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Findings on MDI Return Loss Measurement

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SANTA BARBARA DESIGN CENTER

Supporters

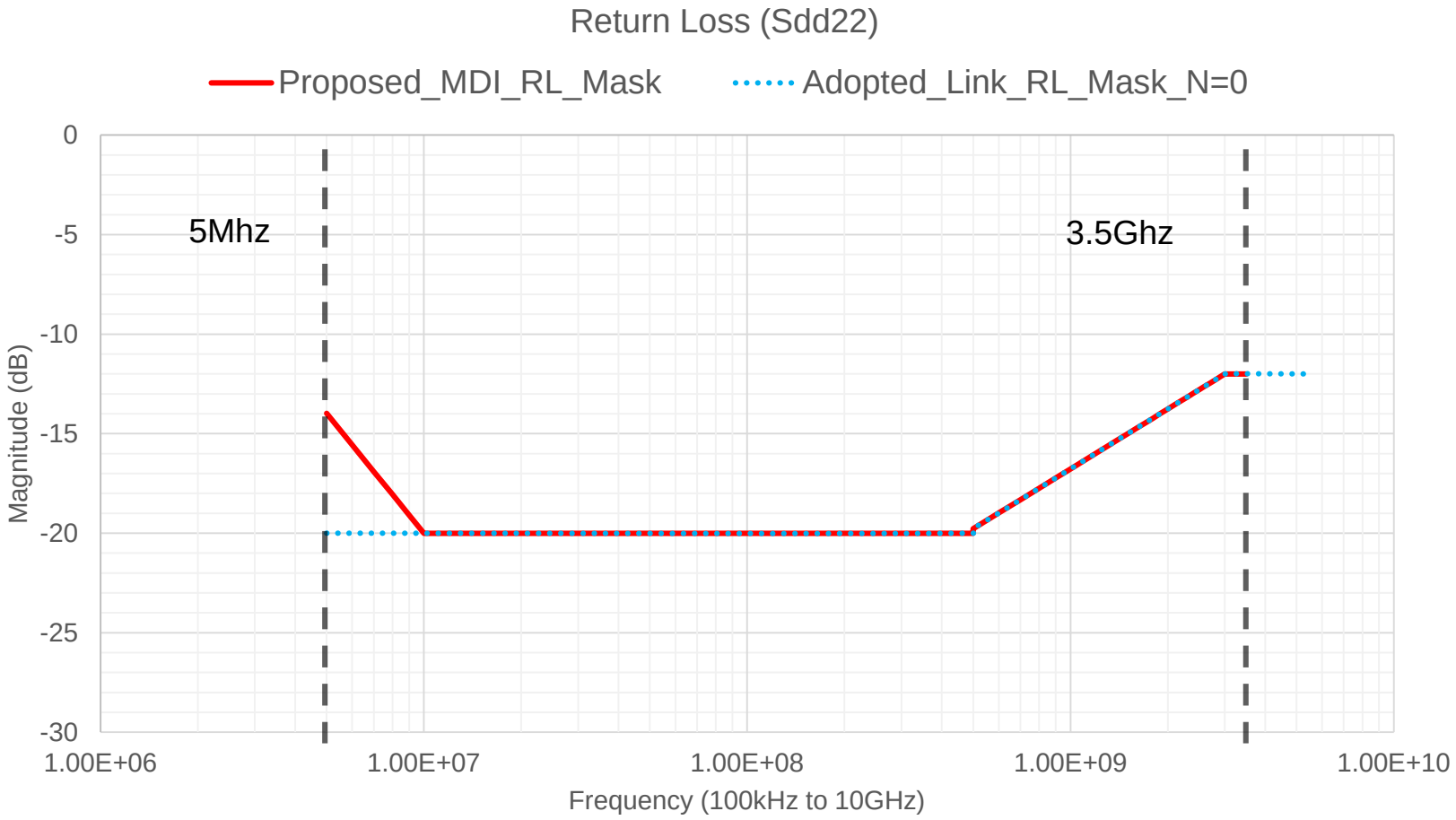
- Eric DiBiaso (TE Connectivity)
- Bin Lin (TE Connectivity)
- Kurt Smith (Coilcraft)

Presentation Outline

- MDI Return Loss Mask
- Power Coupling Inductors
  - Modified Test Fixtures
- Inductance versus Current for same Core
- Test Fixtures with Inductors and MDI Connectors
- Backup Slides
- Additional Measured Data

MDI Return Loss Mask

- Previously Suggested Mask versus Adopted Link Return Loss Mask (N=0)
- Reference: http://www.ieee802.org/3/ch/public/jul18/bhagwat_3ch_02a_0718.pdf



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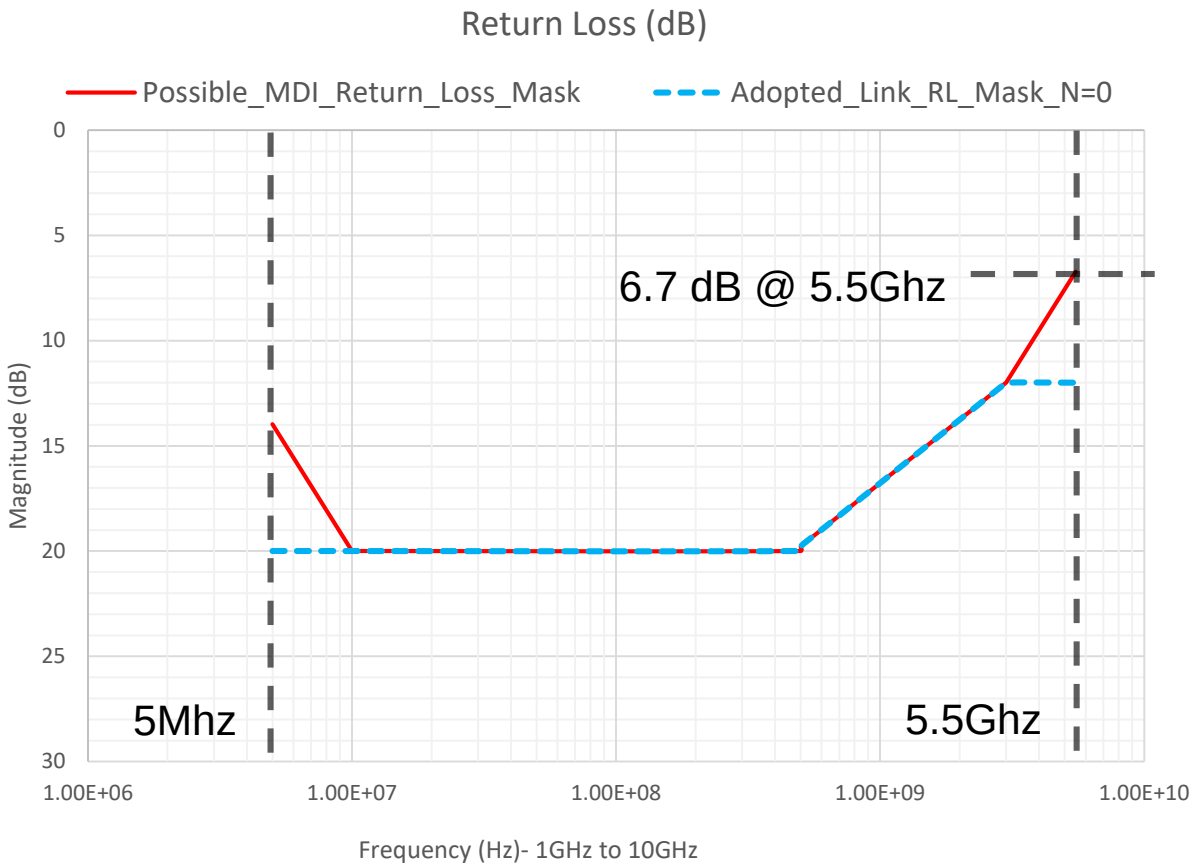
MDI Return Loss Mask

- New Possible Mask to Accommodate Higher Baud Rate of 5.625GHz

Return Loss ≥

- $20 - 20 \times Log_{10}(\frac{10}{f})$ for $5 \leq f \leq 10$
- 20 for $10 \leq f \leq 500$
- $12 - 10 \times Log_{10}(\frac{f}{3000})$ for $500 \leq f \leq 3000$
- $12 - 20 \times Log_{10}(\frac{f}{3000})$ for $3000 \leq f \leq 5500$

where f is frequency in MHz



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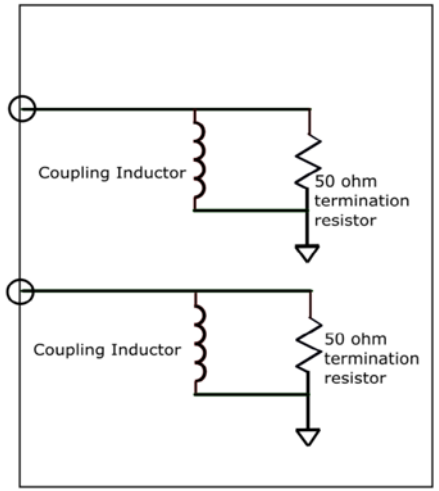
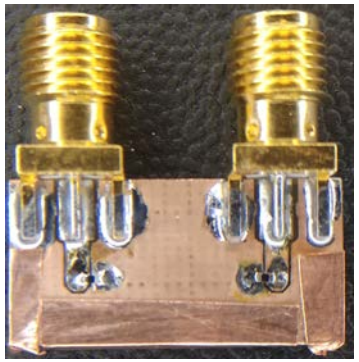
Test Fixtures

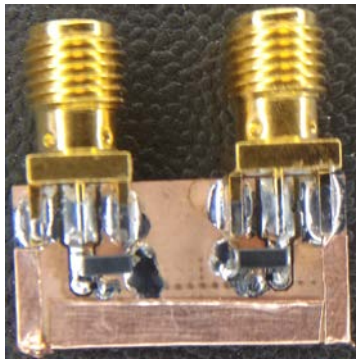
- Copper clad boards, Copper tape to tie GND planes
- Notice the close proximity of the termination resistors, Coupling Inductors and SMA Connector



Schematic

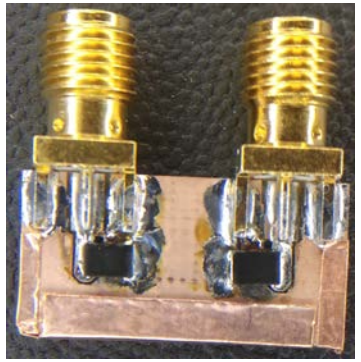


Termination Resistors



1205POC

10.57 mm^3

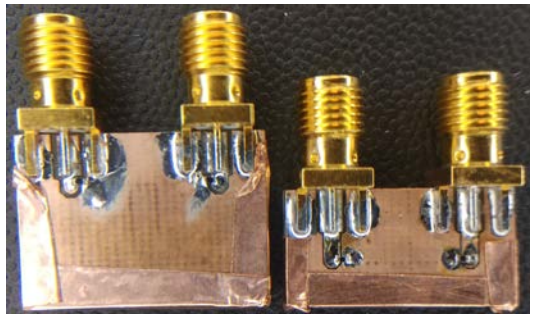


PFL3215

11.04 mm^3

PFL4514

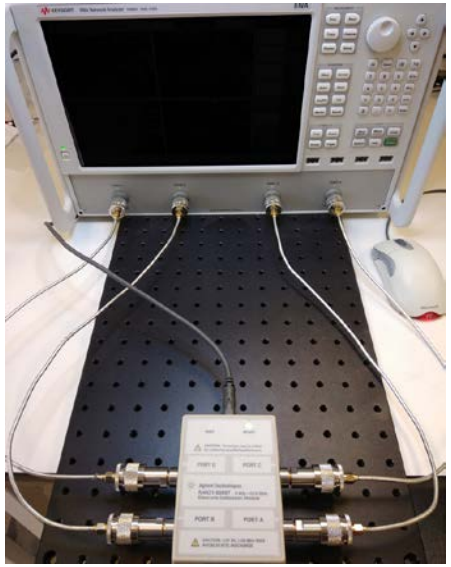
23.32 mm^3

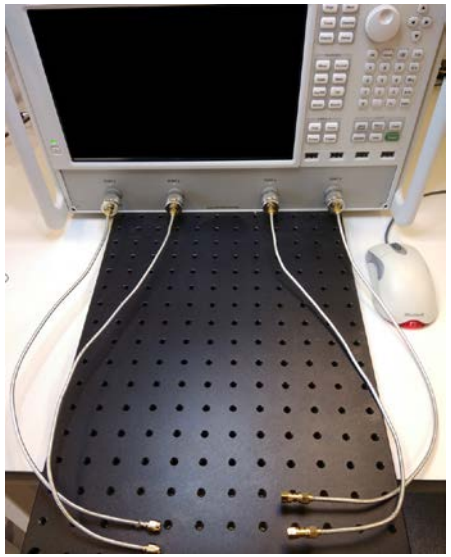


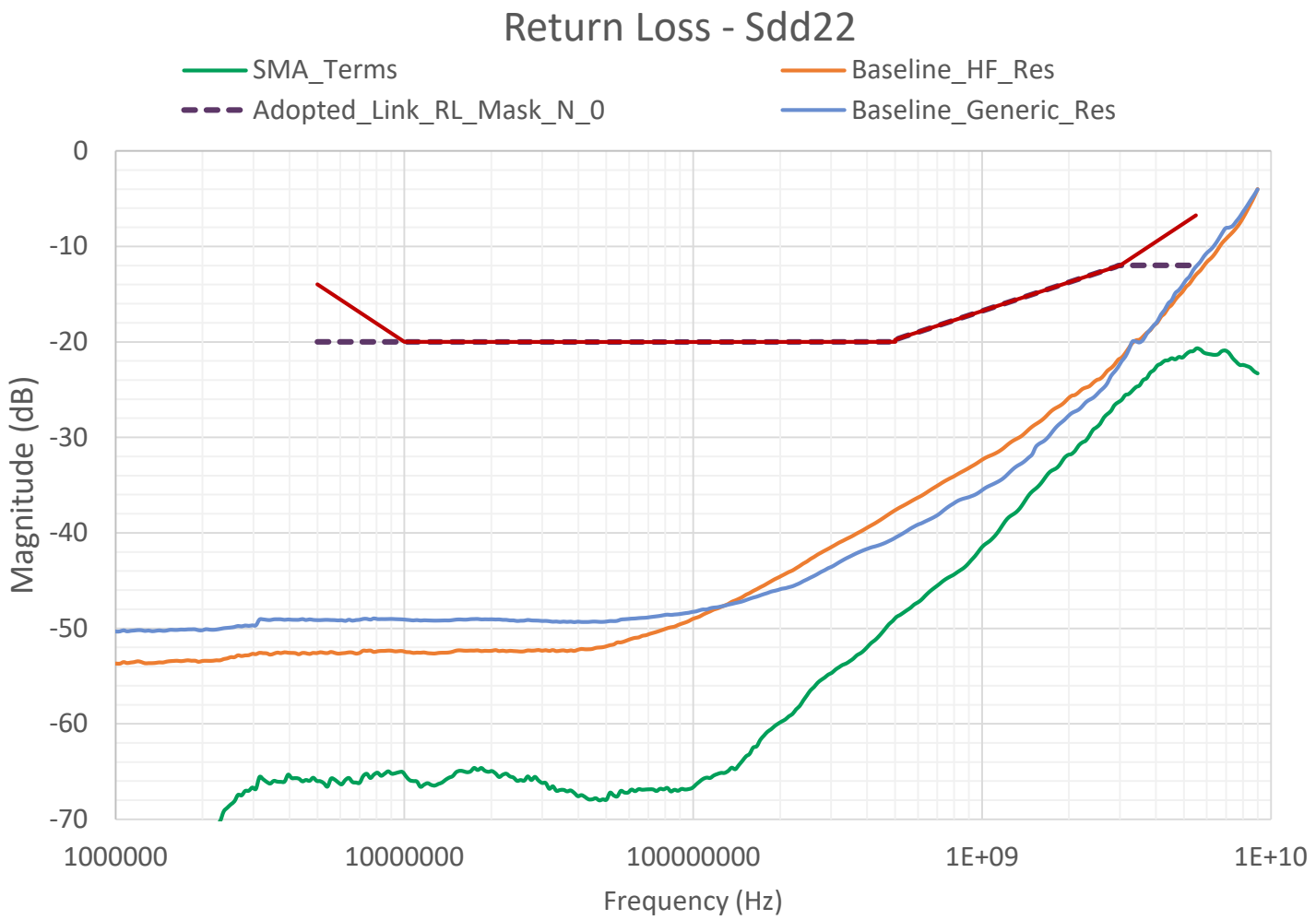
Old vs **New**

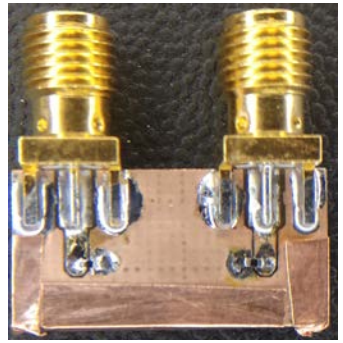
Test Fixture

Return Loss (Sdd22) - Baselines









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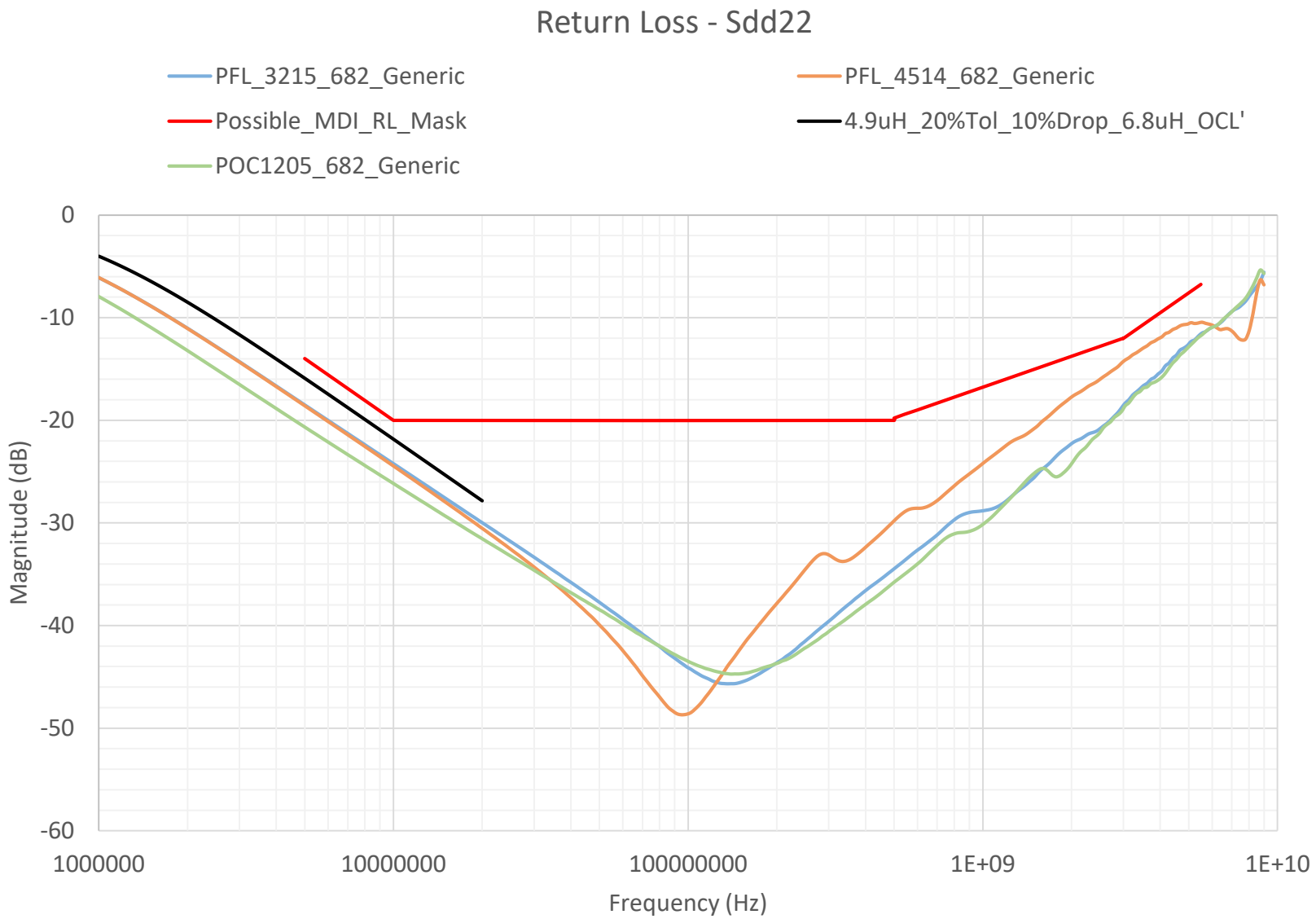
Power Coupling Inductors –Optimum Inductance

Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Core Volume (mm^3)	Max. Ambient Temp (20℃ rise)	Current Rating (20℃ rise)
PFL3215-682	6.8	+/- 20%	3.2 X 2.3 X 1.5	11.04	105℃	370mA
1205POC-682	6.8	+/- 20% *	3.2 X 1.4 X 2.36	10.57	125℃	500mA *
PFL4514-682	6.8	+/- 20%	4.9 X 3.4 X 1.4	23.32	105℃	860 mA

* Estimated Value for preliminary samples

Return Loss (Sdd22) – Power Coupling Inductors



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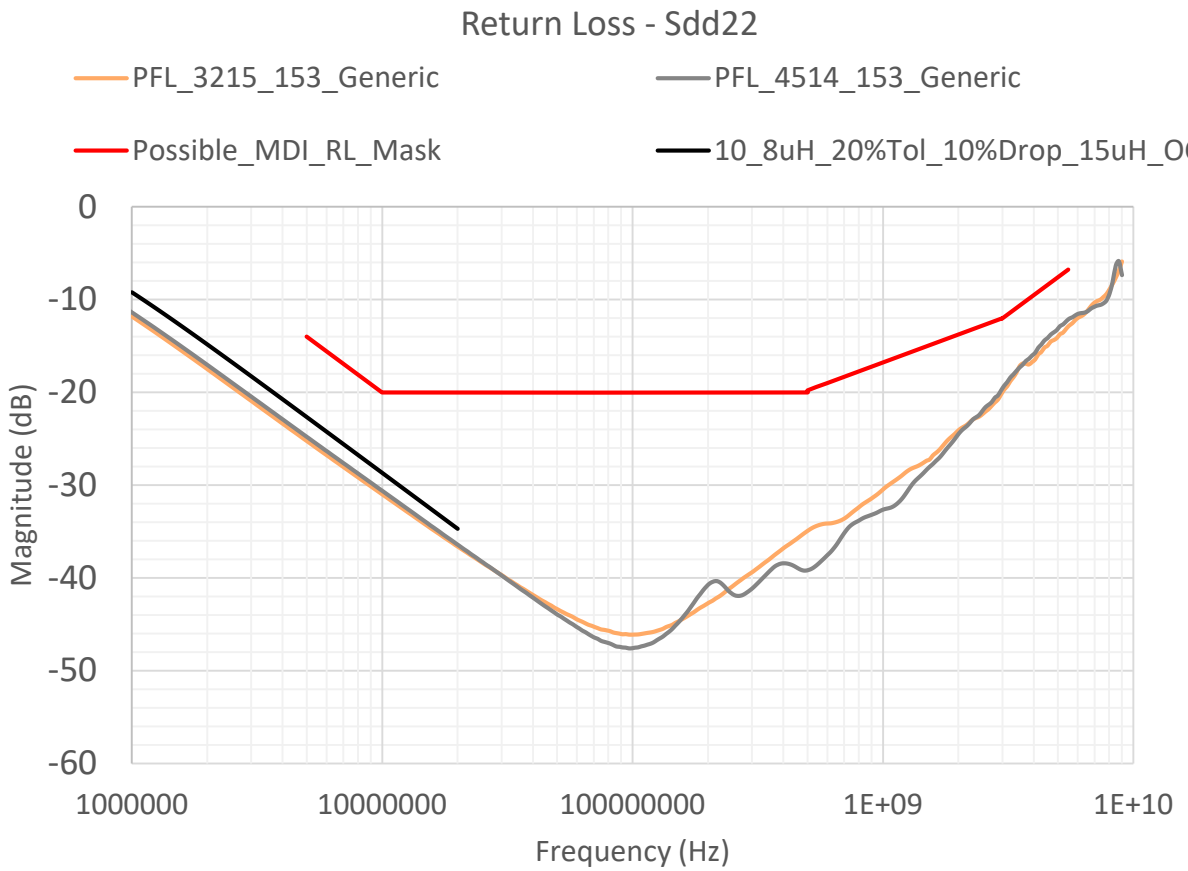
Power Coupling Inductors – Inductance versus Current

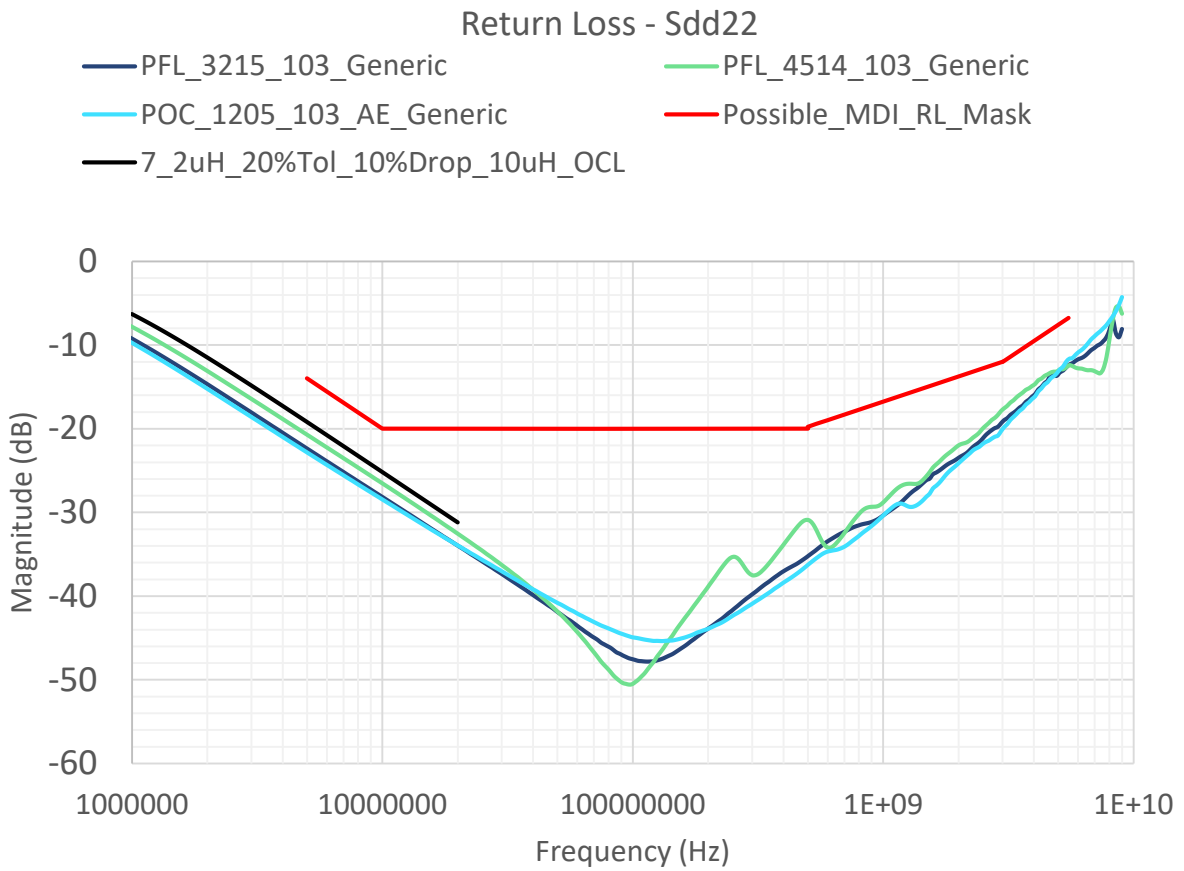
Part Number	Inductance (uH)	Tolerance (%)	Dimensions (mm)	Core Volume (mm^3)	Max. Ambient Temp (20℃ rise)	Current Rating (20℃ rise)
PFL3215-153	15	+/- 20%	3.2 X 2.3 X 1.5	11.04	105℃	240mA
PFL3215-103	10	+/- 20%	3.2 X 2.3 X 1.5	11.04	105℃	300 mA
PFL3215-682	6.8	+/- 20%	3.2 X 2.3 X 1.5	11.04	105℃	370mA
PFL4514-153	15	+/- 20%	4.9 X 3.4 X 1.4	23.32	105℃	440mA
PFL4514-103	10	+/- 20%	4.9 X 3.4 X 1.4	23.32	105℃	490mA
PFL4514-682	6.8	+/- 20%	4.9 X 3.4 X 1.4	23.32	105℃	860 mA
1205POC-103	10	+/- 20% *	3.2 X 1.4 X 2.36	10.57	125℃	420mA- 20% Drop
1205POC-682	6.8	+/- 20% *	3.2 X 1.4 X 2.36	10.57	125℃	500mA *

- For Same Core Volume and Material, Higher Inductance comes at the cost of Lower Current

* Estimated Value for preliminary samples

Return Loss (Sdd22) – Higher Inductances





- Current Capacity sacrificed for Low Frequency Return Loss

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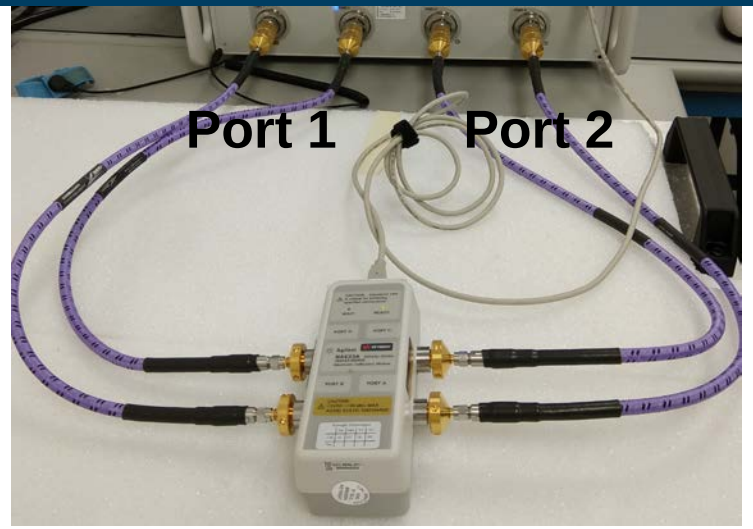
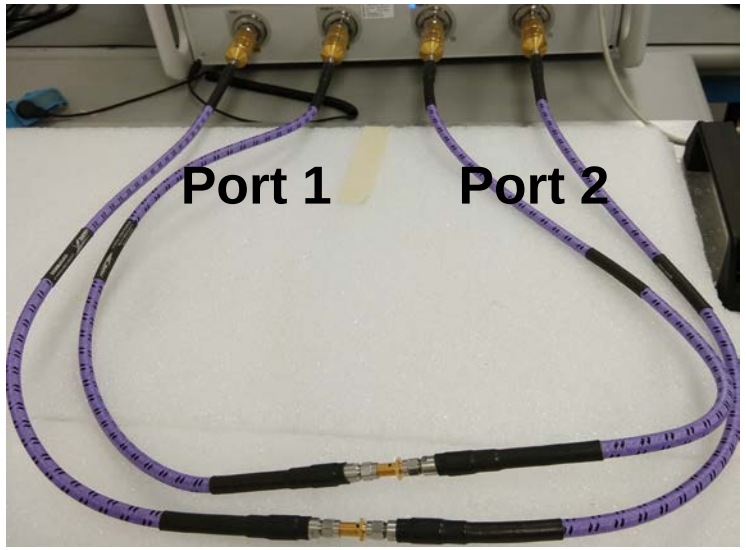
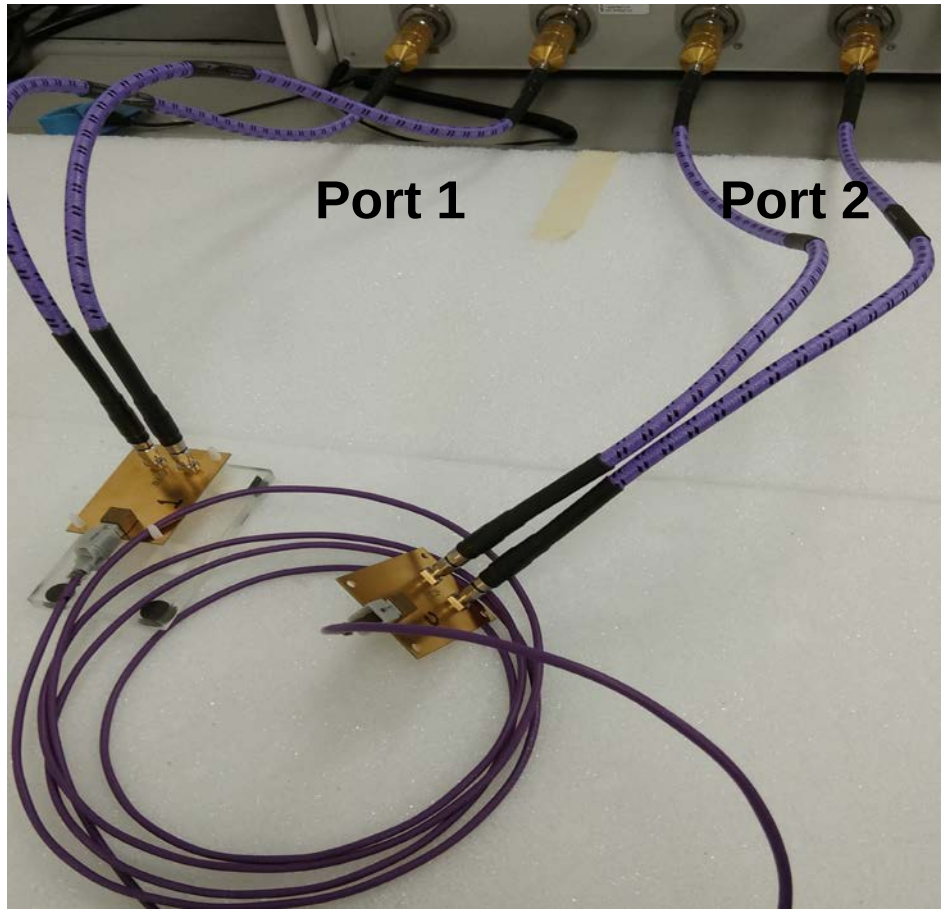
Test Fixtures with Inductors and Prototype MDI Connectors – Thru Configuration



Calibration- “E-Cal”



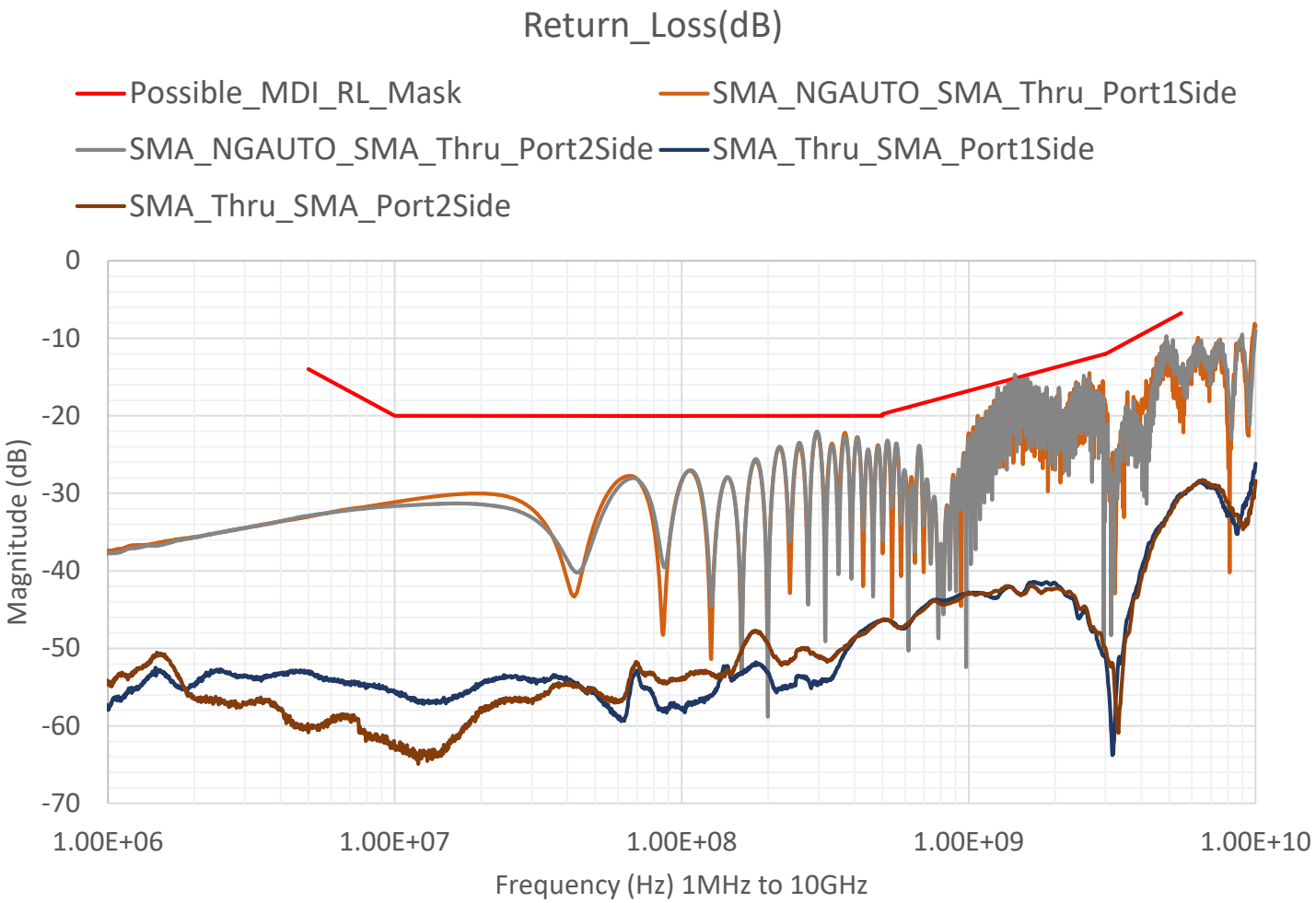
Baseline 1: SMA Thru Connection- “SMA_Thru_SMA”

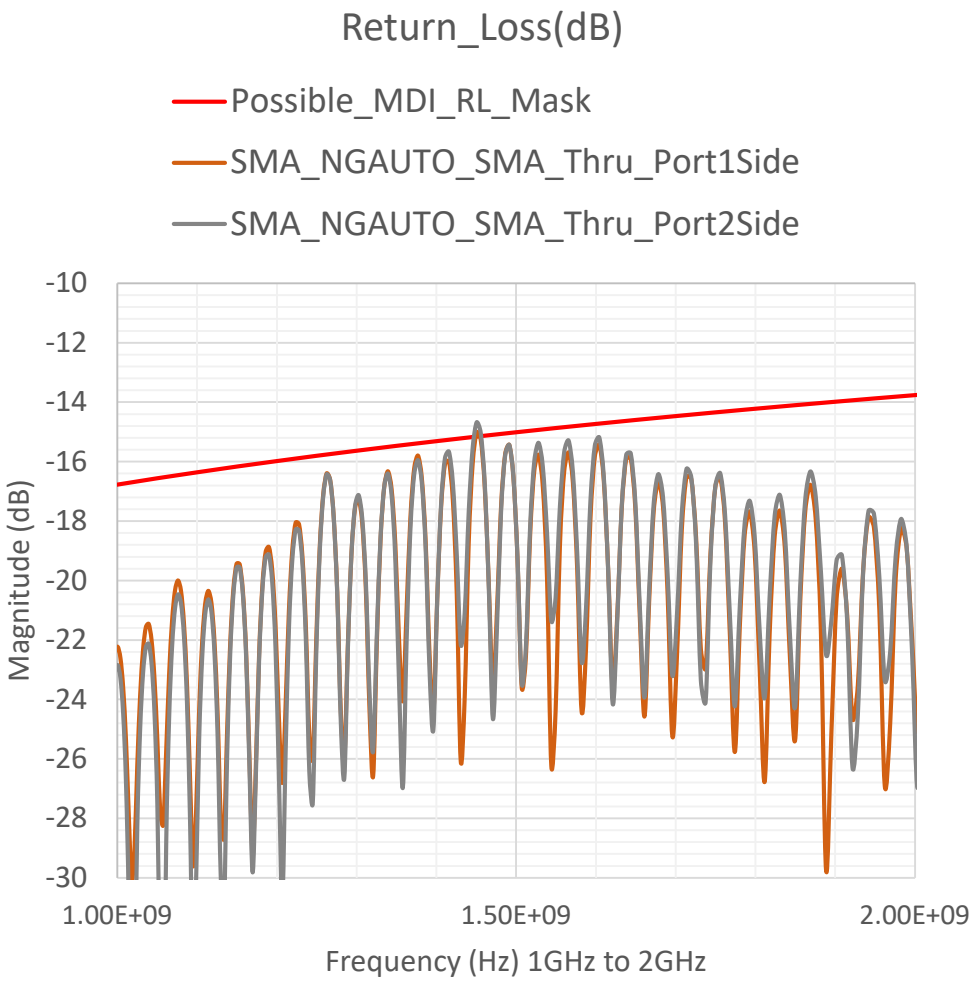


Baseline 2: Thru with NGAUTO Connector and Cable boards- “SMA_NGAUTO_SMA_Thru”

*** 3 meter STP Cable between Connectors**

Baseline Measurement





- Baseline insufficient
- 3mt long STP cable- Not strictly “MDI only”

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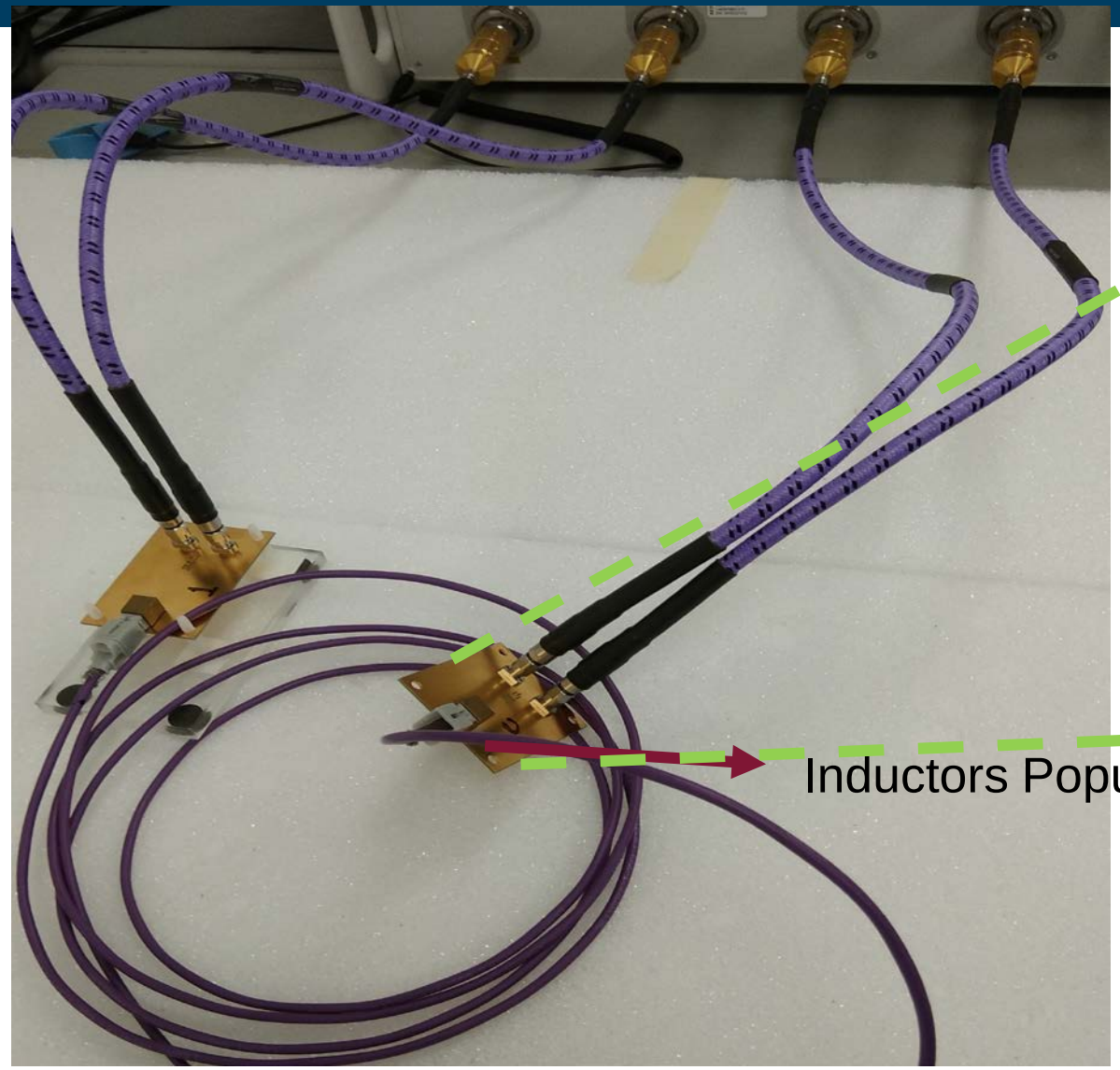
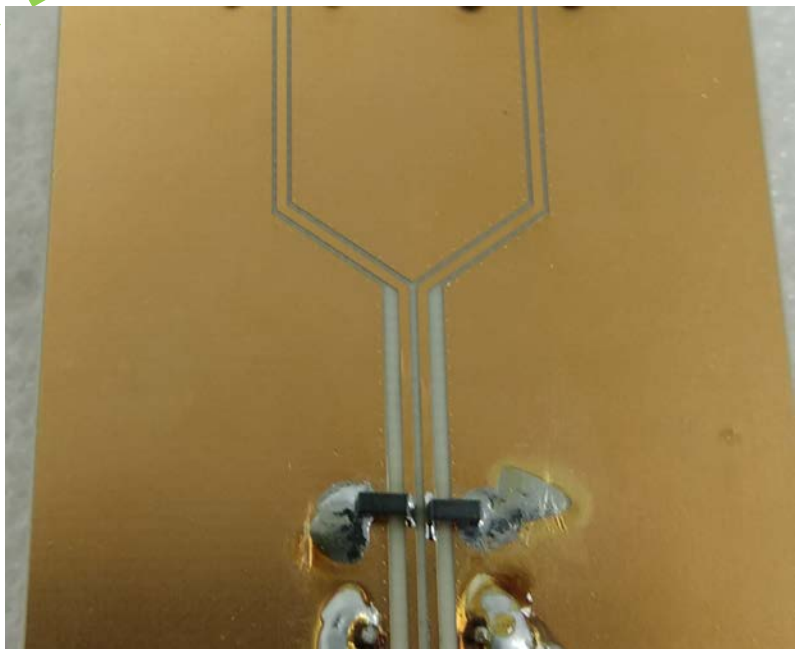
Test Fixtures with Inductors and Prototype MDI Connectors – Thru Configuration

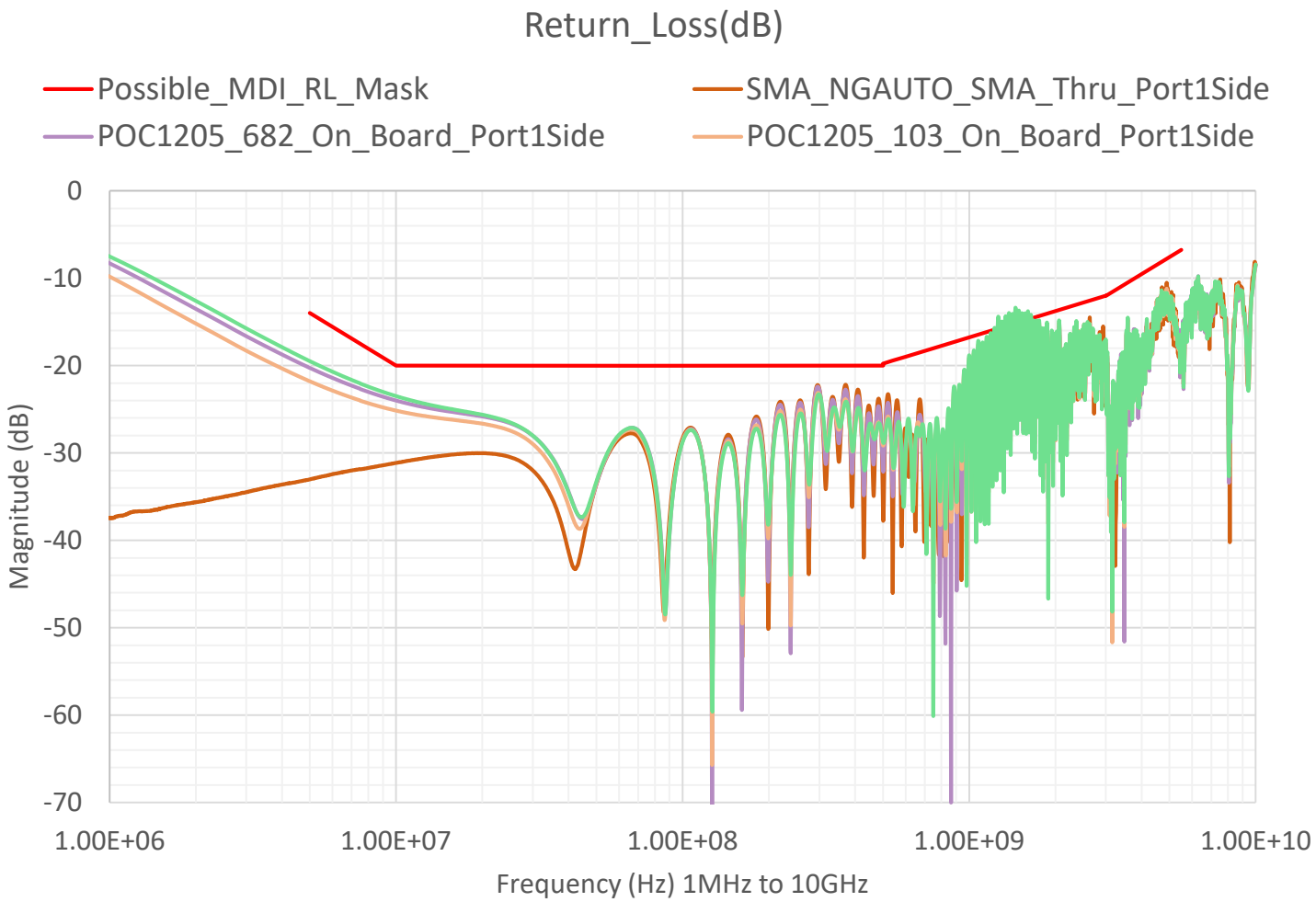


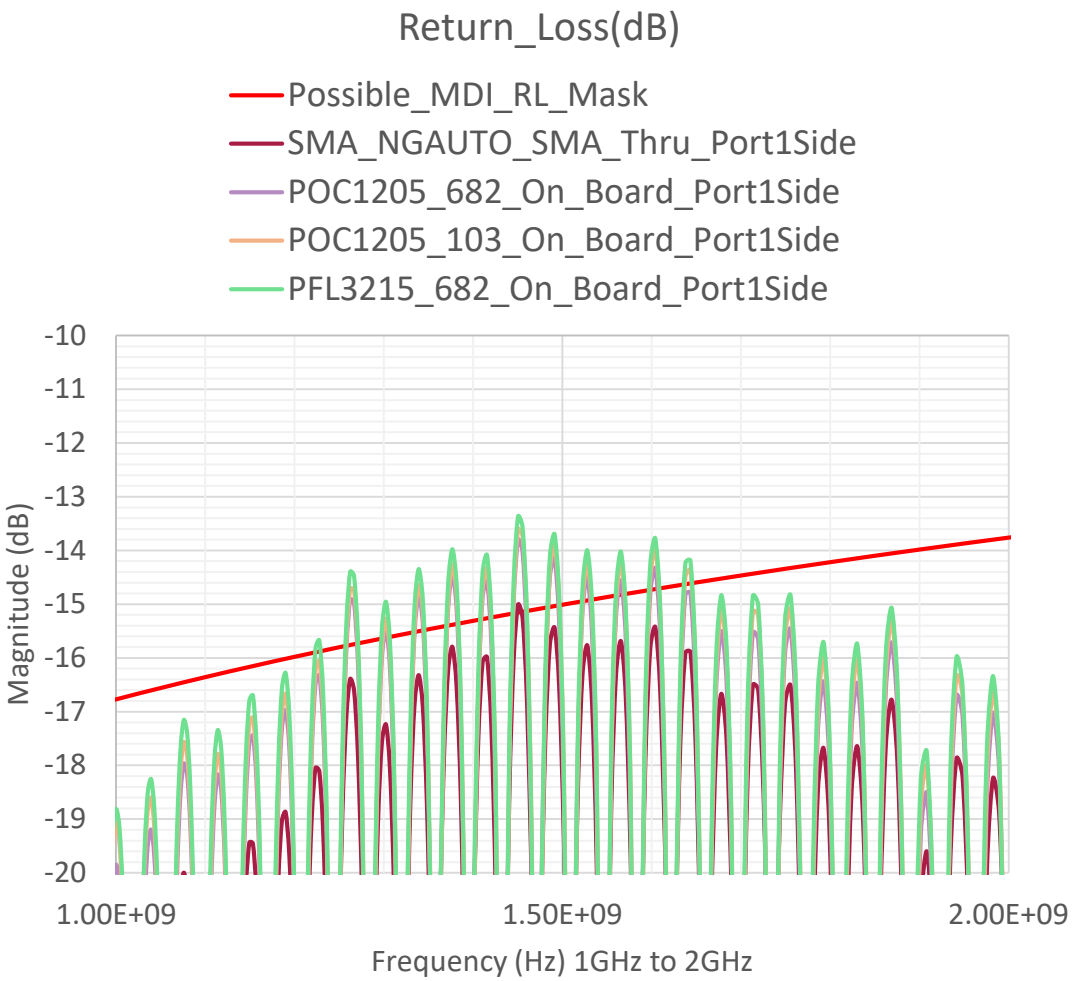


Inductors Populated on Port 2 side

*** 3 meter STP Cable between Connectors**

Return Loss Measurement with Coupling Inductors





- About 1dB to 2.5dB worsening of Return Loss due to Inductors from 1GHz to 2GHz
- Cable Insertion Loss comes into picture for Port1 Side measurements

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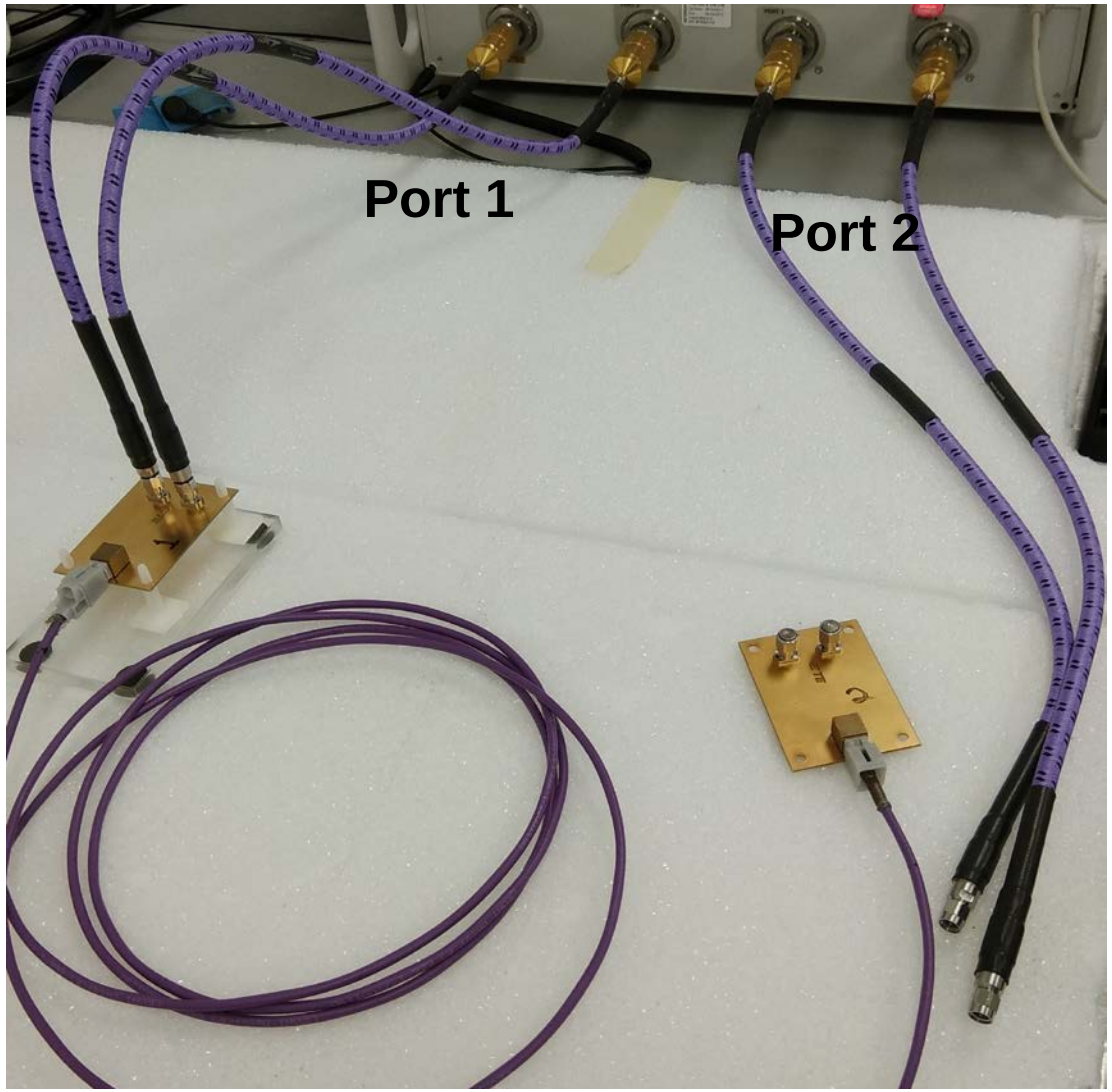
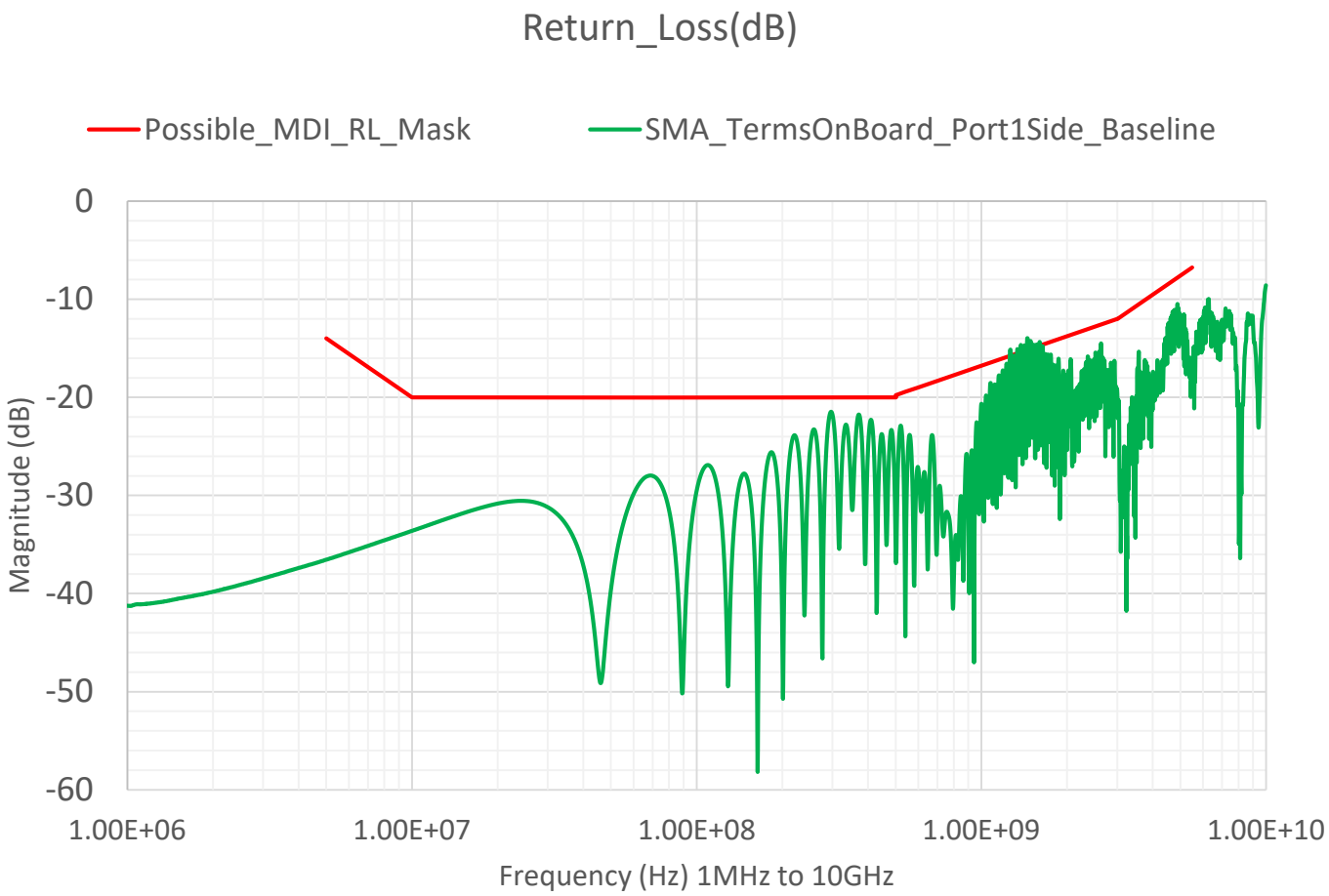
Test Fixtures with Inductors and Prototype MDI Connectors – Reflected Configuration

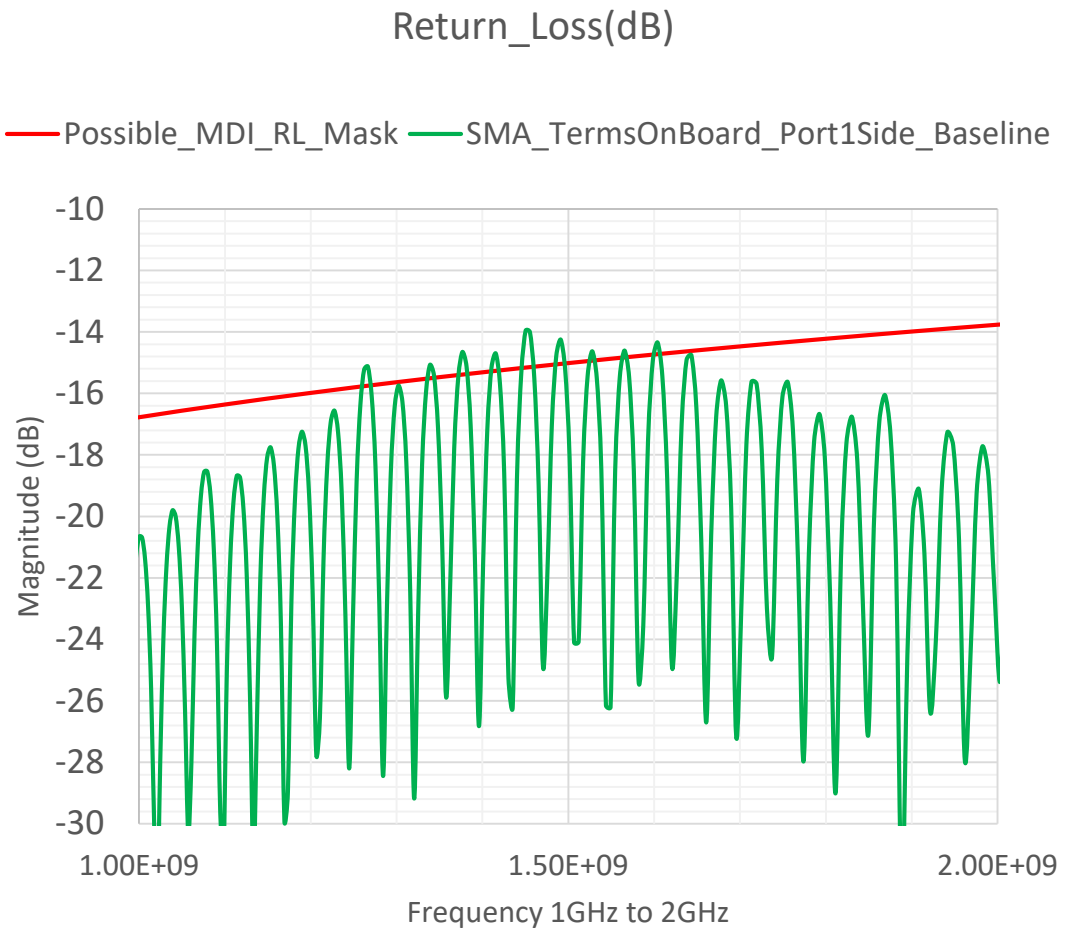


Baseline: 50 ohm SMA terminations on NGAUTO Boards “SMA_NGAUTO_SMA_Term” for reflected only measurements

*** 3 meter STP Cable between Connectors**

Baseline Measurement





- Baseline insufficient
- 3mt long STP cable- Not strictly “MDI only”

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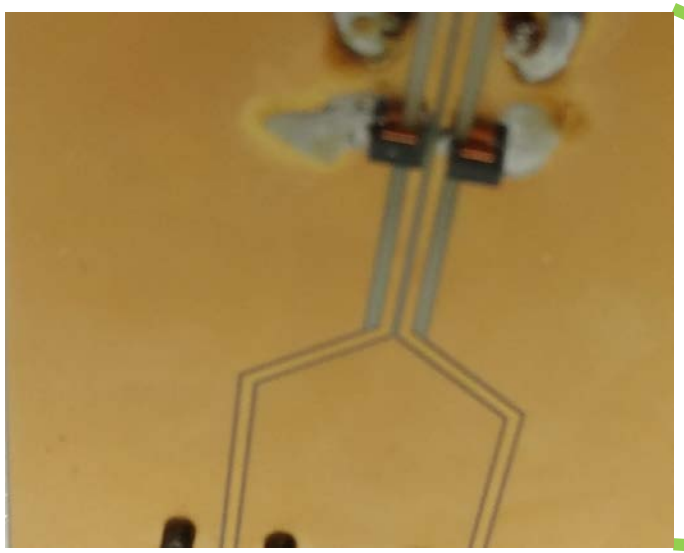
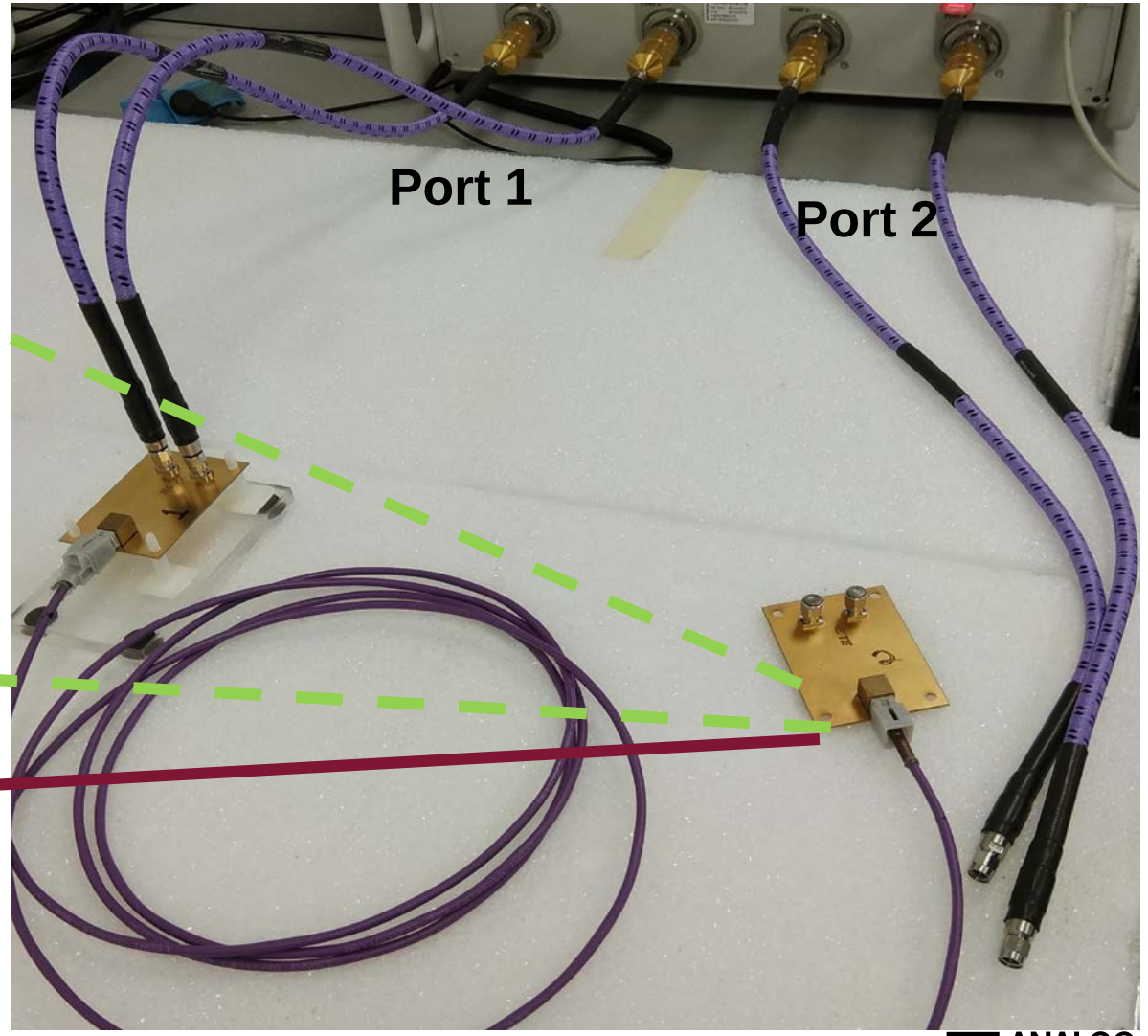
Test Fixtures with Inductors and Prototype MDI Connectors – Reflected Configuration

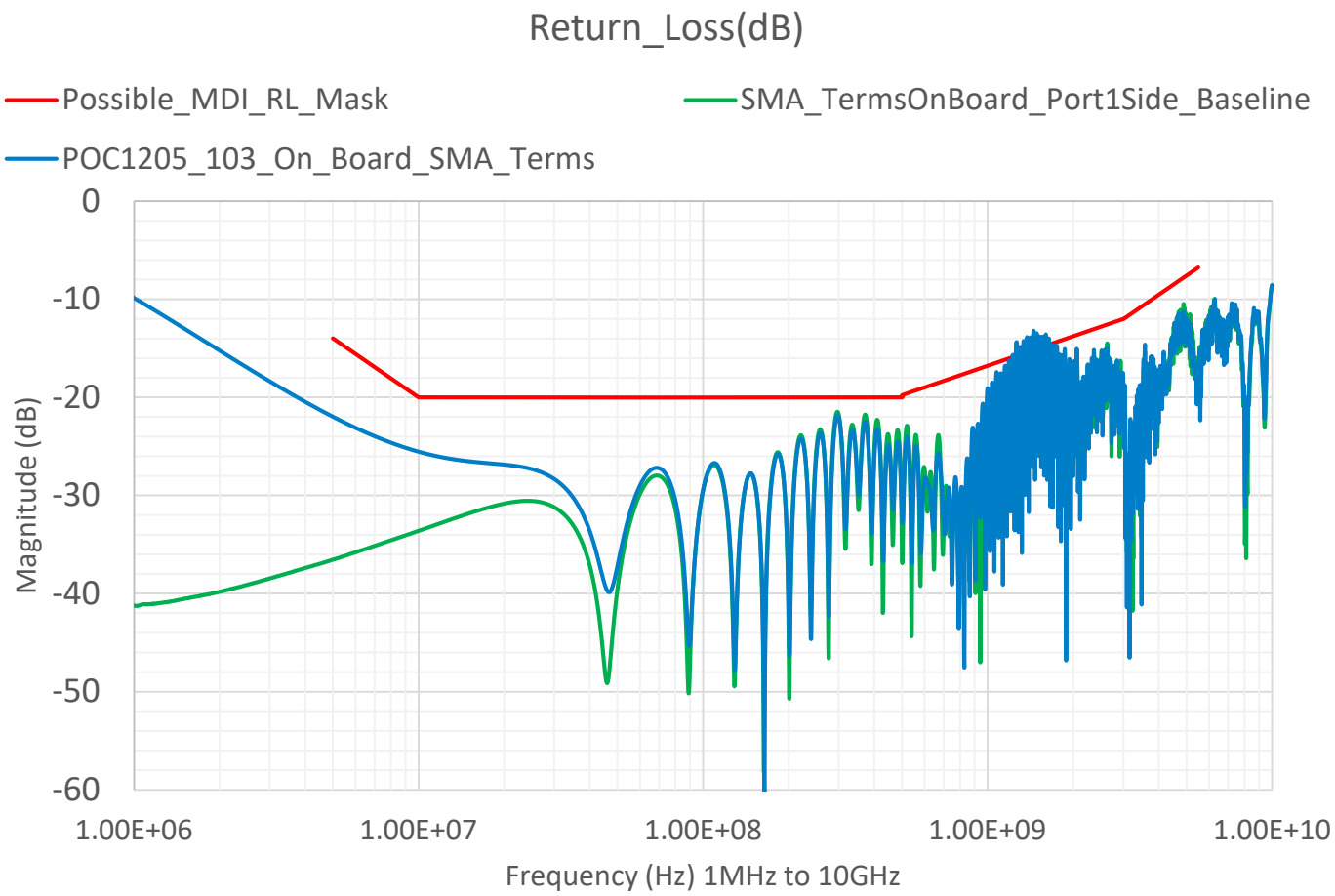


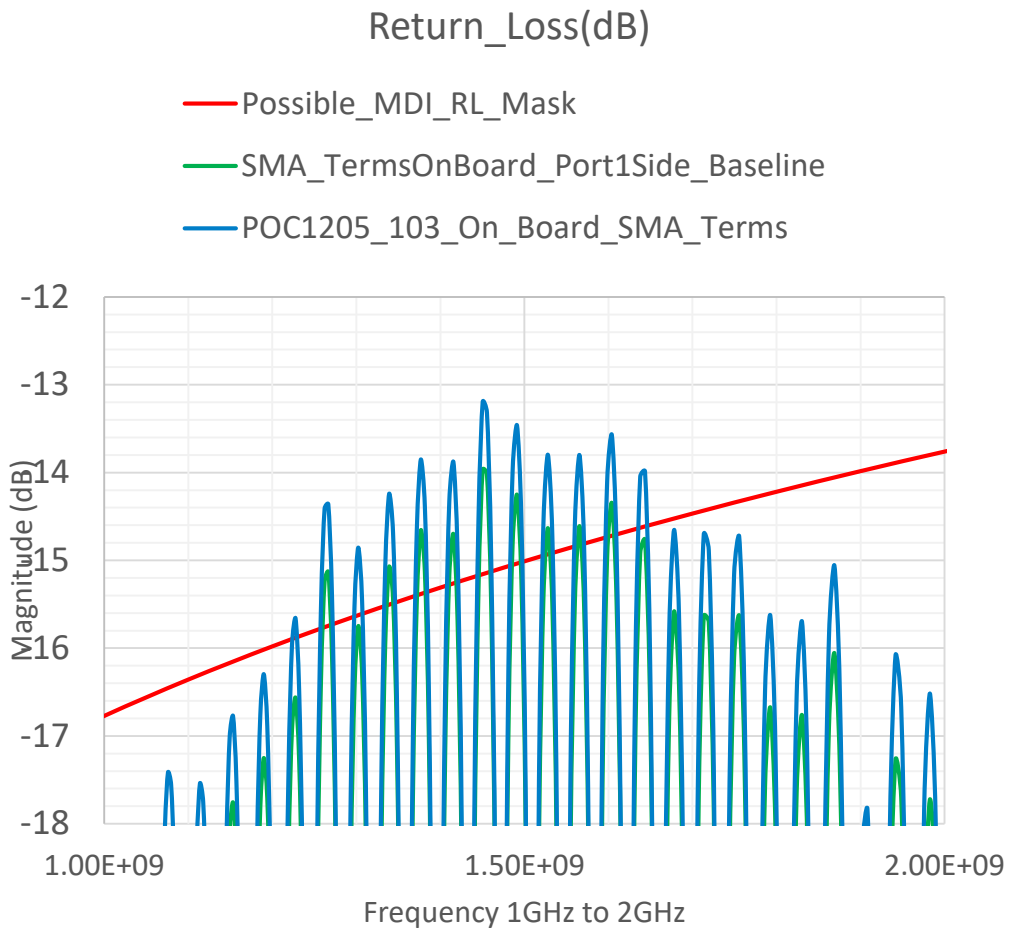


Inductors Populated
on Port 2 side

*** 3 meter STP Cable between Connectors**

Return Loss Measurement with Coupling Inductors





- About 0.5 to 1dB worsening of Return Loss due to Inductors from 1GHz to 2GHz

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Conclusion

- Suggested MDI Return Loss Mask may be technically feasible
- Need to measure a closer approximation of “MDI Only” configuration- Improved Baselines
  - Improvements such as Shorter STP Cable in the test fixtures

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Thank You!

QUESTIONS? FEEDBACK?

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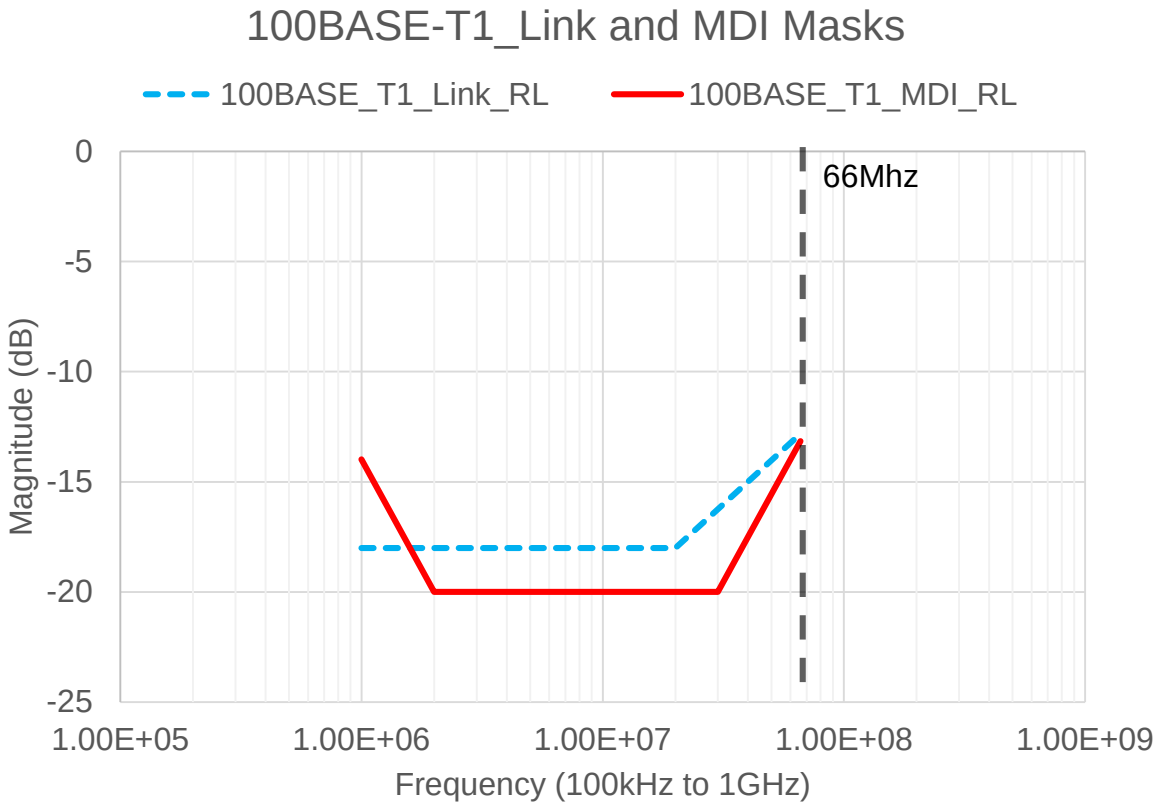
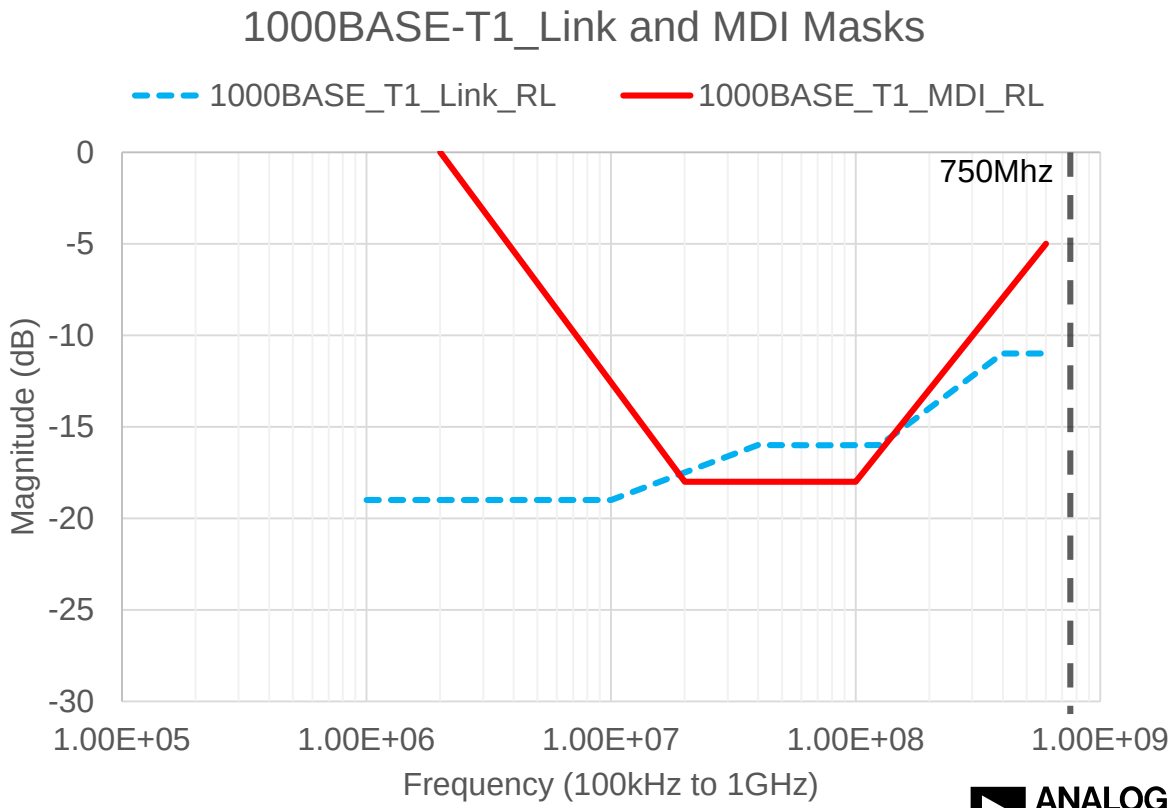
Backup Slides

MDI versus Link Return Loss: 100BASE-T1 and 1000BASE-T1

- Reference: 802.3bw with PoDL
- Return Loss
  - Return Loss Mask Limited at Max. Baud Rate of 66MHz (PAM3)



- Reference: 802.3bp
- Return Loss
  - Return Loss Mask Limited at 600MHz under Max. Baud Rate of 750MHz (PAM3)



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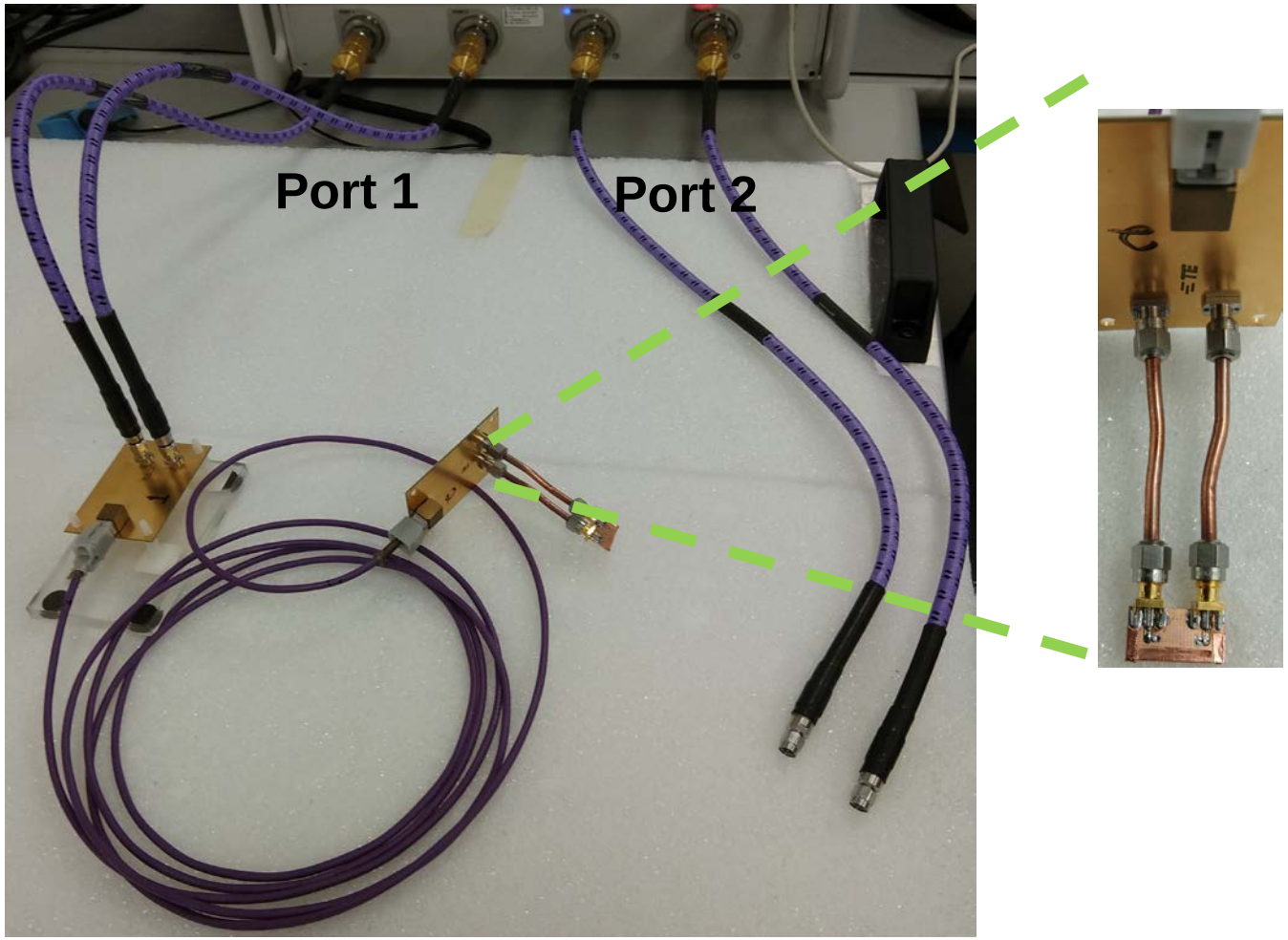
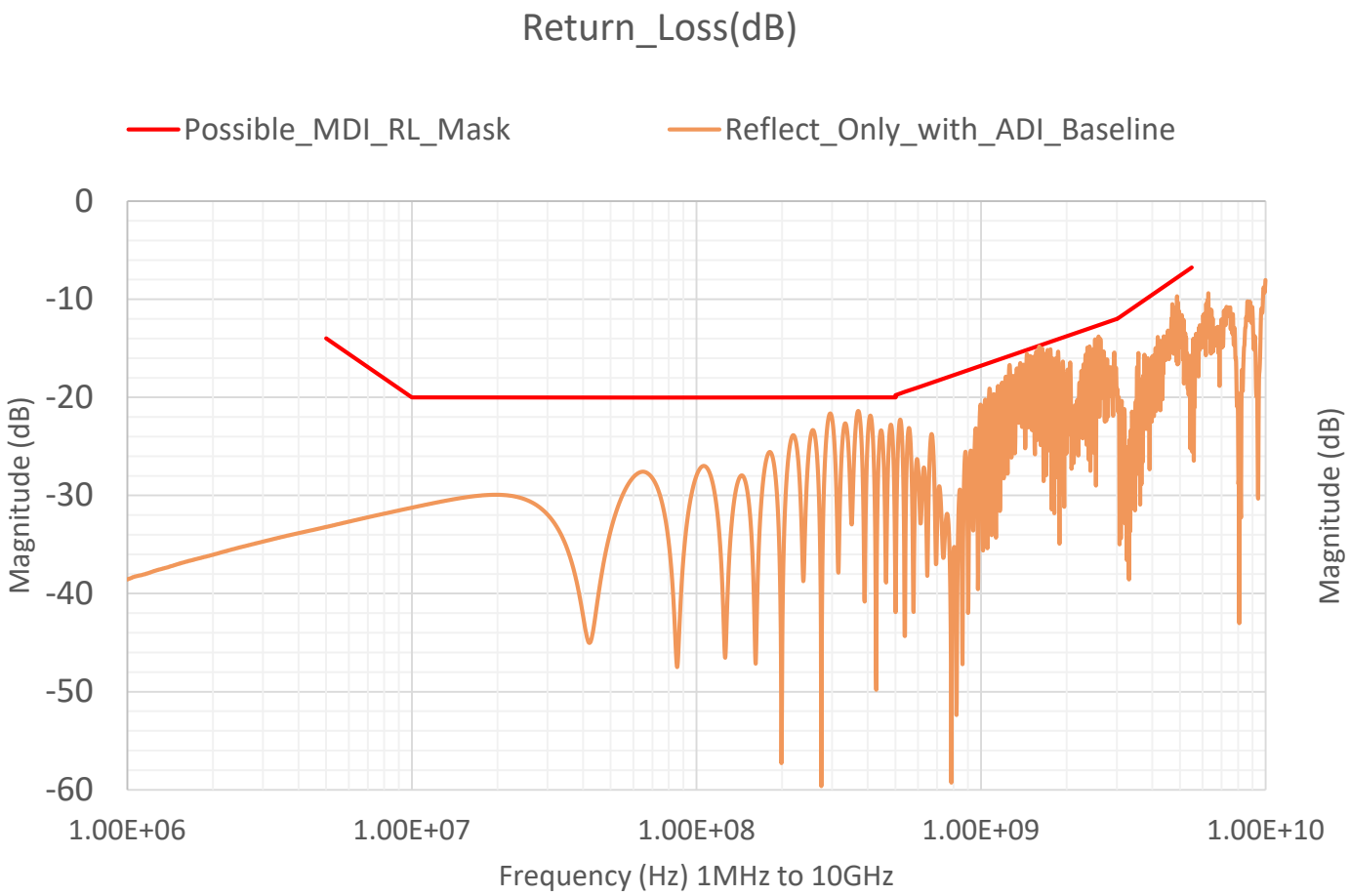
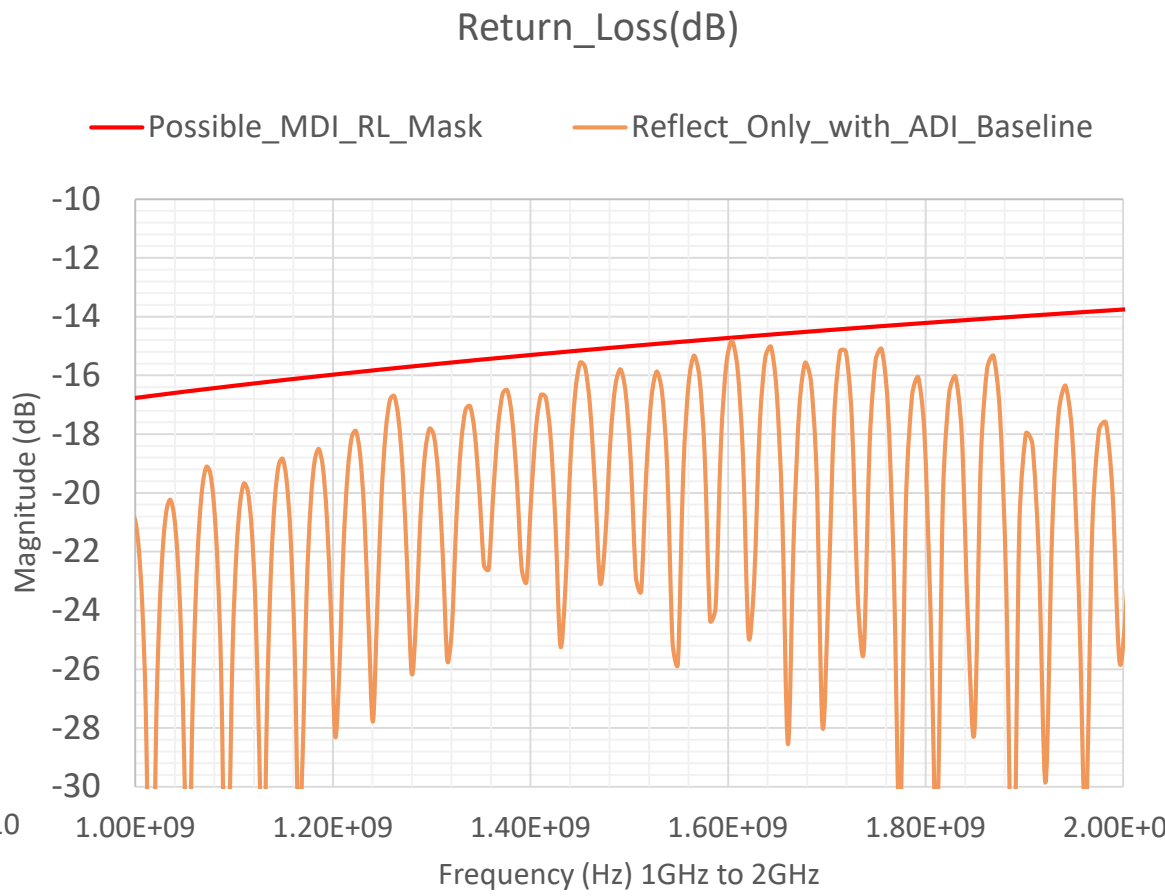
Test Fixtures with Inductors on Copper Clad Boards and Prototype MDI Connectors – Reflected Configuration



Baseline: 50 ohm terminations on Copper boards “SMA_NGAUTO_Rigid_Cu_Term”

Baseline Measurement





- Baseline marginal
- 3mt long STP cable- Not strictly “MDI only”

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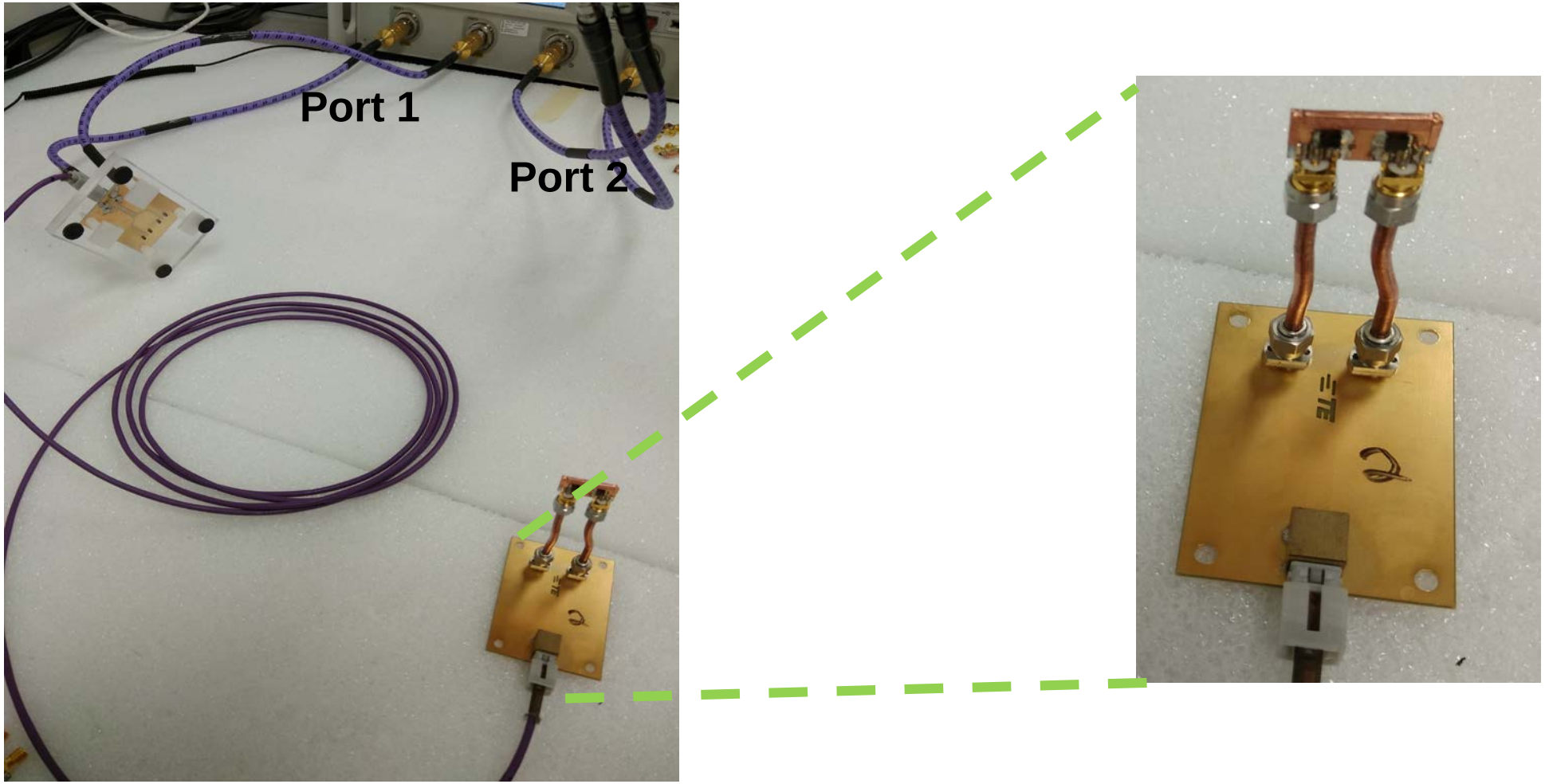
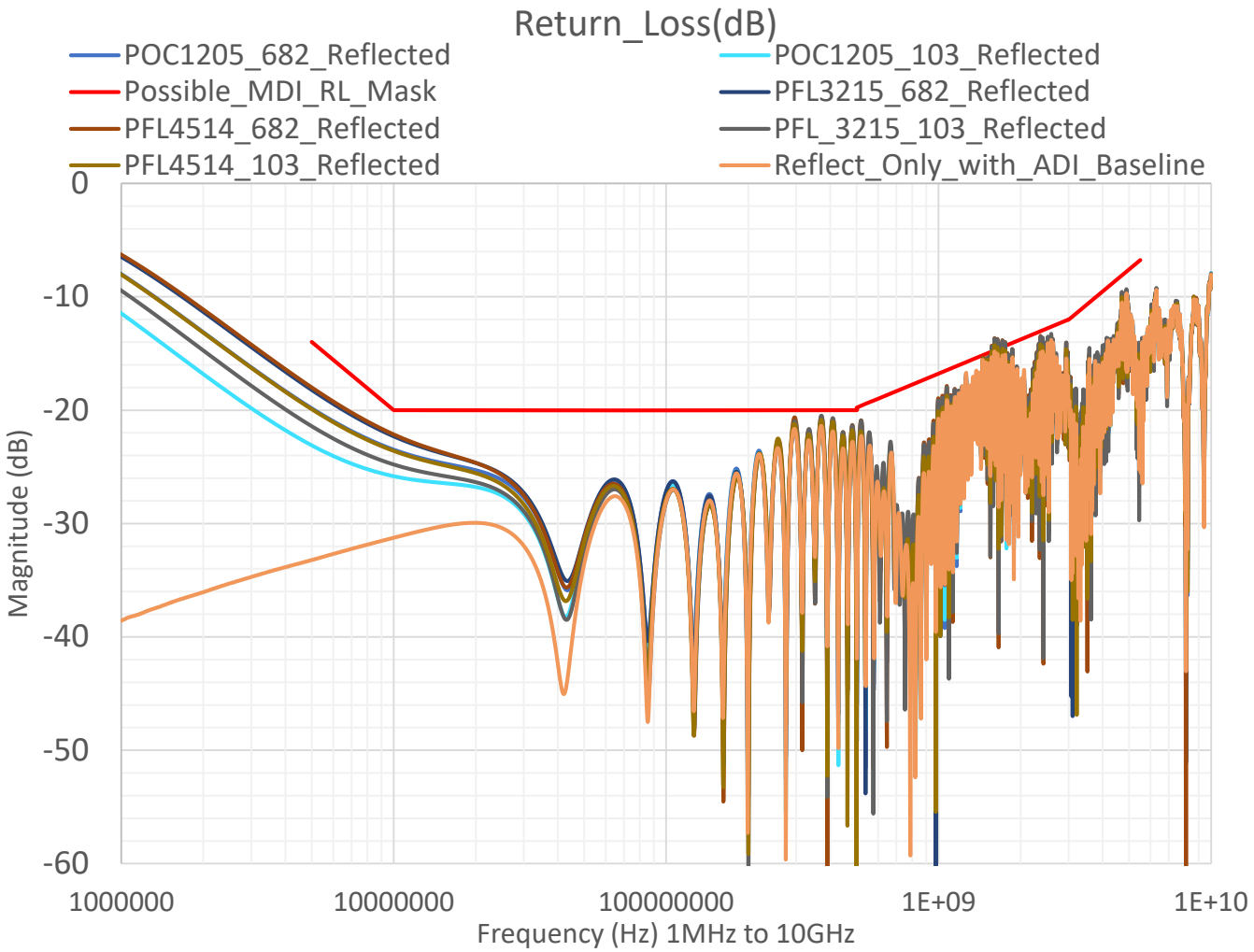
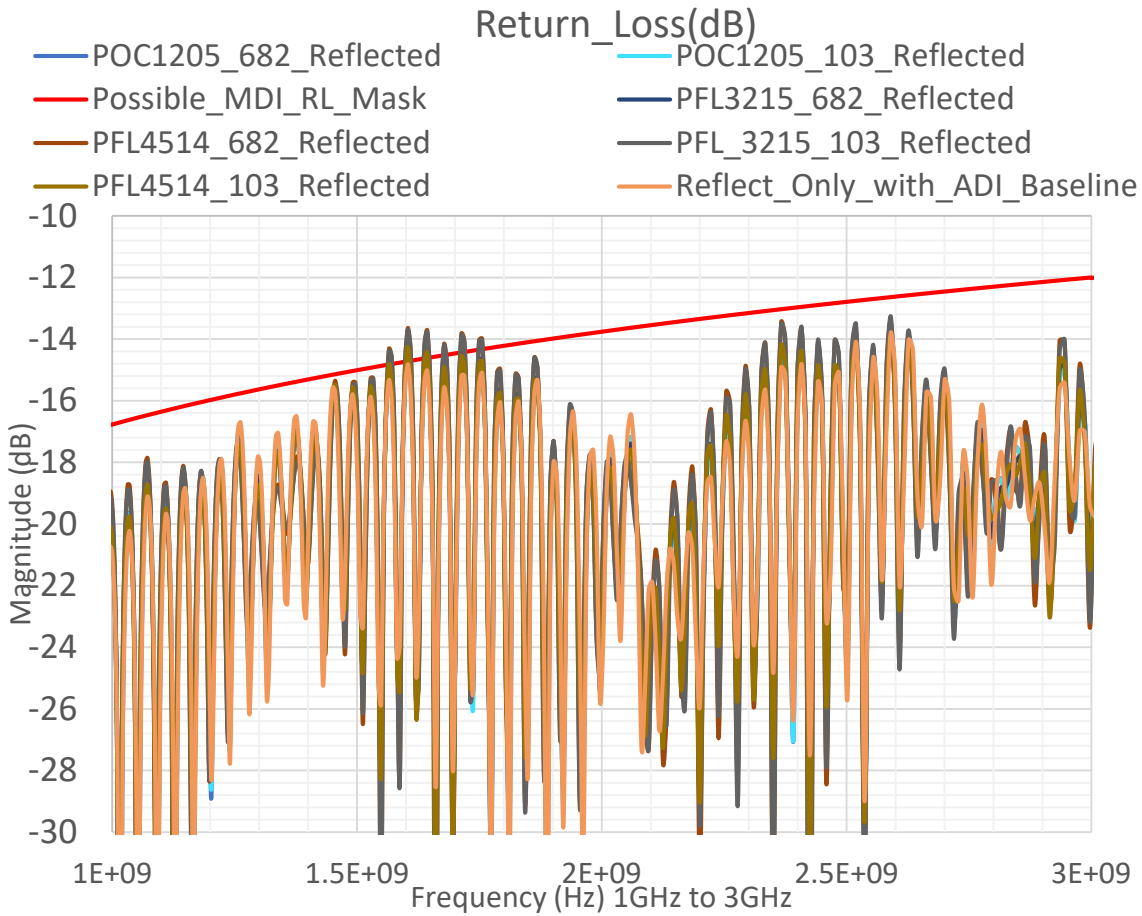
Test Fixtures with Inductors on Copper Clad Boards and Prototype MDI Connectors – Reflected Configuration



“Reflected Only” configuration with Coupling Inductors and Terminations on Copper Boards

Return Loss Measurement with Coupling Inductors





- About 0.8dB worsening of Return Loss due to Inductors from 1GHz to 2GHz

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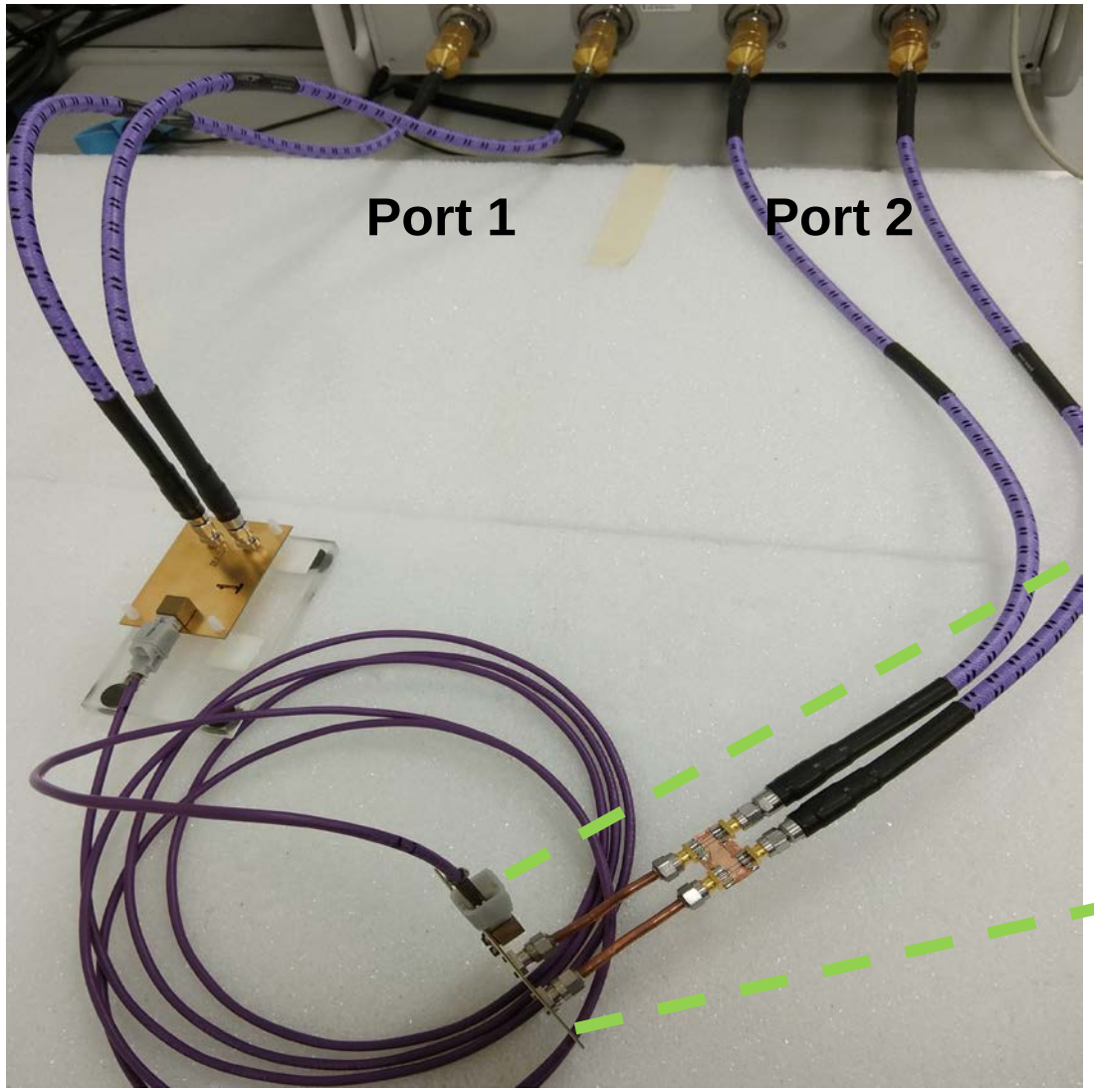
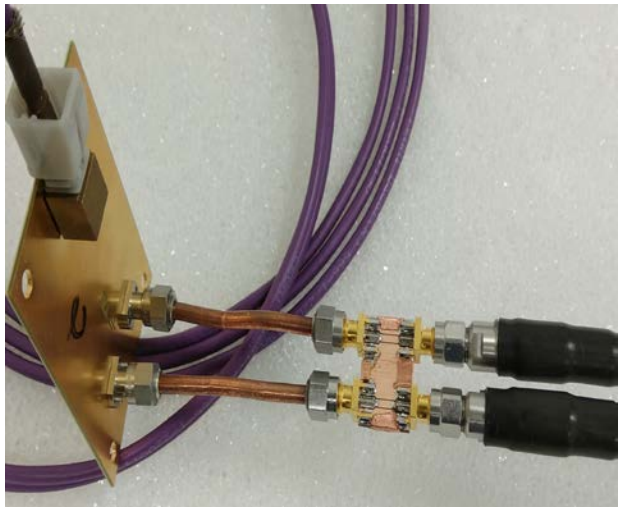
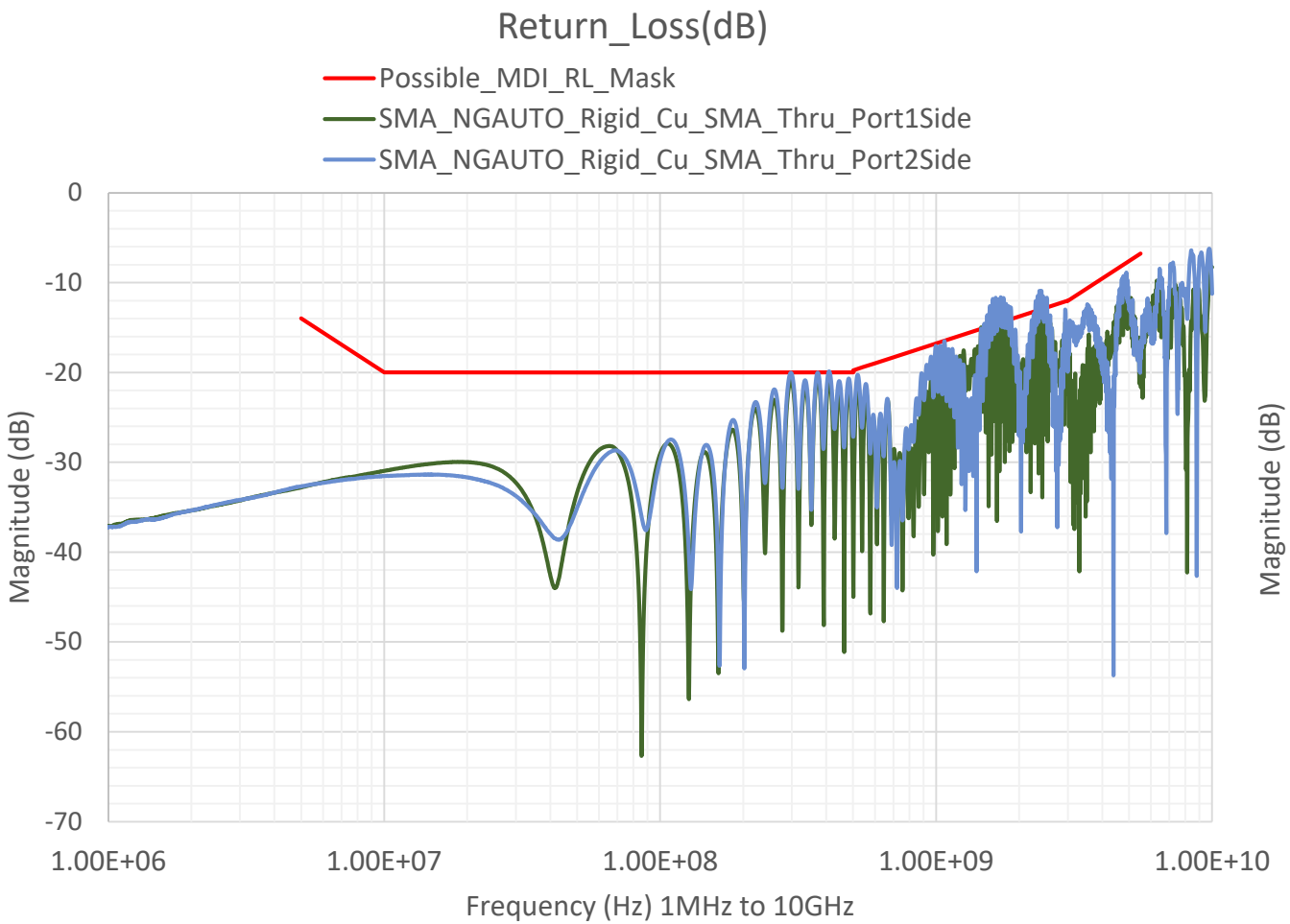
Test Fixtures with Inductors on Copper Clad Boards and Prototype MDI Connectors – Thru Configuration

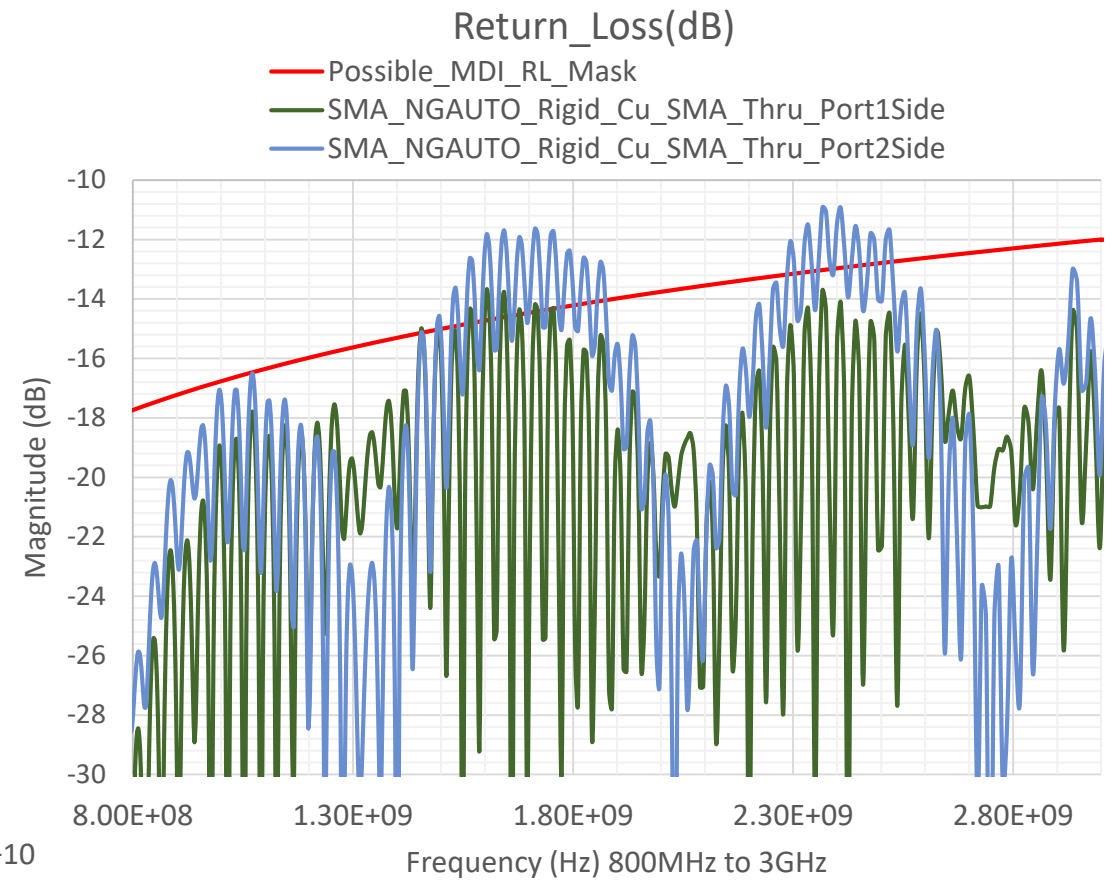




Baseline: Thru with NGAUTO boards, SMA rigid links and Copper boards
“SMA_NGAUTO_Rigid_Cu_SMA_Thru”

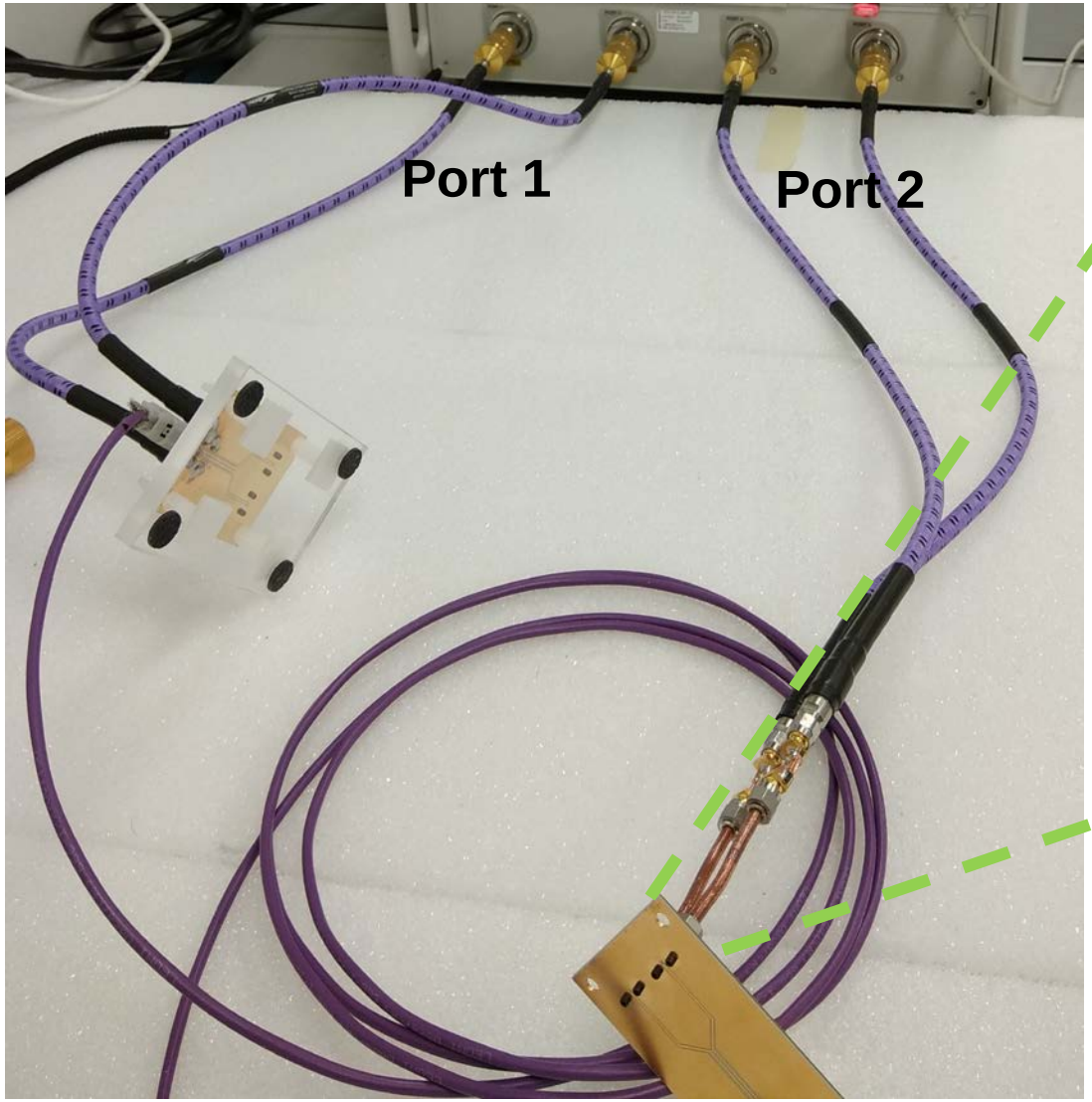
Baseline Measurement

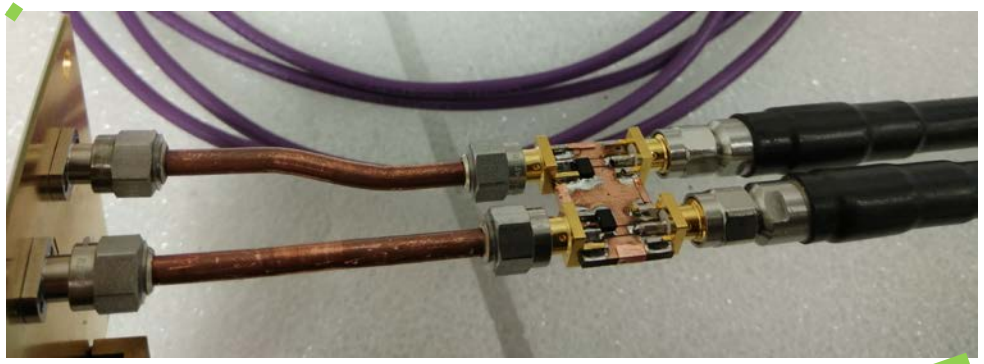




- Baseline marginal, 3mt long STP cable- Not strictly “MDI only”
- Poor Return Loss of Copper Clad Thru Board

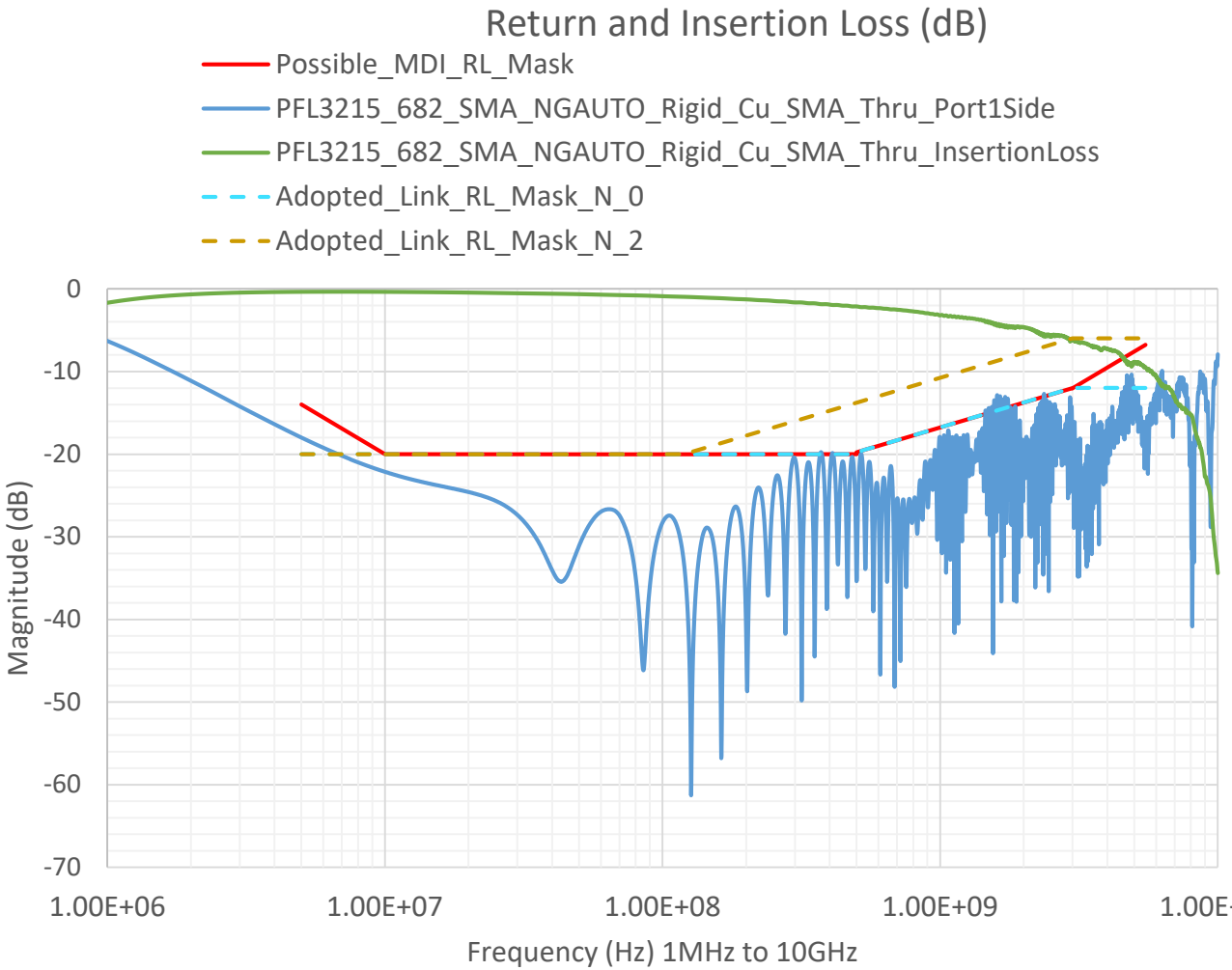
Test Fixtures with Inductors on Copper Clad Boards and Prototype MDI Connectors – Thru Configuration

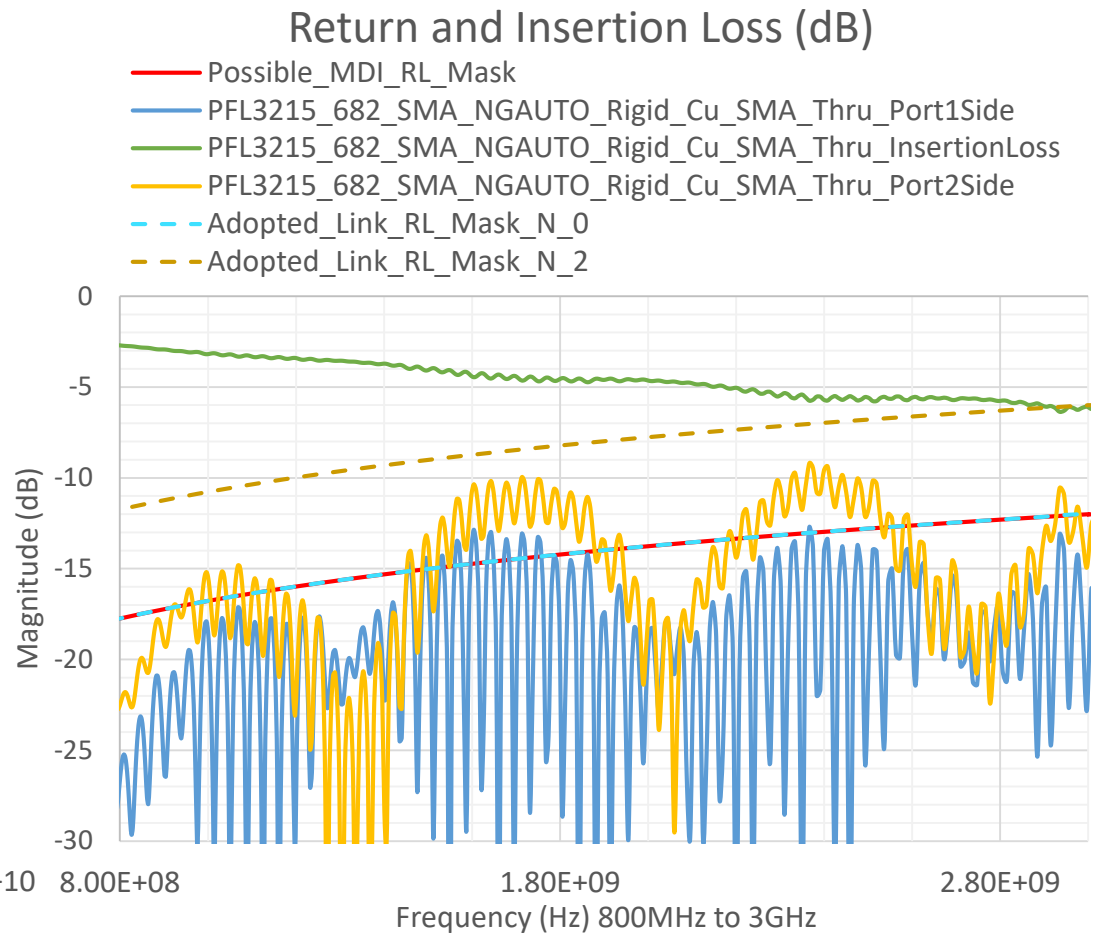




Thru with NGAUTO boards, SMA rigid links and Inductors mounted on Copper boards
“SMA_NGAUTO_Rigid_Cu_SMA_Thru”

Return Loss Measurement with Coupling Inductors





- Baseline marginal, 3mt long STP cable- Not strictly “MDI only”
- Poor Return Loss of Copper Clad Board with Inductors mounted

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