Proposed modifications to 100GBASE-DR

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Background and Motivation

Slide has no changes compared to traverso_020817_3cd_adhoc-v2

- 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

Slide has no changes compared to traverso_020817_3cd_adhoc-v2

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 ≤ -45 dB and > -55 dB								
		0	1	2	3	4	5	6	7	8
Number of discrete reflectances ≤ -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 ≤ -45 dB and > -55 dB								
		0	1	2	3	4	5	6	7	8
Number of discrete reflectances ≤ -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 ≤ -45 dB and > -55 dB**								
		0	1	2	3	4	5	6	7	8
Number of discrete reflectances ≤ -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)

Slide has no changes compared to traverso_020817_3cd_adhoc-v2

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

Recommended Changes to Draft 1.2 (III)

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

Change to 5.6 dB to align to DR4

Change to “See 140.10.2.2”

Change to -35 dB

Change to “5.6 – max channel insertion loss per 140.10.2.2”

Add footnote for these parameters stating, higher penalties may be supported with reduced channel insertion loss. See 140.10.2.2

Recommended Changes to Draft 1.2 (IV)

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

→ Change to “See 140.10.2.2”

→ Update value to 27 dB

Recommended Changes to Draft 1.2 (V)

replace table 140-13 & add text

Slide has no changes compared to traverso_020817_3cd_adhoc-v2

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 ≤ -45 dB and > -55 dB								
		0	1	2	3	4	5	6	7	8
Number of discrete reflectances ≤ -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 (VI)

Table 140–10—Test-pattern definitions and related subclauses

Parameter	Pattern	Related subclause
Wavelength	Square wave, 3, 4, 5, 6 or valid 50GBASE-R signal	140.7.2
Side mode suppression ratio	3, 5, 6 or valid 50GBASE-R signal	—
Average optical power	3, 5, 6 or valid 50GBASE-R signal	140.7.3
Outer Optical Modulation Amplitude (OMA_{outer})	4 or 6	140.7.4
Transmitter and dispersion eye closure for PAM4 (TDECQ)	6	140.7.5
Extinction ratio	4 or 6	140.7.6
$RIN_{21.4}OMA$	4	140.7.7
Stressed receiver conformance test signal calibration	6	140.7.9
Stressed receiver sensitivity	3 or 5	140.7.9

Update to $RIN_{15.5}OMA$

140.7.5 Transmitter and dispersion eye closure for PAM4 (TDECQ)

The TDECQ shall be within the limits given in Table 140–6 if measured using the methods specified in 121.8.5.1, 121.8.5.2, and 121.8.5.3 using a reference equalizer as described in 121.8.5.4, with the following exceptions:

- The signaling rate of the test pattern generator is as given in Table 140–6.
- There are no interfering optical lanes and therefore the delay requirement of at least 31 UI between test pattern on one lane and any other lane, as specified in 121.8.5.1, is redundant.
- The combination of the O/E converter and the oscilloscope has a fourth-order Bessel-Thomson filter response with a bandwidth of 38.68 GHz.

Add bullet to section 140.7.5 stating,
- The optical return loss shall correspond to Table 140-6

Summary

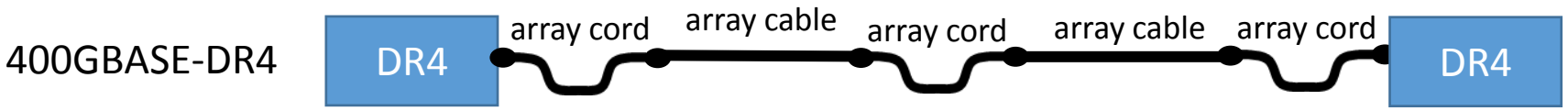
- Proposed to use the total of link loss and MPI penalty in 100GBASE-DR link budget consideration, which would
  - resolve the debate on MPI penalty in the link budget,
  - support more channel usage cases, and
  - keep the same Tx OMA(min) and Rx sensitivity specifications as those in 400GBASE-DR4.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

- Plan to submit comment against D1.2 recommending that the editor adopt the remedies listed slides 8 through 13 in this presentation with editorial license

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

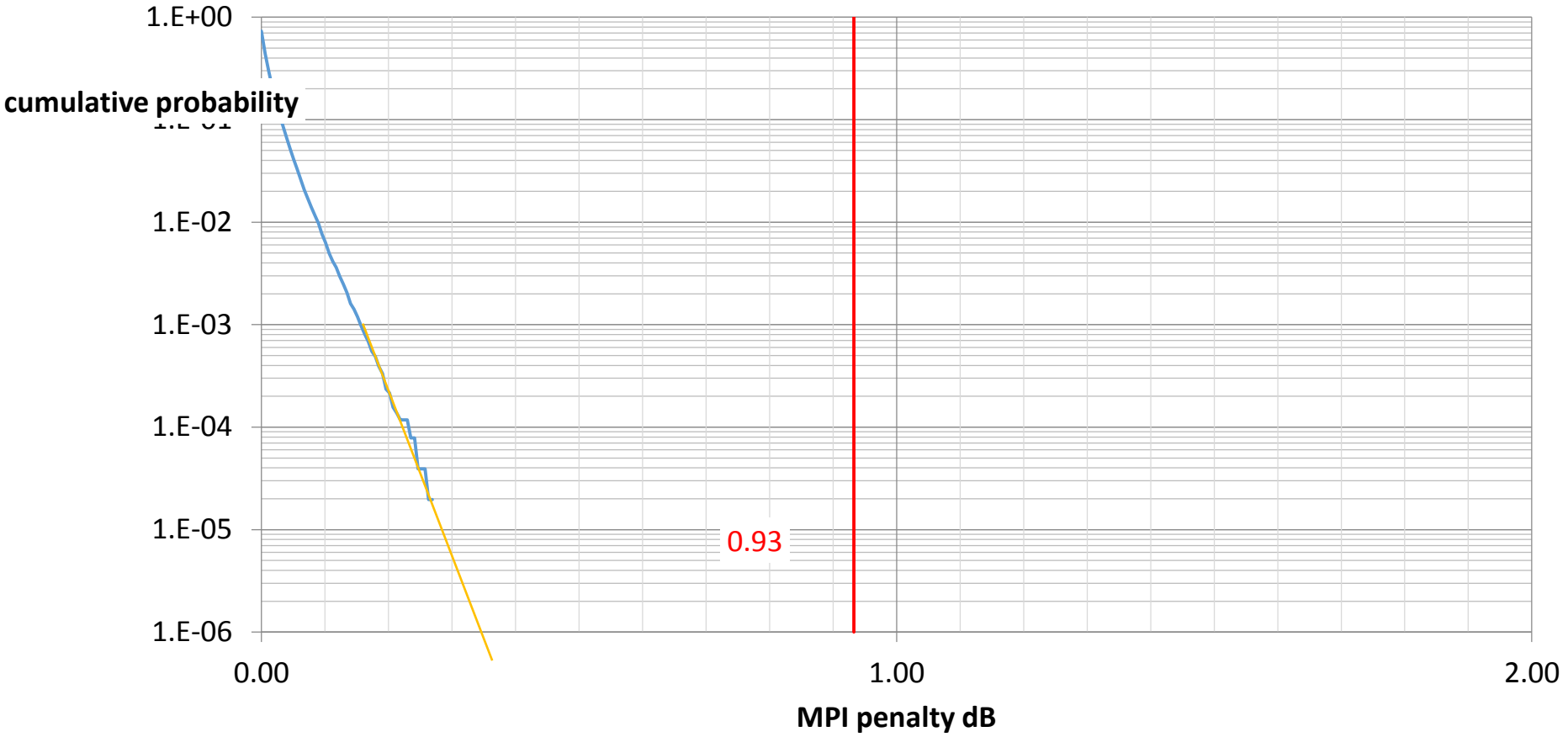
Table 124–13—Maximum value of each discrete reflectance

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