Proposed modifications to 100GBASE-DR

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Background and Motivation

- The MPI (multi-path interference) penalty is a consequence of reflections within the channel medium. These reflections are expected to be challenging to measure and characterize in deployed networks
- In clause 124 (400GBASE-DR4), Table 124-13 describes the maximum number of discrete reflectances > -55 dB within the channel which the PMD can support
- The single column of reflectance tradeoffs in Table 124-13 is consistent with the expected deployed medium which consists of parallel fiber.
- Clause 140 (100GBASE-DR) which is defined over a duplex fiber pair is expected to be deployed over a mix of media – both parallel and duplex
- For example, see kolesar_3bs_01_0514, where a common fiber topology of a mixed duplex and parallel fiber is shown
- To support the heterogeneous environment of Clause 140, this presentation proposes to show impact of multiple magnitudes of reflectances
- Furthermore, we propose to tradeoff the MPI penalty with the supported channel loss

Methodology Used

1) **Reflectances**:
   - Transmitter and Receiver are modeled to each have -26 dB reflectance
   - Using combination of -35 dB reflectances & -45 dB reflectances in channel
     - In the table these will be -35 dB to -45 dB reflectances and -45 dB to -55 dB reflectances respectively
   - Insert text stating that the effect of < -55dB reflectances may be ignored
2) **MPI Calculation:**
   - Using king_02a_0116_smf spreadsheet for MPI calculation
   - Using zero loss for connectors – *pessimistic*
   - Using 3 dB in end-span insertion loss – as was done in Table 124-13 (400GBASE-DR4)
3) **Link Budget Calculation:**
   - Channel insertion loss is 3 dB
   - If MPI penalty is > 0.15 dB, then the penalty will be subtracted from 3.1 dB
   - If MPI penalty is > 0.50 dB, the table will indicate that such channel is not supported

Maximum Optical Return Loss

- To determine the RIN parameter settings, it is important to specify the maximum optical return loss
- Below is a table capturing the return loss
  - Field addition with receiver, without loss in the channel

Optical Return Loss		Number of discrete reflectances between -45 dB and -55 dB								
		0	1	2	3	4	5	6	7	8
Number of discrete reflectances between -35 dB and -45 dB	0		25.08	24.24	23.48	22.78	22.13	21.53	20.97	20.44
	1	23.36	22.67	22.03	21.44	20.88	20.35	19.86	19.39	18.95
	2	21.34	20.79	20.27	19.78	19.32	18.88	18.46	18.06	17.68
	3	19.70	19.24	18.81	18.39	18.00	17.62	17.25	16.90	16.57
	4	18.33	17.93	17.56	17.19	16.85	16.51	16.19	15.88	15.59
	5	17.14	16.79	16.46	16.14	15.84	15.54	15.25	14.97	14.70
	6	16.09	15.79	15.49	15.20	14.93	14.66	14.40	14.15	13.90

x.yz = these values either exceed the proposed MPI penalty limit or the number of connections exceeded the capability of the spreadsheet

Table is for reference – not to be included in standard

MPI penalty

For reference – not to be included in standard

MPI Penalty		Number of discrete reflectances between -45 dB and -55 dB								
		0	1	2	3	4	5	6	7	8
Number of discrete reflectances between -35 dB and -45 dB	0	0	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.10
	1	0.05	0.06	0.05	0.09	0.11	0.12	0.11	0.15	0.12
	2	0.1	0.12	0.13	0.16	0.19	0.2	0.22	0.23	0.22
	3	0.18	0.18	0.2	0.2	0.24	0.3	0.3	0.32	*
	4	0.26	0.27	0.32	0.34	0.36	0.4	0.41	*	*
	5	0.32	0.33	0.38	0.4	0.44	0.48	*	*	*
	6	0.45	0.48	0.51	0.54	0.57	*	*	*	*

x.yz = these values exceed the proposed MPI penalty limit – see slide 3

* = This combination of reflectances exceeds the number of connections supported in the Jonathan King spreadsheet, so were not calculated

Proposed Addition of new table & supporting text

Insert text: Discrete reflectances below -55 dB may be ignored when determining supported channel insertion loss

Channel Insertion Loss		**Number of discrete reflectances between -45 dB and -55 dB**								
		0	1	2	3	4	5	6	7	8
Number of discrete reflectances between -35 dB and -45 dB	0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	2	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9
	3	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	*
	4	2.8	2.8	2.8	2.8	2.7	2.7	2.7	*	*
	5	2.8	2.8	2.7	2.7	2.7	2.6	*	*	*
	6	2.7	2.6	*	*	*	*	*	*	*

* = This combination of reflectances is not supported

Recommended Changes to Draft 1.2 (I)

Table 140–6—100GBASE-DR transmit characteristics

Description	Value	Unit
Signaling rate (range)	53.125 ± 100 ppm	GBd
Modulation format	PAM4	—
Wavelength (range)	1304.5 to 1317.5	nm
Side-mode suppression ratio (SMSR), (min)	30	dB
Average launch power (max)	4	dBm
Average launch power[a] (min)	–2.3	dBm
Outer Optical Modulation Amplitude (OMA_{outer}) (max)	4.2	dBm
Outer Optical Modulation Amplitude (OMA_{outer}) (min)[b]	–0.2	dBm
Launch power in OMA_{outer} minus TDECQ (min)	–1.2	dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	2.5	dB
Average launch power of OFF transmitter (max)	–20	dBm
Extinction ratio (min)	5	dB
$RIN_{21.4}OMA$ (max)	–142	dB/Hz
Optical return loss tolerance (max)	21.4	dB
Transmitter reflectance[c] (max)	–26	dB

→ Change to -2.4 to align to DR4

→ Change to -0.3 to align to DR4

→ Change to -1.3 to align to DR4

→ Change to $RIN_{15.5}OMA$

→ Change to 15.5 dB

Recommended Changes to Draft 1.2 (II)

Table 140–7—100GBASE-DR receive characteristics

Description	Value	Unit
Signaling rate (range)	53.125 ± 100 ppm	GBd
Modulation format	PAM4	—
Wavelengths (range)	1304.5 to 1317.5	nm
Damage threshold[a]	6.5	dBm
Average receive power (max)	4	dBm
Average receive power[b] (min)	–5.3	dBm
Receive power (OMA_{outer}) (max)	4.2	dBm
Receiver reflectance (max)	–26	dB
Receiver sensitivity (OMA_{outer})[c] (max)	–4.5	dBm
Stressed receiver sensitivity (OMA_{outer})[d] (max)	–2	dBm
Conditions of stressed receiver sensitivity test:[e]		
Stressed eye closure for PAM4 (SECQ)	2.5	dB

Change to -5.4 to align to DR4

Change to -4.4 to align to DR4

Change to -1.9 to align to DR4

Table 140–8—100GBASE-DR illustrative link power budget

Parameter	Value	Unit
Power budget (for max TDECQ)	5.8	dB
Operating distance	500	m
Channel insertion loss[a]	3	dB
Maximum discrete reflectance	See 140.10.2.2	dB
Allocation for penalties[b] (for max TDECQ)	2.8	dB
Additional insertion loss allowed	0	dB

5.6 dB as in 400GBASE-DR4

Add footnote stating, higher penalties may be supported with reduced channel insertion loss. See table 140-13. Also, change penalty value to 2.6 to align to DR4

Recommended Changes to Draft 1.2 (III)

Table 140–11—Fiber optic cabling (channel) characteristics

Description	100GBASE-DR	Unit
Operating distance (max)	500	m
Channel insertion loss[a, b] (max)	3	dB
Channel insertion loss (min)	0	dB
Positive dispersion[b] (max)	0.8	ps/nm
Negative dispersion[b] (min)	–0.93	ps/nm
DGD_max[c]	2.24	ps
Optical return loss (min)	37	dB

→ Update value to 27 dB

Recommended Changes to Draft 1.2 (IV)

replace table 140-13 & add text

Insert text: Discrete reflectances below -55 dB may be ignored when determining supported channel insertion loss

Table 140–13—Maximum value of each discrete reflectance

Number of discrete reflectances above –55 dB	Maximum value for each discrete reflectance
	100GBASE-DR
1	–37 dB
2	–42 dB
4	–45 dB
6	–47 dB
8	–48 dB
10	–49 dB

Table 140-13 – Maximum channel insertion loss based on reflectances

Channel Insertion Loss		Number of discrete reflectances between -45 dB and -55 dB								
		0	1	2	3	4	5	6	7	8
Number of discrete reflectances between -35 dB and -45 dB	0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	2	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9
	3	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	*
	4	2.8	2.8	2.8	2.8	2.7	2.7	2.7	*	*
	5	2.8	2.8	2.7	2.7	2.7	2.6	*	*	*
	6	2.7	2.6	*	*	*	*	*	*	*

* = This combination of reflectances is not supported

Summary

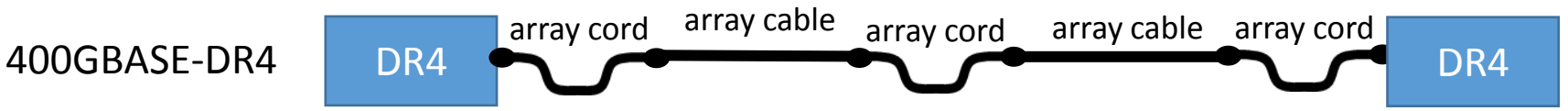
- Proposed to use the total of link loss and MPI penalty in 100GBASE-DR link budget consideration, which would
  - resolve the debate on MPI penalty in the link budget,
  - support more channel usage cases, and
  - keep the same Tx OMA(min) and Rx sensitivity specifications as those in 400GBASE-DR4.
  - enable tradeoff of MPI penalty and channel insertion loss

- Calculated optical return loss for 100GBASE-DR usage cases which gave 15.5 dB as the worst case ORL.

- Recommended changes in 100GBASE-DR link budget.

backup

400GBASE-DR4 Reference



500m Double link with 4 MPO connectors

Connector Losses = 2.65 dB,
Fiber loss = 0.25dB,

-> Link Loss = 2.9 dB (rounded to 3 dB)

MPI Penalty = 0.1 dB
Agreed Budget = 3.1 dB

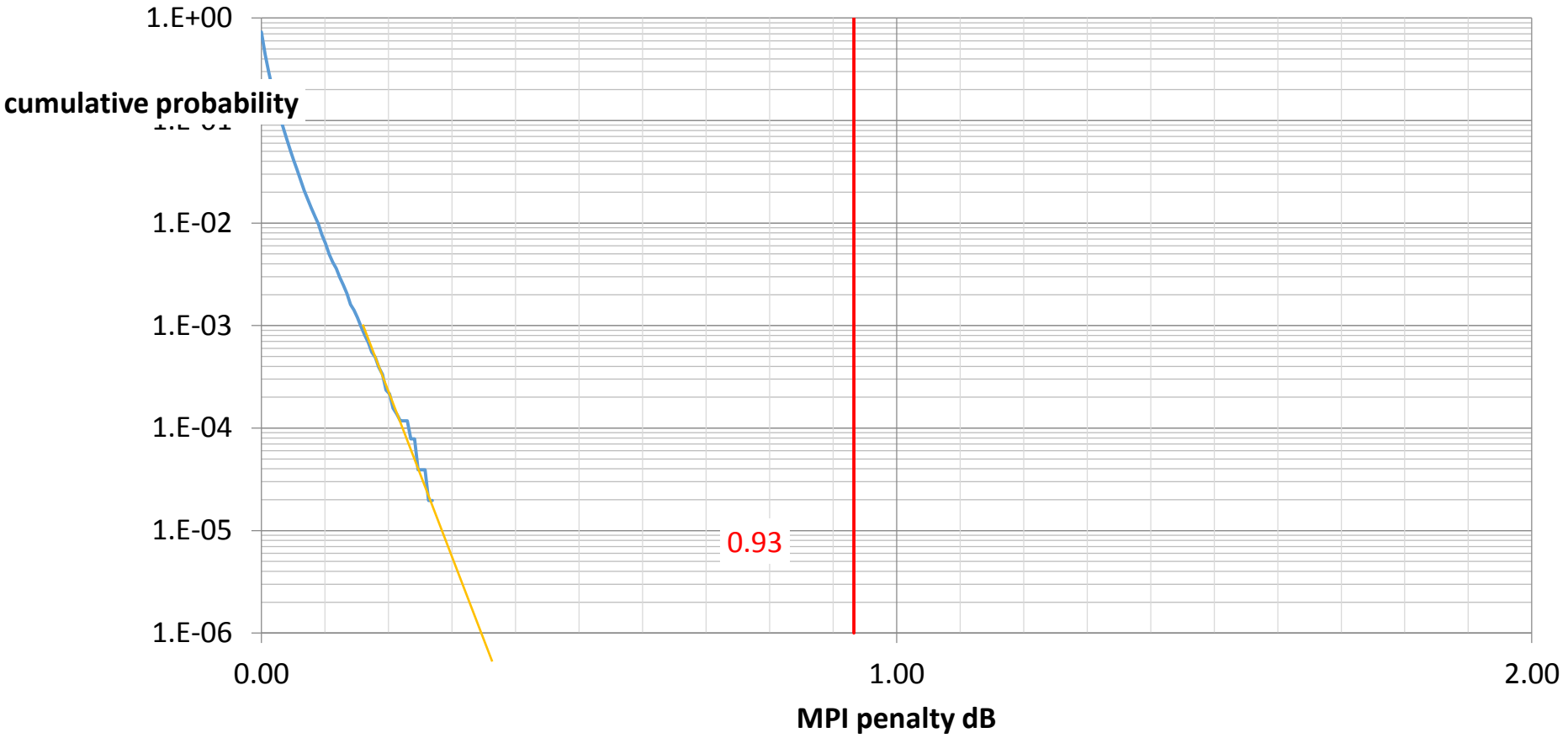
Table 124–13—Maximum value of each discrete reflectance

Number of discrete reflectances above –55 dB	Maximum value for each discrete reflectance
1	–37 dB
2	–42 dB
4	–45 dB
6	–47 dB
8	–48 dB
10	–49 dB

this screenshot is from D2.2

Example: 4LCs + 3MPOs

	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	-35	-35	-35	-45	-45	-45	-1000	-1000	-1000	-26



MPI Penalty = 0.34 dB

Example: 4LCs + 4 MPOs

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
-26	-35	-35	-35	-35	-45	-45	-45	-45	-1000	-1000	-26