Best Practices for Testing Fiber Optics in the Enterprise

Osik Kwon
Solution Engineer, PMP
Korea office, VIAVI Solutions

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
Basics

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

40/100GE Client Interfaces available today

<table>
<thead>
<tr>
<th>Interface/Application</th>
<th>Reach</th>
<th>Medium</th>
<th>Parallelism</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>100GBASE-ER4</td>
<td>40 km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>IEEE 802.3ba</td>
</tr>
<tr>
<td>ER4-Lite</td>
<td>20-25km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>Variation on 802.3ba</td>
</tr>
<tr>
<td>100GBASE-LR4</td>
<td>10 km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>IEEE 802.3ba</td>
</tr>
<tr>
<td>CWDM4</td>
<td>2 km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>CWDM4 MSA</td>
</tr>
<tr>
<td>CLR4</td>
<td>2 km</td>
<td>SMF</td>
<td>4 λ / dir</td>
<td>CLR4 Alliance</td>
</tr>
<tr>
<td>PSM4</td>
<td>500 m</td>
<td>SMF</td>
<td>4 fibers / dir</td>
<td>PSM4 MSA</td>
</tr>
<tr>
<td>SWDM4</td>
<td>100 m</td>
<td>OM5 MMF</td>
<td>4 λ / dir</td>
<td>SWDM Alliance</td>
</tr>
<tr>
<td>40GBASE-SR4</td>
<td>100 m</td>
<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

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

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

- 12 fiber MPO Link (8 fibers used)
- QSFP/CFP at both ends

Single Fiber vs. Multi-Fiber Connectors

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

- 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®
Anatomy of a 12-fiber Multi-Mode MPO Connector

Note: MPO connectors with higher fiber counts (i.e.: 24) will have multiple rows of fiber on the ferrule

Polarity and Gender

TYPE "A" ADAPTER CONFIGURATION

KEY UP TO KEY DOWN

TYPE "B" ADAPTER CONFIGURATION

KEY UP
MPO Patch Cord Configurations

Focused on the Connection

Courtesy of US Conec
Focused on the Connection

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

---

1
2
3
4
5
6
7
8
9
10
11
12

Physical Contact

Clean

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

Back Reflection! And Insertion Loss!

Impact of MPO contamination

If a critical connection is affected, the impact can be exponential
**Reflection on the high bit-rate fiber network?**

- Will be occurred multiple reflection (=Noise!)
- Multiple reflection generate signal dispersion effect
- It is impossible to identify by receive power measurement

![Diagram showing reflected signal and secondary signal over time with power levels](image)

**Contaminated fiber end-face is the #1 cause of network failures**

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.
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 fiber 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 fiber optic connectors and fiber-stub transceivers
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): loss, length, Reflection, ORL and more.
• 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

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 Testing

• Inspect MPO connection to cassettes
  • Test duplex drops

• Inspect MPO connection to cassettes and patch panels
  • Test from MPO to simplex

• Inspect MPO connection
  • Test MPO Links/Channels

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

4 x 10Gbps Ethernet Channels (MMF)

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

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.

Inspect ALL fibers in a Multi-Fiber Connector

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.
IEC 61300-3-35 Sets Requirements for Connector Quality

Even for MPO!

Multimode MPO Connectors

<table>
<thead>
<tr>
<th>ZONE NAME (Diameter)</th>
<th>SCRAPES</th>
<th>DEFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. CORE Zone (6-65µm)</td>
<td>no limit &lt; 5µm 0 &gt; 5µm</td>
<td></td>
</tr>
<tr>
<td>B. CLADDING Zone (65-115µm)</td>
<td>no limit &lt; 2µm 0 &gt; 5µm</td>
<td></td>
</tr>
</tbody>
</table>

Polarity Check (Fiber Map)

- 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. if you fail in Tier 1
- Requires MPO switch
- Pinned/unpinned systems require different launch and receive cords
MPO OTDR Testing (via MPO Switch)

Multi-fibers/channel OTDR testing

Event diagnostic key suggests corrective actions for resolving fiber problems when a fault is detected.
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:
  – Reflection is one of key to manage network performance in high bit-rate network
  – Characterization of the link or channel (uniformity of cable attenuation and connection loss)
  – Length measurements
  – Fault isolation to prevent unnecessary service interruptions
Technology Leadership
Fast Technician Workflows
Best Value

viavisolutions.com/enterprisetest

THANK YOU!