



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



Eugene (Yuxin) Dai PhD

Cox Communications

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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

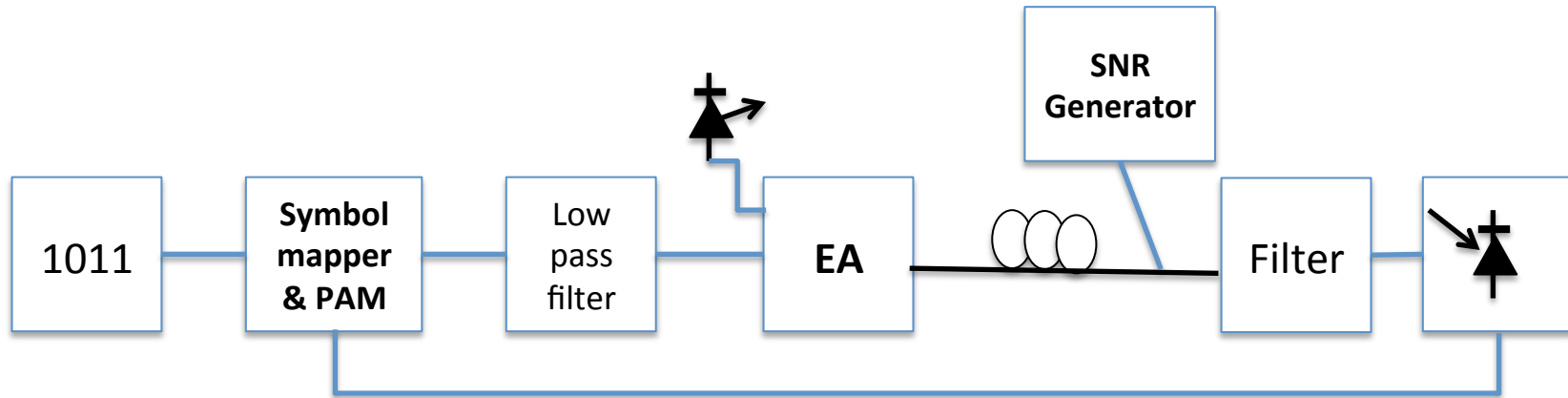
The BER of PAM can be expressed as

$$BER = \frac{M-1}{M \log_2 M} \operatorname{erfc} \left(\sqrt{\frac{3}{2(M^2-1)} \frac{S}{N}} \right)$$

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



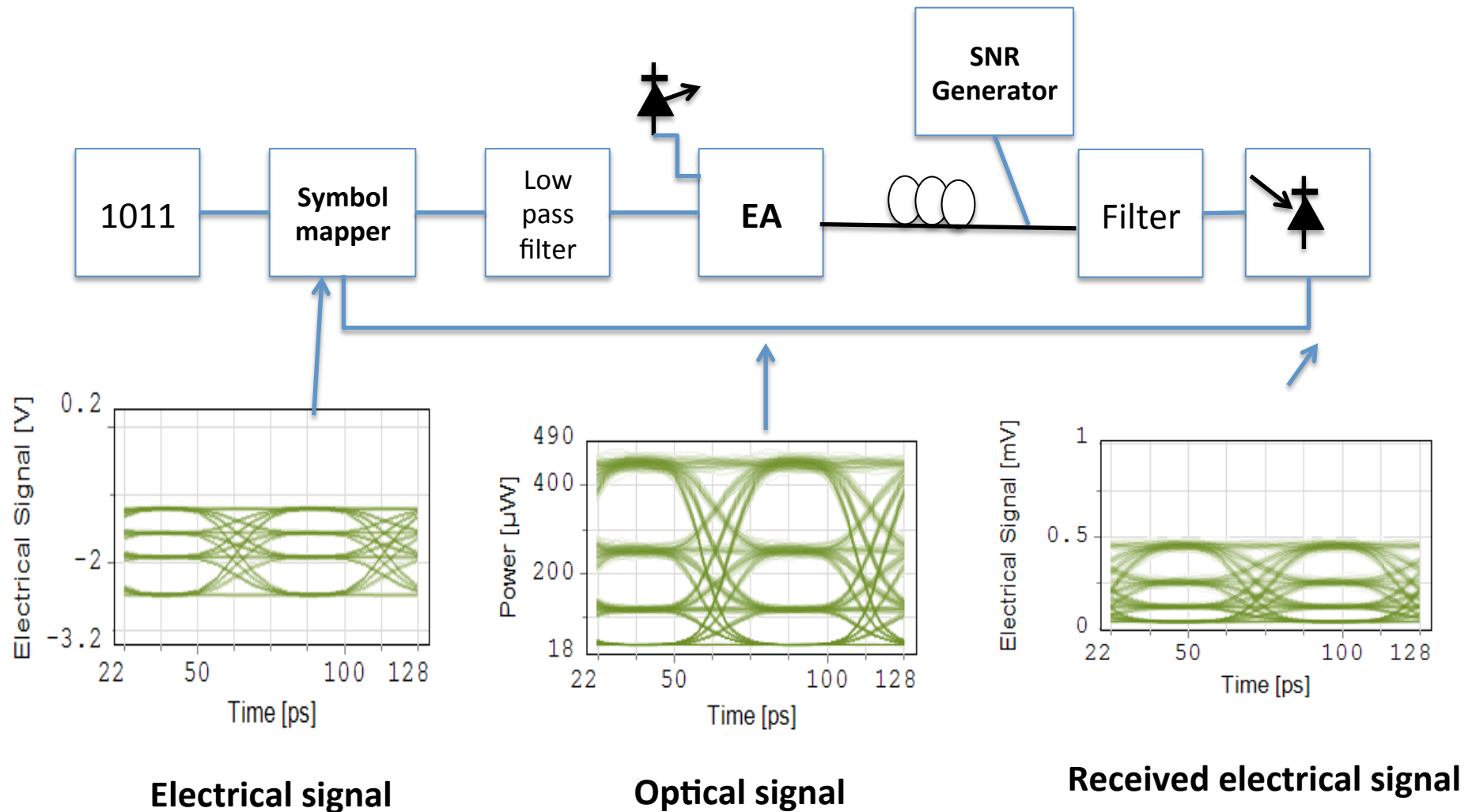
Simulation parameters

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

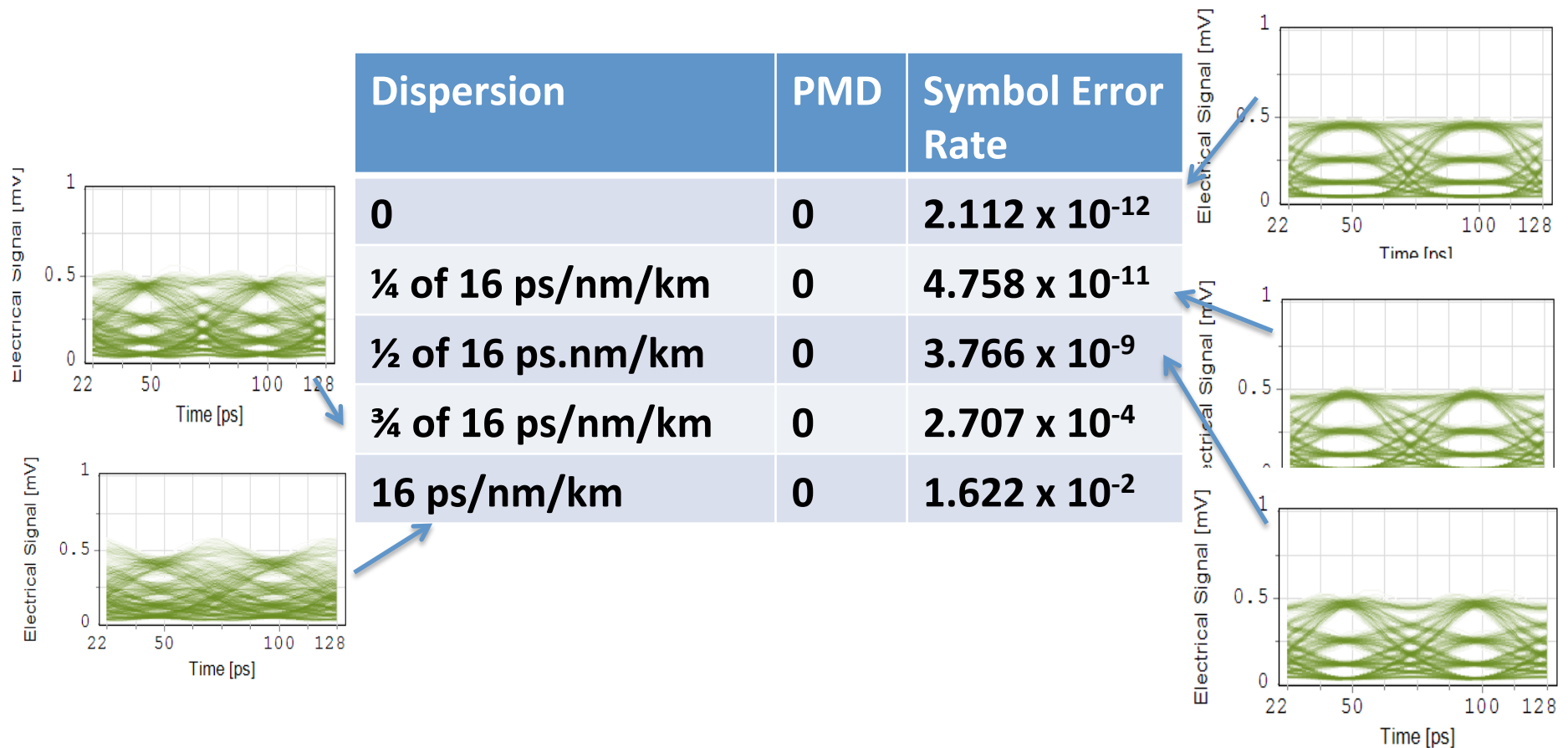
Simulation Methods

- 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

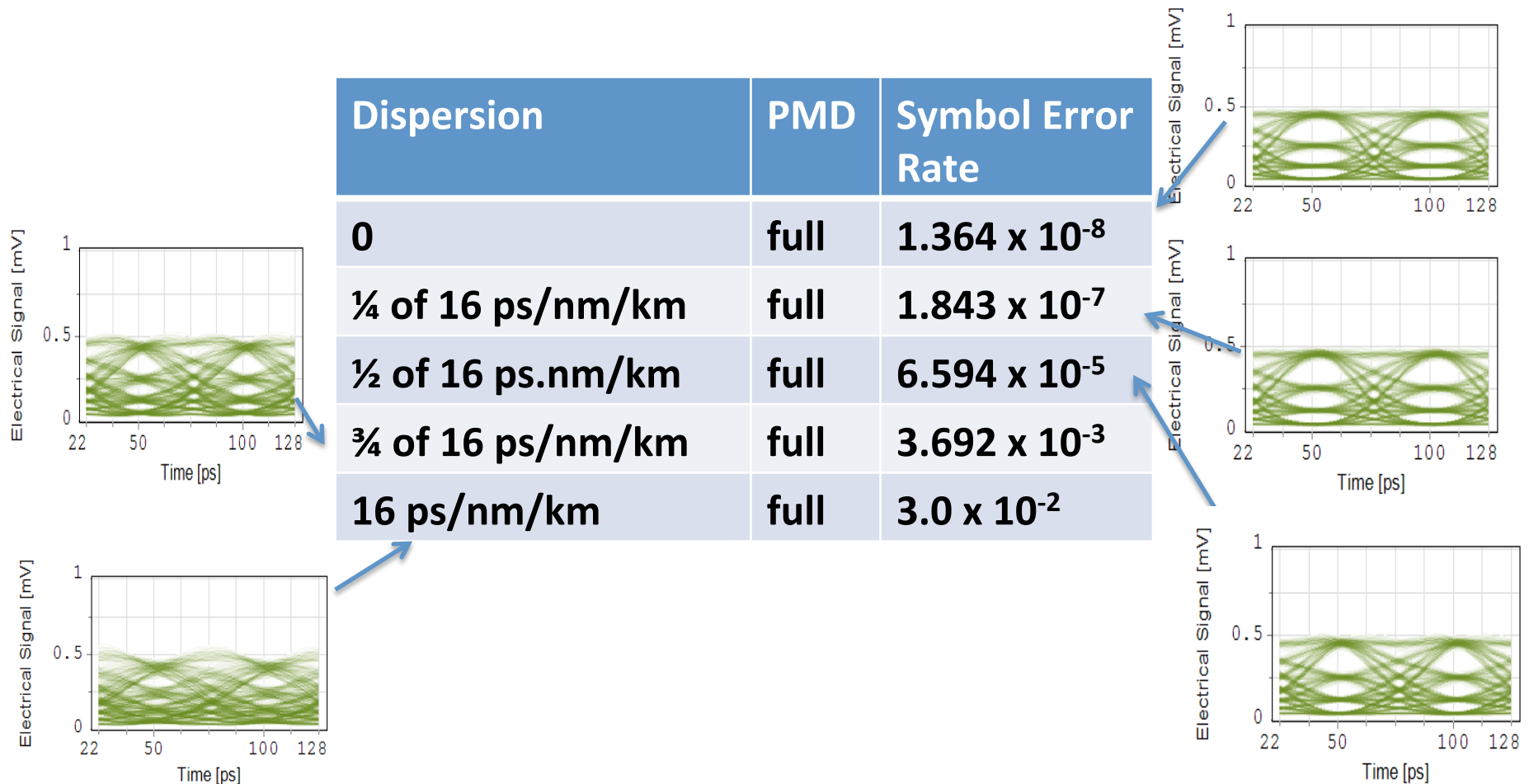


Impacts of dispersion on SER



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

Impact of dispersion and PMD on SER

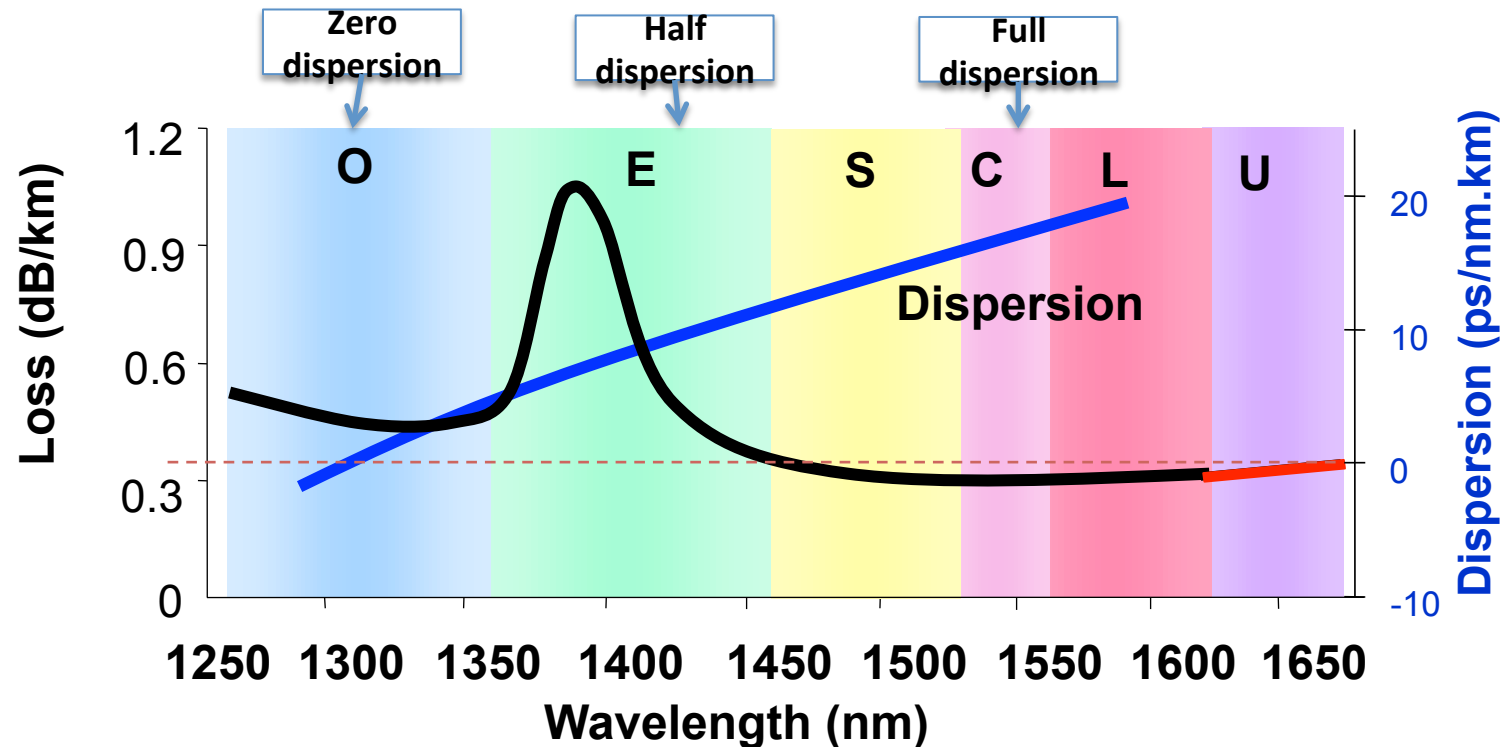


PMD has noticeably impacts on SER at low dispersion regions

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
- 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
- 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

Eugene.dai@cox.com