

Towards Consensus on MPI Penalty for 802.3bs SMF PMDs

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Addressing Comments: 133-142

Supporters

- Vipul Bhatt, Inphi
- Bernard Lee, Senko
- Brian Welch, Luxtera
- Toshiaki Satake, US Conec
- Kent Lusted, Intel
- Rich Mellitz, Intel
- Matt Traverso, Cisco
- Mark Nowell, Cisco
- Ichiro Ogura, PETRA
- Atul Gupta, Macom
- Marek Tlalka, Macom
- Kohichi Tamura, Oclara
- Steve Swanson, Corning
- Bharat Taylor, Semtech
- Ken Jackson, Sumitomo
- Tom Issenhuth, Microsoft
- Brad Booth, Microsoft
- Rob Stone, Broadcom
- William Bliss, Broadcom
- Ed Ulrichs, Source Photonics
- David Chen, Applied Optoelectronics
- David Lewis, Lumentum
- Dan Sadot, MultiPHY
- Hanan Leizerovich, Multiply
- Greg LeCheminant, Keysight
- Pavel Zivny, Tektronix
- Atul Srivastava, NTT Electronics
- Jeff Maki, Juniper Networks
- Ran Adey, Intel
- Matt Brown, APM

Introduction

This presentation builds upon the contributions ([anslow 02 0216 smf](#) and [nicholl 01 0216 smf](#)) and related discussions from the recent SMF ad-hoc meetings, and proposes MPI penalty values and related changes in link budget for the SMF PMDs

Comments addressed against 802.3bs D1.2

- Comments 133-134, 142: DR4 link budget changes with MPI penalty included
- Comment 135: DR4 max. discrete reflectance
- Comment 136: DR4 max. number of -45 dB reflections
- Comments 137-139: FR8 and LR8 link budget changes with MPI penalties included
- Comment 140: FR8 and LR8 max. number of -35 dB reflections
- Comment 141: FR8 and LR8 max. discrete reflectance

Key Assumptions

- Link Models ([nicholl 01 0216 smf](#) and [kolesar 3bs 01 0514](#))
 - DR4 = Double link with 4 MPOs and 3 dB link loss
 - FR8 = Double link with 4 MPOs + 4 LCs and 4 dB link loss
 - LR8 = Triple link with 4 MPOs + 6 LCs and 6.3 dB link loss
- Connector RL
 - 26 dB for Tx and Rx MDI
 - 35 dB for LC and 55 dB for MPO connectors for all link cases
- MPI Analysis and Criteria
 - Monte Carlo simulation ([king 02a 0116 smf.7z](#))
 - Simulation run for 100k rows
 - Baseline BER = 2E-4
 - Signal ER: DR4 = 5 dB, FR8 = 4.5 dB, LR8 = 4.5 dB
 - Extrapolate the MPI penalty at 1E-6 cumulative error probability
 - Maximum link loss inserted at the end of the link for ALL cases ([anslow 02 0216 smf](#))

400GBASE-DR4 (500m)

Simulation Parameters:

Simulation model: [king_02a_0116_smf.7z](#)

Link model: Double link (Parallel-fiber)

Runs: 100k

BER: 2e-4

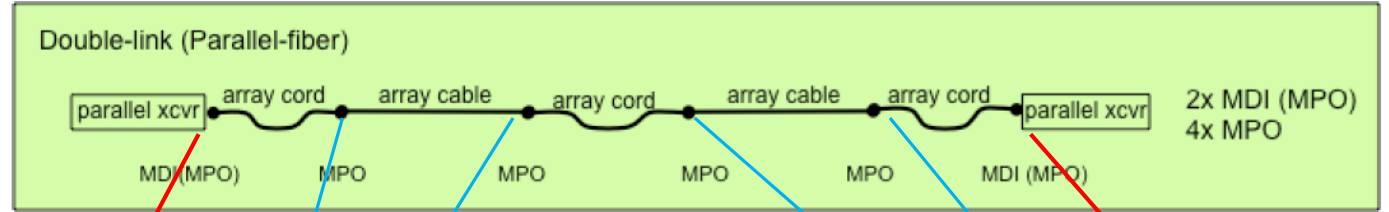
ER: 5 dB

Confidence: 1e-6

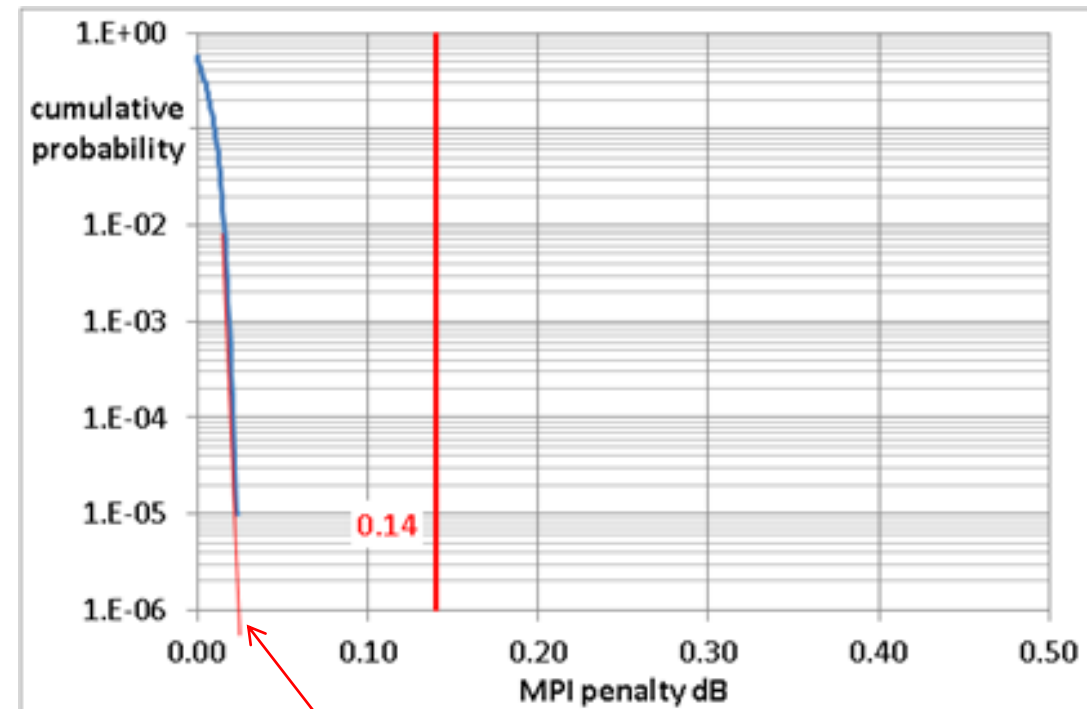
Tx/Rx MDI: 26 dB

Angle polished MPO RL: 55 dB

Loss: 3 dB at end of link



	PMD											PMD
ER	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12
5	RpmF	RconF	RconG	RconG	RconH	RconK	RconK	RconH	RconG	RconG	RconF	Rpmd
Reflection level inputs->	-26	-1000	-55	-55	-1000	-1000	-1000	-1000	-55	-55	-1000	-26
IL dB	0	0	0	0	0	0	0	0	0	0	3	



Round up MPI penalty from 0.03dB to 0.1dB to include in the link budget.

0.03dB

400GBASE-DR4: MPI Penalty with 45 dB MPO RL

Simulation Parameters:

Simulation model: [king_02a_0116_smf.7z](#)

Link model: Double link (Parallel-fiber)

Runs: 100k

BER: 2e-4

ER: 5 dB

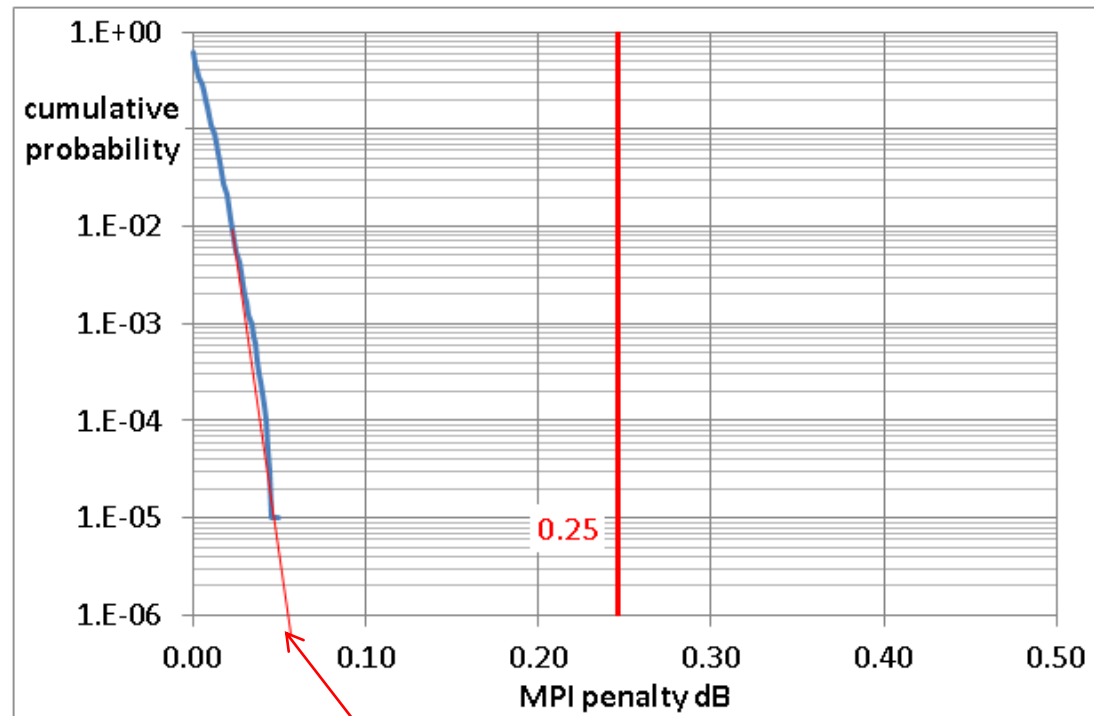
Confidence: 1e-6

Tx/Rx MDI: 26 dB

Angle polished MPO RL: 45 dB

Loss: 3 dB at end of link

Random phase between reflectors, random selection of modulation levels														
Polarization assumed aligned														
													ER	dER
Baseline BER	average phase=											5	0.316	
2.4E-04	3.1478													
	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	-1000	-45	-45	-1000	-1000	-1000	-1000	-45	-45	-1000	-26		
	phase b	phase b	phase b	phase b	phase b	phase b	phase b	phase b	phase b	phase b	phase b	phase b		
	int1-int2	int2-int3	int3-int4	int4-int5	int5-int6	int6-int7	int7-int8	int8-int9	int9-int10	int10-int11	int11-int12			
W/C phases row:	0	0	0	0	0	0	0	0	0	0	0	0		
IL dB	0	0	0	0	0	0	0	0	0	0	0	3		



< 0.1 dB MPI penalty is still ensured even when the MPO RL is 45 dB.

Therefore, plan to use -45dB for the maximum discrete reflectance in the DR4 link budget table.

Reflection budget straw man 400GBASE-DR4

* [anslow_02_0216_smf.pdf](#)

Parameter	D1.2	Pete's Strawman*	This Proposal	Unit	Note
Table 122-6					
Average launch power, each lane (min)	-1.9	-2.2	-2.4	dBm	Max 10 dB ER
Outer Optical Modulation Amplitude (OMA _{outer}), each lane (min)	0.2	-0.1	-0.3	dBm	reduced by 0.2 dB
Launch power in OMA _{outer} minus TDP, each lane (min)	-0.8	-1.1	-1.3	dBm	reduced by 0.2 dB
Optical return loss tolerance (max)	TBD	17.8	TBD	dB	Tx compliance (22.8 dB)
Transmitter reflectance (max)	-20	-26	-26	dB	same
Table 122-7					
Average receive power, each lane (min)	-4.9	-5.2	-5.4	dBm	0.2 dB lower
Receiver reflectance (max)	-26	-26	-26	dB	same
Receiver sensitivity (OMA _{inner}), each lane (max)	-9.1	-9.2	-9.2	dBm	same
Table 122-8					
Power budget (for max TDP)	6	5.8	5.6	dB	reduced by 0.2 dB
Maximum discrete reflectance	-35	-35	-45	dB	change to -45dB
Allocation for penalties (for maximum TDP)	3	2.8	2.6	dB	reduced 0.2dB (MPI=0.1dB)
Table 122-11					
Optical return loss	TBD	17.8	TBD	dB	Channel spec for TDP measurement
Table 122-12					
[Channel] Optical return loss (min)	TBD	29	TBD	dB	Channel characteristics
122.11.2.2					
maximum discrete reflectance	-35	-35	-45	dB	change to -45 dB 7
Max number of -45 dB reflections		4	4		same

400GBASE-FR8 (2km)

Simulation Parameters:

Link model: Double link (2-fiber)

Simulation model: [king_02a_0116_smf.7z](#)

Runs: 100k

BER: 2e-4

ER: 4.5 dB

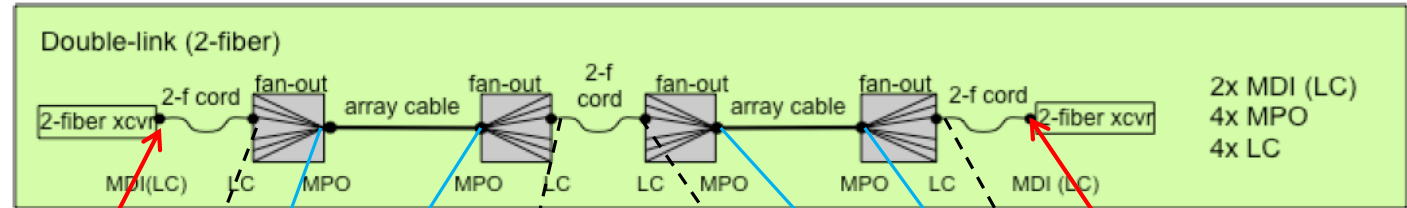
Confidence: 1e-6

Tx/Rx MDI: 26 dB

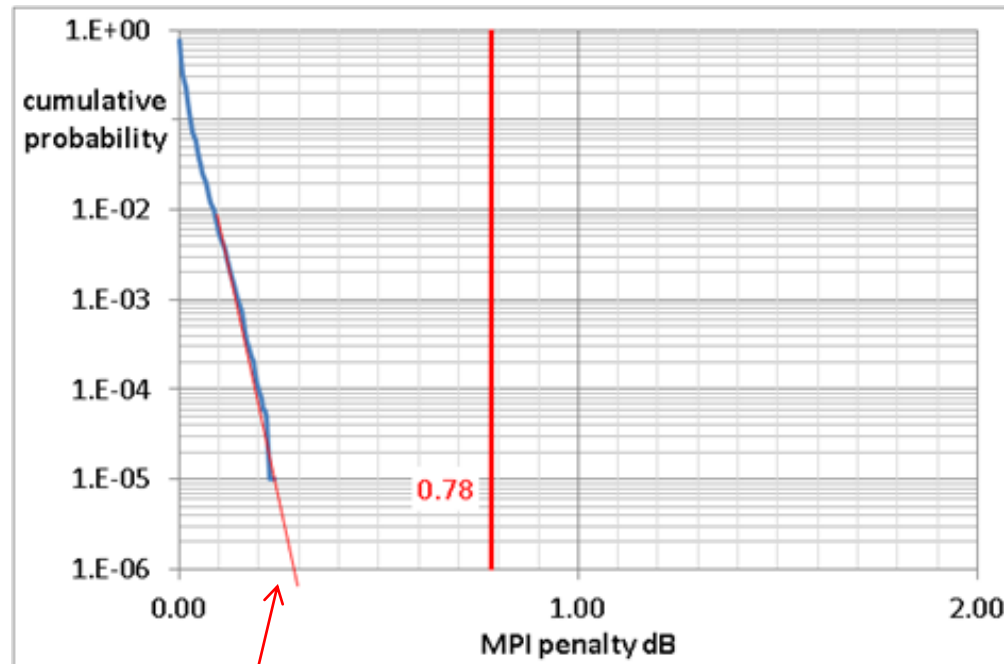
LC: 35 dB

Angle polished MPO: 55 dB

Loss: 4 dB at end of link



	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
ER	Rrmd	RconF	RconG	RconG	RconH	RconK	RconK	RconH	RconG	RconG	RconF	Rpmd
Reflection level inputs->	-26	-35	-55	-55	-35	-1000	-1000	-35	-55	-55	-35	-26
IL dB	0	0	0	0	0	0	0	0	0	0	4	



Recommend to include 0.3 dB MPI penalty into the link budget.

0.3 dB

Reflection budget straw man 400GBASE-FR8

* [anslow_02_0216_smf.pdf](#)

Parameter	D1.2	Pete's Strawman *	This Proposal	Unit	Comment
Table 123-7					
Average launch power, each lane (min)	-3		- 2.9	dBm	assume infinite ER
Outer Optical Modulation Amplitude (OMA _{outer}), each lane (min)	0		0.1	dBm	0.1 dB to Tx
Launch power in OMA _{outer} minus TDP, each lane (min)	-1		- 0.9	dBm	
Optical return loss tolerance (max)	TBD	15.5	TBD	dB	Tx compliance (17.8 dB)
Transmitter reflectance (max)	TBD	-26	-26	dB	same
Table 123-8					
Average receive power, each lane (min)	-7		-6.9	dBm	
Receiver reflectance (max)	TBD	-26	-26	dB	same
Receiver sensitivity (OMA _{inner}), each lane (max)	-9.8		-10	dBm	0.2 dB to Rx
Table 123-9					
Power budget (for max TDP)	6.2	6.8	6.5	dB	0.3 dB lower
Maximum discrete reflectance	TBD	-35	-35	dB	same
Allocation for penalties (for maximum TDP)	2.2	2.8	2.5	dB	reduced 0.3dB (MPI=0.3dB)
Table 123-12					
400GBASE-FR8 Optical return loss	20	15.5	TBD	dB	Channel spec for TDP measurement
Table 123-13					
[Channel] Optical return loss (min)	21	27	TBD	dB	channel characteristics
123.11.2.2					
maximum discrete reflectance	-26	-35	-35	dB	same 9
Max number of -35 dB reflections		6	4		changed to 4

400GBASE-LR8 (10km)

Simulation Parameters:

Simulation model: [king_02a_0116_smf.7z](#)

Link model: Triple link (2-fiber)

Runs: 100k

BER: 2e-4

ER: 4.5 dB

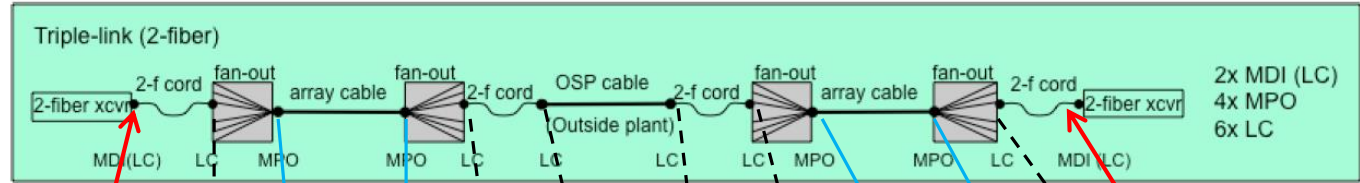
Confidence: 1e-6

Tx/Rx MDI: 26 dB

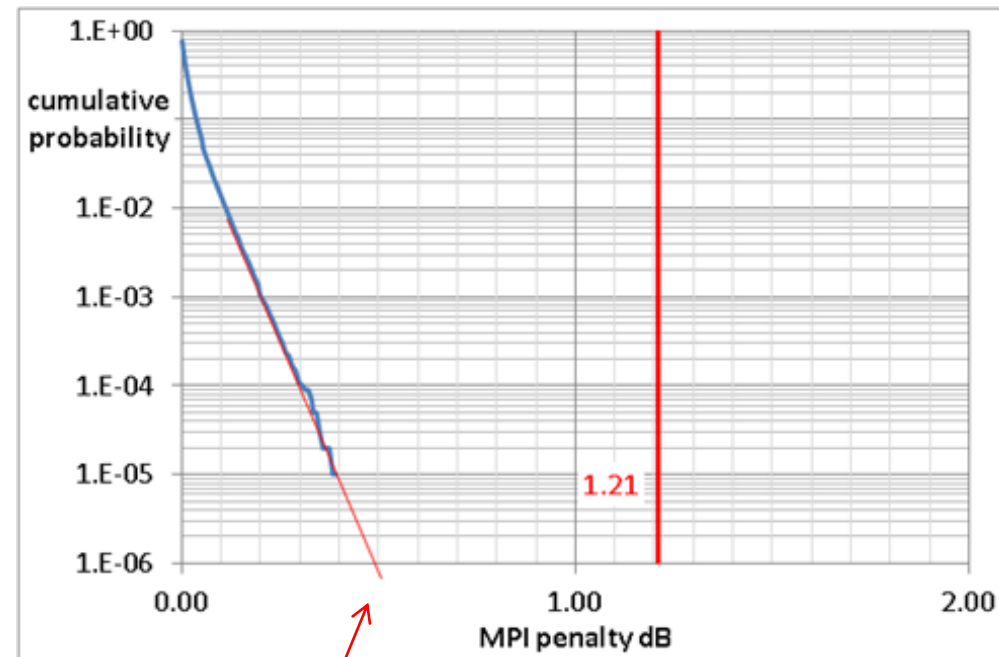
LC: 35 dB

Angle polished MPO: 55 dB

Loss: 6.3 dB at end of link



	PMD											PMD
ER	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12
	R _{pmd}	R _{conF}	R _{conG}	R _{conG}	R _{conH}	R _{conK}	R _{conK}	R _{conH}	R _{conG}	R _{conG}	R _{conF}	R _{pmd}
4.5	-26	-35	-55	-55	-35	-35	-35	-35	-55	-55	-35	-26
Reflection level inputs->	-26	-35	-55	-55	-35	-35	-35	-35	-55	-55	-35	-26
IL dB	0	0	0	0	0	0	0	0	0	0	6.3	



0.5 dB

Recommend to include 0.5dB MPI penalty into the link budget.

Reflection budget straw man 400GBASE-LR8

* [anslow_02_0216_smf.pdf](#)

Parameter	D1.2	Pete's Strawman *	This Proposal	Unit	Comment
Table 123-7					
Average launch power, each lane (min)	-2.5		-2.2	dBm	infinite ER assumed
Outer Optical Modulation Amplitude (OMA _{outer}), each lane (min)	0.5		0.8	dBm	0.3dB to Tx
Launch power in OMA _{outer} minus TDP, each lane (min)	-0.5		-0.2	dBm	
Optical return loss tolerance (max)	TBD	15.5	TBD	dB	Tx compliance (15.7 dB)
Transmitter reflectance (max)	TBD	-26	-26	dB	same
Table 123-8					
Average receive power, each lane (min)	-8.8		-8.5	dBm	same
Receiver reflectance (max)	TBD	-26	-26	dB	
Receiver sensitivity (OMA _{inner}), each lane (max)	-11.6		-11.8	dBm	0.2dB to Rx
Table 123-9					
Power budget (for max TDP)	8.7	9.2	9.2	dB	same
Maximum discrete reflectance	TBD	-35	-35	dB	same
Allocation for penalties (for maximum TDP)	2.4	2.9	2.9	dB	same (MPI=0.5dB)
Table 123-12					
400GBASE-FR8 Optical return loss	20	15.5	TBD	dB	Channel specs for TDP measurement
Table 123-13					
[Channel] Optical return loss (min)	21	27	TBD	dB	channel characteristics
123.11.2.2					
maximum discrete reflectance	-26	-35	-35	dB	same
Max number of -35 dB reflections		6	6		same

Summary

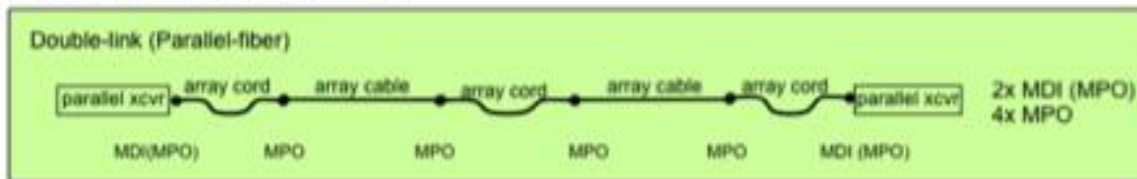
- Proposed MPI penalties for each PMD
 - DR4: 0.1 dB
 - FR8: 0.3 dB
 - LR8: 0.5 dB
- Proposed changes in link budget to account for the MPI Penalties
- Next steps
 - Agree on the optical return loss values for each PMD

Backup

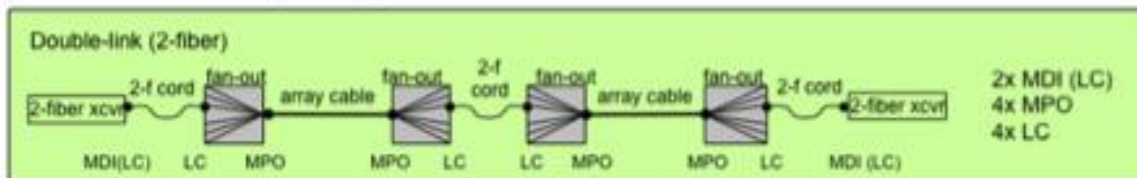
Reference link models for MPI calculation

Proposed reference models for 802.3bs

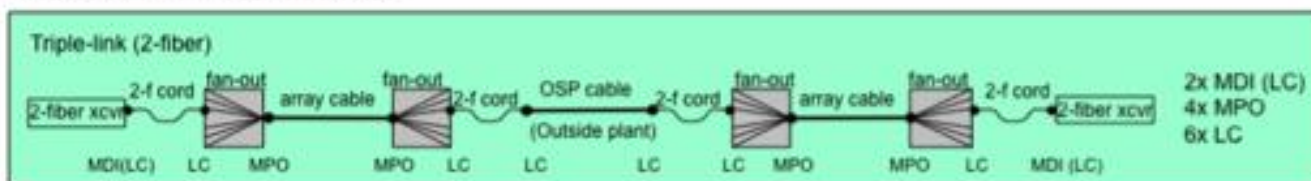
400GBASE-DR4 (500m):



400GBASE-FR8 (2km):



400GBASE-LR8 (10km):



Reference: [nicholl 01 0216 smf](#) and [kolesar 3bs 01 0514](#)