ANALYSIS OF COMMON-MODE SIGNAL AT THE RECEIVER INPUT

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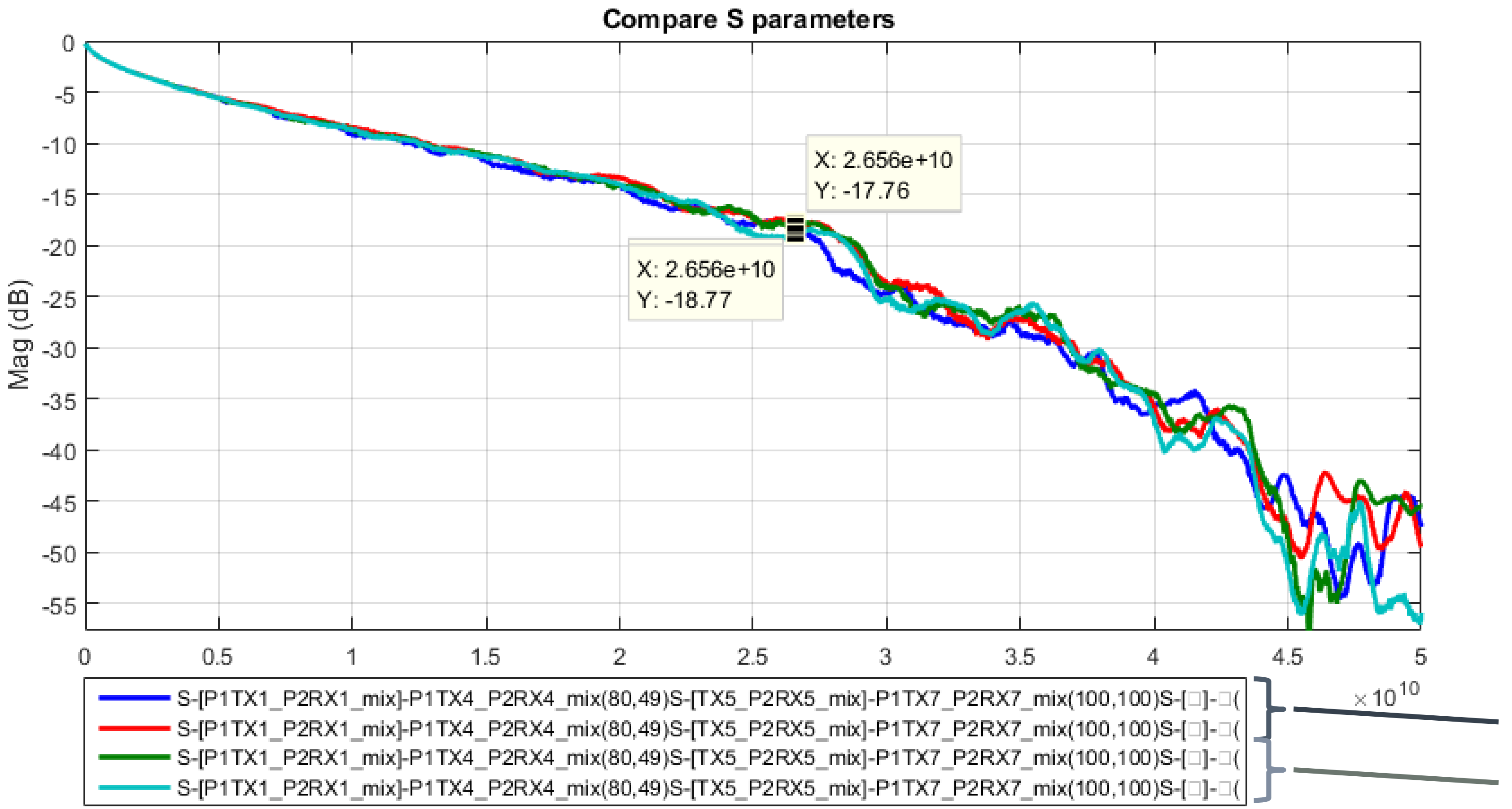
Goal: look at CM signal form Receiver’s point of view

- Questions:
  - How large is the common mode signal from differential signal mode conversion?
  - How large is the common mode signal assuming transmitter’s CM AC is 30 mV RMS?
  - How much common mode signal should the receiver tolerate? What kind is dominant?

Scope of this presentation

- Long-term thoughts (not for D1.4!)
- Focus on cable assembly
  - Assumed to have maximum D-C conversion due to physical length
  - Assumed to be a limiting case for SNR, Rx margins
- Data set: Measured OSFP 2m 25awg Cable contributed by Erdem Matoglu (March 4 2020)
  - Chosen because it is measured data – represents a feasible cable assembly
  - This data set is taken as an example, not necessarily worst or best case in real cables
- Two “best” and two “worst” of the 8 “thru” pairs (in terms of SDC21) were identified
  - Same lanes used for CC and DD analysis
- Host boards and device models are not included
- Rough comparison of DC, CC, DD signals – **not a full analysis**!
- Not trying to analyze how a real receiver is affected by common mode

SDD21 – frequency domain (dB)

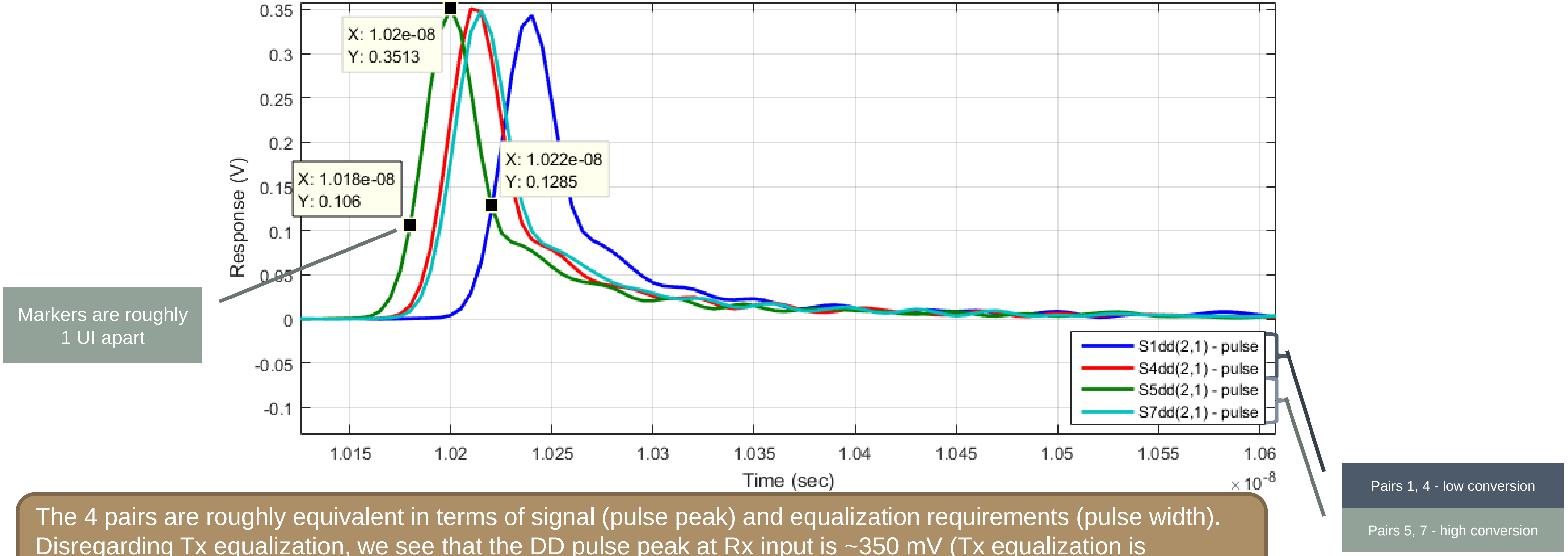


Pairs 1, 4 - low conversion

Pairs 5, 7 - high conversion

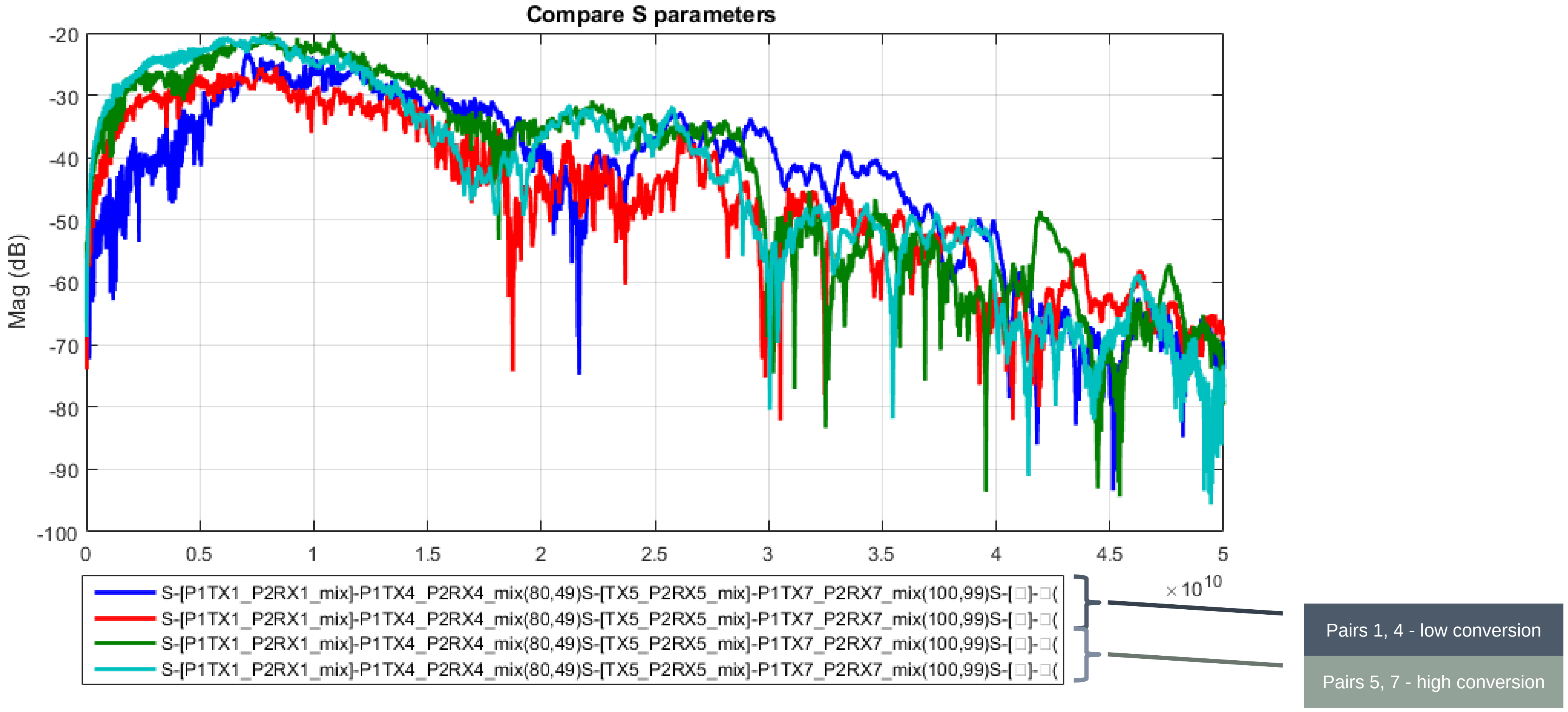
DD (differential to differential) pulse responses

Input is 1V rectangular pulse for 20 ps (roughly 1 UI) – full swing (COM uses 400 mV)

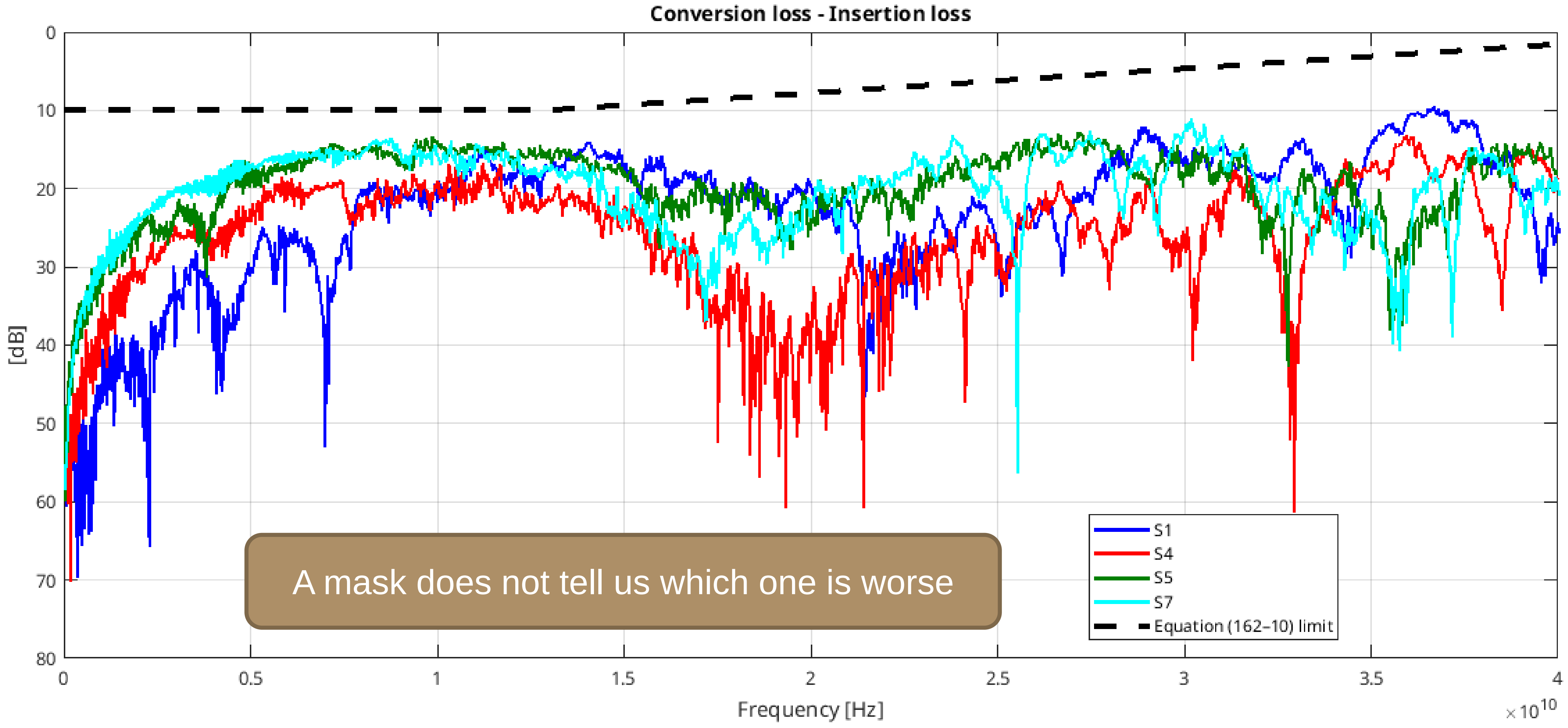


The 4 pairs are roughly equivalent in terms of signal (pulse peak) and equalization requirements (pulse width). Disregarding Tx equalization, we see that the DD pulse peak at Rx input is ~350 mV (Tx equalization is expected to reduce it considerably)

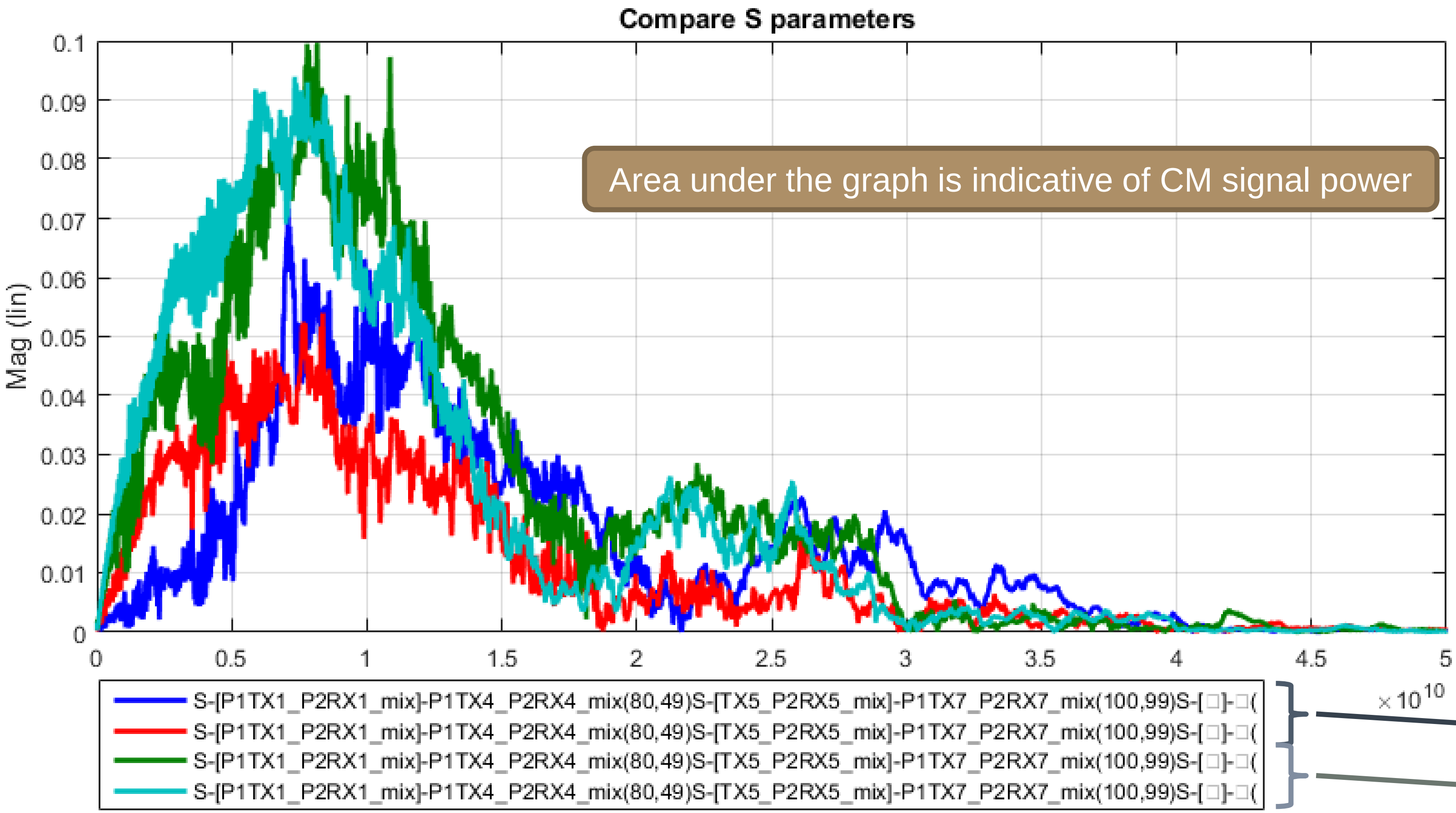
SDC21 – frequency domain (dB)



All pairs meet the SDD21-SDC21 requirements easily



SDC21 – frequency domain (mag)

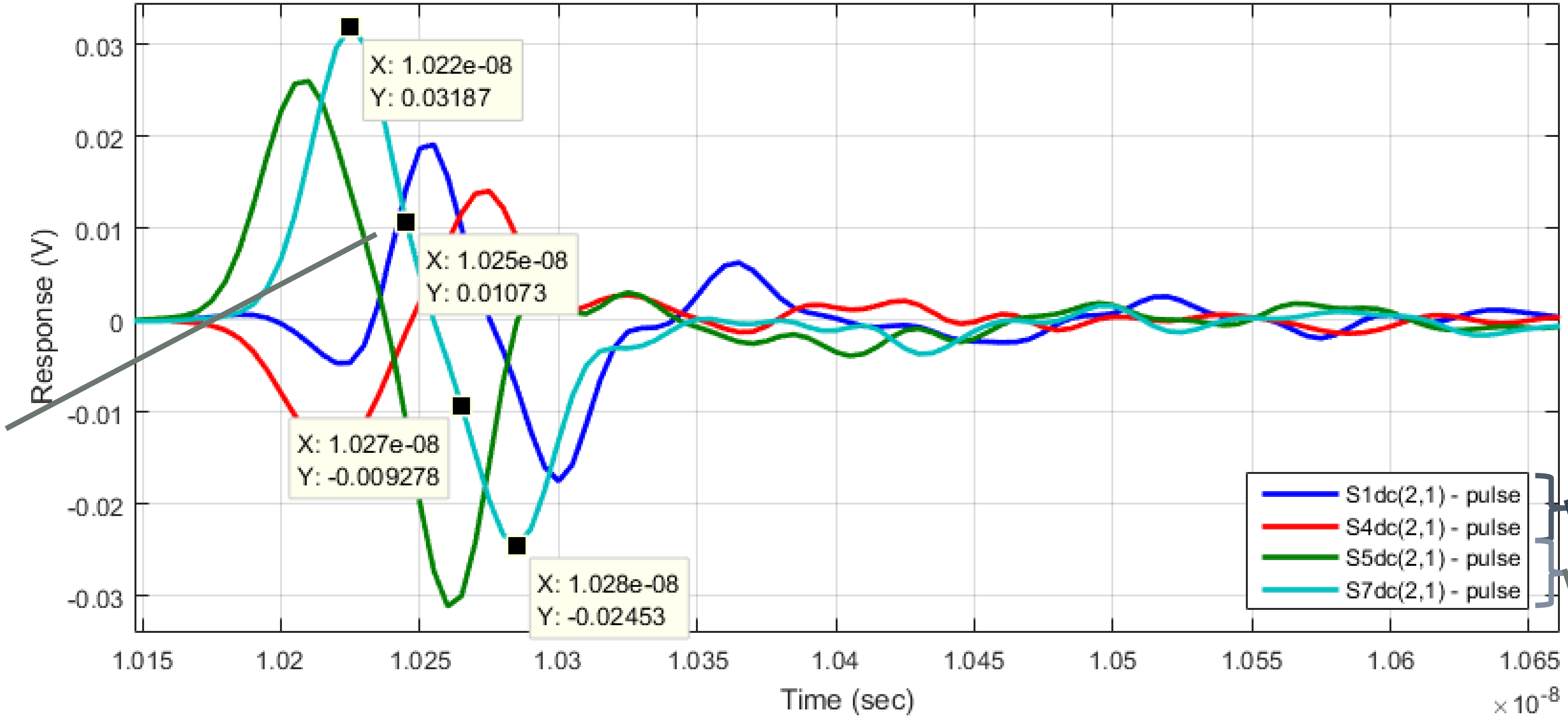


Pairs 1, 4 - low conversion

Pairs 5, 7 - high conversion

DC (differential to common) pulse responses

Input is 1V rectangular pulse for 20 ps (roughly 1 UI) – full swing



Markers are roughly 1 UI apart

RMS estimates:
1: 26 mV
4: 20 mV
5: 41 mV
7: 40 mV

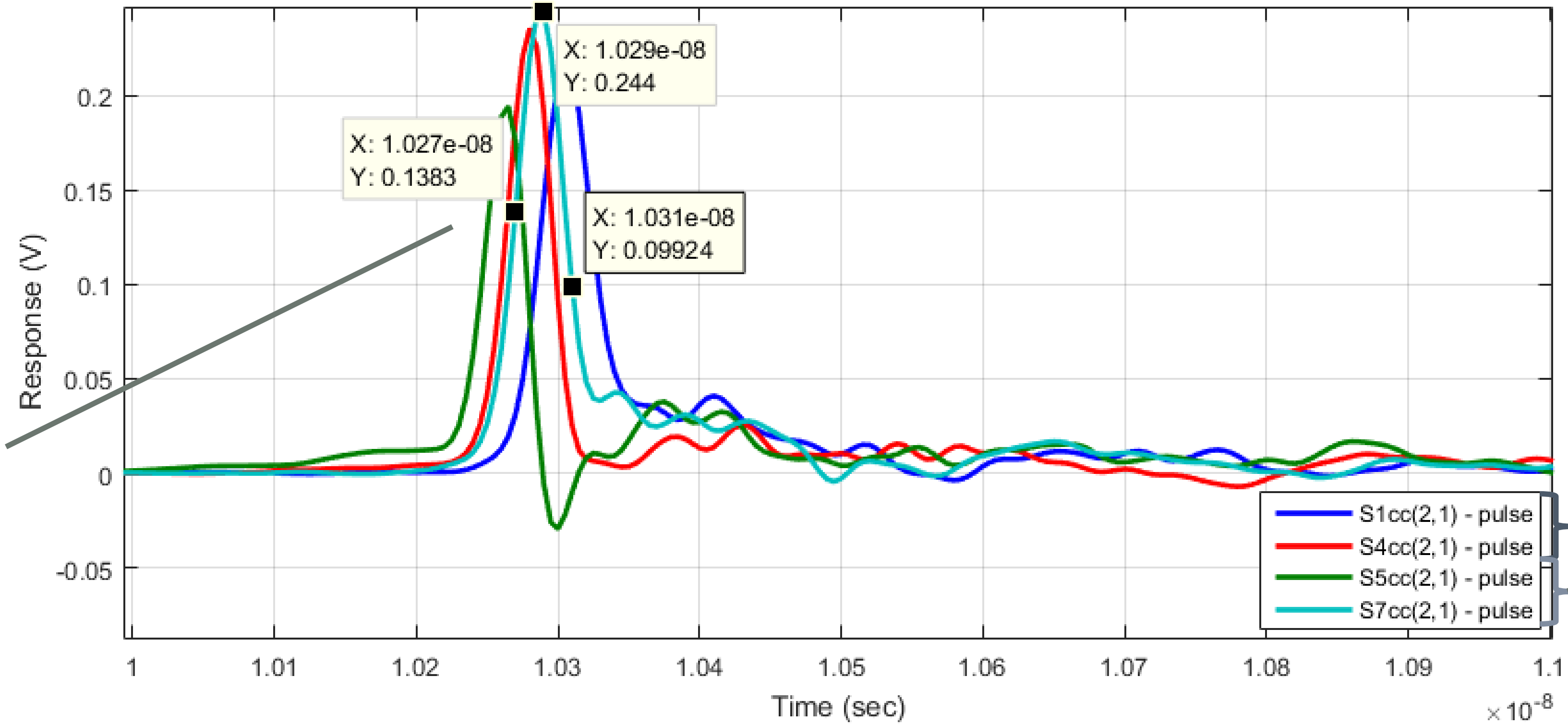
Pairs 1, 4 - low conversion

Pairs 5, 7 - high conversion

CM RMS estimated by taking the RSS of the positive and negative peaks of each pulse. Best case is 25 dB below the signal. Worst case is 18.7 dB below signal.

CC pulse responses

Input is 1V rectangular pulse for 20 ps (roughly 1 UI). Note that CM AC signal of the Tx is much lower (e.g., 30 mV RMS)



Markers are roughly 1 UI apart

RMS estimates:
1: 27 mV
4: 27 mV
5: 22 mV
7: 30 mV

Pairs 1, 4 - low conversion

Pairs 5, 7 - high conversion

CM RMS estimated by taking the RSS of the peak and ±1 UI samples of each pulse, and multiplying by 30/300=0.1 (ratio of TX CM RMS to Diff RMS – assuming PAM4 with Vf=400 mV) Best case is 24 dB below the signal. Worst case is 21.4 dB below the signal.

Observations

- The frequency mask is not helpful as a guard against mode conversion
  - An integrated measure is preferable
  - The current limit line allows much worse conversion than the cases examined here!
- Comparing the AC CM output of 30 mV RMS to the D-C conversion of a long channel, we see that both create DM/CM ratios in the same ballpark…
  - 18.7 dB - 25 dB resulting from conversion ("DC" channel)
    - But likely worse with Tx equalization
  - 21.4 dB – 24 dB resulting from the Tx ("CC" channel)
    - Not expected to change with Tx equalization
  - Mode-conversion component is likely more important, we should not ignore the Tx
- If we treat CM as a sum of random components, its power can be more than (worse than) -17 dB of the differential signal (~15% RMS)

Thoughts

1. 15% CM noise relative to DM signal may not be negligible for Rx input
   - We should consider adding tolerance requirements
   - What kind of stress should be tolerated?
     - The “DC” signal will be fully correlated to the desired (differential) signal
     - The “CC” signal may be partly correlated; any correlated component may further increase the CM signal power (direct sum instead of RSS)
     - Most of the stress in a test should be correlated to the differential signal
   - Possible test condition: add a deliberate P/N skew in the receiver’s ITOL test, to create DM/CM ratio of 17 dB at TP5a?
     - If this is unacceptable – then channel and Tx specs need to be improved!
2. To avoid adding uncorrelated CM noise stress, we may choose to separately limit the Tx uncorrelated CM output
3. Cable assembly spec for mode conversion would better be based on COM method
   - e.g. DD-to-DC signal ratio at Rx input, accounting for the chosen Tx equalization

QUESTIONS? DISCUSSION?

Thank you