Baseline specifications for optical PMDs based on 200G/lane for 500m and 2km

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Introduction

- The task force has finished the 1st Task Force review of P802.3df D1.0, which defines Optical PMDs based on 100G/lane optics.
- The hot issue of 200G/lane optics has been on the choice of technical solution for 10km/40km applications.
- However, the first deployed 200G/lane optics is likely to be targeting applications ≤2km, considering the technical difficulties in longer reach and the large number of shipments in this application space. So far, only a few contributions have been proposed, i.e. welch_3df_01b_220602, welch_3df_01a_221011, ingham_3df_01_221011.
- This contribution joins the discussion on baselines of 200G/lane optical PMDs for applications up to 2km.

Related Objectives		
DRx(500m)	DRx-2	FR4
400Gb/s over 2 pairs		
800Gb/s over 4pairs	800Gb/s over 4pair	800Gb/s over 4λs
1.6Tb/s over 8pairs	1.6Tb/s over 8pairs	

Fundamental Specs of the Optical Channel

	800G-DR4	800G-DR4-2	800G-FR4
Assumed Wavelength Plan	1304.5-1317.5	1304.5-1317.5	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5
power budget (dB)			
channel IL(dB)	3	4	4
max discrete reflectance (dB)	-45	-35	-35
allocation for penalties (dB)			
max positive dispersion (ps/nm)	0.8	3.2	6.6
min negative dispersion (ps/nm)	-0.93	-3.7	-11.7
DGD_max (ps)	1.14	2.28	2.28
optical return loss(min) (dB)	37	25	25

Table 124-8, Table 151-9

Table 124-11, Table 151-13

Same as in P802.3df D1.0 for 400GBASE-DR4-2

$$DGD\_max = PMD\_max * sqrt(Lkm) * S$$

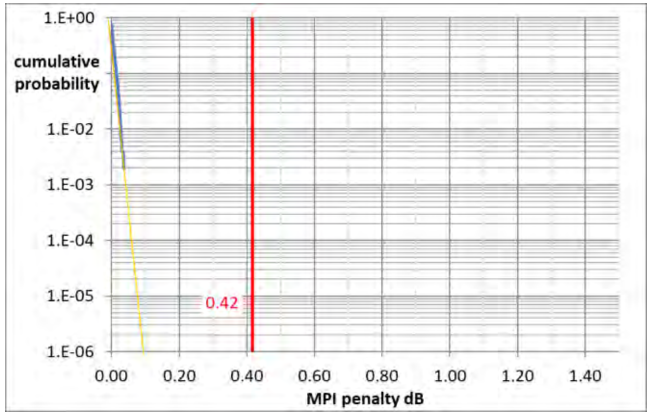
	PMD_Q	PMD_max	S	L(km)	DGD_max (ps)
100GBASE-FR 400GBASE-FR4	0.2	0.43	3.75	2	2.3
800G-DR4	**0.2**	**0.45**	**3.75**	**0.5**	**1.14**
800G-DR4-2 800G FR4	0.2	0.43	3.75	2	2.28

MPI penalty – 500m application

Random phase between reflectors, random selection of modulation levels
Polarization assumed aligned

			PAM-N N=									1
									ER	dER	1/1-dER	inner/outer OM/
Baseline BER	average phase=		4						3.5	0.447	1.8073	0.33 / 1
2.0E-03	3.146353254											
	PMD											PMD
	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12
	Rpmd	RconF	RconG	RconG	RconH	RconK	RconK	RconH	RconG	RconG	RconF	Rpmd
Reflection level inputs->	-26	-45	-55	-55	-55	-55	-45	-45	-55	-55	-45	-26
	phase between int1-int2	phase between int2-int3	phase b int3-int4	phase b int4-int5	phase b int5-int6	phase betwe int6-int7	phase bet int7-int8	phase be int8-int9	phase between int9-int1(	int10-in	int11-int12	

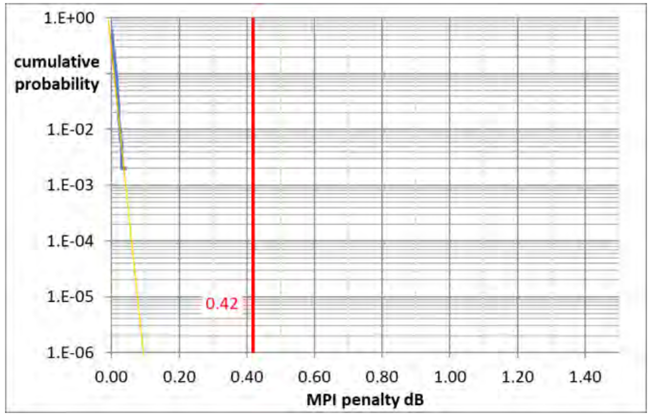
N value used to 4



For DR (500m) applications, MPI penalty 0.1dB

			N=						ER	dER	1/1-dER	inner/outer OMA
Baseline BER	average phase=		4						3.5	0.447	1.8073	0.33 / 1
4.9E-03	3.141941689											
	PMD											PMD
	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12
	Rpmd	RconF	RconG	RconG	RconH	RconK	RconK	RconH	RconG	RconG	RconF	Rpmd
Reflection level inputs->	-26	-45	-55	-55	-55	-55	-45	-45	-55	-55	-45	-26
	phase between int1-int2	phase between int2-int3	phase b int3-int4	phase b int4-int5	phase b int5-int6	phase betwe int6-int7	phase bet int7-int8	phase be int8-int9	phase between int9-int1(	int10-in	int11-int12	

N value used to rai 4



MPI penalty – 2km application

Random phase between reflectors, random selection of modulation levels
Polarization assumed aligned

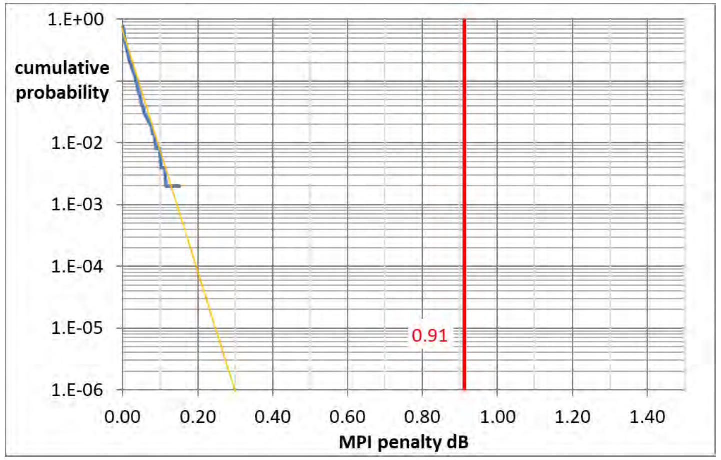
PAM-N N= 4

ER	dER	1/1-dER	inner/outer OMA	
3.5	0.447	1.8073	0.33	1

Baseline BER 2.0E-03 — average phase= 3.106680048

	PMD											PMD
	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12
	Rpmd	RconF	RconG	RconG	RconH	RconK	RconK	RconH	RconG	RconG	RconF	Rpmd
Reflection level inputs->	-26	-35	-55	-55	-55	-55	-35	-35	-55	-55	-35	-26
	phase between int1-int2	phase between int2-int3	phase b int3-int4	phase b int4-int5	phase b int5-int6	phase betw int6-int7	phase bet int7-int8	phase be int8-int9	phase between int9-int1(	int10-in	int11-int12	

N value used to 4



Random phase between reflectors, random selection of modulation levels
Polarization assumed aligned

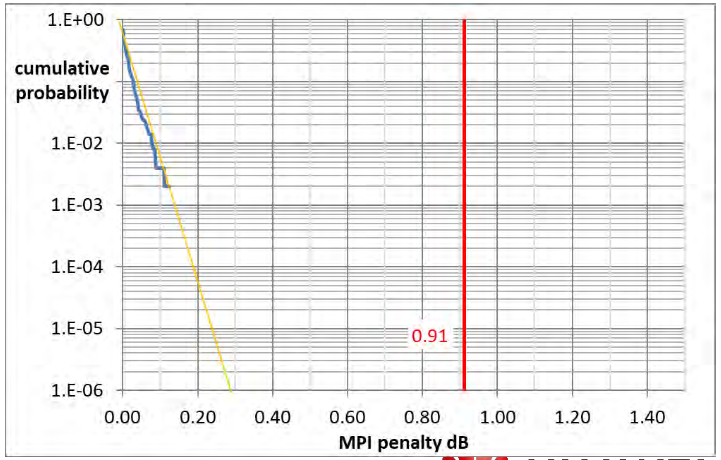
PAM-N N= 4

ER	dER	1/1-dER	inner/outer OMA	
3.5	0.447	1.8073	0.33	1

Baseline BER 4.9E-03 — average phase= 3.118309958

	PMD											PMD
	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12
	Rpmd	RconF	RconG	RconG	RconH	RconK	RconK	RconH	RconG	RconG	RconF	Rpmd
Reflection level inputs->	-26	-35	-55	-55	-55	-55	-35	-35	-55	-55	-35	-26
	phase between int1-int2	phase between int2-int3	phase b int3-int4	phase b int4-int5	phase b int5-int6	phase betw int6-int7	phase bet int7-int8	phase be int8-int9	phase between int9-int1(	int10-in	int11-int12	

N value used to 4



For 2km applications(DR-2 & FR）, MPI penalty 0.3dB

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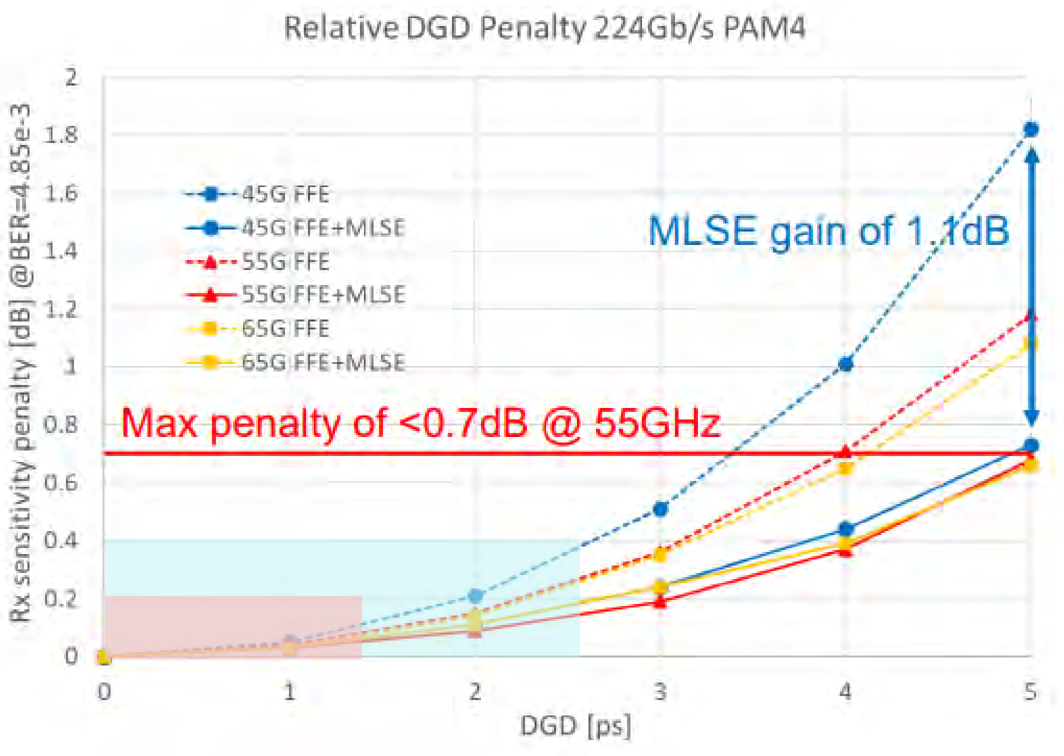
DGD penalty



kuschnerov_3df_01b_221012

- For DR (500m) applications the estimated DGD penalty is well below 0.2dB, even with limited component bandwidth and FFE only at Rx side
- In 2km applications the influence of system impairments and the benefits of strengthened Rx DSP algorithm starts to show.

DGD	1.14ps（500m）	2.28ps（2km）
Rx Sensitivity Penalty	0.2dB	0.4dB

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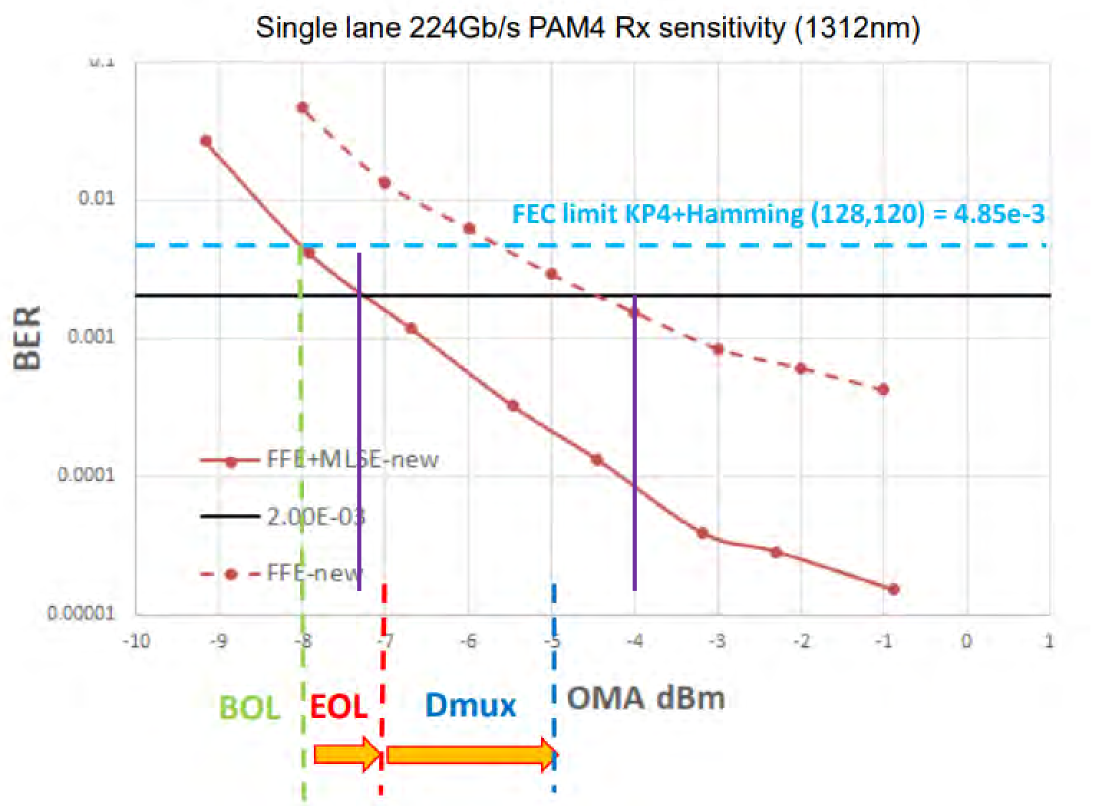
Proposed Link Budget of the Fiber Link

	800G-DR4	800G-DR4-2	800G-FR4
power budget (dB)	6.7	8.1	8.4
channel IL (dB)	3	4	4
max discrete reflectance (dB)	-45	-35	-35
allocation for penalties (dB)	3.7	4.1	4.4
max positive dispersion (ps/nm)	0.8	3.2	6.6
min negative dispersion (ps/nm)	-0.93	-3.7	-11.7
DGD_max (ps)	1.14	2.28	2.28
optical return loss(min) (dB)	37	25	25
MPI Penalty (dB)	0.1	0.3	0.3
DGD Penalty (dB)	0.2	0.4	0.4
TDECQ max (dB)	3.4	3.4	3.7

Revisit the experimental result

- As stated in kuschnerov_3df_01b_221012， with FEC limit @4.85e-3, with a strengthened algorithm, FFE+MLSE for the data
  - ~-8dBm OMA Rx sensitivity
  - Leaves about ~3dB for a Rx sensitivity of -5dBm
- Same applies to assuming FEC limit @2e-3, with a strengthened Rx algorithm, FFE+MLSE for the data
  - ~-7.3dBm OMA
  - Leaves >3dB for a Rx Sensitivity of -4dBm
- The performance can still be improved as the 200G/lane technology evolves
  - Current data were acquired with bandwidth-limited components
  - Room to improve Rx Noise factors



Proposed Transmitter Baseline

Description	800G-DR4	800G-DR4-2	800G-FR4	Unit
Description	Value			Unit
Signaling Rate, each lane(range)	TBD			GBd
Modulation Format	PAM4			-
Lane Wavelength(Range)	1304.5-1317.5	1304.5-1317.5	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Average Launch Power, each lane(max)	4	4	4	dBm
Average Launch Power, each lane(m,in)	-2.9	-2.8	-2.8	dBm
Transmitter OMA_outer max	4.2	4.2	4.2	dB
Transmitter OMA$_{outer\ min}$ — TDECQ<1.4dB	-0.8	0.2	0.2	dBm
Transmitter OMA$_{outer\ min}$ — 1.4dB≤TDECQ≤TDECQ_max	-2.2+TDECQ	-1.5+TDECQ	-1.2+TDECQ	dBm
TDECQ(max)	3.4	3.4	3.7	
TECQ	same as TDECQ			dB
|TDECQ-TECQ|	TBD	TBD	TBD	dB
Average launch power of OFF transmitter, each lane(max)	-15	-15	-16	dBm
Extionction Ratio (min)	3.5	3.5	3.5	dB
Transmitter Transition time	TBD	TBD	TBD	Ps
over/under-shoot(max)	TBD	TBD	TBD	%
RIN$_x$OMA[a]	-139	-139	-139	dB/Hz
Optical Return loss tolerance(max)	21.4	17.1	17.1	dB
Transmitter reflectance(max)	-26	-26	-26	dB

[a]： x refers to the value of Optical return loss tolerance(max) of each column.

Remained the same as 100G/lane, friendly to implementations using SiP-based Transmitter and shared laser source, for low cost.

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Proposed Receiver Baseline

	800G-DR4	800G-DR4-2	800G-FR4	
Description	Value			Unit
Signaling Rate, each lane(range)	TBD			GBd
Modulation Format	PAM4			-
Lane Wavelength(Range)	1304.5-1317.5	1304.5-1317.5	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Damage threshold, each lane	5	5	5	dB
Average receive Power, each lane(max)	4	4	4	dBm
Average receive Power, each lane(min)	-6	-7.1	-7.2	dBm
Receiver OMA_outer max	4.2	4.2	3.7	dB
Receiver reflectance(max)	-26	-26	-26	dB
Reciever Sensitivity OMA_{outer}, each lane(max): TECQ<1.4dB	-4.1	-4.5	-4.5	dBm
Reciever Sensitivity OMA_{outer}, each lane(max): 1.4dB≤TECQ≤TECQ_max	-5.5+TECQ	-5.9+TECQ	-5.9+TECQ	dBm
Stressed receiver sensitivity (OMA_{outer}), each lane(max)	TBD	TBD	TBD	dBm
Conditions of stressed receiver sensitivity(SECQ)	3.4	3.4	3.7	dB

[a]： x refers to the value of Optical return loss tolerance(max) of each column.

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Summary

- A set of link budgets for optical PMDs based on 200G-PMA4 technology for up to 2km applications was proposed.
- The transmitter and receiver baselines were proposed, bearing the awareness of
  - DR(500m) application will continue benefit from the established SiP ecosystem, i.e. low cost and vast deployment.
  - 2km FR4 application, using CWDM, is subject to non-negligible CD penalty, leading to a different TDECQ max value, unlike the days of 100G/lane.
  - Final numbers for OMA_outer may still need to be revisited, pending the decision on FEC and FEC limit
- From the current simulation and experiment result an advanced Rx algorithm is most likely required to close the link
  - With Soft decision FEC， BCJR can be used for such purpose
  - Reference receiver for the TDECQ needs to be optimized for this change.
  - Further investigation on the definition of such reference receiver to facilitate interoperability is needed.

Thank you.

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