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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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.

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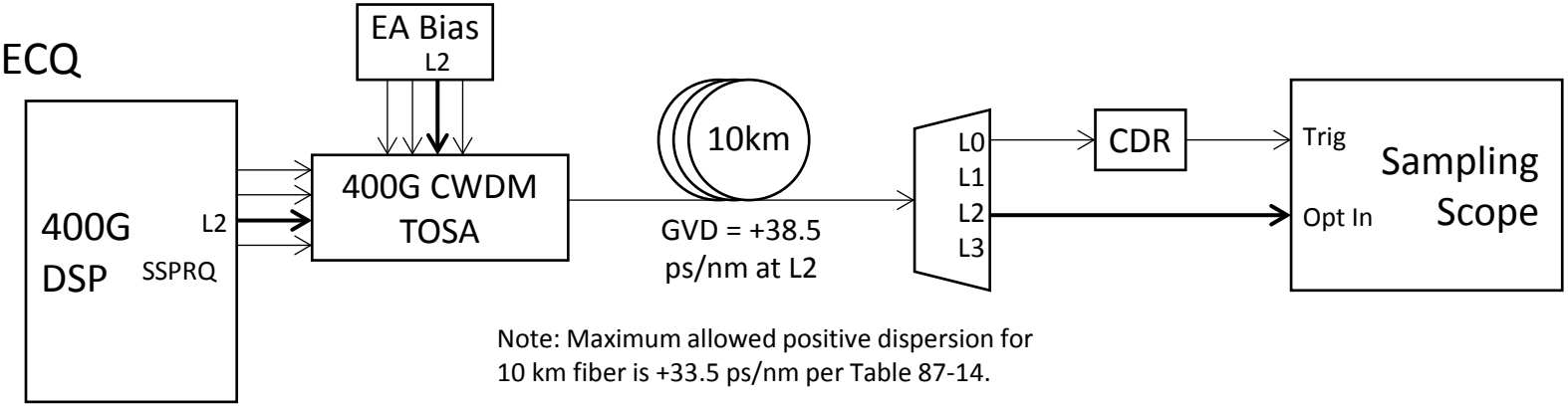
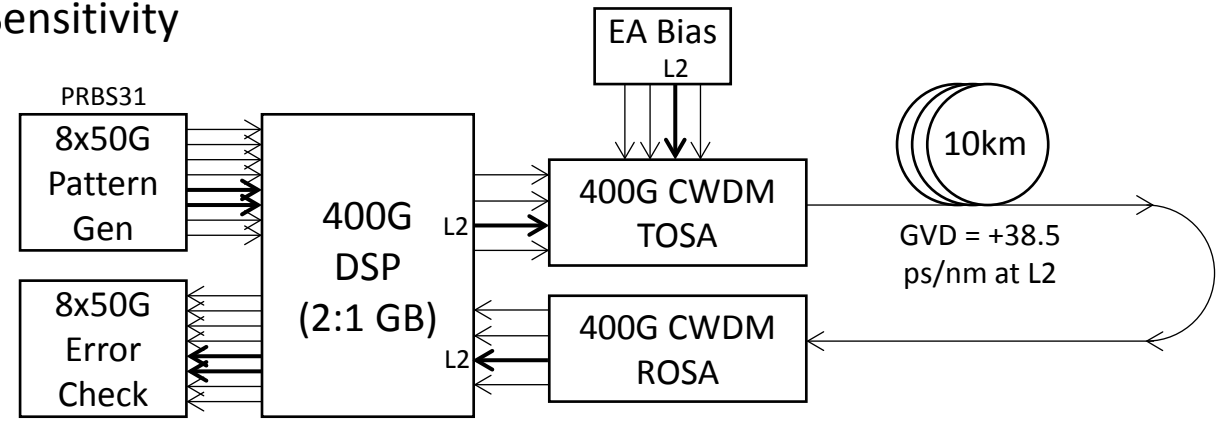
Experimental Configuration

TDECQ

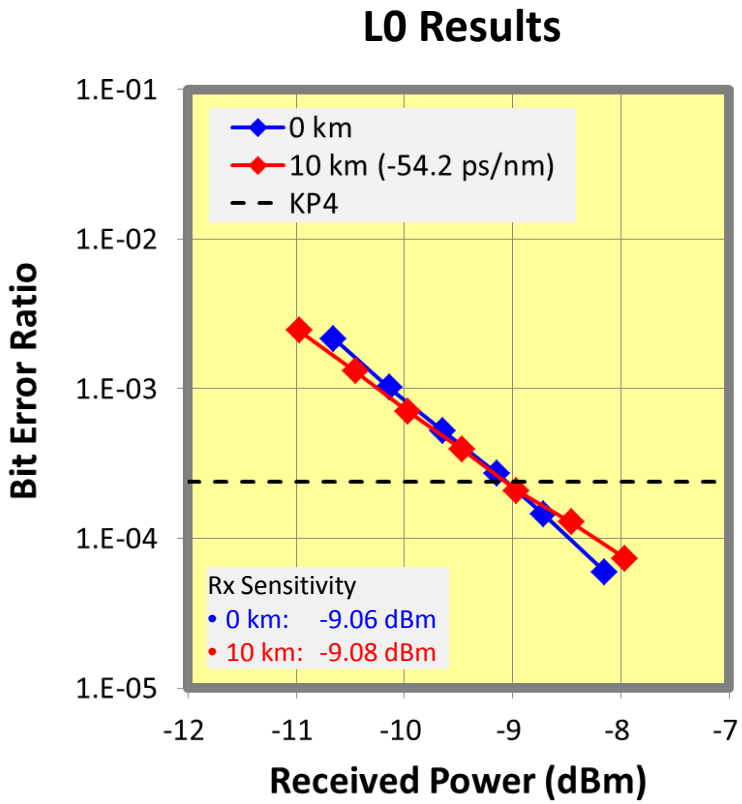


Note: Maximum allowed positive dispersion for 10 km fiber is +33.5 ps/nm per Table 87-14.

Receiver Sensitivity



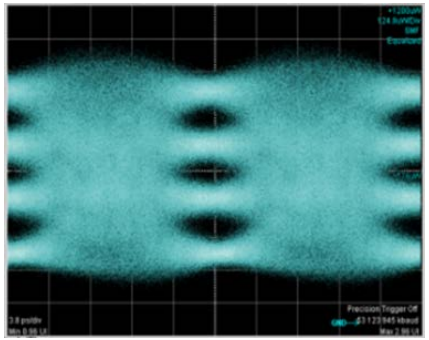
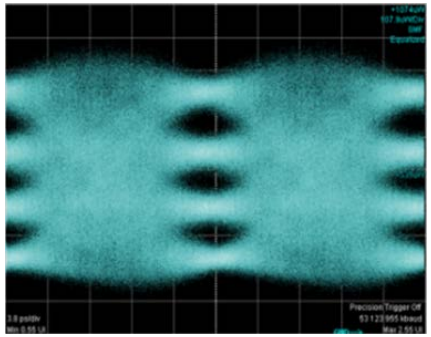
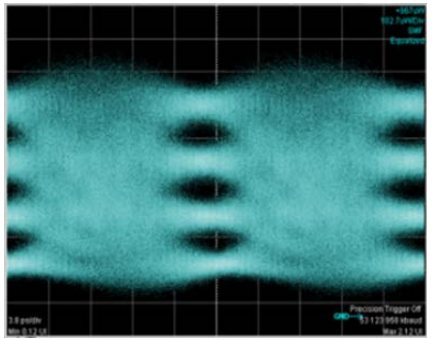
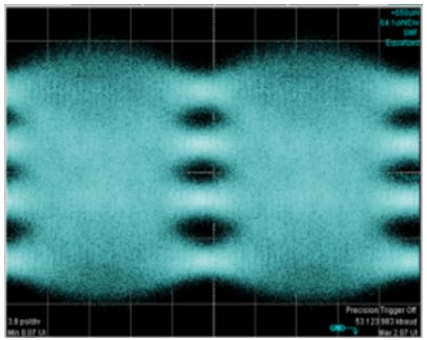
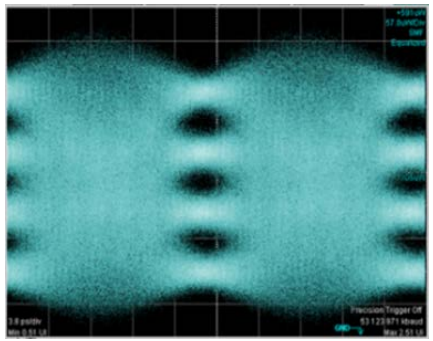
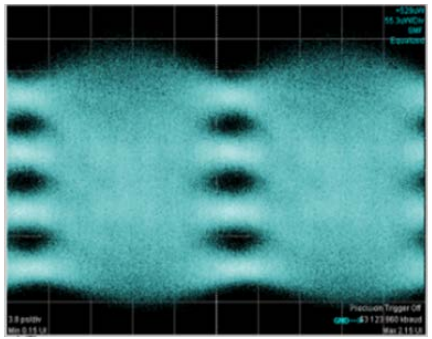
Dispersion Penalty In Negative Dispersion Regime Small For EML



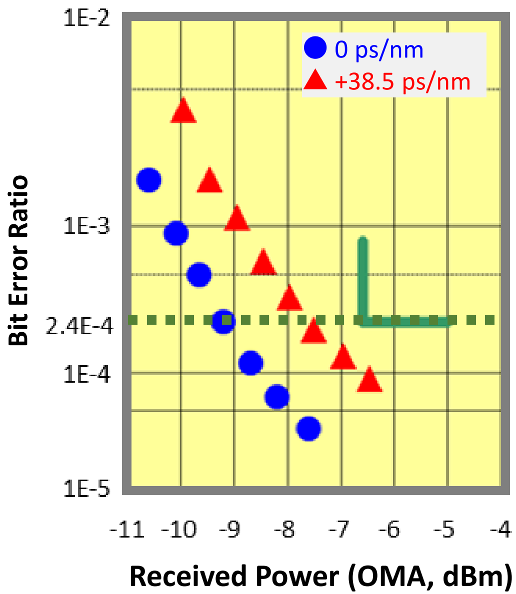
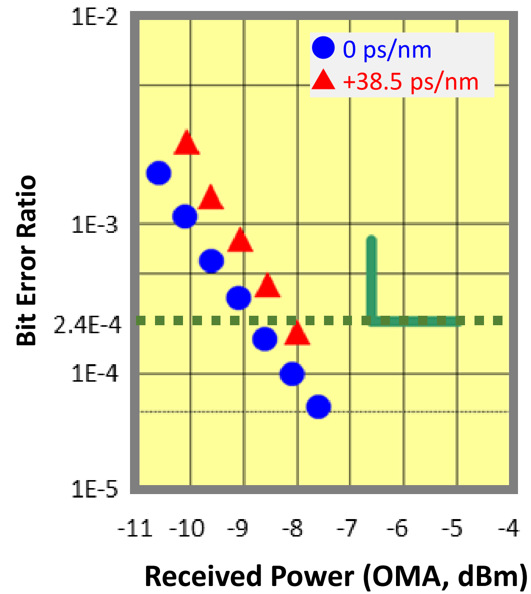
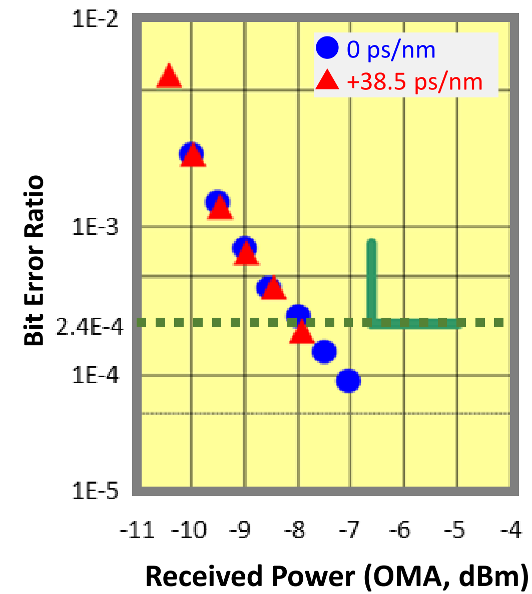
Note: Maximum negative dispersion is -59.5 ps/nm for 10 km SMF channel (see Table 87-14).

- 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 • Optimum linearity and TDECQ back-to-back (default).	Case 2 • Adjust inner eye levels for best linearity at 10 km (+38.5 ps/nm).	Case 3 • Increase extinction ratio and adjust inner eye levels for best linearity at 10 km (+38.5 ps/nm).
0 ps/nm	 EA Bias: -1.52 V TDECQ: 2.30 dB Outer ER: 5.0 dB RLM: 0.99	 EA Bias: -1.52 V TDECQ: 2.16 dB Outer ER: 5.0 dB RLM: 0.92	 EA Bias: -1.72 V TDECQ: 2.86 dB Outer ER: 6.2 dB RLM: 0.91
+38.5 ps/nm	 EA Bias: -1.52 V TDECQ: 3.66 dB Outer ER: 4.9 dB RLM: 0.93	 EA Bias: -1.52 V TDECQ: 3.31 dB Outer ER: 5.0 dB RLM: 0.99	 EA Bias: -1.72 V TDECQ: 3.31 dB Outer ER: 6.2 dB RLM: 0.98

BER and Rx Sensitivity Before/After Maximum Positive Dispersion

<table>
<tr><th></th><th>Case 1
• Optimum linearity and TDECQ back-to-back (default).</th><th>Case 2
• Adjust inner eye levels for best linearity at 10 km (+38.5 ps/nm).</th><th>Case 3
• Increase extinction ratio and adjust inner eye levels for best linearity at 10 km (+38.5 ps/nm).</th></tr>
<tr><td>BER</td><td> 
</td><td> 
</td><td> 
</td></tr>
<tr><td>Rx Sens (dBm)
0 ps/nm</td><td>-9.15</td><td>-8.87</td><td>-7.81</td></tr>
<tr><td>Rx Sens (dBm)
+38.5 ps/nm</td><td>-7.51</td><td>-8.00</td><td>-7.82</td></tr>
<tr><td>Penalty (dB)</td><td>1.64</td><td>0.87</td><td>-0.01</td></tr>
</table>

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).

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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

[a]These channel insertion loss values include cable, connectors, and splices.
[b]Over the wavelength range 1264.5 nm to 1337.5 nm.
[c]Differential 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.