Improving SNDR measurements

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Introduction

- The measurement method defined in 94.3.12.7 may not be accurate enough to verify the stringent signal-to-noise-and-distortion ratio (SNDR) requirements for the 200G/400GAUI-4/8 chip-to-chip interface

- This is the subject of comment #24

- This presentation investigates the measurement method and recommends a modification

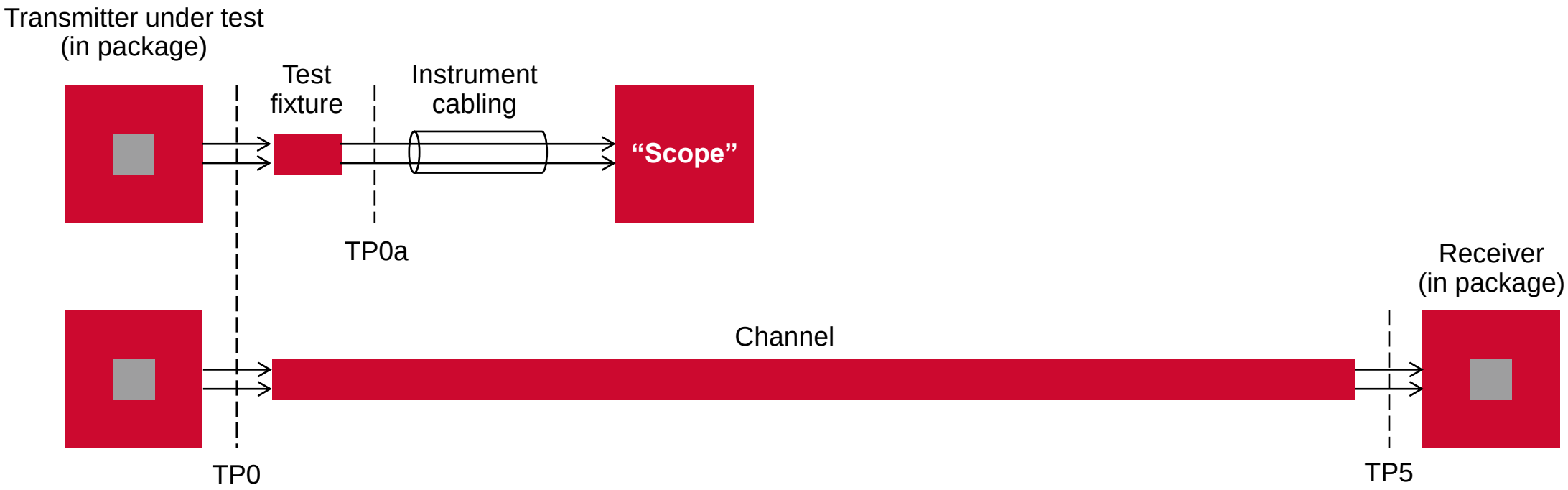
What does the SNDR requirement currently seek to control?

- Correlated (e.g, inter-symbol) interference
- Non-linear distortion
- Uncorrelated noise and interference

- This presentation focuses on the first two terms
- Calculations of “SNDR” do not include the uncorrelated noise/interference term

Inter-symbol interference

- Inter-symbol interference contributed by the test fixture, cabling, and instrument has little bearing on the performance of the transmitter in its target application…
- …yet it can [significantly] degrade the measured SNDR



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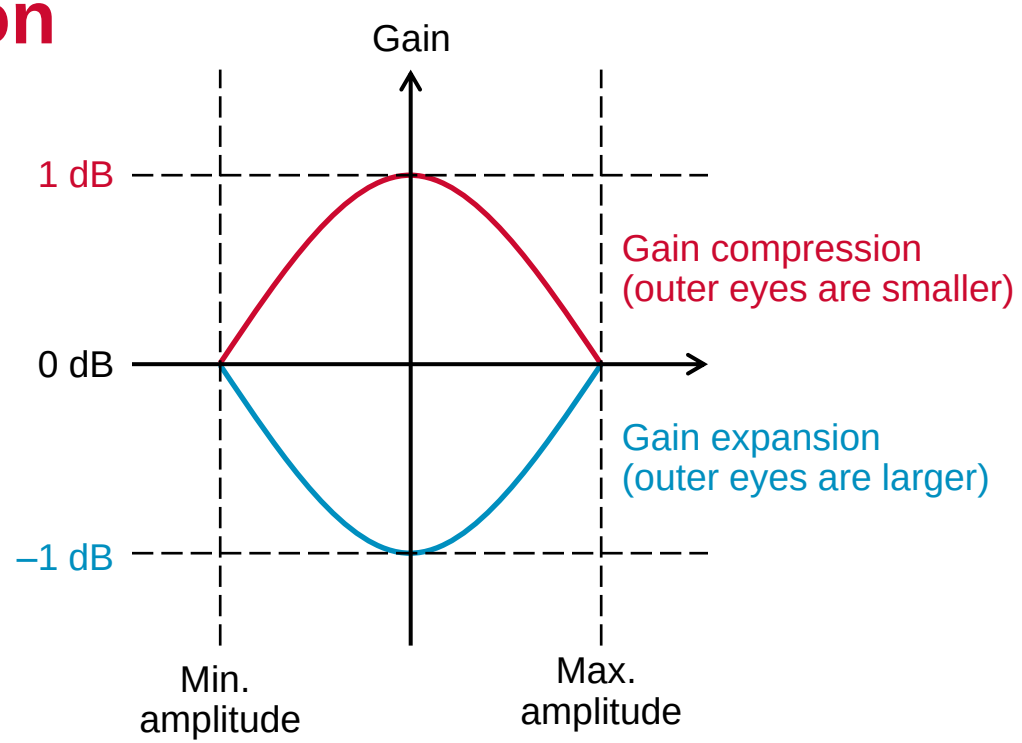
Possible sources of non-linear distortion

- Gain expansion/compression
- Rise/fall time asymmetry
- Even-odd jitter



- Other forms of non-linear distortion are possible but these constitute the most readily modeled terms

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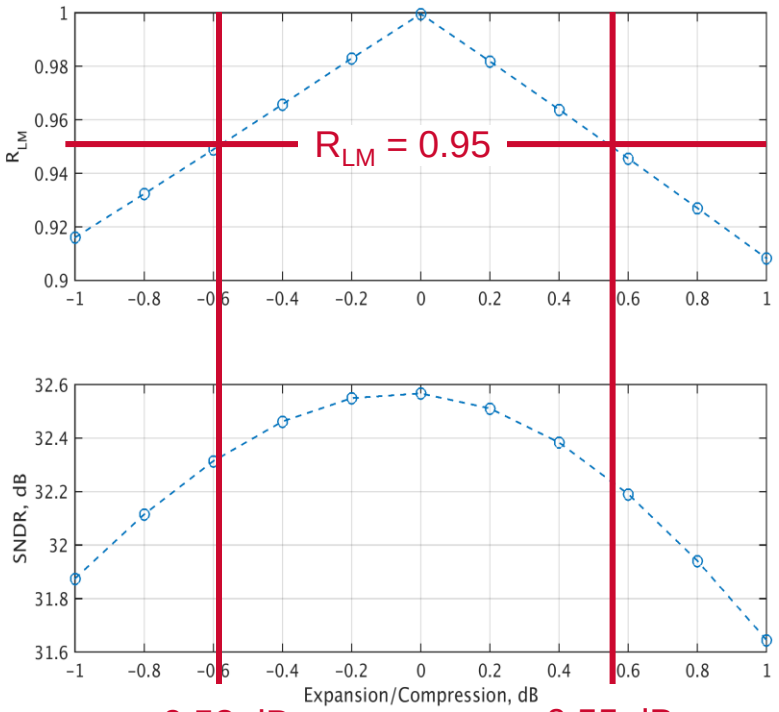
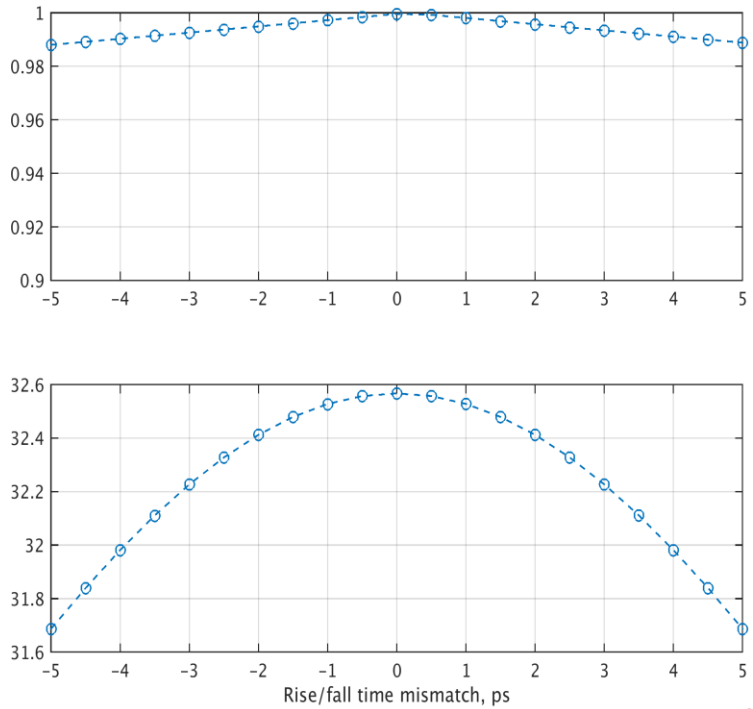
Impact of non-linear distortion on SNDR (D_p = 2, N_p = 13)

Gain expansion/compression



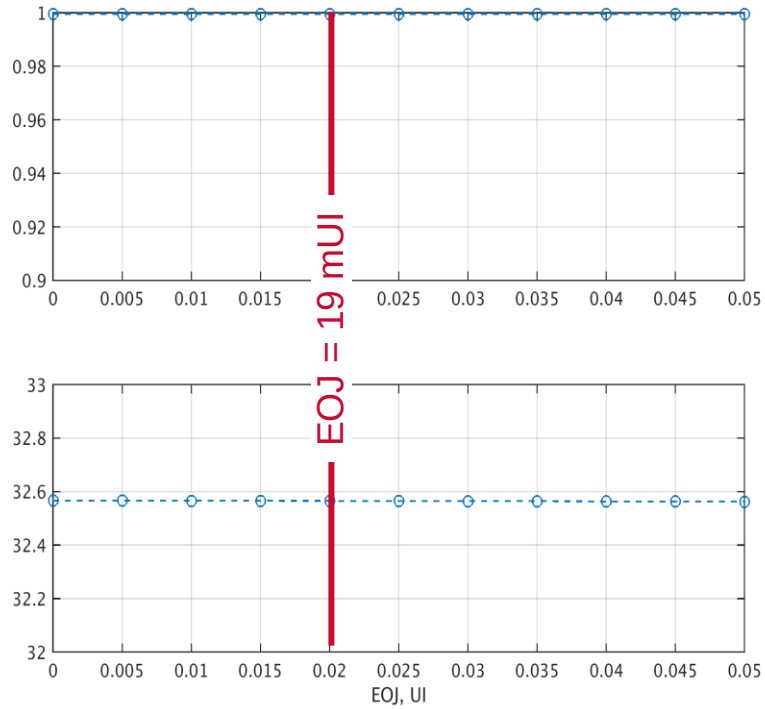
–0.58 dB 0.55 dB

Rise/fall time mismatch



T_r = 15.5 ps
T_f = 10.5 ps

Even/odd jitter



T_r = 10.5 ps
T_f = 15.5 ps

- Table 120D–7 parameter values, z_p = 30 mm
- TP0-TP0a model is 38 mm of host PCB trace
- SNDR is weakly influenced by non-linear distortion – ISI dominates

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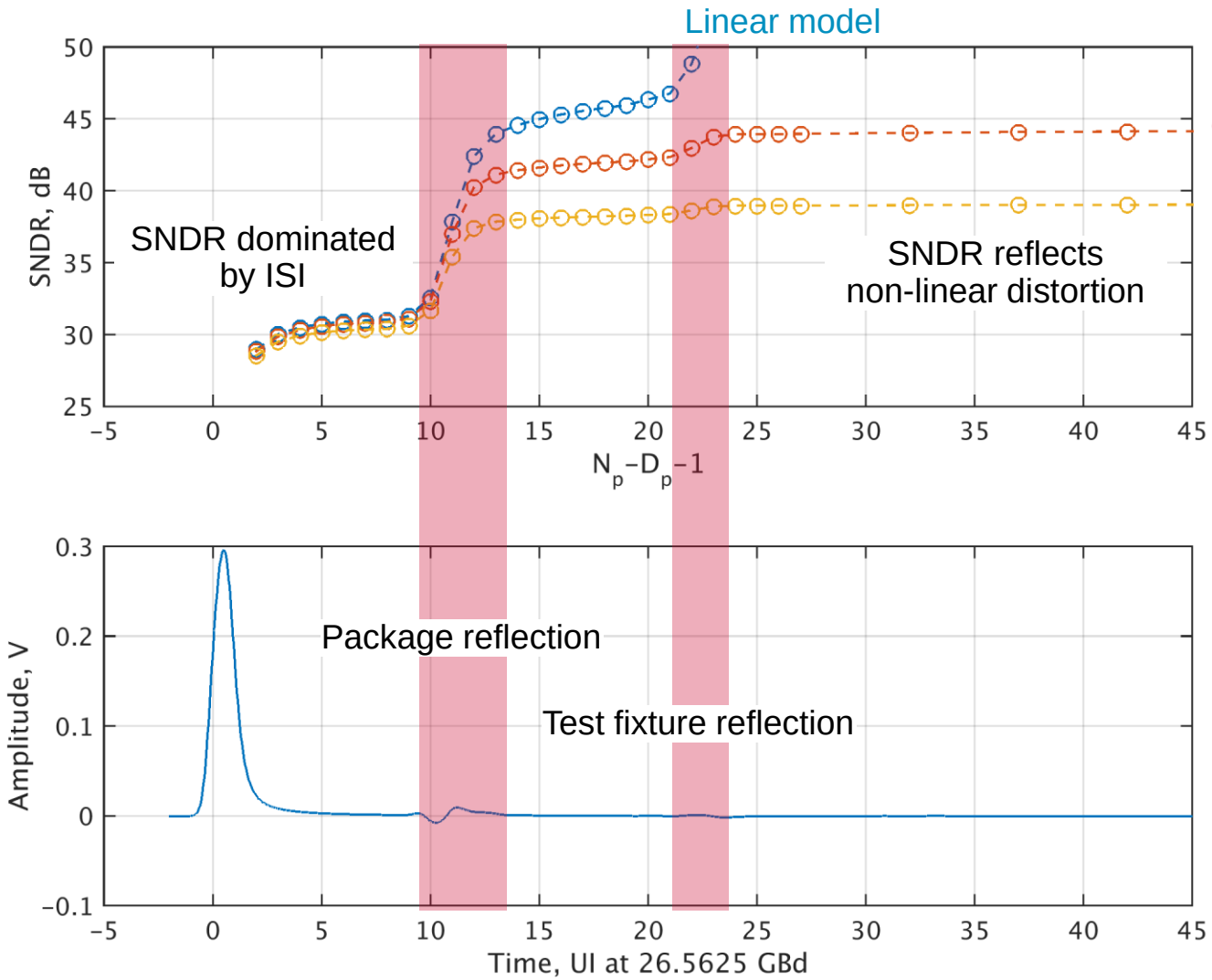
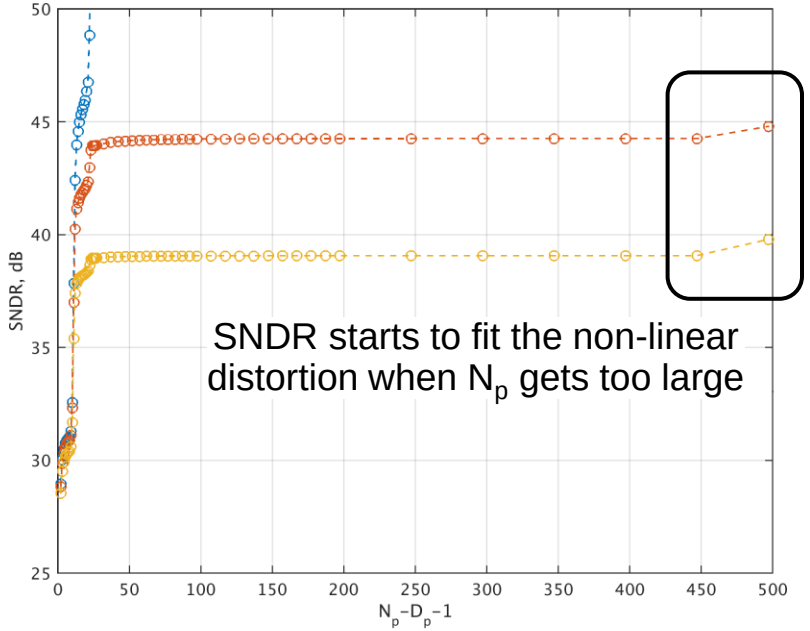
Linear fit pulse profile



Gain expansion (–0.58 dB)

Rise/fall time mismatch (5 ps)



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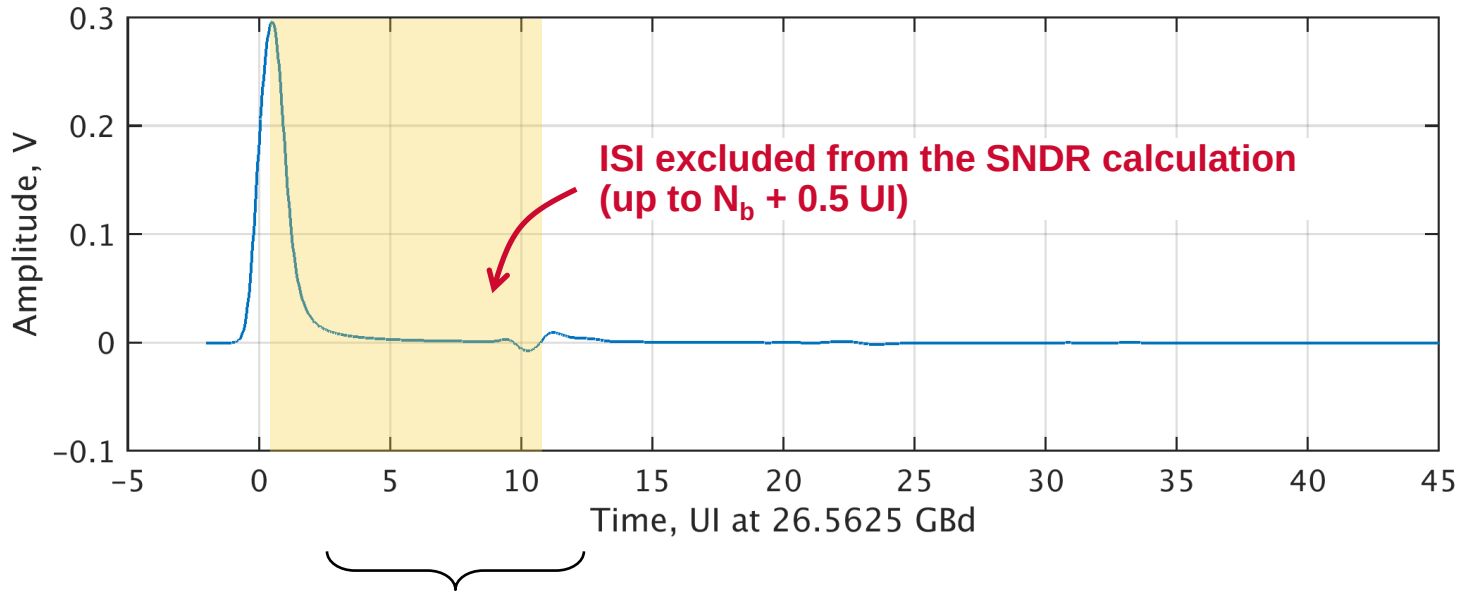
Inter-symbol interference profile



- It is challenging to clearly assign ISI terms to the transmitter under test

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Recommendations

- Compute the linear fit pulse and linear fit error with $D_p = 2$ and $N_p =$ **200**
- This is expected to make the linear fit error a measure of non-linear **distortion**

Summary

- SNDR is dominated by residual ISI
- Residual ISI is influenced by the test apparatus (fixture, cables, scope) which does not appear in the application environment
- It is an amalgamation of ISI for all sampling phases (only one should really matter)
- These considerations could be ignored when the limit was 27 dB
- However, these issues make it more difficult to verify the higher SNDR limit that is required for PAM4
- SNDR is also mapped to the Channel Operating Margin (COM) parameter SNR_{TX}
- COM translates inter-symbol interference from the test apparatus into a Gaussian noise term
- COM also includes residual ISI (beyond N_b UI) that would presumably already be included in SNDR

Conclusions

- This proposal makes SNDR a measure of **distortion** and **noise** aligning it more closely with its namesake
- This proposal should make the test results more repeatable
- This proposal enables clear alignment between SNDR and the COM parameter SNR_{TX}
- How do we ensure alignment between the ISI (at TP0) assumed by COM and the ISI presented by the transmitter under test?
  - p_{max} / v_f ratio is an indicator of signal bandwidth
  - Differential return loss is an indicator of termination quality
  - While additional metrics could be defined, it will be difficult to attribute errors to the transmitter under test without a priori knowledge of the construction of the package, test fixture, etc.