

The Need for Speed: New Challenges for UTP Cables

Introduction

The advances in transmission technology have presented the LAN cabling industry with a set of new challenges. Today's high speed gigabit based equipment works much differently than their 10/100 Mbps predecessors and as such requires better performance from the cabling infrastructure to support these applications. In particular, full duplex, parallel transmission, transmission echo and advanced signal processing present new constraints that demand higher performance cabling.

Full Duplex, Parallel Transmission

With twisted pair cable, cross-talk is always a major concern because it typically is the largest contributor for noise on a circuit. With standard 10/100 Mbps Ethernet transmission, only two pairs are required for operation: one to transmit and one to receive. Each pair can be considered a simplex circuit in that it only transmits in one direction at all times. Cross-talk occurs, but the effect is limited because only one pair induces noise on the other pair (referred to pair-to-pair near end cross-talk or NEXT).

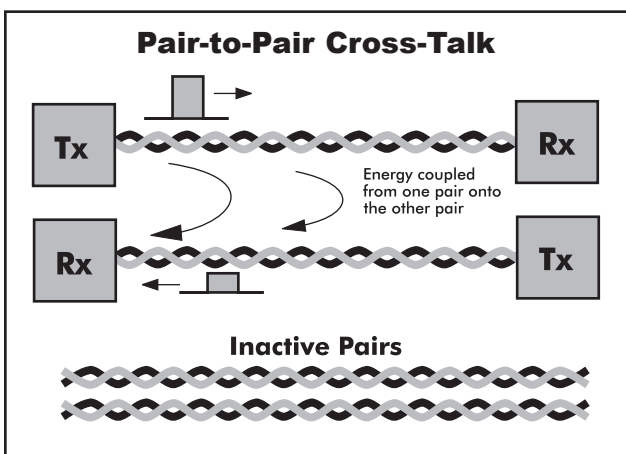


Figure 1

To reach speeds of 1 gigabit or more, the transmission scheme becomes more complex. Instead of two pairs, four pairs are required for transmission (often referred to as parallel transmission). Instead of simplex transmission, each pair must support full duplex transmission which means it must transmit and receive in both direc-

tions simultaneously. The cross-talk noise induced on a pair now comes from three transmitted signals on the receiver end (power sum NEXT) and three transmitted signals on the far end (power sum FEXT).¹

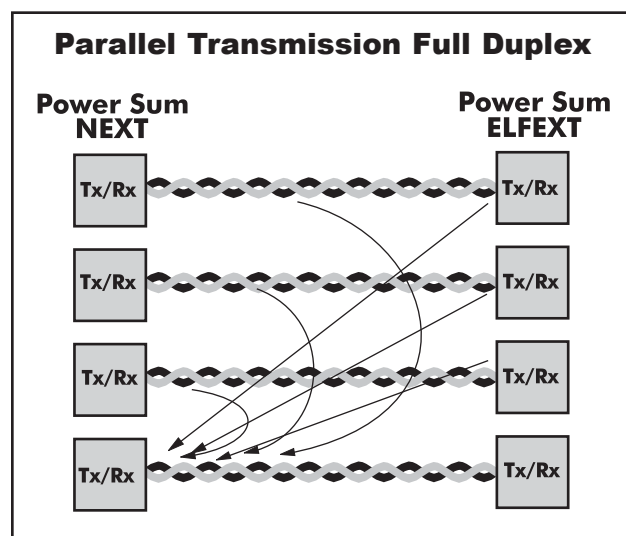


Figure 2

The initial ANSI/TIA/EIA 568A did not account for the added cross-talk noise from the 5 additional transmitted signals. It defines the minimum requirements for a pair-to-pair simplex transmission. A cable may pass the Category 5 requirements, TSB-67 field test, and work at 10/100 Mbps speeds, yet fail under the loads of full duplex, parallel transmission. This was addressed with addendum 5 of ANSI/TIA/EIA 568A with the creation of Category 5e UTP. This was further standardized with the creation of ANSI/TIA/EIA 568B.2 in May of 2001.

Transmission Echo

In addition to power sum cross-talk, a new noise source arises when full duplex transmission is used. When the transmitter injects a signal on to a pair, any reflection of that signal can end up as noise in that pair's own receiver (transmission echo). Signal reflections are caused by impedance mismatches such as connecting a 98 ohm cable to a 101 ohm connector, or by non-uniformities in the cable (i.e. impedance variations).

¹ The key parameter is Equal Level Far End Cross-Talk (ELFEXT). ELFEXT negates the cable's attenuation so that FEXT can be accurately compared from cable to cable.

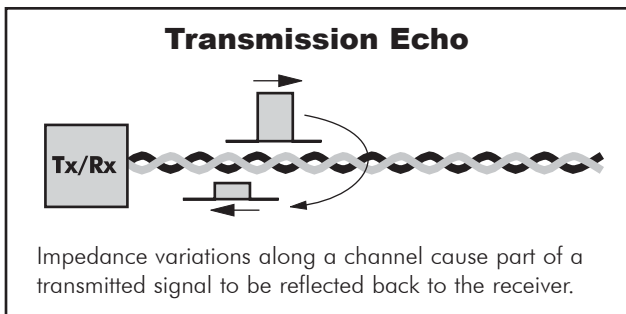


Figure 3

With simplex transmission, signal reflections caused by variations in the cable's impedance did little to effect the transmission. Cables with very poor uniformity tended to have poor attenuation values, but did not directly add significant noise on to the pair since the receiver was not in the path of the reflection.

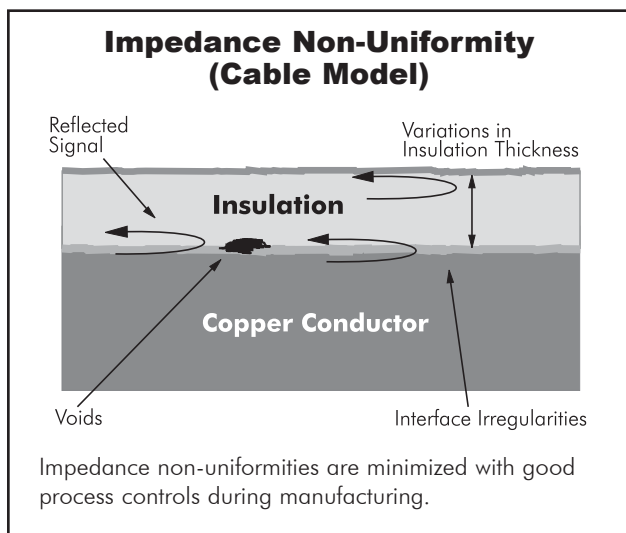


Figure 4

The amount of signal reflection is quantified by a new parameter called return loss. Return Loss (RL) is similar to structural return loss (SRL), but is more stringent to better represent signal reflection for the entire channel. Again the initial ANSI/TIA/EIA 568A did not address return loss and Category 5 compliant cables with poor impedance characteristics may fail because of excessive noise from transmission echo. Of course now return loss is the standard for Category 5e and the recently approved Category 6 standard.

Complex Encoding

Encoding is the signaling method used to send information down a wire pair. While there are many different encoding schemes, they all determine how many bits

may be sent for a given frequency (Hz). Simple encoding schemes such as NRZ (non-return to zero) have a 1 to 1 ratio (i.e. 10 Mbps data rate would require 10 MHz of bandwidth). Higher level encoding such as QAM25 can achieve a 4 to 1 ratio (i.e. 40 Mbps data rate could be sent with only 10MHz of bandwidth).

In data communications, zeros and ones are the binary codes used to communicate. A simple 1:1 encoding method could have two voltage levels: +3 volts to represent the symbol "1" and -3 volts to represent the symbol "0". The differential between the two states is 6 volts and the receiver must be able to discern these voltage states after the cumulative effects of noise and attenuation have degraded the original signal.

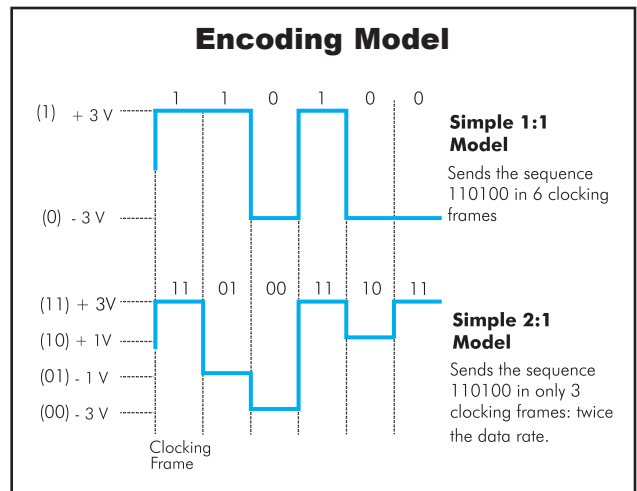


Figure 5

Now, consider a higher 2:1 encoding scheme with four voltage states: +3, +1, -1 and -3 volts. To each voltage state, two symbols are assigned (1,1), (1,0), (0,1) and (0,0). the data rate is doubled using this scheme, but the voltage differential between states has dropped to only 2 volts. The margin of error for the receiver has been significantly reduced while the probability of an error from signal distortions (noise and attenuation) has increased.²

In order to reach gigabit speeds, higher level encoding is necessary. However, the complexity of the sophisticated processors that provide such high data rates makes them very sensitive to noise. Minimally compliant Category 5 cables may support lower speed applications, but they may falter when migrating to more complex encoding.

² A discussion of eye patterns would be a more accurate, but more complex treatment of the subject. However the resulting message is the same.

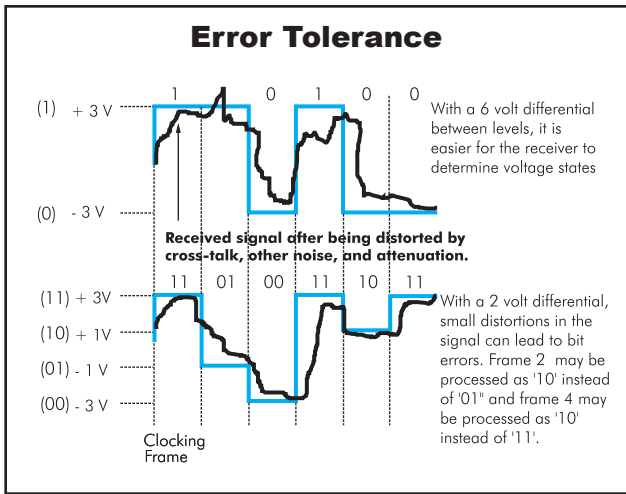


Figure 6

UltraPipe™ - The Next Evolution

With 1 Gbps transmission a reality, there is a need for cable to support communication speeds at and above 1 Gbps. CommScope, a leader in high performance communication cabling, produces UltraMedia™ Category 6 and UltraPipe Category 6e cable designed not just for the current Gigabit standard, but for the stringent demands of multimedia and next generation networks. These cables offer evolutionary advances in UTP performance.

For transmission, the signal to noise ratio (SNR) at the receiver is one determining factor of the bit error rate

(BER) of the circuit. Bit errors ultimately determine the performance level of the network. Since SNR can not be determined until the network is up and running, the closest approximation of a passive channel is its attenuation to cross-talk ratio (ACR). ACR is a good indicator of how well a network will perform.

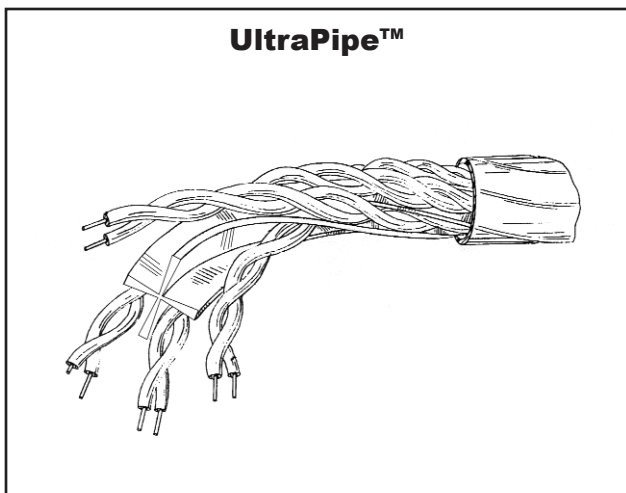


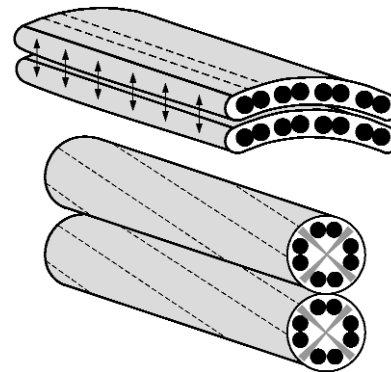
Figure 7

Ultra II and Gigabit Speeds

CommScope has been producing cable capable of the requirements of these next generation applications since January 1, 1995 when we introduced the industry's first enhanced Category 5 cables. The Ultra series cable offers power sum compliant cross-talk performance, an extended frequency range, and superior ACR headroom needed for the higher speed applications all of which are backed by individual test reports verifying performance. So, if you have Ultra product in place, rest assured you have more than enough performance to meet the demands of gigabit networks.

Due to CommScope's revolutionized Isolator™, the UltraPipe provides exceptional cross-talk performance in a round cable design. The new patented design utilizes the Isolator spiral strip to provide separation between individual pairs in the cable. The result is a worst case improvement 6 dB beyond any of the Category 6 isolation requirements (NEXT, PSUM, ELFEXT, PSUM ELFEXT) and 15 dB beyond any Category 5e isolation requirements.

Cable-To-Cable Cross-Talk



During installation flat cables get sandwiched together. Pairs with the same lay length are coupled potentially causing cross-talk when the system is active. Note that each cable may individually pass field tests.

Round cable geometry provides physical separation and the spiral attributes of the Isolator strip randomizes pair-to-pair coupling. Cross-talk between cables is minimized.

Figure 8

Another attribute of the Isolator becomes an important feature when multiple cables are grouped together. It randomizes the pair's lay position so that the cross-talk performance for the cable is maintained in the presence of multiple cables. Flat cable designs suffer from nesting problems with adjacent cables and may induce significant cross-talk. This unaccounted for cross-talk may cause network failures even though each individual cable meets the required specification.

Like all of CommScope's enhanced UTP products, UltraPipe is both power sum NEXT and power sum ELFEXT compliant for assured error free performance under the most demanding full duplex applications.

CommScope's UltraPipe is 3rd party verified and exceeds the current 568B Category 5e ACR values by 18db and the Category 6 ACR values by 6.8db @ 100 MHz. In addition to providing superior headroom performance at 100 MHz, UltraPipe provides the greatest useable bandwidth at extended frequencies with 5.2 dB ACR @ 350 MHz.

While ACR is the most important gauge of network performance, it does not account for ambient noise (noise from electromagnetic sources that permeate the environment where cable is placed). Fluorescent lights, radio transmitters, motors, etc. can create noise that is coupled onto a cable. The ability of the cable to be immune to these noise sources is related to the cable's balance. The better the cable balance (the degree to which each conductor in a pair is identical) the more the cable performs like fiber optics in being immune to noise.

The key to good balance is to maintain consistency throughout manufacturing. Because UltraPipe is manu-

factured with state-of-the-art process controls, its capacitance unbalance (a measure of pair balance) is 58.2 picofarads/100m - a 500% improvement over the standard of 330 pf/100m. These same process controls provide the uniformity throughout the cable manufacturing process so that the final product has superior impedance characteristics which is essential for preventing echo transmission noise.

With so many demands on the cable performance and because many new designs are pushing the limits of twisted pair technology, it has never been more critical to assure the product's integrity. That is why UltraMedia and UltraPipe come with a certified test report attached to each reel or box of cable. By testing out to 550 MHz electronically, CommScope verifies the performance of UltraMedia. UltraPipe is swept to 550 MHz. Without a test report, there is no guarantee the product you buy meets specification.

MHz	Attenuation		NEXT		PSUM NEXT		Return Loss		ACR	
	Ultra II	Cat 5e	Ultra II	Cat 5e	Ultra II	Cat 5e	Ultra II	Cat 5e	Ultra II	Cat 5e
100 MHz	21.0	22.0	40.3	35.3	38.3	32.3	23.0	20.1	19.3	13.3
200 MHz	30.9	32.4	35.8	30.8	33.8	27.8	19.8	18.0	4.9	-1.6
350 MHz	42.6	44.9	32.1	27.2	30.1	24.2	16.3	16.3	-10.4	-17.7
	UltraMedia	Cat 6	UltraMedia	Cat 6	UltraMedia	Cat 6	UltraMedia	Cat 6	UltraMedia	Cat 6
100 MHz	19.7	19.8	47.3	44.3	45.3	42.3	23.0	20.1	27.6	24.5
200 MHz	28.8	29.0	42.8	39.8	40.8	37.8	21.0	18.0	14.0	10.7
250 MHz	32.6	32.9	41.3	38.3	39.3	36.3	20.5	17.3	8.7	5.4
350 MHz	39.5	39.9	39.1	36.1	37.1	34.1	19.8	16.3	-0.4	-3.8
400 MHz	42.7	43.1	38.3	35.3	36.3	33.3	16.9	15.9	-4.4	-7.8
	UltraPipe	Cat 6	UltraPipe	Cat 6	UltraPipe	Cat 6	UltraPipe	Cat 6	UltraPipe	Cat 6
100 MHz	19.0	19.8	50.3	44.3	48.3	42.3	23.0	20.1	31.3	24.5
200 MHz	27.4	29.0	45.8	39.8	43.8	37.8	21.0	18.0	18.4	10.7
250 MHz	30.8	32.9	44.3	38.3	42.3	36.3	20.5	17.3	13.5	5.4
350 MHz	37.0	39.9	42.1	36.1	40.1	34.1	19.8	16.3	5.2	-3.8
400 MHz	39.7	43.1	41.3	35.3	39.3	33.3	16.9	15.9	1.5	-7.8
550 MHz	47.3	51.9	39.2	33.2	37.2	31.2	15.9	14.9	-8.1	-18.7



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