100G CWDM Link Model for DM DFB Lasers

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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.

•This presentation offers a comparison of an implementation of the 100G CWDM baseline proposal with one that accommodates direct modulated (DM) DFB lasers.

Conclusions:

•Links of 500 m SMF operating at a maximum BER of 10^{-12} appear feasible based on a 7.7 dB signal power budget assuming retimers with the same retimer performance in the Tx and Rx as assumed for 100G SR4 links and 100G PSM4 links.

•The power budget in the 100G CWDM baseline proposal presents significant challenges to implementations based on DM DFB lasers.

References:

•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

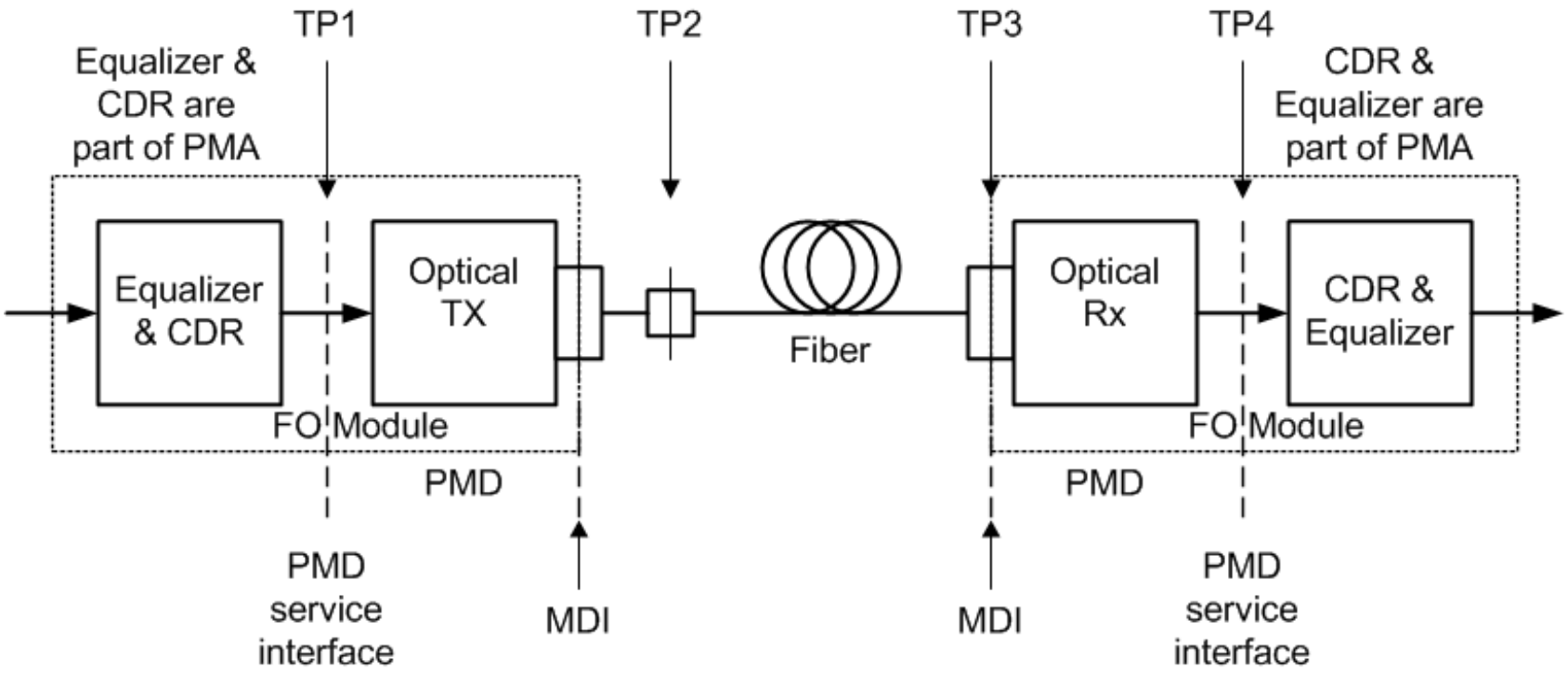

Figure 1

- 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	Baseline proposal	DM DFB budget
Power budget (for max TDP)	dB	6.2	7.7
Operating distance	km	0.5	0.5
Channel insertion loss	dB	4.0	3.92
Max discreet reflectance	dB	-26	-26
Allocation of penalties (for max TDP)	dB	2.2	3.78
Additional insertion loss allowed	dB	0	0

- The above table compares power budget attributes of the CWDM baseline proposal with attributes more feasible for DM DFB lasers.
- The larger power budget for the DM DFB case permits a larger TDP limit that enables lowers bandwidth requirements for the DFB lasers.
- Depending on better Rx sensitivity to increase the power budget avoids a need to cool the DM DFB lasers.

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

Parameter	Unit	Baseline proposal	DM DFB budget	
Signal rate	GBd	25.78125	25.78125	
Q (BER)		7.034 (E-12)	7.034 (E-12)	
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^2km	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	6.2	7.7	
Connector & splice loss allocation	dB	3.73	3.65	
Fiber Insertion loss	dB	0.27	0.27	
Allocation for penalties at max TDP	dB	2.20	3.78	
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	Baseline proposal	DM DFB budget	
Signal rate	GBd	25.78125	25.78125	
Q (BER)		7.034 (E-12)	7.034 (E-12)	
TP1 RJrms tolerance, min	UI	0.0079	0.0079	
TP1 DJ (dual Dirac) tolerance, min	UI	0.11	0.11	
TP3 DJ (dual Dirac) tolerance, min	UI	0.133	0.145	
TP3 DCD tolerance, min	UI	0.05	0.05	
TP4 J2, max	UI	0.365	0.369	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.
- The baseline proposal for the 500 m SMF objective based on CWDM technology did not provide a jitter budget but, since all the baseline proposals are likely to use the same retimer technology, a jitter budget from another proposal can be reasonably assumed.
- 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	Baseline proposal	DM DFB budget	
Signal rate	GBd	25.78125	25.78125	
Q (BER)		7.034 (E-12)	7.034 (E-12)	
Center Wavelength, min	nm	1264.5	1264.5	
Spectral Width, max	nm	0.20	0.20	
OMA at max TDP, min	dBm	-0.8	-0.8	
Extinction ratio, min	dB	4.0	4.0	
Tx output transition times, 20% -80%, max	ps	10.2	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.
- In the above table comparing Tx link model attributes, Tx output transition time stands out as a significant difference between the two approaches.
- For both approaches the max Tx transition time was determined by the TDP requirement for the approach. The more relaxed TDP requirement for the DM DFB approach permits slower Tx transition times.
- Since both approaches plan not to use coolers, it's essential for DM DFB lasers that their LOP and bandwidth requirements are kept low as bandwidth and efficiency can degrade quickly at higher temperatures.

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

Parameter	Unit	Baseline proposal	DM DFB budget	
Signal rate	GBd	25.78125	25.78125	
Q (BER)		7.034 (E-12)	7.034 (E-12)	
Center Wavelength, min	nm	1264.5	1264.5	
Rx sensitivity (OMA), max	dBm	-7.0	-8.5	
Rx Bandwidth, min	MHz	19,336	19,336	
RMS base line wander coefficient	dB/Hz	0.025	0.025	
Rx reflectance, max	dB	-10.78	-10.78	Note 1

Note 1, Rx reflectance is a single point equivalence (yields the same MPI penalty) for a -26 dB Rx reflectance 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.
- In the above table comparing Rx link model attributes, Rx sensitivity stands out as a significant difference between the two approaches.

Better Rx sensitivity permits the larger signal budget that is more accommodating to DM DFB lasers without use of cooling.