802.3da TCI Clause 188 and Clause 189

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Overview

- TCI Return Loss Clause 188 and Clause 189
- TCI Insertion Loss Clause 188 in conjunction to Clause 189
- Mixing Segment Return Loss and Insertion Loss
  - Case 16UL
  - Case 8UL
  - Case 4UL
  - Case 2UL
  - Case 1UL
- Clause 147 Node and Mixing Segment RL
- Measurement T under DC Load

TCI

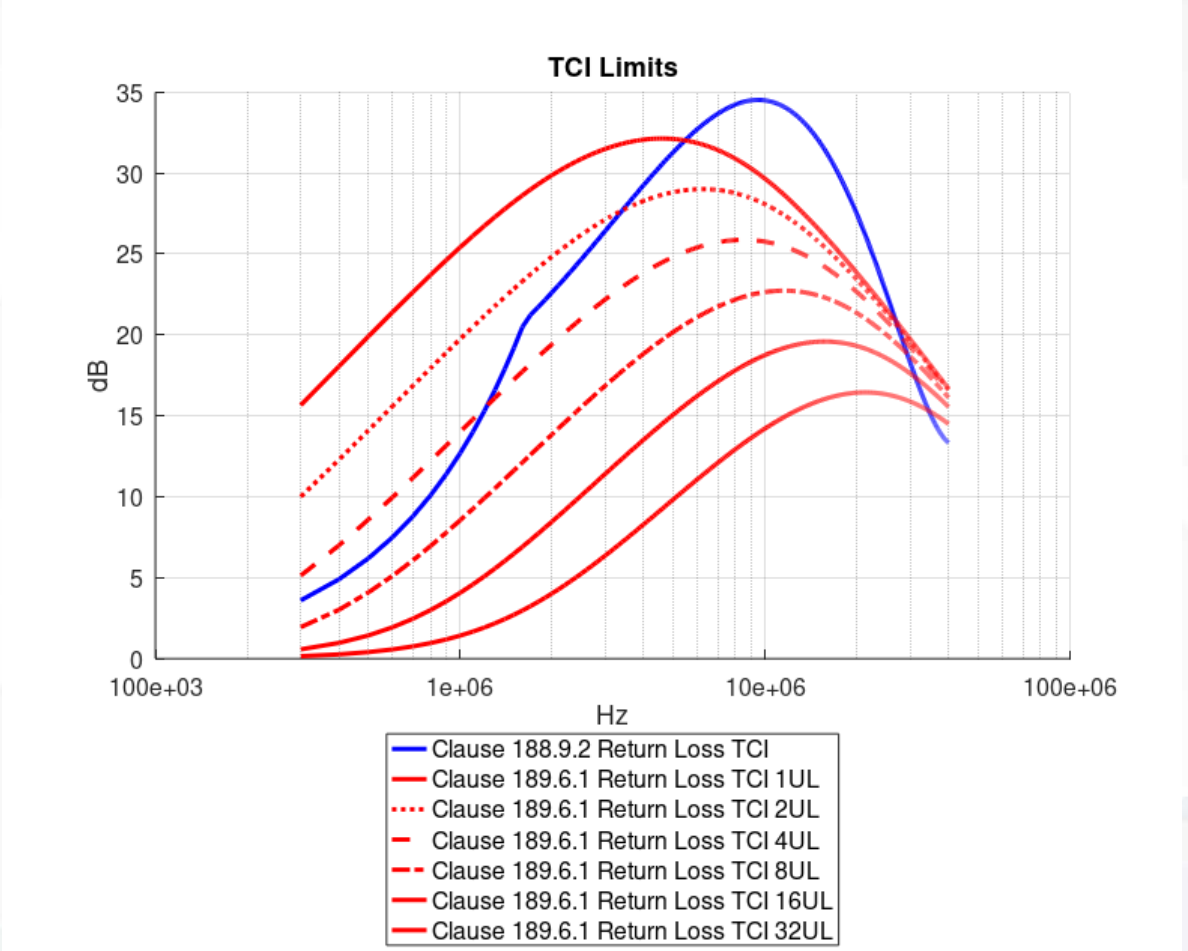
TCI Return Loss Clause 188 / 189

- Clause 188 TCI return loss is defined for 16 Nodes
- Clause 189 TCI return loss is defined for 16 Nodes in case of 1UL

- If 189 TCI return loss is sufficient for the system, clause 188 TCI return loss is more stringent then neccessary

- Introduction of 188.9.1.6 „shall maintain compliance with the specifications 188.9.1.1, 188.9.1.2, 188.9.1.3, 188.9.1.4 and 188.9.1.5 at any current up to 2A in either polarity from TC1 to TC2“ might require additional margin.

- Proposal:
  Change Clause 188 TCI return loss to Clause 189 TCI return loss equation with N_UNIT=1



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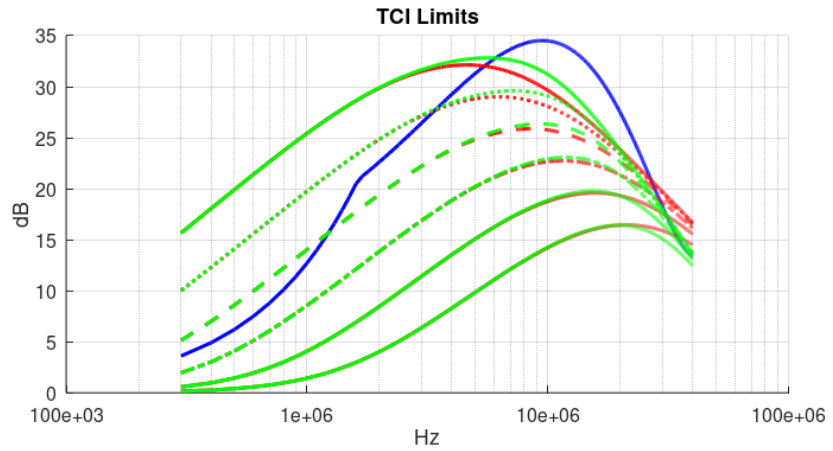
TCI

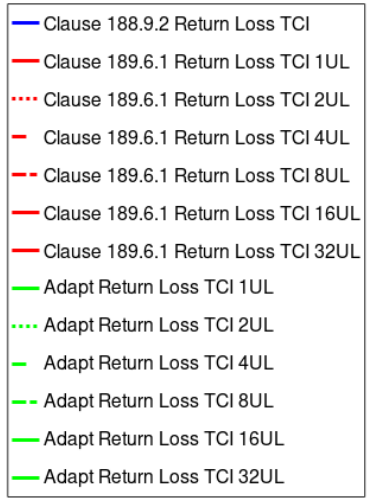
TCI Return Loss

- Measurement of T-Adapters indicates a lower return loss than clause 189 TCI return loss above 25 MHz (ramp has more dB/Dec)
- The main signal content of the DME is in the frequency range between 5 MHz and 17 MHz
- Adapt equation from clause 189 TCI

$$RL(f) = -10 * log10\left(\frac{10e3 + \frac{(40.192f)^2}{N_{UNIT}}}{10e3 + \left(\frac{2010f}{N_{UNIT}}\right)^2} + \frac{f^{\cancel{2.5}\ 3.5}}{\cancel{480e3}\ 9500e3}\right)\ \text{dB}$$

- Difference in the main region is minor (even a little bit more stringent)





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TCI

TCI Insertion Loss

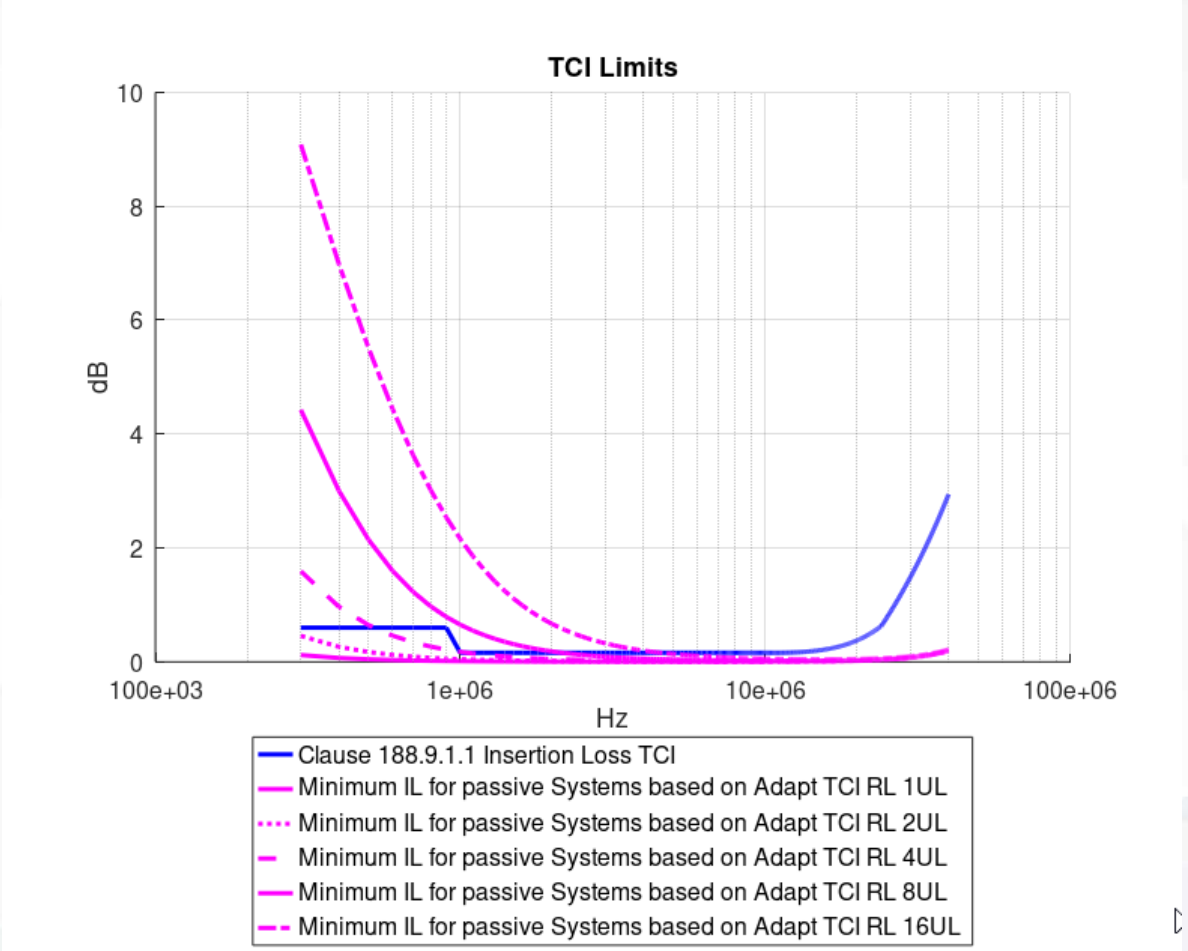
- The intention of the clause 189 TCI return loss is to allow smaller power inductors in case of higher unit loads
- Therefore the new return loss equation was generated
- However, at this position, the required network has to be passive – thus the S-Parameters needs to be passive
  - More simple – reflected energy can‘t be transmitted anymore
  - In numbers: If we have a RL=3dB, the IL must be greater or equal 3dB

- Sdd21<= 10*log10(1 – 10^(Sdd11/10))

- With the clause 189 TCI return loss and the TCI insertion loss of clause 188, passivity is only given up to 2UL.
- Thus, inserting clause 189 TCI return loss for higher unit loads is only useful if TCI insertion loss is also changed

- Possible solutions:
  - Insert an IL curve which is dependent on ULs
  - Remove TCI IL in general
  - Do nothing and make no use of the UL RL benefit

➢ Don‘t know what is better



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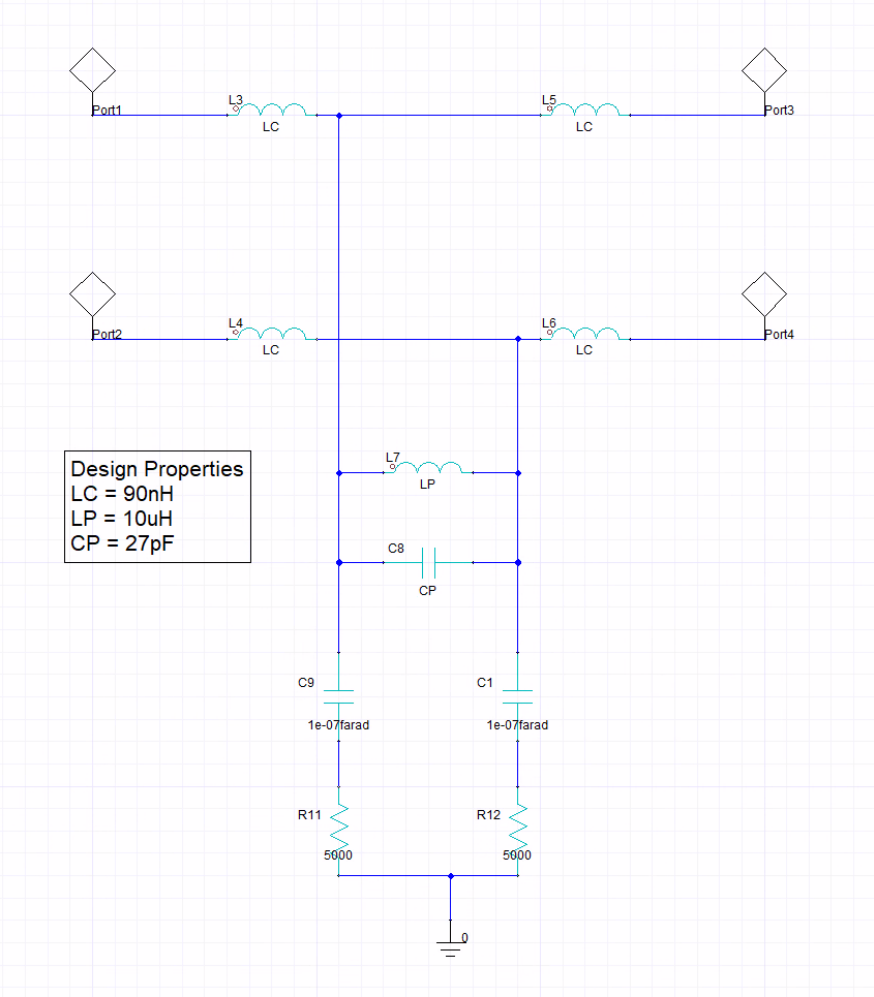
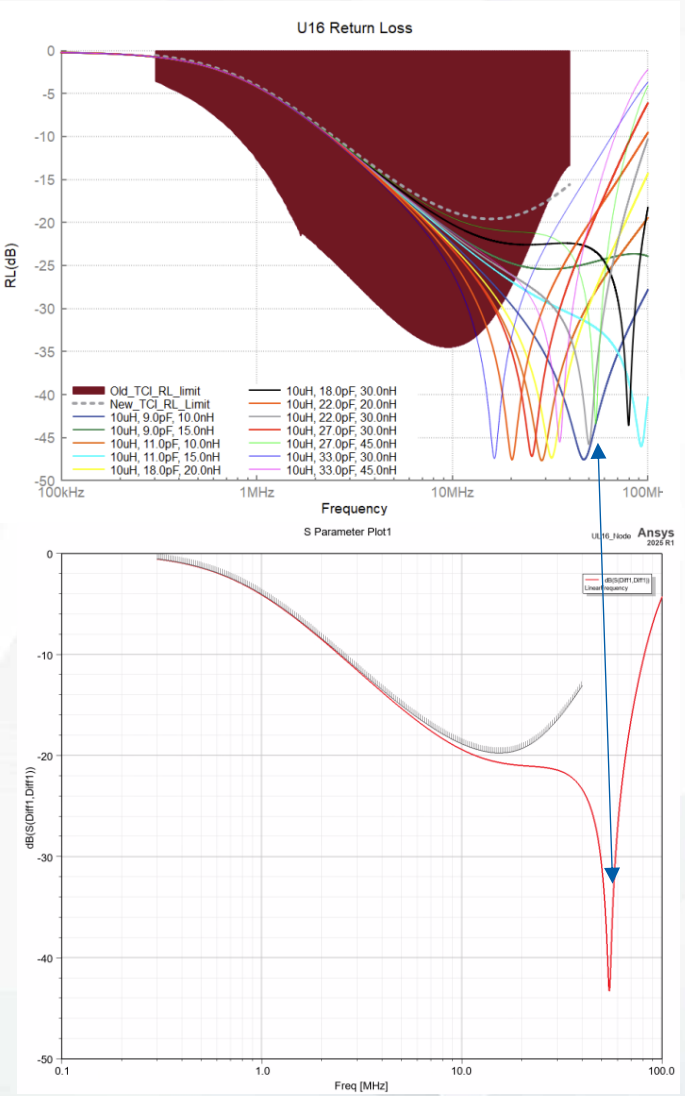
Mixing Segment

Validation of https://www.ieee802.org/3/da/public/0325/mpaul_da_01_20250310_v2.pdf

- UL16 Case





Coupled inductors are used for LC (thus, set LC to 90nH)

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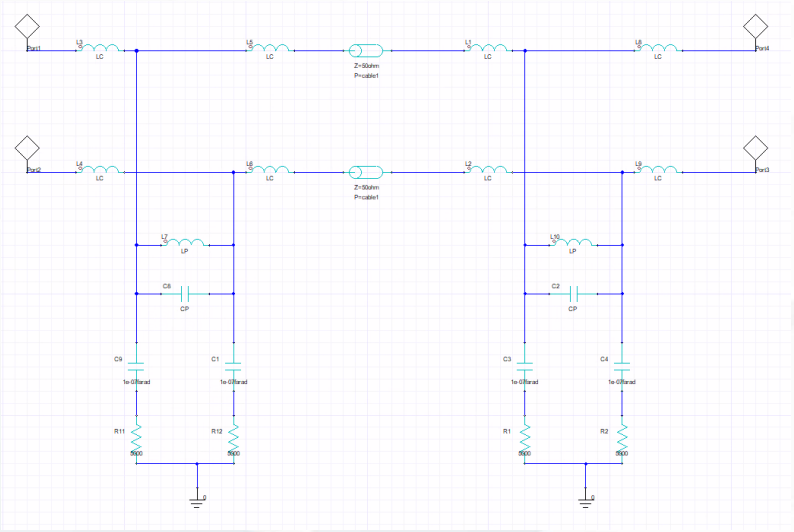
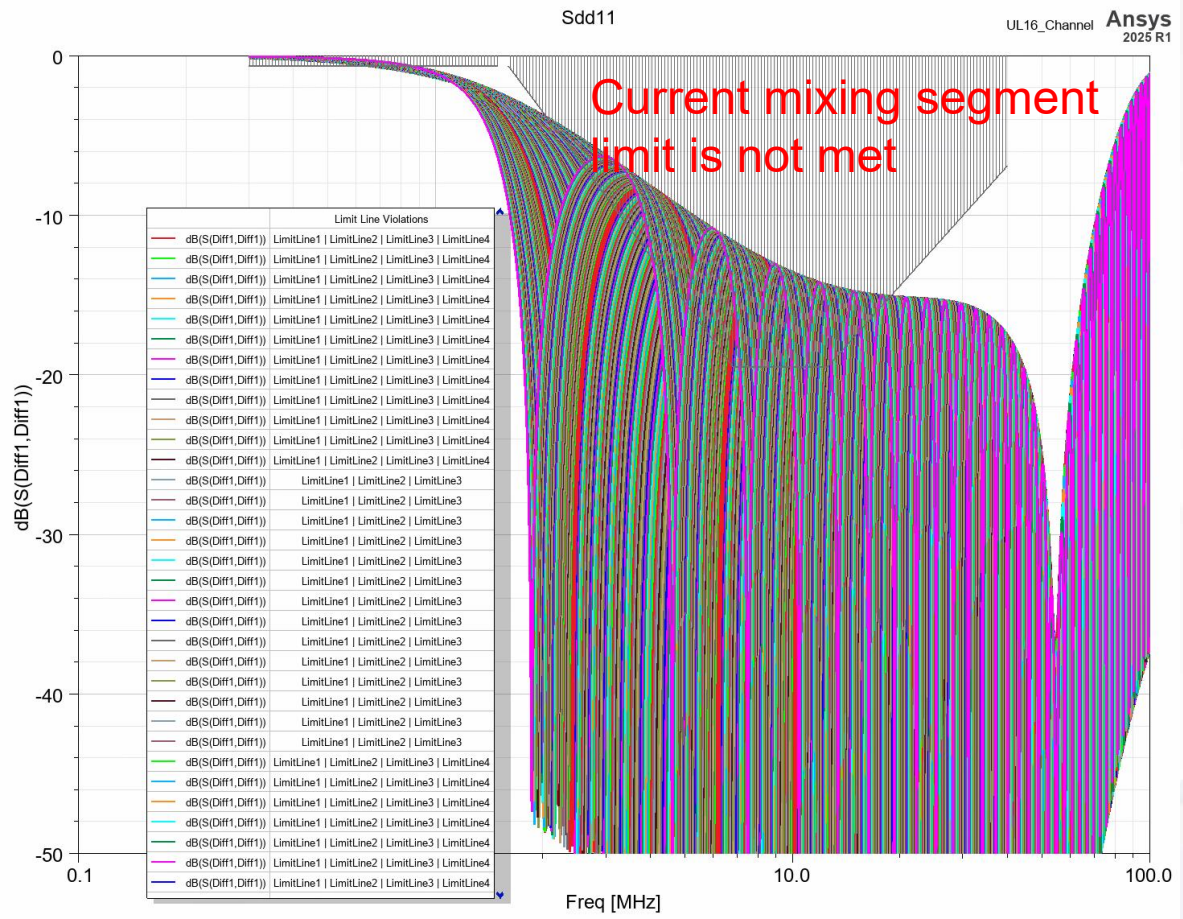
Mixing Segment Return Loss

UL16 Case, Lossless ideal transmission lines – channel Simulation

- Setup:
  - 2 Nodes
    - According to UL16 Limit
    - Ideal loss less transmission lines, distance variations in 0.25m steps from 0.25m to 50m
- Current Mixing Segment Limit is harmed in multiple cases





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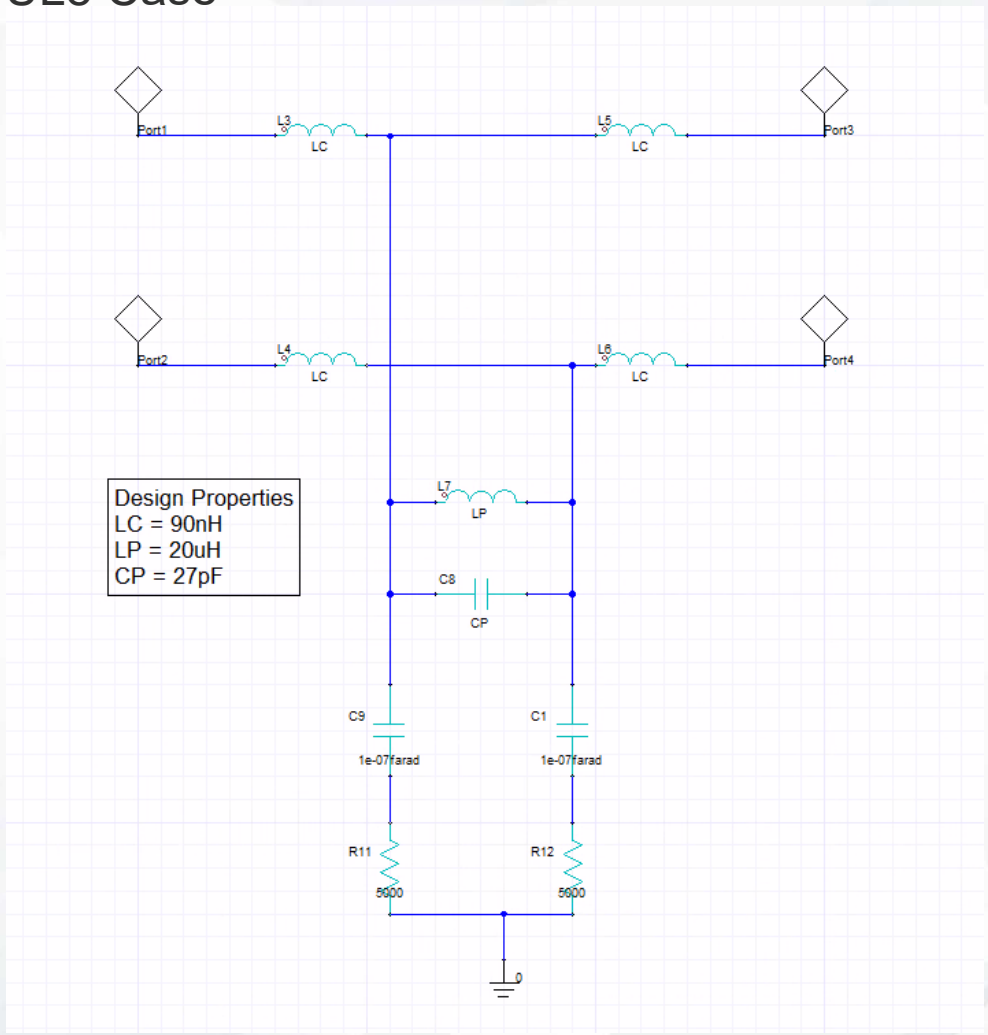
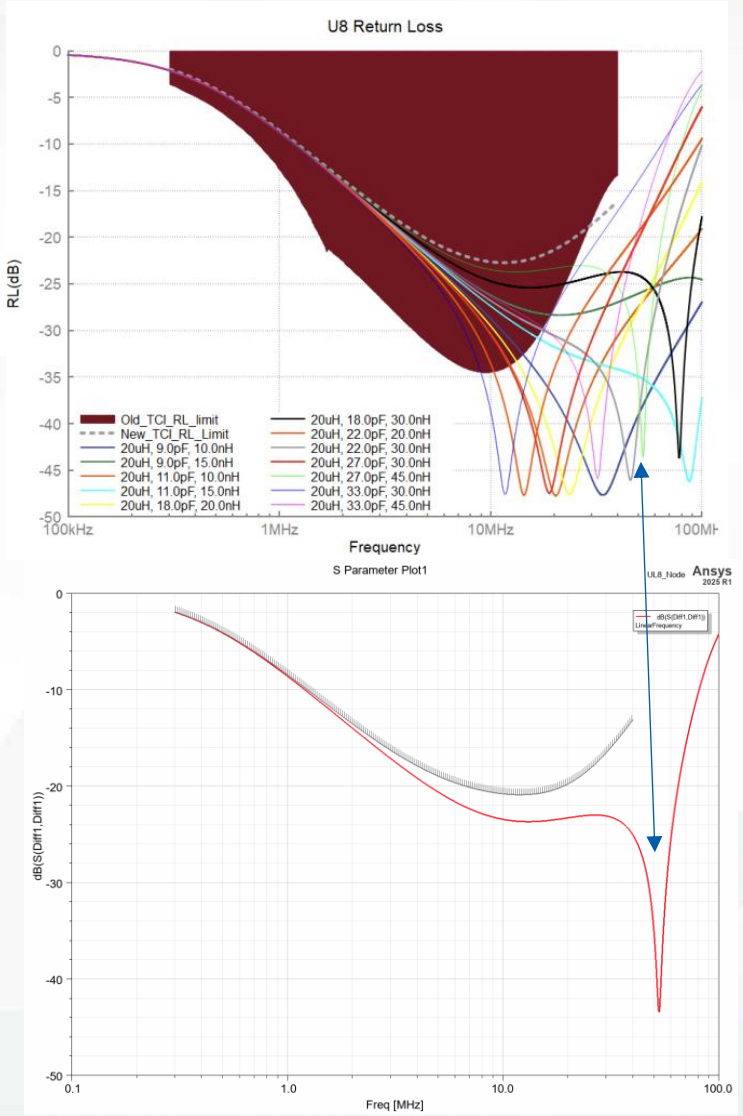
Mixing Segment

Validation of https://www.ieee802.org/3/da/public/0325/mpaul_da_01_20250310_v2.pdf

- UL8 Case





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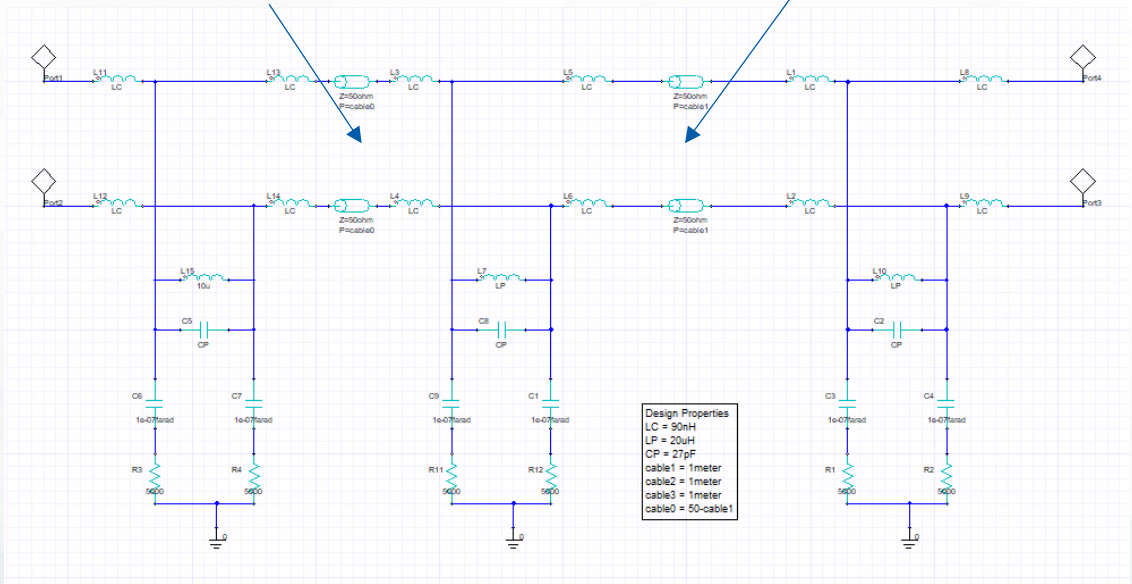
Mixing Segment Return Loss

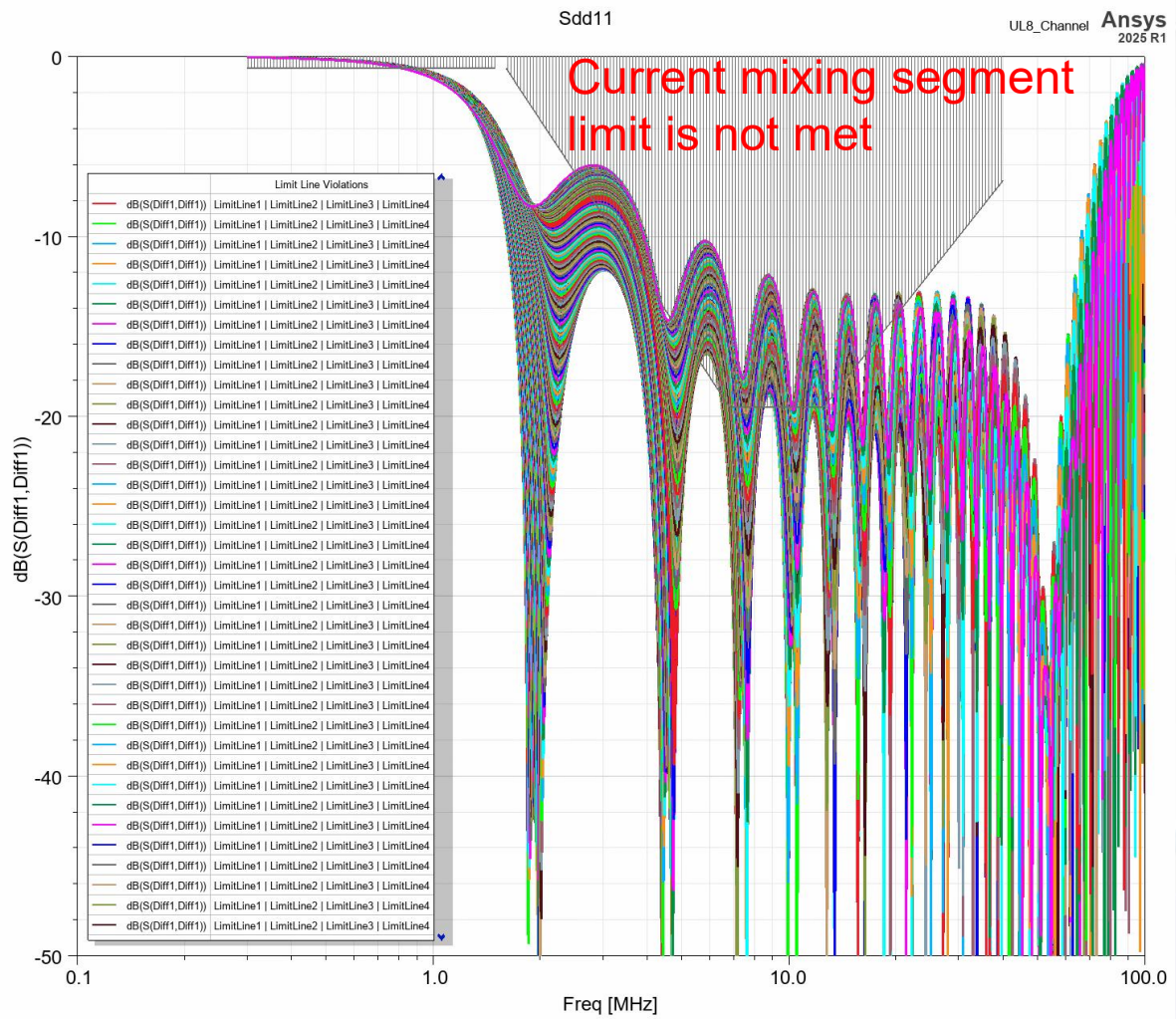
UL8 Case, Lossless ideal transmission lines – channel Simulation

- Setup:
  - 3 Nodes
    - One according to UL16 Limit
    - Two according to UL8 Limit
    - Ideal loss less transmission lines

Tuned to have 50m link length

Variation [0.25m:0.25m:49.75m]





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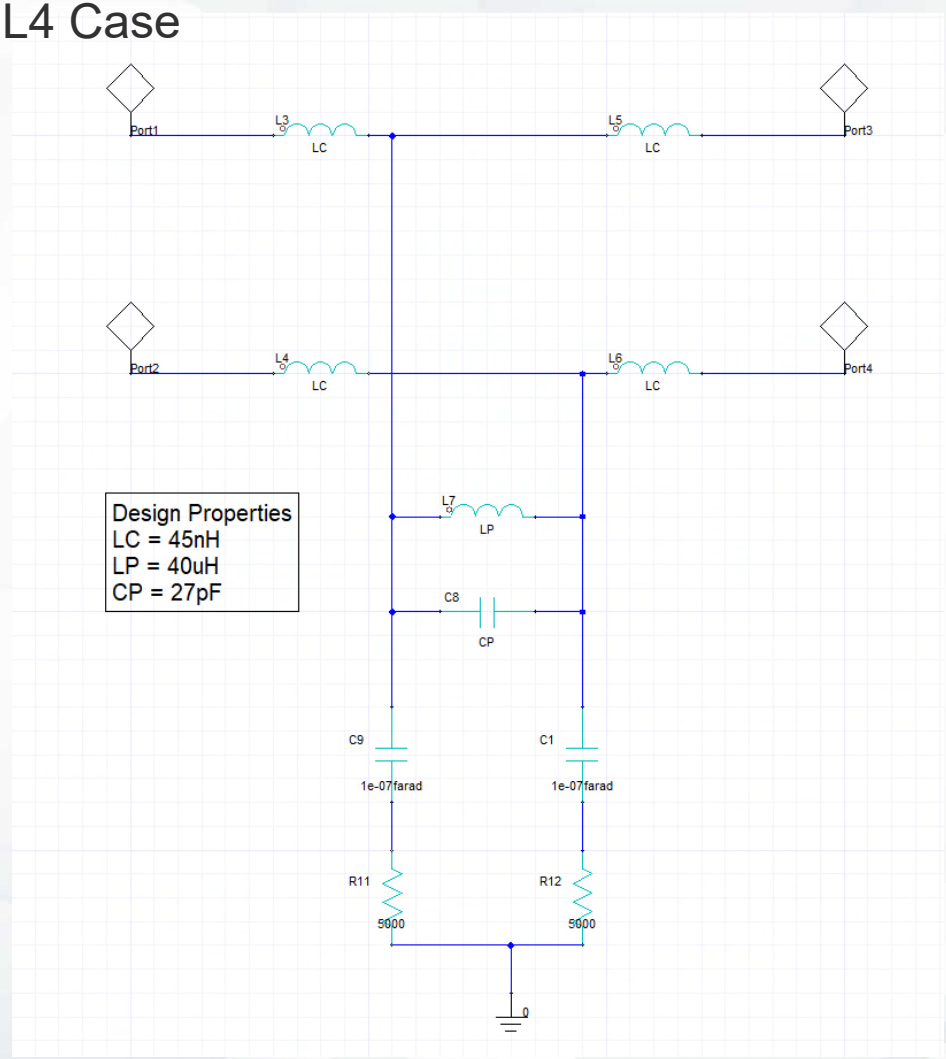
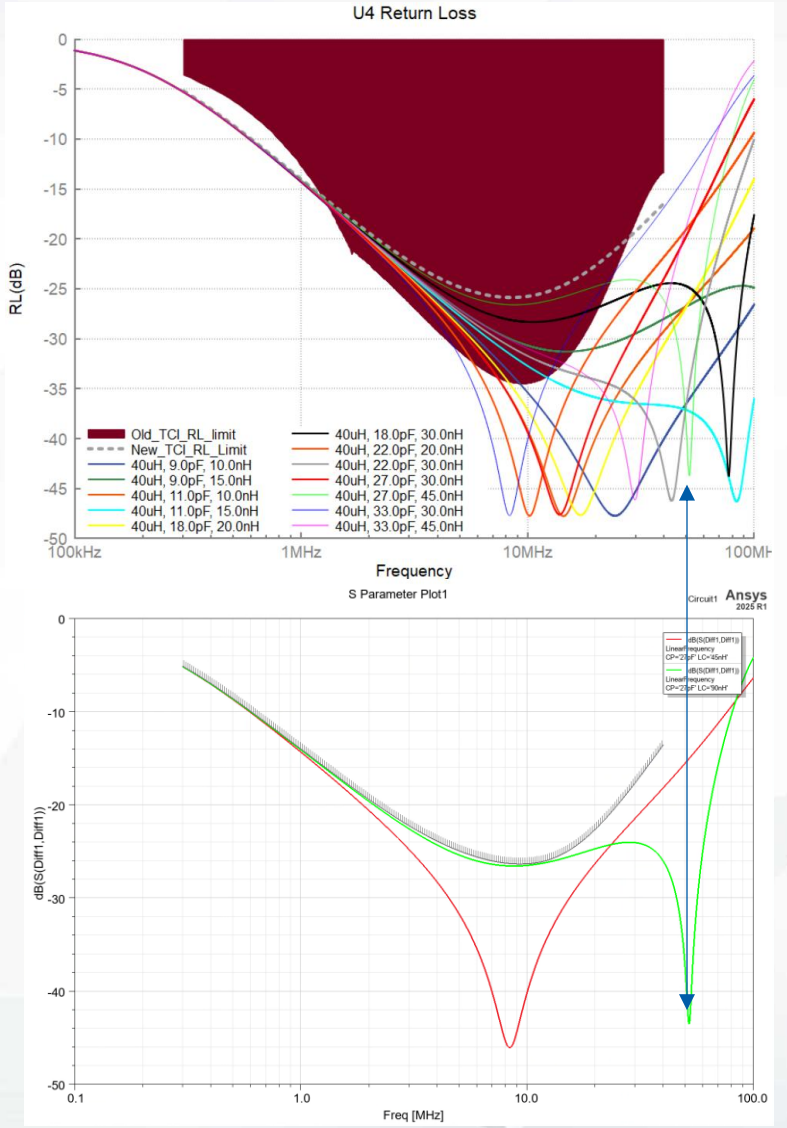
Mixing Segment

Validation of https://www.ieee802.org/3/da/public/0325/mpaul_da_01_20250310_v2.pdf

- UL4 Case





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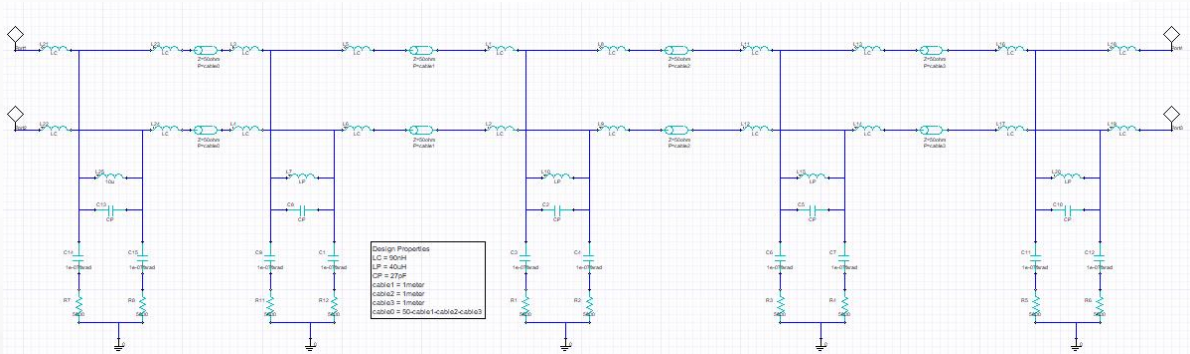
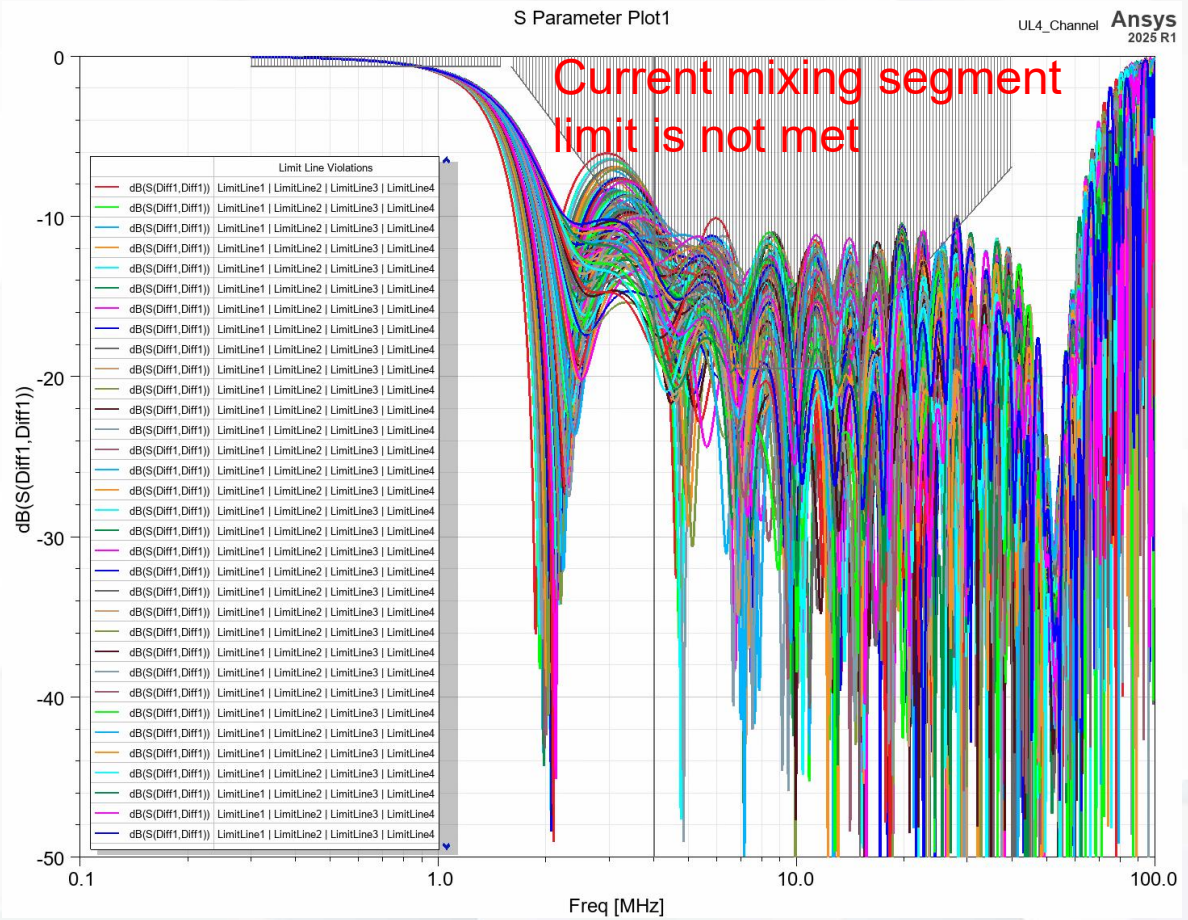
Mixing Segment Return Loss

UL4 Case, Lossless ideal transmission lines – channel Simulation

- Setup:
  - 4 Nodes according to UL4 Limit, first Node according to UL16
  - Transmission Lines 2,3,4 varied between 1m and 15m in 3m Steps, all combinations. Transmission Line 1 tuned to result in a 50m channel
- Current Mixing Segment Limit is harmed in multiple cases





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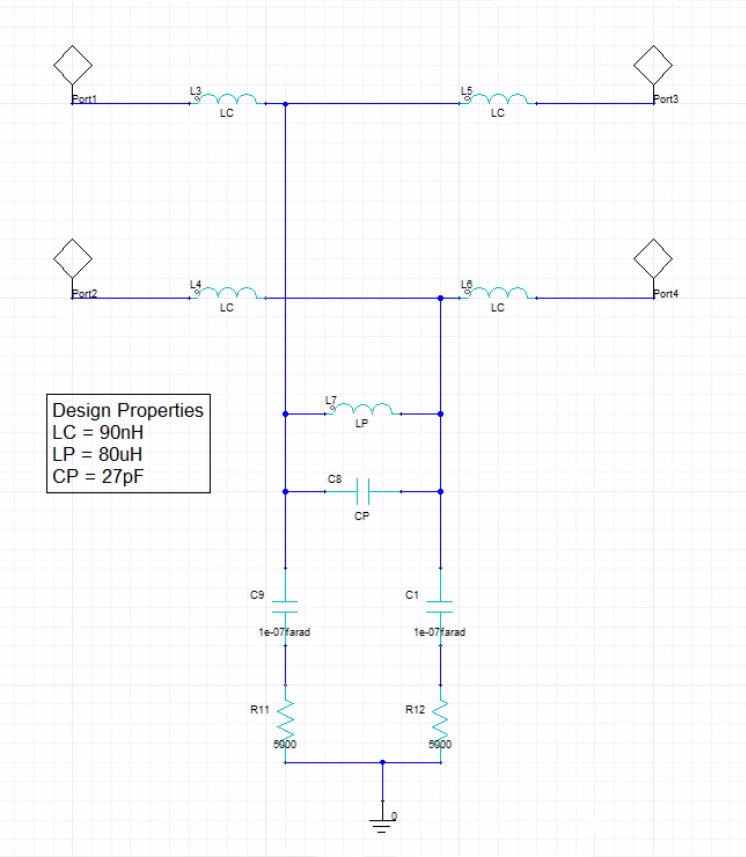
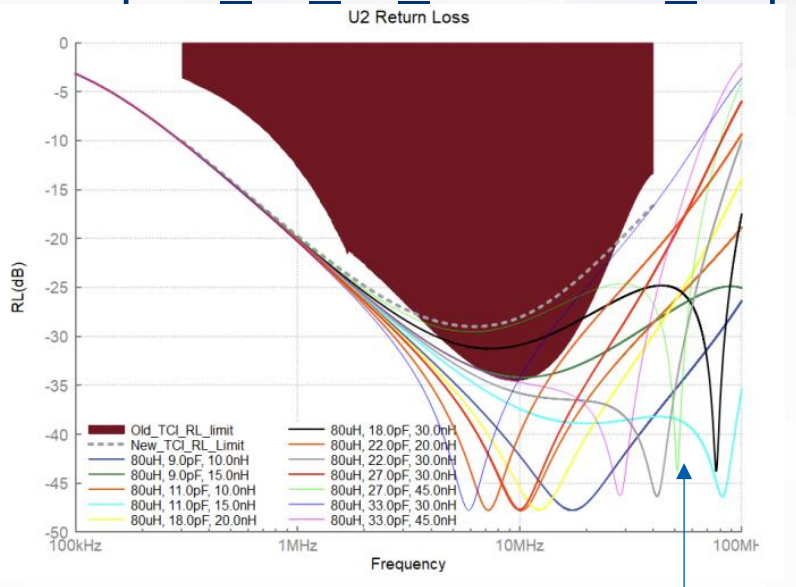
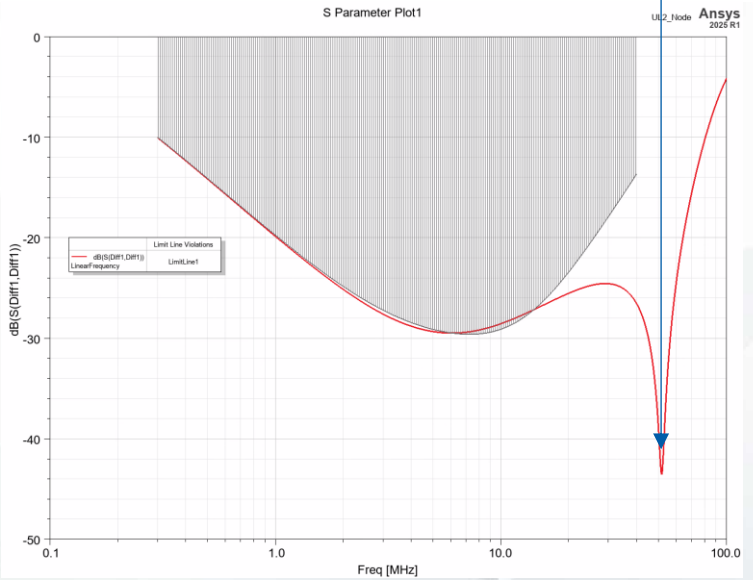
Mixing Segment

Validation of https://www.ieee802.org/3/da/public/0325/mpaul_da_01_20250310_v2.pdf

- UL2 Case







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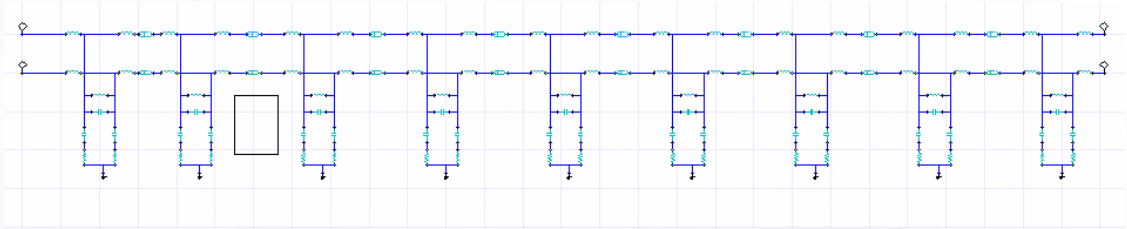
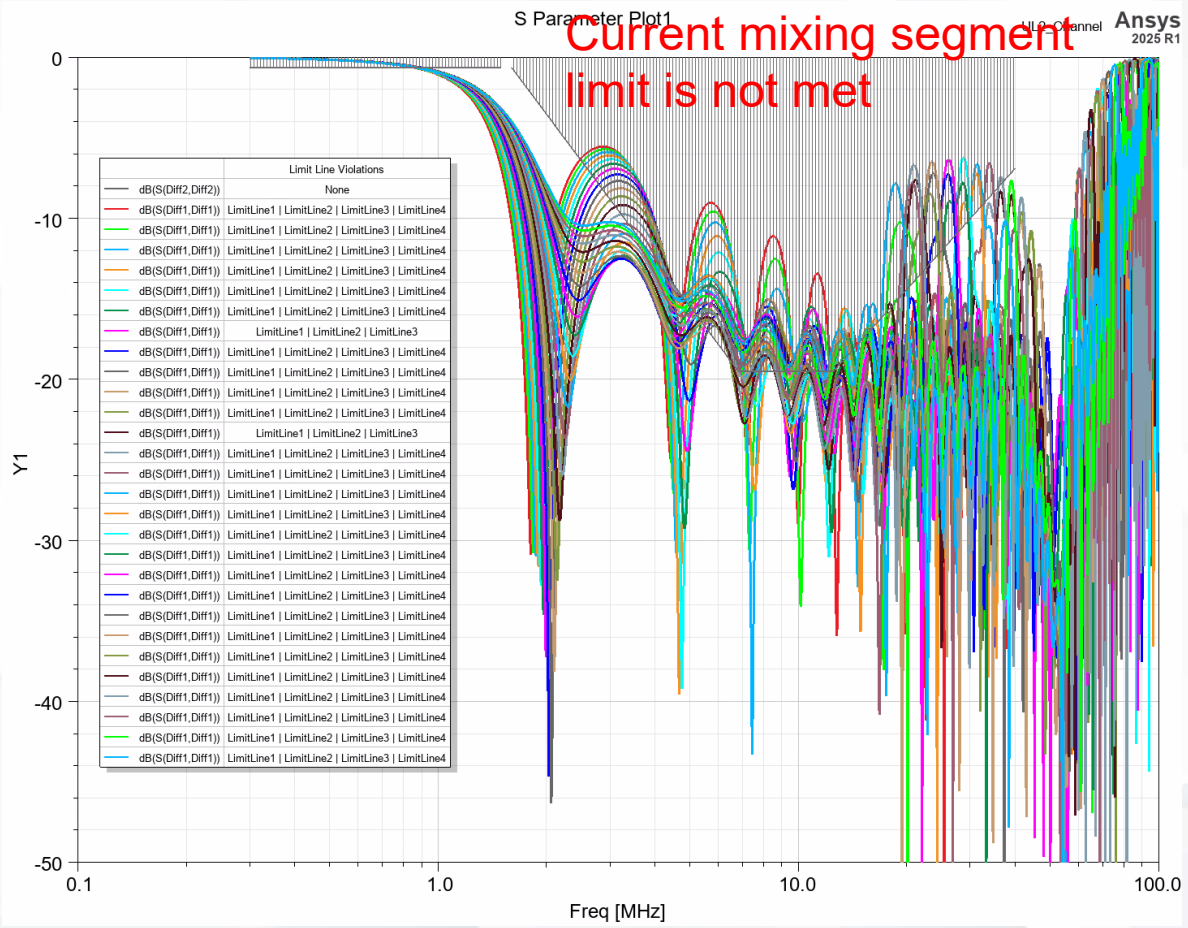
Mixing Segment Return Loss

UL2 Case, Lossless ideal transmission lines – channel Simulation

- Setup:
  - Nodes: 1 x UL16, 8 x UL2,
  - Transmission Lines 1 to 7 same length varied between 1m and 7m in 0.25m Steps, Transmission Line 0 calculated to get a 50m over all
- Current Mixing Segment Limit is harmed in multiple cases





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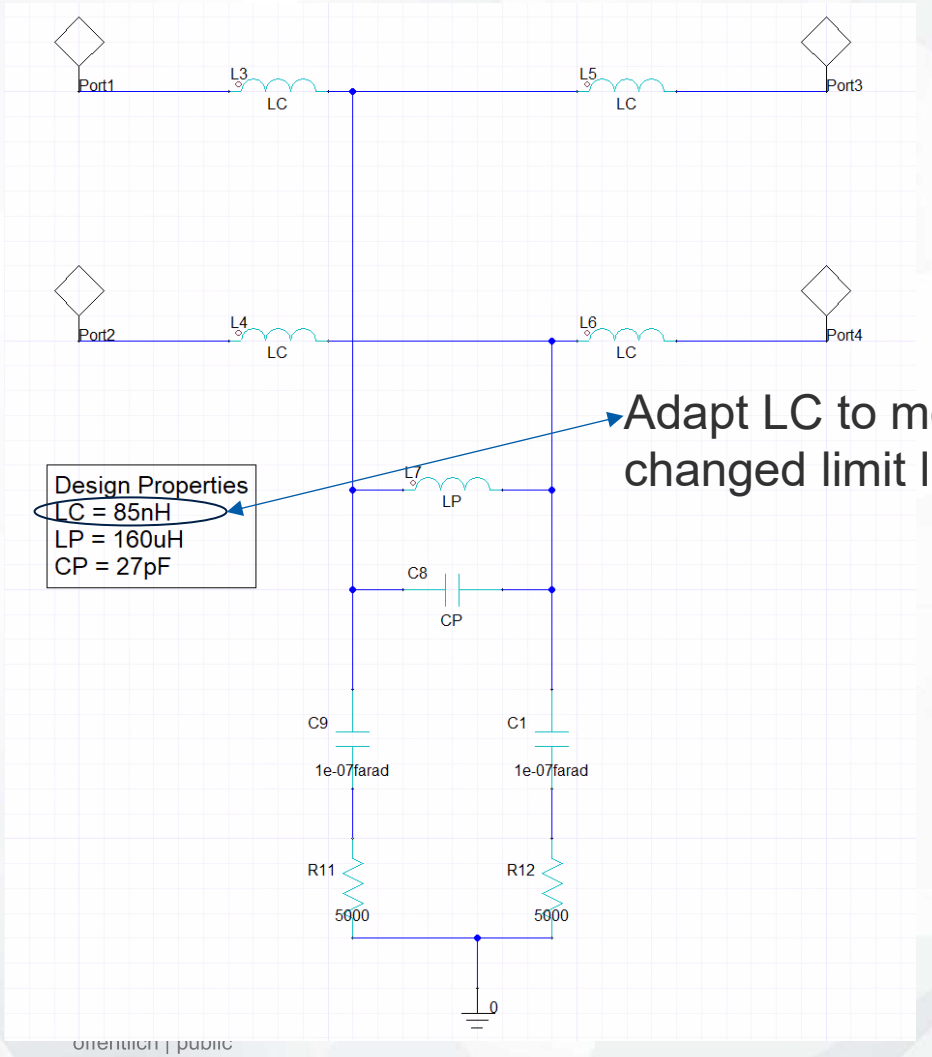
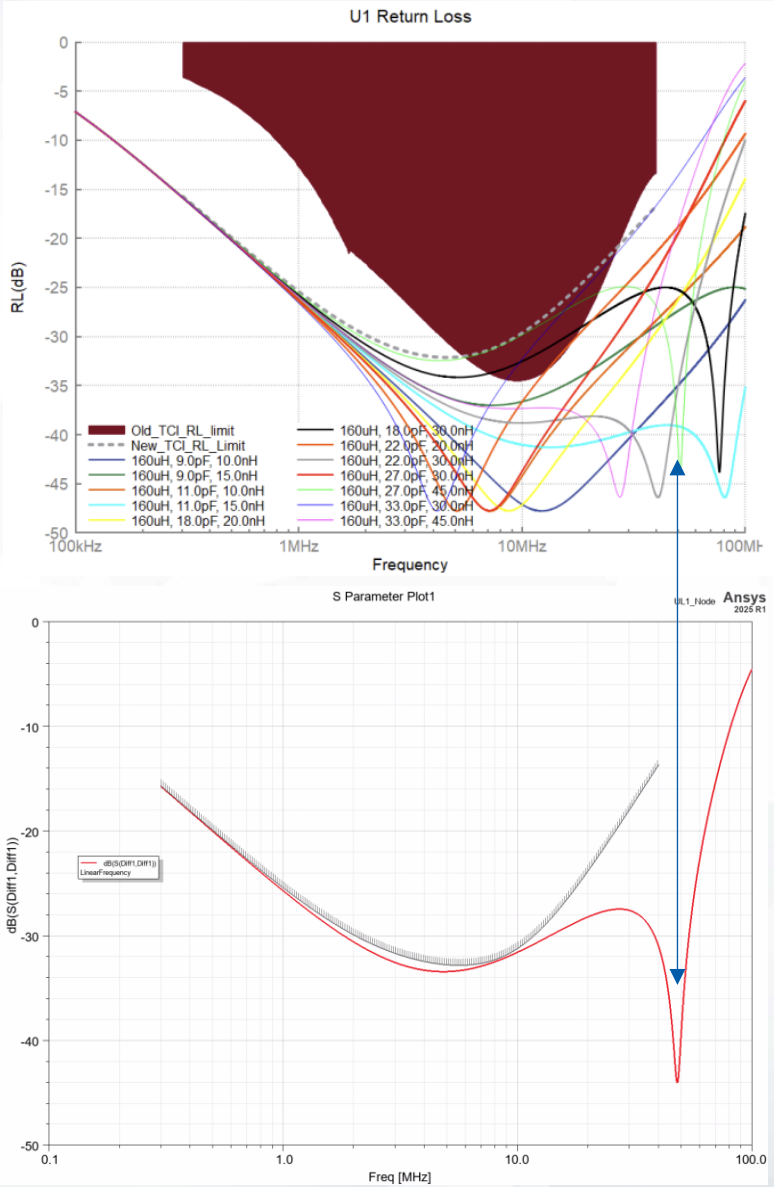
Mixing Segment

Validation of https://www.ieee802.org/3/da/public/0325/mpaul_da_01_20250310_v2.pdf

- UL1 Case



Adapt LC to meet changed limit line



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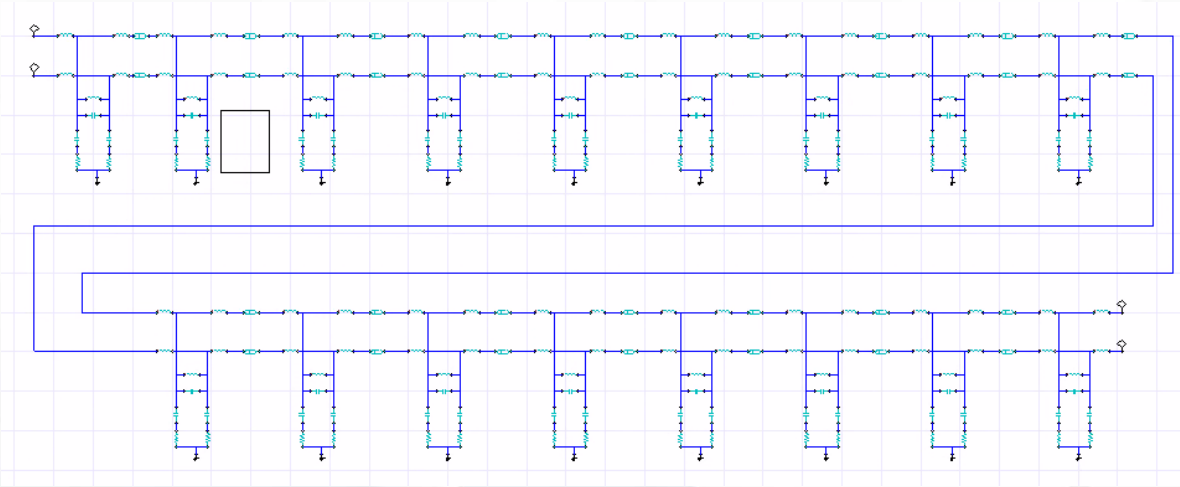
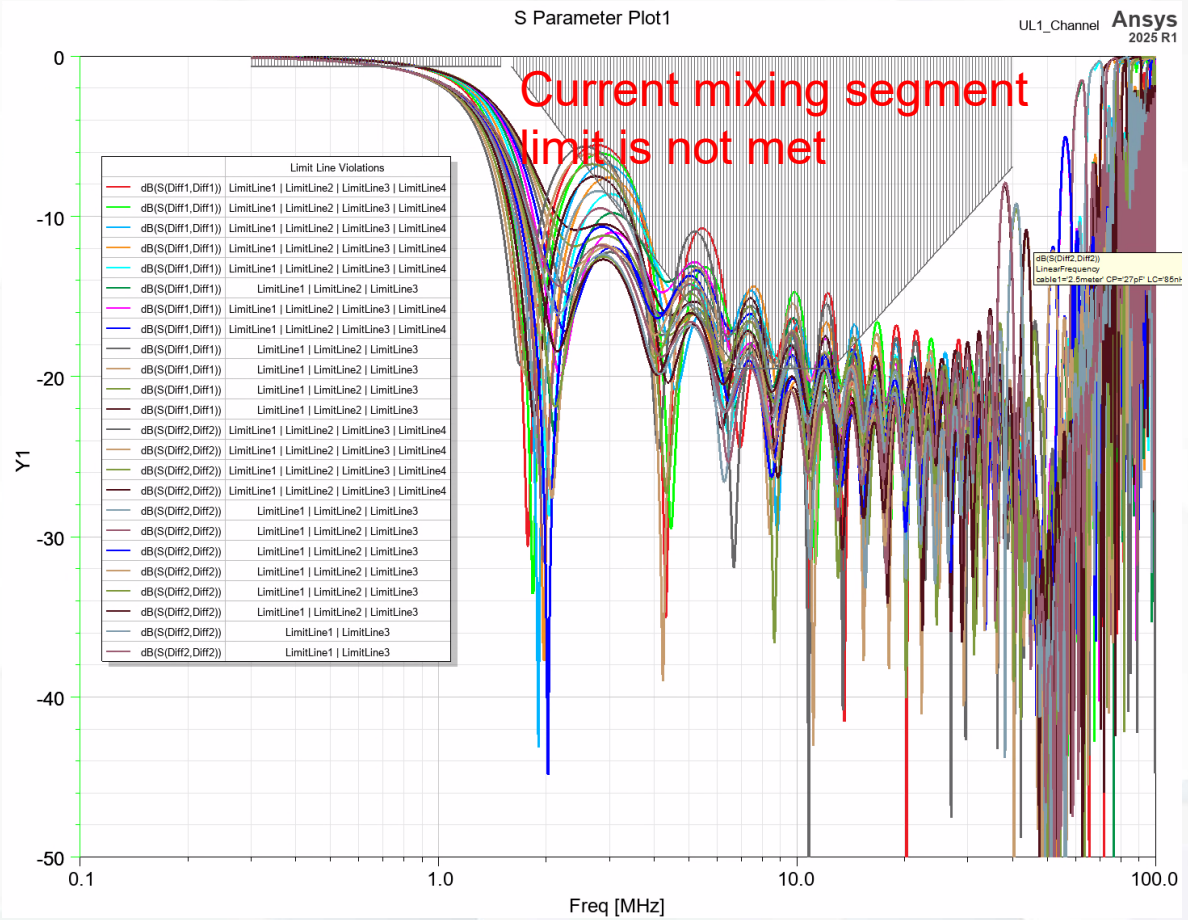
Mixing Segment Return Loss

UL1 Case, Lossless ideal transmission lines – channel Simulation

- Setup:
  - Nodes: 1 x UL16, 16xUL1
  - Transmission Lines 1 to 15 same length varied between 0.25m and 3m in 0.25m Steps, Transmission Line 0 calculated to get a 50m over all
- Current Mixing Segment Limit is harmed for short distances of 0.25m between nodes 1 to 15.





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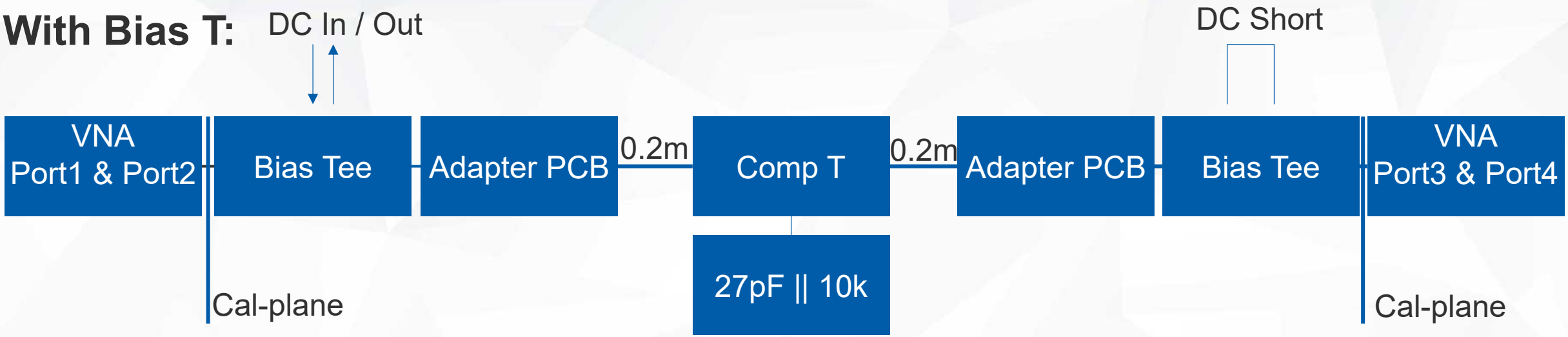
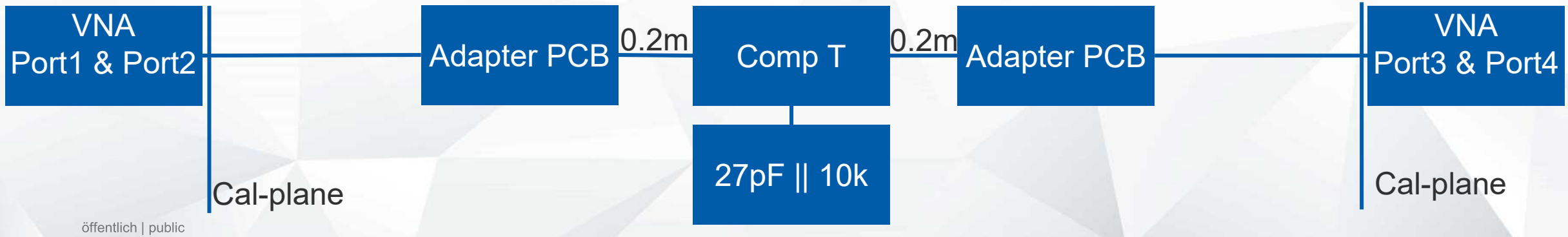
Two Setups for Measurement

With Bias T:



Without Bias T:

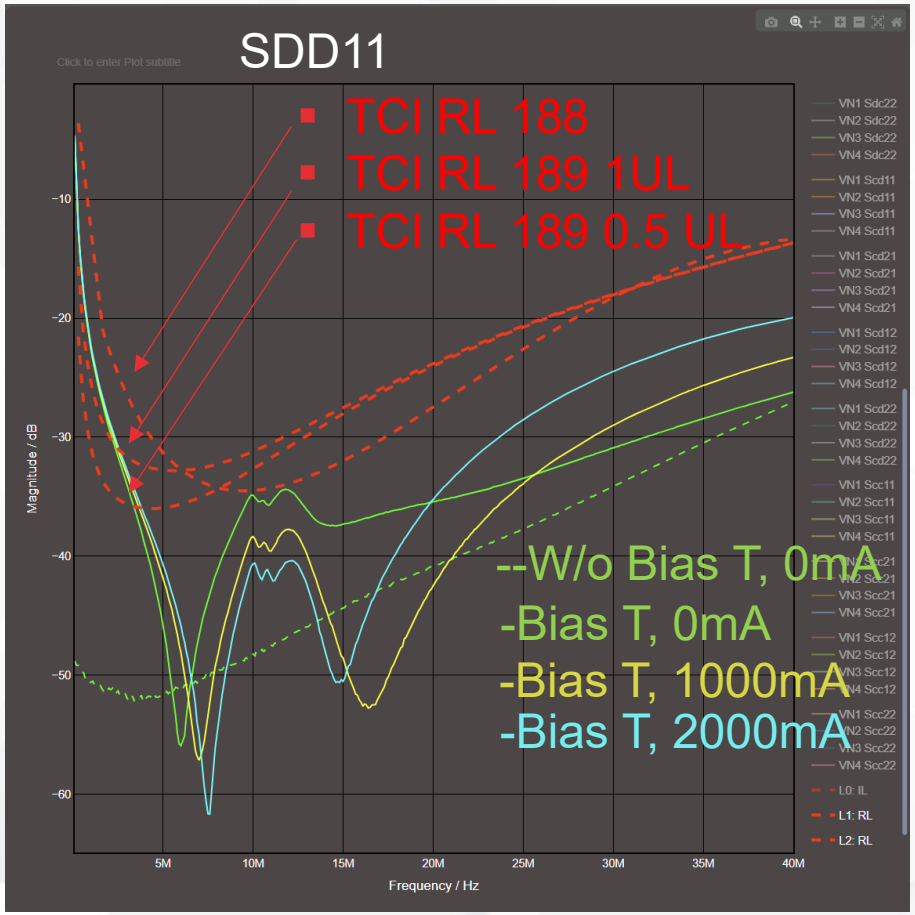


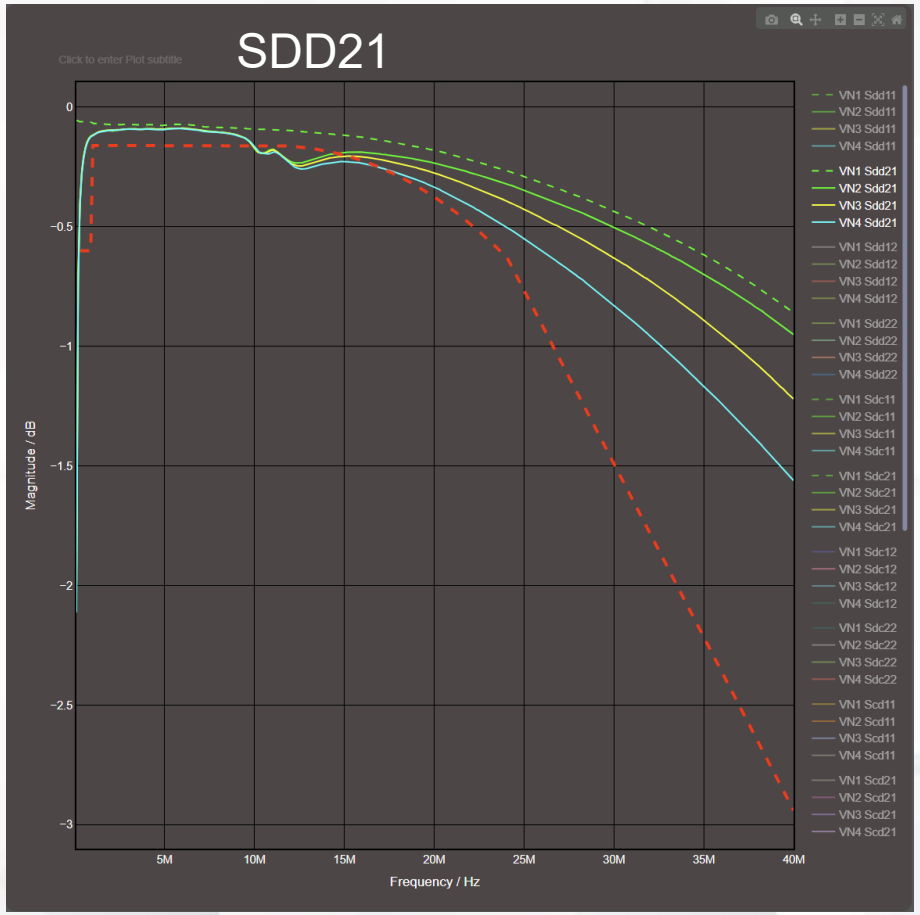
Measurement

Ferrit Compensated T

Version – Prototype 2 Material B, 27pF

- Bias Tee shows significant influence to RL and IL
- Compensated T fullfils spec, however size of compensation ferrit is relatively long
- May be not economically feasible





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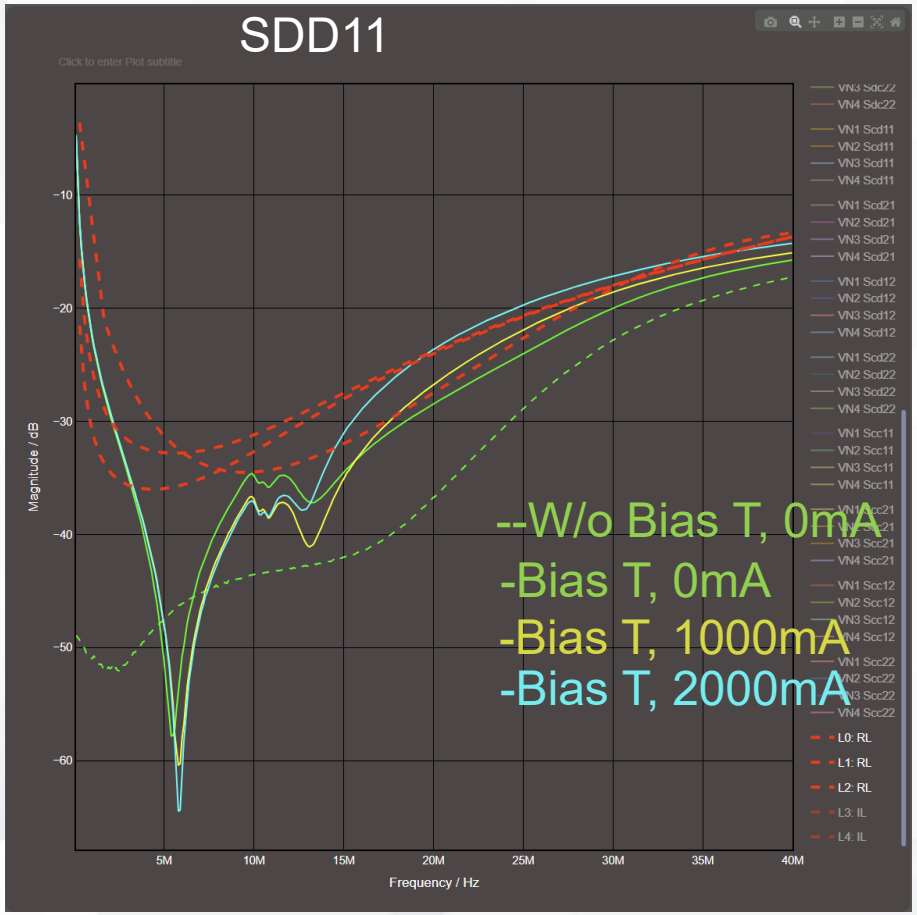
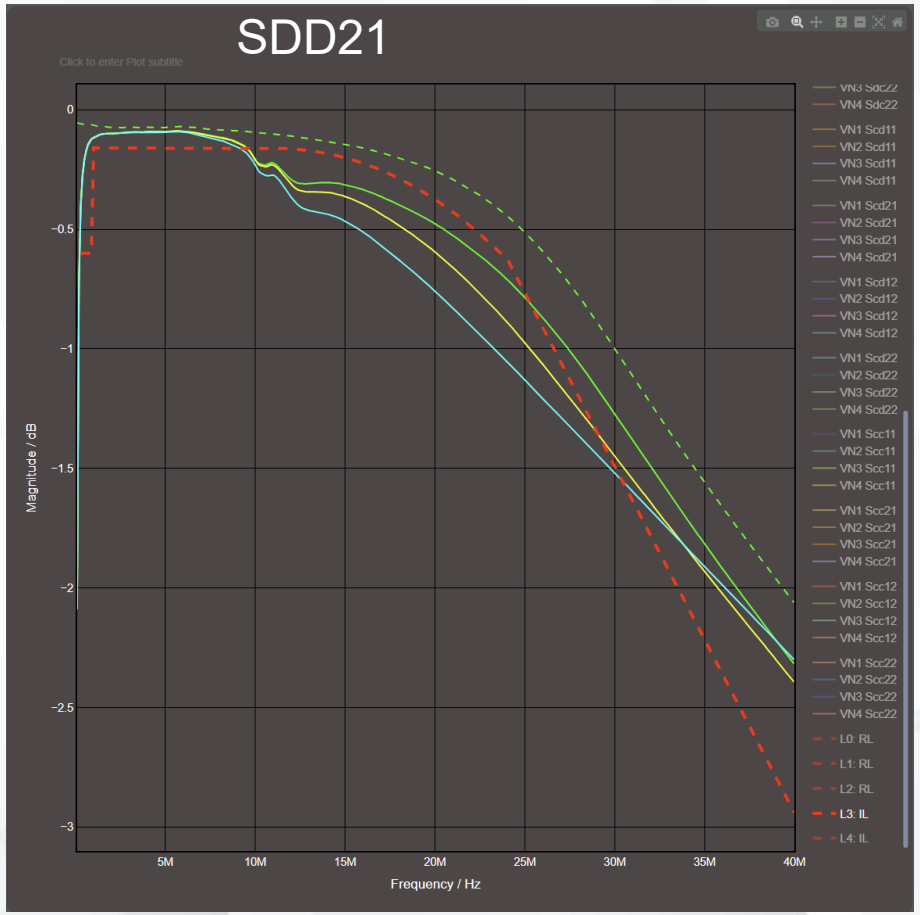
Measurement

Ferrit Compensated T

Version – Prototype 1 (Material A), 27pF

- Small Ferrite
- Bias T shows significant influence in Return Loss and Insertion Loss
- Insertion Loss increases by DC Load
- Shows issues in Return Loss at higher currents, however influence of Bias T is unclear





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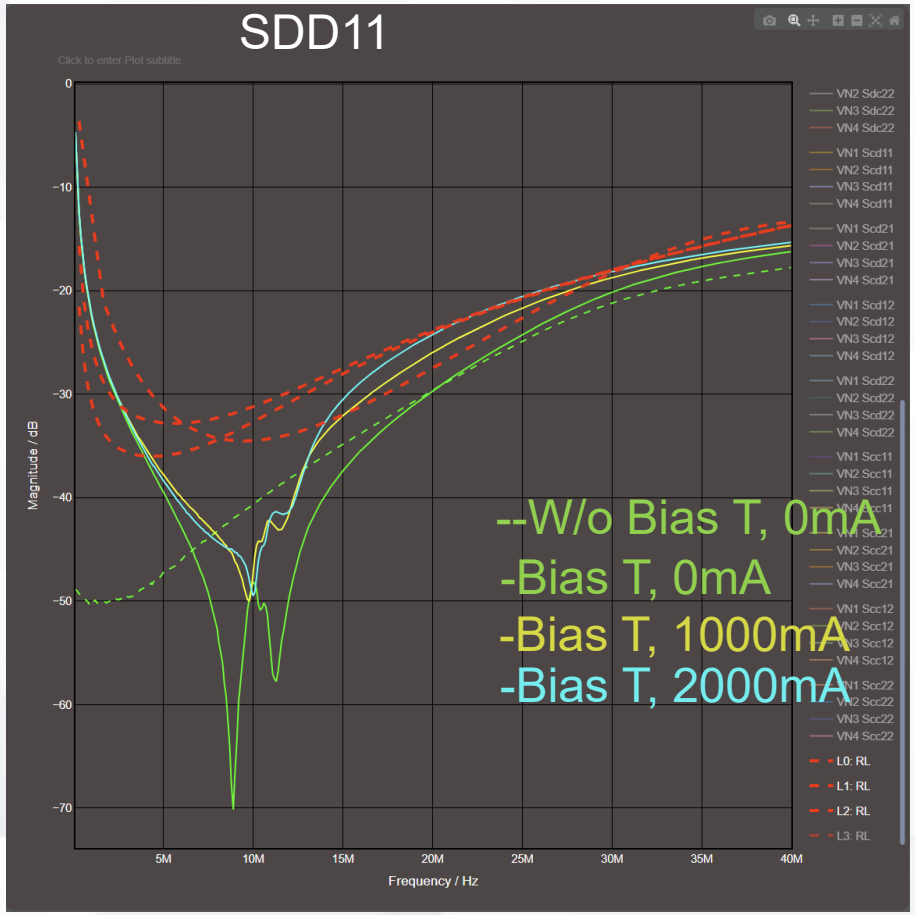
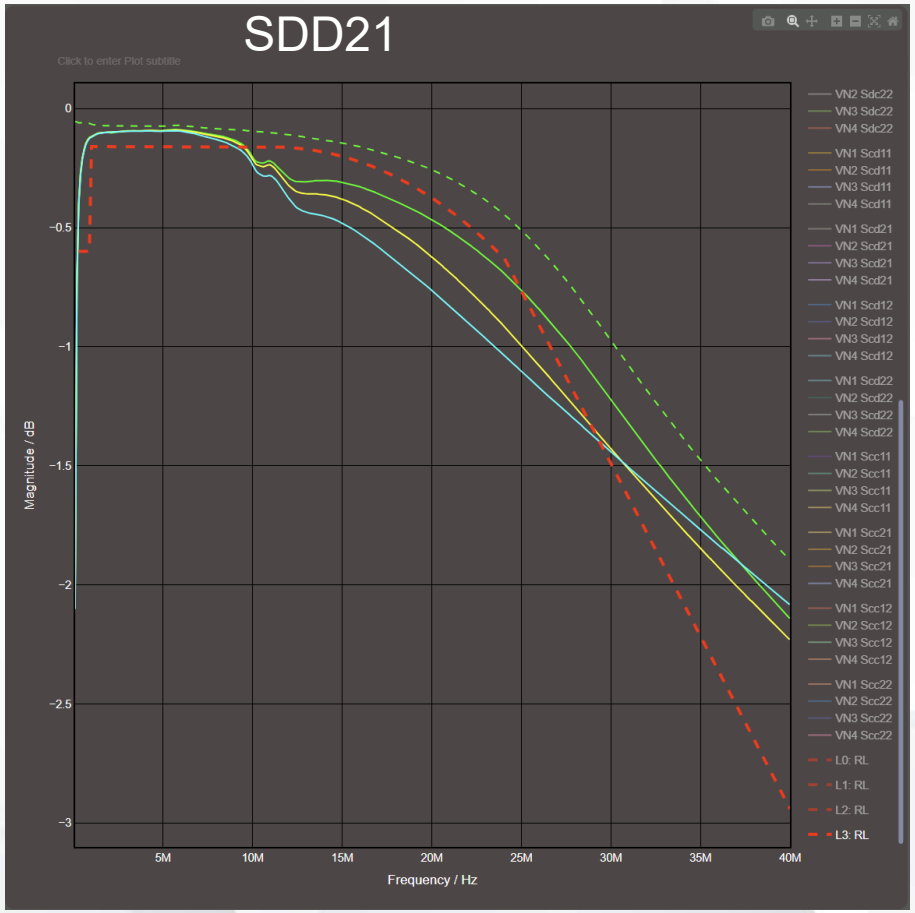
Measurement

Ferrit Compensated T

Version – Prototype 1 (Material A), 22pF

- Small Ferrite
- Reduced capacitance to compensate brings RL into feasible range (still to less margin)
- Insertion Loss increases by DC Load





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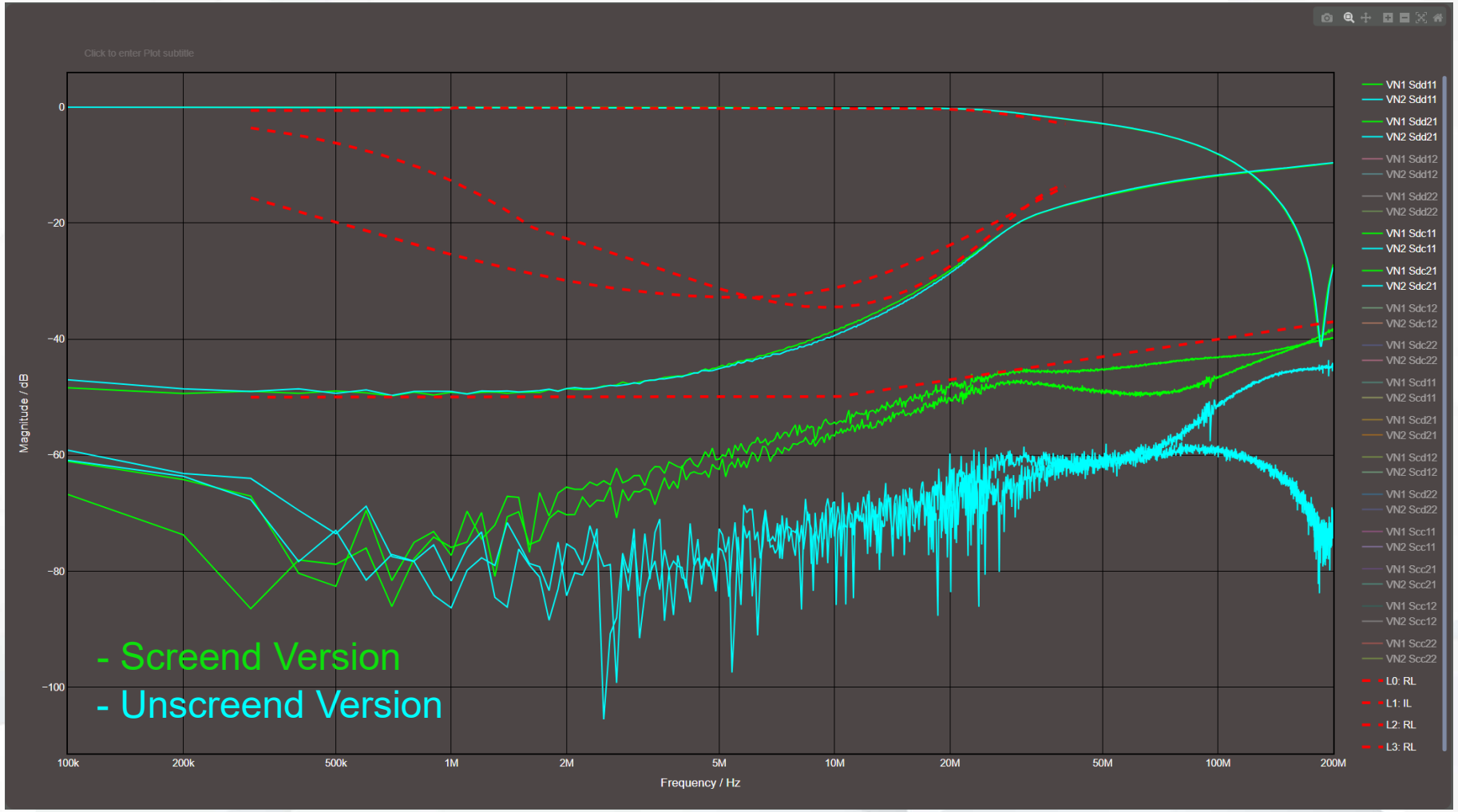
Mode Conversion Loss

Prototype 1, Unscreend Implementation vs. Screend Implementation (Logarithmic Frequency Axis)

- Unscreend Version shows enough margin for series production
- Screend Version is close to the MCL Limit



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Summary

- TCI Return Loss of Clause of 188 and Clause 189 should be aligned
- Measurement of TCI Return Loss under DC derating is challenging
- TCI Return Loss shows a zero margin as best for small implementation

$$RL(f) = -10 * log10\left(\frac{10e3 + \frac{(40.192f)^2}{N_{UNIT}}}{10e3 + \left(\frac{2010f}{N_{UNIT}}\right)^2} + \frac{f^{3.5\ \text{~~2.5~~}}}{\text{~~480e3~~}\ 9500e3}\right) \text{dB}$$

Change

$$RL(f) = -10 * log10\left(\frac{10e3 + \frac{(40.192f)^2}{N_{UNIT}}}{10e3 + \left(\frac{2010f}{N_{UNIT}}\right)^2} + \frac{f^{5\ \text{~~2.5~~}}}{\text{~~480e3~~}\ 650e6}\right) \text{dB}$$

- TCI Insertion Loss has an issue and needs adaption
- TCI Mode Conversion Loss can be held for unscreend implementation. Screend Implementation shows no margin
- Mixing Segment Return Loss shows significant issues

Thank you!

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