Issues in DWDM Testing

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Agenda

› What your Equipment Measurement system limitations
› Challenges with 100G
› Other impairments in optical systems,
What is EMS?

Uses Optical Channel Performance Monitoring using embedded device in EDFA's, ROADM's etc to monitor channels.

- Provide Power, Wavelength & OSNR

I don't need an OSA. My EMS will autobalance and optimise my system
Example output from OCPM for 10G, 100GHz Channel Spacing
An example of a major European operator

<table>
<thead>
<tr>
<th>Ch. #</th>
<th>OSNR (dB)</th>
<th>EMS</th>
<th>EXFO</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35.3</td>
<td>23.4</td>
<td>11.9</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>30.1</td>
<td>24.2</td>
<td>5.9</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>22.0</td>
<td>24.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>21.2</td>
<td>24.0</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>27.4</td>
<td>28.0</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>36.9</td>
<td>27.9</td>
<td>9.0</td>
<td></td>
</tr>
</tbody>
</table>

EMS clearly has no inband capability and is only measuring IEC. Very limited optical performance gives a very distorted trace.

EMS Conclusion

EMS are very limited in accuracy (even where IEC valid).
Limited to 2.5 & 10G systems at 100GHz channel spacing.
Not valid where we have ROADM.
Large errors at 50GHz channel spacing.

An In-Band capable OSA is required to get an accurate picture of the network.
100G OSNR story

For 100G signals:
• ROADM input unfiltered
• 50 GHz filters
• ROADM output filtered

For 100G signals:
• ROADMs still cause noise shaping
• Filtered 100G signals larger than 50 GHz grid.
**Why IEC fails in coherent networks**

**Case 1:** Network operates at 40 Gb/s or 100 Gb/s
- Coherent 40G and 100G signals are closely spaced and overlap.
- The IEC interpolation method leads to an over-estimation of the noise level.
- It creates a false sense of problem.

**Case 2:** ROADM present in network
- A ROADM contains filters that reduce inter-channel noise.
- The traditional interpolation method leads to an underestimation of the noise.
- It creates a false sense of security.
Why OSA’s fail in coherent networks

- Same limitations apply for 100G
  - ROADM’s
  - Spectrally wide
  - Filtering

- Polarization-based in-band OSNR does not work because signal looks unpolarized (two orthogonal pol’s).
  - WDM-aware does not work
  - pol. nulling does not work

Need coherent OSNR (reference-based!)

EXFO’s approach – Reference-Based

- Can measure via Taps -> No service interruption
- Rely on same Maths as WDM-aware
- Use reference-acquired shape (Tap 1)
- Find noise contribution
EXFO’s approach – Reference-Based

- Use Reference Measurement as signal shape to find noise

• Showing with Tap 2 to demonstrate reference with residual OSNR but works well of course with Tap 1

Tap 2

Tap 3

So is coherent OSNR available?

› EXFO now offers reference-based method as analysis service:

› The customer acquires traces at the transmitter and at the location of interest with EXFO OSA.

› The ONLY solution available now in the market!!
Impairments in Next Gen Optical Systems

- Increased network complexity
- New impairments to consider

Next Generation Optical System
Brown Field Installation

Mix & Match 10G, 40G & 100G waves on a fiber as needed using similar engineering rules
**Interchannel crosstalk:**

- In dense channel plans, when neighbor channels have a non negligible portion of their spectrum that extends within the channel bandpass of a given signal.

- OSNR based on ASE noise will give an OSNR that doesn’t equate to the BER the system.

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**Nonlinear Impairments:**

- When signals interact with one another.
  - Have amplitude & phase modulation signals next to one another.
  - Gives rise to **cross-phase modulation**
  - Lead to partial depolarization of neighbouring channels signals

- Behaves like additional noise on top of the ASE
  - can degrade BER
In Phase modulated transmission, a CW source is modulated and is polarisation dependant.
- If poorly aligned – portion of signal transmitted though system un-modulated.
- **Wasted power & extra noise**

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**Conclusion**

- Challenges in measuring OSNR in ROADM based networks
- Challenges to overcome in measuring 100G OSNR

Other contributors include, non-linear impairments, X-talk, misaligned modulators.

These will add to the noise and will effect BER.

Network operators want more visibility of their network

EXFO adding ability to measure;
- PMD, X-Talk, Nonlinear impairments & much more to its OSA portfolio
Thank you