# OTDR PON testing: the challenges—the solution

app note

# OTDR PON testing: the challenges—the solution

app note

EXFO

By Mario Simard,
Senior Product Manager, EXFO

Since the first deployment of passive optical networks (PONs), a variety of testing methods have been designed for the verification and troubleshooting of PONs such as testing all points from the central office (CO) to the optical network terminal (ONT), testing some parts of the network and in some cases, simply not testing at all. With time however, the option of not testing at all has proven to generate more expenses at activation, making it an unsuitable option due to the additional costs in the long-term.

With all PON deployments that are expected to take place in the next three years, operators will repeatedly face the challenge that testing PONs poses. Based on past experience, the best PON-testing method that has emerged is derived from optical time-domain reflectometry (OTDR). The OTDR method has shown reliable results, while reducing the overall cost of testing. Since the OTDR method is a single-ended method, it significantly reduces staff time, which is its key advantage. However the cost of the unit and the required skill level of the user are perceived as its drawbacks. Yet there exists a micro-OTDR that is more affordable, but one drawback still remains: the required user skill level.

OTDR testing and the interpretation of results is highly simplified with a high-quality OTDR, as well as with the reliable information provided to the user by software tools. To help clarify the OTDR testing method used for verification and troubleshooting of PON networks, this application note will demonstrate how a PON-optimized OTDR performs on a PON link with a 1x32 splitter compared to a standard OTDR, as well as how a PON-optimized OTDR—along with the right software tools—will enable technicians to quickly resolve a faulty PON link under test. (Note that most details discussed herein are not part of a common OTDR specification sheet.)

## A Case in Point Using a Standard OTDR

In order to illustrate the benefits of a PON-optimized OTDR, a case in point will be used in the most challenging real-life scenario: an inservice network. The equipment used is an OTDR unit optimized for PON testing—the new FTB-7300E—and a unit that is not optimized for PON testing. Both units are equipped with a 1625 nm single-mode live port. A question answered is why use a 1625 nm or a 1650 nm out-of-band wavelength on a filtered port? The out-of-band signal enables to test without interfering with the other transmission wavelengths (1310, 1550 nm, etc.). Also, the filtered port will reject incoming signals, avoiding to blind the avalanche photodiode of the OTDR and therefore enabling the OTDR to launch an acquisition on a fiber with live signals. For additional details, refer to application note 130: *An Innovative Solution for In-Service Troubleshooting on Live FTTH Networks.*

In this case in point, the two OTDR units are different in many aspects, such as the available pulse width and the receiver bandwidth, which results in different spatial resolution. Moreover, the OTDR faces a significant loss caused by the 1x32 splitter (16 to 17 dB). An important question that arises is: What will happen when the signal crosses the splitter? Note that the tests are done from the ONT toward the optical line terminal (OLT).

The activation of the second half of a 1x32 splitter is demonstrated in this example; the first half of the customers receives good signal strength but all new customers do not. In this case, an operator has to send a team to troubleshoot. The team first goes to one of the faulty ONTs, where they begin by monitoring the signal with a PON power meter. If the signal is too low, they will need to troubleshoot with an OTDR unit. At this point, if the splitter ports are not spliced, they can disconnect the distribution fiber at the splitter and test on a dark fiber, but even in such a case, the team has to move to the splitter to test the fiber—and the more the splitter is manipulated, the more likely it is that errors will occur, such as a wrong customer being unplugged, new dirty connectors, etc., a terminal with a large number of splitters and connectors can easily become a nightmare. The ideal situation is to troubleshoot directly from the faulty ONT to resolve the fiber-link events from the end point up to the OLT. Experienced users will gradually process by troubleshooting with a small pulse width (e.g., 5, 10 or 30 ns) to trace events with more resolution from the ONT to the splitter. Since a break on the distribution fiber could appear as a splitter drop at low pulse, a second acquisition with a PON-optimized OTDR using a larger pulse (e.g., 100 to 500 ns) will enable the user to validate the cumulative loss up to the OLT at the CO, as well as to locate any bending problem on the transport fiber between the OLT and the splitter.

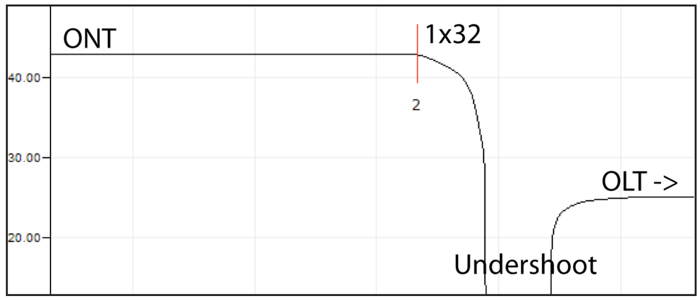
 

# The Standard OTDR

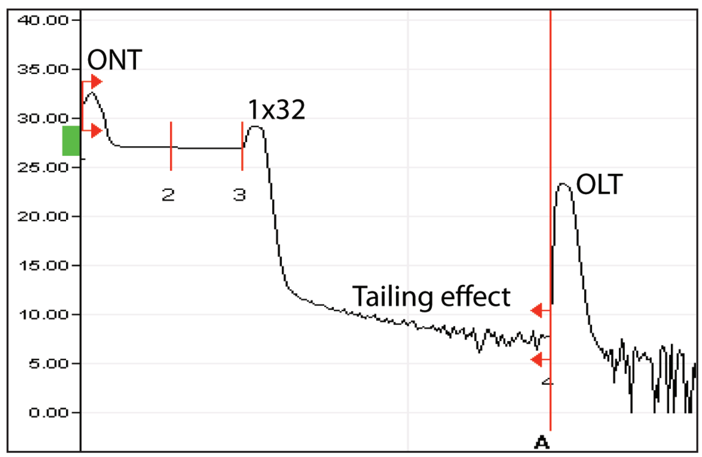
When using a standard OTDR unit, even if it is filtered, many factors can prevent valuable link characterization, such as:

- Lack of dynamic range at intermediate pulse widths (100 to 500 ns)
- Lack of resolution at longer pulse widths (1000 ns)
- Heavy distortion in the step response (splitter drop) created by any of the following:

a. Marginal stability of electronics
(note that the trace shown below does not come from an EXFO OTDR)




b. High tailing effect




c. Unadapted gain stitching and design for PON links


***Figure 1. (a), (b), (c): OTDR trace examples after the 1x32 splitter with a PON OTDR that is not optimized***

## The PON-Optimized OTDR

Returning to the previously mentioned case in point, if the user tries to identify events between the 1x32 splitter and the OLT, the traces in Figure 1 are useless. A macrobend on the fiber between the OLT and the splitter may affect some customers while not affecting others (if their distribution fiber loss is lower). To pinpoint the event and quickly fix it on the faulty ONT, a PON-optimized OTDR is required to fully characterize the fiber link from the ONT to the OLT, as highlighted in Figure 2.

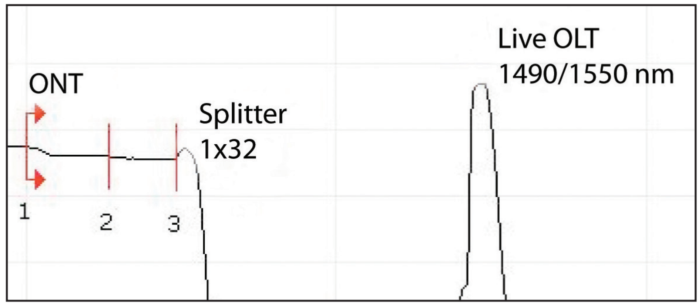



*Figure 2. PON-optimized OTDR trace from the ONT to the OLT splitter*

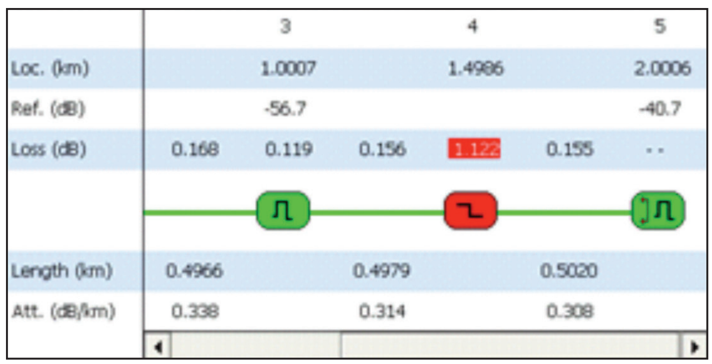



*Figure 3. Linear view simplifying the technician's OTDR trace analysis*

With the PON-optimized OTDR, distortion after the splitter drop is greatly reduced and the result is highly repeatable and reliable. The user can measure the loss of the splitter and the cumulative link loss, as well as identifying whether any unexpected physical event occurred before—or after—the splitter.

The PON-optimized OTDR also has a high value in construction: testing at 1310/1550 nm can significantly reduce the number of problems that occur after the customer activation by certifying end-to-end link integrity. The method previously described only uses 1625/1650 nm—or additional to 1310/1550 nm, which also has some traction in construction of a complete network. In such a case, characterization at 1650 nm is desired. One may consider that only 1625 nm testing is sufficient to validate link integrity.

However, out-of-band testing at construction is useful to compare an OTDR trace done during troubleshooting with the initial trace (templating). By doing so, anomalies are easily located, and the loss for all events (connector, splice and splitter) could be compared, clearly identifying the fault.

This is where the advantage of having a PON-optimized OTDR such as the FTB-7300E OTDR that is equipped with software providing high-quality information comes into play. A summary screen highlighting the pass/fail status at each wavelength, the total span loss, span ORL with the distance from the OLT to the ONT, macrobend identification and location, combined to the linear view provided by the FTB-200 Compact Platform, greatly simplifies the work of the technician.

## Conclusion

For more than 20 years, EXFO has provided solutions that are perfectly adapted to the market. EXFO has also developed innovative solutions such as automatic loss test sets, a PON power meter and the FTB-7300D OTDR—the first PON OTDR designed for measuring through splitters. Today, the new FTB-7300E PON-optimized OTDR with in-service troubleshooting brings PON OTDR live fiber testing to a new level of performance and value. For more information on our PON-optimized products, visit the EXFO website at www.EXFO.com.