

A Quick Start Guide to Fiber-to-the- Antenna (FTTA) Installation and Maintenance Testing

Vol. 2 — Tier 2 Certification

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Electronic test equipment is subject to the EMC Directive in the European Union. The EN61326 standard prescribes both emission and immunity requirements for laboratory, measurement, and control equipment. This unit has been tested and found to comply with the limits for a Class A digital device.

Independent Laboratory Testing

This unit has undergone extensive testing according to the European Union Directive and Standards.

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FTTA

Staggering increases in bandwidth demand are forcing network operators to new models of mobile infrastructure like FTTA to improve the user experience and reduce costs. Optimized cabling and component performance between the radio remote unit (RRU) and the base band unit (BBU) is key to delivering optimized system performance between the backhaul network and the end user.

Network professionals must ensure network uptime and reliability while maximizing the customer experience. The comprehensive VIAVI suite of fiber optic handhelds, portables, and inspection test solutions for FTTA help support this goal.

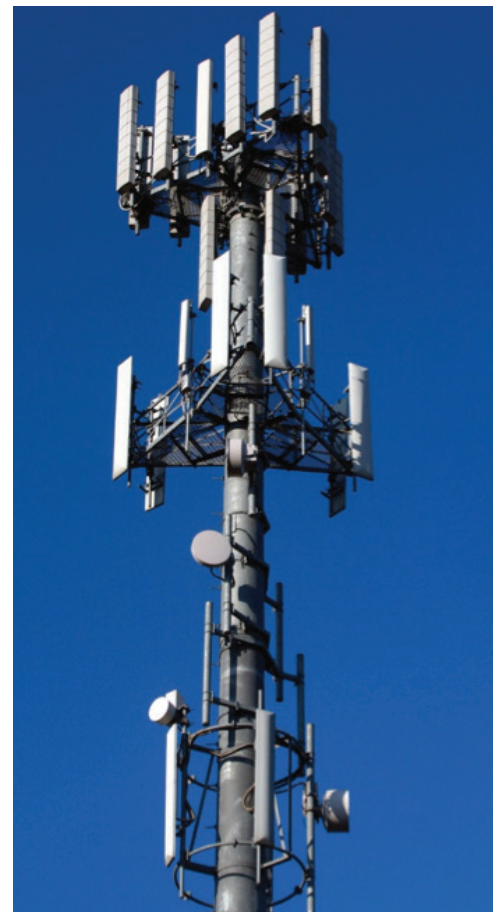
Fiber Optic Cell Acceptance Test (FOCAT) Tier 2 Certification

Installing a fiber network requires close consideration of network topology and equipment specifications. One of the essential tools to provide Tier 2 certification is an optical time domain reflectometer (OTDR). An OTDR measures the end-to-end optical link loss and provides the optical loss and distance for all other impairments (events) along the fiber.

An OTDR is the only single-ended tool able to measure loss from all of the components along the fiber link such as connectors, splices, microbends, and macrobends; these measurements are vital for correctly characterizing the quality of installation or when fault finding. The ability to do single-ended measurements can dramatically impact operational costs when construction or troubleshooting a FTTA network and, in some cases, can prevent unnecessary tower climbs.

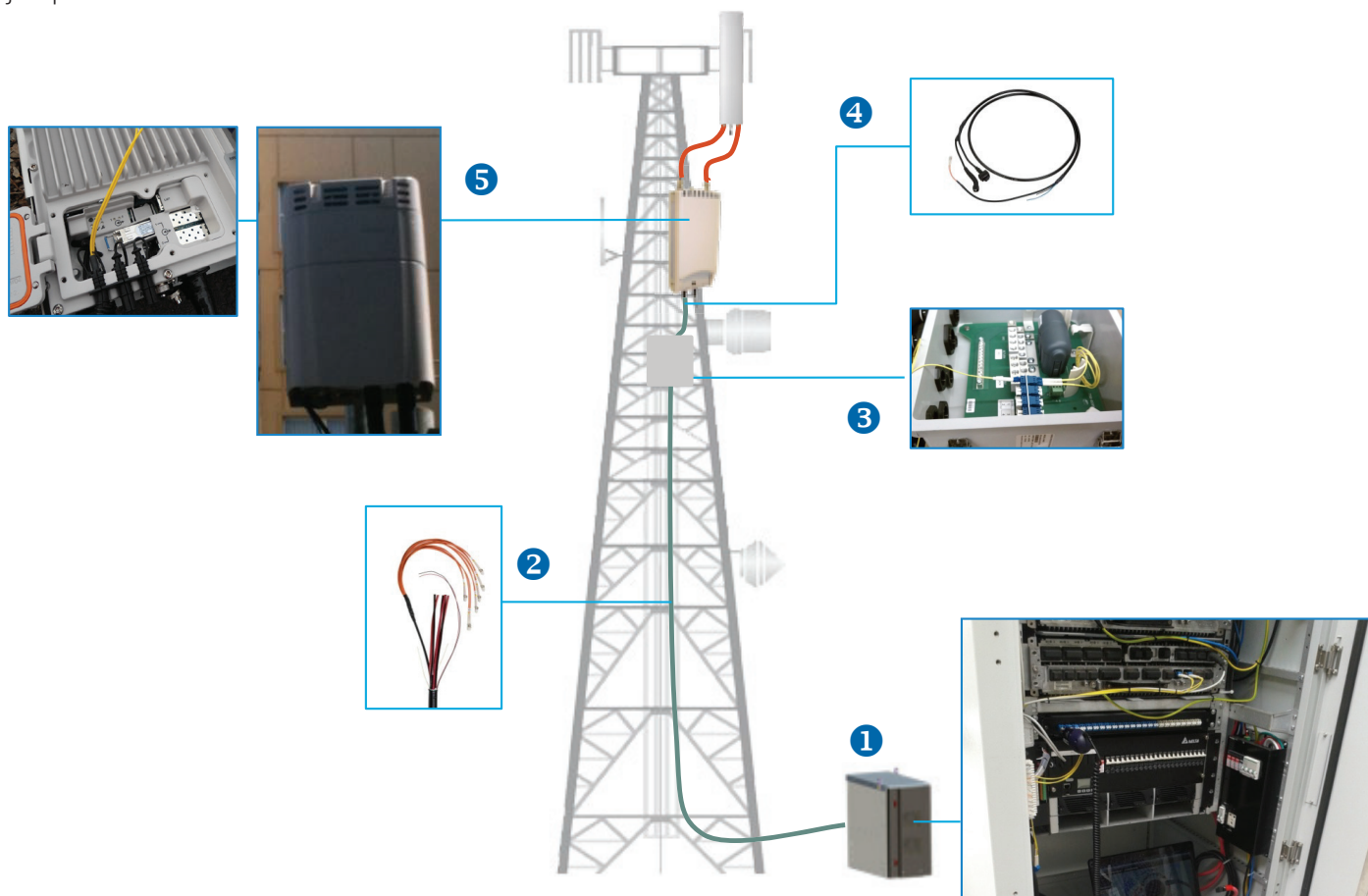
FOCAT certification provides the confidence that network components are optimized to provide a lifetime of performance and deliver world-class services.

This guide addresses FOCAT Tier 2 installation and maintenance testing topics only. Visit www.viavi.com/go/GetFiberSmart for more information about fiber testing.



Macrocell and Fiber Components

This guide will focus on macrocell fiber installation and maintenance tests. This type of network architecture generally involves RRU and BBU functions that are physically separated. The radio equipment is relocated next to their respective antennas in the RRU enclosures. Fiber is deployed using a remote fiber feeder cable (RFF) that interconnects the BBU located at ground level to a breakout box at the top. The fiber is then patched using a jumper into the RRU.

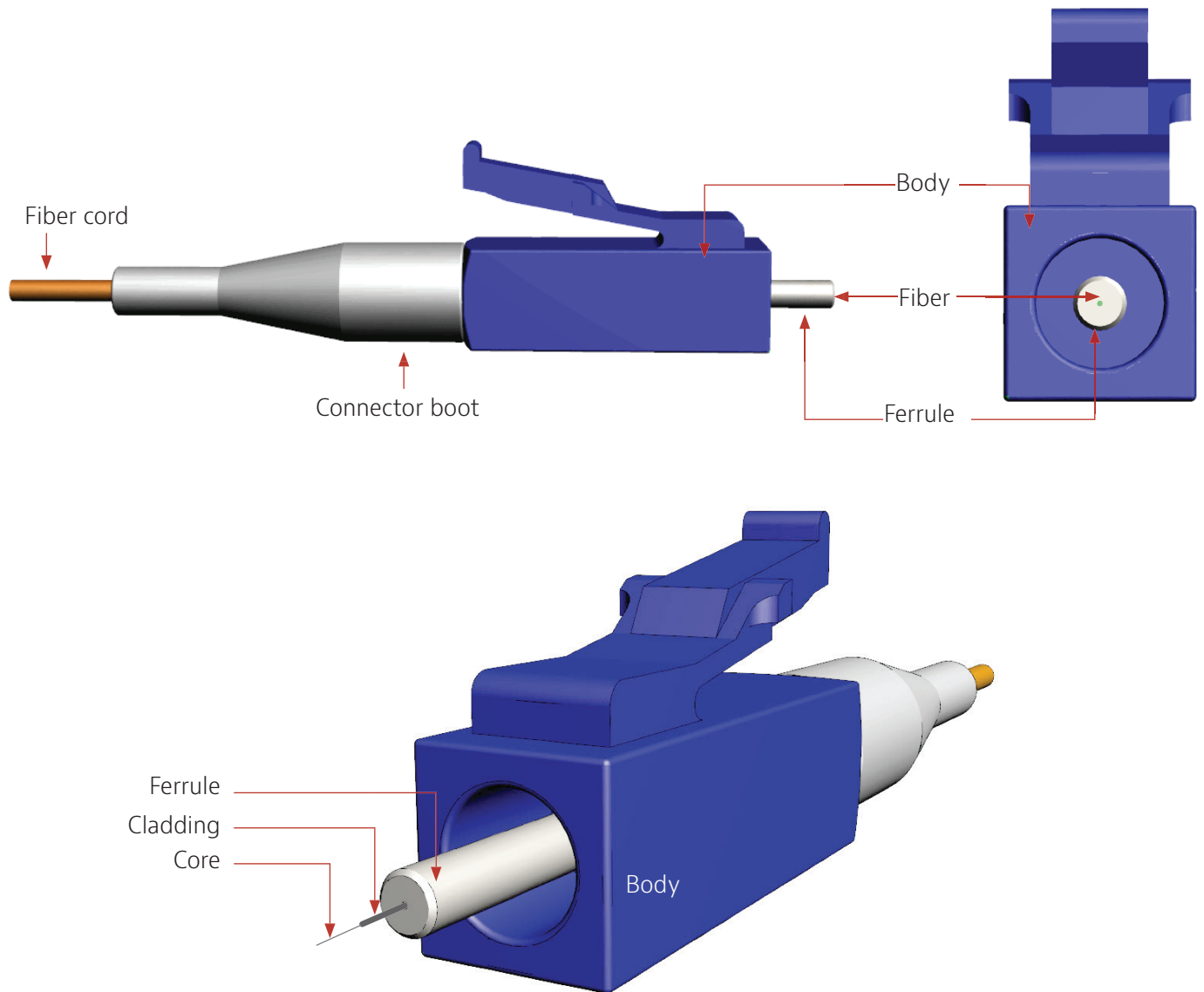


Macrocell tower and network elements

- 1.BBU
- 2.Remote fiber feeder cable or trunk
- 3.Junction box or breakout box
- 4.Jumper cables
- 5.RRU (also termed remote radio head or RRH)

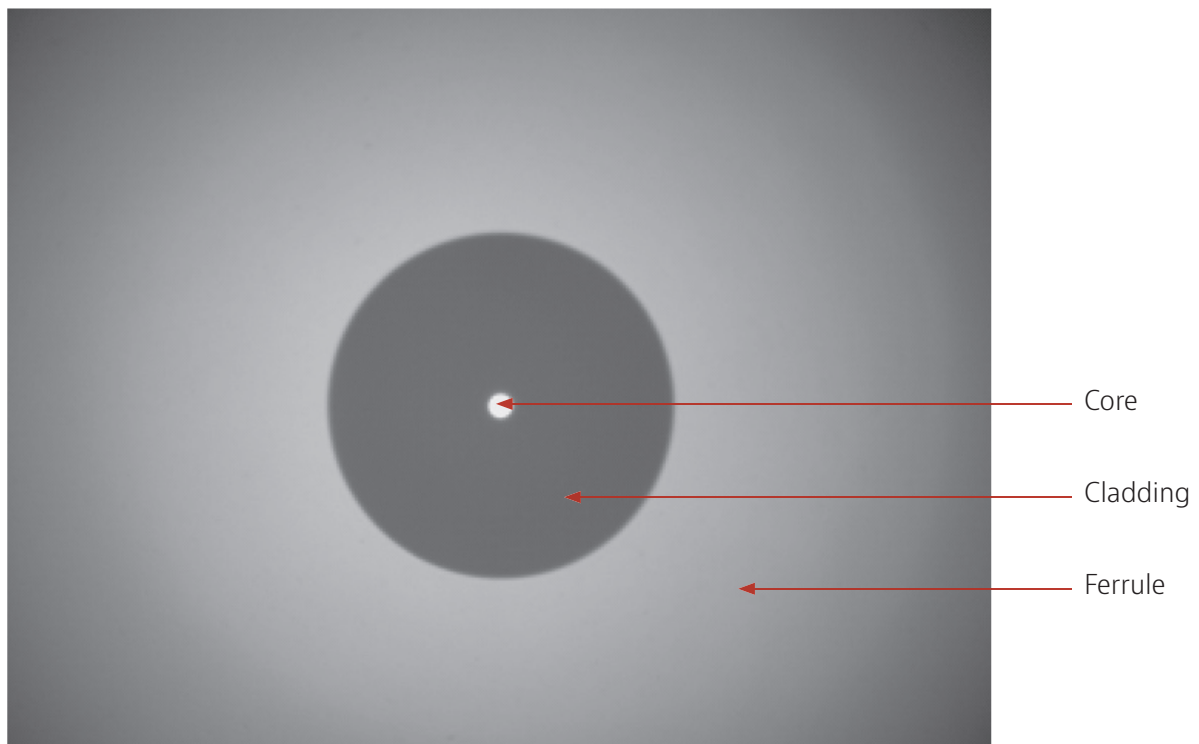
Connectors

Fiber connectors enable fiber-to-fiber mating by aligning the two optical fibers. Fiber connectors come in various types and have different characteristics for use in different applications. The main components of a fiber connector are detailed in the following figures:



Fiber optic connector components and endface (LCPC example)

Simplex Fiber



Fiber endface view

Body: Houses the ferrule that secures the fiber in place; utilizes a latch and key mechanism that aligns the fiber and prevents the rotation of ferrules of two mated connectors.

Ferrule: Thin cylinder where the fiber is mounted and acts as the fiber alignment mechanism; the end of the fiber is located at the end of the ferrule which is referred to as the endface. The overall diameter of the ferrule depends on the relevant connector type. There are typically two ferrule diameters used: 2.5 mm diameter, such as in SC-APC type connectors, and the smaller, 1.25 mm diameter such as in LCPC type connectors.

Cladding: Glass layer surrounding the fiber core that prevents the signal in the core from escaping (125 μm diameter for single connectors).

Core: The critical center layer of the fiber; the conduit that light passes through (8 – 10 μm diameter for single-mode connectors).

Inspect Before You Connect

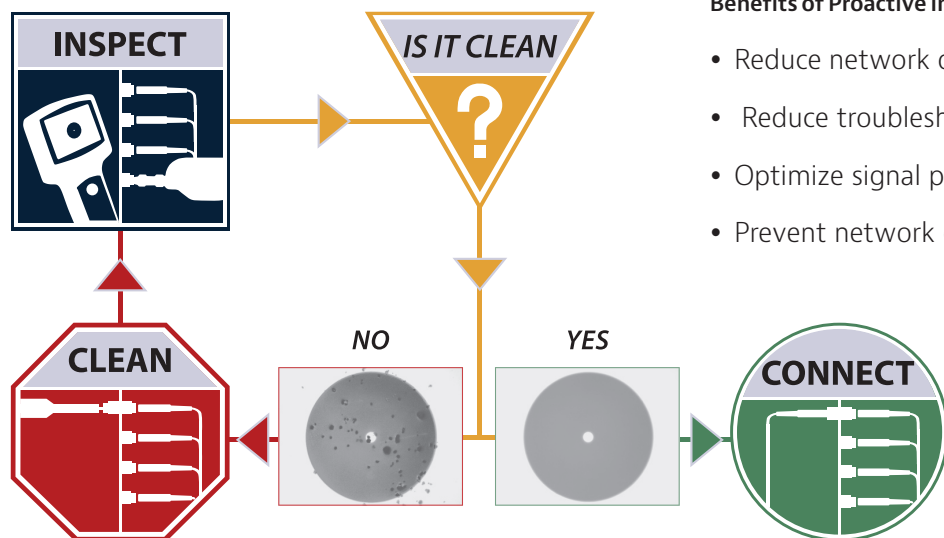
Contamination is the #1 source of troubleshooting in optical networks!

A single particle mated into the core of a fiber can cause significant back reflection (return loss), insertion loss, and equipment damage. Visual inspection is the only way to determine if fiber connectors are truly clean before mating them.



VIAVI T-BERD®/MTS-2000 with OTDR and digital microscope

By implementing a simple yet important process of proactive visual inspection and cleaning, poor optical signal performance and potential equipment damage can be avoided. Network failures can be significantly minimized by up to 80%.



Inspect before you connect diagram

Benefits of Proactive Inspection

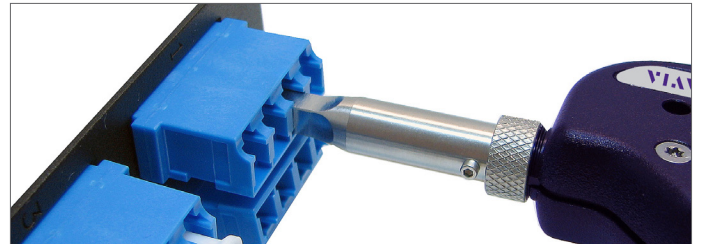
- Reduce network downtime
- Reduce troubleshooting
- Optimize signal performance
- Prevent network damage

Inspect



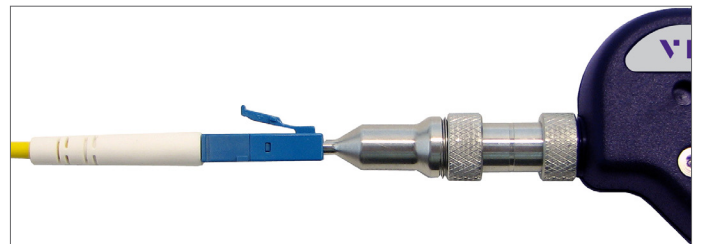
Inspect Bulkhead

1. Select the appropriate bulkhead inspection tip that corresponds to the connector type and install on a probe.
 2. Insert the probe into the bulkhead to inspect.
 3. Determine whether the bulkhead is clean or dirty.
- If clean, do not touch it and CONNECT
 - If dirty, CLEAN



Inspect Patch Cord

1. Select the appropriate patch cord inspection tip that corresponds to the connector type and install on probe.
 2. Attach the patch cord to the probe.
 3. Determine whether clean or dirty.
- If clean, do not touch it and CONNECT
 - If dirty, CLEAN





Inspection Criteria

Dirt is everywhere, and a typical dust particle (2 – 15 µm in diameter) can significantly affect signal performance and cause permanent damage to the fiber endface. Most field test failures can be attributed to dirty connectors, and most connectors are not inspected until the problem is detected, after permanent damage has already occurred.

Zones and Acceptance Criteria

Zones are a series of concentric circles that identify areas of interest on the connector endface. The innermost zones are more sensitive to contamination than the outer zones. Acceptance criteria are a series of failure thresholds that define contamination limits for each zone.

The Grading Process

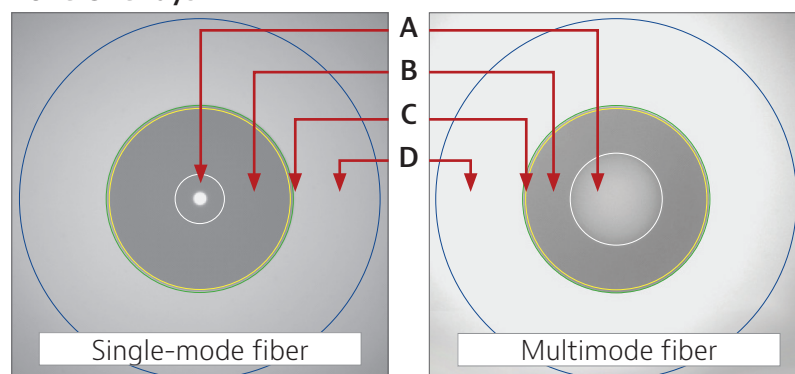
- 1.Count/measure the particles/contamination that are on the fiber surface.
- 2.Estimate or use a grading overlay to grade the fiber by determining the number and size of each particle present in each of the four fiber zones.

In most cases, there are no limits to the number/size of contamination present on zone C (Adhesive/Epoxy).

- If acceptable, do not touch it and CONNECT
- If not acceptable, CLEAN

Zone Overlays

- A. Core zone
- B. Cladding zone
- C. Adhesive/epoxy zone
- D. Contact/ferrule Zone





Acceptance Criteria

The tables below list the acceptance criteria standardized by the International Electrotechnical Commission (IEC) for single-mode and multimode connectors as documented in IEC 61300-3-35 Ed. 1.0.

Single-Mode PC Connectors, RL ≥ 26 dB (Ref: Table 5)

Zone Name	Diameter	Defects	Scratches
A. Core	0 – 25 μm	2 $\leq$ 3 μm none > 3 μm none	2 $\leq$ 3 μm none > 3 μm none
B. Cladding	25 – 120 μm	no limit < 2 μm 5 from 2 – 5 μm none > 5 μm	no limit $\leq$ 3 μm none > 3 μm
C. Adhesive	120 – 130 μm	no limit	no limit
D. Contact	130 – 250 μm	none $\geq$ 10 μm	no limit

Multimode Connectors (Ref: Table 6)

Zone Name	Diameter	Defects	Scratches
A. Core	0 – 65 μm	4 $\leq$ 5 μm none > 5 μm	no limit $\leq$ 5 μm 0 > 5 μm
B. Cladding	65 – 120 μm	no limit < 2 μm 5 from 2 – 5 μm none > 5 μm	no limit $\leq$ 5 μm 0 > 5 μm
C. Adhesive	120 – 130 μm	no limit	no limit
D. Contact	130 – 250 μm	none $\geq$ 10 μm	no limit



Clean

Clean Bulkhead with the IBC™

Guide cap cover

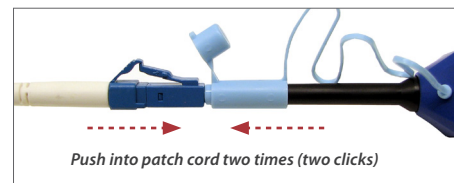


1. Select the appropriate cleaning tool for the connector type.
2. Pull off the guide cap cover.



Dry Clean

3. Attach the cleaning tool to the connector and push the cleaner into the patch cord two times (two clicks).



Impact

Determine whether clean or dirty.

4. If clean, do not touch it and CONNECT
5. If dirty, either repeat step 3 or go to step 5

Wet → Dry Clean

6. Apply a fiber optic cleaning solution onto a clean fiber wipe.
7. Wipe the end of the fiber connector on the wet area of the wipe, then go to step 3.



Repeat steps 3, 4, and 5 if necessary.



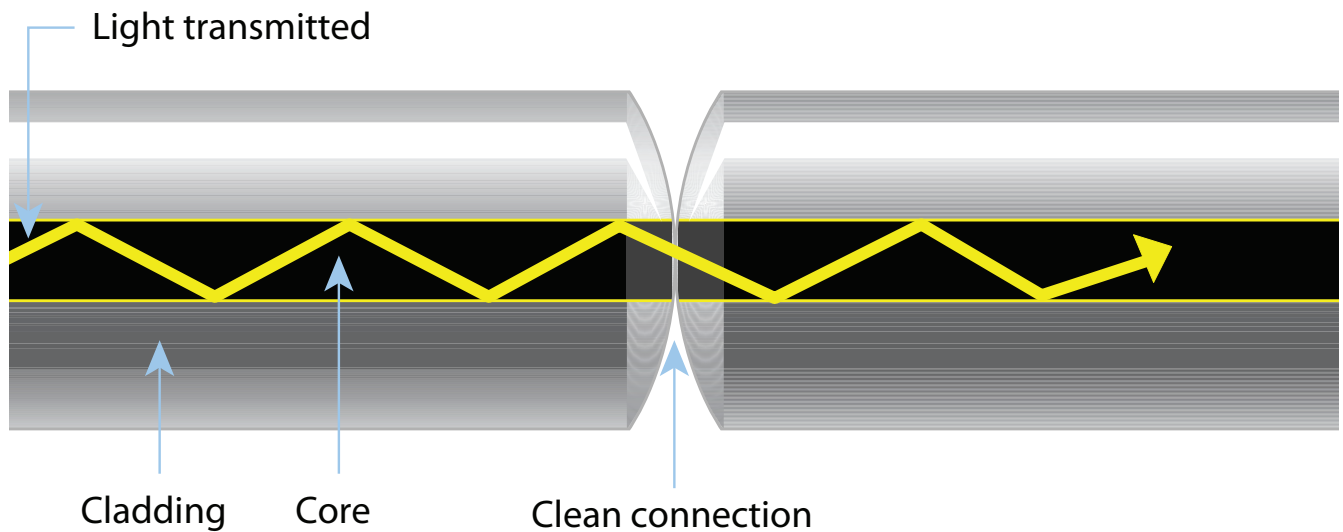
Connect

There are three basic principles that are critical to achieving an efficient fiber optic connection:

- Perfect core alignment
- Physical contact
- Pristine connector interface

Today's connector design and production techniques have eliminated most of the challenges to achieving core alignment and physical contact.

What remains challenging is maintaining a pristine end face. As a result, contamination is the #1 reason for troubleshooting optical networks.





Test Fiber Continuity

A visual fault locator (VFL) emits visible light to let technicians easily see light escaping from bends or breaks in the fiber. This is ideal for continuity checking and also to provide a means to identify the correct RFF fiber is routed to the correct RRU port.



A standalone VFL can check fiber continuity



VIAVI T-BERD/MTS-2000 can integrate a VFL to detect bends or breaks



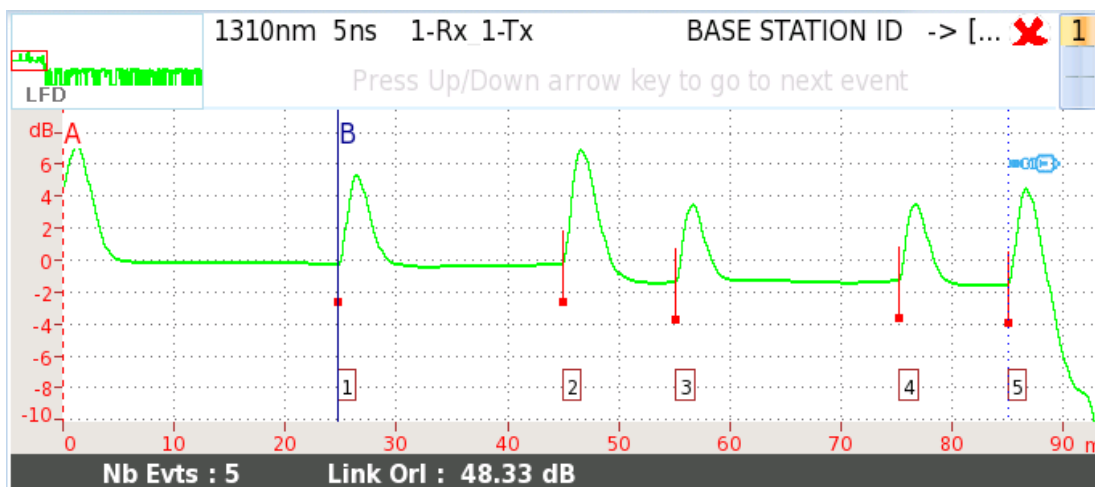
Optical Time Domain Reflectometer (OTDR) Testing

An OTDR is a fiber optic tester for characterizing fiber and optical networks. It detects, locates, and measures events at any location on the fiber link. The ability of an OTDR to characterize a fiber is based on detecting small signals that are returned back to it in response to the injection of a large signal, a process similar to radar technology.

One of the main benefits of an OTDR is that it enables complete fiber characterization from only one end of the fiber. The resolution of an OTDR is between 4 centimeters and 40 meters. It generates geographic information regarding localized loss and reflective events, providing technicians with a pictorial and permanent record of a fiber's characteristics that can be used as the fiber's performance baseline.

Tier 2 certification uses an OTDR to:

- Provide a visual look at the network using an OTDR trace
- Provide results in a schematic map for immediate diagnosis of problems understandable at any skill level
- Identify issues before a link is turned up
- Locate faults such as breaks and macrobends
- Measure the return loss of an installation
- Differentiate how each event contributes to link loss
- Provide the overall link loss (with proper launch cable settings)
- Provide a birth-certificate report of the network condition on install



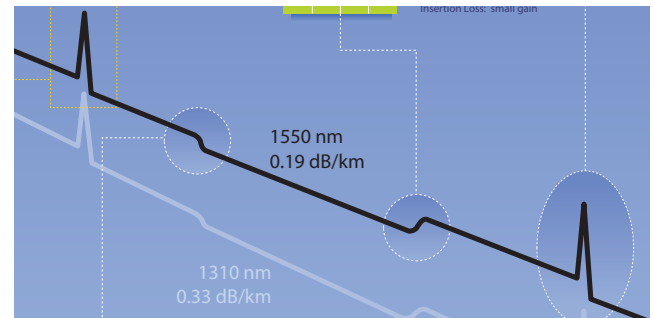
Example of an OTDR trace



OTDR Testing

An OTDR typically makes four vital measurements:

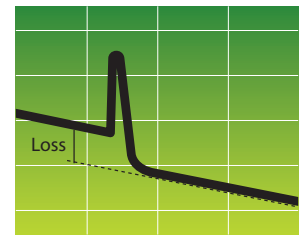
- Distance — An OTDR measurement is based on time: the round-trip time travel of each pulse sent down the fiber. Distance is calculated by knowing the speed of light in a vacuum and the index of refraction of the fiber glass.
- Attenuation (fiber loss) — Expressed in dB or dB/km, this represents the loss or rate of loss between two events along a fiber span.
- Event Loss — An event loss has a direct impact on the total optical budget and has to be checked with an OTDR. In general, two types of events can occur: reflective and non-reflective.



- A reflective event loss such as a connector typically ranges from 0.2 to 0.5 dB.
- A non-reflective event loss such as a fusion splice typically ranges from 0.01 to 0.2 dB. This is measured with an OTDR as the difference expressed in dB in optical power level before and after the event.

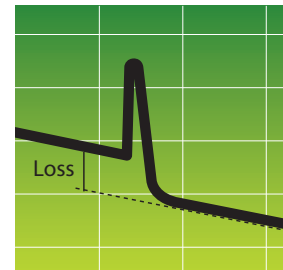


Fusion splice or macrobend



Connector or mechanical splice

- Reflectance — An event reflectance impacts the total optical return loss (ORL). The ORL is the total light that is reflected to the emitter and needs to be limited to avoid increase of bit error rate (BER). This is measured with an OTDR as the ratio of reflected power to incident power of an event and is expressed as a negative dB value. The higher the reflectance (the more light reflected back), the worse the connection. For example, a -50 dB reflectance is better than -20 dB value.



Typical Reflectance Values

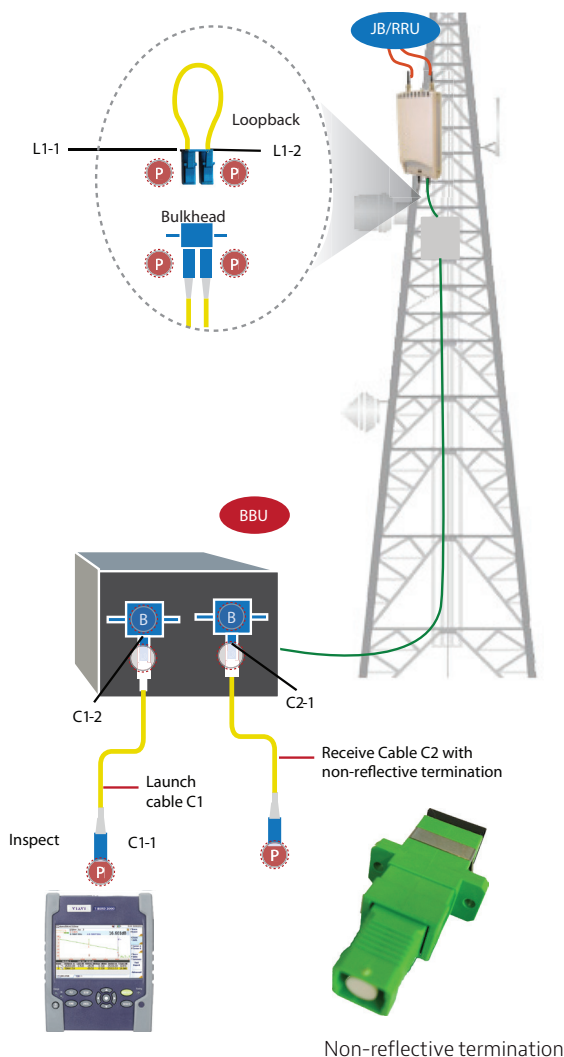
Polished connector $\approx$ -45 dB
Ultra-polished connector $\approx$ -55 dB
Angled polished connector $\approx$ -65 dB



OTDR Testing During the Construction Phase

Testing Tx and Rx Fibers Using a Loopback (recommended)

During construction, a patchcord loop (20 m) is placed on each duplex pair after tower/rooftop installation: a patch cord is looped at the top for a test of the duplex pair. A patch cord allows the two duplex pairs to be measured for loss and reflectance. A launch cable placed between the OTDR and the base station connector and a receive cable placed on the far side of the down-loop base station connector (10– 20 m recommended for each) allows the loss of each of the base station connectors to be measured. On the far end of the receive cable, a non-reflective terminator or an APC connector is recommended to minimize the reflectance on the far connector. Recommendations: overall loss should be <6 dB; reflectance per connector should be >–35 dB.



Test the remote end (at junction box JB/RRU at the top of a tower):

1. Inspect and, if necessary, clean connectors L1–1 and L1–2 of the loopback device.
2. Connect the loopback device on the fiber pair under test using a bulkhead adapter.
3. Wait for the end of OTDR acquisition from the BBU.
4. After the OTDR test is complete, disconnect loopback, inspect, and, if necessary, clean the RRU port.
5. Make the connection.

Test the local end (at the BBU at the bottom of a tower):

1. Inspect and, if necessary, clean connectors C1 and C1–2
2. Inspect and, if necessary, clean the first BBU jumper connector.
3. Inspect and, if necessary, clean the OTDR port
4. Connect C1 – 1 to the OTDR port.
5. Inspect and, if necessary, clean connectors C2 – 1 and C2–2
6. Inspect and, if necessary, clean the second BBU jumper connector
7. Connect c2 – 1 to the second BBU jumper using a bulkhead adapter.
8. Launch OTDR acquisition
9. Check if results pass or fail (use schematic view)
10. Save results and generate a certification report.
11. Inspect and, if necessary, clean BBU ports.
12. Make the connection.



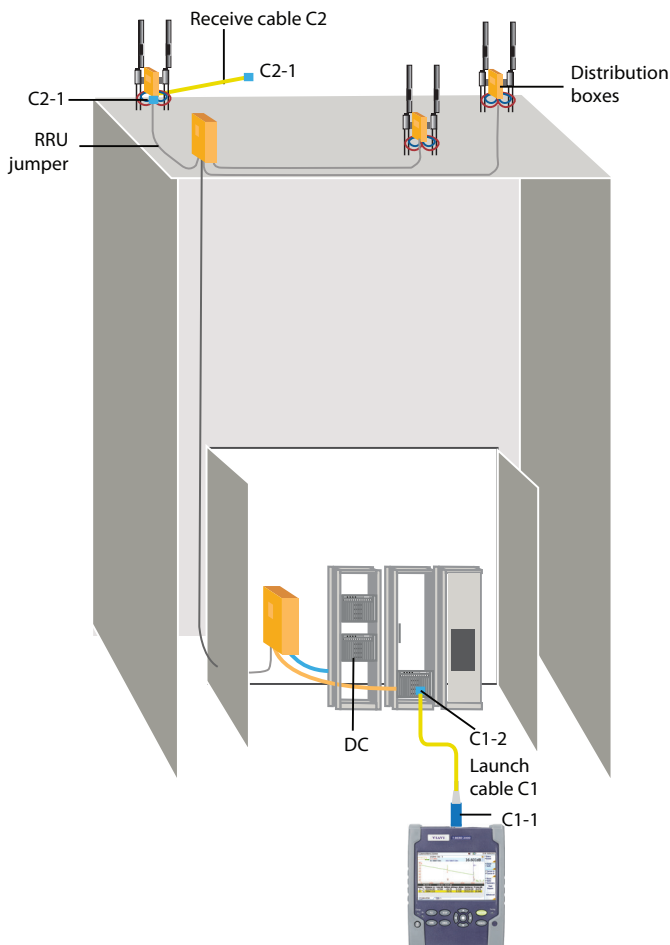
OTDR Testing During the Construction Phase

Testing Tx or Rx Fibers (no loopback)

During construction, a receive cable (10 – 20 m recommended) is placed at the top of a tower/rooftop, connected to the RRU jumper, to allow the measurement of an entire link and the far-end connector loss and reflectance. A non-reflective terminator or an APC connector is recommended to minimize the reflectance on the far connector.

A launch cable placed between the OTDR and the base station connector (10 – 20 m recommended) allows the loss and reflectance of the base station connector to be measured.

Recommendations: overall loss should be <6 dB; reflectance per connector should be >–35 dB.



Test the remote end (at the JB or RRU at the top of the tower):

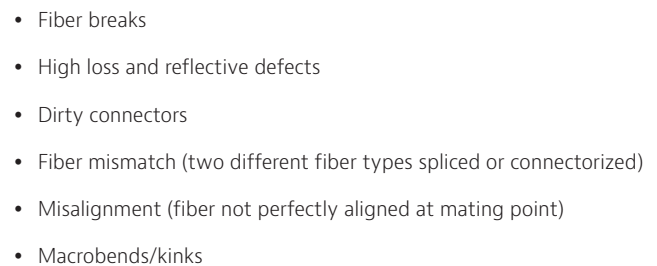
1. Inspect and, if necessary, clean connectors C2– 1 and C2–2.
2. Inspect and, if necessary, clean the RRU jumper.
3. Connect C2–1 to the RRU jumper using a bulkhead adapter.
4. Wait for the end of OTDR acquisition from the BBU.
5. After OTDR acquisition is complete, disconnect receive cable C2.
6. Inspect and, if necessary, clean the RRU port.
7. Make the connection.

Test the local end (at the BBU at the bottom of the tower)

1. Inspect and, if necessary, clean connectors C1–1 and C1–2.
2. Inspect and, if necessary, clean the OTDR port.
3. Connect C1–1 to the OTDR port.
4. Inspect and, if necessary, clean the BBU jumper connector.
5. Connect C1–2 to the BBU jumper using a bulkhead adapter.
6. Launch OTDR acquisition.
7. Check if results pass or fail (use schematic view).
8. Save results and generate a certification report.
9. Inspect and, if necessary, clean the BBU jumper connector.
10. Make the connection.



Recommendation: overall loss <3 dB; reflectance per connector >-35 dB.



OTDR Results Interpretation on a T-BERD/MTS-2000

To speed up the interpretation of measurement results, a Link Mapper View provides results in a schematic map for immediate diagnosis of problems.

- It increases confidence in fiber-network performance during installation and troubleshooting phases
- It empowers field technicians to become instant OTDR fiber-test experts—it requires little to no optical fiber expertise to perform and interpret a test
- It enhances field productivity as it completes the test process faster and more reliably than any standard OTDR solution

1. Icon-based schematic representation of the OTDR results
2. Link summary results: wavelength, link loss, ORL, and distance to fiber end
3. Auto detection of any issues



M_Laser 3ns 1-Rx
4136 MA 16cm 20.0s

Station_ID -> RRU_Id ✖
27/03/2013 11:03



Link Table			
	Laser nm	Link Loss dB	Fiber End m
✖	1310 (3ns)	0.031	22.50
✖	1550 (3ns)	0.040	22.66

Alarms	
Distance m	Fault Detected
4.79	Bend Detected
19.46	Bad or dirty connector

Trace View

Event View

Results Table

Setup

Fast Report



Summary result page for the FTTA-SLM

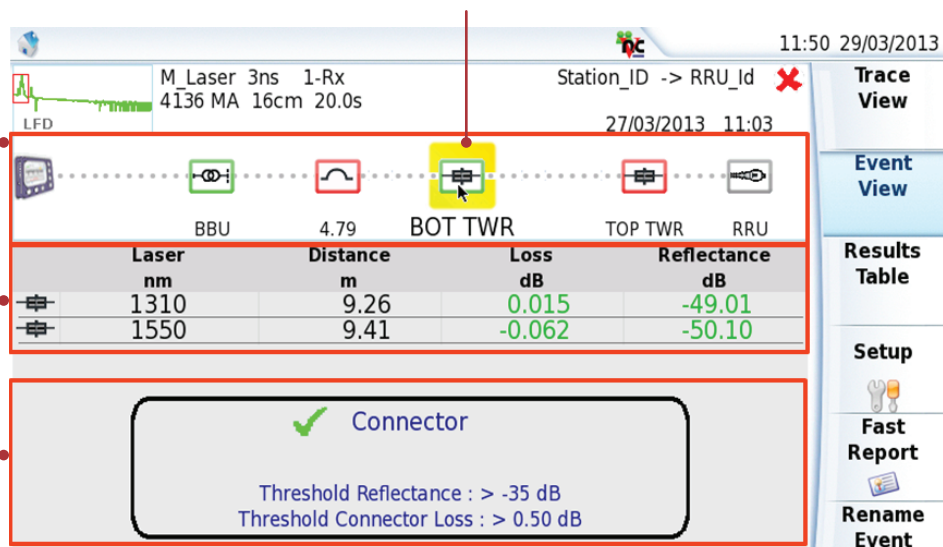
OTDR Results Interpretation on a T-BERD/MTS-2000

Detailed Result Page

1. Auto detection and identification of cell tower elements

2. Event position, loss and reflectance per tested wavelength

3. Explicit optical event name with Pass/Fail information



Detailed result page for the FTFA-SLM

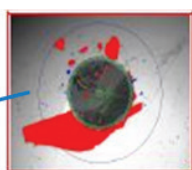
TIER 2 Certification Report

As with Tier 1, a Tier 2 certification report provides documentation to prove fiber performance and quality of work. The goal is to certify work with onboard PDF reports generated directly from the OTDR.

A typical Tier 2 certification should include details related to all OTDR events detected during the acquisition. This information can be displayed in two ways: showing one or multiple OTDR traces as well as a table of events and, if possible, a schematic to complete the traces and eliminate the complexities of OTDR result interpretation.



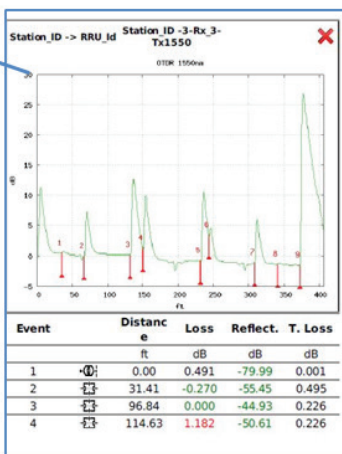
Certification report example



Fiber-end connector picture



Schematic results



OTDR results



VIAVI Essential Fiber Test Tools for FTTA Tier 2 Certification

VIAVI acceptance test tools:

- Ensure reliable, robust operation of the mobile infrastructure
- Future-proof the network to survive environmental effect and aging equipment and components
- Optimize system component and equipment performance
- Drive best practices and field operational efficiencies
- Prevent unnecessary operational costs such as tower climbs



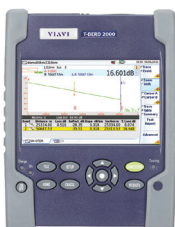
Visual Fault Locator

The FFL-050 has a compact, ergonomic design for ultimate portability using 2.5 mm or 1.25 mm (optional) connector types.



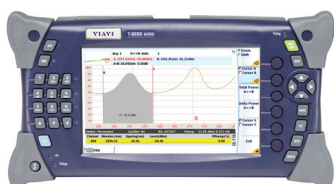
Fiber Probe Microscope

The P5000i digital probe microscope with automated connector Pass/Fail analysis certifies compliance to customer specification or industry standards including IEC 61300-3-35.



T-BERD/MTS-2000 Handheld Modular Test Set

This hands-free-capable test set is for installing, turning-up, and maintaining fiber optic networks.



T-BERD/MTS-4000 Multiple Services Test Platform

This modular handheld test solution is for all-in-one access/FTTx network and triple-play services installation and maintenance.

VIAVI Essential Fiber Test Tools for FTTA Tier 2 Certification



4100 Series OTDR Modules for T-BERD/MTS-2000 and 4000 Platforms

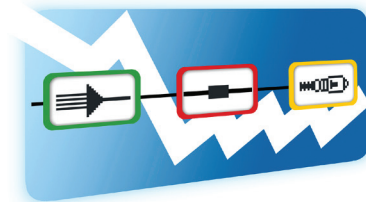
OTDR modules enable field technicians to rapidly, reliably, and cost-effectively install, turn-up, and troubleshoot any optical network architecture—enterprise, FTTx, access point-to-point, point-to-multipoint passive optical networks (PONs), and metro.

- The Quad module combines single-mode/multimode in one module
- The LA module is a dual-wavelength OTDR module with 1310 and 1550 nm and 37/35 dB dynamic range



SmartOTDR™

This simple, compact, upgradable OTDR test solution, based on the T-BERD®/MTS-2000 platform, is dedicated to installing and troubleshooting FTTx networks and to optical fiber across premises.



Smart Link Mapper (SLM) for T-BERD/MTS OTDR Platforms

SLM is an icon-based map view of OTDR events with an instant pass/fail display for easy OTDR interpretation and analysis.



FTTA-SLM for T-BERD/MTS OTDR Platforms

This OTDR application based on SLM software is specifically designed for FTTA testing. In addition to SLM features and benefits, it provides a special user interface in a custom language for FTTA networks.



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