OTDR/iOLM reference poster

EXFO

The evolution of OTDR testing

An optical time-domain reflectometer (OTDR) is a tool of choice to test and troubleshoot fiber networks. However, the level of complexity involved requires a great amount of knowledge and expert skills to use it efficiently. Thankfully, today's OTDRs offer a variety of automated functions helping the user perform faster, more reliable fiber characterization. This reference poster will help you stay on top of OTDR technology.

More specifically, this poster will help you:
- **Refresh OTDR fundamentals**
- **Understand the main components of an OTDR trace**
- **Demystify key OTDR parameters**
- **Benefit from useful tips**
- **Discover a revolutionary test method: EXFO's iOLM**

OTDR fundamentals

The OTDR couples a laser and a detector, with an internal clock and a pulse generator.

The OTDR sends a pulse of laser light into one side of the optical fiber. The light is reflected back from the fiber, connectors, splices and other components on the link to the OTDR. Each measurement in time is plotted onto a graph depicting power in function of distance.

Since the speed of light in a fiber is known, we can calculate distance given the time. We can thus obtain the total length of the fiber and the location of any events on the link.

Why use an OTDR?

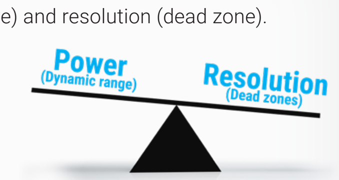
An OTDR is a single-ended test equipment that provides an accurate and complete end-to-end link validation. As opposed to the simple light source and power meter test method, the OTDR can identify and locate any potential faults or breaks that could impact your network performance. No additional tool or test are needed.

The OTDR measures	The OTDR provides
Total loss	Link component characterization
Event loss	Loss, reflectance and attenuation measurements
Optical return loss	Potential fault highlights
Event location	Break locations
Fiber length	

Key test parameters

The OTDR function is a balance between power (dynamic range) and resolution (dead zone).

Three interacting parameters may influence test results:
- **Duration**: allows to increase signal-to-noise ratio (SNR)
- **Distance range**: sets fiber length and repetition rate
- **Pulse width**: determines acquisition power and resolution



How to set up your OTDR

1) Use the file naming and identification features.
2) Use **Automode** to discover the link under test. Based on the results, you may have to manually adjust some test parameters to detect more events.
3) Complete fiber characterization by **using different pulse widths** to find any hidden event undetected by Automode.
   - Use the shortest pulse width to check the **front end** including the first connector of the link.
   - Use larger pulse width to reach **longer distances** and/or to characterize optical splitter (for FTTH/PON).

Common issues	What should you do?
Noisy trace	• Increase averaging time (minimum 45 s) OR • Increase to the next larger pulse width
Events not visible or missing	Event might be located within the OTDR dead zone, try reducing pulse width to heighten resolution and discriminate closely spaced events
No fiber end	• Adjust distance range to link length • Increase pulse width for more dynamic range
OTDR connector fail	• Inspect OTDR port connector and clean if required • Use launch cable to measure the first connector of the link • Ensure OTDR port connector reflectance is < −45 dB

Fiber inspection – The no. 1 step to any OTDR testing

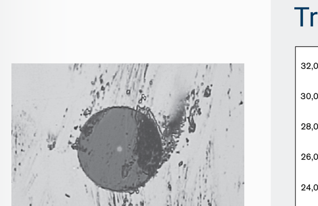
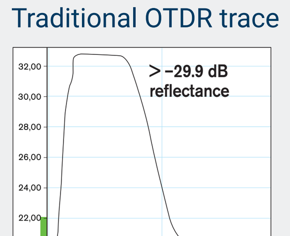
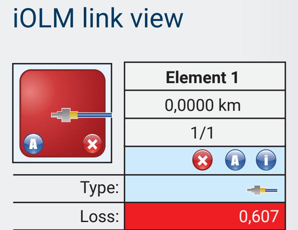
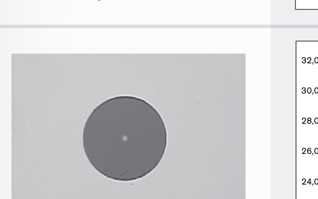
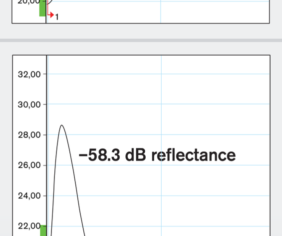
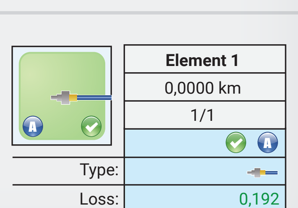
It is well known that bad or dirty connectors in the network are at the root of many problems but did you know that your OTDR/iOLM port is also critical?

Every connector must be inspected and cleaned.

A bad first connector at the OTDR port or launch cable can negatively impact all your test results. It is critical to inspect all connectors manipulated through the test to ensure they are free of any contamination. If dirty, clean properly as per best practices. If damaged, the OTDR must be returned for connector replacement and recalibration.

ConnectorMax fiber inspection scope
FIP-435B

Quick tip
Using a fully automated probe will transform the critical inspection phase into a quick and simple one-step process.

	Traditional OTDR trace	iOLM link view
 **Dirty connector**		
 **Clean connector**		

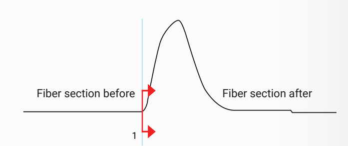
Launch cable

Used together with an OTDR or iOLM, the launch cable (also called a pulse suppressor box, dead zone eliminator or dummy fiber) adds a length of fiber between the OTDR and the network's first connector to cover the OTDR's connector dead zone. This enables loss measurement on the first connection of a fiber under test.

Quick tip
Using a launch cable is good practice. It increases the lifespan of the OTDR connector by reducing the number of matings, thus saving time and money on OTDR connector replacements.

How

The OTDR measures the fiber backscattering level before and after the first connector of the link.



Length

For pulse widths of 100 ns and shorter, the minimum launch cable length recommended is 25 meters. For other pulse widths, use this simplified formula to find the minimum length of the launch cord:

Pulse width in ns divided by 10. Convert to meters. Multiply by 2.

Examples:
- (Pulse width) 1 µs → 1000 ns / 10 → 100 m X 2 = 200 m → Appropriate launch cable length
- (Pulse width) 50 ns → 50 ns / 10 → 5 m X 2 = 10 m → Round up to 25 m, as minimum recommended length

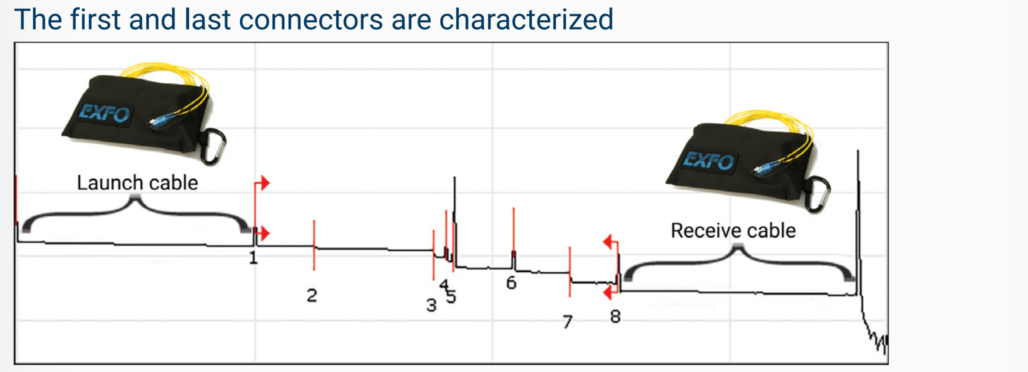
Fiber type

It is recommended to use the same type of fiber for the launch cable as the one under test. If you are testing G657 bend-insensitive fibers with a typical G652 standard fiber launch cable, there will be a gainer on the first connector of the link—potentially compensating for a high loss connector. You would then get a false positive.

Receive cable

A receive cable may be used at the far end for last connector measurements. Combined to first connector loss, this gives complete end-to-end loss (equivalent to the result obtained using a light source and a power meter with one jumper reference). The continuity of the fiber under test can thus be confirmed.

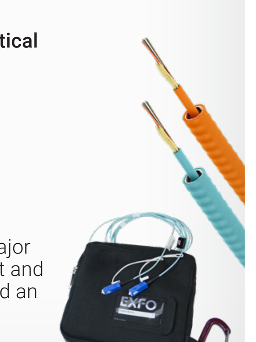
The first and last connectors are characterized



Multimode (MM) testing

Multimode fibers have a larger core (50 µm or 62.5 µm) than singlemode fibers (9 µm). It is **critical** to properly match the same fiber core of the launch cable to the test unit and network fibers.

Multimode fibers types and their usage
- Fiber type C: 50 µm, OM2, OM3, OM4, OM5—used for data centers with high-speed links
- Fiber type D: 62.5 µm, OM1—legacy deployments in LAN/WAN and in-building cabling



Multimode Encircled Flux (EF) launch conditions

For high-speed data networks running under tight loss budget, connector misalignment is a major cause of problems due to quality and tolerance of the connector. Therefore, measuring the first and last connectors of the link is mandatory. Using an external EF conditioner as a launch cable and an appropriate multimode receive cable will provide accurate end-to-end loss results.

For more details, refer to TIA-526-14-B and IEC 61280-4-1 Ed. 2.0.

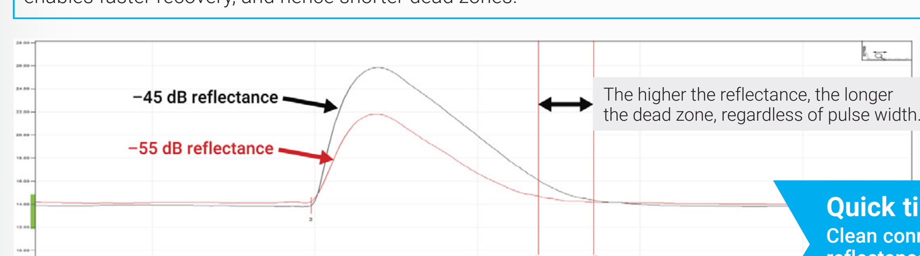
Dead zones

There are two types of dead zones:

1) **Event dead zone**: the minimum distance after a reflective event where an OTDR can **detect** another event.
2) **Attenuation dead zone:** the minimum distance after a reflective event where an OTDR can **accurately measure** the loss of a consecutive event.

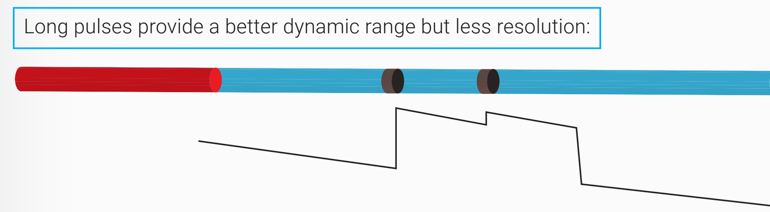
Dead zones are influenced by pulse width, reflectance and OTDR response.

Reflectance: higher reflectance (i.e., −45 dB) will increase dead zones; lower reflectance (i.e., −55 dB) enables faster recovery, and hence shorter dead zones.



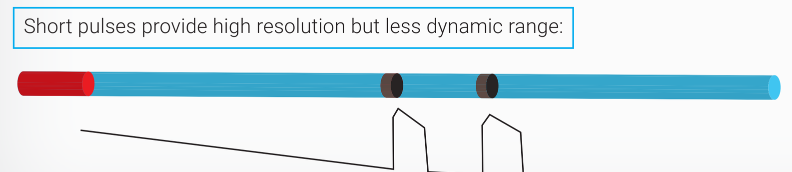
Quick tip
Clean connectors reduce reflectance, which in turn means shorter dead zones.

Long pulses provide a better dynamic range but less resolution:



Merged event: one hidden connector; loss measurement includes two connectors.

Short pulses provide high resolution but less dynamic range:



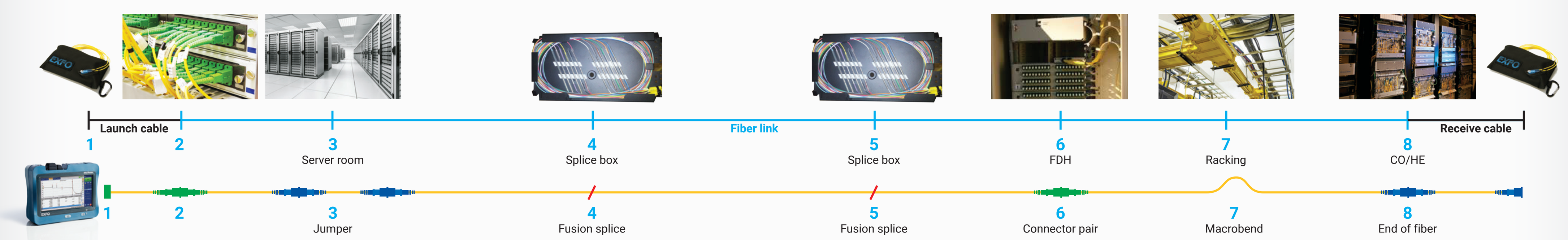
Two distinctive events: individual connector loss is obtained.

THERE'S THE TRADITIONAL OTDR METHOD...

Key components and trace analysis

Fiber link representation

Did you know?
The unit can automatically identify macrobends by comparing the results between two wavelengths. Shorter wavelengths (1310 nm) will show less loss at the macrobend than longer wavelengths (1550 or 1625 nm).



1-2 Launch cable / First network connector
Enables first connector loss measurement.

3 Merged event
Jumper length is shorter than the pulse's attenuation dead zone. When two or more connectors are close, they can be identified but loss will be provided for the group.

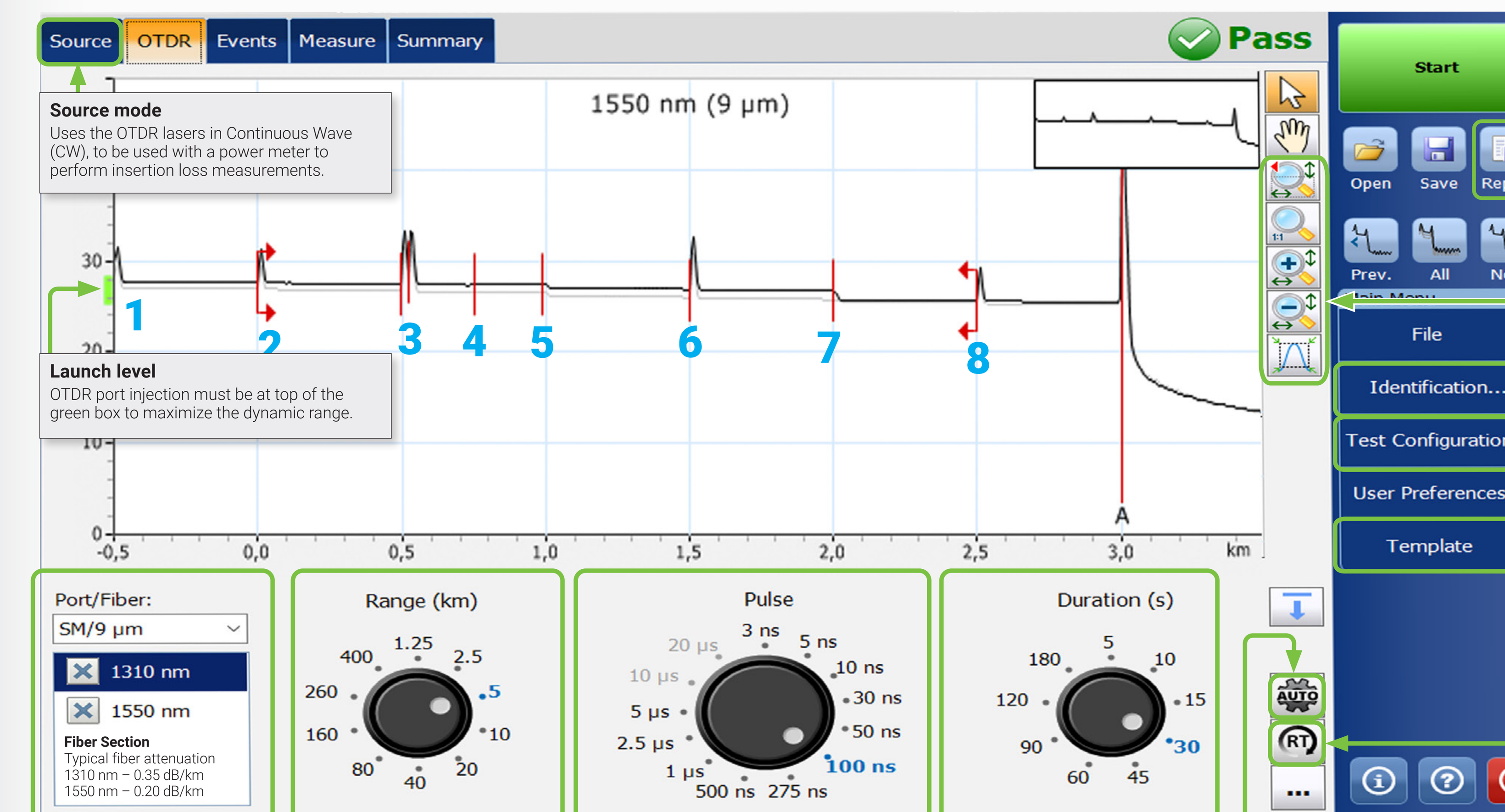
4 Gainer
Occurs when splicing two fibers with different mode field diameter (MFD-specified by the manufacturer). Due to a sudden increase in backscattering level at the splice point, the OTDR sees a **gainer**. Conversely, the OTDR will see an **excess loss** when testing from the other direction. Bidirectional measurements is the only way to provide true splice loss.
For instance:
G652D (larger MFD) → G657A (smaller MFD) = gainer
G657A (smaller MFD) → G652D (larger MFD) = excess loss

5 Fusion splice
Non-reflective event as the two fibers are fused together removing any air gap in between. It typically has low loss.

6 Connector pair
Reflective event as the two fibers are physically mated together, creating a small reflective air gap.
Typical reflectance:
UPC: −45 to −55 dB
APC: −55 to −65 dB

7 Macrobend
Physical bend or kink in the fiber or cable. Requires a dual-wavelength test to identify it.
Displays higher loss at 1550 nm (than at 1310 nm).

8 Receive cable /Network end connector
Highly reflective if connectors are not terminated:
UPC: approx. −14.7 dB
APC: approx. −45 to 60 dB



Source mode
Uses the OTDR lasers in Continuous Wave (CW), to be used with a power meter to perform insertion loss measurements.

Launch level
OTDR port injection must be at top of the green box to maximize the dynamic range.

Key features

Report
Automatically generates clear OTDR reports in PDF or XML format.

Zoom tools
Zoom and center to facilitate the analysis of your fibers. Draw a window around the area of interest and center in the screen quicker.

Identification
Properly document test files (i.e., fiber ID, color, cable ID, operator, location, etc.) before starting to test to facilitate classification and analysis of the files with business-intelligent applications.

Test configuration
Define link characteristics, test parameters and thresholds for pass/fail analysis.

Template
Define a reference trace and measurements on subsequent acquisitions will be systematically taken at the locations of all markers from reference trace. Recommended for cable commissioning.

Real-time mode
Activates OTDR laser in continuous shooting with selected parameters. The OTDR trace is constantly refreshed enabling fiber monitoring for a sudden change or for a quick look at the fiber under test.
This mode should not replace complete acquisition due to its lower dynamic range and absence of trace analysis.

Test wavelengths
Use two or more wavelengths to find macrobends.

Distance range
Adjust the range to your link length (adding 10-15% for optimal test results).

Pulse width
- Short pulse (3 ns) → high resolution, short dead zones, lower dynamic range
- Long pulse (20 µs) → Lower resolution, long dead zones, high dynamic range

Duration
Quick five-second acquisition can be used to find fiber breaks.
For more accurate results, durations of 30-45 seconds are recommended.

Automode
Automatically sets the distance range, duration and best compromised pulse width for the link under test. Recommended for discovering the link under test or fiber breaks.

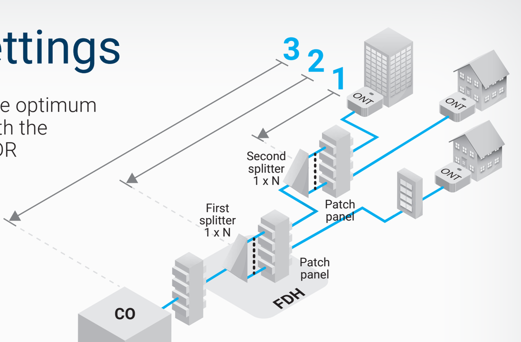
Key test parameters

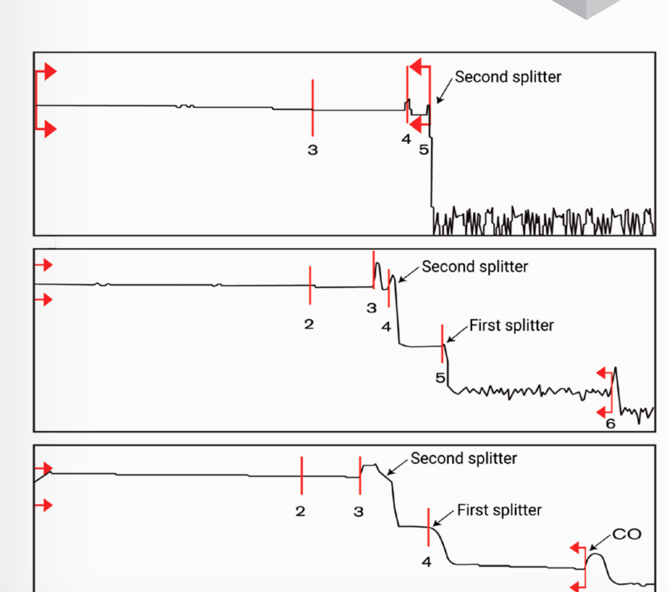
Did you know?
You can change test parameters on the fly at any time during the current acquisition. Adjust the parameters and the unit will automatically start a new acquisition.

There are no ideal settings

When testing with an OTDR, it is key to determine optimum parameters providing enough dynamic range with the highest resolution possible. To compensate OTDR technology limitations, **more than one OTDR trace** is often required to find all the events on the link.

Using different **pulse widths** and **multiple wavelengths** overcomes this limitation.





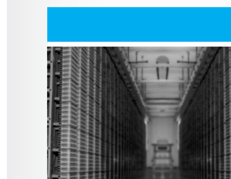
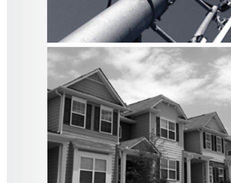
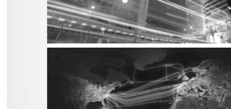
1- SHORT PULSE
To measure the front-end of your link: high resolution, not enough dynamic range to measure through the splitter.

2- MEDIUM PULSE
To measure high loss splitters: best compromise between resolution and dynamic range.

3- LONG PULSE
To reach the fiber end and get an accurate end-to-end loss measurement: high dynamic range, lower resolution.

Choose the right OTDR

Each fiber optic application has its specific testing requirements. The right OTDR must be used for the right purpose. OTDRs can be manufactured to provide more resolution, more power, dedicated wavelengths or any other specific aspect to optimize your test results.

	Applications	Test equipment requirements
	LAN/WAN DATA CENTERS ENTERPRISE/PRIVATE NETWORKS POINT-TO-POINT (P2P) ACCESS	• Short dead zones to locate closely spaced events • Multimode and singlemode testing in a single unit • Encircled Flux (EF) multimode launch conditions for maximum loss measurement accuracy • Single-button certification with clear "go/no-go" status • On-board pass/fail thresholds compliant with the latest international standards (including TIA-568, ISO11801) for data center certification
	FTTA REMOTE RADIO HEAD (RRH) DAS/SMALL CELLS CELL BACKHAUL CATV	• Dynamic range optimized for troubleshooting performance and accuracy on short links • Automated bidirectional testing feature to certify Rx/Tx cable in one go
	FTTx LAST-MILE FTTx/PON FTTH/MDU PASSIVE OPTICAL LAN (POL) SHORT METRO	• Dynamic range and resolution optimized at intermediate pulse widths for accurate 1x128 splitter detection and measurement • In-service testing with filtered 1625 or 1650 nm wavelength • Unique in-line power meter allowing checking the optical power at 1490/1550 nm before troubleshooting with the OTDR. This on a single port with no disconnection between both measurement to ensure a smooth workflow • 39 dB dynamic range to characterize any P2P networks from access to short metro links
	METRO/CORE CWDM LONGHAUL DWDM	• Dynamic range above 40 dB to test metro/core or longhaul links • High resolution at shortest pulse widths to account for many closely spaced splice points • Specific ITU-grid CWDM wavelengths to test through add/drop or MUX/DEMUX
	ULTRA-LONGHAUL SUBMARINE CABLES	• Test reach of up to 250 km • Highest dynamic range possible (up to 50.5 dB) for deploying and maintaining long fiber spans typically seen in ultra-longhaul and high-speed networks

...AND THEN THERE'S THE iOLM

intelligent Optical Link Mapper (iOLM)

OTDR challenges

WRONG OTDR TRACES
COUNTLESS TRACES TO ANALYZE
REPEATING THE SAME JOB TWICE
COMPLEX INSTRUMENT TRAINING/SUPPORT

A better way to test fiber optics

iOLM

iOLM is an OTDR-based application designed to simplify OTDR testing by eliminating the need to analyze and interpret multiple complex OTDR traces. Its advanced algorithms dynamically define the testing parameters, as well as the number of acquisitions that best fit the network under test. By correlating multipulse widths on multiple wavelengths, iOLM locates and identifies faults with maximum resolution—all at the push of a single button.

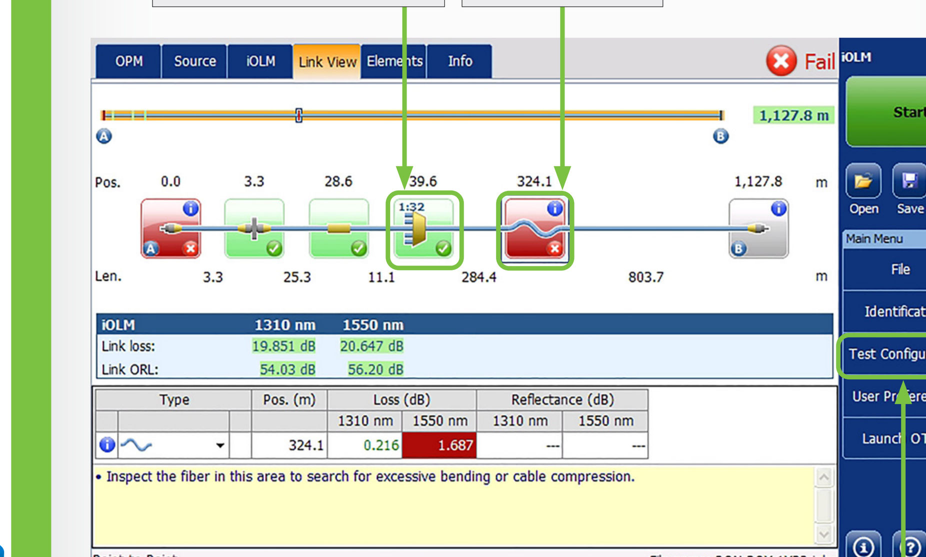
How it works?

Dynamic multipulse acquisition	Intelligent trace analysis	Combine all results in a single link view	Comprehensive diagnosis
iOLM adjusts test parameters dynamically for ANY link under test—using a mix of short, medium and long pulses as needed.	Based on the multiple acquisitions and with the help of advanced algorithms, iOLM is able to detect more events with maximum resolution.	Results are visually displayed in an icon-based fiber-link view to quickly assess each event's pass/fail status per standard selected, eliminating any risk of misinterpretation.	Delivers an analysis of failed events and suggests solutions, guiding the technicians in fixing the fault quickly and successfully.

Turning traditional OTDR testing into clear, automatized, first-time-right results for any technician.

Automatic splitter ratio recognition for FTTH/PON testing.

Automatic macrobend identification.



Did you know?
iOLM can generate an OTDR trace in universal Bellcore format (.sor) for use with any OTDR viewer.

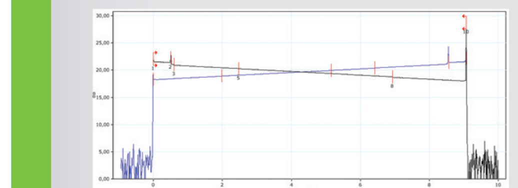
Test configuration
Create and share with your peers as many test configurations as needed for every specific job or network type. Test configurations define the pass/fail criteria, and the network type (i.e., P2P or with PON splitters).

iOLM testing methodologies

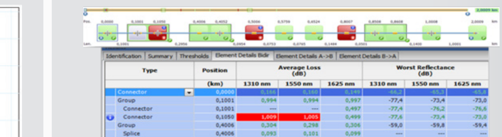
Bidirectional testing

Bidirectional averaging testing is used for accurate splice loss measurement and is recommended in any type of application with singlemode, P2P fiber links.

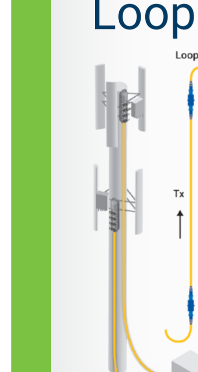
Traditional bidirectional OTDR view
Single OTDR pulse with A to B and B to A directions



Single iOLM bidirectional view
Combining multipulses, multiwavelengths and multidirections



Loopback testing (iOLM)



Loopback testing
- Loops two fibers together at one end to test both fibers at once
- Software application will distinguish between the fibers in the reporting
- Particularly efficient in short- to medium-range fiber deployments
- Allows to test both upstream and downstream links with a single port—ideal for FTTA or DAS applications

Key benefits of using loopback testing
- 50% less testing time
- Single-ended test: less test equipment is required
- Performing loopback testing with two technicians requires minimal expertise from the second technician
- Distinct results for each fiber tested in loop (both OTDR and iOLM)
- Intuitive link view (iOLM) or traditional graphical view (OTDR) to identify loop section easily