



Vector Network Analyzer Quick Start Guide

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About This Guide

This guide is intended for engineers with a background in electronics or communications. It helps readers quickly understand the basic measurement principles, parameter settings, calibration methods, and typical measurement procedures of vector network analyzers, and enables them to use VN / PN series vector network analyzers to perform basic measurements on common RF devices.

First-time users of vector network analyzers are advised to read this guide in the following order:

Chapter 1 introduces basic measurement concepts

→ Chapter 2 helps you understand instrument interfaces

→ Chapter 3 explains measurement parameter settings

→ Chapter 4 describes calibration methods

→ Chapter 5 walks through a complete measurement using a filter test example

→ Chapter 6 summarizes common operating precautions.

Important: Calibration is essential to ensuring vector network analyzer measurement accuracy. Before formal measurement, complete the appropriate calibration according to the current measurement conditions, and keep the test cables, adapters, and calibration reference plane consistent during measurement.

1. What is a Vector Network Analyzer

1.1 Basic Concepts of S-Parameters

A vector network analyzer measures the reflection and transmission characteristics of RF signals between the ports of a device under test (DUT) to obtain the DUT's S-parameters (Scattering Parameters).

For a two-port network, commonly used S-parameters include S11, S21, S12, and S22. The S-parameter subscript can be understood as S(output)(input): the first number indicates the port at which the signal response is measured, and the second number indicates the port into which the signal is input.

- **S11:** the signal is input from Port 1 and reflected back to Port 1 -> **reflection parameter**, which can be used to analyze return loss, voltage standing wave ratio (VSWR), input impedance, etc.;
- **S21:** the signal is input from Port 1 and output from Port 2 -> **forward transmission parameter**, which can be used to analyze insertion loss, gain, phase, group delay, etc.;
- **S22:** the signal is input from Port 2 and reflected back to Port 2 -> **reflection parameter**, which can be used to analyze output port matching characteristics;
- **S12:** the signal is input from Port 2 and output from Port 1 -> **reverse transmission parameter**, which can be used to analyze reverse transmission or isolation characteristics.

For reciprocal passive devices, such as filters and cables, S21 and S12 are usually close to each other. For non-reciprocal devices such as amplifiers, forward and reverse transmission characteristics usually differ significantly.

1.2 Principles of Vector Measurement

A scalar network analyzer mainly measures signal amplitude. The VN and PN series are vector network analyzers; in addition to amplitude, they can measure signal phase, thereby obtaining complete complex S-parameters.

Based on amplitude and phase information, characteristics such as DUT impedance, Smith charts, group delay, and time-domain response can be further analyzed, providing more complete measurement results for device matching, transmission, and time-domain characteristic analysis.

1.3 Typical DUTs and Applications

The VN / PN series are mainly used to measure the reflection and transmission characteristics of RF devices and networks.

- **Typical applications:** measurement of matching, loss, gain, isolation, phase, impedance, and other characteristics of passive devices (filters, antennas, cables, attenuators, couplers) and active devices (amplifiers).
- **Non-typical applications:** signal spectrum analysis, compression, intermodulation, and other large-signal nonlinear measurements. Select the appropriate test equipment or measurement system according to the specific test requirements.

1.4 Full 2-Port and One-Path 2-Port VNAs

Two vector network analyzers may both have “Port 1” and “Port 2” marked on their panels, but differences in internal architecture determine the completeness of the S-parameters they can measure and the calibration methods they support.

Full 2-Port (true two-port): supports excitation of the DUT from both Port 1 and Port 2. It can perform forward measurement from Port 1 → Port 2 and reverse measurement from Port 2 → Port 1. Therefore, with the DUT connected once, it can obtain all four S-parameters—S₁₁, S₂₁, S₁₂, and S₂₂—and supports full two-port calibration.

One-Path 2-Port: usually supports complete reflection and transmission measurement in only one direction. For example, when Port 1 is used as the excitation port, S₁₁ and S₂₁ can be obtained directly. To obtain S₂₂ and S₁₂ of the original DUT, the DUT connection direction must be reversed and measured again. This architecture typically uses response calibration or enhanced response calibration and cannot achieve the same error correction capability as full two-port calibration.

The following uses an amplifier as an example to explain the differences between full 2-port and one-path 2-port VNAs in S-parameter measurement and calibration capability.

1.4.1 Differences in S-Parameter Measurement Methods

Full 2-Port VNA: with the DUT connected once, the following parameters can be obtained directly: S₁₁ (input port matching characteristics), S₂₁ (forward gain), S₂₂ (output port matching characteristics), and S₁₂ (reverse transmission or isolation characteristics).

One-Path 2-Port VNA: in the current connection direction, it can usually obtain only S₁₁ and S₂₁ directly. By reversing the DUT connection, S₂₂ and S₁₂ of the original DUT can be further obtained. The parameter correspondence is as follows:

Table 1 One-Path 2-Port VNA S-Parameter Measurement

Measurement State	Directly Measured Parameters	Corresponding Parameters of the Original DUT
First connection	Reflection + forward transmission	S11、S21
DUT connected in reverse	Reflection + forward transmission	S22、S12

For reciprocal devices such as filters, cables, and attenuators, $S_{21} = S_{12}$ is usually satisfied in theory; therefore, reversing the connection is mainly used to obtain the reflection parameter S_{22} of the other port.

For non-reciprocal devices such as amplifiers, circulators, and isolators, S_{21} and S_{12} usually differ significantly. When the bidirectional transmission characteristics of a device need to be fully analyzed, both forward and reverse transmission parameters should be obtained.

1.4.2 Differences in Calibration Capability

Although the four S-parameters can be obtained separately by reversing the DUT connection, the differences between different calibration models cannot be eliminated. Full two-port calibration can more completely correct system errors in the forward and reverse measurement paths, while enhanced response calibration mainly corrects errors for one-way reflection and transmission measurements.

Table 2 Error Terms Corrected by Full 2-Port SOLT and Enhanced Response Calibration

Error Term	Full 2-Port	Enhanced Response Calibration
Directivity	Corrected	Corrected
Source Match	Corrected	Corrected
Reflection Tracking	Corrected	Corrected
Transmission Tracking	Corrected	Corrected
Isolation	Corrected	Optional
Load Match	Corrected	Not Corrected

Load match error reflects the impact of mismatch between the DUT output port and the instrument measurement port. When load match error is not corrected, multiple reflections may be superimposed on the actual measurement results, affecting the accuracy of transmission and reflection measurements. Full two-port calibration can correct the corresponding load match error, while enhanced response calibration usually does not include this correction.

In addition, reversing the DUT requires disconnecting and reconnecting the test ports. Repeated connector mating, changes in cable position and bend state, and other factors may

introduce additional measurement uncertainty. Full two-port measurement can obtain all four S-parameters with a single DUT connection and under the same calibration state, thereby improving measurement consistency.

Conclusion: By changing the DUT connection direction, a one-path two-port VNA can obtain S11, S21, S22, and S12 separately, but its calibration error correction capability and the measurement uncertainty introduced by repeated connection still differ from those of full two-port measurement. For applications that require complete analysis of bidirectional transmission and port matching characteristics, full two-port measurement is more suitable.

2. Panel and Interface Quick Reference

2.1 VNB Series

The VNB series is a USB-controlled two-port VNA with no built-in screen or physical keys. All operations are performed in VNStudio software on a PC. The instrument is compact with size of only 86 × 70 × 36 mm and covers a frequency range from 100 kHz to 6 GHz.

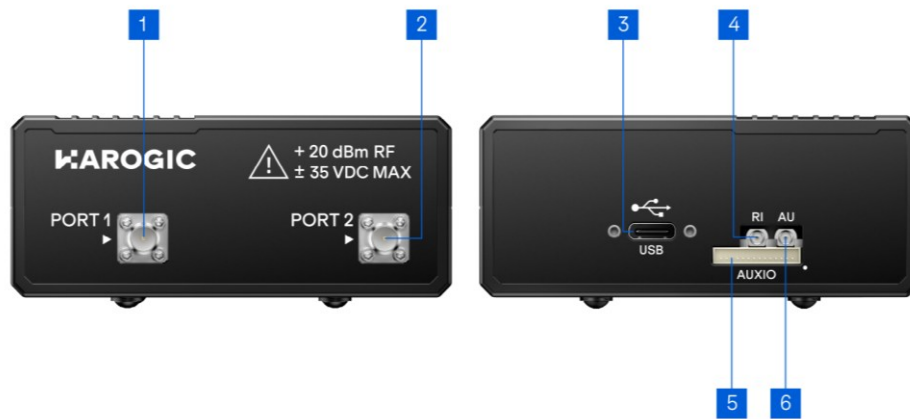


Figure 1 VNB Series Interface Description

The VNB series front panel has two RF ports, and the rear panel has USB data and power interfaces. Details are as follows:

Front panel: two SMA (F) ports with a nominal impedance of 50 Ω , corresponding to Port 1 and Port 2 respectively, for connecting the DUT or calibration standards.

Rear panel: one USB Type-C cable provides both power and data communication; no external power supply is required.

Table 3 VNB-60 Interface Description

No.	Interface Name	Description
1	Port1	SMA (F), nominal impedance 50 Ω
2	Port2	SMA (F), nominal impedance 50 Ω
3	Data Port	Type-C, USB 2.0 or USB 3.0 Use a 5 V/1 A power supply (voltage 4.75 to 5.25 V, ripple < 200 mVpp). Insufficient power supply may cause unstable measurement.
4	Reference Clock Input	MMCX (F), supports 10 MHz reference clock
5	Multifunction AUXIO	For details, refer to the corresponding product user guide.
6	Reserved Interface	/

Note:

- The RF port input limit is +20 dBm RF or ± 35 VDC. Exceeding the limit will permanently damage the port—always confirm the output power before connecting active devices or amplifiers.
- RF ports are delicate. Always use a torque wrench when tightening connectors and do not overtighten (see **Section 4.4** for details).
- Portability does not mean drop resistance. SMA ports are easily damaged by external force; protect the ports during storage.

2.2 PNB Series

PNB series interfaces are located on the top panel. The interface definitions are shown below:



Figure 2 PNB Series Interface Description

Table 4 PNB-60 Interface Description

No.	Interface Name	Description
1	Power Switch	Turn the instrument on/off
2	Charging Port	Instrument charging port, USB PD3.0 (65 W). Connect the power supply according to the operating voltage required by the instrument.
3	Micro HDMI	For extended display.
4	USB3	USB interfaces. USB2 is a USB 3.0 port, while USB1 and USB3 are USB 2.0 ports. These ports can be used to connect an external storage device, a USB keyboard, and a mouse.
5	USB2	
6	USB1	
7	Audio Output	3.5 mm headphone jack.
8	Ethernet Port	Gigabit Ethernet port for remote control of the instrument from a PC over Ethernet.
9	Multifunction AUXIO	For details, refer to the corresponding product user guide.
10	Charging Indicator	Flashing green indicates charging; solid green indicates fully charged.
11	Reserved	/
12	Trigger Output	MMCX (F), 3.3 V CMOS, high impedance
13	Trigger Input	MMCX (F), 3.3 V CMOS, high impedance
14	Reference Clock Input	MMCX (F), 10 MHz Allowable input level: -8 dBm to +10 dBm.
15	Reserved	/
16	Port1	N (F), 50 Ω impedance
17	Port2	N (F), 50 Ω impedance

3. Basic Measurement Setup in Three Steps

The latest version of VNStudio software for the VNB Series is available at the following link:

■ [HAROGIC VNStudio Software | Software defined radios-HAROGIC](#)

VNB series: The VNB series has no screen or physical keys. After connecting USB and opening VNStudio, you can start configuration and operation;

PNB series: The PNB series supports automatic startup. After pressing the power key on the top panel, VNStudio starts automatically.

After VNStudio starts, set the parameters and begin measurement as follows.

3.1 Step 1: Set the Frequency Range

1. Open the "Frequency" menu and set the "Start" and "Stop", or "Center" and "Span", according to the operating band of the DUT;
2. VNB and PNB series instruments cover 100 kHz to 6 GHz. The configured frequency range should cover the target operating band of the DUT and leave appropriate margins on both sides as needed. In general, avoid setting an unnecessarily wide measurement range, as this may reduce effective frequency resolution or increase sweep time;
3. Select an appropriate sweep mode according to the measurement requirements. Linear frequency sweep is typically used for conventional S-parameter measurements, while logarithmic frequency sweep (for low-frequency broadband measurements), power sweep, and CW mode can be selected as needed.

3.2 Step 2: Set Sweep Points, IF Bandwidth, and Output Power

Sweep points, IF bandwidth, and output power are important parameters that affect measurement speed, noise level, and measurement results.

Table 5 Recommended Settings for Common Measurement Parameters

Parameter	Range	Recommended Value	Description
Sweep Points	11 to 65535	401 / 1001 / 1601	More points provide higher frequency resolution and smoother curves, but slow down the sweep.
IF Bandwidth (IFBW)	15 Hz to 75 kHz	Typical: 10 kHz Precision: below 1 kHz	A smaller IFBW reduces noise and produces a cleaner trace, but slows down the sweep.
Output Power	-35 dBm to 5 dBm (10 MHz - 6 GHz)	Passive device: 0 dBm	Resolution: 0.25 dB; reduce power when measuring amplifiers.

- The combination of points and IFBW directly determines sweep time: with 201 points and 75 kHz IFBW, the sweep time is about 45 ms; with the same number of points reduced to 1 kHz IFBW, the sweep time is about 241 ms (longer after two-port calibration).
- When measuring active devices (amplifiers), be sure to reduce the output power first (for example, -20 dBm or lower) to prevent the amplified output from exceeding the +20 dBm limit of the Port and causing damage.

3.3 Step 3: Select the Measurement Parameter and Trace Format

3.3.1 Measurement Parameters

The VNB / PNB series supports S-parameter measurements such as S11, S21, S12, and S22. Select the corresponding parameter according to the measurement purpose:

- S11, S22: used to analyze the reflection and impedance matching characteristics of Port 1 or Port 2;
- S21, S12: used to analyze forward or reverse transmission characteristics.

3.3.2 Trace Formats

VNStudio supports displaying multiple S-parameters in different charts and traces. Users can configure the appropriate display format according to test requirements.

Table 6 Trace Format Parameter Description

Format	Purpose
Mag (dB)	Displays S-parameter amplitude in dB, commonly used to analyze insertion loss/gain/return loss (most commonly used).
Mag (Lin)	Displays S-parameter amplitude in linear form, used to observe amplitude changes in reflection or transmission coefficients.
Phase (°)	Observes the change of S-parameter phase with frequency.
Unwrap Phase (°)	Observes continuous unwrapped phase changes, facilitating analysis of phase linearity and group delay trends.
Real/Imaginary	Displays the real and imaginary parts of complex S-parameters respectively.
SWR	Displays VSWR, mainly used to evaluate the impedance matching characteristics of a port or DUT.
Smith Chart	Displays the Smith chart in impedance form, used to observe resistance, reactance, and impedance matching status.

3.3.3 Common Configuration Examples

- Filter insertion loss: $S_{21} + \text{Mag}(\text{dB})$;
- Antenna matching: $S_{11} + \text{SWR}$ or $S_{11} + \text{Smith}(R+jX)$;
- Amplifier gain: $S_{21} + \text{Mag}(\text{dB})$;
- Phase characteristics: $S_{21} + \text{Phase}(\text{°})$ or $\text{Unwrap Phase}(\text{°})$.

3.4 A Shortcut: Built-in Quick Configurations

VNStudio provides multiple built-in typical measurement presets that can be used to quickly measure common devices such as passive components, cables and connectors, small-signal amplifiers, and antennas.

Click "Quick" on the main menu bar, select the desired quick configuration, and click "Apply". The software automatically loads the configured frequency/points/IFBW/power/trace format, eliminating manual setup. For first-time vector network analyzer users, it is recommended to start with scenario presets before learning manual fine-tuning.

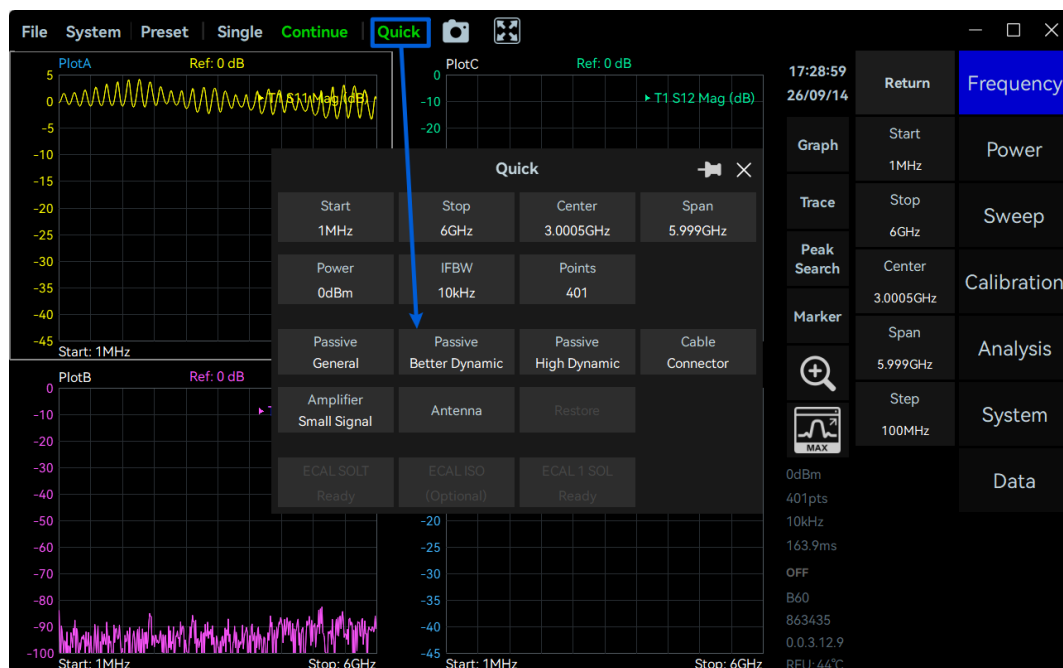


Figure 3 Using Quick Presets

4. Calibration—The Key to Measurement Accuracy (Core of This Guide)

4.1 Why Calibration Is Required

Vector network analyzer measurements are affected by system errors such as directivity, source match, load match, reflection tracking, transmission tracking, and isolation. For full two-port measurements, the classic error model usually contains 12 error terms.

Calibration establishes a system error correction model by measuring calibration standards with known characteristics, and moves the measurement reference plane to the actual test connection position, thereby reducing the influence of the instrument interior, test cables, connectors, and other factors on measurement results.

Therefore, before accurate S-parameter measurement, complete the appropriate calibration according to the current frequency range, connection method, and test configuration.

4.2 Calibration Kit Quality and Calibration Accuracy

Calibration kits are the reference standards used to establish the instrument error correction model. Their characteristic accuracy, connector machining quality, and connection repeatability directly affect calibrated measurement accuracy.

Table 7 Comparison of Characteristics of Different Calibration Kits

Item	High-Quality (Metrology-Grade) Calibration Kit	Economy/Low-Cost Calibration Kit
Characteristic Data	Measured S-parameter files are provided for each kit/piece, and the calibration algorithm uses the real characteristics for inverse correction.	Only fixed empirical polynomials are provided; high-frequency parasitic resonances and individual manufacturing tolerances are not corrected.
Directivity (Residual)	> 40 dB (high-grade kits can reach 45 dB–50 dB)	About 25 dB to 30 dB
Load/Source Match (Residual)	> 40 dB	About 30 dB or worse
Connector Machining	Micron-level concentricity, flat end faces, and thick wear-resistant plating	Large tolerances, thin plating, and easy wear
Mating Life	Thousands of cycles	Hundreds of cycles
Measurement Performance	Can accurately resolve small reflected signals from highly matched devices with $S_{11} \leq -30$ dB (return loss ≥ 30 dB).	Devices with $S_{11} \leq -20$ dB (return loss ≥ 20 dB) may be masked by residual errors, easily producing false ripples and resonances.

In short: when directivity drops from 40 dB to 25 dB, the error in measuring small reflections increases many times over. To accurately measure low-reflection devices, first ensure the calibration kit is a metrology-grade kit with measured data and precision connectors.

4.3 Why Amplitude/Phase-Stable Test Cables Are Required

The calibration error model assumes that "the cable state during calibration = the cable state during measurement", but ordinary cables are precisely the most difficult part to keep unchanged.

Example: take a 1 m ordinary flexible cable operating at 18 GHz. The wavelength at 18 GHz is about 16.7 mm, and only 10° of phase drift corresponds to about 0.46 mm of electrical length change. Bending the cable by 90°, changing its routing, or even slightly shaking it can cause phase drift of more than ten to several tens of degrees, and amplitude may fluctuate by 0.1 dB to 0.5 dB.

Consequence: right after calibration, once you move the cable to connect the DUT, the compensated phase/amplitude no longer matches. Reflection measurement is directly distorted; when measuring small reflections with return loss > 20 dB, tens of degrees of phase error are enough to make the result completely unreliable.

Countermeasure: use amplitude/phase-stable cables (phase-stable cables with special dielectric and braided structures). When bent, phase drift can be controlled within ± several degrees or even ± 1 to 2°, and amplitude can remain stable within ± 0.1 dB. Even when stable cables are used, keep the routing fixed after calibration, avoid bending during the test, and ensure the connector area is fixed and not under stress.

4.4 Role and Importance of a Torque Wrench

A torque wrench ensures that connectors are tightened to the specified torque and is critical for connection consistency and connector protection.

- **Insufficient torque:** poor contact, reflection/loss errors at high frequencies, inconsistent tightening each time, and poor repeatability;
- **Excessive torque:** may crush precision connectors such as 3.5 mm / 2.92 mm / 1.85 mm connectors and damage calibration kit characteristics;
- **Reference torque:** SMA/3.5 mm/2.92 mm ≈ 0.9 N·m, Type N ≈ 0.9 N·m–1.4 N·m, 1.85 mm ≈ 0.4 N·m–0.7 N·m (refer to the manual);

Note: use a torque wrench throughout calibration and measurement to ensure "calibration state = measurement state".

4.5 Selecting a Calibration Method: Prefer Electronic Calibration

Recommended order: electronic calibration (ECal) first -> mechanical calibration (SOLT) second. Calibration methods such as TRL that apply to specific test structures are beyond the scope of this guide and are not described in detail.

Table 8 Calibration Method Comparison

Comparison Item	Electronic Calibration (ECal)	Mechanical Calibration (SOLT)
Operation	One connection; the wizard completes the process automatically.	Connect the Open, Short, Load, and Thru standards in sequence as prompted.
Speed	Tens of seconds to several minutes	Several minutes to more than ten minutes
Accuracy	High, with good repeatability	High (depends on operation technique)
Error Probability	Low (standards switch automatically)	Medium (sequence/torque/standards are easy to get wrong)
Cost	Calibration kit is more expensive	Calibration kit is relatively inexpensive
Applicable Scenario	Preferred choice for production and frequent measurements	Standard solution when no electronic calibration kit is available

Conclusion: When the instrument, interface, and frequency range all match the electronic calibration kit, electronic calibration can be used preferentially. If the corresponding electronic calibration conditions are not available, mechanical SOLT calibration can be used, and each calibration step should be completed according to the software prompts.

4.6 Key Points for Electronic Calibration (ECal)

1. Complete measurement parameter settings such as frequency range, sweep points, IF bandwidth, and output power;
2. Connect the ECal module to the host PC running VNStudio via USB to provide power and control;
3. Connect ports A/B of the electronic calibration kit to the corresponding Port 1 and Port 2 interfaces of the instrument;
4. Click "Calibration" -> "Electronic Calibration" and select "SOLT";
5. Click "Start"; the software automatically performs two-port SOLT calibration;
6. After calibration is complete, the status changes from "Ready" to "Active", indicating that the current calibration is in effect;
7. When the dynamic range required for transmission measurement exceeds 90 dB, isolation

calibration can be further performed according to actual test requirements;

8. Disconnect the electronic calibration kit, keep the test cables, adapters, and other test connections unchanged, and connect the DUT to the calibration reference plane to begin measurement.

4.7 Key Points for Mechanical Calibration (SOLT)

SOLT calibration mainly uses four types of standards: Open, Short, Load ($50\ \Omega$), and Thru (two-port).

1. Click "Calibration" -> "Manual Calibration", select "2Port SOLT", and perform each step as prompted on the screen;
2. When connecting each standard to the corresponding port, be sure to note the following:
 - Use a torque wrench: Type N approximately $0.9\ \text{N}\cdot\text{m}$ – $1.4\ \text{N}\cdot\text{m}$ (per the manual), SMA / 3.5 mm approximately $0.9\ \text{N}\cdot\text{m}$;
 - Tighten only until fully seated; do not overtighten (this can damage standards and ports and change their characteristics);
 - Keep standard ports clean and avoid dust and metal debris.
3. After completing Open/Short/Load for Port 1 and Port 2 and Thru, save the current calibration file if you need to reuse it later.
4. Mechanical calibration strongly depends on technique. If results are abnormal, first check whether the standard is connected incorrectly, whether it is fully tightened, and whether the wrong load is used (for example, mistakenly using $75\ \Omega$).

4.8 Calibration Verification and When to Recalibrate

Verification: measure a verification device with known characteristics. The S21 of a 20 dB attenuator should be approximately -20 dB, the S21 of a through connection should be approximately 0 dB, and S11 should be very low. A clear deviation indicates calibration failure.

When to recalibrate: recalibrate whenever cables/connectors are changed, the frequency range is changed, the ambient temperature changes significantly, or measurement accuracy is suspected to have degraded.

5. Typical Test Example: Bandpass Filter

5.1 DUT and Test Objectives

In this example, a cavity bandpass filter is used as the DUT. Its center frequency is approximately 1.65 GHz, its -3 dB bandwidth is approximately 103 MHz, and its out-of-band rejection is no less than 95 dB.

This test mainly verifies the following indicators:

- S21 passband insertion loss: the smaller, the better. When expressed as the Mag(dB) result of S21, the closer the reading is to 0 dB, the lower the passband transmission loss; ideally it is 0 dB;
- S11 passband return loss: $S_{11} \leq -10$ dB in the passband, corresponding to return loss ≥ 10 dB; $VSWR \leq 2$ can be used as a common reference requirement.
- -3 dB bandwidth (nominally about 103 MHz);
- Out-of-band rejection: stopband rejection ≥ 95 dB.

5.2 Measurement Setup

1. Set the frequency range: 1.42 GHz–1.92 GHz, covering the 1.65 GHz center frequency and the transition bands and stopbands on both sides;
2. Set the number of sweep points: because the cavity filter transition band is steep, set "Points" to 1001 to resolve the transition-band shape.
3. Set IF bandwidth: to observe 95 dB stopband rejection, use a low IFBW (2 kHz or lower); otherwise, noise may mask the stopband noise floor.
4. Perform calibration: after completing the above measurement parameter settings, use electronic calibration or mechanical SOLT calibration. For details, see Chapter 4. After calibration is complete, keep the test cables and connection state unchanged, and connect the filter under test to Port 1 and Port 2.



Figure 4 Bandpass Filter S-Parameter Measurement

5.3 Result Analysis

After measurement is complete, the filter response can be analyzed using markers, bandwidth search, X dB search, and other functions.

- **Passband insertion loss:** observe the Mag(dB) trace of S21 and use markers to read the transmission amplitude in the passband. In this example, S21 near the passband center is approximately -0.5 dB, corresponding to about 0.5 dB insertion loss;
- **Port matching characteristics:** observe the Mag(dB) traces of S11 and S22. In this example, $S_{11} \leq -10$ dB in the passband is used as the reference requirement;
- **-3 dB bandwidth:** use bandwidth search on the S21 trace, use the peak value as the reference, set -3 dB, and find the corresponding frequency boundaries on the left and right sides. The measured value is 103.811 MHz;
- **Stopband rejection:** observe the stopband response of S21 and compare it with the passband reference level. In this example, stopband rejection is ≥ 95 dB;
- **Q value:** also provided by bandwidth search; in this example it is approximately 16.



Figure 5 Measurement Result Analysis

5.4 Save and Export

After measurement is complete, save or export measurement results according to subsequent analysis and data recording requirements.

- **Save measurement configuration:** save the current instrument and measurement parameter configuration to facilitate quickly restoring the test state later;
- **Export CSV data:** export measurement data for the current trace or all traces for subsequent processing and analysis.
- **Export S2P data:** save two-port S-parameter data (.s2p, Touchstone format) for subsequent analysis or simulation.
- **Save measurement image:** save the current measurement result image for test records or reports.

6. Checklist of Common Errors

1. **Measuring without calibration:** results may be too high or too low, and high-frequency errors can reach several dB. Before accurate S-parameter measurement, complete the appropriate calibration according to the current test configuration;
2. **Incorrect connection of calibration standards:** calibration results are wrong, and verification device readings are abnormal;
3. **Improper tightening of RF connectors:** overtightening damages standards and ports, while insufficient tightening introduces repeatability errors;
4. **Unreasonable IF bandwidth (IFBW) setting:** a larger IFBW helps increase sweep speed, but measurement noise is usually higher; reducing IFBW can lower noise and improve trace stability, but increases sweep time. Use low IFBW for precision measurement and high IFBW for quick screening;
5. **Output power set too high:** may damage an active DUT or drive an amplifier into compression;
6. **Contaminated RF interface or connector:** causes poor measurement repeatability and abnormal S11;
7. **Mismatched calibration kit reference impedance:** causes obvious calibration errors;
8. **Unreasonable frequency range or sweep-point setting:** if the frequency range does not fully cover the DUT operating band, the passband, resonance points, or transition bands may be missed; too few sweep points may fail to fully reflect narrowband or rapidly changing response characteristics;
9. **Changing key measurement parameters after calibration:** calibration data is related to the current measurement conditions. After changing frequency range, sweep points, output power, or other parameters, confirm whether the current calibration is still valid and recalibrate if necessary.
10. **Adding test connections after calibration:** if adapters, fixtures, test cables, or other connections are added after calibration, the measurement reference plane changes and may introduce additional delay, loss, and mismatch errors.

Appendix (Glossary)

Table 9 Glossary

Term	Meaning
S11 / S22	Reflection coefficient.
S21 / S12	Transmission coefficient.
Return Loss	$-20 \log S_{11} $, in dB; a larger value indicates less reflection.
Insertion Loss	$-20 \log S_{21} $; smaller is better in the passband.
VSWR	Voltage standing wave ratio; 1 is ideal.
IFBW	Intermediate frequency bandwidth; affects noise and speed.
Cal Set	Calibration data set.
Touchstone (.s1p / .s2p)	Standard S-parameter file format.
SOLT	Short-Open-Load-Thru calibration.
ECal	Electronic calibration kit.
Full 2-port	Full 2-Port VNA which can measure all four S-parameters.

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