VNA and Differential Probe Solution for BGA Feedback Loop Testing Through 56 GHz

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TestConX™

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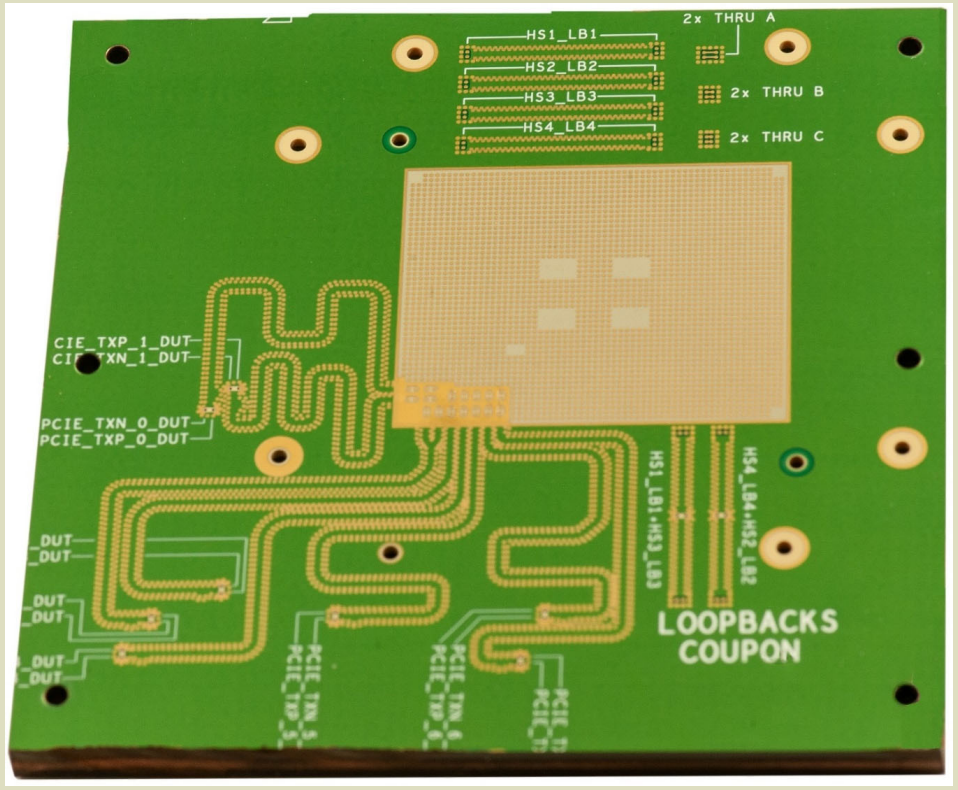
SIGNAL MICROWAVE

Contents

- Description of the DUT (What we tested)
- List of test equipment (What we used to test it)
- Set-up of the probe station (How we tested it)
- Insertion Loss Measurements of the PCB (Test results)
- Creation of the de-embedding files

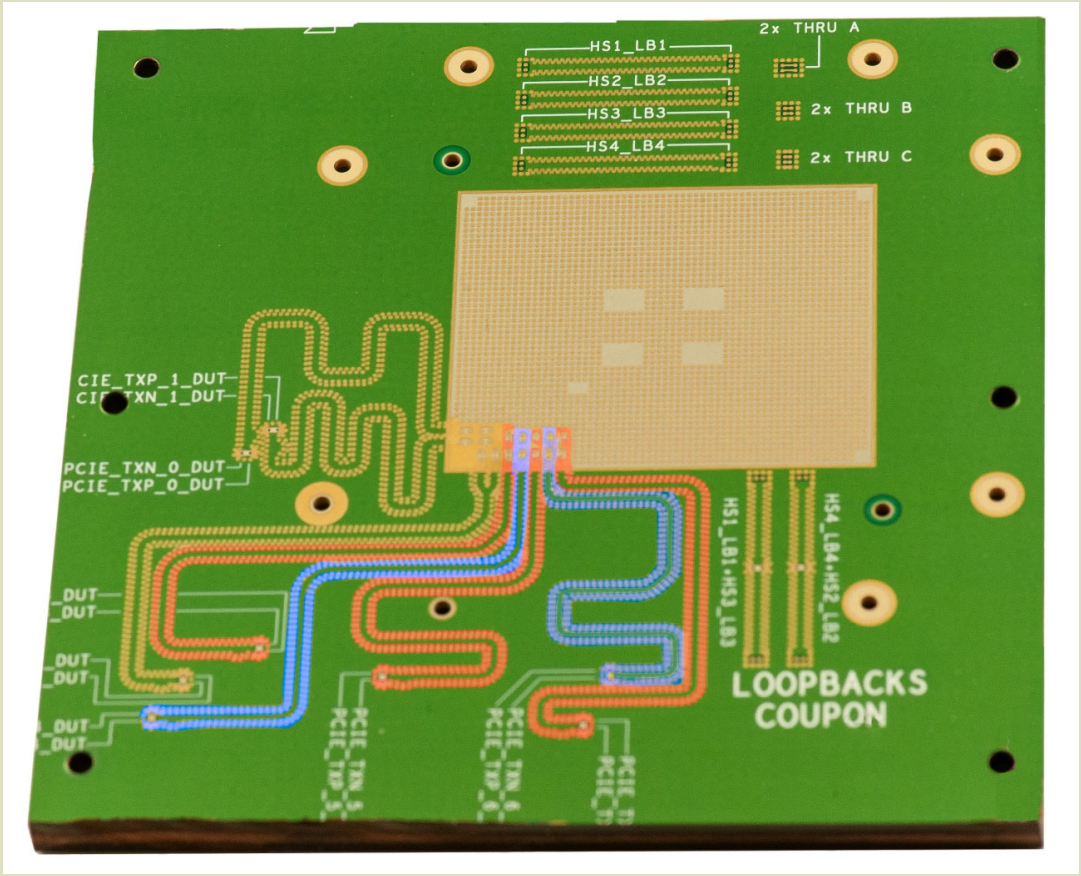
The DUT is a 224 Gps board designed by Dynamic Test Solutions (DTS)

- Test requirements:
  - –Measure the Insertion loss of the loopback lines
  - –This board was designed by DTS for 224 Gbps PAM4 with a Nyquist frequency of 56 GHz

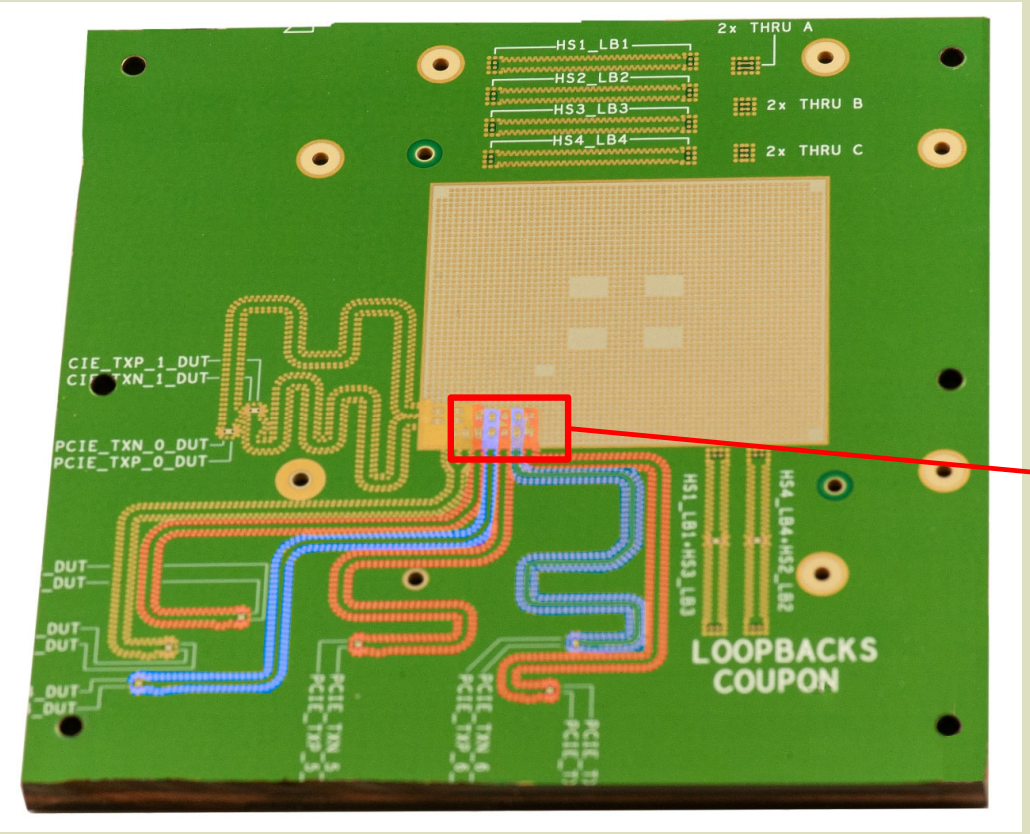


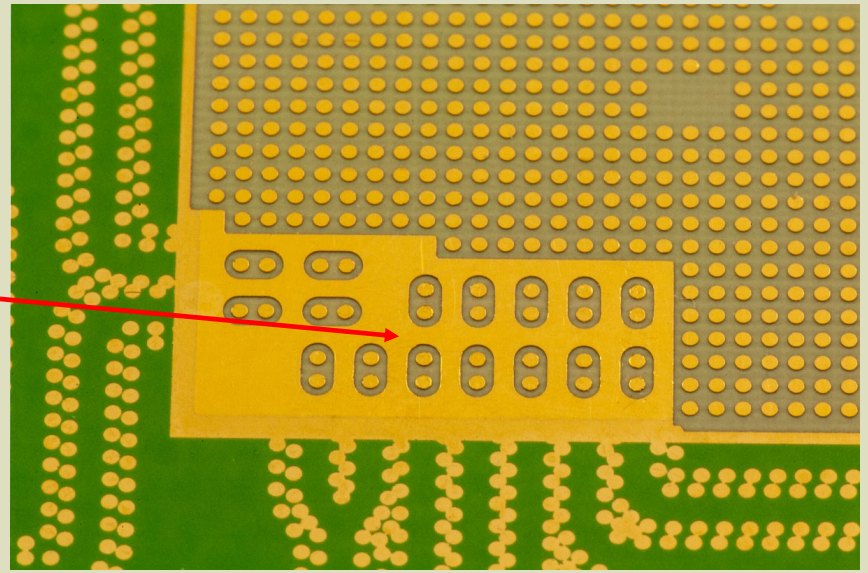
Identifying Test Points and Lines

- We measured 5 lines that included:
  - –5 sets of test points in the BGA footprint
  - –5 lines through two layers using a via halfway through the lines



Close Up View of the Test Points

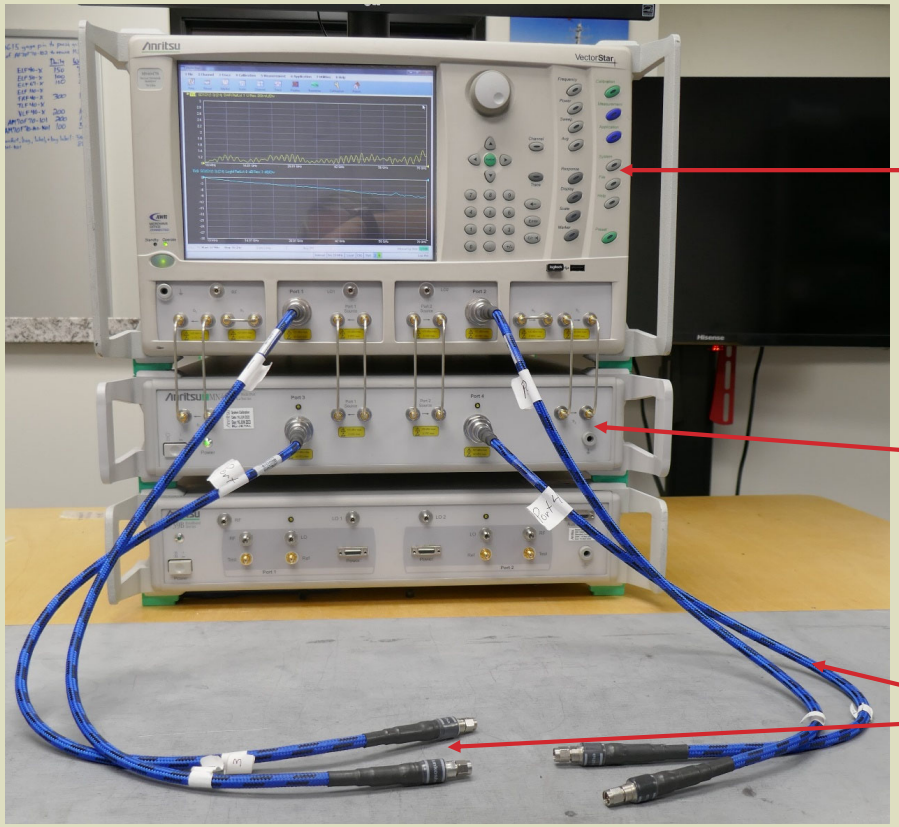




List of Test Equipment

- What we used to test the feedback loops:
  - –Anritsu 4 port 70 GHz VNA system
  - –Signal Microwave 70 GHz differential probes
  - –Junkosha MWX071 70 GHz cables
  - –Probe station
    - Form Factor micro-manipulators
    - Signal Microwave multi-axis probe holders

70 GHz Vector Network Analyzer 4 Port Test System



Anritsu Model MS4647B
70 GHz base system

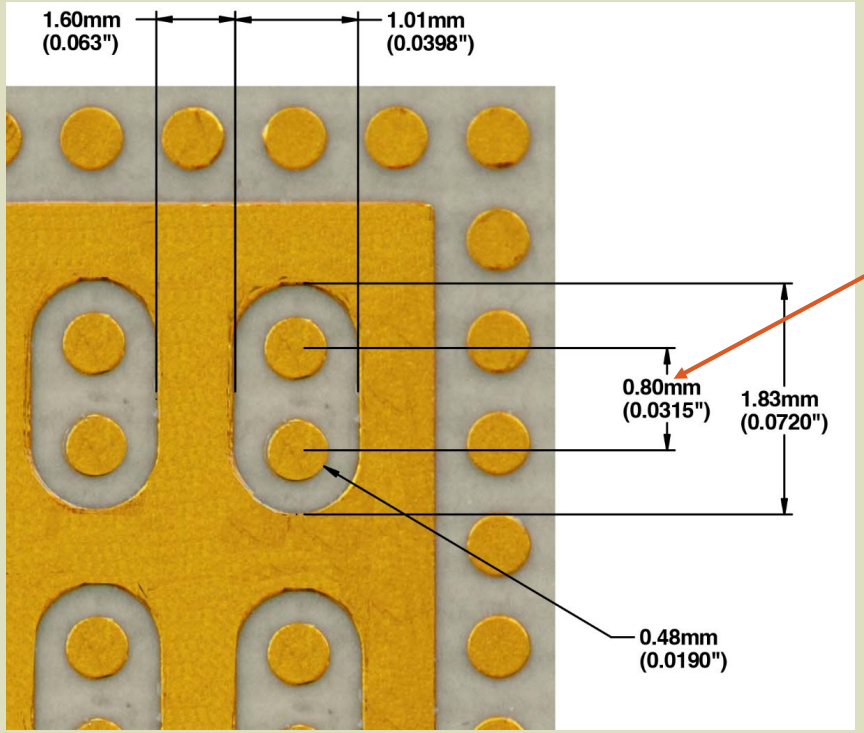
Anritsu MN4697C
Multi-Port Test Set

Junkosha MWX071
70 GHz cables

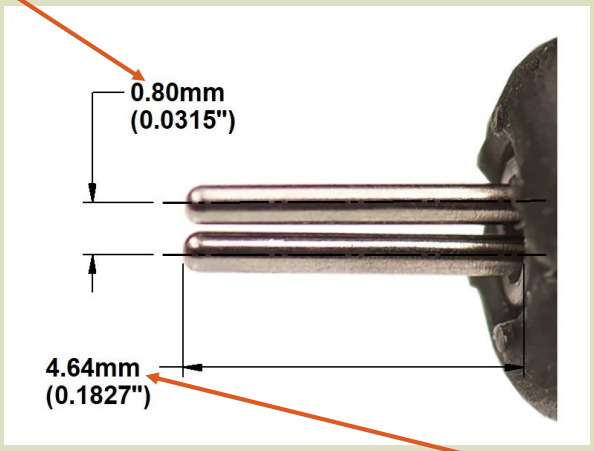
FPP70-1.00-001 is a 70 GHz, 100 Ohm, Probe

- This probe is a true 100 ohm odd mode differential probe
  - –The pins are perpendicular to the front of the probe body
  - –There are no ground pins
  - –The probe pins are 100 ohm signal lines
  - –The pins can be any length

Longer Pins to Fit into Test Point Area



The test point pads and the probe pins are similarly dimensioned – 0.80mm

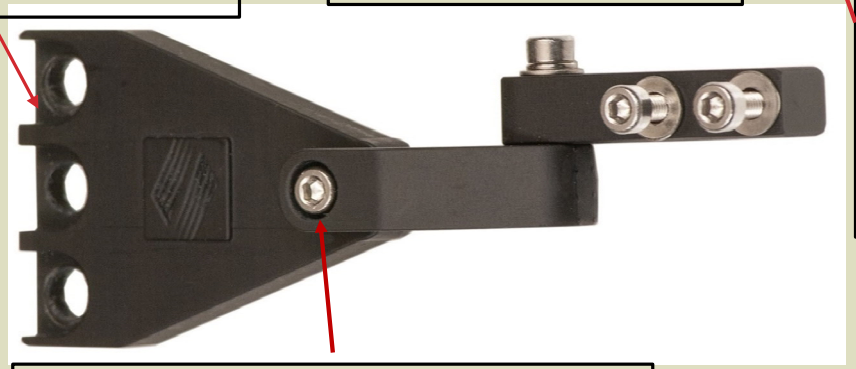


Longer test pins: 4.64mm

Multi-Axis Probe Mount

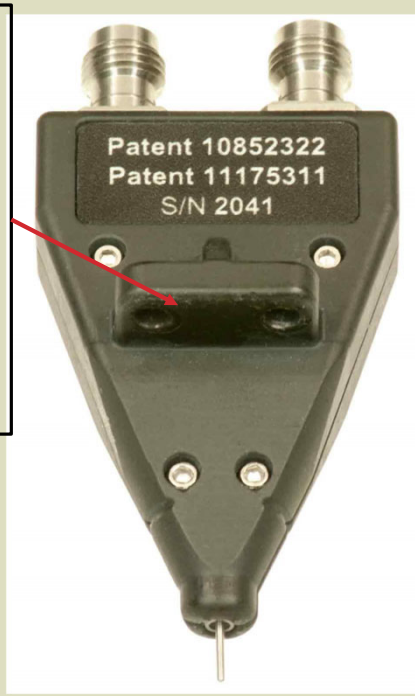
Standard 3-hole mount

Up/Down angle axis

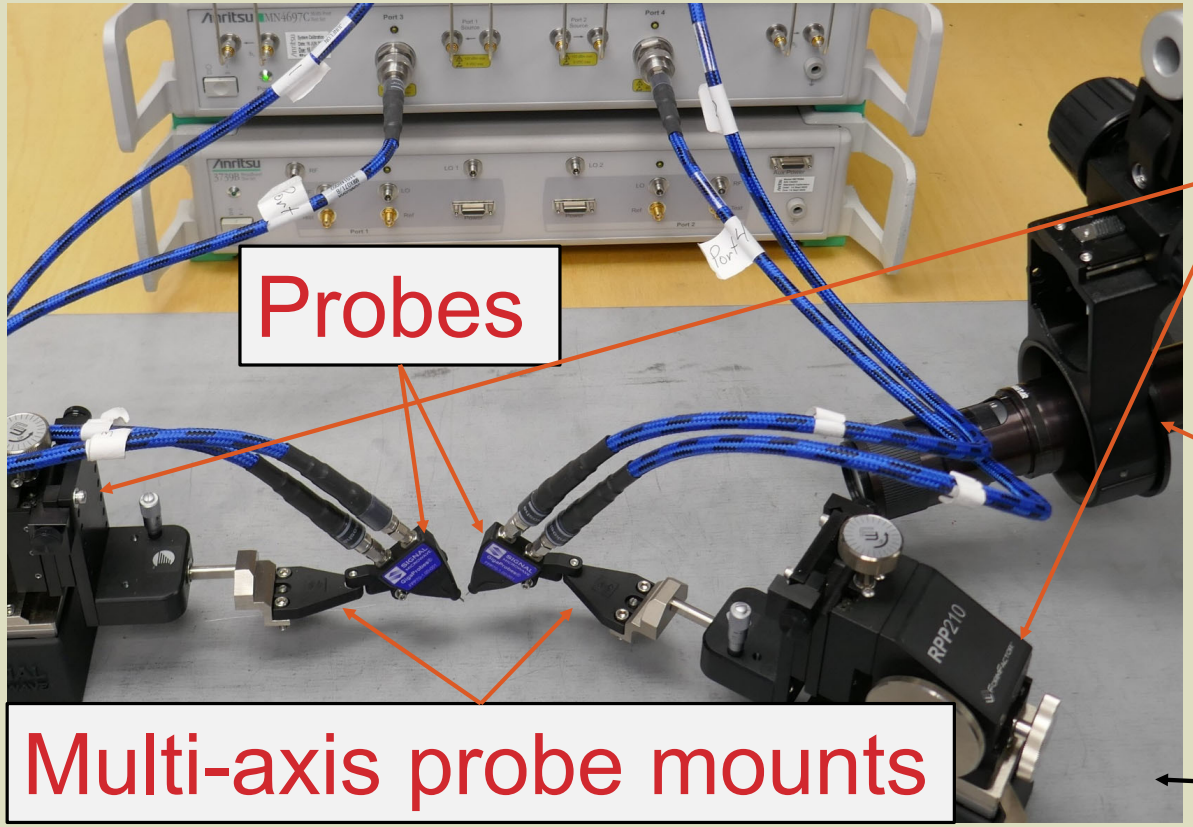


Left/Right axis

The probe Mounts using two screws



Probe Station with Probes Swiveled and Tilted



Probes

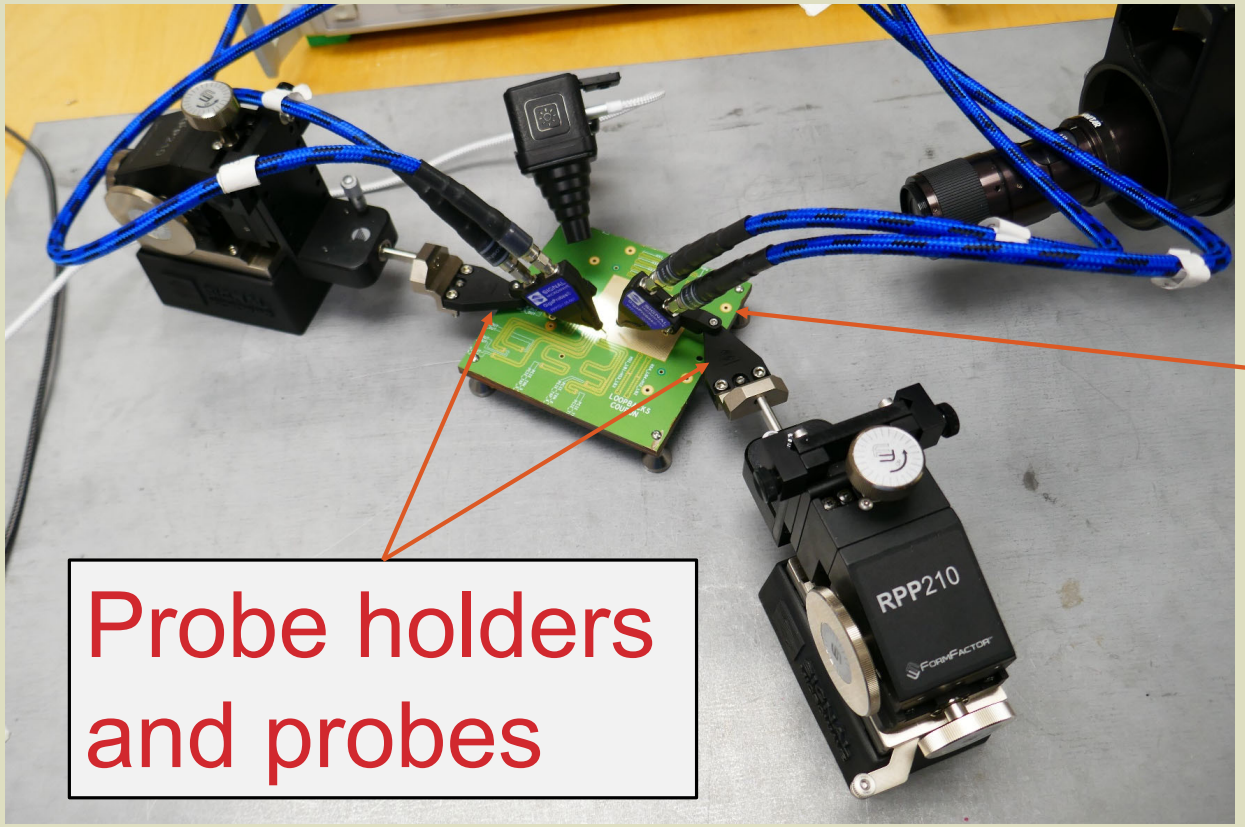
3 axis manipulators with magnetic base

Microscope with camera

Multi-axis probe mounts

Metal plate

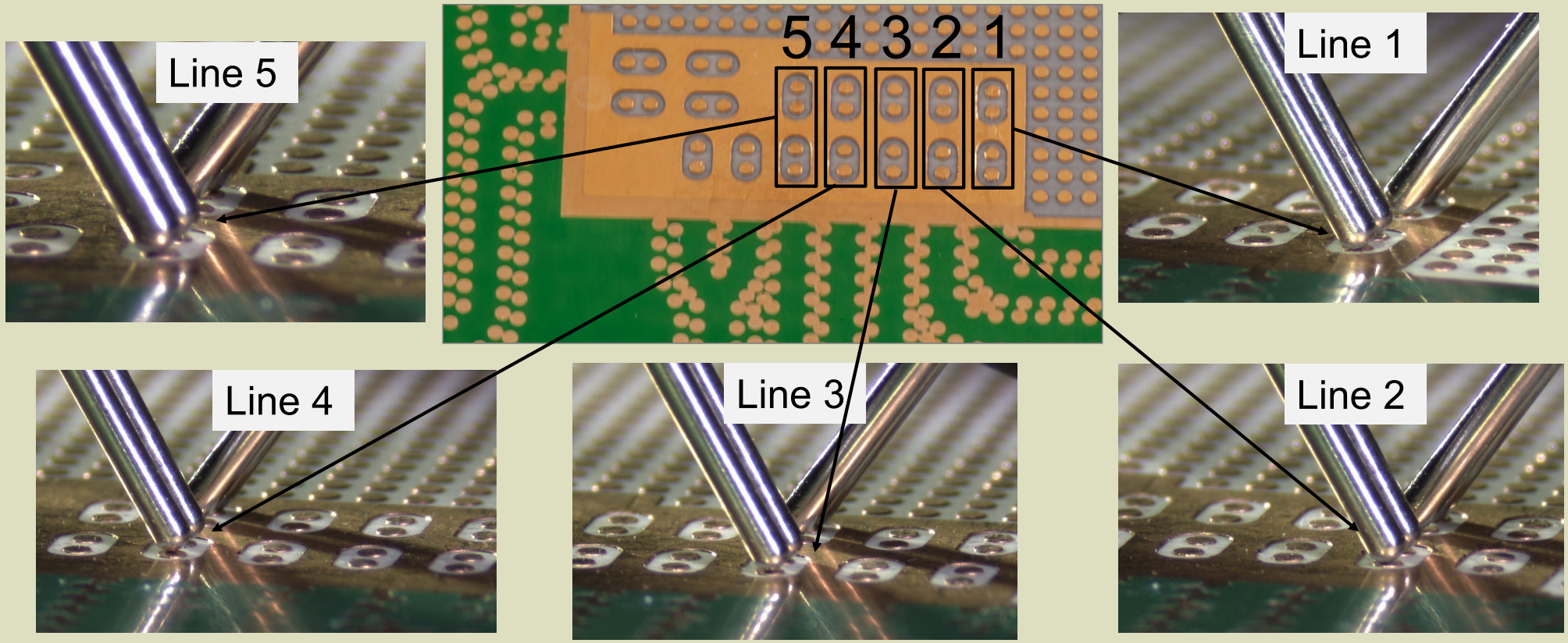
The Testing of the Feedback Loops



Probe holders and probes

BGA feedback loop DUT board in the probe station

Probes Landing on the Test Points of the 5 Lines



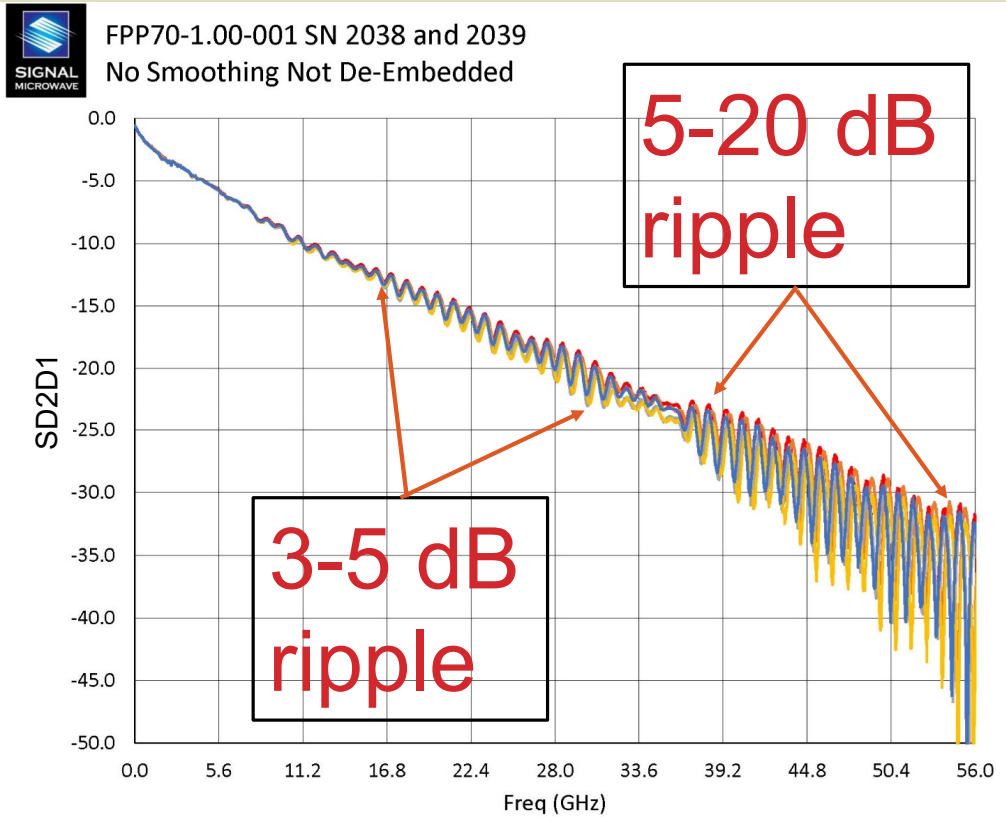
Insertion Loss Measurements of the PCB

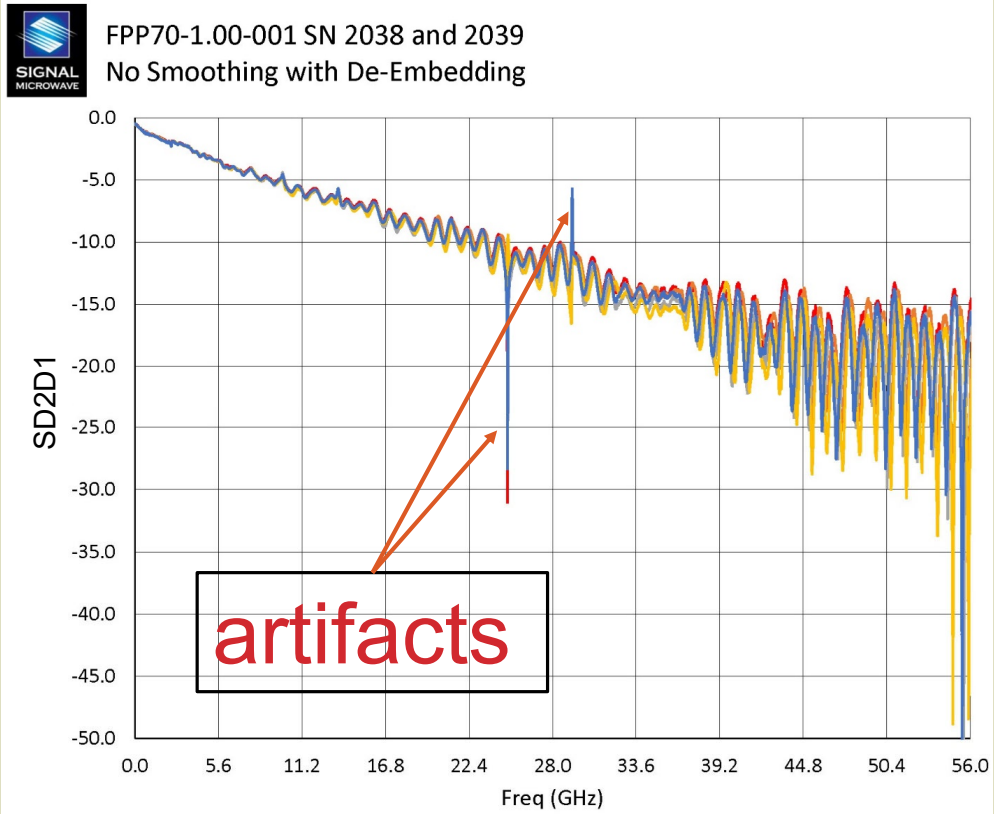
- The VNA was connected to the DUT through the cables and probes
- VNA sweep set-up
  - –Calibrated from 10 MHz to 70 GHz (7,000 points)
  - –Sweep was shortened to 56 GHz (5,600 points)
  - –Data was saved with and without de-embedding
  - –Data was saved as .s4p and .csv files

Final Insertion Loss Data Analysis

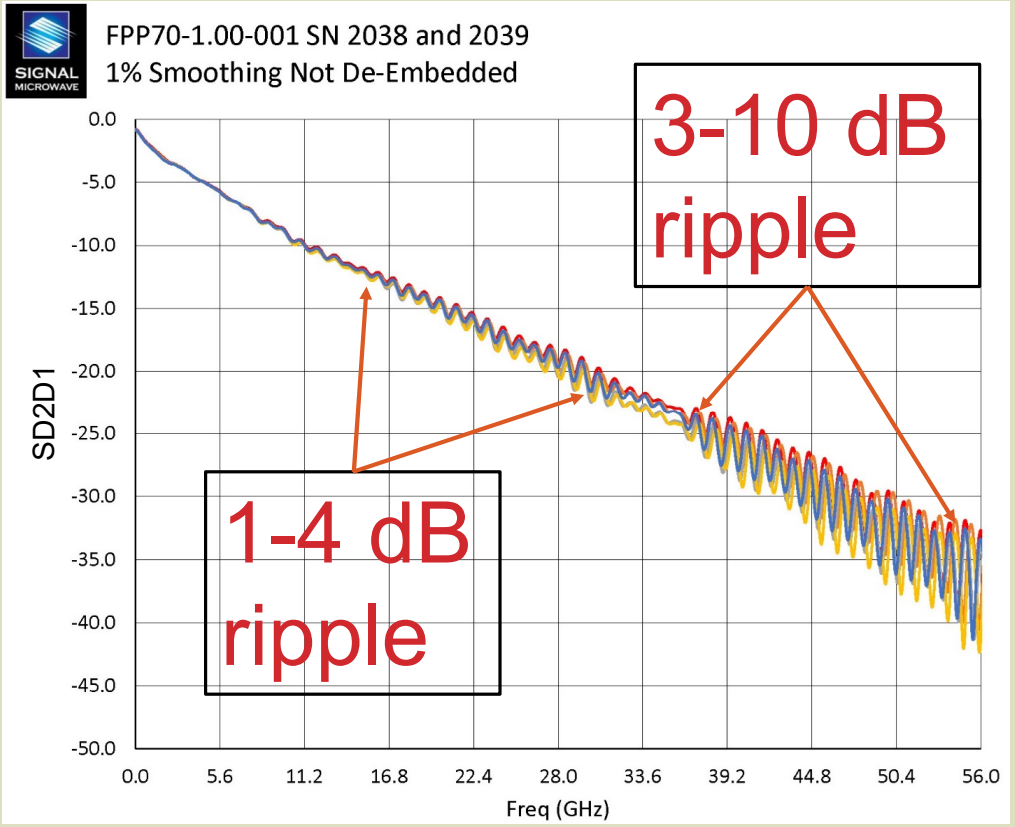
- To analyze the data, smoothing was applied
  - –1% (55 points) and 3% (167 points) smoothing
  - –The data of the 5 lines tested were grouped and overlayed the following ways:
    - No smoothing, with and without de-embedding
    - 1% smoothing, with and without de-embedding
    - 3% smoothing, with and without de-embedding

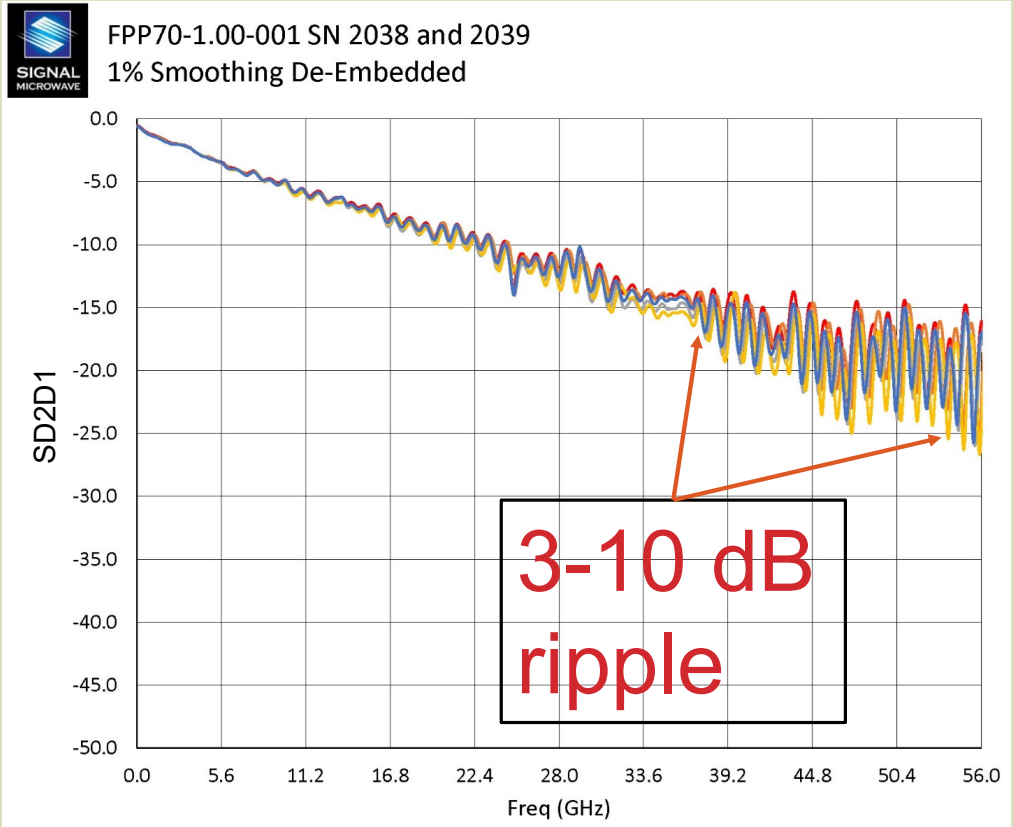
SN 2038 and 2039 Results 0% Smoothing



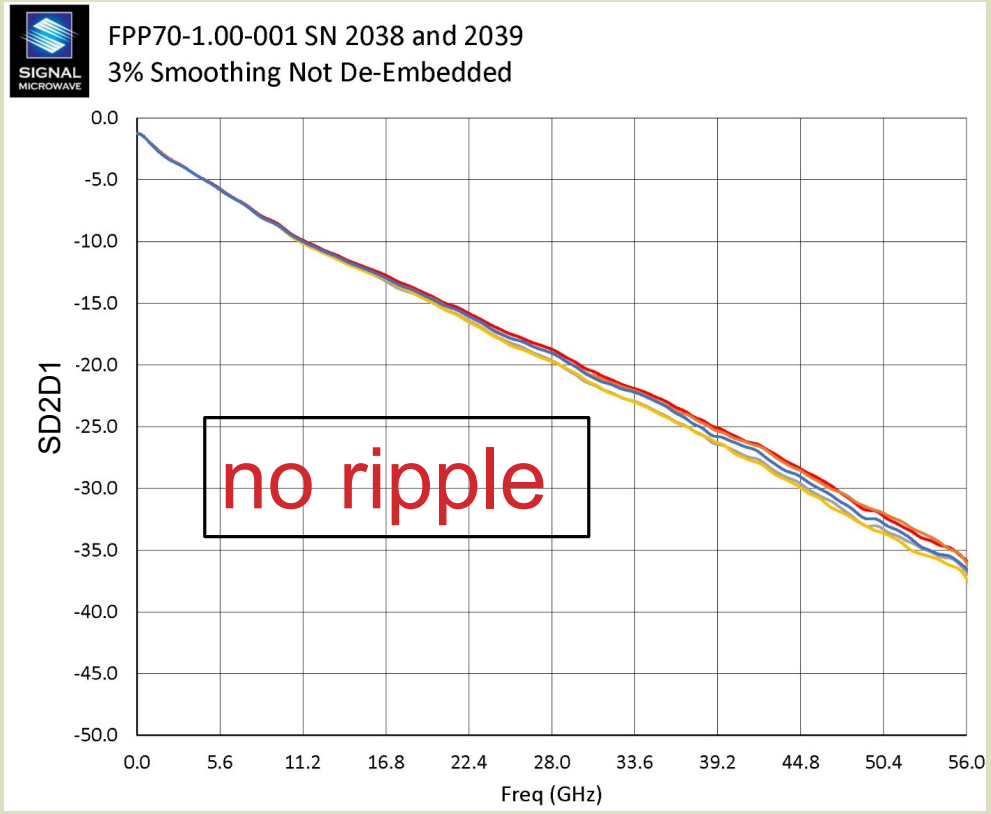


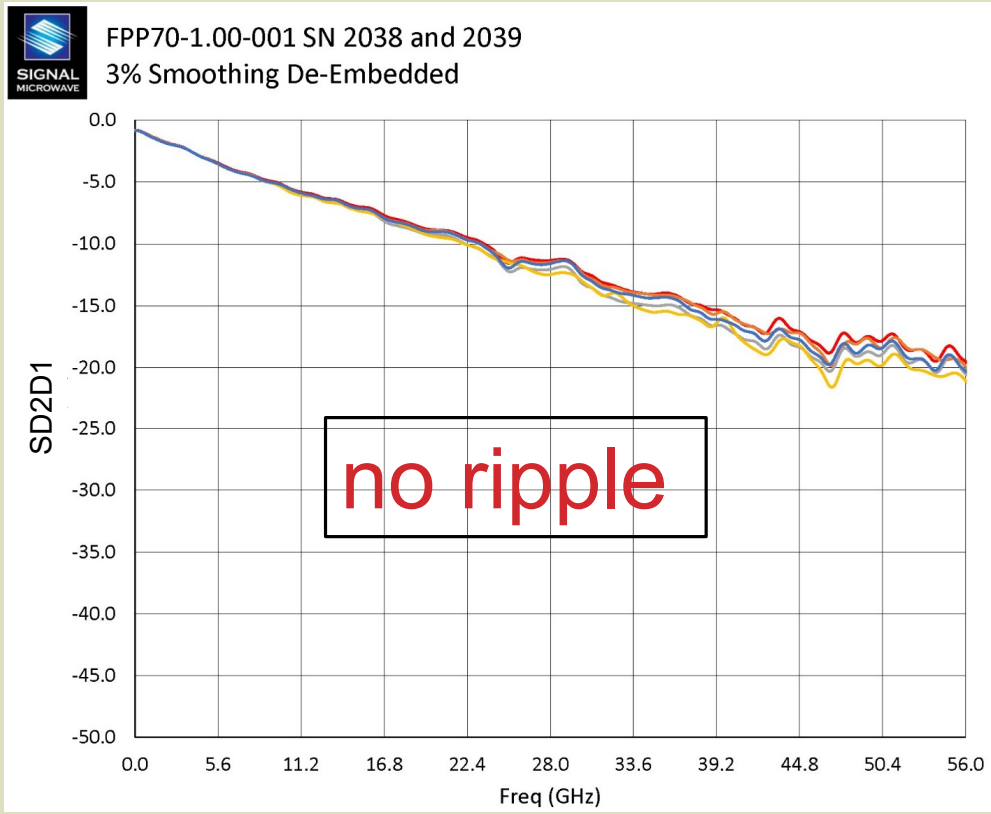
SN 2038 and 2039 Results 1% Smoothing





SN 2038 and 2039 Results 3% Smoothing

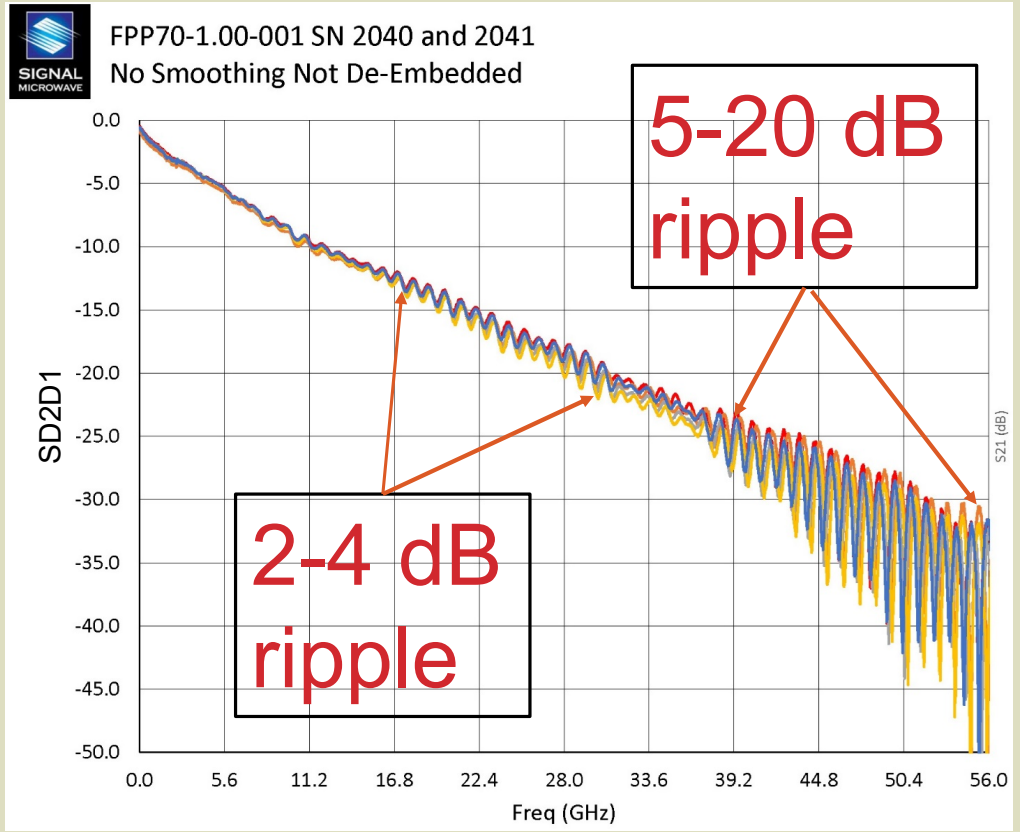


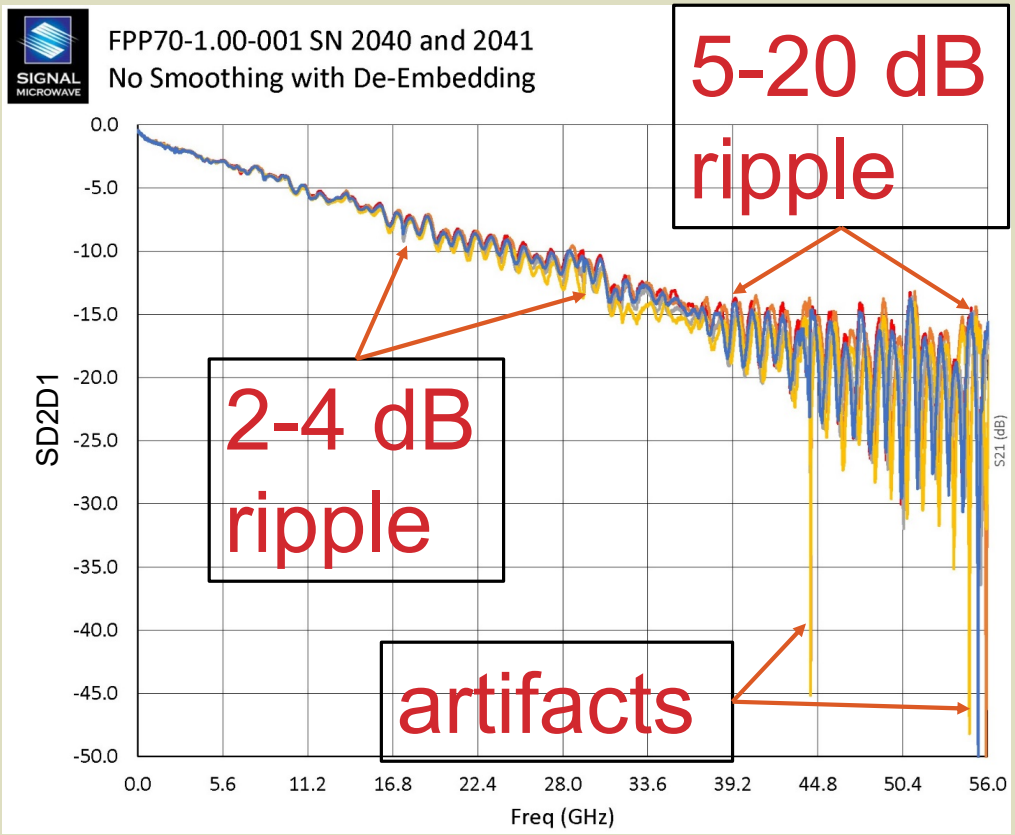


Use of Multiple Sets of Probes

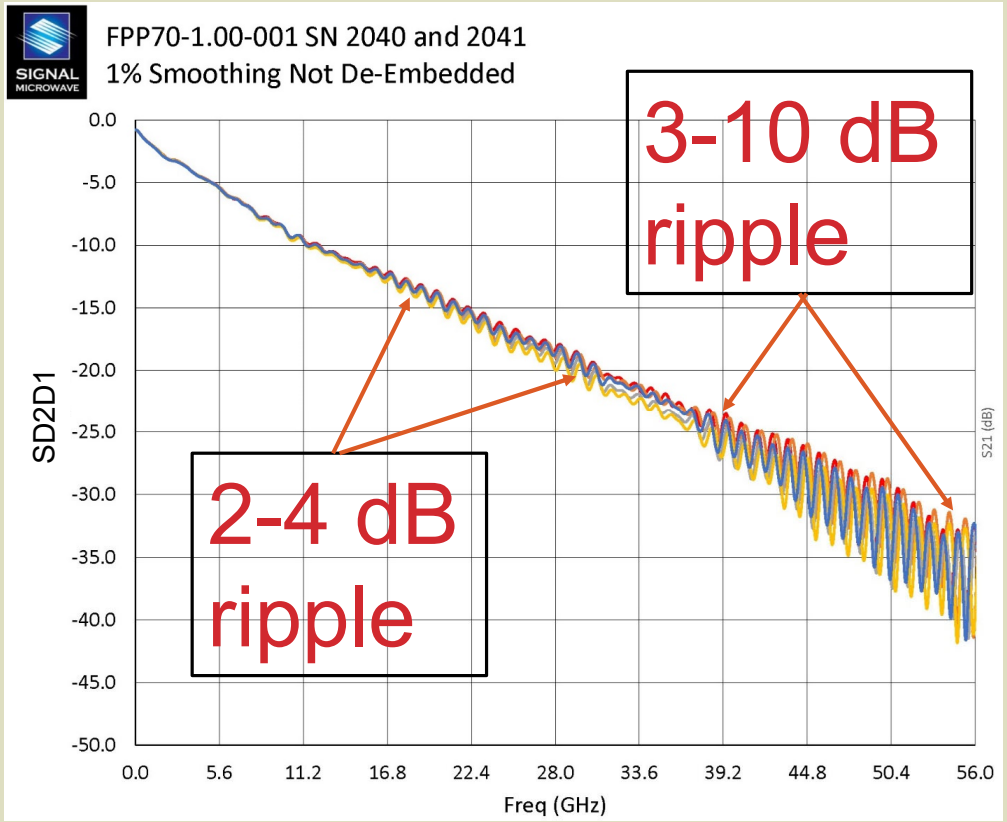
- The probes used were FPP70-1.00-001
- 2 sets of probes were used
  - –The previous serial numbers were 2038 and 2039
  - –The next serial numbers were 2040 and 2041
- Second set was made with a modified process
  - –The test results were very similar
  - –This data shows the consistency of the probes

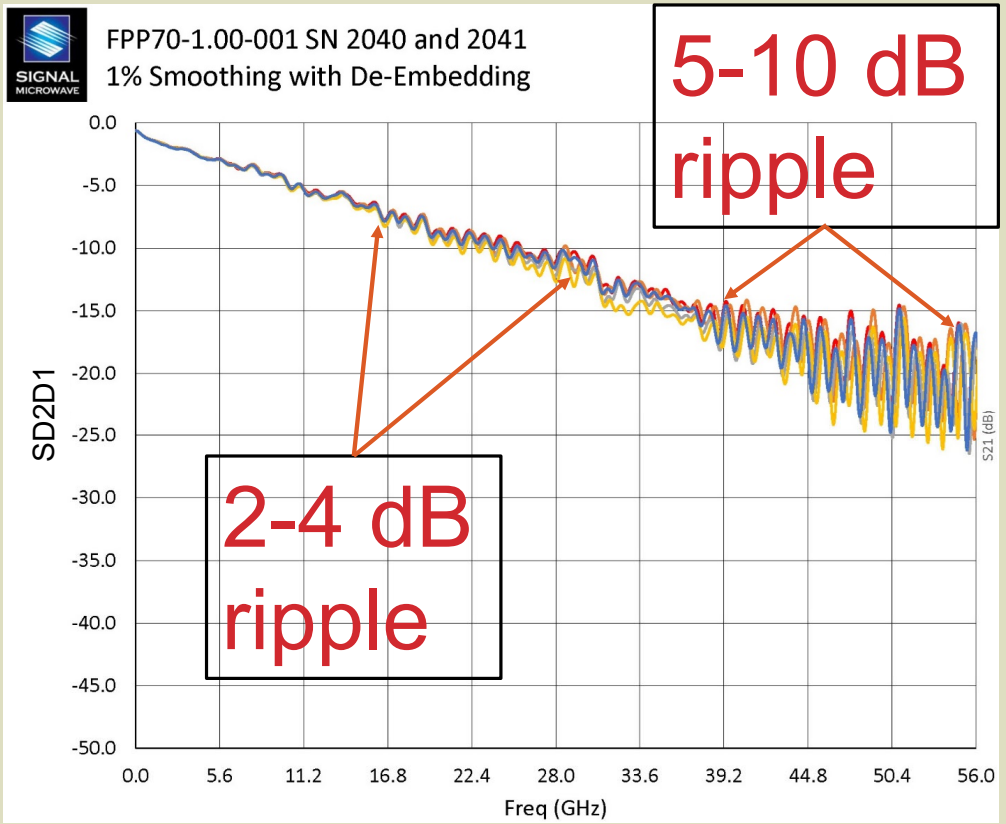
SN 2040 and 2041 Results 0% Smoothing



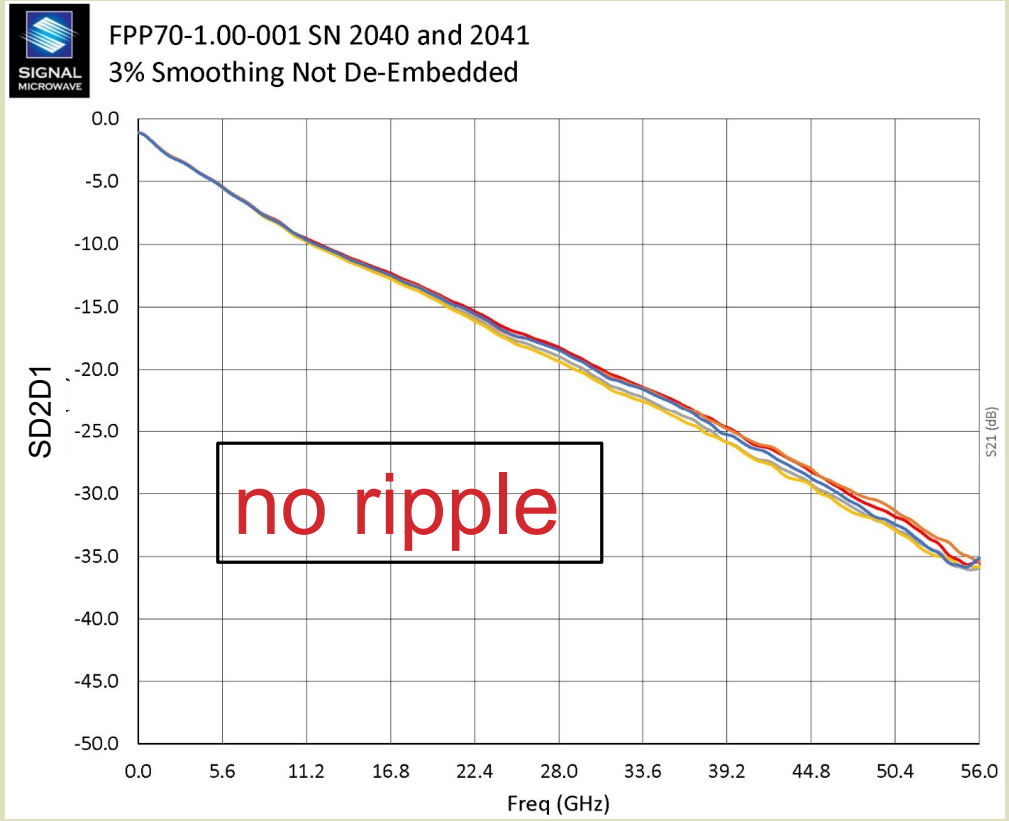


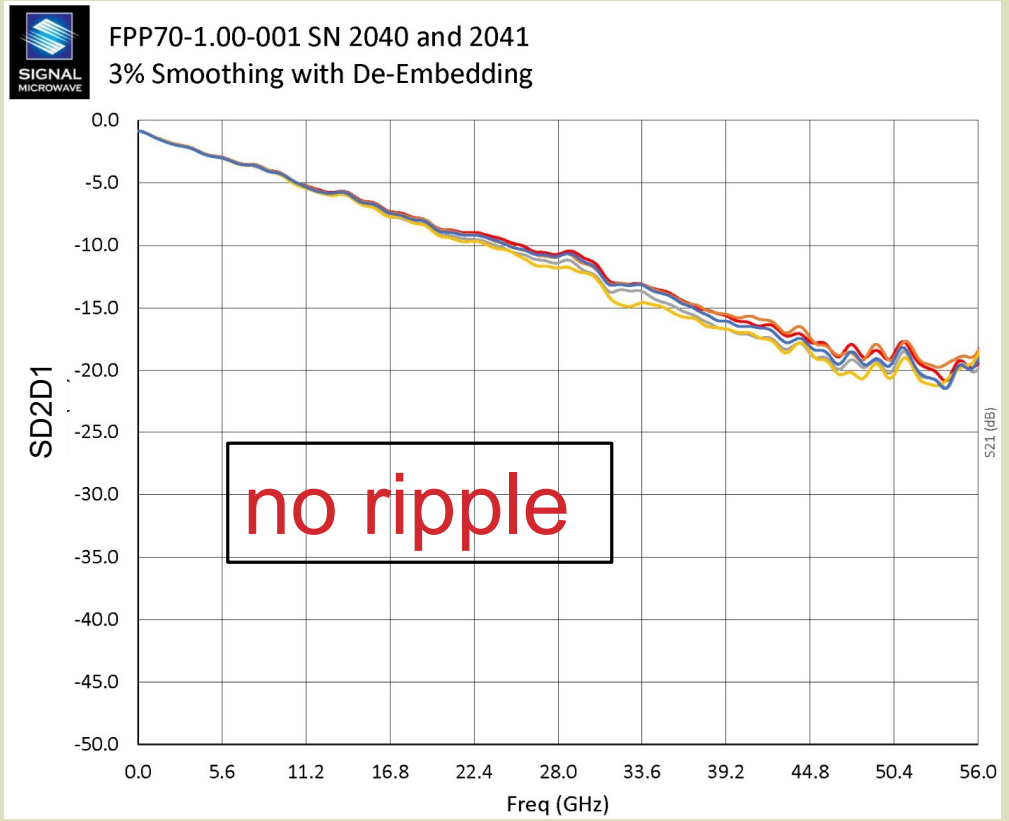
SN 2040 and 2041 Results 1% Smoothing





SN 2040 and 2041 Results 3% Smoothing





Creation of the De-Embedding Files

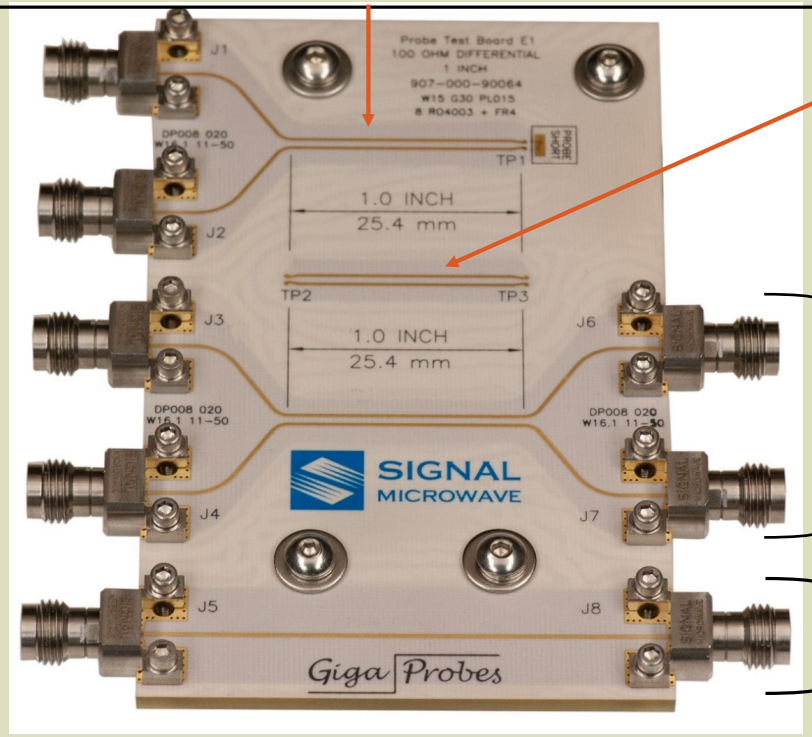
- Ataitec ISD software was used to create the de-embedding files
- Ataitec software requires 3 measurements of the test fixture to be de-embedded
  - –The test fixture terminated to “open”
  - –The test fixture terminated to “short”
  - –The test fixture and a through line

De-Embedding Files for the Probes

- Signal Microwave has a probe “in-situ” board to create the files required by the Ataitec software
  - –50 and 100 ohm connector to connector, and probe to probe (for reference)
  - –100 ohm connector to probe pads (to create the “in-situ” file
  - –It also has a shorting pad to create probe “short” files

In-Situ Board for De-Embedded Files

connectors to probe line

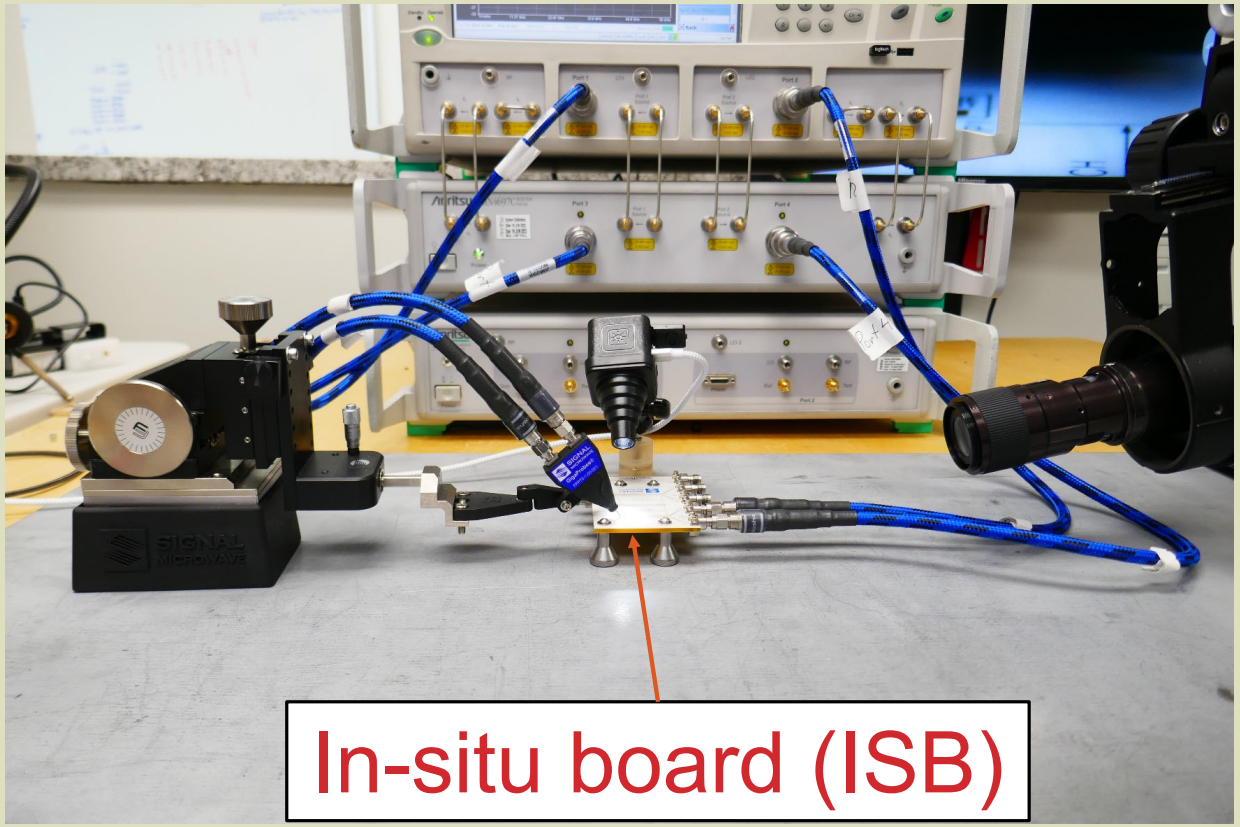


probe to probe line

100 ohm connectors line

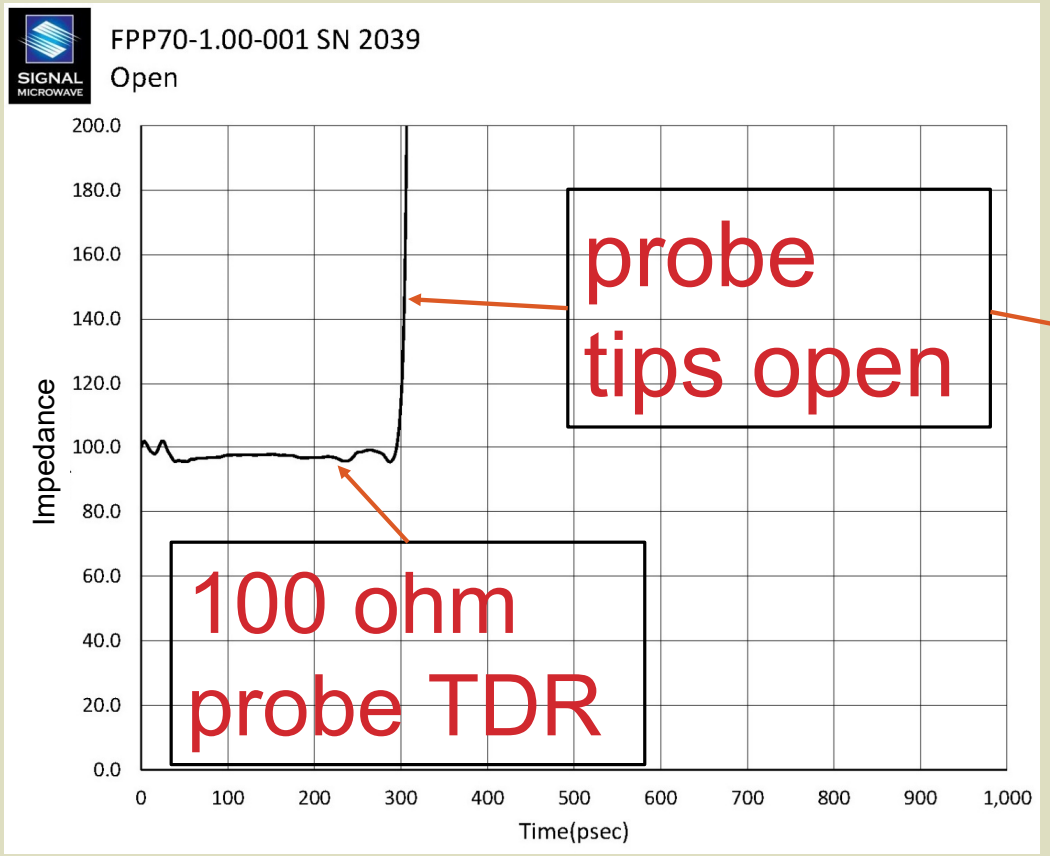
50 ohm connectors line

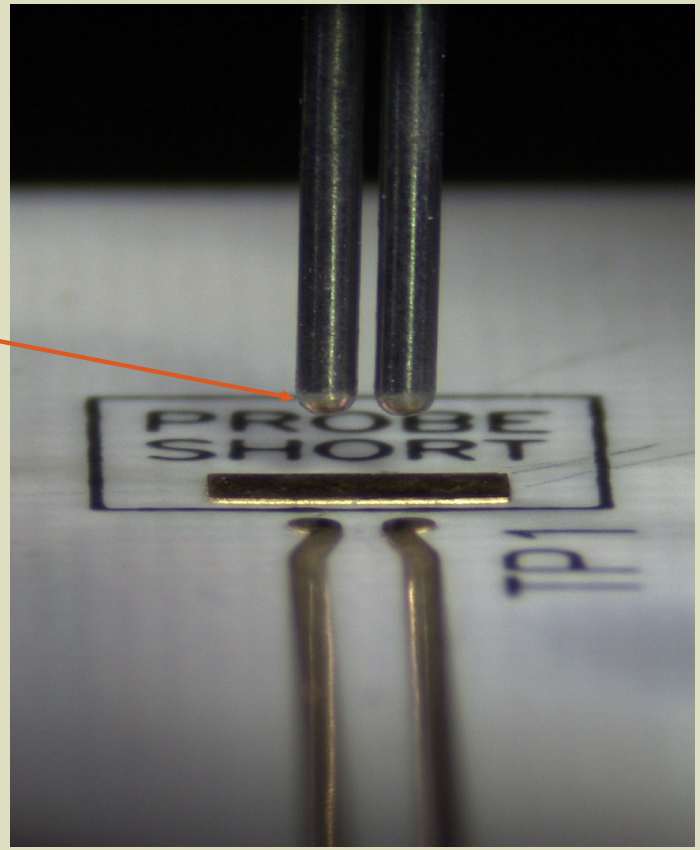
Probe Station with In-Situ Board



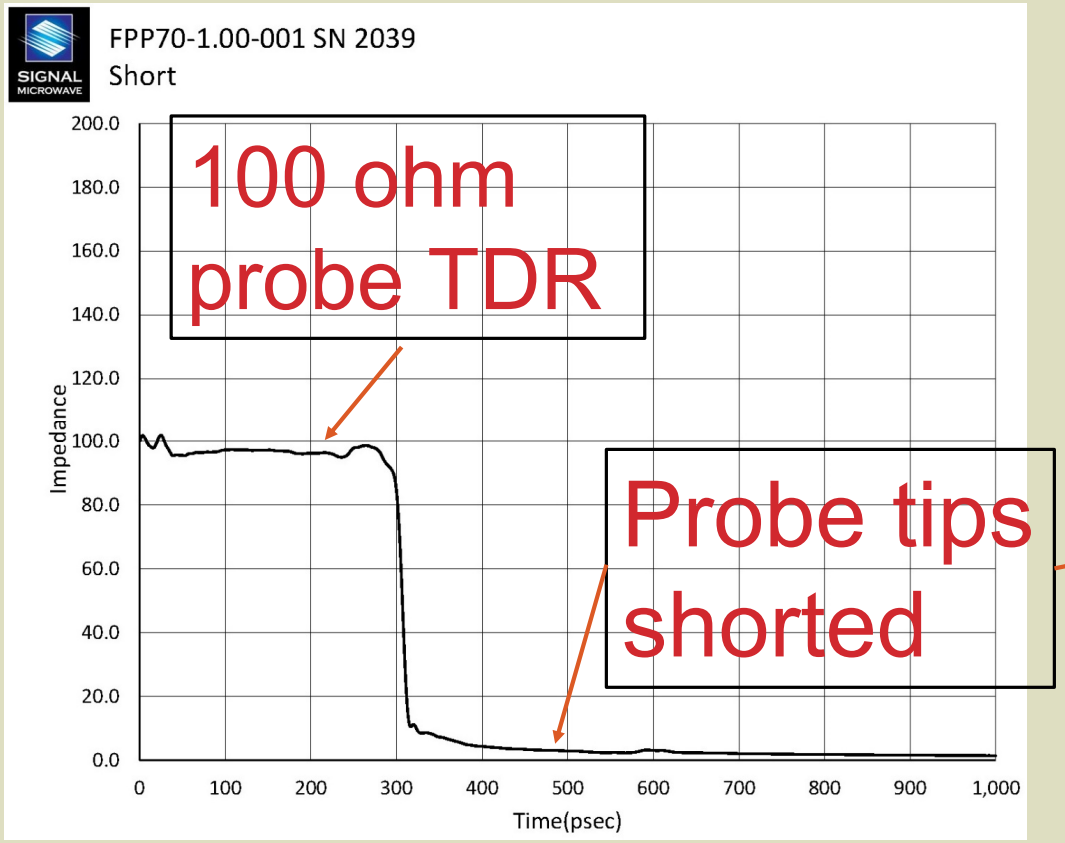
- VNA ports 1 and 3 are connected to the probe
- VNA ports 2 and 4 are connected to the board

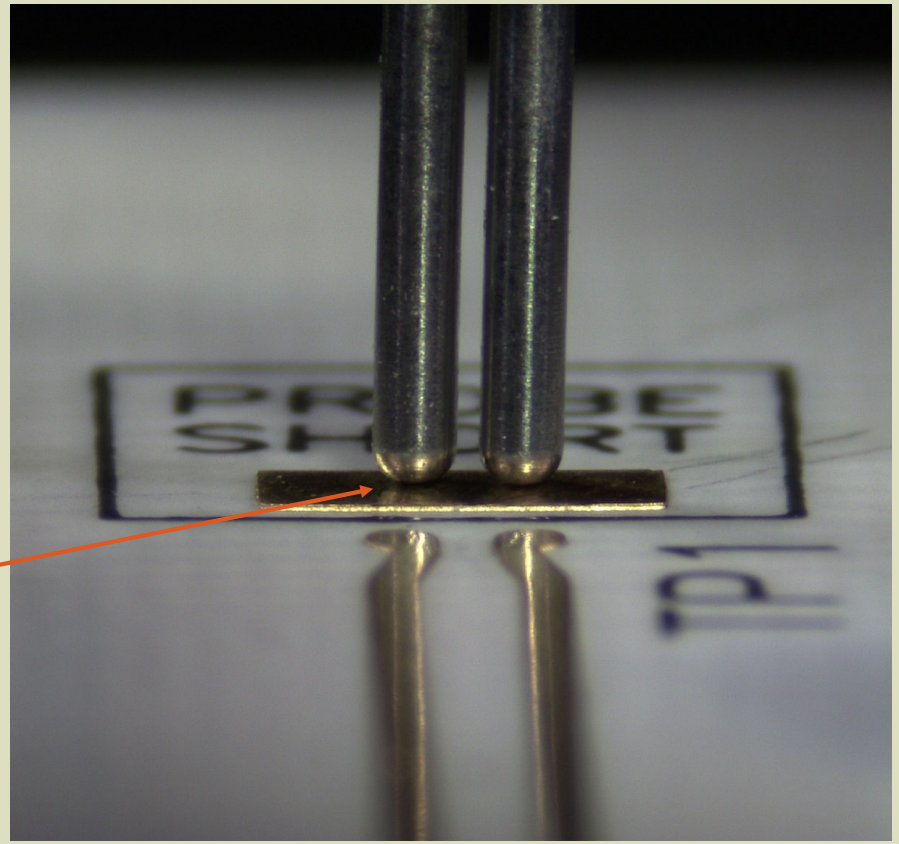
In-Situ De-Embedding – Open Saved as .s2p File



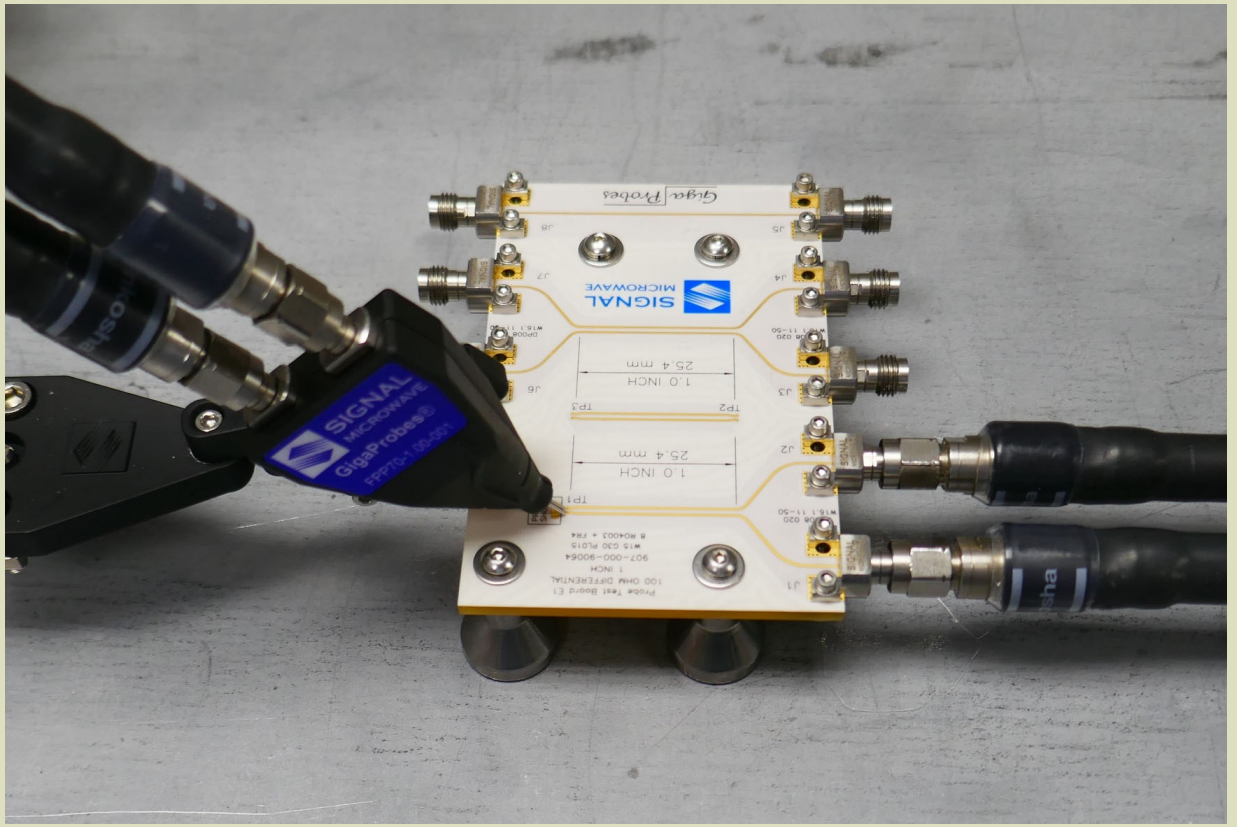


In-Situ De-Embedding File – Short Saved as .s2p

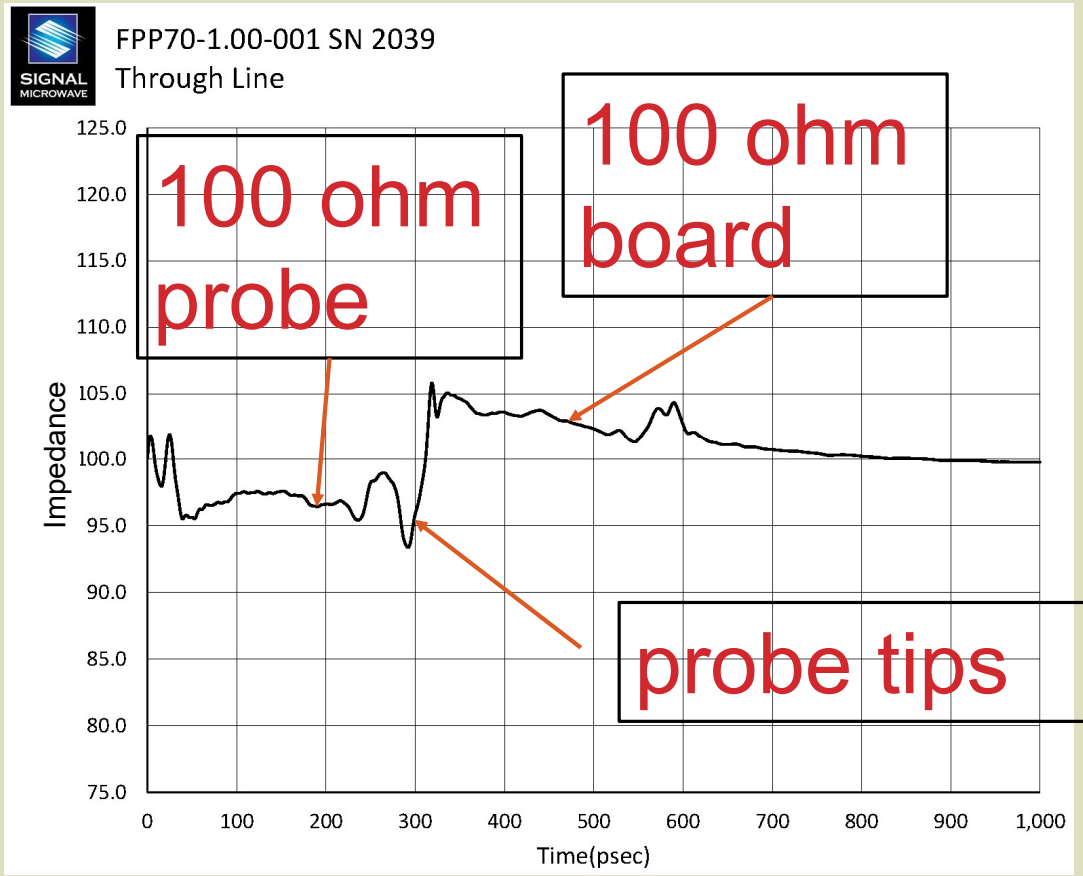


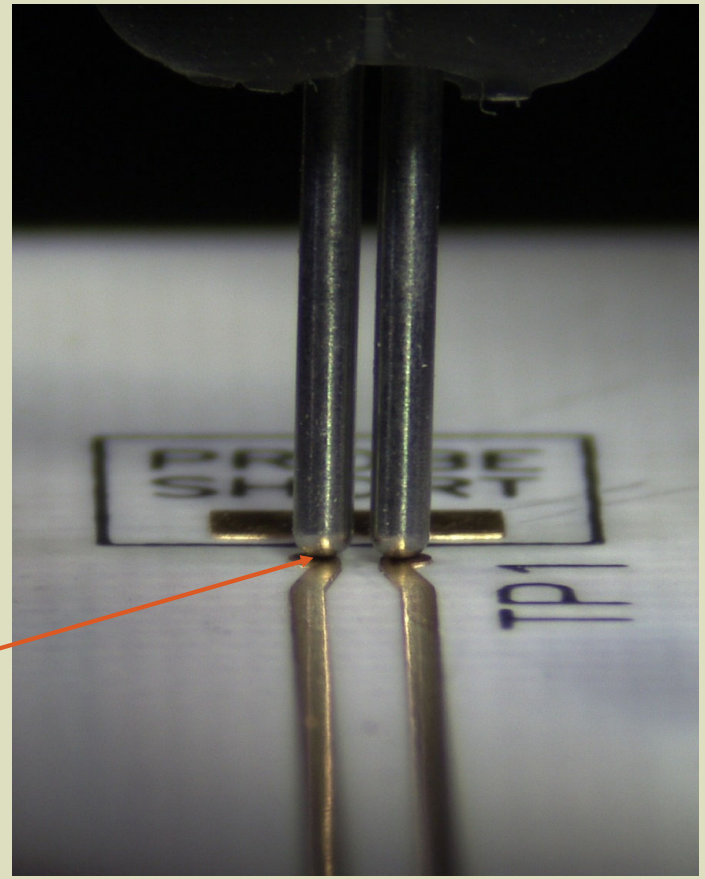


In-Situ Board (ISB) and Probe Through Line

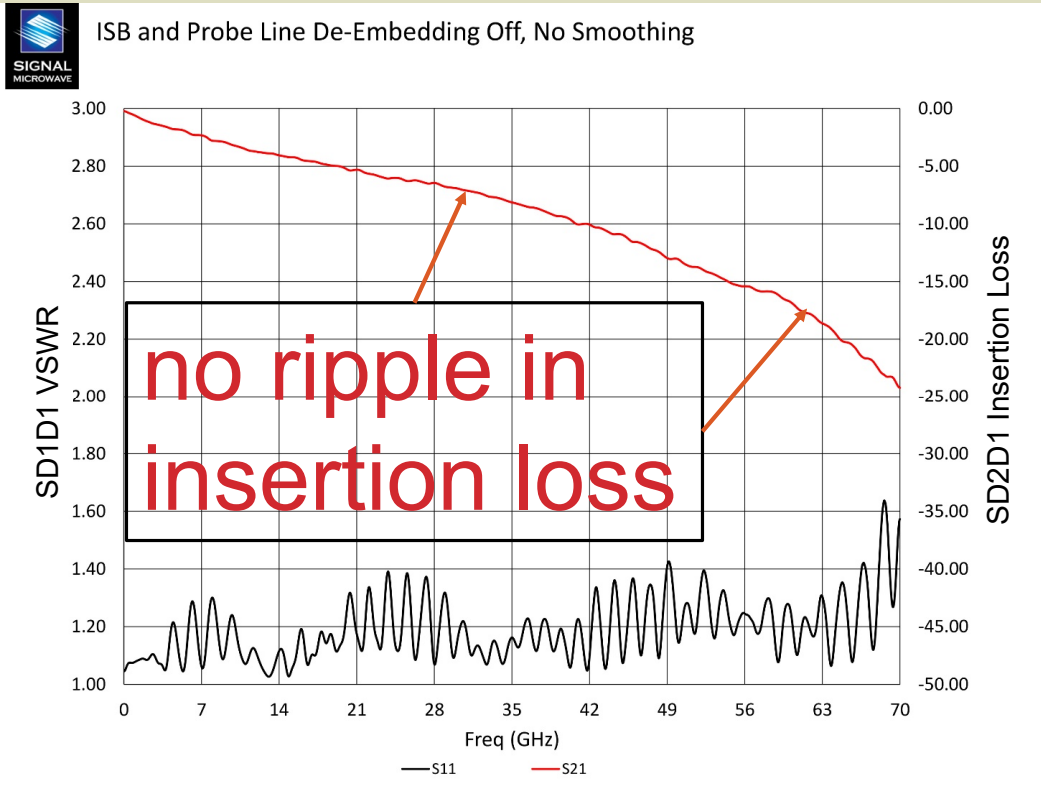


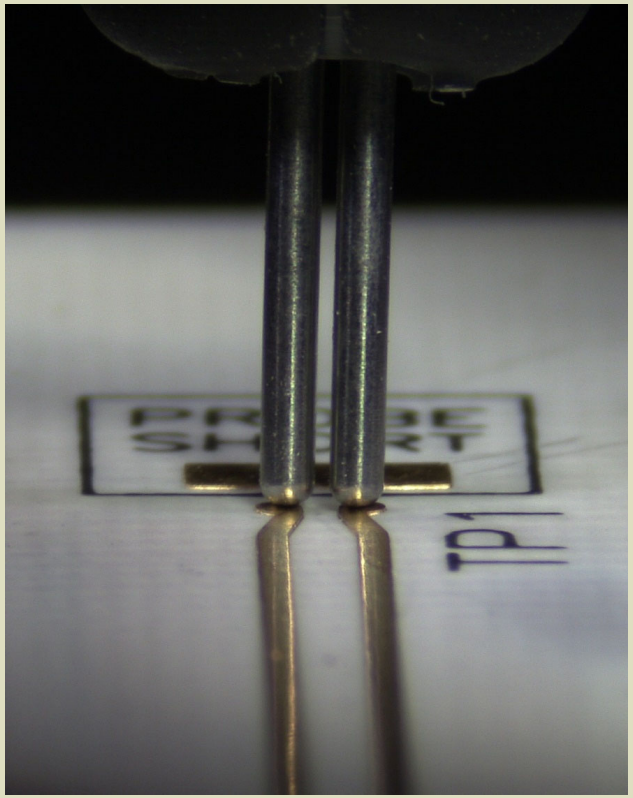
In-Situ Board and Probe Through Line TDR



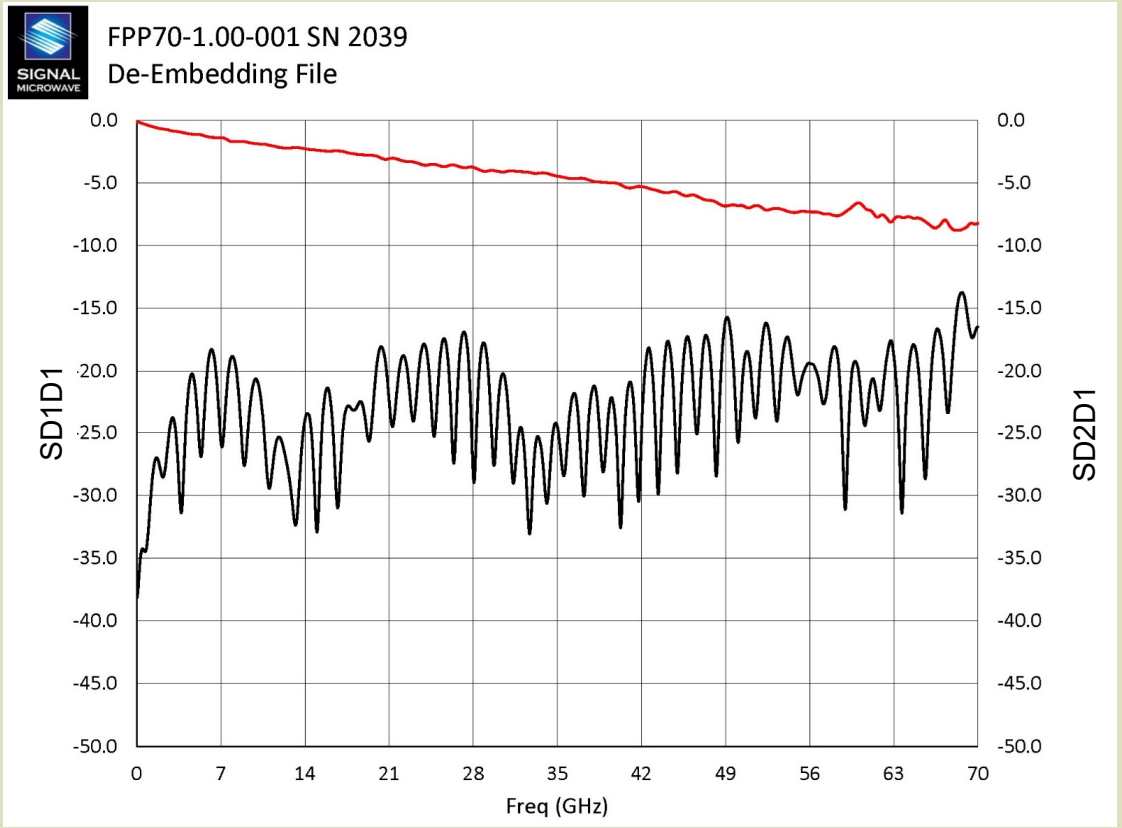


Board and Probe Through Line S-Parameters





S-Parameters of the Probe De-Embedding File



Conclusion

- We demonstrated a successful application of this type of probe with a VNA, highlighting its versatility
- These probes can be used in a wide range of applications with VNAs and other test equipment
  - Line length (skew), PCB component to component line testing, failure analysis, baluns, differential cables, sockets, and packages

Further Work

- 110 GHz with 1.0 mm connectors (completed)
- 90 GHz version with 1.35 mm connectors
- 0.6 mm, 0.8 mm, and 1.0 mm versions available
- Different impedances such as 85 ohms
- Custom probe mount configurations (completed)
- Curved probe body so the probe tips can fit into tighter spaces

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