Understanding Passive Optical Network Testing

VIAVI Solutions

Build & Construction Phase

Requirements	*What to look for*	*What to use*
Connector end face verification	Dirty or damaged fiber connector end faces	Inspection Scope FiberChek/P5000i
Feeder & distribution fiber characterization (mixed fiber types, splices, connectors)	Fiber lengths are as laid out in the design spec Bends Splice loss under 0.1dB	OTDR (Real-time when splicing) Bi-Dir IL/ORL/OTDR (for commissioning) FiberComplete
Commissioning the end-to-end PON once splitters and drop boxes connected in order to prove the final build is within network equipment specifications. (ONT/ONU to OLT direction)	Excessive splitter losses Good inter-connections at Splitters, Drop Terminals & Patch Panels	PON OTDR SmartOTDR with FTTH-SLM
Documentation and reporting	Test fails, missing or duplicated results	Instrument / Cloud StrataSync Test Process Automation (TPA) Suite
Construction Phase: Centralized Test		
Alternate centralized approach to commission the end-to-end PON as it is built out. (OLT to ONT/ONU direction)	As above plus ODN Insertion Loss	PON Test System ONMSi or SmartOTU

Tips

- Feeder & distribution fibers: OTDR uni-directional test as a minimum, better to test bi-directionally as this gives more accurate results and finds more items (potential faults) that might be hidden by OTDR dead zones. Look for solutions that fully automate the process and use only a single test port in order to significantly reduce test and report generation times
- Use a minimum of 2 wavelengths for bend detection, typically 1310 & 1550nm, preferably a third at 1625 or 1650nm as this improves bend detection and future proofs the network for NG- PON2, also gives you a solution that can be used for in-service troubleshooting once the PON is activated.
- 1490nm OTDR testing yields no better results than 1550nm test.

Network Activation Phase

Requirements	*What to look for*	*What to use*
Connector end face verification	Dirty or damaged fiber connector end faces	Inspection Scope FiberChek/P5000i
Downstream power measurement G-PON / XGS-PON	Bad DS power level	Selective power meter OLP-37X V2
Downstream power measurement G-PON / XGS-PON Drop fiber certification Splitter continuity check (to OLT) ONT/ONU connectivity check	Bad DS power levels Confirm no bends, breaks or excessive losses within the drop fiber Confirm drop fiber is connected to a splitter port and there is continuity to the OLT Confirm drop fiber into premises is good and ONT/ONU is connected	Optical Fiber Meter Optimeter
Accurately measure downstream & upstream power with multi-wavelength selective power meter G-PON / XGS-PON / NG-PON2	Bad US/DS power levels ONT/ONU is alive and responding to OLT	PON Power Meters OLP-87 OLP-88
Activation verification (PON-ID)	ONT/ONU connected to correct port of OLT	TRUE-PON Tester with G-PON data analysis OLP-88
Documentation and reporting	Test fails, missing or duplicated results	Instrument / Cloud StrataSync
Network Activation Phase: Centralized Test		
Verify tech install or self install is complete to trigger service activation	Fiber Continuity to the premises Verify reflector installation in the home	PON Test System ONMSi or SmartOTU

Tips

- To verify DS power level only, meter must be wavelength selective if there is RFoG, Video Overlay or Co-existence of multiple PON services (Note: you cannot use a broadband power meter in those situations)
- To verify DS and US power levels for the ONT/ONU and that the device is responding to the OLT you need a through mode PON power meter

Service Activation Phase

Requirements	*What to look for*	*What to use*
Verify PON service delivery independently of ONT/ONU G-PON or XGS-PON connection	Is the PON network connection good Does OLT respond Can ONT/ONU get an IP address PON throughput speed test	PON network & in-premises service tester NSC-100
In-premises service distribution test (Ethernet & WiFi connections)	IP address allocated. Ethernet & WiFi throughput speeds WiFi channel & signal strength	PON network & in-premises service tester NSC-100
Documentation and reporting	Test fails, missing or duplicated results	Instrument / Cloud StrataSync

Tips

- Emulate an ONT to prove the PON network delivery is good and validate service delivery to the premises (PON interface)
- Test Ethernet and WiFi service distribution to prevent future call backs

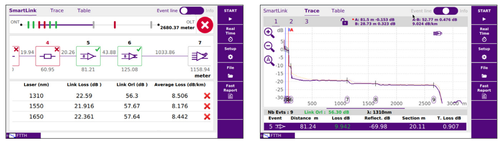
Maintenance & Troubleshooting Phase

Requirements	*What to look for*	*What to use*
Connector end face verification	Dirty or damaged fiber connector end faces	Inspection Scope FiberChek/P5000i
Downstream power measurement G-PON / XGS-PON	Bad DS power level	Selective power meter OLP-37X V2
Downstream power measurement G-PON / XGS-PON Drop fiber certification Splitter continuity check (to OLT) ONT/ONU connectivity check	Bad DS power levels Confirm no bends, breaks or excessive losses within the drop fiber Confirm drop fiber is connected to a splitter port and there is continuity to the OLT Confirm drop fiber into premises is good and ONT/ONU is connected	Optical Fiber Meter Optimeter
Accurately measure downstream & upstream power with multi-wavelength selective power meter G-PON / XGS-PON / NG-PON2	Bad US/DS power levels. ONT/ONU is alive and responding to OLT	Through mode PON power meter OLP-87 OLP-88
Verify PON service delivery independently of ONT/ONU G-PON or XGS-PON connection	Is the PON network connection good Does OLT respond Can ONT/ONU get an IP address PON throughput speed test	PON service meter NSC-100
In-premises service distribution test (Ethernet & WiFi connections)	IP address allocated Ethernet & WiFi throughput speeds WiFi channel & signal strength	PON service meter NSC-100
Check fiber continuity with In-Service 1625/1650nm PON OTDR or fiber meter (ONT/ONU to OLT direction)	Excessive splitter losses Good inter-connections at Splitters, Drop Terminals, Patch Panels Locate fiber breaks	PON OTDR or Optical Fiber Meter SmartOTDR with FTTH-SLM Optimeter
Check fiber continuity with In-Service 1650nm OTDR (OLT to ONT/ONU direction)	Fiber continuity to premises Verify reflector installation in home Locate fiber breaks	Fiber Monitoring ONMSi

Tips

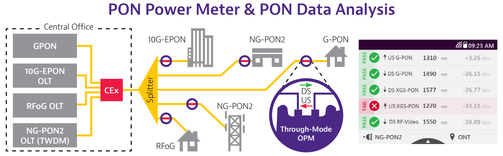
- OTDR test using filtered 1625 or 1650nm so you don't disrupt live services to other customers
- Use a PON OTDR which utilises a multiple pulse acquisition technique with a dedicated test app in order to test through splitters (single or cascaded) and locate faults on any section of the PON
- From the field; check for fiber continuity from premises to the CO (ONT/ONU to OLT) with PON OTDR or fiber meter
- Centrally, check for fiber continuity from the CO to the premises (OLT to ONT/ONU) with monitoring tools

Simplifying OTDR with FTTH-SLM



FTTH-SLM (SmartLink Mapper) is an OTDR software application dedicated to FTTH/PON OTDR testing, to characterize each section of the network as well as passive components such as splitters, connectors and splices. It dynamically adjusts the testing parameters and automatically performs multiple measurements to achieve the optimum test results. All the information gathered is displayed as a single icon-based view and a combined OTDR trace.

PON Power Meter & PON Data Analysis



Through Mode & Upstream Burst Mode

- Wavelength selectivity allows independent and simultaneous measurement of multiple PON services
- Through mode, insert a PON power meter into a network to measure both upstream and downstream power levels, instrument must have low IL
- Must support burst mode measurement because upstream wavelengths use TDM

G-PON Data Analysis

- G-PON & XGS-PON contain network specific information (PON-ID) that can be used to enable service activation test & troubleshooting

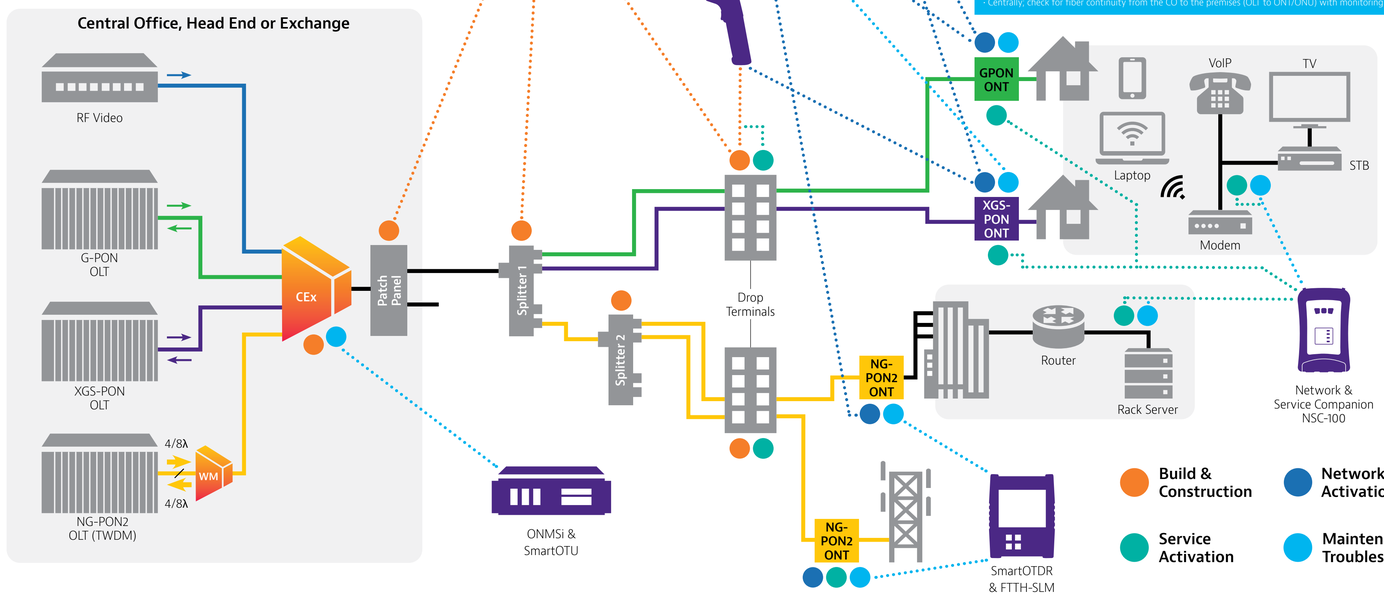
G-PON data analysis enables

- Verification of ONU/ONT activation process
- Identification of OLT Port and ONU/ONT serial number
- Detection of Rogue ONUs/ONTs and Alien devices
- In-service measurement of ODN Insertion Loss

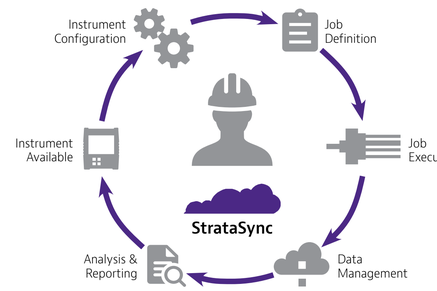
Tip:

- Alien device = CPE not approved by Service Provider, not fully under OLT control (e.g. basic media converter) typically not an ONT/ONU (e.g. media converter) which will disrupt PON service/traffic

Central Office, Head End or Exchange

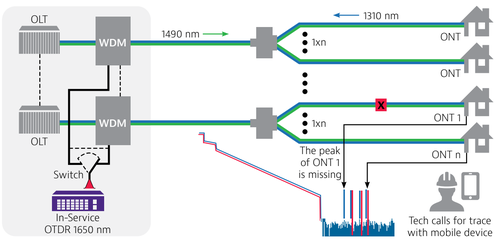


StrataSync Test Process Automation Suite for Field Test Efficiency



Test Process Automation (TPA) allows your team to deliver expert-level test results and close projects on the first try, every time. TPA is a closed loop test system that optimizes workflows, eliminates manual, error prone work and automates immediate data reporting for job close out, team progress updates and network health analytics. Execute jobs efficiently to ensure high quality network builds, rapid turn-up/activation and enhanced operational visibility.

PON Test System



Centralized PON Construction Qualification:

Centralized PON Test is used to characterize, validate and map end to end PON networks remotely from the CO to the termination point. The network is tested as it's built creating a baseline to allow automatic location of faults or damage, saving many hours of test set up, test acquisition and documentation.

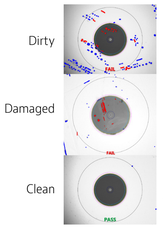
Centralized PON Network Monitoring with a Switched OTDR:

Optical test heads can automatically monitor and locate problems in PON networks. This system checks for fiber continuity from the CO to the customer and is the only way to know whether problems stem from the physical infrastructure (fiber, splitter, connector) or the equipment (OLT, ONU, ONT) without visiting the premises.

Inspect Before You Connect (IBYC)

Contamination is one of the main causes of optical network failure. Just one particle of dust can cause permanent damage and interrupt traffic. Inspection is the only way to determine if fiber optic connectors need to be cleaned or replaced before coupling.

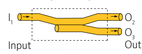
Automated objective assessment, with clear pass/fail information, based on industry standards (such as IEC 61300-3-35) verses subjective assessment is the only way to ensure high quality and reliable connections and avoid damage to expensive equipment (laser Tx/Rx, switches & routers).



Splitter port losses

Number of ports	Insertion loss
2	3 dB
4	6 dB
8	9 dB
16	12 dB
32	15 dB
64	18 dB
128	21 dB

1 x N Optical Splitter



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

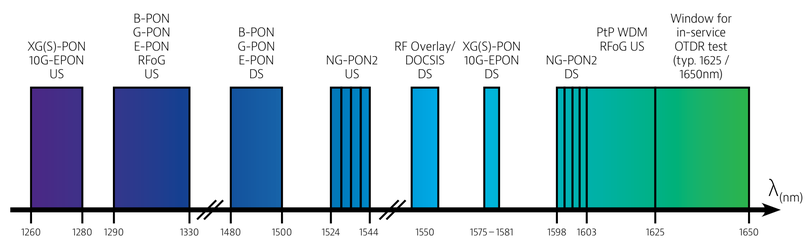
2 x N Optical Splitter

Note: Insertion loss is the same for both types of splitter (1xN & 2xN) but OTDR testing output to input result is different — loss for 2xN is 1.5dB lower than loss shown in the table

PON Standards: Evolution and Deployment

	G-PON	XGS-PON (sym)	NG-PON2	GE-PON	10G-EPON	100G-EPON
Standards	ITU-T G.984 (2003)	ITU-T G.9871 (2016)	ITU-T G.989 (2015)	IEEE 802.3ah (2004)	IEEE 802.3av (2009)	IEEE 802.3ca (2019 TBD)
DS / US Data Rates	2.4 / 1.2 GBps	10 / 10 GBps	40 (4x10) / 40 (4x10) GBps	1.25 / 1.25 GBps	10 / 10 GBps	Up to 100 / 100 GBps
Splitting Ratio	up to 1:64 (128)	up to 1:128 (256)	up to 1:128 (256)	up to 1:64	up to 1:128	TBD
Fiber Type	G.652	G.652 / G.657 (for new inst.)	G.652 / G.657 (for new inst.)	G.652	G.652 / G.657 (for new inst.)	G.652 / G.657 (for new inst.)
Max Loss	32 dB	35 dB	35 dB	29 dB	29 dB	TBD
Co-existence	N/A	YES with G-PON	YES with G-PON and XGS-PON	N/A	Yes with GE-PON	YES with GE-PON and 10G-EPON

PON Spectrum: Wavelength Allocation and Co-existence Plan



Acronyms and Abbreviations

CO	Central Office
NOC	Network Operation Center
FTTH	Fiber To The Home
PON	Passive Optical Network
DS	Downstream
US	Upstream
B-PON	Broadband Passive Optical Network
E-PON	Ethernet Passive Optical Network (IEEE)
10G-EPON	10 Gigabit Ethernet PON (IEEE)
G-PON	Gigabit Passive Optical Network (ITU-T)
XGS-PON	10 Gigabit Symmetrical PON (ITU-T)
NG-PON2	Next Generation PON (ITU-T)
ODN	Optical Distribution Network
OLT	Optical Line Terminal
ONT	Optical Network Terminal (ITU-T)
ONU	Optical Network Unit (IEEE)
IBYC	Inspect Before You Connect
IL	Insertion Loss
ORL	Optical Return Loss
OTDR	Optical Time Domain Reflectometer
RFoG	Radio Frequency Over Glass (DOCSIS)
RF Overlay	Radio Frequency Overlay
TDM	Time Division Multiplexing
WDM	Wavelength Division Multiplexing
CEx	Coexistence Element
WM	Wavelength Multiplexer

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