SMF PMD Objective Modulation Alternatives Technical Feasibility

400 Gb/s Ethernet Study Group
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Outline

- **Objectives**
- **Simulation Model**
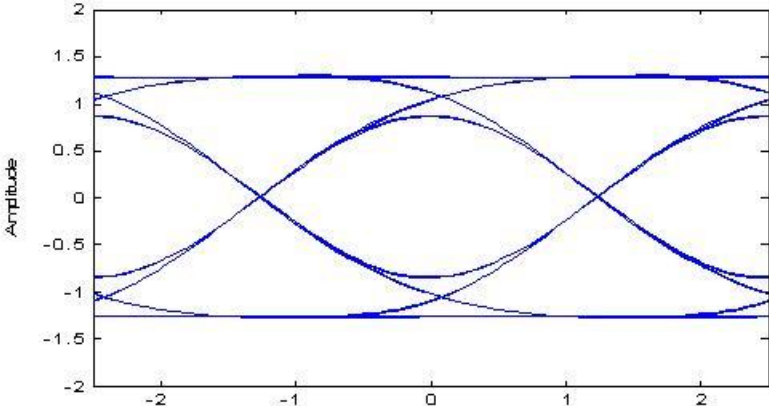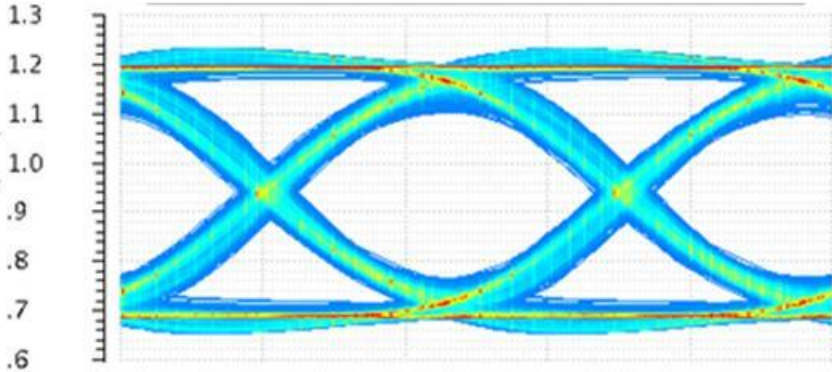- **Simulation Results**
- **Conclusions**

Objectives

- Evaluate 400G system architectures based on 50G per channel NRZ and PAM4

- Compare 56 Gb/s NRZ with PAM4 for a realistic bandwidth limited MZM transmitter

- Discuss relative technical feasibility and resulting impact on economic feasibility of modulation alternatives
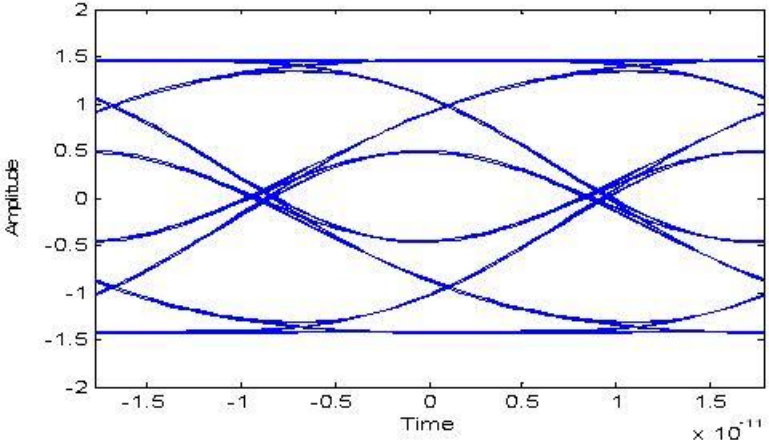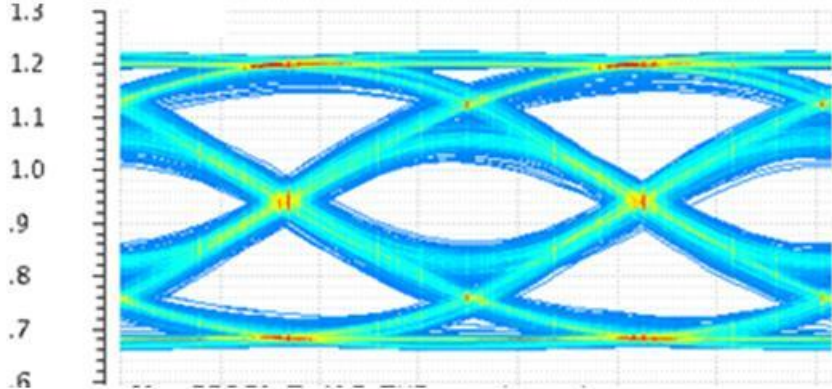
Simulation Model

Parameter	Value	Comments
Bit Rate	56 Gb/s	
Modulation	NRZ or PAM4	
Modulator	MZM	
Tx Bw	16 GHz	4-pole Bessel LPF
Extinction Ratio	4 dB	
RIN	-140 dB/Hz	
Rx Bw	0.75*Baud Rate	4-pole Bessel LPF
Responsivity	0.4 A/W	
TIA noise density	18 pA/sqrt(Hz)	AWGN
Equalizer architecture	FFE-DFE	
Equalizer adaptation	DD-LMS	

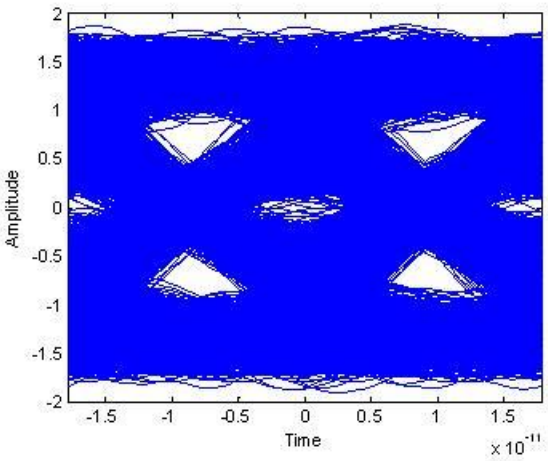# Full Circuit Simulation vs. Matlab Model

Bandwidth limited MZM - a perfect candidate for PAM4 at 28 Gbaud?
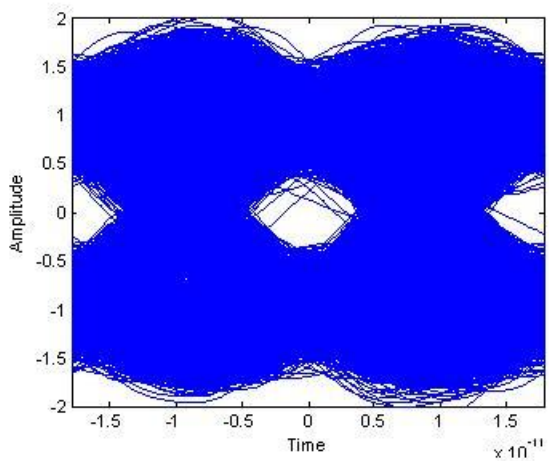
56 Gb/s NRZ and PAM4 Eye Diagrams

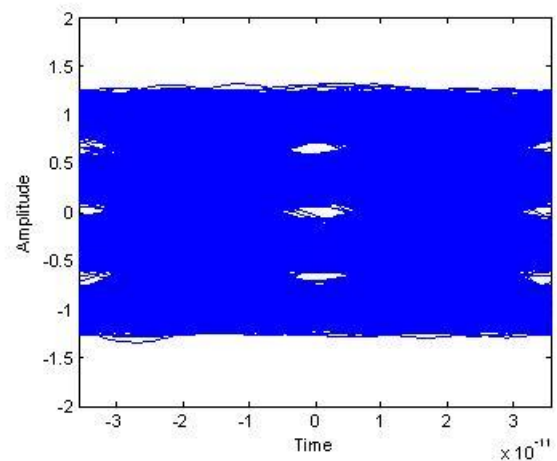**Simulated eyes with Prx = - 6 dBm and RIN = -140 dB/Hz**
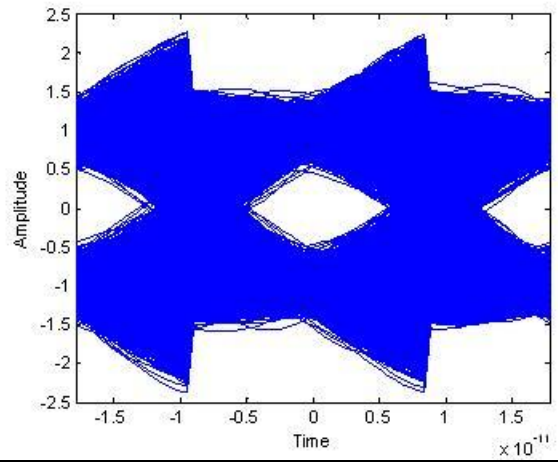

56G NRZ no EQ
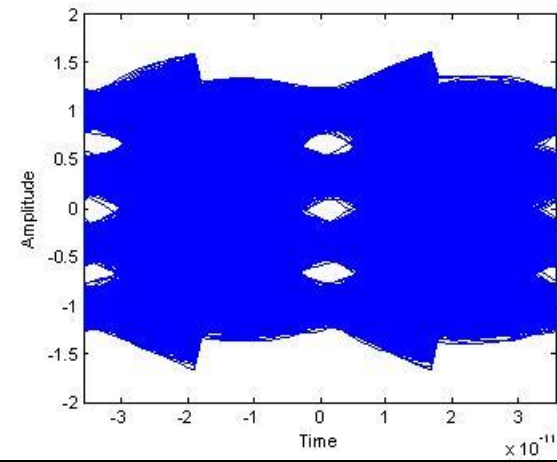

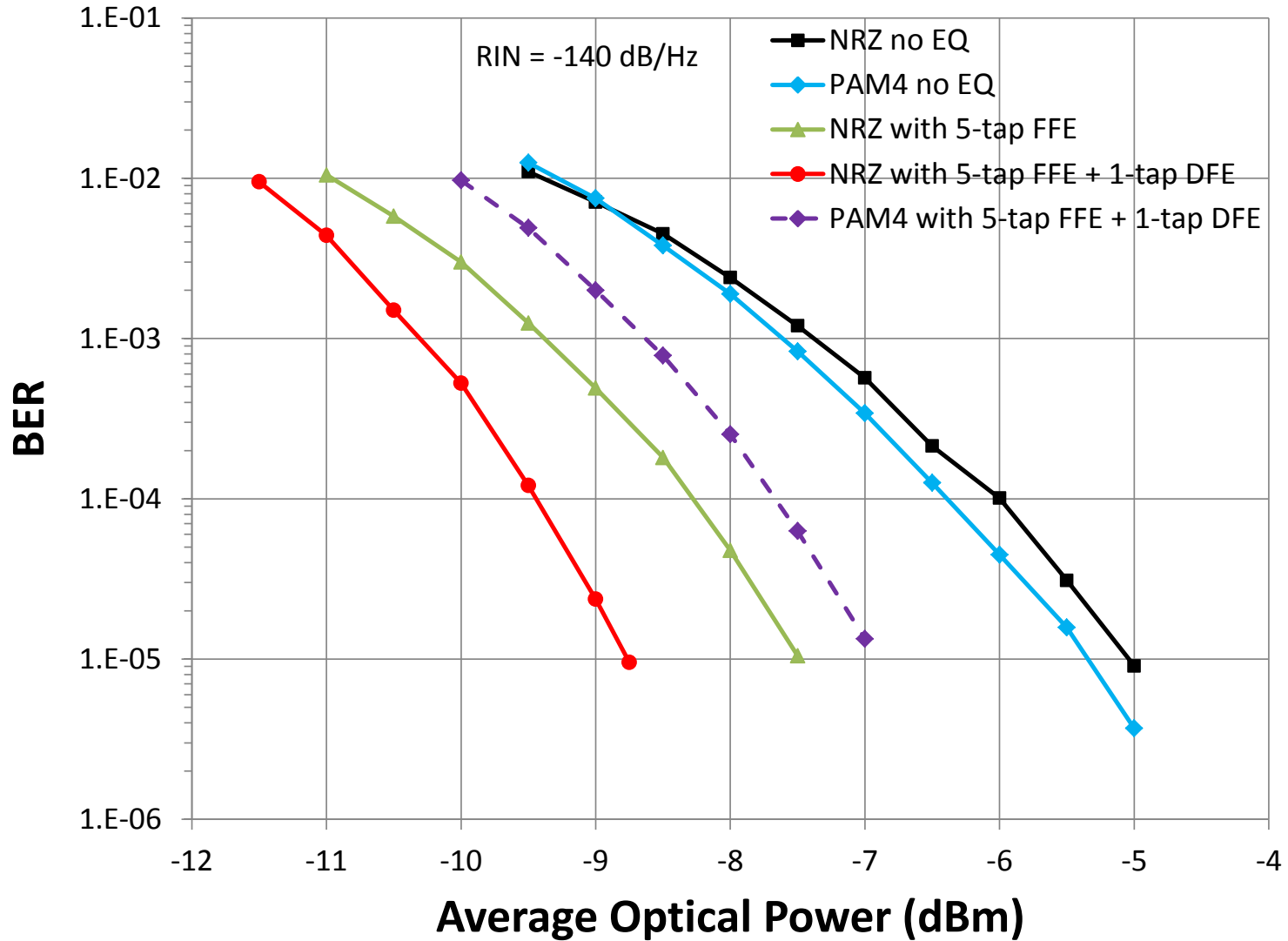56G NRZ with 5-tap FFE

56G PAM-4 no EQ

5-tap FFE+1-tap DFE

5-tap FFE+1-tap DFE

56 Gb/s Monte-Carlo Simulation Results

Conclusions

- We developed a 56 Gb/s Matlab system model with realistic bandwidth limited MZM modulator, and used the model to compare NRZ with PAM4 modulation

- Both qualitative analysis of eye diagrams and Monte-Carlo simulations show NRZ modulation with low-complexity 5-tap FFE equalization outperforms PAM4 with conventional CDR

- NRZ with 5-tap FFE + 1-tap DFE shows more than 3 dB advantage over PAM4 with conventional CDR, and 2 dB advantage over PAM4 with an equivalent FFE-DFE