Trends in Designing and Testing Data Center Infrastructure

Arelis Soto – Corning Optical Communications
Matt Brown – VIAVI Solutions
Agenda

Data Center Market Trends
Transceiver Technology
Connectivity
MPO Test Standards
MPO Testing
Market Trends
The Need for Speed
Market Trends

2018: What Happens in An Internet Minute

- 973,000 Facebook Logins
- 871 Million Video Views
- 18 Million Text Messages
- 4.3 Million Video Downloads
- 174,000 Instagram Posts
- 481,000 Tweets Sent
- 2.6 Million Snapchats Created
- 266,000 Hours Watched
- 1.1 Million Swipes
- 586,823 Online Shoppers
- 38 Million Messages
- 936,073 Emails Sent
- 187 Million Devices Shipped
- 67 Wake-Rest Alerts

Created by: @LostLewis @OfficiallyChadd

Image: Visual Capitalist
Transceiver Technology

So Many Options to Consider
SFP+ Electrical Connector has matured PMDs

Electrical

1 TX/RX lane each at 10G

SFP+ = 10G
10G Electrical

Optical

MM
SM

1λ @ 10G
2 F, LC

1λ @ 10G
2 F, LC

10G-SR
10G-LR
The optical path at higher data rates has a divergent path.
QSFP+ Electrical Connector has matured PMDs

- **Electrical**
  - 4 TX/RX lanes each at 10G
- **IEEE Standard**
  - MSA/Eng

- **Optical**
  - WDM, MM
  - WDW, SM
  - Parallel, MM
  - Parallel, SM

- **40G-SWDM**
- **40G-BiDi**
- **40G-LR4**
- **40G-LR4L**
- **40G-SR4**
- **40G-eSR4**
- **40G-PLR4**

QSFP+ = 40G 4x10G Electrical

- 2λ @ 20G 2 F, LC
- 1λ @ 10G 8 F, MTP®
- 1λ @ 10G 8 F, MTP
100G QSFP28 Electrical Connector almost mature

**Electrical**
- 4 TX/RX lanes each at 25G

**IEEE Standard**
- MSA/Eng

**QSFP28 = 100G**
- 4x 25G Electrical (or 4x10G)

**Optical**
- WDM, MM
- WDW, SM
- Parallel, MM
- Parallel, SM

- 2λ @ 50G 2 F, LC
- 4λ @ 25G 2 F, LC
- 4λ @ 25G 2 F, LC
- 1λ @ 25G 8 F, MTP®
- 1λ @ 25G 8 F, MTP

- 100G-BiDi
- 100G-SWDM
- 100G-LR4
- 100G-SR4
- 100G-PSM4
If the limit is currently 25G for a single lane rate, how is 100G-BiDi doing 50G per wavelength/lane?
200G QSFP56 Electrical Connector is in Development

Electrical

- 4 TX/RX lanes each at 50G

IEEE Standard

- MSA/Eng

Optical

- WDM, MM
- WDW, SM
- Parallel, MM
- Parallel, SM

- 4λ @ 50G 2 F, LC
- 4λ @ 50G 2 F, LC
- 1λ @ 50G 8 F, MTP®
- 1λ @ 50G 8 F, MTP

- 200G-SR1.4 ?? (failed at IEEE)
- 200G-LR4
- 200G-SR4
- 200G-DR4

200G QSFP56 Electrical Connector is in Development

BICSI WINTER Conference & Exhibition
400G QSFP-DD PMDs are still in the early stages

Electrical

IEEE Standard  
MSA/Eng

Optical

Double row of electrical pins

QSFP-DD or OSFP= 400G 8x50G Electrical (or 8x25G)

8 TX/RX lanes each at 50G

WDW, MM

WDW, SM

Parallel WDM, MM

Parallel WDM, MM

Parallel, SM

No solution identified

8λ @ 50G 2 F, LC

2λ @ 50G 8 F, MTP

1λ @ 50G 16 F, MTP

1λ @ 100G 8 F, MTP

400G-LR8

400G-FR8

400G-SR4.2

400G-SR8

400G-DR4

400G-DR4

2020 BICSI WINTER Conference & Exhibition
## Transceiver Technology

<table>
<thead>
<tr>
<th></th>
<th>10G</th>
<th>25G</th>
<th>40G</th>
<th>50G</th>
<th>100G</th>
<th>200G</th>
<th>400G</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duplex OM3/4</strong></td>
<td>SFP+ (1x10G)</td>
<td>SFP28 (1x25G)</td>
<td>QSFP+ (4x10G)</td>
<td>SFP56 (1x50G)</td>
<td>QSFP28 (4x25G)</td>
<td>SFP-DD (2x50G)</td>
<td>QSFP56 (4x50G)</td>
</tr>
<tr>
<td><strong>Parallel OM3/4</strong></td>
<td>-</td>
<td>-</td>
<td>SR4 (150m)</td>
<td>-</td>
<td>SR4 (100m)</td>
<td>-</td>
<td>SR4 (100m)</td>
</tr>
<tr>
<td><strong>Duplex SM</strong></td>
<td>LR (10km)</td>
<td>LR (10km)</td>
<td>LR4 (10km)</td>
<td>LR (10km)</td>
<td>LR4 (10km)</td>
<td>LR4 (10km)</td>
<td>DR (500m)</td>
</tr>
<tr>
<td><strong>Parallel SM</strong></td>
<td>-</td>
<td>-</td>
<td>PLR4 (500m)</td>
<td>-</td>
<td>PSM4 (500m)</td>
<td>-</td>
<td>DR4 (500m)</td>
</tr>
</tbody>
</table>
Connectivity
Backbones, Links and Channels

- A **backbone** MTP/MPO cable is the foundation of the link. It is sometimes called a trunk cable.

Backbone example – 48 fiber backbone cable terminated with four 12-fiber MPOs
Backbones, Links and Channels

- A link is the permanent connection between two locations. Typically it is the cabling between patch panels or distribution frames and can include adapter panels and cassettes. Fiber links can have connections and splices in them.

Link example – backbone cable terminated on MPO adapter panels. Backbone could also be terminated on break-out cassettes.
Backbones, Links and Channels

- A **channel** is the connection between equipment. It is made up of the link plus equipment cords (patch cords) at either end of the link.

Channel example – MPO equipment cords added – Four 40/100/400G channels
1G/10G MM Channels 1/10/100G SM Channels

- LC-LC connectivity using cassettes via LC Links and Channels
1G/10G MM Channels 1/10/100G SM Channels

- LC-MPO Links, LC-LC Channels. LC-LC connectivity using fan-out cables

MPO Backbone
Likely multiples of 8 or 12
i.e. 72, 96, 144, etc.

LC to MPO Links

LC Channels Connecting to SFPs
40/100G SR4 MM, 100G PSM4 SM

- MPO Links and Channels
- MPO-MPO connectivity using Adapter Panels

- 8-fiber MPO Links
- 12f MPO channels Connecting to 40/100G QSFPs

MPO Backbone Likely multiples of 8 i.e. 72, 96, 144, etc.
QSFP to LC for 40/100Gbps to 10/25Gbps

- MPO-MPO links, MPO-LC channels
- MPO-LC connectivity using fan-out cables

MPO Backbone
8-fiber MPO Links
MPO-LC channels – 8 fibers used
Connecting to 40/100/400G QSFPs to 10/25/100G SFPs
Anatomy of a 12-fiber Multi-Mode MPO Connector

- Key
- Fibers
- Polymer Ferrule
- Alignment pins/sockets

Note: MPO connectors with higher fiber counts (e.g. 24) will have multiple rows of fiber on the ferrule
Different Ferrule, Many more fibers

- Polymer ferrule
- Multiple fibers in linear array
- 6x or 12x density connectivity

- White ceramic ferrule
- One fiber per connector
- Common types include SC, LC, FC, and ST
MPO: Multimode vs Single-mode
Pinned and UnPinned
Base8 Has it Covered

2-fiber

8-fiber

8-fiber breakout

16-fiber
MPO TEST STANDARDS
TIA Standards Related to Fiber Testing

• 568.3-D – Optical fiber cabling and component standard
  – Transmission performance and test requirements in Clause 7
  – Annex E (informative) provided guidelines for field testing
  – Addendum ANSI/TIA-568.3-D-1 approved in October 2018
• ANSI/TIA-526-14-C-2015
  – Test procedures for installed multimode fiber cable plant
  – 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
  – Adoption of IEC 61280-4-2 Ed 2.0
Tests Defined in Standards

- Both ANSI/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)
    - 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
Simplex/Duplex vs. MPO Testing

- Existing fiber test standards do not address MPO-specific concerns
  - ANSI/TIA-526-7 and -14 describe testing fiber terminated with single
    ferrule connectors and are difficult to apply to multi-fiber terminated
    cabling
- SC 86C WG 1 released Technical Report (TR) on testing MPO
  - IEC TR 61282-15
- TIA TR42.11 released an addendum to ANSI/TIA-568.3-D that
  references the IEC TR
- SC 86C WG 1 is working on an MPO testing standard
  - To be published as IEC 61280-4-5
Polarity TSB

• TR42.11 is working on TSB-5069

1 Scope

This TSB provides guidelines for polarity when creating optical fiber cabling systems using duplex, single row and dual-row array connector components. This guide is intended to augment the ANSI/TIA-568.3 Optical Fiber Cabling and Components Standard.
MPO TESTING
What do we test?

• Construction phase:
  – Links – equipment cords are not in place yet

• Operational phase:
  – Channels – will the CHANNEL support the application?
Many Topologies, Only 3 Test Scenarios

**LC-LC Links and Channels**

*Tests to perform:*
- Inspect all connections
- Test duplex (LC) links w/duplex OLTS

**MPO-LC Links or Channels**

*Tests to perform:*
- Inspect all connections
- Test from MPO to LC
- OR use fan-out cable and test MPO-MPO

**MPO-MPO Links or Channels**

*Tests to perform:*
- Inspect all connections
- Test MPO links/channels
MPO Specific Test Challenges

• End-face condition
  – Much more challenging to keep MPO clean vs. simplex
• Pinned-unpinned
  – Impact on test cords and/or reference methods
• Number of fibers used
  – 8, 12, 24
  – False failures due to missing fibers
• Polarity
  – A, B, C
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.
Far more area and probability of contamination

1.25mm sleeve = 1.2mm$^2$ area

9.5mm X 5.0mm opening = 47.5mm$^2$ area

Probabilities scale exponentially:
If 1 fiber is 95% likely to be clean, 12 fibers are \((0.95)^{12}\) = 55% likely to be clean

MPO adapters have no sleeve or alignment feature, they are wide open
Inspect Before You Connect

Follow this simple “INSPECT BEFORE YOU CONNECT” process to ensure fiber end faces are clean prior to mating connectors.
Top-view Cross Section (1–12 Fibers)

Example of Dirty Connection
(contamination causing air gaps, back reflection, insertion loss)
Cleaning MPO Connectors

Clicker for cleaning MPO end faces

- Clickers are good for cleaning end faces during network installations
- Cleans both in adapter/cassette and patch cords
- Uses micro woven ultrasonically cut cleaning ribbon

Best Practice for Wet-Dry:

- Apply small amount of cleaning fluid to an optical grade wipe
- Touch the cleaning tip of the clicker on the wet spot on the wipe
- Do NOT apply the cleaning fluid directly to the cleaning ribbon

Courtesy of Sticklers
Pinned vs. unpinned links and channels

- There are four possible configurations for links and channels:
  1. Link with unpinned MPO connectors
  2. Link with one pinned and one unpinned MPO connector
  3. Link with pinned MPO connectors
  4. Channel with unpinned MPO connectors
- Like duplex optical testing, a one cord reference is the Reference Test Method (RTM) for links.
  - The RTM offers the best measurement accuracy
- As the MPO power meter is either pinned or unpinned, performing a one cord reference may require special test cords that allow the configuration to change from pinned to unpinned.
Testing Pinned Links with a Pinned Source and Meter

1. Connect the MPOLS to MPOLP using an unpinned to unpinned test cord of the same polarity of the system to be tested
2. Set reference
3. Disconnect the test cord from the MPOLP and add a second unpinned to unpinned test cord to the MPOLP – also of the same polarity of the system to be tested
4. Verify the reference by adding two type A adapters and a third test cable of the same polarity of the system to be tested. Perform and auto test and ensure the loss is less than expected.
5. Remove the two adapters and the third test cord, connect to the link under test, and test.
Testing Unpinned Links with a Pinned Source and Meter

1. Connect the MPOLS to MPOLP using a test cord of the same polarity of the system to be tested and which has the ability to change from being pinned to unpinned. For this first step, ensure the end connecting to the power meter is unpinned.

2. Set reference

3. Disconnect the test cord from the MPOLP and add a second test cord that is unpinned (at the meter) to pinned (where it will connect to link under test. This cord should be of the same polarity of the system to be tested

4. Verify the reference by adding one type A adapter and connecting the two test cords to each other. Perform and auto test and ensure the loss is less than expected.

5. Remove the adapter, change the launch cord from unpinned to pinned, connect to the link under test, and test.
Selecting Channels

- Can apply to any architecture or test scenario
- Allows selection of which of the 12 channels are present and need to be tested
- Eliminates false fails in cases when 8 or fewer fibers are present in MPO links (e.g. 40/100GBASE-SR4)
- Results reflect architecture
Polarity Check (aka Fiber Map)

For existing installations, the end-to-end polarity is often not known.

Polarity Check tool shows the polarity of the system.
MPO Testing: OLTS vs. Native MPO
Testing MPO to LC Links

1. Set reference – One-cord between MPOLS and MPOLP

2. Disconnect launch TRC from MPOLP and add fan-out TRC
Testing MPO to LC Links

3. Verify Reference – add third cable – measure loss

4. Test system
Tier 2 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 trouble shooting tool to find the cause AND location of excess loss (incl. breaks) and reflectance

- Requires MPO switch
- Pinned/unpinned systems require different launch and receive cords
MPO OTDR Testing (Internal Switch)

Simplex Fiber – connect OTDR module to switch module

Automatic switching
Conclusion and Q&A

- Modern Data Centers present test challenges many are not used to addressing
  - MPO-based systems
  - Inspection and cleaning
  - Different topologies
- There are solutions for addressing these challenges!