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Category 6A
The cabling of choice for new installations

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Introduction

The first Category 6A systems were introduced in 2004 as cabling designed for 10GBASE-T applications, and Category 6A has become the smart technical choice for any new installation supporting power over Ethernet (PoE) or data rates at 1 Gbps or above.

While PoE and 2.5G/5GBASE-T technologies will work on Category 5e and Category 6 cabling, their performance may be subject to "use cases" driven by the arrangement of cable bundles and the density of applications deployed. Cabling is one of the longest-lived assets in a network, and, while initial deployments of multigigabit technologies may be able to take advantage of installed cabling plants, anyone planning for the long term with a new deployment should consider Category 6A cabling to grow into the future without limiting application performance.

This white paper explores the history and likely future of data communications and power over Ethernet technologies to explain: (1) what makes Category 6A fundamentally different from Categories 5e and 6, and (2) why it matters today. When considering these factors together, Category 6A is the clear choice for any new installation, serving applications that are emerging today and are expected to become prevalent over the next five years.

The beginning of Category 6A

To understand what makes Category 6A different, you should look at the beginnings of the application that created it—10GBASE-T. In November 2002, Solarflare Communications and CommScope engineers presented the first step toward what became the IEEE 802.3an-2006 10GBASE-T standard: a tutorial and call for interest. The origins of 10GBASE-T were based on using signal processing technology to mitigate all the internal impairments of the cabling, i.e., equalizing out the insertion loss, cancelling the echo from the return loss, cancelling near-end and far-end crosstalk, and using high-performance analog circuitry so performance was limited only by external noise coupled into the cabling itself (see Figure 1).

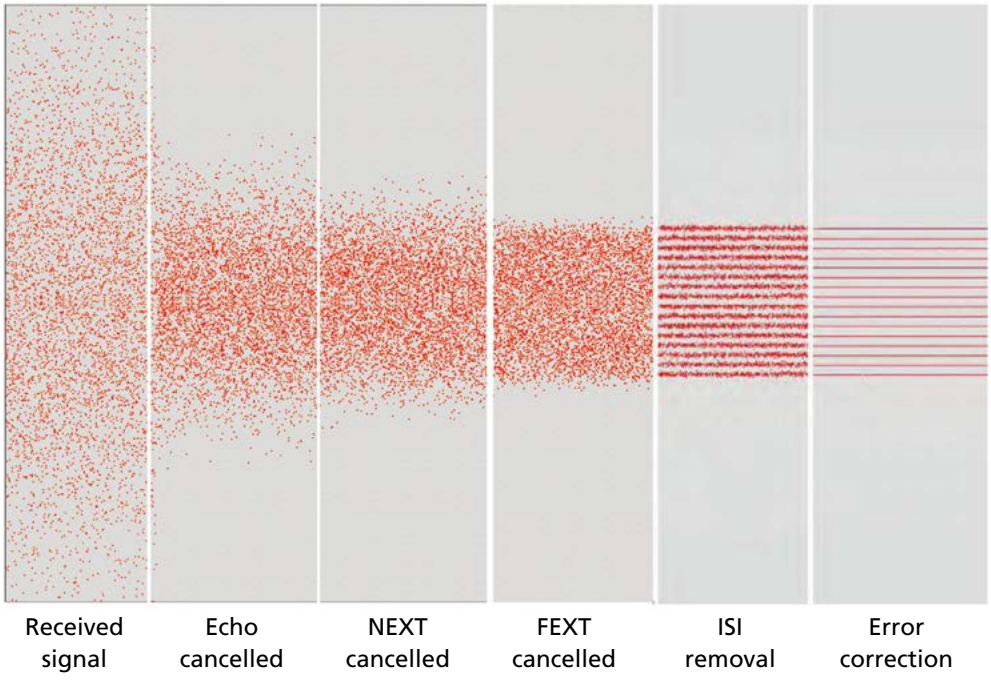

Figure 1: Noise cancellation in 10GBASE-T

Early measurements had shown that, under many conditions, installed Category 6 and even some Category 5e cabling exhibited low enough noise levels to support 10GBASE-T. Further analysis from multiple cabling companies, however, soon showed that the crosstalk between cables in a bundle, called "alien crosstalk," was highly variable and, together with the worst-case insertion loss, would be the limiting factor in 10GBASE-T performance. At that November 2002 meeting, it soon became clear that control of alien crosstalk, along with a reduction in insertion loss, was necessary. A team of CommScope engineers sketched out what additional specifications were necessary to support 10GBASE-T. The requirements derived were the beginning of Category 6A, and were within a few decibels of the final specifications. Category 6A was to be the first cabling specification to specify repeatable alien crosstalk performance, while being specified to a frequency of 500 MHz, and have an insertion loss improved over Category 6 cabling to allow the network electronics to achieve their maximum performance.

What makes Category 6A different

The result, which took shape over the next few years, and is present in the market today, is not much different. In short, Category 6A is different for two reasons: predictable performance in bundled situations and lower cable losses.

Alien crosstalk, measured in Categories 5e and 6, is dependent on the bundling tightness and which disturbing signals are at which locations in the bundle (see Figure 2).

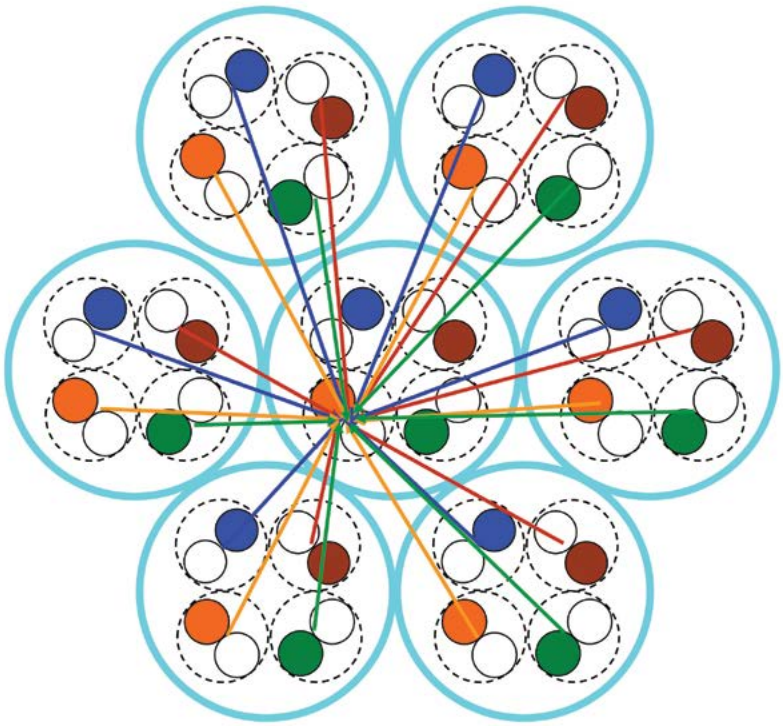

Figure 2: Alien crosstalk from other cables in a bundle

The noise from alien crosstalk can vary dramatically, as shown in Figure 3 and Figure 4. Category 6A, on the other hand, provides predictable alien crosstalk performance at low, specified levels.

Test Configurations cont...

- Each channel underwent four tests for 6 around 1 PSANEXT and PSAACR-F
  - Test 1: Fully bundled from end to end
  - Test 2: 50 m were bundled from the closet end (50 m of the work area was unbundled)
  - Test 3: 10 m were bundled from the closet end (90 m of the work area was unbundled)
  - Test 4: The complete channel was unbundled
- Insertion loss data was also taken
- The following slides contain the results of the testing in frequency swept graphs
- Worst-case alien crosstalk margins were compared to Category 6A limits

Image courtesy of CommScope

Figure 3: Test cases for alien crosstalk (from mei_ngeabt_01b_0115.pdf, IEEE 802.3 Next Generation Enterprise Access BASE-T Study Group January 2015

Category 5e channels worst-case margins

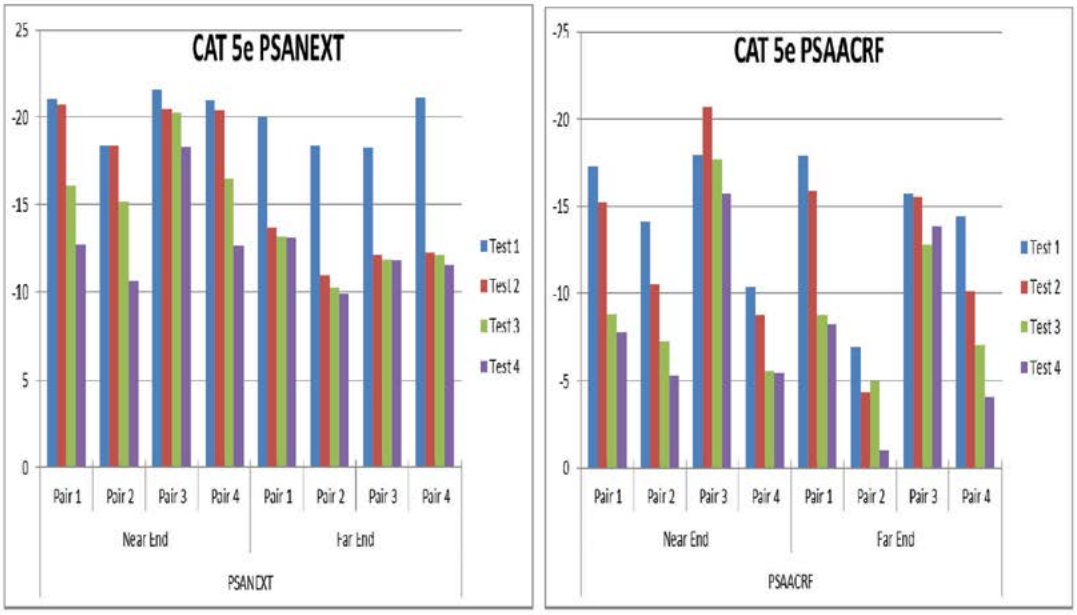

Figure 4: Variation of alien crosstalk versus test cases (from mei_ngeabt_01b_0115.pdf, IEEE 802.3 Next Generation Enterprise Access BASE-T Study Group, January 2015)

Additionally, the insertion loss for Category 6A is specified by the ANSI/TIA-568-C.2 and ISO/IEC 11801 standards to be better than Categories 5e or 6, shown in Table 1.

Table 1: Insertion loss for Category 5e, Category 6, and Category 6A channels (from ANSI/TIA-568-C.2)

	Category 5e	Category 6	Category 6A
100 MHz	24.0 dB	21.3 dB	20.9 dB
250 MHz	–	35.9 dB	33.9 dB
500 MHz	–	–	49.3 dB

Improved insertion loss is typically achieved with larger conductor sizes, resulting in lower dc resistance. While the maximum dc loop resistance specifications in TIA-568 are identical for Categories 5e, 6 and 6A, they typically differ, with Categories 6 and 6A being superior. This is described in TIA TSB-184-A, and is shown in Table 2.

Table 2: Nominal dc loop resistance of channels at 60°C (from TIA-TSB-184-A, Table 2)

Category 5e	Category 6	Category 6A
24.38 Ω	20.09 Ω	20.09 Ω

Power over Ethernet and Category 6A

At the same time as the 10GBASE-T specification was being developed, IEEE 802.3at (or "PoE Plus") was being developed. It soon became apparent that power over Ethernet would need to pay attention to the heat generated when multiple cables in a bundle were carrying power. Like 10GBASE-T, PoE Plus needed to be concerned with both the effects of bundled cabling and the loss (the time-resistive dc loss) of the cabling. Because both the heating of bundles in PoE and the alien crosstalk coupling for which Category 6A was developed are related to a well-controlled spacing between cables, Category 6A would provide superior, repeatable performance. Additionally, the improved insertion loss of Category 6A resulted in the use of typically larger conductor sizes, which aided dc resistance, and hence lower heating. While the 802.3at standard kept current and power levels at a point that could be supported by existing cabling, the evolution of PoE to four-pair powering and 802.3bt would take advantage of Category 6A's performance.

When work began on the four-pair power over Ethernet standards in 2013, the objective was to support powering on all four pairs at and beyond the current levels on the two pairs in 802.3at, and to deliver as much power as possible while staying within safety specifications for the limited power source. This set two targets for the new standard:

- "Type 3," where power sources could provide up to 60 watts and 0.3 amperes per conductor, on all eight conductors of the cable, similar to having two 802.3at systems within the same four-pair cable, and
- "Type 4," where power sources could provide up to 90 watts and 0.48 amperes per conductor on all eight conductors of the cable, extending the specifications to the limits allowed for limited power sources.

It is well known (see, e.g., TSB-184-A, or NEC 2017 at 725.144) that doubling the current-carrying conductors in the cable will increase heating by a factor of 1.4, the square-root of 2, so these new PoE types were expected to increase cable heating. Extensive studies were performed, with the result being the publication of TIA TSB-184-A, ISO/IEC TS 29125 and a new section, 725.144, in the 2017 edition of the U.S. National Electric Code (2017 NEC®) addressing the bundling of cables. While 0.3 amperes per conductor, used in Type 3 (and 802.3af/at, or Types 1 and 2) was found to be within heating assumptions for cables using 24 AWG, the conductor size commonly used in Category 5e horizontal cabling, the nearly 0.5 amperes per conductor used in Type 4 PoE systems to deliver the higher power levels would need conductor sizes of at least 23 AWG at larger bundle sizes to stay cool.

Studies published in TIA-TSB-184-A showed that Category 6A cabling, which is typically 23 AWG or thicker, heats less than Category 5e or Category 6. Additionally, the physical arrangements and cable constructions used in Category 6A cabling can lead to less heating in a bundle. The tables in Annex A of TSB-184-A-1, for example, show that Category 6A can carry more current than Category 6 in bundles with less temperature rise.

Data transmission for the future

While 10GBASE-T was the first technology to directly specify alien crosstalk, alien crosstalk has been a limiting concern of every new twisted-pair Ethernet PHY this millennium. Newer, intermediate-rate and asymmetric technologies—such as 2.5GBASE-T, 5GBASE-T, and HDBASE-T, which are designed to have operation on installed cables—are limited by alien crosstalk. Even 1000BASE-T references alien crosstalk as a limiting source where Annex 40A in IEEE Std 802.3 puts recommended limits on alien crosstalk in hybrid or bundled cables for gigabit Ethernet. 2.5GBASE-T and 5GBASE-T specify operation on Category 5e (with extended frequency qualification for 5 Gbps operation) and Category 6 cabling, but do so for "use cases," which are determined by an alien crosstalk measurement, the ALSNR (alien limited signal-to-noise ratio) criterion. The ALSNR criterion may or may not be met by an installed configuration of Category 5e or Category 6; and, while relative risk may be lowered by implementing mitigation procedures, managing the bundling length, and using Category 6 cabling, the required alien crosstalk performance is always met with Category 6A. The tables below, from the NBASE-T Alliance, show relative risk levels in Category 5e and Category 6 configurations and the assured performance of Category 6A.

Table 3: Internal cabling parameters to support 2.5G and 5G applications

	2.5G BASE-T	5G BASE-T
Installed Cat 5e	✓	Extended frequencies required
Installed Cat 6	✓	✓
Installed Cat 6A	✓	✓

Source: NBASE-T Performance and Cabling Guidelines, NBASE-T Alliance, August 2016

Table 4: ALSNR support risk for 2.5G and 5G applications

Bundled cabling legnth 0 m to 50 m	Category 5e	Category 6	Category 6A
2.5G BASE-T			Assured
5G BASE-T			Assured

Bundled cabling legnth 50 m to 75 m	Category 5e	Category 6	Category 6A
2.5G BASE-T			Assured
5G BASE-T			Assured

Bundled cabling legnth 75 m to 100 m	Category 5e	Category 6	Category 6A
2.5G BASE-T			Assured
5G BASE-T			Assured

ALSNR risk	High	Medium	Low

Source: NBASE-T Performance and Cabling Guidelines, NBASE-T Alliance, August 2016

The trend is clear, and new data access technologies will continue to see alien crosstalk as the main impairment in deployment. The impact of this is only just beginning to become visible, but is expected to grow rapidly. As Wi-Fi access rates and computing needs grow in the future, most analysts see the IEEE 802.3bz/NBASE-T 2.5G/5GBASE-T technology being very successful, with broad support from across the industry and an increasing share of the enterprise switch port market. For more information see these articles from 650 Group and Delloro.

Interoperable 802.11ac Wi-Fi access points, network attached storage, machine vision, gaming and server interface cards, and Ethernet switches with 2.5GBASE-T and 5GBASE-T are already in the market and being installed in enterprises. Over the next five years, technologies faster than 1 Gbps, such as 802.11ac Wave 2 wireless, will become the norm, hitting even the residential market. The economics of scale have already driven 2.5G and 5GBASE-T technology into the high-end prosumer market, including such household names as Apple, and this can only help to accelerate deployment and development of these technologies. The recommendations are clear, from TIA, ISO/IEC, NBASE-T Alliance and in IEEE 802.3bz: New installations expecting to support these applications can be assured using Category 6A cabling.

The growing adoption of Category 6A in buildings and data centers continues to drive down the price premium over Category 6. Additionally, when making cabling decisions, it is important to also consider the installation labor cost. Since the difference in labor requirements is fairly minimal, when including labor costs (and depending on labor rates) the overall premium on first cost is likely to be significantly lower. However, as more and more applications are dependent on alien crosstalk performance, it becomes likely that Category 5e and Category 6 cabling will need to be replaced sooner. This further lessens the total cost of ownership for new Category 6A installations, and makes Category 6A the clear choice.

Conclusion

Any new cable installation must support not only the applications initially running, but should support applications that may spring up over the next 10 to 15 years. Since Category 6A is the first cabling category to specify alien crosstalk performance using the familiar and backward-compatible RJ45 connectivity, it quickly became the first choice for new installations in support of rates greater than 1 Gbps, where applications are ramping up today. Additionally, Category 6A typically offers less cable heating under high-power power over Ethernet applications. The trend toward higher access speeds and more pervasive, higher power PoE delivery makes a compelling case for Category 6A in any new installation preparing for the future.

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