IDEAL NETWORKS

## Introduction

LAN cable certifiers have been the go-to method of testing twisted pair cabling for nearly a quarter century, since the advent of 10Base-T on Class C/category 3 cabling to 10 MHz. This article will explore why certifiers are used to test LAN cabling, what a certifier tests, the benefits certifying cabling even when a customer does not require it, and the differences between certifiers and other types of LAN cable testers.

The very first certifier available was the LANTech 10 manufactured by Beckman Industrial in San Diego, CA. The LT-10 was the first field tester that could measure the near-end crosstalk (NEXT) of a cable to characterise the performance of the termination. It was the first time advanced measurement techniques, beyond resistance, capacitance and delay were available to field engineers in a handheld tester. That was in 1993. Today, companies have changed and LAN cable certifiers have progressed. Beckman Industrial is now IDEAL Networks and the LANTech-10 has given way to the LanTEK III which tests to 1,000 MHz, 100x higher than the certifier that started it all.

While the products have changed, the reasons we certify cable remain mostly the same. It all starts with cabling standards. The two main standardisation bodies that define LAN cabling specifications are the ISO/IEC with the 11801 series standards and ANSI/TIA with the 568 series of standards. These standards define three types of performance requirements: components, cable and cabling.

## Standards

Component standards define the performance of the jacks/outlets and plugs (connectors) for each performance category. Today we have performance standards for category 3, 5e, 6, 6A, 7, 7A, 8.1 and 8.2. These standards are what the manufacturers of components use to design and test their products. When a person purchases a cat 6A outlet they assume the manufacturer guarantees that it provides the performance defined by ISO or TIA for cat 6A.

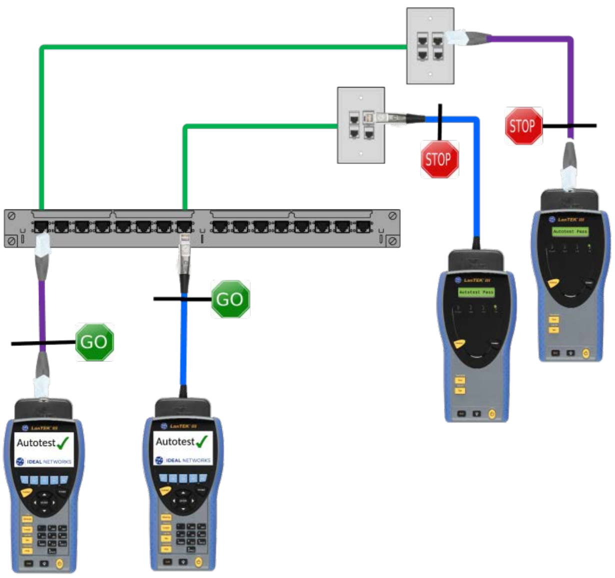
Cable standards define the performance of the bare cable with no connectors attached. Just as with the component standard, we assume a box of cable marked cat 6A meets the performance requirements of the ISO and TIA standards for cat 6A.

The component and cable standards are used by manufacturers of those components for design and testing. The third standard mentioned above, Cabling, is what field engineers use for testing installed cabling. The cabling standard defines the performance of the completed links and channels when connectors and cable are installed in the field. Field testing is critical because the link and channel performance is what determines whether the networking equipment will operate properly and provided the advertised bandwidth.

When setting up a certifier to test cabling, the desired performance standard is selected as well as the configuration of the cable being tested. The two options for certifying commercial cabling are channel and permanent link.

Channel tests consist of the installed cabling plus the patch cords that connect the cabling to the networking equipment. In the diagram below, the installed cabling, called the permanent link (PL) is shown in green and the patch cords are shown in purple. The measurement begins about 2 cm from the channel adapter of the certifier and includes the cable of the patch cord and the connector that mates to the patch panel and work area outlet. The connection at the channel adapter is not included in the test. The black lines and Stop/Go symbols indicate the portions of the cabling being tested.

When testing a permanent link (PL) only the installed cabling (green in the diagram) is tested using special PL adapters on the certifier. Here the test includes the connection at the patch panel and work area outlet, plus about 2 cm of the PL adapter cord. This is the most common test performed in the field because it is a test the components that the installer is responsible for and not patch cords which the end-user of the network can change and invalidate the certification test results.




Channel (purple patch cords) and Permanent Link (blue link adapters) test configurations

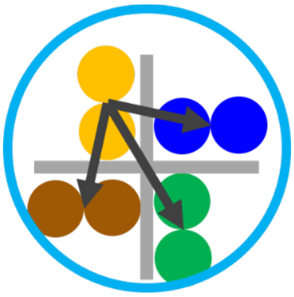
Think of LAN cable certifiers as testing the 3rd element of a cabling system. The first two elements are the cable and the connectors, which are verified by the manufacturers. The 3rd element is the installation of those components in the field. We know that quality connectors and cable will provide their advertised performance when properly installed in laboratory environments. But installation is the field is far different than installation in the laboratory. In the field, the cable can be stretched, kinked, crushed, installed in hot areas, exposed to water and terminated with poor workmanship. It is for these reasons we certify cabling in the field to ensure the individual quality components form a completed quality cabling system.

### What is it that a certifier measures to ensure cabling performance?

The fundamental measurement parameters a certifier tests are return loss and crosstalk. These two measurements are what separate certifiers from all other types of network cable testers, including qualifiers.

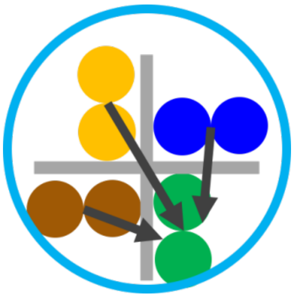
Crosstalk is the measurement of a signal coupling from the intended pair of cable to another. Ideally there is zero signal transfer from one pair on to another but the reality is that it cannot be avoided. Crosstalk is sensitive to frequency and at higher frequencies, even very small disruptions in the transmission line will result in high levels of crosstalk. Crosstalk occurs along the cable and is most pronounced at connectors where the physical construction (twist) of the cable is disturbed. Certifiers measure several types of crosstalk.

> Near End Crosstalk (NEXT): Signal is injected and measured at the same side of the cable. This is measured at both ends of the cable between each of the four pairs resulting in Near End NEXT and Far End NEXT test results. Six results at each end of the cable. NEXT is the key measurement for determining the component quality in workmanship of the cabling.



> Far End Crosstalk (FEXT): Signal is injected at one end of the cable and measured at the other end. FEXT is not reported as a direct test result, though the data is used in calculations for other measurements such as ACR-F (Attenuation to Crosstalk Ratio – Far end).

> Powersum NEXT: A calculated value to simulate the combined crosstalk of any three pairs on the fourth pair of the cable.



Alien Crosstalk: Instead of measuring signal coupled from one pair onto another in the same cable, alien crosstalk measures signal from one cable coupled onto a different cable. Alien crosstalk becomes problematic at frequencies greater than 300 MHz but is nearly eliminated when shielded or screened cables are used.

In any of its various forms, crosstalk is undesirable because it creates interference between the channels of the Ethernet transceiver at either end of the cable. The transceivers are able to operate with some amount of crosstalk, but if it exceeds their tolerance levels, bits will be dropped and data throughput of the link will suffer.

The most common sources of excessive crosstalk are excessive untwisting of the pairs during termination, poor quality connectors and cable/connectors that are not rated to the frequency at which they are being tested.

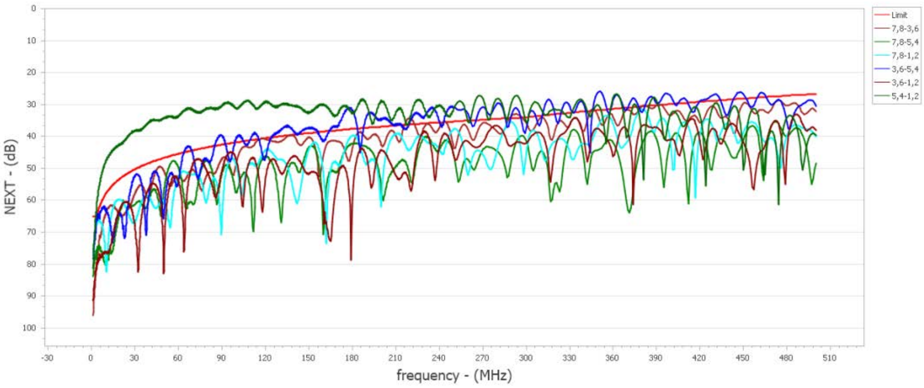
Return loss is the measurement the signal reflected from the cabling back into the transmitting device, like an echo. High levels of return loss can create strong echoes that interfere with the transmission of the signal in one direction but it can also reduce the effective length of a cabling link/channel. Any power that is reflected from the cabling is taken away from the intended signal meaning there will be less power available to travel down a long cable.

The most common sources of excessive return loss are plugs/jacks from vendors that are not compatible with each other, multiple connectors on a channel and poor contact between the cable conductor and contact of the connector (bad termination).

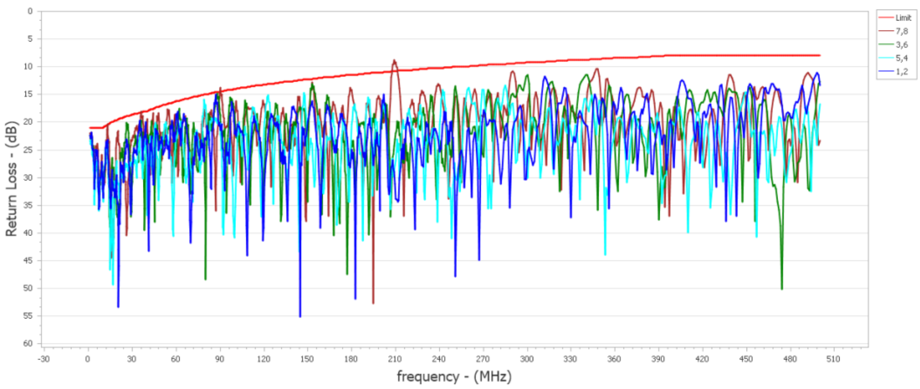
The measurements described above that a certifier performs are precisely defined in the ISO and TIA standards and are not performed by any other type of tester. Unfortunately, these measurements do not come cheap.

Certifiers are measuring signals with approximately 80dB of loss from the reference signal. Using crosstalk as an example, if 1 volt is injected on to the 1,2 pair and measured on the 3,6 pair; an 80 dB loss is equal to 0.001 volts. The equipment required to measure such signals from a frequency of 100 kHz to 1,000 MHz is very difficult to design and expensive to manufacture.

The laboratory instrument that cable certifiers mimic in the field is called a vector network analyser (VNA). A typical VNA costs about $50,000-60,000 and it will only be able to connect to two pairs of a LAN cable at a time. Therefore, an RF switch is needed at an additional $30,000-40,000 bring the total cost of a laboratory system for LAN cabling to $80,000-100,000. Further, testing a single cable with a VNA can take as long as 20 minutes! A handheld cable certifier is performing the same tests as a $100,000 laboratory system and does it in seconds, not minutes for a fraction of the cost.




Example of NEXT failure – all pairs should be below red limit line

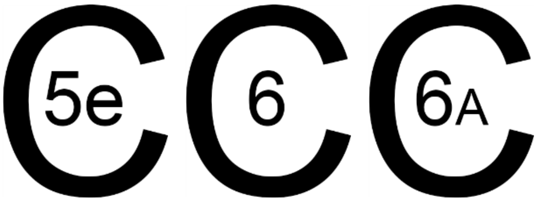



Example of Return Loss failure – all pairs should be below red limit line

## Actual vs. advertised performance

Beyond finding faults in components or installation workmanship, the other important function of a certifier is to determine the true performance of an installed cabling system. Because performance of LAN cabling is not a function of safety, most governmental jurisdictions do not require 3rd party testing to ensure that products provide the level of performance shown on the packaging or marketing literature.

One cannot assume that connectors and cable marked as category 5e, 6, or 6A with the familiar icon guarantees the performance of the components on which they appear. There are products on the market that are falsely labelled with a rating that they do not meet and an installer would never know the performance is subpar without field certification. The vast majority of installed cabling is not certified and manufacturers who intentionally mislabel their products use that knowledge to take advantage of customers who cannot afford to purchase a certifier to test 100% of their installations. To ensure the components purchased provide the required performance, choose reputable brands or test the installation with a certifier to prove they meet the performance standard.




These standardised icons are defined in the ISO 11801 and TIA 568 series of standards to indicate connector performance, however use of these symbols does not guarantee performance.

> *Note about Class and Category. ISO/IEC uses the word "Class" and ANSI/TIA uses the word "Category" to define the performance of installed links. Both organisations use the word "Category" to define the performance of components. Therefore, an ISO/IEC Class EA channel is constructed of ISO/IEC Category 6A components.*

Choosing premium brand components does not completely eliminate risk because those brands are often targeted by makers of counterfeit products hoping to profit off the reputation of well-known brands. There are many cases of installers testing premium brand products with certifiers to find that 100% of the installed links fail and discover that when those components are returned to the manufacturer for evaluation that they were counterfeit. Had those installations not been tested with a certifier the customers would likely never know that counterfeit products had been installed.

## Bandwidth/throughput vs certification

A common question that comes up with certification is "how can a cable fail a certification test yet still pass data"? To answer this question, it is necessary to understand the differences between the performance requirements for various data speeds and cabling performance categories. The best place to start is the frequency requirements of each and the difference between frequency and data rate.

Data rate is the amount of data passed through the cable or network measured in megabits per second (Mb/s). Data rate is key metric in defining Ethernet speeds and is a function of the signaling frequency and the type of encoding used to create data bits. Common data rates available on twisted pair cabling are 10, 100, 1000 (1G) and 10G. 40G has just become available and 25G will be available shortly, though the distance is limited to 30 meters vs 100 meters with the other data rates.

Cable frequency is the frequency at which the cable is tested for certification. The difference between the cable frequency and data rate is due to the encoding used to create the data bits and the number of pairs used to transmit data.

| Ethernet Type | Class/Category | Cable Frequency | Data Rate | No. Pairs Used | Channel Distance |
|---|---|---|---|---|---|
| 10Base-T | C/3 | 10 MHz | 10 Mb/s | 2 | 100 m |
| 100Base-TX | D/5E | 100 MHz | 100 Mb/s | 2 | 100 m |
| 1000Base-T | D/5E | 100 MHz | 1,000 Mb/s | 4 | 100 m |
| 1000Base-TX | E/6 | 250 MHz | 1,000 Mb/s | 2 | 100 m |
| 10GBase-T | EA/6A | 500 MHz | 10,000 Mb/s | 4 | 100 m |
| 25GBase-T | EA/6A or F or FA | 1,250 MHz | 25,000 Mb/s | 4 | 15 m |
| 40GBase-T | I/8.1 or II/8.2 | 2,000 MHz | 40,000 Mb/s | 4 | 30 m |

Notice the discrepancies between the cable frequency and the data rate between the various types of Ethernet. 1000Base-T or 1G Ethernet is the most common application in use today and while it requires only Class D cabling to operate most people are installing class E or EA cabling which are certified to 250 and 500 MHz respectively. Therefore, the cabling is being tested at up to 5x the speed that is required for the network to operate properly. In this scenario, a cable can fail a certification test for Class E/EA and still work perfectly fine on a 1000Base-T network because of the significant difference in what is tested vs the minimum operating requirements.

The most common reason for the difference in the class of installed cabling and the data rate of the network equipment being used is to prepare for future applications. Today, the cost of 10G switches still hover around $300 per port while 1G switches cost $5-10 per port. 10G is still too costly for use at every work station and is limited mostly to data centers, but the cost difference between Class E and EA cabling is small enough that many organisations will pay for the better cabling to ensure they can migrate to 10G networks when the costs come down in the future. So even though a 1G network will run fine on poor quality Class EA cabling today, the infrastructure must be designed and tested to support future applications when organisations are ready to deploy them.

## Certification vs qualification

Early in this article the role standards play in certification testing was discussed. The test and accuracy requirements for cable certifiers are developed in conjunction with the performance requirements for cabling. One cannot proceed without the other.

Cable qualification has no defined tests, performance or accuracy specifications in the standards organisations. Qualification is left up to the manufacturer of the tester to decide what to test, how accurate the instrument is and how to report the results. The problem with non-standardised testing is that the results from one brand of tester cannot be compared to another. Plus, without a definition for pass/fail limits, what does it mean when a qualifier “fails” a cable? For these reasons, no major cable or connector manufacturer will accept test results from a qualifier for cable certification/warranty programs.

When shopping for a tester it can be confusing to know what a true certifier is and what a qualifier is. Sometimes the marketing materials can blur the lines between the two types of testers. All certifiers must meet certain criteria and an examination of the literature for a few key terms will help identify a certifier from a qualifier. Look for:

- Meets ISO/IEC 61935 and TIA 1152-A accuracy requirements
- ETL Level III/IIIe verified accuracy
- Measures NEXT, PSNEXT, Return Loss, Insertion Loss and ACR-F
- Specifies a test frequency range of at least 500 MHz

The last point on cost is interesting because it is not a technical specification. In order to perform the tests required for certifiers the circuitry inside such a tester is expensive, there is no way to avoid it. A new certifier cannot be sold for a couple of thousand dollars, and claims of such a tester should raise a red flag of concern.

For this reason, some distributors have certifiers available for hire to customers who do not test cabling enough to justify purchasing a certifier or for customers who have multiple simultaneous projects and need additional certifiers to fill short term needs. Rental prices vary but are typically a few hundred dollars a week with discounts for long-term rentals. When renting a certifier, make sure to choose a reputable supplier whose fleet of testers have recent factory calibrations and up-to-date software. The last thing you want is to complete testing a large job to have your reports rejected because the tester was out of calibration.

In summary, certifiers are the best tool to guarantee installed cabling meets the stringent performance requirements defined by the ISO/IEC and ANSI/TIA standards bodies. They find faulty components, sources of installation mistakes and help ensure that the materials are genuine products and poor quality not counterfeits.

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