802.3ba copper cable assembly proposal

Chris Di Minico
MC Communications
cdiminico@ieee.org

Contributors

- Galen Fromm, Jay Neer - Molex
- Jens Aumann, Leoni High Speed Cables
- Vivek Telang, Broadcom

Supporters

- Dan Dove, ProCurve Networking by HP
- Shimon Muller, Sun Microsystems
- Tom Palkert, Luxtera
- Gourgen Oganessyan, Quellan
- Piers Dawe, Avago Technologies
- John Petrilla, Avago Technologies
- Ed Cady, Meritec
- Herb Van Deusen, Gore
- Hugh Barrass, Cisco
- ilango Ganga, Intel
- Amir Mezer, Intel
- Rich Mellitz, Intel
- Howard Baumer, Mobius Semiconductor
- Greg McSorley, Amphenol

Summary

- Considerations for 802.3ba Cu cable assembly specifications for 802.3ba baseline proposal.

- Measurement models and simulation models developed to validate usage of 10GBASE-KR (Clause 72) for 10 Gb/s lane options for both 40GBASE-CR4 and 100GBASE-CR10 cable assemblies.

- CX4 twinaxial cable assembly differential parameters proposed as basis for 40GBASE-CR4 and 100GBASE-CR10 link specification (i.e., S-parameters).

802.3ba objectives

- Support full-duplex operation only
- Preserve the 802.3 / Ethernet frame format utilizing the 802.3 MAC
- Preserve minimum and maximum FrameSize of current 802.3 standard
- Support a BER better than or equal to 10^{-12} at the MAC/PLS service interface
- Provide appropriate support for OTN

- Support a MAC data rate of 40 Gb/s
- Provide Physical Layer specifications which support 40 Gb/s operation over:
  - at least 10km on SMF
  - at least 100m on OM3 MMF
  - at least 10m over a copper cable assembly
  - at least 1m over a backplane
- Support a MAC data rate of 100 Gb/s
- Provide Physical Layer specifications which support 100 Gb/s operation over:
  - at least 40km on SMF
  - at least 10km on SMF
  - at least 100m on OM3 MMF
  - at least 10m over a copper cable assembly

Copper cable assembly: lane options considered

- Support a MAC data rate of 40 Gb/s
- Provide Physical Layer specifications which support 40 Gb/s operation over:
  - at least 10m over a copper cable assembly
  - 4 x 10 Gb/s lane

- Support a MAC data rate of 100 Gb/s
- Provide Physical Layer specifications which support 100 Gb/s operation over:
  - at least 10m over a copper cable assembly
  - 10 x 10 Gb/s lane

802.3ba copper cable assembly link diagram

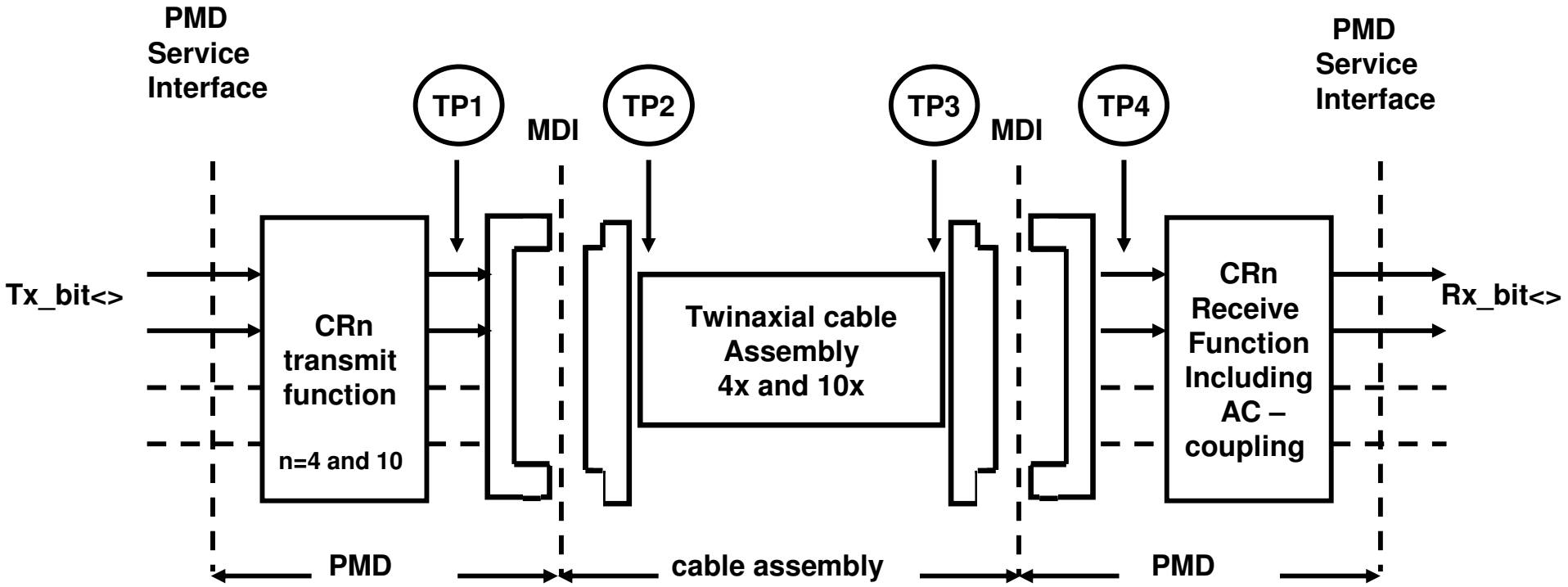


Figure XX–X—40GBASE-CR4 and 100GBASE-CR10 link

40GBASE-CR4 and 100GBASE-CR10 cable assembly

- **Cable assembly differential parameters**

Description	Value	Unit
$Insertion\ \ Loss\ (f) \le TBD\sqrt{f} + TBD \times f + \frac{TBD}{\sqrt{f}}$	TBD	dB
$NextLoss\ (f) \ge TBD - TBD \times \log\left(\frac{f}{TBD}\right)$	TBD	dB
$ReturnLoss(f) \ge TBD$	TBD	dB
$MDNextLoss(f) \ge TBD - TBD \times \log\left(\frac{f}{TBD}\right)$	TBD	dB
$ELFEXT\ \ (f) \ge TBD\ - TBD \times \log\left(\frac{f}{TBD}\right)$	TBD	dB
$MDELFEXT\ (f) \ge TBD - TBD \times \log\left(\frac{f}{TBD}\right)$	TBD	dB

- **TBD's > to be determined from measurement models.**

40GBASE-CR4 and 100GBASE-CR10 layer diagrams

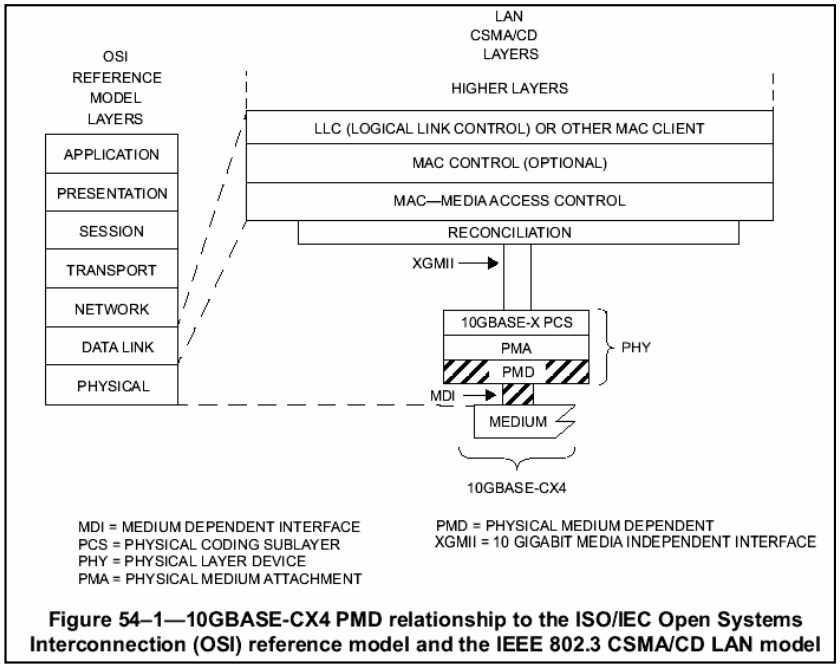


Figure 54–1—10GBASE-CX4 PMD relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and the IEEE 802.3 CSMA/CD LAN model

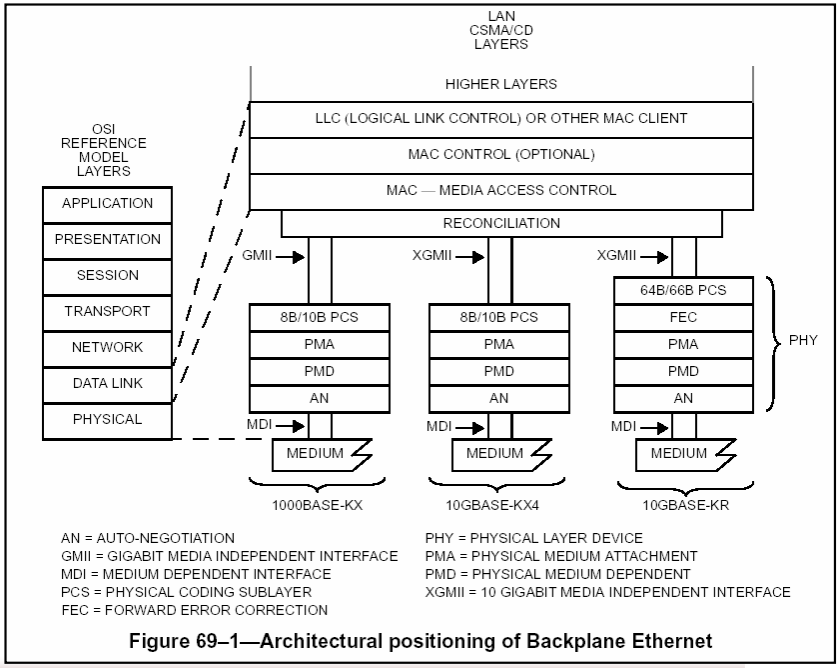
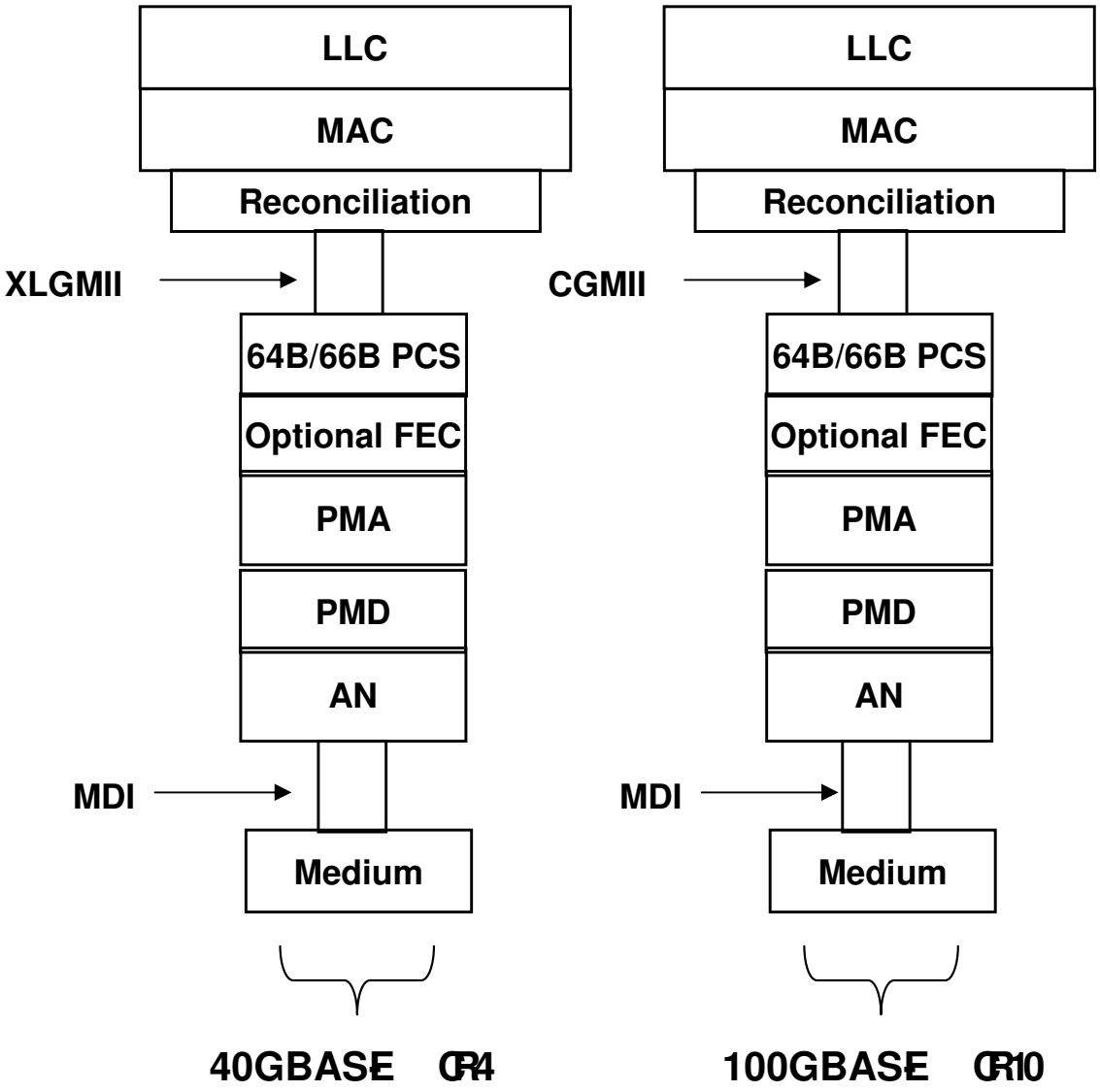


Figure 69–1—Architectural positioning of Backplane Ethernet



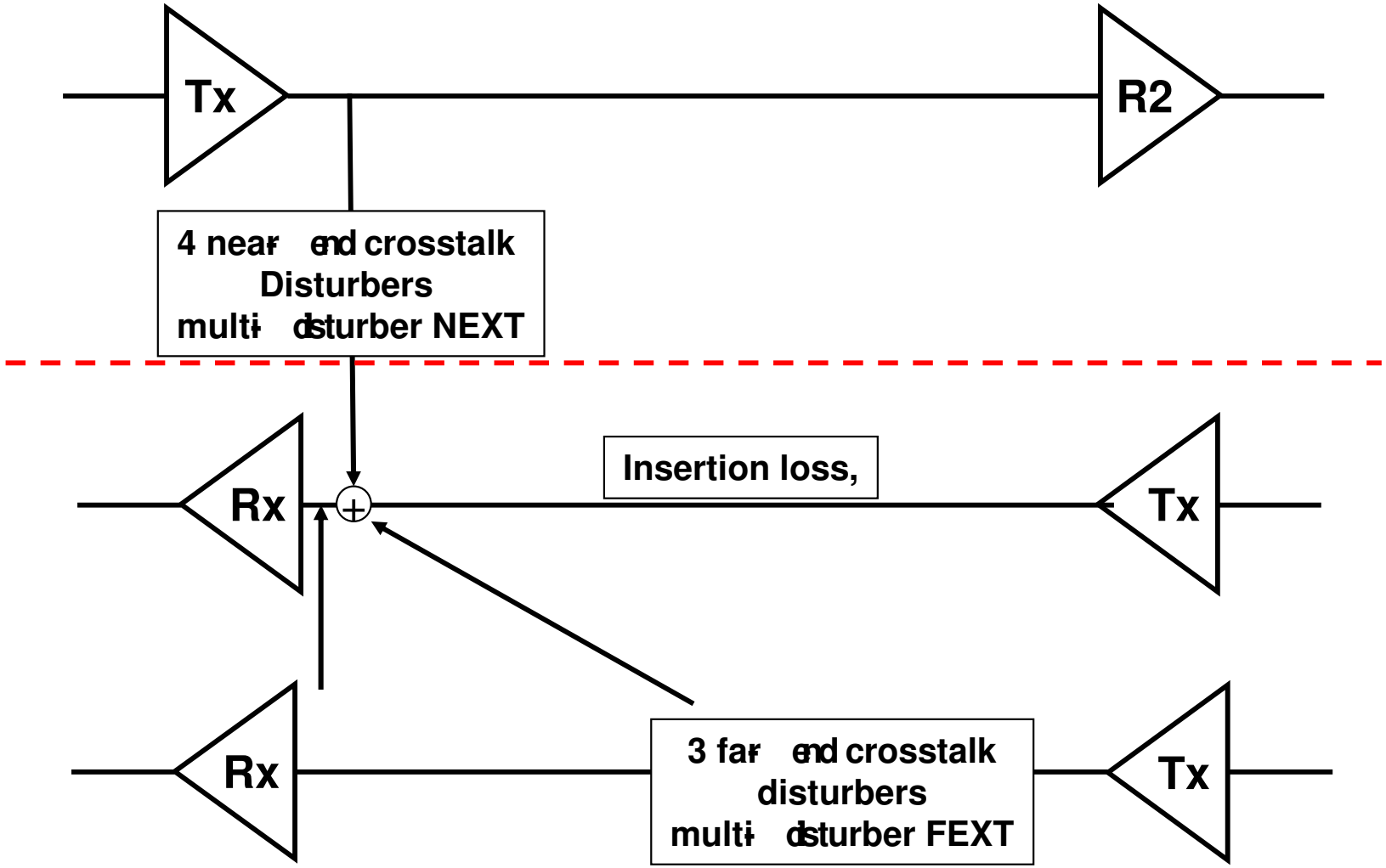
802.3ba Cu cable assembly proposal

- Utilize 10GBASE-KR (Clause 72) and 10GBASE-CX4 to specify 40GBASE-CR4 and 100GBASE-CR10.
  - 64B/66B PCS
  - Signaling speed 10.3125 Gbd (per lane)
  - 4x and 10x - KR transmit and receive functions
  - Commonality with 40 GbE backplane proposal
  - S-parameters - cable assembly differential parameter
  - 4x MDI considered: QSFP and IEC 61076-3-113 mechanical mating interface (10GBASE-CX4 mechanical)
    - QSFP- module and connector dimensions common for both fiber and copper
    - CX4 – connector mechanicals for copper (allows for backward compatibility)
- Optional FEC sublayer - PCS to interface to optional FEC sublayer - consider Clause 74 specification – commonality with 40 GbE backplane proposal
- Auto-Negotiation – consider Clause 73 specification - commonality with 40 GbE backplane proposal

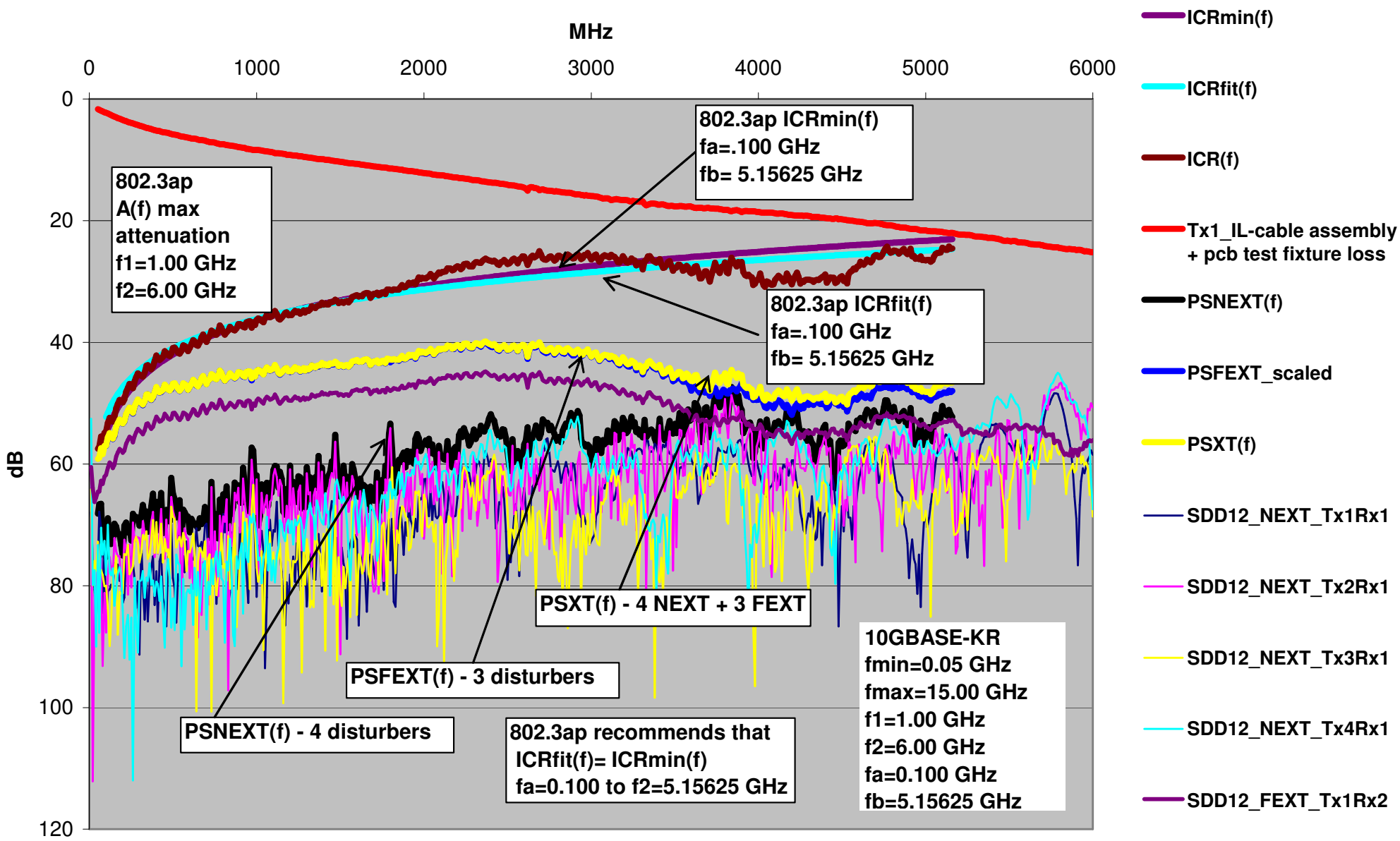
Backup

802.3ap – channel parameter comparisons

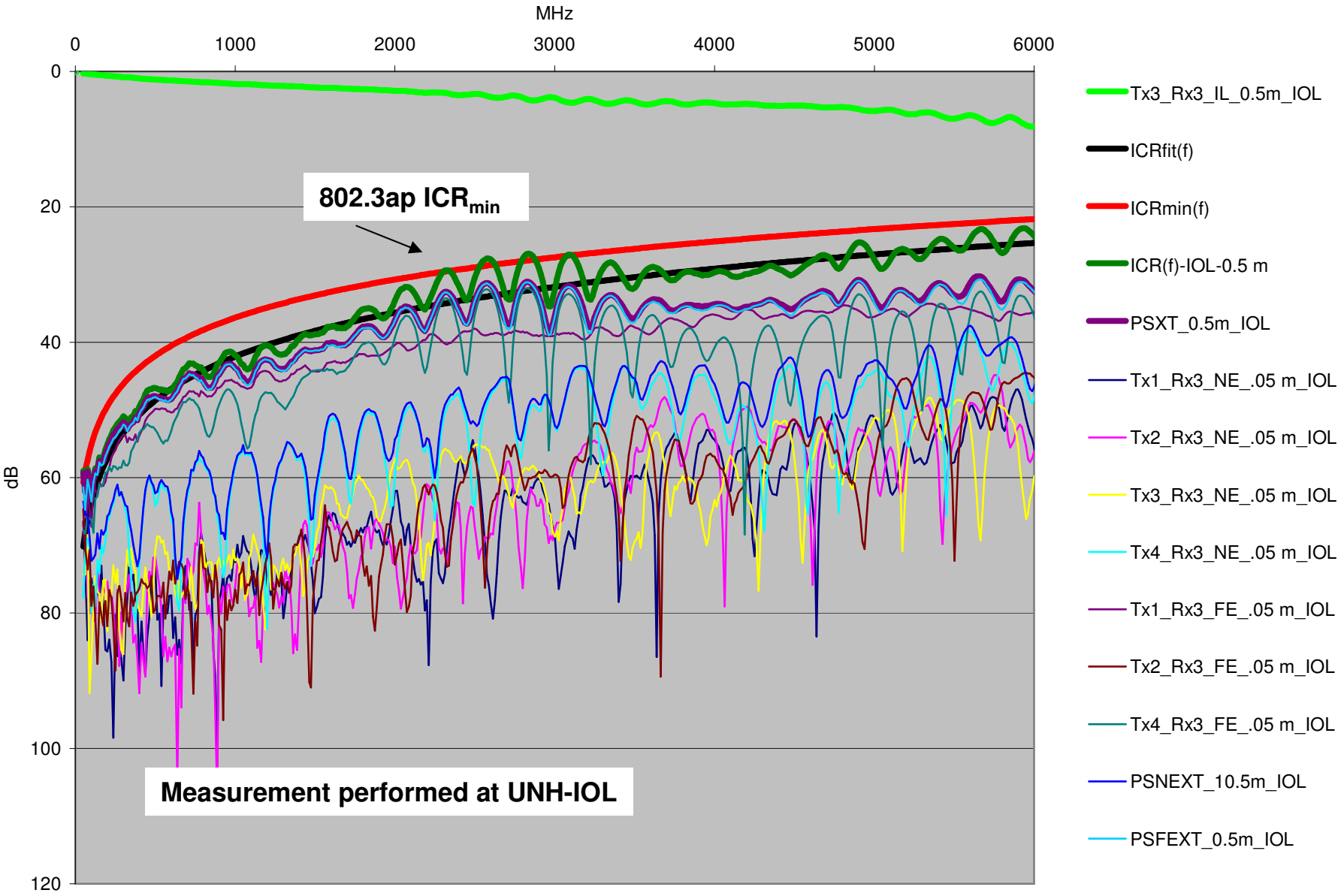
- Insertion loss to crosstalk ratio (ICR) computed from S-parameter measurements and models of QSFP 10 meter copper cable assembly (24 AWG).



802.3ap ICR limits vs 10 m QSFP cable assembly 24 AWG including test fixture



802.3ap ICR limits vs 0.5 m QSFP cable assembly 24 AWG including test fixture

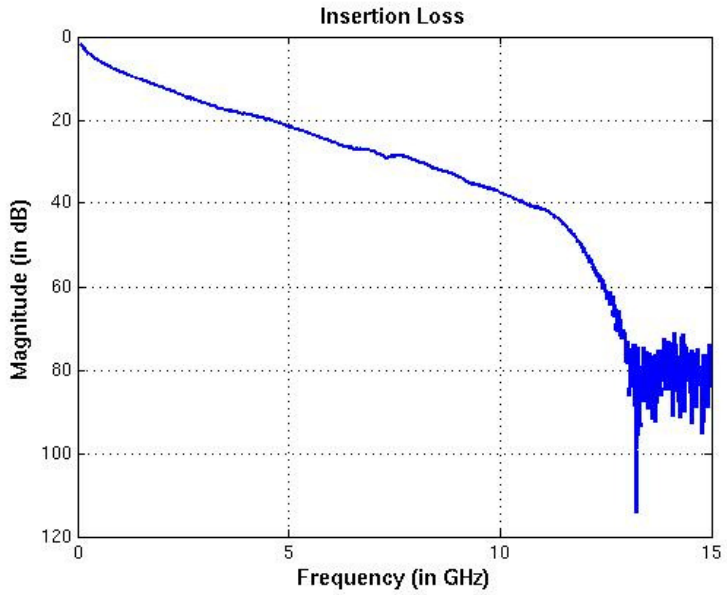


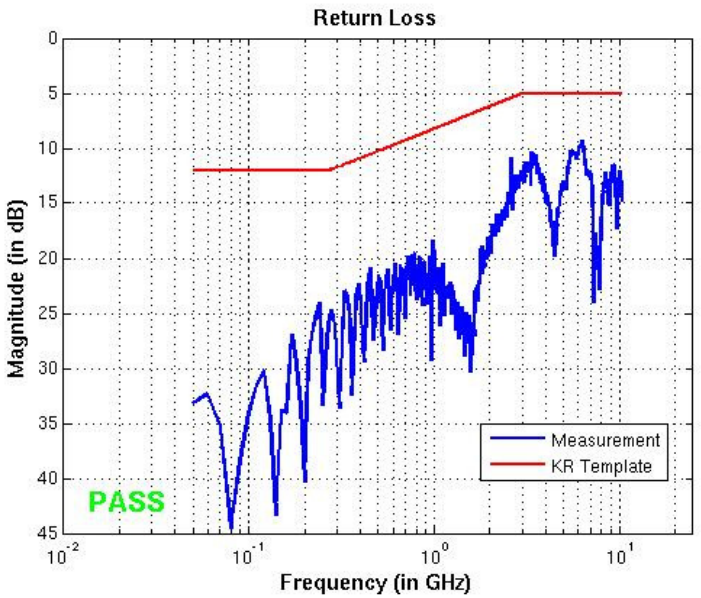
Simulation Setup

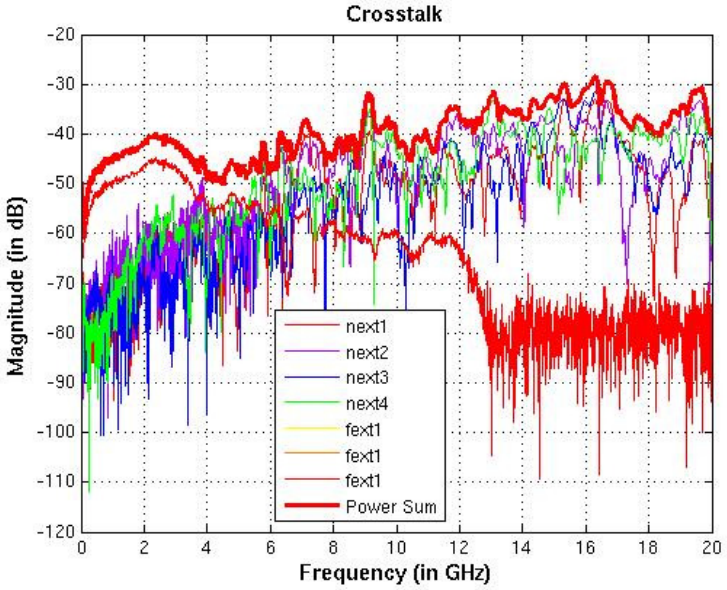
- **Insertion Loss, Return Loss, Crosstalk per data from Chris DiMinico**
- **Package models based on measured data**
- **Receiver architecture same as that used in KR group (802.3ap)**
- **MATLAB simulations**
  - **Pulse Response "Frequency-domain" Analysis, with MMSE optimization**
- **Performance evaluation based on detailed, worst-case error probabilities (not simple Gaussian assumption)**
- **On-chip impairments included**
  - **Clock jitter, Offsets, Front-end noise, Detailed analog circuit models, Detailed equalizer implementation penalties**
- **Worst-casing of ISI data patterns and crosstalk phase**

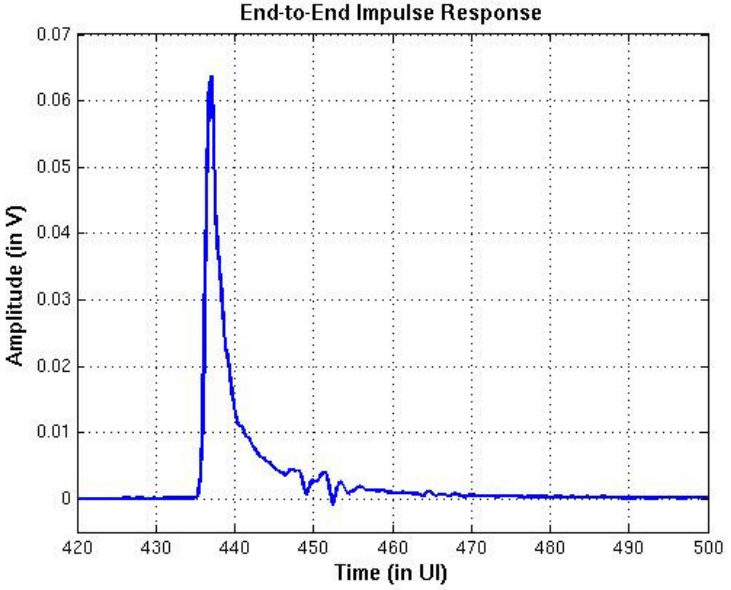
Source: Vivek Telang, Broadcom

Channel models



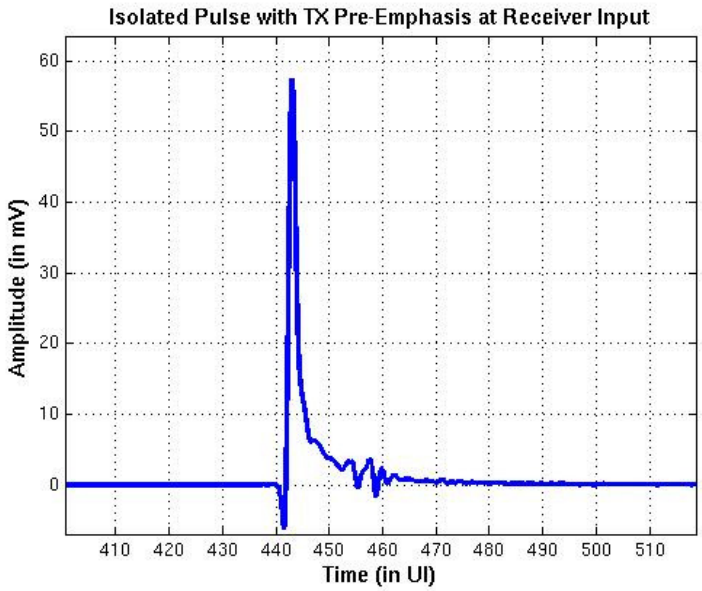




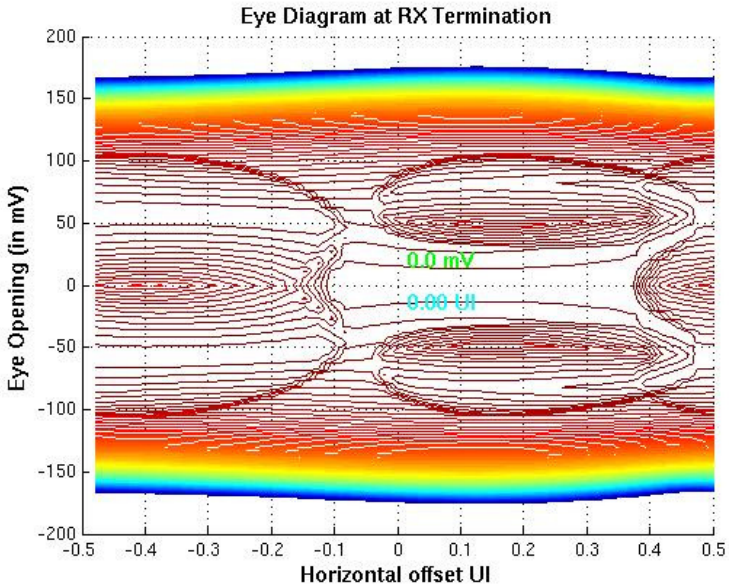


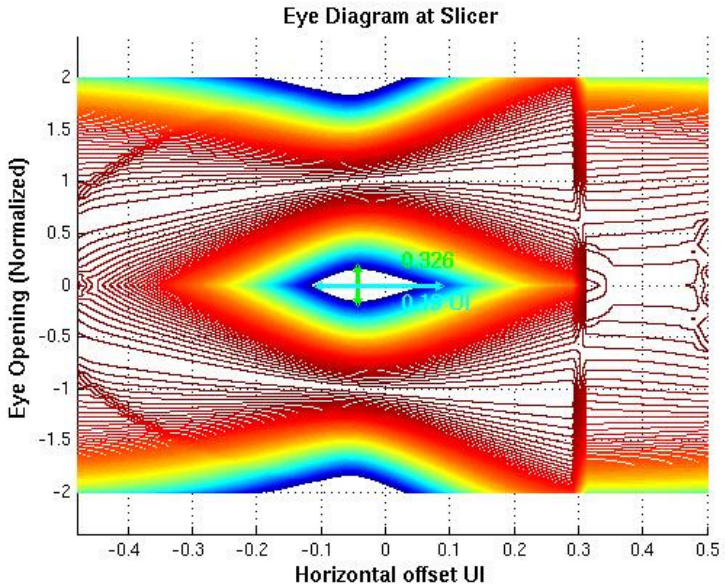
Source: Vivek Telang, Broadcom

Simulation results



Slicer SNR & BER	
SNR (dB)	BER
18.5	1.4×10^{-17}





Source: Vivek Telang, Broadcom

1000BASE-CX (short-haul copper) – MDI

39. Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-CX (short-haul copper)

Connectors meeting the requirements of 39.5.1.1 (Style-1) and 39.5.1.2 (Style-2) shall be used as the mechanical interface between the PMD of 39.3 and the jumper cable assembly of 39.4. The plug connector shall be used on the jumper cable assembly and the receptacle on the PHY. Style-1 or style-2 connectors may be used as the MDI interface. To limit possible cross-plugging with non-1000BASE-CX interfaces that make use of the Style-1 connector, it is recommended that the Style-2 connector be used as the MDI connector.

39.8.3 Major capabilities/options

39.8.4 PICS proforma tables for Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-CX (short-haul copper)

39.8.4.1 PMD functional specifications

***STY1 Style-1 MDI 39.5 Either the style-1 or the style-2**

MDI must be provided O/1 Yes [ ] No [ ]
***STY2 Style-2 MDI 39.5 O/1 Yes [ ] No [ ]**