

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

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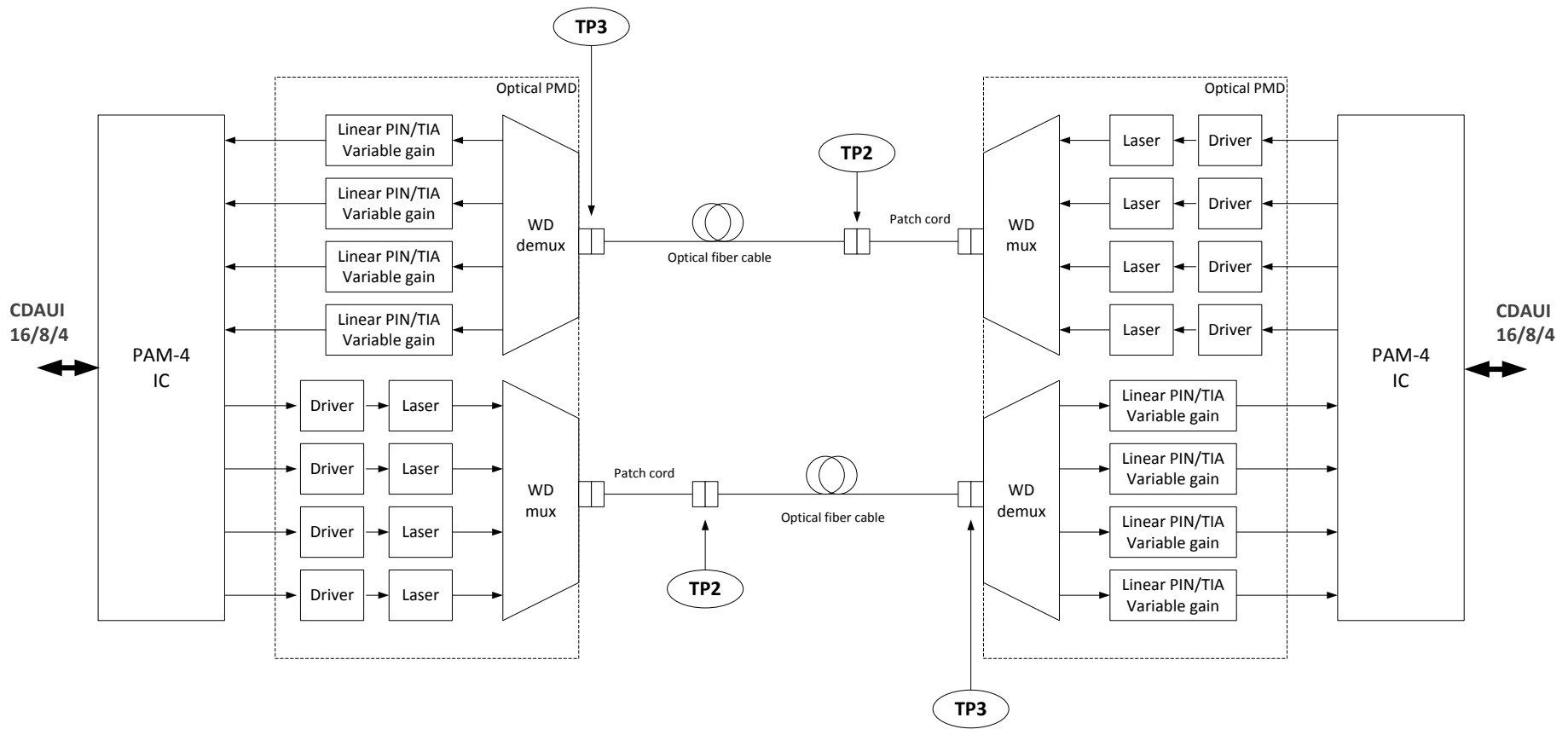
Summary

- This presentation provides a 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 as a placeholder. Proposed FEC Codes for 400 Gbps 802.3bs are in “parthasarathy_400GE_FEC_11_2014”) and will allow compliance to the same budget.

Supporters and Contributors

- Mark Nowell – Cisco
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- Matt Traverso - Cisco
- Neal Neslusan – Multiphy
- William Bliss – Broadcom
- Chuang Liang – Oplink
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- Atsushi Takai - Oclaro
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- Nobuhiko Kikuchi – Hitachi
- Patricia Bower – Fujitsu
- Ed Ulrichs – Source Photonics
- Brad Booth - Microsoft

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

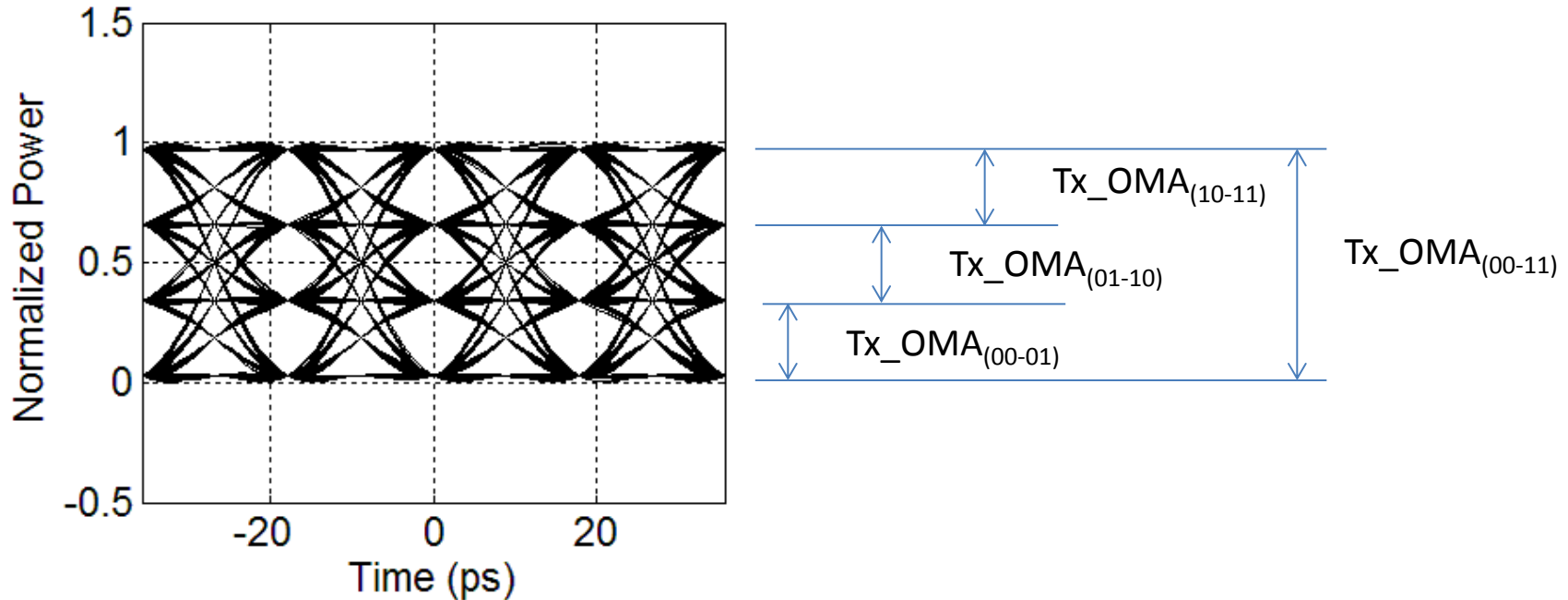


Transmitter Optical Specifications 4x100G PAM4

| Description | 400GBASE-FR4 | Unit | Note |
|--|--|-------|---|
| Input signaling rate, each lane (range) | 103.125 +/-100 ppm | Gb/s | |
| Output signaling rate, each lane (range) ³ | 106.25 +/-100 ppm | Gb/s | * Based on KP4 FEC in PAM-4 IC |
| 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 |
| Average launch power, each lane (max) | 4.0 | dBm | |
| Average launch power, each lane (min) | 1.0 | dBm | |
| Outer Optical Modulation Amplitude (OMA), each lane (max) ^{1,4} | 6 | dBm | |
| Inner Optical Modulation Amplitude (OMA), each lane (min) ² | -2.77 | dBm | |
| Dispersion and MPI penalty, each lane (max) | 1 | dB | |
| Average RIN, each lane (max) | -142 | dB/Hz | |
| Optical return loss tolerance (max) | 26 | dB | |
| Transmitter reflectance (max) | -26 | dB | |
| Extinction Ratio (min) ¹ | 5.5 | dB | |
| Cascaded transmitter 3 dB electrical upper cutoff frequency (min) | 20 | GHz | From DAC input to TP2 (Informative) |
| Total harmonic distortion (max) | 3 | % | TBR |

1. Measured with 10G test pattern for outer eye (00 to 11) modulation amplitude
2. Measured with 10G test pattern for minimum inner eye (00 to 01, 01 to 10, 10 to 11) modulation amplitude
3. Example only. Actual signaling rate will depend on final FEC selection
4. Outer Optical Modulation Amplitude min is not defined but will be no less than three times the minimum inner optical modulation amplitude.

Transmitter Specifications



- Max OMA and ER specified based on outer $Tx_OMA_{(00-11)}$
- Sensitivity and link budget based on inner $Tx_OMA_{(00-01,01-10,10-11)}$
 - Spec applies to minimum of 3 inner eye transitions

Receiver Optical Specifications

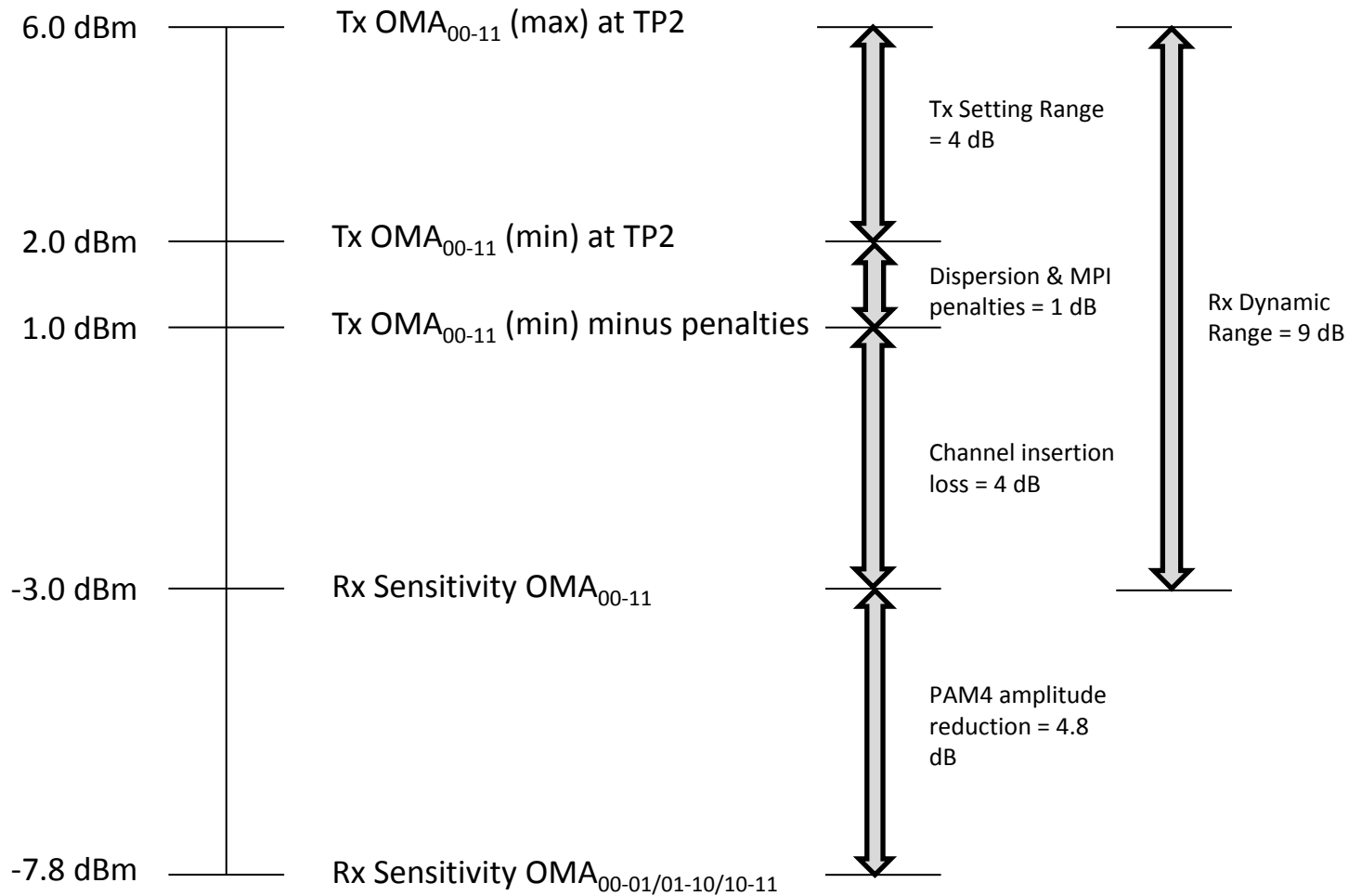
| Description | 400GBASE-FR4 | Unit | Note |
|--|--|------|--------------------------------------|
| Input signaling rate, each lane (range) | 106.25 +/-100 ppm | Gb/s | |
| Output signaling rate, each lane (range) | 103.125 +/-100 ppm | Gb/s | |
| Lane wavelengths (range) | 1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5 | nm | |
| Damage threshold (min) | 7.0 | dBm | |
| Average receive power, each lane (max) | 4.0 | dBm | |
| Average receive power, each lane (min) | -3.0 | dBm | |
| Receiver Overload (Outer) (OMA), each lane (min) ¹ | 6 | dBm | |
| Receiver Sensitivity (Outer) (OMA), each lane (max) ¹ | -3 | dBm | At pre-FEC BER of 2.1E-4 |
| Receiver Sensitivity (Inner) (OMA), each lane (max) ² | -7.77 | dBm | At pre-FEC BER of 2.1E-4 |
| Post FEC BER at Sensitivity | 1E-15 | | |
| Receiver reflectance (max) | -26 | dB | |
| Cascaded Rx 3dB electrical upper cutoff frequency (min) | 20 | GHz | From TP3 to ADC output (informative) |
| Total harmonic distortion | 3 | % | informative |
| Effective number of bits for ADC | 5.5 | bit | informative |

1. Informative spec on Rx sensitivity outer amplitude OMA
2. Normative specification Rx sensitivity each lane inner eye (0 to 1, 1 to 2, 2 to 3)
 - Based on over fiber with worst case compliant transmitter and maximum transmission penalty

Optical Link Budget

| Description | 400GBASE-FR4 | Unit | Note |
|---|--------------|------|------|
| Power budget at maximum link penalty | 5 | dB | |
| Operating distance | 2000 | m | |
| Channel insertion loss | 4 | dB | |
| Allocation for dispersion and MPI penalties | 1 | dB | |
| Additional insertion loss allowed | 0 | dB | |

2km PAM4 Optical Link Model



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 2.1E-4 BER threshold for a 1E-15 corrected BER
- Proposed FEC Codes for 400 Gbps 802.3bs in “parthasarathy_400GE_FEC_11_2014”) will allow compliance to the same budget.