ODN Link Detection Guide

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Objectives

- Upon completion of this course, you will be able to:
  - Understand the components of the ODN and Huawei ODN products.
  - Understand mainstream ODN check tools and parameters.
  - Describe the procedure, tools, and precautions for ODN engineering inspection.
  - Describe the procedures, tools, and precautions for ODN service provisioning and O&M detection.

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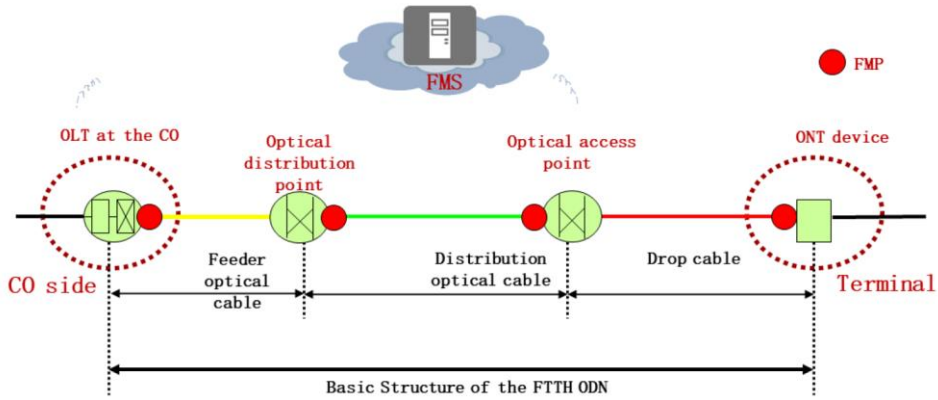
ODN Overview (1)



- Optical distribution network (ODN): Provides optical channels between the OLT and the ONT. The drop cable section is the most difficult part of the ODN deployment.
- Fiber management point (FMP): Indicates the test access points used for ODN fault diagnosis.

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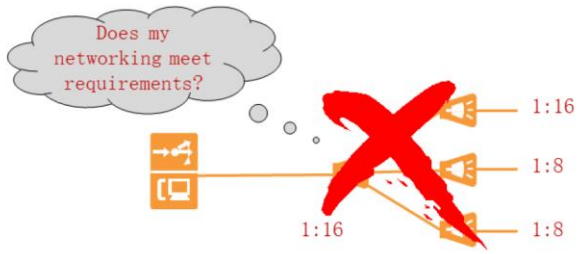
ODN Overview (2)

- Split ratio description
  - Currently, the GPON supports a maximum of 1: 128 optical splitting, and EPON supports a maximum of 1:64 optical splitting. It is recommended that no more than two levels of optical splitting be used in the ODN networking.
- Case of split ratio:
  - An ODN planning engineer plans the following ODN networking diagram:



The split ratio of an ODN link is not determined by the number of connected devices. As long as you connect an optical splitter, optical attenuation occurs. For the first link, the split ratio is 1:16 x1:16 = 1:256, exceeding the maximum split ratio supported currently.

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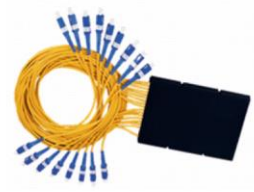
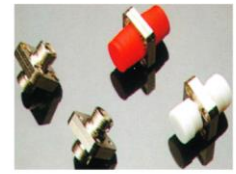
ODN Product Description

ODF

Optical splitter (rack-mounted)

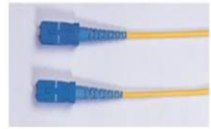


Optical splitter (small sized)



Adapter (FC-FC)

Adapter (SC-SC)



Pigtail

Patch cord

Optical cable

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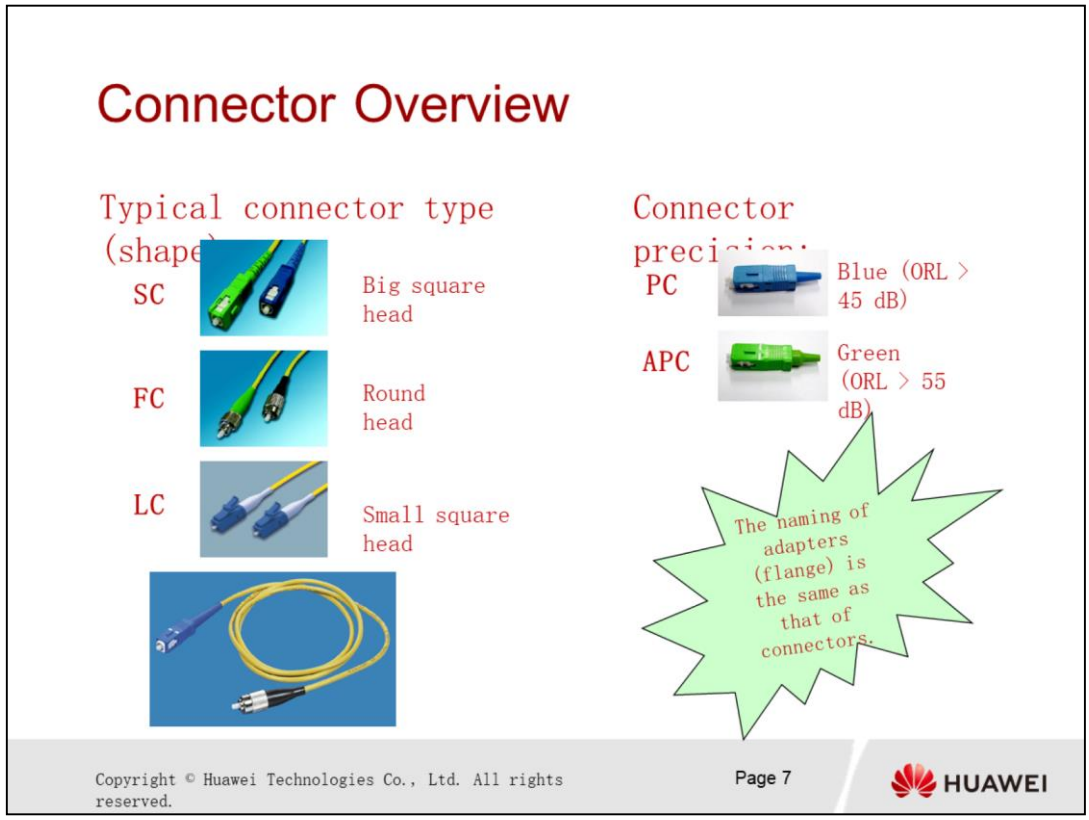

- ORL: Return loss
- Insert the optical fiber connector into the optical fiber adapter. The precision is divided into PC plane-blue, UPC spherical-blue, and APC slope-green.
- An APC connector cannot be interconnected with a PC/UPC connector. APC connectors are mainly used for CATV services.

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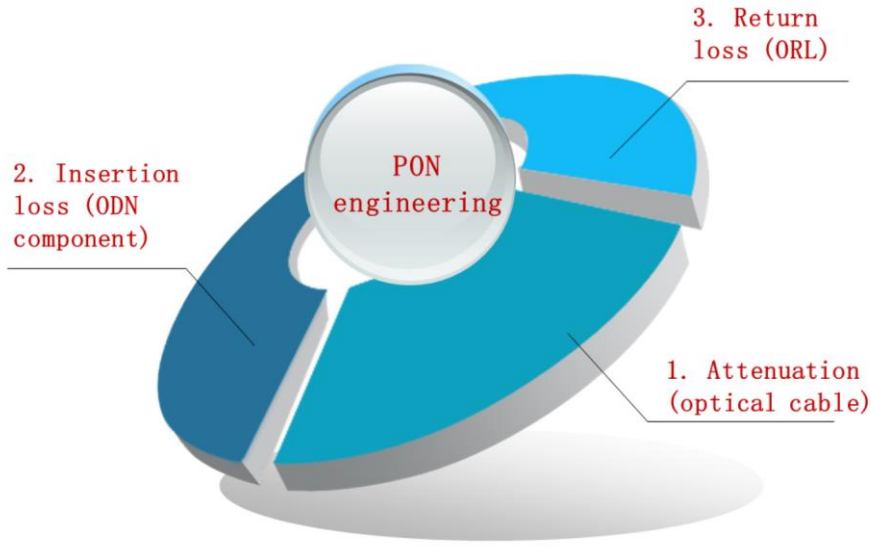
Key Parameters of the ODN Network



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Attenuation

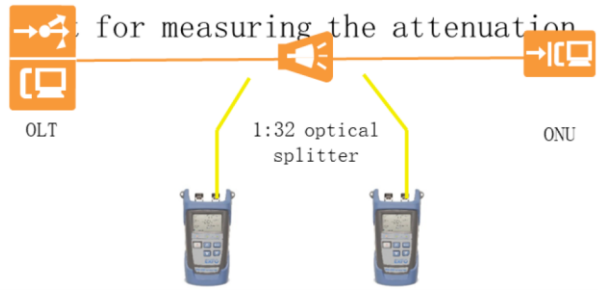
- Attenuation is the decrease of optical power during the transmission of optical signals along the optical cable.

$$DB = 10 \lg\left(\frac{Output\ power}{Input\ power}\right)$$

Name	Type	Average Loss (dB)
Optical fiber (G.652D)	1310 nm (1 km)	≤ 0.35
	1550 (1 km)	≤ 0.21
Optical fiber (G.657A)	1310 nm (1 km)	≤ 0.38
	1550 (1 km)	≤ 0.25

Insertion Loss

- Insertion loss refers to the dB ratio of the output optical power to the input optical power after an optical signal passes through an active connector or an optical splitter.
- The method for measuring the insertion loss is the same as that for measuring the attenuation.



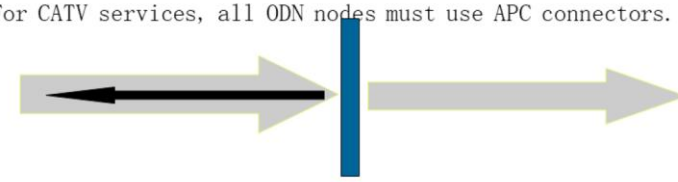
Typical loss of ODN components

Name	Type	Average Loss (dB)
Connector	Cold connection	≤ 0.2
	Splicing	≤ 0.1
	Active connection	≤ 0.3
Optical splitter	1:64 (PLC)	≤ 20.5
	1:32 (PLC)	≤ 17
	1:16 (PLC)	≤ 13.8
	1:8 (PLC)	≤ 10.6
	1:4 (PLC)	≤ 7.5
	1:2 (FBT)	≤ 3.8

- PLC: Planar waveguide optical splitter
- FBT: Fused tapered optical splitter
- The production techniques of the two types of optical splitters are different. For details, see the related documents.

Return Loss (ORL)

- Return loss is also called reflection loss. It refers to the dB ratio of the backward reflection light to the input light at a fiber joint.
  - The larger the return loss is, the better it is to reduce the impact of reflected light on the light source and system.
  - It is recommended that the minimum line ORL be 45 dB.
  - The return loss of precision PC is greater than 45 dB, and that of APC is greater than 55 dB.
  - For CATV services, all ODN nodes must use APC connectors.



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Overview of ODN Link Detection Components

- Common Test Tools
  - Optical power meter and light source
  - OTDR
  - Fiber recognition instrument
  - Fiber connector cleaning tool
- PON network test tool
  - PON network power meter
  - OTDR (penetrable optical splitter)
  - Fault locator

ODN Link Detection Component (1)

- Optical power meter
  - Measure the absolute optical power or the relative loss of the optical power after a section of fiber.

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- In optical fiber systems, an optical power meter is a most basic tool frequently used to measure the optical power in an optical link, very much like a multimeter in electronics. By measuring the absolute power of a transmitter or optical network, an optical power meter can evaluate the performance of the optical devices. If the optical power meter is used with a stable light source, the connection loss and continuity can be measured, and the transmission quality of the optical fiber link can be evaluated.

ODN Link Detection Component (2)

- Light source

- A stable light source refers to a light source with stable output optical power, wavelength, and spectral width. A stable light source transmits light with known power and wavelength in an optical system. It used together with an optical power meter to measure the optical loss of an optical fiber system. For an existing optical fiber system, the transceiver of the system may be used as a stable light source. If the transceiver cannot work or there is no transceiver, a separate stable light source is required. The wavelength of the stable light source should be as close to the wavelength of the system transceiver as possible. After a system is installed, the end-to-end loss often needs to be measured to determine whether the connection loss meets the design requirements.

ODN Link Detection Component (3)

- OTDR (impenetrable optical splitter)
  - By transmitting optical pulses to the tested optical fiber, the tool detects the Rayleigh scattering and Fresnel reflection values returned by the optical fiber to obtain the physical features such as the length and loss of the tested fiber. In addition, the data analysis function can be used to accurately locate event and fault points in the optical path.

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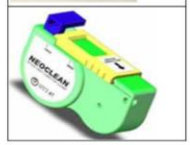
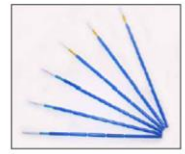
- OTDR: Optical Time Domain Reflectometer

ODN Link Detection Component (4)

- Others:

Fiber cleaning tool





NTT connector cleaning tool

NTT adapter cleaning tool

You can also use the "dust-free cloth + anhydrous alcohol" mode which is more economical.

Fiber recognition instrument

- Tests signal presence, directions, and power.
- Identifies the fiber sequence without interrupting services.

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- During maintenance, installation, cabling, and restoration, an optical fiber recognition instrument is a necessary tool for maintaining optical fibers. It is used to identify optical fibers without interrupting services. It can be used to detect and separate a specific optical fiber at any position of a single-mode or multi-mode optical fiber. It transmits optical signals with a specific modulation signal at 1310 nm or 1550 nm into the optical fiber at one end to recognize a fiber route or indicate the service.

ODN Link Detection Component (5)

- PON network power meter

- Test the optical power values of signals with different wavelengths carrying sound, data, and image at the same time.
- It can work in pass-through mode, that is, the meter is placed between the OLT and the ONT so that all service signals pass through the meter during the test.

ODN Link Detection Component (6)

- OTDR (penetrable optical splitter)

- The maximum dynamic range is 50 dB, and the shortest dead zone is 0.8 m.
- The penetrable optical splitter can be used to test the entire PON network.
- 1310/1490/1550/1625 nm wavelengths are used.
- Touchscreen, easy to operate.

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ODN Link Detection Component (7)

- Fault locator (red light pen)

  - Emits a continuous or pulsed red light into the optical fiber. The read light leaks at sharp bends or fiber break points.
  - Identifies causes of loss such as break points, over bending, connector faults, and splicing.

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- A red light pen is also called a light pen, a pen red light source, a visible light detection pen, a fiber fault detector, and a fiber fault locator. Most of them are used to detect fiber break points. Currently, red light pens are classified by the shortest detection distance: 5 km, 10 km, 15 km, 20 km, 25 km, 30 km, 35 km, and 40 km.

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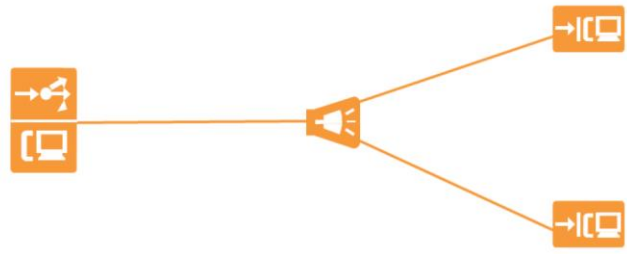
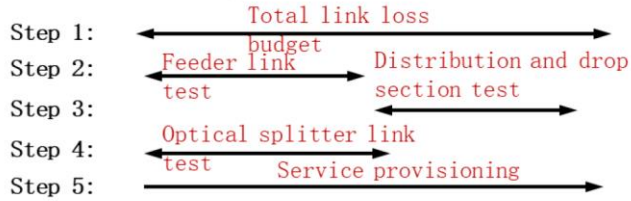
ODN Test Procedure



Recommended test procedure:



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Step 1: Total Loss Budget

- According to the PON type, check each component on the ODN before the test. The total loss of the ODN link includes the following aspects:
  - Optical splitter loss
  - Splicing and cold connection loss
  - Connector and adapter (flange) loss
  - Fiber transmission loss
  - Extra line loss (about 3 dB)
- In the case of the integrated CATV service, the following factors need to be considered:
  - WDM loss. The loss of each WDM coupler is usually about 0.7–1.0 dB.
  - When the 1550 nm wavelength is used for CATV transmission, the link power budget needs to be calculated separately. The attenuation of 1550 nm is about 0.2 dB/km, and the minimum optical power of a CATV receiver is –8 dBm.

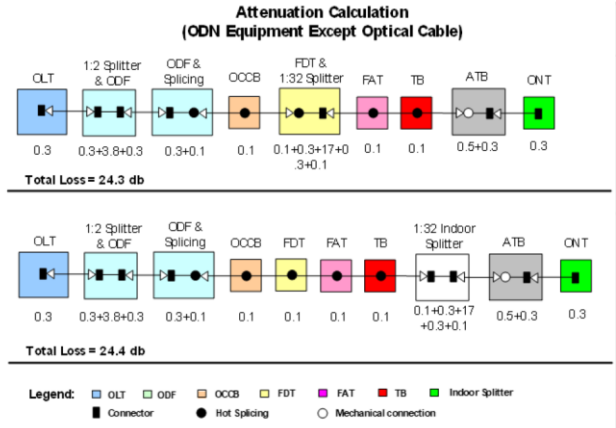
Step 1: ODN Link Attenuation Budget Requirements

- The GPON optical module meets the Class B+/C+ standard and the requirements of 20 km and 1:128

split ratio. Item	Unit	Single-mode optical fiber		
		GPON Class B+	EPON PX10	EPON PX20
Optical power				
Maximum optical link loss	dB	28.5	21	26
Minimum optical link loss	dB	13	5	10

It is recommended that certain attenuation redundancy be reserved for links during ODN network planning.

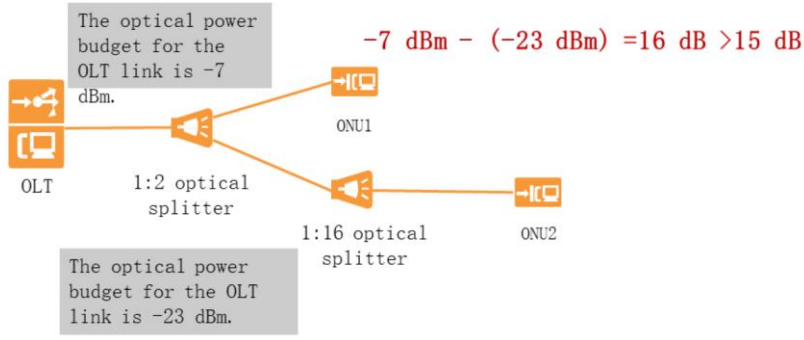
Step 1: Example of Total Loss Budget



Name	Type	Loss (dB)
Connection Point	Cold connection	≤ 0.2
	Splicing	≤ 0.1
	Active connection	≤ 0.3
Optical splitter	1:64 (PLC)	≤ 20.5
	1:32 (PLC)	≤ 17
	1:16 (PLC)	≤ 13.8
	1:8 (PLC)	≤ 10.6
	1:4 (PLC)	≤ 7.5
	1:2 (FBT)	≤ 3.8
Optical fiber (G.652D)	1310 nm (1 km)	≤ 0.35
	1550 (1 km)	≤ 0.21

Step 1: Dynamic Range of Uplink Loss

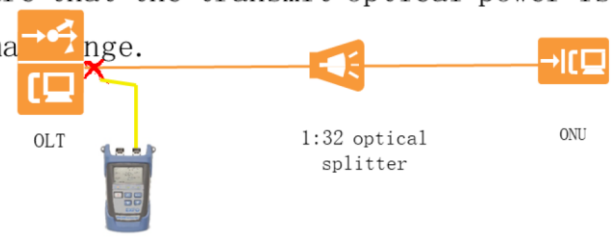
- Dynamic range of an OLT receiver



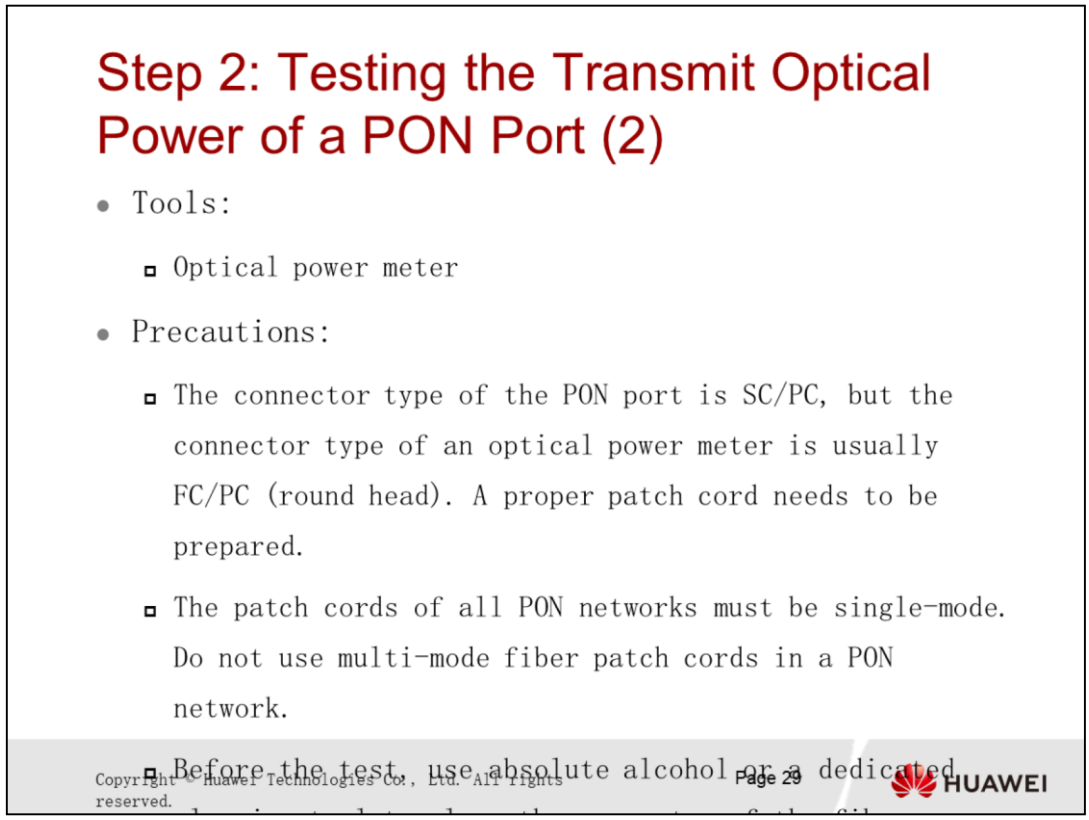
The dynamic range of an OLT receiver is within 15 dB. That is, the difference between the maximum and the minimum optical attenuation should be within 15 dB. Otherwise, the BER increases or even some ONUs go offline.

Step 2: Testing the Transmit Optical Power of a PON Port (1)

- Test the transmit optical power of an OLT PON port to ensure that the transmit optical power is within the normal range.



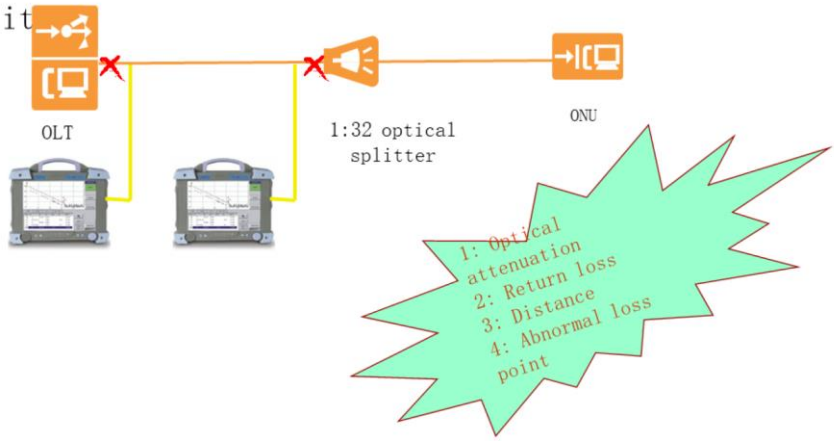
Item	Unit	Single-mode Optical Fiber		
		GPON Class B+	EPON PX10	EPON PX20
OLT				
Minimum average transmit power	dBm	1.5	-3	2
Maximum average transmit power	dBm	5	2	7
Receiver sensitivity	dBm	-28	-24	-27
Overload optical power	dBm	-8	-1	-6



- A single-mode fiber patch cord is yellow, and a multi-mode fiber patch cord is orange (with a darker color).

Step 3: Feeder Link Test - OTDR (1)

- Test the link status of the backbone optical cable (feeder section) from the PON port to the optical split

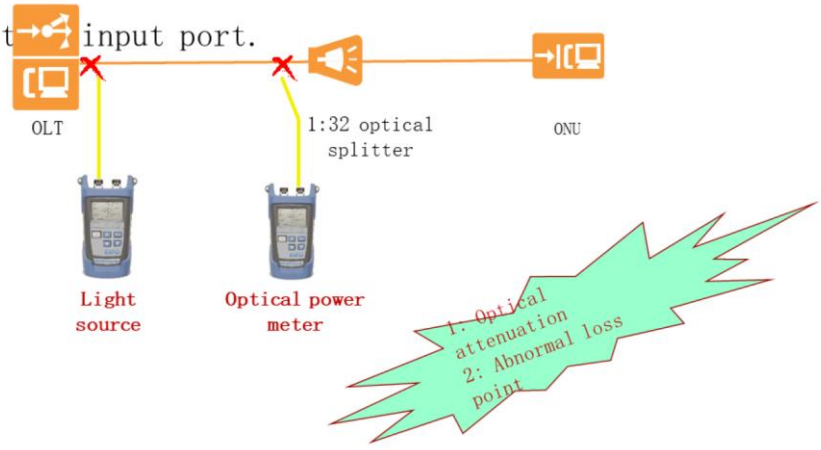


Step 3: Feeder Link Test - OTDR (2)

- Precautions:
  - Most OTDRs cannot penetrate optical splitters. In a downstream test from the OLT side, the distance displayed on the OTDR is the distance from the OLT to the optical splitter.
  - During the OTDR test, the optical fiber link must not have a light source. Otherwise, the OTDR test result will be interfered.
  - When performing an upstream test from the optical splitter to the OLT, disconnect the optical fiber from the PON port if necessary. When performing a downstream test from the OLT, ensure that no device emits light steadily on the ONT side.
  - It is recommended that you perform tests in both directions.

Step 3: Feeder Link Test - Optical Power Meter (1)

- Test the link status of the backbone optical cable (feeder section) from a PON port to the optical split input port.



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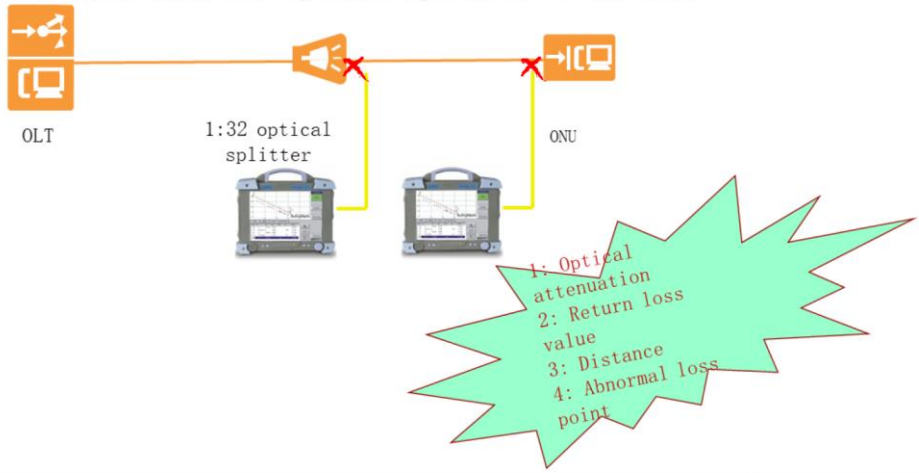
Step 3: Feeder Link Test - Optical Power Meter (2)

- Precautions:
  - If there is no OTDR and only an optical power meter is available, you need to test the optical attenuation of each adapter node separately. In this case, the ORL (return loss) and distance cannot be tested.
  - When using the optical power meter, ensure that the opposite end has a stable light source device.
  - The method of using an optical power meter to test the distribution and drop sections is similar to that of the feeder section. The test is performed node by node.

It is recommended that the OTDR be used for testing and acceptance.

Step 4: Link Test for the Distribution and Drop Sections (1)

- Test the link of the distribution and drop (branch) sections from the optical splitter to the ONT.



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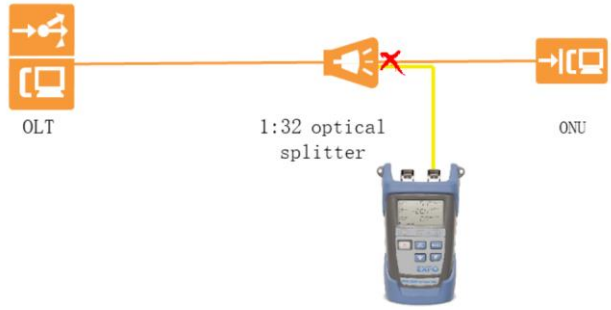
Step 4: Link Test for the Distribution and Drop Sections (2)

- Precautions:
  - Most OTDRs cannot penetrate optical splitters. In an upstream test, the tested distance is the distance between the ONT and the optical splitter.
  - The OTDR test fiber must not have any light source interference along the link. Note that the upstream and downstream wavelengths used for the test must be 1310 nm, 1490 nm, or 1550 nm.
  - It is recommended that you perform tests in both directions.

Step 5: Optical Splitter Port Test (1)

- Test each output port of an optical splitter to ensure that the insertion loss of the optical splitter complies with the specifications.



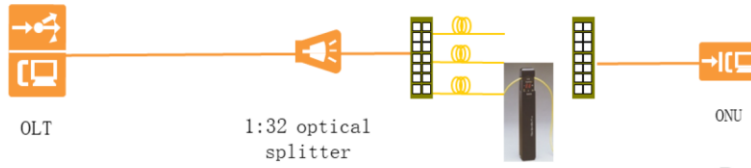
Step 5: Optical Splitter Port Test (2)

- Precautions:
  - Optical splitters have various types of connectors. Therefore, proper fiber patch cords must be prepared in advance.
  - A stable light source is required when the optical power meter is used for the test.
  - The optical splitter connector needs to be removed and inserted frequently during the test. After the test is

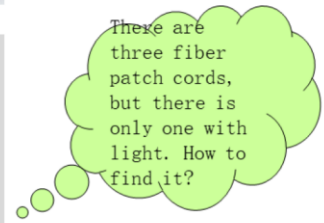
If possible, use an OTDR that can penetrate optical splitters to test each optical splitter.

Optical Fiber Identification (1)

- Tools: Optical fiber recognition instrument or optical power meter.



1. An optical fiber recognition instrument can be used to detect whether a fiber patch cord or pigtail has optical signals.
2. An optical fiber recognition instrument can accurately detect light signals before the optical fiber is spliced. However, an optical power meter must have a matching connector.



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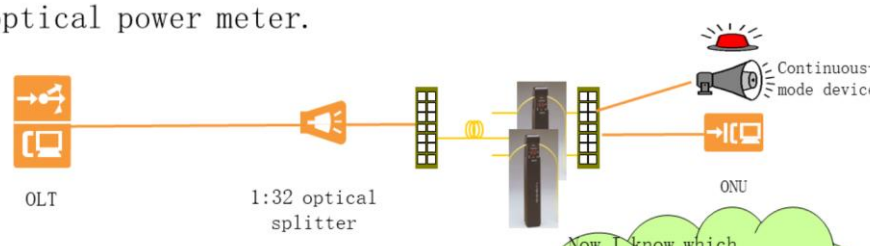
Optical Fiber Identification (2)

- Tools: Optical fiber recognition instrument or optical power meter.



1. Normally, in a PON network, the ONT does not emit light before being connected to the network.
2. If a patch cord from the ONT side has optical signals, it indicates that there are rogue ONTs or other light sources.

Now I know which pigtail is connected to the optical splitter. How to prevent the downstream from being connected to a rogue ONT or other light sources?

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Service Provisioning Test (1)

- The optical power of the OLT GPON optical interface must meet the requirements of the optical module.
  - For example, if the sensitivity of an optical module is -28 dBm and the overload optical power is -8 dBm, the optical power received by the ONT must be greater than -28 dBm and smaller than -8 dBm.

Item	Unit	Single-mode Optical Fiber			
		GPON Class B+	GPON Class C+	EPON PX10	EPON PX20
Minimum average transmit power	dBm	1.5	3	-1	-1
Maximum average transmit power	dBm	5.0	7.0	4	4
Receiver sensitivity	dBm	-28	-30	-24	-27
Overload optical power	dBm	-8	-8	-3	-3

Service Provisioning Test (2)

- The actual loss of the ODN link is within the budget loss.
  - Example: At site A, the optical power of the PON port on the OLT is 3 dBm, the total attenuation budget of the link to an ONT is 15 dB, and the optical power budget at the ONT is -12 dBm. However, the onsite test result shows that the optical power received by the ONT is -21 dBm.

Service Provisioning Test (3)

- Use an optical power meter to test the ONT. Ensure that the ONT optical module does not emit light continuously.
  - In normal cases, the ONT optical module does not emit light before it is connected to the PON network. If the optical module keeps transmitting optical signals (that is, stable optical signals can be tested), replace the ONT or shut down the optical module.

Service Provisioning Test (4)

- Ensure that the distance is within the related PON standard range.
  - A GPON optical module meets the Class B+ standard and meets the requirements of 20 km & 1:64 split ratio.
  - An EPON optical module complies with the PX10/PX20 standard and meets the requirements of 10 km & 1:32 split ratio or 20 km & 1:16 split ratio.

Service Provisioning Test (5)

- Other Issues
  - Ensure that the connectors are of the same type and that the pigtail connectors are clean.
    - For example, if the connector type of the ONT is SC/APC (green square), the type of the two ends of the adapter must be SC/APC. An SC/PC connector cannot be connected to an SC/APC connector.
    - When an SC/PC connector is interconnected with an SC/APC connector, the attenuation can be as high as 20 dB. Even if the attenuation is normal during the test, the network may be faulty at any time later on.

Summary

- Components of ODN Products
- Common ODN Detection Tools
- ODN Construction Detection and O&M Detection

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Appendix: Common Faults in FTTx Optical Line Projects

- Frequent issue
  - Fiber end contamination and damage: dust, water vapor, other foreign, and improper touch or cleaning
  - Water intrusion: FTTH ODN in a harsh environment
- Possible issues
  - The bending radius is too small.
  - The pulling force is too large due to external tearing and cabling problems.
  - Side pressure exceeds the threshold due to tight binding or pressing.
- Reflection points: The fiber connectors are not properly connected, the splicing is poor, or the fiber is cracked.
- Incorrect identification: An optical fiber is incorrectly connected.
- Incorrect fiber type: The optical fiber used does not meet specification requirements.

Appendix: Optical Power Budget - GPON

Item	Unit	Single Fiber (GPON)		
		Class B+	Class C+	Class C++
Minimum average transmit power	dBm	1.5	3	6
Maximum average transmit power	dBm	5	7	10
Receiver sensitivity	dBm	-28	-32	-35
Overload optical power	dBm	-8	-12	-15

Appendix: Optical Power Budget - 10G GPON

Item	Unit	Single Fiber (XG-PON)	
		N1	N2a
Minimum average transmit power	dBm	2	4
Maximum average transmit power	dBm	6	8
Receiver sensitivity	dBm	-27.5	-29.5
Overload optical power	dBm	-7	-9

Item	Unit	Single Fiber (XGS-PON)
		N1
Minimum average transmit power	dBm	2
Maximum average transmit power	dBm	6
Receiver sensitivity	dBm	-28
Overload optical power	dBm	-6

Thank You

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