ISBNN VNA 40 GHz to 110 GHz Test Verification Boards

Pre-Measurement Cable Integrity Testing and Probe De-Embedding Verification

ISBNN VNA Test Board Applications

- Confirm VNA measurement repeatability after calibration
- Rapidly verify VNA system accuracy and identify when recalibration is required
- Prevent inaccurate or inconsistent measurements caused by system drift
- Verify VNA system bandwidth to 110 GHz for differential RF probe measurements
- Use IEEE P370 concepts to verify that the probe de-embedding file removes probe effects while preserving the true PCB interconnect response
- Validate 50-ohm and 100-ohm system performance to 110 GHz
- Train PCB designers and VNA users on proper frequency-domain calibration techniques for time and frequency-domain and PCB measurements

The ISBNN VNA Test Verification Boards include high-bandwidth differential and single-ended connectorized traces designed to provide a *ripple-free, linear insertion-loss response*, supporting 2 and 4-port VNA validation to 110 GHz and ensuring full system measurement integrity and accurate probe de-embedding verification.

In the ISBNN and DVT-FPPNN naming convention, NN defines the probe and board bandwidth: 40, 50, 70, or 110 GHz.

Golden Reference Traces

Procedure: Verifying RF Cable and VNA System Integrity Using ISBNN Golden Reference Traces

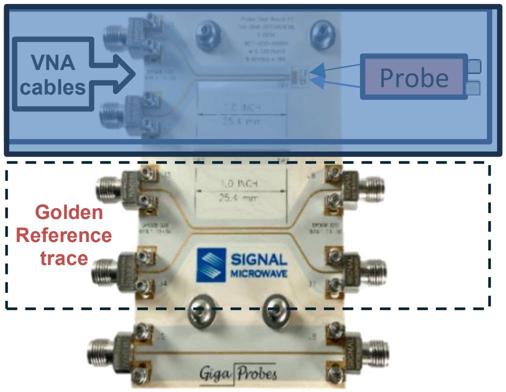
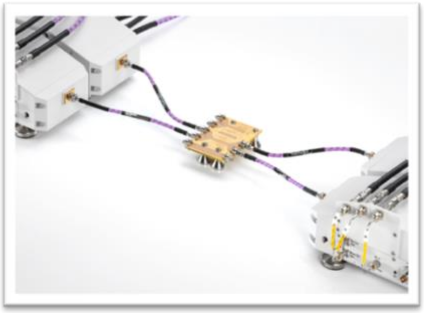


***Figure 1*. Golden reference traces** *on ISBNN VNA Test Verification Board (40 GHz, 50 GHz 70 GHz and 110 GHz)*



Golden reference traces are measured after calibration and before probe measurements to verify overall VNA system integrity, including cable performance, and to help troubleshoot questionable VNA results.

A standard SOLT calibration validates the VNA measurement plane but *does not fully verify cable performance across the entire bandwidth.* Cable defects can remain undetected and directly impact measurement accuracy.

A quick **insertion-loss and return-loss measurement** of the golden reference trace can identify common cable issues, including:

- Narrowband frequency “suck-outs” caused by shield pinholes from repeated cable flexing
- Increased noise due to ground shield degradation
- Ground shield fraying at connector interfaces from repeated torquing

These failure modes are **not detected by SOLT calibration**, but they will appear in S-parameter measurements and degrade DUT accuracy.

Detect defective 110 GHz cables and verify VNA measurement system integrity

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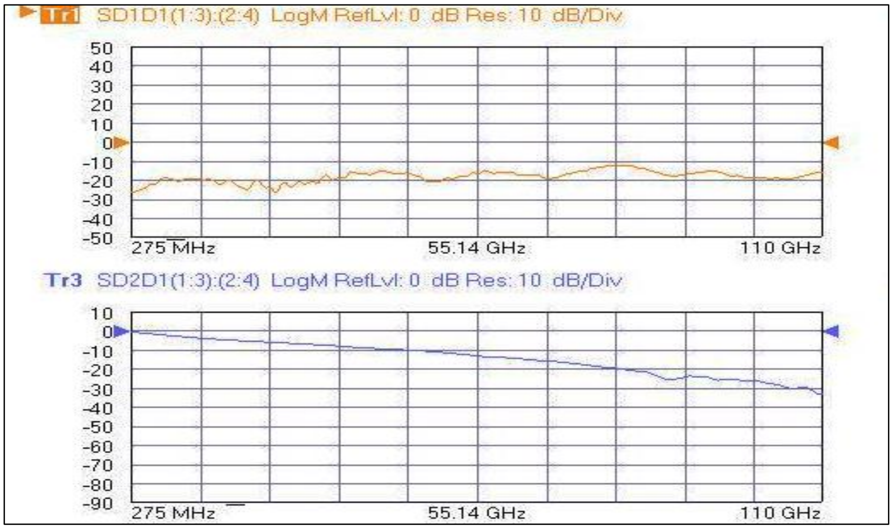

Figure 2. Example of ISB110 differential golden reference trace measurements

By comparing the VNA measured response to the known golden reference trace response, these anomalies can be quickly identified and corrected before making DUT measurements.

S-parameter plots are provided with each board, establishing a **known reference response** for the connector-to-connector traces. These serve as a **measurement baseline** for verifying system accuracy and detecting calibration drift.

Probe-to-Connector Trace

Probe-to-connector traces include differential probe pads on one end and RF connectors on the other. These structures are used to verify the accuracy of **differential probe de-embedding models**.

Using IEEE P370 concepts, Insertion-loss measurements made through these traces are compared before and after applying the VNA de-embedding model.

When the model is accurate, only the trace loss will be shown and the difference between the raw and de-embedded measurements represents the known frequency-dependent loss of the probe.

This method validates the accuracy of the probe model using this 100-ohm Probe-to-Connector Trace structure.

Procedure: Verifying the DVT-FPPNN Differential Probe De-Embedding Model Accuracy using the Probe-to-Connector Trace

This procedure verifies the accuracy of a **DVT-FPPNN PCB-based differential probe de-embedding model** using the **probe-to-connector trace** on an **ISBNN VNA Test Verification Board** (see **Figure 2).** This validation method applies across all **ISBNN boards and DVT-FPPNN probes**.

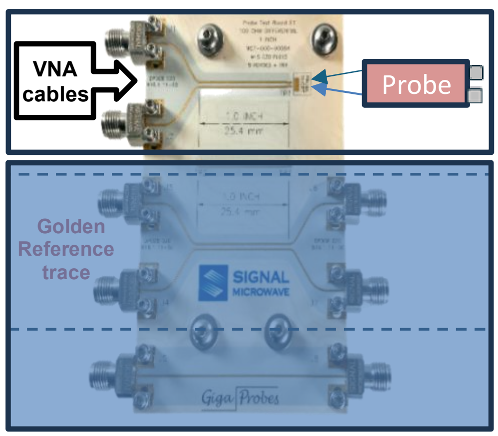

Figure 3. *ISBNN VNA Test Verification Board (40 GHz, 50 GHz 70 GHz and 110 GHz)*

The verification is performed by measuring insertion loss from the differential probe tips, through the **probe-to-connector trace**, to the RF connectors. This raw measurement includes the frequency-dependent loss of both the **DVT-FPPNN probe** and the **ISBNN probe-to-connector trace**. The raw result is then compared with the de-embedded measurement to confirm that the probe model correctly removes the probe loss when applied in the VNA.

The example procedure below uses the **ISB40 40 GHz board** with a **DVT-FPP40 probe** and a de-embedding file generated using the **AtaiTec ISD** (In-Situ De-Embedding) software.

The same process applies to other bandwidth configurations when using the corresponding probe, board, VNA bandwidth, and de-embedding file.

Step 1. Probe Test System Setup Procedure

Measurement setup in **Figure 4** includes the following equipment:

- DVT-FPP40 40 GHz differential probe, or the matching DVT-FPPNN probe for the selected bandwidth
- 4-port VNA with differential calibration and bandwidth matched to the probe and board (not shown)
- ISB40 VNA Test Verification Board, or the corresponding ISBNN board
- DVT-FP250 probe positioner with 2-axis probe adapter to mount the DVT-FPPNN probe
- CS-1 or CS-3 camera system, or equivalent, for probe-tip alignment
- Two RF cables connected from the probe-to-connector trace output connectors to the VNA's second differential port

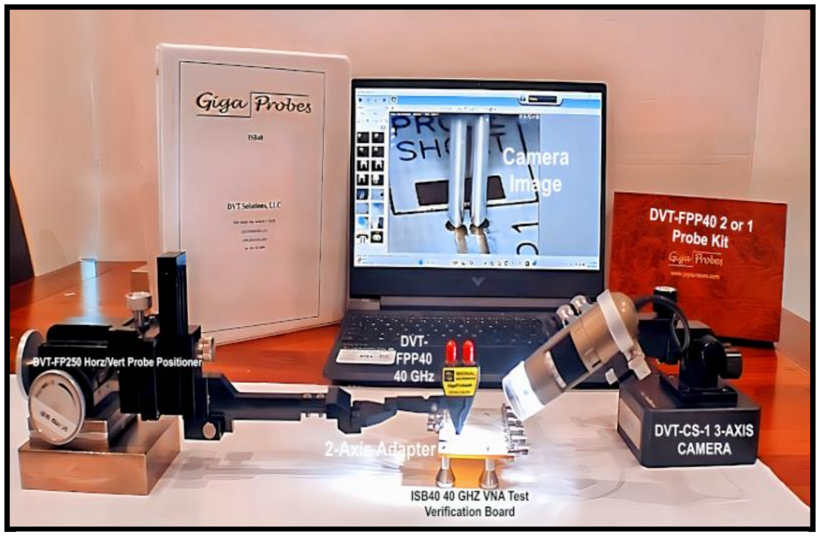

Figure 4. DVT-FPP40 probe system measuring the ISB40 probe-to-connector trace to verify probe de-embedding file accuracy.

1. Mount the DVT-FPPNN probe to the DVT-FP250 probe positioner using the 2-axis adapter.
2. Use the camera system and PC-based software to precisely align the probe tips with the probe-to-connector trace test pads on the ISBNN board.
3. Connect VNA differential port 1 to the DVT-FPPNN probe connectors.
4. Connect the RF cables from the connector end of the probe-to-connector trace to VNA differential port 2. This establishes a differential through S-parameter measurement path from the probe tips, through the ISBNN trace, to the RF connectors.
5. Position the probe tips on the probe-pad end of the trace and confirm stable contact by using the VNA to make a differential TDR measurement.
6. Measure a raw SDD21 insertion loss and SDD11 return loss/SWR.

Step 2. Raw Reference Measurement

The raw brown insertion-loss measurement in **Figure 5** below includes the combined loss of:

- Differential probe
- Probe-to-pad interface
- ISBNN PCB probe-to-connector trace
- RF connector launch

This raw measurement corresponds to the bottom brown insertion-loss trace in **Figure 5.**

Step 3. Save the Raw Measurement as a Reference

1. Save the raw insertion-loss measurement in the VNA memory.
2. Display the saved trace as a VNA reference while maintaining live probe contact on the same pads.
3. The live trace and reference traces should overlap. If they do not overlap, verify the probe alignment and contact stability of the live measurement.

Step 4. Apply the Probe De-Embedding File

1. Load the correct DVT-FPPNN S4P de-embedding file into the VNA and verify the file port assignment is correct for the VNA port configuration.
2. Apply the de-embedding file to the live probe measurement.
3. The upper purple insertion-loss trace in **Figure 5** shows the de-embedded result, with the probe's frequency-dependent loss removed and only the ISBNN PCB trace response remaining.
4. For the ISB40/DVT-FPP40 example, the purple trace de-embedded should show approximately 4 dB less loss than the raw brown trace. This confirms that the probe loss has been removed from the measurement.

Step 5. Verification Result

A correct de-embedding model should produce:

- A smooth insertion-loss response
- A consistent reduction in loss after de-embedding
- No unexpected ripples or artifacts

Figure 5. Verifying Probe De-Embedding Accuracy

The difference between the raw brown trace and the de-embedded purple trace represents the frequency-dependent loss of the probe.

After de-embedding, the remaining live purple measurement represents only the ISBNN PCB probe-to-connector trace loss, confirming the accuracy of the probe model.