

Feasibility Of 400GBASE-LR4 Using EML Transmitters On CWDM Grid Over 10 km (6.3 dB Channel Loss) of Single Mode Fiber

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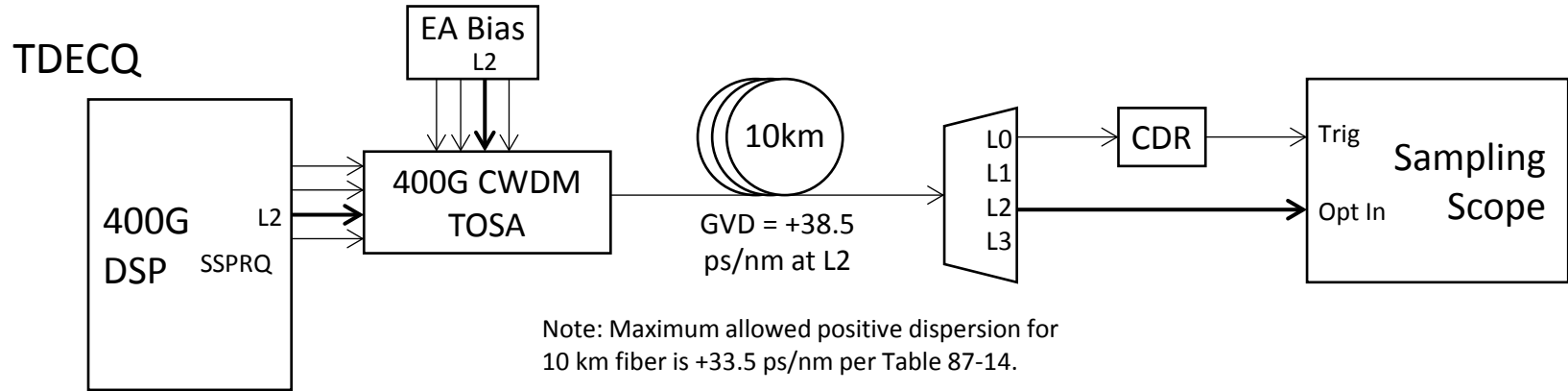
Supporters

Brian Welch, Cisco

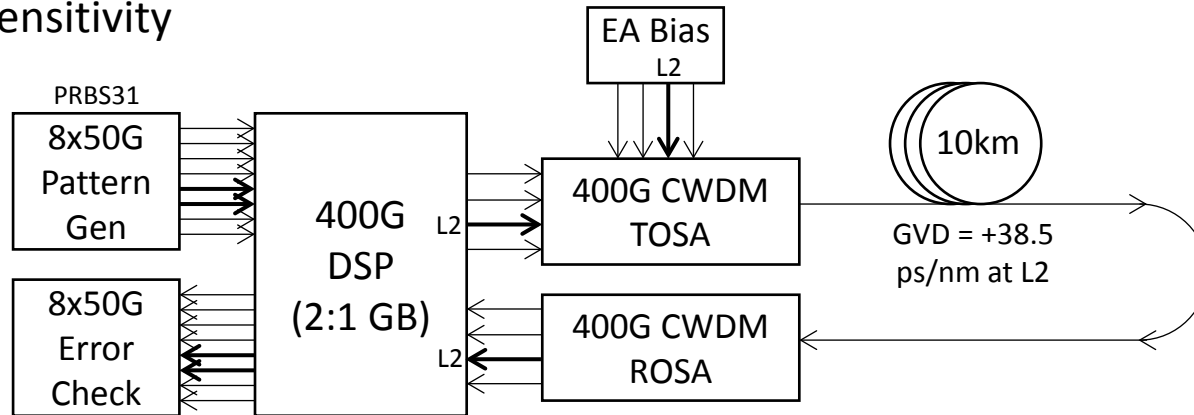
Introduction

- Data is presented that demonstrates the feasibility of 53.125 Gbaud PAM4 optical transmission over 10 km of single mode fiber with chromatic dispersion that exceeds the worst case value.
- The results suggest that the SMF channel, as specified in Table 87-14, does not need to be relaxed (i.e. shortened in reach in order to reduce the chromatic dispersion and/or loss) for a 400GBASE-LR4 specification based on the CWDM grid.

Experimental Configuration

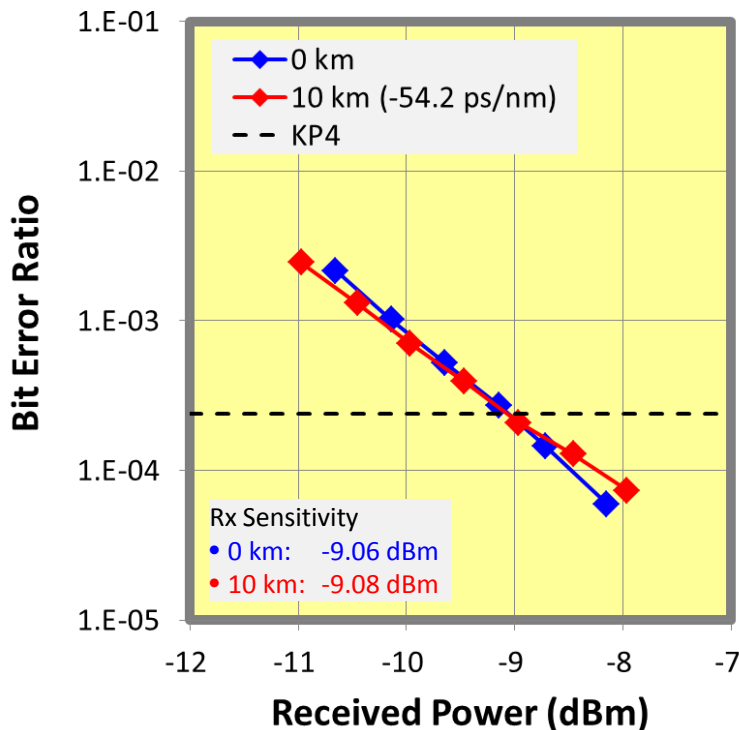


Receiver Sensitivity



Dispersion Penalty In Negative Dispersion Regime Small For EML

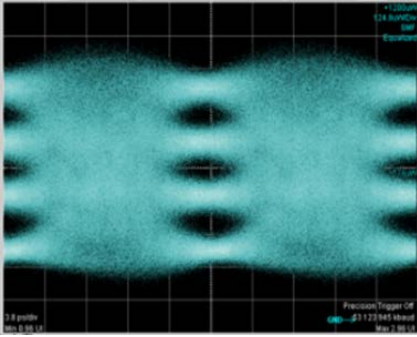
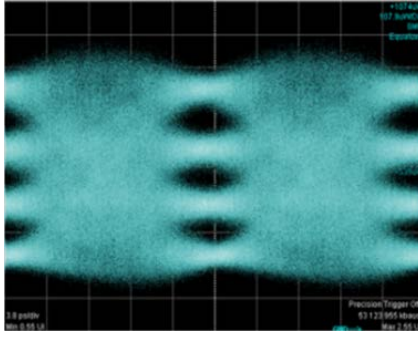
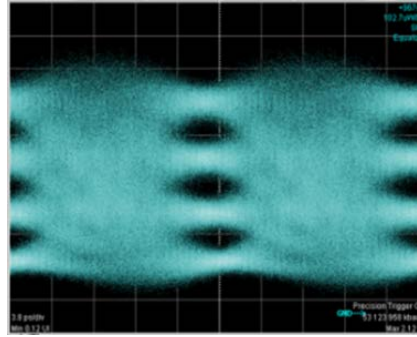
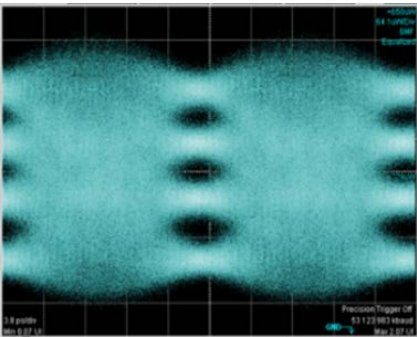
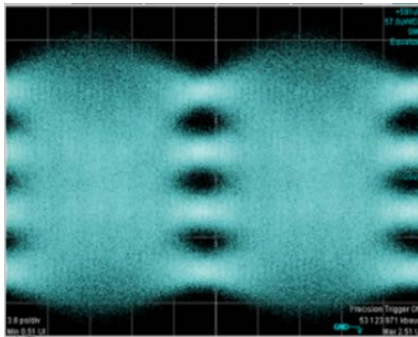
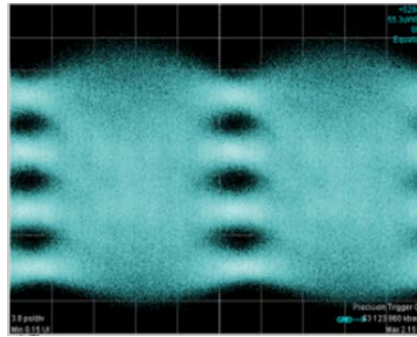
L0 Results



Note: Maximum negative dispersion is -59.5 ps/nm for 10 km SMF channel (see Table 87-14).

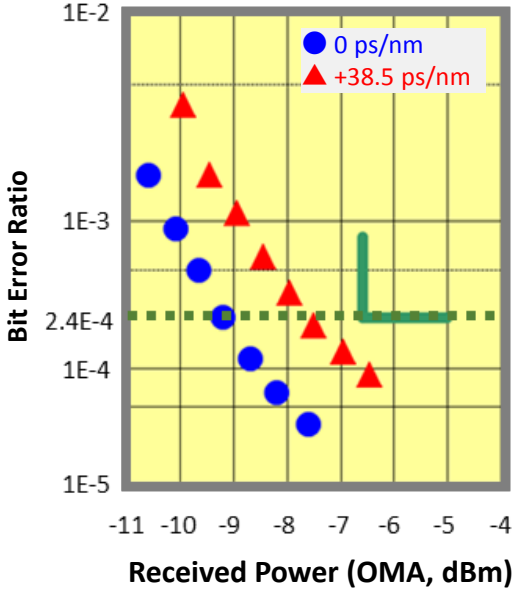
- For EML, 10 km dispersion penalty small for maximum negative dispersion, so can focus on maximum positive dispersion for worst-case dispersion penalty.

Optical Eye Before/After Maximum Positive Dispersion

	Case 1 <ul style="list-style-type: none"> • Optimum linearity and TDECQ back-to-back (default). 	Case 2 <ul style="list-style-type: none"> • Adjust inner eye levels for best linearity at 10 km (+38.5 ps/nm). 	Case 3 <ul style="list-style-type: none"> • Increase extinction ratio and adjust inner eye levels for best linearity at 10 km (+38.5 ps/nm).
0 ps/nm	 <p>EA Bias: -1.52 V TDECQ: 2.30 dB Outer ER: 5.0 dB RLM: 0.99</p>	 <p>EA Bias: -1.52 V TDECQ: 2.16 dB Outer ER: 5.0 dB RLM: 0.92</p>	 <p>EA Bias: -1.72 V TDECQ: 2.86 dB Outer ER: 6.2 dB RLM: 0.91</p>
+38.5 ps/nm	 <p>EA Bias: -1.52 V TDECQ: 3.66 dB Outer ER: 4.9 dB RLM: 0.93</p>	 <p>EA Bias: -1.52 V TDECQ: 3.31 dB Outer ER: 5.0 dB RLM: 0.99</p>	 <p>EA Bias: -1.72 V TDECQ: 3.31 dB Outer ER: 6.2 dB RLM: 0.98</p>

BER and Rx Sensitivity Before/After Maximum Positive Dispersion

CIG

	Case 1	Case 2	Case 3
	<ul style="list-style-type: none">Optimum linearity and TDECQ back-to-back (default).	<ul style="list-style-type: none">Adjust inner eye levels for best linearity at 10 km (+38.5 ps/nm).	<ul style="list-style-type: none">Increase extinction ratio and adjust inner eye levels for best linearity at 10 km (+38.5 ps/nm).
BER	 <p>Legend: 0 ps/nm (blue circle), +38.5 ps/nm (red triangle)</p> <p>Y-axis: Bit Error Ratio (1E-5 to 1E-2)</p> <p>X-axis: Received Power (OMA, dBm) (-11 to -4)</p>	 <p>Legend: 0 ps/nm (blue circle), +38.5 ps/nm (red triangle)</p> <p>Y-axis: Bit Error Ratio (1E-5 to 1E-2)</p> <p>X-axis: Received Power (OMA, dBm) (-11 to -4)</p>	 <p>Legend: 0 ps/nm (blue circle), +38.5 ps/nm (red triangle)</p> <p>Y-axis: Bit Error Ratio (1E-5 to 1E-2)</p> <p>X-axis: Received Power (OMA, dBm) (-11 to -4)</p>
Rx Sens (dBm) 0 ps/nm	-9.15	-8.87	-7.81
Rx Sens (dBm) +38.5 ps/nm	-7.51	-8.00	-7.82
Penalty (dB)	1.64	0.87	-0.01

Summary / Conclusions

- Dispersion penalty investigated for 53.125 GBd PAM4 EML transmitters over SMF channel with dispersion exceeding maximum of allowed positive dispersion ($> +33.5$ ps/nm).
- Operating point (extinction ratio, linearity) at 0 km can be set to minimize dispersion penalty.
- Results support feasibility of 400GBASE-LR4 specification using CWDM grid, where single mode fiber channel has reach of 10 km, maximum loss of 6.3 dB, maximum positive dispersion of $+33.5$ ps/nm, and minimum negative dispersion of -59.5 ps/nm (Note: Dispersion penalty at 10 km is small in negative dispersion regime for EML, so only positive dispersion needs examination).

Tables 87-14 and 88-14

	From Table 87-14	From Table 88-14
Description	40GBASE-LR4	100GBASE-LR4
Operating distance (max)	10	10
Channel insertion loss ^{a, b} (max)	6.7	6.3
Channel insertion loss (min)	0	0
Positive dispersion ^b (max)	33.5	9.5
Negative dispersion ^b (min)	-59.5	-28.5
DGD_max ^c	10	8
Optical return loss (min)	21	21

^aThese channel insertion loss values include cable, connectors, and splices.

^bOver the wavelength range 1264.5 nm to 1337.5 nm.

^cDifferential Group Delay (DGD) is the time difference at reception between the fractions of a pulse that were transmitted in the two principal states of polarization of an optical signal. DGD_max is the maximum differential group delay that the system must tolerate.