High Density Fiber Connection with Very Small Form Factor Connector for Over 51.2Tbps Co-Packaged Optics

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2. MDC and MMC – a Very Small Form Factor Connector

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Demand of High Density Fiber Connection for CPO
Decade of Switch Silicon, SerDes, + Parallel Optics

2010-2022:
• 80X Switch Silicon Bandwidth Increase
• 10X Optics Bandwidth Increase
• Result: 8X fiber (or λ) increase per switch
Front Panel Density Considerations: 1st Gen - 51.2TB CPO
FR 256f

- 128 Duplex LC’s → 2RU
- 16 MPO-16’s → 1RU
- 128 MDC’s → 1RU
- 16 MMC-16’s → 1RU

DR 1024f

- 512 Duplex LC’s → 8RU??
- 64 MPO-16’s → 1RU
- 512 MDC’s → 2-3RU??
- 64 MMC-16’s → 1RU

Not enough utility area.
Demand of High Density Fiber Connection for CPO

<table>
<thead>
<tr>
<th>Connector Type</th>
<th>DxLC</th>
<th>MDC</th>
<th>MPO-12</th>
<th>MPO-16</th>
<th>MPO-24</th>
<th>MMC-16</th>
<th>MMC-24</th>
<th>MMC-32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber Counts/Conn</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>16</td>
<td>24</td>
<td>16</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>Fiber Counts/1RU</td>
<td>144</td>
<td>432</td>
<td>960</td>
<td>1,280</td>
<td>2,560</td>
<td>3,456</td>
<td>5,184</td>
<td>6,912</td>
</tr>
</tbody>
</table>

Fiber Counts/Conn vs. Fiber Counts/1RU graph showing various connector types (DxLC, MDC, MPO-12, MPO-16, MPO-24, MMC-16, MMC-24, MMC-32) and their corresponding counts.
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USConec and Fujikura collaborate to develop next generation miniature optical connector (MMC/MDC) solutions

ELiMENT™MDC

Mini-Multi-Connector

ELiMENT™, a trademark of US Conec Ltd.
Very Small Form Factor Connector

- **DirectConec™** push-pull boot for easy connector insertion and removal
- Optical Cable Outer Diameter
  - Max. 2.0 mm
- SMF, MMF
  - APC polishing support
- **QSFP-DD/SFP-DD/OSFP** MSA specified optical interface
- Complies with IEC standard insertion loss class B (max. value 0.25 dB @ ≥ 97%)
- Compliant with Telcordia GR-326 and TIA-568
- One-Click® for MDC/IBC™ Optical connector cleaner

**ELiMENT™**, a trademark of US Conec Ltd.
Very Small Form Factor Connector

DirectConec™ push-pull boot for easy connector insertion and removal

Guide

Elliptical guide pins

Optical Cable Outer Diameter
Max. 2.5 mm

SMF, MMF

APC polishing support

- Low-loss, IEC Grade B insertion loss performance
- Compliant with Telcordia GR-1435 (expected)
- Standard cabling industry infrastructure support including IBC™/One-Click™ cleaners, polishers, interferometers, and optical testing equipment

- Proven conventional MT mechanical and fiber alignment structure
- Compatible with standard 250 micron OD and pitch optical fibers

3x cabling port density over the MPO format
MMC was designed to be fully compatible pin and fiber alignment with MPO format.
**Very Small Form Factor Connector**

3.0 mm × 7.0 mm × 8.0 mm

1.8 mm × 6.4 mm × 4.0 mm

- Proven alignment structure of MT-16 and Intermateable with MT-16 technology
- 16 fibers at 250 micron pitch.
- Compatible with 250, 200, and 165 micron fibers.
- Ideal for on-board fiber management, as well as transceivers and hardened connector embodiments.

MT ferrule

- .25 mm (length)
- .55 mm (width)

TMT ferrule

- .25 mm (length)
- .55 mm (width)
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Optical performance 1x16 MMC, 1310nm

N  ...Sample size of fibers
Ave.  ...Average of all IL and RL measurements
Max.  ...Maximum value of all IL measurements
<97%.  ...Value that ranks 97% in the IL measurement data sorted from the smallest to the largest
Min.  ...Minimum value of all RL measurements
Environmental Testing

1310 nm

Max : 0.21 dB
Min : -0.14 dB

1550 nm

Max : 0.13 dB
Min : -0.13 dB
The MMC Cleaner is designed to clean high-density connectors one port.

- Tip optimized for TMT ferrule
- 45% thinner
- 20% longer
# Mechanical Testing

<table>
<thead>
<tr>
<th>Test</th>
<th>Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>IL $\leq$ 0.8 dB, IL change $\leq$ 0.3 dB, RL $\geq$ 50dB</td>
<td>IL $\leq$ 0.35 dB, IL change $\leq$ 0.25 dB, RL $\geq$ 55.3 dB</td>
</tr>
<tr>
<td>Flex</td>
<td>IL $\leq$ 0.8 dB, IL change $\leq$ 0.3 dB, RL $\geq$ 50dB</td>
<td>IL $\leq$ 0.51 dB, IL change $\leq$ 0.16 dB, RL $\geq$ 56.4 dB</td>
</tr>
<tr>
<td>Twist</td>
<td>IL $\leq$ 0.8 dB, IL change $\leq$ 0.3 dB, RL $\geq$ 50dB</td>
<td>IL $\leq$ 0.50 dB, IL change $\leq$ 0.01 dB, RL $\geq$ 56.3 dB</td>
</tr>
<tr>
<td>Transmission with Applied Load</td>
<td><strong>Measure w/Load (0deg)</strong></td>
<td><strong>Measure w/Load (90deg)</strong></td>
</tr>
<tr>
<td>• After test</td>
<td>IL $\leq$ 0.8 dB, IL change $\leq$ 0.3 dB, RL $\geq$ 50dB</td>
<td>IL $\leq$ 0.59 dB, IL change $\leq$ 0.09 dB, RL $\geq$ 66.2 dB</td>
</tr>
<tr>
<td>• During Applied Load</td>
<td>IL change $\leq$ 0.5 dB, RL $\geq$ 50dB</td>
<td>IL change $\leq$ 0.04 dB, RL $\geq$ 68.1 dB</td>
</tr>
<tr>
<td>Impact</td>
<td>IL $\leq$ 0.8 dB, IL change $\leq$ 0.3 dB, RL $\geq$ 50dB</td>
<td>IL $\leq$ 0.58 dB, IL change $\leq$ 0.16 dB, RL $\geq$ 62.1 dB</td>
</tr>
<tr>
<td>Durability</td>
<td>IL $\leq$ 0.8 dB, IL change $\leq$ 0.3 dB, RL $\geq$ 50dB</td>
<td>IL $\leq$ 0.18 dB, IL change $\leq$ 0.07 dB, RL $\geq$ 68.1 dB</td>
</tr>
</tbody>
</table>

**Graph:**
- Max increase: 0.07 dB

**Images:**
- Before and After images of the test results.
Intermateability - condition

Molding ferrule

Assembly & Polishing

IL&RL Random mating

Fujikura

Molding ferrule

Assembly & Polishing

IL&RL Random mating
Intermateability - Results

Insertion Loss [dB]

- N = 480 Fibers
- Ave = 0.13 dB
- Max = 0.29 dB
- <97% = 0.22 dB

Return Loss [dB]

- N = 480 Fibers
- Ave = 76.8 dB
- Min = 58.3 dB
Preliminary 2-row MMC results

![24f-MMC](image)

**Insertion Loss [dB]**

- N = 216 fibers
- Ave. = 0.13 dB
- Max. = 0.34 dB
- 97% = 0.28 dB
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MMC Jr. (Inside Box) and Bundled Connector (Patch)

- Much more fiber density inside box application compared with LCs or MPOs
- More room to manage fibers inside box
- Bundled MMC connector for easy to operate outside box patching

Conventional LC  \[\rightarrow\]  \[\text{MMC Jr.}\]  \[\rightarrow\]  Bundled MMC Connector

Much more room to manage fibers inside box
Reduced Cladding Fibers Support

- MT ferrule base connector interface compatibility between conventional 125um cladding/250um pitch and 80um/250um pitch
- 80um PM fiber available with multiple MFD design for external light source

Endface Microscopic Image, Conventional size MT, 80um cladding (top), 125um cladding (bottom)
Reduced Cladding Fibers Support

Intermateability, 125um fiber to 80um SM fiber connection, conventional 12MT

![Graph showing insertion loss for 1310nm and 1550nm frequencies](image_url)
**Reduced Cladding Fibers Support with MMC**

- Benefit of reduced cladding fiber MMC connector as CPO interface:
  - Supporting near future higher densities Si-Photonics interface
  - Supporting external laser light source by reduced cladding PM fiber

<table>
<thead>
<tr>
<th></th>
<th>Conventional 125um Cladding, 250um pitch</th>
<th>Reduced 80um Cladding, 250um pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1x16f</strong></td>
<td><img src="image1" alt="Image of 1x16f connector" /></td>
<td><img src="image2" alt="Image of reduced 1x16f connector" /></td>
</tr>
<tr>
<td><strong>2x12f</strong></td>
<td><img src="image3" alt="Image of 2x12f connector" /></td>
<td><img src="image4" alt="Image of reduced 2x12f connector" /></td>
</tr>
<tr>
<td><strong>2x16f</strong></td>
<td><img src="image5" alt="Image of 2x16f connector" /></td>
<td><img src="image6" alt="Image of reduced 2x16f connector" /></td>
</tr>
</tbody>
</table>

- <250um pitch for single raw 24f or future higher densities e.g. 2x24f
Summary

1. Very small form factor connector like as MMC will be suitable for 102.4Tbps or above optical switch box interface

2. Reduced cladding (i.e. 80um diameter) fiber supports future high density Si-Photonics chip

3. Fiber system from 80um to 125um can be seamlessly designed not only with SM signal fiber, but also with PM light source fiber with 250um fiber pitch
Shaping the future with “tsunagu” technology.

Optical Component Division

http://www.opticalcomponent.fujikura.com/