

Towards a 400GBASE-LR4 Baseline

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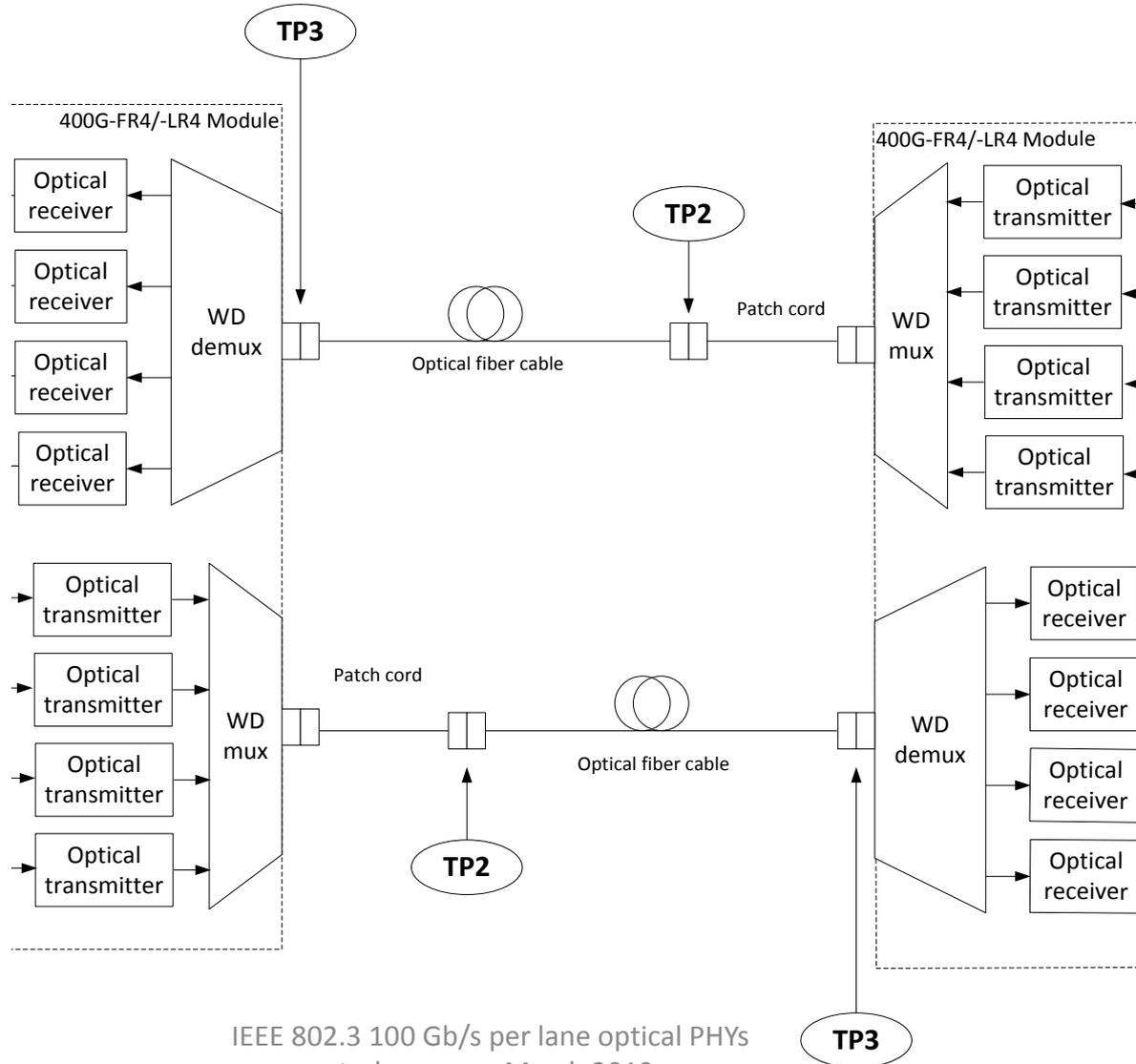
David Lewis, Lumentum

Supporters

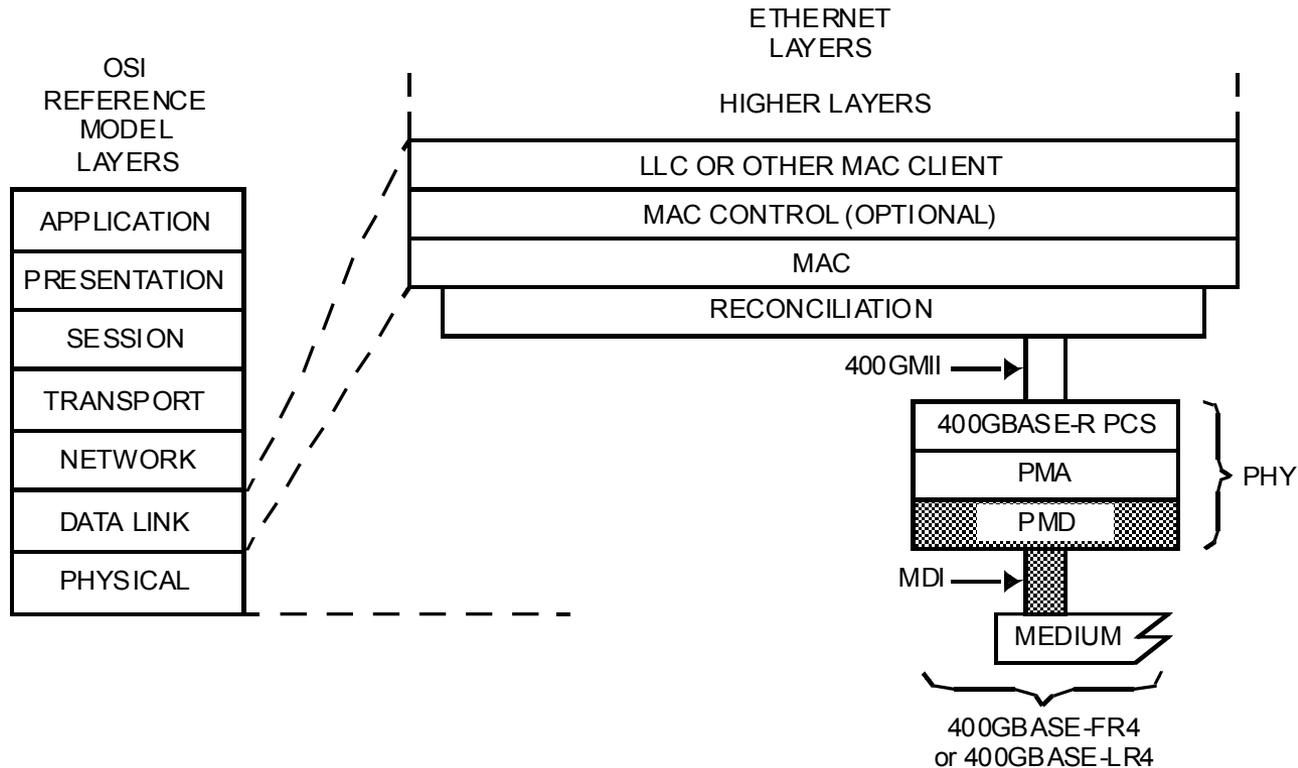
Overview

- This presentation describes a set of values for the Study Group adopted objective:
 - *Define a four-wavelength 400 Gb/s PHY for operation over SMF with lengths up to at least 10 km*
- Based on 100 Gb/s PAM4 signaling on each of four CWDM wavelengths
- Relies on the FEC in 400GBASE-R PCS layer.

Block Diagram



Position in IEEE 802.3 Ethernet Model



400GMII = 400 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

FR4 = PMD FOR SINGLE-MODE FIBER — 2 km
 LR4 = PMD FOR SINGLE-MODE FIBER — 10 km

Transmit Characteristics

Description	400GBASE-LR4	Unit
PAM4 Signaling rate, each lane (range)	53.125 ± 100 ppm	GBd
Lane wavelengths (range)	1264.5 to 1277.5	nm
	1284.5 to 1297.5	
	1304.5 to 1317.5	
	1324.5 to 1337.5	
Side-mode suppression ratio (SMSR), (min)	30	dB
Total average launch power (max)	10.0	dBm
Average launch power, each lane (max)	4.0	dBm
Average launch power, each lane ^a (min)	-2.8	dBm
Outer Optical Modulation Amplitude (OMA _{outer}), each lane (max)	4.2	dBm
Outer Optical Modulation Amplitude (OMA _{outer}), each lane ^b (min)	0.2	dBm
Difference in launch power between any two lanes (OMA _{outer}) max	4	dB
Launch power in OMA _{outer} minus TDECQ, each lane (min): for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	-1.2 -1.1	dBm
Transmitter and dispersion penalty eye closure for PAM4 (TDECQ), each lane (max)	3.9	dB
TDECQ – 10*log ₁₀ (C _{eq}), each lane (max) ^d	3.9	dB
Average launch power of OFF transmitter, each lane (max)	-20	dBm
Extinction ratio (min)	3.5	dB
Transmitter transition time (max)	17	ps
RIN _{15,6} OMA (max)	-136	
Optical return loss tolerance (max)	15.6	dB
Transmitter reflectance ^c (max)	-26	dB

Transmitter compliance channel (for TDECQ test)

Type	Dispersion ^a (ps/nm)		Insertion loss ^b	Optical return loss ^c	Max mean DGD
	Minimum	Maximum			
400GBASE-LR4	$0.2325 * \lambda * [1 - (1324/\lambda)^4]$	$0.2325 * \lambda * [1 - (1300/\lambda)^4]$	Minimum	15.6 dB	0.8 ps

Fiber optic cabling (channel) characteristics

Description	400GBASE-LR4	Unit
Operating distance (max)	10	km
Channel insertion loss ^{a,b} (max)	6.3	dB
Channel insertion loss (min)	0	dB
Positive dispersion ^b (max)	33.5	ps/nm
Negative dispersion ^b (min)	-59.5	ps/nm
DGD_max ^c	10	ps
Optical return loss (min)	21	dB
^a These channel loss values include cable, connectors and splices.		
^b Over the wavelength range 1264.5 to 1337.5 nm.		
^c Differential Group Delay (DGD) is the time difference at reception between the fractions of a pulse that were transmitted in the two principal states of polarization of an optical signal. DGD_max is the maximum differential group delay that the system must tolerate.		

Optical fiber and cable characteristics

Description	Value	Unit
Nominal fiber specification wavelength	1310	nm
Cabled optical fiber attenuation (max)	0.47 ^a or 0.5 ^b	dB/km
Zero dispersion wavelength (λ_0)	$1300 \leq \lambda_0 \leq 1324$	nm
Dispersion slope (max) (S_0)	0.093	ps/nm ² km

^a The 0.47 dB/km attenuation for optical fiber cables is derived from Appendix I of ITU-T G.695.
^b The 0.5 dB/km attenuation is provided for Outside Plant cable as defined in ANSI/TIA 568-C.3.

Receive Characteristics

Description	400GBASE-LR4	Unit
PAM4 Signaling rate, each lane (range)	53.125 ± 100 ppm	GBd
Lane wavelengths (range)	1264.5 to 1277.5	nm
	1284.5 to 1297.5	
	1304.5 to 1317.5	
	1324.5 to 1337.5	
Damage threshold, each lane (min) ^a	5.0	dBm
Average receive power, each lane (max)	4.0	dBm
Average receive power, each lane ^b (min)	-9.1	dBm
Receive power, each lane (OMA _{outer}) (max)	4.2	dBm
Difference in receive power between any two lanes (OMA _{outer}) (max)	4.1	dB
Receiver reflectance (max)	-26	dB
Receiver sensitivity (OMA _{outer}), each lane ^c (max)	$RS = \max(-6.6, SECQ - 8.0)$	
Stressed receiver sensitivity (OMA _{outer}), each lane ^d (max)	-4.1	dBm
Conditions of stressed receiver sensitivity test:		
Stressed eye closure for PAM4 (SECQ), lane under test	3.9	dB
SECQ – 10*log ₁₀ (C _{eq}), lane under test (max)	3.9	dB
OMA _{outer} of each aggressor lane	0	dBm

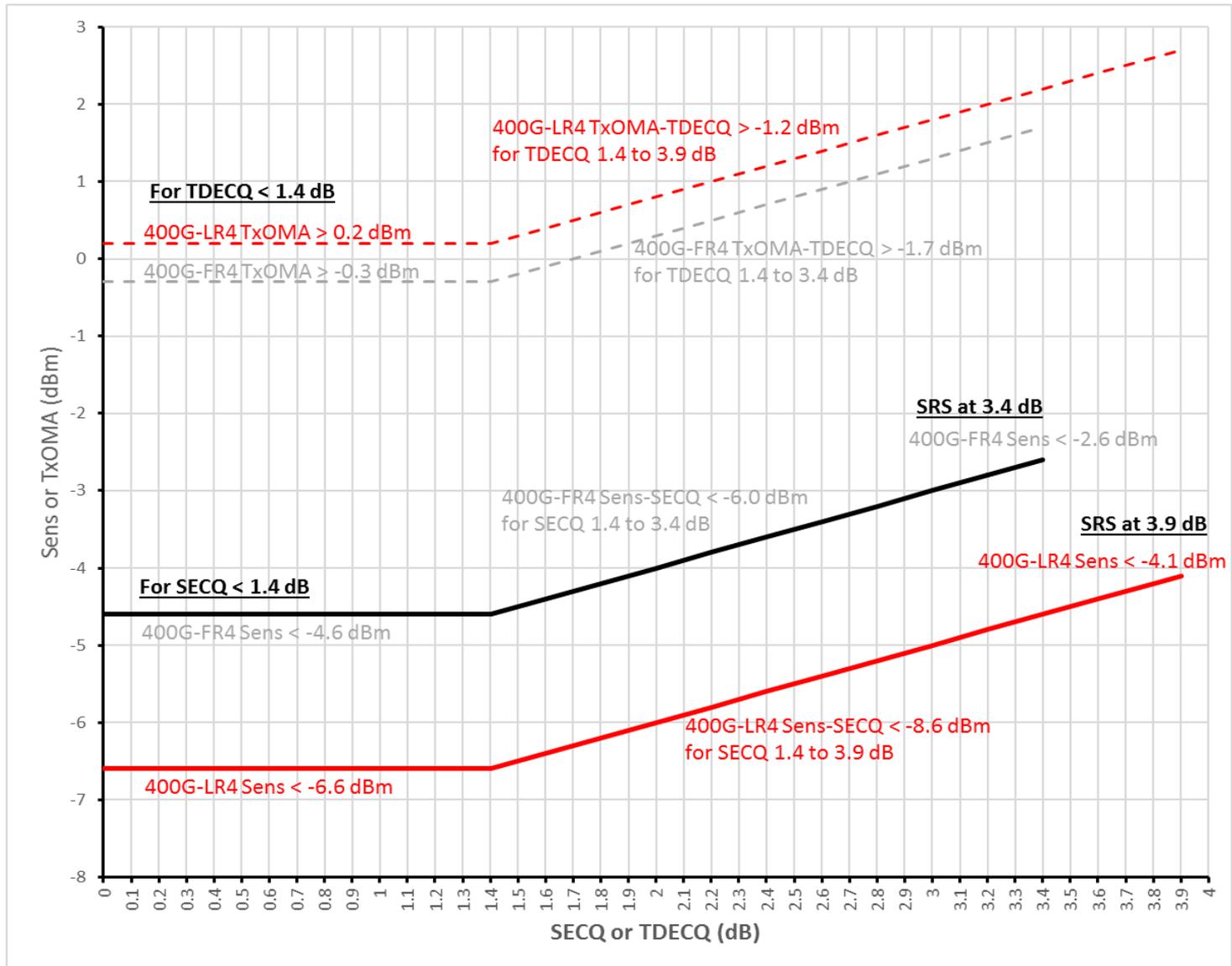
Illustrative Link Power Budget

Description	400GBASE-LR4	Unit
Power budget (for max TDECQ) for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	10.7 10.8	dB
Operating distance	10.0	km
Channel insertion loss ^a	6.3	dB
Maximum discrete reflectance	See Table xx	dB
Allocation for penalties ^b (for max TDECQ) for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	4.4 4.5	dB
Additional insertion loss allowed	0	dB

Table xx

Number of discrete reflectance above -55dB	Maximum value for each discrete reflectance
	400GBASE-LR4
1	-22 dB
2	-29 dB
4	-33 dB
6	-35 dB
8	-37 dB
10	-39 dB

Illustration of receiver sensitivity mask



Thanks