

40GE 10km SMF PMD Technical Feasibility

IEEE 802.3ba Task Force 40GE Ad Hoc

7 February 2008

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Outline

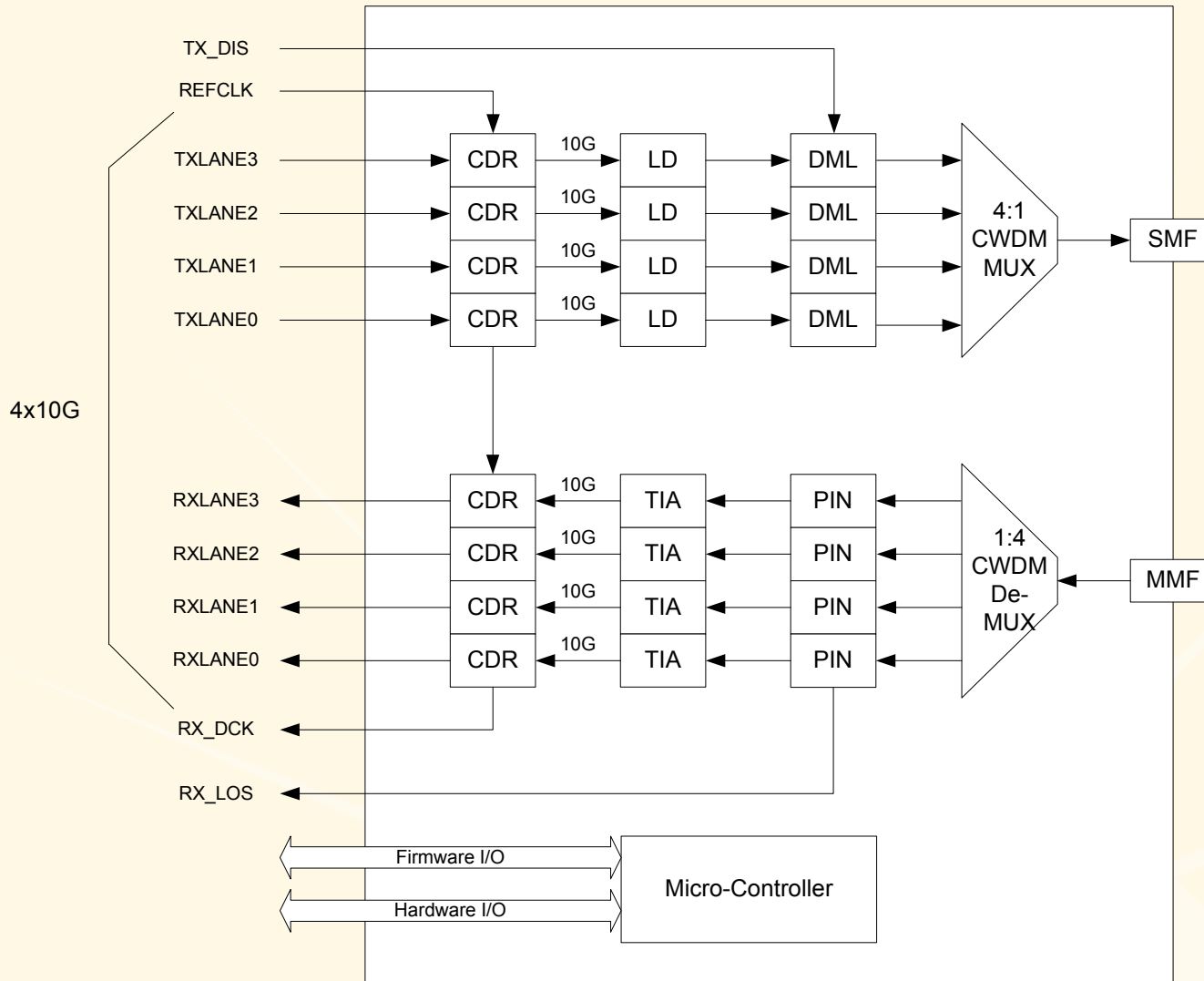
40GE 10km duplex SMF/MMF PMD

- SMF/MMF Transceiver Block Diagram
- SMF Link/Power Budget
- MMF OM3 Comments

Appendix: 40GE 100m parallel MMF OM3

- MMF Transceiver Block Diagram
- MMF Link/Power Budget

4x10G 1310nm DML 10km SMF/MMF Transceiver



Common with LX4:

- Duplex SMF/MMF
- 10km SMF

Different from LX4:

- 4x10G I/O (vs. 4x2.5G I/O)
- 100m OM3 MMF (vs. 300m)
- CWDM grid (vs. LX4 grid)

DC Power

- 8W

Form Factor

- Shared with 100GE Transceivers for interoperability and future high DC power applications

4x10G 1310nm DML 10km SMF Power Budget

10G Link Budget 10km SMF TP2 → TP3	CWDM DML $\lambda = 1331\text{nm}^*$ ER = 3.5dB
Fiber Loss (G.652 A&B)	4.3 dB
Penalties (10GBASE-L)	3.2 **
Connector loss	2.0
Total budget	9.5 dB

10G Pwr. Budget 10km SMF TP2 → TP3 OMA	CWDM DML $\lambda = 1331\text{nm}^*$ ER = 3.5dB
TX Min → Max	2.5 → 5.5 dBm
TP2 TX Min 2.5dB Mux loss	0.0 **
Link Budget (dB)	9.5 dB
TP3 RX Min 2.5dB DeMux loss	-9.5
RX Min (with crosstalk penalty)	-12.0 dBm

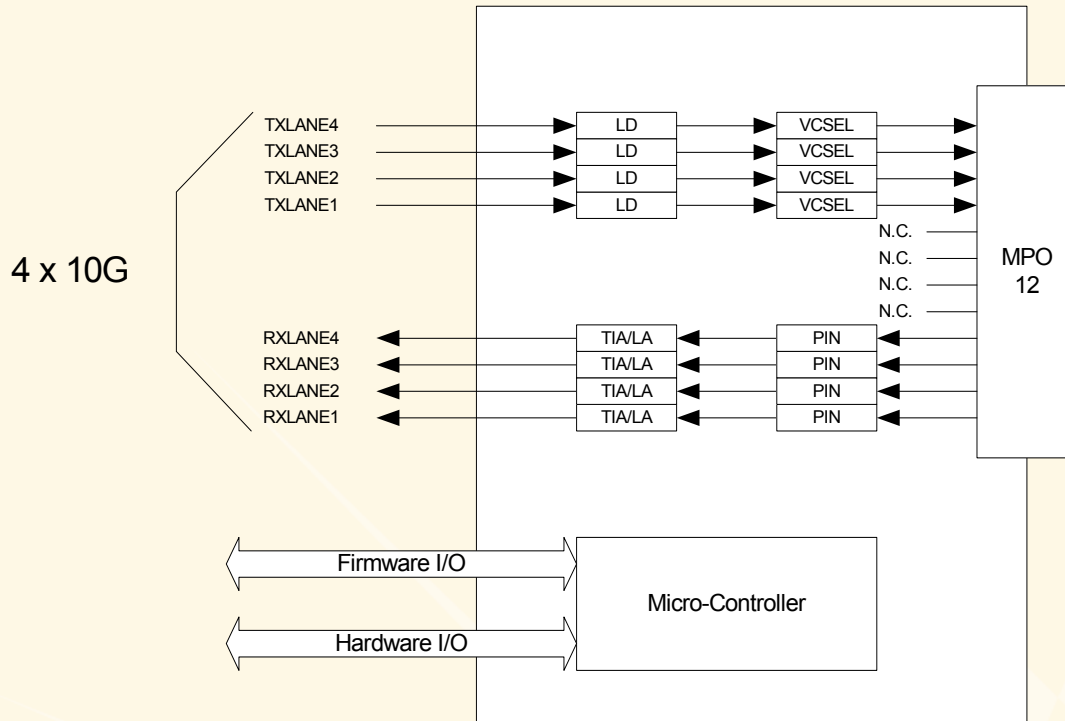
* Additional Link Budget and Power Budget analysis at $\lambda = 1331\text{nm}$ and $\lambda = 1271\text{nm}$ required to confirm final Budget numbers

** TP2 TX Min can be reduced for lower cost by reducing Penalties using today's DML technology transmitter parameters (vs. 10GE parameters)

4x10G 1310nm DML 100m duplex OM3 MMF

- Fiber loss effects are small
- OM3 MMF fiber bandwidth @ 1310nm = 500MHz / km
- 100m bandwidth = 5GHz
- IEEE 10GBASE-S reach recommendation for 500MHz / km fiber (850nm):
Max Reach = 82m
- ISI Penalty for 100m (assuming $t_R, t_F = 40\text{ps}$) = 4.7dB
- 40GE Transceiver shown on page 3 can support 100m duplex MMF OM3 (as well as OM2 MMF) reach, confirmed by IEEE 10GE spreadsheet model. Some TX laser driver pre-emphasis is required.
DC Power = 8W
- Longer reach than 100m OM3 MMF requires LRM EDC per RX channel
DC Power = 10W (with today's SiGe LRM EDC ICs)
= ~ 9W (with next generation CMOS LRM EDC ICs)
- Further analysis is required on realistic fiber profiles and jitter budgets, including using 10GBASE-LRM models.

Appendix: 40GE 100m parallel MMF OM3 Transceiver



- 4x10G 850nm VCSEL
- 100m parallel OM3 MMF (12 fiber MPO cable)
- QSFP form factor

Appendix: 100m 850nm OM3 Transmitter Budget

Transmit Characteristics			
Description	10GBASE-SR	Proposed 40/100G	Unit
Signaling Speed	10.3125	10.3125	GBd
Signaling Speed Variation	±100	±100	ppm
Center Wavelength	840 to 860	840 to 860	nm
RMS spectral width	Triple Tradeoff	0.6	nm
Average launch power max	Class 1 eye safe	0 / Class 1 (NOTE 1)	
Average launch power min	-7.3	-7.5	
Launch power min OMA	Triple Tradeoff	-4.5	dbm
Average launch power off	-30	-30	dBm
Extinction ratio (min)	3	3	dbm
RIN12OMA	-128	-130	dB/Hz
Opt. Return Loss Tolerance (max)	12	12	dB
Encircled flux	footnote f	same as -SR	
Transmitter eye mask	{0.25,0.40, 0.45,0.25, 0.28.0.40}	{0.25,0.40, 0.45,0.25, 0.28.0.40}	
Transmitter and dispersion penalty	3.9	tbd	dB
NOTE 1: Evaluate new limits from IEC for Class 1 / Class 1M for 4 and 12 channel Parallel TX			

Transmit / Receive / Link Budget presented to IEEE 802.3 HSSG, aronson_01_0109

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Appendix: 100m 850nm OM3 Receiver Budget

Receive Characteristics			
Description	10GBASE-SR	Proposed 40/100G	Unit
Signaling Speed	10.3125	10.3125	GBd
Signaling Speed Variation	±100	±100	ppm
Center Wavelength	840 to 860	840 to 860	nm
Average receive power max	-1	0	nm
Average receive power min	-9.9	-9.4	dBm
Receiver sensitivity (max) in OMA	0.077 (-11.1)	0.056 (-12.5)	mW (dBm)
Receiver reflectance (max)	-12	-12	dB
Stressed RX Sensitivity in OMA	0.18 (-7.5)	0.087 (-10.6)	mW (dBm)
VECP	3.5	2.0	dB
Stressed eye jitter	0.3	0.3?	UI pk-pk
RX elec. 3 dB upper cutoff (max)	12.3	12.3	GHz
NOTE: May be worth changing definition of stressed RX test			

■ Other considerations:

- May be worth changing definition of stressed RX test
 - Vertical eye closure now small, DJ stress large.
- Required sensitivity driven by reducing RJ contribution of RX

Appendix: 100m 850nm OM3 Link Budget Comparison

Link Budget				
Parameter	Unit	10GBASE-SR	Proposed 40/100G	Difference
Operating Distance	m	2 - 300	2 - 100	
Connector Loss	dB	1.50	1.50	0.00
Attenuation	dB	1.09	0.36	0.73
Intersymbol Interference	dB	3.02	1.65	1.37
RIN, MPN, Modal Noise, Cross	dB	0.90	0.70	0.20
Total Penalties	dB	6.51	4.21	2.30
Link Power Budget	dB	7.30	8.00	-0.70
Unallocated link margin	dB	0.79	3.79	-3.00

■ Calculated using 10GbE Spreadsheet (Rev 3.1.16a)

- Cell G7: TP2 DJ input = 26.2 ps (0.16UI from host, 0.11 from PMD TX)
- Cell G8: TP3 DCD / PWS = 17.5 ps (50% of host DJ, 0.10 from PMD TX)
 - Same relative assumptions as 8GFC
- All other parameters from original spreadsheet or as in strawman specs
- Link power budget / unallocated power margin driven by RJ considerations only