Impacts of Chromatic Dispersion and PMD on 40Gbit/s EPON with PAM Modulation

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PAM – Advantages and limitations

- Pulse Amplitude Modulation is an advantaged optical modulation technique for future high speed Ethernet (40Gb/s, 100Gb/s…)
- PAM is low cost modulation method
  - It has higher spectrum efficiency
  - Still uses IM – DD
  - Low speed optics can be used for high speed system
- It is well known that PAM requires higher S/N
- In this contribution the impacts of fiber chromatic dispersion and PMD on PAM will be discussed

Factors that impact the performance of PAM

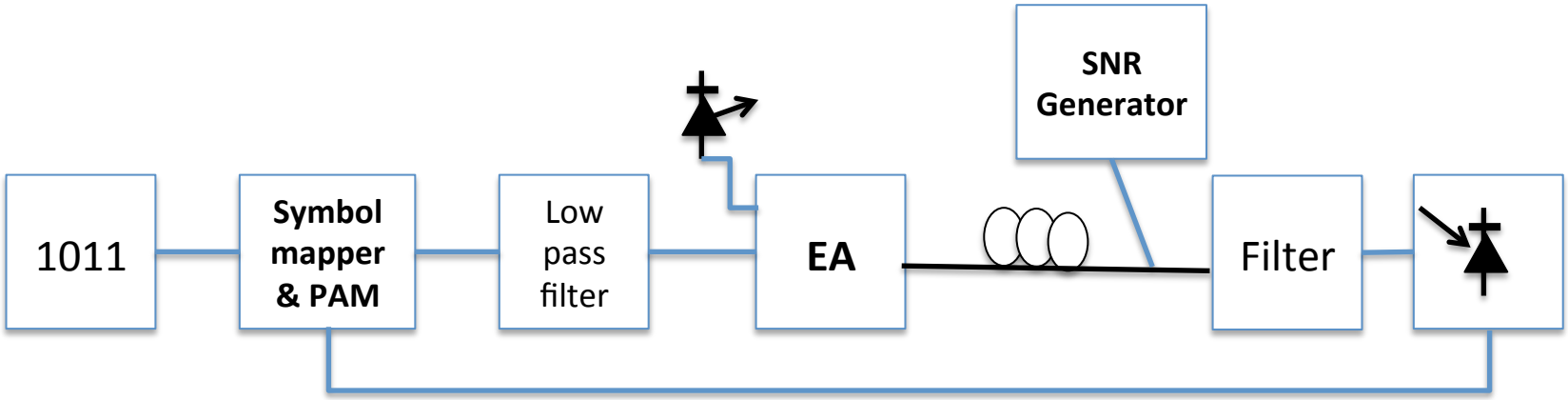
The BER of PAM can be expressed as

$$BER = \frac{M-1}{Mlog_2 M} erfc\left(\sqrt{\frac{3}{2(M^2-1)}\frac{S}{N}}\right)$$

Where M is PAM modulation order and S/N is signal-to- noise ratio.

- **For example, assuming BER = 10^{-6}, the S/N required for PAM-8 is 26.56 dB**
- **Chromatic dispersion and PMD of optical fiber may have significant impacts on the performance of PAM**

PAM– 4 optical simulation setup



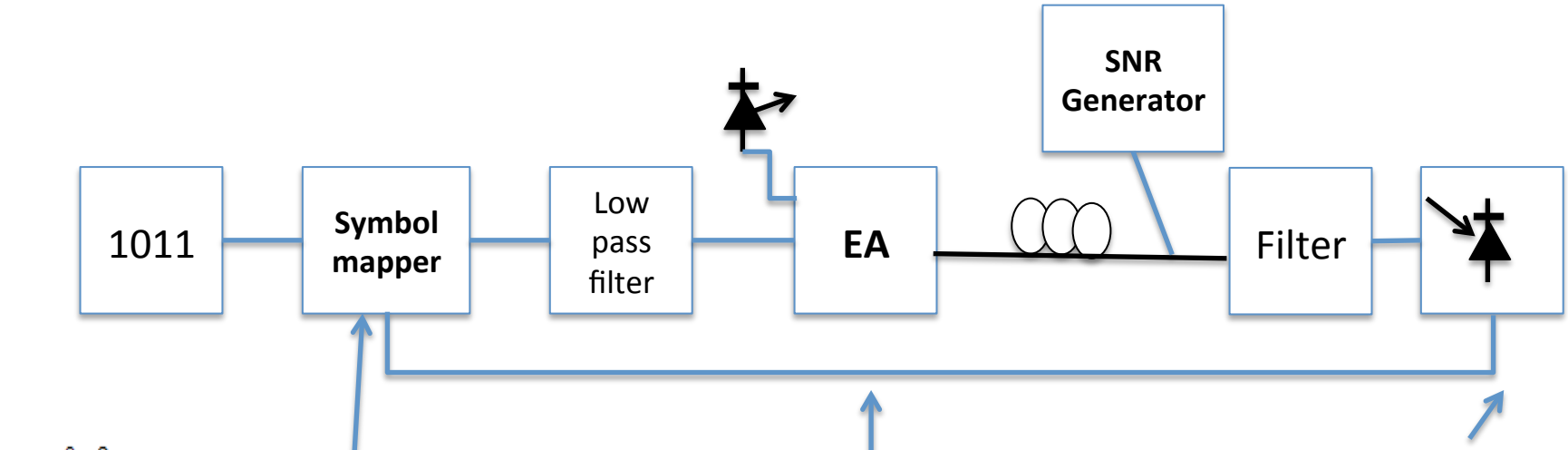
Simulation parameters

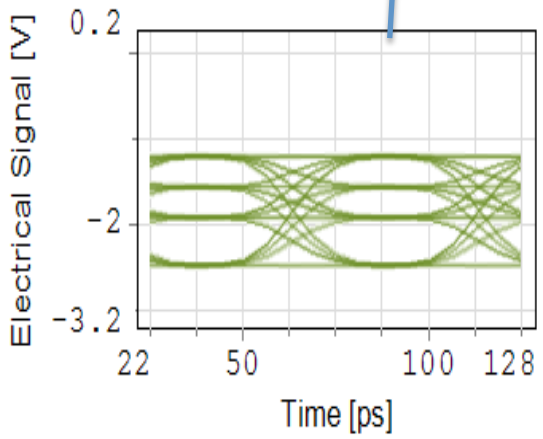
- Wavelength: C,S,E & O bands
- Fiber length = 20 km
- C band dispersion = 16 ps/nm/km
- PMD = 1.58 10^{-11} s/m
- Bits per symbol = 2
- Baud rate = 20 Gbaud/s
- Bit rate = 40Gbit/s

Simulation Methods

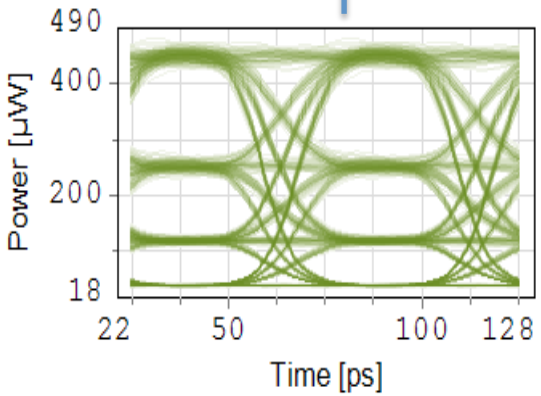
- Vary dispersion to study the impact of dispersion on SER (symbol error rate)
- Vary PMD to study the impact of PMD on SER

Reference Points

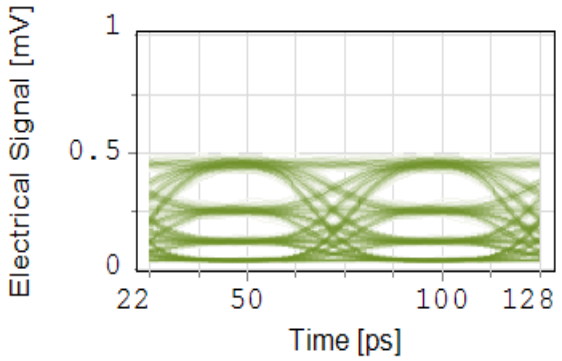




Electrical signal

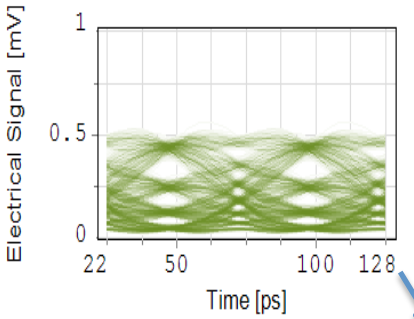


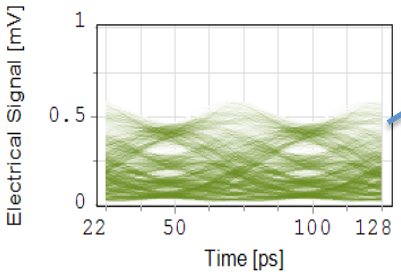
Optical signal



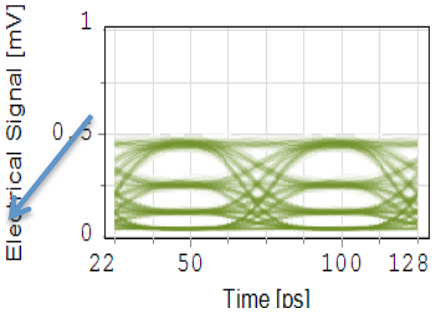
Received electrical signal

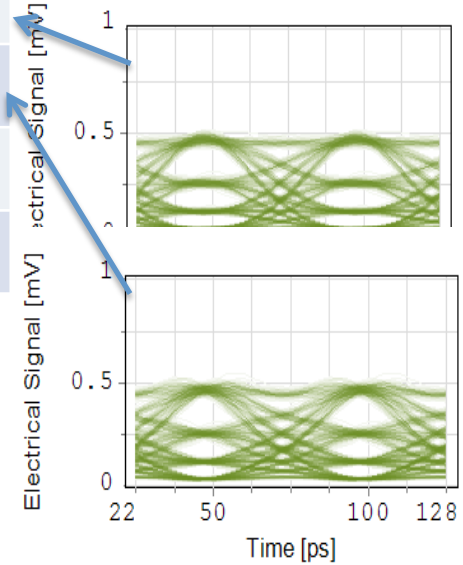
Impacts of dispersion on SER





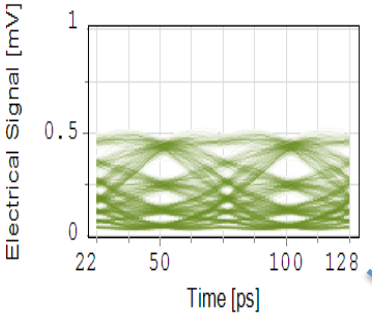
Dispersion(ps/nm/km)	PMD	Symbol Error Rate
0	0	2.112×10^{-12}
¼ of 16	0	4.758×10^{-11}
½ of 16	0	3.766×10^{-9}
¾ of 16	0	2.707×10^{-4}
16	0	1.622×10^{-2}

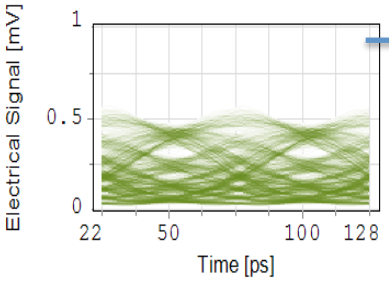




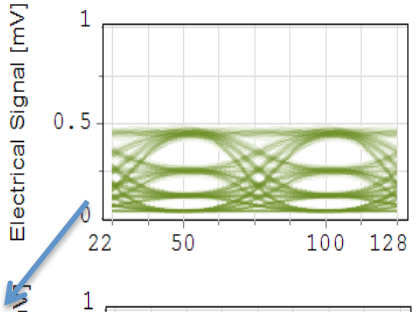
Dispersions have significance impacts on SER of PAM at 20Gbaud/s

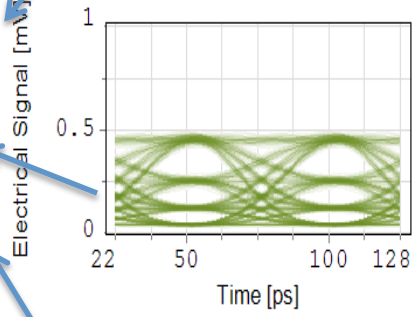
Impact of dispersion and PMD on SER

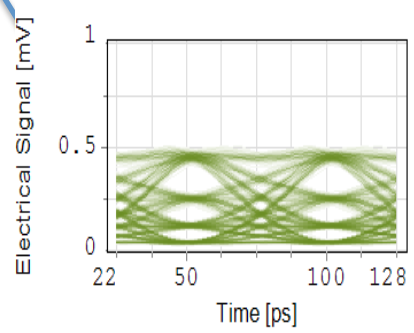




Dispersion (ps/nm/km)	PMD	Symbol Error Rate
0	full	1.364×10^{-8}
¼ of 16	full	1.843×10^{-7}
½ of 16	full	6.594×10^{-5}
¾ of 16	full	3.692×10^{-3}
16	full	3.0×10^{-2}





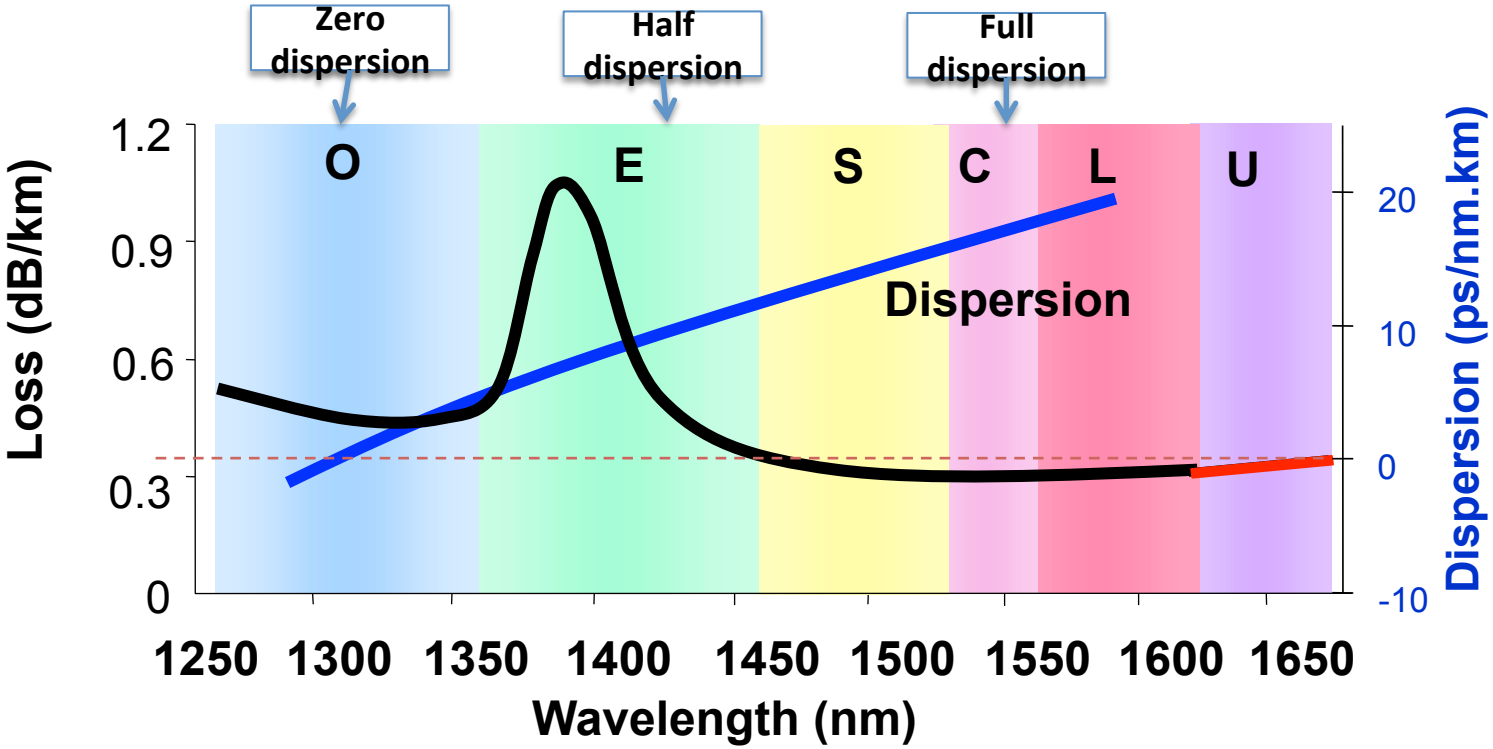


PMD has noticeably impacts on SER at low dispersion regions

Impacts of dispersion and PMD on SER of PAM

- Dispersions have significance impact on SER of PAM at 20Gbaud/s
- PMD has noticeably impact on SER at low dispersion regions (2- 4 orders)
- High dispersions will mask the effects of PMD on SER
- There is no good way to control PMD
- Understand the impacts of dispersion on SER of PAM is important in choosing the wavelength plan

Choices of Wavelengths



- C band wavelengths experience full dispersion, not preferred for PAM-4 at 20Gbaud/s without compensation
- E band is suitable for PAM-4 at 20Gbaud/s, but has higher attenuations
- O band is the best choice for PAM-4 at 20Gbaud/s

Conclusions

- **Dispersions at have significance impact on SER of PAM-4 at 20Gbaud/s**
- **PMD has noticeably impact on SER of PAM at 20Gbaud/s at low dispersion regions**
- **C band is not preferred for PAM-4 at 20Gbaud/s without dispersion compensation**
- **E band is suitable for PAM-4 at 20Gbaud/s, but has higher attenuations**
- **O band is the best choice for PAM-4 at 20Gbaud/s**

Thanks

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