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# Impedance Corrected De-embedding

Stefaan Sercu

# INTRODUCTION

- The Measurement problem
- Calibration versus De-embedding
- Test Fixture Modeling: Standard 2X thru De-embedding
- Test Fixture Modeling: Impedance corrected De-embedding

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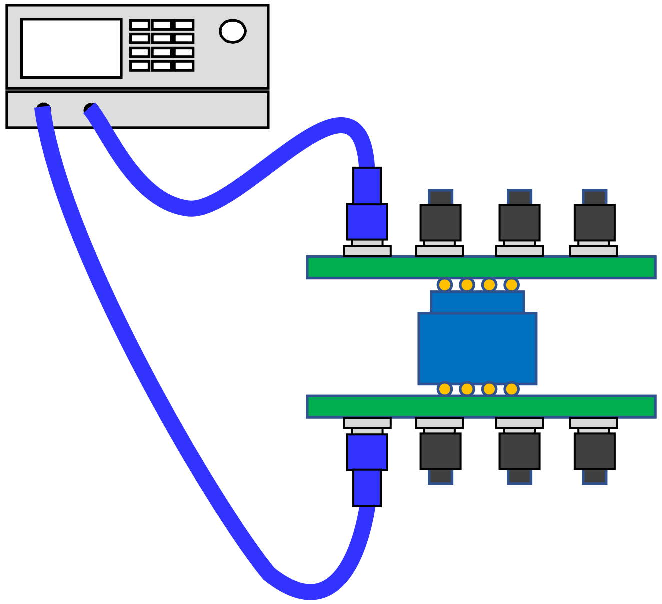
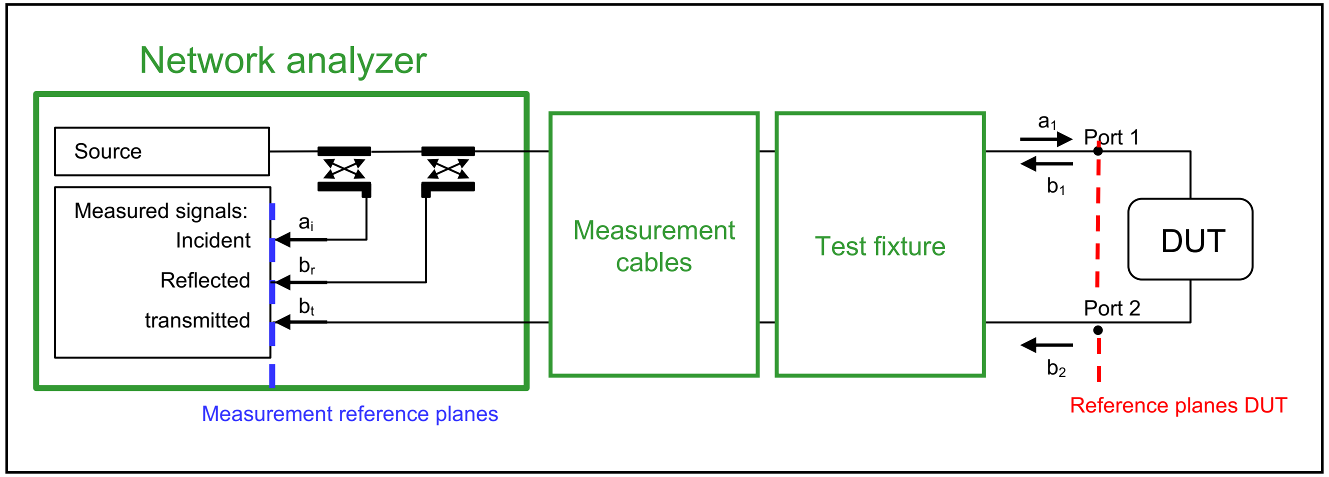
# The Measurement Problem

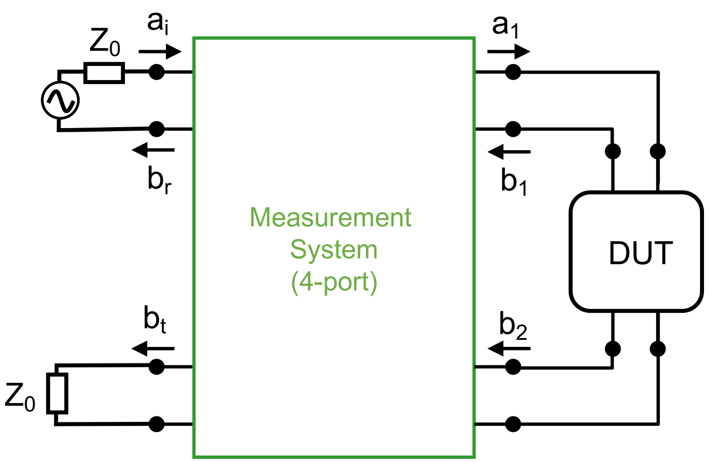





$$S_{11}^{measured} = \frac{b_r}{a_i} \qquad S_{21}^{measured} = \frac{b_t}{a_i}$$

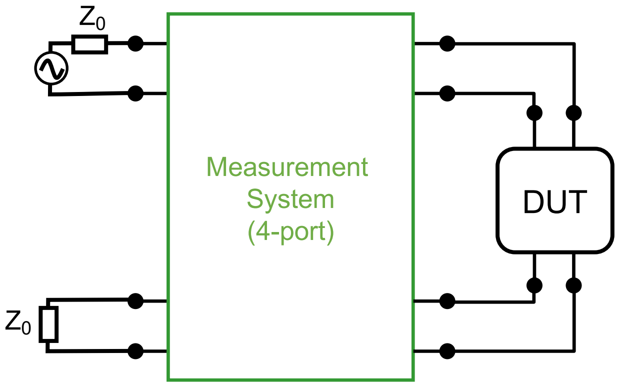
$$\neq$$

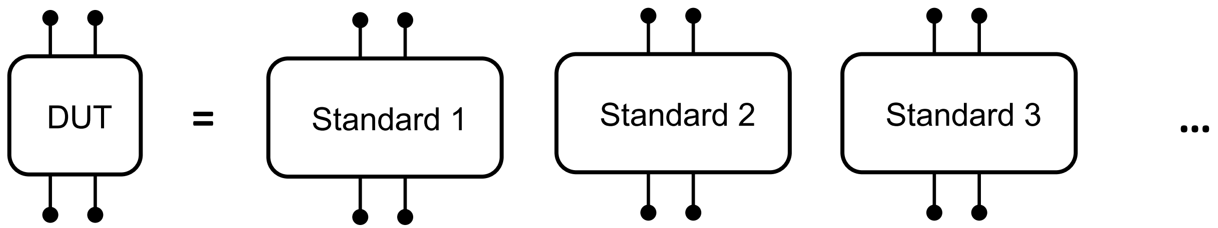
$$S_{11}^{DUT} = \frac{b_1}{a_1} \qquad S_{21}^{DUT} = \frac{b_2}{a_1}$$

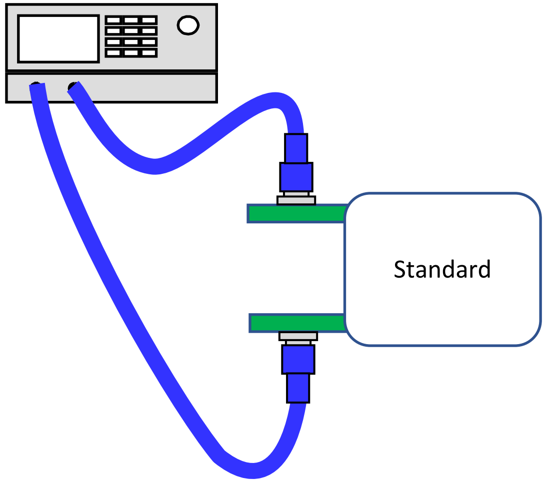


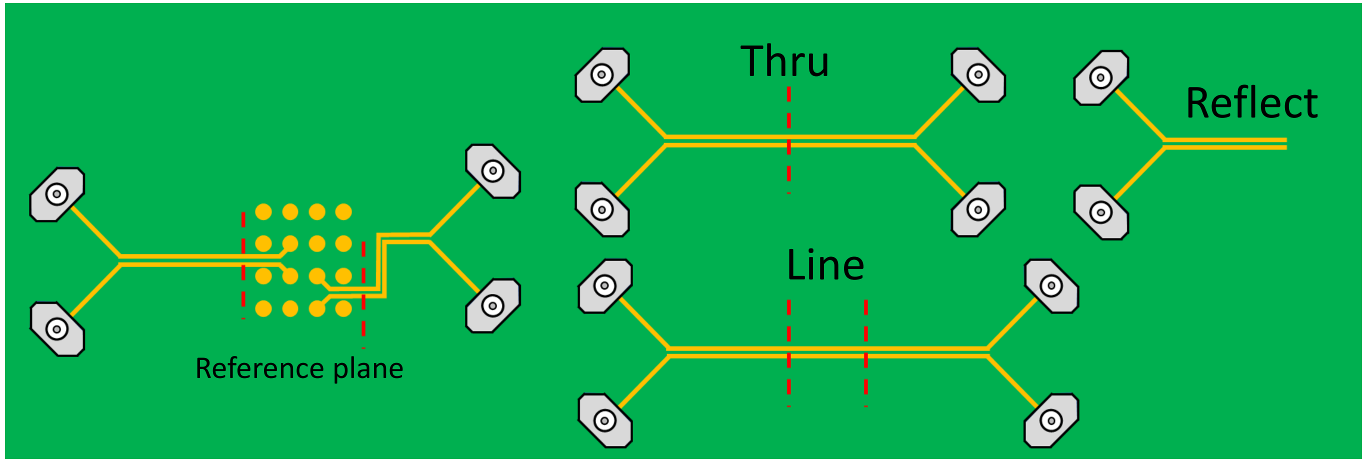

$$S^{DUT} = f\left(S^{measured}, S^{Measurement\ System}\right)$$

# Calibration

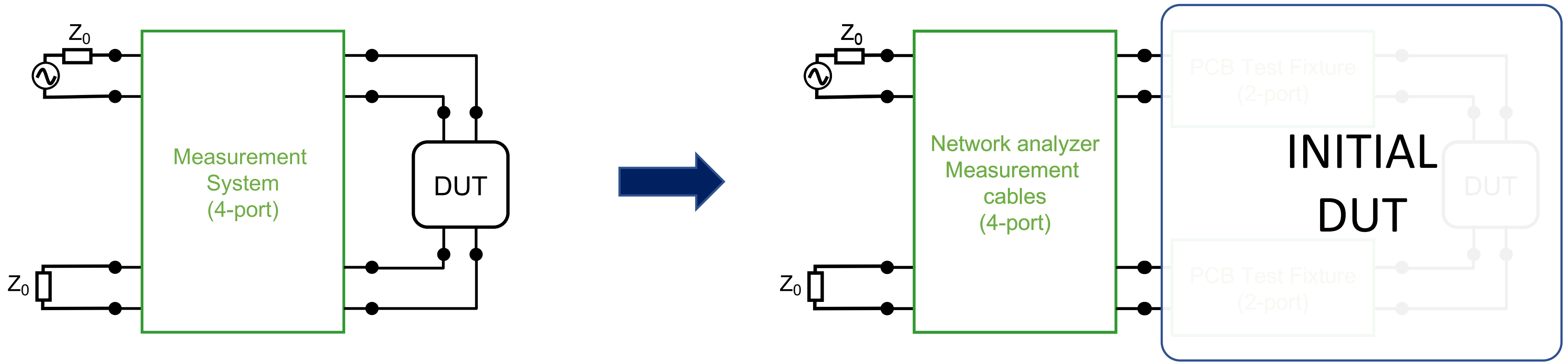


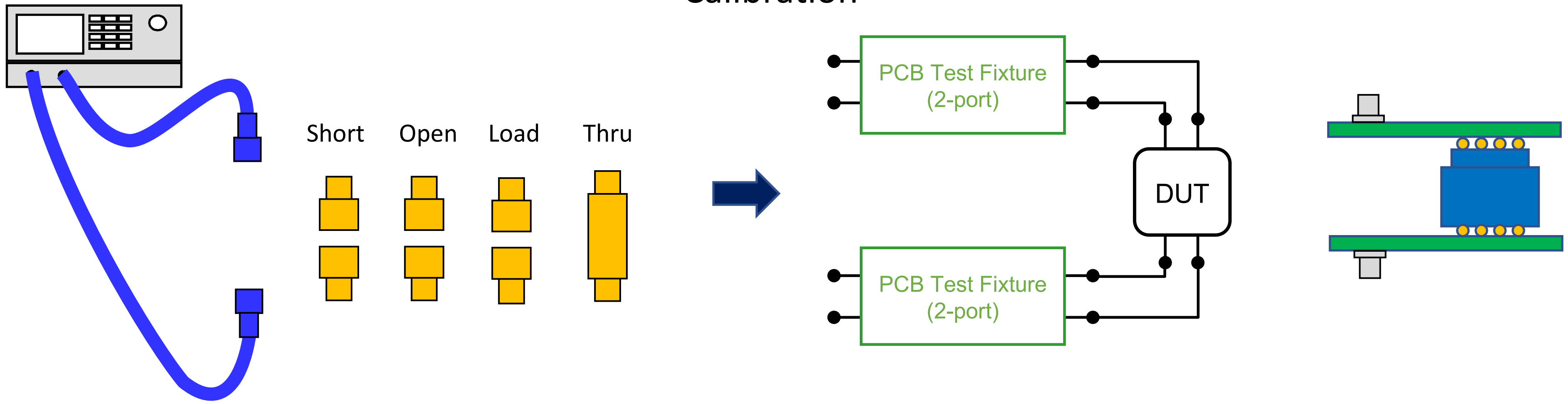



# De-embedding

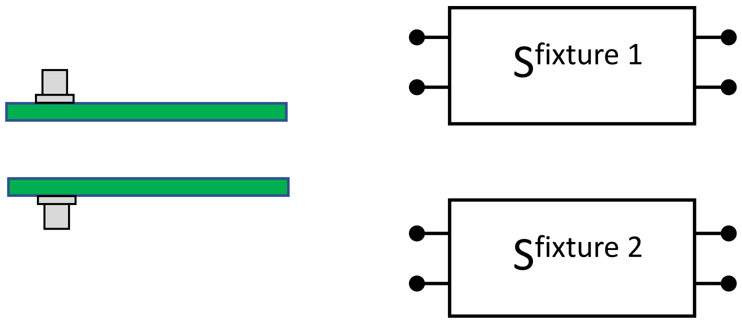


# De-embedding

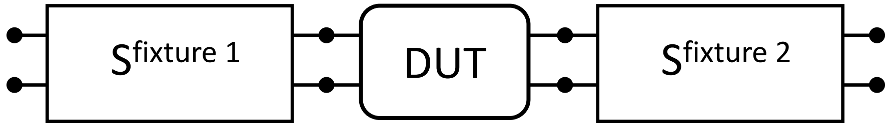
## Calibration




## Test fixture modeling



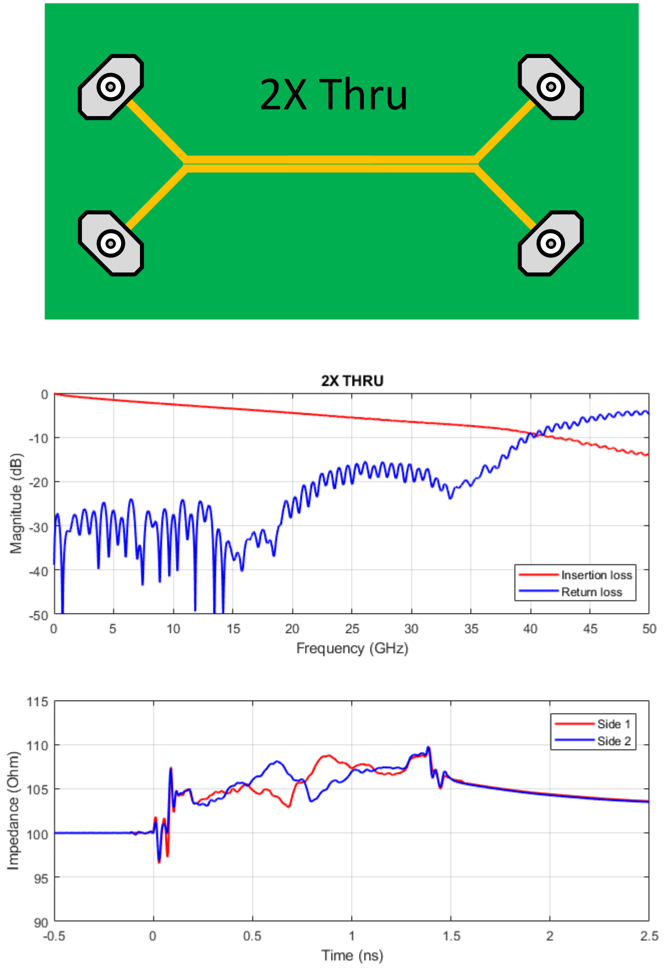

## Test fixture de-embedding



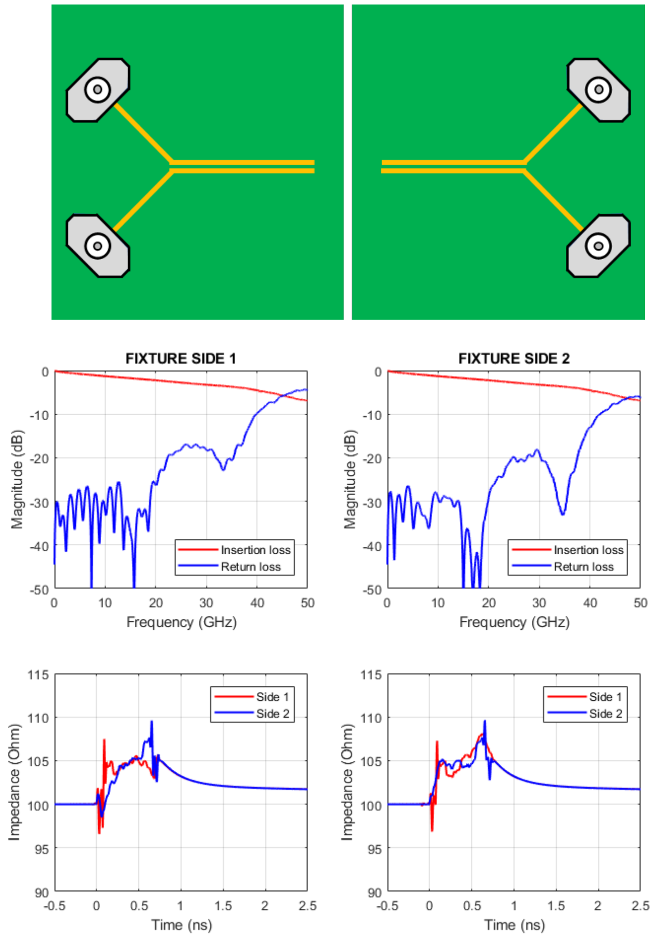

$$T^{\mathrm{DUT}} = \left(T^{\mathrm{fixture\,1}}\right)^{-1} . T^{\mathrm{Calibration}} . \left(T^{\mathrm{fixture\,2}}\right)^{-1}$$

# Test Fixture Modeling
(Standard 2X thru De-embedding)



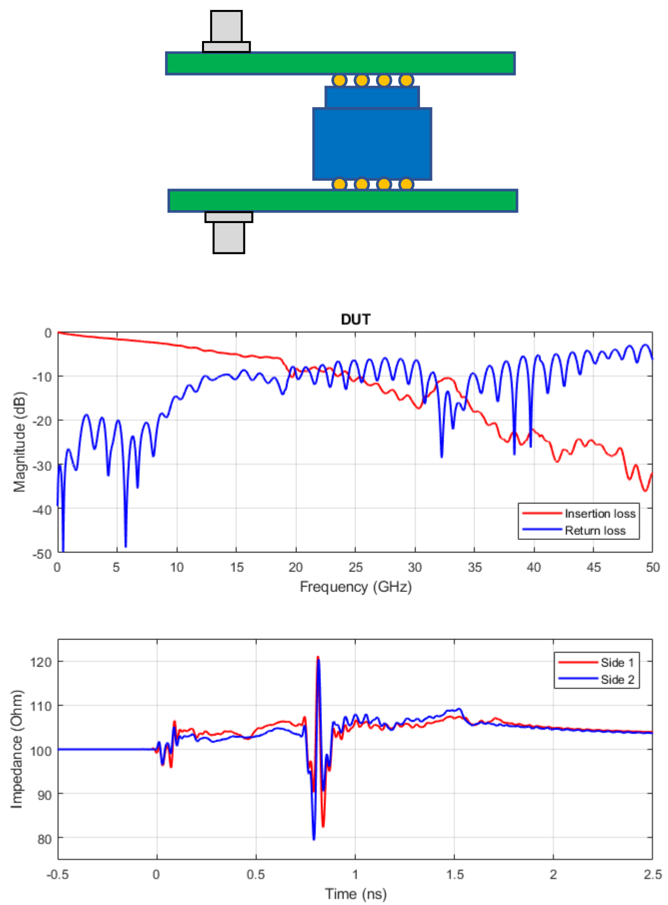


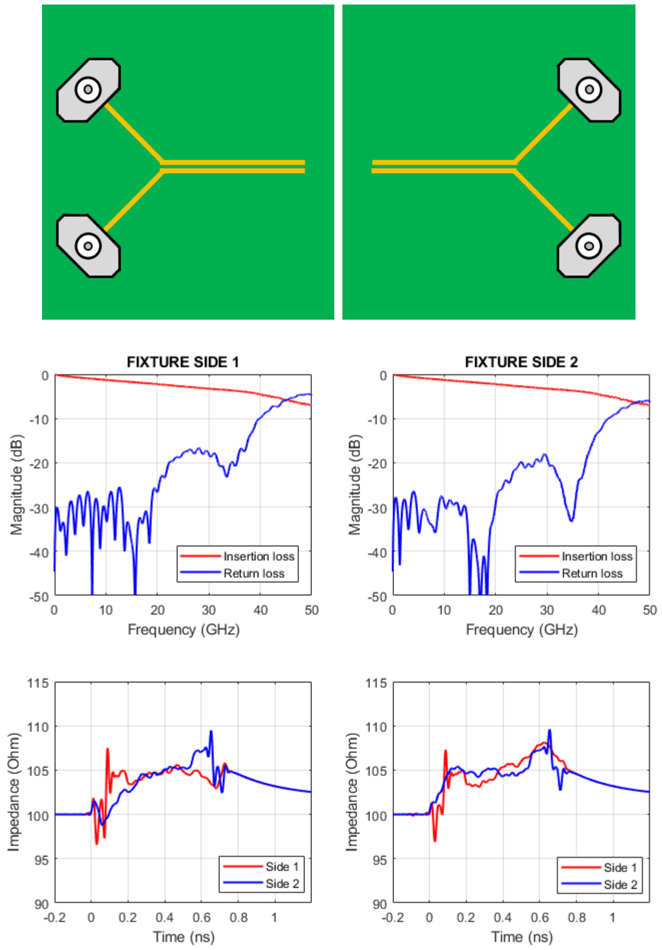

bifurcation

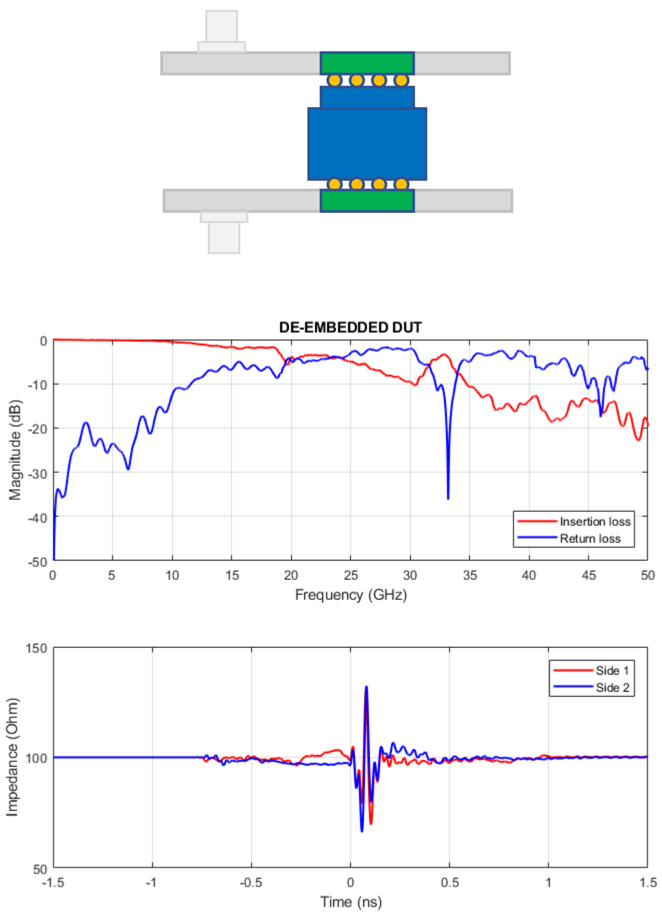


# Test Fixture Modeling

## (Standard 2X thru De-embedding)

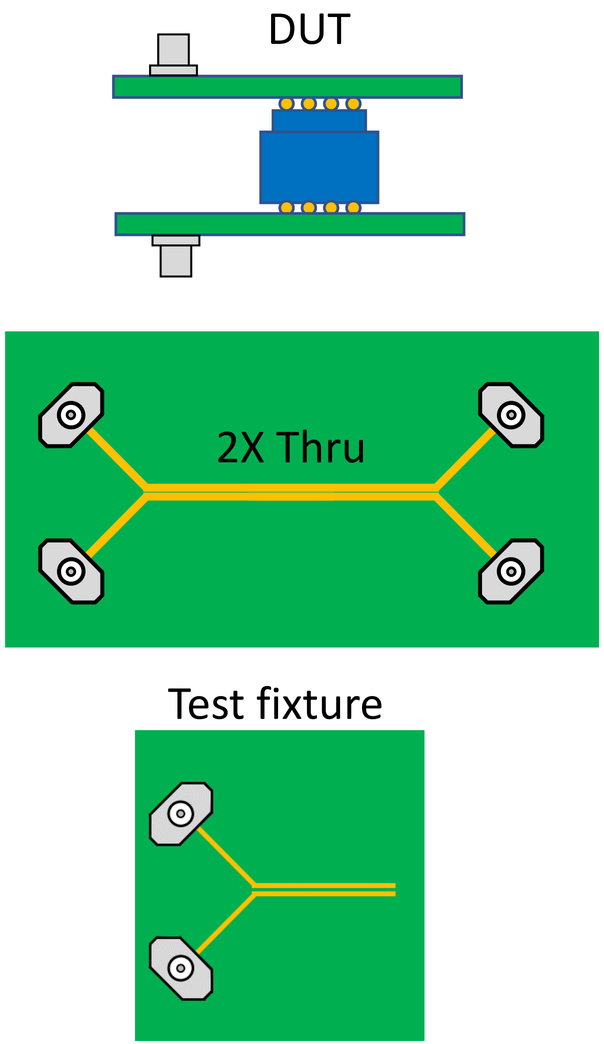


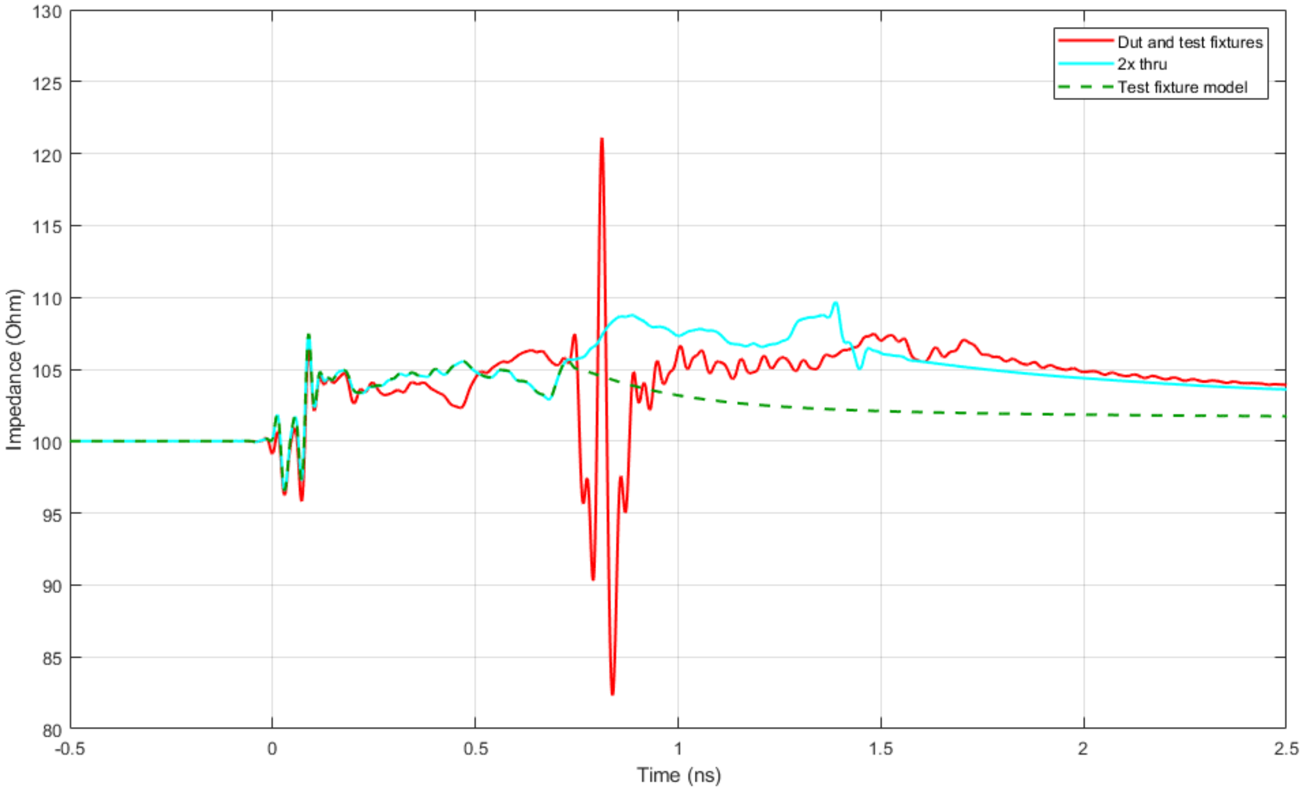




De-embedded results are non causal

# Test Fixture Modeling
(Standard 2X thru De-embedding)




Modeled test fixture impedance matches calibration trace impedance, not the actual test fixture impedance.

# Test Fixture Modeling
## (Standard 2X thru De-embedding)

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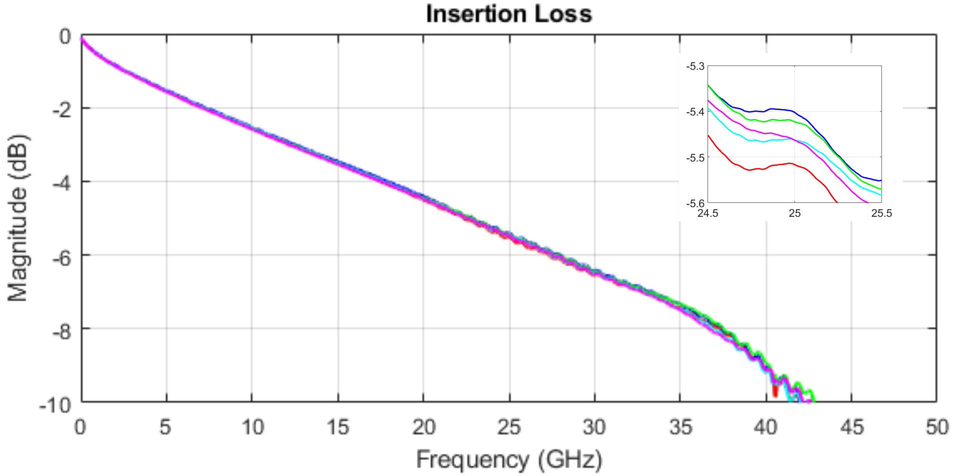
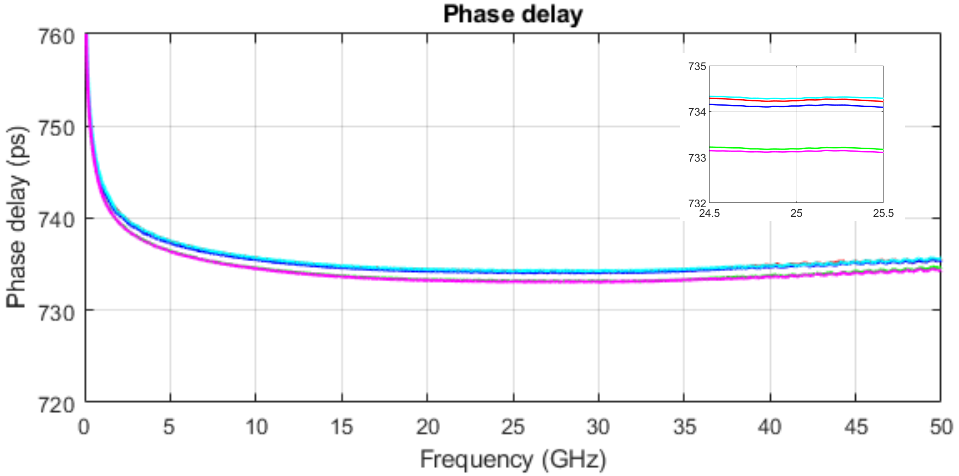
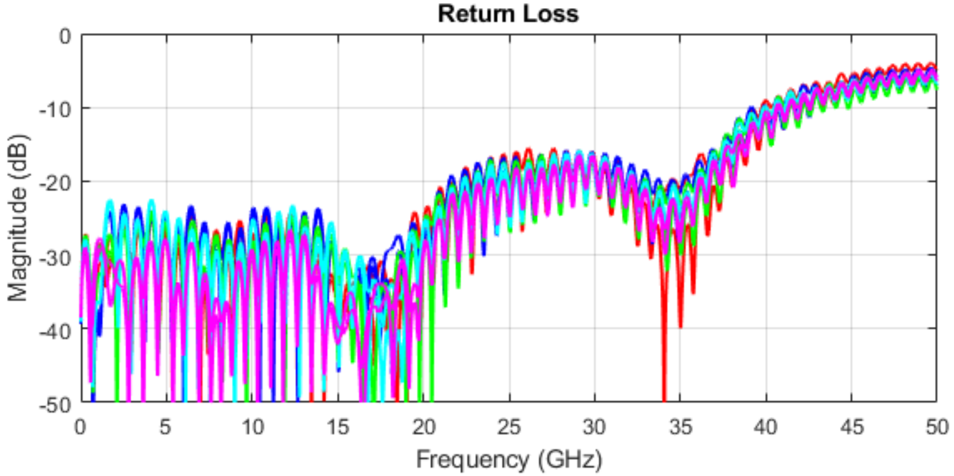
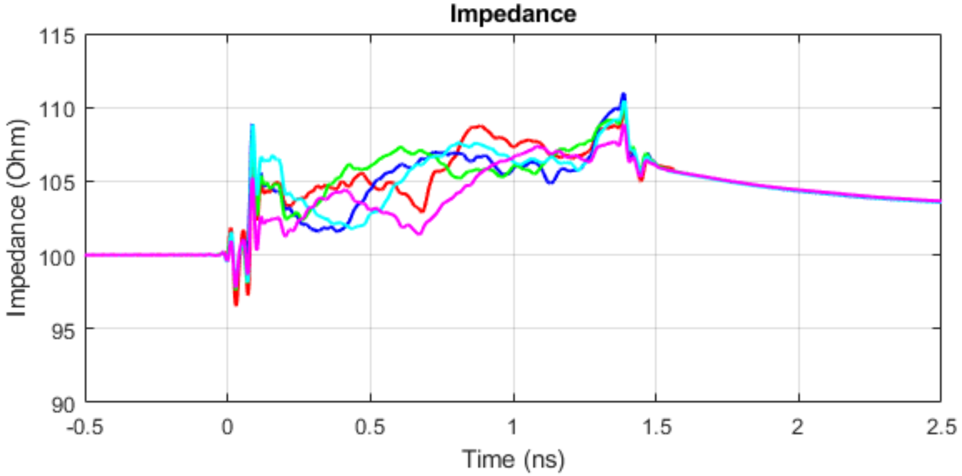
Are the de-embedded results function of the calibration trace performance?

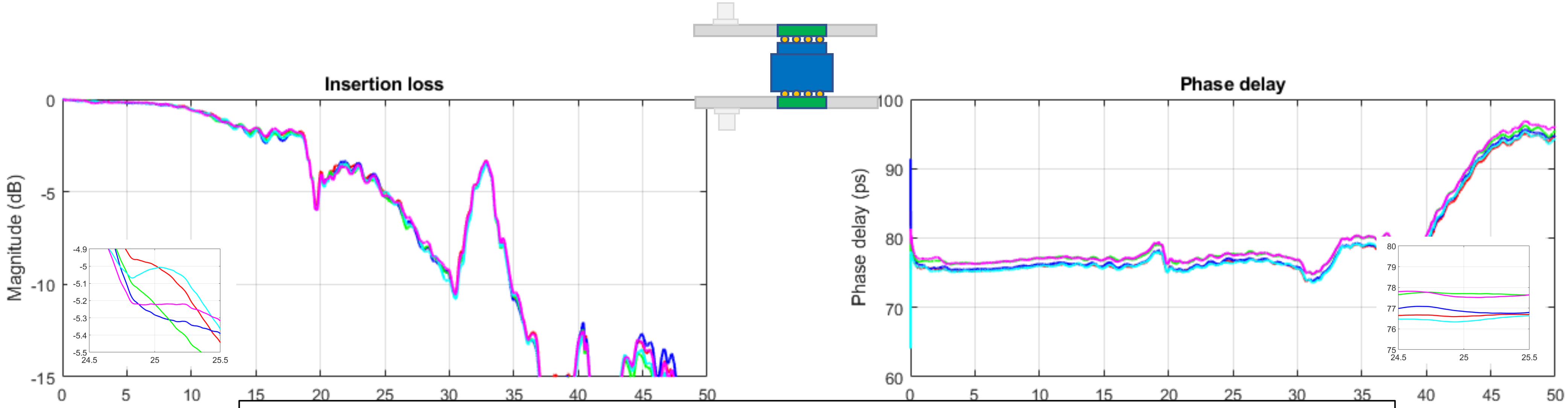


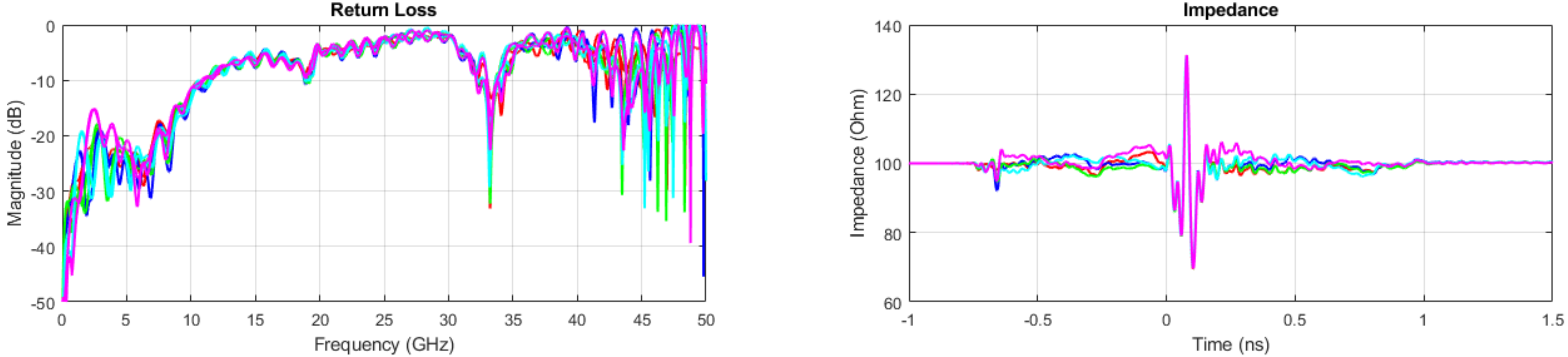



# Test Fixture Modeling
## (Standard 2X thru De-embedding)



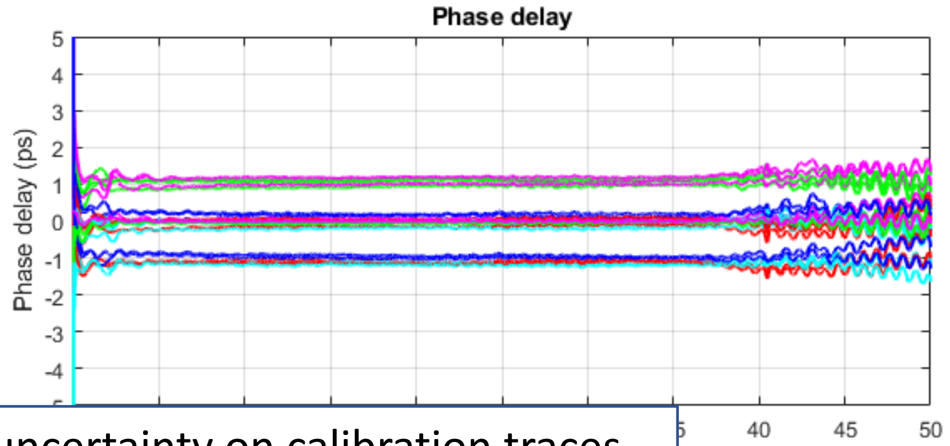

Yes, de-embedded results are function of the calibration trace performance.



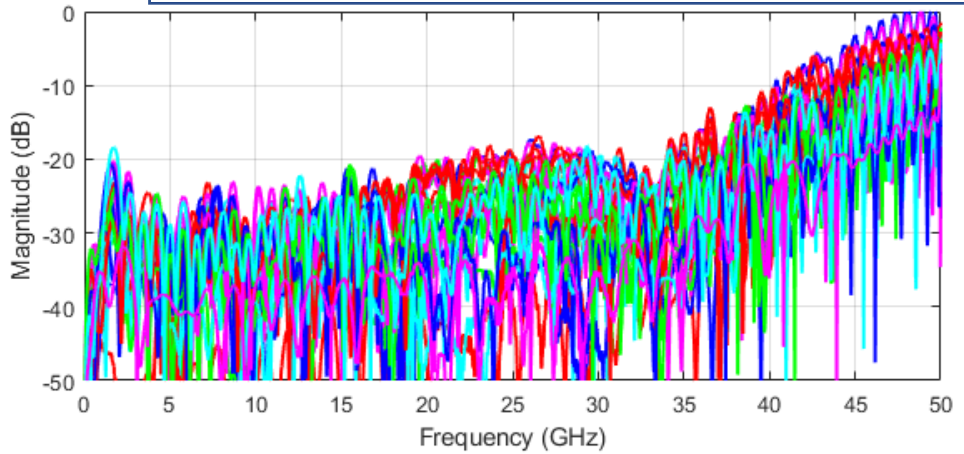
# Test Fixture Modeling

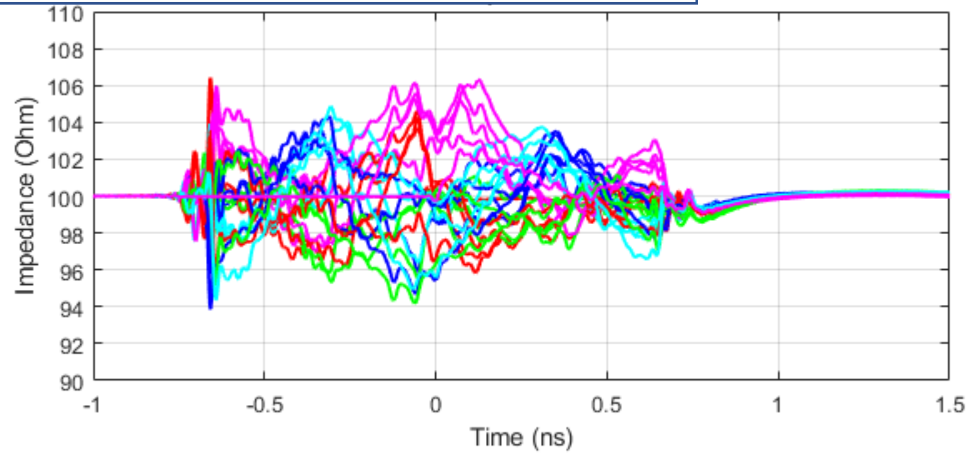
## (Standard 2X thru De-embedding)




Uncertainty on de-embedded results twice the uncertainty on calibration traces
Causal and non-causal uncertainty on impedance results.



# Test Fixture Modeling
## (Impedance Correct De-embedding)

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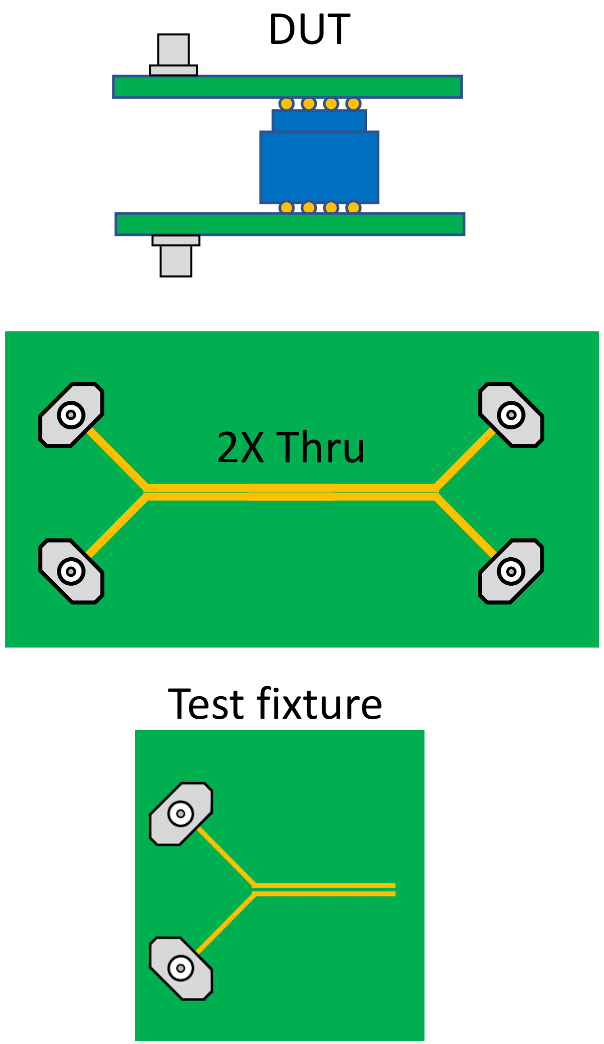
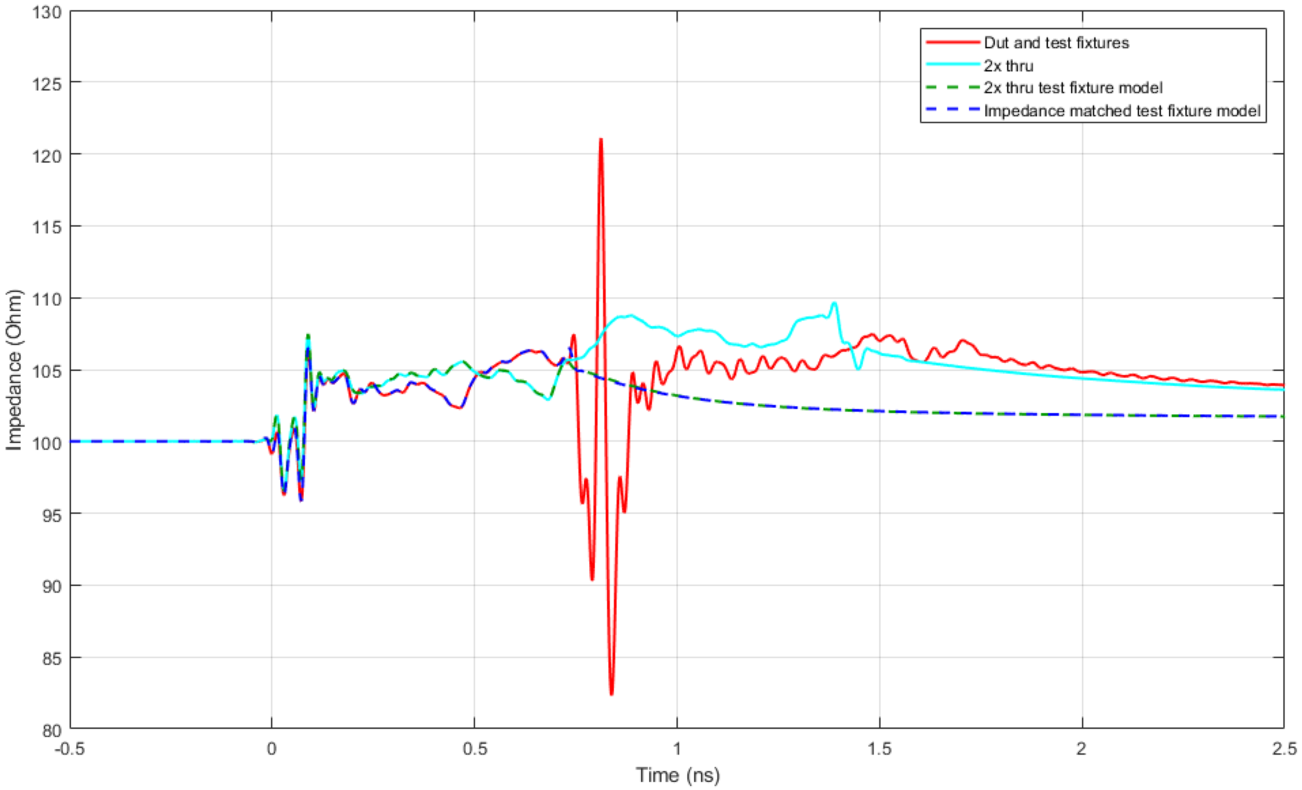
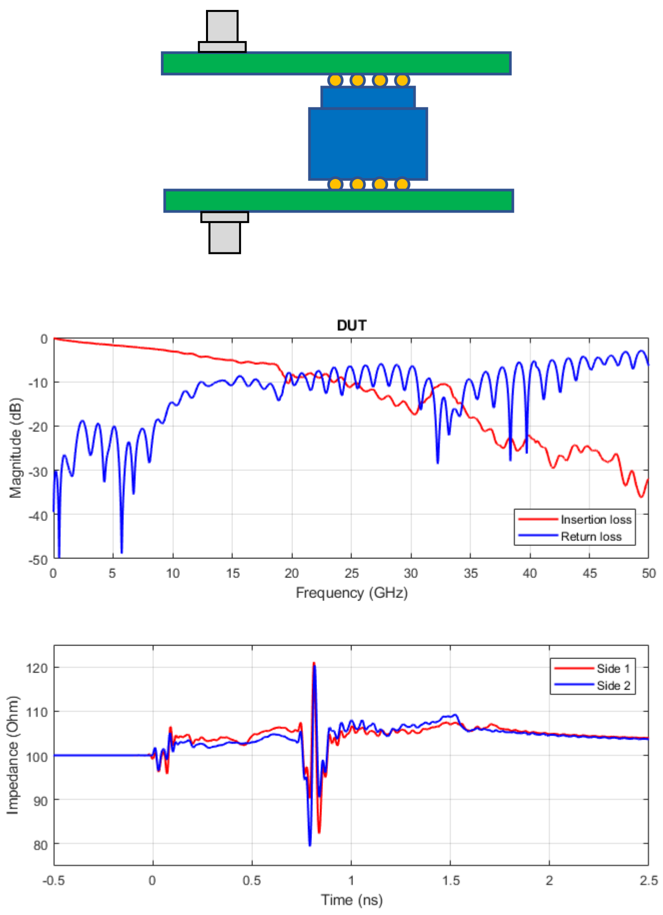


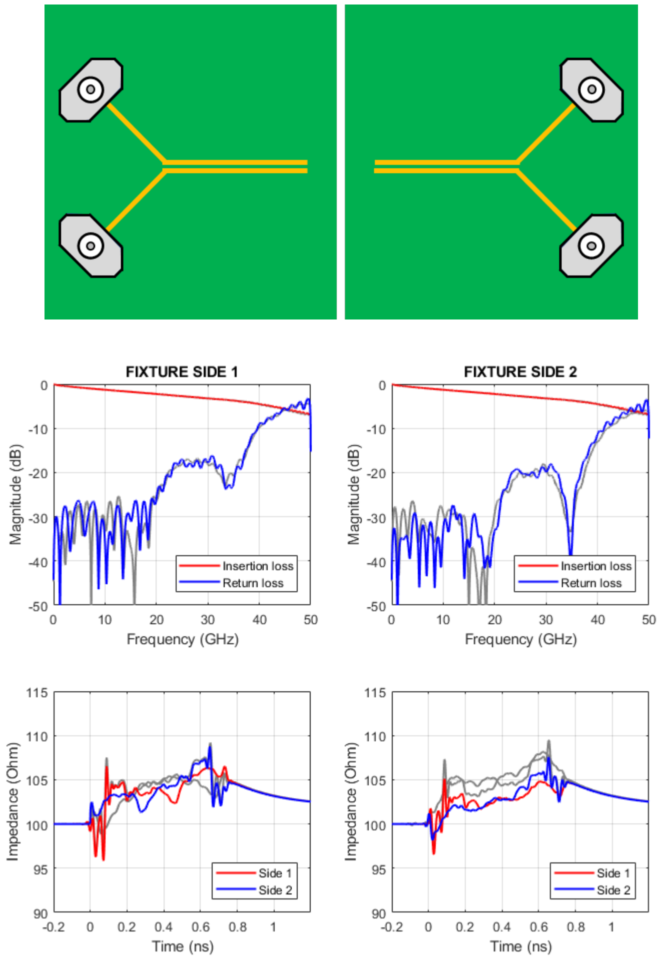



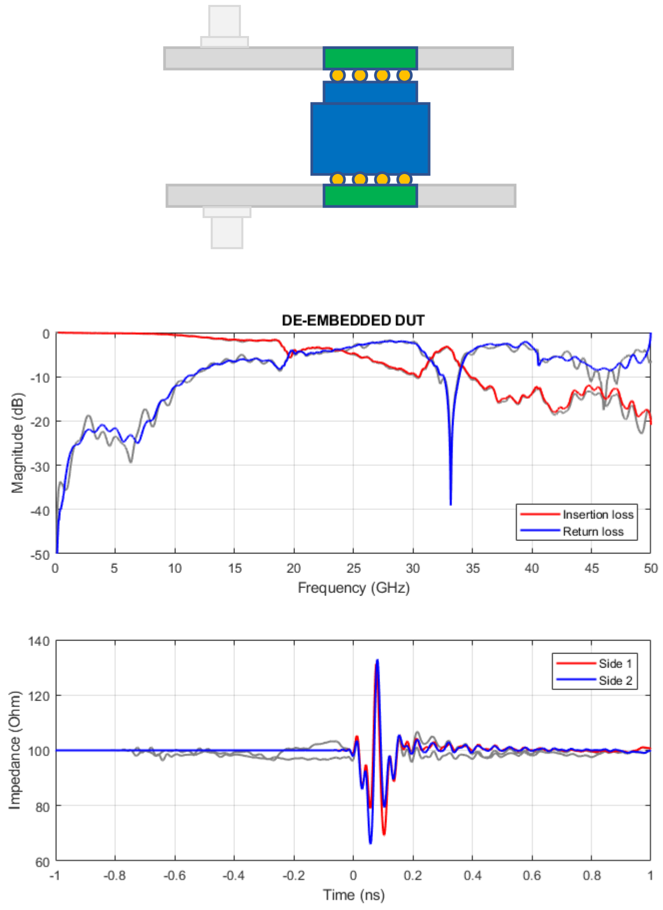

Modeled test fixture impedance matches the actual test fixture impedance.

# Test Fixture Modeling

## (Impedance Correct De-embedding)



# Test Fixture Modeling
## (Impedance Correct De-embedding)

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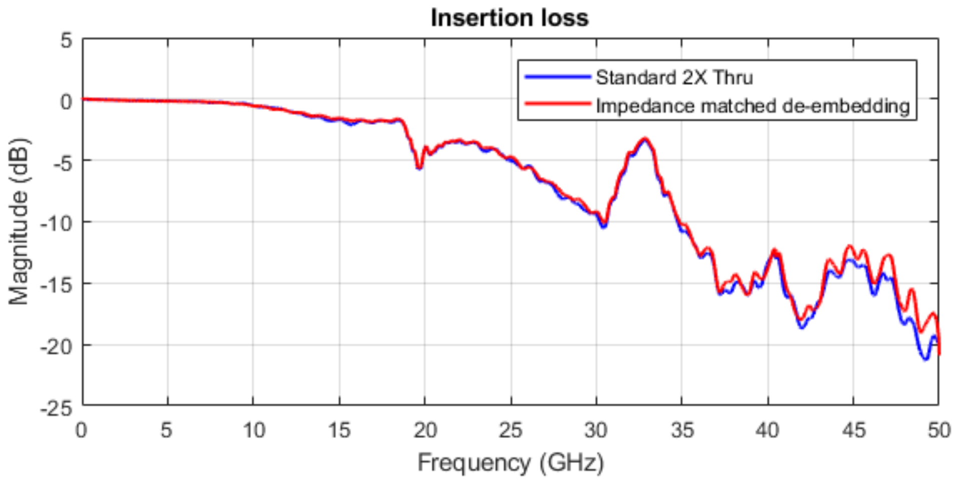


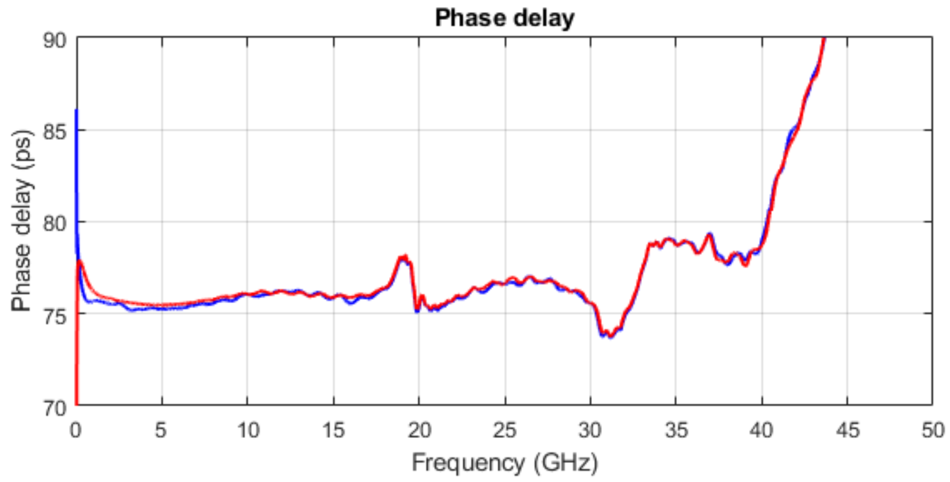


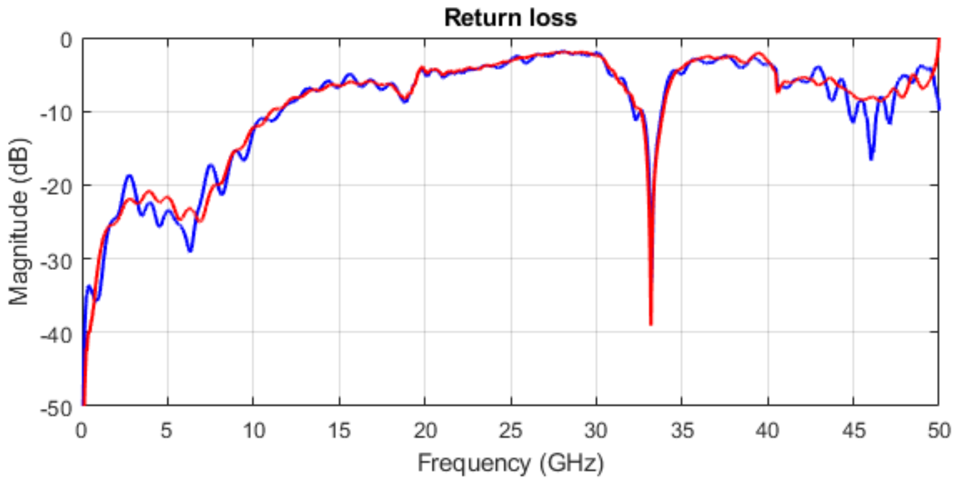


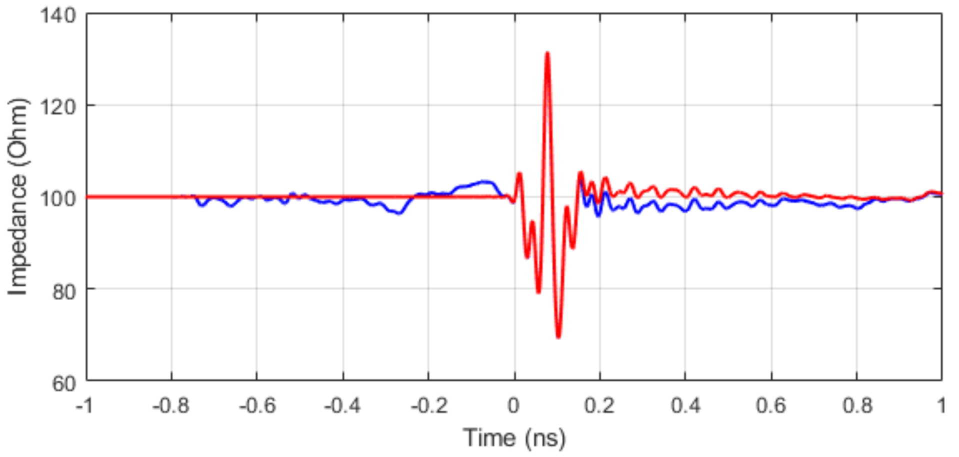

# Test Fixture Modeling
## (Impedance Correct De-embedding)

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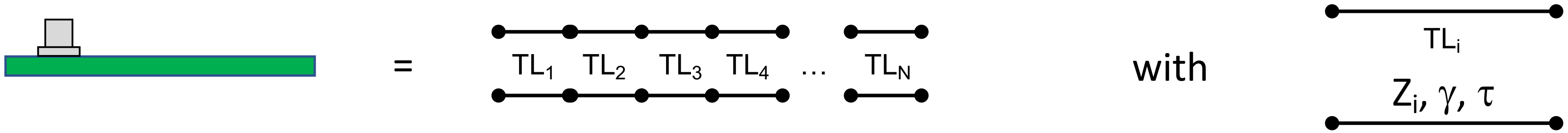
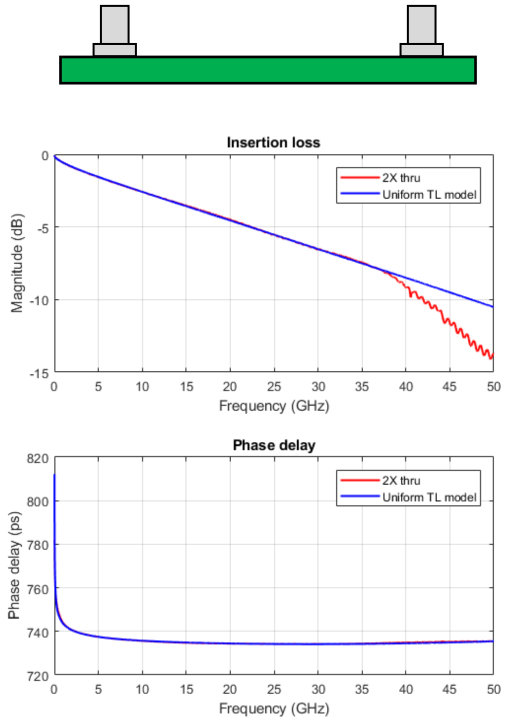



$$\tau = 0.5\,\Delta t$$

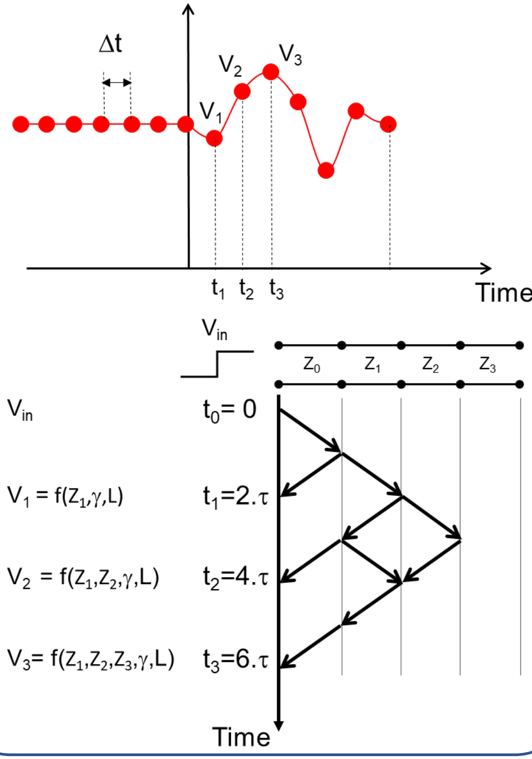
$$N = \frac{\text{Phase Delay 2x Thru cal trace}}{\Delta t}$$

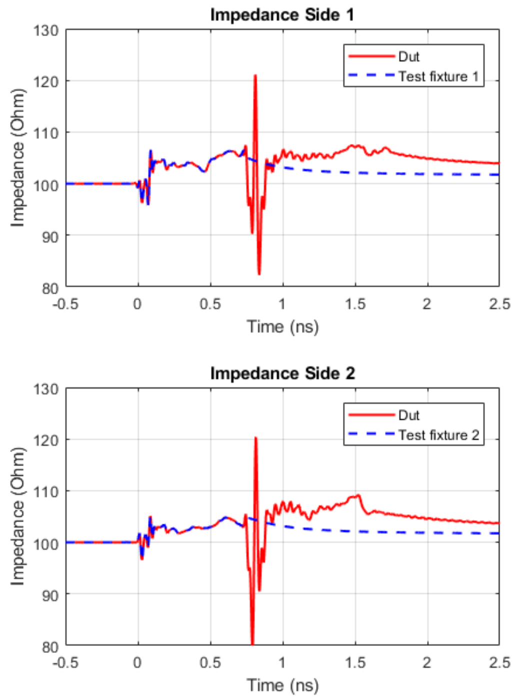
γ




$Z_i$

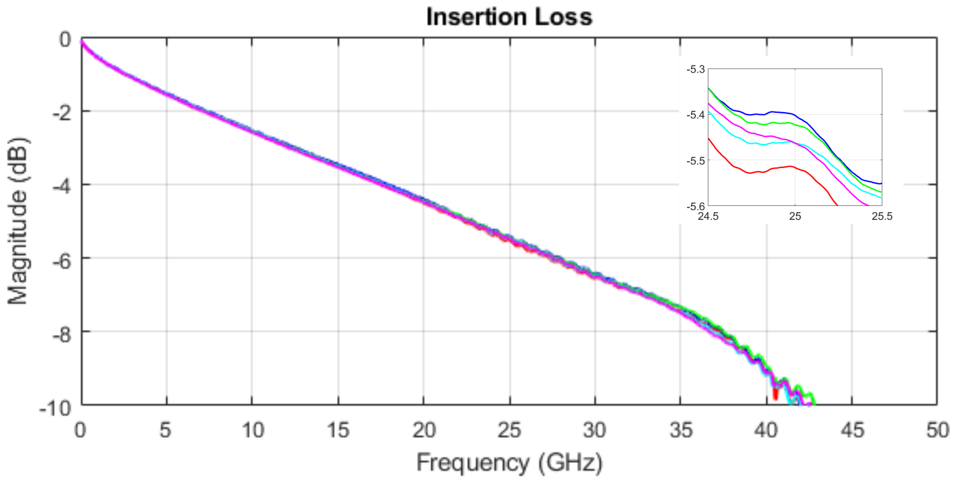
Impedance response DUT and test-fixtures

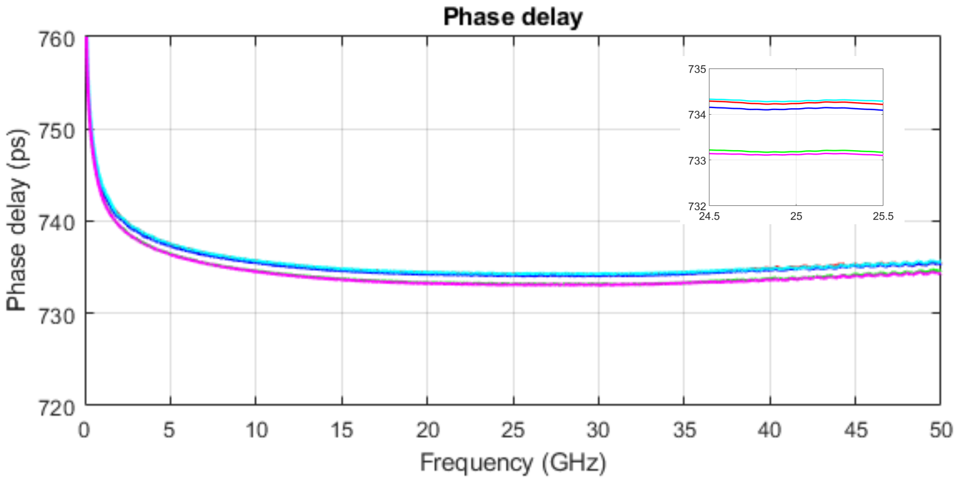


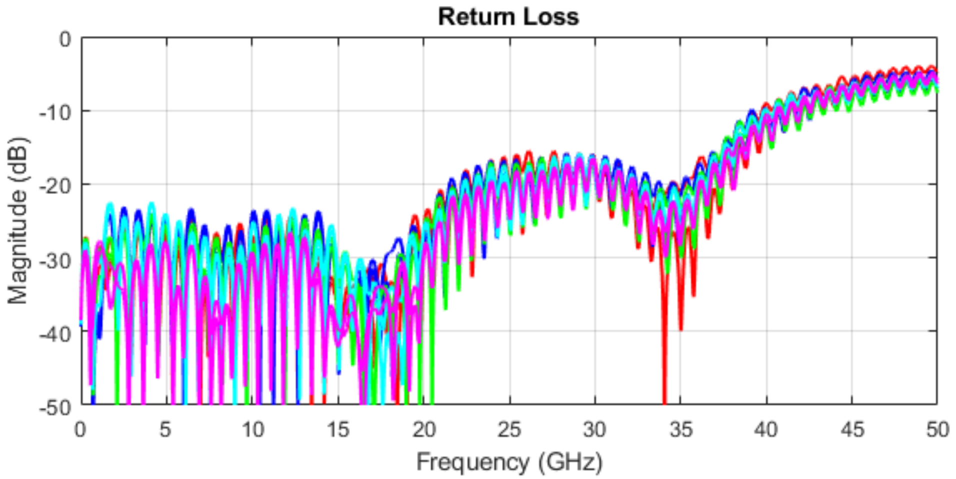



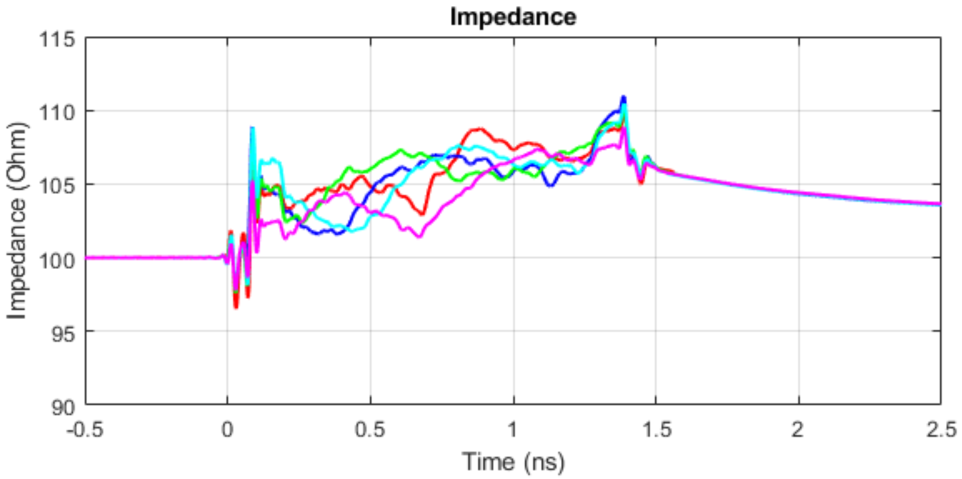
# Test Fixture Modeling
## (Impedance Correct De-embedding)

Are the de-embedded results function of the calibration trace performance?

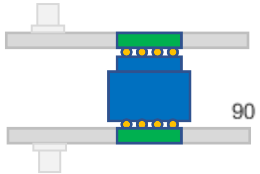


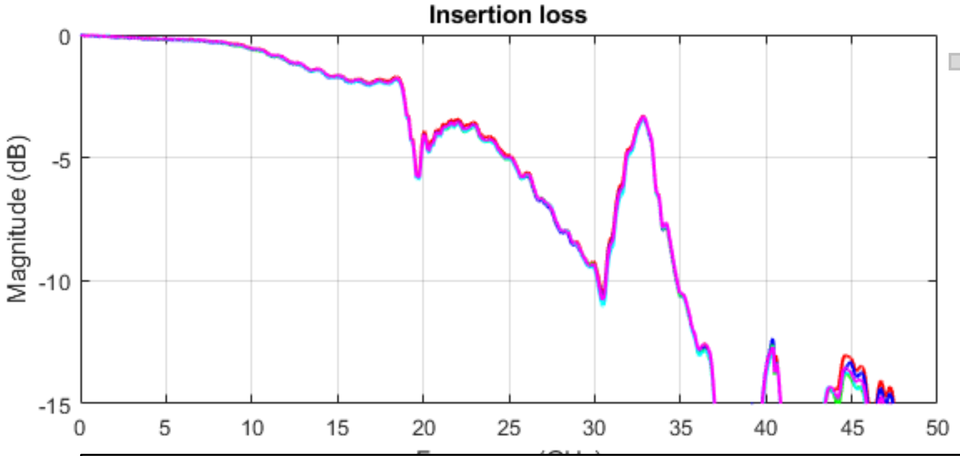



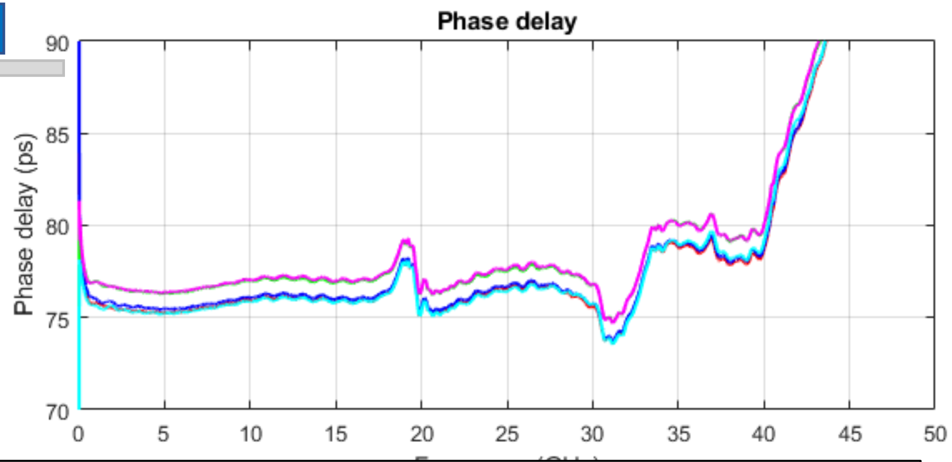



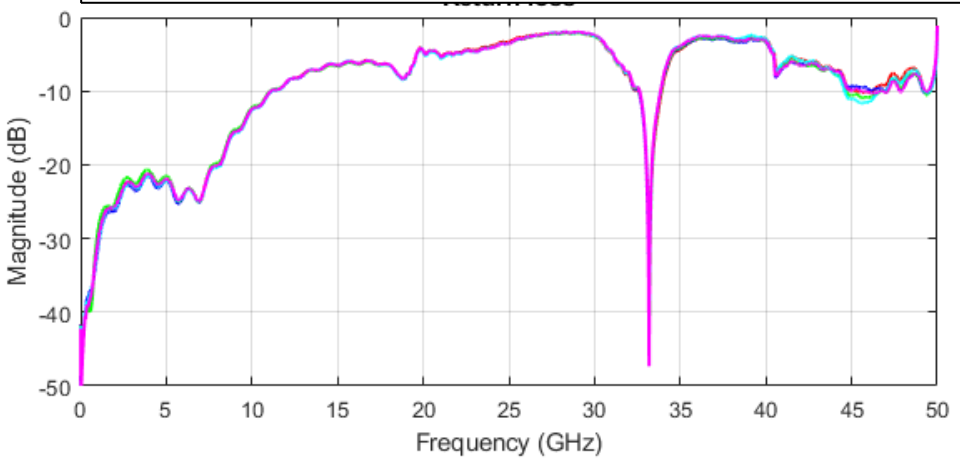
# Test Fixture Modeling
## (Impedance Correct De-embedding)

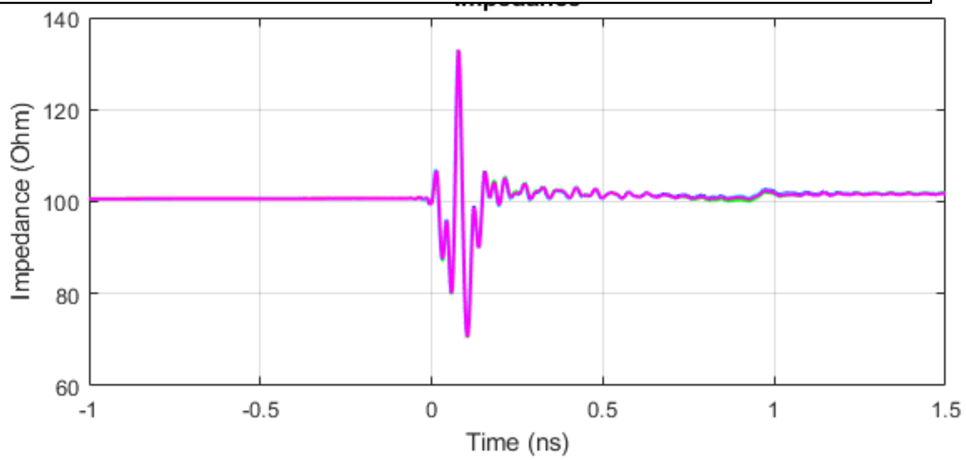




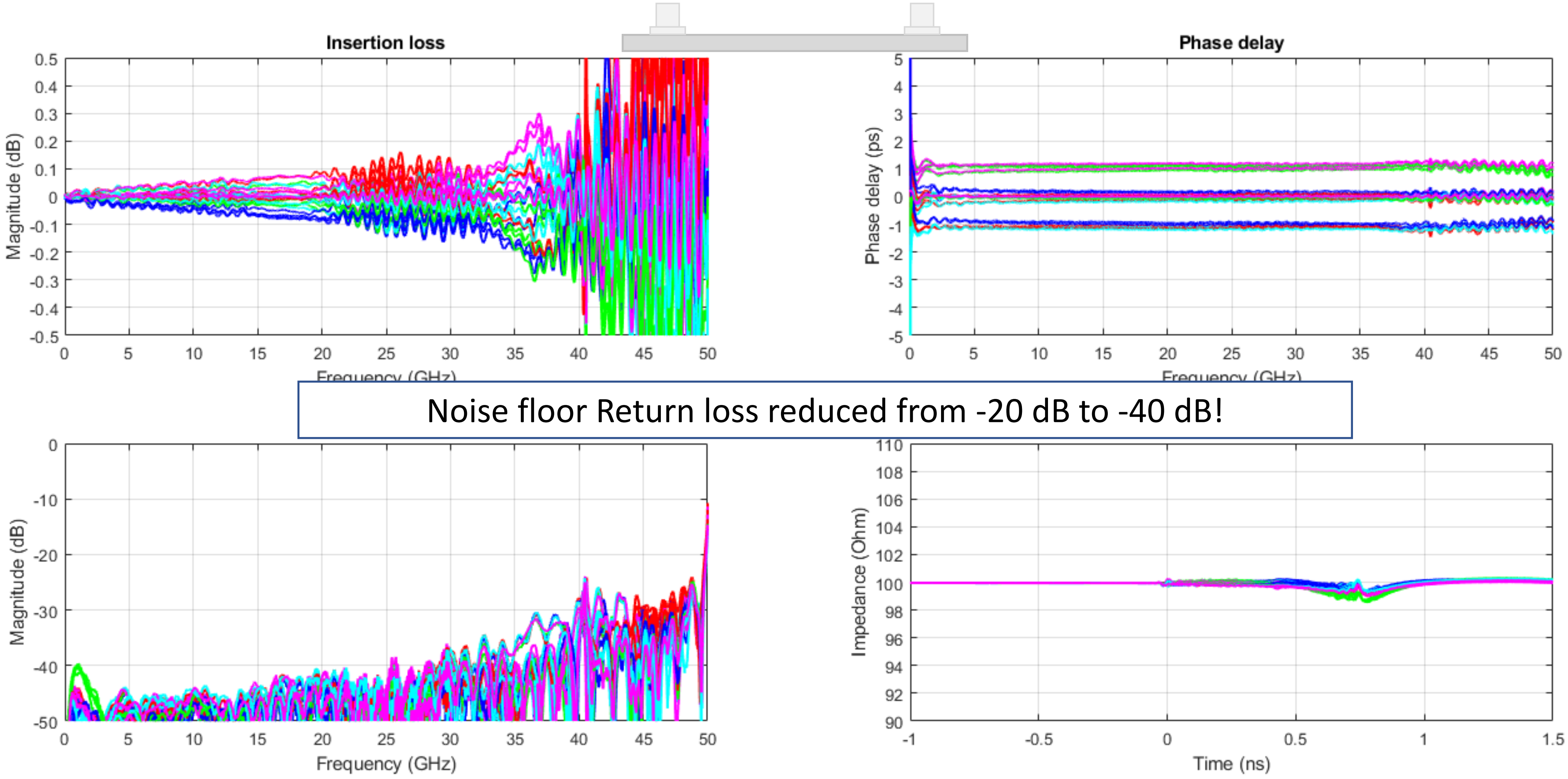




De-embedded Return loss and impedance no longer function of the calibration trace performance.



# Test Fixture Modeling
(Impedance Correct De-embedding)




Noise floor Return loss reduced from -20 dB to -40 dB!

# Coupled Test Fixtures

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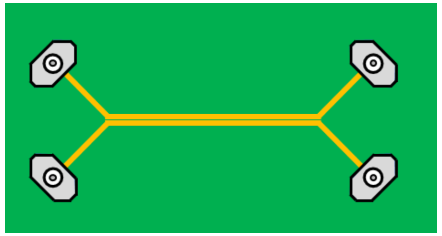
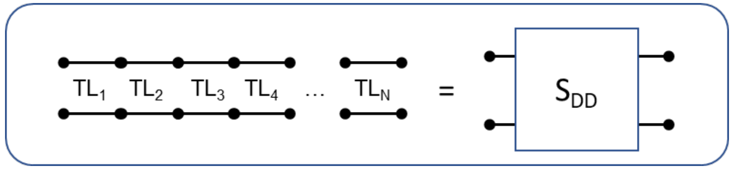
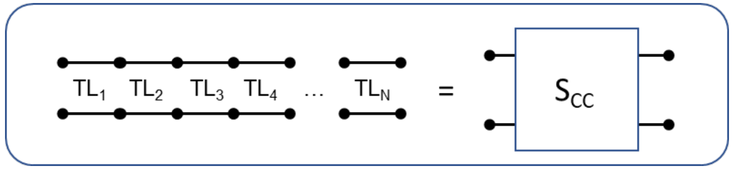
## Symmetrical



### Differential mode

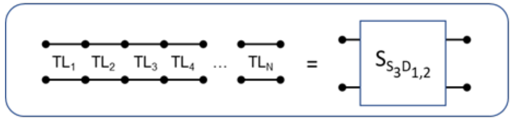



### Common mode

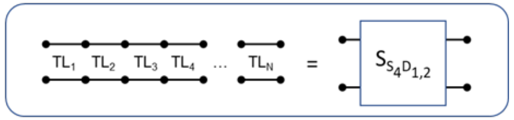



## Asymmetrical

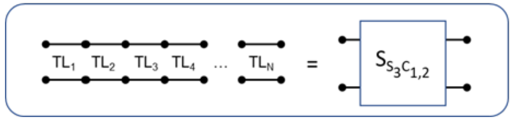
Differential excitation port 1 and 2
SE observation port 3



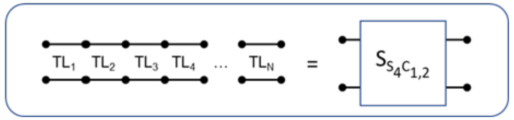

Differential excitation port 1 and 2
SE observation port 4



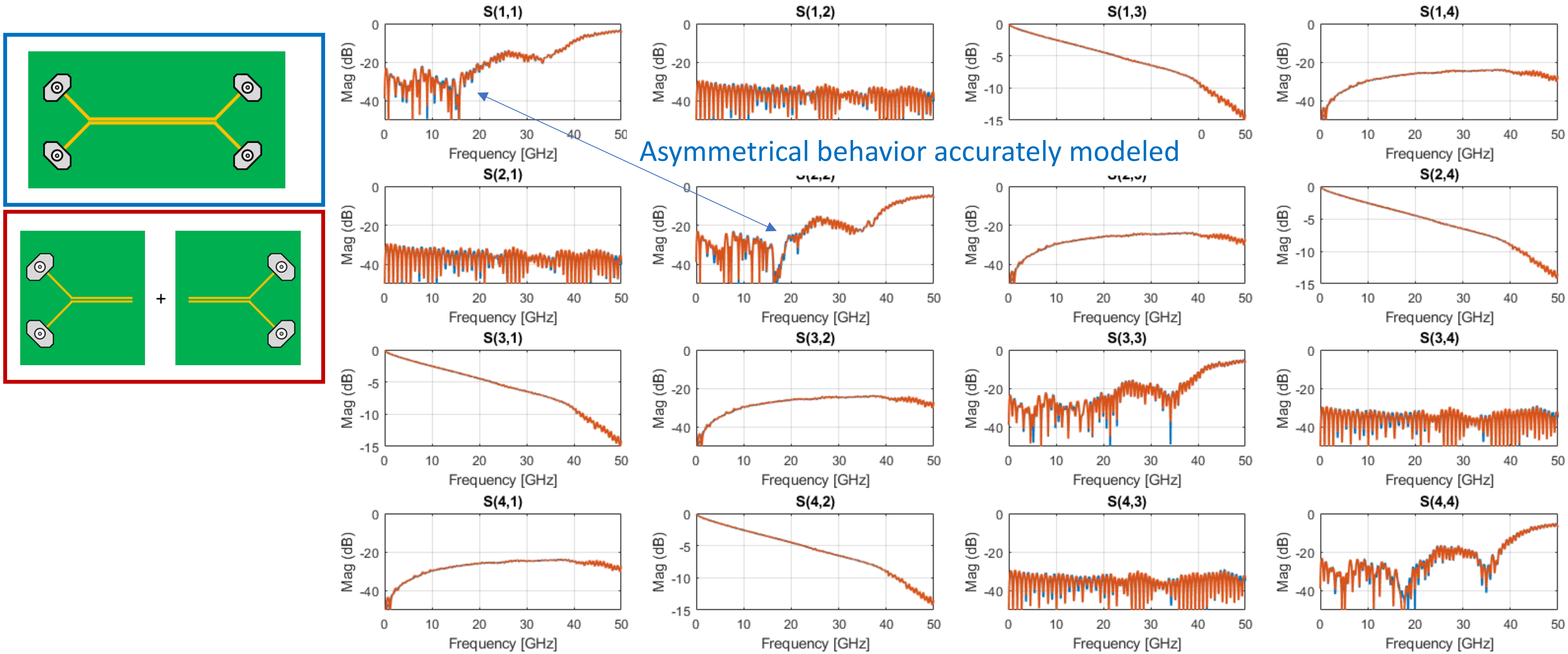

Common mode excitation port 1 and 2
SE observation port 3




Common mode excitation port 1 and 2
SE observation port 4



# Coupled Test Fixtures



# SUMMARY

- Presentations compares standard 2X thru de-embedding with impedance matched de-embedding
- Standard 2X thru de-embedding:
  - Accuracy IL, Phase delay, return loss, impedance determined by repeatability of the 2X thru standard
- Impedance matched de-embedding:
  - Accuracy IL, Phase delay determined by repeatability of the 2X thru standard,
  - Accuracy Return loss and impedance independent of the 2X thru performance

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For Signal Integrity questions, contact: SIG@samtec.com

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