

TECHNIQUES FOR NETWORK ANALYSIS AND TROUBLESHOOTING

Bob Lounsbury
Principal Engineer
Rockwell Automation

Presented at the ODVA
2007 CIP Networks Conference & 12th Annual Meeting
September 18-20, 2007
Englewood, Colorado USA

Abstract

Network down time is costly to the customer base. EtherNet/IP cabling includes an M12-4 “D” coded connector that uses 2 pair cabling. This presents problems for standard off the shelf testers. Because EtherNet/IP is a control network, network acceptance testing is very important. Further, quickly determining a cable fault is key in returning a failed network back to an operational state. Now that Ethernet/IP has been in the market place for several years, it has gained the attention of the network test tool companies. This paper will cover network testing requirements, testing problems and solutions for field test equipment and networks. It will provide guidance on selecting tools and test criteria required to properly commission a network. For example, testing 2 pair cables requires a special adaptation of the standard off the shelf testers. The testers must be capable of testing NEXT, FEXT, RL, Attenuation and now TCL and ELTCTL for all cable types.

Keywords

FEXT, NEXT RL, TCL, ELTCTL, cable fault, M12-4 “D” coded, 2 pair cabling

Introduction

It is important to benchmark (verify and certify) a newly installed network. Benchmarking not only provides assurance that the network will support the intended applications, but also provides useful data in the event that the network performance degrades over time. There are two levels of tests that the planner should require during the installation and commissioning of a industrial Ethernet networks. The two tests differ in their level of testing and expertise required in performing the tests. Further, they are divided by responsibility and equipment cost. The installer who is pulling and terminating the cable and cords should verify the basic permanent link and channel requirements. After the network installation is complete, the network should be certified. Certification should be performed by a autonomous 3rd party to assure objective results. The accuracy of the tester is dependant on the channel category being tested and the needed results. For example, cabling up to and including Category 5e requires at least a level II tester. As the cabling bandwidth increases in support of 10 gigabit the requirements for the tester accuracy increases up to a level IV accuracy. The requirements to meet each accuracy level are describe in the TIA standards. Typically level III and IV testers are needed for network certification. Currently, none of the testers are supporting balance (TCL or ELTCTL) field measurements. This test philosophy is reflected in the draft standards for installation of fieldbus under IEC 61918 and IEC 61784-5-n series standards.

Tests by responsibility

As mentioned above, the permanent link and or channel should be verified after cable installation and termination. This should be required by the planner and carried out by the installer. The suite of tests is designed to verify to the installer that the cable length is correct and the connector is correctly installed. There may be other non- cable related verification requirements that are beyond the scope of the paper. The following cable tests should be carried out by the installer;

- Cable Length,
- Wire Map,
- Faults (shorts to ground or other surfaces).

The length tests are designed to verify that the installer has not exceeded the allowable permanent link and or channel lengths.

Wire Map tests will confirm that the 8 wires are in the assigned contacts. The severity of network degradation is dependant on which wire(s) are in the incorrect circuit. For example in a 10/100Mb/s network if any of the pins 1, 2, 3, or 6 are miss-located, the channel will not work. If wire 4 was used for contact location 3 (split pair) the channel may work, but with severely degraded performance. Incorrect pinning and split pairing is a common mistake.

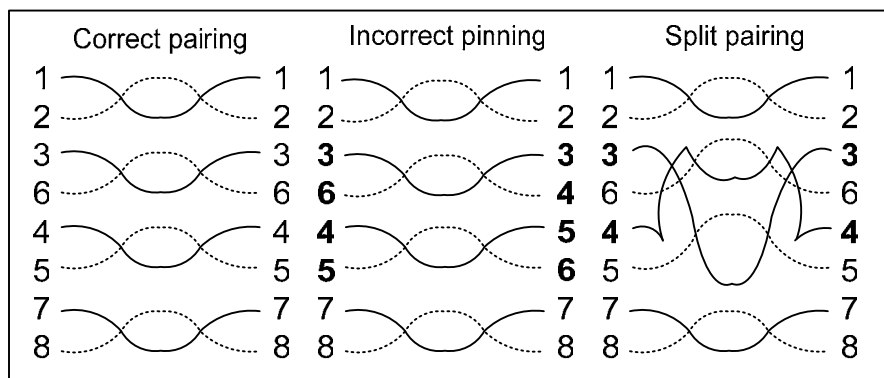


Figure 1: Example of correct and incorrect 8-Way wire mapping

Basic verification testers are available to quickly test for wire map, shorts and incorrect cable length. These testers are cost effective tools that every installer should have for both verification and troubleshooting. The testers range from \$50 to \$150 dollars. An installer can quickly become an expert in the use of these testers in minutes without specialized training. Some have extended ability to locate cables within a bundle or identify cables and perform a ping on a network. Ping is useful in quickly determining if a channel is active and can communicate with the network infrastructure.

The following tests require a visual inspection and DVM to confirm correct installation.

- Correct connector (visual)
- Proper shield termination (visual and measured)
- Proper grounding (visual and measured)

There are a number of companies who are the makers of verification level testers. The coverage of the verification test is limited. For example, the wire map may test to be correct and the channel is marginal in performance. For this reason a network should be certified. Certification is usually performed by a 3rd party. Some 3rd party companies offer maintenance contracts to perform network certification annually or semi annually and troubleshooting services. Not having the ability to self certify and troubleshoot may increase the mean time to repair (MTTR). A cable analyzer that has the ability to certify both copper and fiber network infrastructures can cost upwards of \$18,000. Fiber support adds about \$6,000 - \$8000 to the cost.

The following parameters are measured during certification:

- Wire Map
- Attenuation
- Channel and P-Link length
- Return Loss
- Impedance
- NEXT/FEXT
- Resistance
- Length
- Delay and Skew
- ACR

Other parameters are provided through calculations based on the previous tests.

- ELFEXT
- Power Sum ELFEXT
- Power Sum NEXT
- Power Sum ACR

The certification testers typically display the data in a graphic form (parameter versus frequency) and also indicate the margins in (dB) (pass/fail) with lab quality measurements. Negative margins must be resolved in order to assure that all applications will function as intended.

Since industrial Ethernet networks such as EtherNet/IP use 2 pair cabling, it is important to obtain verification and certification testers that allow the selection of number of cable pairs. Most tests, such as NEXT, FEXT involve multiple pairs; therefore wire mapping must be verified first. As a result testers will halt if the wire mapping is incorrect.

Cable certifiers are far more complex which take some level of training to be effective at using them. Some cable certifiers have the ability to perform TDR functions. These can actually locate with in a reasonable range an open or short or even a mechanically damaged cable.

- There are a number of companies who specialize in verification level testers.

Troubleshooting

Most network related faults can be isolated by the use of a cable verifier. Connecting a cable verifier to a channel or permanent link can within seconds indicate an open or short of any of the 8 conductors including shorts to a shield if present. Figure 2 shows an example of a cable verifier and a failed cable test. The display would show each conductor over the other. In this example, conductors 2 and 4 are swapped at the far end connector. The two pairs are split across each other. This incorrect (split pair) wiring would have caused the error rates to be high in this channel.

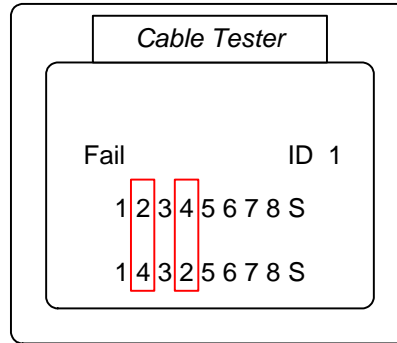
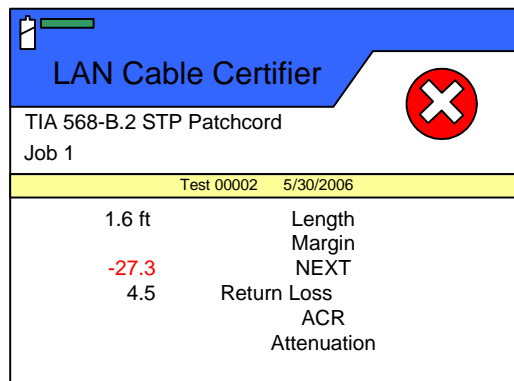


Figure 2: Example Cable Tester

If one or more conductors were shorted, the tool would have indicated a short at the specific conductors. Some verifiers have the ability to indicate the distance to the short if one exists. Degraded performance can occur as connections age or as cables become damaged due to movement, temperature effects. These types of failures can be more difficult to find especially if there is not benchmark data from an initial network certification. A level II, III or IV cable certifier may be needed to determine if one or more of the cable parameters have fallen out of specification.

For example, a cable that has been flexed many times may exhibit high error rates due to a decreased NEXT performance return loss. A negative margin of 27.3dB must be corrected to assure error free communications over all applications.



A cable verification tool would not be capable of finding this type of fault. If the system is production critical it is highly recommended that the support staff has immediate access to these type of tools and be proficient in the use to both the verification and certification tools. Further if M12-4 "D" coding connectors are in the system, the test equipment must be capable of testing 2 pair cabling.

DeviceNet, DeviceNet Safety, CIP, CIP Motion, CompoNet, CIP Safety and CIP Sync are trademarks of ODVA. EtherNet/IP is a trademark of ControlNet International under license by ODVA. Other trademarks are property of their respective owners.

The ideas, opinions and recommendations expressed herein are intended to describe concepts of the author(s) for the possible use of CIP Networks and do not reflect the ideas, opinions, and recommendation of ODVA per se. Because CIP Networks may be applied in many diverse situations and in conjunction with products and systems from multiple vendors, the reader and those responsible for specifying CIP Networks must determine for themselves its suitability and the suitability of ideas, opinions, and recommendations expressed herein for intended use.

Copyright ©2007 Open DeviceNet Vendor Association, Inc. (ODVA). All rights reserved.

For permission to reproduce excerpts of this material, with appropriate attribution to the author(s), please contact ODVA on:

TEL	+1 734-975-8840
FAX	+1 734-922-0027
EMAIL	odva@odva.org
WEB	www.odva.org