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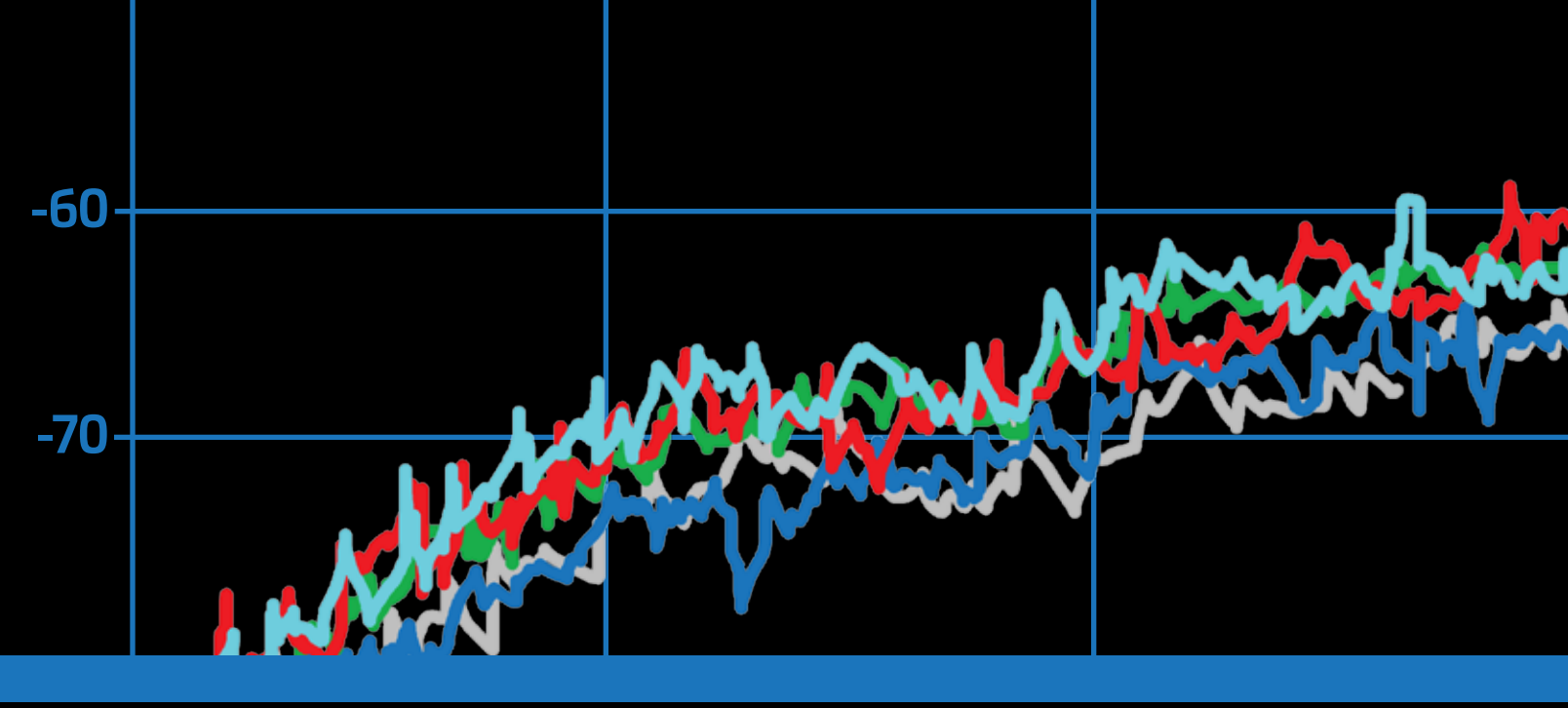

Alien Crosstalk and 10GBASE-T Developments

Limiting alien crosstalk may require mitigation, shorter channels or use of shielded twisted-pair.

BY DAN PAYERLE

Alien crosstalk has been an area of discussion in the LAN cabling community for nearly three years now. The topic generates a lot of strong opinions depending on which side of the camp a person is on. This article attempts to examine all sides of the issue and let readers develop their own opinion about how to deal with alien crosstalk and 10GBASE-T.

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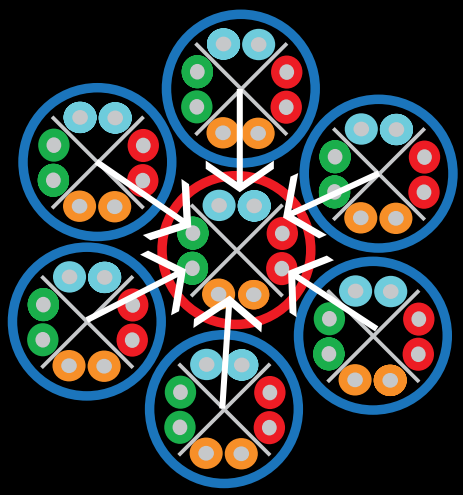
Figure 1: Pair to Pair NEXT

Figure 2: Alien Crosstalk



What Is Alien Crosstalk?

Alien crosstalk is a term that describes the general phenomena where energy is coupled between cables in a common bundle or installation. The notion is very similar to internal near-end crosstalk (NEXT), which has been tested in the field for about a decade. See Figure 1. Internal NEXT differs from alien crosstalk in that it is a measurement of crosstalk between pairs within a single cable.

Alien crosstalk was brought to light by the development of active network hardware that could provide 10 Gigabit Ethernet over twisted-pair cabling (10GBASE-T). As with internal crosstalk, alien crosstalk becomes worse as the operational frequency increases. Currently, 10GBASE-T is specified to run at an analog frequency of 400 MHz, which is 220 percent higher than the 125 MHz operational frequency of 1000BASE-T. The cabling requirements for 10GBASE-T specify category 6_A/ISO Class E_A, either shielded or unshielded. Category 6/ISO Class E also can be used in limited instances to upgrade existing networks to 10GBASE-T.

Since the frequency range required to support 10GBASE-T is so much higher than that of 1000BASE-T, it is understandable that crosstalk, both internal and alien, has become a difficult obstacle to overcome when designing and installing LAN cabling to support the latest technology.

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Deploying 10GBASE-T to the Field

The most striking change in field measurement is the broadening of the frequency range. For category 6_A and ISO Class E_A, the frequency range goes up from 250 MHz to 500 MHz. For ISO Class F_A, the test range increases from 600 MHz to a formidable 1000 MHz. Upgrading the measuring range does not necessarily lead to a new definition of measurement accuracy. While devices with Level III accuracy were standard for previous measurements up to 250 MHz, the new category 6_A/ISO Class E_A measurements require a new accuracy category: Level IIIe. For ISO Class F_A, there will be a corresponding Level IVe definition, a further development of the existing Level IV accuracy category for measurements up to 600 MHz. It is worth noting here that the accuracy categories Level IV and Level IVe are downward compatible to Level IIIe. In practice, this means that every current Level IV category 7/Class F testing device is already suitable for measurements according to category 6_A and ISO Class E_A.

As mentioned earlier, 10GBASE-T can operate over a variety of cabling types with certain limitations. The most commonly deployed cabling today in new installations is category 6/ISO Class E, which is field tested to 250 MHz per the TIA 568-B.2 and ISO 11801 cabling standards. Since 10GBASE-T operates at 400 MHz, additional qualification needs to be performed to prove that a particular category 6/ISO Class E installation will support 10GBASE-T. The TIA has created a new Telecommunications Systems Bulletin titled TSB-155, which provides guidelines for channels (including equipment cords) running 10GBASE-T over category 6 cabling.

Some of the key elements to 10GBASE-T operation over category 6 are:

- Channels up to 37 m (121 ft) should support 10GBASE-T.
- Channels between 37 m (121 ft) and 55 m (180 ft) should support 10GBASE-T depending on the alien crosstalk conditions.
- Channels between 55 m (180 ft) and 100 m (328 ft) may require mitigation to support 10GBASE-T when alien crosstalk margins are not sufficient.

Essentially, these guidelines say that many variables determine whether or not 10GBASE-T can be deployed successfully over a category 6 cabling plant. Short channels up to 37 m (121 ft) should operate just fine, but that is no guarantee. Anything over 37 m (121 ft) needs to be tested for sufficient alien crosstalk margin. When a failure occurs, some mitigation actions can be taken in an attempt to alleviate the alien crosstalk conditions.

Mitigation Techniques

1. When 10GBASE-T is being selectively deployed, do not use adjacent ports in the patch panel. Understandably, there may be no alternative when deploying 10GBASE-T to several workstations that are located near each other; the point is that proximity is the key contributor to alien crosstalk.
2. When deploying 10GBASE-T in adjacent ports of a patch panel, alien crosstalk testing should be performed in the field.
3. In the event the alien crosstalk test fails, take the following actions to reduce the level of alien crosstalk:
    a. Separate equipment and patch cords and unbundled horizontal cables to increase the space between the cables.
    b. If the cords cannot be separated, use either category 6_A or category 6 screened twisted-pair (ScTP) cords.
    c. Reconfigure any cross-connect as an interconnect.
    d. Replace category 6 connecting hardware with category 6_A.
    e. Replace the category 6 horizontal cable with category 6_A.

Retest the channel after performing any mitigation techniques to be sure that thetechniques have brought the alien crosstalk margins back to acceptable levels.

Field Testing Alien Crosstalk

As of this writing, the TIA 568-C.2 standard is still in development and is expected to be finalized sometime in the first quarter of 2008. With this document, the field testing requirements of category 6_A cabling will be

defined, and hopefully some raging debates within the standards committees will be settled. One of the most contentious debates is the requirement for alien crosstalk field testing when category 6_A cabling is deployed. Some manufacturers argue that alien crosstalk testing should be a requirement of category 6_A, while others say that it be an optional test. Either way, it is critical to know what is involved in field testing alien crosstalk in the event it is a standard or a contractual requirement.

Understand that unlike typical link certification, it will not be necessary to test 100 percent of the installed links for alien crosstalk. Initial certification of a link to meet category 6_A or Class E_A will be no different than testing category 6, with the exception that the test frequency will increase from 250 MHz to 500 MHz. It is still a quick end-to-end test that takes less than 30 seconds.

Alien crosstalk testing on the other hand involves testing various combinations of links that are identified as victims and disturbers. In Figure 2, the red cable in the center of the bundle is referred to as the disturbed or victim link and the blue cables are the disturber links. This configuration is known as a 6-around-1 or 6A1 and represents the worst-case situation for testing alien crosstalk. Performing a 6A1 test on a single victim cable actually involves at least six different testing configurations and as many as 12 depending on the manufacturer of the field test equipment.

Given that multiple tests are required for each victim link, it is not practical to require 100 percent testing of every link as a victim in any particular installation. The calculation used to determine the number of unique testing combinations should 100 percent testing be required is $(n^2+n)/2$ where n is the number of links in the installation. Using this formula, testing a 500 link installation would require 125,250 unique test configurations! This is obviously far beyond what anyone can be expected to test, so guidelines for sample testing have been created to determine the alien crosstalk condition on an installation in a more reasonable time.

Before any alien crosstalk tests can be done, all links have to be tested according to TIA category 6_A, TSB155 (category 6), ISO Class E_A or ISO TR24750.

Selection of Disturbed Links (Victims)

The following links have to be selected as a victim in an installation:

- 1 percent or 5 links, whichever is more, of those links with the highest insertion loss (longest).
- 1 percent or 5 links, whichever is more, of those links with the lowest insertion loss (shortest).
- 1 percent or 5 links, whichever is more, between the lowest and highest insertion loss (medium).

When testing, if the first three victim/disturber combinations reveal a condition known as insignificant

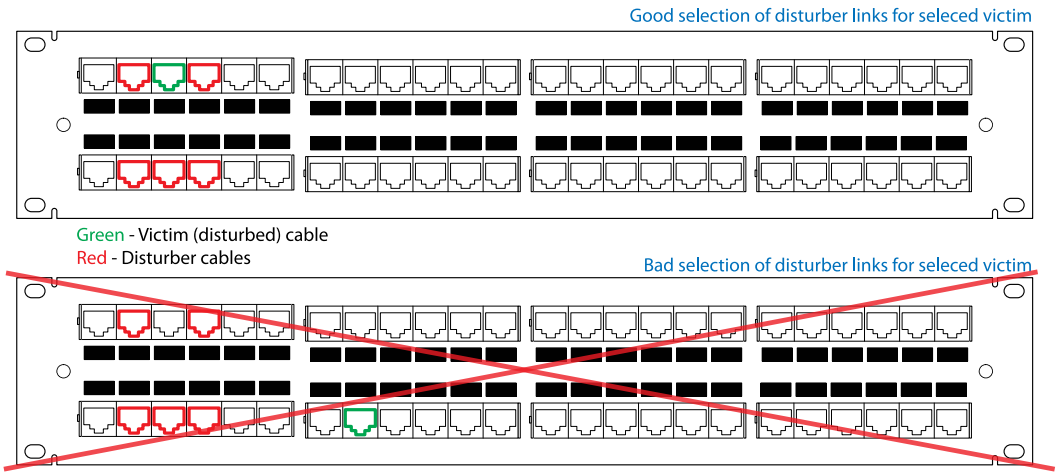

Figure 3: Link Selection: Top panel is correct; bottom panel is incorrect.

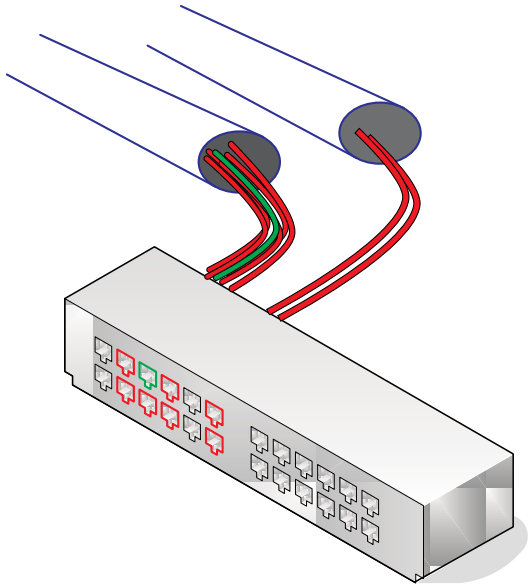

Figure 4: Correct Link Selection

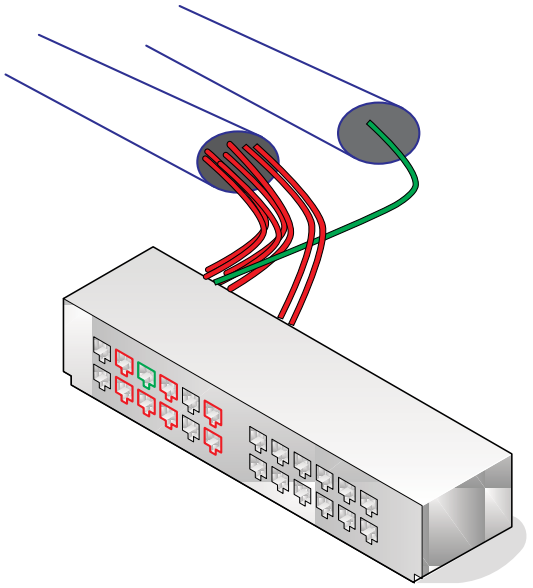

Figure 5: Incorrect Link Selection.

alien crosstalk, the test can be stopped at that point without finishing the 1 percent or minimum 5 victim links. Insignificant alien crosstalk is a condition where the measurement is below a certain level and may not be detectable by some field test instruments.

For example, at an installation with 100 links, 10 short, 10 medium and 10 long links have to be selected as victim links with some number of disturber links tested against each victim. It is important to note that in cases where different cable types and connecting hardware are used (e.g., category 6 and category 6_A), the above selection should be repeated for each different hardware and cable type.

Selection of Disturber Links

The selection of disturber links has to be done individually for every victim link. In Figure 3, the green port on the patch panel represents the victim link and the red ports represent the disturber links.

Select all links that run in the same cable bundle or are most consistently positioned relative to the victim cable. These bundles may be found in the patch panel, cross connect or conduit. Add any additional links that occupy adjacent positions in the patch panel or outlet.

When selecting links to test, in addition to the location of the links in the patch panel the routing of the links also must be considered. The disturber links should be run in the same pathway as the victim link to have the most impact on alien crosstalk measurements.

The link routing shown in Figure 4 is the proper selection to ensure that the disturber and victim links will have some measurable effect of alien crosstalk. In this example, the links are terminated near each other at the panel so there will be some alien crosstalk coupling and most of the disturbers run in the same pathway as the victim link.

The link routing shown in Figure 5 is not correct for proper alien crosstalk measurements. The victim link will be disturbed to some degree since it is positioned near the disturbers in the patch panel, but since it runs in a pathway that is different from the disturbers, the measurement may be inaccurate. In this scenario, additional disturbers should be included in the measurement. These disturbers can be links that run in the same pathway but may terminate at a point in the panel far from the victim.

In Figure 6, additional disturber links are selected as part of the alien crosstalk test of the green victim link. By choosing all of these disturber links, the test has a high degree of certainty since disturber links are chosen that both terminate near the victim and run in the same pathway or bundle as the victim.

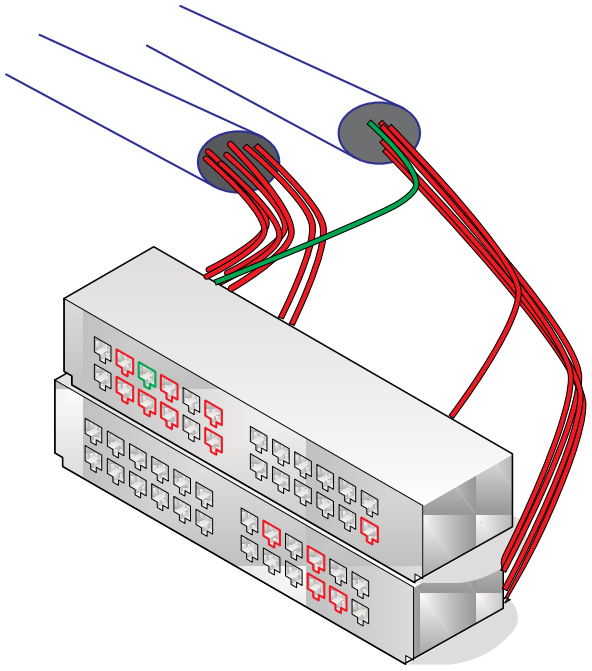

Figure 6: Selecting Additional Disturbers

The proper selection of links for alien crosstalk testing is critical and requires a certain degree of knowledge about the topology of the cabling plant. Without knowing where the various links are routed to within the building, the process of testing can be very inaccurate since it is possible that the chosen disturber links may not be close enough to the victim to provide any significant data. Take the time to ensure that adequate disturber links are chosen for each victim link.

Configuring Your Tester

After deciding on the victim and disturber links to check, the field tester needs to be connected to the cabling according to the manufacturer's directions. Some field testers require a personal computer (PC) to be attached to the field tester during the measurement process to gather the data and compute the alien crosstalk results. Additionally, unlike standard link certification where the test runs from both sides of the link simultaneously, the tester and PC may need to be moved to the opposite side of the link for the second half of the alien crosstalk testing process.

Because the number of links to test and the time to test each victim/disturber combination can be significant, choosing the right field tester can save a lot of time and hassle. A field tester that does not require a PC for data acquisition nor double testing of each victim/disturber combination can cut out 75 percent of the total alien crosstalk testing time, saving the contractor significant time and money while eliminating the need to bring a fragile laptop PC into the field.

See Figures 7 through 11 for sample plots from alien crosstalk field test reports.

UTP Versus STP

Perhaps the most significant change as a result of 10GBASE-T and alien crosstalk, particularly in the U.S. market, is the resurgence of STP or shielded cabling systems. STP is specifically categorized into ScTP, foil twisted-pair (FTP) or pairs in metal foil (PiMF) types.

ScTP utilizes a metallic screen or braid over the group of four pairs to provide alien crosstalk and electromagnetic interference (EMI) shielding.

FTP is similar but uses a thin metallic foil as opposed to a braid. The difference between these two is that the screen shield is more durable and easier to terminate onto a shielded jack, but the foil shield provides better coverage (no holes) and is effective at higher frequencies but can easily tear if mishandled.

PiMF cables have a foil shield for each pair to virtually eliminate internal crosstalk and usually include an overall foil or screen to provide additional EMI immunity. PiMF cables are sometimes referred to as double shielded or screened shielded twisted-pair (SSTP).

Additionally, a change in the naming convention is being proposed to make the configuration of the cable easier to understand, shown in Table 1.

Current Designations	Proposed Designations	Description
UTP	U/UTP	Unshielded twisted-pair
FTP	F/UTP	Foil over UTP
S-FTP	SF/UTP	Screen and foil over UTP
S-STP	S/FTP	Screen over foil shielded pairs

Table 1: Cable Designations

Whatever the shield type, STP cables have two distinct advantages over UTP when deployed in 10GBASE-T environments.

When properly installed, the shield eliminates virtually all alien crosstalk at the

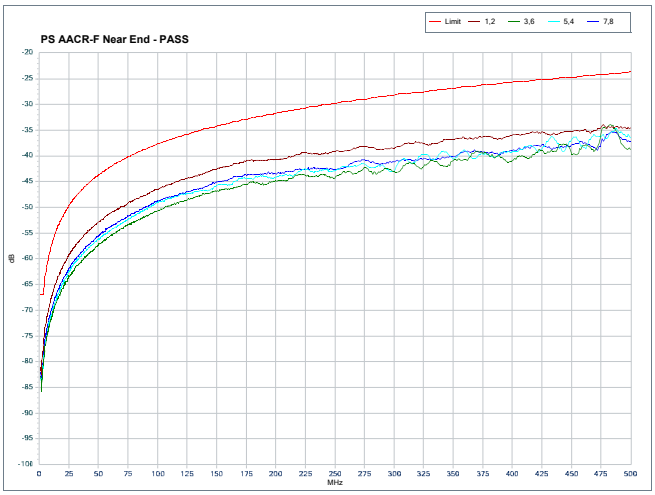

Figure 7. This plot shows Power Sum Alien Attenuation to Crosstalk Ratio—Far End, from the near end of the link (patch panel side). All pairs are well within the limit with roughly 20dB of margin at the higher frequencies.

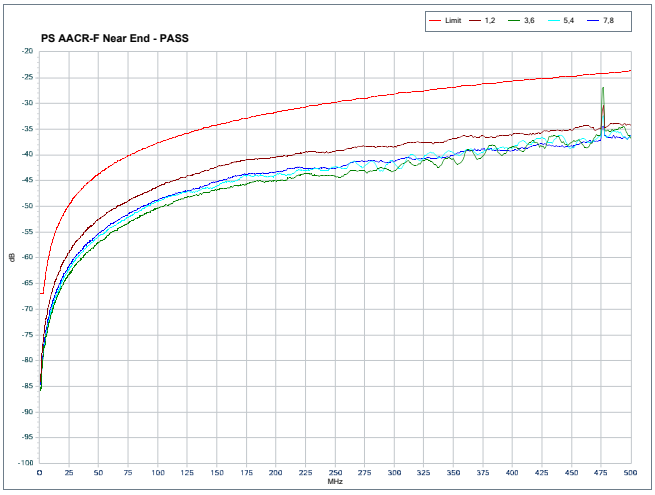

Figure 8. This plot shows Power Sum Alien Attenuation to Crosstalk Ratio—Far End, from the near end of the link (patch panel side). All pairs are passing but there is an obvious spike at about 480MHz. This spike was induced by a VHF handheld radio that was being used during the time of the test. This plot demonstrates the susceptibility of UTP cabling to external noise sources. Properly installed shielded cabling would have mitigated the ingress of much of this noise into the link. As cabling frequencies reach higher into the VHF spectrum these issues will become more common.

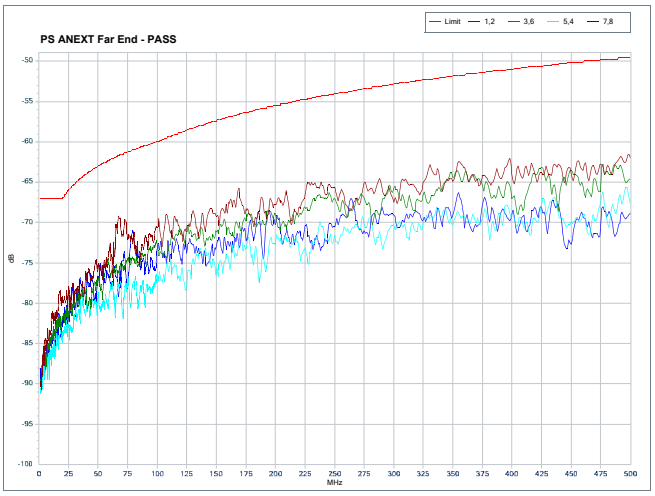

Figure 9. This plot shows Power Sum Alien NEXT from the far side (work station side) of the cabling link. The margins are very good at the higher frequencies because of the physical distance between the jacks at the workstation outlets. While some jacks are in the same four-port outlet, others are in adjacent outlets and the power sum calculations between all the disturber-victim calculations reduce the net PSANEXT results.

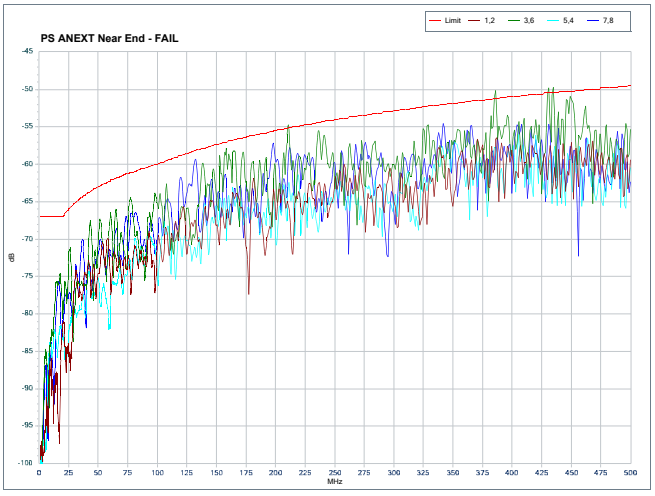

Figure 10. This plot shoes PSANEXT from the near end (patch panel) side of the link. This particular test fails or goes over the limit at several frequency points. The failing pair is the 3,6 pair (green) which due to it being split in the plug and jacks disturb the impedance matching and results in more crosstalk.

frequencies being used in category 6_A, ISO F and F_A systems, shown in Figure 13. When using shielded cabling, it becomes unnecessary to perform alien crosstalk testing in the field. Depending on a number of factors, the overall cost of the project can be less when using STP versus UTP. These factors include the cost of the cabling and components; the additional time to terminate the shielded connectors; and when necessary, the time and cost to train technicians on the proper installation and grounding techniques required to properly install STP systems. Also remember that in the United States, STP is not nearly as common as UTP, so lead times can become a critical factor when ordering materials for a job.

While UTP cables, especially category 6_A, are increasing in diameter to provide the necessary air space and separation in a bundle to minimize alien crosstalk, STP cables remain noticeably smaller. The difference in

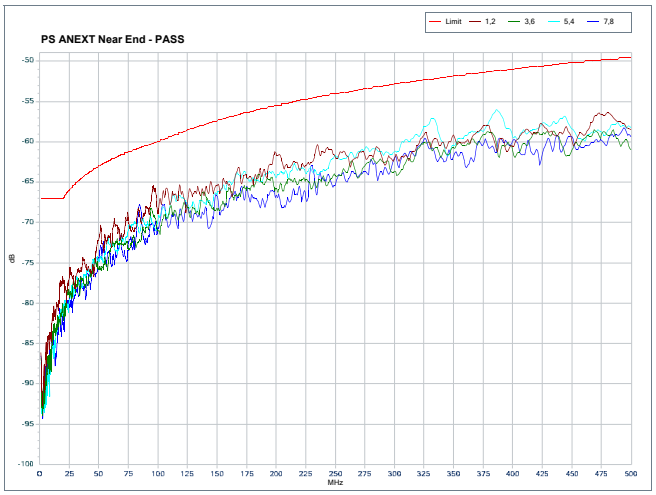

Figure 11. This plot is of a passing PSANEXT test also from the patch panel side. Compared to Figure 9, which is the far side of the cable, you can see the reduced margins. This is due to the proximity of the jacks to each other in the patch panel.

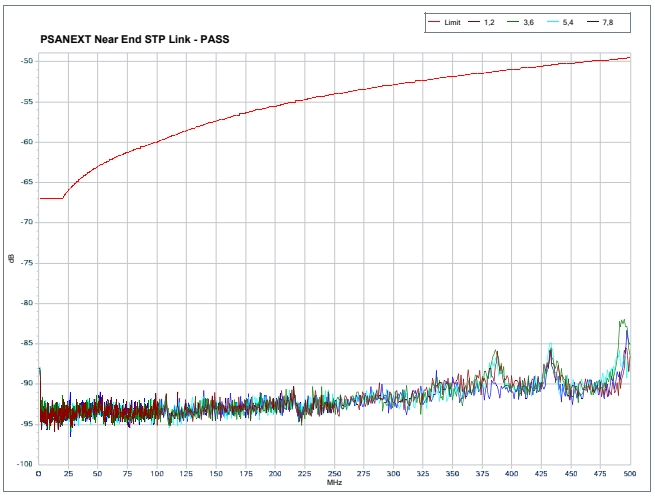

Figure 12: Power Sum ANEXT on category 7 STP cable with category 6A STP jacks exhibits very little alien crosstalk. According to the IEC standard, measurements with ANEXT values less than 90dB between 100 and 250MHz are deemed insignificant and do not need to be reported. Field testers that can measure below this limit may still report the data as long as the test is tagged "insignificant."

size can be up to 25 percent, meaning that shielded cables allow for higher density in wire tray and conduit. The cost of high-performance UTP cables is also increasing at a faster rate than their STP counterparts mostly because increasing the size is usually accomplished by making the jacket thicker. The increased material in the jacket leads to higher costs and more price instability since the jacket material is made from petroleum, which suffers from market volatility.

Conclusion

Category 6_A and 10GBASE-T are still in their infancy and the growing pains are sure to come. The appetite for bandwidth is insatiable, and the industry is working to market solutions that meet both performance and cost objectives. The key to the next step in the evolutionary ladder of LAN cabling is to know that the materials and techniques are available to successfully deploy 10GBASE-T today. Designers and contractors will need to develop the tools and techniques to ensure success whether shifting from UTP to STP cabling or using improved installation techniques and field testing to certify alien crosstalk margins. ■

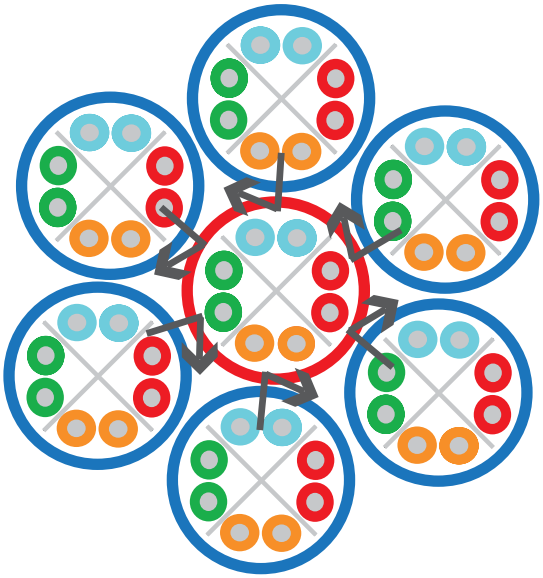

Figure 13: Alien Crosstalk with STP Cable

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