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# Frequency-Based

# VS.

# Application-Based Cable and Network Testers

Project requirements and capabilities of testers determine the right tool for the job. **BY DAN PAYERLE**

CABLE CERTIFICATION

FREQUENCY TEST

Modern LAN cable testers can perform an astounding range of network tests, and produce pages and pages of data. However, in a world where “time is money,” more is not always better. The industry has seen the development of simpler, cheaper, and more streamlined testers that focus on Ethernet testing—the most common commercial and residential network transmission technology. However, the rise of these new, “application based” testers has raised important questions: Do they satisfy industry standards? How do they differ from traditional LAN testers? Though the technology is simple, the answers to these questions are not.

This article attempts to answer them by first imparting an understanding of the evolution of the standards and the technology itself.

INSTALLATION

APPLICATION TEST

## A Brief History

Field testing telecommunications cables in the LAN environment developed partially as a result of the need to use existing cable infrastructure to support newly-installed network servers and terminals. It was often much easier to utilize unused pairs in the telephone cabling than install new cable. Because of the various proprietary systems of the day, installers employing this technique had to be keen experts in adapting and troubleshooting the cabling.

The most common tools in the arsenal were a break-out-box (BoB), volt-ohm meter (VOM) and budget-permitting, a time domain reflectometer (TDR). The BoB allowed technicians to re-map connectors with jumper wire and route the signals to get the system running. They could then make a permanent connector that duplicated the cross-over pattern they had created with the BoB. The VOM measured voltages and checked for shorts or opens on their custom wired connectors. The most advanced tool was the TDR, which allowed the technician to determine the length of a cable, if it was terminated into an open, short or load, and if mid-span connectors were causing significant impedance mismatches.

As helpful as these tools of the trade were for providing information about connectivity, none provided information about the ability of the cabling to support data transmission without error.

CABLE CERTIFICATION

## ANSI/TIA/EIA-568-A Standard—The Considerable Costs and Benefits

Industry efforts led to the adoption of the American National Standards Institute/Telecommunications Industry Association/Electronic Industries Alliance (ANSI/TIA/EIA)-568-A structured wiring standard for commercial buildings, which defined common or generic practices in the design, installation and testing of communications cabling. Among other things, the standard defined a common color code and pin-out configuration for the RJ-45 connector, called the T568A termination code (and later appended the T568B code which was favored by AT&T), as well as field testing requirements. The field testing requirements revolutionized the standard.

By having a set of performance requirements that could be tested in the field, installers could now test the cabling they were installing to ensure it provided the performance the networking hardware required.

Several integrated field testers were available to the industry before the adoption of the ANSI/TIA/EIA-568-A standard. One of the first was the Beckman Industrial transmission media tester (TMT), which became available in the very early 1990s. The TMT combined a four-pair continuity tester, direct current (dc) resistance tester, TDR for length measurements and an impedance tester into a single portable, battery operated box. However, ANSI/TIA/EIA-568-A required technicians to measure near-end crosstalk (NEXT) and attenuation. Both parameters were frequency-specific and required a field tester that could sweep a cable across a given frequency range and provide test results for all pairs and their unique combinations. The Beckman TMT thus evolved into the Lantech 10, which provided NEXT and attenuation data to 16 megahertz (MHz) (cabling requirements of 10BASE-T Ethernet with some margin). Other field cable testers came to market from many now-defunct manufacturers, but the field certification arms race had begun.

MAINTENANCE

## The Cost of the Arms Race

Standards are living documents. Because technology never stops advancing, industry must also continue to update its guidelines to take advantage of new technologies. As a result, cabling grades quickly advanced from category 3 to category 4, 5, 5e, 6, and now 6A (16, 20, 100, 100, 250 and 500 MHz respectively). To remain competitive, tester manufacturers began introducing testers that swept to higher frequencies than the standards required (hence the arms race), because if testing to 100 MHz was good, 155 MHz had to be better, right?

Today, in the parts of the world that follow TIA, category 6A is superior. It requires the following tests to be run from 1 to 500 MHz: wire map, length, delay and skew, attenuation (now called insertion loss), near-end crosstalk (NEXT), power sum NEXT, equal level far-end crosstalk (ELFEXT), power sum ELFEXT, return loss, attenuation-to-crosstalk ratio (ACR), and power sum ACR. Unfortunately the circuitry required to perform these tests is not simple, nor can ready-made circuits be found readily obtainable. This means that engineers are tasked with devising very sophisticated test equipment that is affordable, durable enough to be used in the field, and can perform all the above tests quickly. By comparison, the reference equipment used in the lab to test network cables cost as much as \$100,000, weighs dozens of pounds, is as big as a dorm-fridge, and can take up to an hour to test one cable.

LAN cable certifiers continue to become more expensive and complex because test frequencies continue to rise as new technologies become available. When sweeping to higher frequencies, the cost and difficulty of designing the certifier also increase because high performance LAN cabling exhibits very little crosstalk. The noise from the tester's own internal circuitry must be reduced so it does not affect the measurements of the cabling's crosstalk.

## The Cost of Broad Testing Requirements

In addition to testing higher frequencies, LAN cable certifiers must also test a defined number of frequency points or steps. It is easy to forget that the original purpose of the ANSI/TIA/EIA-568-A standard was to provide a generic cabling infrastructure that was application-independent. Today, we in the LAN industry are only concerned with Ethernet in all of its various forms. However, the ANSI/TIA/EIA-568-B still requires the cable to be tested across a broad range of frequencies to support current and legacy voice and data signaling.

This broad requirement of the standard keeps the development and manufacturing cost of LAN cable certifiers high. A LAN certifier limited to testing 1 Gigabit Ethernet (GbE) would be much simpler to design and

build since it would need to test only a very small range of frequencies.

## The Cost of Tough Accuracy Requirements

Finally, the accuracy requirements of the LAN cable certifiers drive the costs up. An additional specification in ANSI/TIA/EIA-568-A defined the accuracy requirements for field testers. The original accuracy requirement was known as Level I, and testers that met this level could field certify cabling to perform to category 3 requirements. Later, as part of ANSI/TIA/EIA-568-B standard, Level II testers were defined as being able to perform close enough to the laboratory equipment that they could certify cables to category 5 ratings. Level IIe was for cat 5e, Level III was for cat 6 and now Level IIIe has been defined for cat 6A installations. There is also a little-known Level IV definition for category 7 components (cable and connectors), but it does not define field testing requirements. This is left to the International Organization for Standardization (ISO) 11801 class F standard (600 MHz), and the soon-to-be Class F<sub>A</sub> which will define field testing to 1000 MHz. These particular ISO systems use a cable called pairs in metal foil (PiMF), which individually shields each pair and has extraordinary little crosstalk.

As a result of the thoroughness and accuracy of LAN cable certifiers, cabling system manufacturers are willing to extend warranties to installations that are certified to comply with the appropriate standard. While all LAN cable certifier manufacturers use 3rd party testing agencies such as ETL and UL<sup>®</sup> to verify their accuracy claims, most cabling manufacturers still have internal programs to audit the accuracy and approve a particular field tester for use in certification of its cabling systems. In many cases it has become the job of the field tester to verify the headroom and performance claims made by the cabling manufacturers.

## New Products Keep Costs Down

A question often arises—Is there a cheaper way to test the performance of LAN cabling?

The answer, in many cases, is yes. It can be done by streamlining testers to test only the technology that most business are deploying—Ethernet. Virtually all of the critical voice, data and video systems in use today are Internet Protocol (IP) or are rapidly becoming IP. Fast Ethernet and GbE are the standard deployment for data networks. IP phone systems are favored for voice and closed-circuit television (CCTV) camera systems are quickly transitioning to IP.

One reason for the rapid deployment of IP systems is the low development cost of the devices. Unlike custom designed circuits, engineers of IP devices can simply choose from a huge number of off-the-shelf components

to inspire their designs and create the software to make it all work. The use of off-the-shelf components and circuits allow manufacturers to take advantage of economies of scale. With so many companies using the same core components in their Ethernet devices, the cost of the parts decreases year after year.

Using this same logic, test equipment manufacturers are now developing application based testers specifically designed to certify only Ethernet. Because these streamlined testers no longer have to verify that any application in existence can run over a given cable, many of the design limitations are removed and designers can employ off-the-shelf components much like the designers of the IP telephones, CCTV cameras, and network adapters do. In short, by limiting the scope of field testing to just one application, much of the cost and complexity is removed.

## Negotiating the Field of Testing Alternatives

Today, the issue of alternative certification has not been entirely embraced by the industry. The greatest fear is that the term certifier has definite meaning and that the availability of two completely different types of field testers, both called certifiers, will cause confusion. Indeed, there is much debate about what a “real” certifier is. Convention in this industry is that a “certifier” refers to the type of equipment that performs a number of frequency sweep tests on a cabling link to test its compliance with the complete ANSI/TIA/EIA-568 field testing standards, not just the interconnect portion.

### The Testers

There are currently four true ANSI/TIA/EIA-568 field certifiers in production, which provide complete radio frequency (RF) tests of the cabling. All of these certifiers sell for \$5000 or more depending on the capabilities of the particular model in question. A number of manufacturers also sell alternative, cost-effective, application-based testers that may or may not claim to certify a cabling link, but universally test the performance characteristics of LAN cabling. These certifiers cost between \$1000-1500 for a copper only version and \$2000-3000 for a model that can test both copper and fiber.

### What is the difference?

Most of the world uses standards written by the TIA, ISO and International Electrotechnical Commission (IEC), which all describe testing methods that span the cabling across a range of frequencies and aim to determine if the installed cabling actually meets the desired category rating. Application-based testers do not comply

with these standards and may or may not comply with other international standards when determining the pass/fail status of a cabling link.

Application-based testers are useful for certain jobs. Some manufacturers choose to test to the Institute of Electrical and Electronics Engineers (IEEE®) 802.3x standard. This set of standards provides the signaling requirements for Ethernet in all of its various flavors and is a favorite for alternative certification since it does determine if a cabling link has “passed” or “failed.”

This test is adequate for smaller commercial and residential installations because many building owners and tenants do not particularly care about the cable; they just want to know that data can be passed throughout the building without problems. The usefulness of this distinction can be illustrated with an analogy comparing cable testing to car racing. A race car’s ability to go around a track at 200 mph without crashing can be measured in one of two ways:

1. By measuring all of the characteristics of the race track such as the paving material, turn diameter, bank angle, current weather conditions, and overall length, then comparing that data to the capabilities of the race car, a determination can be made as to the car’s ability to go 200 mph around the track.
2. Put the car on the track with an attempt to run at 200 mph and see if the car does it without crashing.

The first method is analogous to traditional certification. It requires gathering a lot of data about the track and the requirements and abilities of the race car to test its ability to accomplish the task. Similarly, without actually sending the “car” (network data) around the “track” (cable), traditional LAN certifiers take complex measurements and calculations to determine if the cabling complies. Then, in theory, when put to use, the cabling should support data transmission of a particular data rate without problems.

The second method is analogous to application-based testing. It is much more brute force than finesse, but is a more direct way of determining whether the task at hand can be accomplished. When testing cabling using this method, data is sent across the link at the desired speed for a given duration and the tester simply checks to see if there were any “crashes” or lost data. That is, instead of testing the cabling to see if it should support data transmission at a certain rate, the test verifies that the data does transmit across the cabling without errors. This type of practical application testing is less sophisticated than the analytical method used by traditional LAN cable certifiers, but it is useful in answering the most critical question—can my network cabling pass data?

This form of application certification only applies to the data that is sent across the cabling during the test, in this case Ethernet at 10, 100 or 1000 megabits per second (Mb/s) data rates.

It should be clear now that there are two basic methods of LAN cable certification available today. What is not clear is an absolute way to identify what type of tester you are considering purchasing or may have already purchased. Since application testers described in method two above are not recognized by ANSI/TIA/EIA-568 test- ing standards, there is no official designation that can be

given to them. The test equipment industry uses several different naming conventions, so a user must look at the features to determine what type of tester he or she has.

## How to Determine Which Type of Tester is Best for You?

First, determine the needs of your customer. The most important task for the cabling installer is to meet the obligations spelled out in the contract. Does the contract make reference to accuracy requirements of the testers used to certify the cabling? Does the installation

need to carry a warranty from a system vendor? Does the contract require data reports to comply with the requirements of ANSI/TIA/EIA-568-B or that frequency and dB data for NEXT, return loss, ACR, etc., be reported? If the answer to any of these questions is yes, then a traditional frequency-based certifier is required. Application-based testers do not provide this information or capability and cannot be used to satisfy the requirements of most commercial cabling contracts.

If there is no need to provide a vendor warranty and the obligations of the cabling installer are to simply prove performance of the cabling and provide documentation of such performance, an application-based tester is perfectly acceptable.

Installation testing with an application-based certifier confirms that, as installed, the cabling components are able to support data transmission of 1 Gb/s at an acceptable error rate. An additional benefit that application-based testers provide, which traditional certifiers do not, is they can be

**Table 1:** Methods for tester identification

Criteria	Traditional Frequency-Based Certifier	New Application Based-Certifier
Tester Description	LAN cable certifier, cable certifier, cable analyzer, network analyzer	Cable qualifier, Ethernet certifier, Ethernet qualifier, speed certifier, network certifier
Standards Referenced	ANSI/TIA/EIA-568A/B, ISO 11801	ANSI/TIA/EIA-568A/B interconnect, IEEE 802.x, or none at all
Accuracy Level Specified	TIA Level II, IIe, III, IIIe or IV	None
Data Provided	NEXT, PSNEXT, ELFEXT, PSELFEXT, attenuation (insertion loss), return loss, ACR. Complete frequency and decibel (dB) data for each test	Packet loss rate, total packet loss, signal-to-noise ratio (SNR), headroom

**Table 2:** Advantages and disadvantages of each type of tester

Feature	Traditional Frequency-Based Certifier	New Application-Based Certifier
Recognized for cable/connector manufacturer warranty program	Yes	No
Standards compliance	ANSI/TIA/EIA 568-B, ISO 11801, complete standard	IEEE 802.3 (some models)
Certifies cabling to meet category 5e, 6, 6A or ISO class D, E, E <sub>A</sub> compliance	Yes	No
Instrument accuracy verified by independent testing laboratories	Typically yes. ETL or UL	No
Graphical plot data provided for RF tests across frequency range	Yes	No
Performs bit error rate (BER) or packet error rate tests	No	Yes (some models)
Prove operation of Ethernet over cabling links	No	Yes (some models)
Optical fiber testing option	Yes (some models)	Yes (some models)

affected by electromagnetic interference/radio frequency interference (EMI/RFI). A traditional frequency-based LAN cable certifier is designed to have very high common mode rejection (CMR) performance. This means the certifier does not “see” the effects of external noise on the cabling. Its receiver circuitry measures only the signals that its own transmitters apply to the cable under test. The effect is that even when cabling is installed in an electrically noisy environment (i.e., a factory or casino with an abundance of electrical equipment), the certifier is not going to measure those links any differently than it would if those same links were installed in perfect laboratory conditions. At first this sounds like a flaw, but one must keep in mind the purpose of the test equipment. It is specifically designed to measure the internal effects of NEXT, insertion loss, return loss, and the litany of other parameters required by the TIA/ISO. It goes back to answering one question—Does this cabling link meet the requirements of the performance standard, regardless of its environment?

Application-based testers do not ignore the effects of external noise on the cabling. Because they monitor the flow of data packets across a link, any EMI/RFI influence that is bad enough to cause data corruption and re-transmission of packets will be detected by the tester and reported to the user.

There are other advantages of application-based certifiers that go beyond the initial testing of new cabling that users should keep in mind. For example, end users are always performing changes to their networks. From simple moves, adds, or changes (MACs) to new technology roll-outs, the network is always in flux. An application-based certifier is the perfect low-cost tool to ensure that cabling can indeed perform as expected when changes are made.

One example is the rollout of gigabit Ethernet in existing networks. Over the years, many thousands of buildings were wired with cat 5 and cat 5e cabling with the expectation that some day gigabit Ethernet would be introduced to all users in the network. Back in the mid-1990s this sounded crazy, but today even the most modest new computers come equipped with 1 Gb Ethernet NICs. If an IT manager were to decide to replace all the existing 10/100 infrastructure with gigabit Ethernet, they have few choices in the matter—either install the equipment and hope it works or have the cabling retested to ensure it can support the new application. An interesting situation arises if the cabling is older cat 5 and not cat 5e. Gigabit Ethernet is designed to run over cat 5 and does not need cat 5e cable. Since the cat 5 standard is officially obsolete according to TIA and no longer acceptable for

new installation certifications, many traditional LAN certifiers do not even have it as an option in their firmware anymore. Therefore, testing the cat 5 cable to the current cat 5e test limits is bound to cause problems since many of the links will likely fail this test.

While the intent in this case is to verify the ability of the cabling to support gigabit Ethernet, testing it with an application-based certifier will basically stress-test the cabling to confirm its ability to support gigabit Ethernet without excessive errors. An Ethernet certifier does not care about the cabling, its only purpose is to pump data onto the cabling and measure what happens to it. If the old cat 5 cabling can handle the task, the certifier will pass it with flying colors. On the other hand, if for example, some of the links exhibit excessive error rates because they are too long and have insufficient attenuation to crosstalk margins, the IT manager can flag those drops as being able to support only 10/100 Ethernet. This test provides the IT manager with the exact information he or she is looking for.

## Conclusion

Cabling contractors need to be aware of the requirements placed on them as well as the capabilities of their test equipment to be sure that the right tool is used on the job. The worst case scenario is that time and money is spent testing with one type of equipment when another was actually required. The result is lost profits when the job needs to be retested or even stiff penalties if the job is not finished on schedule. Making an informed, educated decision when choosing which field tester to use on a job will prevent these problems and may even improve profitability by allowing lower cost test equipment to be used on jobs that do not require traditional certification. ■



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