Optical PAM4 RX SRS Results Update*

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Problem Statements

- There exists Interoperability concerns/risks associated with SRS
  - Lack of correlation between TDECQ vs. Sensitivity
  - Lack of Rx validation with SRS testing
- **This is the first time ever to do such PAM4 SRS tests in industry**
  - 26Gbaud SRS is just in final stage of developments by test equipment vendors
  - 53Gbaud SRS is not yet available in any form
  - No SRS data available so far during 802.3bs spec definition
- **Schedule optical SRS tests jointly with Source**
  - From Week of 10/16th with Keysight at Inphi WVL lab
- Purpose:
  - To validate the existing SRS testing methodology
  - To help define SRS spec at 26GBd (and 53GBd due to similarity).

What's in mind to validate SRS?

- Pattern comparison
  - SSPRQ vs PRBS31
- Interplay between S.I. vs. G.N (and S.J.)
- Different ROSA behavior
  - Various prevailing product-grade PAM4 ROSAs
- Critical contributing parameters affecting SECQ
  - Redefine calibration procedures
- ER impact on SECQ
- Impact of number of taps for un-stressed and stressed
- Impact of TX filter BW
- Impact of RX filter BW
- Different DSP modes

Optical SRS Reqs for compliance tests

- Optical SRS is critical pass/fail specs on optical RX at TP3
  - SECQ=Stressed eye closure for PAM4

Parameter	Units	200GBASE-DR4	200GBASE-FR4	200GBASE-LR4	400GBASE-FR8	400GBASE-LR8	50GBASE-FR	50GBASE-LR	100GBASE-DR	400GBASE-DR4
Baudrate	GBaud	26.5625	26.5625	26.5625	26.5625	26.5625	26.5625	26.5625	53.125	53.125
Reference Rx bandwidth	GHz	13.28125	13.28125	13.28125	13.28125	13.28125	13.28125	13.28125	26.5625	26.5625
Reference Rx equalizer	Taps, Spacing	5, T	5, T	5, T	5, T	5, T	5, T	5, T	5, T	5, T
TDECQ (max)	dB	3.4	3.3	3.4	3.1	3.3	3.2	3.4	3.4	3.4
SRS	dBm	−4.1	−3.6	−5.2	−3.1	−4.7	−5.1	−6.4	−1.9	−1.9
Dispersion (max)	ps/nm	0.8	6.7	9.5	1.9	9.5	3.2	16	0.8	0.8
Dispersion (min)	ps/nm	−0.93	−11.9	−28.4	−10.2	−50.8	−3.7	−18.6	−0.93	−0.93
ΔTdisp / Tsymbol (GVD max)	%	0.3%	2.7%	3.8%	0.8%	3.8%	1.3%	6.4%	1.3%	1.3%
ΔTdisp / Tsymbol (GVD min)	%	0.4%	4.7%	11.3%	4.1%	20.2%	1.5%	7.4%	1.5%	1.5%
Draft	–	P802.3cd D2.1	P802.3bs D3.3	P802.3bs D3.3	P802.3bs D3.3	P802.3bs D3.3	P802.3cd D2.1	P802.3cd D2.1	P802.3cd D2.1	P802.3bs D3.3
Clause	–	121	122	122	122	122	139	139	140	124

Optical SRS Testing Setups

- Complex and expensive test setups
  - Establish hard/solid correlation between URS and SRS

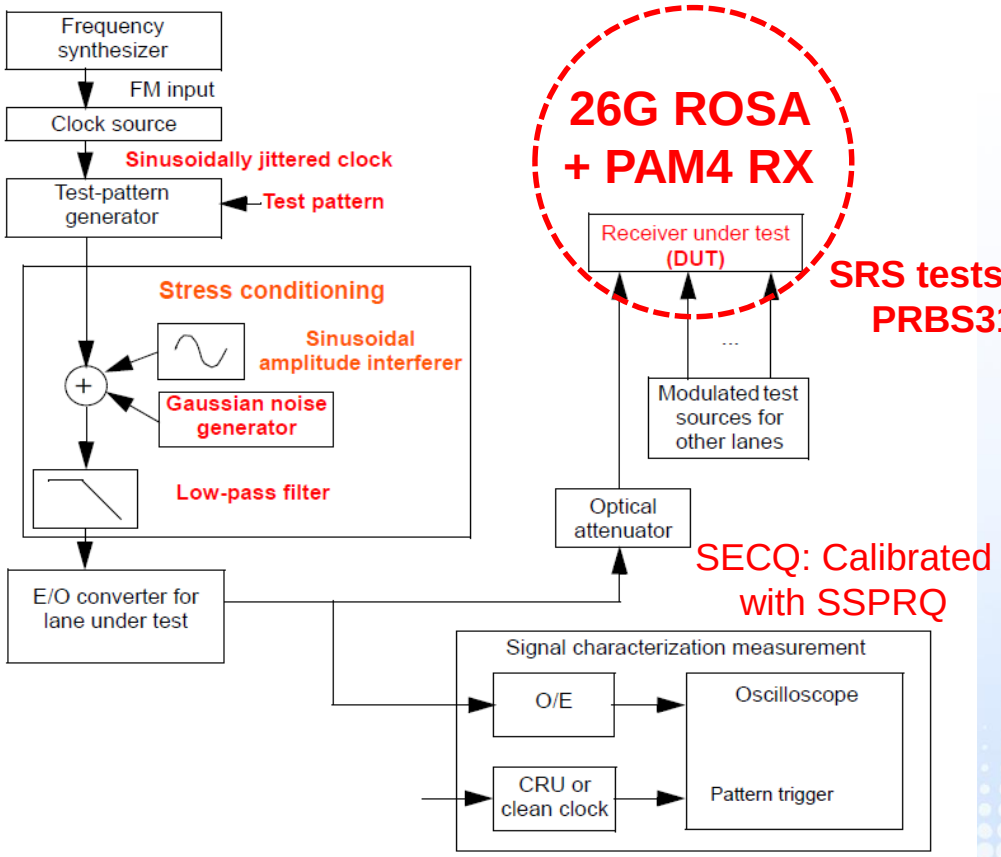
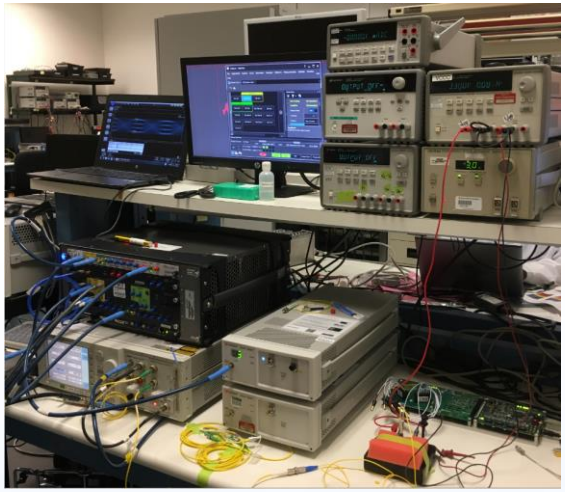


Figure 121–6—Stressed receiver conformance test block diagram

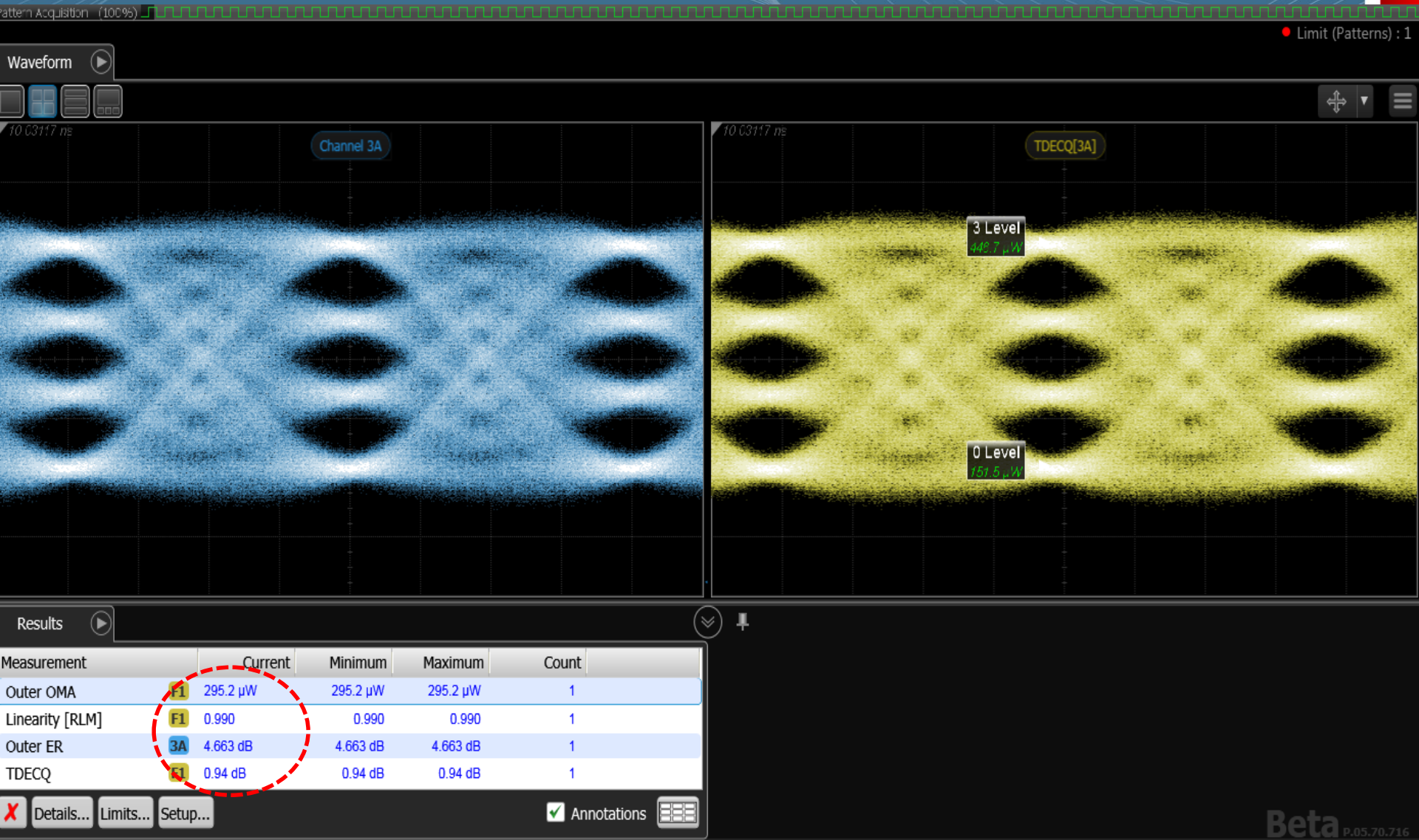
SRS tests with PRBS31Q



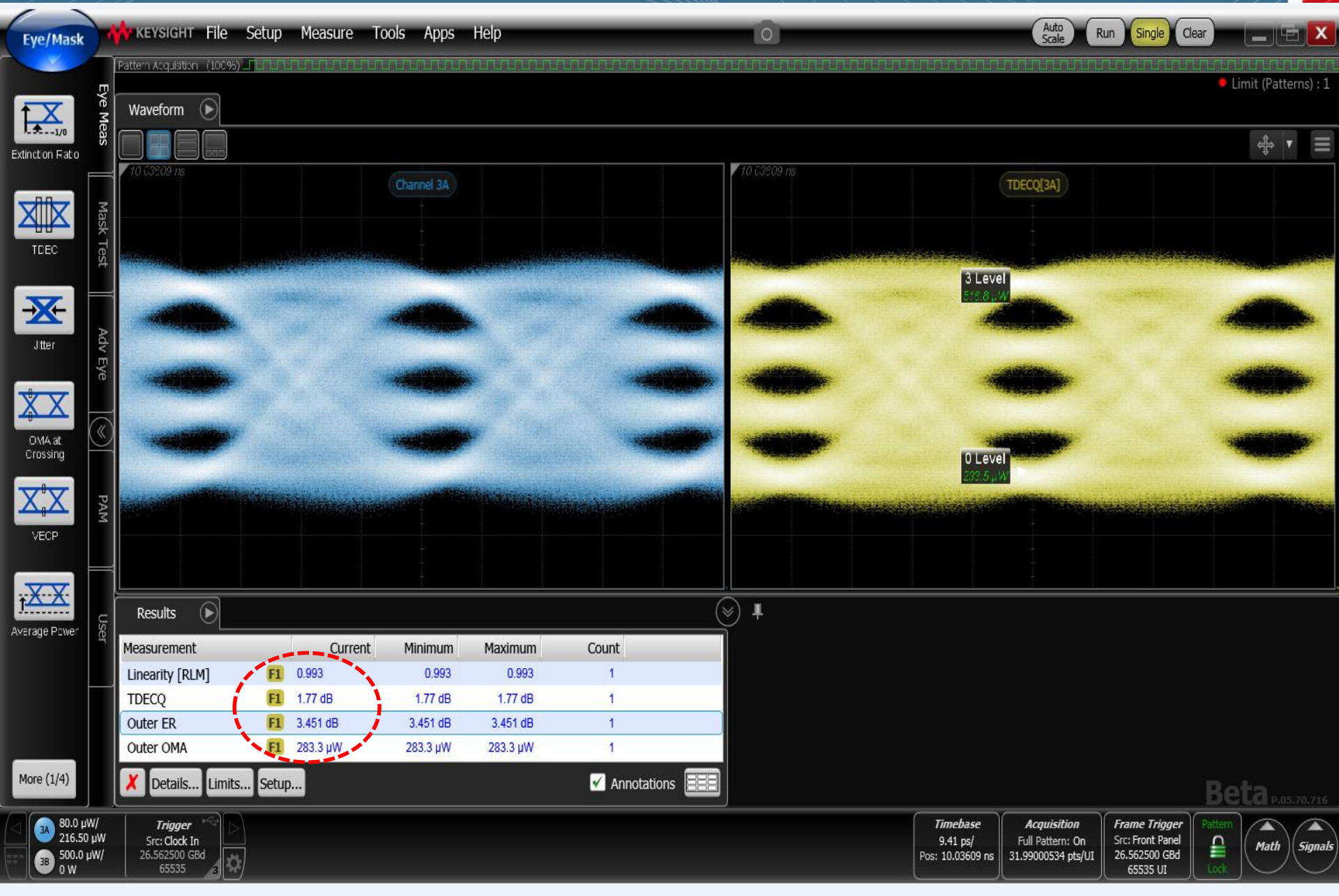
Key calibration procedures:

- Select SSPRQ pattern
- Ideal LN MZM TX with SECQ~0.9dB
- Set ER=3.5dB
- TX E/O+LPF generate half of the SECQ
- S.J. 0.05mUI @100MHz
- S.I.+ G.N to meet SECQ=3.4dB

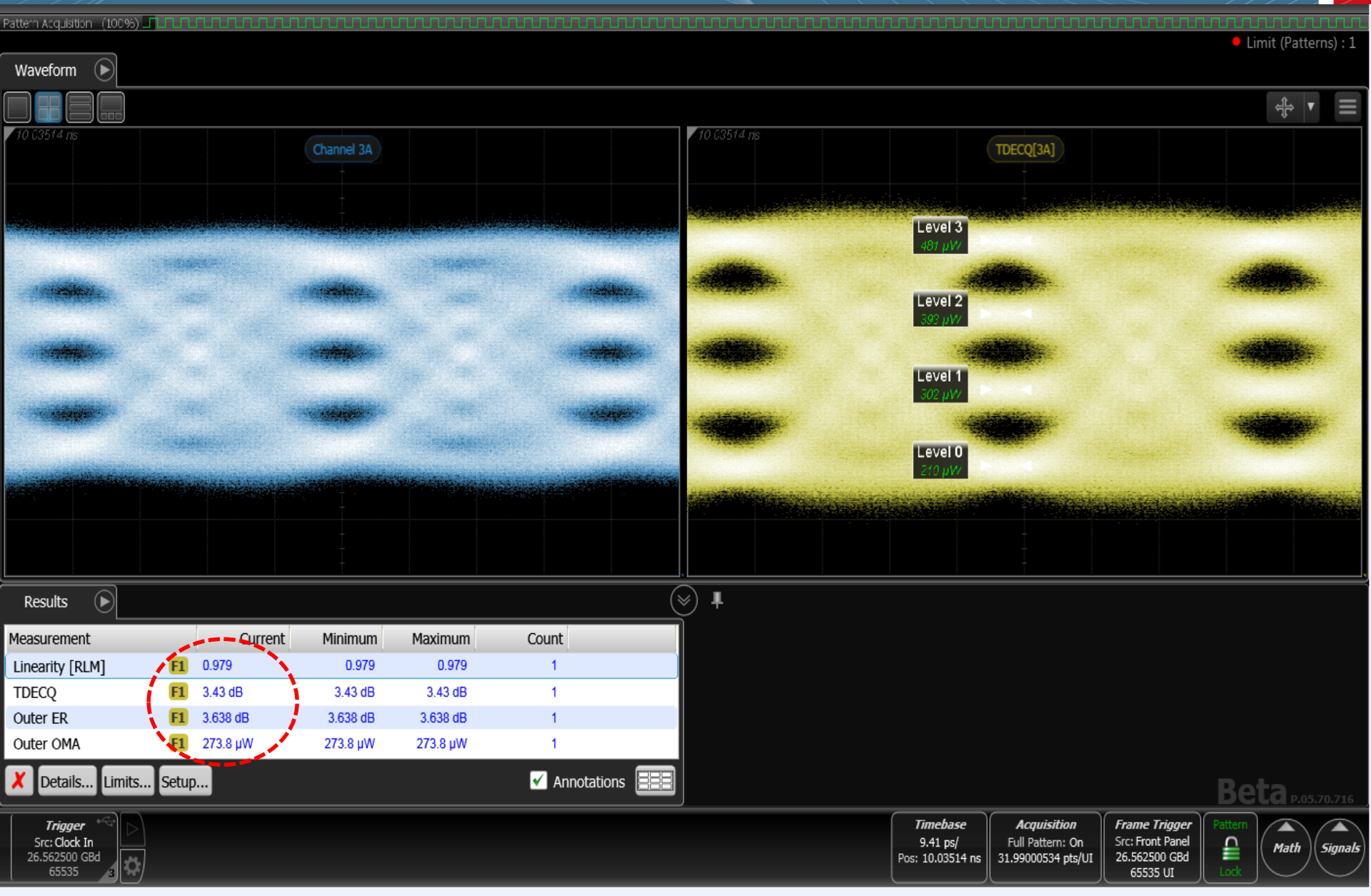
Generate stressed eyes – Ideal TX eye (SSPRQ)



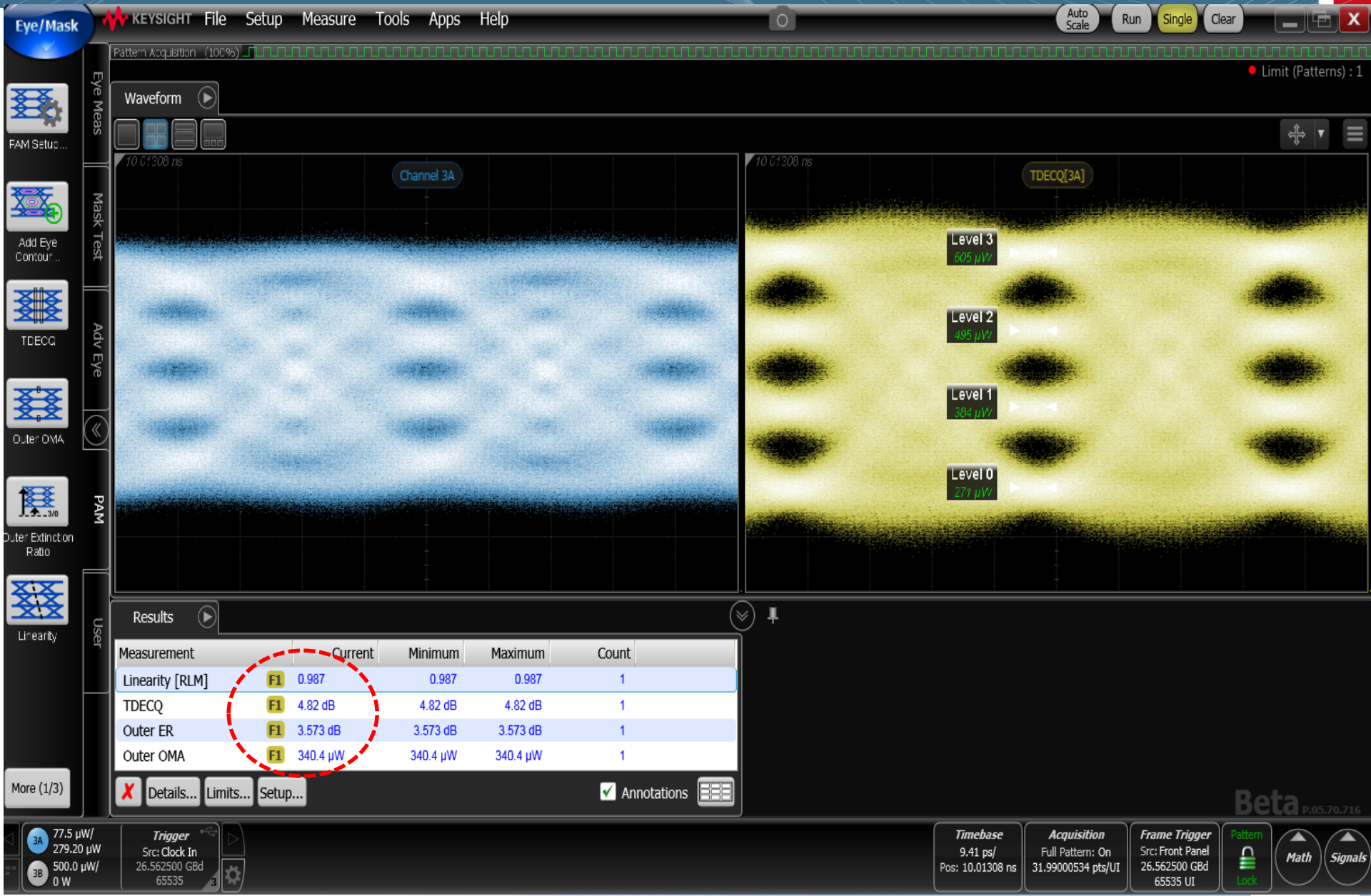
Generate stressed eyes – ideal TX w/ LPF (SSPRQ)



Generate stressed eyes – Fully stressed (SSPRQ)

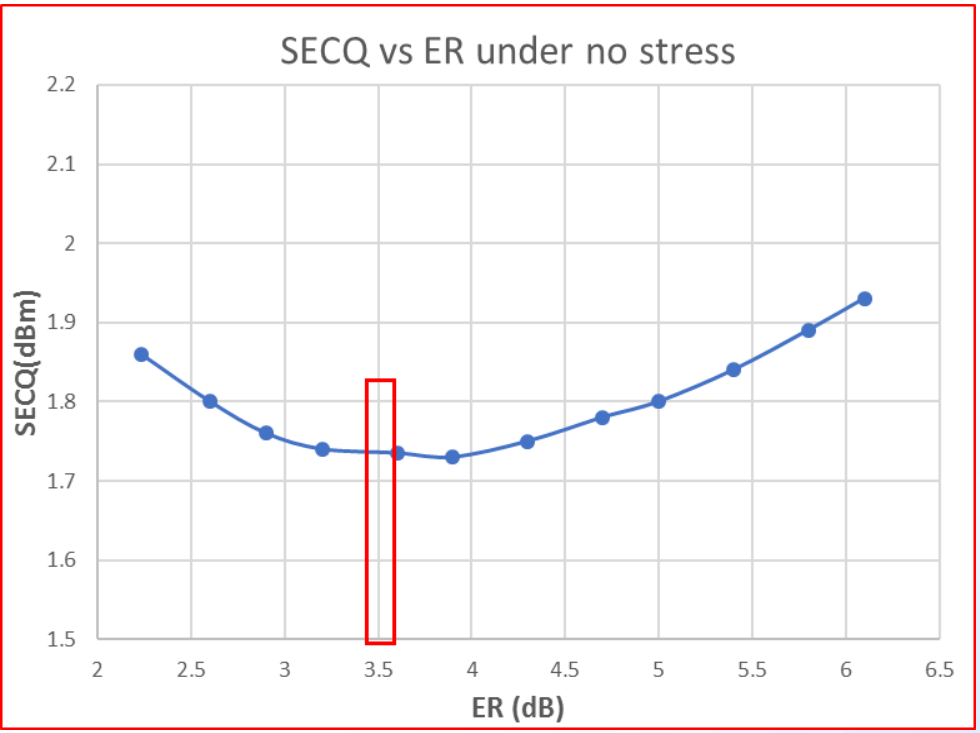


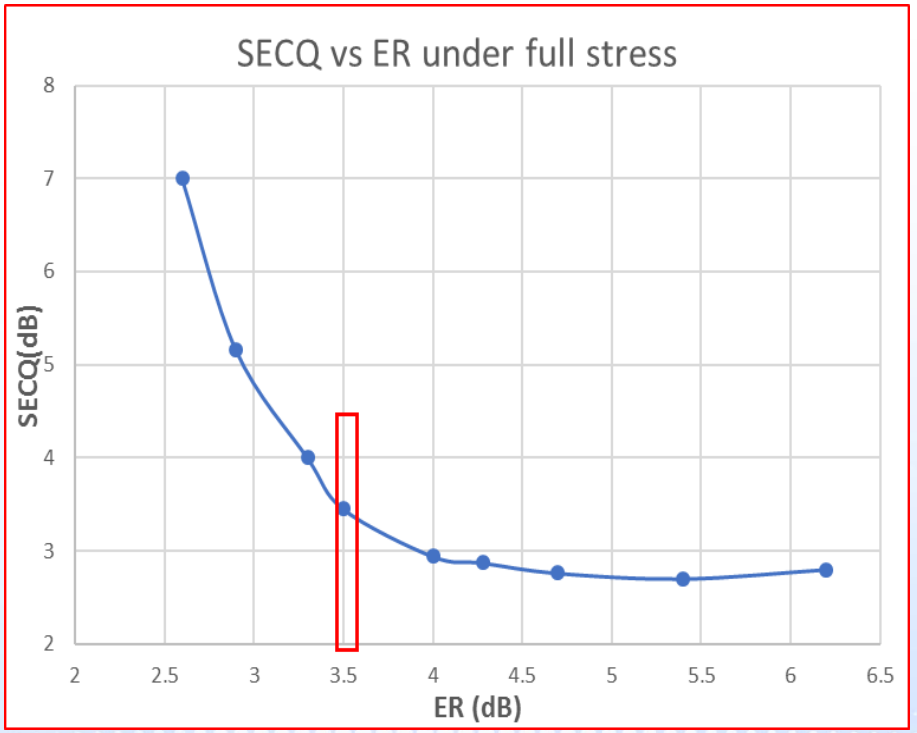
Generate stressed eyes – Fully stressed with TX Filtering by 12GHz Cable (SSPRQ)



ER Impact on SECQ (SSPRQ)

- SECQ behave differently under full or no stress
  - ER is varied with changing RF modulation amplitude (Vpp) only

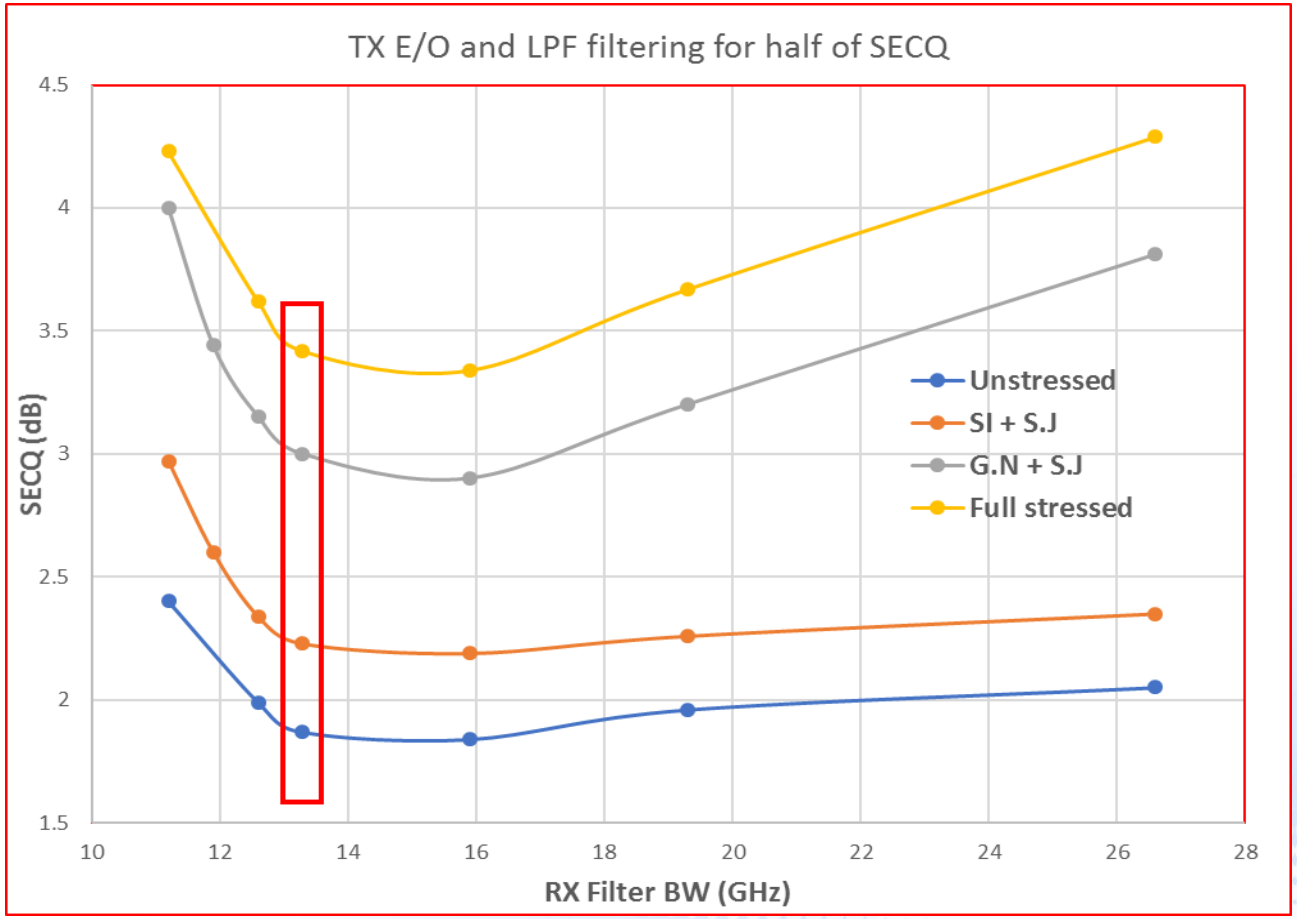




Note: Refer to DCA-M N1092B RX BW ~33GHz.

TX and Rx BW on SECQ (SSPRQ)

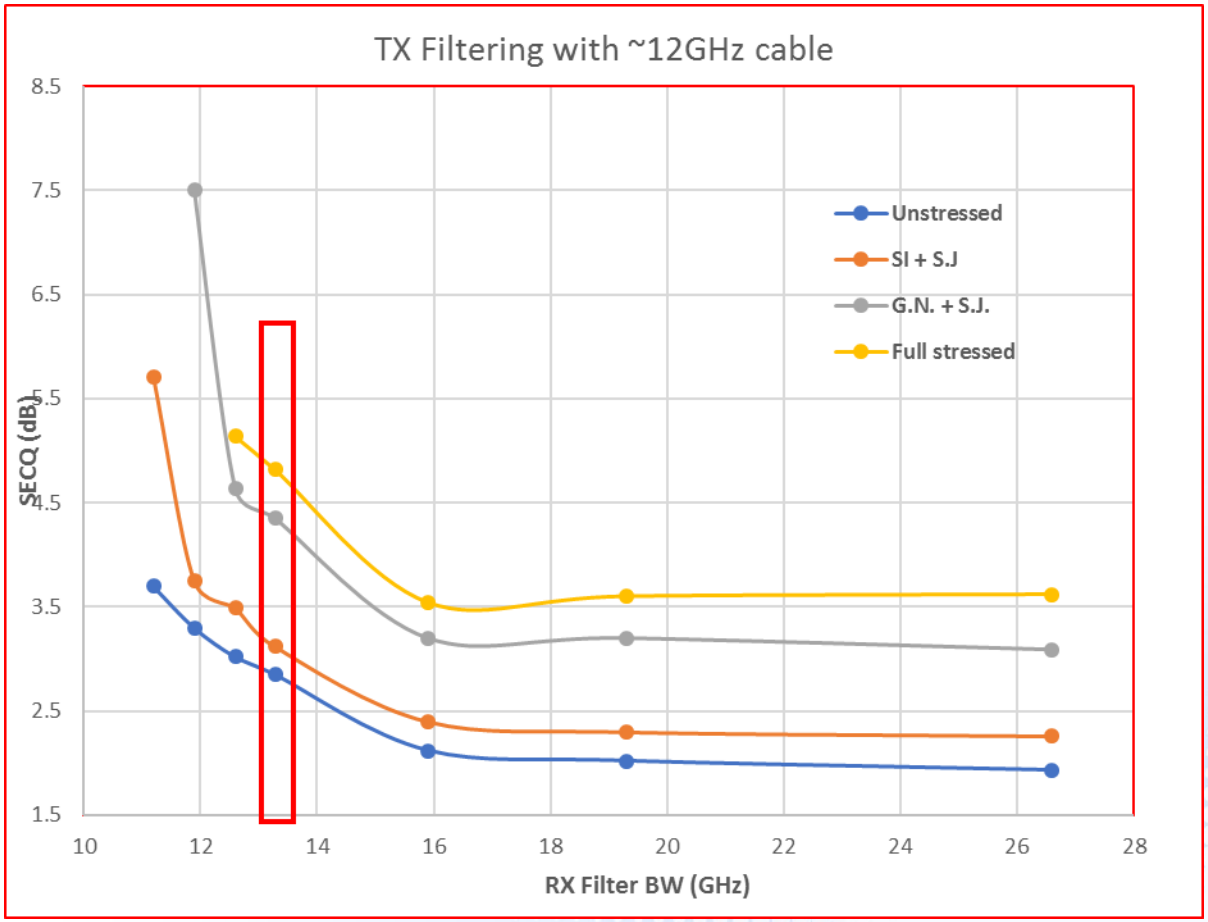
- RX filtering impact differently for higher stressed cases.
  - Also look into the scenarios when TX is highly BW limited (next 2 slides).



Note: Refer to DCA-M N1092B RX BW ~33GHz.

TX and Rx BW on SECQ (SSPRQ)

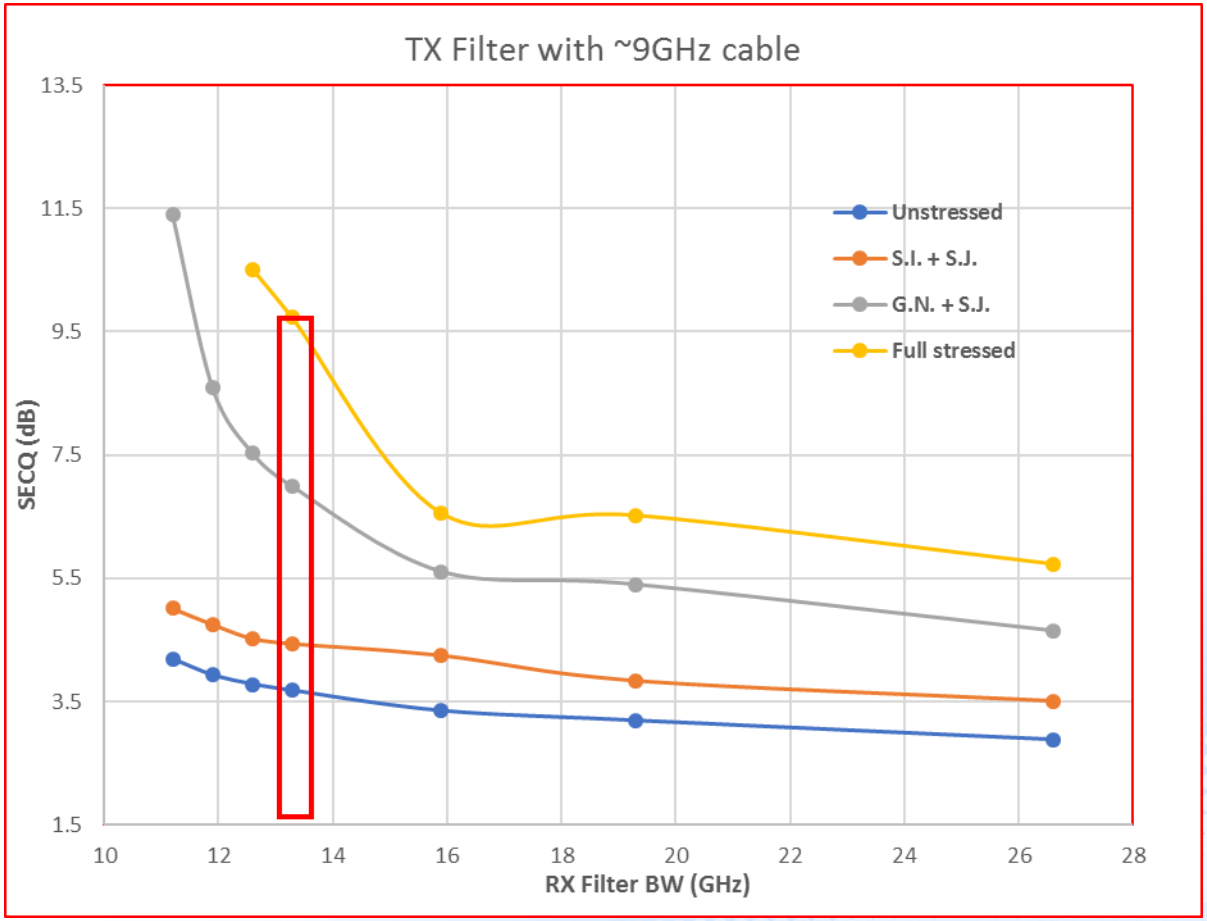
- RX filtering impact differently for higher stressed cases.
  - Under TX filtering at ~12GHz BW LPF cable



Note: Refer to DCA-M N1092B RX BW ~33GHz.

TX and Rx BW on SECQ (SSPRQ)

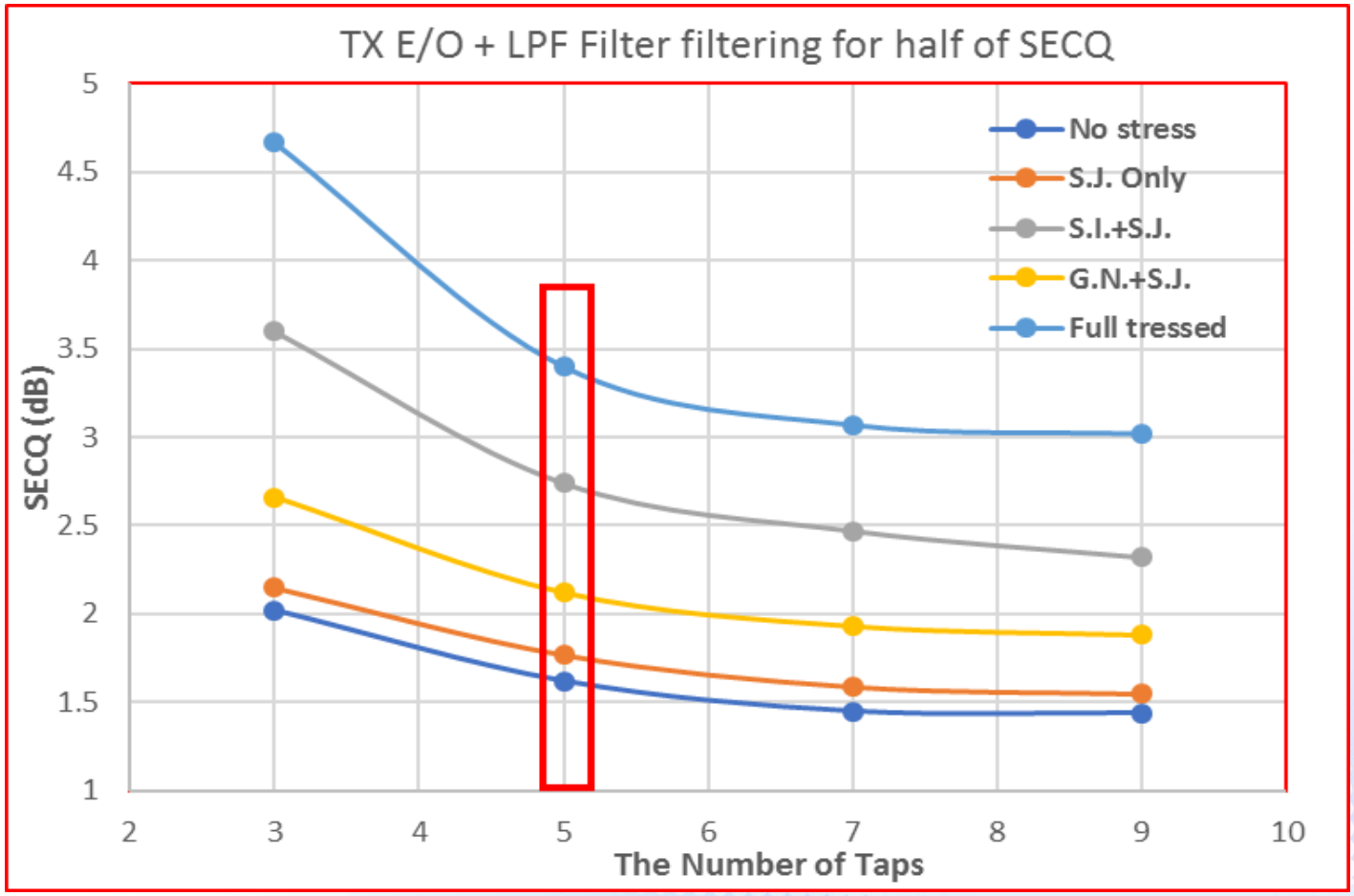
- RX filtering impact differently for higher stressed cases.
  - Under TX filtering at ~9GHz BW LPF cable



Note: Refer to DCA-M N1092B RX BW ~33GHz.

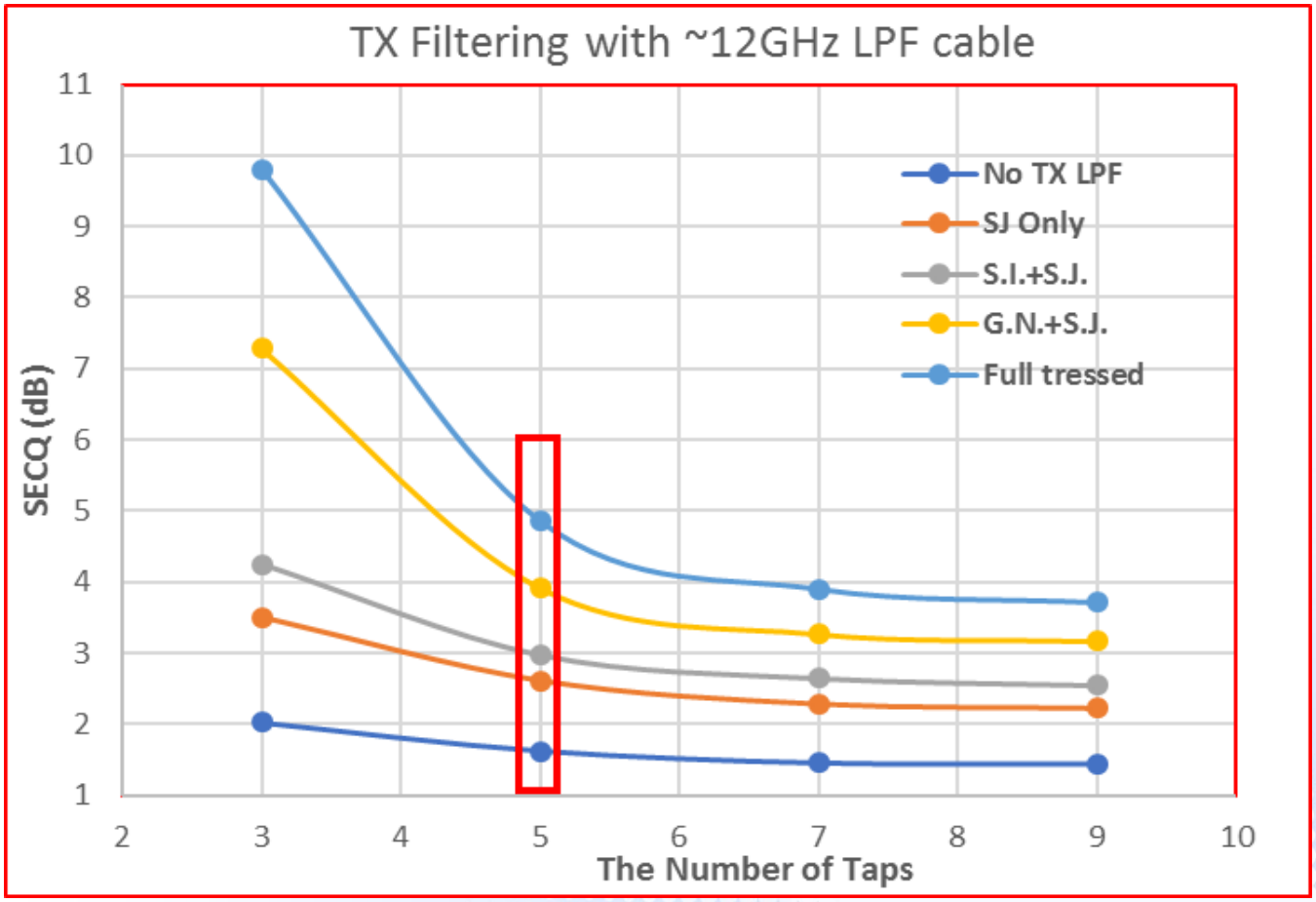
The Number of Taps on SECQ (SSPRQ)

- More taps help the most for higher or full stress
  - Also look into the scenarios when TX is highly BW limited (next 2 slides).



The Number of Taps on SECQ (SSPRQ)

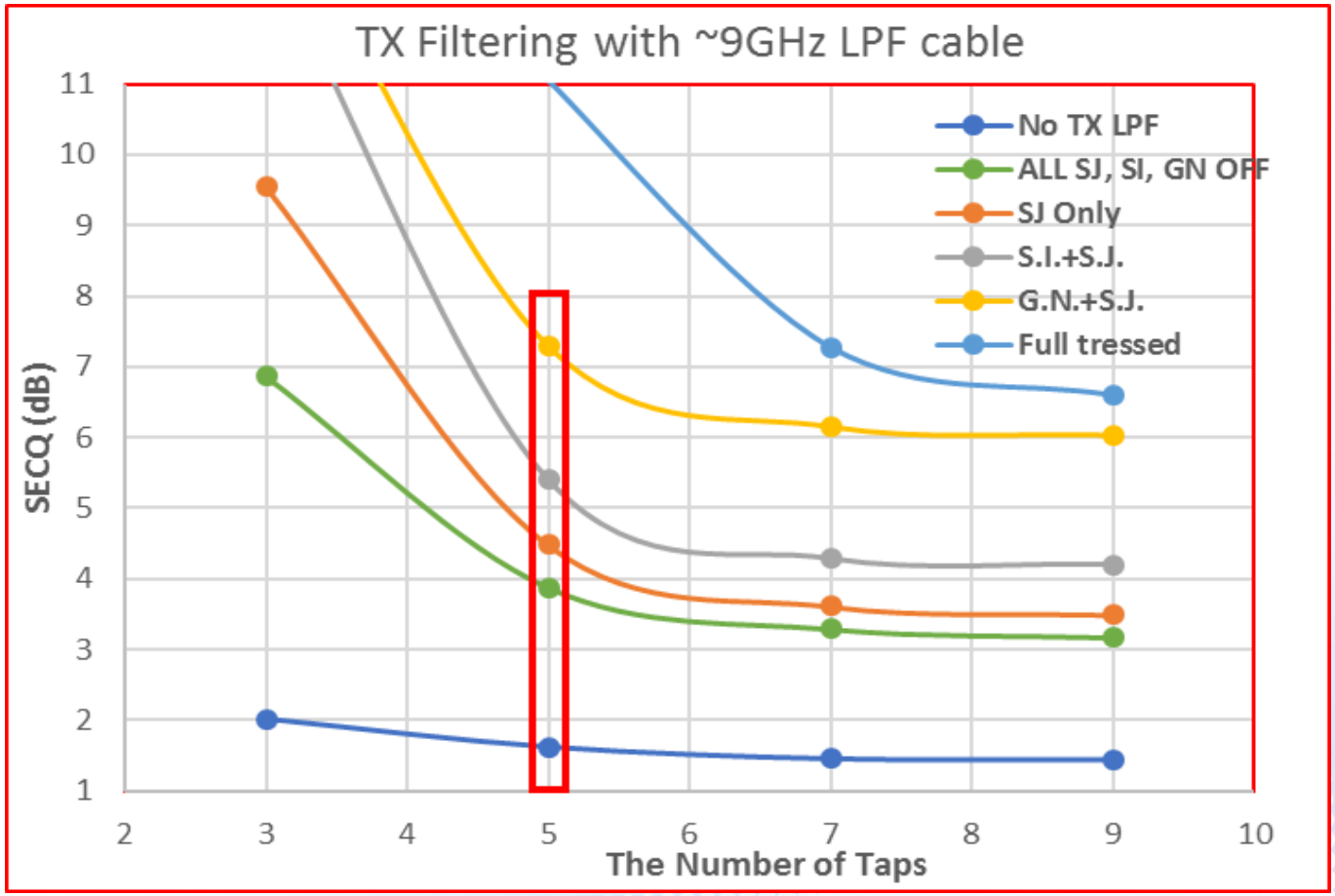
- More taps help the most for higher or full stress
  - Under TX filtering at ~12GHz BW LPF cable



Note: Refer to DCA-M N1092B RX BW ~33GHz at RX 13.28GHz filtering

The Number of Taps on SECQ (SSPRQ)

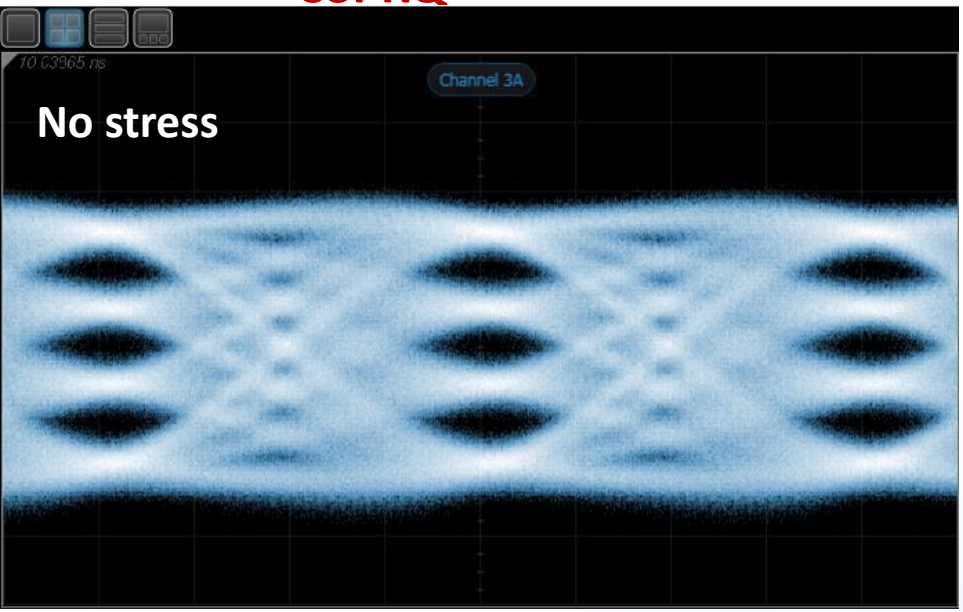
- More taps help the most for higher or full stress
  - Under TX filtering at ~9GHz BW LPF cable

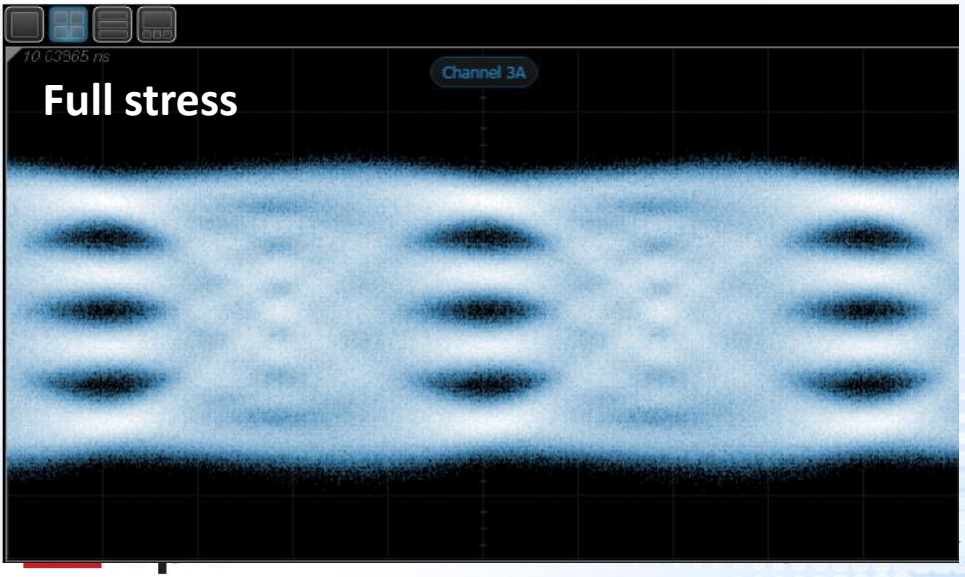


Note: Refer to DCA-M N1092B RX BW ~33GHz at RX 13.28GHz filtering

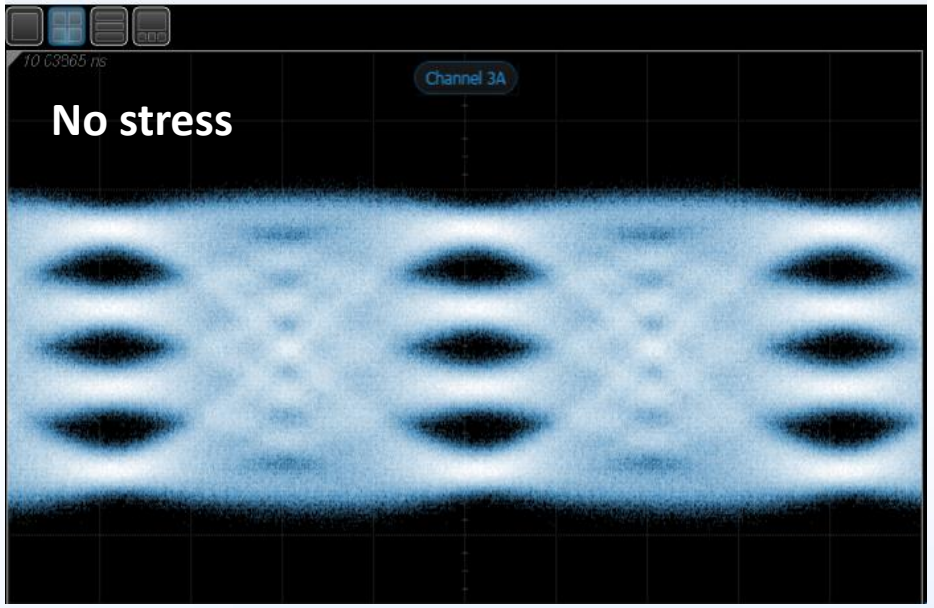
SSPRQ vs. PRBS31Q Pattern Comparison

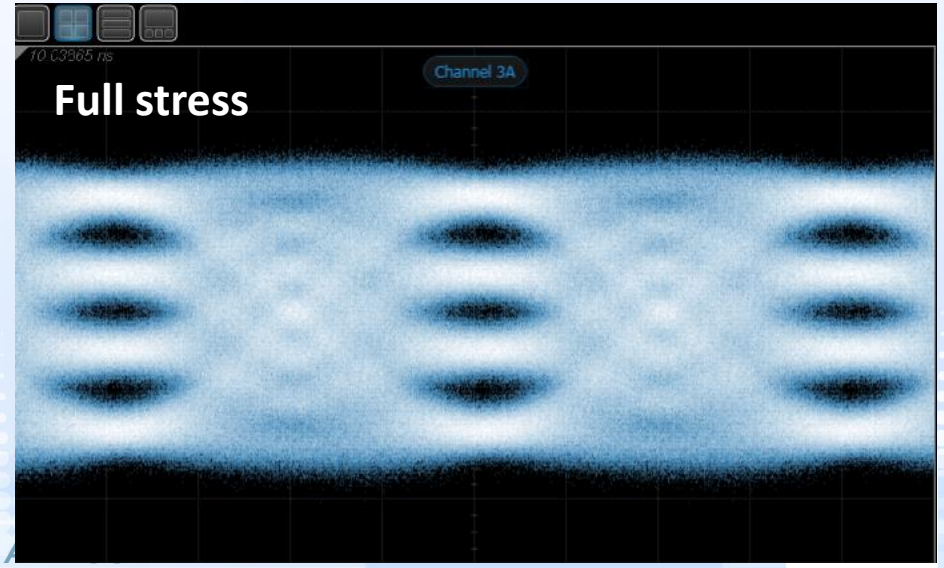
SSPRQ





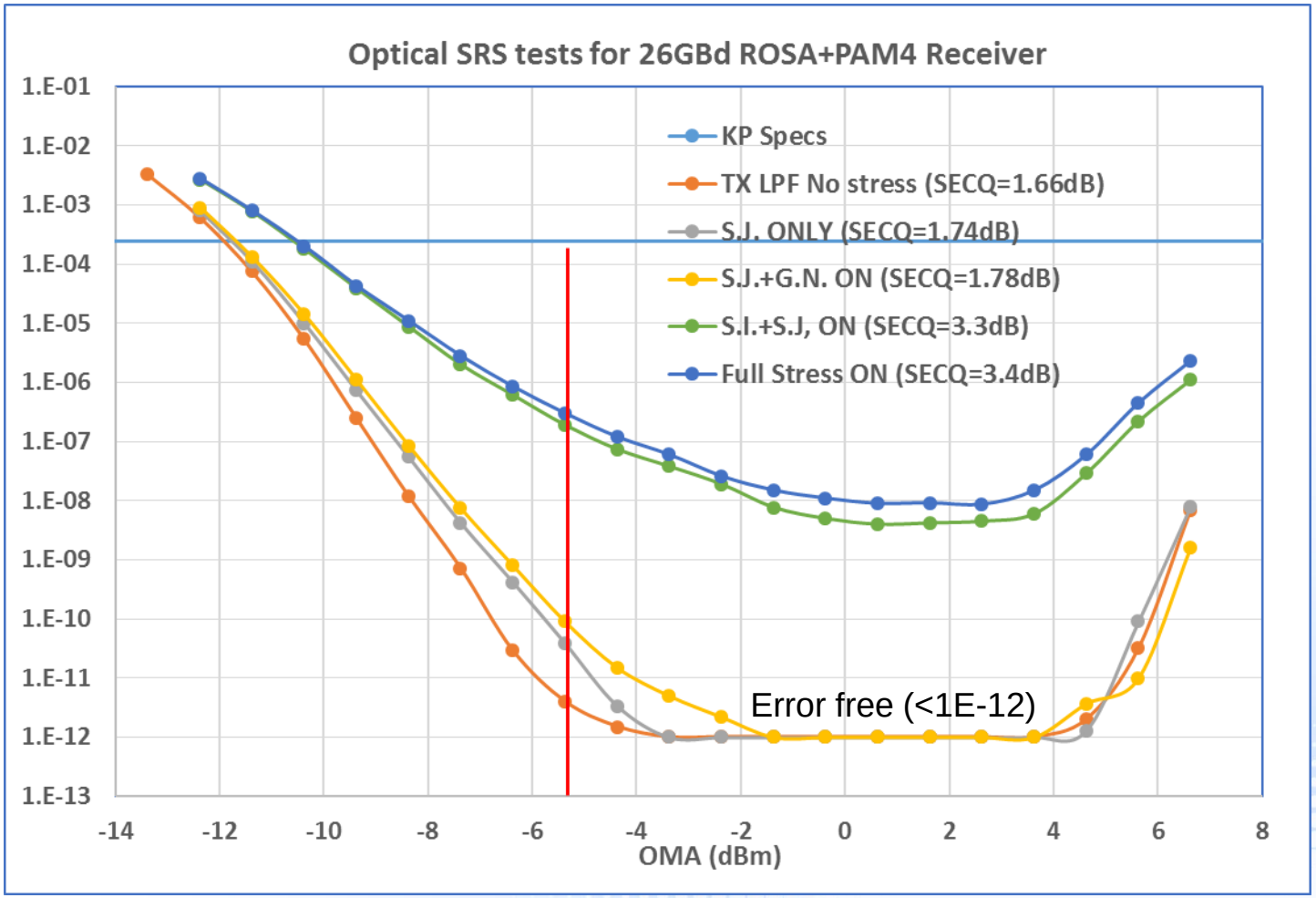
PRBS31Q





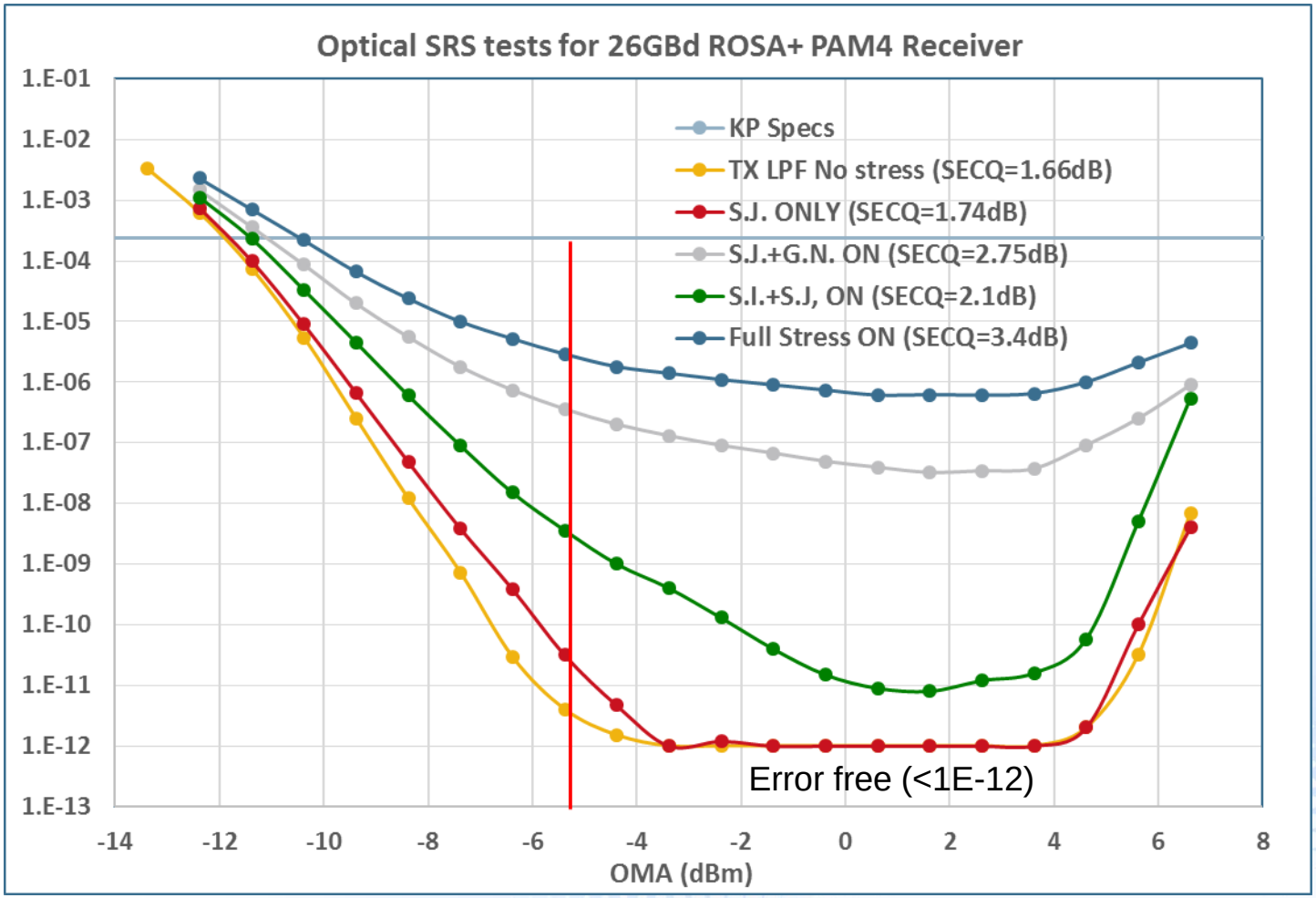
RX SRS Tests with PRBS31Q – Case 1

- Case 1 with S.I. dominance



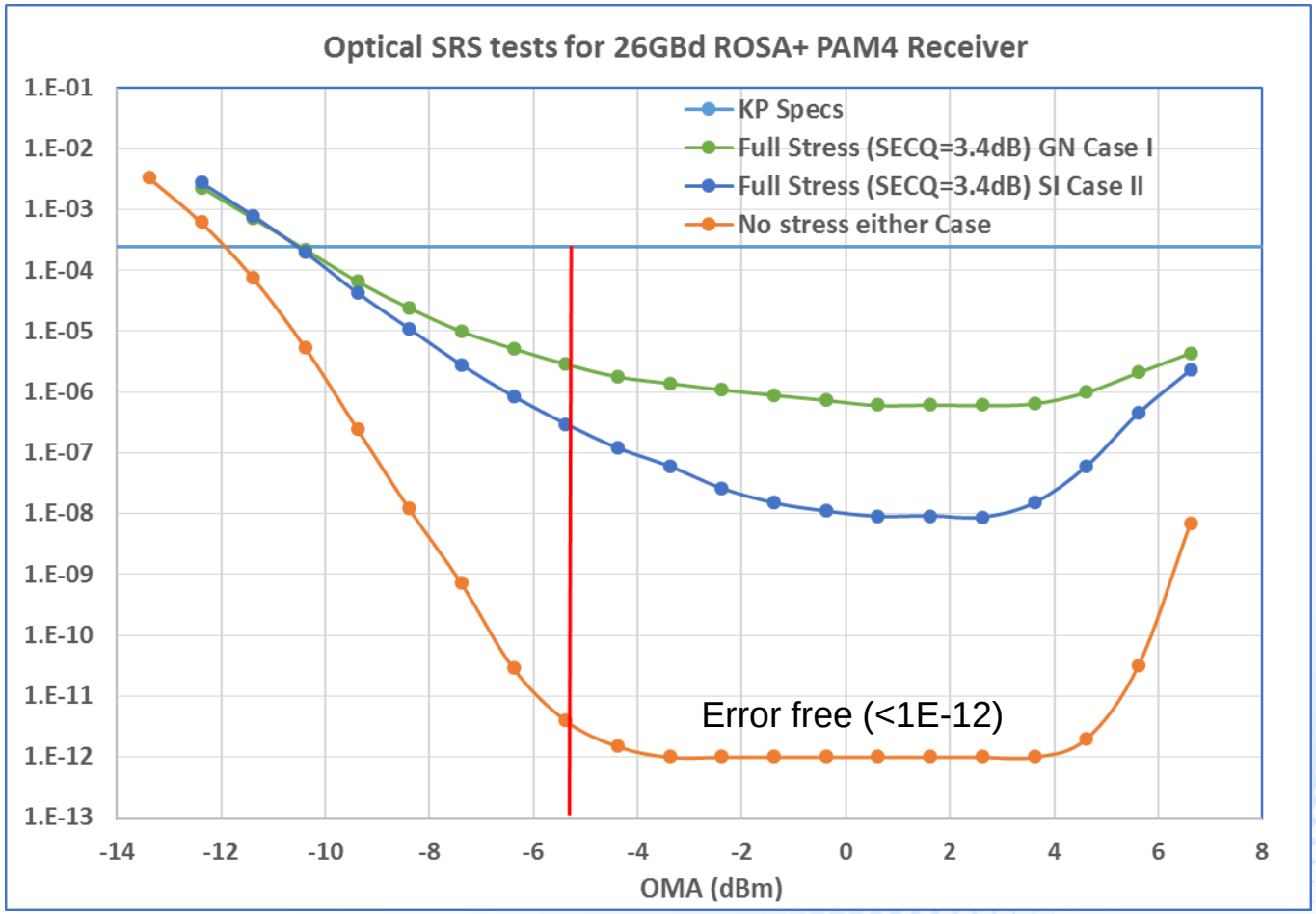
RX SRS Tests with PRBS31Q – Case 2

- Case 2 with G.N. dominance



Compare Two Cases with PRBS31Q

- Same SECQ=3.4dB but with different BER behavior



Case1	S.I. dominance
	SECQ
Ideal Tx	0.87
TX+LPF	1.66
S.J. only	1.74
S.J+G.N.	1.78
S.J.+ S.I.	3.3
S.J.+ G.N.+S.I.	3.4

Case2	G.N. dominance
	SECQ
Ideal Tx	0.87
TX+LPF	1.66
S.J. only	1.74
S.J+S.I.	2.1
S.J.+ G.N.	2.75
S.J.+ G.N.+S.I.	3.4

Summary & Recommendation

- Optical SRS are investigated extensively, major observations from preliminary results:
  - SRS setup is pretty complex, but stable and repeatable once well calibrated.
  - SSPRQ seems to show good representative of PRBS31 pattern
  - More Ref equalizer taps help the most for higher and full stress situation
  - Lower ER does not help high stressed signals due to small eye opening.
  - There exists strong interplay between G.N and S.I (with S.J.). G.N. impact most the BER degradation in SRS.
  - Ref transmitter used for SRS may not be able to represent “Non-ideal” product grade transmitters.
  - Data repeatedly show SECQ correlates well with BER flooring (or equivalently SNR). (Referring to way_3bs_01a_0717.pdf and way_3bs_01a_0517.pdf)
    - Correlation of SECQ with RX sensitivity seems to follow similar trend with validation, may still need re-investigated carefully (e.g. TX and ROSA dependent).
- Recommendations:
  - Production implementation could possibly induce interop risks.
  - Each contributing items (and ratio) in setting SRS should be well defined in specs.

Thank You !

QUESTIONS?