Effective Return Loss (ERL) To Limit COM Variability

For Comment Resolution of r02-26, r02-55, and r02-56

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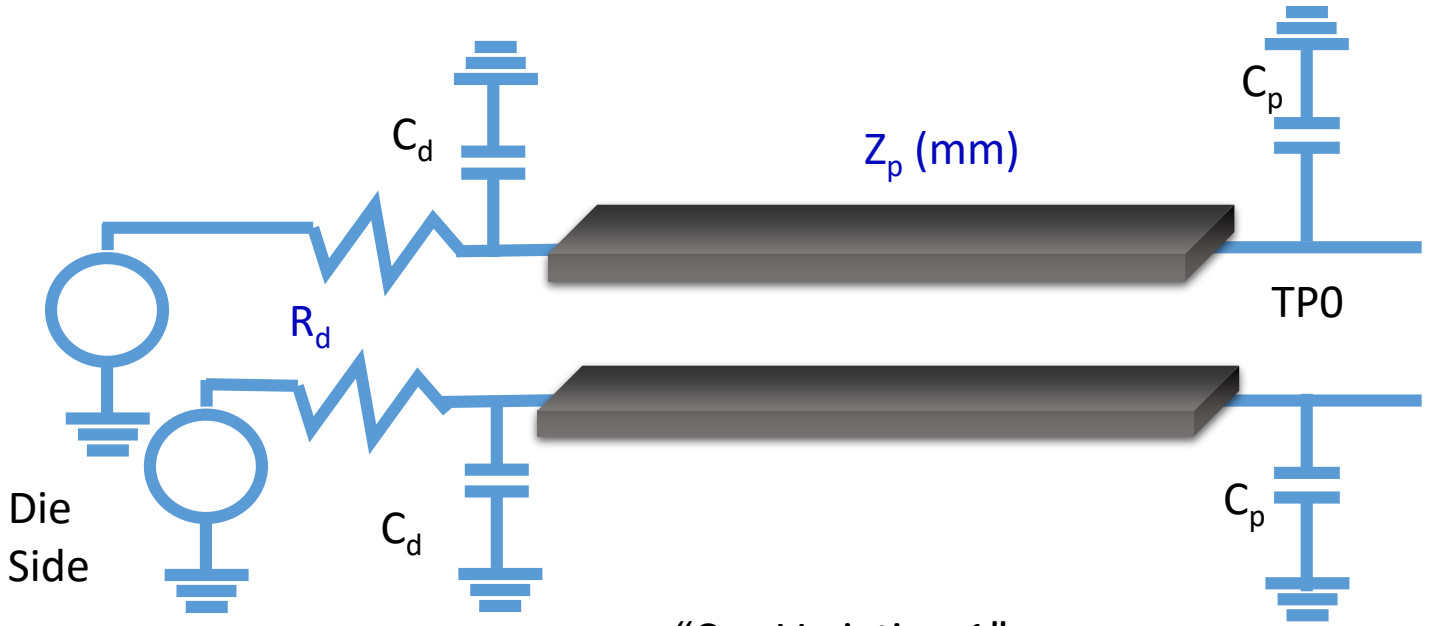
TOC

- New Package example
- Compare COM variability to “*dudek_062817_3cd_adhoc*”
- Introduction to Effective Return Loss (ERL)
- ERL data for prior package parameter sweeps
- ERL edit suggestions
- ERL description
- Recommendations

Consider

- A COM like package which passes the Return Loss Mask, Minimum SNR_{ISI}, and exceeds the V_p/V_f ratio.

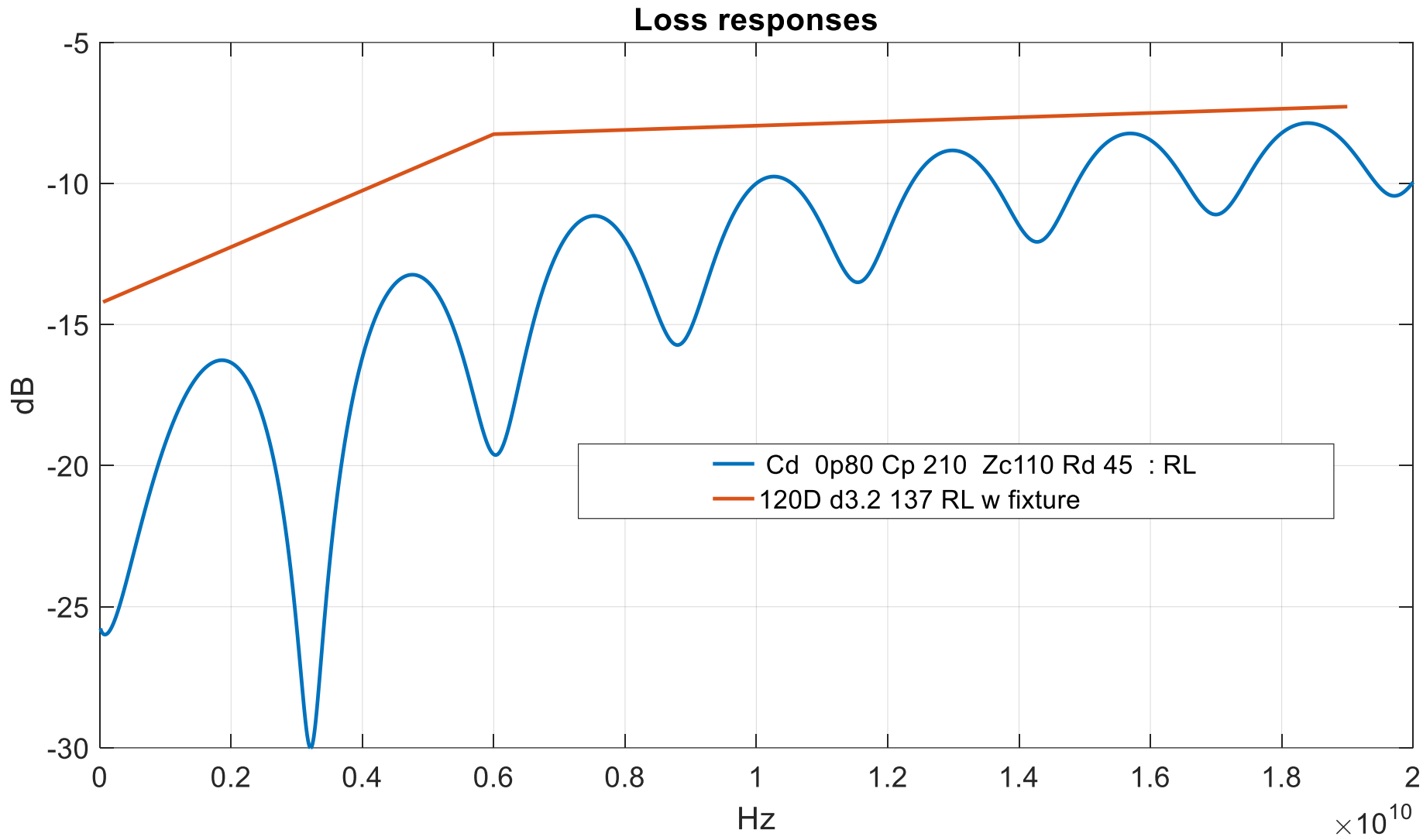


Pkg_Zc (Ω)	110
Cd (nF)	2.1E-04
Rd (Ω)	[45 45]
Cp (nF)	8.0E-05
Zc(mm)	30

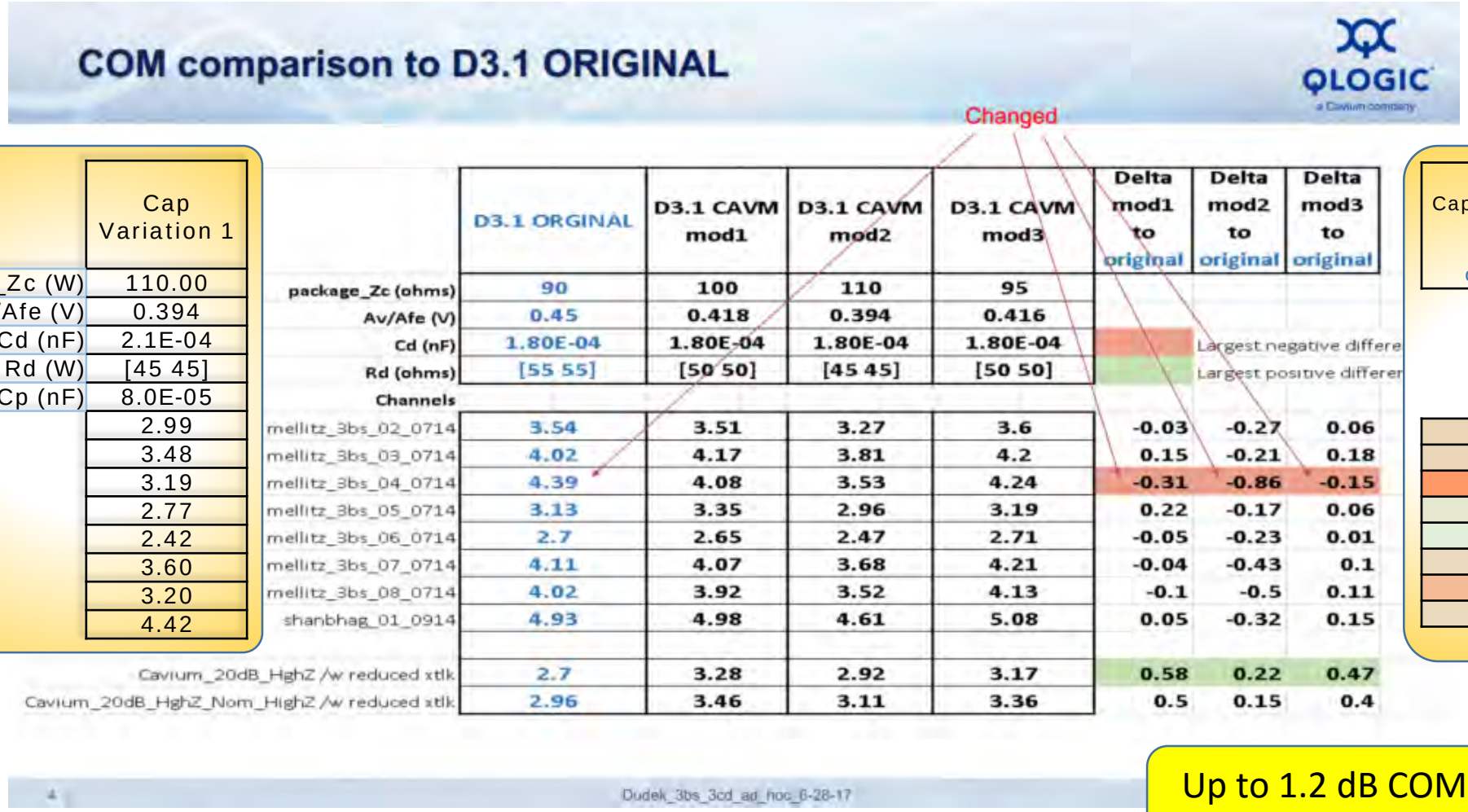
"Cap Variation 1"

- Has less device capacitance
- But more package capacitance

Return Loss for “Cap Variation 1” Passes



“Cap Variation 1” for Table in *dudek_062817_3cd_adhoc*



	Cap Variation 1
Pkg_Zc (W)	110.00
Av/Afe (V)	0.394
Cd (nF)	2.1E-04
Rd (W)	[45 45]
Cp (nF)	8.0E-05
	2.99
	3.48
	3.19
	2.77
	2.42
	3.60
	3.20
	4.42

	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3	Delta mod1 to original	Delta mod2 to original	Delta mod3 to original
package_Zc (ohms)	90	100	110	95			
Av/Afe (V)	0.45	0.418	0.394	0.416			
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04			
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]			
Channels							
mellitz_3bs_02_0714	3.54	3.51	3.27	3.6	-0.03	-0.27	0.06
mellitz_3bs_03_0714	4.02	4.17	3.81	4.2	0.15	-0.21	0.18
mellitz_3bs_04_0714	4.39	4.08	3.53	4.24	-0.31	-0.86	-0.15
mellitz_3bs_05_0714	3.13	3.35	2.96	3.19	0.22	-0.17	0.06
mellitz_3bs_06_0714	2.7	2.65	2.47	2.71	-0.05	-0.23	0.01
mellitz_3bs_07_0714	4.11	4.07	3.68	4.21	-0.04	-0.43	0.1
mellitz_3bs_08_0714	4.02	3.92	3.52	4.13	-0.1	-0.5	0.11
shanbhag_01_0914	4.93	4.98	4.61	5.08	0.05	-0.32	0.15
Cavium_20dB_HghZ /w reduced xtlk	2.7	3.28	2.92	3.17	0.58	0.22	0.47
Cavium_20dB_HghZ_Nom_HighZ /w reduced xtlk	2.96	3.46	3.11	3.36	0.5	0.15	0.4

Delta Cap Variation 1 to original
-0.55
-0.54
-1.20
-0.36
-0.28
-0.51
-0.82
-0.51

Up to 1.2 dB COM change
Compare to “original”

The Proposed "Mod1" Reduces the Difference But Still Has up to 0.9 dB COM Change

COM comparison to Mod3 (OIF adopted)

QLOGIC
a Cavium company

Changed

	Cap Variation 1
Pkg_Zc (W)	110.00
Av/Afe (V)	0.394
Cd (nF)	2.1E-04
Rd (W)	[45 45]
Cp (nF)	8.0E-05
	2.99
	3.48
	3.19
	2.77
	2.42
	3.60
	3.20
	4.42

	D3.1 ORGINAL	D3.1 CAVM mod1	D3.1 CAVM mod2	D3.1 CAVM mod3	Delta original to mod3	Delta mod1 to mod3	Delta mod2 to mod3	Delta Cap Variation 1 to mod1 proposal
package_Zc (ohms)	90	100	110	95				
Av/Afe (V)	0.45	0.418	0.394	0.416				
Cd (nF)	1.80E-04	1.80E-04	1.80E-04	1.80E-04		Largest negative difference		
Rd (ohms)	[55 55]	[50 50]	[45 45]	[50 50]		Largest positive difference		
Channels								
mellitz_3bs_02_0714	3.54	3.51	3.27	3.6	-0.06	-0.09	-0.33	-0.52
mellitz_3bs_03_0714	4.02	4.17	3.81	4.2	-0.18	-0.03	-0.39	-0.67
mellitz_3bs_04_0714	4.39	4.08	3.53	4.24	0.15	-0.16	-0.71	-0.89
mellitz_3bs_05_0714	3.13	3.35	2.96	3.19	-0.06	0.16	-0.23	-0.58
mellitz_3bs_06_0714	2.7	2.65	2.47	2.71	-0.01	-0.06	-0.24	-0.23
mellitz_3bs_07_0714	4.11	4.07	3.68	4.21	-0.1	-0.14	-0.53	-0.47
mellitz_3bs_08_0714	4.02	3.92	3.52	4.13	-0.11	-0.21	-0.61	-0.72
shanbhag_01_0914	4.93	4.98	4.61	5.08	-0.15	-0.1	-0.47	-0.56
Cavium_20dB_HghZ /w reduced xtlk	2.7	3.28	2.92	3.17	-0.47	0.11	-0.25	
Cavium_20dB_HghZ_Nom_HighZ /w reduced xtlk	2.96	3.46	3.11	3.36	-0.4	0.1	-0.25	

5 Dudek_3bs_3cd_ad_hoc_6-28-17

Proposal: Add a New Requirement for Effective Return Loss (ERL)

ERL is in the context of signaling

ERL uses a time domain “echo” from single pulse (symbol)

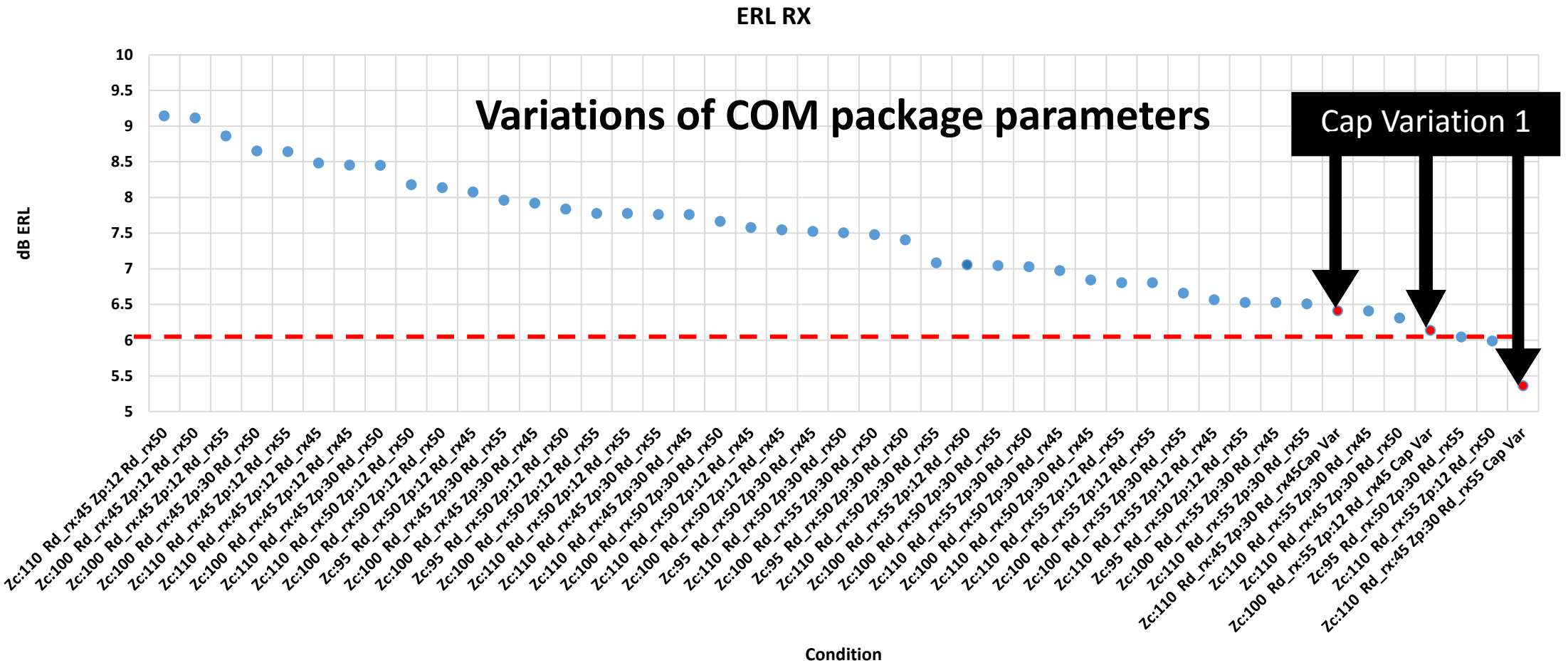
- Pulse based Time Domain Reflectometry (PTDR)

ERL is computed from the pulse echo response (PER) using methods similar to COM

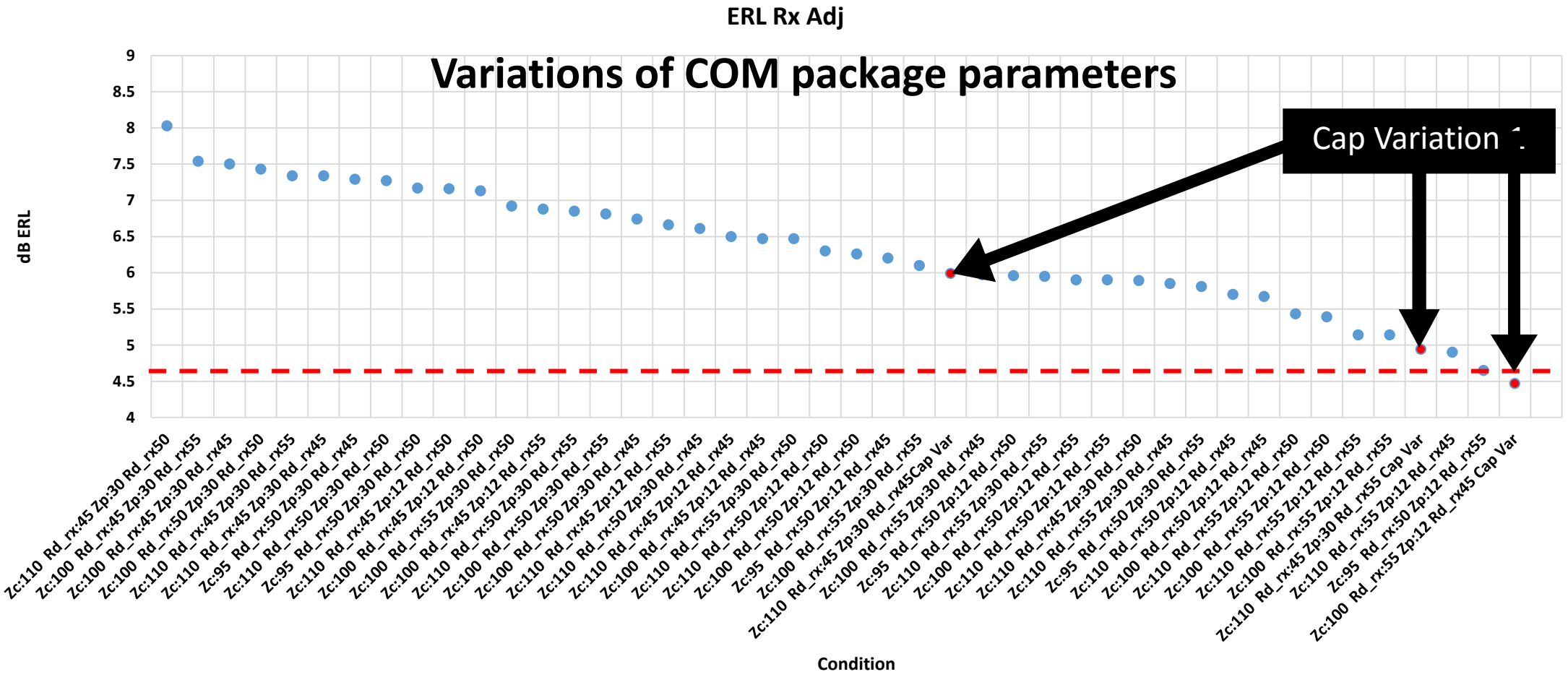
- Statistical noise convolution (mellitz_3cd_02_060717_elect_adhoc)

Compensate ERL for transmitter using V_p/V_f ratio

Propose ERL for Tx > 6.0 dB



Propose ERL for Rx > 4.6 dB



Add ERL Row to Table 120D-1

- Add note for the ERL row
  - use a 18 ps (20%-80%) transition time and
  - Use a 4th order Bessel-Thomsen Filter with dB point at 0.75 f_b
  - $Zt \in \begin{cases} 55 \\ 50 \\ 45 \end{cases}$
- ERL_{tx} max > 6.0 dB

Table 120D–1—200GAUI-4 and 400GAUI-8 C2C transmitter characteristics at TP0a

Parameter	Reference	Value	Units
Signaling rate per lane (range)		26.5625 ± 100 ppm	GBd
Differential peak-to-peak output voltage[a] (max) Transmitter disabled Transmitter enabled	93.8.1.3	 30 1200	 mV mV
Common-mode voltage[a] (max)	93.8.1.3	1.9	V
Common-mode voltage[a] (min)	93.8.1.3	0	V
AC common-mode output voltage[a] (max, RMS)	93.8.1.3	30	mV
Differential output return loss (min)	120D.3.1.8	Equation (120D–9)	dB
Common-mode output return loss (min)	93.8.1.4	Equation 93-4	dB
Output waveform[b] Level separation mismatch ratio R_{LM}(min) Steady state voltage v_f(max) Steady state voltage v_f(min) Linear fit pulse peak (min) Pre-cursor equalization Post-cursor equalization	 120D.3.1.2 120D.3.1.4 120D.3.1.4 120D.3.1.4 120D.3.1.5 120D.3.1.5	 0.95 0.6 0.4 0.736 × v_f Table 120D–3 Table 120D–4	 — V V V — —
Signal-to-noise-and-distortion ratio (min)	120D.3.1.6	31	dB
Transmitter Output residual ISI SNR_{ISI} (max)	120D.3.1.7	38	dB
Output jitter J_{RMS} (max) J4 (max) Even-odd jitter (max)	 120D.3.1.1 120D.3.1.1 120D.3.1.1	 0.023 0.118 0.019	 UI UI UI

[a]Measurement uses the method described in 93.8.1.3 with the exception that the PRBS13Q test pattern is used.
[b]The state of the transmit equalizer is controlled by management interface.

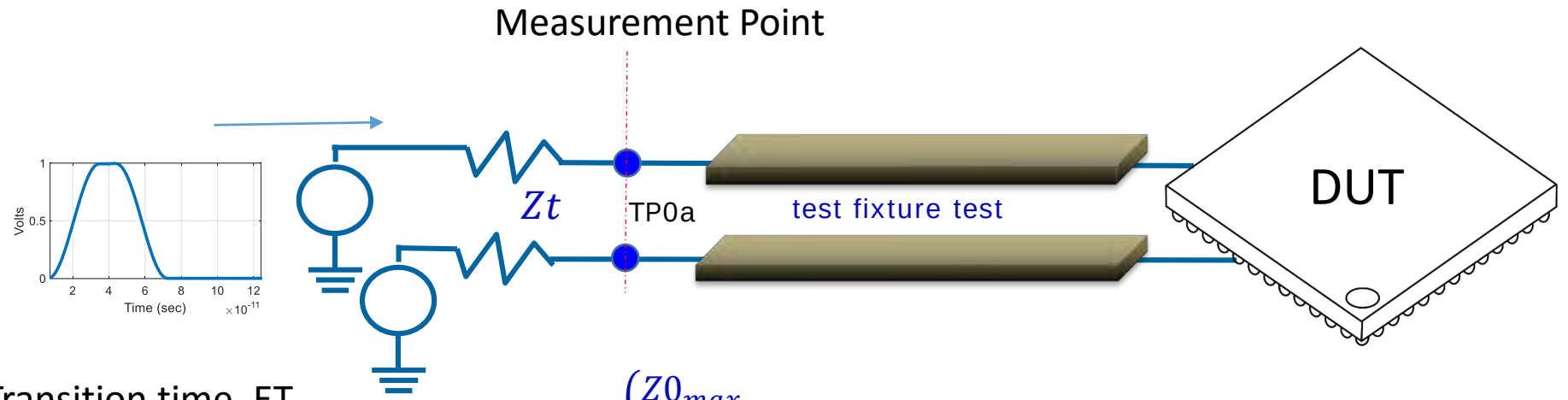
Add ERL Row to Table 120D-5

- Add note for the ERL row
  - use a 18 ps (20%-80%) transition time and
  - Use a 4th order Bessel-Thomsen Filter with dB point at 0.75 f_b
  - $Zt \in \begin{cases} 55 \\ 50 \\ 45 \end{cases}$
- ERL max > 4.6 dB

Table 120D–5—200GAUI-4 and 400GAUI-8 C2C receiver characteristics at TP5a

Parameter	Reference	Value	Units
Differential input return loss (min)	93.8.1.4	Equation (93-3)	dB
Differential to common mode input return loss	93.8.1.4	Equation (93-5)	dB
Interference tolerance	120D.3.2.1	Table 120D–6	—
Jitter tolerance	120D.3.2.2	Table 120D–7	—

ERL Annex: Basic Concept, pulse TDR (PTDR)

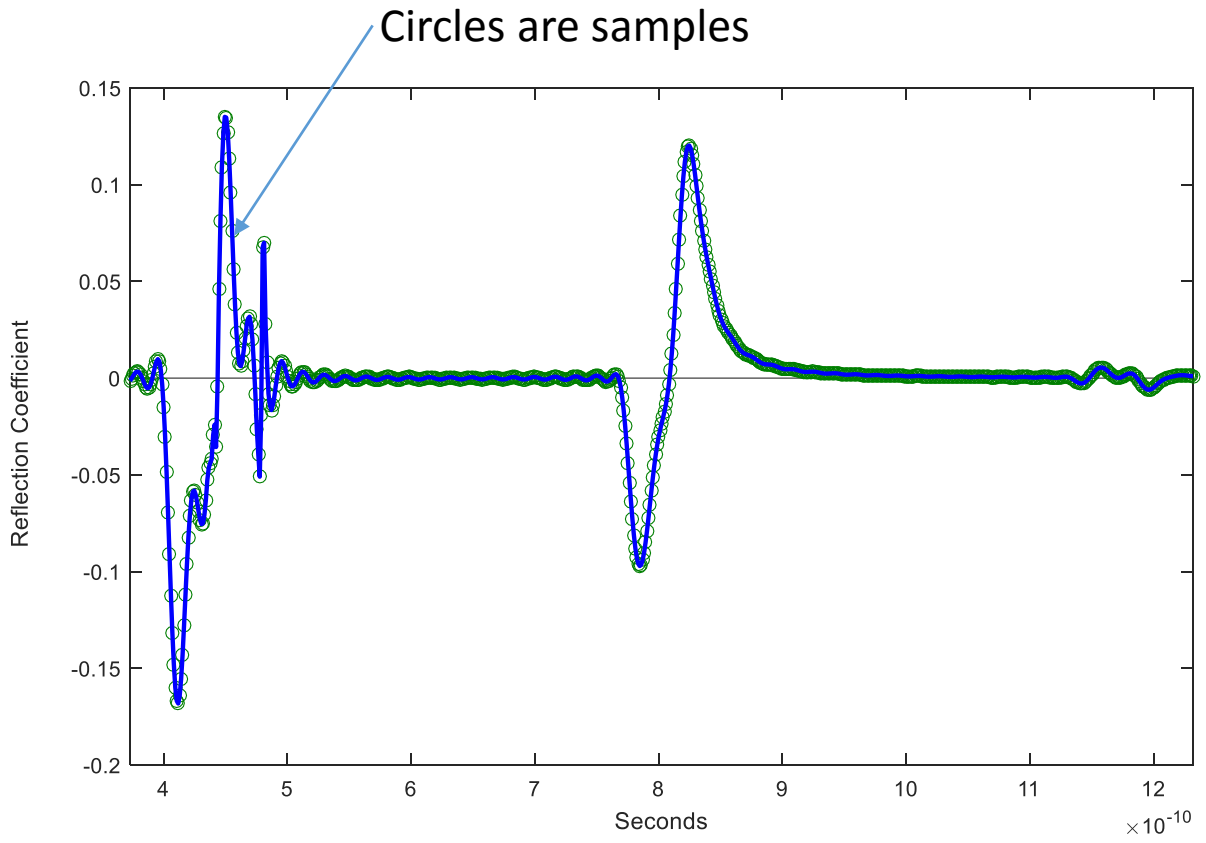


ERL Transition time, ET_r

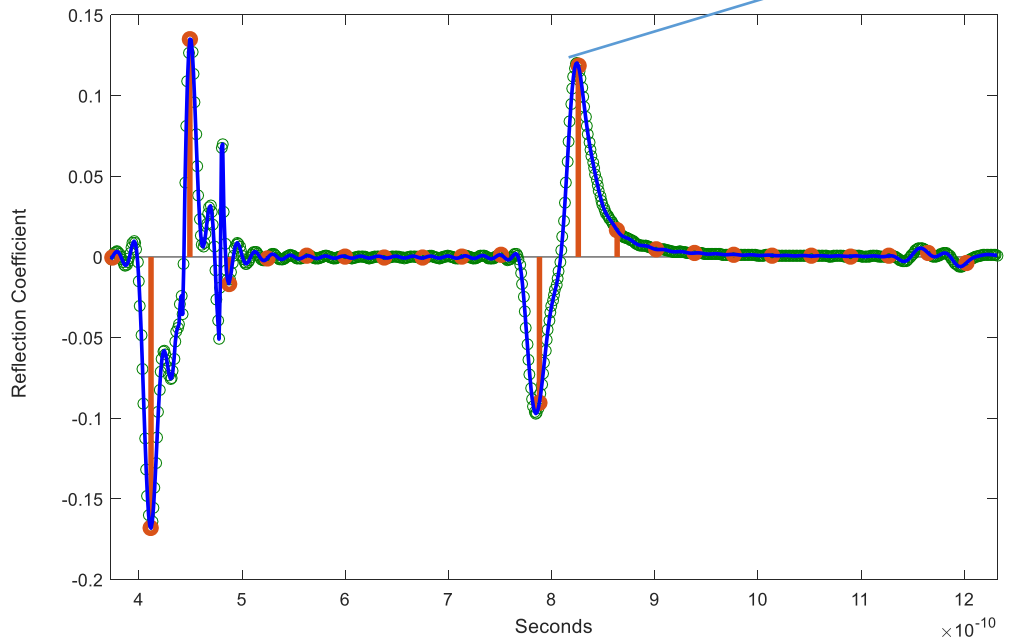
$$Zt \in \begin{cases} Z0_{max} \\ Z0_{mid} \\ Z0_{min} \end{cases}$$

PTDR measurements are in terms of rho (ρ)
PTDR may be computed from s-parameter responses

Determine PTDR response for each Zt



Determine effective reflection coefficient for each sample in a unit interval



S(n,m) where m = 1 to numbers samples per UI, M and n = 1 to number of UI's in response , N

Note: MxN is the number samples response

Compute a Probability Density Function (PDF) and Cumulative a Distribution Function (CDF) for the ERL Response

- Referring to equation 93A-39 and 93A-40
  - Commute PDF $p_n(y)$ where h(n) is replaced which S(n,m) for each m
  - And $p_n(y)$ is indexed by $p_{n,m}(y)$
- Determine the CDF (cumulative distribution function) for each $p_{n,m}(y)$
  - This a set of CDF's of the reflection coefficients.
- Choose the worst ERL for all m by
  - Determining the value of P(n,m) where the CDF just equals DER0
    - This value converted to dB is the ERL
- The sample which has the most ERL is chosen for each Zt
- The reported ERL is the one with most ERL for all the Zt values

93A.1.7.1 Interference amplitude distribution

The interference amplitude distribution is computed from the sampled pulse response $h(n)$ with the assumption that the transmitted symbols are independent, identically distributed random variables and that the symbols are uniformly distributed across the set of L possible values. For the purpose of this subclause, $h(n)$ is a general notation that corresponds to $A_{DD}h_f(n)$ (see 93A.1.7.2), $h_{ISI}(n)$, or $h^{(k)}((i/M+n)T_b)$ (see 93A.1.7.3).

Equation (93A–39) defines the nth component of the interference amplitude distribution function where $\delta(y)$ is the Dirac delta function.

$$p_n(y) = \frac{1}{L}\sum_{l=0}^{L-1}\delta\left(y-\left(\frac{2l}{L-1}-1\right)h(n)\right) \quad \text{(93A–39)}$$

The set of N such components are combined via convolution to obtain the complete interference amplitude distribution. Initialize $p(y)$ to $\delta(y)$ and then evaluate Equation (93A–40) sequentially for n=0 to N–1.

$$p(y) = p(y) * p_n(y) \quad \text{(93A–40)}$$

NOTE 1—COM is expected to be numerically computed using a quantized amplitude axis y. The amplitude step Δy introduces quantization error in the calculated distribution function that is compounded by subsequent convolutions with other quantized distribution functions. It is recommended that Δy be no larger than 0.1% of A_v or 0.01 mV, whichever is smaller.

NOTE 2—It is recommended that components of the pulse response whose amplitude is less than 0.1% of A_v be ignored as they likely correspond to measurement noise or numerical artifacts.

Package Loss Compensation for Transmitter

- ERL is adjusted by removing the insertion loss contributor
- ERL_{tx}= ERL- 20*LOG10(0.736/(V_p/V_f))*2

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Output waveform[b] Level separation mismatch ratio R_{LM}(min) Steady state voltage v_f(max) Steady state voltage v_f(min) Linear fit pulse peak (min) Pre-cursor equalization Post-cursor equalization	 120D.3.1.2 120D.3.1.4 120D.3.1.4 120D.3.1.4 120D.3.1.5 120D.3.1.5	 0.95 0.6 0.4 0.736 × v_f Table 120D–3 Table 120D–4	 — V V V — —

Recommendations

- ❑ Add an ERL_{tx} row to Table 120D-1 where the max entry is 6.0 dB
- ❑ Add an ERL row to Table 120D-5 where the max entry is 4.6 dB
- ❑ Add an Annex describing the measurement of ERL

Or

- ❑ Do not change D3.2 COM and RITT