



# Updated 1060nm Data

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# This contribution

- Updates discussion of 1060 nm optimized fiber bandwidth (a combination of modal and chromatic) at the telephonic interim on March 3 ([lewis 3ds adhoc 01 260303.pdf](#))
  - Removed the confusion of  $BW_{\text{eff}}(\text{elec})$  which is the adjusted BW of a software 4<sup>th</sup> order BT filter used to emulate the effects of MMF modal and chromatic dispersion for the TDECQ test
  - Updates the proposed fiber tables with OM860 optimized at 860 nm, and made chromatic dispersion slope (S0) a tbd for OM1060
- Added a slide on the case for 1060 nm VCSEL, including challenges in common with 850 nm VCSEL for 200G PAM4 operation

# S21 of L1060 using 1060nm Lumentum VCSEL

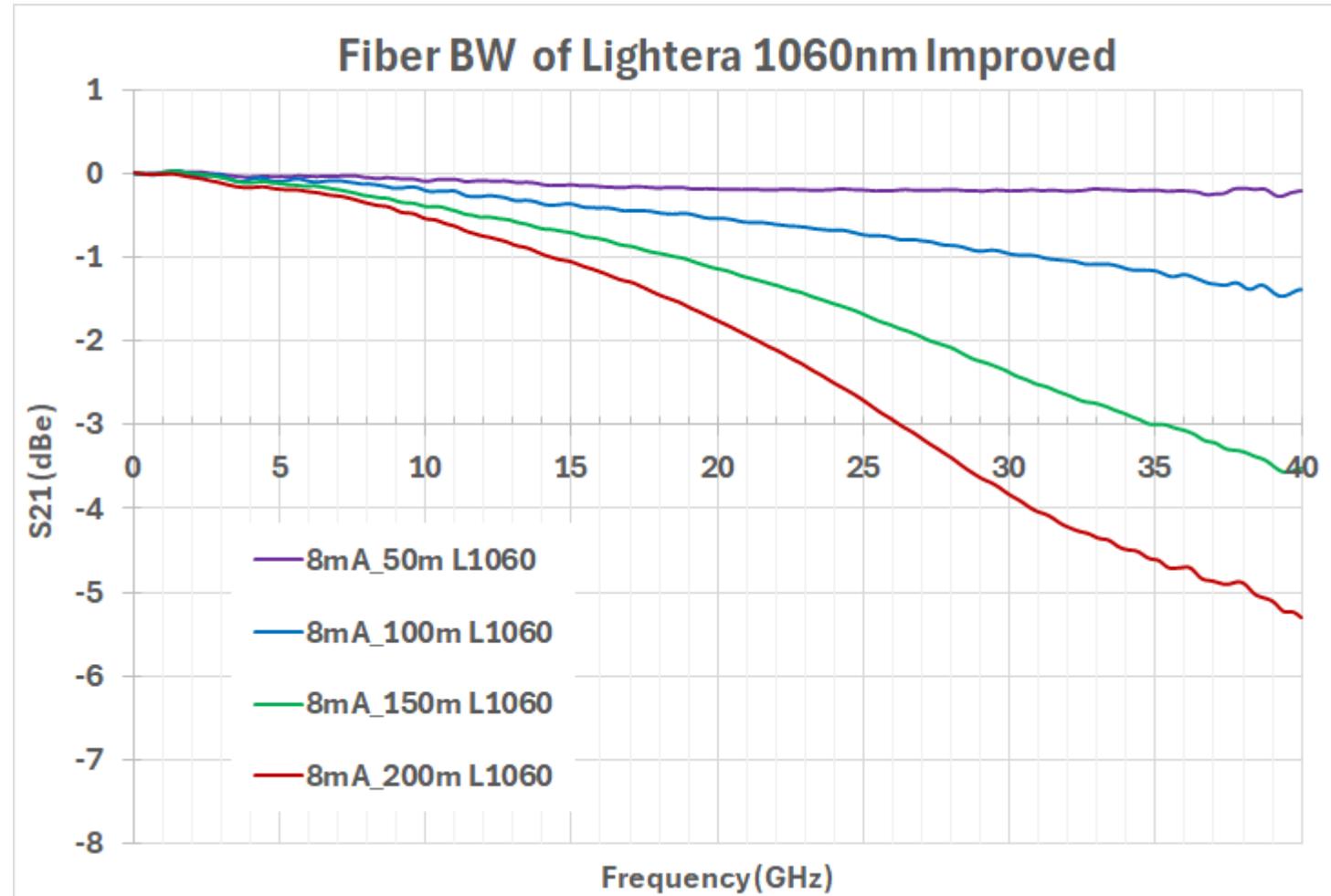
All fiber BW includes both modal and chromatic

## Measurement Method

1. Lumentum 1060nm VCSEL with 0.45 nm RMS spectral width at I<sub>bias</sub> 8 mA
2. Measured S<sub>21</sub> using 1 m OM5
3. Measured S<sub>21</sub> with different fiber lengths
4. Subtracted the 1 m OM5 S<sub>21</sub> to remove component of laser and equipment

## Results

- ~5,200 MHz-km effective BW (-3 dBc)
- Minimal penalty over 50 m to 40 GHz



# 50Gbs NRZ transmitted by L1060

RMS Spectral Width  
0.40nm



0.52nm

OM5
OM2
L1060

Temp. (C)	25C							
Fiber	1m OM5	30m L1060	30m OM2	50m L1060	50m OM5	100m L1060	150m L1060	
8mA Ibias 50Gbs NRZ Eye Digram								
	ER (dB)	4.4	4.3	4.0	4.3	3.7	4.1	3.8
	<b>Eye margin (%)</b>	<b>12.0</b>	<b>13.2</b>	<b>10.6</b>	<b>13.7</b>	<b>6.8</b>	<b>12.7</b>	<b>12.5</b>
	Tr (ps)	10.6	10.7	12.3	11.0	13.4	11.9	13.0
	Tf (ps)	11.9	11.9	13.1	12.1	14.2	12.9	13.9
	Crossing (%)	47.1	47.2	47.7	47.3	48.2	47.9	48.3
Fiber	1m OM5	30m L1060	30m OM2	50m L1060	50m OM5	100m L1060	150m L1060	
9mA Ibias 50Gbs NRZ Eye Digram								
	ER (dB)	4.3	4.2	3.9	4.2	3.6	3.9	3.7
	<b>Eye margin (%)</b>	<b>15.3</b>	<b>17.5</b>	<b>12.9</b>	<b>17.2</b>	<b>10.5</b>	<b>16.6</b>	<b>11.9</b>
	Tr (ps)	10.2	10.3	11.8	10.6	13.3	11.4	12.7
	Tf (ps)	11.4	11.5	12.7	11.8	14.1	12.4	13.5
	Crossing (%)	47.4	47.6	48.0	47.6	48.5	48.1	48.4
Fiber	1m OM5	30m L1060	30m OM2	50m L1060	50m OM5	100m L1060	150m L1060	
10mA Ibias 50Gbs NRZ Eye Digram								
	ER (dB)	4.2	4.1	3.9	4.0	3.5	3.8	3.6
	<b>Eye margin (%)</b>	<b>18.8</b>	<b>20.2</b>	<b>16.4</b>	<b>18.6</b>	<b>10.5</b>	<b>19.6</b>	<b>12.7</b>
	Tr (ps)	10.0	10.1	11.4	10.4	13.4	11.2	12.9
	Tf (ps)	11.3	11.4	12.2	11.5	14.1	12.1	13.6
	Crossing (%)	47.7	47.9	48.1	48.0	48.6	48.1	48.7

**Eye-Margin at 50Gb/s NRZ same for Back-to-Back and 100m L1060 fiber**

# The case for 1060 nm optimized MMF

- MMF at 1060 nm has lower chromatic dispersion than at 850 nm
  - e.g. at 850 nm,  $D = -98.5$  ps/nm/km and  $BW_{cd} = 3,164$  MHz-km
  - at 1060 nm,  $D = -36.3$  ps/nm/km and  $BW_{cd} = 11,462$  MHz-km
- This means that effective BW ( $BW_{eff}$ ) (modal + chromatic) is higher for the same modal BW (EMB)
  - e.g. for EMB of 4700 MHz-km
    - at 850 nm,  $BW_{eff} = 2,625$  MHz-km
    - at 1060 nm,  $BW_{eff} = 4,349$  MHz-km
- This higher MMF bandwidth of 1060 nm optimized fiber means:
  - opportunity for lower EMB 1060 nm fiber with potentially higher yield
  - higher data rate capability for the same reach, or longer reach at the same rate
  - potential for higher data rates over useful reaches, e.g., 400G over 30 m?

# The case for 1060 nm VCSEL

- Benefits:
  - Higher quantum well material gain versus current density enables higher intrinsic BW
  - Enables flip chip assembly, due to transmission through the GaAs substrate, directly to the electronics to improve signal integrity
  - Expect very high reliability
- Challenges (in common with 850 nm VCSEL):
  - High speed device design requires low capacitance and low resistance to achieve target of >40 GHz bandwidth when integrated with a driver
  - S21 linearity across frequency range for 200G PAM4 modulation

*Ref: L.Coldren, et al, Photon. Soc. Sum. Top., Playa Del Carmen, pap TuD2.1, July, 2010*

# Proposed baseline tables for 1060 nm fiber

Table Cl#-aa Fiber optic cabling (channel) characteristics

Description	OM4	OM860	OM1060	Unit
Operating distance (max)	50			m
Cabling skew (max)	39.5			ns
Cabling skew variation (max)	1.2			ns
Channel insertion loss (max)	1.7			dB
Channel insertion loss (min)	0			dB

Table Cl#-bb Optical fiber and cable characteristics

Description	OM4	OM860	OM1060	Unit
Nominal core diameter	50		tbd	um
Nominal fiber specification wavelength	850	860	1060	nm
Effective modal bandwidth at nominal fiber specification wavelength (min)	4700	5200	tbd	MHz*km
Cabled optical fiber attenuation (max)	3			dB/km
Zero dispersion wavelength ( $\lambda_0$ )	1297 $\leq \lambda_0 \leq$ 1328			nm
Chromatic dispersion slope (max) (S0)	-412 / (840(1-( $\lambda_0$ /840)^4))		tbd	ps/nm^2 km

# Summary

- Promising results with Lightera 50  $\mu\text{m}$  core MMF optimized for 1060 nm (L1060)  $\rightarrow$  ~5,200 MHz-km
- Plan to measure 1060 nm optimized small-core (<30 $\mu\text{m}$ ) MMF from 2 suppliers over the next few weeks
- Outlined the case for 1060 nm optimized fiber
- Discussed the benefits of 1060 nm VCSELs and the challenges common to all 200G PAM4 VCSELs
- Proposed to add L1060 fiber to the 802.3ds baseline tables for optical fiber and cable characteristics