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

Vol. 1 — Certifying Next-Generation FTTA
Cabling and Components

JDSU

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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 backhaul network and the end user.

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

Fiber Optic Cell Acceptance Test (FOCAT) Tier 2 Certification

Fiber microbends, macrobends, and dirty connectors are all common problems when installing fiber cable systems because they can induce signal or power loss, permanent damage to cables or components, 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.

This guide addresses FOCAT Tier 1 installation and maintenance testing topics only. Visit **www.jdsu.com/go/GetFiberSmart** for more information about fiber testing.

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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.

❶ BBU
❷ Remote fiber feeder cable or trunk
❸ Junction box or breakout box
❹ Jumper cables
❺ RRU (also termed remote radio head or RRH)
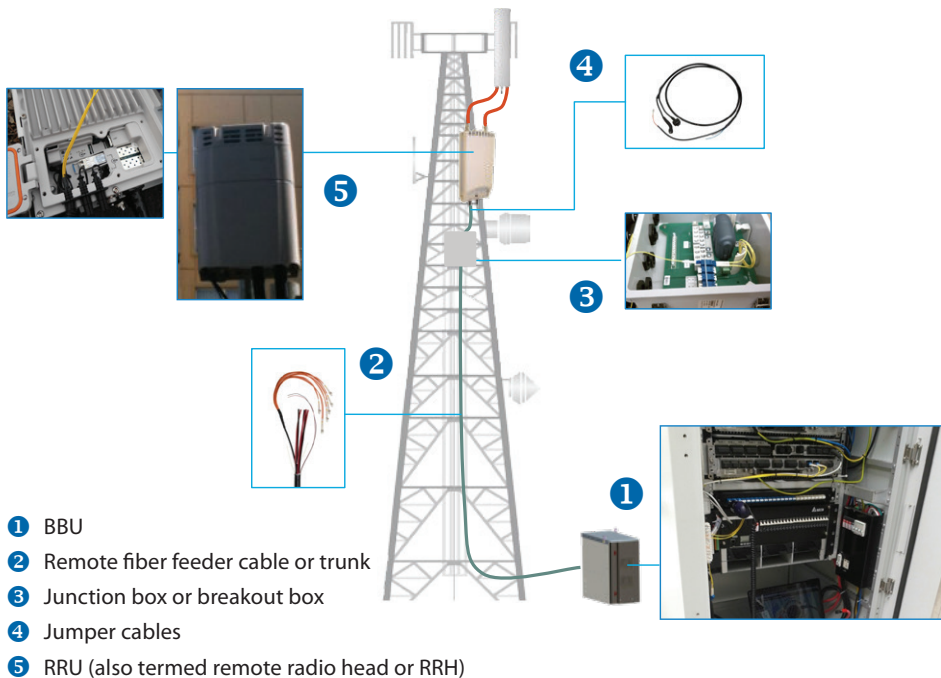
Macrocell tower and network elements

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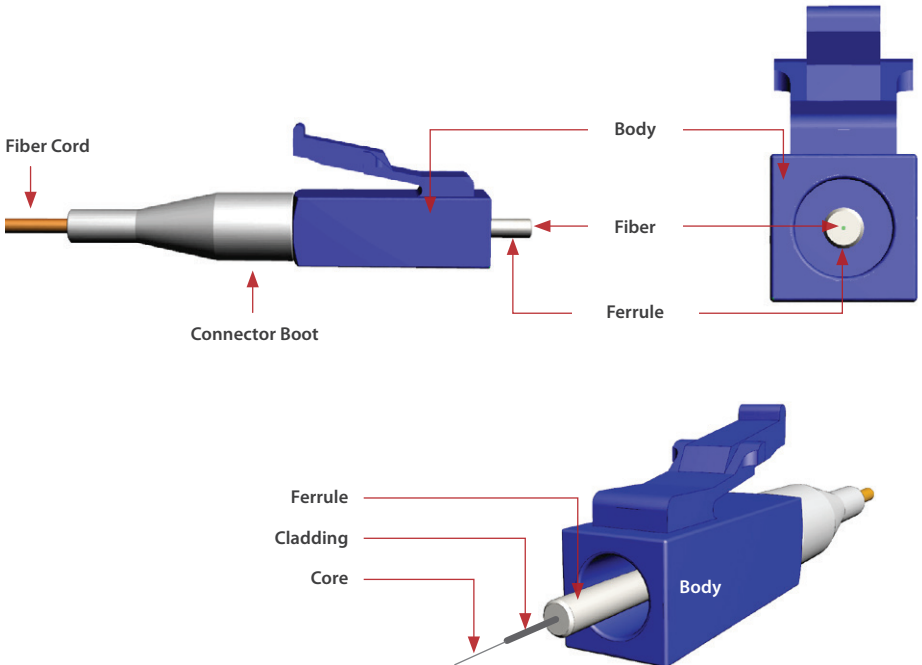
Fiber connectors enable fiber-to-fiber mating by aligning the two optical fibers. Fiber connectors come in various types and have different characteristics for use in different applications. The main components of a fiber connector are detailed in the following figures:

Fiber optic connector components and endface (LCPC example)

Fiber Components

Simplex Fiber
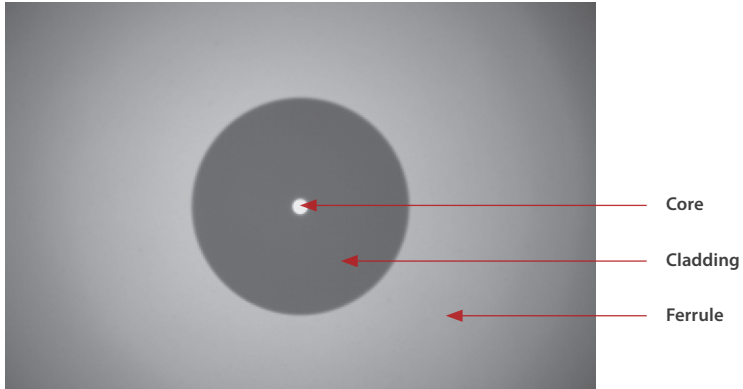
Fiber endface view

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 ferrules 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).

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.

The JDSU SmartClass Fiber family is the next generation of optical handheld test solutions that let technicians inspect, test, certify, and save using a single device. Designed to help users work smarter and faster, SmartClass Fiber solutions incorporate 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 generate certification reports

• Use it anywhere!

SmartClass Fiber system with integrated power meter and patch-cord microscope

Simple Solution

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%.
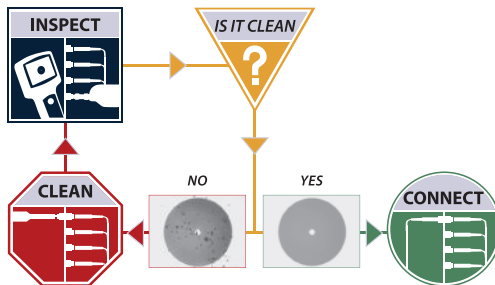
Inspect before you connect diagram

Benefits of Proactive Inspection

• Reduce network downtime

• Reduce troubleshooting

• Optimize signal performance

• Prevent network damage

Fiber Attenuation Overview

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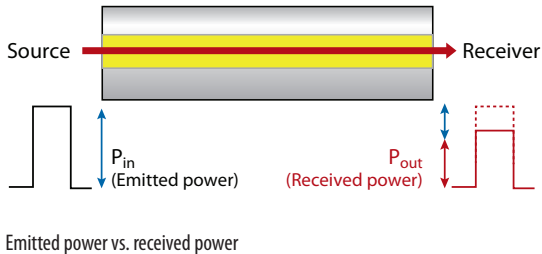rements and is ready to survive network aging and environmental effects. As the light signal traverses a fiber, it decreases in power level. The decrease in power level is expressed in (dB) or as a rate of loss per unit distance (dB/Km).

Source $\rightarrow$ Receiver

P_{in} (Emitted power)

P_{out} (Received power)

Emitted power vs. received power
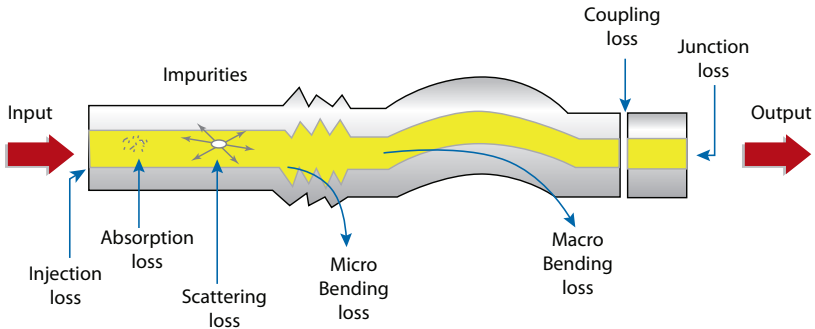
Attenuation is caused by:

- Absorption of light by impurities within the fiber
- 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 parameter to look at in fiber optic networks.

Fiber loss is not a deterministic process that always behaves in the same way. There are many different factors that can produce signal loss in the fiber link, including fiber impurities and poor installations. During transmission, losses also occur when light is injected and by the differentcouplings and junctions made by connectors and splices.

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.

Fiber Attenuation Overview

Attenuation effects in a typical fiber

Microbending occurs when the fiber core deviates from the axis. It 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 include 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 2 mm 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 1550 nm will attenuate more than a signal travelling at 1310 nm in the presence of a bend.
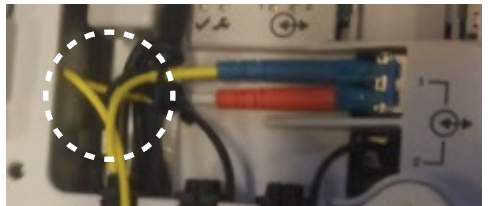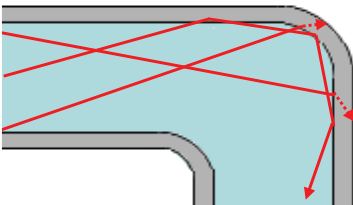

Macrobends, typically found in RRU enclosures, junction boxes, and fiber trays.
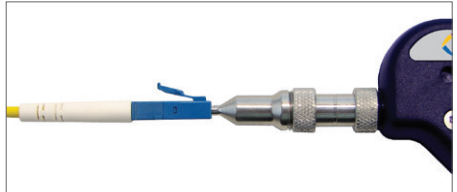
Inspect

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
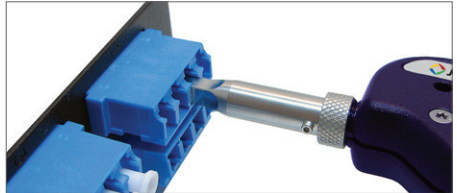
Inspect Patch Cord

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

Inspect Patch Cord with Microscope

An 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 the PCM.

2. Attach the patch cord to the PCM.

3. Determine whether clean or dirty.

   • If clean, do not touch it and CONNECT

   • If dirty, CLEAN

Patch cord adapter

Inspect: Is It 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 contaminations 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

Zone Overlays

A
B
C
D

Single-mode fiber

Multimode fiber

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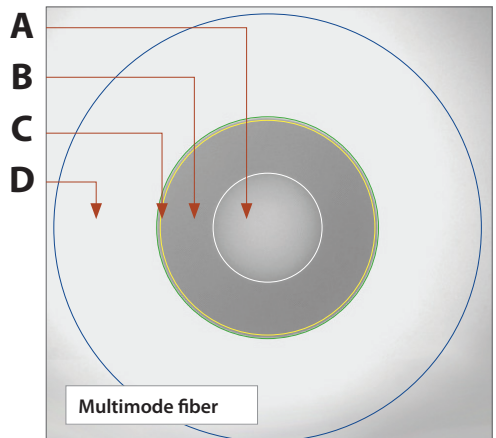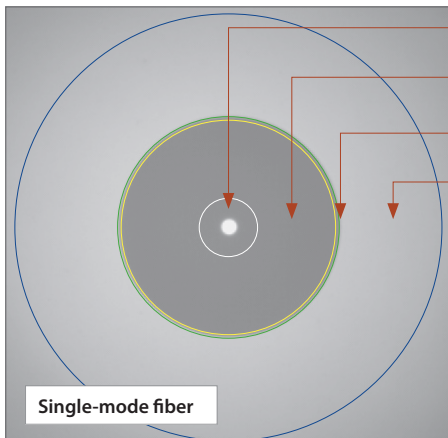
The tables below list the acceptance criteria standardized by the International Electrotechnical Commission (IEC) for single-mode and multimode connectors as documented in *IEC 61300-3-35 Ed. 1.0.*

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

Zone Name	Diameter	Defects	Scratches
A. Core	0 – 25 µm	2 ≤3 µm none >3 µm none	2 ≤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 ≤3 µm none >3 µm
C. Adhesive	120 – 130 µm	no limit	no limit
D. Contact	130 – 250 µm	none ≥10 µm	no limit

Multimode Connectors (Ref: Table 6)

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

Clean

Clean Bulkhead with the IBC™

Guide cap cover

Guide cap   **Nozzle**

Nozzle extender lock

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

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

Guide cap

Dry Clean

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

For hard-to-reach places, push the nozzle extender lock and pull the nozzle out.
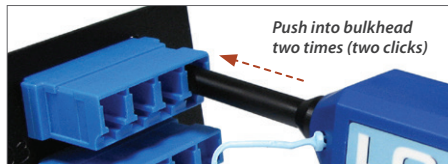
Push into bulkhead two times (two clicks)

Inspect

4. Determine whether clean or dirty.

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

Repeat steps 3, 4, and 5 if neccessary.
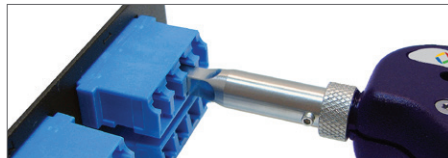
Wet ➜ Dry Clean

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

6. Dab the cleaning tool onto the wet area of the wipe to moisten the cleaning tip, then go to step 3.
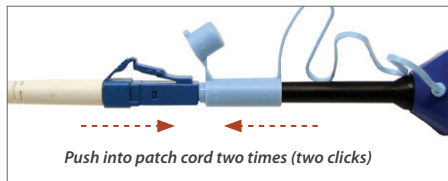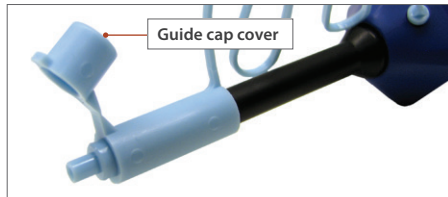
Clean

Clean Patch Cord with the IBC™

Guide cap cover

Guide cap **Nozzle** **Nozzle extender lock**

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

2. Pull off the guide cap cover.

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).

Inspect

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

Push into patch cord two times (two clicks)

Wet ➜ Dry Clean

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

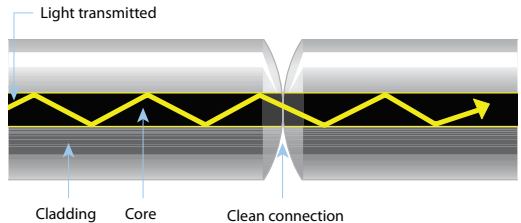**6.** Wipe the end of the fiber connector on the wet area of the wipe, then go to step 3.

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

Light transmitted

Cladding   Core   Clean connection

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

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 JDSU FFL-050 VFL detects bends, breaks, and fiber continuity.

JDSU FFL-050 VFL

Test: Power Measurement

## Absolute Power Level Measurement Using a JDSU Optical Power Meter

The absolute power level (the 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 level or (when tested at the end of the link) to determine if the signal level is within the receiver's sensitivity range. The test is commonly performed at various access points (BBU, RRU).

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

Integrated SmartClass Fiber optical power meter 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

TEST

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 provisioning onsite or where cable infrastructure and equipment installs are 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 (for example, 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 OPM at the RRU to check the link loss. However, in order to minimize the operations and tools required at the remote end, **a loopback device is often used** to enable measuring the loss of the entire channel. Both methods are described below.*

To measure attenuation, you must:

1. **Get a reference measurement.**
2. **Get an 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.*
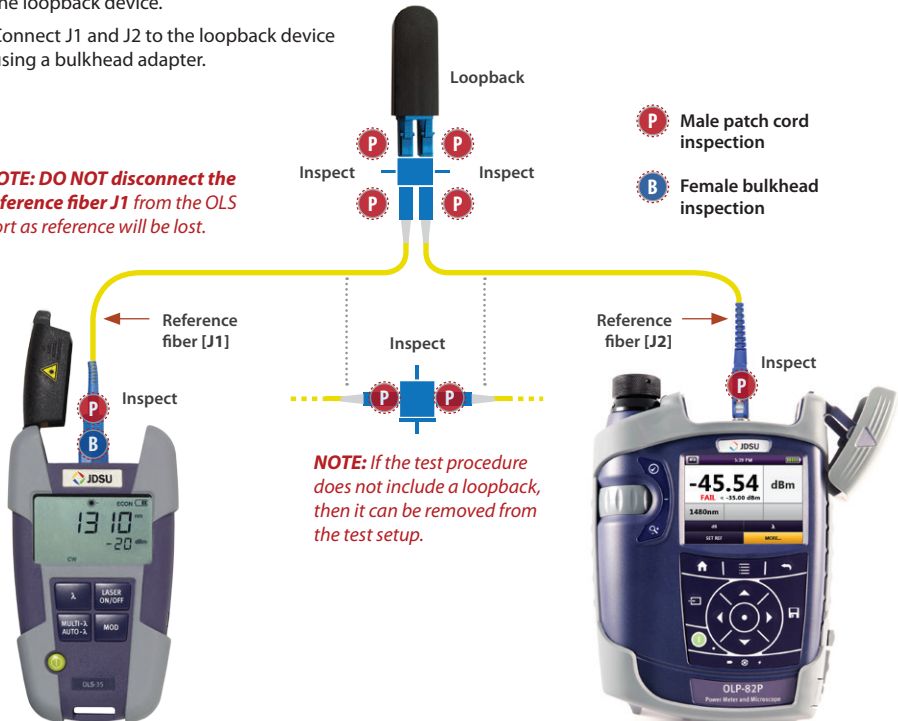
Test: Reference Power Measurement

Reference Power Measurement (single-mode fiber) Using a JDSU Optical Light Source

1. Inspect and, if necessary, clean both ends of the 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 the 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 the wavelength to Auto-lambda (1310 – 1550 nm).

9. Touch [SET REF] on the OLP to reference out the power level at 1310 – 1550 nm until 0.00 dB is displayed.

10. Set the OLS to Multi-lambda mode for operation.

11. Disconnect the loopback and adaptor for use at the remote end.

Loopback

P Male patch cord inspection

B Female bulkhead inspection

Inspect

Inspect

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

Reference fiber [J1]

Inspect

Reference fiber [J2]

Inspect

Inspect

NOTE: If the test procedure does not include a loopback, then it can be removed from the test setup.
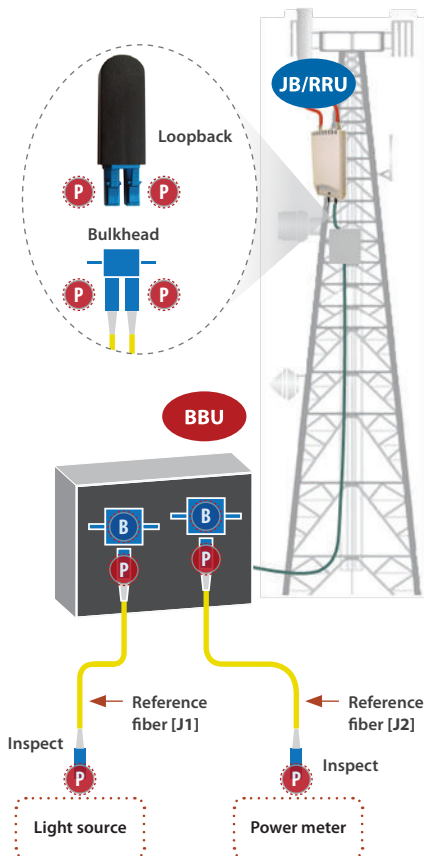
-45.54 dBm
FAIL < -35.00 dBm
1480nm

JDSU OLS-35 with jumpers and loopback device and OPM (OLP-82)

Test: Attenuation Measurement

P Male patch cord inspection

B Female bulkhead inspection

Loopback

Bulkhead

JB/RRU

BBU

Reference fiber [J1]

Reference fiber [J2]

Inspect

Inspect

Light source

Power meter

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.*

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

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.

At the RRU
(tower structure or rooftop)

3. Connect a 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 a connection.

Local End (at BBU)

1. Inspect and, if necessary, clean J1 and J2.

2. Inspect and, if necessary, clean the male end of the fiber pair under test. Save images for report generation.

3. Connect J1 and J2 to the fiber pair under test using a bulkhead adaptor.

At the BBU

4. Save channel loss by clicking the SAVE button on the OLP at 1310 and 1550 nm.

- 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 a connection.

TIER 1 Certification Report

Qualification testing of the link throughout deployment and maintenance ensures 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 IEC standards and details related to link and power loss.

Typical JDSU certification report

Visual Fault Locator

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

Fiber Probe Microscope

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

SmartPocket™ Optical Light Source

OLS-3X Series instruments are small and rugged optical light sources for quick, easy, and convenient field insertion-loss measurement and continuity checking at multimode and single-mode wavelengths.

SmartClass™ Fiber Optical Power Meter

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

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

USB Optical Power Meter

The MP-60 USB 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

An OMK-3X SmartPocket optical test kit is a pocket-sized and rugged loss-test instrument to install and maintain fiber optic networks. It incorporates a laser light source and a power meter.

![JDSU logo]
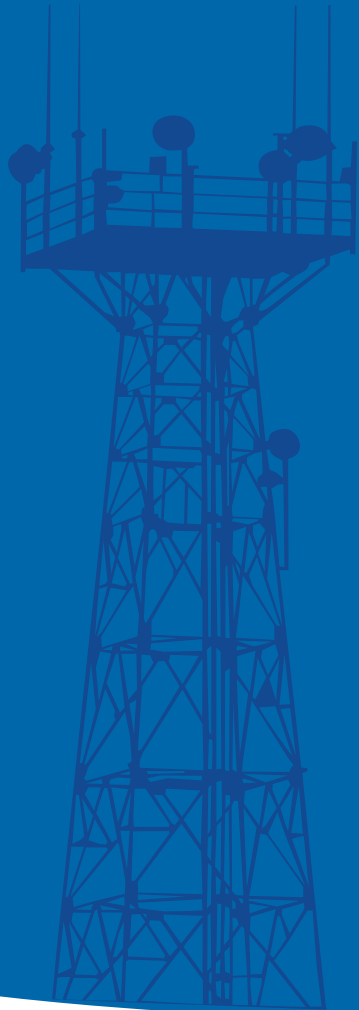
Network and Service Enablement