PAM-8 Optical Simulations

IEEE 100GNGOPTX Study Group

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Overview

- Simulation setup and feasibility of PAM-8 optical

- Baseline link model and performance for PAM-2

- Impact of rise times and jitter

- PAM-8 optical eyes

- PAM-8 receive eye

- Next step

Basic Simulation Assumptions

- Modulator is linear amplitude modulator
  - 4 input signal with amplitude 1/7, 2/7, and 4/7 are linearly summed into MZ modulator

- Modulator Type MZ RC BW of 34 GHz zero chirp
  - Input electrical signal $V\pi/2$

- RIN=-150 dBm/Hz

- TX Wavelength=1280 nm

- TX DJ = 0 or 2 ps

- TX Output Power = - 3 dBm

- Optical transmitter 20-80% rise/fall 8 or 12 ps

- Data pattern=PN12

- Extinction Ratio= 7.5 dB

- Receiver BW=28 GHz PD+TZ/PostAMP with 1 kΩ

- Receiver sensitivity at -16 dBm at 1e-5
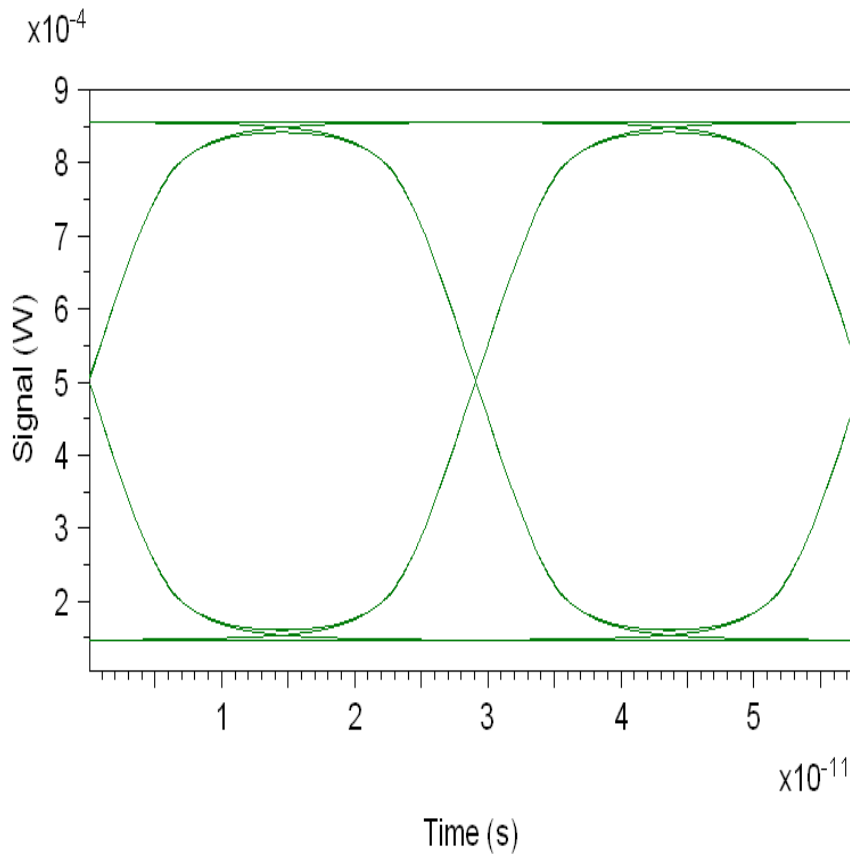
- Rsoft Schematic
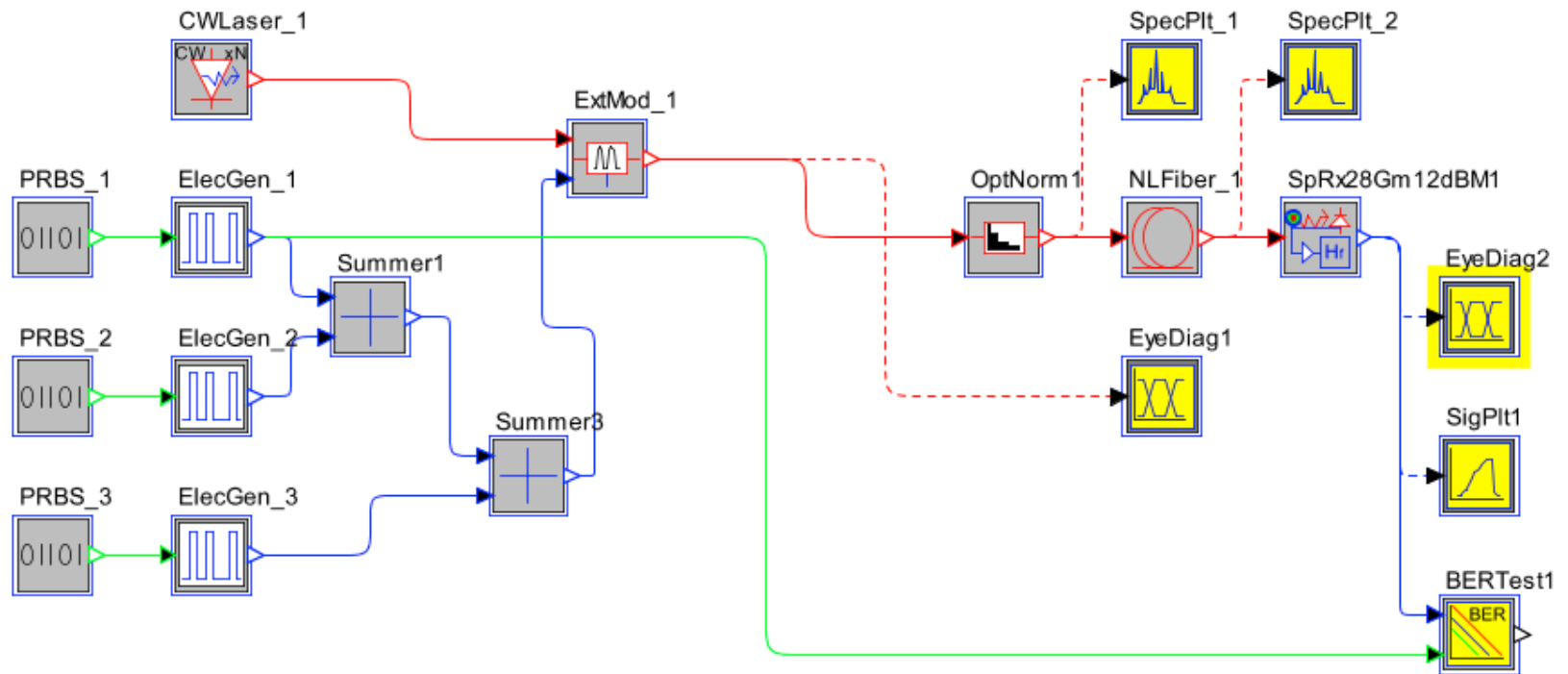
Optical Receiver Response

- Response of a realistic PD+TZ AMP with 28GHz BW as well as response of 34 GHz BT4 front end
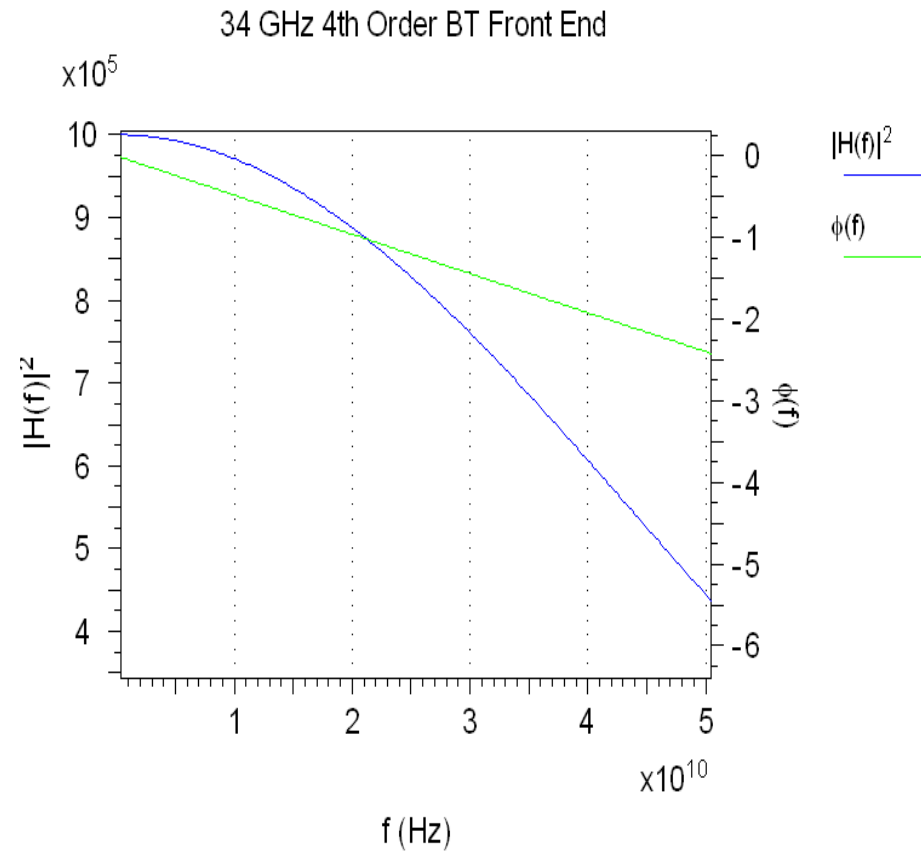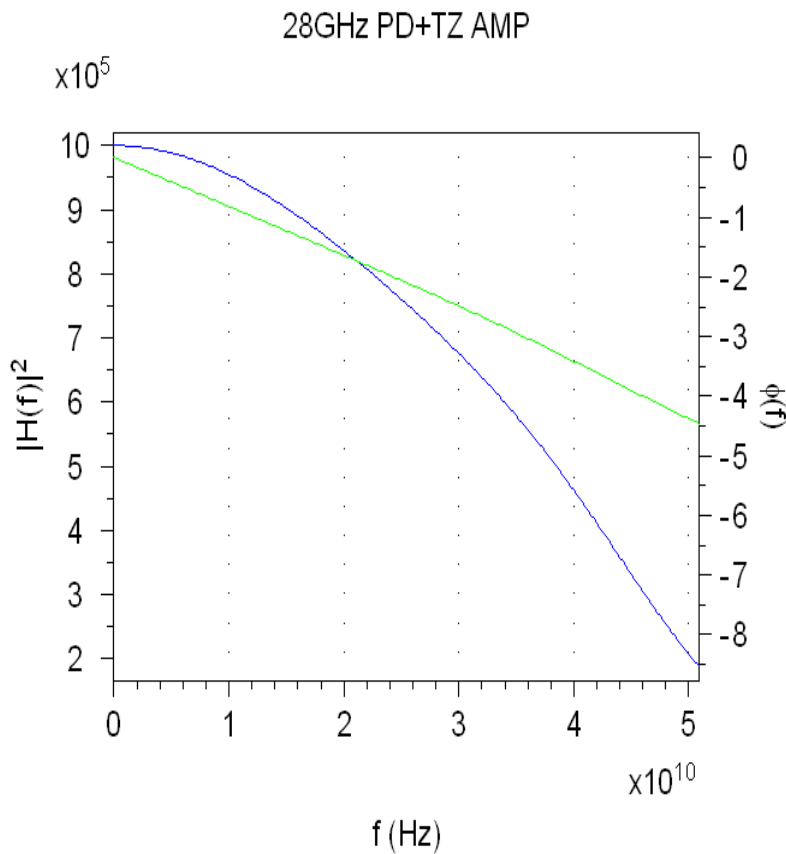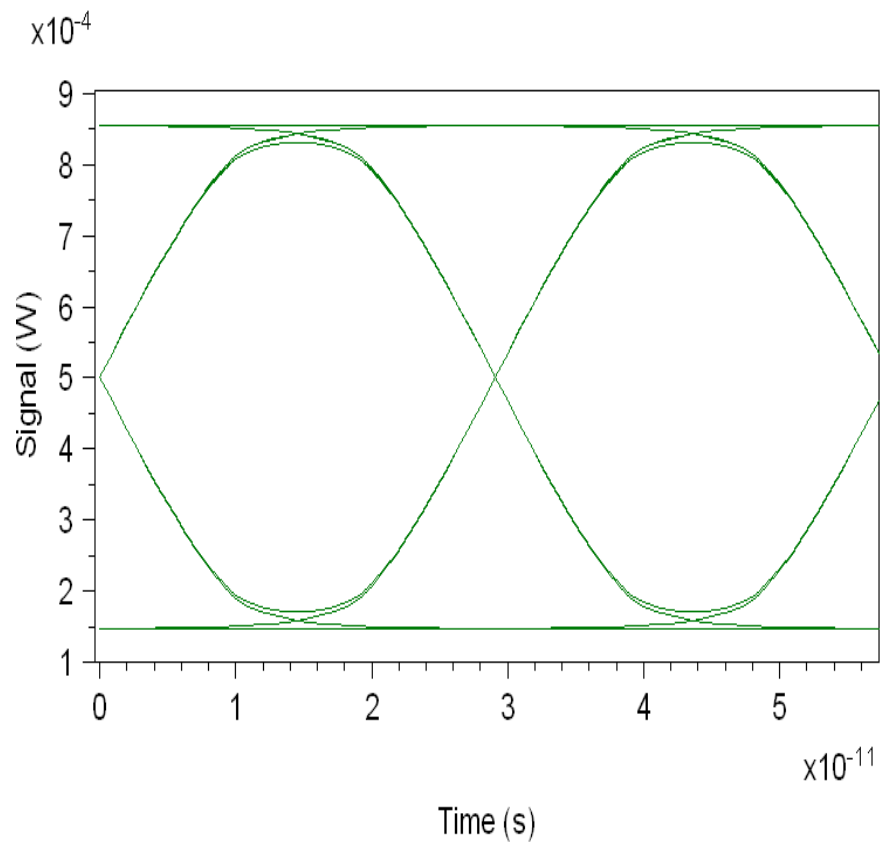
Transmitter PAM-2 Response

- Fast transmitter with 8 ps and slow transmitter with 12 ps 20-80% rise time
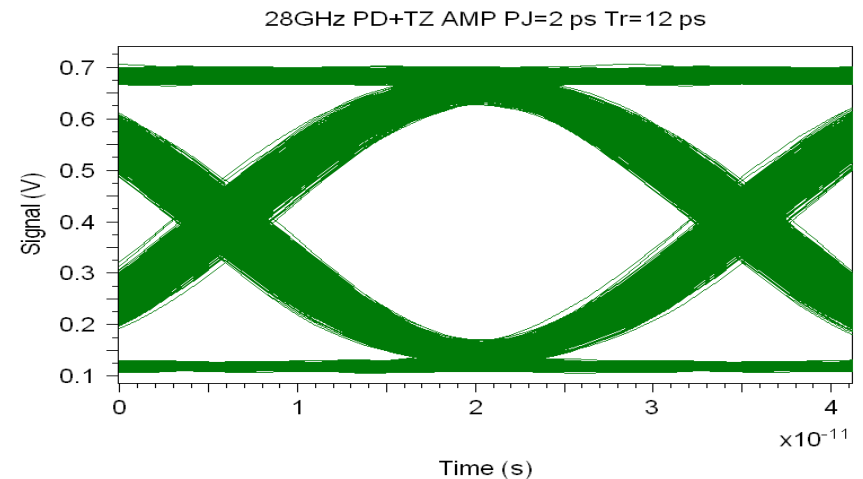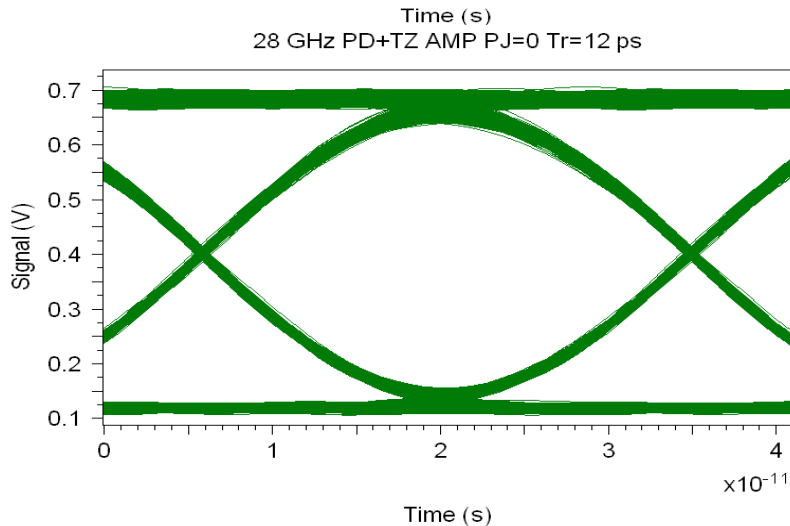
- Receive eyes after 2 km for 28GHz PD+TZ AMP for 8 ps and 12 ps 20-80% transmitter trise, with and without 2 ps of PJ.

RX Eye 28 GHz PD+TZ AMP PJ=0

RX Eye 28GHz PD+TZ PJ=2 ps

28 GHz PD+TZ AMP PJ=0 Tr=12 ps
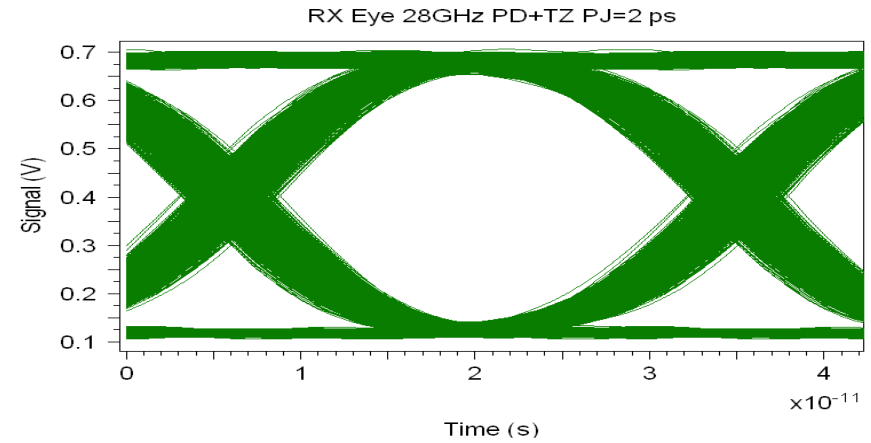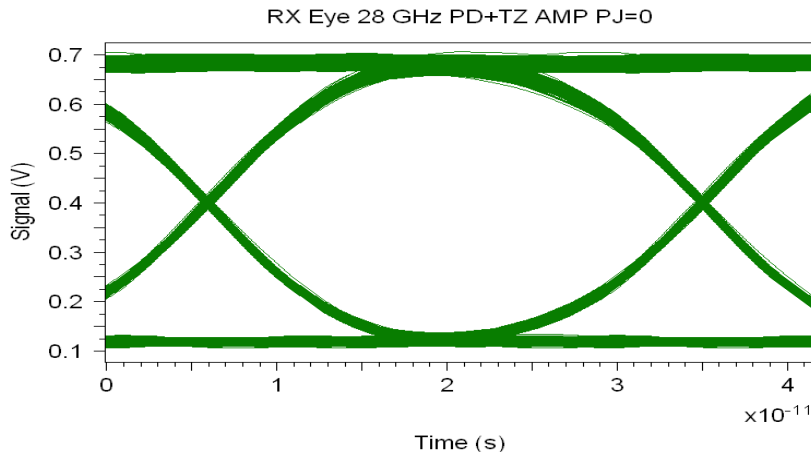
28GHz PD+TZ AMP PJ=2 ps Tr=12 ps

- For 8 ps 20-80% rise time optical transmitter
  - With no TX jitter and with PJ=2 ps

- For 12 ps 20-80% rise time optical transmitter
  - With no TX jitter and with PJ=2 ps

Transmitter Optical Eye PJ=0 Tr=12 ps
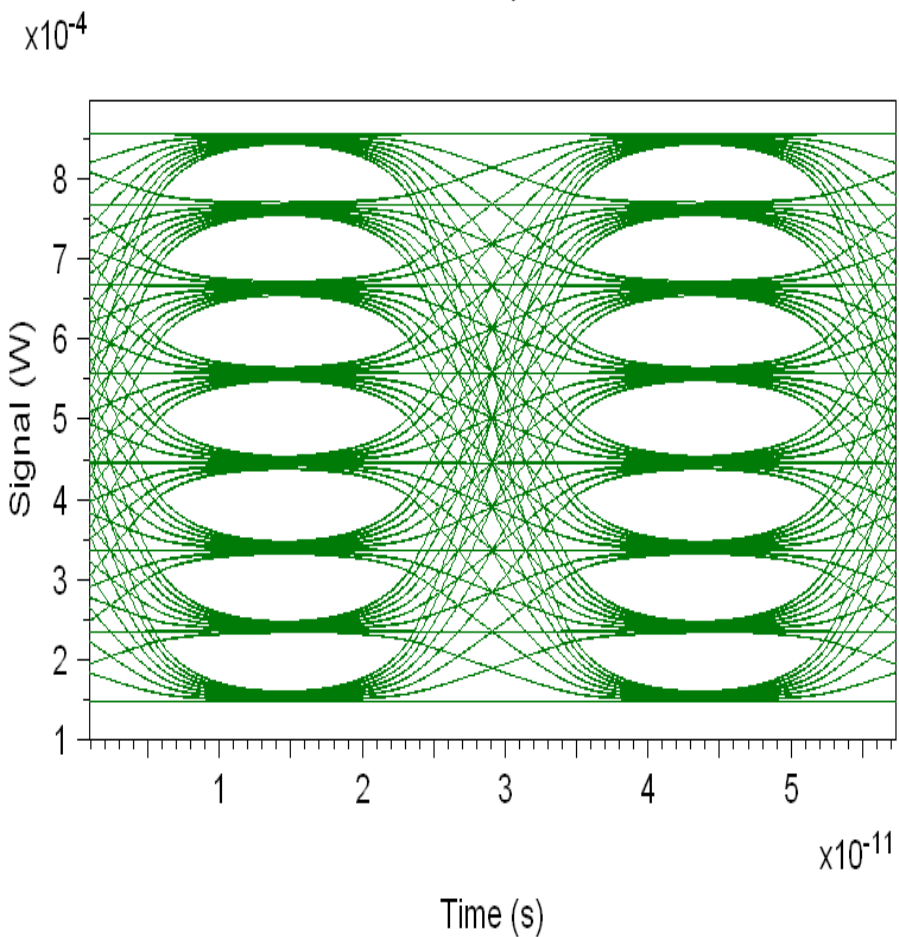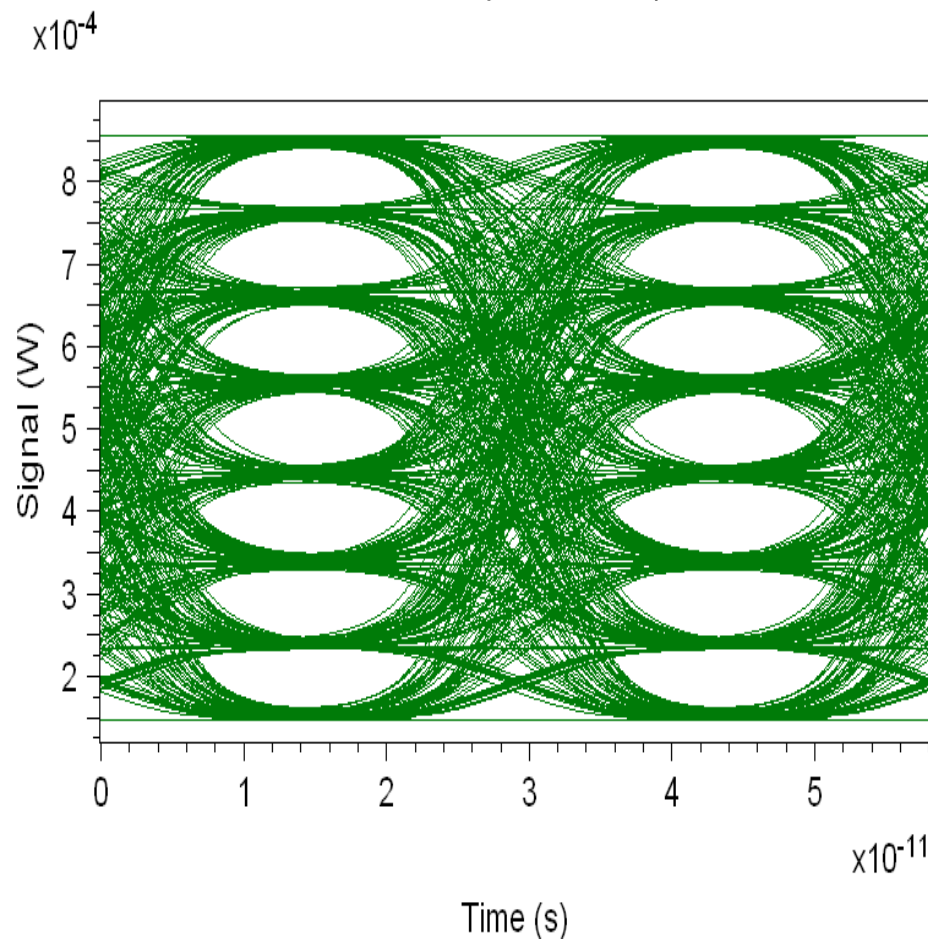
PAM Optical TX Eye PJ=2ps Tr=12 ps
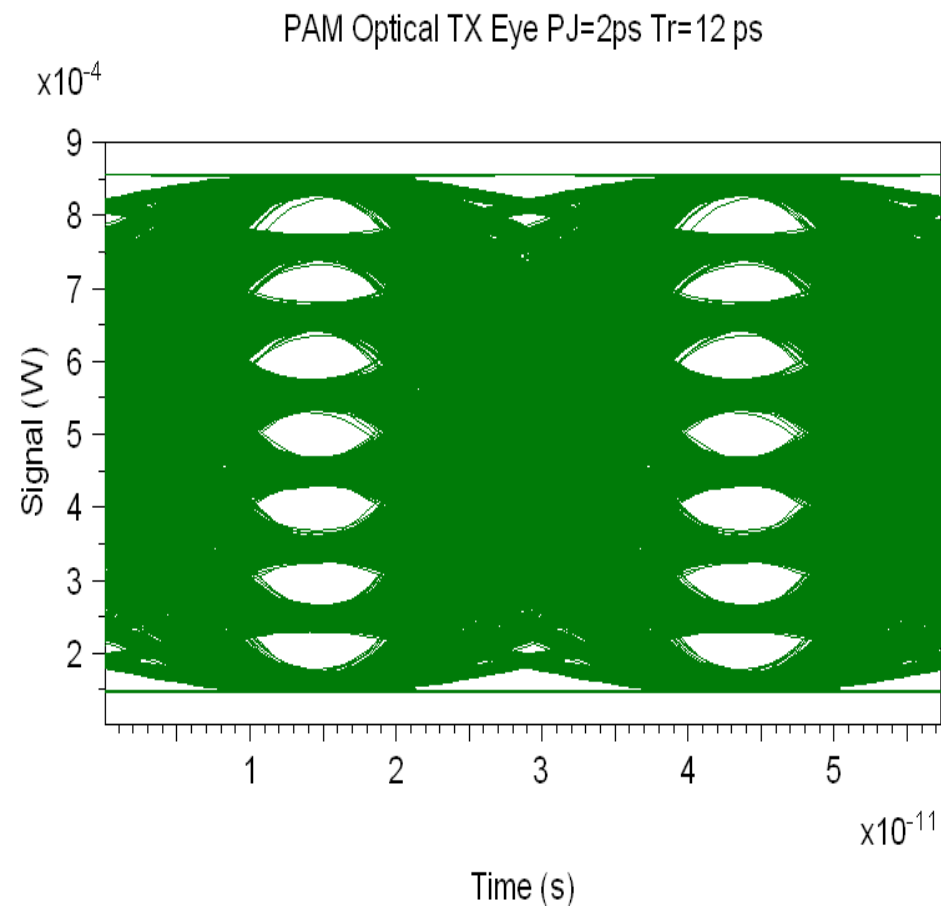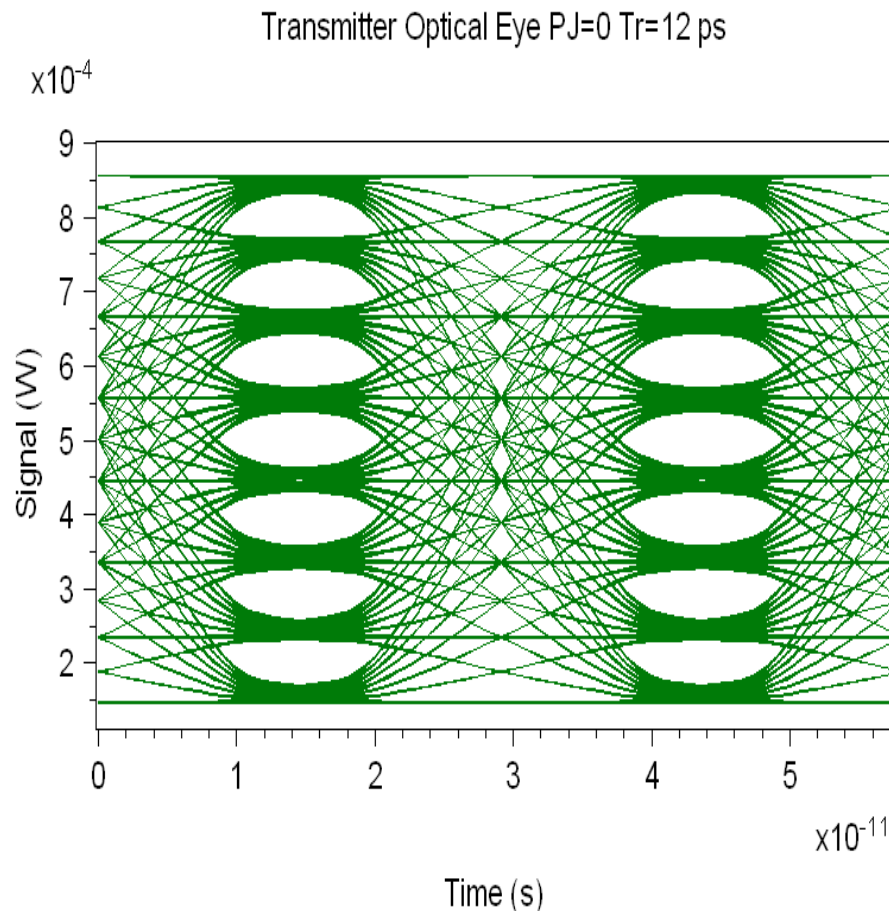
Receive Eye without TX Jitter

- For the 8 ps and 12 ps transmitter with PJ=0 ps
  - All simulation with 2 km of SMF28 eye is practically identical to 2m

RX Eye 28GHz TIA PJ=0 L=2 km

RX Eye 28 GHz TIA L= 2km PJ=0 Tr=12 ps
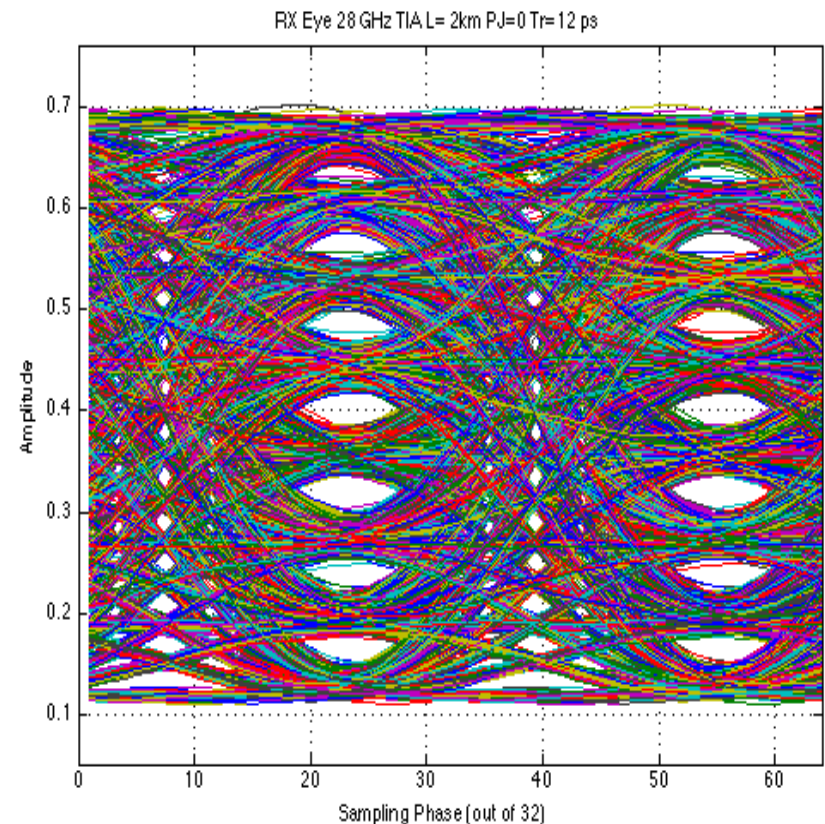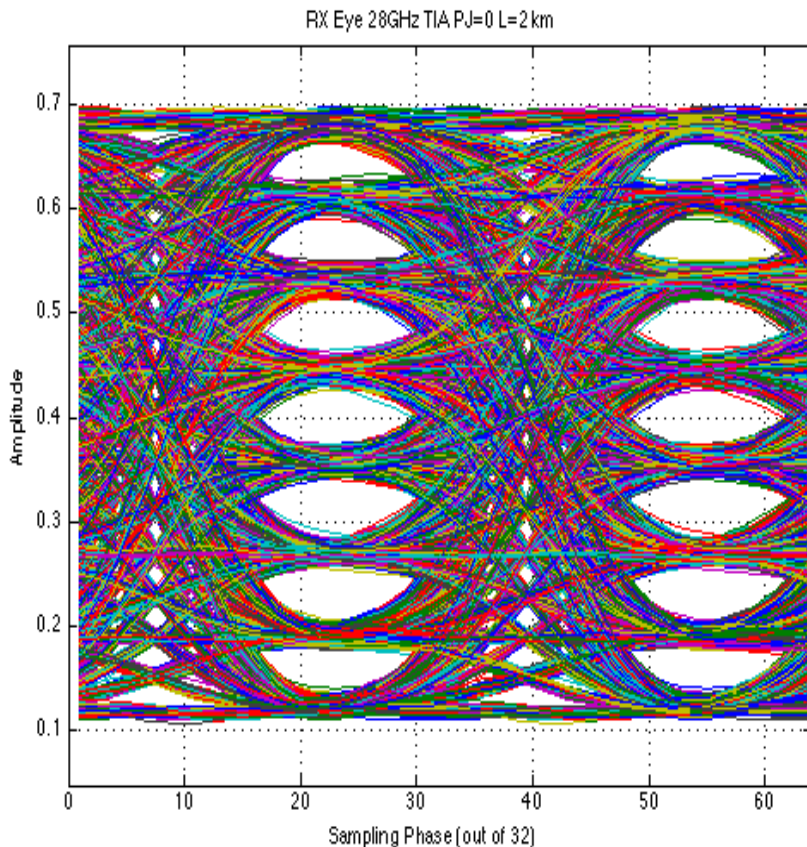
Receive Eye with PJ=2ps Jitter

- For the 8 ps and 12 ps transmitter with PJ=2 ps
  - All simulation with 2 km of SMF28 eye is practically identical to 2m

RX Eye 28GHz TIA PJ=2 ps L=2 km

RX Eye with 28Ghz TIA L=2km PJ=2ps Tr=12 ps

- 802.3 SMF connector return loss 26 dB has not been revised since the days of 802.3z or some 15 years ago

- Connector class of return loss available
  - PC polished RL better than 26 dB
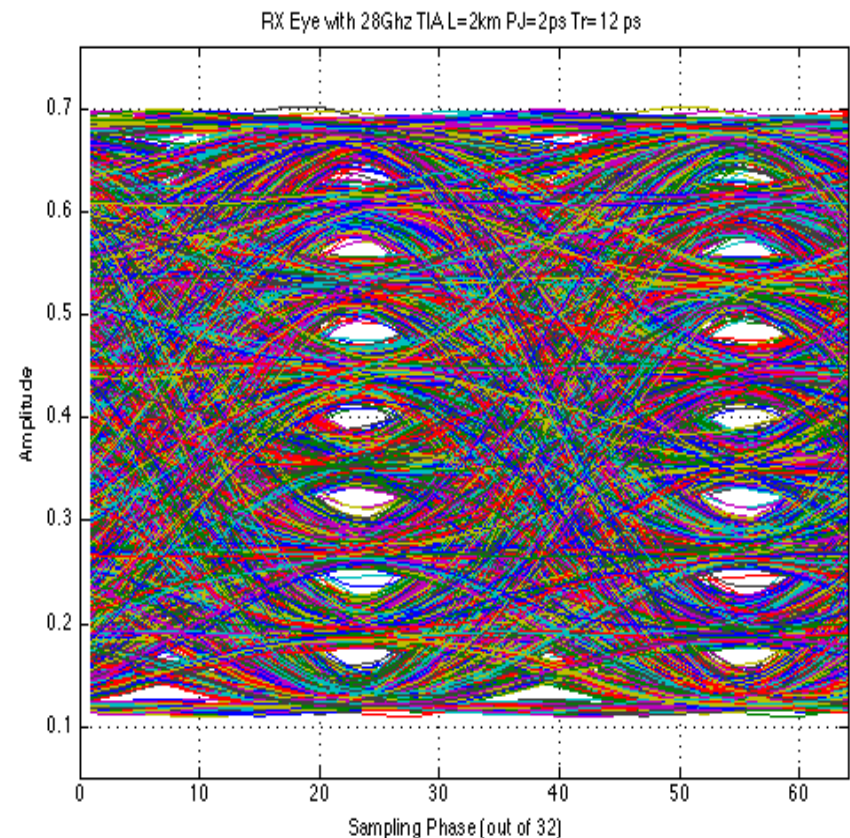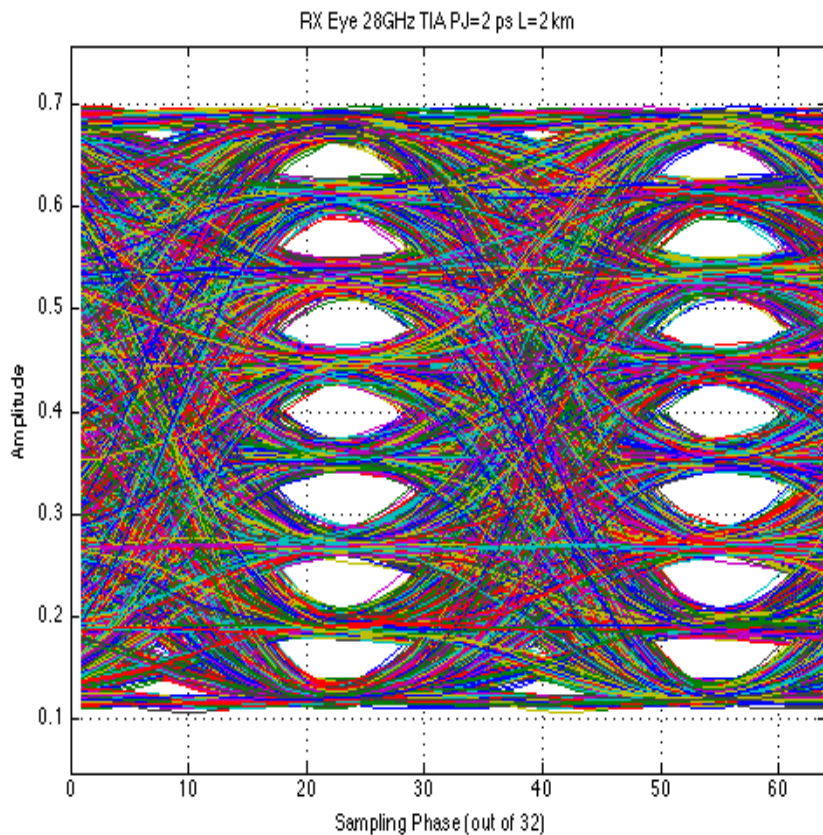   - I was not even able to purchase PC jumpers from a major cable supplier in Bay area as everything they build is either UPC or APC and I was told it will cost me more to build PC polished as all their automated equipment's is setup for UPC or APC
  - UPC polished RL better than 35 dB
  - APC polished RL better than 60 dB

- Over the same period we have introduced two generation of MMF fiber the OM3 and the OM4

- UPC connector if maintained it is guaranteed to meet RL of 35 dB
  - All PC/UPC connectors to meet the worst case RL they must be dirt free, scratch free, and have no air gap

- Installed based already is using either UPC or APC
  - MPI is an small overall penalty if connector RL is 35 dB.

- MPI penalty from reference below compared to the spreadsheet which assume single path cord

  http://www.ieee802.org/3/100GNGOPTX/public/mar12/plenary/ghiasi_03_0312_NG100GOPTX.pdf

Multipath Inteference Penalty for ER=8 dB

Summary
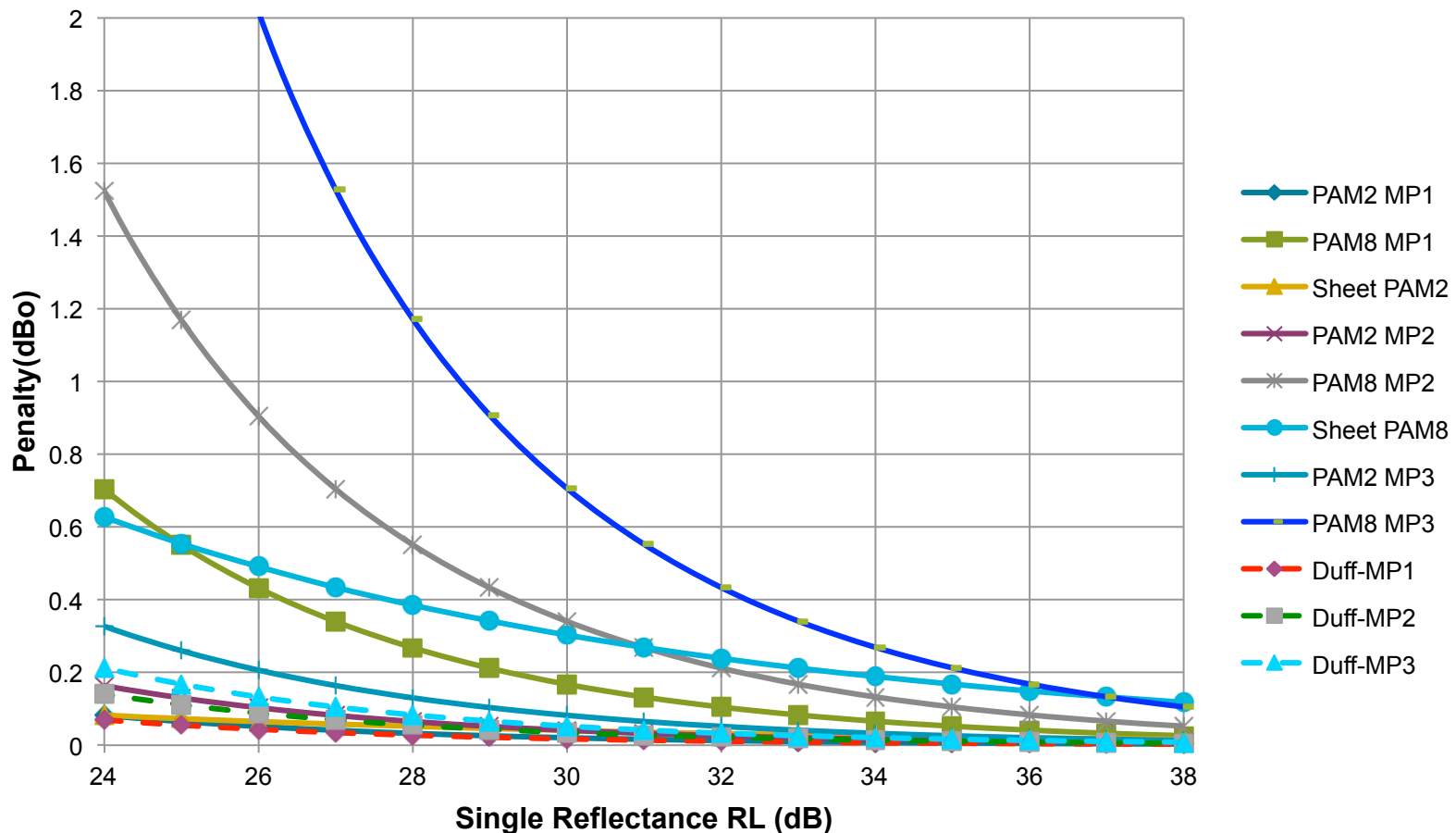
- The fiber B2B nearly identical to 2km so result not shown

- The receiver has realistic front end as well as noise power spectral density resulting in -16 dBm sensitivity for PAM-2

- RSOFT time domain simulation include realistic driver, transmit jitter, MZ modulator with 34 GHz RC BW
  - With concern raised during March meeting realistic jitter and rise time are considered in these simulations
  - Increasing transmit optical rise time from 8 ps to 12 ps does significantly close the PAM-8 eyes and PJ of 2 ps to lesser extend

- With modern connector such as UPC with max RL of 35 dB MPI penalty is <0.25 dB assuming 3 coherent pathcord interference
  - IEEE spreadsheet only uses single patchcord and the penalty is even less!

- Next step is to investigate if moderate equalizer can compensate PAM-8 receive eye degradations as well looking into other advance modulation such as CAP-16 and QAM-16.

Thank You