SWTEST 2021 CONFERENCE
PROBE TODAY, FOR TOMORROW
30TH ANNIVERSARY

A Vertical Probe Solution for the High-Density 5G Market

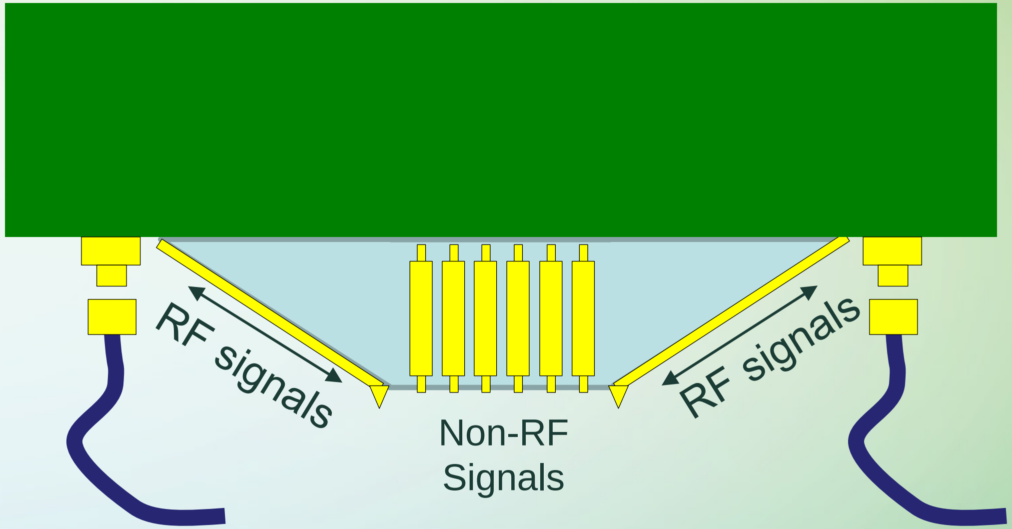
R&D Altanova® Nidec SV TCL

Don Thompson (*R&D Altanova*)
Svetlana Sejas (*SV Probe*)

Aug. 30 – Sep. 1, 2021

Perimeter Probing is Great!

- The established solution for RF probing
- RF signals go straight to Coax connectors
- PCBs are very simple
- Very simple routing and very high performance!



Except when it isn't…

- Often low compliance
- High RF channel count is a problem
- High site count is a problem
- Density leads to complex cable routing and expensive delicate cabling solutions

"We Need Vertical RF Probing" – 5G Market

There's no way to do that

MLOs can't go that fast

You can't match perimeter probing performance

That's too complicated

Vertical probe performance isn't good enough

Show me!

Prove it!

The Dream Solution:

High Density RF Vertical Probe

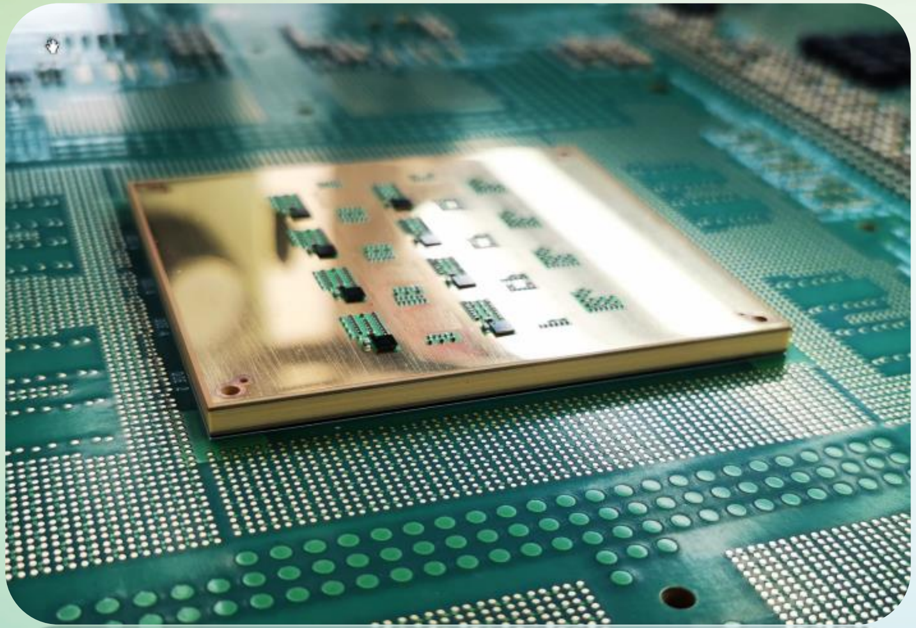
Advantages:

- High RF signal density (50+ RF channels)
- Allows for high site count
- Good compliance and familiar probe behavior
- Allows for PCB mounted RF circuits for BALUNs, filters, etc.
- Allows PCB mounted switching which can significantly reduced cabling

Technology Gaps:

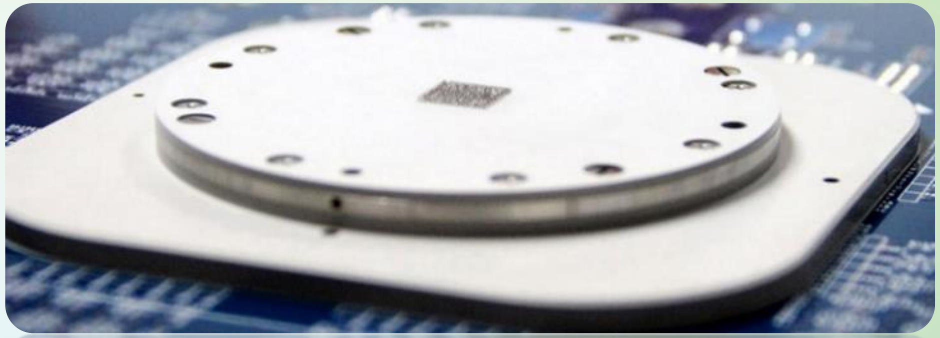
- Need high performance vias in both MLO and probe PCB
- Need multiple crossing RF routing layers - can't just be microstrip
- Need a vertical probe solution with high bandwidth

Two Piece Puzzle



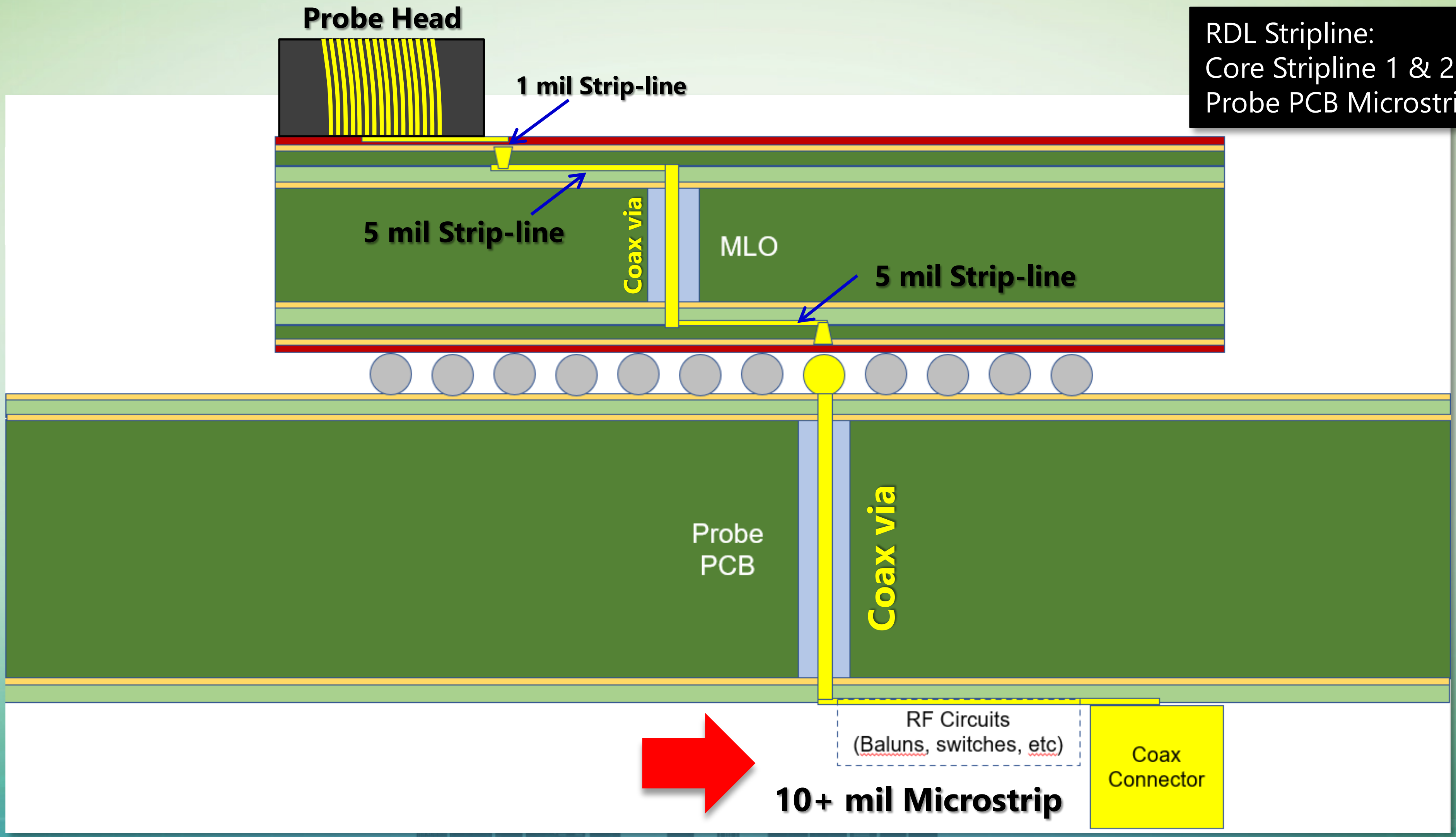
RF MLO + RF Probe PCB

+



RF Vertical Probe

Proposed Vertical Probe Card Architecture



RDL Stripline:	~50-200 mils
Core Stripline 1 & 2:	< 500 mils
Probe PCB Microstrip:	> 500 mils

Alternate Options for RF Vertical Probe

High-Speed RF MLOs

- **Vertical Probe Loop-back**
- **Vertical Probe to coax connectors on MLO (e.g. Inverted SSMP)**
- **Vertical Probe to opposite side of Probe PCB to circuit to coax connector**

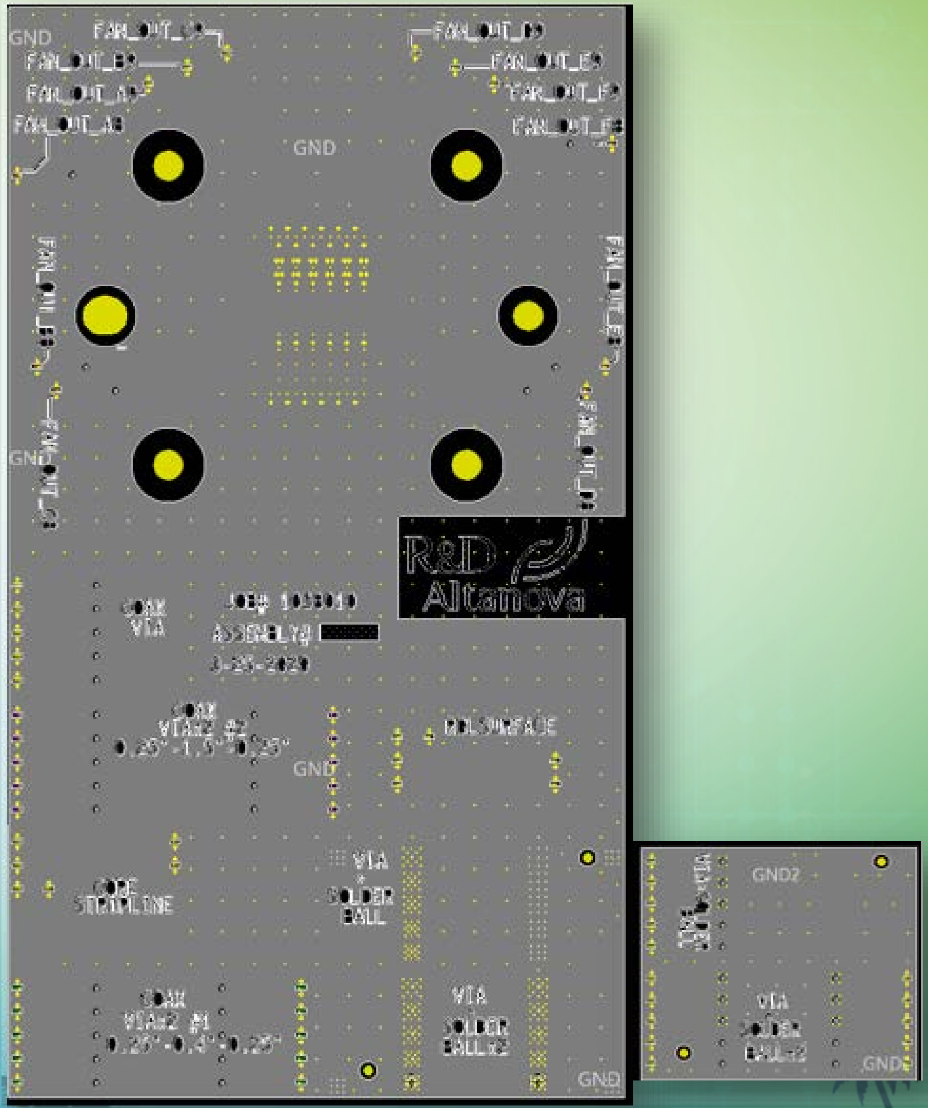
The goal of this presentation is high-light the capabilities of a high-speed RF MLO and find the right opportunity to advance the industry capabilities at wafer test.

Eval Board Results

Probe head performance measurements:
- Loopback
- Probe head to coax

Each transition with bracketed impedance steps:
- Coax via
- Solder ball interface

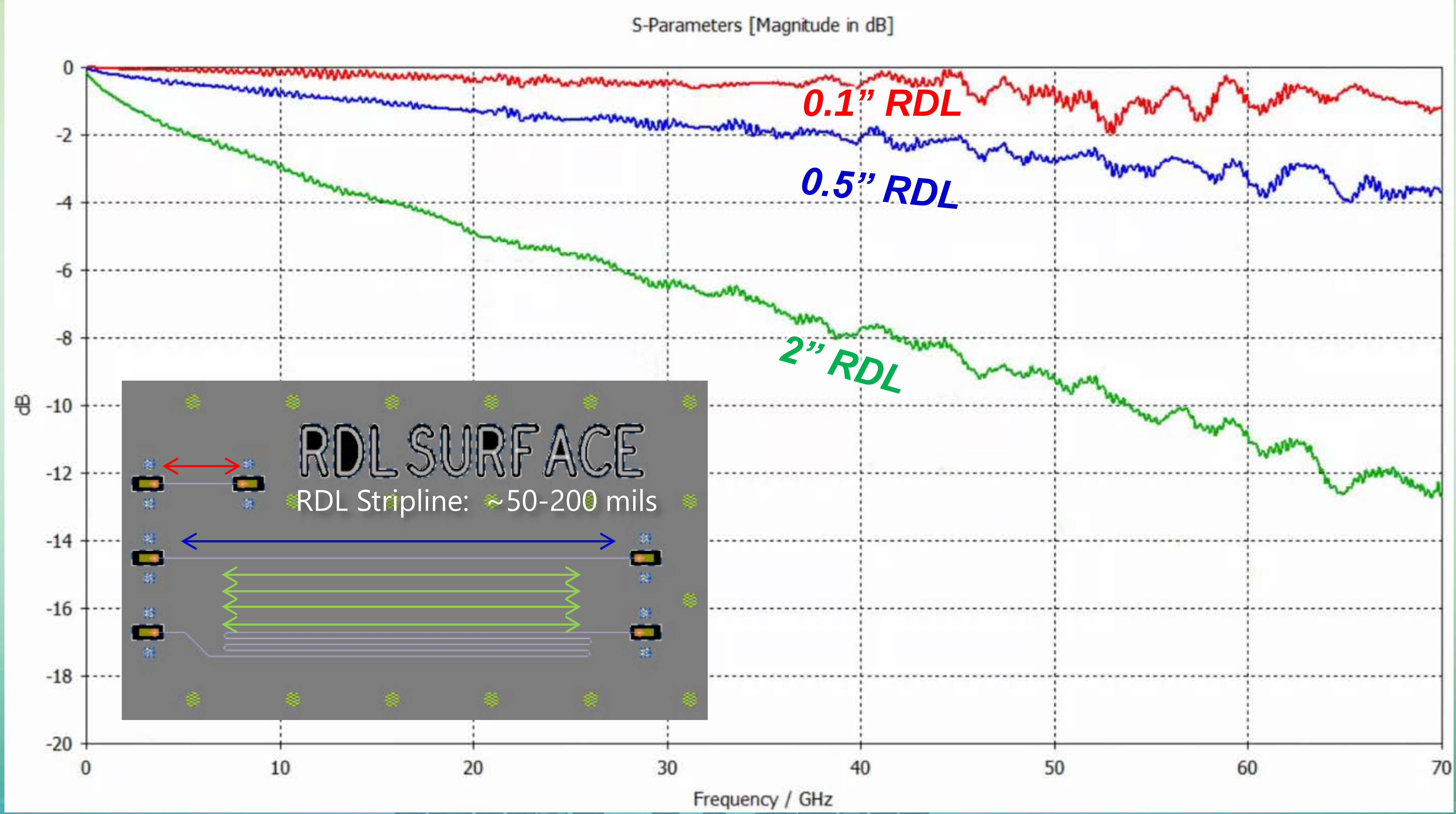
Characterize loss for:
- MLO transition
- RDL layers (0.5", 1", 2")
- Stripline (0.5", 2", 8")
- Solder ball via transition
- Coax Via



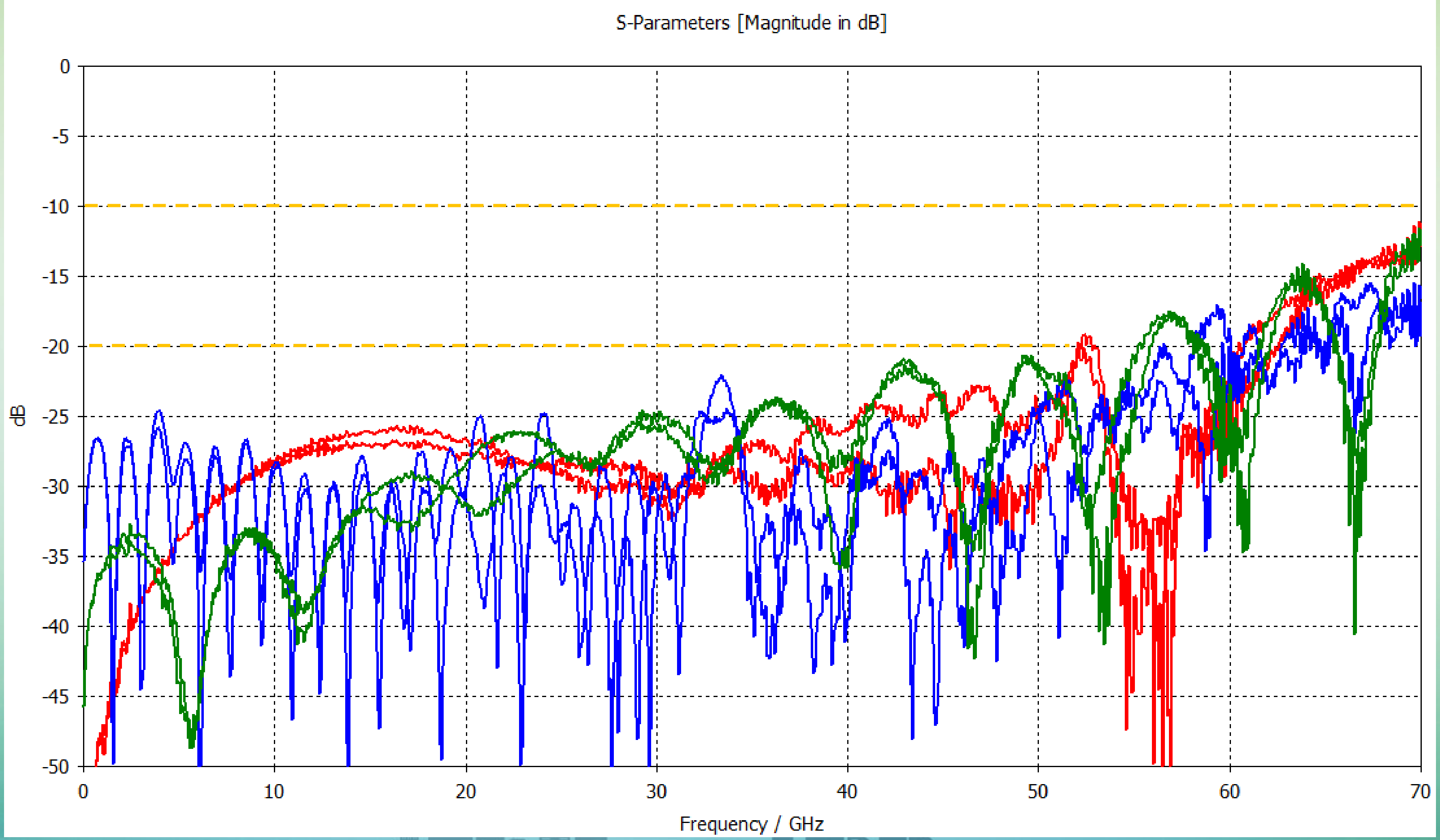
1. Trace & Transition Performance

RDL Insertion Loss (0.1”, 0.5”, 2”)

Probes are de-embedded, but transitions remain

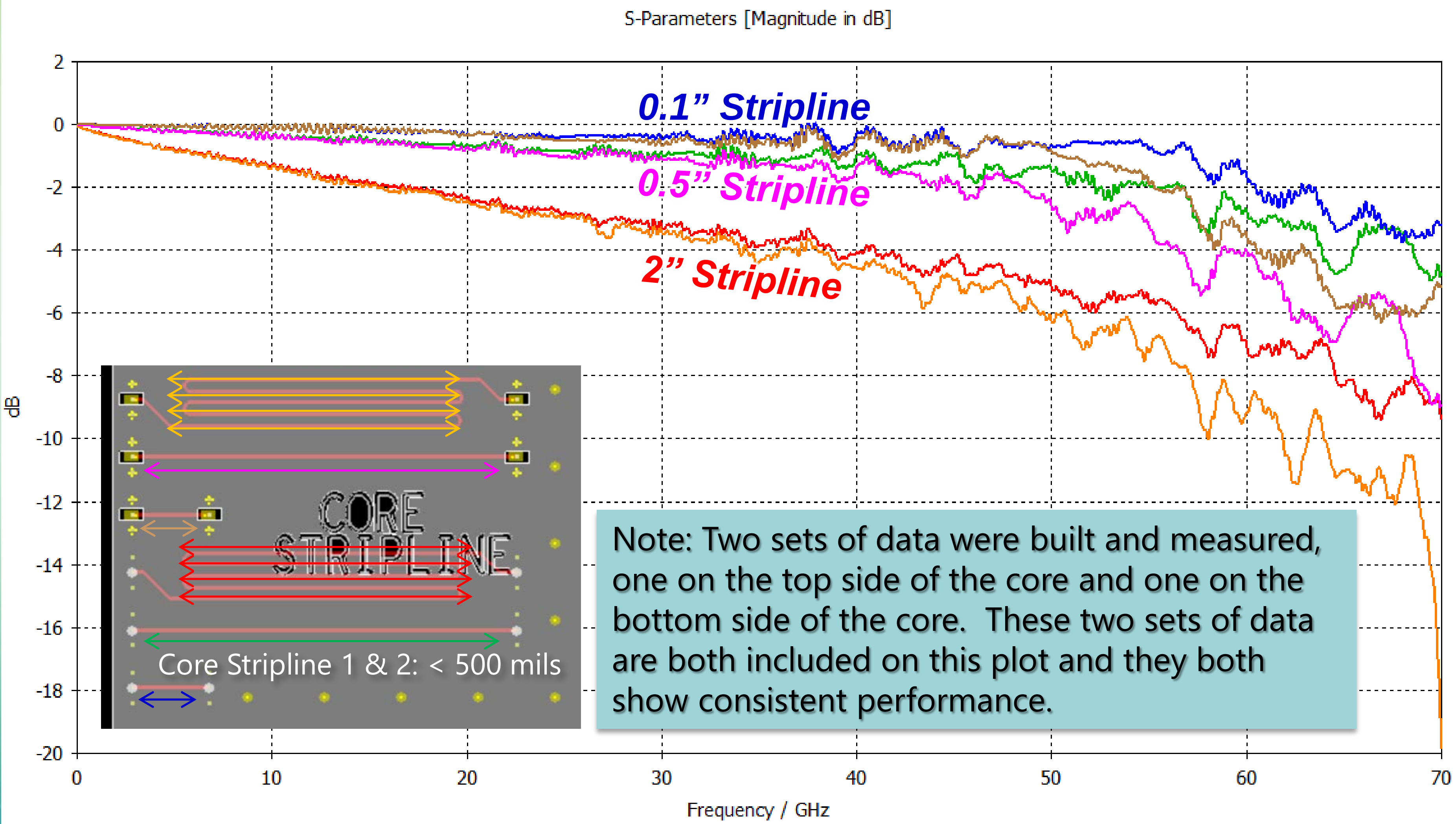


RDL Return Loss (0.1”, 0.5”, 2”)



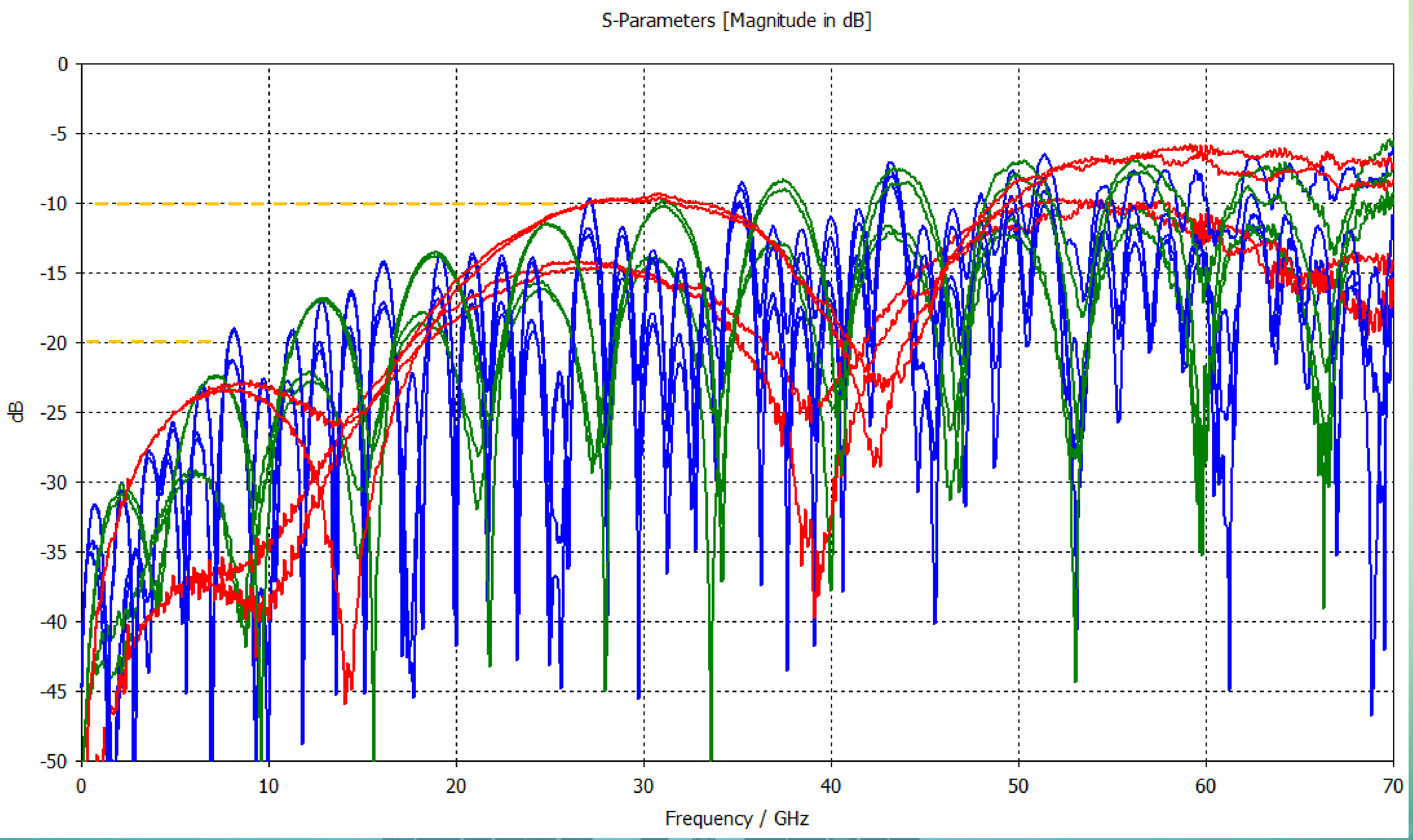
Stripline Insertion Loss (0.1”, 0.5”, 2”)

Probes are de-embedded, but transitions remain



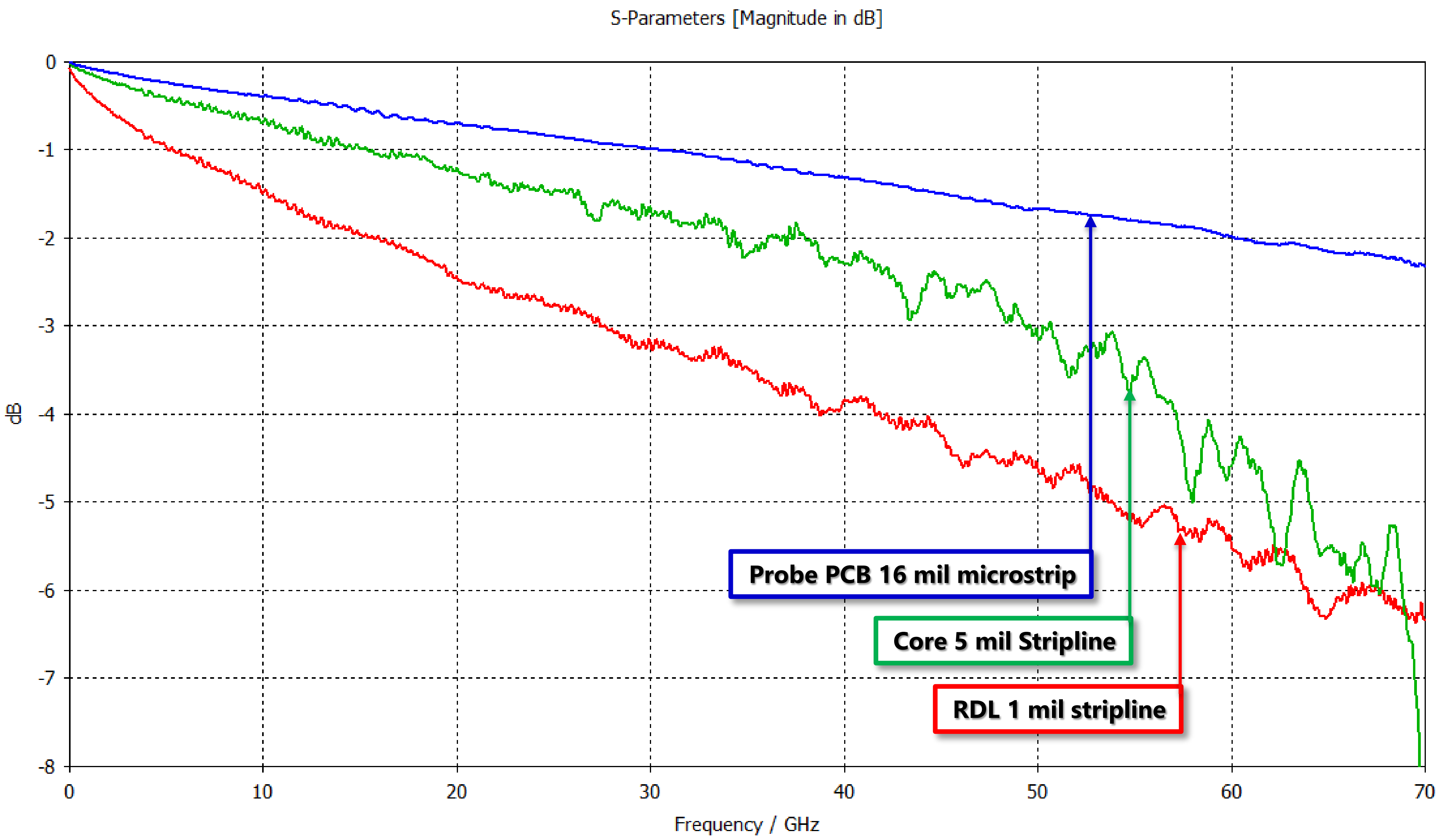
Note: Two sets of data were built and measured, one on the top side of the core and one on the bottom side of the core. These two sets of data are both included on this plot and they both show consistent performance.

Stripline Return Loss (0.1”, 0.5”, 2”)



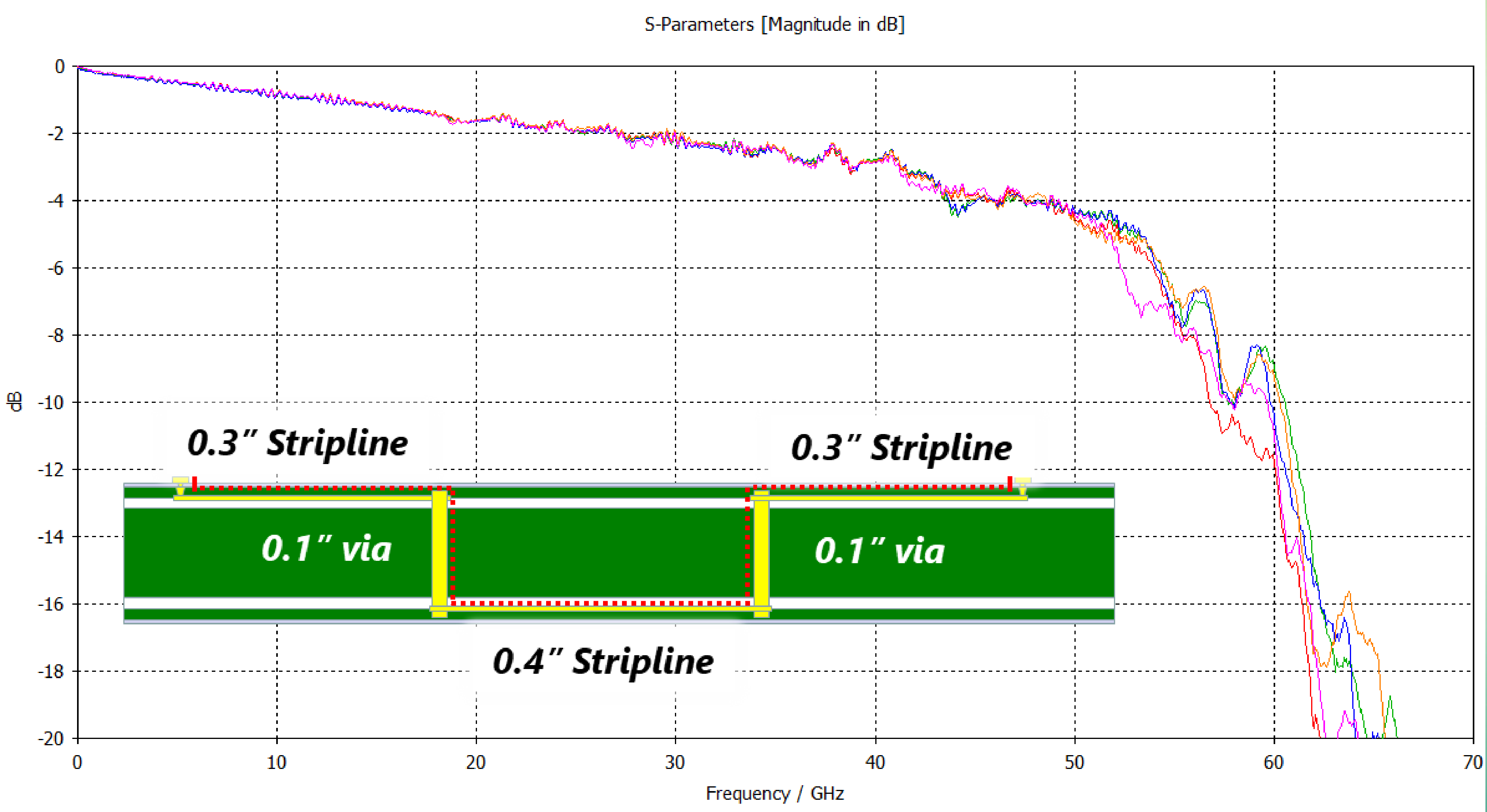
RDL vs. Stripline vs. Microstrip

Measured Insertion Loss Per Inch

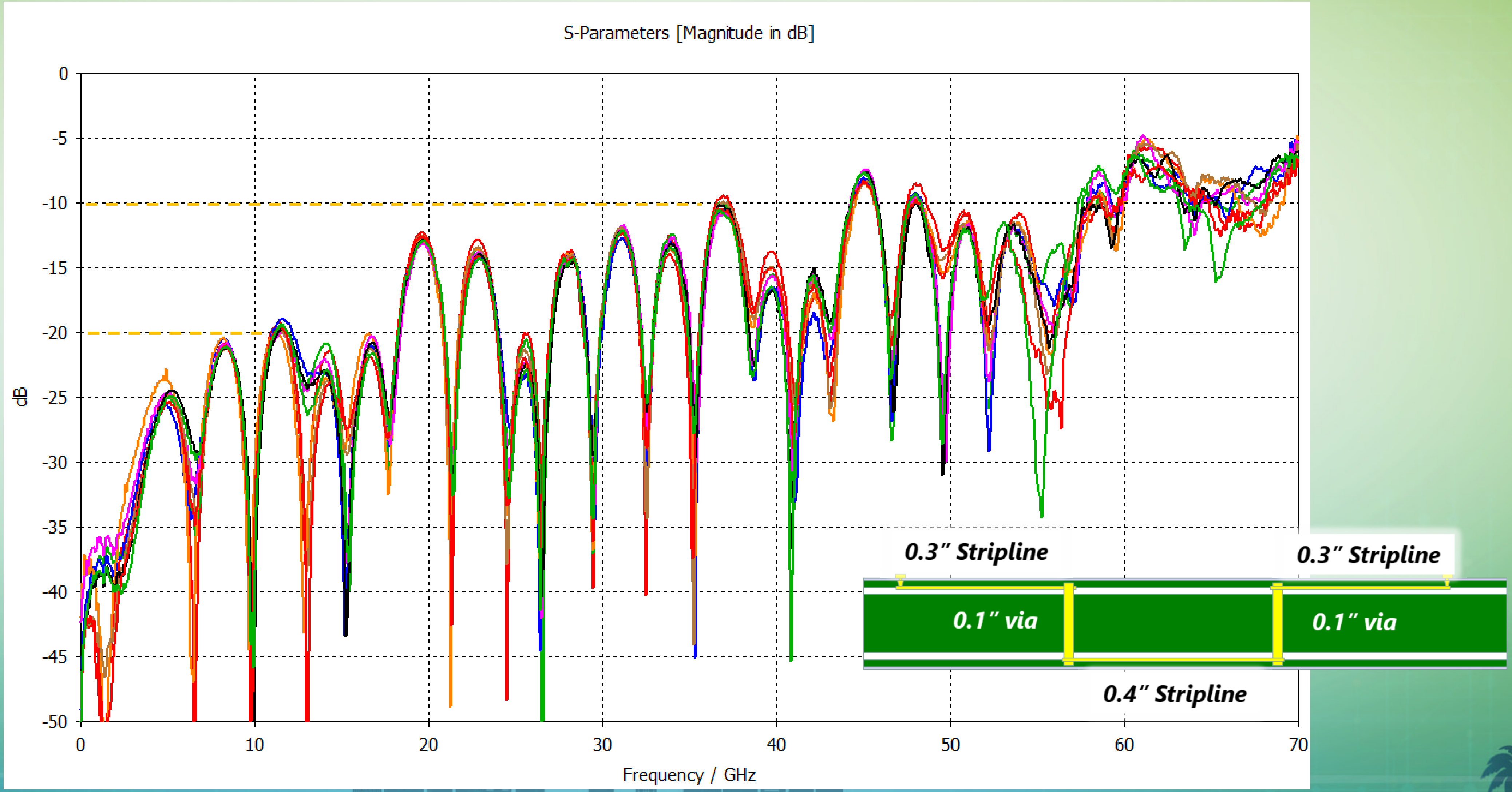


2. Add Coax Via

2xVia + 1.0" Trace Insertion Loss



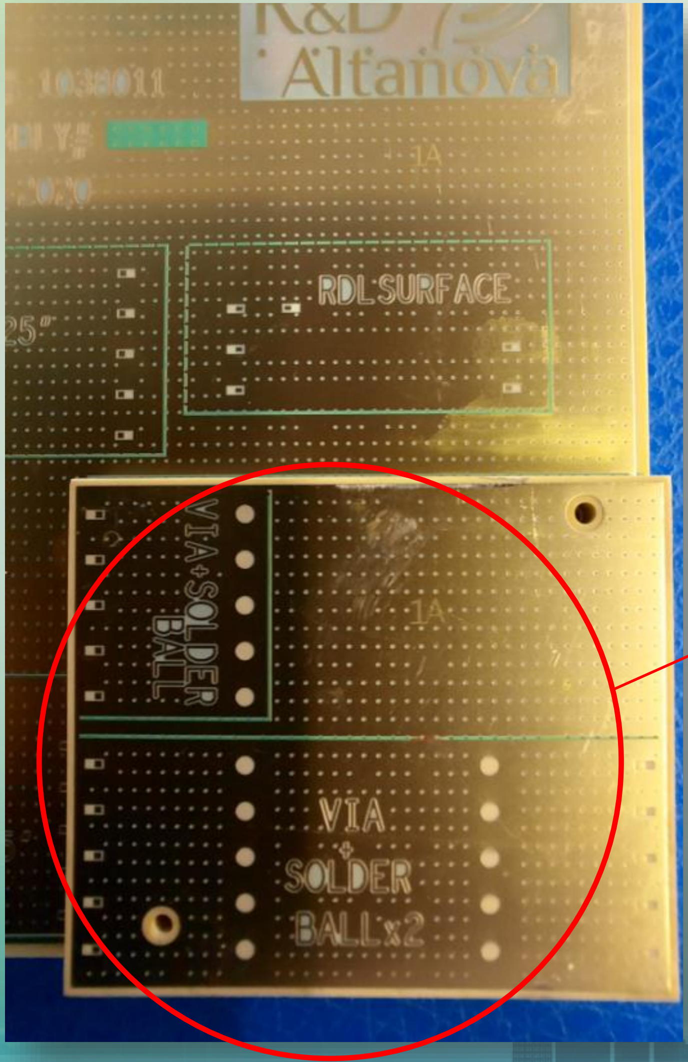
2xVia + 1.0" Trace Return Loss

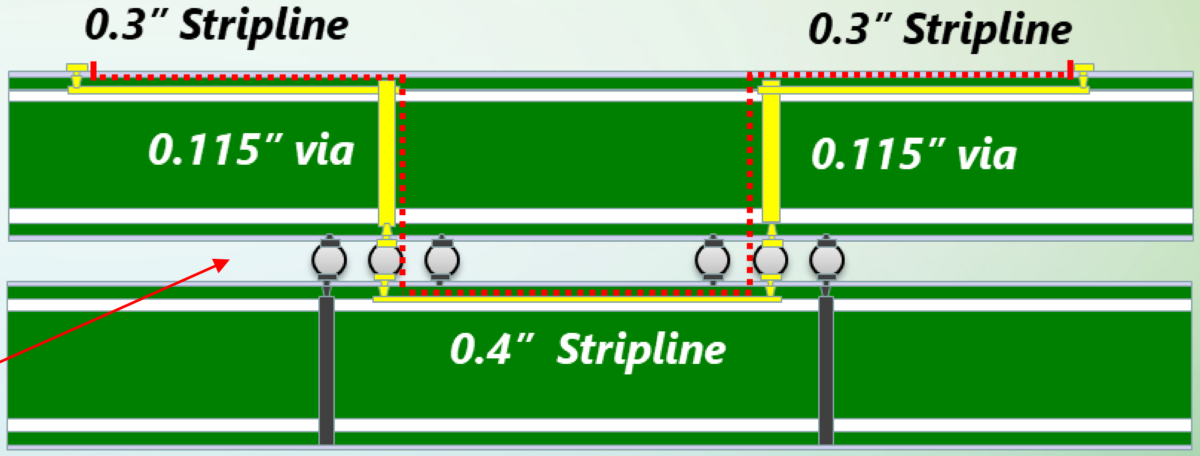


3. Add BGA Transition

Also Known As "Full Path"

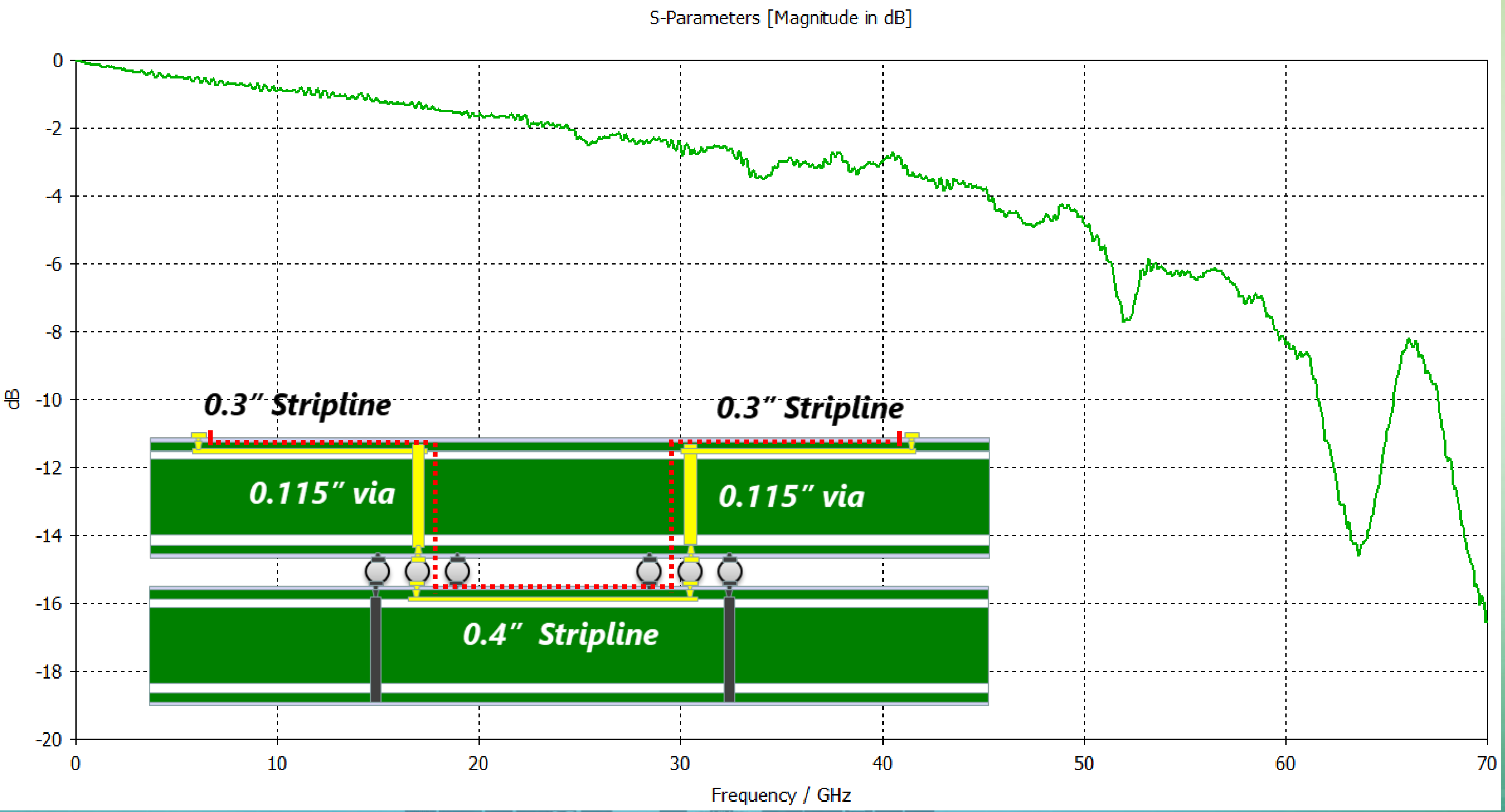
Solder-Ball Connection Measurements





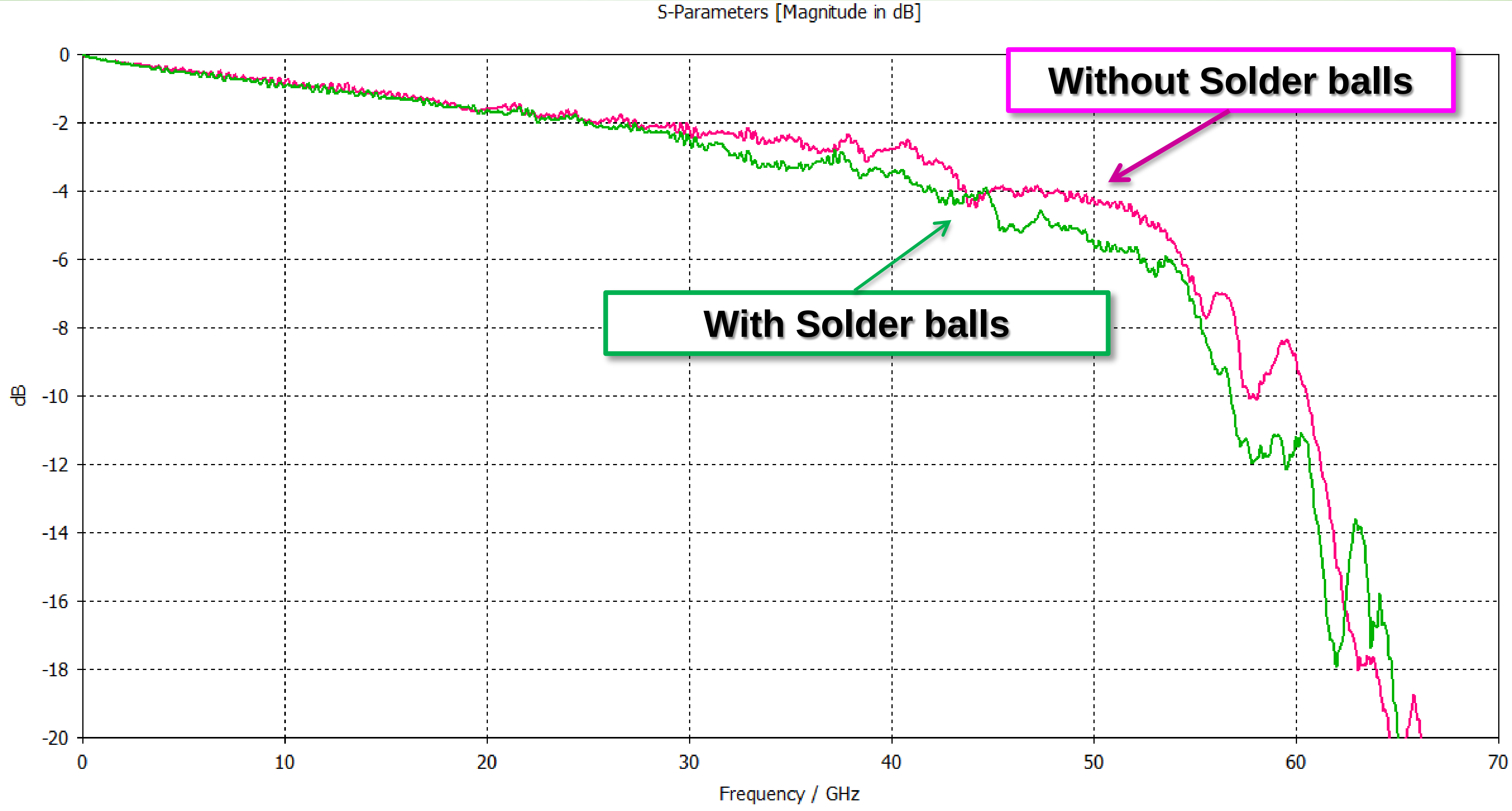
"Full Path"

1in Trace, 2 Vias, 2 Solder Ball Attach



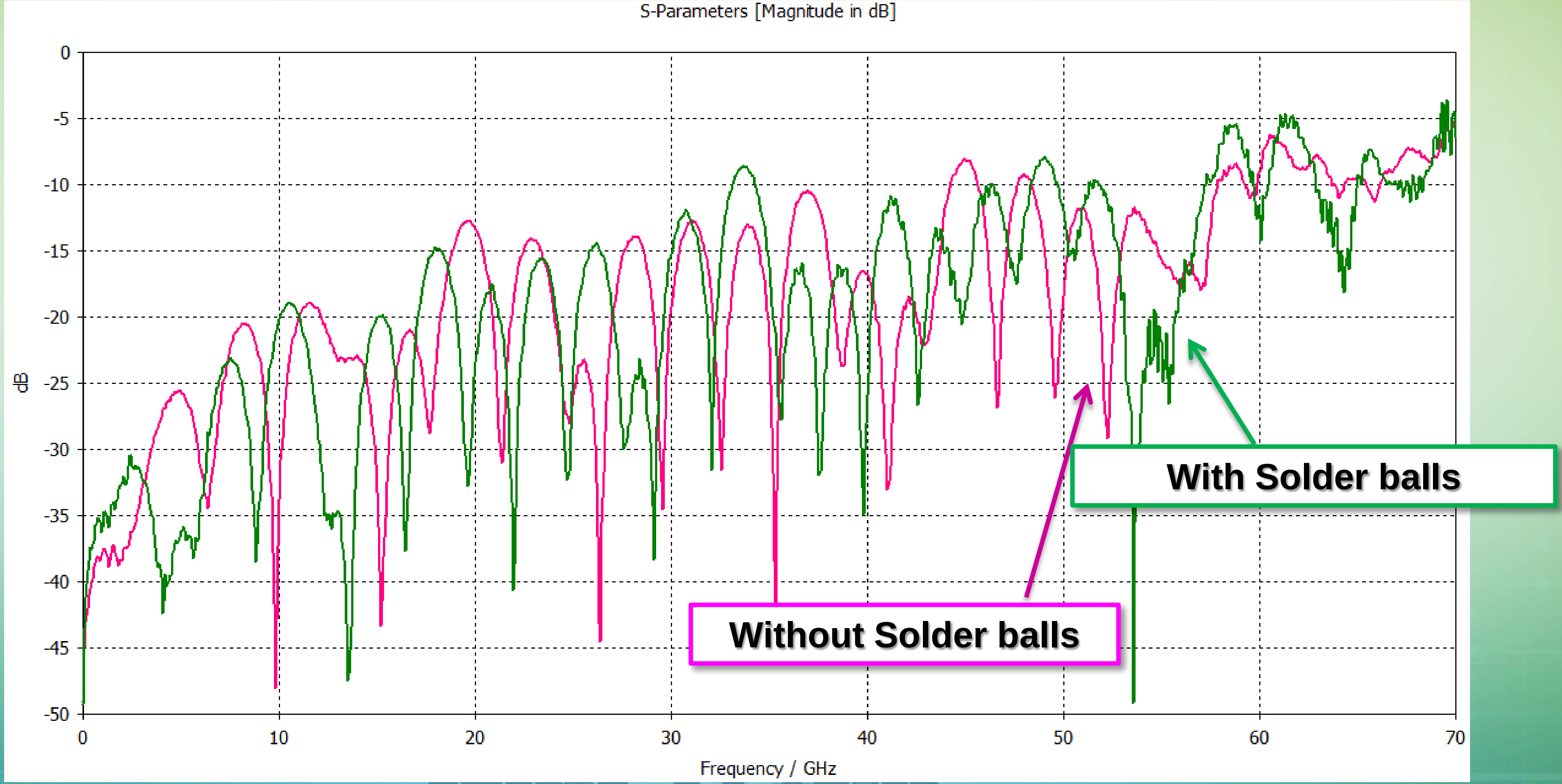
With and Without Solder Balls Compared

Insertion Loss



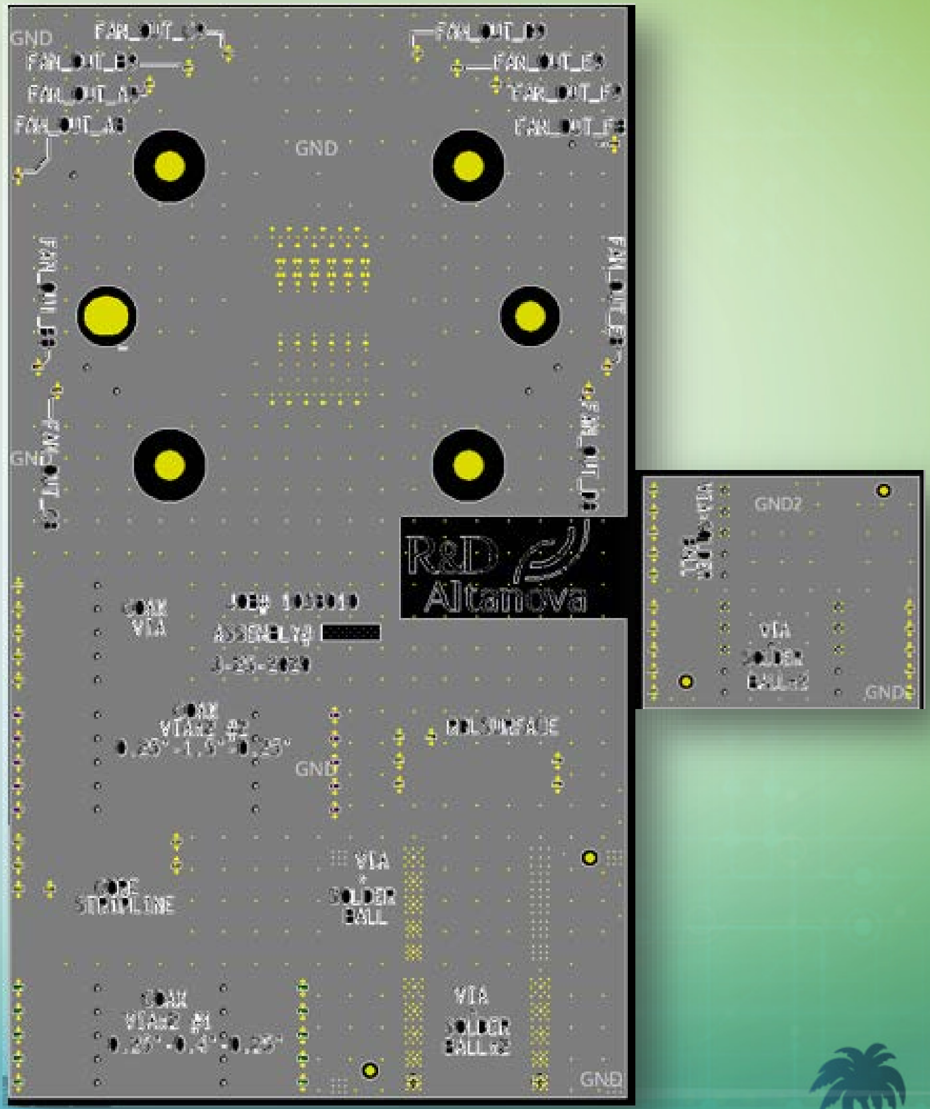
With and Without Solder Balls Compared

Return Loss



RF Coax MLO Conclusions

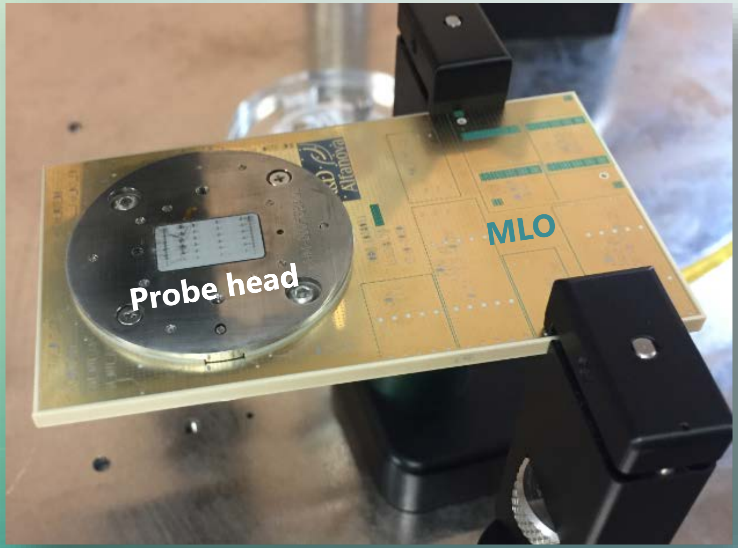
- All MLO structures are performing well up to 40 GHz
- Some non-linear roll off occurring around 50 GHz; appears to be linked to coax via transition
- Probe head measurements is presented next

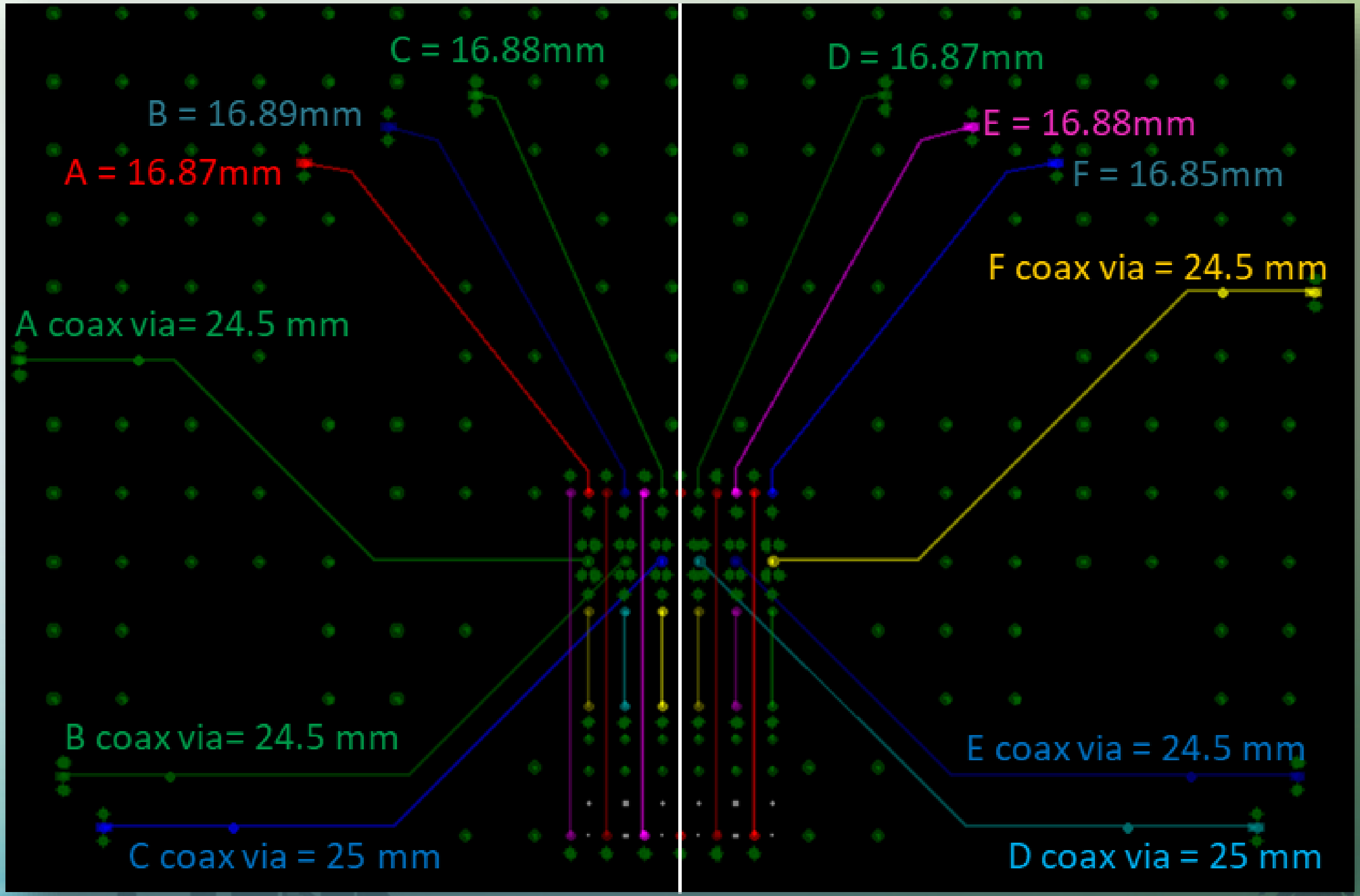


SV probe and RDA – Probe Head and MLO design

For the assessment of signal path measurements of SV Probe Head connected to RDA MLO was performed at high frequencies.

1. RDA MLO with and without COAX via.
2. SV Probe head with different ground configurations.



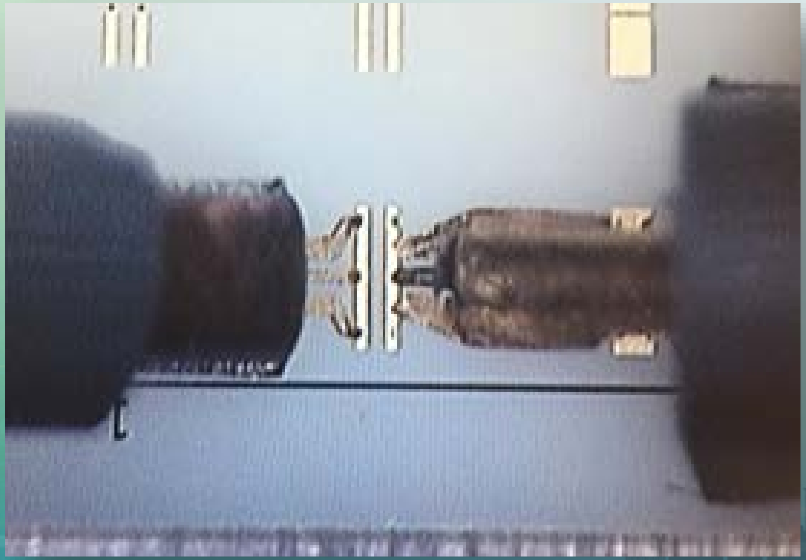


Test setup

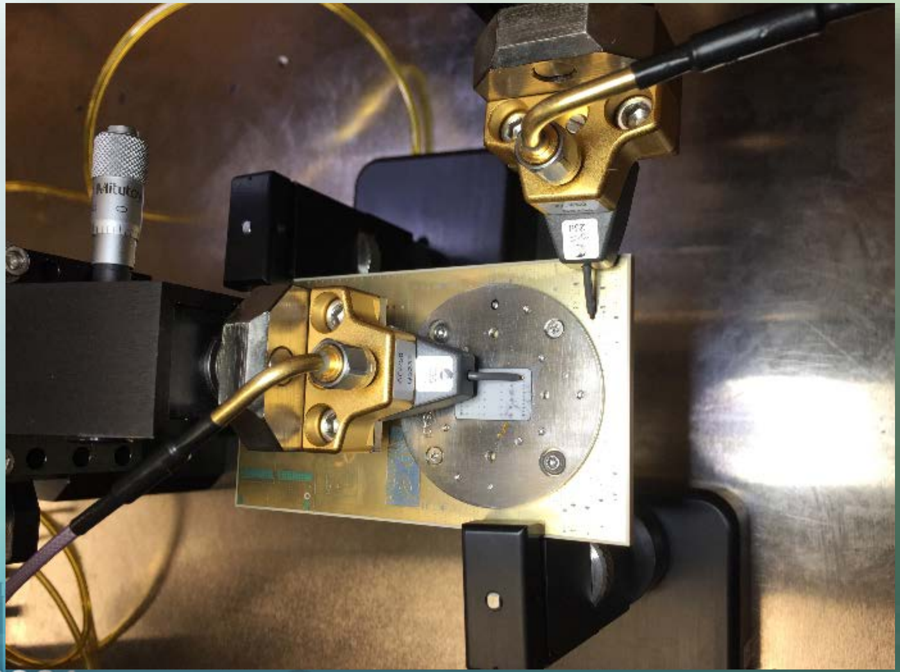
There are two different pitches at the test vehicle: 150 um at the Probe Head and 250 um at the MLO. For that reason, two different configuration were tested to performed the measurements:

1. Hybrid calibration for 150um-250um pitches (picture 1)
2. Calibration for 250 um (picture 2)

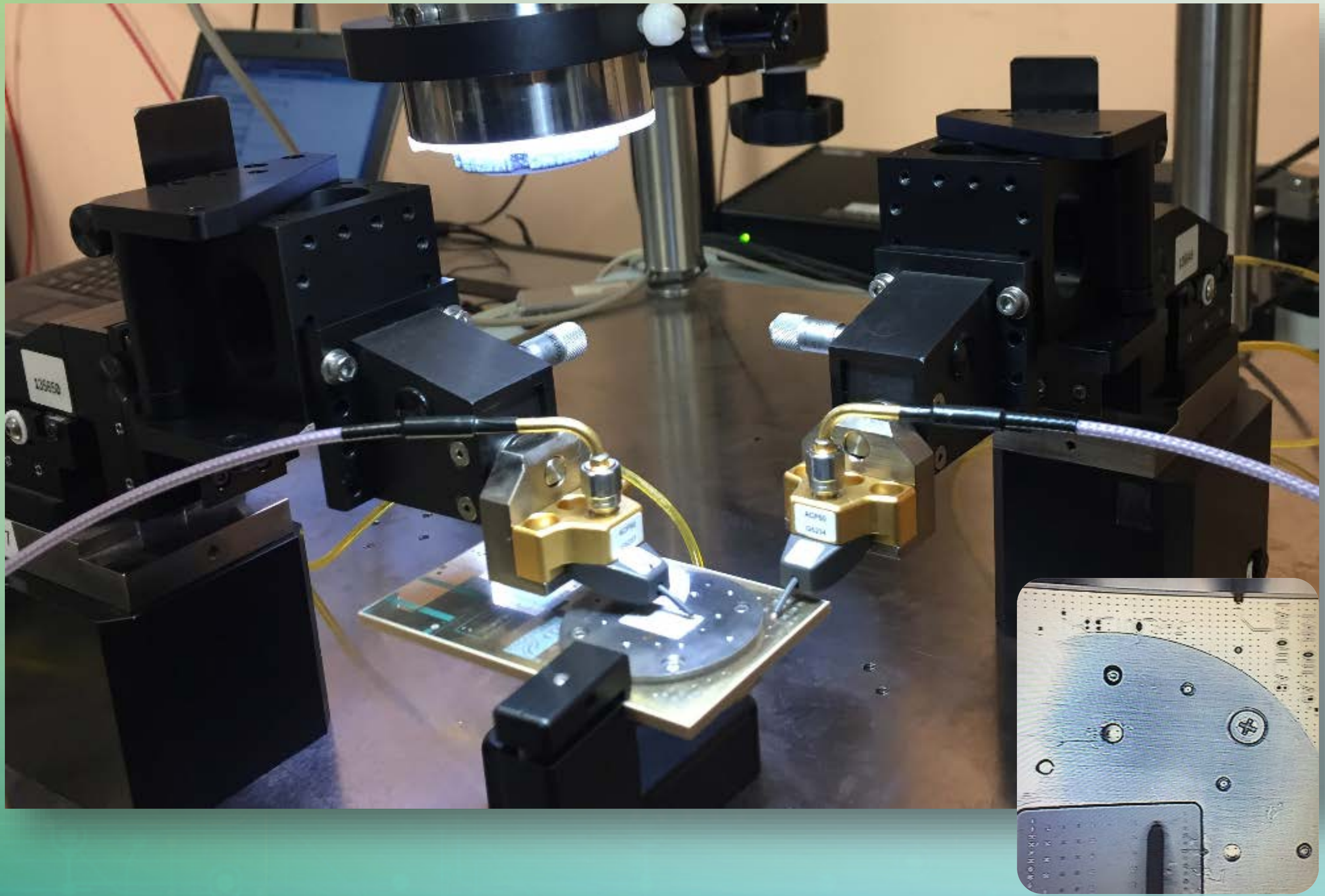
Picture 1. Probe pitch 250 um and Probe pitch 150 um



Picture 2. Both probes with 250 um pitch



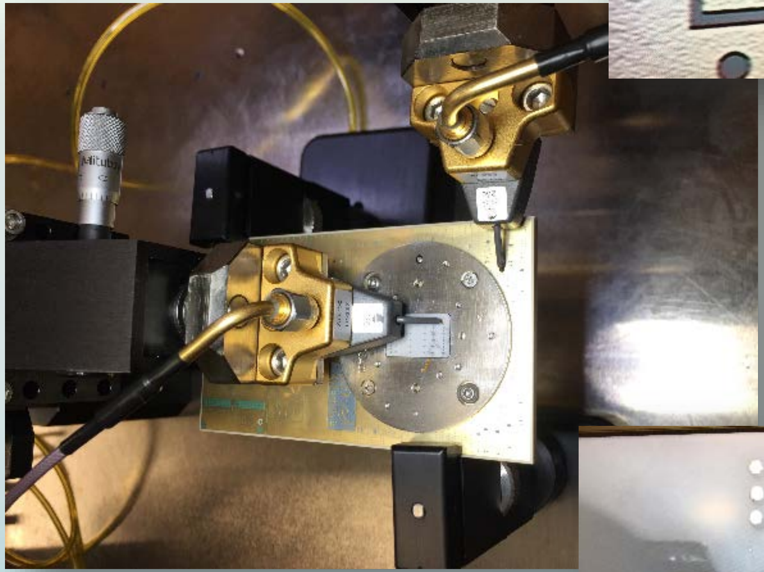
Measurement setup



- The first set of measurement were performed with 250um probes at MLO and 150um probes at the Probe Head.
- The second set of measurement were performed with 250um probes at MLO and 250um probes at the Probe Head.

Measurement with probes 250 um

Cases presented here are A and B with and without coax vias measured with a pitch of 250um.



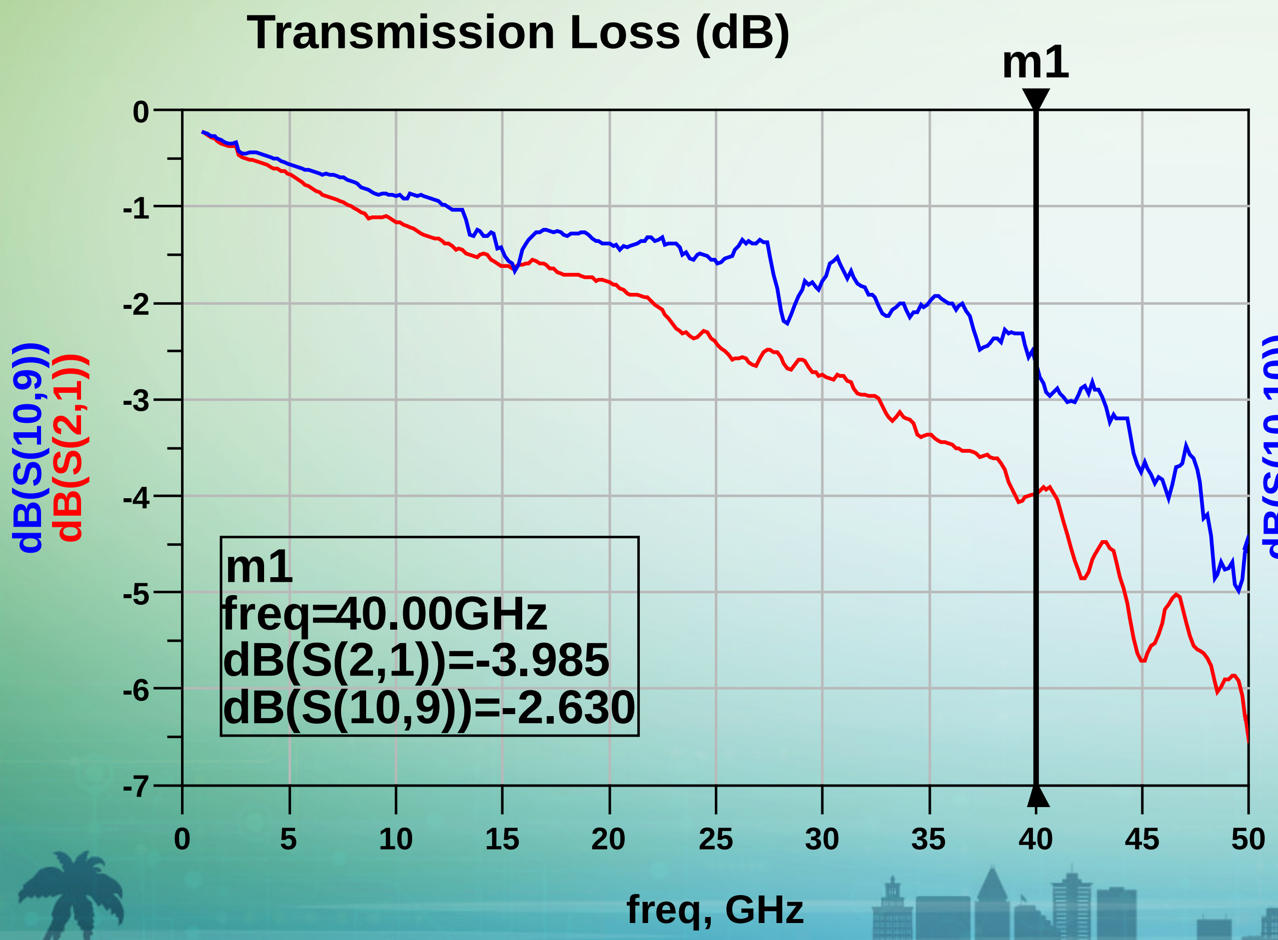
Probe in MLO

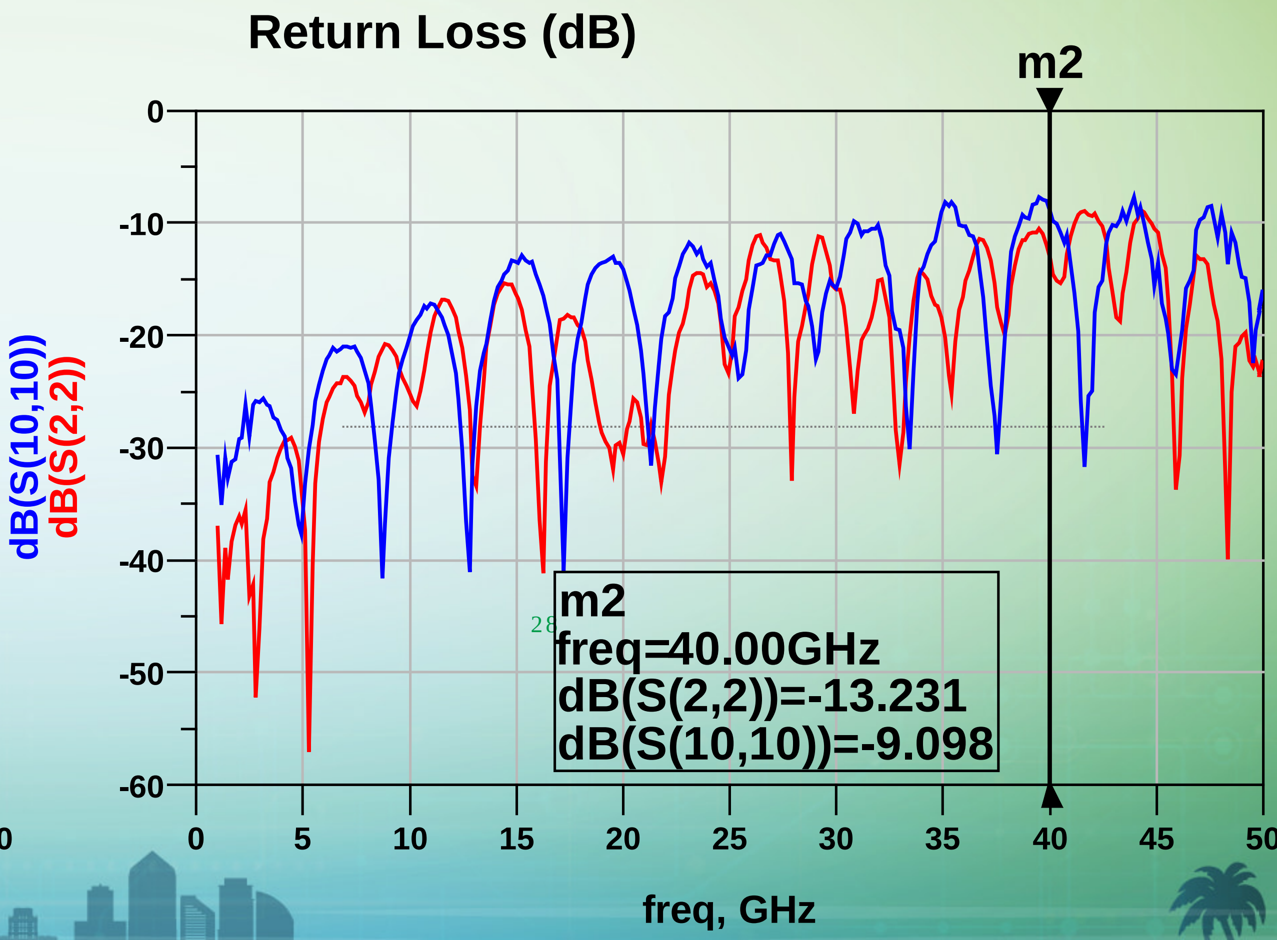
Probe in Case A

Probe in Case B

CASE A, two ground probes

Case A9 (Length 16.9 mm)
Case A8 (Length 25.0 mm) + 2*Coax Vias



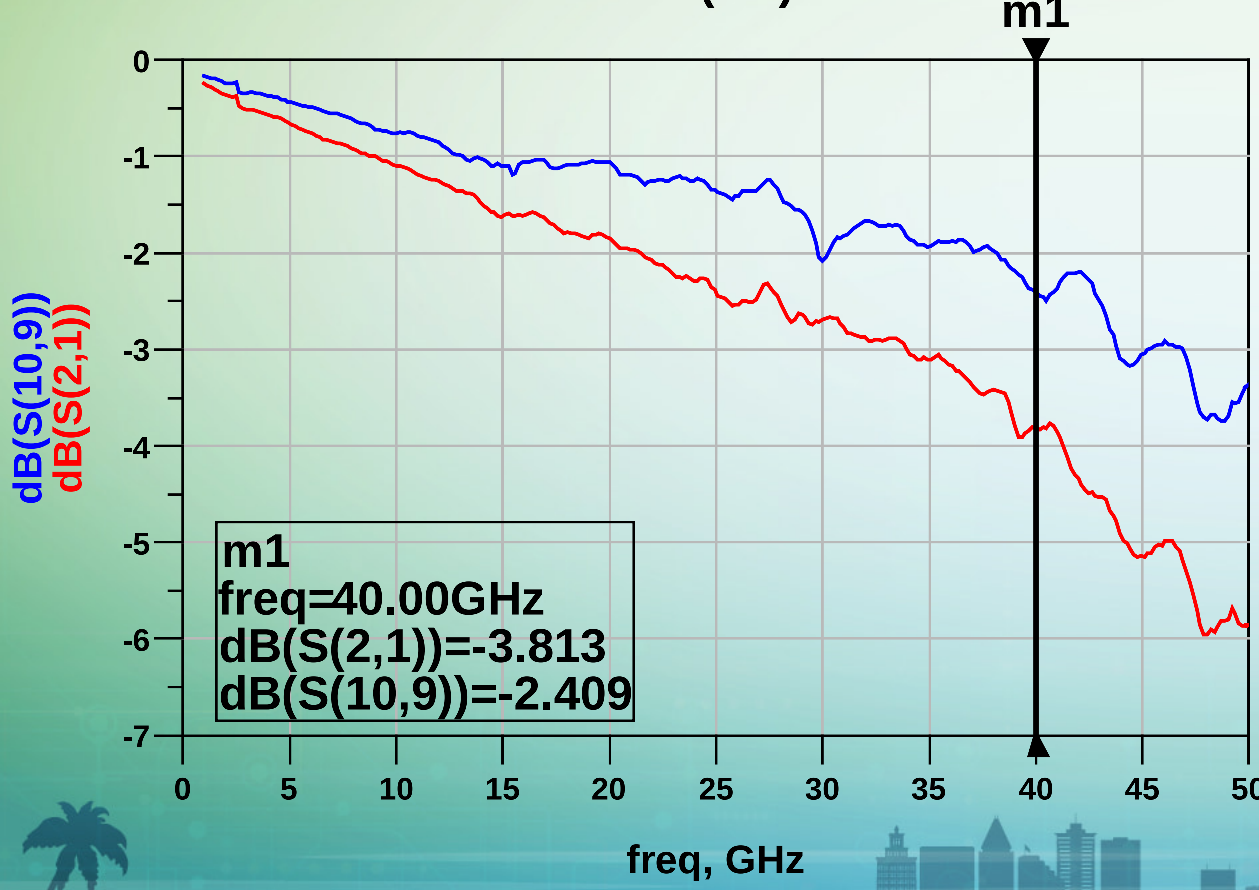


CASE B, four ground probes

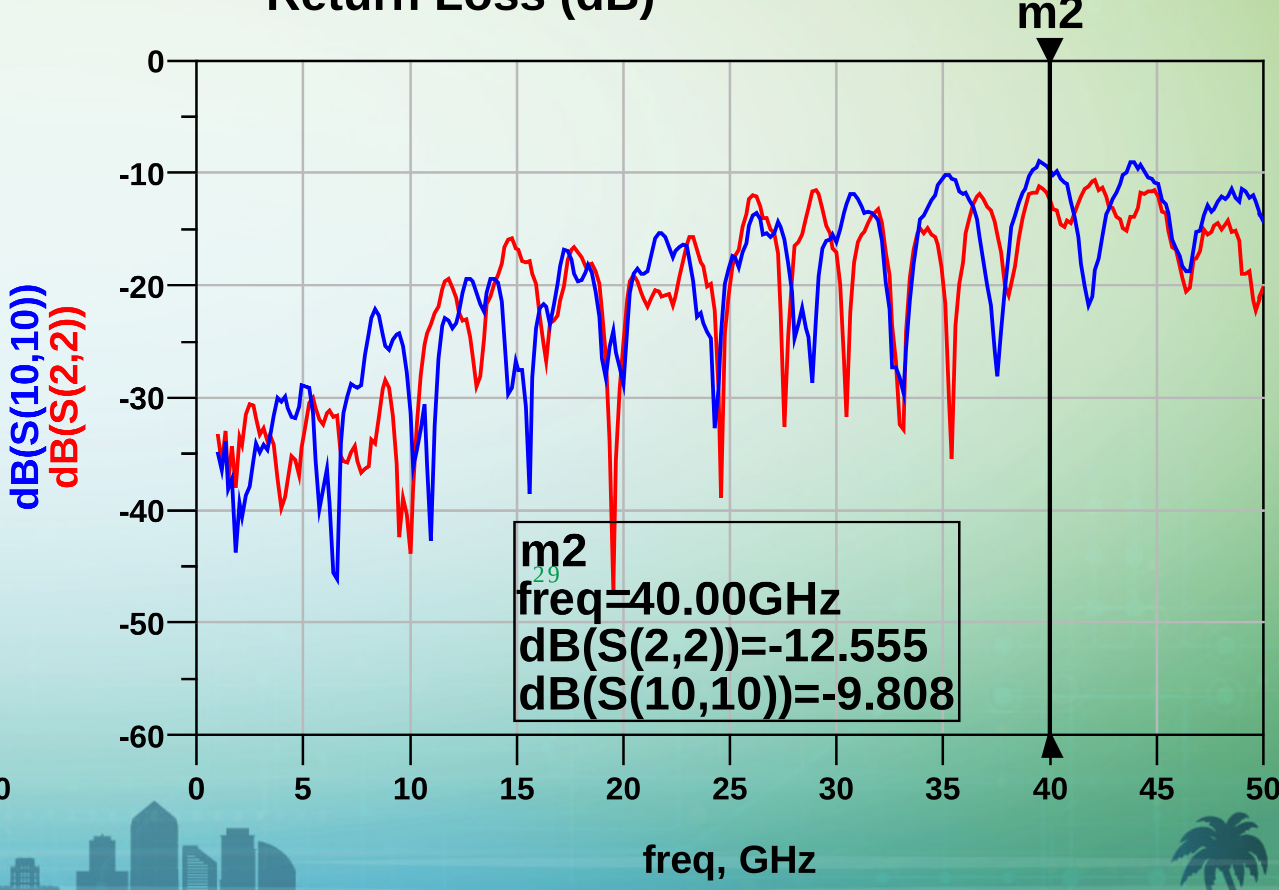
Case B9 (Length 16.9 mm)
Case B8 (Length 25.0 mm) + 2*Coax Vias

Pitch between signal and ground probes 150 um

Transmission Loss (dB)



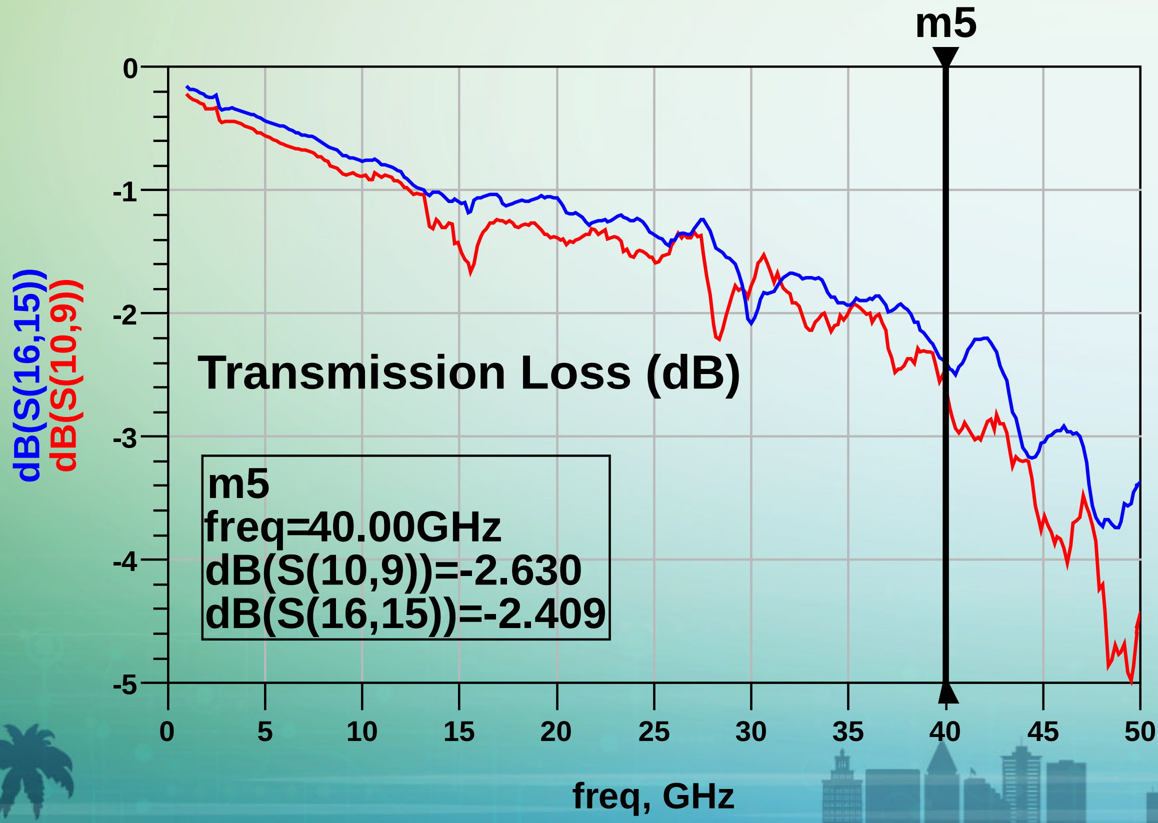
Return Loss (dB)

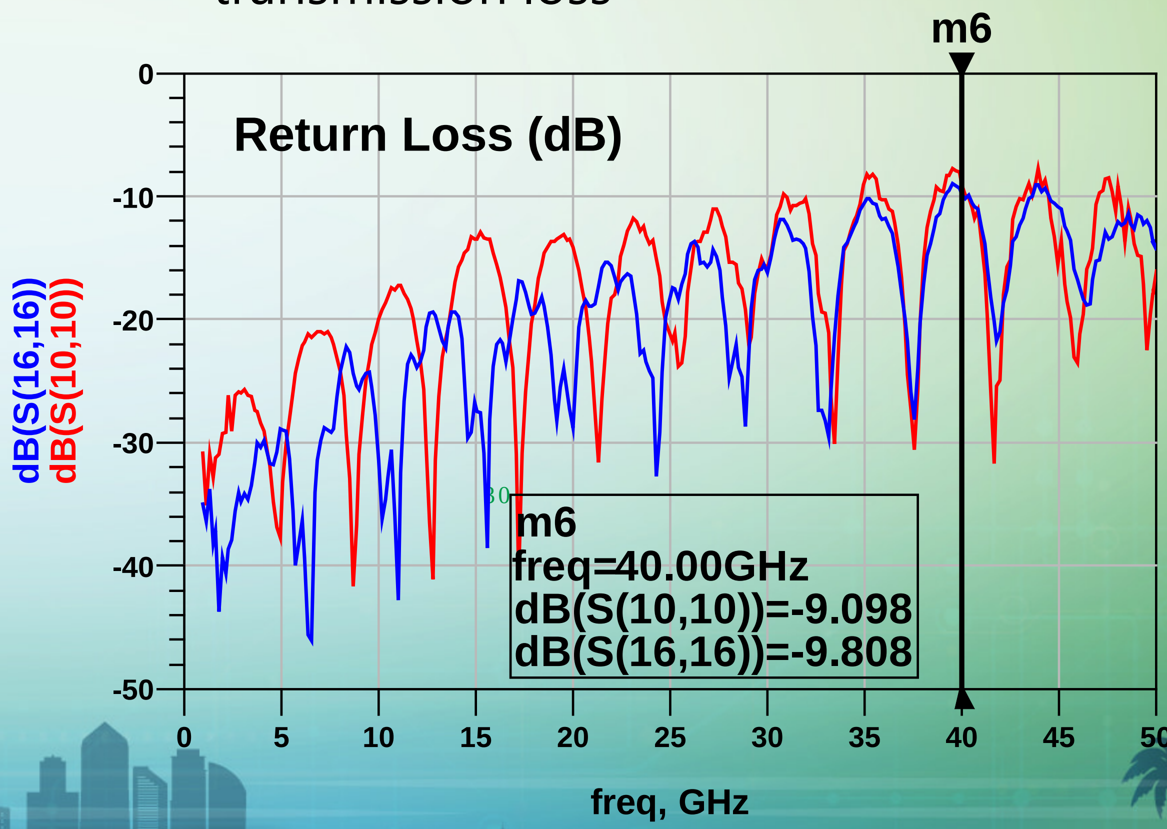


Number of ground probes effects

Trace length 16.9 mm and no via
Case A9 (two ground)
Case B9 (four ground)

In this plots are comparing cases with different ground configurations, and it can be observed that incrementing the ground probes will improve the reflection loss and transmission loss





Learned items

1. Every part of the signal path needs to optimized as the frequency increases. Vertical transitions are complicated and without optimization we can not meet customer requirements.

2. The C4 pattern must be designed in consultation with the probe head supplier to make sure the vertical probe performance will meet requirements. A simple and clean ground path can not be left to chance.

Conclusions

- **RF vertical probing is proven capable to 50 GHz**
- **This work can enable high density RF designs (50+ channels)**
- **This also enables high site count RF designs that are only limited by the non-RF resource requirements**
- **Enabling lower cost of test and an alternate to the limitations of today's RF probing solutions**

We hope this convinces you vertical probing is the future of high density RF probe!