Field Testing and Troubleshooting of PON LAN Networks per IEC 61280-4

Jim Davis

Regional Marketing Engineer

Fluke Networks

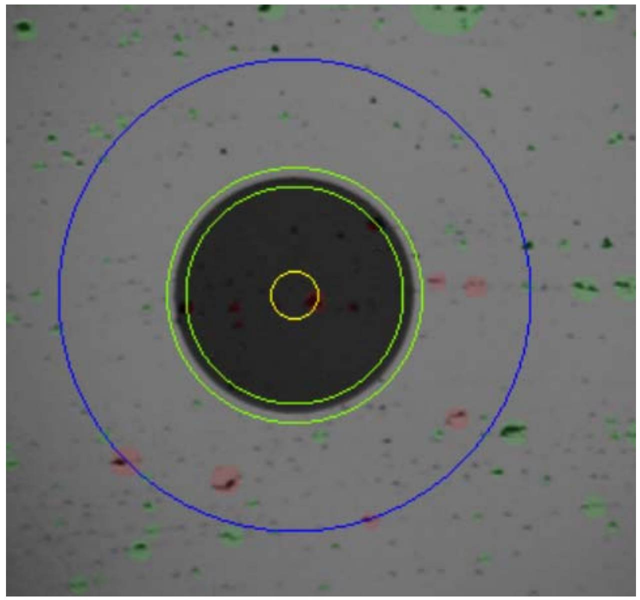
Agenda

- Inspection and Cleaning
  - APC vs UPC
- PON basics
  - Wavelengths
  - Architecture
    - Splitters
- Loss Budget – how many Connectors/Splitters
  - Setting a reference
  - Far End Source
- Troubleshooting
  - Where to connect?
  - OTDR
  - Power Meter
- Document Results

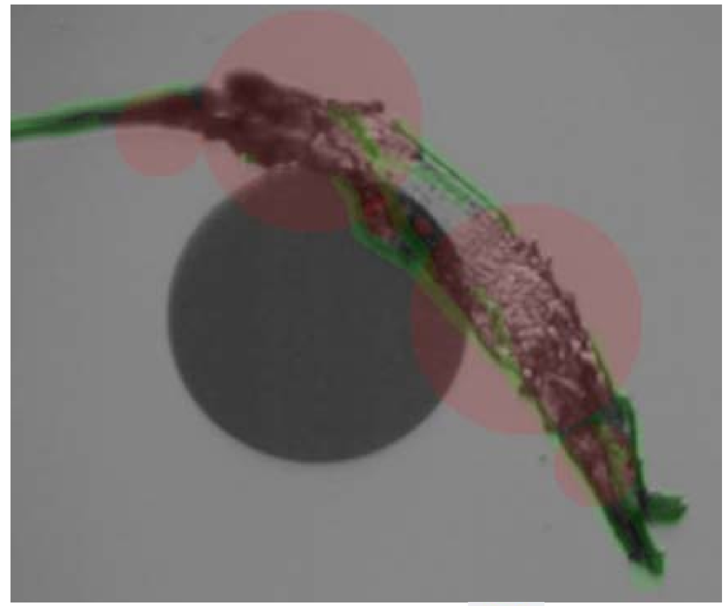
Inspection, and, if necessary, Cleaning
(repeat as needed)

Please be sure to Inspect ALL Connectors before installing, clean them if necessary, inspect again!!

Video Microscope



Brand new out of bag

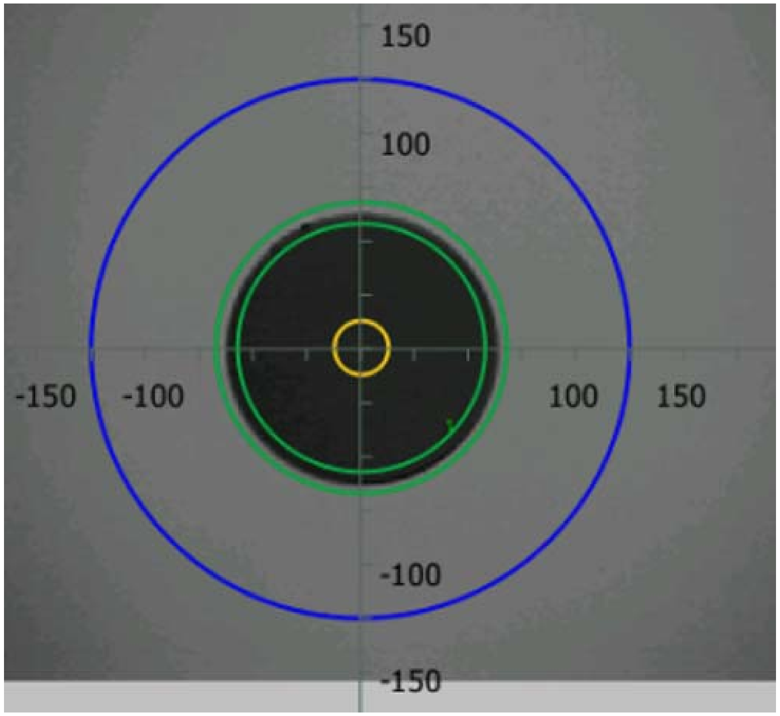


After Cleaning 🙄

Automated Analysis – Single Mode APC Limits

IEC 61300-3-35 ED.2 SM APC

Zone Name	Scratches	Defects
A: Core (0-25µm)	4 ≤ 3 µm None > 3 µm	None
B: Cladding (25-115µm)	No Limit	No Limit < 2 µm 5 from 2 - 5 µm None > 5 µm
C: Adhesive	No Limit	No Limit
D: Contact (135-250 µm)	No Limit	No Limit < 10 µm None > 10 µm

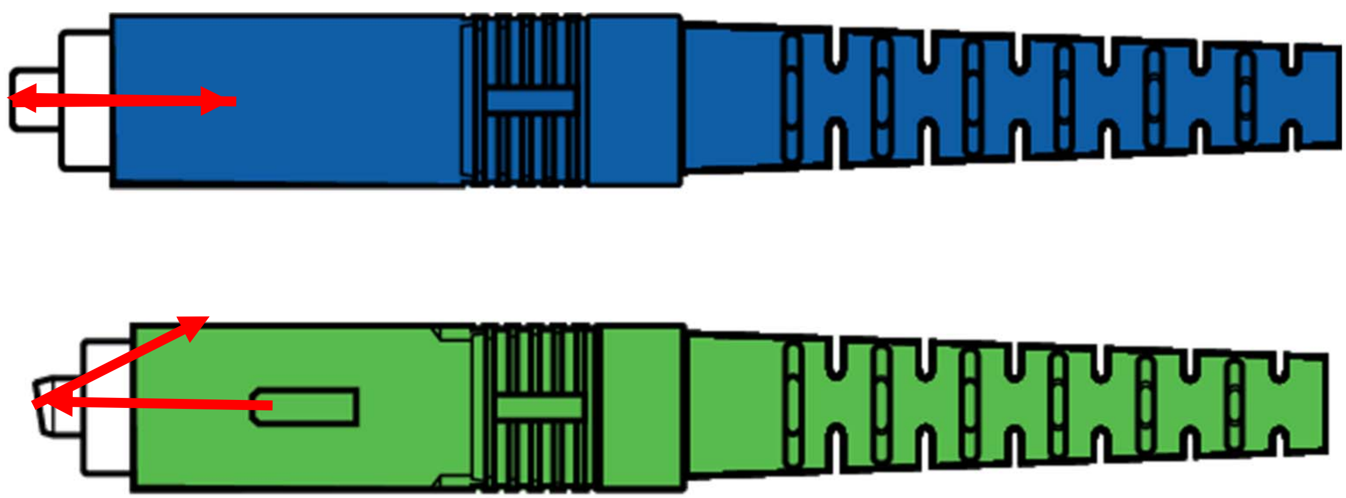


That little angle on the APC minimizes back reflection

Especially important with high-power transmissions to avoid damage to equipment

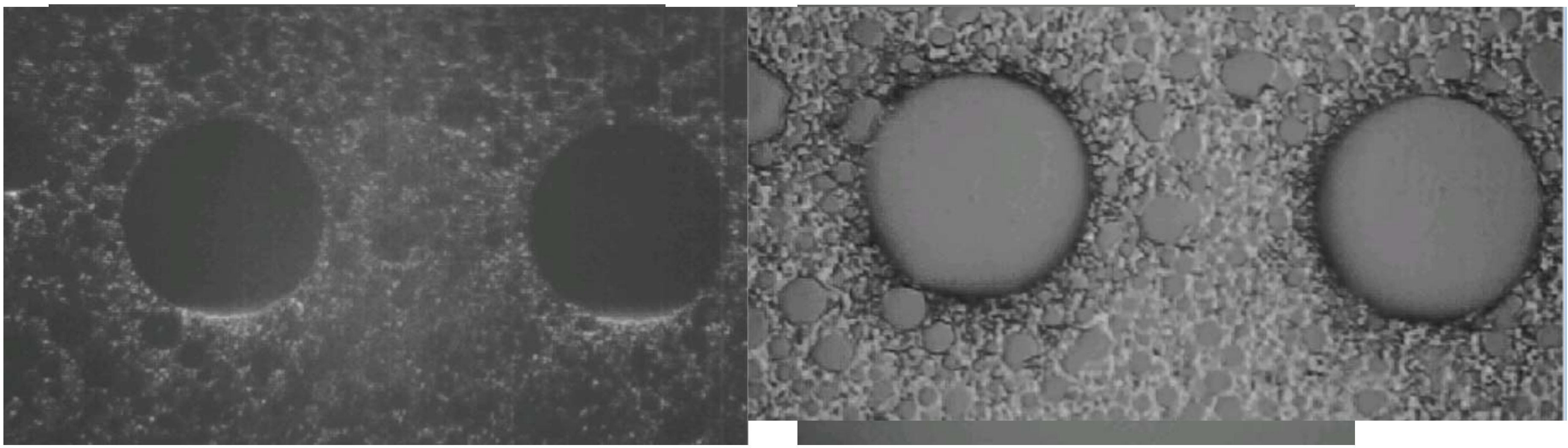
PC/UPC

APC



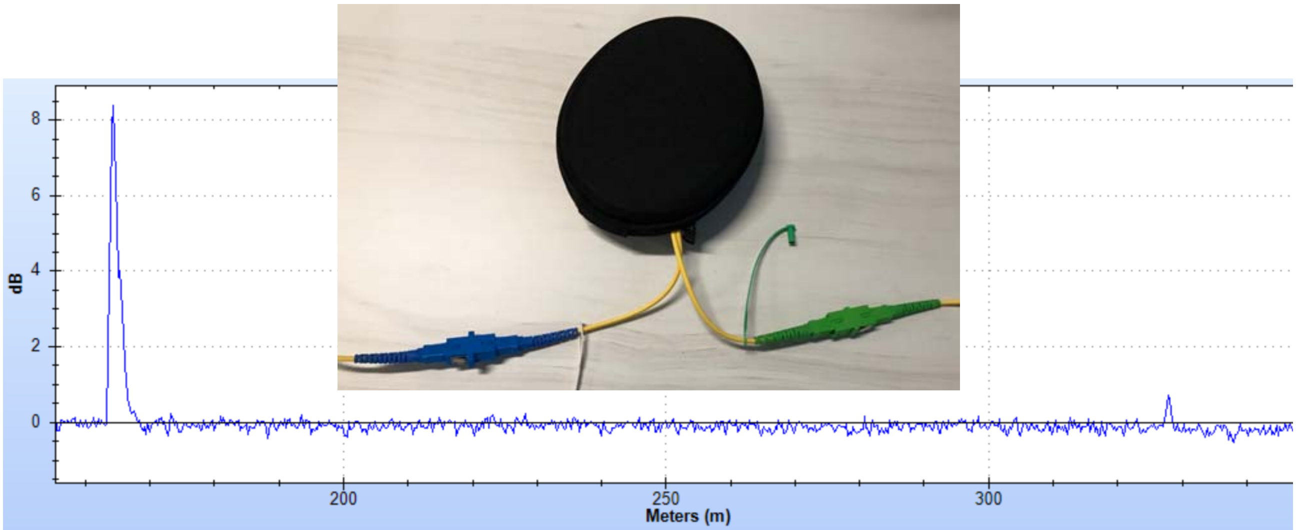
APC Tips have a slight bend – these are SC

APC connectors may need a "Twist" to show up



Single Mode MPO connectors will also require a special adapter

UPC vs APC Reflectance



Active Trace | Overall Results | Events | Settings

1310 nm End1 (LAUNCH FIBER TEST 02 CLEAN)

Location	Type	Status	Loss	Reflectance	Attn Coeff	Notes
0.00 m	OTDR Port	N/A	N/A	-87.60 dB	N/A	
163.36 m	Reflection	PASS	0.02 dB	-53.18 dB	0.36 dB/km	
327.10 m	Reflection	PASS	0.07 dB	-73.28 dB	0.40 dB/km	

ectance

Active Trace | Overall Results | Events | Settings

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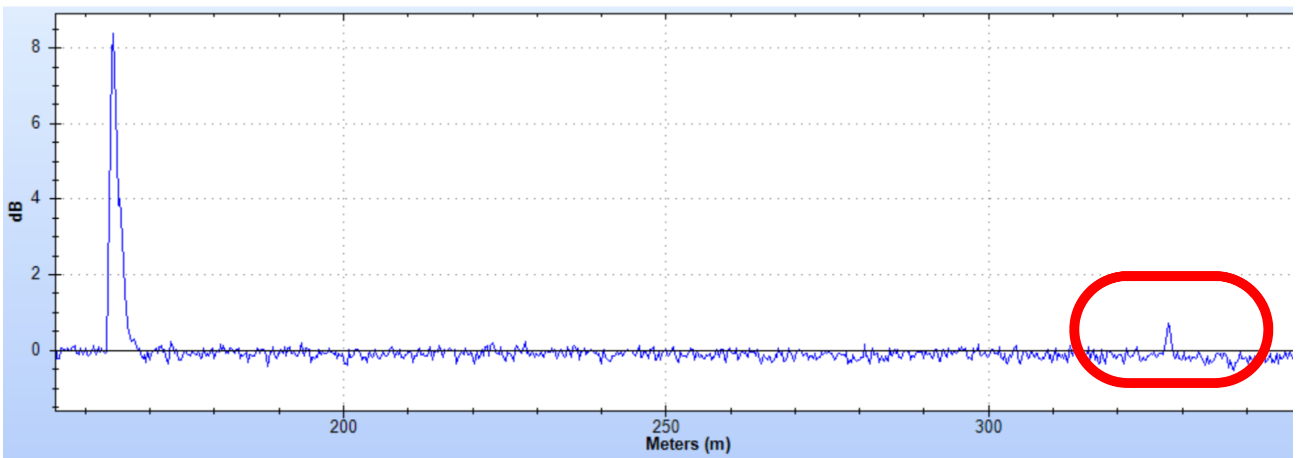
UPC vs APC Reflectance



Active Trace | Overall Results | **Events** | Settings

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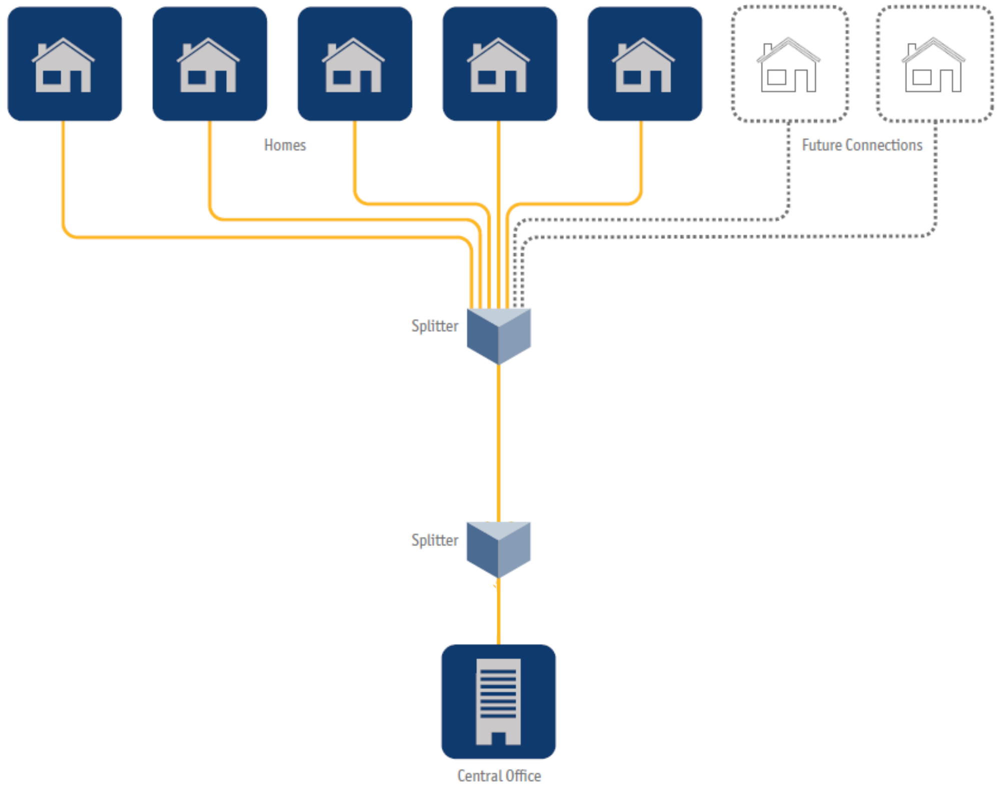
327.10 m	Reflection	PASS	0.07 dB	-73.28 dB	0.40 dB/km	

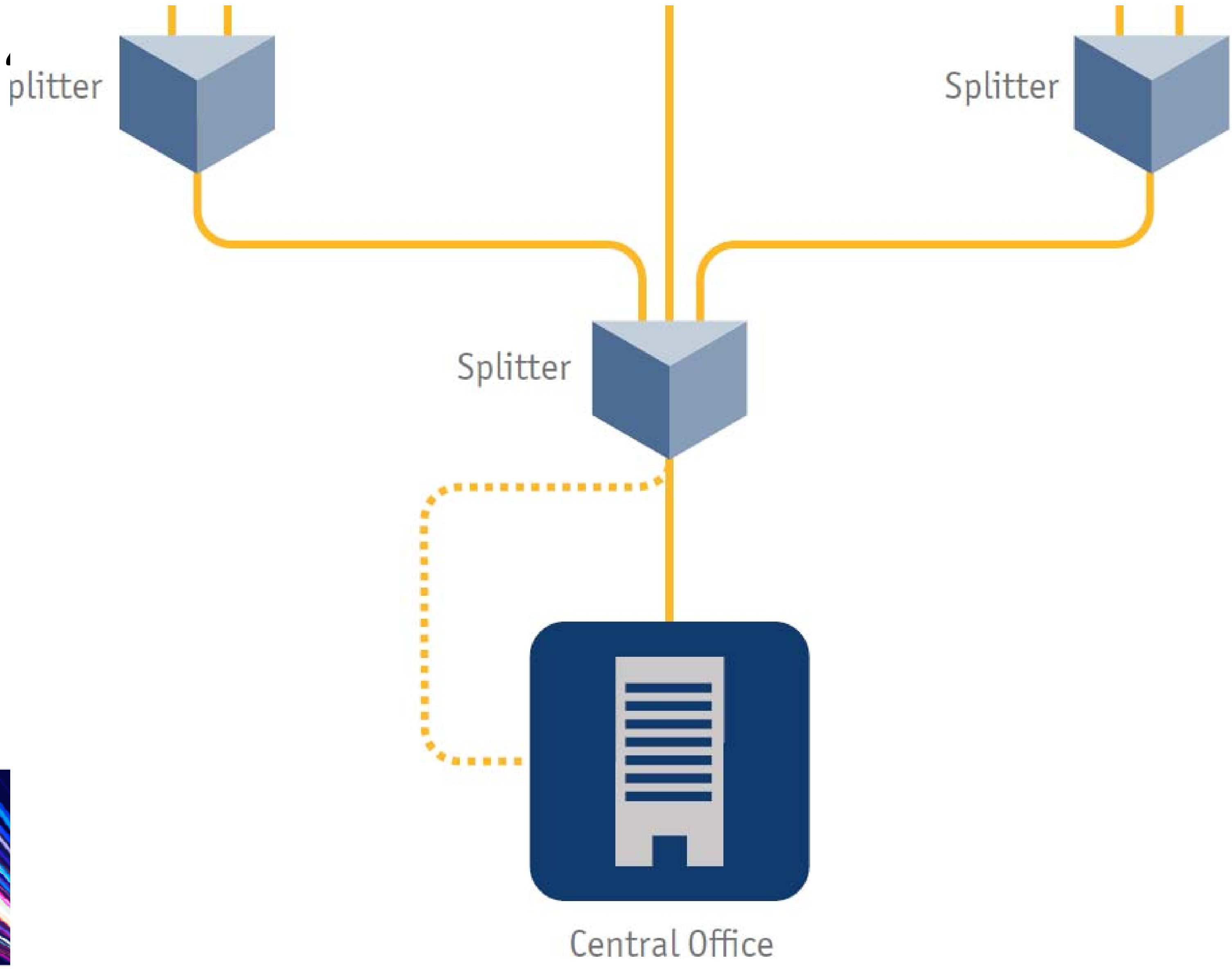
Back to Passive Optical Networks

“Flavors” of Passive Optical Networks

- E-PON and G-PON – most common today
- 10G or XG-PON, NG-PON, NG-PON2
- TBD-PON
- FTTx
- PON-LAN
- We don’t care what you put on the road – we want to make sure the road is in good shape to support today’s applications
    - Loss Budgets, Distances, Reflectance limits may be tighter with future versions

‘basic’ PON architecture




plitter
Splitter
Splitter
Central Office

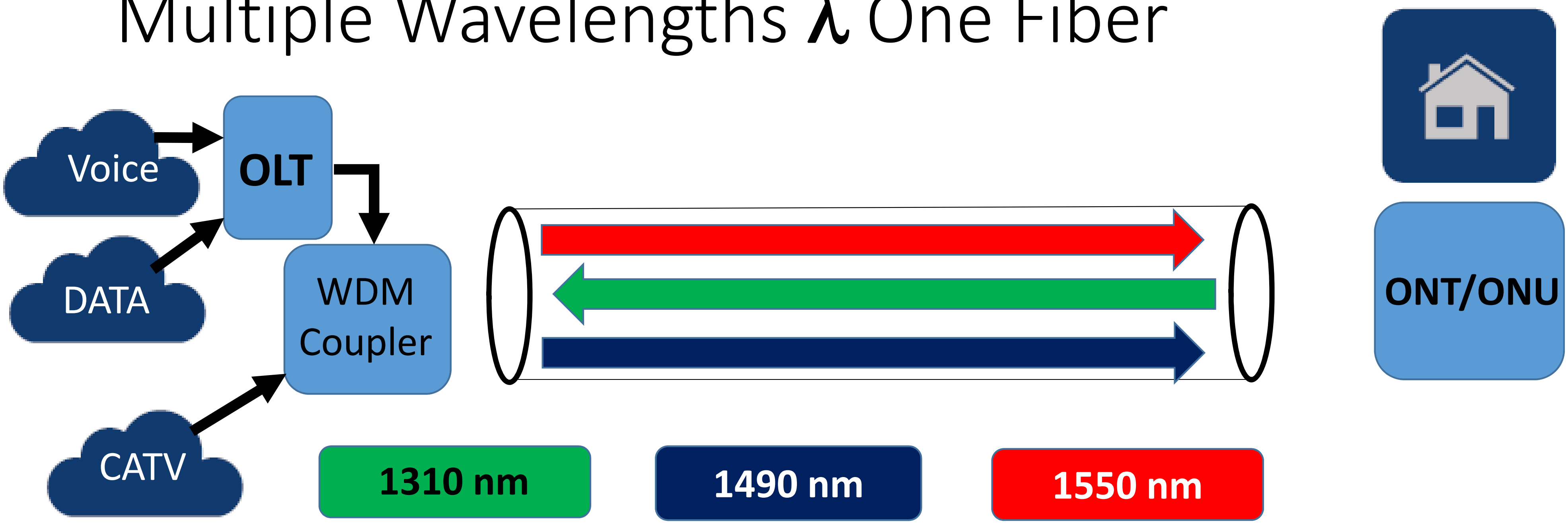
Basic PON LAN Layout

Fiber Concentration Point (FC/FCP)

Fiber Distribution Terminal (FDT)

Fiber Distribution Hub (FDH)
DataCenter/MDF Single Administration Point

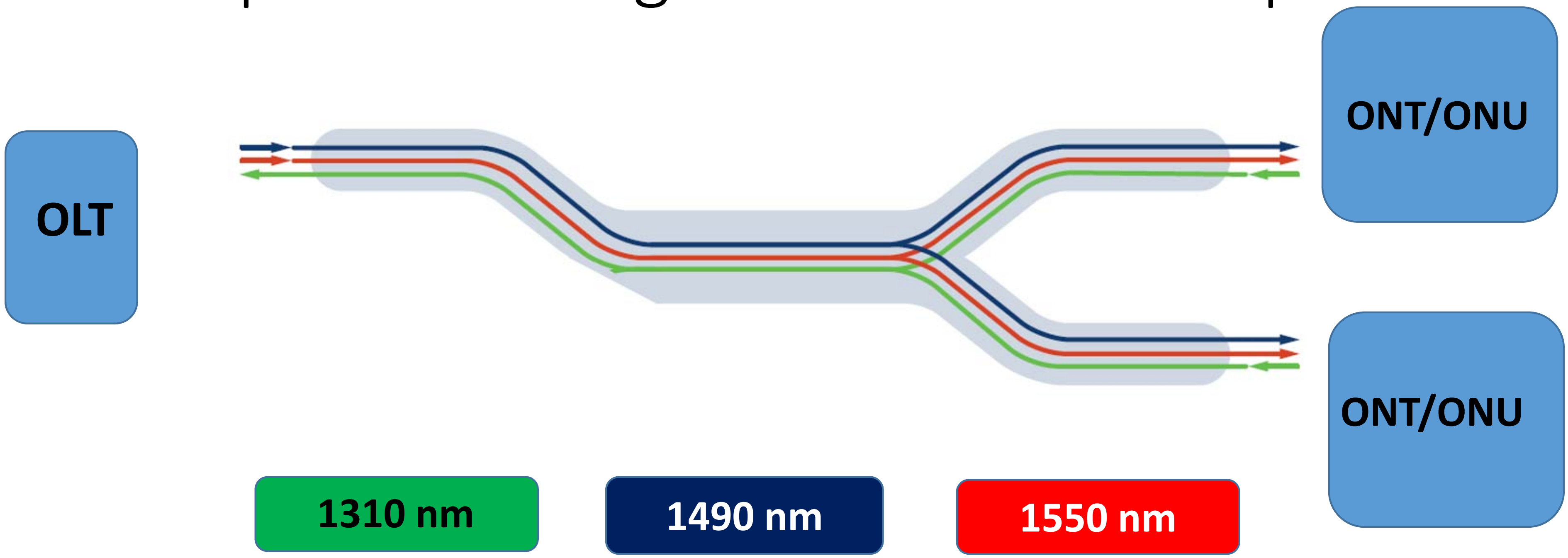
Multiple Wavelengths λ One Fiber



OLT – Optical Line Terminal
ONU – Optical Network Unit (ONT – Optical Network Terminal)

Splitters – Putting the *P*assive in *P*ON

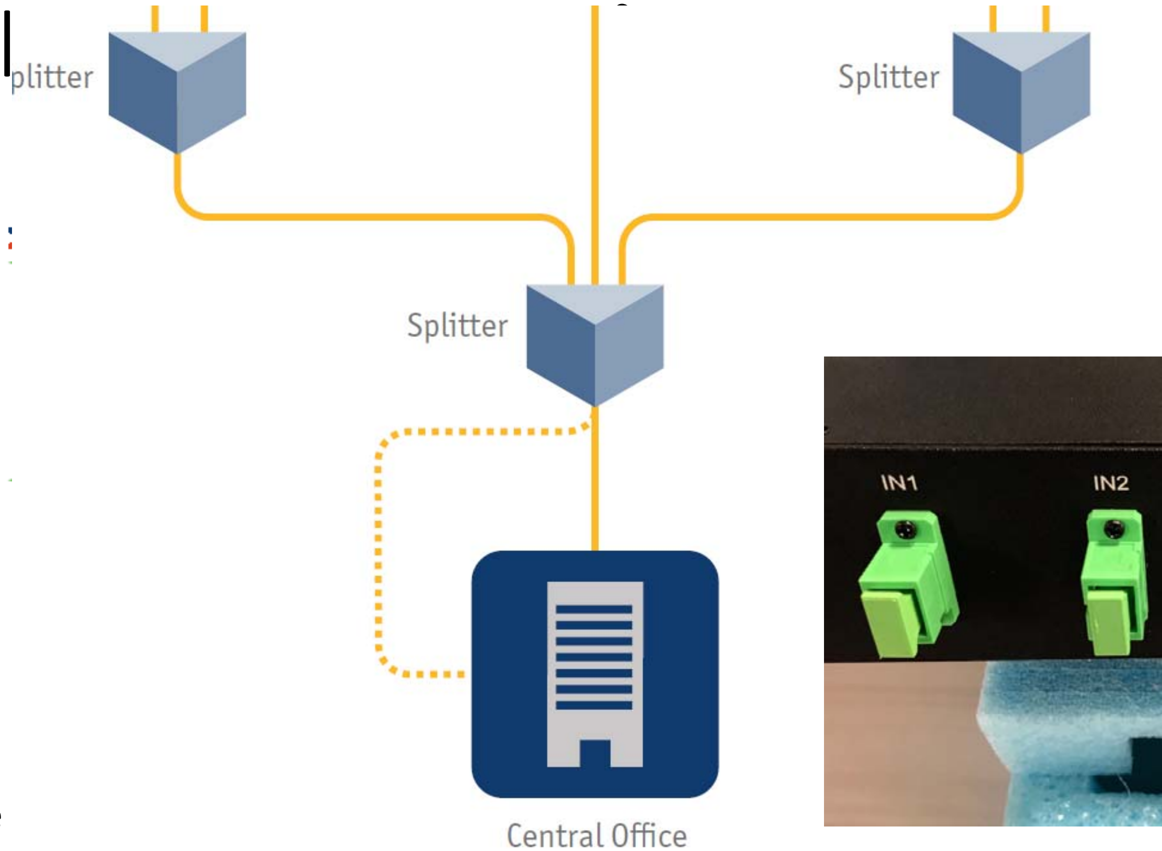
Multiple Wavelengths λ One Fiber - Split



OLT – Optical Line Terminal
ONU – Optical Network Unit (ONT – Optical Network Terminal)

Multipl… Redundancy

OLT



ONT/ONU

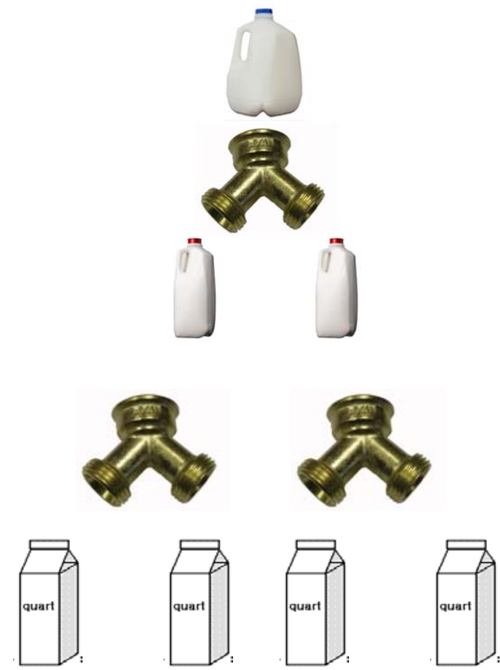
OLT – Optical Line
ONU – Optical Network Unit (ONT – Optical Network Terminal)

Splitters as the name suggests divide the light

- Think of a splitter like a "Y" on a garden hose
  - If you put a gallon of water into the hose, you will get ½ gallon on each port
  - In optical power, that "loss" would be expressed as 3 dB
    - And a little bit for the connectors more for SC or LC connectors than a fusion splice
    - A 1 x 2 splitter should have about 3.5 dB of loss

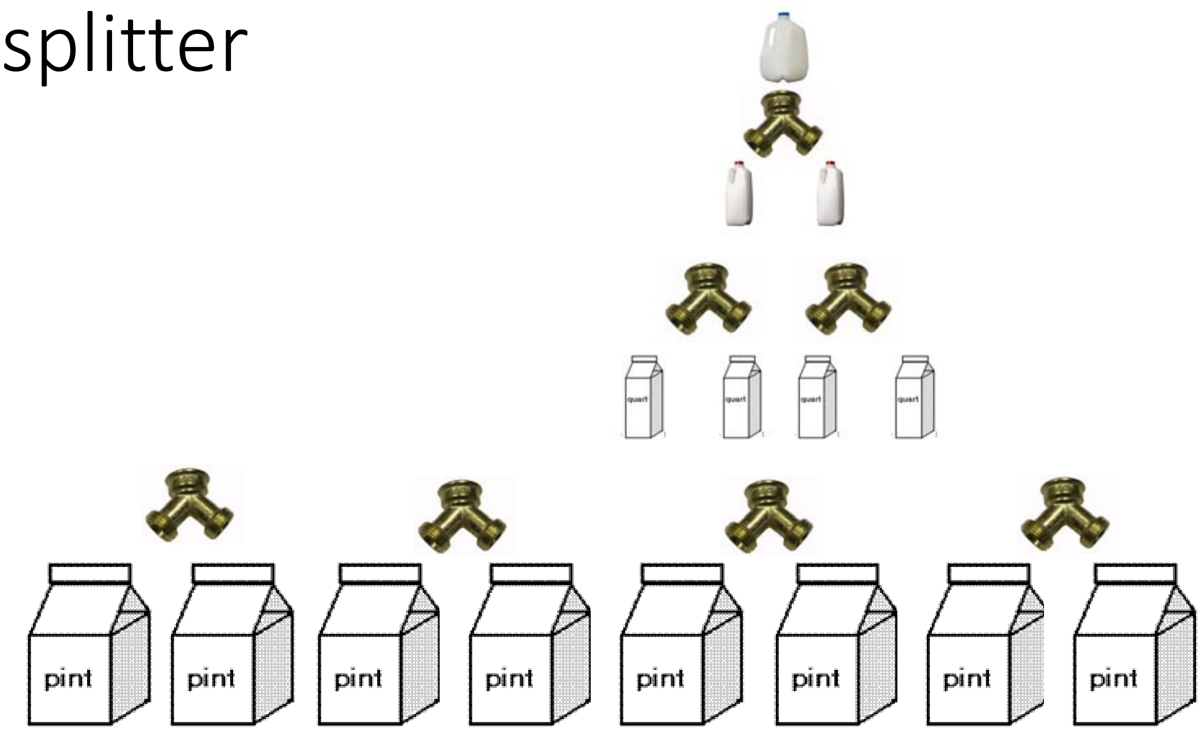
As you increase the split, you attenuate the light that is coming out of a splitter

- A 1 x 2 = 3.5 dB of loss
- 1 x 4 = 7 dB of loss



As you increase the split, you attenuate the light that is coming out of a splitter

- A 1 X 2 = 3.5 dB of loss
- 1 X 4 = 7 dB of loss
- 1 X 8 = 10.5 dB of loss



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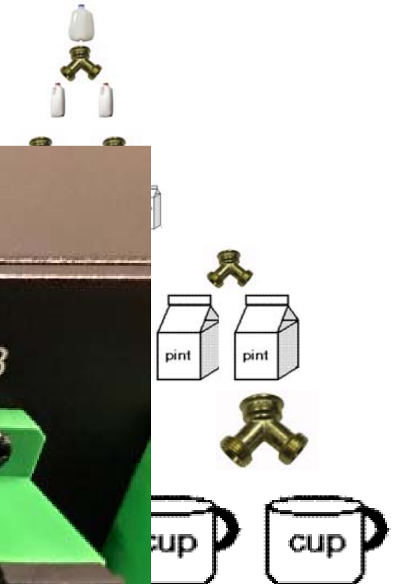
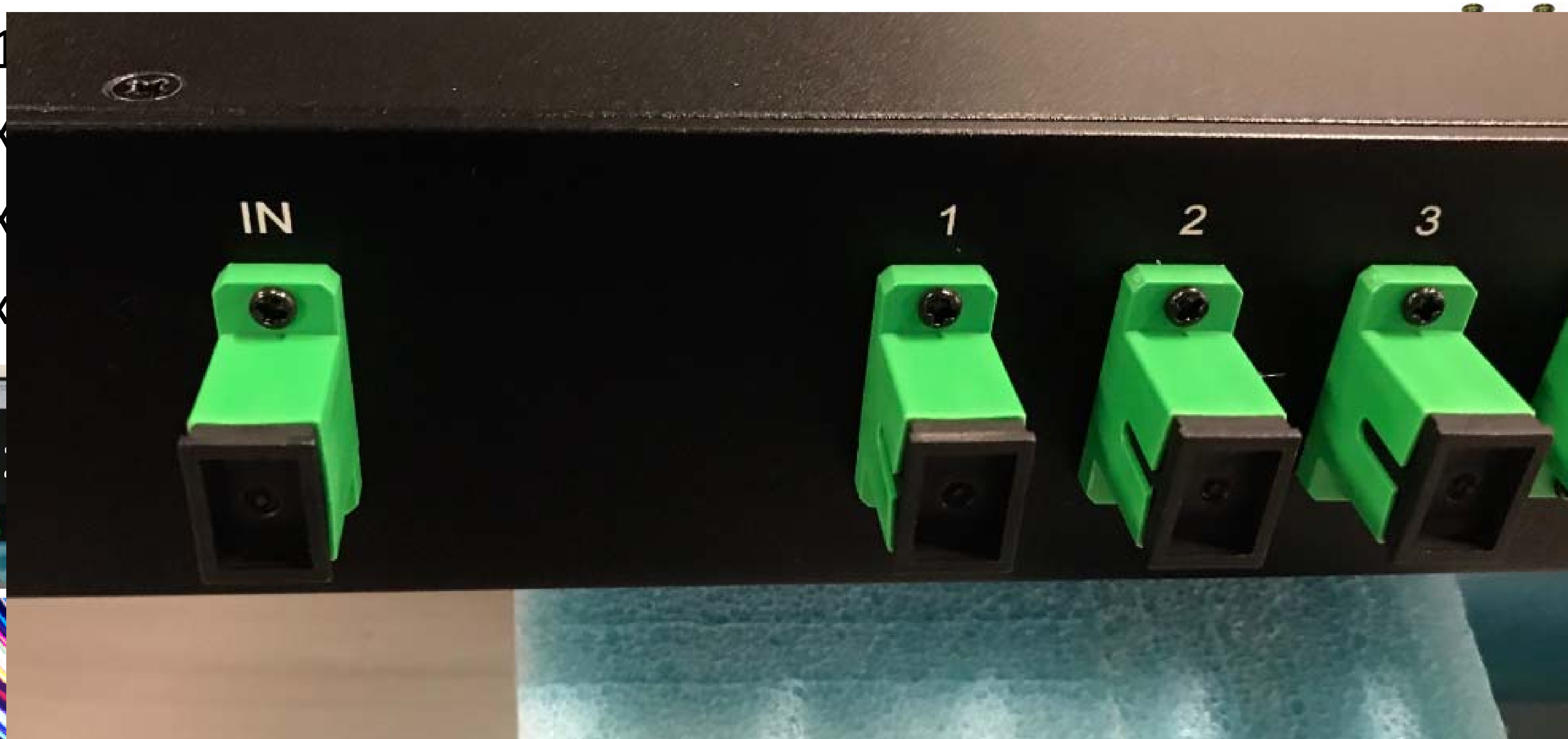
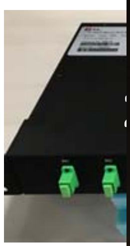
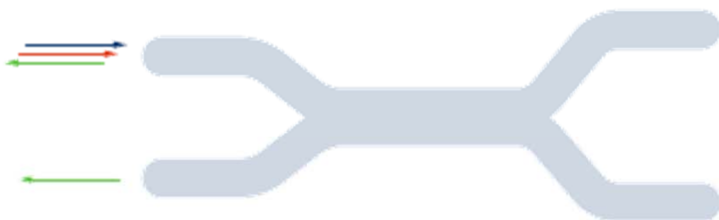


- A 1
- 1 X
- 1 X
- 1 x





Loss Budget per Split per TIA-568 Annex D



Maximum permitted loss 3.9 dB

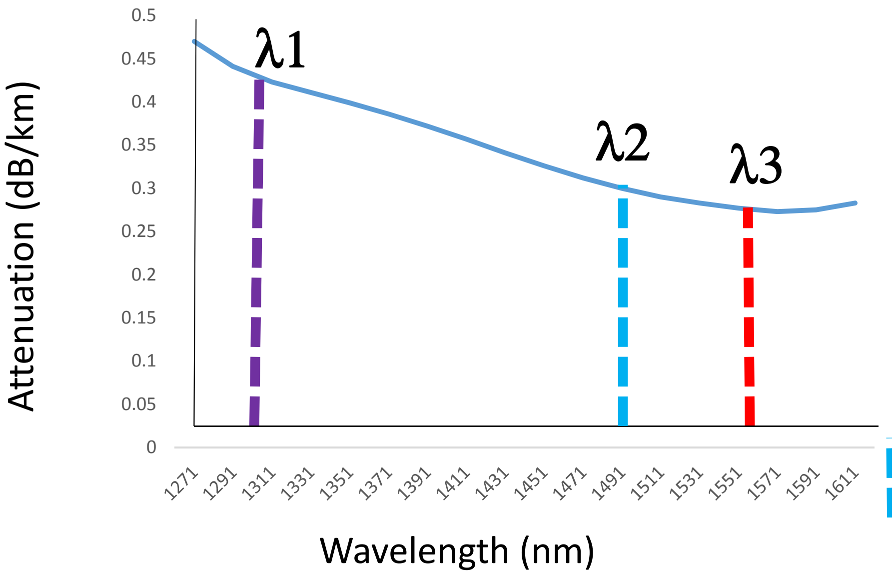
Test of PON Networks

What To Test – Per IEC 61280-4-3

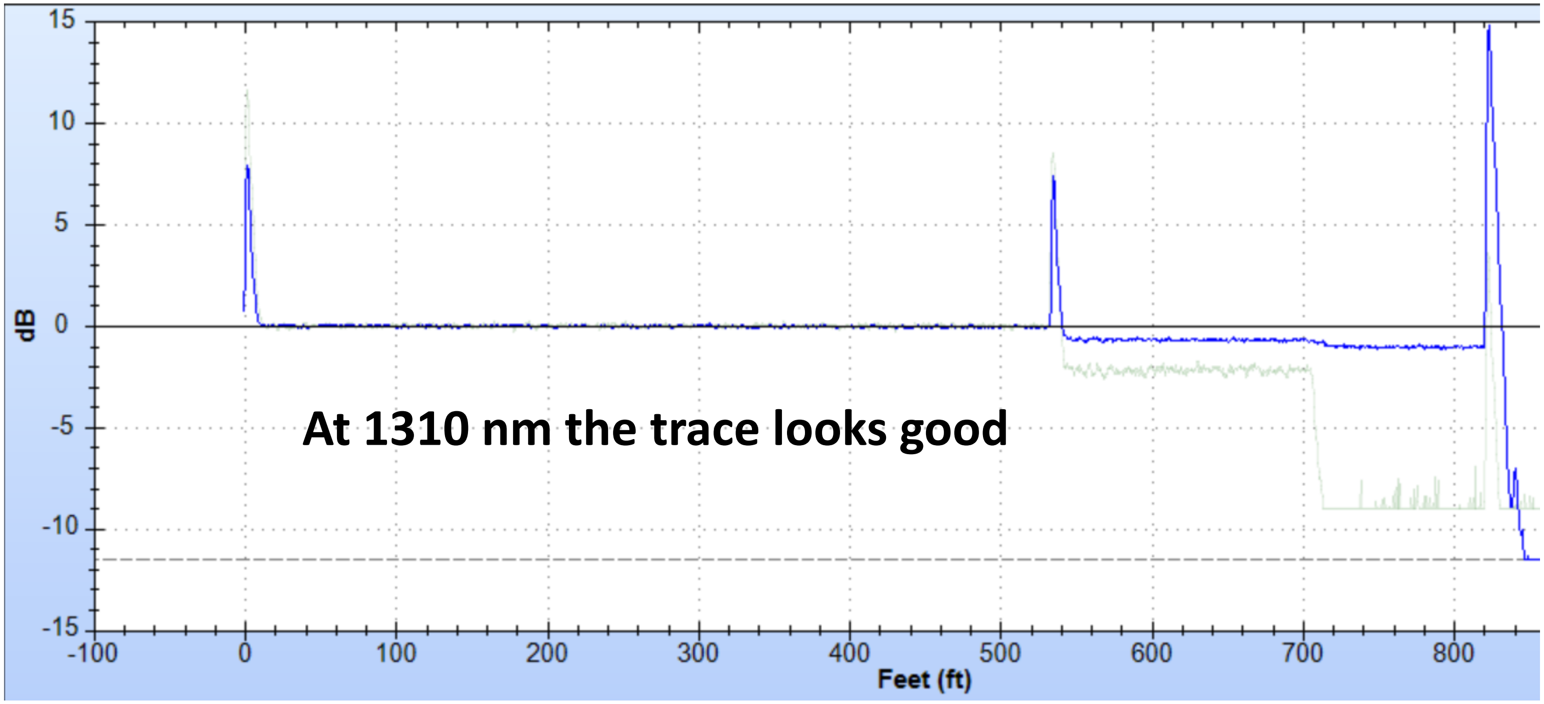
- Single Stage Optical Distribution Network (ODN)
- Multiple Stage ODN
- Attenuation
  - Light Source and Power Meter
  - 1310 and 1550 nm
  - OTDR (only in the upstream direction)
- ORL and Reflectance
  - OTDR

We don't need to test every wavelength to identify problems – they are bound

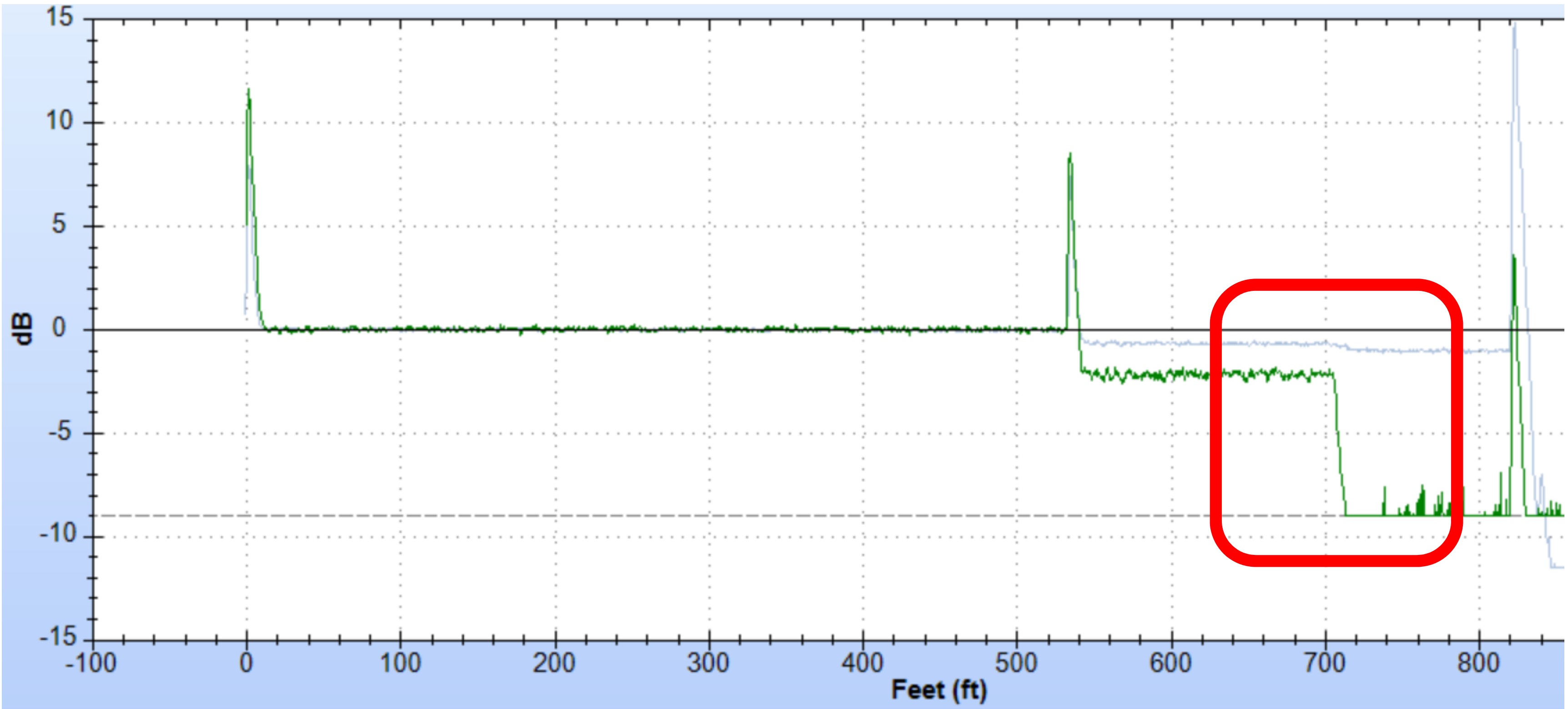
If one of two wavelengths is off – there is a problem



Here is an example of a cracked fiber that was identified by testing at 1310 and 1550 nm



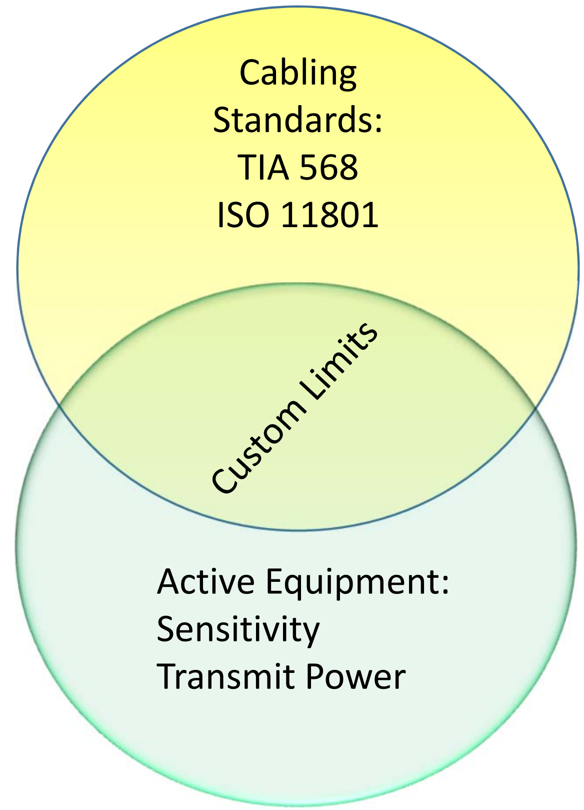
At 1550 nm, you can see the Problem



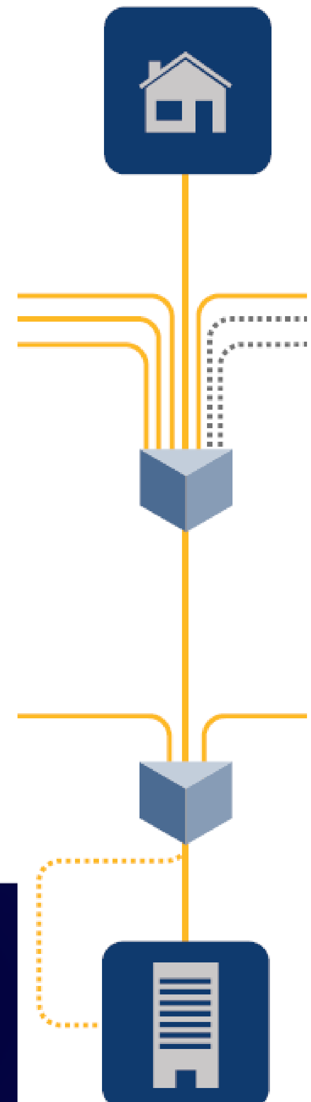
Loss Budget Calculation

What loss budget to use when testing

- There can be different loss budgets that can be used
  - A Cabling limit, like the one called out in the IEC standard
    - Cable + Connectors + Splitters
  - An active equipment limit – depends on equipment
    - Fixed value 27 dB



Loss Budget Calculation



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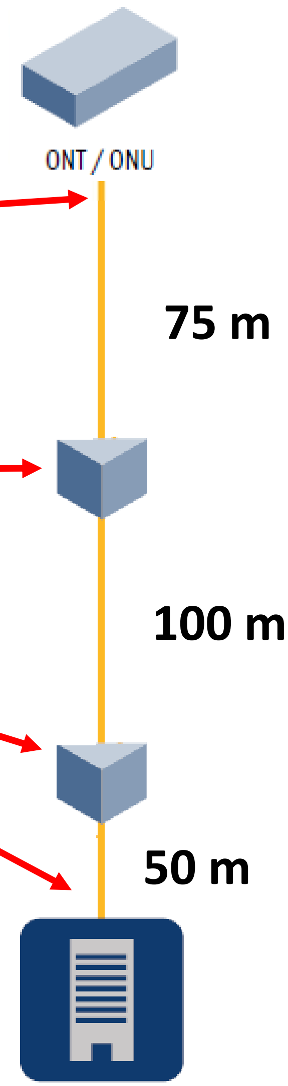
Loss Budget Calculation



Loss testing with minimal uncertainty and maximum repeatability

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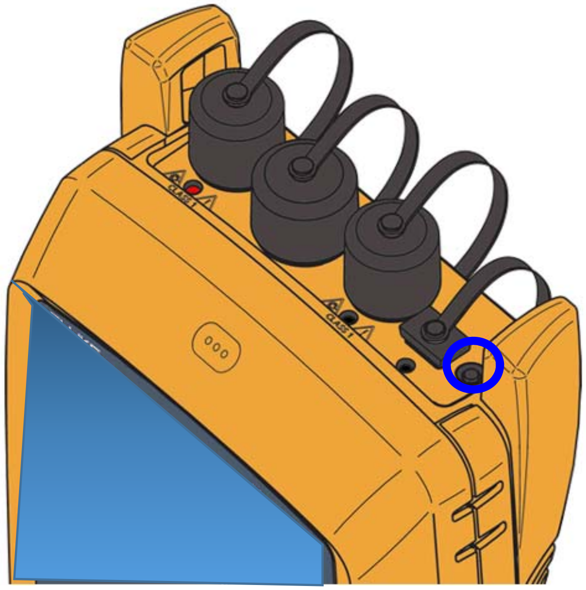
Accurate Loss Testing will assure support for today's and future network applications

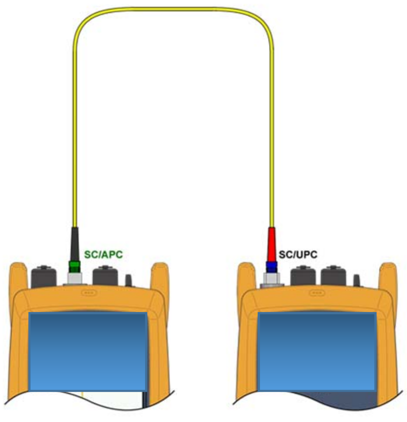


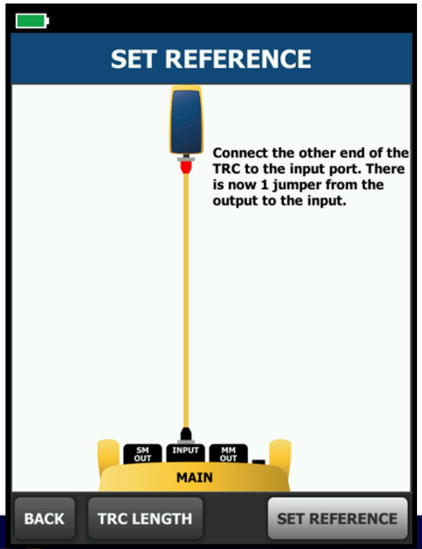
- A One Jumper reference is called out in the standard
- A Simple Light Source and Power Meter can be used, or you can use common **OLTS** units, provided they can be put into a "Far End Source Mode"

Pressing this button again sets the singlemode port to 1310/1550 nm

Single fiber testing – setting a reference

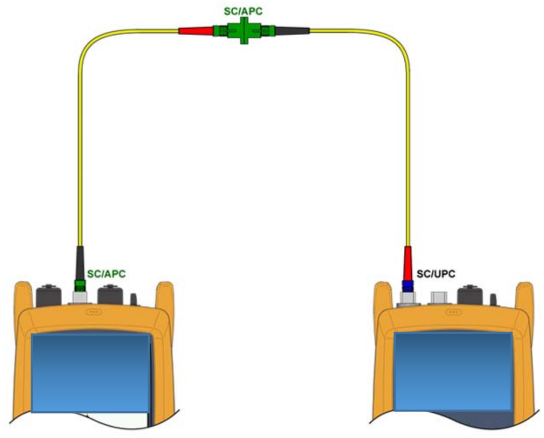
- Connect the MAIN and SOURCE units together
  - **One Jumper Reference**
  - **Must have input port that is the same as the connector to be tested**

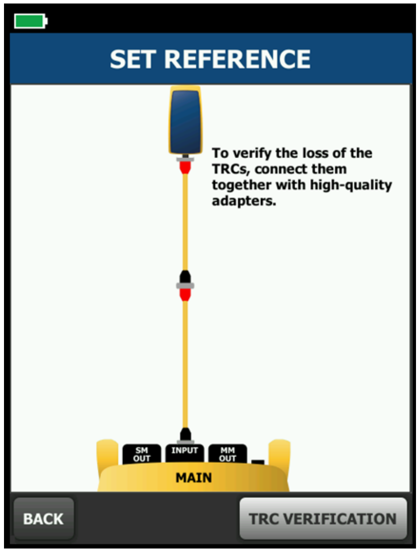




Single fiber testing – setting a reference

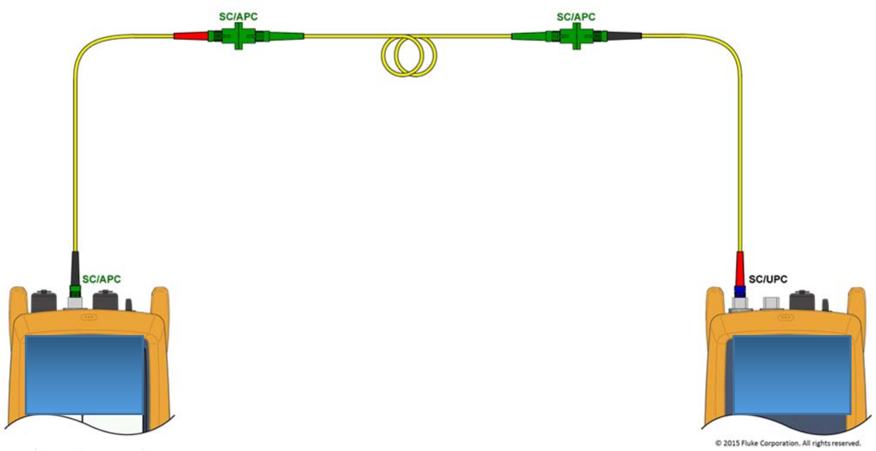
- After the reference is set, verify the condition of the other Test Reference cord
- Save this in your test results!

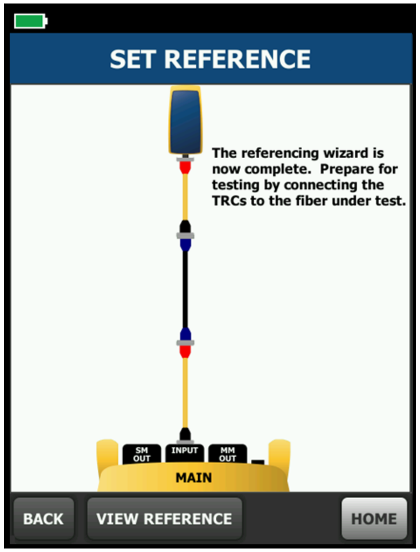




Single fiber testing – setting a reference

- Connect to the link you wish to test





Sample Test Results

Cable ID: HGI ROOM 204 — **Test Summary: PASS**

Date / Time: 12/29/2017 09:28:09 AM
Cable Type: OS2 Singlemode

n = 1.4670 (1310 nm)
n = 1.4680 (1550 nm)

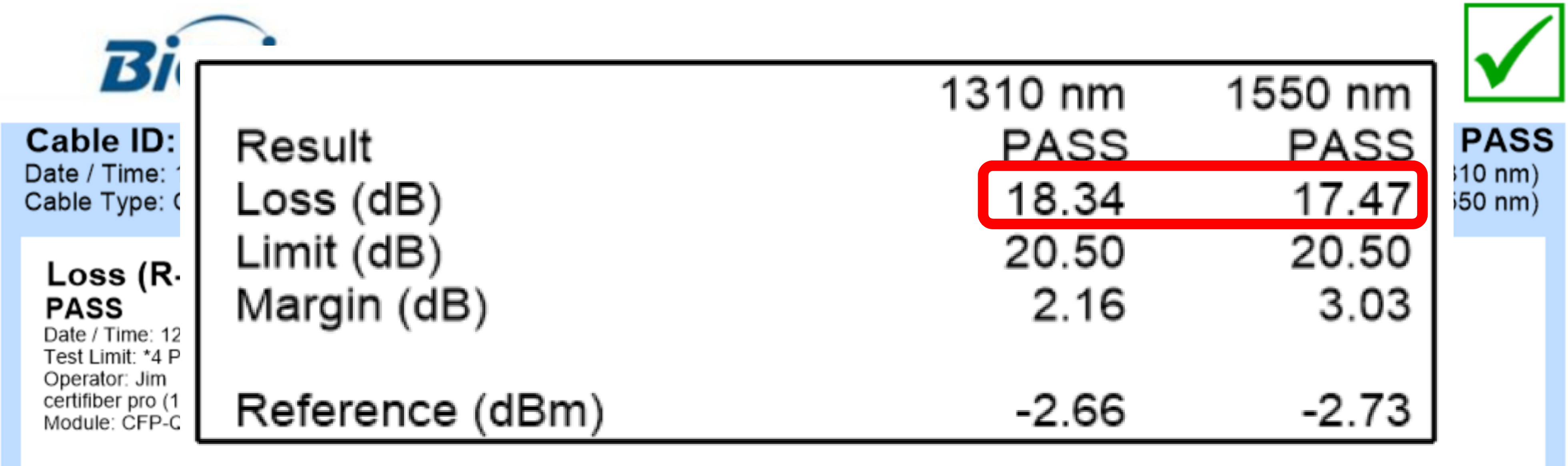
Backscatter Coefficient: -79.5dB (1310 nm)
Backscatter Coefficient: -82.0dB (1550 nm)

Loss (R->M)
PASS
Date / Time: 12/29/2017 09:28:09 AM
Test Limit: *4 PORT & 8 PORT*
Operator: Jim
certifiber pro (17455007 v5.3 build 20171229
Module: CFP-QUAD(2427616)

	1310 nm	1550 nm
Result	PASS	PASS
Loss (dB)	18.34	17.47
Limit (dB)	20.50	20.50
Margin (dB)	2.16	3.03
Reference (dBm)	-2.66	-2.73

Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 12/29/2017 09:08:10 AM
1 Jumper

Sample Test Results - Detail



Cable ID:
Date / Time:
Cable Type:

Loss (R-
PASS
Date / Time: 12
Test Limit: *4 P
Operator: Jim
certifiber pro (1
Module: CFP-C

	1310 nm	1550 nm
Result	PASS	PASS
Loss (dB)	18.34	17.47
Limit (dB)	20.50	20.50
Margin (dB)	2.16	3.03
Reference (dBm)	-2.66	-2.73

PASS
10 nm)
50 nm)

Alternate Loss Budget Calculation

- Single Mode light
- Often, they can a
  - Usually -27 dBm

Interface P

GPON Port

- Class B+
- Receiver sensitivity: -27dBm
- Wavelengths: US 1310 nm, D

Cisco

Table

Table

Typ
PON

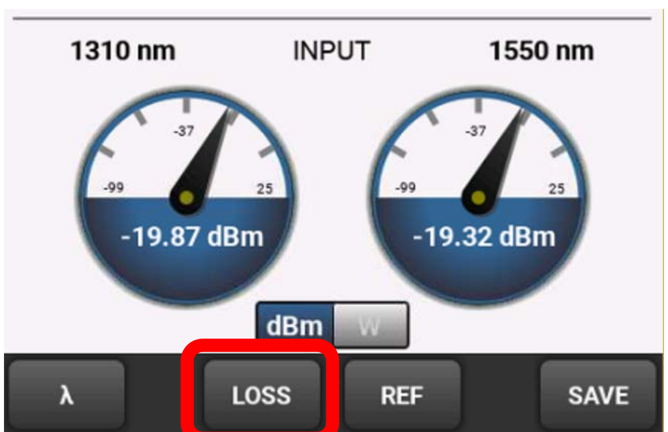
GPON

- De acordo com o padrão GPON ITU-T G.984.x;
- Transmissor de 1.244Gbps sentido upstream em mo
- Receptor de 2.488Gbps sentido downstream;
- Comprimento de onda de transmissão: 1310nm;
- Comprimento de onda de recepção: 1490nm;
- Framing totalmente compatível com ITU-T G.984;
- Múltiplos T-CONTs por dispositivo;
- Múltiplos GEM Ports por dispositivo;
- Suporta modo Single T-CONT ou modo Multiple T-C
- Mapeamento flexível entre GEM Ports e T-CONTs;
- Forward Error Correction (FEC);
- Suporte para Multicast GEM Port;
- Mapeamento de GEM Ports em um T-CONT com filas de prioridade;
- Potência Óptica de Transmissão: 0,5dBm ~ +5dBm
- Potência Óptica de Recepção: -8dBm ~ -27dBm

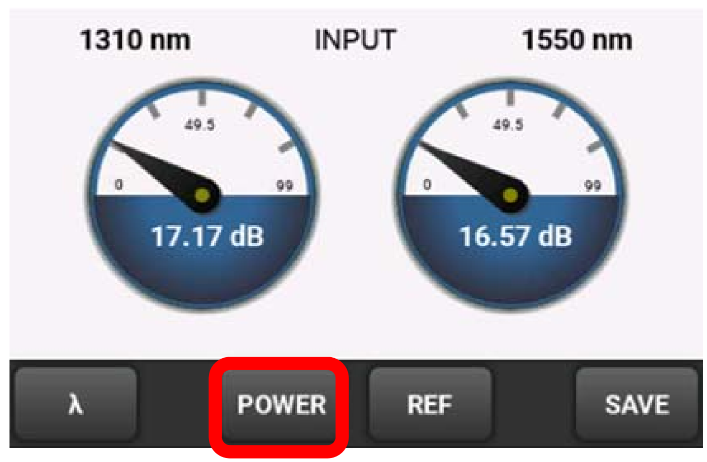
- BBF TR.156 - Using GPON in the context of TR
- Advanced Encryption Standard (AES)
- Forward Error Correction (FEC)
- Class B+ optics (28dB)

Alternate Loss Budget Calculation

- Single Mode light sources are very powerful
- Often, they can accept any amount of light down to a given level
  - Usually -27 dBm
  - Rule of thumb – give yourself some margin 3 dB?
- When troubleshooting or testing with the OLT installed check for greater than -27 dBm in the POWER mode, not LOSS mode
  - - 26 dBm is greater than -27 dBm
  - -28 dBm is less than -27 dBm



The Button in this example changes from one to the other



Alternate Loss Budget Calculation

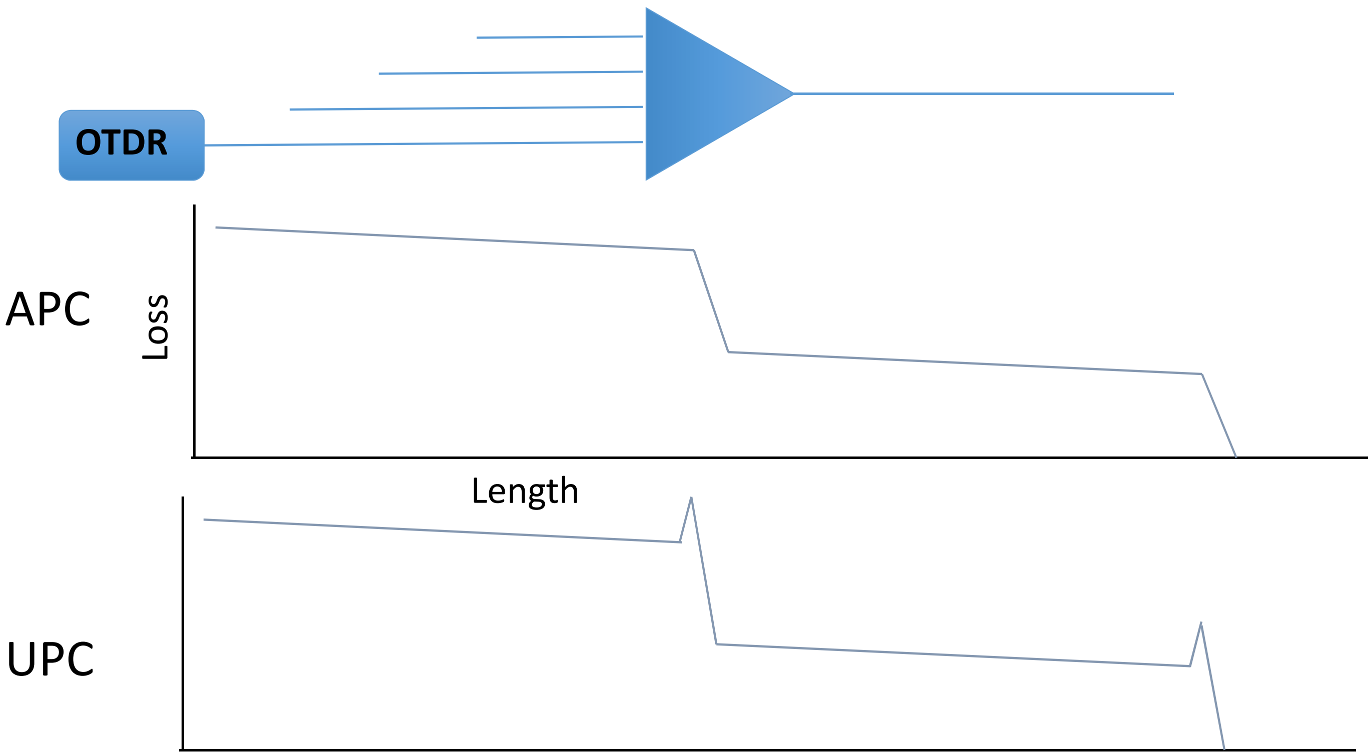
- Single Mode light sources are very powerful
- Often, they can accept any amount of light down to a given level
  - Usually -27 dBm
  - Rule of thumb – give yourself some margin 5 dB?
- When troubleshooting or testing with the OLT installed check for greater than -27 dBm in the POWER mode, not LOSS mode
  - - 26 dBm is greater than -27 dBm
  - -28 dBm is less than -27 dBm

*** Laser source, not OLT**

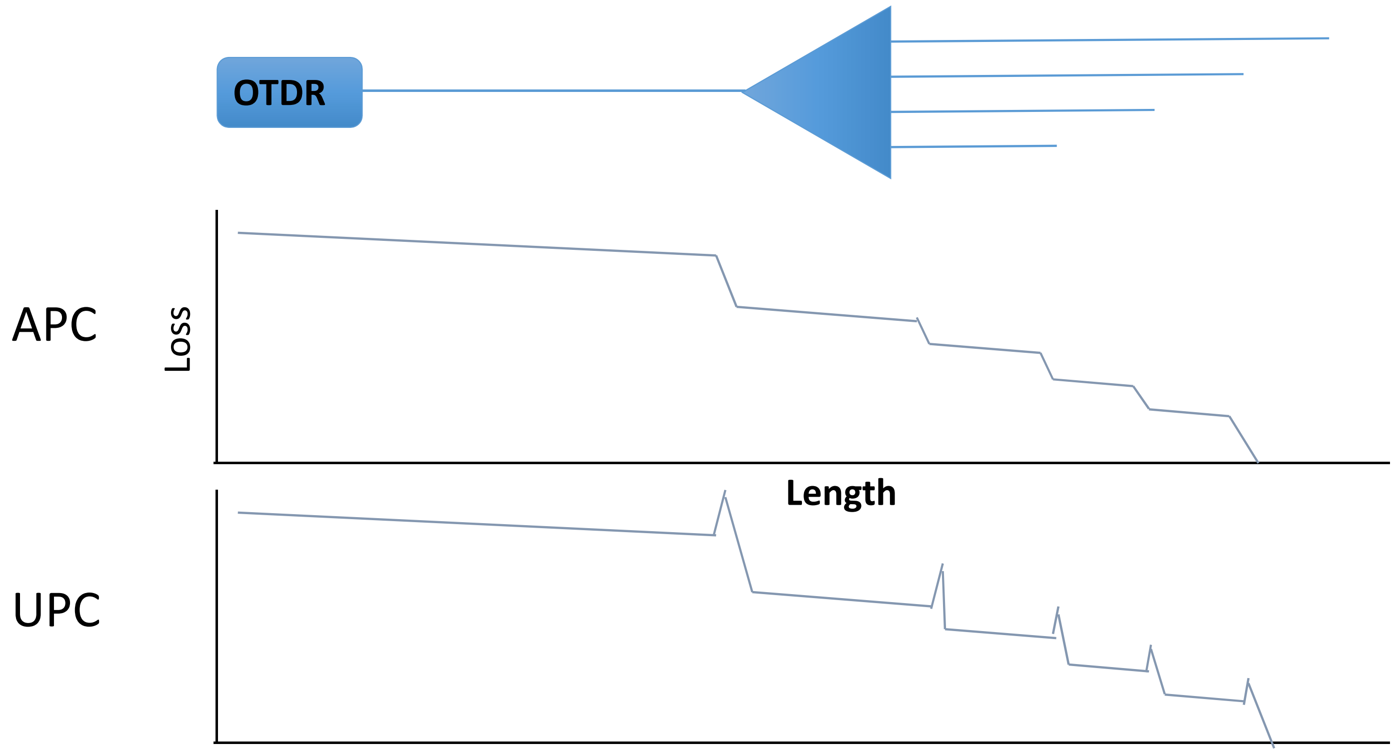
OTDR testing

- Used to measure loss and reflectance of events
- Upstream only
- Requires a launch and tail cord
  - Cords should have close backscatter coefficient to link under test
- Shall be capable of using a short pulse ≤ 20ns
- Check the launch a receive cords prior to testing (B.6.2)

Upstream OTDR Testing



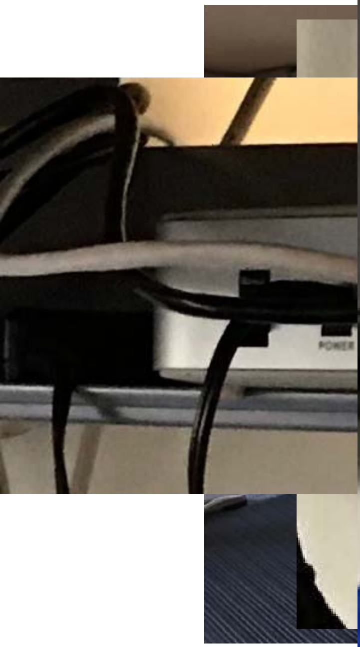
Downstream Testing



Troubleshooting Links

Did you try rebooting?

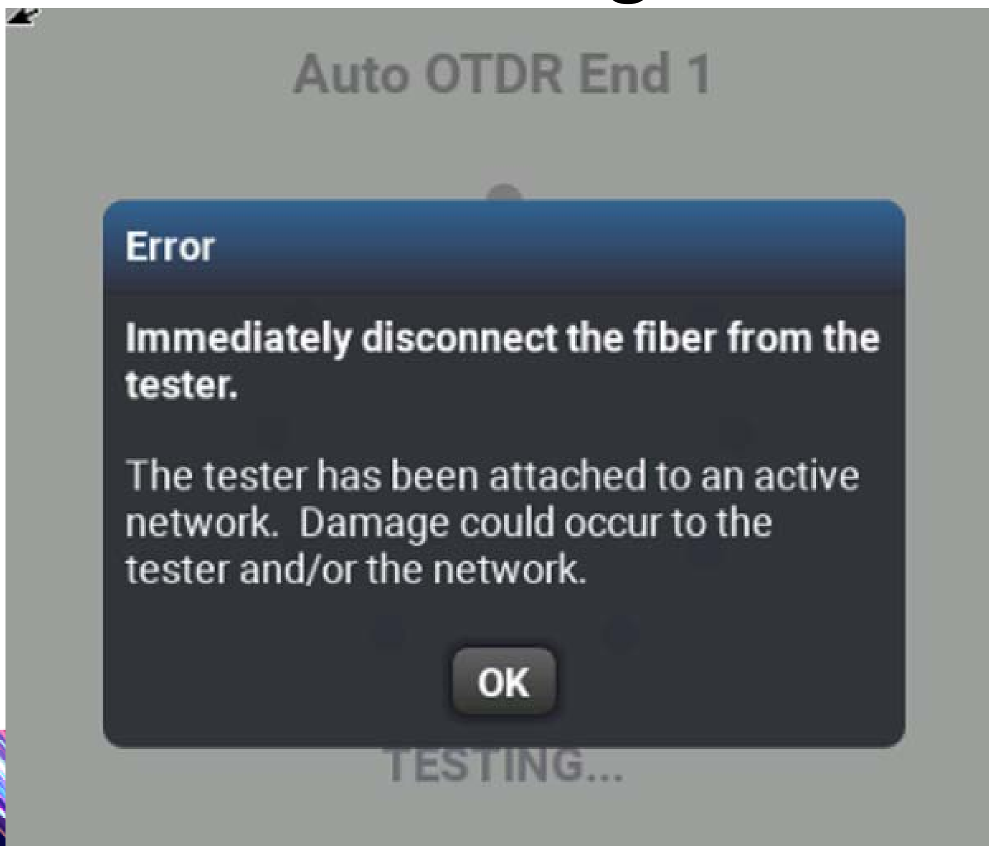
Examp



iber

tch – in this
provide copper
o phone, PC,
WAP, etc.

Troubleshooting a live network with an OTDR

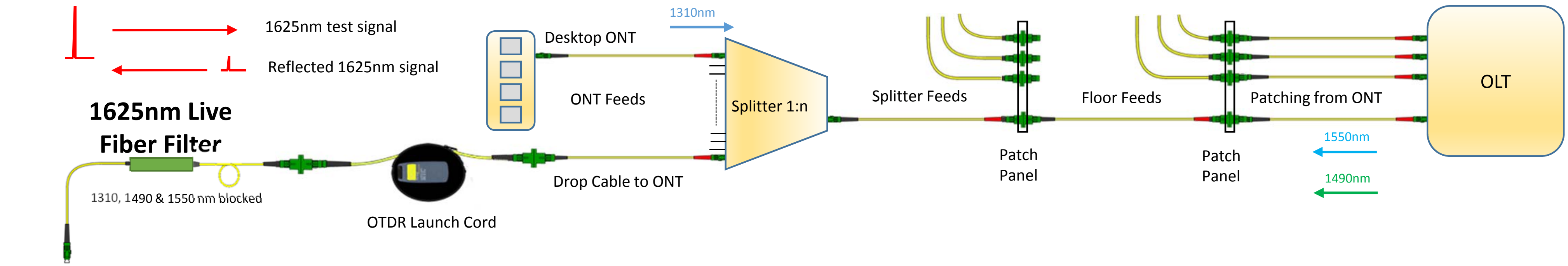


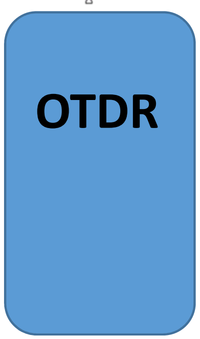
n t

ansmitted pulse and OLT pulse

nm

Filtered test configuration for POLAN

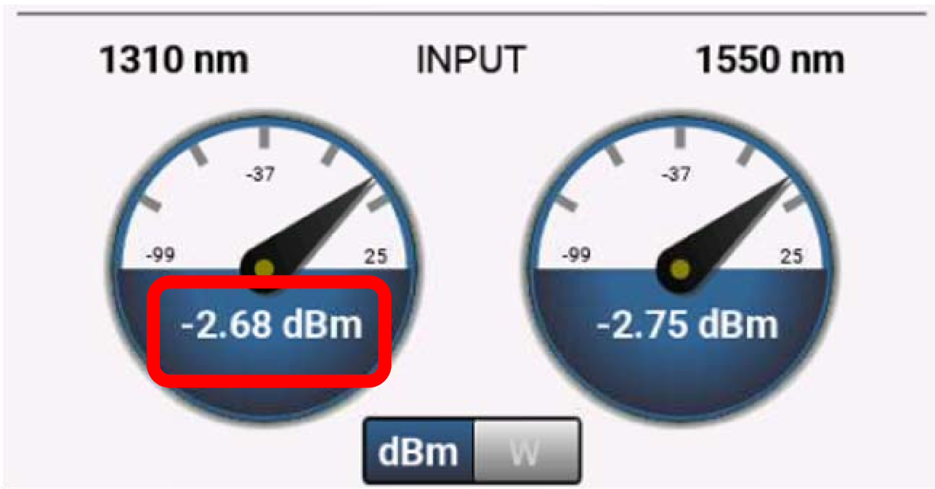




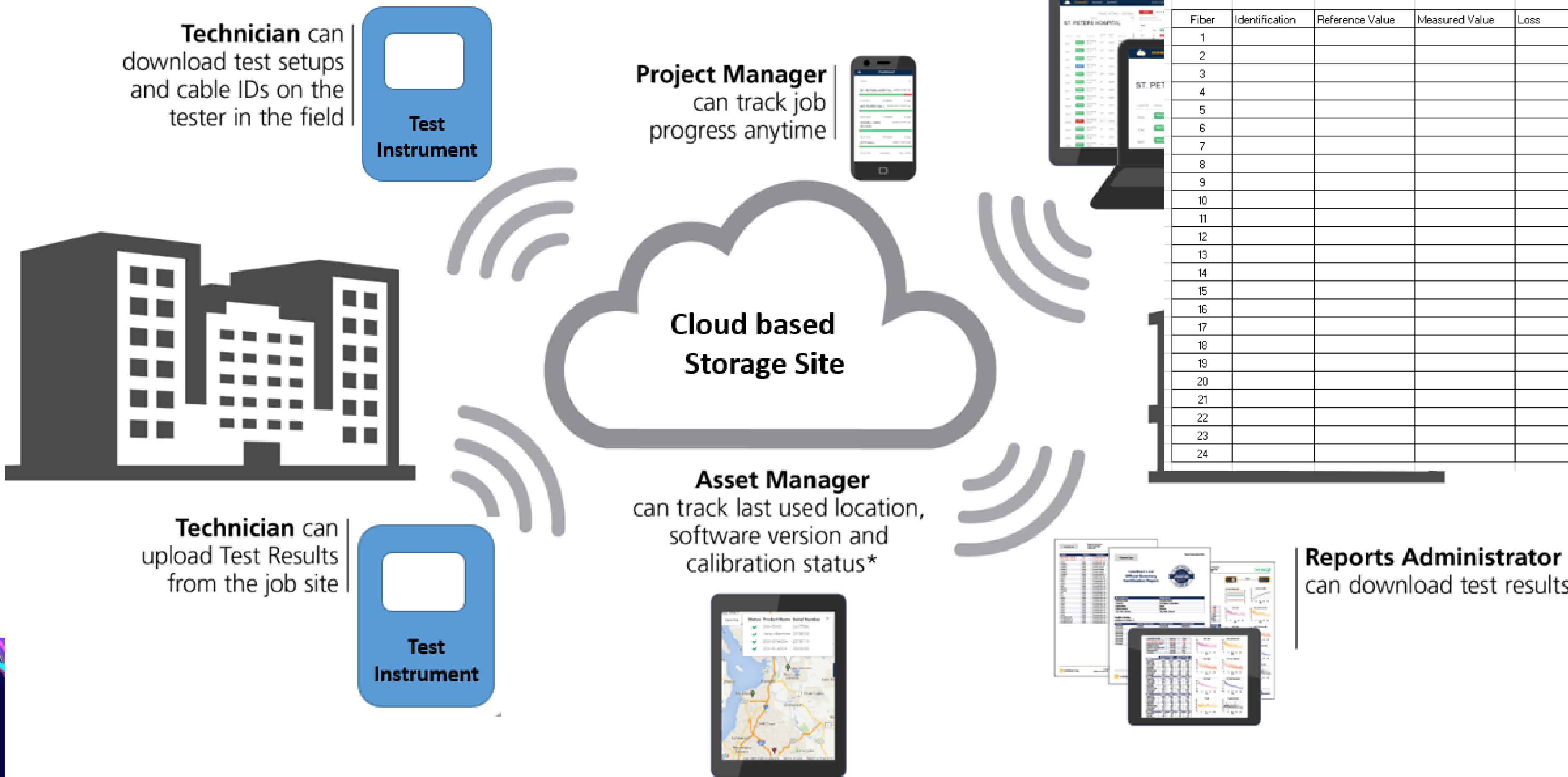
- When troubleshooting a connectivity issue you need to be able to connect into a live system with an OTDR to troubleshoot without disturbing the system and without the POLAN signals interfering with the OTDRs measurements.
  - A 1625nm **Live Fiber Filter** allows the OTDR to use an out of band 1625nm test wavelength to meet this purpose.
    - 1625nm will not interfere with the active POLAN signals
    - The filter blocks the 1310nm, 1490nm and 1550nm wavelengths from entering the OTDR port, preventing them from interfering with the measurement

Gotcha – don’t plug ONT to OLT with 2 meter patch cord to check if it works ☺

- Potência Óptica de Transmissão: 0,5dBm ~ +5dBm
- Potência Óptica de Recepção: -8dBm ~ -27dBm



Documenting Results



Fiber Loss Measurements:
Date and Time of test:
Location:
Personel:

Fiber	Identification	Reference Value	Measured Value	Loss	Limit	P/F
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						

In Conclusion

- PON or POL is a valid alternative to pure copper networks
- Many niche markets are appearing
  - Hospitals
  - Hotels
  - Government
- Follow best practices for loss testing
  - One Jumper reference, accurate loss budget
- OTDRs can be used for Troubleshooting
  - Clean the fibers before you connect them!

Thank you, Gracias, Obrigado

Jim Davis

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