

10 GbE CWDM 850 nm VCSEL for Installed and New MM Fiber

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Abstract

10 GbE CWDM 850 nm for Installed/ New MM Fibers

- **Benefit in Using 850 nm VCSEL with 62.5 um Installed Fibers**
 - 850 nm VCSEL – low-cost, gigabit rate, mature technology
 - Installed fiber – no rewiring, save cost and time, share media (1000-SX)
 - Early market introduction – less than a year
 - New Fiber –Support up to 550 meter

- **Critical Component and Parameter**
 - CWDM – low cost, easy manufacturing, multiple sources
 - RML bandwidth – FOTP-204
 - Restricted launch – FOTP-203

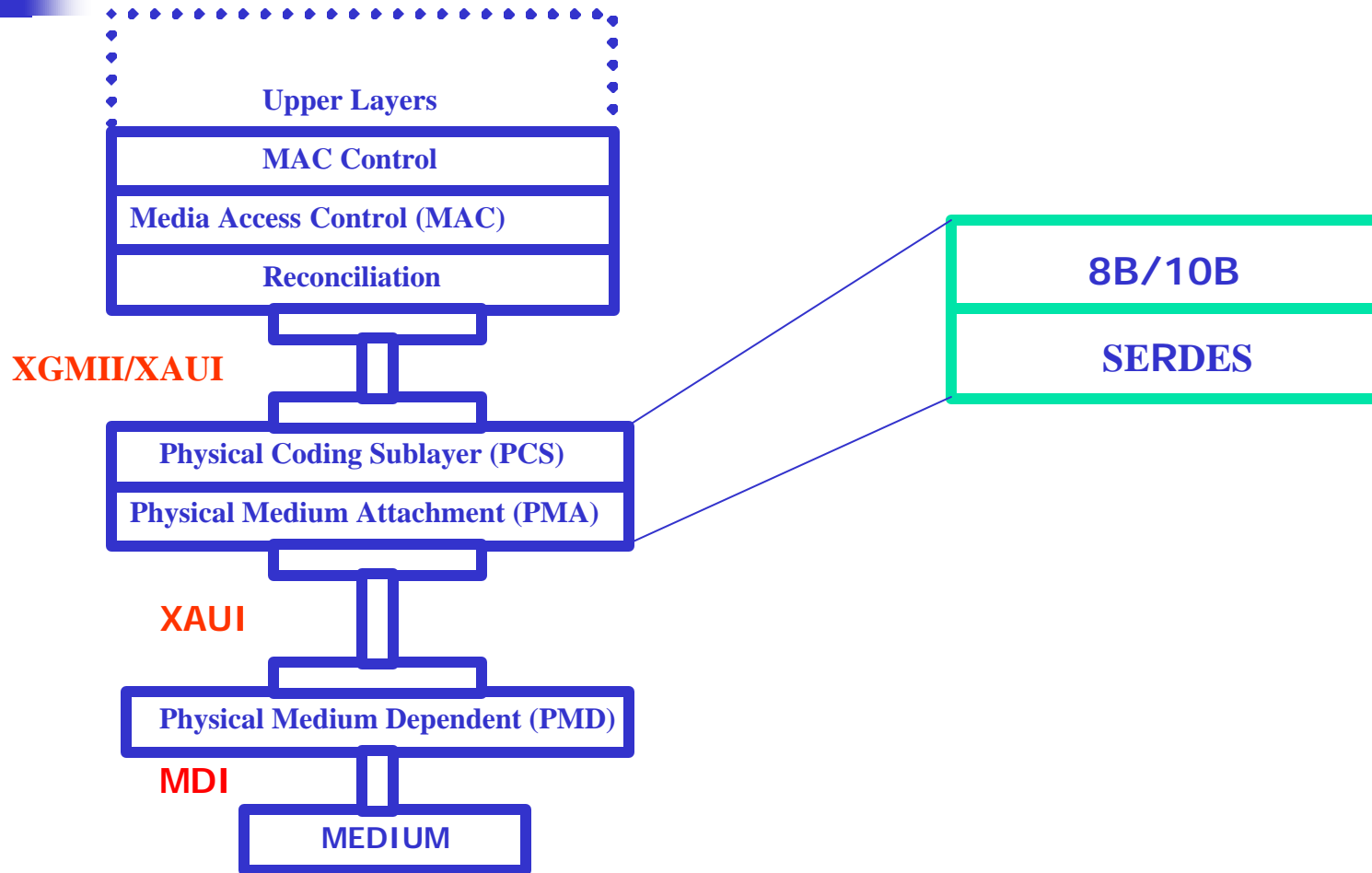
- **Design**
 - System
 - Optical link

- **Support of VCSEL Serial Solution**

- **Recommendation**

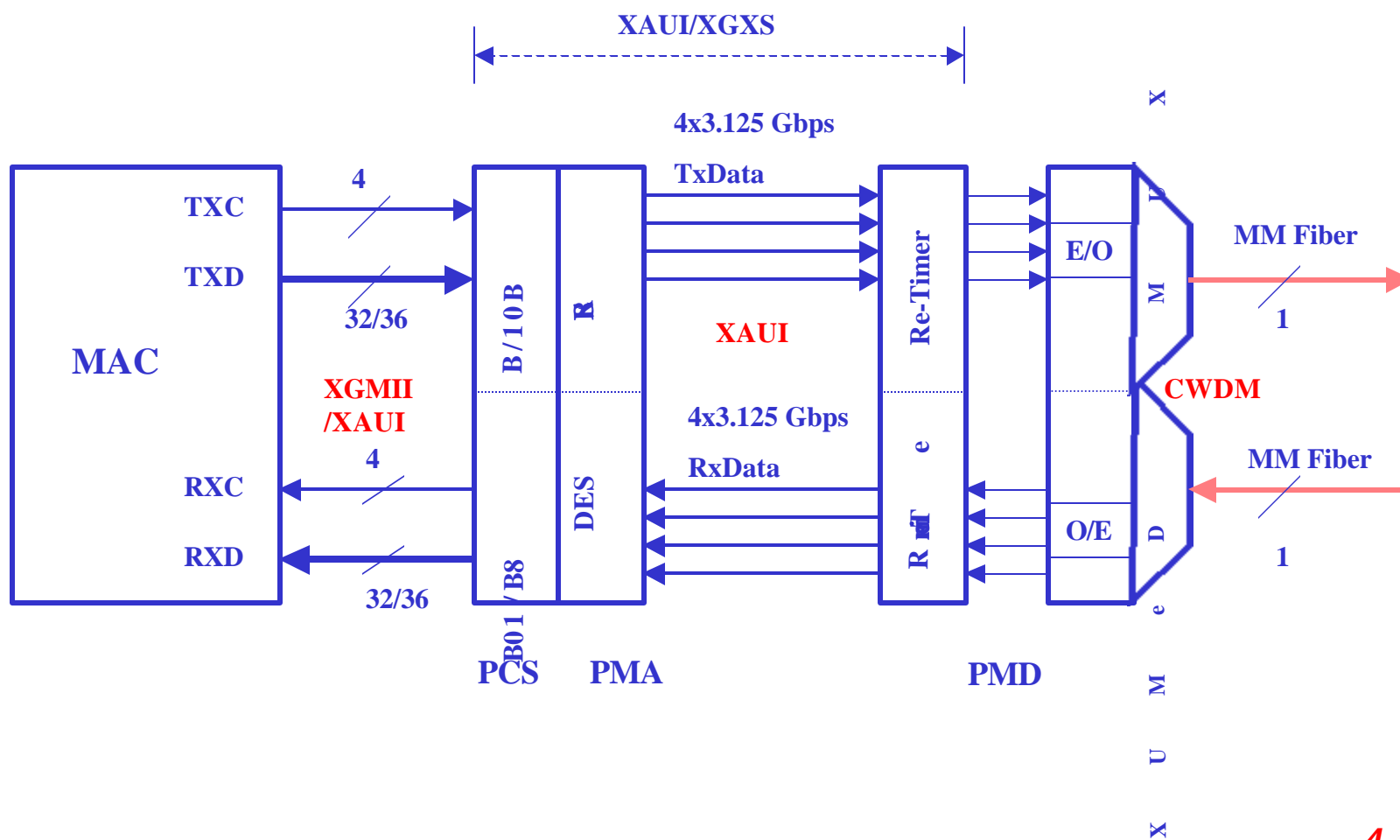
System Design - Reference Model

10 GbE CWDM 850 nm for Installed/New MM Fibers



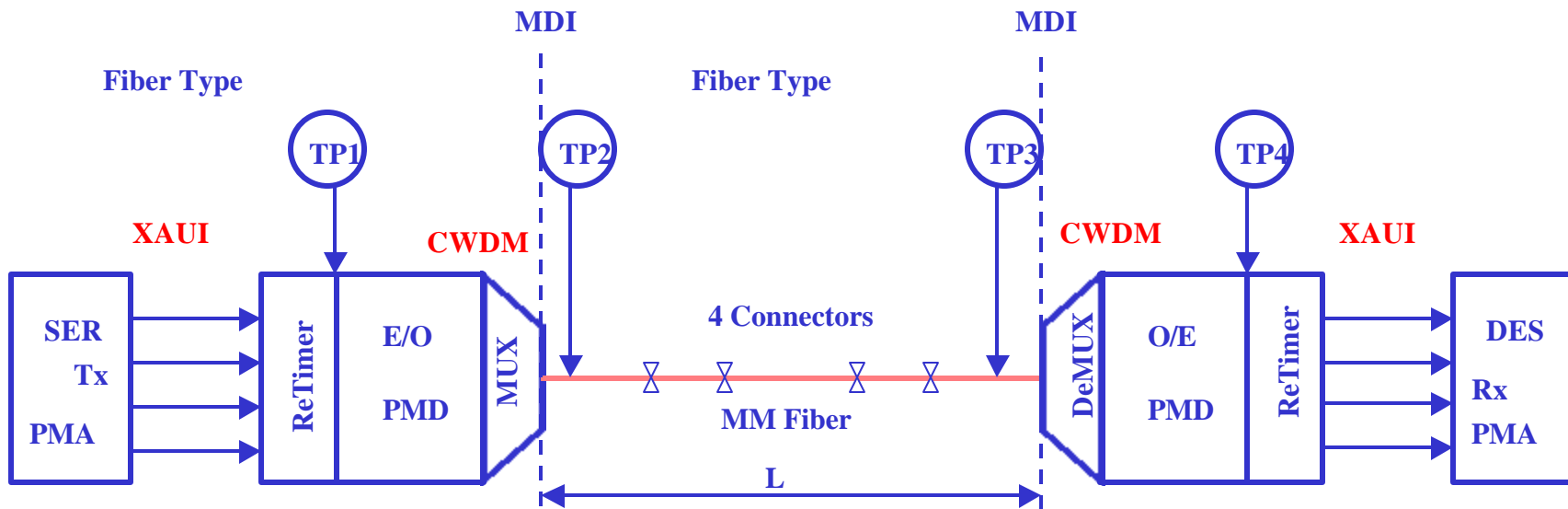
System Design - Block Diagram

10 GbE CWDM 850 nm for Installed/New MM Fibers



Link Design – Over View

10 GbE CWDM 850 nm for Installed/New MM Fibers



Target Operating Distance

Fiber Type	Installed 62.5 um	Installed 62.5 um	Installed 50 um	New 50 um
BW (850 nm)	160 MHz-km (OFL)	385 MHz-km (RML)	500 MHz-km (OFL)	2.0 GHz-km (RML)
L (meter)	100	220	300	550

Link Design – Bandwidth

10 GbE CWDM 850 nm for Installed/New MM Fibers

- Design Rules
 - RML BW (FOTP-204) -- 385 MHz-km (62.5 um), 2.0 GHz-km (New fiber)
 - Restricted launch (FOTP-203) -- EFD over 75% at 15 um radius
 - Installed 50 um fiber bandwidth = 500 MHz-km OFL BW
 - Vortex launch (donut launch) -- assure over 80% flux density by Digital Optics
 - CWDM -- 805/825/845/865 nm by BLAZE
 - Code -- 8B/10B at 3.125 Gbps

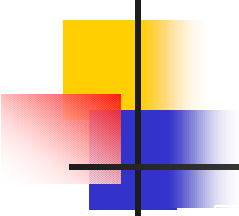
- Bandwidth Equation
 - $0.8 T \Rightarrow (tT^2 + tF^2 + tR^2)^{0.5} \dots\dots\dots (1)$
 - $T = 320 \text{ ps}$ ----- a cell time at 3.125 Gbps
 - $tT = 100 \text{ ps}$ ----- transmitter rise time
 - $tR = 81 \text{ ps}$ ----- receiver rise time, $tR = 310/3.8 \text{ GHz}$ (receiver BW)
 - $tF = 233 \text{ ps}$ -----fiber rise time.....(2)



Link Design – Bandwidth(2)

10 GbE CWDM 850 nm for Installed/New MM Fibers

- Installed 62.5 um Fiber ---220 Meter
 - Fiber bandwidth = $440/tF = 1.8$ GHz
 - Fiber length $L = (0.385 \times 1000)/1.8 = 220$ meter
- Installed 50 um Fiber -- 300 meter
 - Fiber bandwidth = $440/tF = 1.8$ GHz
 - Fiber length $L = (0.5 \times 1000)/1.8 \sim 300$ meter
- New 50 um Fiber -- 550 meter
 - Fiber bandwidth = $440/tF = 1.8$ GHz
 - Fiber length $L = (2.0 \times 1000)/1.8 = 1110 > 550$ meter



Link Design – Power

10 GbE CWDM 850 nm for Installed/New MM Fibers

- Design Rules
 - 4 connectors
 - RIN < -117 dB/Hz
 - Return loss = 12 dB
 - ISI = $1/\{1-1.425\exp[-1.28(T/Tc)^2]\}$ dB
 - MPN = $1/[1-(Q*\Sigma)^2]^{0.5}$ dB

- Power Margin Equation
 - $P_m = P_o - P_i - \{ISI + MPN + 3.5L + 2P_{cwdm} + 4x.25 + 3[4x(.1)^2]^{0.5}\}$
= $P_o - P_i - (ISI + MPN + 3.5L + 3.7)..... (3)$
 - $P_o = -5.5$ dBm
 - $P_i = -13.5$ dBm



Link Design – Power(2)

10 GbE CWDM 850 nm for Installed/New MM Fibers

- Installed 62.5 um Fiber – 220 Meter
 - Link power penalty = 4.3 dB
 - Fiber attenuation = 0.77 dB
 - From (3), Power margin Pm = **1.4** dB

- Installed 50 um Fiber – 300 meter
 - Link power penalty = 4.5 dB
 - Fiber attenuation = 1.05 dB
 - From (3), Power margin Pm = **1.0** dB

- New 50 um Fiber – 550 meter
 - Link power penalty = 2.4 dB
 - Fiber attenuation = 1.9 dB
 - From (3), Power margin Pm = **2.1** dB



Link Design – Jitter

10 GbE CWDM 850 nm for Installed/New MM Fibers

- Design Rules
 - Extrapolate GbE Jitter Budget (Table 38-10)
 - Re-timer – remove DJ, negligible RJ
 - T (cell time) \Rightarrow Sum DJ + Sum rms RJ + Clock skew

- Jitter Table (ps)

UI = 320 ps

▪ TP1	TJ = 76.8	DJ = 32
▪ TP1 to TP2	TJ = 90	DJ = 32
▪ TP2	TJ = 138	DJ = 64
▪ TP2 to TP3	TJ = 16	DJ = 16
▪ TP3 to TP4	TJ = 54	DJ = 67
▪ TP4	TJ = 239	DJ = 147

Link Summary – Transmitter (Reference to GbE Table 38-7)

10 GbE CWDM 850 nm Installed/New MM Fibers

Description	62.5 mm MMF 50 mm MMF 50 mm MMF (new)	Unit
Transmitter Type	Shortwave Laser	
Signaling speed per channel (range)	3.125 ± 100 ppm*	GBd
Wavelength (range), four channels	800 to 870	nm
Channel center wavelengths	805, 825, 845, 865 ± 5.0 nm	nm
Channel separation	20.0	nm
Trise/Tfall (max. 20-80% response time)	100	ps
RMS spectral width (max)	0.5	nm
Average launch power, four channels (max)	+4.7	dBm
Average launch power per channel (max)	-1.3	dBm
Average launch power per channel (min)	-5.5	dBm
Extinction ratio, (min)	7	dB
RIN (max)	-117	dB/Hz

* 8B/10B coding

Link Summary – Receiver (Reference to GbE Table 38-8)

10 GbE CWDM 850 nm for Installed/New MM Fibers

Description	62.5 mm MMF	50 mm MMF	50 mm MMF (new)	Unit
Signaling speed per channel (range)	3.125 ± 100 ppm*			GBd
Wavelength (range), four channels	800 to 870			nm
Channel center wavelengths	805, 825, 845, 865 ± 5.0 nm			nm
Channel separation	20.0			nm
Average receive power, four channels (max)	+4.7			dBm
Average receive power, per channel (max)	-1.3			dBm
Return loss	12			dB
Receive electrical 3 dB upper cutoff frequency (max)	3750			MHz
Receive sensitivity	-13.5	-13.5	-13.5	dBm
Stressed receive sensitivity	-8.2	-8.5	-9.4	dBm
Vertical eye closure penalty	3.6	3.6	1.4	dB

* 8B/10B coding

Link Summary – Power Budget (Reference to GbE Table 38-5)

10 GbE CWDM 850 nm for Installed /New Fibers

Parameter	62.5 μm MMF	50.0 μm MMF	50.0 μm MMF (new)	Unit
Modal bandwidth as measured at 850 nm (min overfilled launch)	385	500	2000	MHz*km
Link power budget	8.0	8.0	8.0	dB
Operating distance	220	300	550	m
Channel insertion loss	2.3	2.6	3.5	dB
Link power penalties	4.3	4.5	2.4	dB
Unallocated margin in link power budget	1.4	1.0	2.1	dB

Note 1: MMF parameters are calculated with DCD_DJ = 25.0ps



Support of VCSEL Serial Solutions

10 GbE CWDM 850 nm for Installed/New MM Fibers

- VCSEL Serial Link
 - Distance limited by fiber bandwidth
 - Given: BR=10.3125 Gbps, $t_r = 30$ ps, receiver BW = 12.36 GHz
 - Use BW equation (3) to obtain operating distance

Operating Distance (L) at 850 nm

Fiber Type	Installed 62.5 um	Installed 62.5 um	Installed 50 um	New 50 um
BW (MHz-km)	160 (OFL)	385 (RML)	500 (OFL)	2,000 (RML)
L (meter)	20	53	70	300

Conclusion

10 GbE CWDM 850 nm for Installed/New MM Fibers

- VCSEL CWDM -- The lowest cost 10GbE proposal
- Early introduction to market
- Support installed 62.5 um, 50 um and new 50 um fibers
- Support 100 meter, 220 meter, 300 meter, 550 meter
- VCSEL-- proved, mature, high BW, low cost technology
- CWDM -- The lowest cost solution, multiple sources
- Specification -- similar to the popular GbE-SX