Best Practices for Testing Parallel Optics in the Enterprise

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Agenda

• Quick review of some basics and standards
• End-face inspection and certification
• Polarity Check / Fiber map
• Loss, Length and Polarity testing
• OTDR testing
• Wrap up
Is MPO new?

No – MPO connectors and ribbon fiber have been around for well over a decade.
What’s changed?

- Relentless need for speed

- MPO being extended to the equipment
  - Switches and Servers
  - QSFP ports

Courtesy of Leviton
## Newer Data Center Interfaces:

<table>
<thead>
<tr>
<th>Interface/Application</th>
<th>Reach</th>
<th>Medium</th>
<th>Parallelism</th>
<th>Standard</th>
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</thead>
<tbody>
<tr>
<td>100GBASE-ER4</td>
<td>40 km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>IEEE 802.3ba</td>
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<tr>
<td>ER4-Lite</td>
<td>20-25km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>Variation on 802.3ba</td>
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<tr>
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<td>SMF</td>
<td>4 λ / dir</td>
<td>IEEE 802.3ba</td>
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<tr>
<td>CWDM4</td>
<td>2 km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>CWDM4 MSA</td>
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<tr>
<td>CLR4</td>
<td>2 km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>CLR4 Alliance</td>
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<tr>
<td>PSM4</td>
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<td>SMF</td>
<td>4 fibers / dir</td>
<td>PSM4 MSA</td>
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<tr>
<td>SWDM4</td>
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<td>OM5 MMF</td>
<td>4 λ / dir</td>
<td>SWDM Alliance</td>
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<tr>
<td>40GBASE-SR4</td>
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<td>OM4 MMF</td>
<td>4 fibers / dir</td>
<td>IEEE 802.3bj</td>
</tr>
<tr>
<td>100GBASE-SR4</td>
<td>70 m</td>
<td>OM4 MMF</td>
<td>4 fibers / dir</td>
<td>IEEE 802.3bm</td>
</tr>
</tbody>
</table>
Data Center Examples of MPO/Ribbon Fiber

6 x 1/10Gbps Ethernet Channels (MMF)
6 x 1/10Gbps Ethernet Channels (SMF)

- Fiber consolidation and migration path
- SFP/SFP+ at each end
- 12 fiber MPO Link w/Cassettes at either end

4 x 10Gbps Ethernet Channels (MMF)

- 8 fiber MPO Link w/Cassette
- Fiber consolidation and migration path
- QSFP at switch SFP+ at server

40/100Gbps Ethernet Channels (MMF)
40/100Gbps Ethernet Channels (SMF – PSM4)

- 12 fiber MPO Link (8 fibers used)
- QSFP/CFP at both ends
Single Fiber vs. Multi-Fiber Connectors

SINGLE FIBER CONNECTOR

- White ceramic ferrule
- One fiber per connector
- Common types include SC, LC, FC, and ST

(example: LC)

MULTI-FIBER CONNECTOR

- Polymer ferrule
- Multiple fibers in linear array (for example, 8, 12, 24, 48, and 72) in single connector providing high-density connectivity
- Common type is MPO or MTP®

(example: MPO)
Anatomy of a 12-fiber MPO Connector

Note: MPO connectors with higher fiber counts (ie: 24) will have multiple rows of fiber on the ferrule
Polarity and Gender
MPO Patch Cord Configurations

**Type A Cable**
- Connector A: 1 2 3 4 5 6 7 8 9 10 11 12
- Connector B: 1 2 3 4 5 6 7 8 9 10 11 12

**Type B Cable**
- Connector A: 1 2 3 4 5 6 7 8 9 10 11 12
- Connector B: 12 11 10 9 8 7 6 5 4 3 2 1

**Type C Cable**
- Connector A: 1 2 3 4 5 6 7 8 9 10 11 12
- Connector B: 2 1 4 3 6 5 8 7 10 9 12 11
Focus on the Connection

MPO Unpinned (Female)

MPO Pinned (Male)

Adapter

Courtesy of US Connec
The Physical Contact area is the critical joining point in the fiber network. If there is no clean physical connection, the light path is disrupted and the connection is compromised.

NOTE: Single mode uses Angled Polished Connectors (APC). Multimode uses PC.
Top-View Cross Section of 12 Fiber MPO

Physical Contact

Clean

MPO Front View
Top-View Cross Section of 12 Fiber MPO

Particle of Dirt

Air Gap

Particle of Dirt

Dirt
Back Reflection
Insertion Loss

Contaminated
Impact of MPO contamination

If a critical connection is affected, the impact can be exponential!
In a study by NTT-Advanced Technology, 98% of installers (blue) and 80% of network owners (red) reported that issues with connector contamination was the greatest cause of network failure.
Real End-Faces Examples

Cracked MPO

Happy MPO
TEST & CERTIFICATION
IEC Standards Related to Fibre Testing

**ISO 11801**
Information technology -
Generic cabling for
customer premises

**ISO 14763-3**
Information technology -
Implementation and operation of
customer premises cabling - Part 3:
Testing of optical fibre cabling

**IEC 61280-4-1**
Installed cable plant -
Multimode attenuation measurement

**IEC 61280-4-2**
Installed cable plant -
Single-mode attenuation and optical return loss measurement

**IEC 61280-1-4**
General communication subsystems - Light source encircled flux measurement method

**IEC 61300-3-35**
Visual inspection of fibre optic connectors and fibre-stub transceivers

SC 25 WG 3

SC 86C WG 1
Test Procedures

Bicsi
TIA Standards Related to Fiber Testing

• **568.3-D** – Optical fiber cabling and component standard
  – Updated to revision “D” in October 2016
  – Transmission performance and test requirements in Clause 7
  – Annex E (informative) provided guidelines for field testing

• **ANSI/TIA-526-14-C-2015**
  – Test procedures for installed multimode fiber cable plant
  – Released in April 2015
  – Adaptation of IEC 61280-4-1 Ed. 2.0
  – Encircled Flux for 850nm/50 micron

• **ANSI/TIA-526-7-A**
  – Test procedure for installed single mode fiber cable plant
  – Released in July 2015
  – Adoption of IEC 61280-4-2 Ed 2.0
Tests Defined in Standards

• Both TIA and ISO/IEC standards specify two tiers of certification
  – Tier 1 (or basic): loss, length, and polarity
  – Tier 2 (or extended): Optical time domain reflectometer (OTDR)

• Tier 2 (extended) tests are an optional addition to tier 1 (basic) tests

• Fiber end-face inspection and certification is also a requirement to ensure pristine end-face condition PRIOR to mating
Simple/Duplex vs MPO testing

- Existing fiber test standards do not address MPO-specific concerns
- SC 86C WG 1 has published a Technical Report (TR) on testing MPO

IEC 61282-15/TR

Testing Multi-fiber optic cable plant terminated with MPO connectors

Cabling testing standards such as IEC 61280-4-1 for multimode attenuation measurements and IEC 61280-4-2 for single-mode attenuation and optical return loss measurement describe testing simplex or duplex fibre cabling terminated with single-fibre ferrule connectors. These IEC standards are difficult to apply to the testing of installed multi-fibre cabling terminated with multi-fibre connectors (MPO).
Challenges for testing MPO

- End-face condition at ALL connection points
- When to test MPO vs. duplex/simplex
- Fiber map (polarity)
- Gender (pinned/unpinned) and its impact on reference methods and types of cables
- QSFP to LC connections
- Loss test vs. OTDR test
Data Center Examples of MPO/Ribbon Fiber

6 x 1/10Gbps Ethernet Channels (MMF)
6 x 1/10Gbps Ethernet Channels (SMF)
• Inspect MPO connection to cassettes
• Test duplex drops

4 x 10Gbps Ethernet Channels (MMF)
• Inspect MPO connection to cassettes and patch panels
• Test from MPO to simplex

40/100Gbps Ethernet Channels (MMF)
40/100Gbps Ethernet Channels (SMF – PSM4)
• Inspect MPO connection
• Test MPO Links/Channels
Inspect Before You Connect™

Follow this simple “INSPECT BEFORE YOU CONNECT” process to ensure fiber end faces are clean prior to mating connectors.
Inspect and Clean Both Connectors in Pair

**Inspecting BOTH sides** of the connection is the **ONLY WAY** to ensure that it will be free of contamination and defects.

Patch cords are easy to access and view compared to the fiber inside the bulkhead, which is frequently overlooked. The bulkhead side may only be half of the connection, but it is far more likely to be dirty and problematic.
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IEC 61300-3-35 Sets Requirements for Connector Quality

Even for MPO!

Multimode MPO Connectors

<table>
<thead>
<tr>
<th>ZONE NAME (Diameter)</th>
<th>SCRATCHES</th>
<th>DEFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. CORE Zone (0–65μm)</td>
<td>no limit &lt;= 5μm 0 &gt; 5μm</td>
<td>4 &lt;= 5μm none &gt; 5μm</td>
</tr>
<tr>
<td>B. CLADDING Zone (65–115μm)</td>
<td>no limit &lt;= 5μm 0 &gt; 5μm</td>
<td>no limit &lt; 2μm S from 2–5μm none &gt; 5μm</td>
</tr>
</tbody>
</table>
• For existing installations, the end-to-end polarity is often not known

• Fiber Map shows the polarity of the system
Tier 1 (Basic) MPO to MPO Certification

- Test Links and Channels
- Loss, Length and Polarity
MPO Power Meter

- MPO power meter – Using any MPO source
  - Fault Isolation
  - Testing output power from 40G optics
Selecting Channels

- Can apply to any of the above Test scenarios
- Helps in cases when 8 or fewer fibers are present in MPO links (e.g. 40GBASE-SR4)
- Allows selection of which of the 12 channels are active
  - At the Remote (TX) and at the Local (RX)
- Results reflect topology
- No unwanted “fails” due to nonexistent channels
Tier 2 (Extended) Testing of MPO

• Tier 1 testing cannot ensure individual event (splices and connection) losses are within spec OR the cable attenuation is uniform

• Tier 2 (OTDR) testing adds the characterization of these events to the certification test

• Tier 2 testing is also the ideal fiber troubleshooting tool to find the cause AND location of excess loss (incl. breaks) and reflectance for eg. if you fail in Tier 1

• Requires MPO switch

• Pinned/unpinned systems require different launch and receive cords
MPO OTDR Testing (via MPO Switch)

Connector endface inspection test points

Permanent Link

LC12 Receive Tails

MPOx12 Launch Lead

MPOx12 Launch Lead

PORT 3
40G SWITCH

PORT 2
40G SWITCH

PORT 1
40G SWITCH

192 FIBER MPO TRUNK
24x8 MPO to 16x12F MPO 2:3 FLIPPED HD

192 FIBER NGF BLOCK
STRAIGHT OR 2RU Q38000 PANEL WITH 4 - MPO/LC BLADES

6xLC Duplex Receive box

1 2 3 4 5 6
Schematic test results (pass example)
Wrap-up

- MPO end-face condition is the most critical element in a channel with MPO connections.
- Polarity can be a challenge – especially when adapting existing MPO backbones to new services.
- Be aware of pinned/unpinned – presents challenges for testing (test cords must mate with system – challenges with test device and test cord gender).
- Loss testing is typically done on links:
  - 1/10G MM, 1/10/40/100G SM link is duplex.
  - 40/100G MM, PSM4 SM link is MPO.
- Testing channels may make sense if hydra (fan cables) are used.
- OTDR testing of MPO allows for:
  - Characterization of the link or channel (uniformity of cable attenuation and connection loss).
  - Fault isolation to prevent unnecessary service interruptions.
  - Length measurements.
Thank you