Topics

- Wavelength technology discussion
- Technology types and wavelengths used
- Co-existence
- Summary
TOPICS:

• Wavelength Discussion
Today’s Spectrum Usage

- The figure below attempts to show the reality of taking ALL of today’s coexistence characteristics into account, assuming use of Pre-1990 fibers.
So long term use of RFoG Overlay presents a potential evolution problem.
TOPICS:

• Technology types and wavelengths used
Standards: EPON and 10G EPON

- The **Rates** of EPON and 10G EPON are shown below:

<table>
<thead>
<tr>
<th>Classes “x” =</th>
<th>Application</th>
<th>Down-Stream</th>
<th>Up-Stream</th>
</tr>
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<tbody>
<tr>
<td>PX</td>
<td>EPON</td>
<td>1G</td>
<td>1G</td>
</tr>
<tr>
<td>PRX</td>
<td>10GEPON</td>
<td>10G</td>
<td>1G</td>
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<tr>
<td>PR</td>
<td>10GEPON</td>
<td>10G</td>
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</table>

- The **Link Classes** of EPON and 10G EPON are shown below:

<table>
<thead>
<tr>
<th>Classes</th>
<th>Application</th>
<th>Budget (dB)</th>
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<tbody>
<tr>
<td>x10</td>
<td>10 km, 1:16</td>
<td>20</td>
</tr>
<tr>
<td>x20</td>
<td>20 km, 1:16</td>
<td>24</td>
</tr>
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<td></td>
<td>10 km, 1:32</td>
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<tr>
<td>x30</td>
<td>20 km, 1:32</td>
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<td></td>
<td>20 km, 1:64</td>
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</table>
Standards: EPON, 10G EPON, NGPON2, GPON

- **IEEE 802.3 Rev 2012 details for EPON & 10GEPON**
  - EPON 1G down: 1480-1500 nm
  - EPON 1G up: 1260-1360 (although in N.A. this is normally 1290-1330 nm)
  - 10GEPON 10G down: 1575-1580 nm
  - 10GEPON 10G up: 1260-1280 nm

- **ITU SG15/Q2 NGPON2 details**
  - NGPON2 down: 1596-1603 nm (TWDM PON)
  - NGPON2 up: 1524-1544 nm (TWDM PON)
  - NGPON2 up/down: 1524-1625 nm (Full Spectrum PtP WDM)

- **ITU G.984.5/Table 1 GPON 1310 nm Upstream wavelength range options**
  - Regular 100 nm 1260-1360 nm
  - Reduced 40 nm 1290-1330 nm
  - Narrow 20 nm 1300-1320 nm
## PON Optical PMD comparison

EPON, 10G-EPON (Px10,20,30,40), GPON, NGPON2

<table>
<thead>
<tr>
<th>Link Budget (dB)</th>
<th>System</th>
<th>Class</th>
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</thead>
<tbody>
<tr>
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<td>IEEE</td>
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<td>IEEE</td>
<td>Px20</td>
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<td>28</td>
<td>GPON</td>
<td>B+</td>
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<td>29</td>
<td>IEEE / XG-PON1 / NG-PON2</td>
<td>Px30 / N1</td>
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<td>31</td>
<td>XG-PON1 / NG-PON2</td>
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<tr>
<td>35</td>
<td>XG-PON1 / NG-PON2</td>
<td>E2</td>
</tr>
</tbody>
</table>
Reference ODN Architecture
Standards Evolution - NG-PON2

- FSAN/ITU is developing 40/80G PON standards now

- Based on a multi-wavelength scheme (similar to 100GbE)
  - Primary Solution is a Time & Wavelength Division Multiplexing (TWDM) scheme
  - Optional Solution is a Point-to-Point Wavelength Division Multiplexing (PtP WDM) scheme
  - Both schemes use colorless Power Splitters in the ODN, and “Colorless” ONUs

- Consists of a series of standards:
  - G.989.1 (Operational Requirements – Operators)  Already available
  - G.989.2 (PMD or Optical Requirements)  Out for vote
  - G.989.3 (TC or MAC Layer)  Anticipated mid-2014
  - G.multi (the multi-wavelength control)  Still under discussion/standardization
Standards Evolution - NG-PON2

TWDM
- This is hybrid PON approach, taking aspects of traditional TDM/TDMA PON and WDM PON.
- In TWDM PON, ONUs share individual wavelengths in a TDMA scheme.

PtP WDM
- This is a pure wavelength per user PON approach.
- In PtP WDM PON, ONUs have dedicated wavelengths per ONU/User.

In both schemes, colorless power splitters are still used (re-use of ODN).
TOPICS:

• Co-existence
**Discussion**

- EPON ONUs need to have Wavelength Blocking Filters (WBF) to block future PON wavelengths (10G EPON, TWDM, etc).
  - If considering CWDM on the same fiber, need CWDM type Band-pass filters (BPF)
  - CWDM also has ramifications on the RFOG ONU, needing appropriate BPFs

- The FSAN & ITU groups did not consider RFOG as a coexistence requirement and therefore there is a wavelength conflict between future (Beyond 10G) xGPON and RFOG solutions

- One additional observation
  - RFOG and NG PON technologies both have high power optical levels
  - This results in RAMAN associated interactions and degradations
    - RFOG ONU video can be impacted due to RAMAN depletion of the RFOG 1550nm carrier
    - 10GEPON impact is limited, especially for lower power budget classes, but should be evaluated
    - Multi-wavelength (NG EPON) type solutions would need mitigation mechanisms
Summary

• Presented for information only

• No specific proposals being made at this time

• This information is being presented to help aid the NG EPON group to PON in considering fiber wavelength conflicts, service coexistence, and potential optical component economies of scale