Alternate MDI return loss proposal

German Feyh

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Return loss and system cost from Ahmad Chini and Hui Pan http://www.ieee802.org/3/bp/public/jan15/pan_3bp_01_0115.pdf

- Finite RL necessitates digital echo cancellation
  - Increased signal processing cost
- 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

- 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.

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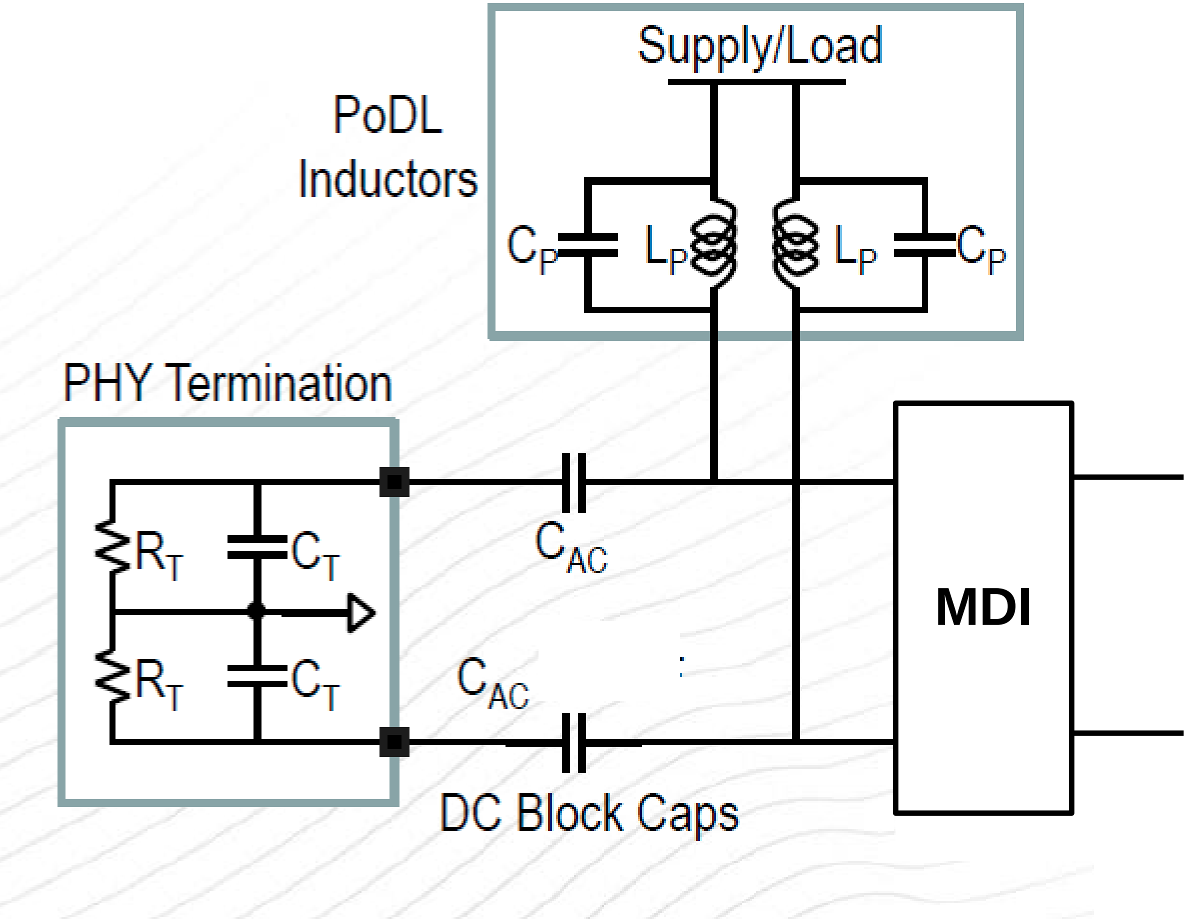
Considered topology and PoDL inductors

- 4 different available inductors
- Inductance lower than the 6.8uH inductance considered by bhagwat_3ch_01a_0918.pdf
- Parasitic capacitance computed from **S**elf-**R**esonant **F**requency
- $SRF = \frac{1}{2\pi\sqrt{CL}}$

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



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Single sided parasitic termination capacitance: Cterm 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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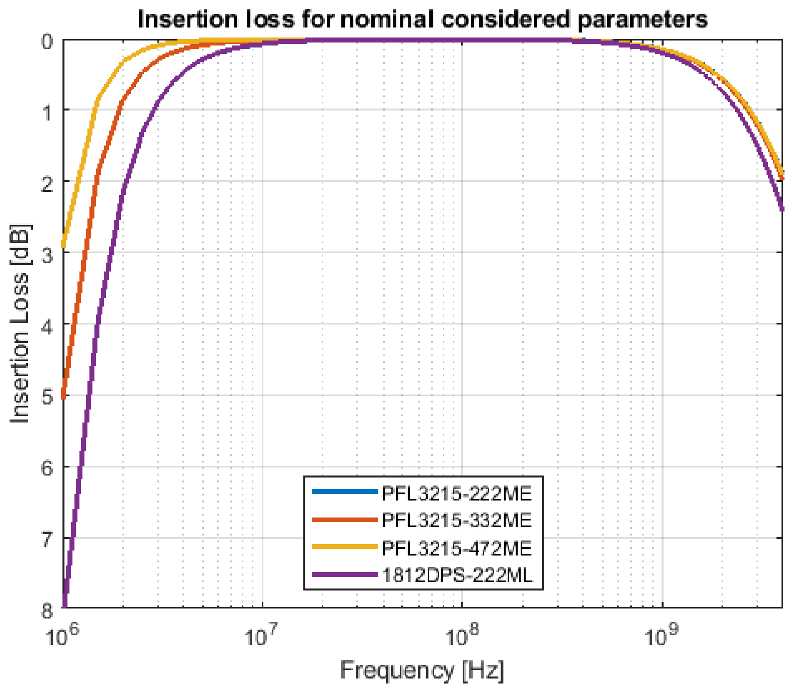

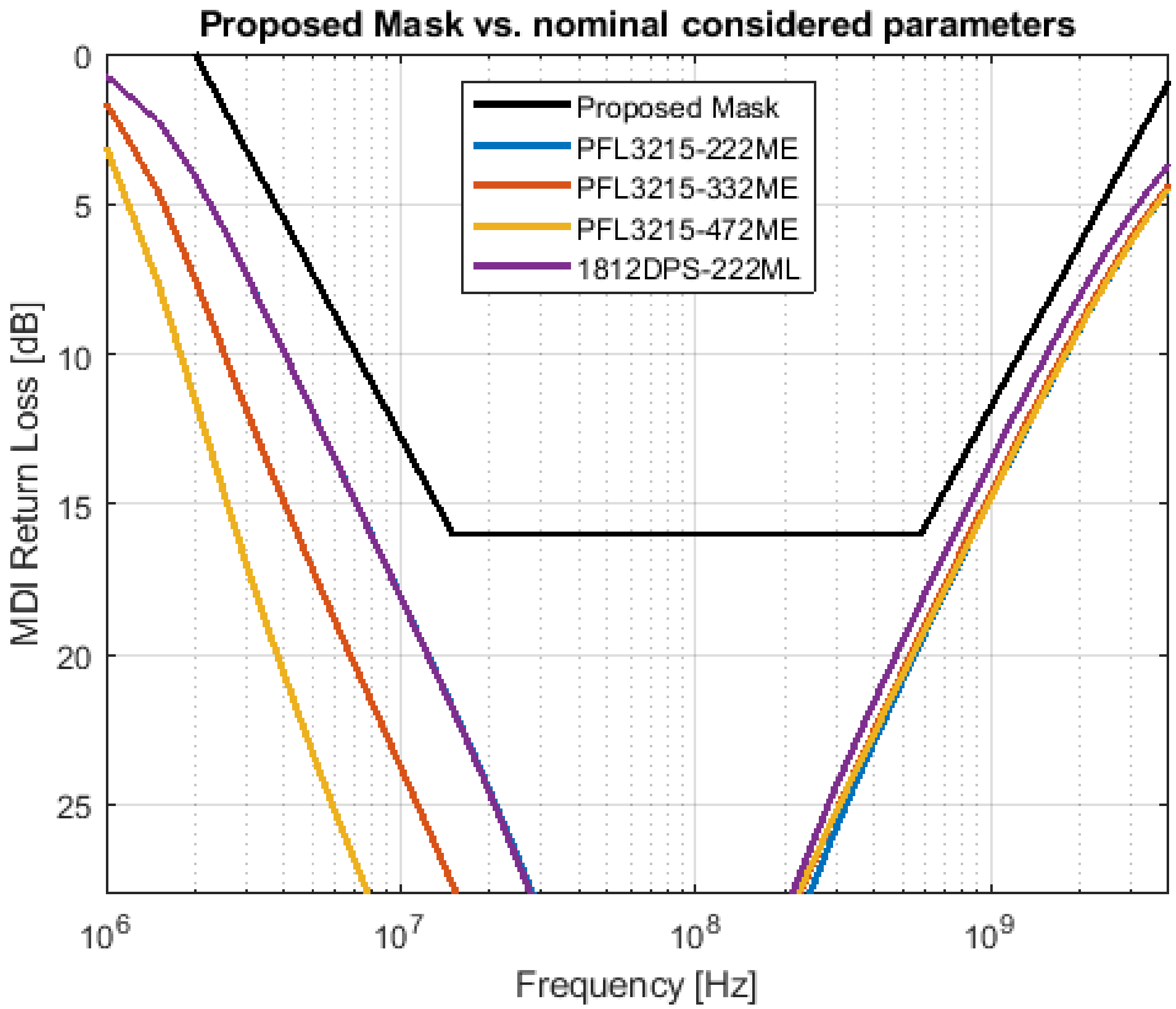

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Mask in numerical form considering single sided parasitic termination capacitance Cterm=1.0pF

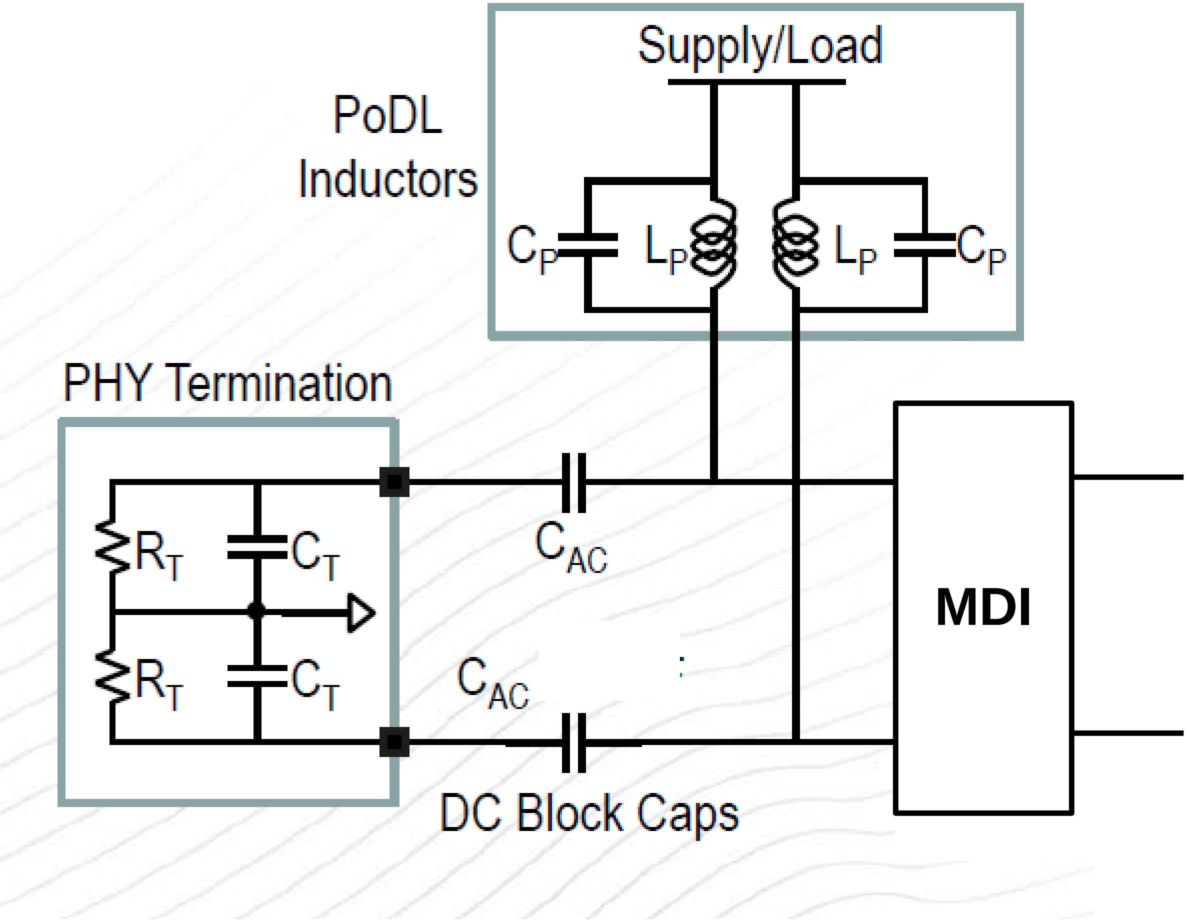
$$\text{MDI return loss} = \begin{cases} 16 + 18\log_{10}(f/15) & 2 \le f < 15 \\ 16 & 15 \le f < 580 \\ 16 - 18\log_{10}(f/580) & 580 \le f < 4000 \end{cases}$$

Return loss in dB, frequency in MHz

Parameter variation study

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

		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	µH	75%	100%	125%
C_P	pF	75%	100%	125%



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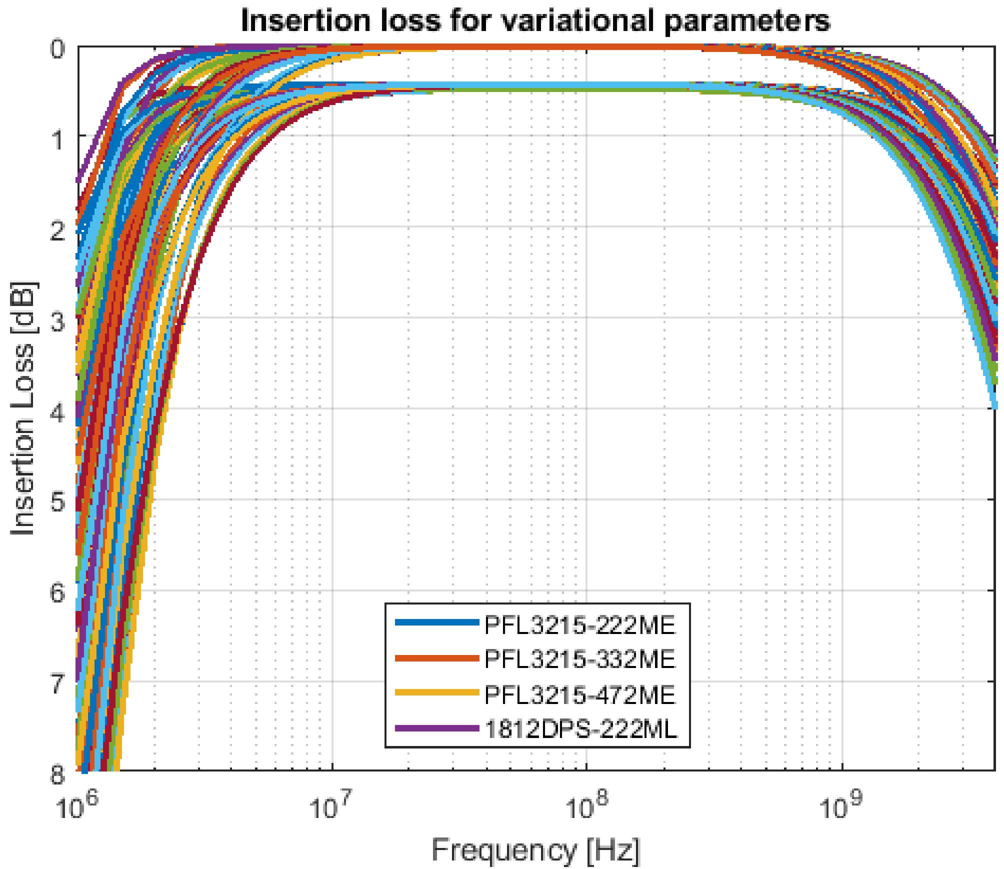
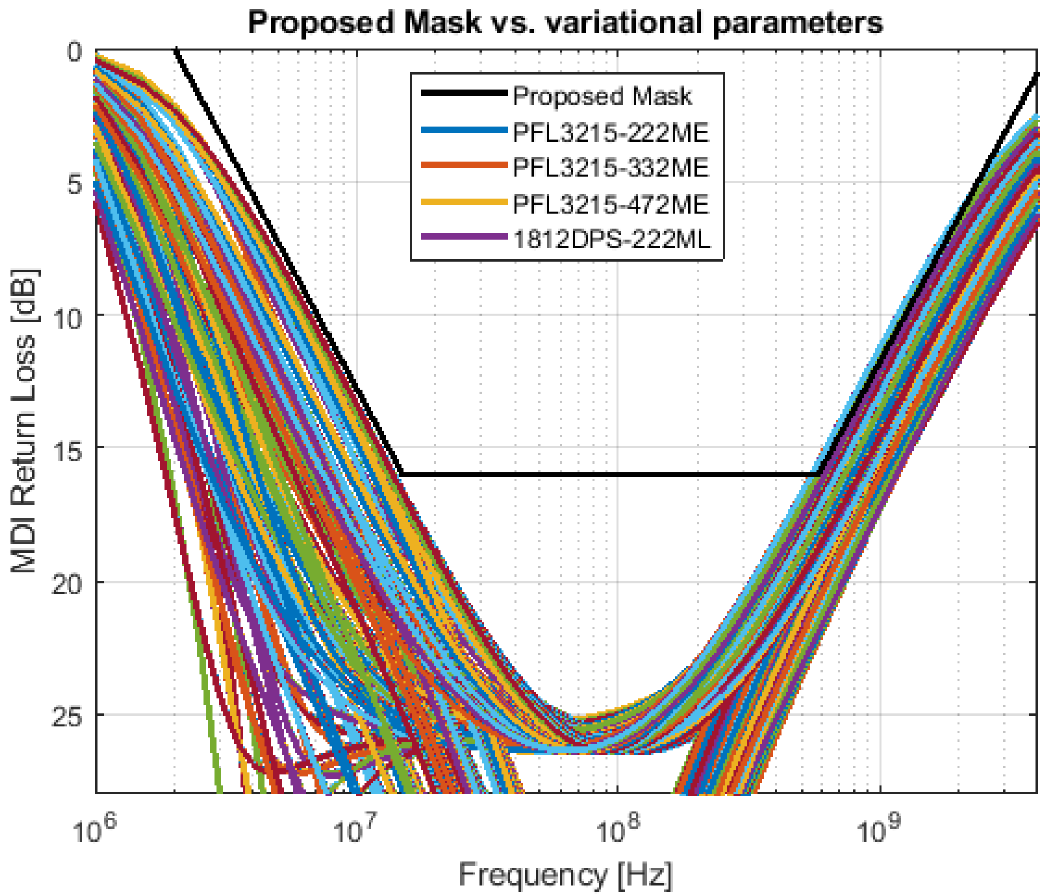
Parameter variation

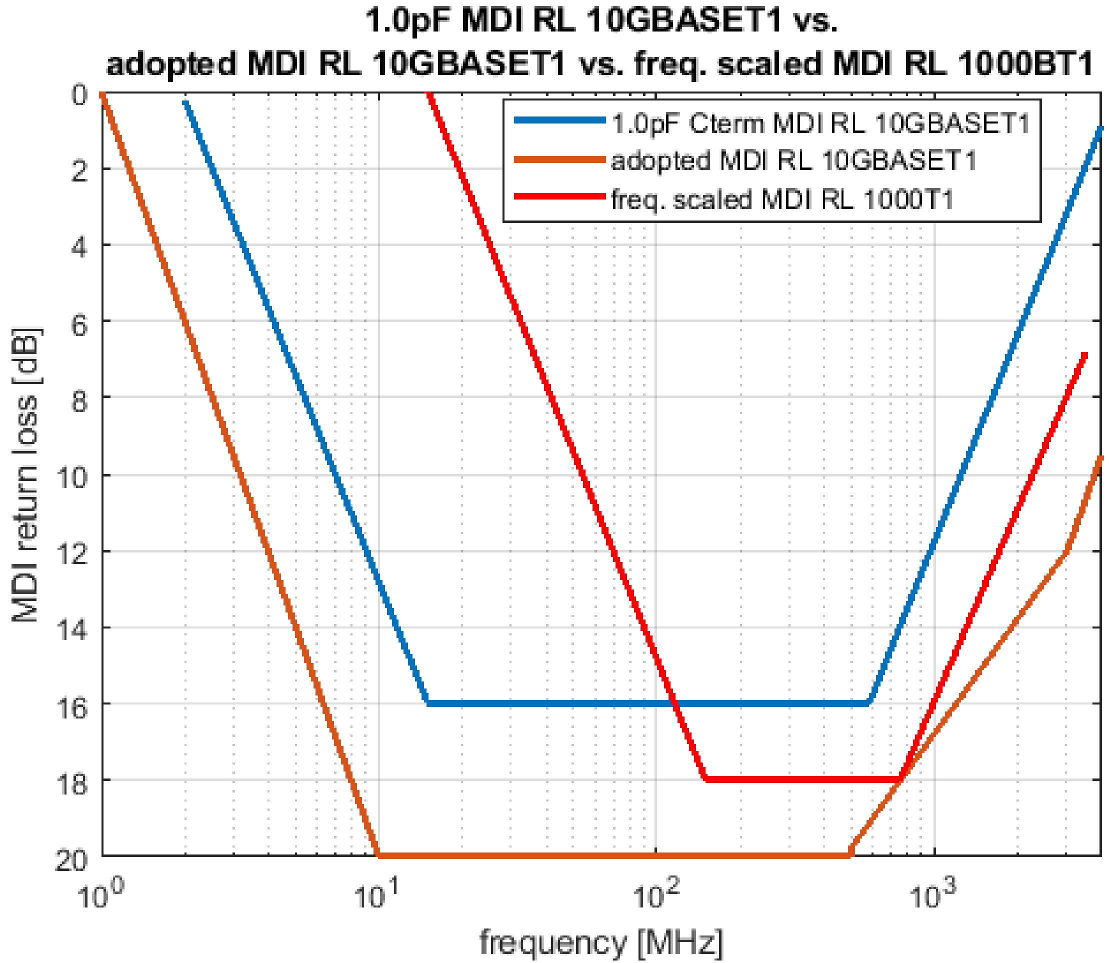
- Low PoDL inductance sets low frequency behavior 2 ≤f<15 [MHz]
- Termination resistor variation sets middle frequency behavior 15 ≤f<580 [MHz]
- Overall capacitance sets upper frequency behavior 580≤f<4000 [MHz]

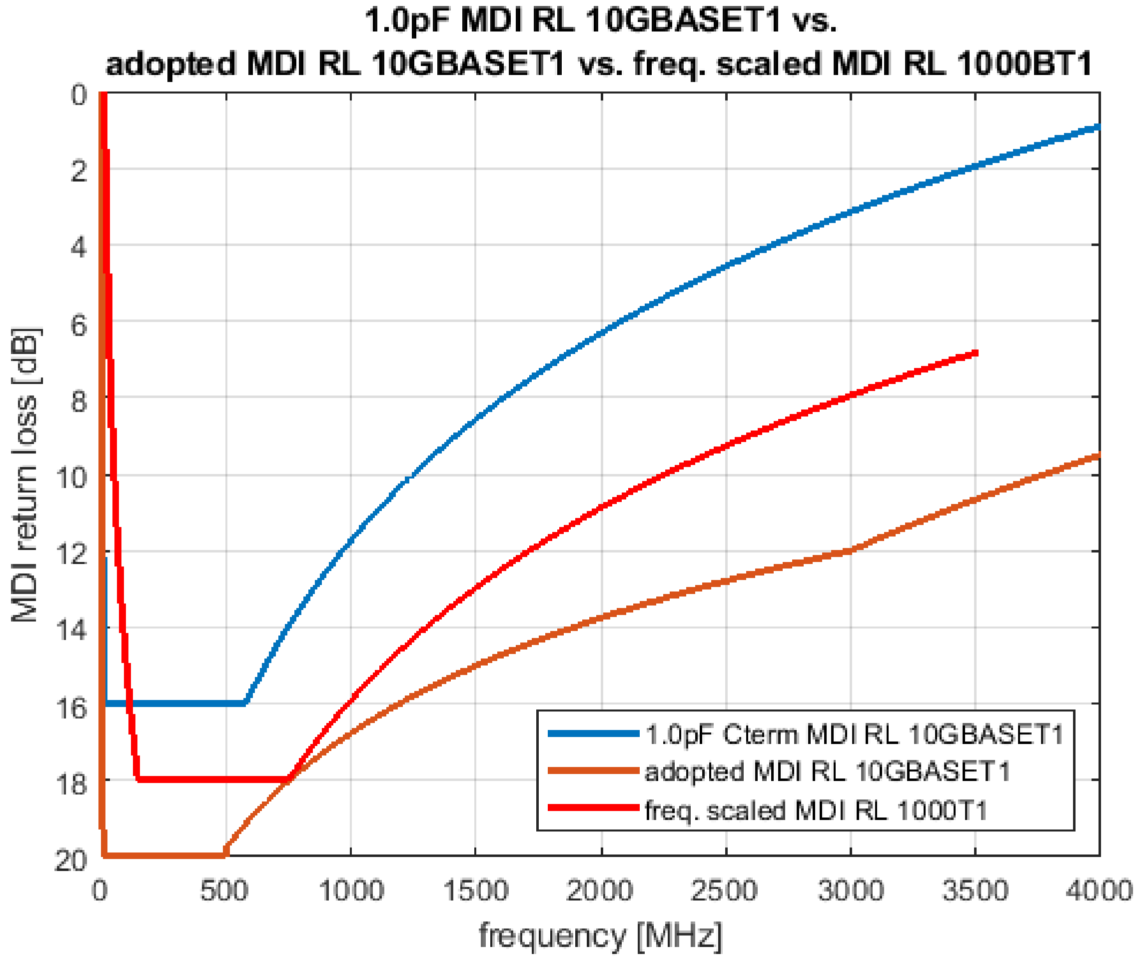




Proposed MDI return loss mask in comparison

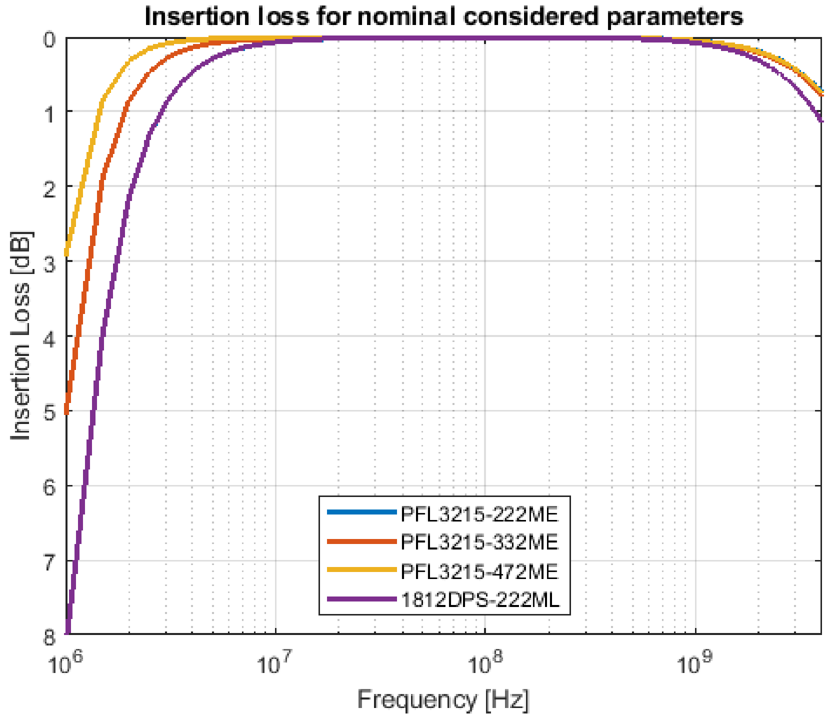
- Lower transition band: 2MHz to 15MHz: allow for smaller inductors.
- Mid frequency: allow for same termination resistor variation as 10GBASET.
- Upper transition band: 580MHz to 4GHz: allow for ESD parasitic capacitance

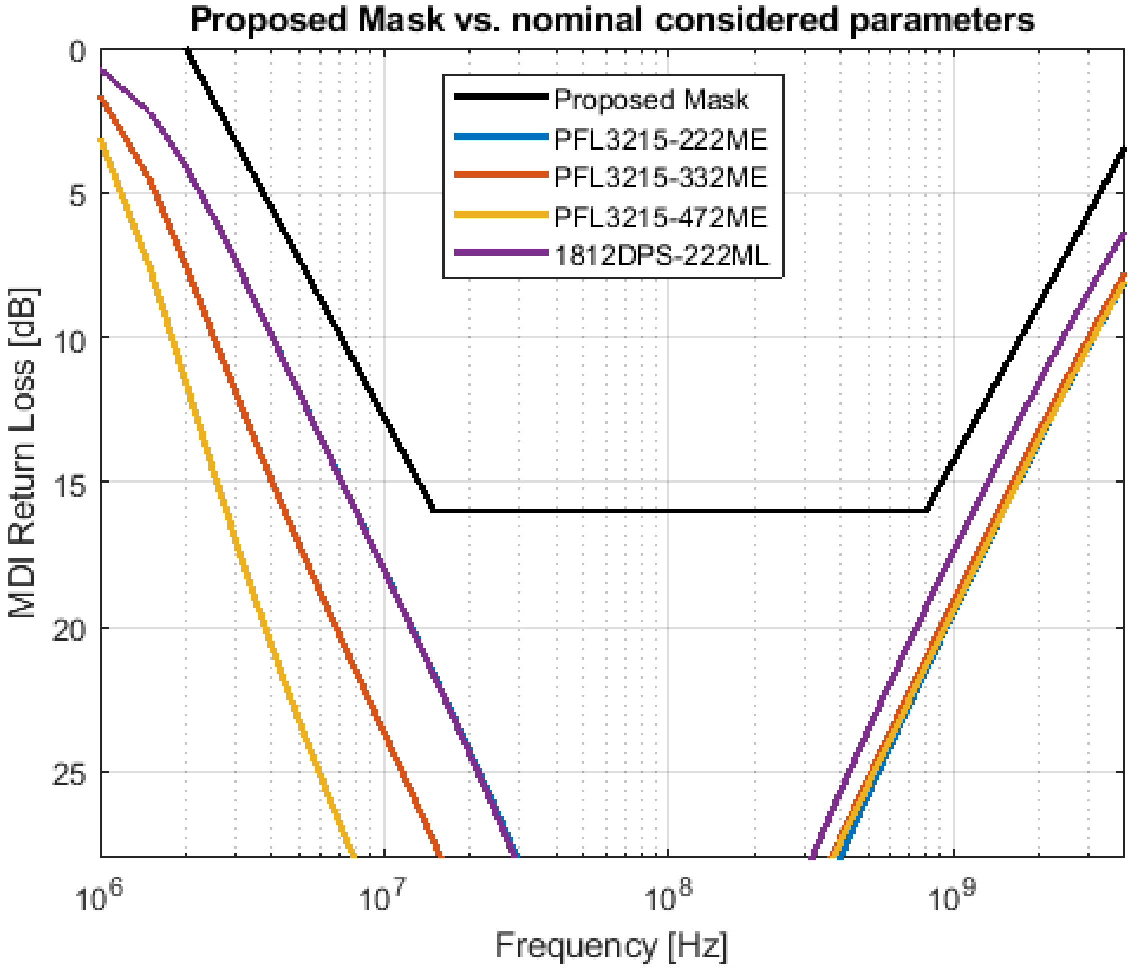




Single sided parasitic termination capacitance: Cterm 0.5pF to support HBM only

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





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Mask in numerical form considering single sided parasitic termination capacitance Cterm=0.5pF

$$\text{MDI return loss} = \begin{cases} 16 + 18*\log10(f/15) & 2 \le f < 15 \\ 16 & 15 \le f < 800 \\ 16 - 18*\log10(f/800) & 800 \le f < 4000 \end{cases}$$

Return loss in dB, frequency in MHz

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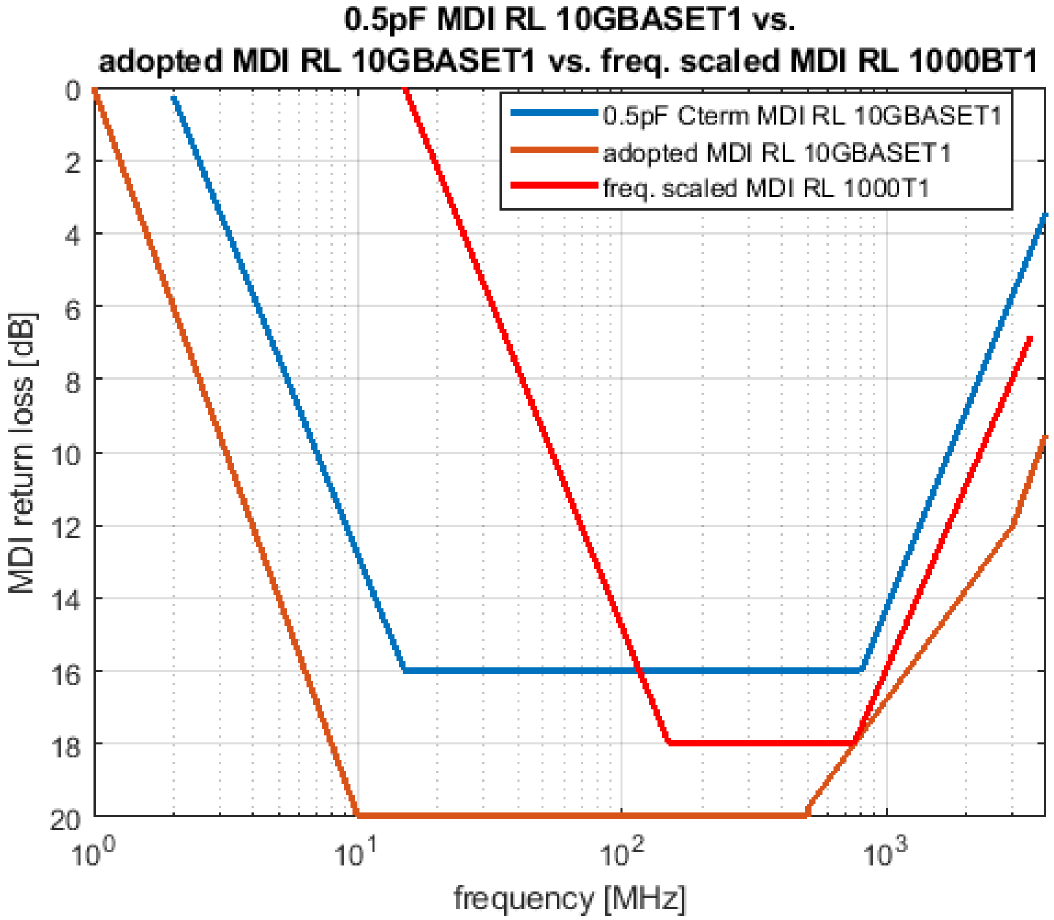
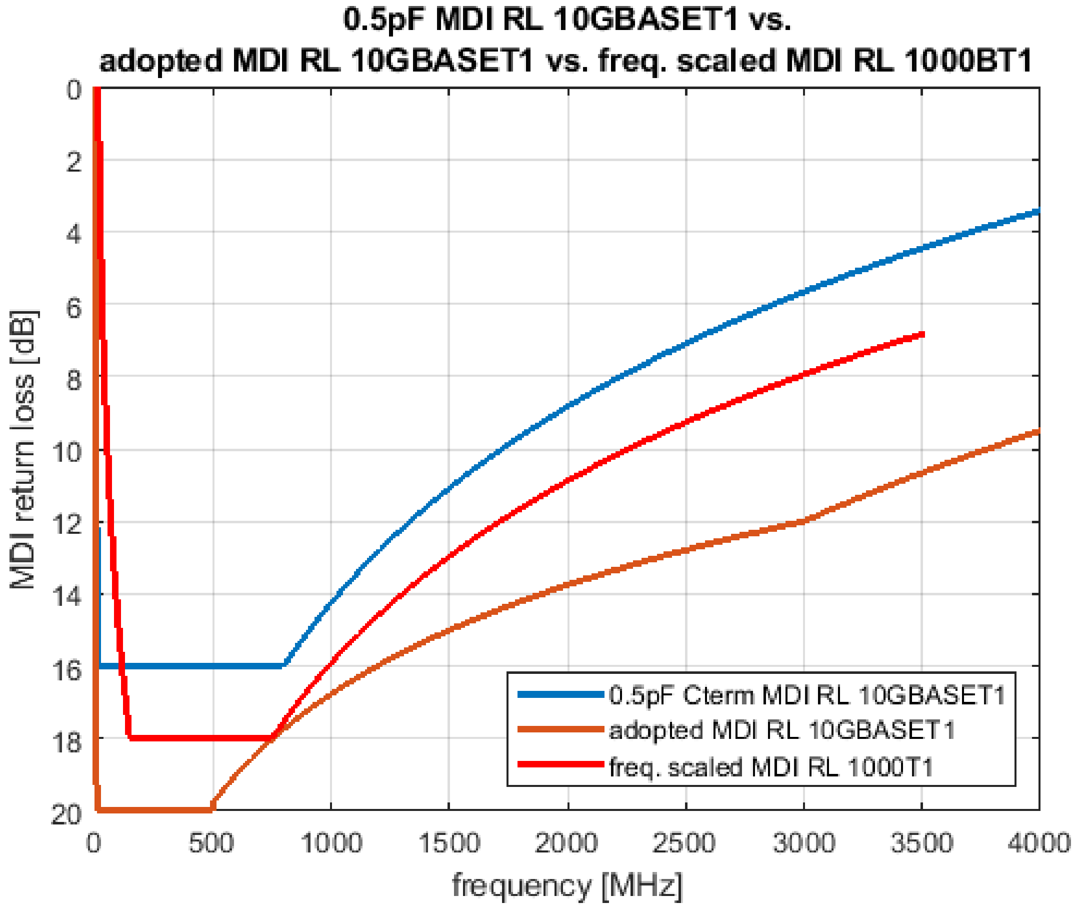
Proposed MDI return loss mask in comparison

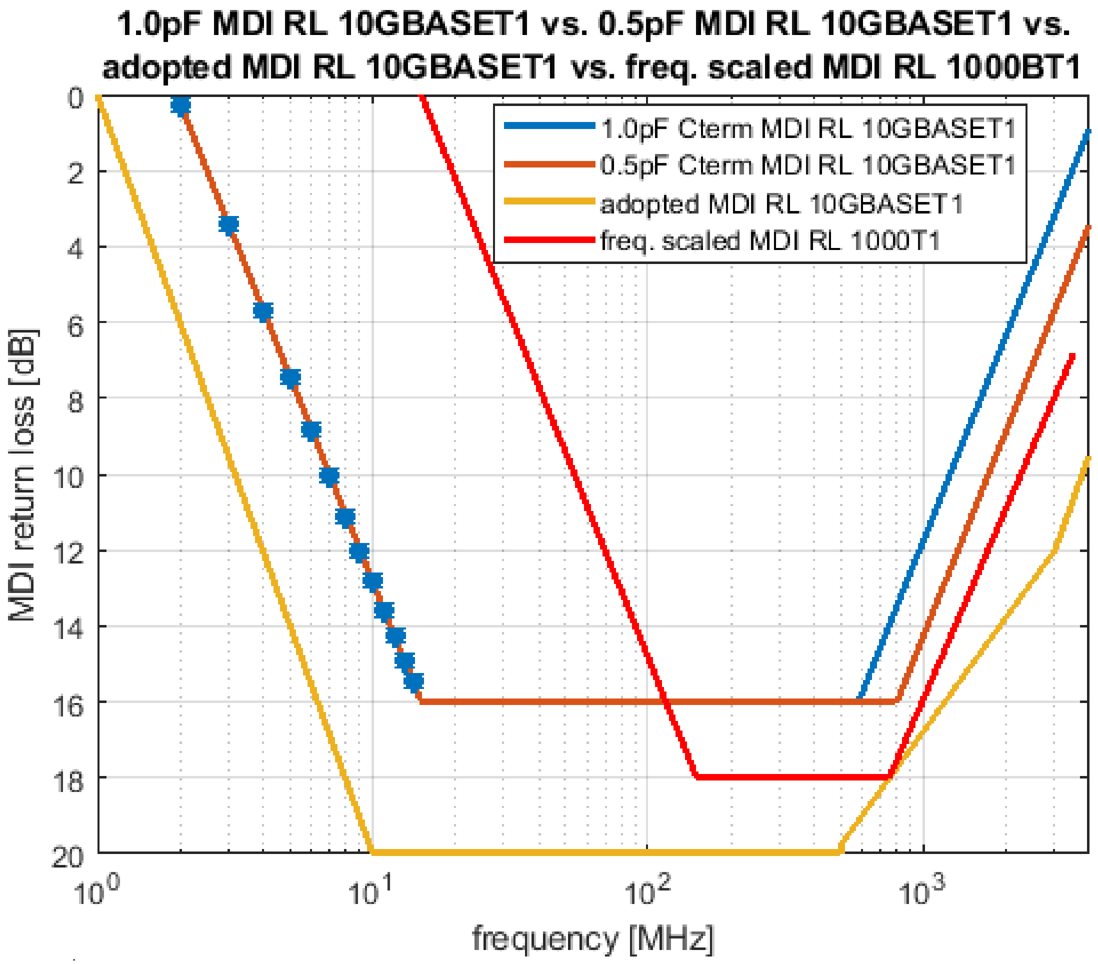
- Low PoDL inductance sets low frequency behavior 2 ≤f<15 [MHz]
- Termination resistor variation sets middle frequency behavior 15 ≤f<800 [MHz]
- Overall capacitance sets upper frequency behavior 800≤f<4000 [MHz]

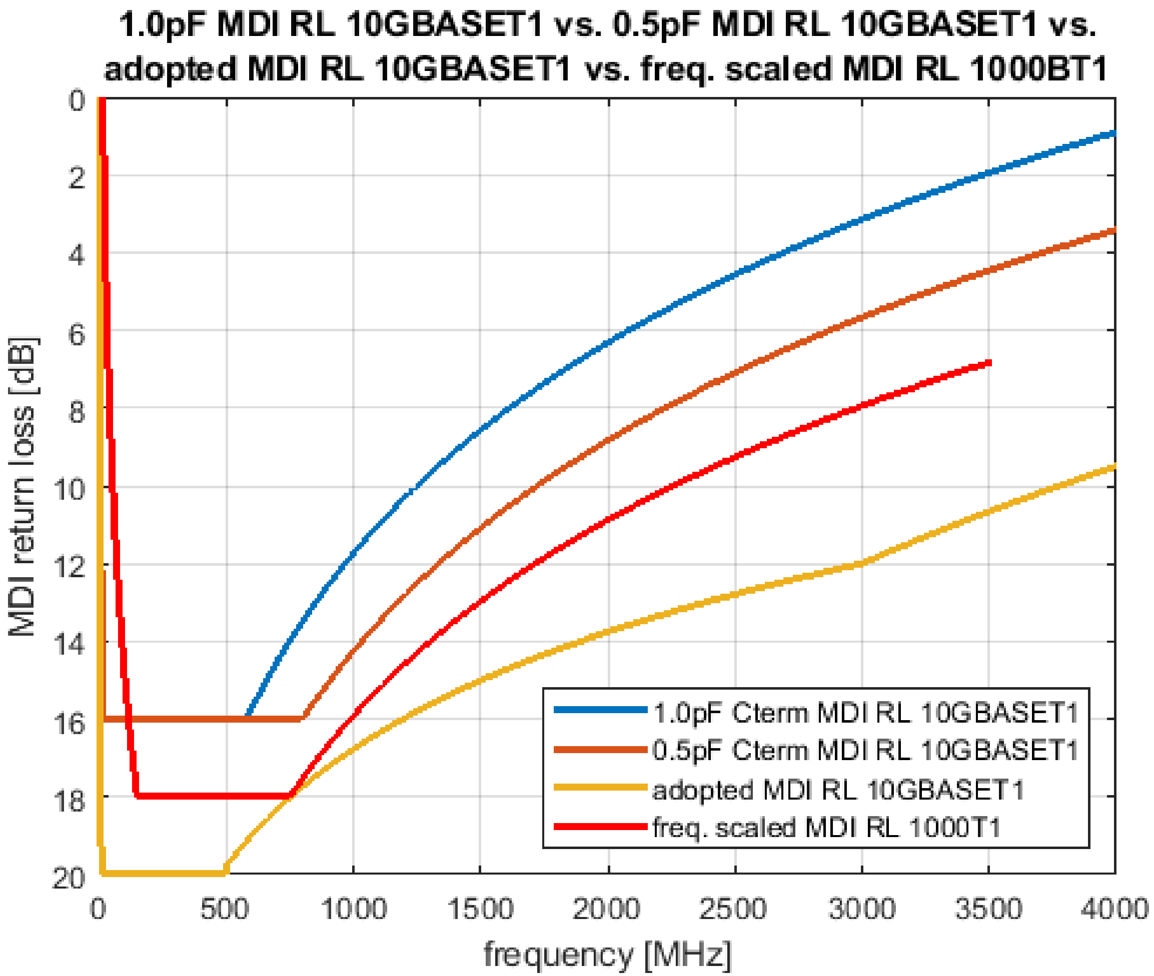




Overview

- Comparison of the MDI return loss mask for
  - 1.0pF termination capacitance Cterm for 10GBASET1
  - 0.5pF termination capacitance Cterm for 10GBASET1
  - Adopted MDI RL mask for 10GBASET1
  - Frequency scaled for 1000BASET1





Conclusion

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

$$\text{MDI return loss} = \begin{cases} 16 + 18\log_{10}(f/15) & 2 \le f < 15 \\ 16 & 15 \le f < 580 \\ 16 - 18\log_{10}(f/580) & 580 \le f < 4000 \end{cases}$$

Return loss in dB, frequency in MHz

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