

100G CWDM Link Model for DM DFB Lasers with KR4 FEC

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100G CWDM Link Attributes

Background:

- Since the baseline proposal for the 500 m SMF objective based on CWDM technology shows block diagrams of implementations using directly modulated lasers, a link model based analysis was made to explore the feasibility of such implementations.
- A prior presentation, petrilla_03_0513_optx , offered a comparison of an implementation of the 100G CWDM baseline proposal with one that accommodates direct modulated (DM) DFB lasers.
- This presentation offers a comparison of that prior DM DFB based implementation with one that includes the benefits of KR4 FEC.

Conclusion:

Links of 500 m SMF operating at a maximum BER of 5×10^{-5} appear feasible based on a 7.25 dB signal power budget assuming benefits from KR4 FEC and retimers with the same retimer performance in the Tx and Rx as assumed for 100G SR4 links and 100G PSM4 links.

References:

- 100G CWDM Link Model for DM DFB Lasers found at http://www.ieee802.org/3/bm/public/may13/petrilla_03_0513_optx.pdf
- Example 100G CWDM Link Model (petrilla_03_0413_smf), found at http://www.ieee802.org/3/bm/public/smfadhoc/meetings/apr16_13/petrilla_03_0413_smf.xlsx
- The 500 m link insertion loss allocation is based on kolesar_02_0313_optx found at http://www.ieee802.org/3/bm/public/mar13/kolesar_02_0313_optx.pdf

Fiber Optic Link Interfaces

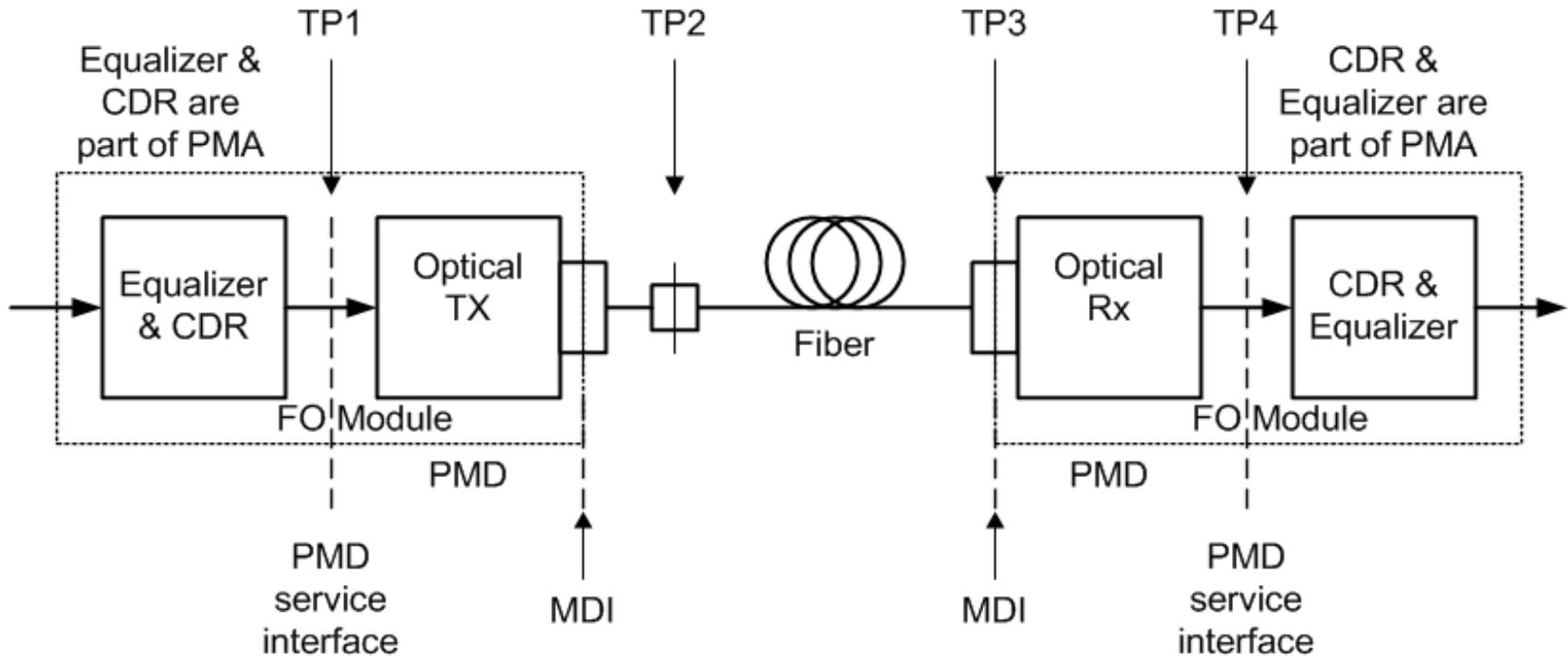


Figure 1

- For cases, as shown above in Figure 1, where retimers are incorporated in the optical module, the PMD service interface is not exposed. TP1 and TP4 remain as points on the PMD service interface and, consequently not exposed.
- The high speed signal inputs and outputs of the optical module are expected to be defined by CAUI-4.

100G CWDM illustrative link power budget

Parameter	Unit	petrilla_03_0513_optx	petrilla_01_0613_smf
Power budget (for max TDP)	dB	7.7	7.26
Operating distance	km	0.5	0.5
Channel insertion loss	dB	3.92	3.98
Max discreet reflectance	dB	-26	-26
Allocation of penalties (for max TDP)	dB	3.78	3.28
Additional insertion loss allowed	dB	0	0

- The above table compares power budget attributes of DM DFB based CWDM proposals with and without KR4 FEC.
- The slightly larger insertion loss in petrilla_01_0613_smf is due to correcting the inadvertent setting of the fiber attenuation to 0.50 dB/km at 1300 nm instead of 0.50 dB/km at 1310 nm.
- The larger power budget for the DM DFB cases permits a larger TDP limit that enables lowers bandwidth and OMA requirements for the DFB lasers.**
- Better Rx sensitivity (due to operating at the higher BER enabled by KR4 FEC) reduces the min Tx OMA requirement and avoids a need to cool the DM DFB lasers.**

100G CWDM: Link Model Channel Attributes (each lane)

Parameter	Unit	petrilla_03_0513_optx	petrilla_01_0613_smf	
Signal rate	GBd	25.78125	25.78125	
Q (BER)		7.034 (E-12)	3.891 (5E-5)	
Reach	km	0.5	0.5	
Fiber Attenuation at 1310 nm	dB/km	0.50	0.50	
Dispersion, min Uo	nm	1324	1324	
Dispersion, So	ps/nm ² km	0.093	0.093	
PolMD DGD max	ps	2.24	2.24	
Reflection Noise Factor		0.6	0.6	
Signal power budget at max TDP	dB	7.7	7.26	
Connector & splice loss allocation	dB	3.65	3.70	
Fiber Insertion loss	dB	0.27	0.28	0.50 dB/km at 1310 nm
Allocation for penalties at max TDP	dB	3.78	3.28	
Additional insertion loss allowed	dB	0.0	0.0	

- Attributes and values in the above table are provided in order to populate example link models.
- The channel and connector loss for the CWDM baseline proposal and the DM DFB budget follow the recommendations in "Loss Budgeting for Single-Mode Channels"

http://www.ieee802.org/3/bm/public/mar13/kolesar_02_0313_optx.pdf

100G CWDM: Link Model Jitter Attributes (each lane)

Parameter	Unit	petrilla_03_0513_optx	petrilla_01_0613_smf	
Signal rate	GBd	25.78125	25.78125	
Q (BER)		7.034 (E-12)	3.891 (5E-5)	
TP1 RJrms tolerance, min	UI	0.0079	0.0079	
TP1 DJ (dual Dirac) tolerance, min	UI	0.110	0.110	
TP3 DJ (dual Dirac) tolerance, min	UI	0.145	0.160	
TP3 DCD tolerance, min	UI	0.05	0.05	
TP4 J2, max	UI	0.369	0.372	Model output
TP4 TJ at BER, max	UI	0.78	0.78	Model output

- Attributes and values in the above table are provided in order to populate example link models.
- Nomenclature: Terms TP1, TP2, TP3 and TP4 are used as defined in 802.3 clause 88 and shown in above Figure 1. Note that TP1 is downstream of the input CDR and equalizer for an optical transmitter.
- TP1 and TP4 jitter allocations are based on the same retimer assumptions as for the retimers for 100G SR4 and 100G PSM4.**

100G CWDM: Tx Link Model Attributes (each lane)

Parameter	Unit	petrilla_03_0513_optx	petrilla_01_0613_smf	
Signal rate	GBd	25.78125	25.78125	
Q (BER)		7.034 (E-12)	3.891 (5E-5)	
Center Wavelength, min	nm	1264.5	1264.5	
Spectral Width, max	nm	0.20	0.20	
OMA at max TDP, min	dBm	-0.8	-2.2	
Extinction ratio, min	dB	4.0	4.0	
Tx output transition times, 20% -80%, max	ps	16	16	
RINcOMA, max	dB/Hz	-130	-130	
RIN coefficient		0.7	0.7	
Tx reflectance, max	dB	-12	-12	
Tx optical return loss tolerance, max	dB	20	20	

- Attributes and values in the above table are provided in order to populate example link models.
- Max Tx transition time is driven by the TDP requirement for the approach. The more relaxed TDP requirement for the DM DFB approach permits slower Tx transition times.
- Relaxation in the transition time (now 16 ps) and OMA (now -2.2 dBm) requirements enable DM DFB lasers without internal cooling.**

100G CWDM: Rx Link Model Attributes (each lane)

Parameter	Unit	petrilla_03_0513_optx	petrilla_01_0613_smf	
Signal rate	GBd	25.78125	25.78125	
Q (BER)		7.034 (E-12)	3.891 (5E-5)	FEC corrects BER to $< 10^{-12}$
Center Wavelength, min	nm	1264.5	1264.5	
Rx sensitivity (OMA), max	dBm	-8.5	-9.46 (5E-5)	-6.89 dBm at Q = 7.034
Rx Bandwidth, min	MHz	19,336	19,336	
RMS base line wander coefficient		0.025	0.025	
Rx reflectance, max	dB	-10.78	-8.23	Note 1

Note 1, Rx reflectance is a single point equivalence (yields the same MPI penalty) for a -26 dB Rx reflectance (petrilla_03_0513_optx) and a -21 dB Rx reflection (petrilla_01_0613_smf) and four inline connectors each at -26 dB reflectance. The single point equivalence was determined with the Upper Bound penalty calculation in "PAM MPI – Overview & Recommendations",

http://www.ieee802.org/3/100GNGOPTX/public/may12/bhatt_01_0512_optx.pdf

•Attributes and values in the above table are provided in order to populate example link models.

Better Rx sensitivity from KR4 FEC permits the larger signal budget that can accommodate DM DFB lasers without use of cooling and also relax the ORL requirement of the Rx.