100G SR4 Link Model Update & TDP

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100G 100m Transceivers Summary

Presentation Objectives:

•Provide an update of the example link model for 100G 100m MMF

•Discuss TDP setup and requirements for 100G 100m MMF Tx

Link Model Reference

http://www.avagotech.com/docs/AV02-2485EN
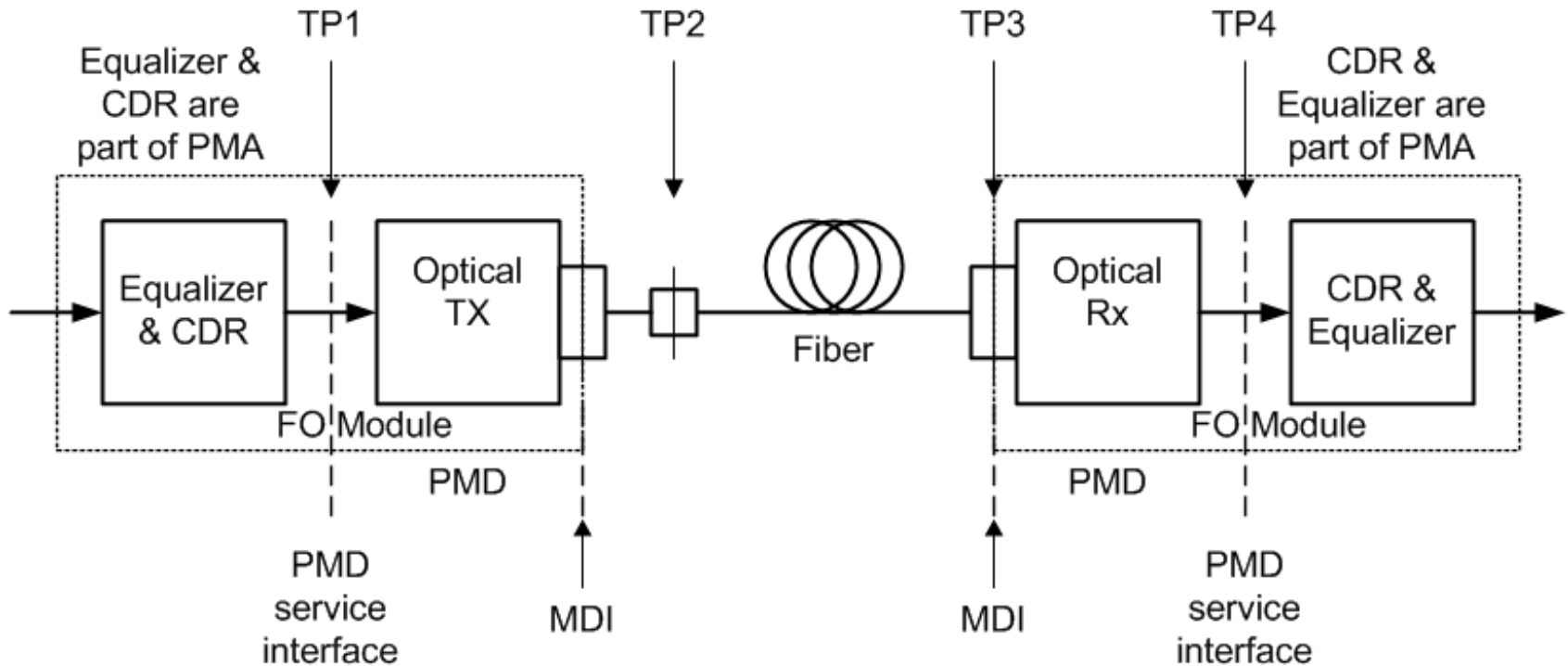
Fiber Optic Links Interfaces

Figure 1

- For cases, as shown above in Figure 1, where retimers are embedded 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 SR4: Updates and Comments

<u>Optical Link Update Overview</u>

- Reduced Q for the MMF link from $Q_o = 7.034$ for a BER $= 10^{-12}$ to $Q_i = 3.8905$ yielding a BER $= 5.0 \times 10^{-5}$, corresponding to the benefit from KR4 FEC, enhances the Rx sensitivity by $10\log(Q_o/Q_i) = 2.57$ dB and provides a larger signal power budget, now 8.2 dB. Rx Sensitivity now -11.2 dB

100G SR4 with KR4 FEC: Example Link Model Tx Attributes (each lane)

Parameter	Unit	100G SR4	
Signal rate	GBd	25.78125	
Q (BER)		3.8905 (5.0E-5)	FEC corrects BER to < 1.0E-12
Center Wavelength, min	nm	840	
Spectral Width, max	nm	0.60	
OMA at max TDP, min	dBm	-3.0	
Extinction ratio, min	dB	3.0	Previously 4.0
Tx output transition times, 20% -80%, max	ps	21	
$RIN_{12}OMA$, max	dB/Hz	-128	
RIN coefficient		0.7	
MPN coefficient		0.3	
Modal Noise Penalty	dB	0.129	Scaled with Q
Tx reflectance, max	dB	-12	
Tx optical return loss tolerance, max	dB	12	

Attributes and values in the above table are provided in order to populate example link models and are not presented as specification recommendations.

100G SR4 with KR4 FEC: Example Link Model Ch Attributes (each lane)

Parameter	Unit	100G SR4	
Signal rate	GBd	25.78125	
Q (BER)		3.8905 (5.0E-5)	FEC corrects BER to < 1.0E-12
Reach	m	106	Previously 100
Fiber Attenuation	dB/km	3.5	For 850 nm center wavelength
Dispersion min Uo	nm	1316	
Dispersion So	ps/nm^{2}km	0.10275	
Fiber modal bandwidth	MHz·km	4400	For 840 nm center wavelength
Reflection Noise Factor		0	
Signal power budget at max TDP	dB	8.20	Model output
Connector & splice loss allocation	dB	1.50	
Fiber Insertion loss	dB	0.38	Model output
Allocation for penalties at max TDP	dB	4.24	Model output
Allocation for target TP4 eye at max TDP	dB	2.08	Model output
Additional insertion loss allowed	dB	0	Model output

Attributes and values in the above table are provided in order to populate example link models and are not presented as specification recommendations.   Various model outputs are provided.

100G SR4 with KR4 FEC: Example Link Model Jitter Attributes (each lane)

Parameter	Unit	100G SR4	
Signal rate	GBd	25.78125	
Q (BER)		3.8905 (5.00E-5)	FEC corrects BER to < 1.0E-12
TP1 RJrms tolerance, min	UI	0.0079	
TP1 DJ tolerance, min	UI	0.11	
TP3 DCD tolerance, min	UI	0.05	
TP3 DJ tolerance, min	UI	0.225	
TP4 J2, max	UI	0.438	Model output
TP4 TJ at BER, max	UI	0.780	Model output

Attributes and values in the above table are provided in order to populate example link models and are not presented as specification recommendations.   Various model outputs are provided.

Nomenclature: Terms TP1, TP2, TP3 and TP4 are used as defined in 802.3 clause 86 and shown in above Figure 1. Note that TP1 is downstream of the input CDR and equalizer for an optical transmitter.

100G SR4: Developing TDP Requirements
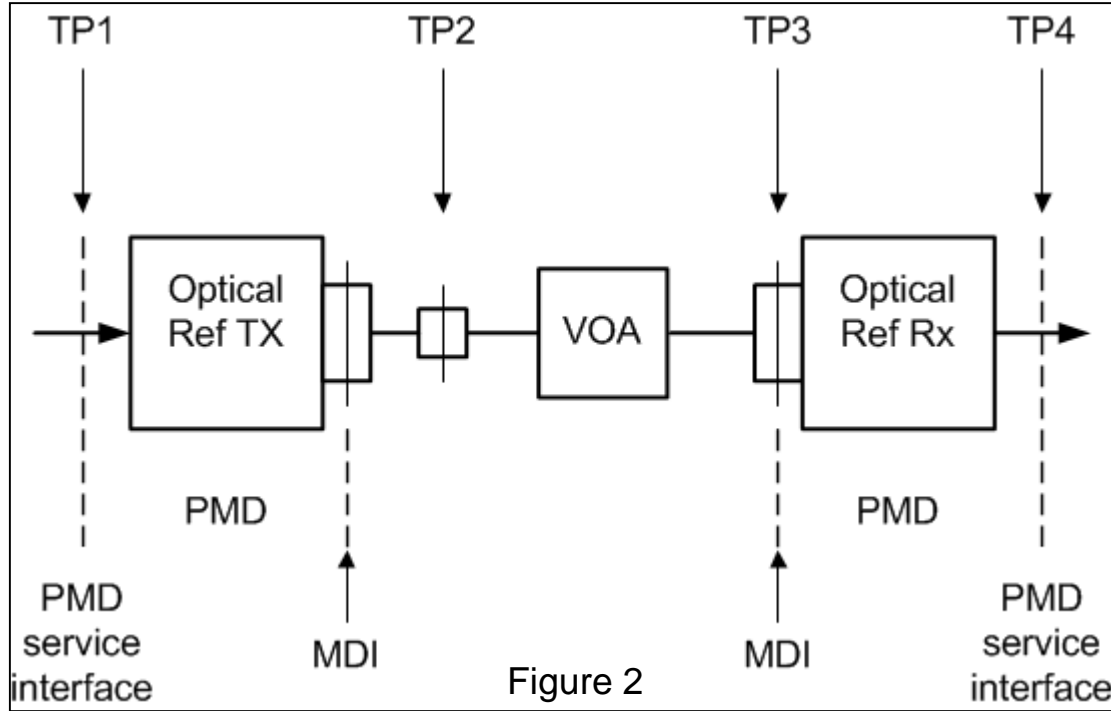
Figure 2

- The above figure shows a starting point for development of TDP requirements for a MMF link.
- This is entirely a link model excerise based on idealized reference devices and the defined worst case Tx operating at defined worst case TP1 conditions over the defined worst case optical channel.
- A reference transmitter, Ref Tx, and a reference receiver, Ref Rx, are defined. These are idealized devices and are not expected to be implemented.
- The sensitivity, S, of the Ref Rx is defined by the signal level at TP3 at the point that the requirements at TP4 are met.
- Link model attributes for Ref Tx and Ref Rx, TP1 and TP3 are provided on following pages.
- In the spread sheet link model cell L7, normally the entry for connector loss, is used to enter the VOA attenuation.

100G SR4 with KR4 FEC: Example Ref Tx Attributes

Parameter	Unit	100G SR4	
Signal rate	GBd	25.78125	
Q (BER)		3.8905 (5.0E-5)	FEC corrects BER to < 1.0E-12
Center Wavelength	nm	860	
Spectral Width	nm	0.05	
OMA at max TDP	dBm	-3.0	
Extinction ratio	dB	3.0	
Tx output transition times, 20% -80%	ps	1	
$RIN_{12}OMA$	dB/Hz	-128	
RIN coefficient		0.0	
MPN coefficient		0.3	
Modal Noise Penalty	dB	0	
Tx reflectance, max	dB	-12	
Tx optical return loss tolerance, max	dB	12	

- Attributes and values in the above table represent an ideal device to use as a reference case. There's no expectation that such a transmitter can be implemented.
- Note that all noise sources are disabled.

100G SR4 with KR4 FEC: Example Ref Rx Attributes

Parameter	Unit	100G SR4	
Signal rate	GBd	25.78125	
Q (BER)		3.8905 (5.0E-5)	FEC corrects BER to < 1.0E-12
Wavelength, min	nm	840	
Ref Rx sensitivity (OMA)	dBm	-14.60	-12.03 dBm at Q = 7.034
Rx Bandwidth	MHz	19,336	
RMS base line wander coefficient		0	
Rx reflectance, max	dB	-12	

•Attributes and values in the above table represent an ideal device to use as a reference case. There's no expectation that such a receiver can be implemented.

100G SR4 with KR4 FEC: Example Ref Ch Attributes (each lane)

| Parameter	Unit	100G SR4	
Signal rate	GBd	25.78125	
Q (BER)		3.8905 (5.0E-5)	FEC corrects BER to < 1.0E-12
Reach	m	2	
Fiber Attenuation	dB/km	0.0	For 850 nm center wavelength
Dispersion min Uo	nm	1316	
Dispersion So	ps/nm^{2}km	0.10275	
Fiber modal bandwidth	MHz·km	2000	
Reflection Noise Factor		0	
Signal power budget at max TDP	dB	11.60	Model output
Fiber Insertion loss	dB	0.00	Model output

Attributes and values in the above table are provided in order to populate a link model representing the test setup for the TDP reference case.

100G SR4 with KR4 FEC: Example Ref Tx Rx Jitter Attributes

Parameter	Unit	100G SR4	
Signal rate	GBd	25.78125	
Q (BER)		3.8905 (5.0E-5)	FEC corrects BER to < 1.0E-12
TP1 RJrms	UI	0	
TP1 DJ	UI	0	
TP3 DCD	UI	0	
TP3 DJ	UI	0	
Attenuation (aka Connector loss)	dB	11.50	Adjusted to yield zero margin
TP4 TJ at BER, max	UI	0.780	Model output

•Attributes and values in the above table represent an ideal input at TP1 to use as a reference case. There's no expectation that such an input can be realized.

•Note that the only noise in the link is the noise that determines the sensitivity of the Ref Rx

•Nomenclature: Terms TP1, TP2, TP3 and TP4 are used as defined in 802.3 clause 86 and shown in above Figure 1 and Figure 2.

• For the Ref Tx, Ref Rx, reference channel and TP1 conditions defined above, a VOA attenuation entry of 11.50 dB should yield a TP4 TJ (BER = $5x10^{-5}$) of 0.78 UI consistent with the TP4 requirement in the example link model for an S = -14.5 dBm.

100G SR4: Developing TDP Requirements

Figure 3
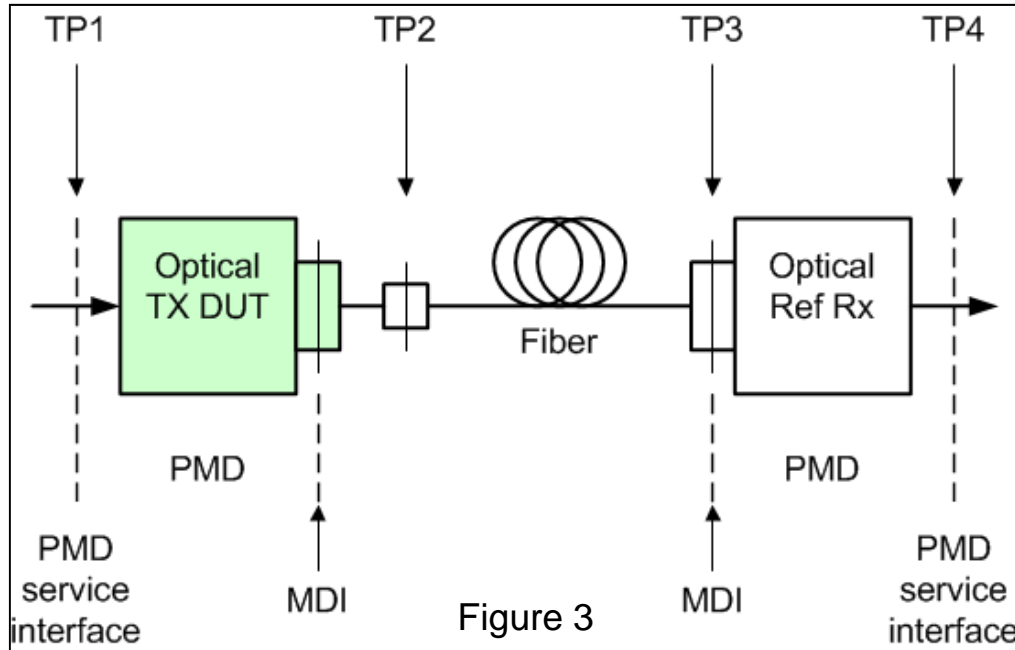
- Now that the sensitivity, S, of the Ref Rx has been established, the Ref Tx and reference channel is replaced by the worst case Tx operating with the worst case TP1 conditions and the worst case optical channel. This channel should also include a VOA (not shown) which is adjusted such that the requirements at TP4 are met.
- The difference between the signal level at TP3 for this case and S yields the max limit for TDP, here 5.02 dB.
- Finally, the worst case channel is replaced by the reference channel and a filter is added to the Ref Rx input with a bandwidth that yields the same Ptotal central (link model cell T28) as did the worst case channel.
- For the example link model, this filter in combination with the Ref Rx yields a BW of 11.656 GHz.

100G SR4 with KR4 FEC: Example TDP Test Channel (each lane)

Parameter	Unit	100G SR4	
Signal rate	GBd	25.78125	
Q (BER)		3.8905 (5.0E-5)	FEC corrects BER to < 1.0E-12
Reach	m	2	
Fiber Attenuation	dB/km	0.0	For 850 nm center wavelength
Dispersion min Uo	nm	1316	
Dispersion So	ps/nm^2km	0.10275	
Fiber modal bandwidth	MHz·km	2000	
Reflection Noise Factor		0	
Signal power budget at max TDP	dB	11.60	Model output
Fiber Insertion loss	dB	0.00	Model output
Attenuation (aka Connector loss)	dB	6.48	Adjusted to yield zero margin
Rx Bandwidth for TDP	MHz	11656	Adjusted to match Ptot of Ref Ch with106 m of OM4
TDP	dB	5.02	

Attributes and values in the above table provide a summary of the test channel using the TDP filter.