

# RF Probing With Rohde & Schwarz ZNB VNA



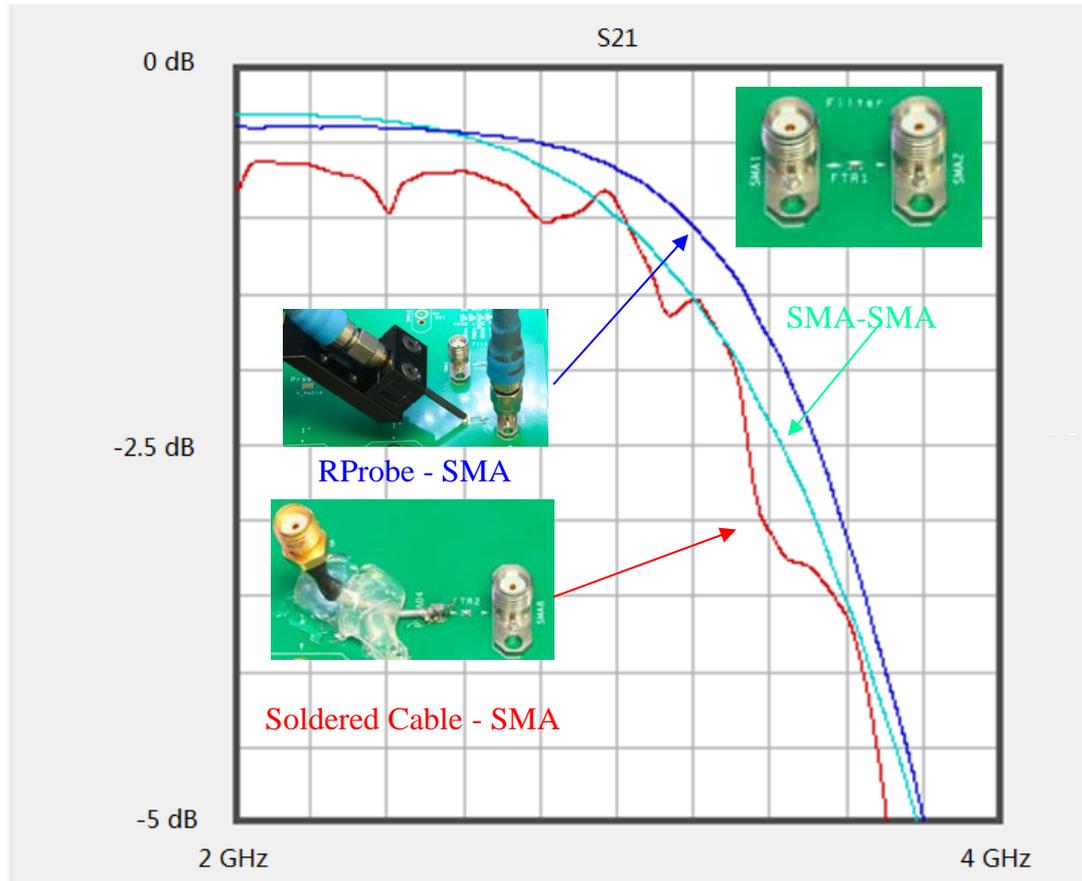
# Outline

- **Why RF Probing** Page 3 – 7
- **S-Probe Overview** Page 8 - 10
- **Tools: Positioners, Microscopes** Page 11 – 13
- **RF Probing Tips** Page 14
- **Probe Planarization with Mylar** Page 15 - 19
- **Probe Planarization with Marker** Page 20 - 22
- **Import TCS70xx.calkit file** Page 23 - 24
- **SOLT Probe-tip Calibration** Page 25 - 38
- **Test Case** Page 39 - 42
- **Manual Entry of TCS70 into VNA** Page 43 - 52

# Why RF Probing?

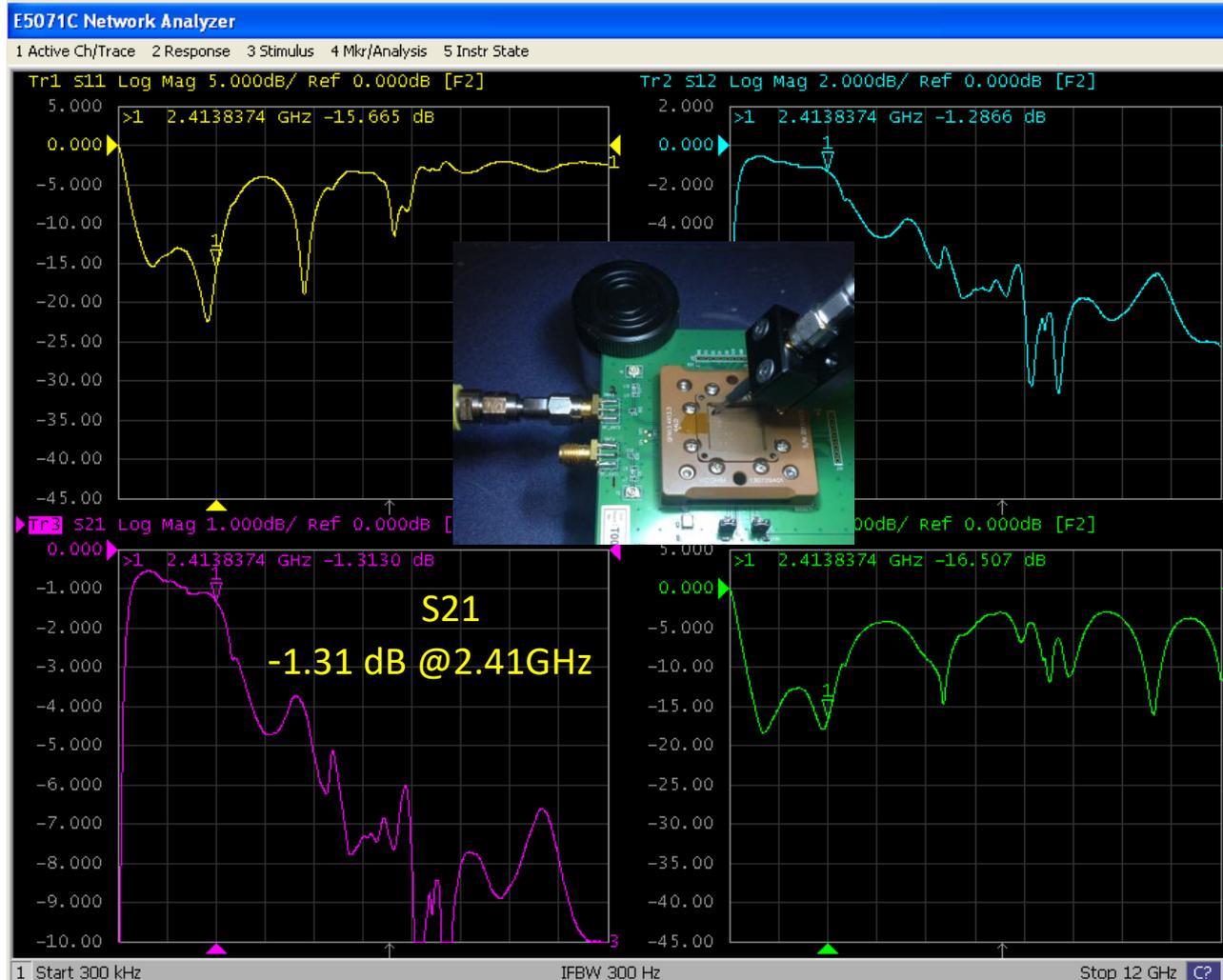
- **Necessity:** Constant shrinking size of circuit components makes soldering semi-rigid RF cables to test gigahertz circuits impractical.
- **Accuracy:** RF probes and calibration substrates allow engineers to perform probe-tip calibration for accurate, repetitive measurements.
- **Productivity:**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

# Measurements of RF Low-Pass Filter

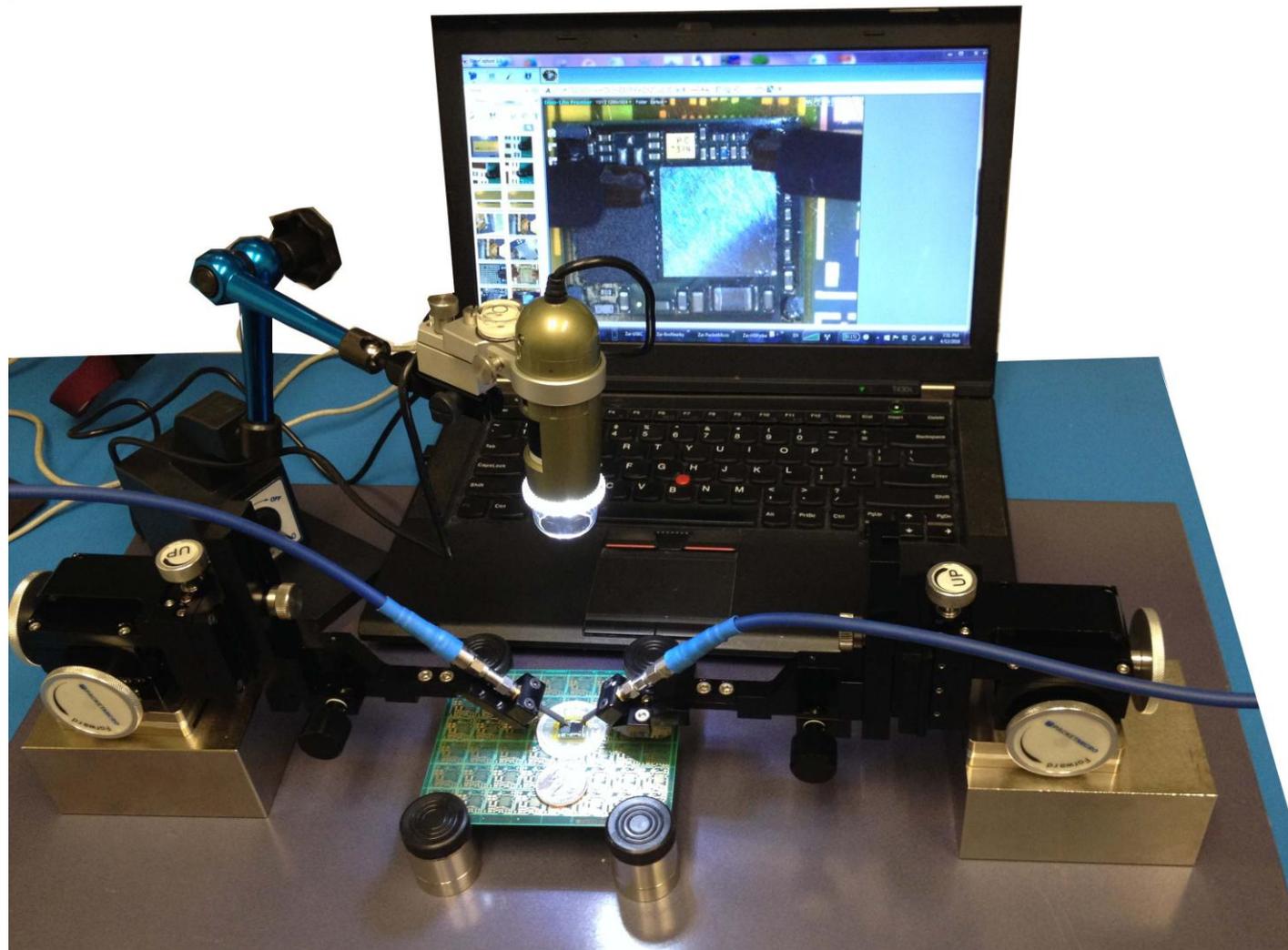


**RF probe is almost as good as SMA connector!**

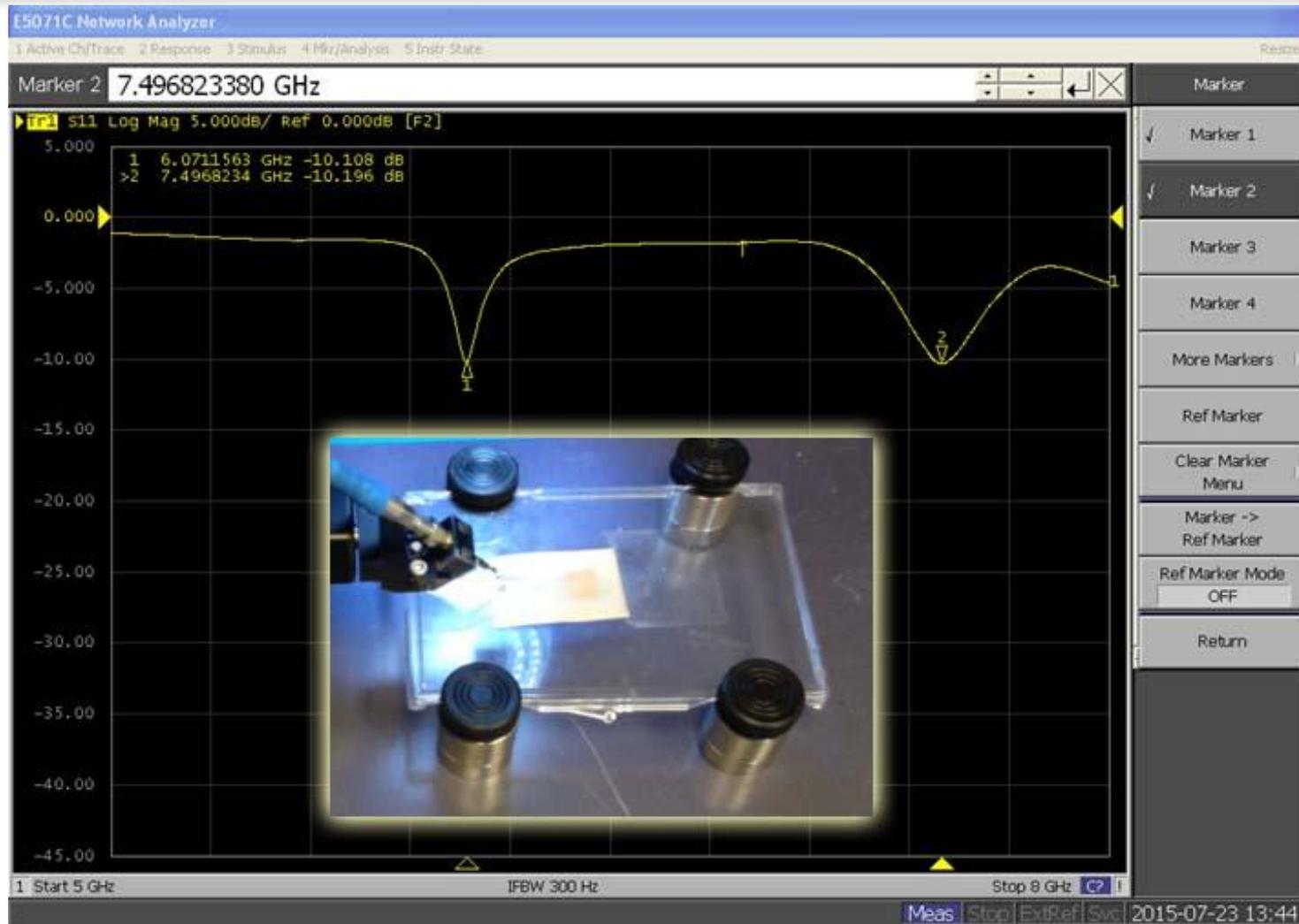
# RF Fixture Testing



# RF Module Testing



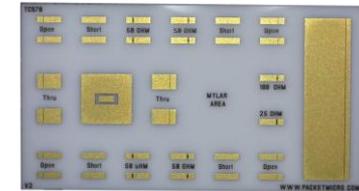
# RF Antenna Testing



# 30/20 GHz S-Probe

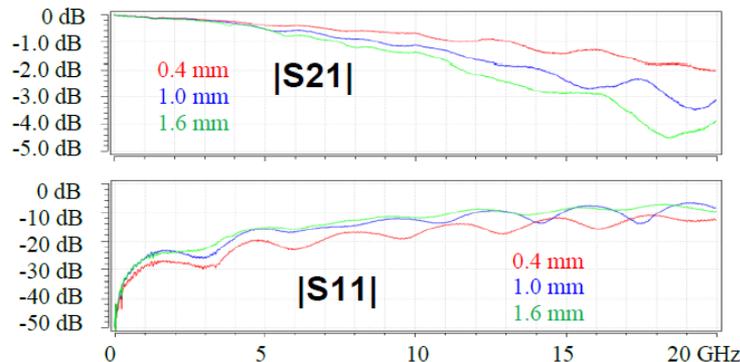


S-Probe  
(1.5" x 0.4" x 0.3")

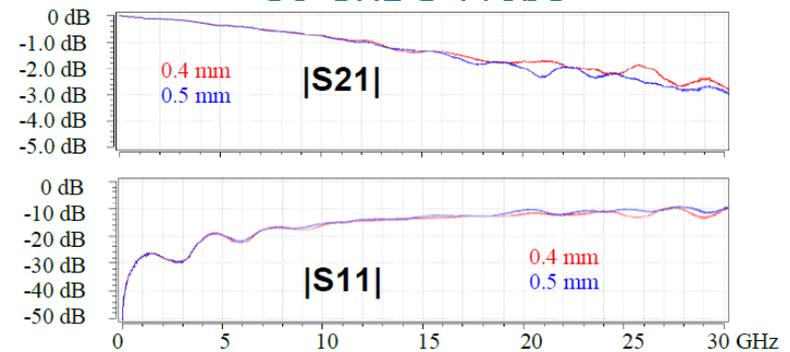


TCS70 Cal Substrate  
(0.7" x 0.4" x 0.025")

## PCB Probing with S-Probe



## 30 GHz S-Probe



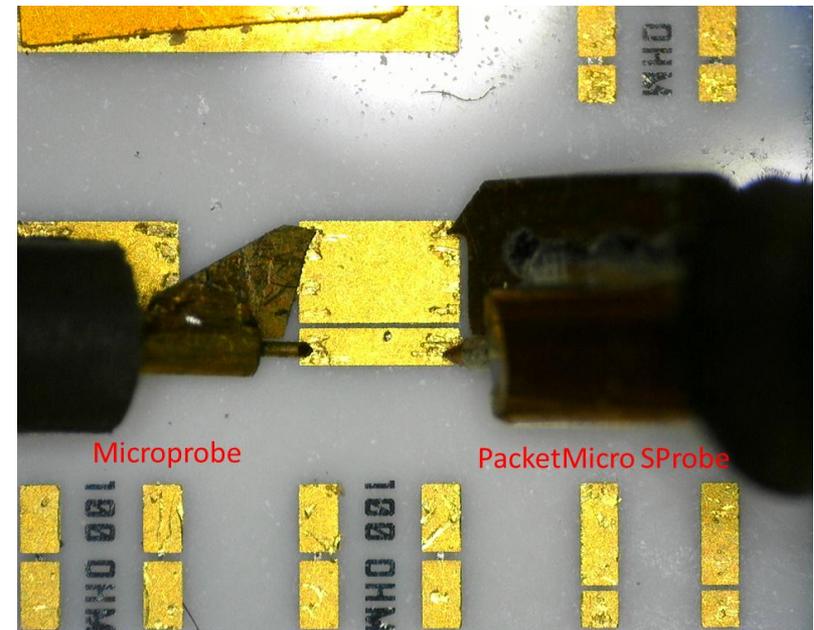
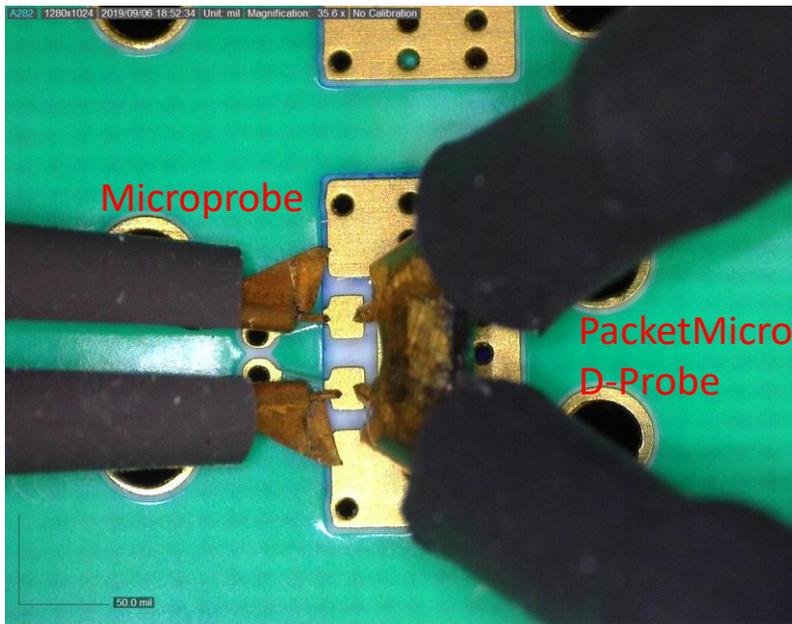
- **SP-GR-2015025** – 20 GHz, 0.25 mm
- **SP-GR-201504** – 20 GHz, 0.4 mm
- **SP-GR-201505** – 20 GHz, 0.5 mm
- **SP-GR-181508** – 18 GHz, 0.8 mm
- **SP-GR-181510** – 18 GHz, 1.0 mm
- **SP-GR-161512** – 16 GHz, 1.2 mm
- **SP-GR-161514** – 16 GHz, 1.4 mm
- **SP-GR-161516** – 16 GHz, 1.6 mm

- **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:

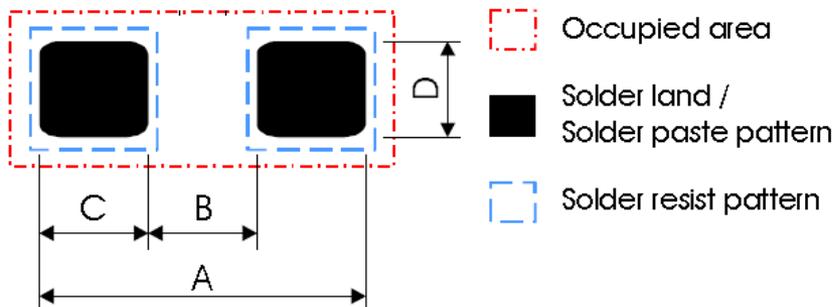
[https://packetmicro.com/Videos/PacketMicro\\_Probe\\_Planarization.mp4](https://packetmicro.com/Videos/PacketMicro_Probe_Planarization.mp4)

# 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:

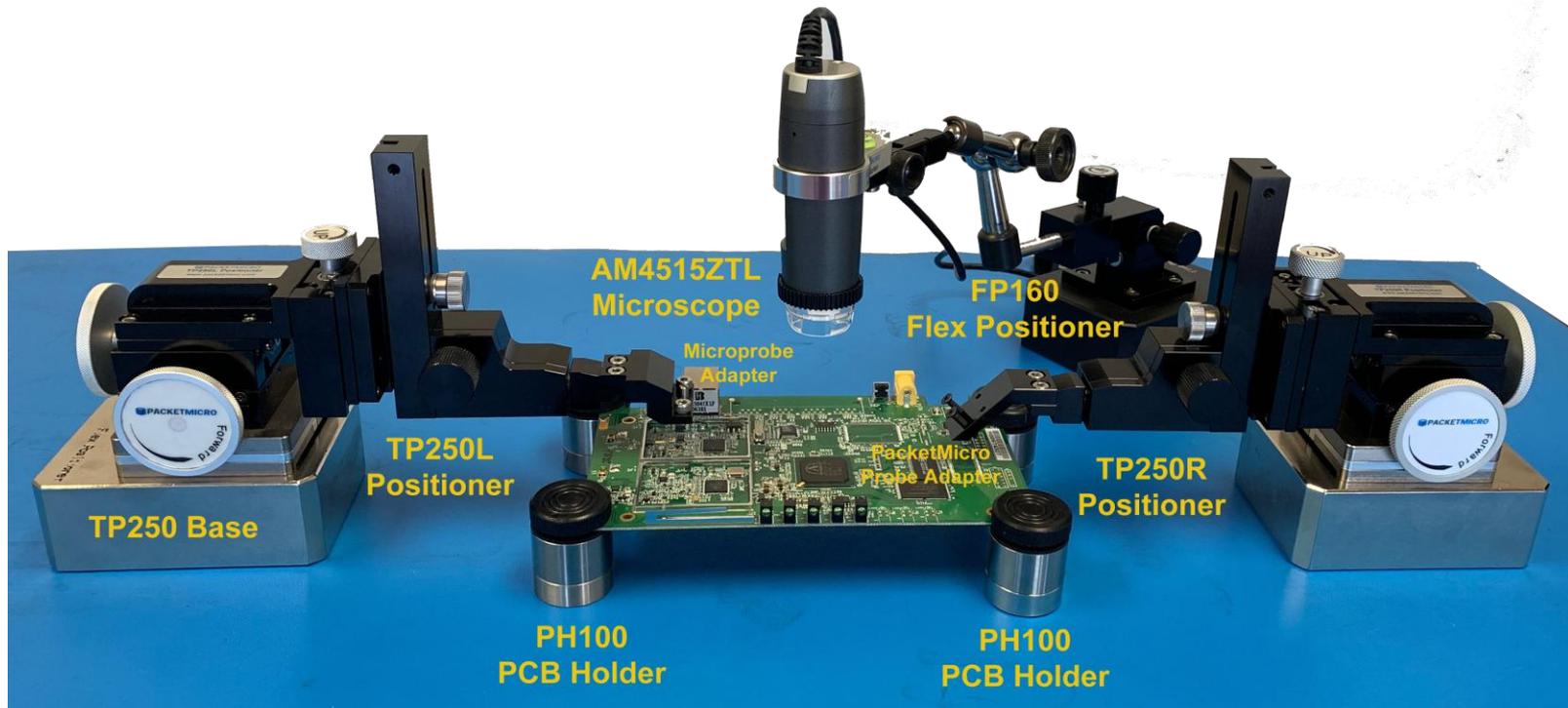
- **SP-GR-2015025** – 20 GHz, 0.25 mm/10 mil pitch
- **SP-GR-201504** – 20 GHz, 0.4 mm/16 mil pitch
- **SP-GR-201505** – 20 GHz, 0.5 mm/20 mil pitch
- **SP-GR-181508** – 18 GHz, 0.8 mm/32 mil pitch
- **SP-GR-181510** – 18 GHz, 1.0 mm/40 mil pitch
- **SP-GR-161512** – 16 GHz, 1.2 mm/48 mil pitch
- **SP-GR-161514** – 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	0.52	0.12	0.20	0.21	0.4 x 0.2
0201	SP-GR-201505	0.90	0.30	0.30	0.35	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 < 2.2mm	2.40	0.60	0.90	1.00	1.6 x 0.8
0805	1.2mm < Pitch < 2.8mm	3.0	1.0	1.0	1.25	2.0 x 1.25

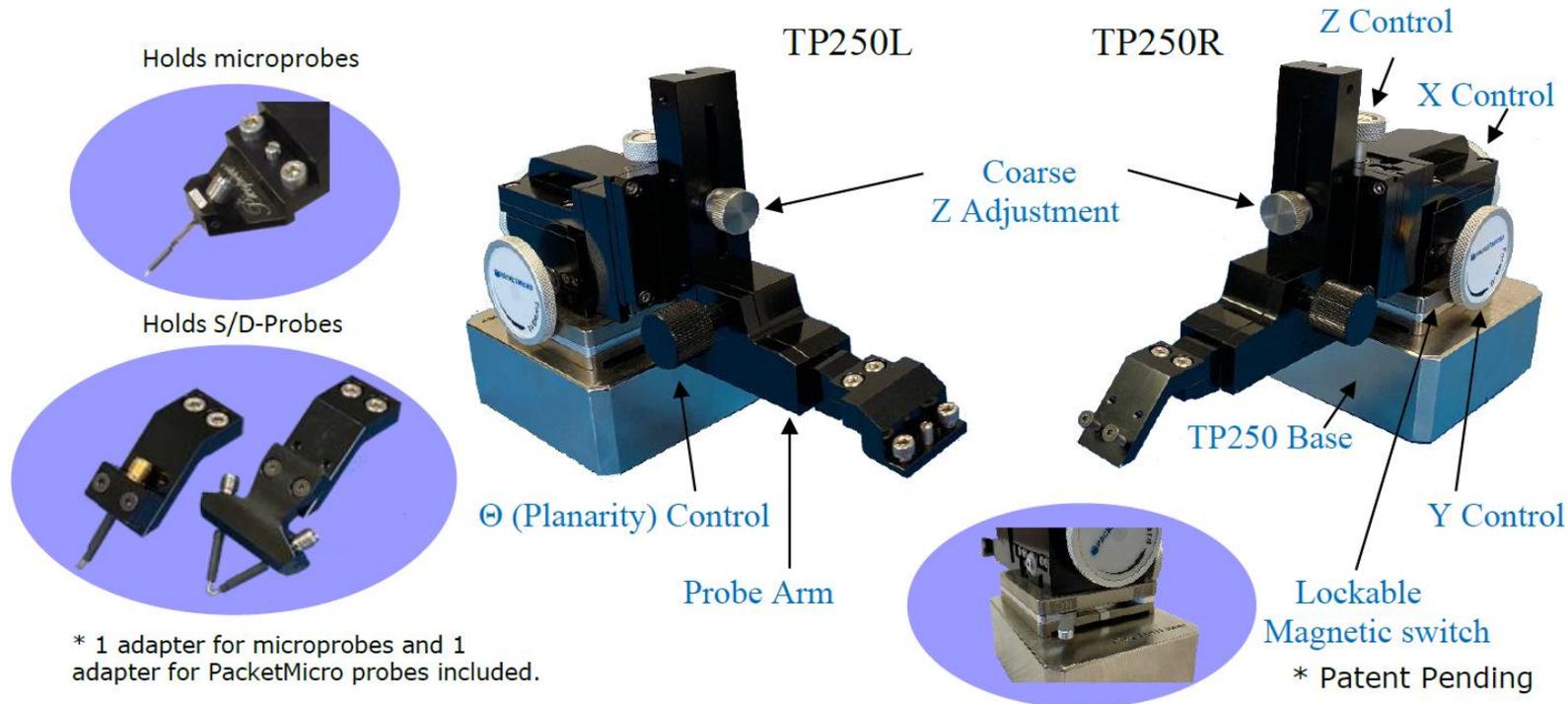
- The above component footprints are for reference only.
- Please use the specific component footprints in your PCB layout.

# Simple DIY Probe Station



**Set up your probe station in 5 minutes !**

# Precision Positioner – TP250



- **Precise:** XYZ stage (50 TPI, 2.5  $\mu\text{m}$  resolution)
- **Versatile:** detachable  $\theta$  stage
- **Easy:** lockable magnetic base

# Tools - Accessories

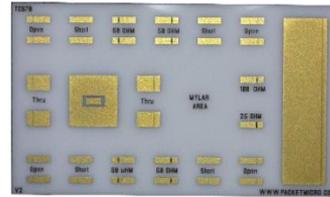


Optical Microscope  
(~ 90 x magnification)



USB Digital Microscope  
(~ 90 x magnification)

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



TCS70  
Calibration  
Substrate



Mylar  
Tape



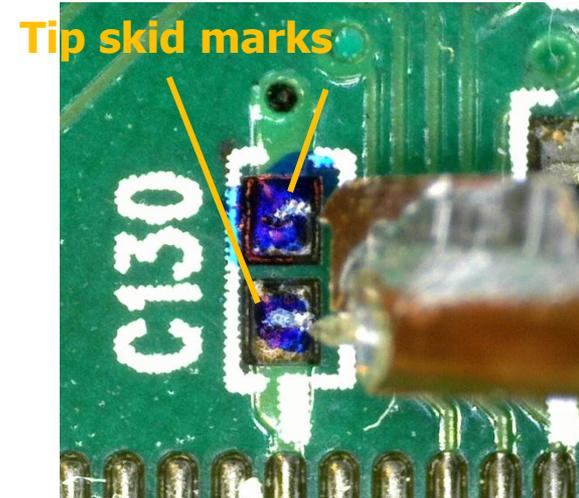
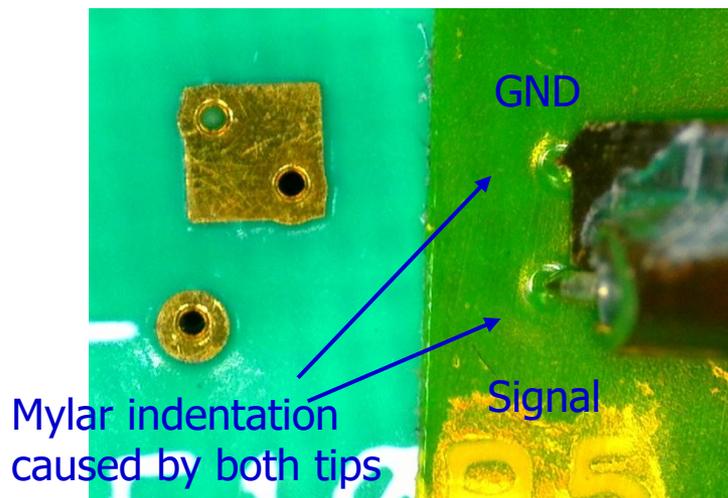
Fine-tip  
Sharpie pen

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

# Probe Planarization Tips

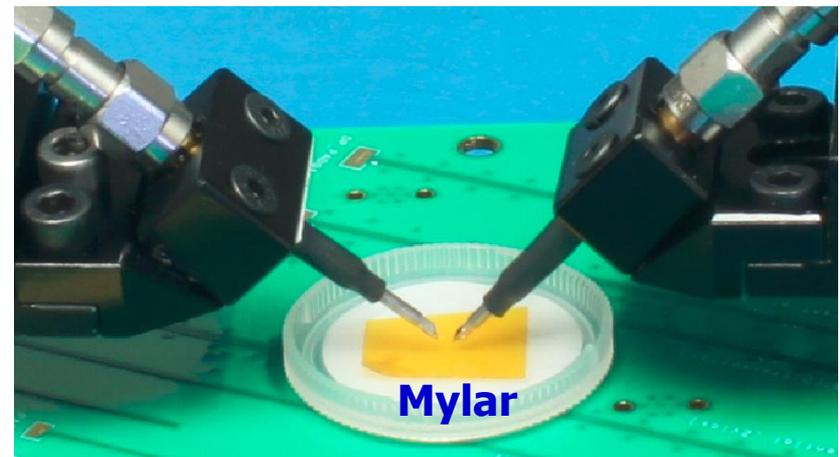
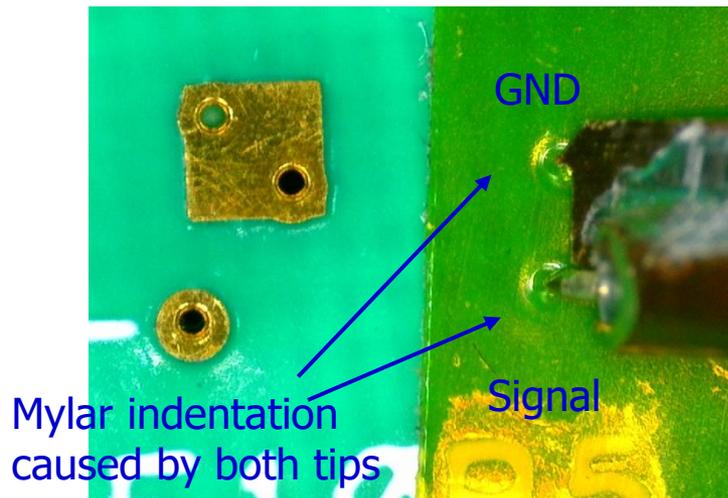
- A good microscope is important. You may damage the probe if you cannot see its tips well.
- Good contact of both probe tips with the DUT is essential to accurate calibration and measurements.
- Mylar tape provides leveling guidance on flat, even surface (bare PCB).
- Color marker helps on uneven surface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

[https://packetmicro.com/Videos/PacketMicro\\_Probe\\_Planarization.mp4](https://packetmicro.com/Videos/PacketMicro_Probe_Planarization.mp4)

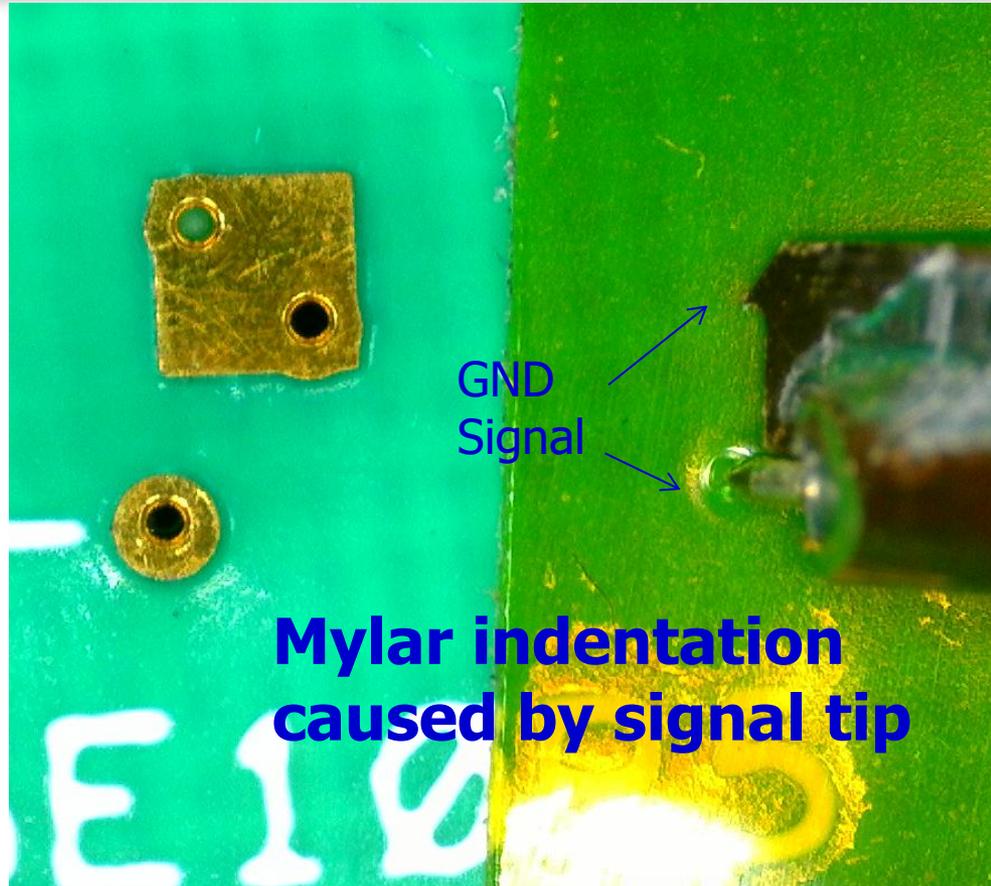


# Probing Test Pads on Even Surfaces

- 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.



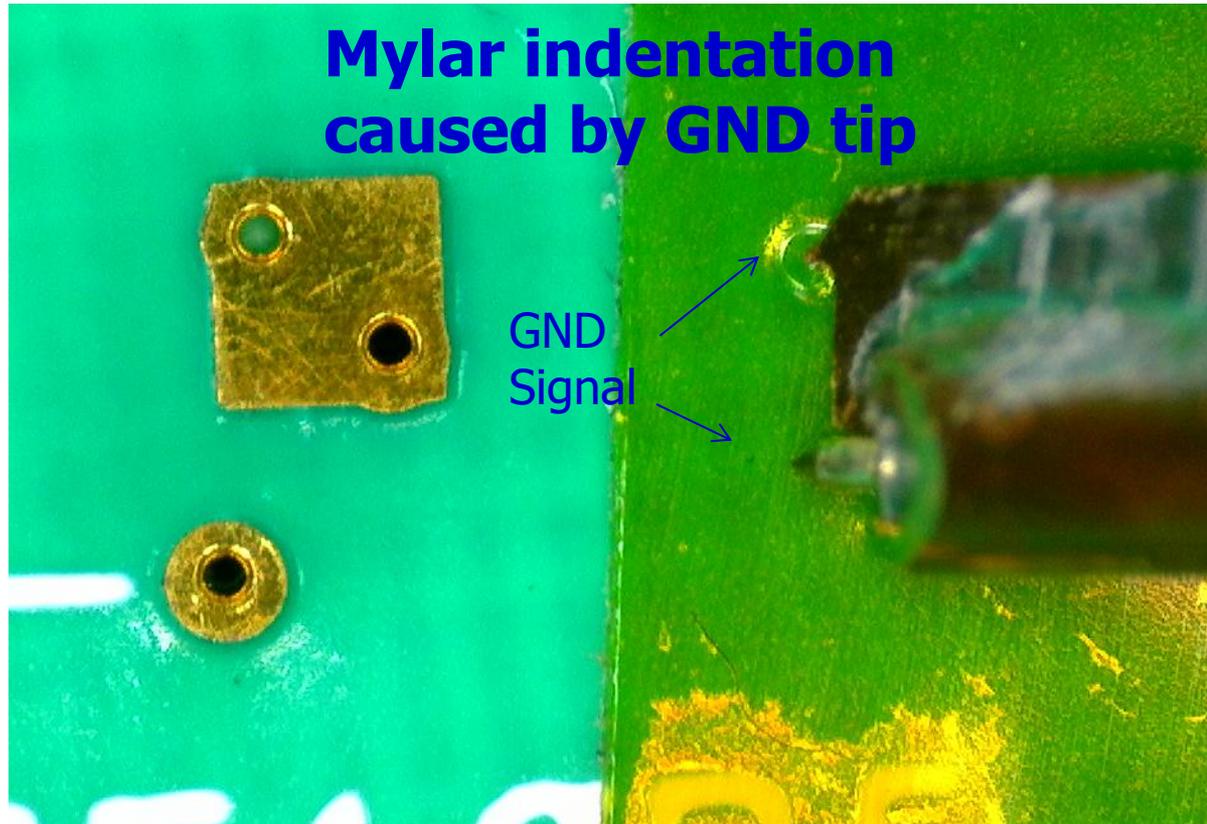
# Signal tip touches down first



## 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.

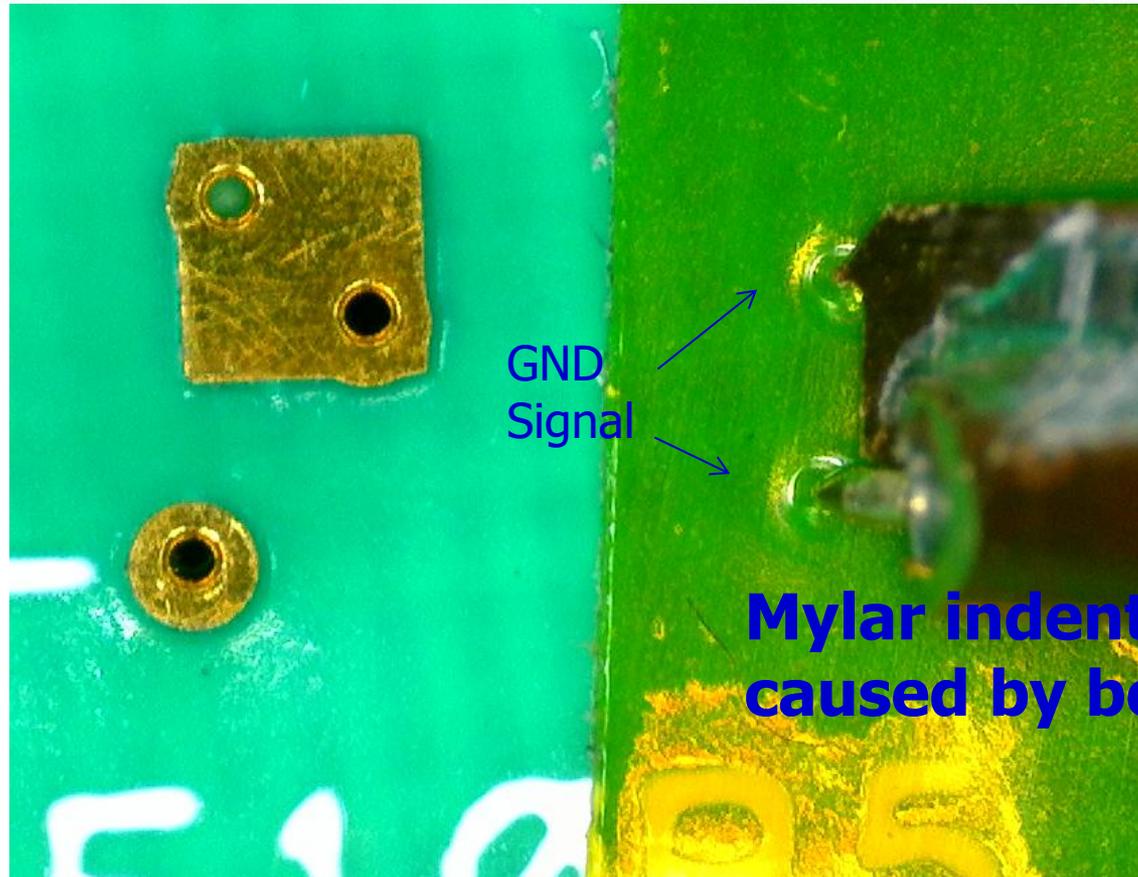
# GND tip touches down first



## 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.

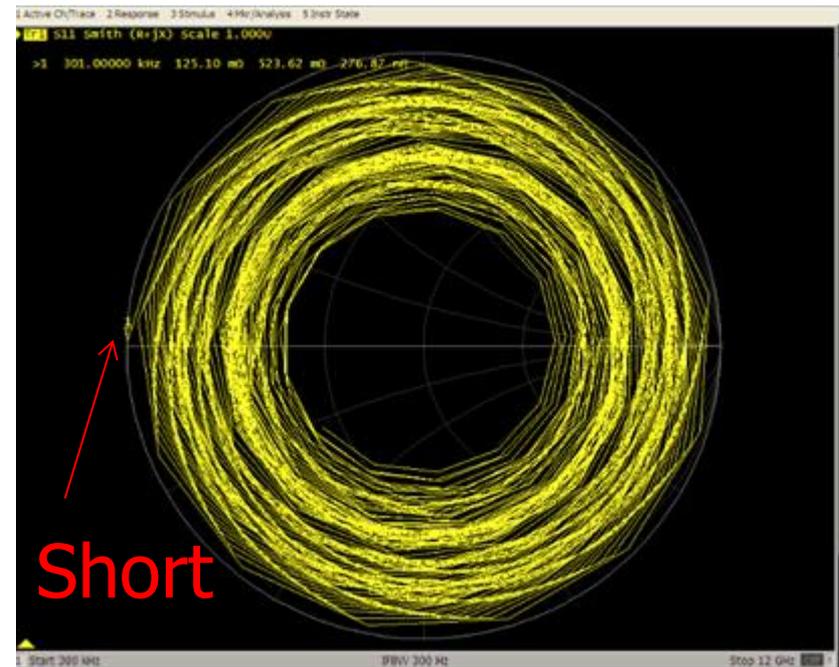
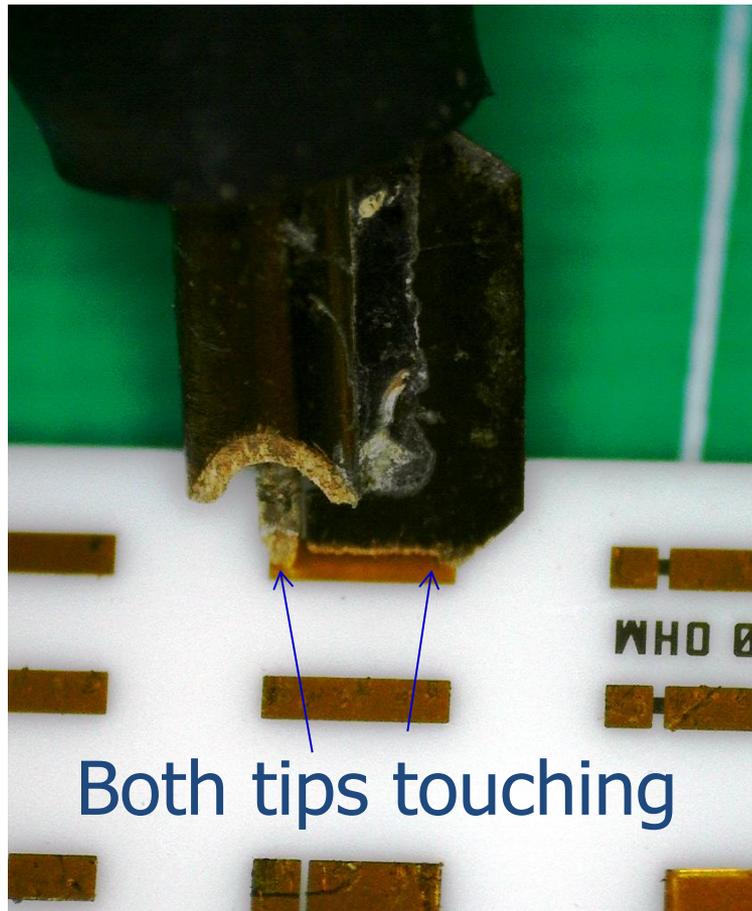
# Both tips touch down simultaneously



## 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.

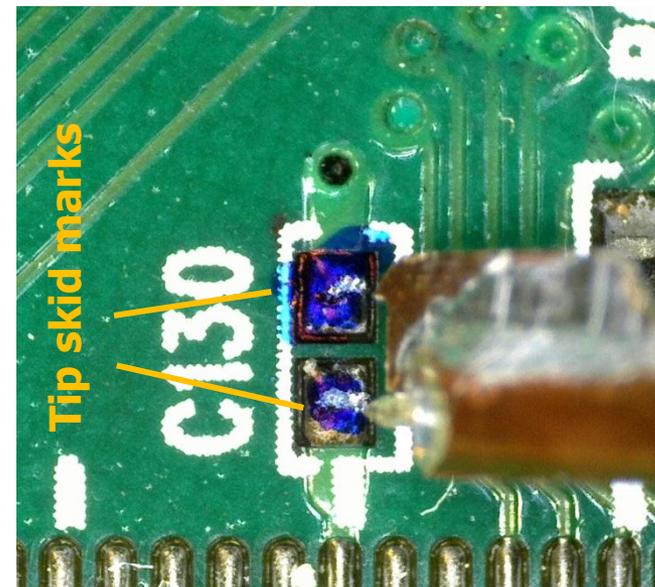
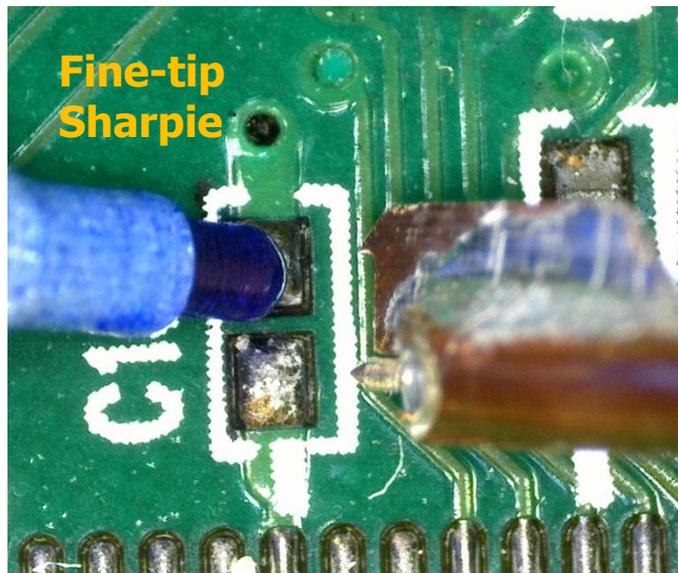
# Use VNA to Verify Probe Contacts



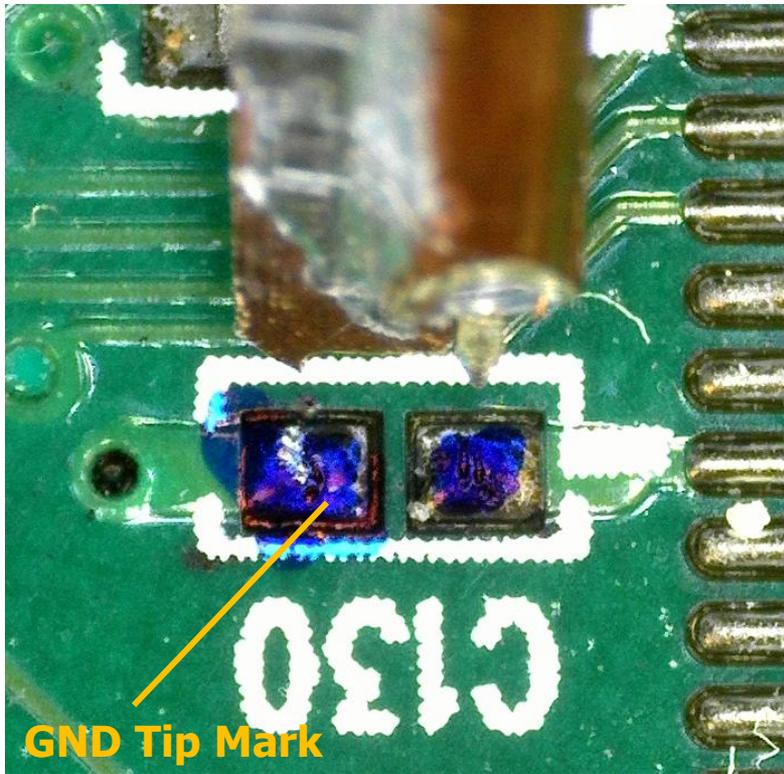
- Both tips leave light probe marks
- VNA Smith Chart shows “Short”

# Probing Test Pads on Uneven Surfaces

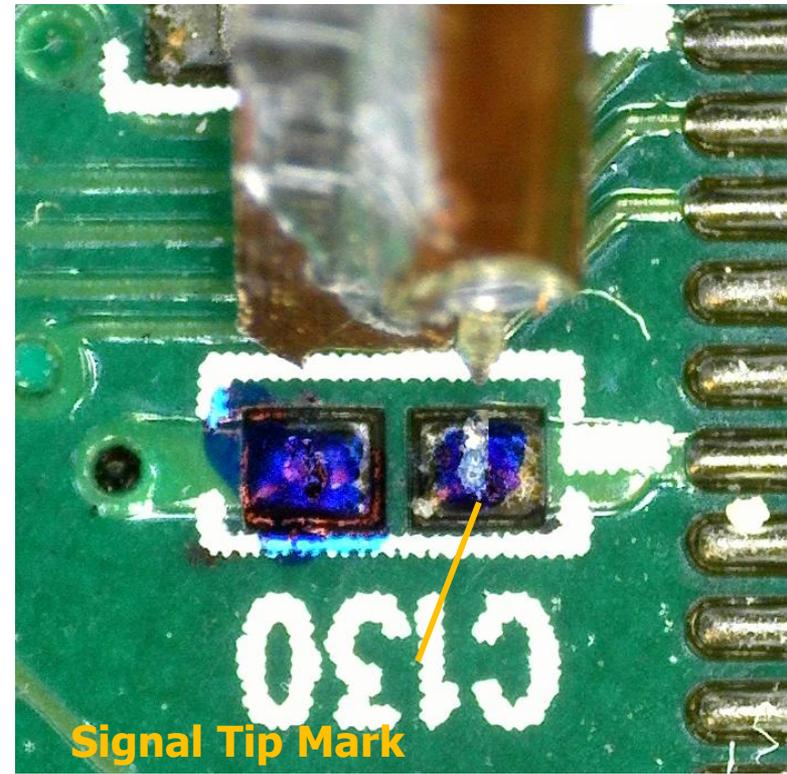
- Color solder bumps with a Sharpie
- Use the probe skid marks to confirm good tip contact
- Clean up the solder bumps with industrial alcohol after probing



# Use Probe Skid Marks on Solder Bumps

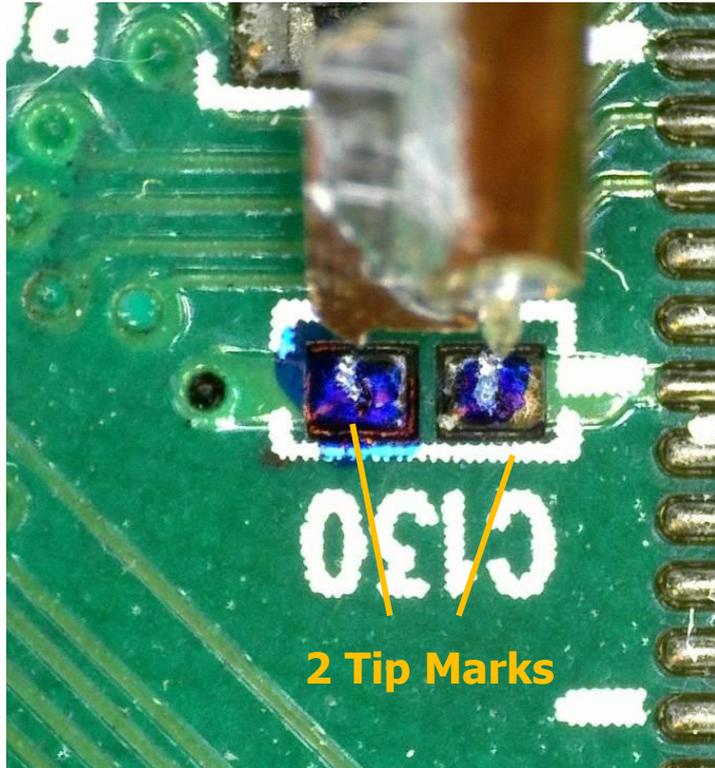


**Left GND tip touches down first**

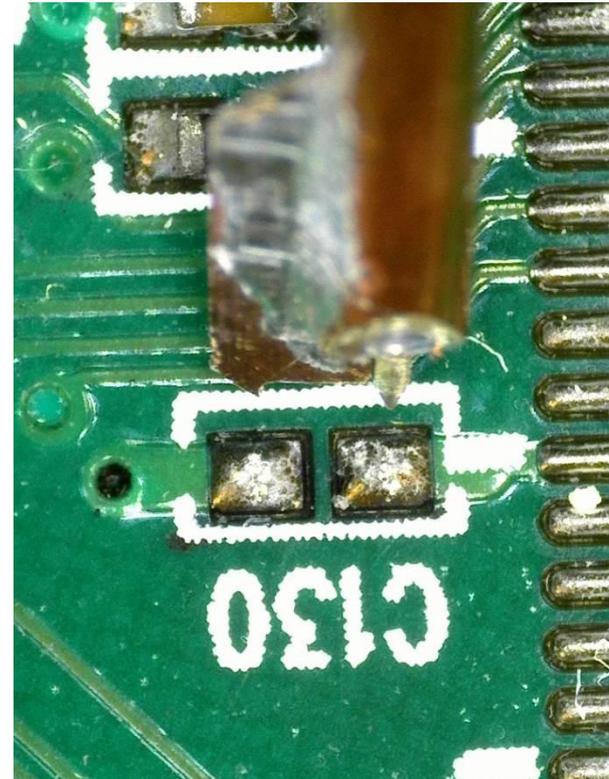


**Right signal tip touches down first**

# Both Tips Touch Down Simultaneously



**Both tips touch down simultaneously**



**Clean up solder bumps with industrial alcohol after probing**

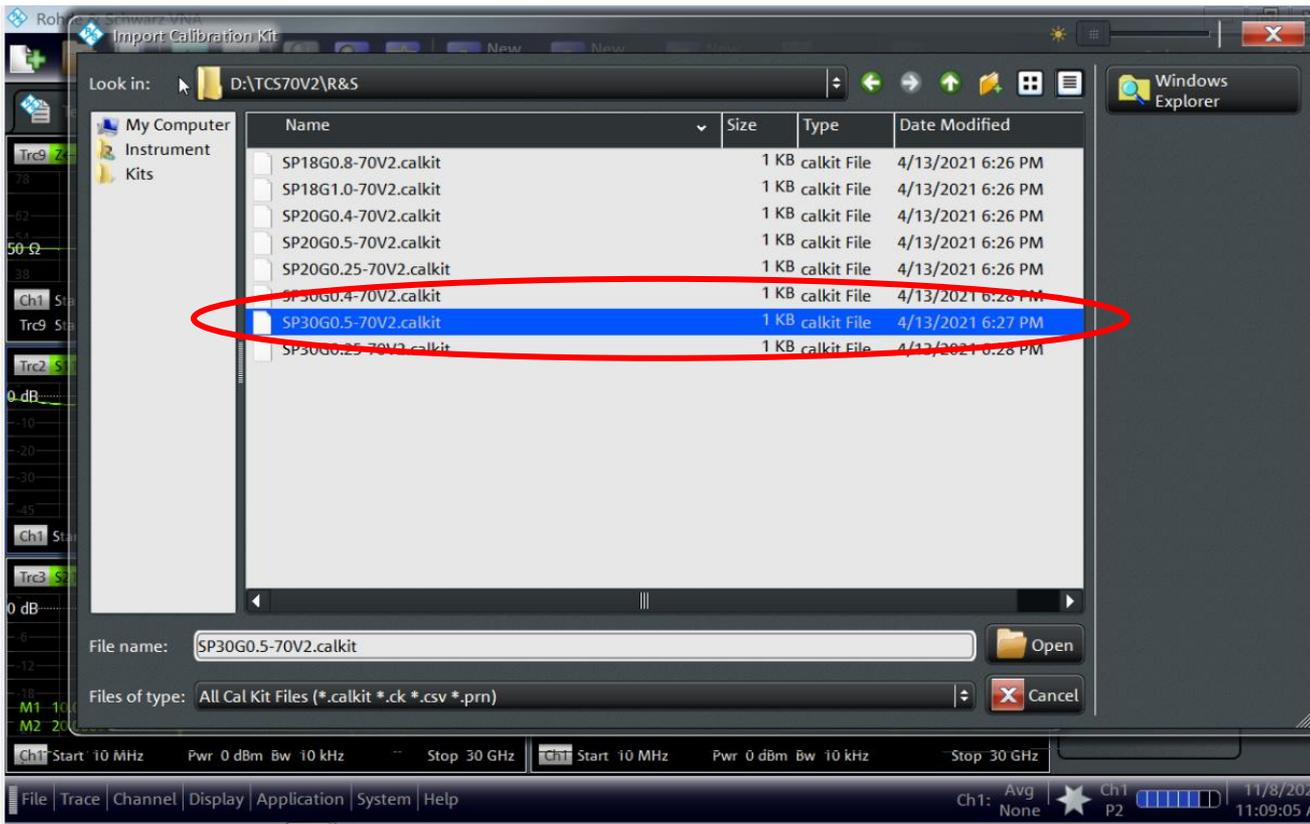
# Import TCS70xx.calkit file

Press hard "Cal" button -> Cal Devices -> Cal Kits -> Import Cal Kit



# Import SP30G0.5-TCS70V2.calkit file – cont.

- Import the correct .calkit file for your probe
- **SP30G0.5-TCS70V2.calkit** is for 30GHz, 0.5 mm S-Probe (SP-GR-301505)

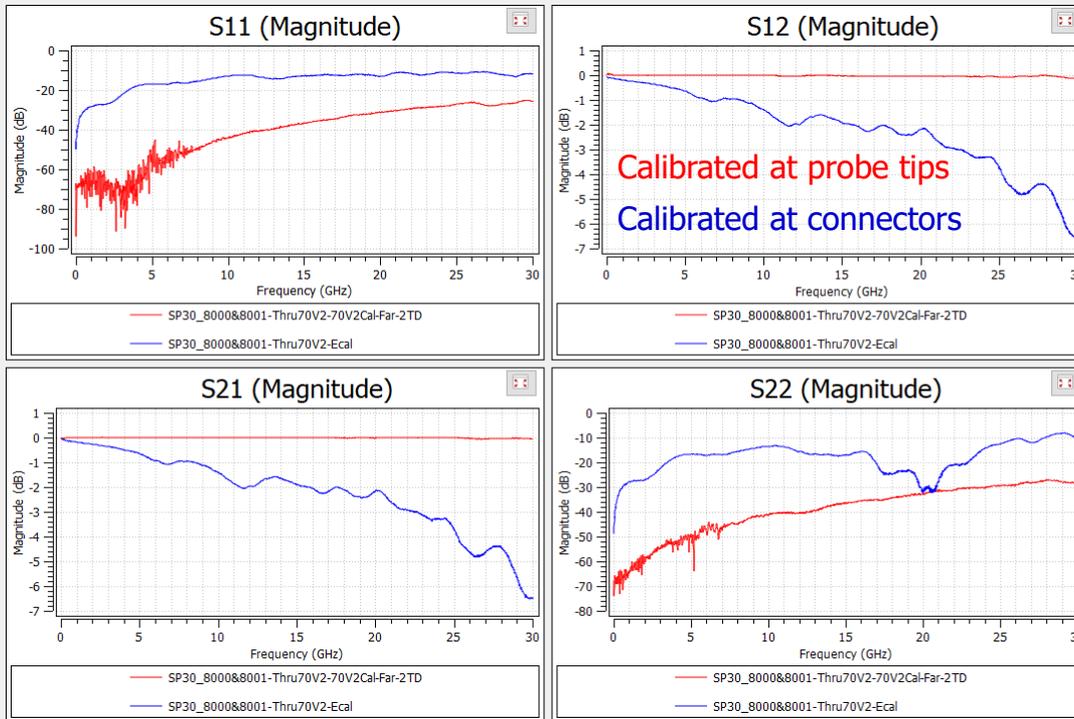


# 2-Port Probe-Tip Calibration Setup



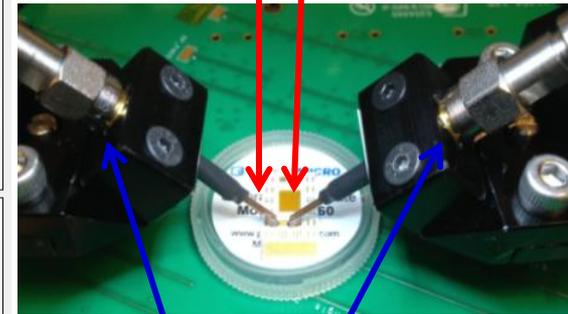
**Precision TP250 Positioners with S-Probes**

# Thru Measurement with Probe-Tip Calibration



## Thru Measurement

Calibrated at probe tips

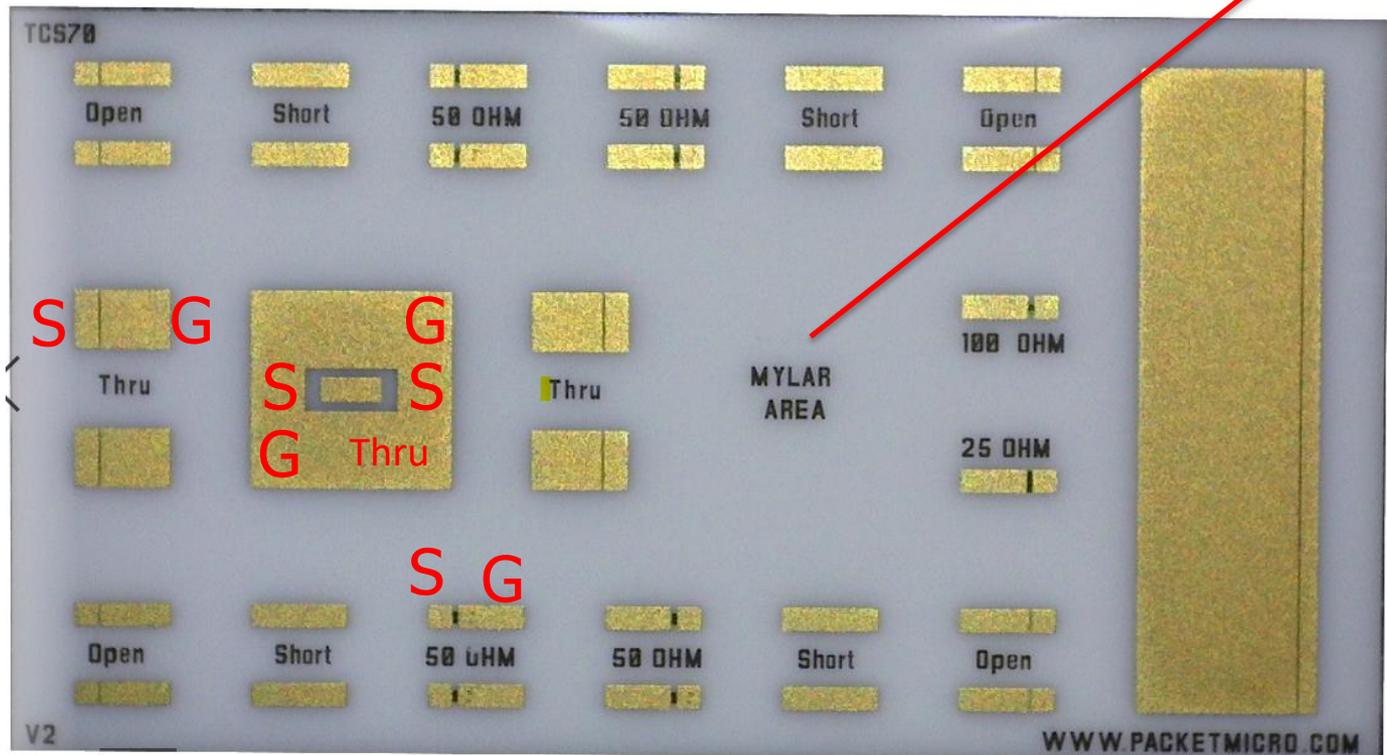
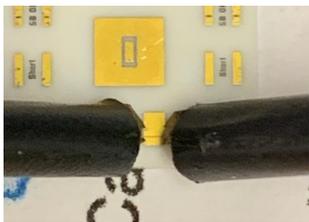


Calibrated at connectors

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)



# Start Manual Calibration

Press hard "Cal" button -> Start Cal -> Start (Manual)



# Select Cal Kit

- Select "Probe" connector -> "Cal Kit" -> Start

R&S Remote Tool

**Connectors and Cal Kits**  
Select connector type and gender for ports. If necessary, change the Cal Kit or load an appropriate one.

Ports	P1	P3	P2	P4
Connector	Probe		Probe	
Gender				
Cal Kit	SP30G0.5-70V2		SP30G0.5-70V2	

Buttons: Same Connector all Ports, Same Gender all Ports, Import Cal Kit ...

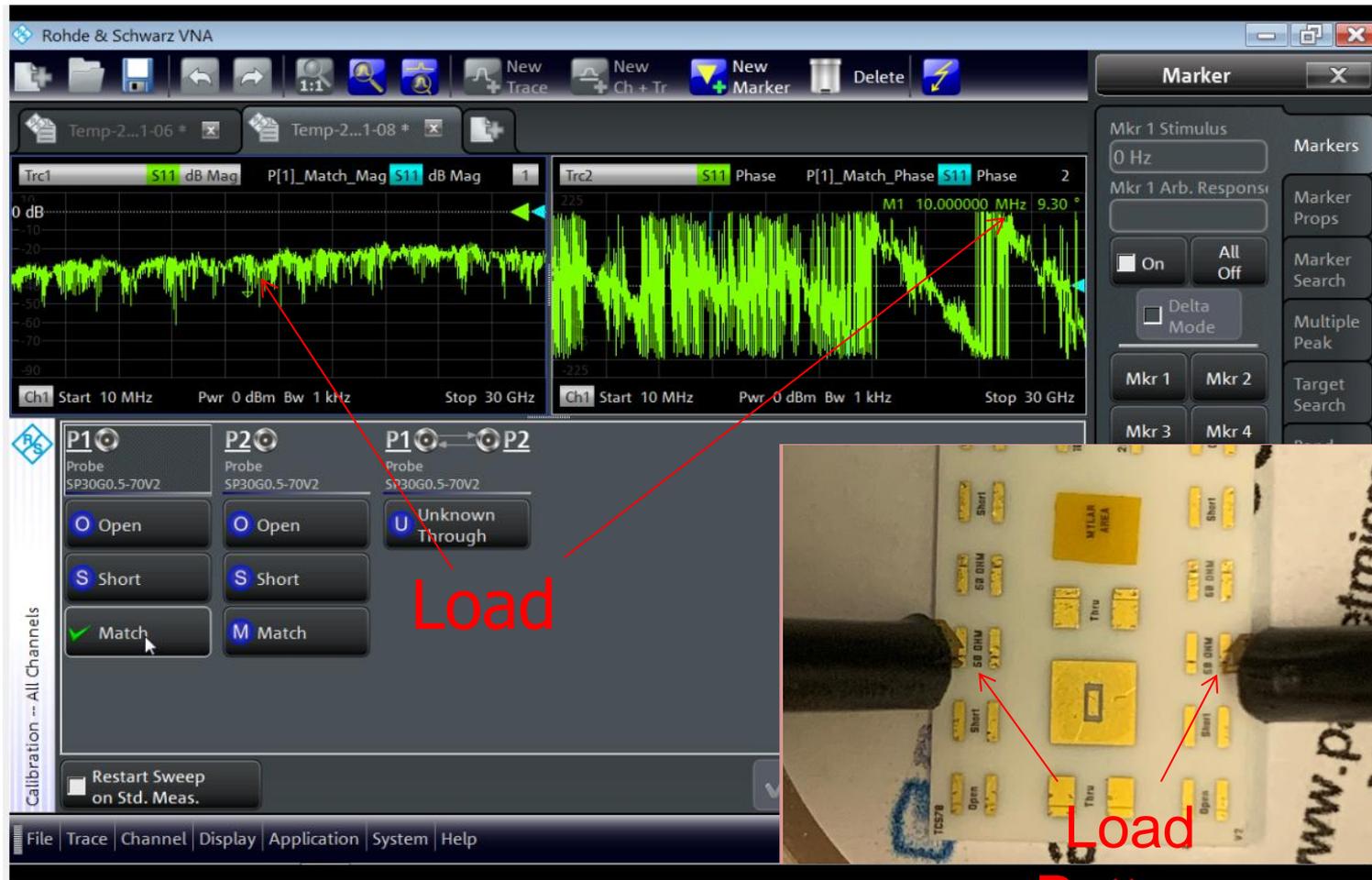
Buttons: Back, Start, Cancel, Help

# Set Marker to Lowest Frequency

Use 180° change in phase to detect short.

The screenshot displays the Rohde & Schwarz VNA software interface. The main display area is split into two traces: Trc1 (dB Mag) and Trc2 (Phase). A marker 'M1' is placed at 10.000000 MHz, with a phase value of -33.72°. The 'Marker' panel on the right shows 'Mkr 1 Stimulus' set to '10 MHz'. The 'Calibration -- All Channels' panel at the bottom left shows three probes (P1, P2, P1) with various test settings like 'Open', 'Short', 'Match', 'Through', and 'Isolation'. The status bar at the bottom indicates 'Ch1: Avg None' and the date '11/8/2021'.

# Reflection Calibration - Load

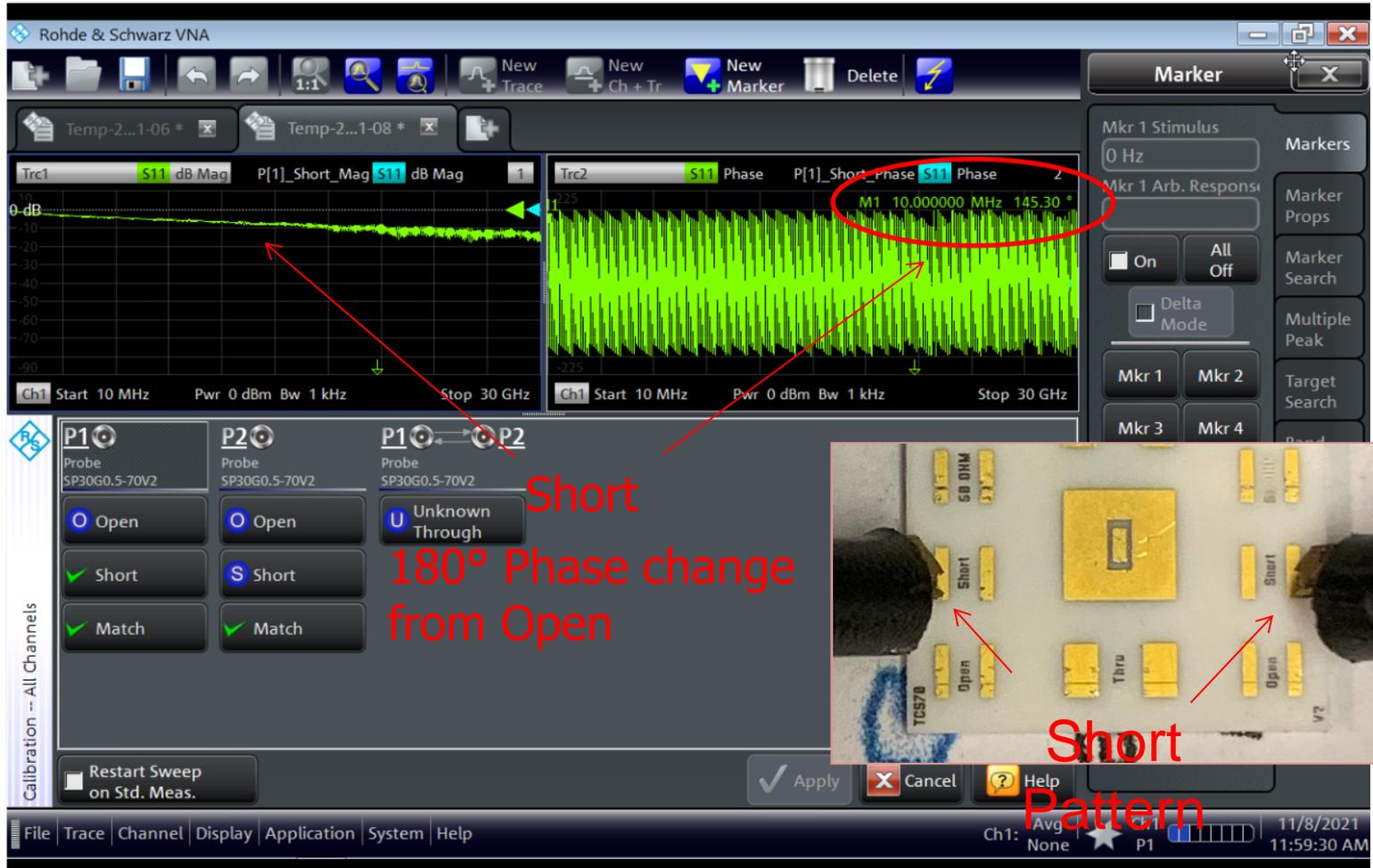


Load

Load  
Pattern

# Reflection Calibration - Short

- Perform Short first to verify probe planarization



# Reflection Calibration - Open

The screenshot displays the Rohde & Schwarz VNA software interface. The main plot shows two traces: Trc1 (S11 dB Mag) and Trc2 (S11 Phase). The calibration menu is open, showing the following settings:

Port	Probe	Open	Short	Match
P1	SP30G0.5-70V2	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>
P2	SP30G0.5-70V2	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>

The inset photo shows the physical calibration pattern on a PCB, with red arrows pointing to the 'Open' markers. The text 'Open Pattern' is overlaid on the inset.

# Complete Reflection OSM Cal

The screenshot displays the Rohde & Schwarz VNA software interface. The main display area shows two traces: Trc1 (S22 dB Mag) and Trc2 (S22 Phase). The calibration setup is visible in the lower-left panel, which is circled in red. It shows three ports (P1, P2, P1) with their respective calibration states (Open, Short, Match) and a 'Restart Sweep on Std. Meas.' button. The right-hand side of the interface features a 'Marker' panel with various settings and a 'Coupled Markers' button. The bottom status bar indicates the current channel settings and the date/time.

# Correct Thru Calibration

The screenshot displays the Rohde & Schwarz VNA software interface. The main display area shows two traces: Trace 1 (S21 dB Mag) and Trace 2 (S21 Phase). The calibration status is shown in the bottom left, with 'Through' selected for the S21 parameter. The 'Apply' button is circled in red. An inset image shows a physical thru calibration standard with a red arrow pointing to the connection point and the text 'Thru Pattern'.

**S21 should be a line**

**Thru Pattern**

# Transmission Calibration - Thru

- At least one probe does not touch down.
- Need to redo the Thru measurement



# Completion of SOLT Calibration



# S11/S22 Measurements of a 50Ω Standard



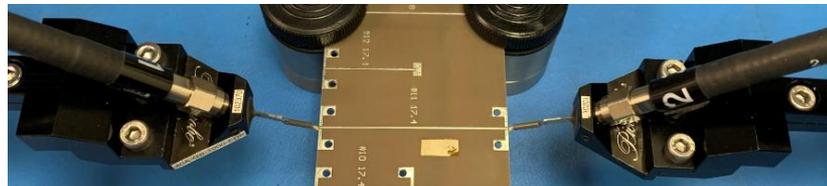
# Test Trace: 2" (5.08 mm) Microstrip

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

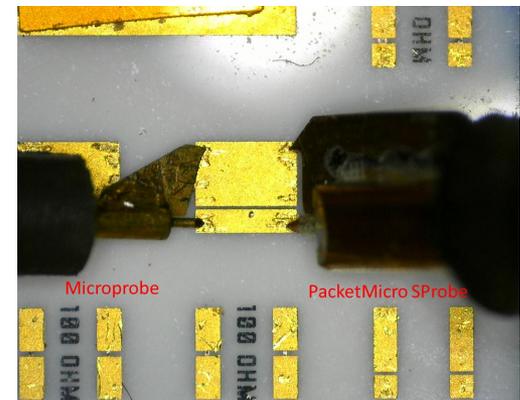
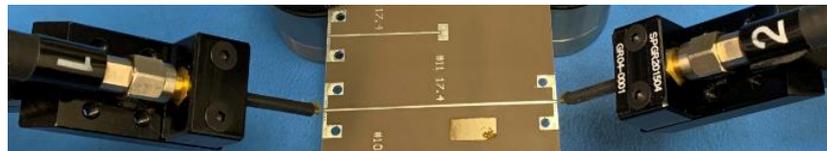
40 GHz  
2.92 mm  
connector



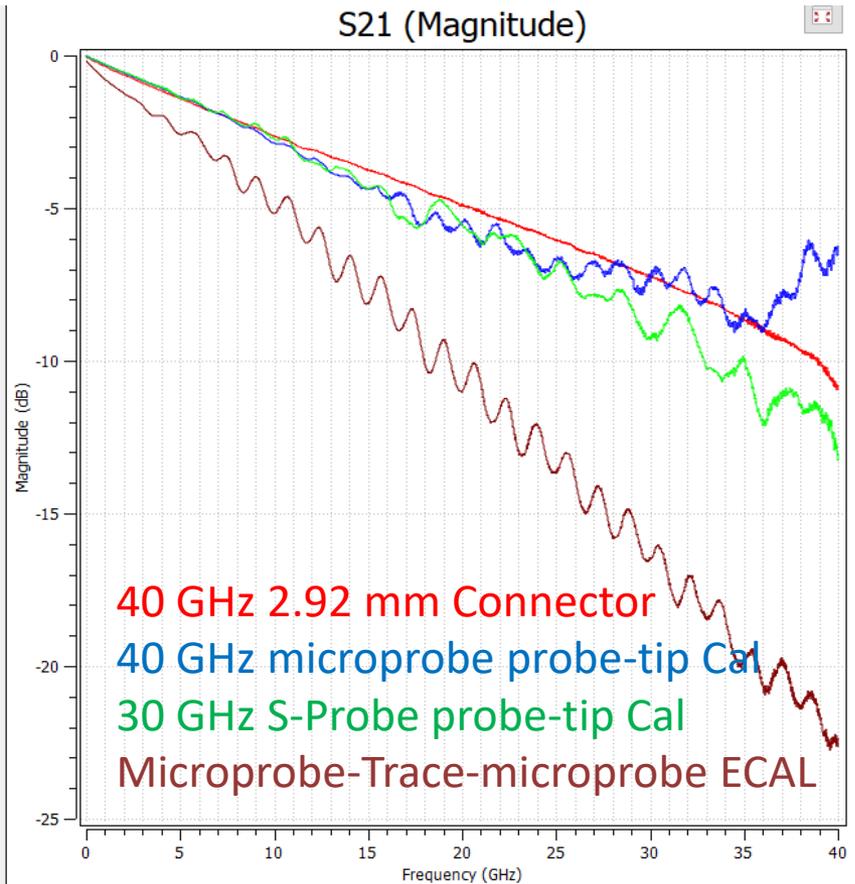
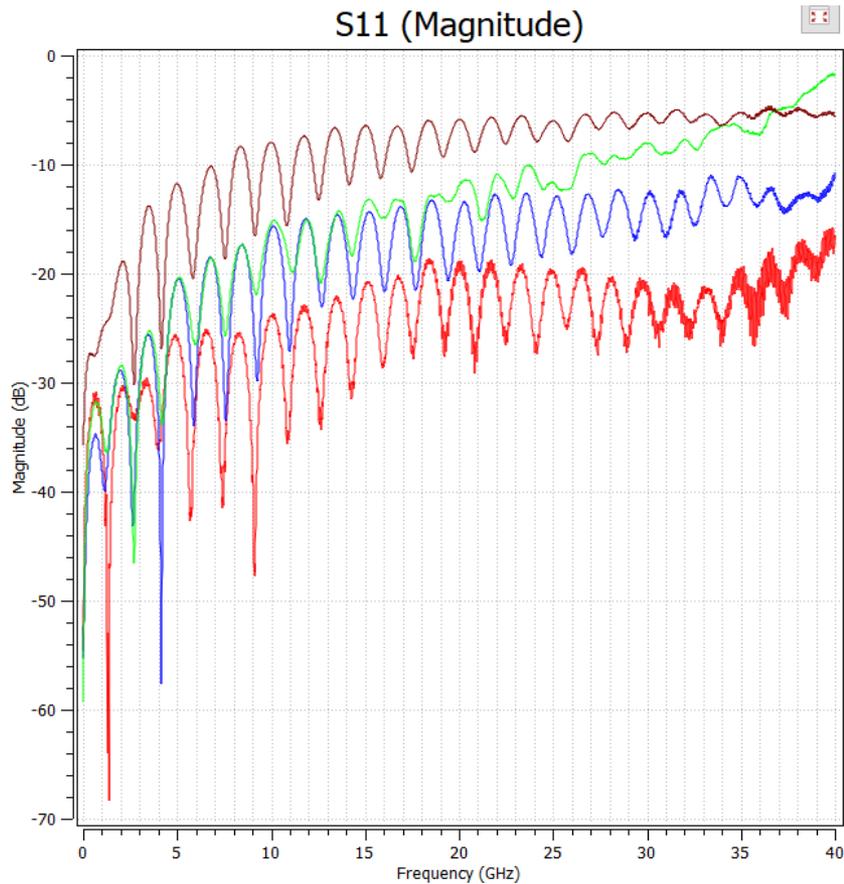
40 GHz  
Microprobe



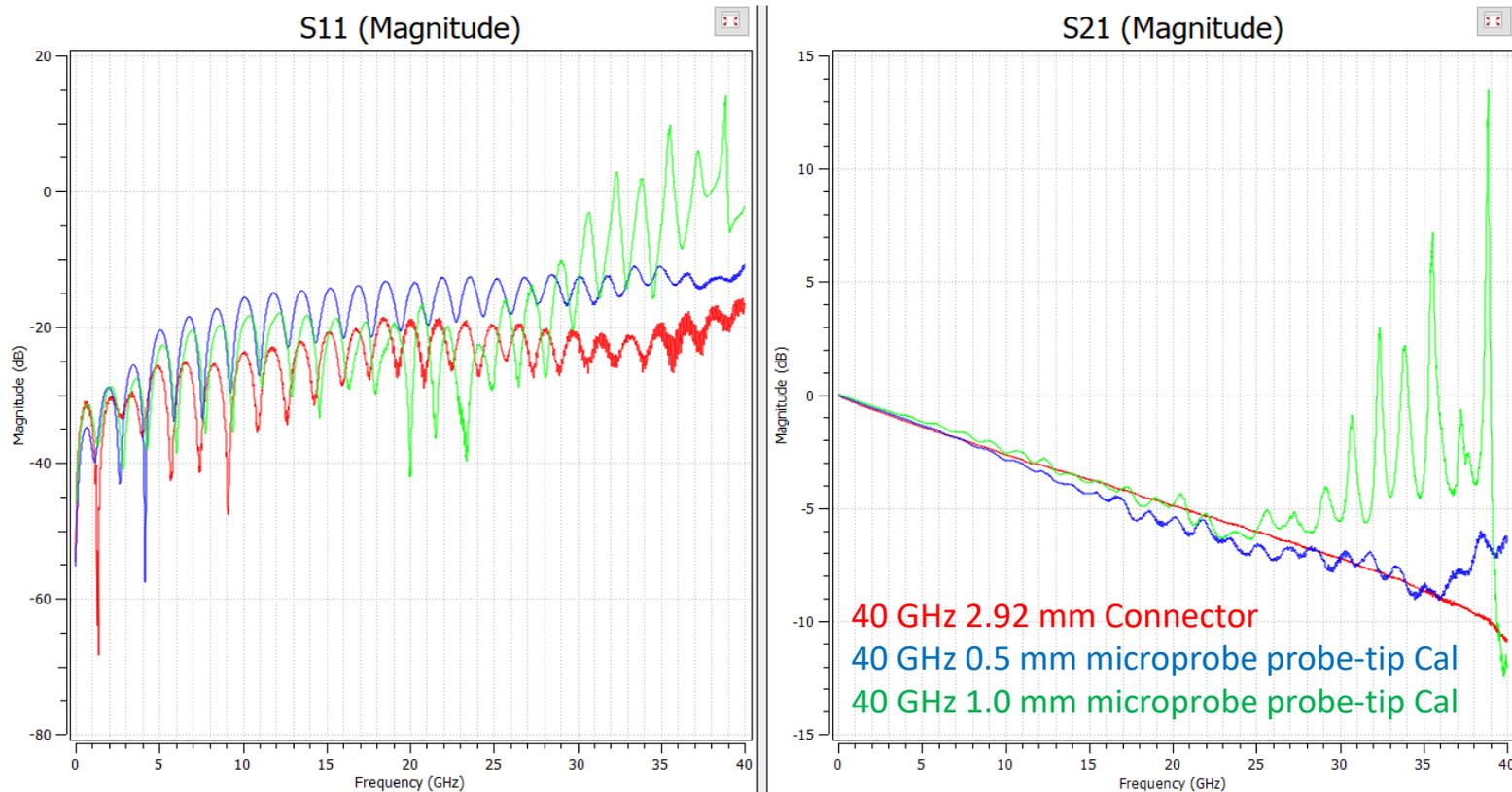
30 GHz  
S-Probe



# Connector vs. Probes

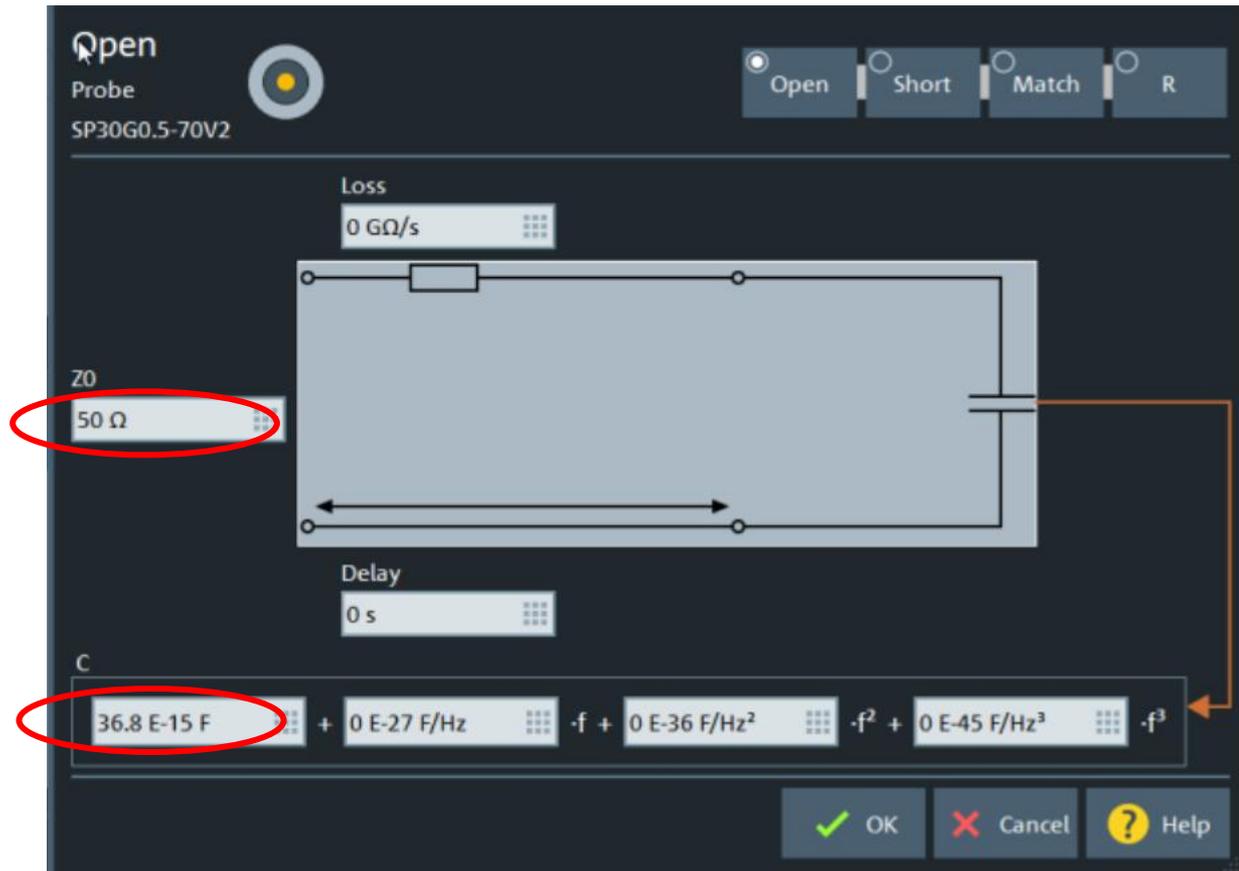


# Limitation of Probe-Tip SOLT CAL



**Typical probe-tip SOLT calibration for GS probes is accurate up to ~50% of probe bandwidth because higher order coefficients cannot be defined due to probe contact.**

# Cal Kit Standard



Typically, only the coefficient of  $f^0$  is used for Open and Short standards for probes

# Manual Entry of TCS70 Coefficients

Press hard "Cal" button -> Cal Devices -> Cal Connector Types

Conn. Type	Sexless	Char. Imp.	Line Type	Rel. Permittivity $\epsilon_r$	Cutoff Freq.
1 N 50 $\Omega$	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
2 N 75 $\Omega$	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	--
3 3.5 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
4 7 mm	<input checked="" type="checkbox"/>	50 $\Omega$	TEM	1.001	--
5 2.92 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
6 2.4 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
7 1.85 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
8 7-16	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
9 Type F (75)	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	--
10 BNC 50 $\Omega$	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
11 BNC 75 $\Omega$	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	--

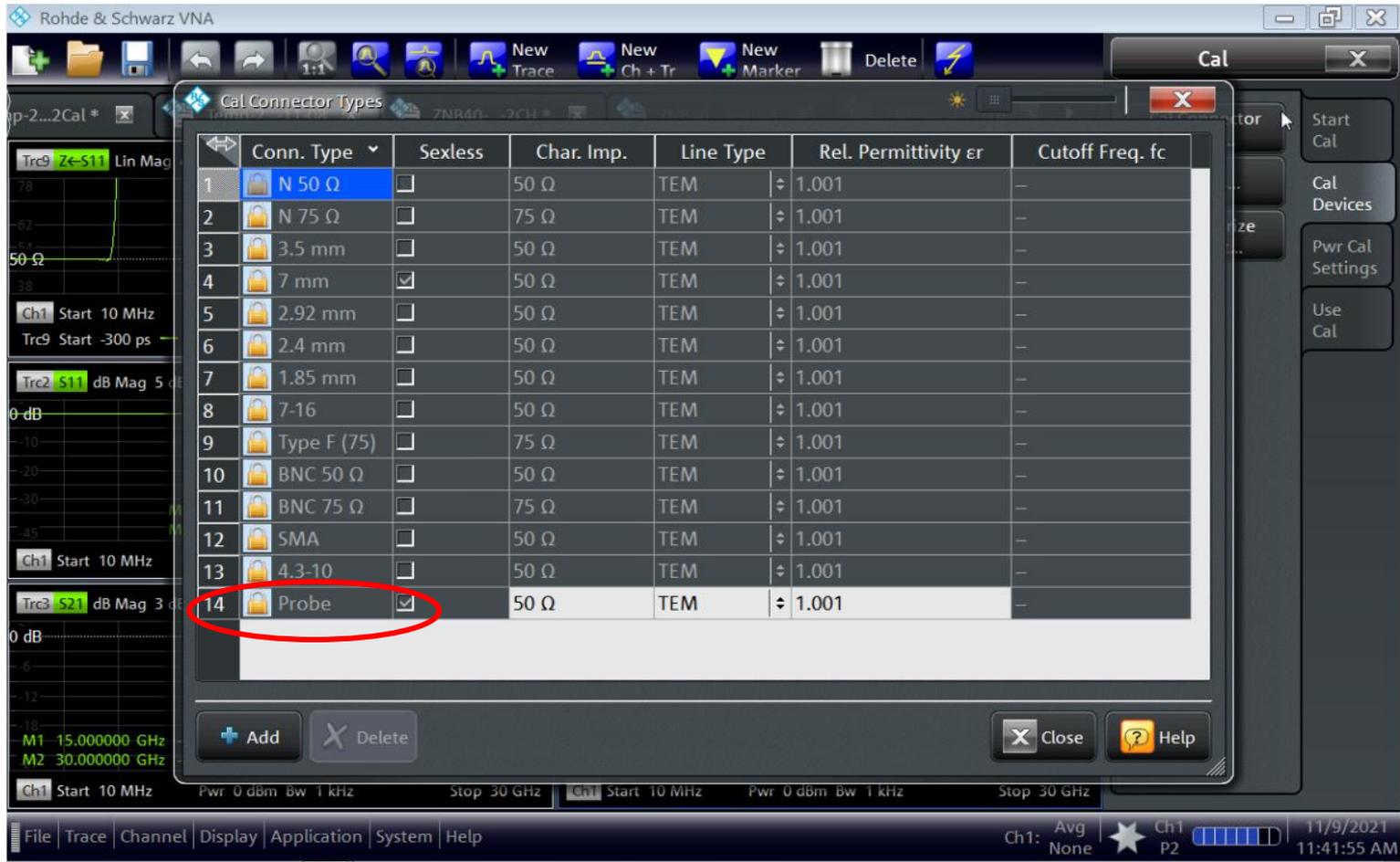
**Need to add connector type before adding the Cal Kit!**

# Select Connector Type

Conn. Type	Sexless	Char. Imp.	Line Type	Rel. Permittivity $\epsilon_r$	Cutoff Freq
2 N 75 $\Omega$	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	--
3 3.5 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
4 7 mm	<input checked="" type="checkbox"/>	50 $\Omega$	TEM	1.001	--
5 2.92 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
6 2.4 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
7 1.85 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
8 7-16	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
9 Type F (75)	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	--
10 BNC 50 $\Omega$	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	--
11 BNC 75 $\Omega$	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	--
12 User Conn 1	<input checked="" type="checkbox"/>	50 $\Omega$	TEM	1.001	--

Select "Sexless and 50 $\Omega$ " for connector type and rename it to "Probe"

# Probe Connector Type

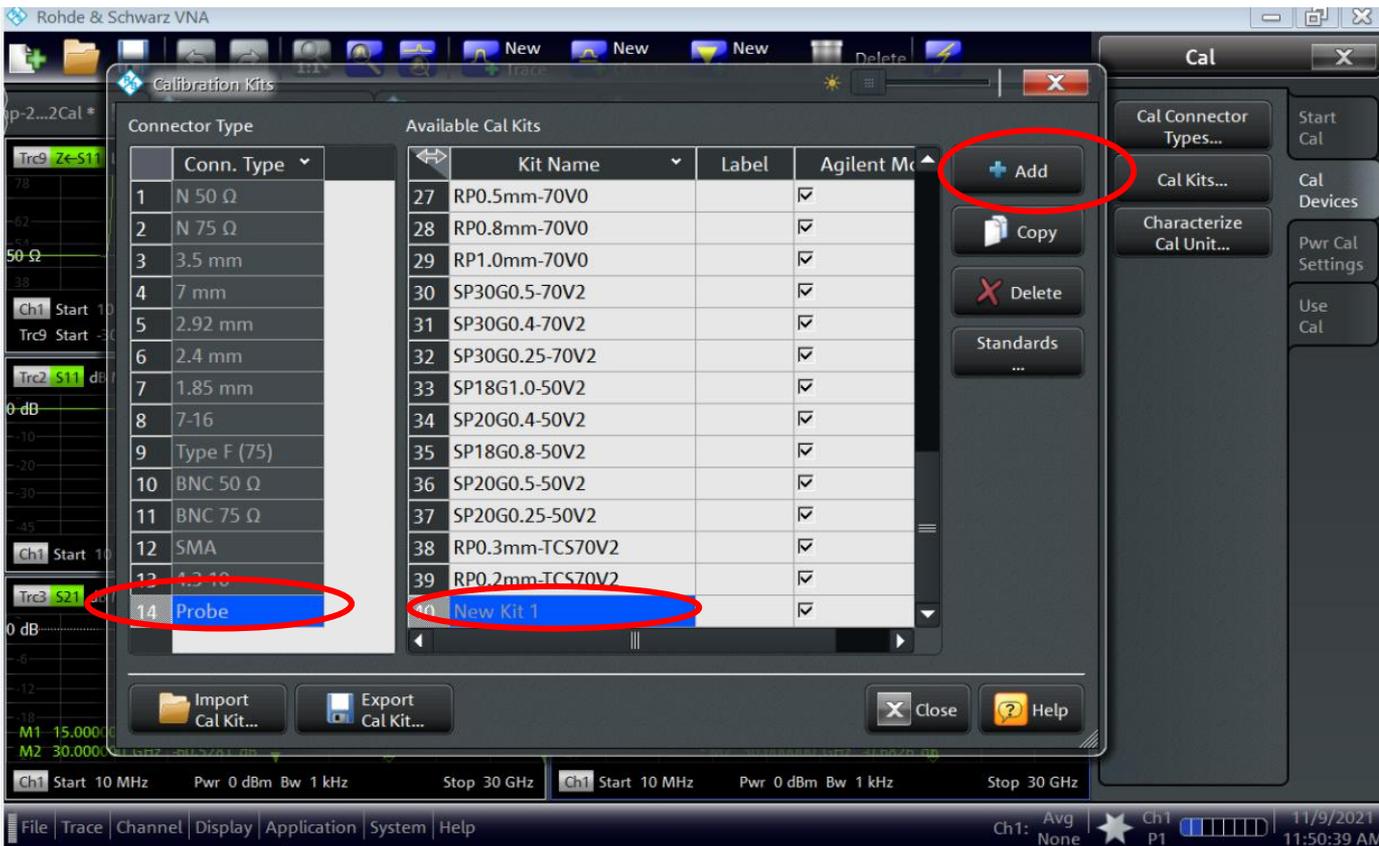


The screenshot shows the 'Cal Connector Types' dialog box in the Rohde & Schwarz VNA software. The dialog box contains a table with the following columns: Conn. Type, Sexless, Char. Imp., Line Type, Rel. Permittivity  $\epsilon_r$ , and Cutoff Freq.  $f_c$ . The 'Probe' connector type is highlighted with a red circle, and its 'Sexless' checkbox is checked.

Conn. Type	Sexless	Char. Imp.	Line Type	Rel. Permittivity $\epsilon_r$	Cutoff Freq. $f_c$
N 50 $\Omega$	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
N 75 $\Omega$	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	—
3.5 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
7 mm	<input checked="" type="checkbox"/>	50 $\Omega$	TEM	1.001	—
2.92 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
2.4 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
1.85 mm	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
7-16	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
Type F (75)	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	—
BNC 50 $\Omega$	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
BNC 75 $\Omega$	<input type="checkbox"/>	75 $\Omega$	TEM	1.001	—
SMA	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
4.3-10	<input type="checkbox"/>	50 $\Omega$	TEM	1.001	—
Probe	<input checked="" type="checkbox"/>	50 $\Omega$	TEM	1.001	—

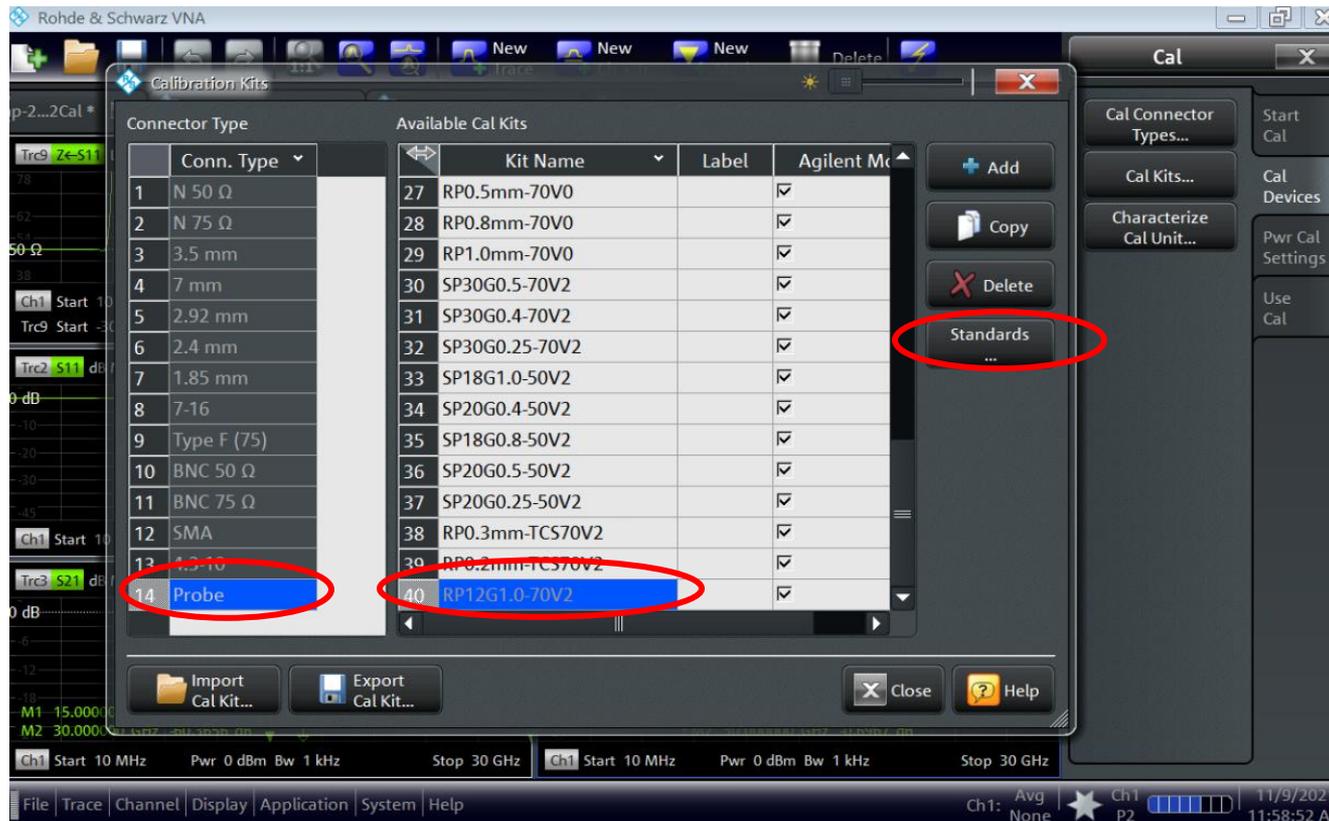
# Add Cal Kit

Press hard "Cal" button -> Cal Devices -> Cal Kits  
 Click on "Probe" -> Add -> Rename "New Kit 1" to "RP12G1.0-70V2"



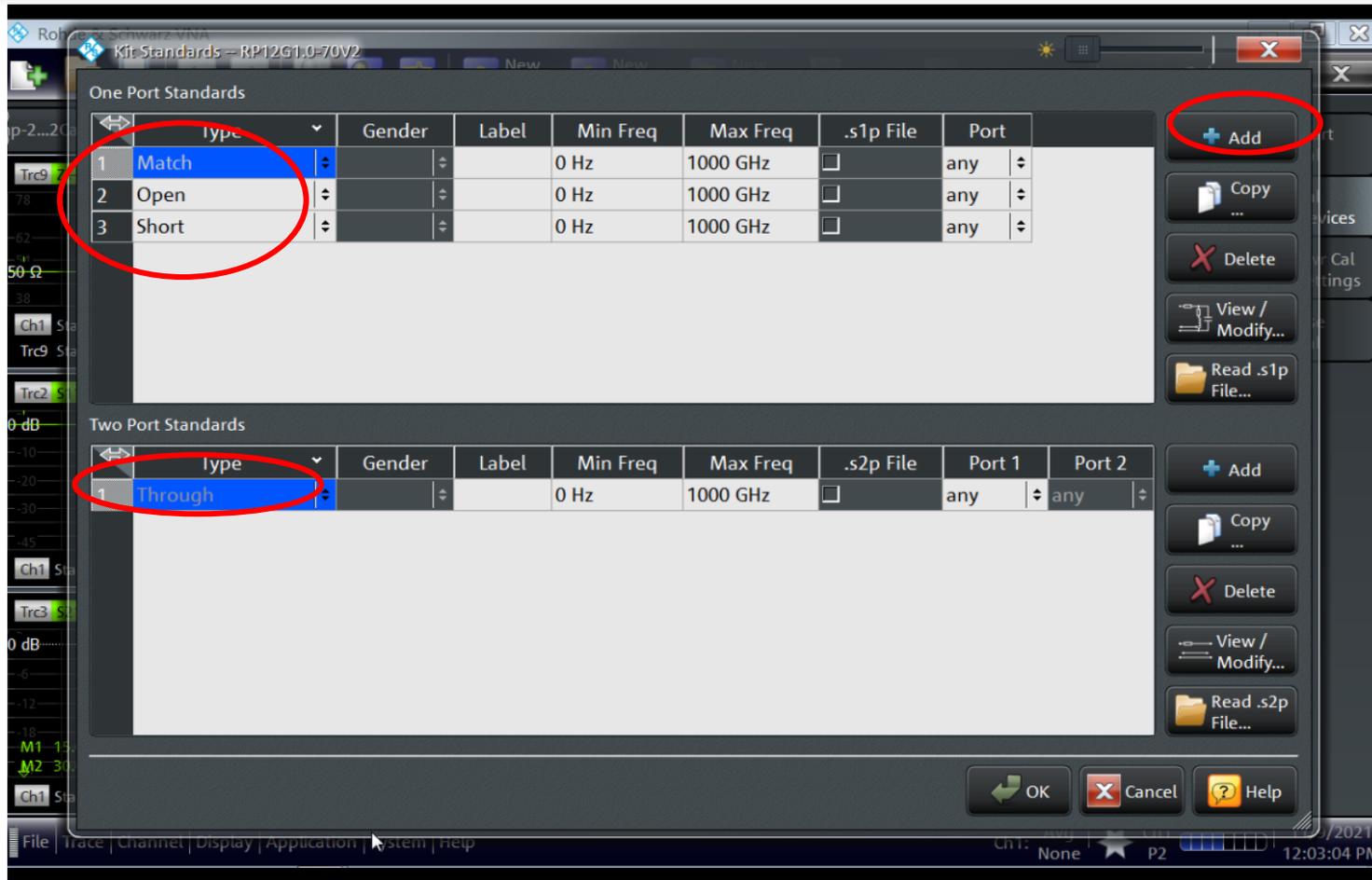
# View or Modify Cal Kit Standards

Press hard "Cal" button -> Cal Devices -> Cal Kits  
 Click on "Probe" -> RP12G1.0-70V2 -> Standard



Define or modify Cal Kit Standards

# Add Cal Kit Standards



Add Open, Short, Match and Through standards

# Enter Open Coefficient

Kit Standards – SP30G0.5-70V2

One Port Standards

Type	Gender	Label	Min Freq	Max Freq	.s1p File	Port
1 Open						
2 Short						
3 Match						

View / Modify Cal Kit Standards

Open

Probe  
SP30G0.5-70V2

Loss  
0 GΩ/s

Z0  
50 Ω

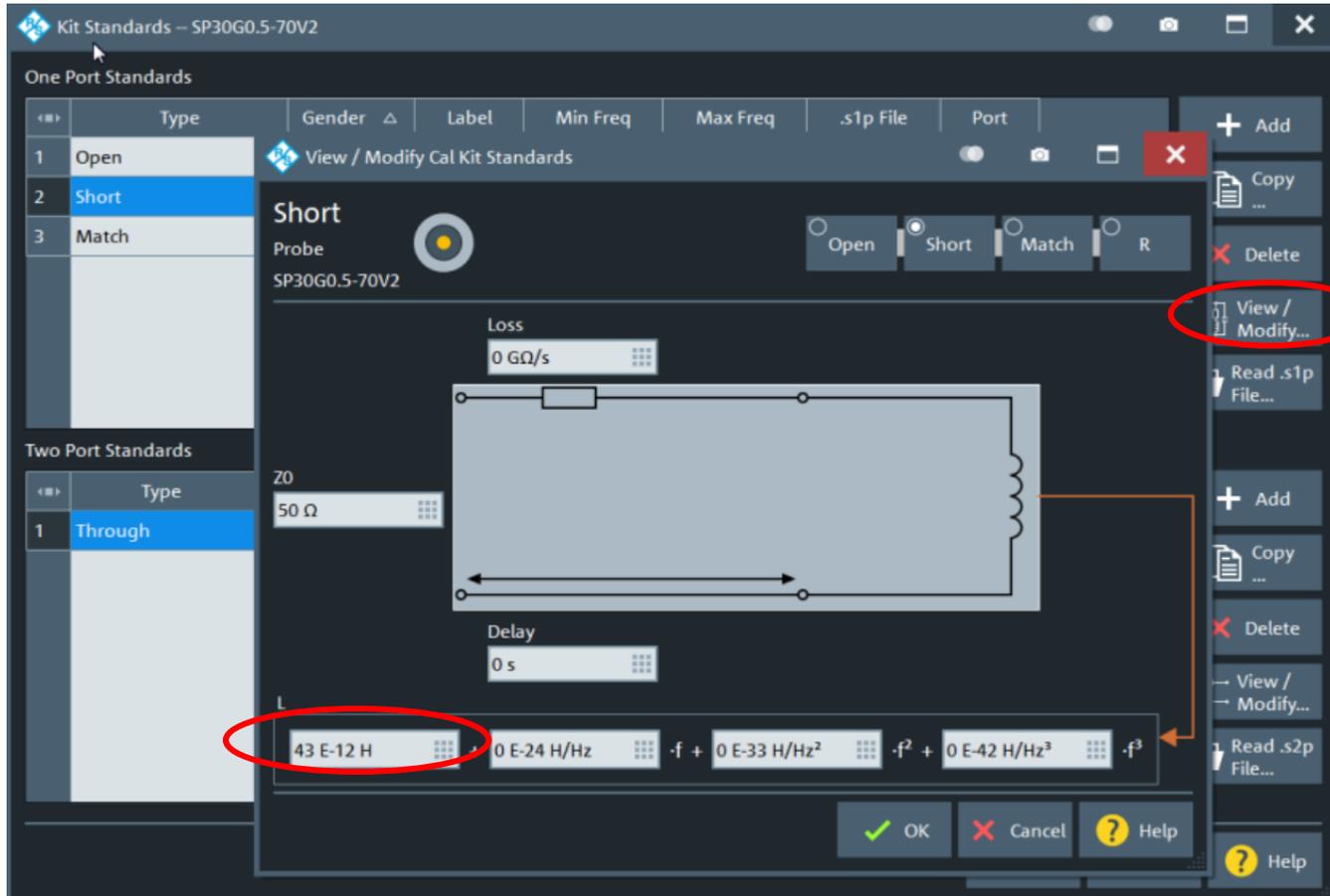
Delay  
0 s

C  
36.8 E-15 F    0 E-27 F/Hz    -f + 0 E-36 F/Hz²    -f² + 0 E-45 F/Hz³    -f³

OK    Cancel    Help

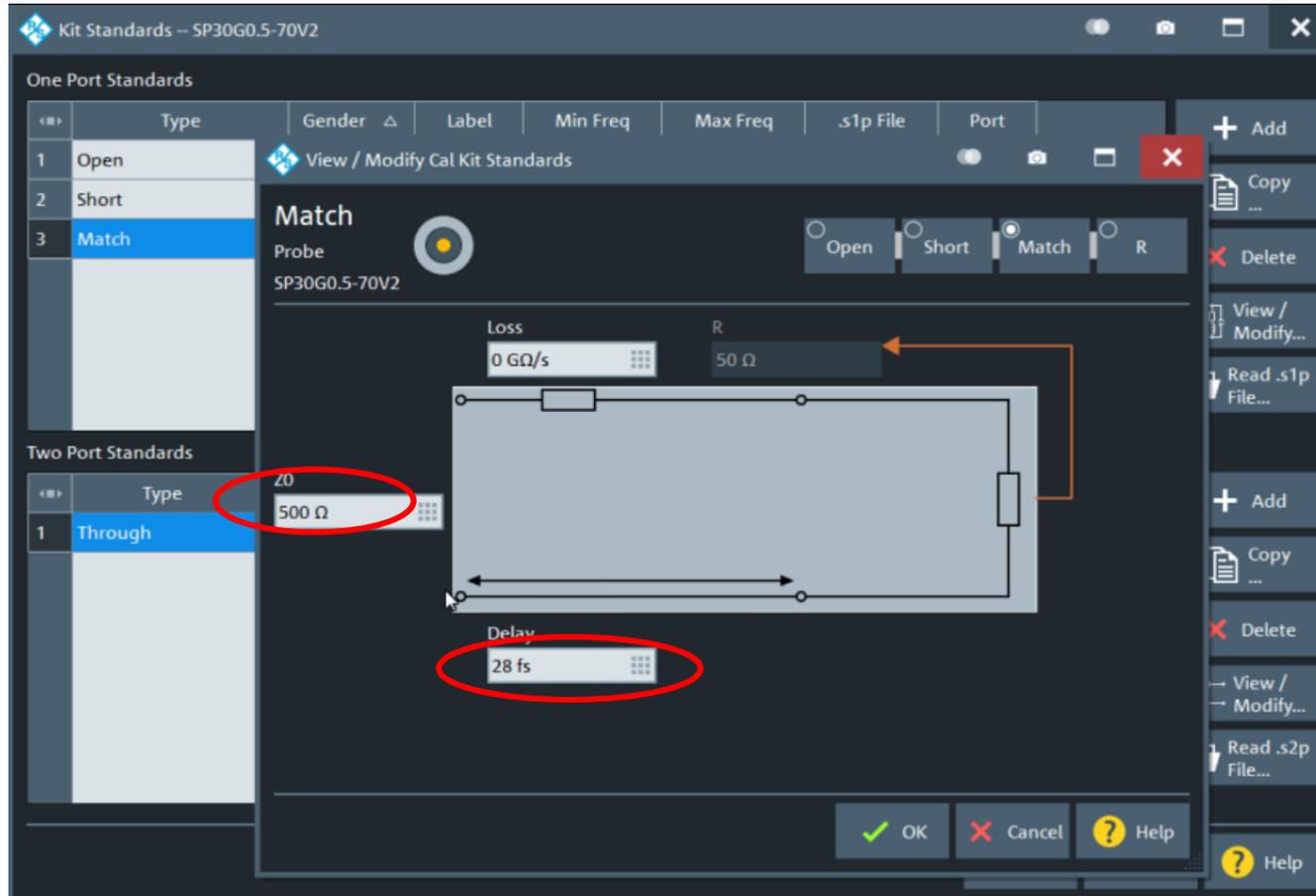
Enter coefficient for Open standard

# Enter Short Coefficient



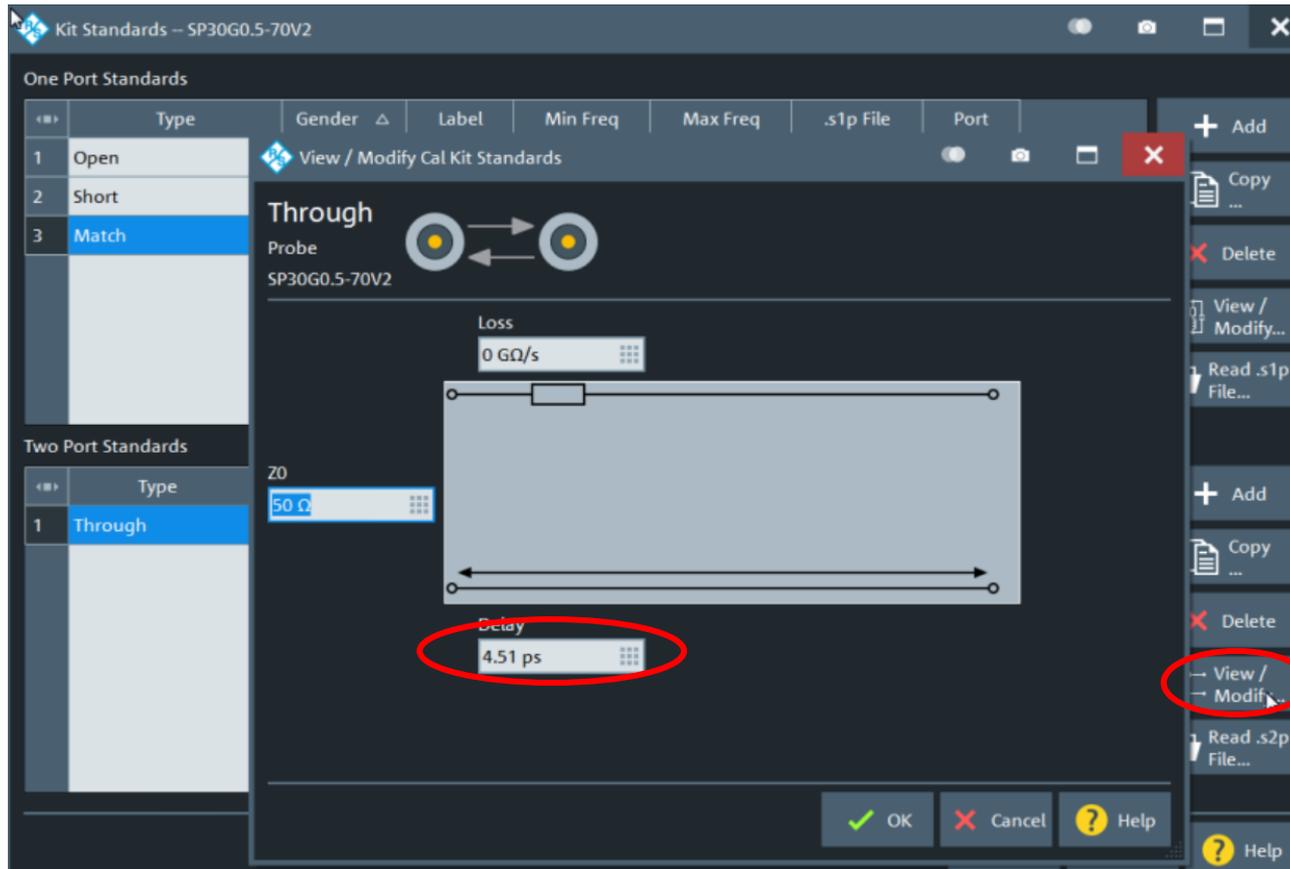
Enter coefficient for Short standard

# Enter Match (Load) Coefficient



Enter coefficient for Match (Load) standard

# Enter Through Coefficient



Enter coefficient for Through standard

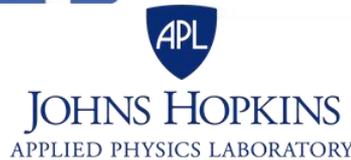
# PacketMicro Product Offering

<p>D-Probe S-Probe R-Probe</p>	<p>R-Probe for PDN testing</p>	<p>Delta-L 4.0 Solution</p>	<p>TCS70 Cal Substrate</p>	<p>S-Probe</p>
<p>Precision Positioners TP250 TP150</p>	<p>VPS10 2-Sided Probe Station</p>	<p>F80 FP40</p>	<p>Flex Positioners FP160MS FP160</p>	
<p>USB Type-C Fixtures</p>	<p>HPS24 Probe Station</p>	<p>AITT SI Tool</p>	<p>Slim Phase Stable Cable Up to 67 GHz Junkosha MWX161</p>	<p>Flex Probe Station Vertical &amp; Horizontal Probing in Minutes</p>

**PacketMicro offers one-stop shopping for your needs in PCB probing and SI analysis.**

- Rugged 40/30 GHz probes
- Probe Positioners
- DIY Probe Stations
- Junkosha phase-stable cables
- CSS AITT Signal-Integrity Tool
- Dino-Lite Microscopes

# PacketMicro Customers (of 200+ in 30+ Countries)



# Thank You

## We help make your probing tasks easy!

- Benchtop DIY Probe Stations
- Rugged 40 GHz Differential Probes
- Rugged 30 GHz Single-ended Probes
- Laboratory Rental
- Engineering Services
- Signal Integrity Consulting

### Contact:

support@packetmicro.com

Office: 408-675-3900

2312 Walsh Avenue, Suite A, Santa Clara, CA 95051, USA