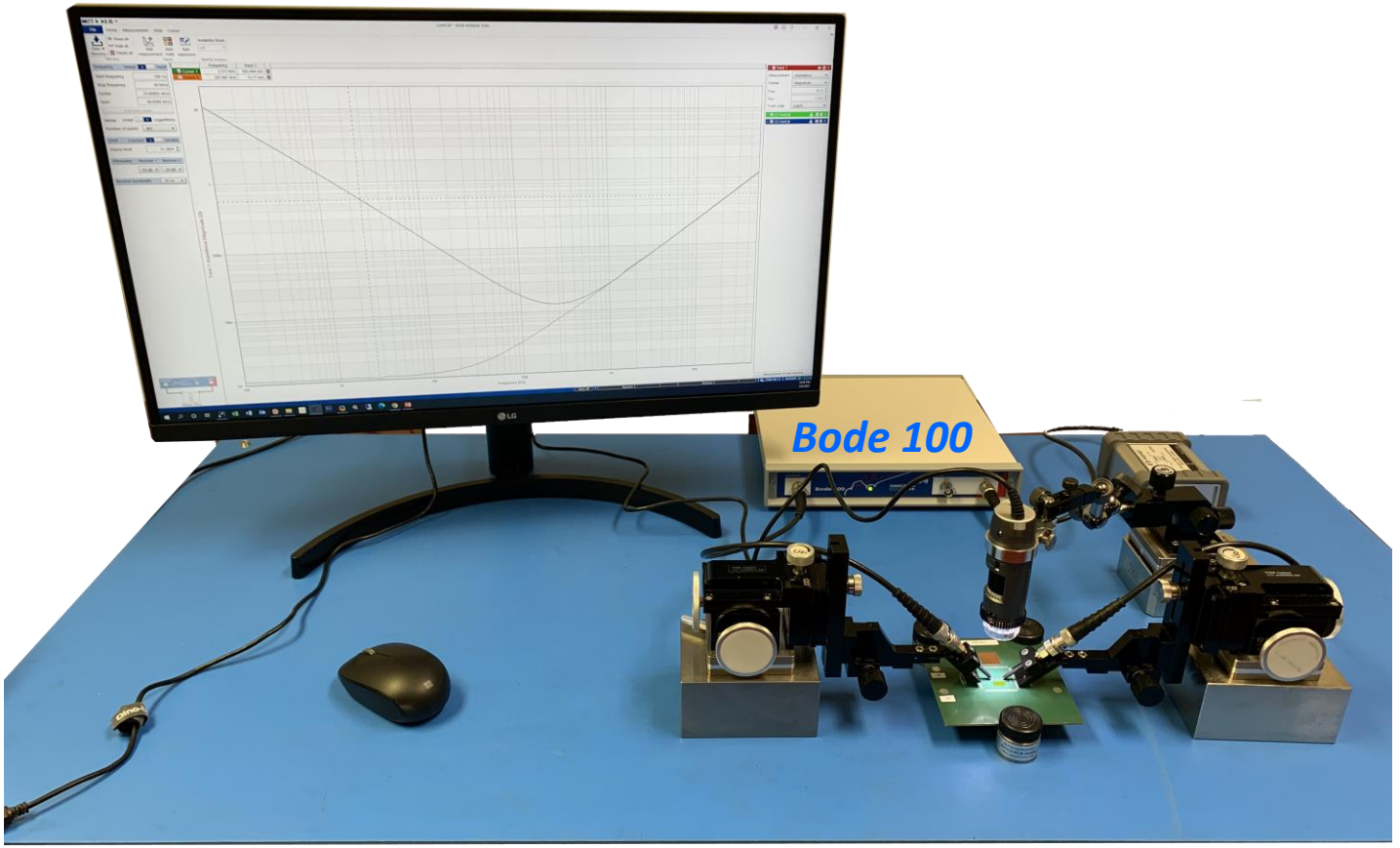
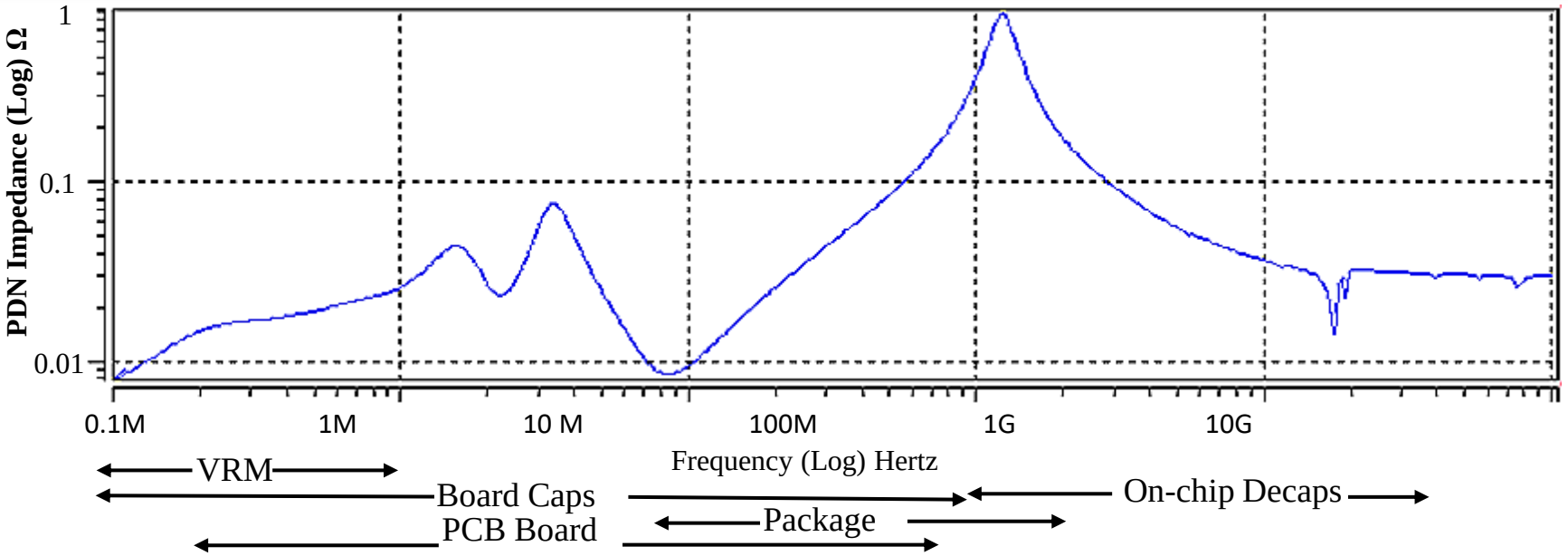
PACKETMICRO
Innovative Benchtop Probing Solutions

Power Integrity Measurement
With
Omicron Lab Bode 100 VNA

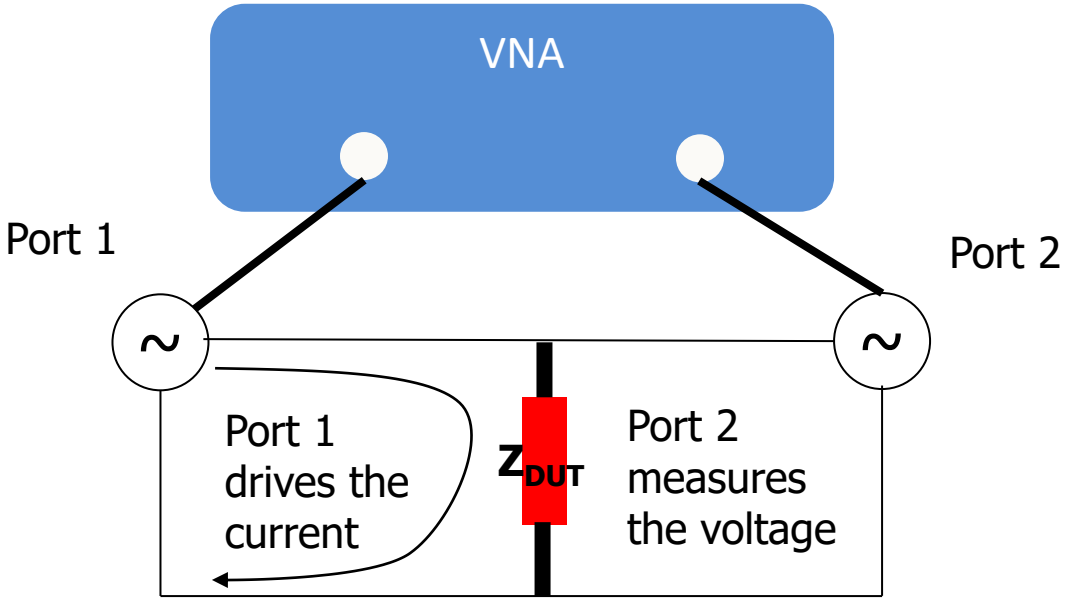


Typical PDN Impedance Profile



- 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

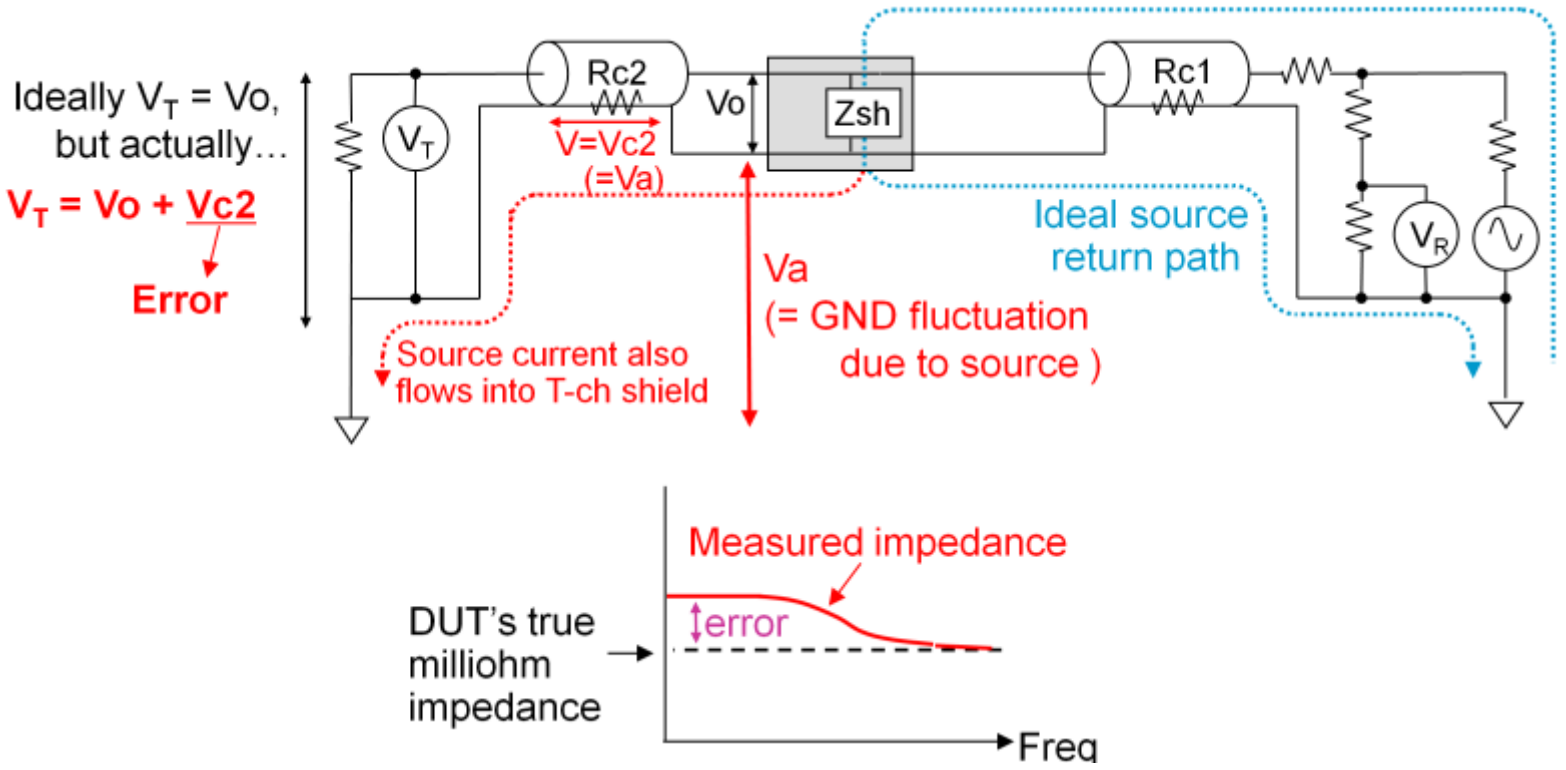
  ($Z_{DUT} << Z_o$)

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

- 2nd order Analysis

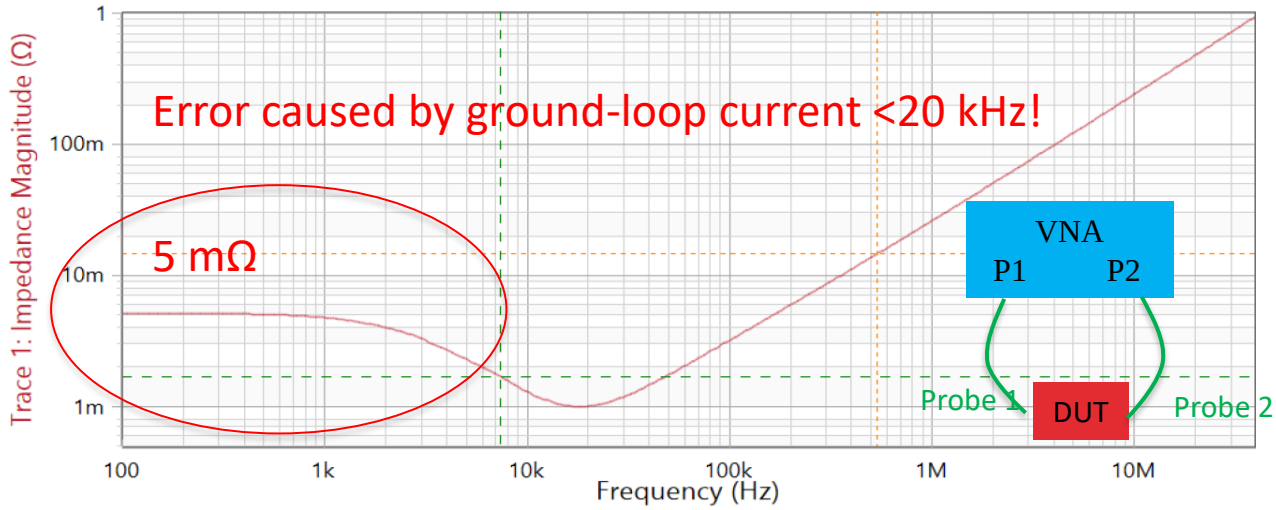
  $$Z_{DUT} = 25\ \frac{S_{21}}{1 - S_{21}}\ \Omega$$

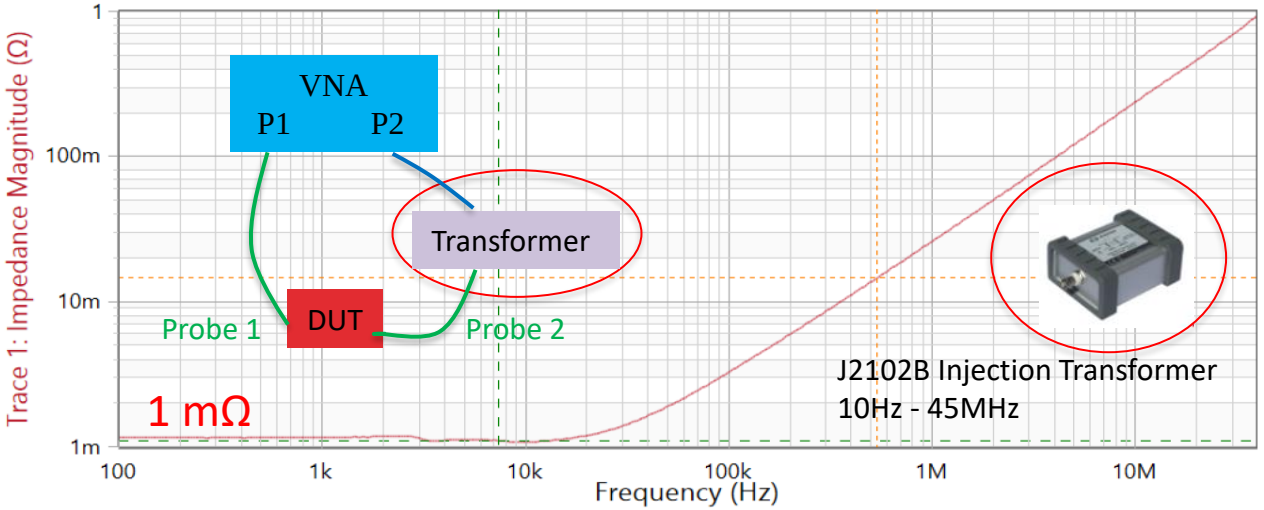
Low-Freq Errors Caused by Ground Loop



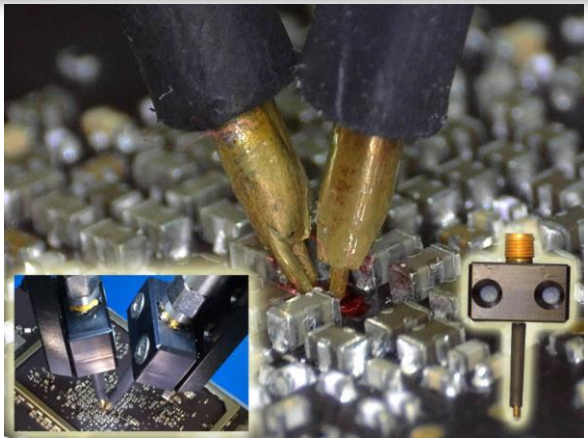
If the DUT's impedance is very small (ZDUT < tens of milliohms)
Source current flows into source-to-receiver cable GND loop.
Measurement errors occur at LF range (<20kHz)

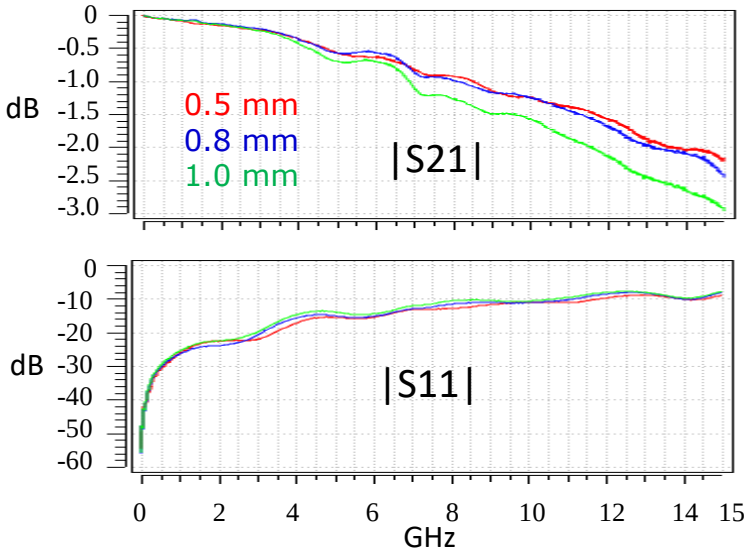
Use Transformer to Break the Ground Loop





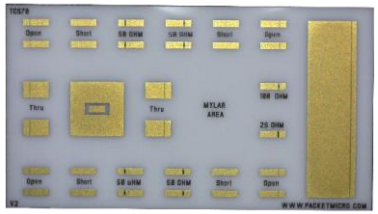
18 GHz R-Probe





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.

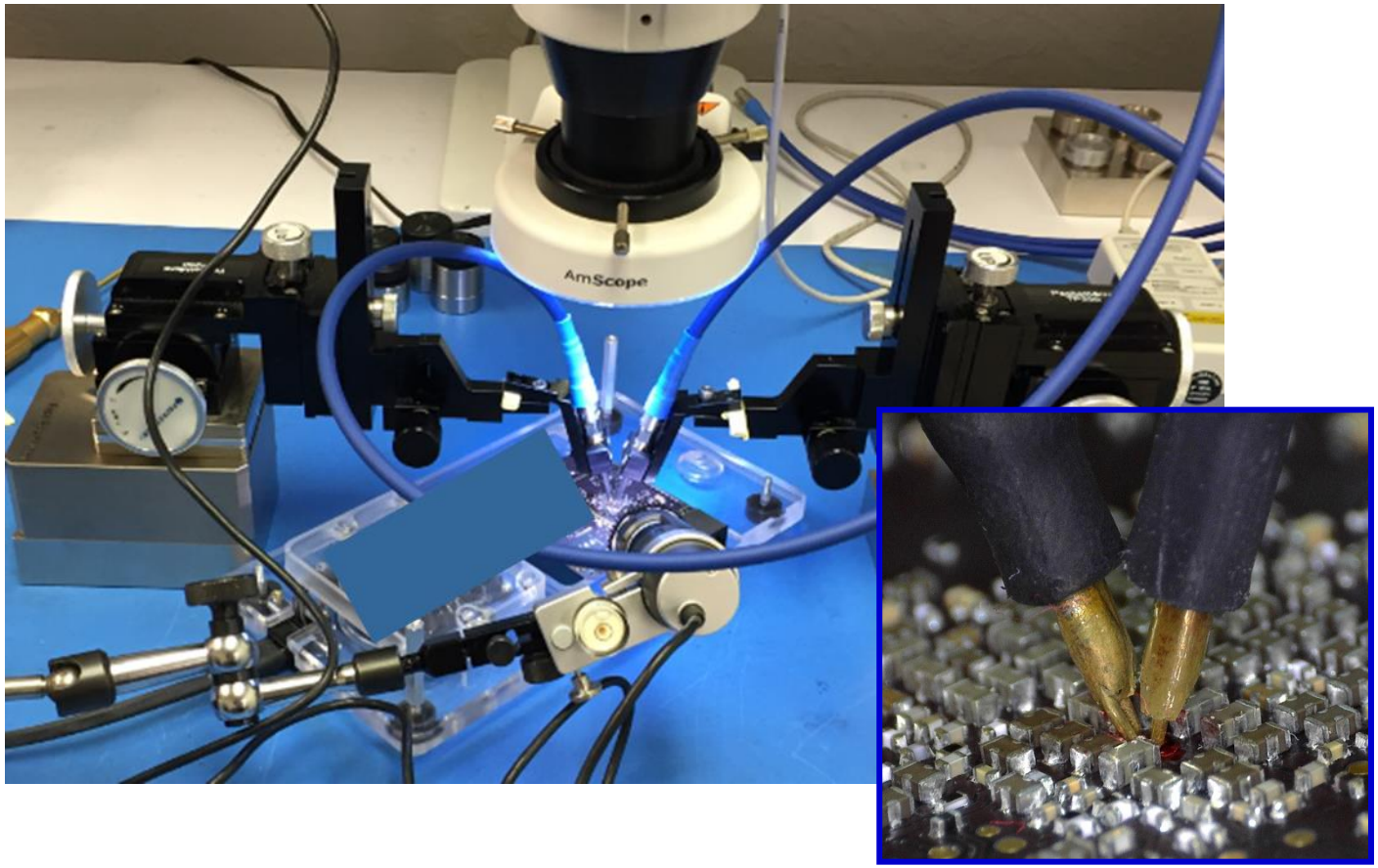
TCS70 Calibration Substrate



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)

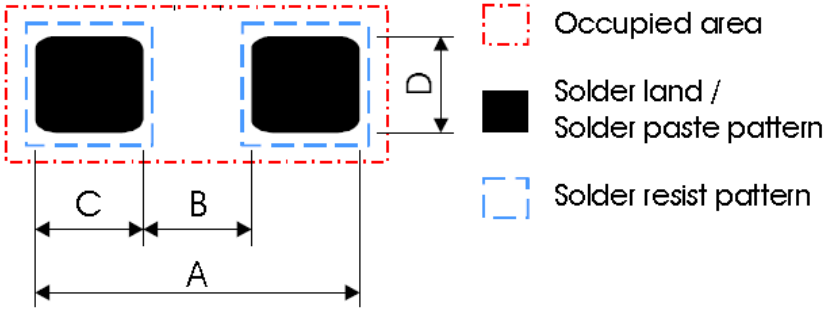
R-Probe Part No.
- **RP-GR-151502** – 18 GHz, 0.2 mm/ 8 mil pitch
- **RP-GR-151503** – 18 GHz, 0.3 mm/ 8 mil pitch
- **RP-GR-151504** – 15 GHz, 0.4 mm/16 mil pitch
- **RP-GR-151505** – 15 GHz, 0.5 mm/20 mil pitch
- **RP-GR-121508** – 12 GHz, 0.8 mm/32 mil pitch
- **RP-GR-121510** – 12 GHz, 1.0 mm/40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

Power Integrity Probing



- PI Probing amid surrounding components is challenging

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

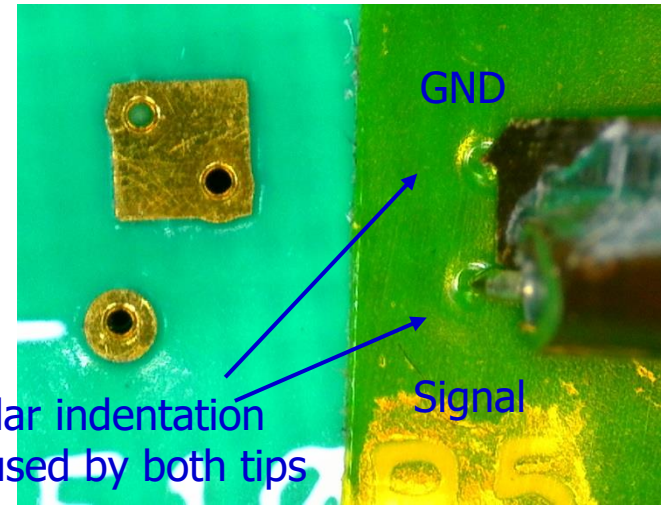
Size	Probe Pitch	A	B	C	D	Component Size
01005	RP-GR-181503	0.48	0.12	0.18	0.20	0.4 x 0. 2
0201	RP-GR-151505	0.75	0.30	0.30	0.30	0.6 x 0.3
0402	0.7mm < Pitch <1.3mm	1.50	0.50	0.50	0.60	1.0 x 0.5
0603	0.8mm < Pitch <1.9mm	2.10	0.60	0.90	0.90	1.6 x 0.8
0805	1.2mm < Pitch <2.8mm	3.0	1.0	1.0	1.25	2.0 x 1.25

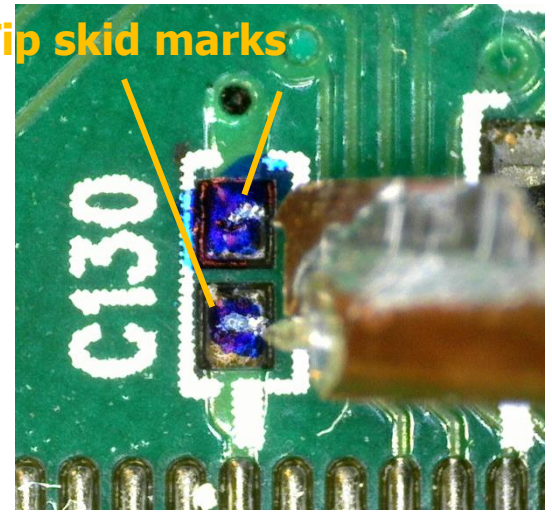
Typical Reflow Soldering Footprint and Component Size in mm

Milliohm PDN Measurements

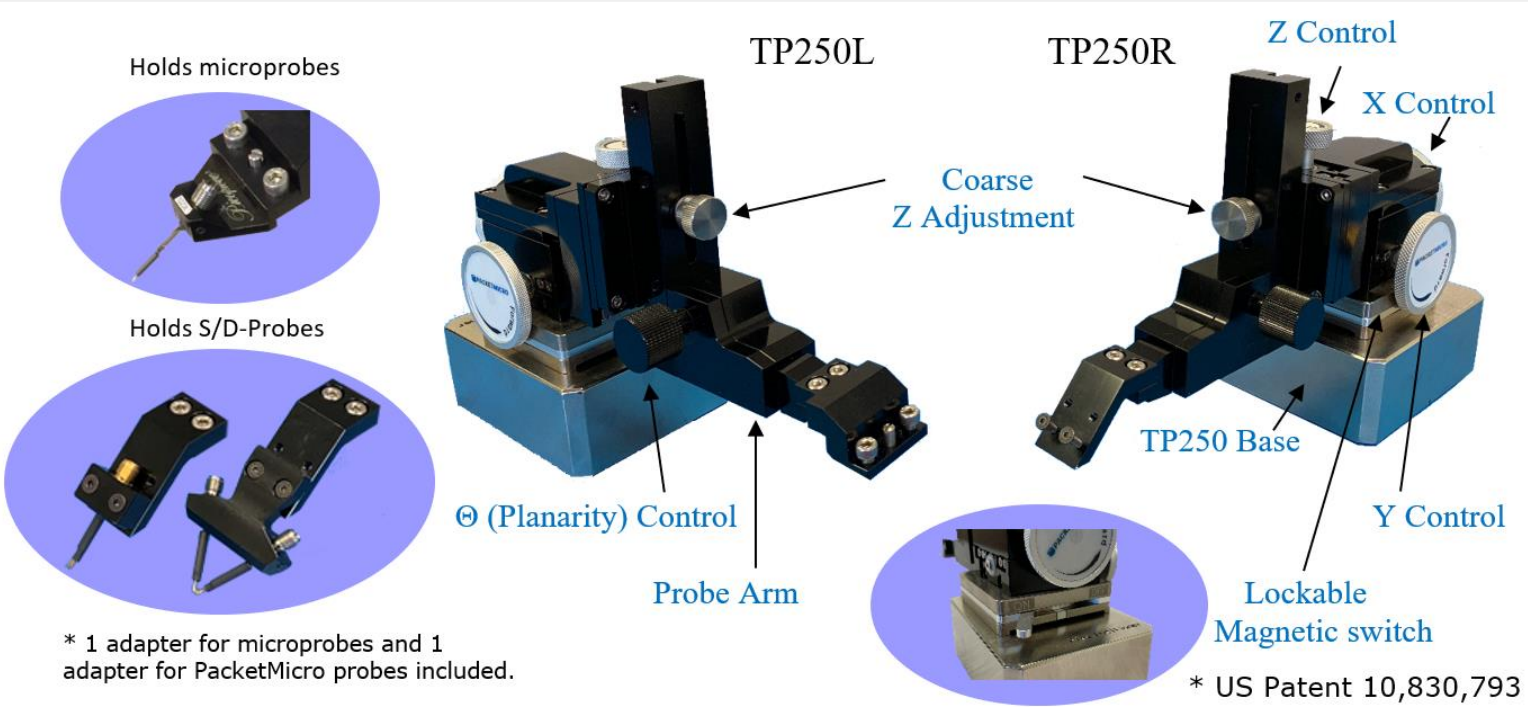
Probe Planarization Tips

- 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.



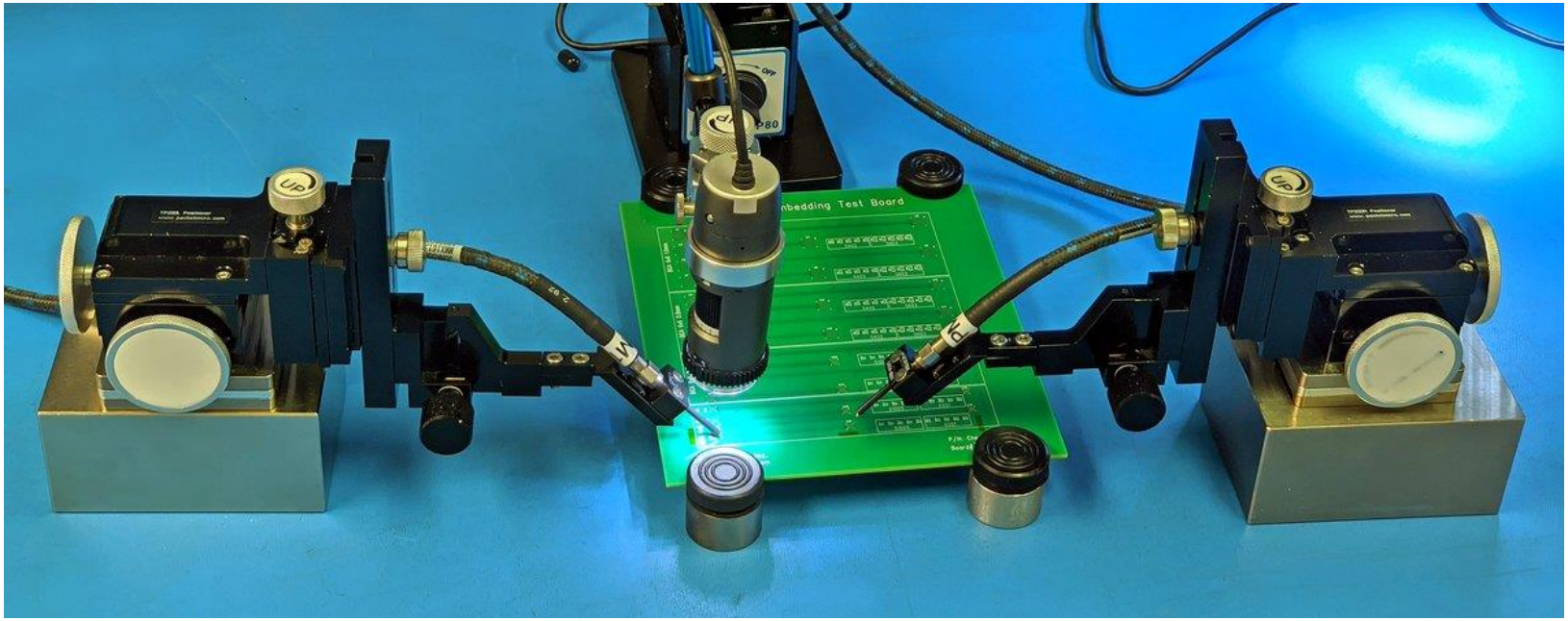


TP250 Precision Positioner



- **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

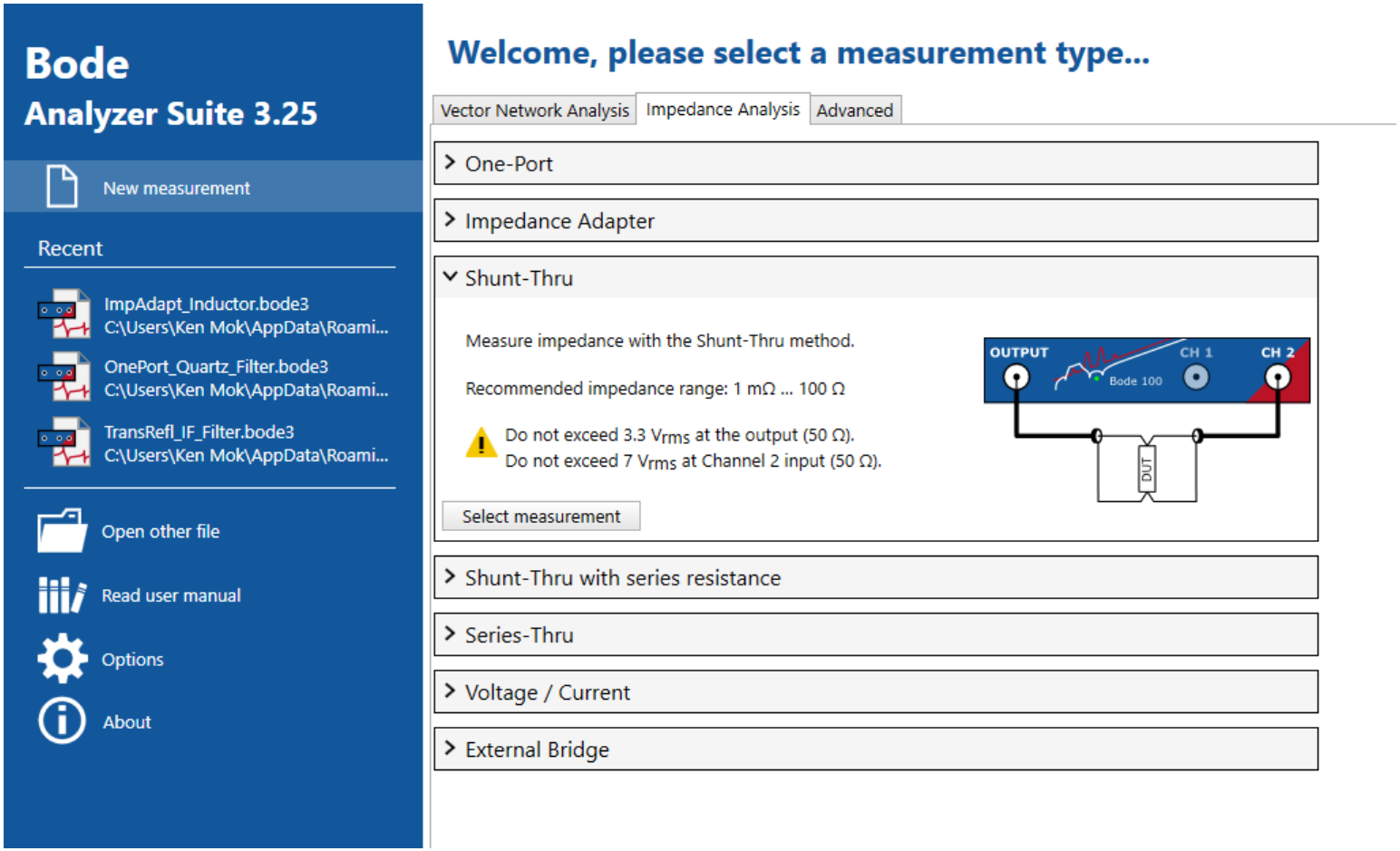


Probe Planarization Video:
https://packetmicro.com/Videos/PacketMicro_Probe_Planarization.mp4

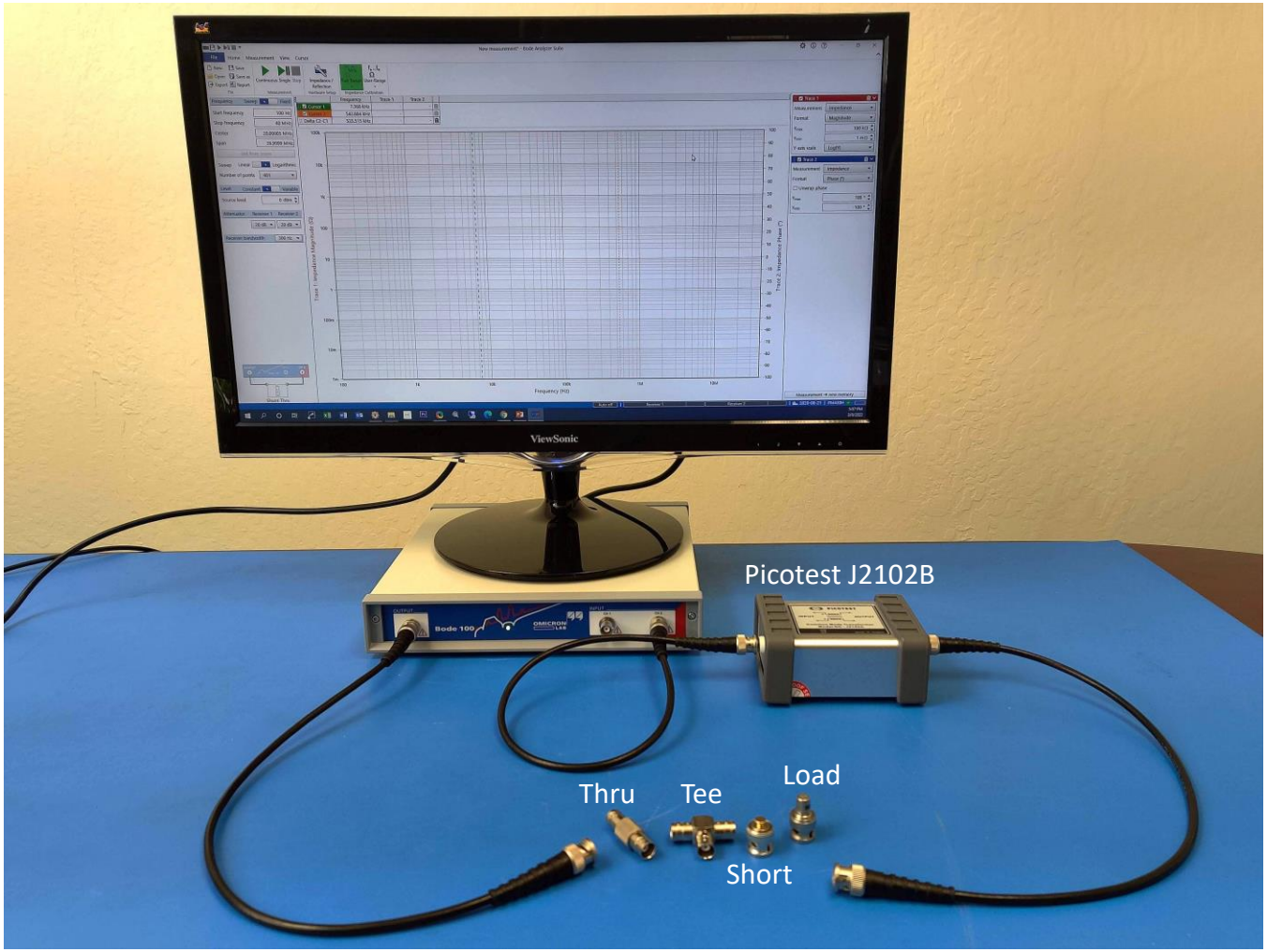
PDN Measurements with Bode 100

- **Probe-tip calibration is recommended for making PDN measurements with Bode 100.**
- **Separate copper pad should be used for short calibration.**
- **Bode 100 shows comparable measurement accuracy with a standard VNA.**

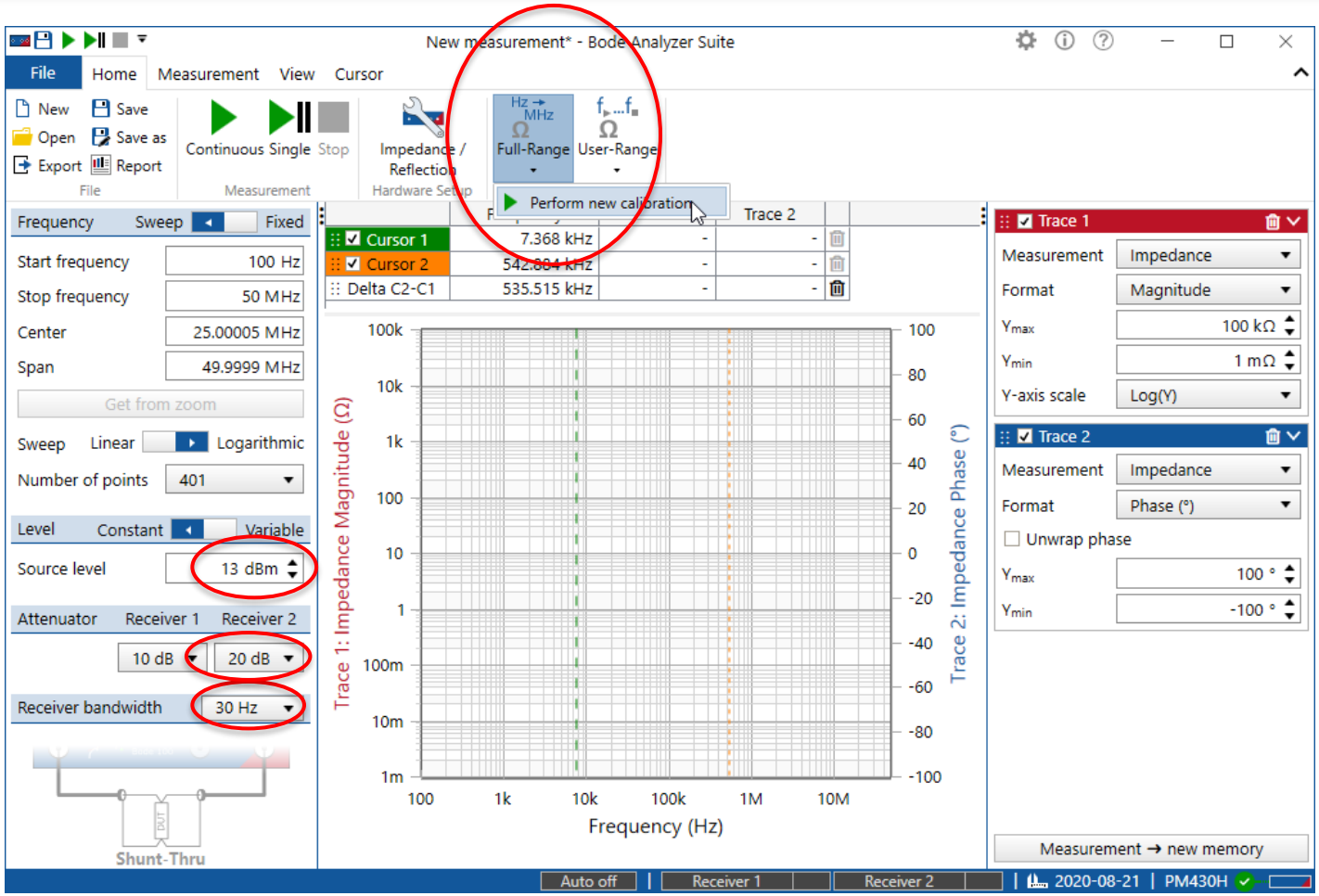
PDN Shunt-Thru Impedance Analysis



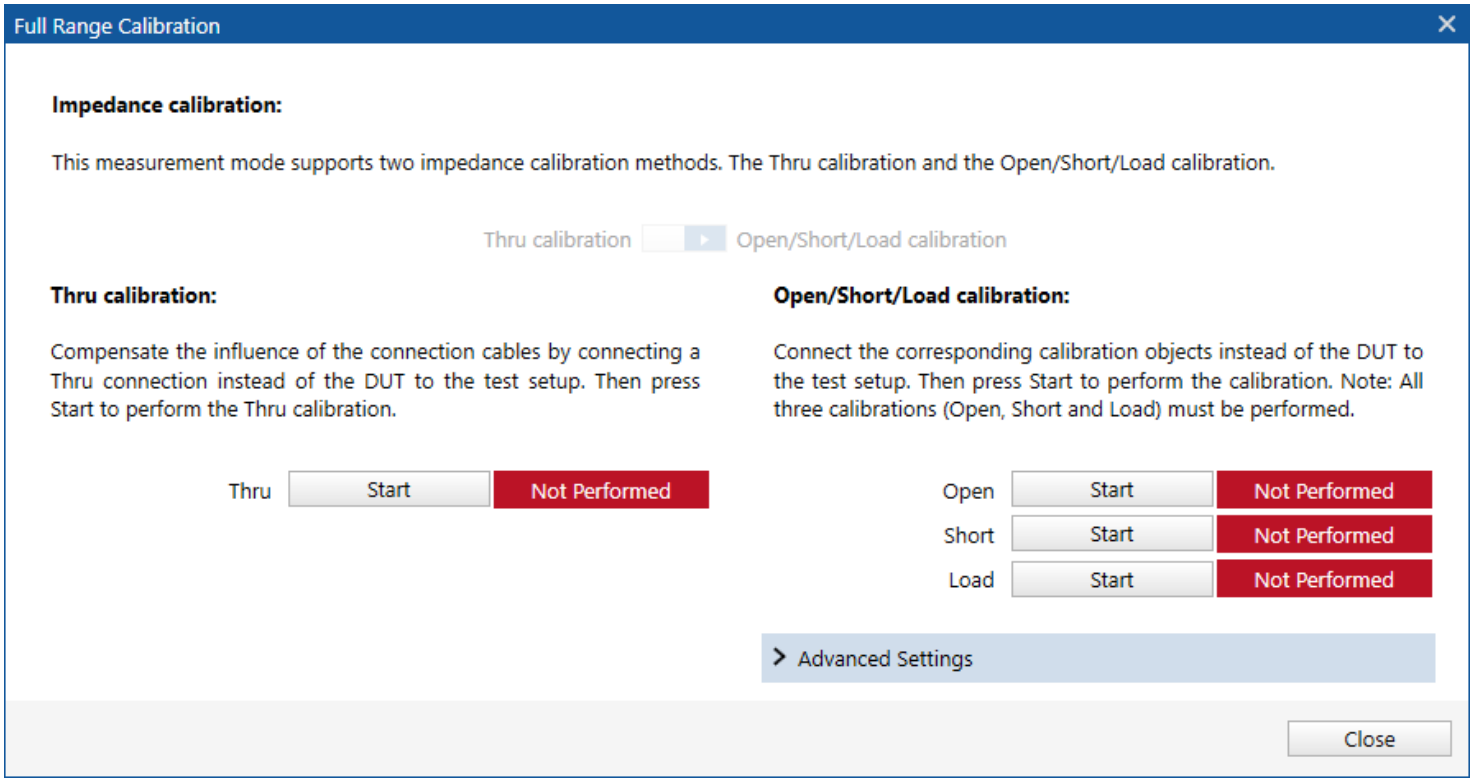
PDN Connector Calibration Setup



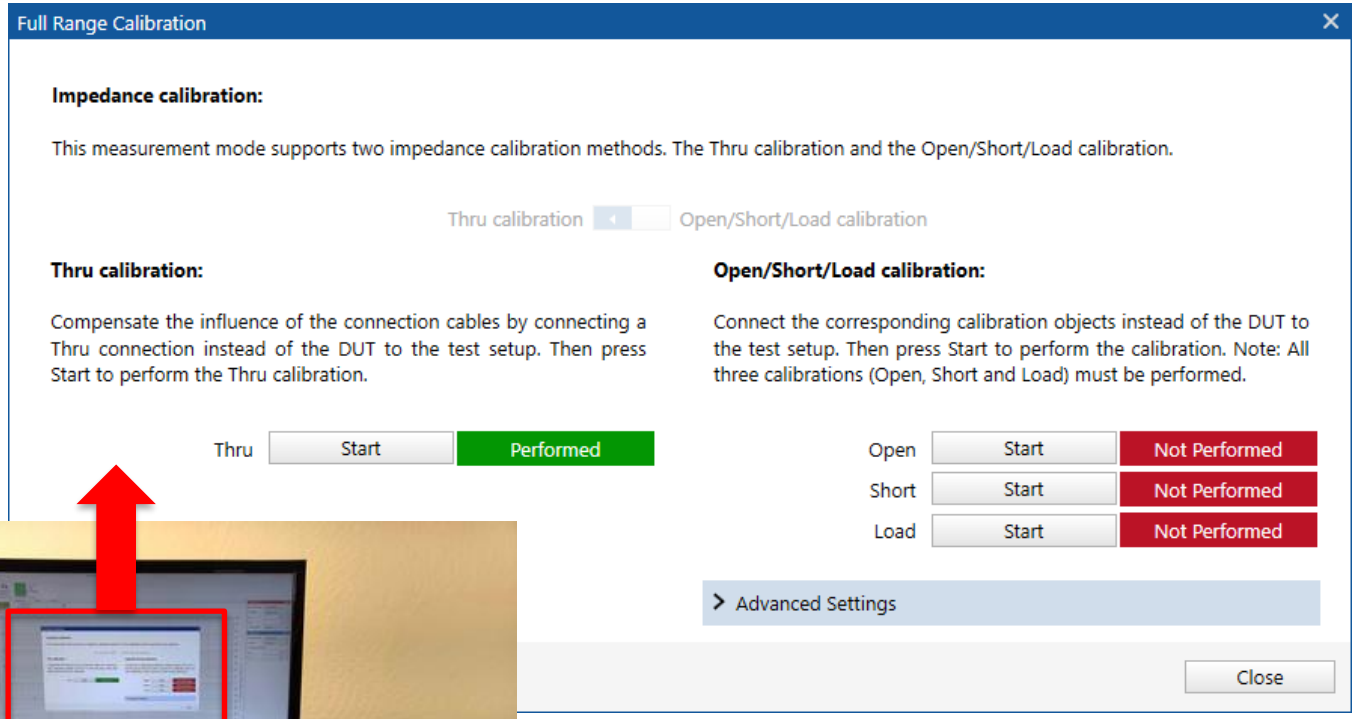
Set Configuration for Open/Load/Thru

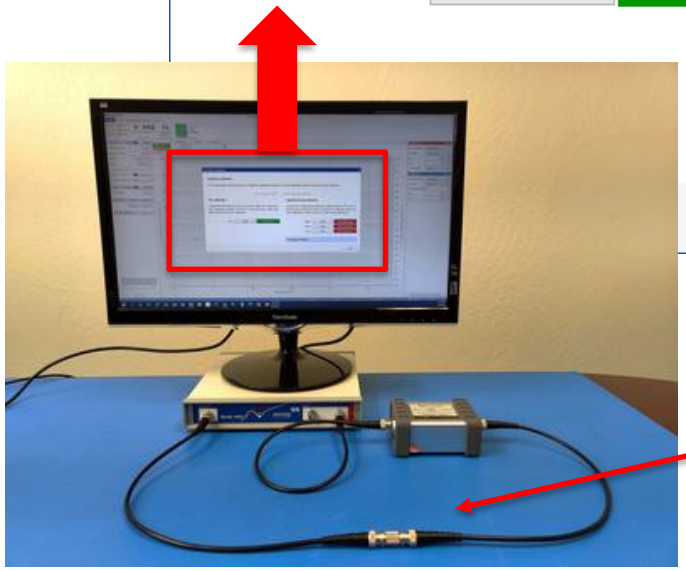


Short/ Open/Load/Thru/ Calibration

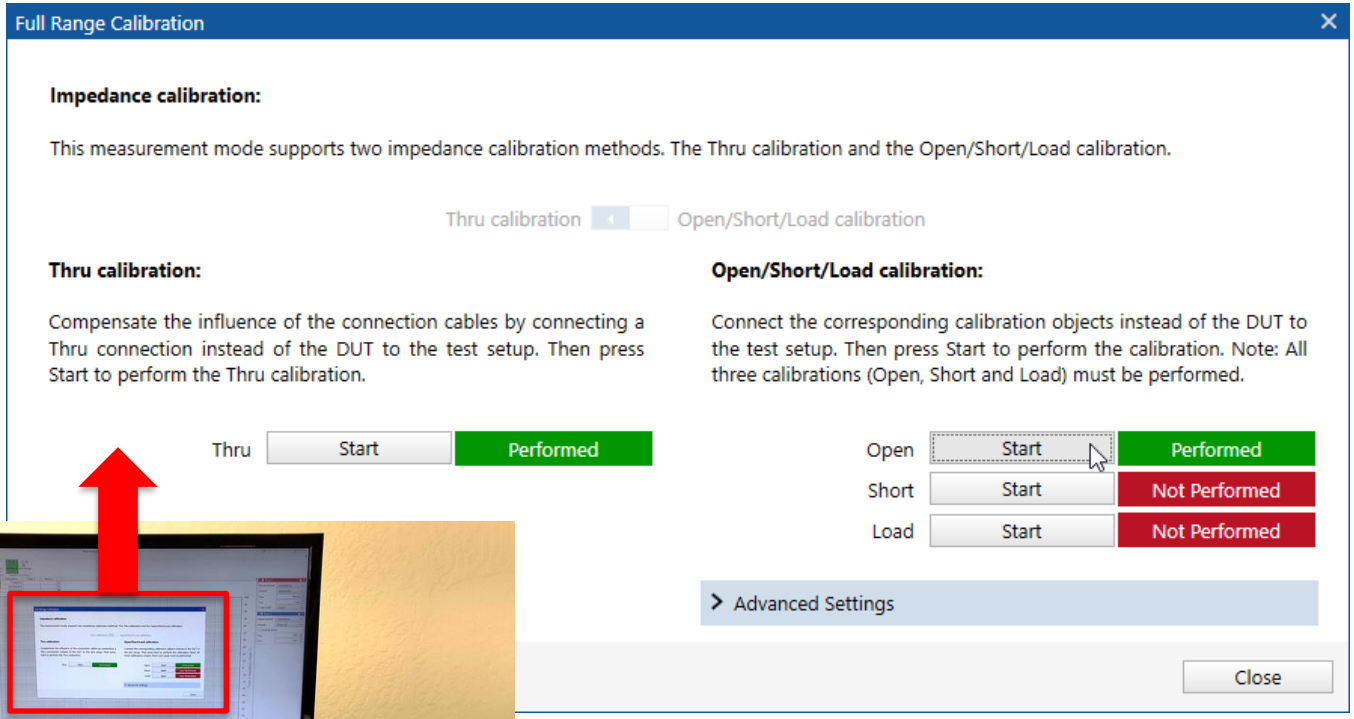


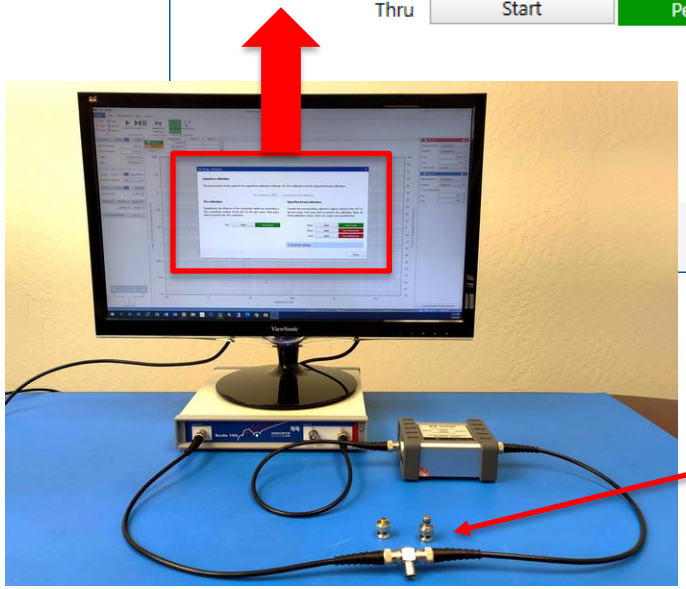
Thru Calibration



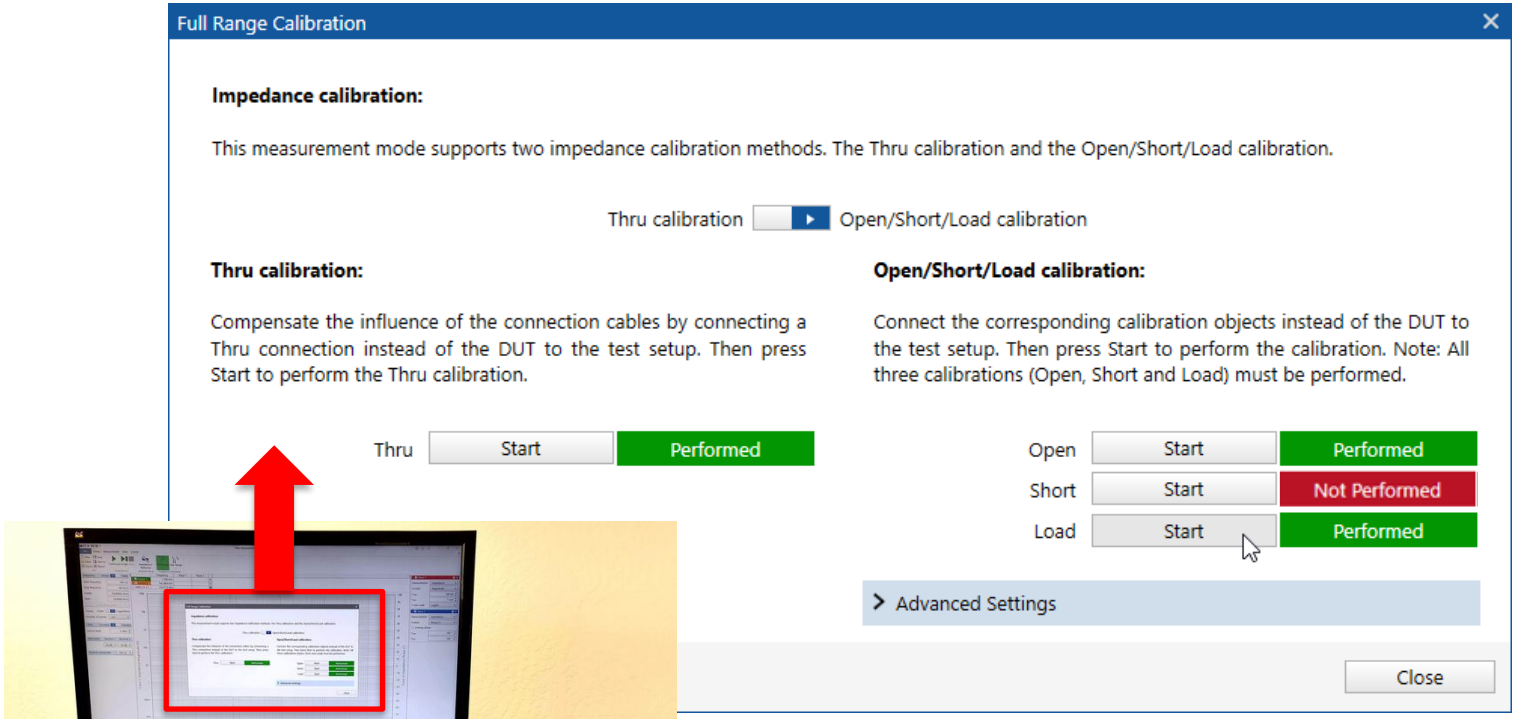


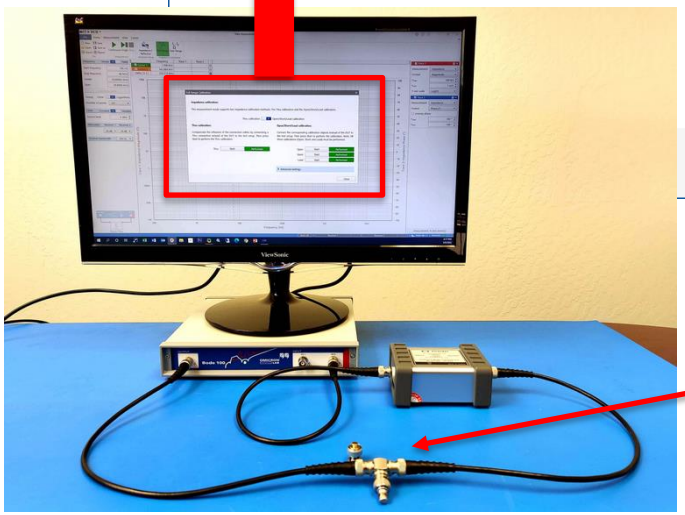
Open Calibration



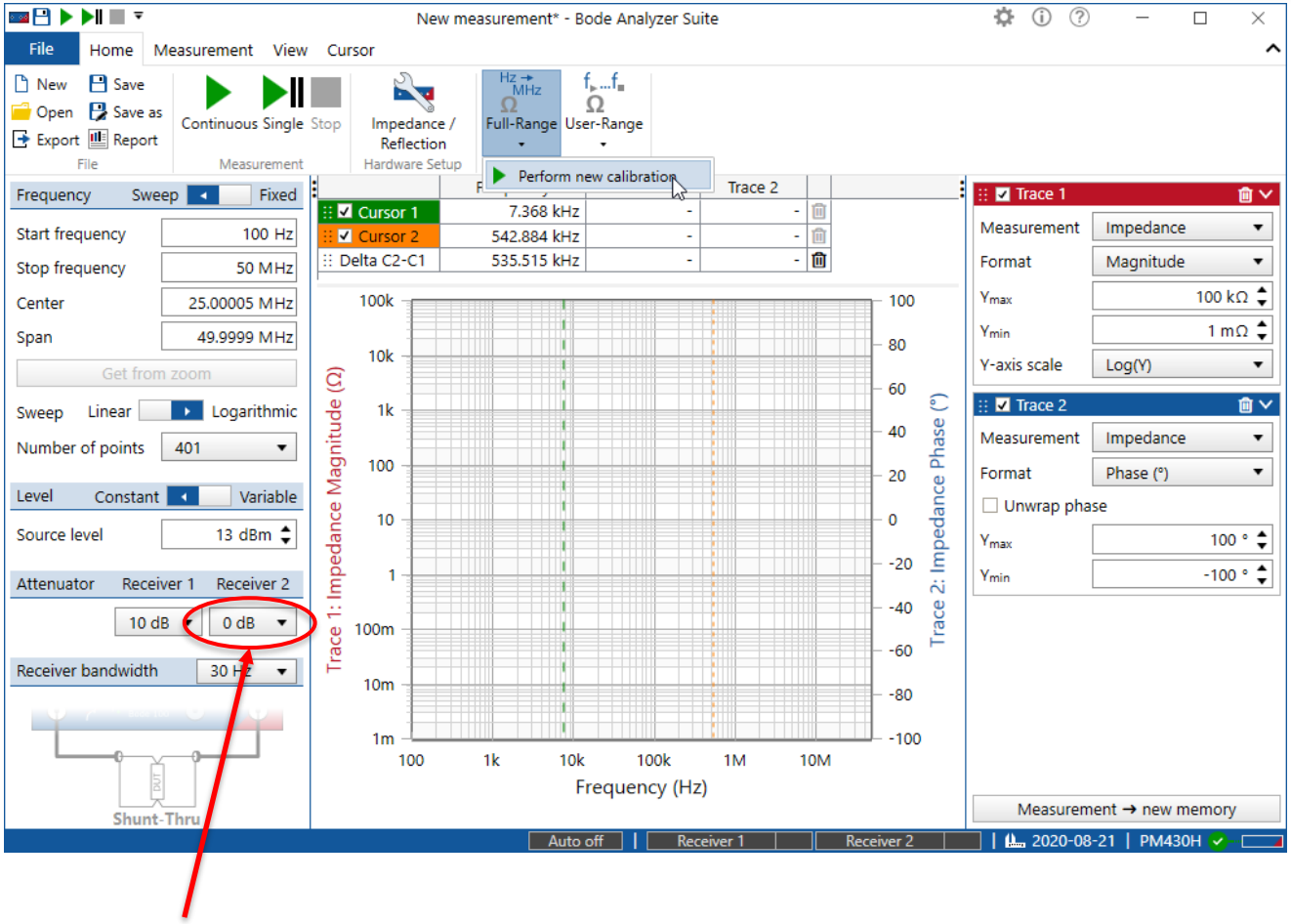


Load Calibration



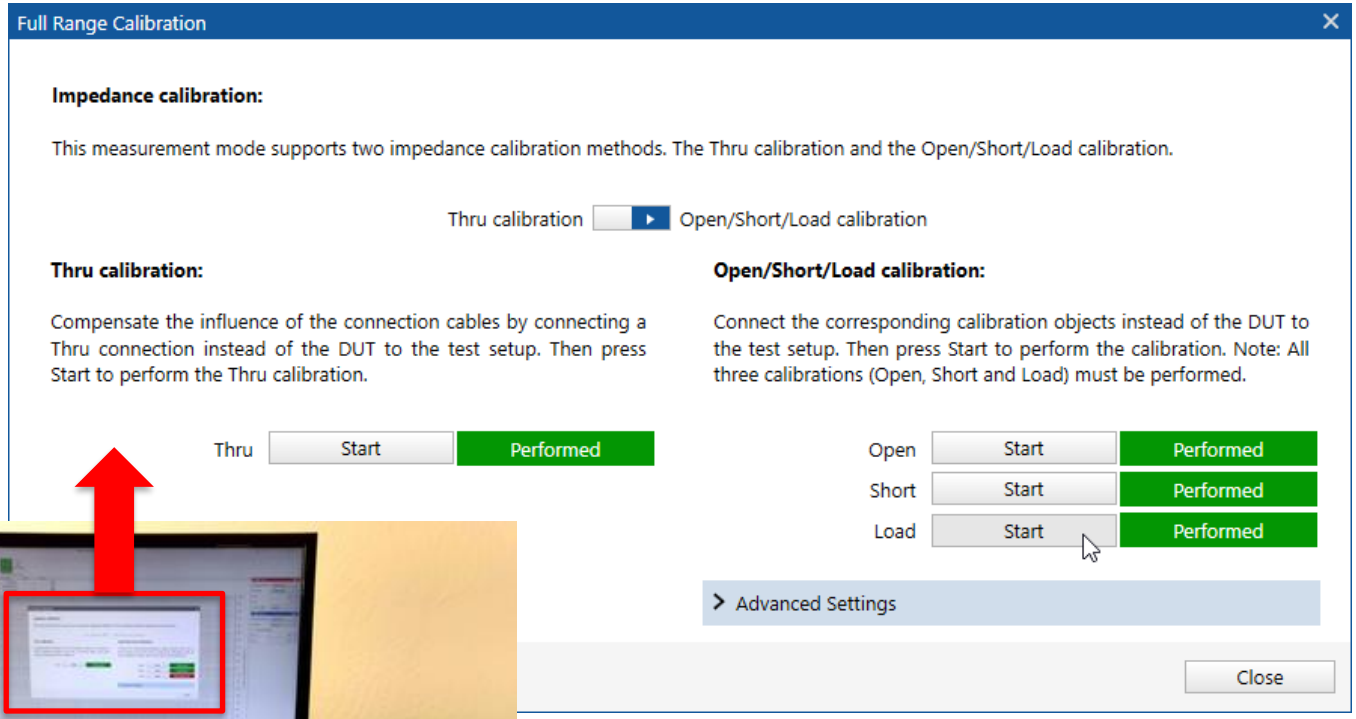


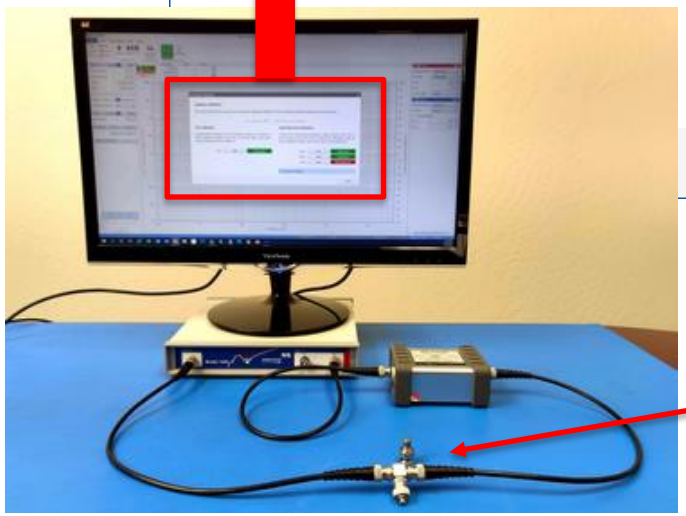
Set Configuration for Short



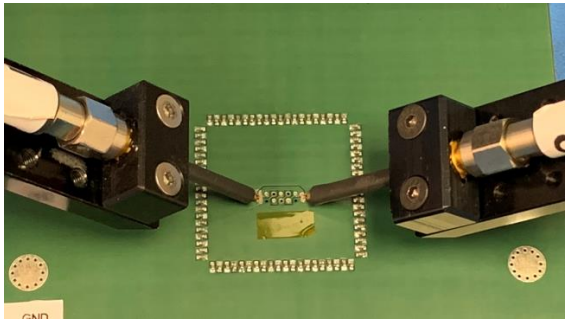
Change Receiver 2 Attenuator to 0 dB for improved sensitivity !

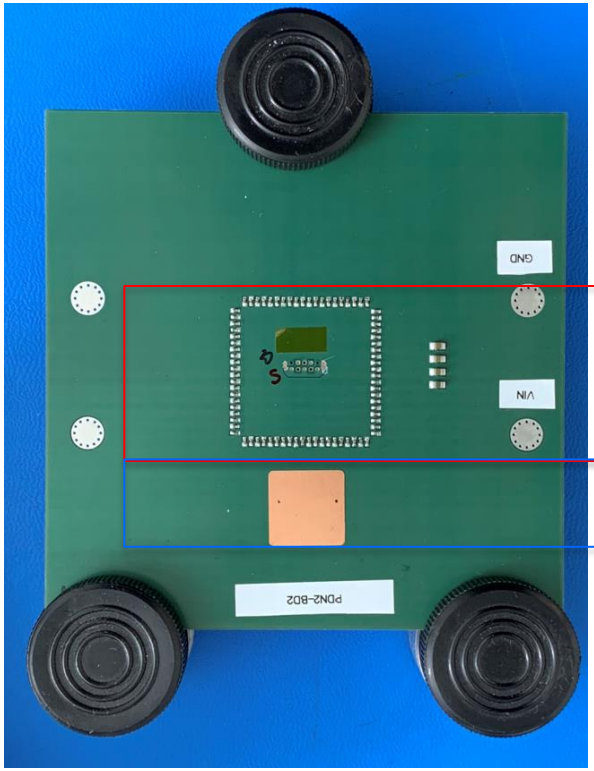
Complete Short Calibration





Test Cases

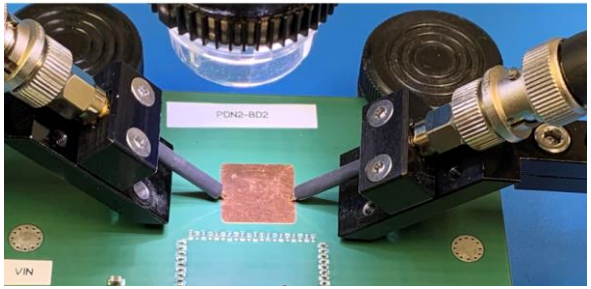




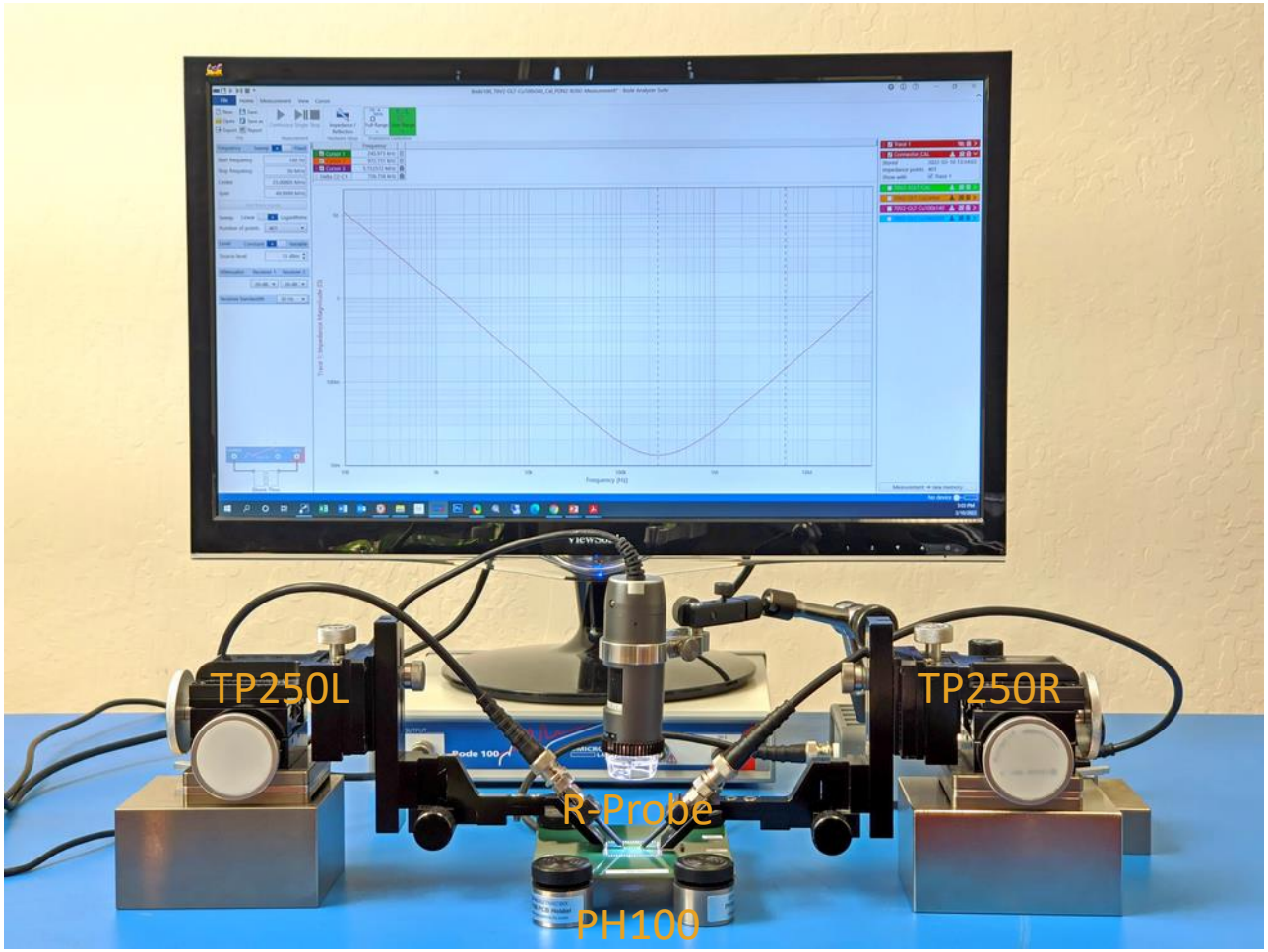
Case 1: PDN Board

Component Description	QTY	Ref Des	Mfg P/N #
CAP CER 22UF 6.3V X5R 0805	4	C1,C2,C3,C4	C0805C226M9PACTU
CAP CER 1UF 6.3V X6S 0402	80	C5-C84	GRT155C80J105ME01D

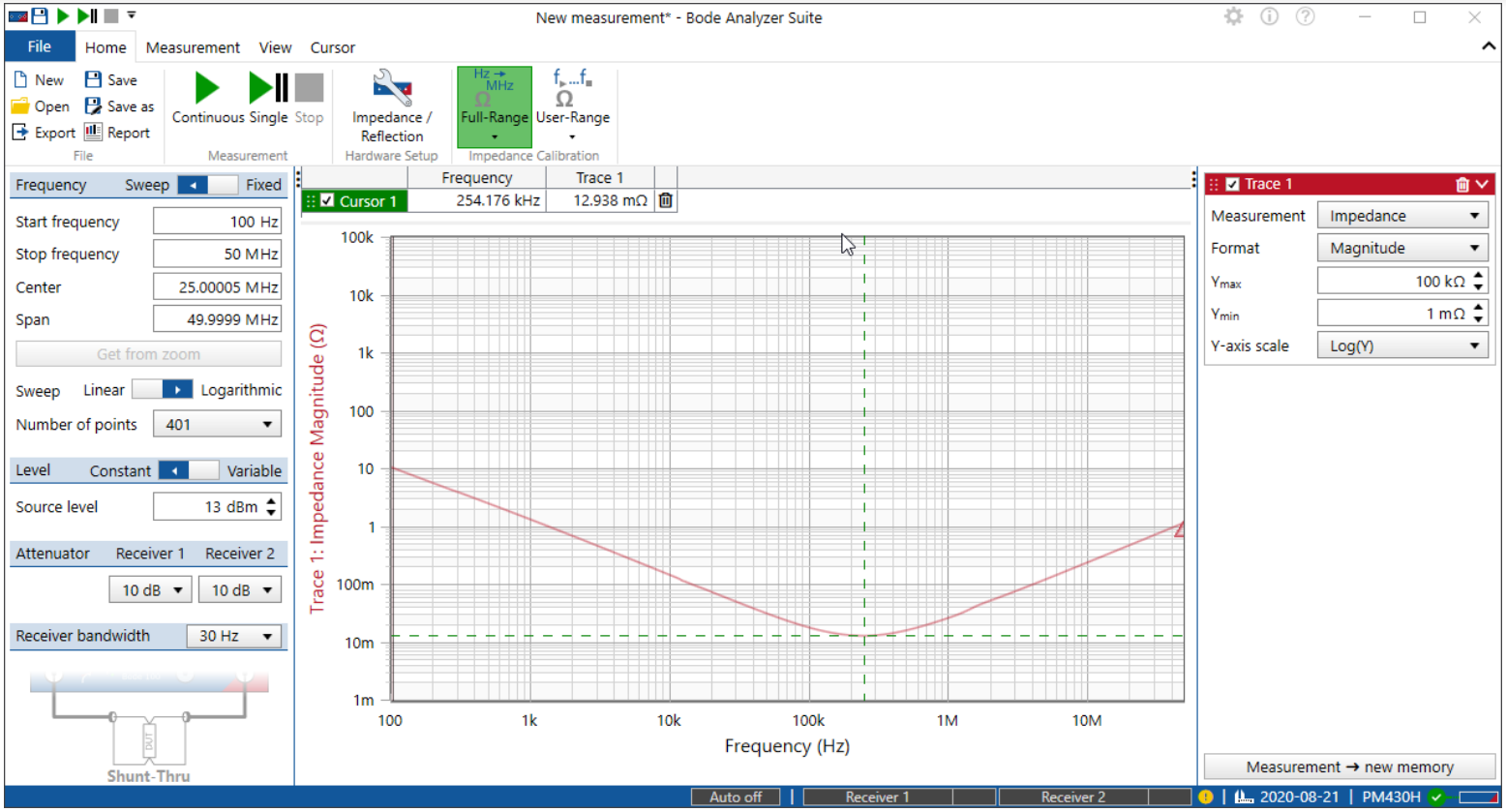
Case 2: Copper 60x60x10 mils (1.5 x1.5 x0.1 mm

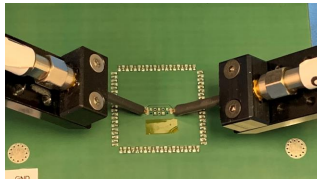


Test Setup



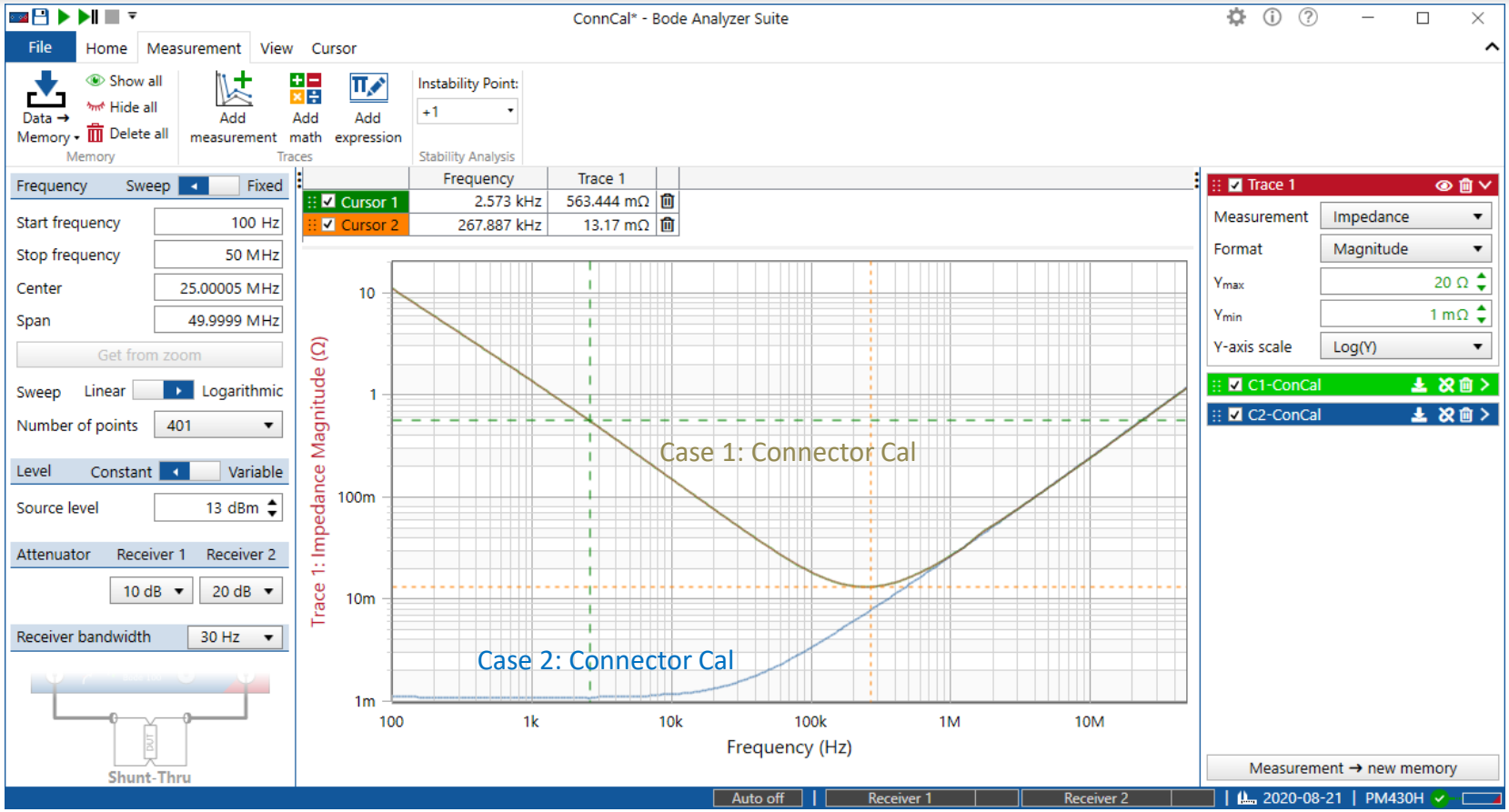
Case 1: Connector-end Calibration

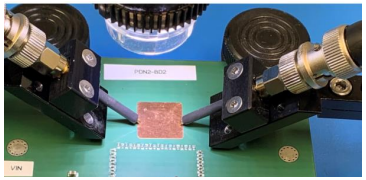




Minimum impedance: 13 mΩ @ 254 kHz

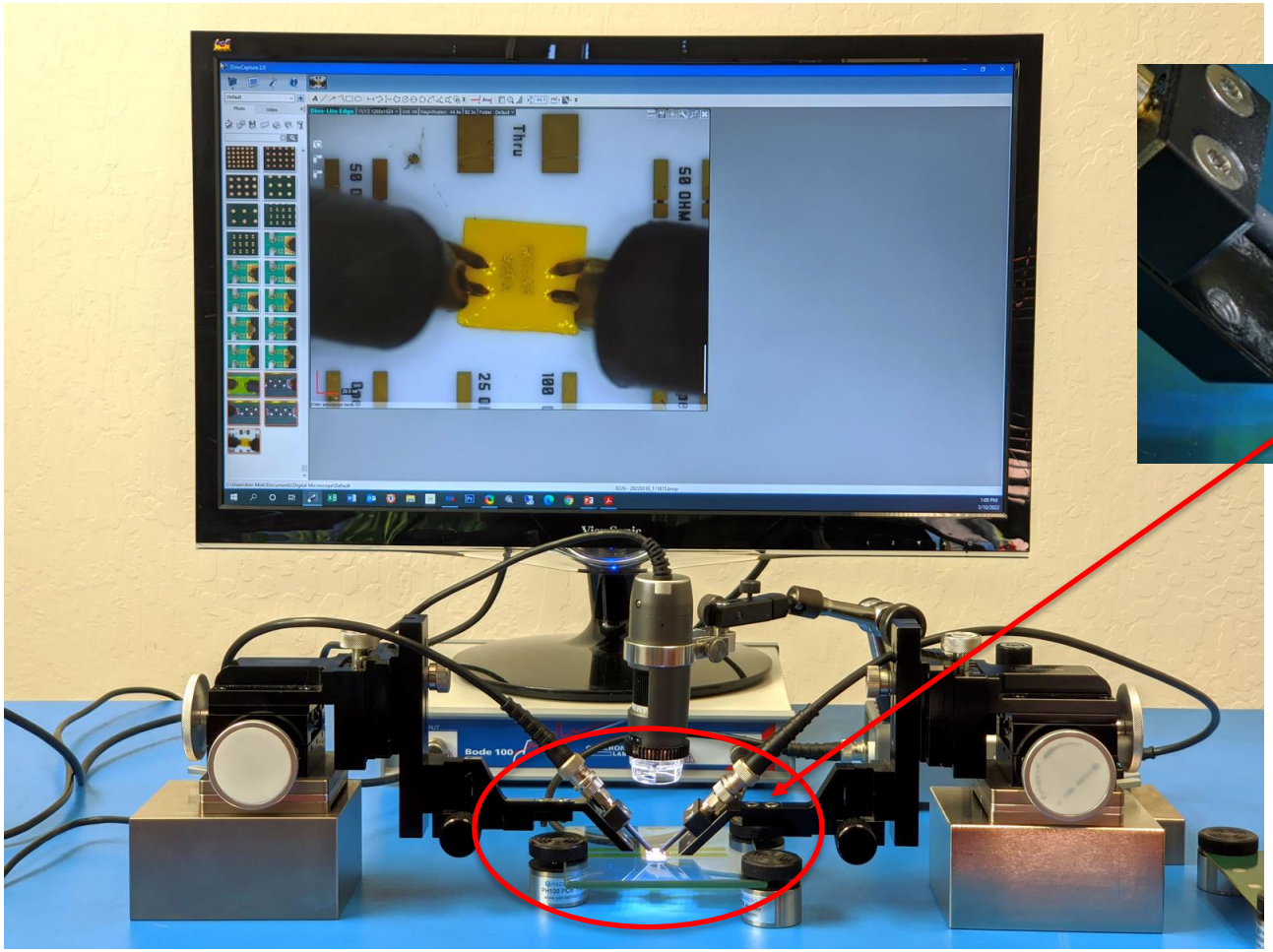
Case 2: Connector-end Calibration

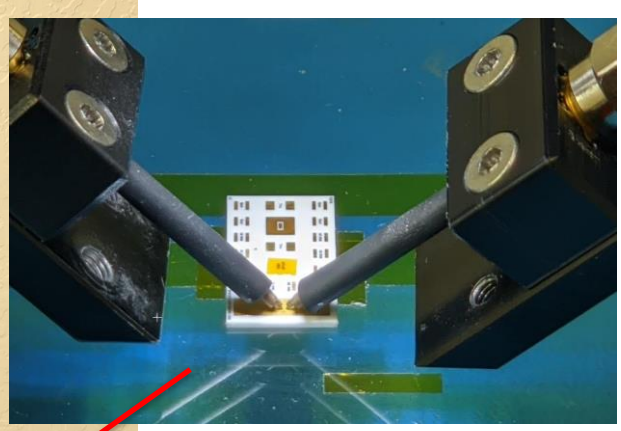


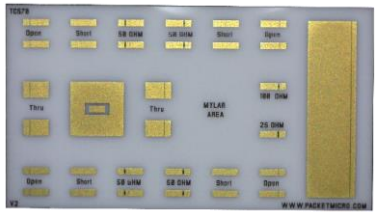


Minimum impedance: 1 mΩ below 3 kHz

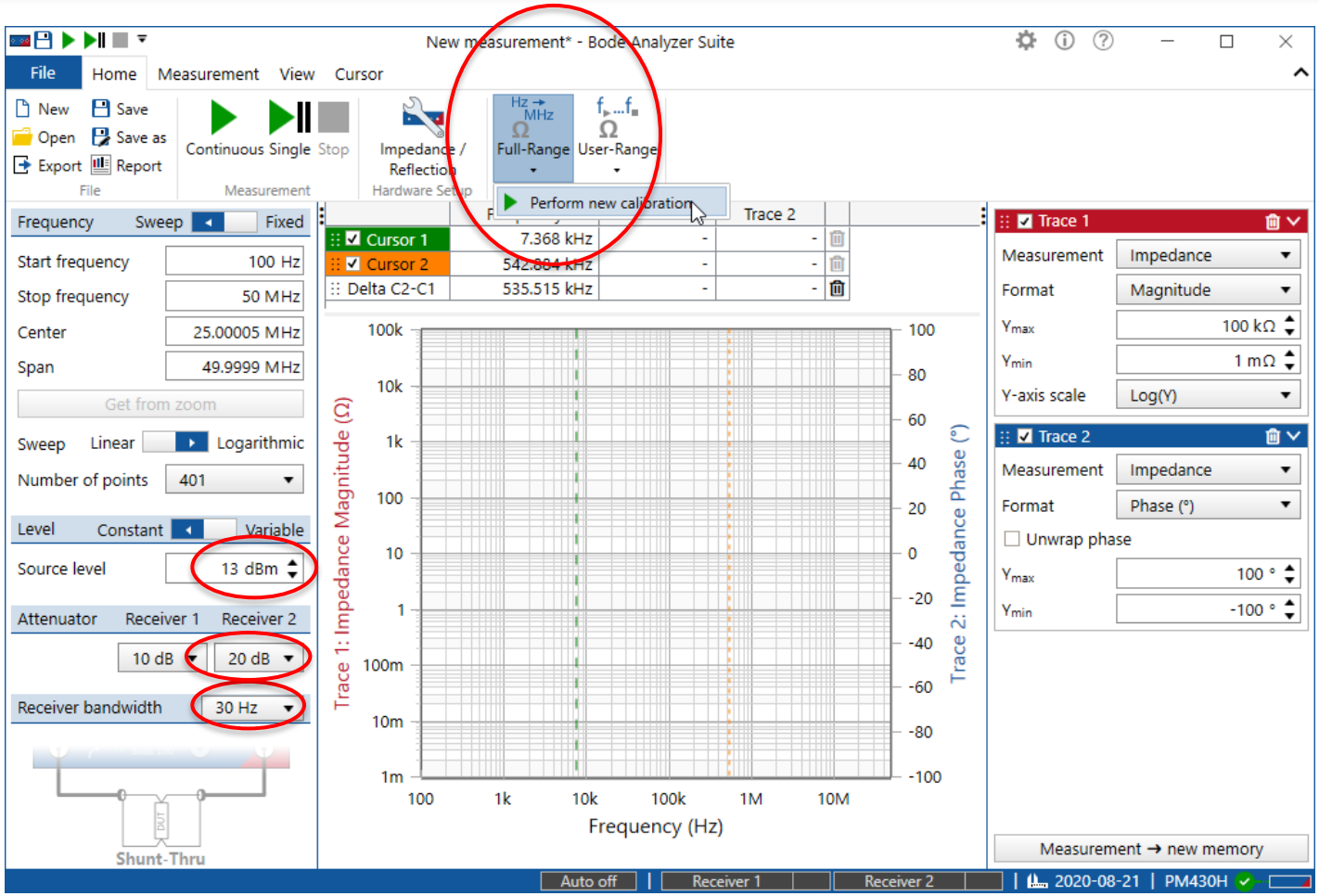
Probe-tip Calibration with TCS70V2



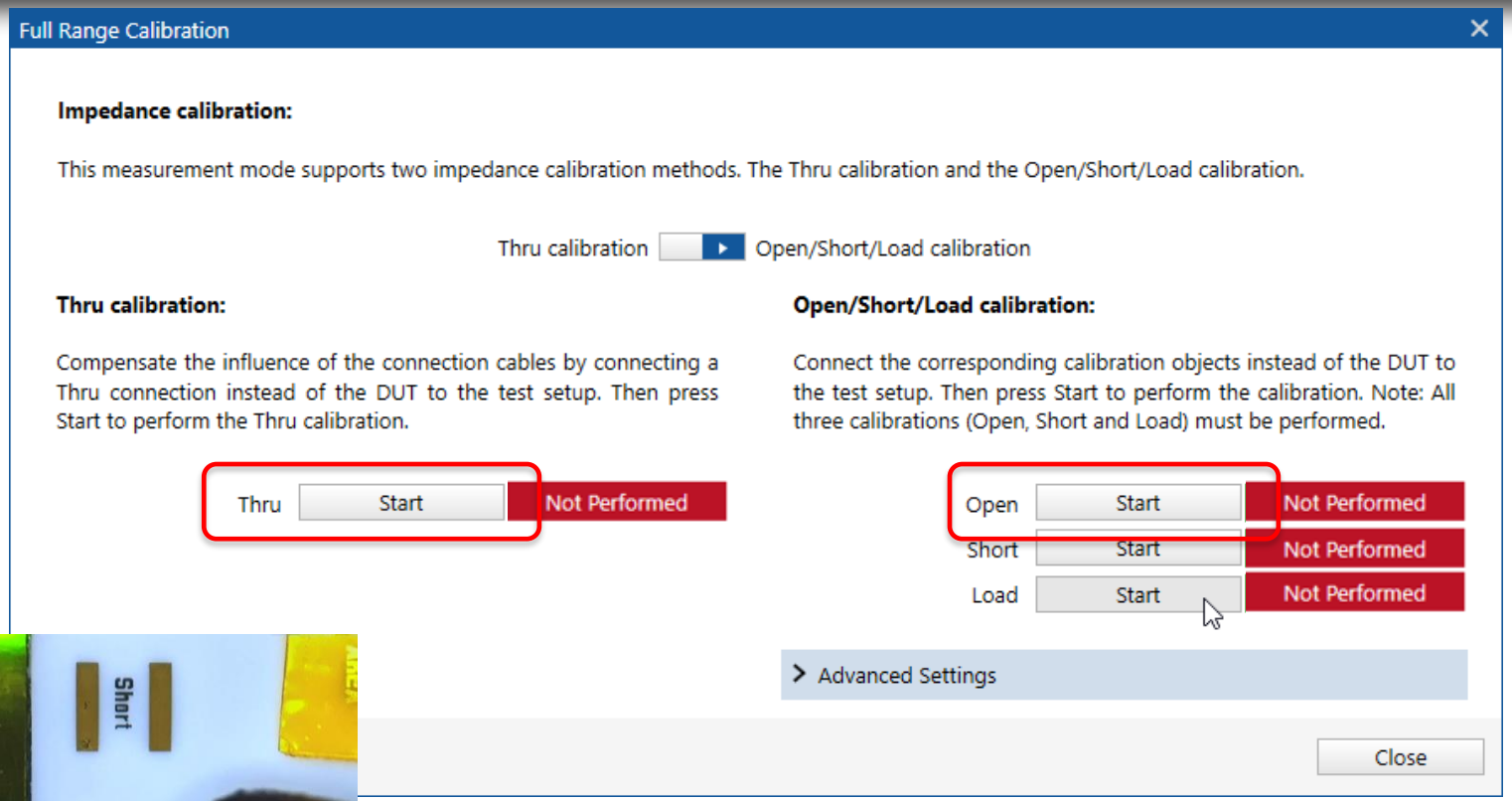


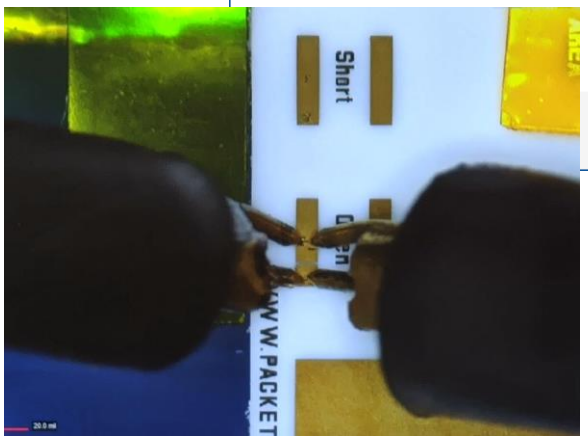


Set Configuration for Open/Load/Thru



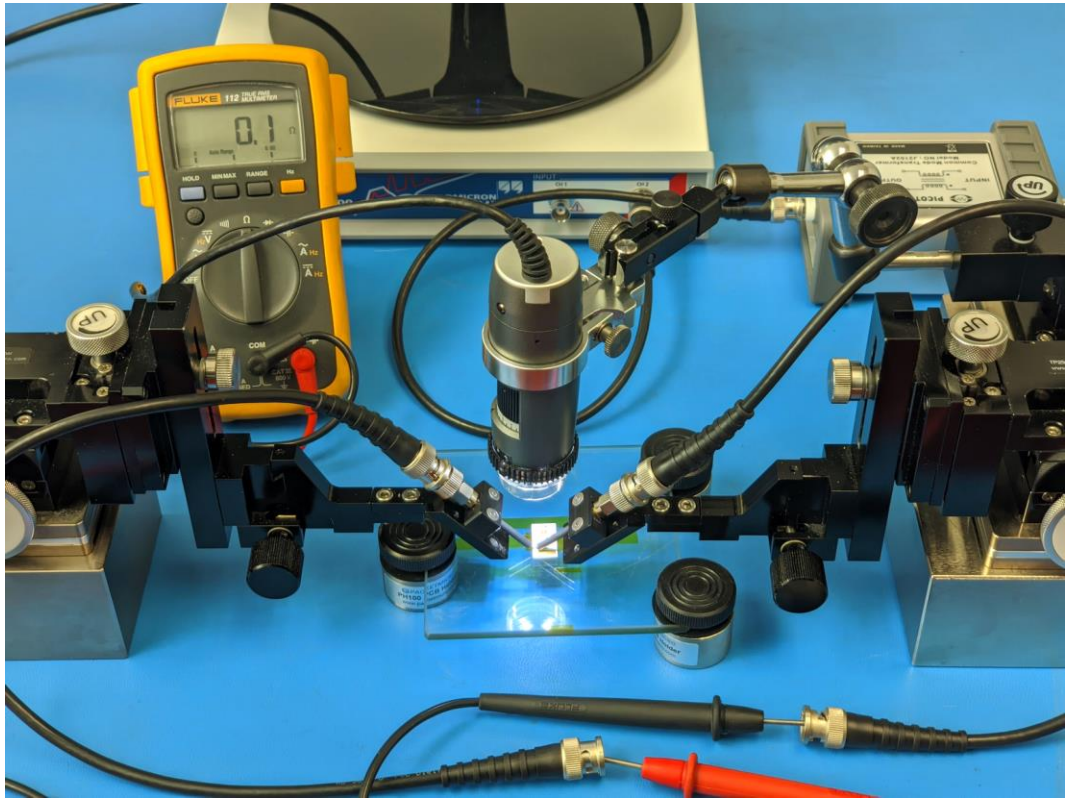
Open and Thru Calibration

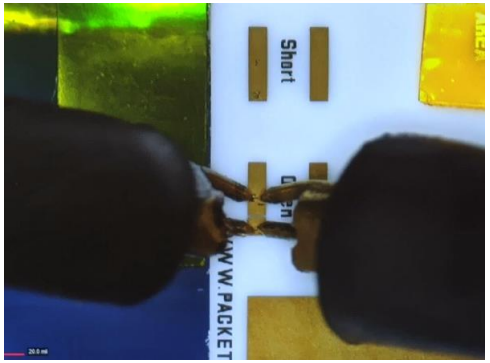




- Use TCS70V2 substrate's Open pad to perform both OPEN and THRU calibrations

Note: Open and Thru Calibration

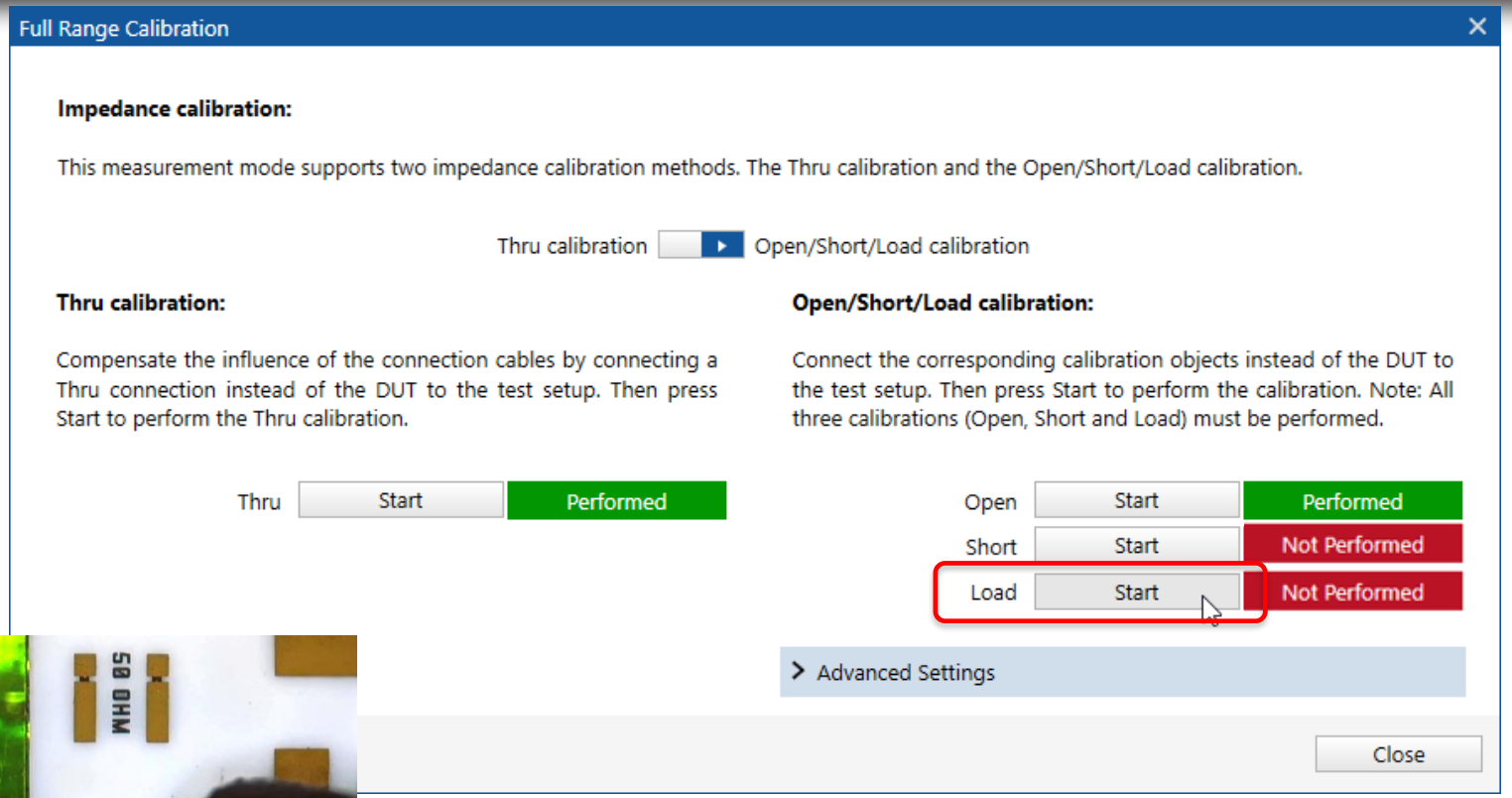


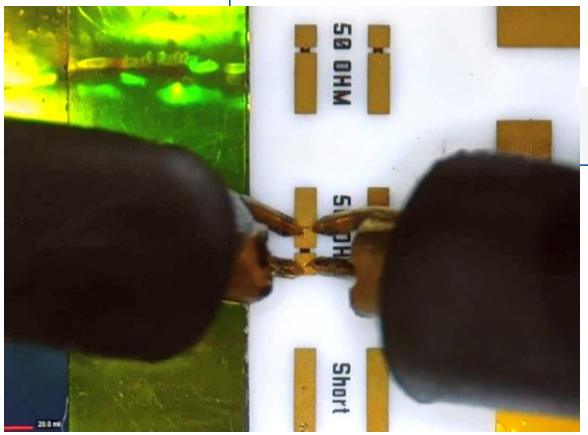


To ensure both the R-Probe tips are making good contact to the TCS70V2's Open substrate pad for OPEN and THRU calibration:

1. Disconnect the BNC cables from the Bode-100 and J2102B Injection transformer
2. Measure the continuity between the left and right BNC cable center-to-center conductors
3. Measure the continuity between the left and right BNC cable outer-shell to outer-shell
4. Reconnect the BNC cables back to the Bode-100 and injection transformer before continuing on to perform the Bode-100 Open and Thru calibrations

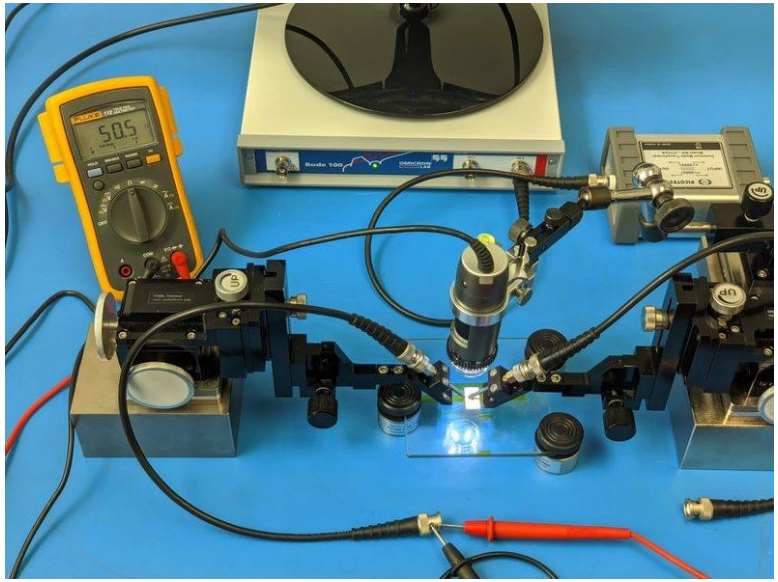
Load Calibration

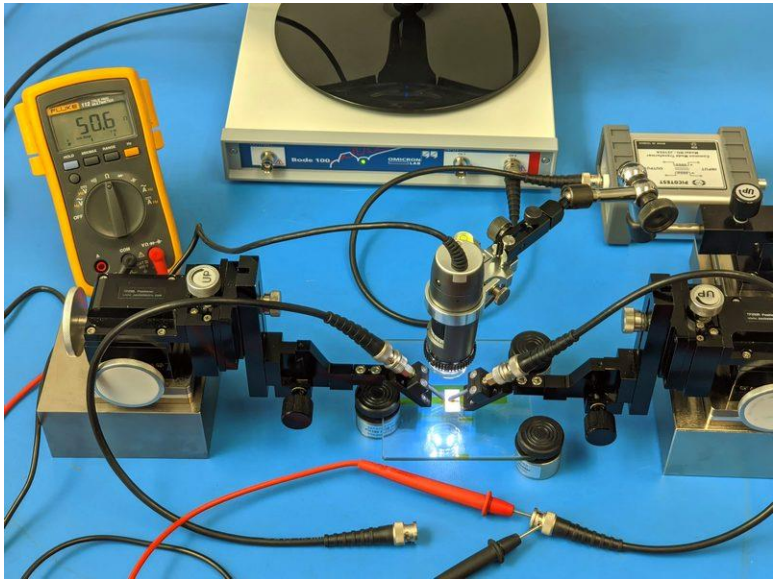


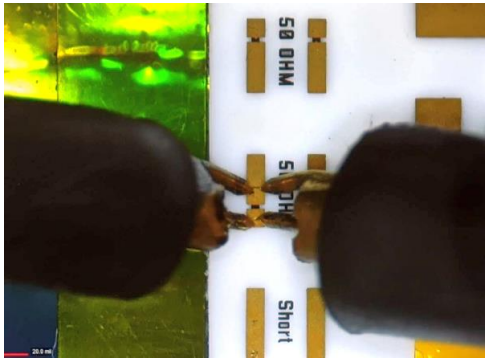


- Use TCS70V2 substrate's 50-OHM pad to perform Load calibrations

Note: Load Calibration



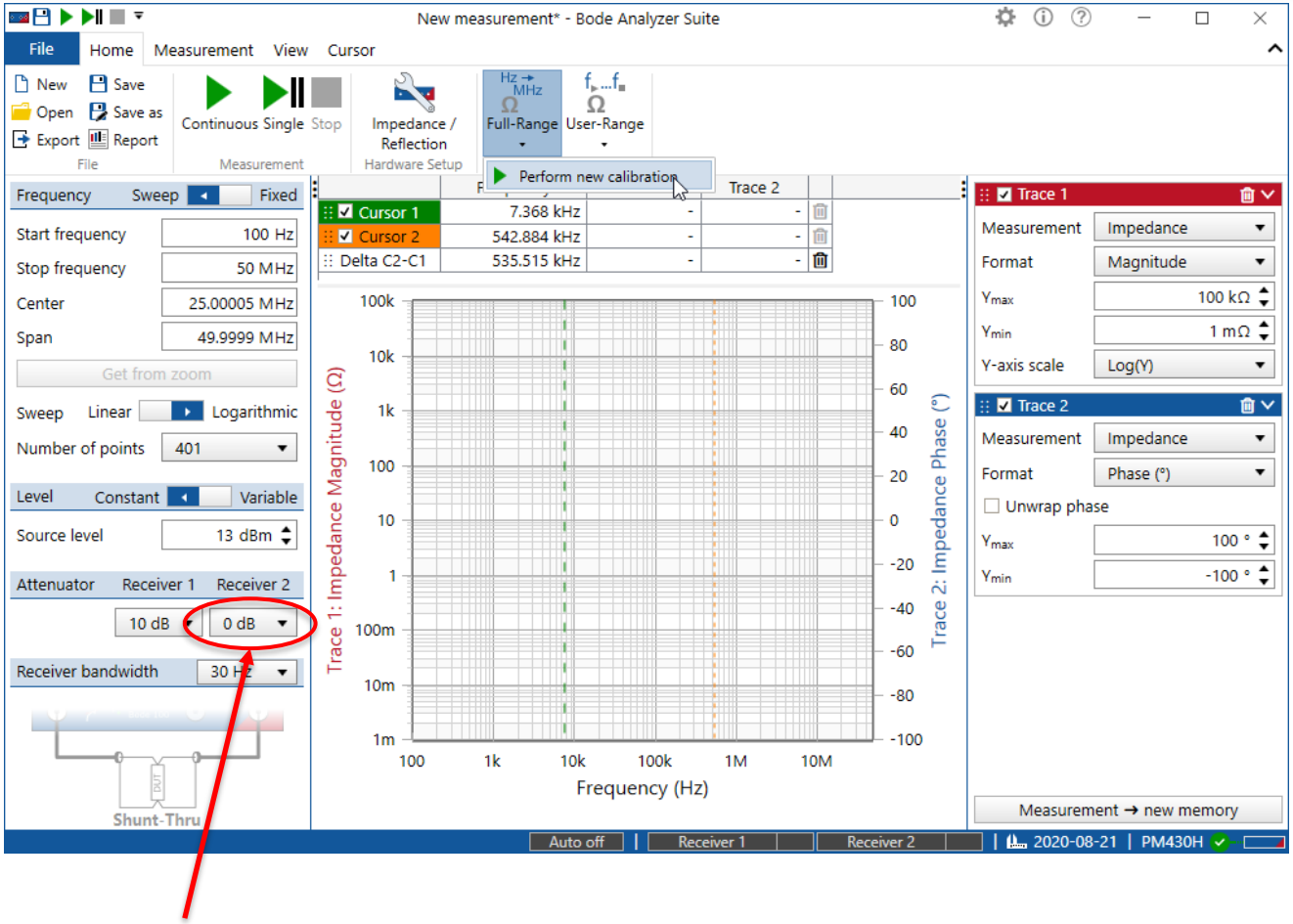




To ensure both the R-Probe tips are making good contact to the TCS70V2's 50-Ohm substrate pad for LOAD calibration:

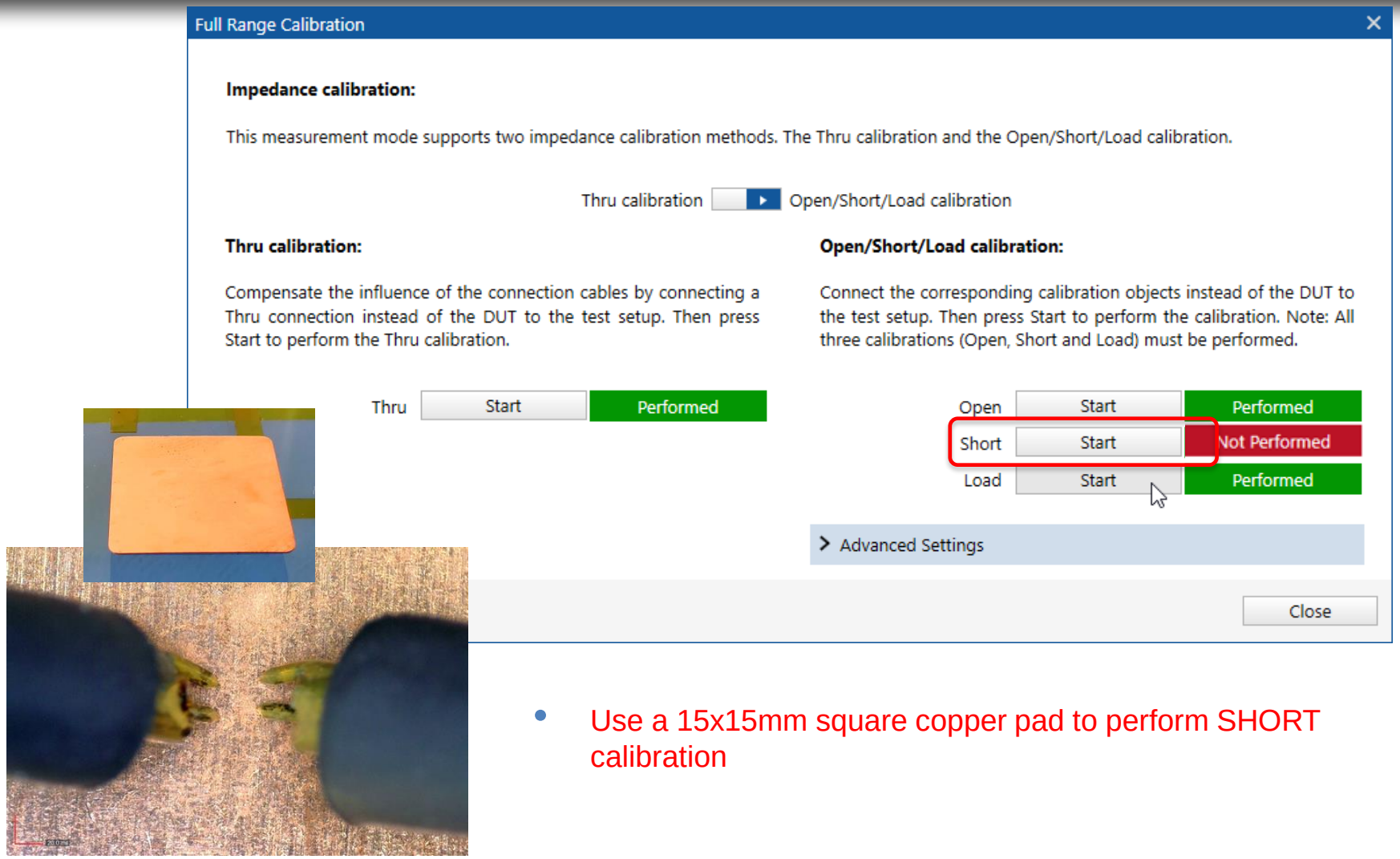
1. Disconnect the BNC cables from the Bode-100 and J2102B Injection Transform
2. Measure the LOAD resistance (50-Ohms) between the BNC cable center to the outer shell on both BNC cable ends.
3. Reconnect the BNC cables back to the Bode-100 and Injection Transformer before continue on to perform the Bode-100 OPEN calibration

Set Configuration for Short Calibration



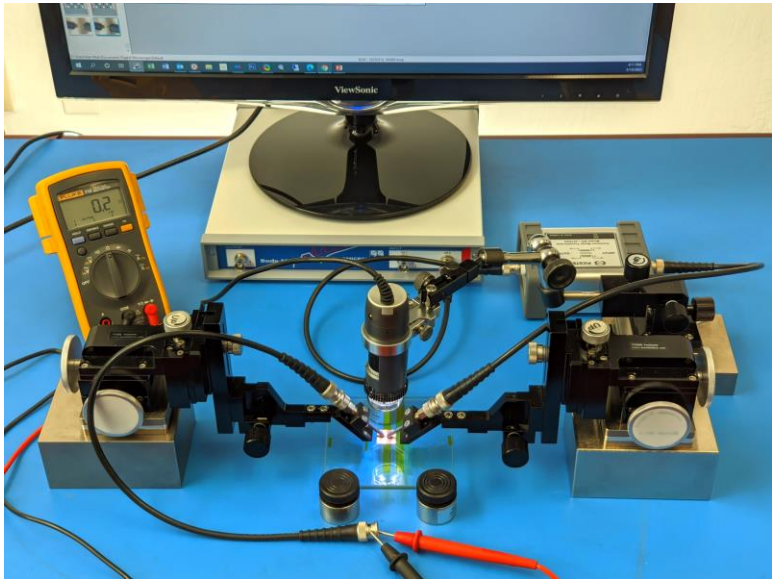
Change Receiver 2 Attenuator to 0 dB for improved sensitivity !

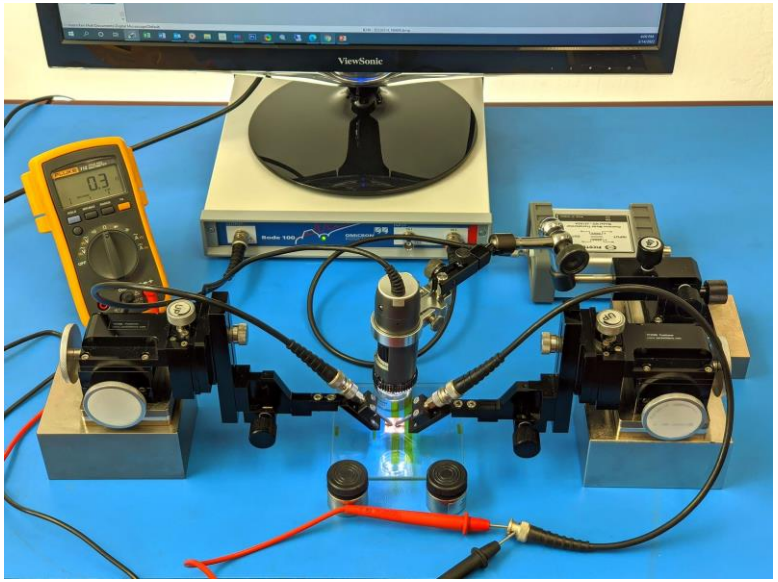
Short Calibration

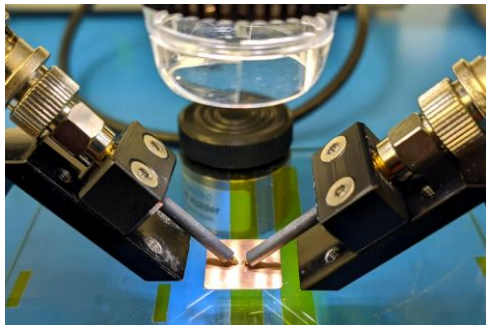


- Use a 15x15mm square copper pad to perform SHORT calibration

Note: Short Calibration



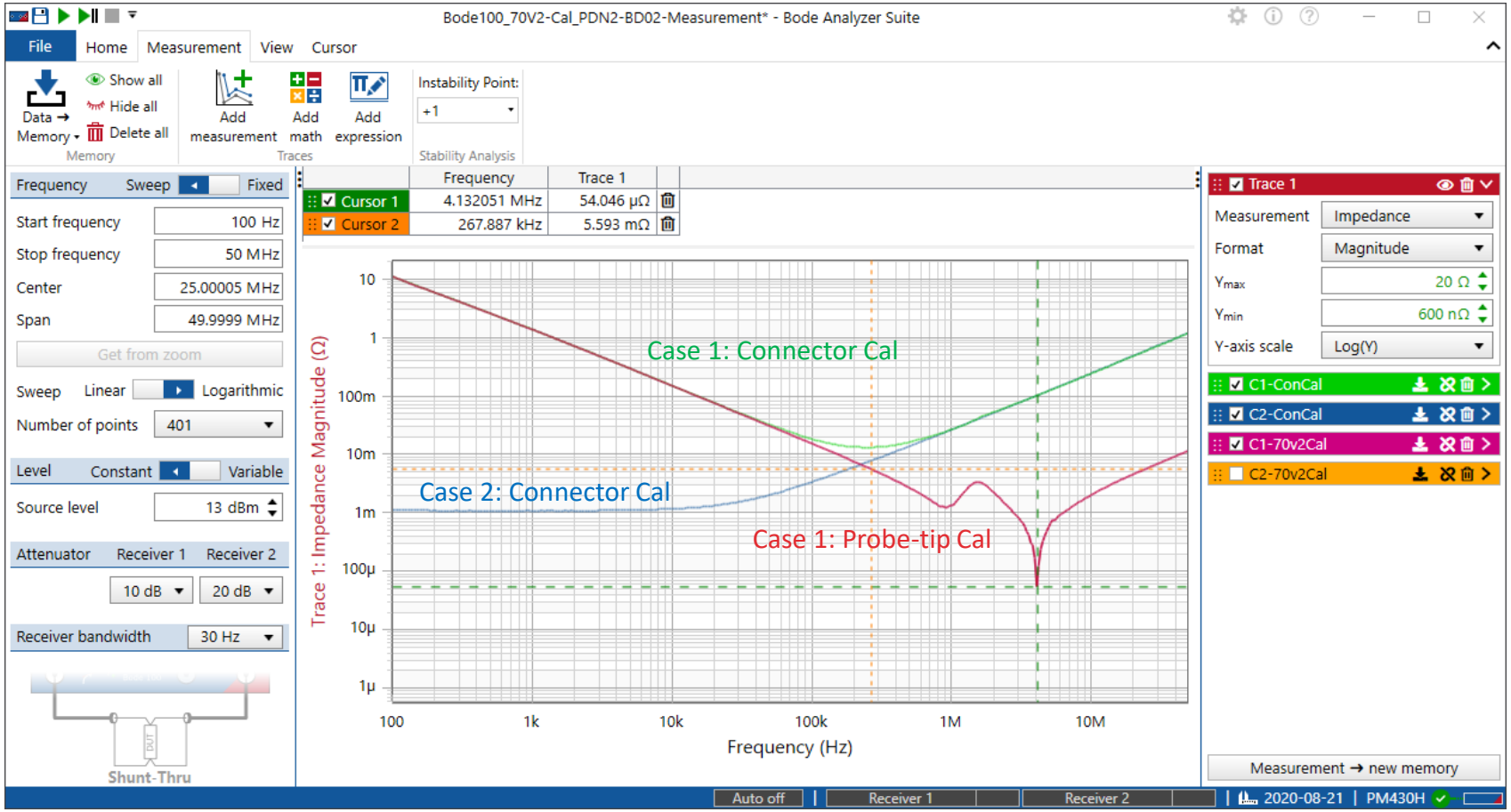




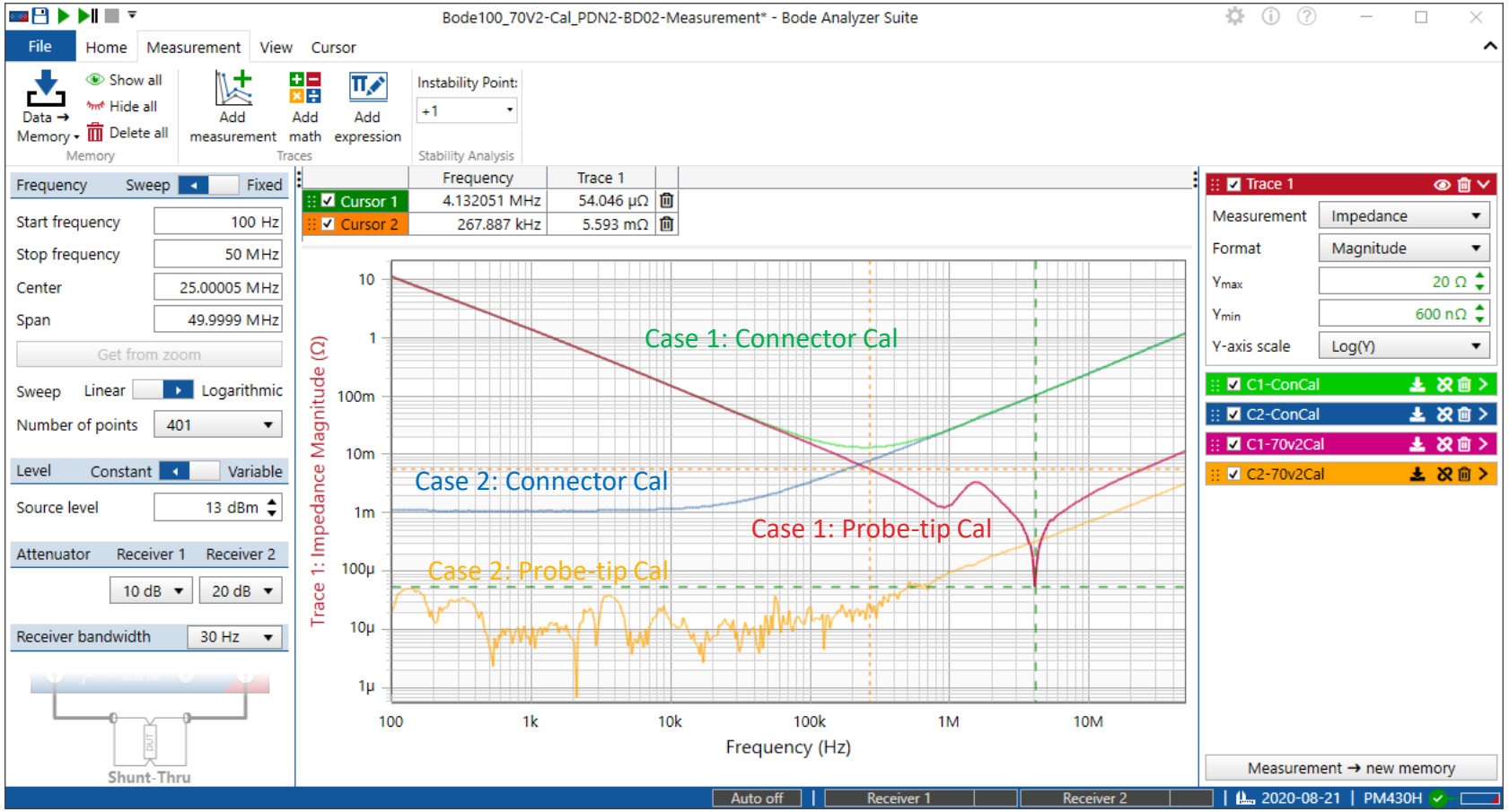
To ensure both the R-Probe tips are making good contact to the square copper pad SHORT calibration:

1. Disconnect the BNC cables from the Bode-100 and J2102B Injection Transform
2. Measure the continuity between the BNC cable center conductor to the BNC connector outer shell on both cable ends.
3. Reconnect the BNC cables back to the Bode-100 and Injection Transformer before continue on to perform the Bode-100 SHORT calibration

Case 1: Probe-tip Calibration

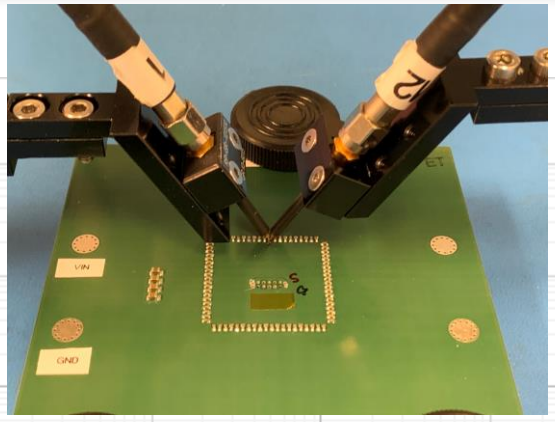


Case 2: Probe-tip Calibration



Probe-tip calibration is recommended for making PDN measurements with Bode 100 !

Omicron Bode 100 vs. Rohde ZNB40



Measurements of two VNAs show comparable results for the overlapping frequency range between 100 kHz and 50 MHz .

https://packetmicro.com/documents/Power_Integrity_Probing_with_Rohde_VNA.pdf

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)

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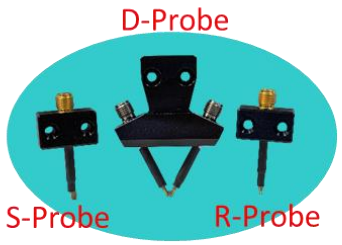
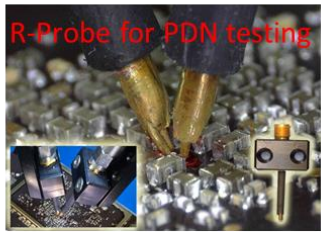
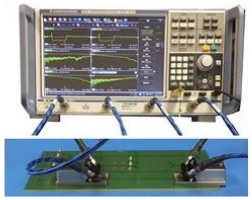





Delta-L 4.0 Solution

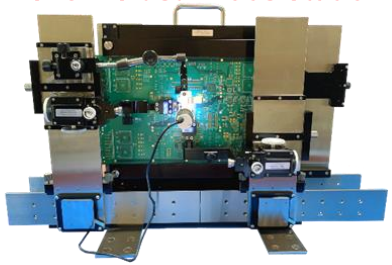

TCS70
Cal Substrate

Precision Positioners


TP250


TP150

VPS10 2-Sided Probe Station



Flex Positioners

F80

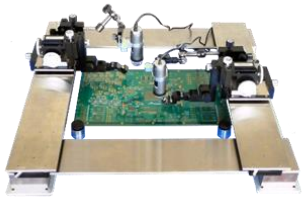

FP40

FP160MS

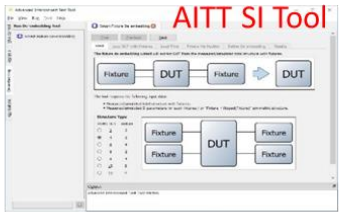

FP160

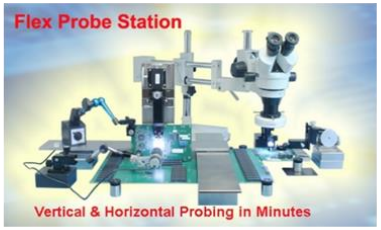
USB Type-C Fixtures

HPS24 Probe Station



AITT SI Tool





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