400Gb/s 2km & 10km duplex SMF PAM-4 PMD Baseline Specifications

400 Gb/s Ethernet Task Force

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- Vasudevan Parthasarathy, Broadcom
- Rick Pimpinella, Panduit

Select Preceding References

- Sept. 2014: 8x50G WDM Technology background

  http://www.ieee802.org/3/bs/public/14_09/stassar_3bs_01b_0914.pdf

- Nov. 2014: Nominal Specifications

  http://www.ieee802.org/3/bs/public/14_11/cole_3bs_02a_1114.pdf

- Jan. 2015: Updated Nominal Specifications

  http://www.ieee802.org/3/bs/public/15_01/cole_3bs_02_0115.pdf

- BTI

  http://www.ieee802.org/3/bs/public/15_01/big_ticket_items_3bs_01_0115.pdf#page=13

  http://www.ieee802.org/3/bs/public/15_01/big_ticket_items_3bs_01_0115.pdf#page=19

Discussion

- During the March 2015 P802.3bs TF meeting 50G PAM-4 RX Sens. (inner eye OMA) data was presented
  - Finisar RX Sens. = ~-13.5dBm (BER = 2e-4)

    http://www.ieee802.org/3/bs/public/15_03/cole_3bs_02_0315.pdf#page=24
  - Huawei RX Sens. = ~-18dBm (BER = 2e-4)

    http://www.ieee802.org/3/bs/public/15_03/stassar_3bs_01a_0315.pdf#page=5
- Since the meeting, below deltas were identified:

Parameter	Finisar	Huawei
Noise Current	16.5pA/√HZ	15pA/√HZ
PD responsivity	0.5A/W	0.85A/W
Pattern	SSPR	PRBS15
GBaud	28	25.8

- With 0.8A/W PD responsivity, Finisar has since measured RX Sens. = ~-17dBm (BER = 2e-4)

Discussion, cont.

- -17 to -18dBm OMA RX Sens. enables 2km and 10km 8x50G PAM-4 PMDs using PIN PD RX
- Optical margin for 2km PMD results in sufficiently high manufacturing yield
- Optical margin for 10km PMD results in lower manufacturing yield
- Manufacturing a combination of 2km and 10km PMDs results in sufficiently high yield
- 25G linear APD technology when commercialized will have acceptable stand-alone 10km PMD manufacturing yield, although at a higher cost than PIN PD

Transmit Characteristics

Description (Outer Eye)	400GBASE-FR8	400GBASE-LR8	Unit
Reach	2	10	km
Signaling Rate, each lane	26.6	26.6	GBd
Operating BER*	2.0E-04	2.0E-04	
Total average launch power (max)	13.2	13.2	dBm
OMA, each lane (max)	5.5	5.7	dBm
OMA, each lane (min)	0.0	0.5	dBm
Launch Power in OMA – TDP, each lane (min)	-1.0	-0.5	dBm
Transmitter and dispersion penalty, (TDP) each lane (max)	2.0	2.2	dB
Extinction ratio (ER) (min)	4.5	4.5	dB
RIN OMA (max)	TBD	TBD	dB/Hz
Optical return loss tolerance (max)	TBD	TBD	dB

* The exact operating BER will be determined by the final FEC and PMA definition

Receive Characteristics

Description (Inner Eye)	400GBASE-FR8	400GBASE-LR8	Unit
Signaling Rate, each lane	26.6	26.6	GBd
Operating BER*	2.0E-04	2.0E-04	
Receiver reflectance (max)	TBD	TBD	dB
Receiver Sensitivity (OMA), each lane (max)	-10.0	-11.8	dBm
Receiver 3 dB electrical upper cutoff frequency, each lane (max)	21.0	21.0	GHz
Stressed receiver sensitivity (OMA), each lane (max)	TBD	TBD	dBm
Conditions of stressed receiver sensitivity test	TBD	TBD	

* The exact operating BER will be determined by the final FEC and PMA definition

Illustrative Link Power Budgets

Parameter	400GBASE-FR8	400GBASE-LR8	Unit
Reach	2	10	km
Power Budget (for maximum TDP)	11.0	13.5	dB
Operating Distance	2.0	10.0	km
Channel Insertion Loss	4.0	6.3	dB
Maximum Discrete Reflectance	TBD	TBD	dB
Allocation for Penalties* (for maximum TDP)	2.0	2.2	dB
Allocation for Modulation Penalties	5.0	5.0	dB

* Includes MPI penalty. As with all other parameters, it is subject to change in Task Force review.

WDM Lane Assignments

Lane	Center Frequency THz	Center Wavelength nm	Wavelength Range nm
L0	235.4	1273.55	1272.55 to 1274.54
L1	234.6	1277.89	1276.89 to 1278.89
L2	233.8	1282.26	1281.25 to 1283.28
L3	233.0	1286.66	1285.65 to 1287.69
L4	231.4	1295.56	1294.53 to 1296.59
L5	230.6	1300.05	1299.02 to 1301.09
L6	229.8	1304.58	1303.54 to 1305.63
L7	229.0	1309.14	1308.09 to 1310.19

Optical Margin

Description (Inner Eye)	400GBASE-FR8	400GBASE-LR8	Unit
Receiver Sensitivity (OMA), each lane, pre-DeMux (max)	-10.0	-11.8	dBm
DeMux Loss	3.0	3.0	dB
Cross-talk penalty	0.3	0.3	dB
Receiver Sensitivity (OMA), each lane, post-DeMux (max)	-13.3	-15.1	dBm
Receiver Sensitivity (OMA) single lane (typical measured)	-17	-17	dBm
Optical Margin	3.7	1.9	dB

Recommendations

- Adopt 8x50G PAM-4 WDM duplex SMF architecture for P802.3bs 2km and 10km SMF PMD objectives as per baseline specifications in this presentation
- Develop the 2km and 10km specifications so that 10km is a higher performance variant of the 2km specification and can be built from upper end of the performance distribution of 2km PMD optical components
- Develop the 10km specification to be compatible with linear APD receivers
- All baseline specification parameters will undergo further analysis and are subject to change by the Task Force

2km & 10km PAM-4 PMD Baseline Specs

Thank you