Baseline Proposal for 100 Gb/s per Lane Optical PMDs Supporting 50 and 100m OM4 MMF

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IEEE P802.3db 100 Gb/s, 200 Gb/s, and 400 Gb/s Short Reach Fiber Task Force

Ad Hoc Teleconference

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Adopted Objectives

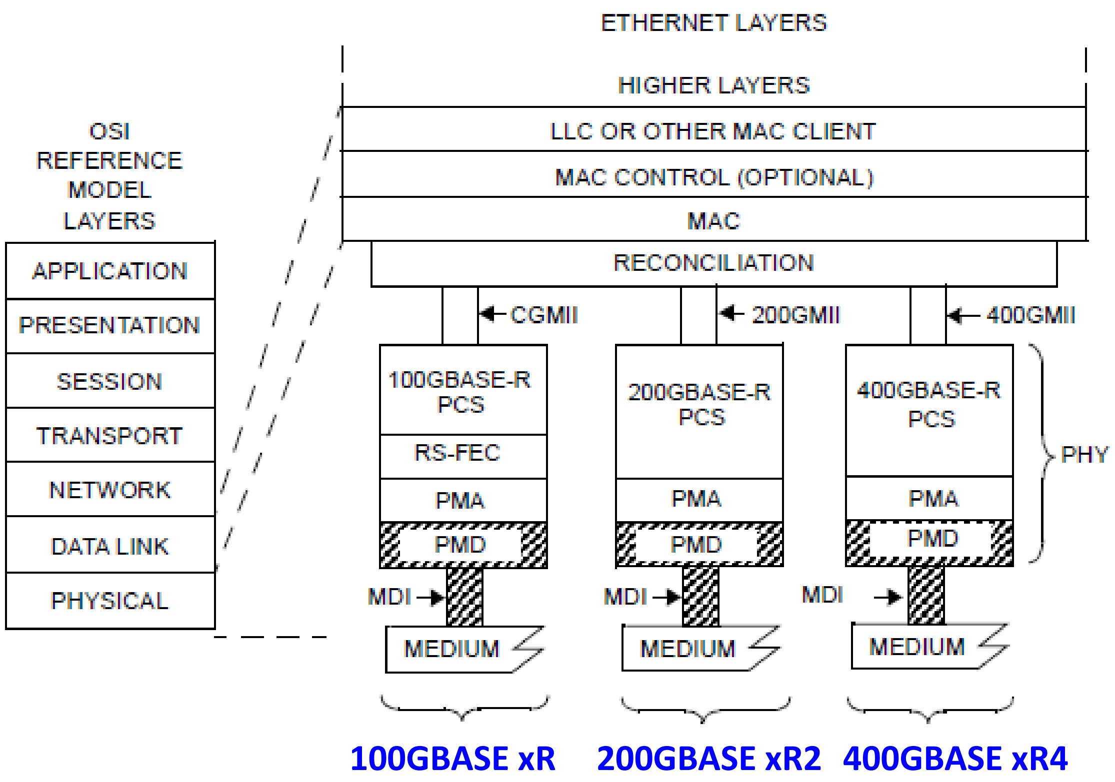
Reach Objective A

Define a physical layer specification that supports 100 Gb/s operation over 1 pair of MMF with lengths up to at least 50m.
Define a physical layer specification that supports 200 Gb/s operation over 2 pairs of MMF with lengths up to at least 50m.
Define a physical layer specification that supports 400 Gb/s operation over 4 pairs of MMF with lengths up to at least 50m.

Reach Objective B

Define a physical layer specification that supports 100 Gb/s operation over 1 pair of MMF with lengths up to at least 100m.
Define a physical layer specification that supports 200 Gb/s operation over 2 pairs of MMF with lengths up to at least 100m.
Define a physical layer specification that supports 400 Gb/s operation over 4 pairs of MMF with lengths up to at least 100m.

Position in the 802.3 Ethernet Architecture



400GMII = 400 Gb/s MEDIA INDEPENDENT INTERFACE
200GMII = 200 Gb/s MEDIA INDEPENDENT INTERFACE
CGMII = 100 Gb/s MEDIA INDEPENDENT INTERFACE
LLC = LOGICAL LINK CONTROL
MAC = MEDIA ACCESS CONTROL
MDI = MEDIUM DEPENDENT INTERFACE
PCS = PHYSICAL CODING SUBLAYER

PHY = PHYSICAL LAYER DEVICE
PMA = PHYSICAL MEDIUM ATTACHMENT
PMD = PHYSICAL MEDIUM DEPENDENT
RS-FEC = REED-SOLOMON FORWARD ERROR CORRECTION

xR represents two PMDs (naming TBD)
PMD FOR MULTIMODE FIBER 50 m
PMD FOR MULTIMODE FIBER 100 m

Links

- PMD reach chosen so that the OM4 fiber determines the test methodology.

PMD type	Fiber type	Operating range (m)
Reach Objective A	OM3	0.5 – 30
	OM4	0.5 – 50
	OM5	0.5 – 50
Reach Objective B	OM3	0.5 – 60
	OM4	0.5 – 100
	OM5	0.5 – 100

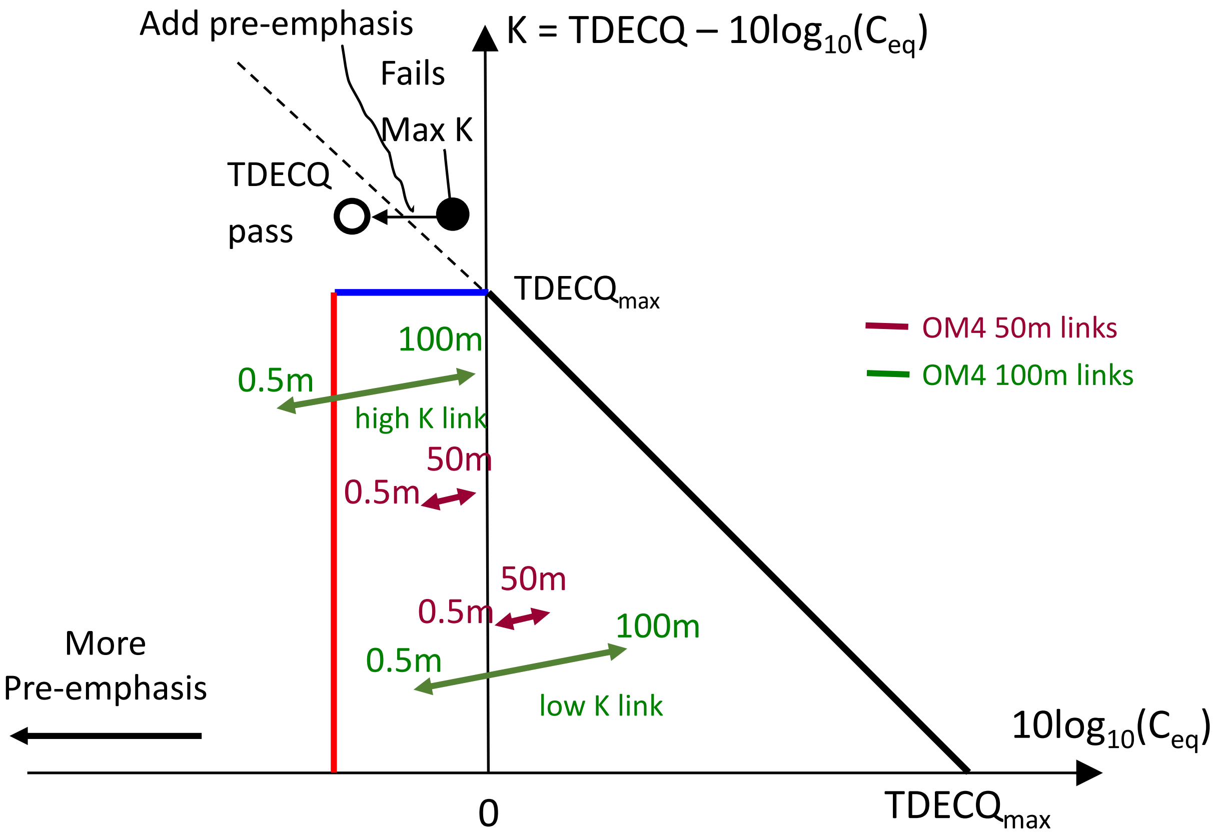
- The BER when processed by the PMA shall be less than 2.4×10^{-4} provided the error statistics are sufficiently random.

Assumptions

- Link budget is drawn with a TDECQ budget of 4.5 dB for the OM4 100m reach, same as in 50GBASE-SR and 400GBASESR4.2.
- Interoperability: When the OM4 cable is shorter than 50m, Tx for 100m reach must operate with a Rx for 50m reach and vice versa.
- Allocation of 1.5 dB for connector loss.
- Fiber chromatic dispersion parameters U0 = 1328 nm and S0 = 0.093477 ps/($nm^2 \cdot km$). [Ref. 4]

Pre-emphasis

<u>100G MMF links will use pre-emphasis.</u>



C_{eq} noise enhancement at the Rx equalizer.
K non-equalizable component of signal before Rx equalizer.

TDECQ = K + $10\log_{10}(C_{eq})$

Specifications that impact and limit the use of pre-emphasis.
Measurements and simulation/modeling are needed to set reasonable values.

1. TDECQ – $10\log_{10}(C_{eq})$, each lane (max) [blue line]
   Tx indicated by dot (●) can pass (○) TDECQ by applying pre-emphasis.
   (a) Should the Tx be rejected for K > $TDECQ_{max}$?
   (b) Will the Tx be rejected by another criterion?
   Propose not including in link specification (following 802.3cu).

2. Minimum value for the cursor on the reference equalizer [red line]
   Tx must work over 0.5 – 100m resulting in a wide range of C_{eq}.
   Minimum value for the Rx FFE cursor must be set sufficiently small
   to allow devices with high K (but less than $TDECQ_{max}$) to operate.
   Propose a min value of 0.7 for the cursor in the reference equalizer.

TIA-related specifications introduced in 802.3cu

3. Tx optical power excursion (max) = max(Pmax – Pav, Pav – Pmin)
   Accounts for TIA linearity.

4. Tx optical power over/under-shoot (max) as a fraction of outer OMA.
   Accounts for TIA linearity.
   Balance the need for sufficient pre-emphasis and TIA linearity.

Transmit Characteristics

Description	Value		Unit
	OM4 50m	OM4 100m	
Signaling rate, each lane (range)	53.125 ± 100ppm		GBd
Modulation format	PAM4		
Center wavelength (range)	842 to 868	844 to 863	nm
RMS spectral width (max)[a]	0.65	0.6	nm
Average launch power, each lane (max)	4		dBm
Average launch power, each lane (min)	-5		dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (max)	3.5		dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (min)[b]	-3		dBm
Transmitter excursion, each lane (max)	2		dBm
Transmitter overshoot/undershoot as a fraction of OMA_{outer}	TBD		
Launch power in OMA_{outer} minus TDECQ (min)	-4.6	-4.4	dBm
TDECQ, each lane (max)	4.5		dB
Average launch power of OFF transmitter, each lane (max)	-30		dB
Extinction ratio, each lane (min)	2.5		dB
Transmitter transition time, each lane (max)	17		ps
$RIN_{12}OMA$ (max)	-131		dB/Hz
Optical return loss tolerance (max)	12		dB
Encircled flux[c]	≥ 86% at 19 μm, ≤ 30% at 5 μm		

[a] RMS spectral width is the standard deviation of the spectrum.

[b] Even if TDECQ is less than 1.4 dB, outer OMA (min) must exceed this value.

[c] If measured into type A1a.2 or type A1a.3, or A1a.4, 50 um fiber, in accordance with IEC 61280-1-4.

Receive Characteristics

Description	Value		Unit
	OM4 50m	OM4 100m	
Signaling rate, each lane (range)	53.125 ± 100ppm		GBd
Modulation format	PAM4		—
Center wavelength (range)	842 to 868		nm
Damage threshold (min)[a]	5		dBm
Average receive power, each lane (max)	4		dBm
Average receive power, each lane (min)[b]	-6.9		dBm
Receive power each lane (OMA_{outer}) (max)	3.5		dBm
Receiver reflectance	-12		dB
Stressed receiver sensitivity (OMA_{outer}), each lane (max)[c]	-1.9		dBm
Receiver sensitivity (OMA_{outer}), each lane (max)[d]	max (-5, SECQ – 6.4)		dBm
Conditions of stressed receiver sensitivity test[e]			
Stressed eye closure for PAM4 (SECQ), lane under test	4.5		dB
OMA_{outer} of each aggressor lane[f]	3.5		dBm

[a] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level on one lane. The receiver does not have to operate correctly at this input power.

[b] Average receive power, each lane (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.

[c] Measured with conformance test signal at TP3 for the BER specified.

[d] Receiver sensitivity is informative and is defined for a transmitter with a SECQ up to 4.5 dB.

[e] These test conditions are for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

[f] Only applies to 200GBASE-SR2 and 400GBASE-SR4.

Test Methodology

Test methodology is based on Clause 138.

Description	Value		Unit
	OM4 50m	OM4 100m	
Half-symbol-rate filter bandwidth	26.5625		GHz
TDECQ reference response bandwidth*	21.0	15.0	GHz
Number of taps on T-spaced FFE	9		

Constraint on position of the cursor tap: Tap 1, 2, 3, 4, or 5 has the largest magnitude with a minimum value of 0.7.

* TDECQ reference response -3dBe bandwidth is for the best fit 4th order Bessel-Thompson filter to the combined fiber modal and chromatic dispersion modeled as a Gaussian LPF, and the receiver modeled as a 4th order Bessel-Thompson filter with bandwidth of 26.5625 GHz.

Illustrative Link Power Budget

Parameter	Reach Objective A			Reach Objective B			Units
	OM3	OM4	OM5	OM3	OM4	OM5	
Effective modal bandwidth at 850 nm[a]	2000	4700		2000	4700		MHz.km
Power budget (for max TDECQ)	6.3			6.5			dB
Operating distance	0.5 to 30	0.5 to 50		0.5 to 60	0.5 to 100		m
Channel insertion loss[b]	1.6	1.7		1.7	1.9		dB
Allocation for penalties (for max TDECQ)[c]	4.6			4.6			dB
Additional insertion loss allowed	0.1	0		0.2	0		dB

[a] Per IEC 60793-2-10

[b] The channel insertion loss is calculated using the maximum distance specified and cabled optical fiber attenuation of 3.5 dB/km at 850 nm plus an allocation for connection and splice loss given in 138.10.2.2.1

[c] Link penalties are used for link budget calculations. They are not requirements and not meant to be tested.

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6. Roberto Rodes, Greg D Le Cheminant, and Vipul Bhatt, “Update on Overshoot Spec,” rodes_3cu_01a_052620.pdf.

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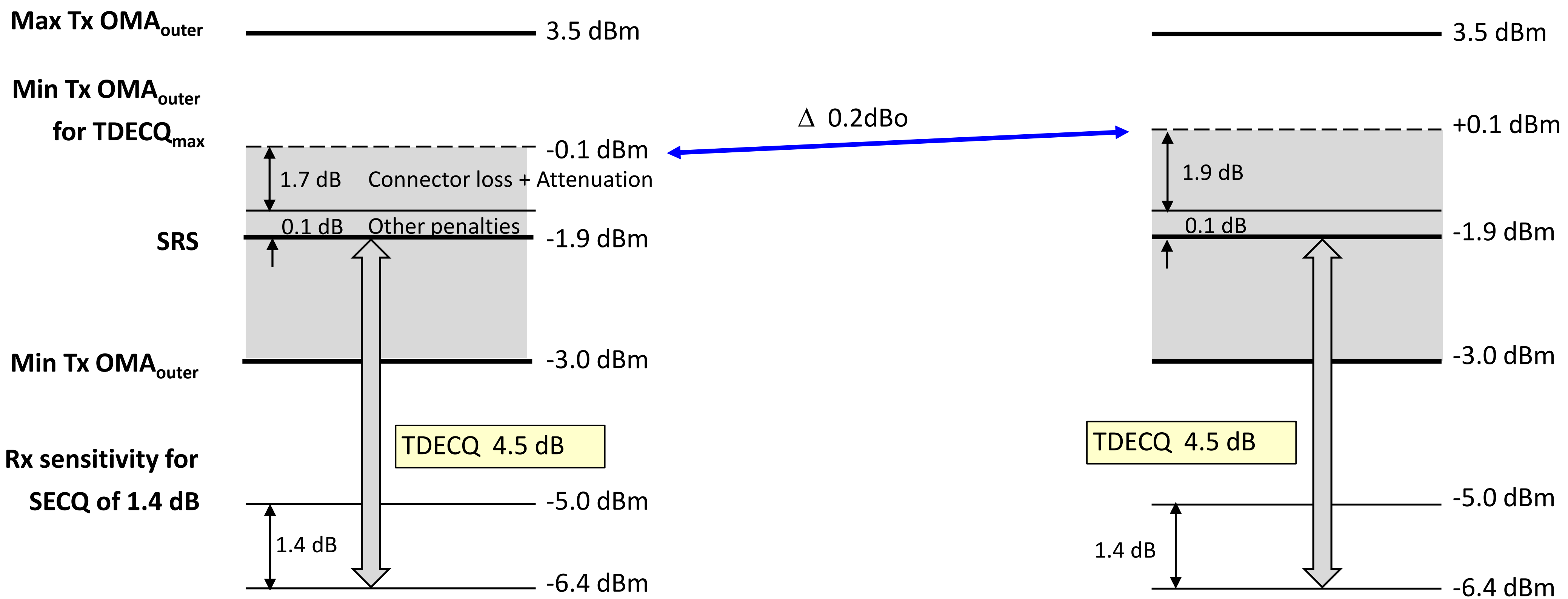
Appendix

Link Budget for OM4 50m and OM4 100m

802.3db
53.125 GBd
50m OM4

802.3db
53.125 GBd
100m OM4



Link Budget: Comparing 50G and 100G