

# Optical Specifications of SMF PMDs Study

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Chris Cole



*Finisar*<sup>®</sup>

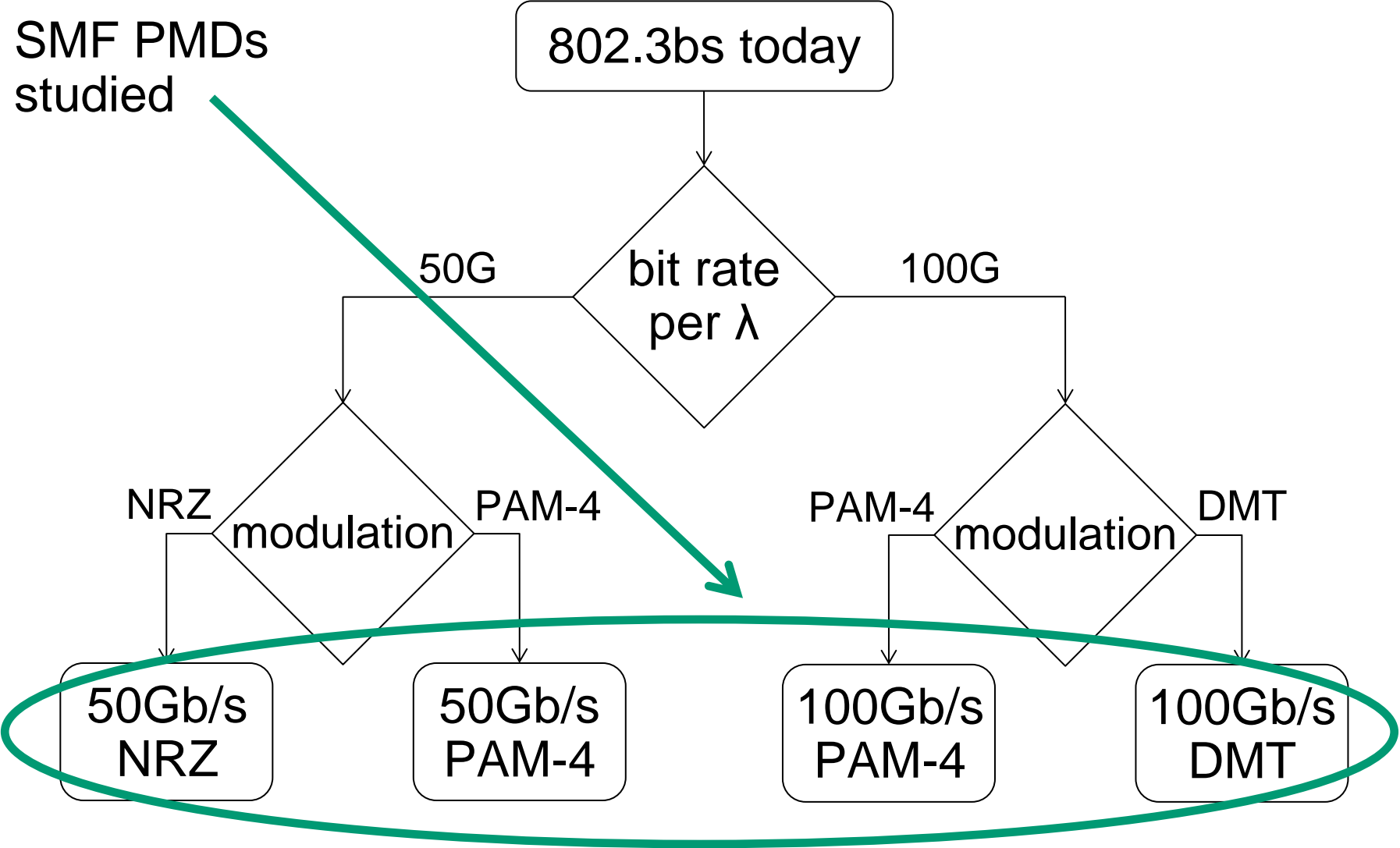
# Finisar Contributors

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- Gilles Denoyer
- Bernd Huebner
- Jonathan King
- Chris Kocot
- William Ling
- Ilya Lyubomirsky
- Daniel Mahgerefteh
- Thelinh Nguyen
- Thang Pham
- Jack Xu

# Duplex SMF & PSM4 PMDs Decision Tree

SMF PMDs studied



# TX Limit, Mux Loss & Modulation Penalty

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- Eye safety limit (1310nm) = 14.1dBm AOP
- Mux loss
  - 2:1 ratio = 1.5 dB
  - 4:1 ratio = 2.5 dB
  - 8:1 ratio = 3.5 dB
- Modulation penalty
  - NRZ = 0.0 dB
  - PAM-4 = 4.8 dB
  - DMT-k (25G DML, +/- 3 $\sigma$  clipping) = 8.8 dB
- Modulation 5% accuracy penalty = 0.2 dB
- DMT-k sub-carrier I & Q channel power split factor penalty
  - $F_k = 10 * \log_{10} (2 * k)$

# TDP 2km

2km	8x50G NRZ	8x50G PAM4	8x50G PAM4	4x100G PAM4	4x100G DMT-k
Source	Mod	Mod	DML	Mod	25G DML
Grid	LAN WDM	LAN WDM	LAN WDM	CWDM	LAN WDM
FEC	KP4	KP4	KP4	KP4	BCH
Operating BER	2.0e-4	2.0e-4	2.0e-4	2.0e-4	1.0E-03
TX analog BW *	20	20	20	20	21
RX analog BW *	40	20	20	31	21
RX FFE taps or FFT pts.	3	3	3	13	k
<b>TDP dB</b>	<b>1.8</b>	<b>0.7</b>	<b>1.0</b>	<b>2.5</b>	<b>2.5</b>

- Methodology as per [cole\\_3bs\\_01a\\_0714](#), updated with jitter, and residual quantization effects for 100G PAM-4 & DMT
- \* TX & RX analog BW added as per requests from the floor

# TDP 10km

10km	8x50G NRZ	8x50G PAM4	8x50G PAM4	4x100G PAM4	4x100G DMT-k
Source	Mod	Mod	DML	Mod	25G DML
Grid	LAN WDM	LAN WDM	LAN WDM	LAN WDM	LAN WDM
FEC	BCH	BCH	BCH	BCH	BCH
Operating BER	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
TX analog BW *	21	21	21	21	21
RX analog BW *	42	21	21	32	21
RX FFE taps or FFT pts.	3	3	3	13	k
<b>TDP dB</b>	<b>2.3</b>	<b>0.7</b>	<b>1.5</b>	<b>2.5</b>	<b>3.0</b>

- Methodology as per [cole\\_3bs\\_01a\\_0714](#), updated with jitter, and residual quantization effects for 100G PAM-4 & DMT
- \* TX & RX analog BW added as per requests from the floor

# RX Channel Loss & FEC Gain

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- 2km Channel Insertion Loss & MPI Penalty = 5 dB
  - 4.0 dB channel base loss
  - up to 1.0 dB MPI Penalty
- 10km Channel Insertion Loss & MPI Penalty = 7 dB
  - 6.3 dB channel base loss
  - up to 0.7 dB MPI Penalty
- FEC Optical Gain (vs.  $1e-12$  BER )
  - KR4 = 2.6 dB
  - KP4 = 3.2 dB
  - BCH (2858, 2570,  $t=24$ ) = 3.8 dB

# RX DeMux Loss & Bandwidth Penalty

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- DeMux loss
  - 2:1 ratio = 1.5 dB
  - 4:1 ratio = 2.5 dB
  - 8:1 ratio = 3.5 dB
- Bandwidth Penalty (vs. 25G NRZ)
  - 50G NRZ = 1.5 dB
  - 50G PAM-4 = 0.0 dB
  - 100G PAM-4 = 1.0 dB
  - 100G DMT = 0.0 dB
- FEC overhead Bandwidth Penalty
  - KR4 (0%) = 0.0 dB
  - KP4 (3%) = 0.1 dB
  - BCH (8%) = 0.2 dB
  - BCH (DMT, 25G DML) = 0.0 dB



# RX Design Penalty

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- 50G TIA device noise penalty (vs. 25G) = 1.0 dB
- Linear TIA AGC noise penalty (vs. Limiting) = 0.5 dB
- TIA cross-talk penalty
  - 25G NRZ = 0.2 dB
  - 50G NRZ = 0.4 dB
  - 50G PAM-4 (linear) = 0.3 dB
  - 100G PAM-4 (linear) = 0.4 dB
  - 100G DMT-k (linear) = 0.3 dB
- Analog equalizer non-idealities or ADC quantization penalty
  - 50G NRZ 3-tap FFE = 0.4 dB
  - 50G PAM-4 3-tap FFE = 0.5 dB
  - 100G PAM-4 6-bit ENOB ADC = 0.4 dB
  - 100G DMT-k 6-bit ENOB ADC = 0.6 dB

# 400G 2km Duplex SMF PMDs TX Specs

TX Specifications	4x25G NRZ LR4 No FEC MOD / DML		8x50G NRZ KP4 FEC MOD	8x50G PAM4 KP4 FEC MOD / DML		4x100G KP4 FEC PAM4 MOD	4x100G DMT BCH FEC 25G DML
	Operating BER	1.0E-12		2.0E-04	2.0E-04		2.0E-04
ER Full Scale (min) dB	7.0	4.0	4.5	7.0	4.5	7.0	4.5
TX OMA pre-Mux (min) @TDP (max) dBm	<b>1.2</b>	<b>2.4</b>	<b>1.5</b>	<b>2.2</b>	<b>2.5</b>	<b>3.5</b>	<b>5.0</b>
Mux Loss dB	2.5		3.5	3.5		2.5	2.5
TX OMA (min) @TDP (max) dBm	-1.3	-0.1	-2.0	-1.3	-1.0	1.0	2.5
Modulation Penalty dB	0.0		0.0	5.0		5.0	9 + Fk
TX OMA Eye (min) @TDP (max) dBm	-1.3	-0.1	-2.0	-6.3	-6.0	-4.0	-6.5 - Fk
TDP (max) dB	1.0	2.2	1.8	0.7	1.0	2.5	2.5
TX OMA Eye - TDP each lane (min) dBm	<b>-2.3</b>		<b>-3.8</b>	<b>-7.0</b>		<b>-6.5</b>	<b>-9 - Fk</b>

# 400G 2km Duplex SMF PMDs RX Specs

RX Specifications	NRZ 4x25G LR4 No FEC MOD / DML	8x50G NRZ KP4 FEC MOD	8x50G PAM4 KP4 FEC MOD / DML	4x100G KP4 FEC PAM4 MOD	4x100G DMT BCH FEC 25G DML
Symbol (or Sample) Rate Gbaud (or GS)	25.8	53.2	26.6	53.2	55.9
Operating BER	1.0E-12	2.0E-04	2.0E-04	2.0E-04	1.0E-03
TX OMA Eye - TDP each lane (min) dBm	-2.3	-3.8	-7.0	-6.5	-9 - Fk
Channel Insertion Loss & MPI penalty dB	6.3	5.0	5.0	5.0	5.0
RX Sens. OMA pre-FEC each lane (max) dBm	<b>-8.6</b>	<b>-8.8</b>	<b>-12.0</b>	<b>-11.5</b>	<b>-14 - Fk</b>
FEC Optical Gain v. 1e-12 BER dB	0.0	3.2	3.2	3.2	3.8
DeMux Loss + Lane BW Penalty dB	2.5	5.1	3.6	3.6	2.5 - Fk
TIA, Xtalk, Quantization Penalties dB	0.2	1.8	1.3	1.8	1.3
RX Sens. OMA post- DeMux v. LR4 dBm	<b>-11.3</b>	<b>-12.5</b>	<b>-13.7</b>	<b>-13.7</b>	<b>-14.0</b>

# 400G 2km Duplex SMF PMDs Comparison

400G 2km specs minus LR4 specs 4x25G NRZ no FEC MOD & DML	8x50G NRZ KP4 FEC MOD	8x50G PAM-4 KP4 FEC MOD DML	4x100G PAM-4 KP4 FEC MOD	4x100G DMT-K BCH FEC 25G DML	
TX OMA delta (pre-Mux) dB	<b>0.3</b>	<b>1.0</b>	<b>0.1</b>	<b>2.3</b>	<b>2.6</b>
RX Sens. delta (post-DeMux) dB	<b>-1.2</b>	<b>-2.4</b>	<b>-2.4</b>	<b>-2.7</b>	

Every RX Sens. delta is idealized, incomplete, and optimistic

# 400G (4x100G) PSM4 PMDs TX Specs

TX Specifications CWDM Grid	4x25G NRZ CWDM4 KR4 MOD / DML		2x50G NRZ KP4 FEC MOD	2x50G PAM4 KP4 FEC MOD / DML		1x100G KP4 FEC PAM4 MOD	1x100G DMT BCH FEC 25G DML
	Operating BER	5.0E-05		2.0E-04	2.0E-04		2.0E-04
ER Full Scale (min) dB	6.5	3.5	4.5	7.0	4.5	7.0	4.5
TX OMA pre-Mux (min) @TDP (max) dBm	<b>-1.5</b>	<b>0.5</b>	<b>-1.0</b>	<b>-0.3</b>	<b>0.0</b>	<b>0.0</b>	<b>1.5</b>
Mux Loss dB	2.5		1.5	1.5		0.0	0.0
TX OMA (min) @TDP (max) dBm	-4.0	-2.0	-2.5	-1.8	-1.5	0.0	1.5
Modulation Penalty dB	0.0		0.0	5.0		5.0	9 + Fk
TX OMA Eye (min) @TDP (max) dBm	-4.0	-2.0	-2.5	-6.8	-6.5	-5.0	-7.5 - Fk
TDP (max) dB	1.0	3.0	1.8	0.7	1.0	2.5	2.5
TX OMA Eye - TDP each lane (min) dBm	<b>-5.0</b>		<b>-4.3</b>	<b>-7.5</b>		<b>-7.5</b>	<b>-10 - Fk</b>

# 400G (4x100G) PSM4 PMDs RX Specs

RX Specifications CWDM Grid	4x25G NRZ CWDM4 KR4 MOD / DML	2x50G NRZ KP4 FEC MOD	2x50G PAM4 KP4 FEC MOD / DML	1x100G KP4 FEC PAM4 MOD	1x100G DMT BCH FEC 25G DML
Symbol (or Sample) Rate GBaud (or GS)	25.8	53.2	26.6	53.2	55.9
Operating BER	5.0E-05	2.0E-04	2.0E-04	2.0E-04	1.0E-03
TX OMA Eye - TDP each lane (min) dBm	-5.0	-4.3	-7.5	-7.5	-10 - Fk
Channel Insertion Loss & MPI penalty dB	5.0	5.0	5.0	5.0	5.0
RX Sens. OMA pre-FEC each lane (max) dBm	<b>-10.0</b>	<b>-9.3</b>	<b>-12.5</b>	<b>-12.5</b>	<b>-15 - Fk</b>
FEC Optical Gain dB	2.6	3.2	3.2	3.2	3.8
DeMux Loss + Lane BW Penalty dB	2.5	3.1	1.6	1.1	0 - Fk
TIA, Xtalk, Quantization Penalties dB	0.2	1.8	1.3	1.8	1.3
RX Sens. OMA post- DeMux v. CWDM4 dBm	<b>-10.1</b>	<b>-11.0</b>	<b>-12.2</b>	<b>-12.2</b>	<b>-12.5</b>

# 400G (4x100G) PSM4 PMDs Comparison

4x100G 2km specs minus CWDM4 Specs 4x25G NRZ KR4 FEC MOD & DML	2x50G NRZ KP4 FEC MOD	2x50G PAM-4 KP4 FEC MOD DML	1x100G PAM-4 KP4 FEC MOD	1x100G DMT-K BCH FEC 25G DML	
TX OMA delta (pre-Mux) dB	<b>0.5</b>	<b>1.2</b>	<b>-0.5</b>	<b>1.5</b>	<b>1.0</b>
RX Sens. delta (post-DeMux) dB	<b>-0.9</b>	<b>-2.1</b>	<b>-2.1</b>	<b>-2.4</b>	

Every RX Sens. delta is idealized, incomplete, and optimistic

# 400G 10km Duplex SMF PMDs TX Specs

TX Specifications LAN WDM Grid	4x25G NRZ LR4 No FEC MOD / DML		8x50G NRZ BCH FEC MOD	8x50G PAM4 BCH FEC MOD / DML		4x100G BCH FEC PAM4 MOD	4x100G DMT BCH FEC 25G DML
	Operating BER	1.0E-12		1.0E-03	1.0E-03		1.0E-03
ER Full Scale (min) dB	7.0	4.0	4.5	7.0	4.5	7.0	4.5
TX OMA pre-Mux (min) @TDP (max) dBm	<b>1.2</b>	<b>2.4</b>	<b>2.5</b>	<b>2.7</b>	<b>3.5</b>	<b>4.0</b>	<b>5.0</b>
Mux Loss dB	2.5		3.5	3.5		2.5	2.5
TX OMA (min) @TDP (max) dBm	-1.3	-0.1	-1.0	-0.8	0.0	1.5	2.5
Modulation Penalty dB	0.0		0.0	5.0		5.0	9 + Fk
TX OMA Eye (min) @TDP (max) dBm	-1.3	-0.1	-1.0	-5.8	-5.0	-3.5	-6.5 - Fk
TDP (max) dB	1.0	2.2	2.3	0.7	1.5	2.5	3.0
TX OMA Eye - TDP each lane (min) dBm	<b>-2.3</b>		<b>-3.3</b>	<b>-6.5</b>		<b>-6.0</b>	<b>-9.5 - Fk</b>



# 400G 10km Duplex SMF PMDs RX Specs

RX Specifications LAN WDM Grid	NRZ 4x25G LR4 No FEC MOD / DML	8x50G NRZ BCH FEC MOD	8x50G PAM4 BCH FEC MOD / DML	4x100G BCH FEC PAM4 MOD	4x100G DMT BCH FEC 25G DML
Symbol (or Sample) Rate Gbaud (or GS)	25.8	55.9	28.0	55.9	55.9
Operating BER	1.0E-12	1.0E-03	1.0E-03	1.0E-03	1.0E-03
TX OMA Eye - TDP each lane (min) dBm	-2.3	-3.3	-6.5	-6.0	-9.5 - Fk
Channel Insertion Loss & MPI penalty dB	6.3	7.0	7.0	7.0	7.0
RX Sens. OMA pre-FEC each lane (max) dBm	<b>-8.6</b>	<b>-10.3</b>	<b>-13.5</b>	<b>-13.0</b>	<b>-16.5 -Fk</b>
FEC Optical Gain v. 1e-12 BER dB	0.0	3.8	3.8	3.8	3.8
DeMux Loss + Lane BW Penalty dB	2.5	5.2	3.7	3.7	2.5 - Fk
TIA, Xtalk, Quantization Penalties dB	0.2	1.8	1.3	1.8	1.4
RX Sens. OMA post- DeMux v. LR4 dBm	<b>-11.3</b>	<b>-13.5</b>	<b>-14.7</b>	<b>-14.7</b>	<b>-16.6</b>

# 400G 10km Duplex SMF PMDs Comparison

400G 10km specs minus LR4 specs 4x25G NRZ no FEC MOD & DML	8x50G NRZ BCH FEC MOD	8x50G PAM-4 BCH FEC MOD DML	4x100G PAM-4 BCH FEC MOD	4x100G DMT-K BCH FEC 25G DML	
TX OMA delta (pre-Mux) dB	<b>1.3</b>	<b>1.5</b>	<b>1.1</b>	<b>2.8</b>	<b>2.6</b>
RX Sens. delta (post-DeMux) dB	<b>-2.2</b>	<b>-3.4</b>	<b>-3.4</b>	<b>-5.3</b>	

Every RX Sens. delta is idealized, incomplete, and optimistic

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Thank you