Avoiding the Category 6 Danger Zones *October 2003*

The ratification of the Category 6 standard has undoubtedly fueled customer's confidence in this high performance cabling; however achieving the required infrastructure performance often means accepting a restrictive choice of channel lengths, configurations and components. Since awareness of these restrictions is new to most customers, this article aims to help customer's understand the limitations of the standards, and how they can be overcome.

Since standards-based performance parameters are minimum requirements, customers should be concerned about relying on a cabling system that is just "compliant". Many factors occur in the field that can cause these minimally Category 6 compliant cabling systems to fail or provide less than expected performance. The standards cater for some of the phenomena by stating limitations/ assumptions to qualify the performance stated. Three examples of such limitations are 'short link resonance', 'the 15 meter rule', and 'four connections in a channel'.

To overcome these, a network needs an end-to-end structured cabling solution, designed and built for performance with nothing left to chance. This is far from simple since the science underlying many cabling issues is complex. Variations in cable and cord lengths, number and type of connectors and connector direction all influence performance. The tool to see, understand, simulate and tune all transmission effects in a four-pair cabling system is the Modal Decomposition Modeling (MDM) developed by Systimax Labs. This tool has been used to develop the top performing Cat 6 solutions in the industry.

Some Theory

There are two types of signals that can co-exist in a four-pair cabling system. Differential mode signals have equal but opposite polarity traveling on the two conductors of a pair. Common mode signals have equal and the same polarity. Differential mode signals are generally preferred, while common mode signals are undesirable. Unfortunately, due to the imperfection of the transceivers, common mode signals always exist. Imperfection in cable and connecting hardware can also create additional common mode signals.

Modal decomposition is a sophisticated tool to analyze the interaction of these signals. The concept of modal decomposition is based on a theory of multi-conductor transmission lines. When a differential or common mode signal strikes a boundary, i.e. from a cable to a connector, it will be scattered into multiple waves. Some will continue to propagate through, while others will be reflected. These waves may be either differential mode, common mode or a combination of both. Modal decomposition recognizes all transmission modes that are naturally present in a multi-conductor transmission system.

Modal measurements quantify all these modes and their interaction to help us understand the transmission phenomena occurring in cabling in much greater depth.

The Application of Modal Decomposition Modeling

The benefit of this innovative platform is not only measurement accuracy but also its ability to mathematically cascade individual components into a link or a channel. Each component such as cable, cordage and mated connector, is characterized by a data file is stored in computer. A virtual link or channel can be constructed by using these characterized components from a database of such measurements. Through a mathematical process, one can simulate a link or a channel as if all components were physically connected. The correlation between the simulated channel and the actual channel has been established at Systimax Labs.

In practice, not every link or channel will use up the maximum distance allowed by the standards. In most cases, the horizontal cables are shorter than 50 meters. There is a false assumption that a link or a channel with the maximum distance can be used to identify the worst-case performance. This assumption may be true for insertion loss, ELFEXT and PSELFEXT. However, this is not the case for NEXT, PSNEXT and return loss. The interaction of multiple connectors in a short link starts to surface because the cable attenuation may not be strong enough to taper the multiple reflections and couplings caused by connectors. If the connecting hardware is poorly designed, the degradation of system performance is inevitable under these conditions. An example of this is a strange phenomenon called the "**short link resonance**". Category 6 components that meet all the industry standards can potentially still fail Category 6 channel specifications in a short link/channel. The channel failure is due to unbalanced transmission resonance between close spaced connectors, where the cross modal conversion of the connectors is too high. In addition to the pure differential crosstalk between pairs, common mode crosstalk is generated and converted back to the differential mode and becomes additional crosstalk causing a severe resonance in the channel. This additional coupling is not part of the original design criteria and may only occur in certain conditions, which makes the problem more irritating as it cannot easily be predicted.

Resonance occurs when multiple connectors are placed in close proximity with specific lengths between multiple connectors. The only way to ensure all possible configurations have been accounted for is to simulate all foreseeable combinations or perform massive bulk testing. It is very important to assure that the guaranteed claims of a solution are derived from an extensive modal simulation of all conceivable configurations; thousands of simulations should be done for each channel or link configuration. This powerful simulator allows Systimax Labs to assess the link and channel performance much more accurately than by methods adopted in the cabling industry at this time. There is no need to physically setup bulky links and channels for testing, nor sacrifice the sample size to accommodate space. Any large installation sites with multiple link and channel configurations can be simulated.

Established cabling performance models do not account for this complexity, and so cannot predict dramatic reductions in performance occurring with some combinations of cabling and components. Individual component specifications do not guarantee cabling channel performance.

Enabling Design Options beyond the Standards

The illustration below shows the ANSI/TIA/EIA-568-B1 Commercial Building Telecommunications Cabling Standard and ISO/IEC 11801 Information Technology-Generic Cabling for Customer Premises defined channel configuration containing up to four connections. If a solution must conform to the TIA and ISO standards, cabling configurations are limited to **a maximum of four connections in the channel**. A maximum of two connections is allowed at either end of the channel.

The 4-connector channel limits are based on 90 m of horizontal cable, a work area cord, a telecommunications outlet/connector, an optional transition point close to the work area, and a cross-connect in the telecommunications closet. The combined length of equipment cords, patch cords, and jumpers shall not exceed 10 meters. A 15 meter minimum length of cable between CP and C1 in the figure above is recommended by TIA/EIA 568B, and is required by ISO/IEC 11801 2nd Ed. This is a limitation often referred to as the **'15 meter rule'**.

The connections to the equipment at each end of the channel are not included in the channel definition.

To exceed the current performance requirements established by the standard specifications, the answer is the GigaSPEED XL solution from AVAYA. Through the extensive testing and performance simulation possible with the MDM tools, the GigaSPEED XL solution overcomes the limitations of 4 connectors and the '15 meter rule'. The solution performance allows additional design options; all covered by an extensive manufacturer's 20-Year Extended Product Warranty and Application Assurance Program.

Standards Defined Channels:

GigaSPEED XL Additional Channel Flexibility: GigaSPEED XL allows for up to six connections in a channel, providing additional flexibility for example to customers that need to support additional cross-connection configurations, redundancy patch points, or designs for extending the flexibility of Open Office cabling. The extra connectors may be used anywhere in the channel.

Reaping the Benefits of Performance Tuning and Margin

Modal Decomposition Modeling (MDM) was used in development of the GigaSPEED XL Solution. Using simulations of thousands of possible channel configurations, the solution is designed so that performance with margin above Category 6/Class E standards is always guaranteed. The GigaSPEED XL Solution offers improvements on ALL key electrical parameters, such as:

1. ACR
2. PSACR
3. Return Loss
4. ELFEXT, and
5. NEXT.

Using NEXT, a critical electrical parameter in Category 6, as an example for a standards based 4 connector channel, the GigaSPEED XL7 Solution NEXT electrical performance is:

"6 dB beyond the Category 6 standards across the entire frequency range (1 - 250MHz)"

Additionally, the use of MDM in the design of the products allows additional design and installation flexibility with up to six connectors positioned anywhere in a channel and channels of any length up to 100 meters.

FINAL NOTES

1. Differences do exist between the major cabling standards
2. Current cabling standards do not provide the complete picture: only deal with balanced transmission mode requirements
3. Standards may not guarantee interoperability between different vendors in all configurations – an end to end solution guarantee from a single manufacturer is recommended
4. Current cabling standards have design limitations – solutions like the GigaSPEED XL overcome these limitations