

Technical Reference

10Gigabit Ethernet: CopperTen™ Cabling Solution

For years, copper solutions have been the preferred medium over which most local area networks communicate. And in this same period, a debate has raged as to when optical fibre would displace copper as the preferred infrastructure.

For years, optical fibre has led the Ethernet industry forward in port speed progression. So if optical fibre is one step ahead why doesn't it replace copper? The answer is quite simple. To convert electrons to photons and then back to electrons adds cost (from an active hardware perspective). This makes the cost of fibre optic active hardware more expensive per port than the equivalent speed copper solution on Gigabit Ethernet switch ports.

The IEEE develops the electrical parameters needed to run transmission protocols and then asks ISO/IEC to standardise the cabling parameters. For 10Gigabit Ethernet over copper, an IEEE 802.3an Study Group was formed to discuss how best to approach running 10Gigabit transmission over a copper infrastructure. The group was composed of representatives from several different parts of the networking community, such as chip manufacturers, hardware manufacturers and cabling/connectivity manufacturers.

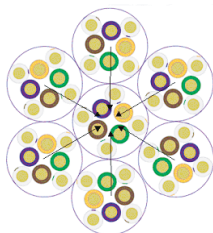
The study group discussions included which protocol encoding would be used, how it would relate to the bandwidth of the cabling infrastructure (what the frequency range is) and what measurement of Shannon's capacity is needed to support them, measured in bits per second. To achieve 10Gbps transmission, a Shannon's capacity of >18Gbps was specified for the cabling solution. The additional capacity over the actual data rate is due to the amount of bandwidth used within the active hardware noise parameters (i.e. jitter, etc.).

In order to prevent the effects of crosstalk within cables, pairs within a single cable are twisted at different rates (as the different colours in the cable would indicate). This technique is used to minimise the crosstalk between pairs along parallel runs. While this works well within the cable, it doesn't greatly reduce cable-to-cable crosstalk (alien crosstalk). The two options for minimising alien crosstalk are to use a UTP cable with patented geometry or use shielded F/UTP or S/FTP cable.

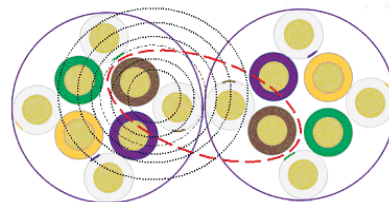
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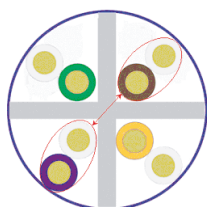
Alien crosstalk is quite simply the amount of noise measured on a cabling pair in a channel induced from a cabling pair in an adjacent channel. This is not only a concern for different twist lay pairs between cables, but more so between same twist lay pairs between adjacent cables.



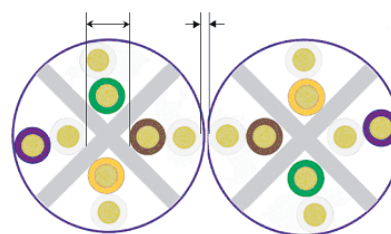
Example of a centre cable being impacted by the adjacent 6 cables in the bundle.



Example of how cables with same twist lays impact one another.



The star filler used within several Category 6 cable designs increases and controls the distance between pairs.



While the distance between pairs within the same cable is maintained, the distance between same lay lengths on adjacent cables is still compromised.

Initial testing on existing Category 6 UTP cable designs quickly showed that the rationale behind reducing the impact of crosstalk between pairs within a cable could not support alien crosstalk requirements. Twist lay variation and controlled distances between the pairs have been standard design practice for achieving Category 6 compliance. While the distance between pairs can be controlled within a cable jacket, it could not be controlled between same lay length pairs on adjacent cables.

Testing Shannon's capacity on existing Category 6 UTP solutions only yielded results in the 5Gbps range. The results achieved previously did not provide the needed additional throughput to allow for active electronic anomalies. This was a far cry from the desired 18Gbps. Therefore the question was asked: Is there a UTP solution capable of achieving the needed alien crosstalk requirements or would optical fibre finally rule the day? The August 2003 meeting of the 802.3an Working Group would yield three main proposals:

1. Lower the data rates to 2.5Gbps and use Category 6 UTP. This would be the first time optical fibre would not be matched in speed and that a tenfold increase in speed would not be achieved.
2. Allow 10Gbps data rates but reduce the length of the supported channel to 37-55 metres from the industry standard 100 metres for Category 6 UTP. This would greatly impact the flexibility of the cabling plant, considering most facilities are designed with the 100 metre distance incorporated into the floor plans.
3. Use shielded solutions and abandon the much more broadly adopted UTP as a transport medium for 10 Gigabit Ethernet over copper.

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Category 5e would also be dropped as a proposed transport medium entirely. Equipment manufacturers would now question the value of producing active hardware to support transmission rates that only increased by 2.5 times, or for 10 Gigabit Ethernet over copper if distance limitations of 55 metres were really worthwhile. UTP could very well have reached its limit.

The next meeting of the working group was pivotal in addressing the above questions. How could a UTP cable achieve the desired capacity of >18Gbps and maintain the 100 metre distances to which the industry has become accustomed while remaining within the normal size constraints?

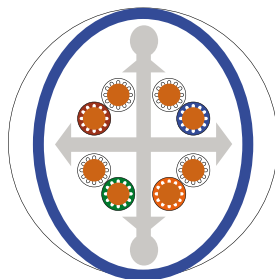
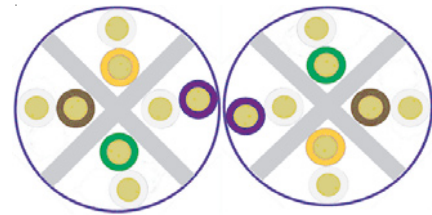
At the next meeting, ADC KRONE's CopperTen™ presented a solution to the 10 Gigabit Ethernet over 100 metres of UTP problem.

Addressing Pair Separation

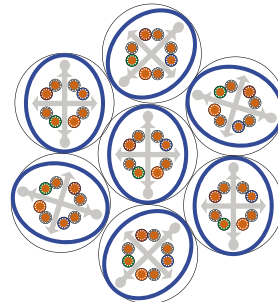
With standard Category 6 cable construction, increased pair separation within the cable is counter-productive to pair separation between cables.

The often-used star filler pushed the pairs within the cable as close to the jacket as possible leaving same pair combinations between cables susceptible to high levels of crosstalk.

In CopperTen cables' new design, the pairs are now kept apart by creating a higher degree of separation through a unique oblique star filler design. Crowned high points are designed into the filler to push the cables away from one another within the bundle. The bundled cables now have sufficient separation between same lay length (same colour) pairs to prevent alien crosstalk.



Elliptical, offset filler, which rotates along its length to create an air gap between the cables within a bundle.

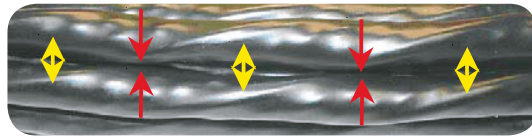


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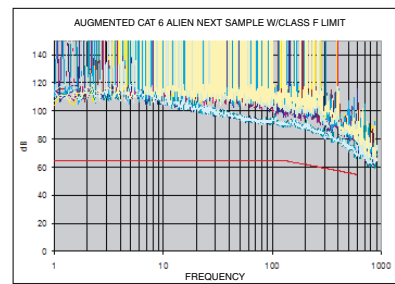
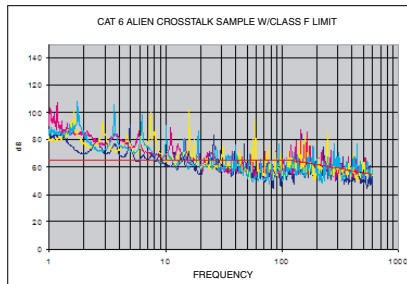
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The unique design keeps cable pairs of the same twist rate within different cables at a greater distance from one another than in the past.

This effect is even more dramatic when viewed from the side of a cable bundle. The peaks of the elliptical filler (red arrows) are used as the contact points along the length of the run. These provide the greatest distance between the actual pairs by vaulting the sides of the ellipse (yellow arrows) where the pairs are housed.



The reduction of alien crosstalk is now greatly improved over the standard Category 6 cable and the new CopperTen cable. The improvements are approximately 20dB better on CopperTen cable than standard Category 6 cable. To put this in perspective: for every 3dB of extra noise there's a doubling effect resulting in standard Category 6 cable being more than six times noisier than CopperTen cable.



For the purpose of comparison, the Category 7 cable limit line was used to show the dramatic improvement in preventing alien crosstalk.