MOLEX PREMISE NETWORKS WHITE PAPER

BEYOND CATEGORY 5 - THE DEVELOPMENT OF COPPER CABLING REQUIREMENTS FOR GIGABIT ETHERNET

1991 saw the introduction of two Technical Systems Bulletins, TSB 36 and TSB 40A, which defined the parameters for cables and components respectively up to 100MHz. These bulletins were eventually incorporated into the top level TIA/EIA 568A standard. Similar component specifications were also written into ISO/IEC 11801 (International) and EN 50173 (European) cabling standards published in 1995. These component specifications and their associated channel and link definitions provided a "blueprint" for a generic cabling system which active equipment manufacturers could use as a baseline for cabling system performance when considering the design of transmission and reception hardware.

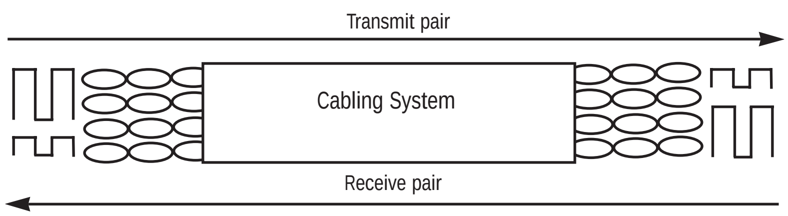
The upper frequency for Category 5, defined as 100Mhz, has since been regarded as sufficient bandwidth for manufacturers of networking hardware and end users alike, offering data rates above 100 Mbps through 155 Mbps and potentially higher with advanced compression and encoding algorithms.

As technological advances were realised, protocols such as 100 Base TX offering switched 100 Mbps Ethernet were beginning to be considered too slow, showing parallels with the processor speed developments in the computer industry. Consequently active equipment manufacturers began to develop Gigabit Ethernet products and an IEEE task group was established to begin the standardisation process. Initially these developments were conceived with optical fibre as the cabling medium of choice and the Gigabit capability regarded as an integral part of the backbone architecture. Inexorably, however, thoughts turned to a paradigm involving Gigabit capability on copper in the horizontal segment and therefore, around 1997, manufacturers started investigating higher bit rate Ethernet transmission up to One Gigabit or 1000 Mbps over standard Category 5 cabling.

In parallel, as Category 5 cables and components became somewhat commodity items, cabling system manufacturers began to stretch the available bandwidth of cables and connectors in search of greater market share. It became evident that the frequency response ceiling, set at 100 MHz in the early 90's, could be relatively easily extended out towards 350 MHz. Subsequently many cable manufacturers would market cables which met "the Crosstalk and attenuation limits for Category 5 cable when extrapolated to 350 MHz" (it should be noted that this is not the same as "operable at 350 MHz").

As the exploration of Gigabit Ethernet continued it became clear that the transmission technology required to achieve 1000 Mbps over a 100 metre distance was not adequately supported by the physical manifestation of a minimally compliant Category 5 channel as defined by EIA/TIA 568 et al. It is important to realise that when the category 5 specification was originally drafted the highest speed data networking protocols were the now ubiquitous 10 Base T Ethernet variant and the less common 16 Mb Token Ring system. Both of these protocols defined differential transmission utilising a single transmit and a single receive pair (see Figure 1) and consequently the category 5 specification was built around the requirements of these systems and the (then) emerging specifications for TPPMD, (the FDDI over copper proposal). Gigabit Ethernet would require something in addition.

DIFFERENTIAL TRANSMISSION (FIGURE 1)



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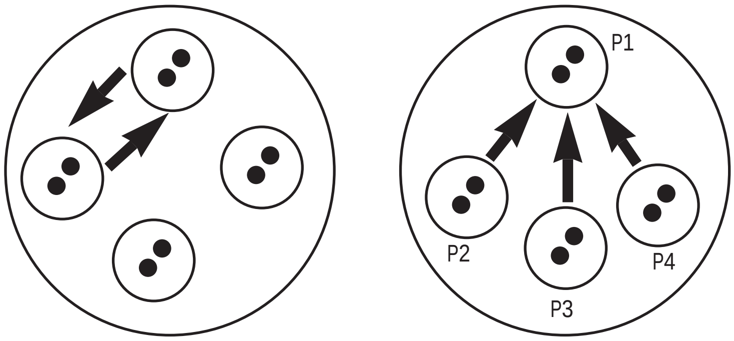
The proposal for 1000 Base T is for a half and/or full duplex system operating on 4 pairs of category 5 unshielded twisted pair cabling, which poses some fairly daunting challenges.

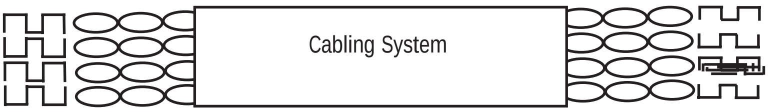
The first identified issue was the idea of simultaneous transmission on all four pairs, as this was at variance with the idea of pair to pair Crosstalk as specified for Category 5 systems, what was required was a way of expressing the effect on any one pair, if all others were energised and thus the specification of PowerSum Crosstalk in 4 pair systems was indicated. (see Figure 2)

POWERSUM CROSSTALK

FIGURE 2



As the transmission is taking place in the same direction concurrently, it is also important to consider the effect of Crosstalk at the far end of the cable, as the receiving equipment has to deal with simultaneous attenuated signals (see Figure 3)

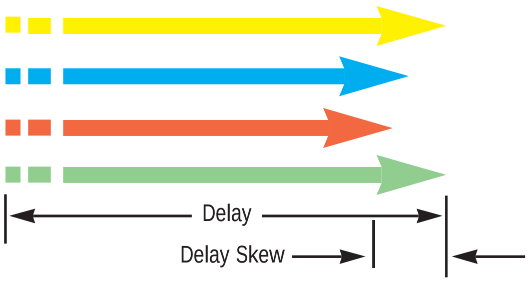


POWERSUM FAR END CROSSTALK (ELPSFEXT) FIGURE 3

This has lead to a requirement for the specification of Far End Crosstalk, which because it is referred to an attenuated signal is known as “Equal Level” far end Crosstalk or ELFEXT. It is also important to bear in mind that all four pairs are also energised at the far end of the cabling system and therefore PowerSum ELFEXT must be specified in addition.

Since the head end transmitter separates the Gigabit data stream into four equal parts for transmission, it becomes important to have control of the delay introduced by the cabling system. More importantly because, due to the variance in twist rates between the pairs in the cable (used to control Crosstalk), transmission on each pair takes a slightly different time. As the signal has to be recombined at the receiver end, the difference between the fastest and slowest pair is also important. Consequently a specification for the delay is required and also the delay skew (see Figure 4)

DELAY AND DELAY SKEW (FIGURE 4)



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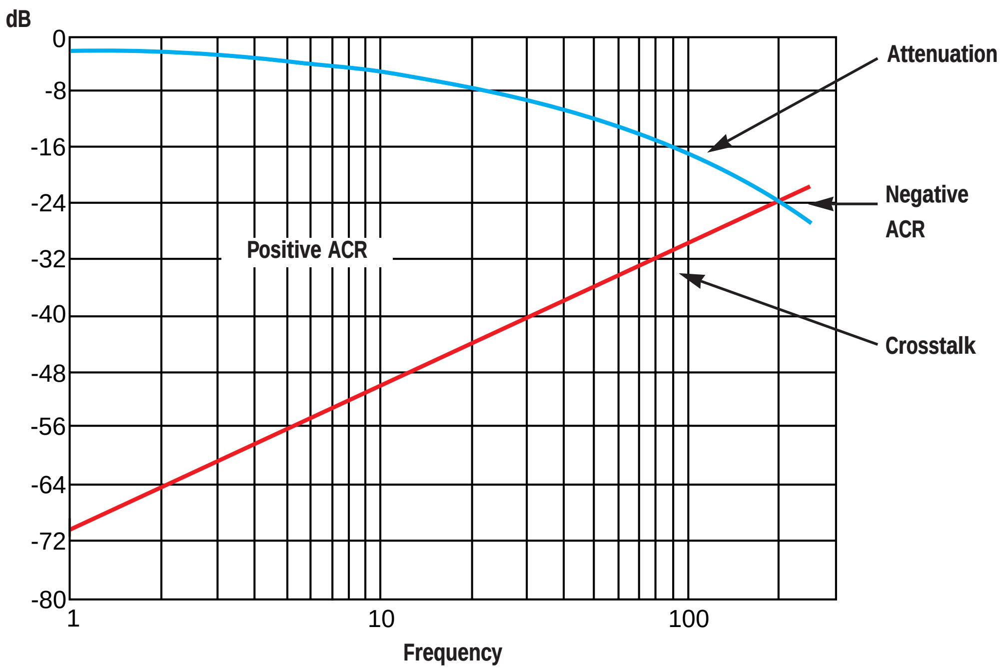
Minimum requirements for these measurements will now be added to the existing Category 5 specifications in order to enhance the Category 5 systems. This will manifest itself as an “amendment” to ISO 11801 and EN 50173 and as a TSB from EIA. Very importantly though, these will not be a specification for Category 6; the ISO/EN amendment will still be called Class D, the EIA TSB refers to category 5+ or enhanced category 5.

The main objective of these amendments is to allow current and emerging technologies such as 1Gb Ethernet and possibly even 1Gb Token Ring, to utilise an enhanced Category 5 cabling infrastructure.

Mention was made in an earlier paragraph of Category 6 and much has been said in the press and in manufacturer claims recently about Category 6 and 7 products. The following is a brief outline of the current state of affairs:

In terms of Category 6 the main objective is to keep 4 twisted pair, 100-ohm cable as the preferred medium. The intention is to provide a positive attenuation to Crosstalk ratio at 200 MHz with a cable and component specification to 250 MHz on the basis that IEEE believe DSP algorithms will be able to recover usable data from the negative ACR portion of the frequency response of a cabling system (see Figure 5).



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Besides these two very important issues, there are some further considerations, and the first of these concerns the "system side" panel. In a traditional structured cabling system a panel is employed to allow for the convergence of multiple equipment interface connections into the standard RJ 45 connector interface employed. Thus the system side panel represents additional connections and therefore has a Crosstalk and attenuation budget. Since the majority of current active equipment is already RJ 45 based, the contention is that the system side panel is redundant and therefore the transmission budget could be spread amongst the remaining components making their individual performance requirements less severe.

The same argument applies to the question of the allowance of a consolidation point, this being a "flexibility" point within the horizontal cabling which also represents an additional conneCtion

The last two points concern attenuation. Firstly the attenuation of the horizontal cable, IEEE would prefer to see a reduced cable attenuation profile as this will be advantageous to the DSP algorithm designers but this implies an increase in the diameter of copper employed and therefore a cost increase. Secondly the question remains as to whether there will be harmonisation between the 120% attenuation allowance for patch cables specified by EIA and the 150% allowed by ISO/EN standards.

Conclusion

Category 6 does not exist yet - the first published specification will probably not be available before December 2000.

There are no current applications which demand Category 6.

"Good quality" Category 5 systems will support Gigabit Ethernet in the majority of cases however Enhanced Category 5 systems will allow transmission speeds of at least 1Gbps using current technology with more assurance.

The cost increases implicit in Category 6 and 7 cabling systems and the reductions in the cost of fibre NIC's point to fibre being potentially more cost effective as a long term solution.

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