OPTICAL FIBER CABLING FOR DATA COMMUNICATION

Test and Troubleshooting Handbook

FLUKE networks

Table of contents

Introduction

As fiber links support higher speed network bandwidths with increasingly stringent requirements, it is becoming all the more important to ensure that these critical links meet tightening loss standards. The need for higher data transmission capacity continues to grow as network applications grow and expand. These higher transmission speeds demand cabling that delivers higher bandwidth support. This test and troubleshooting guide outlines cabling performance requirements, field testing, certification and troubleshooting techniques, and instruments you need to ensure that installed optical fiber cabling supports high data rate applications such as 1 and 10 Gigabit per second (Gbps) Ethernet, Fiber Channel, and 40 and 100 Gbps Ethernet applications.

A local area network (LAN) or an enterprise ("premises") network connects users up to a distance of 2 to 5 km. It encompasses the intra-building cabling as well as inter-building or campus cabling. Optical fiber cabling is primarily used for longer distance, higher bandwidth connectivity while twisted pair copper cabling typically provides the connection to the end-user or to the edge devices. This copper cabling can support network connectivity to a distance of 100 meters (328 feet). Optical fiber cabling is the preferred medium for distances beyond 100 meters such as riser cables in the building or where very high performance is required. "Certification," or the process of testing the transmission performance of an installed cabling system to a specified standard, ensures a quality installation. It also provides official documentation and proof that the requirements set by various standards committees are fully satisfied.

Optical fiber is a reliable and cost effective transmission medium. But, because accurate transmission of optical signals requires precise conditions, problems ranging from end-face contamination to excessive modal dispersion can cause failures. Isolating the source or sources of a failure is often a time-consuming and resource-intensive task.

That's why Fluke Networks has created this enterprise-focused fiber troubleshooting guide—to help you better assess the quality of a cable installation and to help you troubleshoot more effectively so you can fix a problem faster, rather than spending time trying to identify it. Note: this guide doesn't address issues that are uniquely relevant to fiber optic technology used in long-haul telecommunications applications.

Optical fiber end-face inspection and cleaning

Inspection

Proper inspection helps you detect two of the most common (yet easiest to prevent) causes of failure: damaged and dirty fiber end-faces.

Damage occurs in the form of chips, scratches, cracks, and pits on the core or cladding and can result from mating contaminated end-faces or from improper cleaning or polishing techniques.

Sources of contamination are everywhere, whether it be from a touch of a finger, the brush of a clothing fabric, or the omnipresent dust or static- charged particles in the air. Ports are also subject to the same contamination but are often overlooked. Mating a clean connector to a dirty port not only contaminates the previously clean connector but can also cause fiber damage or failure. Even the protective coverings or “dust caps” on straight-from-the-package connectors and assemblies can add contamination due to the nature of the production process and materials.

The typical assumption is that a quick visual check of the end-faces is sufficient to verify cleanliness. This is hardly the case, since the cores of these fibers are extremely small, ranging from roughly 9 to 62.5μm. Put into perspective, the average human hair, with a diameter of 90μm, is anywhere from 1.5 to 9 times larger! With such a tiny core size, it is impossible for any end-face defects to be spotted without the aid of a microscope. The

FLUKE networks

most important quality of a fiber microscope is detection capability—basically, the smallest-sized object that it can detect.

Figure 1. Optical Microscope

Figure 2. The probe that is part of the FI-500 FiberInspector ™ Micro shown in Figure 37

There are three main types of fiber inspection microscopes:

Optical (figure 1): tube-shaped and compact, they let you inspect the end-faces directly. These are popular because they are inexpensive. However, they don't let you view end-faces inside equipment or through bulkheads.

Video (figure 2)**:** a small optical probe is connected to a handheld display. The probe size makes it excellent for examining ports in hard-to-reach places. A large displays enables easy identification of end-face defects. They are also safer as they show an image and not the actual end-face being observed, reducing the risk of exposing one's eye to harmful radiation.

Auto Grading Video: This is an evolution of the video microscope mentioned in the preceding sections. This kind of microscope not only detects scratches and defects, but shows you where they are in the end-face zones identified in the IEC 61300-3-35 standard for end-face inspection.

An example is the Fluke Networks FI-7000 FiberInspector™ Pro. This video microscope is connected to a Versiv™ mainframe to become an automatic pass/fail fiber end-face inspection test tool. Scratches, dirt, and other defects are shown in red or green, which define pass or fail, and an overall pass or fail is given for the end face (figure 3). The pass/fail criteria is based on the IEC 61300-3-35 standard, which is for field and factory polished end-faces. The standard defines the type and size of scratches and defects allowed in the four zones of a fiber end-face, as shown in the table below.

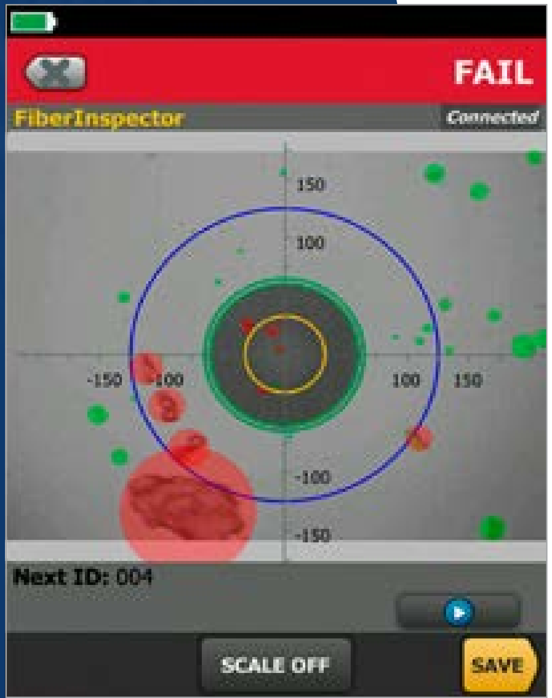

Figure 3. Fluke Networks FI-7000 FiberInspector™ Pro “FAIL” screen

IEC 61300-3-35 MM Specifications

Zone name	Scratches	Defects
A: Core	None	None
B: Cladding	No limit ≤ 3µm, 0 > 3µm	No limit < 2 µm 5 from 2 µm to 5 µm None > 5 µm
C: Adhesive	No limit	No limit
D: Contact	No limit	None ≥ 10 µm

The FI-7000 FiberInspector Pro includes tips for standard types of fiber connectors. A special tip is available to let you inspect MPO/MTP plugs and connectors (figure 4). Turn the knobs to move the lens to inspect each of the 12 or 24 fibers.

Figure 4. The NF370 MPO/MTP Video Probe Adapter

Cleaning

Regardless of the type of fiber, application, or data rate, the transmission of light requires a clear pathway along the link, including through any passive connections or splices along the way. A single particle on the core of a fiber can cause loss and reflections, resulting in high error rates and degraded network performance. Contamination on a fiber end-face, as shown in figure 5, can also adversely impact the interface of expensive optical equipment, and in some cases even render equipment inoperative.

As network applications require more bandwidth and transmission speeds continue to climb from 1 and 10 gigabits per second (Gbps) to 40 and 100 Gbps, loss budgets have become tighter than ever. Dirt, dust, and other contaminants are the enemies of these higher- speed data transmission rates over fiber networks.

It is therefore critical that all optical connections be kept free of contaminations to avoid application performance issues.

Figure 5. Contaminated fiber end-face

With contamination being the single greatest cause of fiber failures, spending the extra few seconds to properly inspect and clean every connector end-face will save time and money in the long run. While accidently touching a fiber end- face and working in dirty, dusty construction environments are known causes of contamination, there are plenty of other ways to mishandle fiber that may not be obvious sources of contamination. Brushing an end-face on clothing that can contain body oils, lint, or other substances can cause contamination. In fact, any time an end-face is exposed to the surrounding environment, it is subject to contamination, even if it was recently cleaned. Dust in the air can easily collect on a fiber end-face, especially in the presence of static electricity.

Common misconceptions on cleaning

Protective caps keep end-faces clean

- **False.** Caps can be a source of contamination, as they can contain mold- inhibiting compounds from manufacturing
- End-faces are not always clean when they come pre-terminated from the factory in a sealed bag

Canned air will blast away dirt

- **False.** Canned air is ineffective on smaller, static-charged particles and it blows larger particles around rather than removing them
- Canned air is ineffective on oils and compound contaminants

Isopropyl alcohol (IPA) is the best solvent

- **False.** IPA does not work on non-polar contaminants, pulling lubricants, or buffer gels, etc
- IPA leaves a residue when not used properly

FLUKE networks

Isopropyl alcohol is not recommended, and, if used, should be greater than 98% concentration. Rubbing alcohol is 70% and local pharmacies only stock IPA that is no better than 91%, which is not good enough. There are disadvantages to IPA. Over time, IPA absorbs water and lose its concentration. When this happens it will not remove non-ionic compounds and may leave a residue behind.


Figure 6. Clean fiber end-face

Hybrid cleaners, such as the Fluke Networks Fiber Optic Solvent Pen, are a more aggressive cleaner and are better than IPA. They offer the user significant advantages as they evaporate very quickly, making it less likely that residue will be left behind. Another plus is they have antistatic properties, so dust in the air is less likely to be attracted to the end-face of the connector.

Properly cleaned end-faces can actually “add” up to 1.39 dB onto your loss allowance (figure 6). In other words, if you have a fiber plant with an overall loss of 5.0 dB against a specified budget of 4.5 dB, cleaning any dirty end- faces may help to drop the link loss down to just above 3.6 dB, providing a “Pass” and plenty of headroom. Consequently, it is important to choose your cleaning tools and methods wisely while avoiding commonly- practiced bad habits.

FLUKE networks

Figure 7. The Fluke Networks Quick Clean™ pens

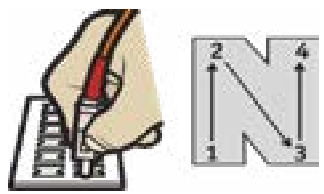

Figure 8. "Wet to Dry": cleaning methodology Using a Fluke Networks Optic cleaning card. The solvent drop is placed at "1", and the end face moved across the cleaning material from "1" to "4"

Contamination easily migrates from one port to another every time a connector end-face is mated. So it's essential that port connections are clean. Quick Clean™ Cleaning pens are dry cleaners that are ideal for cleaning ports on devices and patch panels, but not patch cords where end-faces may be exposed to grease.

Three sizes of Fluke Networks Quick Clean™ pens are available (figure 7)**:**

1. 1.25 mm for LC and MU connectors and end-faces

2. 2.5 mm for SC, ST, FC and E2000 connectors and end faces

3. MPO for MPO connectors

If inspection reveals that contamination is not removed after dry cleaning, "wet" cleaning will be required. When using solvents, the proper cleaning direction is "wet to dry" on a clean, lint-free wipe. Start by applying a small spot of solvent to the starting edge of a wipe. Then, holding the end-face connector perpendicularly, swipe the end-face from the wet spot to the dry zone (figure 8). Finally check the end-face again using a microscope.

Cleaning supplies vary in complexity and price, ranging from simple wipes to devices that incorporate ultrasound with water. Which tool you use will be dependent upon need and budget—but for the majority of the cabling jobs and projects, the pairing of lint-free wipes and swabs with engineered solvents now found in fiber inspection, certification, and cleaning kits will be sufficient.

Basic/tier 1 fiber testing

Before certifying a fiber in accordance to the applicable industry standards (such as ISO or TIA), fiber verification testing (including end-face inspection and cleaning) should be a part of your standard operating procedure. After the cable installation process and before certification, you should measure the loss of cabling segments to verify the quality of the installation's workmanship. This type of a testing is normally done with a Light Source and Power Meter (LSPM) test set. Fiber verification test tools are typically less expensive tools. They're also effective for troubleshooting links. A quick inspection of the end-to-end link loss may indicate whether or not the optical fiber cable is suspect or whether other network functions are the cause of a malfunction.

An LSPM determines the total light loss along a fiber link by using a known light source at one end of the fiber and a power meter at the other. But, before you perform the test, you must measure and record a reference power level from the source to set a baseline for the power loss calculation. After this reference is established, plug the meter and source into the opposite ends of the fiber link to be tested. The source emits a continuous wave at the selected wavelength. On the other end, the power meter measures the level of optical power it receives and compares it to the reference power level to calculate the total amount of light loss (figure 9). If this total loss is within the specified parameters for the link-under-test, the test passes.

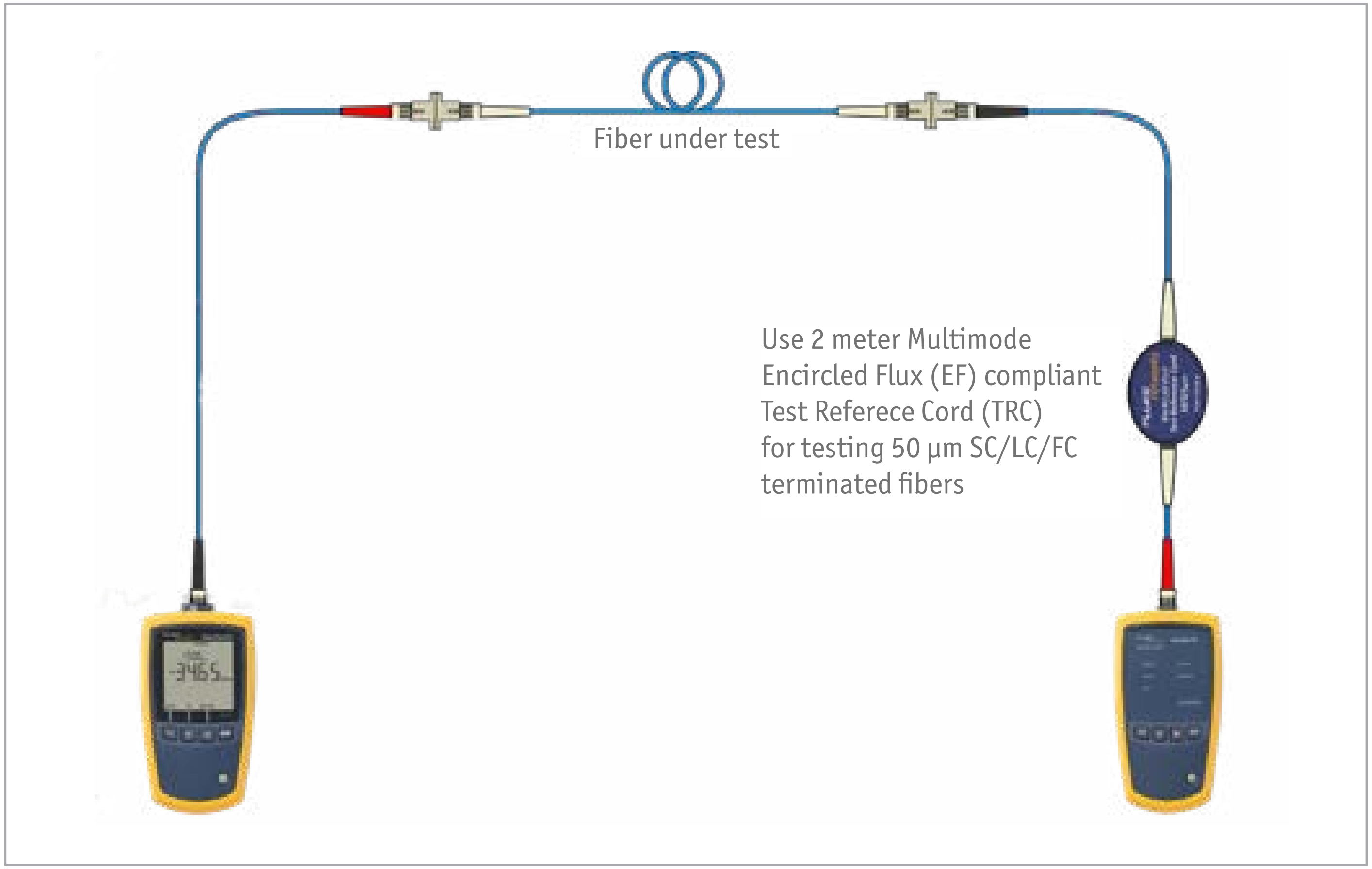

Figure 9. Conducting an LSPM test

A loss budget should be established and used as a benchmark during cabling installation. If verification testing is performed during installation, you can expect that yield will increase and certification testing will go more smoothly.

Historically, LSPM test sets require manual calculations and subjective interpretation by experienced technicians. However, newer instruments automatically compare power measurements to set references, eliminating the time-consuming loss calculations.

Using an LSPM set to verify end-to-end loss is convenient. But when the loss is within a specified threshold, the LSPM set doesn't provide any warning or indication of where a defect or problem may be that can cause a failure during certification. In other words, although an entire link may pass, it's possible that individual splices or connections within it may not meet industry specifications. This creates a potential problem in the future during adds, moves, or changes where multiple failing connectors might be grouped together and result in an overall failure. An Optical Time Domain Reflectometer (OTDR) can pinpoint locations (connections) that have a high loss or reflectance.

How to certify optical fiber cabling with OLTS and LSPM

Industry standards require use of an LSPM or Optical Loss Test Set (OLTS) to certify that the loss of each link meets performance standards. This is referred to as “basic” or Tier 1 Certification and considered the most important testing for new cabling installations.

Tier 1 Certification is a double-ended test which produces an absolute loss measurement. The tester then compares the measurement with cabling standards and/or channel application standards. Fluke Networks’ Versiv CertiFiber Pro OLTS and OptiFiber Pro OTDR can be equipped with optional multimode or singlemode fiber test modules that automate most of the test and make ‘basic’ or Tier 1 certification very easy.

An OTDR can also provide loss results for the total link. But, this instrument calculates the loss based on the reflected light energy. The standards require that basic (Tier 1) certification be done with an OLTS or LSPM, as results provided by these methods are more accurate

Follow these steps to perform a basic loss length certification test:

1. Establish Pass/Fail test limits
2. Choose a test method and set a 1-jumper reference
3. Run the test, save results and synchronize them to the cloud using the LinkWare™ Live service
4. Export results to LinkWare PC to manage and archive the test results. LinkWare PC is Fluke Networks' free cable test management software you can use to create printed or electronic reports.

1

Establish Pass/Fail limits

Figure 10. Screen of Fluke Networks CertiFiber Pro

Your Pass/Fail limits will vary depending on your certification goals. In this example, we will establish limits for the total allowable loss based on an application standard by using the Fluke Networks CertiFiber™ Pro OLTS. The CertiFiber Pro offers multimode and singlemode modules as well as a Quad Module—a dual mode and dual wavelength module that lets you do both multimode (850 nm/1300 nm) and singlemode (1350 nm/1550 nm) tests with one module. This is the module we will use in the example below.

The CertiFiber Pro mainframe works with several different test modules, so once the tester is turned on, make sure you have the correct module (CertiFiber Pro) plugged in as shown on the screen shot in figure 10 in order to make optical loss tests. Also note the screen shows the project as “DEFAULT”. The Versiv provides the unique ProjX™ system, which manages jobs from setup to systems acceptance. ProjX manages all aspects of the job (project name, operator, test set ups, and cable identifiers) ensuring that all tests are done correctly. From the home screen, we navigate away to enter these details.

Figure 11. Test setup for Test Type, Fiber Type and Test Limit

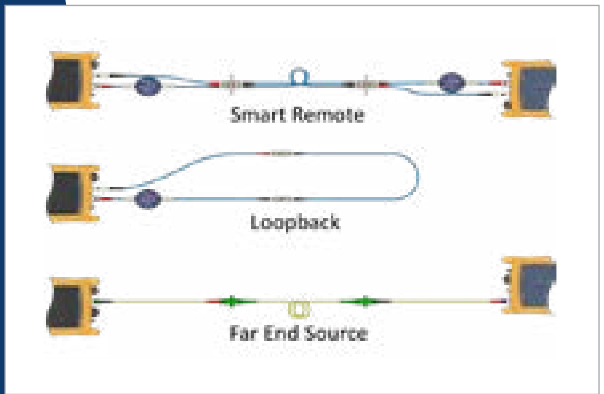

Figure 12. OLTS Fiber Test Modes available on CertiFiber Pro

Setting the test type: On the home screen, touch PROJECT. Then from the PROJECT screen, touch a Test Setup or NEW TEST to see the TEST SETUP screen (figure 11). Touch Test Type to select a test type: Loopback, Far End Source or Smart Remote, or FI-7000 FiberInspector™ Pro. See figure 12 to review the connections for each setting.

Touch Smart Remote to select it. Smart Remote mode, the most-commonly used mode for certification, lets you run a bi-directional autotest (i.e. run a loss test from both ends of a duplex fiber link). Note that bi-directional testing takes a little more time, as you will need to swap the fiber connections at each end of the link halfway through the test.

Setting fiber type: This changes the refractive index which affects the length result and the length limit for tests. From the TEST SETUP screen touch Fiber Type. On the Last Used list, touch the fiber type required. If you don't see the fiber type you need, touch the More button to see the Fiber Groups: Last Used, Custom, Generic, and Manufacturers. Select the fiber group that contains the fiber type for your specified fiber.

Figure 13. CertiFiber Pro Customs limits setup screen.

Set the Test Limit: Touch Test Limit then select the test limit required for your project from the Last Used list if it's shown. Otherwise touch the More button. Select the limit group that includes the limits required in the specification for your project. Select from Last Used, Custom, TIA, Application, China, EN, ISO, JIS, Korea, Miscellaneous, and Russia. You can create custom limits if the specification if the project requires tighter limits for loss than those in the standards. This is required when the expected applications require extremely high performance and the project consultant has requested these tighter limits.

As an example, setting custom limits can be useful if the fiber link you're testing contains Multi-fiber Push-On (MPO) connectors. The standards treat an MPO Module as two connections, allowing for losses of two connectors. In the real world, vendors treat MPO modules as a single connection, therefore a custom loss limit should be set to meet tighter limits. Another example is when you test single fibers, where the test tool cannot determine length as it can with duplex fiber testing. Figure 13 shows that custom limits can also define Fixed and Length Based loss budgets, letting you set a loss limit for single fiber testing.

2

Choose a test method and set a reference

By choosing a test method, we mean choosing the one, two or three jumper method for setting the reference. The method you choose determines whether your loss measurements show the loss of just the fiber in the link (three jumper method), the fiber and one connection at one end (two jumper method), or the fiber and the connections at both ends (one jumper method). Since the standards recommend the one jumper method for most applications, this is what we will set up.

Guidelines for setting a reference

- Use high-quality Test Reference Cords (TRCs); when used to test multimode fiber, they should also be Encircled Flux (EF) compliant
- Do not connect APC connectors to the tester's light source connector
- Clean and inspect the connectors on the tester and the TRC ends before you set the reference
- Let the tester warm up to a steady-state internal temperature (about 10 min. with ambient temp and storage temp difference of <20°F)
- Use the preferred one-jumper reference method
- Plug the TRC's SC connectors with the red boots into the source (OUT) connectors on the testers
- After setting the reference, DO NOT unplug the TRC from the light source
- The reference must be re-set each time the testers are powered up

To ensure that the precise launch conditions of the reference are maintained, do not disturb the output port connections on the testers.

From the Test Setup screen under Test Limit, select Reference Method . In the Set Up Wizard, shown in f igures 14, set the Jumper Reference number to 1. Set the number of splices expected in the link and the total number of connections, then touch DONE. Back on the TEST SETUP screen, touch Connector Type, then choose the connector type used in the link: General, SC, ST, FC, LC, MT-RJ, or MPO Module. When completed, return to the home page.

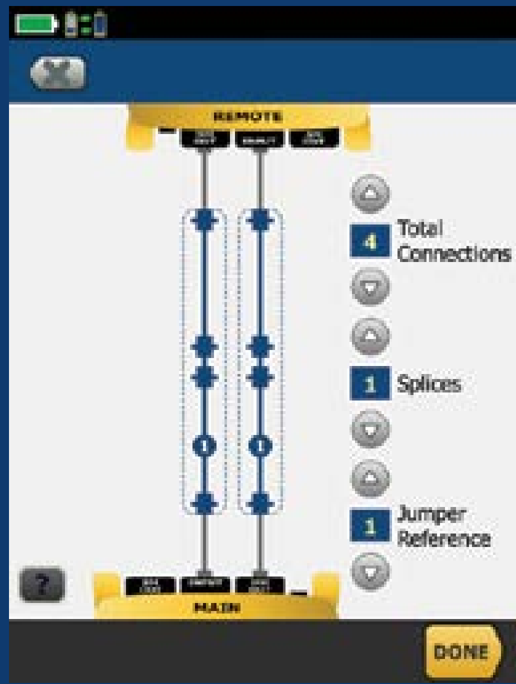

Figure 14. CertiFiber Pro has a wizard to help set up the link test and show the link under test for Total connections, splices and Jumper reference

Set the Reference: From the HOME screen touch the SET REF button, which opens the SET REFERENCE wizard. Then touch the RUN WIZARD button. Follow the wizard by making the connections as shown on the screen (figure 15, top three screens) then touch the VIEW REFERENCE button to see the reference.

After you set the reference for the TRCs connected to the sources, you need to measure the loss of the TRCs you will add to connect to the link under test to make sure the losses are less than 0.15 dB. This part of the wizard can be seen in the bottom three screens of figure 15.

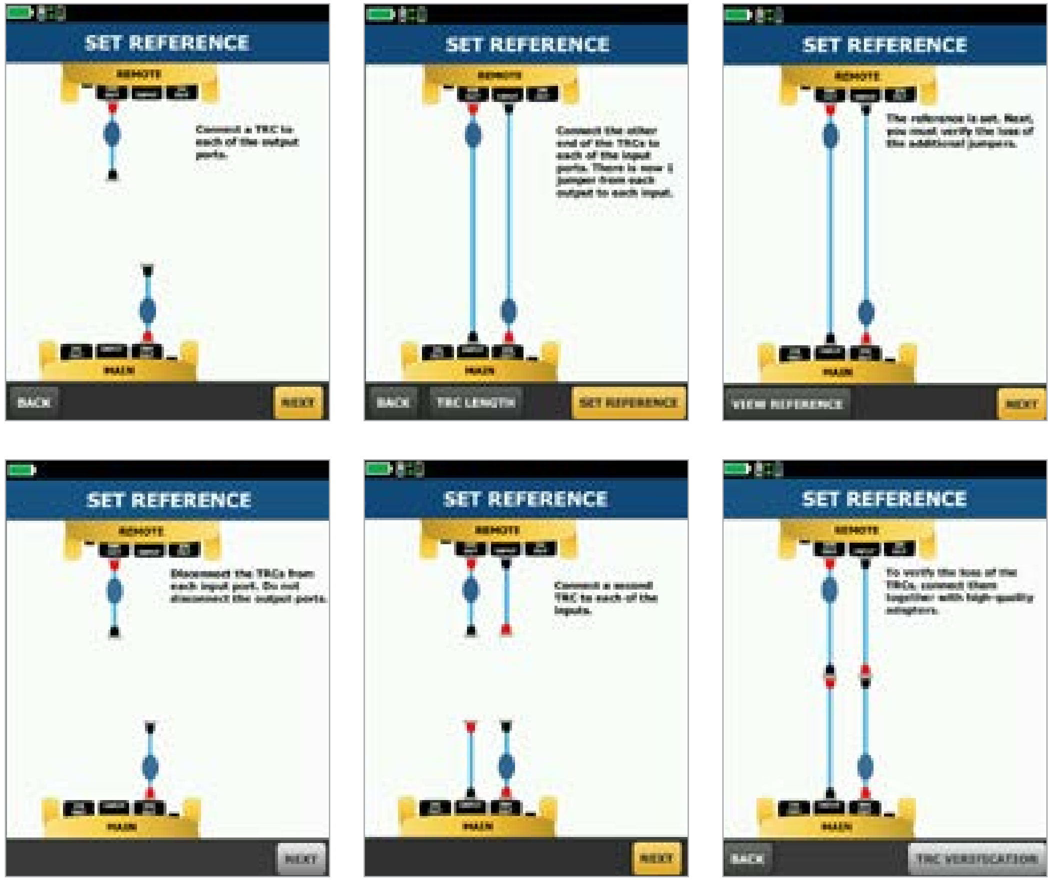

Figure 15. Set Reference Wizard showing how to set the reference on the EF compliant TRCs and measure the loss of the patch cords you will add.

When the TRCs have been connected as in the last screen in figure 15, touch the TRC VERIFICATION button to do the loss test. The tester shows the loss of each TRC and also assigns an ID to each cord, as shown in figure 16.

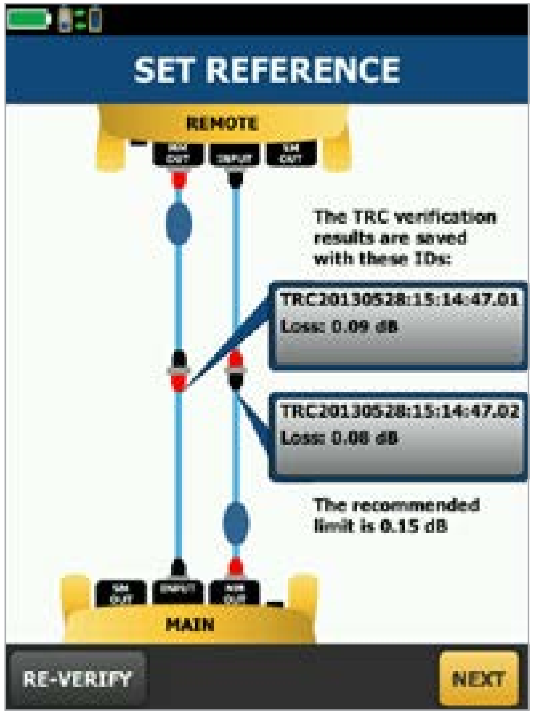

Figure 16. Verify the loss of the added TRCs

3

Run the autotest and save results

Now that you have set the reference and checked the loss of the TRCs, you can connect the fiber link under test between the TRCs by adding two adapters. Once connected, from the HOME screen, touch the TEST button to test the fiber link.

The first screen in figure 17 shows the results of the test. After the test is complete, touch SAVE to save the results. The tester shows the IDs that will be used for each fiber, as shown in the second screen in figure 17. You can swap the IDs if you have inadvertently reversed the input and output fibers while testing. The third screen shows the link IDs reversed.

Figure 17. CertiFiber Pro OLTS screens from a bi-directional test

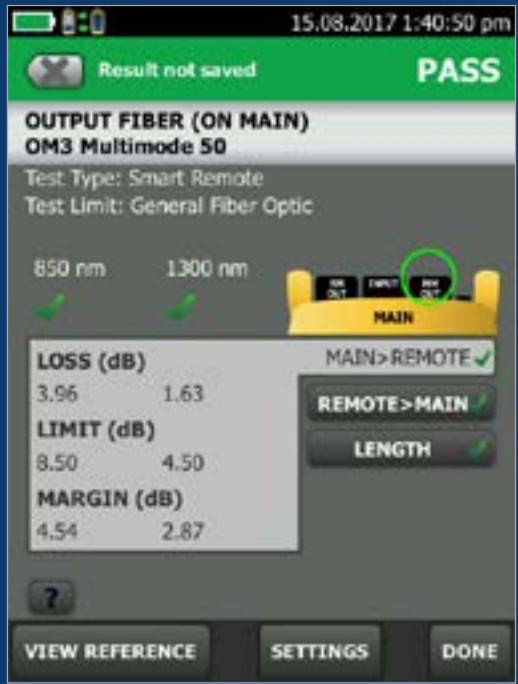

Figure 18. Results of CertiFiber Pro Bi-directional OLTS test

To see more details about the results, touch a result on the main results screen. The detailed results screen, figure 18, shows more information about the test, such as the limit and margin, and, for bi-directional results, the loss in each direction. The tester can measure length because this is a duplex link. When you select an Application standard as your test limit, it includes the maximum length for the application depending on the bandwidth rating of the fiber used in the link under test.

4

Export to LinkWare to manage and archive the test results

Once you have tested all the links and saved each record for your project, you can download the results directly to a PC via a USB stick or USB connection. Or, you can upload results to a cloud storage account on LinkWare Live. From LinkWare PC software, you can import results from a drive or from LinkWare Live. Once results are available in LinkWare PC, you can manage and inspect them on your PC. You can also print a Summary Test Report for the job as well as a professional-quality report for each link tested. LinkWare PC also lets you create reports in PDF form.

About LinkWare Live SaaS (figure 19): LinkWare Live is only available for Versiv mainframe units with version 3 firmware or later and LinkWare PC version 9 or later. The LinkWare Live web application lets you manage your projects from a desktop or mobile device. To get your projects into LinkWare Live, you connect your tester to a wired or wireless network, then log into your account to transfer projects.

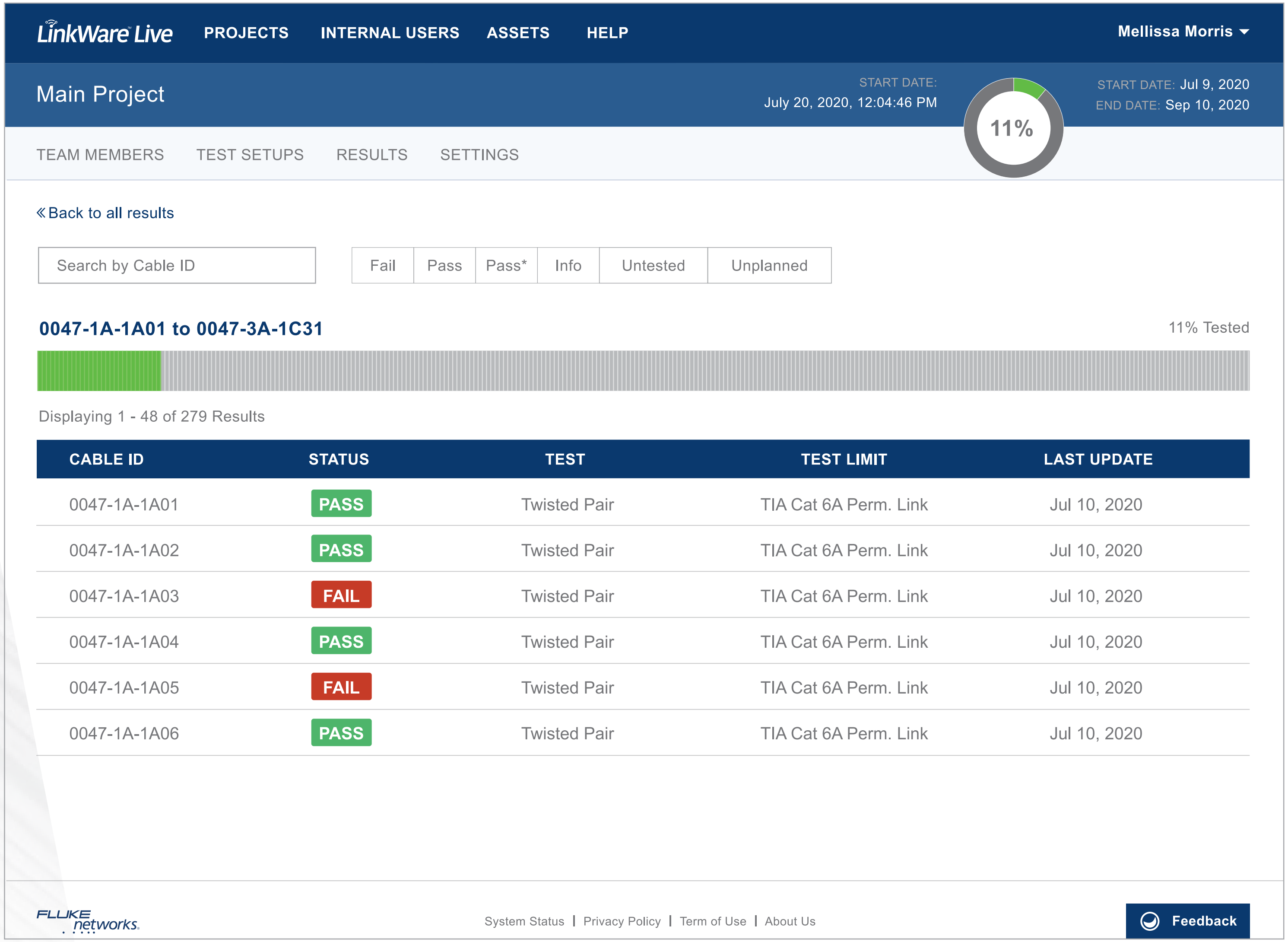

Figure 19. LinkWare Live website with stored projects and results for copper, fiber and end face inspection results uploaded to the cloud from multiple Versiv units

LinkWare Live lets you do these tasks:

- Manage your projects from a desktop or mobile device and keep track of every test on every job
- See an overview of every project, but still let you drill down to each individual test and instantly see incorrect test setting or cable IDs
- Define cable IDs and test settings from your PC or tablet, then download them to testers or supported labelers at the jobsite for mistake-free testing
- Keep your testers up-to-date. Standards can change without notice, and out-of-date test limits can mean hours of rework. LinkWare Live automatically ensures your testers are using the latest standards.
- Upload your test results straight from the job site to LinkWare Live over Wi-Fi. Then download them automatically to the right job for fast report generation with LinkWare PC. This saves you the time and energy costs of travelling back to the office from the jobsite and helps you avoid losing track of results.
- Track the last-used location and monitor the status of all testers to ensure they are always calibrated and running the latest firmware, avoiding project delays
- Please note, some LinkWare Live functionality is not available in all geographies

LinkWare PC is available for free download from the Fluke Networks website. Many installation companies now provide project results in digital format so that customers may use and view all the results in LinkWare PC and Link Stats, thus providing a valuable service by providing comprehensive documentation for their customers. To download the most recent version of LinkWare PC please visit **www.flukenetworks.com/linkware**. To create your own LinkWare Live account, go to **www.linkwarelive.com**.

LinkWare stats: LinkWare PC includes LinkWare Stats statistical report software. It provides statistical analysis of cable test reports and generates browsable, graphical reports. LinkWare Stats reports show key statistics from twisted pair and fiber cable test records exported from a LinkWare PC database.

These statistics help you to:

- Quickly determine the overall quality of cabling installation
- Identify link performance consistency, trends, and the best and worst links
- Review the capability of the cabling infrastructure
- Monitor the usage of your test equipment and spot trends in equipment and operator performance
- Document an installation to get a manufacturer's extended cabling system warranty
- Compare the capabilities of different cabling systems

Testing MPO cabling components

MPO connections provide an additional challenge for loss testing. An MPO connection contains multiple optical fibers, each of which need to be tested. This can be done with the use of a fan-out cord to isolate and test each individual fiber using the method above for each fiber in turn. This means that the process described above is made once for each pair of fibers in the link, for example 6 individual tests for a 12 fiber MPO. This can take some time, and it's easy to lose track of which pairs are being tested and make mistakes.

Figure 20. MultiFiber Pro making MPO testing easier and faster

To overcome this tedious process, Fluke Networks developed the MultiFiber Pro figure 20), which is available in singlemode and multimode versions. The tester automatically scans and tests all 12 fibers in a MPO connector with its “Scan All” function, eliminating the need for fan-out cords when testing MPO fiber trunks. MulitiFiber Pro interprets the test results with minimal navigation and displays all 12 fibers. In addition the MultiFiber Pro can automatically check for polarity and make 8, 10, and 12-fiber measurements allowing you to easily troubleshoot MPO fiber links.

To test a multi-fiber cable, start with setting the reference. As usual, clean the end-face connectors on the supplied MPO test reference cord with an MPO fiber cleaner, then connect the test cord between the power meter and light source. Make sure the light source is in “Scan All” mode with “Auto Wavelength” on.

- Press the MENU button on the power meter to enter the “SET REF” mode. When the reference is set, press F1 to save it.
- After you’ve set the reference, select a loss limit. Press MENU for 3 seconds, and then use the arrow keys to move to LOSS LIMIT. Press MENU again and use the F1 or F2 key to set your designated loss limit value.
- Now press MENU once to save the limit. Then press and hold the MENU key to go back to the main screen.

Now connect your test cords to the MPO trunk cable and, in less than six seconds, you’ll have the loss and polarity measurements for all 12 fibers. The simple user interface lets you easily determine if the cable passes the loss criteria you’ve set. Any fiber that has excessive loss will be easy to spot in the simple bar graph.

To document MultiFiber Pro test results, simply upload them to LinkWare PC by connecting the meter to a laptop with LinkWare PC running. In LinkWare PC, use the “Import” function to extract all the tests results from the MultiFiber Pro power meter and create professional-quality test reports.

How to certify optical fiber cabling with an OTDR

As was stated in the Optical Loss Test section above, industry standards require the use of a LSPM or Optical Loss Test Set (OLTS), to for Tier 1 testing to make sure the loss of each link meets performance standards. However, Tier 2 testing using an OTDR (Optical Time Domain Reflectometer) equipment can give you additional information, enabling you to find potential weak points in a link to improve performance or troubleshoot problems in the link.

ANSI/TIA 568.3-D and ISO/IEC 14763-3 recommend OTDR testing as a complementary test to ensure that the quality of fiber installations meets component specifications. The standards don't designate Pass/Fail limits for this test, but the results help you evaluate the performance of individual components in a link. For example, you can see the losses of individual connectors. You should consider generic cabling requirements for components and design criteria for the specific job. You can use an OTDR as a single-ended troubleshooter, for bi-directional tests (for higher accuracy), and with a receive fiber for certification testing. For faster bi-directional testing of multiple links, the Fluke Networks OptiFiber Pro OTDR offers the SmartLoop™ OTDR test, which is covered later in this section.

What you need to know about OTDRs. OTDRs used to be hard-to-operate laboratory equipment—impractical for field use. They were big, heavy and complicated for inexperienced technicians to set up and operate. Test results were difficult to understand. This created fear and confusion. Today, however, many new OTDRs are small, light, and easy to use. With minimal training, an ordinary technician can troubleshoot like an expert, but a basic understanding of how an OTDR works is still helpful.

- **Basic operation:** An OTDR infers loss, reflectance, and locations of events from light reflected back from the fiber. It sends pulses of light into the fiber, uses a sensitive photo detector to see the reflections, then plots them graphically over time. For accurate results, the optical characteristics of the fiber must be determined and set before testing.
- **OTDR trace:** The OTDR plots the reflectance and loss over time in a graphical "trace" of the fiber. Experienced technicians can "read a trace" and explain it. For example, in Figure 21, an experienced eye can spot that one side of a cross connect shows excessive loss.

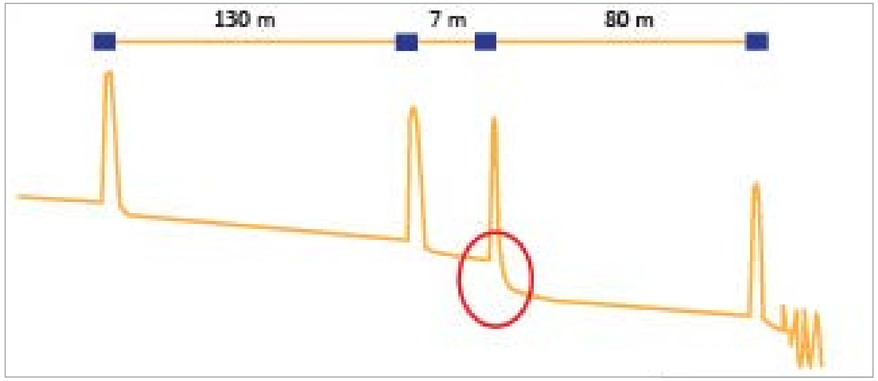

Figure 21. Sample OTDR trace with high loss connector at 137 m

- **Event analysis software:** The latest OTDRs run sophisticated software that automates trace analysis and the setup of test parameters. Fluke Networks' OTDRs can automatically optimize setup parameters, not only revealing where events (instances of reflectance and loss) are on the trace, but also indicating what the events are and qualifying each event. The Fluke Networks OptiFiber Pro OTDR can also be manually configured for Range, Pulse Width, Averaging Time, End Threshold, and Loss Threshold. Changing these parameters will affect the outcome of your test results, so they should be changed with care. For example, setting a wide pulse width to test a long link will increase the deadzone (described below) and may result in missing an event.

Dead zone: The distance after a connector, splice, break, or macro- bend along the fiber cabling where the OTDR can make an attenuation measurement or differentiate between closely spaced events such as connectors. Event dead zone is the minimum distance between two consecutive reflective events that the OTDR can make a measurement. Attenuation dead zone is the minimum distance after a reflective event that the OTDR can make a loss measurement.

Dynamic range: Determines the length of fiber that can be tested. The higher the dynamic range, the longer the fiber-under-test can be. There is a drawback, however, as the dynamic range increases, the wider the OTDR pulse becomes and as a result, the deadzone increases.

Ghosts: Not as scary as they might seem, ghosting is caused by an echo due to highly reflective events in the link under test. Fluke Networks' OTDRs identify ghosts on the trace and tell you where the source of the ghost is so you can eliminate it.

Non-reflective events: The cause of non-reflective events is usually splices, however Angled Physical Contact connectors (APCs) are designed to have excellent reflectance so an APC connector could have no measurable reflectance and look like a splice.

Gainers: Another misunderstood phenomenon on an OTDR trace is a gainer. Simply put, a gainer is an apparent negative loss at an event where there is a change in the optical performance. (A negative loss is like a negative time in a race—it's not possible.) This is usually due to a mismatch between the index of refraction of two spliced fibers or connection of a 50 μm multimode fiber into a 62.5 μm fiber. This type of event will often exhibit excessive loss when tested in the other direction.

SmartLoop: As stated previously, the standards now require bi-directional testing for a link. Fluke Networks SmartLoop OTDR test lets you test in both directions from one end of the fiber link. Bi-directional averaging is then done directly in the OptiFiber Pro OTDR itself.

The OptiFiber Pro OTDR is built specifically for the enterprise and data centers. It locates, identifies, and measures reflective and loss events in multimode and singlemode fibers. Typical maximum test ranges are less than 35 km at 850 nm and 1300 nm wavelengths for multimode fiber, which is well below the instrument's range of 130 km for singlemode fiber, typically tested at 1310 nm and 1550 nm.

Figure 22. OptiFiber Pro TABLE example. Test result (Pass/ Fail) and events shown depend on the characteristics of the test link

The tester can show the OTDR results in three formats (figure 22):

1. **Table:** Shows a table of the events on the fiber. Use this screen to quickly see measurements for all events and see the types of events on the fiber. The table includes the distance to the event, the loss of the event, the size of the reflection from the event, and the type of event. To see details for an event, tap the event in the table.

2. **EventMap™:** Shows a diagram of the events on the fiber, the fiber length, and the overall loss of the fiber. Use this screen to quickly locate connectors and faults on the fiber. To see details for an event, tap the event in the map, then tap the information window for the event.

3. **Trace:** Shows the OTDR trace. Use this screen to see the dead zones of reflective events and examine the characteristics of unexpected events such as ghosts and gainers.

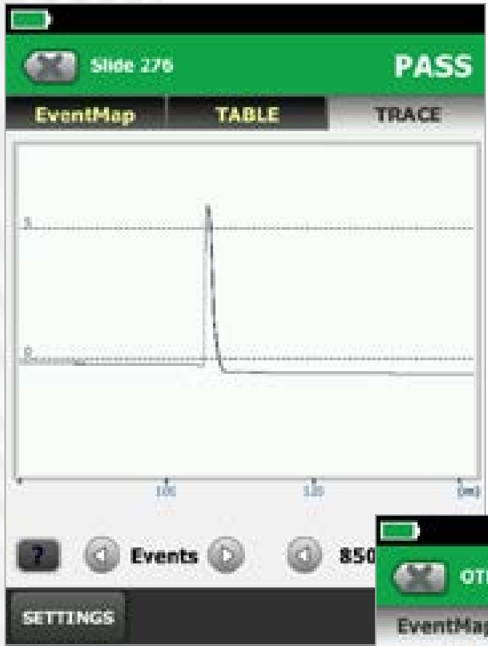

Figure 24. OptiFiber Pro TRACE example

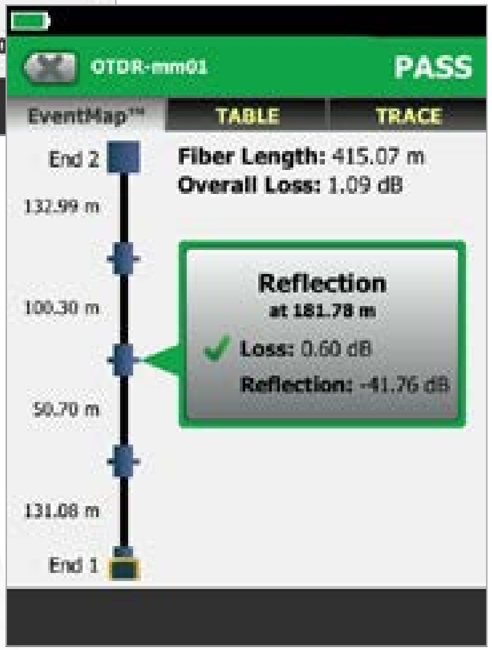

Figure 23. OptiFiber Pro EventMap™ example

EventMap™ View: In figure 23 is an example of a PASSING test using launch and tail fiber.

- Different icons indicate events such as these:
  - Passing reflective event
  - Failing reflective event
  - Hidden reflective event
  - Passing loss event
  - Failing loss event

  Note that a hidden event's loss is added to the previous event's loss.
- Details are provided for the event's loss, reflectance and segment attenuation

Trace View (figure 24): When testing a fiber link or channel, you can easily change the wavelength to view the corresponding trace. Use the touch screen to inspect the trace:

- Jump to next/previous event
- Pinch to zoom out
- Reverse pinch to zoom in
- Drag to move the trace
- Use the slide controls to adjust x or y zoom
- Double tap to zoom to 100%

Figure 25. OptiFiber Pro with a multimode test set up

Figure 26. OptiFiber Pro Set Launch Method settings

OTDR certification set-up

Launch Fiber Compensation Setup:

With a multimode, singlemode, or quad OptiFiber Pro module installed in your Versiv mainframe and an OTDR test selected in your project, as seen in figure 25, touch the TOOLS icon at the bottom of the screen. Select Set Launch Compensation to set the LAUNCH METHOD. Select Launch + Tail as in figure 26. Using a launch cord and a tail cord lets you to view the first connection and last connection of the fiber link and removes the length and loss of your launch and tail fiber from the results of your OTDR measurement. Bi-directional testing can be done only with the Launch+Tail setting.

FLUKE networks

- Launch only compensation removes the loss and length of only the launch fiber
- The Launch+Fiber+Tail setting removes the loss and length of your launch and tail fiber while ignoring the fiber link between them. This is very convenient if you get to the other end of a long link and you forgot to set the launch compensation before you tested the link.
- Manual Entry lets you manually set the position of the first and last connections. Use this method when your launch and tail fibers have connectors that have no measurable reflectance, such as APC connectors.

After you connect the launch and tail fibers as shown on the SET LAUNCH METHOD screen, touch the SET button at the bottom of the screen to make the launch compensation measurement. Save the settings, then return to the home screen to set up the OTDR test.

OTDR test set up

From the home screen touch the first panel under the PROJECT name to select the test setup. If there is more than one setup, select the OTDR test you want to modif,y then touch EDIT. Otherwise, touch NEW TEST.

From the TEST SETUP screen touch the arrow on Test Type: > and select the type of test from the following selections (figure 27):

- Auto OTDR
- Manual OTDR
- DataCenter OTDR
- FaultMap
- SmartLoop OTDR (Auto)
- SmartLoop OTDR (Manual)
- FiberInspector

For this example we will select Auto OTDR.Set the Launch Compensation to On and the Wavelength to both 850 and 1300 nm for multimode fiber. Now set the Fiber Type to OM4 Multimode 50. Then set the Test Limit. The Last Used test limits are displayed on screen. To access all the test limits, touch the MORE button.

The test limit selections include these:

- Custom
- TIA
- Applications
- ISO
- JIS
- Miscellaneous (General Fiber with a variety of return loss limit values)

Figure 27. OptiFiber Pro Test Type settings

Select the appropriate test limit for your project. In this case, select TIA-568.3-D. The tester goes back to the TEST SET UP screen; touch SAVE to save the setup. This takes you back to the CHANGE TEST screen if the tester has more than one test setup. Select the test you want to make and touch USE SELECTED, which takes you back to the home page.

Running the autotest

Connect the link to be tested to the launch and tail fibers as shown in figure 28. An additional short OTDR protection TRC can be placed in front of the launch cord (not shown) to protect the OTDR port from damage caused by repeatedly connecting and disconnecting the launch fiber. Note this should be done before setting the launch compensation.

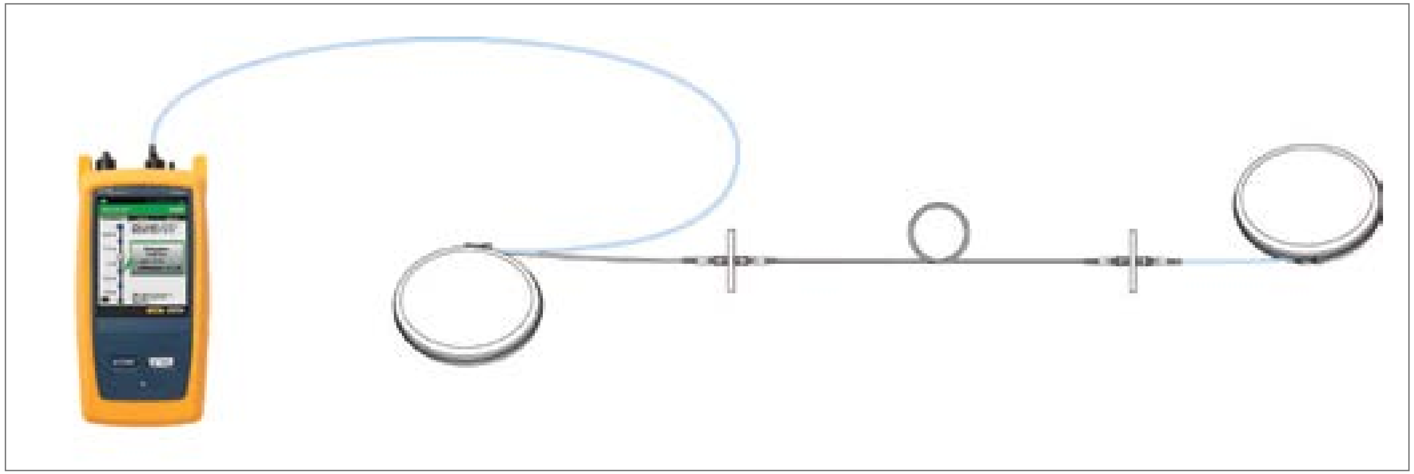

Figure 28. OTDR Test setup with launch and tail fibers

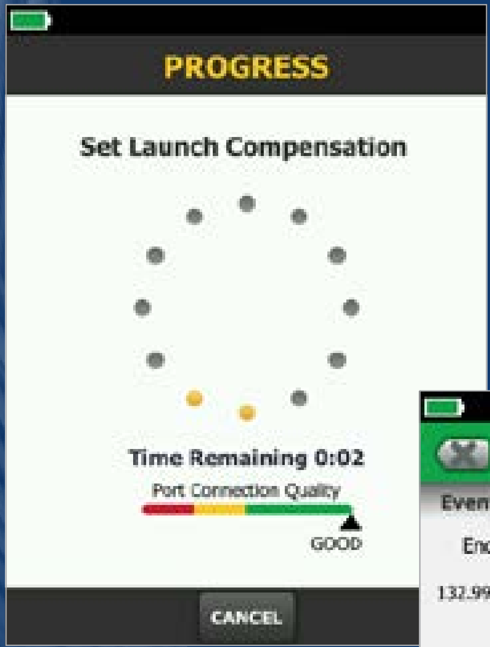

Figure 29. OptiFiber Pro OTDR port connection quality. Anything less than good could affect your OTDR measurement

Figure 30. OptiFiber Pro EventMap

Press the TEST button to start the Autotest. For every OTDR test, OptiFiber Pro assesses the port connection quality, which should be green (GOOD). See figure 29. When the OTDR test is completed you are presented with an EventMap showing the fiber link with the number of connections and splices and the length of each section of fiber. The EventMap is a quick and easy way to understand the components and measurements in each part of the fiber link. See figure 30. Should you want to view the OTDR trace, simply touch the TRACE tab. Results can also be viewed as a TABLE.

All tabs can swap the view between the 850 and 1300 nm results. Just touch the left or right arrow at the bottom of the screen. Touch the SAVE button to save the results. Before you touch the SAVE button again on the SAVE RESULTS screen, select which end you tested (End 1 or End 2). Make sure you are using the correct Cable ID and, if not, change it. When you have finished, touch the SAVE button to save the result for that end. To test from the opposite end, leave the launch and tail fibers in place, move the OTDR to the far end of the link, then repeat the process.

Fluke Networks SmartLoop OTDR test process

As you can imagine, walking from one end of a link to the other to do a bi-directional test can take a lot of time. The SmartLoop feature lets you test two fibers in a single test. This patent-pending process automatically separates the two fibers for individual pass/fail analysis, display, and reporting. Not only does this cut the testing time by at least half, it also lets you do bi-directional testing without moving the OTDR to the far end. In addition to getting the job done quicker, SmartLoop™ OTDR further enhances the ease and speed of testing in environments where the far end is difficult of even dangerous to reach because the OTDR never has to be moved to the far end. OptiFiber Pro bi-directionally averages the results so you know if you have a PASS or FAIL as soon as the test has completed.

SmartLoop compensation setup

The SmartLoop compensation process removes the length and loss of the launch, loopback, and tail fibers from the measurement. As with a normal OTDR test, if you are testing links which include APC connectors, the manual SmartLoop OTDR TEST TYPE should be selected.

To set the SmartLoop launch compensation, first inspect and verify the launch fiber ends are clean, then connect the three launch fibers as in figure 31. From the home screen touch TOOLS, Set Launch Compensation. then touch the SET button.

Figure 31. SmartLoop launch fiber compensation setup

Figure 32.
Set Launch
Compensation
results screen

To view the results of the SmartLoop Launch compensation: from the SET LAUNCH COMP screen, which now shows the distance and End as in figure 32, touch the VIEW TRACE button to verify that the launch fibers are good. A good guide for the loss at each connection should be ≤ 0.15 dB for multimode and ≤ 0.25 dB for singlemode. These figures assume all cords have the same backscatter coefficient. Assuming the loss values are ok, touch the SAVE button and then OK on the confirmation screen.

Inspect, connect and test

To do the SmartLoop OTDR test, make sure your fiber ends are still clean. Then connect the fiber links to be tested to the launch fibers as shown in figure 33. On the home screen touch TEST. When the test has finished, disconnect the OptiFiber Pro from Fiber A and connect it to Fiber B, then from the CONNECT TAIL CORD screen touch the DONE button to continue.

When the test is completed, the SmartLoop OTDR results show the following:

- Fiber A measured from End 1
- Fiber A measured from End 2
- Fiber B measured from End 1
- Fiber B measured from End 2
- Fiber A bi-directionally averaged
- Fiber B bi-directionally averaged

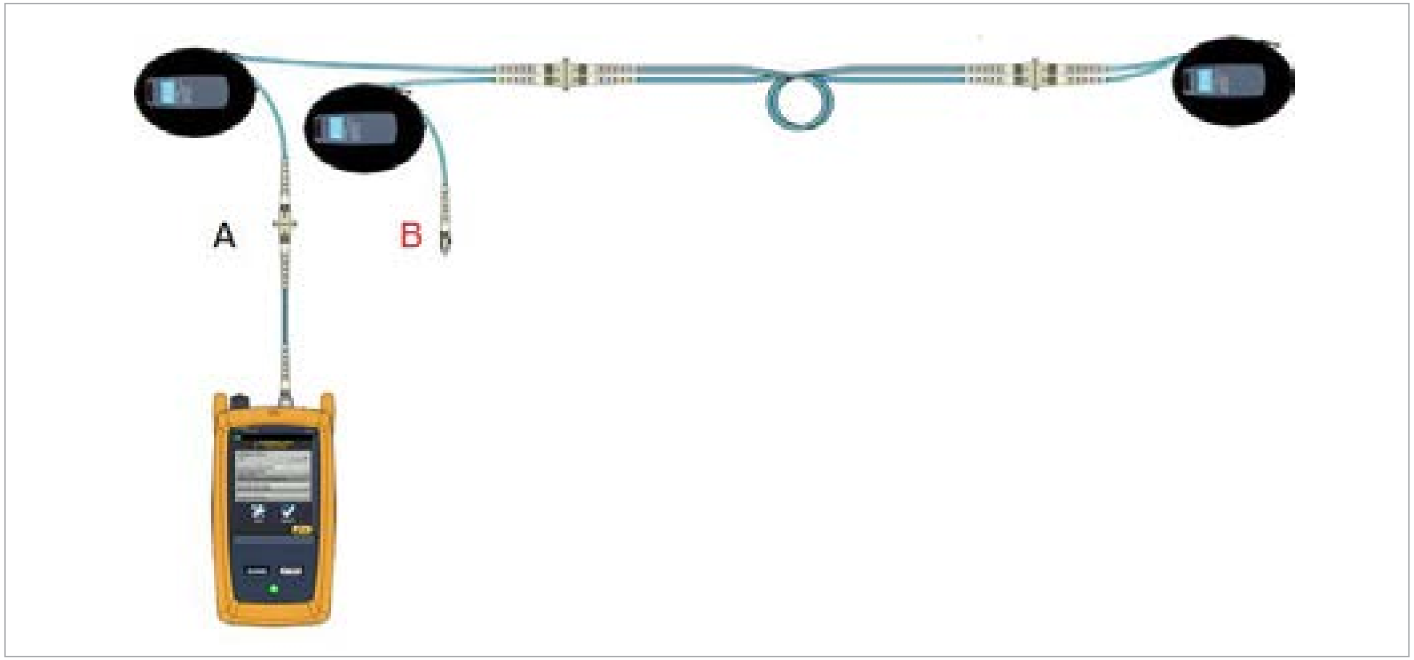

Figure 33. SmartLoop OTDR test set up

Before you save the test, you can use the 1, 2 and or fiber A/ B buttons to review the individual results from each end (1/2), from each fiber (A/B), and the averaged results for each fiber x̄. From the results screens you can touch the SAVE button to save the results. with the correct cable IDs for each fiber. The tester saves SmartLoop results in two records-one for each fiber. Figure 34 shows an example of the results screen for saved results for Fiber A.

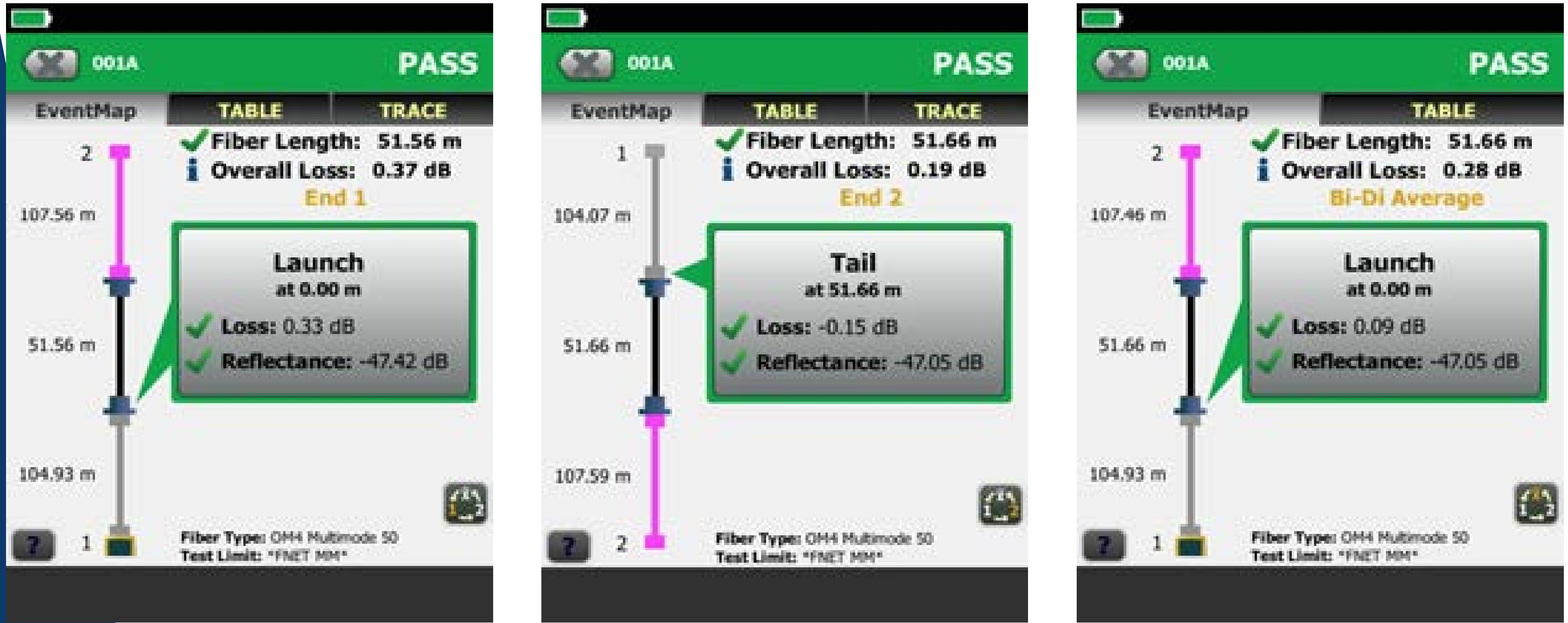

Figure 34. SmartLoop OTDR results for Fiber A from End 1, End 2 and Averaged

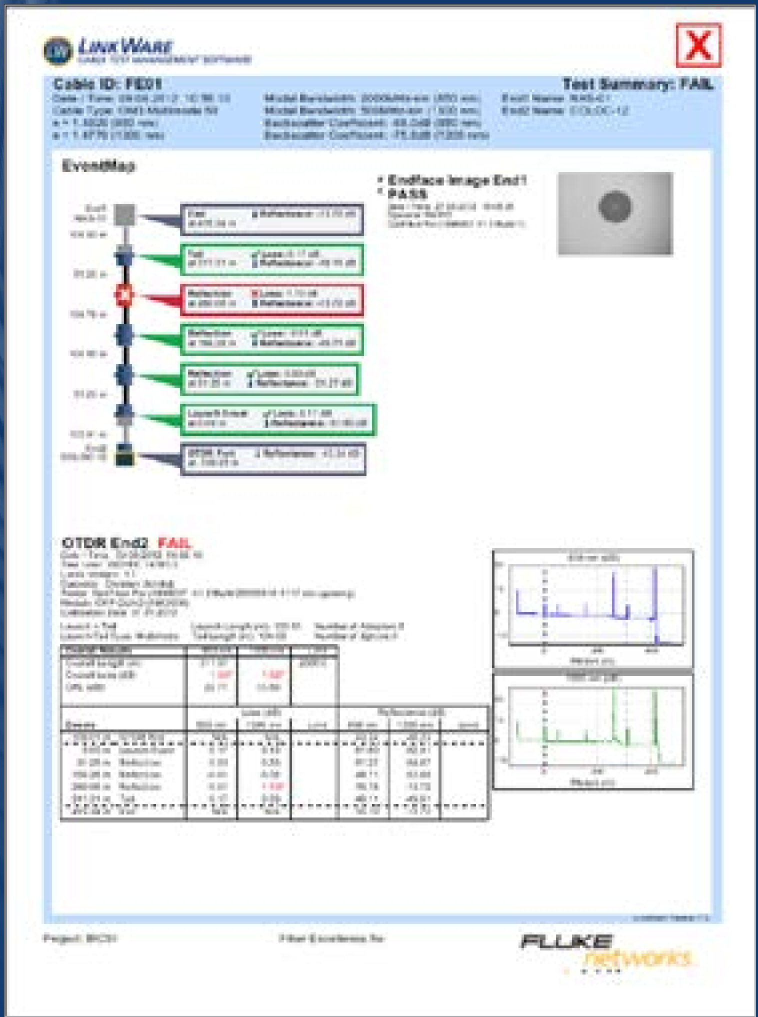

Figure 35. Sample LinkWare PC printout with merged OTDR and end face images for a single fiber link

Summary of Tier 2 testing

Tier 2 testing-extended certification using an OTDR-is an important part of fiber certification for these reasons:

- It characterizes the individual components of a fiber link, such as connectors, splices, and other loss events. Extended certification compares the test results to specifications for these events to determine if they are acceptable.
- It is critical because it identifies faults that may be invisible to basic (Tier 1) certification.
- It provides evidence that every component in a fiber optic cabling system was properly installed.

As with the basic, Tier 1 testing, you can download OTDR results to a PC and manage them with LinkWare PC Software (figure 35). It is easy to merge OTDR test results with the other records if the same fiber cable naming sequence was used. You can also merge end-face images from the optional FI-7000 FiberInspector Pro Video Microscope into the same records to prove cleanliness and generate professional reports that combine all the test data into one document. These can be easily created and printed out or emailed in PDF form.

Practical cable certification test strategy

There are several ways to perform a complete certification test of fiber optic cabling. The standards are clear about defining required and optional tests, test limits, and acceptable test equipment. But they don't suggest how the testing should be performed for optimum efficiency in the field.

Based on decades of work with contractors, installers, and technicians, Fluke Networks has developed proven, best-practice procedures to perform a complete fiber certification in the most efficient way:

- Make sure that design criteria and test limits are established before installation. This is easily done within the ProjX™ project management system on all of the Versiv copper and fiber testing platforms. You can set up all the tests and test limits before arriving on site. In addition, the project can be copied into multiple Versiv units so other operators can test using the same configurations. Each operator can be identified within the project so that individual test results can be identified by operator. Results can be saved in the cloud so that the person compiling the results can receive all results from all operators without operators needing to go back to the office or email them.

Figure 36. OptiFiber Pro EventMap

- Confirm proper fiber strand polarity, end-face conditions, and verify loss with simple verification tools during installation
- Perform extended tests using the Tier 2 certification tests (OTDR analysis) as the first certification step

  Doing so:

  - ensures that connector performance meets generic cabling standards or system designer's requirements;
  - Qualifies workmanship for cabling installation qualifies workmanship for cabling installation
  - and identifies problems for immediate troubleshooting with the OTDR.
- Perform basic or Tier 1 testing for the channel against the application standard. This certifies channel length and loss and calculates margin based on the standard.
- If dual wavelength testing is not required, measure channel loss at the wavelength of the application

Finding and analyzing fiber cabling faults

Common faults

Fiber optic connections involve the transmission of light between fiber cores that are smaller than the diameter of a human hair. Minimizing the loss of signal power requires good mating of the fiber end-faces, among other things. Insufficient power or signal disturbances that cause failures in optical transmissions can result from these common faults:

Contaminated fiber connections: This leading cause of fiber failures results from poor connector hygiene. Dust, fingerprints, and other oily contamination causes excessive loss and possibly permanent damage to connector end-faces.

Too many connections in a channel: Simple, but it is important to consider the total allowable loss (per intended application standard) and typical loss for connector type during the design process. Even if the connectors are properly terminated, if there are too many in a channel, the loss may exceed the applications requirements for correct operation.

Misalignment: The best way to achieve good fiber alignment is to fuse the two fibers together with a precision splicing machine. But for several practical reasons, the connection of fibers is often done mechanically with fiber optic connectors. There are many commercially available connector types, each with their advantages and disadvantages. Typical loss specifications are a good proxy for how well a connector can align fibers. Any such specifications used for data communications should be compliant with Fiber Optic Connector Intermateability Standards (FOCIS). Alignment is affected by these conditions:

- **Poor-quality connectors or faulty termination:** Good-quality connectors have very tight tolerances that maintain precise alignment
- **End-face geometry:** Performance of fiber optic connectors is largely a function of the geometry of the end-face. This geometry can be measured in a laboratory with precision interferometry equipment. In the field, the following parameters are inferred in loss and reflectance measurements:
  - Roughness: Scratches, pits and chips produce excess loss and reflectance
  - Radius of curvature: The convex surface of the connector should mate properly with another connector
  - Apex offset: The core of the fiber should be centered near the highest point of the end-face

FLUKE networks

- Fiber height: A protruding (under-polished) fiber does not mate well and an undercut (over-polished) connector will perform poorly due to the presence of an air gap

  These factors can make issues with fiber height worse:

  - Unseated connectors: A connector may be plugged into an adapter bulkhead but may not be seated and connected with its mate. Worn or damaged latching mechanisms on connectors or adapters are sometimes the culprit. Poor cable management—Strain on a connector may cause misalignment due to becoming partially retracted, broken, or unplugged.
  - Poor cable management: Strain on a connector may cause misalignment due to a connector becoming partially retracted, broken, or unplugged.

- **Polarity:** Perhaps the simplest fiber cabling fault is a reversal of transmit and receive fibers. This is usually easy to detect and repair. But sometimes connectors are paired together and must be broken apart to be reversed. Standards designate polarity with a labeling convention that is seldom used, resulting in confusion. The following can help prevent polarity problems:
  - Polarity should be designated with A and B labels or colored boots
  - A is for transmit and B is for receive; OR, red is for transmit and black is for receive

Poor cable management, system design, or damaged cable also causes faults in fiber cabling systems. Fiber has a very high tensile strength, but is susceptible to crushing and breaking if abused.

Bends: Macro and micro bending caused by tight cable ties or bend radius violations resulting in excessive and unexpected loss. See figure 37.

Figure 37. Example of a common cause of a fiber failure

Breaks: Light will not propagate past a point in an optical fiber where the glass is crushed or cracked.

Intersymbol interference (ISI): Disturbed Signal is a fault that is usually the result of poor system design. A system that is not certified with the application standard in mind is susceptible to ISI. Other issues which can affect fiber performance include these:

- Modal dispersion. This results from a violation of distance limitations on multimode fibers. Typically, the loss from such long fibers will become an issue long before modal distribution becomes a problem.
- Reflections from too many highly reflective connectors causing increased bit errors due to excessive return loss

Best practices for testing fiber

- Keep it clean. Dirt and contamination are the biggest cause of failing connections and testing challenges
- Dust blocks light transmission
- Finger oil reduces light transmission
- Dirt in fiber connectors spreads to other connections
- Contaminated end-faces make testing difficult
- Remember to inspect equipment ports, as these ports, such as on routers, switches, and NICs can get dirty too. Also be sure to inspect the ports on your test equipment

Clean fibers every time they are connected. You can verify that fibers are clean by using an instrument such as the FI-7000 FiberInspector Pro or FI-500 FiberInspector Micro to examine fiber end-faces. Figure 38 shows the FI-500.

- Use the correct test setup. Test standards, as per specifications will ensure that you get the most accurate, consistent, understandable and repeatable results
- Use recommended EF compliant TRCs to improve loss measurement accuracy and repeatability when testing multimode fibers

Figure 38.
Fluke Networks
FI-500 FiberInspector
Micro

- Always use high quality TRCs and launch fibers. Do not use test cords or launch fibers of unknown quality. All TRCs to be used for loss testing should come with manufacturing test data.
  - All TRCs to be used for loss testing should come with manufacturing test data. Cords should be kept clean and replaced when they show signs of wear.
  - Test cords should make polarity easy for you—Fluke Networks' cords feature red boots on the end at which light enters and black boots on the end at which light exits
  - Cords should be kept clean and replaced when they show signs of wear
- Choose test limits that are appropriate to both generic cabling standards and application standards

Figure 39.
Fluke Networks
Fiber QuickMap
identifies events
along a link

Finding simple faults

Continuity and polarity problems from breaks or unlatched connectors are common and sometimes difficult to locate and identify with loss testers.

Visual Fault Locators (VFLs), such as the Fluke Networks VisiFault VFL, provide the simplest method of troubleshooting these faults. Just shine the VFL's light down a fiber link and check the far end to makes sure the light gets through on the correct fiber. Problems such as breaks or tight bends will cause the fiber to glow through the jacket as light escapes the cladding.

Optical fault finders, such as the Fluke Networks Fiber QuickMap (for MultiMode, in figure 39) and Fiber OneShot PRO (for SingleMode) are recommended for finding breaks or unplugged connectors in a fiber link, filling the gap between a VFL and an OTDR. These troubleshooting instruments have the simplicity of a VFL, and provide distance and power information on high losses, breaks, and the end of the fiber. They also identify live fiber.

As these fiber troubleshooters are single ended testers, launch cables are recommended. Simply plug the Fiber QuickMap (shown in figure 39) into one end of a fiber channel and press the Test button to reveal the locations of events of interest, confirm channel connectivity and distance to failures.

How to troubleshoot common faults with a Light Source/Power Meter (LSPM)

Note that with some basic testing knowledge, efficient first-line troubleshooting can also be done with an LSPM kit. For example, basic polarity verification can be conducted using the SimpliFiber Pro Fiber Test Kit's 'FindFiber' feature. This same capability can also greatly simplify the normally time-consuming and personnel-intensive project of cable identification between patch panels. Using FindFiber Remote ID sources (Figure 40), a single technician can complete end-to-end testing by plugging them into the port(s) to be tested, before checking the ports on the far end with the SimpliFiber Pro power meter, to read the unique identifying signals transmitted by the FindFiber sources.

Figure 40. SimpliFiber Pro FindFinder helps identify cable IDs.

As an instrument that tests from one end of a fiber plant to the other, the LSPM can also be used to narrow down any questionable connections. By leaving a light source at one end, a technician can systematically disassemble a link by disconnecting each component at the connector(s), inspect and clean the fiber end-faces, then test the plant up until that connection point. If the loss measurement is within expectations, you can reconnect (after inspecting and cleaning the end-face of the link to be mated, of course) and repeat at the next connection down the line until the problem point is identified and corrected.

Detecting intermittent power fluctuations is also a common issue where an LSPM can be invaluable when troubleshooting. Whether it is a faulty switch or a poor connection into the back end of a connector, power fluctuations are problematic but difficult to detect and capture because they are so fleeting. However, the 'Min/Max' feature on the SimpliFiber Pro power meter helps you to ensure that transmission power is stable over a link by automating the precision tracking of the power level. By providing the upper and lower bounds of a wavelength measurement throughout the duration of a testing session, you obtain better visibility into the stability of the transmitted power.

How to troubleshoot common faults with an OTDR

OTDRs are the most powerful troubleshooting tool for fiber optic cabling. Smart use of an OTDR can eliminate time consuming trial and error troubleshooting.

Benefits of troubleshooting with an OTDR include:

- Single ended testing. No need place test equipment at both ends of a fiber optic link, making it easier for one technician to efficiently troubleshoot.
- Precise location of faults. OTDRs can see the location of breaks, too tight bends, and dirty connectors.
- Qualification of known events such connectors and splices with their locations infer their associated loss and reflectance

Finding faults with an OTDR

1. Make sure that opto-electronics are not live on fiber links to be tested
2. Turn the OTDR on and plug a good quality, clean launch fiber (at least 100 m) into the OTDR port
3. Plug the launch fiber into one end of the channel (don't forget to clean the end-face before connecting to the link)
4. Set up the OTDR for testing

   a. Choose the fiber type to be tested and/or characteristics from setup menu

   b. Set a pass/fail limit of 0.3 dB for connectors and 0.1dB for splices

   c. Choose 'Dual Wavelength Testing' from OTDR setup menu

   d. Set launch fiber compensation to simplify your testing by setting the end of your launch fiber as the starting point (zero feet/meters) on the trace

   e. Check to make sure that pulse widths, averaging time, distance range are set to 'Automatic Mode'

   f. Set loss threshold to 0 .01dB

5. If you cannot see past the end of your launch fiber, the problem is that the connector is not fully seated in the back of the patch panel

   a. You should see all connectors and cabling segments that you expected to see. If not, you have a break or an unplugged cable

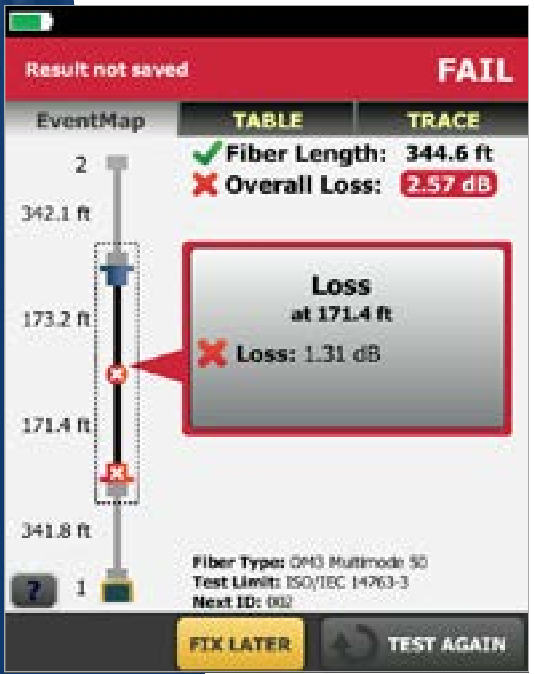

Figure 41.
OptiFiber Pro
EventMap
identified a FAIL

6 The advanced features of the OptiFiber Pro OTDR 'EventMap' (figure 41) uses the OTDRs' event analyzer to determine the quality of each connection without any user setup or programming. If 'EventMap' identifies a connector as questionable, further analysis is warranted to ensure acceptable connector or splice performance.

a. If the display says that you failed the test, look at the EventMap, TRACE or TABLE to identify where the failing event is to locate and identify the failure

b. If the end of the fiber is much closer than it should be, you have a broken fiber at that location

c. You may use a visual fault locator or create a macro bend with a real time trace running to physically locate the break or failing event

d. Press the right arrow on any of the tabs to see the same fiber at a longer wavelength. This will often magnify poor events, as longer wavelengths are more susceptible to certain types of losses

e. If you have connectors that fail limits and have long sweeping tailing on the trace, you probably have dirty connectors. You should use an FI-7000 FiberInspector Pro to physically inspect each connector. Make sure to have a good cleaning kit with you.

7 Once you have cleaned and repaired any faults, retest the link.

a. If it now passes your test limits, save the results and export them to LinkWare PC for record keeping. If you have the FI-7000 FiberInspector Pro option, you can also save your clean fiber end-face images to the same report!

b. If you would like to do a before and after comparison, you can change the display mode of the OTDR Trace in LinkWare PC and display up to 12 fibers at one time

Conclusion

Cabling installation is a multi-step process. It is a prudent practice to certify the cabling system after installation to ensure that all installed links meet their expected level of performance. Certification will likely identify some failing or marginally passing links. In order to deliver a high quality cabling system, the defects that cause the failures and marginal passes must be detected and corrected.

It is imperative that the certification is executed with instrumentation that has valid calibration. When Fluke Networks designs a product, a specification is developed that takes into account long term drift of the electronic, optical and mechanical components. The usual timeframe is one year and the goal is to have 95% of the population of all instruments for a given model number to be in tolerance at the specified time period.

Fluke Networks' full suite of fiber certification instruments (Appendix 1) have an unparalleled history of providing unique and powerful diagnostic assistance to installation technicians. By knowing the nature of typical faults and how the tester's diagnostics report them, you can significantly reduce the time needed to correct an anomaly, an installation error, or a defective component. Personnel responsible for the network's operation can also benefit from the diagnostic capabilities of a certification test tool; with the tester's assistance, they can limit the duration of network downtime and restore service quickly.

We highly recommend that you thoroughly familiarize yourself with the capabilities of your test tool—it is truly a modest investment that pays for itself many times over. In addition to your precision instrument, Fluke Networks also provides a wide variety of expert and timely support options. Whether you are an installer, network owner, or contractor, the following resources are available:

- **Cabling chronicles blog:** Updates on the latest in standards, testing tips and Cabling 101 topics.
  www.flukenetworks.com/blog
- **White papers and knowledge base articles:** Insightful studies and helpful advice on relevant structured cabling topics.
  www.flukenetworks.com/support
- **Unsurpassed technical assistance** from the highly trained Fluke Networks Technical Assistance Center (TAC).
  Email: **support@flukenetworks.com**
- **Certified Test Technician Training (CCTT) classes** available around the world
  www.cctttraining.com/
- **Gold Services Membership Program:** Comprehensive maintenance and support including priority repair with loaner, annual calibration and priority TAC support with after hours and weekend coverage.
  www.flukenetworks.com/gold

FLUKE networks.

Glossary

Certification testing	The process of testing the transmission performance of an installed cabling system to a specified standard; requires an OLTS for "Tier 1" certification and an OLTS plus OTDR for "Tier 2" certification.
Channel	End to end transmission medium between a transmitter and receiver dB—logarithmic unit of measurement used to express magnitude of power relative to a specific or implied reference level; usually associated with loss.
dBm	Power level expressed as the logarithm of the ratio relative to one milliwatt.
EF	Encircled Flux, a method of specifying power throughout the MM fiber core using multiple control radii providing a tight tolerance on mode power distribution in the outer radii enabling improved agreement between EF-compliant test instruments.
FiberInspector	Fluke Networks' popular line of handheld fiber end-face and bulkhead port inspection instruments, ranging from tube to video microscopes.
Gbps	Gigabits per second.

FLUKE networks

Launch cord fiber	Length of fiber placed between the link segment under test and the OTDR to improve the OTDR's ability to grade the near-end connector and any abnormalities in the first connection.
LED	Light Emitting Diode, a relatively low-intensity light source.
Link	The physical cabling for a transmission.
LSPM:	Light Source/Power Meter, basic fiber verification instrument composed of a power meter and a source to measure loss over a link.
Mbps	Megabits per second.
MPO	Multi-fiber push on connectors, or MPOs for short, are fiber connectors comprised of multiple optical fibers. While defined as an array connector having more than 2 fibers, MPOs are typically available with 8, 12, or 24 fibers for common data center and LAN applications.
OLTS	Optical Loss Test Set, a baseline "Tier 1" certification instrument that measures the loss of a link over its length.
OTDR	Optical Time Domain Reflectometer, powerful fiber optic tester often used for troubleshooting. OTDRs are also used in addition to OLTSs for "Tier 2" testing.

TRC Test Reference Cord, a high-quality fiber cord between 1 and 3 meters long with high performance connectors, and ideally with end-faces with special scratch resistant hardened surfaces that enable numerous insertions without degradation in loss performance.

VCSEL Vertical Cavity Surface Emitting Laser, commonly used in multimode light sources. VCSELs should not be used as a testing source per the standards, only for network system verification.

Verification testing The process of testing the transmission performance of an installed cabling system to ensure that it meets a minimum threshold.

VFL Visual Fault Locator, optical source that transmits low-powered laser light to locate breaks and sharp bends in fiber links.

Fluke Networks fiber test and troubleshooting instruments

	Inspection and Cleaning			MPO Testing	Loss Length Testing (Tier 1 Certification)		Plant Characterization and Troubleshooting (Tier 2 Certification)		
	 FI-500 FiberInspector™ Micro Fiber Inspection Scope	 FI-7000 FiberInspector™ Pro Video Microscope	 Fiber Optic Cleaning Kits	 MultiFiber Pro MPO Tester	 CertiFiber Pro Optical Loss Test Set	 SimpliFiber Pro Power Tester and Fiber Test Kits	 VisiFault Visual Fault Locator	 Fiber OneShot™ PRO and Fiber QuickMap™	 OptiFiber Pro OTDR
Check end-face contamination or damage	✓	✓				✓			✓
End-face inspection grading		✓				✓			✓
Port Illumination	✓								
Auto-focus	✓								
Clean contamination			✓						
Check connectivity				✓	✓	✓	✓		✓
Check polarity				✓	✓	✓	✓		
Verify loss over entire link to ensure loss budget not exceeded				✓	✓	✓			
Dual-fiber loss testing						✓			✓
Singlemode Tier 1 certification				✓	✓	✓			
Multimode Encircled Flux Compliant Tier 1 Certification				EF compliant at the bulkhead	with EF TRC's	✓			
Locate faults							✓	✓	✓
Tier 2 certification									✓
Pass/fail results		✓		✓		✓		✓	✓
Document test results		✓		✓	✓	✓			✓
Fiber types supported	Multimode Singlemode	Multimode Singlemode, MPO	Multimode Singlemode, MPO	MPO (Multimode and Singlemode)	Multimode Singlemode	Multimode Singlemode	Multimode Singlemode	Multimode Singlemode	Multimode Singlemode
Source type				LED, FP Laser	LED, FP Laser	LED, FP Laser	Laser	Laser	LED, FP Laser

For additional resources to help you establish Fiber Testing Best Practices visit:
www.flukenetworks.com/FBPPG

For additional resources to help you establish Copper Testing Best Practices visit:
www.flukenetworks.com/CBPPG

Want to talk to an expert then locate you local contact number on:
www.flukenetworks.com/contact

P.O. Box 777, Everett, WA USA 98206-0777

Fluke Networks operates in more than 50 countries worldwide. To find your local office contact details, go to **www.flukenetworks.com/contact**.

4/2019 19086

FLUKE networks.