High Speed Channel Modeling and Analysis – Part 2

Eric DiBiaso (TE Connectivity),

Bert Bergner (TE Connectivity), Chris Mandel (TE Connectivity)

May 24, 2018

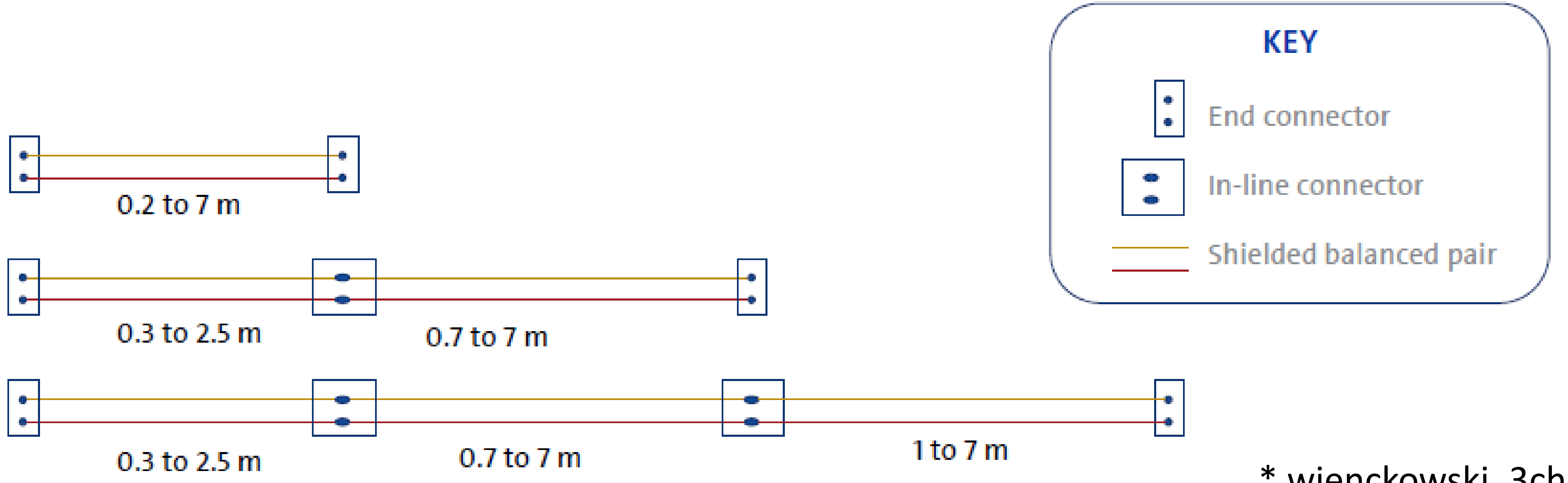
Motivation – Channel Modeling & Analysis

- Make improvements to existing simulations based on input from last meeting
- Evaluate new 95% and 5% topologies based on OEM input
- Investigate 24AWG cables for longer links (11m to 15m)
- Propose a new IL Limit

Specific Topologies to Analyze

Topology Set 1
(95th Percentile)

- Implementation may contain 0,1, or 2 in-line connections
- Cable segments are 0.2m to 11.0m in total length
- May include sealed connectors

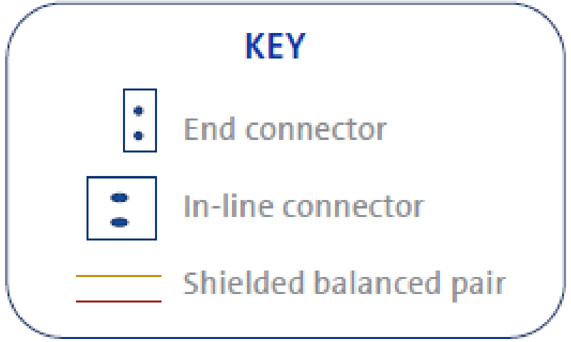


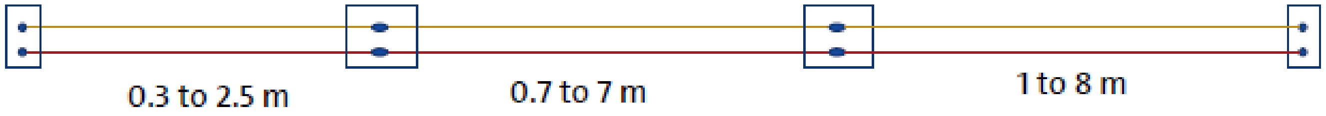
* wienckowski_3ch_01_032118

Specific Topologies to Analyze

Topology Set 2
(Upper 5th Percentile)

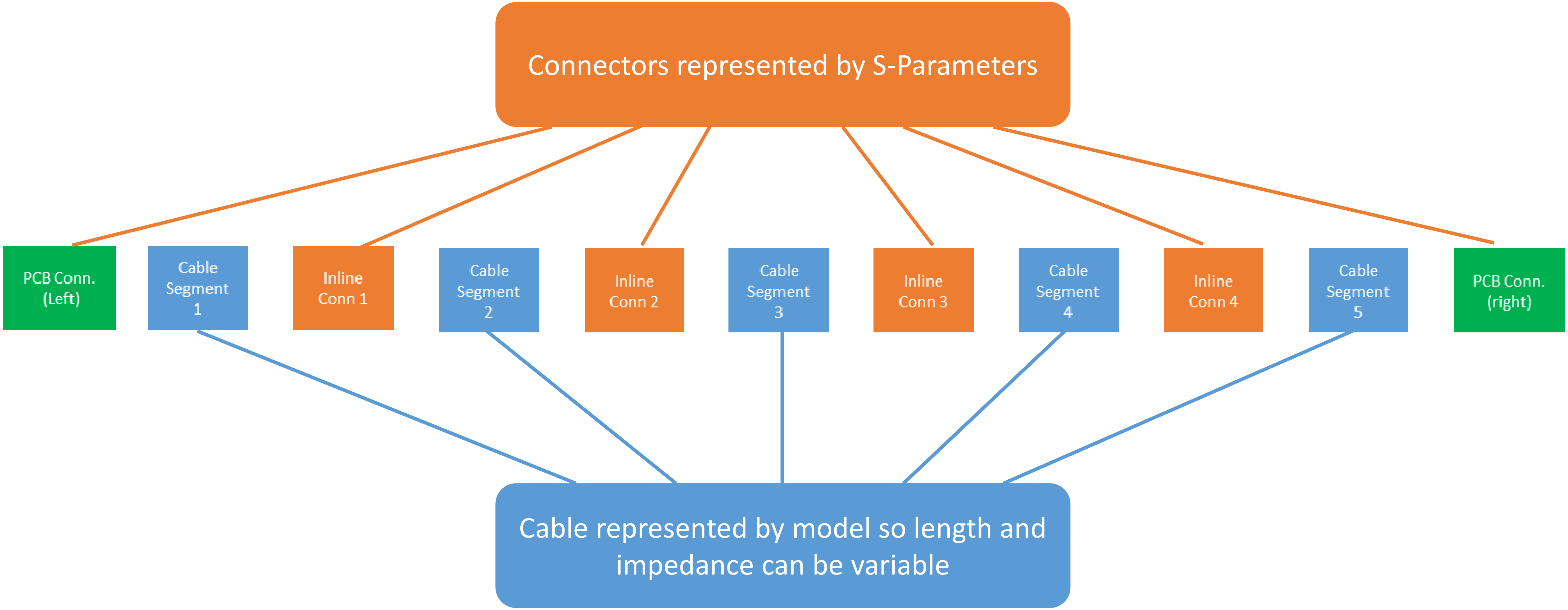
- Implementation contains 2 in-line connections
- Cable segments are 11m to 15m in total length
- May include sealed connectors



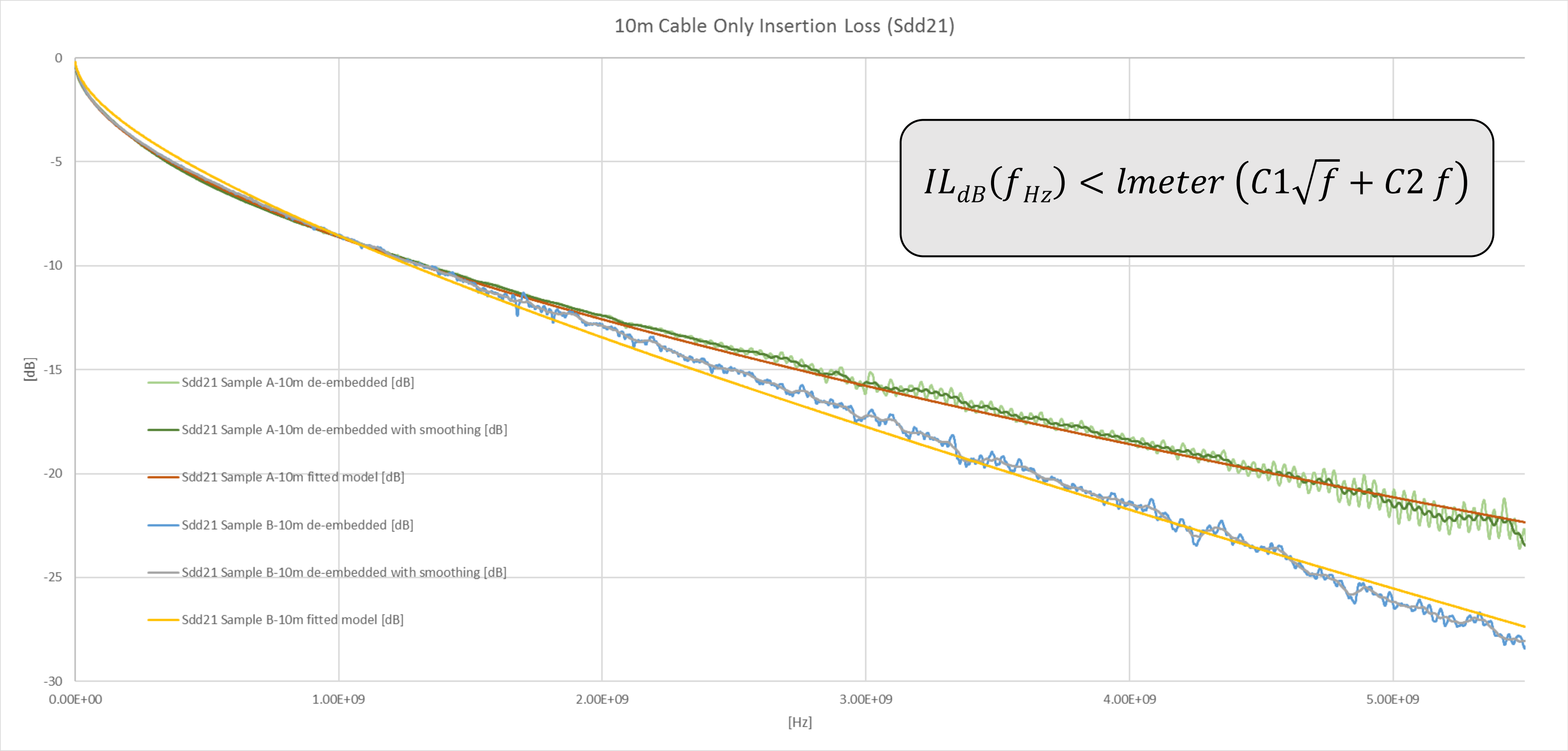


* wienckowski_3ch_01_032118

Channel Model



Cable Modeling Parameters (Differential Pair)



$$IL_{dB}(f_{Hz}) < lmeter\left(C1\sqrt{f} + C2\, f\right)$$

Cable A

C1 = -2.5898e-5

C2 = -6.7924e-11

Vp = 2.16e8

Cable B

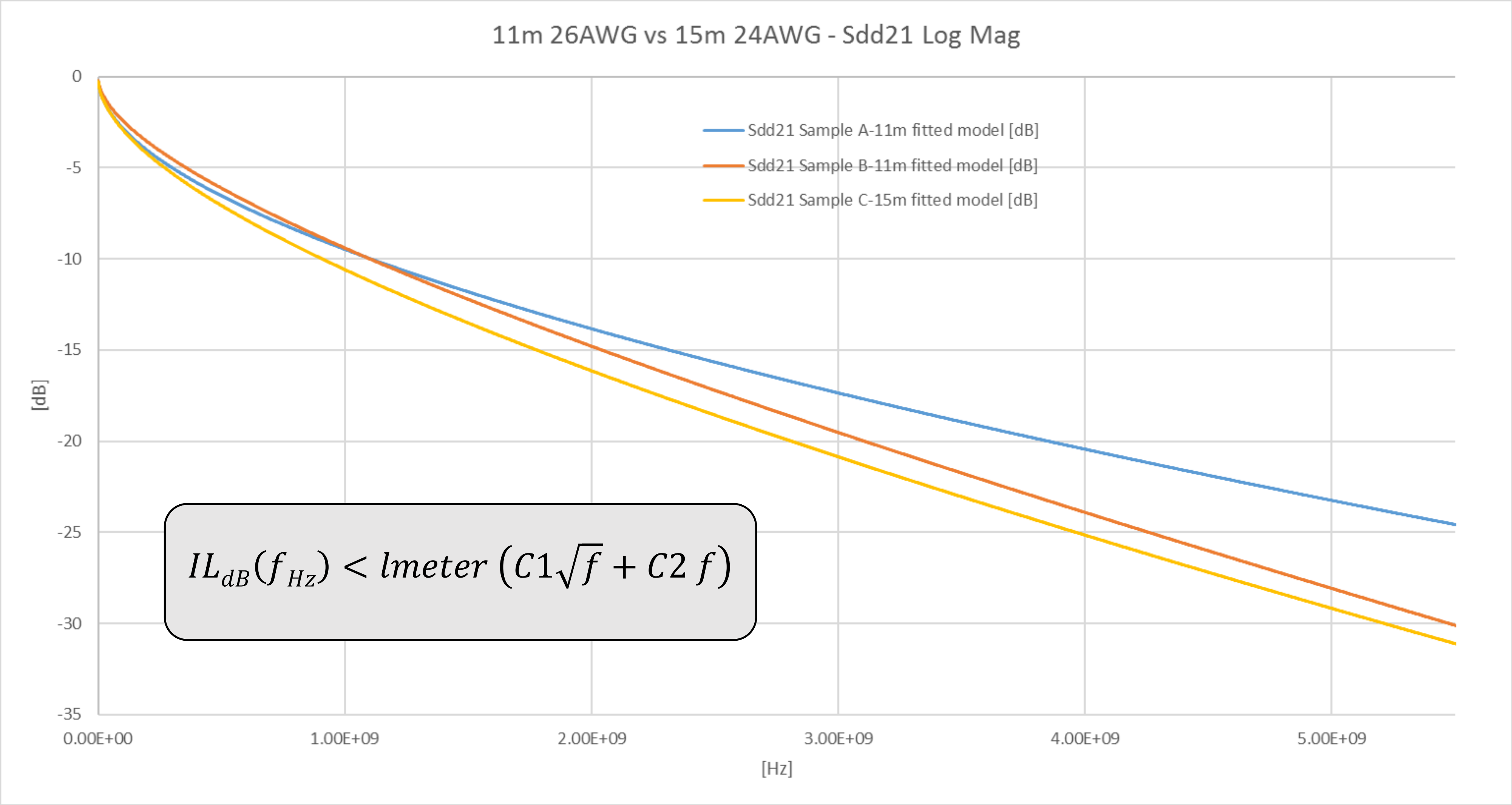
C1 = -1.97042e-5

C2 = -2.31881e-10

Vp = 2.16e8

Both cables are 26AWG, but vary in construction

Cable Comparison – 24AWG vs 26AWG



$$IL_{dB}(f_{Hz}) < lmeter\left(C1\sqrt{f} + C2\, f\right)$$

Cable A (11m)

C1 = -2.5898e-5

C2 = -6.7924e-11

Vp = 2.16e8

Cable B (11m)

C1 = -1.97042e-5

C2 = -2.31881e-10

Vp = 2.16e8

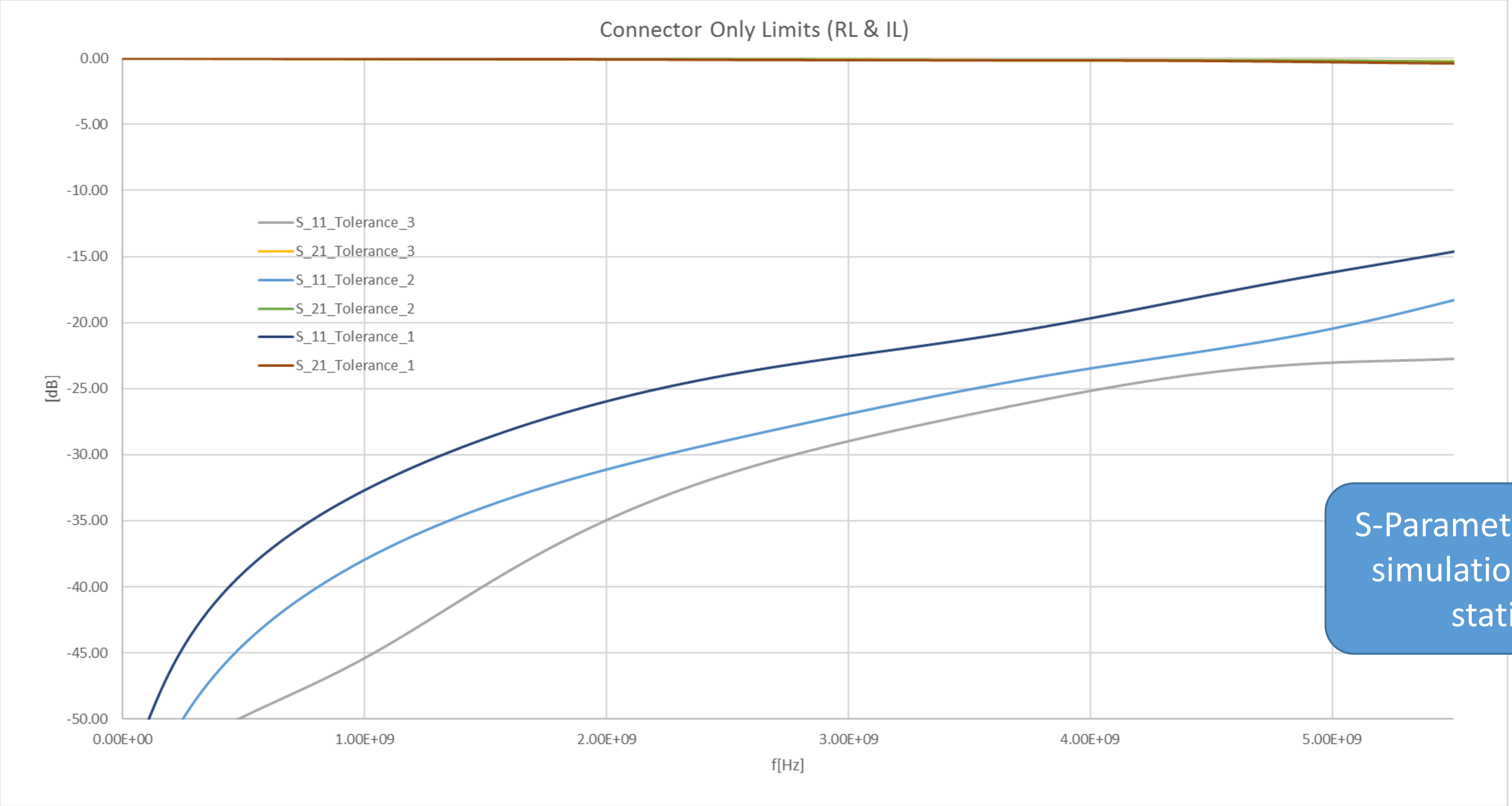
Cable C (15m)

C1 = -1.81334e-5

C2 = -1.32573e-10

Vp = 2.16e8

Connector Modeling Parameters (Diff. Pair)



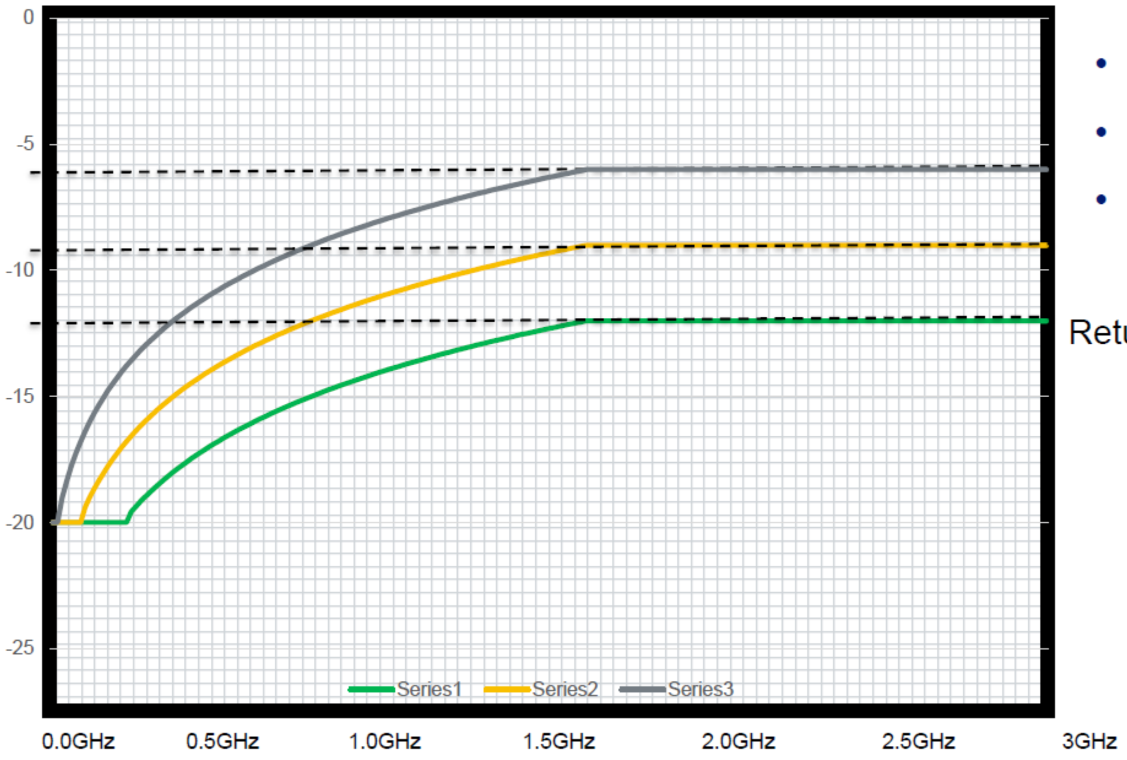
Initial performance budgets for both MDI and Inline Connectors

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)



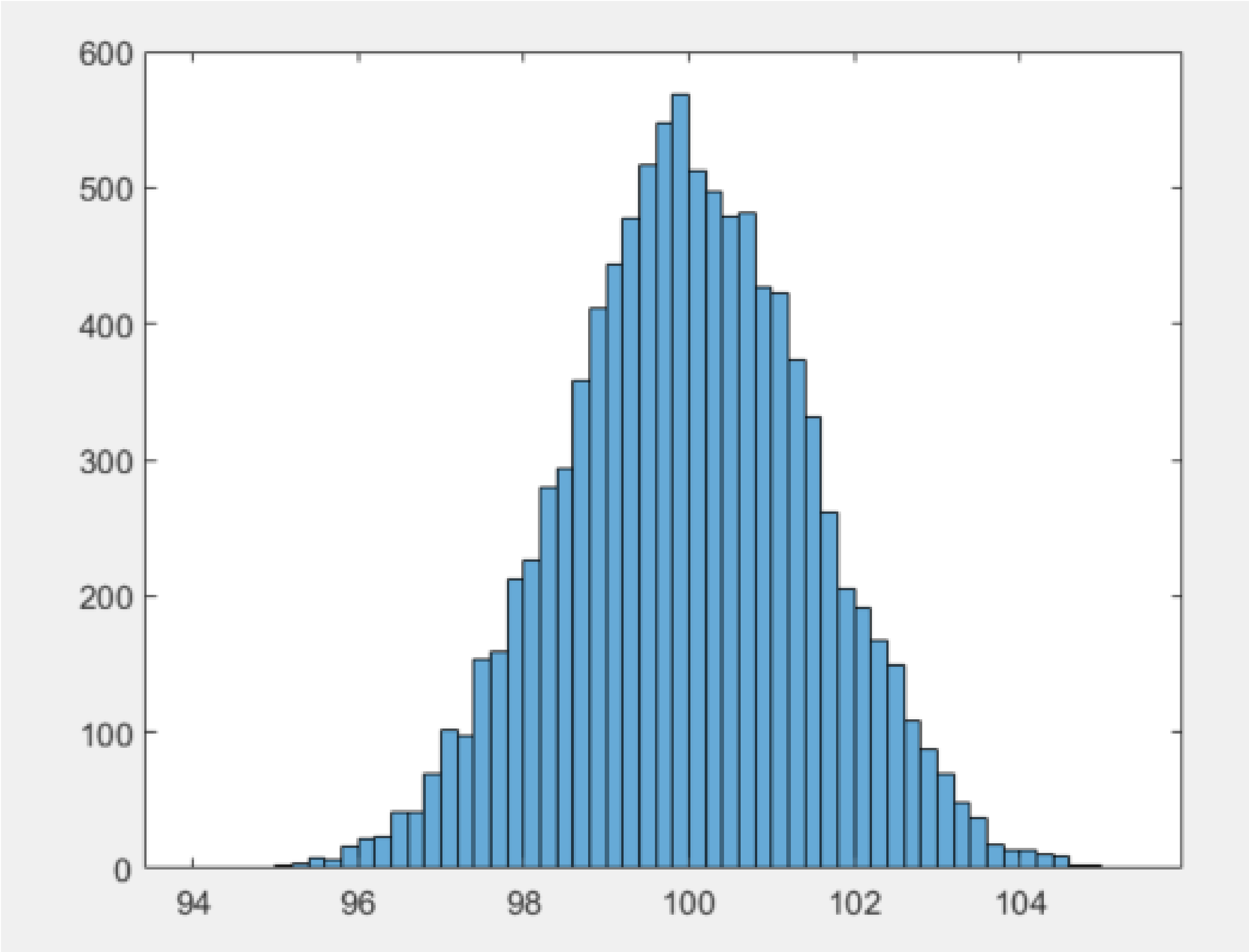
- $IL_{3GHz} > 20dB$ → N=0
- $10dB < IL_{3GHz} < 20dB$ → N=1
- $IL_{3GHz} < 10dB$ → N=2

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

(f in MHz)

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

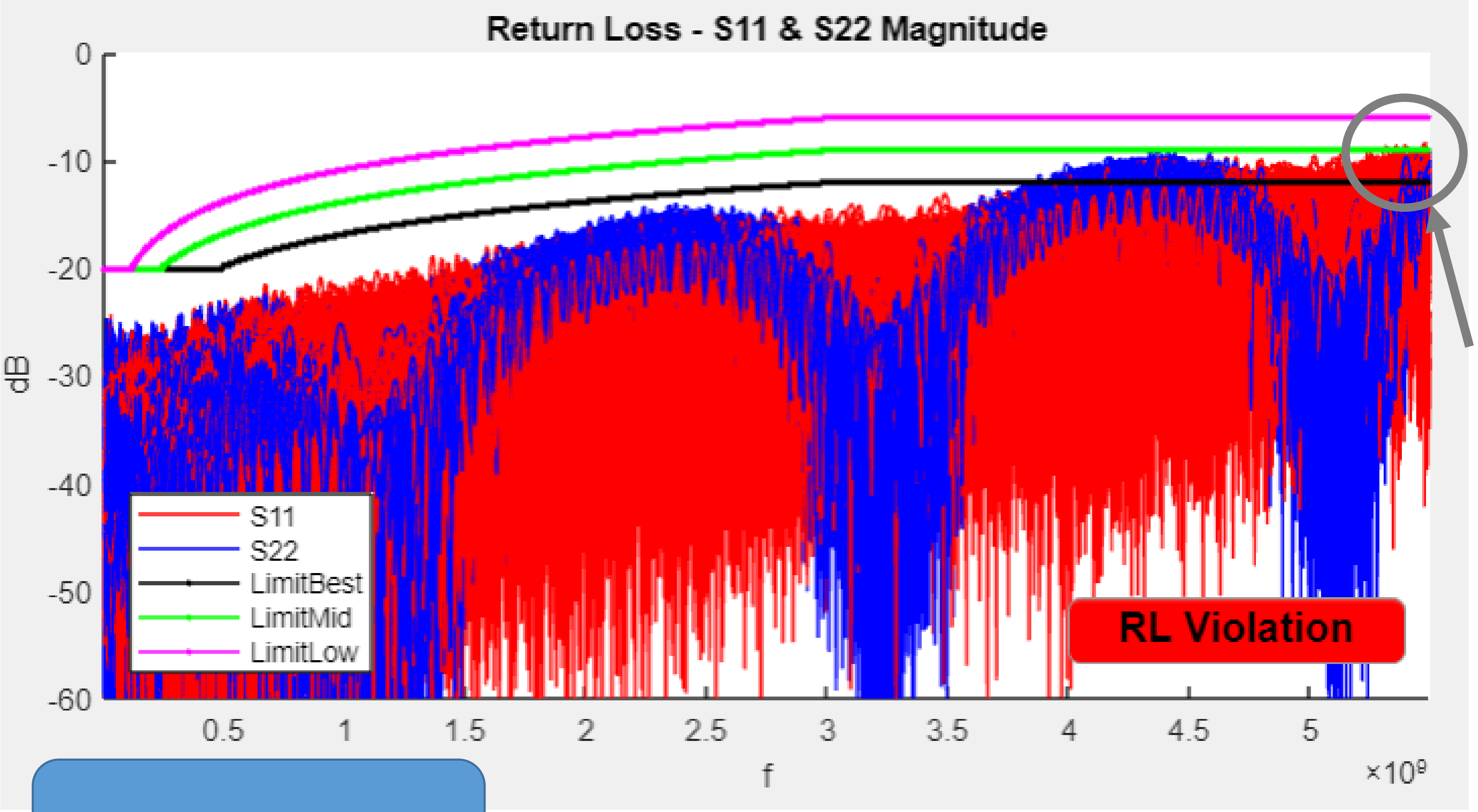
Cable Impedance – Gaussian Distribution



10,000 Iterations

Topology Set 1 – Random – 500 iterations

(Max. 3 Segments, 11m)



Topology Set 1

Cable A Parameters

C1 = -2.50898e-5

C2 = -6.79241e-11

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

(Gaussian Dist.)

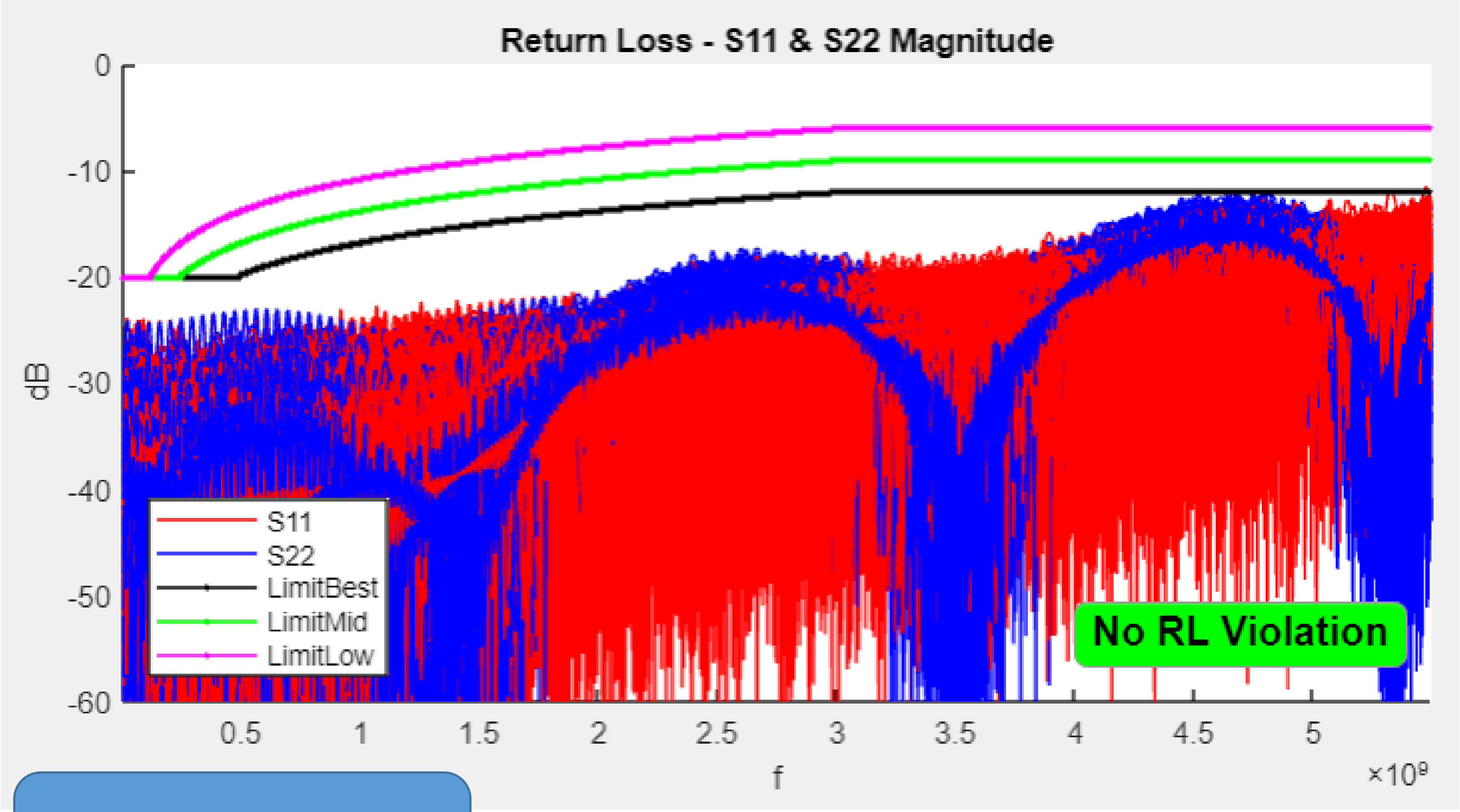
2 RL Violations

S11/S22 > 5.2 GHz

Connector Tolerance Profile #1

Topology Set 1 – Random – 500 iterations

(Max. 3 Segments, 11m)



Cable A Parameters

C1 = -2.50898e-5

C2 = -6.79241e-11

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

(Gaussian Dist.)

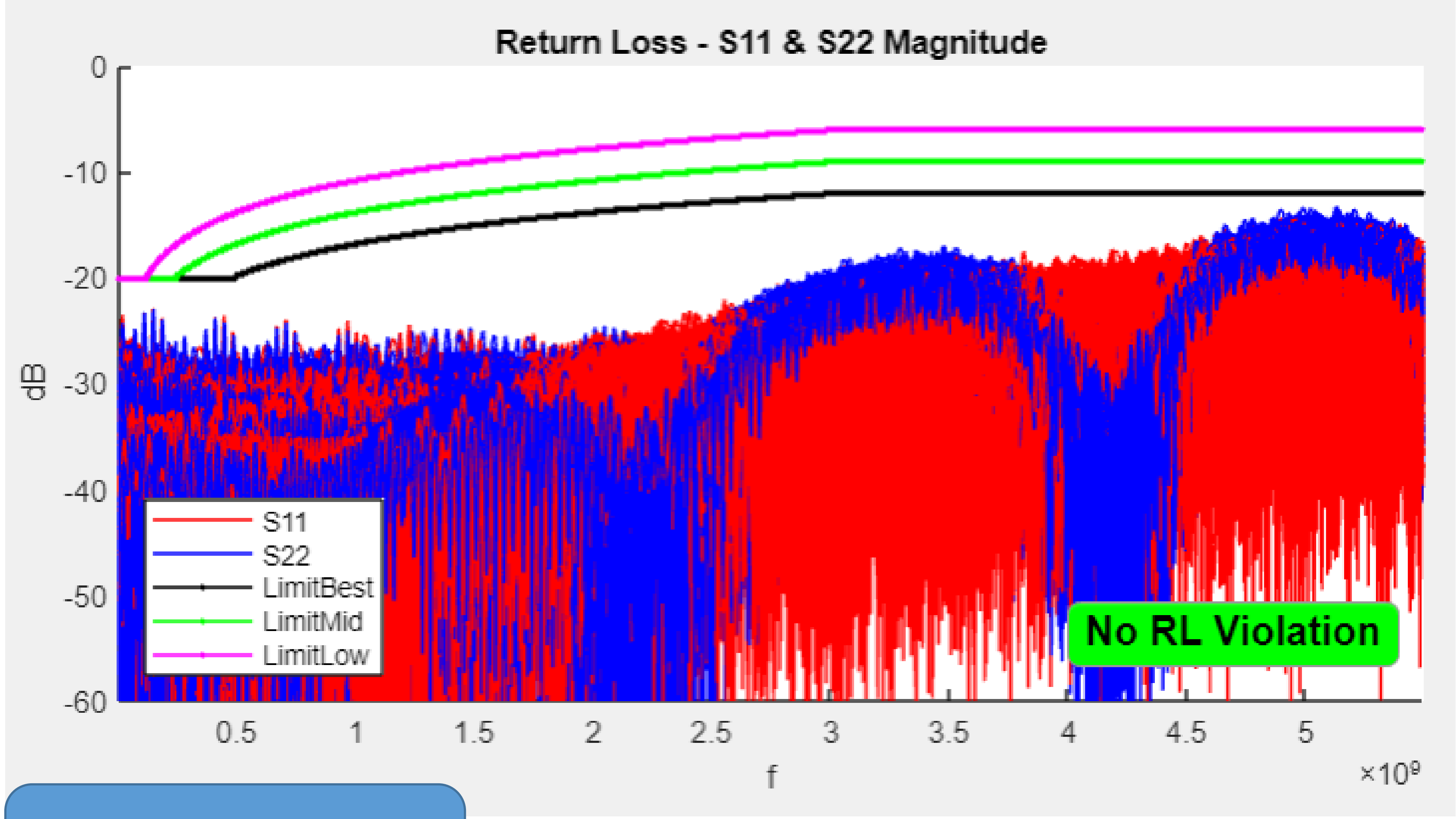
0 RL Violations

Connector Tolerance Profile #2

Topology Set 1

Topology Set 1 – Random – 500 iterations

(Max. 3 Segments, 11m)



Cable A Parameters

C1 = -2.50898e-5

C2 = -6.79241e-11

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

(Gaussian Dist.)

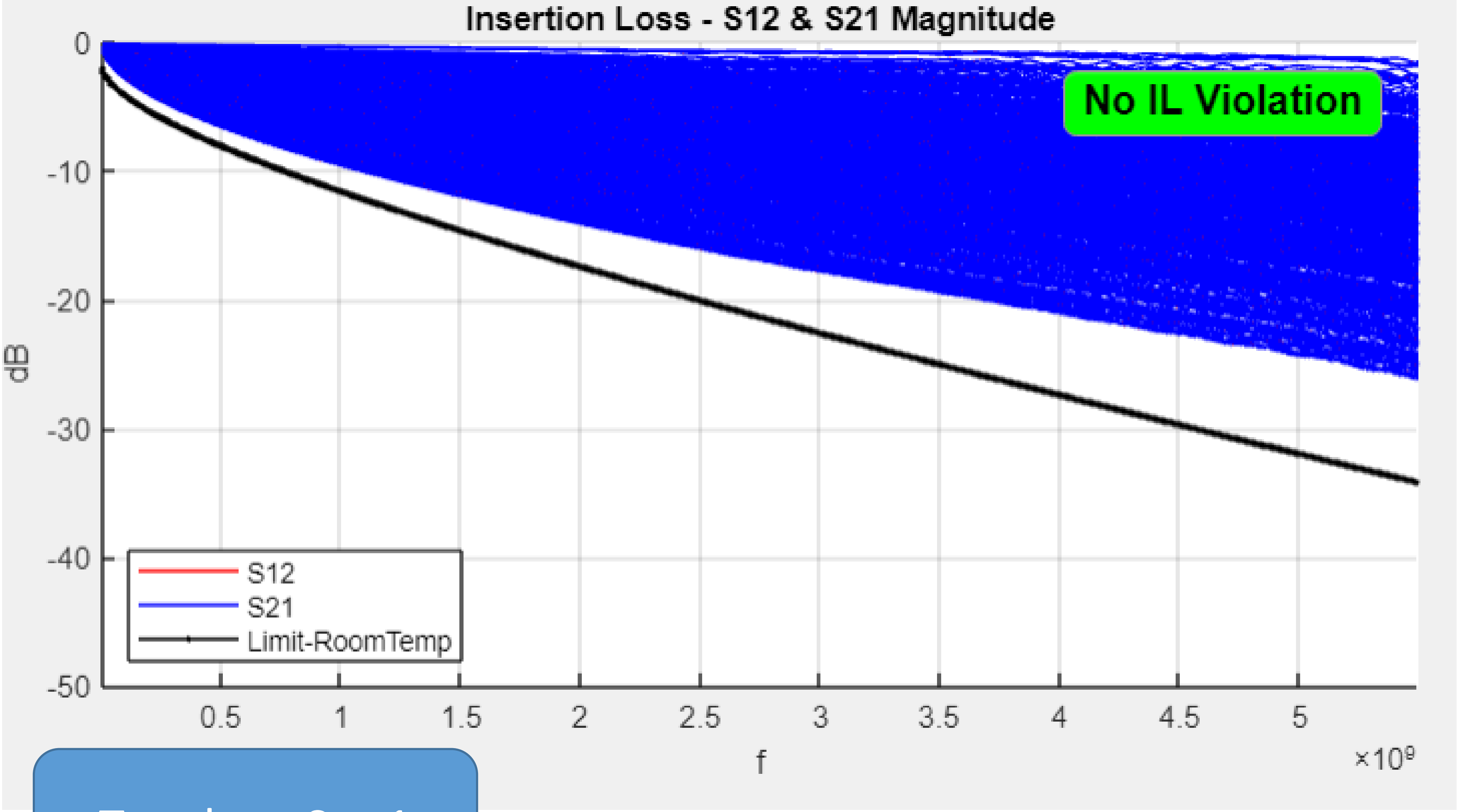
0 RL Violations

Connector Tolerance Profile #3

Topology Set 1

Topology Set 1 – Random – 500 iterations

(Max. 3 Segments, 11m)



Cable A Parameters

C1 = -2.50898e-5

C2 = -6.79241e-11

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

(Gaussian Dist.)

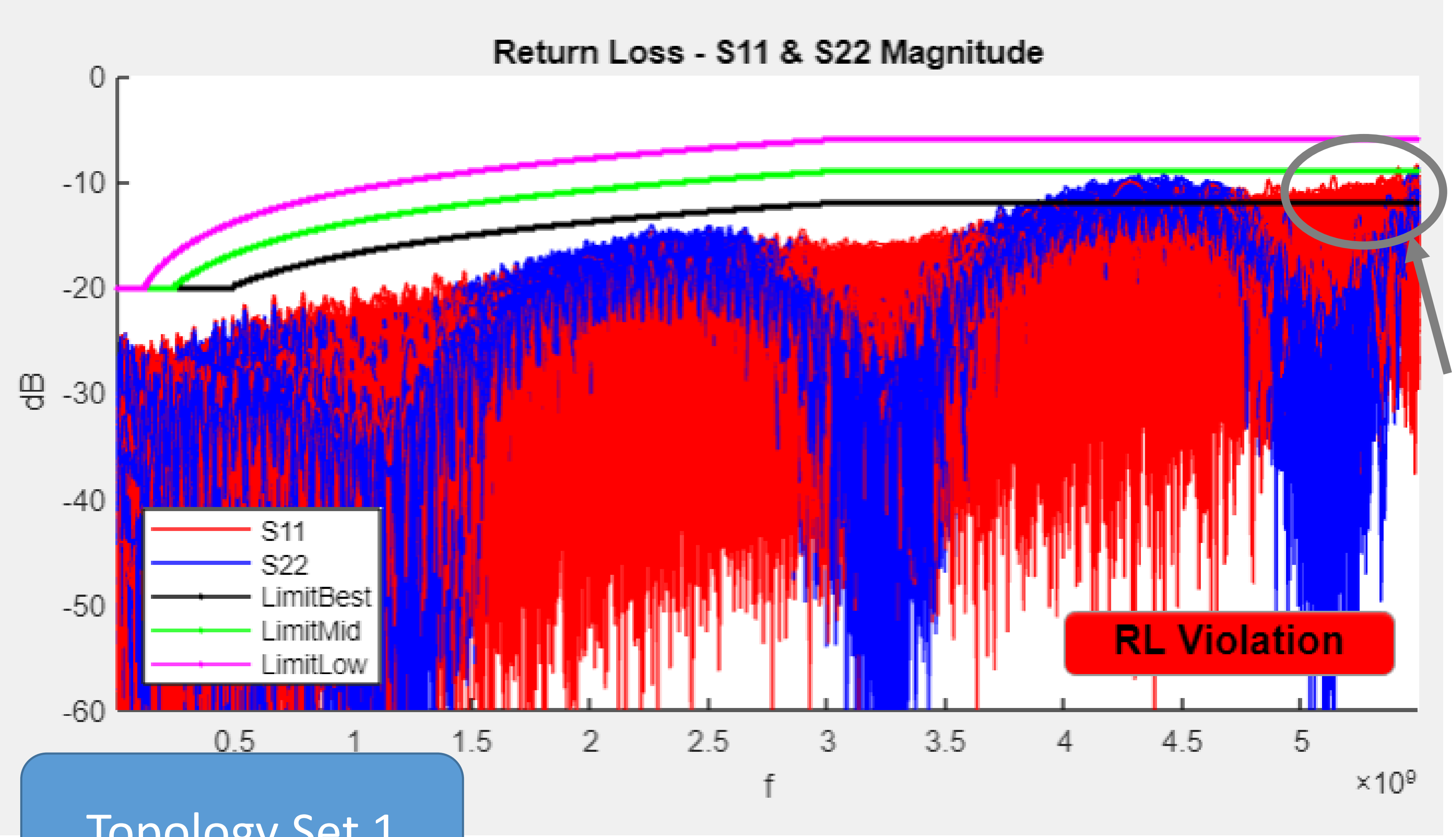
0 IL Violations

Connector Tolerance Profile #1

Topology Set 1

Topology Set 1 – Random – 500 iterations

(Max. 3 Segments, 11m)



Topology Set 1

Cable B Parameters

C1 = -1.97042e-5

C2 = -2.31881e-10

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

(Gaussian Dist.)

1 RL Violations

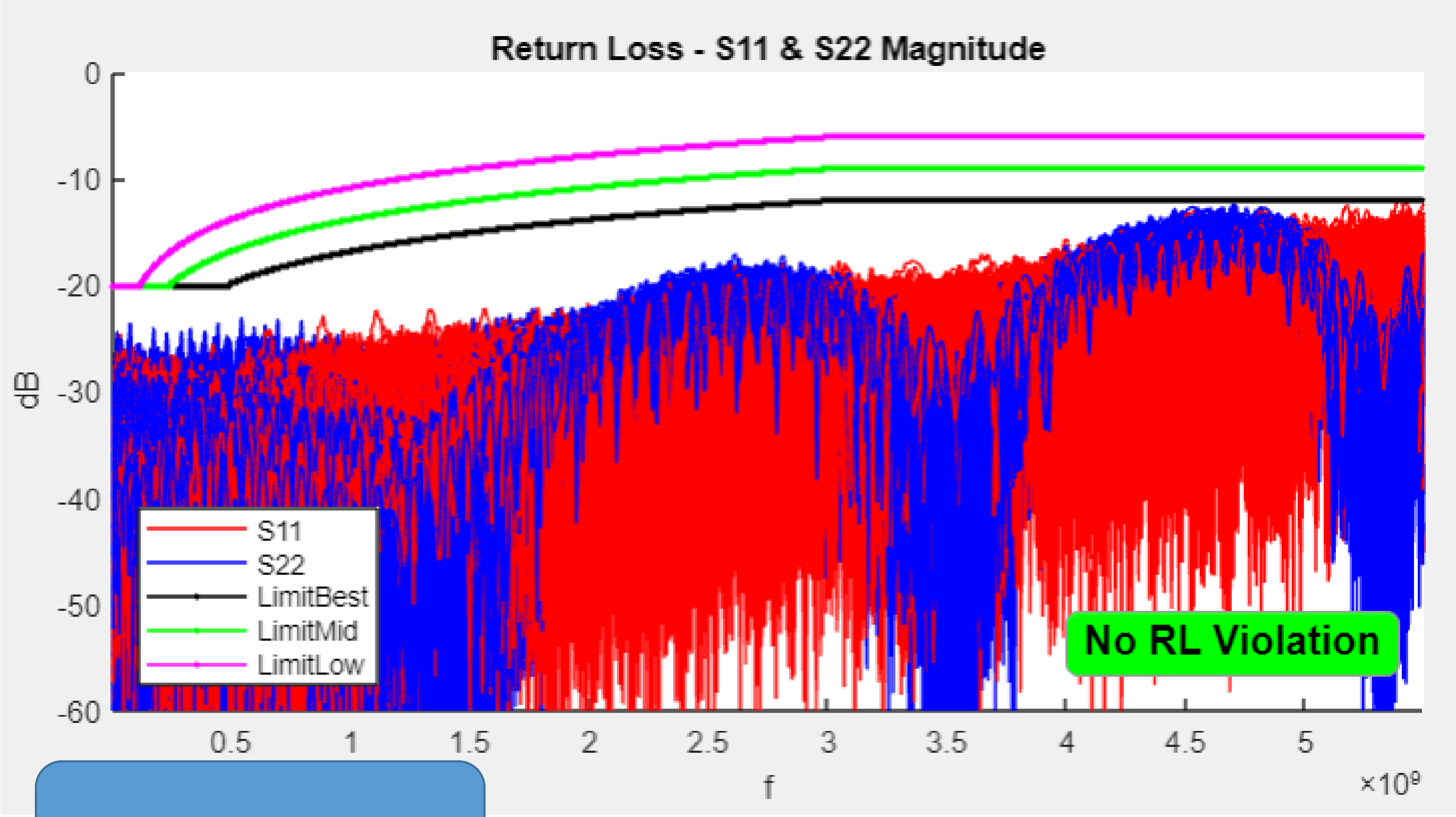
S11/S22 > 5 GHz

Greater than 20dB attenuation at 3GHz so black limit line violation

Connector Tolerance Profile #1

Topology Set 1 – Random – 500 iterations

(Max. 3 Segments, 11m)



Topology Set 1

Cable B Parameters

C1 = -1.97042e-5

C2 = -2.31881e-10

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

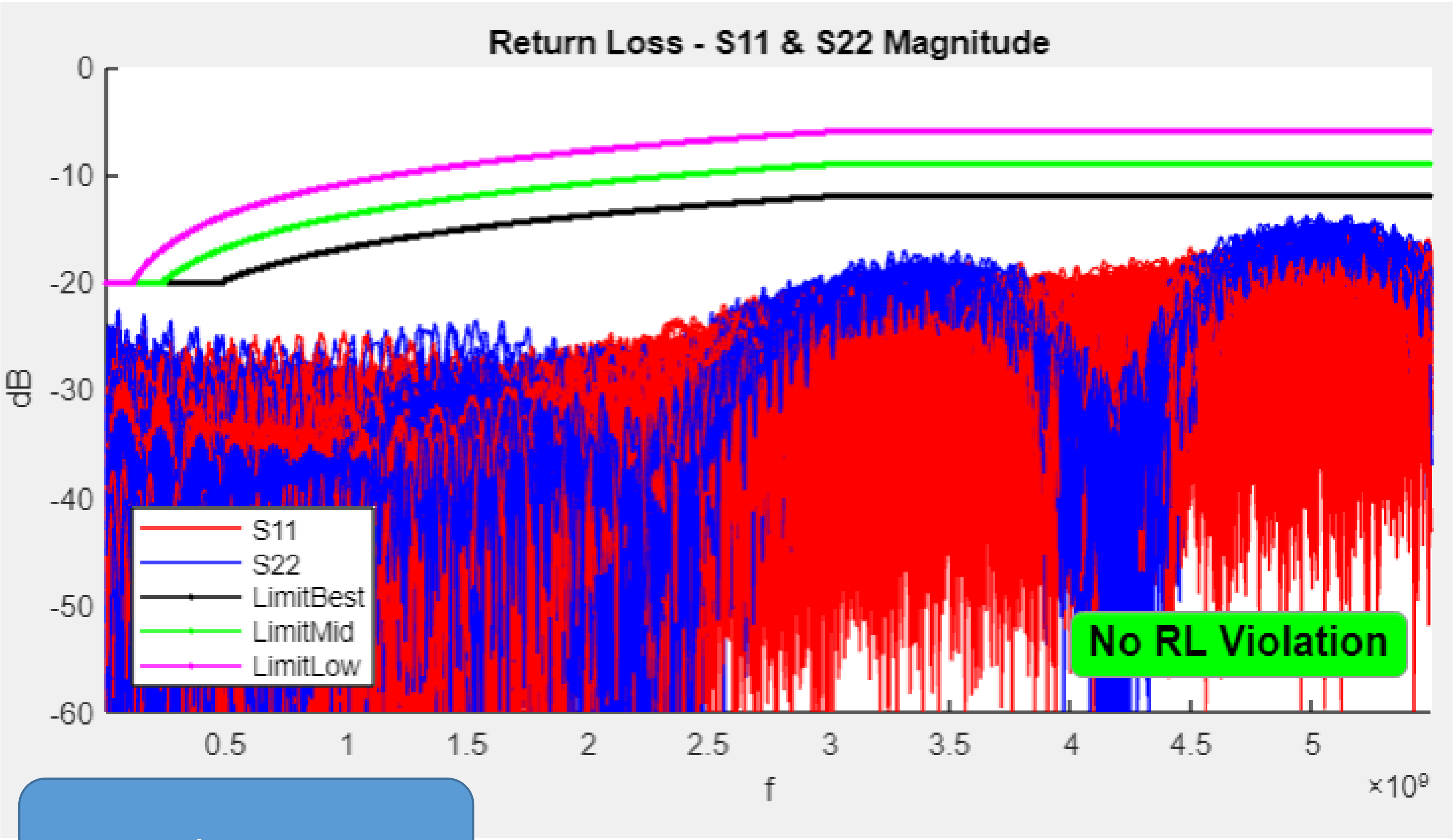
(Gaussian Dist.)

0 RL Violations

Connector Tolerance Profile #2

Topology Set 1 – Random – 500 iterations

(Max. 3 Segments, 11m)



Topology Set 1

Cable B Parameters

C1 = -1.97042e-5

C2 = -2.31881e-10

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

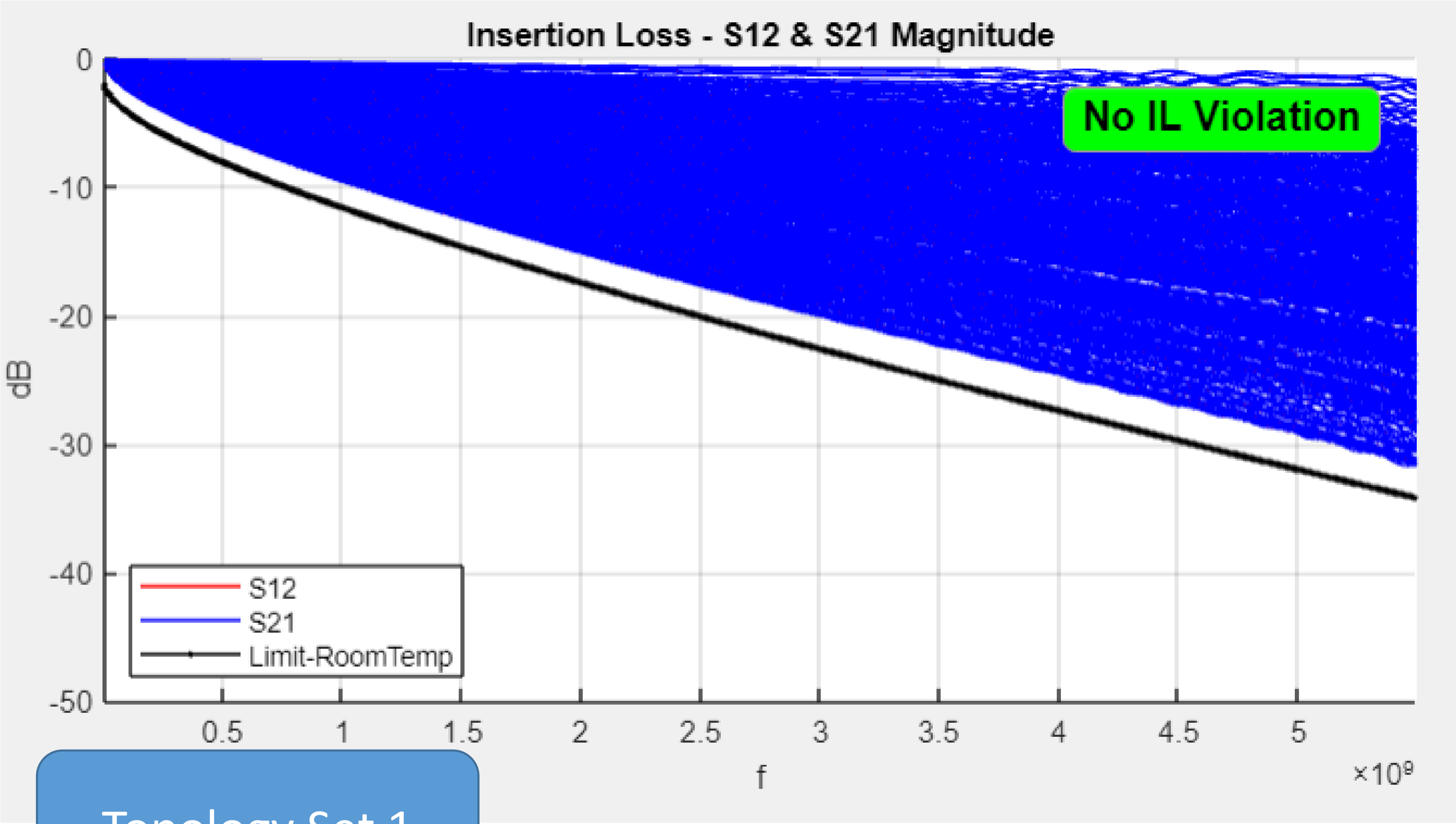
(Gaussian Dist.)

0 RL Violations

Connector Tolerance Profile #3

Topology Set 1 – Random – 500 iterations

(Max. 3 Segments, 11m)



Topology Set 1

Cable B Parameters

C1 = -1.97042e-5

C2 = -2.31881e-10

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

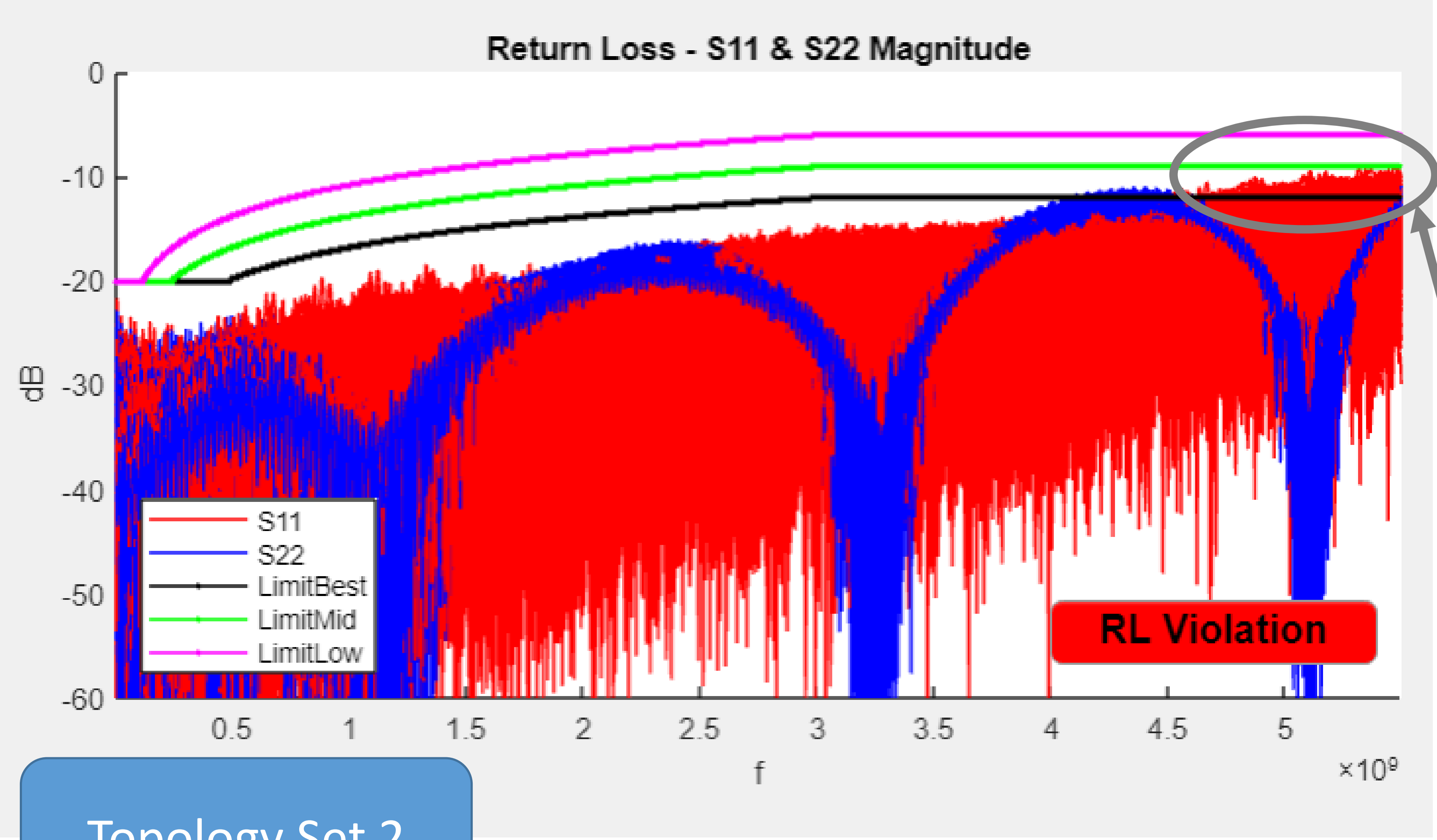
(Gaussian Dist.)

0 IL Violations

Connector Tolerance Profile #1

Topology Set 2 – Random – 500 iterations

(3 Segments, 11m-15m)



Cable C Parameters (24AWG)

C1 = -1.81334e-5

C2 = -1.32573e-10

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

(Gaussian Dist.)

60 RL Violations

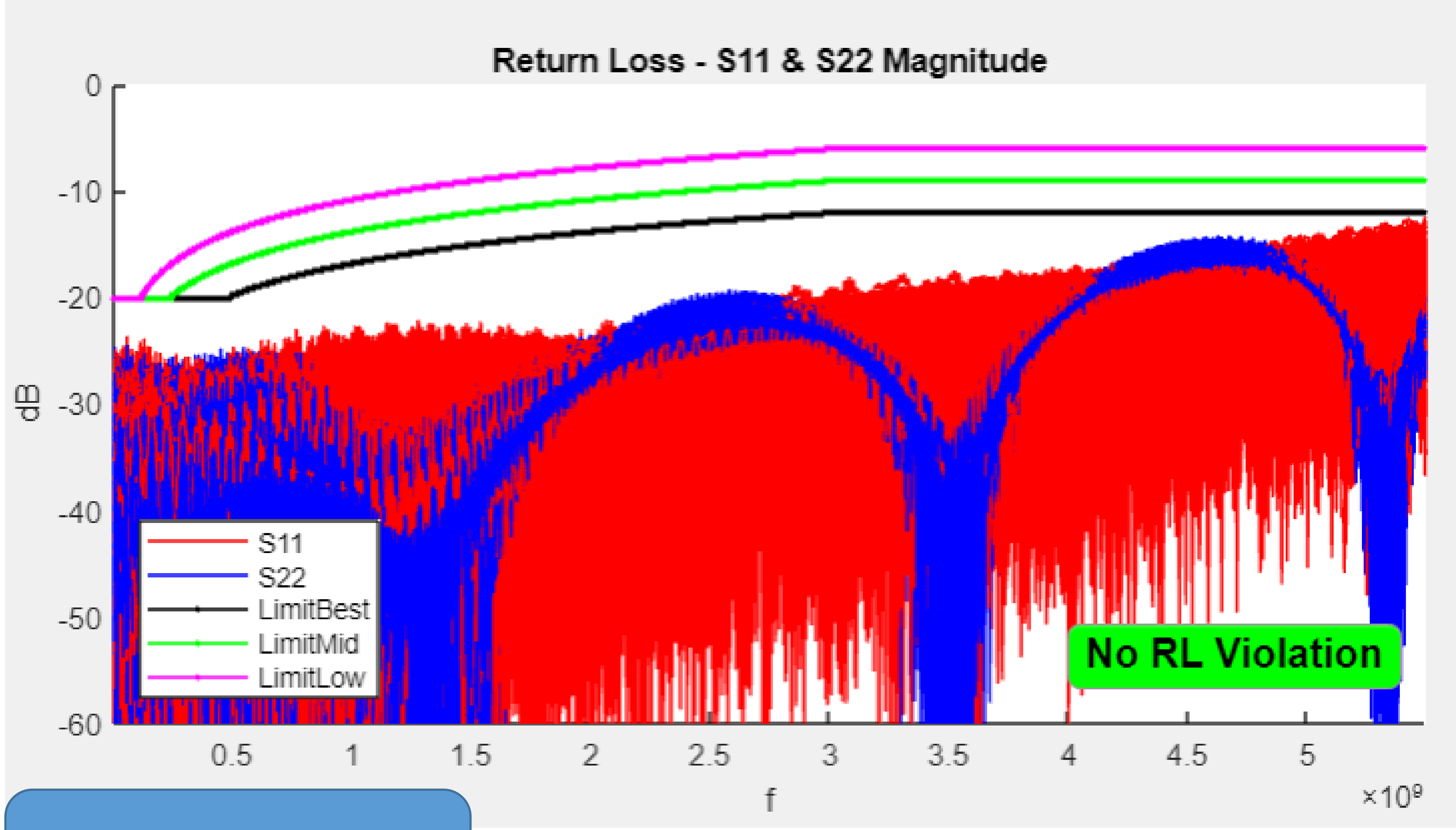
S11/S22 > 4.6 GHz

Connector Tolerance Profile #1

Topology Set 2

Topology Set 2 – Random – 500 iterations

(3 Segments, 11m-15m)



Cable C Parameters (24AWG)

C1 = -1.81334e-5

C2 = -1.32573e-10

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

(Gaussian Dist.)

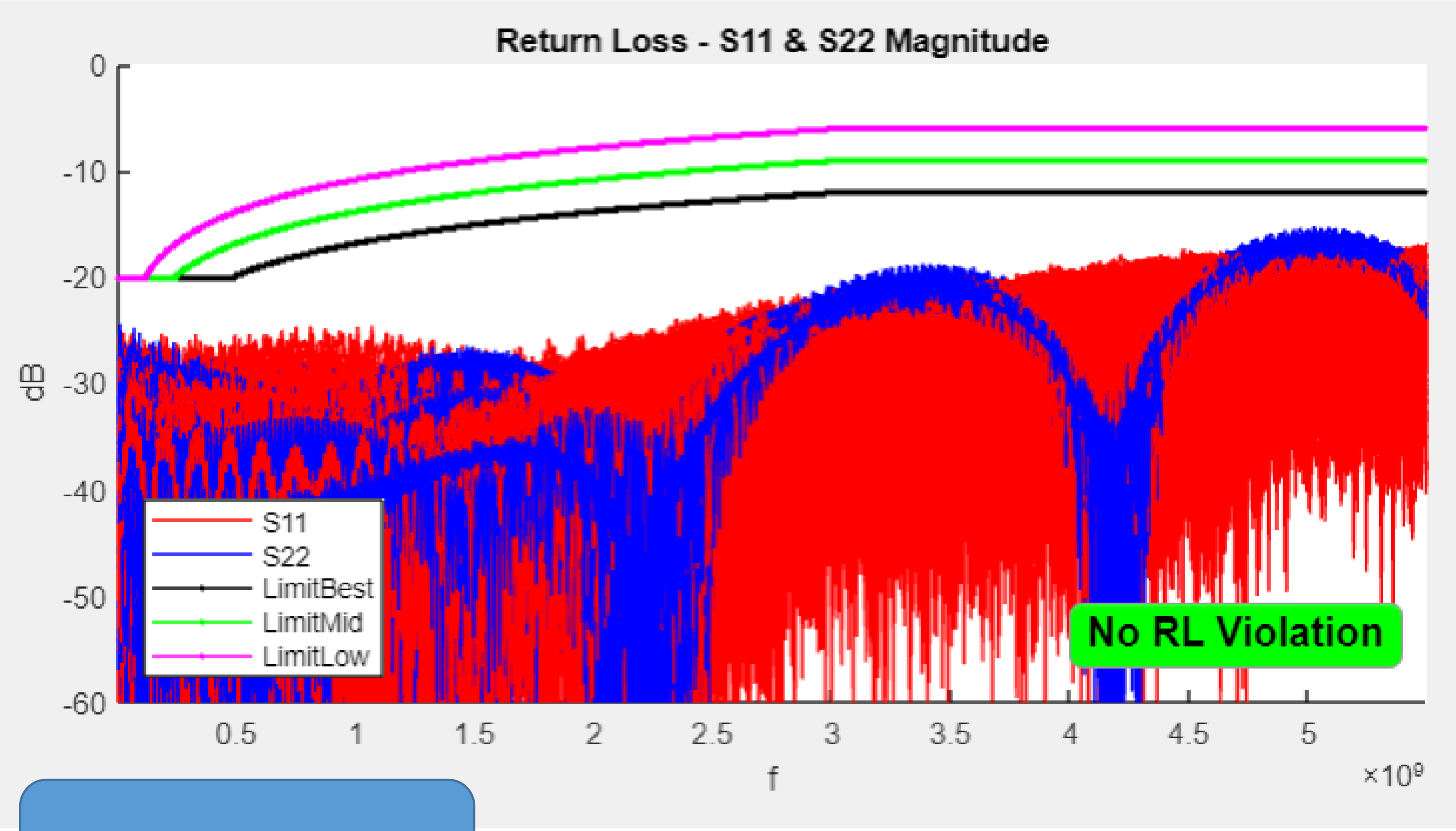
0 RL Violations

Connector Tolerance Profile #2

Topology Set 2

Topology Set 2 – Random – 500 iterations

(3 Segments, 11m-15m)



Cable C Parameters (24AWG)

C1 = -1.81334e-5

C2 = -1.32573e-10

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

(Gaussian Dist.)

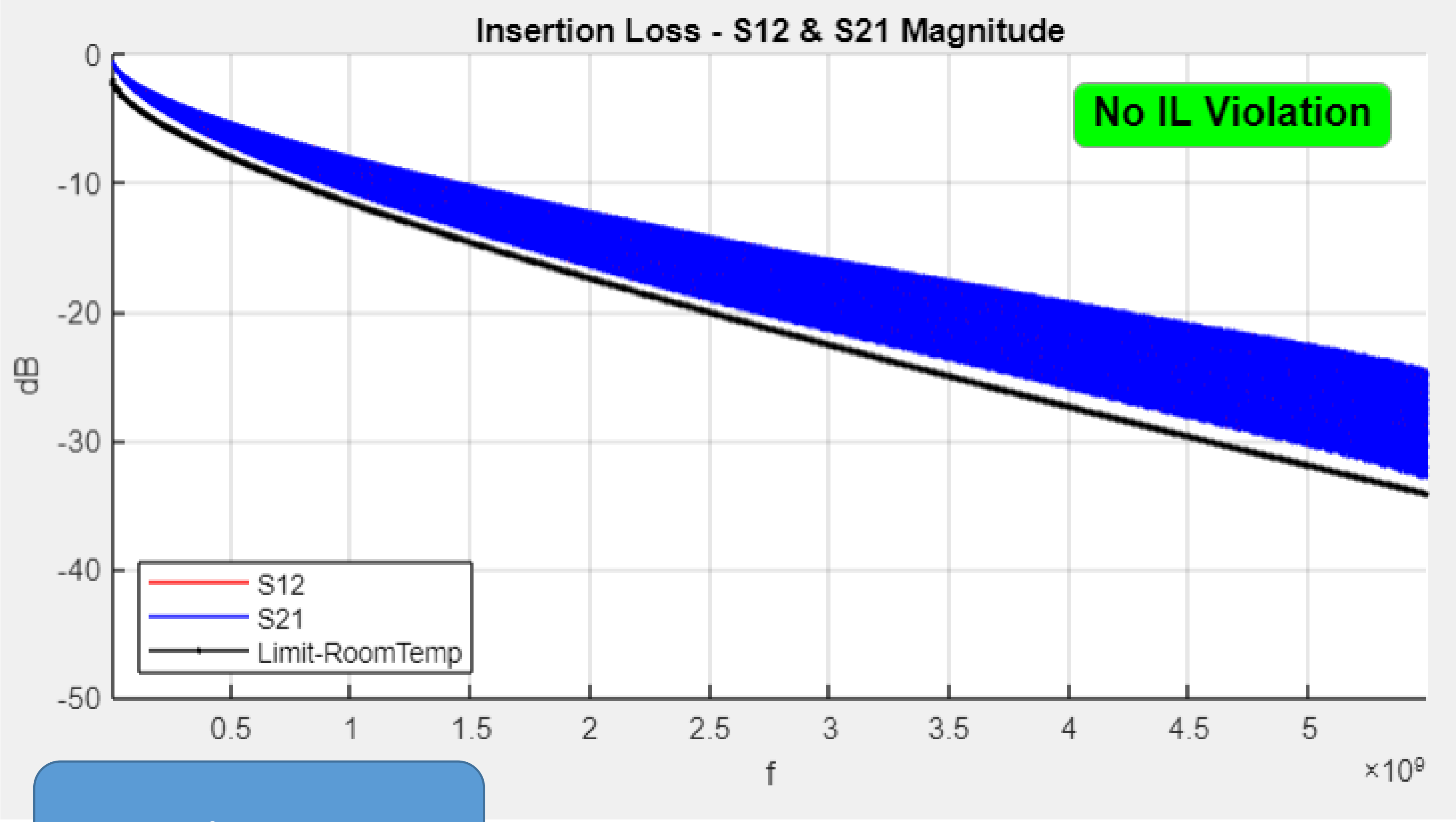
0 RL Violations

Connector Tolerance Profile #3

Topology Set 2

Topology Set 2 – Random – 500 iterations

(3 Segments, 11m-15m)



Cable C Parameters (24AWG)

C1 = -1.81334e-5

C2 = -1.32573e-10

Vp = 2.16e8

Cable Imp: 100Ω mean 1.5 SD

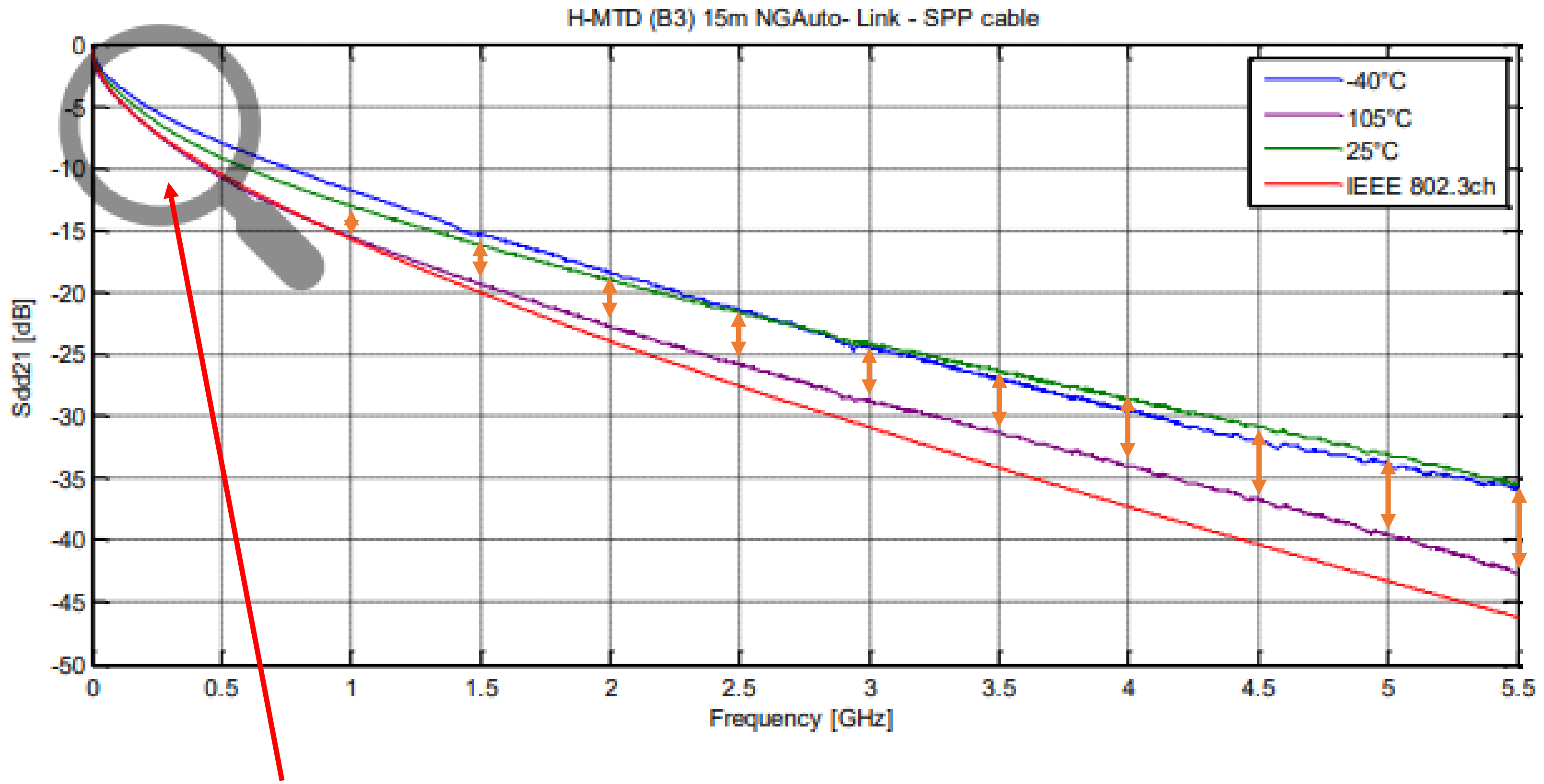
(Gaussian Dist.)

0 IL Violations

Connector Tolerance Profile #1

Topology Set 2

How much additional Insertion Loss for 105°C?

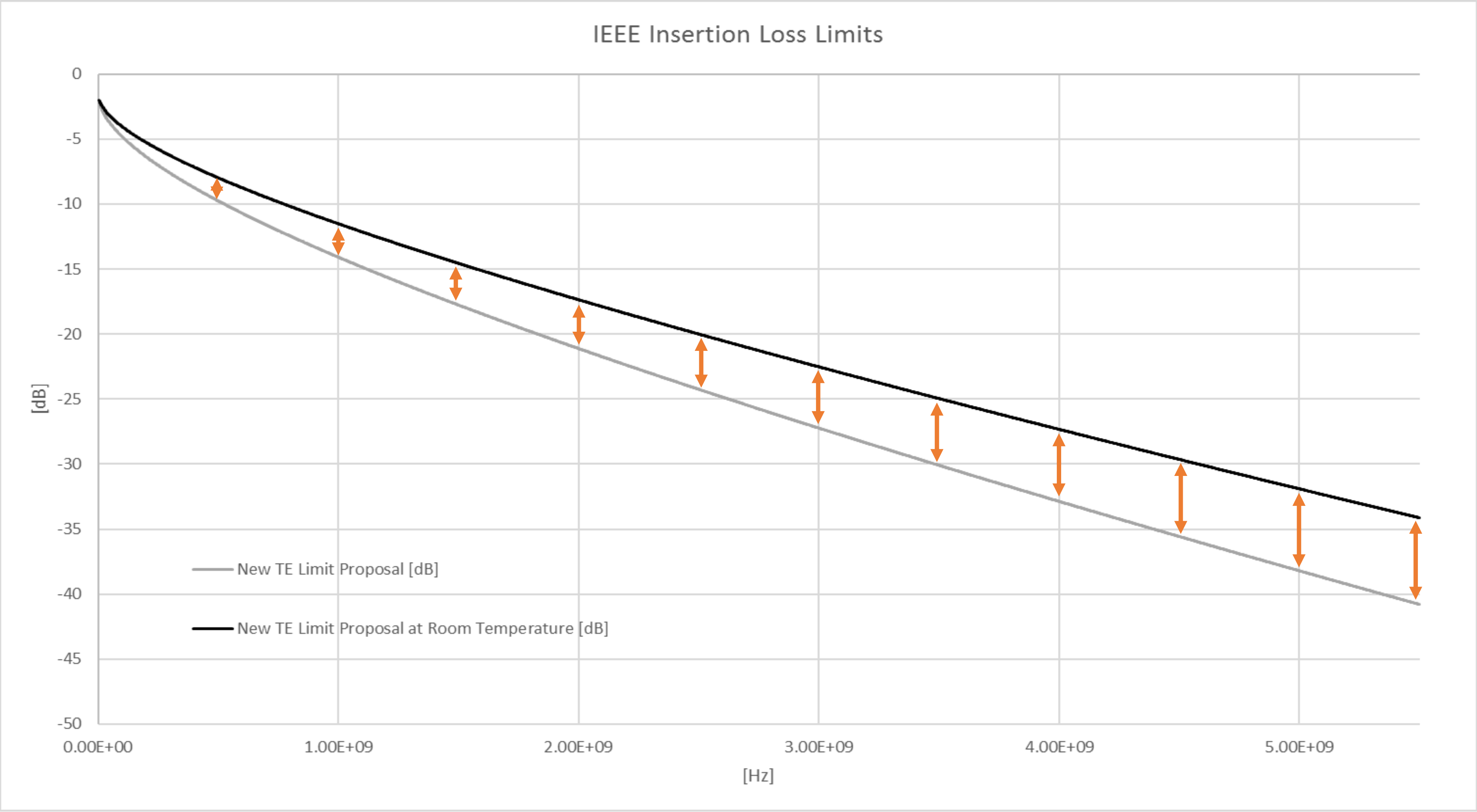


IL Violations at low Frequencies
(recommend to add 0.5dB)

* mueller_3ch_01_0318.pdf

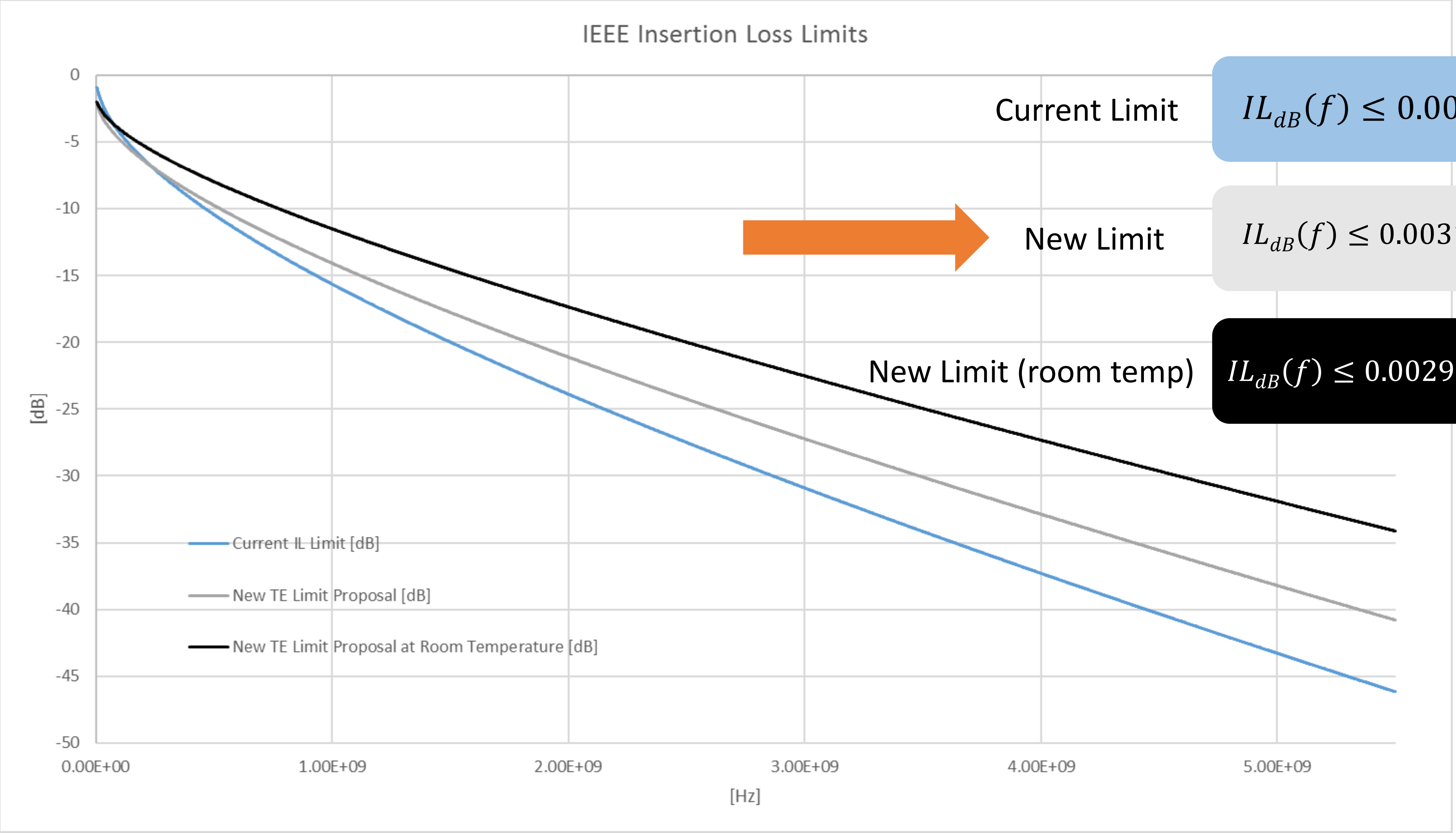
Frequency [MHz]	Mueller Temp. Difference
100	0.65
200	0.85
500	2.5
1000	2.5
1500	3.15
2000	3.75
2500	4.1
3000	4.6
3500	5
4000	5.45
4500	5.9
5000	6.3
5500	7.2

Insertion Loss Limit – Temperature Compensation



Frequency [MHz]	Mueller Temp. Difference	New Limit Temp. Difference
100	0.65	0.77
200	0.85	1.10
500	2.5	1.78
1000	2.5	2.57
1500	3.15	3.20
2000	3.75	3.75
2500	4.1	4.25
3000	4.6	4.71
3500	5	5.14
4000	5.45	5.54
4500	5.9	5.93
5000	6.3	6.30
5500	7.2	6.66

Insertion Loss Limits



Current Limit

$$IL_{dB}(f) \leq 0.0030 * f + 0.40 * \sqrt{f}$$

New Limit

$$IL_{dB}(f) \leq 0.0031 * f + 0.30 * \sqrt{f} + 1.5$$

New Limit (room temp)

$$IL_{dB}(f) \leq 0.0029 * f + 0.225 * \sqrt{f} + 1.5$$

Conclusions

- Both 95% and 5% Topologies were investigated
  - 26AWG was used for 95% use cases (Topology #1)
  - 24AWG was used for 5% use cases (Topology #2)
- 3 Different connector tolerance profiles were simulated
  - Profile #1 exhibited RL violations at upper frequencies
  - Profiles #2 & #3 had 0 RL violations for both topologies
- Gaussian Distribution was used for generating the cable segment impedance
  - Eliminated the RL violations at low frequencies previously seen with a uniform distribution
- New IL Limit is proposed based on these simulations

Motion

- Move to adopt a new Insertion Loss Limit given by the equation:

$$IL_{dB}(f) \leq 0.0031 * f + 0.30 * \sqrt{f} + 1.5$$

as shown by the “gray curve” on page 25 of DiBiaso_3ch_01_0518.pfd for all 3 speeds for frequencies from 5MHz to 5.5GHz.

- M: Eric DiBiaso
- S:
- (Technical >= 75%)
- Y: N: A:
- Motion Passes/Fails

Thank You!!!