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05-342r0: SAS-2 Adaptive Equalizer Physical Layer Feasibility



Kevin Witt, Mahbul Bari

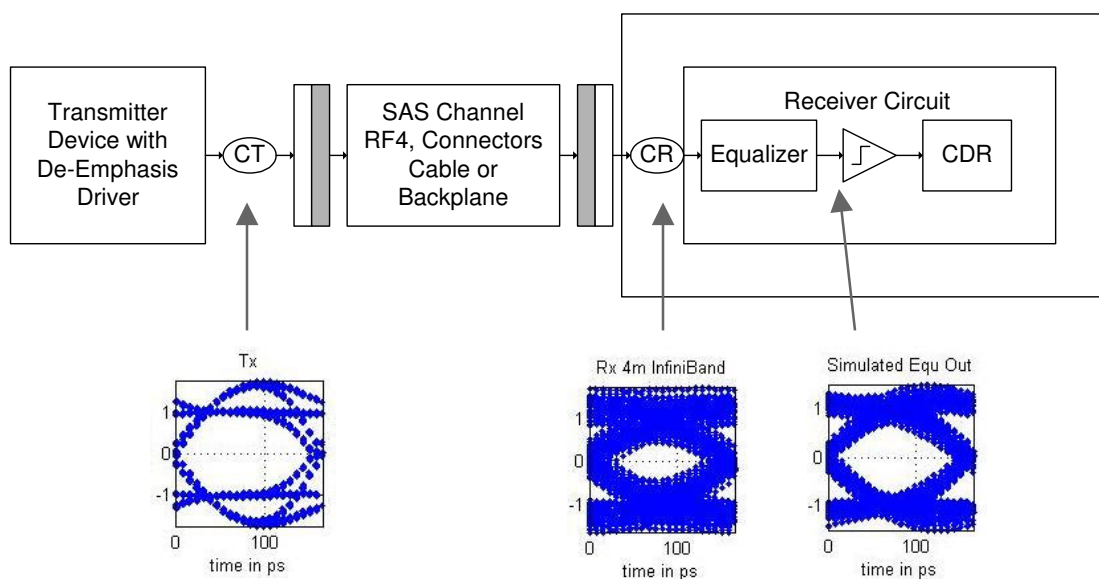
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Equalization Overview

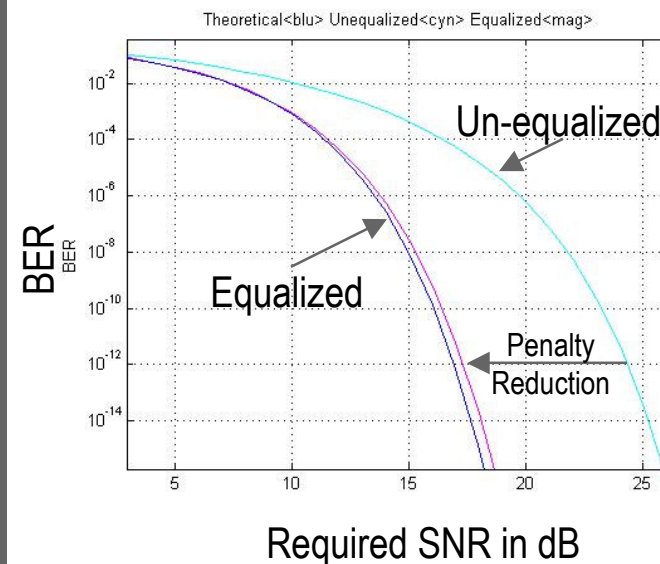
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- Equalizers enable longer reach and higher data rates over band-limited channels.
- Transmitter De-emphasis and Receive Equalization (FFE/DFE) enhance the effective link margin by reducing the inter-symbol interference (ISI) penalty.
 - Eye opening / Q-factor is enhanced
- The sensitivity and Link Margin of the link is enhanced.
 - ISI penalty is reduced

Eye Opening Enhancement



Sensitivity Plot

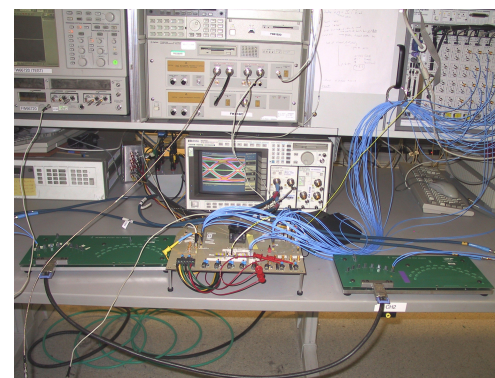


Need for Equalization in SAS-2

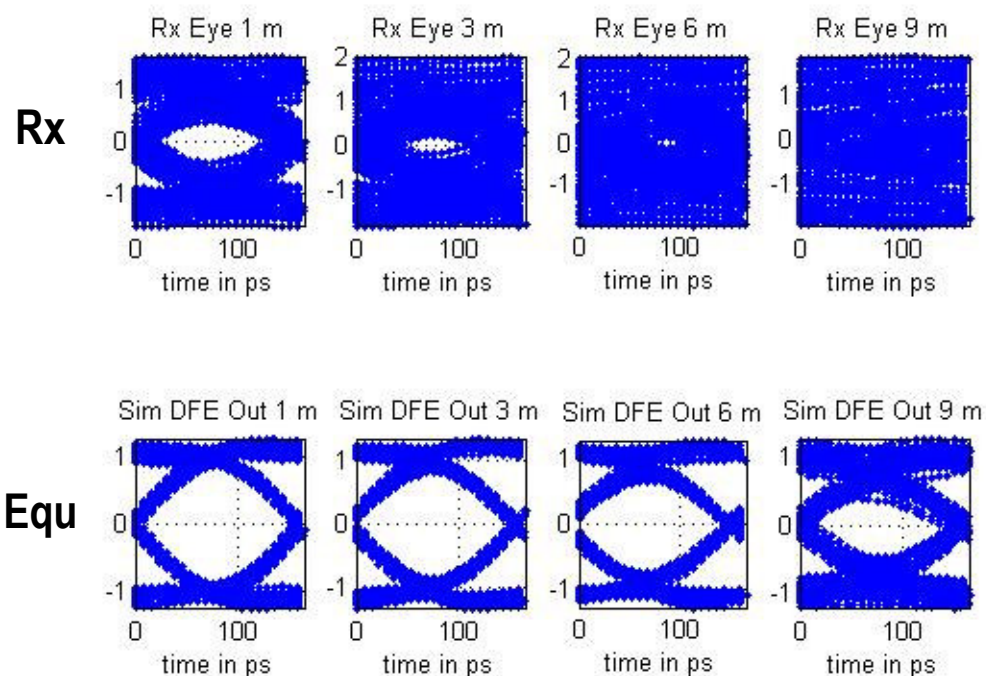
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External Infiniband Cable Example at 6Gbps

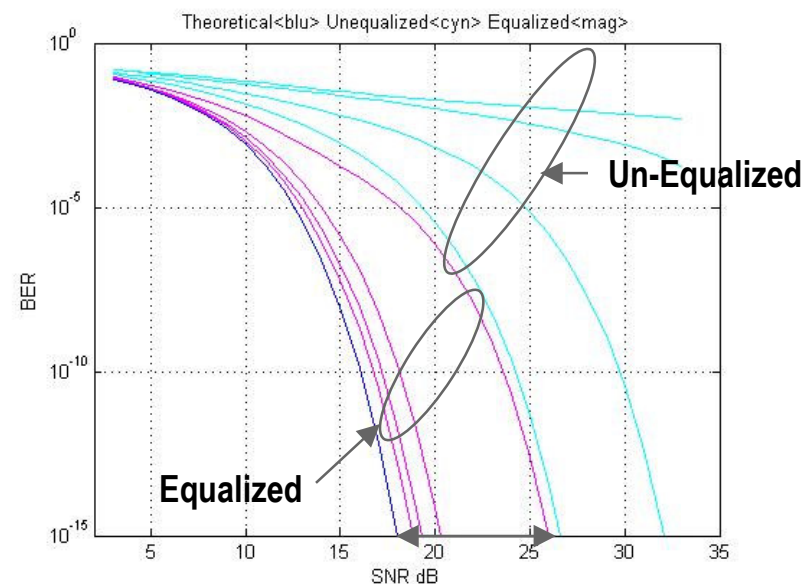
- 10 meters for Rack to Rack interconnect will require equalization with SFF8484
 - Rx eye Closed @ 6m without Tx De-emphasis
- Equalization will enable operation of these links up to 9 meters



Infiniband Eyes 1->9 meter (w/o De-Emphasis)



Infiniband Sensitivity



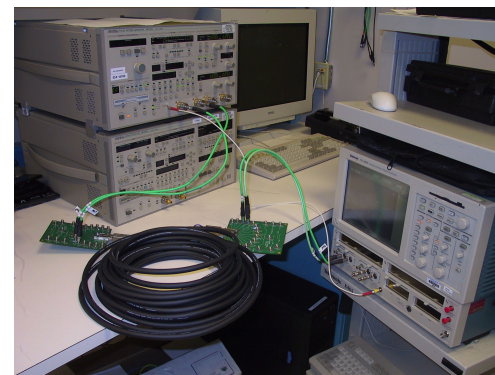
Power Penalty ~8.0 dB
@ 1e-15

Need for Equalization in SAS-2

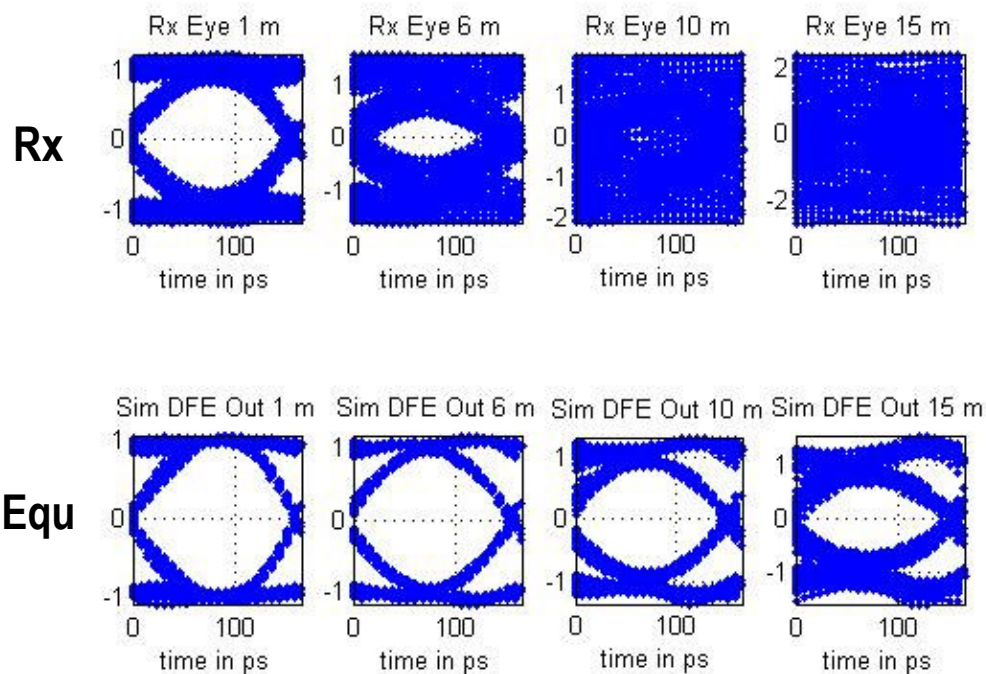
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External Molex iPASS™ Cable Example at 6Gps

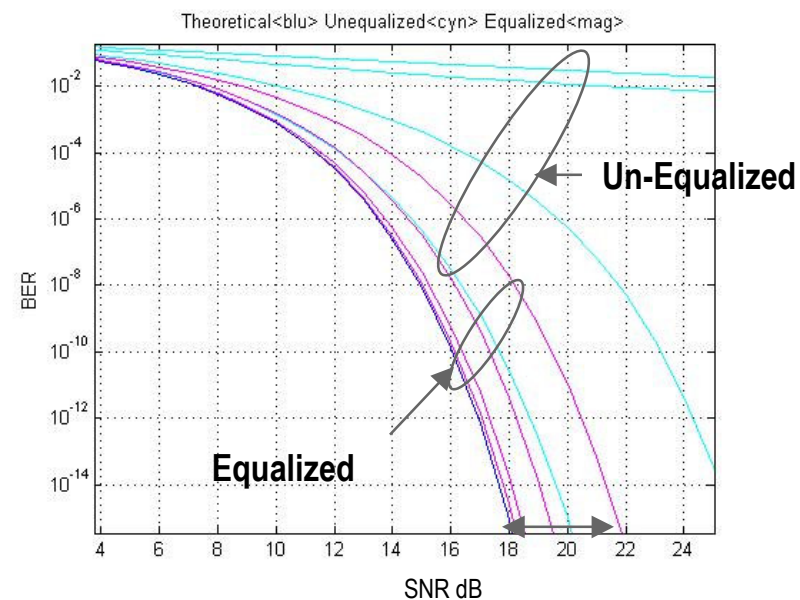
- 10 meters for Rack to Rack interconnect will require equalization with SFF8088
 - Rx eye Closed @ 10m without Tx De-emphasis
- Equalization will enable operation of these links at 10 meters with margin



iPASS™ Eyes 1->15 meter (w/o De-Emphasis)



iPASS™ Sensitivity



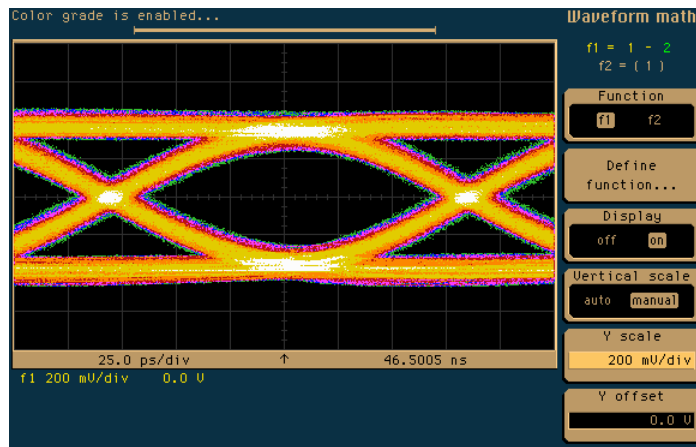
Power Penalty ~4.0 dB
@ 1e-15

iPASS™ Links with Tx De-Emphasis

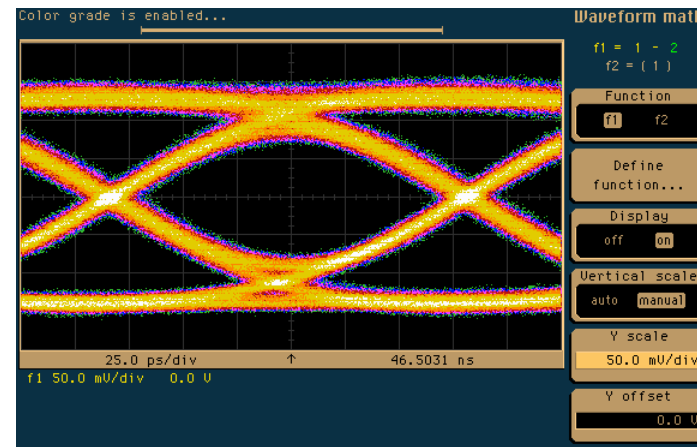
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📖 Test Results iPASS™ Cable De-Emphasis Enabled at 6Gbps

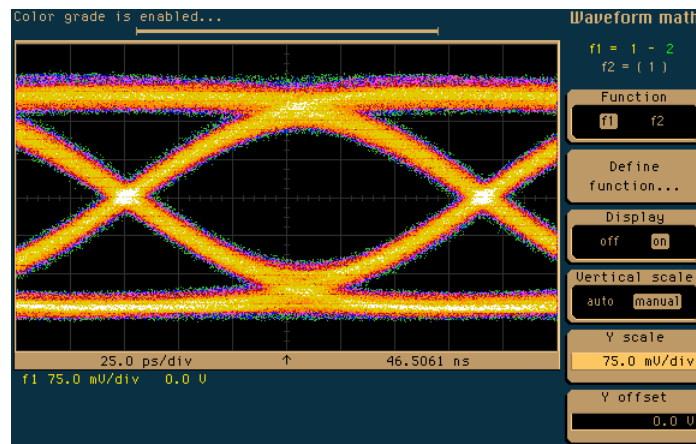
1m



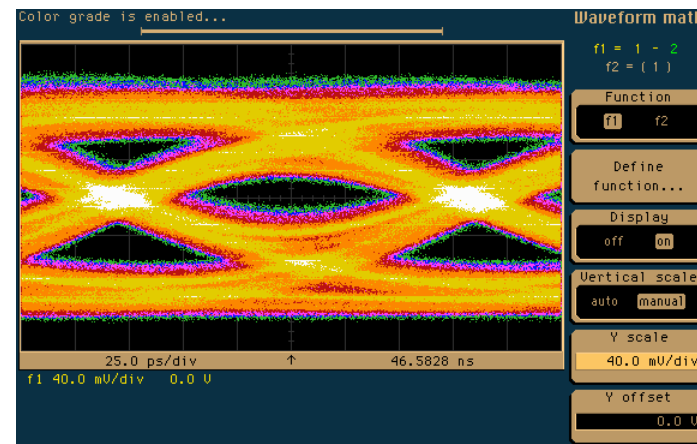
10m



6m



15m



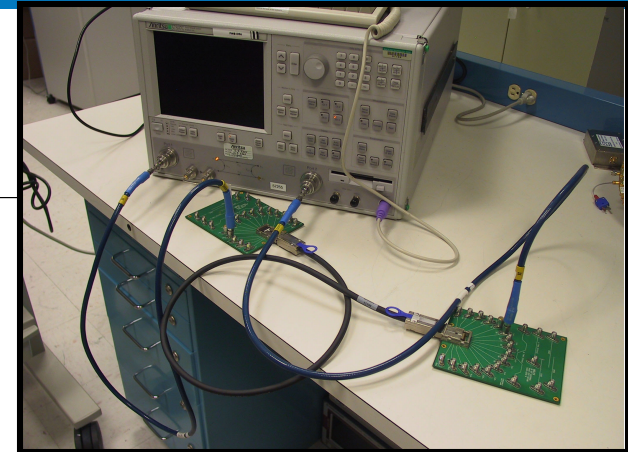
iPASS™ and Tx De-Emphasis Enable 10m Operation

Insertion Loss of Infiniband and iPASS™

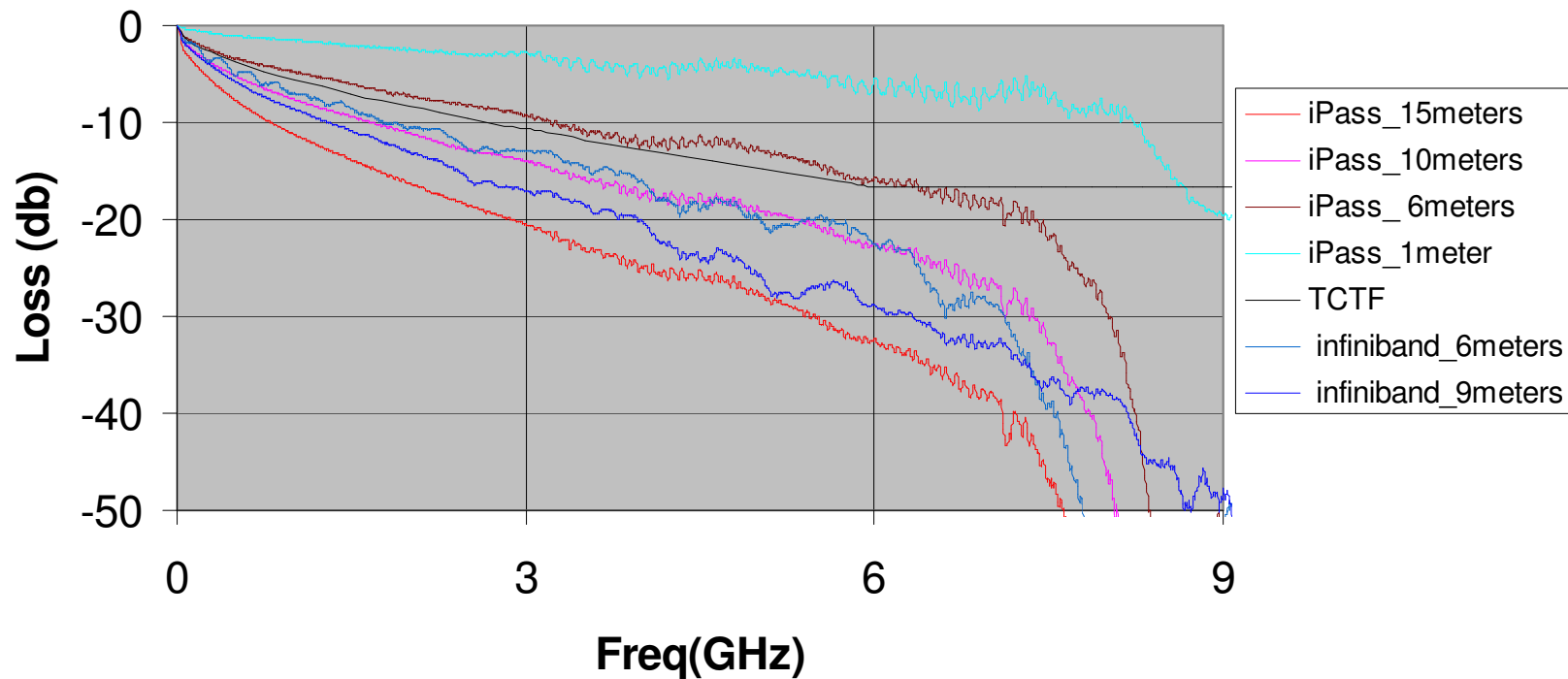
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📖 SDD21 compared to extended TCTF

- iPASS™ at 10m is comparable to Infiniband at 6m



**Insertion Loss (SDD21) for iPass cable
VS.
Infiniband Cable**

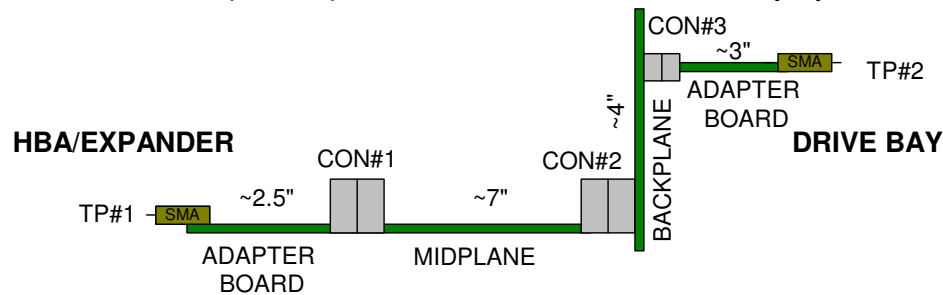


HBA/Expander to mid-plane to back-plane to drive Example

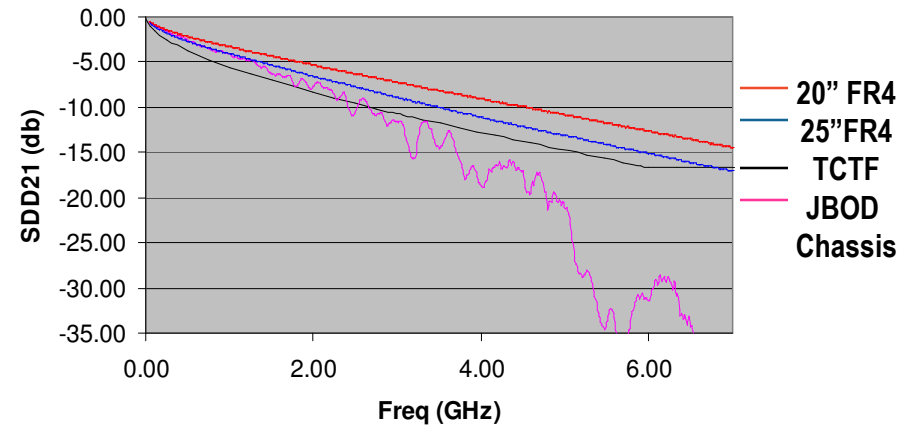
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Typical JBOD Chassis example at 6Gpbs

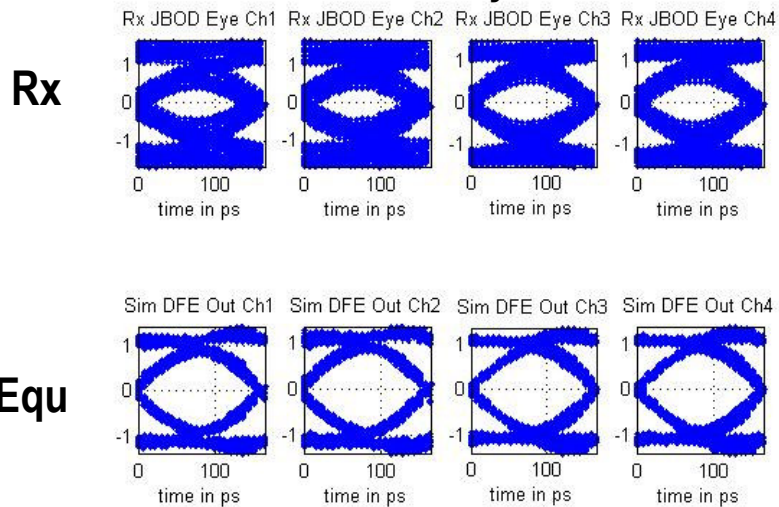
- 15->16" FR4 & 3 Connectors (< 1m target)
- Equalization may be needed to mitigate ISI with existing designs.
- Adaptive equalization reduces Power Penalty by > 6dB



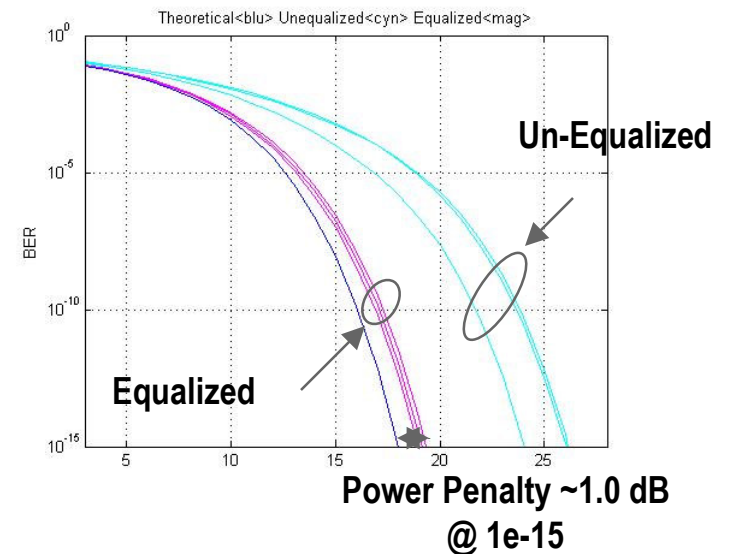
Loss Characteristics of various boards



JBOD Eyes



JBOD Sensitivity



Benefits and Feasibility of Adaptive Equalizers for SAS-2

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Adaptive Equalization Enables New Capabilities

- Longer reach over existing cables technology at 6 and 3 Gbps.
- Reduced EMI/RFI since launch amplitudes may be reduced.
- Improved interoperability.
- Reduction in manual parameter settings.
- Post Equalizer eye opening measurement (Q-Monitor) for link margin assessment.

Feasibility of Adaptive Equalization for SAS-2

- Vitesse and other IC vendors have implemented adaptive equalized for 3, 6, 8 and 10Gbps NRZ systems (see May 6G kick off meeting minutes and slides)
- Power and Area Estimates indicate 36 port SAS-2 expander feasible
- Today's IC Foundry process are adequate
 - (0.13um , 0.09um CMOS, 0.25um, .13um SiGe)

Summary

- Tx / Rx equalization reduces ISI penalty.
- Adaptive equalizer are included in other Multi-Gbps standards (OIF and IEEE).
- Equalizers are available in today's IC technology and have been demonstrated by multiple IC vendors.
- Equalization will be required for SAS-2 External Links at 10 meters.
 - iPASS™ superior to InfiniBand for 6Gbps links.
 - External links of 10m can be supported with Tx De-Emphasis or Rx equalization
 - External links of 15m may be feasible with Tx De-Emphasis & Rx equalization
- Equalization will most likely be required for SAS-2 Internal connections.
 - HBA/Expander-midplane-backplane-drive bay.