

100GBASE-SR4 TDEC & SEC Review Comments r02-36 & r02-37

John Petrilla: Avago Technologies
October 2014

Presentation Summary

- Link model analysis addressing max value for TDEC and effect of M on TDEC and SEC
- Measurements results and correlations among RxS, SEC and TDEC
- Measurements of J2 and J4 at TP3; comparison of TDEC & SEC eyes
- Eye charts

Comment r02-37 Sub-clause 97.7.1, Page 114

The max limit for TDEC and the tradeoff between TDEC, min OMA and operating margin would benefit from more data.

Suggested Remedy

Reconsider values for max TDEC and min OMA based on best information at the time.

In Table 95-6 reduce max TDEC from 4.9 to 4.3 dB and increase min OMA values by 0.6 dB (keeping fully impaired Tx OMA at – 3.0 dBm to yield zero margin for worst case link).

Comment r02-36 Sub-clause 97.7.2, Page 115

The stressed receiver setup instructions in 95.8.8.1 and 95.8.8.2 call for SEC, J2 & J4 values in Table 95-7 to be met "simultaneously while also passing the stressed receiver eye mask in Table 95–7". Unfortunately, results have not yet been presented to show that this is possible. Values for J2 and J4 appear most suspect.

Suggested Remedy

Change the values in Table 95-7 for J2, J9 and if, needed, SEC to align with the best information available at the time.

In Table 95-7 reduce SEC from 4.9 to 4.3 (maintain J2 and J4 values and definition of SEC with $M = 0$).

In Table 9507 increase SRS OMA by the value of M for TDEC = 4.3 dB.

Rework Equation 95-4 to reduce effect of M on TDEC by half.

Edits are recommended for the SRS setup.

Max TDEC (100G SR4 Example Link Model Analysis)

	WC	RefRx	TDEC	Trans. time loss		RIN loss		Jitter loss		Total loss	
Reach	100	100	2	100	2	100	2	100	2	100	2
Uc	840	840	840	840	840	840	840	840	840	840	840
Uw	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Transition time	21	21	21	1	1	21	21	21	21	1	1
Prin	0.74	0.59	0.58	0.17	0.16	0	0	0.27	0.27	0	0
Pmpn	0.11	0.11	0	0.11	0	0.11	0	0.09	0	0.09	0
Pmn	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
TP1 RJ (BER)	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0	0	0	0
TP1 DJ	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0	0	0	0
DCD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0
TP3 DJ	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0	0	0	0
Rx DJ	0.049	0	0	0	0	0	0	0	0	0	0
TP4 TJ	0.780	0.780	0.780	0.780	0.780	0.780	0.780	0.780	0.780	0.780	0.780
BLW	0.025	0	0	0	0	0	0	0	0	0	0
RxBW	18.05	19.34	12.6	19.34	12.6	19.34	12.6	19.34	12.6	19.34	12.6
Signal Budget	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20
IL	1.86	1.86	1.51	1.86	1.51	1.86	1.51	1.86	1.51	1.86	1.51
LP Pen	6.34	5.35	5.18	2.33	2.19	4.68	4.55	3.44	3.32	0.98	0.88
Margin	0.00	0.99	1.52	4.01	4.51	1.66	2.14	2.89	3.37	5.35	5.81

•The table shows comparisons of penalties and margin for various cases against reference cases of a worst case link (WC), a worst case Tx and fiber with a reference Rx (RefRx) and a worst case Tx with a TDEC Rx (TDEC). The cases evaluate the best and worst case values for the attributes captured in the TDEC measurement.

•With the RefRx, the difference between a worst case Tx and best case Tx is 5.35 dB – 0.99 dB = 4.36 dB.

•With the TDEC Rx, the difference between a worst case Tx and best case Tx is 5.81 dB – 1.52 dB = 4.29 dB.

•Changing the max TDEC value in Table 95-6 from 4.9 to 4.3 is recommended.

M in TDEC (100G SR4 Example Link Model Analysis)

	WC	WC(M=0)	RefRx	RefRx(M=0)	TDEC	TDEC(M=0)
Reach	100	100	100	100	2	2
Uc	840	840	840	840	840	840
Uw	0.60	0.60	0.60	0.60	0.60	0.60
Transition time	21	21	21	21	21	21
Prin	0.74	0.74	0.59	0.59	0.58	0.58
Pmpn	0.11	0	0.11	0	0	0
Pmn	0.129	0	0.129	0	0.129	0
TP1 RJ (BER)	0.059	0.059	0.059	0.059	0.059	0.059
TP1 DJ	0.110	0.110	0.110	0.110	0.110	0.110
DCD	0.05	0.05	0.05	0.05	0.05	0.05
TP3 DJ	0.247	0.247	0.247	0.247	0.247	0.247
Rx DJ	0.049	0.049	0	0	0	0
TP4 TJ	0.780	0.780	0.780	0.780	0.780	0.780
BLW	0.025	0.025	0	0	0	0
RxBW	18.05	18.05	19.34	19.34	12.6	12.6
Signal Budget	8.20	8.20	8.20	8.20	8.20	8.20
IL	1.86	1.86	1.86	1.86	1.51	1.51
LP Pen	6.34	5.94	5.35	5.02	5.18	5.01
Margin	0.00	0.40	0.99	1.31	1.52	1.69

- The table shows the penalty and margin results for the references cases from the previous matrix for cases where Pmn and Pmpn are at worst case and reduced to zero.

- With the worst case link, WC, the cumulative effect of Pmn and Pmpn is 0.40 dB – 0 dB = 0.4 dB.

- With the Ref Rx link, RefRx, the cumulative effect of Pmn and Pmpn is 1.31 dB – 0.99 dB = 0.32 dB.

- With the TDEC link, TDEC, the cumulative effect of Pmn and Pmpn is 1.69 dB – 1.52 dB = 0.17 dB.

- The effect of M in TDEC and SEC as presently defined appears larger (~ 2x) than the effect of Pmn and Pmpn in the link model. See charts on following pages for results with M = 0 and M active.

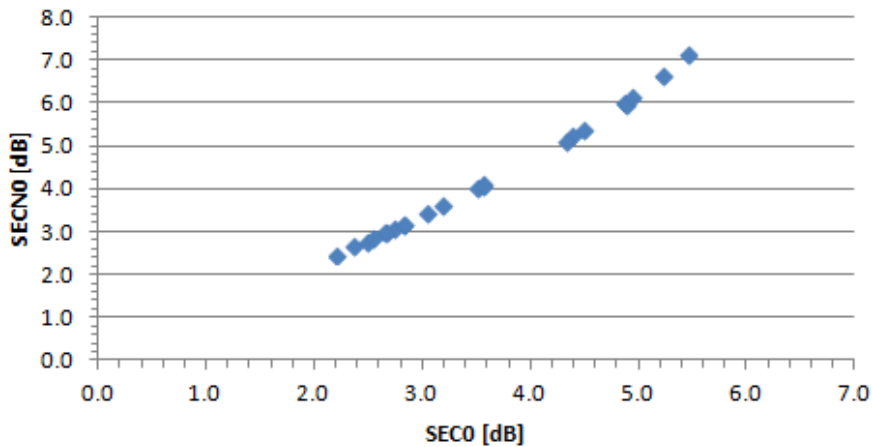
- Redefining M such that its effect on TDEC and SEC is reduced by half is recommended.

Equipment Notes for TDEC, SEC, RxS, VECP, J2 and J4 Results

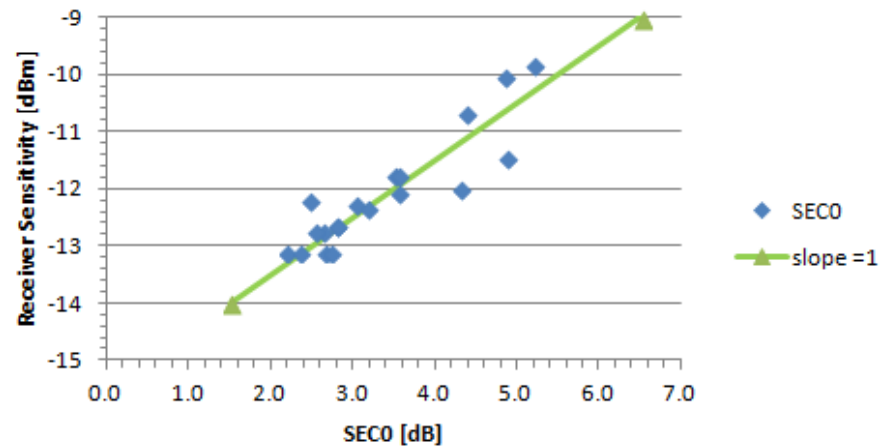
- The following pages provide measured results for TDEC, SEC, Rx Sensitivity, TP3 VECP, TP3 J2 and TP3 J4. Some equipment information follows.
- Ideally a worst case Tx would be used in combination with a worst case fiber to yield the worst case effect of chromatic dispersion, etc. Here the Tx had a center wavelength of 851.5 nm vs the worst case of 840 nm and a spectral width of 0.342 nm vs the worst case of 0.60 nm. In order to compensate for the better than worst case Tx, a 150 m OM4 fiber with 4529 MHzkm EMBW was found and used. The length of such a fiber that would yield the same combined modal BW and chromatic dispersion BW as a worst case Tx and OM4 fiber was determined to be 143 m.
- A DCA was used for optical measurements.
 - The 19.34 GHz optical plug-in exhibited 14 uW of additive noise.
 - The 12.6 GHz optical plug-in exhibited 9 uW of additive noise.

SEC & Rx Sensitivity (RxS) Correlations

SECN0 vs SEC0

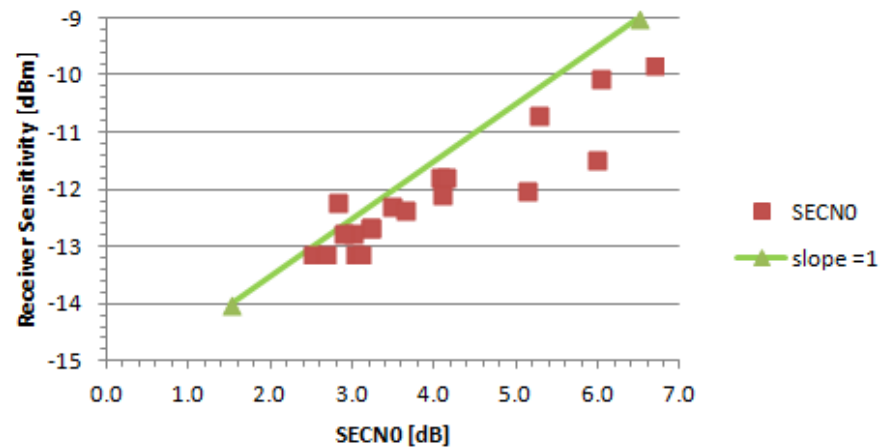


RxS vs SEC0



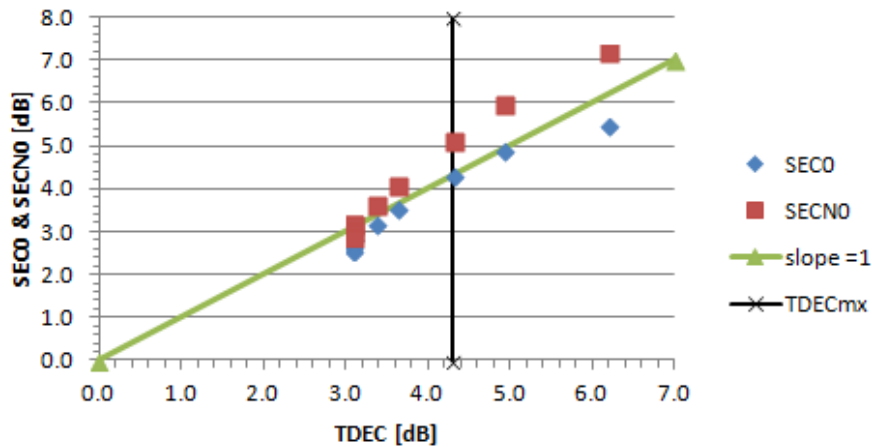
- The top left chart show that the correlation between SEC with M active (SECN0) and M = 0 (SEC0) is very tight and super-linear. The data includes data from 1 m fiber link as well as 150 m fiber links.
- The charts on the left show a more linear correlation between SEC0 (M = 0) and RxS than between SECN0 and RxS.
- It's recommended that the stressed receiver conditions setup continue to use SEC with M = 0 and that stressed receiver sensitivity is adjusted to avoid double inclusion of the stress that M represents.

RxS vs SECN0

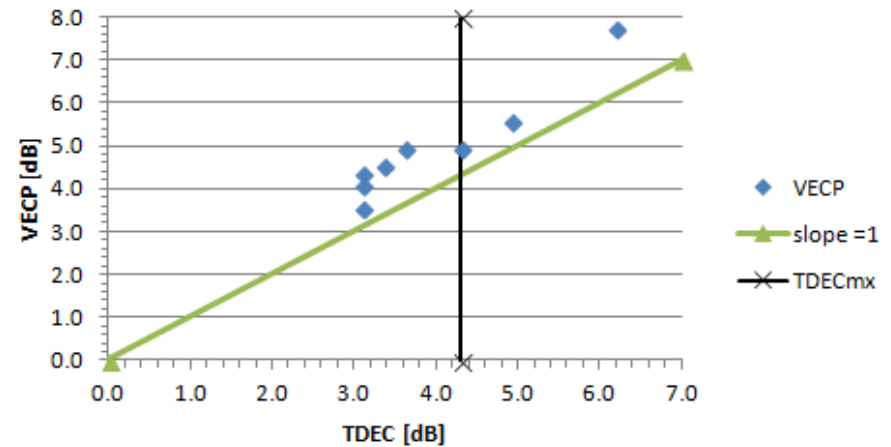


Receiver Sensitivity, SEC and TDEC Correlations

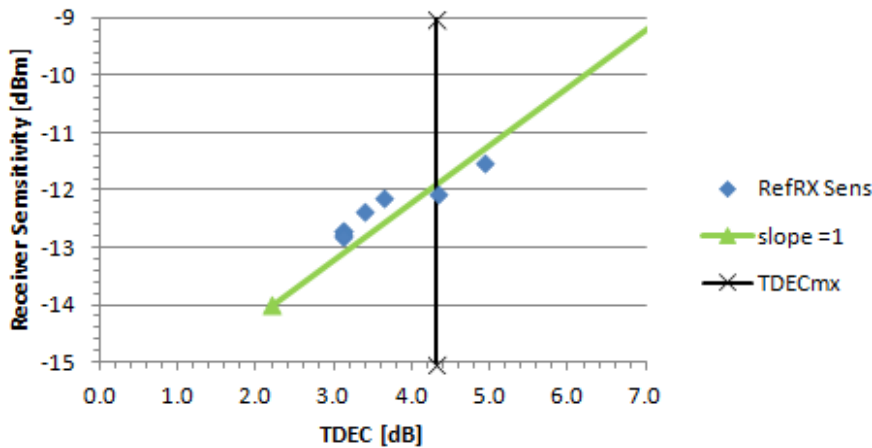
SECO & SECNO vs TDEC



VECP vs TDEC

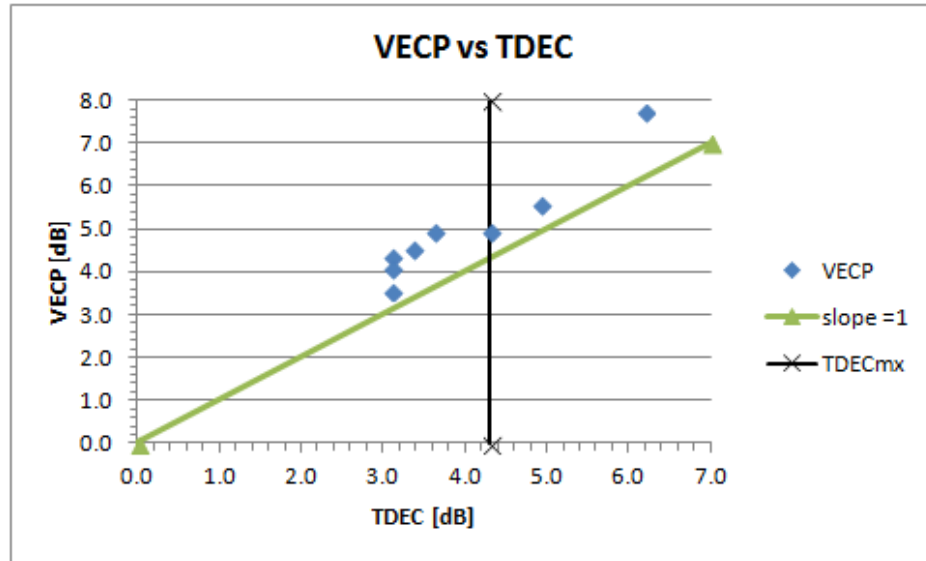
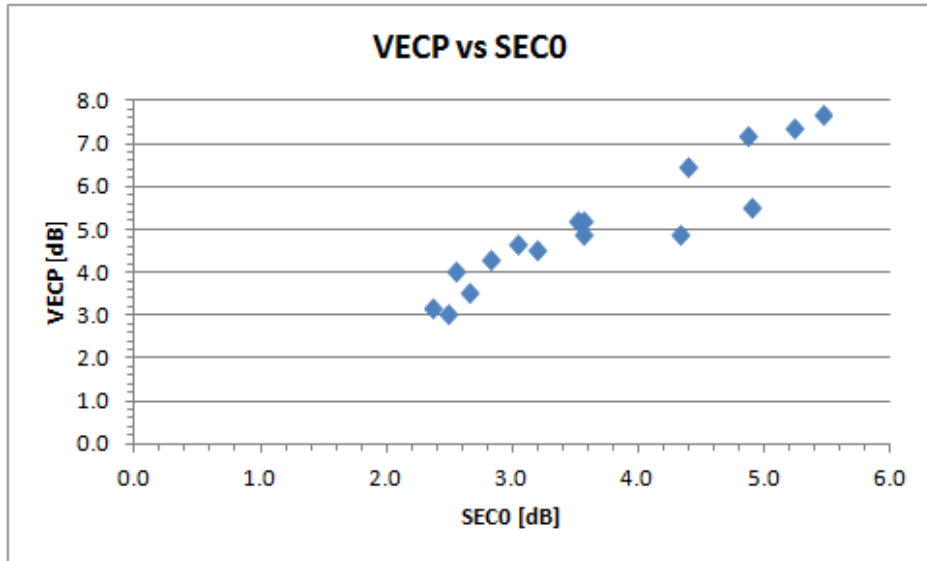


RxS vs TDEC



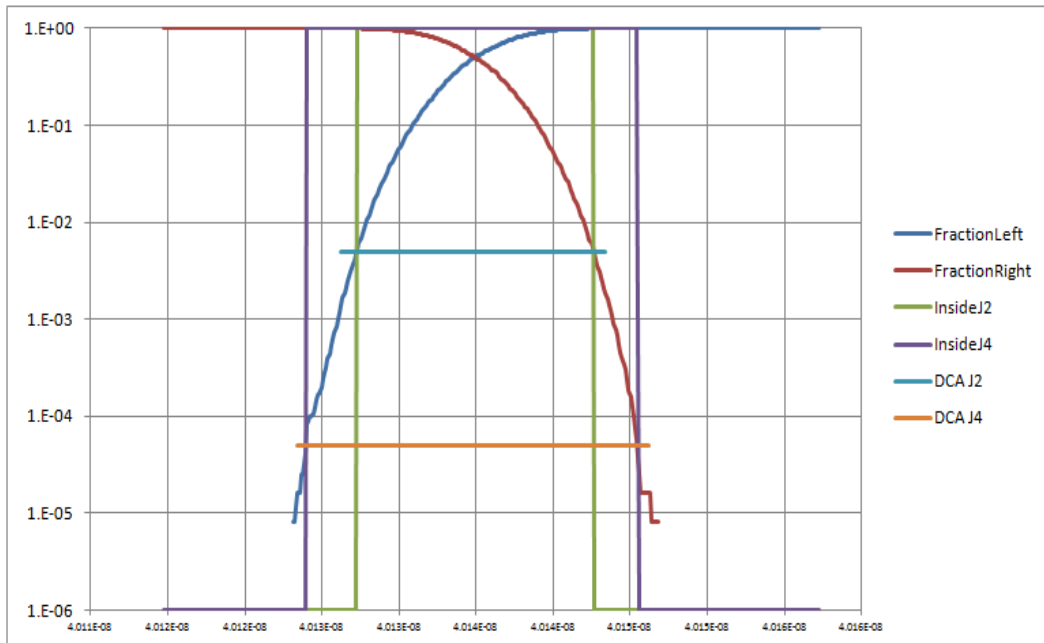
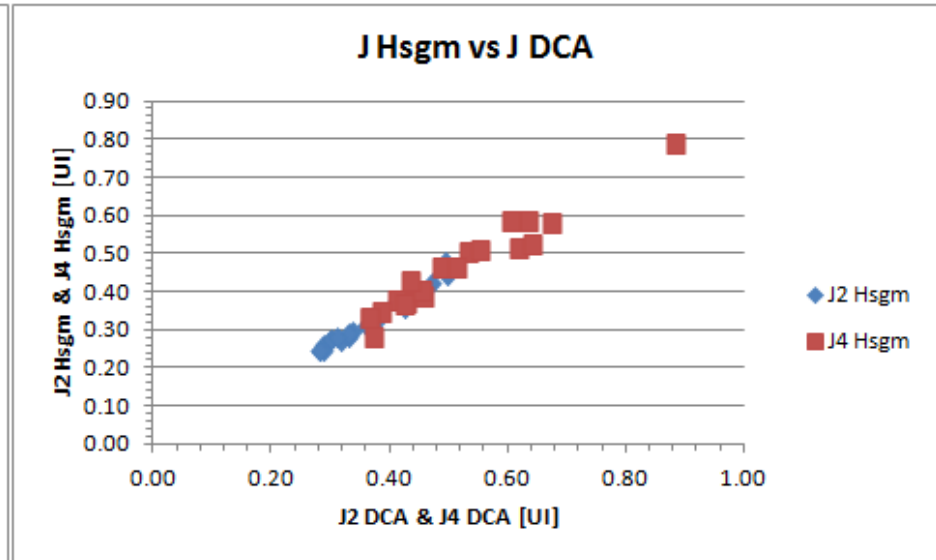
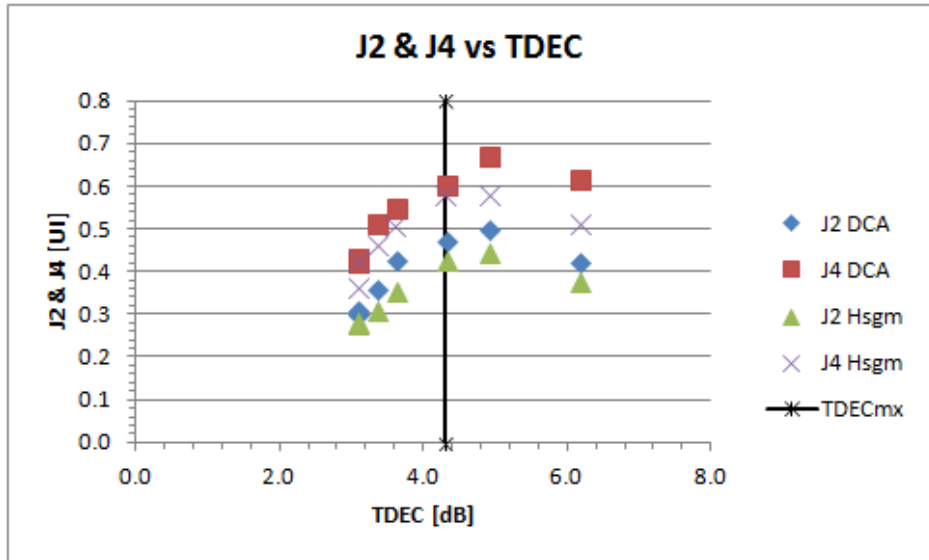
- All the results on the charts on this page are from links with the 150 m OM4 fiber.
- The top left chart shows correlations between TDEC and SECO and SECNO.
- The data indicates that there may be one-to-one correlations between TDEC and SECO, between SECO and RxS and between TDEC and RxS.
- Following the previous recommendation for max TDEC = 4.3 dB a limit line is included on the charts.
- The top right chart shows the correlation between VECP and TDEC results.

VECP Correlations with SEC0 and TDEC



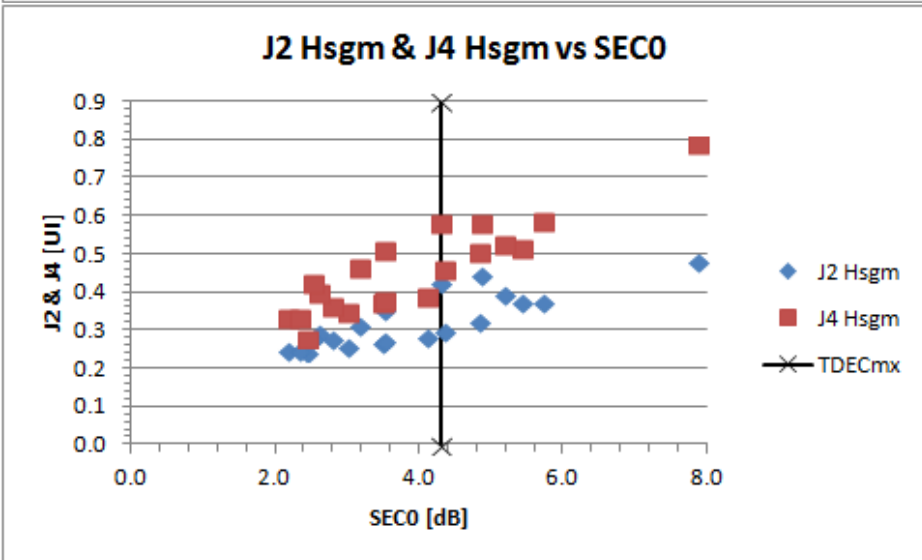
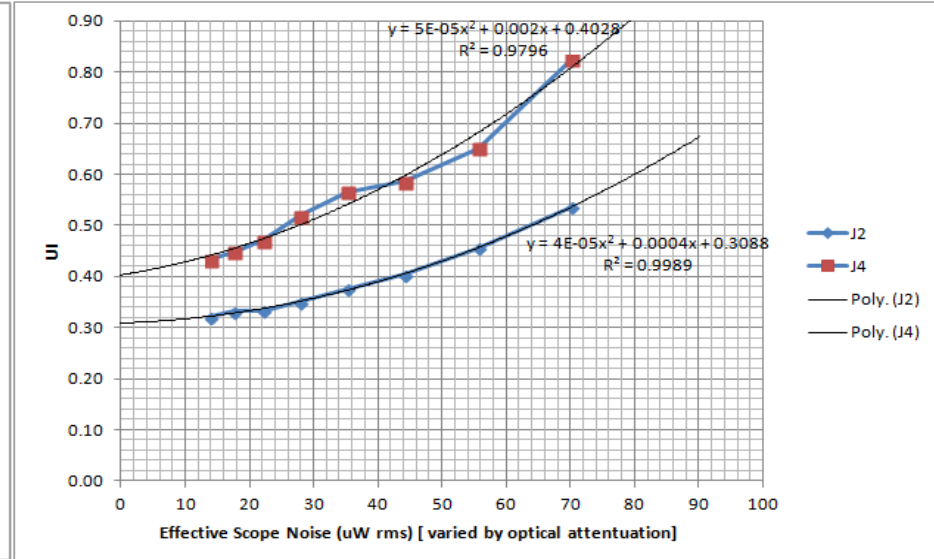
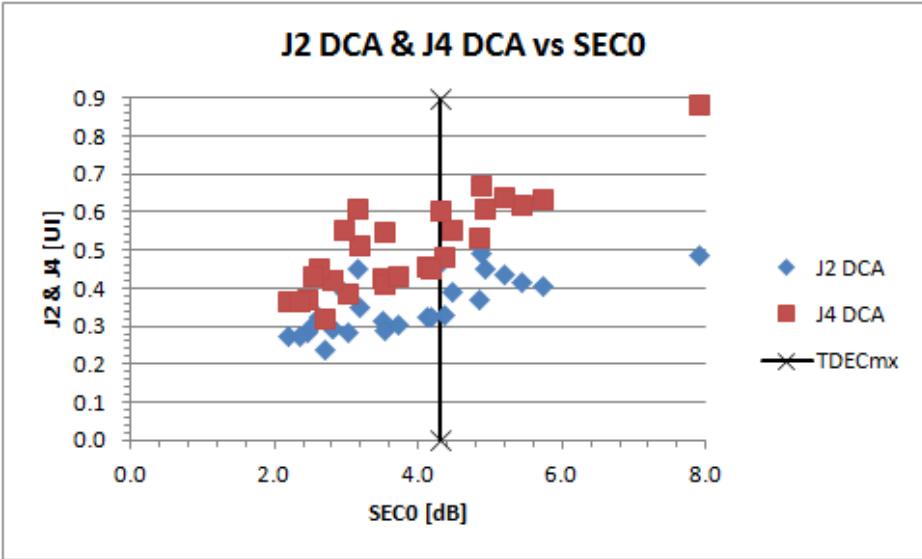
- The top left chart show correlations between VECP and SEC0.
- The top right chart shows the correlation between VECP and TDEC results.

TP3 J2 and J4 (aka Stressed Rx Sensitivity Jitter Conditions)



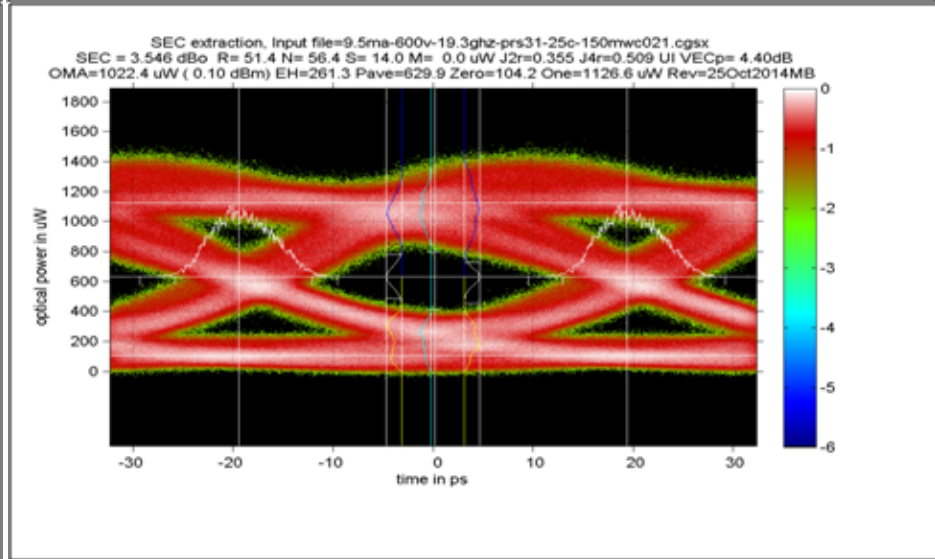
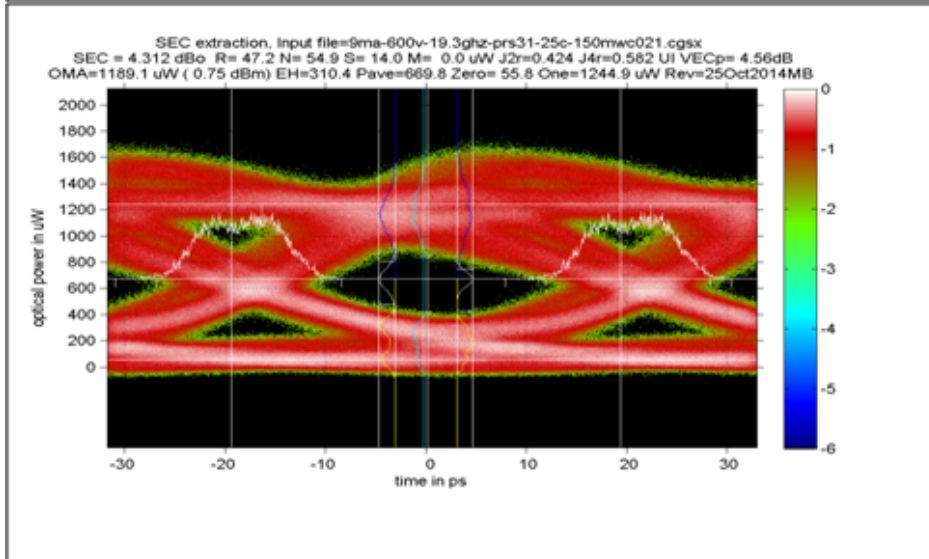
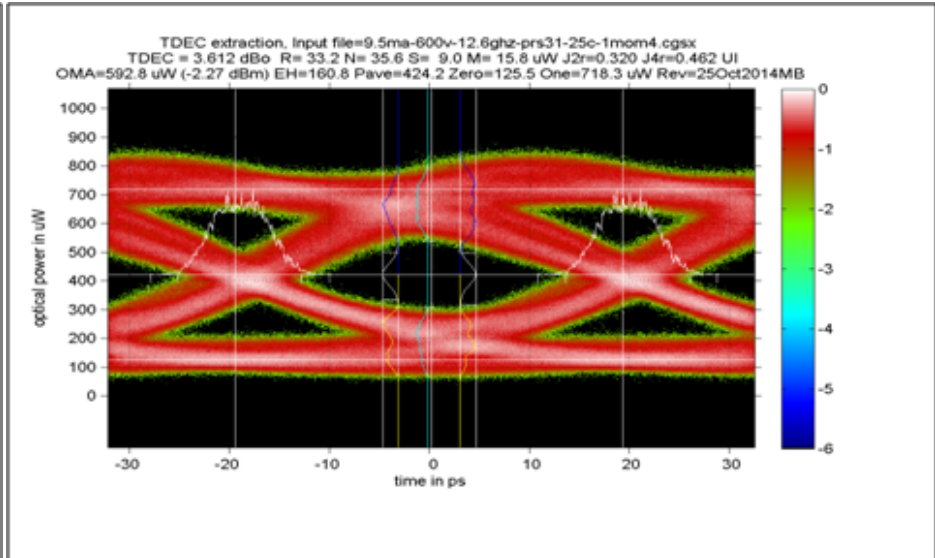
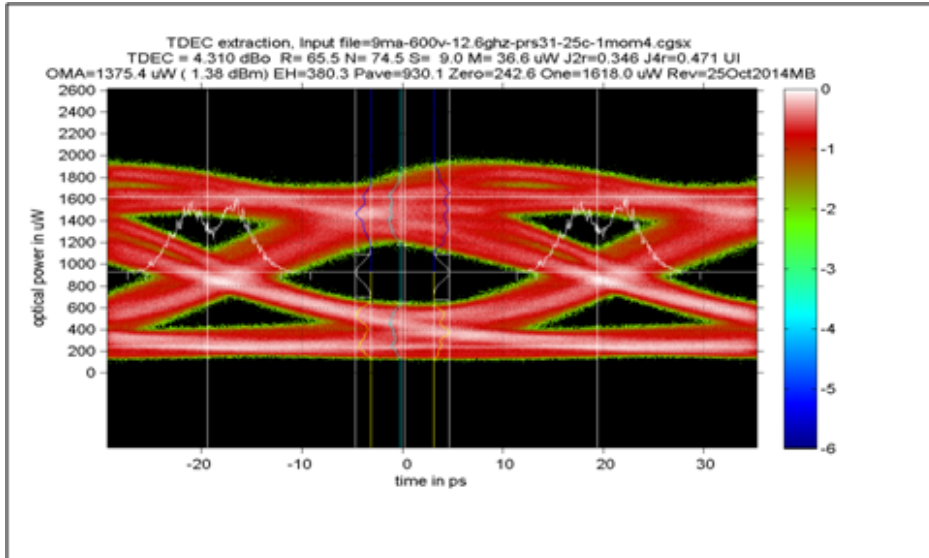
- The top left chart show correlations between J2 & J4 and TDEC for various Tx conditions over the 150 m OM4 fiber link. Where TDEC < 5 dB Tx bias was used to vary TDEC. Where TDEC > 6 dB, a LPF was used to condition the Tx. Differences are seen in jitter values between results reported by the DCA (J DCA) and results (J Hsgm) extracted from the captured histograms.
- The bottom left chart show the histogram extraction method.
- The top right chart shows the correlation between J DCA and JHsgm.

J2 & J4



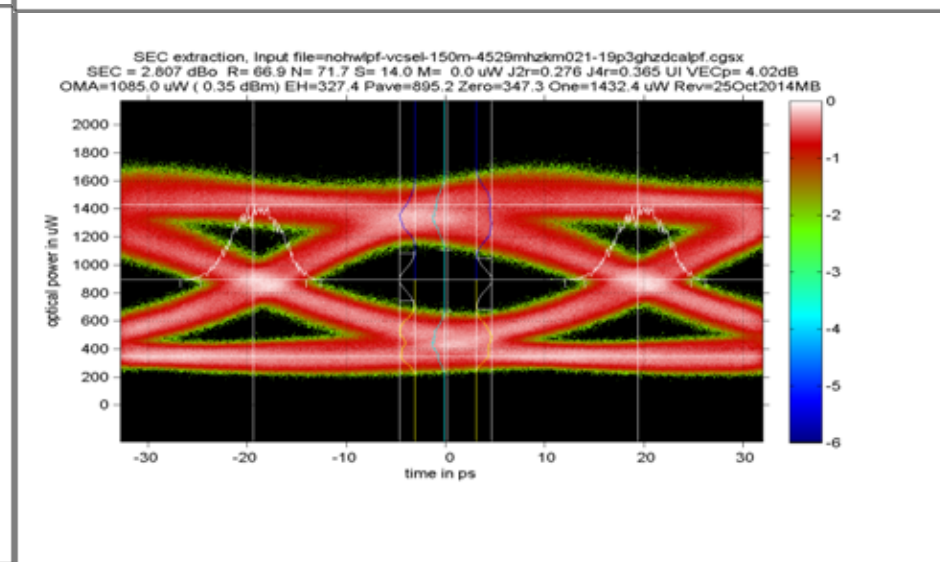
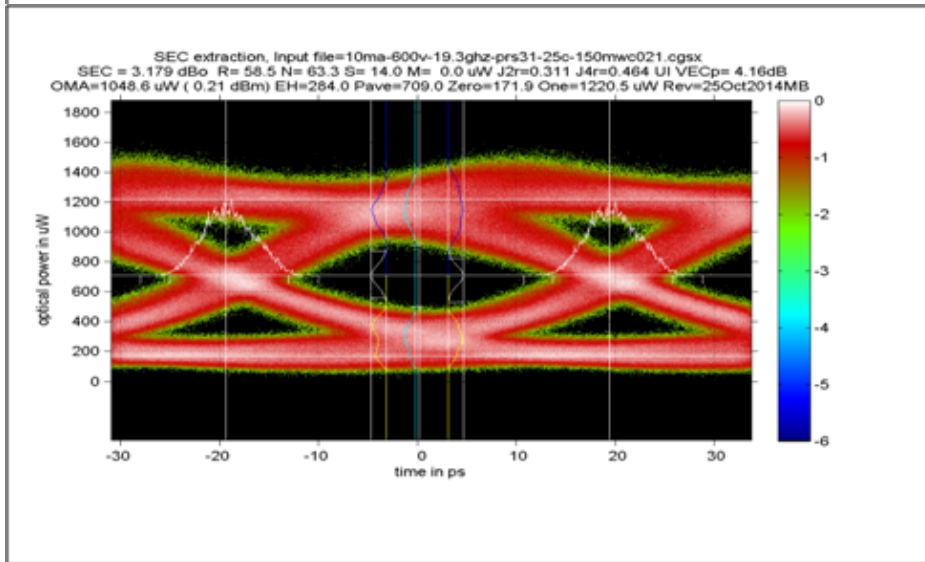
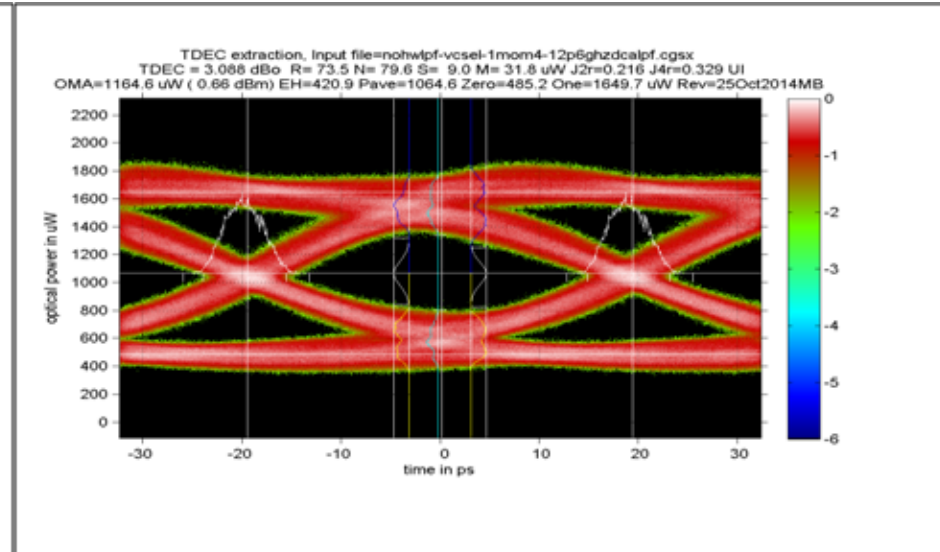
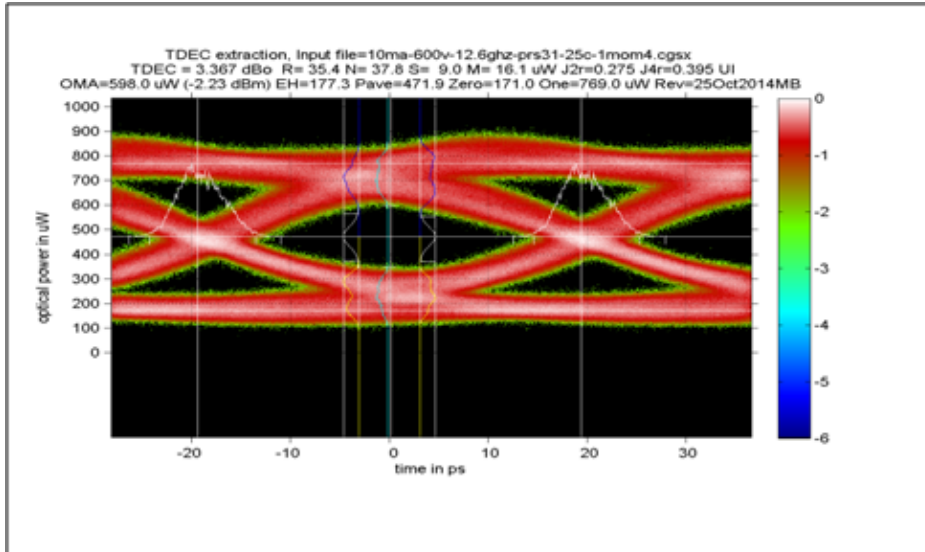
- The charts on the left show the J2 and J4 correlation with SECO. The limit line corresponding with the recommendation for max TDEC = 4.3 dB is included for reference.
- The chart on the right show the effect of scope additive noise on jitter results.

TDEC and Corresponding SEC Eyes (1of 2)



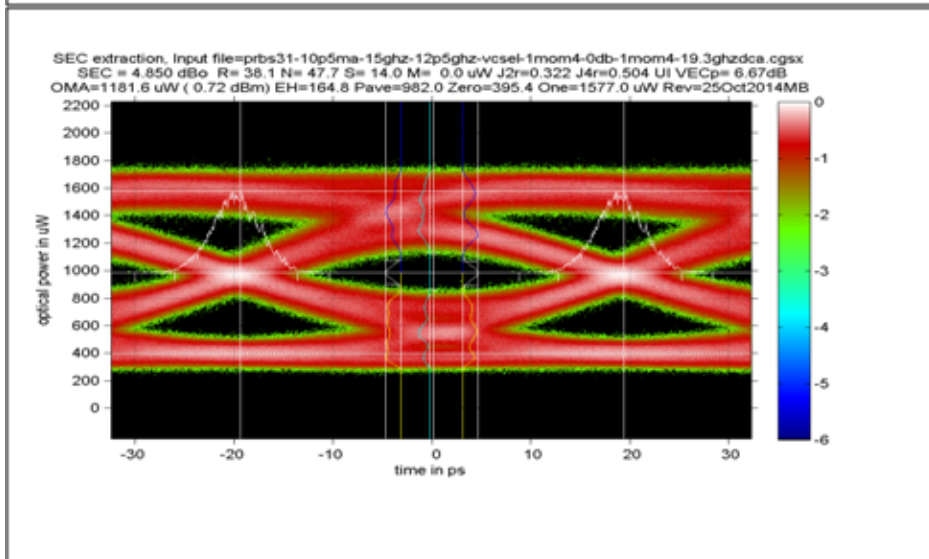
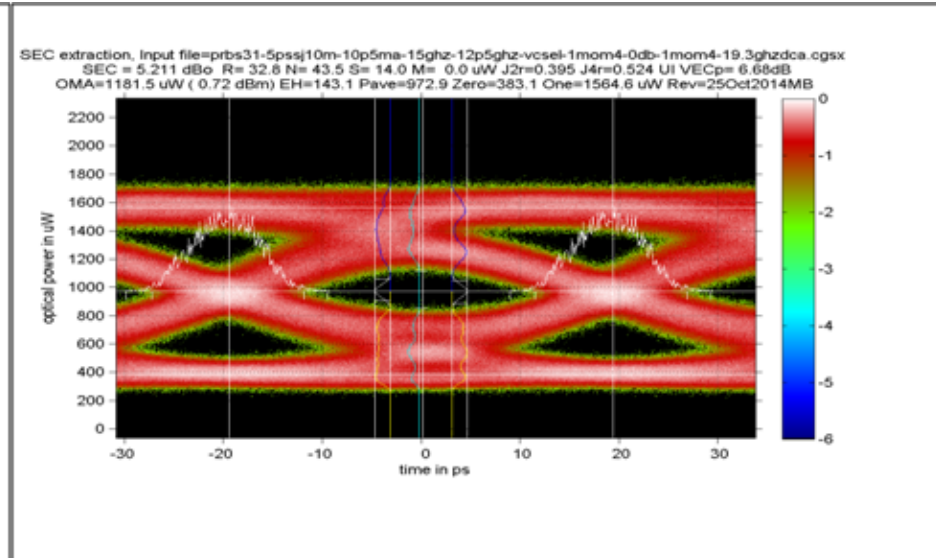
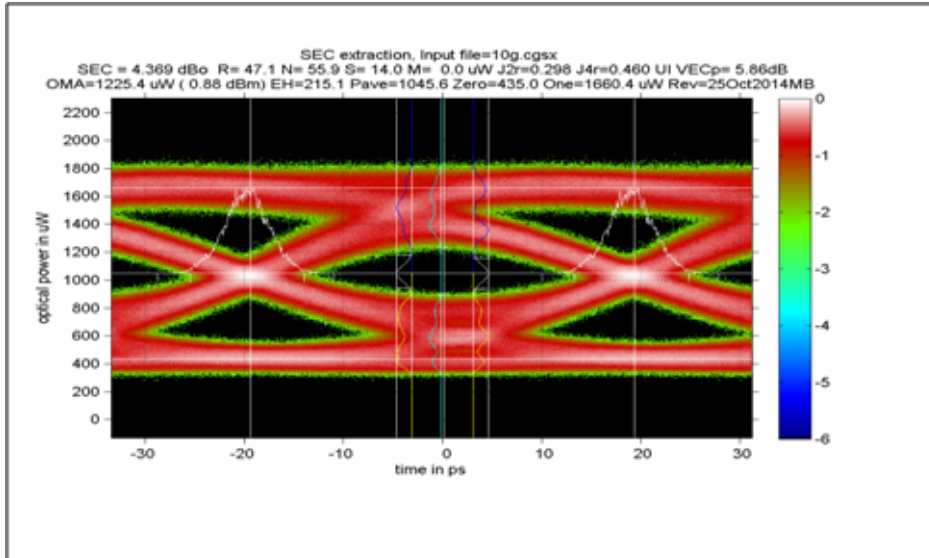
•The top chart of a top-bottom pair show the eye for a TDEC measurement. The bottom of the pair shows the eye after the 150 m OM4 fiber.

TDEC and Corresponding TP3 Eyes (2of 2)



•The top chart of a top-bottom pair show the eye for a TDEC measurement. The bottom of the pair shows the eye after the 150 m OM4 fiber.

SEC Eyes



- Recommended SEC Recipe for target SEC₀ = 4.3 dB
- With laser bias and LPF try to generate target value of SEC; but at least 2.5 dB.
- If not at target SEC, add SJ to reach SEC target
- Check for J2 and J4 targets, ER ≥ 2dB & mask margin > 0%. If not at target values adjust laser bias, LPF and SJ and iterate as needed. It may not be possible to reach all target simultaneously.
- The sinusoidal amplitude interferers and the Gaussian noise generator do not seem needed.