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Co-Packaged Copper at 448G: Balancing Electrical Efficiency with System Level Complexity

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OCP SILVER Member

What is Co-Packaged Copper?

- As data rates increase, the distance electrical signals can travel through a conventional PCB decreases.
- CPC is about using fundamental pieces of technology that we understand well and deploying them in new areas.
- CPC advantages:
  - Shorter electrical paths
  - Lower signal loss
  - Higher bandwidth density
  - Cost-effective and simplified connectivity



Traditional Motherboard



Near Packaged Copper “NPC”

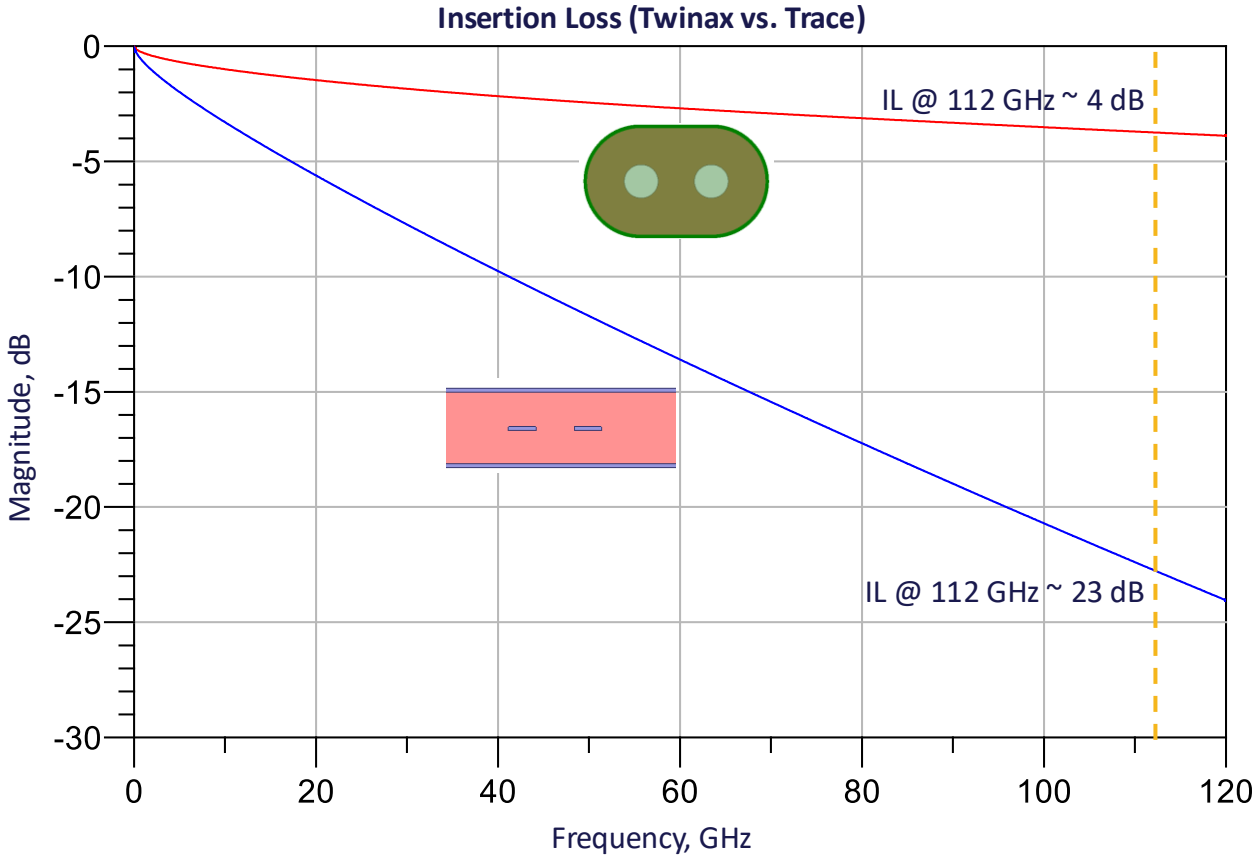


Co-Packaged Copper “CPC”

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System Level Considerations for CPC

- Twinax vs. PCB Trace:
  - Twinax cable delivers lower loss and better cross-talk
- Drainless vs. Drain Cables:
  - Drain cable simplifies shield termination and increases stiffness
- Cable/Connector Terminations:
  - Maintain controlled differential impedance
- Breakout Region Design:
  - Pin escape/fanout is often the channel limiter
- Skew:
  - Intra-pair skew limits BER
  - Inter-pair to stay within de-skew budgets
- Cable Loss:
  - Low-Dk/foam-like dielectrics and optimized shields reduce high-frequency loss



Assumptions:
- 250 mm 30AWG cable vs. 254 mm stripline trace

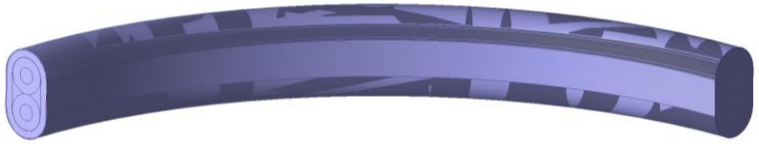
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System Level Challenges – Bending/Twisting

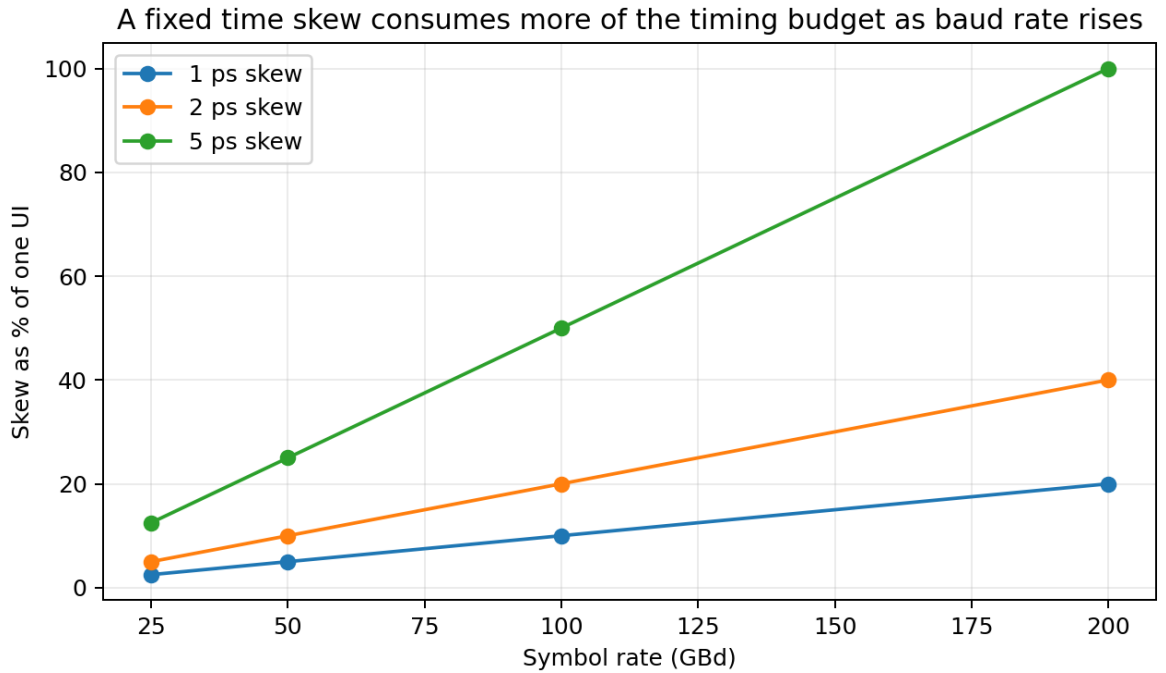
- 448G is sensitive to bend radius and results in skew
- Ideally, each bend would be followed by an equal and opposite bend to minimize skew
- A fixed time skew consumes more timing budget at higher data rates



45-degree radial bend

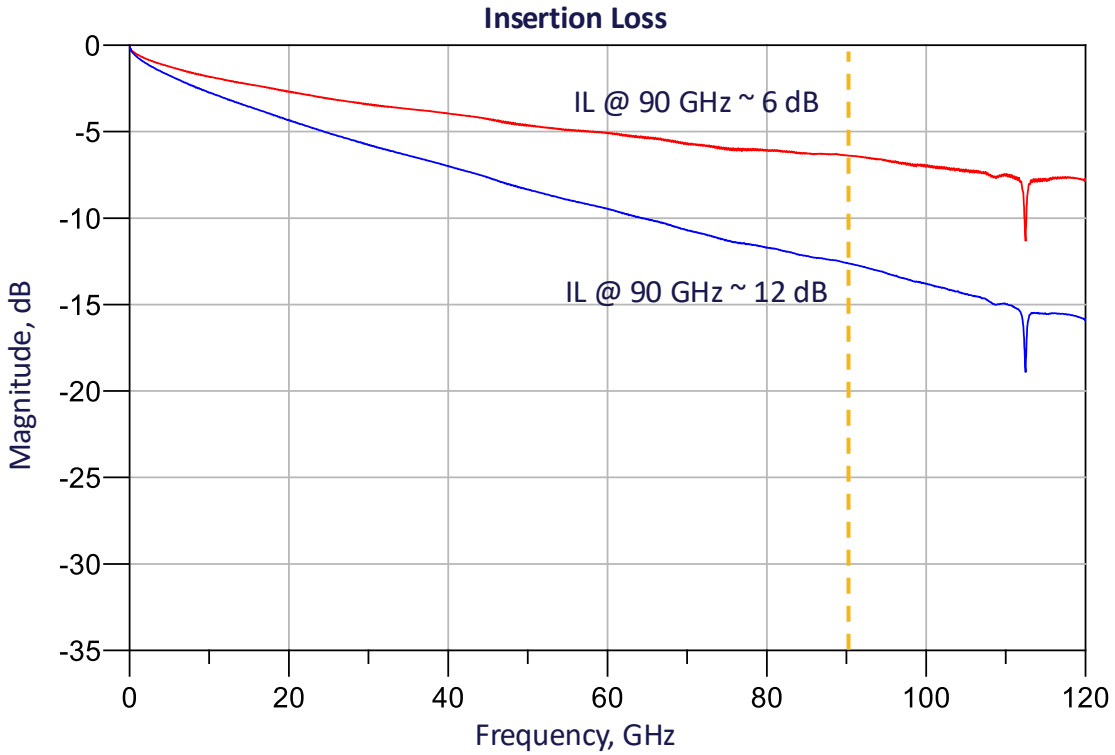


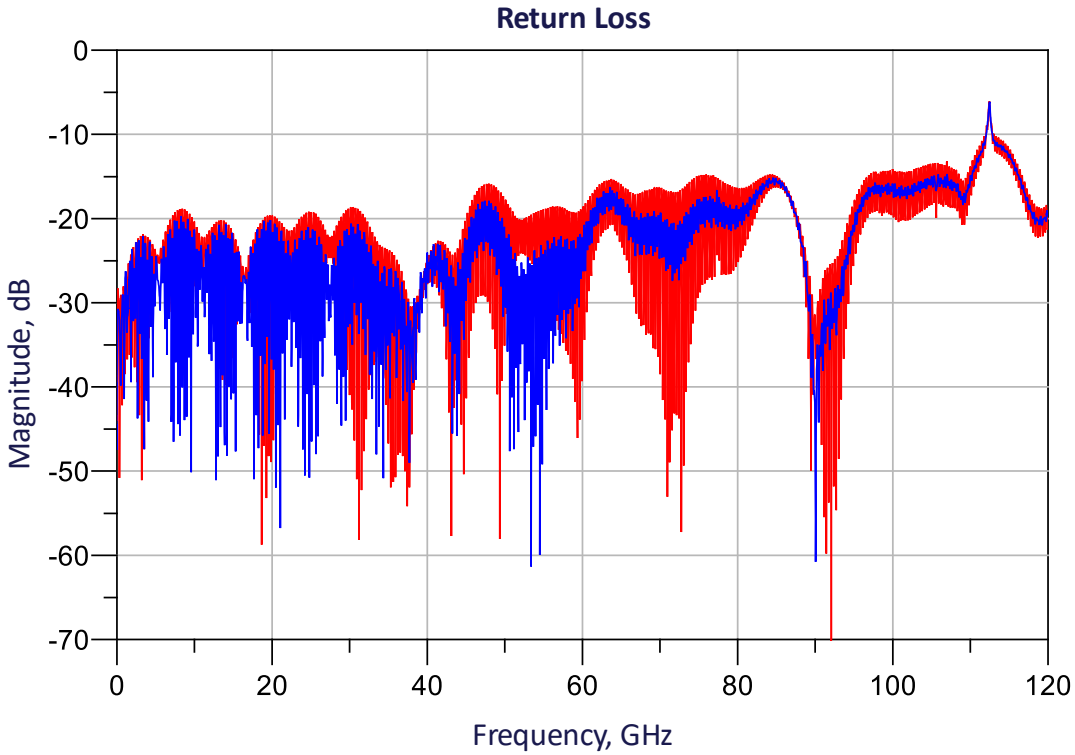
0-degree radial bend (good-way bend)

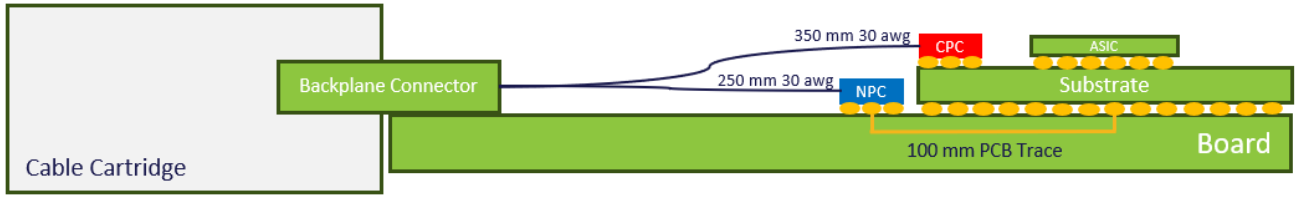


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Simulated - 448G CPC/NPC to Backplane Channel (PAM6)







Assumptions:

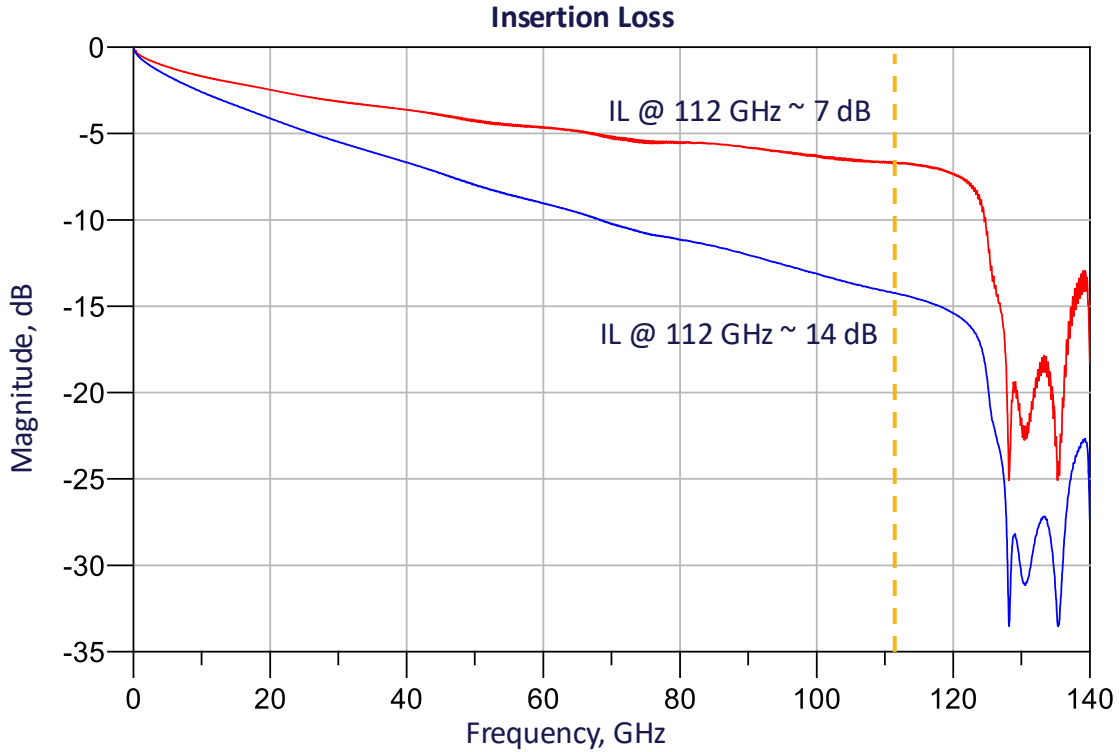
- No package loss included in channel

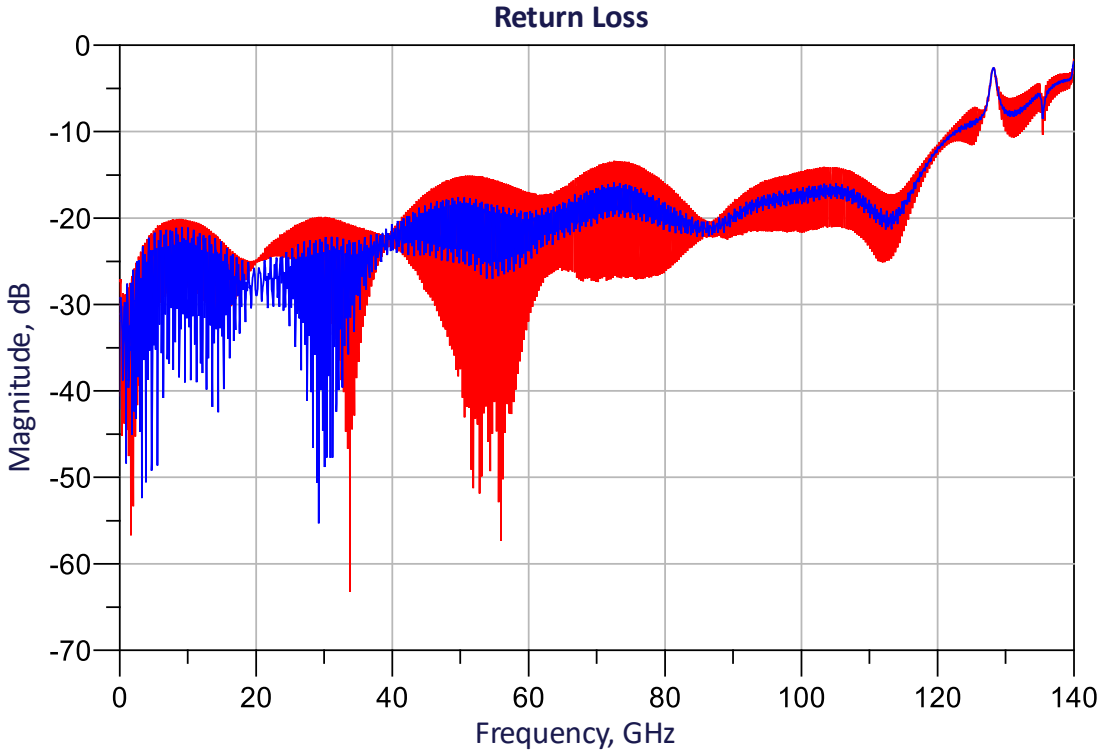
Key Takeaway:

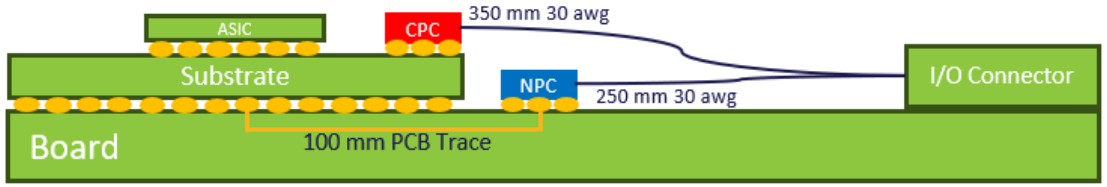
- At 448G, CPC provides lower insertion loss than NPC

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Simulated - 448G CPC/NPC to I/O Channel (PAM4)







Assumptions:

- No package loss included in channel

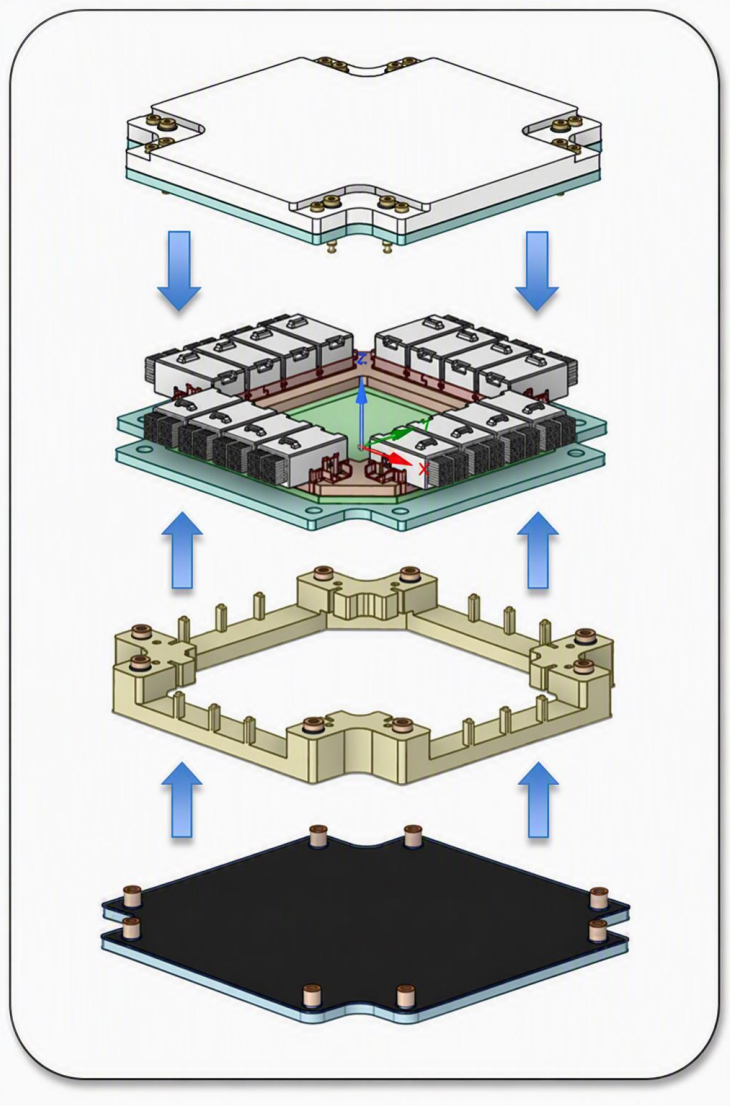
Key Takeaway:

- At 448G, CPC provides lower insertion loss than NPC

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High Radix Systems vs. Manufacturing Complexity

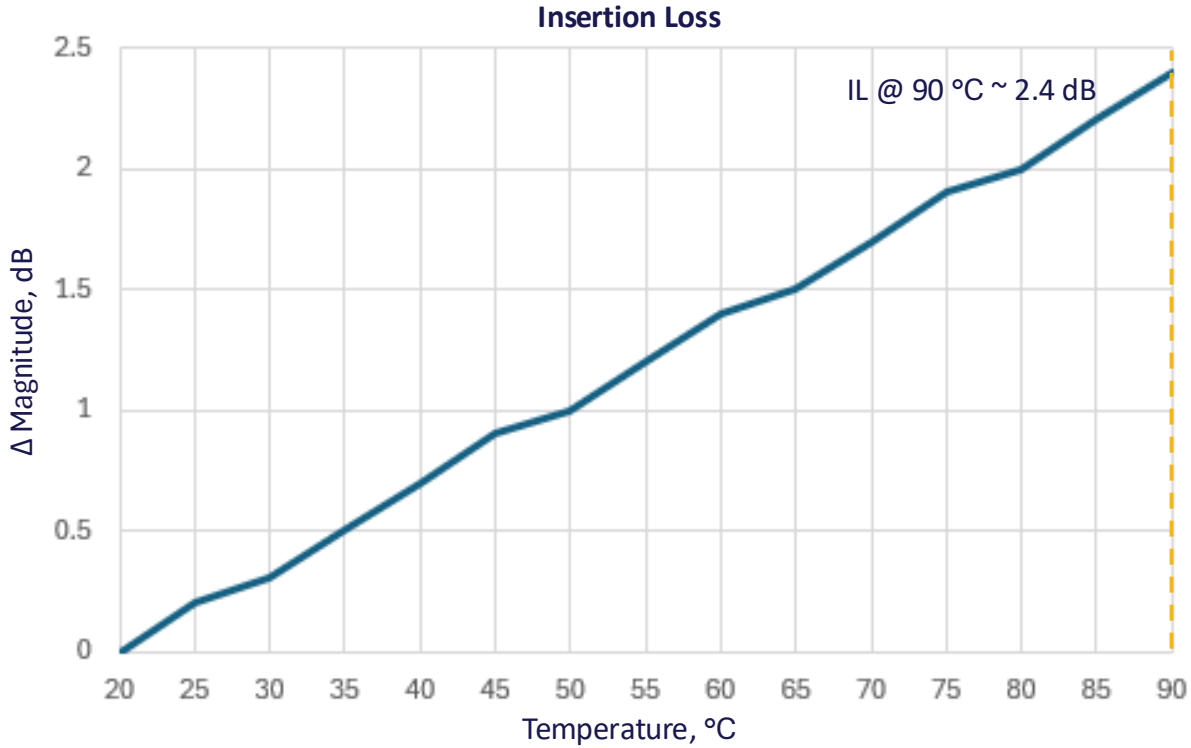
- CPC solves the ASIC “escape” problem by moving high-speed signals quickly from the package into twinax cables.
- Now the cable/connector system becomes part of the ASIC package itself, so all these components must be designed together.
- As bandwidth and I/O density increase, the available ASIC package perimeter remains constrained, increasing connector, cable routing, and assembly complexity.
- Manufacturing Considerations:
  - Connector tolerances become increasingly important at the system level
  - Cable strain needs to be managed at the package interface
  - Package warpage needs to be accounted for when integrating materials with different coefficients of thermal expansion



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Designing CPC for the ASIC Thermal Environment

- CPC places high-speed connectors directly within the ASIC package thermal environment
- CPC design partners are accounting for package, substrate, cold-plate, and cable induced mechanical loads across thermal cycling
- Temperature dependent cable loss is understood and is incorporated into channel margin



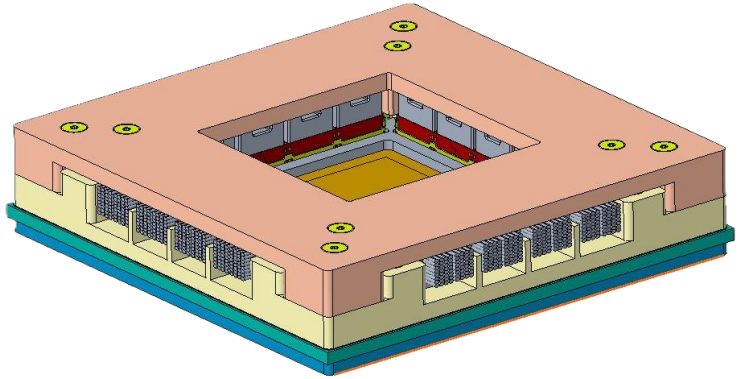
Key Takeaway:

- Cable loss (in dB) increases 3% - 5% for every 10°C increase for a 1m cable

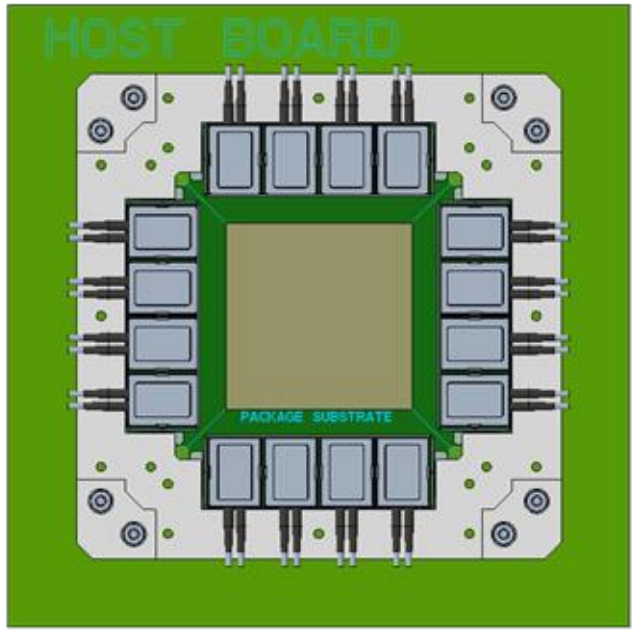
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CPC as a Natural Transition to CPO

- CPC and CPO can share a common reference architecture for front panel or backplane connectivity
- Co-Packaged Copper builds the package-level electrical, mechanical, and thermal integration practices that can support a future transition to CPO.



Co-Packaged Copper



Co-Packaged Optics

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Call to Action

- Next Steps:
  - Share channel-level SI data to support next-generation channel analysis and validation
  - Work with ecosystem partners to develop common standards and interoperability guidelines for copper and optical interconnects
- Contacts:
  - TE 448G CPC: Rahul Sharma (sharmar@te.com)
  - TE System Architecture: Sakina Naqvi (sakina.naqvi@te.com) & Usman Saeed (usman.saeed@te.com)
- Where to find additional information:
  - OCP Server Project Wiki
  - Server Specifications & Designs

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