A simple method to characterize and accurately remove the effects of push-on connectors.

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KEYSIGHT TECHNOLOGIES

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Outline

Introduction

Calibration Techniques

AFR Measurements and Models

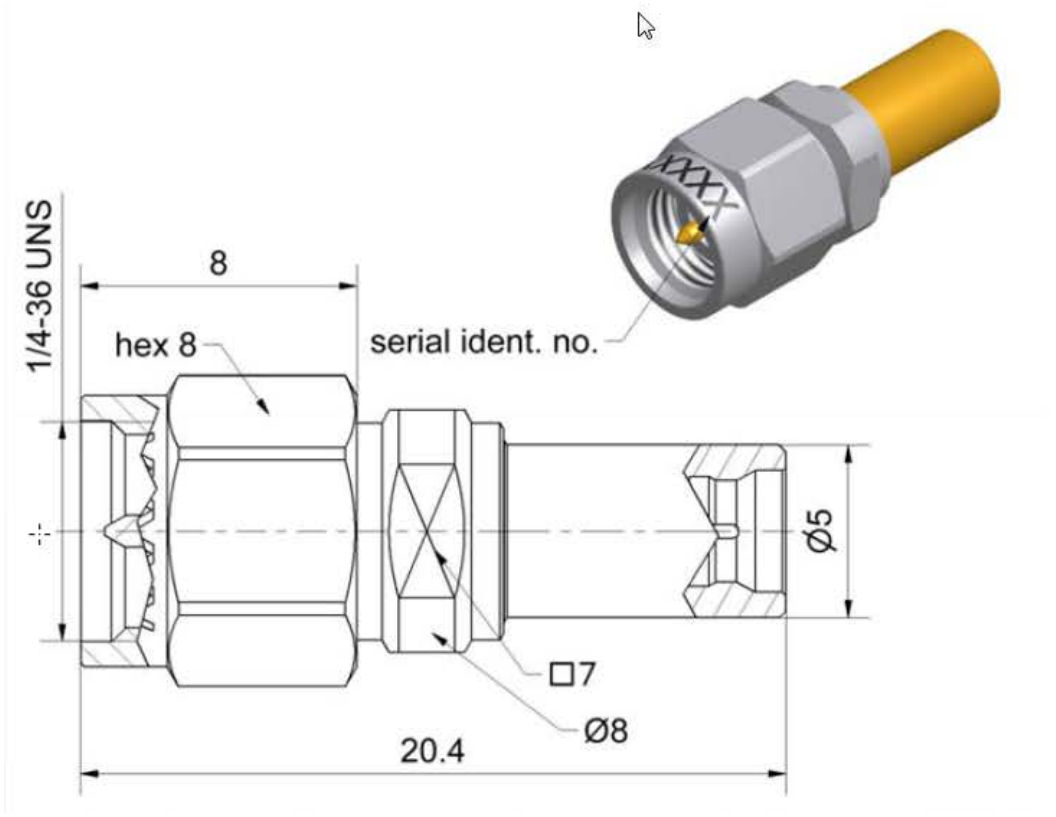
Results and Limitations

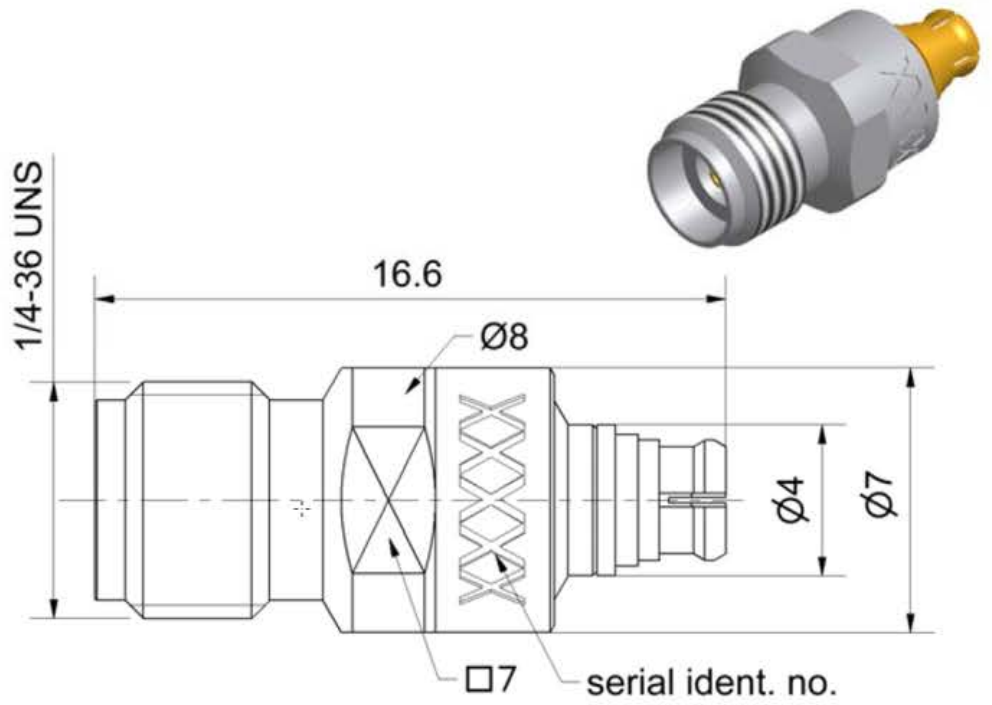
Push-on (blind mate) connectors

- SMP, Mini-SMP, GPO, GPPO, ...

- Small footprint (higher density)
- Quick connect
- Lack of high quality calibration kits for all types

RPC-2.92 to SMP adapters





Challenges

Electrically very short

Very low insertion loss

Discontinuity at the end of the connector (mated connection)

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Calibration Techniques

Use a cal kit for the desired connector type

- Easy
  - get testport cables with connector type
  - Or use adapters on standard testport cables
- Not available for all connector types
- Some manufacturers do NOT cover the full range of the connector

Calibration Techniques

Cal kit for the SMP connector

- SOLT kit to 40 GHz
- Standards for Plug and Jack
- Most use “polynomial” model open and short effects
- Broadband load (perfect)

Calibration Techniques

What if there is no cal kit available?

- Calibrate at testport cable (RPC 2.4)
- Removes cable effects and VNA errors
  - Ignore adapter (short and low loss)
  - Model adapter and de-embed

Model for Adapter

EM Simulation

- Requires mechanical details on adapter

Adapter Characterization (VNA)

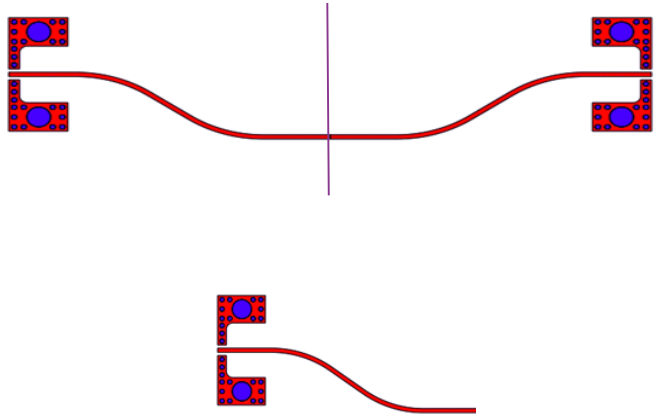
- *Requires 2 cal kits: RPC-2.4 and SMP*

Automatic Fixture Removal

Automatic Fixture Removal

Introduced ~6 years ago

- Originally 2X Thru (left and right fixture)
  - well established as an accurate alternative to TRL calibration kits for PCB fixtures and cables
- Last year 1X fixture (open or short)
  - Very good comparison to 2X – still being evaluated



AFR Process

1. Calibrate at the RPC 2.4 cable ends
   - 1 port, 2 port, or 4 port calibration
2. Measure fixture, compute and save “model” of fixture(s)
3. Measure fixtured DUT
4. Remove fixture(s) using de-embedding

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Measurements and Models

2X AFR (Jack / Plug) – 2 port 2.4

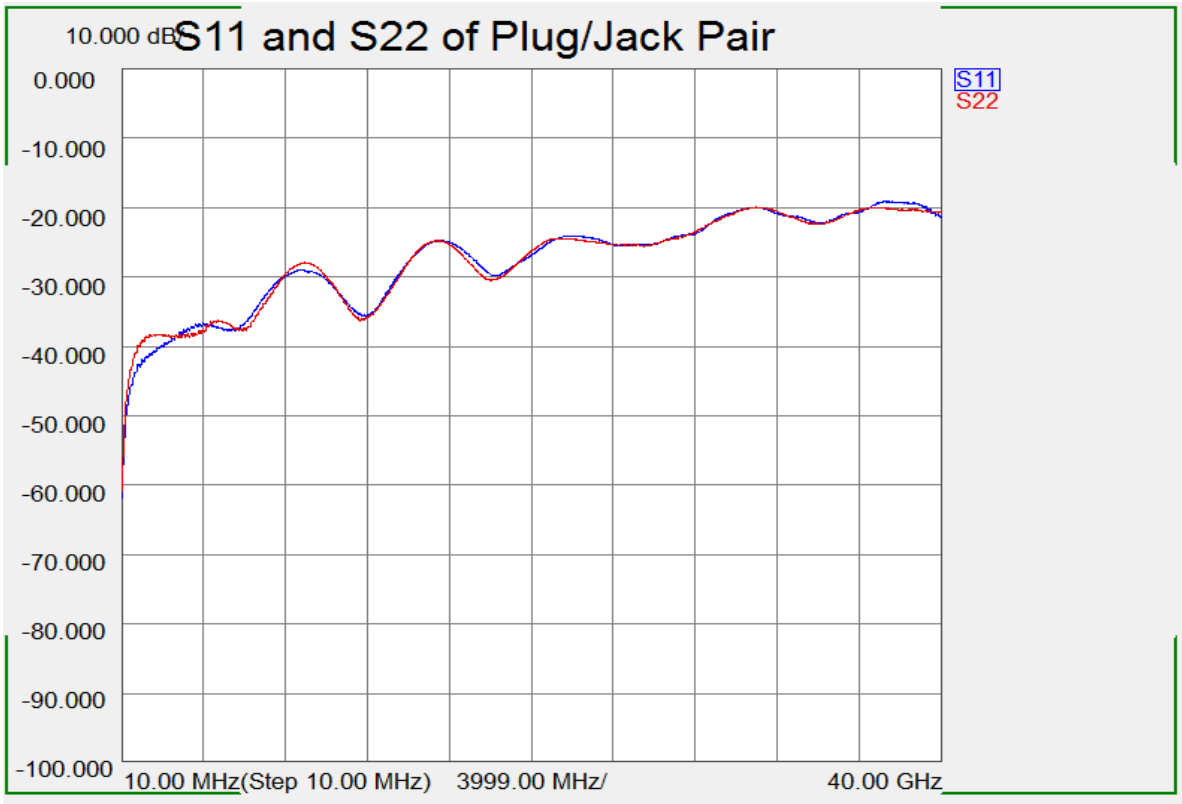
1X AFR (Jack and Plug) – 1 port 2.4

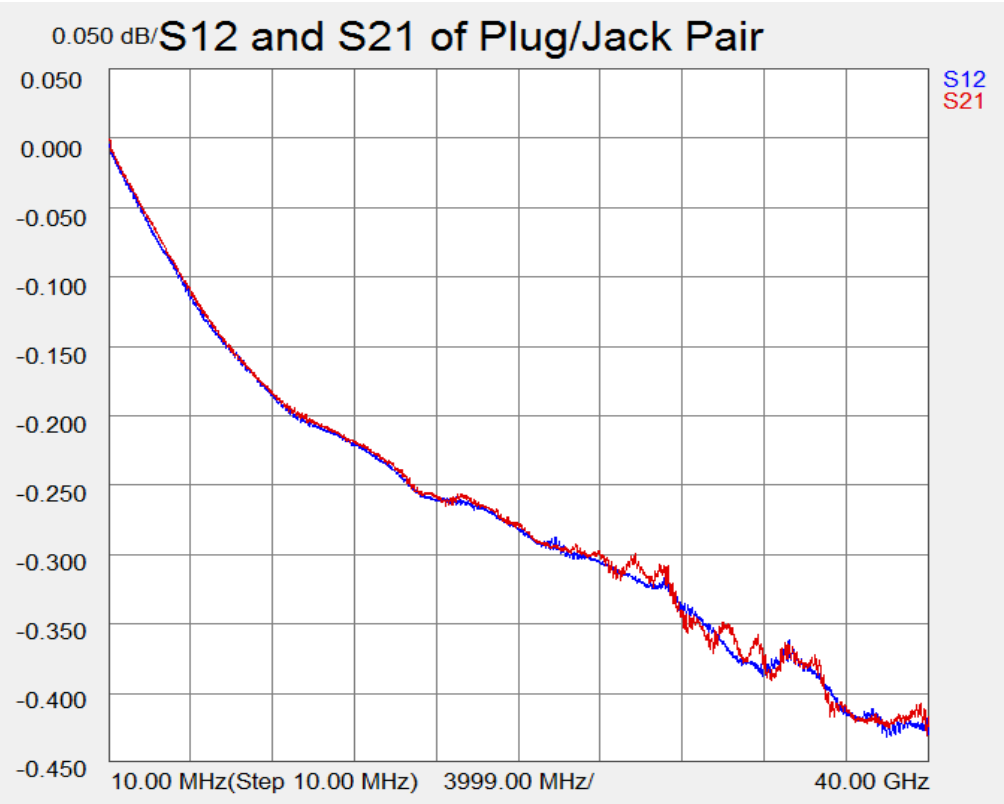
Adapter Characterization – 1 p 2.4 & SMP

SOLR Measurement – 2 port 2.4 & SMP

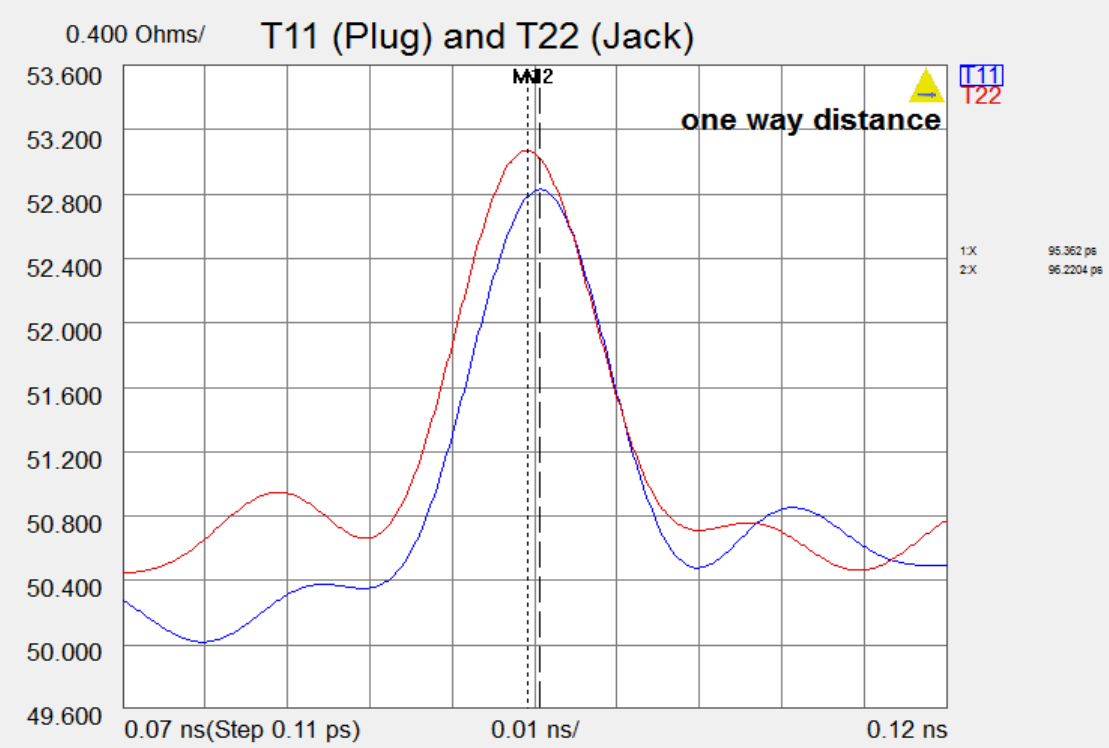
EM Simulation Results

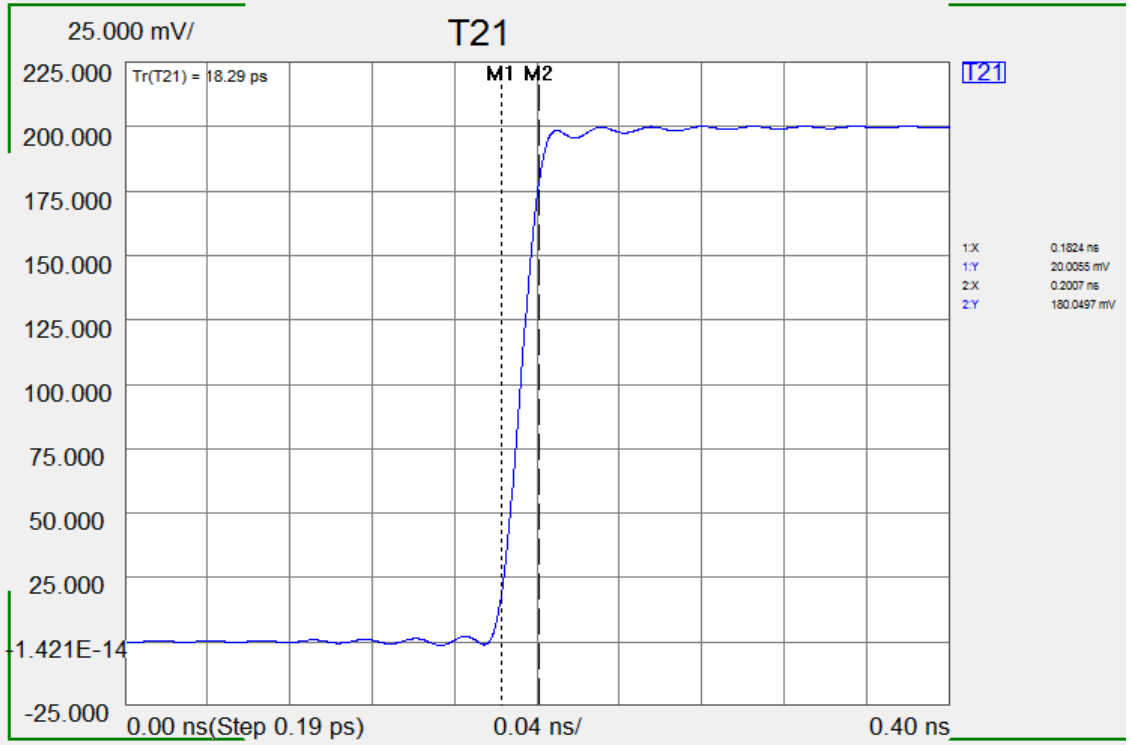
Mated Pair of Adapters





Time Domain of Mated Pair





Rise Time Test

40 GHz measurement

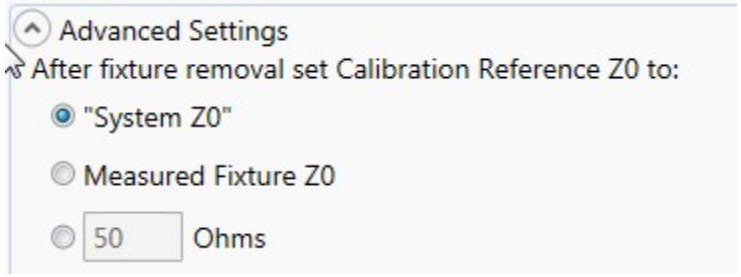
- Spatial resolution = 12.5 ps
- Risetime 18.0 ps

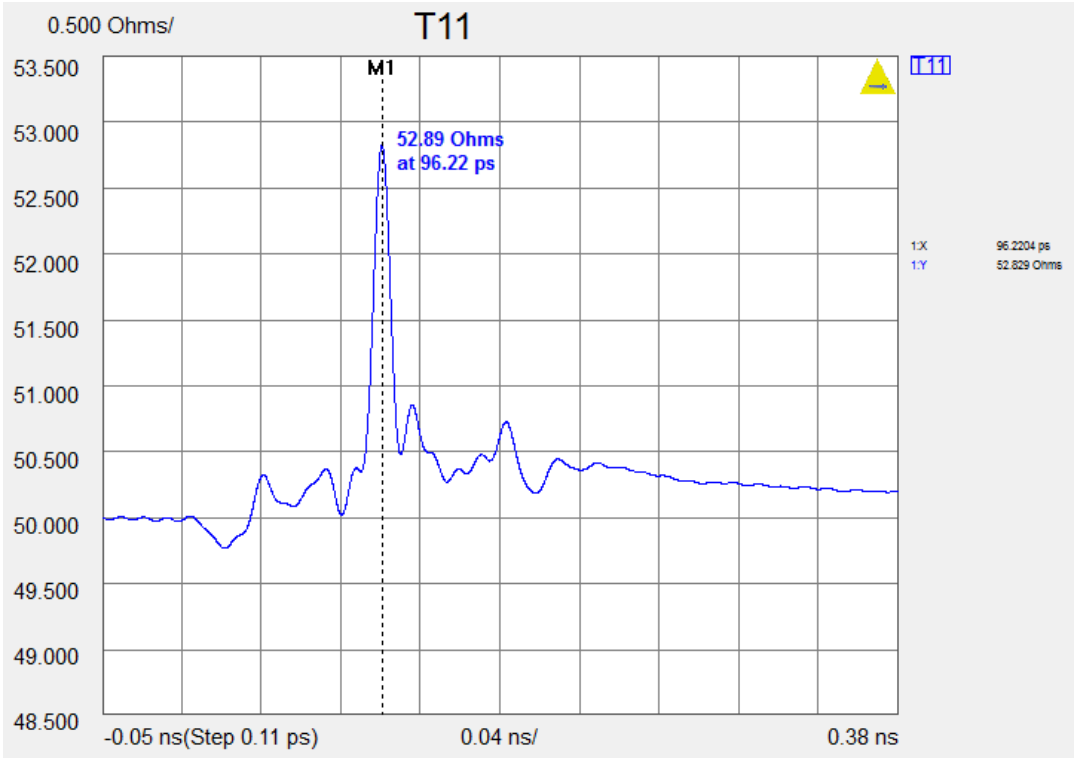
Plug = 95.36 ps and Jack = 96.22 ps

Risetime = 18.29 ps (4X = 73.16 ps)

Time Domain of Mated Pair

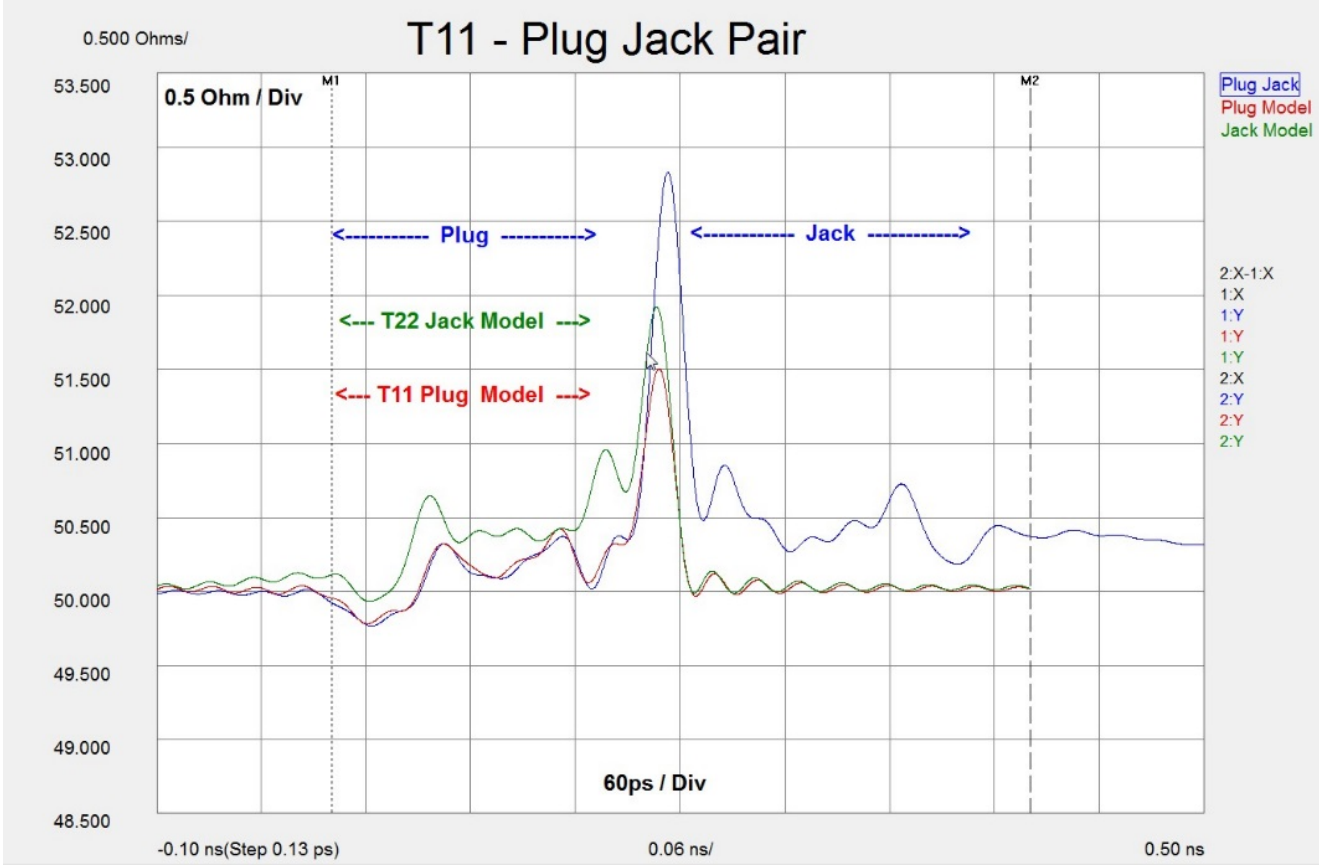
- Discontinuity at the split point – usually try to avoid this in your design of the fixture.
- For this case we will use the AFR option that sets the Calibration Reference Z0 back to 50 Ohms





Time Domain of Mated Pair

- About ½ of the discontinuity is included in each models
- The models goes back to 50 Ohms at the end of the adapter.
- The jack adapter has slightly more of the discontinuity due to the ~1 ps difference in lengths.



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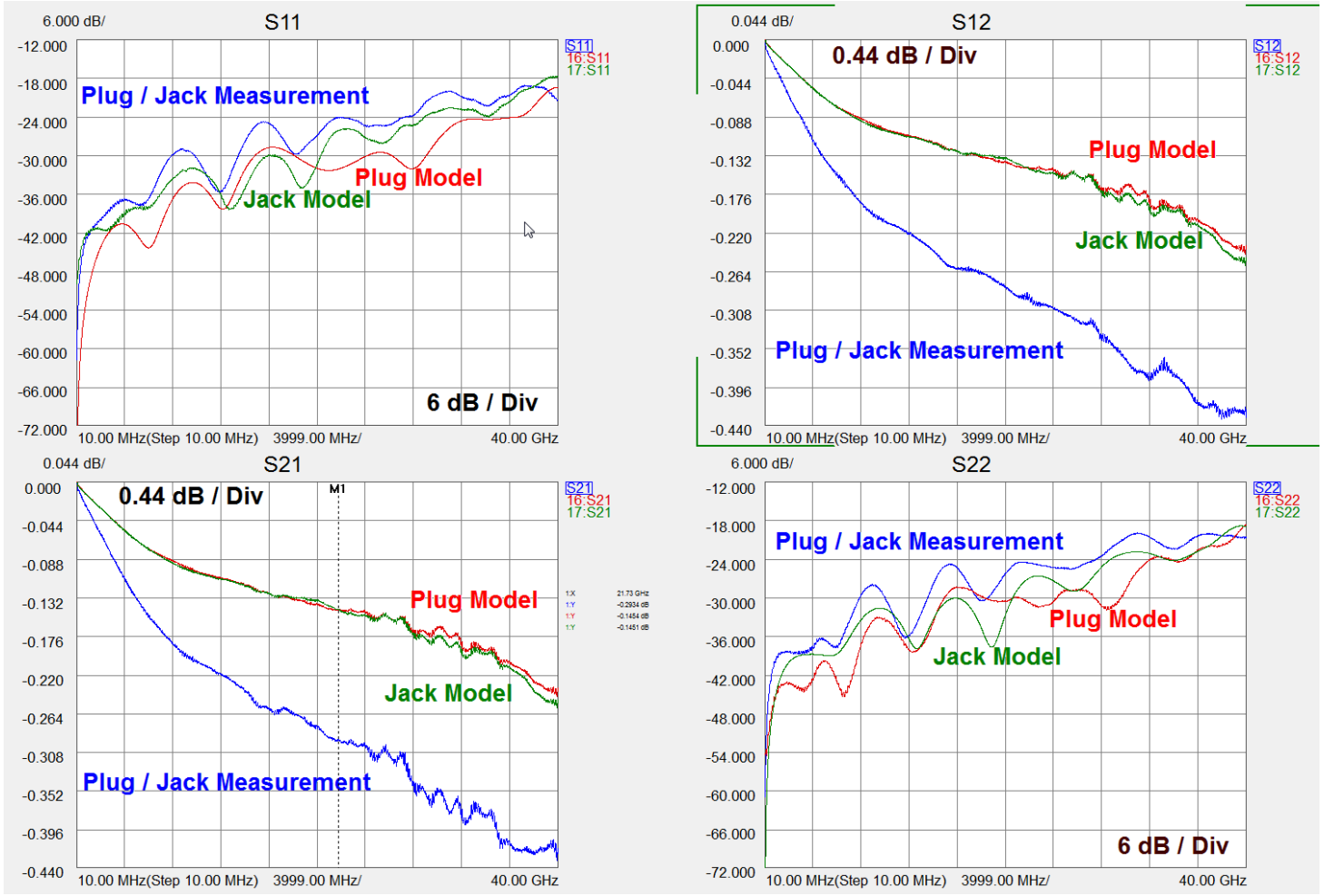
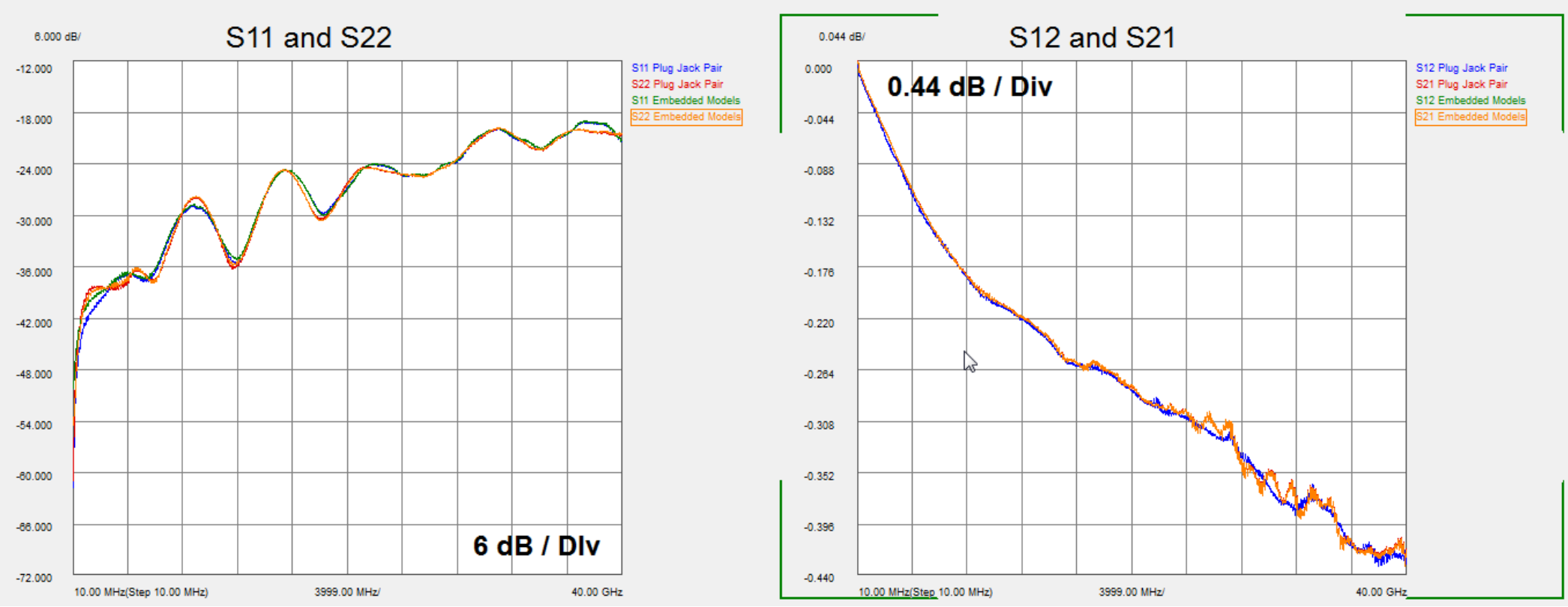
Frequency Domain

- Insertion Loss of models is ~1/2 of the pair.
- The Return Loss of models is better than the pair.
- To a first order this seems reasonable.

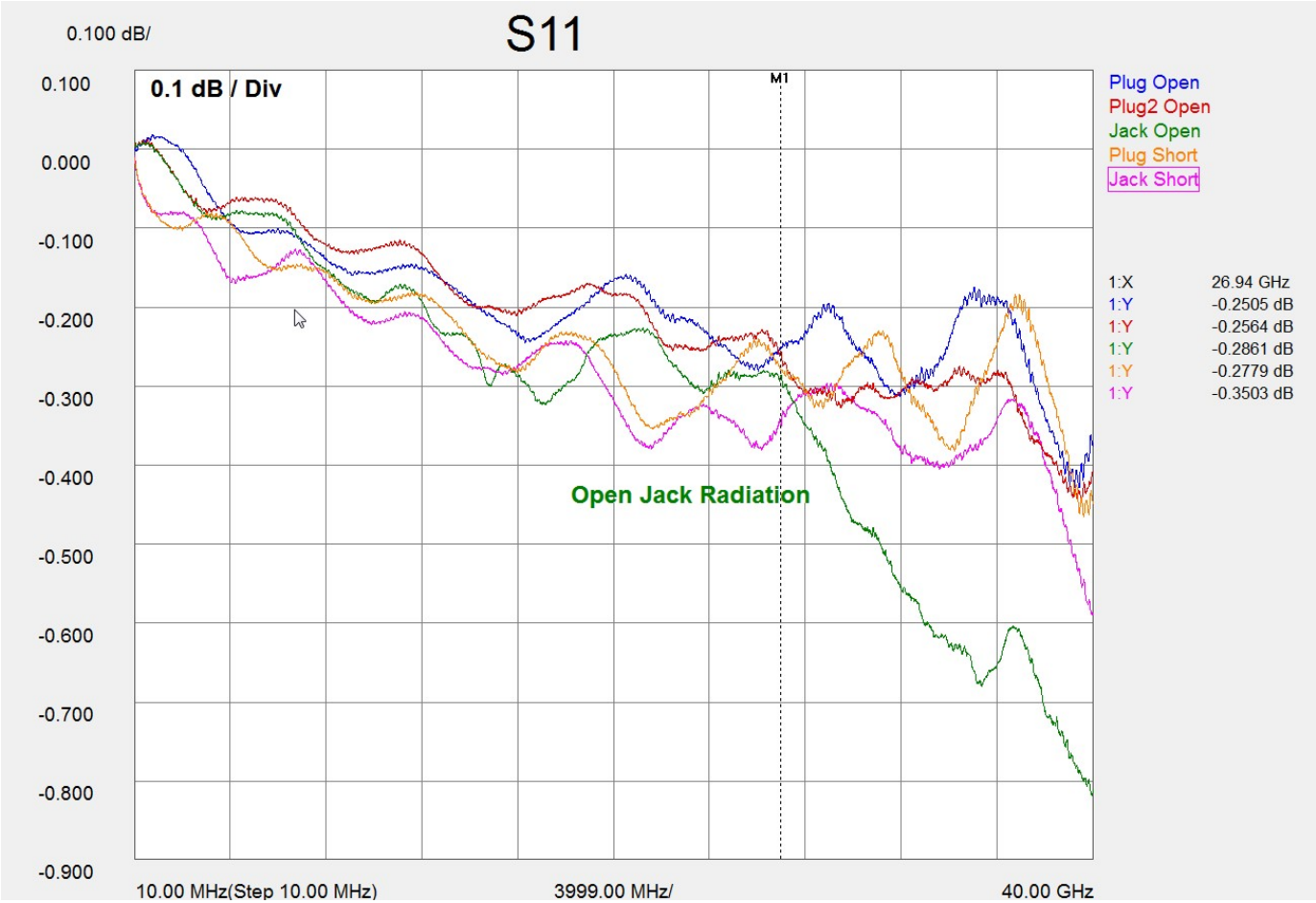


Embedded Adapters vs Original Measurement



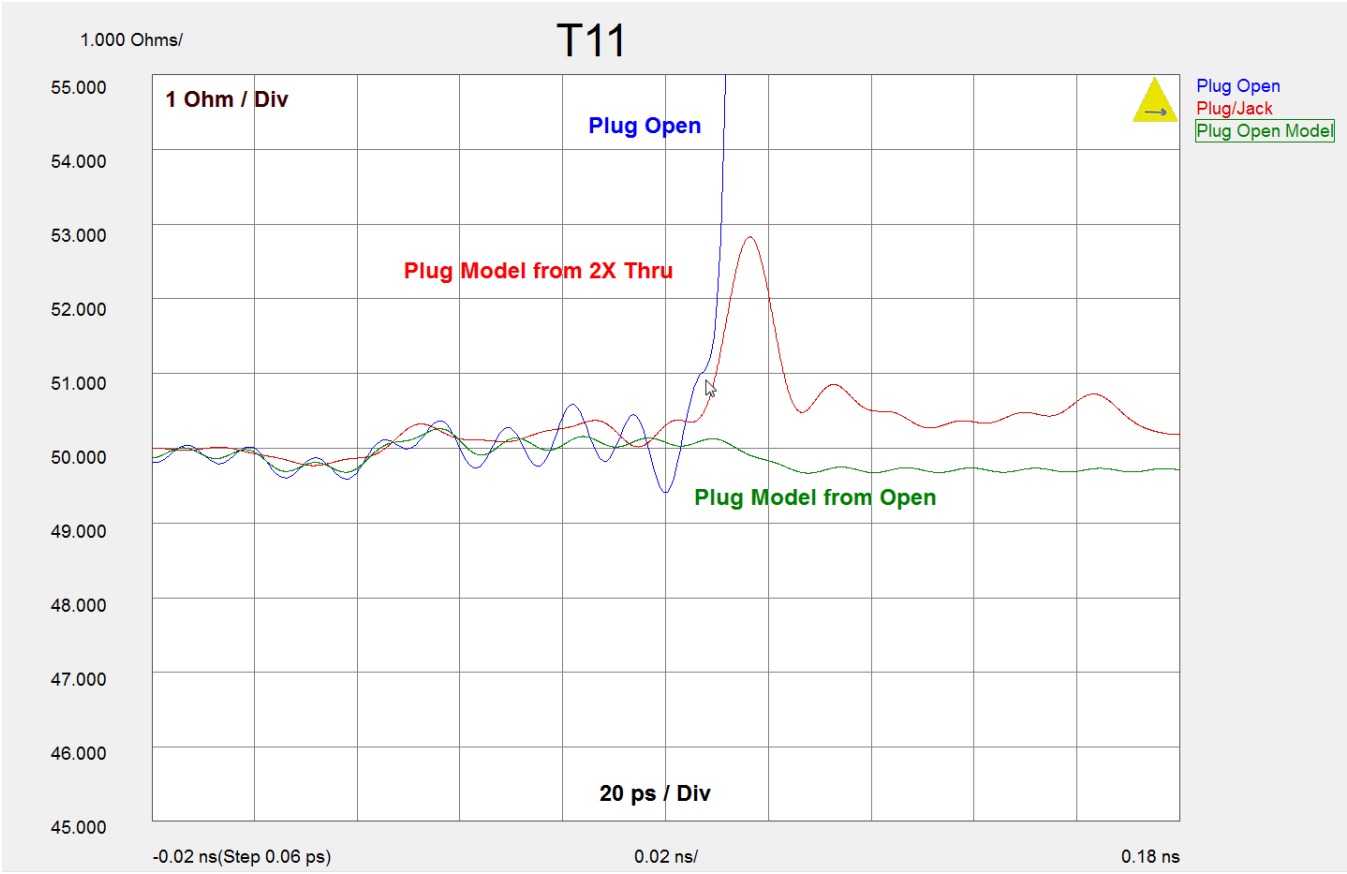
1X AFR

- Both open plugs and the shorted plug look very similar.
- The open jack radiates > 27 GHz.
- The shorted jack compares well with the open below 27 GHz and is very similar to the plug response where the open radiates.

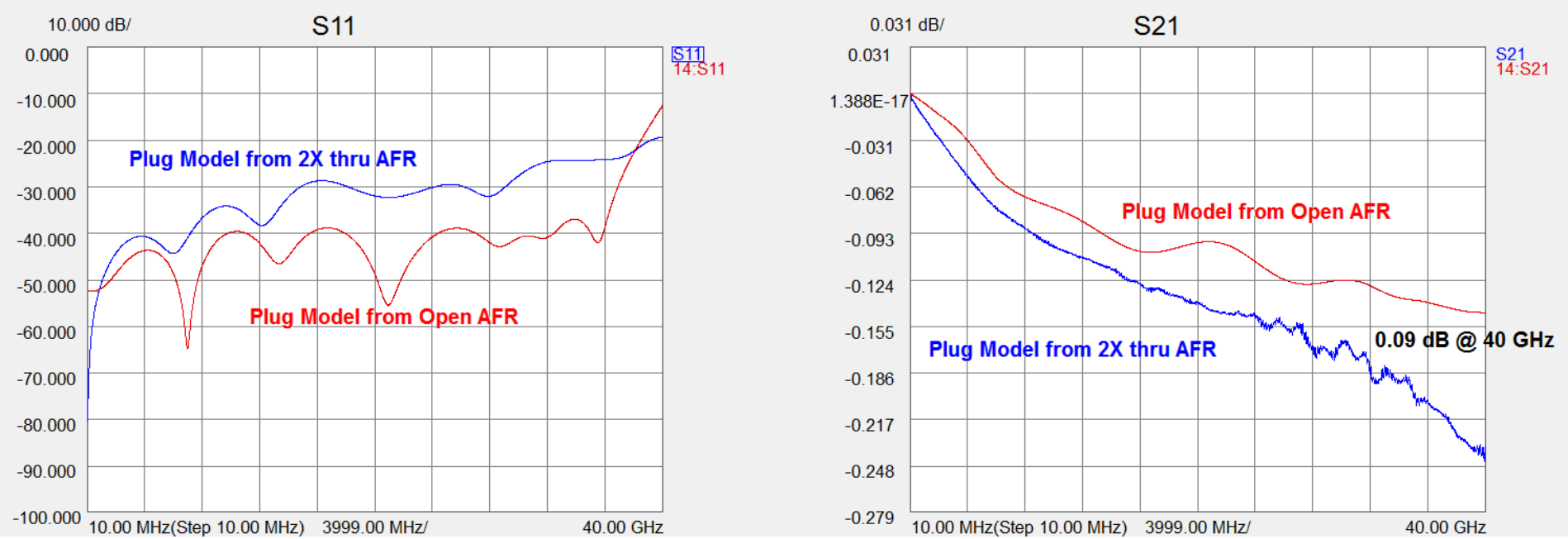


1X AFR

- This discontinuity is too close to the open response to be accurately modeled.
- Wider frequency range might help resolve the discontinuity from the open response.

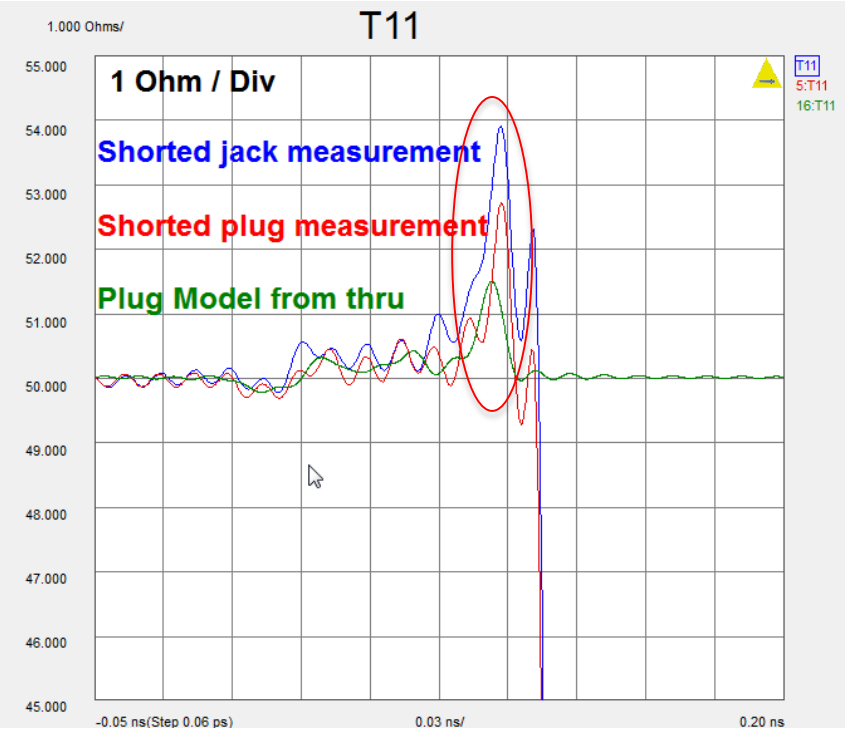


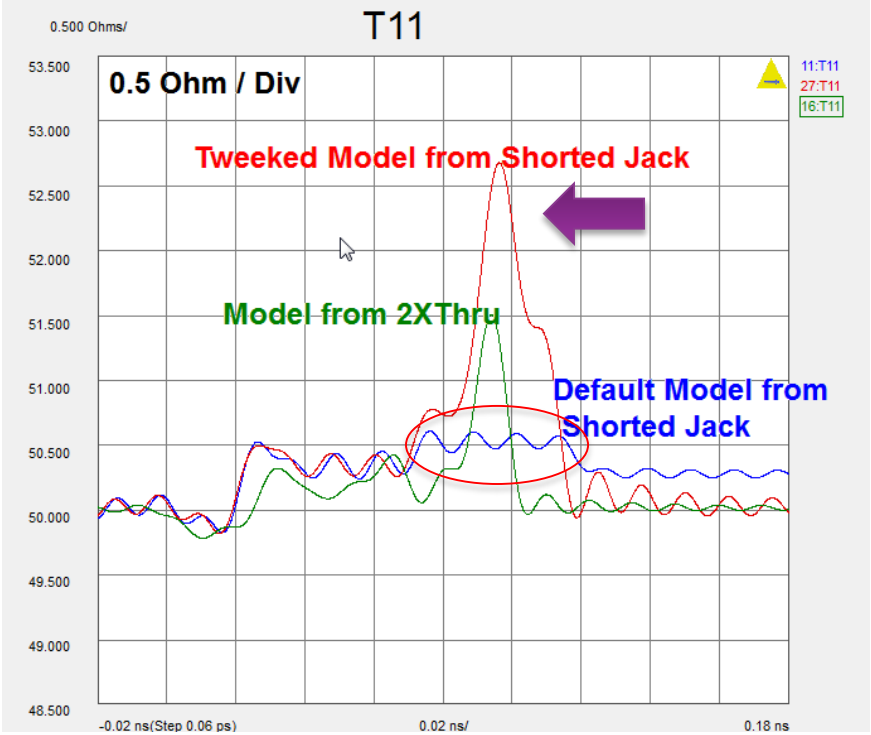
1X vs 2X Models



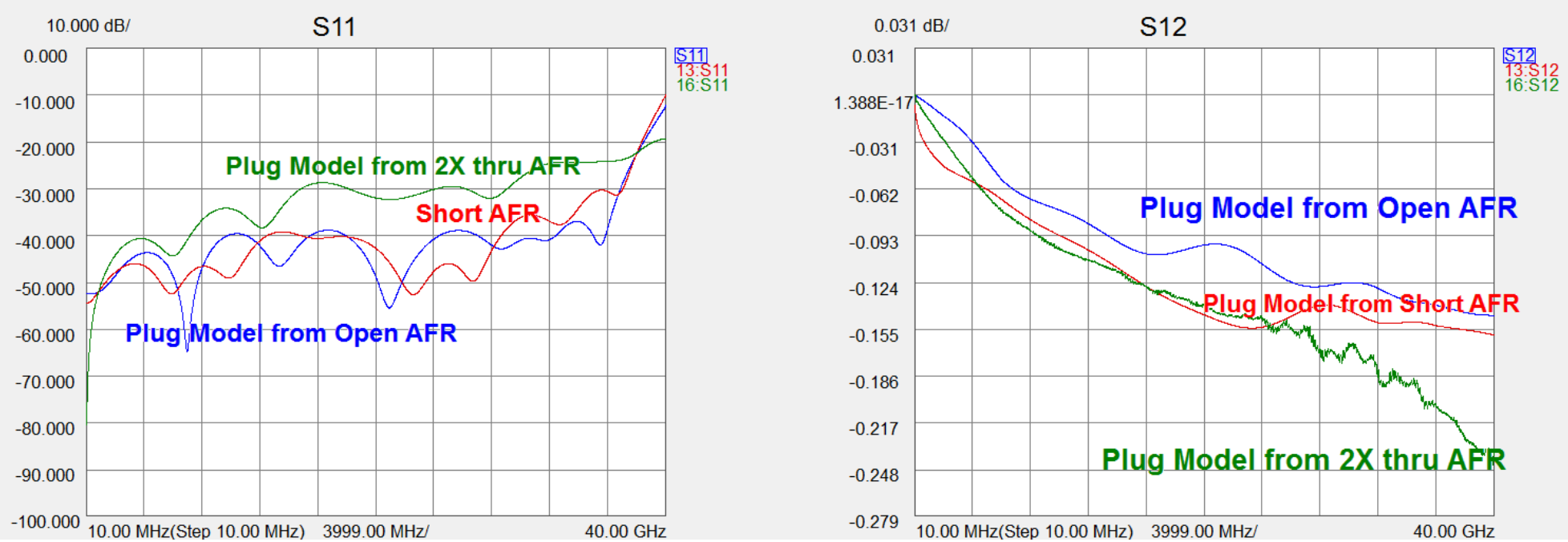
Without including the discontinuity effects (1X), both the return loss and insertion loss are too good compared to the 2X models.

Shorted Adapters





Model Comparison

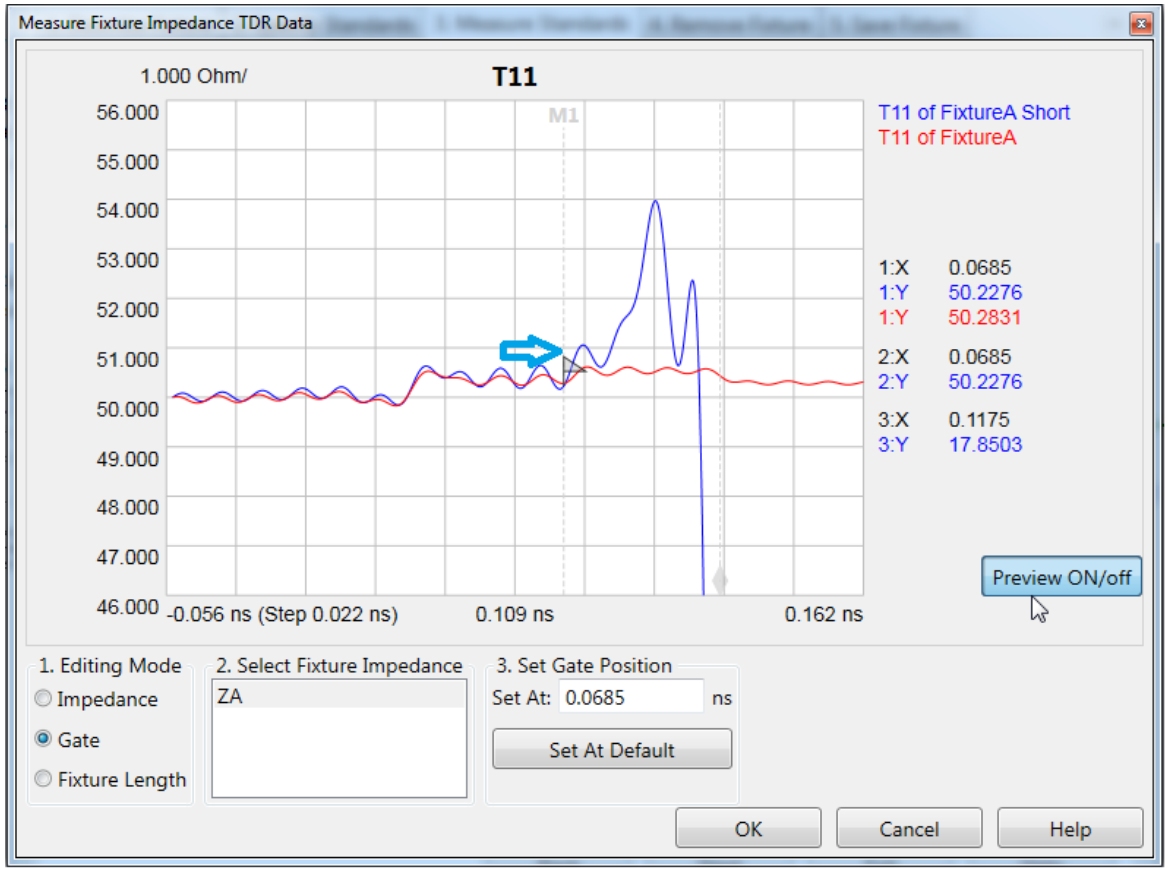


The short seams to give somewhat better results compared to the open.

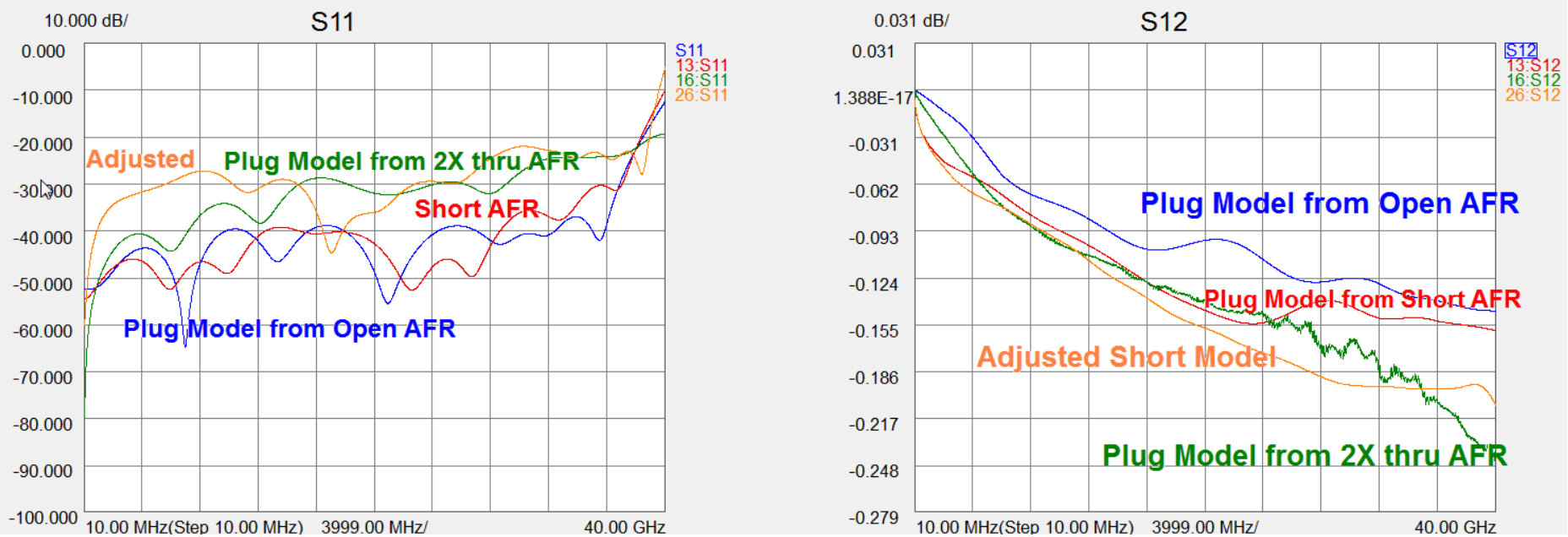
Editing the 1X AFR Settings

- There are 3 available adjustments:
  - Impedance
  - Gate Position
  - Fixture Length

- In this case we adjusted the Impedance and Gate markers.



Tweaked Short Model



Adjusting the parameters to include the discontinuity can give better results.

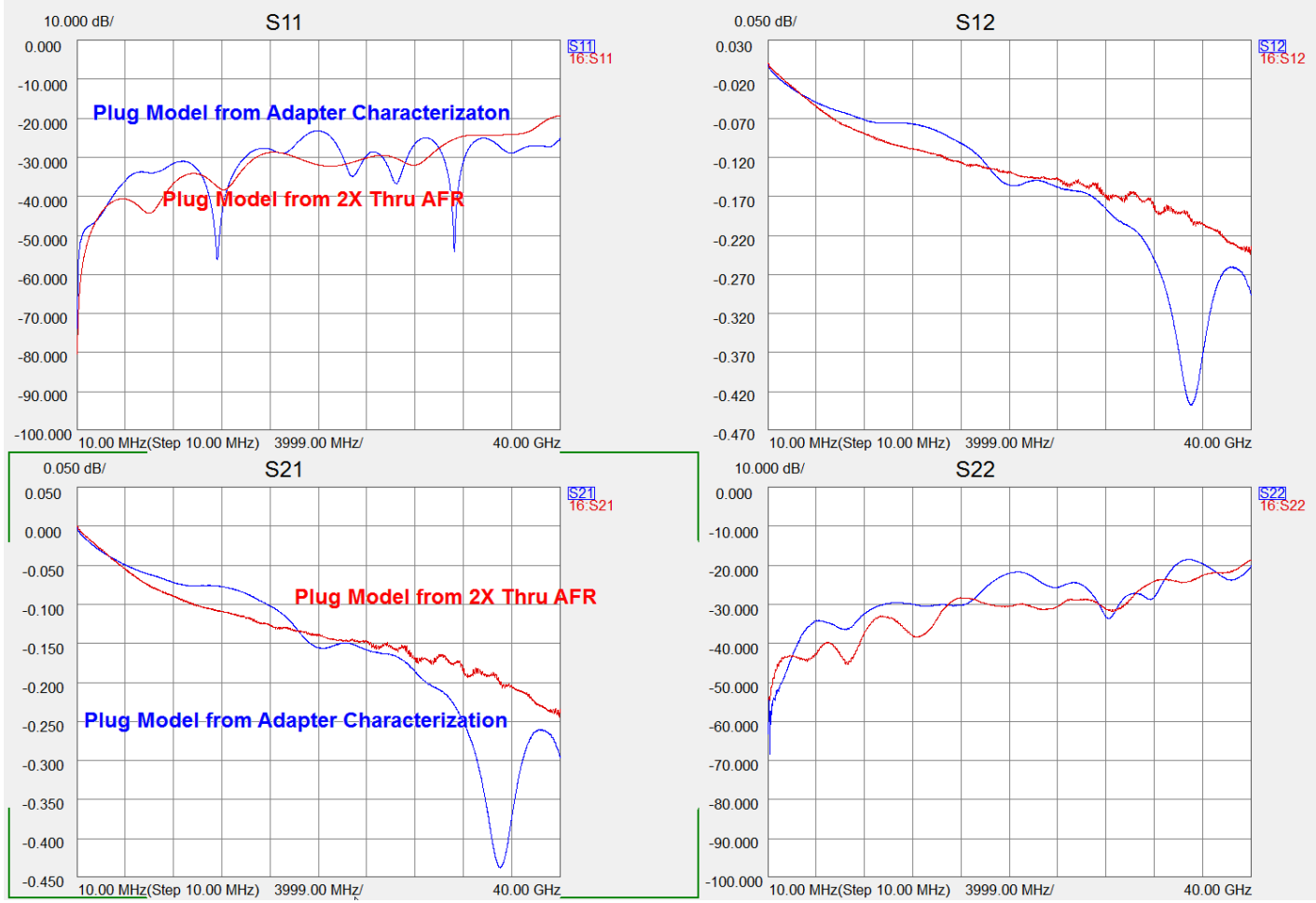
Adapter Length Comparisons

	Plug Adapter	Length			Jack Adapter	Length
	simulated	28.7mm			simulated	28.7mm
method	2x Thru	28.7mm		method	2x Thru	28.7mm
	1 port - short	28.7mm			1 port - short	28.7mm
	1 port - open	29.5mm			1 port - open	28.85mm
	"open fringing"	*0.8mm*			*"open fringing"*	*0.15mm*

Both 2X AFR and 1X AFR (short) agree with the simulated length. The open measurements show fringing effects and not the same for the plug and jack.

Adapter Characterization

- Requires 2 1-port calibrations:
  - RPC 2.4
  - SMP
- For short low loss measurements cable movement is critical. (use testport of VNA)
- Results are not as good as AFR.



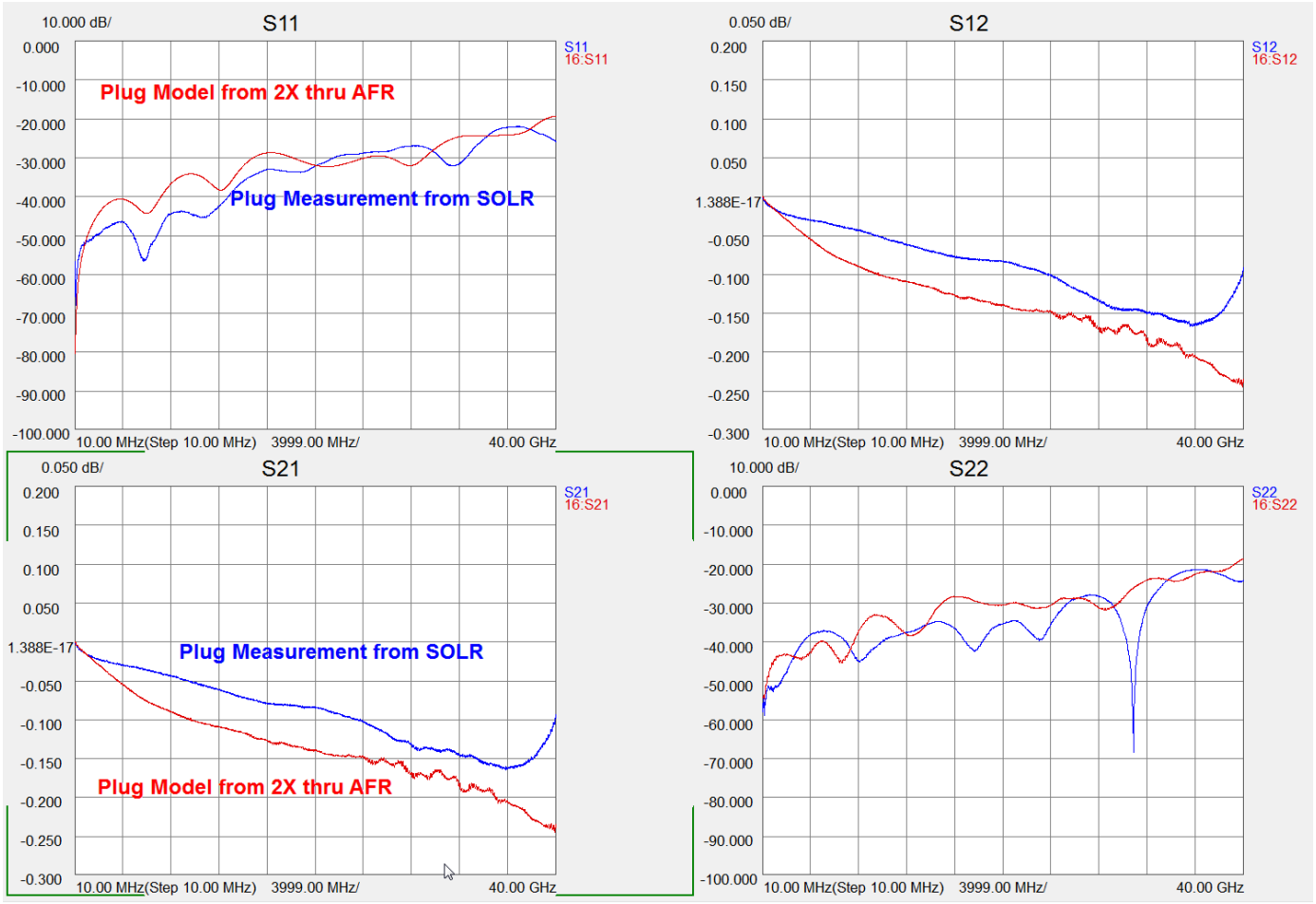
SOLR Measurement

Requires a full 2 port calibration

- Port 1 is RPC 2.4
- Port 2 is SMP
- The “thru” is the DUT as unknown
  - Helps minimize cable movement

SOLR Measurement

- Good correlation for match.
- Insertion loss shows a little less loss and a high frequency curve.



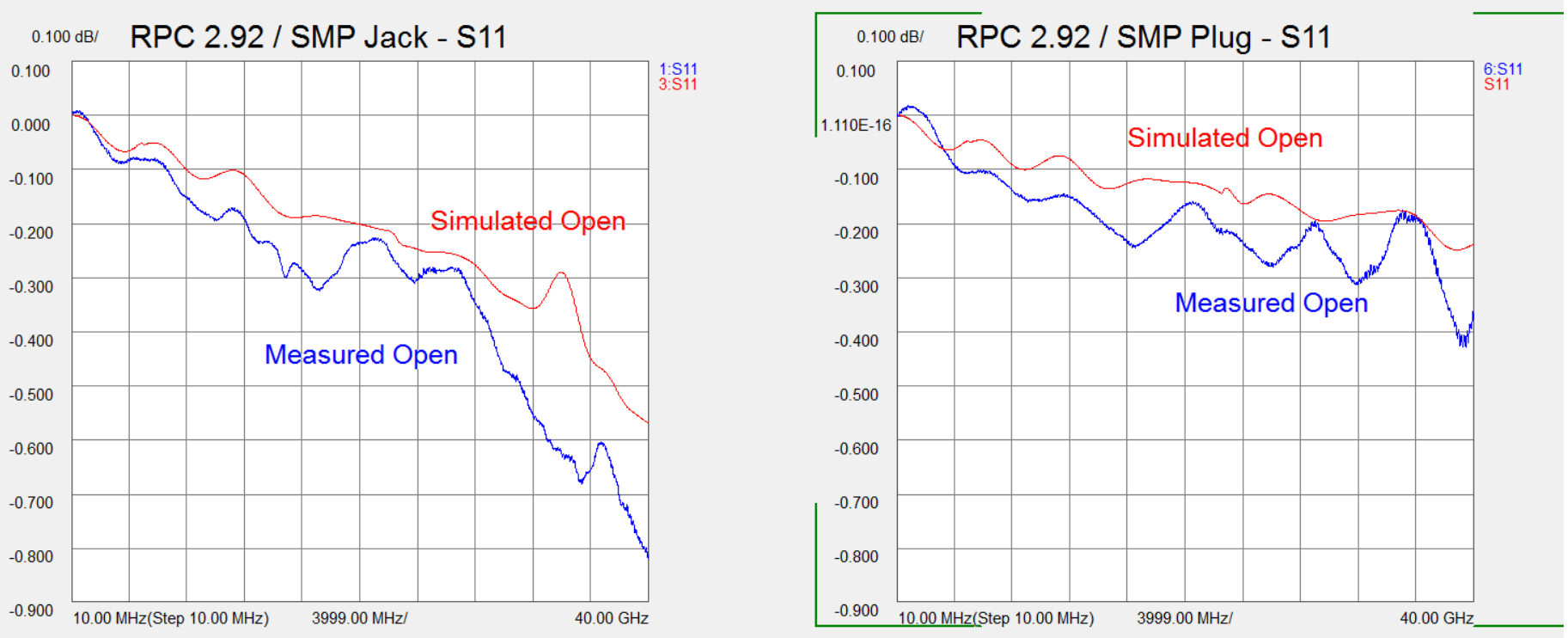
EM Simulation Results

3D EM simulations using HFSS were run:

- for the “open” jack and plug. (.s1p)
- For the “thru” jack and plug (.s2p)

Simulations were based on the manufacturer’s mechanical specifications for the adapters.

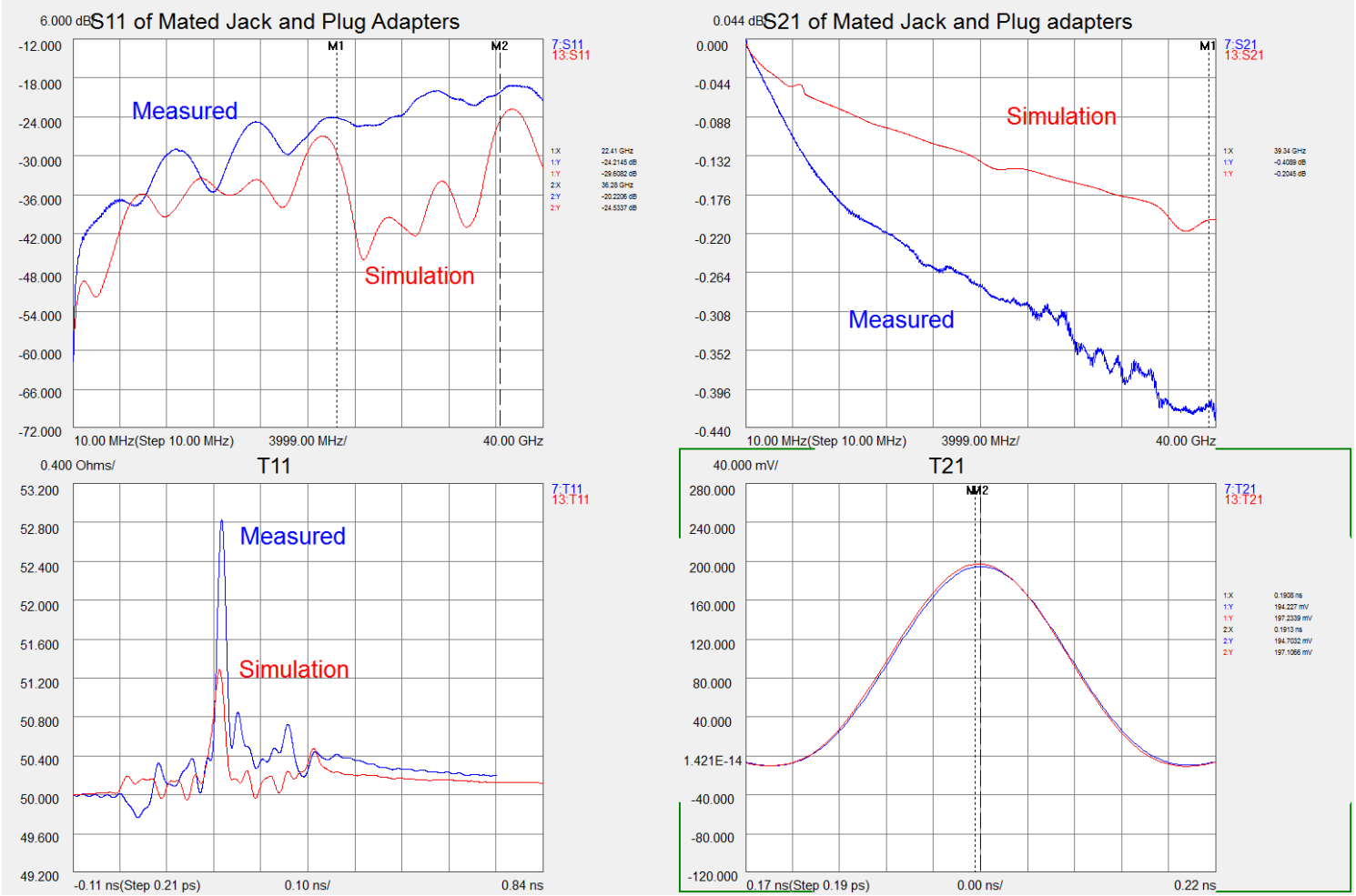
EM Simulation Results



Reasonably good agreement between simulation and measurements.

EM Simulation Results

- Simulated Match of the model is better than measurement.
- Simulated Insertion loss is significantly less that measurement.
- Time domain data shows discontinuity is smaller for simulated data.



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Potential Causes for Differences

mechanical tolerances of the piece parts

forces used during assembly

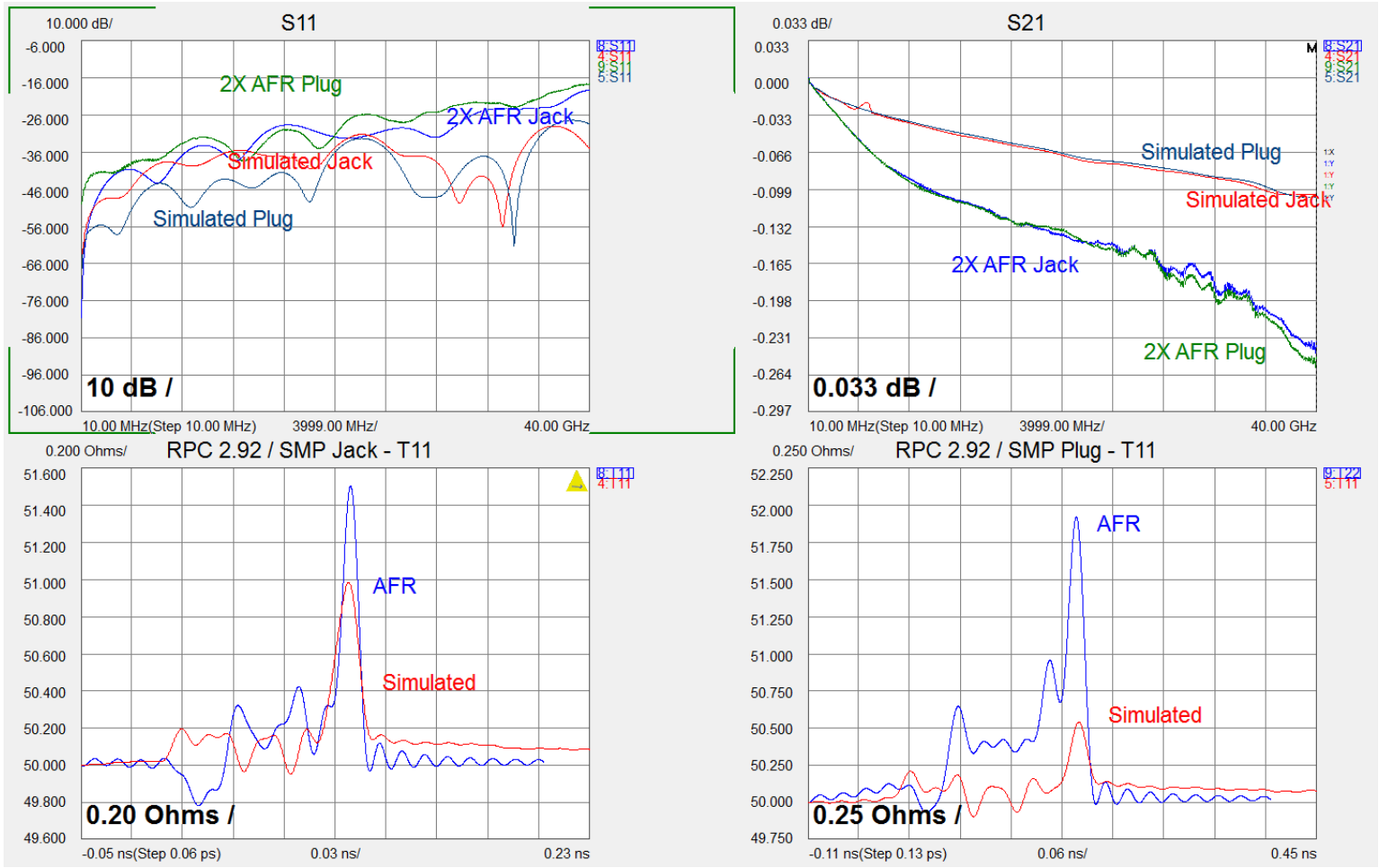
conductivities and surface roughness not exactly known

exact layer composition of the plating not included in the simulation

errors due to calibration are not included in the simulation

EM Simulation Results

- Simulated Match of the model is ~6dB better than measurement and has more variation.
- Simulated Insertion loss is significantly less that measurement.
- Time domain data shows discontinuity is smaller for simulated data.



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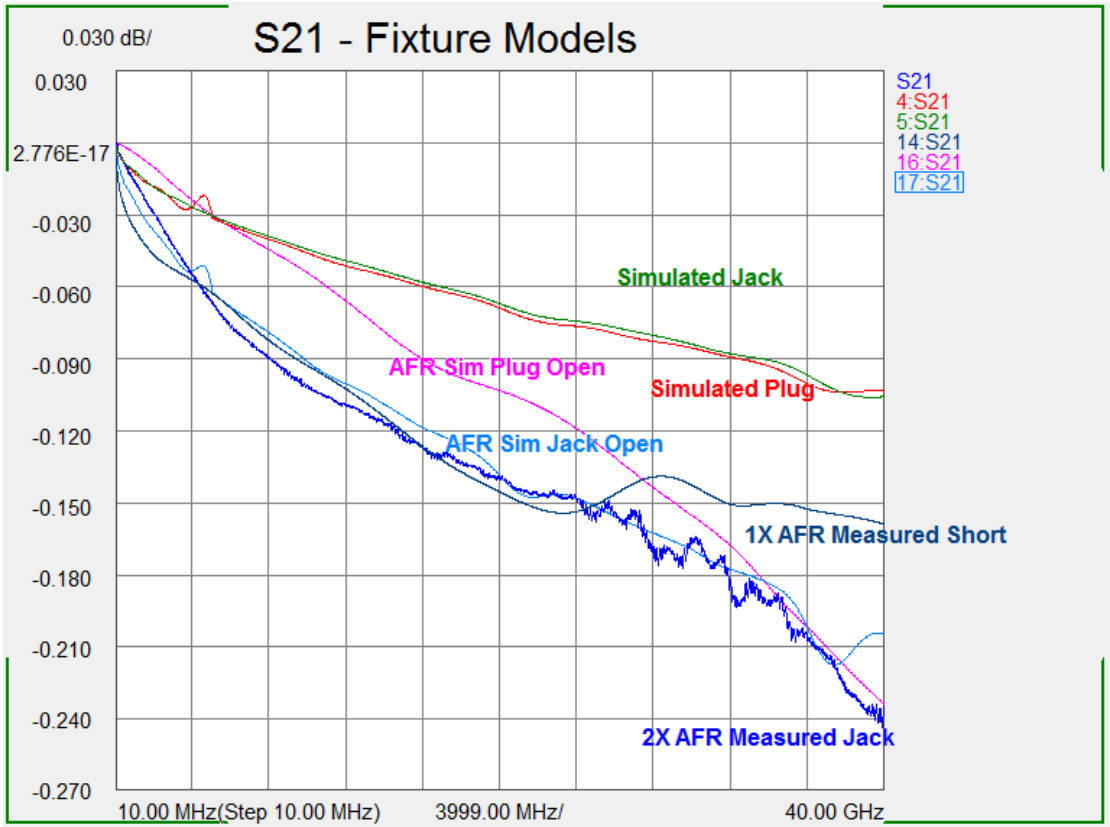
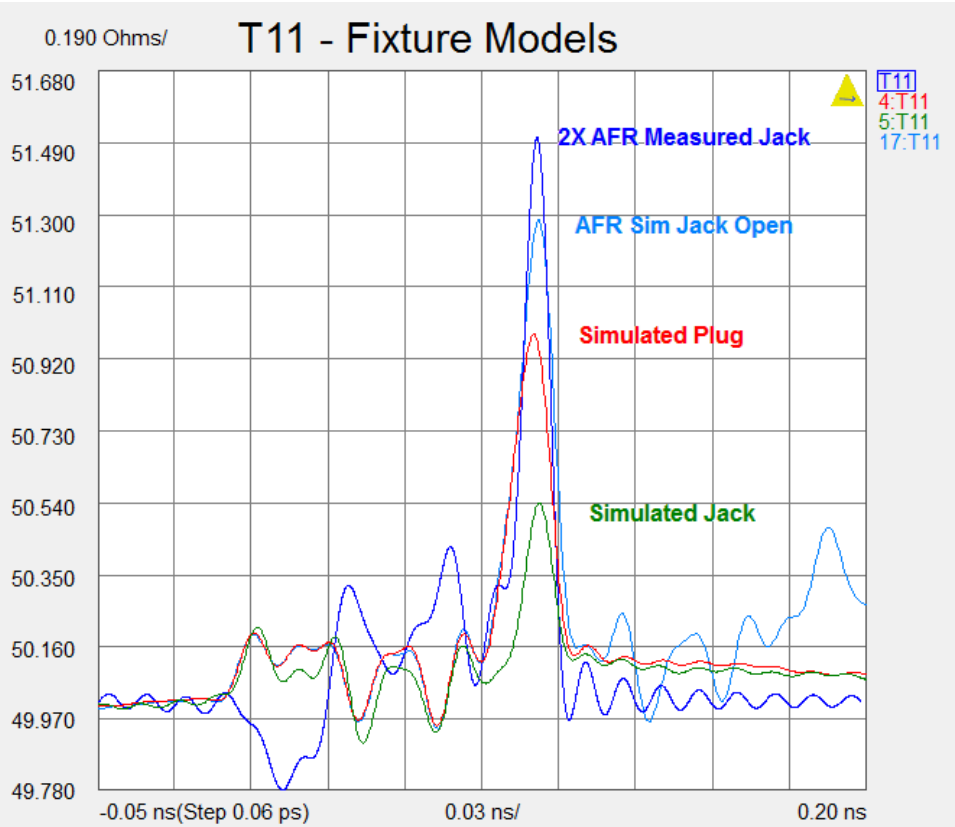
Fixture Model Comparisons





The size of the discontinuity has the major effect on the loss and match.

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Summary

Blind-mate adapters are very challenging do to low loss and short length.

The variation in the discontinuity at the mated junction is critical to the match and loss

AFR (1X and 2X) can provide a quick and accurate to remove the adapter effects.

2X AFR seems to generate better models when there is a discontinuity at the reference plane.

High bandwidth measurements are required to get good models.

Acknowledgements

Reinhold Wolpert – Rosenberger for the simulation results.

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