The Rise of Tier 2 Testing

Why enterprises today demand better visibility into their fiber infrastructure

Unprecedented demand for more bandwidth, faster network speeds, lower latency, and improved data reliability and security all contribute to the increasing need for better network visibility.

Industry standards have been established to ensure performance, consistency, and interoperability between network equipment vendors. However, the consistent implementation and operation of these standards become even more critical as speeds and bandwidth increase.

At the fiber infrastructure level, this also means more testing may be needed beyond the basic fiber end-face inspection certification and Tier 1 testing.

This white paper explores Tier 2 optical time domain reflectometer (OTDR) testing and examines its relationship to Tier 1 testing and how inspection plays into both. This paper defines Tier 2 testing and explains when it is needed. It also addresses the OTDR complexity argument.

"To address network issues, often Tier 1 testing does not provide the level of visibility required to fully assess the condition of the link. This is where Tier 2 testing comes in."

Tier 1 vs. Tier 2 Testing

It is important to understand that level Tier 2 testing does not replace Tier 1. It is performed selectively *in addition* to Tier 1 testing under specific conditions and situations. Tier 2 testing provides a deeper level of link visibility unlike any other fiber infrastructure tests.

In this document, we discuss when and how Tier 2 testing occurs within campus backbones, intrabuilding runs and interconnects in equipment rooms and data centers. Like Tier 1, Tier 2 testing applies to both multimode and single-mode fiber links.

Note: You can find more detailed information about Tier 1 testing in the 2015 Viavi white paper, "*Four Factors in Accurate Fiber Certification*."

Enterprise Testing	
Connector Inspection, Cleaning & Certification	
Tier 1	**Tier 2 OTDR**
Length	Visual Link View
Polarity	Event: Location
Link Loss	Loss Reflectance

What can go wrong with a fiber link?

Three fundamental problems can occur with an Enterprise fiber link:

Polarity or Continuity Issues

A fundamental problem with newly installed fiber links is incorrect polarity or lack of fiber continuity, meaning the light did not end up where it was supposed to be and was directed toward the wrong location. This can occur if ports are mislabeled or fibers are connected to incorrect ports. Incorrect polarity can simply mean the A and B sides of a duplex connector or fibers in a multifiber connector are incorrectly aligned and effectively plugged in backwards.

Excess Link Loss

An operating link will fail or a new link will not turn up when link loss exceeds the maximum decibel limit in which the system can operate. More specifically, this loss limit is defined by the difference between the network equipment transmitter minimum output power and the minimum decibel sensitivity level on the receive end. Contributors to link loss include fiber attenuation and loss through mated connectors or splices. Contaminated, damaged, or poorly mated connectors are by far the most common sources for excess link loss. Stress on the fiber by over-bending, pinching, or kinking is also a frequent source of problems. This is commonly referred to as macro- or micro-bending.

Poor ORL Performance

While too much link loss in the forward direction is a problem, some of the light that is lost actually reflects back toward the transmitter. Too much of this reflected energy can also create problems. Optical return loss (ORL) is the ratio of reflected light to the transmitted optical signal over the entire link. While ORL is usually not an issue in sub-10 Gbps or lower power links, it can cause significant issues in higher speeds (10 Gbps and up) and higher power networks. Exceeding ORL limits can cause data errors, increase system noise, and can sometimes damage transmitters in higher-power environments.

To address enterprise network issues, often Tier 1 testing does not provide the visibility required to fully assess the link's condition, thus requiring Tier 2 testing.

Table 1. Common causes of network issues

Problem Category	Unit of Measure	Most Common Causes	Underlying Causes
Optical Polarity or Port Continuity	Yes/No	Incorrect port connected on one end	Wrong placement or incorrect documentation
		Duplex cord reversed	Wrong cord configuration used
		MPO/MTP connector reversed	Wrong cord configuration used
Excess Link Loss	dB	Contaminated or damaged connector end-faces	Inspection and cleaning procedures not being followed
		Physical stress on fiber by over-bending (macro-bend)	Poor fiber management in cabinets, patch panels, splice trays/closures, slack loops, routing
		Physical stress on fiber by pinching or compression pressure on fiber (micro-bend)	Patch cords pinched in hinge or cabinet door, or any other compresssion source
		Bad splices	Poor splicing or mismatched fibers
		Link length exceeding maximum design limits	Link designed to push beyond standards limits
		Transmitter or Receiver actual performance not matching design specifications	Wrong vendor or model number; vendor advertised performance exceeds actual
		Wrong fiber type used	Mixed fiber types: 62.5 µm and 50 µm; multimode and single-mode
Poor ORL Performance	dB	Contaminated or damaged connector end-faces	Inspection and cleaning procedures not being followed
		Connector ORL performance below standards	Substandard factory patch cords, or poorly built field installed connectors
		Wrong connector type used (UPC vs. APC)	APC connectors must be used in high power applications
		Connector pair not properly mated	Not fully connected or key misaligned (FC)
		Bad or old mechanical splices	Old or temporary splice

What is a Tier 2 test?

While Tier 1 (polarity, length, and overall loss) tests can identify problems in terms of pass or fail, they cannot determine the root cause or location of the problem. Tier 2 testing is used to pinpoint root-cause locations and the amount of loss, ORL, or reflectance from each problem contributor. The OTDR is used to perform Tier 2 testing.

What is an OTDR and how does it work?

The OTDR provides the unique ability to visually see and map the link and any passive events over its length. The OTDR sends an optical test pulse over the fiber. Similar to radar, a small amount of this energy is scattered, or reflected, some of which returns to a detector in the OTDR. This reflected energy is mapped based on its round-trip travel time converted to distance (based on the speed of light in optical glass). Because the scattered/reflected signal is so weak, thousands of pulses are sent and averaged to obtain a valid trace.

As shown in Figure 1, the OTDR displays a dynamic map of the link as a line sloping downward from left to right. Each fiber section is separated by events (connectors, splices, and impairments) along the fiber. Each event is shown at its respective location and represents the energy signature that it contributes. For instance, a connector pair will show up as a large bump due to its high reflective property, but it will also show a drop in signal, or loss. A fusion splice or bend does not reflect and will show only the signal drop, indicating the localized loss value. The X (vertical) axis shows changes in attenuation (loss) and the Y (horizontal) axis shows distance.

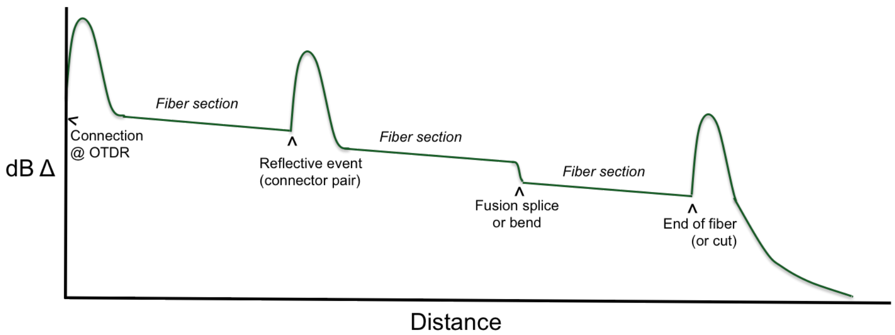


Figure 1. Definitions of events on OTDR trace

In Figure 2, the same trace is shown in the context of what is measured. The blue lines show how distance to each event is measured, including the fiber end. Each fiber section (gray) can be measured to check the fiber attenuation against the specification (highlighted areas with dB/km). The red dashed lines show how each event is measured for loss. The event loss is the vertical difference between the trace level before and after the event. The dark green lines show how the height and width of a reflection are factors in measuring reflectance.

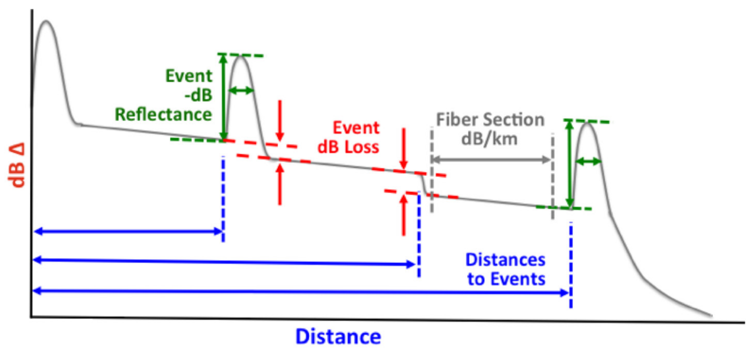


Figure 2. OTDR trace measurements

Reflectance is similar to ORL, but while ORL is the reflective energy impact of the entire link, reflectance is the ratio of the reflected energy contribution from each reflective event. In fact, the OTDR measures both reflectance and ORL. Because it can measure so many different aspects of the link, the OTDR is often referred to as a multitool for fiber networks.

What's so scary about OTDR testing?

OTDRs have a reputation of being complicated and intimidating for network technicians. Learning to read a trace might look easy to more experienced users, but it can be complex, especially when various factors cause confusing results. Setting up OTDRs to test accurately also requires knowledge and experience. Knowing what you are testing and translating that knowledge to the right test setup can take years to master. Figure 3 shows a traditional OTDR trace and results table.

Figure 3. Actual OTDR trace display

New Advances Simplify OTDR Testing

The good news is that much effort has gone into the OTDR user interface design making the tool much easier to use. Technicians can operate many modern OTDRs easily with very little training because of new software enhancements.

Preconfigured Instrument Setups

The OTDR must be set up for each job category, but the technician does not necessarily have to be the one setting it up. Operations managers or network engineers often know the links better than anyone. They not only need accurate test results but, ideally, consistent test setup conditions between technicians. Today an experienced user can set up an OTDR in advance to define optimum settings, file naming standards, pass/fail thresholds, and other settings for a particular job category. These test setups can be stored as unique configuration files. Each technician then simply selects the test category (multimode or single-mode), the application (Enterprise), and loads the specified configuration file from the onboard memory. Once loaded, the technician can just press Start and wait for the results (typically 20 to 30 seconds per wavelength).

Easier-to-Read Schematic Test Results

Once the test is complete, users can view a schematic of the link rather than viewing a traditional OTDR trace. The schematic-based results provide direct information regarding each event in the link with distance and pass/fail statuses for each.

Better Documentation

Many of today's OTDRs offer built-in reporting features that can improve documentation of the network. PDF reports can be generated and stored quickly and easily. Figure 4 shows the correlation between the network elements, fiber elements, and the Tier 2 test setup.

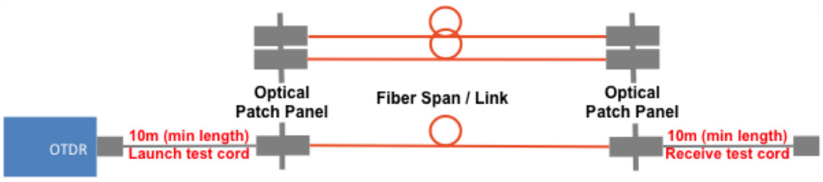


Figure 4. Setting up the OTDR to perform a test

Inspection Tip

Always start by inspecting and cleaning the connector end. If the inspection shows contamination, clean the end face and re-inspect. Only connect when both end faces are clean, including the OTDR port!

Step-by-Step Tier 2 Testing

Before beginning the procedure, it is important to first visualize how you plan to test the link. Below are a few best practices on how to set up and test using an OTDR equipped with a schematic-based results view.

1. **Use launch and receive test cords**

   Use a launch cord of at least 10 meters in length between the OTDR and the link access port or connector. The length of the launch cord allows the first connector interface of the fiber link to be evaluated. A receive test cord is also recommended on the far end for the same reason. You cannot evaluate the first and last connector pairs if you cannot see the fiber slopes on both sides of each connector pair.

2. **Inspect and clean OTDR port**

   Before a test can be performed, proper fiber handling procedures are critical for an accurate test that represents the actual network view, and to ensure no contamination is present when end faces are mated. To avoid damaging your OTDR and to ensure a quality launch into the link, it is especially important to inspect the OTDR interface. Use the bulkhead inspection tip for the particular connector type that is installed on the OTDR. Inspect and, if needed, clean and re-inspect the port before attaching the launch cord.

3. **Inspect and clean all launch cord end faces and link access ports**

   Using an appropriate inspection tip on the inspection probe, inspect and clean/re-inspect (if needed) both connectors on the launch cord. Start with the end of the cord that will be plugged into the OTDR. Once it is clean, connect it to the OTDR. Repeat this process with each connector and patch panel interface or link access connector. Repeat at the far end to attach the receive test cord.

Time Saver Tip

When inspecting connectors and bulkheads, attach a connector interface sleeve to the connector being inspected to inspect both connectors and bulkheads without changing tips.

4. **Load OTDR settings for test configuration**

   From the schematic OTDR application, recall the configuration file that is specific to your particular test, as shown in Figure 5. Once loaded you are ready to test.

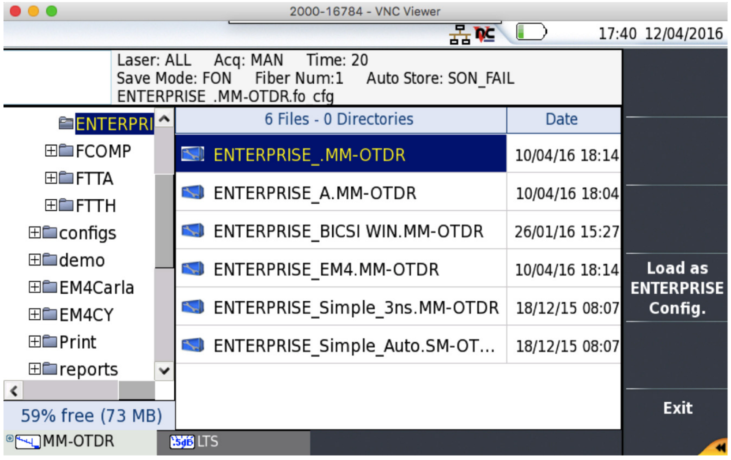


Figure 5. Stored configuration files

5. **Start test and review results for any problems**

Start your test and wait for the OTDR to show the schematic-based test results. Results are provided with clear information about any issues on the link. Following are some examples.

Figure 6 is an example of a screen view that provides an overview of the link. It includes some overall loss, ORL and length info. If the link passed the test this screen displays a green checkmark (upper right).

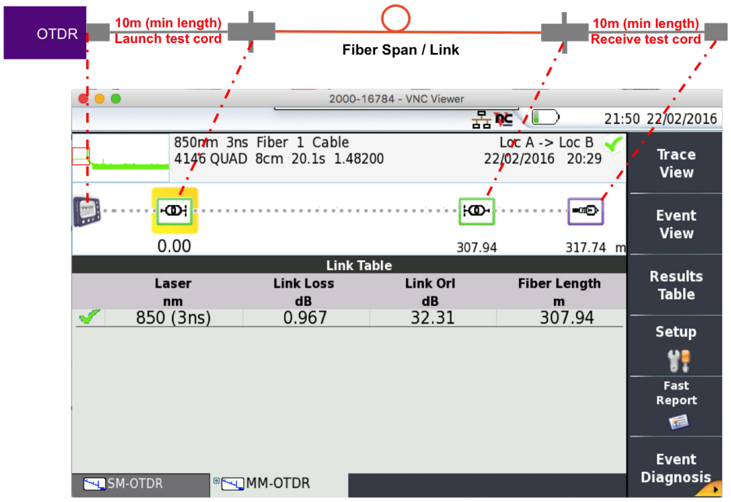


Figure 6. Example of a schematic overview

Figure 7 shows an event view with more details about each event (whether pass or fail). In this example, selecting each event provides the details in the box at the bottom.

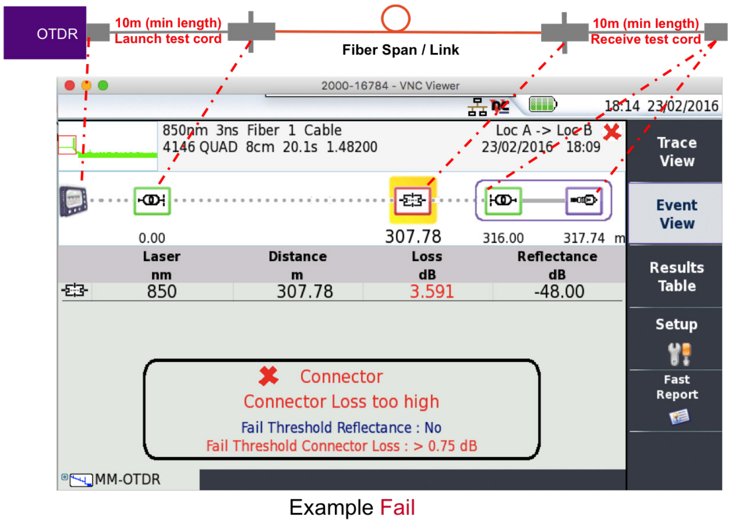
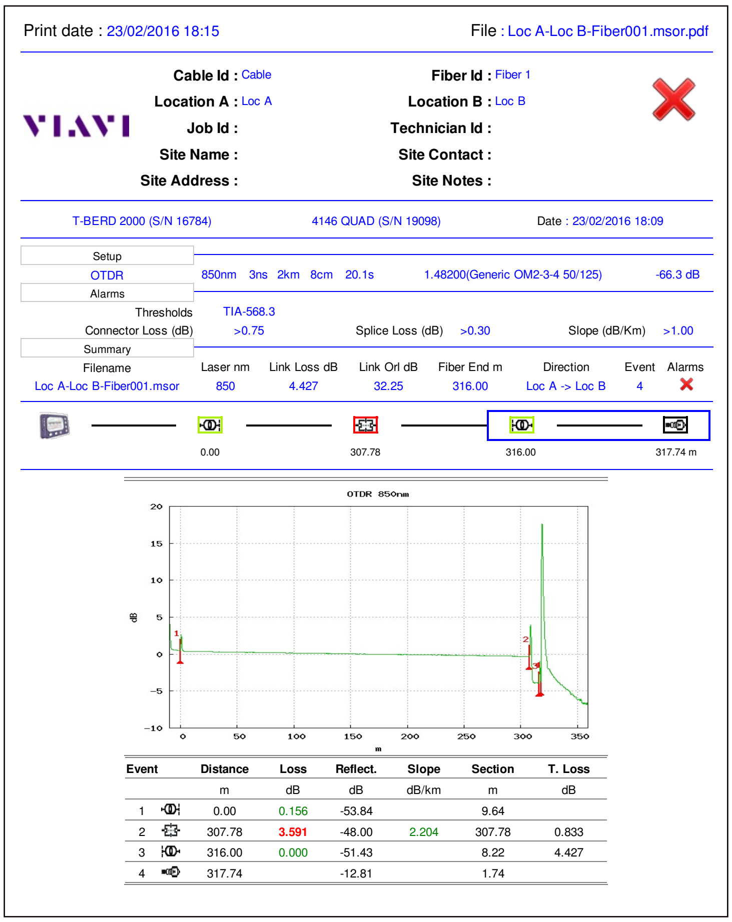


Figure 7. Schematic detailed event view

To document test results, most OTDRs can now quickly generate a preformatted report. In this case, the Fast Report feature will generate a PDF file (see Figure 8) quickly and easily for each fiber. Results in other data formats can also be saved for other documentation options.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Cable Id : Cable Fiber Id : Fiber 1
Location A : Loc A Location B : Loc B
Job Id : Technician Id :
Site Name : Site Contact :
Site Address : Site Notes :

T-BERD 2000 (S/N 16784) 4146 QUAD (S/N 19098) Date : 23/02/2016 18:09

Setup
OTDR 850nm 3ns 2km 8cm 20.1s 1.48200(Generic OM2-3-4 50/125) -66.3 dB
Alarms
Thresholds TIA-568.3
Connector Loss (dB) >0.75 Splice Loss (dB) >0.30 Slope (dB/Km) >1.00
Summary

Filename	Laser nm	Link Loss dB	Link Orl dB	Fiber End m	Direction	Event	Alarms
Loc A-Loc B-Fiber001.msor	850	4.427	32.25	316.00	Loc A -> Loc B	4	✗

0.00 307.78 316.00 317.74 m

OTDR 850nm

Event	Distance	Loss	Reflect.	Slope	Section	T. Loss
	m	dB	dB	dB/km	m	dB
1	0.00	0.156	-53.84		9.64	
2	307.78	3.591	-48.00	2.204	307.78	0.833
3	316.00	0.000	-51.43		8.22	4.427
4	317.74		-12.81		1.74	

Figure 8. PDF report

Summary

Whether you are managing existing fiber links or building new ones, it is important to know which tests are required to ensure a quality network. It is also important to be aware of tests that can be performed to provide added visibility into the network, especially when troubleshooting problems. The following summarizes several key points to consider related to Tier 2 testing as part of your fiber test toolkit:

- Tier 2 testing is performed *in addition to* Tier 1 testing and is not a replacement. It provides a more comprehensive view of the link and enables troubleshooting of fiber-link related problems.
- As with Tier 1 testing, proper preparation for the Tier 2 test is the most important part. This includes selecting the right fiber type and launch fiber. Inspecting and cleaning all connector end faces from the OTDR port to the link connector is also critical. Inspection should also be performed on the far side if a receive fiber is used.
- With newer schematic-based OTDR views, setting up the instrument for the test has never been easier. Simply load the preset test configuration file into the unit and start the test.
- Results are displayed as simple schematic-based views, identifying each event with distance and pass or fail status. A quick PDF report can be generated on demand for each fiber and wavelength.

Many of today's OTDRs provide schematic-based display and automated analysis capabilities. Tier 2 testing in the Enterprise can now be performed by almost anyone. Technicians can perform Tier 2 tests like the experts with today's smarter fiber-testing tools.

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