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# TESTING FTTX NETWORKS WITH THE PPM-350B

APPLICATION NOTE

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The telecom world is experiencing an important transformation. Over the past few years, much has been done to implement the information super highway; large fiber-optic backbones have been built, both at the long-haul and metropolitan levels. What we are about to witness is the extension of this highway to the “last mile”–access networks allowing carriers to offer top-of-the-line triple-play services (multiple phone lines, high-speed data transmission, as well as enhanced digital and analog video) thanks to the advent of fiber-to-the-premises (FTTP) networks.

These evolutions will radically transform the way people communicate and entertain by enhancing their access to the world. They will also allow traditional telcos to offer comprehensive bundled services.

Change will not stop there. Fiber will be installed further in the loop than ever, and installation and maintenance crews who are used to working with copper-based POTS and xDSL will have to get acquainted with fiber.

As for any type of fiber network, proper testing is a critical part of building and maintaining “next-generation” networks. This application note focuses on the key aspects of FTTx network testing.

## Understanding FTTx

The FTTx (fiber-to-the-home, or FTTH; fiber-to-the-premises, or FTTP; etc.) architecture offers an attractive avenue for emerging applications. Through a passive optical network (PON), it allows several customers to share a connection, without any active components–i.e., without having to generate or transform light through optical-electrical-optical (OEO) conversion.

Figure 1 shows the general architecture of an FTTx network. At the central office (CO, also called the headend), the public switched telephone network (PSTN) and Internet services are interfaced with the optical distribution network (ODN) by the optical line terminal (OLT). The downstream 1490 nm and upstream 1310 nm wavelengths are used to transmit data and voice. Video services are converted to optical format at 1550 nm by the optical video transmitter. The 1550 nm and 1490 nm wavelengths are combined by the WDM coupler and transmitted downstream together (until now, there have been no plans for upstream video transmission). This combination results in the three wavelengths (1310, 1490 and 1550 nm) carrying different information simultaneously and in various directions over the same fiber.

The feeder cable carries the optical signals between the CO and the splitter, which allows a number of ONTs to be connected to the same feeder cable. An ONT is required for each subscriber and provides connections for the different services (POTS, Ethernet and video). Since one FTTx network typically provides services to 32 subscribers, many such networks originating from the same CO are usually required to serve a community.

The figures below illustrate typical FTTx network architectures. The splitter is located at the fiber distribution hub (FDH), or primary flexibility point (PFP). The common splitter port is spliced, the outputs are pigtailed and connectorized, and the distribution fibers are terminated at the patch panel and at the drop terminal. Each patch-panel connector is associated with a subscriber (see Figure 3), so whenever a new subscriber is activated, a jumper is used to connect a splitter port to the patch panel.

If analog video is offered, angled polished connectors (APC) are used, since high-power transmitters that are sensitive to reflections are required. Ultra-polished connectors (UPC) connectors may be used if only digital video is offered (when less power and sensitivity are required). The diagrams below present details on how the network equipment is installed.

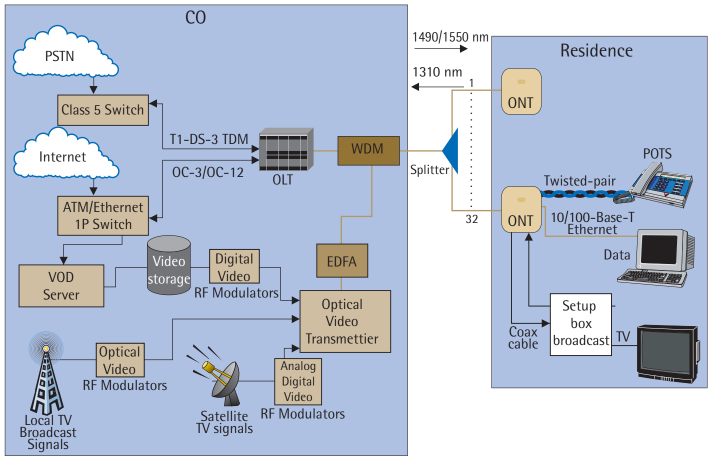


*Figure 1. A typical FTTx network architecture.*

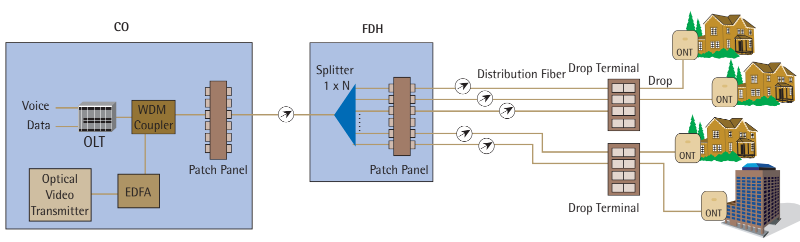


*Figure 2. FTTP network architecture with outside plant equipment.*


*Figure 3. Fiber distribution hub (also called primary flexibility point or PFP), distribution fiber and drop terminal.*

## Installation Testing Requirements

### Feeder Fiber

From the CO's patch panel to the splitter output. Each output must be tested.

- A light source and a power meter (or OLTS) are used to measure the total loss from the CO to the splitter output (main fiber or feeder fiber).
- Optical return loss (ORL) also must be measured.
- For complete link characterization and to locate a problem, an OTDR is used.
- Once tested, each splitter output (all are connectorized) will remain unconnected and be put in a "parking area", to be available later for subscriber activation.

### Distribution Fiber

Distribution fibers are run (aerial or buried) from the fiber distribution hub's (FDH) patch panel to the drop terminal, which can comprise 4 to 12 ports. Similarly, the optical cable can be made of 4 to 12 fibers. After the fiber and drop terminal are installed and connected, the following tests should be performed.

- A light source and a power meter (or OLTS) are used to measure the loss from the FDH to the drop terminal.
- ORL must also be tested.
- For complete link characterization and to locate a problem, an OTDR is used.

## Service Activation Testing Requirements

### Initial CO Activation of Downstream Signals

When two signals are combined, testing occurs at 1550 nm–high power (21 to 23 dBm), for video applications–and at 1490 nm (optical line terminal, or OLT), for data and voice applications. Initially, all splitter outputs are unconnected.

- Measuring optical power at the CO is required to ensure that sufficient power is being delivered to the ONT's network. This is done during the initial activation only, because it cannot be repeated without interrupting service for the entire network.
- To perform this measurement, disconnect the feeder fiber and measure the power directly at the output of the WDM (combining video and OLT). Three methods can be used:
  - A power meter measures the total optical power. Optical filters can be used to measure the power at individual wavelengths.
  - An optical spectrum analyzer (OSA) can be used to perform simultaneous power measurements over a range of wavelengths.
  - A specific wavelength-separating power meter, such as EXFO's PPM-350 PON Power Meter, can be used. This product is outlined further in this article.
- The same type of testing described above should also be performed at the FDH's splitter output.

### Subscriber Activation Scenario

<u>At the fiber distribution hub (FDH)</u>

- Take one available splitter output. Test: measure the two downstream signals to ensure proper level criteria are met. The two signals (1490 and 1550 nm) must be separated.
- Connect the splitter output to the patch-panel subscriber port.

At the subscriber premises

- Install ONT and power up.
- Install and connect the drop cable from the drop terminal to the ONT.

Between drop terminal and ONT (drop installation)

Two downstream signals (1490 and 1550 nm) and one upstream signal (1310 nm) must be tested. Each must meet optical-power-level criteria according to:

- Standards
- Manufacturer recommendations
- Equipment type, bandwidth, etc.

## New Testing Needs and Challenges

PONs and other FTTx networks are generating new fiber-optic testing needs. Indeed, more people will have to work with fiber optics due to the potentially high number of subscribers combined with a highly distributed network. Consequently, technicians mostly accustomed to copper-based networks will need to perform basic tests mostly related to circuit activation and troubleshooting, while experienced "fiber people" will continue to be responsible for installation and qualification.

This creates a need for straightforward test instruments that use pass/fail indicators–namely, power meters–and that require virtually no fiber-optic experience or training, such as EXFO's PPM-350 PON Power Meter.

**PPM-350 PON Power Meter: Main Features**

| | |
|---|---|
| The PPM-350 can measure all signals simultaneously, thanks to a patent-pending approach. | • This is the only way to measure the ONT's signal, since the ONT doesn't transmit when disconnected. |
| It can measure the optical power for any type of signal. | • Continuous (e.g., a TV signal at 1550 nm)<br>• Framed (e.g., ATM, Ethernet at 1490 nm or 1310 nm)<br>• Measurement of all baud rates (e.g., 155 Mb/s, 622 Mb/s, 1 Gb/s and 2.5 Gb/s (synchronous or asynchronous)<br>• Measurement of optical power even if only a keep-alive message is transmitted from the ONT. This is very important, especially when ATM is used (most cases), since there can be long "silent" periods. A power meter not considering this would read no power during ONT installation. |
| It is designed to be used by all technicians, even if they are not specialized in fiber optics. | • Pass/fail interface (optical signals must meet power-level criteria)<br>- Pass (green indicator): optical power level enables perfect operation.<br>- Warning (yellow indicator): system is functional, but a little degradation will cause problems; this may be due to dirty connectors.<br>- Fail (red indicator): power level is too low or inexistent, resulting in disrupted service or no service at all. |
| It allows for testing at various locations. | • Users can specify locations (CO, FDH, drop terminal, ONT, etc.) directly from the unit.<br>• Configurable thresholds: threshold values can be transferred to and from a PC. |

The PPM-350B is available in two configurations, one or two ports, for one-way or pass-through testing.

Connected between the OLT and the ONT, the PPM-352B's two-port configuration acts as a pass-through device. A small percentage of the signal is extracted so as to reach the power meter's detectors. This approach enables all wavelengths to be used simultaneously. Also, since the PON equipment can keep functioning normally, the ONT continues to operate (to respond to the OLT), and therefore to transmit.

The PPM-352B performs simultaneous measurement, display and pass/warning/fail analysis of all signal types including upstream voice and data at 1310 nm; downstream voice and data at 1490 nm; and downstream video at 1550 nm and presents all the values simultaneously on the screen.

The PPM-351B's one-port configuration is ideal for one-way testing, allowing measurement of downstream voice and data at 1490 nm; and downstream video at 1550 nm. This unit also presents all the values simultaneously on the screen.

Both models feature two power-measurement ranges; namely, normal and extended. The extended range allows for measuring high power levels at the central office and before the splitter.

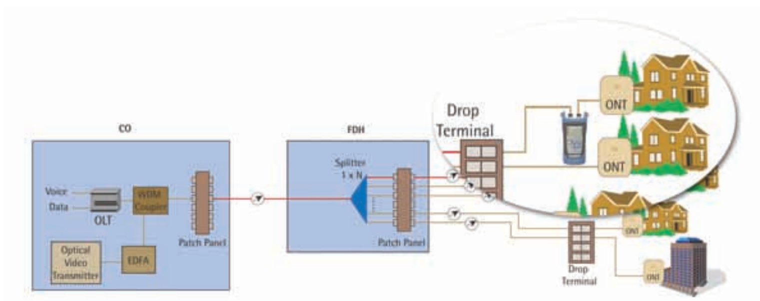


*Figure 4. Testing with the PPM-350B*

## Using the PPM-350 PON Power Meter

The following is an overview of the procedure that must be followed for optimum results.

### *Step 1. Cleaning and Connecting Optical Fibers*

It is especially important that all connectors be properly cleaned and inspected because of the high power levels involved. As singlemode fibers have very small cores, typically 9 µm in diameter, a single particle of dust or smoke can block more than 10% of the transmission area. When making connections, observe the following recommendations:

- Never allow unmated connectors to touch any surface, and never touch a connector ferrule for any reason other than cleaning.
- Clean and inspect each connector using a fiberscope or, better yet, a videoscope after cleaning or prior to mating, even if it was only temporarily disconnected. Clean and inspect test equipment connectors every time the instrument is used, and use a fiberscope or videoscope after cleaning.
- Use an appropriate cleaning method. A dry-air blower, cleaning kit, surface-cleaning pad, tape, or optical-quality fabric cleaner is recommended. Pure alcohol, rated for cleaning fiber-optic components, can also be used.
- Keep unused connector ports capped and keep unused caps in a sealable plastic bag.

**WARNING!** Never look directly into a live fiber with the naked eye. Always use protective gear to inspect cable ends and connectors.

Carefully follow all safety procedures described in each test instrument's user guide.

Never look directly into fibers, equipment apertures or connectors unless you are absolutely sure that the light source has been powered off.

When using a fiberscope, always be absolutely sure that the light source has been powered off. If possible, use a videoscope to inspect fiber ends and connectors.

Do not power on any equipment with laser transmitter(s) until you are sure that all work has been completed on the transmission system and that all cabled fibers have been properly cleaned and connected.

As a number of installations will use APC connectors, special care should be taken when cleaning and connecting these connectors as they are angled. Never connect an APC connector to a PC or UPC connector.

***Step 2. Nulling***

Temperature and humidity variations affect the performance of electronic circuits and optical detectors. Nulling the electrical offsets eliminates these effects. You should perform it whenever environmental conditions change significantly or when measuring very low power values. To perform an offset nulling, simply hold down the corresponding button for a few seconds, and the offsets will be cancelled. The unit displays NULL while nulling the offsets, then returns to the previous mode (Normal or Absolute).

***Step 3. Connecting the PPM-350B***

As shown in Figure 5, the PPM-350B can be used at different locations on the network.

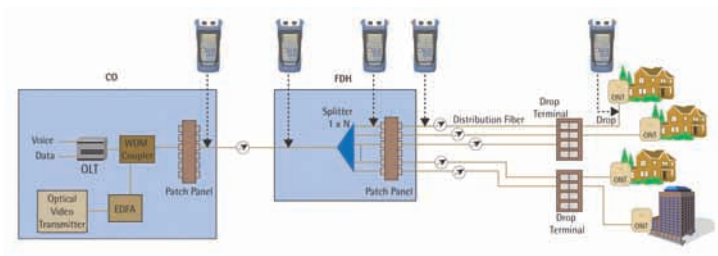


*Figure 5. Testing locations*

For testing at the ONT:

- Connect the drop cable to the PPM-350B's OLT port (directly or through a test jumper if required).
- Connect a test jumper between the PPM-350B's ONT port and ONT.

For testing at the drop terminal:

- Connect a test jumper between the drop terminal and the unit's OLT port.
- Connect another test jumper between the unit's ONT port and the drop cable.

For testing at the fiber distribution hub (FDH) or splitter:

- Connect the splitter's output pigtail directly to the unit's OLT port.
- Connect a test jumper between the unit's ONT port and the patch panel.

***Step 4. Reading the values***

- By default, the PPM-350B displays optical power values and Pass/Warning/Fail status. If LEDs are not lit, press the P/F button to activate them.
- As soon as the connections are performed, the status LEDs of each of the wavelengths will simultaneously light up using the following color code:
  - Green = Pass
  - Yellow = Warning
  - Red = Fail
- To visualize the optical power of each wavelength, simply press the lambda button to switch to the next wavelength.


### Choosing the Right Threshold Set

Different threshold values can be required depending on where the test is performed and on the type of equipment required. The unit allows users to select up to 10 sets of thresholds. Threshold values are also configurable via a PC-based software.

## Ensuring Reliable Troubleshooting and Maintenance

Of course, FTTx networks need to offer the same level of reliability and availability as traditional copper-based access networks. Reliability and availability need to be properly addressed, since the typical access loop comprises more active devices; namely, the ONT, which is powered locally (at the premises) using a small rectifier and battery. Achieving this requires two things: efficient network management and quick on-site problem identification, isolation and fixing.

### Efficient Network Management

The ONT reports any malfunction or degradation to the OLT and, in turn, reports it to the element management system (EMS).

### Quick On-Site Problem Identification, Isolation and Fixing

The first step is to determine if all customers associated with a given splitter experience a similar type of problem, which will indicate whether the problem is located in the feeder fiber or distribution fiber (before or after the splitter).

Then, for the optical portion of the network, the PPM-350B enables the user to accurately locate the problem by measuring all signals to verify if each one is still within specifications–at the ONT, at the drop terminal, at the FDH and at the CO (if required).

### Conclusion

FTTx-based PONs bring never-before-seen services and bandwidth. Subscribers, however, will expect the same level of reliability and availability as for traditional POTS–which can only be achieved by using the right testing approach, as well as the right tools.

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