RL, ERL, COM, & PTDR alternative
to remedies for comments 16, 21, 22, 25 for D2.2
and unsatisfied comments 21037,21049. 21050, 21052, and 20113

Richard Mellitz, Samtec

Ed Sayre, Samtec

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How much impact does return loss have on the electrical standards?

- Much of the analysis in past standards is rooted in broadband concepts which specify a combination of computation from the following concepts
  - Magnitude of frequency domain (FD) insertion loss (IL)
  - Magnitude of FD return loss (RL)
  - Magnitudes of FD crosstalk (NEXT, FEXT)

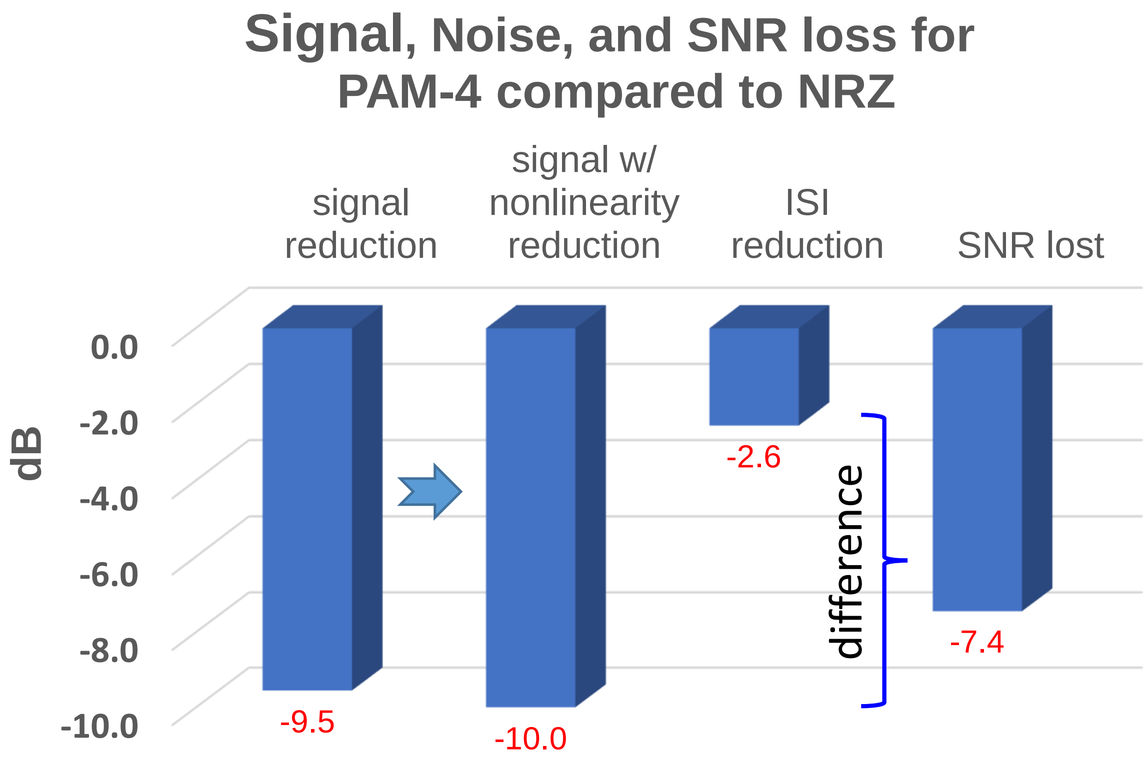
- COM specifies a minimum signal to noise ratio computed in the time domain (TD)
  - COM analysis is rooted in baseband concepts
  - Computed from
    - The IFFT of complex s-parameters models for the reference package and the channel
    - Device specification
  - These inheritably include return loss and crosstalk
- Problem:
  - It is possible that a channel fails in practice even though it passes the specification analysis using the appropriate device and channel characteristics. From the point of view of the specification, this is a "False Positive" result.
  - It is also possible that a channel passes in practice even though it fails the specification analysis using the appropriate device and channel characteristics. This is a "False Negative" result.
  - Identify the connection between a device return loss analysis results and the time domain COM results

What will be shown

- PAM 4 is more sensitive to return loss than NRZ
- Package reflections and channel reflections interplay with a DFE
- Channel reflections from near device locations have worse (COM) performance
- Channel reflections near electrically short packages may be absorbed if a DFE is present
  - Suggests presence of DFE alters RL requirements
- Return loss has components of insertion loss and re-reflections making it a poor metric for the prediction of channel performance.
  - Short packages have worse return loss than long package but perform better
- A return loss specification is improved by adjusting for a DFE and insertion loss
- A method to compute a single value metric based on reflected voltage at a chosen test point… called Effective Return Loss (ERL).

Why return loss is more of an issue for PAM-4

- ❑ Required signal bandwidth reduces by about ½
- ❑ Signals goes down by 2/3
- ❑ The impact of non-linearity reduces the signal by another 5 %
- ❑ ISI noise only goes down by about ¼, not 2/3
- ❑ That means RL impairment is 7.4 dB worse for PAM-4 vs NRZ



- ❑ Hence the RL impact can be expected to be more critical and worsen the problem of the false positives
- ❑ So let’s look closer at how return loss effects performance

Isolating impact of Return Loss and Reflections

- ❑ Consider a channel whose only impairment besides loss are reflections
  - Keep loss constant and only alter reflections
- ❑ Evaluate pulse response at the receiver for reflection choices
- ❑ Perform comparisons between
  - Channel operating margin (COM)
  - Effective Return loss (ERL)
  - Effective Return loss (ERL) with time gated weighting filter
  - FD Return Loss

Channel RL Experiment

Consider a channel with just 2 impairments

1) Loss ~27 dB @ 13.3 GHz
2) Two reflections

Determine ISI impact by using a COM computation

- Signaling: 50Gbs PAM4 – IEEE802.3 cd clause 137 equalization and the 30 mm COM package
- For COM computation, remove all noise sources and jitter except SNR_Tx
  - Adjust SNR_Tx to achieve just slightly higher than 3 dB COM
  - For these experiments 24 dB was used for SNR_Tx

- ❑ Access correlation between COM and channel PTDR computation into a single number called ERL
- ❑ Access computation methods for ERL
- ❑ Tie ERL to parameters in the device and channel specifications together

Reflection experiment using a 27* dB IL channel and 2 reflections

“a” is lead in to reflection features
“b” is separation between reflections

Adjust channel length by “a” and ‘b’ to keep IL constant

*27.1 dB @ 13.3 GHz

Channel model is similar to IEEE802.3bj CR host board model

Gamma 0	0
Alpha 1	4.114e-4
Alpha2	2.547e-4
Tau	6.191e-03
Z0	100
Rev Z	50

Gamma 0	0
Alpha 1	0.0004114
Alpha2	0.0002547
Tau	0.006191
Z0	120
Rev Z	50

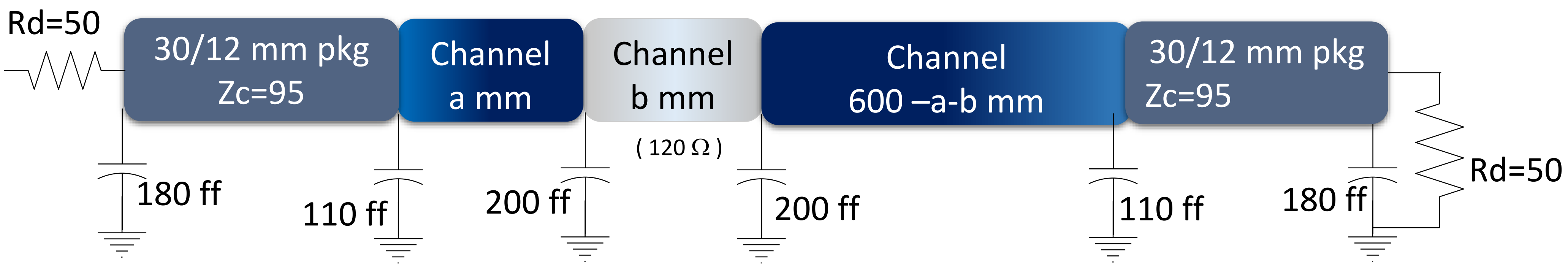
Gamma 0	0
Alpha 1	4.114e-4
Alpha2	2.547e-4
Tau	6.191e-03
Z0	100
Rev Z	50

Details, Keys, and Example ~ 27 dB @ 13.3 GHz

Differential RL11 and ERL11 are associated with Port 1

One side of a differential channel

Differential RL22 and ERL22 are associated with Port 2

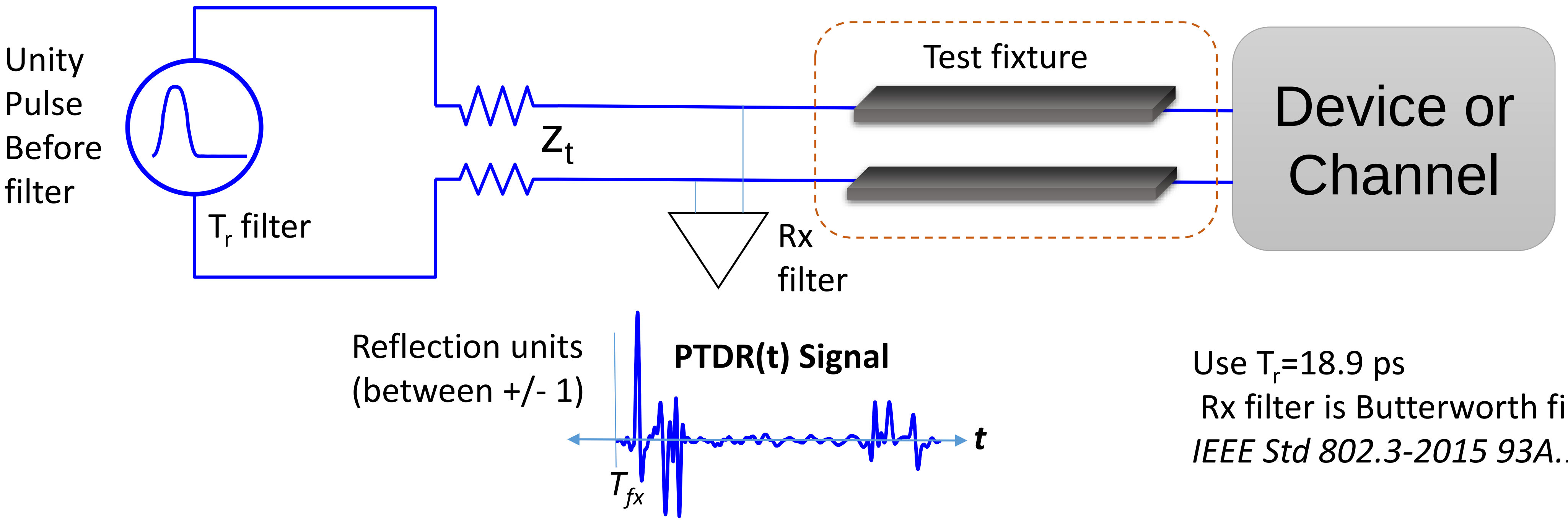


~27 dB @ 13.3 GHz

mm	ff	Ω	mm	ff	mm	ff	mm	ff	mm	ff	mm	Ω	ff	Ω
30	180	95	12	110	a	200	b	200	600 -a-b	110	30	95	180	50

Introduction Pulse Time Domain Reflectometry (PTDR)

- PTDR is time domain reflectometry using a pulse as a source
- T_{fx} is the time associated with the end of the test fixture
- For this work the test fixture is not included but will be revisited later
  - i.e. $T_{fx} = 0.$



Use T_r=18.9 ps
Rx filter is Butterworth filter as in *IEEE Std 802.3-2015 93A.1*

Effective reflection $R_{eff}(t)$ and ERL Computation

- ❑ $R_{eff}(t)$ is computed by time gating and weighting the PTDR waveform, PTDR(t)
  - where $T_{fx} < t < T_b(N_b + 1)$
    - N_b is the number for DFE taps
    - T_b is the time for one symbol (aka UI)
    - t is time in seconds
    - T_{fx} is the time associated with the end of the test fixture
- ❑ $reff_{l,m}$ is the time sampled waveform of $R_{eff}(t)$
  - Samples per UI (T_b) is represented by “i”
  - Number of UI (T_b) is represented by “m”
- ❑ Method 1: ERL=RMS($reff_{i,1:m}$)
- ❑ Method 2: ERL=Greatest CDF(PDF($reff_{i,1:m} \otimes$ [1]Constellation)) @BER
- ❑ Converting ERL to positive dB makes ERL somewhat similar to RL in the frequency domain

[1]*Constellation for PAM-4 = [-1 -1/3 1/3 1]*

Effective reflection waveform, $R_{eff}(t)$, is a $PTDR(t)$ filtered with a time gated weighting function

$$R_{eff}(t) = PTDR(t)\underbrace{\left(1 - \rho_x(1+\rho_x)e^{-\left(\frac{t-T_{fx}}{T_b}-N_b-1\right)^2}\right)}_{\text{DFE compensation and re-reflection}}\underbrace{10^{\frac{\beta_x\left(t-T_{fx}-T_b(N_b+1)\right)}{20}}}_{\text{Loss compensation}}$$

DFE compensation and re-reflection

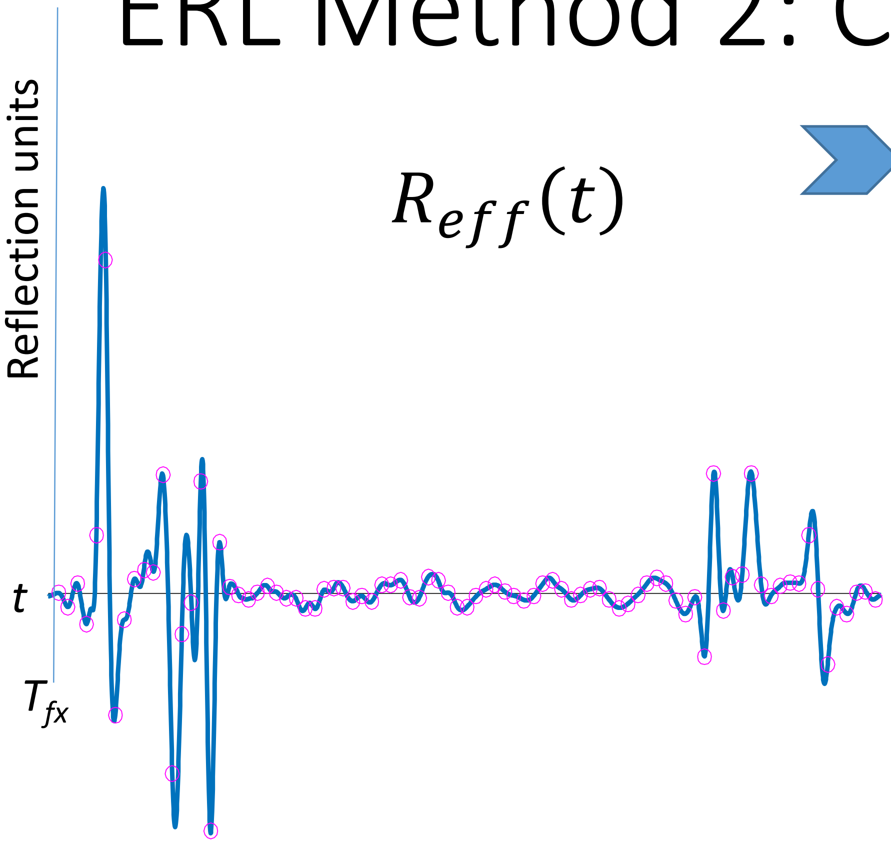
Loss compensation

β_x=10.7e9, $\rho_x = 10^{-\frac{ERL_{cx}}{20}} = 0.31$,
$ERL_{cx} = 10.2\ dB$

N_b is the number for DFE taps
T_b is the time for one symbol (aka UI)
t is time in seconds
T_{fx} is the time associated with the end of the test fixture
ERL_{cx} is the minimum channel ERL

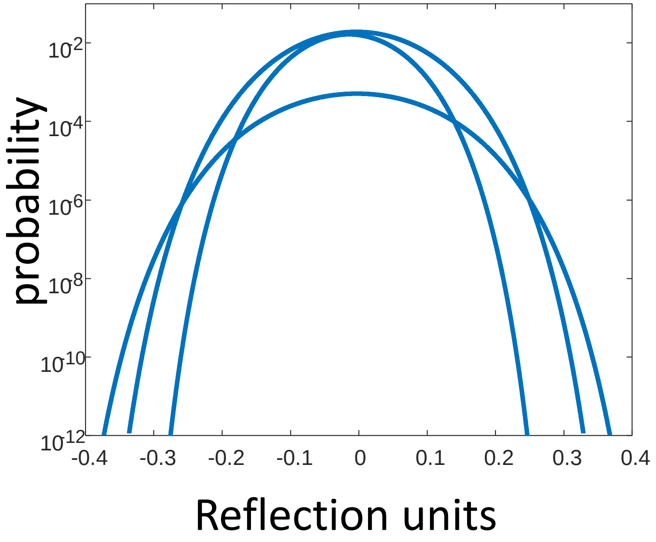
Gate and weighing accounting for Loss and DFE

ERL Method 2: Convolution method



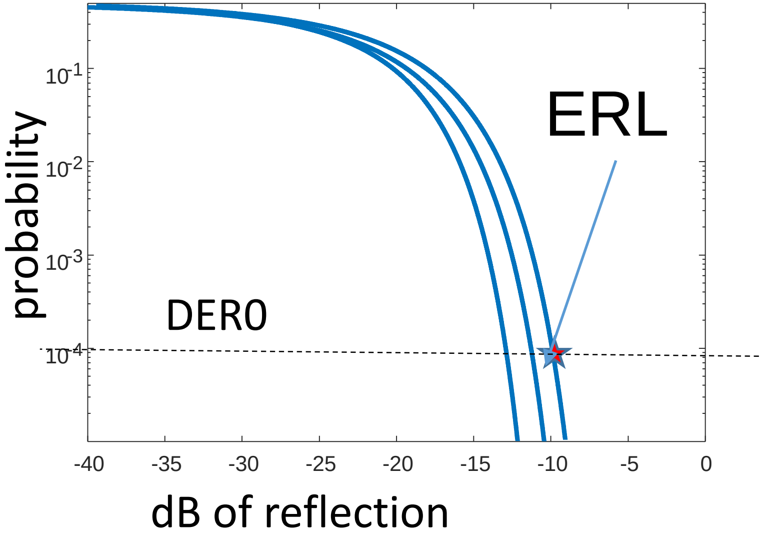
Single reflection symbol/ bit

PDF for each sample



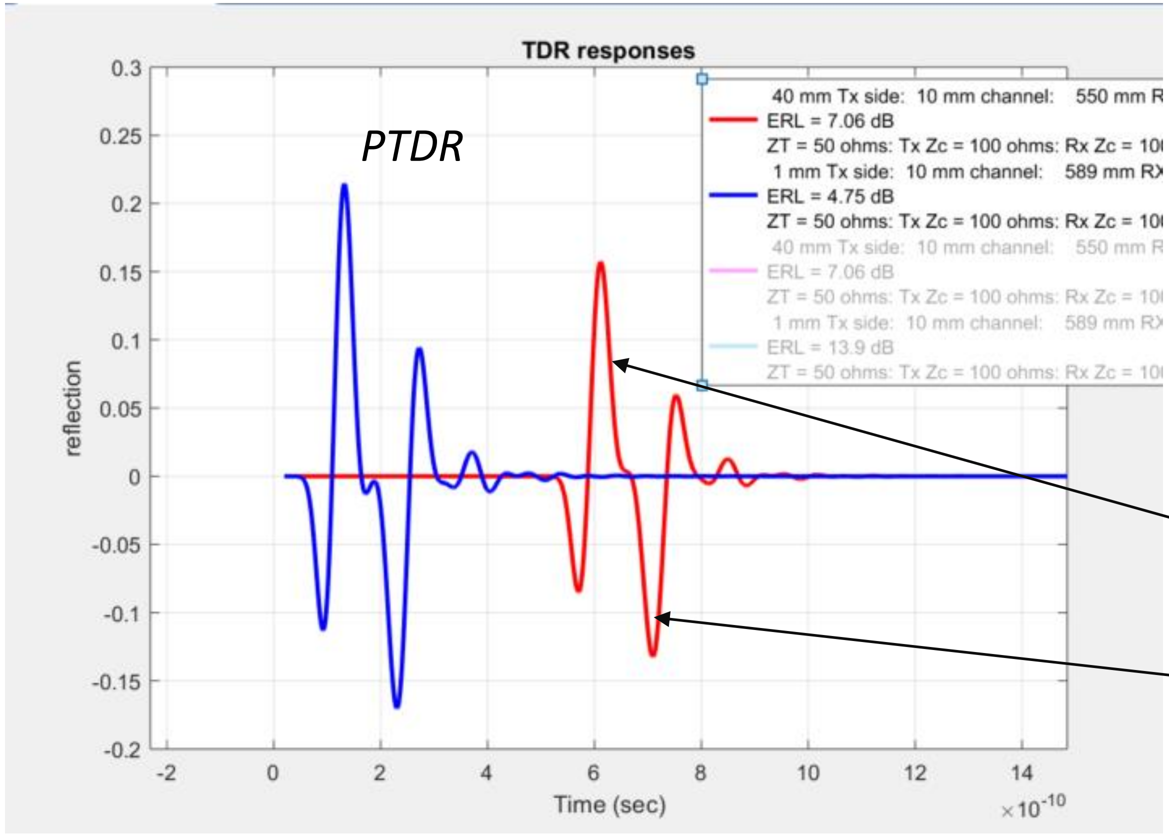
Superposition of reflections from many bits/symbols (PRBS) determines a probability for aggregate reflections

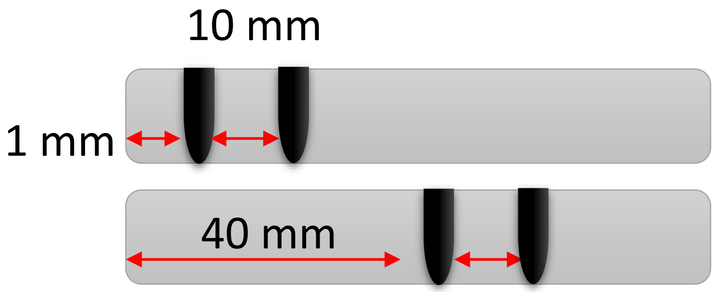
CDF for each sample



Cumulative reflection probability for many bits/symbols (PRBS)

PTDR for 1 mm and 40 mm lead in (a) 10 mm space (b): same insertion loss no gating



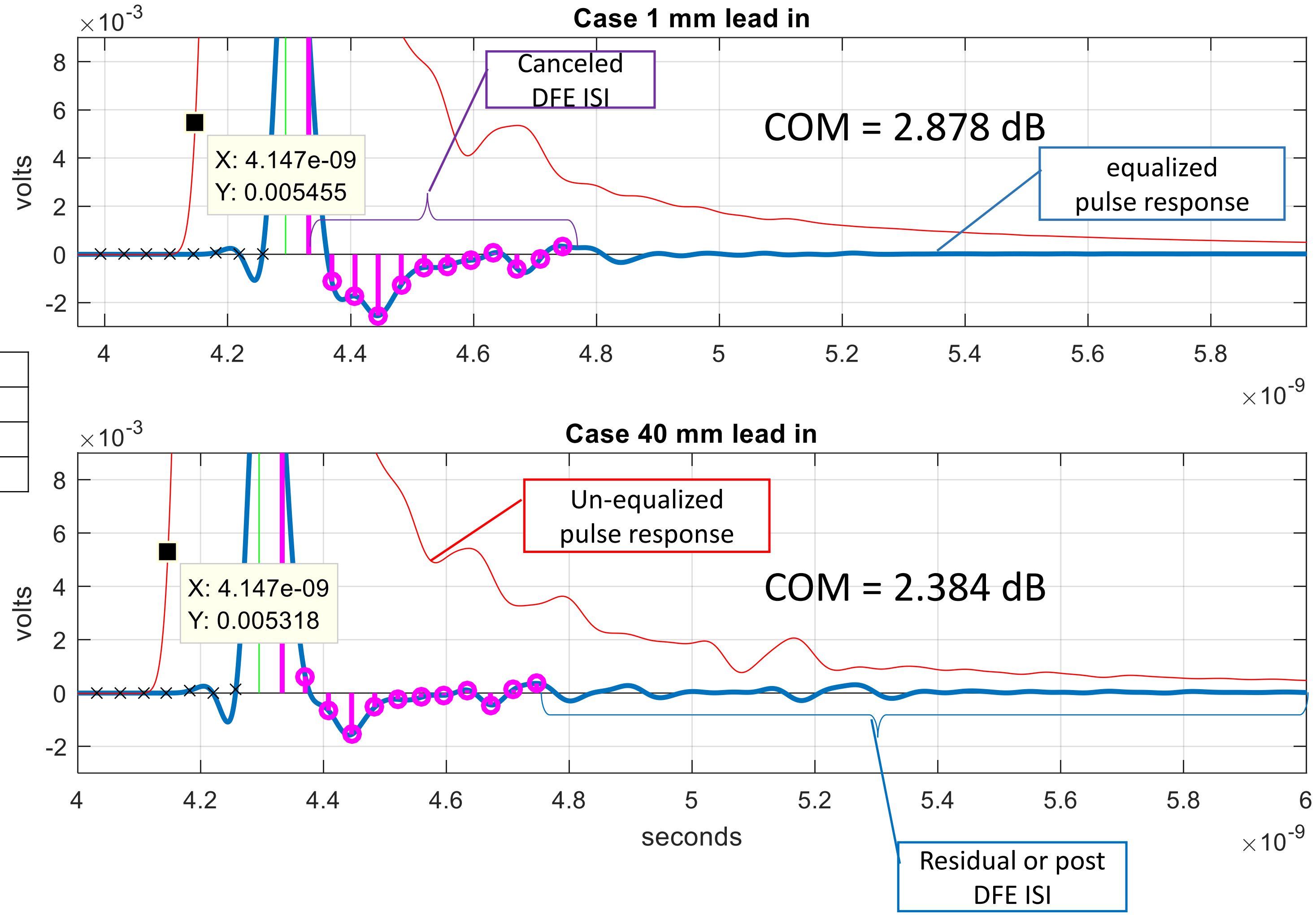


mm	ff	mm	ff	mm
1	200	10	200	589
40	200	10	200	550

Observation: More post DFE ISI in a=40 mm case, but less ISI in DFE region

Adjusted values to achieve around 3 dB COM

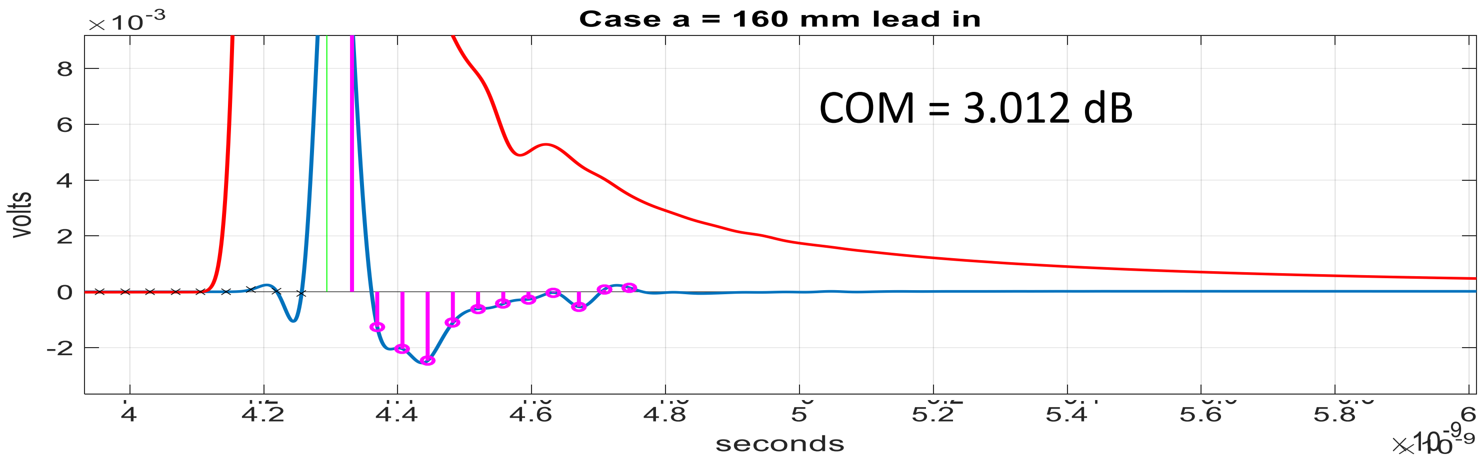
sigma_RJ	0
A_DD	0
eta_0	1.64E-99
SNR_TX	24



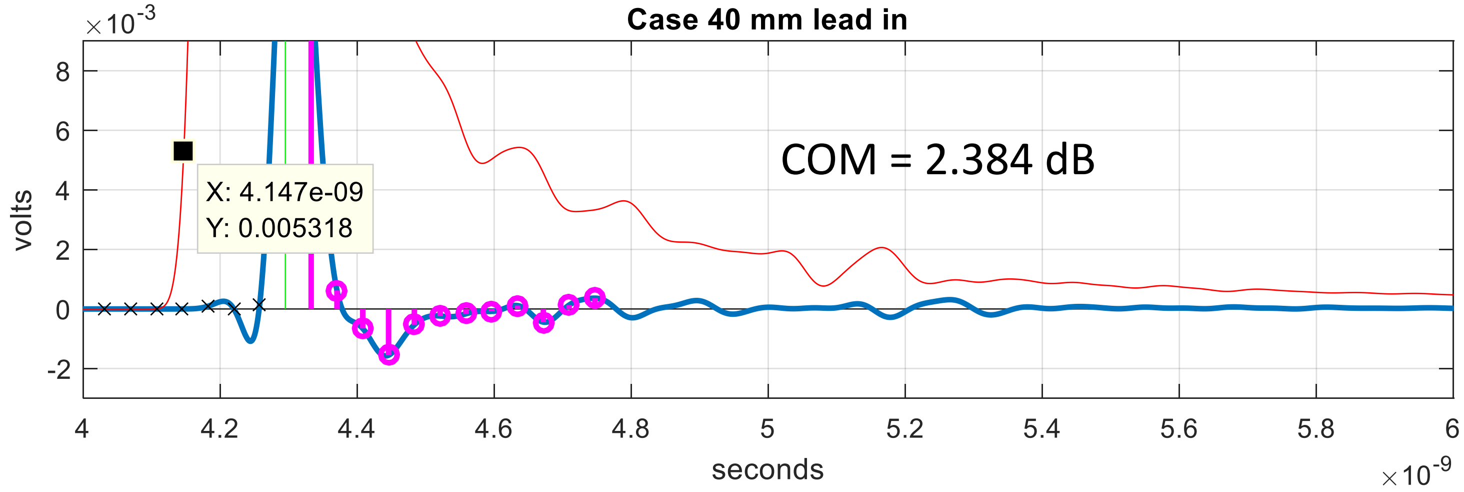
a=1 mm b=10 mm

a=40 mm b=10 mm

When a = 160 mm COM improves, However ISI is worse in DFE region

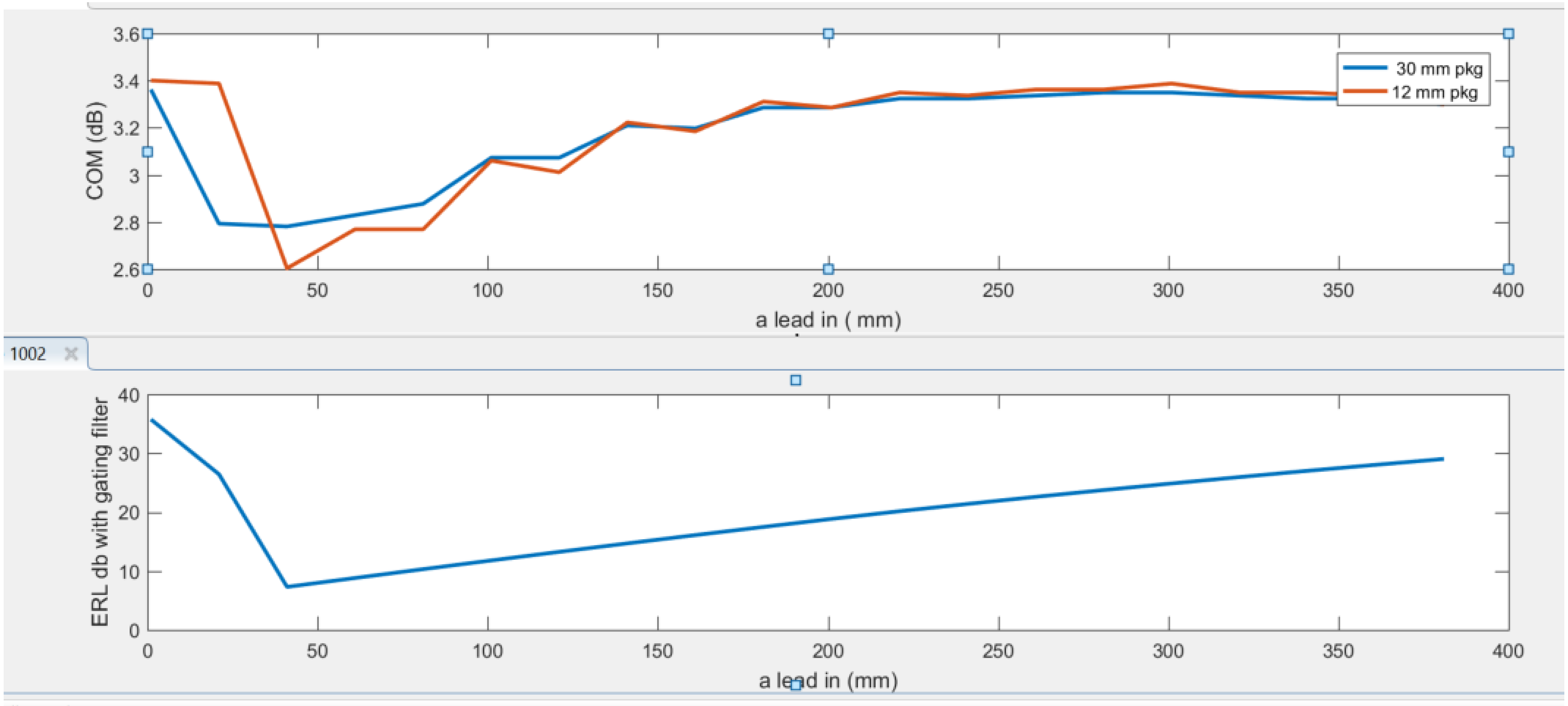


a=160 mm b=10 mm

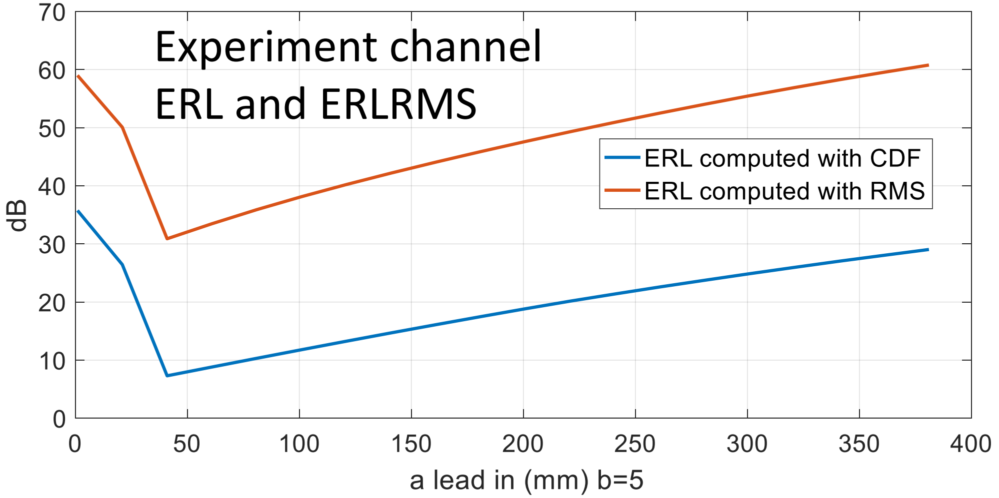


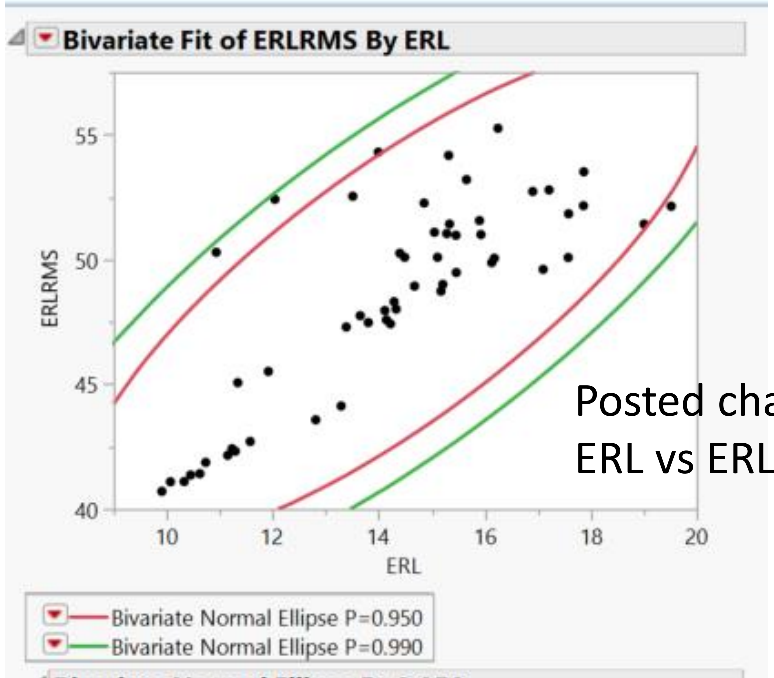
a=40 mm b=10 mm

Plot COM, ERL11 gated vs lead in (a) for b=10 mm and package length = 12 mm and 30 mm



ERLRMS seems to correlate well to ERL for channels with simple reflections... However





Bivariate Normal Ellipse P=0.950

Variable	Mean	Std Dev	Correlation	Signif. Prob	Number
ERL	14.28983	2.428231	0.796621	<.0001*	54
ERLRMS	48.53835	4.085123			

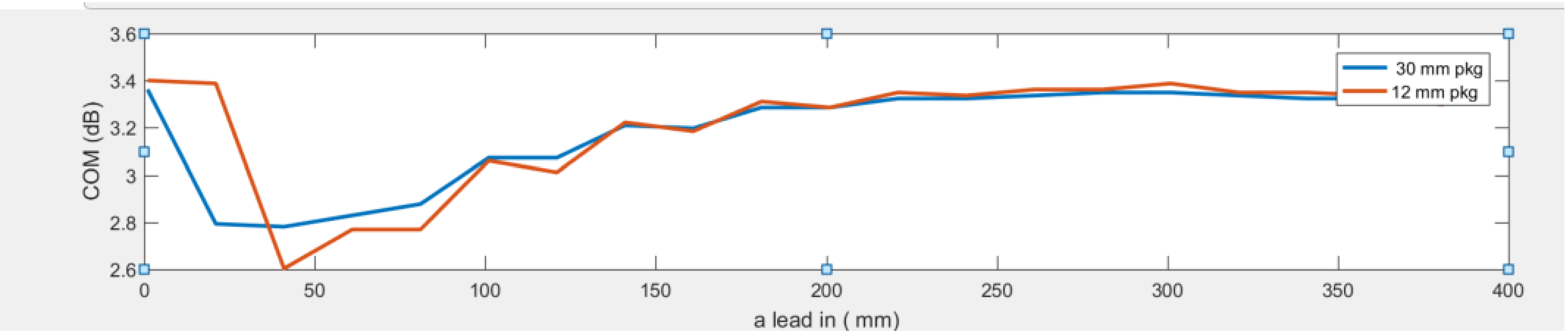
Bivariate Normal Ellipse P=0.990

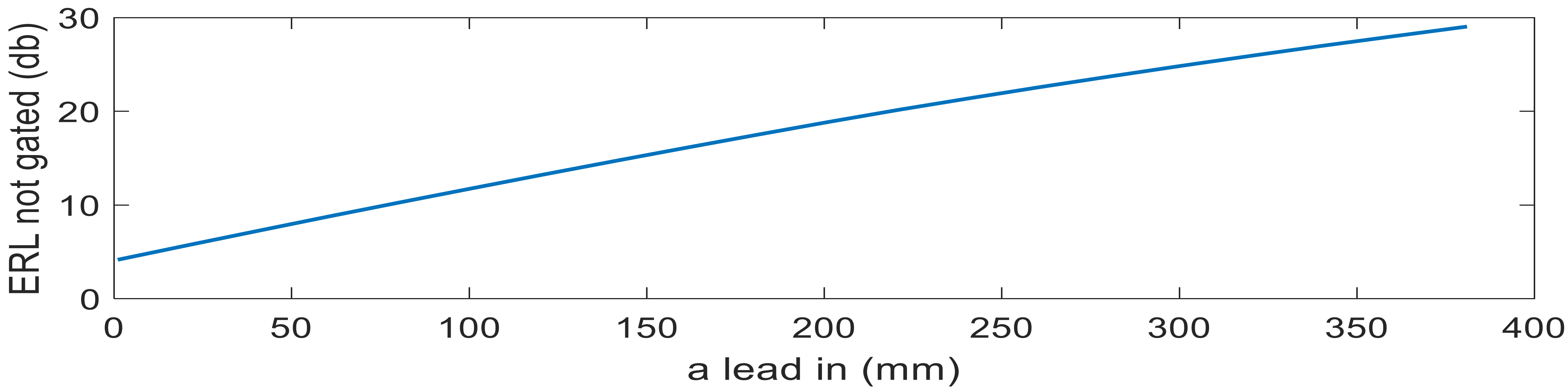
Variable	Mean	Std Dev	Correlation	Signif. Prob	Number
ERL	14.28983	2.428231	0.796621	<.0001*	54
ERLRMS	48.53835	4.085123			

Posted channels
ERL vs ERLRMS

- ❑ Reference package with parameters variations are 90% correlated
- ❑ Posted channel only seem to be 80% correlated
- ❑ Recommendation use convolution method

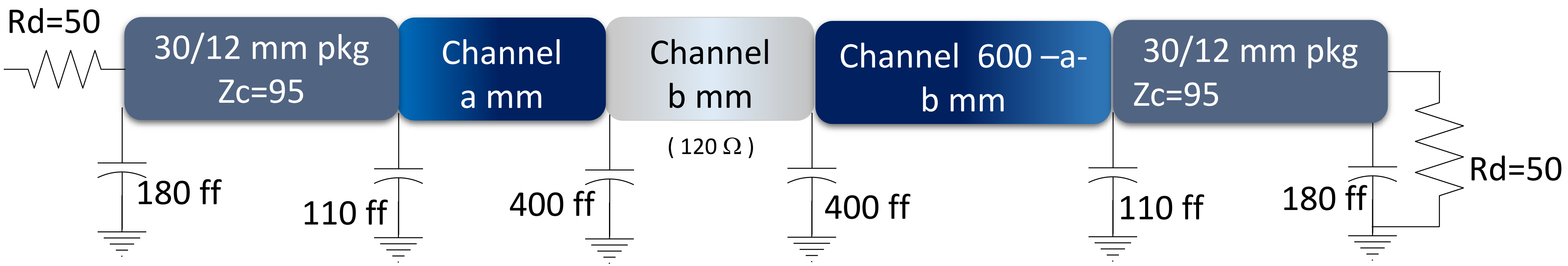
Ungated ERL does not track COM because of DFE effects





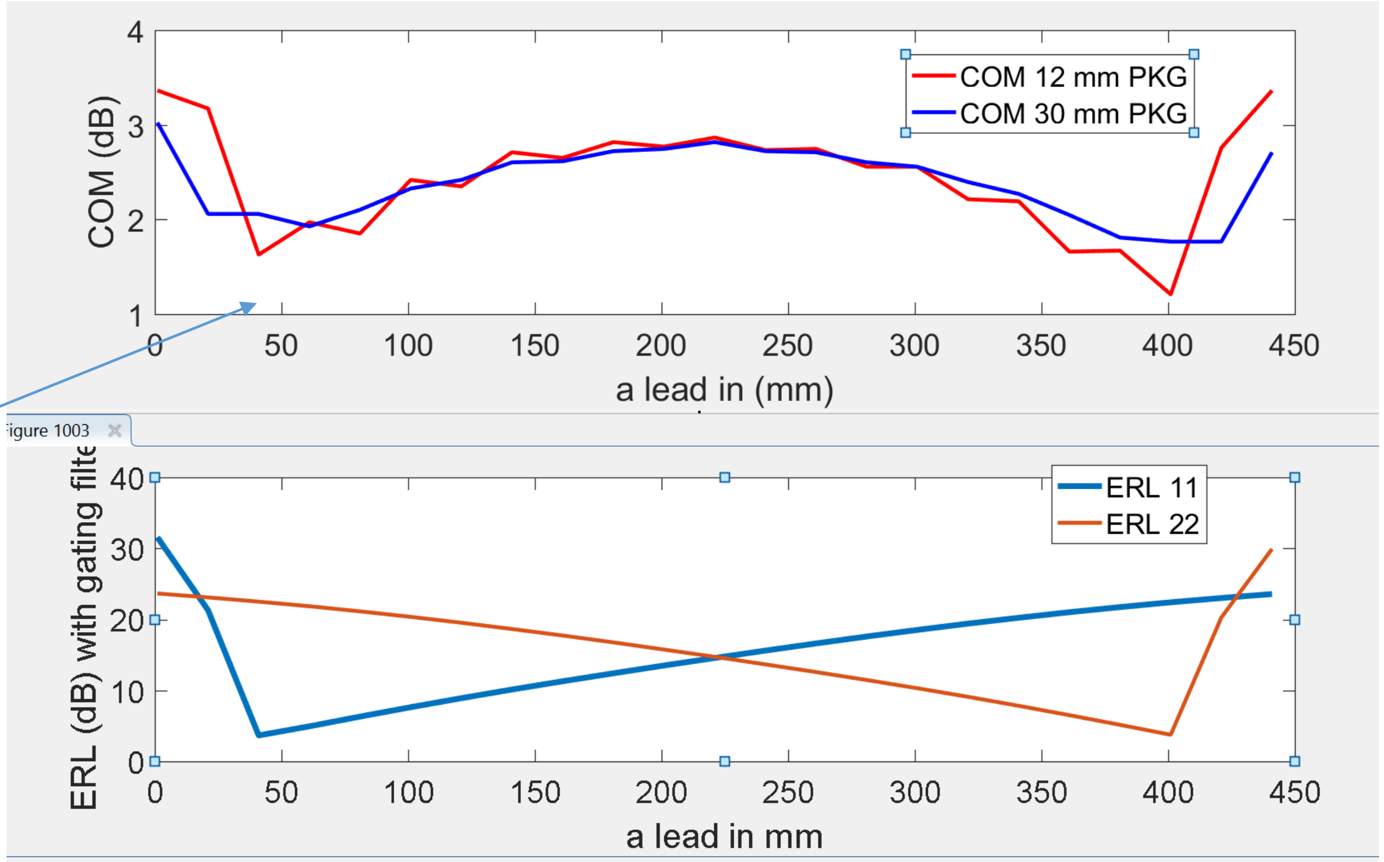
Would changing the amount of reflection alter the trends of the results?

- ❑ Change the capacitor to 400 ff from 200 ff
- ❑ Shorten the total length to 450 mm from 600 mm to keep around 3 dB of COM



mm	ff	Ω	mm	ff	mm	ff	mm	ff	mm	ff	mm	Ω	ff	Ω
30	180	95	12	110	a	400	b	400	450 -a-b	110	30	95	180	50

Similar trends regardless of reflection magnitude

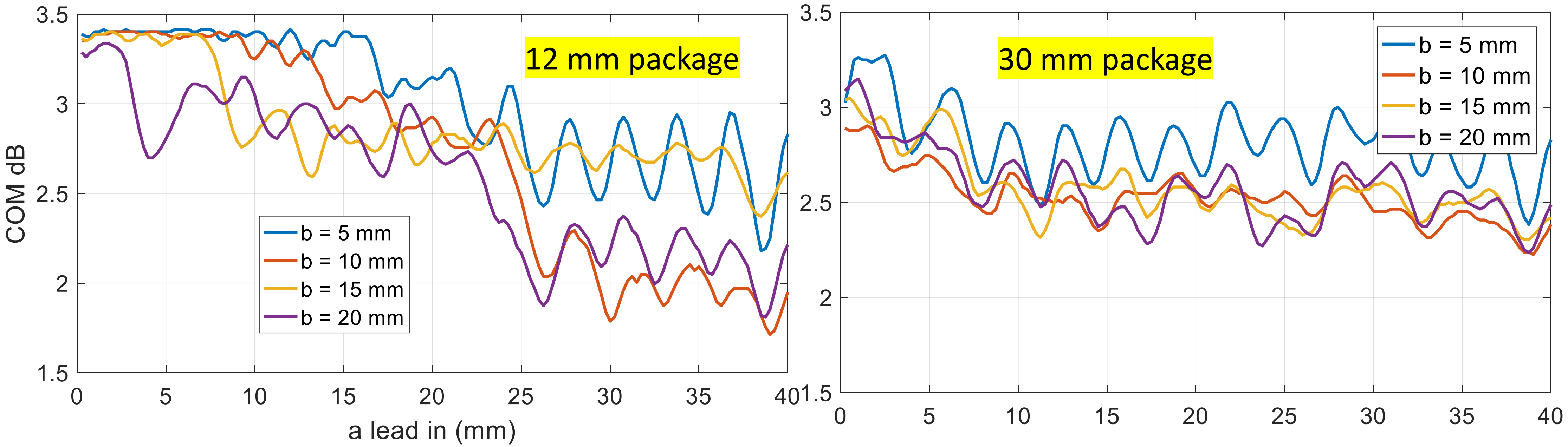


$T_b(N_b + 1)$

Takeaway:

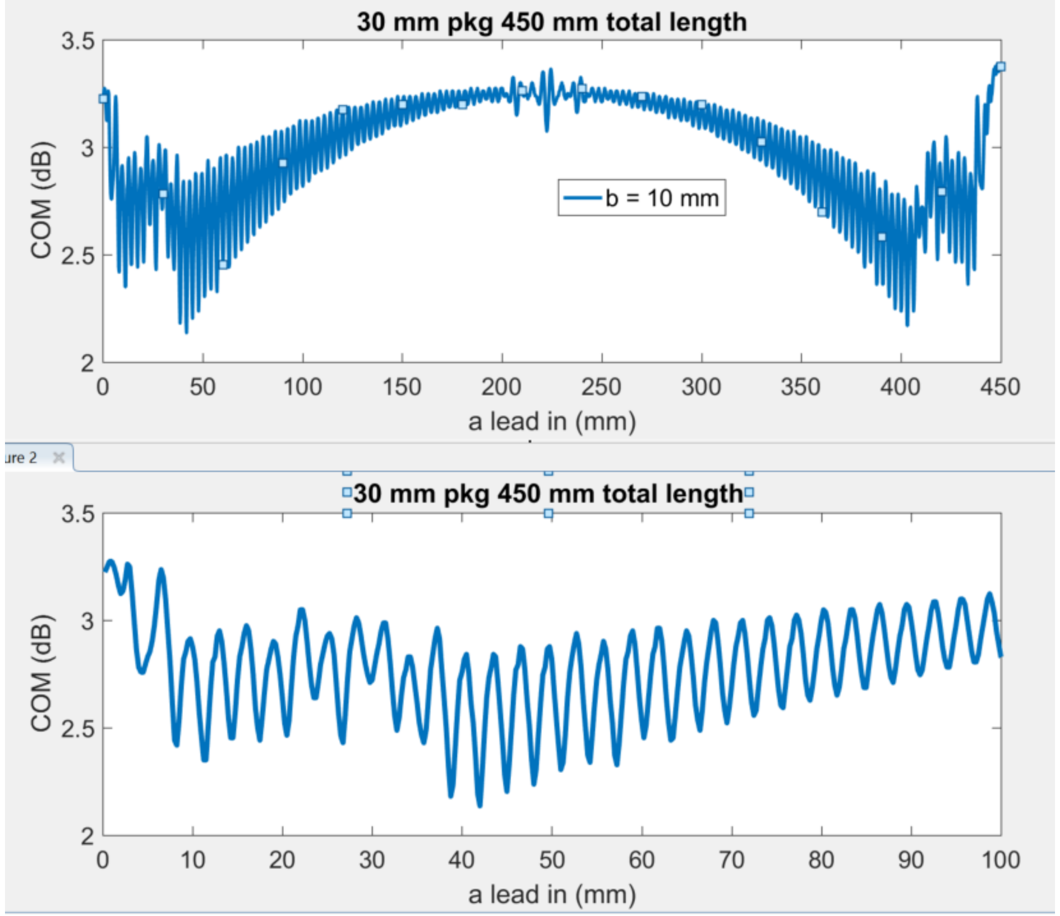
- Similar effects on either end of the channel
- A key factor is the distance a channel reflection is from either Tx or Rx package

Finer “lead in” (a) step sizes show DFE effects

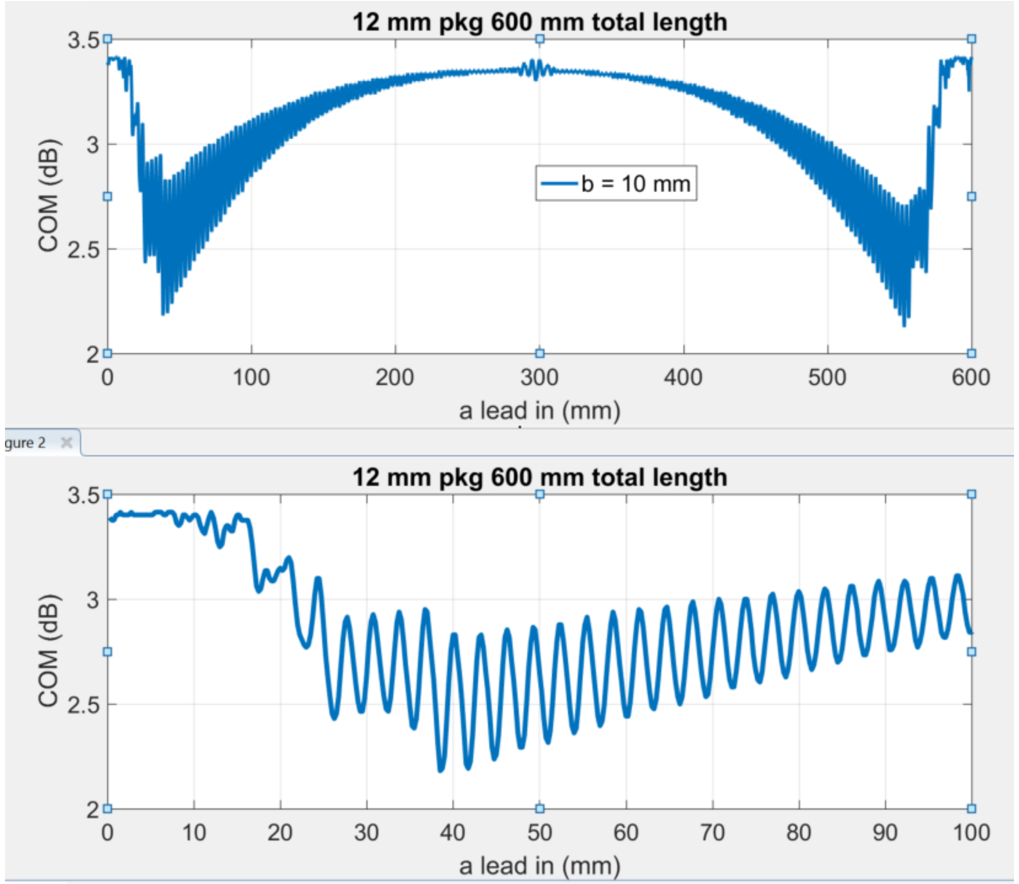


- ❑ COM packages seem somewhat interactive with the lead in (a) distance
- ❑ DFE effect can clearly be seen as COM is constant for b=5, 10, and 15 for progressively shorter lead in (a) values for the 12 mm package
- ❑ This suggest there are two components of package return loss:
  - Loss
  - Reflections

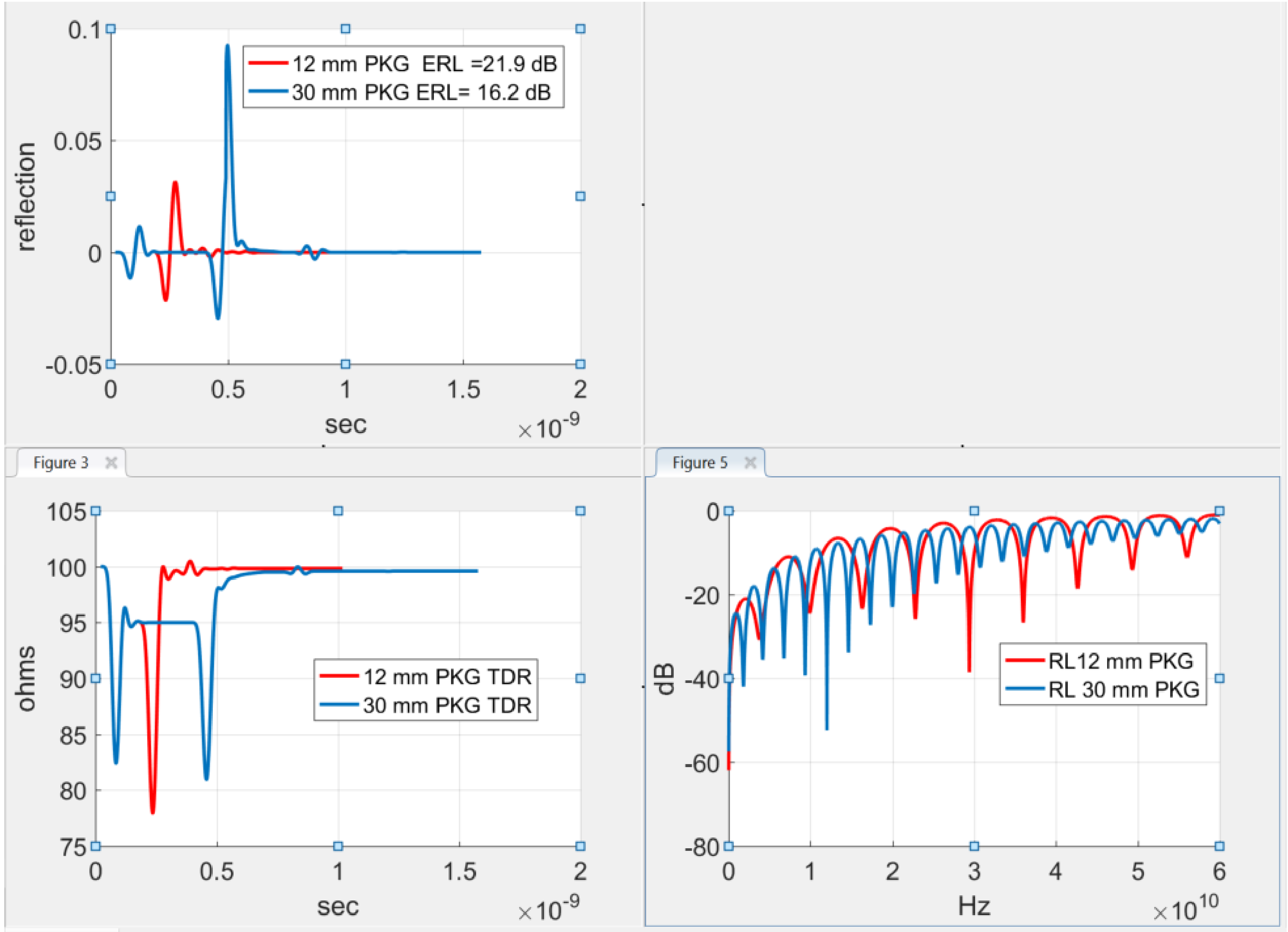
0.25 mm steps lead in (a) also show reflection placement sensitivity



- COM reference package used



TDR and ERL for COM reference package



Experiment* is with 27 posted channels** and wide variations of COM package parameters

- ❑ Determine COM and device ERL for
  - Each channel
    - 50G Base KR channels** without crosstalk
  - Each package parameter combination
- ❑ Use design of experiments (DOE) to create a distribution of 1 million package parameter combinations for each channel
- ❑ Limit package ERL and observe variability of COM

*http://www.ieee802.org/3/cd/public/adhoc/archive/mellitz_083017_3cd_adhoc.pdf
** http://www.ieee802.org/3/cd/public/channel/index.html

27 Channel Key

http://www.ieee802.org/3/cd/public/channel/index.html

number	Channel designator
1	'5F3N--Ch1_10_5F3N_t
2	'TEC_STRADAWhisper11p75in_Meg6_Channel_IEEE802_3_cd_Cu_07282016--TEC_Whisper11p75in_THRU_G14G15-07212016
3	'mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_100ohm_10dB_Nom_thru
4	'mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_100ohm_10dB_HzLzHz_thru
5	'mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_100ohm_10dB_LzHzLz_thru
6	'mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_85ohm_10dB_Nom_thru
7	'mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_85ohm_10dB_HzLzHz_thru
8	'mellitz_01_021716_10dB_6_channels--PAM4_2conn_MP_v2_85ohm_10dB_LzHzLz_thru
9	'5F3N--Ch4_20_5F3N_t
10	'TEC_STRADAWhisper27in_Meg6_Channel_IEEE802_3_cd_Cu_07282016--TEC_Whisper27in_THRU_G14G15_07202016
11	'mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_100ohm_20dB_Nom_thru
12	'mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_100ohm_20dB_HzLzHz_thru
13	'mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_100ohm_20dB_LzHzLz_thru
14	'mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_85ohm_20dB_Nom_thru
15	'mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_85ohm_20dB_HzLzHz_thru
16	'mellitz_01_021716_20dB_6_channels--PAM4_2conn_MP_v2_85ohm_20dB_LzHzLz_thru
17	'5F3N--Ch8_30_5F3N_t
18	'TEC_STRADAWhisper40in_Meg6_Channel_IEEE802_3_cd_Cu_07282016--TEC_Whisper40in_THRU_G14G15_07202016
19	'mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_100ohm_30dB_Nom_thru
20	'mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_100ohm_30dB_HzLzHz_thru
21	'mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_100ohm_30dB_LzHzLz_thru
22	'mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_85ohm_30dB_Nom_thru
23	'mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_85ohm_30dB_HzLzHz_thru
24	'mellitz_01_021716_30dB_6_channels--PAM4_2conn_MP_v2_85ohm_30dB_LzHzLz_thru
25	'20dB_HghZ--20dB_HighZ_thru
26	'20dB_HghZ_Nom_HighZ--20dB_HighZ_Nom_HighZ_thru
27	'30dB_HighZ--30dB_HighZ_thru

COM and ERL

- No crosstalk
- 30 mm and 12 mm package
- “Reference” COM for each channel

Channel number	Channel designator	COM (dB) 30 mm PKG	COM (dB) 12 mm PKG	Channel ERL11 (dB)	Channel ERL22 (dB)
1	'5F3N--Ch1_10_5F3N_t	6.2	5.8	11.3	11.9
2	_THRU_G14G15-07212016	7.0	7.4	14.7	15.1
3	_100ohm_10dB_Nom_thru	5.6	5.6	11.1	10.9
4	00ohm_10dB_HzLzHz_thru	5.9	5.9	10.4	10.3
5	00ohm_10dB_LzHzLz_thru	4.9	4.7	9.8	10.0
6	2_85ohm_10dB_Nom_thru	7.8	7.9	12.8	13.0
7	85ohm_10dB_HzLzHz_thru	7.2	7.2	11.2	10.5
8	85ohm_10dB_LzHzLz_thru	7.2	6.9	10.0	11.3
9	'5F3N--Ch4_20_5F3N_t	5.8	6.0	10.9	13.5
10	_THRU_G14G15_07202016	5.4	6.0	15.6	14.8
11	_100ohm_20dB_Nom_thru	6.5	6.8	15.3	14.7
12	00ohm_20dB_HzLzHz_thru	5.9	6.2	14.3	13.3
13	00ohm_20dB_LzHzLz_thru	5.9	6.5	13.9	13.7
14	2_85ohm_20dB_Nom_thru	7.4	7.7	16.1	15.6
15	85ohm_20dB_HzLzHz_thru	6.9	7.1	14.0	13.0
16	85ohm_20dB_LzHzLz_thru	6.7	7.1	13.6	13.9
17	'5F3N--Ch8_30_5F3N_t	3.5	4.5	12.0	14.0
18	_THRU_G14G15_07202016	3.0	4.1	16.2	15.3
19	_100ohm_30dB_Nom_thru	4.3	5.1	16.6	15.2
20	00ohm_30dB_HzLzHz_thru	4.1	4.8	15.4	13.9
21	00ohm_30dB_LzHzLz_thru	3.9	4.9	15.5	14.5
22	2_85ohm_30dB_Nom_thru	5.0	5.9	17.7	16.5
23	85ohm_30dB_HzLzHz_thru	4.7	5.5	15.2	13.9
24	85ohm_30dB_LzHzLz_thru	4.6	5.4	15.2	14.5
25	B_HghZ--20dB_HighZ_thru	6.3	6.7	17.6	17.1
26	B_HighZ_Nom_HighZ_thru	6.6	6.9	19.5	19.0
27	B_HighZ--30dB_HighZ_thru	4.2	4.9	17.9	17.6

COM package parameter variations

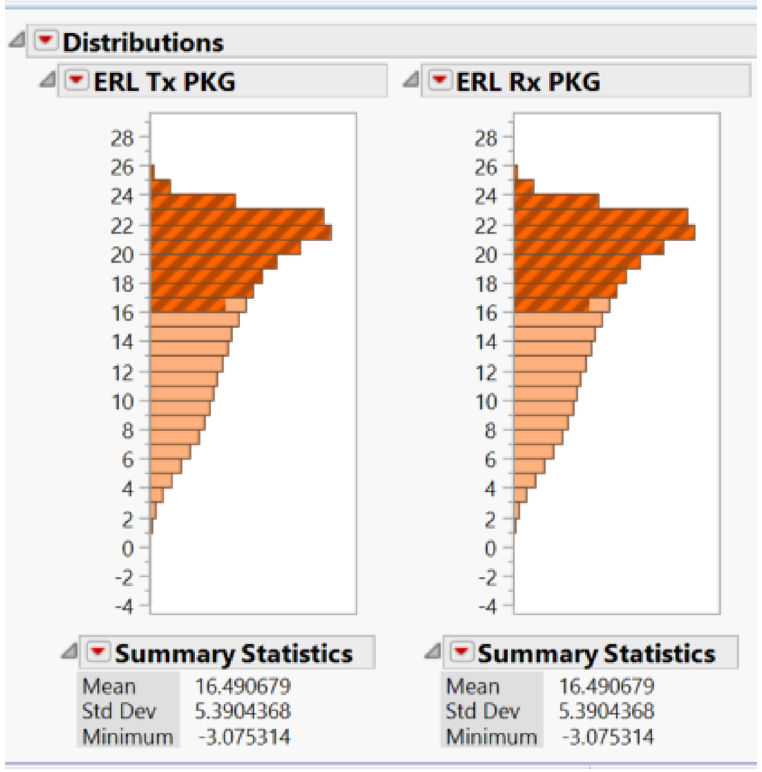
(Syntax from IEEE Std 802.3-2015 93A.1)

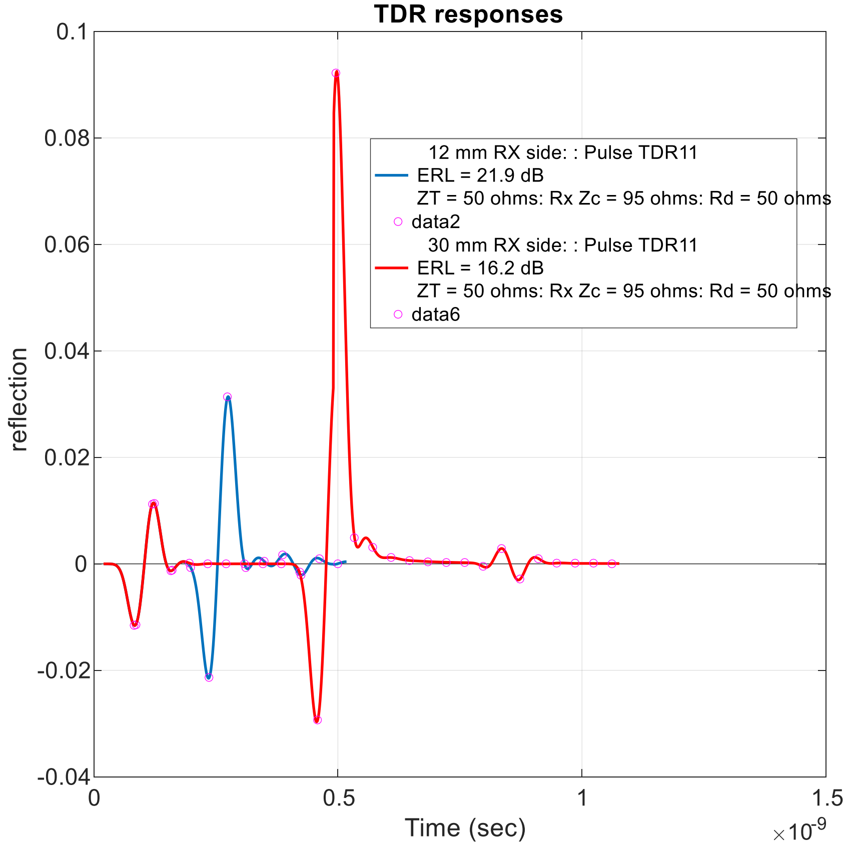
Zc Rx	Rd Tx	Rd Rx	Cd Tx	Cd Rx	Cp Tx	Cp Rx	Zp Rx	Zp Tx
85	35	50	0.9	0.9	0.3	0.3	40	40
105	35	65	0.9	1.8	1.8	0.3	40	40
85	65	65	2.7	2.7	1.8	1.8	40	40
105	65	35	0.9	2.7	1.8	1.8	40	10
105	35	35	2.7	2.7	0.3	1.8	25	10
85	35	65	2.7	2.7	1.8	0.3	10	40
105	65	35	2.7	0.9	1.05	1.8	10	25
105	35	65	0.9	0.9	0.3	1.8	10	10
85	65	65	2.7	0.9	1.05	1.8	25	10
85	65	65	0.9	0.9	1.8	1.8	10	40
85	35	35	2.7	0.9	1.8	1.8	10	40
105	65	65	0.9	2.7	0.3	0.3	10	40
85	35	35	0.9	2.7	0.3	1.8	40	10
95	35	35	2.7	2.7	1.8	0.3	40	40
105	65	35	0.9	2.7	1.8	0.3	10	40
105	65	50	2.7	0.9	1.8	1.8	40	40
85	65	35	0.9	2.7	0.3	0.3	40	25
85	65	50	2.7	2.7	0.3	0.3	10	10
105	35	65	2.7	0.9	0.3	1.8	40	40
85	65	65	0.9	0.9	0.3	1.8	40	40
85	35	35	2.7	0.9	0.3	1.8	10	10
85	35	35	0.9	0.9	1.8	0.3	40	10
105	65	50	2.7	2.7	0.3	1.8	40	10
105	65	65	2.7	2.7	1.8	0.3	25	10

Zc Rx	Rd Tx	Rd Rx	Cd Tx	Cd Rx	Cp Tx	Cp Rx	Zp Rx	Zp Tx
85	50	65	0.9	2.7	1.8	0.3	10	40
105	65	35	0.9	0.9	1.8	0.3	40	40
105	35	35	0.9	2.7	1.8	1.8	10	25
105	65	65	0.9	0.9	1.8	0.3	10	10
105	65	35	0.9	2.7	1.05	0.3	10	10
95	50	65	2.7	0.9	1.8	1.8	10	10
95	35	65	0.9	0.9	0.3	1.8	40	10
85	65	35	1.8	2.7	0.3	1.8	10	40
105	65	65	0.9	2.7	0.3	1.8	10	10
85	35	50	2.7	2.7	1.8	0.3	10	10
85	35	65	0.9	2.7	1.8	1.05	25	10
85	35	65	2.7	2.7	0.3	0.3	40	10
105	35	65	2.7	2.7	1.8	1.8	40	10
85	35	50	0.9	2.7	1.8	1.8	40	40
105	35	50	1.8	2.7	0.3	0.3	40	10
85	50	35	2.7	2.7	1.8	1.8	10	10
105	65	65	2.7	2.7	0.3	1.05	40	40
85	35	65	2.7	0.9	1.8	0.3	40	10
105	35	35	2.7	0.9	1.05	0.3	40	40
105	65	35	0.9	0.9	0.3	0.3	25	10
105	50	65	1.8	0.9	0.3	1.8	10	40
85	35	35	0.9	2.7	0.3	0.3	10	40
85	35	65	0.9	0.9	1.8	1.8	40	25
85	65	35	2.7	0.9	1.8	0.3	10	40
85	65	65	0.9	0.9	0.3	0.3	10	10

Zc Rx	Rd Tx	Rd Rx	Cd Tx	Cd Rx	Cp Tx	Cp Rx	Zp Rx	Zp Tx
85	65	35	2.7	0.9	0.3	1.8	40	40
95	50	35	0.9	0.9	0.3	1.8	10	40
95	65	65	2.7	0.9	0.3	0.3	10	40
85	65	35	0.9	0.9	1.8	1.8	25	10
105	35	35	0.9	0.9	1.8	1.8	10	10
85	35	65	0.9	1.8	0.3	1.8	10	25
85	65	65	0.9	0.9	1.05	0.3	40	40
85	65	35	2.7	0.9	1.05	1.05	40	10
105	35	35	0.9	0.9	0.3	1.05	40	40
95	35	65	2.7	0.9	0.3	1.05	10	25
85	50	35	2.7	0.9	0.3	0.3	25	25
105	35	50	0.9	0.9	1.05	0.3	40	10
105	65	65	0.9	1.8	1.8	1.8	10	40
105	65	35	0.9	2.7	1.05	1.8	40	40
105	35	65	1.8	0.9	1.8	0.3	10	40
105	50	65	2.7	1.8	0.3	0.3	10	10
95	35	65	0.9	2.7	0.3	1.8	10	40
105	35	35	2.7	0.9	1.8	1.05	25	10
85	65	65	0.9	1.8	1.8	0.3	40	10
105	35	50	2.7	2.7	0.3	1.05	10	40
95	35	35	1.8	1.8	0.3	0.3	10	10
95	50	50	1.8	1.8	1.05	1.05	25	25
95	50	50	1.8	1.8	1.1	1.1	12	12
95	50	50	1.8	1.8	1.1	1.1	30	30

ERL for the 30 mm reference package is 16.2 dB

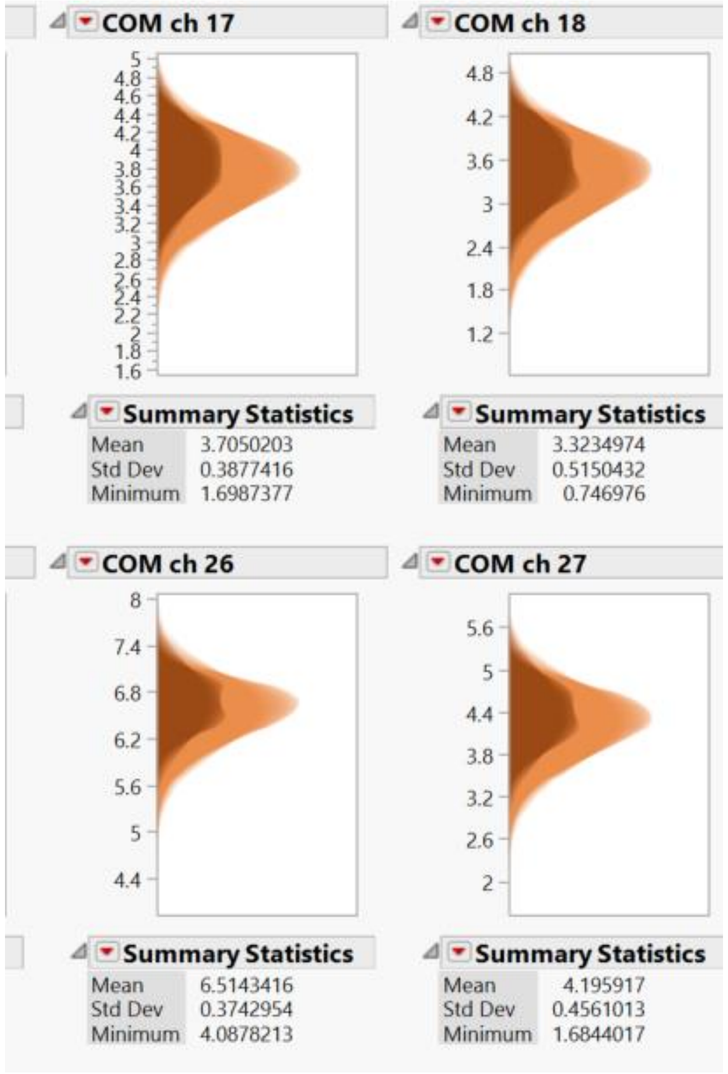




Dark area: Selection limit for ERL set to > 16.2 dB for the million cases
Light area: 1 million cases base on DOE

Example of gated PTDR for reference package

Distribution view of COM a few channels



- The value to watch is the minimum COM in the distribution.
- A low minimum COM compared to the reference COM can lead to false positives.
- Hence if the distribution's minimum COM increases as a result of ERL test limits the likelihood of false positives decrease

ERL limits raise the average COM minimum by an average of 0.3 dB

	COM (dB) 30 mm PKG	Mean all	mean passing	minimum COM all	minimum COM passing	change in minimum COM							
COM ch 1	6.16	6.15	6.26	2.76	3.49	-0.72	COM ch 15	6.94	6.72	6.83	4.22	4.59	-0.38
COM ch 2	6.98	7.05	7.20	4.06	4.48	-0.42	COM ch 16	6.71	6.42	6.58	4.08	4.23	-0.15
COM ch 3	5.61	5.54	5.52	2.33	2.51	-0.18	COM ch 17	3.54	3.70	3.85	1.50	1.80	-0.30
COM ch 4	5.94	5.55	5.51	1.84	1.84	0.00	COM ch 18	3.04	3.32	3.55	0.61	1.38	-0.76
COM ch 5	4.89	4.95	5.04	1.77	1.95	-0.18	COM ch 19	4.29	4.37	4.57	1.92	2.53	-0.61
COM ch 6	7.76	7.61	7.62	4.87	4.94	-0.07	COM ch 20	4.11	4.15	4.32	1.86	2.35	-0.49
COM ch 7	7.19	6.86	6.86	3.68	3.68	0.00	COM ch 21	3.94	3.95	4.20	1.10	1.90	-0.80
COM ch 8	7.18	6.79	6.88	3.44	3.44	0.00	COM ch 22	5.04	5.01	5.20	2.43	2.61	-0.19
COM ch 9	5.78	5.70	5.78	3.58	3.91	-0.33	COM ch 23	4.69	4.67	4.85	2.45	2.71	-0.26
COM ch 10	5.38	5.67	5.85	3.03	3.48	-0.45	COM ch 24	4.61	4.47	4.68	1.39	1.65	-0.26
COM ch 11	6.52	6.43	6.55	3.95	4.04	-0.09	COM ch 25	6.27	6.25	6.40	3.83	4.35	-0.52
COM ch 12	5.94	5.89	5.97	3.11	3.11	0.00	COM ch 26	6.58	6.51	6.68	4.21	4.80	-0.59
COM ch 13	5.88	5.79	5.96	3.04	3.14	-0.11	COM ch 27	4.18	4.20	4.39	1.53	1.94	-0.42
COM ch 14	7.45	7.24	7.36	5.19	5.31	-0.12							-0.31
													average minimum change

Not perfect, but would seem to reduce the likelihood of false positives

Summary

- ERL removes the penalty for short packages
  - Perhaps the most important step
- ERL incorporates the effects of DFE
- ERL may be computed from a gated and weighted PTDR with a convolution method
  - The ERL RMS method may be sufficient and is simpler but less accurate
- Need to adjust for test fixture and actual product packages
  - Tentatively require for a device ERL > 16.2 dB
    - β_x=10.7e9, $\rho_x = 10^{-\frac{ERL_{cx}}{20}} = 0.21$
- Require for a channel ERL > 10.2 dB
  - Use β_x=10.7e9, $\rho_x = 10^{-\frac{ERL_{px}}{20}} = 0.15$
- Consider an ERL for a test channel to be better. ERL > 20 dB… more work required here
- Refine for January Interim with decisions on
  - RMS vs convolution method
  - ERL limits
  - Test fixture data
  - Actual product package data