XPO (eXtra Dense Pluggable Optics): A High-Density, Liquid-Cooled Optical Interconnect Architecture for Next-Generation AI Networks

Terry Little

Sr. Development Engineering Manager

Foxconn Interconnect Technology

XPO (eXtra-dense Pluggable Optics) Introduction

Today, we are proud to introduce our XPO (eXtra-dense Pluggable Optics) platform—a fully integrated, high-density "pluggable" connectivity architecture.

We will discuss a scalable path forward from today's 224 Gbps solutions, to the next-generation 448 Gbps AI and high-performance computing systems.

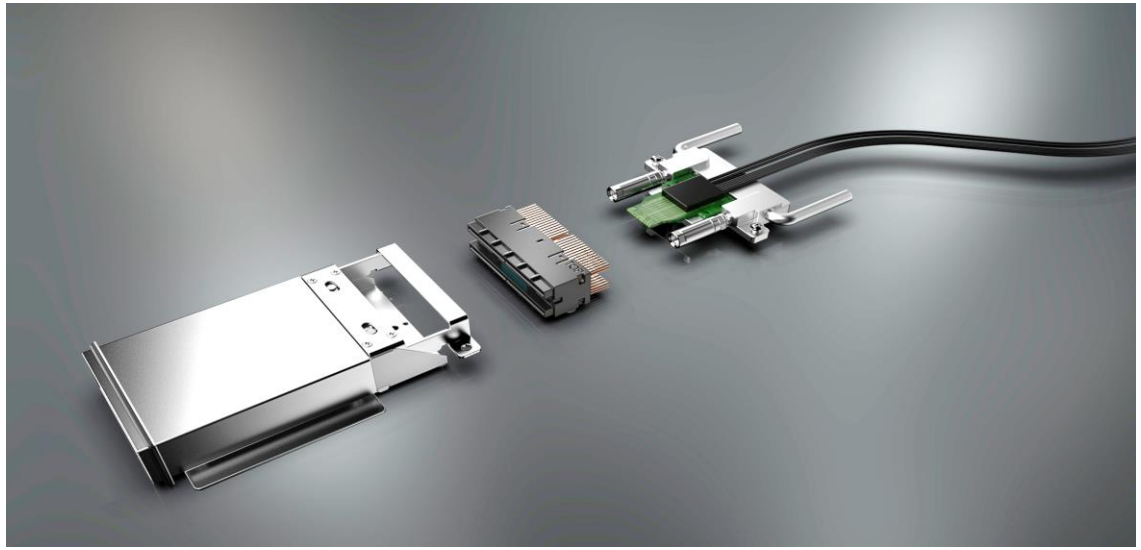
I would like to acknowledge the leadership and vision of Andy Bechtolsheim, Co-founder and Chief Architect of Arista Networks, and the contributions of the XPO MSA member companies in advancing the next generation of high-density optical interconnect technology.

Key highlights include:

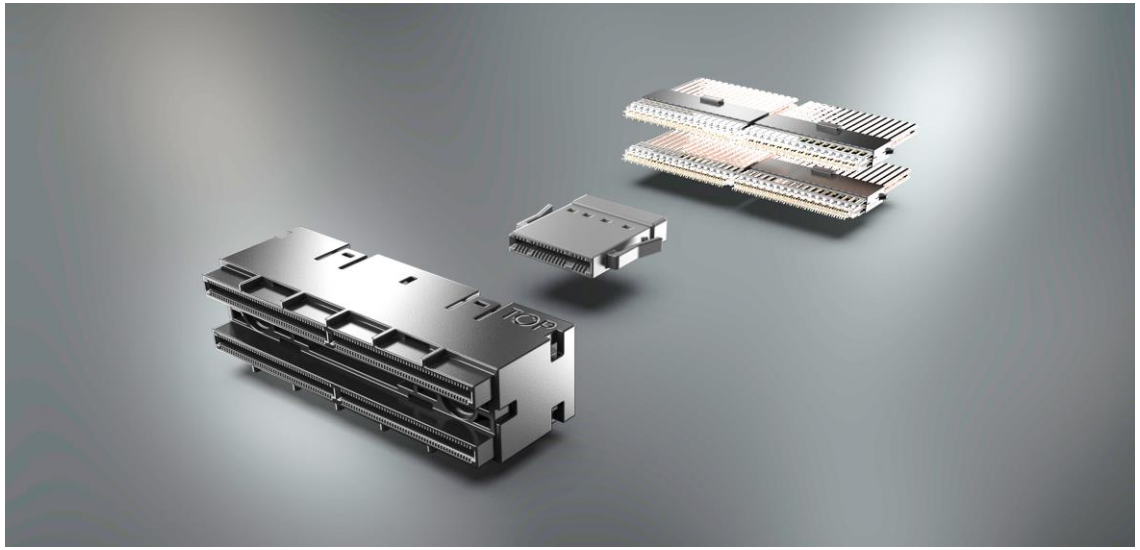
- High-density "Card-edge" connector for next-generation AI infrastructure, both for 224 Gbps, and **keeping the same existing XPO connector form factor as we progress towards 448 Gbps..**
- Builds upon the proven 224 Gbps architecture to provide a scalable path to 448 Gbs.
- "XPO is more than a connector—it is a complete platform engineered to deliver greater bandwidth, improved cooling, and higher system efficiency."

XPO HS Connector, Power Connector, Cage and Plug Module Product

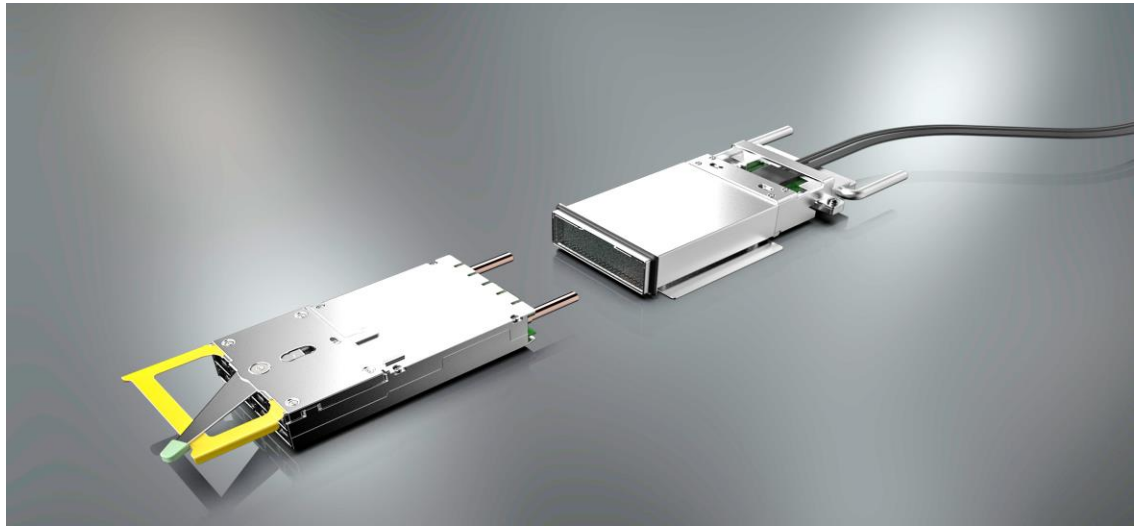
XPO High Density Pluggable Connector, Cage, Liquid Cooling and Cable Assembly



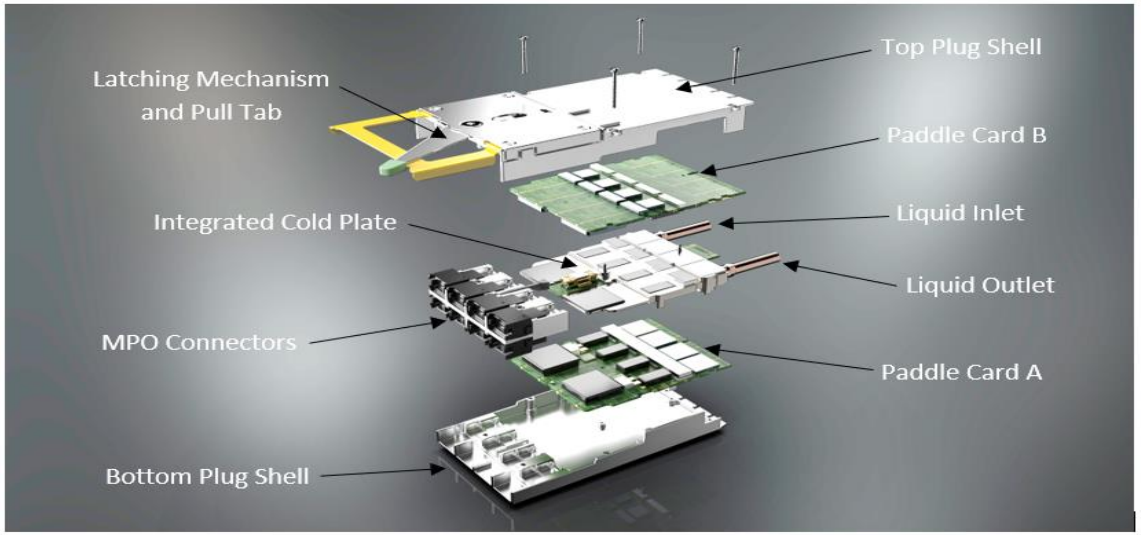
XPO Host Connector Architecture



XPO Host Liquid Cooling Architecture



XPO Host Plug Module Architecture

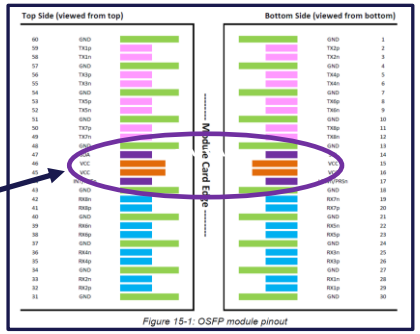


XPO increased density per Plug Module

The XPO architecture consolidates the full connectivity of **eight individual OSFP plug modules** including high-speed signals, power, and sideband communications—into **one compact XPO plug module**

- **The same bandwidth of 8 OSFP modules is consolidated into 1 XPO module**
- **For 224 Gbps signaling:** delivers up to **12.8 Tbps** per XPO plug module
- **For future 448 Gbps signaling:** will deliver up to **25.6 Tbps** per XPO plug module
- Integrates **high-speed data, power, sidebands, and liquid cooling**
- Delivers significantly greater **bandwidth density** in a compact footprint
- Reduces front-panel space and simplifies system integration

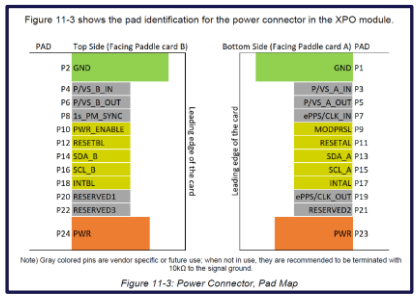
OSFP Module



Equivalent of 8 OSFP Sidebands and Vcc. Contact Groups

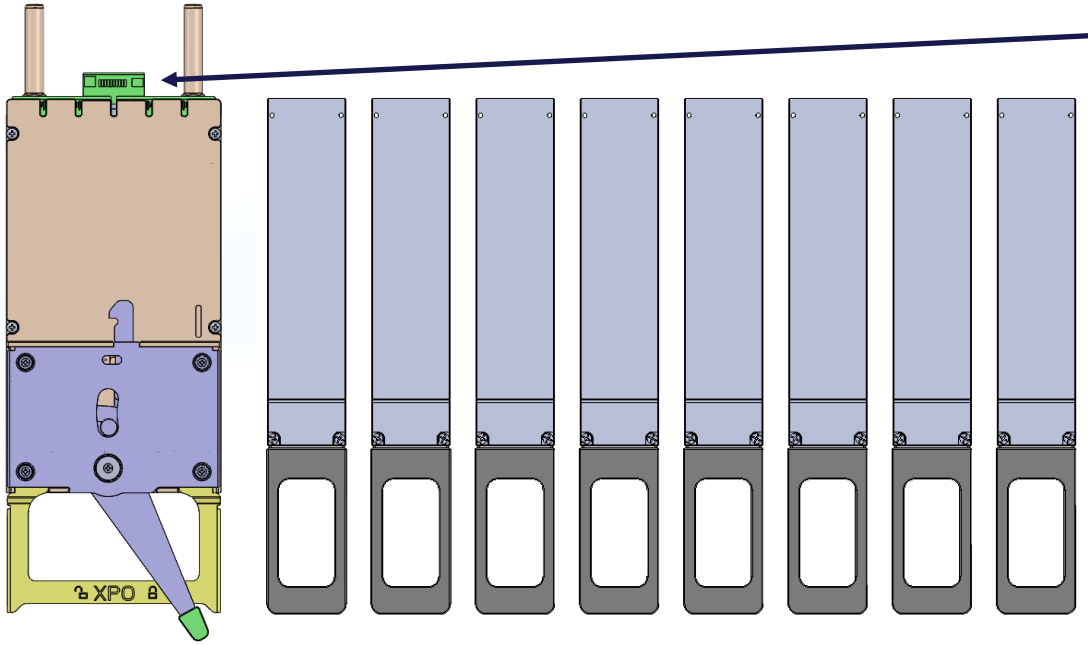
Combined into 1 Compact XPO Power and Sideband PCB

XPO Module



1 XPO Plug Module

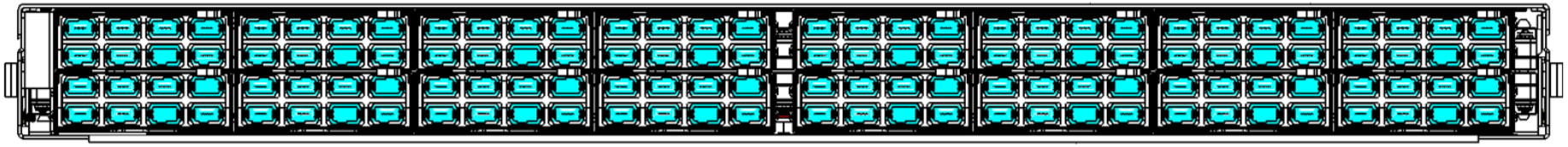
XPO C/L pitch for HS signals is 0.56mm



1 XPO Plug Module has the same HS signal bandwidth, power and sidebands as 8 OSFP Plug Modules.
OSFP C/L pitch for HS signals is 0.60mm

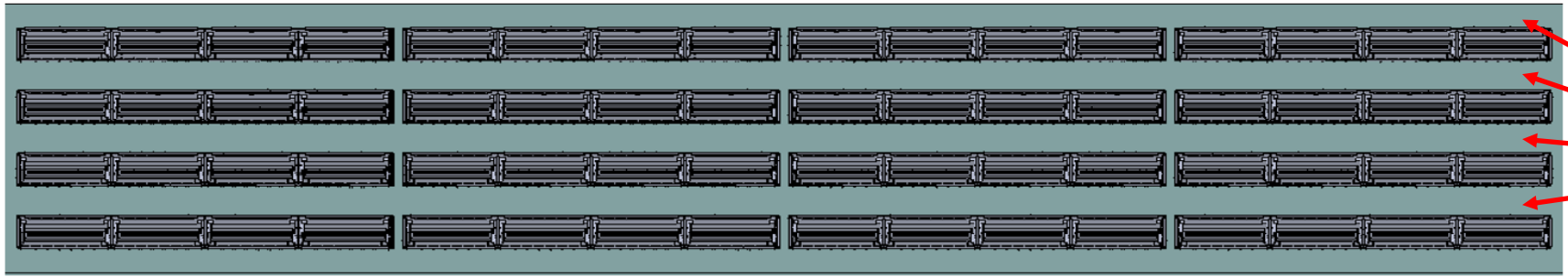
XPO increased density per Front Panel Real Estate

128 XPO PORTS IN A 1 OU SWITCH

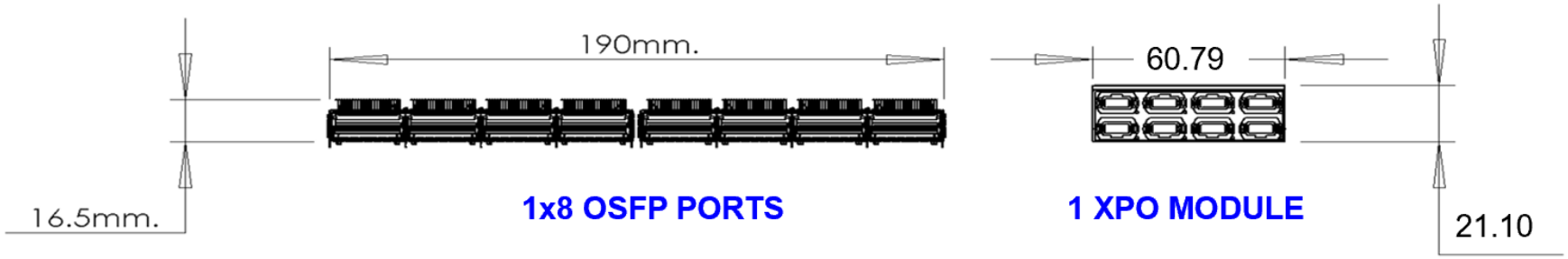


Liquid Cooling Cold Plates are integrated into the XPO Plug Modules which provide a significant reduction in "Z" height

64 OSFP PORTS IN A 2 RU SWITCH



Vertical Spaces are occupied by OSFP Cold Plates or Riding Heat-sinks



1x8 OSFP PORTS **1 XPO MODULE**

NOTE: A potential 128-port XPO implementation in a 1OU switch is being carefully considered, paying close attention to the mechanical, thermal, and routing design requirements associated with the limited available space.

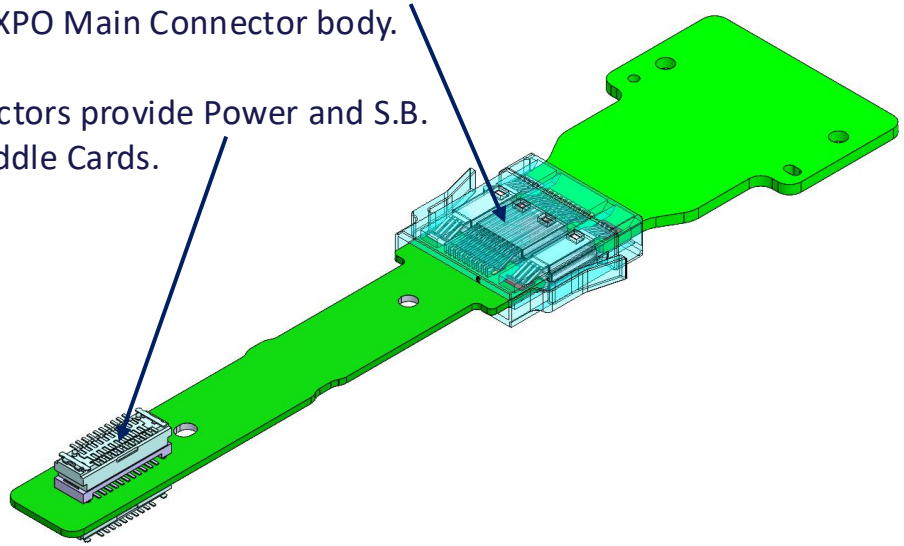
The XPO architecture delivers a major improvement in front-panel density compared with conventional OSFP solutions.

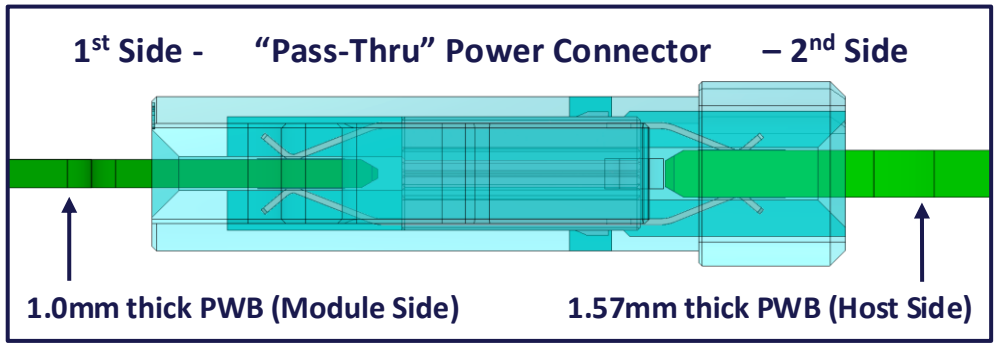
- A single compact XPO module consolidates the connectivity and bandwidth of eight OSFP ports.
- Eight OSFP ports require approximately **190 mm × 16.5 mm** of front-panel space.
- One XPO module occupies only approximately **60.79 mm × 21.10 mm**, significantly reducing the required panel width.
- On a rack-unit basis, XPO provides approximately **4× greater port density**.
- XPO enables higher total switch bandwidth in a smaller enclosure, making it well suited for next-generation AI, HPC, and hyperscale data-center systems.

XPO Power Board Assembly – Module and Host Side

XPO Power Board (PWB) Plug Module Side

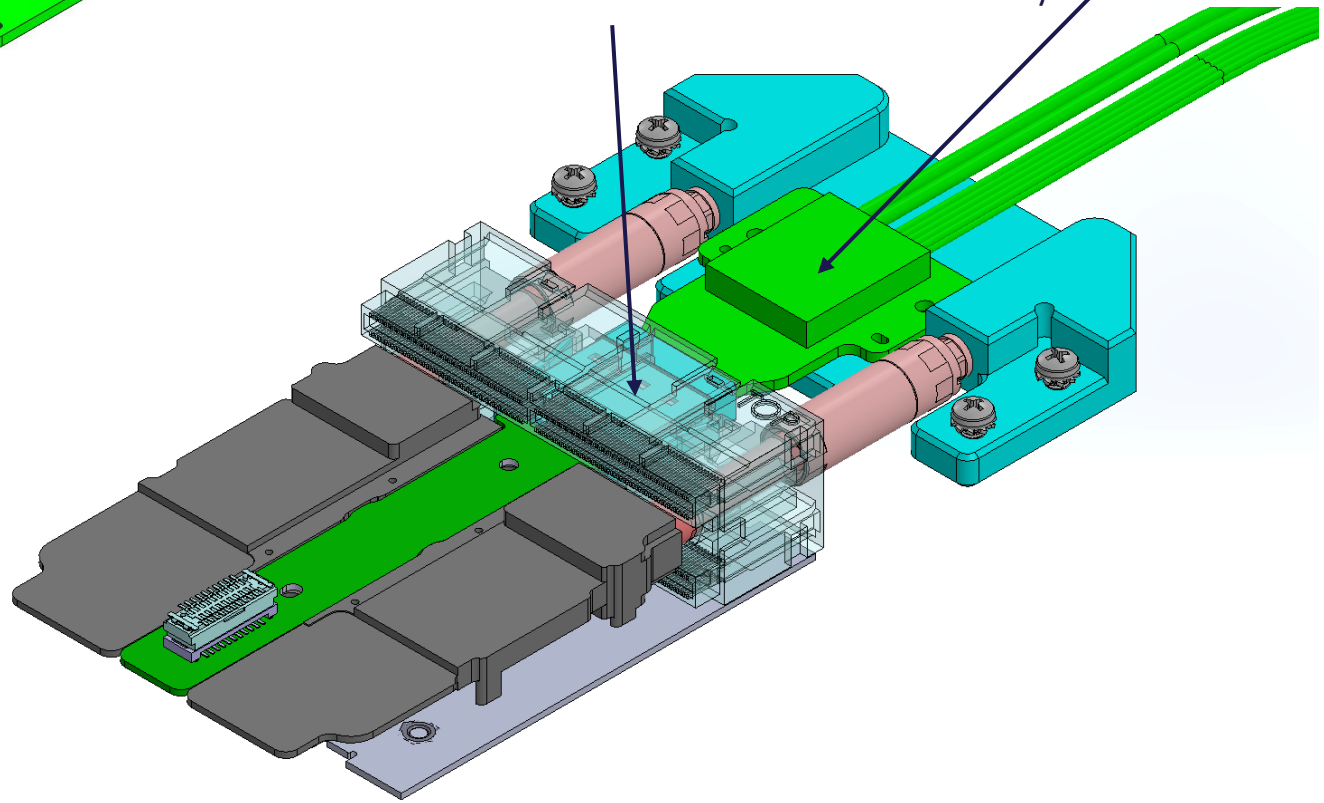
1. This side mates to the **FIRST SIDE** of the Power Connector inside XPO Main Connector body.
2. Mezzanine Connectors provide Power and S.B. control to XPO Paddle Cards.





XPO Power Board (PWB) Host Side

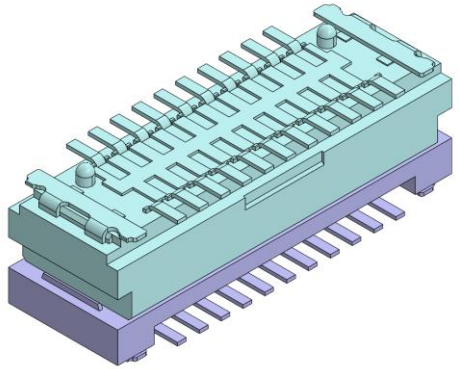
1. This side accommodates a Power Cable which will attach to the customer's IO board inside the system.
2. This side mates to the **SECOND SIDE** Power Connector inside XPO Main Connector body.

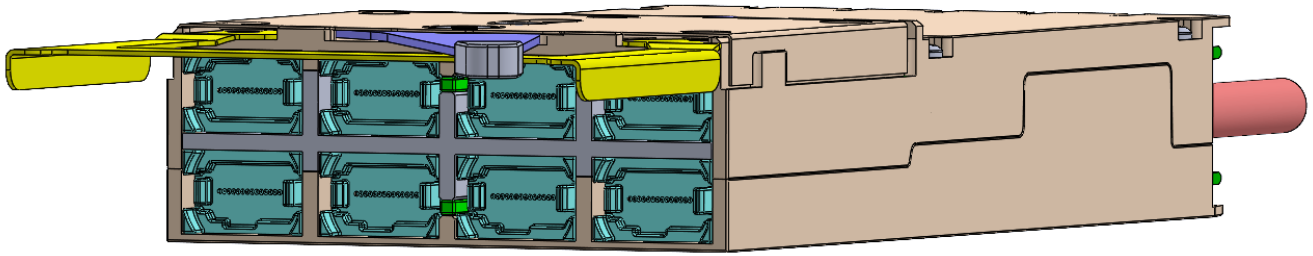


XPO Power Board Assembly – Module and Host Side (cont.)

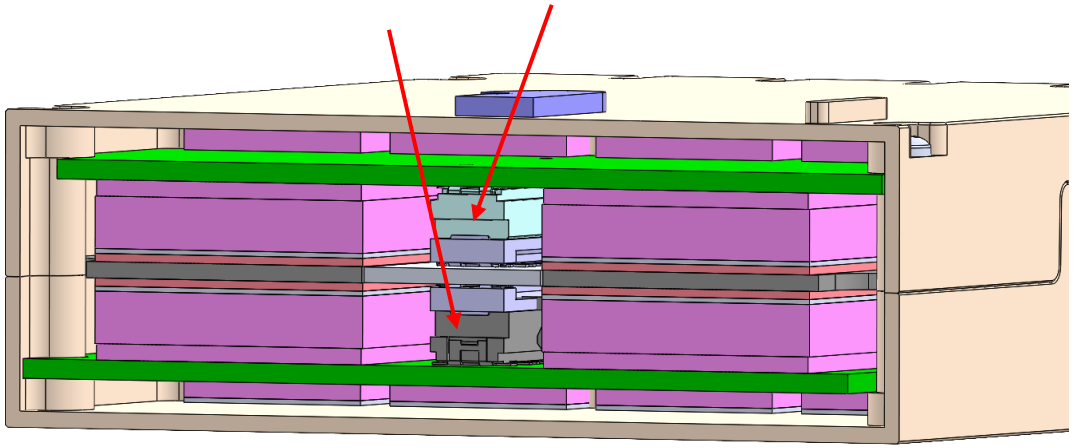
Mezzanine Connectors

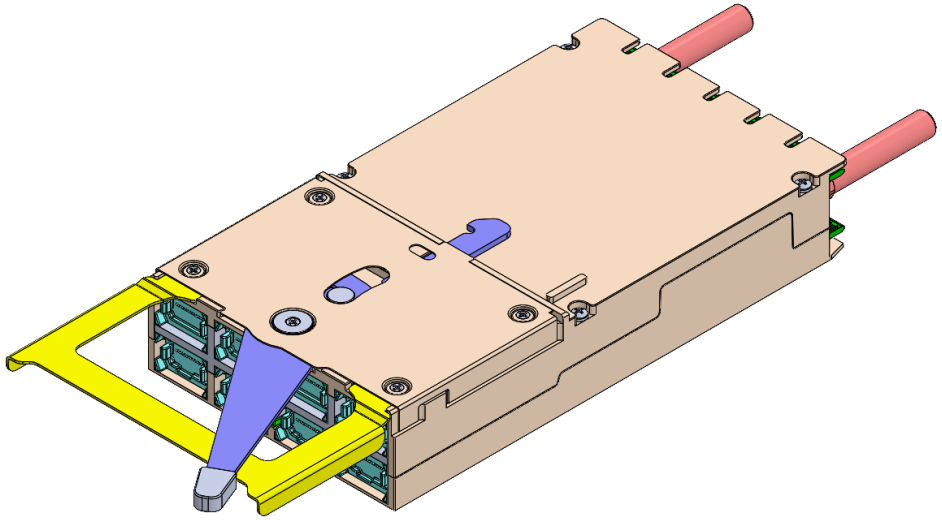
2 Mated Pairs Per PLUG MODULE Assembly





1. Mezzanine Connectors provide Power and S.B. control to XPO Paddle Cards.





XPO “Pluggable Optics” versatility

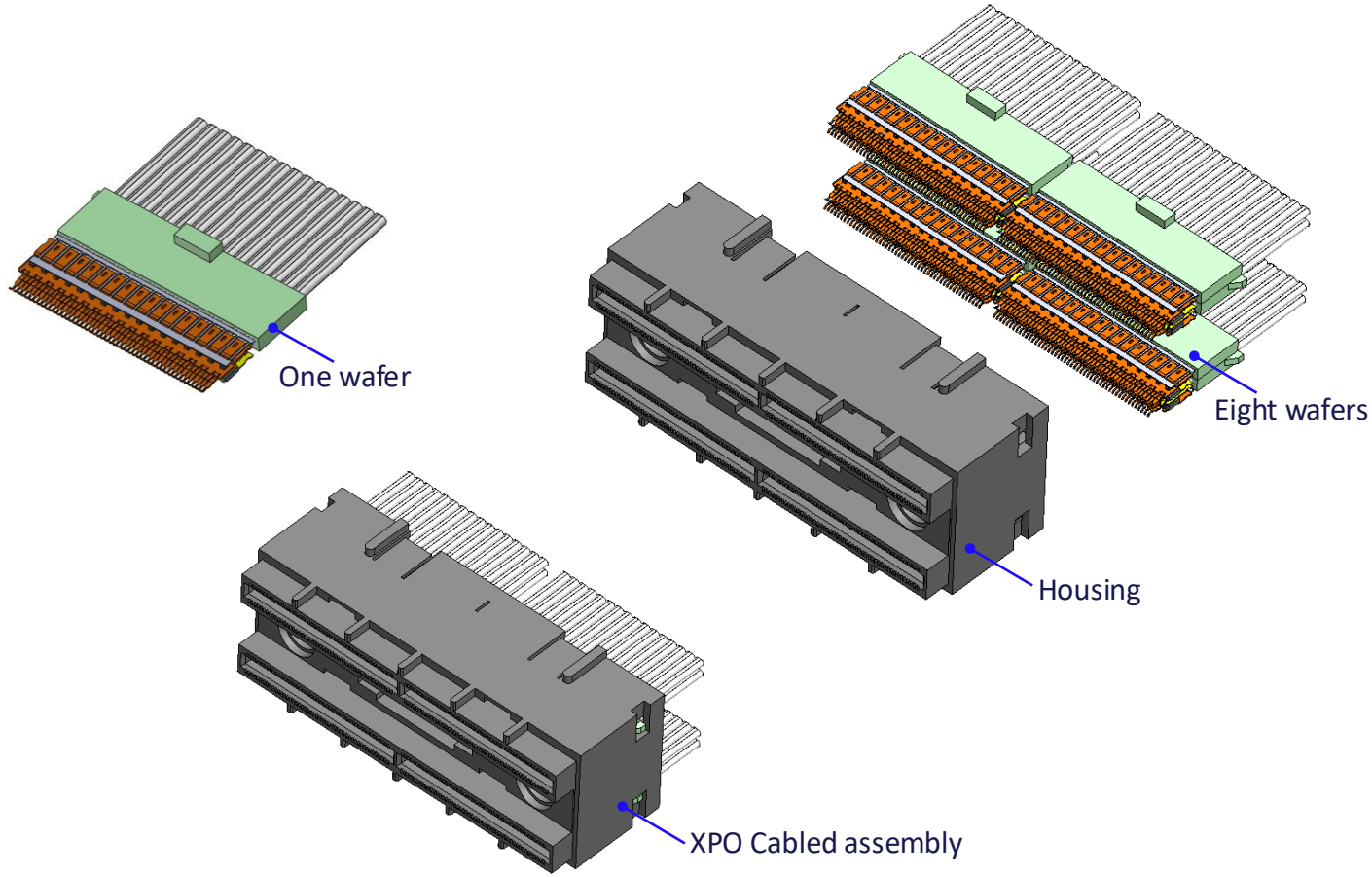


- XPO is designed as an optical-technology-independent platform that can support LPO, LRO, DSP-based and retimed modules, as well as emerging silicon-photonics.
- XPO accommodates multimode and single-mode optical technologies.
- XPO enables applications ranging from short-reach intra-rack links to longer-reach data-center interconnects.
- XPO provides a common electrical and mechanical platform for multiple optical suppliers and evolving standards.
- XPO protects the system investment by allowing future optical technologies to be adopted without replacing the entire switch.
- The versatile Optical technology is in the Plug Module, outside of the switch.

XPO Cabled Assembly Exploded View – Total 128 DP (64 Tx / 64 Rx)

XPO Cabled Connector Assembly Summary:

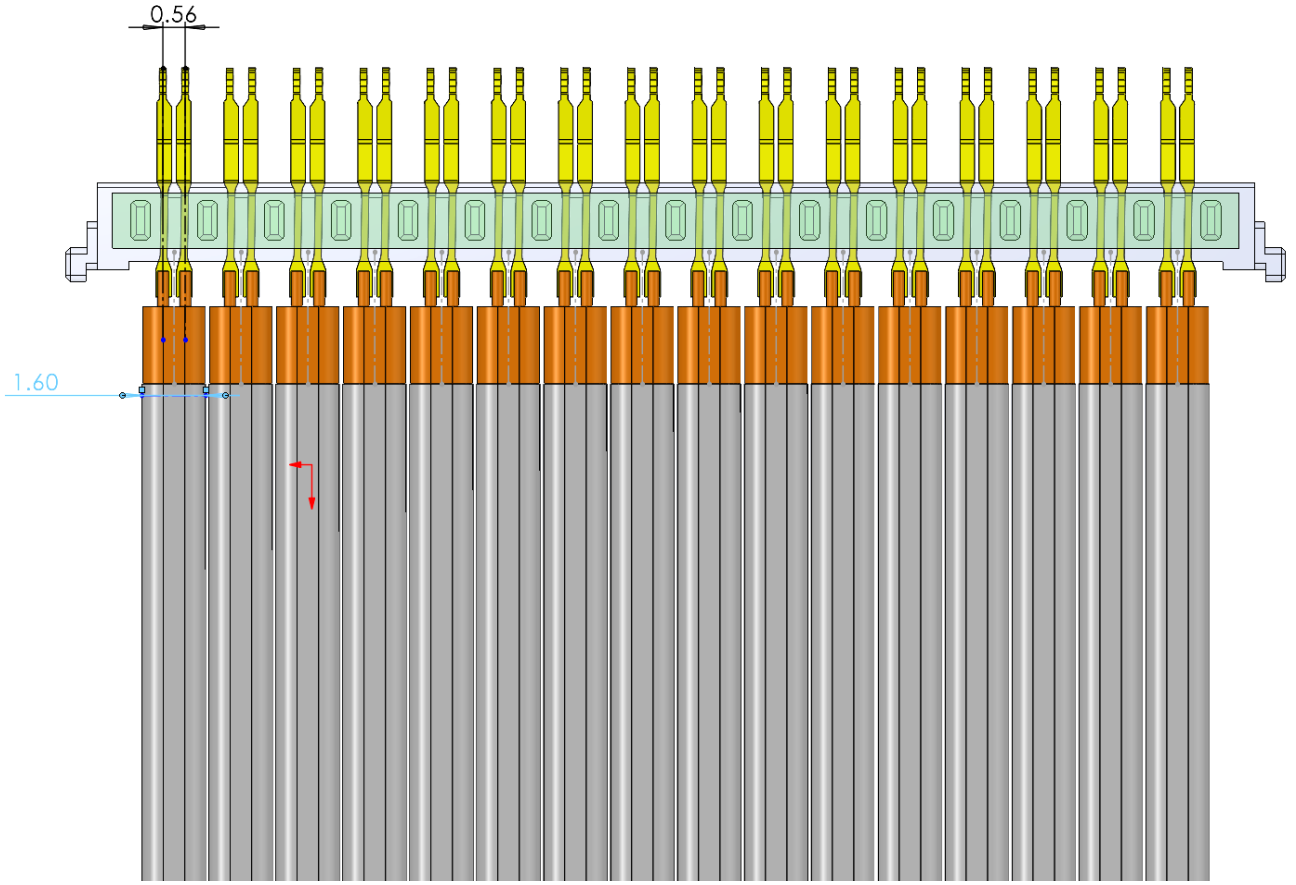
- The XPO connector provides 128 differential pairs (DP): 64 transmit (Tx) and 64 receive (Rx).
- Each cable wafer contains a portion of the high-speed signal connections.
- Eight wafers are stacked and integrated into a single compact connector housing.
- The housing aligns, protects, and mechanically secures the wafer stack.
- The final XPO cabled assembly combines all eight wafers into one high-density interface, delivering the equivalent high-speed connectivity of eight OSFP plug modules in a much smaller form factor.



XPO “Direct Wire Attach” Connector

This slide illustrates how **ultra-fine 30 and 32-AWG drainless twin-ax cable** enables the XPO connector’s extremely high-speed signal integrity **existing 224G and future 448G-per-lane performance**.

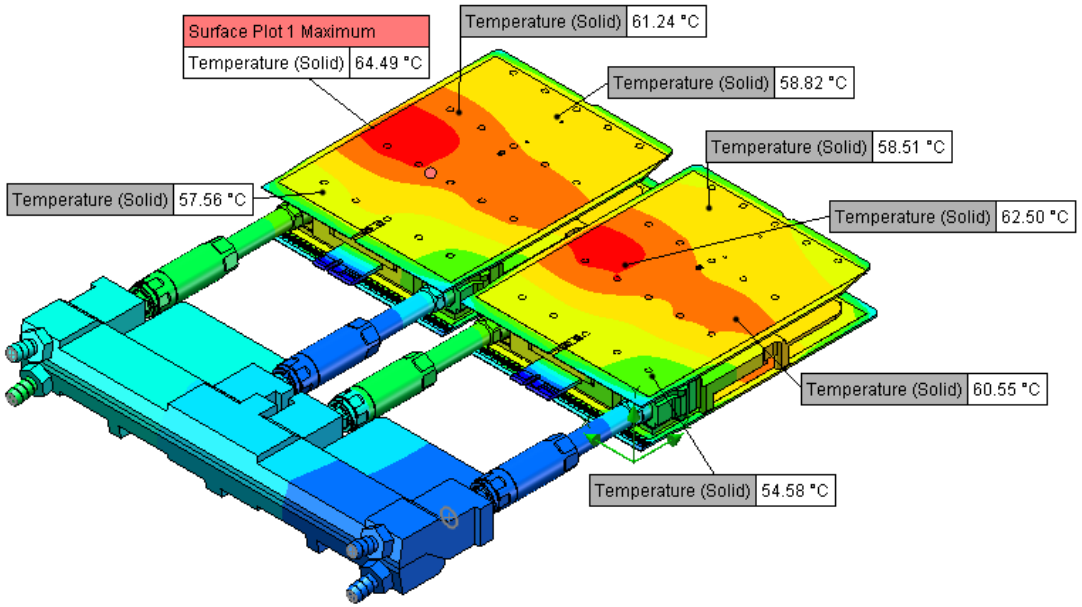
- The **0.56 mm conductor spacing** allows for many differential pairs to be tightly arranged within each XPO wafer.
- The **92 Ω controlled-impedance design** supports a stable, low-reflection high-speed transmission path.
- The **drainless raw cable construction** eliminates conventional drain wires, reducing cable size and simplifying dense termination.
- Metal-foil shielding with full coverage helps control **EMI and pair-to-pair crosstalk**.
- The anticipated insertion-loss targets through **112 GHz** indicate that the raw cable is engineered for next-generation **448G signaling**.

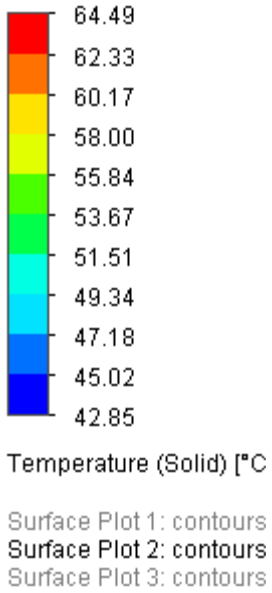


XPO Cold Plate Thermal Simulation

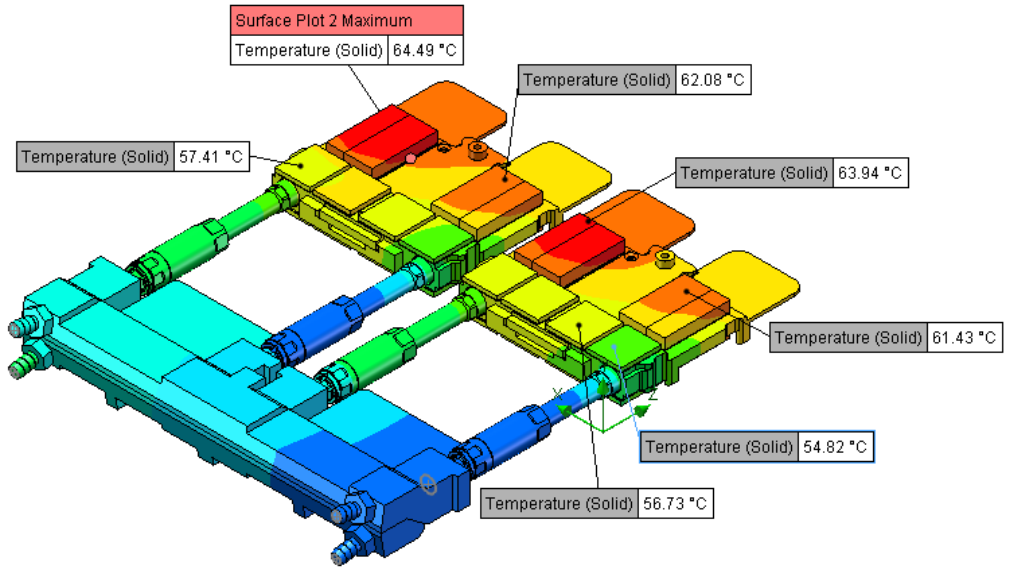
1x2 Design – Parallel Configuration – 200W

Outside temperature contours





Inside temperature contours

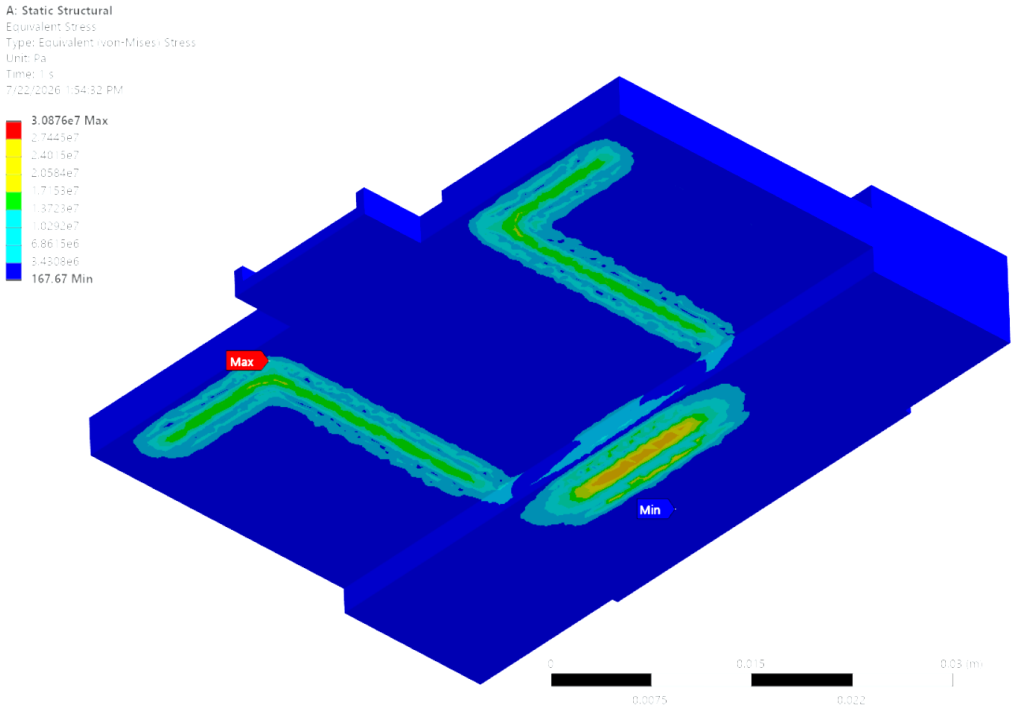


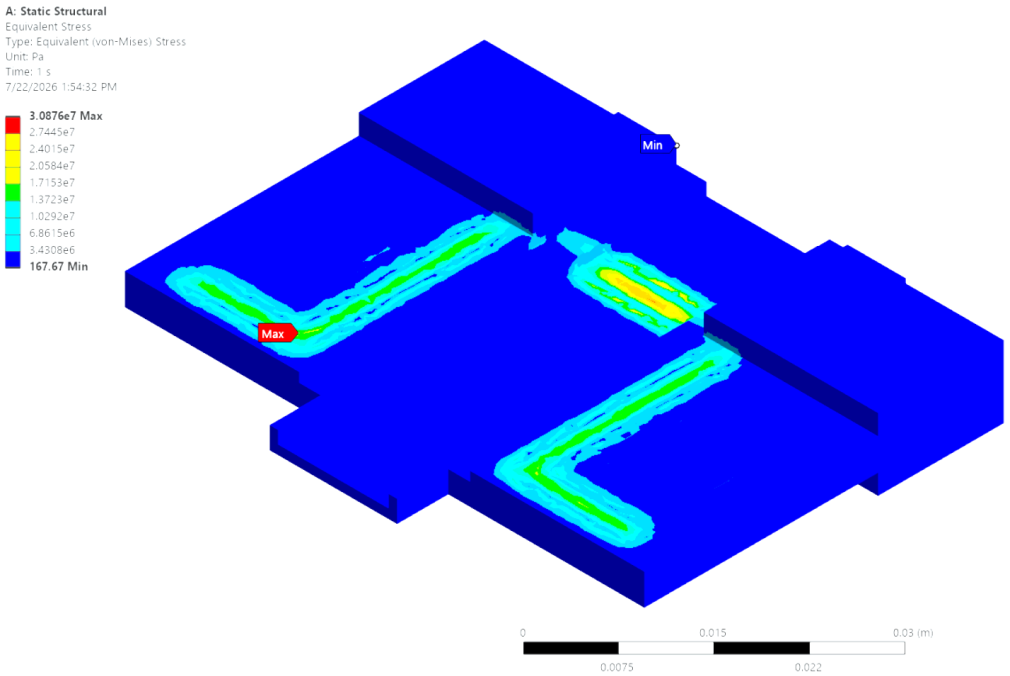
Notes:

1. The pressure drop is 34.63 kPa (5.02 PSI) at Maximum flow rate 0.4L/min,can meet spec(＞5PSI).
2. The pressure drop is 36.44 kPa (5.29 PSI) at Maximum flow rate 0.4L/min,can meet spec(＞5PSI).
3. The max temperature of Module is 64.49℃,can meet spec(＜70℃).

XPO Cold Plate Mechanical Burst Pressure Simulation

Item`	Description
Analysis Type	Static Structural Analysis
Material	Copper, C10200, Soft
Material Yield Strength	49.8 MPa
Loading Condition	200 psi pressure applied on all internal flow channel walls
Evaluation Criteria	Total Deformation & Equivalent (Von-Mises) Stress

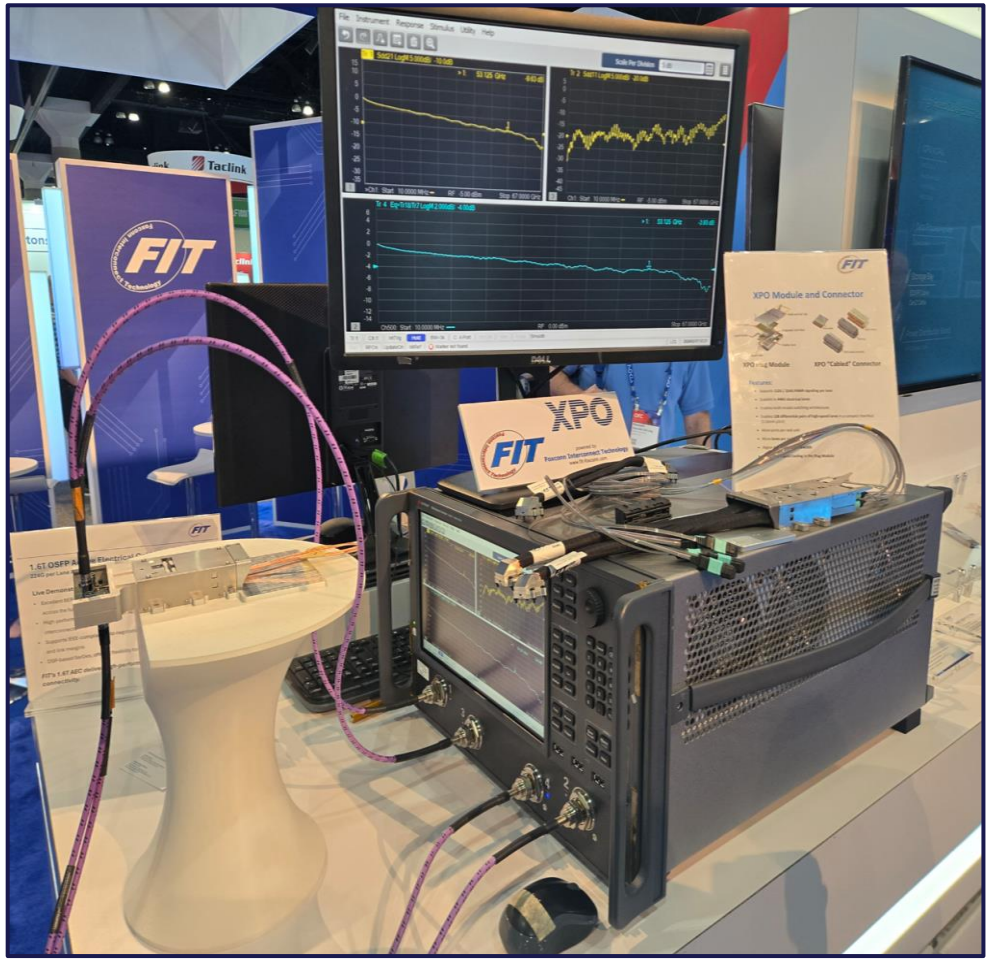


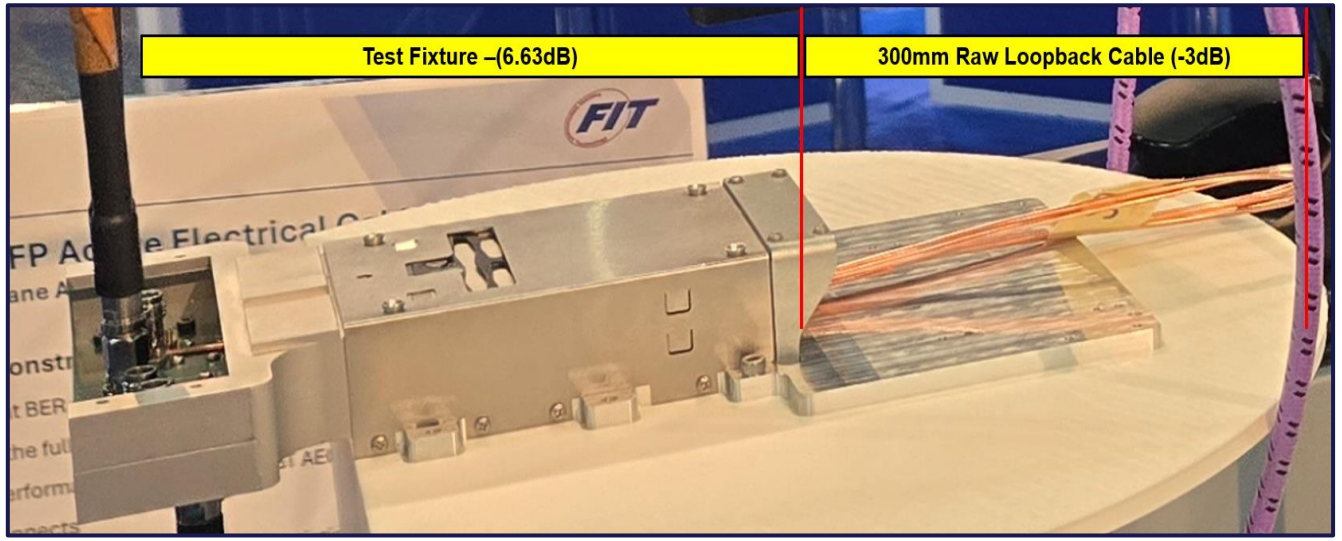


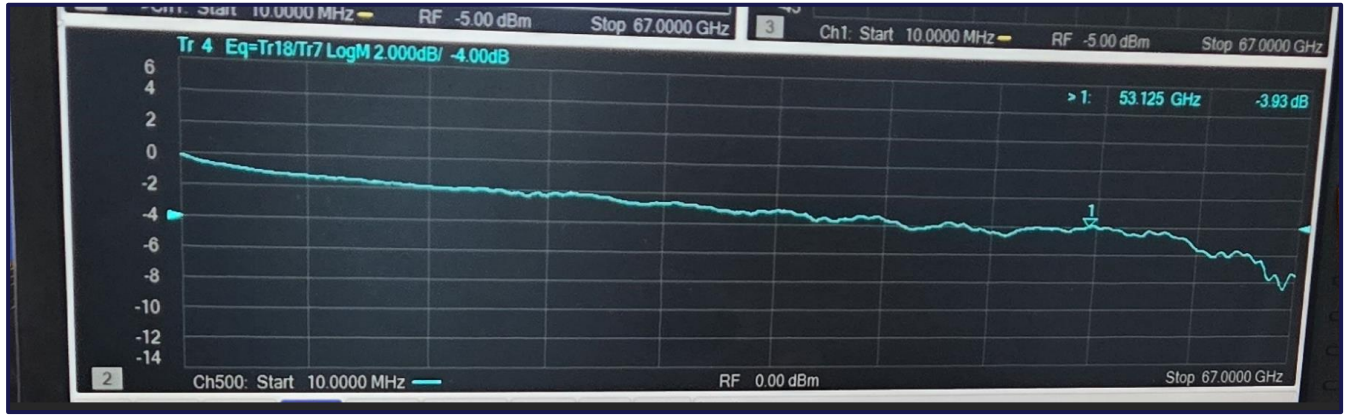
Maximum von-Mises stress 30.87 Mpa

Maximum deformation 1.136 µm

FIT XPO 224 Gbps High Speed Test Data – OFC 2026 XPO Live Demo

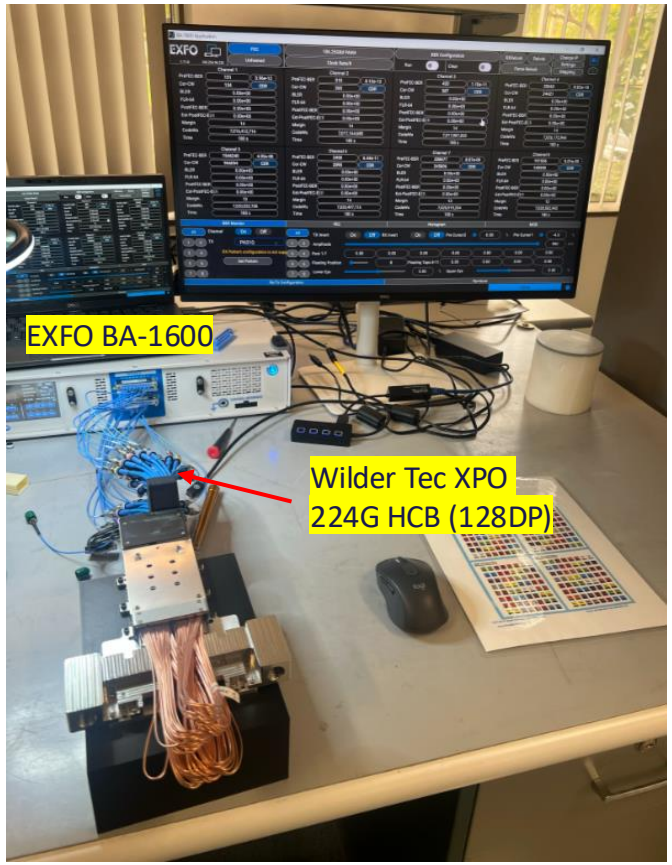






After De-embedding the Test Fixture, the TRUE TEST DATA WITH LOOPBACK CABLE shows -3.93 dB IL minus the 3.0 dB for Raw Loopback Cable which is -0.93 dB. Then divide by 2 for the 2 connector interfaces – (Top and Bottom) which results as -0.465 dB IL.

FIT XPO 224 Gbps Connector Loop-back BER Test– 8 Differential Pairs



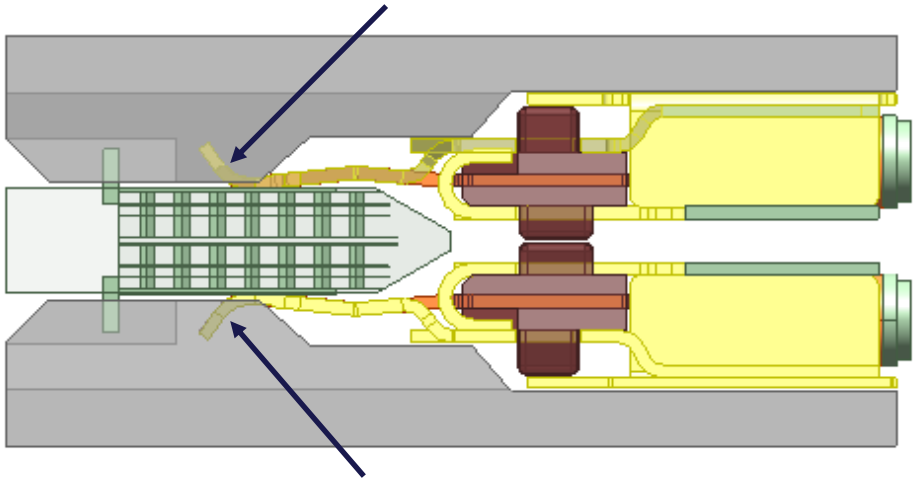


	TX 60	TX 54	TX 52	TX 56	TX 59	TX 63	TX 51	TX 55
Pre FEC BER	5.28E-12	2.77E-12	1.07 E-12	3.50E-11	7.25E-10	7.31E-11	2.65E-10	2.67E-10
Post FEC BER	0	0	0	0	0	0	0	0

Fast-forward to 448 Gbps XPO

XPO “Fast-forward” to 448 Gbps

Traditional 224G “Cantilever Beam” Contact Geometry



Objectives

The mechanical objective is to maintain the same XPO “Card-Edge” Form Factor. (0.56mm Pitch)

The electrical objective is to minimize undesirable stub effects at high frequencies.

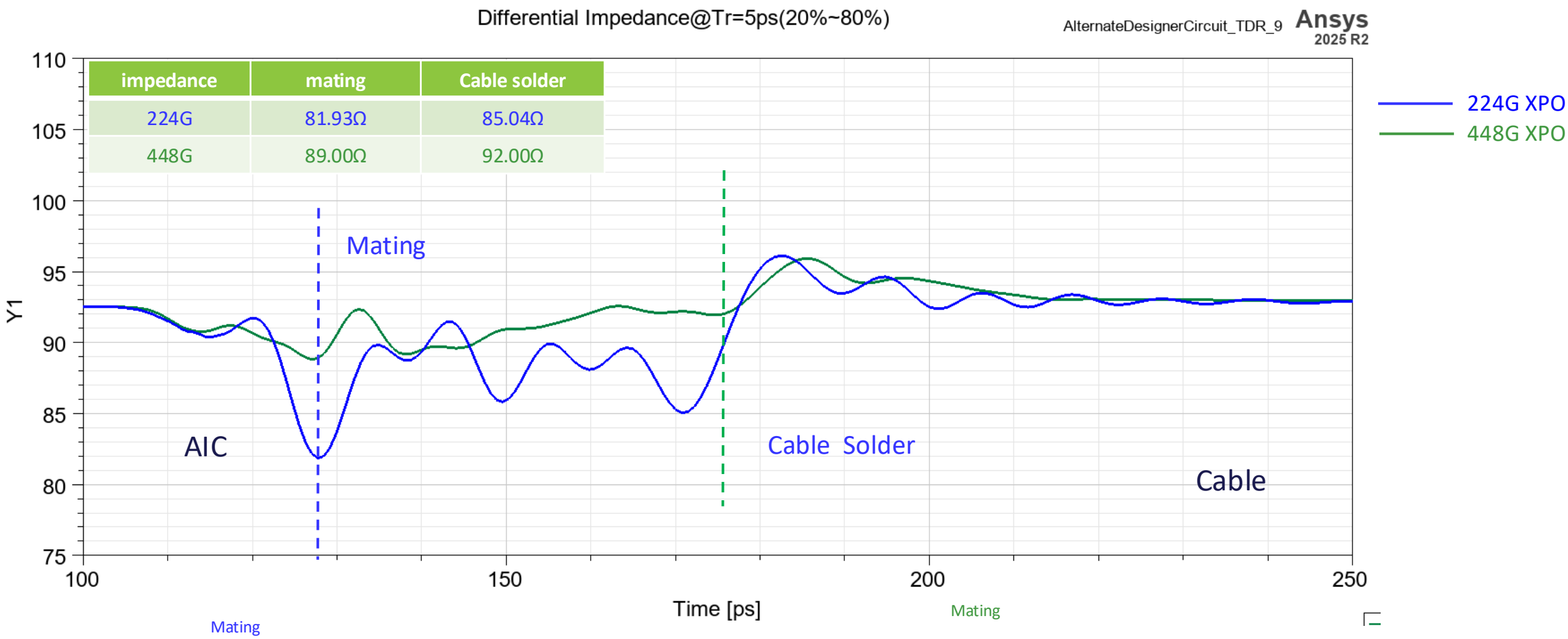
High-speed interfaces are sensitive to:

- Stub length
- Impedance discontinuities
- Reflection-induced insertion loss

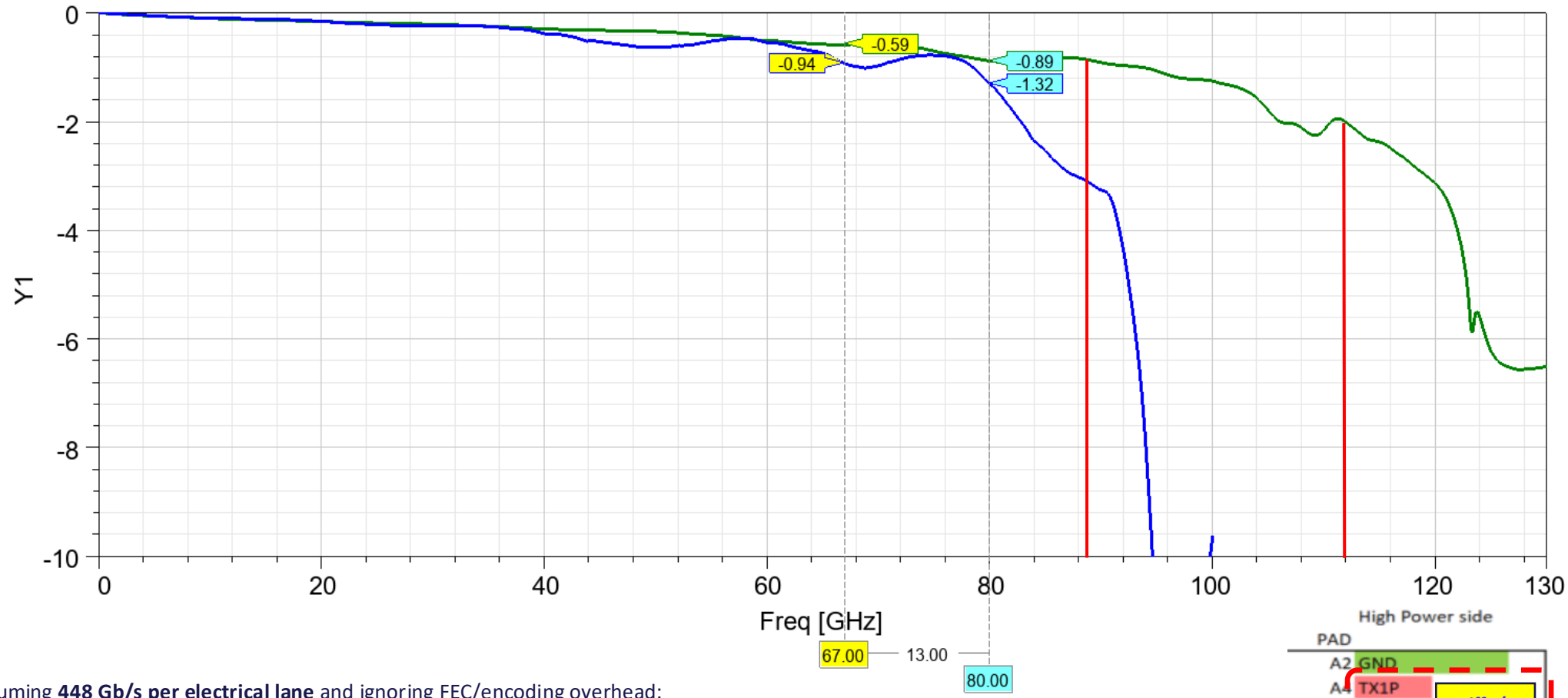
- Traditional “Cantilever Beam Contact Geometry produces un-desirable IL “roll-off” at high frequency.

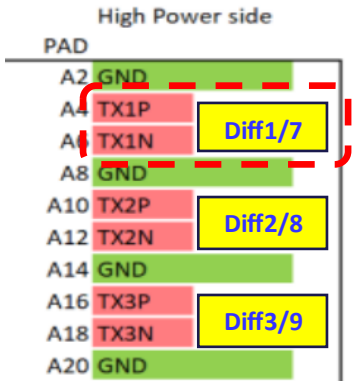
- The New 448G XPO system connector delivers optimization for:
- Improved Electrical Performance
- Reduced stub length
- Improved insertion loss performance
- Enhanced high-frequency signal integrity

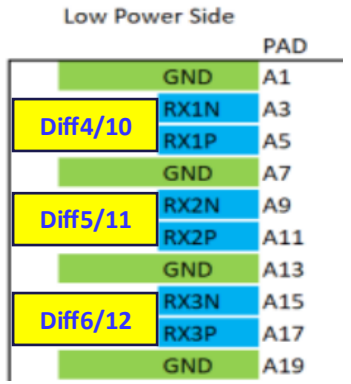
XPO Card-edge 448G Simulation Results--Differential Impedance



XPO Card-edge 448G Simulation Results--Differential Insertion Loss







Assuming **448 Gb/s per electrical lane** and ignoring FEC/encoding overhead:

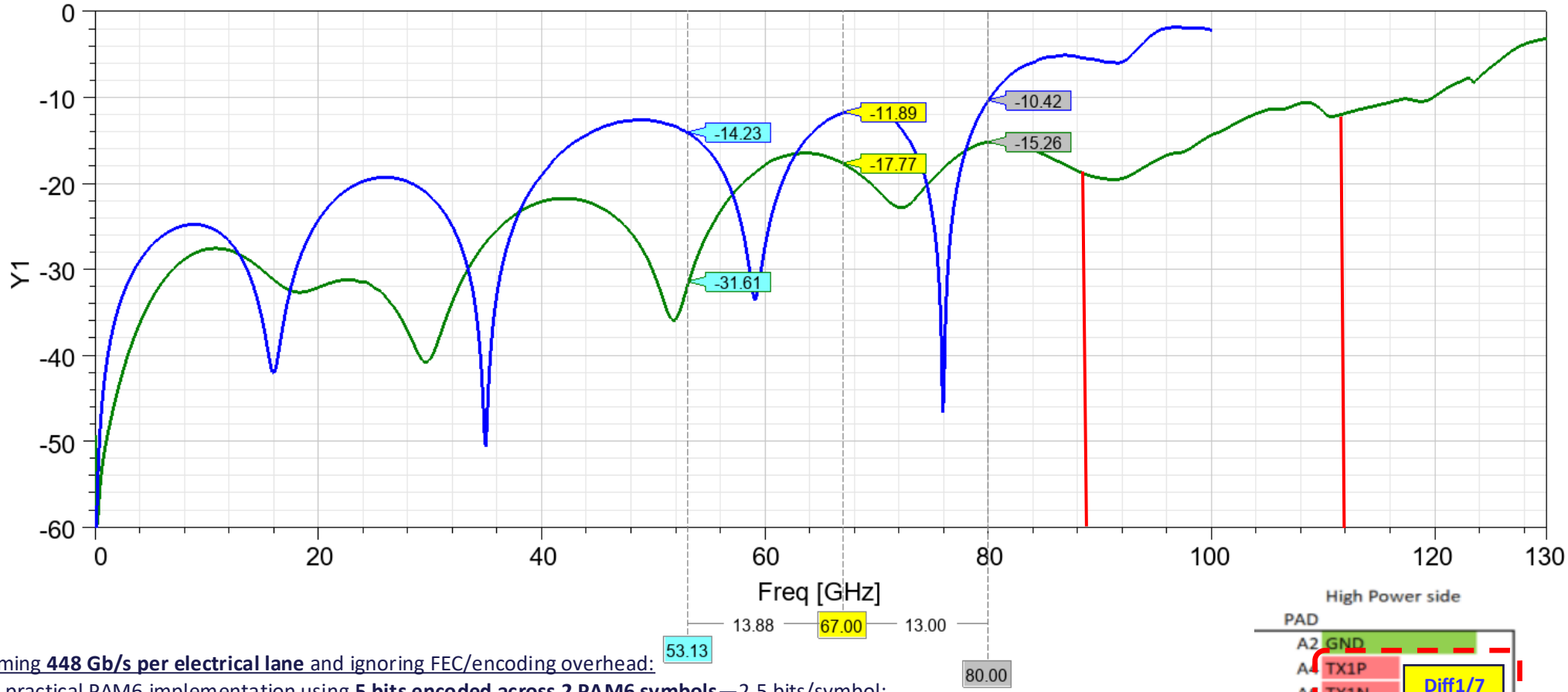
For a practical PAM6 implementation using **5 bits encoded across 2 PAM6 symbols**—2.5 bits/symbol:

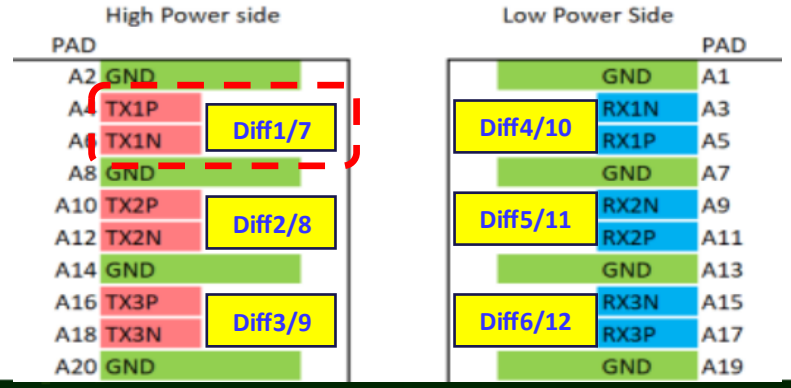
- Symbol rate: 448 ÷ 2.5 = **179.2 GBd**
- Nyquist frequency: 179.2 ÷ 2 = **89.6 GHz**

So, the anticipated targets are approximately:

- **448G PAM4: 112 GHz**
- **448G PAM6: 87–90 GHz**
- Actual baud rate and Nyquist frequency will be slightly higher when line-coding or FEC overhead is included.

XPO Card-edge 448G Simulation Results--Differential Return Loss





Assuming **448 Gb/s per electrical lane** and ignoring FEC/encoding overhead:

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So, the anticipated targets are approximately:

- **448G PAM4: 112 GHz**
- **448G PAM6: 87–90 GHz**
- Actual baud rate and Nyquist frequency will be slightly higher when line-coding or FEC overhead is included.

Call to Action

448G XPO Path-forward is critical

448G solutions are needed to support both PAM-6 and PAM-4 modulations

Additional information:

XPO MSA | https://xpomsa.com/
IEEE 802.3dv | https://www.ieee802.org/3/dv/
FIT | https://www.fit-foxconn.com/



Thank You!

