A Beginners Guide to Copper Cable Certification

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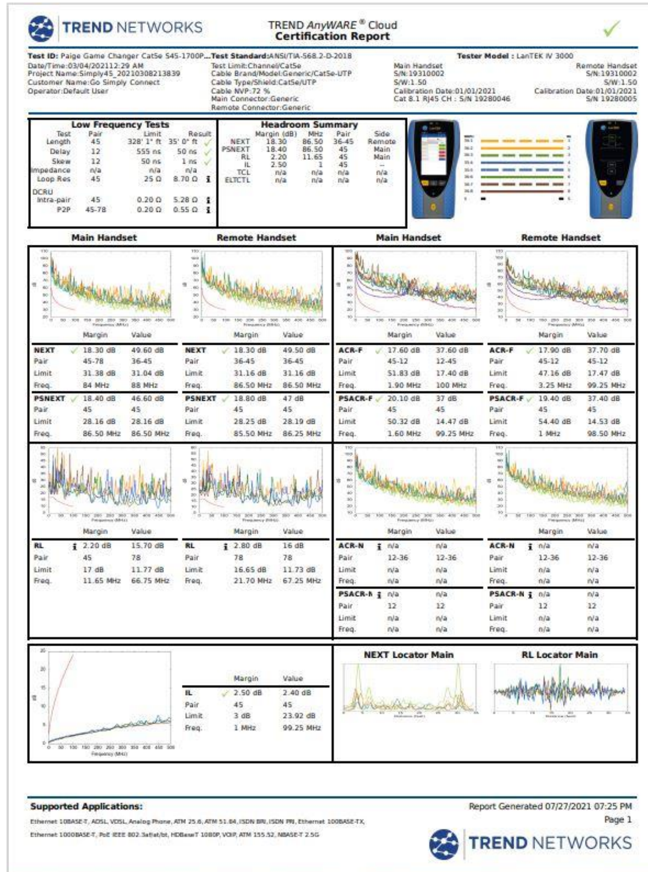
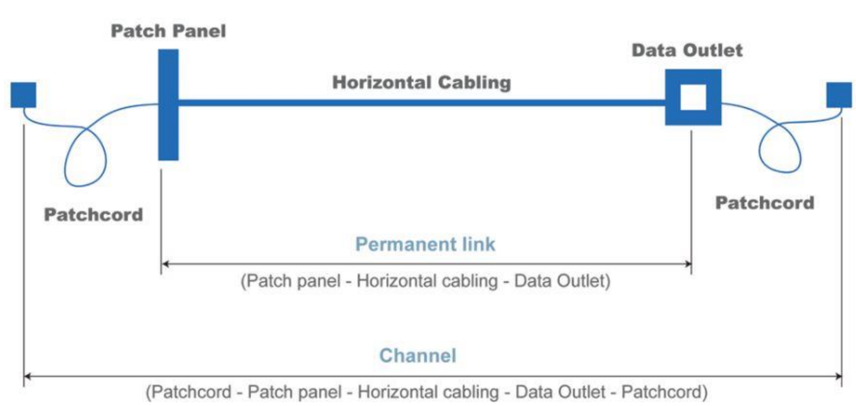


Cabling certification testing is the last vital step to installing a structured cabling system. The certification report assures the customer that the cable and connectivity listed on the RFP (Request for Proposal) has been installed properly and that the entire system will operate according to the specific system requirements. Installers use these reports to bill and close out the project. Cable manufacturers also rely on the test reports to be able to provide proper product and installation warranties to the customer.

Testing methods are built around industry standards and applications. All testing procedures and field-test instruments shall comply with applicable requirements of: 1. ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling; 2. ANSI/TIA-568.0, Generic Telecommunications Cabling for Customer Premises; and, 3. ANSI/TIA-568.1, Commercial Building Telecommunications Infrastructure Standard, and ANSI/TIA 568.2 Balanced Twisted-Pair Telecommunications Cabling and Components Standard.

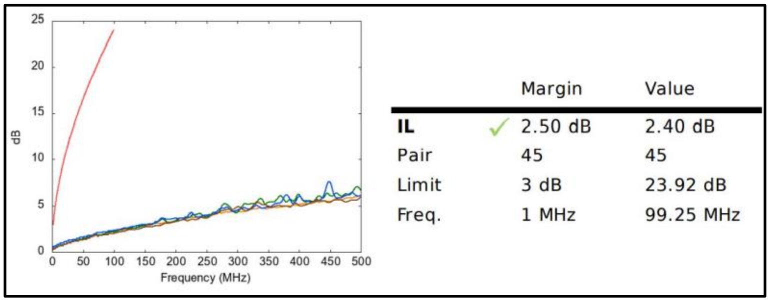


Best test results are dependent on two important factors – quality cable and connectivity products, as well as quality trained installers. It's important that the technician/installer has received in-depth training on best installation practices to understand how his/her installation skills affect the test results. There are many training resources such as manufacturers of the cable and connectivity, manufacturers of the test equipment used for the field certification and training organizations such as BICSI and ACP (Association of Cabling Professionals™). Test reports should also assure the support of future applications, which can be found on the reports through the set parameters and test results. Test reports are comprised of many pages as each link is specified in detail. Contractors need to understand how to interpret the report to the end user before turning over the cable plant to the owner.

These tests are usually set to test each permanent link versus channels. Channel testing would include the patch cords, but these are often moved or changed out so testing the channel would not be feasible for the long term of the structured cabling system.

The first page of the report is an overall summary of the test results and set criteria for which the testing was based. Let's take a deeper dive on these parameters as shown in the sample

The two most important criteria: did the test result pass and what was the cable test limit? If there is a green check at the top of the page it indicates the tests "PASS" or a red "X" indicates a "FAIL." If only one test fails, the entire summary page will have a red "X" and the installer will need to find that particular link and fix it before turning in the report. The cable test limit is based on the Category and cable type. For example, if a Category 6A cable was installed, but the cable was tested to a Category 6, then the cable results will give the customer a false sense of performance and scalability.



The most important test parameter to measure is the capacity of a cable to support high-speed data, which is based on signal strength and low noise interference. Signal strength, or loss, is measured between the near and far end of the link. Signal loss is defined as "attenuation" and also called "insertion loss" (IL) and is measured in decibels (dB). A low insertion loss means a stronger signal. Noise is made up of two parameters – near-end crosstalk (NEXT) and return loss (RL). Putting these parameters together will provide a signal to noise ratio (SNR).

Project Information

The basic information should include the customer's name, project name, cable type (Category, manufacturer product name), and the date and time the test was done. It's important that the project is given a specific identifiable name because when changes occur, such as moves, adds or changes, then there needs to be a job reference. At that time, specifically retesting the cables/patch cords in the links that have been moved needs to happen, not the entire cable plant. The operator/installer's name should also be listed for any questions that need to be addressed during the initial installation, or during any future moves.

It is imperative that the test results are provided in the native software of the tester itself. Customers should not accept PDF reports as these could be altered. Also, information in a PDF cannot be sorted, so trying to find the one "bad" cable will mean sorting through many pages and is inefficient.

Cable Type and Length

Every test will list the specific performance standard to which the cable is tested, cable brand, cable type and connector type. In the example shown, the test standard is to the latest version of ANSI/TIA-568.2-D Telecommunications Cabling standard. Standards set the minimum requirements for categories of copper cabling and define the components in the balanced twisted pair cable systems. In this example it is a

Category 5e cable type. The connectivity must match the Category. In this example, the connectors are Category 5e RJ-45’s from Simply45®.

In addition, the Nominal Velocity Propagation (NVP), should be stated with the cable type. This is the speed at which the data signals travel down the cable expressed as a percentage based on the speed of light. This is an important factor as the tester used the NVP to determine the length of the cable. The NVP percentage can vary between manufacturers as every twisted pair cable has different signal speed from the main unit to the remote. The exact manufacturer’s cable type is listed on the manufacturer’s data sheet, and it can be manually entered into the tester at the time of set-up. The wrong NVP percentage or even a “generic” NVP will affect the distance information, which could contribute to an insertion loss.

In this example, the channel distance limit is shown, which represents standards’ limit of 328’ including the patch cords. The pass or fail criteria is based on the maximum length allowed for the channel or permanent link as specified in the ANSI/TIA-568.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. Industry standards allow a 10% uncertainty in length for link or channel, but if the cable type is programmed into the tester, the cable type can override the standards. An example is the GameChanger Cable™ from Paige Datacom, which is guaranteed to run twice the distance, depending on the application.

Tester Brand and Model

Just as cables vary from manufacturer to manufacturer, so can the tester. The tester model needs to be listed as a reference to the specific test method. On this example, the field tester is a LanTEK IV 3000 from Trend Networks. The software version (SW) is listed as 1.50 it is important to use the latest software version as tester manufacturers continually update the software to revise international standards or update the cable manufacturer’s specifications.

The calibration date is important. Depending on the test equipment manufacturer, the tester should be calibrated, as recommended which is usually every 12 months. This cannot be changed by the operator. It’s important to compare the calibration date with the date of the test procedures. Here the tester was calibrated on 1/1/2021 so it’s good until 1/1/2022. Since the test was done in March, it is well within the calibration date limit.

Test Standard:ANSI/TIA-568.2-D-2018	**Tester Model :** LanTEK IV 3000	
Test Limit:Channel/Cat5e	Main Handset	Remote Handset
Cable Brand/Model:Generic/Cat5e-UTP	S/N:19310002	S/N:19310002
Cable Type/Shield:Cat5e/UTP	S/W:1.50	S/W:1.50
Cable NVP:72 %	Calibration Date:01/01/2021	Calibration Date:01/01/2021
Main Connector:Generic	Cat 8.1 RJ45 CH : S/N 19280046	S/N 19280005
Remote Connector:Generic		

Autotest

Most testers that meet the TIA standard parameters are capable of performing an autotest procedure which can automatically perform sixteen tests at once in a matter of seconds. If all tests pass, a green check will appear. If one or more test fail, then a red “x” will appear and the contractor will need to find out which cable and which test failed to be able to address the issue and retest.

Autotests are built into the field testers and include the following parameters, some of which are for informational only and will not show up as a “PASS” or “FAIL”: 1. Wire Map; 2. Length; 3. Propagation Delay; 4. Delay Skew; 5. DC Loop Resistance (required for Cat3-Cat8, channel and permanent link); 6. DC Resistance Unbalance (DCRU is now a requirement for Cat 5e-8 ANSI/TIA 568.2-D-2); 7. Insertion Loss; 8.

NEXT (Near-End Crosstalk); 9. PS NEXT (Power Sum Near-End Crosstalk); 10. ACR-N (Attenuation to Crosstalk Ratio Near-End) (recorded for information only); 11. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) (recorded for information only); 12. ACR-F (Attenuation to Crosstalk Ratio Far-End); 13. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End); 14. Return Loss; 15. TCL (Transverse Conversion Loss) (recorded for information only); and, 16. ELTCTL (Equal Level Transverse Conversion Transfer Loss) (recorded for information only).

Summary of Low Frequency Tests

The summary page will include the main low frequency tests performed. These include cable length, delay skew, and pair-to-pair comparison. This summary will show the TIA limit and refer to the worst performing pair in the entire report. Most of the test results are measure in time, designated as nanoseconds (ns) or signified by signal loss, which is designated in decibels (dB).

Low Frequency Tests

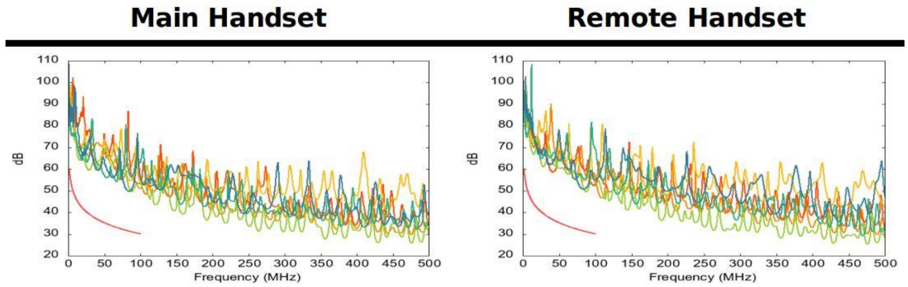
Test	Pair	Limit	Result	
Length	45	328' 1" ft	35' 0" ft	✓
Delay	12	555 ns	50 ns	✓
Skew	12	50 ns	1 ns	✓
Impedance	n/a	n/a	n/a	
Loop Res	45	25 Ω	8.70 Ω	i
DCRU				
Intra-pair	45	0.20 Ω	5.28 Ω	i
P2P	45-78	0.20 Ω	0.55 Ω	i

The length is calculated by the NVP (as mentioned above). The length also affects the propagation delay, measured in time (ns) that it takes for a signal to get from one end of the cable to the other. The result is called “delay skew” which is the largest different in propagation delay from one pair to another. The cable type affects the delay skew result as each manufacturer has different unique twist ratios per pair as well as employing different types of insulation materials that can affect the results.

Skew is an important measurement to enable high-speed networking technologies, notably Gigabit Ethernet, which employs all four pairs in the cable. If the delay on one or more pairs is significantly different from any other, then signals sent at the same time from one end of the cable may arrive at significantly different times at the receiver. Well-constructed and properly installed structured cabling shall have a skew less than 50 nanoseconds (ns) for channel and 44ns for permanent link over a 100-meter link. If the skew is high, provided the intended application is a 2-pair application such as a low-bandwidth applications such as 10BASE-T, should still perform. The lower the number (ns), the better. Anything under 25 ns is excellent.

Impedance is measured in Ohms and represents the total resistance that the cable presents to the electrical current passing through it. DC resistance unbalance (DCRU) test is used for PoE up to 90 W. If the DC resistance of individual wires differs too much, a link will heat up too much when 60 or 90 W are applied. This value is measured only from one side of the link.

Translating the graphs and charts



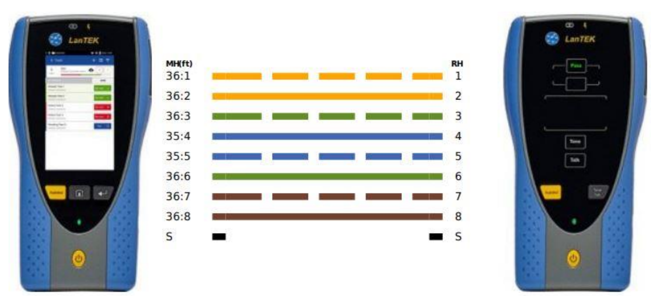
The test report summary page shows the worst-case margin and values for both the main test unit (MAIN) and the remote unit (SR). But what is the difference?

Worst-case margin is based on where the value came the closest to the limit line, which is of most concern by the contractor and end user. Worst-case value is the amount of margin at the point where the value was the worst overall, but not in relation to the limit line. And because the tester looks for worst-case margin and worst-case value for all pairs and pair combinations, the worst-case margin and worst-case value might not be on the same pair. They can, however, be the same value on the same pair.

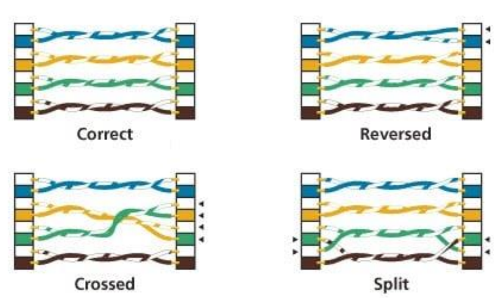
The graphs show the NEXT and return loss (RL) values in dB, as they vary by frequency. The horizontal axis denotes frequency (100 MHz for Cat 5e, 250 MHz for Cat 6 and 500 MHz for Cat 6a) and the vertical axis represents the dB limit value. In each case, the lower red trace shows the testing limits and the mixed color traces above show the six pair combinations comparisons for NEXT (and PowerSum NEXT) or four pairs for Return Loss (RL). The larger the value, the better the result. As long as the traces for the pairs and pair combinations stay above the applicable limit line, the cable passes the specification.

Wire Map

The wire map verifies pin-to-pin termination at each end and checks for installation connectivity errors. This test is shown by the color-coded lines between the main and remote units. The four pairs (eight conductors) are designed as: orange, orange/white, blue, blue/white, green, green/white, brown, brown/white. The wire map can visually show continuity to the remote end or any miswiring which would include: shorts between any two or more conductors; reversed pairs; split pairs; or transposed pairs.



It's important to know the correct connectivity wiring scheme for eight-position RJ-45 plugs, outlets, and connectors. Defined in the ANSI/TIA-568.0 standard, there are two wiring schemes permitted – T568A and T568B. Both are allowed and the only difference is that the orange and green pairs are interchanged. The customer needs to define which scheme is to be used, because it needs to be consistent on the RJ-45 connector on both ends and at patch panel. If there are any wire map issues, the first line of correction is to re-terminate.



Understanding the Field Test Parameters

The rest of this document lists the test parameters that are reported on the certification summary and their importance to the reliability of the cabling plant. There are other tests that address cable properties that are for information only or may be requested by the end user or building owner.

Crosstalk is defined as the unwanted induction of signal (noise interference) from one circuit to another. Crosstalk occurs between each pair/pair combination in the cable and is tested from the main (near end - NEXT) and at the remote (far - FEXT) and measured against the standards' limit. NEXT (dB) shows the value of the worst pair compared with the testing limit. Frequency (MHz) shows the frequency at the worst NEXT margin and value. Limit (dB) shows the limit value in dB at the frequency shown.

Power Sum Near-End Crosstalk (PSNEXT) is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling. Both worst case and worst margins are reported.

Attenuation to Crosstalk Ratio (ACR) is the ratio of the received strength of a signal on a pair of wires compared to the amount of crosstalk between the conductors. ACR is a calculation that happens in the tester which is the result of NEXT minus the insertion loss. The attenuation-to-crosstalk ratio is calculated to ensure that signal transmissions are stronger at the receiver side than the interference caused by crosstalk. Attenuation and crosstalk need to be minimized for acceptable signal transmissions. The higher ACR (in dB) for any given cable, the less chance of signal errors. The ACR is also referred as "head room" because the better ACR results, the better the capacity for future applications and faster communications. The cable type and length can affect the ACR.

Attenuation Crosstalk Ratio Far-End (ACR-F) is a calculated result, rather than a measurement. It is derived by subtracting the Insertion Loss (IL) of the disturbing pair from the Far End Crosstalk (FEXT) and measuring the amount of interference on the adjacent pair.

Power Sum Attenuation to Crosstalk Ratio Near End (PS-ACR-N) PS ACR-N is the difference (dB) between each wire pair's attenuation (insertion loss) and the combined crosstalk received from the other pairs. The tester uses the PS NEXT and attenuation values to calculate PS ACR-N values. PS ACR-N is a calculation of PS NEXT minus Insertion Loss of the disturbed pair, but shall be recorded for all 8 possible pair combinations. Higher PS ACR-N values correspond to better cabling performance.

Return Loss (RL) - Is the difference (dB) between the transmitted signal and the power of the signal that is reflected. RL is the measure of all reflections that are caused by the impedance mismatches at all locations along the link. Additional unnecessary untwist in terminations can add several dB of return loss in many cases.

Achieving Max Headroom

Headroom is the measurement between the standards limit and is shown on the graphs of the cable pairs' performance. For example, the attenuation-to-crosstalk ratio is often defined as headroom as the better the ACR result, the better capacity for future applications and faster communications.

Headroom Summary

	Margin (dB)	MHz	Pair	Side
NEXT	18.30	86.50	36-45	Remote
PSNEXT	18.40	86.50	45	Main
RL	2.20	11.65	45	Main
IL	2.50	1	45	--
TCL	n/a	n/a	n/a	n/a
ELTCTL	n/a	n/a	n/a	n/a

One of the biggest goals for best cable performance is being able to provide maximum headroom which will become important when upgrading to future applications over the existing cable plant. Listed on the test report are the supported Ethernet applications, defined by bandwidth and speed. But the owner should plan for the future as data speeds and bandwidth is constantly growing.