VCSEL-Friendly 1310nm Serial PMD Specifications

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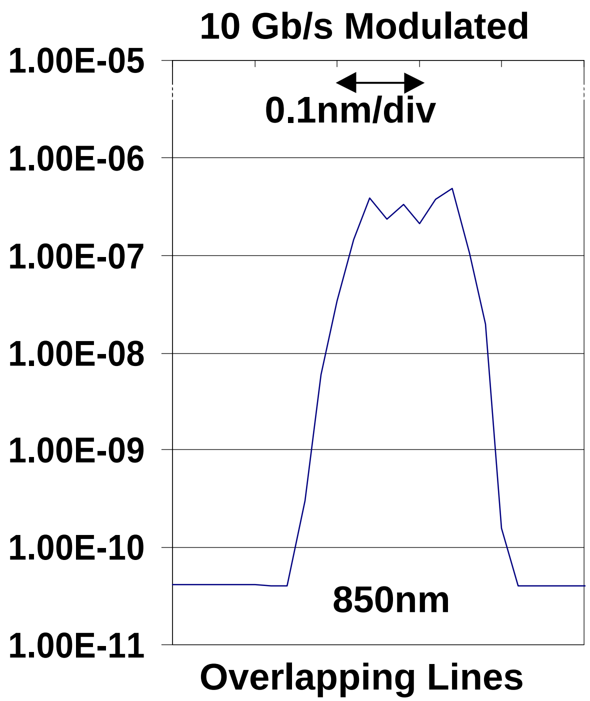
Why Tweak the Specs for VCSELs?

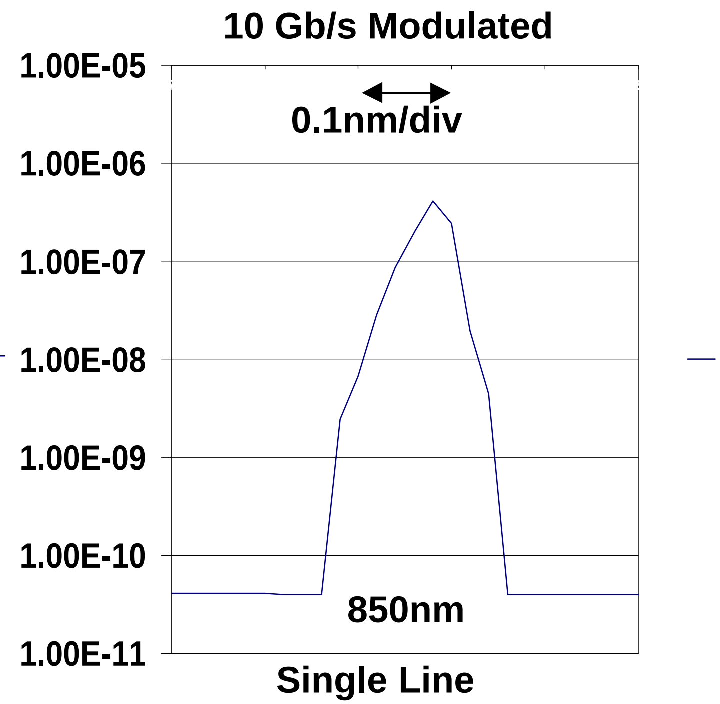
- **1310nm serial specs intended to be VCSEL-friendly**
- **VCSELs have significant advantages over DFB's**
  - **Narrow linewidth under modulation**
  - **VERY different side mode characteristics**
- **VCSEL solutions should be more cost effective**

- **<u>Proposed Spec Changes</u>:**
- **Trade off Spectral Width vs Wavelength Range**
- **Relax Side-Mode Suppression Ratio (SMSR)**
- **Keep Return Loss spec open**

Modulated 850nm VCSEL Spectra

Modulated VCSELs show negligible chirp/broadening

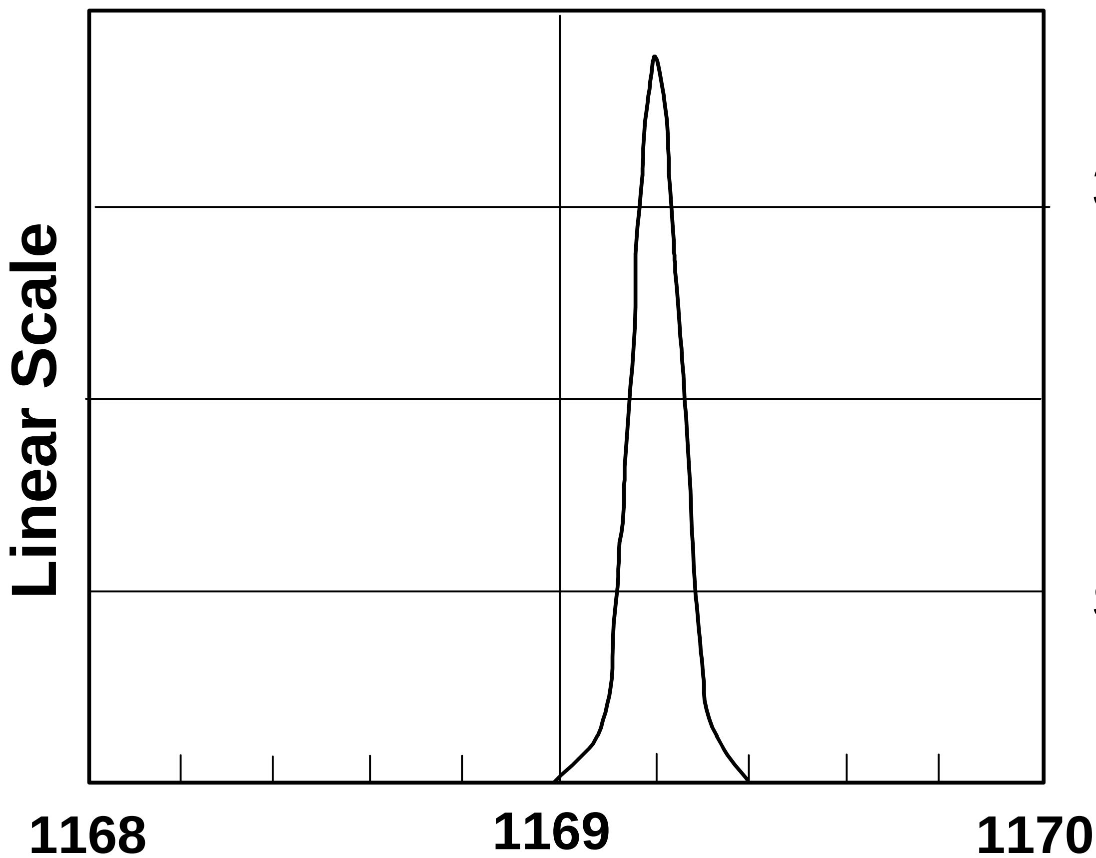




- **Little Change Between Modulated and Unmodulated Spectra**
- **Total <u>Multi-Mode</u> RMS Half-Width <0.3nm**
- **RMS Half-Width of Single Line <0.05nm**
- **Scales to <0.10nm at 1300nm**

Modulated 1170 VCSEL Spectra

Modulated VCSELs show negligible chirp/broadening



3.2Gb/s

ER>6dB

RMS~0.05nm
Spectrometer-Limited

Link Model Simulations

Narrow VCSEL linewidths allow wider wavelength range

Del Hanson, David Cunningham, Piers Dawe, Agilent Technologies — Case: 13100nr

Input=	**Bold**				
		BWm(MHz*km)=	**1000000**	L_start (km)=	**-----**
Uc(nm)=	**1310**	So(ps/nm^2*km)=	**0.093**	L_inc (km)=	**-----**
Uw(nm)=	**0.40**	Uo(nm)=	**1324**	C1=	**480**
Spec ER=	**6** dB	Atten=	**0.5** dB/km	Q=	**7.04**
Ts(20-80)=	**40** ps	se Rate=	**10313** MBd	TP4 Eye Opening=	**24**
RIN=	**-130** dB/Hz	ec_BW=	**7725** MHz	DCD_DJ(ps)=	**8**
MPN, k=	**0**	ower Budget P (dB)=	**10**	Min Launch Pwr(dBm)=	**-4.0**
MN (dB)=	**0**	Connections C (dB)=	**2**	Test Source ER (dB)=	**6**
				RMS Baseline wander S.D.=	**0.025**

Link Power Budget and Penalties (10GbE) — 1310 nm

Description	1	2	3	4	5	6	Units
Operating Distance (km)	10	10	10	10	10	10	km
Zero Dispersion Wavelength (nm)	1300	1324	1324	1324	1324	1324	MHz km
Wavelength (nm)	**1355**	**1290**	**1275**	**1265**	**1255**	**1238**	nm
Link Power Budget (dB)	10.0	10.0	10.0	10.0	10.0	10.0	dB
Channel Insertion Loss	6.77	7.04	7.12	7.17	7.22	7.32	dB
Link Power Penalties	2.19	2.27	2.19	2.17	2.08	2.00	dB
Unallocated Margin	1.05	0.69	0.69	0.66	0.70	0.69	dB
Pisi	1.63	1.71	1.63	1.61	1.54	1.46	dB

Transmit Characteristics (10GbE)

Description							Units
Signal Speed	10.313	10.313	10.313	10.313	10.313	10.313	Gbd
Wavelength (nm)	1355	1290	1275	1265	1255	1238	nm
Trise / Tfall (20%-80%)	40	40	40	40	40	40	ps
RMS Spectral Width (max)	**0.25**	**0.40**	**0.25**	**0.20**	**0.15**	**0.10**	nm

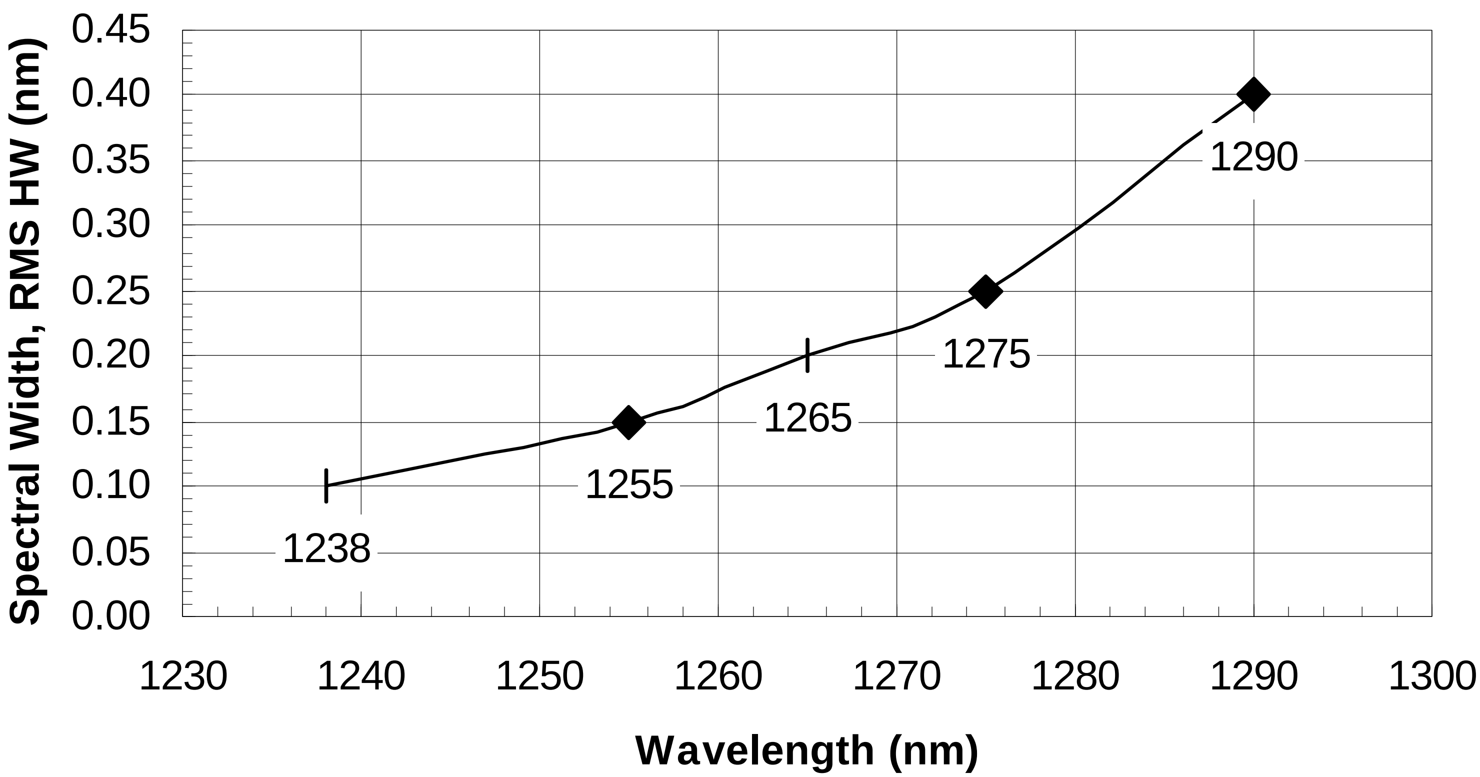
046 Spreadsheet

Same values as the "3pmd" spreadsheet on the IEEE website

Column 2 matches the "3pmd" spreadsheet

Link Model Simulations

Graph of Wavelength and RMS Widths from Columns 2-6



What About the 1240-1265nm Region?

Multiple Benefits Could Be Gained Via Its Use

- **Earlier time-to-market for VCSELs**
- **WWDM could use wider channel spacing → *lower cost***
  - **~35nm rather than ~25nm greatly increases laser wavelength spec [especially w/ temperature]**
  - **±5.7nm → ±12.7nm [±2nm → ±7nm]**
  - **1245nm, 1280nm, 1315nm, 1350nm**
  - **"046" w/ 0.62nm linewidth → λ down to 1222nm**
- **Even more attractive for future higher-bandwidth WDM**
- **Bi-directional Access on SMF could use wider spacing**
  - **E.g. 1250nm, 1340nm**

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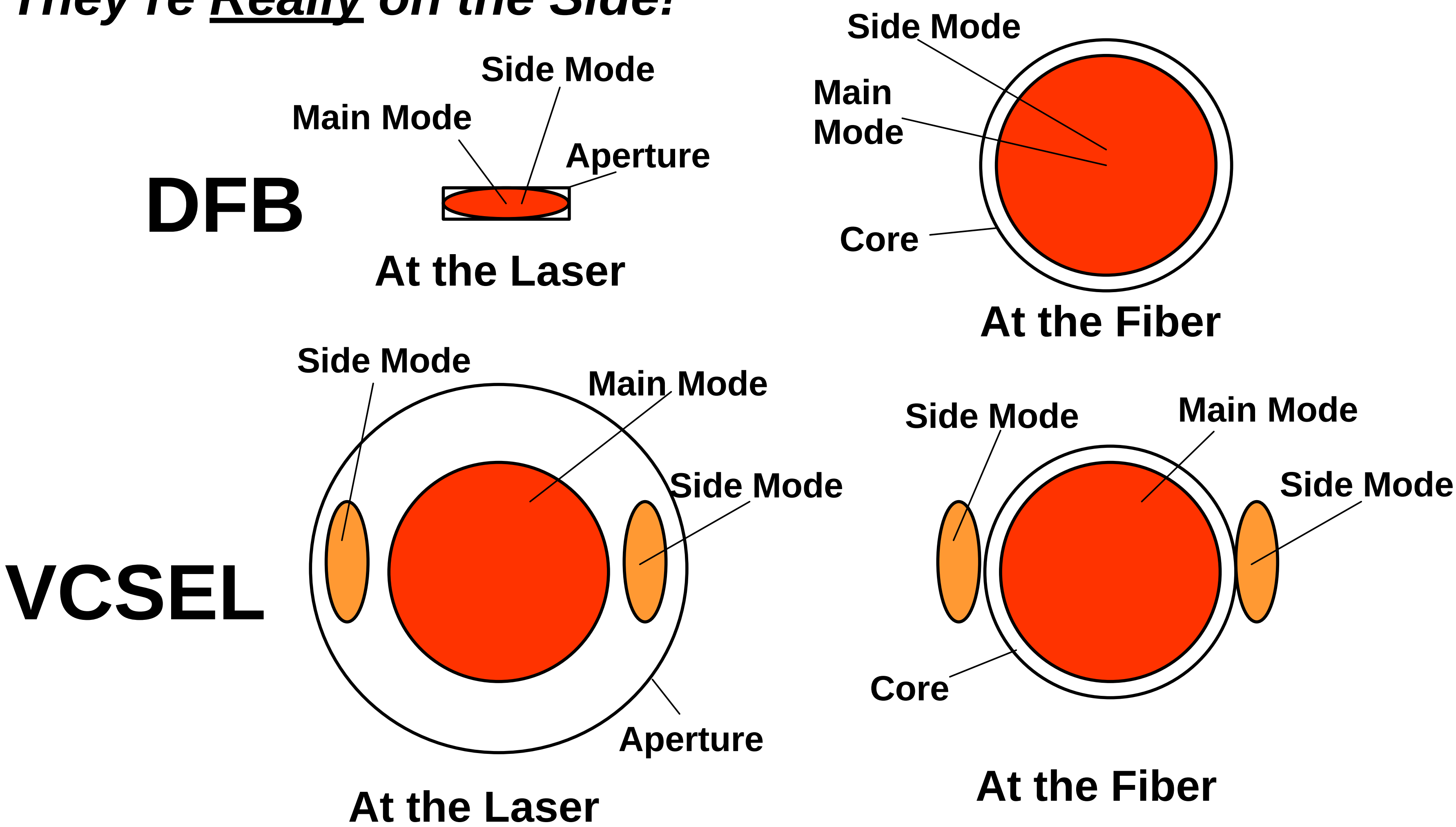
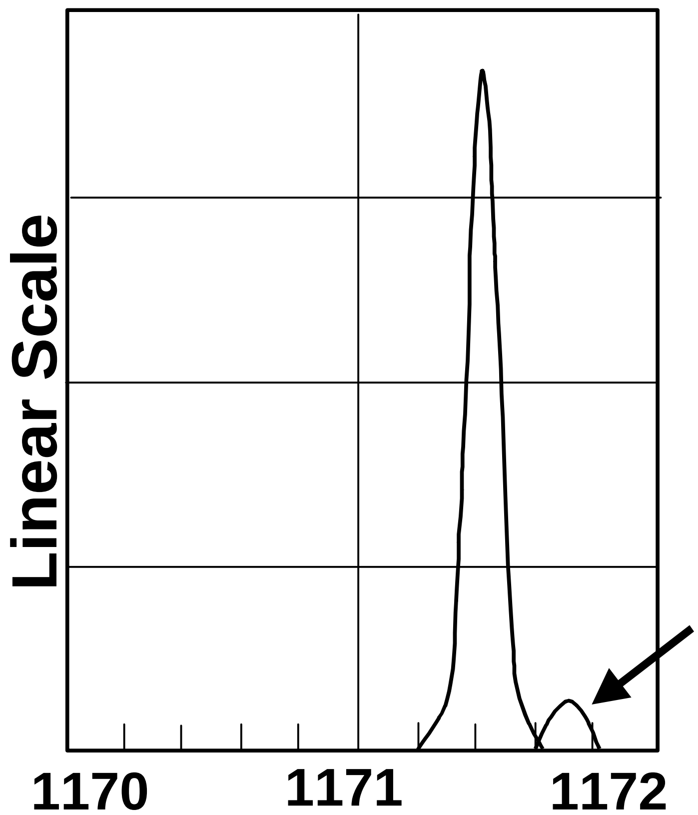
VCSEL Side Modes are Different

They're <u>Really</u> on the Side!

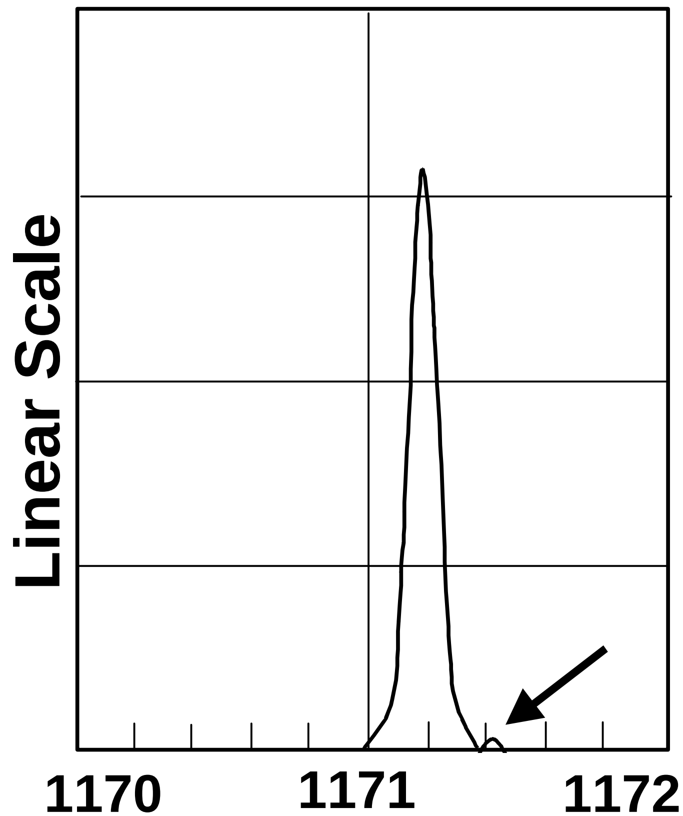


SMF-Coupled 1170 VCSEL Spectra

Side Mode Does NOT Couple Into the Single-Mode Fiber



Through MMF



Through 2m SMF

Return Loss

- **Not Yet Quantified**
- **Large source of RL-related noise in DFB lasers is stimulation of the side mode $\rightarrow$ mode competition. This will NOT occur in SMF-coupled VCSELs**

Summary

- **Modulated VCSELs show negligible broadening of spectral widths. Recommend split-column spec for Spectral Width and Wavelength Range. New columns:**
  Spectral Width: 0.20nm, Wavelength Range: 1265-1355nm
  Spectral Width: 0.10nm, Wavelength Range: 1240-1355nm

- **VCSEL "side modes" do not couple into SMF. Recommend split-column spec for SMSR. New column:**
  SMSR: -10dB

- **VCSEL side mode does not compete for same gain space as fundamental mode. Insufficient data to quantify sensitivity to Return Loss. Recommend NOT jumping into an overly stringent Return Loss spec.**

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Split-Column Transmit Table

10GBASE-LR/LW transmit characteristics

Description			Unit
Signal Speed (range) **10GBASE-LR** **10GBASE-LW**	 10.3125+-100ppm 9.95328+-100ppm	 10.3125+-100ppm 9.95328+-100ppm	 GBd GBd
Wavelength (range)	**1290-1330**	**1265-1355**	nm
Trise / Tfall (20%-80%)	40	40	ps
RMS Spectral Width (max)	**0.40**	**0.25**	nm
Side Mode Suppression Ratio	**30**	**10**	dB
Avg Launch Power (max)	1.0	1.0	dBm
Avg Launch Power (min)	-4.0	-4.0	dBm
Avg Launch Power of OFF Transmitter (max)	-30	-30	dBm
Extinction Ratio (min)	6.0	6.0	dB
RIN (max)	-130	-130	dB/Hz