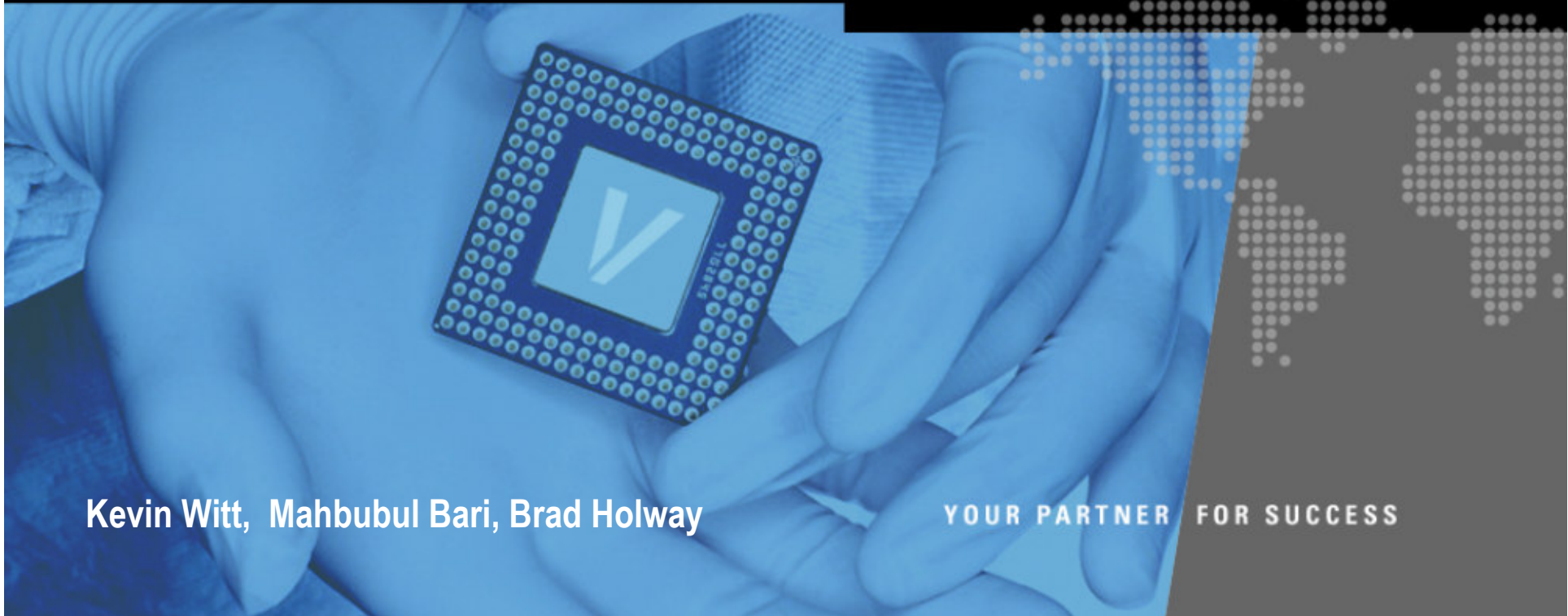# VITESSE

05-341r0: Updated Test and Simulation Results in Support of SAS-2

Kevin Witt, Mahbubul Bari, Brad Holway

YOUR PARTNER FOR SUCCESS

Equalization Overview

- 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 enhance

- The sensitivity and Link Margin of the link is enhanced.
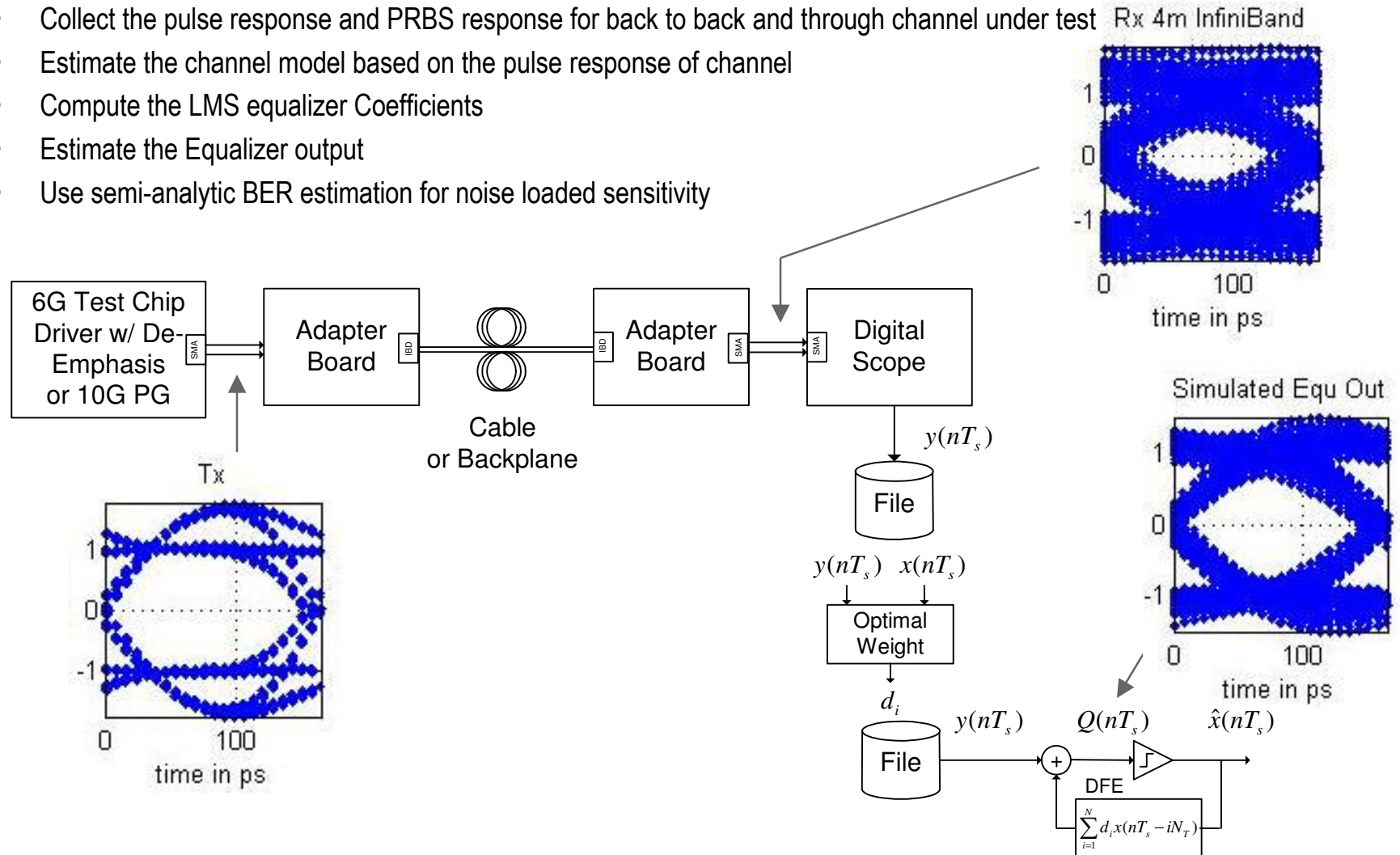 - ISI penalty is reduced

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Eye Opening Enhancement

Sensitivity Plot

Equalization Simulation Methodology
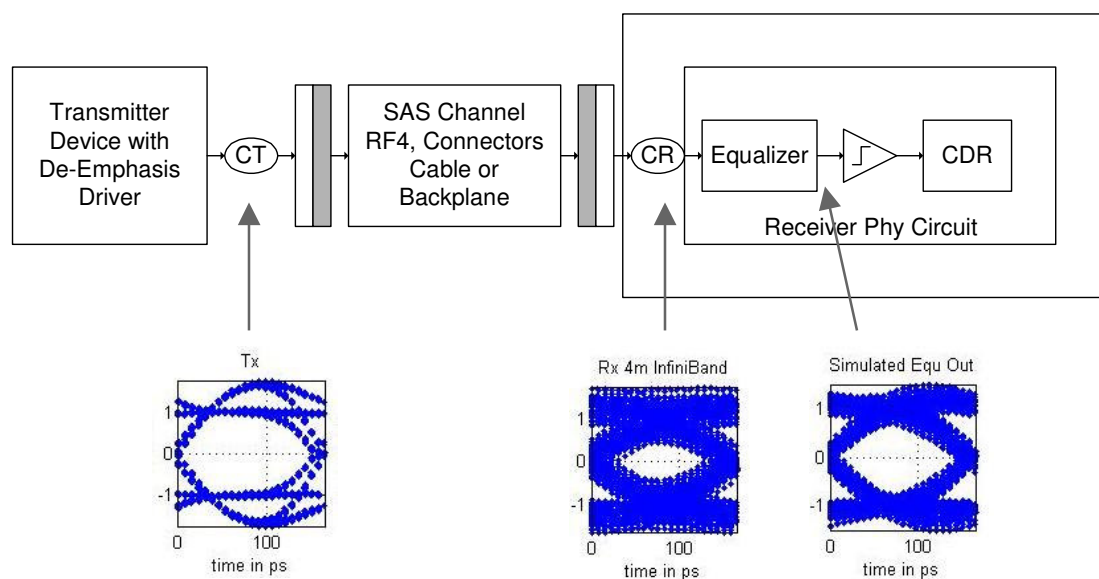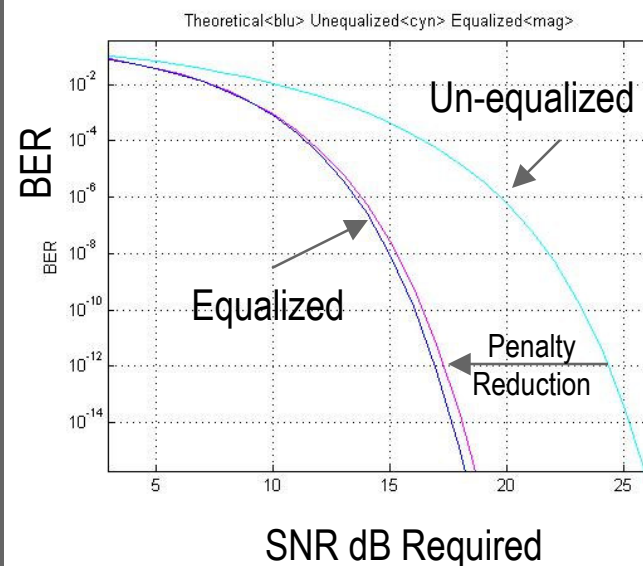
DFE Simulation Methodology

- Collect the pulse response and PRBS response for back to back and through channel under test
- Estimate the channel model based on the pulse response of channel
- Compute the LMS equalizer Coefficients
- Estimate the Equalizer output
- Use semi-analytic BER estimation for noise loaded sensitivity

Rx 4m InfiniBand

| 6G Test Chip Driver w/ De-Emphasis or 10G PG | → SMA | Adapter Board | IBD | Cable or Backplane | IBD | Adapter Board | SMA → SMA | Digital Scope |

Tx

$y(nT_s)$

File

$y(nT_s)$ $x(nT_s)$

Optimal Weight

d_i

File

$y(nT_s)$ $Q(nT_s)$ $\hat{x}(nT_s)$

$+$ ⊳ DFE

$$\sum_{i=1}^{N} d_i x(nT_s - iN_T)$$
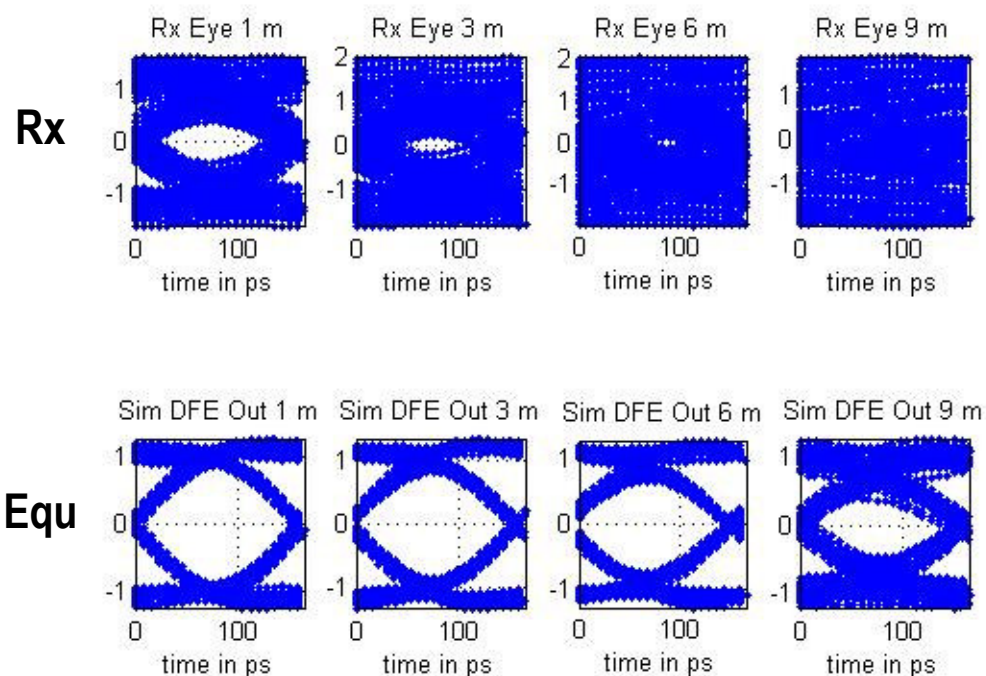
Simulated Equ Out

Need for Equalization in SAS-2

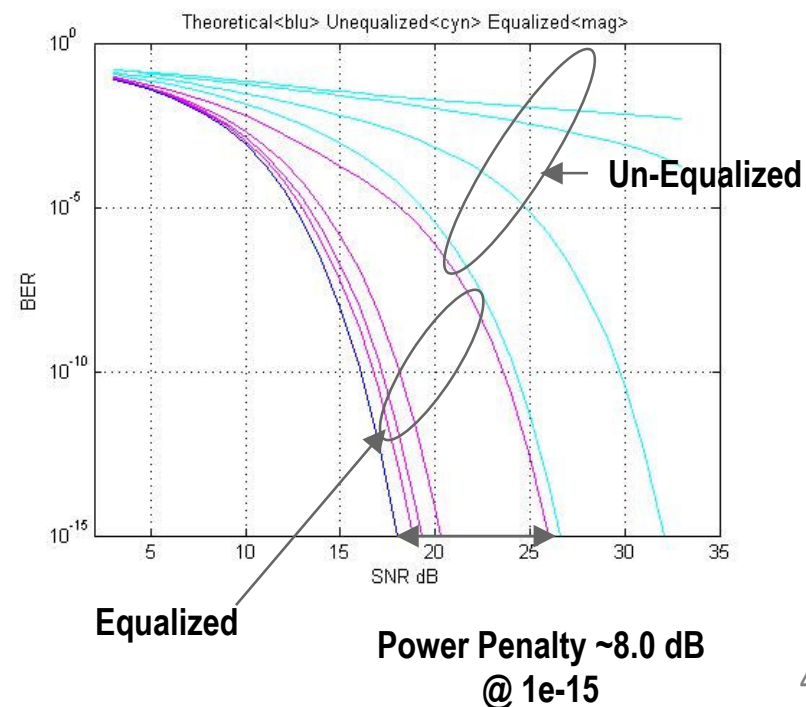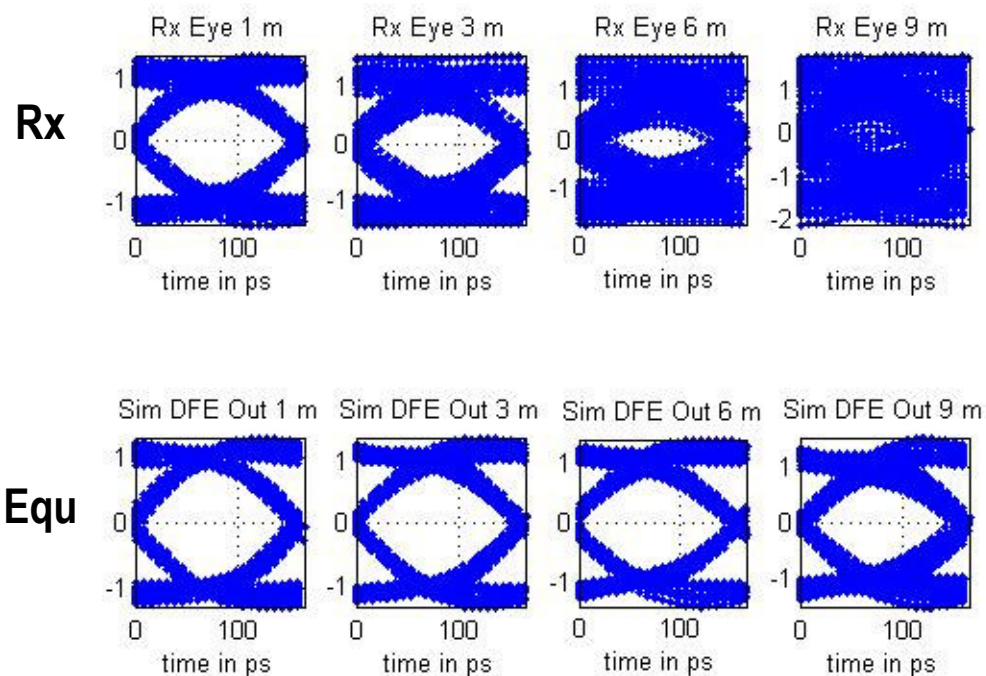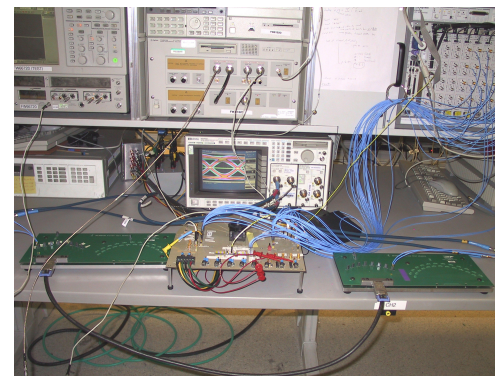External Infiniband Cable Example at 6Gbps

- 10 meters for Rack to Rack interconnect will require equalization with SFF8484
  - Closed Rx eye @ 6m without Tx De-emphasis
- Equalization will enable operation of these links up to 9 meters
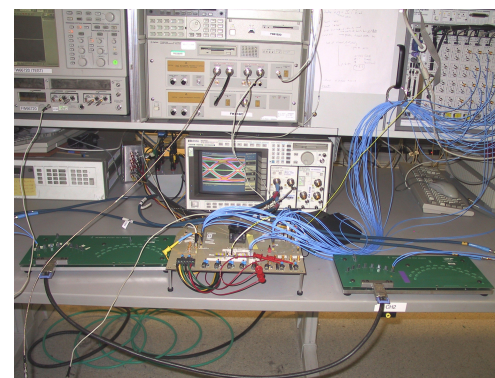
Infiniband Eyes 1->9 meter (w/o De-Emphasis)

Rx

Equ

Infiniband Sensitivity

Un-Equalized

Equalized

**Power Penalty ~8.0 dB
@ 1e-15**

4

Need for Equalization in SAS-2

- External Infiniband Cable Example at 6Gbps
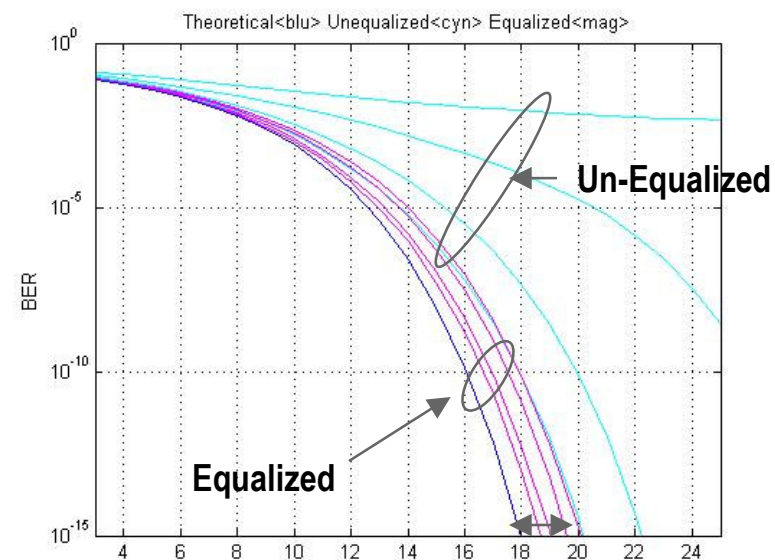
  - 10 meters for Rack to Rack interconnect will require equalization with SFF8484

    - Closed Rx eye @ 9m with Tx De-emphasis

  - Tx De-Emphasis reduces the power penalty

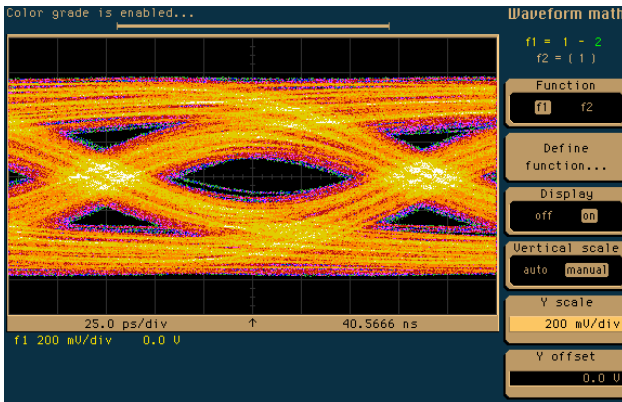**Infiniband Eyes 1->9 meter (w/ De-Emphasis)**

Infiniband Sensitivity

Rx

Equ

Theoretical<blu> Unequalized<cyn> Equalized<mag>

Un-Equalized

Equalized

Power Penalty ~2.0 dB @ 1e-15

Infiniband Links without Tx De-Emphasis

VITESSE
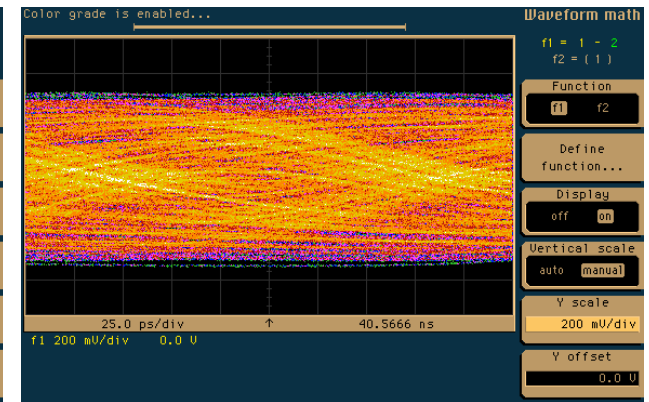
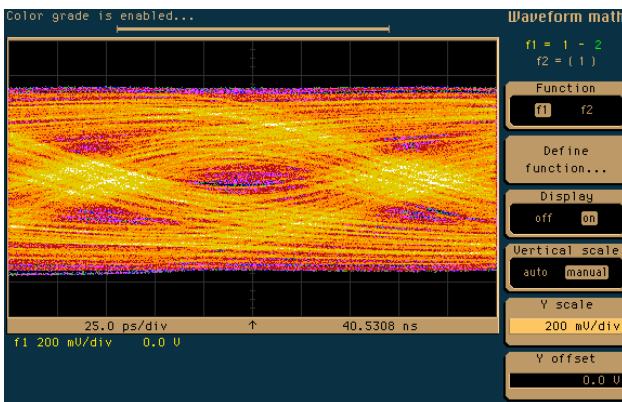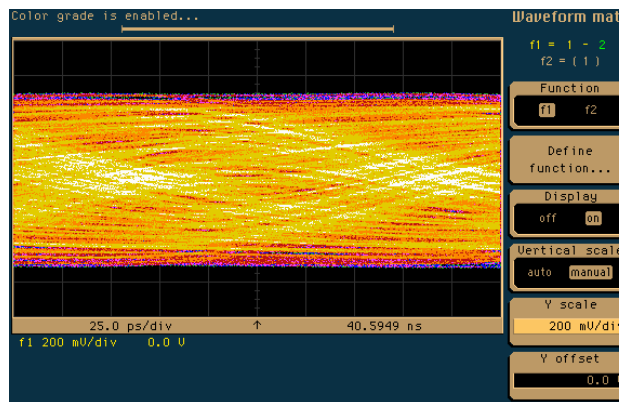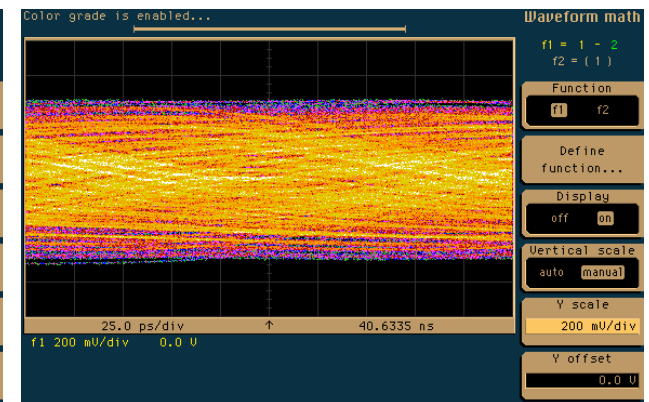Test Results InfiniBand Cable De-Emphasis Disabled (6Gbps)
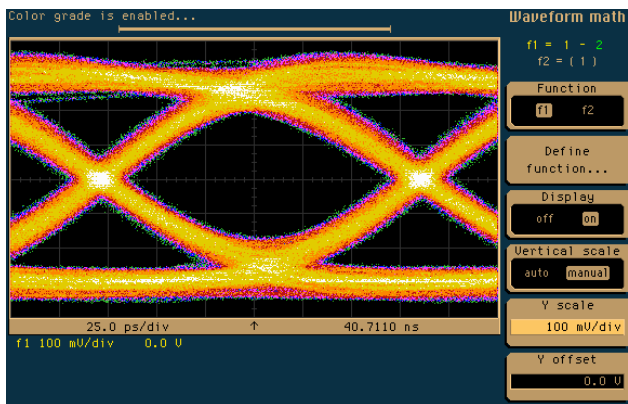
1m

4m
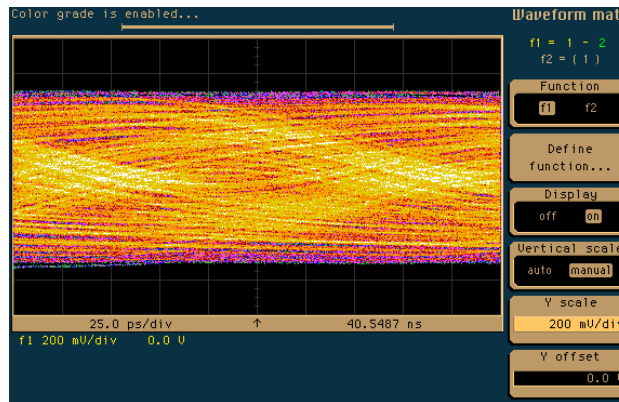
7m

3m

6m

9m

Signal integrity issues at 6G are more interesting
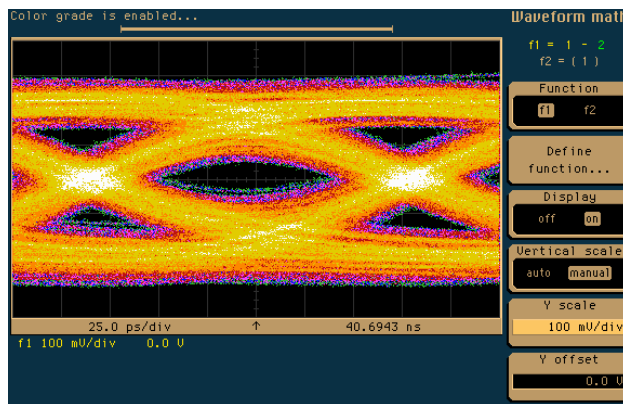
Infiniband Links with Tx De-Emphasis

VITESSE

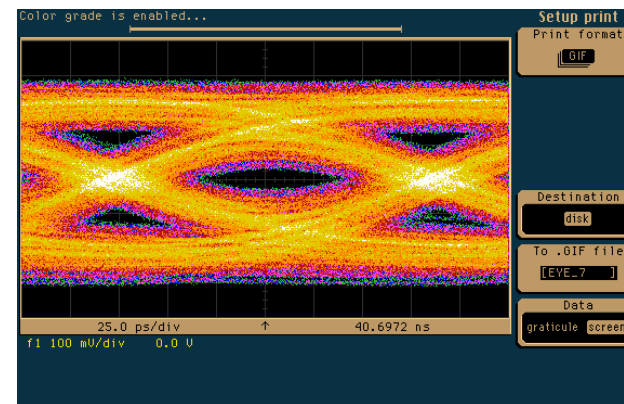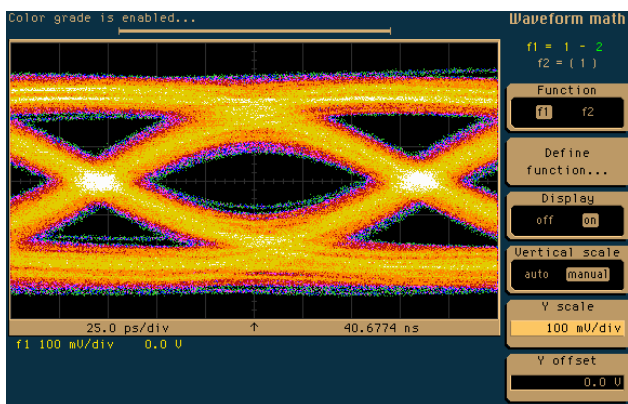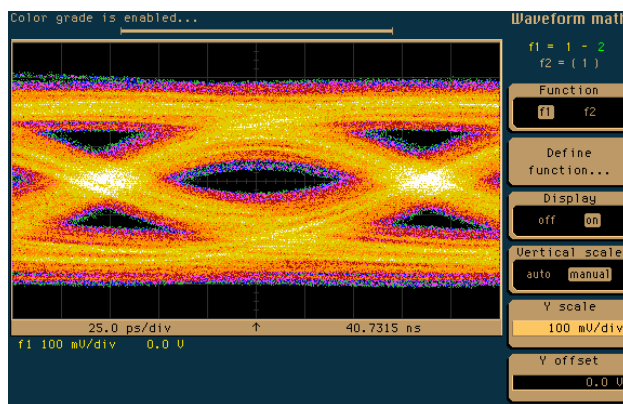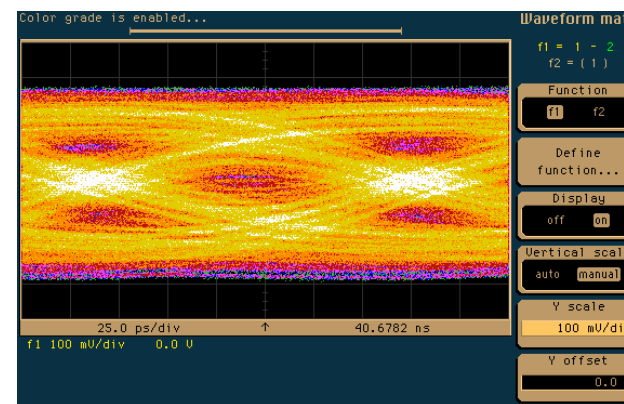Test Results InfiniBand Cable De-Emphasis (1:0.5) Enabled (6Gbps)
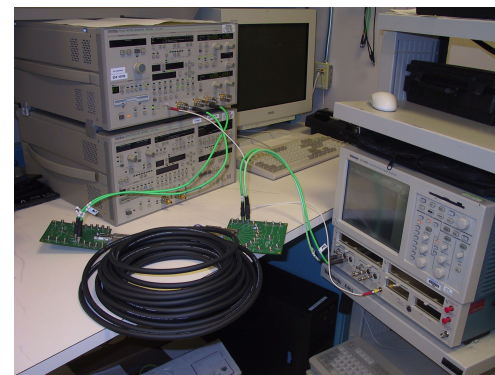
1m

4m

7m

3m

6m

9m

Tx De-Emphasis only is not enough!

Need for Equalization in SAS-2

- External Molex iPASS™ Cable Example at 6Gbps
  - 10 meters for Rack to Rack interconnect will require equalization with SFF8088
    - Closed Rx eye @ 10m without Tx De-emphasis
  - Equalization will enable operation of these links at 10 meters with margin

iPASS™ Eyes 1->15 meter (10G PG w/o De-Emphasis)

Rx

Equ

iPASS™ Sensitivity

Theoretical<blu> Unequalized<cyn> Equalized<mag>

Un-Equalized

Equalized

Power Penalty ~4.0 dB @ 1e-15
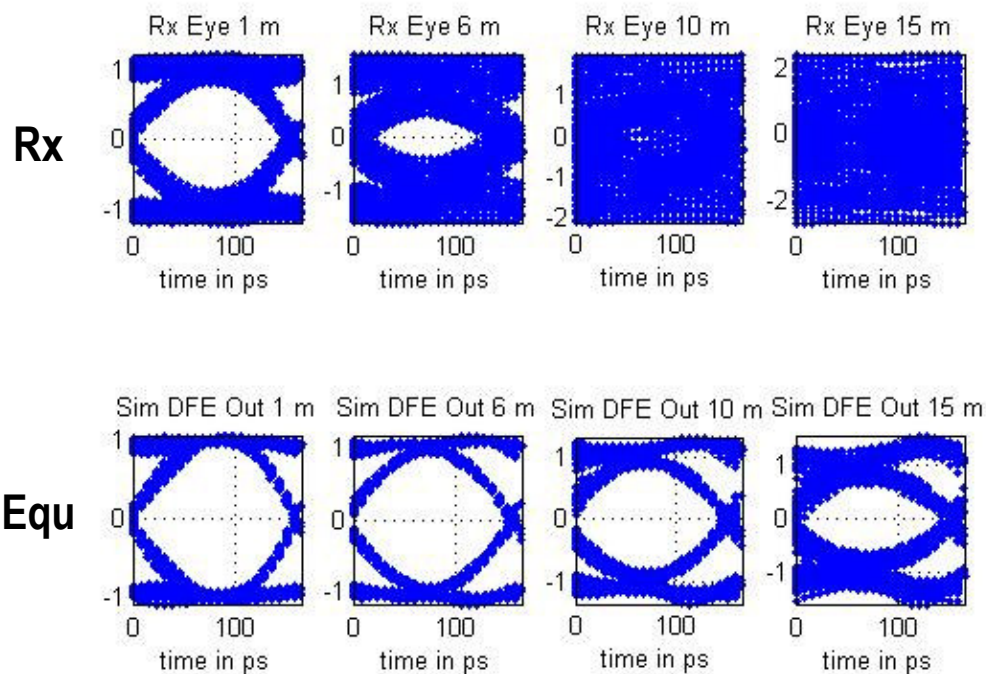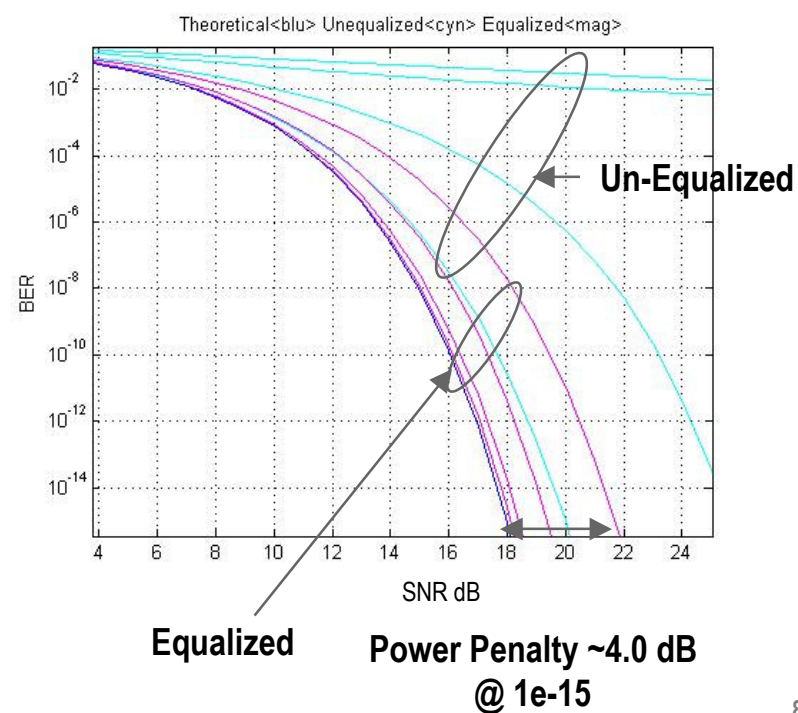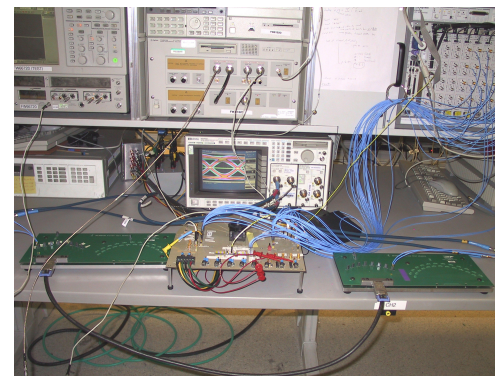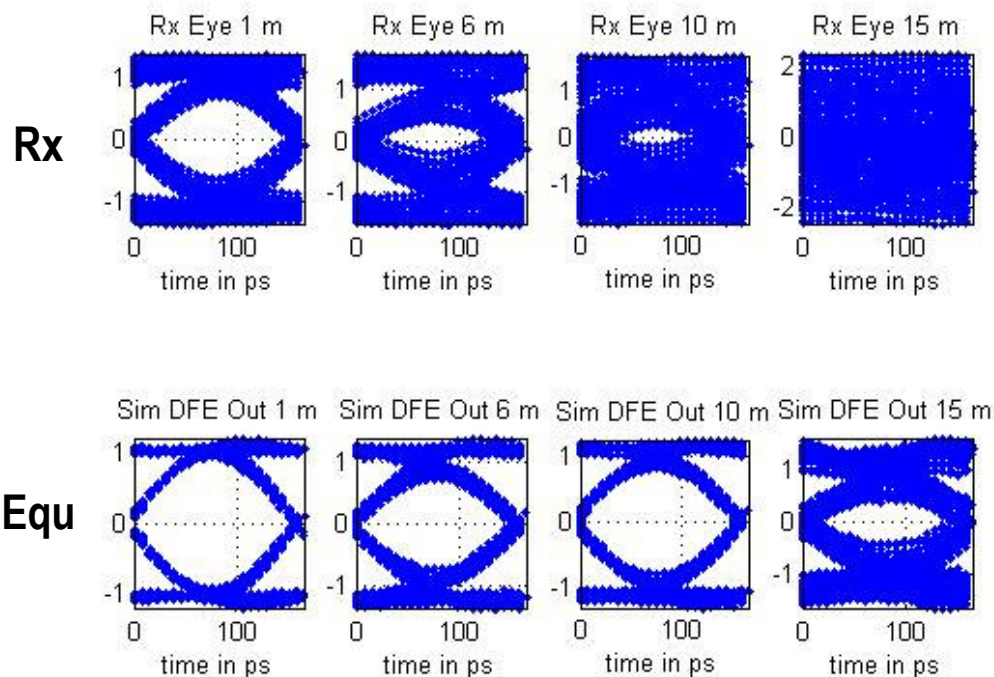
8

Need for Equalization in SAS-2

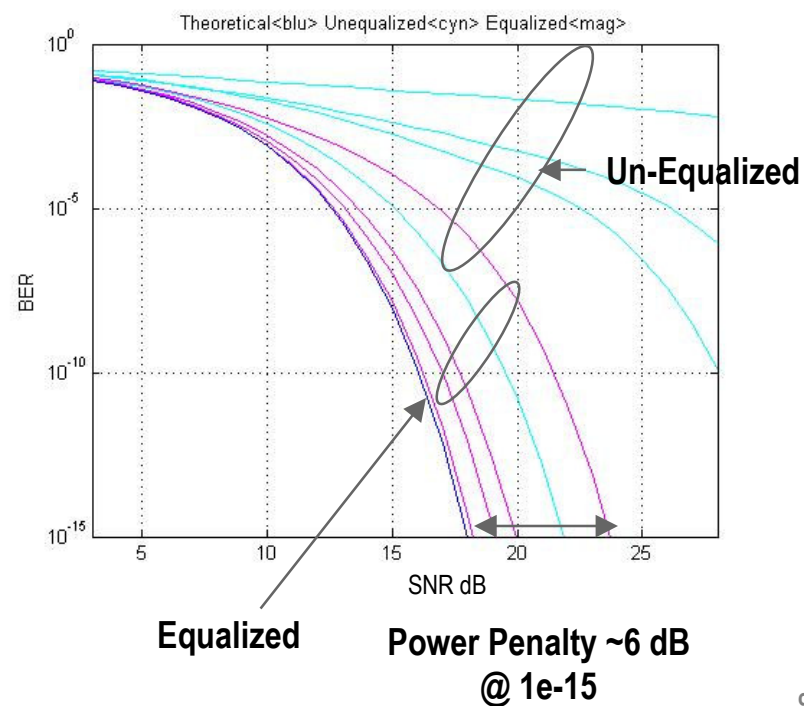External Molex iPASS™ Cable Example at 6Gbps

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

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

Rx

Rx Eye 1 m | Rx Eye 6 m | Rx Eye 10 m | Rx Eye 15 m

Equ

Sim DFE Out 1 m | Sim DFE Out 6 m | Sim DFE Out 10 m | Sim DFE Out 15 m

iPASS™ Sensitivity

Theoretical<blu> Unequalized<cyn> Equalized<mag>

Un-Equalized

Equalized

Power Penalty ~6 dB @ 1e-15

9

- External Molex iPASS™ Cable Example at 6Gbps

    - 10 meters for Rack to Rack interconnect will required equalization with SFF8088

        - Open Rx eye @ 10m with Tx De-emphasis

    - Equalization with De-emphasis will enable operation of these links at 15 meters with margin
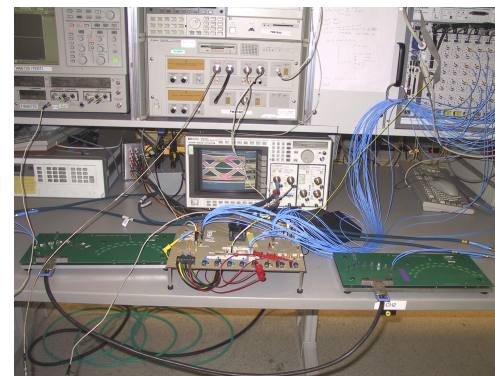
iPASS™ Eyes 1->15 meter (Test Chip w/ De-Emphasis)

iPASS™ Sensitivity

Un-Equalized

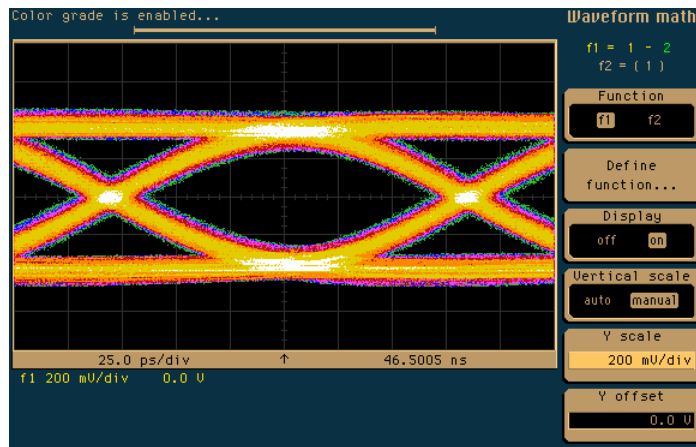Equalized

Power Penalty 2 dB @ 1e-15
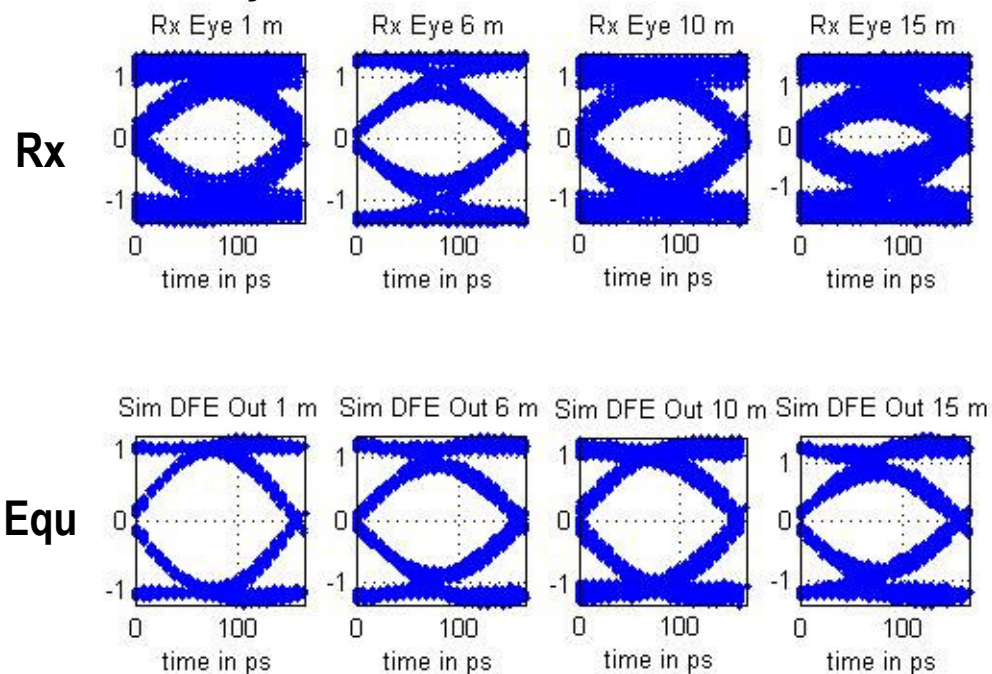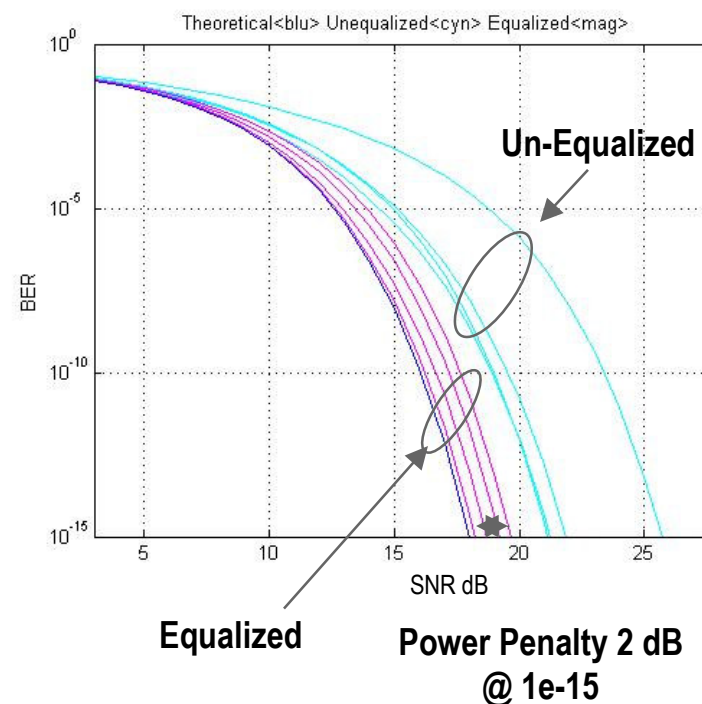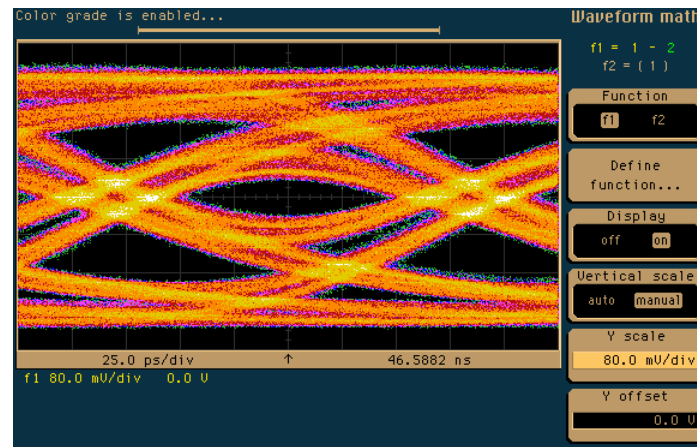
iPASS™ Links without Tx De-Emphasis

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Test Results iPASS™ Cable De-Emphasis Disabled (6Gbps)
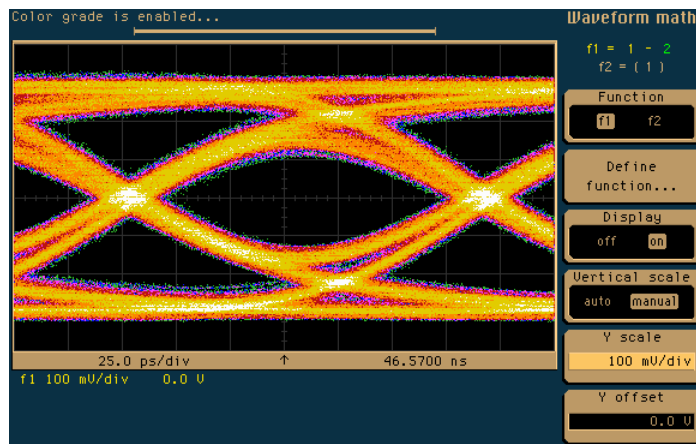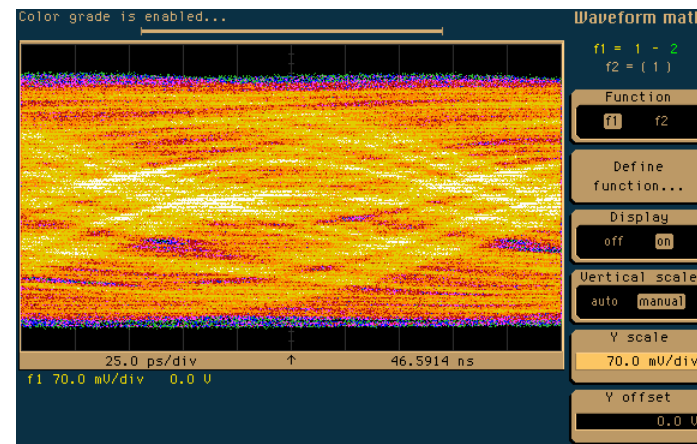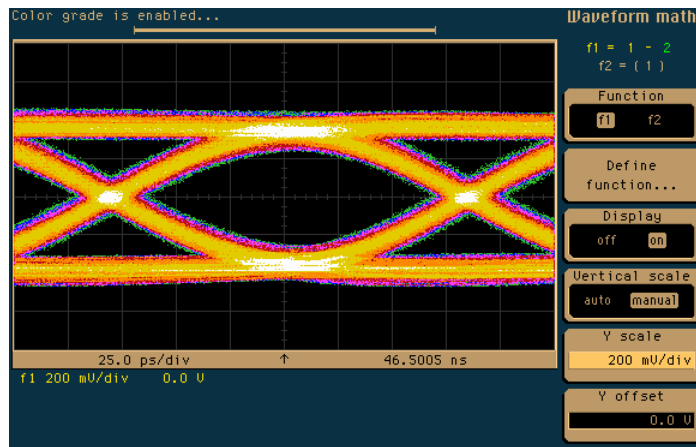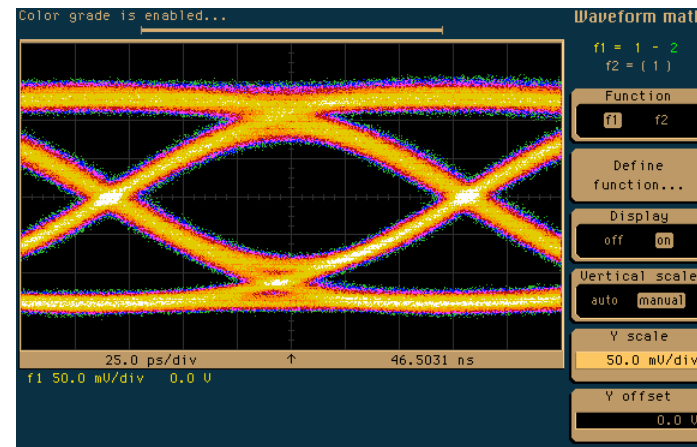
1m

10m

6m

15m

Signal integrity issues improved with iPASS™ Cables compared to InfiniBand

iPASS™ Links with Tx De-Emphasis
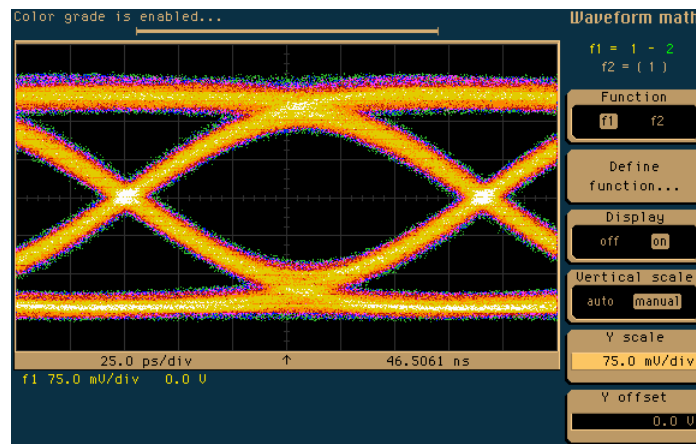
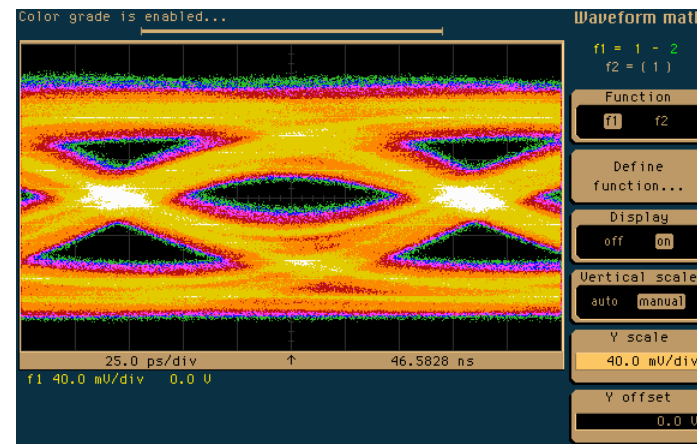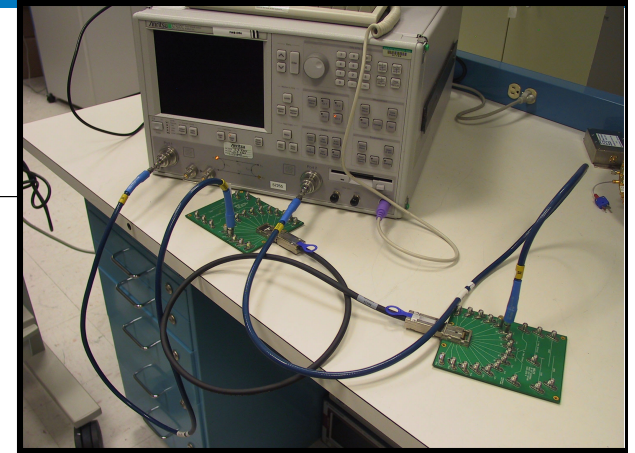- Test Results iPASS™ Cable De-Emphasis Enabled (6Gbps)

iPASS™ and Tx De-Emphasis Enable 10m Operation

Insertion Loss of Infiniband and iPASS^TM

SDD21 compared to extended TCTF

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

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

Legend:
- iPass_15meters
- iPass_10meters
- iPass_ 6meters
- iPass_1meter
- TCTF
- infiniband_6meters
- infiniband_9meters

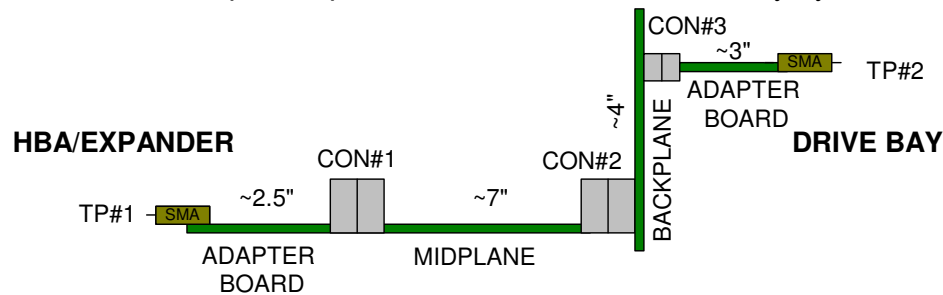x-axis: Freq(GHz)
y-axis: Loss (db)

13
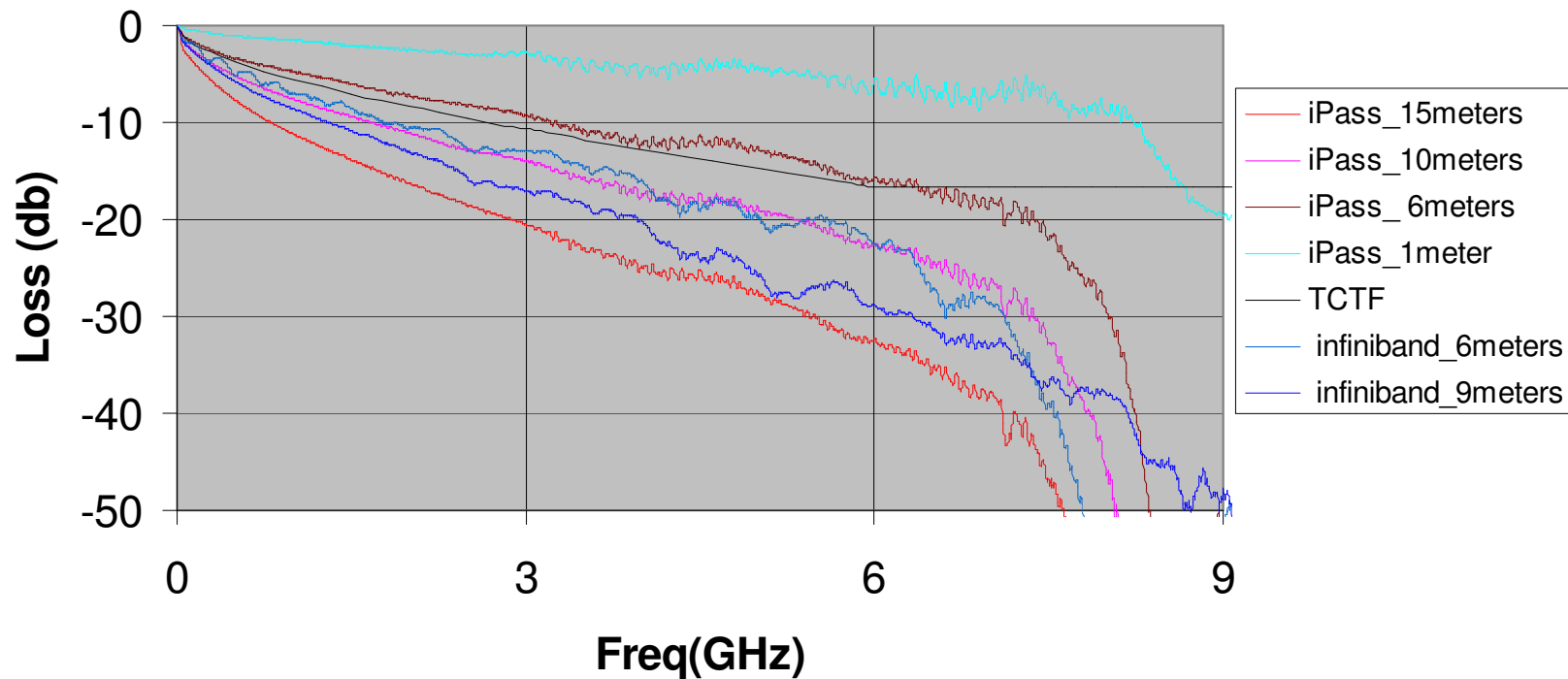
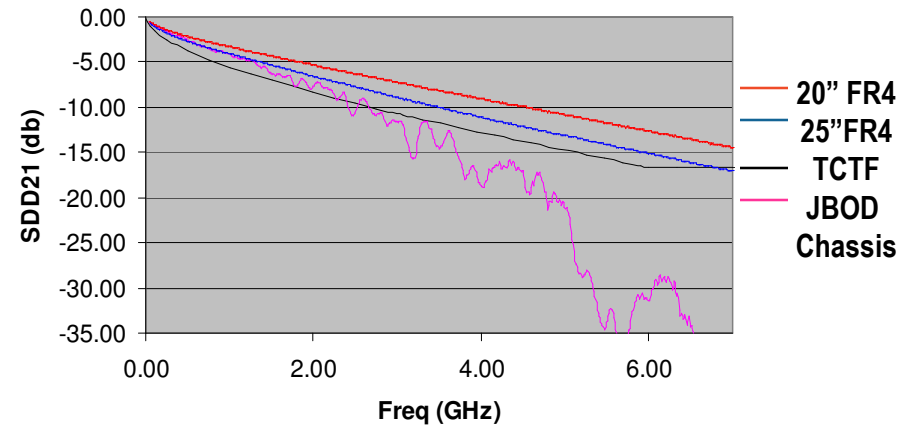# HBA/Expander to mid-plane to back-plane to drive Example

VITESSE
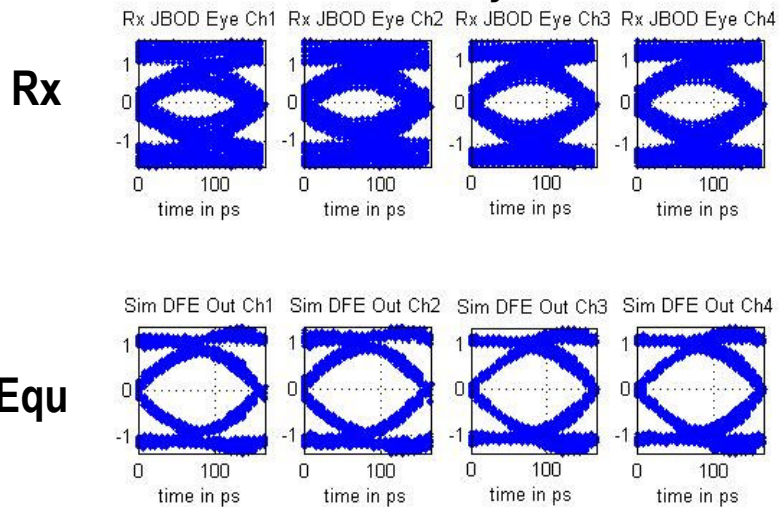
🐚 Typical JBOD Chassis example at 6Gpbs

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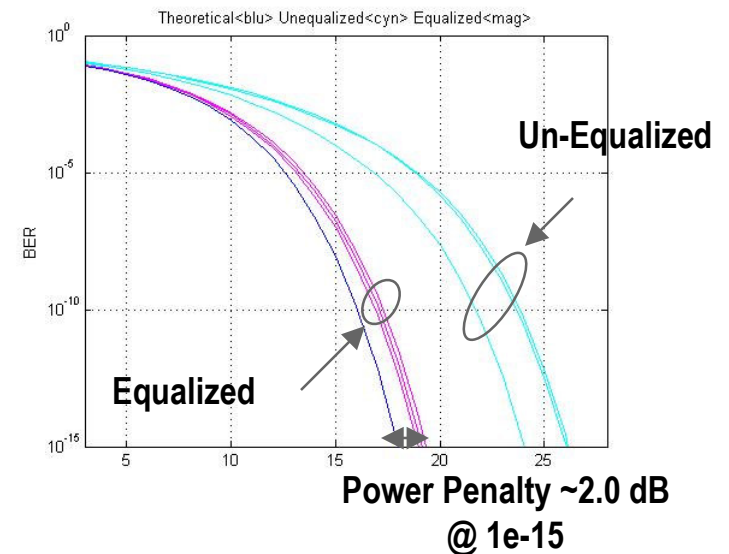- Adaptive equalization reduces Power Penalty by > 6dB

Loss Characteristics of various boards

JBOD Eyes

Rx

Equ

JBOD Sensitivity

Power Penalty ~2.0 dB @ 1e-15

Feasibility of Adaptive Equalizers for SAS-2

VITESSE

Summary

- Tx / Rx equalization reduces ISI penalty in SAS-2 Links

- Equalization will be required for SAS-2 External Links at 10 meters.

  - iPASS^{TM} superior to InfiniBand for 6 Gpbs 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

- Tx Pre-Emphasis and/or Rx Equalization will be required for SAS-2

  - External Links at 10 meters

  - Internal HBA/Expander-Midplane-backplane-drive