Proposal for 400GE Optical PMD for 2km SMF Objective based on 4 x 100G PAM4

David Lewis – JDSU
Gary Nicholl - Cisco
Jeffery J. Maki – Juniper Networks
Brian Welch - Luxtera
Vipul Bhatt - Inphi
Keith Conroy - MultiPhy
Vasudevan Parthasarathy - Broadcom
Ram Rao – Oclaro
Alan Tipper - Semtech

Supporters and Contributors

David Lewis – JDSU
Gary Nicholl - Cisco
Jeffery J. Maki – Juniper Networks
Brian Welch - Luxtera
Vipul Bhatt - Inphi
Keith Conroy - MultiPhy
Vasudevan Parthasarathy - Broadcom
Ram Rao – Oclaro
Alan Tipper - Semtech
Mark Nowell – Cisco

Big Ticket Items – 2km SMF PMD

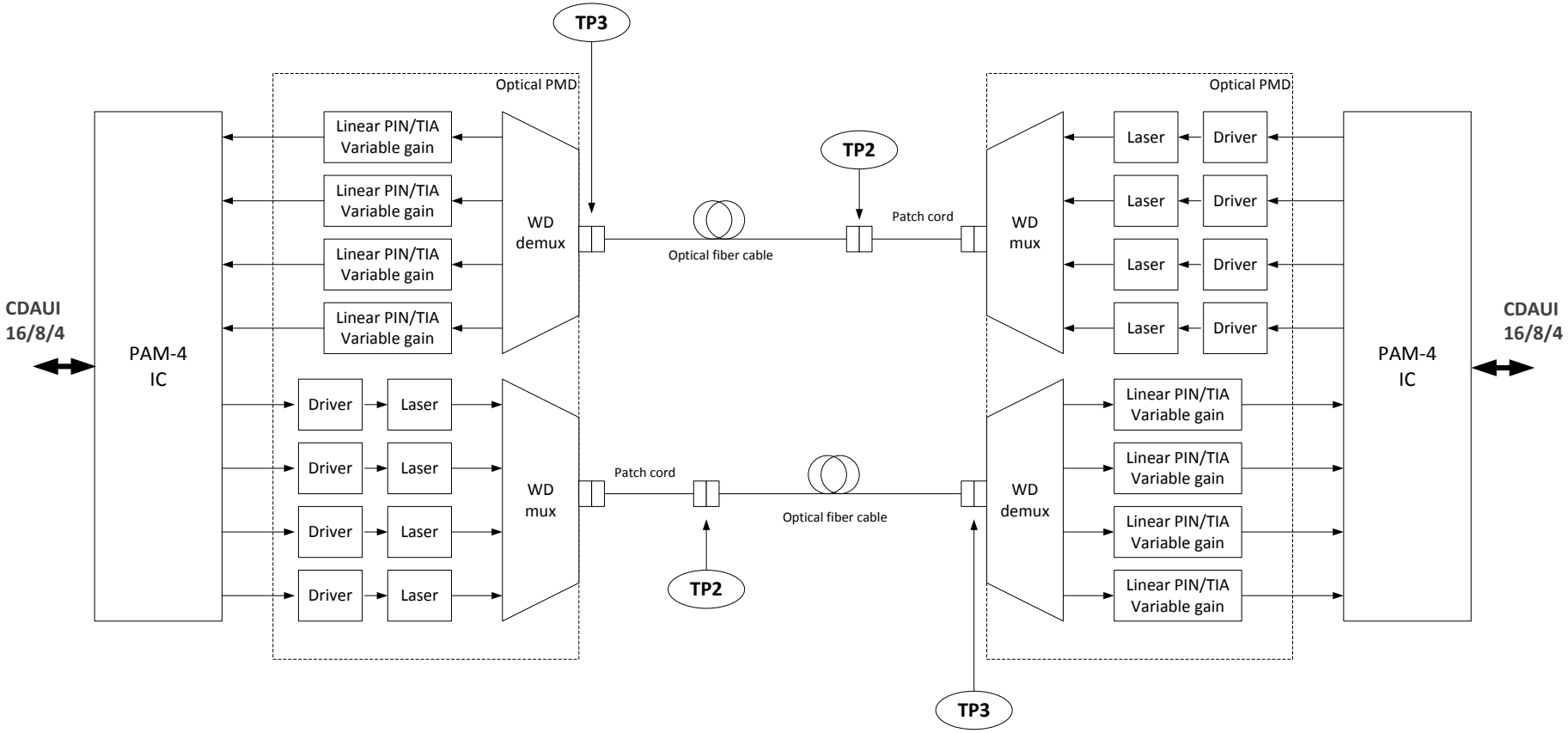
(From page 21 of big_ticket_items_3bs_01_0115.pdf)

- Proposals
  - Lewis_3bs_01a_0115 (PAM4)
- Actions:
  - Evaluate Coupling between electrical and optical interfaces
    - *See szczepanek_3bs_01_0315 at this meeting.*
  - Dispersion penalty worst case (in SMF ad hoc)
    - *See tipper_3bs_01_0315 at this meeting*
  - TDP. MPI
    - Specifications added in this presentation. *See tipper_3bs_01_0315.*
  - RX Technical feasibility & RX sensitivity
    - *Experiments to demonstrate unstressed & stressed sensitivity needed. Timing TBD.*

Summary

- This presentation provides an updated baseline proposal for
  - 2 km reach on duplex SMF (400GBASE-FR4)
- Approach is based on 100G/λ transmission on four CWDM wavelength channels using PAM4 signaling
- Link budget is based on KP4 FEC
- Updated to standard IEEE format – including TDP and Stressed Sensitivity

PMD Block Diagram – for Duplex SMF (2 km reach)

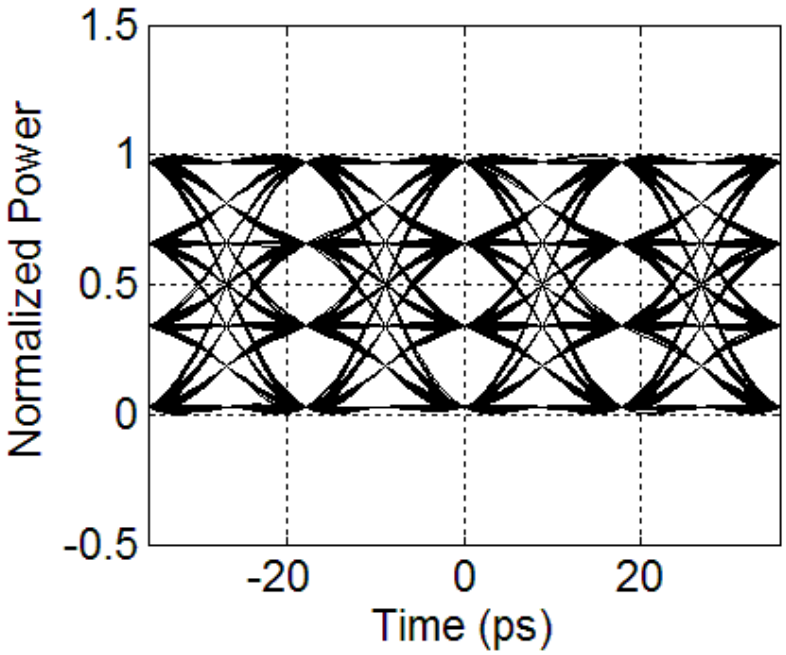


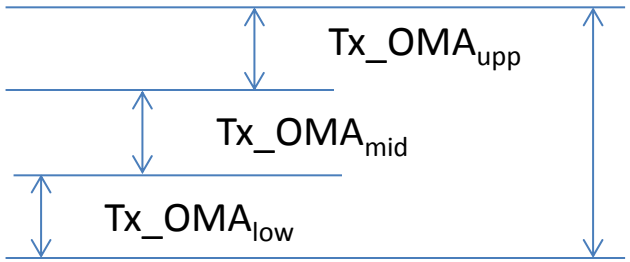
Transmitter Optical Specifications 4x100G PAM4

Description	400GBASE-FR4	Unit	Note
Signaling rate, each lane (range)	106.25 +/-100 ppm	Gb/s	* Assuming KP4 FEC
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm	* Aligned to 40GBASE-LR4 CWDM wavelength grid
Total average launch power (max)	10.5	dBm	
Average launch power, each lane (max)	4.5	dBm	
Average launch power, each lane (min)	-1	dBm	Informative at ER=Inf
Outer Optical Modulation Amplitude (OMA), each lane (max)	6	dBm	
Outer Optical Modulation Amplitude (OMA), each lane (min)	2	dBm	Even if TDP < 1dB, this minimum applies
Launch power in Outer OMA minus TDP, each lane (min)	1	dBm	
Transmitter and dispersion penalty (TDP), each lane (max)	1.5	dB	
Average launch power of OFF transmitter, each lane (max)	-30	dBm	
Extinction Ratio (min)	5.5	dB	
Average RIN, each lane (max)	-142	dB/Hz	
Optical return loss tolerance (max)	20	dB	Assumes cable plant with multiple -26dB reflections
Transmitter reflectance (max)	-26	dB	

Note: Highlighted areas are changes from lewis_3bs_01a_0115

Transmitter Specifications





- Max OMA and ER specified based on outer Tx_OMA_{outer}
- Sensitivity and link budget based on inner $Tx\_OMA_{low/mid/upp}$
  - Spec applies to minimum of 3 inner eye transitions

Receiver Optical Specifications

Description	400GBASE-FR4	Unit	Note
Output signaling rate, each lane (range)	103.125 +/-100 ppm	Gb/s	
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm	
Damage threshold (min)	5.5	dBm	
Average receive power, each lane (max)	4.5	dBm	
Average receive power, each lane (min)	-5	dBm	Informative at ER=Inf
Receive power, each lane (Outer OMA), (max)	6	dBm	
Receiver reflectance (max)	-26	dB	
Receiver Sensitivity, each lane (max)	-8.8	dBm	Informative. Unstressed at BER = 2.3E-4
Stressed receiver sensitivity, each lane (max)	TBD	dBm	At BER of 2.3E-4
Conditions of stressed receiver sensitivity test			
Vertical eye closure penalty, each lane	TBD		
Stressed eye J2 Jitter, each lane	TBD		
Stressed eye J4 Jitter, each lane	TBD		

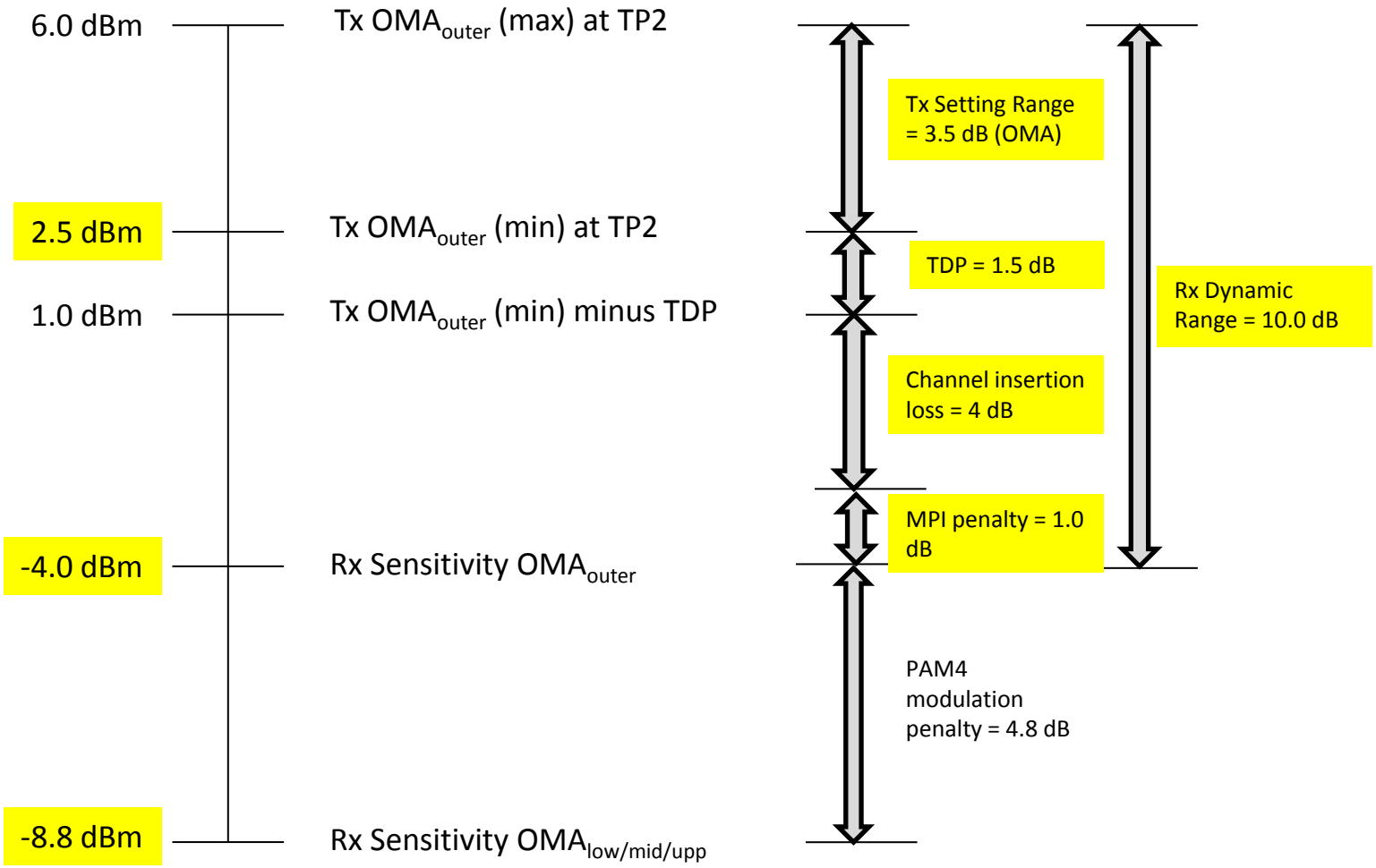
Note: Highlighted areas are changes from lewis_3bs_01a_0115

Illustrative Link Power Budget

Description	400GBASE-FR4	Unit	Note
Power budget (for maximum TDP)	11.3	dB	Tx Outer OMA – Rx Inner OMA Sensitivity
Operating distance	2	km	
Channel insertion loss	4.0	dB	
Allocation for penalties (for maximum TDP)	2.5	dB	Includes up to 1.0 dB for MPI penalty
Modulation penalty	4.8	dB	=Min[$OMA_{low/mid/upp}$] / OMA_{outer}
Additional insertion loss allowed	0	dB	

Note: Highlighted areas are changes from lewis_3bs_01a_0115

2km PAM4 Link Power Budget at max TDP



Summary

- Baseline proposal for a 2km SMF 400GE PMD based on PAM4 modulation with 100G/λ using 4 wavelengths on a CWDM grid
- Sensitivity defined based on a KP4 FEC with a 2.3E-4 BER threshold
- TDP and SRS specifications added