

Understanding Passive Optical Network Testing

Loss Budget

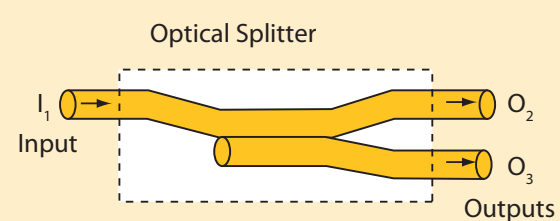
Typical PON loss budget			
	Loss	Number/Link	Total Loss
Splitter (1:64)	18 dB	1	18 dB
Splices	0.1 dB	4	0.4 dB
Connectors	0.5 dB	2	1 dB
Fiber loss			
1310 nm	0.35 dB/km	10 km	3.5 dB
1490 nm	0.22 dB/km	10 km	2.2 dB
1550 nm	0.2 dB/km	10 km	2 dB
	1310 nm	1490 nm	1550 nm
Total Loss	22.9 dB	21.6 dB	21.4 dB

When the network is in service:
 Downstream transmission from OLT to ONT:
 - Voice, data & optional IP video at 1490 nm
 - Optional analog video at 1550 nm
 Upstream transmission from ONT to OLT:
 - Voice & data at 1310 nm

Attenuation $A = aL + x + y$
 a : attenuation coefficient of the fibre
 L : link length
 x : mean splice loss
 y : mean loss of line connectors
 x : number of splices
 y : number of line connectors

Splitter Port Loss

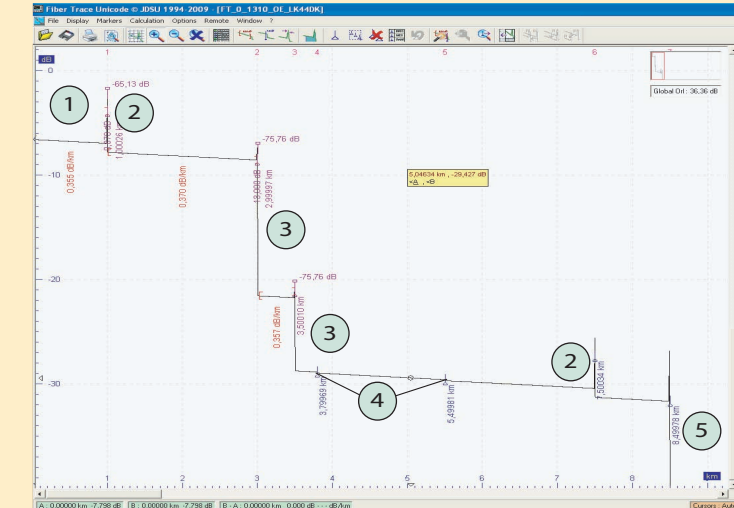
Number of ports	Insertion loss
2	3 dB
4	6 dB
8	9 dB
6	12 dB
32	15 dB
64	18 dB
128	21 dB



Note: Cascaded splitters always induce a higher loss than a single splitter (for the same split ratio)

Typical loss = $10 \log(1/n \text{ ports})$

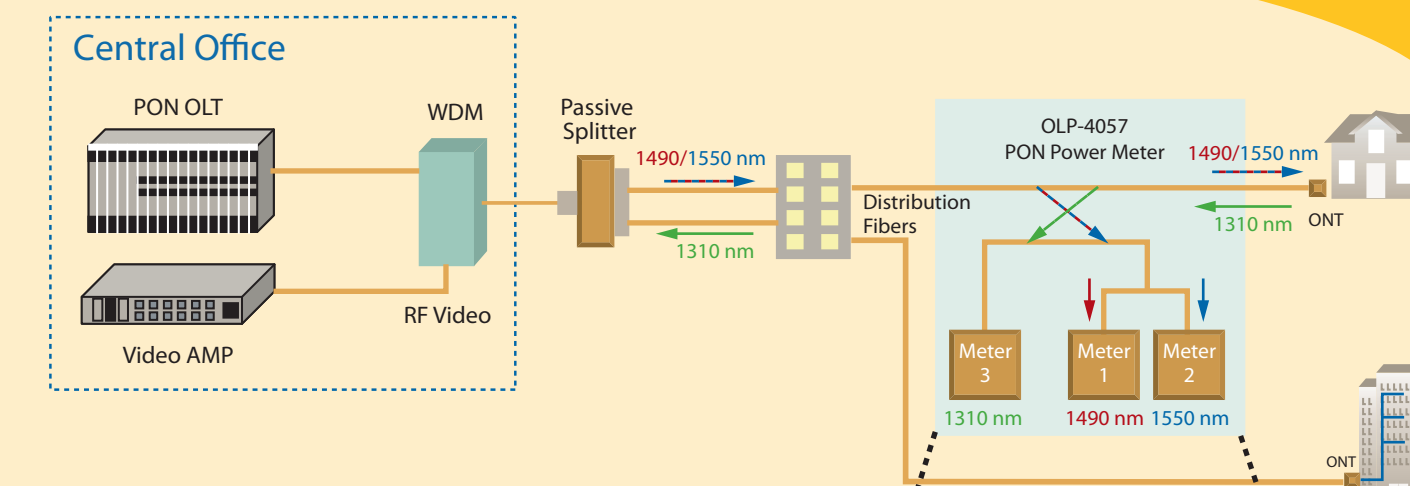
OTDR PON Trace



- Launch cable
- Connector
- Splitter
- Splice
- End of fiber

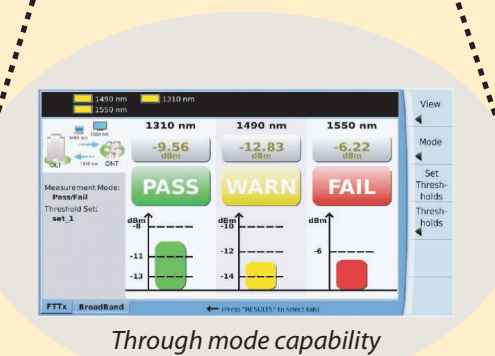
OTDR PON trace from the ONT with cascaded splitters

PON Power Meter



Through Mode

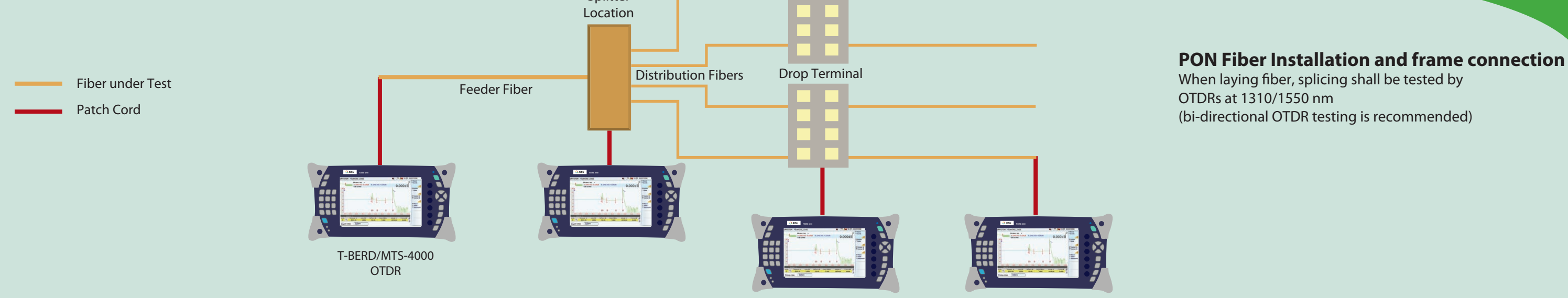
- FTTH PON power meter for turn-up and maintenance.
- Simultaneous measurement at 1490, 1550 nm (downstream) and 1310 nm (upstream)
- PON power meter can be inserted in through mode in a network to measure power levels (for both upstream and downstream).
- The PON power meter does not affect the traffic and can be used to troubleshoot at any point in the network.



Broadband Mode

- Broadband power meter (780 up to 1650 nm)
- Basic power level measurements (when no 1550 nm video overlay is present).

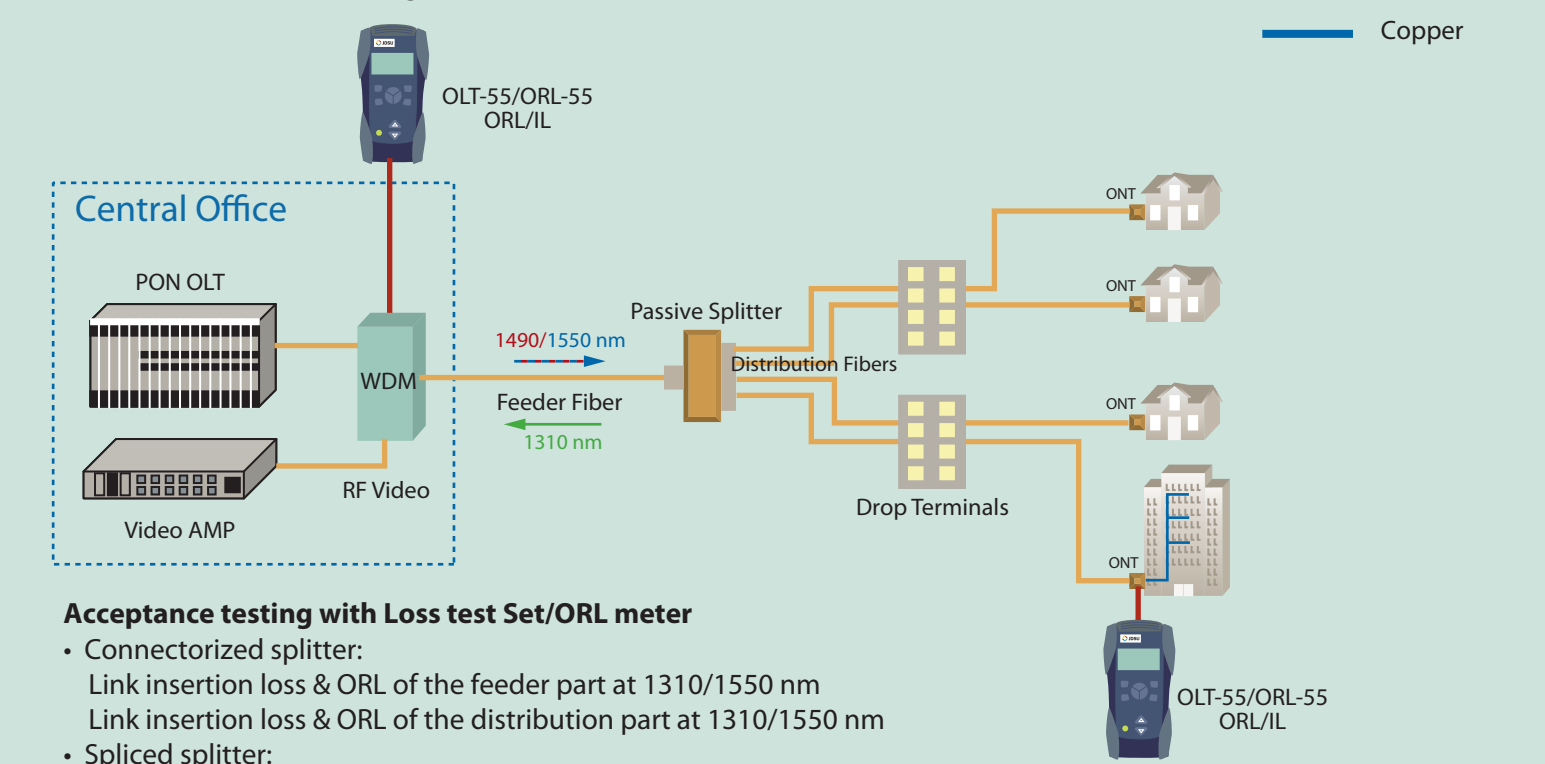
Fiber Installation



PON Fiber Installation and frame connection
 When laying fiber, splicing shall be tested by OTDRs at 1310/1550 nm (bi-directional OTDR testing is recommended)

Construction/Acceptance Testing

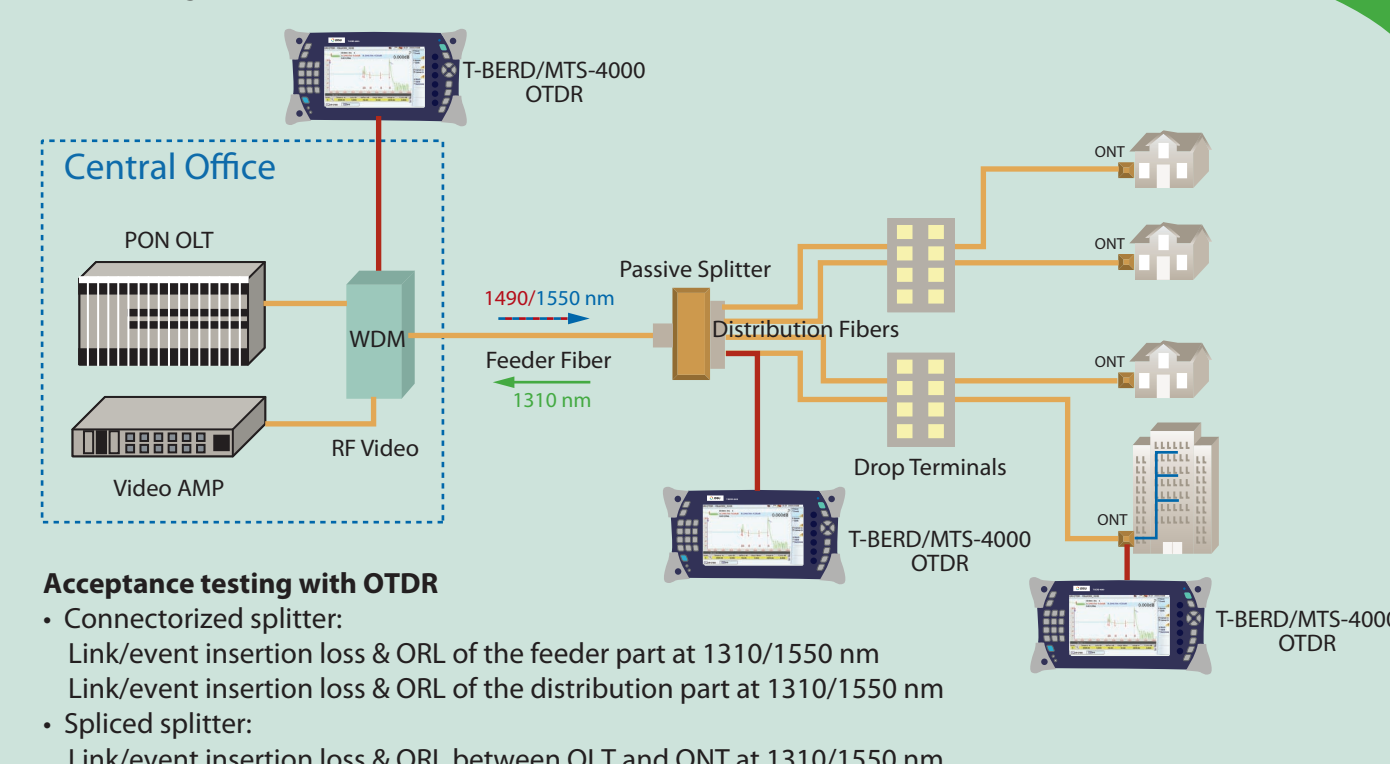
Loss Test Set/ORL Meter Testing



Acceptance testing with Loss test Set/ORL meter

- Connectorized splitter: Link insertion loss & ORL of the feeder part at 1310/1550 nm
Link insertion loss & ORL of the distribution part at 1310/1550 nm
- Spliced splitter: Insertion loss & ORL between OLT and ONT at 1310/1550 nm

OTDR Testing

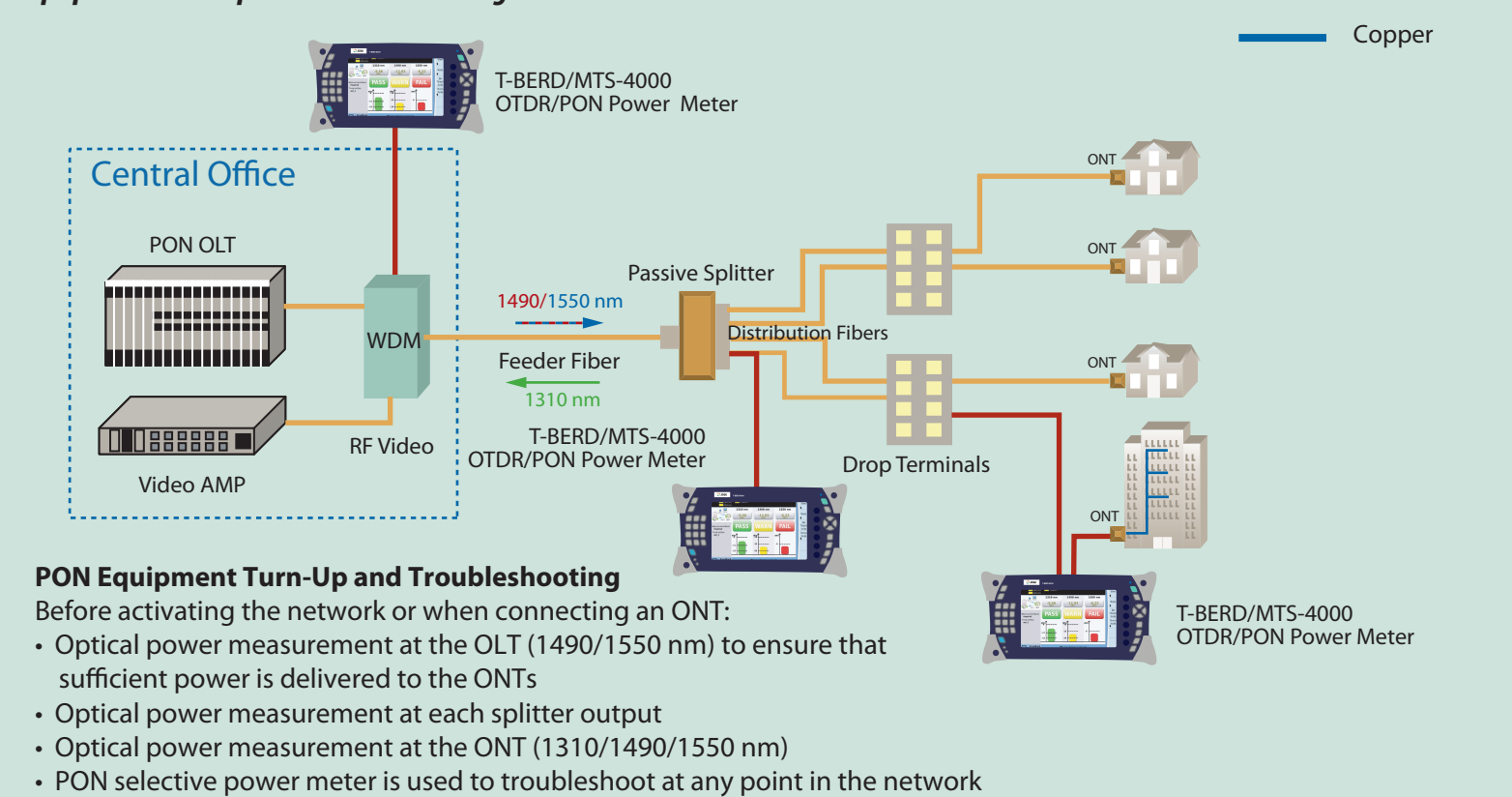


Acceptance testing with OTDR

- Connectorized splitter: Link/event insertion loss & ORL of the feeder part at 1310/1550 nm
Link/event insertion loss & ORL of the distribution part at 1310/1550 nm
- Spliced splitter: Link/event insertion loss & ORL between OLT and ONT at 1310/1550 nm

Turn-up and Troubleshooting Testing

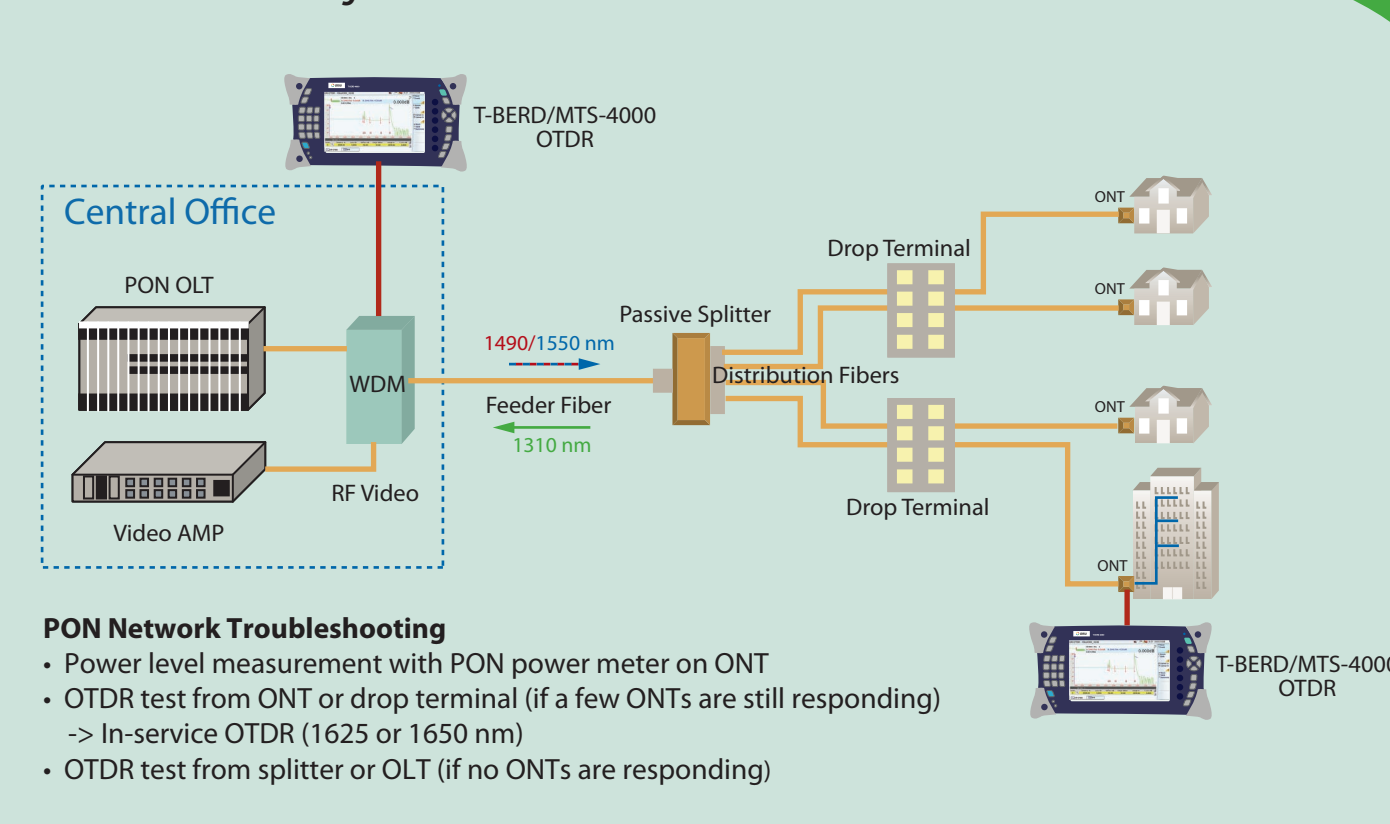
Equipment Turn-up and Troubleshooting



PON Equipment Turn-Up and Troubleshooting

- Before activating the network or when connecting an ONT:
- Optical power measurement at the OLT (1490/1550 nm) to ensure that sufficient power is delivered to the ONTs
- Optical power measurement at each splitter output
- Optical power measurement at the ONT (1310/1490/1550 nm)
- PON selective power meter is used to troubleshoot at any point in the network

Network Troubleshooting



PON Network Troubleshooting

- Power level measurement with PON power meter on ONT
- OTDR test from ONT or drop terminal (if a few ONTs are still responding) -> In-service OTDR (1625 or 1650 nm)
- OTDR test from splitter or OLT (if no ONTs are responding)

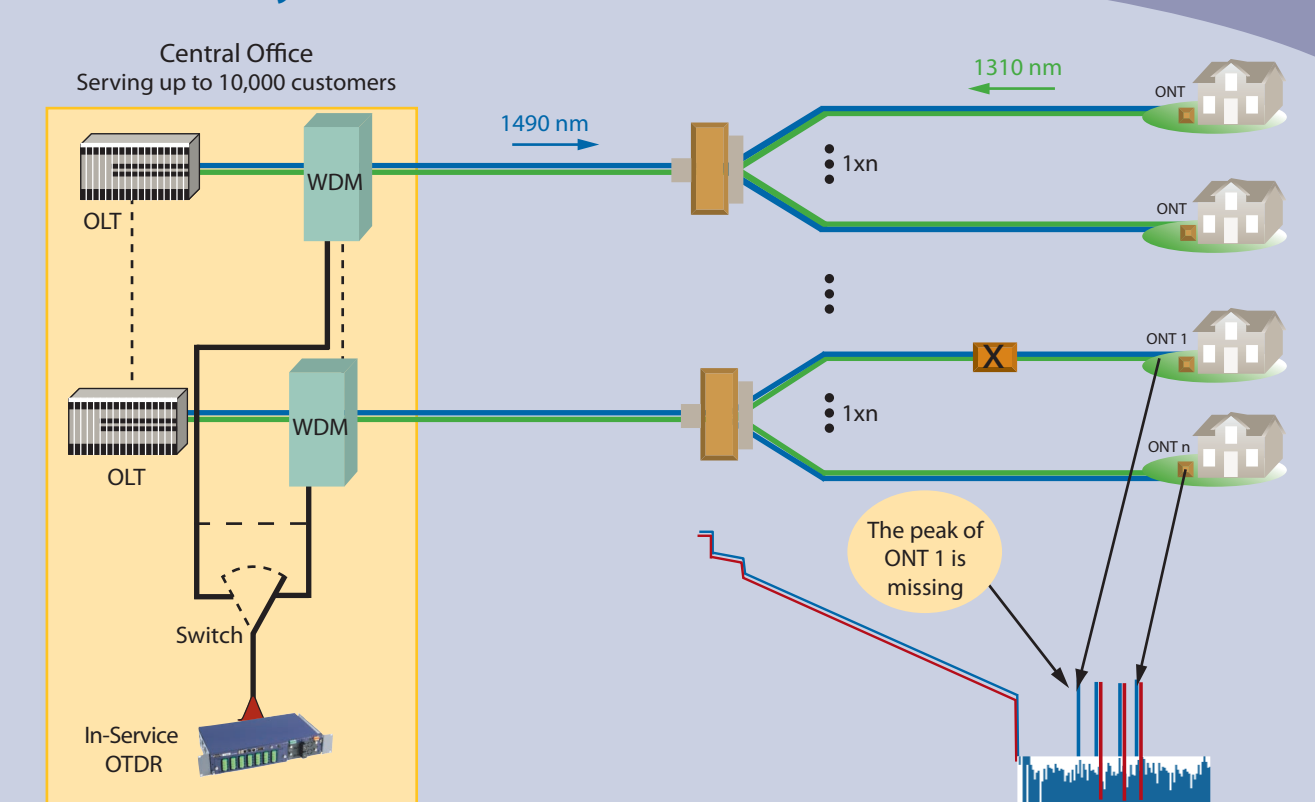
JDSU Solutions

	FI-10 Fiber Identifier	VFL-100 Visual Fault Locator	FBP Video Probe	OTS-55 Optical Talk Set	OLT-55 Loss Test Set	ORL-55 Return Loss Meter	OLP-57 Selective PON Power Meter	T-BERD/MTS-4000	OTU-8000
Description	The FI-10 identifies the presence of optical signal on fiber without the need to open the fiber at the splice point. It detects continuous wave, live optical transmission, and 270 Hz, 1 and 2 kHz modulated tones.	Visual Fault Locator - Is an essential tool that quickly and easily locates problem areas in fiber cables. By pinpointing the exact location of fiber damage, technicians can diagnose, troubleshoot, and fix the problem efficiently.	The FBP-series of video inspection probes are used to inspect fiber optic connector end faces. Combined with the T-BERD/MTS-4000 via USB, they provide fast and easy connector inspection.	The OTS-55 provides clear digital voice transmission over a single fiber. Handsfree operation makes communication even more convenient for technicians by using either a headset or the "speakerphone" mode.	The OLT-55 performs Optical Power Measurement, Insertion Loss. It is a universal instrument for installation, maintenance and troubleshooting of single mode fiber. It can also be used as a standalone power meter or laser source.	The ORL-55 Optical Return Loss Meter combines three different functions in one field-optimized instrument, including an optical return loss meter, an optical power meter, and a triple-wavelength laser source.	The OLP-57 is a Selective Power Meter for testing FTTH/PON systems. Its through mode allows simultaneous measurement at all three wavelengths on the fiber: 1490 nm and 1550 nm downstream and 1310 nm upstream.	The T-BERD/MTS-4000 is a Multiple-Services Test Platform. Its OTDR module permits to measure attenuation along the fiber, detect events, measure ORL, IL. The selective PON power meter provides power level measurements, with pass-through mode.	The OTU-8000 lies at the core of JDSU optical network management system (ONMS) combining in-service OTDR and optical switch for monitoring hundreds of fiber links.
Construction	✓	✓	✓	✓	✓	✓	✓	✓	
Turn-up	✓	✓	✓	✓	✓	✓	✓	✓	
Troubleshooting	✓	✓	✓	✓	✓	✓	✓	✓	

Acronyms and Abbreviations

ATM	Asynchronous Transfer Mode
B-PON	Broadband Passive Optical Network
CO	Central Office
DSLAM	Digital Subscriber Line Access Multiplexer
E-PON	Ethernet Passive Optical Network
G-PON	Gigabit Passive Optical Network
IL	Insertion Loss
NOC	Network Operation Center
OLT	Optical Line Terminal
ONT	Optical Network Terminal
ONU	Optical Network Unit
ORL	Optical Return Loss
OTDR	Optical Time Domain Reflectometer
PON	Passive Optical Network
RFoG	Radio Frequency Over Glass
TDM	Time Division Multiplexing
WDM	Wavelength Division Multiplexing

PON Test System



Using an OTDR, PON network can be automatically monitored in service. The level of the peak generated by the reflective termination is checked at each acquisition. The peak disappears if the fiber is cut or its level decreases in case of fiber attenuation. This system allows to check the fiber continuity from the central office up to the customer. Such a system is the only way for technicians to know if the problem comes from the physical infrastructure (fiber, splitter, connector) or from the equipment (OLT, ONU, ONT).

PON Standards

Span	Next Gen PON						
	B-PON	G-PON	E-PON	10G-PON	10GE-PON	RFoG over PON	Pure WDM-PON
Span	20 km	60 km max, 20 km differential	10/20 km	60 km max, 20 km differential	10/20 km	20 km	60 km max, 20 km differential
Maximum insertion LOSS	20/25/30 dB	20/25/28/30/32 dB	15/20 dB	20-30+ dB TBD	20/24/29 dB	Like selected PON	To be defined
Maximum number of branches	32	64 (128 considered)	32	64 (128/256 possible)	64 (128 possible)	64	64 (128/256 possible)
Bit rates (Gbit/s)	Down: 0.155, 0.62, 1.25 Up: 0.155-0.62	Down: 1.25 - 2.5 Up: 0.155, 0.62, 1.25, 2.48	Down: 1.25 Up: 1.25	Down: 10 Up: 10	Down: 10 Up: 10	Like selected G/E-PON Like selected G/E-PON	May fall under NG-PON2 May fall under NG-PON2
Wavelengths (nm)	Down: 1480-1500 Up: 1260 - 1360	Down: 1480 - 1500 (WDM overlay possible) Up: 1260 - 1360	Down: 1400 - 1500 (Video overlay 1550)	Down: 1575-1580 (WDM overlay possible) Up: 1260-1280	Down: 1575-1580 Up: 1260-1280	Down: 1490 Up: 1310	To be defined
Traffic Mode	ATM	ATM, TDM, WDM, Ethernet	Ethernet	TDM, WDM, Ethernet NG-PON1: G-PON compatible	Ethernet	TDM, WDM, ATM	WDM
Video overlay	1550 nm	1550 nm	1570 nm	1550 nm	1550 nm	1550 nm	Yes, to be defined
Applicable standard	ITU-T G.983.x	ITU-T G.984.x	IEEE 802.3ah	ITU-T G.987.x Mid 2010	IEEE 802.3av End 2009	IPS SP910	To be defined

Understanding PON Testing

To learn more, visit www.jdsu.com/fttx



We wrote the book on Triple Play Testing. Visit us online for your free copy.

