Snapshot of Receiver Module Input tests (No convergence on high-loss (TP1a) channel)

John Calvin: DataCom Planner *Varun Garg: R&D Measurement Scientist* *Ryan Chodora: R&D Measurement Engineer*	***2021.06***
Affiliated with and employed by Keysight Technologies	

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P802.3ck Module Input Section 120G background

Draft Amendment to IEEE Std 802.3-2018
IEEE P802.3ck 100 Gb/s, 200 Gb/s, and 400 Gb/s Electrical Interfaces Task Force

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10th March 2021

120G.3.4 Module input characteristics

The module input shall meet the specifications given in Table 120G–10. Channel equalization is provided by an adaptive equalizer in the module.

Table 120G–10—Module input characteristics

Parameter	Reference	Test point	Value	Units
Signaling rate, each lane (range)		TP1	53.125 ± 100 ppm	GBd
Differential pk-pk input voltage tolerance (min)	120G.5.1	TP1a	900	mV
Differential to common-mode return loss (min)	120G.3.3.1	TP1	Equation (120G–2)	dB
Effective return loss, ERL (min)	120G.3.4.2	TP1	8.5	dB
Differential termination mismatch (max)	120G.3.1.3	TP1	10	%
Module stressed input test[a]	120G.3.4.1	TP1a	See 120G.3.4.1	
Single-ended voltage tolerance range (min)	120G.5.1	TP1a	–0.4 to 3.3	V
DC common-mode voltage (min)[b]	120G.5.1	TP1	–350	mV
DC common-mode voltage (max)[b]	120G.5.1	TP1	2850	mV

[a] Meets BER specified in 120G.1.1.
[b] DC common-mode voltage generated by the host. Specification includes effects of ground offset voltage.

120G.3.4.1 Module stressed input test

The module stressed input tolerance is measured using the procedure defined in 120G.3.4.1.1. The input shall satisfy the input tolerance with the parameters in Table 120G–11.

Table 120G–11—Module stressed input parameters

Parameter	Value
Applied pk-pk sinusoidal jitter	Table 120G–9
Eye height (target)	10 mV
Vertical eye closure (min)	12 dB
Vertical eye closure (max)	12.5 dB

120G.3.4.1.1 Module stressed input test procedure

The module stressed input test is summarized in Figure 120G–10. The stressed signal is applied at TP1 and is calibrated at TP1a. A reference CRU with a corner frequency of 4 MHz and slope of 20 dB/decade is used to calibrate the stressed signal using a PRBS13Q pattern.

Eye height vertical eye closure are measured according to the method described in 120G.5.2.

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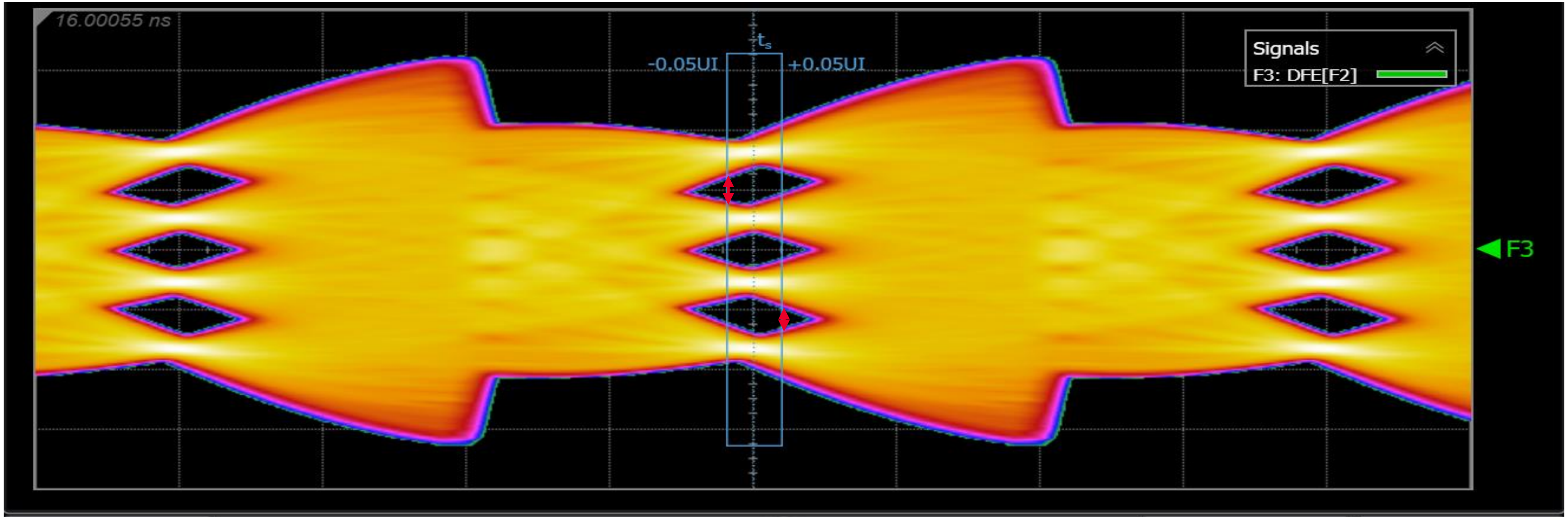
Two levels of frequency-dependent attenuation are used for the module stressed input test: high-loss and low-loss.

For the high-loss case, frequency-dependent attenuation is added such that the loss at 26.56 GHz from the output of the pattern generator to TP1a is 18.2 dB. The 18.2 dB loss represents 16 dB channel loss with an additional allowance for host transmitter package loss. Eye height and VEC are then measured at TP1a as described in 120G.5.2. Random jitter and the pattern generator output levels are adjusted (without exceeding the differential peak-to-peak input voltage tolerance specification as shown in Figure 120G–10) to result in the eye height for all three eyes given in Table 120G–11 using the reference receiver with the setting that minimizes the vertical eye closure. The CTLE setting, $g_{DC}+g_{DC2}$, has to be less than or equal to –13 dB.

For the low-loss case, discrete frequency-dependent attenuation is removed such that from the output of the pattern generator to TP1a comprises the mated HCB/MCB pair as described in 120G.5.3. Eye height at TP1a is then adjusted in the same way as described for the high-loss case except that the restriction on the CTLE setting does not apply.

In both the low-loss and high-loss cases, the input VEC is within the range specified in Table 120G–11.

P802.3ck VEC centering (BoxCar) around ts



Eye | Level | Graphs

Src: F3 Rate: 53.125208 GBd Pat. Length: 8191 PROB SP

Measurement	Eye 0/1	Eye 1/2	Eye 2/3
Eye Width (1.0E-5)	155 mUI	180 mUI	155 mUI
Eye Height (1.0E-5)	24.1 mV	26.2 mV	23.7 mV
VEC (1.0E-5)	11.6 dB	10.5 dB	11.7 dB
Eye Skew	5 mUI	0 UI	0 UI

Details... Limits...

Src: F3 Rate: 53.125208 GBd Pat. Length: 8191 PROB SP
Receiver RN: 1.12 mV

Measurement	Level 0	Level 1	Level 2	Level 3
Level	-133.6 mV	-42.4 mV	44.6 mV	135.7 mV
TI (1.0E-5)	33.2 mV	35.2 mV	34.8 mV	33.4 mV
RN (rms)	1.115 mV	1.115 mV	1.125 mV	1.135 mV

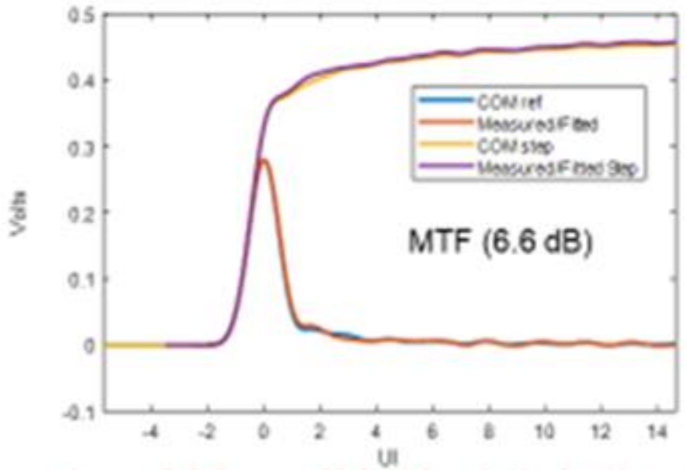
Details... Limits... beta P.06.80.107

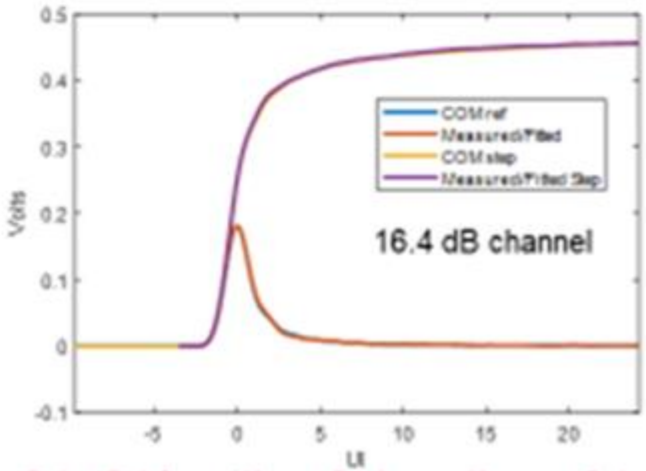
P802.3ck Host/Module Input Calibration Challenges

Test Point	Configuration **	Insertion Loss	Meas. EH SJ = 50mUI	Meas. VEC SJ = 50mUI	Spec. EH SJ = 50mUI	Spec. VEC SJ = 50mUI
TP4	Near-end short	6.6 dB	16.25 mV	11.6 dB	15 mV	12.5 dB
TP4	Far-end long	17.1 dB	15.45 mV	9 dB	15 mV	12.5 dB
TP1a	High Loss	16.4 dB	13.1 mV	13.5 dB	10 mV	12.5 dB*

** 600mV crosstalk (targets 900mVpp, not achievable with M8045A)
Crosstalk doesn't have much impact on EH/VEC

*Comments by Ali Ghiasi and Richard Mellitz to challenge this value. Discussion scheduled after May 4th.

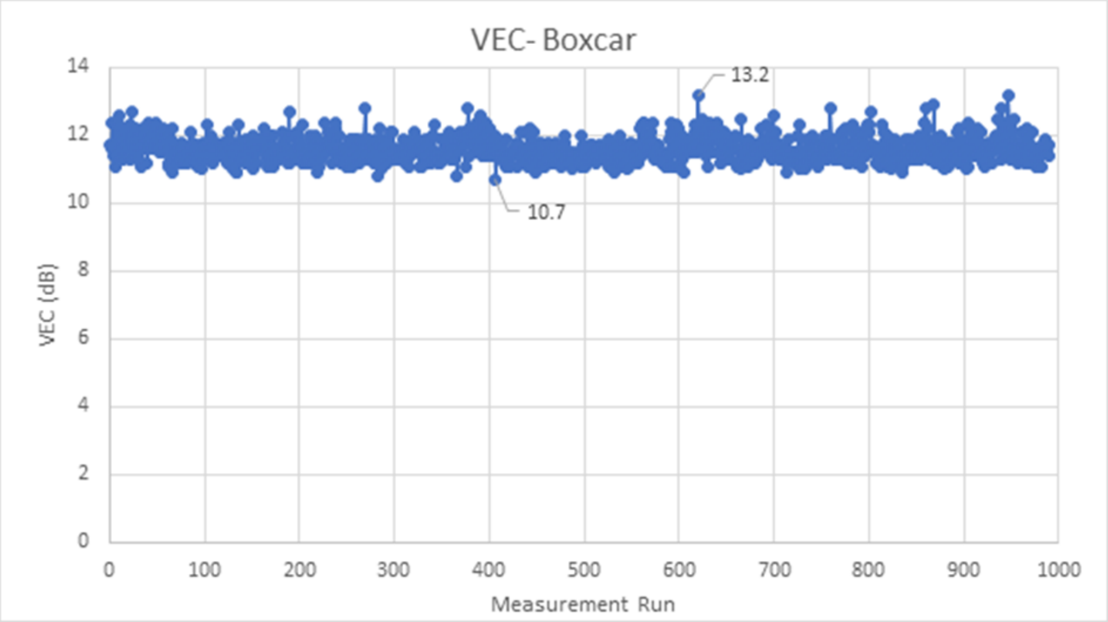




https://www.ieee802.org/3/ck/public/adhoc/mar31_21/mellitz_3ck_adhoc_01_033121.pdf

To date, Keysight has been unable to reliably close the calibration loop on TP1a at 12.5dB VEC with precision lab equipment. Has anyone else managed to get this to converge?

P802.3ck Module Input Run-Run VEC variability

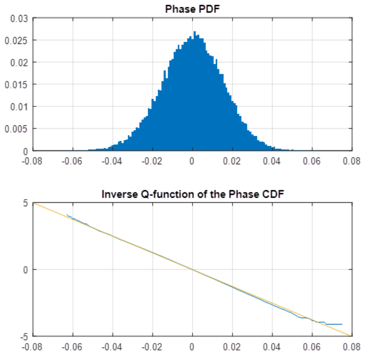


TP1a (high-loss long channel) calibration

Spec (Table 120G-11)	COM	Measured
VEC (dB) no SJ	9.4	10.6
VEC Std Dev no SJ	0	***0.317***
Eye Height (mV) no SJ	13.3	16.1
VEC (dB) with SJ	10.85	13.2
VEC Std Dev with SJ	0	***0.365***
Eye Height (mV) with SJ	11.2	13.25

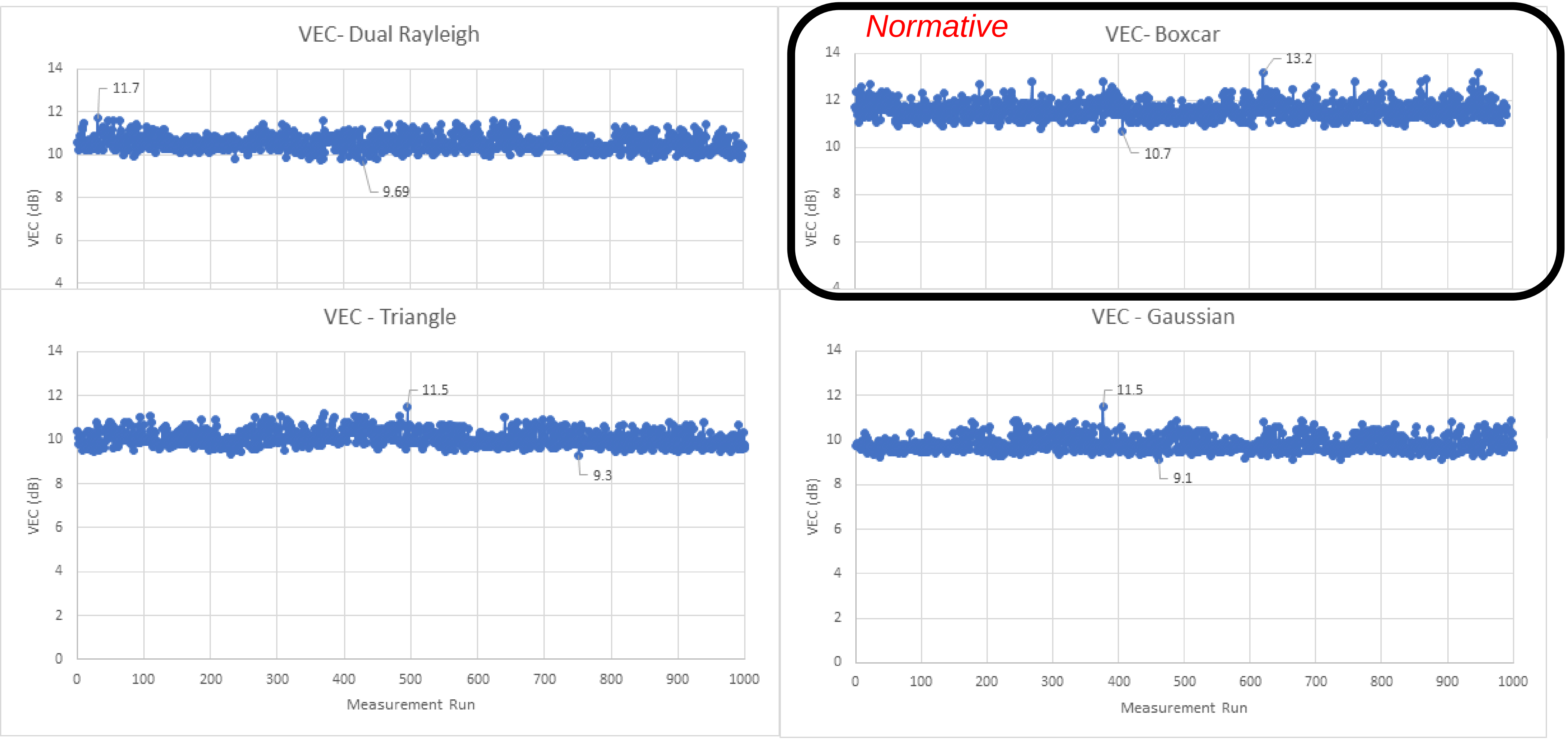
Theories on variability:

- SJ (40MHz in these cases) could introduce a beat frequency which when coupled with the PRBS13Q test pattern and co/counter-prop aggressors could impact results.
- Physical CDR may be "hunting" pattern harmonics or have internal noise contribution
  - Todo: Verify on a RT instrument.
- Square (Boxcar) measurement window is meta-stable, alternates next slide

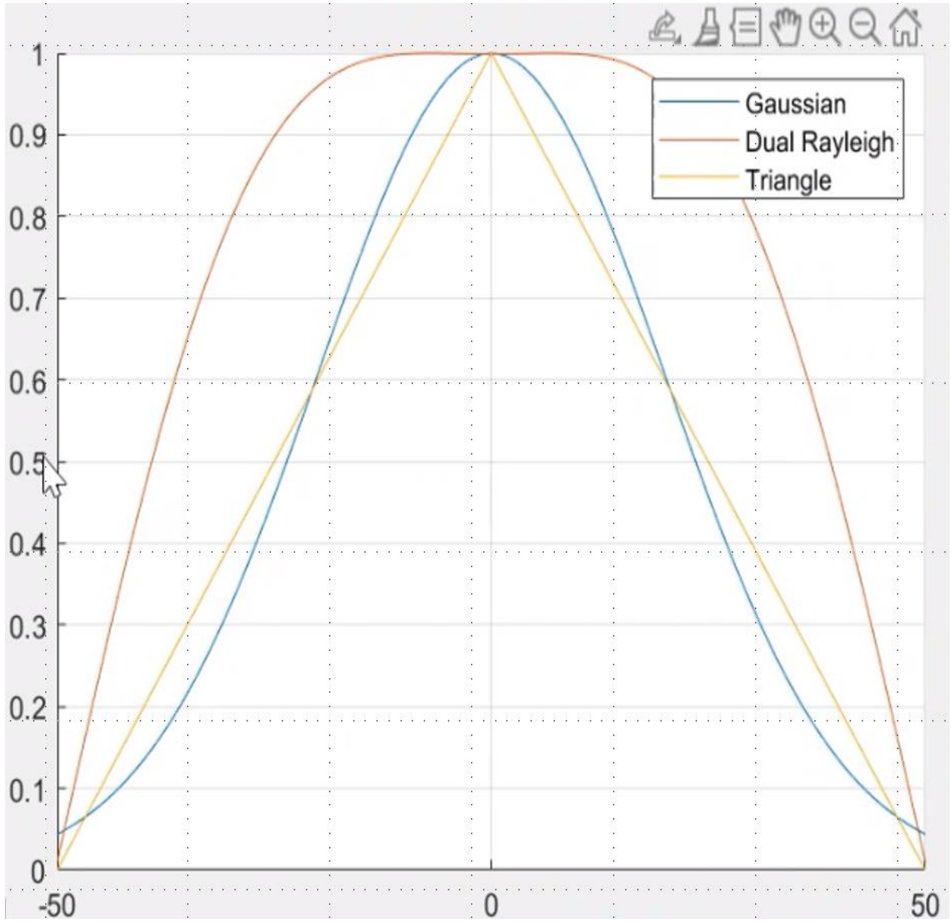


Contribution: Adee Ran, 29 June 2021

P802.3ck Module Input : Windowing Tests



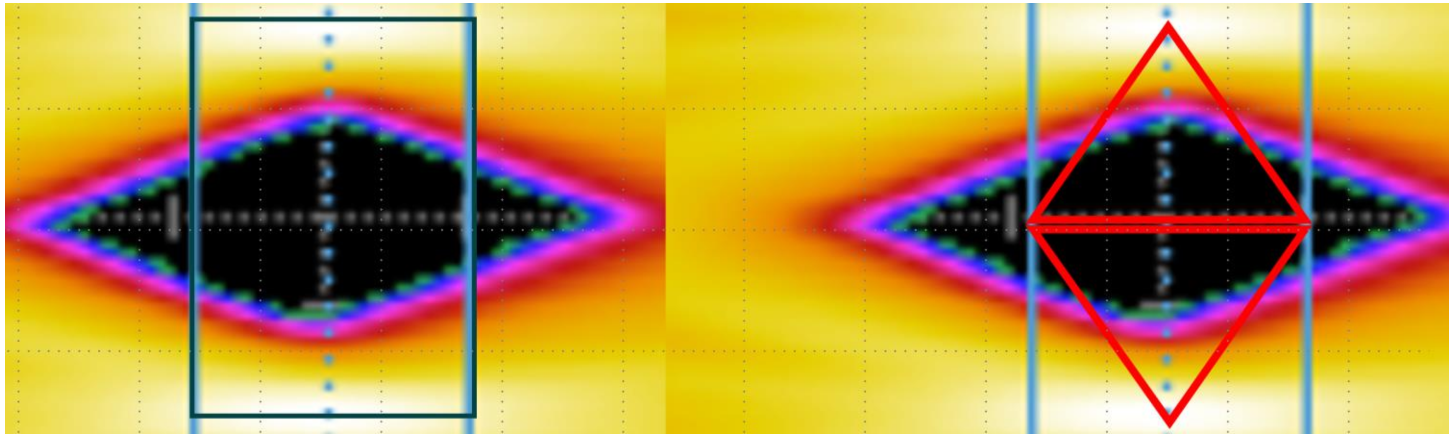
P802.3ck Module Input : Windowing Results



Windowing function	Mean (dB) Same Stimulus	Std. Dev (dB)	variation range (dB)
Gaussian	9.84895	0.34953	2.4
Triangle	10.08471	0.354949	2.2
Dual Rayleigh	10.54787	0.367252	2.01
Boxcar	11.61162	0.365577	2.5

P802.3ck Module Input : Observations/Call to action

- It’s premature to assert there is a well understood root cause to VEC run-run variability
- Measurement Windowing tests indicate a 25% reduction in variability with a Dual Raleigh window as opposed to currently defined Boxcar windowing
- Even for short channels (TP4) the Host Input VEC/impairment calibration solution space is small
- For the long channel (TP1a) the Module Input VEC/impairment calibration has no known solution space
- The historical conventions behind an “inner diamond” BER contour lends weight to a modified windowed function to emphasize EH evaluation toward the center of the eye rather than the edges.



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