NGAuto Channel Modeling and Analysis

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Supporters:

IEEE 802.3ch Multi-Gig Automotive Ethernet PHY Task Force
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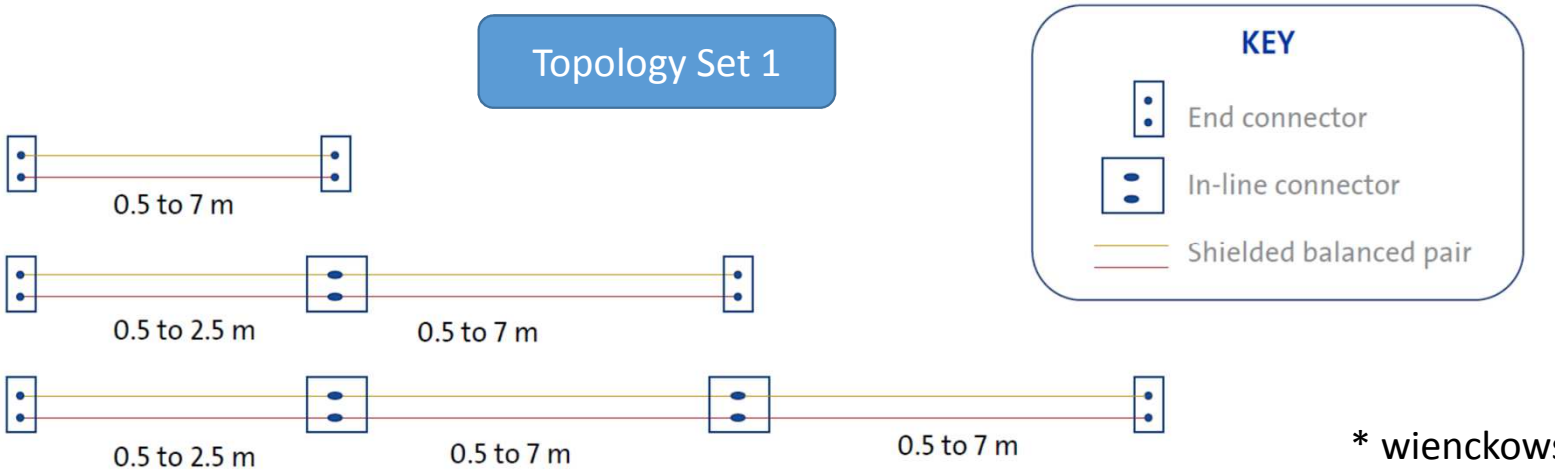
Motivation – Channel Modeling & Analysis

- Develop a channel model test bench to quickly and accurately emulate potential NGAuto use cases
- Provide link segment simulation results for previously shared topologies for comparison to currently adopted RL & IL limits
- Attempt to define performance limits for individual components

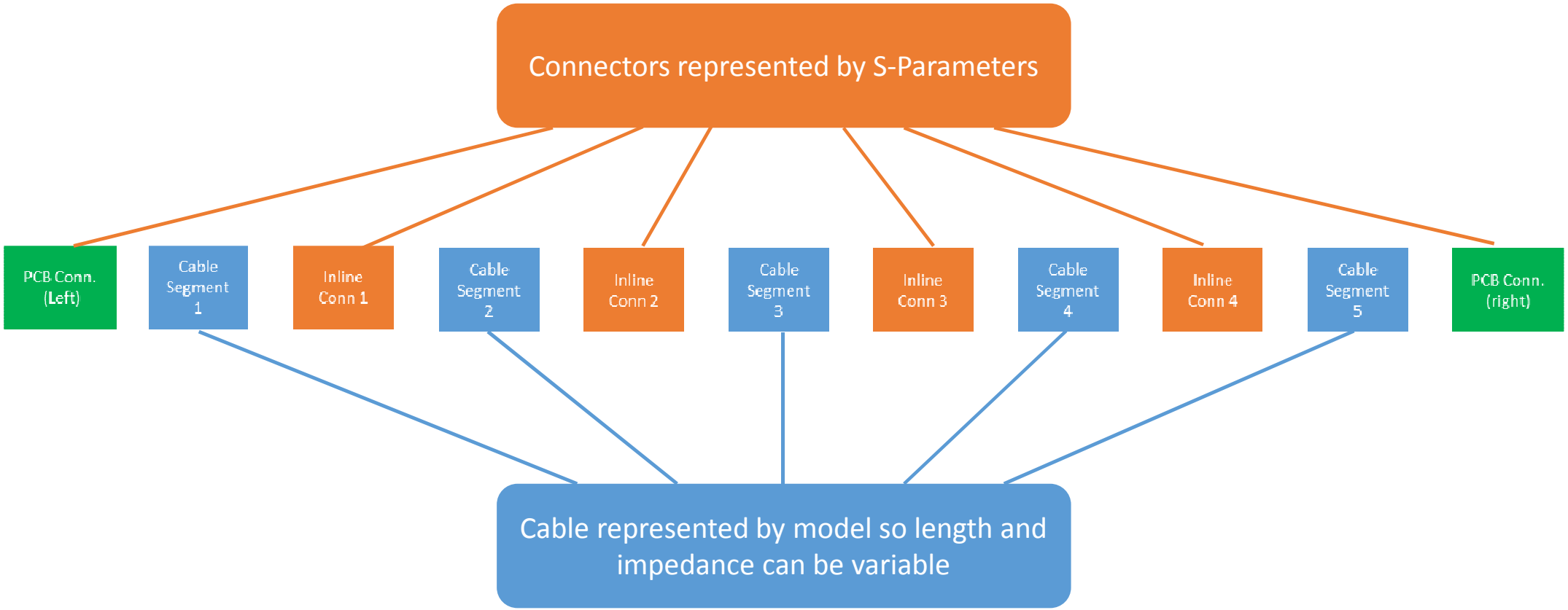
Specific Topology to Analyze

- Implementation may contain 0,1, or 2 in-line connections
- Cable segments are 0.5m to 11.0m in total length
- May include sealed connectors

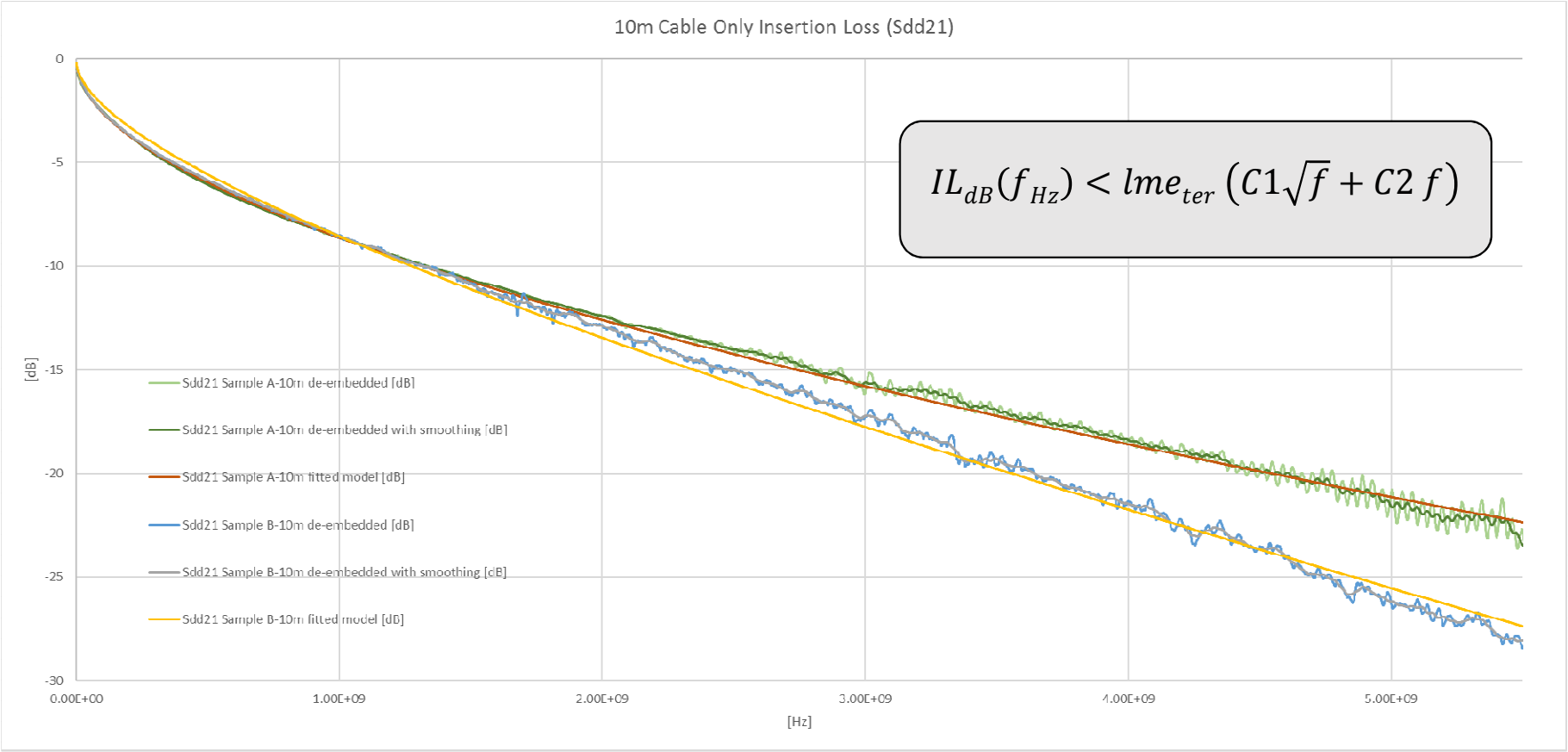


* wienckowski_3ch_01_022118

Channel Model



Cable Modeling Parameters

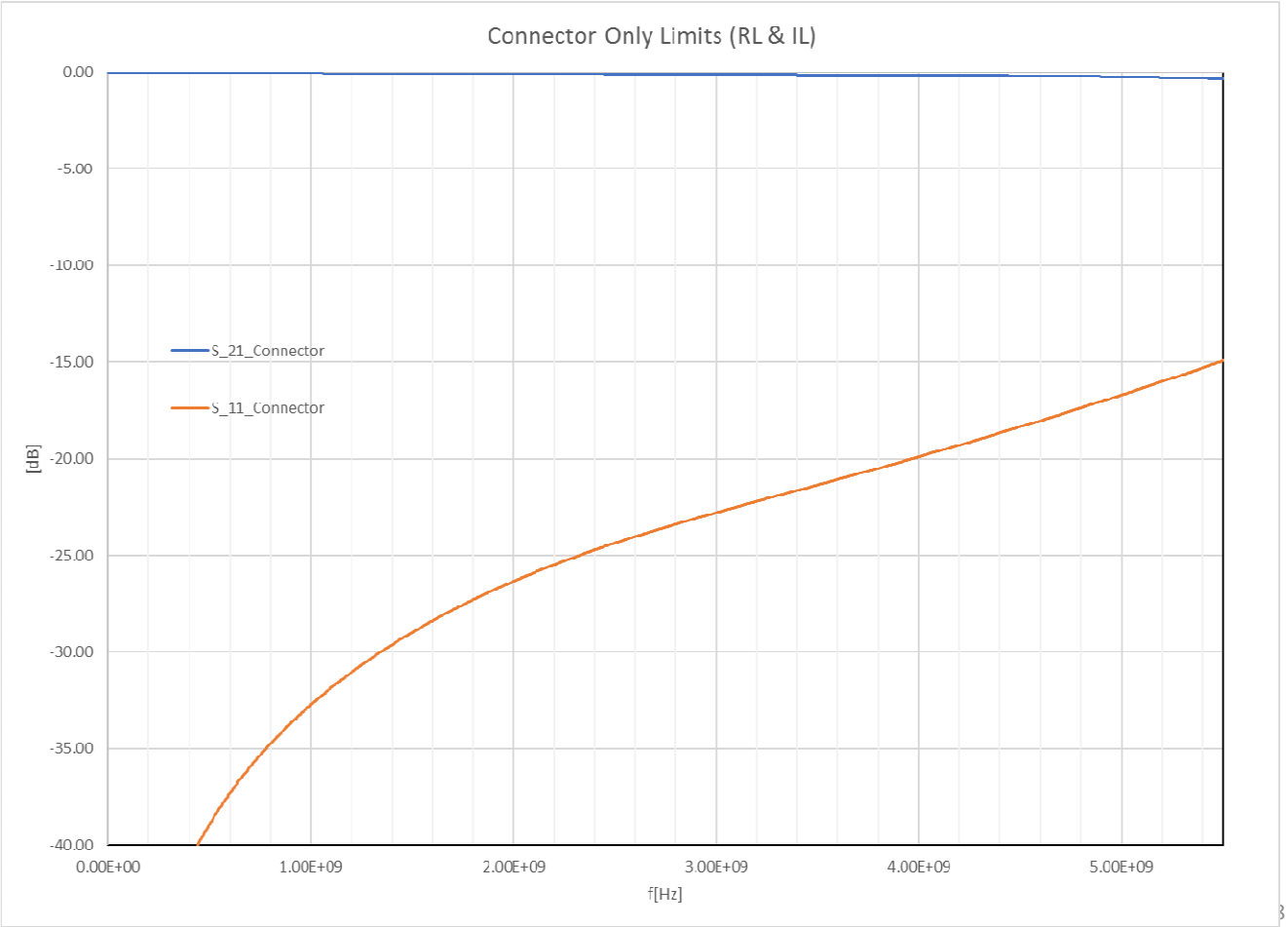


Cable A
C1 = -2.5898e-5
C2 = -6.7924e-11
Vp = 2.16e8

Cable B
C1 = -1.97042e-5
C2 = -2.31881e-10
Vp = 2.16e8

Both cables are 26AWG, but vary in construction

Connector Modeling Parameters



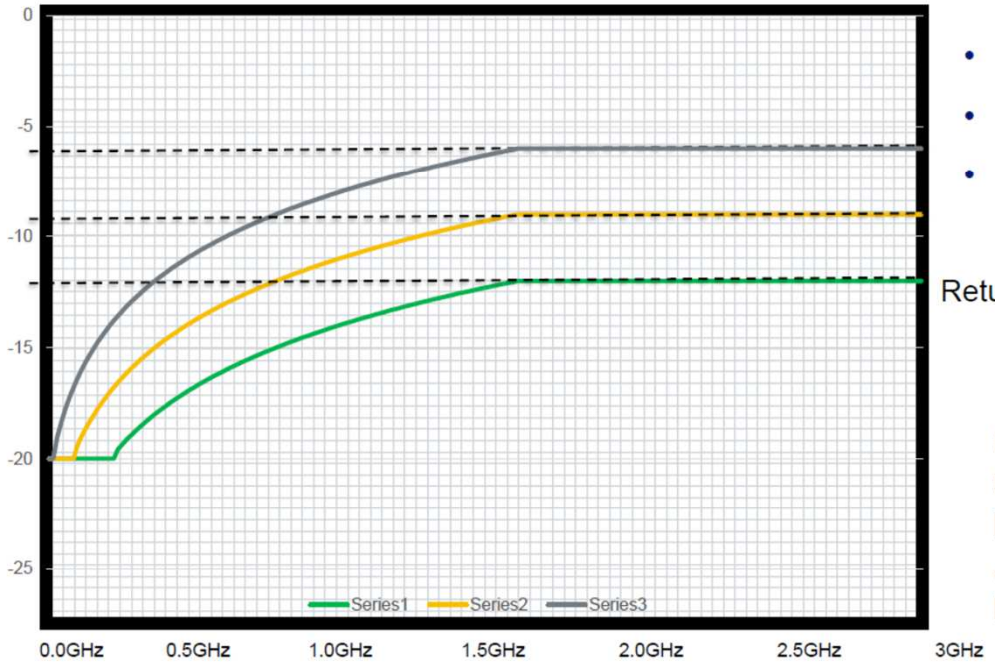
Initial performance budget for both MDI and Inline Connectors

S-Parameters for Connectors in this simulation should be viewed as a static limit assumption

Adopted RL Limits

* Farjad_3ch_01b_0118.pdf

Group 10G: Return Loss Limit Line (Adjusted with IL)



- $IL_{3GHz} > 20dB \rightarrow N=0$
- $10dB < IL_{3GHz} < 20dB \rightarrow N=1$
- $IL_{3GHz} < 10dB \rightarrow N=2$

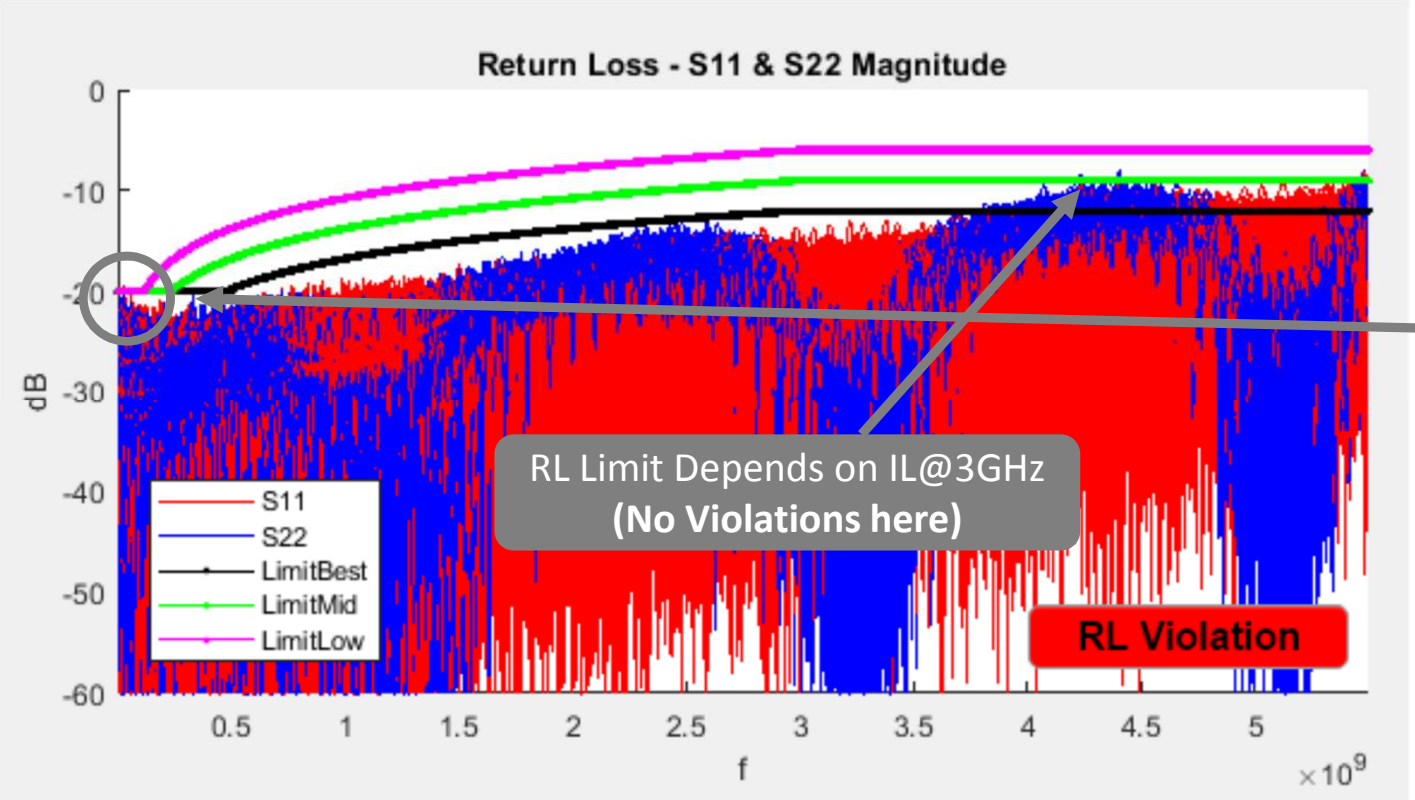
$$\text{Return.Loss(dB)} \le \begin{cases} 20\text{dB} & 5 \le f < 500/2^N \\ 12\text{-}3N - 10\log(f/3000) & 500/2^N \le f < 3000 \\ 12\text{-}3N & 3000 \le f < 5500 \end{cases}$$

(f in MHz)

Contributions from :
Garret den Besten
Bert Bergner
James Withey
Masood Shariff

Topology Set 1 – Random – 1000 iterations

(Max. 3 Segments, 11m)



Cable A Parameters

C1 = -2.5898e-5
C2 = -6.7924e-11
Vp = 2.16e8
Cable Imp: 95Ω to 105Ω

2 RL Violations

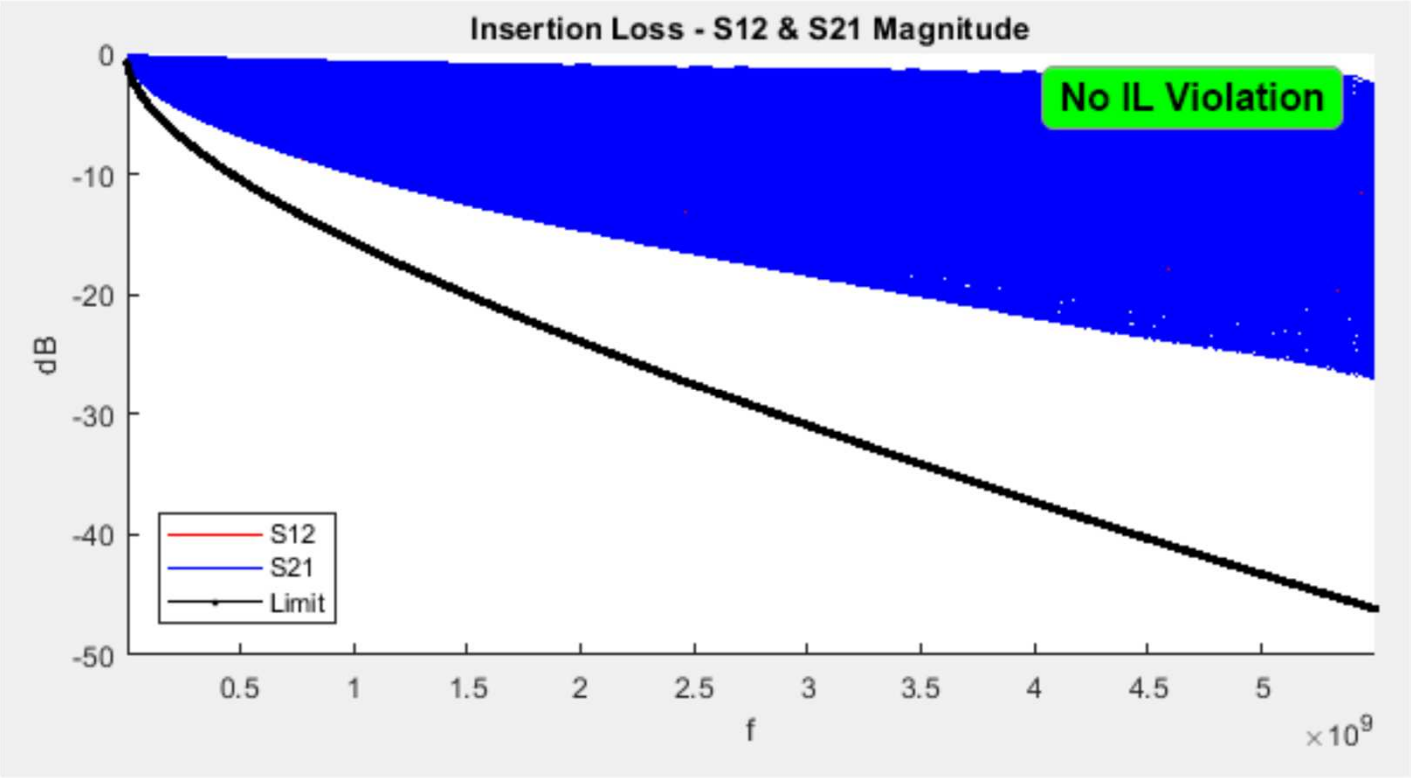
S11 @ 30MHz & 63.75MHz (<.5dB)
S22 @ 30MHz (.3dB)

Causes:
Low – High – Low Cable Impedance

Cable Len (m)	0.8422	4.1478	4.1871
Cable Imp (Ω)	95.326	103.82	96.90

Topology Set 1 – Random – 1000 iterations

(Max. 3 Segments, 11m)



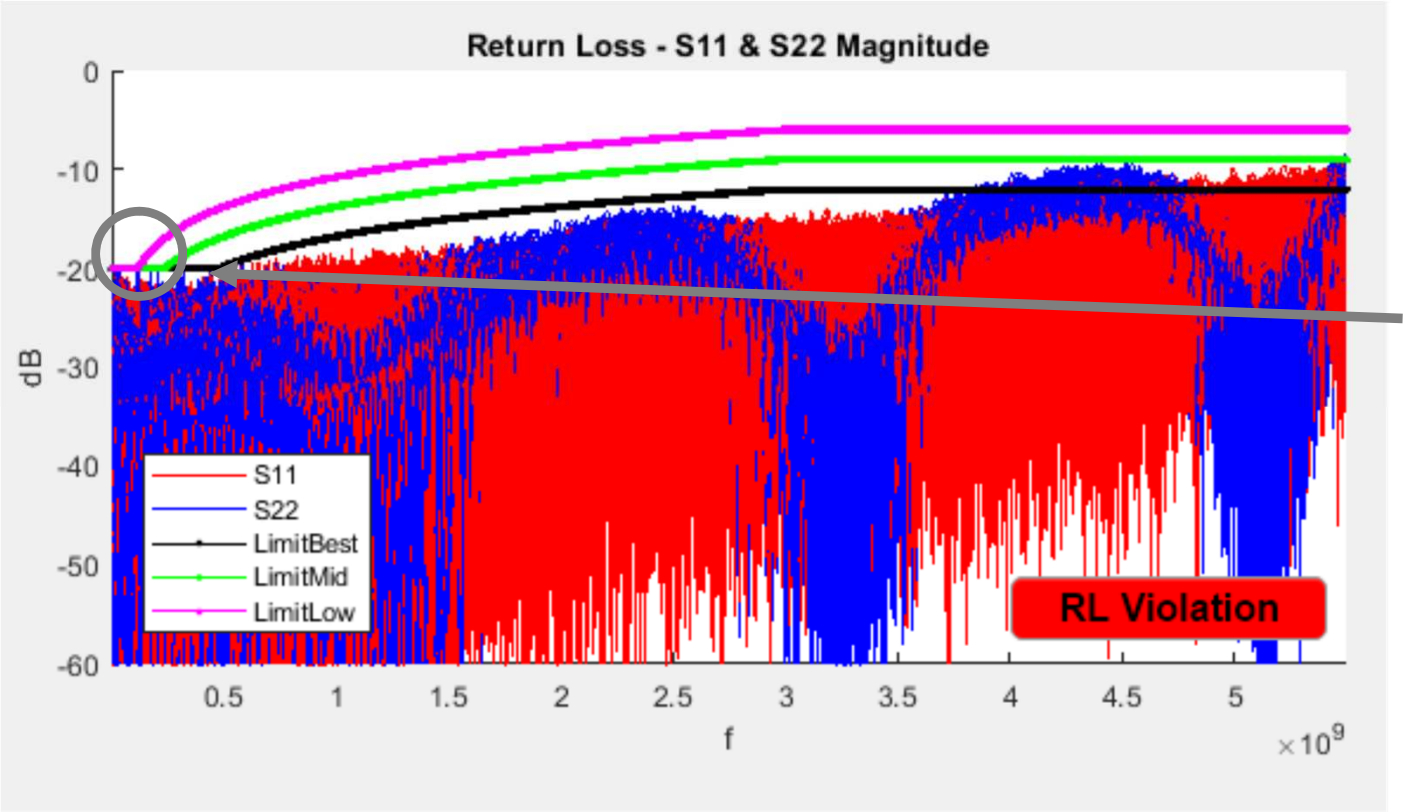
Cable A Parameters

C1 = -2.5898e-5
C2 = -6.7924e-11
Vp = 2.16e8
Cable Imp: 95Ω to 105Ω

NO IL Violations since max cable length is 11m

Topology Set 1 – Random – 1000 iterations

(Max. 3 Segments, 11m)



Cable B Parameters

C1 = -1.97042e-5
C2 = -2.31881e-10
Vp = 2.16e8
Cable Imp: 95Ω to 105Ω

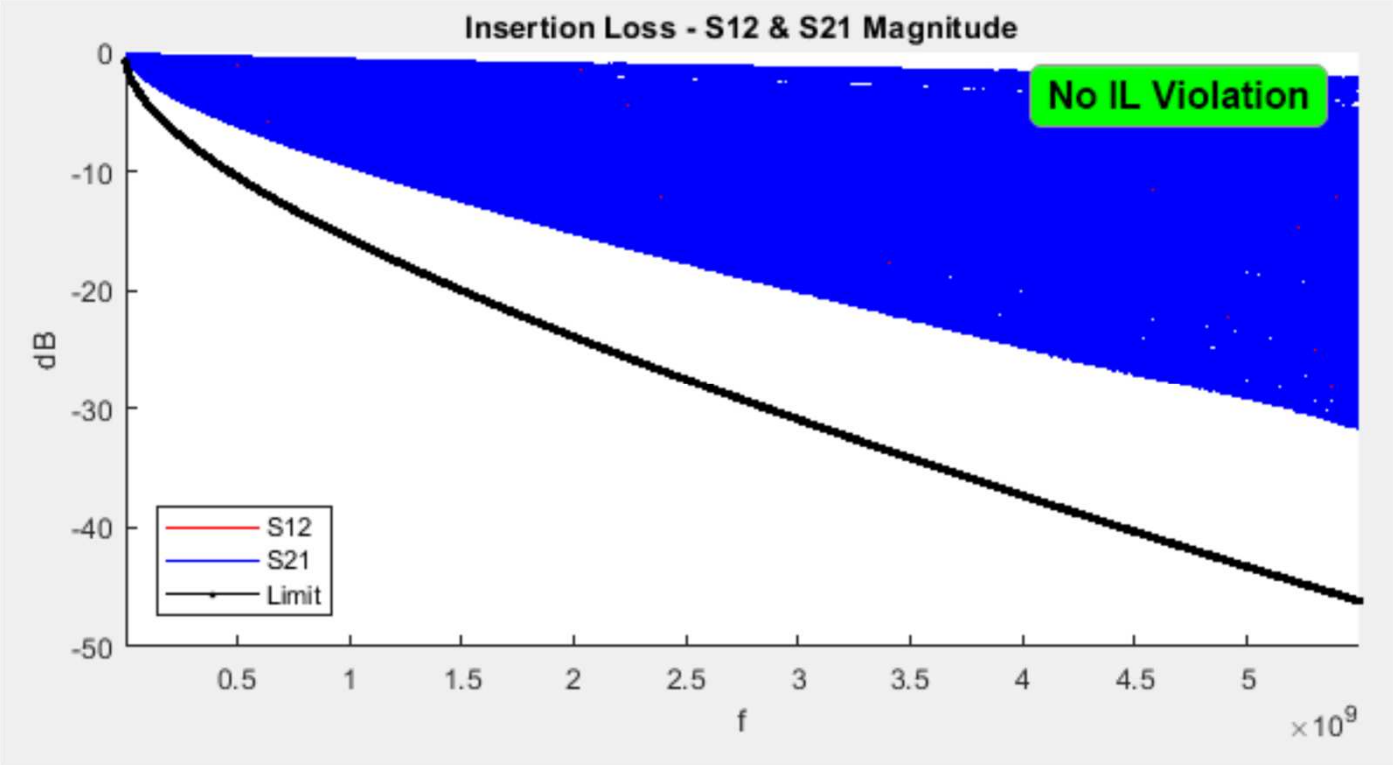
3 Iterations with RL Violations

S11 @ 26.25, 33.75, & 120MHz (<.5dB)
S22 @ 26.25, 33.75, 120, 210MHz (<.3dB)

Causes:
Low – High – Low Cable Impedance

Cable Len (m)	2.27	4.85	1.24
Cable Imp (Ω)	95.5	104.76	95.84

Topology Set 1 – Random – 1000 iterations



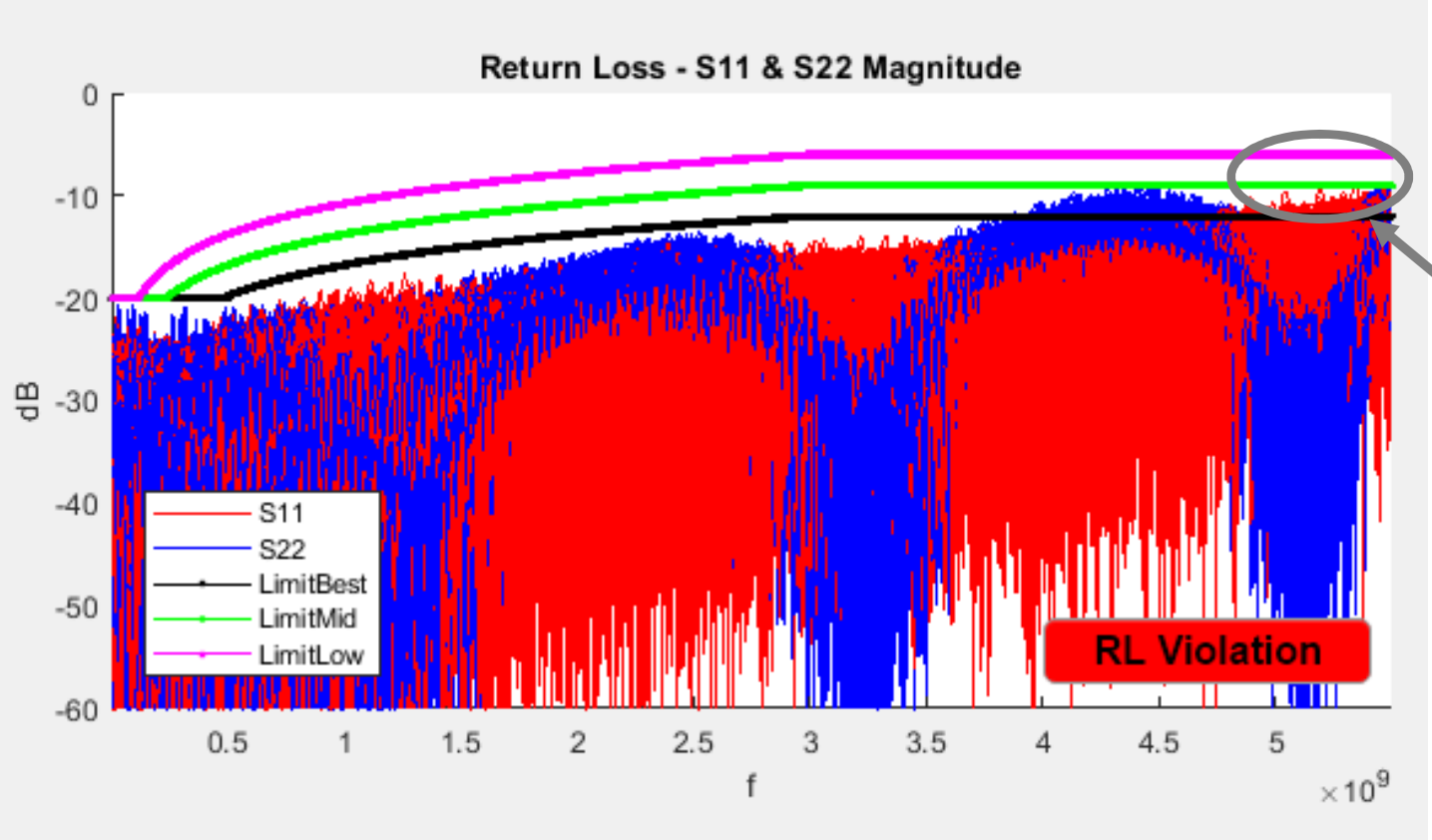
Cable B Parameters

C1 = -1.97042e-5
C2 = -2.31881e-10
Vp = 2.16e8
Cable Imp: 95Ω to 105Ω

NO IL Violations since max cable length is 11m

Topology Set 1 – Random – 1000 Iterations

(Max. 3 Segments, 11m)



Cable B Parameters

C1 = -1.97042e-5

C2 = -2.31881e-10

Vp = 2.16e8

Cable Imp: 96Ω to 104Ω

3 RL Violations

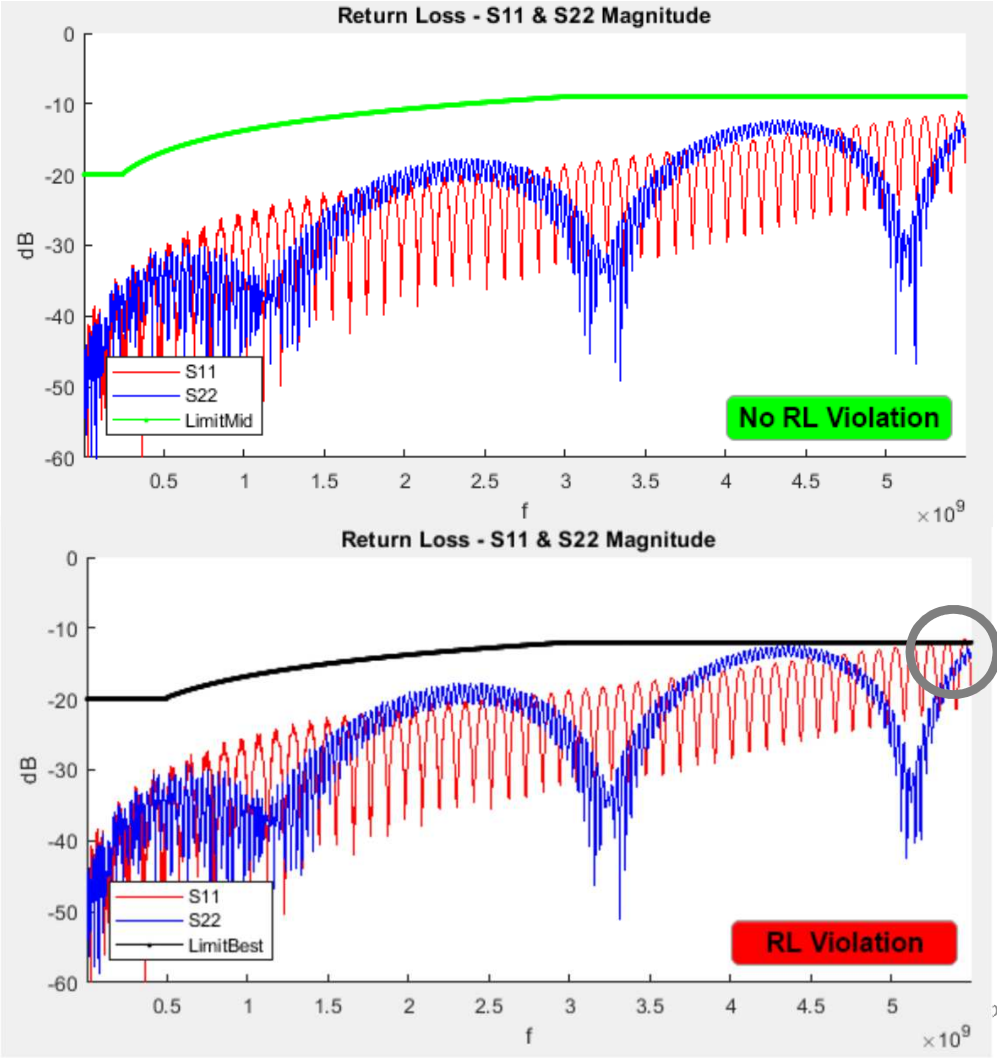
All instances have IL @ 3GHz over 20dB requiring best Limit line. (This doesn't occur with C2 value from Cable A)

Example of RL Violation (3 segments)

Cable Len (m)	.9545	6.94	3.0652
Cable Imp (Ω)	99.2	99.7	99.99

Total Cable Length = 10.96m

Topology Set 1 – Worst Case Example



Cable A Parameters
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Vp = 2.16e8

Example of RL Violation (3 segments)

Cable Len (m)	.9545	6.94	3.0652
Cable Imp (Ω)	99.2	99.7	99.99

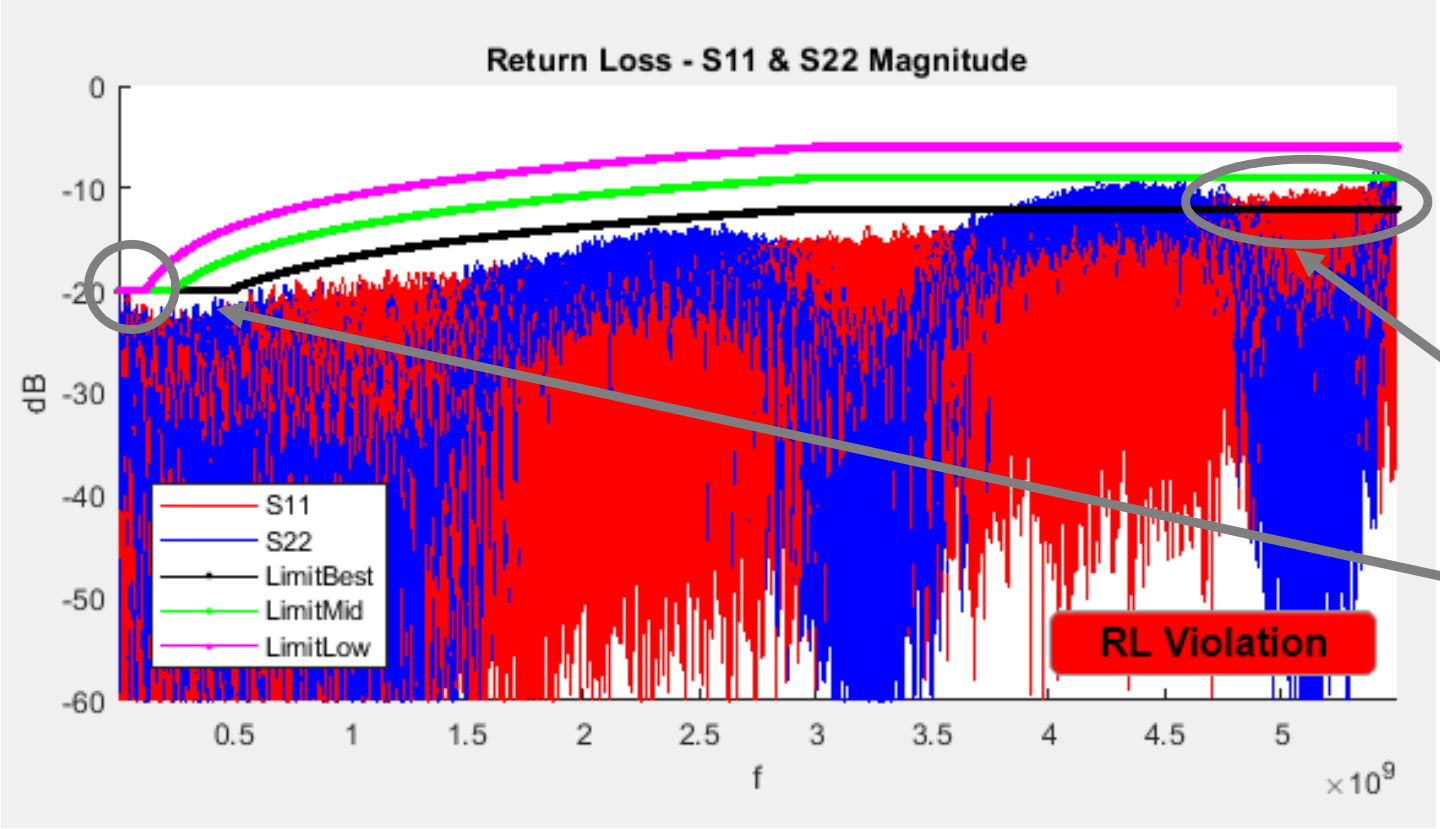
Total Cable Length = 10.96m

Cable B Parameters
C1 = -1.97042e-5
C2 = -2.31881e-10
Vp = 2.16e8

IL @ 3GHz > 20dB
RL Limit becomes more strict

Violations occur above 4.5GHz

Max. 15m x 4 inlines – Random - 1000 Iterations



Cable B Parameters

C1 = -1.97042e-5

C2 = -2.31881e-10

Vp = 2.16e8

Cable Imp: 96Ω to 104Ω

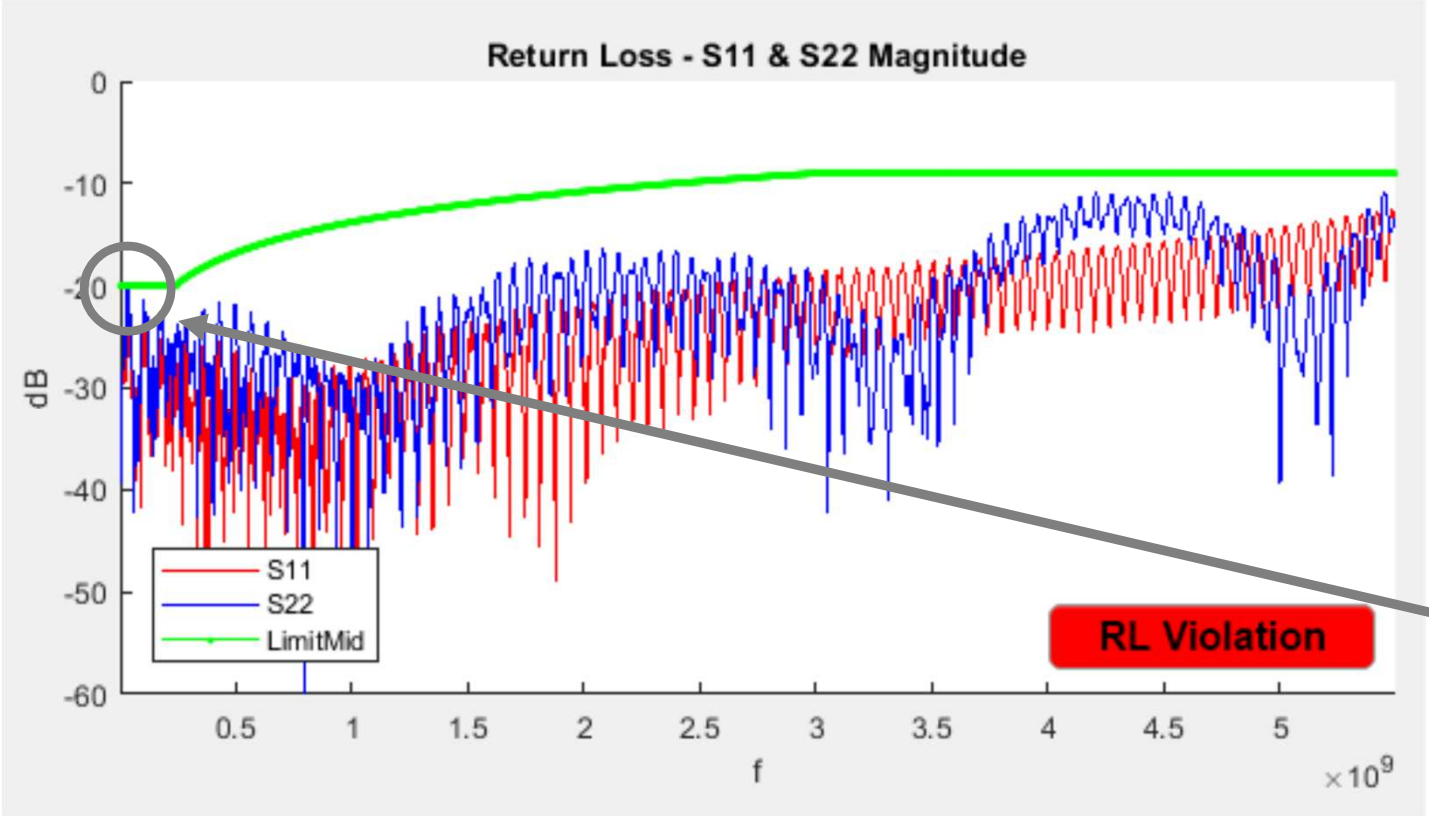
128 Iterations with RL Violations

All of the 128 except 1 had a total Cable Length > 10.9m… (IL@3GHz > 20dB)

1 exception had 4 segments and Length of 9.3551m.

Cable Len (m)	1.58	4.83	1.3	1.6
Cable Imp (Ω)	101.6	97.4	103.99	96.26

Max. 15m x 4 inlines – Worst Case Example



Cable B Parameters
C1 = -1.97042e-5
C2 = -2.31881e-10
Vp = 2.16e8

Example of RL Violation (4 segments)

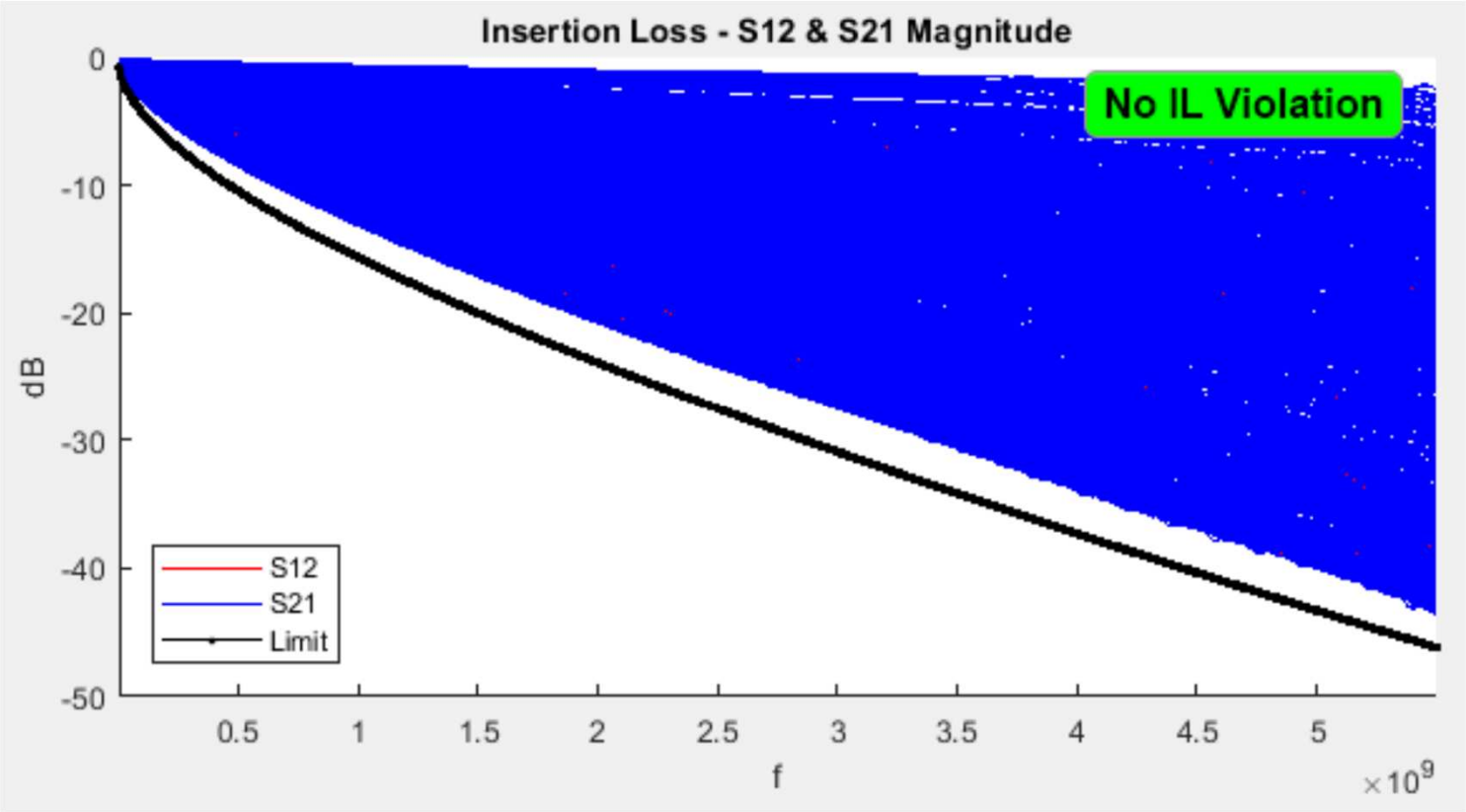
Cable Len (m)	1.58	4.83	1.3	1.6
Cable Imp (Ω)	101.6	97.4	103.99	96.26

Total Cable Length = 9.3551m

S11 @ 33.75 (<.1dB)
S22 @ 33.75 (<.25dB)

Violation due to Cable Impedances

Max. 15m x 4 inlines – Random - 1000 Iterations



Cable B Parameters

C1 = -1.97042e-5

C2 = -2.31881e-10

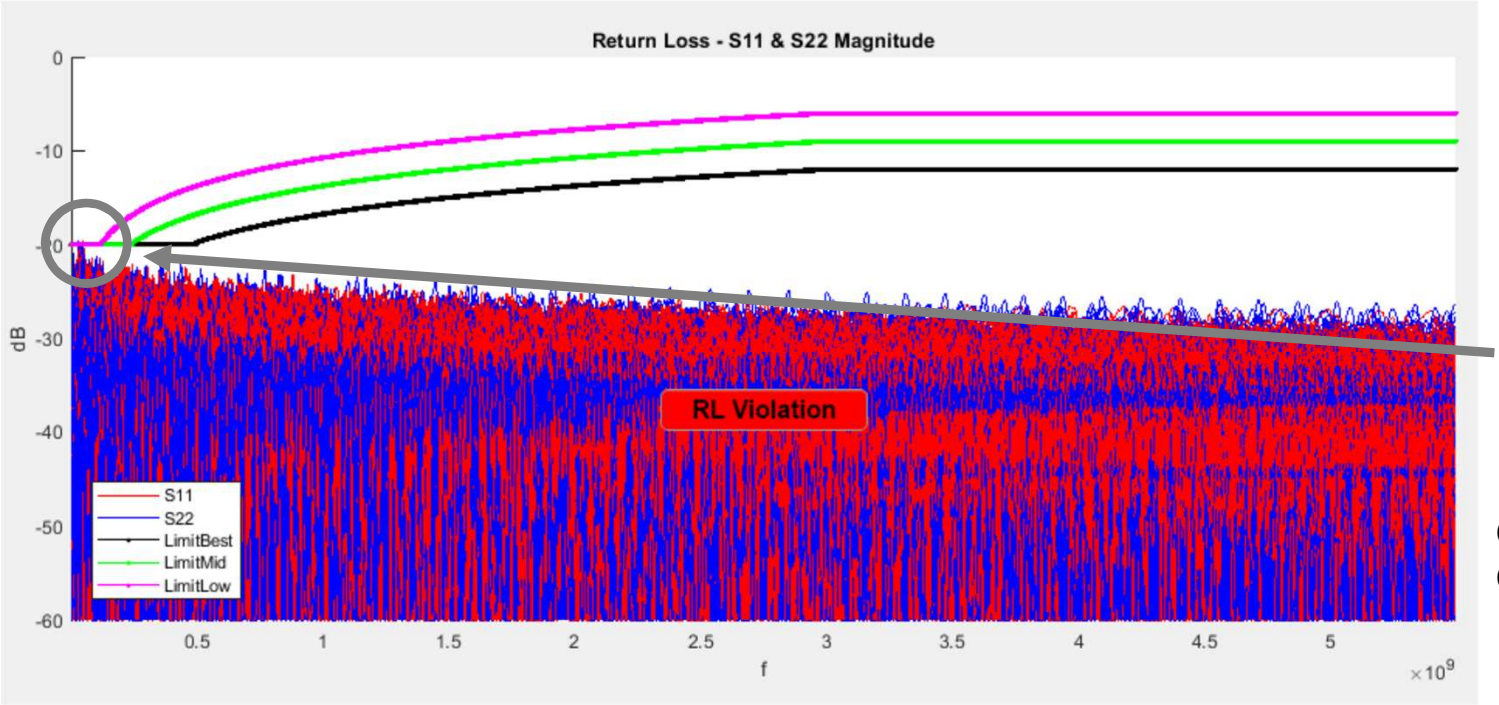
Vp = 2.16e8

Cable Imp: 96Ω to 104Ω

0 IL Violations

IL Limit is Good!!!
Gives margin for additional variations of C2

Max. 15m x 4 inlines – Random - 1000 Iterations (no Connectors)



Cable B Parameters

C1 = -1.97042e-5
C2 = -2.31881e-10
Vp = 2.16e8
Cable Imp: 96Ω to 104Ω

1 Iterations with RL Violations

S11 @ 52.5MHz (<.5dB)
S22 @ 52.5MHz (<.1dB)

Cable Len (m)	1.04	5.02	2.1	3.3	2.9
Cable Imp (Ω)	103.5	96.8	103.5	103.1	96.1

Conclusions

- Simulation Model developed demonstrates some RL limit violations at longer link lengths using 26AWG cables
  - 2 Different topologies were investigated with 1000 random variations
- Cable Parameters
  - 5% Impedance mismatch could lead to RL violations at low frequencies
  - 3% Impedance mismatch would eliminate these RL violations
  - 5% Impedance tolerance might be acceptable if 6 Ohm segment to segment mismatch is guaranteed
  - Variations in cable C2 coefficient could lead to RL violations since IL@3GHz > 20dB
- Connector model used in these simulations serves well as worst case assumption for fulfilling proposed channel limits

Proposed Next Steps

- Analyze different topologies suggested from other OEMs
- Get input from cable/connector manufactures on realistic component limits
- Should relaxed RL/IL limits be investigated for 2.5Gbit or 5Gbit links?
- Investigate Mode Conversion
  - Current simulations will not work for mode conversion

Thank You!!!