

Backplane Ethernet Study Group

Technical Feasibility 10GE serial per backplane pair across 40" average
grade FR4 and connectors

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Outline

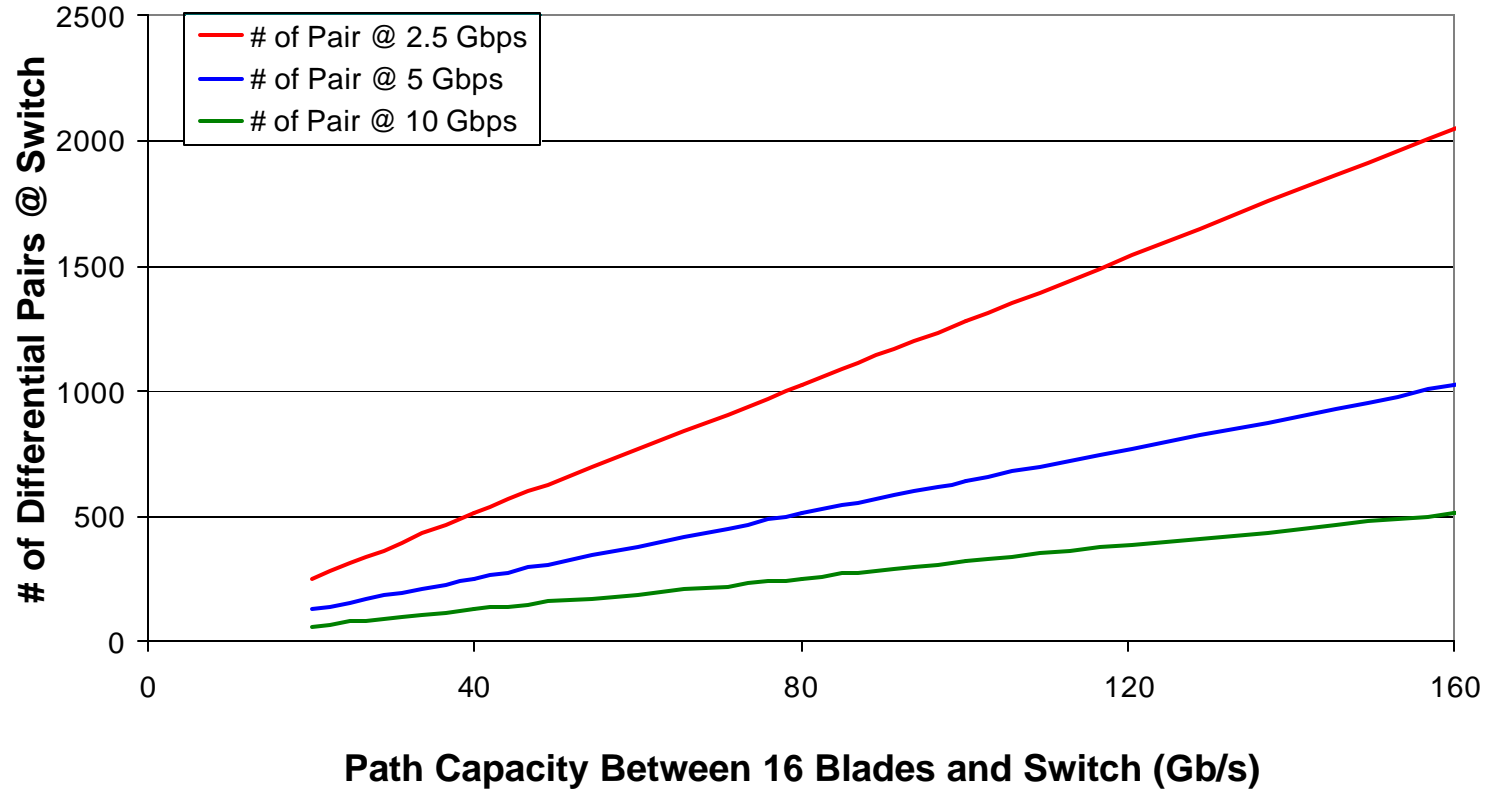
- Benefits of 10G serial per backplane pair
- Brief multilevel signaling (MLS) overview
- 10G serial MLS simulation results
- 10G serial MLS measured results, two implementations
- Applicability to 5 criteria
- Summary

Why 10G serial per backplane pair ?

- 10G per pair means fewer pairs and enables higher capacities
- Line rate 10GE traffic more straightforward for system architecture
- Operates with the standard 10GE MAC

- Cost effective 10G serial backplane pairs are critical to success
- “Cost effective” means feasible on typical backplanes with typical materials and design techniques

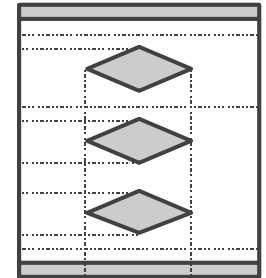
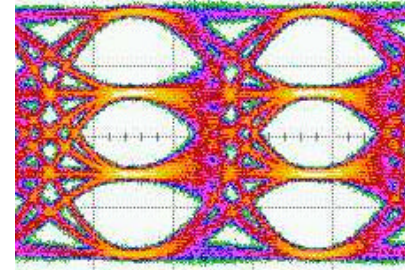
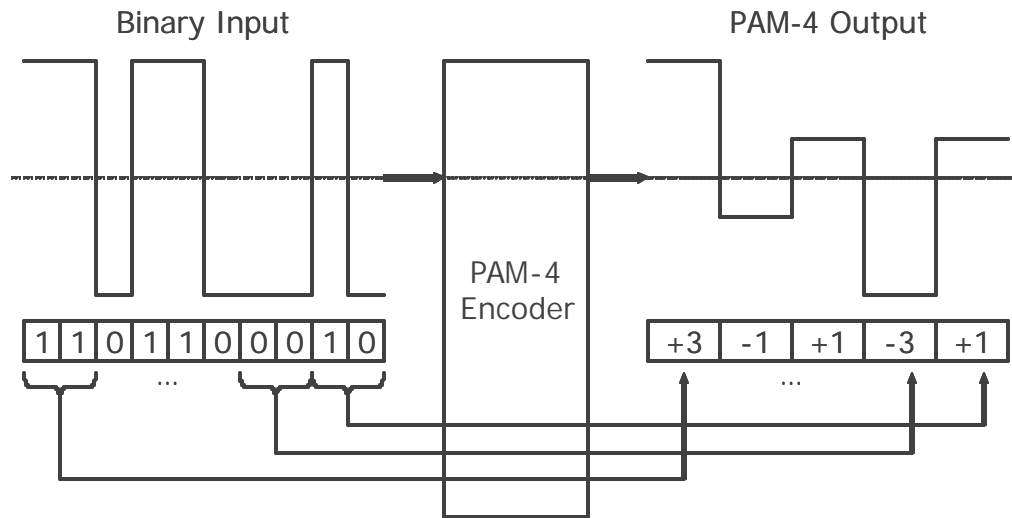
Capacity drives need for faster pairs



- Faster pairs keep backplane implementations less complex

160G to 2 switches = 4000 pair backplane (@2.5G) vs. 1000 pair backplane (@10G)

Multilevel Signaling (MLS)



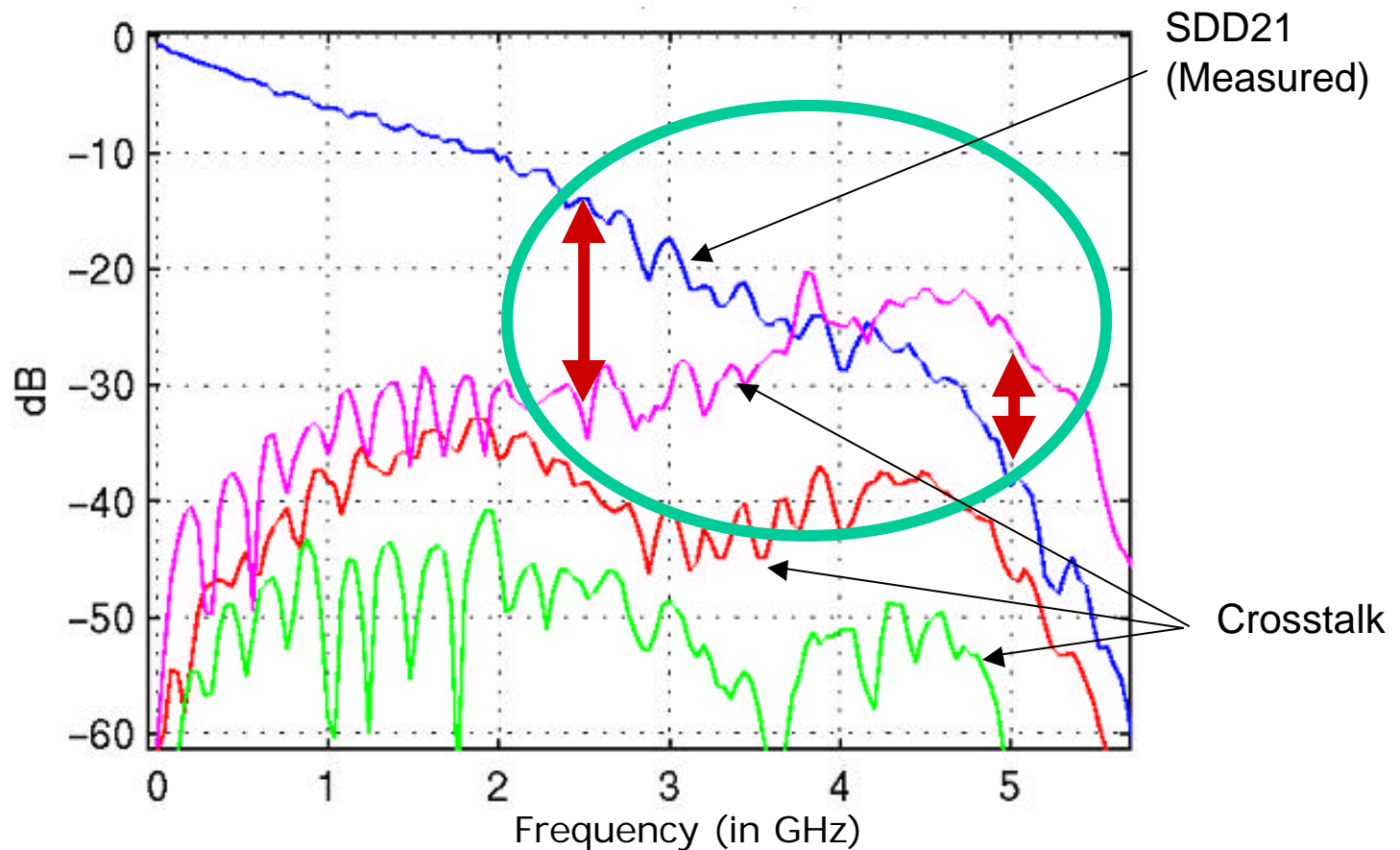
- Multilevel Signaling is not new
 - Example: 100BASE-TX, 1000BASE-T
 - Reduces Nyquist through addition of levels (ex. PAM-4 = $\frac{1}{2}$ Nyquist)
 - Lower Nyquist reduces effect of loss and impedance mismatch
 - Reduced baud rate simplifies implementation and lowers cost

When to consider MLS signaling ?

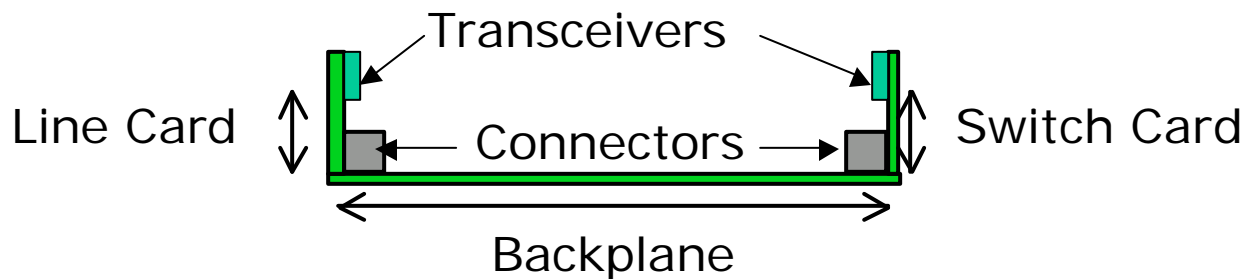
- Steeper slope of backplane channel SDD21 vs. frequency
- Analyze slope with respect to noise including crosstalk and other system noise
- MLS offers more margin when the ratio of signal-to-noise is greater than the loss associated with additional voltage levels
 - Example: 4 level MLS (PAM-4) offers greater margin when greater than 9.6dB of SNR is achieved at $\frac{1}{2}$ Nyquist

When to consider MLS signaling ?

- Example: 4 level MLS (PAM-4) give 15dB positive SNR at 2.5GHz Nyquist
- Compared with -10db SNR at 5GHz Nyquist for Binary

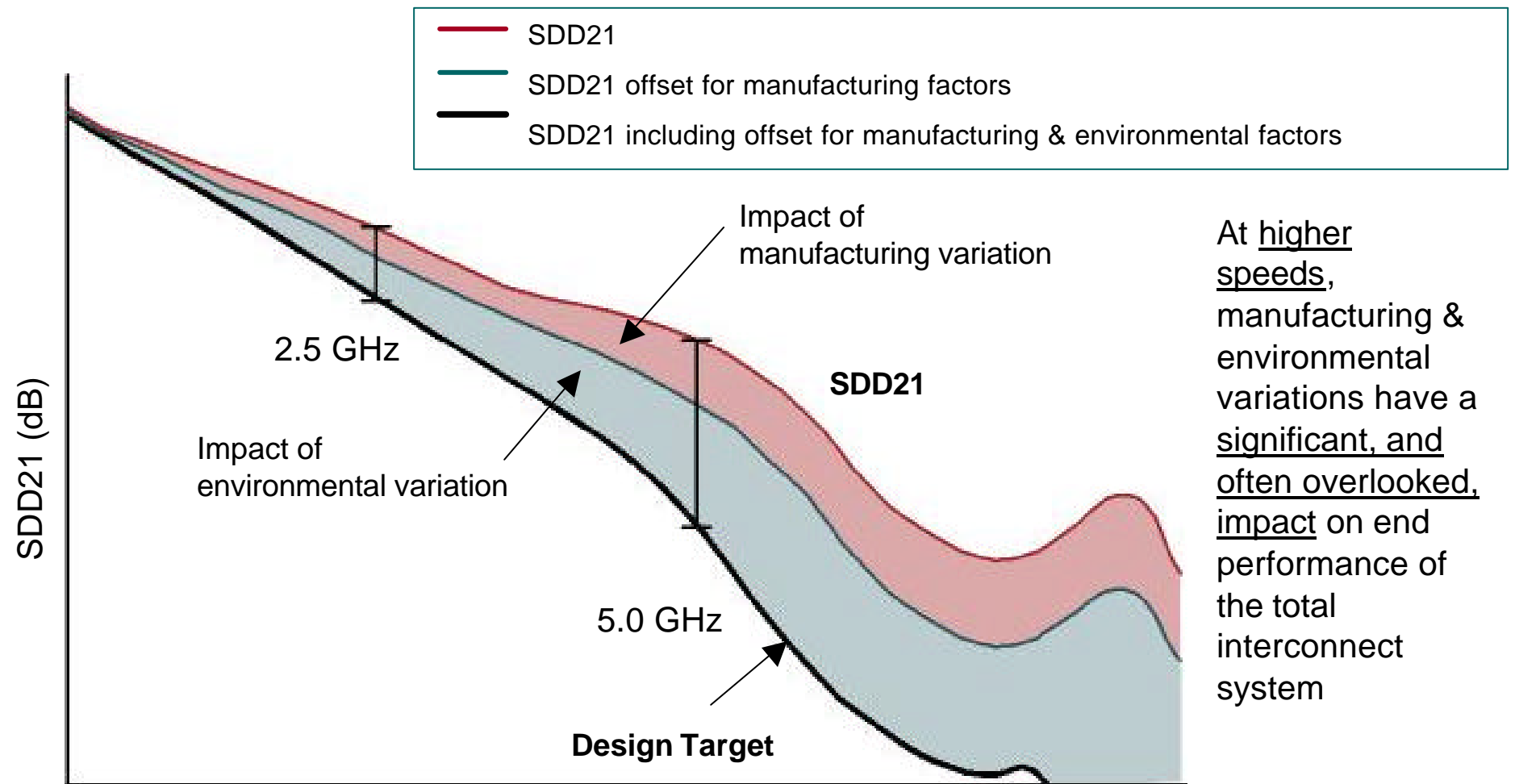


The backplane channel



- The backplane channel includes characteristics of
 - Line card (blade) pairs and switch card pairs
 - Connector/via pairs
 - Backplane pairs
- Backplane channel characteristics help optimize
 - Appropriate signaling vs. speed
 - Backplane design/utilization of cost effective materials

Design target: SDD21 for margin



10G simulation results

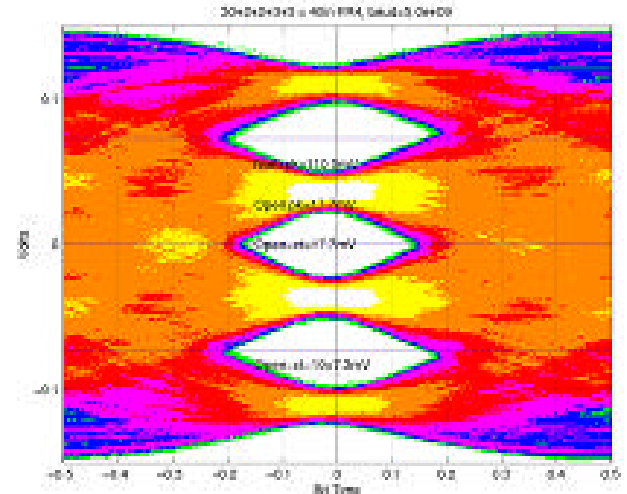
Simulated 10Gb/s results across:

40" average grade FR4

12" Coax, and 4 SMA connectors

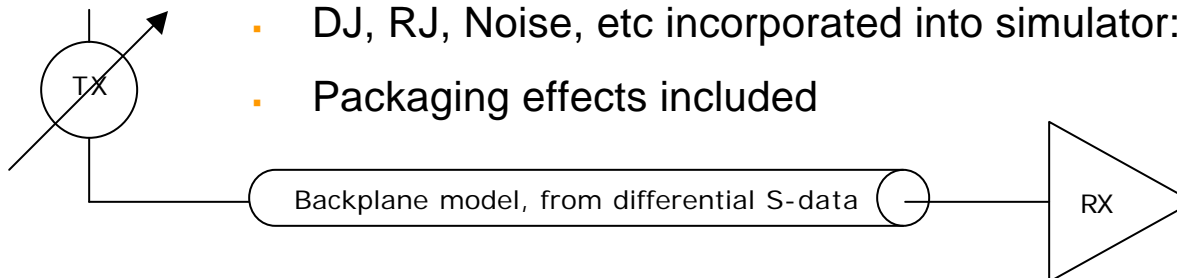
Two backplane connectors

10e-18 BER

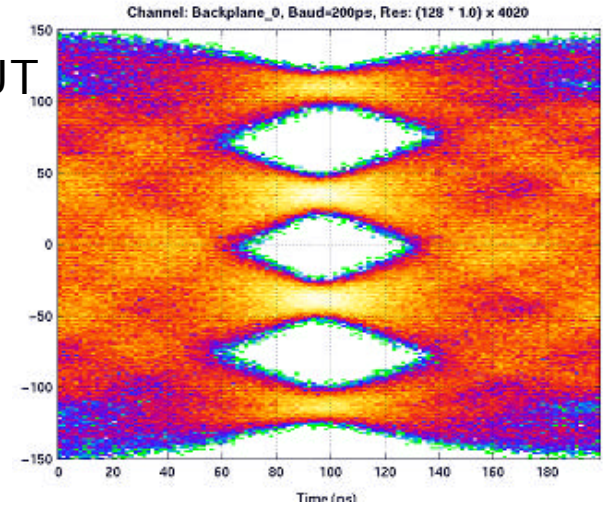
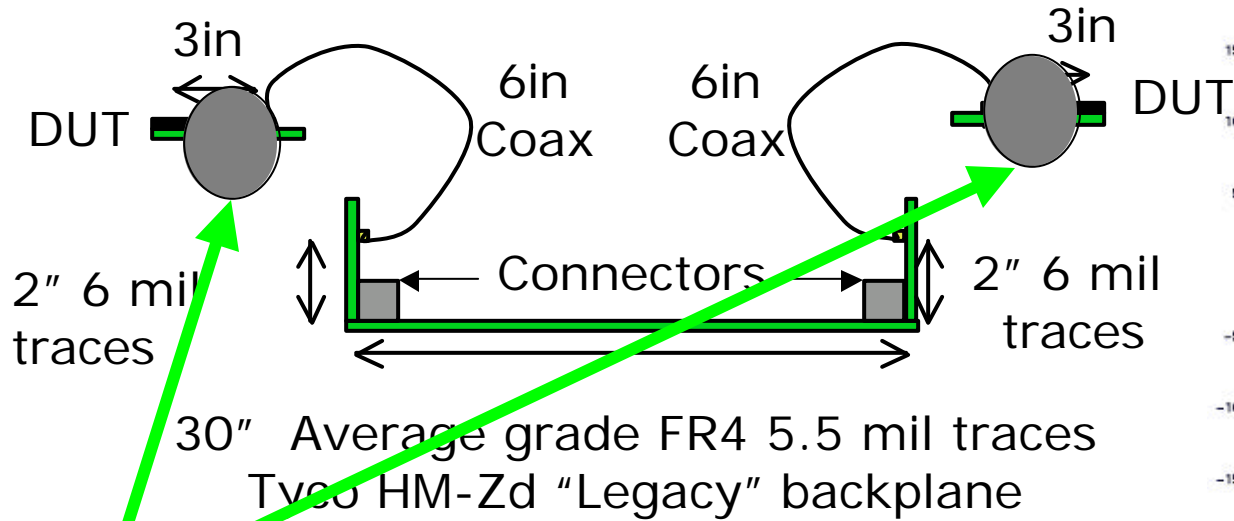


■ Simulation features

- S-parameter of Tx, Rx and backplane feeds simulator
- DJ, RJ, Noise, etc incorporated into simulator: well verified
- Packaging effects included



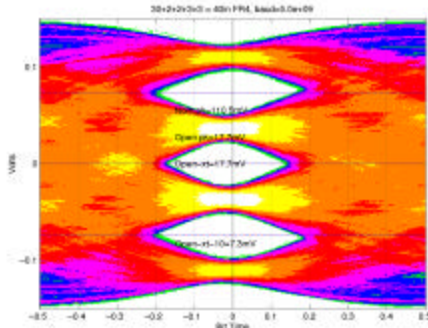
10G measured results on 40" inches FR4



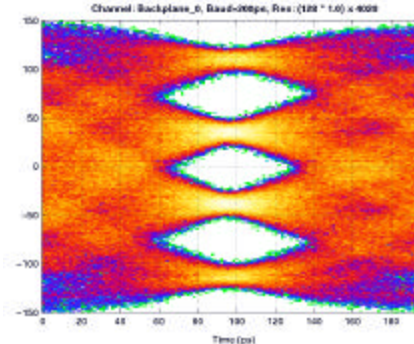
- Measurements include 6" FR4 from eval boards
- Channel for measurements same as simulated
 - Total of 40" average grade FR4 plus 2 backplane connectors
 - Additional 12" Coax and 4 SMA connectors

10G Simulation vs. Measurements

- Encouraging fit: two MLS implementations over 40" FR4 channels

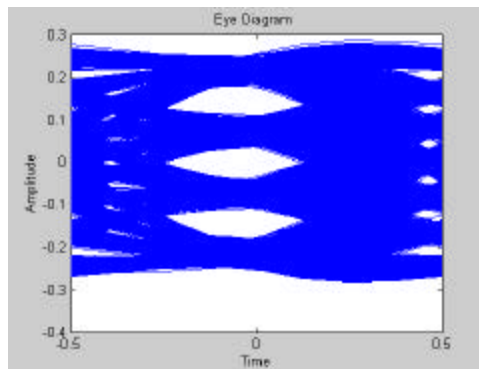


Simulated Rx eye results 10G
10E-18 BER

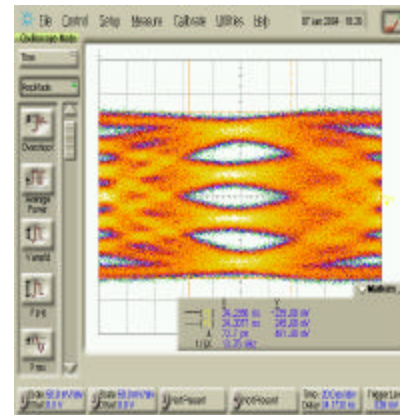


Measured Rx eye results 10G
10E-17 BER

Implementation A



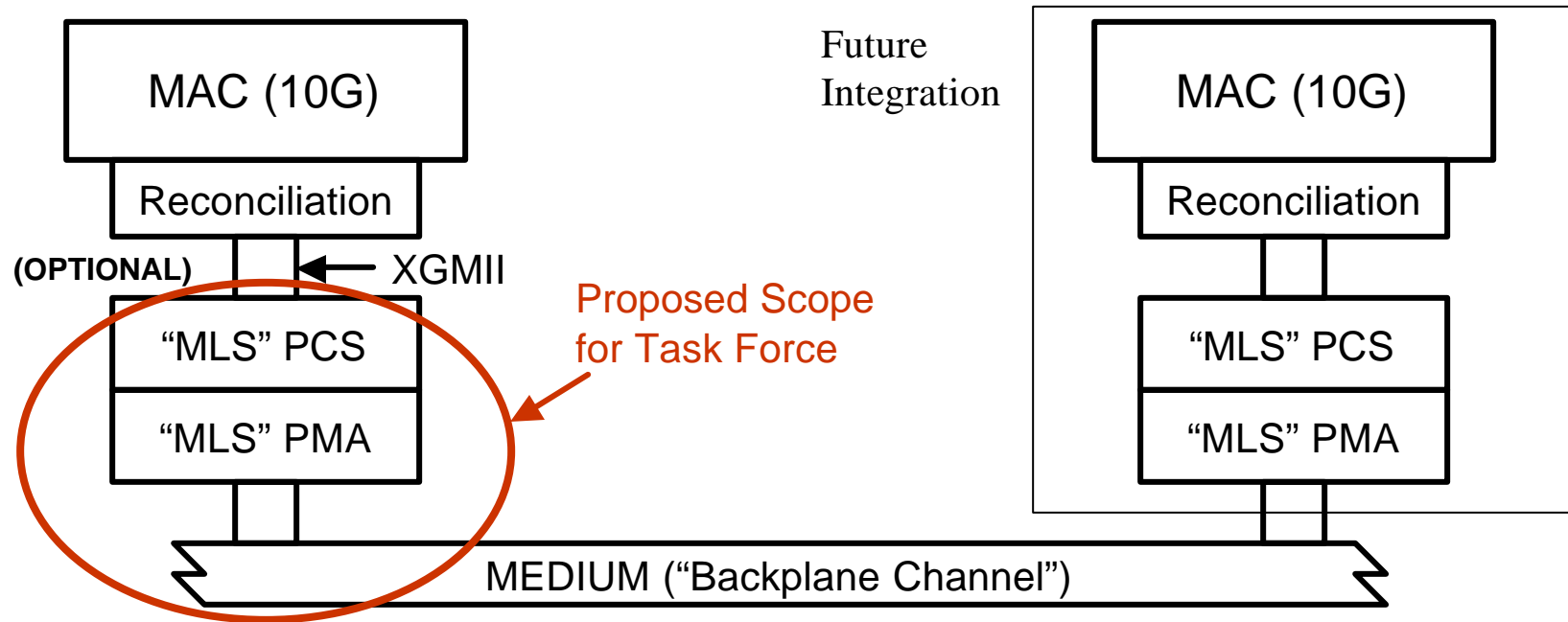
Simulated Rx eye results 10G
10E-20 BER (with Rx eq)



Measured Rx eye results 10G
10E-18 BER (with Rx eq)

Implementation B

Architecture



- 10G serial per backplane pair is feasible using MLS
- 10G serial works with existing 10GE MAC

Applicability to 5 Criteria

- Distinct Identity
 - No IEEE standard for 10G serial Ethernet over backplane pairs
- Compatible with other 802.3 standards
 - Will work with existing 10GE MAC
- Economic feasibility
 - Works over low cost, already qualified backplane board materials
 - Easily integrated onto 10GE MAC chips

Applicability to 5 Criteria

- Broad market potential
 - Many factors driving bandwidth to the backplane
 - Enables upgrade of installed base
- Technical feasibility
 - 10G serial per backplane pair can be demonstrated today on average grade FR4
 - Room for improvement with targeted 10G applications
 - Lower frequency operation (EMI/RFI, loss, crosstalk)

Summary

- The need for 10G backplane pair is here
- 10G serial is technically feasible and demonstrated over 40" average grade FR4 and two connectors using MLS (including SMA and coax connections)
- 10G backplane pairs directly apply to all 5 criteria
- Economic feasibility is achieved by enabling cost effective backplane implementations with 10G backplane pairs
- Backplane Ethernet objectives should include 10G serial per backplane pair over 40 inches of average grade FR4 including connectors