Differential, Conversion, and Common Mode Return Losses

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IEEE 802.3ck Task Force

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Overview

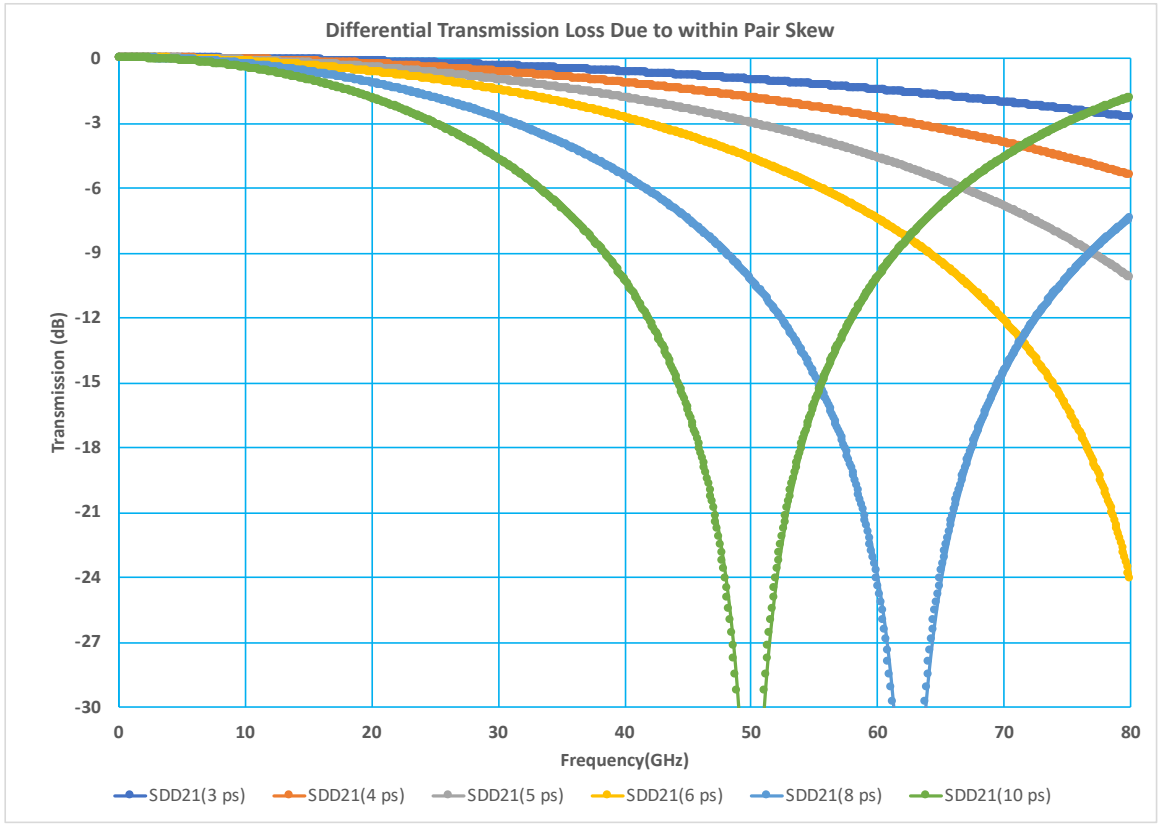
- **Contribution in support of following C2M comments**
  - TP1a SCC22 comment 207
  - TP4 SCC22 comment 208
  - TP1a SCD22 comment 209 (equation 120G-1 will also change TP4a SCD11)
  - TP4 SCD22 comment 210 (equation 120G-1 will also change TP1 SCD11)
- **This contribution with additional supporting material also addresses questions raised during March telephonic conference calls.**

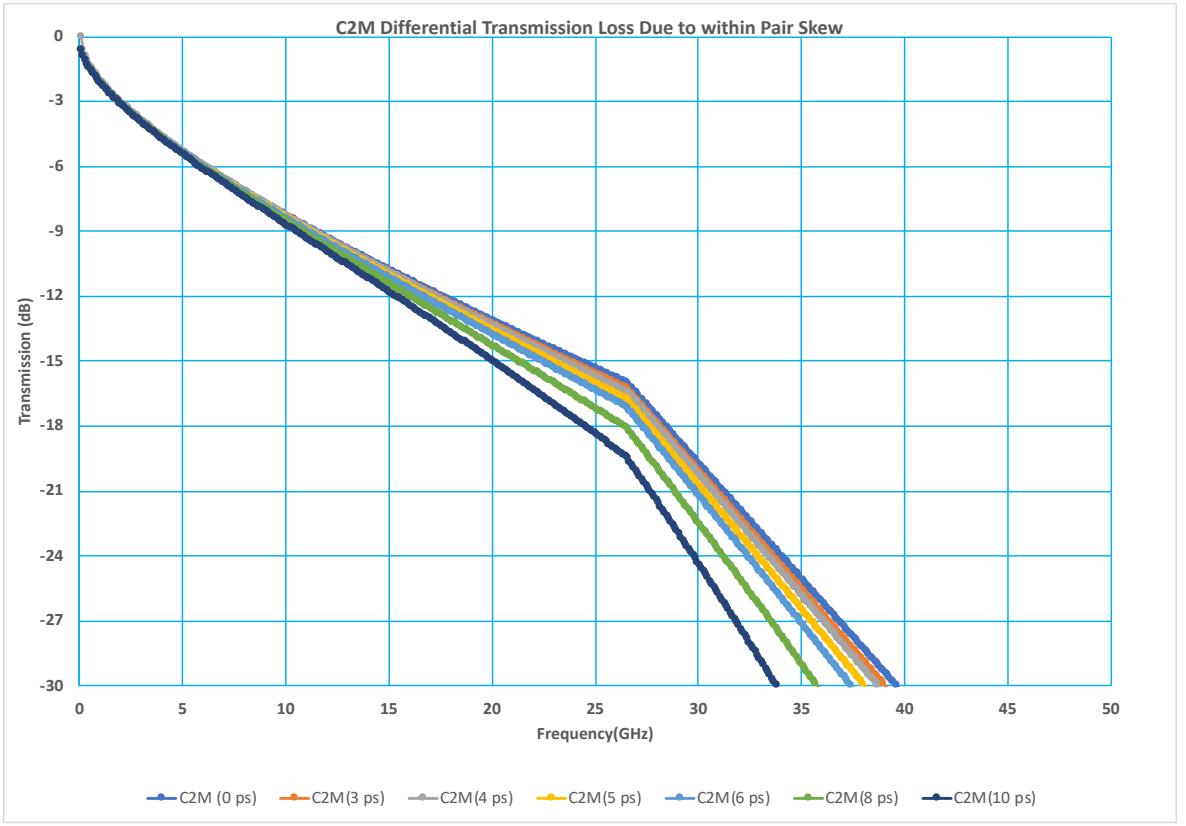
Background Material

- **The basic methodology came from SFF-8431 SFP+ then carried into IEEE nPPI**
  - Transmitters
    - Limits SDD22 and SCC22
    - AC VCM generated with value of 12 mV RMS defined
  - Channel/far end
    - AC VCM out defined with value of 15 mV RMS
  - Receiver
    - Max AC VCM tolerance with value of 15 mV RMS
    - Limits on SDD11 and SCD11 (differential to common mode)
    - SDC11 (common mode to differential) was not defined given that VCM was only 15 mV and only 3-5% of the differential signal that travel back gets reflected by the channel
    - SCD11 coverts 100's mV of p-p signal at the receiver
- **In the 25G AUI 802.3bm we made following changes**
  - Increased TP1a AC VCM to 17.5 mV to account for 25.78 GBd channels
  - For some reason receiver SCD11 was swapped with SDC11, given that in most cases SCD11~SDC11 there probably not a material impact
  - Given that both SCD11 and SDC11 play important roll to covert differential/common mode signal back to spurious differential signal recommend to define both SCD11/SDC11 for the receivers

Sources of Common Mode

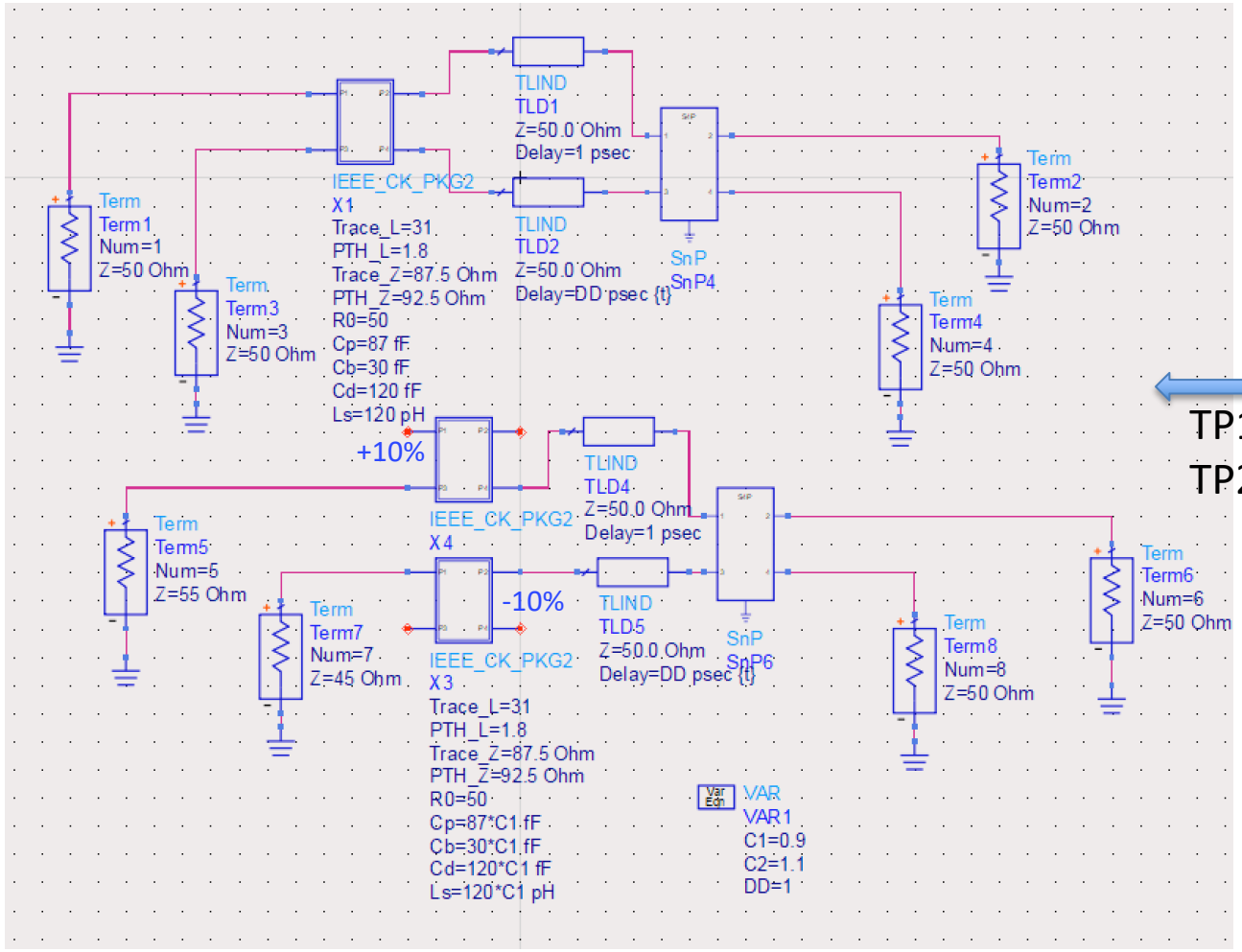
- **Driver P/N asymmetry and interconnect P/N mismatch are the two sources of common mode generation**
  - Graph show the theoretical impact of 3-10 ps of skew on C2M IL where the penalty increases with the Baudrate increase , D. Nozadze, IEEE EPEPS, 2017
  - The CK channels already include effects of P/N mismatch but currently COM reference model and package don't excite the common modes and obviously the impact is overlooked at the receiver.





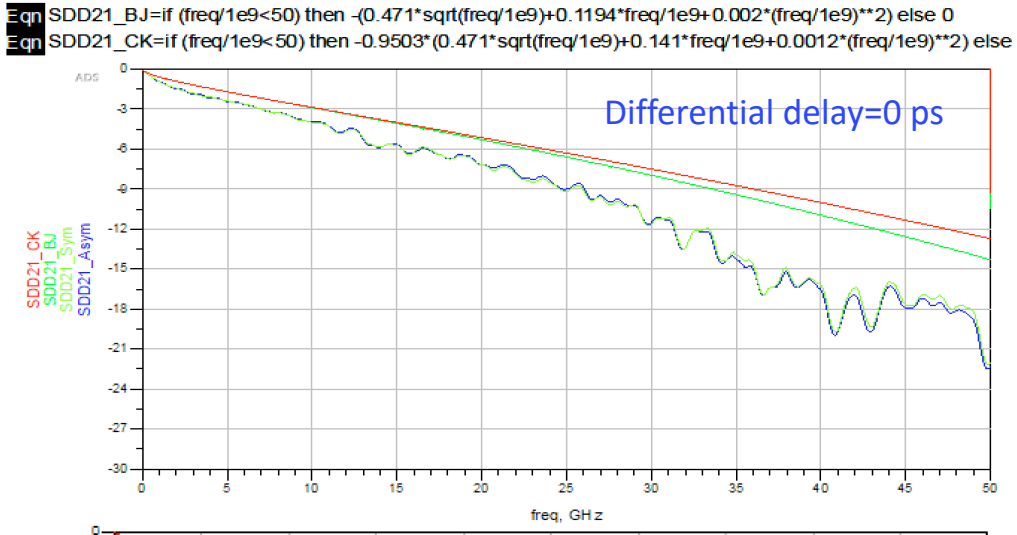
Host Circuit

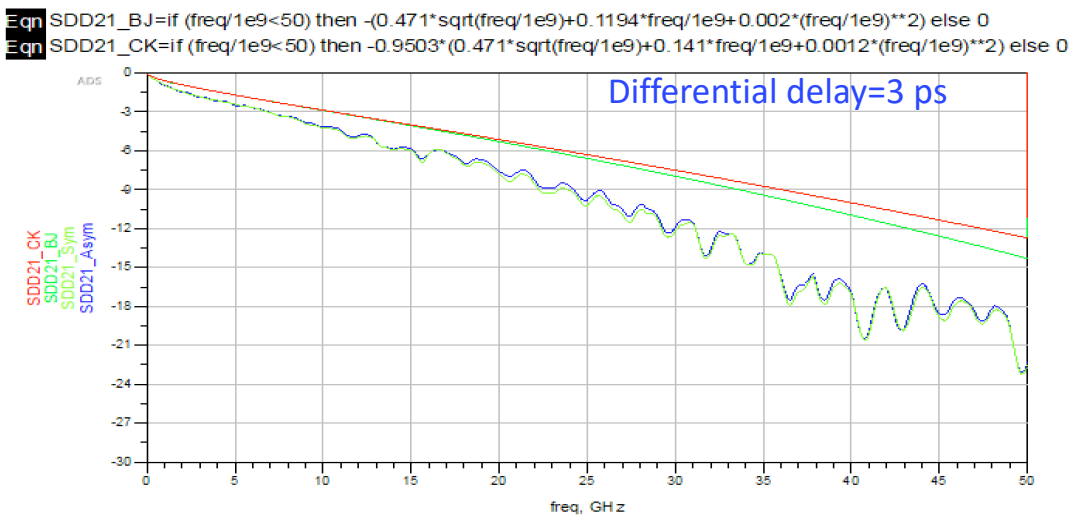
- **Host circuit for SCC, SCD:**
  - Yamaichi MCB/HCB
  - ±10% term mismatch for 2nd CKT
  - IEEE PKG ±10% C/L for 2nd CKT
  - Delay mismatch up to 11 ps.

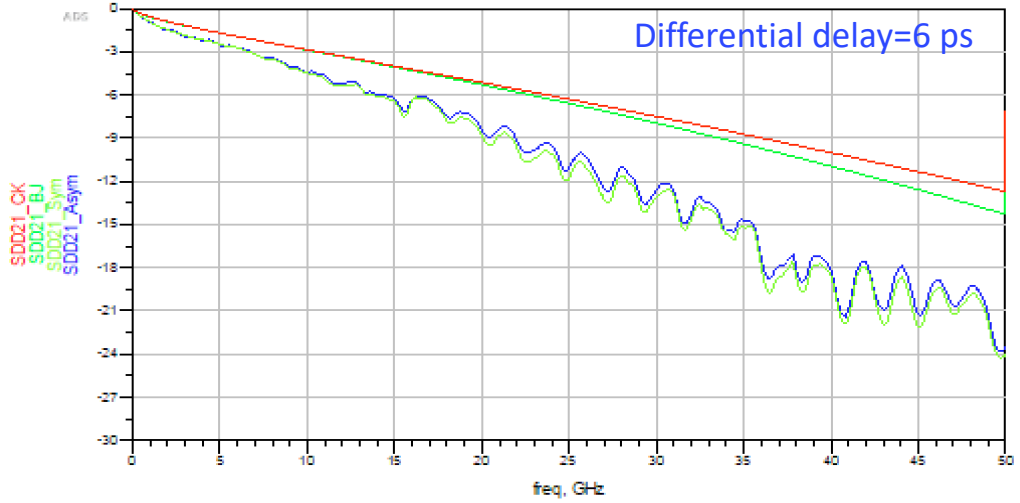


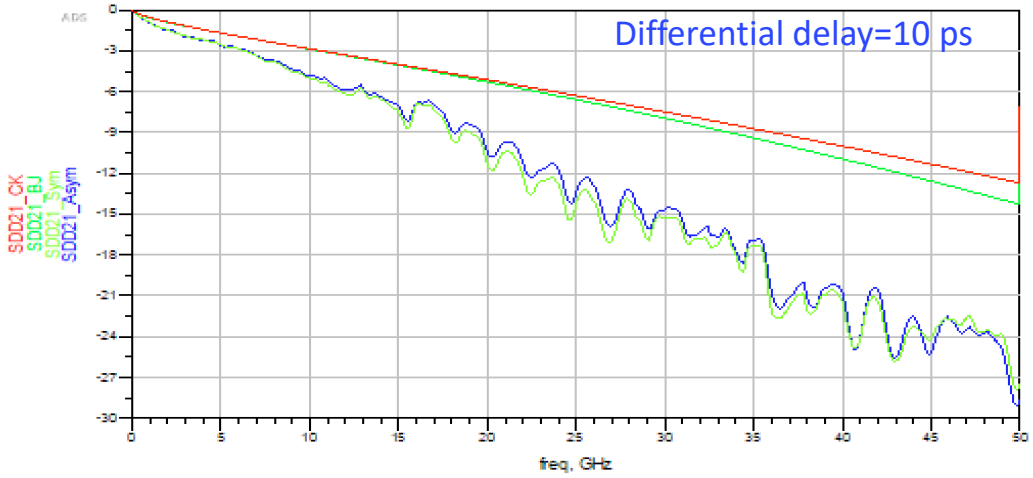
Host Transfer Response for Package Asymmetry and Differential Delay

- **A well design host expected to meet 3 ps of differential delay**
  - Package/device asymmetry of ±10 has negligible impact on ILD.



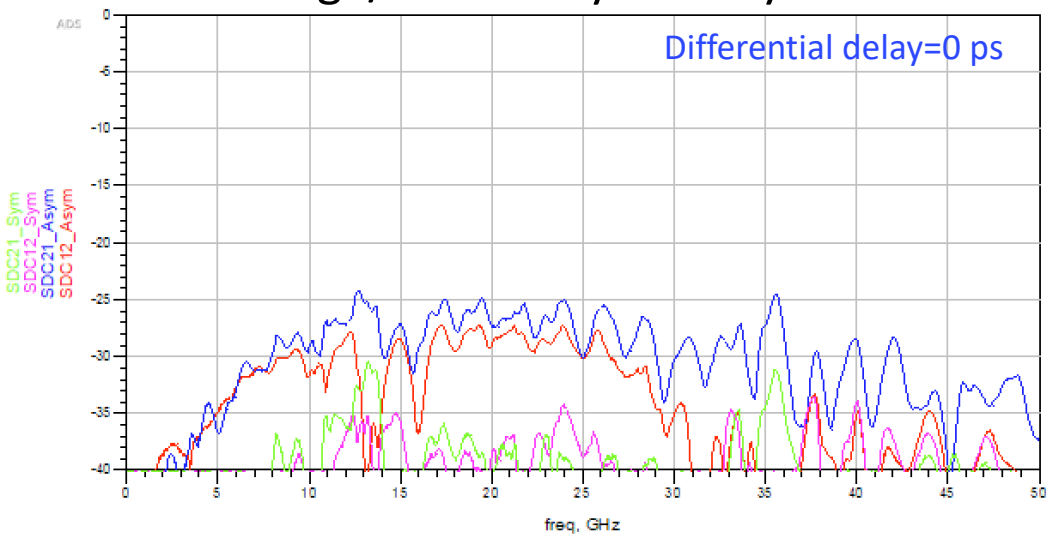


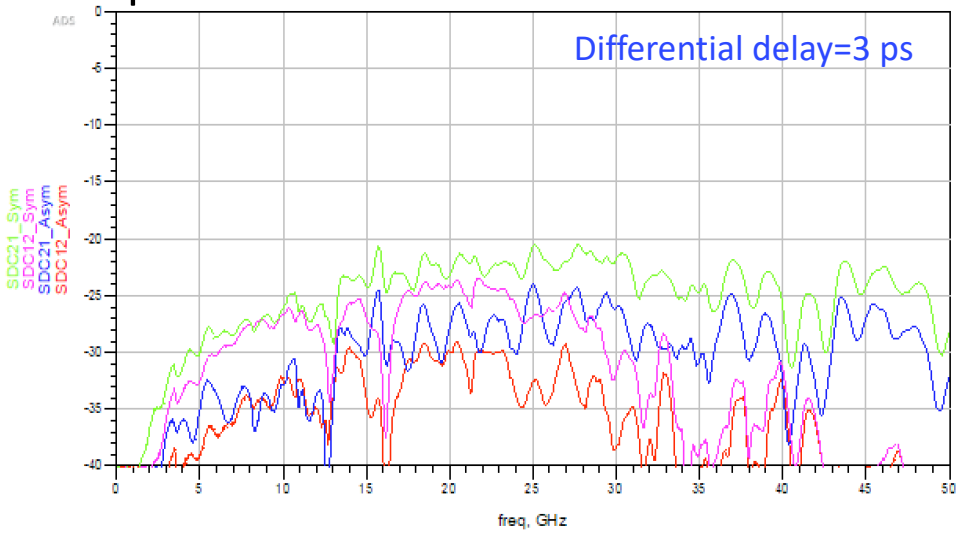


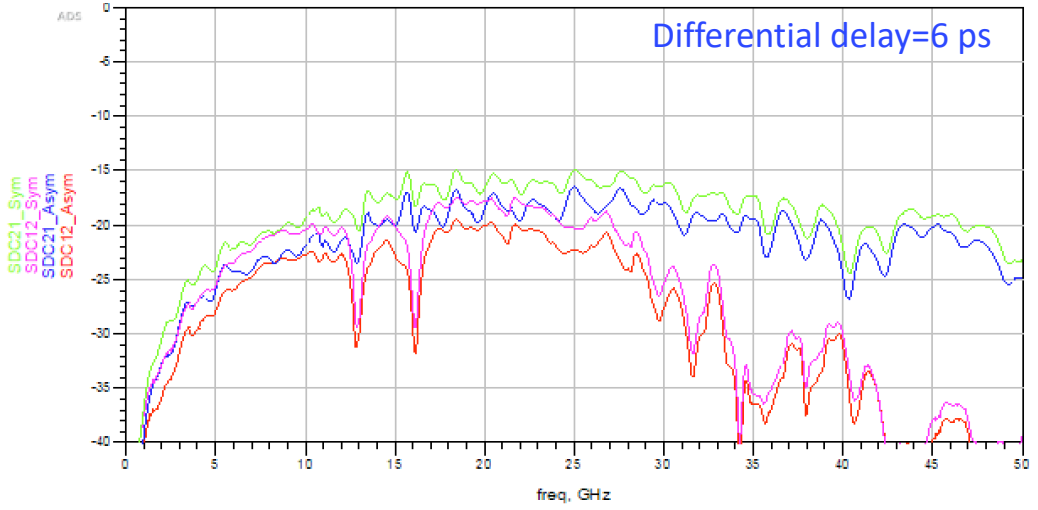


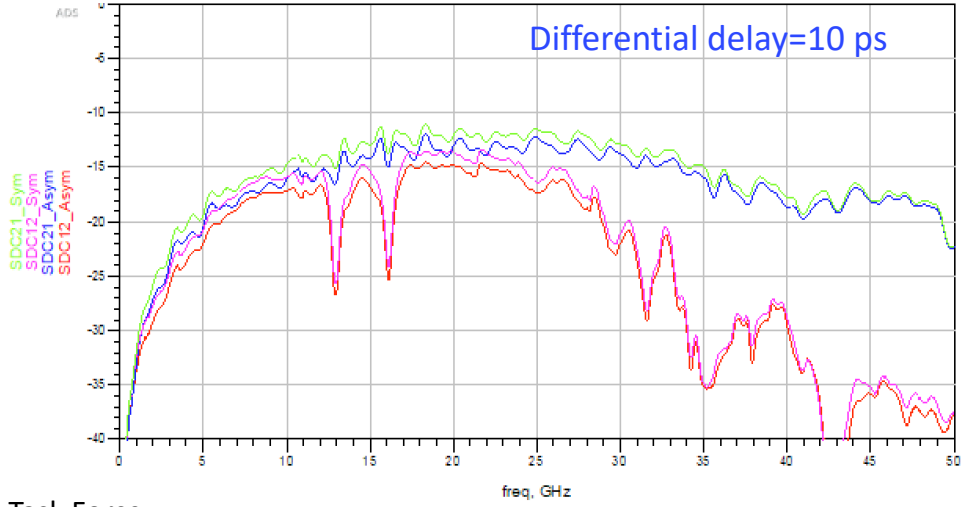
MCB-HCB Differential to Common Mode Transfer Response with Package Asymmetry and Differential Delay

- **A well design host with 3 ps of differential delay has negligible conversion penalty**
  - Package/device asymmetry of ±10 has negligible impact on conversion.





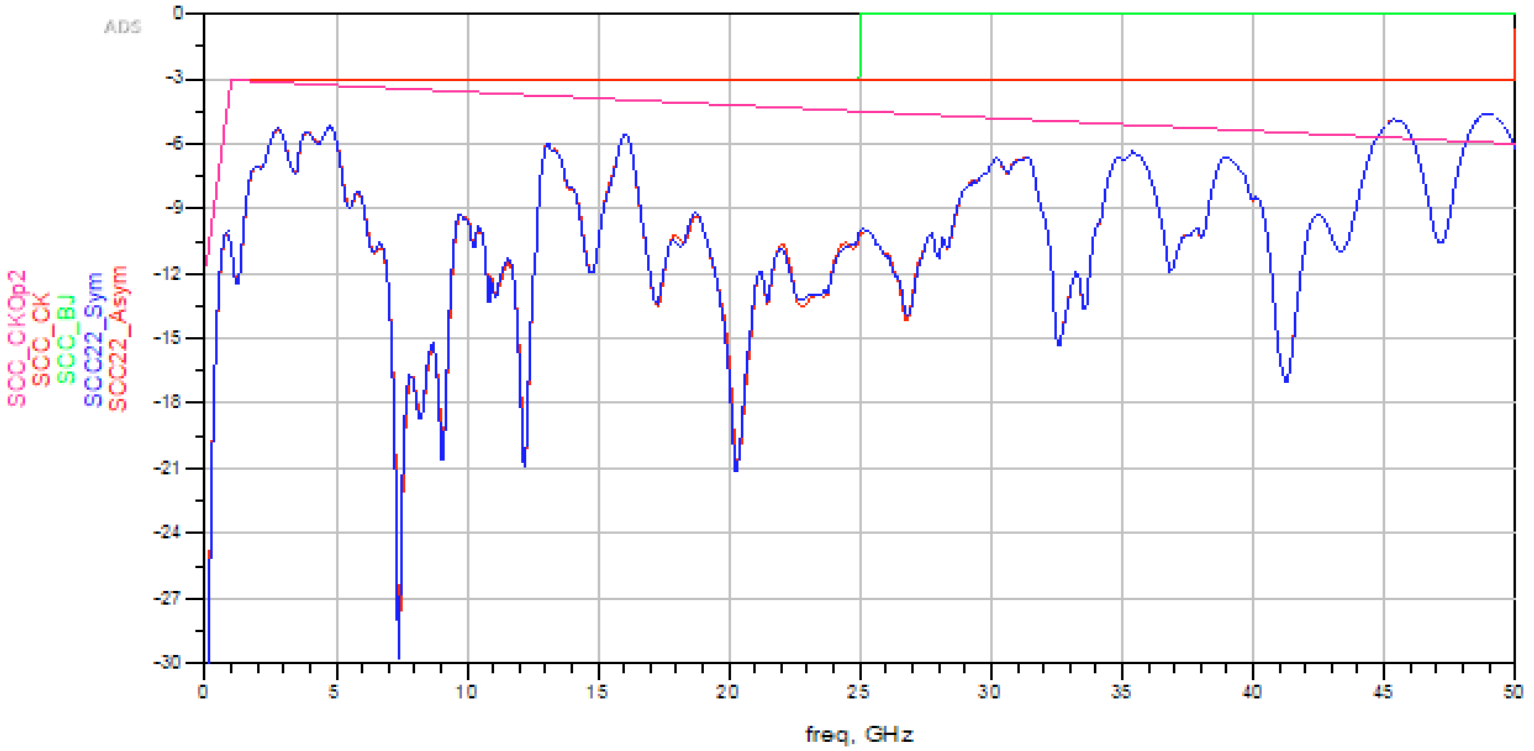




Host SCC11/22

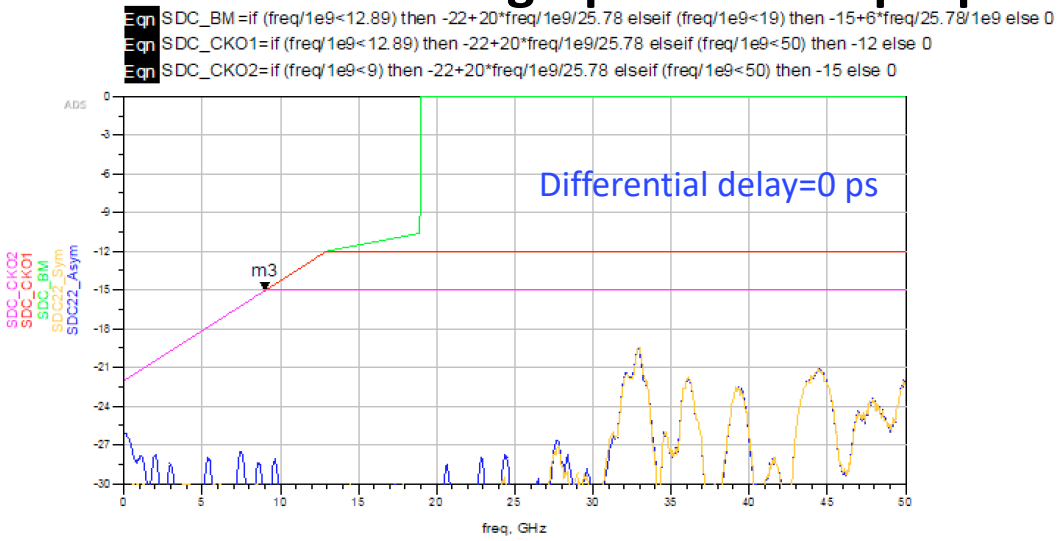
- **Graph are in reflectance but IEEE 802.3ck specifies return loss**
  - Two SCCxx limited are presented but on the host side but option 2 will -6 dB limit.

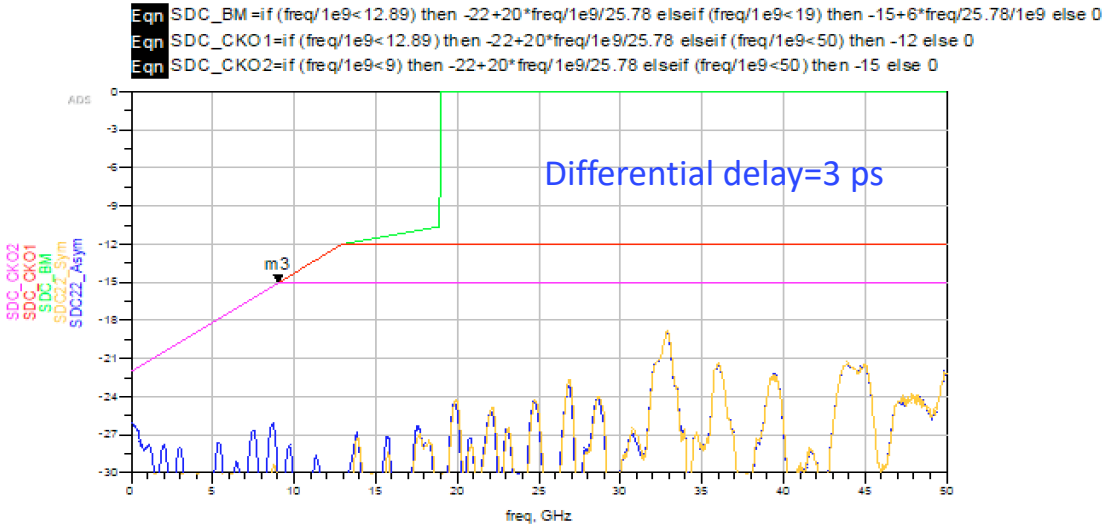
Eqn SCC_BJ=if (freq/1e9<1) then -12+9*freq/1e9 elseif (freq/1e9<25) then -3 else 0
Eqn SCC_CK=if (freq/1e9<1) then -12+9*freq/1e9 elseif (freq/1e9<50) then -3 else 0
Eqn SCC_CKOp2=if (freq/1e9<1) then -12+9*freq/1e9 elseif (freq/1e9<50) then -3-1.55*freq/25.78/1e9 else -6

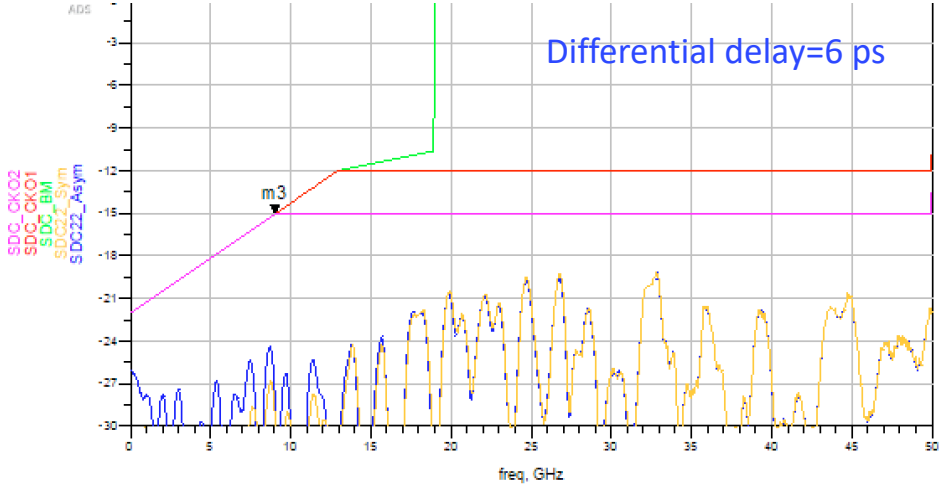


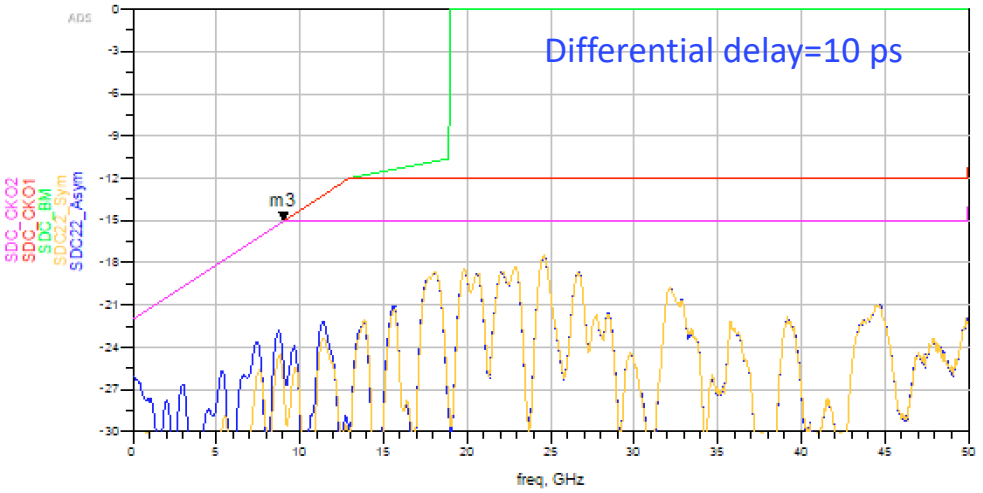
Host Input SDC22/SCD22

- **802.3bm SDC22 graph and two proposed limit for CK**









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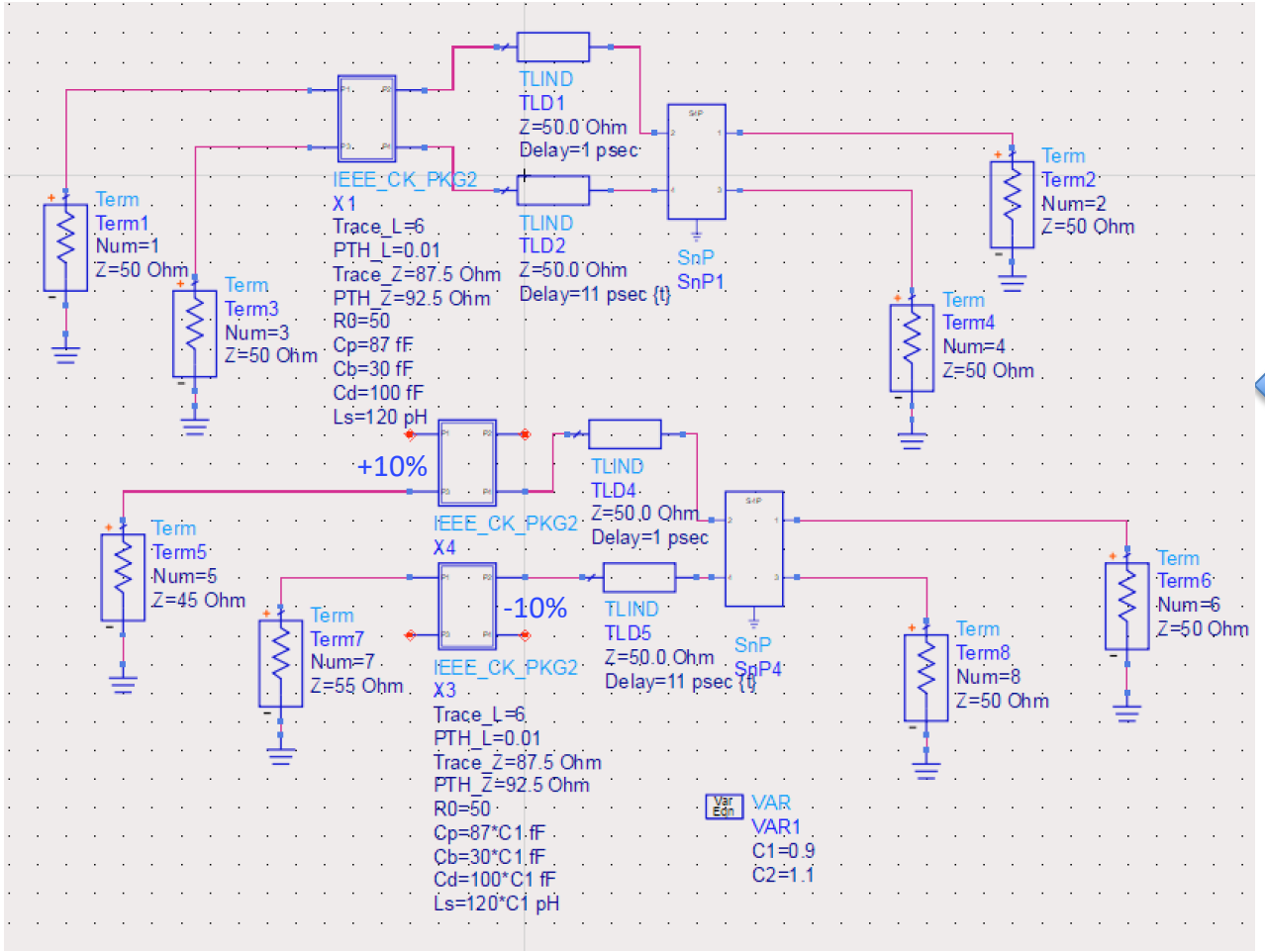

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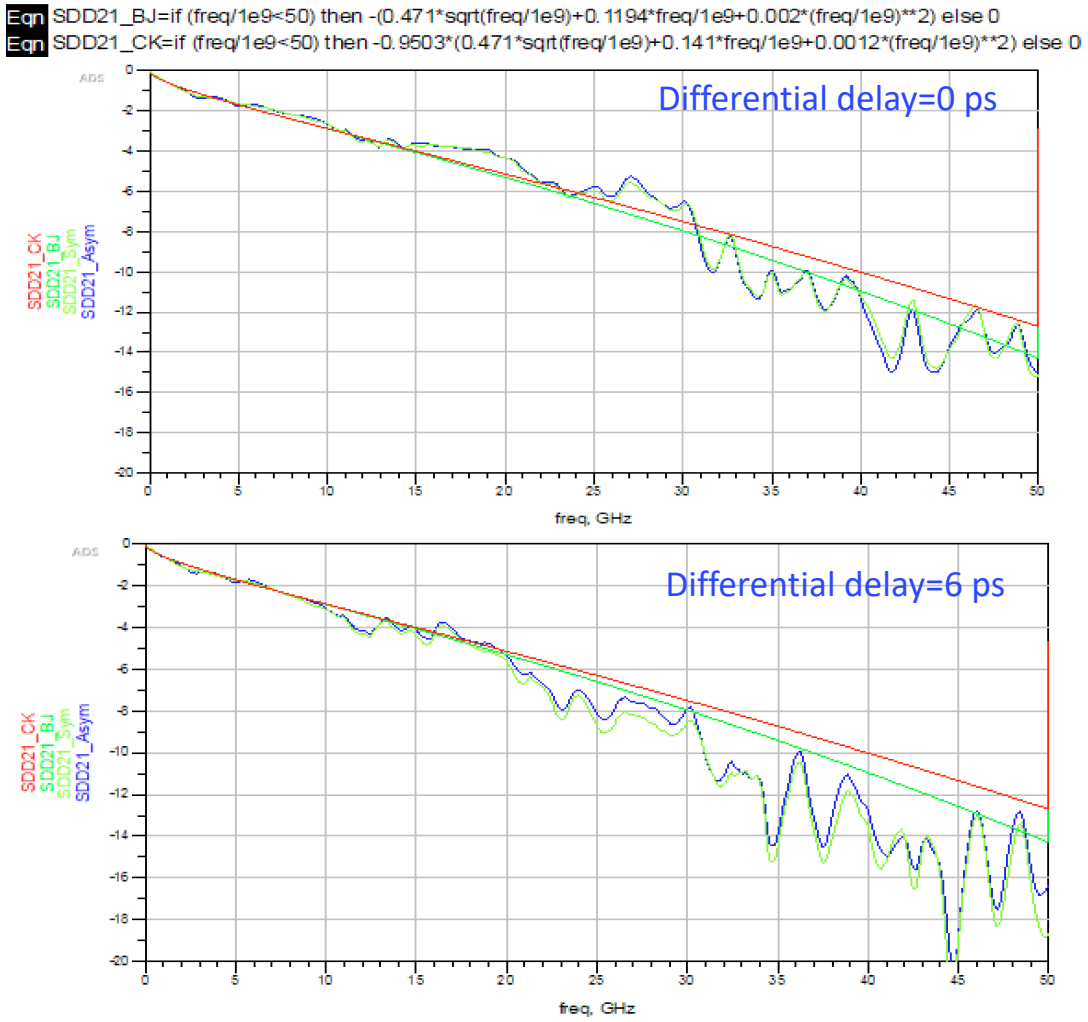
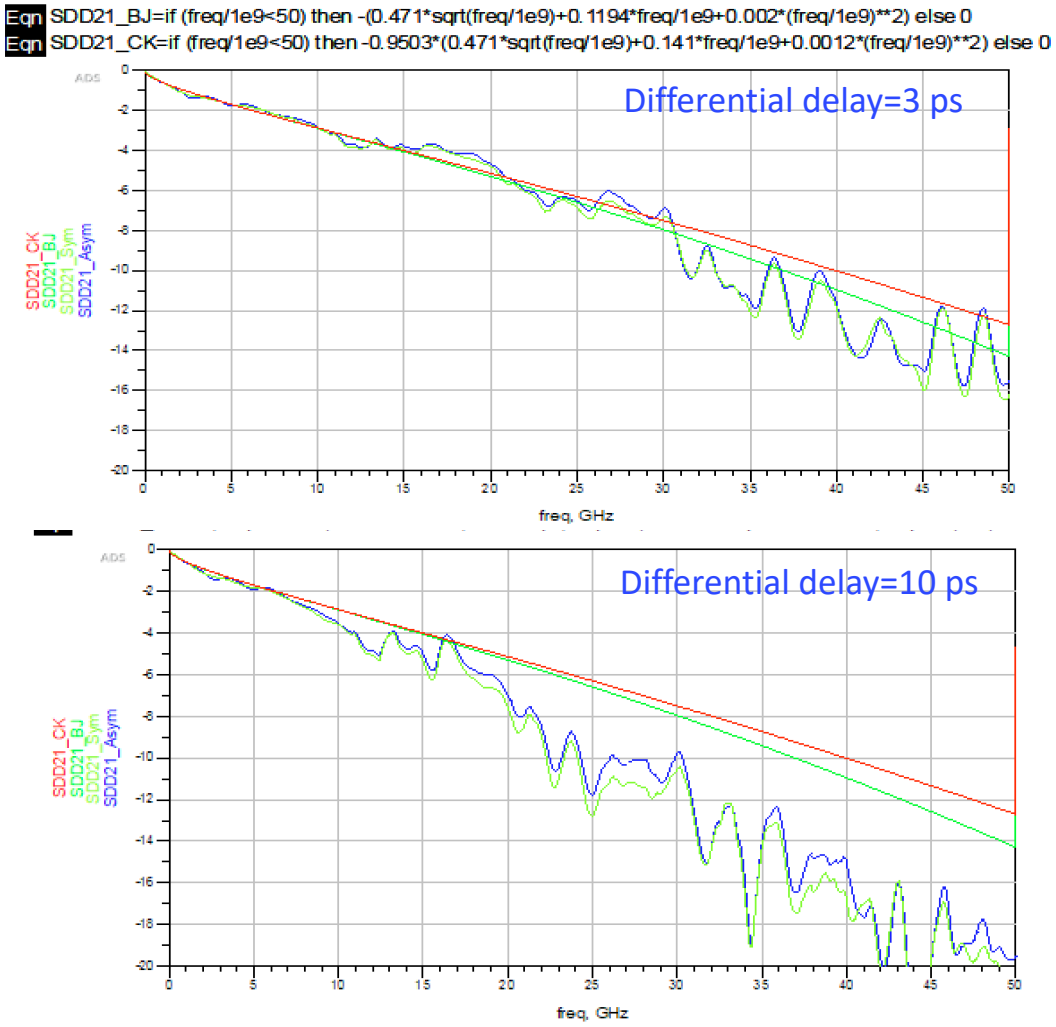
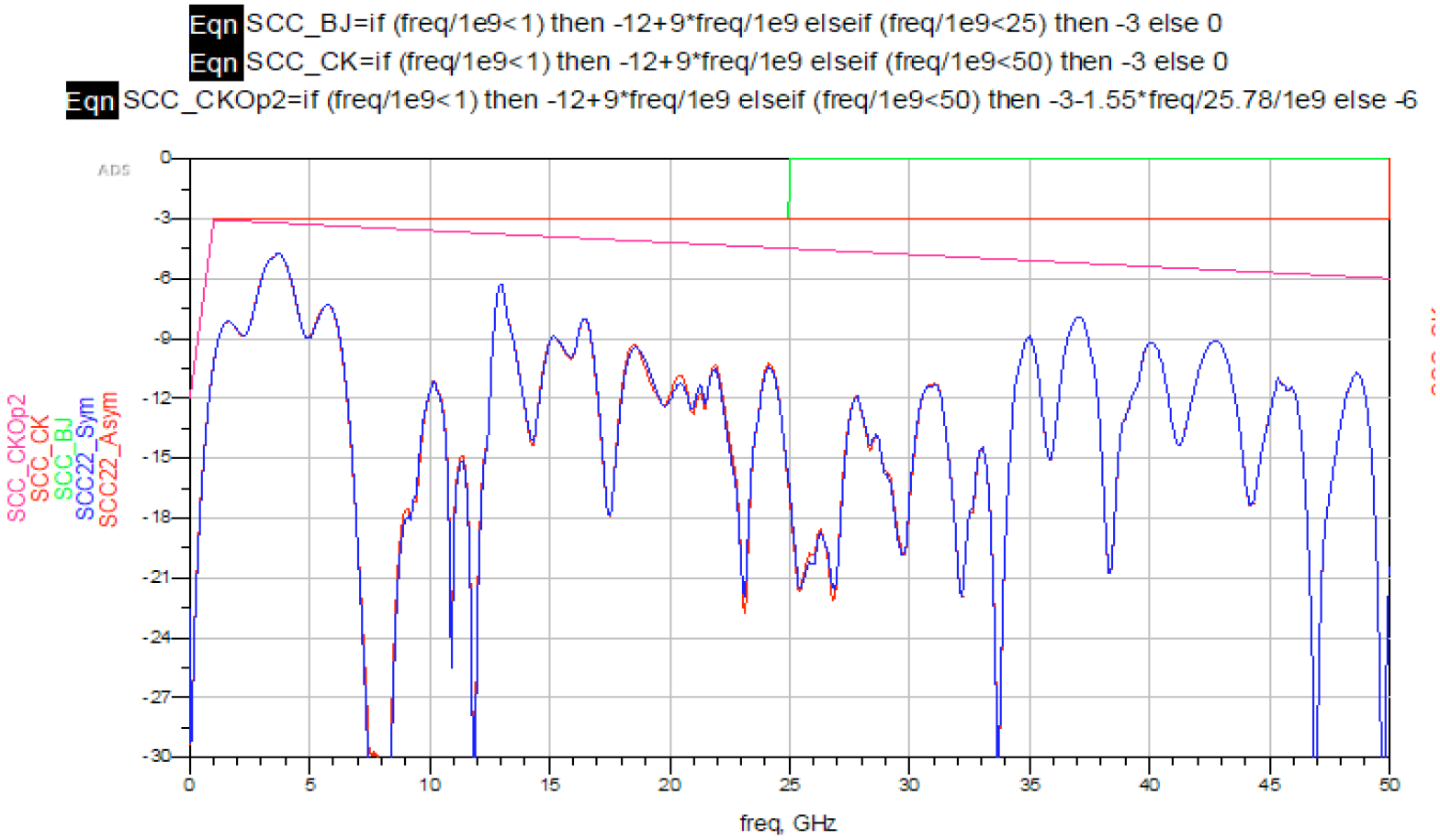




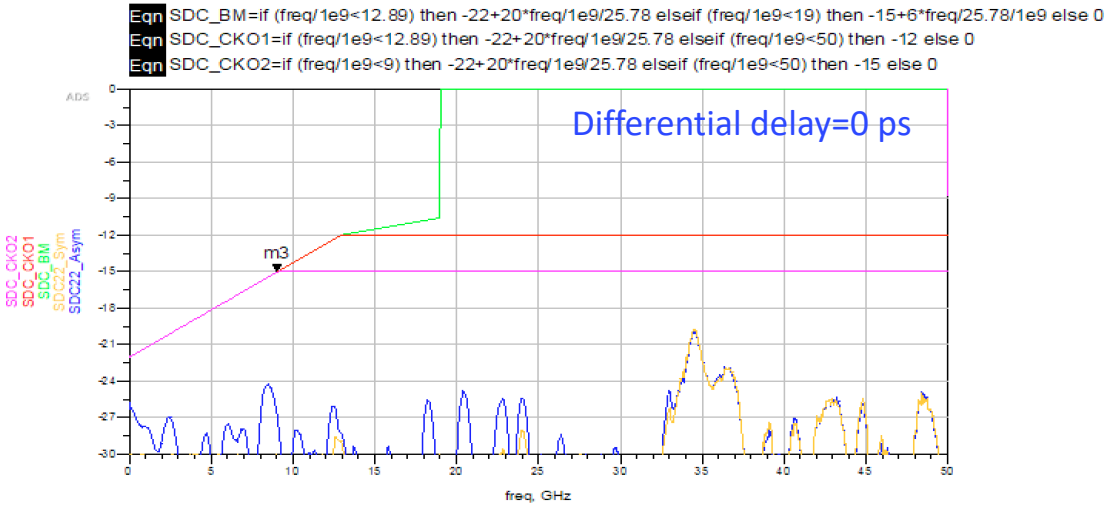
Module Output SCC22 Limits

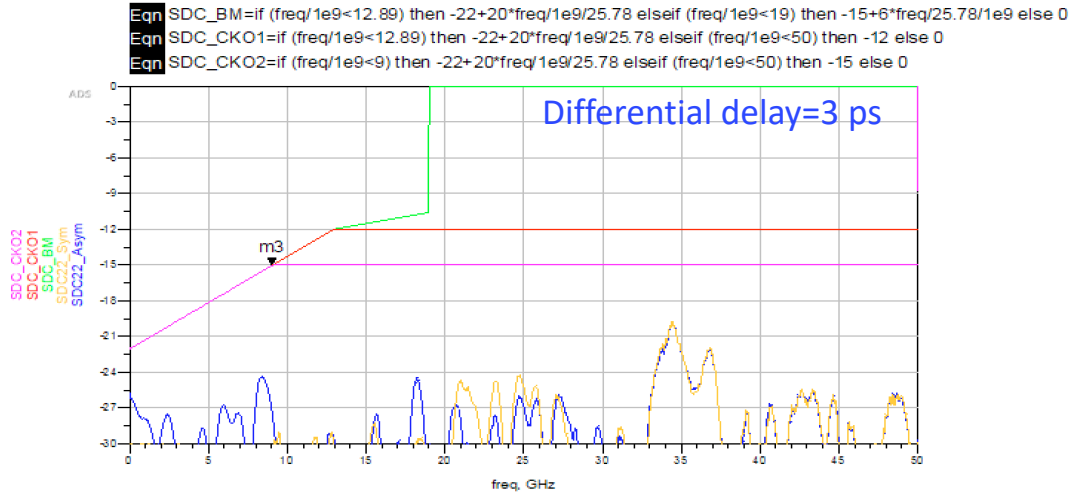
- **Graph are in reflectance but IEEE 802.3ck specifies return loss**
  - Two SCCxx limited are presented.

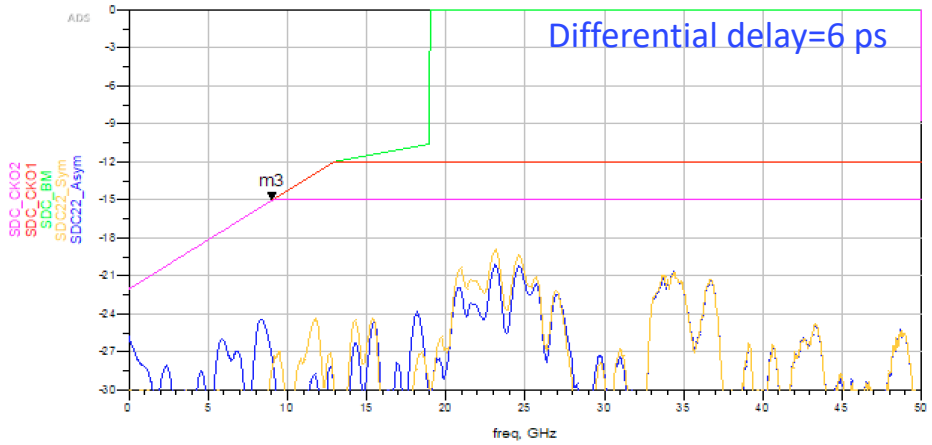


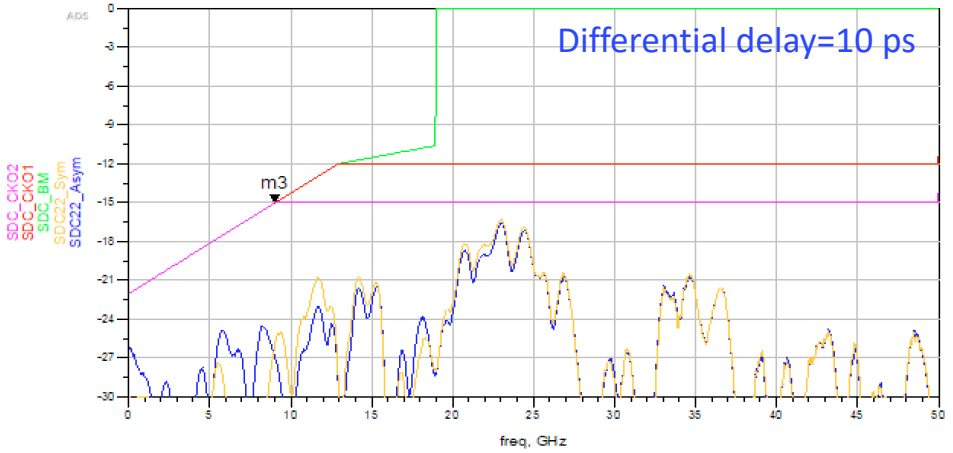
Module Input SDC11/SCD11

- **802.3bm SDC11 graph and two proposed limit for CK**









Summary

- **The need for common mode return loss and conversion return losses have been questions:**
  - The source common mode SCC22 serves to partially absorb the converted differential to common mode and reflected common mode
  - Receiver SDC11/SCD11 help absorb, reduce common-mode-differential and differential-common-mode conversion that with secondary reflection can result in spurious differential signal
  - In SFP+/IEEE nPPI SDC11 were defined for the receiver and has larger spurious contribution
  - But in CL83E SDC11 was swapped with SCD11
  - SDC11 and SCD11 are identical for passive networks both should be defined in the 802.3ck
- **COM analysis in mellitz_3ck_adhoc_01_061720 indicate common mode converted spurious differential signal may have several dB of SNR penalty**
  - The limits proposed for common mode return loss and receiver SDC11/SCD11 will mitigate spurious differential signals.