Technical Feasibility Study of 106 Gb/s PAM4 Optical Link

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Motivations

There have been a number of presentations on 100Gb/s PAM4 optical links

way_3bs_01a_0115.pdf

mazzini_02a_1215_smf.pdf

traverso_3cd_01a_0716

where Rx sensitivity (OMA $_{outer}$) in the range of - 6.5 dBm to - 11.8 dBm @ 2E-4 BER were reported for PRBS15 data pattern through post-processing.

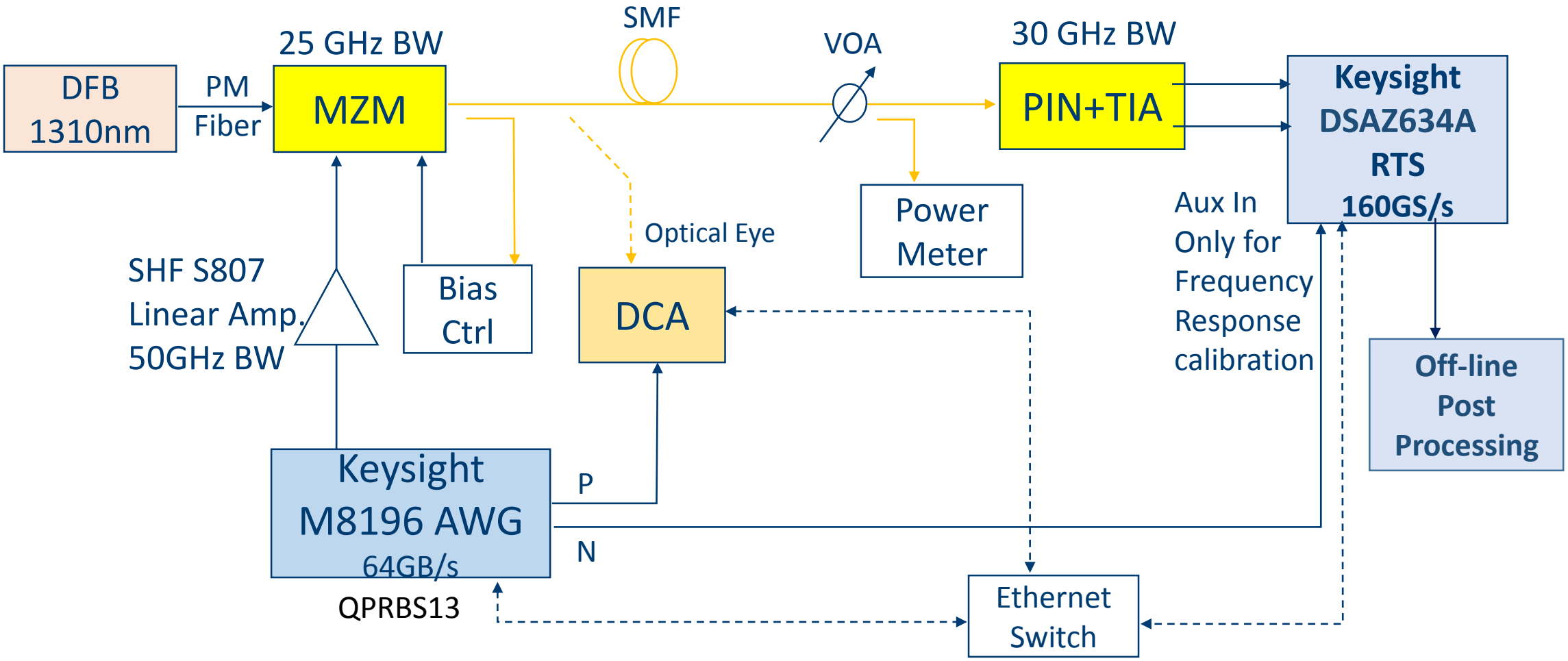
Concerns were raised regarding the performance with more complicate data patterns and the ability to reach <1E-6 BER

This presentation will compare the BER and Rx sensitivity of a 106 Gb/s PAM4 link obtained by post-processing with those from real-time scope measurements and show

< 1E-6 BER with QPRBS13 data pattern

> 5 dB margin over the Rx sensitivity spec in DR4 (Draft2.0)

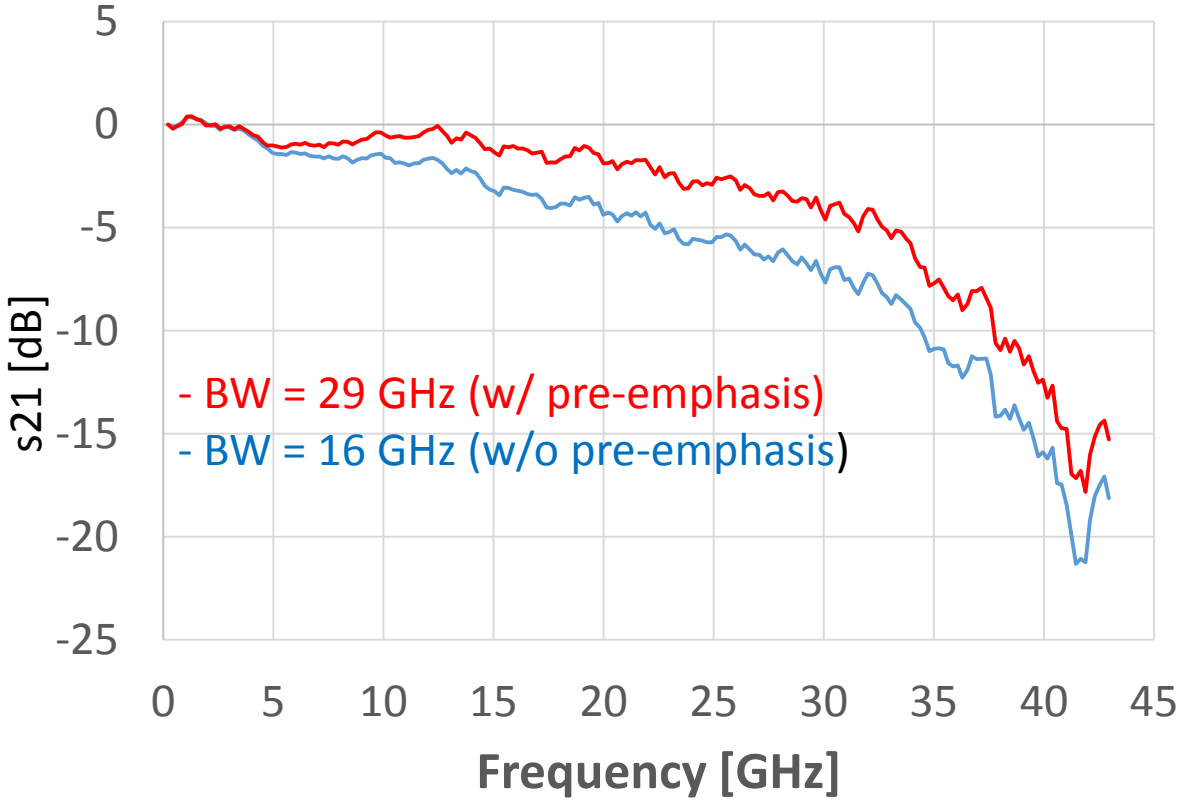
106 Gb/s PAM4 Test Setup



Tx BW and Pre-emphasis

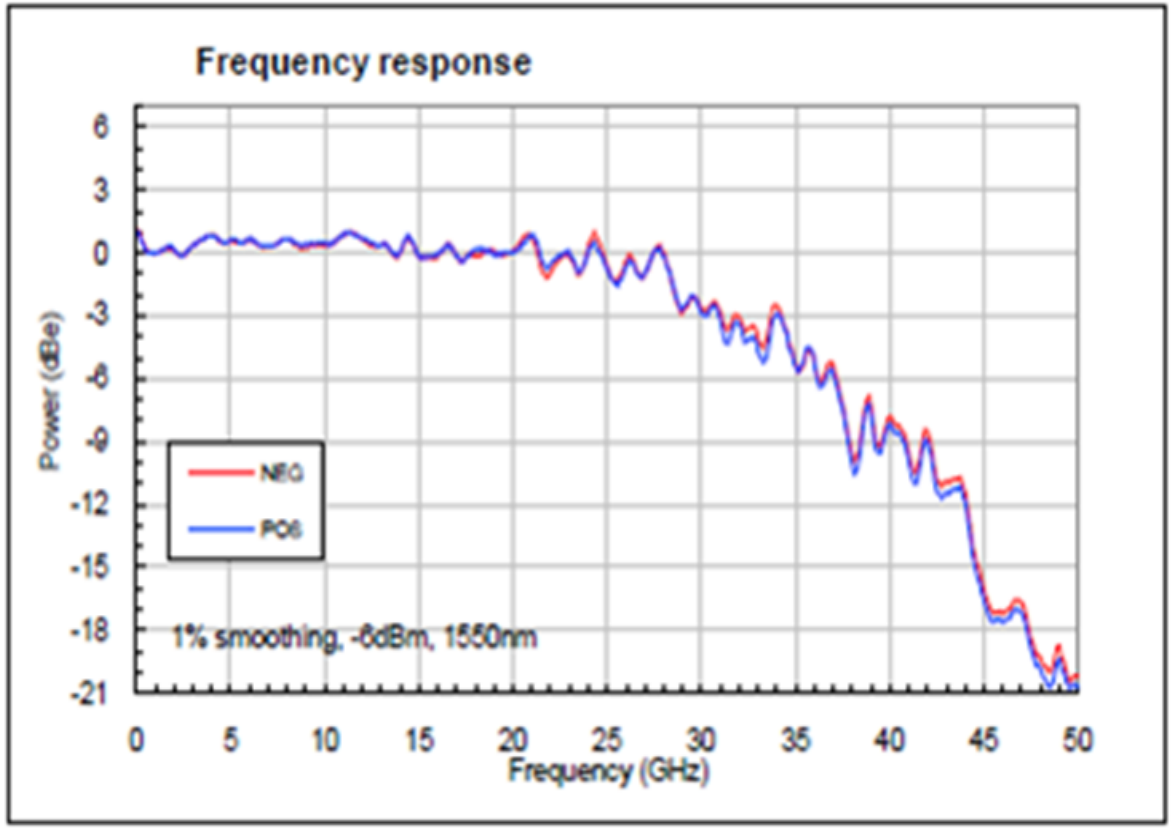
LiNO3 Modulator BW = 24. 7 GHz

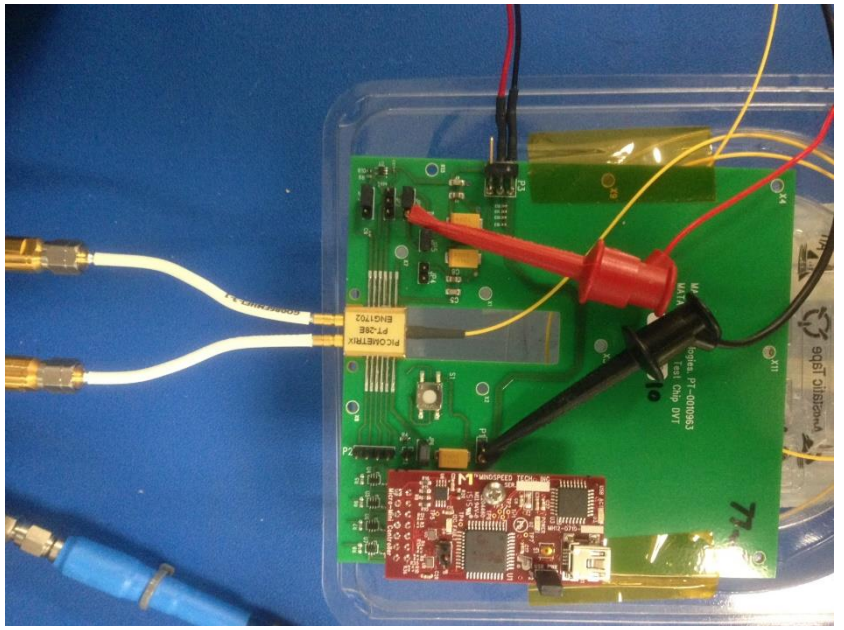
Overall Tx Chain Frequency Response



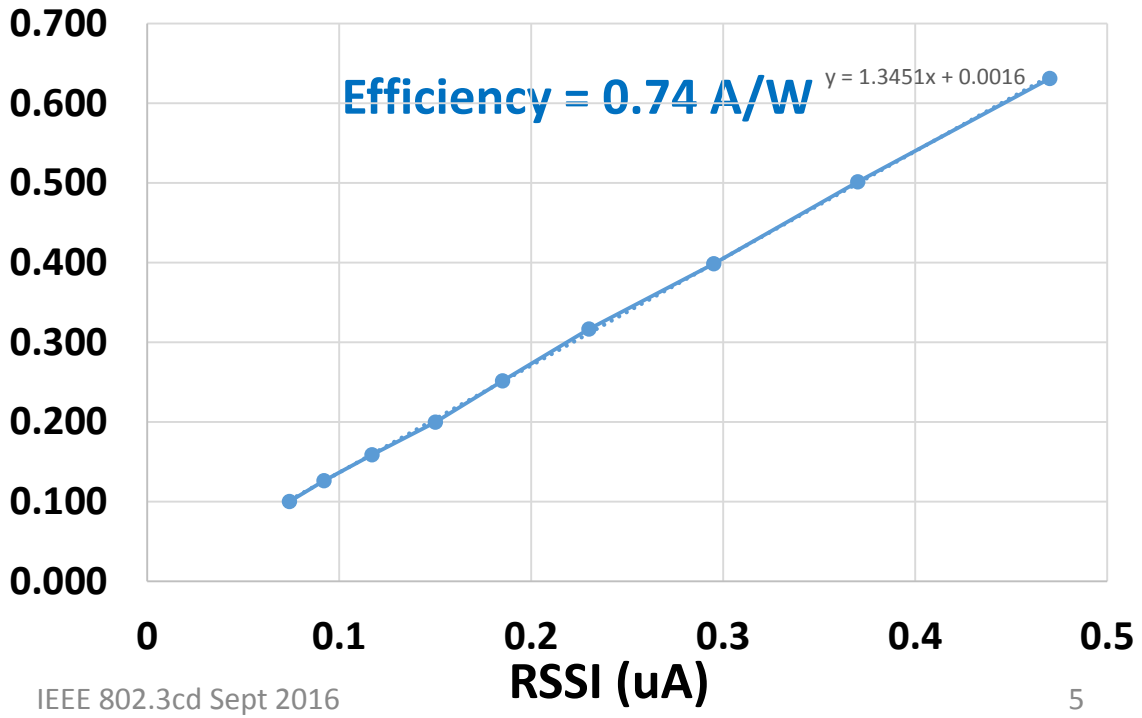
Rx Module

TIA BW = 30 GHz, Noise ~ 13 pA/sqrt(Hz)

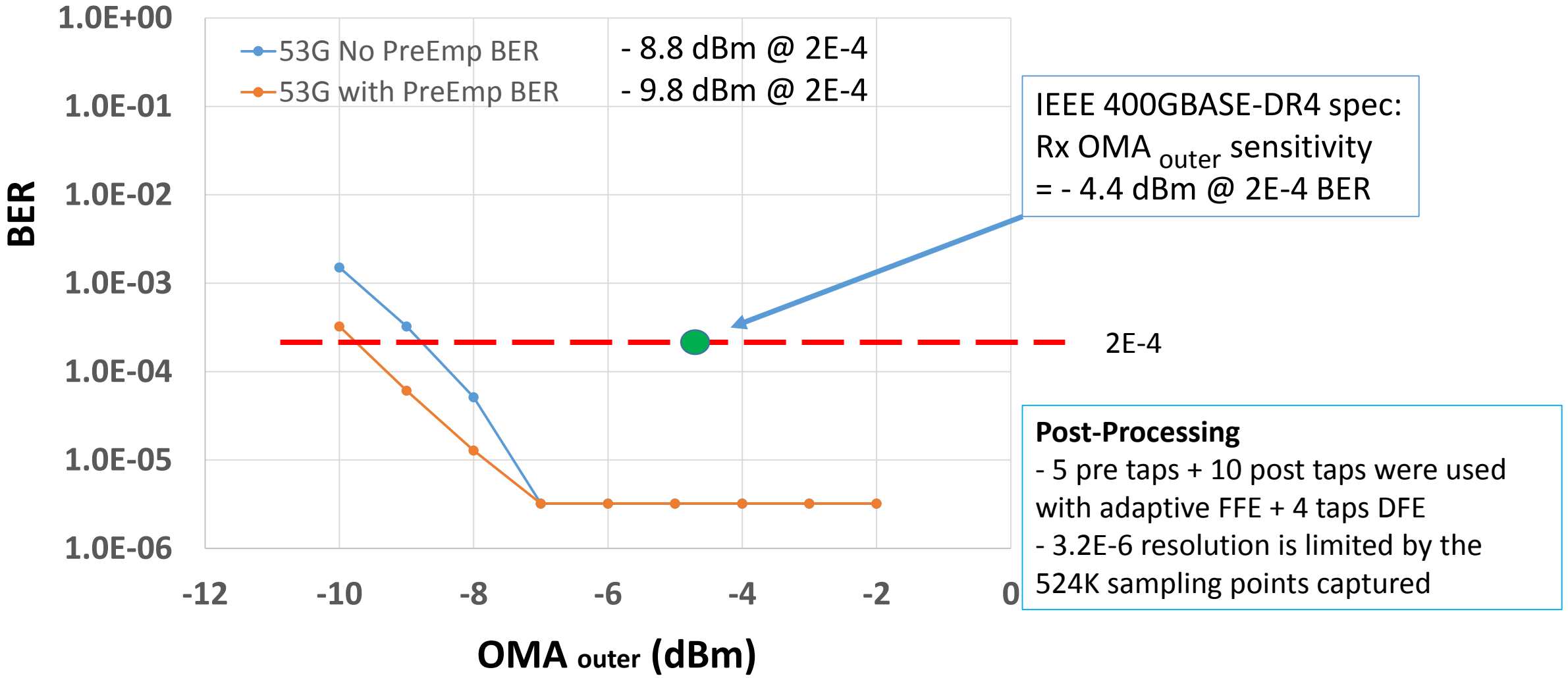




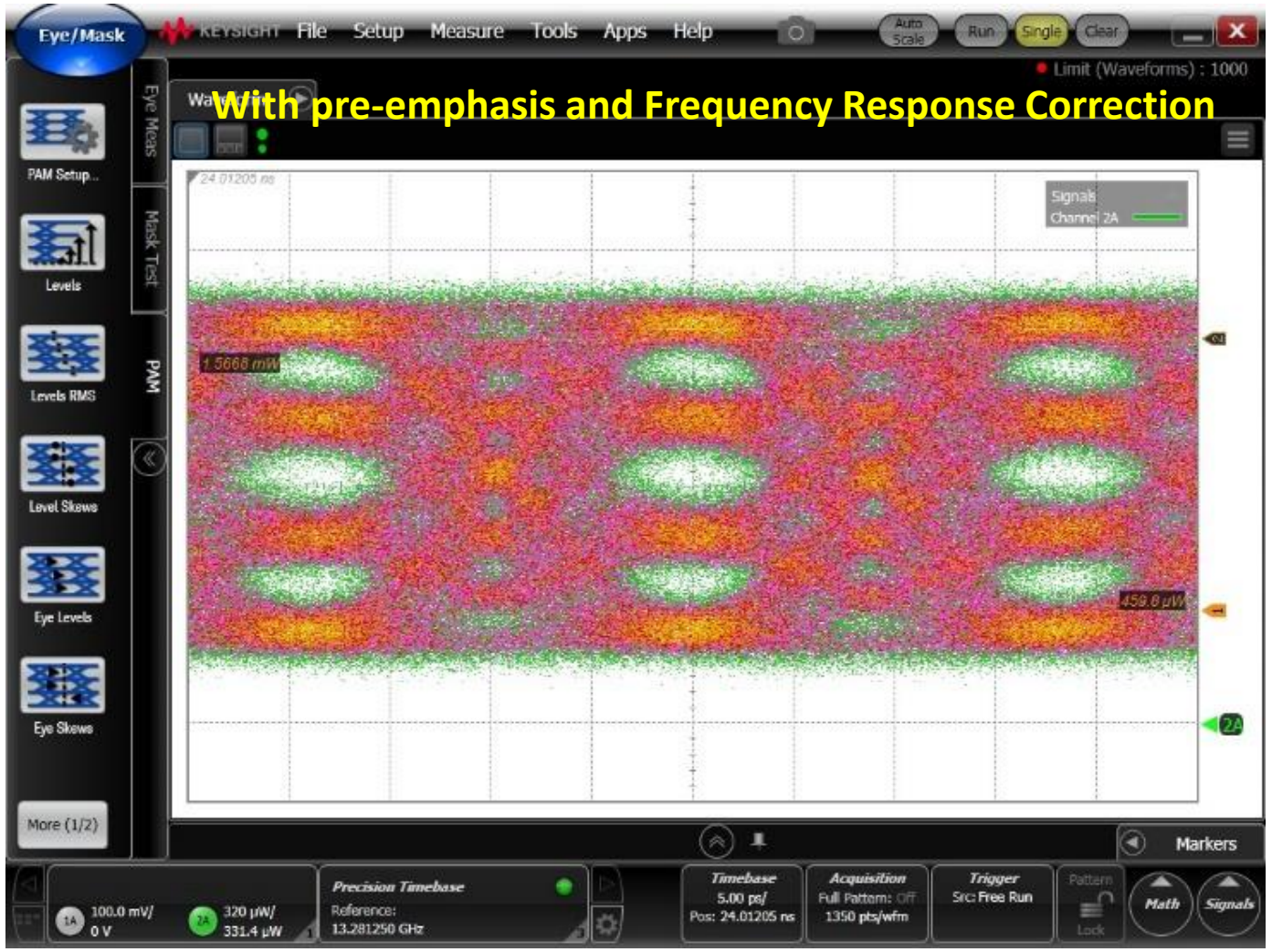
Optical Power (mW)



BER Measurements through Post–Processing with Adaptive Equalization

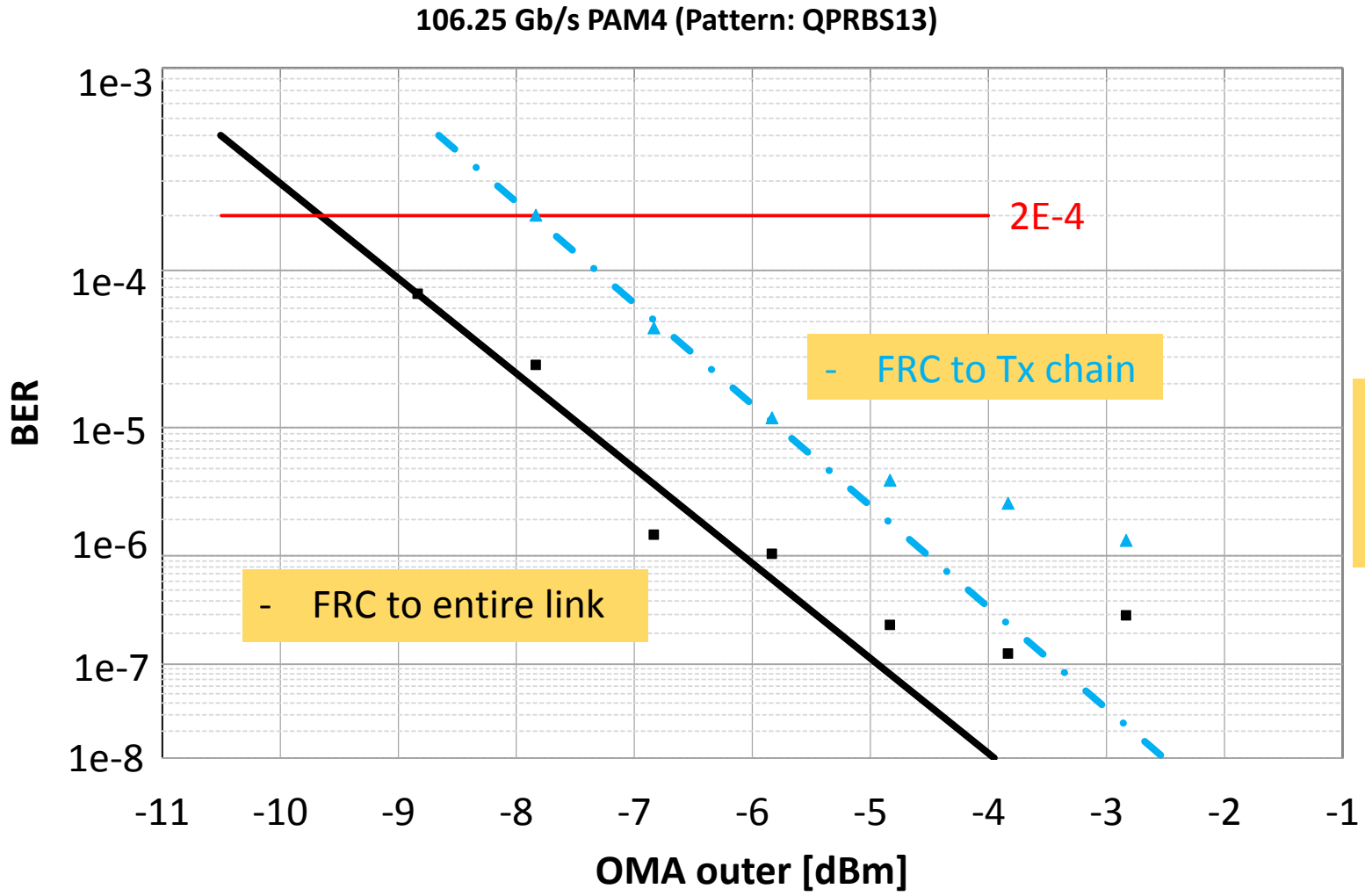


Tx Output Measured by Sampling-scope



- ER = 5 dB
- Tx RIN OMA = -150 dB/Hz

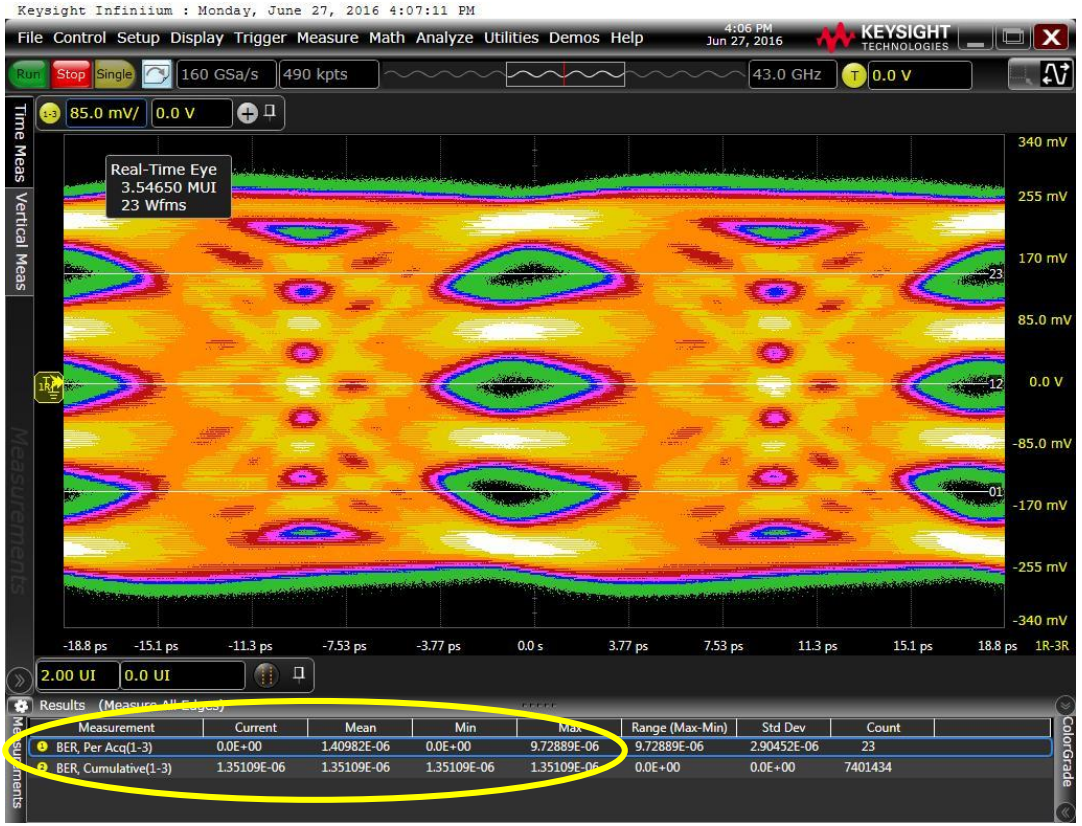
BER Measured by Real-time Scope



At 2E-4 BER
- Sen. = - 9.7 dBm (FRC to entire link)
- Sen. = - 7.9 dBm (FRC to Tx chain)

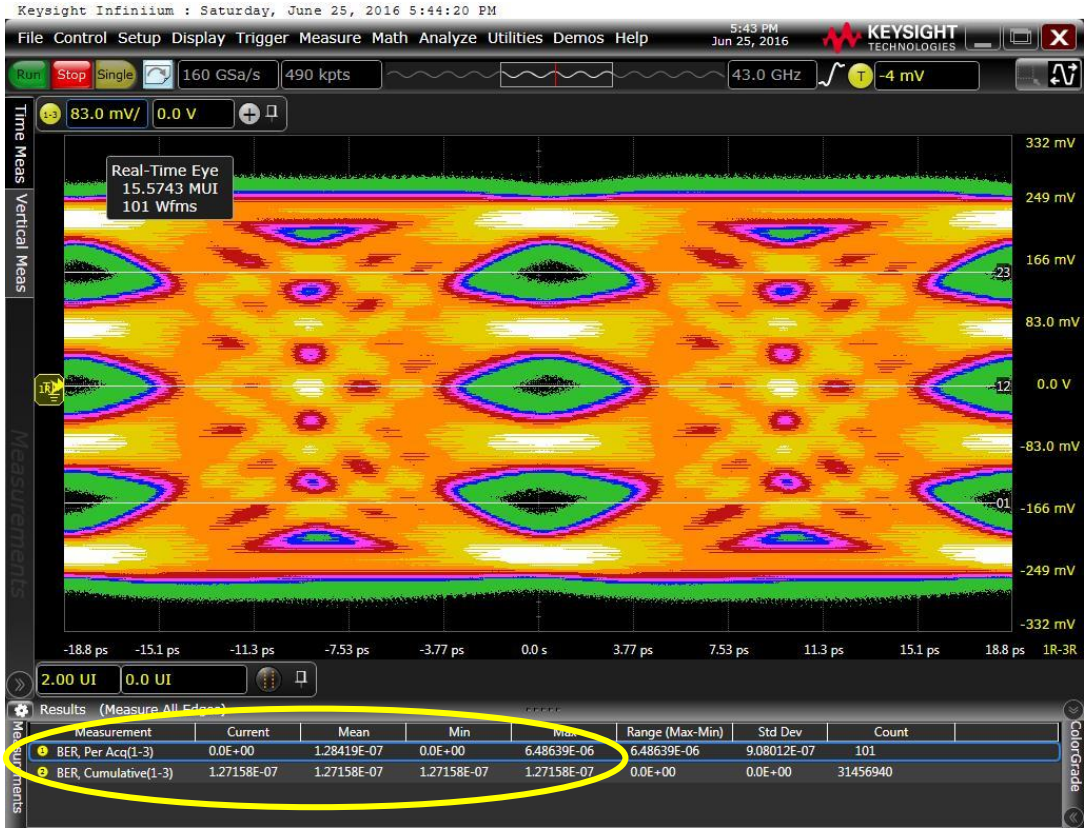
Eye Diagrams Measured by Real-time Scope

FRC applied to Tx chain



BER = 1.35E-6

FRC applied to entire link



BER = 1.27E-7

Summary

- Consistent results from post-processing and real-time scope measurements
- Achieved < 1E-6 BER with QPRBS13 data pattern
- Measured Rx sensitivity (OMA outer @ 2E-4 BER) has > 5 dB margin over the spec in IEEE 400GBASE-DR4 spec (Draft 2.0)

Acknowledgement:

Test equipment were kindly provided by Keysight Technologies.

Thank you

Backup

Post Processing Resolution Limit

- Total number of sampling points captured = 2^19 = 524288 samples
- 160GS/s Sampling rate gives 6.25 ps between samples
- Total sampling time = 3276800 ps (524288 X 6 = 3145728 GS at 960 GS/s up converted)
- Baud rate 53.125 $\Rightarrow$ Symbol period = 18.8235 ps,
- # of symbols captured = sampling time/symbol period = 174080 (5.75E-6 SER = 2.87E-6 BER)
- 166000 symbols and discarding few ~20-30 before for FFE and rest at the end. (6.024E-6 SER)

- QPRBS13 = 15548 symbols
- Only 15548 X 10 = 155480 symbols out of 166000 were chosen, leading to 3.21E-6 BER Resolution
- # of symbols discarded = 166000-155480 = 10520