Troubleshooting Guide for Industrial Ethernet and other Network Protocols

Keeping today's industrial networks up and running

Industrial Networks

What are they? How do they affect you?

Network systems are rapidly automating more and more of today's factories and plants, controlling tasks such as data gathering, process control, and production automation. This is because systems are migrating from analog to digital networked standards such as:

- ASI, MODBus, RS-485 or RS-232 derivatives
- DeviceNet, a CAN bus derivative
- Fieldbus Foundation, TCP/IP based
- ProfiBus, TCP/IP based
- Ethernet, TCP/IP based

The increasing integration of these technologies onto the plant floor is creating a new set of challenges as 4 to 20 mA analog control, serial digital control, and industrial networks are all found on the same plant floor. Each technology plays a role in the operation of a plant with the networked devices controlling:

- Managed and unmanaged switches, PCs, routers
- PLC's, remote IO, variable frequency drives, motion controllers, sensors, transducers, encoders, actuators, robot controllers

These changes mean a convergence between what had formerly been only thought of as IT issues as ones that need to be dealt with by people in job functions such as:

- Plant Operations
- Industrial Maintenance
- Process Control
- Industrial Automation
- Field Service
- Control Engineer

Industrial networks are found in virtually every industry:

All of this means that minimizing downtime has gotten more complicated. New tools are needed to identify, troubleshoot, and resolve industrial network problems. Industrial networks can present many symptoms, but by asking the right questions and using the right tools, troubleshooting can be made easy. It is invaluable to be able to see into your network and assess where the problem is. Often, time is spent calling an "expert" to troubleshoot problems that could be solved quickly by the first responder. Fluke and Fluke Network tools are intuitive and easy-to-use and allow industrial technicians to solve a broad range of industrial network problems with little or no training.
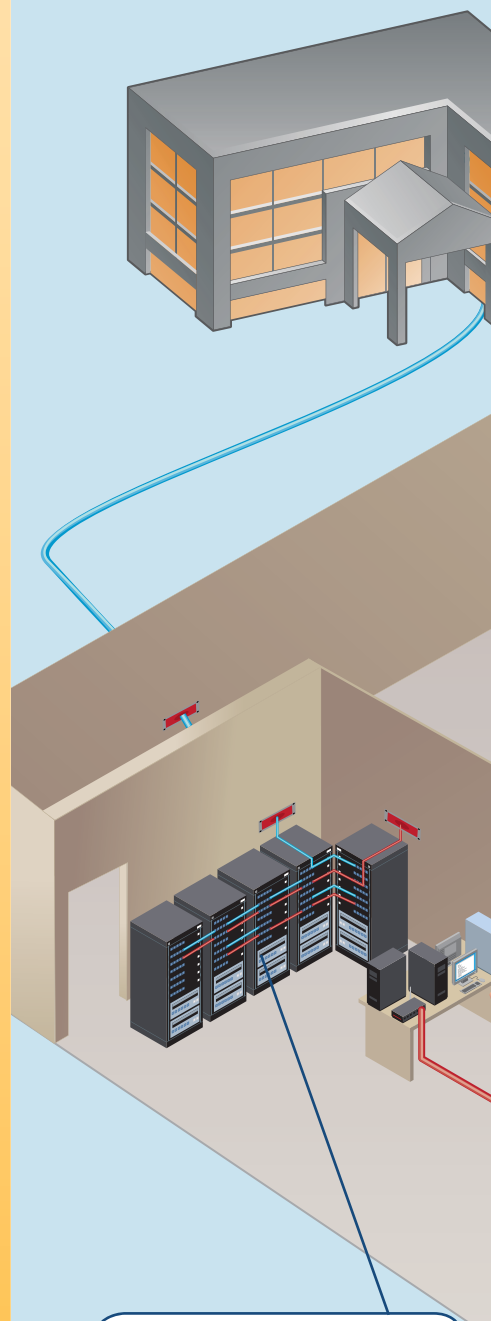
Control Room with Application Server or DCS
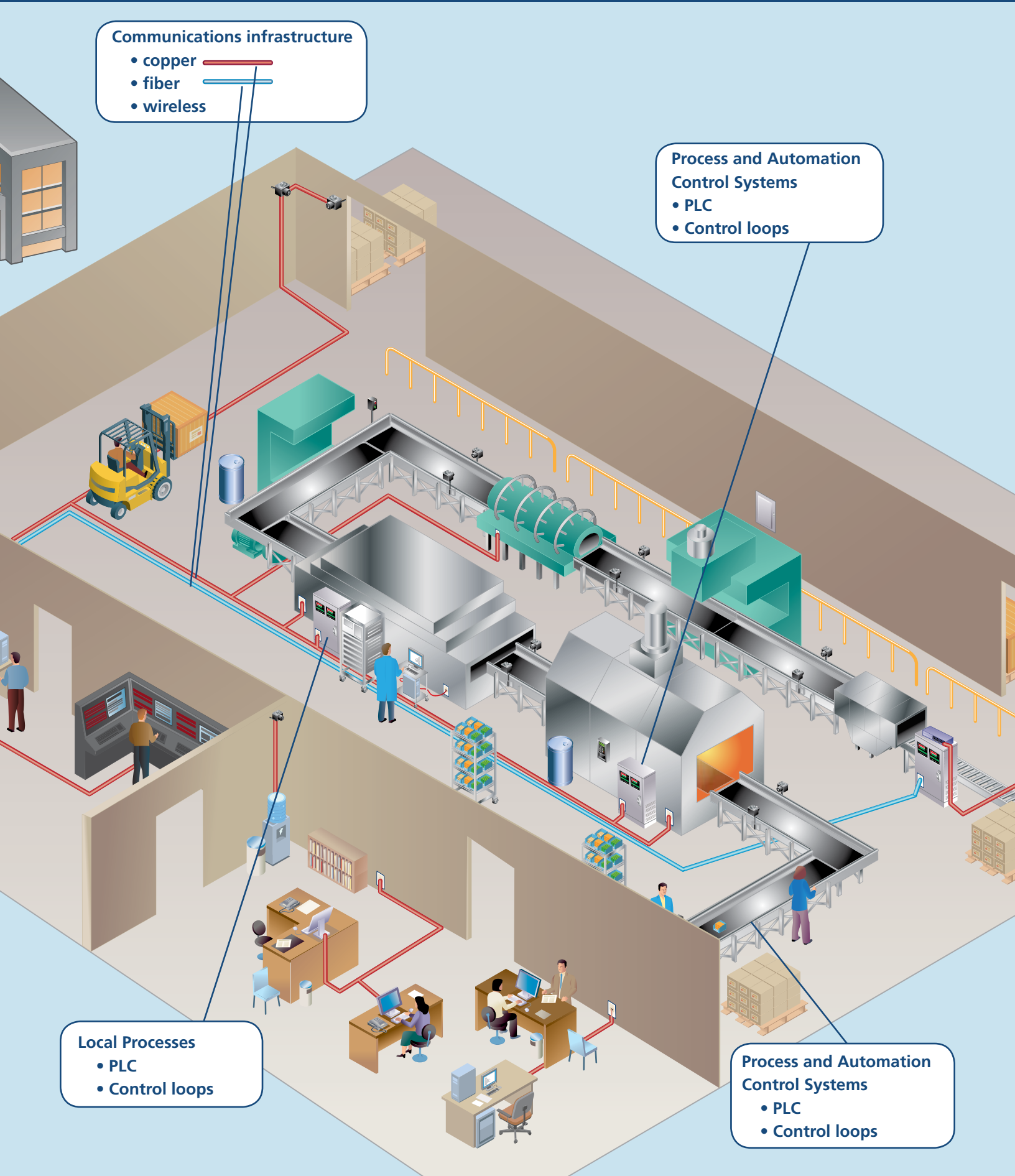
Communications infrastructure
- **copper**
- **fiber**
- **wireless**

Process and Automation Control Systems
- **PLC**
- **Control loops**

Local Processes
- **PLC**
- **Control loops**

Process and Automation Control Systems
- **PLC**
- **Control loops**

Don't let network issues take you – or production – down

Networks aren't perfect and being able to troubleshoot them quickly and effectively is fundamental to your production process. One failure can trigger another, resulting in a significant loss of time and money.

There are three primary areas where issues can occur: the network, electrical signaling, or cabling infrastructure.

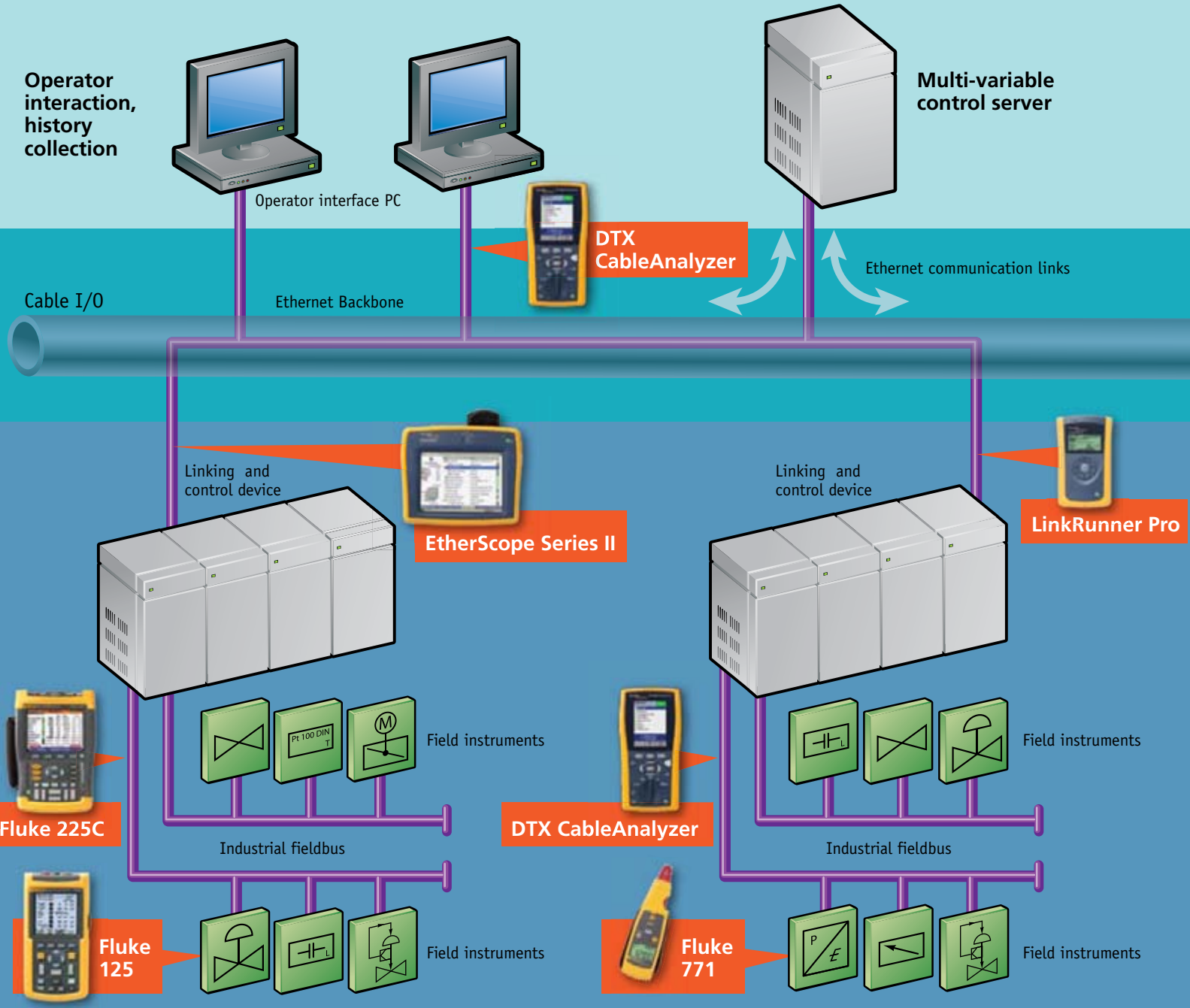| Industrial Network Problem	How it Affects Production
Network Communications • What devices and who is on the network? • Alarm & error detection • Bandwidth "hogs"	Process interruptions
Electrical Signaling • Poor signal integrity • Electrical disturbances • Induced noise	Random shutdowns or device resets
Cable Infrastructure • Deteriorating connectivity • Cabling installation errors • Cable performance	Segments go down, all data communication lost

Cabling infrastructure

Network

Electrical signaling and cabling infrastructure

Today's Industrial Network

Operator interaction, history collection

Operator interface PC

Multi-variable control server

DTX CableAnalyzer

Ethernet communication links

Cable I/O

Ethernet Backbone

Linking and control device

EtherScope Series II

Linking and control device

LinkRunner Pro

Fluke 225C

Pt 100 DIN T

M

Field instruments

DTX CableAnalyzer

Field instruments

Industrial fieldbus

Industrial fieldbus

Fluke 125

Field instruments

Fluke 771

P E

Field instruments

Troubleshooting Common Industrial Network Issues

Common Network Issues

Q: My LAN is slow and PLCs can't seem to connect. How can I quickly isolate the problem and get to root cause?

A: The inability to connect tends to be a point-source problem. Keep in mind that the PLC must have connected properly at least once before or the problem is approached as a new installation instead of a troubleshooting event. The best new install approach is to certify the infrastructure. The best troubleshooting approach is the "divide and conquer" strategy. Assuming that this is an IP-based installation, there are a minimum number of requirements for normal PLC communications.

- If Ethernet Link state is not established, check for:
  - Bad cables
  - Ethernet errors on the local link
  - Failed, marginal, blocked, or misconfigured switch ports (including accidentally VLAN tagged ports)
  - Failed, marginal, or misconfigured PLC Ethernet interface

Most problems of this nature are identified quickly by connecting EtherScope Network Assistant in place of the PLC using the PLC's Ethernet cable. The cable may also be reversed so that EtherScope tests the PLC Ethernet interface and attempts to establish link.

- If a valid IP address for the local subnet is not present, check the following:
  - Ensure that any statically assigned IP address on the PLC is correct for the local subnet, including subnet mask and default router.
  - Verify that a DHCP (or BOOTP) address may be obtained from the PLC's Ethernet connection using either the PLC or EtherScope. If the local switch port has been accidentally configured as a VLAN tagged port then this will fail. EtherScope will report the presence of tagged traffic.
  - Ping each server which the PLC communicates to over the PLC's Ethernet connection using either the PLC or EtherScope.

If these tests all pass, then reconnect the PLC and see if it is now working. Sometimes a cable is not fully inserted or the switch port is reset by dropping link state. If it begins working, then double-check the local cable connections carefully. It may be a poorly crimped RJ45, or the RJ45 connector is designed for solid conductors instead of stranded (or the reverse) and has become intermittent. Check also for water or other contamination of the Ethernet port or water ingress in the link.

The most common reasons for slow or poor performance include overloaded or underpowered servers, unsuitable switch or router configurations, traffic congestion on a low capacity link, and chronic frame loss. The EtherScope can help determine which of these reasons is causing performance issues.
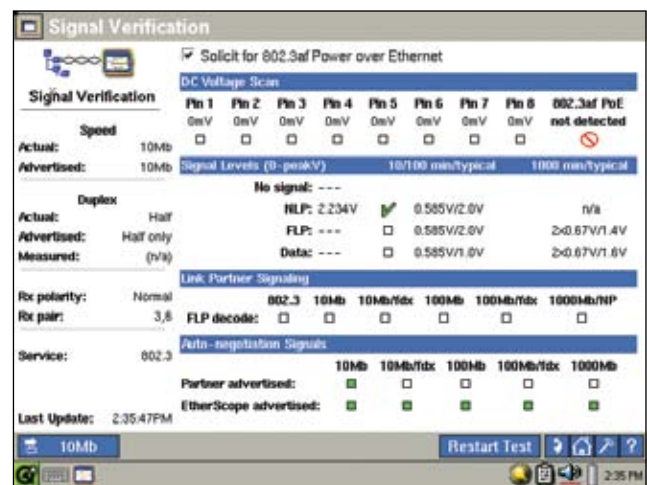

Q: My connection continues to be dropped. What could be causing this?

A: The reason for dropped connections is a logical or physical connectivity loss. The EtherScope Network Assistant can help you determine which of these problems is causing the dropped connection:

- Errors on the ports which are used in the path
- Duplex settings
- Spanning tree problems
- Routing problems
- Overloaded WAN link or a marginal interface in the WAN path
- EMI or other electrical of RF interference

Q: I suspect unauthorized devices have been added to the network. Is there an easy way to verify this?

**A:** The EtherScope Network Assistant helps you to proactively baseline your network to register devices on the network. This allows you to know which devices are normally there, then when the reactive/tactical discovery reveals a list of currently attached hosts you would recognize anything inappropriate.
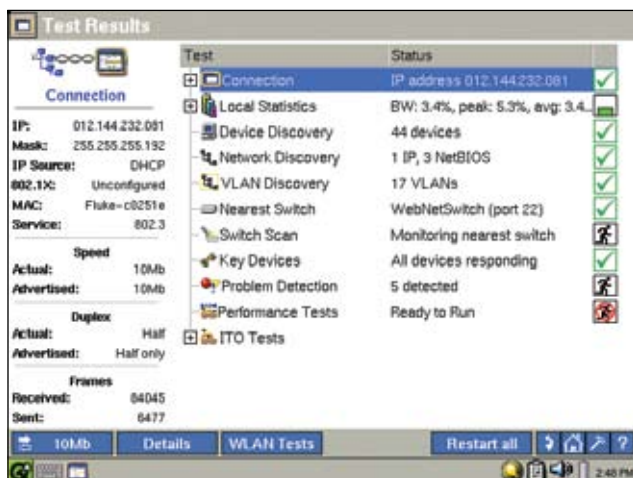
For wireless, there are "rogue" detection features built in to scan detect and locate unauthorized WLAN devices. EtherScope does not rely on simply MAC and IP addressing. If an unknown device is found, EtherScope will report a great deal of information about its configuration, including: SNMP host name, NetBIOS name, Ethernet interface manufacturer, what services are running, and so on. You may also use the EtherScope SNMP tests to discover which switch port the unknown device is connected to, and simply go look at it.

Q: How do I make sure my network changes are successful?

A: Identify the devices consuming the most bandwidth with the Ether-Scope "Top Talkers" feature. This allows you to see how much bandwidth each device on your network is using in a real-time setting. Also, confirm the connections are as you planned by tracing the link between two IP addresses by switch and port.
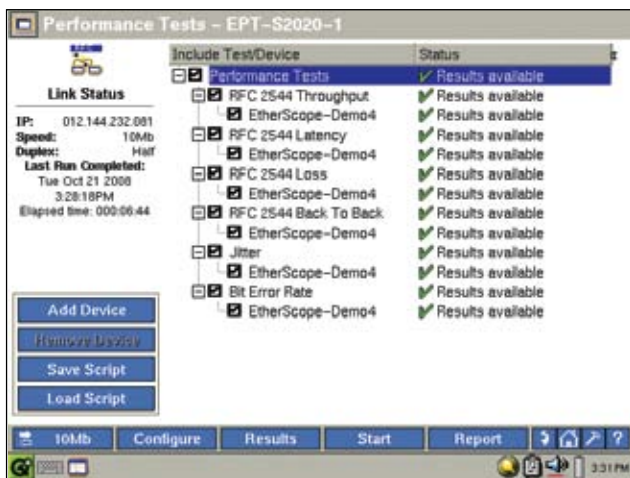

Q: How do I know whether my connectors and ports are live?

A: A key part of resolving connectivity issues is finding which port a user is connected to. LinkRunner Pro is the first connectivity tool to support the new IEEE Link Layer Discovery Protocol (LLDP) in addition to the Cisco and Extreme Discovery Protocols (CDP and EDP). This feature allows technicians to speed problem resolution by quickly and precisely locating the nearest switch port. In just seconds, LinkRunner Pro will display the make, model, address, slot, and port of the nearest LLDP device. The new LLDP standard has been adopted by Cisco, Avaya, Extreme, Nortel, Mitel, and many others.

## Common Electrical Signaling Issues

Q: I hate analyzing and interpreting complicated waveforms. Is there an easier way to check the integrity of network signals?

A: Yes, the Bus Health test on a ScopeMeter Test Tool measures critical parameters, showing a go/no go result compared to industry standards.
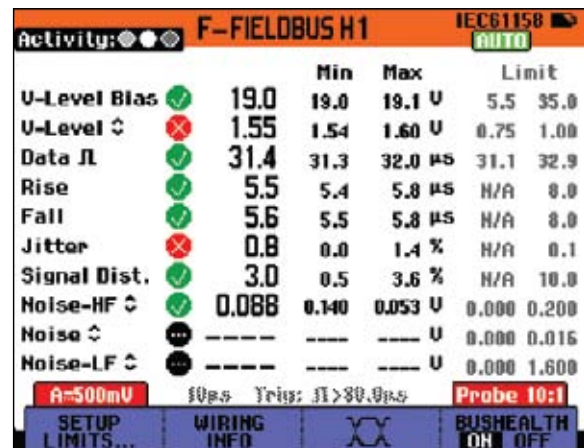
Q: How do I capture waveform disturbances and anomalies ?

A: Use an eye pattern, waveform analysis, to easily identify problems.
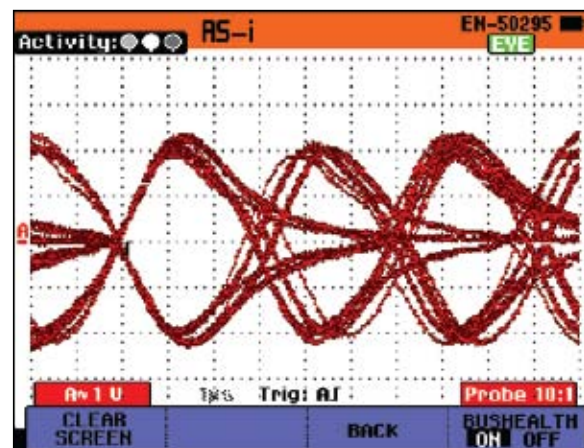
Q: Many network types use two-wire differential signaling, making it difficult to test without bringing the segment down. Is there an easy solution?

A: If connected incorrectly, a scope with common grounded inputs will short differential network signals to earth ground. A portable floating oscilloscope (215C or 225C) with isolated inputs (reference inputs) makes it safe and easy to test two wire differential network signals.

Q: It's difficult to remember how to connect the probes correctly to the different network types.

A: The 215C or 225C with Bus Health test includes a help screen that illustrate the probe connection points.

Common Cabling Infrastructure Issues

Q: Where are my bad connections located?

A: Cable troubleshooting tools such as DTX Cable Analyzer and CableIQ can quickly locate faults, opens, and miswires, helping you to trace downtime to connections, equipment, or building infrastructure. These tools can also identify and locate impairments such as opens, shorts, and split pairs. Additionally, they can verify that the wiremap is installed correctly.

Q: What is the effect of EMI on my networks?

A: Any high current draw usage, including Arc welders and VF motor drives, cause EMI interference. If a low-voltage communications cable runs near this, it is exposed to high amplitude, high frequency noise power supplies. If the twists in the cable become inconsistent from incorrect installation with sharp bends or excessive pull force or weight, the cable becomes more sensitive to EMI noise and can be contribute to excessive transmission errors. The DTX CableAnalyzer can locate these crosstalk and return-loss issues.

Q: I inherited a pre-existing cabling plant, but no records are available on the infrastructure layout or cable-performance capabilities. How do I know what I'm working with and whether or not the current infrastructure will support the bandwidth requirements of my network?

A: 1. Full cable certification with the DTX Cable Analyzer with documentation is the best way to understand the cabling in your plant. With easy to use software like Linkware - each cabling link can be recorded and filed.
2. CableIQ can map out individual cabling links, show what is at the far end of the cable, and determine what speeds and technologies the link will support. It can effectively locate and ID tag any links with built-in digital or analog tonings, as well as RJ45/coax cables. A qualification tester will also determine whether a cabling link, based on its length, wiremap, and signal performance should be able to support 10/100 or Gigabit Ethernet. If the existing cabling link cannot support the bandwidth requirements of the network, your qualification tester can tell you why, with detailed information on the nature and location of the fault.

Q: Many of my cable components are exposed to very harsh conditions, including different lubricants and cutting fluids found on the plant floor, moisture steam cleaning, and vibration. How do I ensure my cabling is reliable?

A: It is important to specify industrial-grade components for use on the plant floor, as office-grade components can corrode and exhibit higher resistance over time, impacting the signal voltage levels and causing corrupted data transmission. Examples include IP 67 rated M12 connectors. Additionally, having the right testers, such as DTX CableAnalyzer, CableIQ or MicroScanner[2] available to meet your termination and daily troubleshooting needs is important.

Q: I need to improve switch utilization. How do I free up and redeploy unused ports?

A: The CableIQ qualification tester or LinkRunner Pro Network Multimeter can identify unused ports with infrastructure discovery and Switch blink features.
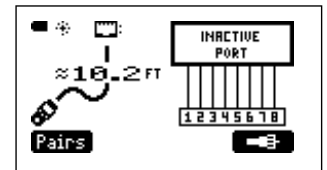
Q: How do I know if my fibers optic cables are mapped correctly?

A: The SimpliFiber Pro is equipped with a FindFiber feature, allowing you to identify cabling runs and ensure polarity. This feature provides fast cable-routing identification with just one technician, enabling easy cable-mapping verification and documentation.

Fiber Links

Patch Panel

SimpliFiber Pro meter

ID #3

ID #4

ID #5
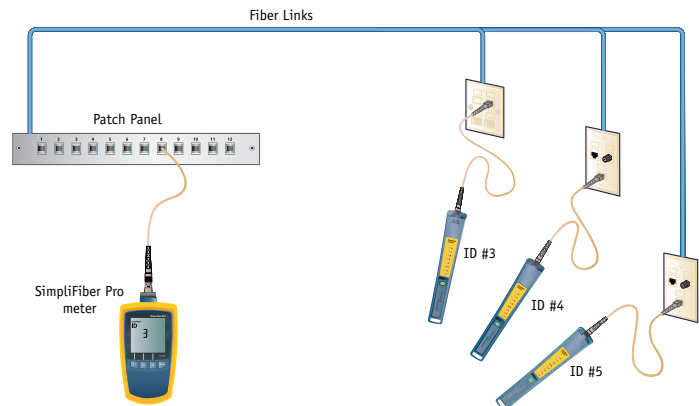
Network Tools

EtherScope™ Series II
Network Assistance
Visibility into the entire network

As industrial networks continue to evolve and mesh with traditional business Ethernet environments, it will become mandatory that engineering system architects in the plant work very closely with business IT professionals to ensure different application priorities can coexist on a common network topology.

First responders to network emergencies rely on the EtherScope Series II Network Assistant – a handheld portable network troubleshooter for 10, 100 and Gigabit copper, fiber and wireless LANs – to solve problems fast. It combines essential tools that help frontline users quickly solve the wide range of problems they encounter.

The EtherScope helps users identify problems on both sides of the access point, discover active networks, mobile clients, and access points, as well as the presence of 13 industrial protocols. It also measures critical parameters such as VLAN statistics, top network talkers, and expected vs. unexpected traffic

The EtherScope Series II is used to:

- Remotely monitor and troubleshoot for rapid in-service diagnostics to ensure critical network links don't bring your network down
- Characterize your network for deterministic performance instrumentation, including latency and jitter
- Detect network bottlenecks and areas for optimizing network and applications discrete process
- Switch element provisioning, management, and troubleshooting
- Evaluate vendor equipment prior to installation
- Test port-level security and Quality of Service (QoS)
- Create, distribute, and archive reports for preventative maintenance records
- Simulate multicast traffic generation and client signaling prior to new equipment installations (stress testing and worst-case loading)
- Test LAN provisioning and prioritization
- Perform wireless service turn-up and troubleshooting

LinkRunner™ Pro Network Multimeter
Industrial link troubleshooting

LinkRunner Pro provides front-line troubleshooters with a simple, dedicated tool for resolving the most common PC, user, and device-connectivity issues.

Because of rapid network evolution, today's connectivity problems are much more complex than they used to be. Higher bandwidth requirements have expedited Gigabit proliferation. Greater security threats have necessitated tighter control measures like 802.1X. And technologies like VoIP and WLAN have given rise to a greater reliance on PoE for power. LinkRunner Pro recognizes these changes, and empowers users to address today's new challenges.

When no test documentation is available, solving downtime issues can be a frustrating and time-consuming process. Finger pointing among different groups and redundant testing are just a couple of the wastes that occur. With the focus on minimizing production downtime, there is no time for wastes like these. LinkRunner Pro can eliminate finger pointing and reduce redundant testing by generating objective, professional link status reports that can be printed or routed electronically.

LinkRunner Pro is used to:

- Identify device capabilities and confirm actual connected speed/duplex status
- Verify availability, voltage level, and pairs of Power over Ethernet per IEEE 802.3af specifications
- Identify nearest switch address, slot, and port with Cisco, Extreme, and IEEE Link Layer Discovery Protocols
- Test cable wiremap and length; detect miswires, shorts, split pairs or opens; measure distance to faults with TDR
- Locate and ID cables using IntelliTone digital toning, hub blink feature, or optional cable IDs to locate cables at patch panels or wall jacks
- Document test results by saving link, ping, PoE, security, and cable test results in the unit with the ability to upload to a PC via a USB cable

Network Tools Comparison		
	EtherScope Series II	**LinkRunner Pro**
Cable Length and wiremap	✓	✓
Speed/duplex detection	✓	✓
Tone	Analog	Analog
Network discovery	Active	
Ping	✓	✓
Switch diagnostics	✓	
VLAN discovery	✓	

Electrical Signaling Tools

ScopeMeter Test Tools

Industrial network physical layer signal test

ScopeMeter test tools are designed for troubleshooting industrial machinery and the industrial network connecting machinery. Today's industrial plant control and manufacturing processes are connected via a digital network.

Determining if a network problem is with the cabling, electrical signaling, or the digital protocol is critical. Use the ScopeMeter 125, 215C or 225C to verify the electrical integrity of a plant's digital network signaling, perform 'physical layer tests' and get answers quickly and easily.

The Fluke 125, 215C and 225C simplify the task of troubleshooting networks by adding automatic physical layer signal measurement plus:

- **The Fluke 125, 215C and 225C**
  - Validate signal integrity on multiple types of industrial networks
  - Capture signal disturbances, anomalies and display induced noise
  - Compare critical measurement against industry standards for easy go/no-go results
- **The Fluke 125**
  - A cost effective tool for electrical & electro-mechanical plus bus health test
- **The 225C and 215C**
  - Performance oscilloscope for industrial electronic and electrical

equipment plus bus health troubleshooting.
  - Gives more-extensive industrial bus signal analysis capabilities
  - Isolated inputs for differential measurements

The ScopeMeter is used to:

- Obtain quantitative measurement results to isolate network communication problems to signal amplitude, attenuation, data rate/timing or signal noise, distortion or jitter.
- Eliminate the guesswork or signal analysis and complex interpretation by comparing measurement values to industry standards
- Use the clear Go/No-go indicators to simplify troubleshooting
- Use the eye pattern display mode for easy to view qualitative signal analysis, displaying extent of noise or signal disturbances
- Fully isolated inputs for true differential signal measurements

Fluke 771 Milliamp Process Clamp Meter

Don't break the loop on 4 mA to 20 mA signal measurements

Use the 771 mA Clamp Meter for PLC and control systems analog I/O. The detachable clamp with extension cable allows you to take measurements in tight locations. The 771 is used to:

- Measure mA signal for PLC and control system analog I/O
- Measure 4 mA to 20 mA output signals from transmitters without breaking the loop.
- Measure mA signals with 0.01 mA resolution

Electrical Signaling Tools Comparison			
	125	**215C**	**225C**
Display	Monochrome	Color	
Inputs	2 Scope & Dual DMM	2 Scope & DMM	
Bandwidth	40 MHz	100 MHz	200 MHz
Sample Rate	25 MSa/s Real time, 5 GSa/s Equivalent time	1 GSa/s	2.5 GSa.s
Bus Health	✓	✓	✓
Bus Health with Noise Measurements	-	✓	✓
Bus Health Connection Diagrams	-	✓	✓
TrendPlot ™	✓	✓	✓
ScopeRecord ™	-	✓	✓
100 Screen Replay	-	✓	✓
Battery	7 Hr NiMH	4 hr NiMH	
Isolated Inputs	No	CATII 1000V, CATIII 600V	
Safety Rating	CATIII 600V	CATII 1000V, CATIII 600V	
Designed For	Electrical and electro-mechanical systems & industrial bus diagnostics	Electrical, electro-mechanical and electronic troubleshooting, waveform analysis and bus health analysis and troubleshooting	

Cabling Infrastructure Tools - Copper

DTX CableAnalyzer™

A cable testing platform for harsh environments

DTX CableAnalyzer is the only cable tester that can completely certify copper across datacenter and industrial cabling. Only the DTX platform offers optional on-board M12 modules for testing industrial-strength components. The DTX can be used for certification and troubleshooting and provides unparalleled ease of use, installer-friendly features, and an intuitive user interface. The DTX is the industry-leading certification tool for network owners and maintenance engineers alike and is well suited for use in an industrial setting.

The DTX is used to:

- Test cable three times faster than exiting testers with the 9-second Cat 6 auto-test feature
- Analyze test results and create professional test reports using LinkWare reporting software for documentation
- Verify the availability of network and IP services using the Network Service Module

CableIQ™ Qualification Tester

Your vision into cabling bandwidth

CableIQ is a front-line cable troubleshooting tool that gives even the most novice tech the vision to see what speeds existing cabling can support, quickly isolate cabling from network problems, and discover what is at the far end of any cable, reducing escalated problems by as much as 30%. Is the port active? Are the duplex settings matched? Is it a network problem or a cable problem? Can the cable support the required network bandwidth? CableIQ is the only tool that can answer all these questions before, solving issues immediately and minimizing production downtime.

The CableIQ is used to:

- Qualify whether or not your existing cabling has the bandwidth to support 10/100 or Gigabit Ethernet
- Troubleshoot why existing cabling cannot support the network's bandwidth requirement (e.g. crosstalk at 11 meters)
- Discover what is at the end of any cable and display device configuration (speed/duplex/pairing)
- Identify unused switch ports that can be reallocated
- Graphically map wiring configuration and show distance-to-faults with Intelligent Wiremap feature

MicroScanner² Cable Verifier

Streamline verification testing and rule out service problems fast

The MicroScanner² Cable Verifier can rule out a whole host of potential cable and service issues before determining the cause of a connection problem. MicroScanner² gives you high-power vision to verify today's most common voice, data, and video services, translating into faster, more comprehensive troubleshooting.

This cable verification tool starts by taking results from what was four different test modes and displays them all at once – graphic wiremap, pair lengths, distance to fault, cable ID, and far-end devices. The end result is reduced troubleshooting time and fewer errors.

The MicroScanner² is used to:

- Test all common media types, including RJ11, RJ-45, and coax with no need for adapters
- Graphically display wiremap, length, cable ID, and distance to fault

Cabling Infrastructure (Copper) Tools Comparison			
	DTX	CableIQ	MicroScanner²
Continuity and wiremap testing	✓	✓	✓
Measures distance to a break or short	✓	✓	✓
Measures distance to connection fault	✓	✓	
Measures distance to performance defect (NEXT, RL), identifies corrective actions and graphically displays crosstalk and impedance behavior	✓		
Verifies whether existing cable can support network speed (e.g., 10BASE-T, 100BASE-TX, GBE)		✓	
Identifies whether or not your new cabling complies with performance requirements of TIA/ISO standards (e.g., category 5e, 6, Class E)? Provides pass/fail results compliant to TIA/ISO standards	✓		
Documents and prints full reports with measurement data (Pass/Fail, MHz, dB measurements, etc)	✓		
Required to receive warranty from connector and cabling OEMs	✓		

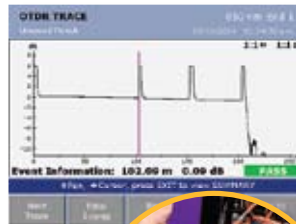# Cabling Infrastructure Tools - Fiber

OptiFiber™ OTDR

Fiber troubleshooting solution for your most critical network cabling.

Unlike a Power Meter and light source, an OTDR sees the performance of individual connectors and splices on a fiber link. It also is the most powerful troubleshooting tool for fiber optics because 1) it is single ended; you don't need a far-end device or another technician working with you, and 2) it shows distance to faults and characterizes every event within the link. An OTDR tells you loss and reflectance at every event. Without an OTDR you would not even know there is an event there.

OptiFiber enables users of all experience levels to certify fiber to customer specifications and new industry standards, troubleshoot connection-rich links, and thoroughly document results – therefore, improving the health of your fiber network. Your fiber cabling will be ready and capable to perform for high-bandwidth applications.

The OptiFiber is used to:

- Perform inspection, verification, certification, troubleshooting, and documentation of fiber cabling in a single, easy-to-use tool
- Save time and money when diagnosing fiber cabling problems that are causing network performance issues
- Easily locate and eliminate fiber problems

SimpliFiber® Pro Optical Power Meter and Fiber Test Kits

Measure end-to-end loss with a Power Meter and source

Your industrial networks depend on a reliable fiber optic infrastructure. Proper installation and maintenance of fiber cabling is imperative for minimizing network – and subsequently production - downtime. Whether you require basic fiber verification capabilities, advanced troubleshooting and inspection, or documented loss and power measurements, Fluke Networks' SimpliFiber® Pro Optical Power Meter and Fiber Test Kits are the best first-line fiber instruments to meet your needs.

With new advanced capabilities that make testing simple, SimpliFiber Pro is ideal for anyone involved in first-line optical fiber cabling installation and troubleshooting. Many industry-leading features to help you reduce testing time and manpower, including simultaneous dual-wavelength testing and measurement recording, CheckActive™, FindFiber™, and Min/Max function.
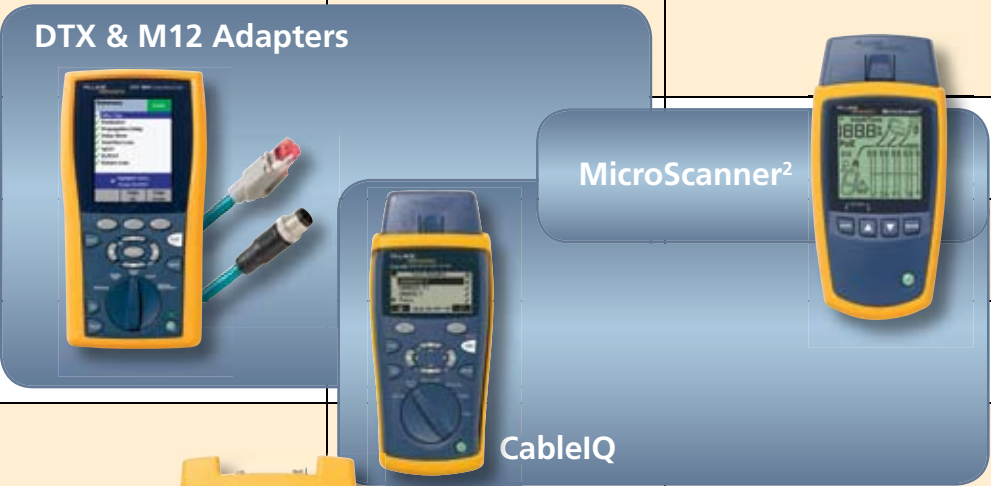
The SimpliFiber Pro Kits are used to:

- Verify optical loss and power levels
- Ensure smooth, clean fiber connections for maximum performance
- Verify and locate faults

Cabling Infrastructure Tools - Fiber Comparison		
	OptiFiber	**SimpliFiber Pro**
Fiber types supported	Multimode, Singlemode	Multimode, Singlemode
Fiber end-face inspection	✓	✓
Indentifies faults/breaks	✓	✓
Finds location of faults/breaks	✓	
Verifies optical power/fiber link loss	✓	✓
Dual-wavelength testing	✓	✓
Basic (Tier 1) loss test	✓	✓
Dual fiber-loss testing	✓	
Extended (Tier 2) OTDR test	✓	
Source type	LED, FP, laser	LED, FP, laser
Pass/fail results Documents test results	✓	✓
Single-ended test	✓	

Selection Guide

Task	Control Engineer	Engineer	Technician
Network			
Trending Utilization	**EtherScope Series II**		
Detect Application Connectivity Problems			
Test PC Connectivity			
Confirm Device Connectivity (Ping)			**LinkRunner Pro**
Verify Actual Link Speed/Duplex			
Cabling Infrastructure			
Copper Certification	**DTX & M12 Adapters**		
Verify location and continuity			**MicroScanner²**
Troubleshoot Performance Faults			
Troubleshoot Wiremap Faults		**CableIQ**	
Qualify Bandwidth (10/100/1000)			
Fiber Certification	**OptiFiber**		
Verify Optical Loss and Power Levels – Singlemode and Multimode		**SimpliFiber Pro**	
Electrical Signaling			
Validate Signal Integrity on Multiple Network Types	**ScopeMeter 215C/225C**	**ScopeMeter 125**	
Capture Signal Disturbances and Anomalies			
Perform BUS Health Analysis and Troubleshooting			
4 to 20 mA signal measurements	**771 Milliamp Process Clamp Meter**		

Access additional product information, application notes, and case studies at **www.flukenetworks.com/industrial**

Order Information Table

Product List		
Model Number	**P/N**	**Description**
Network Communications		
ES2-PRO SX/I-KIT-IE	3340803	EtherScope 2 LAN WLAN ITO Kit Industrial Ethernet
ES2-LAN-SX-IE	3340790	EtherScope 2 LAN Industrial Ethernet
LRPRO-1000-IE	3336925	LinkRunner Pro Industrial Ethernet
Cabling Infrastructure		
DTX-1800-IE	3336916	DTX CableAnalyzer Industrial Ethernet
DTX-CHA021S	3311054	M12 Channel Adapters – set of 2
DTX-CHA021	3311068	M12 Channel Adapters – 1 ea
CIQ-GSV-IE	3354552	Gigiabit Service Kit Industrial Etherent
CIQ-KIT-IE	3336902	Cable IQ Industrial Ethernet
MS2-KIT-IE	3336893	MicroScanner 2 Industrial Ethernet
OF*	various	OptiFiber Product Family
FTK1450-IE	3403144	SimpliFiber Pro Complete Fiber Verification Kit
Electrical Analysis		
FLUKE-225C/003	3379655	Fluke 225C Scope Meter, 200 MHz dual channel portable oscilloscope
FLUKE-225C/003S	3379727	Fluke 225C, with carry case, software and isolated interface cable kit
FLUKE-215C/003	3379526	Fluke 215C Scope Meter, 100 MHz dual channel portable oscilloscope
FLUKE-215C/003S	3379598	Fluke 215C, with carry case, software and isolated interface cable kit
FLUKE-125/003	2838895	Fluke 125 ScopeMeter, 40MHz Dual input portable scope & DMM
FLUKE-125/003S	2838986	Fluke 125, with carry case, software and isolated interface cable
FLUKE-771	2646347	Fluke 771 Clamp Meter
Accessories		
M12PCP-IE	3347218	M12/ RJ45, 2M
M12PCJ-IE	3347207	M12/ RJ45, 2M
M12PC-IE	3347191	M12/M12, 2M
BHT190	3379374	ScopeMeter Bus Health DB-9, RJ45 & M12 breakout adapter set (Included with 215C & 225C)

*Must drop ship to end user; For complete ordering information, visit **www.flukenetworks.com/IndustrialOrderInfo**