Measuring Common Mode Voltage (ref Comment #123)

Richard Mellitz, Samtec

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Supporters

- John Calvin, Keysight Technologies
- Adee Ran, Cisco

Agenda

- ❑ Background references
- ❑ Classification of CM sources
- ❑ Examples of histogram and power spectral considerations of CM
- ❑ CM Measurement recommendation

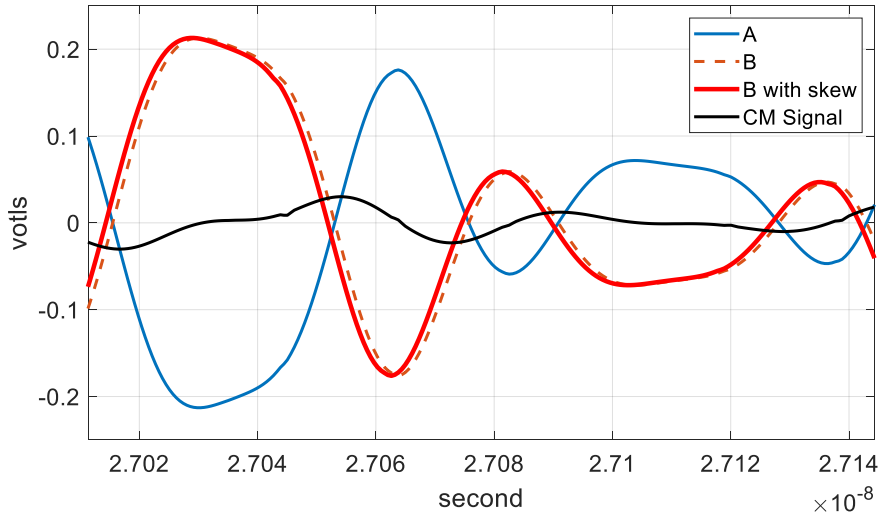
Follow on to Adee Ran's work in ran_3ck_adhoc_01_063021 "AC common mode considerations for C2M"

Previous work on CM specs

Presentation name	Title	Content
ran_3ck_adhoc_01_010621	Analysis of Common-Mode Signal at the Receiver Input	Assessment of CM levels at RX side for CR; need for CM stress test
mellitz_3ck_adhoc_01_121620	Common Mode (CM) Noise: Next Steps	CM noise from crosstalk
ran_3ck_04_1020	Considerations for TX AC Common-Mode Specifications	Correlated (mode conversion) vs uncorrelated (CM noise) effect
wu_3ck_01_1020	AC Common Mode Spec by TP0v	Proposal for CM AC specification at TP0v (KR)
wu_3ck_adhoc_01_090920	AC Common Mode Noise and Common Mode to Differential Conversion Exploration	Conversion loss metrics (IDCR/INCM) analysis for CR/KR
ghiasi_3ck_03a_0720, ghiasi_3ck_03_0720	Differential, Conversion, and Common Mode Return Losses (Return Loss and ERL Limits for C2M and CR)	Sources of CM; s-parameter results but no RMS results
wu_3ck_01a_0720	AC common mode and SDC21 limits	Analysis of uncorrelated CM noise effect on COM (CR/KR)
mellitz_3ck_adhoc_01_062420, mellitz_3ck_adhoc_01_061720	Common Mode: Fact or Fiction	Proposal to add Tx AC CM conversion term into COM à la SNR_{TX}

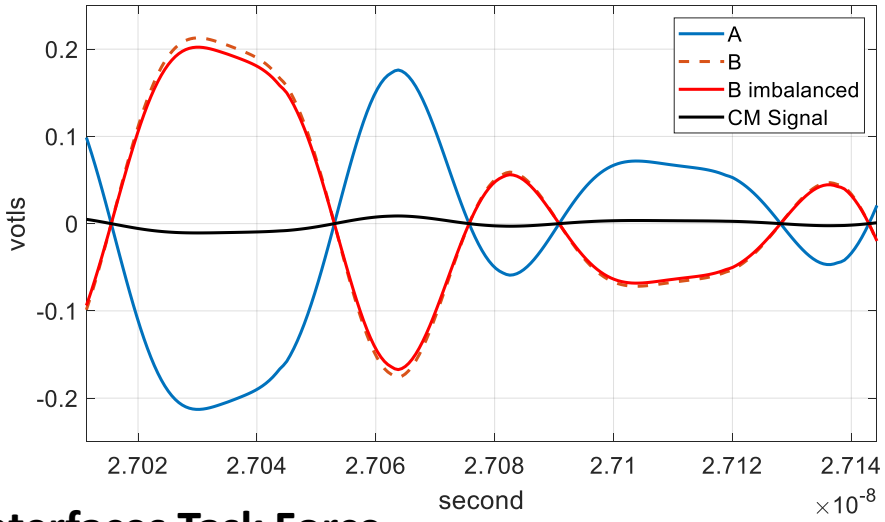
Coherent Sources of Common Mode (CM)

- Skew



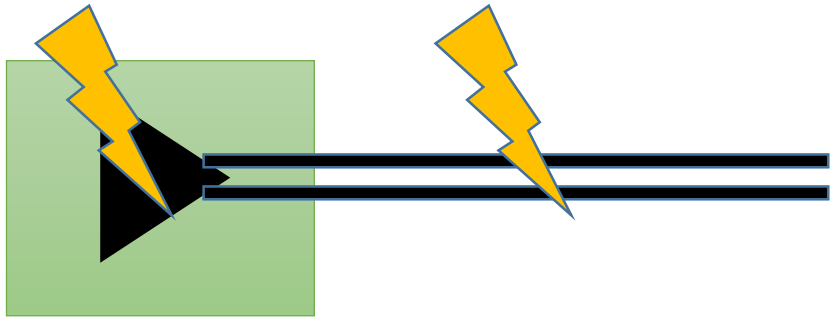
+/- Waveform clip: 106.6 Gb/s PAM4 signaling

- Signal Imbalance

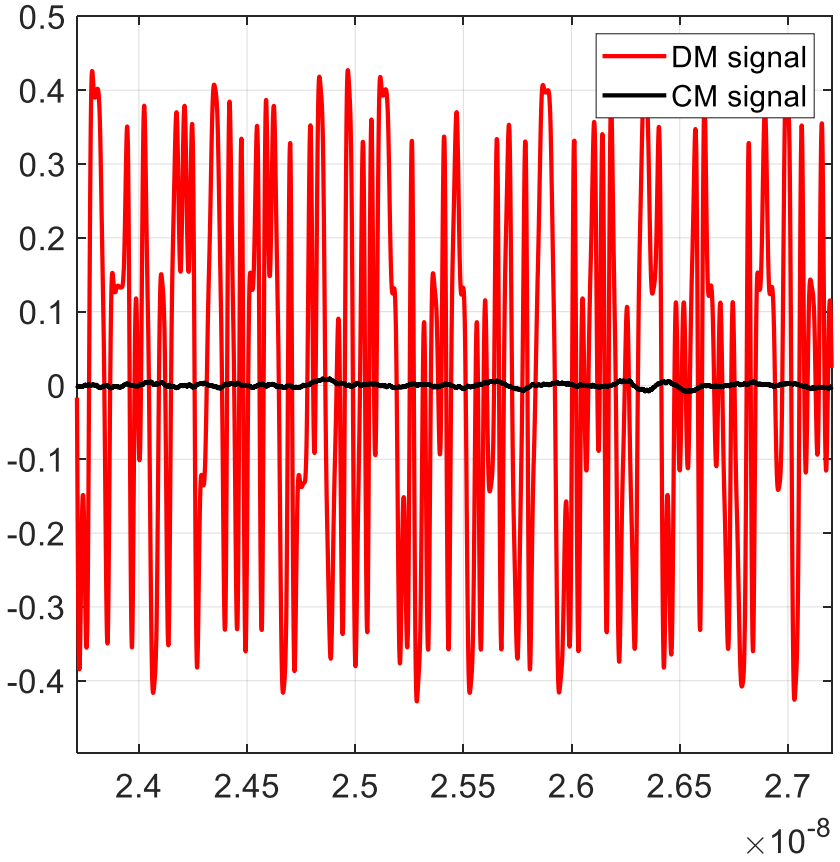


Asynchronous Sources of Common Mode (CM)

External Noise

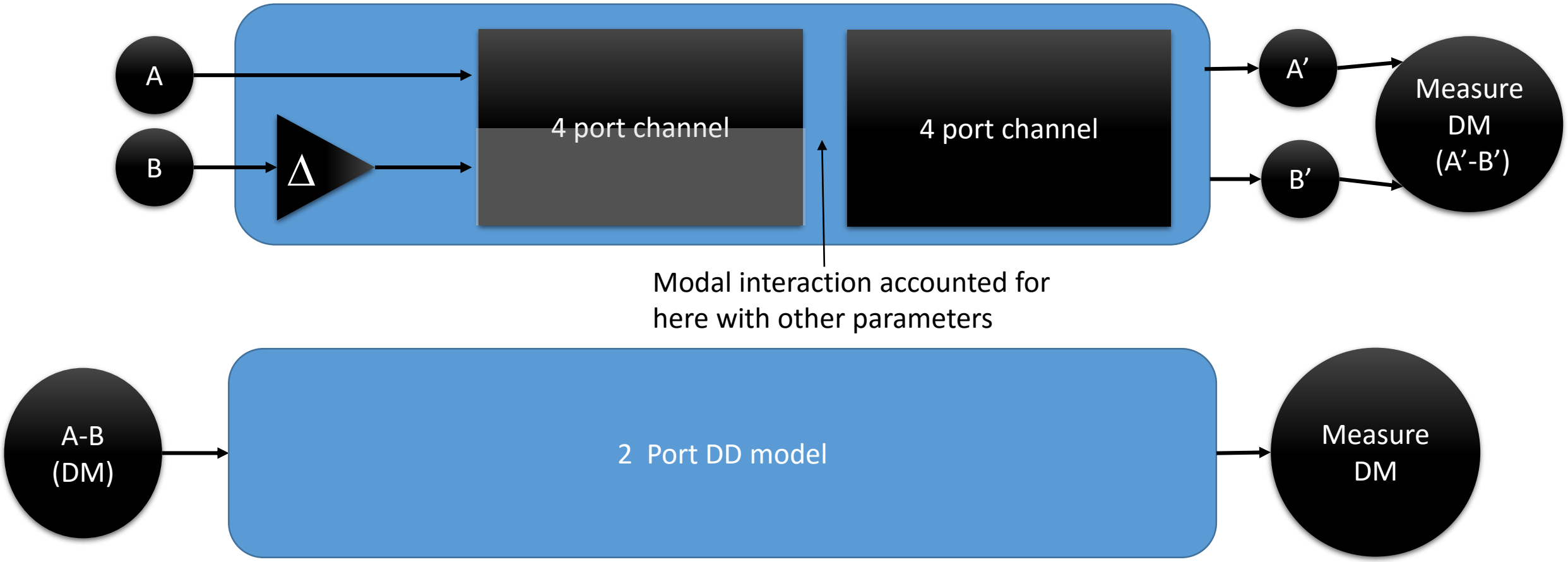


106.6 Gb/s PAM4 CM and DM waveforms

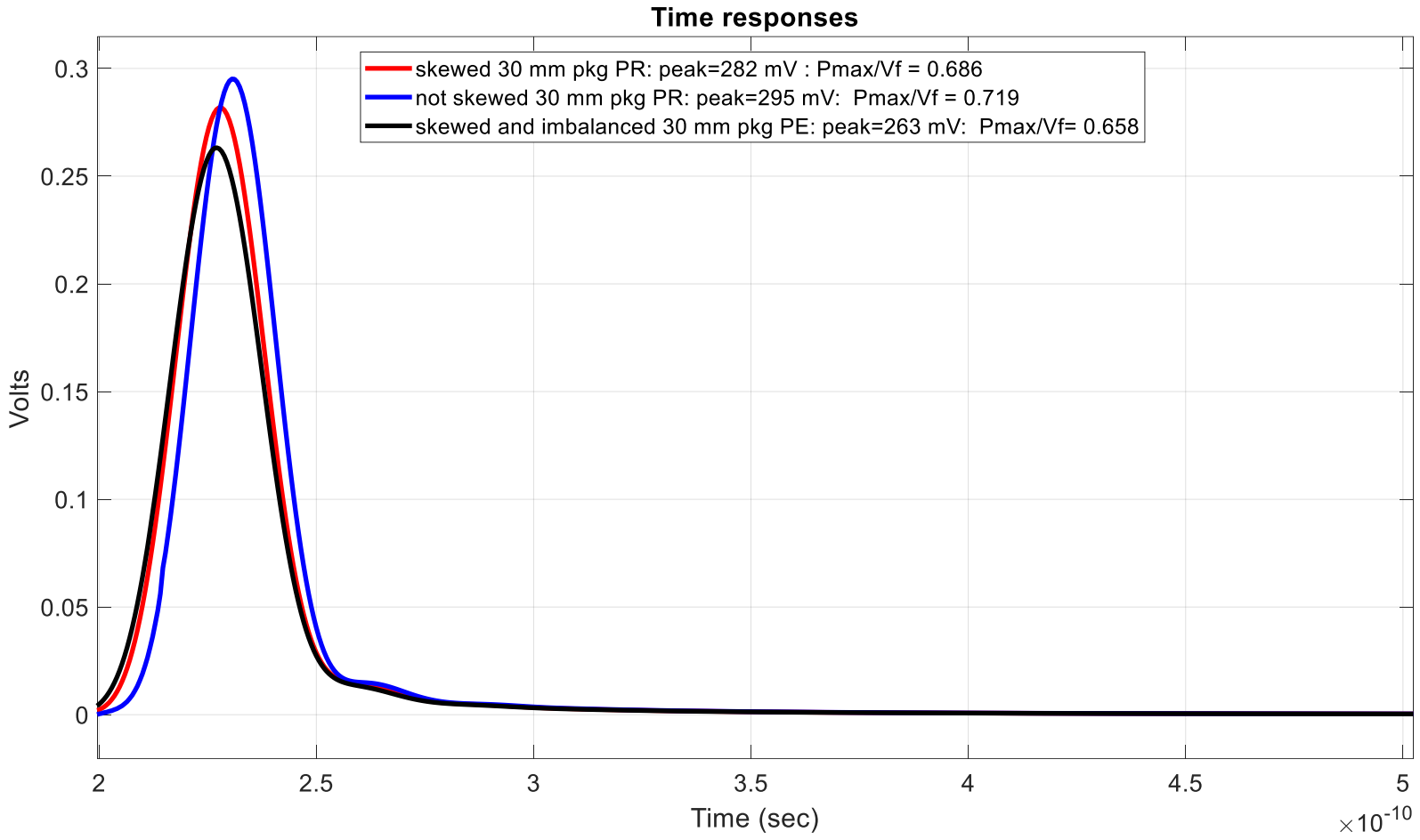


Full S-parameter and DM Simulations Can Agree

These two produce the same results

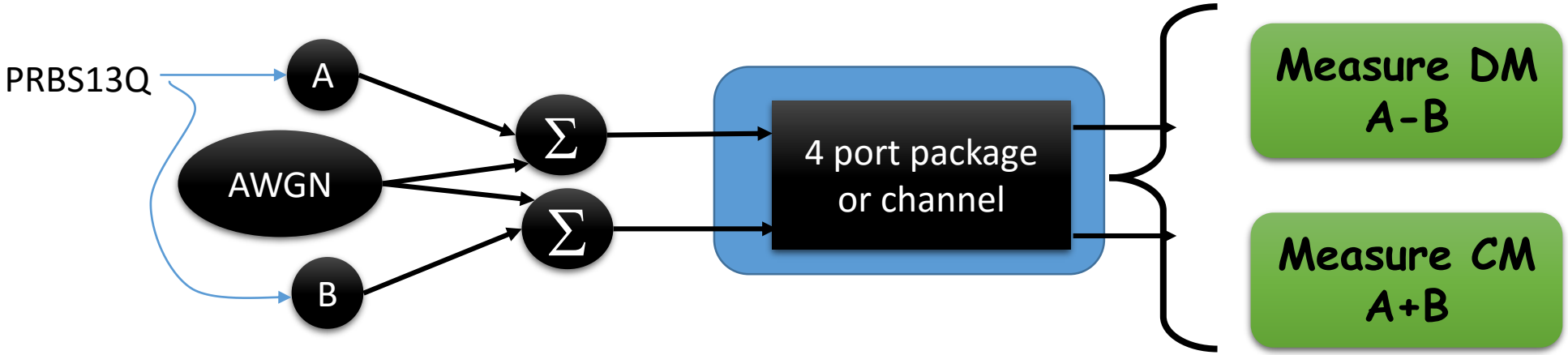


Modal interactions for skew and imbalance show up as pulse height and P_{max}/V_f reduction



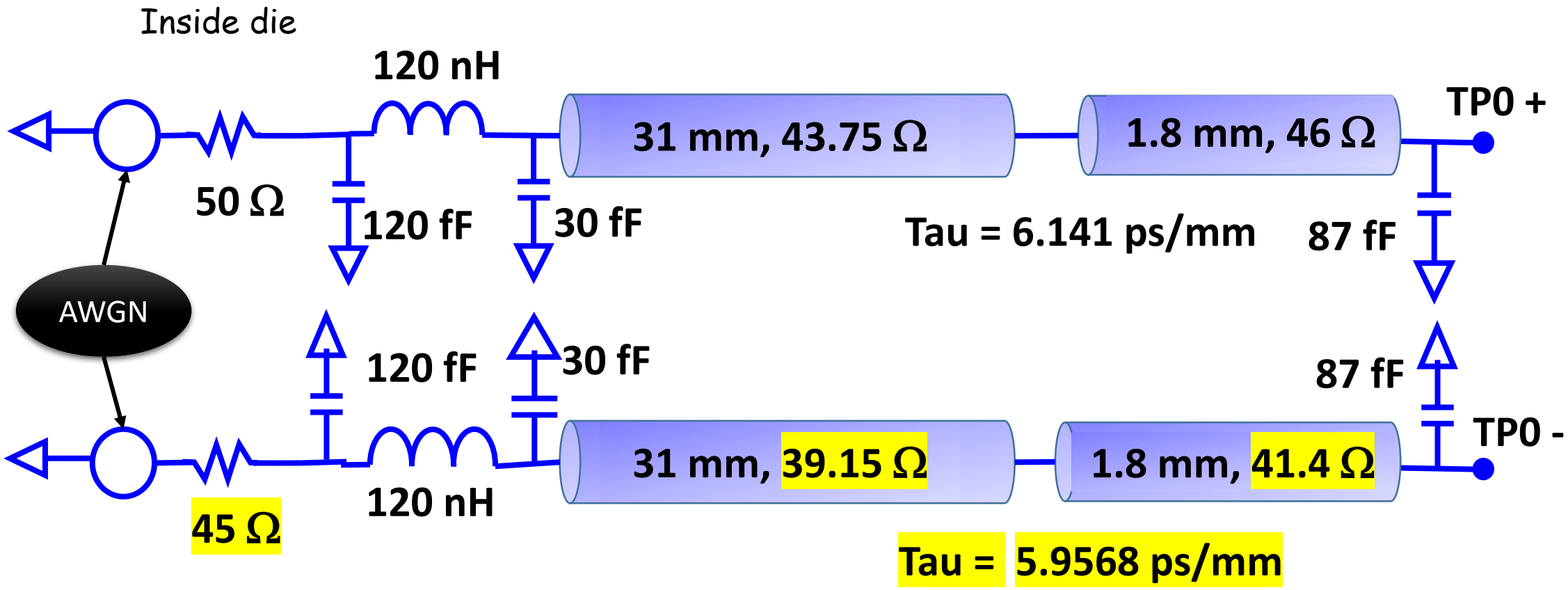
- Skew at left is 5 ps
- Impedance imbalance is 10%
- There is also a likely impact to SNDR since Pmax is reduced and σ_n is likely to be the same.
- Conclusion: CM noise is at least partially included in other Tx measurements

Problem: Coherent and Asynchronous are lump in a traditional AC CM measurement



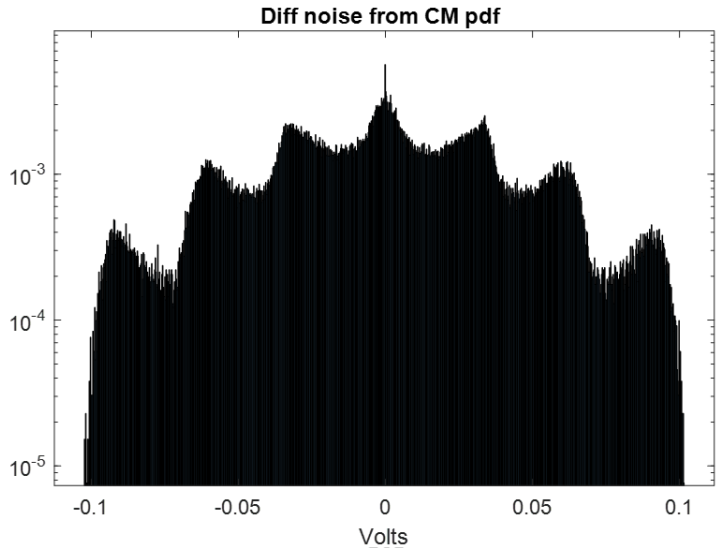
- Above is a simple mode for measuring DM and CM waveforms
- The frequency content, power spectral density (PSD), and statistics are different for skew, imbalance, and asynchronous CM noise.

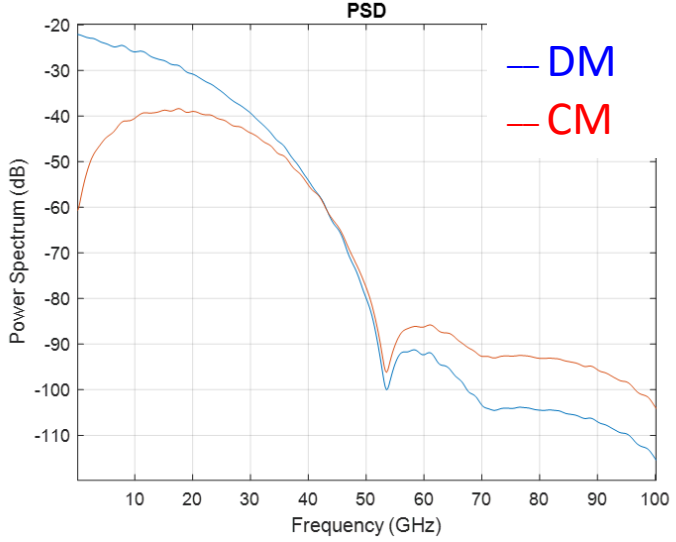
For this presentation we will look at TP0 TP0v is follow-on work



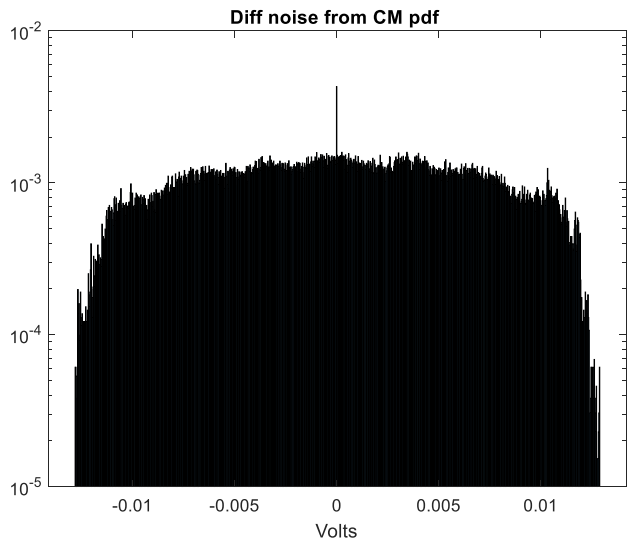
CM (@TP0) noise histograms and PSDs are very different

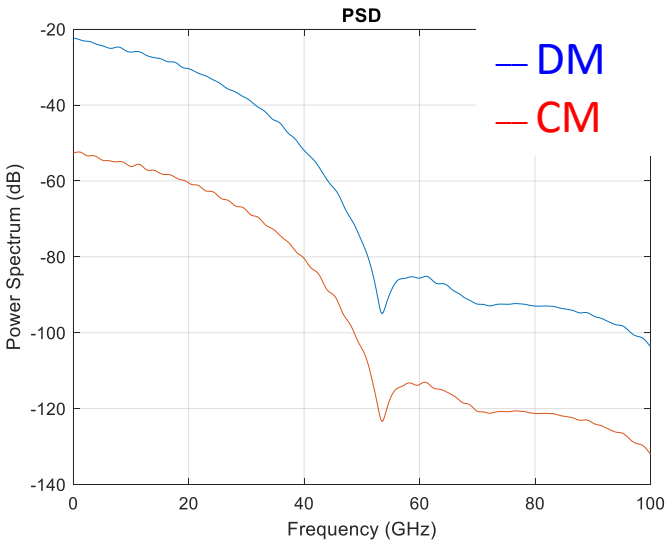
5 ps Skew



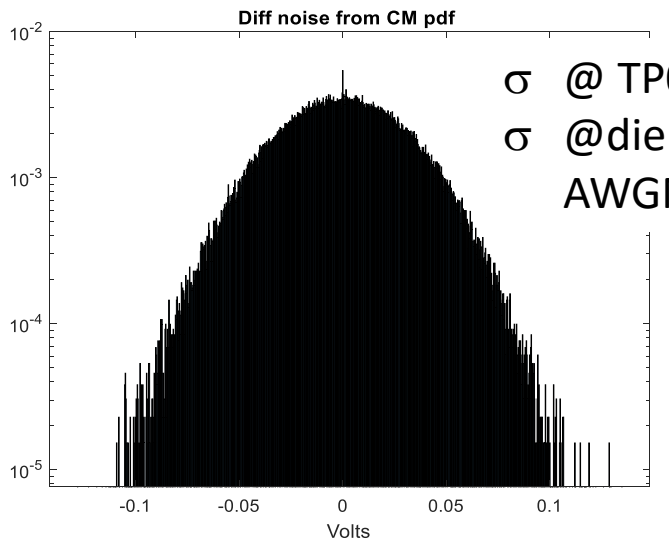


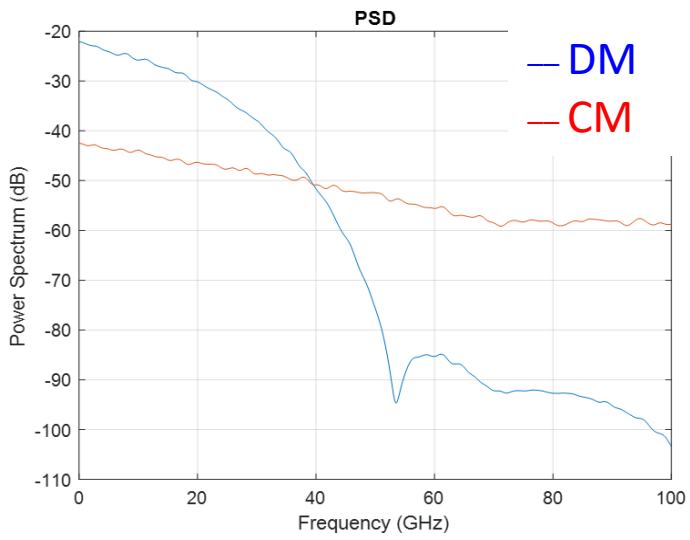
10 % imbalance





CM AWGN

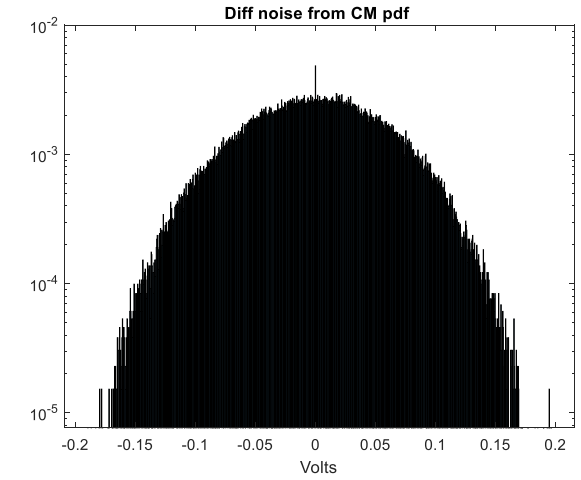


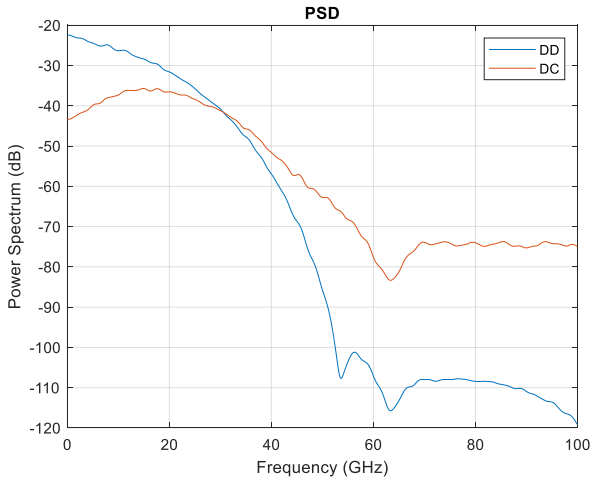


σ @ TP0 = 30 mV

σ @die = 168 mV AWGN

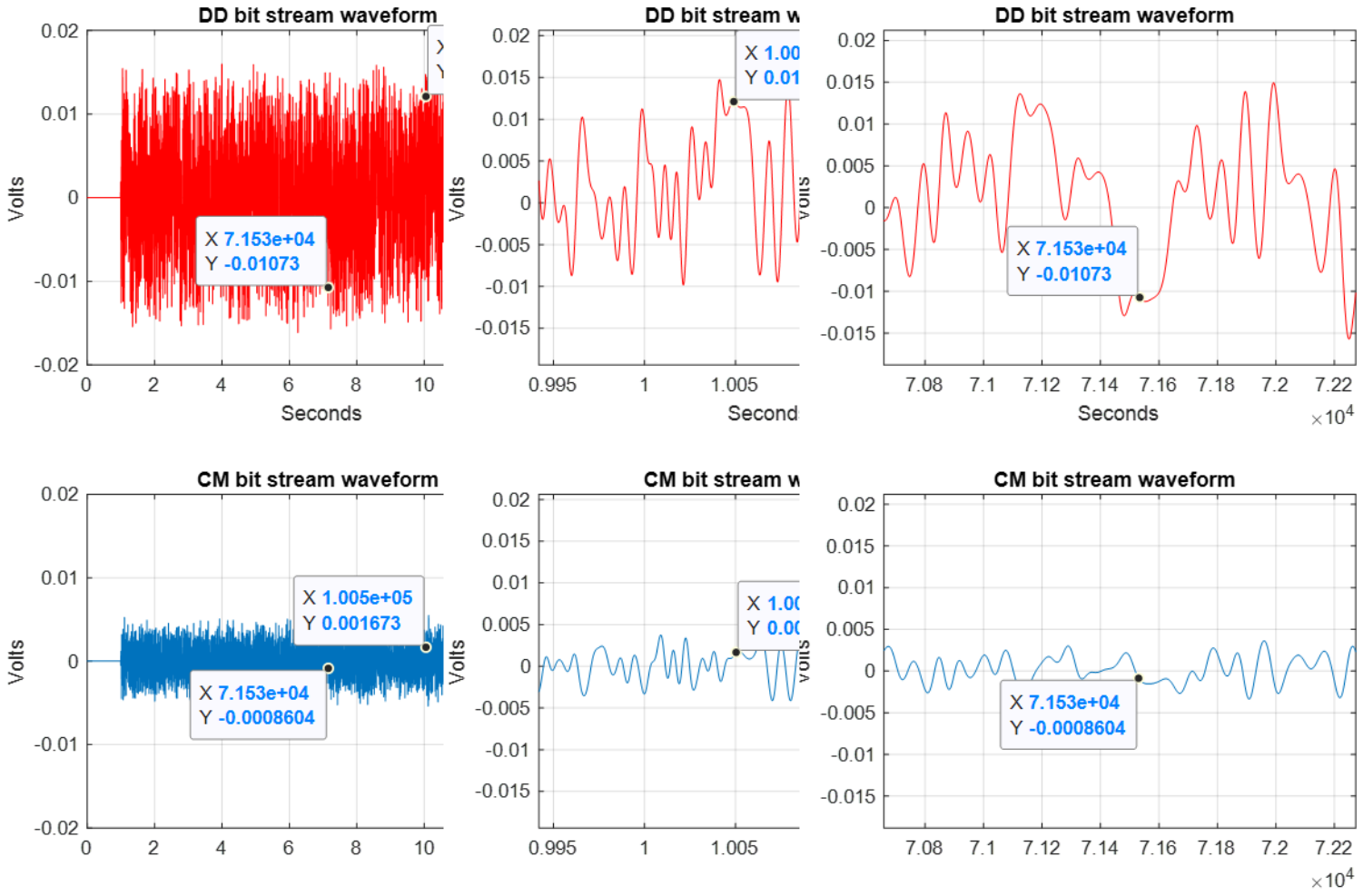
The CM measurement contain all the previously mentioned impairments





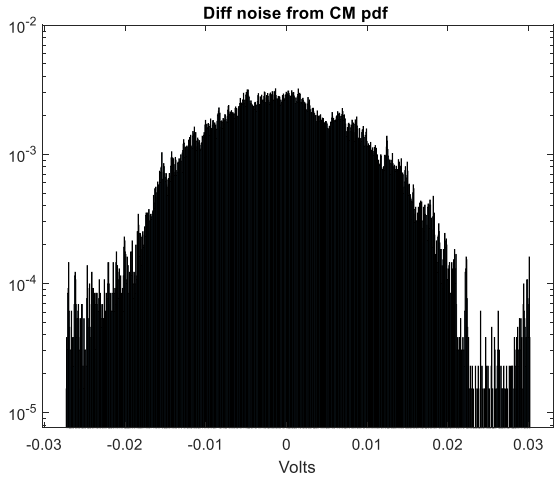
- Example on the left impairments in package model
  - 5 ps skew
  - 10% impedance imbalance
  - 30 mV AWGN at TP0
- The problems is like unscrambling an egg ☺

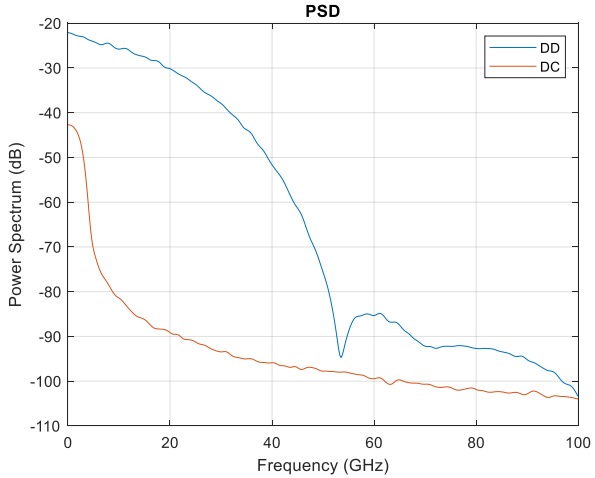
Suggestion



- Use modification of σ_n method in 120D.3.1.6
- 120D.3.1.6:
  - "Using the same configuration of the transmitter equalizer, measure the RMS deviation from the mean voltage at a fixed low-slope point in runs of at least 6 consecutive identical PAM4 symbols. PRBS13Q includes such a run for each of the PAM4 levels. The average of the four measurements is denoted as σ_n. "
- Consider: the CM and DM signal are time synchronized because both are combines of "A" and "B".
- Measure AC common-mode (CM) output voltage $\sigma_{AC\text{-}CM}$ using the following procedure.
  - "Using the same configuration of the transmitter equalizer, measure the RMS deviation from the mean of the CM voltage at a time point corresponding to where the DM signal is at a fixed low-slope point in runs of at least 6 consecutive identical PAM4 symbols. PRBS13Q includes such a run for each of the PAM4 levels. The average of the four measurements is denoted as $\sigma_{AC\text{-}CM}$. "
- A sufficiently large number of repeats of the data pattern is required.

Additional Thoughts





- Much of the AC RMS may be expected to be frequency lower than $f_b/2$.
- Using the Tukey window described in 93A–58a with f_b set to 2.675GHz ($f_b/20$) and f_r set 2.5412 GHz (.95 $f_b/20$) sufficiently large number of repeats of the data pattern is required
- AC CM RMS is 8.5 mv with filter and 30 mV without filter.
- Using the whole CM waveform (no skew, no imbalance, AWGN only)

Recommendation

- ❑ Specific AC Common mode voltage as on slide 13
- ❑ Discussion: Filtering