400G/800G Modular Architecture Enabled By Flyover™ Twin-Ax

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Agenda

- Conventional Architecture
- Path to 800G
- Flyover Technology
- Modular Architecture
- Summary
Each design requires a unique Electrical/Mechanical/Thermal Design. There are no key building blocks/sub assemblies.
Conventional Architecture: Lossy PCB

As bandwidth requirements rapidly increase to 800G, routing signals through lossy PCBs, vias and other components has become one of the most complex challenges designers face.
Conventional Architecture: ASIC placement concentrate heat

High speed materials and/or Retimers increase cost and heat

Localized Heat further increases trace insertion loss
<table>
<thead>
<tr>
<th>Feature</th>
<th>Conventional</th>
<th>Modular with Flyover</th>
<th>Co-Packaged Optics</th>
</tr>
</thead>
<tbody>
<tr>
<td>400G</td>
<td>✓</td>
<td>✓</td>
<td>NA</td>
</tr>
<tr>
<td>800G</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Latency</td>
<td>✗</td>
<td>✓</td>
<td>✓✓</td>
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<tr>
<td>Insertion Losses</td>
<td>✗</td>
<td>✓</td>
<td>✓✓</td>
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<tr>
<td>System Thermals</td>
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<td>✓</td>
<td>✓✓</td>
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<tr>
<td>Optics Thermals</td>
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<td>✗</td>
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<tr>
<td>Manufacturability</td>
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<td>✓✓</td>
<td>✗</td>
</tr>
<tr>
<td>Cost</td>
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<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Technology</td>
<td>✓</td>
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<td>✗</td>
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Flyover

**END 1:** QSFP28 or QSFP28 Double Density

**CABLE:** Choice of Low Skew Twin-ax

**END 2:** Choice of ASIC-Adjacent Connectors
Samtec High Speed Twinax Cable

- Co-extruded, low loss construction
  - Surrounded by low loss Dk
  - 360° Cu wrap Ground
  - Tighter tolerance between signal conductors
  - Flexible manufacturing lines to tune to 85/92/100 Ω
- Ultra low skew twinax < 3.5 ps/meter
Insertion Loss: Twin-Ax vs PCB

- 4x lower insertion loss than Megtron 7
- Lower temperature variation than Megtron 7
End 1: Flyover QSFP and QSFP-DD

Optimized SI and X-talk performance due to elimination of tight bends, equal lengths of 4 rows of pins
### Data Rate and Features

<table>
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<th>Features</th>
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<tr>
<td>NRZ 28 Gbps</td>
<td>Use of Substrate Allows Customized Signal Mapping</td>
</tr>
<tr>
<td>PAM4 56 Gbps</td>
<td>High-Density, High-Performance</td>
</tr>
<tr>
<td>PAM4 56 Gbps</td>
<td>Direct Attach Technology Excellent Blend of Performance and Density</td>
</tr>
<tr>
<td>PAM4 112 Gbps</td>
<td>The Ultimate in Performance</td>
</tr>
</tbody>
</table>

**End 2:** Choice of ASIC-adjacent connectors Vertical & Horizontal
400G/800G Demo

12.8 Tb Switch (400G per port)
- 32 QSFP-DD
- 18” Samtec Flyover QSFP-DD to NovaRay/AcceleRate
- BER 1e-12 Pre-FEC
- Apples to apples comparison:
  - 1e-3 to 1e-7 for Conventional design with same board stack up

800G performance of Flyover QSFP-DD
- Credo Pelican chip
- BER 3e-7 Pre-FEC
Insertion Loss Breakdown
400G (56G PAM4)

Total Channel Loss ~= 24.7dB (6dB link margin over VSR spec)

~6.4dB
VSR Spec = 9.4dB @13.28GHz

Cable 1
34 AWG, 100 ohm (Solid Core)
Length: 460mm (18”)

Cable 2
3 meter QSFP-DD
Samtec 28awg twin-ax (11.85 dB @13.28GHz)

~11.85dB
802.3 CD trending = ~ 12.3dB w/o fixture & connector budget

~6.4dB
VSR Spec = 9.4dB @13.28GHz
But customers always ask...

How do you fit all these cables into a 1RU?

Will the cables impede air flow and thermals?

Isn’t Flyover an expensive solution?
The Solution: Modular Architecture

Conventional OCP Wedge Design

Modular Architecture Design

ASIC module

Fan module

Com/Power Module – FR4

Front Panel Module – FR4

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Cable Management

Architect in 3 dimensions

- Cables take up <1% of available volume in 1RU
- Cables laid flat to ease air flow
- Longer cables are easier to manage than very short cables.
- Pushing the ASIC further back has the advantage of separating the high power ASIC away from the temperature sensitive QSFP-DD → much better thermal solution
- Multiple cable management options available

- https://vimeo.com/260765517
**Thermal Management**

- **Separation of ASIC and Optics** → better thermals
- **Belly to Belly Optics** → better thermals

*Using Flyover Technology*
Cost

• PCB Cost Savings
  • Only the ASIC Module PCB is of a high speed material
  • \(~1/4^{th}\) the size and fewer layers than a conventional PCB
  • All other PCBs are simple FR4

• No re-timers needed
• Lower thermal cost
• Can enable >3m DAC \(\rightarrow\) significant cost savings to the end user
• ASIC Module can be re-sued in different switch designs

• All these savings make the Modular architecture cost competitive or cheaper than the conventional architecture while still delivering a superior SI, low latency and Thermal Performance
Typical Applications

At 400G, Flyover QSFP-DD is being used in hybrid solutions in which some of the outer or mezzanine ports are Flyover
  - Design ins with Tier1 customers

At 800G, Flyover QSFP-DD will be the solution of choice for all ports

OPEN. FOR BUSINESS
Other OCP Products

• The OCP Wedge can be easily scaled from 3.2 Tbps to 6.4 /12.8/ 25.6 Tbps with this modular architecture.
• The various modules in this architecture can also be used-as-is to fit into different OCP Top of Racks (ToR) like Telco, OCPv2 and Olympus.
• The same modularity can be applied to Middle of Row (MoR), End of Row(EoR) and Spine Switches by leveraging the OCP Facebook BackPack’s and SidePlane’s concept.
Summary

Modular Architecture enabled by Flyover results in a cost competitive while still delivering a superior SI, low latency and Thermal Performance while showing easy scalability to 800G.