



# Alternate MDI return loss proposal

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# Return loss and system complexity from Ahmad Chini and Hui Pan

[http://www.ieee802.org/3/bp/public/jan15/pan\\_3bp\\_01\\_0115.pdf](http://www.ieee802.org/3/bp/public/jan15/pan_3bp_01_0115.pdf)

- Finite RL necessitates digital echo cancellation
  - Increased signal processing complexity
- Excessive echo reduces effective ADC dynamic range
  - Lower SNR and shorter cable reach
- High freq. echo amplifies jitter to noise conversion
  - Lower SNR and shorter cable reach
  - Slower timing recovery and longer startup
- Serial reflections cause system resonance
  - Degraded driver stability
  - More DM/CM conversions

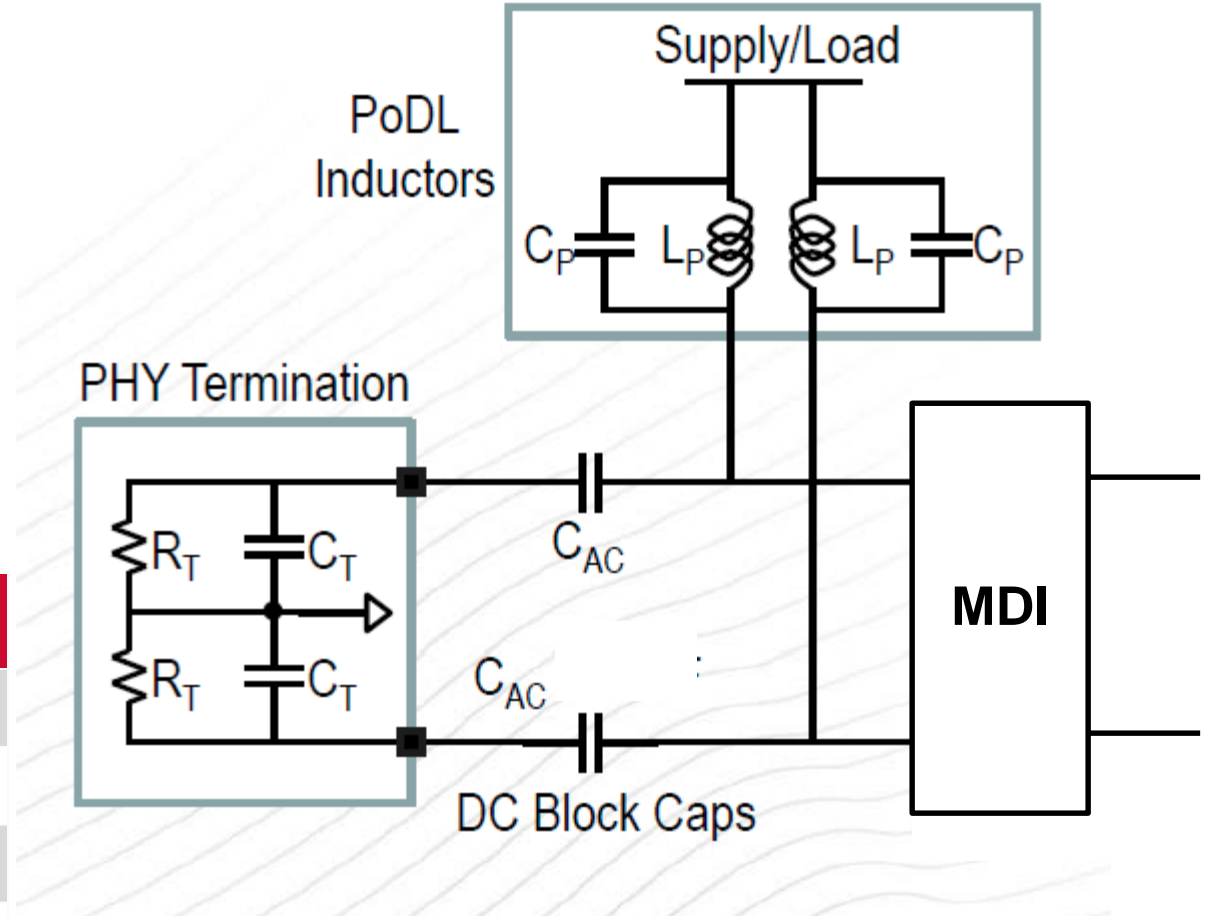
## Comparison to adopted MDI return loss mask by [http://www.ieee802.org/3/ch/public/nov18/bhagwat\\_3ch\\_01a\\_1118.pdf](http://www.ieee802.org/3/ch/public/nov18/bhagwat_3ch_01a_1118.pdf)

- To generate the MDI return loss mask, Bhagwat considers only the parasitic capacitance of the PoDL network.
- Additionally the ESD requirements have to be considered:
  - Chip handling, HBM (Human Body Model)
  - Zapping exposed pins, IEC 61000-4-2
- For an implementable system, MDI return loss mask should be relaxed:
  - At the lower frequency range to allow for smaller PoDL inductors.
  - Mid frequency range to allow for a similar variation of termination resistors as 10GBASET
  - High frequency range to allow for the parasitic capacitance of ESD protection diodes.

# Considered topology and PoDL inductors

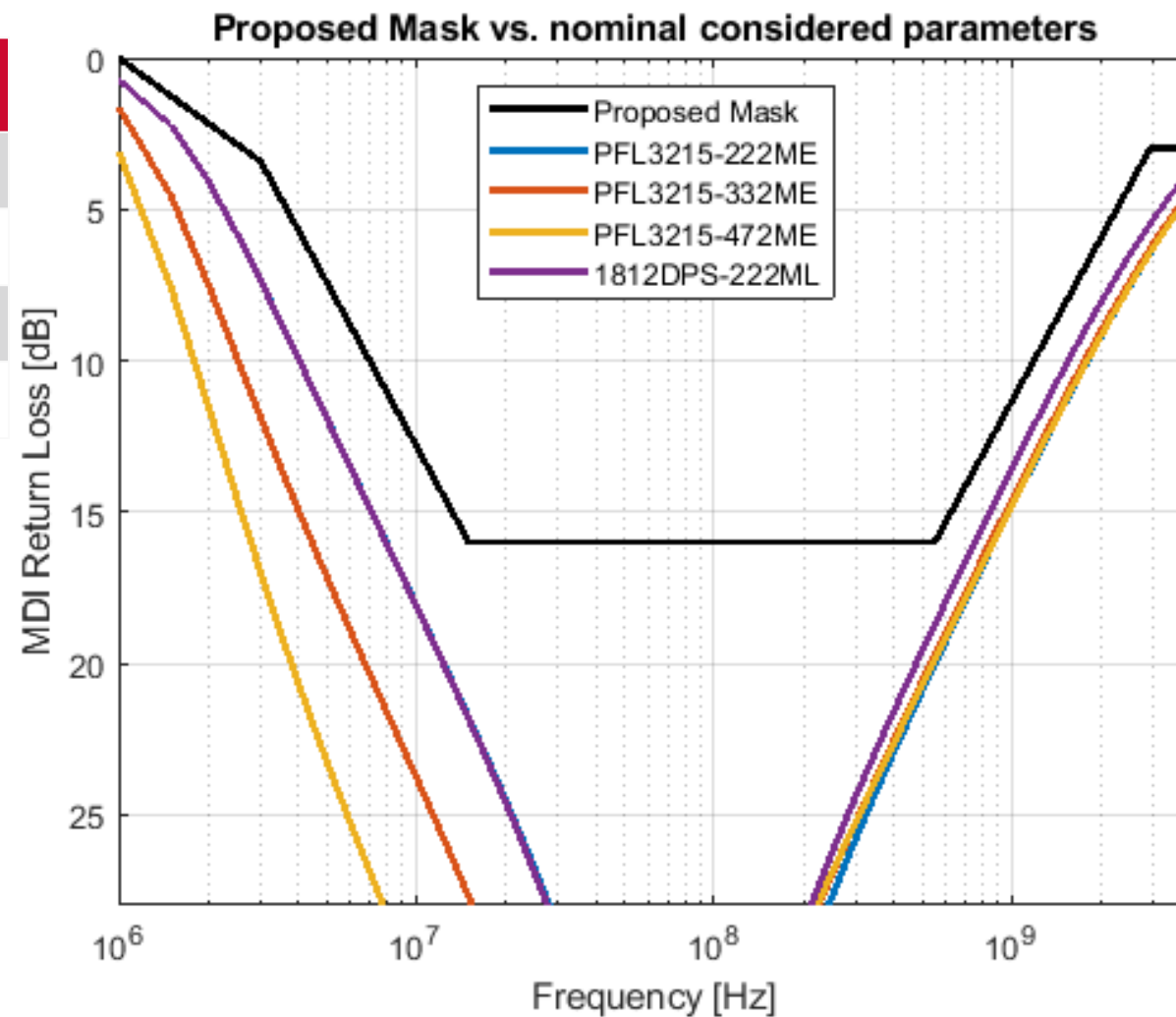
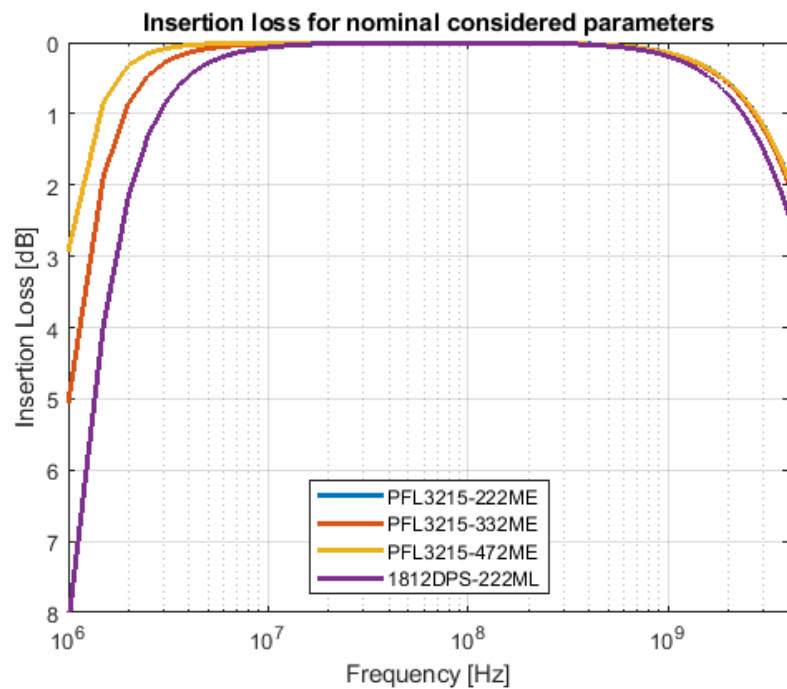
- 4 different available inductors
- Inductance lower than the 6.8uH inductance considered by bhagwat\_3ch\_01a\_0918.pdf
- Parasitic capacitance computed from **Self-Resonant Frequency**
- $SRF = \frac{1}{2\pi\sqrt{CL}}$

Part Number	Inductance [uH]	Self-Resonant Frequency [MHz]	Parasitic Capacitance [pF]
PFL3215-222ME	2.2	250	0.184
PFL3215-332ME	3.3	190	0.180
PFL3215-472ME	4.7	170	0.184
1812DPS-222ML	2.2	175	0.376



# Single sided parasitic termination capacitance: $C_{term}$ 1.0pF to support HBM and IEC 61000-4-2

Part Number	Inductance [uH]	Self-Resonant Frequency [MHz]	Parasitic Capacitance [pF]
PFL3215-222ME	2.2	250	0.184
PFL3215-332ME	3.3	190	0.180
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1812DPS-222ML	2.2	175	0.376



# Mask in numerical form considering single sided parasitic termination capacitance $C_{term}=1.0pF$

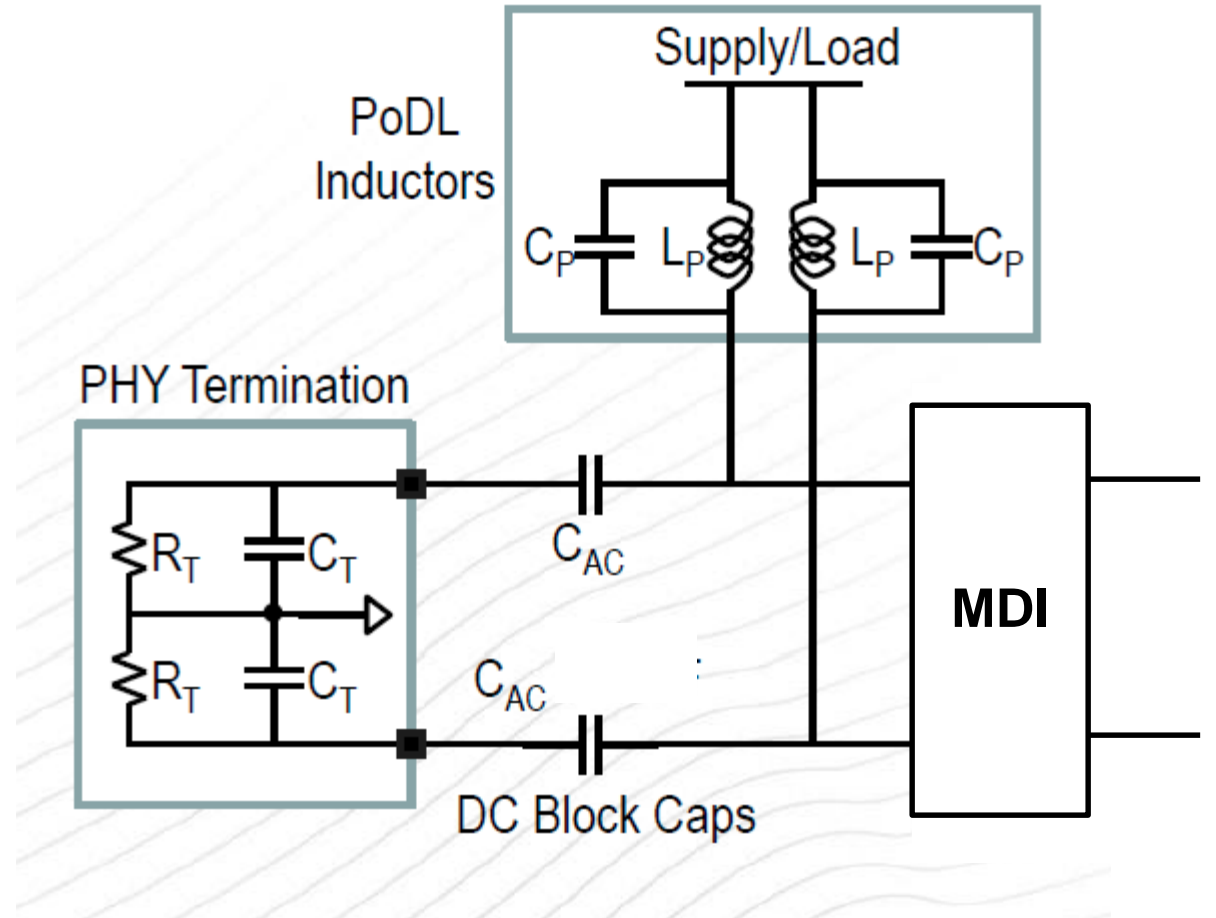
$$\text{MDI return loss} = \begin{cases} 3.42+7.17*\log_{10}(f/3) & 1 \leq f < 3 \\ 16 + 18*\log_{10}(f/15) & 3 \leq f < 15 \\ 16 & 15 \leq f < 550 \\ 16 - 18*\log_{10}(f/550) & 550 \leq f < 2900 \\ 3 & 2900 \leq f < 4000 \end{cases}$$

Return loss in dB, frequency in MHz

# Parameter variation study

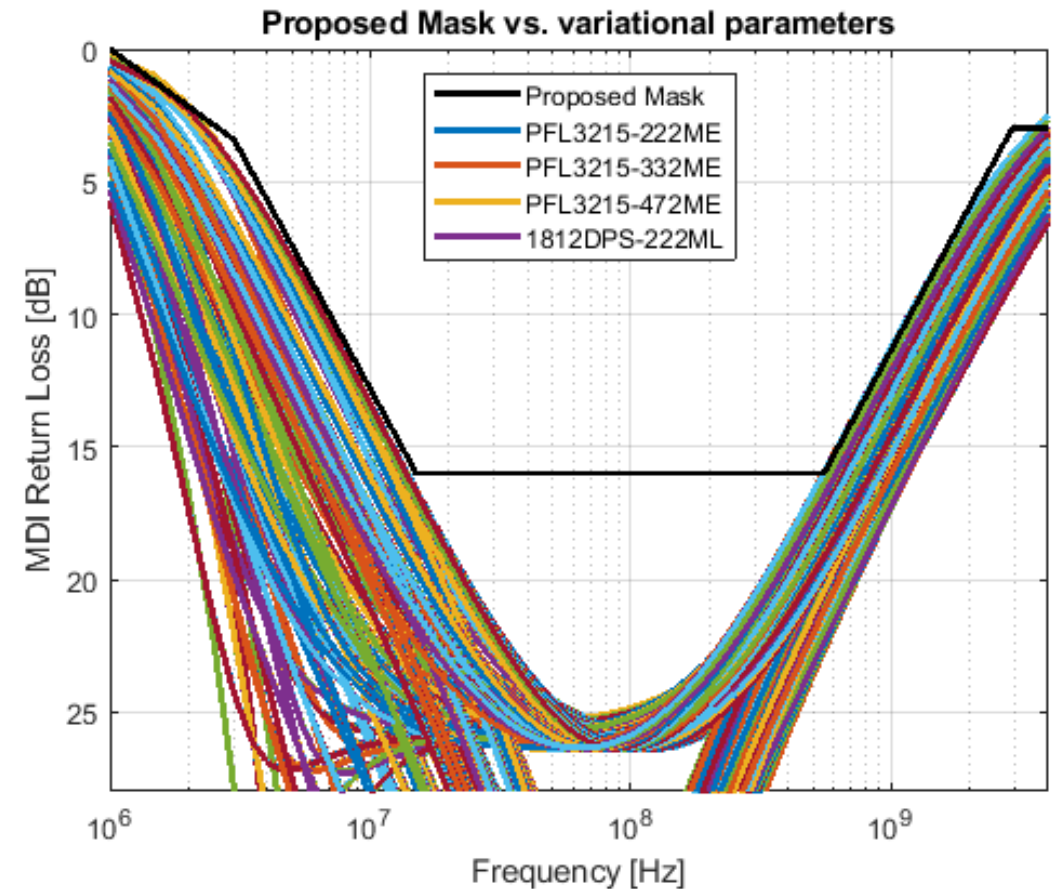
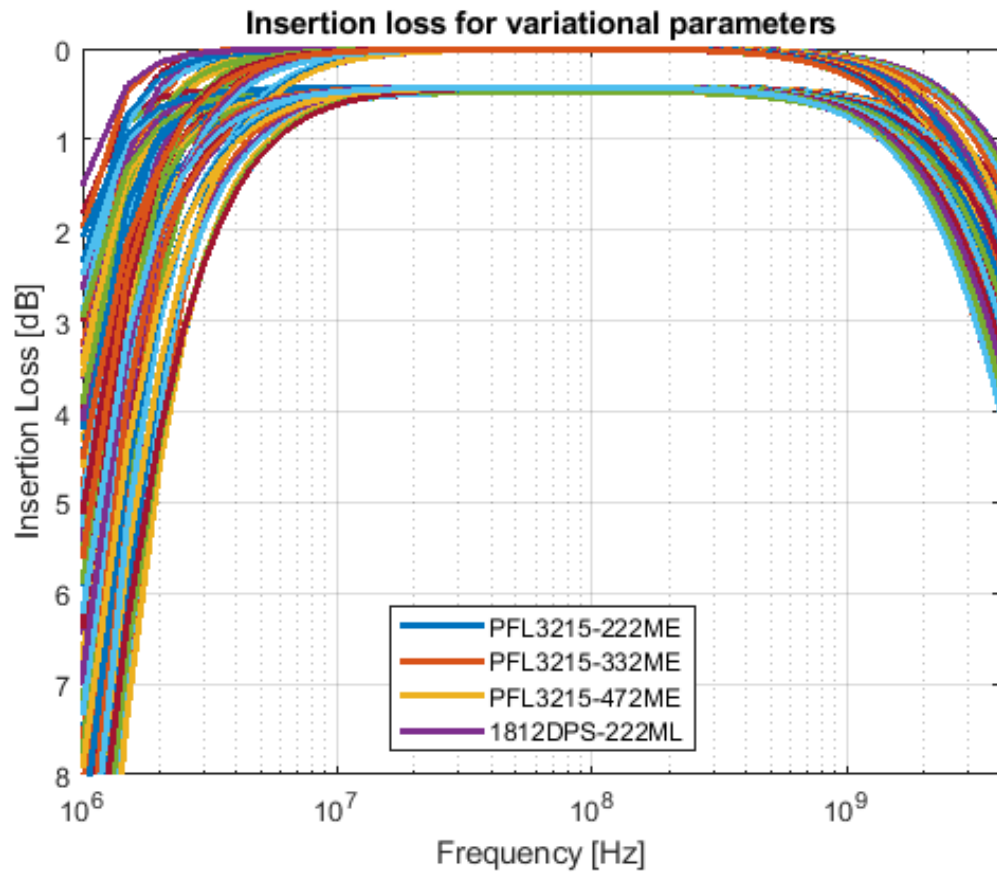
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		min	nom	max
R_T	Ohm	45	50	55
C_T	pF	0.75	1.0	1.25
C_AC	nF	2.16	2.88	3.6
L_P	uH	75%	100%	125%
C_P	pF	75%	100%	125%



# Parameter variation

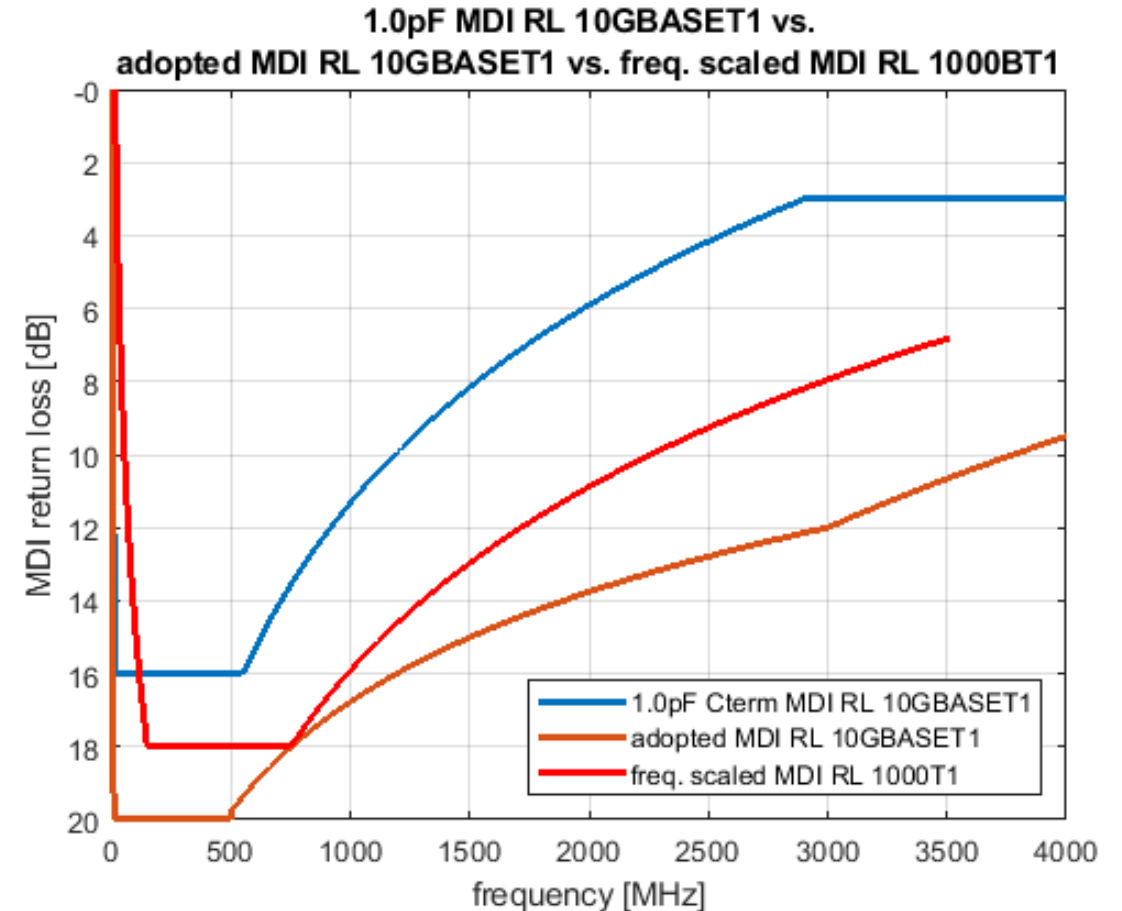
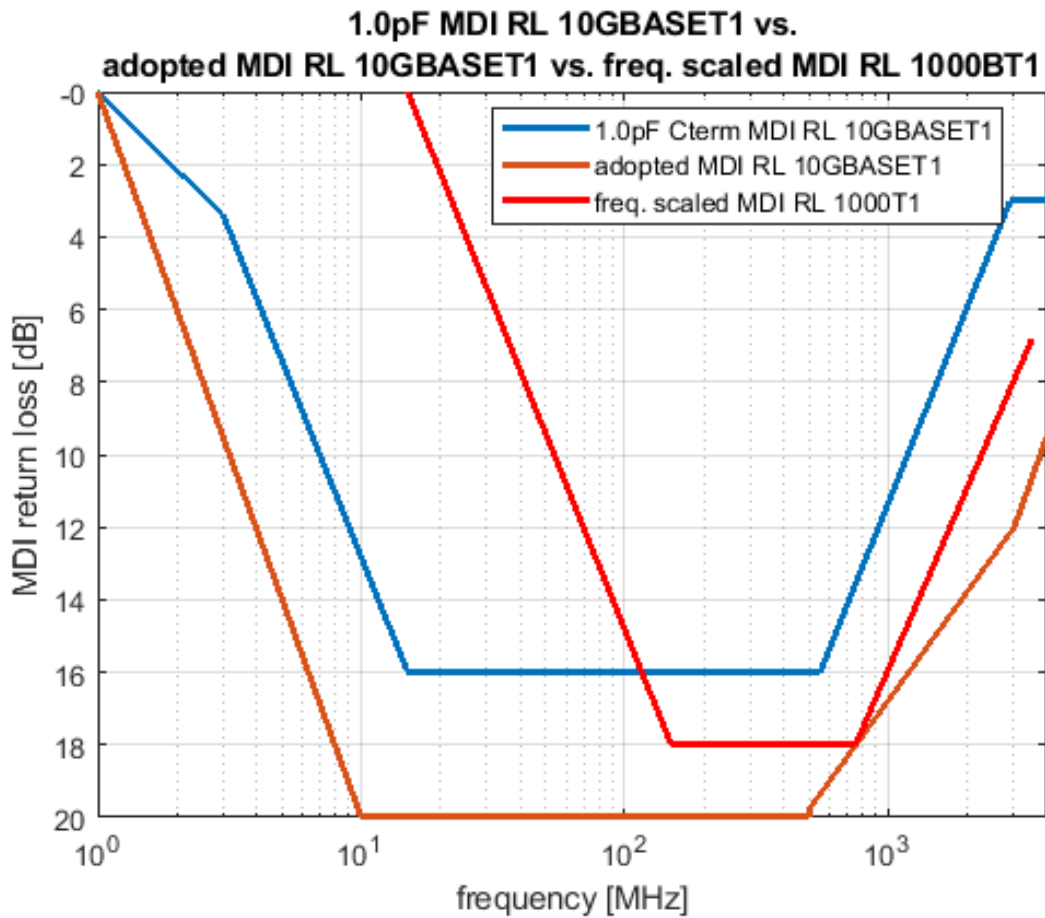
- Low PoDL inductance sets low frequency behavior  $1 \leq f < 15$  [MHz]
- Termination resistor variation sets middle frequency behavior  $15 \leq f < 550$  [MHz]
- Overall capacitance sets upper frequency behavior  $550 \leq f < 4000$  [MHz]





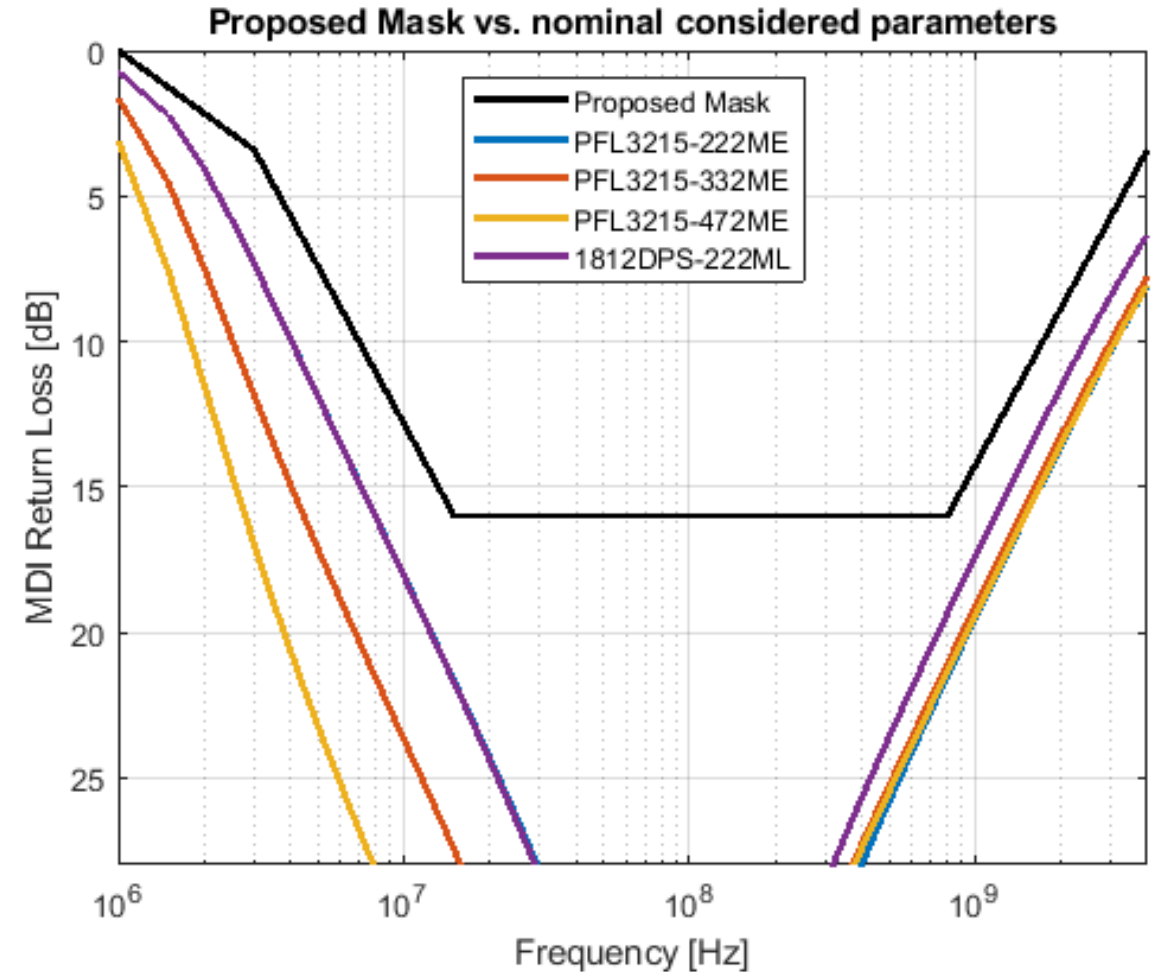
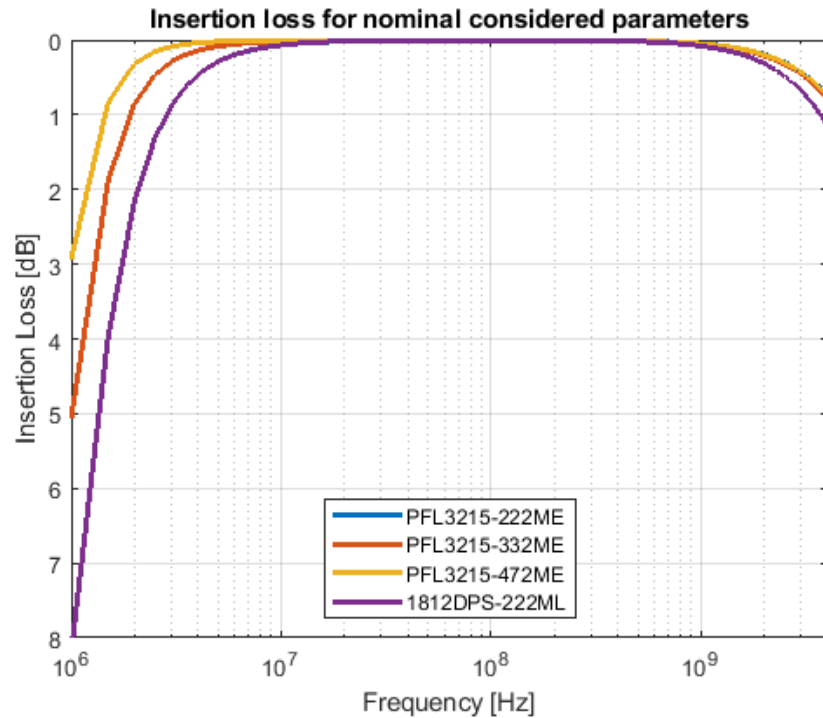
# Proposed MDI return loss mask in comparison

- Lower transition band: 1MHz to 15MHz: allow for smaller inductors.
- Mid frequency: allow for same termination resistor variation as 10GBASET.
- Upper transition band: 550MHz to 4GHz: allow for ESD parasitic capacitance



# Single sided parasitic termination capacitance: $C_{term}$ 0.5pF to support HBM only

Part Number	Inductance [uH]	Self-Resonant Frequency [MHz]	Parasitic Capacitance [pF]
PFL3215-222ME	2.2	250	0.184
PFL3215-332ME	3.3	190	0.180
PFL3215-472ME	4.7	170	0.184
1812DPS-222ML	2.2	175	0.376



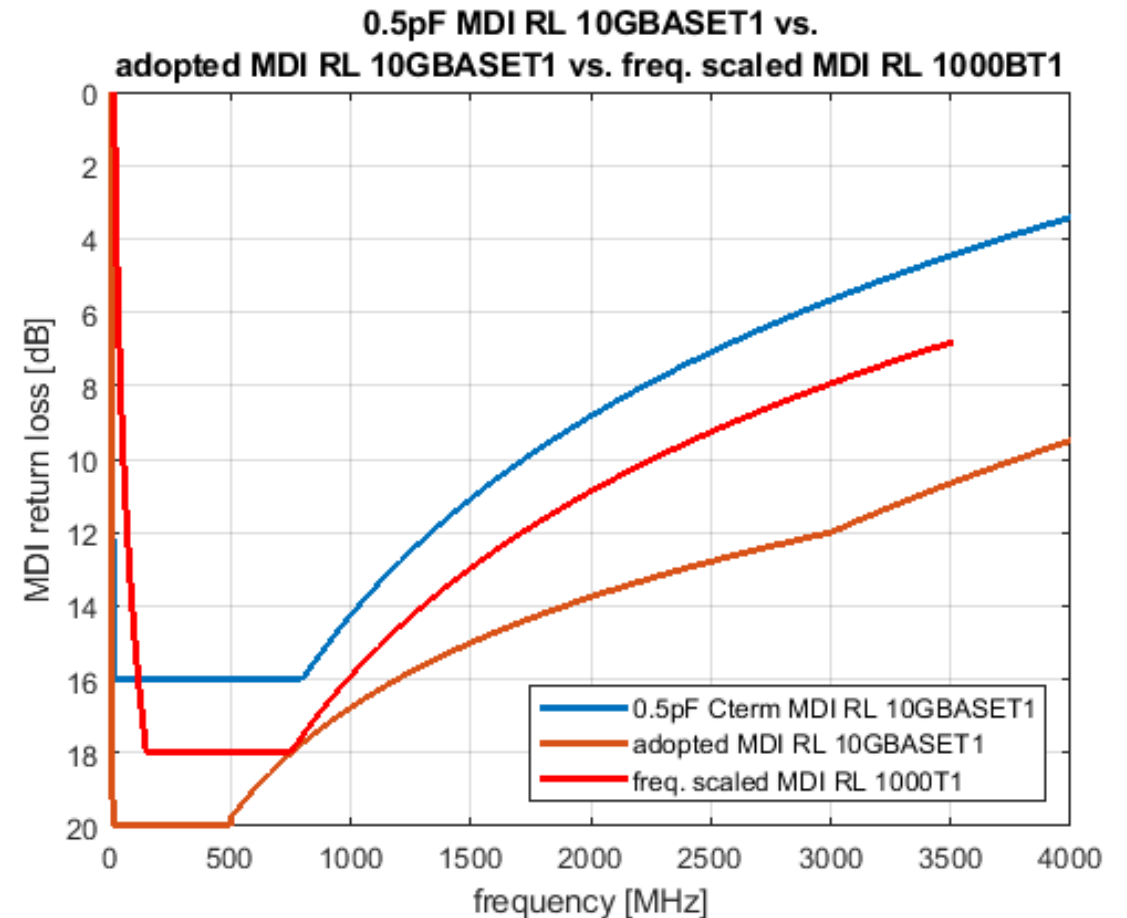
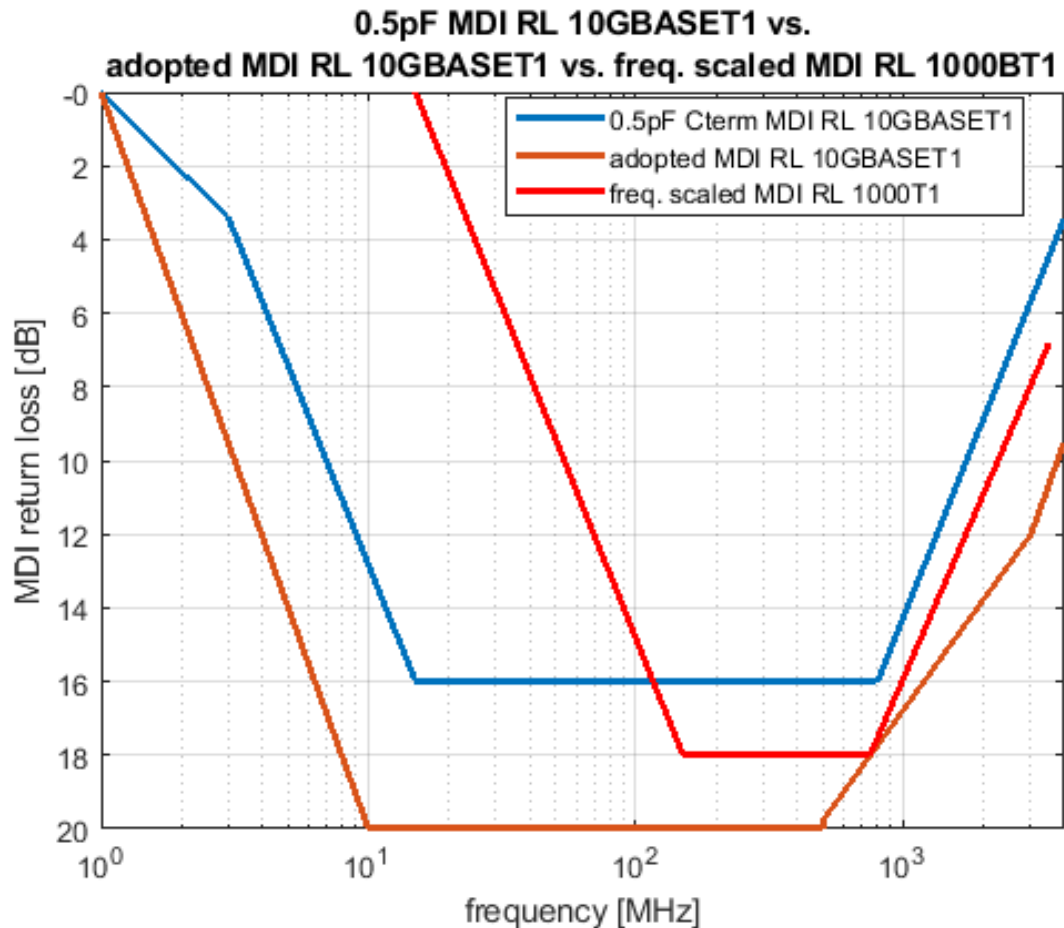
## Mask in numerical form considering single sided parasitic termination capacitance $C_{term}=0.5pF$

$$\text{MDI return loss} = \begin{cases} 3.42+7.17*\log_{10}(f/3) & 1 \leq f < 3 \\ 16 + 18*\log_{10}(f/15) & 3 \leq f < 15 \\ 16 & 15 \leq f < 800 \\ 16 - 18*\log_{10}(f/800) & 800 \leq f < 4000 \end{cases}$$

Return loss in dB, frequency in MHz

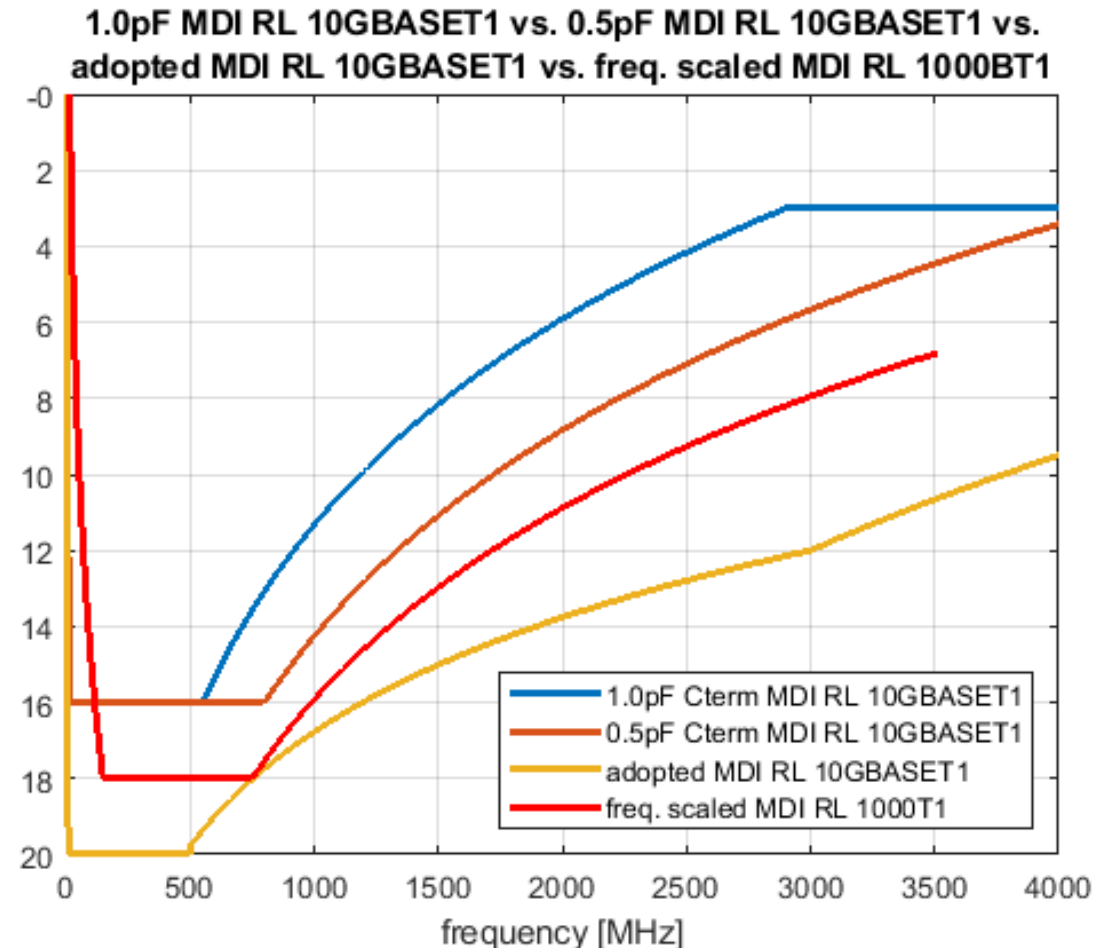
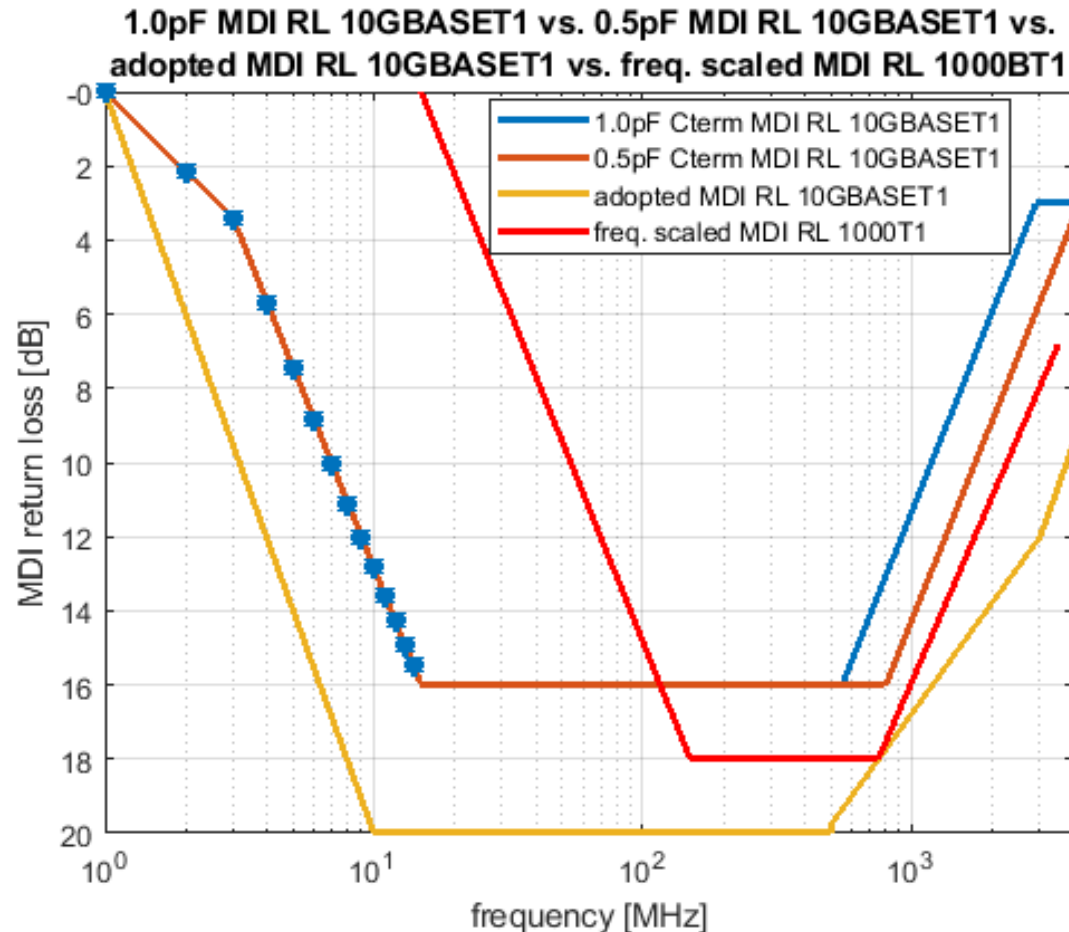
# Proposed MDI return loss mask in comparison

- Low PoDL inductance sets low frequency behavior  $1 \leq f < 15$  [MHz]
- Termination resistor variation sets middle frequency behavior  $15 \leq f < 800$  [MHz]
- Overall capacitance sets upper frequency behavior  $800 \leq f < 4000$  [MHz]



# Overview

- Comparison of the MDI return loss mask for
  - 1.0pF termination capacitance  $C_{term}$  for 10GBASET1
  - 0.5pF termination capacitance  $C_{term}$  for 10GBASET1
  - Adopted MDI RL mask for 10GBASET1
  - Frequency scaled for 1000BASET1



# Conclusion

- Recommend to support both HBM and IEC 61000-4-2 ESD requirements.
- Propose to change the MDI return loss mask to

$$\text{MDI return loss} = \begin{cases} 3.42 + 7.17 \cdot \log_{10}(f/3) & 1 \leq f < 3 \\ 16 + 18 \cdot \log_{10}(f/15) & 3 \leq f < 15 \\ 16 & 15 \leq f < 550 \\ 16 - 18 \cdot \log_{10}(f/550) & 550 \leq f < 2900 \\ 3 & 2900 \leq f < 4000 \end{cases}$$

Return loss in dB, frequency in MHz