White Paper

Meeting the Unique Test Challenges of FTTx Deployment

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Synopsis

Passive optical networks are being deployed worldwide to more cost-effectively deliver high-bandwidth broadband services to subscribers. FTTx PONs present unique installation verification and maintenance troubleshooting challenges. These challenges are effectively overcome when technicians understand FTTx PON architecture and are equipped with test tools designed to address the unique test requirements of FTTx PONs.

Introduction

Rapid growth of fiber optic networks has resulted in an explosion of improved services to the residential consumer. Fiber to the home (FTTH or FTTx) passes more than 262 million homes globally, 20 million of which are in the United States[1]. As telecommunications companies replace old copper technologies with fiber, they are able to deliver more bandwidth, reliability, flexibility and security to end-users.

While many carriers with deployed twisted-pair copper networks utilize increasingly complex DSL technology to deliver broadband services, bandwidth demand will ultimately exceed the capacity which can be delivered over those networks.

With nearly unlimited bandwidth, FTTH fiber networks are becoming the go-to technology for next-generation communications worldwide, including distance learning, cloud computing, tele-medicine and more. Additionally, many governments have sponsored broadband plans to install and improve this critical fiber infrastructure in remote and rural areas.

FTTH passive optical networks (PONs) are increasingly being deployed to provide optical fiber's bandwidth advantages at a lower cost than point-to-point architecture affords. However, PONs present unique test challenges when installing and maintaining the FTTH network. This white paper provides an overview of FTTx PON architectures, identifies test challenges unique to FTTx PONs, and describes optical tests recommended to verify or troubleshoot FTTx PONs, including in-service (live) PONs.

FTTH Network Architectures

FTTH networks may be deployed using either point-to-point or point-to-multipoint network architecture.

Point-to-point architectures include active Ethernet, and offer a dedicated fiber connection from the operator's local exchange—either a central office (CO) or powered, environmentally-controlled vault (EV)—to each subscriber's premise. A point-to-point architecture also requires electro-optics for each subscriber at both CO or EV and the customer premise.

Gigabit-capable passive optical network (GPON) and Ethernet passive optical network (EPON) are two PON technologies commonly deployed in point-to-multipoint networks. In both GPON and EPON networks, active electronics are located only at the end-points of the PON, reducing network cost and increasing network reliability. An optical line terminal (OLT) residing in the carrier's CO communicates across the passive optical distribution network (ODN) to optical network terminals (ONTs) located at subscribers' premises (see Fig. 1).

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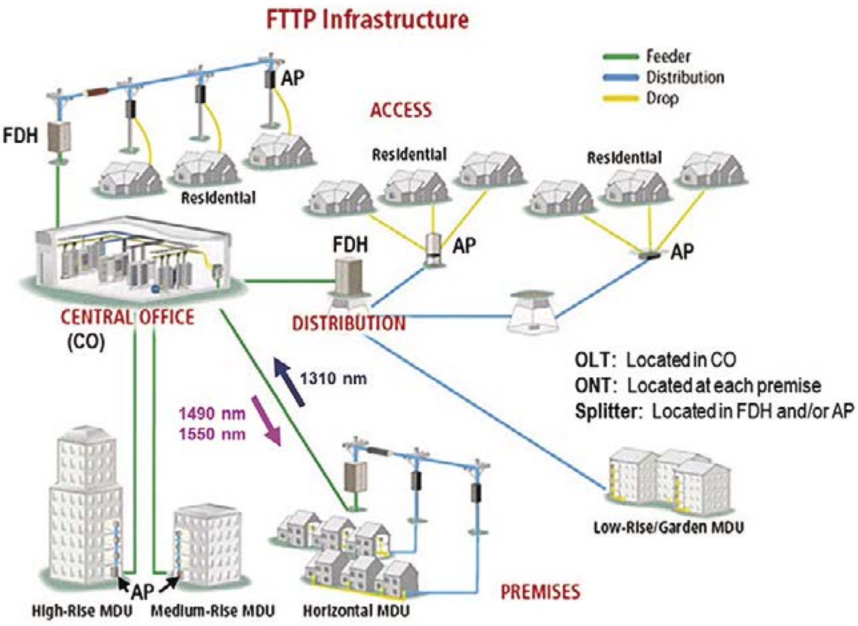


Fig. 1—FTTH PON Architecture using GPON or EPON

In the ODN, a single feeder fiber connects the CO to a pedestal- or pole-mounted fiber distribution hub (FDH). The FDH may be located in a neighborhood or the entry level of a multi-dwelling unit (MDU).

In single splitter PON architectures, a single 1x32, 1x64 or 1x128 splitter is installed at the FDH. A feeder fiber connects the central office to the splitter at the FDH. This splitter separates the downstream signal into 32, 64, or 128 copies. Each of the many splitter ports are then connected through a distribution fiber to a pedestal- or pole-mounted Access Point (AP) terminal. A drop fiber connects each AP terminal to an ONT installed at each subscriber's premise. The ONT may be installed either inside or outside the customer premise.

In a distributed PON, two lower split ratio splitters are installed, one at the FDH followed by a second splitter at the multi-port access terminal. The effective split ratio in a distributed PON is the multiple of the distributed splitters (e.g. 1x4 followed by 1x8 results in an effective split ratio of 1x32). This configuration may be used in rural applications to save fiber, or in dense applications, such as MDUs or apartment buildings. For example, drop fibers from a secondary splitter located in the entry level of an MDU would connect to each subscriber's apartment.

A PON's trunk-and-branch architecture reduces the amount of fiber required. Additionally, the downstream signal is broadcast to all attached subscribers, so a single downstream transmitter serves multiple customers. In the upstream direction, subscribers are assigned unique time slots in which to transmit, with the signals from the subscribers combined at the passive splitter and sent to the CO over the single feeder fiber. Consequently, a single CO receiver also serves multiple customers.

Traffic on the network

Both GPON and EPON deliver voice, data, and IP video signals downstream using 1490 nm wavelength. An optional video overlay may be transmitted downstream at 1550 nm. Voice and data is communicated upstream from the ONT on the same fiber using 1310 nm wavelength.

Downstream signals are optically divided at the splitter into multiple identical signals. The optical power of each signal is reduced by the split ratio plus some additional insertion loss. For example, the optical power level through a 1x32 splitter is reduced by approximately 16 dB, which is slightly more than a factor of 32. While each ONT sees the same downstream signal, downstream data is encrypted and addressed to specific ONTs, so each ONT can only access data addressed to it.

In the upstream direction, multiple subscribers may simultaneously wish to send data upstream to the CO. Since all ONTs use the same 1310 nm upstream wavelength, time division multiple access (TDMA) is used to prevent multiple ONTs from sending signals at the same time. With TDMA, the OLT assigns each ONT unique time slots during which it can send data in the upstream direction, preventing multiple ONTs from transmitting simultaneously.

FTTH PON Testing Overview

Proper testing is a critical part of installing, activating and maintaining a PON. While most components are tested during the manufacturing process, they are tested again after splicing and installation of splitters and access terminals. Field testing is required to ensure no excess loss or reflectance has been introduced due to micro-bends in installed fiber, poor splices, macro-bends in splice closures or access terminals, or dirty, damaged, or improperly seated connectors. If not detected and corrected, excess loss or reflectance often results in poor network performance. Performance may initially seem acceptable, but over time, transmission errors may begin to increase long before the need for any maintenance activity would normally be expected.
Tests commonly used to verify optical links include the following:

- Connector inspection
- Insertion loss test
- Optical return loss test
- Optical time domain reflectometry (OTDR)

Connector inspection and cleaning during installation and maintenance are among the most effective methods for ensuring an optical network will deliver expected performance. Connector inspection is typically performed using an optical microscope. To prevent accidental eye damage when inspecting fibers potentially carrying live traffic, a video microscope images the connector end-face and displays the magnified image on a handheld display. Dirt, debris, or damage are easily detected. Images may be captured before and after cleaning, then compared for any variation. Connector contamination and damage are the most common causes of poor optical network performance, according to a recent study by NTT-Advanced Technology[2].

An **insertion loss test** measures the end-to-end loss of the installed link by injecting light with a known power level and wavelength at one end, and measuring the received power level output from the other end. The measured difference between the transmitted and received power levels indicates the optical loss through the network. Insertion loss is considered acceptable when the measured loss level is lower than the budgeted loss level.

An **optical return loss test** injects light with known wavelength and power level into one end and measures the power level returned to that same end. The difference between the injected power level and the measured return level is the return loss. Return loss is considered acceptable when it is higher than the budgeted return loss target. A low return loss value (below 35 dB) is often an indication of one or more sources of excess reflection in the network under test, typically due to dirty or damaged connectors or a fiber break.

Since optical network loss is wavelength-dependent, insertion and return loss testing is typically performed using wavelengths at or near those which will be used during network operation. In the case of FTTx PONs, downstream wavelengths of 1490 nm and 1550 nm may be used, while 1310 nm is used in the upstream direction. Consequently, insertion and return loss testing at 1310 nm, 1490 nm, and 1550 nm may be required. In practice, testing is often performed only at 1310 nm and 1550 nm, reasonably expecting loss and return loss at 1490 nm to be between the levels measured at 1310 nm and 1550 nm.

If the loss and return loss measured at each wavelength are within the levels budgeted for the link, the optical network may be considered ready for activation. However, in many cases, the network operator requires the network to be more fully documented using an optical time domain reflectometer (OTDR).

An **OTDR** scans a fiber from one end to measure the length, loss and optical return loss of an optical network. It also locates and measures reflective and non-reflective events in the network due to splices, connectors, micro- or macro-bends, splitters or faults.

Operating like a radar, an OTDR injects narrow pulses of light into the fiber-under-test. As each pulse travels down the fiber, imperfections in the fiber scatter some of the light, with some of this Rayleigh-scattered light being guided back up the fiber.

Optical pulses and backscatter experience some loss as they traverse a mated connector pair, mostly due to imperfect alignment between the two connectors. By measuring the difference between backscatter levels before and after the connection, the OTDR is able to measure the loss across each connection.

A Fresnel reflection is generated whenever the pulse encounters a mismatch in the index-of-refraction, usually at a mated connector. An air gap at a poorly mated connector or an open connector end will generate a strong reflection. This reflected energy is also guided back up the fiber. (Note: The ends of APC connectors are angled to ensure that light is reflected off the end-face at such an angle that it is not captured and guided back up the fiber.)

The OTDR measures the level of returned backscatter and reflections vs. time. Since the speed of light through the optical fiber is known, the OTDR is able to convert time-of-flight into distance, creating a trace which plots changes in backscattered and reflected light levels vs. fiber length. Losses due to connectors or macro-bends appear as abrupt changes in the backscatter signal level. Reflections due to connectors, air gaps and open ends appear as spikes in the OTDR trace, as shown in Fig. 2.

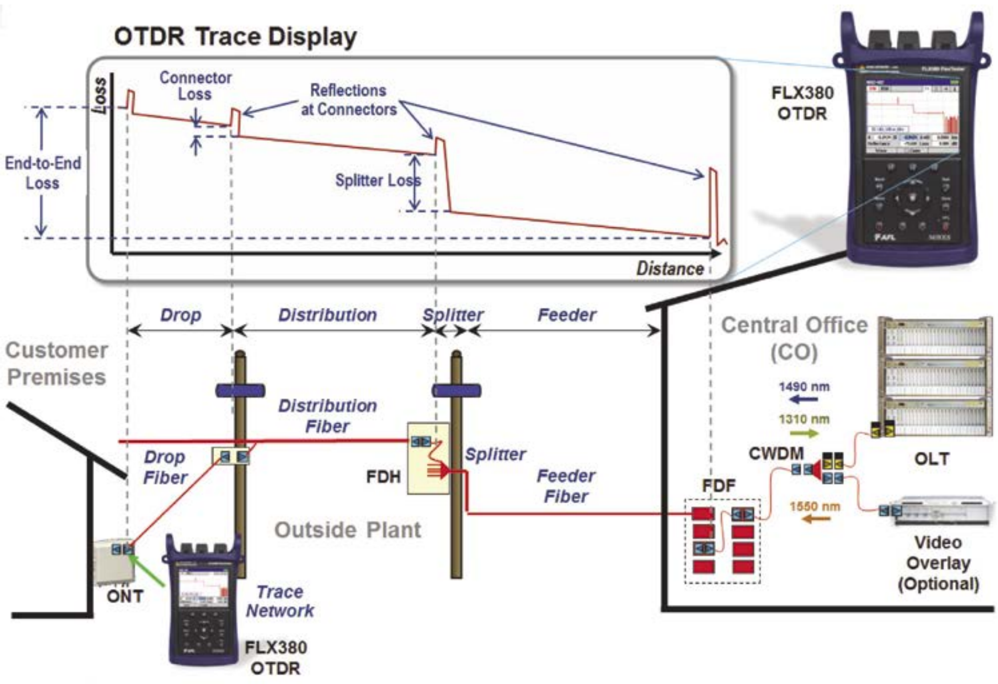


Fig. 2— Example OTDR trace showing backscatter, reflections, and loss events

End-to-end loss is measured by comparing backscatter level at the beginning of the fiber to backscatter level at the end of the fiber. Reflectance levels are determined by comparing the backscatter level just before a connector to its reflective spike level. Optical return loss can be computed by summing end-to-end backscatter and reflection levels and comparing them to the transmitted pulse power level.

For more accurate connector or end-to-end loss measurements, OTDR traces from opposite ends of a point-to-point network are often averaged using PC-based trace analysis software. Note: Insertion and return loss tests each provide a single numeric value which can be compared to network-specific limits to determine if the optical plant is within acceptable performance values. However, when unacceptable or marginal values are found, insertion or return loss tests cannot locate the source of the problem. An OTDR also measures loss and return loss, but can additionally locate the sources of excess loss and reflections, reporting the distance to high loss or highly reflective events.

Which Tests, When and Where?

Optical testing is typically performed at various points in a network's lifetime:

Installation verification testing occurs as the network is being constructed or after network installation is complete, but before the network is activated. This is usually when the most complete testing is performed, and may include insertion and return loss testing as well as OTDR testing. Pass/fail criteria may be applied to end-to-end length, loss and ORL results, as well as to individual event loss and reflectance measurements for splices, connectors, and splitters. Formal reports may be generated, including all of the measurements, OTDR traces, pass/fail criteria and pass/fail results.

Maintenance troubleshooting is performed when service outages occur, and typically requires rapid response to restore service as quickly as possible. This is done through reroute restoration and/or fault location, repair, and verification before restoring active service. Troubleshooting may also require nondisruptive fiber identification to ensure in-service fibers are not disconnected. Maintenance personnel may require a visual fault locator (VFL) to precisely pinpoint the location of breaks or macro-bends in splice or access enclosures.

Table 1 summarizes installation and maintenance tests which may be performed, indicates the equipment required for each test, when the test is most likely to be performed (e.g. during installation or troubleshooting), typical test wavelengths, and where the test is performed.

Table 1— FTTx PON Installation Verification and Maintenance Troubleshooting Tests

TEST	DESCRIPTION	WHEN USED		REQUIRED EQUIPMENT	WAVELENGTHS (NM)	TEST FROM	NOTES
		INSTALLATION	TROUBLESHOOT				
Out-of-Service Feeder Fiber Test	Test insertion loss of feeder fiber before splitter installed (OLT <--> FDH)	Yes	No	OLS & OPM	1310/1550 or 1310/1490/1550	OLT to FDH, or FDH to OLT, or Both (bidirectional)	Does not verify connection to splitter; Either test requires equipment at both ends; Wave ID shortens test time and eliminates setup errors
	Test insertion loss of feeder fiber after splitter installed (OLT <--> FDH)	Yes	No	OLS & OPM	1310/1550 or 1310/1490/1550	OLT to FDH, or FDH to OLT, or Both (bidirectional)	Test through any splitter port verifies feeder fiber and splitter connection; Must test through all splitter ports to verify each splitter port is OK
	OTDR test of feeder fiber before splitter installed (OLT <--> FDH)	Yes	No	OTDR	1310/1550 or 1310/1490/1550	OLT to FDH, or FDH to OLT, or Both (bidirectional)	Locate all splices and connectors; Verify no excess losses or reflections, or locate any excess losses and reflections for repair
	OTDR test of feeder fiber after splitter installed (OLT --> Splitter)	Yes	No	OTDR	1310/1550 or 1310/1490/1550	OLT	Locate all splices and connectors; Verify no excess losses or reflections, or locate any excess losses and reflections for repair; Does not test individual splitter ports
	OTDR test of feeder fiber after splitter installed (Splitter --> OLT)	Not recommended	Possibly	OTDR	1310/1550 or 1310/1490/1550	Splitter ports	Not recommended for verifying feeder fiber splices since wide pulse width (low resolution) required to see through splitter to detect & verify low-loss splices; May be used to verify loss through each splitter port.

table ccontinued →

Table 1— FTTx PON Installation Verification and Maintenance Troubleshooting Tests

TEST	DESCRIPTION	WHEN USED		REQUIRED EQUIPMENT	WAVELENGTHS (NM)	TEST FROM	NOTES
		INSTALLATION	TROUBLESHOOT				
Out-of-Service Splitter, Distribution & Drop Fiber Tests	Test insertion loss of feeder fiber, splitter and distribution fiber (drop fiber not installed)	Yes	No	OLS & OPM	1310/1550 or 1310/1490/1550	OLT to AP, or AP to OLT, or Both (bidirectional)	Verify loss of feeder fiber, splitter and distribution fiber; Requires equipment at both ends; Use Wave ID to shorten test time and eliminate setup errors
	Test insertion loss of feeder fiber, splitter, distribution, and drop fibers	Yes	Possibly	OLS & OPM	1310/1550 or 1310/1490/1550	OLT to ONT, or ONT to OLT, or Both (bidirectional)	Verify loss of feeder fiber, splitter and distribution fiber; Requires equipment at both ends; Use Wave ID to shorten test time and eliminate setup errors
	OTDR test of splitter plus distribution fiber (drop fiber not installed) (PON out-of-service)	Yes	Possibly	OTDR	1310/1550 or 1310/1490/1550	AP toward OLT	Test from AP downstream from splitter; PON must be out-of-service to test at 1310/1490/1550 nm; High-resolution test possible on distribution fiber (from AP to splitter); Can measure splitter loss and end-to-end loss
	OTDR test of splitter, distribution and drop fibers (PON out-of-service)	Yes	Possibly	OTDR	1310/1550 or 1310/1490/1550	ONT toward OLT	Test from ONT (end of drop fiber); PON must be out-of-service to test at 1310/1490/1550 nm; High-resolution test possible on drop & distribution fibers; Can measure splitter loss and end-to-end loss
In-service Distribution & Drop Fiber Tests	Test end-to-end insertion loss of PON	Not typical	Possibly	OLS & OPM	1625 or 1650	OLT to ONT, or ONT to OLT, or Both (bidirectional)	Requires WDM test port at OLT; Requires unused or out-of-service ONT port; Only measures end-to-end loss through single splitter port
	OTDR test of splitter, distribution and drop fibers (PON in-service)	No	Yes	OTDR	1625 or 1650	ONT toward OLT	Test in-service PON from unused or out-of-service drop fiber; Must use out-of-band OTDR wavelength (e.g. 1625 or 1650 nm); High-resolution test possible on drop & distribution fibers; Can measure splitter loss and end-to-end loss
	Measure downstream power level	No	Yes	PON OPM	1490, 1550	ONT	Detect and measure downstream power level at ONT; Verify received power ≥ minimum acceptable power level.
	Pinpoint faults in AP, FDH or splice closure	Yes	Yes	VFL	635 or 650	ONT toward AP, FDH	Connect VFL (visible red laser) at ONT end of drop fiber; Visually inspect fiber in fault region for red glow pinpointing fault location.
Active ONT detection	Non-intrusively detect active ONT	No	Yes	Active ONT Identifier	1310 nm	900 µm, 2 or 3 mm fiber between splitter and ONT	Clamp onto accessible buffered or jacketed fiber; Indicates if ONT actively responding to OLT
Fiber Identification	Non-intrusively detect live fiber	Possibly	Yes	OFI	1310/1490/1550	900 µm, 2 or 3 mm fiber between splitter and ONT	Use OLS to inject tone into one end of out-of-service fiber;
	Non-intrusively detect out-of-service fiber carrying test tone	Possibly	Yes	OLS & OFI	1310/1490/1550	900 µm, 2 or 3 mm fiber between splitter and ONT	Clamp onto accessible buffered or jacketed fibers in a bundle of fibers (some active, some out-ofservice, one carrying identifying tone); OFI Indicates if no signal, live fiber, or test tone (270, 1k, 2k Hz) present

FTTx PON Insertion Loss Tests

Insertion loss tests are primarily used to test FTTx PONs during installation. Insertion loss testing may be performed on individual fiber segments as they're installed (e.g. test feeder fiber from CO to FDH, test distribution fiber from FDH to AP, or test drop fiber from AP to subscriber's premise). An end-to-end insertion loss test may also be performed on the FTTx PON after it is partially or fully installed (from CO through feeder fiber, splitter, distribution and drop fibers to the AP or customer's premise).

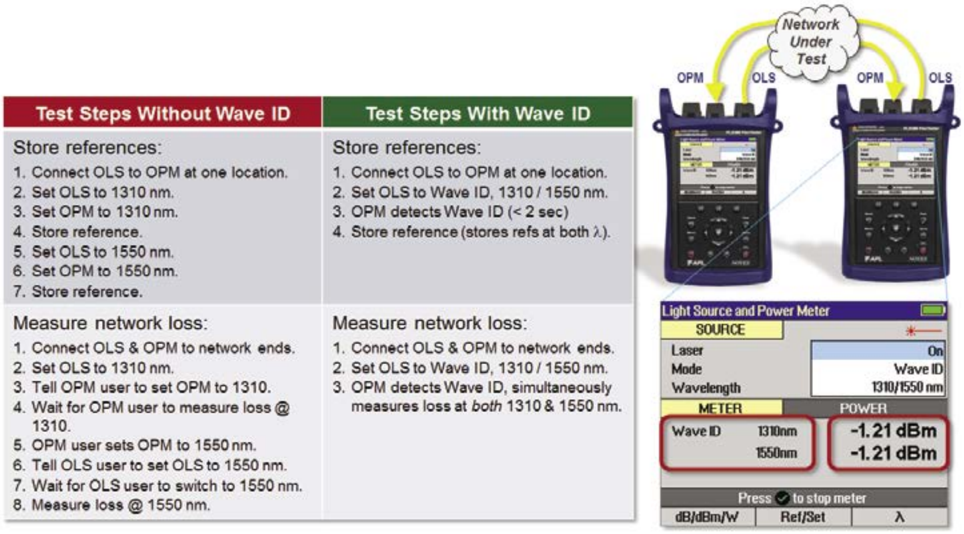
A stable optical light source and an optical power meter are required to measure insertion loss. Access to both ends of the fiber-under-test is required. Consequently, this is typically an out-of-service test.

To measure loss, received power at the far end of the fiber-under-test must be compared to transmit power injected into the fiber at the near end of the fiber under-test. To simplify loss measurements, the power meter is initially connected to the source with a short jumper cable and the source power level is measured and stored as the 0 dB reference level for that wavelength. Since the source's output power levels and the power meter's detector response are different at each wavelength, the power meter must be referenced to the source at each test wavelength.

Once the source and power meter have been referenced at each of the test wavelengths, the source—with the reference jumper still attached—is connected to one end of the fiber under test. The power meter is connected to the other end of the fiber-under-test. Received power level is measured and displayed. More conveniently, the power meter can compare the received power level to the stored reference, directly displaying optical loss in dB.

Simple power meters measure power at only one wavelength at a time. To make loss measurements at multiple wavelengths, the source must be configured for each test wavelength in turn. At the same time, the power meter operator must select the appropriate wavelength at the power meter so the correct detector calibration factor and reference level are applied. This is both time-consuming and error prone, as it requires coordination between the source operator on one end and the power meter user at the other end of the fiber-under-test.

To reduce test time and eliminate this potential for errors, AFL's FLX380 FlexTester includes Wave ID. A Wave ID source alternately transmits light at each wavelength. A Wave ID power meter automatically synchronizes to the received wavelengths, eliminating the need for source and power meter to be manually switched between wavelengths (see Fig. 3).



Test Steps Without Wave ID	Test Steps With Wave ID
Store references: 1. Connect OLS to OPM at one location. 2. Set OLS to 1310 nm. 3. Set OPM to 1310 nm. 4. Store reference. 5. Set OLS to 1550 nm. 6. Set OPM to 1550 nm. 7. Store reference.	Store references: 1. Connect OLS to OPM at one location. 2. Set OLS to Wave ID, 1310 / 1550 nm. 3. OPM detects Wave ID (< 2 sec) 4. Store reference (stores refs at both λ).
Measure network loss: 1. Connect OLS & OPM to network ends. 2. Set OLS to 1310 nm. 3. Tell OPM user to set OPM to 1310. 4. Wait for OPM user to measure loss @ 1310. 5. OPM user sets OPM to 1550 nm. 6. Tell OLS user to set OLS to 1550 nm. 7. Wait for OLS user to switch to 1550 nm. 8. Measure loss @ 1550 nm.	Measure network loss: 1. Connect OLS & OPM to network ends. 2. Set OLS to Wave ID, 1310 / 1550 nm. 3. OPM detects Wave ID, simultaneously measures loss at *both* 1310 & 1550 nm.

Light Source and Power Meter
SOURCE
Laser On
Mode Wave ID
Wavelength 1310/1550 nm
METER
POWER
Wave ID 1310nm -1.21 dBm
1550nm -1.21 dBm
Press ✓ to stop meter

Fig. 3— Store reference and measure loss using Source and Power Meter with Wave ID

FTTx PON Out-of-Service OTDR Tests

OTDR testing is typically completed as the FTTx PON is being deployed. The feeder fibers connecting CO to FDH are typically the longest links in the PON, are usually the first fibers installed, and may include multiple splices. These may be tested as point-to-point links before the splitter is installed at the FDH.

If a splitter is spliced to the feeder fiber before testing, the loss through each of the splitter legs may be verified. However, this requires testing from each of the multiple splitter outputs, and requires a launch fiber (1000 m recommended) to allow the splitter loss to be clearly seen and measured. Splitter losses through each of the legs cannot be easily verified by testing from the CO end of the feeder fiber.

Using an OTDR, distribution fibers are typically tested after installation and connection to the splitter. Once attached to the splitter, these fibers may only be tested from the downstream access point or subscriber premise (if the drop fiber is also installed and connected). High-resolution of the distribution and drop fibers may be obtained using narrow pulses, but the OTDR may not be able to measure the splitter loss using narrow pulses. Wider pulses improve the OTDR's dynamic range, enabling it to more accurately measure the loss of the attached splitter.

OTDR testing during FTTx PON installation testing is usually performed only at 1310 and 1550 nm. During operation, the FTTx PON always utilizes 1490 nm in the downstream direction and 1310 nm in the upstream direction. It may additionally utilize 1550 nm as a second downstream wavelength. Fiber loss is highest at 1310 nm and lowest at 1550 nm, while bending-induced loss is highest at 1550 nm. If end-to-end loss is within acceptable limits at both 1310 and 1550 nm, it is nearly certain to be acceptable at 1490 nm. If no excess losses or reflections are found at 1310 or 1550, none are likely to be found at 1490 nm. Even if the PON will initially be operated using only 1490 and 1310, testing at 1310 and 1550 nm can detect any micro- or macro-bends, and ensures the FTTx PON is capable of adding 1550 nm operation in the future.

Troubleshooting an In-Service FTTx PON

Because of its point-to-multi-point architecture, it is possible for one or only a few subscribers to lose service while other subscribers on the same PON continue to receive service. There are several possible causes:

- Equipment or connection problem inside the customer's premise;
- Failed ONT at the customer's premise;
- Fault in the distribution or drop fiber from the splitter to the subscriber;
- Fault introduced at the splitter connection to the subscriber's distribution or drop fiber (e.g. macro-bend introduced while adding another subscriber, or inadvertently disconnecting the distribution or drop fiber to an active subscriber).

If some, but not all subscribers are affected in an FTTx PON built using distributed splitter architecture, it is possible that all of the affected customers are served from a single secondary splitter. In this case, likely causes include:

- Fault in the distribution fiber serving the secondary splitter;
- Fault in the secondary splitter itself.

In either case, a fault in the feeder fiber or a failure within the OLT is not likely, since the feeder fiber and OLT are also shared by subscribers who are still receiving service.

Troubleshooting normally requires a visit to the subscriber's premise. A recommended troubleshooting process is illustrated in Fig. 4 and described on pages 11 and 12.

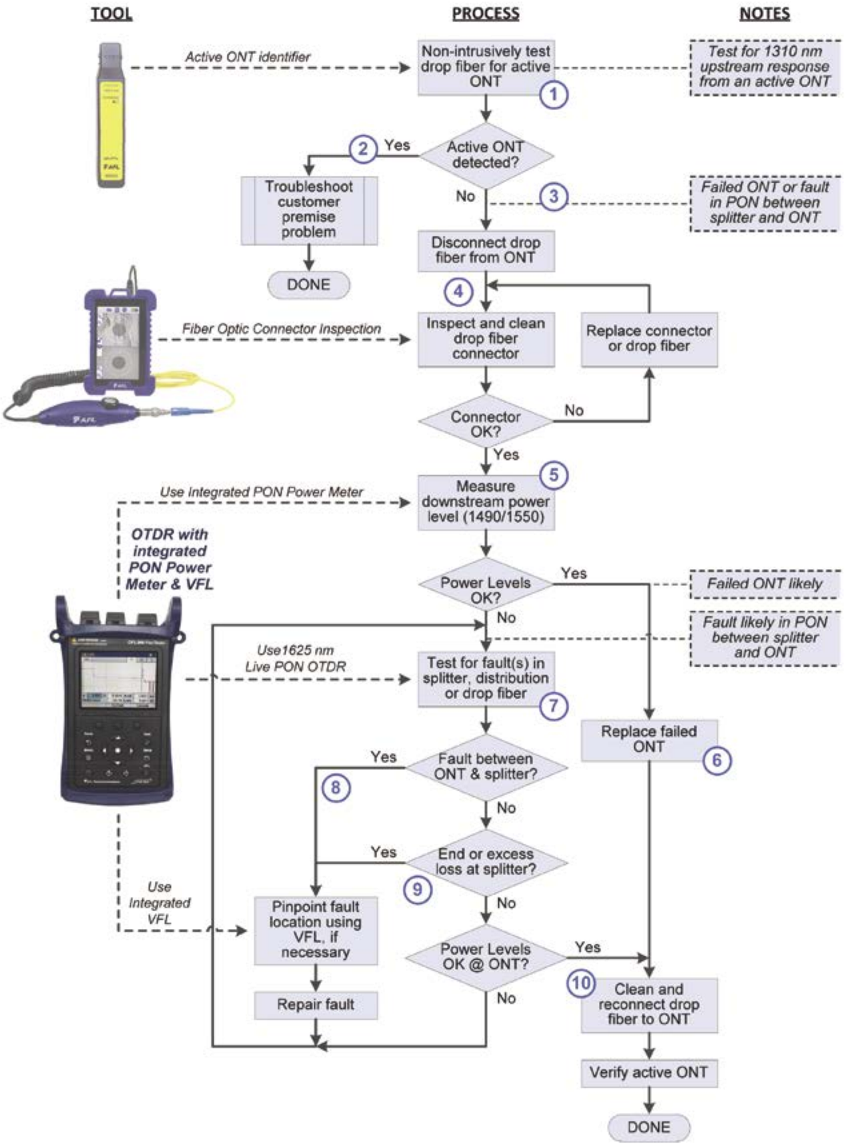


Fig. 4— Troubleshooting a Live PON

Test Procedure when Troubleshooting an In-Service (Live) PON

1. Use an Active ONT Identifier to determine if the ONT at the subscriber's premise is responding to downstream signals from the OLT. The Active ONT identifier clamps on to 900 µm buffered fiber, or 2 or 3 mm jacketed fiber, senses and reports the presence or absence of the 1310 nm upstream response from an active ONT.
2. If an active ONT is detected, the fault is either an equipment or connection problem inside the customer's premise (most likely), or the ONT itself (less likely). Optical tests at the ONT are unlikely to resolve the problem.
3. If an active ONT is not detected, the fault may either be a failed ONT or a fault in the splitter, distribution or drop fiber connecting the feeder fiber to the subscriber.
4. In this case, disconnect the drop fiber from the ONT, inspect and clean the optical connectors on the drop fiber and the ONT. If a damaged optical connector is found on the drop fiber, replace, clean and inspect the new connector before proceeding. If a damaged optical connector is found on the ONT, the ONT likely will have to be swapped out.
5. If connectors are clean and undamaged, check the downstream power level at the ONT using a PON Power Meter. Some OTDRs include a PON Power Meter integrated into their OTDR port, enabling immediate detection and measurement of downstream power levels at both 1490 and 1550 nm.
6. If the measured downstream power levels are acceptable, the problem is likely a failed ONT. Swap out the ONT, clean and reconnect the drop fiber, and verify the ONT synchronizes to the upstream OLT.
7. If the measured downstream power level(s) are not acceptable, the problem is likely a fault in the distribution or drop fiber, or a fault introduced at the splitter in the FDH. In this case, connect a live PON OTDR to the drop fiber and initiate an upstream OTDR test using the out-of-band 1625 nm wavelength. To prevent disrupting service on the live PON, select an OTDR which prevents the user from initiating 1310, 1490, or 1550 nm OTDR tests when live traffic is present.
8. Some OTDRs also allow the operator to test only the customer fiber (distribution and drop), or to test through the splitter. Unless multiple customers are affected, the problem is most likely in the distribution and drop fiber, so testing only the distribution and drop fiber is a good bet.
9. Review the 1625 nm trace and event table to determine if there is a break or any excess losses or reflections in the distribution and drop fibers. If so, locate the problem location, repair the fault, then verify the fix by rescanning the fiber using the same 1625 nm test. To precisely pinpoint macrobends or breaks within a splice enclosure or access point, disconnect the OTDR and connect a Visual Fault Locator (VFL, a visible red laser). Enable the VFL and look for the point where the fault causes red light to escape from the fiber.
10. If no excess losses or reflections were identified in the OTDR trace, rescan the FTTx PON from the same location at 1625 nm using the "Test through Splitter" setup. This will provide a trace of the distribution and drop fibers with sufficient dynamic range to see through the splitter and measure the splitter loss. Since other probable causes have been eliminated, likely problems are a break or macrobend at the splitter, or the splitter has been disconnected from the distribution fiber. These will manifest themselves either as excess loss at the splitter, or as the fiber end being detected at the splitter. Repair the fault, then verify the fix by rescanning the fiber using the same setup.
11. Once fiber restoration is complete, verify the proper downstream power levels are available at the end of the drop fiber, clean and reconnect the drop fiber to the ONT, and verify the ONT synchronizes to the upstream OLT.

Summary

Passive optical networks are being deployed worldwide to more cost-effectively deliver higher bandwidth broadband services to subscribers. FTTx PONs present unique installation verification and maintenance troubleshooting challenges. These challenges are effectively overcome when technicians understand FTTx PON architecture and are equipped with test tools designed to address the unique test requirements of FTTx PONs.

Notes:

[1] "Telecom Cable Market Outlook 2012 Executive Summary," CRU International, August 2012.

[2] NTT—Advanced Technology; http://www.bicsi.org/uploadedFiles/PDFs/Presentations/Fibre%20Optic%20Connector.pdf

About Michael Scholten

Michael is Sr. Product Marketing Manager at AFL, one of the world's leading manufacturers of fiber optic cable. The company's diverse product portfolio includes fibre optic cable, transmission and substation accessories, outside plant equipment, connectors, fusion splicers, test equipment and training. AFL's service portfolio includes market-leading positions with the foremost communications companies supporting inside plant central office, EF&I, outside plant, enterprise and wireless areas.