive signals is shown in figure 2. Receive signals are attenuated by 100m cabling, with 10GBASE-T signals having the greatest attenuation due to the higher frequencies involved (approx. 1mV per signal level).

One of the most significant contributions to channel robustness is system noise; including internal noise from cabling impairments and external noise from power cables, other data cables

Figure 2: Transmit Signals (left) & Receive Signals (right) for Ethernet BASE-T Transceivers



and active equipment. Internal noise may be suppressed by using DSP techniques, as discussed. External noise is *uncorrelated* and cannot be cancelled; it must therefore be taken into account in the transmission system design.

Channel robustness is defined in terms of statistical error frequency (Bit Error Rate) and failure mode. Figure 3 illustrates the latter by comparing the behaviour of different Ethernet BASE-T systems when the cabling channel is non-compliant. All systems will deliver maximum throughput when attached to compliant cabling, however each system will behave differently as the channel becomes increasingly non-compliant. 10BASE-T throughput will reduce gracefully, and will eventually fall to zero, as shown. Corrupt packets are detected and re-sent by higher level software, causing the network to slow down. 100BASE-TX throughput will reduce more rapidly before falling to zero but still has significant headroom. Both of these BASE-T systems employ simple transmission techniques whose robustness is largely determined by cable attenuation, internal crosstalk and return loss (signal echo). I refer to the gap between compliance and failure limits as the *twilight zone*. 1000BASE-T and 10GBASE-T employ complex transmission and sophisticated DSP techniques. They both have limited headroom, and channel robustness is largely determined by external noise, in particular alien crosstalk. Consequently, the *twilight zones* for 1000BASE-T and 10GBASE-T are relatively small and failure modes are more catastrophic, as shown. Catastrophic failure only becomes important when we have minimally compliant cabling or when there is uncertainty in its qualification; both of these conditions are issues with unscreened cabling (see Planning & Installation Issues below).

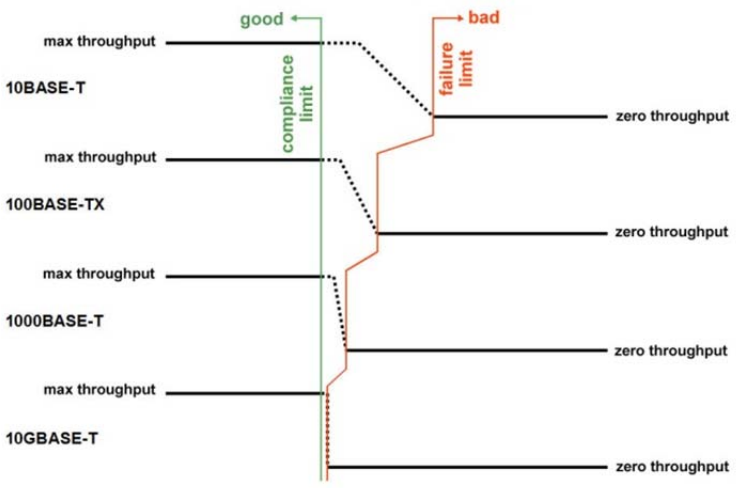


Figure 3: Operation of Ethernet BASE-T Systems with Non-compliant Cabling

Planning & Installation Issues

An international standard is now available for cabling planning and installation, ISO/IEC 14763-2. This document provides detailed support for the deployment and testing of all types of cabling, including the high performance screened and unscreened cable types specified in design standards such as ISO/IEC 11801 for the commercial office and ISO/IEC 24764 for the data centre. ISO/IEC 14763-2 has brought together best practices from industry groups such as BICSI, TIA, IEC & CENELEC and is expected to become the definitive global handbook for all practical aspects of planning and installation. ISO/IEC 14763-2 includes detailed requirements for grounding & bonding, segregation of data and power cables, and qualification testing of parameters such as alien crosstalk.

A wealth of experience in grounding & bonding has come from Continental Europe, where screened cabling has been the norm for many years. Lack of established practices for grounding cable screens has been cited as a negative point in pro-UTP regions of the world, such as the USA, but this is no longer true. Grounding systems in modern data centres are excellent and earthing cable screens is simple and safe.

Requirements for the segregation of data and power cables have recently changed following a number of in-depth studies. Segregation distance will depend upon the number of power cables and their rating. It will also depend upon the type of data cable used and the nature of any containment system (e.g. plastic or metallic trunking, with or without separators). As a guideline, segregation for STP data cables such as Cat $7/7_A$ is approximately 10% of that for unscreened cables.

Alien crosstalk testing is a complex topic. To accurately determine the alien crosstalk for each and every cable in an installation, this must be measured from each cable end to every other cable end. Measured results should then be calculated as a power-sum (root of the sum of all squared results). So, if the installation has many related cable links (i.e. same bundle, common patching), then the number of permutations is huge and practical testing of this scenario is unthinkable. Controlled sample testing is done instead to reduce test time and cost, however this is obviously not as accurate. As specified by ISO/IEC 11801, alien crosstalk testing is unnecessary if the cable in question has good electromagnetic performance – or coupling attenuation (quote follows):

If Coupling Attenuation is 10dB better than specified, then Class E_A and Class F alien crosstalk is considered to be "met by design".

If Coupling Attenuation is 25dB better than specified, then Class F_A alien crosstalk is considered to be "met by design".

Being "met by design" means that alien crosstalk does not need to be measured. The majority of foil & braid screened cables, such as Cat $7/7_A$, exceed these exclusion limits by a comfortable margin and therefore escape the need for alien crosstalk testing, with significant savings in time and cost.

Alien crosstalk performance of previous generation UTP cables (up to Cat 6) is poor, especially between pairs of the same twist rate. This has been improved for Cat 6_A UTP cables by varying twist rates and increasing the outer jacket thickness. While this enhancement has been proclaimed by suppliers as a major

breakthrough in cable technology, it has a number of drawbacks. Cat 6_A alien crosstalk performance is specified but this does not apply to mixtures of Cat 6_A UTP and any other UTP cable type. The latter scenario is undefined and is addressed qualitatively by TIA TSB-190. As Cat 6_A cable designs are proprietary, there is considerable variation in alien crosstalk when mixing cables from different manufacturers. Alien crosstalk from UTP patch cords is also an issue due to their close proximity. Great care is therefore required in patch cord management - and alien crosstalk will change after reconfigurations. All of this is simplified by using screened cables.

Screened cables were once criticised for their size, stiffness and cost when compared with unscreened cables. This is no longer the case when we compare them with the latest Cat 6_A UTP cables, which may have an outside diameter of up to 9mm. The majority of screened Cat $6_A/7/7_A$ cables are thinner and similar in cost.

Higher Speeds over Copper

Detailed investigations have taken place into the feasibility of higher speeds over twisted pair cabling. Studies indicate that 40G is feasible, perhaps even 100G, over 50-100m of screened cabling such as Cat $7/7_A$. There is general agreement that unscreened cabling will not offer the capacity to operate at speeds above 10G. We anticipate a new project within IEEE for 40GBASE-T sometime this year.

Cabling Deployment Trends

A major data centre cabling survey conducted by BSRIA in 2011 indicated that only 13% of respondents planned to install unscreened cabling to support 10G applications (see figure 4). The remainder planned to install screened cabling of one form or another. This illustrates a strong trend in the deployment of screened cabling in data centres.

Key factors in selecting cable type were cited as reliability, security and resilience. This survey had 335 respondents and was conducted in USA, China, India, Germany, France and the UK.

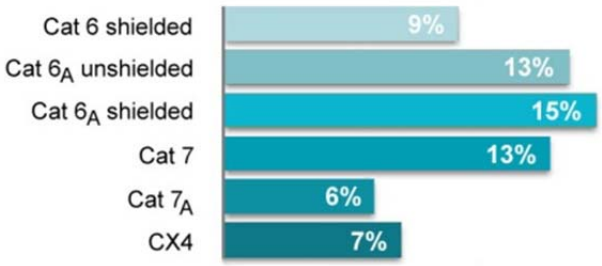


Figure 4: Data Centre Cabling End User Survey (source: BSRIA Report 54433-1, Nov 2011)

Most major cabling suppliers offer both screened and unscreened cabling products to support 10G applications. Many leave the customer to choose but some clearly position their screened version as the lowest risk solution.

Summary

The main advantages of screened cabling for 10G operation are lower cost of ownership and lower operational risk, the latter being essential in a data centre environment. With considerable performance margin, there is no need to field test screened cabling for alien crosstalk compliance and there is no need to worry about interactions with existing cabling. Also, with sufficient capacity to support 40G, screened cabling will remain on the drawing board for at least another generation. Screened cabling is therefore the preferred approach for high speed copper links. 10GBASE-T products have finally been launched and are expected to witness rapid adoption in the data centre.

Author: Alan Flatman is an independent consultant with over 30 years experience in the electronics and computer industries. He has advised on network technology and strategy since 1980. In 1993, he formed LAN Technologies, a UK-based consultancy business whose clients include major end users within Europe, USA and Asia plus a wide range of suppliers from the cabling and LAN industries. Alan represents the UK in the development of international cabling standards and provides the vital link with IEEE 802 as their liaison officer. Alan Flatman is a Chartered Engineer and a Fellow of the Institution of Engineering & Technology.

