

# Feasibility of PAM-2 on a 1 Meter Backplane Channel

IEEE P802.3bj 100 Gb/s Backplane and Copper Cable Task Force  
Atlanta, GA

**Vittal Balasubramanian**  
Staff Signal Integrity Engineer  
November 2011

# Supporters and Contributors



- Mounir Meghelli, IBM
- Andrew Zambell, FCI
- Stephen Smith, FCI

- The IEEE P802.3bj task force objective is to
  - *“Define a 4-lane 100 Gb/s backplane PHY for operation over links consistent with copper traces on “improved FR-4” (as defined by IEEE P802.3ap or better materials to be defined by the Task Force) with lengths up to at least 1m.”*
- This presentation attempts to evaluate the feasibility of the task force objective using a 1 Meter (40”) backplane channel with two connectors and under 30 dB of insertion loss.
- The channel S-parameter data used in the analysis is available on the IEEE P802.3bj website at
  - <http://www.ieee802.org/3/100GCU/public/channel.html>
  - Channel Name: Connector Concept Simulated 1m Backplane Channel
  - Filename: balasubramanian\_01\_1111.zip
- Other companies are encouraged to simulate the channel as well.

# Backplane Link Description



## LINE CARD (SIDE A):

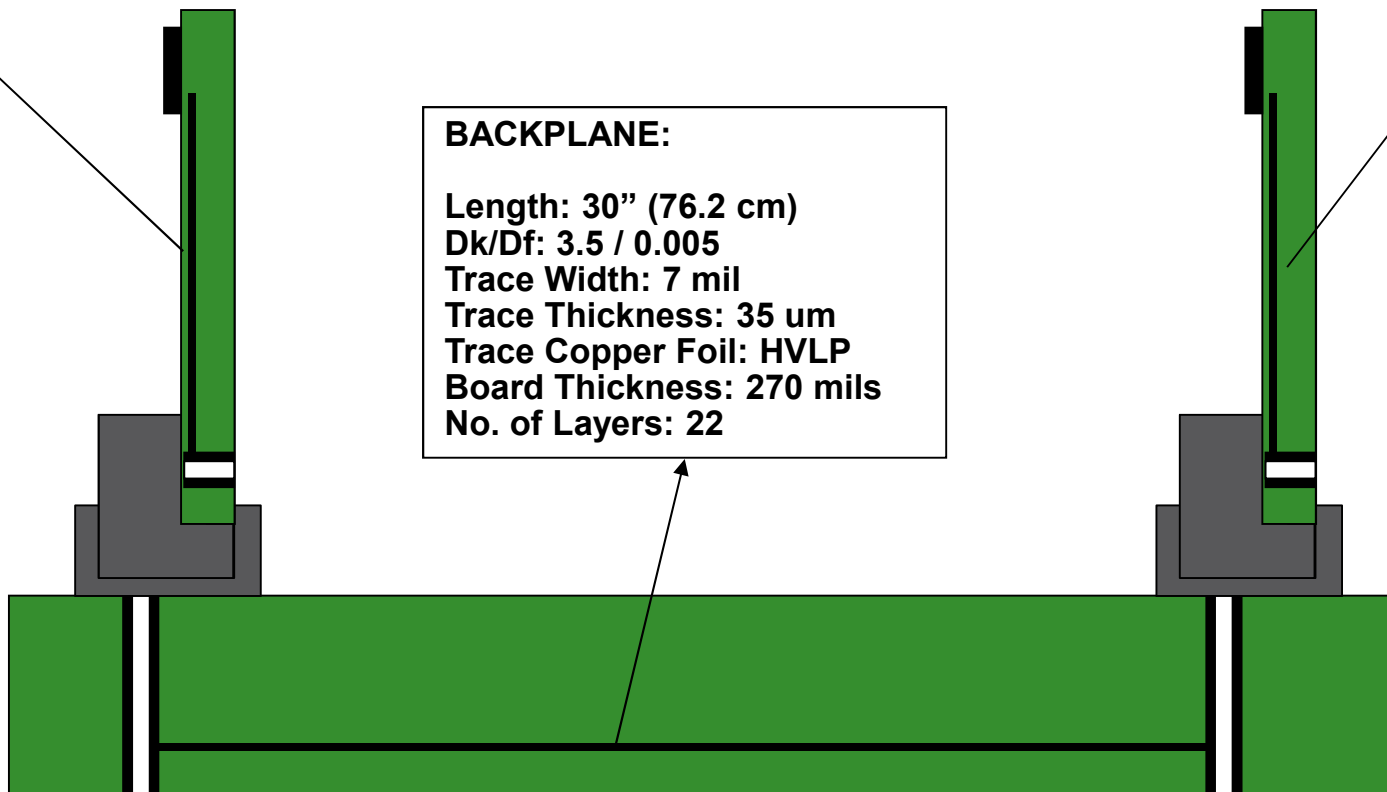
Length: 5" (12.7cm)  
Dk/Df: 3.5 / 0.005  
Trace Width: 6 mil  
Trace Thickness: 35 um  
Trace Copper Foil: VLP  
Board Thickness: 106 mils  
No. of Layers: 16

## SWITCH CARD (SIDE B)

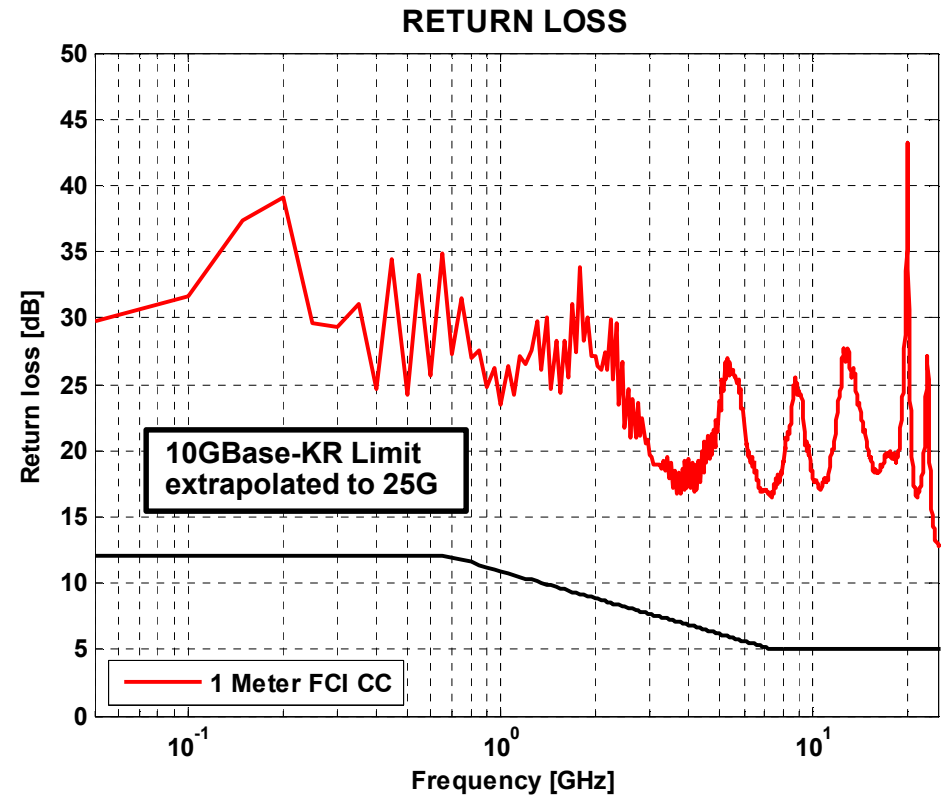
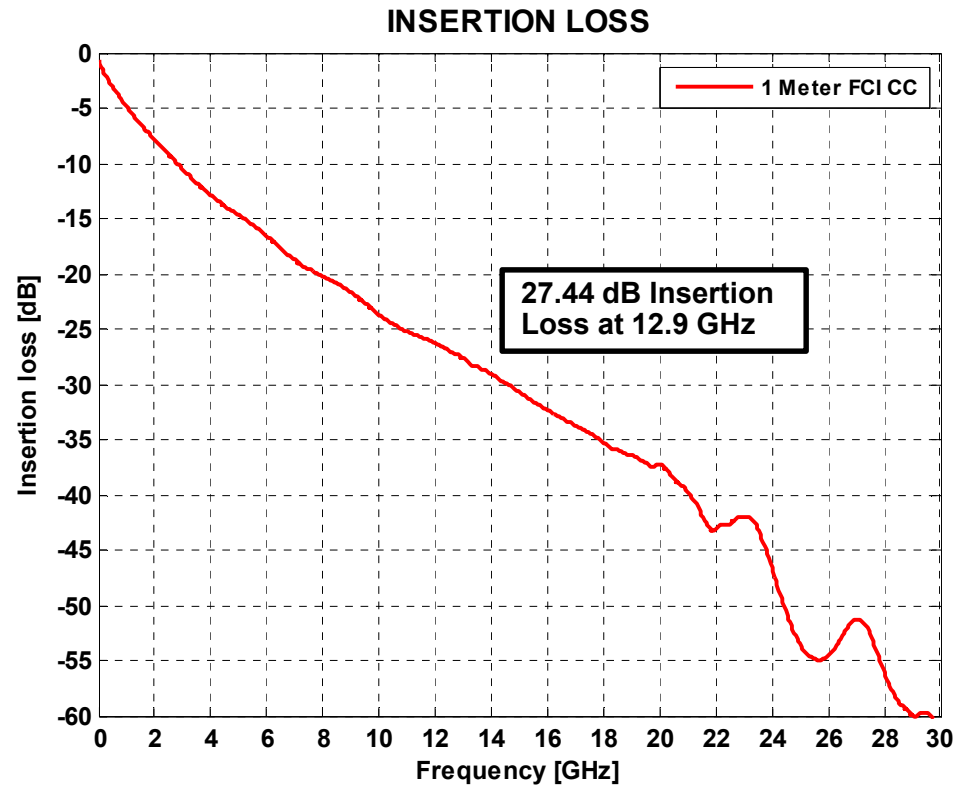
Length: 5" (12.7cm)  
Dk/Df: 3.5 / 0.005  
Trace Width: 6 mil  
Trace Thickness: 35 um  
Trace Copper Foil: VLP  
Board Thickness: 106 mils  
No. of Layers: 16

## BACKPLANE:

Length: 30" (76.2 cm)  
Dk/Df: 3.5 / 0.005  
Trace Width: 7 mil  
Trace Thickness: 35 um  
Trace Copper Foil: HVLP  
Board Thickness: 270 mils  
No. of Layers: 22



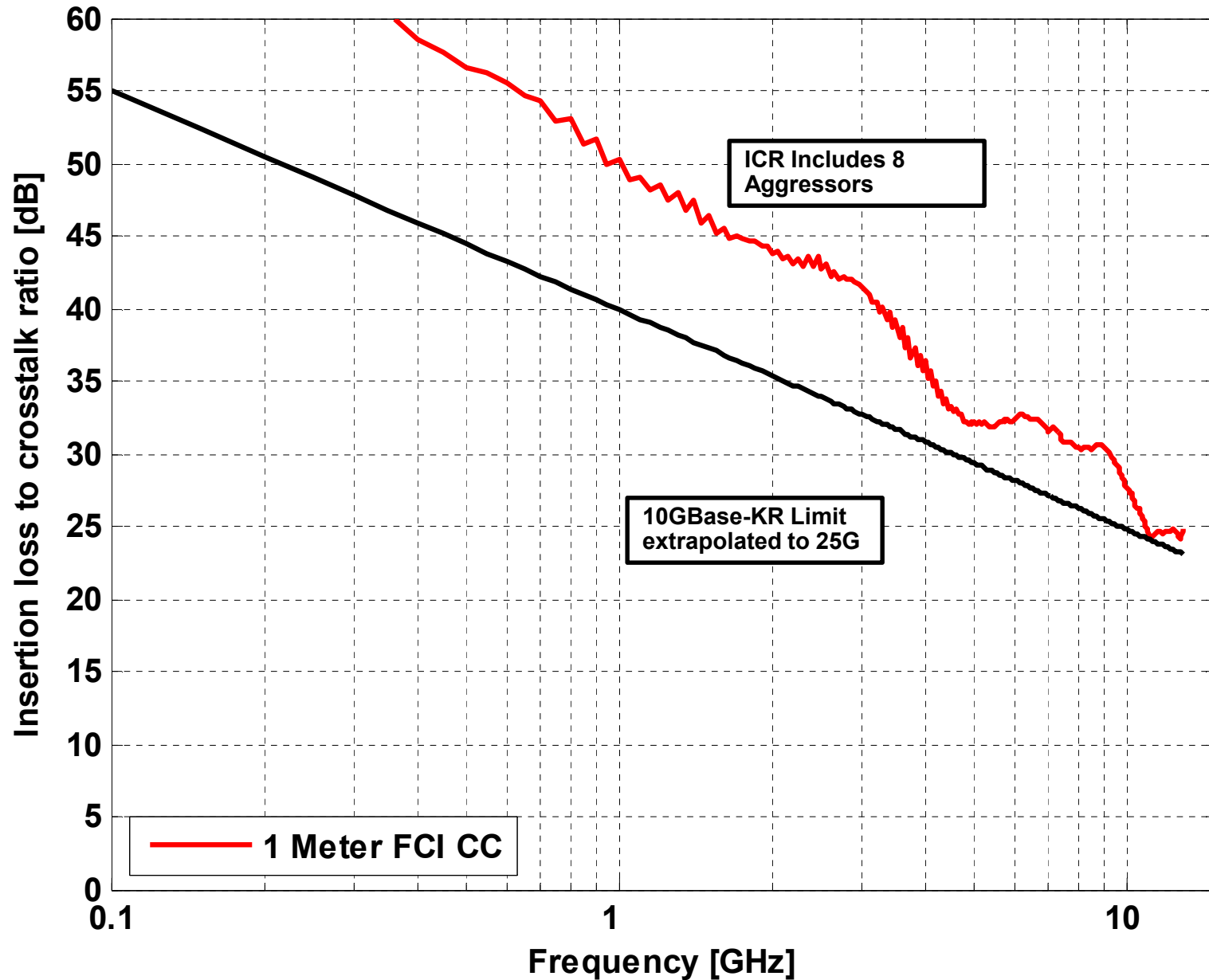
# 1 Meter Channel Response



# 1 Meter Channel Response



## INSERTION LOSS TO CROSSTALK RATIO



- NRZ signaling simulation results reported at the Rx slicer input
  - Net vertical eye opening (Veye) at 1e-12 and 1e-15 BER
  - Net horizontal eye opening (Heye) at 1e-12 and 1e-15 BER
  - BER floor (minimum BER)
  - SNR and SNR margin at the minimum BER (assuming Gaussian noise at low BER)
  - 10M bits simulated, randomly generated
  - Default data rate 25.78125Gb/s (no FEC)

Channel Length (meter)	Loss at Baud/2 (dB)	Eye Height (1e-12) (mVpd)	Eye Width (1e-12) (%UIpp)	Eye Height (1e-15) (mVpd)	Eye Width (1e-15) (%UIpp)	BER Floor	SNR (dB)	SNR Margin (dB)	Satisfies 1 m and 1E-12 BER objective
1.01	27.44	38.2	27.3	34.4	23.8	1.3e-53	23.84	5.84	Yes

- 25Gb/s NRZ signaling across 1m backplane with low loss material (i.e. Megtron6) allow for sufficient transmission margins at 1e-15 BER (no FEC applied)
  - >20% horizontal and >30mVpd vertical eye opening margins
  - >5dB SNR margin
- Core I/O Parameters
  - Identical to slide 14 in meghelli\_01a\_0911.pdf



# Passive Channel Evaluation



- Channel evaluated using method proposed by Healey and Moore in moore\_01\_0311.pdf

Case	Pulse Gain	Dibit Gain	Available Signal (mV)	Implementation Noise (mV)	ILD Noise (mV)	Re-reflect ion Tx (mV)	Re-reflect ion Rx (mV)	Re-reflect ion Tx-Rx (mV)	Total Channel Noise (mV)	XT 1 (mV)	XT 2 (mV)	XT 3 (mV)	XT 4 (mV)	XT 5 (mV)	XT 6 (mV)	XT 7 (mV)	XT 8 (mV)	PSXT (mV)	total noise (mV)	S/N	margin (mV)	flipped Sign
FCI CC 1.01m Link	190.128m	135.019m	35.969	3.528	2.485	1.357	1.358	1.353	3.419	0.151	0.151	0.279	0.279	0.658	0.658	0.160	0.097	1.049	5.023	7.160	0.965	no

Simulation parameters used as recommended in healey\_01\_0111  
 “Suggested practices of reporting simulation results”:

Bit rate	25 Gb/s
Modulation	PAM2
Signaling rate	25 Gbaud
Number of symbols simulated	N/A
Target symbol error ratio	1e-12
Tx Test pattern	N/A
Tx output voltage, peak-to-peak	0.8V (NEXT is 1.2V)
Tx Deterministic jitter, peak-to-peak	N/A
Tx Deterministic jitter, distribution	N/A
Tx Random Jitter, RMS	N/A
Rx Random noise, RMS	Included in implementation noise
Rx Deterministic jitter, peak-to-peak	N/A
Rx Random jitter, RMS	N/A
Rx Low-frequency gain	1.0
Tx, Rx Device package	No loss, indefinite phase
Tx, Rx Single ended resistance	66 ohms (gives magnitude but not phase of device reflection coefficient)
Tx, Rx Single ended capacitance	200 fF (gives magnitude but not phase of device reflection coefficient)

- Presented a 1 meter Backplane channel which
  - Meets the 1m and 1e-12 BER objective
  - Meets the Eye Height and Eye Width criteria of the IBM NRZ IO System Model
  - Meets the Margin requirement per moore\_01\_0311.pdf
  
- Loss budget of 30dB at 12.89 Ghz is achievable using NRZ signaling
  - This loss budget would allow for a 1m channel using Megtron6 type materials