

# Technical feasibility of 100 Gb/s per lane MMF PMDs using VCSELs

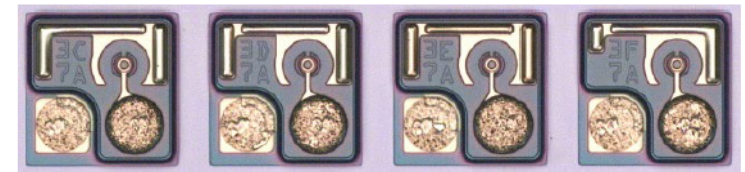
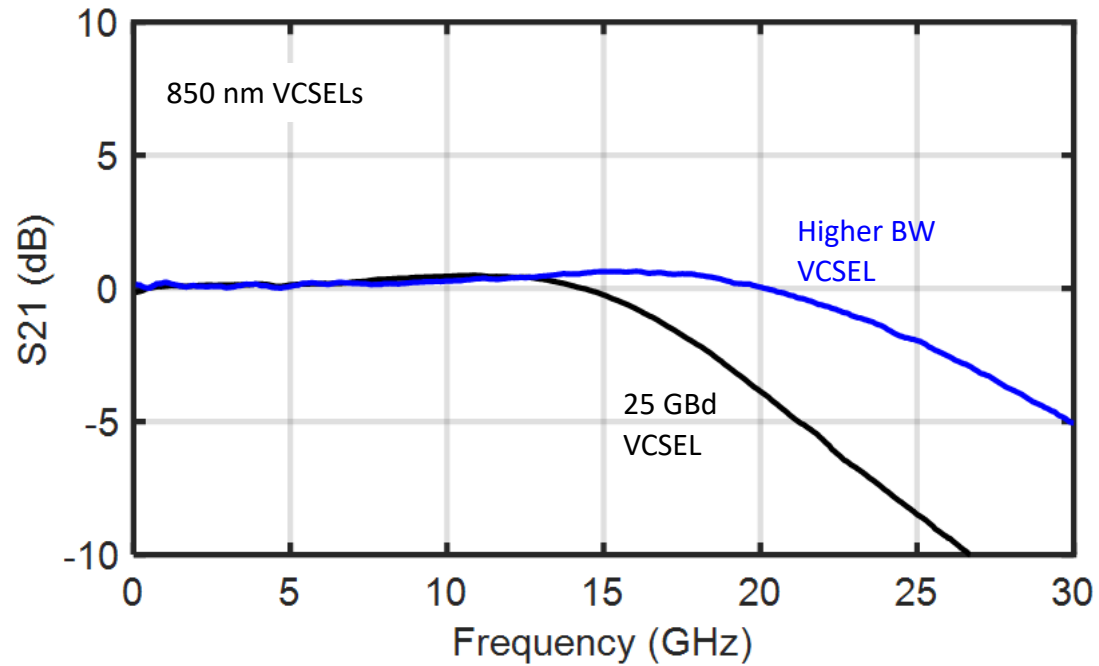
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IEEE 802.3 100 Gb/s Wavelength Short Reach PHYs Study Group  
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# Introduction

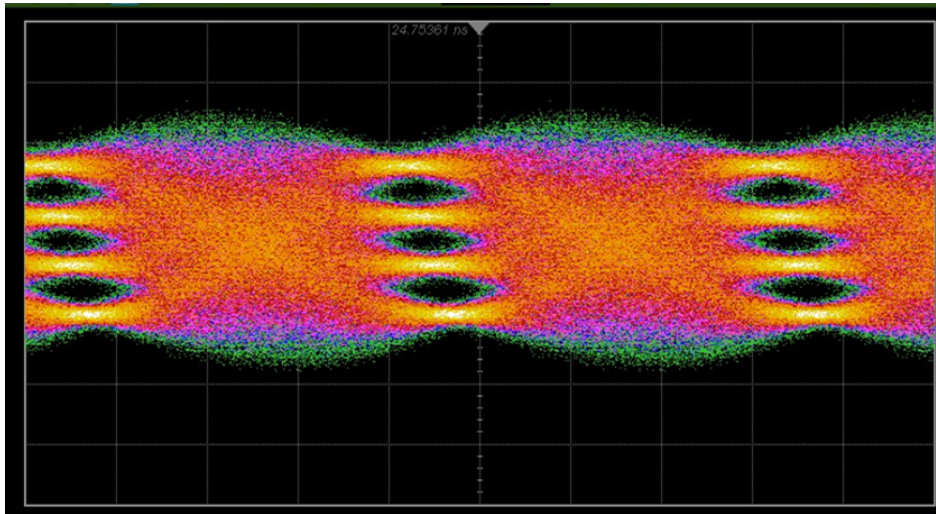
- Development of 50 GBd PAM4 VCSEL is in progress
  - Substantial increase in bandwidth over 25 GBd VCSELs for 400GBASE-SR8 and 400GBASE-SR4.2 achieved
  - Targeting low RIN and k factor to reduce modal noise and MPN penalties in the link
- 50 GBd PAM4 VCSEL can lead to a low-cost solution for next generation short-reach optical links
  - 850 nm wavelength will continue the use of OM3 and OM4 MMF
  - Equalization (pre-emphasis and Rx FFE) expected to reduce VCSEL bandwidth requirement
  - Link simulations suggest feasibility of a 50 m OM4 link

# Frequency response



Broadcom 50 GBd VCSEL under development

# Eye diagram after 75 m OM4 MMF



TDECQ: 3.7 dB

Modulation format	PAM4
Symbol rate	53.125 GBd
Pattern	PRBS15Q
Temperature	Room
Center wavelength	853 nm
RMS spectral width	0.56 nm
DCA optical plug-in bandwidth	34 GHz
DCA SIRC response	4 <sup>th</sup> -order BT
DCA SIRC bandwidth	26.6 GHz
DCA FFE	5-tap T-spaced
SER target for TDECQ	$4.8 \times 10^{-4}$

- Measured after 75 m “worst-case” OM4 MMF (estimated EMB of  $\approx 4700$  MHz km at 850 nm)
- TDECQ is within the 4.5 dB limit from Clause 138 and Clause 150

# MPN considerations

Modulation format      PAM4  
Symbol rate              53.125 GBd  
Center wavelength      844 nm  
RMS spectral width    0.6 nm  
Q                            3.41

## Chromatic Dispersion Model

Dispersion slope  $S_0$       0.10275 ps/(nm<sup>2</sup>·km)  
Dispersion zero  $U_0$       1316 nm

Link Length	k factor	MPN Power Penalty (dB)* OM4 MMF
50 m	0.1	0.07
70 m		0.22
100 m		0.60
50 m	0.05	0.02
70 m		0.05
100 m		0.14

**MPN penalty is small when k factor is less than 0.05**

\*MPN penalty calculated according to the Ogawa-Agrawal model

# Recommended path forward

- It is recommended that the Study Group decide on objectives to define:
  - a single-lane 100 Gb/s PHY over duplex MMF with lengths up to at least 50 m
  - a four-lane 400 Gb/s PHY over four pairs of MMF with lengths up to at least 50 m
- Such objectives would be expected to be met using the RS(544, 514) FEC in Clause 91 and Clause 119, thereby enabling a “PMD-only” specification
- Clause 138 and Clause 150, particularly the TDECQ and SECQ methodology, would provide an excellent technical basis for the PMD specifications