100GBASE-SR4
Extinction Ratio Requirement

John Petrilla: Avago Technologies

September 2013

Presentation Summary

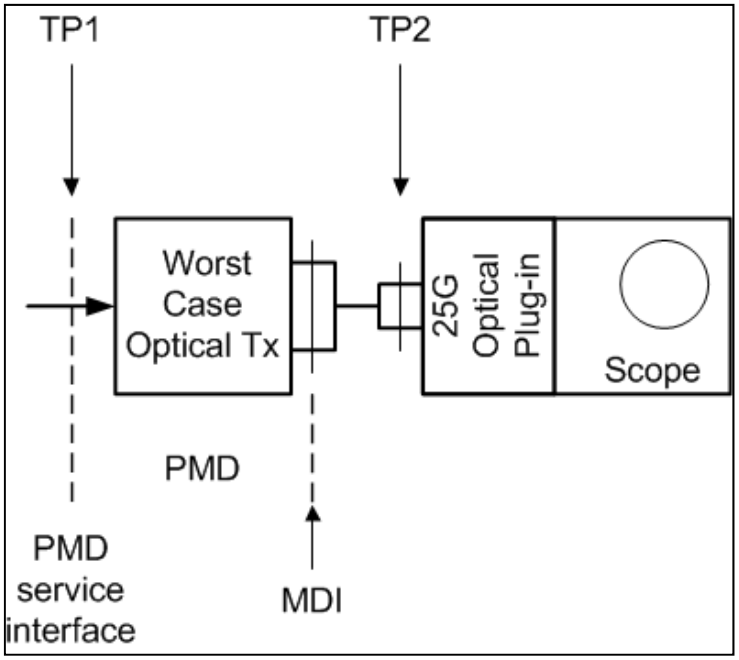
•Eye displays for the worst case TP1 and Tx conditions that were used to define Clause 95 TP2 and TP3 requirements are presented to show the impact of Extinction Ratio (ER) measurements taken on eye displays.

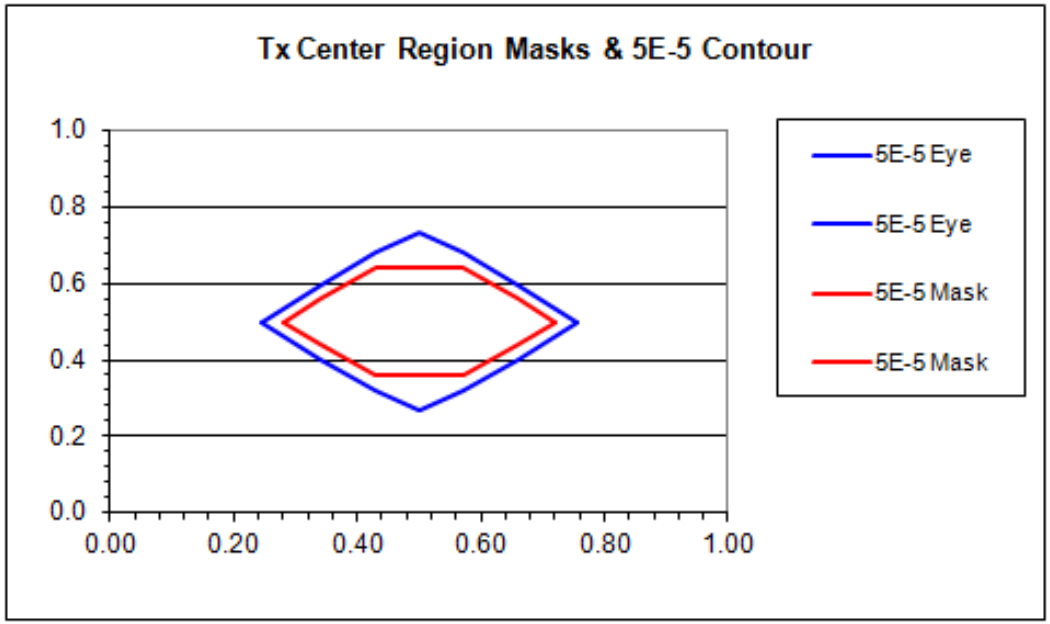
•Sensitivities of ER and TDP with Tx output transition times are compared.

•Link model attributes for the worst case conditions that were used to develop Clause 95 transmitter and receiver requirements are provided for reference.

•Information in support of Draft D1.1 comments 66 & 70 is provided.

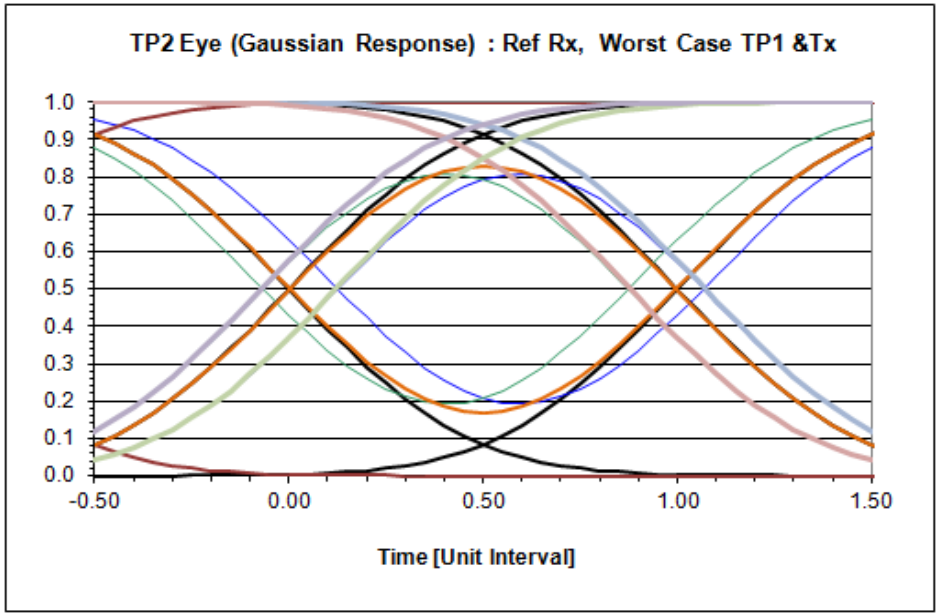
100G SR4: Tx Eye Mask, OMA & ER Test Setup

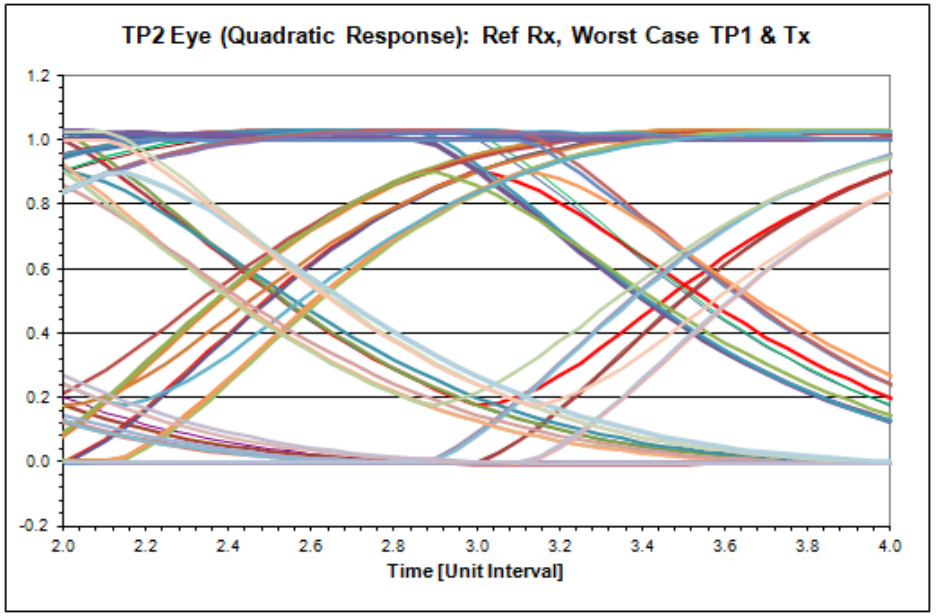




- The Tx output is examined at TP2, as shown above, with the Clause 95 defined Ref Rx here comprising an oscilloscope with a 25G optical plugin via a short patch cord.
- A link model can be setup to represent such an oscilloscope with an optical plugin that yields the sensitivity and bandwidth characteristics of the Ref Rx.
- The 5E-5 hit ratio eye mask and a 5E-5 Tx output jitter contour for a worst case Tx and TP1 conditions are shown for reference.
- Although significant ISI can be expected at TP2 for worst case conditions as shown in the above 5E-5 eye diagram, acceptable link operation and interoperation is assured by the OMA, TDP and SRS requirements.

100GBASE-SR4: Tx Output Eyes

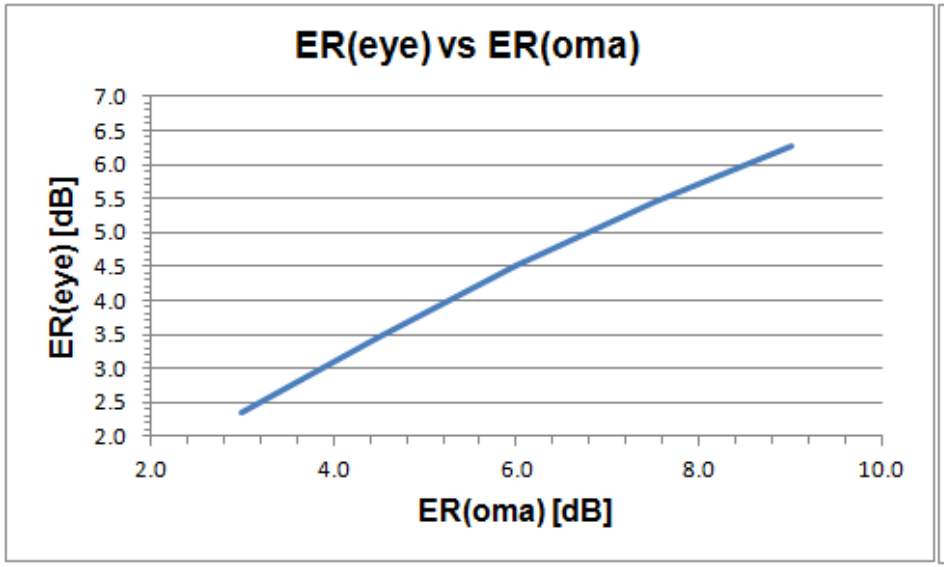


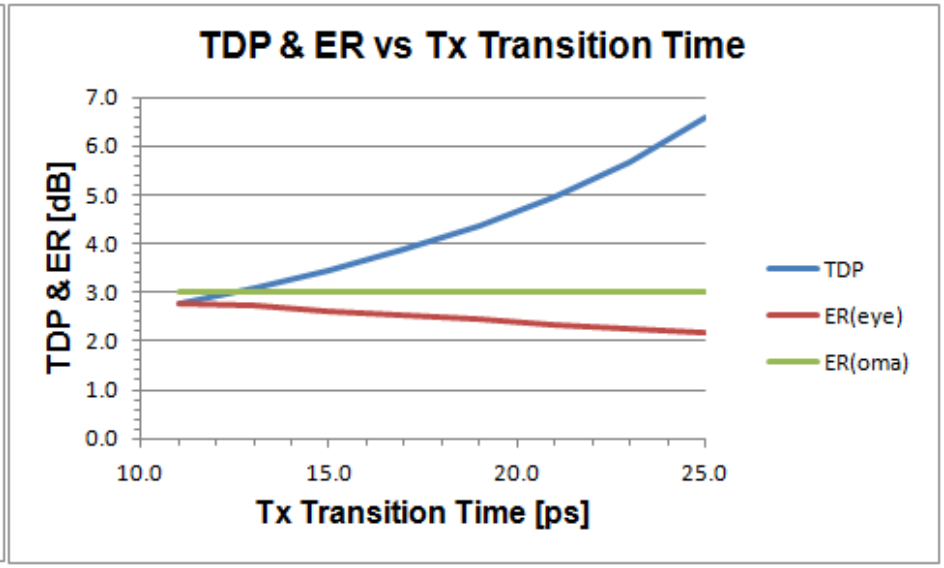


- The above chart was generated from the link model for TP2 as observed with the Ref Rx. The vertical axis is normalized OMA in mW.
- Although worst case TP1 and Tx conditions were used, RJ is not included since ER measurements are based on averages.
- Transitions are symmetrical and > 99% complete in 2 UI, limiting the cases (run lengths of 3) to consider, likely to be optimistic for ISI.
- Waveforms in the high state at 0.5 UI were averaged, weighted for probability of occurrence, from 0.40 UI to 0.60 UI yielding an average of 0.898.
- For the worst case OMA at max TDP of -3.0 dBm, with an ER = 3.0 dB, if measured as OMA is measured (these are the conditions in the link model on which Clause 95 is based), the ER based on the above eye would be 2.36 dB.

- The above chart was generated using a quadratic response to include very modest overshoot and non-symmetrical transitions.
- Due to ringing, minor transitions effects are observed up to 3 UI.
- Run lengths of 4 were considered, likely optimistic for ISI effects.
- Waveforms in the high state at 3.0 UI, weighted for probability of occurrence, were averaged from 2.90 UI to 3.10 UI yielding an average of 0.933.
- Waveforms in the lowstate at 3.0 UI were averaged, weighted for probability of occurrence, from 2.90 UI to 3.10 UI yielding an average of 0.112.
- For the worst case OMA at max TDP of -3.0 dBm, with an ER = 3.0 dB if measured as OMA is measured, the ER based on the above eye would be 2.39 dB.

100GBASE-SR4: ER, TDP & Tx Transition Times





- The above chart shows the correlation between Extinction Ratio, ER(oma) measured with the same test pattern as OMA and Extinction Ratio ER(eye) measured from an eye display.
- The ER(eye) method compresses a 6 dB range (from 3 dB to 9 dB) for the ER(oma) method into a 3.9 dB range offering less resolution.

- The above chart shows the sensitivities of TDP, ER(eye) and ER(oma) to Tx transition time.
- TDP is shown to have a significantly stronger sensitivity to transition times than ER(eye) and provides a superior means for blocking unacceptable ISI conditions.
- Note that even with exceptionally low transitions times, ER(eye) is less than ER(oma).

Presentation Summary & Conclusions

•Eye displays for the worst case TP1 and Tx conditions that were used to define Clause 95 TP2 and TP3 requirements were presented to show the impact of Extinction Ratio (ER) measurements taken on eye displays.

- •Transmitters that are otherwise acceptable would be rejected by a minimum ER(eye) requirement of 3.0 dB.

• Sensitivities of ER and TDP with Tx output transition times are compared.

- •The maximum TDP requirement is shown to provide a superior means of protection against unacceptable ISI conditions.
- •TDP also captures effects of RIN and RJ; ER does not.

•A minimum ER requirement is not needed to ensure sufficient OMA. The minimum OMA requirements provide that assurance.

•The Tx eye mask test, as does TDP, captures effects of TP1 jitter, Tx jitter and transition times and RIN.

•The ER requirement protects against no impairment that isn't also protected by the minimum OMA, TDP and Tx eye mask requirements. It can be dropped with no increase in risk of non-interop.

•If the ER requirement is not dropped, the test pattern should be changed to those used for OMA, so that transmitters that would otherwise provide satisfactory performance are not discarded. This can simply testing and lead to lower costs.

•If the ER requirement is not dropped and the test pattern is not aligned with those for OMA, the minimum ER(eye) should be reduced to 2 dB, so that transmitters that would otherwise provide satisfactory performance are not discarded.

Fiber Optic Links Interfaces

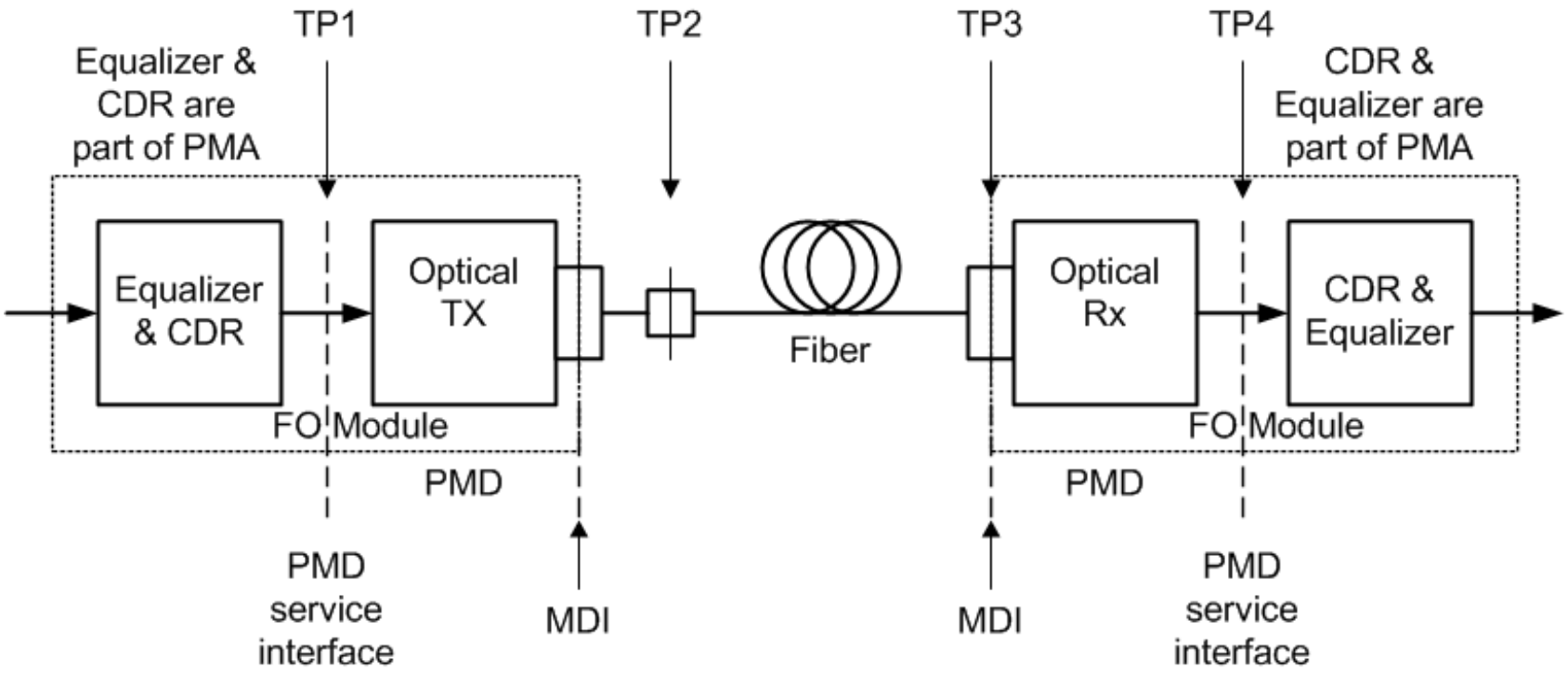


Figure 1

- 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.

100GBASE-SR4: 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	
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^2
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. Not all attributes will be normative requirements.

100GBASE-SR4: Example Link Model Rx 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	
Rx sensitivity (OMA), max	dBm	-11.2	-8.63 dBm at Q = 7.034
Rx Bandwidth, min	MHz	18,047	
RMS base line wander coefficient		0.025	
Rx reflectance, max	dB	-12	

Attributes and values in the above table are provided in order to populate example link models. Not all attributes will be normative requirements.

100GBASE-SR4: 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	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, 4700 MHz·km at 850 nm
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	0.36	Model output
Allocation for penalties at max TDP	dB	6.34	Model output Includes Peye
Allocation for target TP4 eye at max TDP	dB	0	1.88 dB included in Allocation for penalties at max TDP
Additional insertion loss allowed	dB	0	Model output

Attributes and values in the above table are provided in order to populate example link models. Not all attributes will be normative requirements. Various model outputs are provided.

100GBASE-SR4: 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	0.243	
TP4 J2, max	UI	0.592	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. Not all attributes will be normative requirements. 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.

100GBASE-SR4: 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.