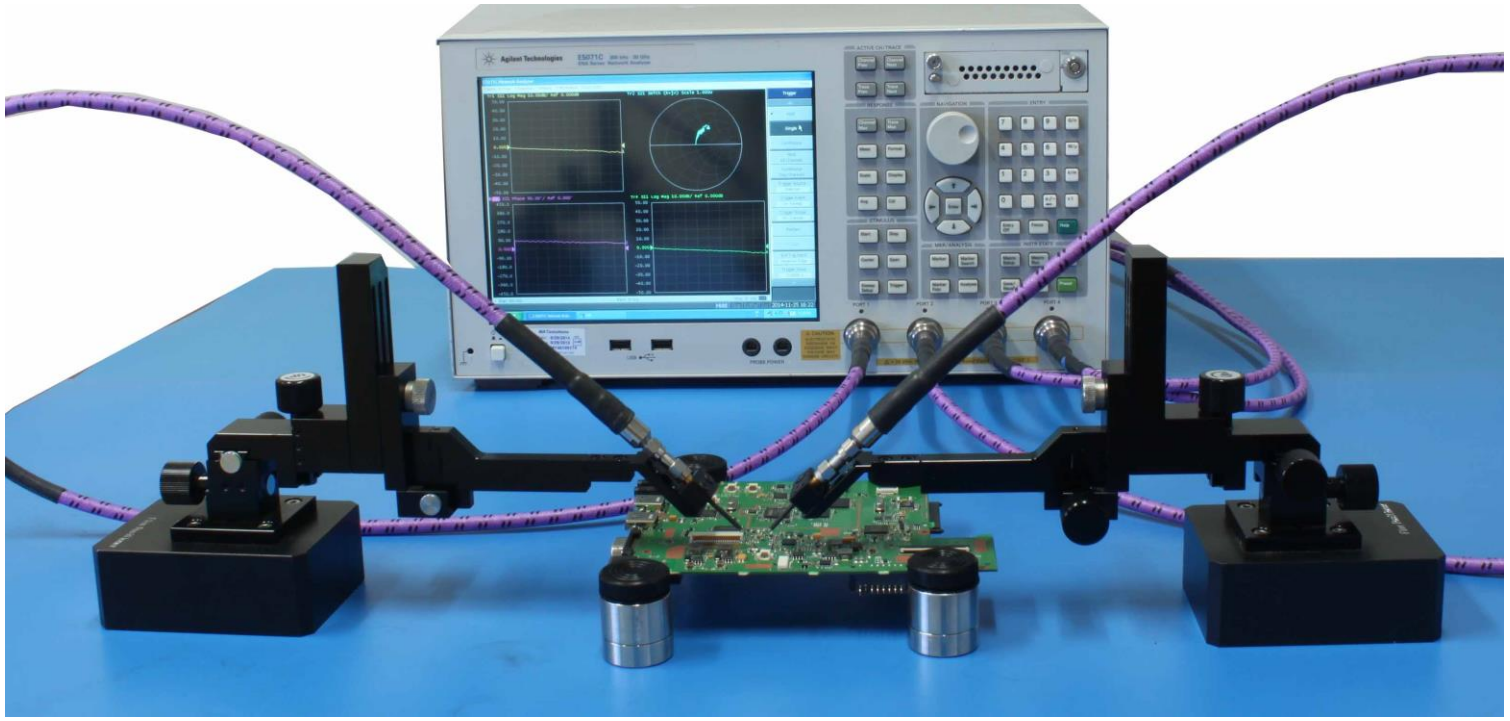
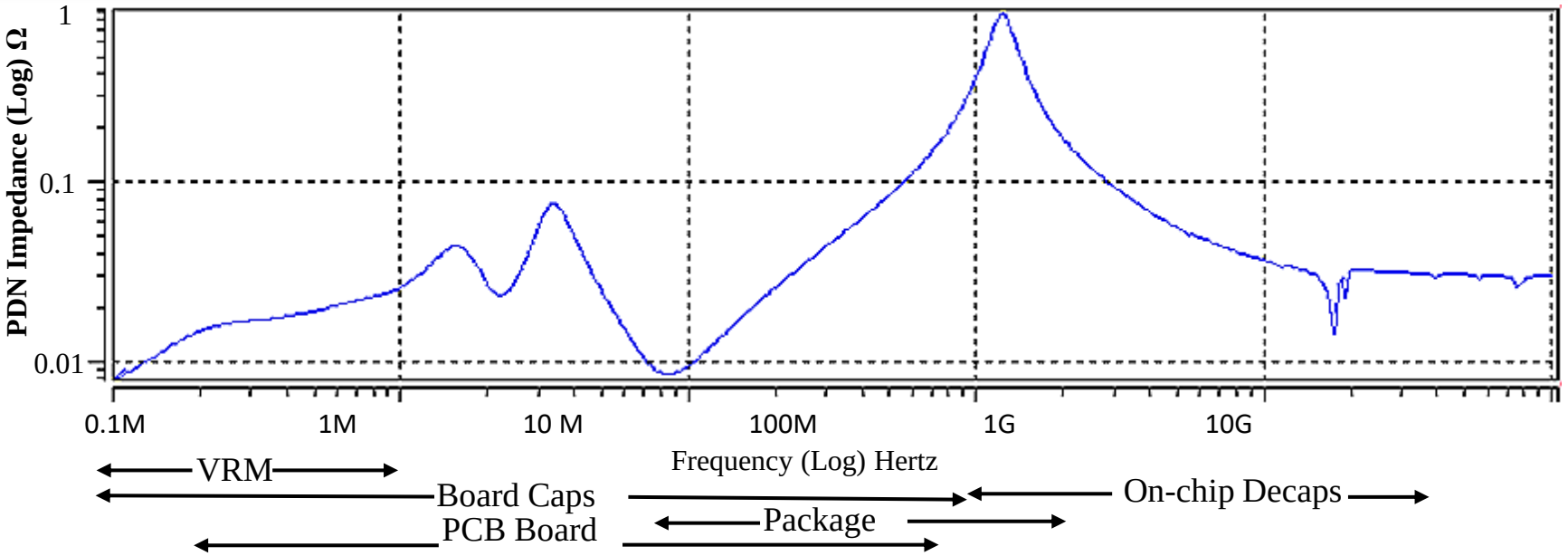
PACKETMICRO
Innovative Benchtop Probing Solutions

Power Integrity Measurement
With
Keysight VNA

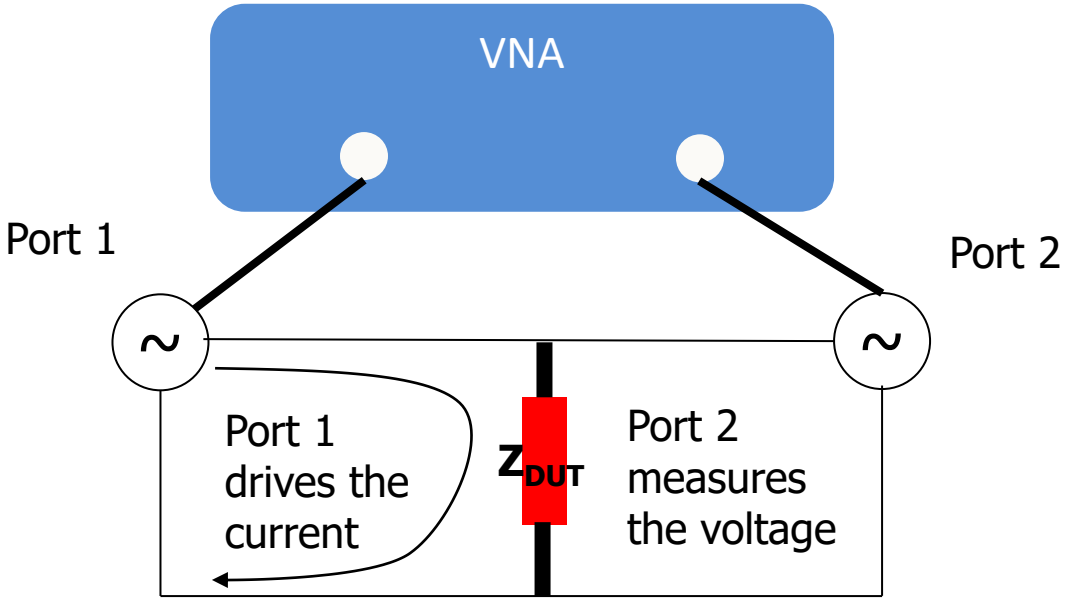


Typical PDN Impedance Profile



- Impedance profile formed by the interaction of various PDN components
- Impedance peak at package/chip resonance
- Peak impedance dependent on package, PCB, and on-chip parameters
- Typical impedance in the range of tens of milliohms

2-Port VNA Measurements of Low Z_{DUT}



- 1st order Analysis

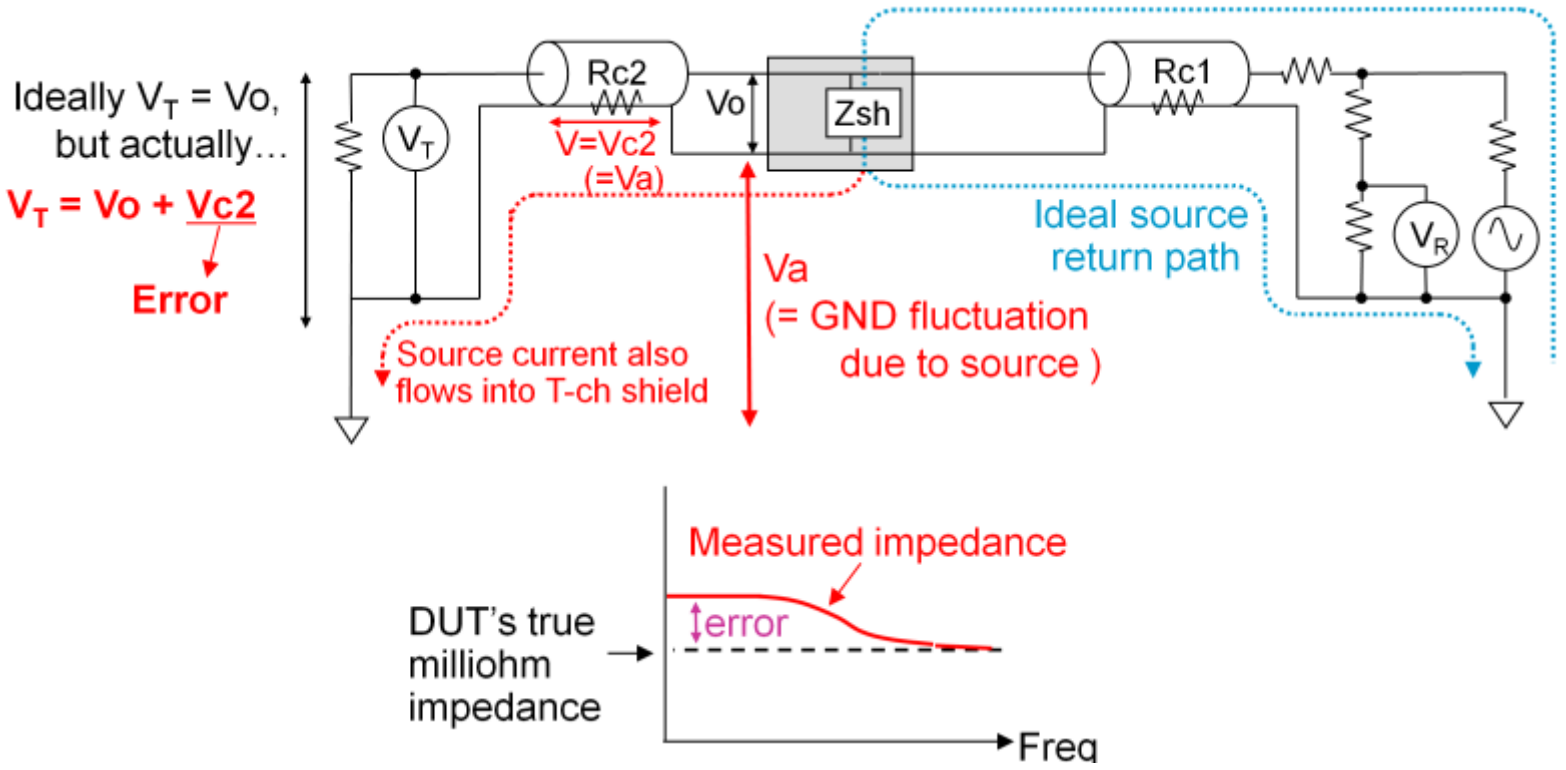
  ($Z_{DUT} << Z_o$)

  $$Z_{DUT} = 25\ S_{21}\ \Omega$$

- 2nd order Analysis

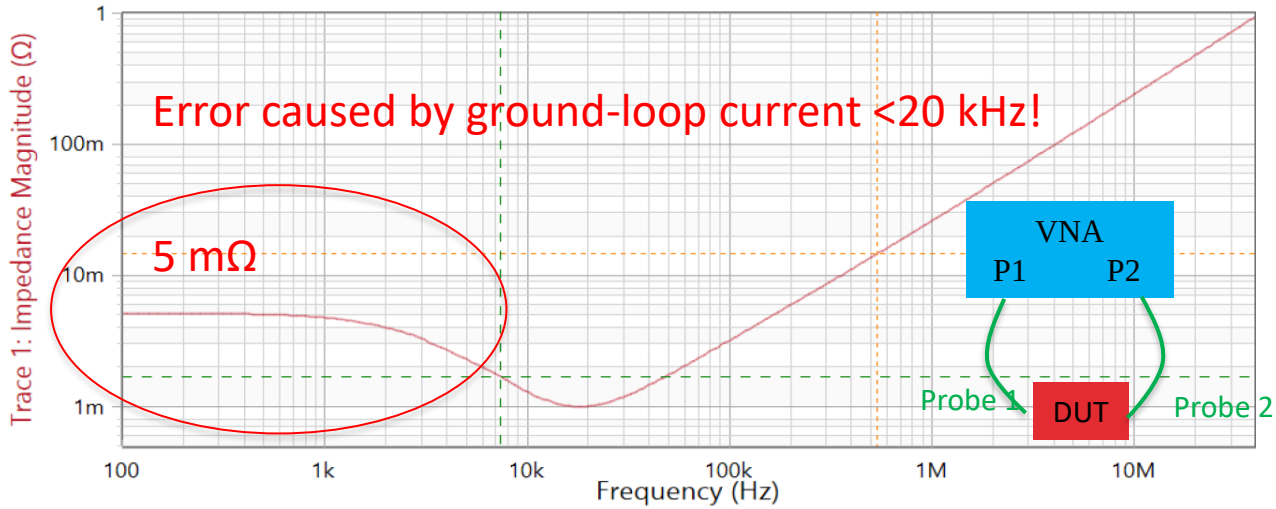
  $$Z_{DUT} = 25\ \frac{S_{21}}{1 - S_{21}}\ \Omega$$

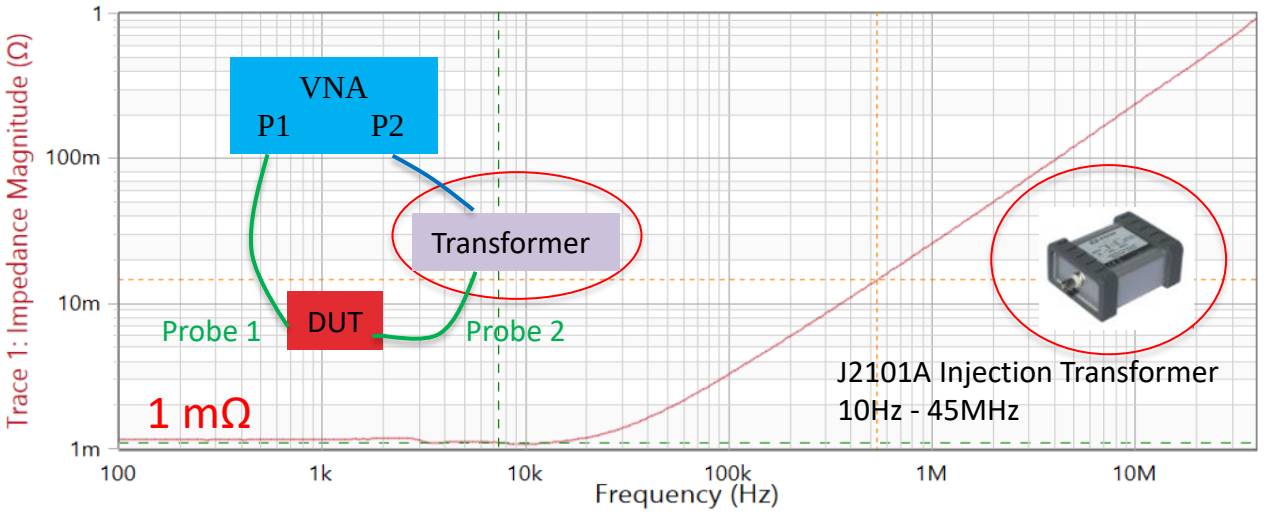
Low-Freq Errors Caused by Ground Loop



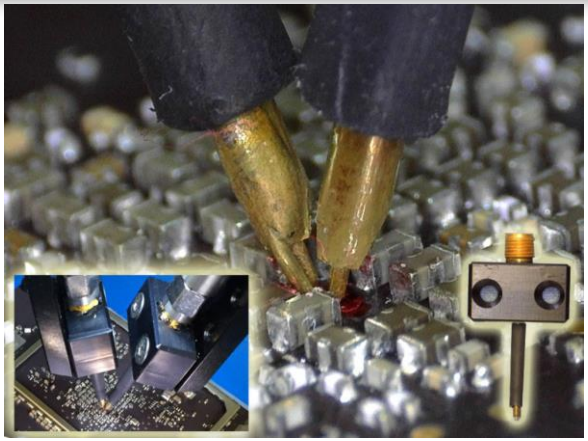
If the DUT's impedance is very small (ZDUT < tens of milliohms)
Source current flows into source-to-receiver cable GND loop.
Measurement errors occur at LF range (<20kHz)

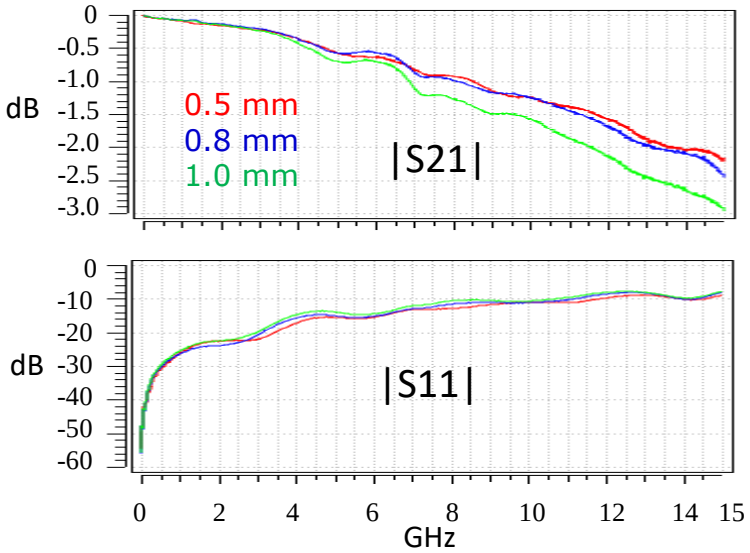
Use Transformer to Break the Ground Loop





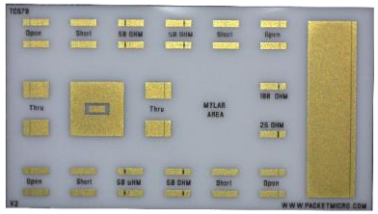
18 GHz R-Probe





R-Probe is ideal for probing a populated board with test points surrounded by components because of its 30-mil probe tips. Typical R-Probe applications are PDN and RF measurements.

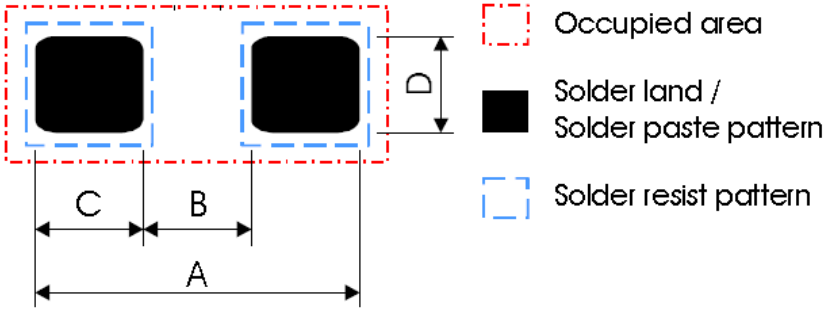
TCS70 Calibration Substrate



Specifications:
Substrate: Polished alumina
Structure: Open, short, thru, 25 Ω, 50 Ω, 100 Ω
Contact Material: Gold
Accuracy: 25 Ω, 50 Ω < 0.5%, 100 Ω < 1%
Size: 17.3 x 9.4 x 0.6 mm (0.68 x 0.37 x 0.025 in)

R-Probe Part No.
- **RP-GR-151502** – 18 GHz, 0.2 mm/ 8 mil pitch
- **RP-GR-151503** – 18 GHz, 0.3 mm/ 8 mil pitch
- **RP-GR-151504** – 15 GHz, 0.4 mm/16 mil pitch
- **RP-GR-151505** – 15 GHz, 0.5 mm/20 mil pitch
- **RP-GR-121508** – 12 GHz, 0.8 mm/32 mil pitch
- **RP-GR-121510** – 12 GHz, 1.0 mm/40 mil pitch

Probe-Pitch Selection



R-Probe Part Number:

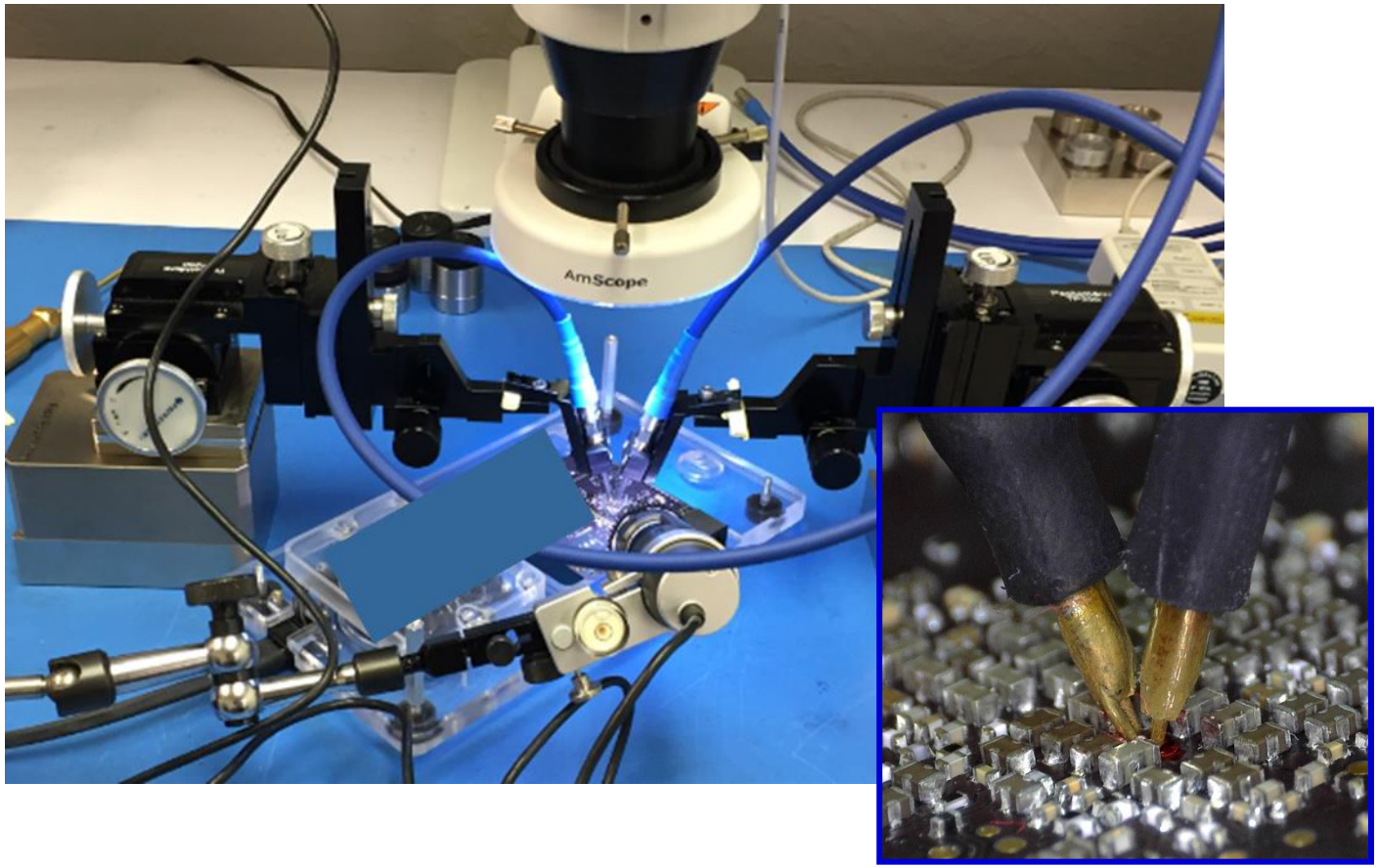
- **RP-GR-181502** – 18 GHz, 0.2 mm/ 8 mil pitch
- **RP-GR-181503** – 18 GHz, 0.3 mm/ 12 mil pitch
- **RP-GR-151504** – 15 GHz, 0.4 mm/ 16 mil pitch
- **RP-GR-151505** – 15 GHz, 0.5 mm/ 20 mil pitch
- **RP-GR-121508** – 12 GHz, 0.8 mm/ 32 mil pitch
- **RP-GR-121510** – 12 GHz, 1.0 mm/ 40 mil pitch

Recommendation: B + 0.2 mm < Probe Pitch < A – 0. 2mm

Size	Probe Pitch	A	B	C	D	Component Size
01005	RP-GR-181503	0.48	0.12	0.18	0.20	0.4 x 0. 2
0201	RP-GR-151505	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

Typical Reflow Soldering Footprint and Component Size in mm

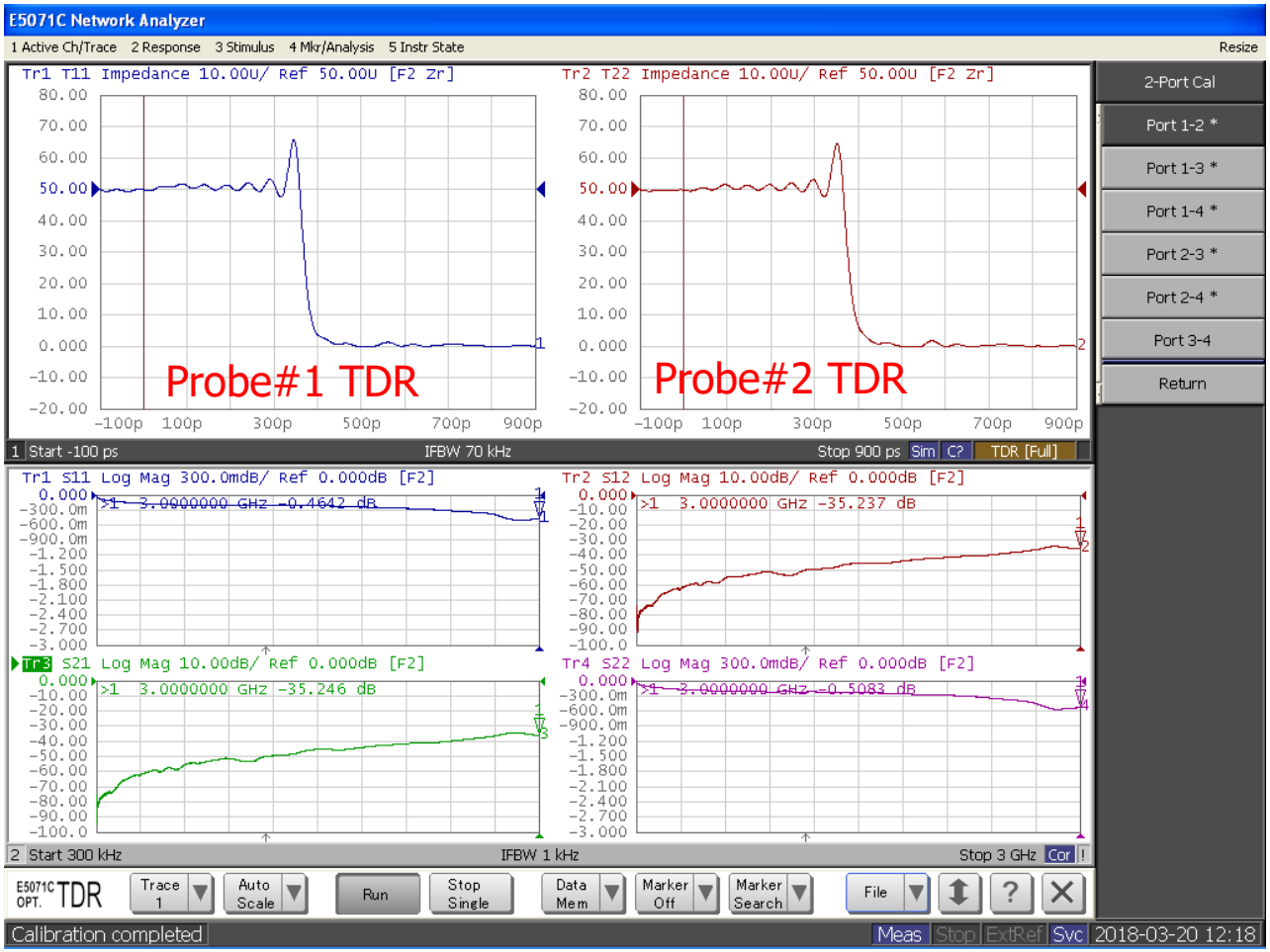
Power Integrity Probing



- PI Probing amid surrounding components is challenging

Milliohm PDN Measurements

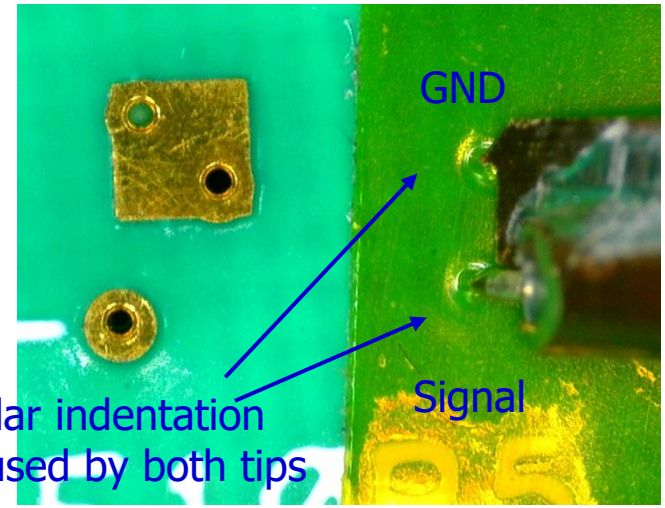
PDN Measurement with E5071C VNA

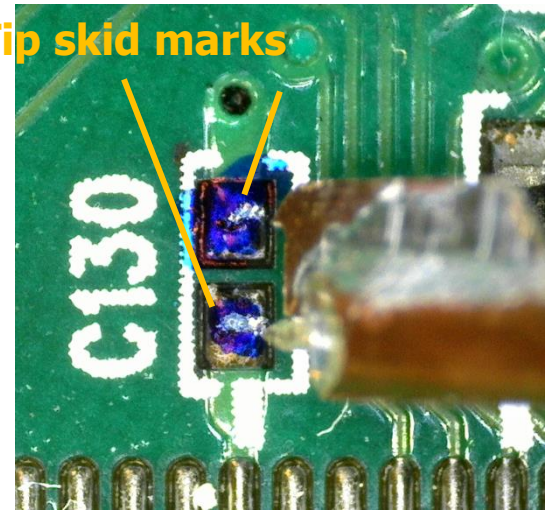


Use TDR channel to ensure good probe-tip contact!

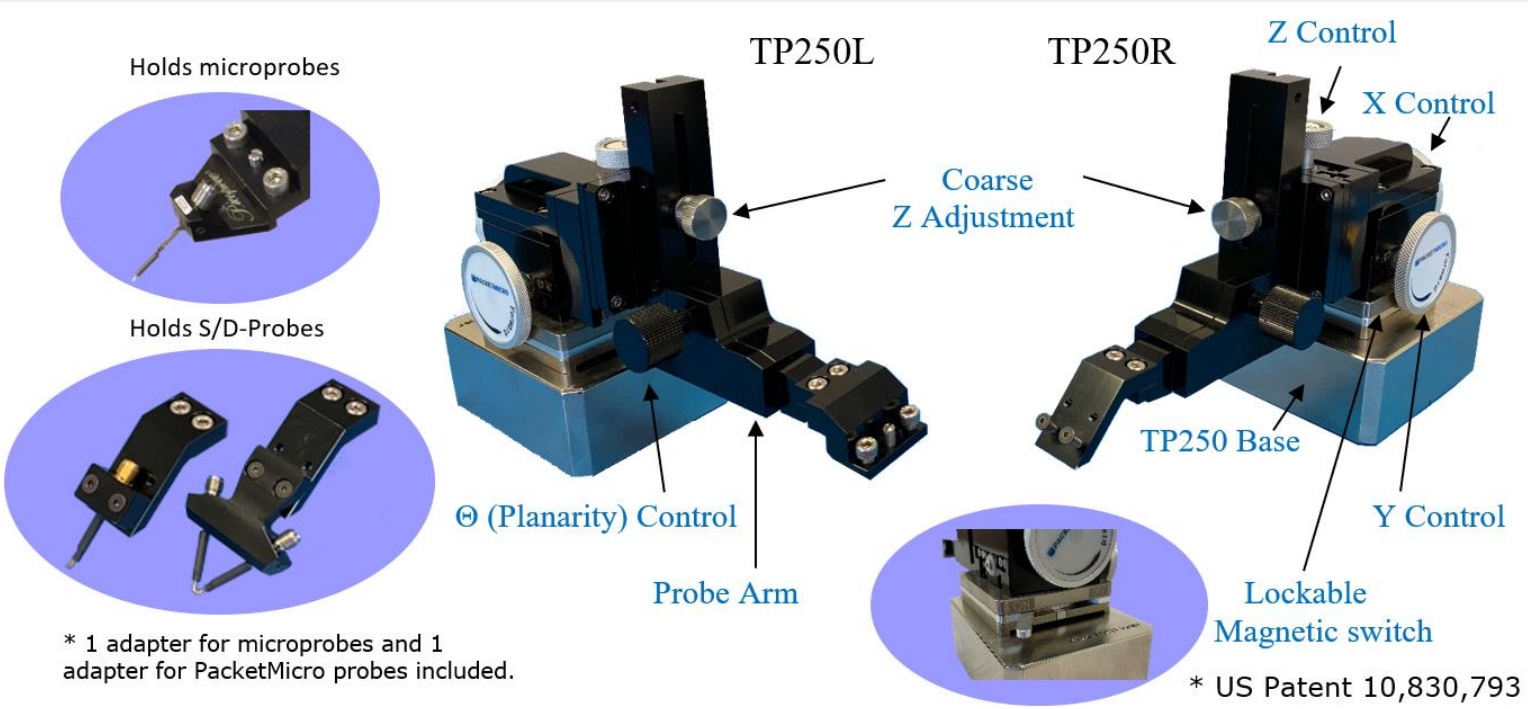
Probe Planarization Tips

- 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).
- A good microscope is important. You might damage the probe if you cannot see its tips well.



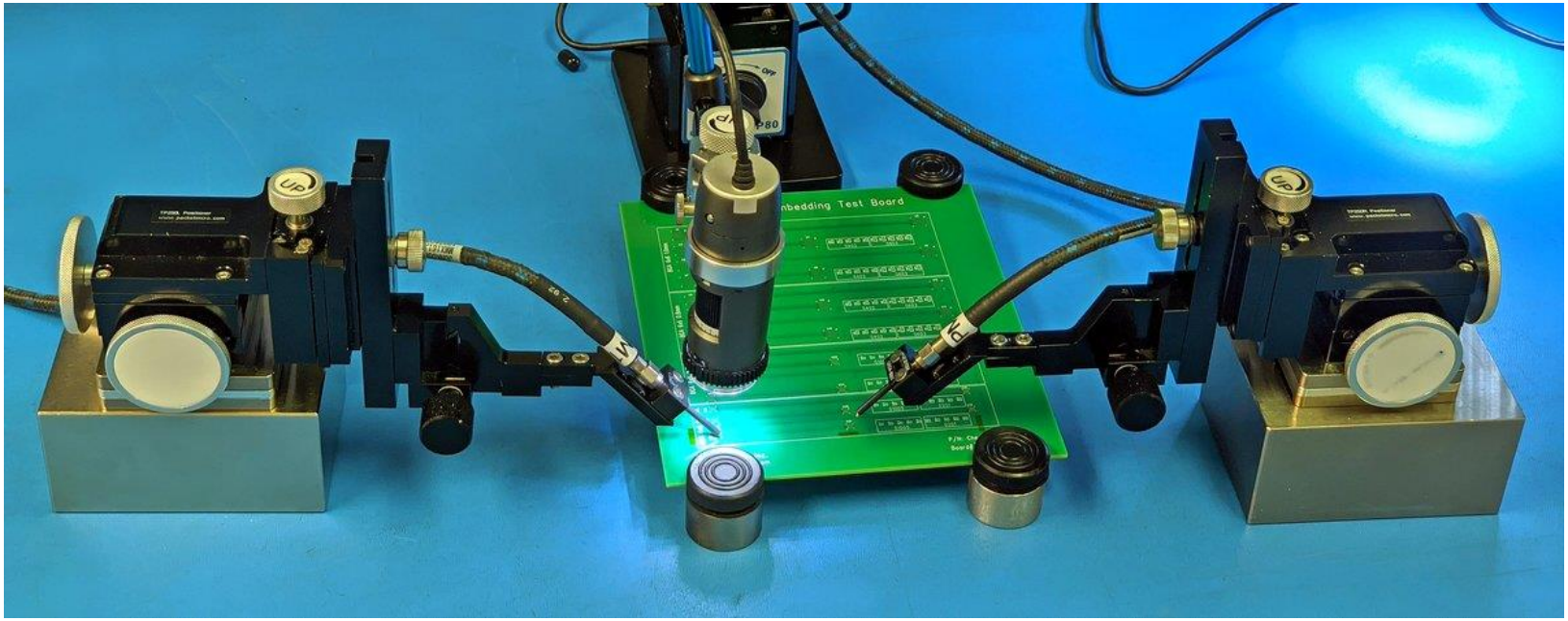


TP250 Precision Positioner



- **XYZ-axis travel**: 16 mm with 500 μm/turn (50 TPI, 5μm resolution)
- **Height coarse adjustment**: 5 mm/step (14 steps)
- **Θ (Planarity) control**: ±10° with 2.5° /turn and 0.025° resolution
- **Dimension**: 9” L x 2.7” W x 4.3” H
- **Weight**: 2.86 lb./1.30 kg

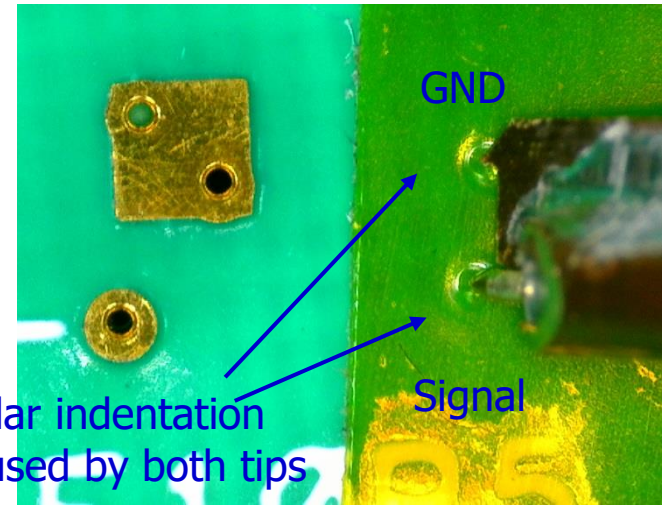
Probe Planarization with TP250

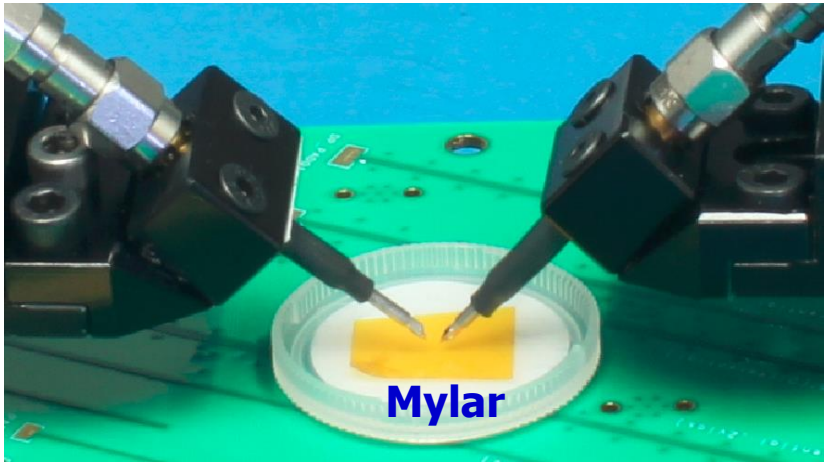


Probe Planarization Video:
https://packetmicro.com/Videos/PacketMicro_Probe_Planarization.mp4

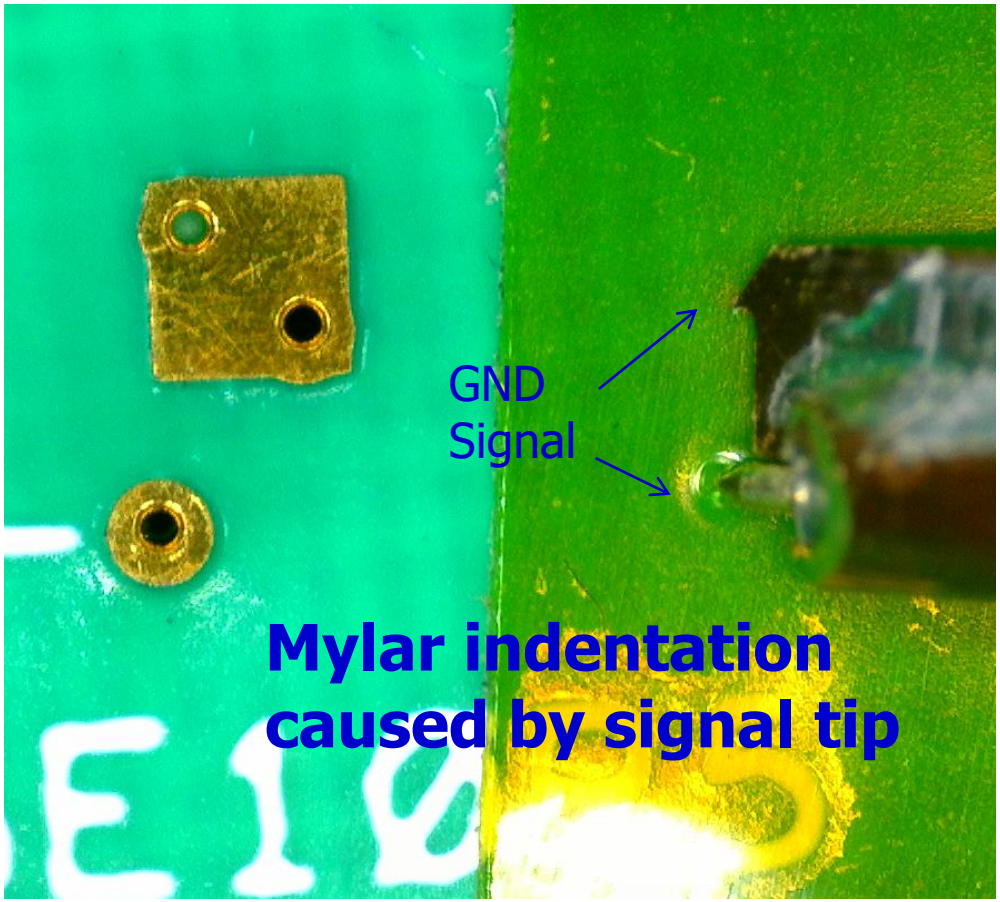
Probe Planarization on Even Surface

- 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.





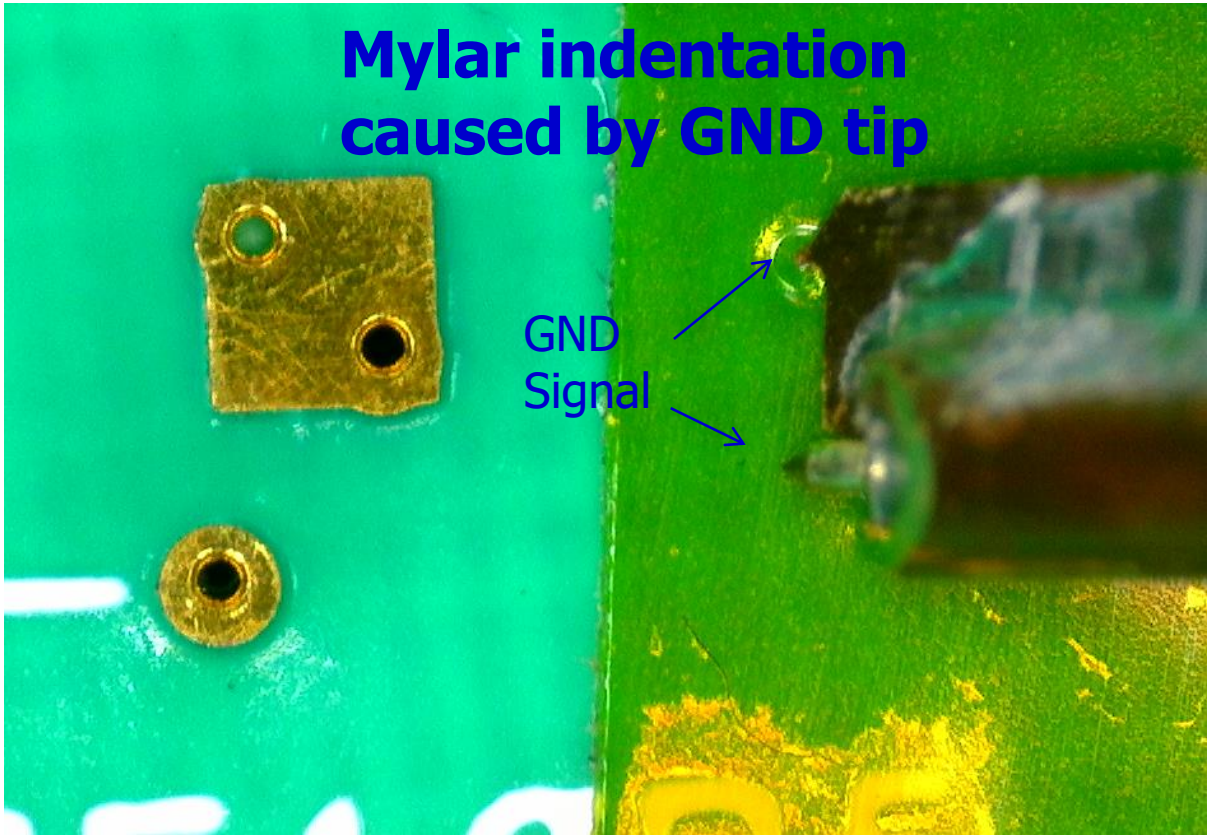
Signal tip touches down first



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.

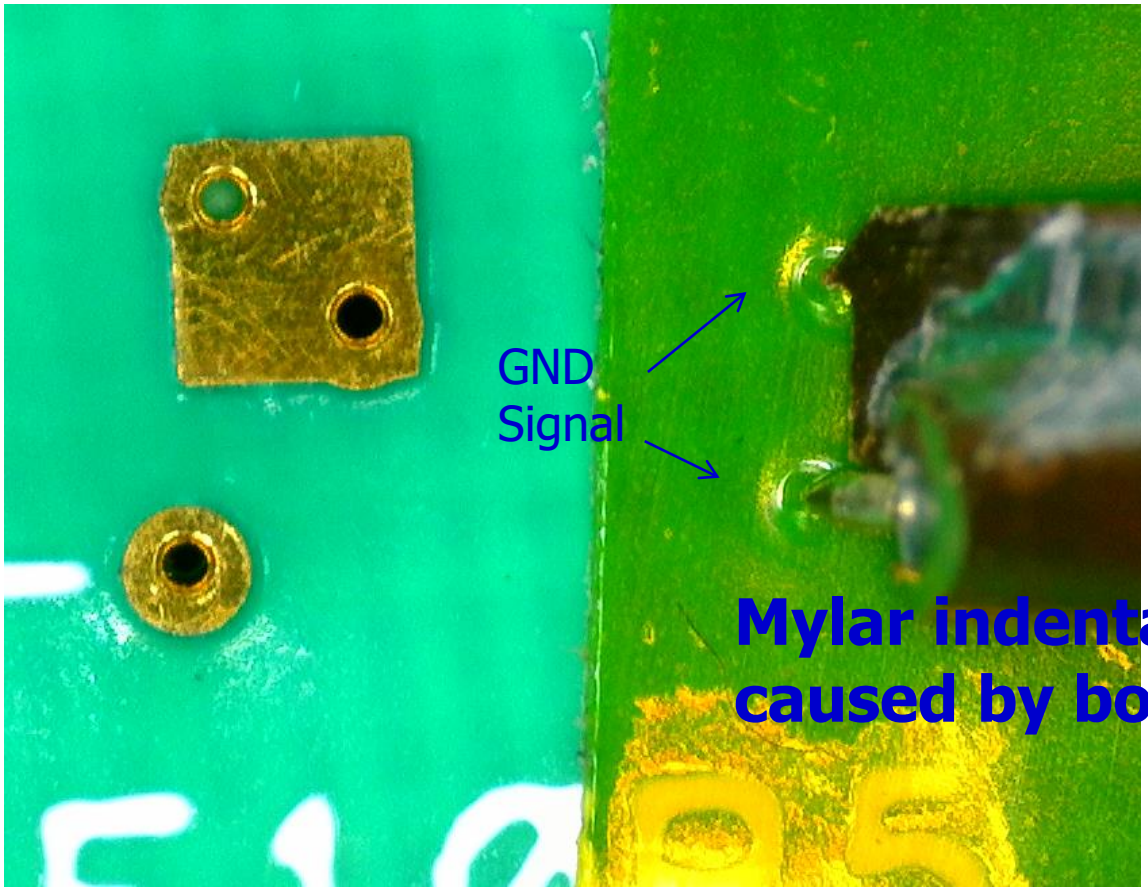
GND tip touches down first



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

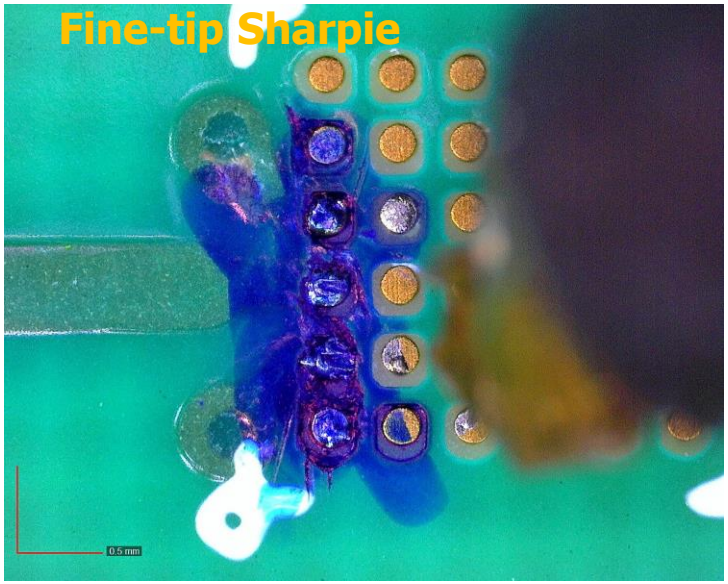


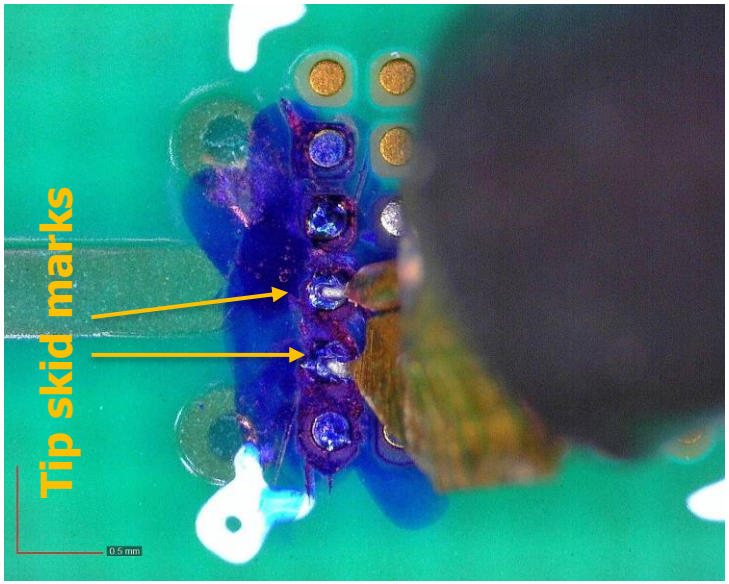
Step 3:

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

Land Probe Tips on Solder Bumps

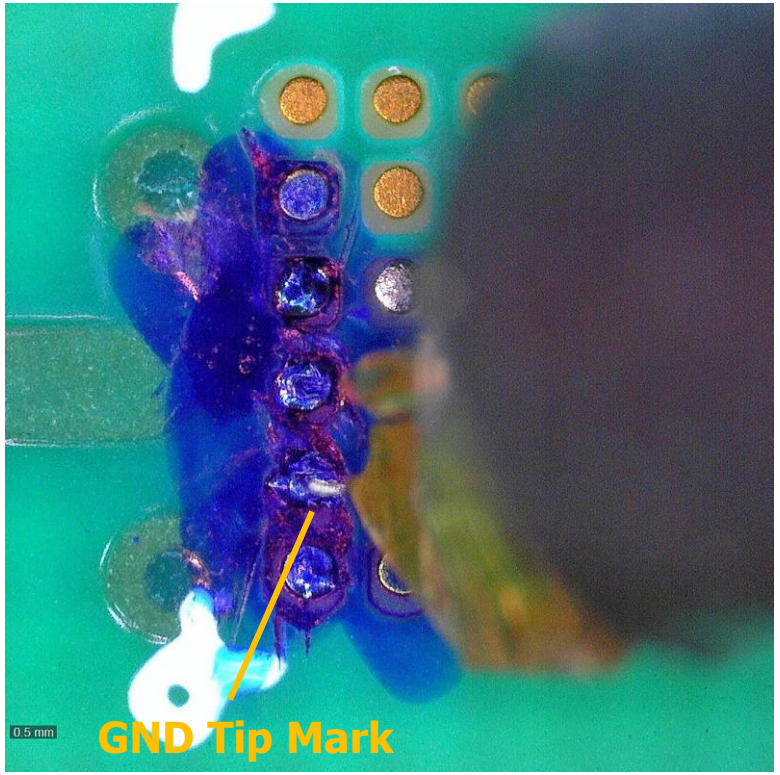
- Color solder bumps with a Sharpie
- Use the probe skid marks to confirm good tip contact
- Clean up the solder bumps with industrial alcohol after probing





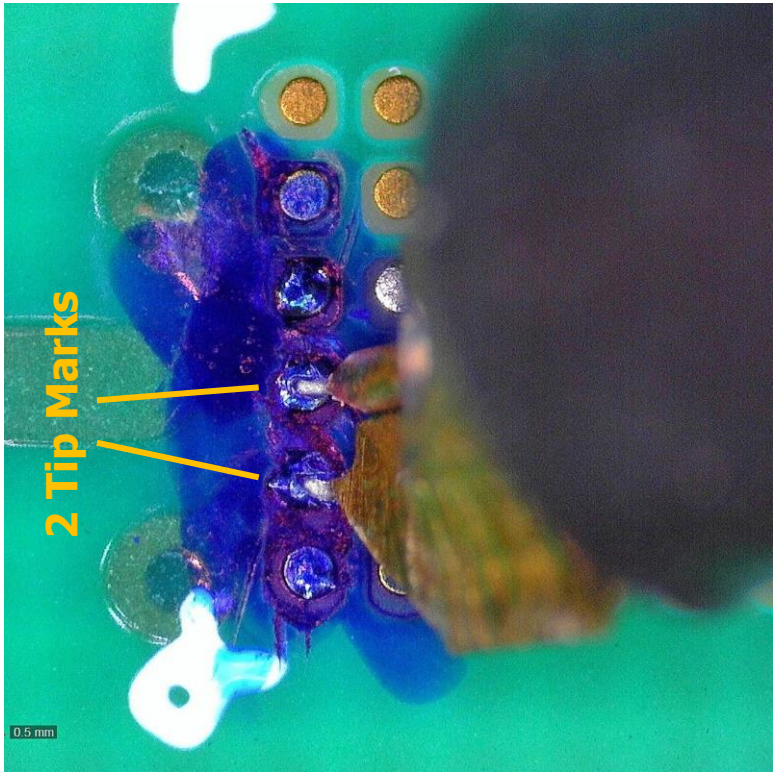
Use Probe Skid Marks as Guidance

Top signal tip touches down first

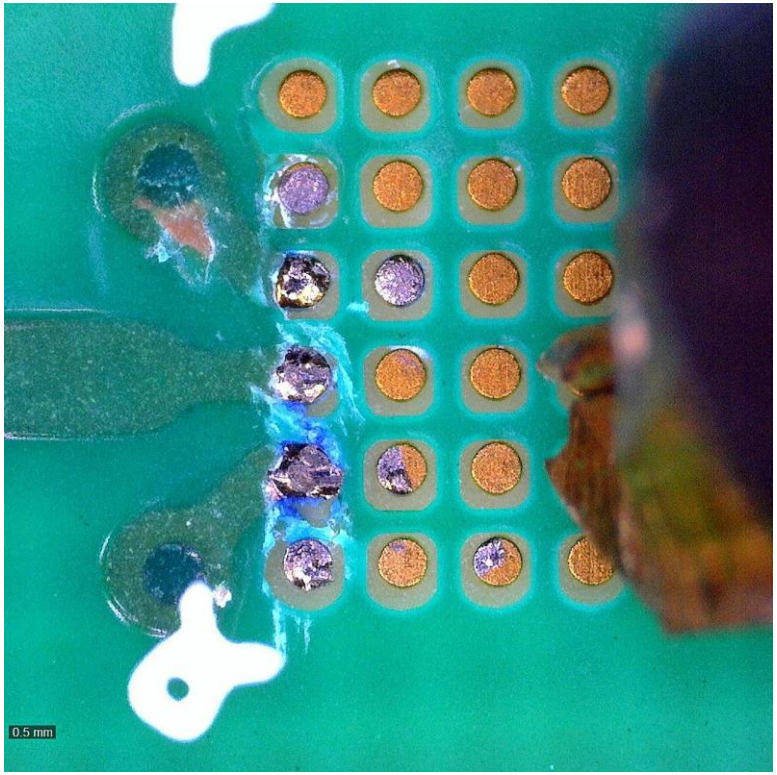


Bottom GND tip touches down first

Both Tips Touch Down Simultaneously

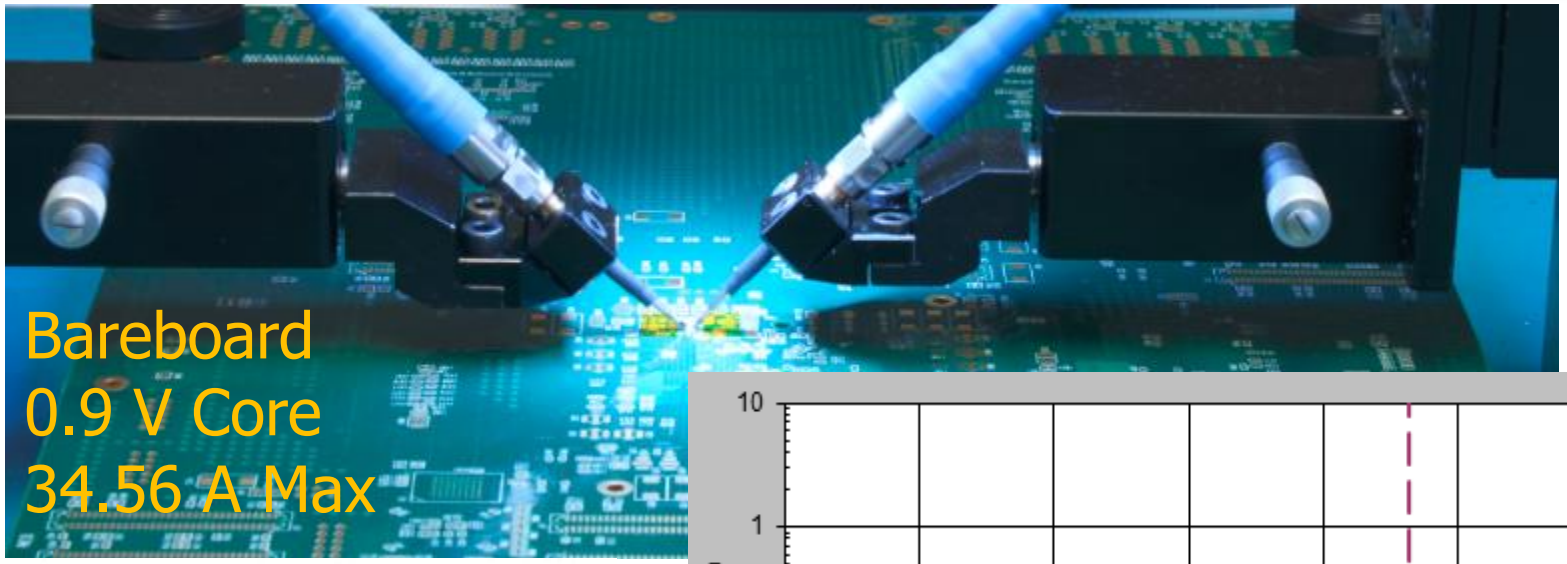


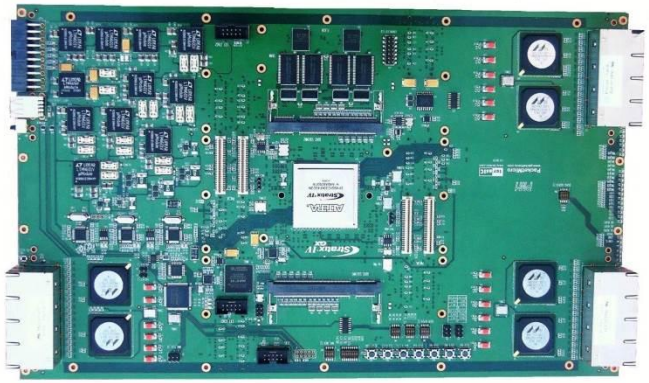
Both tips touch down simultaneously



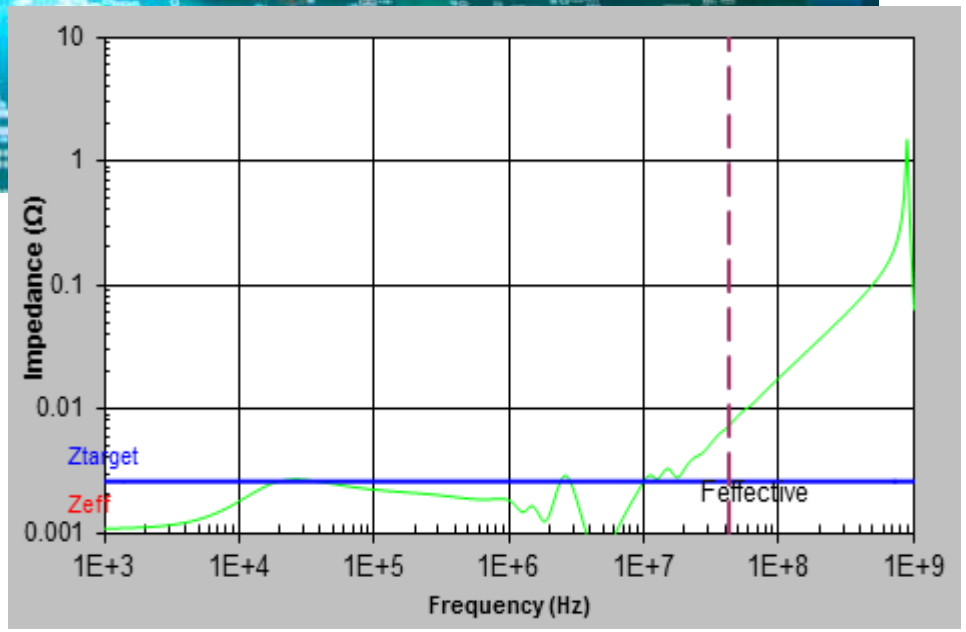
Clean up solder bumps with industrial alcohol after probing

22-Layer Stratix III Test Board



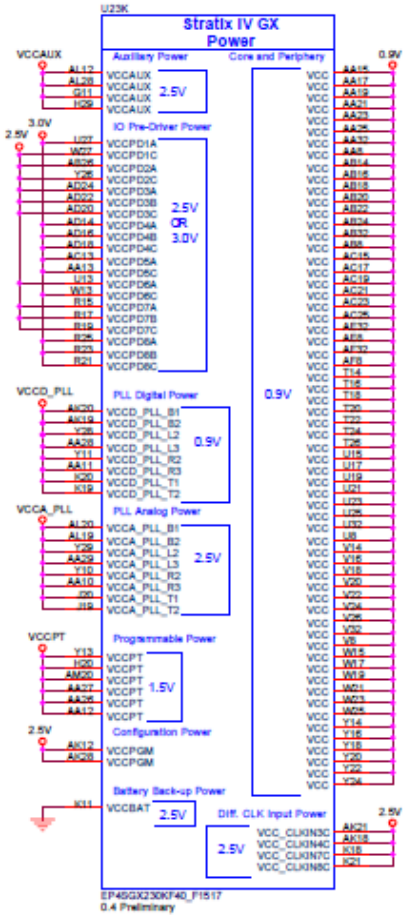


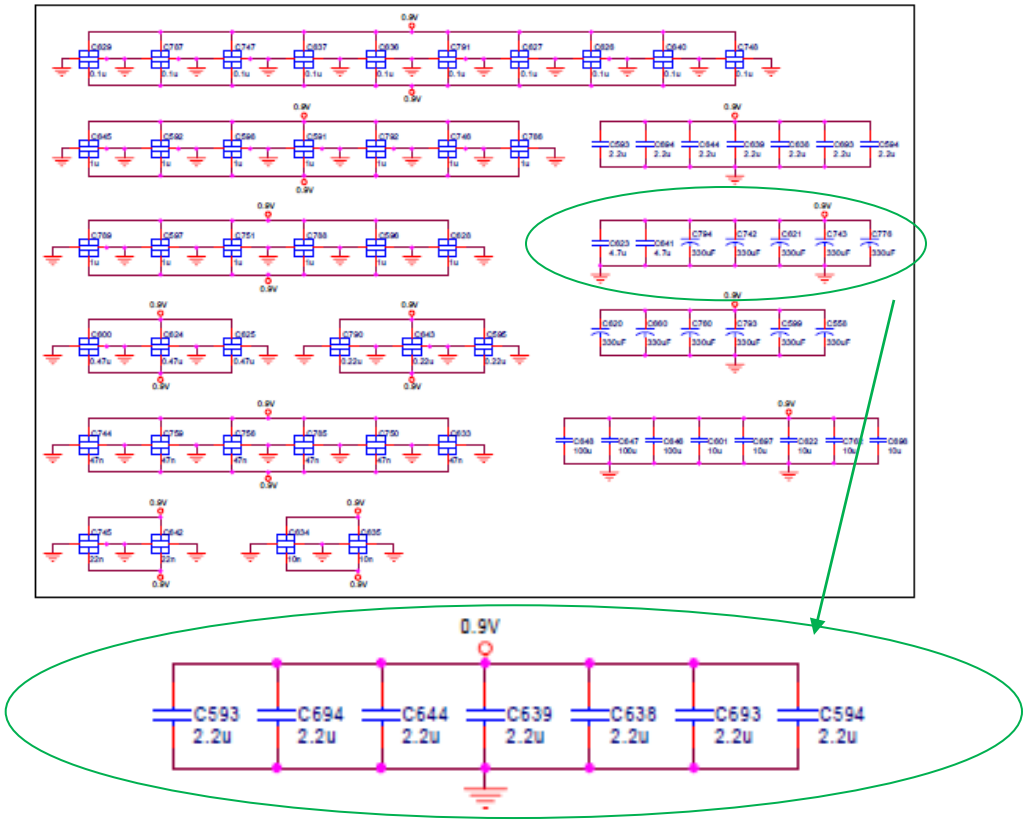
22-layer Stratix III board



PDN Impedance Requirement

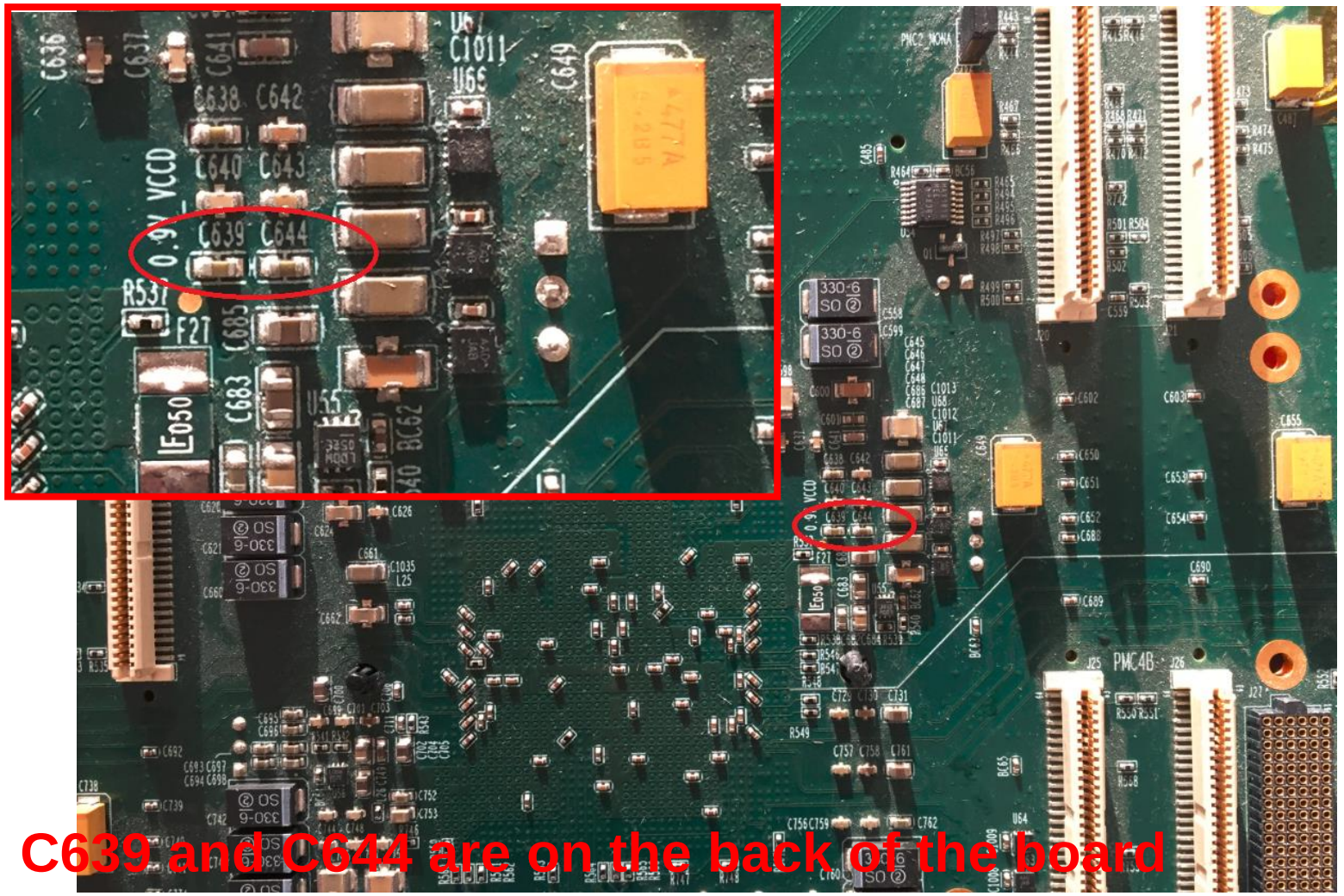
PI Probing Demo



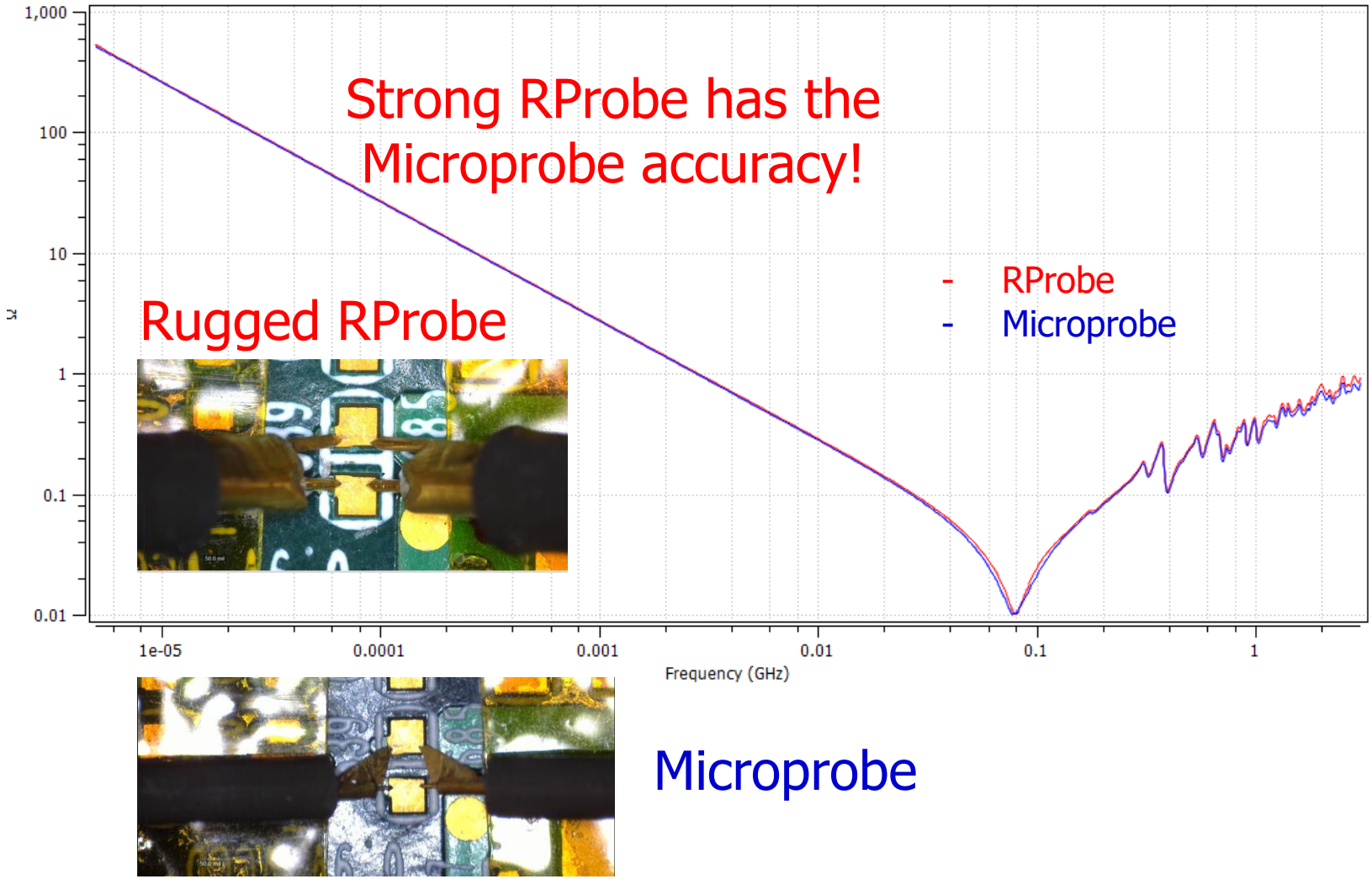


- **Measure impedance of 0.9 V core voltage**
- **Probe on C639 and C644**

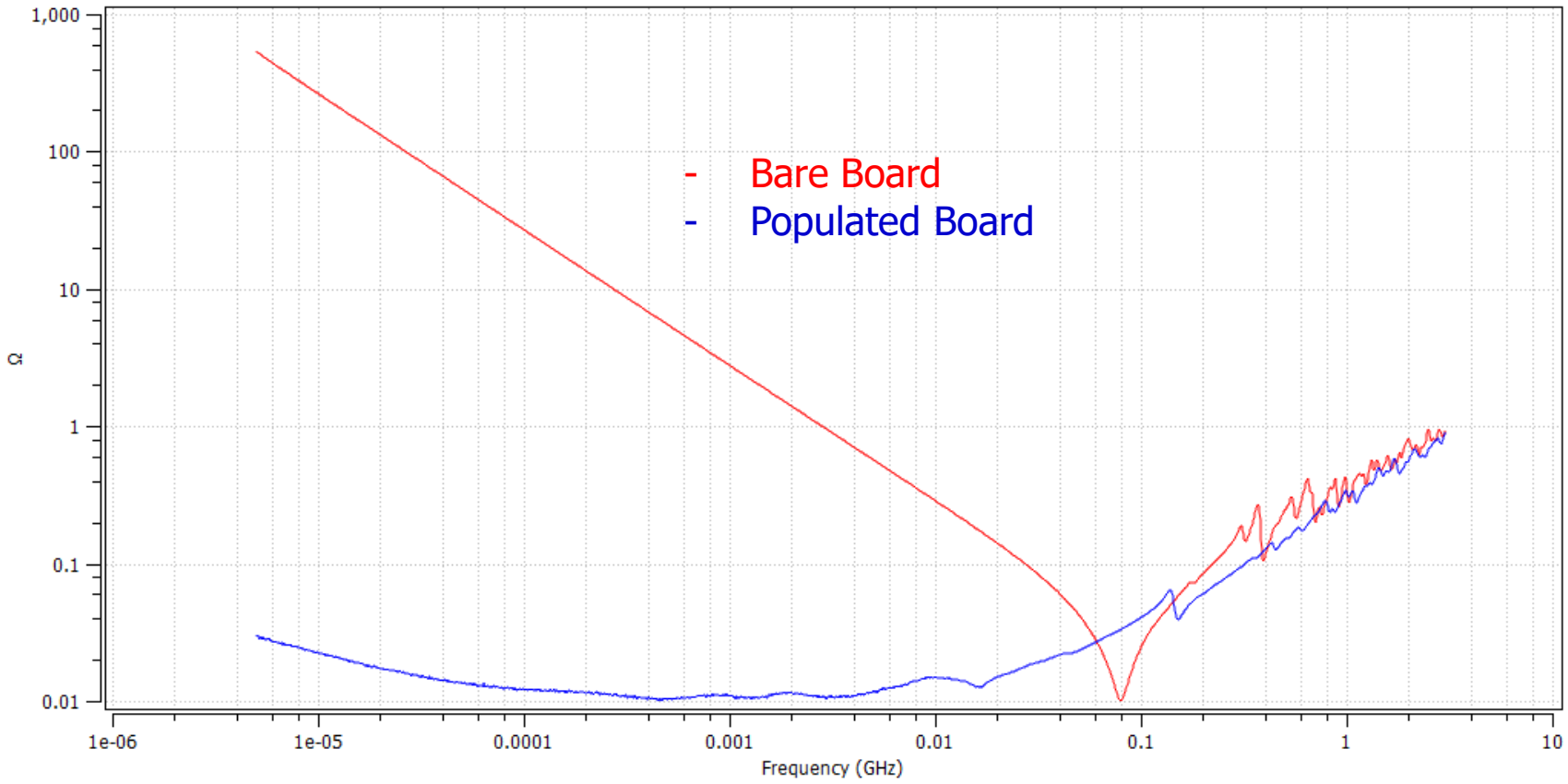
PI Probing Demo



R-Probe & Microprobe Comparison



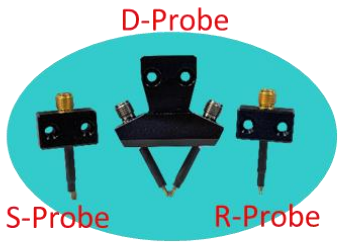
Impedance Between Bare and Populated Boards

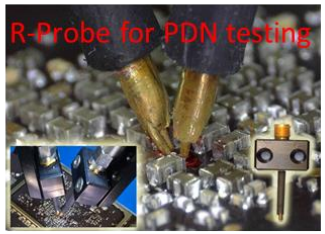


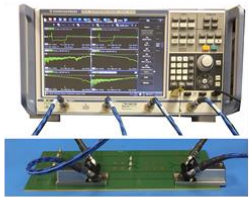
References

- Istvan Novak, “Power Integrity: Advanced Design and Characterization” (http://www.cei.se/media/48264/cei%20europe%20course%2056.pdf)
- Istvan Novak, “Measuring Milliohms and Pico Henrys in Power Distribution Networks” (http://electrical-integrity.com/Paper_download_files/DC00_MeasuringMiliohms_slides.pdf)
- Istvan Novak, “PDN Measurements: Reducing Cable-Braid Loop Error” (http://www.electrical-integrity.com/Quietpower_files/Quietpower-3.pdf)

PacketMicro Product Offering






Delta-L 4.0 Solution

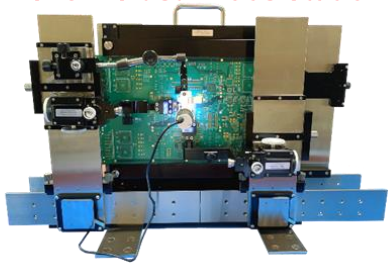

TCS70
Cal Substrate

Precision Positioners


TP250


TP150

VPS10 2-Sided Probe Station



Flex Positioners

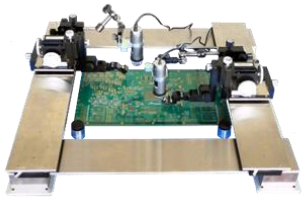

F80
FP40

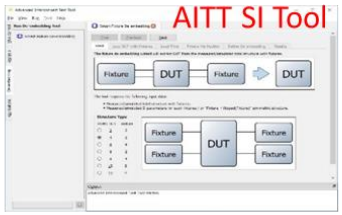

FP160

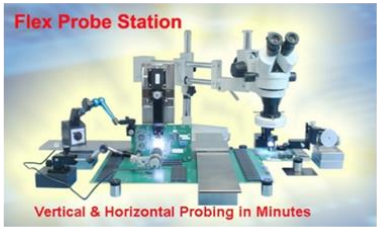

FP160MS

USB Type-C Fixtures

HPS24 Probe Station







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- CSS AITT Signal-Integrity Tool
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2312 Walsh Avenue, Suite A, Santa Clara, CA 95051, USA