Exploring Effective Return Loss (ERL) as a Means to Improve Channel and Device Specifications

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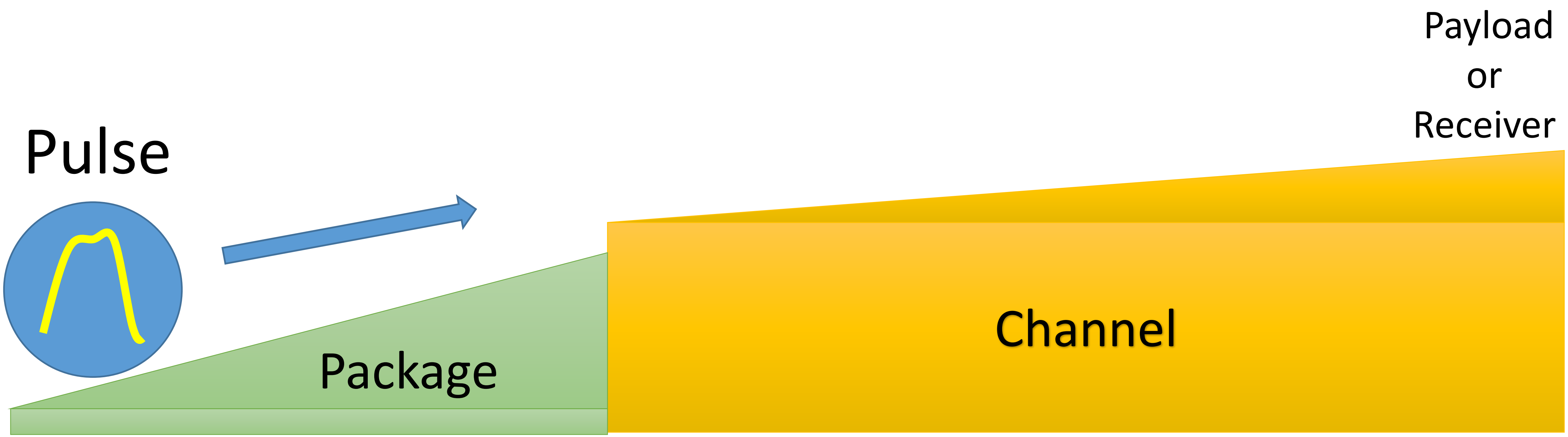
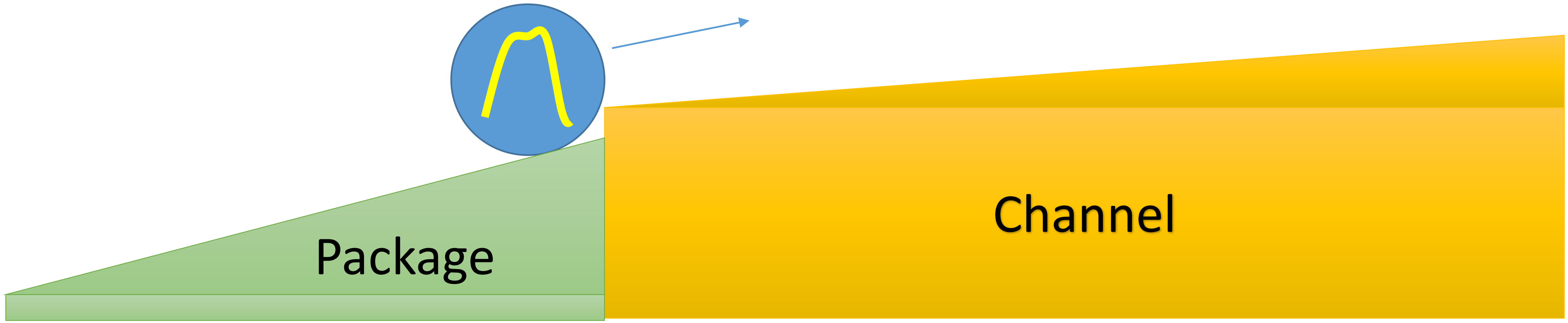
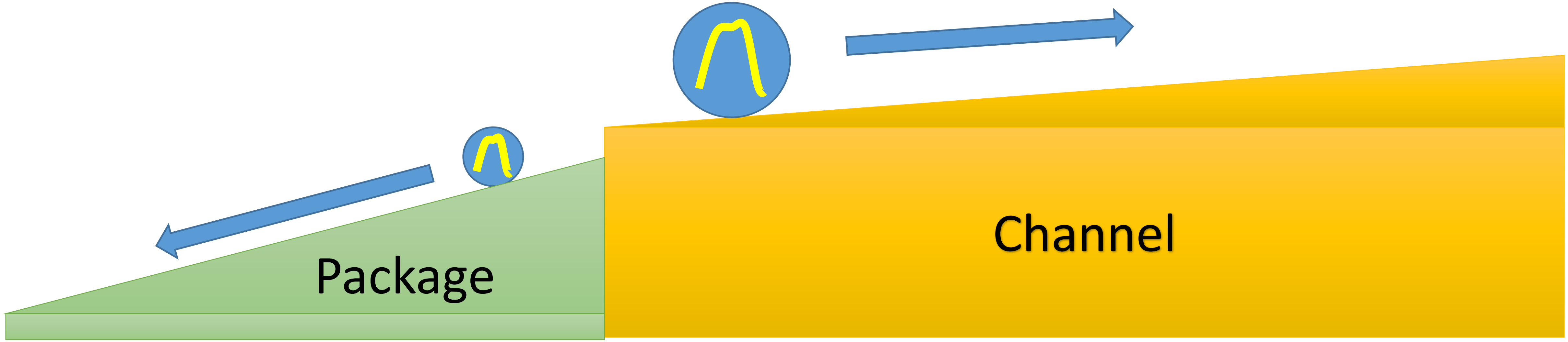
Simple Discrete Reflection Concept Example



Pulse impinges on channel

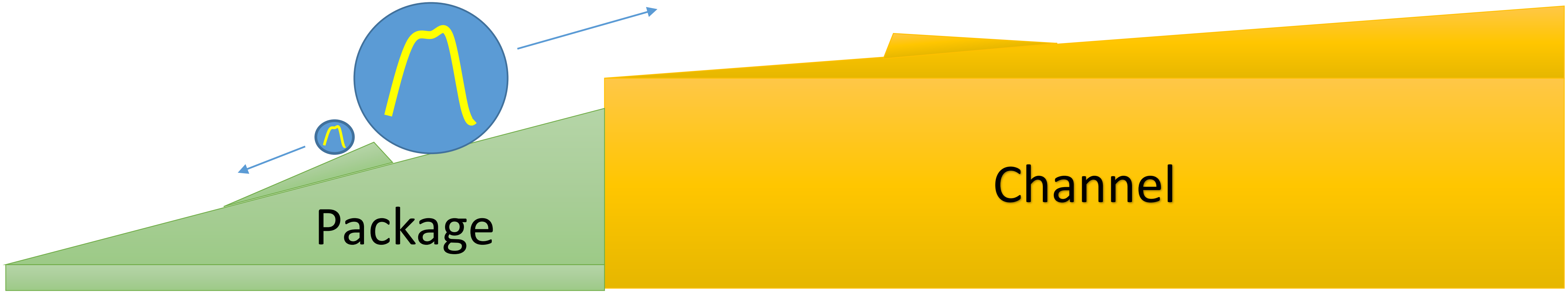


Some passes through and some is reflected

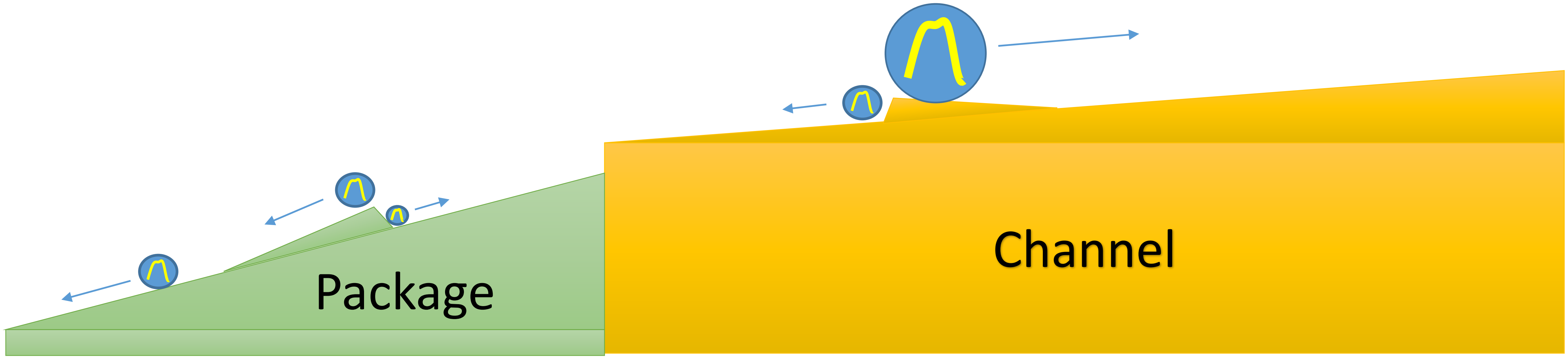


Now add reflection in the package and channel

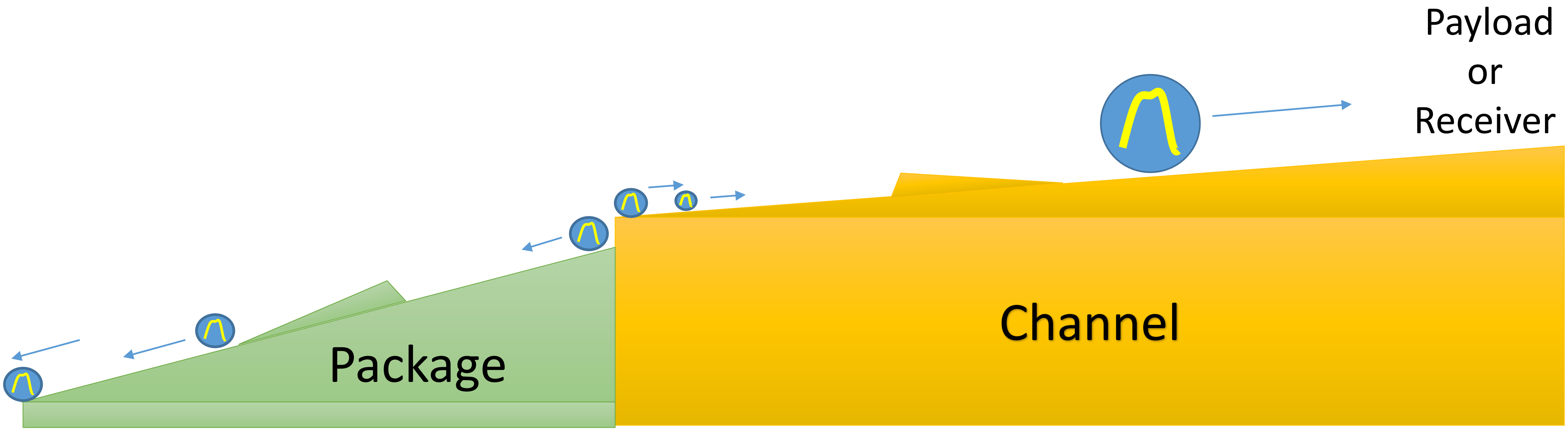
Pulse go both ways inside package



Bouncing of reelections gets complex, even in a simple example



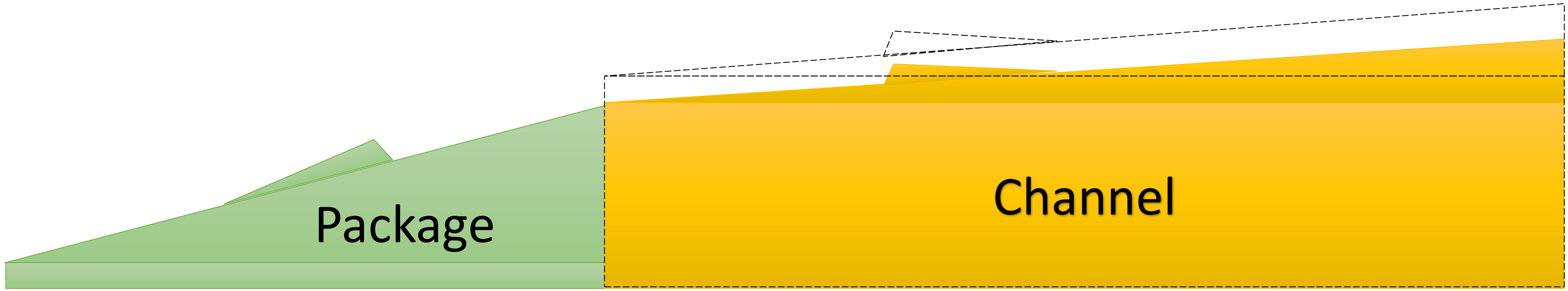
Pulses go both way in the channel based on reflection bounces in channel, package, and package to channel interface



COM and simulations predict the payload at the receiver for all the complex bouncing

Changing the package will change the bounces

There are all sort of different channels where a worst bounce for one package on a certain channel may not be a worst bounce for another channel



What to do?

Solution

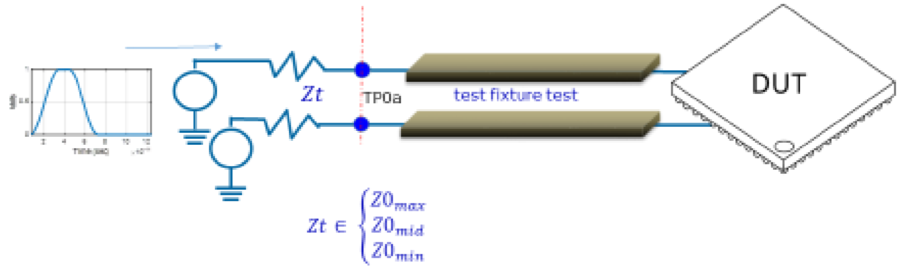
- ❑ Limit the bounces by
  - Quantizing the reflection impact

ISSUE: Return loss frequency domain plots are difficult to quantize

- ❑ Proposal to use Pulse TDR (PTDR) with a quantized parameter Effective Return Loss (ERL)
- ❑ Following slides will illustrate

Review (mellitz_3cd_02_060717_elect_adhoc)

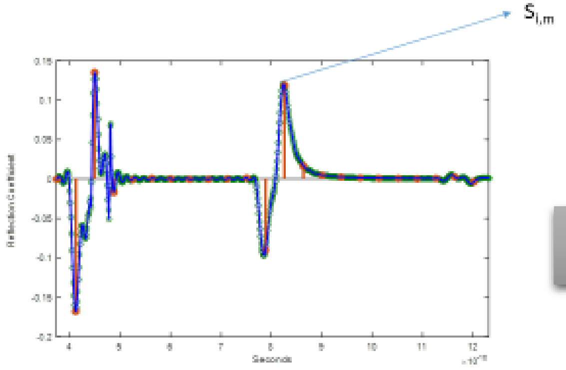
Single bit reflection concept: I.e. Pulse TDR (PTDR)



IEEE P802.3 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet Task Force

Use Pulse TDR response to determine Effective Return Loss (ERL)

Determine effective reflection coefficient for each sample in a unit interval



where i = 1 to numbers samples per UI
and m = 1 to number of UI's in response

Pulse TDR

IEEE P802.3 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet Task Force 7

Review Options for computing ERL

- ❑ Greatest [1]RSS($S_{i,1:m}$) for any Zt (unbounded Gaussian assumption)

  Or Bit stream convolution and

- ❑ Greatest CDF(PDF($S_{i,1:m} \otimes$ [2]Constellation)) @BER for any Zt

- ❑ Converting ERL to dB makes it somewhat familiar because of RL units in the frequency domain

Following slides suggest an apparent relation between PTDR and the pulse response shown in following slides

[1]*RSS is root of the sum of squares*

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

Moving forward

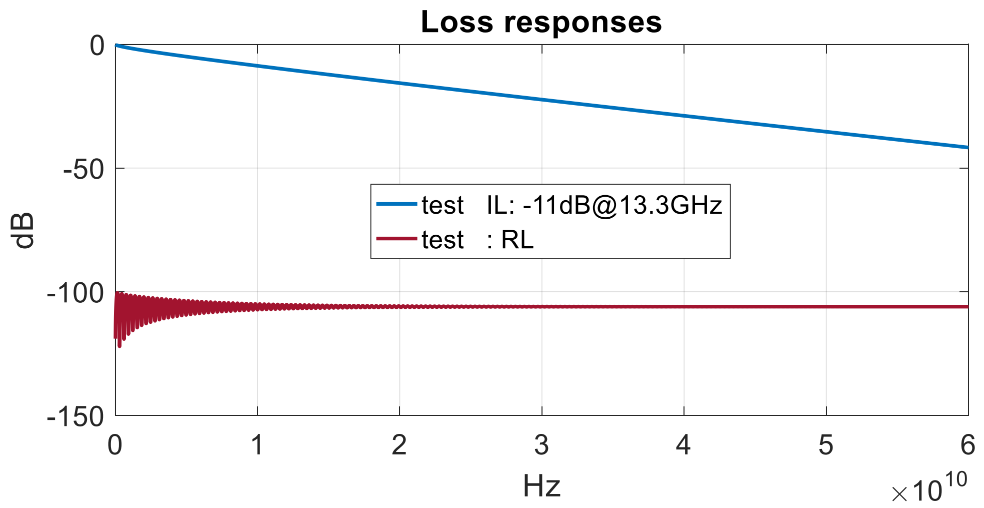
- **Next few slides are simple channel examples showing PTDR, the pulse response, and COM**
- **Simple data suggests convolving PTDR with data has merit**
  - **Similar algorithm as in COM**
  - **Ties in signal modulation and BER (DER0)**
- **Seems to correlate to COM better than frequency domain mask**

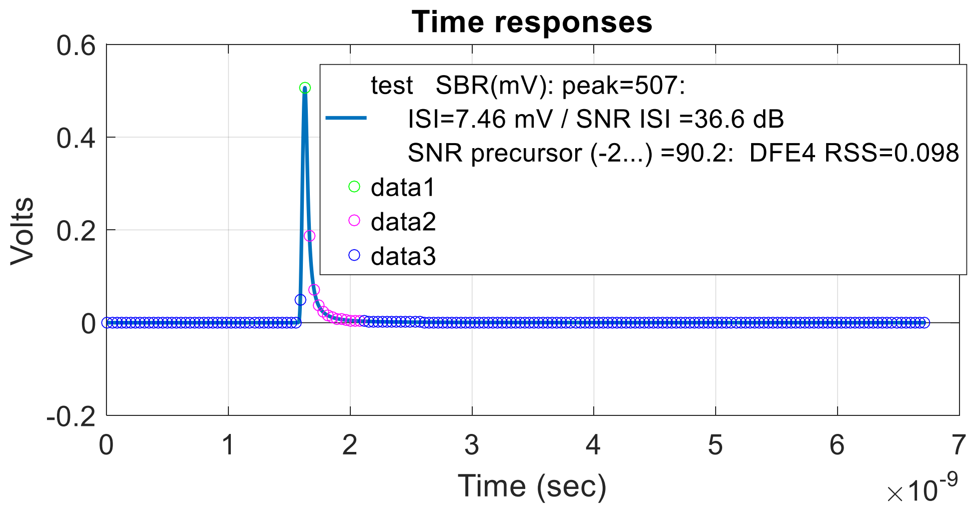
Experiment Using Clause 92 Table 92-12 Transmission Lines

Zc1=100 ohm, 30 mm

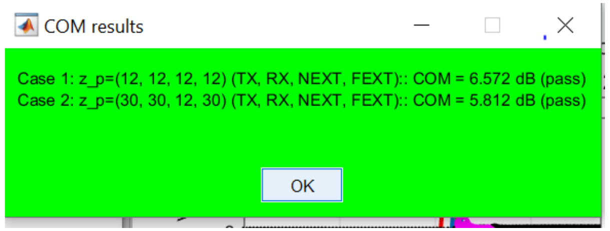
Zc2=100 ohm, 300 mm

Z_{c2}=100 ohm, 30 mm

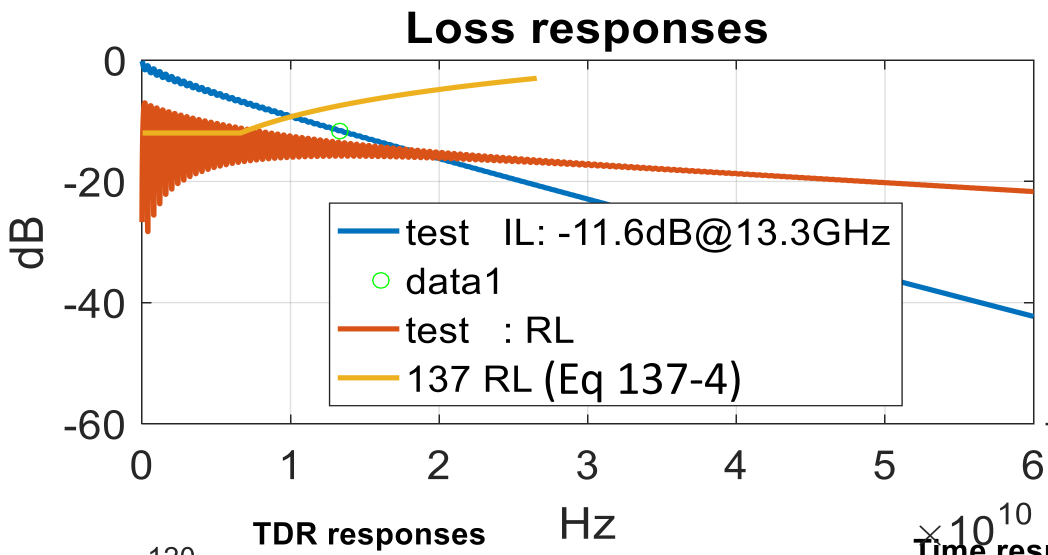


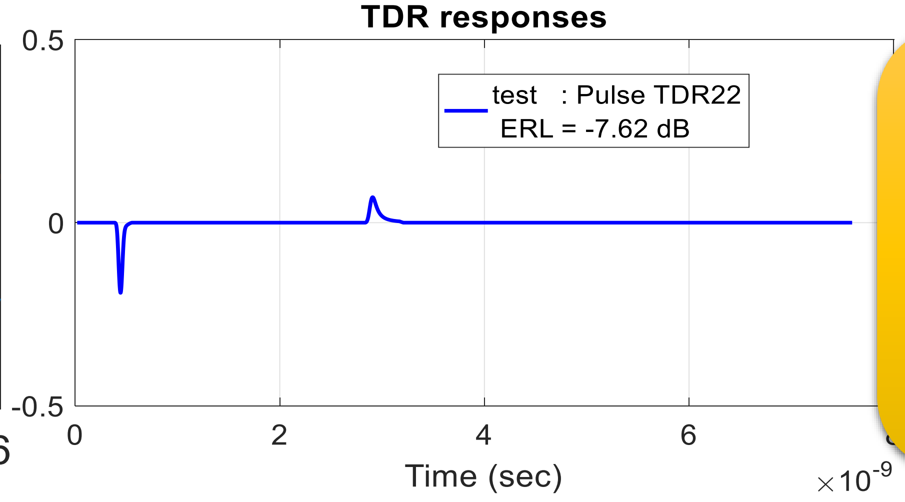


Using CL120D COM table

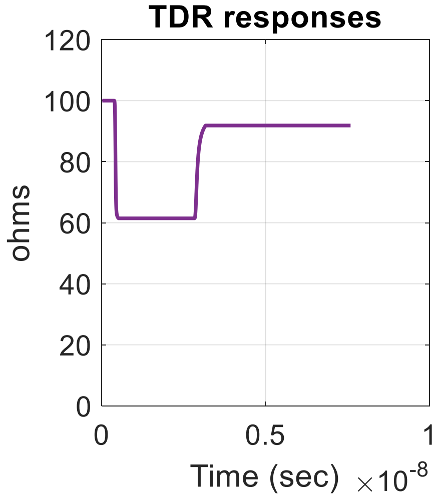


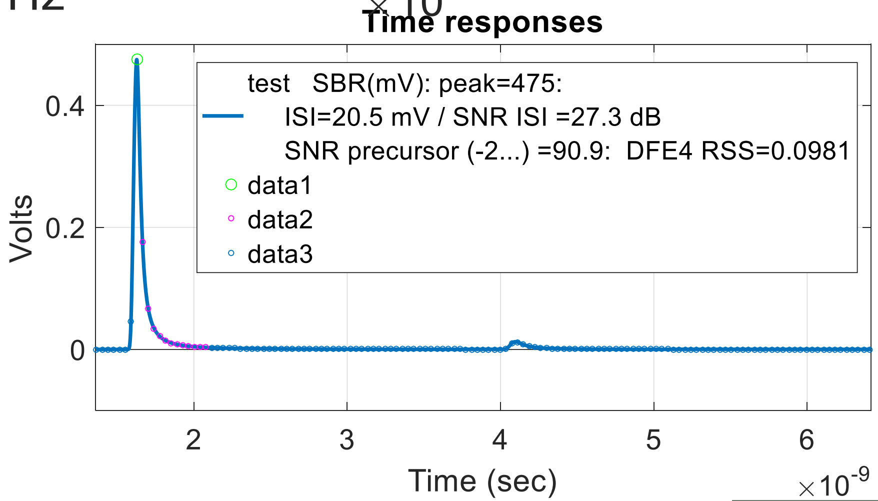
Experiment with Z_{c2} = 60 ohms

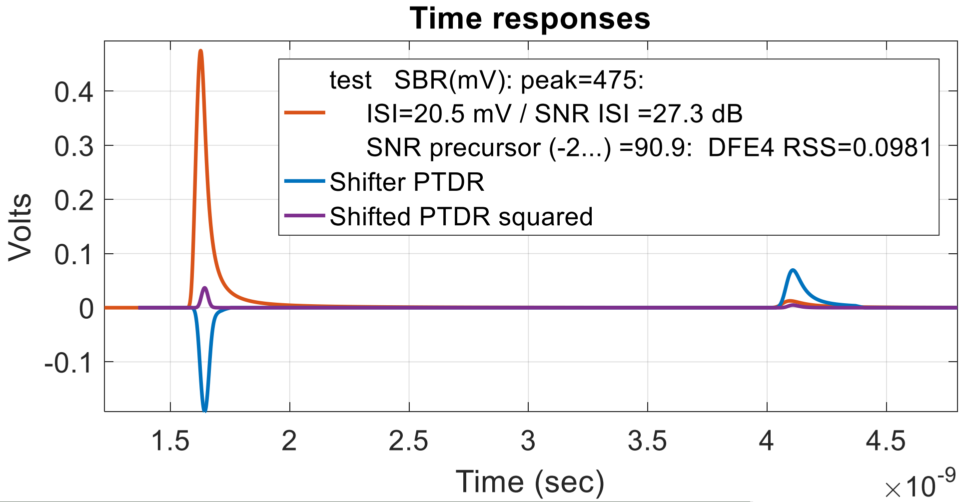




Apparent relation between PTDR and the pulse response for Z_{c2} = 60 ohms







fails 137 RL mask

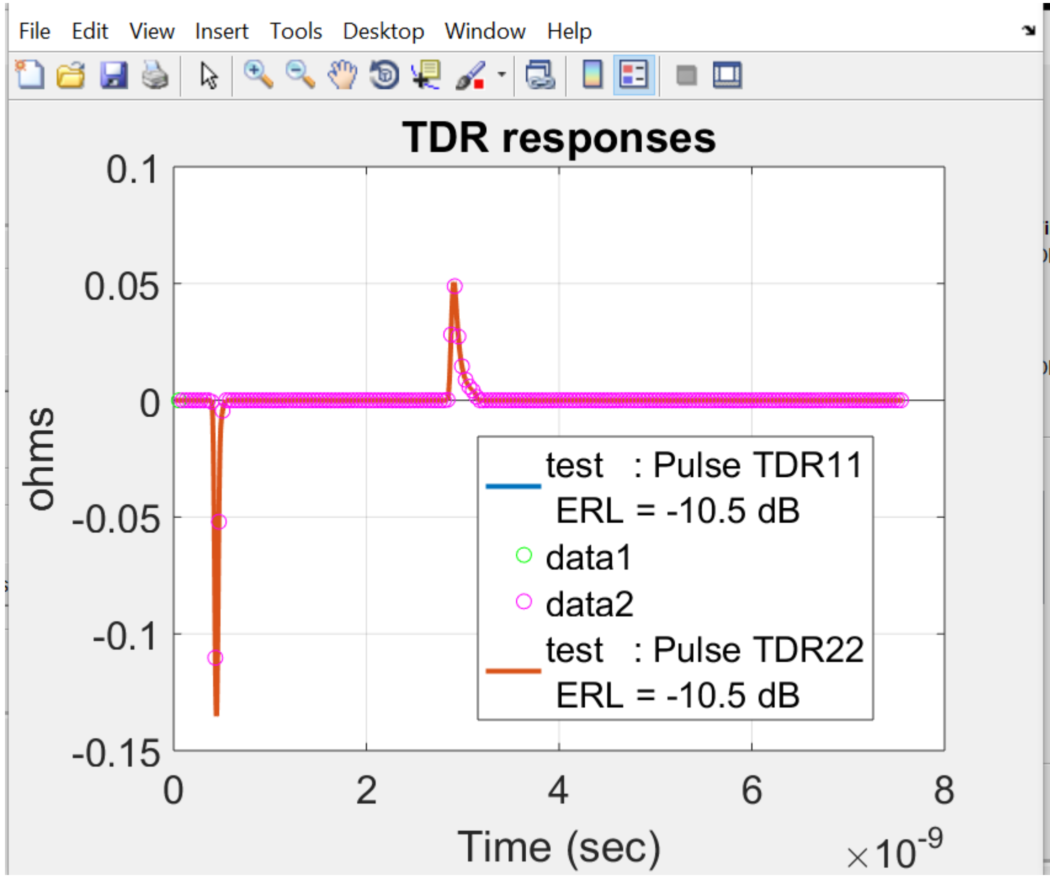
fails COM

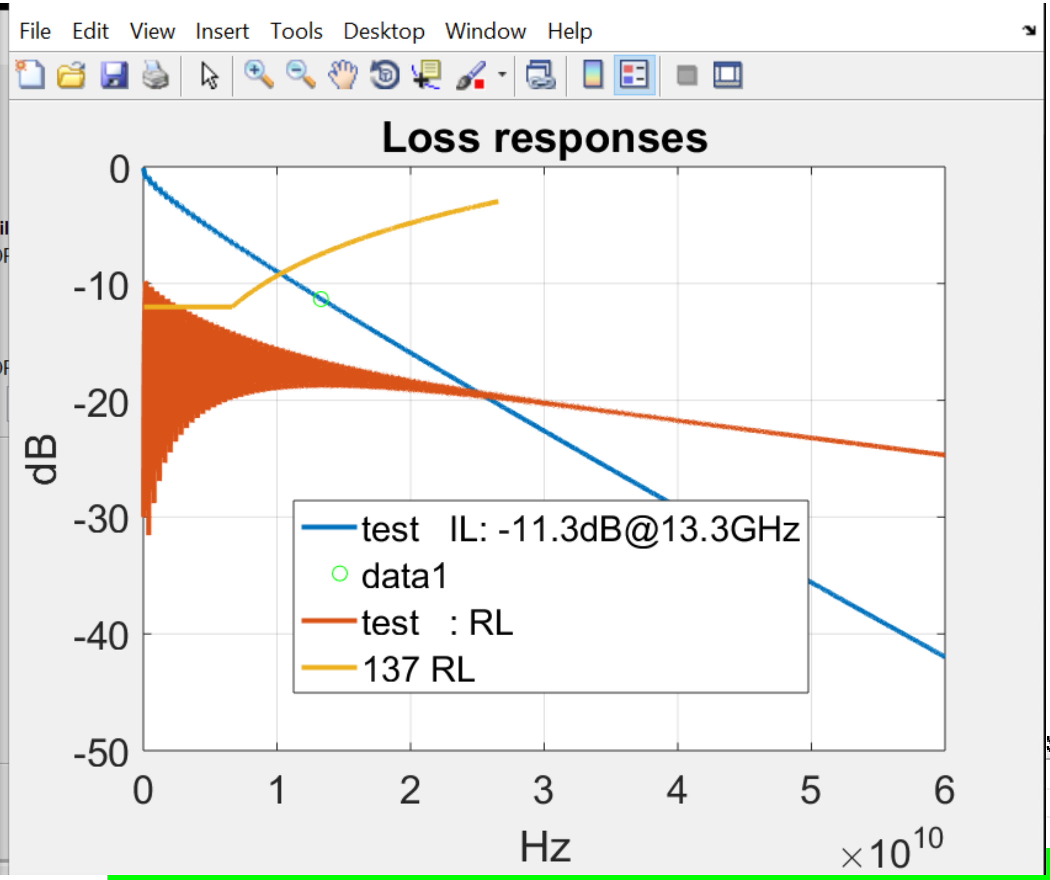
Using CL120D COM table

COM results

Case 1: z_p=(12, 12, 12, 12) (TX, RX, NEXT, FEXT):: COM = 2.146 dB (FAIL)
Case 2: z_p=(30, 30, 12, 30) (TX, RX, NEXT, FEXT):: COM = 2.265 dB (FAIL)

Experiment with Zc2 = 70 ohms





fails 137 RL mask

Passes COM

Using CL120D COM table

Using CL120D COM table

Case 1: z_p=(12, 12, 12, 12) (TX, RX, NEXT, FEXT):: COM = 3.924 dB (pass)
Case 2: z_p=(30, 30, 12, 30) (TX, RX, NEXT, FEXT):: COM = 3.703 dB (pass)

OK

Example on how to incorporate into a specification

- Add ERL specification for channel
  - use a 18.9 ps (20%-80%) transition time and
  - Use a receiver filter as in Eq. 93A-20
  - $Zt \in \begin{cases} 55 \\ 50 \\ 45 \end{cases}$
- For 90 ohm target
  - $Zt \in \begin{cases} 99.5 \\ 45 \\ 41.5 \end{cases}$
- ERL max < TBD (10dB is first pass guess so far for a channel)

From: mellitz_3bs_01b_0717.

Compute a Probability Density Function (PDF) and Cumulative Distribution Function (CDF) for the PDTR 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 $A_{DD}h_J(n)$ (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.

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

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.

$$p(y) = p(y) * p_n(y) \qquad (93A–40)$$

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_s 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_s be ignored as they likely correspond to measurement noise or numerical artifacts.

From: mellitz_3bs_01b_0717.

Next

- ❑ Incorporate PTDR/ERL into COM for exploration – **Done**
- ❑ Promote PTDR/ERL correlation on existing .3cd channels
  - Determine effect on COM/package variability
- ❑ Evaluate ERL applicably to Tx and Rx devices
- ❑ Refine concepts from data
- ❑ Perhaps a few consensus group meeting to facilitate