100G Signaling Options over Backplane Classes

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Outline

1. **Signaling Options (Line Code and Transmission Type)**
2. **SNR Margin Analysis (Salz) over 50 Channels (Old/New)**
3. **Representative Channels for Time-Domain Simulation**
4. **Simulation Result Analysis**
5. **Roadmap to the Next Generation 400G System**
6. **Summary**

100G Signaling Options

Option 1: PAM-2, 25Gbaud*[1], 4-Lane

Option 2: PAM-4, 12.5Gbaud, 4-Lane

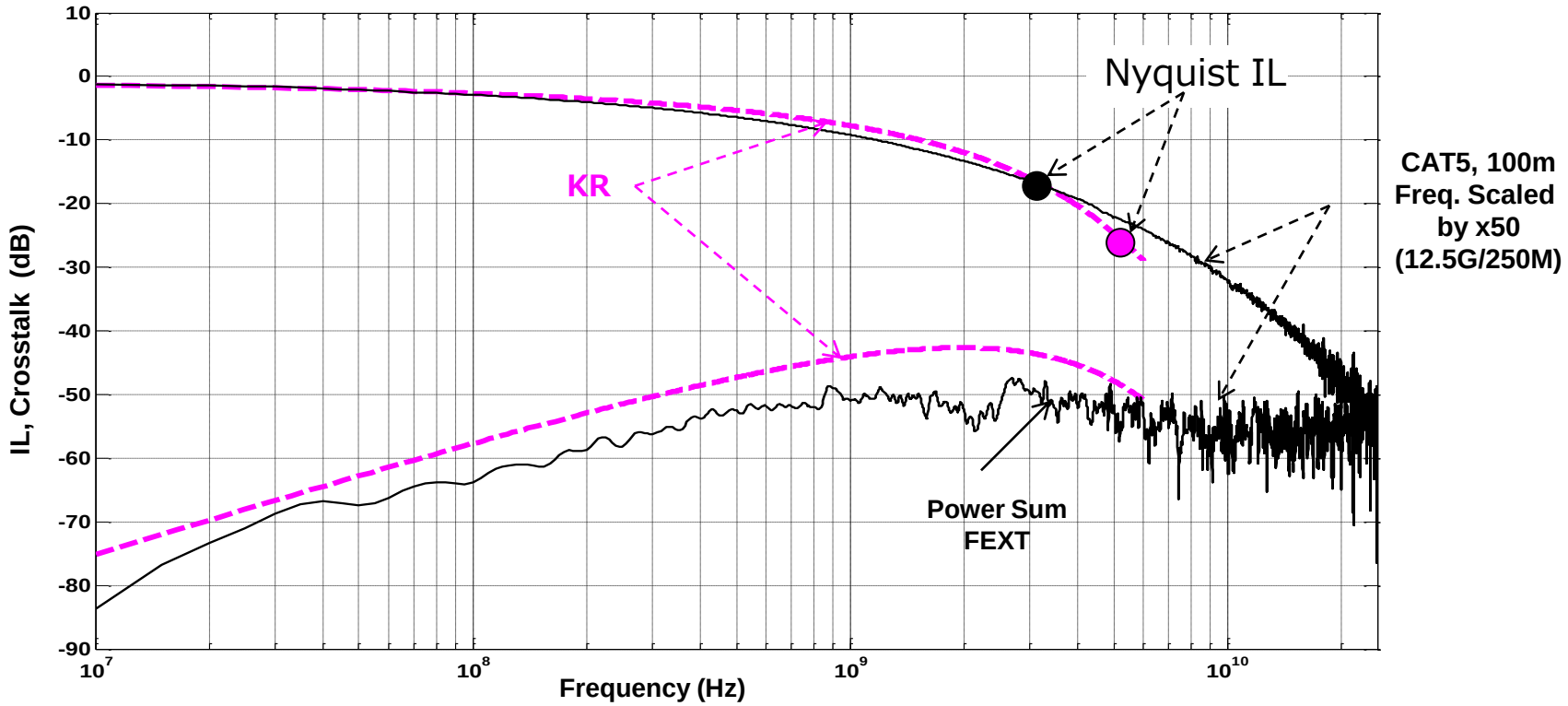
Option 3: PAM-4C*[2], 6.25Gbaud, 8-Lane (Full Duplex by EC)

50 Industry Backplane CHs (New Material, KR, and Pre-KR) are evaluated with three different options.

***1) No coding overhead assumed at this stage**

***2) 4-D TCM Coded as per 802.3ab, 1000BASE-T**

802.3ab Channel Mapped to 802.3ba

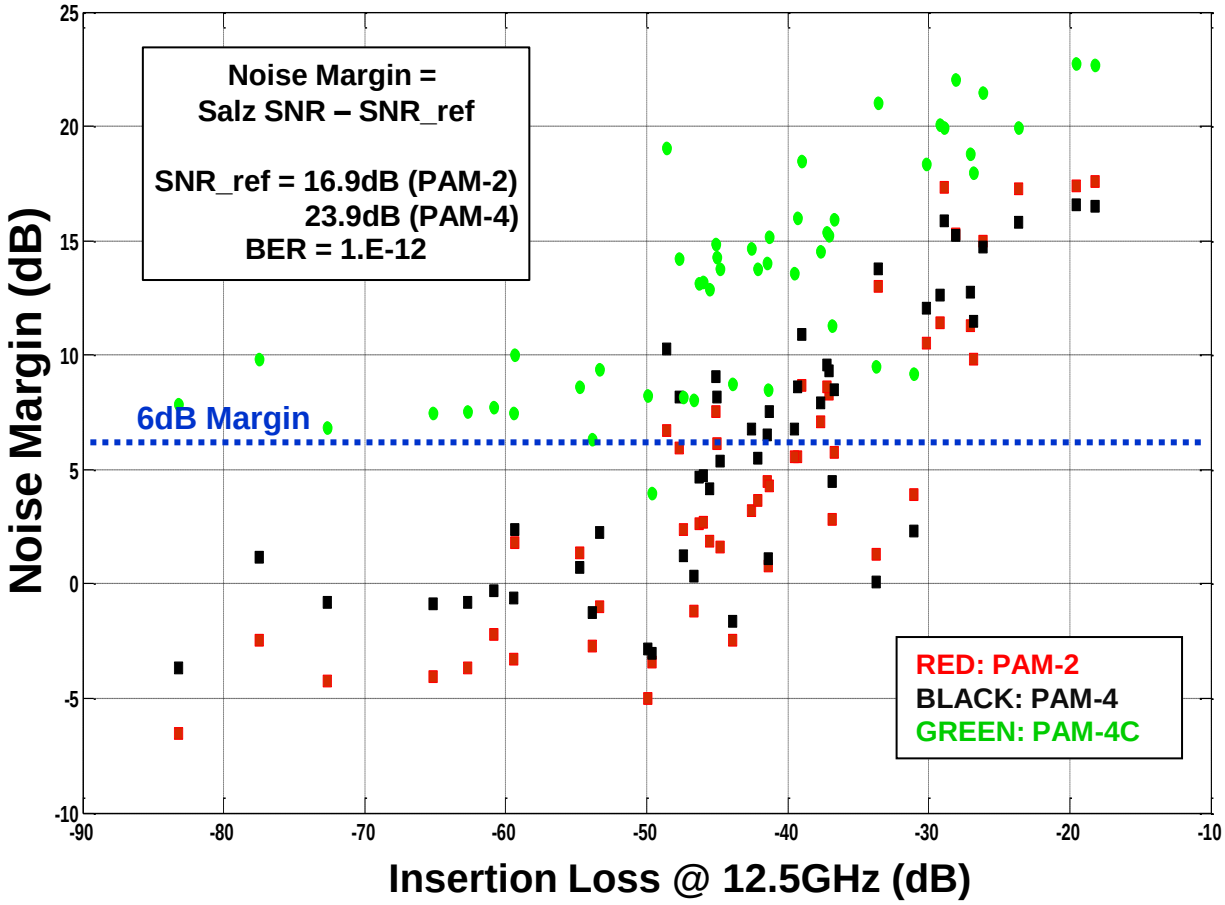


802.3ab (1000BASE-T) Channel IL is much more relaxed vs. KR at Nyquist.

Makes 8-lane Bi-Directional Signaling a Promising Candidate over KR-compliant and Pre-KR Channels

SNR Margin (Salz)

(-146dBm/Hz BGN, w/o FEC)



1. PAM-4 has advantage over PAM-2 for greater loss CHs.
2. However, PAM-2 and, to some extent, PAM-4 channel support not widest.
3. PAM-4C covers higher IL and boarder majority of the channels.

Further analysis is done by the time domain behavioral simulation that included key system impairments and IC implementation losses.

Channels for Time-Domain Analysis

CH1 Improved Materials

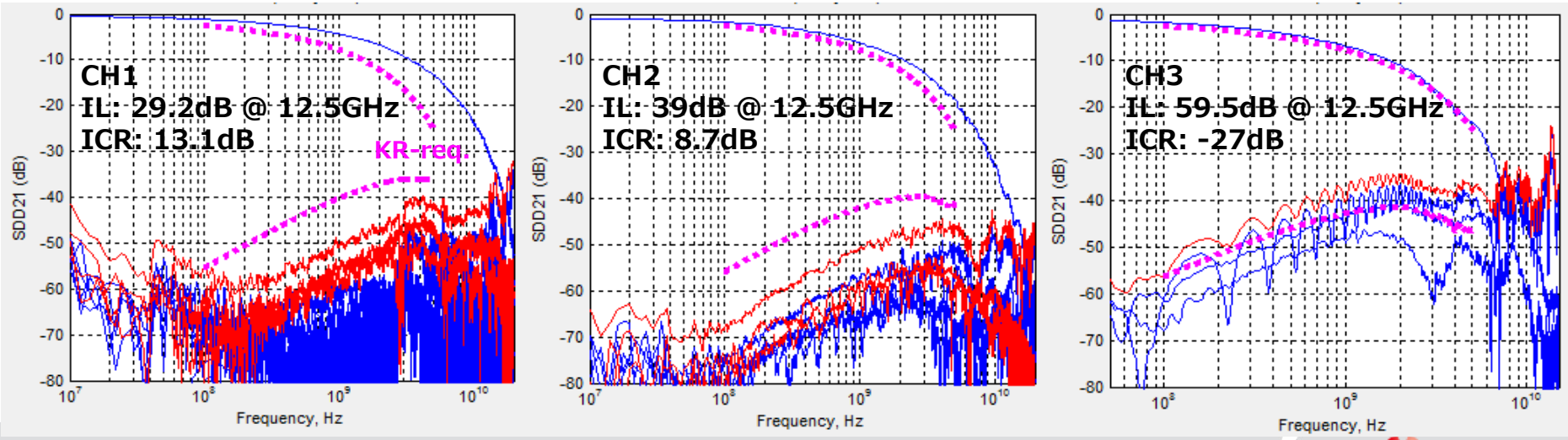
1 Meter Backplane Channel, IBM "http://www.ieee802.org/3/100GCU/public/channel.html
Similar to above from TE, Merson, Q-Logic, and FCI

CH2 KR Compliant

Typical Backplane channel designed after KR

CH3 KR Marginal

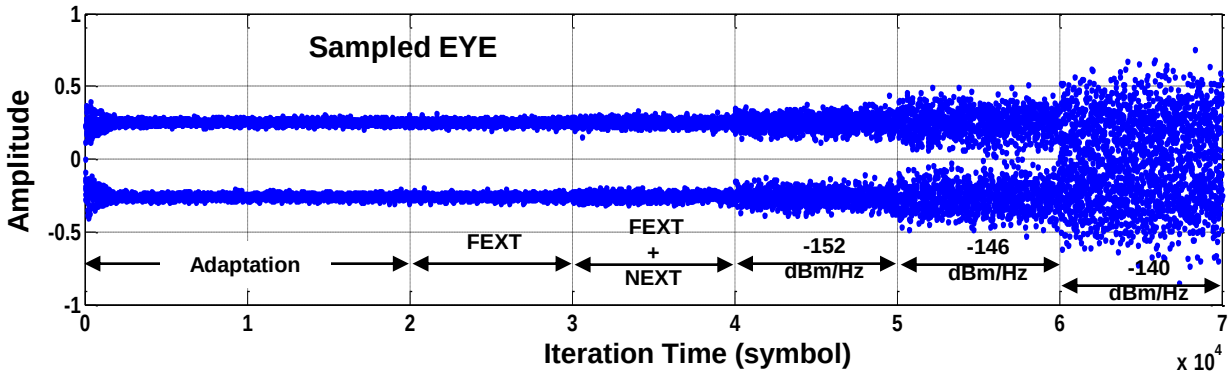
http://www.ieee802.org/3/ap/public/sep04/dambrosia_01_0904.pdf etc

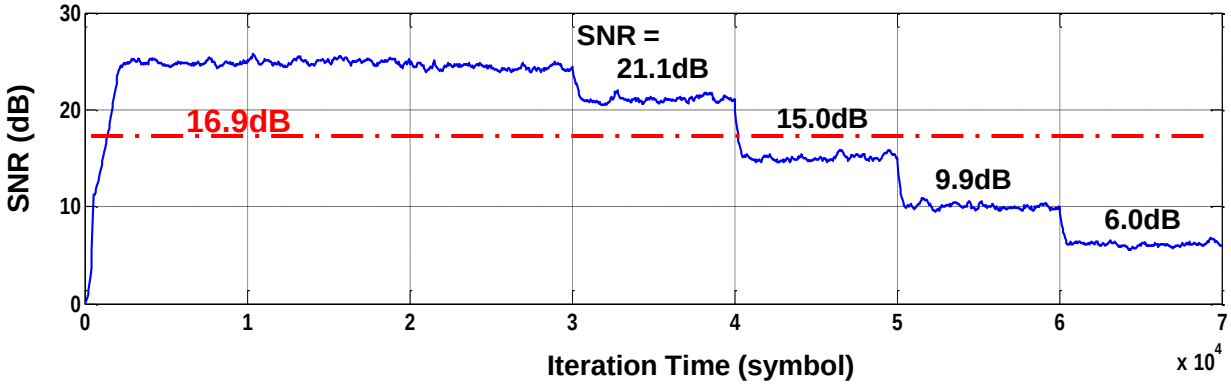


Time Domain Behavioral Simulation

Reference PHY

TX: 5dBm, 3~4 tap FIR filter with 1st order LPF, 40dB THD
RX: CTLE, High-pass filter, 16 tap DFE, 40dB THD
Jitter: 0.35ps(rms), both transmit and receive clock
Noise: NEXT, FEXT, and BGN (-152, 146, and -140dBm/Hz)





Impairments are added in time one by one after the adaptation.

1.	FEXT	20000~
2.	FEXT + NEXT	30000~
3.	FEXT + NEXT + BGN	40000~

The noise margin is calculated by subtracting SNR_ref. from SNR.
SNR_ref = 16.9dB (PAM-2)
= 23.9dB (PAM-4)

Result shown in this page uses
- **Option-1(PAM-2, 25Gbaud)**
- **CH-2 (KR compliant).**

Noise margin in this case is

+4.2dB (Crosstalk only)
-1.9dB (BGN = -152dBm/Hz)
-7dB (BGN = -146dBm/Hz)
-10.9dB(BGN=-140dBm/Hz)

Simulations are repeated for three options over different channels.

Noise Margin Result

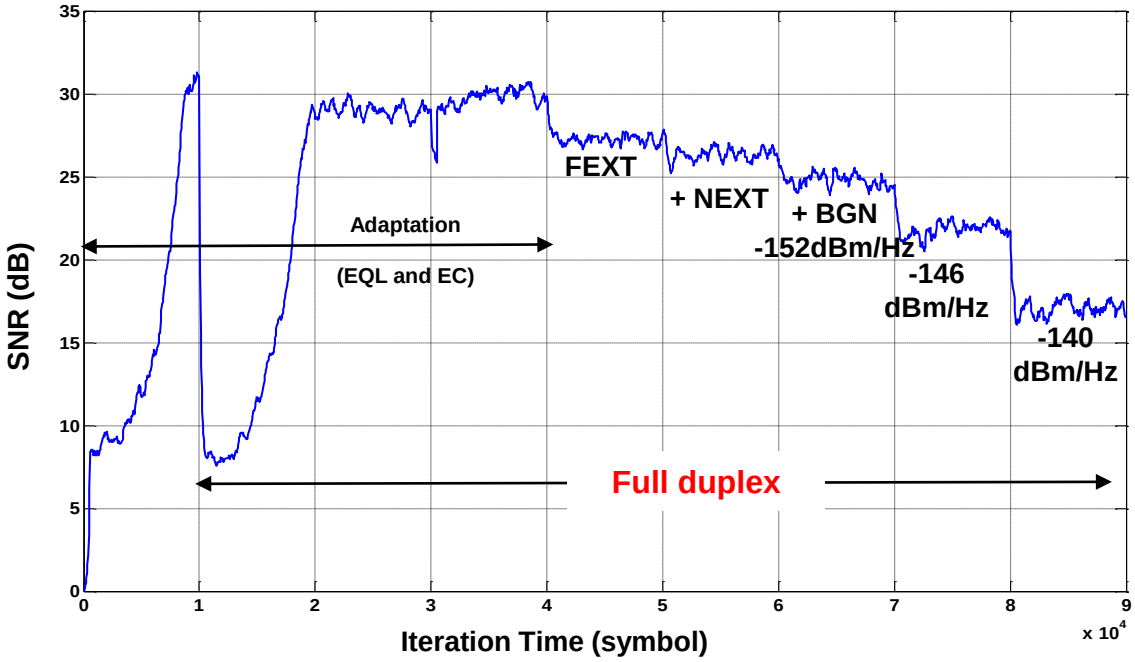
Time Domain Behavioral Simulation

	BGN (dBm / Hz)	CH1 Improved Material	CH2 KR Compliant	CH3 KR Marginal
Option1 PAM2, 25G baud	-152	4.4 dB	-1.9 dB	FAIL
	-146	2.5	-7	FAIL
	-140	-1.7	-10.9	FAIL
Option2 PAM4, 12.5G baud	-152	5.8 dB	3.4 dB	-6.2 dB
	-146	4.4	0.8	-7.2
	-140	1.0	-3.6	-9.9
Option3 PAM4C, 6.25G baud Full Duplex	-152	9.0 dB	9.5 dB	2.7 dB
	-146	8.2	7.9	2.1
	-140	6.4	4.5	0.3

No FEC coding gain is included
Package + BGA crosstalk are not included

Feasibility of Next Gen 400G System

Channel: CH1 (IBM 1m Backplane)
Signaling: PAM-4C, 25Gbaud (OPTION-3, 4X speed)



Assuming 5dB coding gain, greater than 3dB noise margin is possible.

400G system is feasible.

Followings will be necessary for industry grade products.

A. **Minor material improvement over CH1**
B. **SerDes porting by 4X.**

Summary

1. Three signaling options have been studied over key classes of channels --- Improved Low-loss material, KR, and Pre-KR
2. PAM-2 is marginal even with improved Low-loss material and requires extremely low noise environment.
3. PAM-4 would work over Low-loss channels, however, w/o FEC it would be marginal over KR spec backplanes.
4. PAM-4C will work well over KR backplanes with sufficient margin even w/o additional FEC.
5. PAM-4C is the best performing signaling so far on a roadmap to the next generation 400G system.