DVT Solutions, LLC
GigaProbes®

Return Loss to Power Transfer Table		
Return Loss (dB)	Reflected Power (%)	Transmitted Power (%)
0	100%	0%
1	79.40%	20.60%
2	63.10%	36.90%
3	50.10%	49.90%
4	39.80%	60.20%
5	31.60%	68.40%
6	25.10%	74.90%
7	20.00%	80.00%
8	15.80%	84.20%
9	12.60%	87.40%
10	10.00%	90.00%
12	6.30%	93.70%
14	4.00%	96.00%
15	3.20%	96.80%
16	2.50%	97.50%
18	1.60%	98.40%
20	1.00%	99.00%
25	0.32%	99.68%
30	0.10%	99.90%
40	0.01%	99.99%

−20 dB return loss corresponds to **~99% of incident power is delivered to the DUT** (~1% reflected). This represents **excellent probe performance**.

−17 dB return loss (typical of PCB-based probes such as DVT-FPPNN) corresponds to **~98% power delivered** (~2% reflected), indicating **very high transmission efficiency**.

−4 to −5 dB return loss (typical of wire-based probes) corresponds to **~60–68% power delivered** (~32–40% reflected), resulting in **significantly reduced measurement fidelity** compared to higher-return-loss PCB probes .

Where Measurement Errors Begin

Wire Based vs PCB Based Probes

Probe Tips Are the First Discontinuity in the Measurement Path

Typical Measurement Path

VNA → Cables → Probe → Test Pads → PCB Trace → Cables → VNA

VNA and cables are calibrated using SOLT standards to establish the measurement reference plane. However, this calibration does not remove probe-induced errors introduced by wire-based probes. These errors—such as impedance mismatch, reflections, and resulting measurement ripple—remain present in the measurement. In contrast, these effects are minimized or not seen at all with PCB-based probes that can achieve bandwidths from 40 GHz up to 11 0GHz , as illustrated on the next page.

Wire-based probes can introduce significant S-parameter measurement errors when the probe input impedance is not properly matched to the PCB trace impedance. These errors manifest in several ways:

TDR Discontinuities at Probe Contact
Impedance mismatch at the probe-to-pad interface creates localized discontinuities observable in TDR measurements, degrading impedance accuracy at the point of contact.

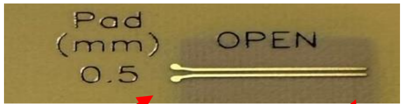
- **Increased Return Loss and Reduced Usable Bandwidth**
  Mismatch-induced reflections at the probe input result in higher return loss, which limits the effective bandwidth over which accurate measurements can be obtained.
- **Insertion Loss Ripple from Standing-Wave Effects**
  Impedance mismatches between the probe tips and PCB trace generate reflections that propagate back and forth along the signal path. These interacting forward and reflected waves form standing-wave patterns, which appear as ripple in insertion loss (S21) and additional S-parameter measurements, reducing measurement fidelity and repeatability.

DVT Solutions, LLC
GigaProbes®

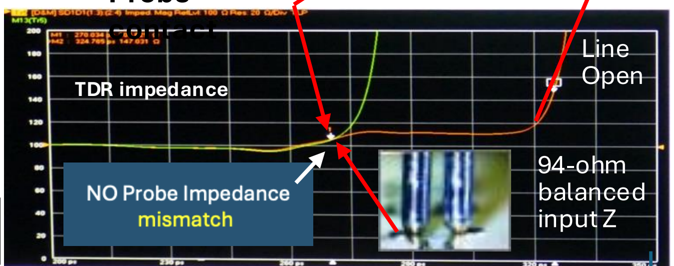
Differential Probe Architectures: Wire vs. PCB-Based

Impact of Probe Design on S-Parameter Measurement Accuracy

DVT-FPP70 70 GHz PCB-Based True Differential Probes (SS)



Probe



NO Probe Impedance mismatch

70GHz @ -17Db

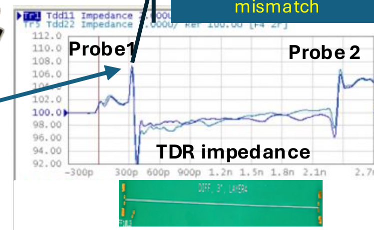
Note: 94 Ω probe PCB input matches trace, eliminating ripple and reducing return loss for higher accuracy measurements.

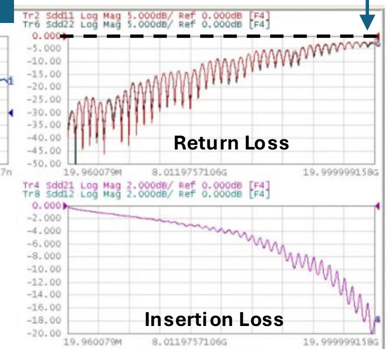
Higher return loss → Less reflection = More accurate S-parameters

Example 1 Wire-Based probe (SS)

20GHz BW @ -4 Db

Probe Impedance mismatch

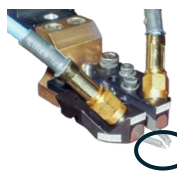




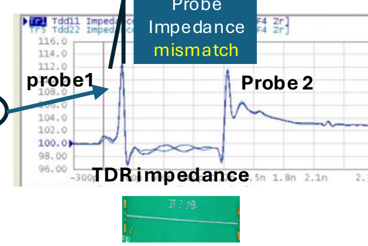
Probe mismatch creates S-Parameter standing-wave ripple →

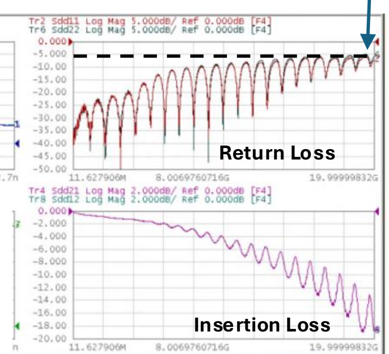
Example 2 Wire-Based probe (GSSG)

20GHz BW @ -5 Db



Probe Impedance mismatch





Probe mismatch creates S-Parameter standing-wave ripple →

DVT Solutions, LLC
Giga Probes®

Architecture Comparison

True Differential PCB-Based vs. Wire-Based SS Probes

Probe architecture directly affects differential SI measurement accuracy

Wire-Based SS Probes

Datasheet: SS differential probe, **50 ± 2 Ω** input

Architecture: Two separate internal conductors with internal ground/shield reference

Electrical behavior: Two **50 Ω single-ended paths**

Not *a true 100 Ω balanced differential structure*

Time domain: poor to significant mismatch impedance reflections at probe tips

Frequency domain: Insertion-loss contains standing wave ripple which lowers return loss (~4dB) measurements

VNA Measurements: Odd-mode S-Parameters

Probe de-embedding file: Often not included, requiring additional software, a 2xThru board, and extra customer time to create them.

Probe tips: fixed pitch: One probe may be required to each unique test pad pitch, increasing cost and setup time.

DVT-FPPNN PCB-Based SS Probes

Datasheet: True differential 94 Ω input impedance

Architecture: Tightly coupled, fully balanced internal PCB differential trace

Electrical behavior: One **controlled true differential transmission structure**

Time domain: No mismatch Impedance reflections

Frequency domain: Linear insertion loss, no standing wave ripple, High return loss (-10dB/-17dB)

VNA Measurements: Odd mode S-Parameters

Probe de-embedding file: included with probe, no extra software required

Unique probe tips design: Enables one 0.6 mm DVT-FPPNN probe to contact >10 differential test pad pitches from 0.35 mm to 1.0 mm for complete prototype PCB characterization without multiple fixed-pitch probes.

A wire-based SS probe can measure differential signals, but a PCB-Based DVT-FPPNN probe is designed to preserve differential signal fidelity.

One DVT-FPPNN 0.6 mm Probe Covers 0.35 mm to 1.0 mm Pad Pitches

Reducing the Need for Multiple Fixed-Pitch Probe Purchases

Test Coverage Procedure: *Probe contact was verified using a 70 GHz VNA in low-pass time-domain mode with an approximately 14 ps equivalent TDR rise time. A* ***DVT-FPP70 with a 0.6 mm probe-tip pitch*** *was used on a controlled differential test board containing ten pad geometries from* ***0.35 mm to 1.0 mm*** *pitch.*

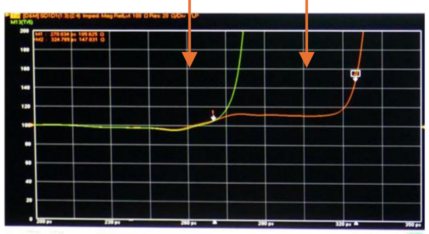
At each structure, contact quality was confirmed by correlating the TDR measurement with camera images of the probe tips contacting the pads. The TDR responses showed little to no impedance mismatch at probe contact, indicating a well-matched transition that supports ***low-ripple insertion loss*** *and* ***high return loss measurements****. For the full set of ten measurements, request the application note,* ***"A Single DVT-FPPNN Probe covers 0.35 to 1mm pad pitches 03-20-26R.pdf."***

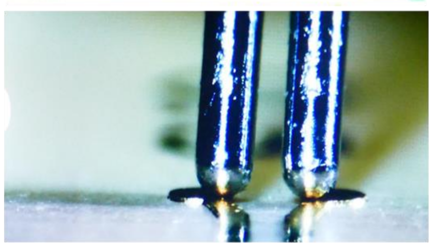
- **94 Ω differential probe input** reduces 14ps TDR impulse probe-to-trace impedance mismatch
- Wide pad-pitch coverage with fewer probe changes, reduces test times
- One 0.6 mm probe can contact test pad pitches from 0.35 mm to 1.0 mm

Board with **1.0mm** pads Pitch and 0.5mm dia,pads

Probe tips

Line open



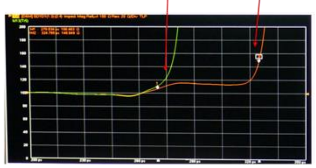


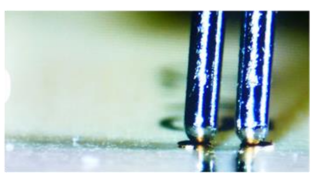
FPP70-0.60-001 SN 2083 Probe with 0.60mm pitch probe tips

Board with 0.8mm pads pitch and 0.45mm diameter pads

Probe tips

Line open



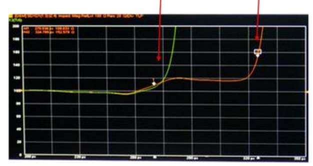


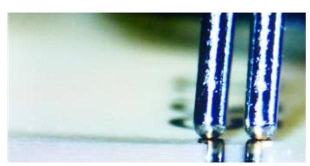
FPP70-0.60-001 SN 2083 Probe with 0.60mm pitch probe tips

Board with 0.6mm pads pitch and 0.4mm diameter pads

Probe tips

Line open



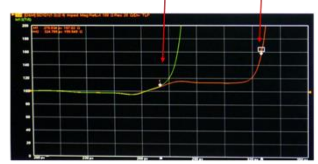


FPP70-0.60-001 SN 2083 Probe with 0.60 mm pitch probe tips

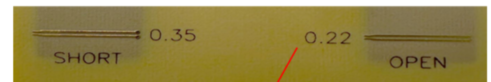
Board with 0.5mm pads pitch and 0.25mm diameter pads

Probe tips

Line open



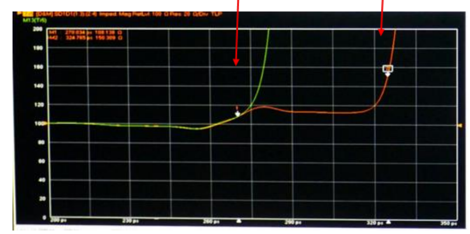
FPP70-0.60-001 SN 2083 Probe with 0.60 mm pitch probe tips



Board with **0.35.0mm** pads Pitch and 0.5 mm dia.pads

Probe tips

Line open



FPP70-0.60-001 SN 2083 Probe with 0.60 mm pitch probe tips

DVT Solutions, LLC
GigaProbes®

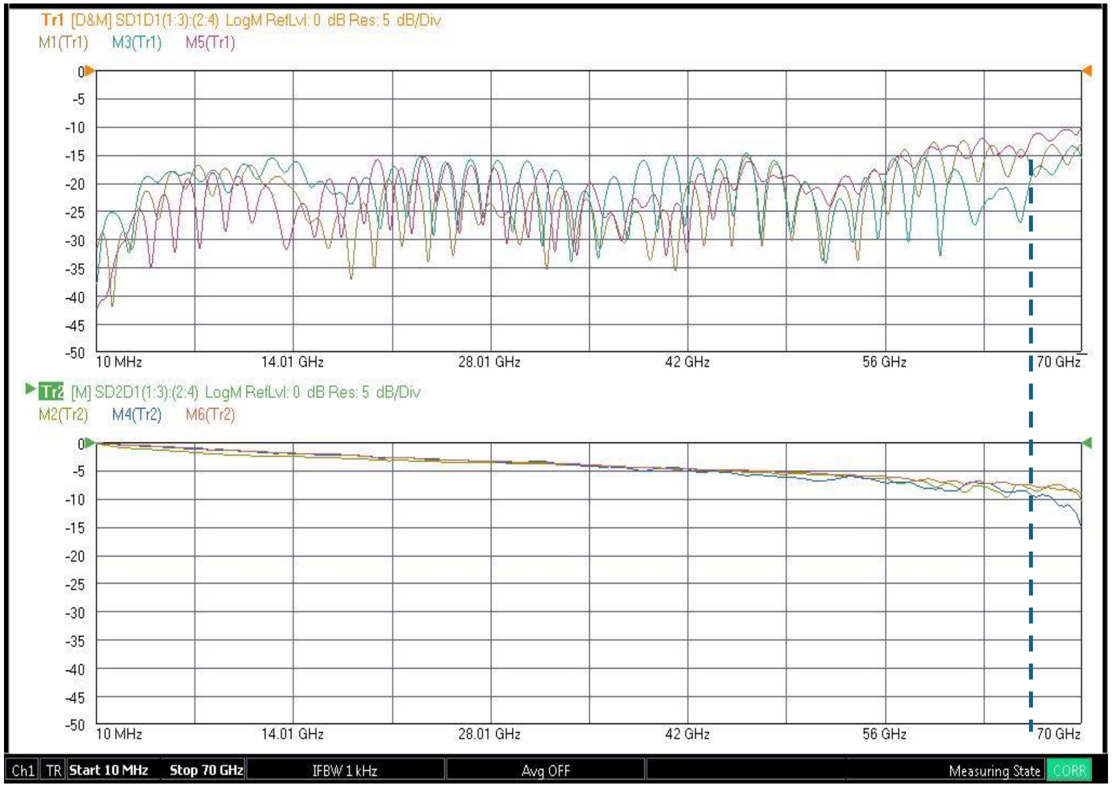
DVT-FPP70 70 GHz Wide-Pitch Bandwidth Performance

Measured with **0.6 mm**, **0.8 mm**, and **1.0** mm Probe Pitches

- Linear insertion loss at 0.6 mm, 0.8 mm, and 1.0 mm probe pitches
- Bandwidth is independent of probe pitch
- No standing-wave ripple in insertion loss
- High return loss: -25 dB to -10 dB from 10 MHz to 70 GHz

110 GHz bandwidth is maintained across 0.6 mm and 0.8 mm rated probe pitches.

One DVT-FPP110 .6 mm probe can contact 10+ differential test pad pitches from 0.35 mm to 1.0 mm (although it is not bandwidth-rated at a 1.0 mm pitch).



Note: These raw probe insertion loss measurements were made using a 70 GHz VNA sweep with 1.85 mm RF connectors rated to 67 GHz. On this plot, 67 GHz is slightly to the right of the midpoint between 63 GHz and 70 GHz.