Proposed changes to P802.3dj MPI and DGD penalty specifications

John Johnson, Broadcom

Implementation details for P802.3dj D2.0 comments #15-35, 286-288

Supporters

- Ali Ghiasi, Ghiasi Quantum
- Haifeng Liu, Genuine Opto
- Guangcan Mi, Huawei
- Peter Stassar, Huawei
- Karl Muth, Broadcom
- Michael He, TeraHop
- Frank Chang, Source Photonics
- Liming Wang, Google
- Amad El-Chayeb, Keysight

- Roberto Rodes, Coherent
- Chris Cole, Coherent
- Ryan Yu, TeraHop
- Mark Kimber, Semtech
- Mike Dudek, Marvell

Proposed MPI specification

- This contribution provides editorial details in support of proposed changes to P802.3dj D2.0 MPI penalties and related specifications.
  - CL 180 comments #15-20
  - CL 181 comments #21-27
  - CL 182 comments #28-35
  - CL 183 comments #286-288
- The proposed spec changes are identical to those presented in johnson_3dj_01a_2505, which had wide support in P802.3dj.
  - Details on the MPI calculation methodology are in the above presentation.
  - Proposed changes to MPI and DGD penalty allocation are in agreement with those presented in ghiasi_3dj_01_2505.

CL 180.7.1 Transmitter optical specifications

- Change the values in Table 180-7 as shown in red
- Update footnote b:
  - An average launch power of -3.1 dBm corresponds to an OMA of -0.1 dBm with an infinite extinction ratio.
- Update Figure 180-3 to match the changes to OMAouter in Table 180-7.
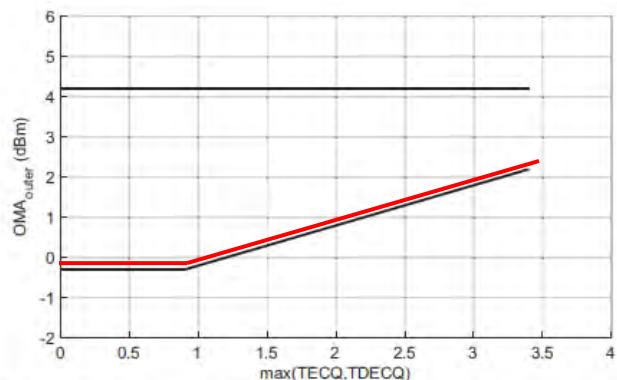
Figure 180-3—OMA_{outer} each lane (max) and OMA_{outer} each lane (min) versus max(TECQ, TDECQ)

Table 180–7—200GBASE-DR1, 400GBASE-DR2, 800GBASE-DR4, and 1.6TBASE-DR8 transmit characteristics

Description	200GBASE-DR1	400GBASE-DR2 800GBASE-DR4 1.6TBASE-DR8	Unit
Signaling rate, each lane (range)	106.25 ± 50 ppm		GBd
Modulation format	PAM4		—
Lane wavelength (range)	1304.5 to 1317.5		nm
Side-mode suppression ratio (SMSR), each lane (min)	30		dB
Average launch power, each lane (max)	4		dBm
Average launch power, each lane[a] (min)	-3.3 → -3.1		dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (max)	4.2		dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (min) for max(TECQ, TDECQ) < 0.9 dB for 0.9 dB $\leq$ max(TECQ, TDECQ) ≤ 3.4 dB	-0.3 → -0.1 -1.2 + max(TECQ, TDECQ) → -1		dBm dBm

CL 180.7.2 Receive optical specifications

- Change the values in Table 180-8 as shown in red

Table 180–8—200GBASE-DR1, 400GBASE-DR2, 800GBASE-DR4, and 1.6TBASE-DR8 receive characteristics

Description	Value	Unit
Signaling rate, each lane (range)	106.25 ± 50 ppm	GBd
Modulation format	PAM4	—
Lane wavelengths (range)	1304.5 to 1317.5	nm
Damage threshold[a], each lane	5	dBm
Average receive power, each lane (max)	4	dBm
Average receive power, each lane[b] (min)	~~-6.3~~ -6.1	dBm
Receive power (OMA$_{outer}$), each lane (max)	4.2	dBm

CL 180.7.3 Illustrative link power budget

- Change the values in Table 180-9 as shown in red
- Update footnote b:

  This channel insertion loss may be reduced by up to 0.5 dB depending on …
- Update footnote c:

  …includes an allocation of 0.1 dB for MPI penalty and 0.2 dB for DGD penalty. … the allocation for penalties should be "6.7 – channel insertion loss".
- Update Figure 180-5 to match the changes to TX OMAouter in Table 180-7.

Table 180–9—Illustrative link power budget

Parameter	Value	Unit
Power budget (for max TDECQ)	6.5 6.7	dB
Operating distance	500	m
Channel insertion loss[a, b]	3	dB
Maximum discrete reflectance	−35	dB
Allocation for penalties[c] (for max TDECQ)	3.5 3.7	dB
Additional insertion loss allowed	0	dB

[a] The channel insertion loss is calculated using the maximum distance specified in Table 180–6 and cabled optical fiber attenuation of 0.5 dB/km at 1304.5 nm plus an allocation for connection and splice loss given in 180.8.2.

[b] The channel insertion loss of 3 dB shown in this illustrative link power budget is valid for a maximum MPI penalty of 0.1 dB, which depends on the number and value of discrete reflectances present in the link. This channel insertion loss may be reduced by up to 0.4 dB depending on the discrete reflectances in the link as shown in Table 180–12.

[c] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested. In this illustrative link power budget the value shown includes an allocation of 0.1 dB for MPI and DGD penalties. For cases with a channel insertion loss less than 3 dB, as shown in Table 180–12, the allocation for penalties should be "6.5 – channel insertion loss".

Figure 180–5—Transmitter OMA$_{outer}$ each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA$_{outer}$) each lane versus TECQ

CL 180.8.2 Optical fiber connection

- Replace the maximum channel insertion loss values in Table 180-12 with the new values shown at right.

Table 180–12—Maximum channel insertion loss versus number of discrete reflectances

Maximum channel insertion loss (dB)	Number of discrete reflectances > −55 dB and ≤ −45 dB								
	0	1	2	3	4	5	6	7	8
0	3	3	3	3	3	3	2.9	2.9	2.9
1	3	3	3	2.9	2.9	2.9	2.9	2.8	2.8
2	2.9	2.9	2.9	2.8	2.8	2.8	2.7	2.7	2.7
3	2.8	2.8	2.7	2.7	2.7	2.6	2.6	2.6	2.6
4	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.5	—[a]
5	2.5	2.5	2.5	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]
6	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]

(Row header, left side: Number of discrete reflectances > −45 dB and ≤ −35 dB)

[a] The indicated combination of reflectances does not provide a supported maximum channel insertion loss.

CL 181.7.1 Transmitter optical specifications

- Change the values in Table 181-5 as shown in red
- Update footnote b:
  - [b] An average launch power of -2.1 dBm corresponds to an OMA of 0.9 dBm with an infinite extinction ratio.
- Update Figure 181-3 to match the changes to OMAouter in Table 181-5.
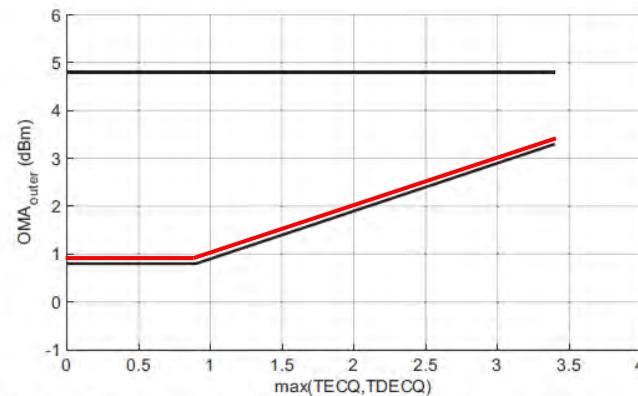
Figure 181–3—OMA$_{outer}$ each lane (max) and OMA$_{outer}$ each lane (min) versus max(TECQ, TDECQ)

Table 181–5—800GBASE-FR4-500 transmit characteristics

Description	800GBASE-FR4-500	Unit
Signaling rate, each lane (range)	106.25 ± 50 ppm	GBd
Modulation format	PAM4	—
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Side-mode suppression ratio (SMSR), each lane (min)	30	dB
Total average launch power (max)	10.9	dBm
Average launch power, each lane (max)	4.9	dBm
Average launch power, each lane[a] (min)	~~-2.2~~ -2.1	dBm
Outer Optical Modulation Amplitude (OMA$_{outer}$), each lane (max)	4.8	dBm
Outer Optical Modulation Amplitude (OMA$_{outer}$), each lane (min) for TDECQ <0.9 dB for 0.9 dB $\leq$ max(TECQ, TDECQ) $\leq$ 3.4 dB	~~0.8~~ 0.9 ~~-0.1~~ 0 $+$ max(TECQ, TDECQ)	dBm dBm
Difference in launch power between any two lanes (OMA$_{outer}$) (max)	4	dB

CL 181.7.2 Receive optical specifications

- Change the values in Table 181-6 as shown in red

Table 181–6—800GBASE-FR4-500 receive characteristics

Description	800GBASE-FR4-500	Unit
Signaling rate, each lane (range)	106.25 ± 50 ppm	GBd
Modulation format	PAM4	—
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[a], each lane	5.9	dBm
Average receive power, each lane (max)	4.9	dBm
Average receive power, each lane[b] (min)	~~-5.7~~ -5.6	dBm
Receive power (OMA$_{outer}$), each lane (max)	4.8	dBm

CL 181.7.3 Illustrative link power budget

- Change the values in Table 181-7 as shown in red.
- Update footnotes b and c following the form of Table 180-9, with appropriate changes shown in red.
- Table 181-xx refers to the new table of maximum channel insertion loss to be added to CL 181.8.2.
- Update Figure 181-5 to match the changes to TX OMAouter each lane (min) versus max(TECQ, TDECQ) in Table 181-5.
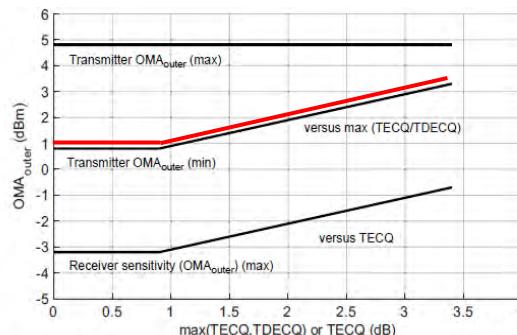
Figure 181–5—Transmitter OMA$_{outer}$ each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA$_{outer}$) each lane versus TECQ

Table 181–7—800GBASE-FR4-500 illustrative link power budgets

Parameter	800GBASE-FR4-500	Unit
Power budget (for maximum TDECQ)	~~7.4~~ 7.5	dB
Operating distance	500	m
Channel insertion loss[a, b]	3.5	dB
Maximum discrete reflectance[b]	–35	dB
Allocation for penalties[c] (for maximum TDECQ)	~~3.9~~ 4	dB
Additional insertion loss allowed	0	dB

[a] The channel insertion loss is calculated using the maximum distance specified in Table 181–4 and fiber attenuation of 0.5 dB/km plus an allocation for connection and splice loss given in 181.8.2.1.

[b] The channel insertion loss of 3.5 dB shown in this illustrative link power budget is valid for a maximum MPI penalty of 0.4 dB, which depends on the number and value of discrete reflectances present in the link. This channel insertion loss may be reduced by up to 0.2 dB depending on the discrete reflectances in the link as shown in Table 181–xx.

[c] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested. In this illustrative link power budget, the value shown includes an allocation of 0.4 dB for MPI penalty and 0.2 dB for DGD penalty. For cases with a channel insertion loss less than 3.5 dB, as shown in Table 181–xx, the allocation for penalties should be "7.5 –channel insertion loss"

CL 181.8.2 Optical fiber connection

- CL 181.8.2 is to be rewritten to mirror the sub-clause structure and text in CL 180.8.2, with liberal use of editorial license.
- Table 181-10, Maximum value of each discrete reflectance, is to be deleted.
- A new Table 181-xx of Maximum channel insertion loss is to be added with the values shown at right.
- Table 181-8 in CL 181.8 is modified as shown below in red.

Table 181-xx —Maximum channel insertion loss versus number of discrete reflectances

Maximum channel insertion loss (dB)	Number of discrete reflectances > −55 dB and ≤ −45 dB								
	0	1	2	3	4	5	6	7	8
0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
1	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
2	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
3	3.5	3.5	3.5	3.5	3.5	3.5	3.4	3.4	3.4
4	3.5	3.5	3.4	3.4	3.4	3.3	3.3	3.3	—[a]
5	3.3	3.3	3.3	3.3	—[a]	—[a]	—[a]	—[a]	—[a]
6	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]

(Row label at left, vertical): Number of discrete reflectances > −45 dB and ≤ −35 dB

[a] The indicated combination of reflectances does not provide a supported maximum channel insertion loss.

Table 181–8—Optical channel characteristics

Description	800GBASE-FR4-500	Unit
Operating distance (max)	500	m
Channel insertion loss[a, b] (max)	See Table 181-xx	dB
Channel insertion loss (min)	0	dB
Positive dispersion[b] (max)	1.5	ns/nm

CL 182.7.1 Transmitter optical specifications

- Change the values in Table 182-7 as shown in red
  - Note that these are the same TX specs as CL 180 for component commonality
- Update footnote b:
  - An average launch power of -3.1 dBm corresponds to an OMA of -0.1 dBm with an infinite extinction ratio.
- Update Figure 182-3 to match the changes to OMAouter in Table 182-7.
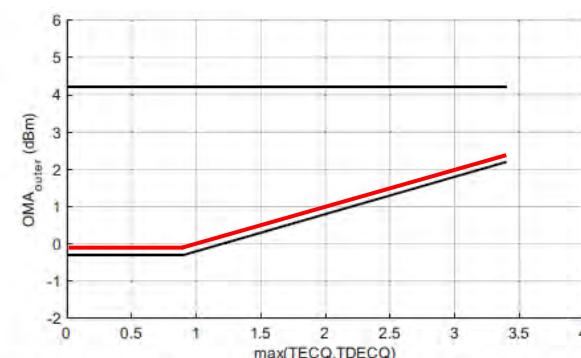
Figure 182–3—OMA$_{outer}$ each lane (max) and OMA$_{outer}$ each lane (min) versus max (TECQ, TDECQ)

Table 182–7—200GBASE-DR1-2, 400GBASE-DR2-2, 800GBASE-DR4-2, and 1.6TBASE-DR8-2 transmit characteristics

Description	200GBASE-DR1-2	400GBASE-DR2-2 800GBASE-DR4-2 1.6TBASE-DR8-2	Unit
Signaling rate, each lane (range)	113.4375 ± 50 ppm		GBd
Modulation format	PAM4		—
Lane wavelength (range)	1304.5 to 1317.5		nm
Side-mode suppression ratio (SMSR), each lane (min)	30		dB
Average launch power, each lane (max)	4		dBm
Average launch power, each lane[a] (min)	-3.5[b] -3.1		dBm
Outer Optical Modulation Amplitude (OMA$_{outer}$), each lane (max)	4.2		dBm
Outer Optical Modulation Amplitude (OMA$_{outer}$), each lane (min) for max(TECQ, TDECQ) < 0.9 dB for 0.9 dB ≤ max(TECQ, TDECQ) ≤ 3.4 dB	-0.3 -0.1 -1 $-1.2 + \text{max(TECQ, TDECQ)}$		dBm dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ), each lane (max)	3.4		dB

CL 182.7.2 Receive optical specifications

- Change the values in Table 182-8 as shown in red
- Update Figure 182-4 to match the changes to Receiver sensitivity (OMAouter) in Table 182-8.
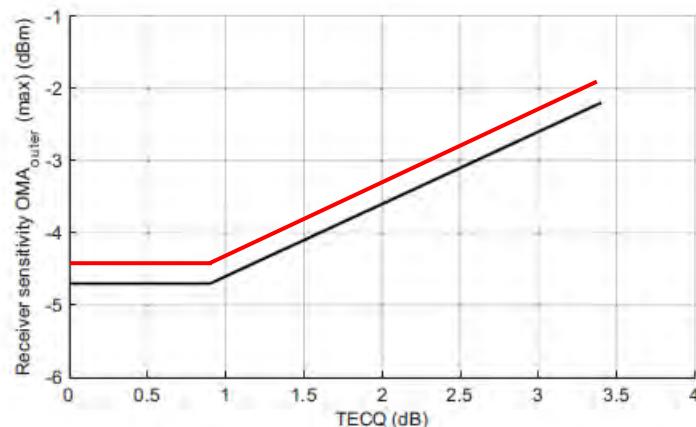

Figure 182–4—Receiver sensitivity (OMA$_{outer}$), each lane (max)

Table 182–8—200GBASE-DR1-2, 400GBASE-DR2-2, 800GBASE-DR4-2, and 1.6TBASE-DR8-2 receive characteristics

Description	Value	Unit
Signaling rate, each lane (range)	113.4375 ± 50 ppm	GBd
Modulation format	PAM4	—
Lane wavelengths (range)	1304.5 to 1317.5	nm
Damage threshold[a], each lane	5	dBm
Average receive power, each lane (max)	4	dBm
Average receive power, each lane[b] (min)	~~-7.3~~ -7.1	dBm
Receive power (OMA$_{outer}$), each lane (max)	4.2	dBm
Receiver reflectance (max)	−26	dB
Receiver sensitivity (OMA$_{outer}$), each lane[c] (max) for TECQ < 0.9 dB for 0.9 dB ≤ TECQ ≤ SECQ	~~-4.7~~ -4.4 -5.3 ~~-5.6~~ + TECQ	dBm
Stressed receiver sensitivity (OMA$_{outer}$), each lane[c] (max)	~~-2.2~~ -1.9	dBm
Conditions of stressed receiver sensitivity test[d]:		
Stressed eye closure for PAM4 (SECQ), lane under test	3.4	dB
OMA$_{outer}$ of each aggressor lane[e]	4.2	dBm

CL 182.7.3 Illustrative link power budget

- Change the values in Table 182-9 as shown in red
- Update footnotes b and c following the form of Table 180-9, with appropriate changes shown in red.
- Table 182-xx refers to the new table of maximum channel insertion loss to be added to CL 182.8.2.
- Update Figure 182-5 to match the changes to OMAouter in Tables 182-7 and 182-8.
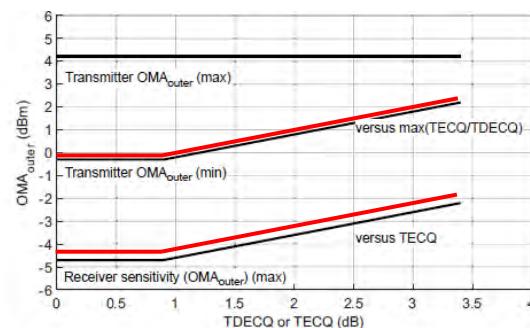
Figure 182–5—Transmitter OMA$_{outer}$ each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA$_{outer}$) each lane versus TECQ

Table 182–9—Illustrative link power budget

Parameter	Value	Unit
Power budget (for max TDECQ)	~~7.8~~ 7.7	dB
Operating distance	2000	m
Channel insertion loss[a, b]	4	dB
Maximum discrete reflectance	−35	dB
Allocation for penalties[b, c] (for max TDECQ)	~~3.8~~ 3.7	dB
Additional insertion loss allowed	0	dB

[a] The channel insertion loss is calculated using the maximum distance specified in Table 182–6 and cabled optical fiber attenuation of 0.5 dB/km at 1304.5 nm plus an allocation for connection and splice loss given in 182.8.2.1.

[b] The channel insertion loss of 4 dB shown in this illustrative link power budget is valid for a maximum MPI penalty of 0.1 dB, which depends on the number and value of discrete reflectances present in the link. This channel insertion loss may be reduced by up to 0.5 dB depending on the discrete reflectances in the link as shown in Table 182–xx.

[c] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested. In this illustrative link power budget, the value shown includes an allocation of 0.1 dB for MPI penalty and 0.2 dB for DGD penalty. For cases with a channel insertion loss less than 4 dB, as shown in Table 182–xx, the allocation for penalties should be "7.7 – channel insertion loss"

CL 182.8.2 Optical fiber connection

- CL 182.8.2 is to be rewritten to mirror the sub-clause structure and text in CL 180.8.2, with liberal use of editorial license.
- Table 182-12, Maximum value of each discrete reflectance, is to be deleted.
- A new Table 182-xx of Maximum channel insertion loss is to be added with the values shown at right.
- Table 182-10 in CL 182.8 is modified as shown below in red.

Table 182-xx —Maximum channel insertion loss versus number of discrete reflectances

Maximum channel insertion loss (dB)	Number of discrete reflectances > −55 dB and ≤ −45 dB								
	0	1	2	3	4	5	6	7	8
Number of discrete reflectances > −45 dB and ≤ −35 dB 0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.9	3.9
2	4.0	4.0	4.0	3.9	3.9	3.9	3.9	3.9	3.9
3	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.8
4	3.8	3.8	3.8	3.8	3.8	3.7	3.7	3.7	3.7
5	3.7	3.7	3.7	3.7	3.7	3.6	3.6	3.6	3.6
6	3.6	3.6	3.6	3.6	3.5	3.5	3.5	3.5	—[a]

[a] The indicated combination of reflectances does not provide a supported maximum channel insertion loss.

Table 182–10—Optical channel characteristics

Description	200GBASE-DR1-2	400GBASE-DR2-2 800GBASE-DR4-2 1.6TBASE-DR8-2	Unit
Operating distance (max)	2000		m
Channel insertion loss[a,b] (max)	See Table 182-xx		dB
Channel insertion loss (min)	0		dB

CL 183.7.3 Illustrative link power budget

- Update footnotes following the form of Table 180-9, with appropriate changes shown in red.
- Table 183-xx and 183-yy refer to the new tables of maximum channel insertion loss to be added to CL 183.8.2.
- If the proposed footnotes are too lengthy, they may be shortened or partially moved to the adjacent text of CL 183.7.3, with editorial license.

- Note that per johnson_3dj_01_2505, there are no changes to the optical power budget for 800GBASE-FR4 or 800GBASE-LR4.

Table 183–8—800GBASE-FR4 and 800GBASE-LR4 illustrative link power budgets

Parameter	800GBASE-FR4	800GBASE-LR4	Unit
Power budget (for maximum TDECQ)	7.9	11.3	dB
Operating distance	2	10	km
Channel insertion loss[a]	4[b]	6.3[c]	dB
Maximum discrete reflectance	−35	−35	dB
Allocation for penalties[e] (for maximum TDECQ)	3.9[f]	5[g]	dB

[a] The channel insertion loss is calculated using the maximum distance specified in Table 183–5 and fiber attenuation of 0.5 dB/km plus an allocation for connection and splice loss given in 183.8.2.
[b] The channel insertion loss of 4 dB shown in this illustrative link power budget is valid for a maximum MPI penalty of 0.3 dB, which depends on the number and value of discrete reflectances present in the link. This channel insertion loss may be reduced by up to 0.5 dB depending on the discrete reflectances in the link as shown in Table 183–xx.
[c] The channel insertion loss of 6.3 dB shown in this illustrative link power budget is valid for a maximum MPI penalty of 0.4 dB, which depends on the number and value of discrete reflectances present in the link. This channel insertion loss may be reduced by up to 0.2 dB depending on the discrete reflectances in the link as shown in Table 183–yy.
[e] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.
[f] In this illustrative link power budget the value shown includes an allocation of 0.3 dB for MPI penalty and 0.2 dB for DGD penalty. For cases with a channel insertion loss less than 4 dB, as shown in Table 183–xx, the allocation for penalties should be "7.9 – channel insertion loss"
[g] In this illustrative link power budget the value shown includes an allocation of 0.4 dB for MPI penalty and 0.7 dB for DGD penalty. For cases with a channel insertion loss less than 6.3 dB, as shown in Table 183–yy, the allocation for penalties should be "11.3 – channel insertion loss"

CL 183.8.2 Optical fiber connection (1)

- CL 183.8.2 is to be rewritten to mirror the sub-clause structure and text in CL 180.8.2, with liberal use of editorial license.
- Table 183-11, Maximum value of each discrete reflectance, is to be deleted.
- A new Table 183-xx of Maximum channel insertion loss for 800GBASE-FR4 is to be added with the values shown at right.
- Table 183-9 in CL 183.8 is modified as shown below in red.

Table 183–9—Optical channel characteristics

Description	800GBASE-FR4	800GBASE-LR4	Unit
Operating distance (max)	2	10	km
Channel insertion loss[a, b] (max)	See Table 183-xx	See Table 183-yy	dB

Table 182-xx —Maximum channel insertion loss versus number of discrete reflectances for 800GBASE-FR4

Maximum channel insertion loss (dB)	Number of discrete reflectances > −55 dB and ≤ −45 dB								
Number of discrete reflectances > −45 dB and ≤ −35 dB	0	1	2	3	4	5	6	7	8
0 to 3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.9	3.9
5	3.9	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8
6	3.8	3.8	3.8	3.8	3.7	3.7	3.7	3.7	—[a]
7	3.5	3.5	3.5	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]
8	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]

[a] The indicated combination of reflectances does not provide a supported maximum channel insertion loss.

CL 183.8.2 Optical fiber connection (2)

- A new Table 183-yy of Maximum channel insertion loss for 800GBASE-LR4 is to be added with the values shown at right.

Table 182-yy —Maximum channel insertion loss versus number of discrete reflectances for 800GBASE-LR4

Maximum channel insertion loss (dB)	Number of discrete reflectances > −55 dB and ≤ −45 dB								
	0	1	2	3	4	5	6	7	8
0 to 4	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
5	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
6	6.3	6.3	6.3	6.3	6.2	6.2	6.2	6.2	6.2
7	6.2	6.2	6.1	6.2	6.1	6.1	6.1	6.1	—[a]
8	6.1	6.1	6.1	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]

(Row label, rotated: Number of discrete reflectances > −45 dB and ≤ −35 dB)

[a] The indicated combination of reflectances does not provide a supported maximum channel insertion loss.

Thank You

IEEE P802.3dj, johnson_3dj_01_2507

Backup slides from
johnson_3dj_01_2505

MPI and DGD penalty budget proposal

802.3dj Optical PMD	P802.3dj draft D1.5			Ghiasi_3dj_01_2503		This Proposal	
	MPI Penalty Budget (dB)	DGD Penalty Budget (dB)	DGD_max (ps/nm)	MPI Penalty Budget (dB)	DGD Penalty (dB)	MPI Penalty Budget (dB)	DGD Penalty Budget (dB)
Cl. 180 DRn	0.1*		2.24	0.12	0.18	0.1	0.2
Cl. 181 FR4-500	0.5*		2.24	0.41	0.18	0.4	0.2
Cl. 182 DRn-2	0.4*		2.3	0.1	0.18	0.1	0.2
Cl. 183 FR4	0.5*		2.3	N/A	N/A	0.3	0.2
Cl. 183 LR4	0.4	0.7	4	0.3	N/A	0.4	0.7

* Combined MPI+DGD Penalty budget.

- The table at left shows a comparison of existing and proposed MPI and DGD penalty budgets.
  - D1.5 doesn't break out MPI and DGD penalty budgets separately except for 800G-LR4.
  - MPI and DGD penalty budget proposals made by Ali against D1.4 are shown for reference.
- The proposed MPI penalty budget values are very close to those proposed by Ali.
- Pending new data on DGD penalty, propose to adopt the values in ghiasi_3dj_01_2503.
- Where the proposed MPI+DGD penalty budget is different than D1.5, adjustments must be made to the power budget for max TDECQ and TX launch OMA specs.

Additional spec adjustments

Parameter (dB or dBm)	Cl. 180, DRn		Cl. 181, FR4-500		Cl. 182, DRn-2	
	P802.3dj D1.5	This Proposal	P802.3dj D1.5	This Proposal	P802.3dj D1.5	This Proposal
Power Budget						
Power budget (for max TDECQ)	6.5	6.7	7.4	7.5	7.8	7.7
Allocation for penalties (for max TDECQ)	3.5	3.7	3.9	4	3.8	3.7
TX Characteristics						
Average launch power, each lane (min)	-3.3	-3.1	-2.2	-2.1	-3.3	-3.1
Outer Optical Modulation Amplitude (OMAouter), each lane (min) for max(TECQ, TDECQ) < X dB for X dB < max(TECQ, TDECQ) < Y dB	-0.3 -1.2 + TDECQ	-0.1 -1 + TDECQ	0.8 -0.1 + TDECQ	0.9 0 + TDECQ	-0.3 -1.2 + TDECQ	-0.1 -1 + TDECQ
RX Characteristics						
Average receive power, each lane (min)	-6.3	-6.1	-5.7	-5.6	-7.3	-7.1
Receiver sensitivity (OMAouter), each lane (max) for TECQ < X dB for X dB < TECQ < SECQ	— 	— 	— 	— 	-4.7 -5.6 + TECQ	-4.4 -5.3 + TECQ
Stressed receiver sensitivity (OMAouter), each lane (max)	—	—	—	—	-2.2	-1.9

- Cl. 180 and Cl. 181 TX OMA are changed to match new power budgets. RX sensitivity is unchanged.
- Cl. 182 TX OMA is changed to be the same as proposed Cl. 180. Adjust RX sensitivity to match new power budget.
- No power budget changes required for Cl. 183 PMDs.
- Associated updates will be needed to some footnotes, equations and OMA vs. TDECQ figures.

Cl. 180 – 500m DR1/2/4/8
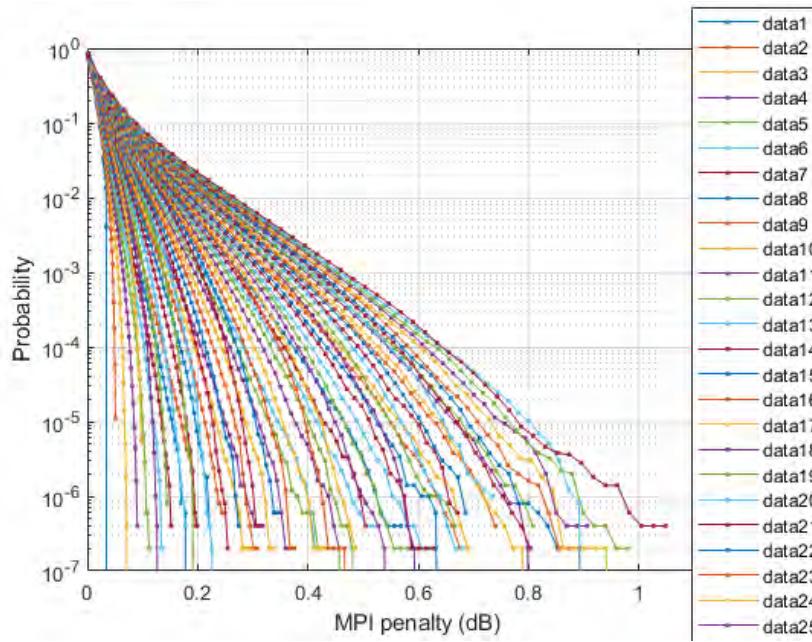
Cl. 180 – 500m DR1/2/4/8
Target PAM4 SER = 4.56e-4
Extinction ratio = 3.5 dB
Insertion loss = 1.5 dB at mid-span
Monte Carlo iterations = 50M, conf. level = 1e-6

Baseline cabling = Double-link, parallel fiber
MPI penalty budget = 0.1 dB
Max allowable MPI penalty = 0.65 dB

MPI Penalty (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
Number of -35dB reflections: 0	0.04	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.20
1	0.10	0.13	0.14	0.17	0.20	0.22	0.24	0.28	0.29
2	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.40
3	0.31	0.34	0.37	0.40	0.42	0.45	0.48	0.49	0.53
4	0.43	0.47	0.51	0.53	0.57	0.58	0.63	0.65	0.68
5	0.58	0.62	0.64	0.66	0.69	0.72	0.72	0.77	0.79
6	0.73	0.75	0.78	0.84	0.86	0.85	0.90	0.89	0.98

Double-link parallel cabling → MPI penalty budget = 0.1 dB.
MPI penalty > 0.65 dB highlighted in RED.

Max Channel IL (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
Number of -35dB reflections: 0	3.0	3.0	3.0	3.0	3.0	3.0	2.9	2.9	2.9
1	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.8	2.8
2	2.9	2.9	2.9	2.8	2.8	2.8	2.7	2.7	2.7
3	2.8	2.8	2.7	2.7	2.7	2.6	2.6	2.6	2.6
4	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.4
5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.3	2.3
6	2.4	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.1

Reduce maximum channel insertion loss for MPI penalty > 0.15 dB.
Channels in RED would be disallowed based on MPI penalty > 0.65 dB, i.e.
replaced with "—" in the table, with an explanatory footnote as in Table 140-13.

Cl. 181 – 800GBASE-FR4-500
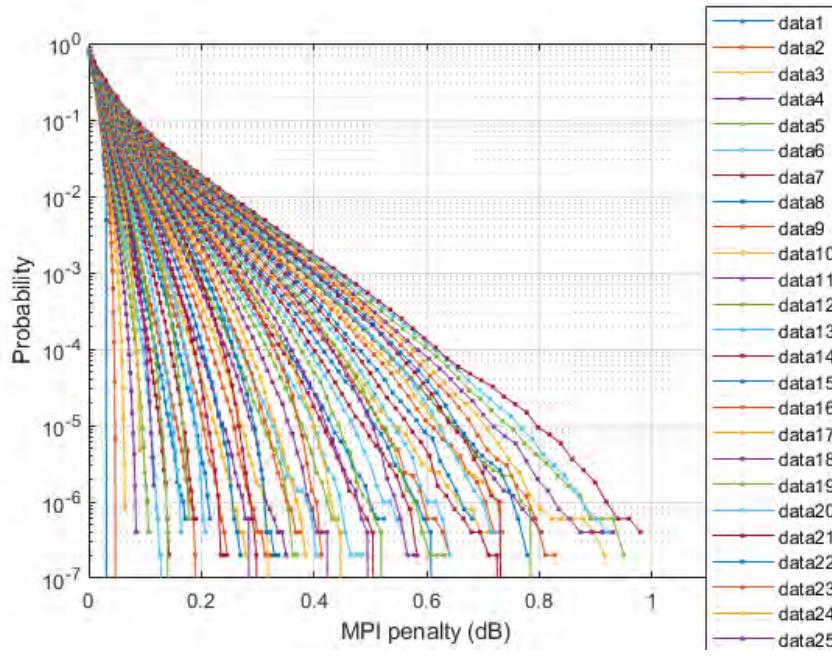
Cl. 181 – 800GBASE-FR4-500
Target PAM4 SER = 4.56e-4
Extinction ratio = 3.5 dB
Insertion loss = 1.75 dB at mid-span
Monte Carlo iterations = 50M, conf. level = 1e-6

Baseline cabling = Double-link, duplex fiber
MPI penalty budget = 0.4 dB
Max allowable MPI penalty = 0.65 dB

MPI Penalty (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
Number of -35dB reflections 0	0.03	0.05	0.06	0.08	0.10	0.12	0.14	0.17	0.19
1	0.09	0.12	0.14	0.16	0.19	0.22	0.24	0.26	0.28
2	0.18	0.20	0.23	0.26	0.29	0.32	0.32	0.35	0.39
3	0.29	0.32	0.35	0.37	0.40	0.42	0.46	0.48	0.50
4	0.41	0.44	0.48	0.51	0.52	0.57	0.59	0.61	0.67
5	0.55	0.59	0.63	0.65	0.67	0.70	0.73	0.77	0.78
6	0.70	0.72	0.76	0.79	0.80	0.83	0.86	0.88	0.92

Double-link duplex cabling → MPI penalty budget = 0.4 dB.
MPI penalty > 0.65 dB highlighted in RED.

Max Channel IL (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
Number of -35dB reflections 0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
1	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
2	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
3	3.5	3.5	3.5	3.5	3.5	3.5	3.4	3.4	3.4
4	3.5	3.5	3.4	3.4	3.4	3.3	3.3	3.3	3.2
5	3.3	3.3	3.3	3.3	3.2	3.2	3.2	3.1	3.1
6	3.2	3.2	3.1	3.1	3.1	3.1	3.0	3.0	3.0

Reduce maximum channel insertion loss for MPI penalty > 0.45 dB.
Channels in RED would be disallowed based on MPI penalty > 0.65 dB.

Cl. 182 – 2km DR1/2/4/8-2
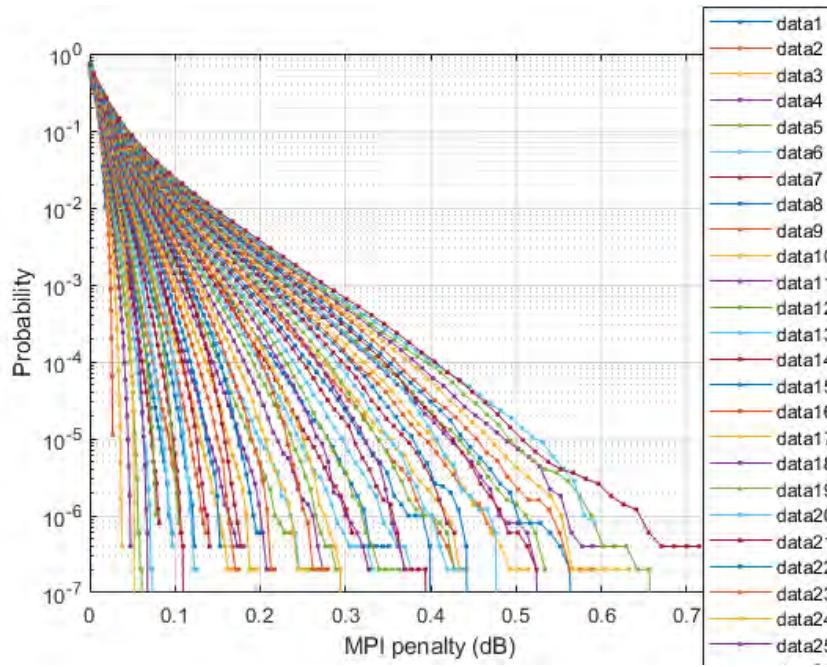
Cl. 182 – 2km DR1/2/4/8-2
Target PAM4 SER = 9.6e-3
Extinction ratio = 3.5 dB
Insertion loss = 2 dB at mid-span
Monte Carlo iterations = 50M, conf. level = 1e-6

Baseline cabling = Double-link, parallel fiber
MPI penalty budget = 0.1 dB
Max allowable MPI penalty = 0.65 dB

MPI Penalty (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
0	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.11
1	0.05	0.07	0.08	0.09	0.11	0.12	0.13	0.16	0.17
2	0.10	0.12	0.14	0.15	0.16	0.18	0.20	0.22	0.24
3	0.17	0.20	0.21	0.24	0.27	0.27	0.29	0.31	0.33
4	0.26	0.28	0.30	0.32	0.34	0.36	0.40	0.39	0.42
5	0.35	0.39	0.40	0.42	0.44	0.47	0.47	0.49	0.51
6	0.48	0.49	0.50	0.54	0.55	0.57	0.60	0.62	0.66
7	0.59	0.60	0.64	0.65	0.67	0.69	0.71	0.70	0.73
8	0.74	0.76	0.77	0.79	0.80	0.80	0.84	0.84	0.87

(Leftmost column label: **Number of -35dB reflections**)

Double-link parallel cabling → MPI penalty budget = 0.1 dB.
MPI penalty > 0.65 dB highlighted in RED.

Max Channel IL (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.9	3.9
2	4.0	4.0	4.0	3.9	3.9	3.9	3.9	3.9	3.9
3	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.8
4	3.8	3.8	3.8	3.8	3.8	3.7	3.7	3.7	3.7
5	3.7	3.7	3.7	3.7	3.7	3.6	3.6	3.6	3.6
6	3.6	3.6	3.6	3.6	3.5	3.5	3.5	3.5	3.4
7	3.5	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4
8	3.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.2

(Leftmost column label: **Number of -35dB reflections**)

Reduce maximum channel insertion loss for MPI penalty > 0.15 dB.
Values in RED would be disallowed based on MPI penalty > 0.65 dB.

Cl. 183 – 800GBASE-FR4
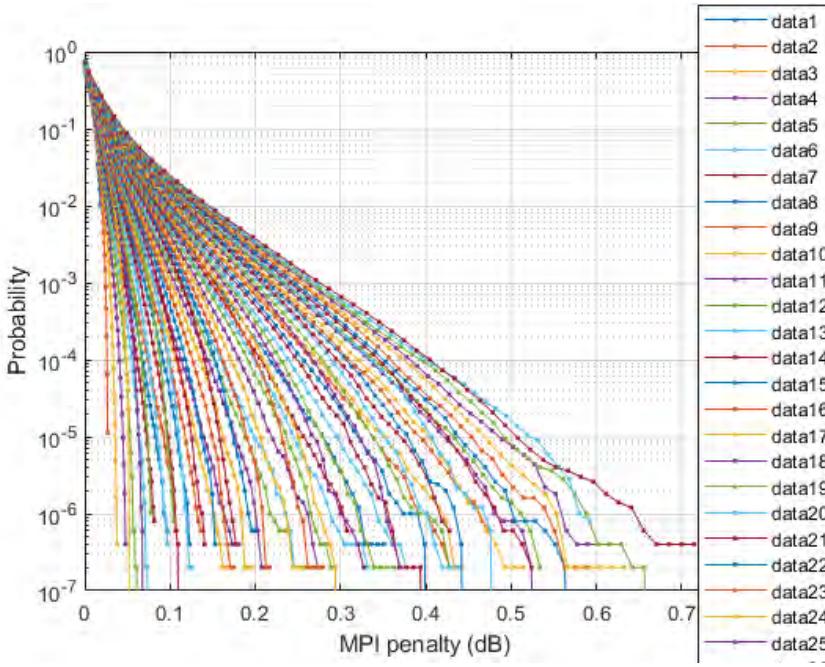
Cl. 181 FR4-500 PMD

Target PAM4 SER = 9.6e-3

Extinction ratio = 3.5 dB

Insertion loss = 2 dB at mid-span

Monte Carlo iterations = 50M, conf. level = 1e-6

Baseline cabling = Double-link, parallel fiber

MPI penalty budget = 0.3 dB

Max allowable MPI penalty = 0.65 dB

MPI Penalty (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
0	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.11
1	0.05	0.07	0.08	0.09	0.11	0.12	0.13	0.16	0.17
2	0.10	0.12	0.14	0.15	0.16	0.18	0.20	0.22	0.24
3	0.17	0.20	0.21	0.24	0.27	0.27	0.29	0.31	0.33
4	0.26	0.28	0.30	0.32	0.34	0.36	0.40	0.39	0.42
5	0.35	0.39	0.40	0.42	0.44	0.47	0.47	0.49	0.51
6	0.48	0.49	0.50	0.54	0.55	0.57	0.60	0.62	0.66
7	0.59	0.60	0.64	0.65	0.67	0.69	0.71	0.70	0.73
8	0.74	0.76	0.77	0.79	0.80	0.80	0.84	0.84	0.87

(Left header label: Number of -35dB reflections)

Double-link parallel cabling → MPI penalty budget = 0.3 dB.

MPI penalty > 0.65 dB highlighted in RED.

Max Channel IL (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
0 to 3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.9	3.9
5	3.9	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8
6	3.8	3.8	3.8	3.8	3.7	3.7	3.7	3.7	3.6
7	3.5	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4
8	3.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.2

(Left header label: Number of -35dB reflections)

Reduce maximum channel insertion loss for MPI penalty > 0.35 dB.

Values in RED would be disallowed based on MPI penalty > 0.65 dB.

Cl. 183 – 800GBASE-LR4
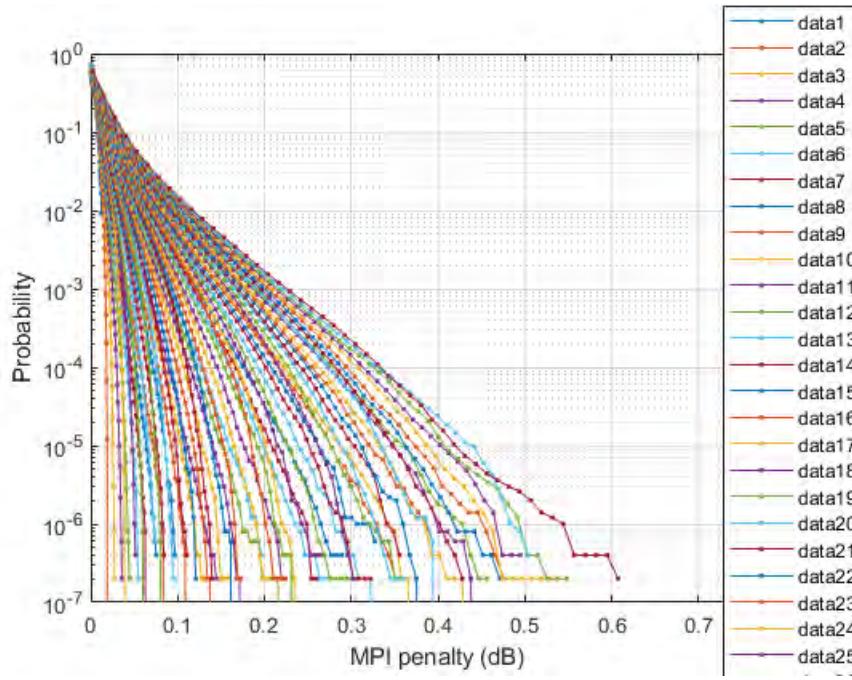
Cl. 183 – 800GBASE-LR4

Target PAM4 SER = 9.6e-3

Extinction ratio = 3.5 dB

Insertion loss = 3.15 dB at mid-span

Monte Carlo iterations = 50M, conf. level = 1e-6

Baseline cabling = Triple-link, duplex fiber

MPI penalty budget = 0.4 dB

Max allowable MPI penalty = 0.65 dB

MPI Penalty (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
Number of -35dB reflections — 0	0.01	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.08
1	0.04	0.05	0.06	0.07	0.08	0.09	0.11	0.12	0.13
2	0.08	0.09	0.11	0.12	0.13	0.15	0.16	0.18	0.19
3	0.14	0.15	0.17	0.19	0.22	0.22	0.24	0.25	0.27
4	0.21	0.22	0.25	0.26	0.28	0.30	0.33	0.33	0.35
5	0.29	0.32	0.33	0.35	0.37	0.39	0.39	0.40	0.43
6	0.39	0.41	0.42	0.44	0.46	0.47	0.50	0.53	0.54
7	0.51	0.51	0.55	0.55	0.57	0.61	0.60	0.60	0.66
8	0.59	0.62	0.64	0.67	0.71	0.74	0.68	0.72	0.74
9	0.73	0.80	0.78	0.76	0.80	0.81	0.82	0.80	0.86

Triple-link duplex cabling → MPI penalty budget = 0.4 dB.

MPI penalty > 0.65 dB highlighted in RED.

Max Channel IL (dB)	Number of -45dB reflections								
	0	1	2	3	4	5	6	7	8
Number of -35dB reflections — 0 to 4	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
5	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
6	6.3	6.3	6.3	6.3	6.2	6.2	6.2	6.2	6.2
7	6.2	6.2	6.1	6.2	6.1	6.1	6.1	6.1	6.0
8	6.1	6.1	6.1	6.0	6.0	6.0	6.0	6.0	6.0
9	6.0	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.8

Reduce maximum channel insertion loss for MPI penalty > 0.45 dB.

Values in RED would be disallowed based on MPI penalty > 0.65 dB.