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100G Copper Proposal: Technical Feasibility From Connector Technology Standpoint

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MOLEX

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Background



- To facilitate next generation Ethernet, all parts of the system must be considered
- Data center links must be included to fully facilitate next generation Ethernet
- Data center links are typically implemented with copper cable
- Copper interconnect technology is currently available operating at 10 Gbps per differential pair
- This presentation provides an overview of this technology and available form factors



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Overview of Current Technology



- **Interconnect technology has demonstrated 10 Gbps per pair capability**
- **Copper cables can be plugged directly to the host connector for data center links**
- **For longer runs, a fiber transceiver can be plugged into the copper host connector providing capability for a fiber link**



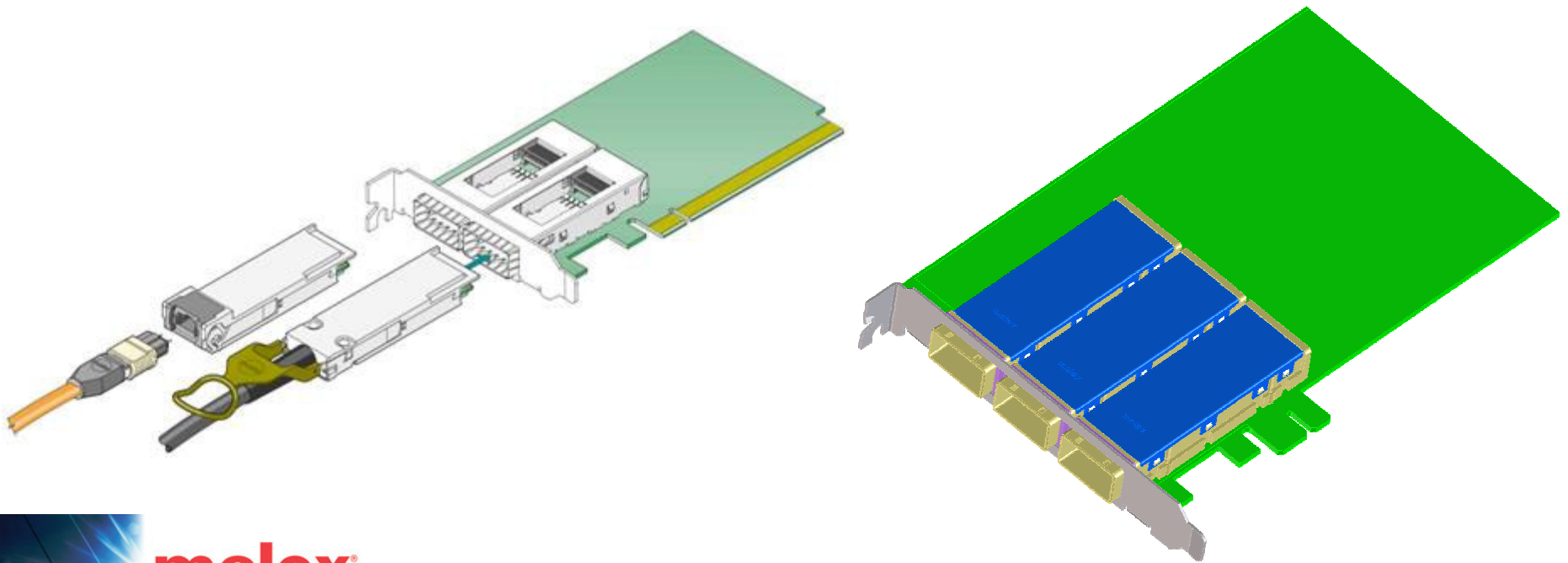
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Overview of Current Technology



Solutions currently exist enabling 10 Gbps serial lane rates over 10m Twinax cable:

- QSFP Pluggable (electrical/optical) 4x10 Gbps in a small form factor.
- 10x10 Gbps Pluggable Interconnect (demonstrated up to 10 m)



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4 Lane Form Factor

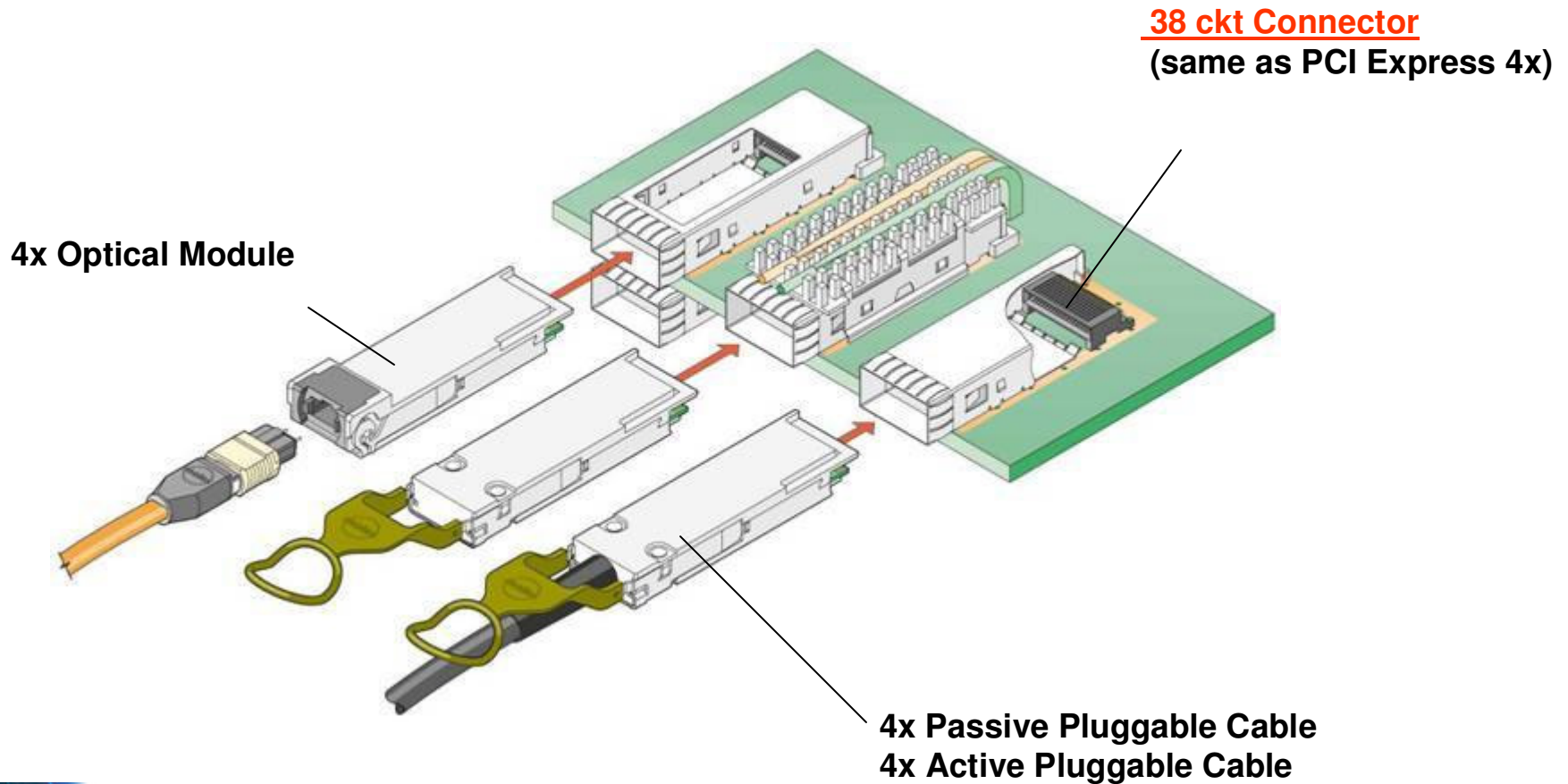
(40G 4x10 available today, extendable to 100G 4x25)

QSFP – Quad Small Form-factor Pluggable



The QSFP MSA was released 12/4/2006

- The MSA defines an 8 Differential Pair (4x) Pluggable Copper Cable & Optical Module
- Each pair is 10Gb capable



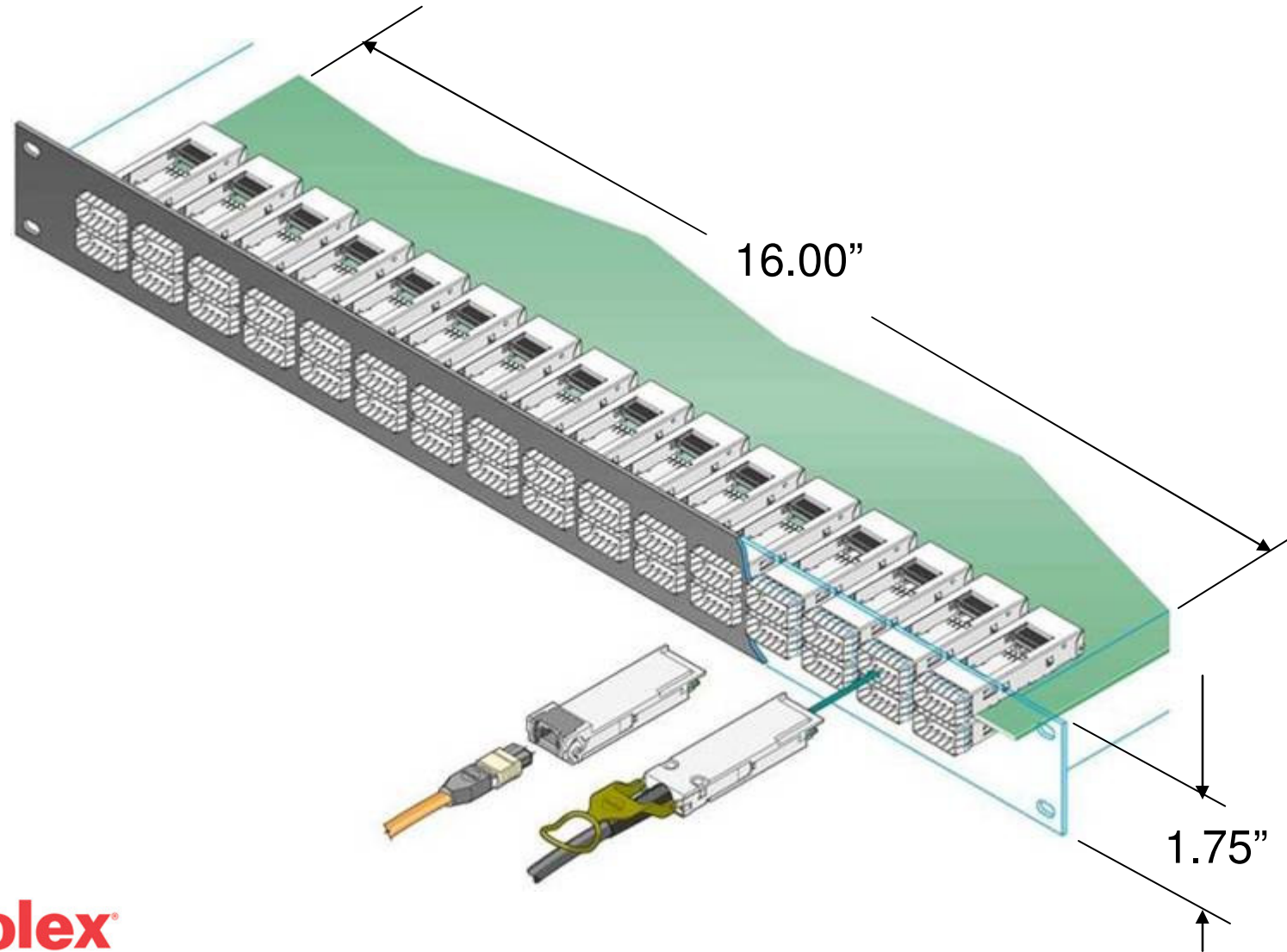
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QSFP – 1U Rack Mount Enclosure



16 x 4 = 64 1x Lanes

16 over 16 = 32 x 4 = 128 1x Lanes



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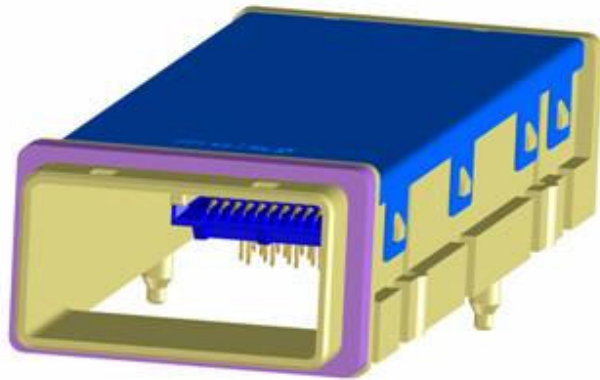
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10 Lane Form Factor

(100 Gbps 10x10 solution)

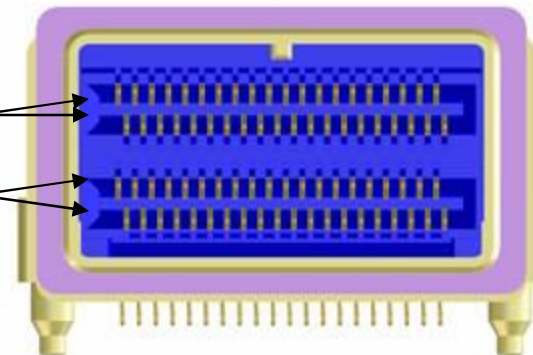
10 Lane Pluggable Interconnect



- 80 ckt integrated press-fit connector/cage assembly provides 12 differential channels:
 - 10 lanes of 10 Gbps, as well as additional circuits for power, sidebands, coding, clocks, etc.
- Host interconnect can accept copper or optical cable solutions
- EMI performance proven to 10 Gbps.

Receive Group →

Transmit Group →



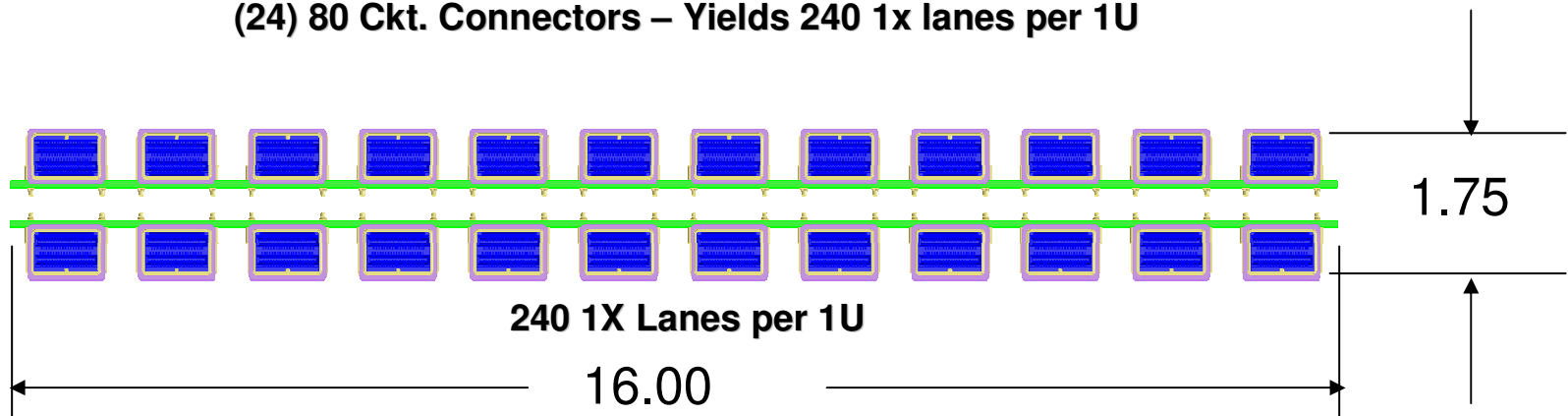
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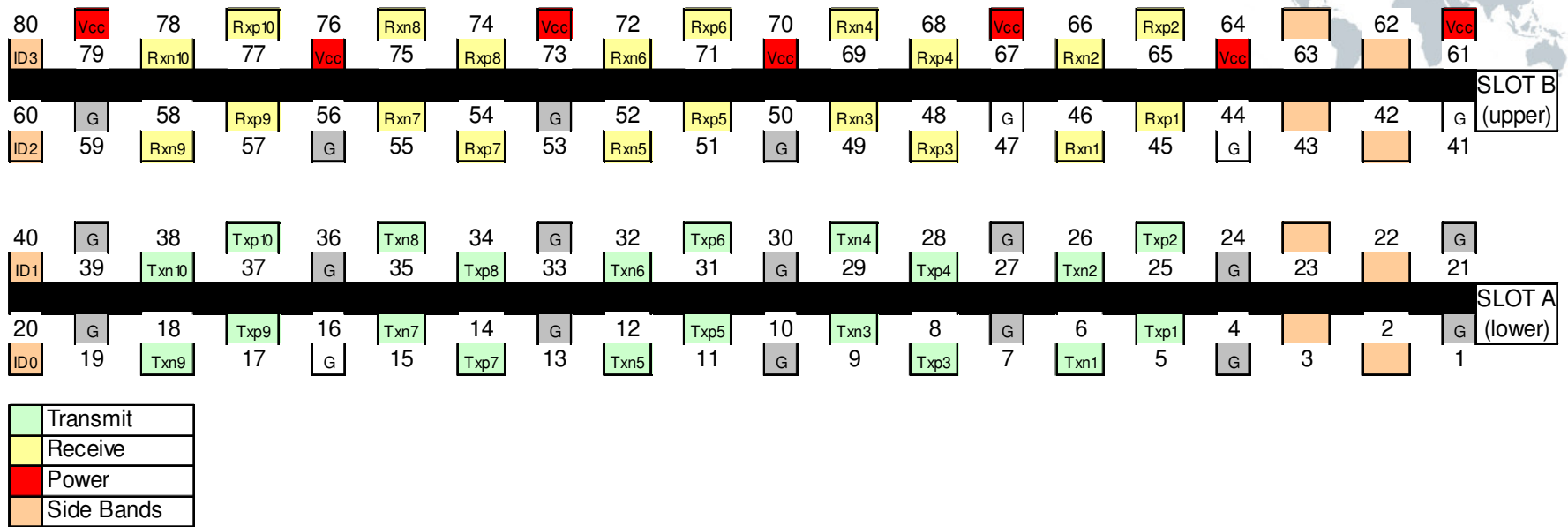
10 Lanes On a 1U Blade

- Figures compare the number of available lanes that fit within a typical 1U panel
 - 406.4 mm (16”) width PCB
 - 44.45 mm (1.75”) standard 1U overall height
- Pluggable 80 ckt. connectors utilize 1/3 of the rack space of traditional I/O's
 - 240 lanes in 1U form factor

(24) 80 Ckt. Connectors – Yields 240 1x lanes per 1U



Example HSSG 10 Lane Pin Out



- Transmit pairs could be aggregated in lower slot “A” to optimize isolation within the channel
- Signal pairs can be optimized for direct ASIC routing from the connector
- Power pins in upper slot “B” could enable active-equalized cable assemblies
- Twelve sideband signal pins provide capability for cable identification, clocks or other functionality



Link Reach Extension (Active)



- Link extensions to up to 30m have been demonstrated using active RX equalization and/or EDC in the module. Several vendors (Quellan, Phyworks, Vitesse, TI, Scintera, others) have low-power solutions that have been shown to work successfully. See Appendix for details.
- An example of 25-30m 10G serial link solution would be a QSFP module with a lane extender module and a high-performance 24 AWG cable.



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Doing 100 Gbps

- 100 Gbps with small number of aggregate lanes (5x20 or 4x25) is possible using current hardware by employing signaling schemes alternative to NRZ.
 - PAM4 and Duobinary are possible candidates.
 - Signal Integrity/Crosstalk data supports 10 Gbps NRZ operation, extendable to 20-25 Gbps
- Duobinary seems particularly promising: it allows 20-25 Gbps transmission over 10-12 Gbps NRZ channels, with low coding, power and SNR penalty.

For details refer to: 25 Gbit/s electrical duobinary transmission over FR-4 backplanes

Adamiecki, A. Duellk, M. Sinsky, J.H.
Lucent Technol., Bell Labs., Holmdel, NJ, USA;
Electronics Letters, Volume: 41, Issue 14.



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Conclusion

- **100 Gbps copper Ethernet within data center is feasible in a cost-effective solution.**
- **Currently available interconnect hardware providing 10 Gbps serial links can be utilized in parallel for copper 100G Ethernet by using high-performance components and adjusting the signaling scheme.**



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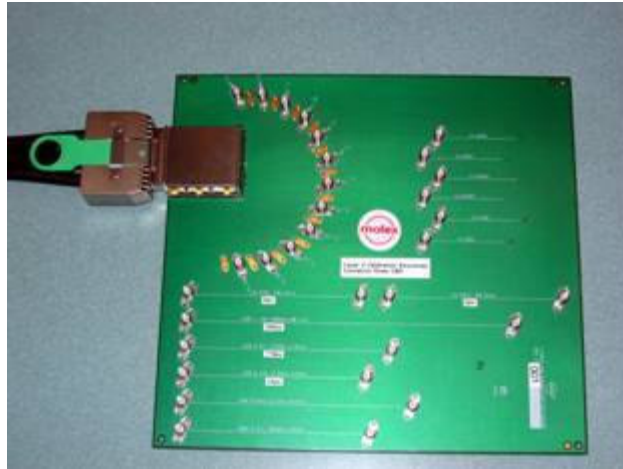
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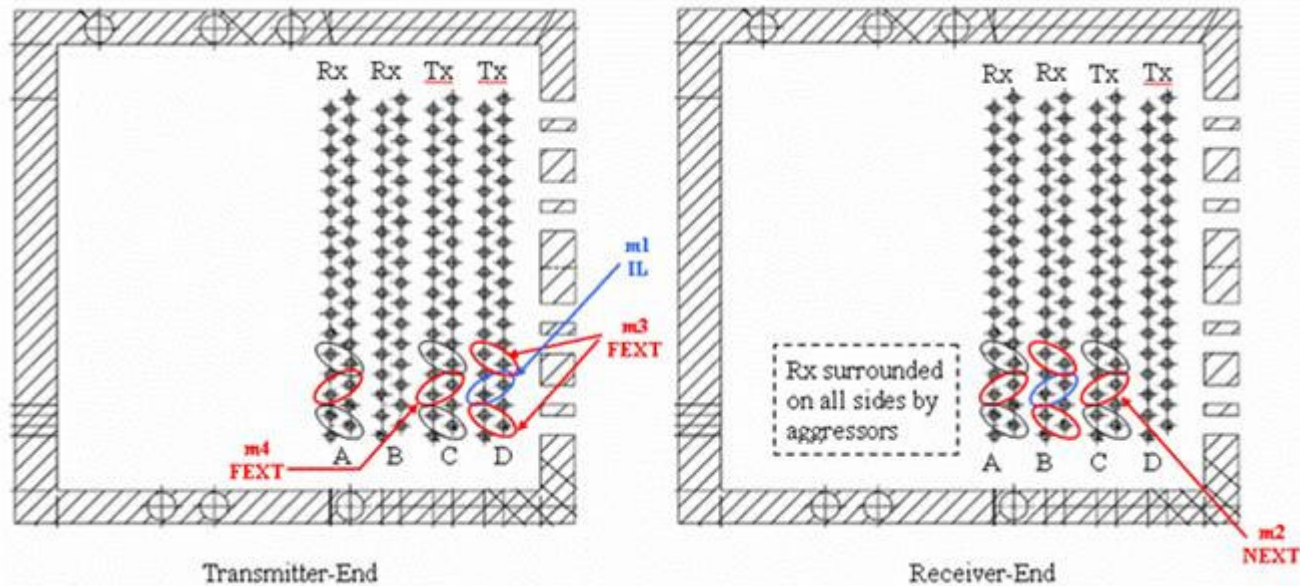


**APPENDIX A:
Crosstalk data for 4 Lane and 10 Lane
Solutions**

10 Lane Crosstalk Data: Test Setup

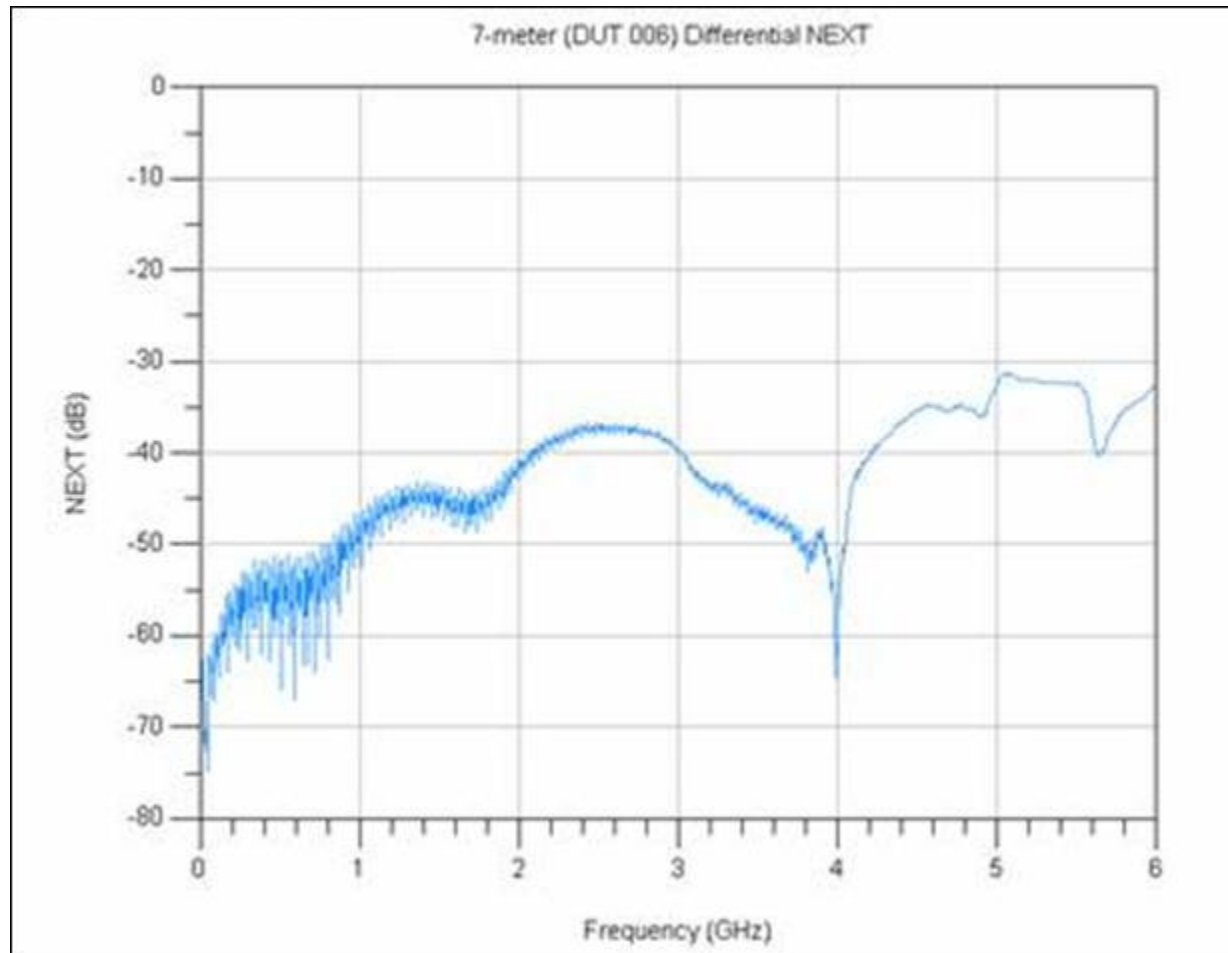


Tested Implementation:
x16 PCIe (iPass+)
connector



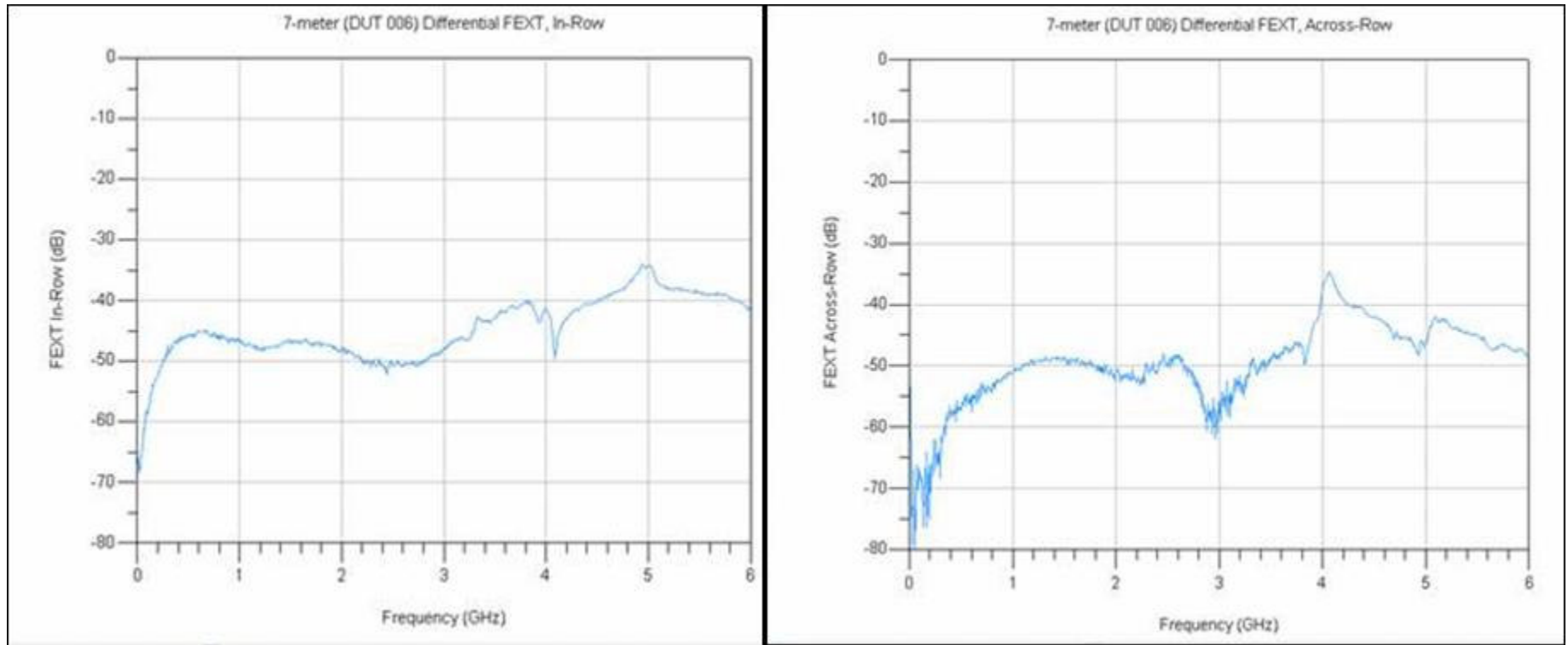
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10 Lane Crosstalk Data: NEXT (7m 24 AWG Cable)

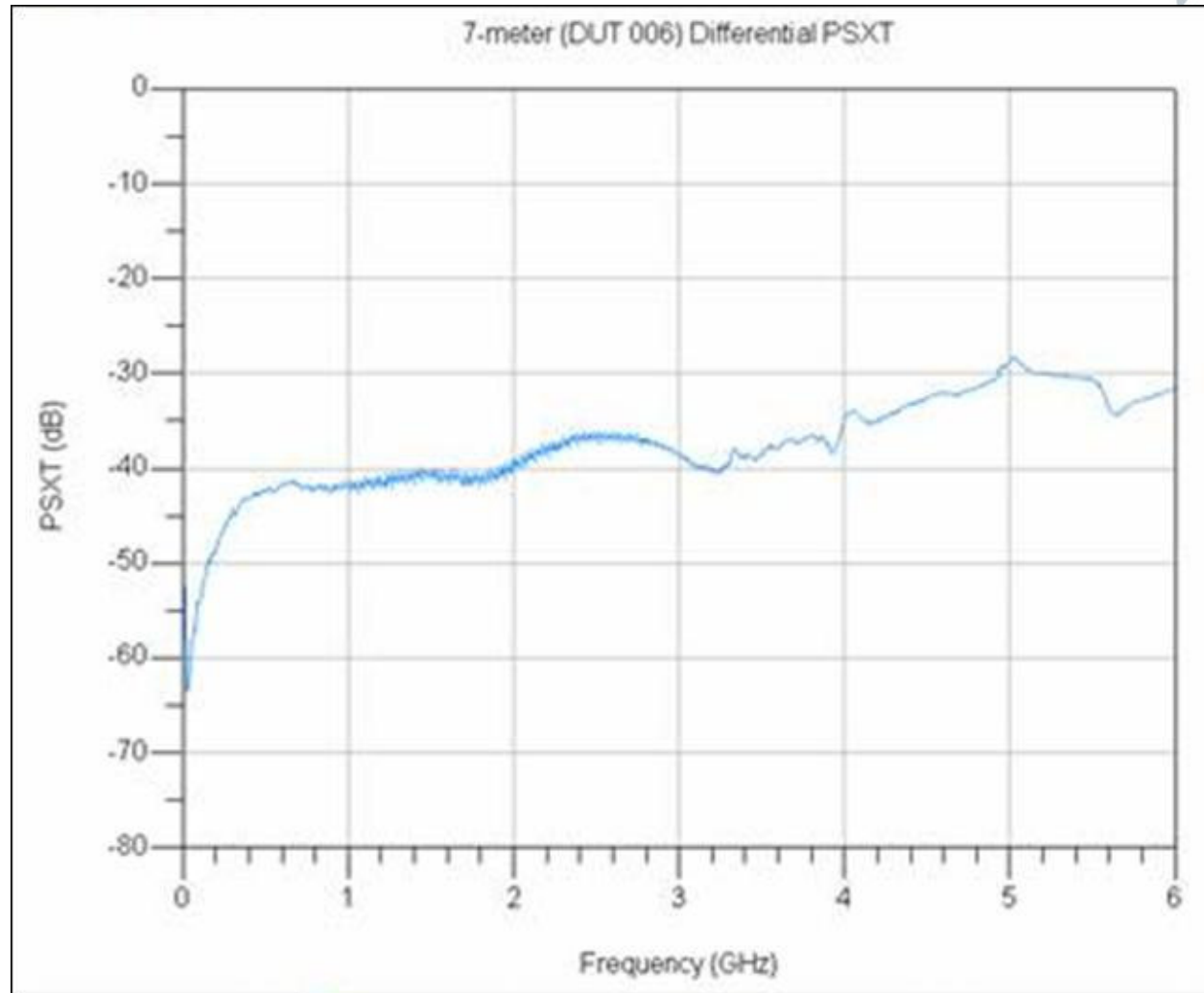


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10 Lane Crosstalk Data: FEXT (7m 24 AWG Cable)

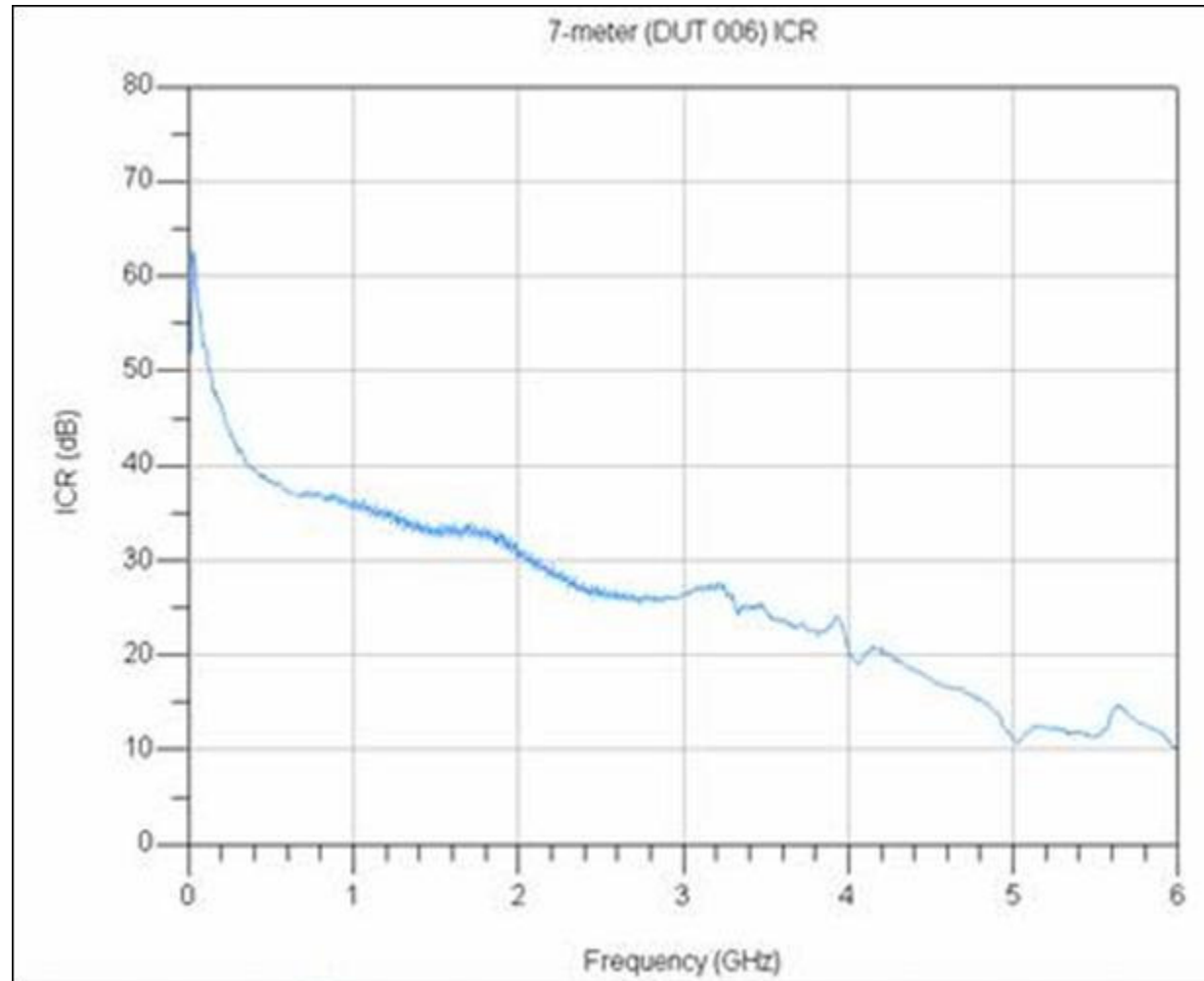


10 Lane Crosstalk Data: Power-Sum Xtalk – PSXT (7m 24 AWG Cable)



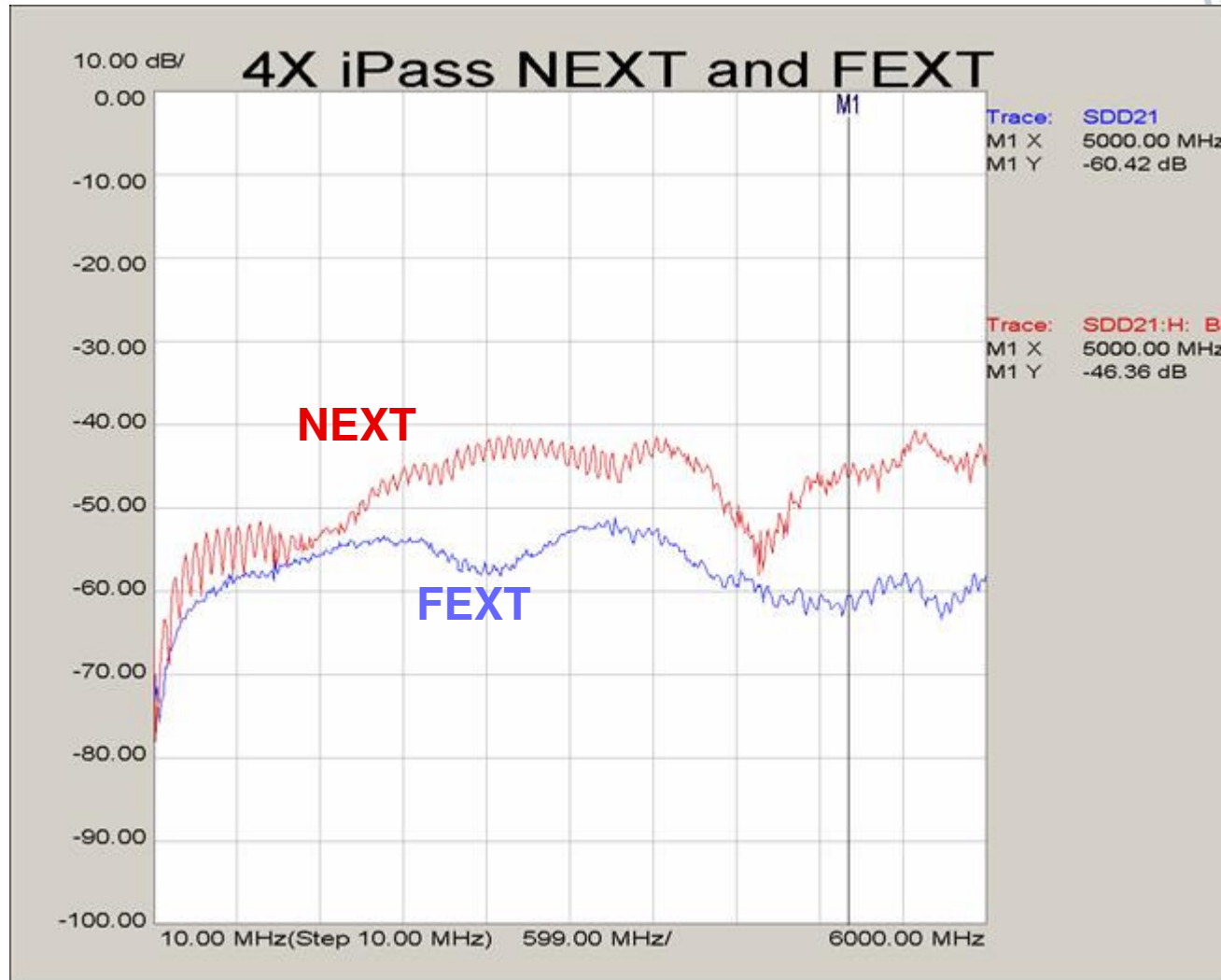
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10 Lane Crosstalk Data: ICR (7m 24 AWG Cable)



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4 Lane Crosstalk Data: NEXT & FEXT (10m 24 AWG Cable)



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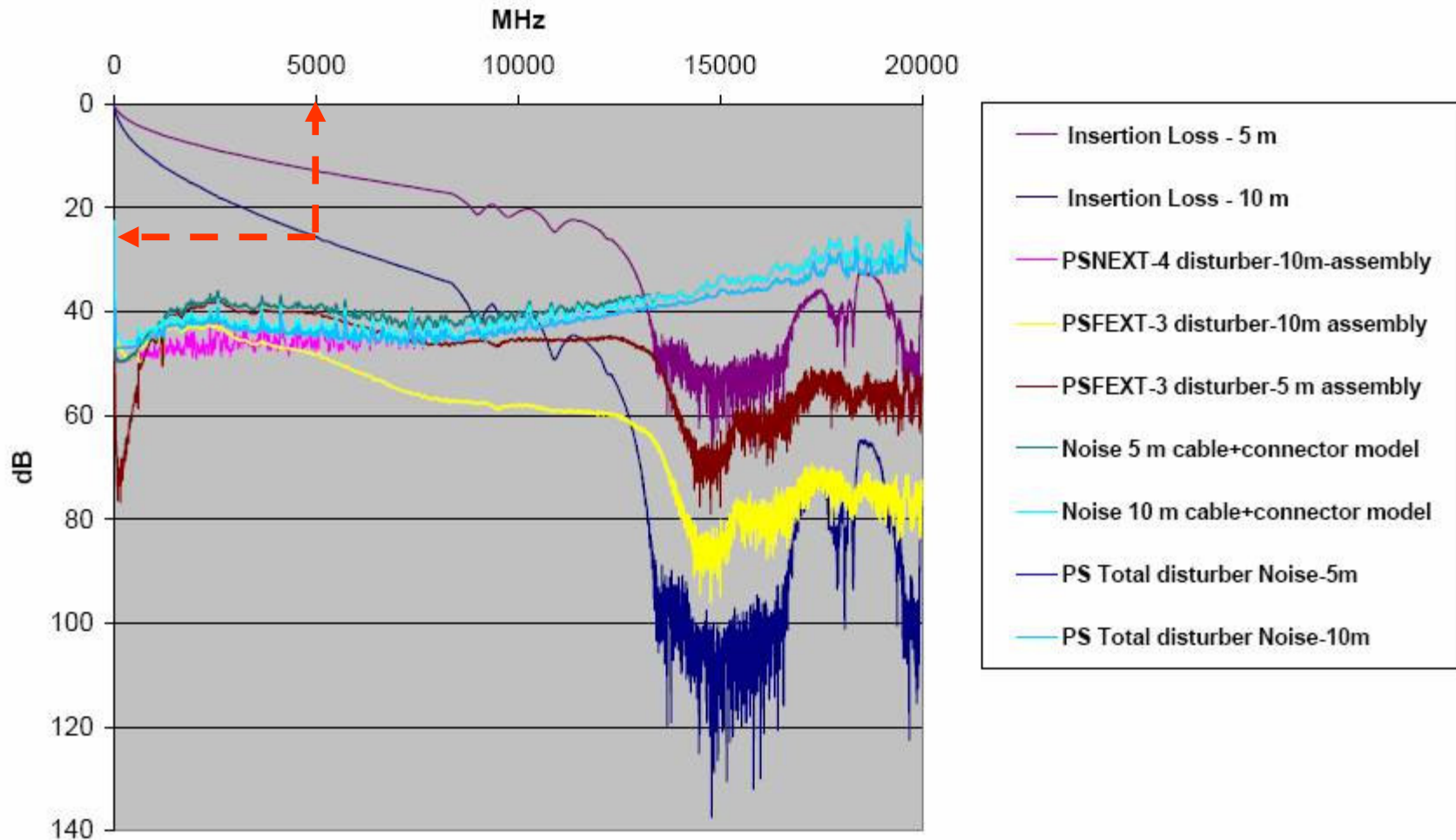
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**APPENDIX B:
An Example of EDC Technology
Enabling 10G Serial Transmission**

Materials courtesy of Phyworks LTD

~26 dB Cable Loss (28AWG, 10m @ 5GHz)

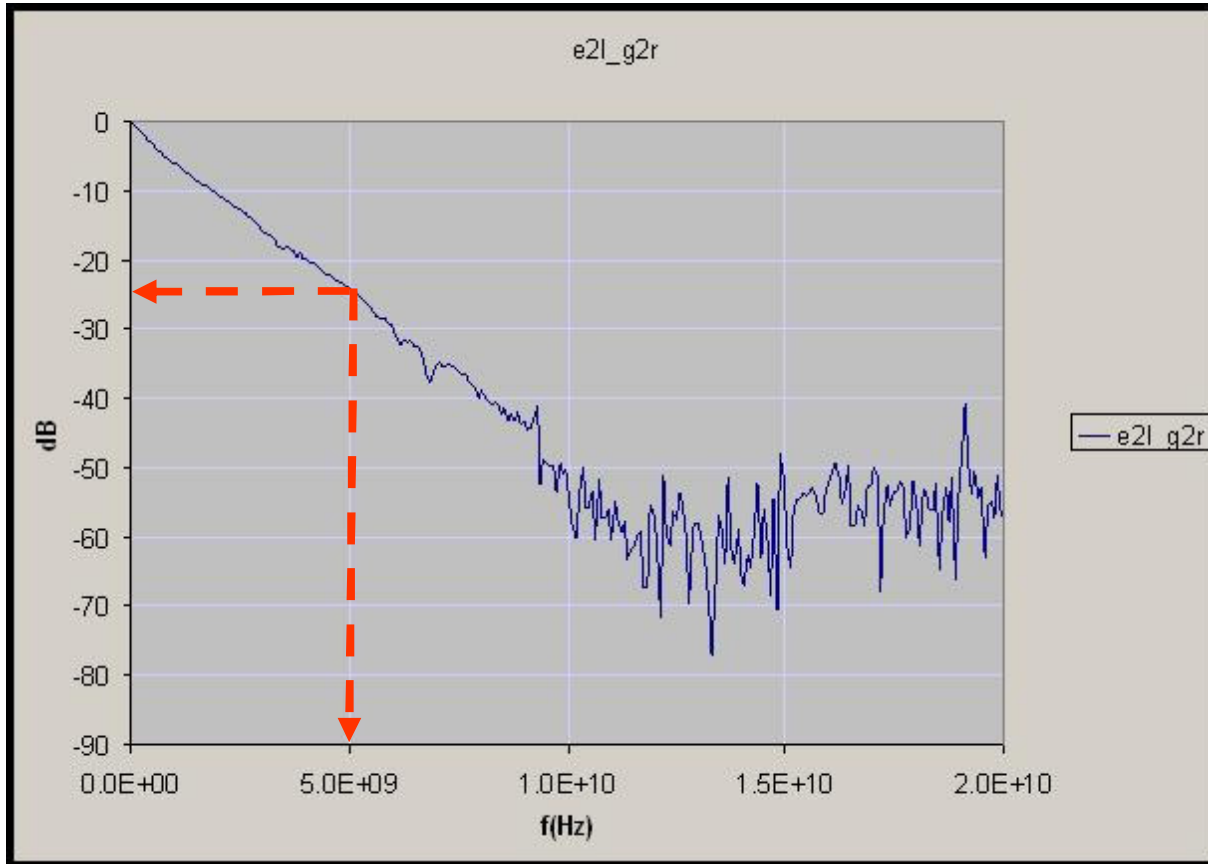


■ Data from Chris DiMinico – MC Communications



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~25 dB Backplane loss 1m @ 5Ghz



- 2 Molex I-Trac Connectors
- Molex Reference Backplane – Port E2 left, G2 right
- Similar Loss Characteristic to 10m Cable



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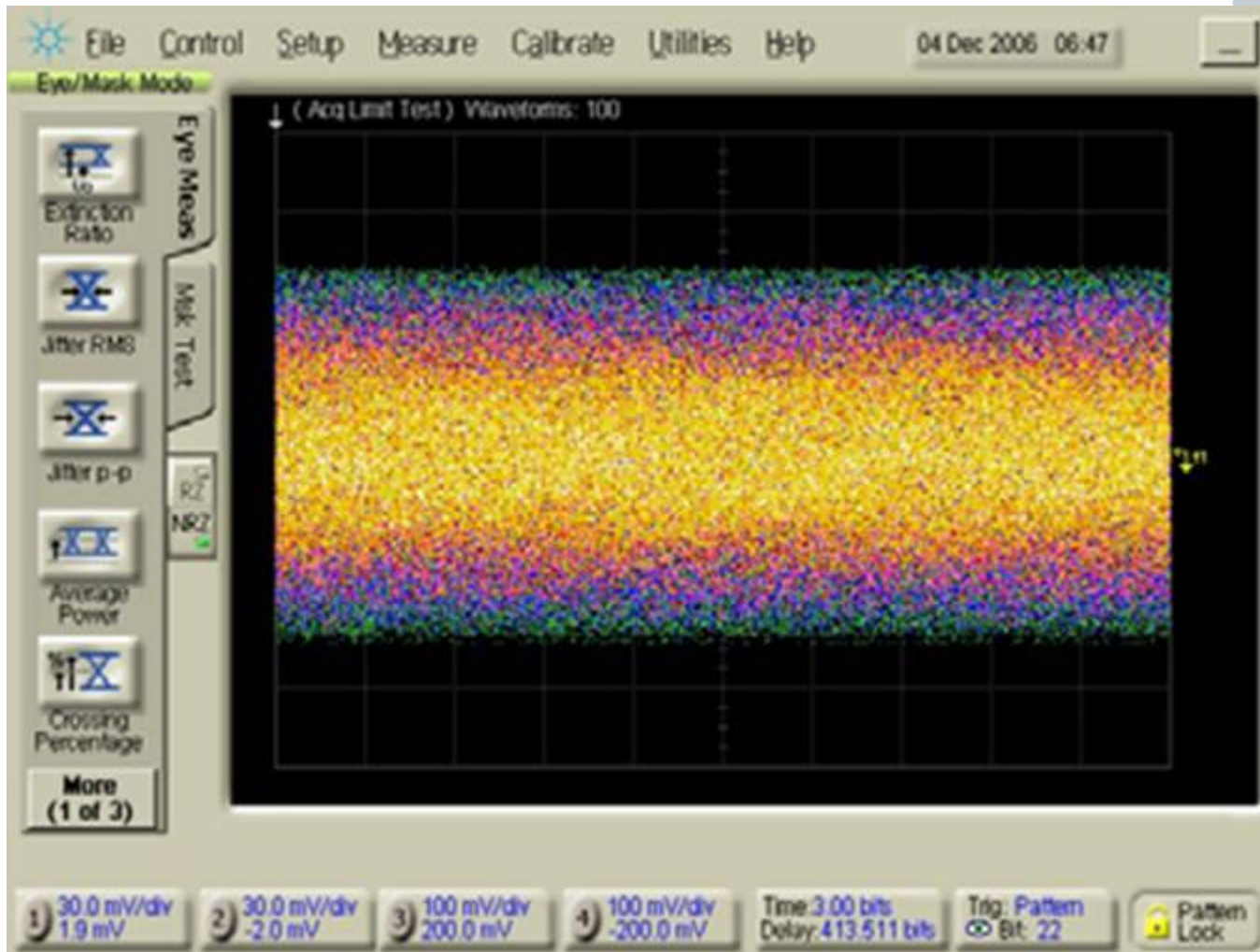
Available Measurements



- **Molex Reference Backplane Channel**
 - 25 dB loss at 5 GHz
 - 3 NEXT interferers
 - 1 FEXT interferer
- **Phyworks 1066**
 - Pre-emphasis TX (fixed – no training)
 - Same pre-emphasis setting provides error free back to back case
 - Blind adaptive equalizing RX
- **Channel Reasonably Comparable to 10m Cable**
 - Further work planned with actual cables

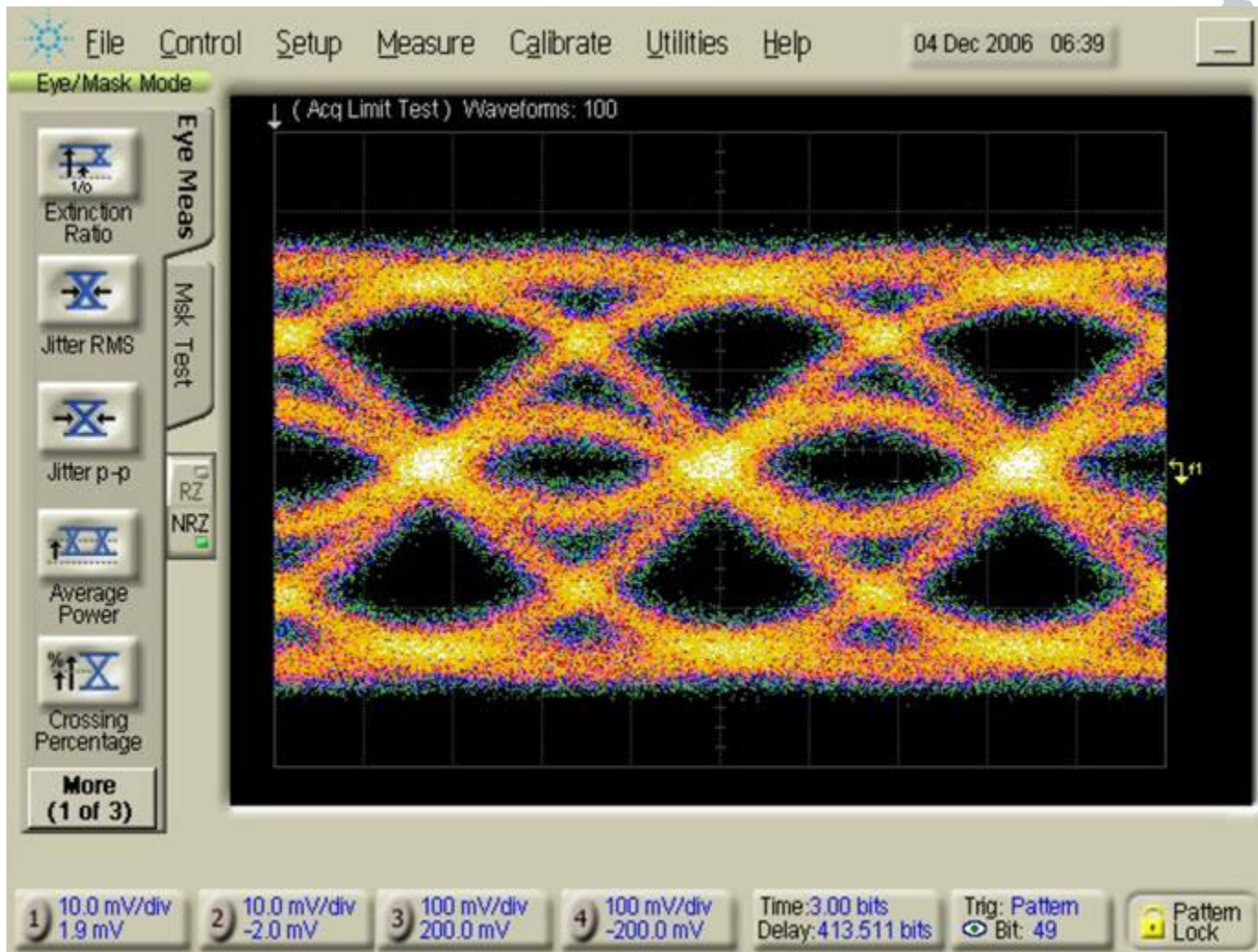


Channel Output – No Pre-Emphasis



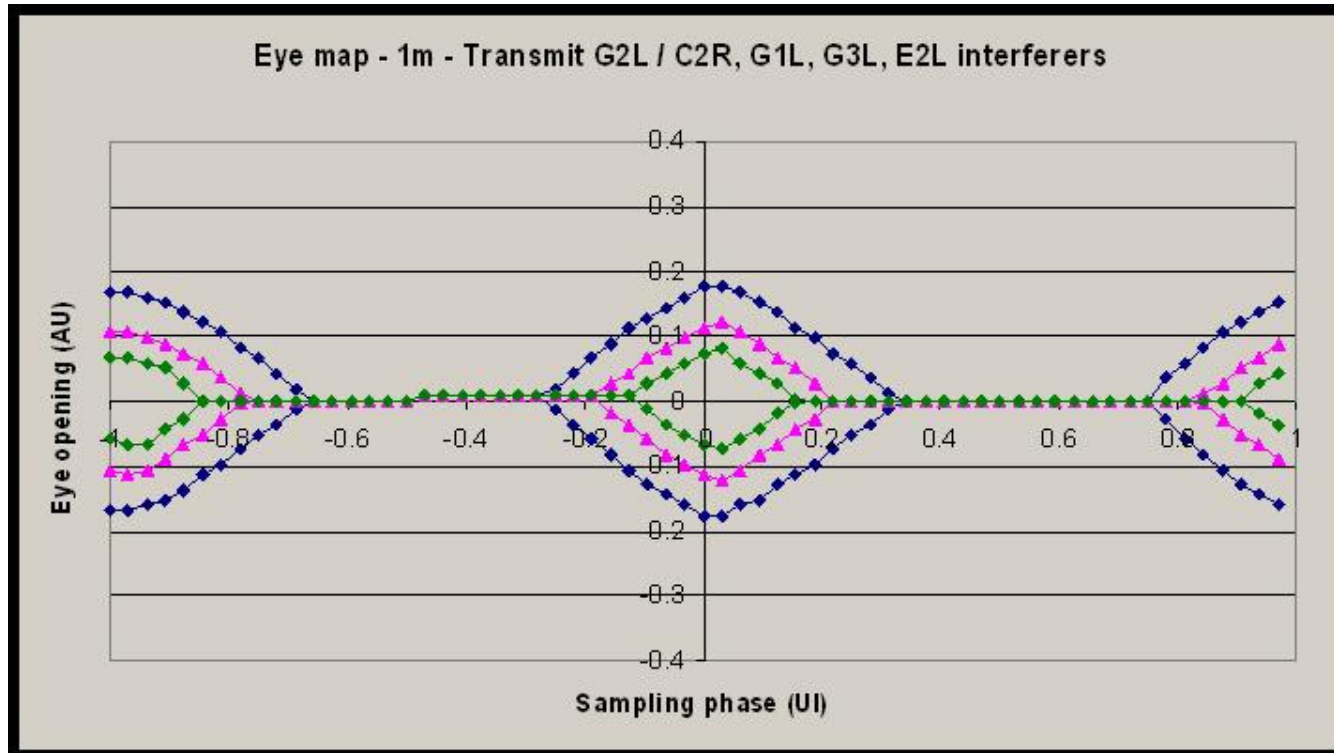
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Channel Output – With Pre-Emphasis



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BER Contour Eye (10^{-3} , 10^{-6} , 10^{-9})



- No Errors in $>10^{14}$ Bits
- Eye Opening Extracted at Slicer
 - Output of equalizer
 - Sampling level and time adjusted and BER measured
 - PRBS31



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Summary



- **Silicon technology for 10 Gbps is available today**
- **Measurements of correlated channel encouraging**
- **Longer cable reaches and higher data rates merit further investigation**
- **For more information contact Paul Denny
paul.denny@phyworks-ic.com**

