A Quick Start Guide to Fiber-To-The-Antenna (FTTA)

Installation and Maintenance Testing

Certifying Next Generation FTTA Cabling and Components

JDSU

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Independent Laboratory Testing

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

Table of Contents

Introduction to Fiber-To-The-Antenna (FTTA)

Staggering increases in bandwidth demand are forcing network operators to new models of mobile infrastructure like fiber-to-the-antenna (FTTA) to improve user experience and reduce costs. The performance of the cabling and components between the RRU (Radio remote Unit) and BBU (Base Band Unit) is key to delivering optimized system performance between the back haul network and the end user.

Network professionals must ensure network uptime and reliability while maximizing customer experience. JDSU's comprehensive suite of Fiber optic handhelds, portables and inspection test solutions for FTTA help support that goal.

FOCAT (Fiber Optic Cell Acceptance Test) Certification

Fiber microbends, macrobends and dirty connectors are all common problems when installing fiber cable systems because they can induce signal or power loss, cable or component permanent damage and create signal transmission errors. FOCAT certification provides the confidence that network components are optimized to provide a lifetime of performance and deliver world class services.

Benefits of JDSU 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.

NOTE: *This Quick Start Guide only addresses FOCAT Tier 1 Certification installation and Maintenance testing only. See JDSU FTTA product Selection Guide for more information.*

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Key FTTA Terms

This guide will focus on Macro-Cell fiber installation fiber certification test only.

The network architecture generally involves the **Remote Radio Unit (RRU)** and **Base Band Unit (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.

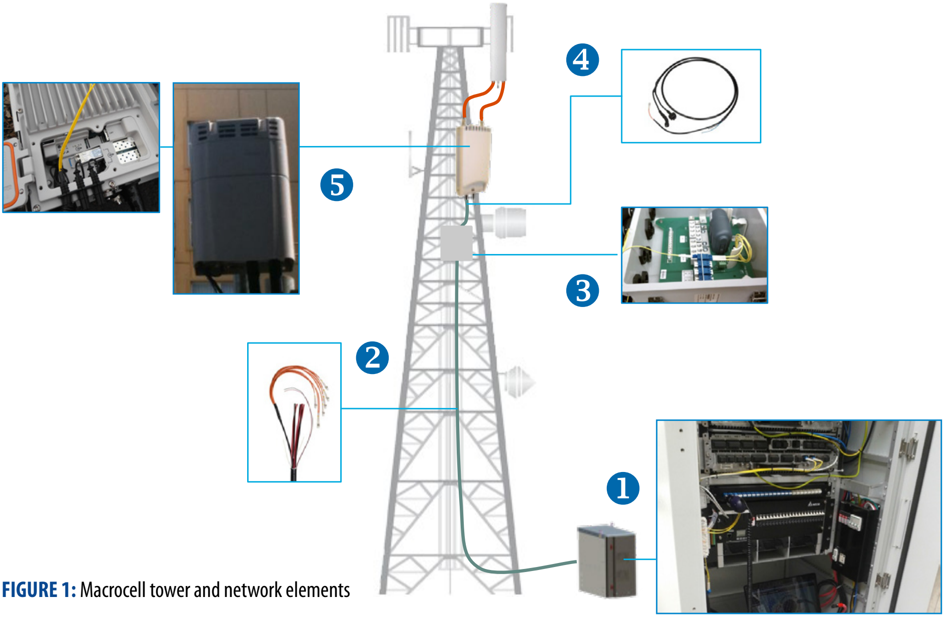


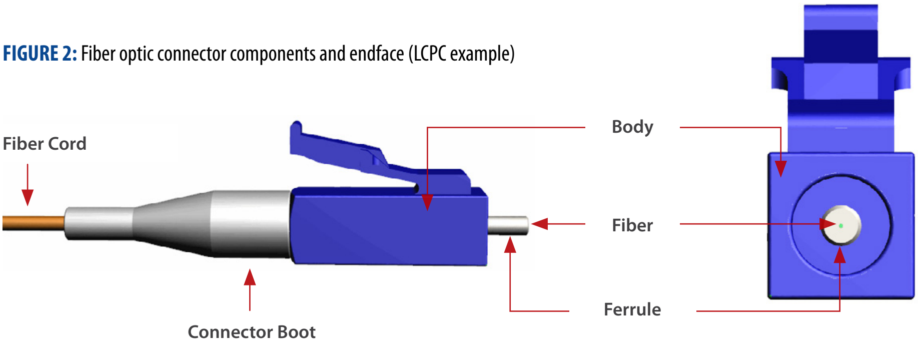
FIGURE 1: Macrocell tower and network elements

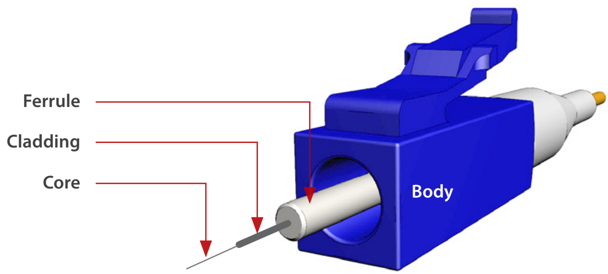
1. BBU – Base Band Unit
2. Fiber Feeder Cable or Trunk
3. Junction Box or Breakout Box
4. RRU Jumper Cables
5. RRU – Remote Radio Unit

Key Terms and Concepts

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:

FIGURE 2: Fiber optic connector components and endface (LCPC example)





Fiber Connectors

SIMPLEX FIBER

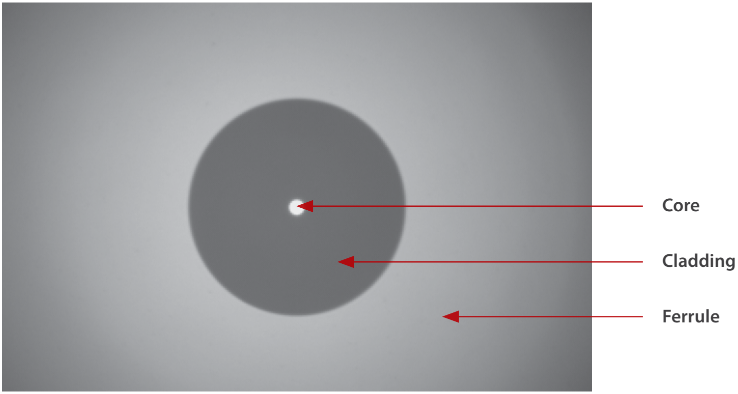


FIGURE 3: Fiber endface view

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' throughout this document. The overall diameter of the ferrule depends on the relevant connector type. There are typically two ferrules diameters used: 2.5 mm diameter e.g. SC-APC type connectors and the smaller 1.25 mm diameter. e.g., LCPC type connectors.

Fiber **CLADDING:** Glass layer surrounding the core, which 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).

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 (also known as Return Loss), insertion loss, and equipment damage. Visual inspection is the only way to determine if fiber connectors are truly clean before mating them. JDSU's SmartClass Fiber family is the next generation of optical handheld test solutions that allow technicians to inspect, test, certify, and save on a single device. Designed to help users work smarter and faster, the SmartClass Fiber family incorporates the features that technicians rely on every day to deliver best-in-class reliable networks to their customers.

- Complete jobs faster, correctly, and on time—the first time
- Eliminate subjective guesswork with PASS/FAIL analysis results
- Easily generates certification reports
- Use it anywhere!

FIGURE 4: SmartClass fiber system with integrated power meter and patchcord microscope

Simple Solution

Implementing a simple yet important process of proactively inspecting and cleaning before mating can prevent poor signal performance and equipment damage.

Benefits of Proactive Inspection

1. Reduce Network Downtime
2. Reduce Troubleshooting
3. Optimize Signal Performance
4. Prevent Network Damage

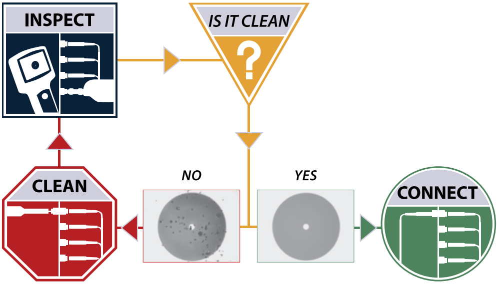


FIGURE 5: Inspect Before You Connect (IBYC) diagram

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Fiber Attenuation Overview

For any optical fibre link we need to know the loss or attenuation of the cable or link to ensure it meets system requirements and is ready to survive network aging or environmental effects. As the light signal transverses the fiber it decreases in power level. The decrease in power in power level is expressed in (dB) or as a rate of loss per unit distance (dB/Km).

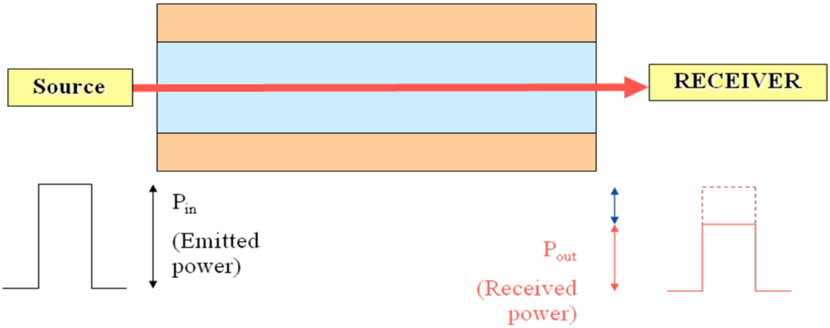


FIGURE 6: Emitted power vs. received power

Attenuation is mainly caused by:

- Absorption of light by impurities within the fiber itself.
- Scattering losses from variations in the silica structure within the fiber.
- Bending losses due to over tightening of clamps or cable ties.
- Contaminated or damaged connectors of the equipment and patch panels.

Attenuation is the most critical parameters to look at in fiber optic networks.

Fiber loss is not a deterministic process that behaves always in the same way. There are many different factors that can produce signal loss in the fiber link, due to either fiber impurities or poor installations.

For a fiber optic span, the effects of passive components and connector losses must be added to the inherent attenuation of the fiber in order to obtain the total signal loss.

During the light transmission, light losses also occur when the light is injected and by the different couplings and junctions made by connectors or splices.

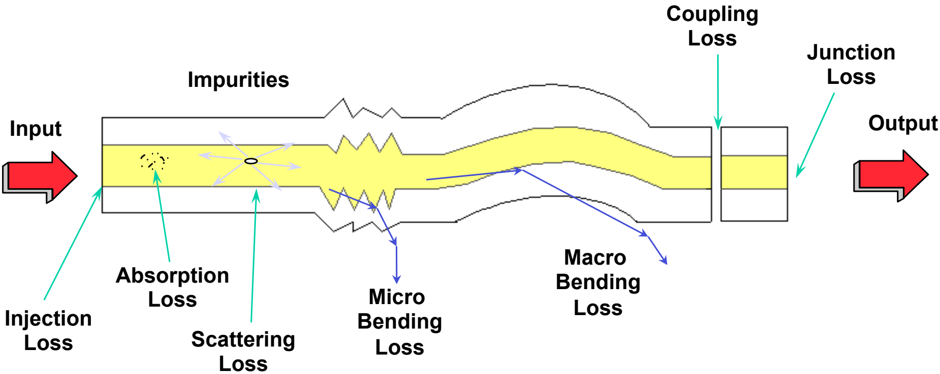
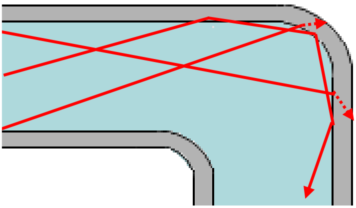


FIGURE 7: Attenuation effects in a typical fiber

Microbending occurs when the fiber core deviates from the axis and can be caused by manufacturing defects, mechanical constraints during the fiber laying process, and environmental variations (temperature, humidly or pressure) during the fiber's lifetime. Typical causes can be freezing water causing external pressure or sharp objects impeding the fiber.

Macrobending is caused by physical bends in the fiber that exceed fiber bend radius limitations (more than a 2mm radius). Typical causes are poor installation or loading of fiber into BBU/RRU enclosures, fiber trays or junction boxes and tampering. Optical signal level attenuation due to macrobending increases with wavelength. For example, a signal travelling at 1550nm will attenuate more than a signal travelling at 1310nm in the presence of a bend.



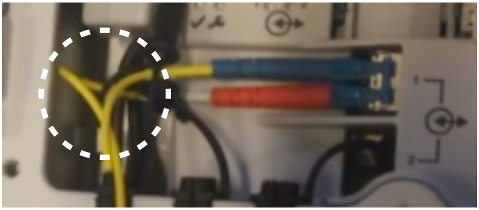
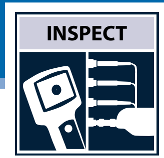
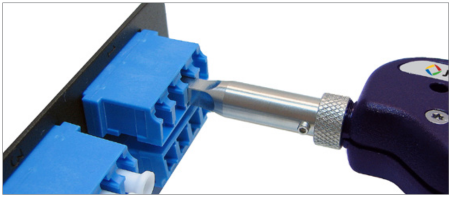


FIGURE 8: Macrobends, typically found in RRU enclosures, junction boxes and fiber trays.

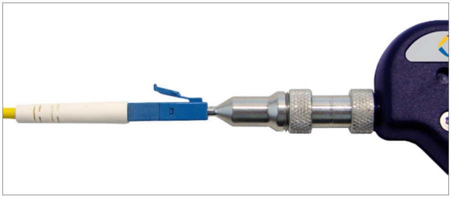


Inspect Bulkhead with Probe



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

Inspect Patch Cord with Probe



1. Select the appropriate ***patch cord inspection tip*** that corresponds to the connector type and install onto 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,** and cleaning is required, **CLEAN.**

Inspect Patch Cord with PCM

The integrated Patch Cord Microscope (PCM) improves workflow by letting users inspect both the bulkhead and patch cord quickly and easily.

1. Select the appropriate ***FMAE patch cord adapter*** that corresponds to the connector type and install onto PCM.
2. Attach the patch cord to the PCM.
3. Press the **HOME** key, then select **INSPECT (PCM).**
4. Determine whether **PASS (clean) or FAIL (dirty).**
   - **If clean, *do not touch it*** and **CONNECT.**
   - **If dirty,** and cleaning is required, **CLEAN.**

Is It Clean?

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 inner-most 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.

Grading Process

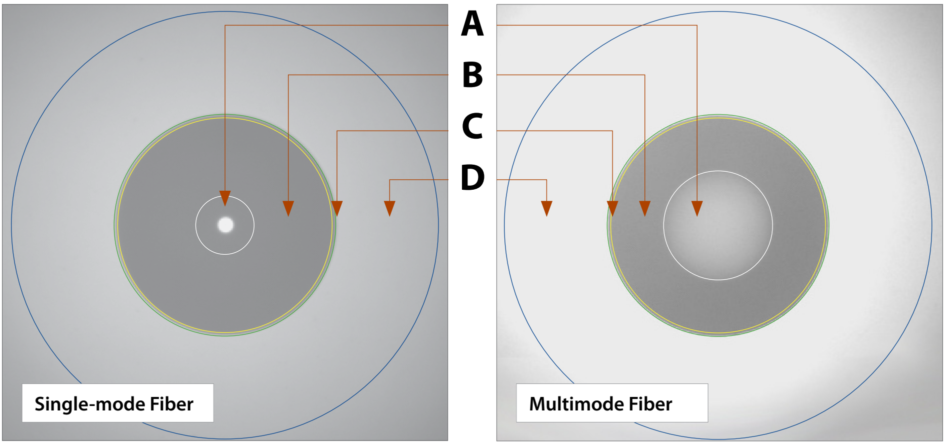
1. Count/measure the particles/contamination that are on the fiber surface.
2. Estimate or use a grading overlay to ***grade*** the fiber by determining the number and size of each particle present in each of the 4 fiber zones.

**__Note:__ 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.**

A. **Core** Zone
B. **Cladding** Zone
C. **Adhesive / Epoxy** Zone*
D. **Contact / Ferrule** Zone

Zones Overlays



Acceptance Criteria

IS IT CLEAN ?

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 ≥ 26dB: (Ref: Table 5)

Zone Name	Diameter	Defects	Scratches
A. CORE Zone	0 – 25 µm	2 ≤ 3 µm none > 3 µm none	2 ≤ 3 µm none > 3 µm none
B. CLADDING Zone	25 –120 µm	no limit < 2 µm 5 from 2 – 5 µm none > 5 µm	no limit ≤ 3 µm none > 3 µm
C. ADHESIVE Zone	120 – 130 µm	no limit	no limit
D. CONTACT Zone	130 – 250 µm	none ≥ 10 µm	no limit

Multimode Connectors: (Ref: Table 6)

Zone Name	Diameter	Defects	Scratches
A. CORE Zone	0 – 65 µm	4 ≤ 5 µm none > 5 µm	no limit ≤ 5 µm 0 > 5 µm
B. CLADDING Zone	65 –120 µm	no limit < 2 µm 5 from 2 – 5 µm none > 5 µm	no limit ≤ 5 µm 0 > 5 µm
C. ADHESIVE Zone	120 – 130 µm	no limit	no limit
D. CONTACT Zone	130 – 250 µm	none ≥ 10 µm	no limit

Clean: Bulkhead

IBC™ Cleaner

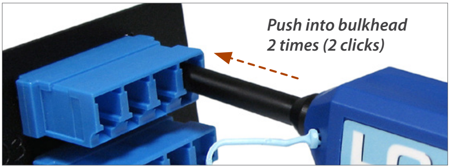
1. Select the appropriate cleaning tool for the connector type.
2. Pull off the ***guide cap***.

Dry Clean

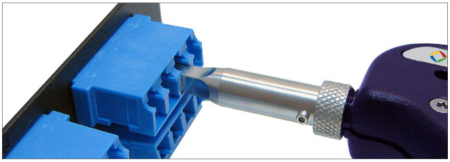
Repeat steps 3, 4, and 5 if necessary.

3. Insert the cleaning tool into the bulkhead adapter and ***push the cleaner into the bulkhead 2 times (2 clicks).***

   Note: *For hard-to-reach places, push the* ***nozzle extender lock*** *and pull the* ***nozzle*** *out.*



4. **Inspect**



5. Determine whether **clean or dirty.**
   - **If clean, *do not touch it*** and **CONNECT.**
   - **If dirty,** either repeat **DRY** cleaning ***or*** go to **WET→DRY** cleaning.

Wet → Dry Clean

6. Apply fiber optic cleaning solution onto a clean fiber wipe.
7. Dab the cleaning tool onto the wet area of the wipe to moisten the cleaning tip, then **go to STEP 3.**

Clean: Patch Cord

IBC™ Cleaner

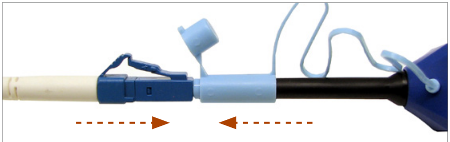
1. Select the appropriate cleaning tool for the connector type.

2. Pull off the ***guide cap cover.***

Dry Clean

Repeat steps 3, 4, and 5 if necessary.

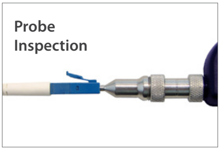
3. Attach the cleaning tool to the connector and ***push the cleaner into the patch cord 2 times (2 clicks).***


Push into patch cord 2 times (2 clicks)

4. **Inspect**

5. Determine whether **clean or dirty.**

- **If clean, *do not touch it*** and **CONNECT.**
- **If dirty,** either repeat **DRY** cleaning ***or*** go to **WET→DRY** cleaning.


Probe Inspection


PCM Inspection

Wet → Dry Clean

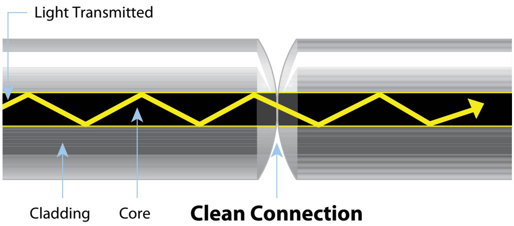
6. Apply fiber optic cleaning solution onto a clean fiber wipe.

7. Wipe the end of the fiber connector on the wet area of the wipe, then **go to STEP 3.**

Good Fiber Connection

There are **3 basic principles** that are critical to achieving an efficient fiber optic connection:

1. **Perfect Core Alignment**
2. **Physical Contact**
3. **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 endface.** As a result, **CONTAMINATION is the #1 reason for troubleshooting optical networks.**

Fiber Connections

Optical connections are made for one of two reasons:

1. **Completing a System Light Path (TX to RX)**

   Connectors are used extensively throughout optical networks. They give us the ability to re-configure the network and provision services. If contamination is present in the light path, system performance will be degraded.

   NOTE: *Always* ***inspect*** *and, if necessary,* ***clean*** *the contamination from the optical port and optical cable before connecting.*

2. **Connecting a Test Device to Part of the System**

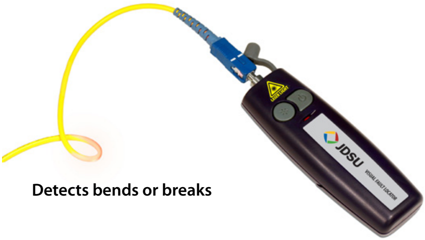
   Test devices are frequently connected and disconnected to elements of the network. Often, test leads are systematically connected to each port in a network element in sequence. This duty cycle makes test leads especially prone to contamination and damage. If a test lead is contaminated, it can quickly spread that contamination through a large portion of the network.

   NOTE: *Always* ***inspect*** *and, if necessary,* ***clean*** *the contamination from the network port and test lead before connecting.*

Test: Fiber Continuity

Visual Fault Locator

A visual fault locator (VFL) can be used to send visual Light which lets technicians easily see bends or breaks in the fiber as the light exits it, this is ideal for continuity checking and also to provide a means for fiber identification at the junction box or RRU to ensure that the RFF fibers are routed correctly.



Detects bends or breaks

Check fiber continuity

FIGURE 9: Visual fault location

Test: Power Measurement

Absolute Power Level Measurement

The absolute power level (system power measurement) is the amount of optical power present in the system, measured in dBm. The source of this power is the transmitter or transceiver sending information through the system. This test determines whether the output power of the transceiver is at the correct levels or at the end of the link to determine if the signal level is within receiver sensitivity range. Test commonly performed at various access points (base station transceiver (BBU), or remote radio unit transceiver (RRU).

NOTE: *This method is more common for network maintenance and troubleshooting.*

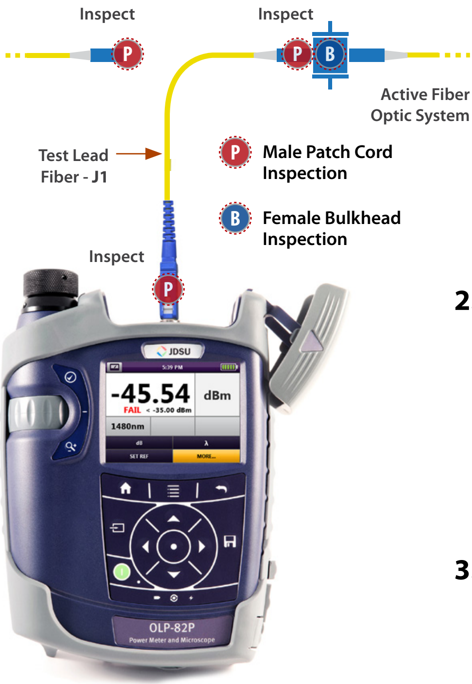


FIGURE 10: Integrated SmartClass Fiber optical power meter (OPM) and Inspection Tool

1. Certify the male patch cord/test lead [J1] endfaces

a. Press the to activate the PCM
b. Inspect patch cord/test lead [J1] end A using the PCM
c. Press the [TEST] button on the PCM
d. Press to save result (if necessary)
e. Move [J1] end A over to the OPM port
f. Inspect patch cord/test lead end B using the PCM
g. Press the [TEST] button on the PCM
h. Press to save result (if necessary)
i. Leave end B in the PCM

2. Certify the female bulkhead connector endface

a. Press the to activate the Probe Microscope
b. Inspect the bulkhead endface using the Probe Microscope
c. Press the [TEST] button on the Probe
d. Press to save result
e. Plug patch cord/test lead [J1] end B into the bulkhead port

3. Measure the optical power

a. Press the to switch to the OPM
b. Select desired wavelength (OPM value will be displayed on the screen)
c. Press to save result
d. Repeat as necessary for other wavelengths

Test: Attenuation Measurement

An insertion loss measurement for fiber acceptance test during onsite build is a non-destructive method and is used to measure the attenuation across a fiber, a passive element or the entire optical link. This is often required where install phases do not have active equipment provision onsite or where cable infrastructure and equipment installs is performed by separate teams. Measure the output from the source fiber and a reference fiber directly. Then obtain a measurement with the fiber under test added to the system. The difference between the two results provides the attenuation of the fiber.

Attenuation Measurement ***(optical link loss)*** on optical components or fiber optic links (e.g., fiber connectors, cable assemblies, and installed fiber optic links) are acquired by measuring the relative power level (dB) at the far end of the link or device under test.

Relative Power Level ***(attenuation measurement)*** is the amount of power lost (attenuated) by the optical link being tested, measured in **dB**. The source of this power is typically a handheld optical light source. This test determines whether the optical link is constructed properly, either as a qualification test or when troubleshooting the fiber cabling.

NOTE: *It is common practice to make a simple insertion loss measurement using an Optical Light Source (OLS) at the BBU and an Optical Power meter OPM at the RRU to check the link loss. However, in order to minimize the operations and tools required at the remote end* ***often times a loop back device is used*** *which allows the loss of the entire channel to be measured. Both methods are described below.*

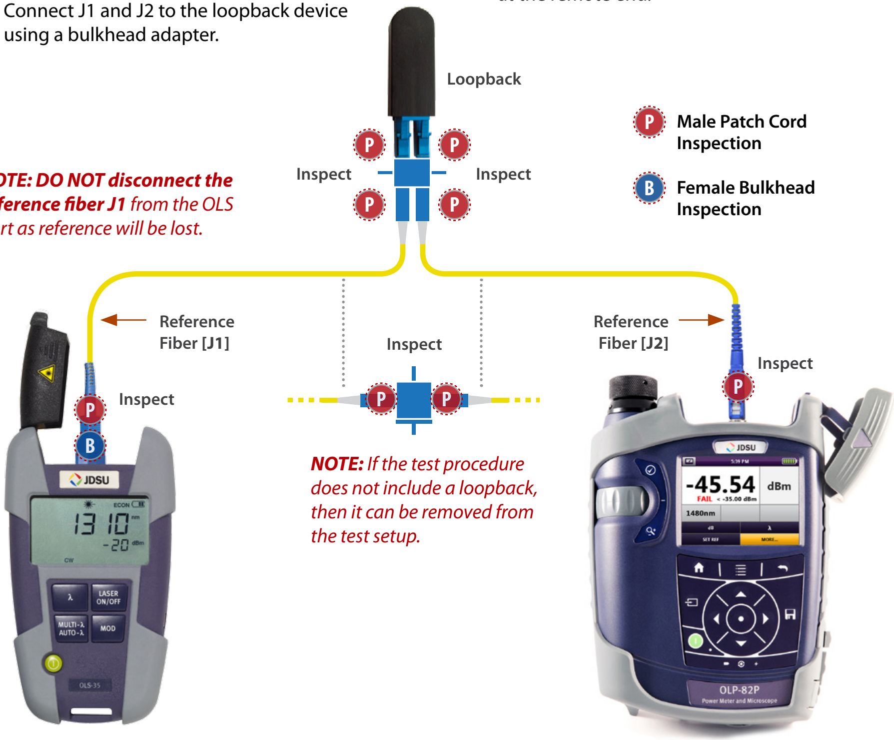
To measure attenuation, you must:

1. **Get a reference measurement**
2. **Get attenuation measurement**

NOTE: *Loss testing of* ***single-mode*** *fiber links is specified in ANSI/TIA/EIA-526-7 and ISO/IEC-TR-14763-3.*
Loss testing of ***multimode*** *fiber links is specified in ANSI/TIA/EIA-526-14A and ISO/IEC-TR-14763-3.*

Reference Power Measurement (Single-Mode)

1. Inspect, and if necessary, clean both ends of reference fiber jumper [J1].
2. Inspect and if necessary clean the OLS Port.
3. Connect J1 to the OLS port.
4. Inspect, and if necessary, clean both ends of reference fiber jumper [J2]
5. Connect J2 to the OPM port.
6. Inspect, and if necessary, clean both ends of the loopback device.
7. Connect J1 and J2 to the loopback device using a bulkhead adapter.
8. Power on the OLS and set wavelength to Auto-lambda (1310–1550nm).
9. Touch [SET REF] on the OLP to reference out power level at 1310 and 1550nm until 0.00 dB is displayed.
10. Set the OLS into Multi-lambda mode for operation.
11. Disconnect the loopback and adaptor for use at the remote end.



***NOTE: DO NOT disconnect the reference fiber J1** from the OLS port as reference will be lost.*

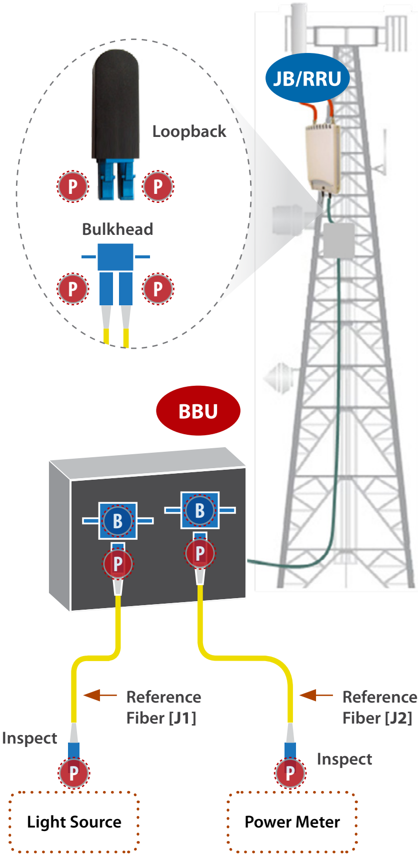
***NOTE:** If the test procedure does not include a loopback, then it can be removed from the test setup.*

FIGURE 11: OLS-35 with jumpers and loopback device and OPM (OLP-82)

Test: Attenuation Measurement

P Male Patch Cord Inspection

B Female Bulkhead Inspection



Remote End (at Junction Box [JB] or RRU)

At the RRU
(tower structure or rooftop)

1. Inspect, and if necessary, clean both ends of the loopback device using the PCM port on the inspection microscope.
2. Inspect, and if necessary, clean the male end of fiber pair under test on the RFF or Jumper cable – Save images for report generation.
3. Connect loopback device on the fiber pair under test using a bulkhead adapter.
4. After attenuation measurement is complete.
5. Inspect, and if necessary clean the female end of fiber pair under test and make connection.

Local End (at BBU)

At the BBU

1. Inspect, and if necessary, clean J1 and J2.
2. Inspect, and if necessary, clean the male end of fiber pair under test – Save images for report generation.
3. Connect J1 and J2 to the fiber pair under test using a bulkhead adaptor.
4. Save channel Loss by clicking SAVE button on OLP at 1310 and 1550nm.
    - The OLS will auto toggle between wavelengths (Twin Test).
5. Inspect and if necessary clean the female end of the fiber pair under test and make connection

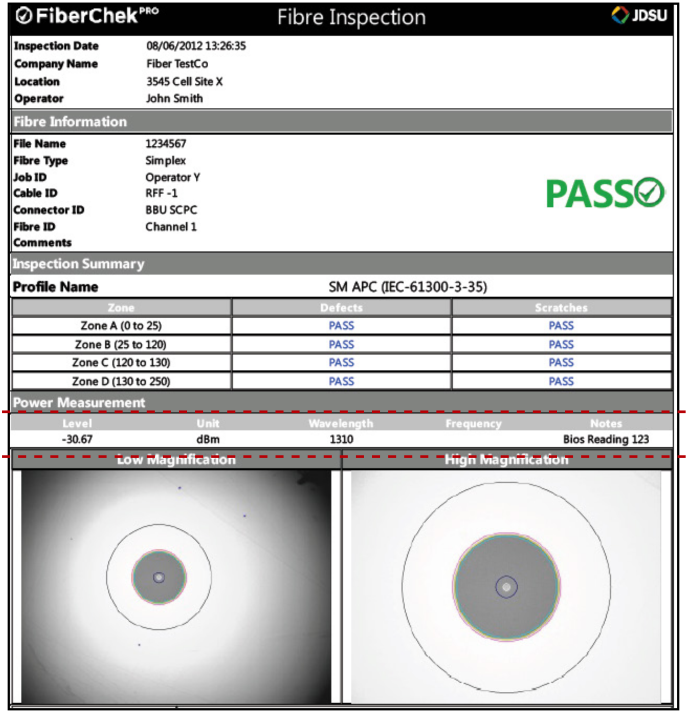
NOTE: *If the test procedure does not include a loopback, then the OLS is connected at the BBU and the OLP is connected to the fiber under test at the JB or RRU to perform a link Loss measurement.*

Report: TIER 1 Certification Report

Qualification testing of the link throughout deployment & maintenance ensure problems are identified and resolved quickly. Proactive testing during key installation phases will help avoid turn-up delays and can significantly reduce the cost of deployment and maintenance.

A certification report provides documented authentic proof (birth certificate) on the quality of installation, ensures that installation meets industry standards and equipment specification requirements and is ready to survive network aging and environmental effects.

A typical TIER 1 certification should include details related to the PASS/FAIL condition in accordance with the IEC standards and details related to the Link or Power Loss.



FiberChek PRO — Fibre Inspection — JDSU

Inspection Date	08/06/2012 13:26:35
Company Name	Fiber TestCo
Location	3545 Cell Site X
Operator	John Smith

Fibre Information

File Name	1234567
Fibre Type	Simplex
Job ID	Operator Y
Cable ID	RFF -1
Connector ID	BBU SCPC
Fibre ID	Channel 1
Comments	

PASS

Inspection Summary

Profile Name: SM APC (IEC-61300-3-35)

Zone	Defects	Scratches
Zone A (0 to 25)	PASS	PASS
Zone B (25 to 120)	PASS	PASS
Zone C (120 to 130)	PASS	PASS
Zone D (130 to 250)	PASS	PASS

Power Measurement

Level	Unit	Wavelength	Frequency	Notes
-30.67	dBm	1310		Bios Reading 123

Low Magnification | High Magnification

FIGURE 12: Certification Report

JDSU Essential Fiber Test Tools

Visual Fault Locator

FFL-050 comes in a compact, ergonomic design for ultimate portability and can be used on 2.5mm or 1.25mm (optional) connector types.

Fiber Probe Microscope

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

SmartPocket™ Optical Light Source

The OLS-3X series is a small and rugged optical light sources for quick, easy and convenient field insertion loss measurement and continuity check at multimode and single-mode wavelengths.

SmartClass™ Fiber Optical Power Meter: OLP-82 / OLP-82P

The JDSU OLP-82 and OLP-82P SmartClass Fiber optical handheld tools integrate automatic PASS/FAIL certification for inspecting fiber and measuring optical power with one rugged hands free portable solution.

SmartPocket™ Optical Power Meter

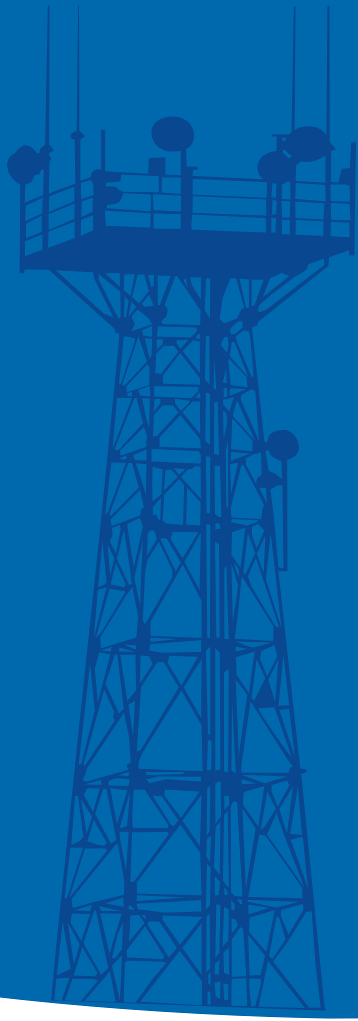
The JDSU OLP-3X Series are small and rugged optical power meters for quick, easy and convenient field measurement of optical power level and loss in multimode and single-mode fiber networks.

USB Optical Power Meter

The MP-60 USB Optical Power Meter (OPM) provides a small-form-factor OPM that can connect to a PC/laptop and other JDSU devices via USB 2.0.

SmartPocket™ Optical Loss Test Kits

The OMK-3X SmartPocket™ Optical Test Kits are pocket-sized and rugged loss test instruments to install and maintain fiber optic networks. It incorporates an optical laser source OLS and optical power meter OLP.



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