Proposal for Relaxed MDI Return Loss Limit and Results of Prototype PoDL Coupling Network for 1000BASE-T1

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Presentation Objectives

- To propose a relaxed MDI return loss limit for IEEE P802.3bp in order to make PoDL economically feasible.

- To review the measured performance of a PoDL coupling network circuit prototype.

- To propose next steps for demonstrating an economically feasible, compliant PoDL coupling network using improved circuit optimization and/or further relaxation of the low frequency MDI return loss specification.

MDI Return Loss Limits

- MDI return loss equation 97-29 was relaxed below 20MHz for equation (104-3) in order to make 1000BASE-T1 PoDL coupling inductors economically feasible.

- Propose that equation (104-3) be adopted as the new equation for (97-29).

$$MDI\ RL\ (dB) \geq \begin{cases} 18 - 18 \times log_{10}\left(\dfrac{20}{f}\right) & 2 \leq f < 20 \\ 18 & 20 \leq f < 100 \\ 18 - 16.7 \times log_{10}\left(\dfrac{f}{100}\right) & 100 \leq f < 600 \end{cases}$$

where f is frequency in MHz

MDI Return Loss Limits

Clause 104 D2.0 MDI Return Loss Limit Line (Equation 104-3)

Clause 97 MDI Return Loss Limit (Equation 97-29)
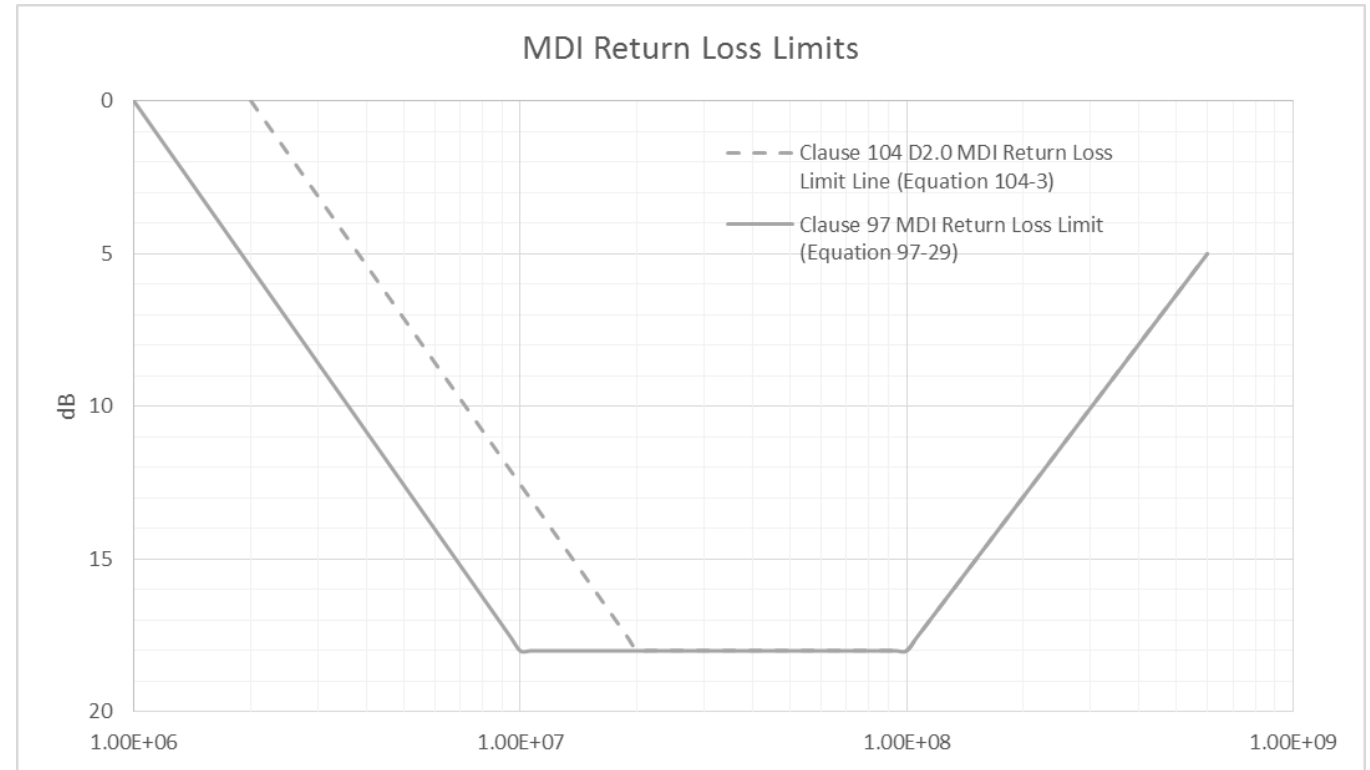
Requirements for PoDL Coupling Network

- Meet proposed MDI return loss and mode conversion loss specifications with sufficient margin for economic feasibility.

- Provide total DCR < 2 ohms and saturation current greater than 400mA.

- Achieve a low enough solution cost and footprint in order to be economically feasible.
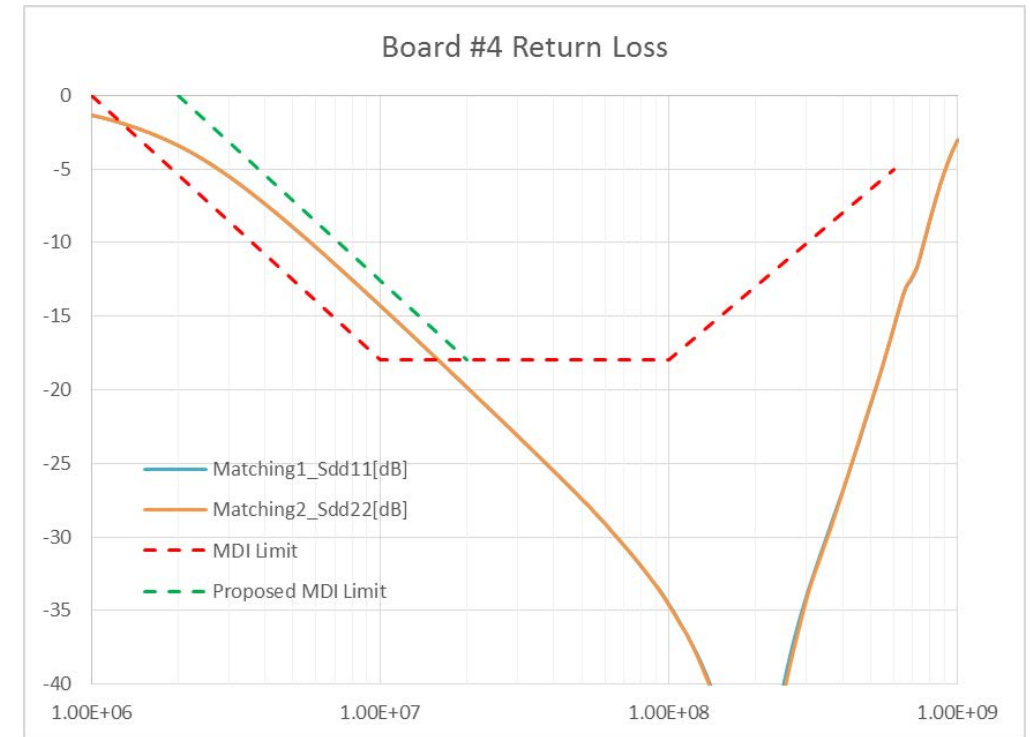
PoDL Coupling Network Test Setup

- The following setup was used to measure the performance of the PoDL coupling network prototype.
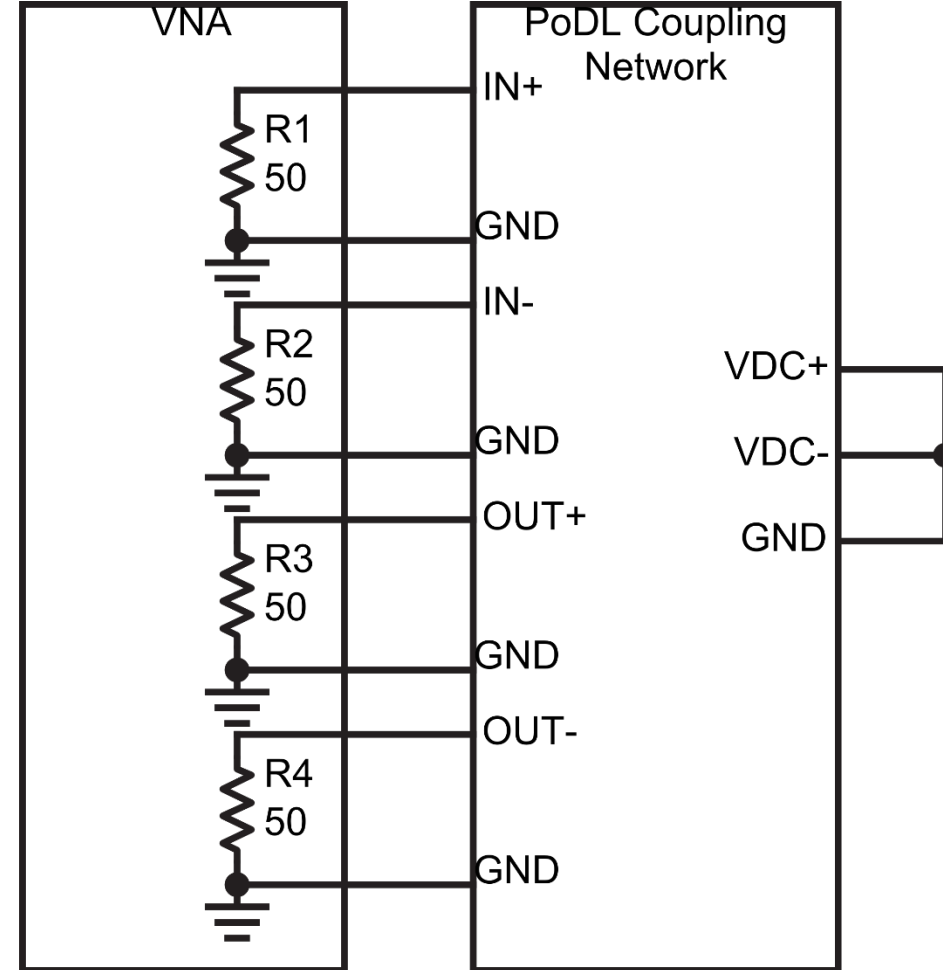
Note: Initial prototype used SMA connectors and coax cables to facilitate evaluation; final prototype board will use UTP connectors and cables.

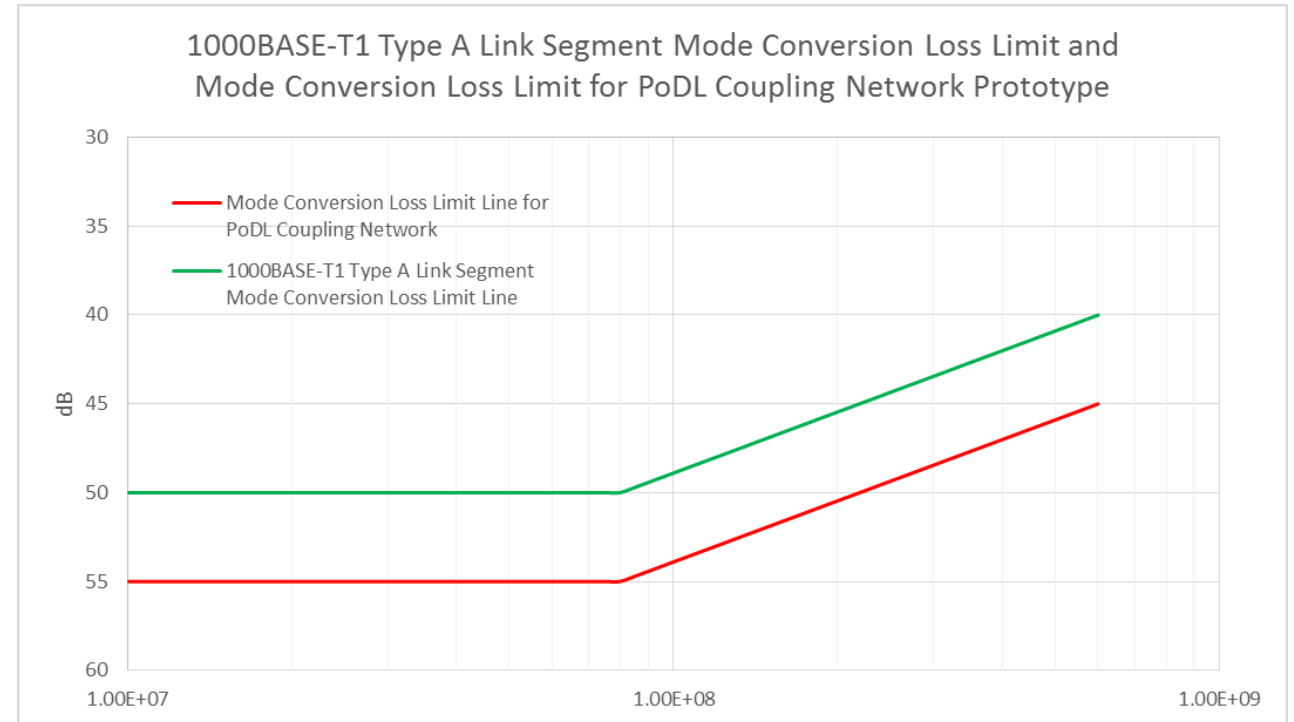# Measured Return Loss Data for PoDL Coupling Network Prototype

- Return loss limit was met by prototype, but compensation of 1uH coupled inductors was still required to ensure the proposed spec was met with adequate margin up to 600MHz.

- Compensation of the coupled inductors with unmatched components tends to result in mode conversion.
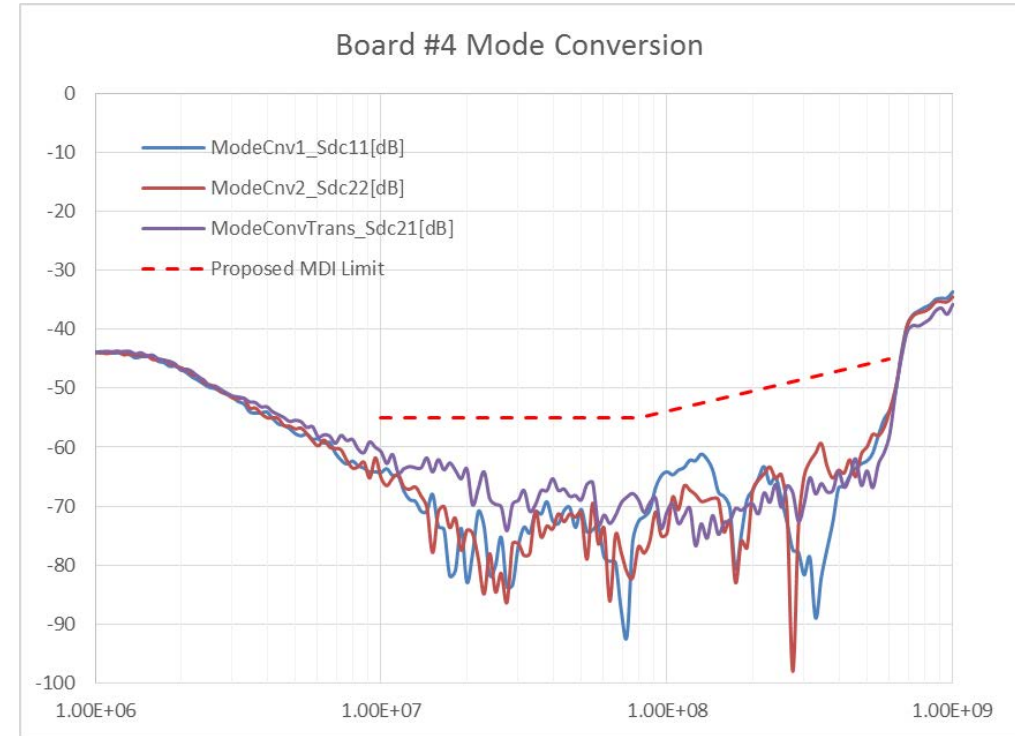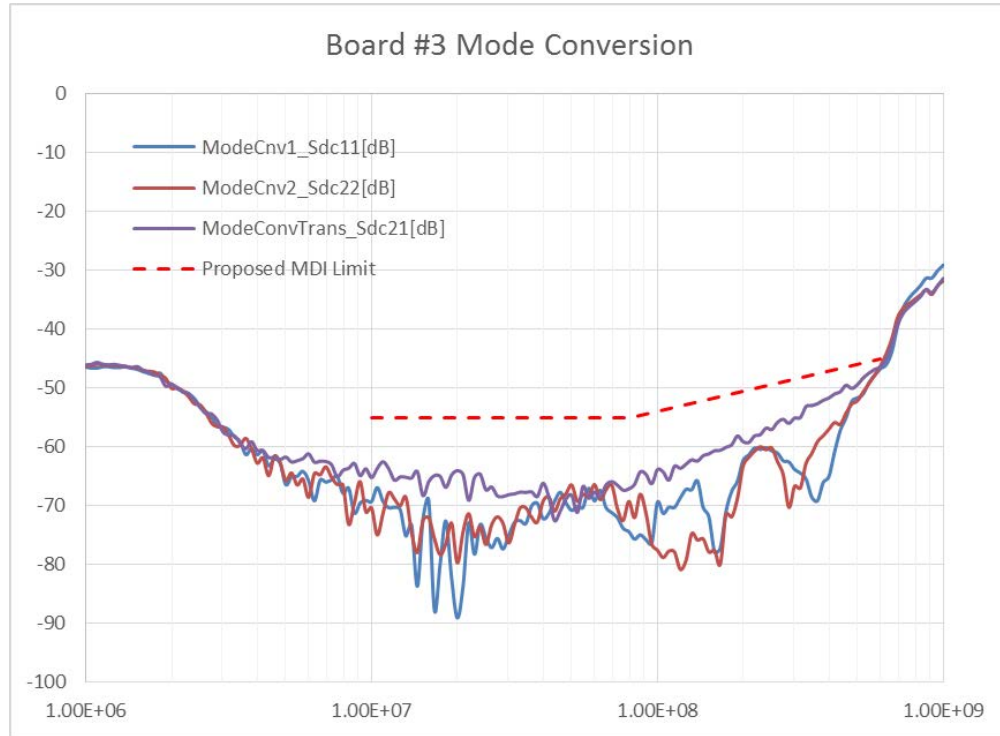
Mode Conversion Loss Limits

- There currently is no MDI mode conversion loss limit in Clause 97, but the performance of the network was compared against the proposed limit in chini_3bp_1115_02a.pdf.

$$MDI\ Mode\ Conversion\ Loss\ (dB) \geq \begin{cases} 55 & 10 \leq f < 80 \\ 55 - 11.42 \times log_{10}\left(\dfrac{f}{80}\right) & 80 \leq f < 600 \end{cases}$$

where f is frequency in MHz

1000BASE-T1 Type A Link Segment Mode Conversion Loss Limit and Mode Conversion Loss Limit for PoDL Coupling Network Prototype

Mode Conversion Loss Limit Line for PoDL Coupling Network

1000BASE-T1 Type A Link Segment Mode Conversion Loss Limit Line

Measured Mode Conversion Loss Data for PoDL Coupling Network

- Mode conversion loss limit was met by prototype, but compensation of 1uH coupled inductors with discrete components resulted in little or no margin at 600MHz.
- Repeatability of the mode conversion loss performance needs to be verified over a bigger sample size.
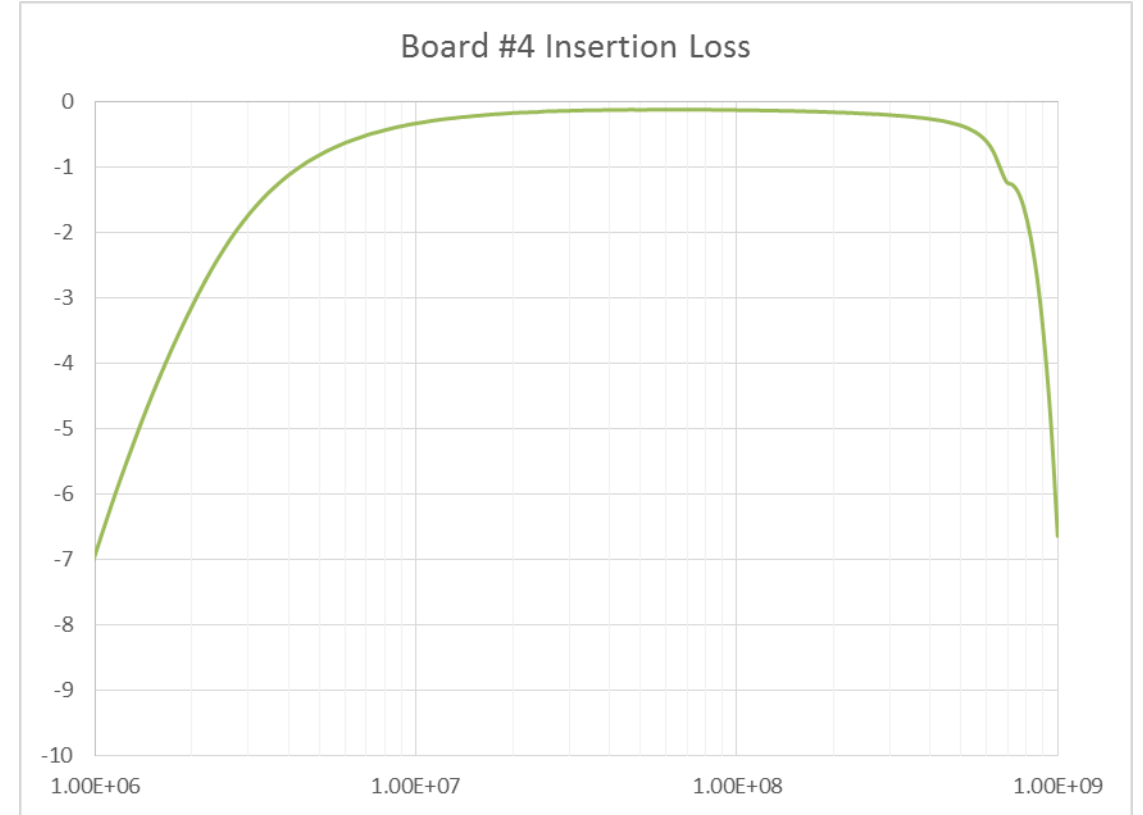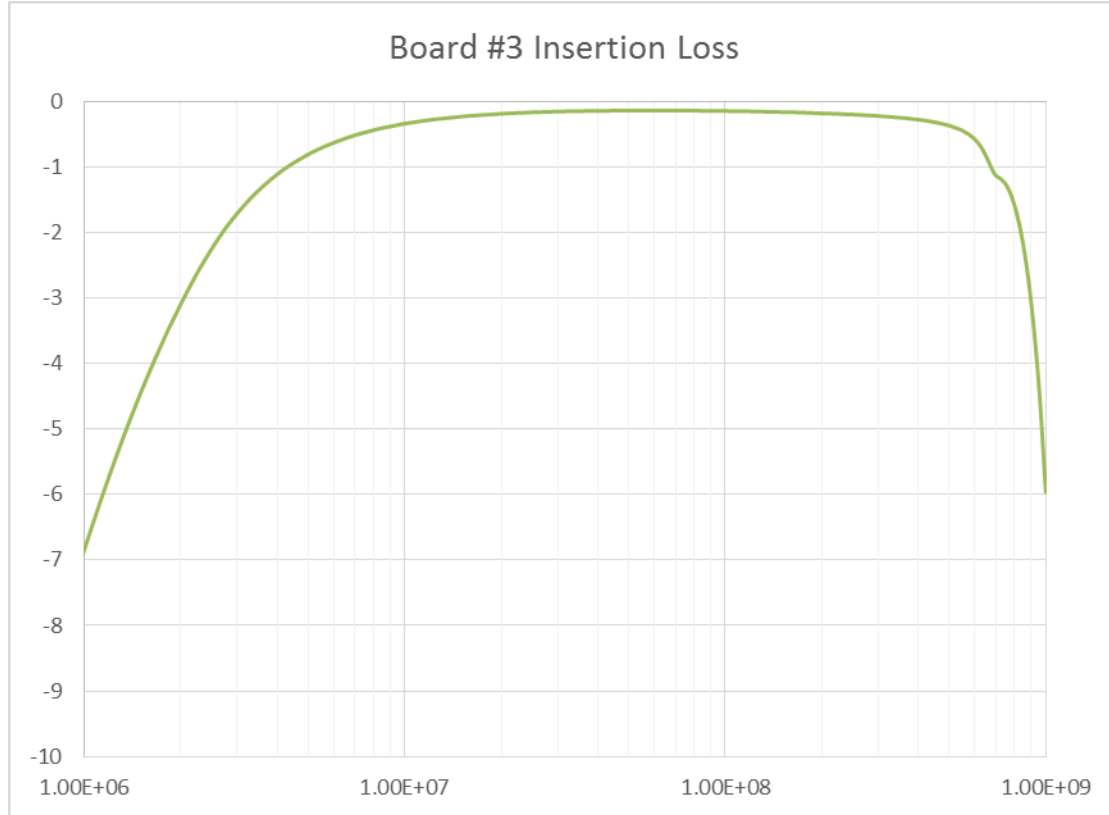
Next Steps

- Convert test setup from SMA connectors and coax cables to UTP connectors and cables.
  - Performance may degraded by this conversion.
- Experiment with trading off return loss margin for improved mode conversion loss performance around 600MHz.
- Experiment with increasing MDI return loss 18dB low corner frequency in order to improve high frequency return loss without resorting to compensation of the coupled inductors.
- Introduce DC bias into the coupling network in order to observe the effects on circuit performance.
- Build-up a statistically significant number of prototypes and characterize the subsequent distributions of MDI mode conversion loss and return loss.
- Incorporate the PoDL coupling network into the MDI of a working PHY and evaluate impact on performance.

Conclusions

- A relaxed MDI return loss limit was proposed for incorporation into IEEE P802.3bp in order to make PoDL inductors economically feasible.

- A PoDL coupling network prototype potentially suitable for use with 1000BASE-T1 PHYs was demonstrated.

- The proposed MDI return loss specification was met with good margin.
    - Compensation of the 1uH coupled inductor's return loss was required to meet spec with margin at high frequencies, and this fix degraded mode conversion loss at and above 600MHz.

- The proposed MDI mode conversion loss specification was met, but there was insufficient margin for economic feasibility.

- Additional relaxation of the low frequency MDI return loss limit beyond 18dB at 20MHz may be required if the mode conversion loss cannot be improved by further circuit optimization and trading off return loss margin at 600MHz.

- Collaboration in finding an economically feasible, compliant solution for 1000BASE-T1 PoDL is welcome!

Questions?

Annex A – Insertion Loss of PoDL Prototype Coupling Network

Thank You!

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