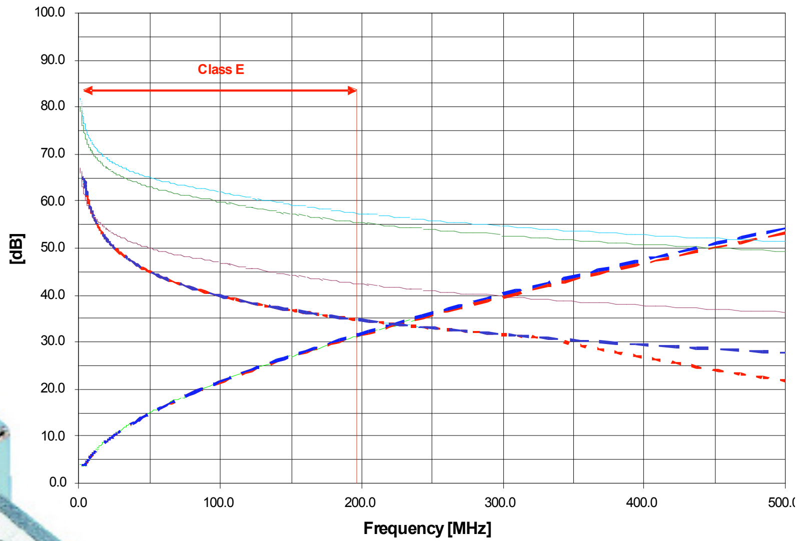
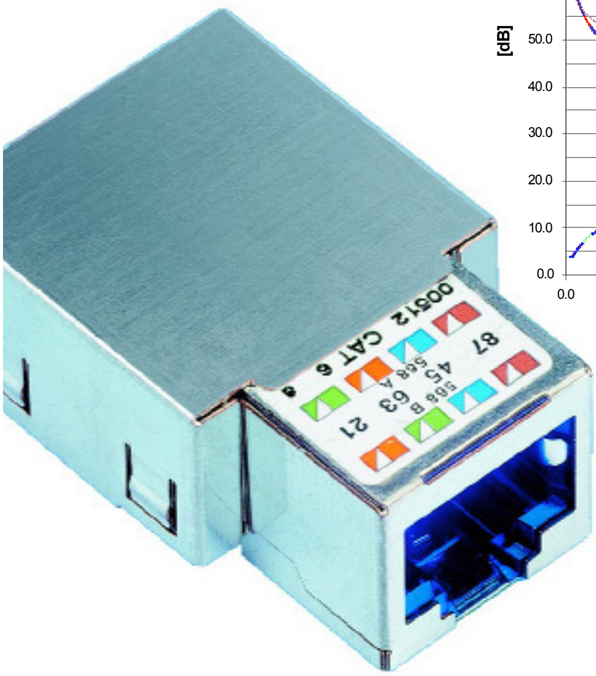
Technical article





10 Gigabit Ethernet over Copper

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Convincing cabling solutions

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The challenge for IT managers and end users:
Planning an installation without a finalized standard.

10 GbE over fiber is up and running. 10 GbE over copper is on the way: The new IEEE standard should be ready by the summer of 2006. Unfortunately, many IT managers, planners and end users already need to move forward with the necessary infrastructure. Cold, hard facts are what you need now if you want to keep your decision-making on the future-proof side of things.

Author: Regina Good-Engelhardt

There are certain driving forces behind the push for 10 Gigabit Ethernet in enterprise networks, including greater bandwidth, unified technology and lower overall costs. 2002 saw the release of IEEE 802.3ae, the standard for 10 Gigabit Ethernet over fiber (10BASE-xx). Market growth has been strong since that point as component costs have dropped. 10 Gigabit Ethernet seems to have a clear shot at becoming the dominant technology from the corporate backbone to the wide area network (WAN).

10 Gigabit Ethernet is also pushing its way into the workplace and thus into the horizontal building cabling. Due to prohibitive costs, however, fiber is not an option at this time. Copper is the only way to go. Unfortunately, IEEE 802.an, the standard for 10 Gigabit Ethernet over copper (10GBASE-T), will probably not be released until the summer of 2006. Before the exact requirements have been assessed, the relevant workgroups at the ISO/IEC and EIA/TIA cannot release any binding recommendations for the cable specifications. However, an "augmented" Cat. 6/Class E specification is now under discussion which is causing confusion among IT managers, planners and end users who need to make decisions about their installation now.

A state of flux

Let's face it: It happened before. Prior to November 2002, as the standardization bodies were working on norms for Cat. 6/Class E, many manufacturers took advantage of the confusion about classes and categories to disguise the true performance of their products. Now, it's happening again: Certain manufacturers are offering "augmented" Cat. 6 products despite the fact that no limits are defined. Some players have even gone so far as to guarantee 10 GbE viability based on specifications that are still under development. Under these circumstances, it is very tough for decision-makers to know whether they will really get what they are paying for.

Of course, an understanding of the facts of the matter helps to make a rational decision.

The technology

10 Gigabit Ethernet will use application-neutral, structured copper cabling as described in ISO/IEC 11801. All four copper pairs in the cable will be used in full-duplex mode so that each pair will have to be able to transport 2.5 Gbit/s in each direction. This will require some complex encoding techniques to achieve. Until very recently, the IEEE preferred pulse amplitude modulation using five different levels (PAM-5). This would

require a transmission bandwidth of 625 MHz. However, the current discussion is tending towards DSQ-128 PAM 16 encoding with a bandwidth of 500 MHz.

The range is dependent on the losses and interference. The crosstalk among the four copper pairs within the cable can be largely suppressed using active components. If the copper pairs are individually shielded, the crosstalk should be low anyway. However, interference from adjacent cables tends to be more dramatic.

So far, research by the IEEE workgroup has shown that alien NEXT (Near-end crosstalk = Interference from other cables) is the most critical factor when attempting to achieve 2.5 Gbit/s per copper pair. This is a problem only with unshielded twisted pairs (UTP). However, interference can also affect shielded cabling in systems where the cable is shielded as a whole. The best solution involves the use of modules that are individually shielded.

Standardization

The IEEE is working to promote the 802.3an standard for 10GBASE-T. The current plan involves four channel models with different ranges (see table 1).

Channel model	Cable type	Range
1	Class F	100 m
2	Class E UTP	55 m
3	Class E shielded	100 m
4	Class E UTP, NEXT-optimized	55 m < L ≤ 100 m

Table 1: Channel models from IEEE 802.3an (as of July 2004)

At the same time, the workgroups at the ISO/IEC (JTC 1/SC 25 WG3) and TIA/EIA (TR-42) are developing relevant cabling specifications. The results will come in the form of addenda to ISO/IEC 11801:2002 (2nd edition) and TIA/EIA-568-B.2.

As of the latest meetings of the TIA group in October 2004 in San Antonio, Texas and the ISO/IEC group in January 2005 in Mexico City, the trend is towards an “augmented” Class E:

- The Class E limits which were previously specified up to 250 MHz will be extrapolated on a linear basis up to 500 MHz.
- The channel insertion loss (IL) will have to meet the Class F specification from ISO/IEC 11801.
- Limits for the critical crosstalk values such as alien NEXT will be specified for the first time.

The objectives

For the IEEE 802.3an standard to succeed, transmission must be feasible via most existing cabling systems. Everyone involved, including manufacturers of the equipment and software, has an interest in seeing this happen. In this aim, the IEEE has even considered using Cat. 5e/Class D as the transport medium. However, this approach was abandoned for technical reasons.

The tactic has now shifted towards an “augmented” Cat. 6/Class E, but just what does “augmented” mean? In precise terms, this concerns the standard and not the installation material. The reason is that if a cable works well up to 250 MHz, it will probably be okay up to 500 MHz. So it is actually the quality of the existing installation that is the determining factor for 10 GbE. Of course, the cable manufacturer needs control over its manufacturing processes. Quality-conscious manufacturers like R&M have already had their Cat. 6

connecting modules tested in a “de-embedded” fashion by independent laboratories. R&M chose to work with 3P. Since 2002, R&M has also had its channels tested by 3P up to 600 MHz.

Cat. 6 or Cat. 7?

Here’s a question: Why not just immediately move on to Cat. 7/Class F if you need a new installation anyway? The cables are not really any more expensive relative to the overall installation costs and this would provide some reserve for the future.

Well, the problem is in the connectors. If you wish to take advantage of Cat. 7 cable specifications, you also need Cat. 7 connecting modules. There are two systems currently available. Both are standardized but they are incompatible. IEC 60603-7-7 is based on RJ45 and can claim backwards compatibility since the connecting module can also be used as a RJ45 Cat. 6 connection with standard patch cables. IEC 61076-3-104 leaves the old concept behind but provides better specs: The connection is specified up to 1.2 GHz (twice the 600 MHz provided by Class F).

What has happened here is that users must choose between two systems which are standardized but which have the typical problems of proprietary solutions. Moreover, if the terminals are not equipped with Cat. 7 connectors, a hybrid cable will be needed to connect them. By the time you reach the end with the RJ45 connector, all of the benefits of Cat. 7 are lost.

Shielded or unshielded?

There is another important issue: Should you use shielded or unshielded cabling? The critical parameters are alien NEXT and common noise. If you install shielded Cat. 6 cables and connectors, you won’t have any problems with such interference. But what if you want to keep using your recently installed UTP cabling for 10 Gbit/s too? In new installations, the (initially) lower price of UTP can also be very enticing. Many manufacturers are even advertising “augmented” UTP cabling which they guarantee as “ready for 10 GbE”.

Decision-making based on facts

The main issue is not how these manufacturers can guarantee conditions which have not yet been defined. The real problem is the potential for disappointment over technical issues.

Alien NEXT is not a property of the material or the components. It is a function of the installation. How many cables are situated too close to one another and how long are the cable runs where this happens? How closely spaced are the connectors in the patch panels and the outlets?

These are the problems currently faced by the EIA/TIA and ISO/IEC workgroups. How do you go about defining suitable measurement techniques? With shielded cabling, the crosstalk between the four copper pairs is well-defined and even premeasured by the manufacturer. The actual installation will not influence the results. However, with unshielded cabling that is installed in groups of, say, 20 cables in a shaft, the potential for crosstalk undergoes an gigantic increase. The workgroups still have much research to do before they can come up with a practical measurement technique.

With shielded cabling, you can assume that the installation complies with the specifications without making any measurements. With unshielded cabling, since you need to make measurements, the results cannot be known beforehand. In many cases, the results will indeed be satisfactory. If not, the manufacturer can simply point to its proven cable and component specifications. This turns the installer into a scapegoat who is left to clean up the mess. But it is the customer who ends up paying.

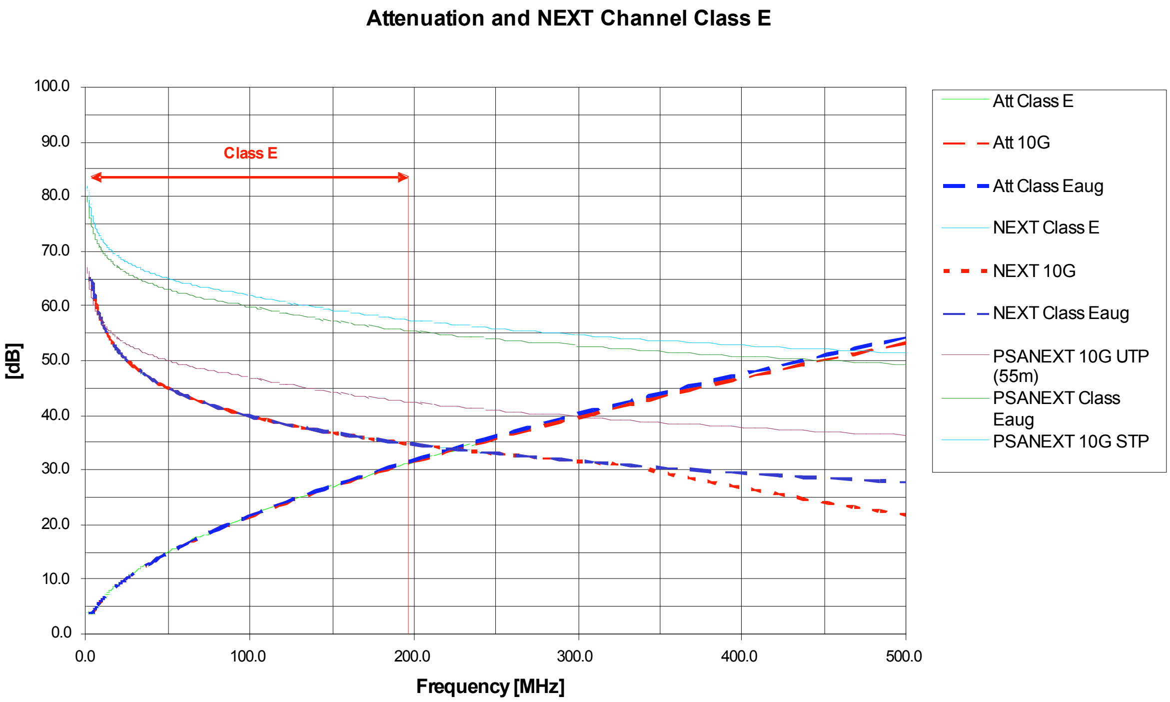

Fig. 1: Limit curves for Cat. 6/Class E up to 500 MHz. The graph shows the planned extrapolation of the limits.

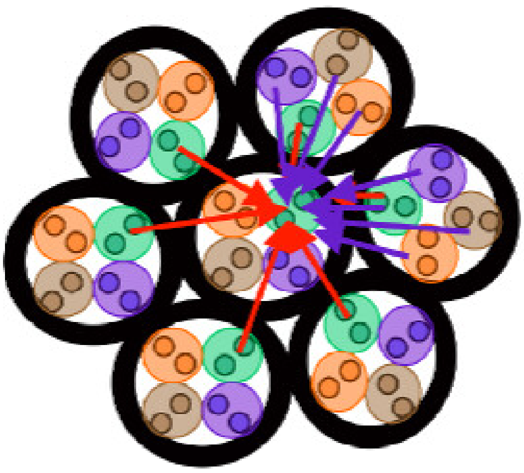

Fig. 2: Crosstalk between cables based on the troublesome case of a "6 around 1" configuration.

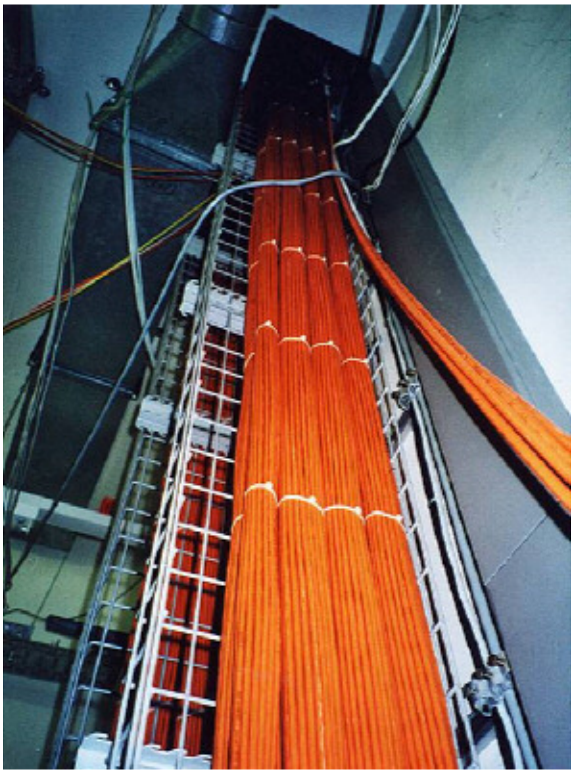

Fig. 3: Alien NEXT becomes critical when many unshielded cables are laid in parallel over long distances as shown here in a riser zone.

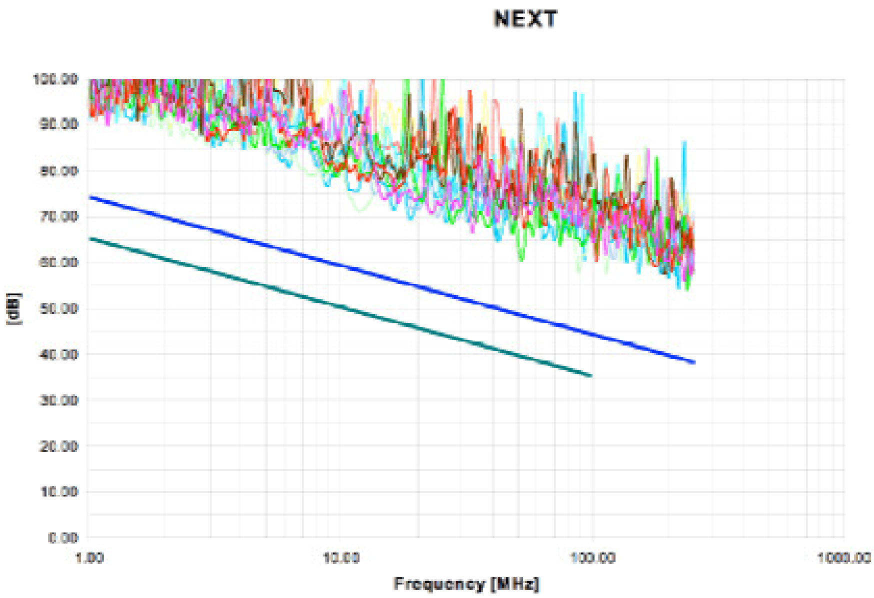

Fig. 4: Internal NEXT (near-end crosstalk) for a single cable with a length of 5 meters. Shown are the limit curves for Cat. 5 (green) and Cat. 6 (blue).

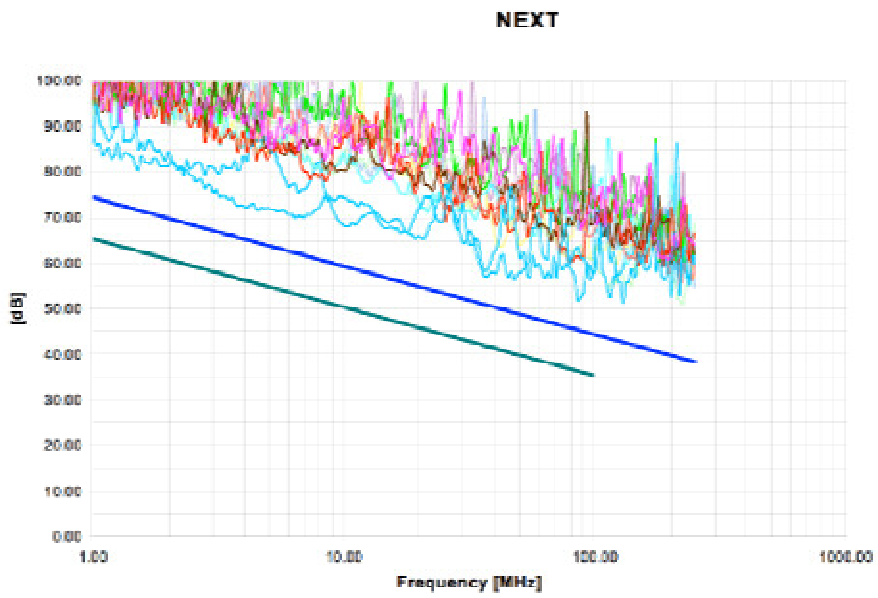

Fig. 5: In a cable bundle with only three unshielded cables, the alien NEXT is already approaching the limits for NEXT. The cable length is 5 meters (as before).

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R&M is a member of the ISO/IEC workgroup JTC 1/SC 25 WG3 and is actively involved in the cabling specification process.