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Specifying 10 Gigabit Ethernet in the Physical layer

Part 2: Copper solutions

Introduction

With the approval by the IEEE of the 10GBASE-T standard in June of 2006, there is now more of an air of reality about this much-discussed technology. The standard is published as an amendment to the 802.3 Physical Layer and Management Parameters and is known to the IEEE as 802.3an1

802.3an in turn refers to two other American standards, from the TIA, that give more product detail for the next generation of Category 6 cabling and also information on how to test the abilities of installed cabling.

10GBASE-T is designed to run up to 100 metres on the new augmented Cat 6 cabling and a shorter distance on existing cat 6 cabling. This shorter distance is either up to 55 m or even as little as 37 m depending upon which standard one reads.

The standards themselves are a little coy about whether screened or unscreened cabling is required and only give an electrical specification that has to be met.

Standards

The new standards basically come from three families and cover three applications.

The IEEE writes the Ethernet standard which has a subsection detailing the physical interfaces required to make it work. This is IEEE 802.3an, which describes the 10GBASE-T requirements.
The TIA are writing two cable standards; TSB 1552 to measure existing cabling for 10GBASE-T compliance, and Amendment 10 of the TIA/EIA-568-B.23 standard to describe the performance requirements of the new augmented Cat 6 products.

All these changes and amendments will be rounded up in the next edition of the 568 standard to be known as ANSI/TIA/EIA-568.C.

ISO is producing a new standard to measure the same parameters which will become ISO/IEC TR 247504 and the current ISO 11801 standard will be modified to become Amendment 1.2 of ISO 11801 2nd Ed.

CENELEC, the organisation that writes electrical standards for the European Union, will also catch up with draft EN 50173-99-1 to measure installed cabling and there will be future upgrades of the EN 50173 main body of standards to reflect the augmented Cat 6 requirements.

One thing we can say from the above list is that when somebody claims a 10GBASE-T compliant system, the first question needs to be, “To what standard?” All the standards mentioned are similar but by no means identical.

**Timescales**

IEEE 802.3an (10GBASE-T) was approved in June 2006. TSB 155 may be available by October 2006 and amendment 10 of 568-B.2 will be ready by spring 2007. The ISO and CENELEC versions are also expected by the end of 2007.

**What does 10GBASE-T do?**

10GBASE-T technology allows ten gigabit per second transmission speeds over Cat 6 cable and Augmented Cat 6 cable, also to be known as Cat6A or Class EA, cabling. The new augmented Cat 6 cables should be able to support the protocol over 100 metres. However, according to TSB 155, existing Cat 6 UTP cables will probably be limited to 37 metres whereas screened Cat 6 should still be good for 100 metres. There is another ‘short reach’ version of 10GBASE-T which will work for 30 metres of Cat6A but is not specified for ‘old’ Cat 6.

Cat 7, or Class F, will also comfortably handle 10GBASE-T over the 100 metres and Cat 7 will be reclassified in the new ISO and CENELEC standards as being rated at 1000 MHz instead of the existing 600 MHz, which will give it a greater ‘blue water’ product differentiation from the forthcoming 500 MHz Cat 6A. The new Cat 7 will also probably take the name of Cat 7A.

Cat 5 is not specified at all for 10GBASE-T.
What’s the difference between Cat 6 and Cat 6A?

The main difference is that Cat 6A is specified up to 500 MHz instead of the current 250 MHz seen with existing Category 6. This extra requirement of course places a lot of demands on the engineering of the cable. Cat 6 is already well defined with:

- Insertion loss; how much signal is absorbed by the cable

- Return loss; how much energy is reflected back from the cable and connectors due to impedance mismatch

- Crosstalk; a measure of how much energy leaks from one conductor to another in a cable. Crosstalk is further divided into Near End, i.e. near the transmitter, and Far End, i.e. from the other end of the cable and all the way along the cable. NEXT is the name given to the Near End Crosstalk between two pairs in the same cable, whereas Power Sum NEXT is the addition of all the crosstalk from any three pairs into the fourth.

Cat 6A has these same parameters, but extended up to 500 MHz. However at these higher frequencies we have to take into account the interference coming into the cable from outside, whether from adjacent cables (most likely) or any external source. Interference from outside the cable is classed as Alien Crosstalk and now becomes ANEXT and PSANEXT.

There is a fundamental difference between alien crosstalk and the ‘in-cable’ sources of interference described above. The insertion loss, return loss, NEXT and FEXT is predictable. These parameters hardly change so the transmitting device can measure these effects itself and make corrections for their damaging effects on the transmitted signal. This ability has a huge effect on the cable to cope with this internally generated noise and still transmit gigabit speed signals.

Alien crosstalk is not predictable and so the digital signal processing techniques cannot cancel it out. This is why alien crosstalk has become the limiting factor in 10GBASE-T transmission.

Practical considerations

If Alien crosstalk is the limiting factor then there are only two ways to combat it. The first is a metallic screen around the cable and the second is to arrange significant physical distance from the source of interference.

Screened cables deal with alien crosstalk, and all forms of interference, very well. Unscreened cable however must take the latter route and also use a number of ‘mitigation’ features to assist the solution of the crosstalk issue.
Unscreened cables employ a number of devices to minimise the alien crosstalk. The main one is an enlargement of the overall cable diameter. The TIA standards have been changed recently to allow cables to be up to 0.354 of an inch in diameter; that’s nearly 9 mm!

Not all UTP Cat 6A cables are circular and to use less material they have adopted a range of oval, elliptical and even triangular shapes, or have plastic wires placed under the sheath to give a wider effective diameter. Even if the cables aren’t solid they still have the effect of taking up the same space as a circular, solid 9 mm diameter cable. The cables also employ methods of spiralling the conductors down the cable so that when two cables are lying parallel the pairs within the cable won’t be lying directly parallel over the whole distance.

The effect on the cross sectional area taken up by bundles of these cables is dramatic. Going from conventional 6 mm diameter UTP Cat 6 cables to 9 mm takes up 225% more space.

There are also the mitigation factors recommended for the use of unscreened cable such as separating out patchcords and unbundling cables wherever possible. There is also a question over whether unscreened cables can meet the EC and FCC directives for electromagnetic compatibility at these frequencies.

Screened cable, where each pair has an aluminium foil wrapped around it, handles alien crosstalk much better, and has no EMC issues. Screened Cat 6A cable is typically around 7.5 mm in diameter, and although bigger than standard Cat 6, it is significantly smaller than unscreened Cat 6A. Screened cable must be installed properly and correctly earthed if it is to perform according to expectations.

What are the testing implications?

Hand held testers for use in the field can measure all the ‘internal’ noise sources and electrical parameters such as insertion loss and NEXT up to the required 500 MHz. However measuring alien crosstalk between cables will be much more demanding. It will be impractical to test every cable link due to the huge amount of combinations possible. At present there is no portable equipment that can do this job anyway but the cable field-tester manufacturers are developing ways of modifying existing equipment to test some of the cable bundles for alien crosstalk.
Alien crosstalk tests in the field are not part of the required acceptance tests, not yet anyway. Most manufacturers will be proving their components as proof of concept performance in a lab. Many customers, especially those contemplating using existing Cat 6 UTP, would be well advised however to make some general alien crosstalk tests to demonstrate the performance of their existing plant.

**Conclusion**

Although IEEE 802.3an has been published, the other component and test standards haven’t. Buyers need to carefully consider the implications of buying 10GBASE-T components today in terms of extra space required for UTP variants, mitigation factors needed when using UTP and the test requirements for proving alien crosstalk performance in the field. Screened Cat 6A cables will be smaller than their UTP equivalents and will not suffer from alien crosstalk or any EMC issues.

Finally, ten gigabit Ethernet isn’t the only show in town, and a copper version of Fibre Channel is being developed for data centre SANs. The proposal, from the latest draft ANSI Fibre Channel standard, suggests that only augmented Cat 6 will be able to offer 100 metres transmission for the new four gigabit copper ‘Fibre’ channel standard. Yet another reason to consider Cat6A for new data centre installations.
References

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ANSI/TIA-TSB-155; Additional guidelines for 4-pair 100 ohm Category 6 Cabling for 10GBASE-T Applications.

ANSI/TIA/EIA-568-B.2-10 (draft, 2006); Transmission performance specifications for 4-pair 100 ohm augmented Category 6 cabling.

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Amendment 1.2 to ISO/IEC 11801 2nd edition

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