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!!
Automated Analysis – Single Mode APC Limits

### IEC 61300-3-35 ED.2 SM APC

<table>
<thead>
<tr>
<th>Zone Name</th>
<th>Scratches</th>
<th>Defects</th>
</tr>
</thead>
</table>
| A: Core (0-25µm)   | $4 \leq 3 \mu m$  
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
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
Reflectance

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Status</th>
<th>Loss</th>
<th>Reflectance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 m</td>
<td>OTDR Port</td>
<td>N/A</td>
<td>N/A</td>
<td>-87.60 dB</td>
</tr>
<tr>
<td>163.36 m</td>
<td>Reflection</td>
<td>PASS</td>
<td>0.02 dB</td>
<td>-53.18 dB</td>
</tr>
</tbody>
</table>
UPC vs APC Reflectance
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
Basic PON architecture - redundancy
Basic PON LAN Layout

Fiber Concentration Point (FC/FCP)

Fiber Distribution Terminal (FDT)

Fiber Distribution Hub (FDH)
DataCenter/MDF Single Administration Point
Multiple Wavelengths \( \lambda \) One Fiber

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

- Voice
- DATA
- CATV

\[ \begin{align*}
1310 \text{ nm} & \\
1490 \text{ nm} & \\
1550 \text{ nm} & 
\end{align*} \]
Splitters – Putting the Passive in PON
Multiple Wavelengths λ One Fiber - Split

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

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

Central Office

Revundancy

OLT

ONT/ONU

2018 BICSI WINTER CONFERENCE & EXHIBITION
Orlando, FL | February 4-8
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
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
- 1 x 16 = 14 dB
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 1310 nm the trace looks good.
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
Loss Budget Calculation

- Connectors: 2 * 0.75 dB = 1.5 dB
- Splitters: 1 X 4 Port = 7.3 dB, 1 X 8 Port = 10.7 dB
- KM of Fiber: 50 m + 100 m + 75 m = 0.225 dB

Total Loss Budget = 19.73 dB
Loss testing with minimal uncertainty and maximum repeatability
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
Date / Time: 12/29/2017 09:28:09 AM
Cable Type: OS2 Singlemode
n = 1.4670 (1310 nm)
n = 1.4680 (1550 nm)

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

<table>
<thead>
<tr>
<th>Loss (R-&gt;M)</th>
<th>1310 nm</th>
<th>1550 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>Loss (dB)</td>
<td>18.34</td>
<td>17.47</td>
</tr>
<tr>
<td>Limit (dB)</td>
<td>20.50</td>
<td>20.50</td>
</tr>
<tr>
<td>Margin (dB)</td>
<td>2.16</td>
<td>3.03</td>
</tr>
<tr>
<td>Reference (dBm)</td>
<td>-2.66</td>
<td>-2.73</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>1310 nm</th>
<th>1550 nm</th>
</tr>
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<tr>
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</table>

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

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<table>
<thead>
<tr>
<th>Interface Port</th>
<th>Receiver sensitivity: -27dBm</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPON Port</td>
<td></td>
</tr>
</tbody>
</table>

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- De acordo com o padrão GPON ITU-T G.984.x;
- Transmissor de 1.244Gbps sentido upstream em modo;
- 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-CONTs;
- 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 filhas de prioridade;
- Potência Óptica de Transmissão: 0,5dBm ~ +5dBm
- Potência Óptica de Recepção: -8dBm ~ -27dBm

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- 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 $\leq 20\text{ns}$
- Check the launch and receive cords prior to testing (B.6.2)
Upstream OTDR Testing

OTDR

APC  Loss

UPC  Length
Downstream Testing

OTDR

APC  Loss

UPC  Length
Troubleshooting Links

Did you try rebooting?
Example of PON to the desk:

- Just a single fiber
- Four port switch – in this example to provide copper connectivity to phone, PC, WAP, etc.
Troubleshooting a live network with an OTDR

- OTDR shoots a pulse of light
- Measures time for light to return
- Closer events come back sooner
- Farther events take longer to return

What if there is an OLT transmitting on the fiber?
- Light is always arriving
- How to tell the difference from OTDR transmitted pulse and OLT pulse
- Unplug from OLT (and run)
- Unused wavelength – 1625 nm or 1650 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

- Request your test results in Native Format, not .pdf
- Your tester only delivers results in Paper format? Consider using a cloud based results management service
- Check that the reference value is correct and recent
- Did they verify the known good leg?
- Deliver the results today, not in a month
- While your team still has access to the site
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
Fluke Networks
Jim.Davis@flukenetworks.com
6920 Seaway Blvd
Everett, WA 98271