NET CLEAR™
A BERK-TEK / ORTRONICS ALLIANCE

White Paper

Short Links and Channels

Robert A. Aekins
Ortronics Senior Development Engineer
CE, RCDD

Gregg Lafontaine
Ortronics Senior Product Manager, Copper Channel Products

In the years following the establishment of the TIA/EIA 568 cabling standards, many installers have observed that short links or channels have measurably inferior performance values, and higher rate of failure, than longer links and channels. This has come to be known as the "short link phenomenon".

The Initial Blueprint

When the TIA/EIA-568 Standard was introduced, it was assembled around the basic model of no more than 90 meters of horizontal cable, a workstation outlet, a cross-connection and a maximum of 10 meters of patch cordage. Laboratory versions of this channel configuration were used to measure the expected near-end cross-talk noise and signal loss within this model. These links and channels were measured extensively by committee members of the TIA using network analyzers. These tests were used to insure correlation between labs when testing cabling system performance. This data also helped to determine parameters, such as near-end cross-talk, insertion loss (attenuation) and return loss tolerances for each element of the link and channel and was used to refine and validate component specifications. Yet it wasn't until the issuing of TIA/EIA TSB-67, and the introduction of portable test equipment, that field-testing of installations actually became practical. Handheld field testers, though not as accurate as network analyzers, did make contributions that lab testers could not. The use of field testers very quickly and dramatically increased the volume of available test data. Some of this data was used in refining the field testers and testing. Other data identified the performance trends of installation scenarios, which had not yet been fully tested or characterized in the lab.

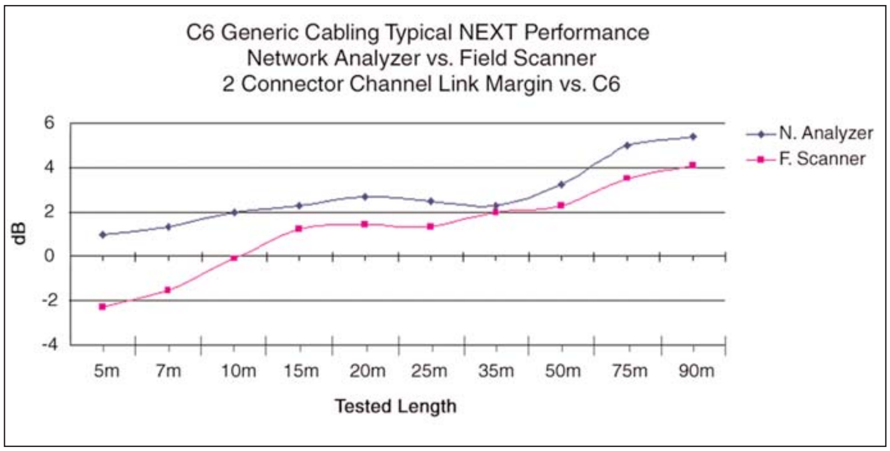
These performance trends revealed the short link phenomenon. Field test results helped to confirm that 90-meter links or 100-meter channels did not always represent the worst case performance. The TIA recognized an issue that the original standards (Category 3, 4 and 5) had not anticipated. In many installations, tests for short links or channels (less than 20 meters) revealed measurably inferior values than longer links and channels. The short link phenomenon was caused by the close proximity of multiple connections and the effects of their accumulative signal imbalances and additive noise.

Early Category 5 examples of this situation were caused in large part by design approaches used with some jacks for canceling cross-talk introduced by the plug end of a cord. The compensation circuitry used by some manufacturers of connecting hardware was excessive or overbalanced, so when two or more connections were combined in a short link, unbalanced additive noise produced resonant NEXT peaks. The issue of excessive unbalance in component compensation design was addressed with the introduction of additional requirements in the Category 5e and 6 component specifications. However, this situation did identify that some types of performance degradation could be more visible in a short link or channel. When tests for near-end cross-talk were conducted, testers identified gr eater levels of cross-talk noise originating from the far end which had not been attenuated due to the short length of the horizontal run. Most importantly, it identified that the 90-meter link or 100-meter channel models did not represent the worst case in all situations and should not be used exclusively when conducting performance comparisons.

What you might see when testing

To demonstrate this phenomenon, several tests were conducted on generic Category 6 channels constructed from components available in the market. When comparing channel tests at different lengths, the erosion of NEXT (near-end cross-talk) margin as the channel lengths got shorter was evident. A configuration of a 90-meter horizontal cable with a panel connection on one end and a jack on the other and two 1-meter patch cords was used to measure the worst case NEXT margin. Testing continued using horizontal cable of shorter lengths down to 5 meters.

By comparing the worst case NEXT margin for the lengths tested, we noticed the highest margin was at 90 meters with a downward trend to the five-meter channel length. The change in NEXT margin was 4.4dB when tested with a network analyzer across the range of channel lengths. The reduction in NEXT margin was even greater when tested with a handheld field-testing device, experiencing a failure below 10 meters in the test example.



Length	F. Scanner	N. Analyzer
5 m	-2.3	1.0
7 m	-1.5	1.3
10 m	-0.1	2.0
15 m	1.2	2.3
20 m	1.4	2.7
25 m	1.3	2.5
35 m	2.0	2.3
50 m	2.3	3.2
75 m	3.5	5.0
90 m	4.1	5.4

Category 5e and 6 help reduce the impact of short link phenomenon

One benefit of the development of the Category 5e specification was the introduction of measurements that could help identify and assist in eliminating the causes of poor short link performance. Adding Return Loss as a measurement of connector and channel balance has helped. Introducing FEXT identified the significance of cross-talk (noise) introduced on the near end but measured on the far end.

Connectors that are now tuned to a narrower range of targets minimize noise effects in a short link. This prevents excessive compensation. Category 5e and Category 6 component testing introduced high and low range de-embedded test plugs for testing NEXT. The new Category 5e and draft Category 6 component specifications identify a narrowing range of performance targets. For example, the Category 5e de-embedded range for pairs on positions 4,5 and 3,6 is 34.4dB to 37.6dB while the Category 6 de-embedded range for the pairs on positions 4,5 and 3,6 is 36.4dB to 37.6dB. Category 6 is a narrower range within the Category 5e range. Improving balance in tandem with noise control minimizes the cumulative effect from the close proximity of the connectors as well as lengths of horizontal cable shorter than 90 meters.

To qualify connectors (jacks and panels) to the TIA Category 6 component specifications, parts must pass testing with a high and low range of test plugs (de-embedded plugs). This high and low range of test plugs defines the window of inter-operability and backwards compatibility. When testing cross-talk for Categories 5e and 6 connecting hardware, high and low plug values for 6 pairings (pairs 1&2, 1&3, 1&4, 2&3, 2&4, 3&4) are used. This requires 12 tests across the entire range of tested frequencies and is intended to represent the range of plugs that might be connected with in the field. Links, channels and assembled components that meet these specs are assured to meet minimum Category 6 field requirements for cross-talk.

The component's role in the short link

The performance characteristics of the mated connector unions significantly influence the performance of the connectivity/connections in a resultant channel. The mated union of plugs and jacks has long been recognized as a contributor to performance degradation. This stems from two primary causes, susceptibility to noise and unbalance. There have been many improvements for controlling the unbalances caused by plug and jack positions 3, 4, 5,and 6, where the pair at positions 3 & 6 is separated by pair 1 on positions 4 & 5.

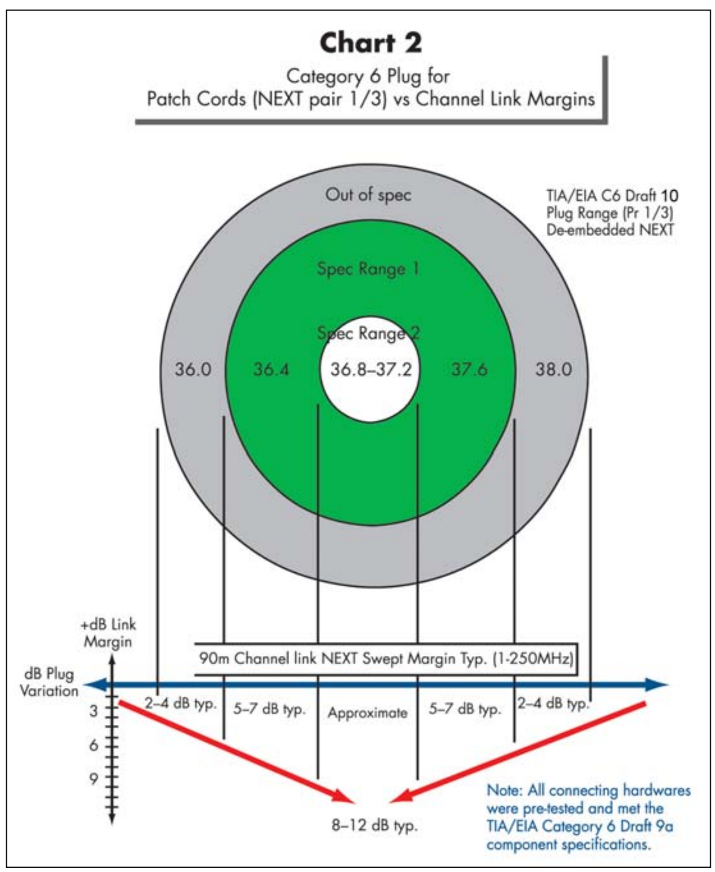
Today, we also understand the advantages of tuning plug-jack connections to make this interface more seamless to the channel. Most first generation Category 6 channel solutions relied on tuning connectivity to achieve a Category 6 field pass. The upcoming ratification of the Category 6 standard requires that this component tuning must also be compatible with the TIA specifications for backwards compatibility and interoperability. Testing has shown that components will perform better with specific de-embedded plug values. We have found additional benefits to tuning all connector elements to the common center values of the TIA test plugs. This tuning to the standards defined center targets of the de-embedded plug range eliminates incompatibility of noise compensation techniques. All jacks, patch panel ports and patch cord terminations share the same precise target. The result is viewable in the lab or in the field with improved cabling system performance.

Equally important is that tuning shows its benefits across all types of installation configurations, links and channels, short or long lengths. This balance must start with a uniform target, and all connectors must be designed to these targets. It does no good to have jack and panel ports with different values since both have to connect with the same patch cord design. In fact, the patch cord terminated plug value should be the foundation value to which all other connectivity is built.

Starting with the patch cord

The perfect cord termination would fall right in the middle range of the de-embedded test plugs that the TIA has identified to qualify connectors (jacks, panels, etc.). The TIA's high and low range of test plugs determines the window of inter-operability and backwards compatibility. At a minimum, cord terminations must fall within this range. However, better performance can be accomplished if design and manufacturing processes can hold tighter tolerances within the range, keeping each cord termination value in the center of this target. More importantly, these cords will experience even better installed performance when mated with jacks and panels that are tuned to the same target plug termination value.

To construct these higher performing cords, manufacturers need to control pairs after they exit the cable jacket, maintaining designed pair twist. The Ortronics design keeps each pair in quadrant separated spacing as they approach the plug contact. This quadrant spacing matches Category 5e and the internal star construction of most Category 6 cable. Prior to being placed under the contacts, conductors are oriented to a plug-wiring format using a balanced separation sled. The sled compartmentalizes and segregates each pair, minimizing the cross-talk effect of adjacent pairs. Cords are then terminated with a plug designed with a proprietary balanced contact array centered to the TIA Category 6 performance values.



This type of cord technology gives a consistently centered target to which connectors can be designed. Eliminating unbalance between the cord and connector reduces the opportunity for noise to be introduced into the circuit. This becomes more significant as when testing at the higher frequencies of Category 6 (up to 250 MHz).

Tuning the connector

Historically, the connector design has compensated for noise (cross-talk) introduced by the plug termination. Yet introducing large amounts of cross-talk compensation within the PC boards of jacks and panels can degrade balance and will result in degradation viewable as return loss. In addition, compensation not precisely tuned to the noise characteristics of the plug will worsen cross-talk. Designing to common center de-embedded plug values allows the utilization of targeted noise elimination techniques that minimize unbalance introduced to the system.

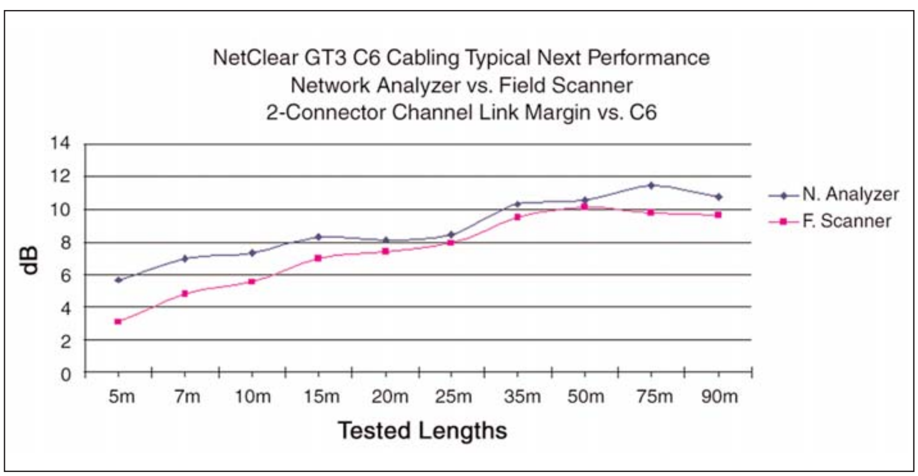
To accomplish this, Ortronics developed Dual Reactance technology for its modular connectivity. In each port, the modular insert uses contact separation and positioning with the mating plug to compensate for plug contacts that are very close to the noise source for a more balanced union with the plug. This is an improvement from previous noise compensation methods that degrade the balance of the connection, in turn causing issues with return loss and FEXT, especially at higher frequencies.

When using a centered system technology, the result is visible with laboratory and field testing, and becomes increasingly apparent when the lengths of the tested links or channels are shortened. This tuning to the standards defined center targets provides a superbly balanced system. All jacks, patch panel ports and patch cord terminations share the same precise target.

The impact of center tuning on short link testing

To validate the positive effects of balanced systems, channels assembled from center-tuned connectivity and cable were then compared. Using a test set-up of 90-meter LANmark™ 2000 horizontal cable with a Clarity^6 panel connection on one end and a Clarity^6 jack on the other and two Clarity^6 1-meter patch cords (assembled using LANmark 2000 patch cordage and Paralign II plug termination), a Category 6 channel test was conducted to identify the measurement for worst case NEXT margin for that channel. Again, testing continued using horizontal cable of shorter lengths down to 5 meters.

When comparing the worst case NEXT margins for the lengths tested, it was evident that the margin for the NetClear^{GT3} channel is significantly higher than the generic Category 6 channel at longer lengths. Although there was a decrease in NEXT margin at the shorter lengths, the margin was greater with the NetClear^{GT3} channels than with the generic Category 6 channels all the way down to 5 meters with both network analyzer and field test units. The network analyzer measured just less than 6dB margin at 5 meters and the handheld field tester still yielded 3dB of margin.



Length	F. Scanner	N. Analyzer
5 m	3.1	5.7
7 m	4.8	7.0
10 m	5.5	7.3
15 m	7.0	8.3
20 m	7.4	8.1
25 m	7.9	8.5
35 m	9.5	10.3
50 m	10.1	10.6
75 m	9.8	11.5
90 m	9.6	10.8

Conclusion

In the past, many installed short links or channels have tested with measurably worse values than longer links and channels. The "short link phenomenon" is caused by the closer proximity of unbalanced components and the additive noise from these connections.

Standards specify the minimum levels of acceptable performance. Using components that meet TIA Category 5e and Category 6 specification requirements is only the first step. Attaining maximum headroom is accomplished by installing and using a center-tuned cabling system. The tuning of connector elements to the common center values of the TIA specification improves system balance and increases the transparency of these connections within the cabling system. Jacks, patch panel ports and patch cord terminations must share the same precise target. System balance can be further enhanced when the cable used for horizontal and patch cords shares a common core design.

The technology utilized in NetClear^{GT3} was built on this foundation. All elements of Clarity connectivity are tuned to the center of the TIA target connector values. Berk-Tek LANmark-2000 patch cordage and horizontal cable share common premium core designs. Tuned connectivity is key to providing a cabling path that seeks to be transparent to the signal.

Short-link testing should be included when making comparisons between cabling systems. Improved performance should be viewable in the lab or in the field across the entire spectrum of potential installed lengths (7 -100 meters). We witness the benefits of system tuning when comparing the tests of cabling solutions across a range of installed lengths. Better balancing of a tuned system will cause less resonance. Elevated performance should be visible in 2, 3 and 4 connector channels and in permanent link tests for short (7-meter) and long (90-meter) configurations, though you may witness a 3dB+ deviation between tests conducted with network analyzers and those done with field test units.

For more information, call 1-877-96CLEAR or visit our web sites.

NetClear: http://www.netclear-channel.com

Berk-Tek: http://www.berktek.com

Ortronics: http://www.ortronics.com