

RF Probing With Anritsu ShockLine VNA



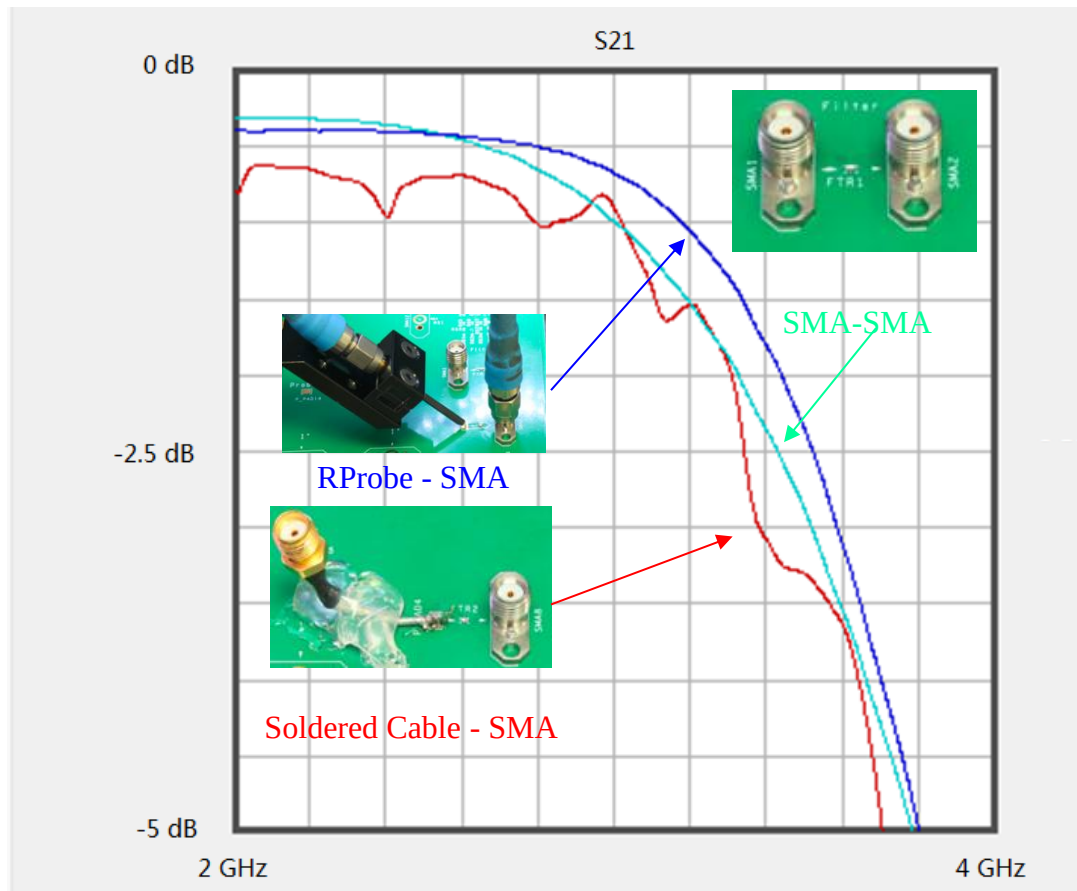
Outline

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Why RF Probing?

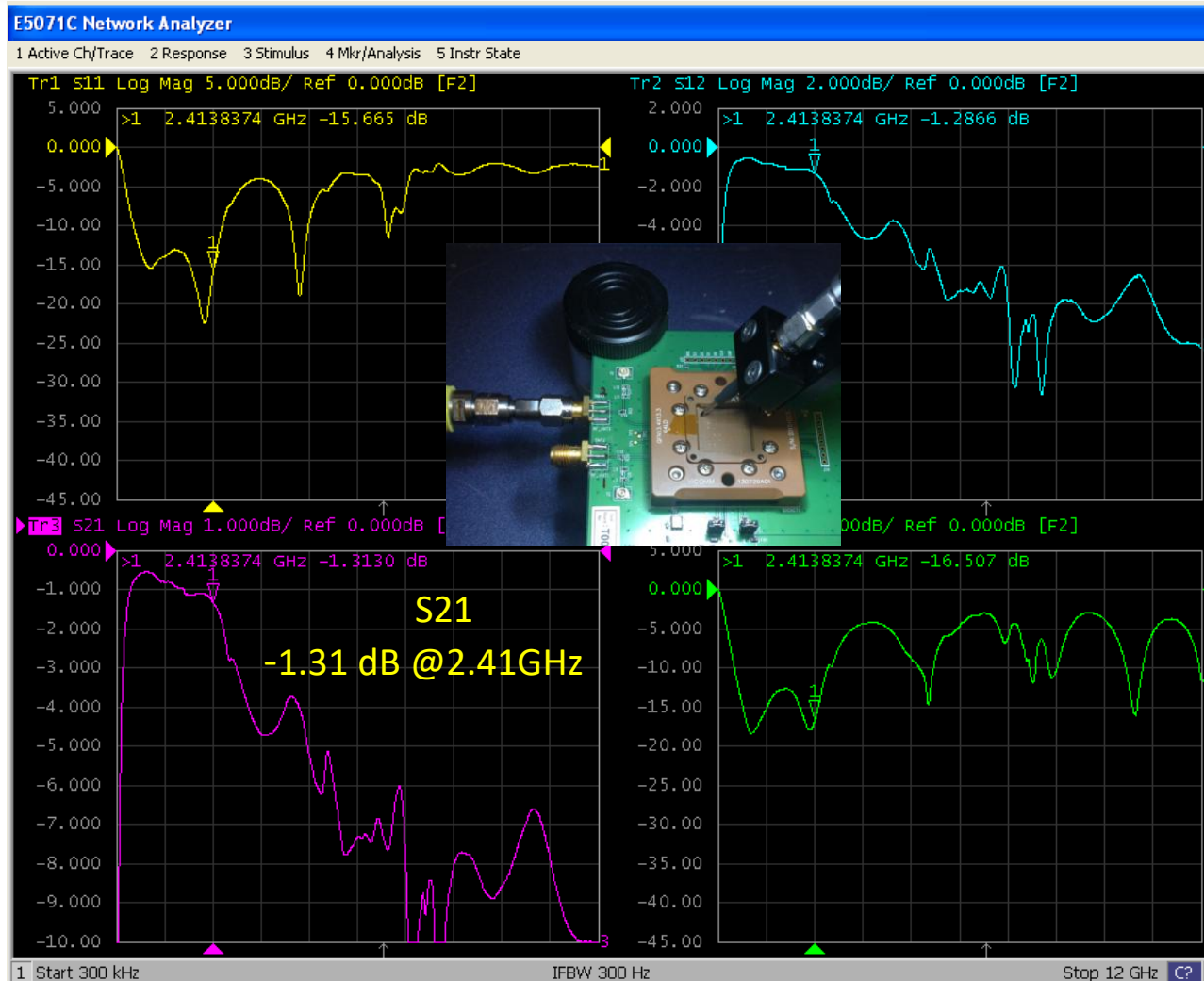
- **Necessity:** Constant shrinking size of circuit components makes soldering semi-rigid RF cables to test gigahertz circuits impractical.
- **Accuracy:** RF probes and calibration substrates allow engineers to perform probe-tip calibration for accurate, repetitive measurements.
- **Productivity:** Any engineer can do RF measurements in minutes without the need of soldering semi-rigid cable

Measurements of RF Low-Pass Filter

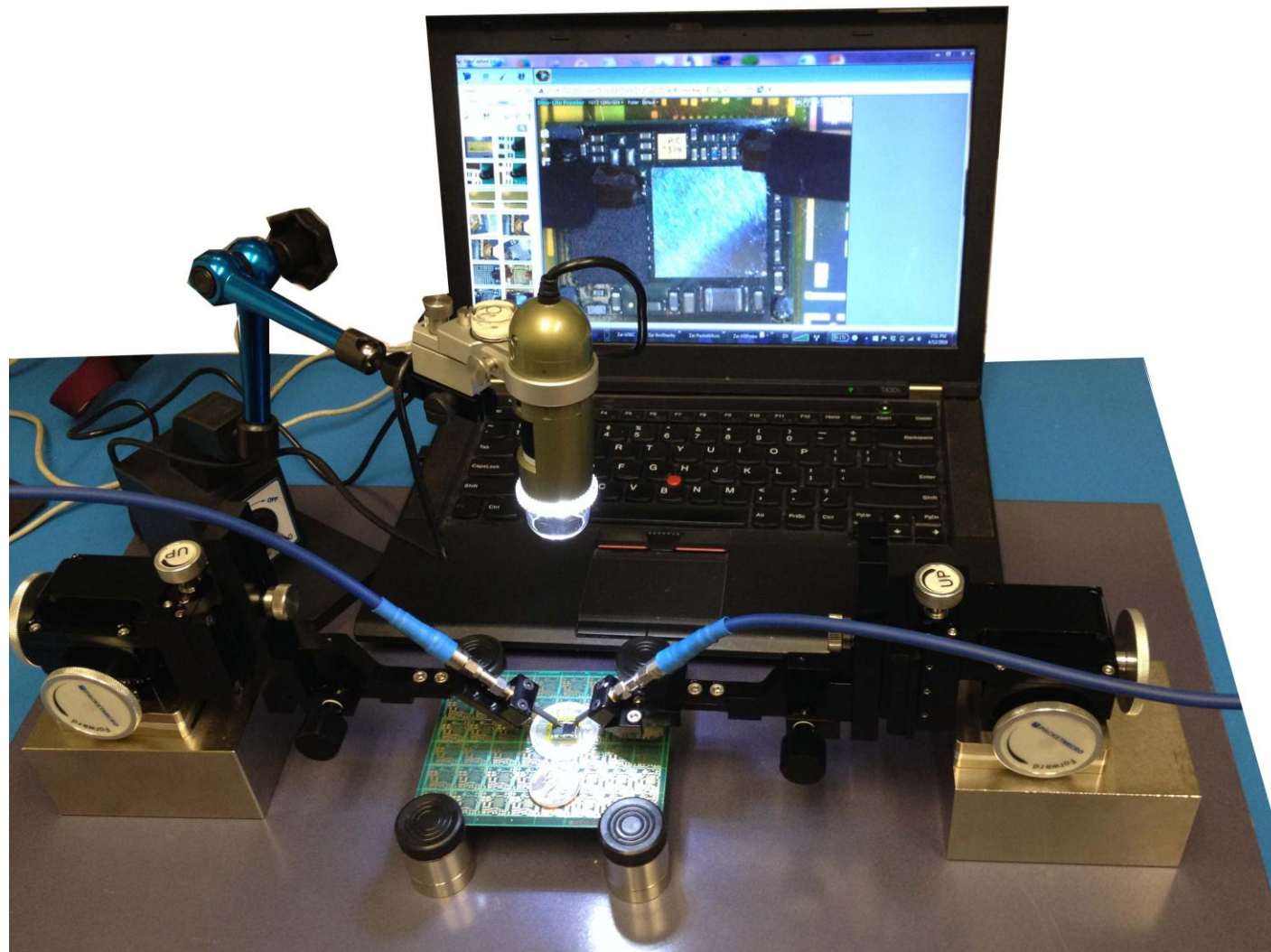


RF probe is almost as good as SMA connector!

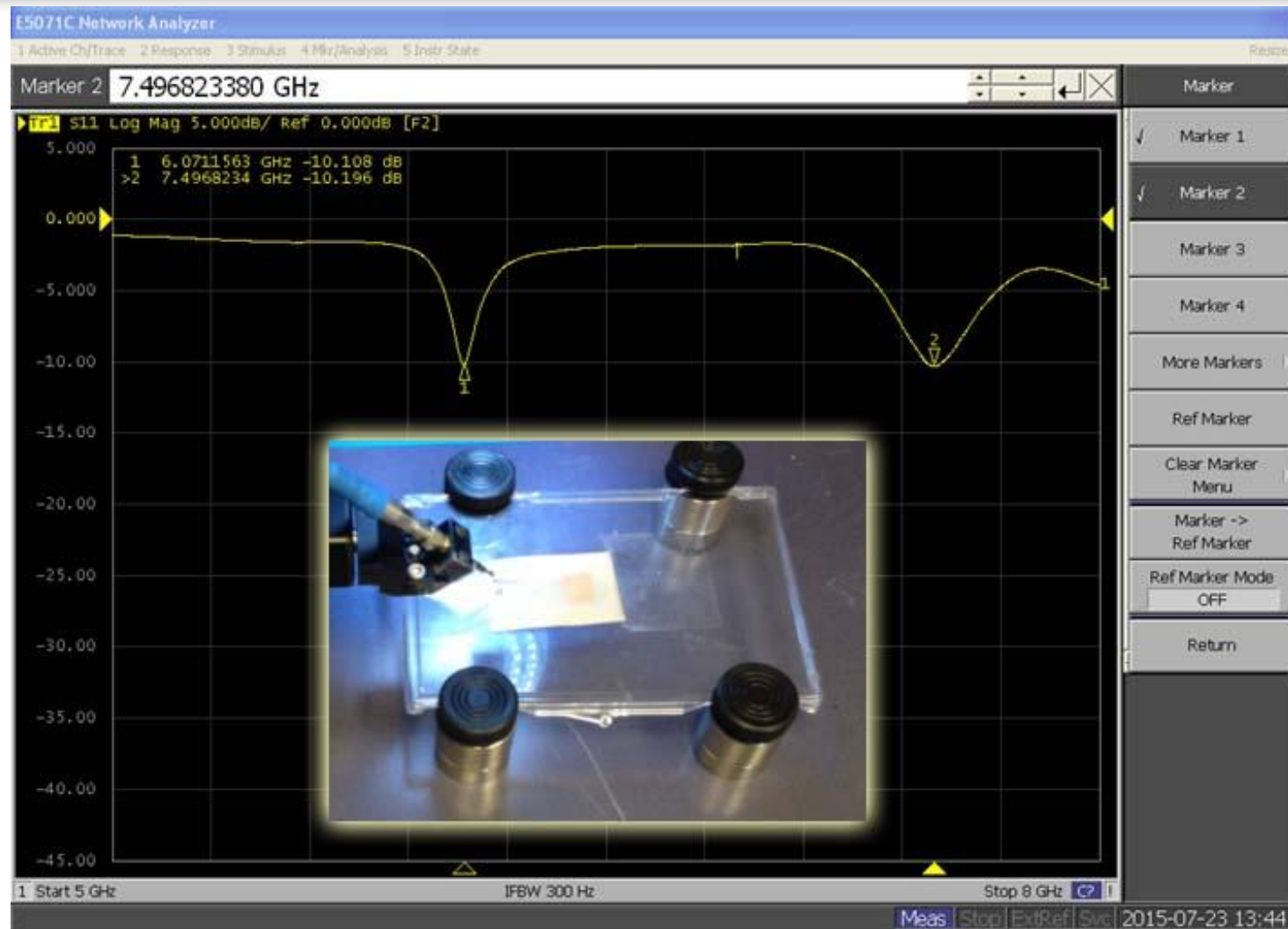
RF Fixture Testing



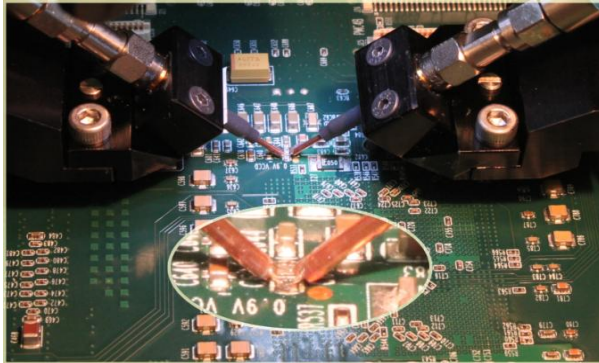
RF Module Testing



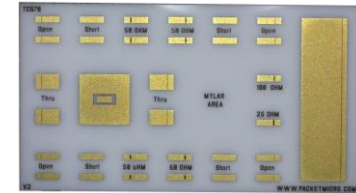
RF Antenna Testing



30/20 GHz S-Probe

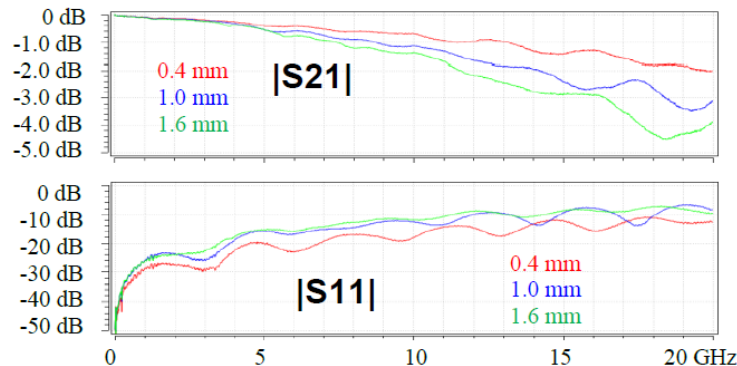


S-Probe
(1.5" x 0.4" x 0.3")



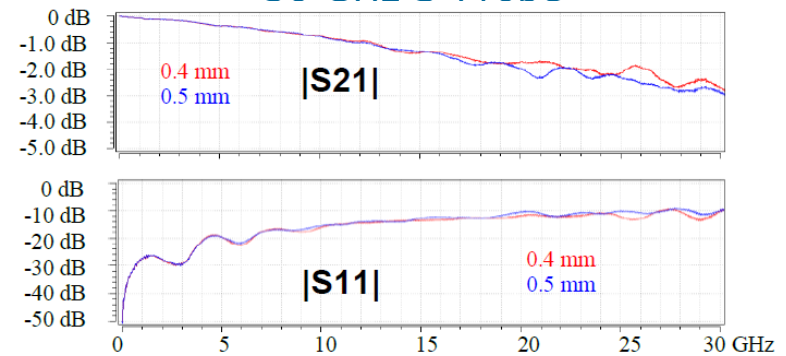
TCS70 Cal Substrate
(0.7" x 0.4" x 0.025")

PCB Probing with S-Probe



- **SP-GR-2015025** – 20 GHz, 0.25 mm
- **SP-GR-201504** – 20 GHz, 0.4 mm
- **SP-GR-201505** – 20 GHz, 0.5 mm
- **SP-GR-181508** – 18 GHz, 0.8 mm
- **SP-GR-181510** – 18 GHz, 1.0 mm
- **SP-GR-161512** – 16 GHz, 1.2 mm
- **SP-GR-161514** – 16 GHz, 1.4 mm
- **SP-GR-161516** – 16 GHz, 1.6 mm

30 GHz S-Probe

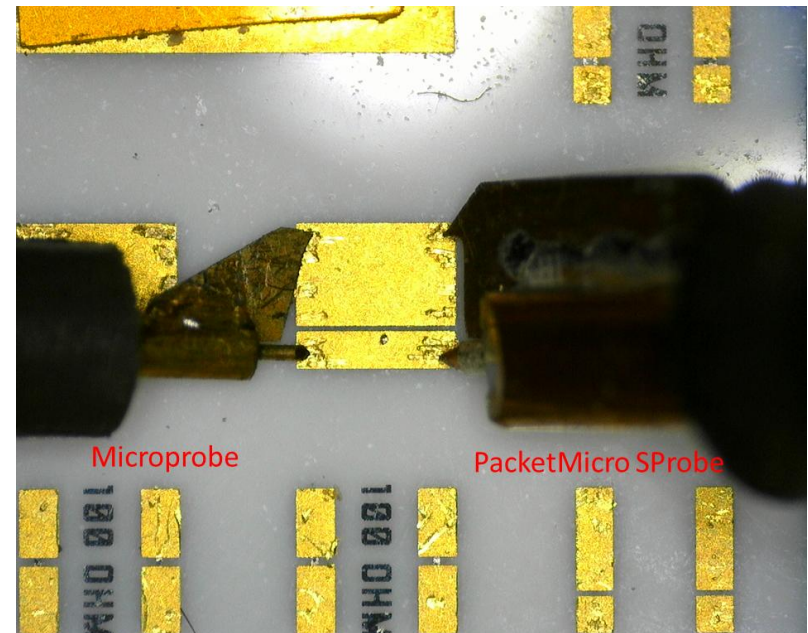
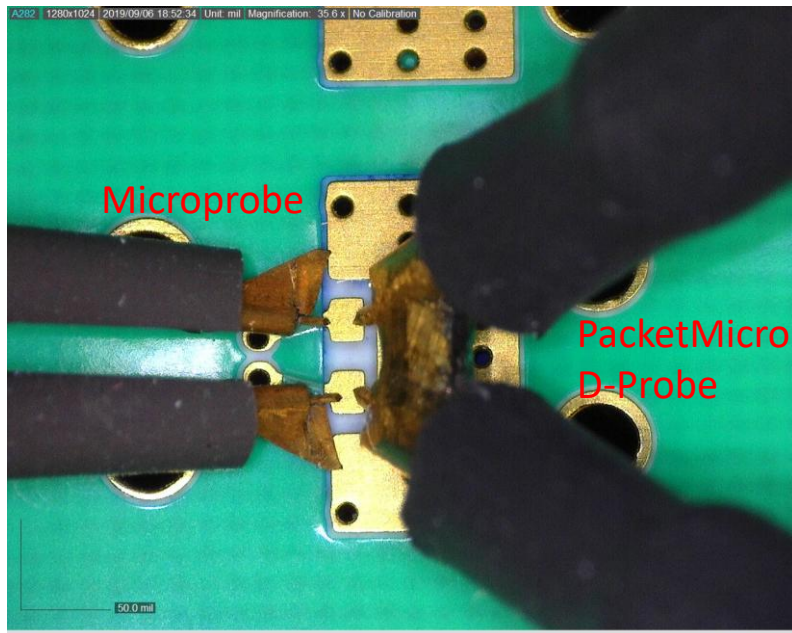


- **SP-GR-3015025** – 30 GHz, 0.25 mm
- **SP-GR-301504** – 30 GHz, 0.4 mm
- **SP-GR-301505** – 30 GHz, 0.5 mm

Video demo:

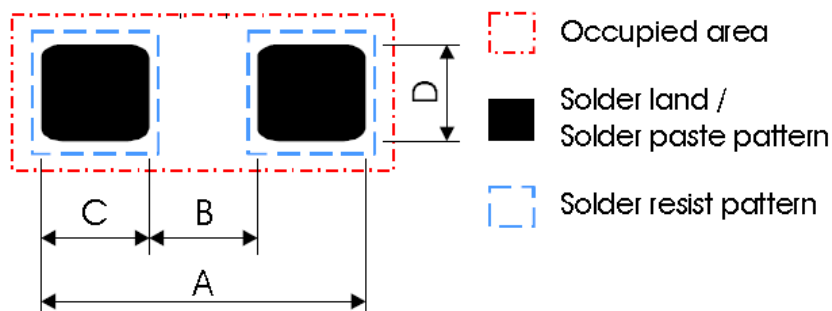
https://packetmicro.com/Videos/PacketMicro_Probe_Planarization.mp4

Rugged Probes vs. Microprobes



- **PacketMicro rugged probes are specifically designed for probing on test pads on uneven surfaces.**

Probe-Pitch Selection



S-Probe Part Number:

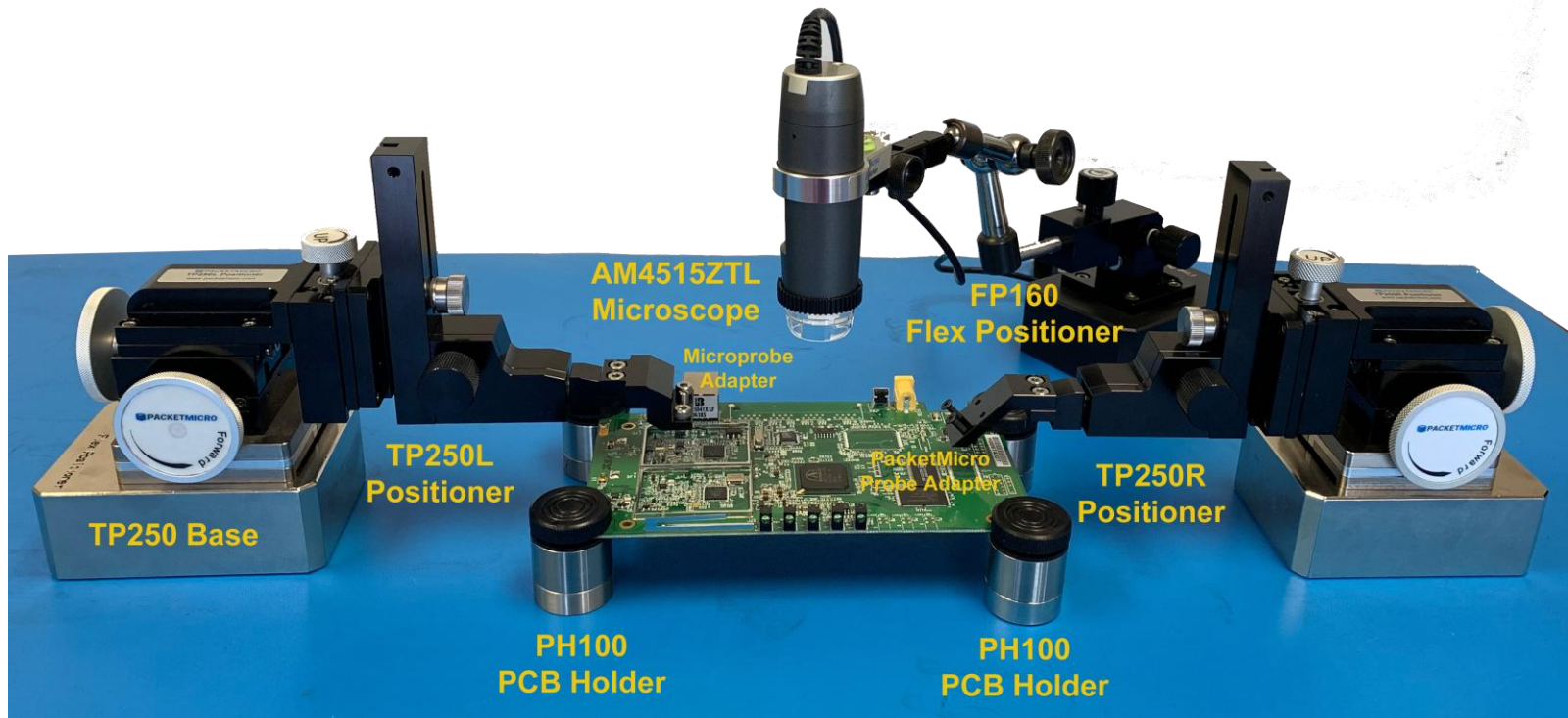
- **SP-GR-2015025** – 20 GHz, 0.25 mm/10 mil pitch
- **SP-GR-201504** – 20 GHz, 0.4 mm/16 mil pitch
- **SP-GR-201505** – 20 GHz, 0.5 mm/20 mil pitch
- **SP-GR-181508** – 18 GHz, 0.8 mm/32 mil pitch
- **SP-GR-181510** – 18 GHz, 1.0 mm/40 mil pitch
- **SP-GR-161512** – 16 GHz, 1.2 mm/48 mil pitch
- **SP-GR-161514** – 16 GHz, 1.4 mm/56 mil pitch
- **SP-GR-161516** – 16 GHz, 1.6 mm/64 mil pitch
- **SP-GR-3015025** – 30 GHz, 0.25 mm/10 mil pitch
- **SP-GR-301504** – 30 GHz, 0.4 mm/16 mil pitch
- **SP-GR-301505** – 30 GHz, 0.5 mm/20 mil pitch

Recommendation: $B + 0.2 \text{ mm} < \text{Probe Pitch} < A - 0.2 \text{ mm}$

Size	Probe Pitch	A	B	C	D	Component Size
01005	SP-GR-2015025	0.48	0.12	0.18	0.20	0.4 x 0.2
0201	SP-GR-201505	0.75	0.30	0.30	0.30	0.6 x 0.3
0402	0.7mm < Pitch < 1.3mm	1.50	0.50	0.50	0.60	1.0 x 0.5
0603	0.8mm < Pitch < 1.9mm	2.10	0.60	0.90	0.90	1.6 x 0.8
0805	1.2mm < Pitch < 2.8mm	3.0	1.0	1.0	1.25	2.0 x 1.25

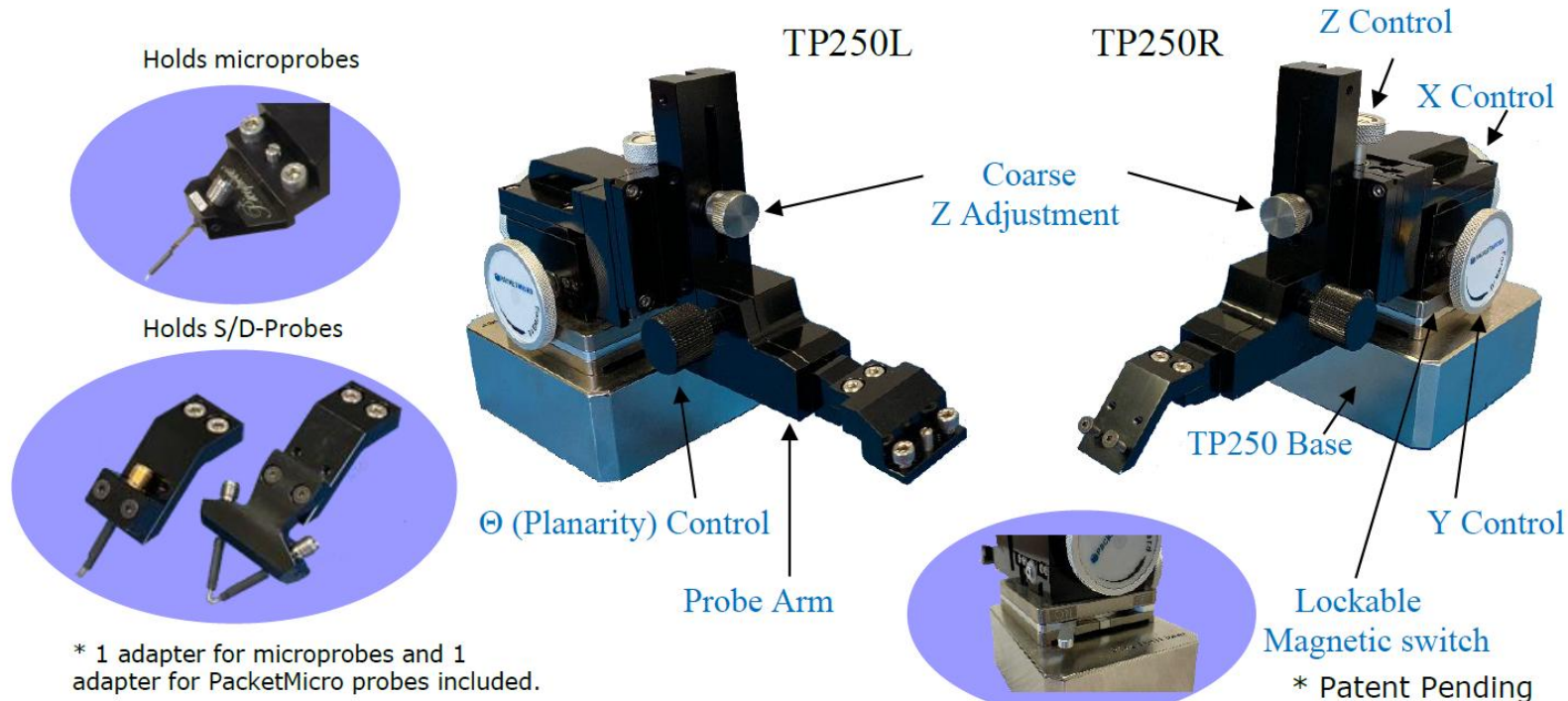
- The above component footprints are for reference only.
- Please use the specific component footprints in your PCB layout.

Simple DIY Probe Station



Set up your probe station in 5 minutes !

Precision Positioner – TP250

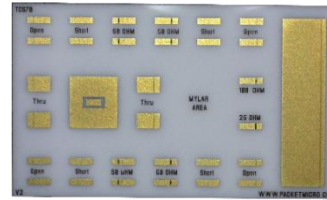


- **Precise:** XYZ stage (50 TPI, 2.5 μm resolution)
- **Versatile:** detachable θ stage
- **Easy:** lockable magnetic base

Tools - Accessories



Optical Microscope
(~ 90 x magnification)



TCS70
Calibration
Substrate



Mylar
Tape



Fine-tip
Sharpie pen



USB Digital Microscope
(~ 90 x magnification)

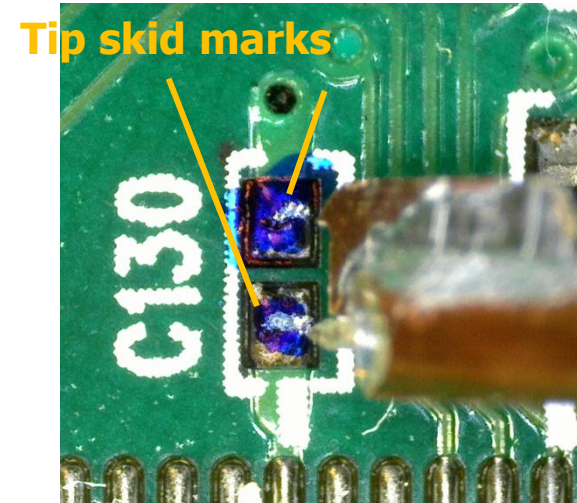
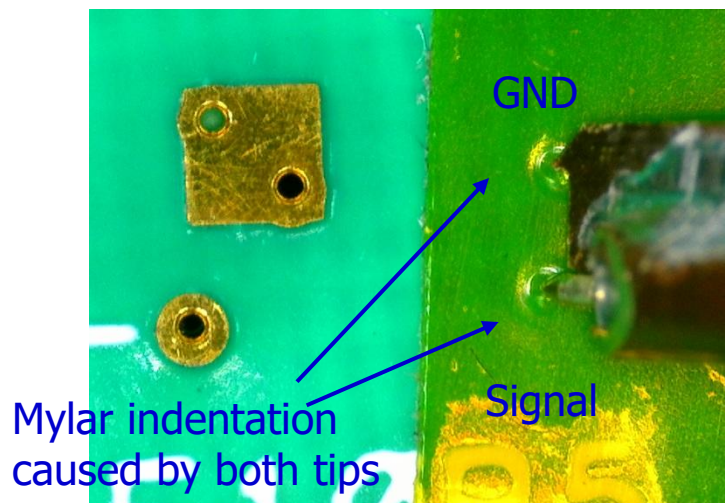
(Make sure to use a long working range (5 cm @ 90x) microscope!)

- Using a good microscope is essential.
- You might damage the probe if you cannot see its tips well.

Probe Planarization Tips

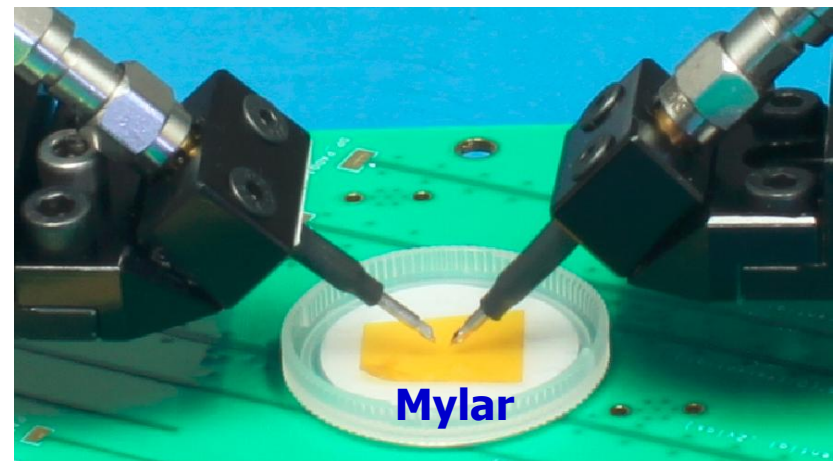
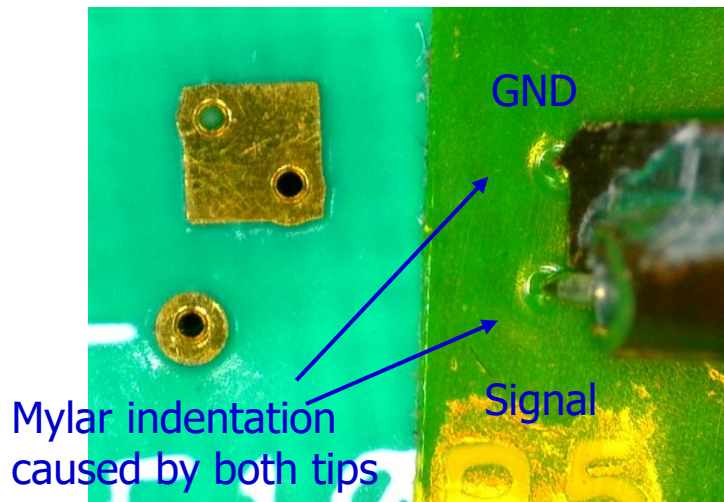
- A good microscope is important. You may damage the probe if you cannot see its tips well.
- Good contact of both probe tips with the DUT is essential to accurate calibration and measurements.
- Mylar tape provides leveling guidance on flat, even surface (bare PCB).
- Color marker helps on uneven surface (solder bump).
- Probe Planarization Video:

https://packetmicro.com/Videos/PacketMicro_Probe_Planarization.mp4

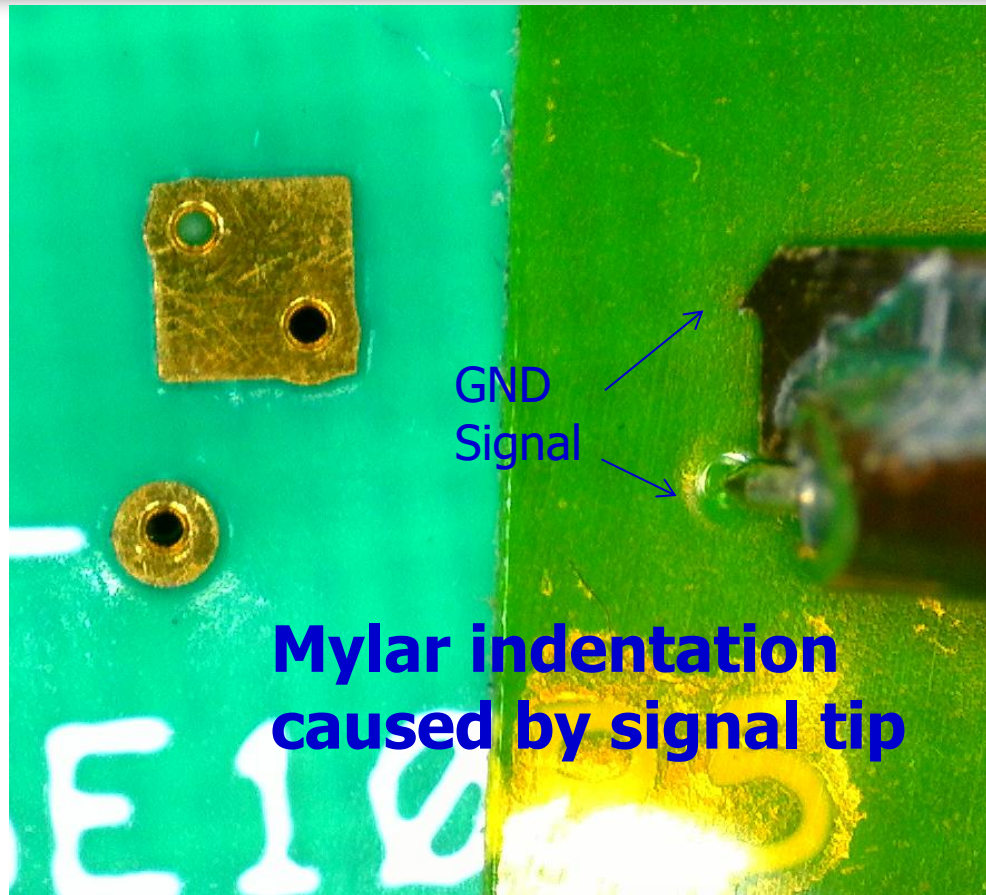


Probing Test Pads on Even Surfaces

- Use the Mylar tape on the back of the plastic cap for probe planarization by observing the indentation caused by the tips.
- Remove the plastic cap and perform probing
- Affix a Mylar tape next to test pads if there is not enough space for placing the plastic cap.



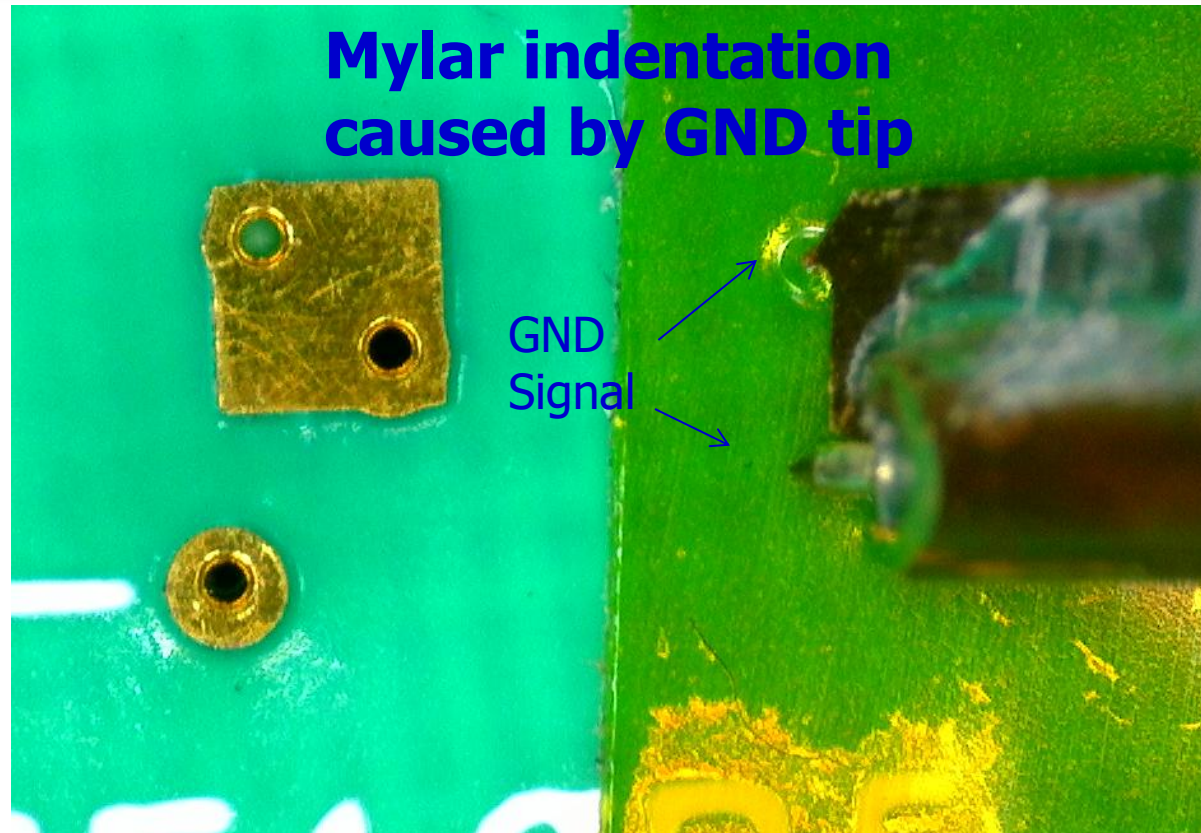
Signal tip touches down first



Step 1:

Land the probe tips on the tape and observe the probe-tip footprint. Above image shows that signal tip touches the surface first.

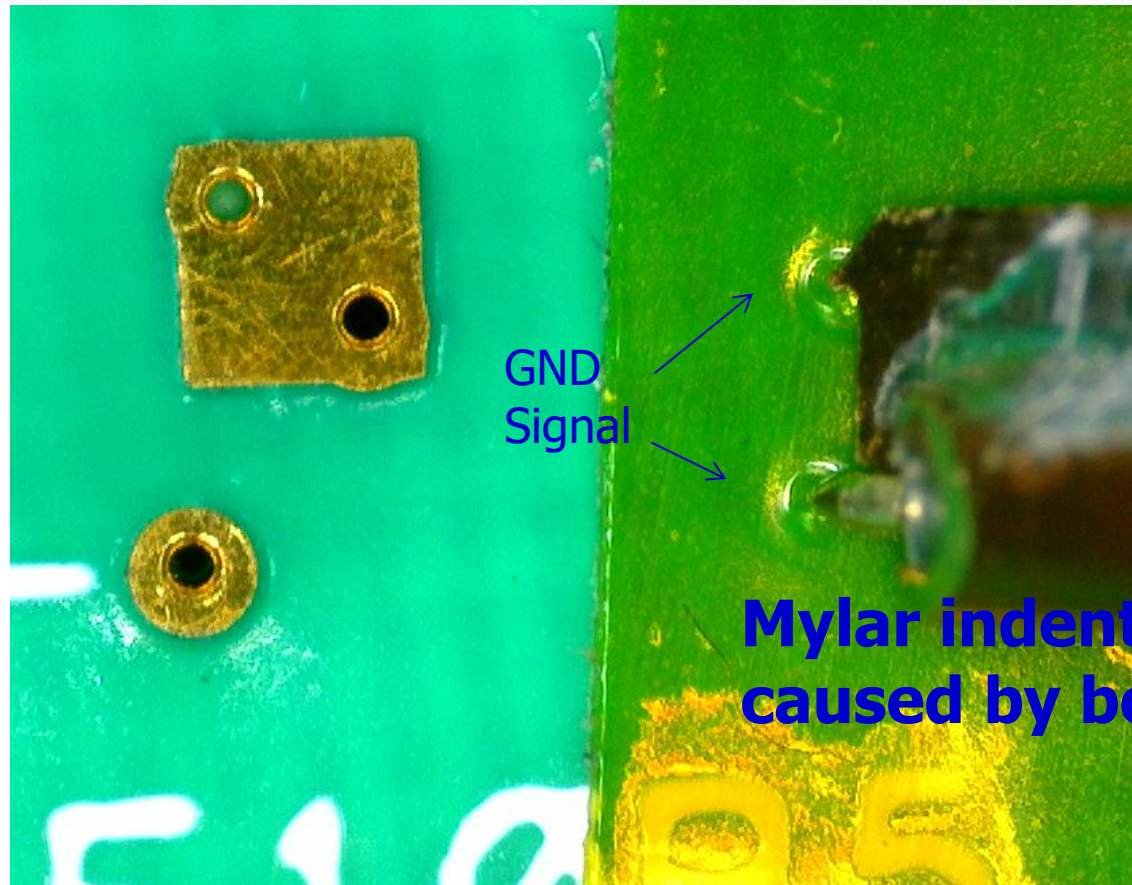
GND tip touches down first



Step 2:

Adjust the planarization knob on the TP150 positioner to lower the GND tip. Above image shows that GND tip touches the surface first.

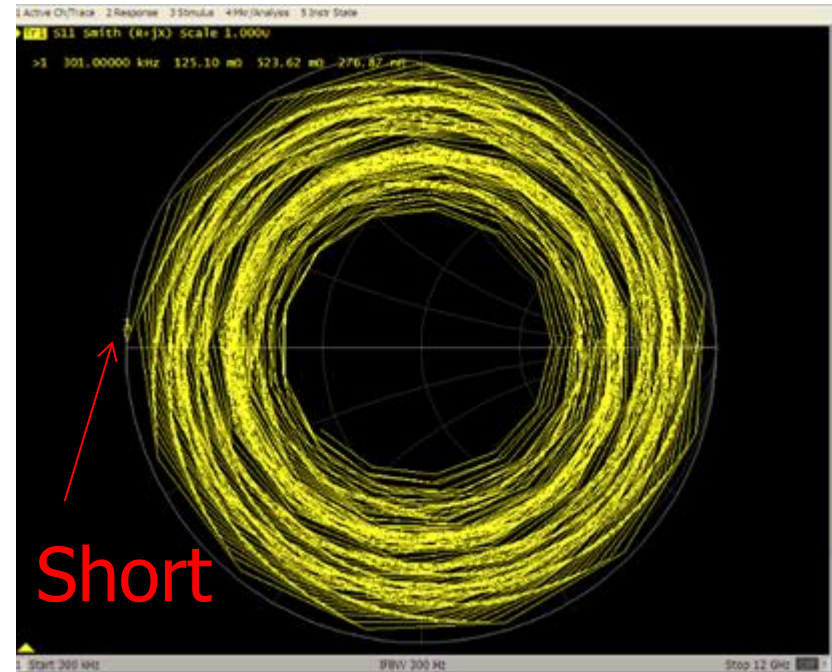
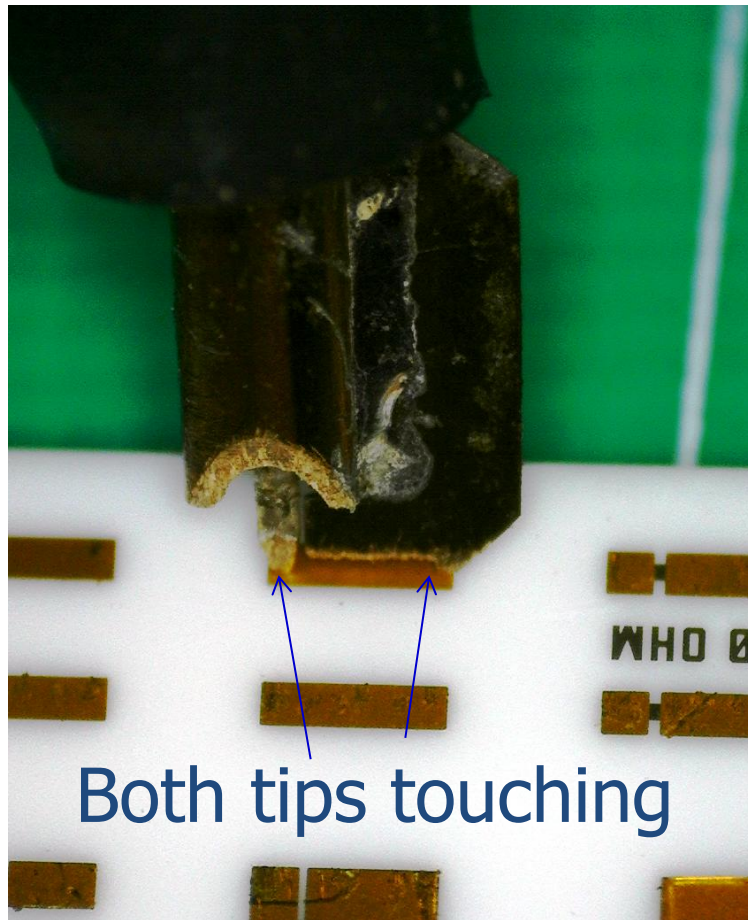
Both tips touch down simultaneously



Step 3:

Adjust the planarization knob on the positioner to land both probe tips. Above image shows the two probe tips touch the surface evenly.

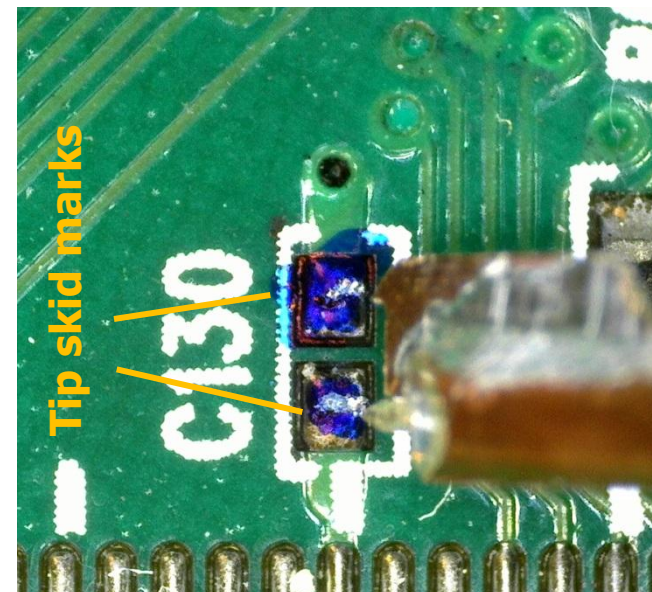
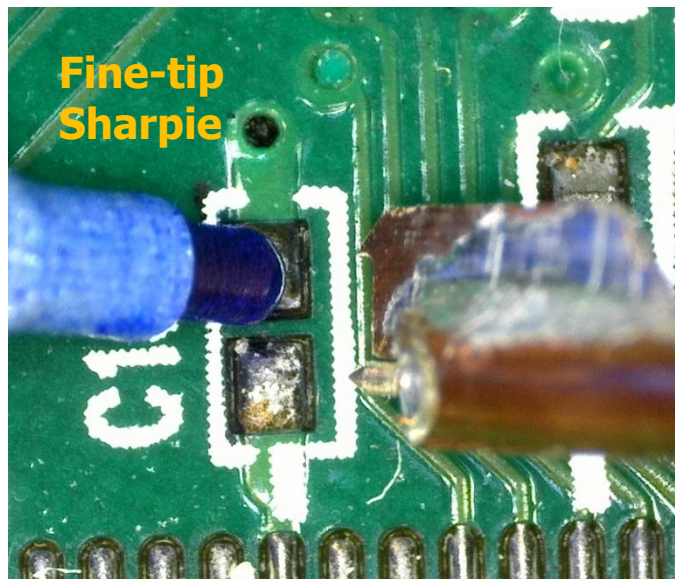
Use VNA to Verify Probe Contacts



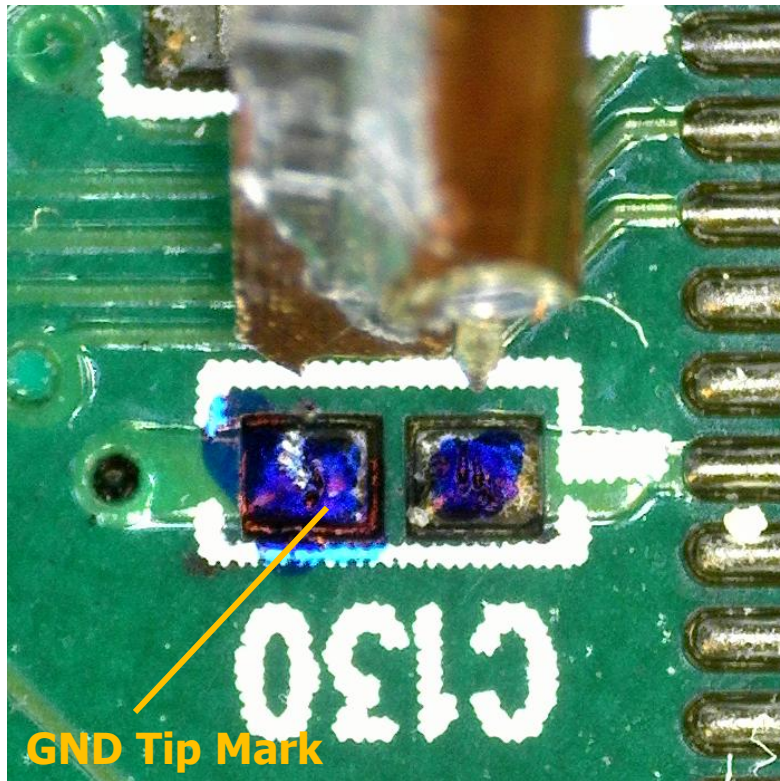
- Both tips leave light probe marks
- VNA Smith Chart shows “Short”

Probing Test Pads on Uneven Surfaces

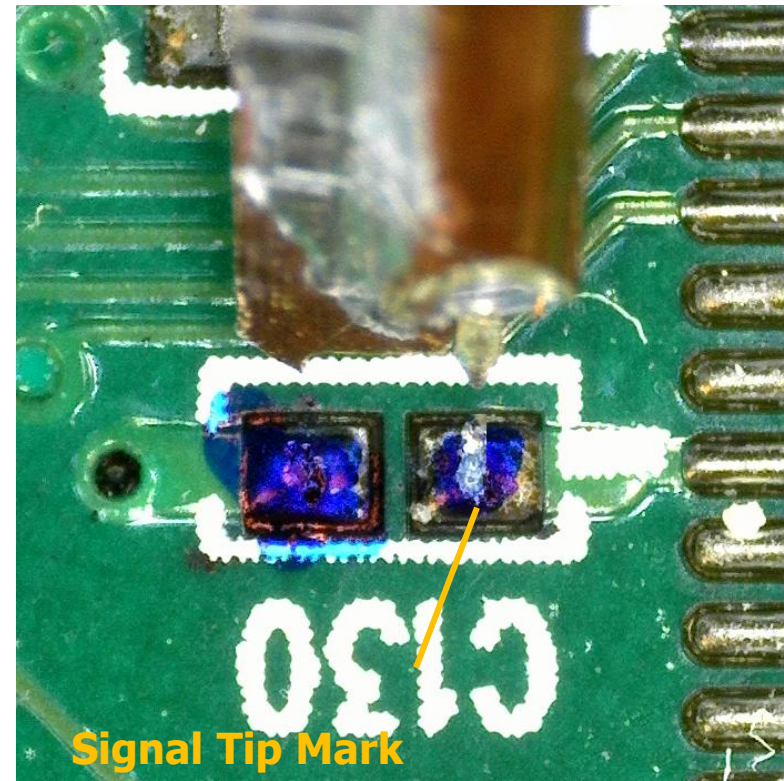
- Color solder bumps with a Sharpie
- Use the probe skid marks to confirm good tip contact
- Clean up the solder bumps with industrial alcohol after probing



Use Probe Skid Marks on Solder Bumps

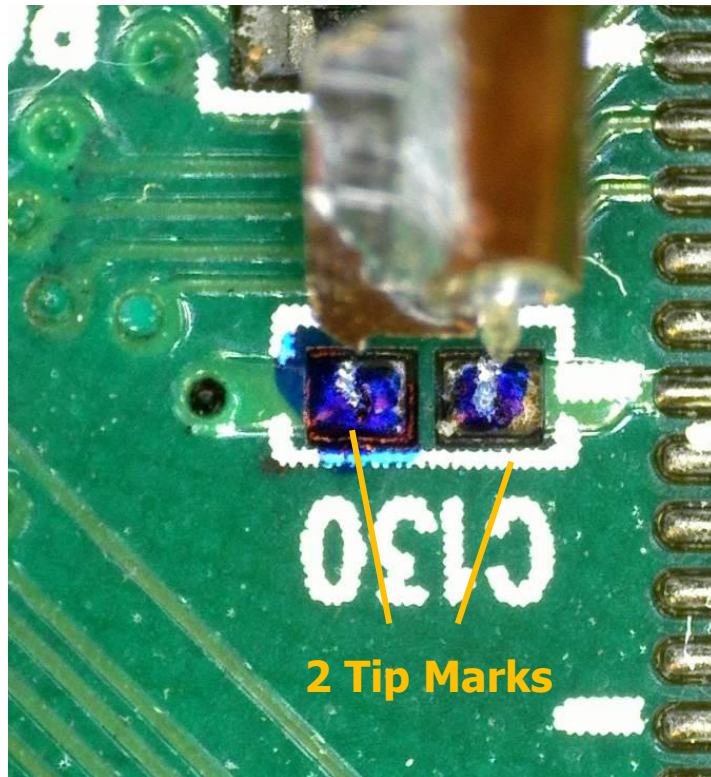


Left GND tip touches down first

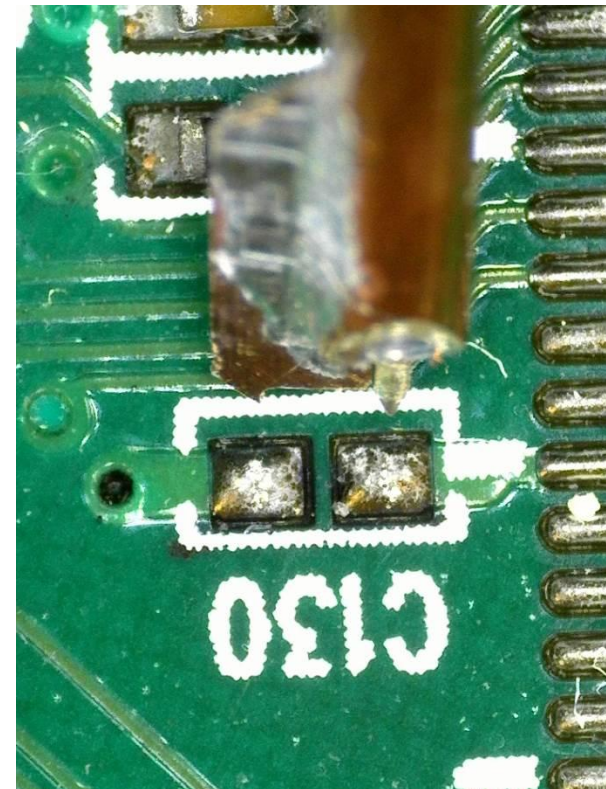


Right signal tip touches down first

Both Tips Touch Down Simultaneously



Both tips touch down simultaneously



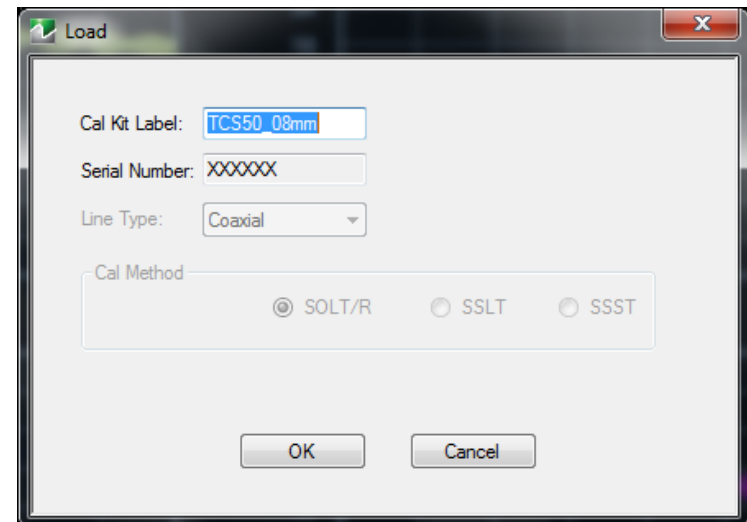
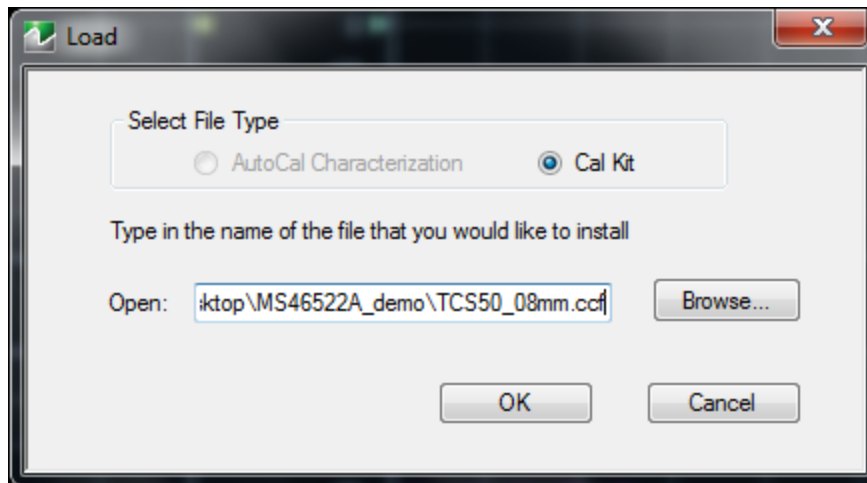
Clean up solder bumps with industrial alcohol after probing

2-Port Probe-tip Calibration Steps

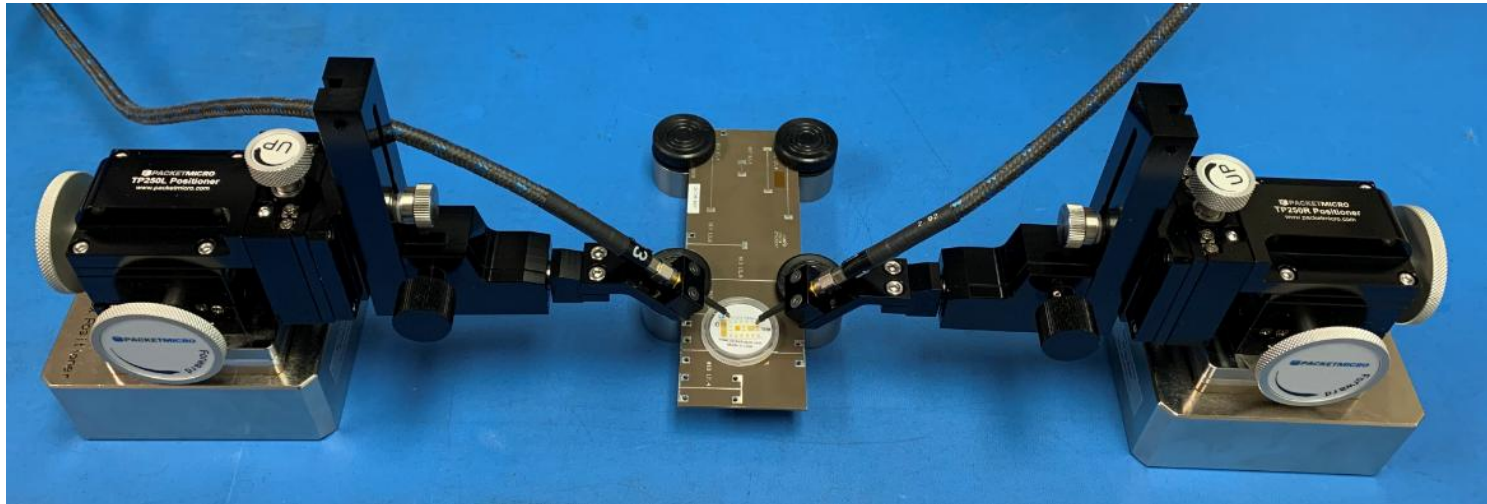
1. Load probe-dependent TCS70 cal kit file (e.g. TCS70_08mm.ccf) into VNA
2. Go to "Edit Cal Params" page
3. Select TCS70 cal kit for Test Port 1 and Test Port 2
4. Enter Thru Coefficient
5. Perform SOLT calibration

Load Calkit File

- 1) Calibration -> Calkit Options -> Load Kit/Charac
- 2) Browse -> Load TCS70_XXmm.ccf

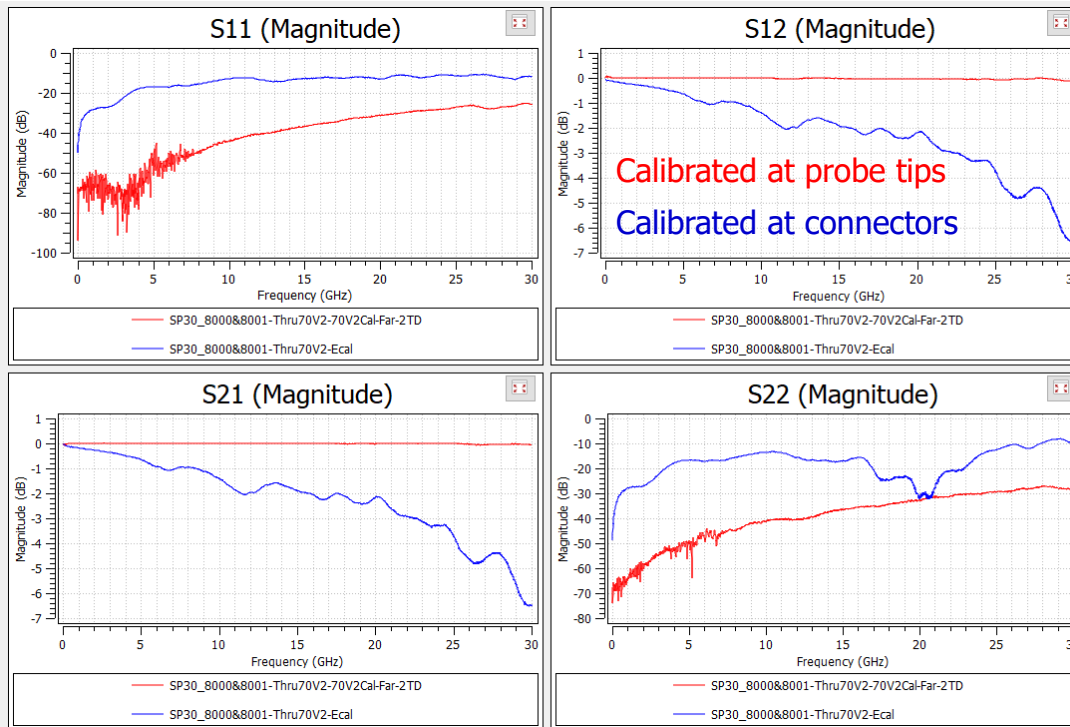


2-Port Probe-Tip Calibration Setup



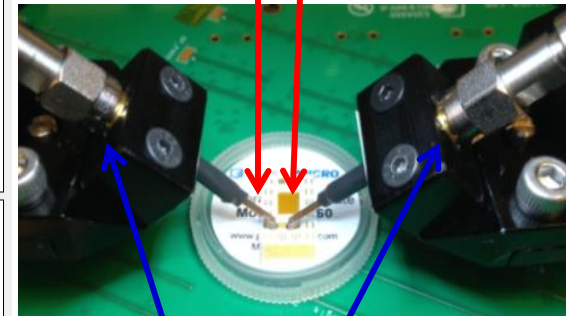
Precision TP250 Positioners with S-Probes

Thru Measurement with Probe-Tip Calibration



Thru Measurement

Calibrated at
probe tips

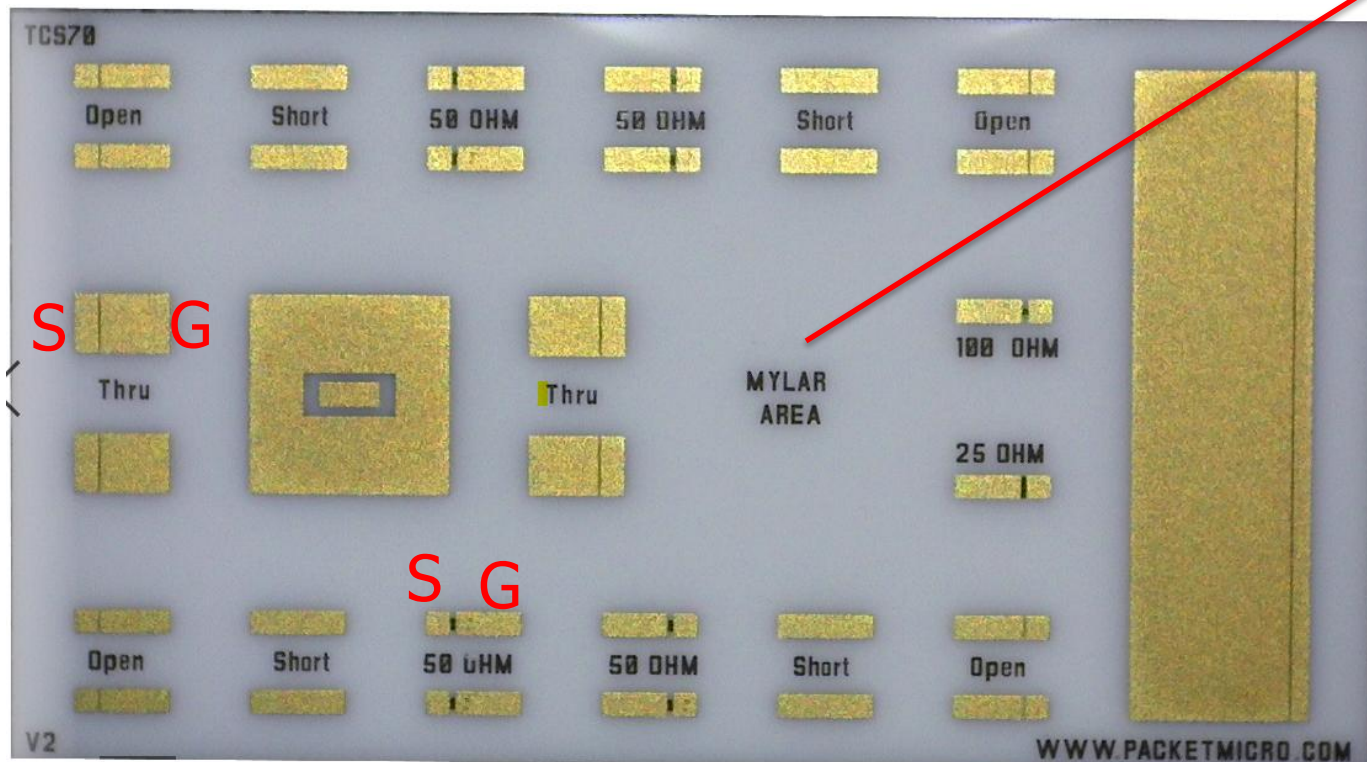


Calibrated at
connectors

Probe-tip calibration (30 GHz 0.5 mm S-Probe)

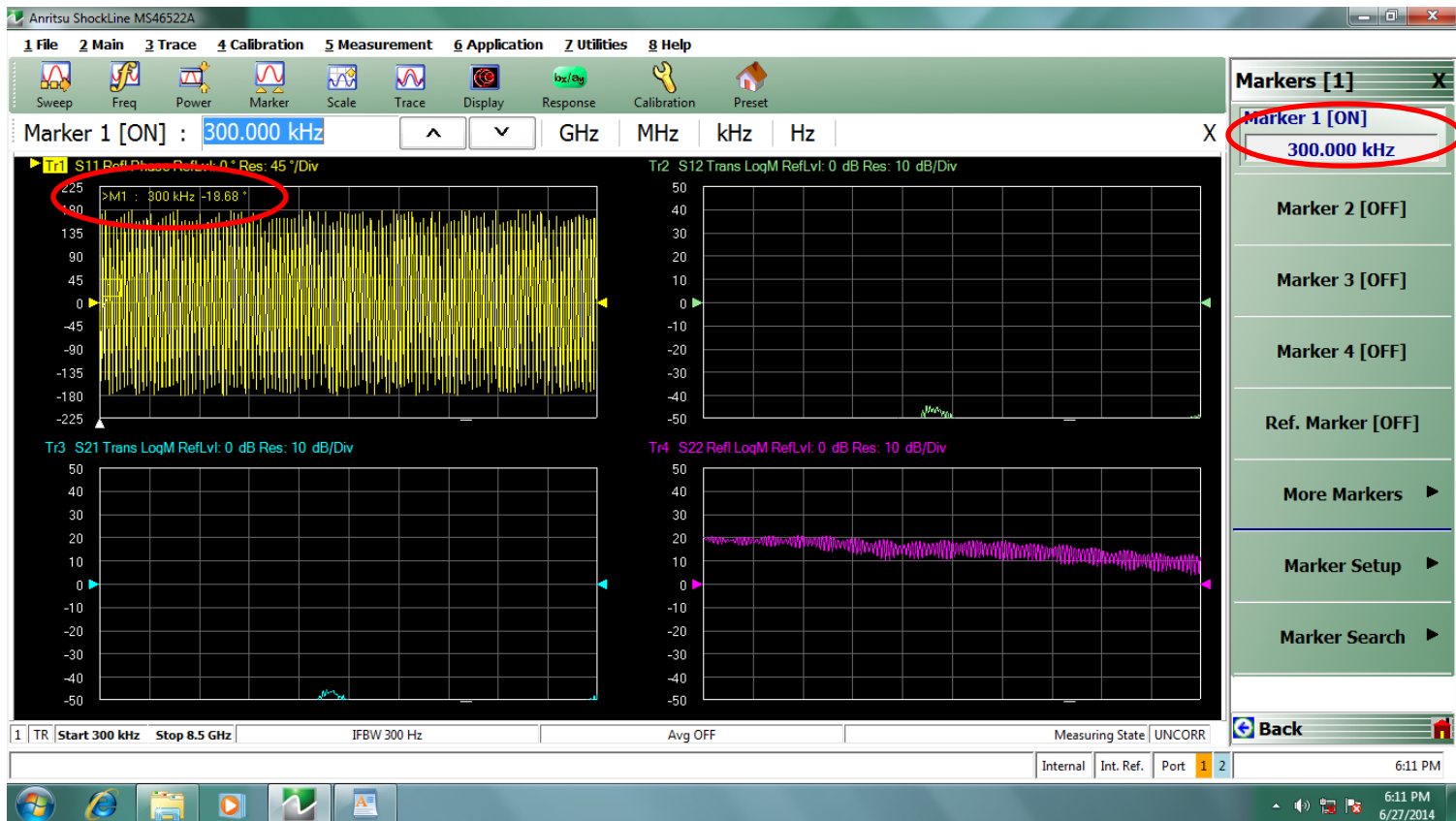
2-Port Calibration with TCS70

- Reflection calibration (Short, Open, Load calibration for two ports)
- Transmission calibration (Thru calibration)



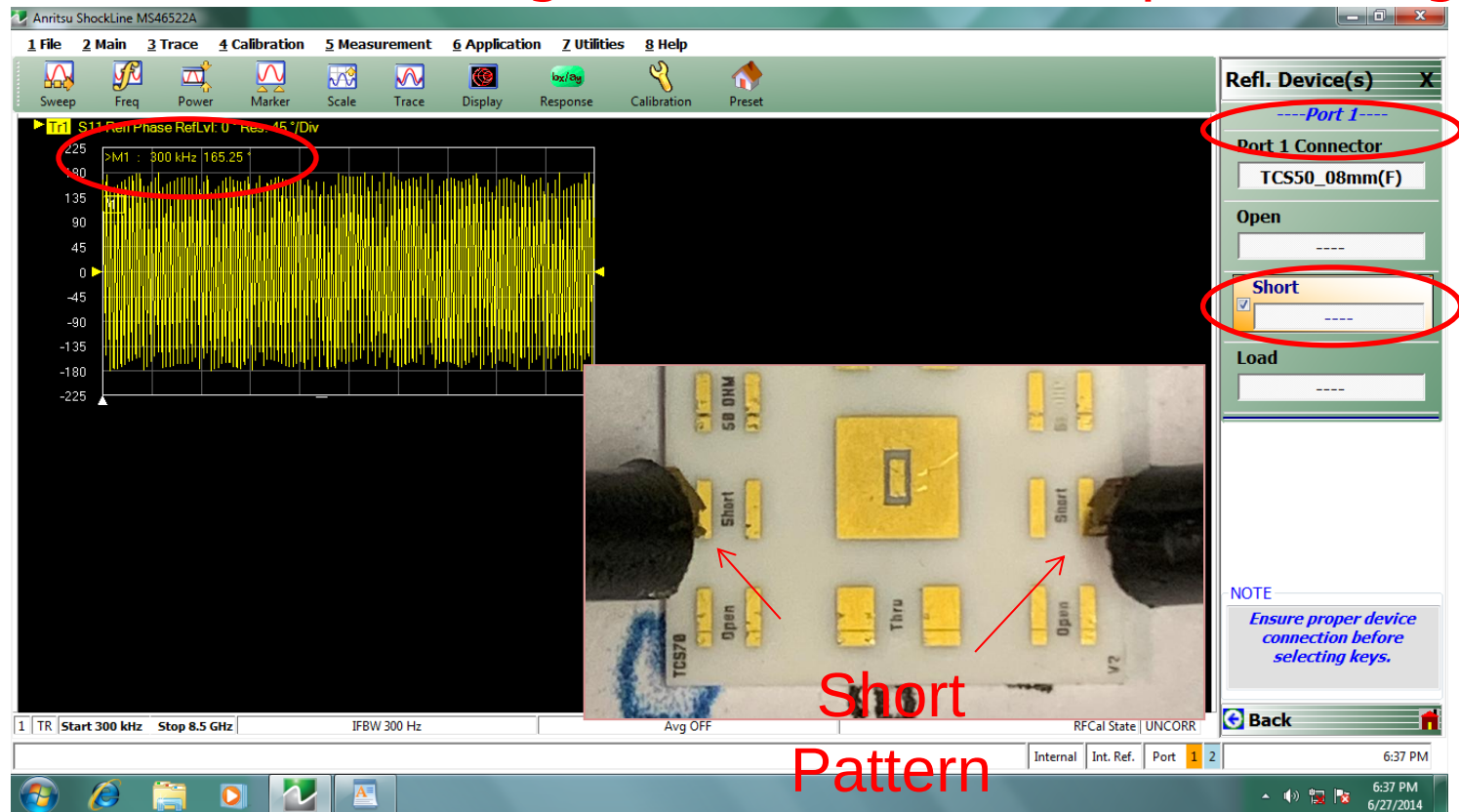
Set S11 to Display Phase Before Cal

- 1) Response -> S11
- 2) Display -> Trace Format -> Phase
- 3) Marker -> Marker 1 (ON)



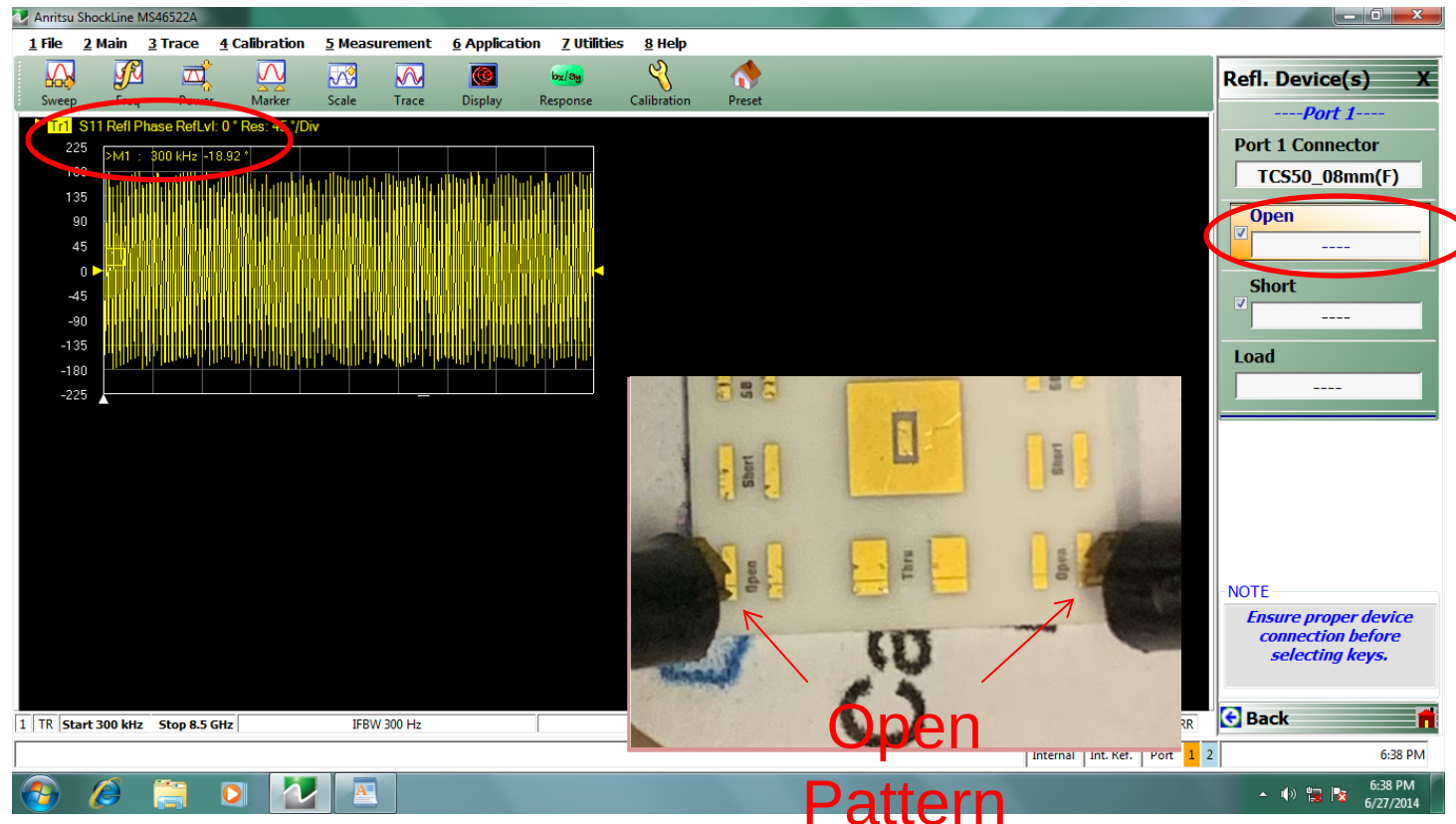
Probe-tip Calibration - Short

- Calibration -> Manual Cal -> 2-Port Cal -> Port 1 Reflective Devices
- **S11 Phase Changes 180° when both tips touching**



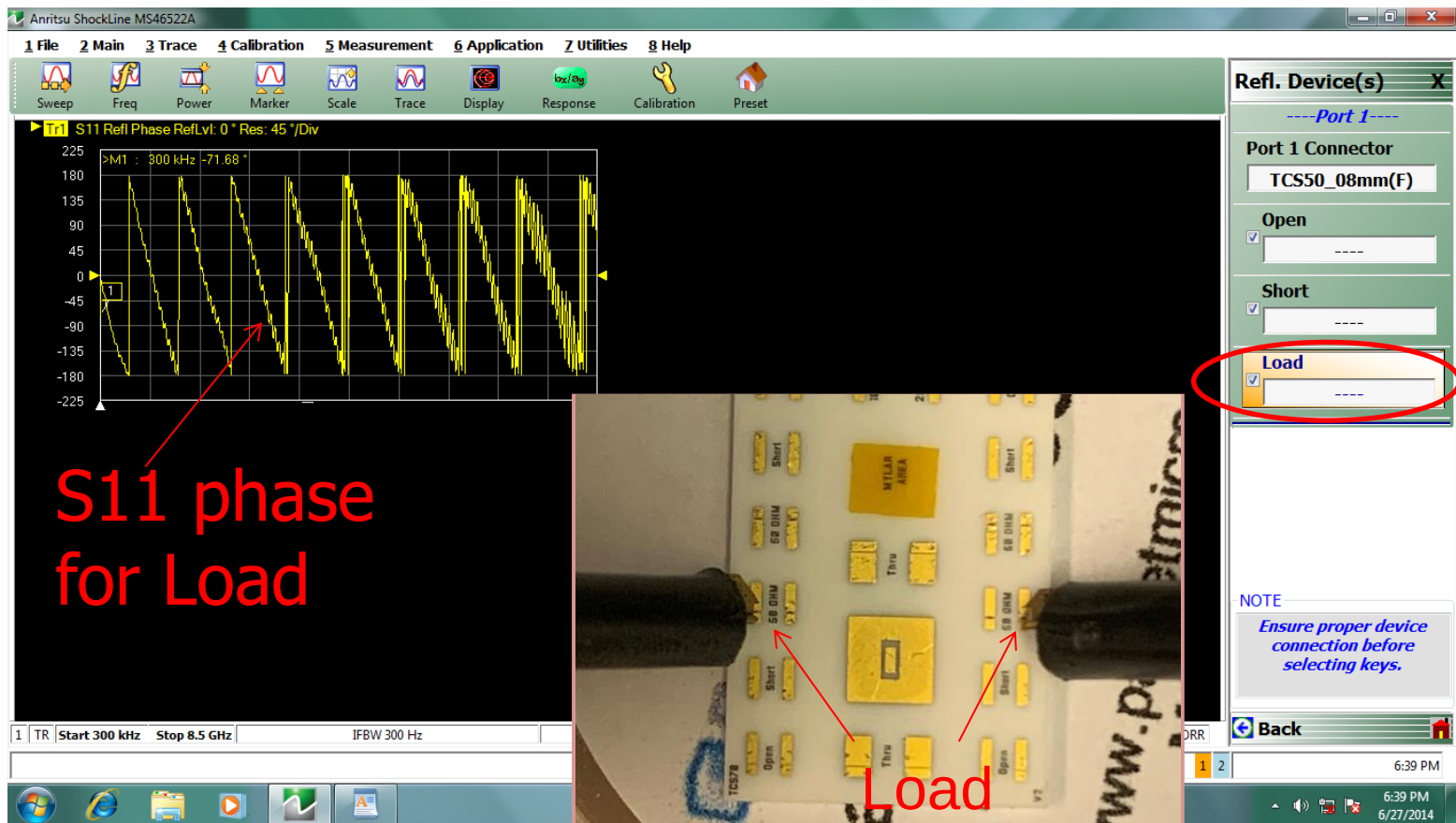
Probe-tip Calibration - Open

- Land the probe tips on “Open” pattern
- **S11 Phase should not change**
- Click Open



Probe-tip Calibration - Load

- Land the probe tips on “Load” pattern
- Click Load



The screenshot displays the Anritsu ShockLine MS46522A software interface. The main window shows a plot of S11 phase (in degrees) versus frequency (in kHz). The plot is titled "S11 Refl Phase RefLvl: 0° Res: 45°/Div". The y-axis ranges from -225 to 225, and the x-axis ranges from 0 to 8.5 GHz. A red arrow points to the plot with the text "S11 phase for Load".

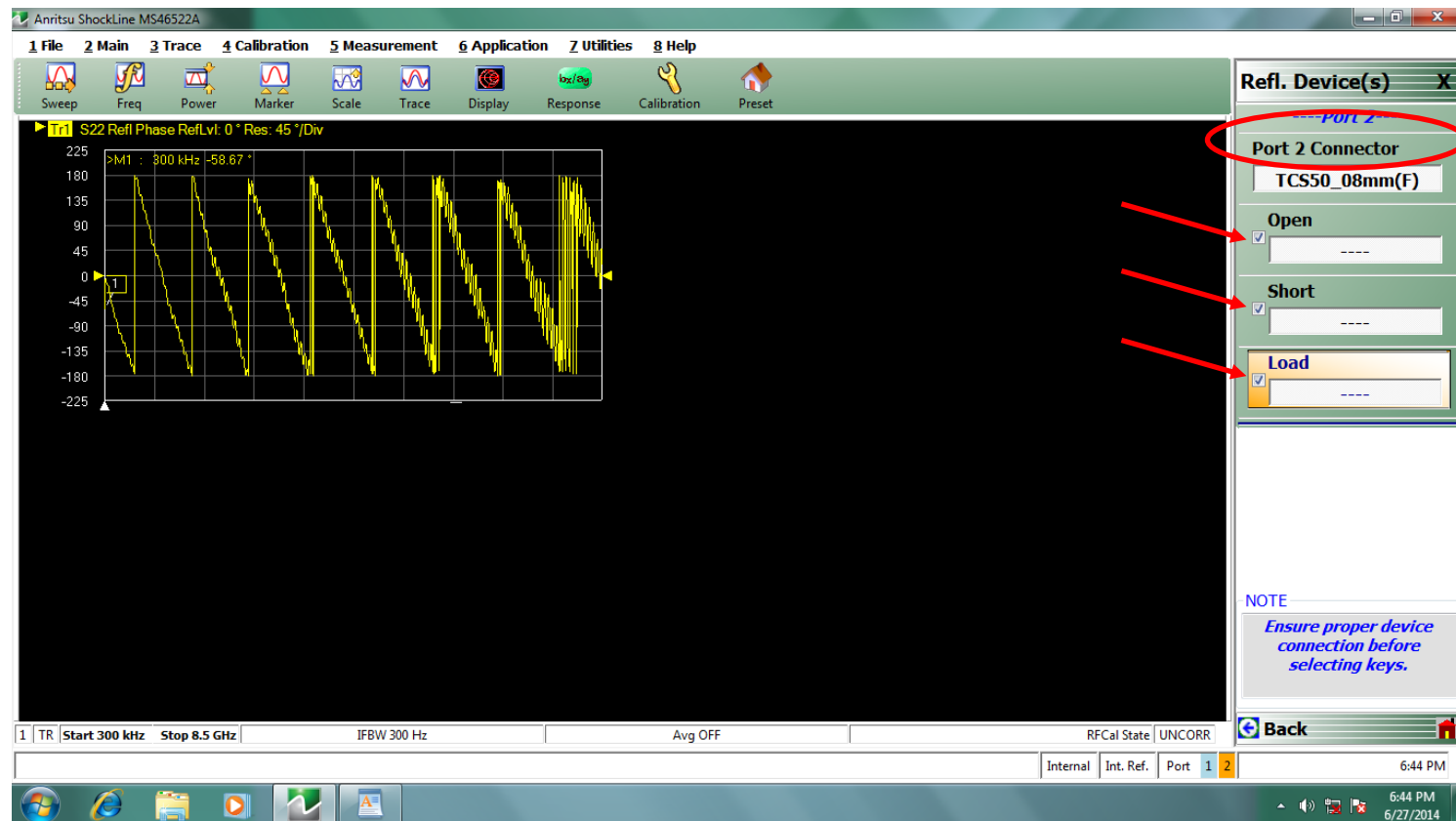
On the right side of the interface, the "Refl. Device(s)" panel is visible. It shows the "Port 1 Connector" set to "TCS50_08mm(F)". Under the "Open" and "Short" sections, there are checkboxes and input fields. The "Load" section is highlighted with a red circle, and the "Load" button is also highlighted with a red circle.

Below the plot, there is a photograph of a probe tip on a calibration pattern. The pattern includes labels for "Short", "Open", "Thru", and "Load". A red arrow points to the "Load" pattern with the text "Load Pattern".

The bottom status bar shows the frequency range "Start 300 kHz Stop 8.5 GHz" and "IFBW 300 Hz". The bottom right corner shows the time "6:39 PM" and the date "6/27/2014".

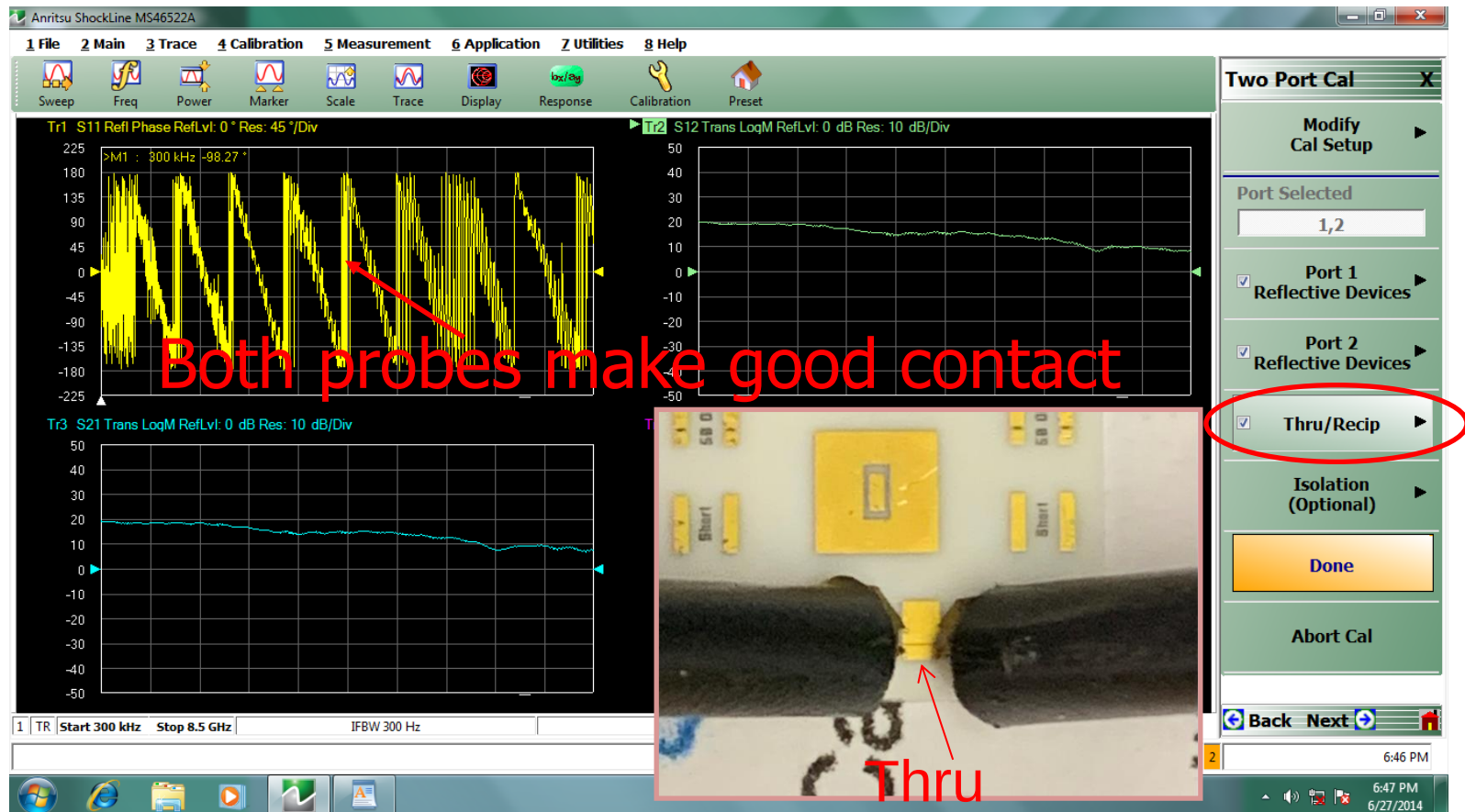
Probe-tip Calibration – Port 2

- Back-> Port 2 Reflective Devices
- Click "Open" and VNA automatically displays S22
- Perform SOL for Port 2



Probe-tip Calibration – Thru

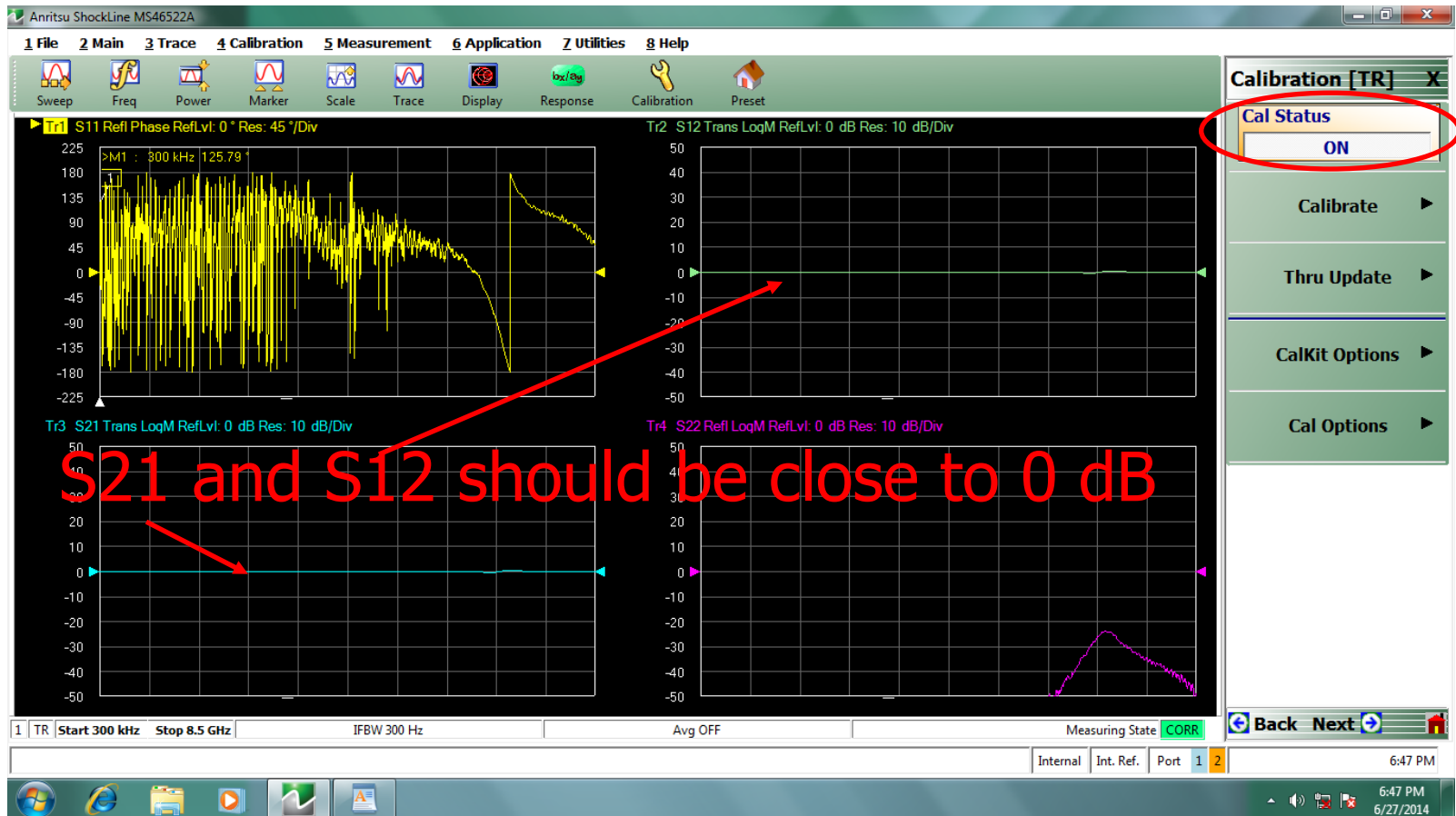
- Back-> Thru/Recip.
- Make sure both probes make good contact



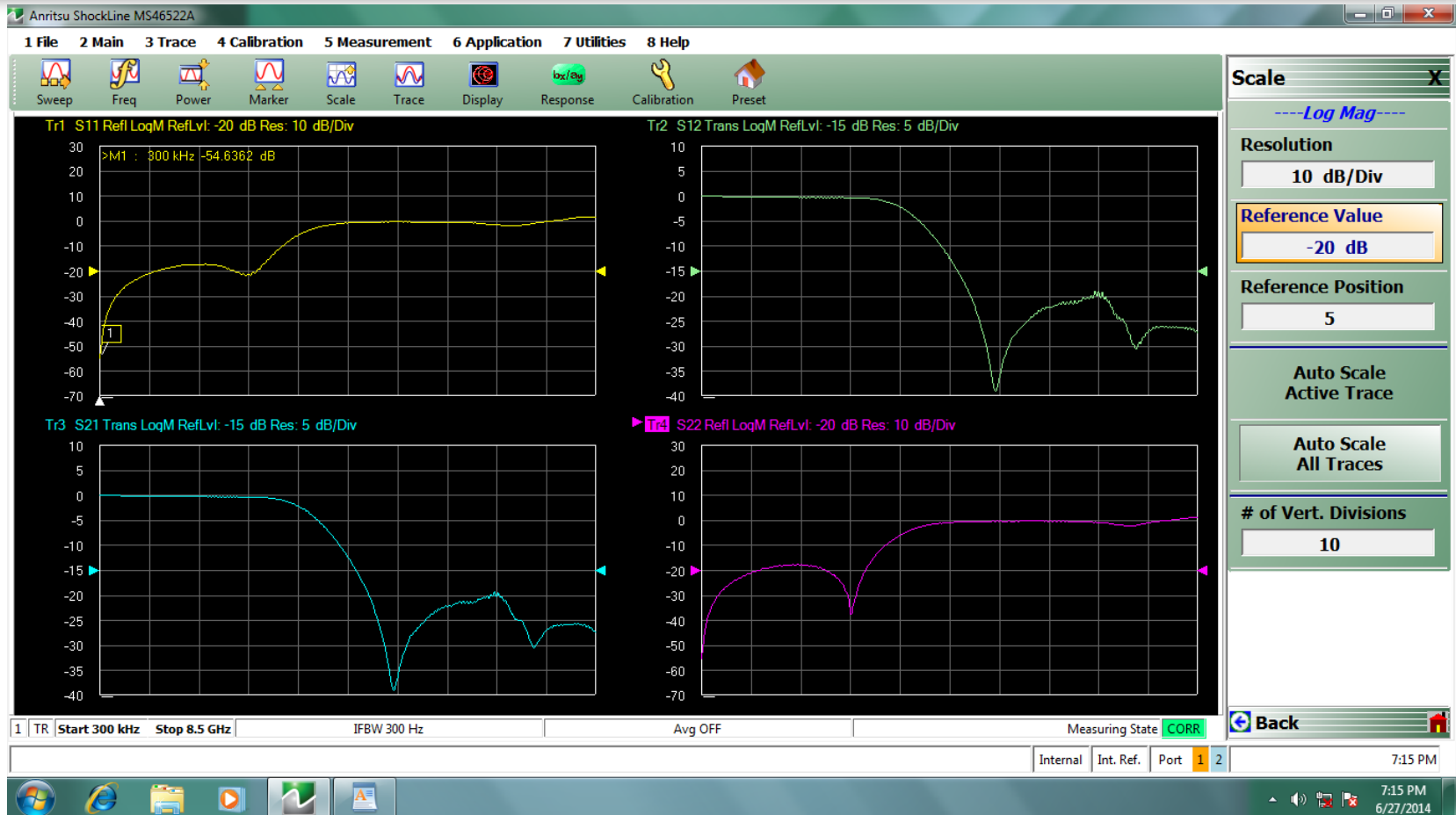
Thru
Pattern

2-Port Calibration Completed

- Back-> Done
- Cal Status becomes "ON"



2-Port Measurement of a RF Filter



TDK 2.45 GHz Low Pass Filter (P/N: DEA102500LT-6307A1, Size 0402)

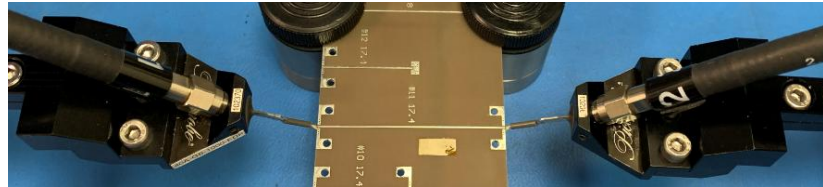
Test Trace: 2" (5.08 mm) Microstrip

- Compare measurements between 2.92 mm connectors and probes with probe-tip SOLT calibration

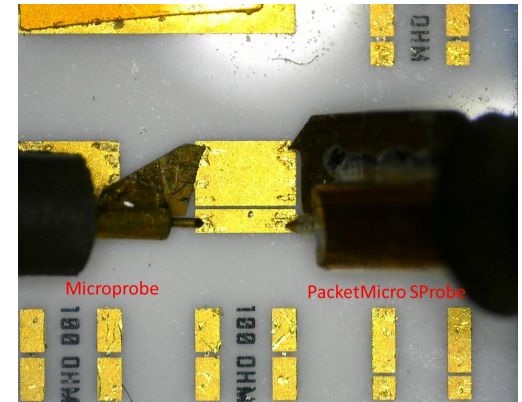
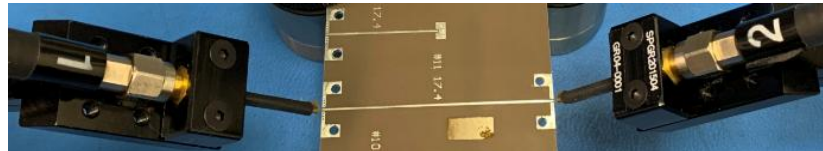
40 GHz
2.92 mm
connector



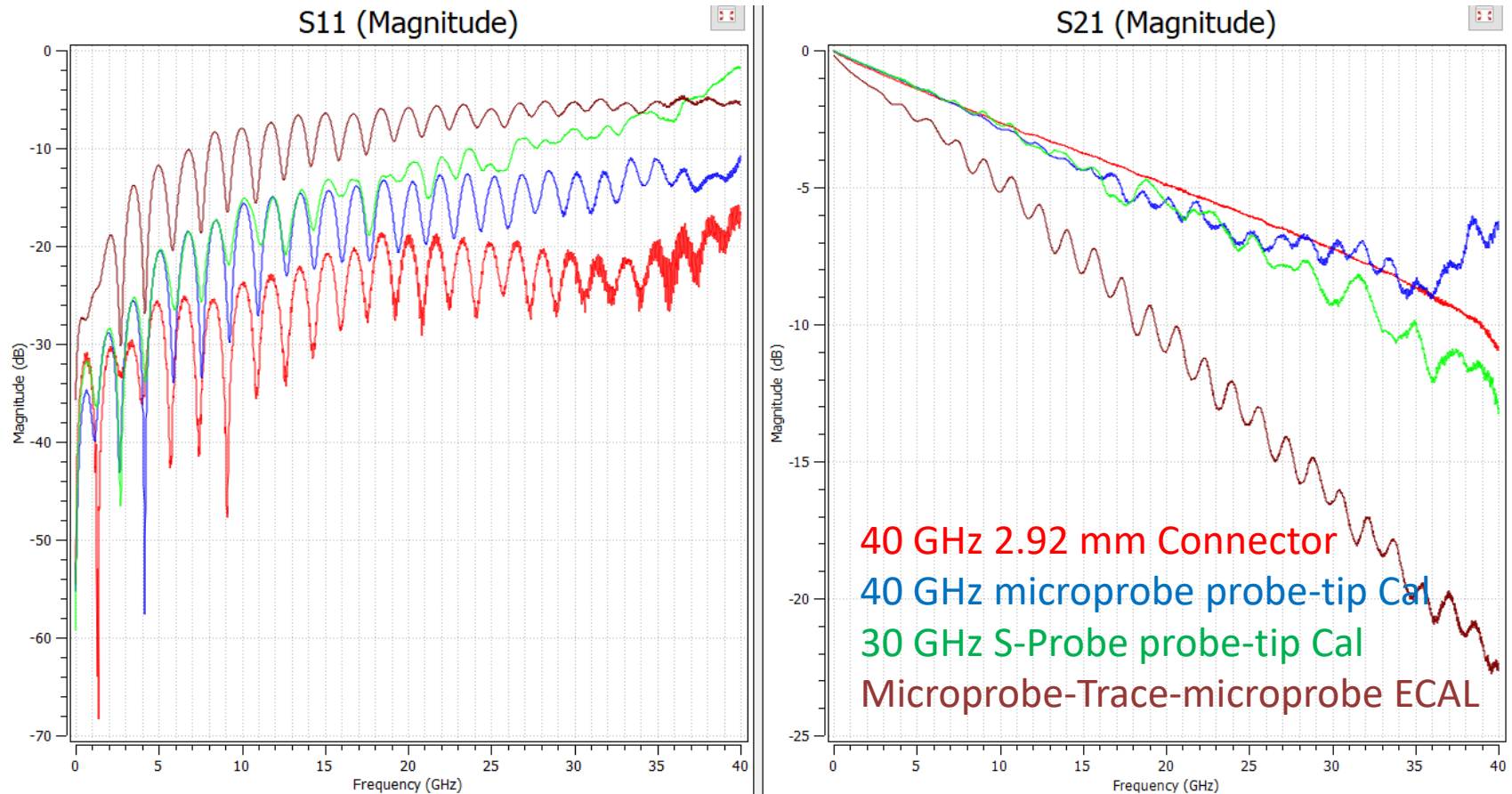
40 GHz
Microprobe



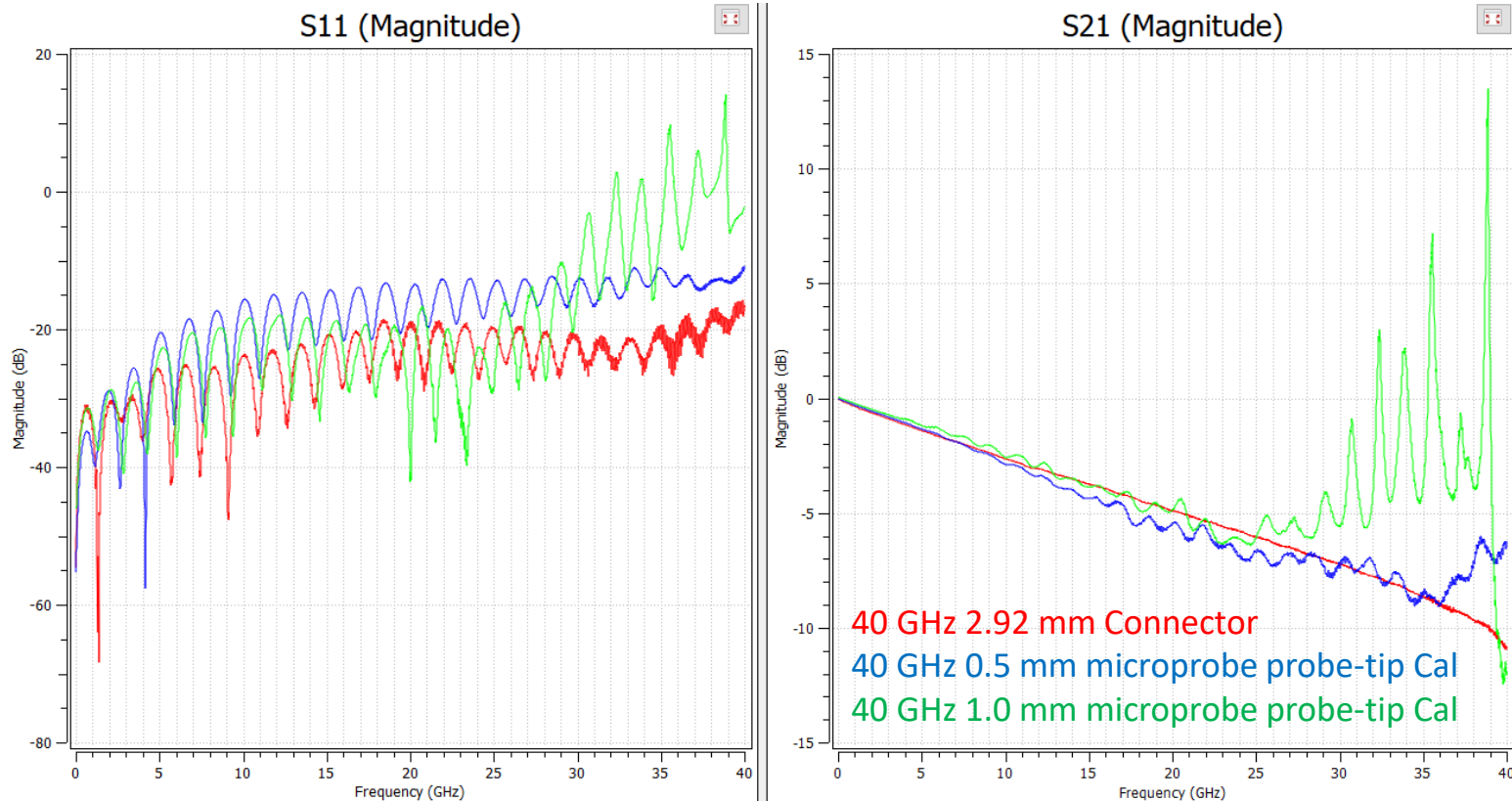
30 GHz
S-Probe



Connector vs. Probes



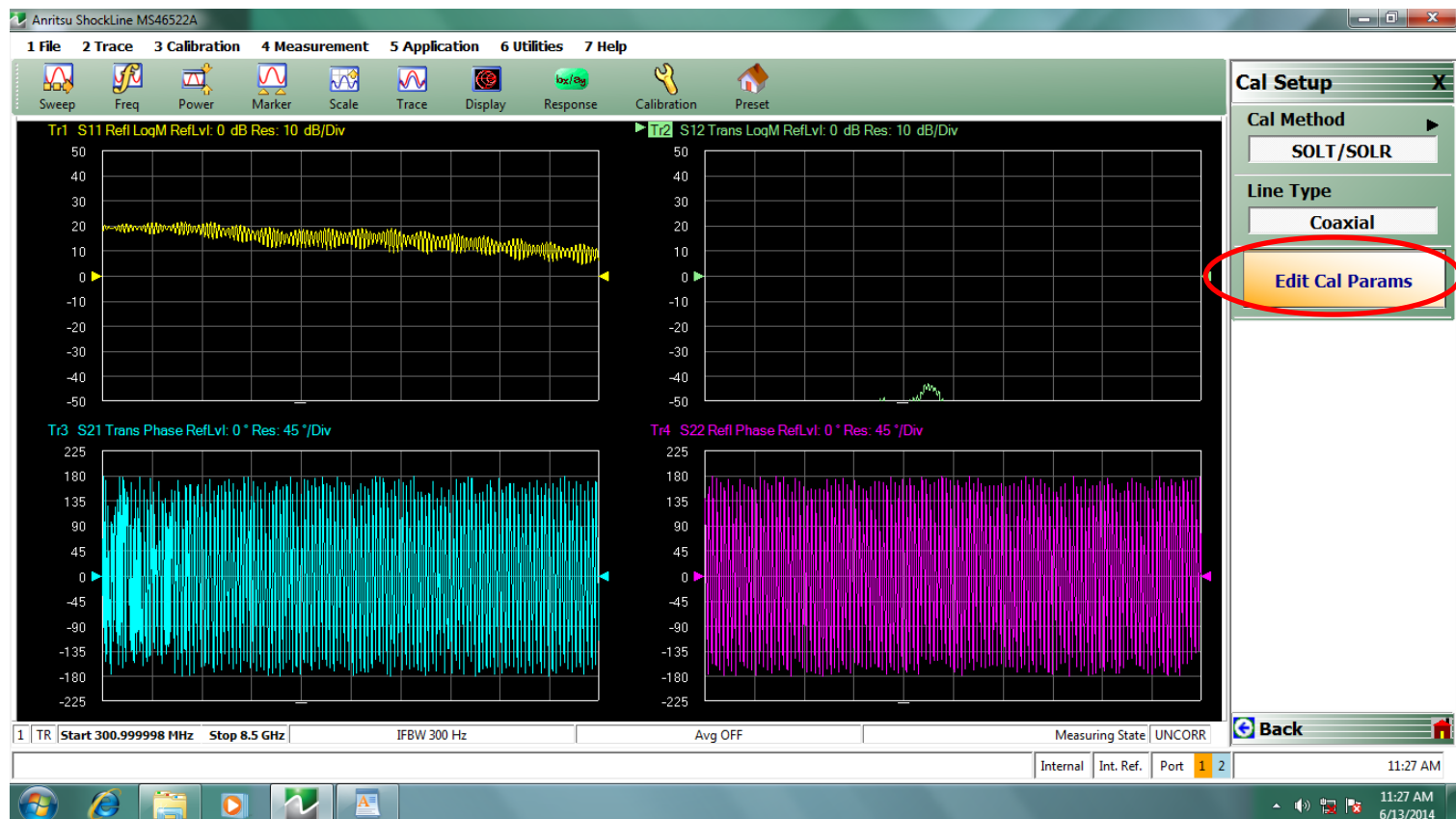
Limitation of Probe-Tip SOLT CAL



- Typical probe-tip SOLT calibration for GS probes is accurate up to ~60% of probe bandwidth because higher order coefficients are not used due to probe contact

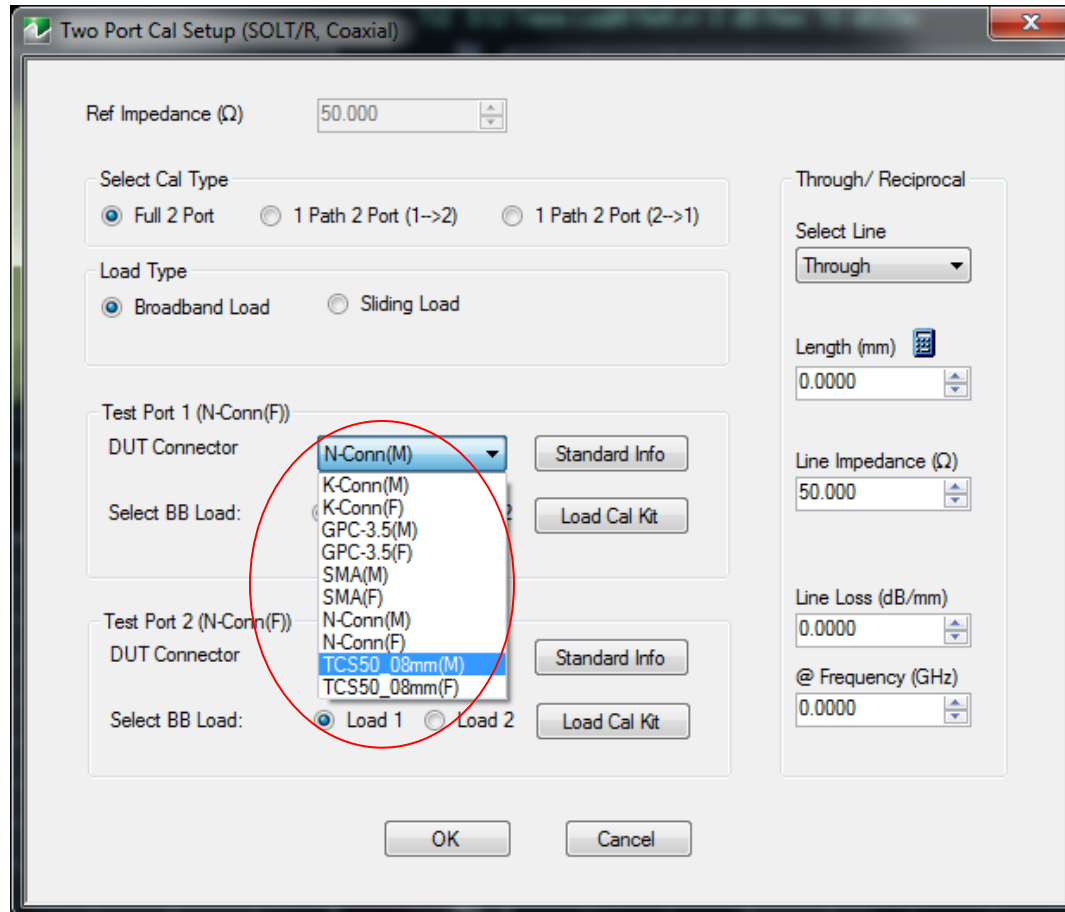
Manual Entry of TCS70 Coefficients

1) Calibration -> Manual Cal -> 2-Port Cal -> Modify Cal Setup -> Edit Cal Params.



Select Cal Kit for Test Ports

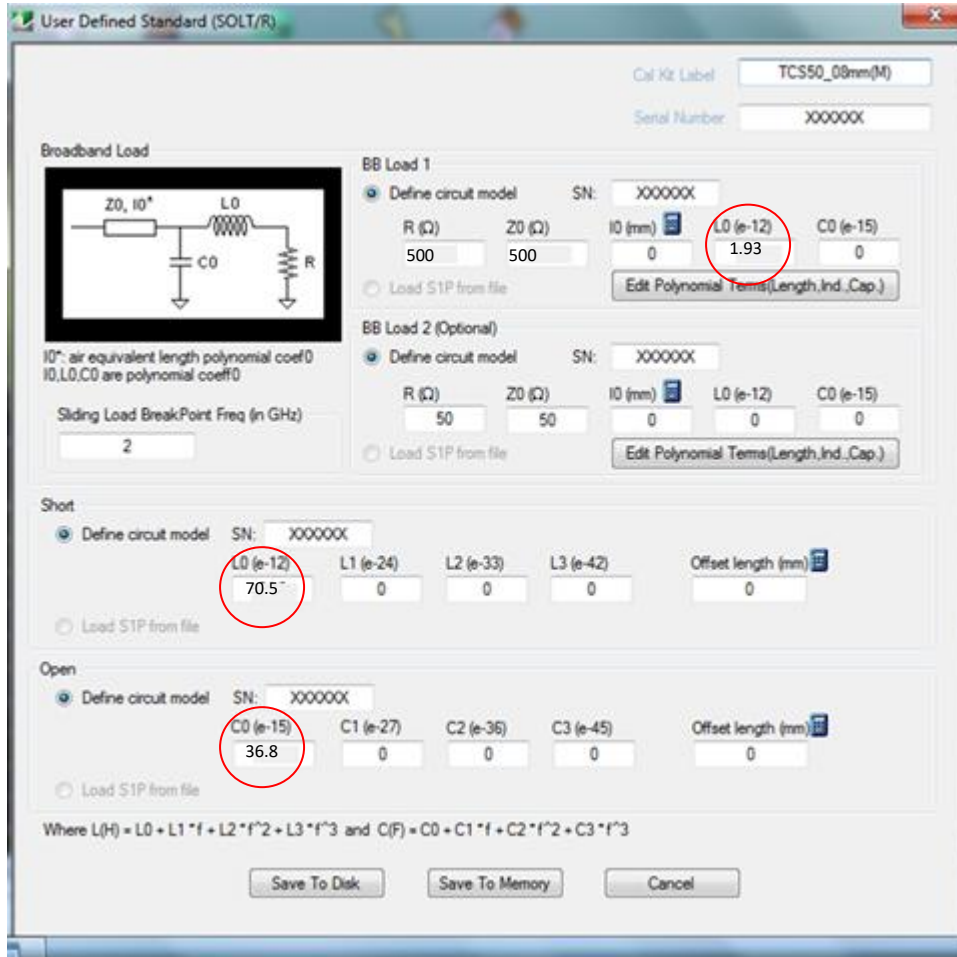
1) Edit Cal Params -> Select TCS70_XXmm (M)



The image shows a software dialog box titled "Two Port Cal Setup (SOLT/R, Coaxial)". It contains various configuration options for a two-port calibration setup. A red circle highlights the "DUT Connector" dropdown menu for "Test Port 1 (N-Conn(F))", which is currently open and showing a list of options. The options in the list are: N-Conn(M), K-Conn(M), K-Conn(F), GPC-3.5(M), GPC-3.5(F), SMA(M), SMA(F), N-Conn(M), N-Conn(F), TCS50_08mm(M), and TCS50_08mm(F). The "TCS50_08mm(M)" option is currently selected. Other settings in the dialog include "Ref Impedance (Ω)" set to 50.000, "Select Cal Type" set to "Full 2 Port", "Load Type" set to "Broadband Load", "Through/ Reciprocal" set to "Through", "Length (mm)" set to 0.0000, "Line Impedance (Ω)" set to 50.000, "Line Loss (dB/mm)" set to 0.0000, and "@ Frequency (GHz)" set to 0.0000. There are also buttons for "Standard Info", "Load Cal Kit", "OK", and "Cancel".

Verify CalKit

1) Verify the TCS50_SPx.xMM coefficients, if necessary



User Defined Standard (SOLT/R)

Cal Kit Label: TCS50_08mm(M)

Serial Number: XXXXXX

Broadband Load

☒ Define circuit model SN: XXXXXX

$R (\Omega)$ 500 $Z_0 (\Omega)$ 500 L_0 (mm) 0 **L_0 (e-12)** 1.93 C_0 (e-15) 0

☐ Load S1P from file

BB Load 1

☒ Define circuit model SN: XXXXXX

$R (\Omega)$ 50 $Z_0 (\Omega)$ 50 L_0 (mm) 0 **L_0 (e-12)** 1.93 C_0 (e-15) 0

☐ Load S1P from file

BB Load 2 (Optional)

☒ Define circuit model SN: XXXXXX

$R (\Omega)$ 50 $Z_0 (\Omega)$ 50 L_0 (mm) 0 L_0 (e-12) 0 C_0 (e-15) 0

☐ Load S1P from file

Short

☒ Define circuit model SN: XXXXXX

L_0 (e-12) 70.5 L_1 (e-24) 0 L_2 (e-33) 0 L_3 (e-42) 0 Offset length (mm) 0

☐ Load S1P from file

Open

☒ Define circuit model SN: XXXXXX

C_0 (e-15) 36.8 C_1 (e-27) 0 C_2 (e-36) 0 C_3 (e-45) 0 Offset length (mm) 0

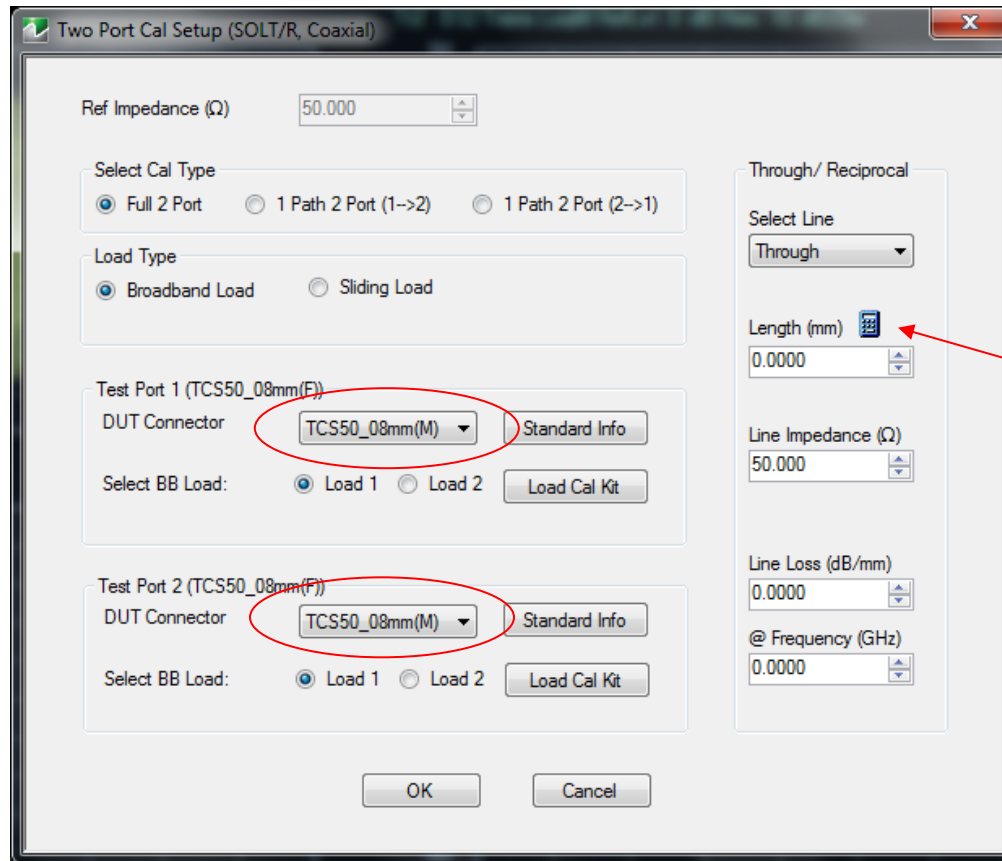
☐ Load S1P from file

Where $L(f) = L_0 + L_1 \cdot f + L_2 \cdot f^2 + L_3 \cdot f^3$ and $C(f) = C_0 + C_1 \cdot f + C_2 \cdot f^2 + C_3 \cdot f^3$

Save To Disk Save To Memory Cancel

Enter Thru Coefficient

- 1) Check the TCS70_XXmm (M) is selected on Test Port 1 and Test Port 2
- 2) Use Thru calculator to enter length

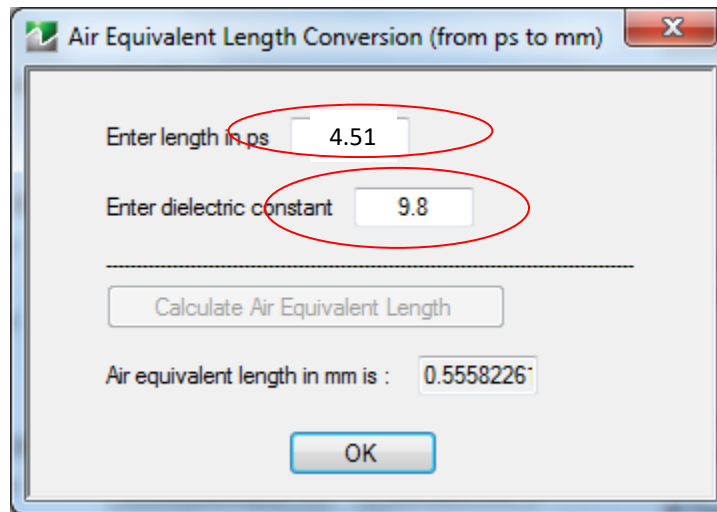


The image shows a software dialog box titled "Two Port Cal Setup (SOLT/R, Coaxial)". It contains several configuration options for a two-port calibration setup. The "Ref Impedance (Ω)" is set to 50.000. Under "Select Cal Type", "Full 2 Port" is selected. Under "Load Type", "Broadband Load" is selected. For both "Test Port 1 (TCS50_08mm(F))" and "Test Port 2 (TCS50_08mm(F))", the "DUT Connector" is set to "TCS50_08mm(M)", which is circled in red. The "Select BB Load" for both ports is set to "Load 1". On the right side, under "Through/ Reciprocal", "Select Line" is set to "Through". The "Length (mm)" is set to 0.0000, with a red arrow pointing to it from the text "Thru calculator". The "Line Impedance (Ω)" is set to 50.000, "Line Loss (dB/mm)" is 0.0000, and "@ Frequency (GHz)" is 0.0000. At the bottom are "OK" and "Cancel" buttons.

Thru
calculator

Enter Thru Coefficient – cont.

1) Enter length (4.51 ps) and dielectric constant (9.8)



Air Equivalent Length Conversion (from ps to mm)

Enter length in ps: 4.51

Enter dielectric constant: 9.8

Calculate Air Equivalent Length

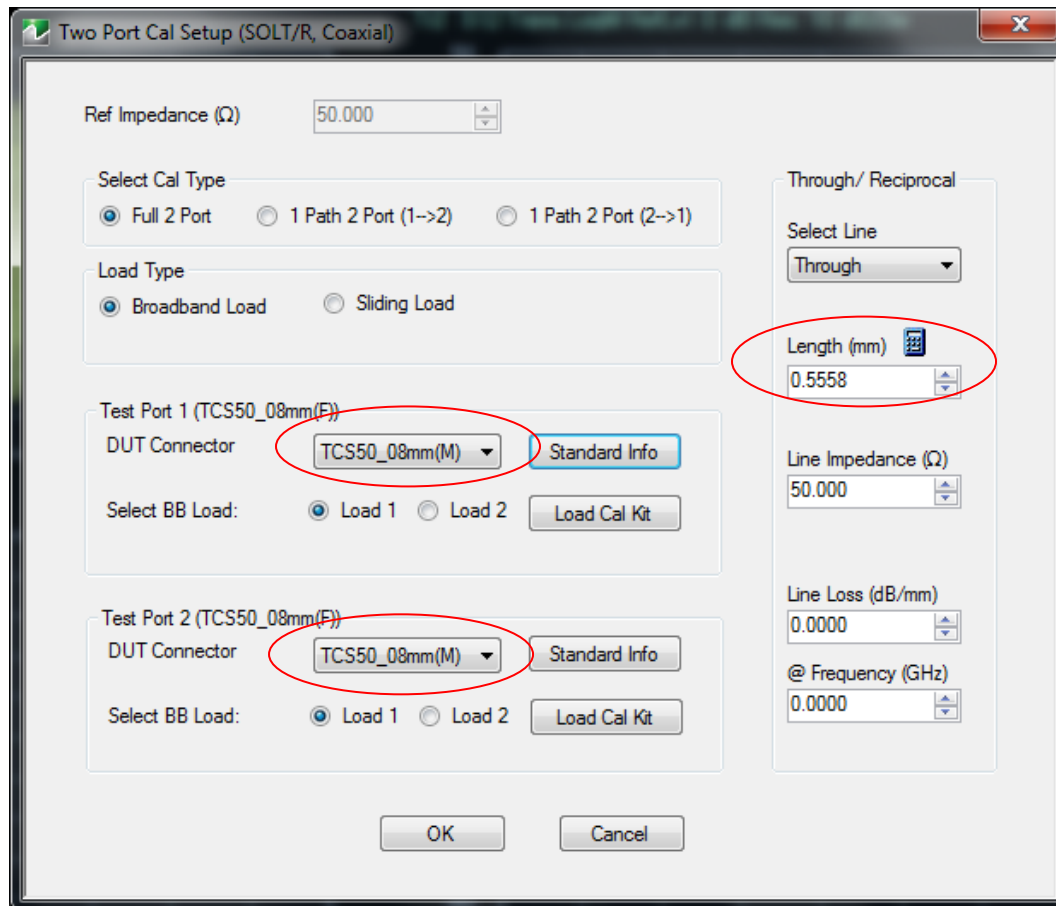
Air equivalent length in mm is : 0.5558226

OK

The dialog box is titled "Air Equivalent Length Conversion (from ps to mm)". It contains two input fields: "Enter length in ps" with the value "4.51" and "Enter dielectric constant" with the value "9.8". Both input fields are circled in red. Below these fields is a button labeled "Calculate Air Equivalent Length". At the bottom, it displays the result "Air equivalent length in mm is : 0.5558226" and an "OK" button.

Verify CalKit Before Performing SOLT

- 1) Check the TCS70_XXmm (M) is selected on Test Port 1 and Test Port 2
- 2) Check Thru is entered



The image shows a software dialog box titled "Two Port Cal Setup (SOLT/R, Coaxial)". The dialog contains several configuration options for a two-port calibration setup. Red circles highlight specific settings: the "DUT Connector" for both Test Port 1 and Test Port 2 is set to "TCS50_08mm(M)", and the "Length (mm)" is set to "0.5558".

Ref Impedance (Ω): 50.000

Select Cal Type: ☒ Full 2 Port ☐ 1 Path 2 Port (1->2) ☐ 1 Path 2 Port (2->1)

Load Type: ☒ Broadband Load ☐ Sliding Load

Test Port 1 (TCS50_08mm(F))

DUT Connector: TCS50_08mm(M)

Select BB Load: ☒ Load 1 ☐ Load 2

Test Port 2 (TCS50_08mm(F))

DUT Connector: TCS50_08mm(M)

Select BB Load: ☒ Load 1 ☐ Load 2

Through/ Reciprocal

Select Line: Through

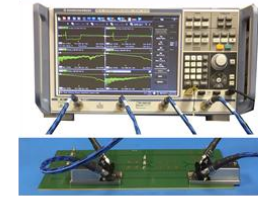
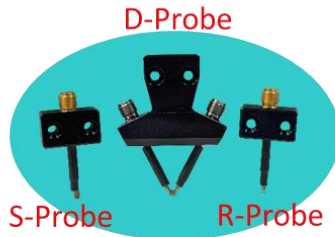
Length (mm): 0.5558

Line Impedance (Ω): 50.000

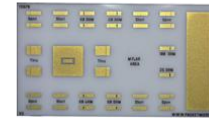
Line Loss (dB/mm): 0.0000

@ Frequency (GHz): 0.0000

PacketMicro Product Offering



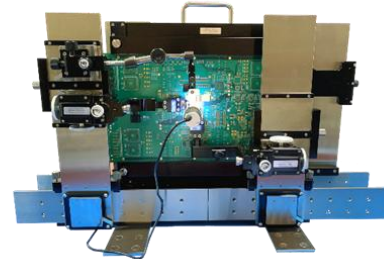
Delta-L 4.0 Solution



TCS70
Cal Substrate



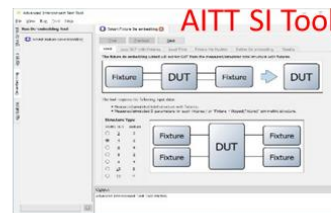
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Flex Positioners



USB Type-C Fixtures HPS24 Probe Station



Slim Phase Stable Cable
Up to 67 GHz Junkosha MWX161



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- CSS AITT Signal-Integrity Tool
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