Interpreting Cable Test Data

Selecting the appropriate communication cable for a project can be challenging. Whether you are a consultant designing an infrastructure for a major customer or an IT professional who is tasked with turning a large open area into a cubicle farm, choosing the best cable for the project can be daunting. One factor that can make it even more challenging is the manner in which some companies provide the performance data for their cables. Terms like “Average”, “Typical”, “Max” and “Guaranteed” are being used by different manufacturers to describe their cable’s performance. Which term or terms most accurately depict the cable’s performance and, more importantly, the company’s obligation to that performance?

This document will attempt to shed light on some of the confusing terminology used in the cable industry and will hopefully make readers better informed when choosing cable for their next project.

What are the cables tested to?

When it comes to Category cable, such as Category 5e, 6 and 6A, the physical and electrical testing parameters were established by an industry organization known as the Telecommunications Industry Association and put forth in a document known as *Telecommunications Cabling for Customer Premises*. The current version of this standard is known as TIA-568-C.0. This is the standard to which all cable and connectivity manufacturers should design and build their products. For example, the standard states what color the conductor’s insulation is to be, the maximum allowable length for an installed horizontal cable (90m), the copper size to utilize (22 AWG to 24 AWG) and where on a jack each conductor is to be terminated, among many other specifics. The purpose of the standard is to ensure that if someone purchases products labelled as compliant, regardless of the manufacturer, they will work together. Products with characteristics that fall outside the limits identified in the standard should be avoided. Also, to correct a belief that has been perpetuated throughout the years, there is no Category 6e (or 6E) standard. This is merely marketing gone awry. Many companies manufacture enhanced Category 6 cables, and that is how they should be marketed. In addition, “enhanced” is a subjective term. It is up to the buyer to determine how much enhancement they desire. Unfortunately, some in the industry continue to refer to enhanced Category 6 cables as 6e(E), only exacerbating the problem.

In the TIA-568-C.2 standard, cables and connective hardware are placed into different categories. The standard identifies electrical performance tests and parameters for each category. The tests include a number of electrical tests performed within a specific electrical frequency range or bandwidth. Table 1 shows the test frequency range for each recognized category of cable.

Cable Category	Frequency Range
Category 3	1 – 16 MHz
Category 5e	1 – 100 MHz
Category 6	1 – 250 MHz
Category 6A	1 – 500 MHz

Table 1.

The main electrical performance parameters for categories 5e through 6A are Insertion Loss, Return Loss, Near-End Crosstalk (NEXT), Power Sum Near-End Crosstalk (PSNEXT), Attenuation-to-Crosstalk Ratio Far-End (ACRF). Power Sum Attenuation-to-Crosstalk Ratio Far-End (PSACRF). Powersum Alien Near-End Crosstalk (PSANEXT) and Powersum Attenuation to Alien Crosstalk Ratio, Far-End (PSAACRF) are required tests for Category 6A cable only. For each of these tests, with the except of Insertion Loss, there are minimum values that the cable must perform to at a given frequency to be considered complaint to the standard. Due to the nature of Insertion Loss, the standard indicates a maximum performance level. For the purposes of this paper, we will not define each test parameter. We merely wish to point out that numerous tests, including some not referenced above, are required by the standard.

Additionally, for each category of product, the TIA-568-C.2 standard provides three different product configurations, each with unique electrical performance parameters:

- Configuration 1: Utilized by cable and connectivity manufacturers for stand-alone testing of their products.
- Configuration 2: Permanent link parameters in which cable and the connective hardware are measured as one.
- Configuration 3: Channel parameters that include the cable, the hardware connected to it and the patch cords that are attached to each end of the link.

All three configurations have distinct performance values for the range of frequencies referenced for each performance category. It is worth noting that handheld testers used at the installation site can test permanent link and channel performance only.

The purpose of the three configurations is to establish performance goals for the individual components in the infrastructure, as well as establishing their performance once all these components are mated together (e.g. in a permanent link or channel). The three configurations of testing exist to ensure product uniformity, regardless of manufacturer, and product performance post installation. For example, you can pass a permanent link test, but you could then fail a channel test if low quality or faulty patch cords are used. Conversely, you could pass a channel test, which includes the patch cords, but then move or swap cords and result with a failing circuit if you perform the channel test again.

What should I look at when comparing cables?

Directly comparing test parameters.
Depending on your specific needs, there are a few ways that you can compare cables. If you wish to compare multiple cables on a strictly cable performance level, you can look at some of the test parameters and compare those parameters between your choices. For example, you plan on operating Gigabit Ethernet on your network so you are looking for a Category 6 solution. When comparing Category 6 cables, you can choose the test parameters NEXT and PSNEXT at a specific frequency, such as 250 MHz, which is the maximum frequency for Category 6. Just remember that for all parameters, except Insertion Loss (sometimes referred to as Attenuation) a higher value is preferred. You can also compare ACR and PSACR values, if they are provided. If not, you can calculate them from the NEXT, PSNEXT and Insertion Loss values.

ACR & PSACR, which are often thought of as being tests in the standard, but actually are not, are an abbreviation for Attenuation-to-Crosstalk Ratio and PowerSum Attenuation-to-Crosstalk Ratio. Values for ACR and PSACR are derived from an equation involving two test parameters. ACR is NEXT minus Insertion Loss and PSACR is PSNEXT minus Insertion Loss. So, for every frequency at which Insertion Loss, NEXT and PSNEXT is tested, an ACR and PSACR value can be obtained. ACR and PSACR are considered important indicators in regards to a cable's performance. Often referred to as headroom, the ACR and PSACR values demonstrate how well a product performs above the standard, so it is often the focal point when comparing cables.

When comparing cables based on their published performance, keep in mind that if the values between two manufacturers' cables are within 1 dB or so of each other, or if one cable shows slightly higher values in one parameter but slightly lower values in another parameter when compared to the other cable, they are likely to perform similarly. These slight differences in manufacturers' published specifications become less apparent after the cable has been installed and connectors have been attached. Variables that will influence final cable performance include the skill of the installers, the quantity and quality of cable support devices (J-hooks), the quality and size of conduit, ladder rack, tray, etc., the temperature both during and after installation, humidity, the quality of the connectors and how well they are attached, the quality of the testing unit (when was it last certified?), the quality of the test cables for the testing unit, etc. So, if the electrical performance of two cables is within 1 dB or so of each other, they could be considered similar.

Does the cable's maximum test frequency matter?

Another piece of test data often touted by cable manufacturers is the maximum frequency to which their cable was tested. Many manufacturers, including Hitachi Cable America, choose to sweep test some cables out beyond the maximum frequency identified in the TIA 568-C.2 standard. Since the Category 6 standard only goes up to 250 MHz, the purpose of higher frequency sweep testing is to identify the cables behavior beyond that which is required by the standard. The electrical performance indicated for frequencies above the standard act as valuable indicators to assist the cable manufacturer in monitoring and controlling their manufacturing process. Keep in mind that the applications designed to run on Category 6 cable do so within the Category 6 test frequency range identified in the standard.

If a manufacturer provides performance values beyond the frequencies in the standard, usually the higher the frequency at which the ACR values are positive, the better the cable is. For example, the Hitachi Cable Category 6 PLUS™ is sweep tested to 555 MHz. Its ACR is positive beyond 300 MHz. If a competitor's cable is positive only to 260 MHz, then the Hitachi cable could be considered more robust. However, the maximum indicated test frequency for a Category 6 cable, when beyond 250 MHz, by itself, should play little to no role when evaluating cables. It's like knowing the top speed of the Ford Taurus. It's interesting, but not particularly relevant since roads have speed limits. Even more important, you don't know how the car will handle at its top speed. Compared to a Porsche, it might not be that good. A cable tested to a higher frequency than another cable simply means the manufacturer chose to sweep test it to that higher frequency. A higher frequency also has no bearing on a cable's "speed" as some might believe. There is no connection between a cable's performance and the maximum frequency to which it is tested. A Category 6 cable could be sweep tested to 850 MHz, but without values with which to compare that performance to, the information is not particularly useful. Knowing the cable's performance at 850 MHz is, like the top speed of the Taurus, irrelevant. Additionally, since the TIA-568-C.2 Category 6 standard tests to a maximum frequency of 250 MHz, you can't verify the values provided by the manufacturer.

Transmission Specifications

TIA/EIA-568-C.2 Category 6 Verified
ISO/IEC 11801, 2nd ed. Class E Compliant

	Ins Loss		NEXT		PSNEXT	
Freq. (MHz)	Std.	Max	Std.	Min	Std.	Min
1	2.0	2.0	74.3	77.3	72.3	75.3
4	3.8	3.8	65.3	68.3	63.3	66.3
8	5.3	5.3	60.8	63.8	58.8	61.8
10	6.0	6.0	59.3	62.3	57.3	60.3
16	7.6	7.6	56.2	59.2	54.2	57.2
31.25	10.7	10.7	51.9	54.9	49.9	52.9
62.5	15.4	15.4	47.4	50.4	45.4	48.4
100	19.8	19.8	44.3	47.3	42.3	45.3

Table 2: Hitachi Category 6 Plus™ Performance (cropped section taken from product transmission specifications)

Why do some cable manufacturers use different terms from others?

When comparing the test data from one cable manufacturer to that of another, there are additional challenges that can arise. These challenges revolve around how a company chooses to present their data and how they support those performance claims. As stated previously, in the TIA standard, there are distinct values for each performance parameter at a given frequency. A company may choose to provide their performance values while also showing the values referenced in the standard. Table 2 above shows how Hitachi Cable America presents the electrical performance data. The values from the TIA-568-C.2 standard are provided as well as the anticipated minimum (or maximum) performance from our cable. In this case, the cable is Hitachi Cable's Category 6 PLUS™. The PLUS™ is Underwriters Laboratories verified to the Category 6 standard and is internally tested beyond the standard's requirements of 250 MHz. Table 2 represents a portion of the test data provided.

Table 2 clearly shows the performance values required by the standard and the "Min" or "Max" performance provided by the cable. Hitachi Cable America's minimum and maximum values are guaranteed. These are the performance values that our cables are tested to in our lab, before they are allowed to ship from the facility. These increased levels of performance provided by Hitachi Cable America cables offer the customer an additional performance cushion that ensures the highest level of data throughput. The additional headroom can also help mitigate installation issues that may have a negative impact on link performance. Using experienced, certified installers is, of course, always strongly recommended as well.

Not all manufacturers, however, present performance data in this manner. Some provide results under headings entitled *Typical* or *Average* and some even use a completely unique title, such as their name. What does that mean? One manufacturer entitles their performance values *Expected Performance*. How much confidence does that instill? One should be critical of values provided under any of these headings especially when they lack clear definition. What are typical or average values based on? If there is no explanation regarding the term used, how much weight should the term carry? Some manufacturers also provide guaranteed values alongside their typical values. If there is any difference between their typical values and their guaranteed values, shouldn't one question the validity of the typical data? What is the point of claiming very high typical performance values but guaranteeing something substantially lower?

Typical values should never be used when comparing cables. Here's a simple analogy. You work for a police department and you are tasked to buy bullet proof vests for your fellow officers. You are looking at products from two companies. One guarantees that their vests will stop a 9mm round. The other company says that their vests will typically stop a 9mm round, but they guarantee it will stop a .22 caliber round. Which vest would you want to wear?

The analogy is intended to demonstrate that many manufacturers choose to use vague terms to exaggerate the actual performance of their products. This trend has made comparing cables very challenging. Additionally, some cable manufacturers (though they themselves may not actually make the cable) who also sell connectivity, often choose not to make cable performance data readily available. Rather, they choose to provide the channel test data for their solution, making it very difficult for consumers to compare that cable to another. Channel test data includes all the components of a channel, i.e. cable, jacks, patch panels, consolidation points (devices onto which cables can be terminated to and then extended from) and patch cords. So, if a manufacturer only provides channel test data, how can you compare the cable being identified in that channel to another cable? The answer is you really can't.

Can I compare cables when only using Channel or Permanent link test data?

Channel testing is one of the configurations identified in the TIA-568-C.2 standard. The values in the TIA standard for channel testing differ from those for cable testing. They are more relaxed than those for just the cable. The cable is the performance maker in a circuit. The other components; jacks, patch panels and consolidation points, all borrow performance from the cable. So you can have a circuit that has a good cable and low performing devices and it provides performance X. You can also have a circuit that has a low performing cable and high performing devices and also get performance X. Regardless, channel test data should only be used when comparing channel performance. It's not a viable data source when trying to compare the cables in those channels. This is also one of the reasons why many cable manufacturers provide multiple Category 6 cables, each with a specific level of performance. Hitachi Cable currently offers four different Category 6 cables with four levels of performance available. By using a higher performing Category 6 cable, such as Hitachi Cable's Premium™ or Supra 660™, you bring additional performance to the channel, so the performance of the connective hardware and the patch cords has less of an impact on the channel's overall performance. The use of higher performing cable frees you to choose from a wider range of connectivity without performance concerns.

Some manufacturers maintain that only channel testing can provide an accurate measure of a circuits performance. When a channel is tested, the patch cords are included in the test. In reality, most circuits in a new construction environment are tested as a permanent link, which includes only the horizontal cable and the jacks (or patch panels). This is often due to the construction site environment and the customer's move-in schedule. The addition of patch cords when testing in a construction environment is not often practical. For a channel test to be of value, the patch cords for a particular circuit need to remain with that circuit post testing to deliver the performance identified in the test results. In reality, patch cords often get moved around or replaced, often with another manufacturer's cord. If the patch cords get substituted, it will impact the channel performance, rendering channel test data irrelevant.

Conclusion

When selecting components for your infrastructure, it is important to compare the products on a level playing field. Evaluate "typical" and "average" test results with skepticism. Compare results from the same test configurations, e.g. channel to channel. Evaluate the warranty of the manufacturer's involved. What type of restrictions might the warranty have? Some solution manufacturers will void the warranty for an entire building if another manufacturer's cables or jacks are used on the site. Most importantly, evaluate the manufacturer. What is their track record? Where do they manufacture their products? Are they willing to let you tour their manufacturing facility?

The products are ultimately only as good as the manufacture making them and the technicians installing them.