Measurement Guide

Vector Network Analyzer (VNA) Measurement Guide

MS2085A Site Master™
MS2089A Site Master™

Vector Network Analyzer	**Options 904/906**
Time-Domain with Gating	**Option 2**

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Part Number: 10580-00496
Revision: A
Published: March 2025

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Table of Contents

Chapter 1—General Information

Chapter 2—VNA Overview (Option 904/906)

Chapter 3—VNA Calibration and Measurements

Chapter 1 — General Information

1-1 Introduction

This measurement guide describes the Site Master 2-Port 1 Path Vector Network Analyzer (VNA) measurement functions of the Anritsu MS2085A/89A Site Master instruments. VNA is available as an optional application by installing Options 904/906. It includes both 1-port and 2-port measurements (coaxial and waveguide) and features the key considerations that you are required to make regarding calibration types, IF Bandwidth (IFBW), power levels, graph types, and graph formats (display layout).

Refer to Section 1-2 “Option Descriptions” for references regarding the discussion of the supported option. Refer to Chapter 2 for an overview of the VNA user interface. Refer to Chapter 3 for detailed information on the VNA calibrations. Refer to Chapter 3 to learn about setup and measurement settings. Refer to Chapter 4 for detailed information on the time domain with gating measurement settings.

Related Manuals

For additional information and literature covering your product, visit the product page of your instrument and select the Library tab:

https://www.anritsu.com/en-US/test-measurement/products/ms208xa

Product Information, Compliance, and Safety

Read the Product Information, Compliance, and Safety Guide for important safety, legal, and regulatory notices before operating the equipment, PN: 10100-00069.

User Guide

For a complete overview of the instrument hardware and system functions, refer to your instrument user guide. The user guide provides information on the following topics:

- Listing of all related documentation such as measurement guides, programming and maintenance manuals.
- Instrument Care, maintenance and calibration.
- External Connections to the top and side panels.
- Power Requirements and Battery Information.
- System settings such as Wi-Fi, GNSS/GPS, date/time, language settings, etc.
- Other advanced settings and tools such as file management, screenshot settings, port setup, and option configuration.
- Diagnostics and software updates.
- Secure data environment

1-2 Option Descriptions

This section provides a brief overview of the available options covered in this guide.

Note	Not all instrument models offer every option. Some options are available as a time-limited trial. For example, Vector Network Analyzer option is offered as a 90-day time-limited option by ordering Option 9904/9906. The option start time begins when the user first activates the option. Please refer to the Technical Data Sheet of your instrument for information on purchasing and activating time-limited options.

Time Domain with Gating (Option 2)

The Option 2 Time Domain feature provides the ability to transform the native frequency domain data (that is measured by the Vector Network Analyzer) into time domain or distance domain information to help in determining the location of impedance discontinuities.

Vector Network Analyzer (Option 904/906)

Vector Network Analyzers that measure the magnitude and phase characteristics of 1-port or 2-port networks, including cables, antennas, filters, isolators, attenuators, and amplifiers. The Vector Network Analyzer compares the signal that leaves the analyzer port (the reference signal) with either the signal that is transmitted through the test device (the transmitted signal) or the signal that is reflected from the input or the output of the test device (the reflected signal).

Other Options and Features

For descriptions of other options and features not covered in this guide, refer to your instrument user guide or the product page for a comprehensive list of available documentation.

1-3 Document Conventions

The following conventions are used throughout the instrument documentation set.

User Interface Navigation

The user interface consists of menus, buttons, toolbars, and dialog boxes. Elements in navigation paths are separated as follows: MARKER > PEAK SEARCH > NEXT PEAK.

Illustrations

Screen-captured images contained in this document are provided as examples. The chapters included in this measurement guide provide information on advanced measurement features, instrument settings and menu overviews, for a featured option. The actual displays, screen menus, and measurement details may differ based on the instrument, model, firmware version, installed options, and current instrument settings.

1-4 Contacting Anritsu for Sales and Service

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Chapter 2 — VNA Overview (Option 904/906)

2-1 Introduction

This chapter provides an overview of the MS2085A/89A Site Master VNA user interface and describes the main graphical displays and menus presented in the VNA mode. This chapter also includes VNA fundamentals.

The Site Master VNA mode can measure the magnitude and phase characteristics of 1-port or 2-port networks, including cables, antennas, filters, isolators, and attenuators.

VNA provides advantages over Cable-Antenna Analyzer Mode via more advanced measurements, more flexibility, and more calibration choices. The main advantages are scattering parameter (S-parameter) choices, graph type choices, and domain choices. In VNA mode, these three measurement choices can be mixed and matched to provide users with more freedom and flexibility. For simplicity in Cable-Antenna Analyzer mode, the choices are more fixed and limited. Advanced graph types allow you to look at the same device measurements in many different ways. The ability to display four traces provides you with the flexibility of comparing various measurements to obtain the results you need more efficiently. Advanced graph types such as Group Delay, Real, Imaginary, inverted Smith Chart, Real Impedance, and Imaginary Impedance are available in the MS2085A/89A in addition to the standard graph types, Log Mag, SWR, Phase, and Smith Chart. The MS2085A/89A gives you the ability to display four traces overlaid, or they can be displayed in individual graphs. In Cable-Antenna Analyzer Mode, the MS2085A/89A is a two-port, 1-path instrument. In VNA Mode, the MS2085A/89A is a full-reversing VNA that is capable of measuring all S-parameters (S11, S21, User, and S21 (Ext. Sen)) of a 2-port device with a single connection. Being able to measure both forward and reverse S-parameters allows you to use more advanced calibration methods and to make more accurate measurements of a 2-port device.

2-2 Selecting the Application/Mode

The instrument applications/modes are selected from the 9-dot icon or the current measurement mode. For example, SPA is referred to as an application and the displayed icons are called as modes. To select an application or a mode, press the 9-dot icon in the title bar or the current measurement mode to display all the available applications and corresponding modes, as illustrated in Figure 2-1. Simply touch the desired icon to load the new mode, for example, VNA in this case. The applications available for selection depend on the options that are installed and activated on your instrument. Some measurements and views are accessed via other measurement setup menus.

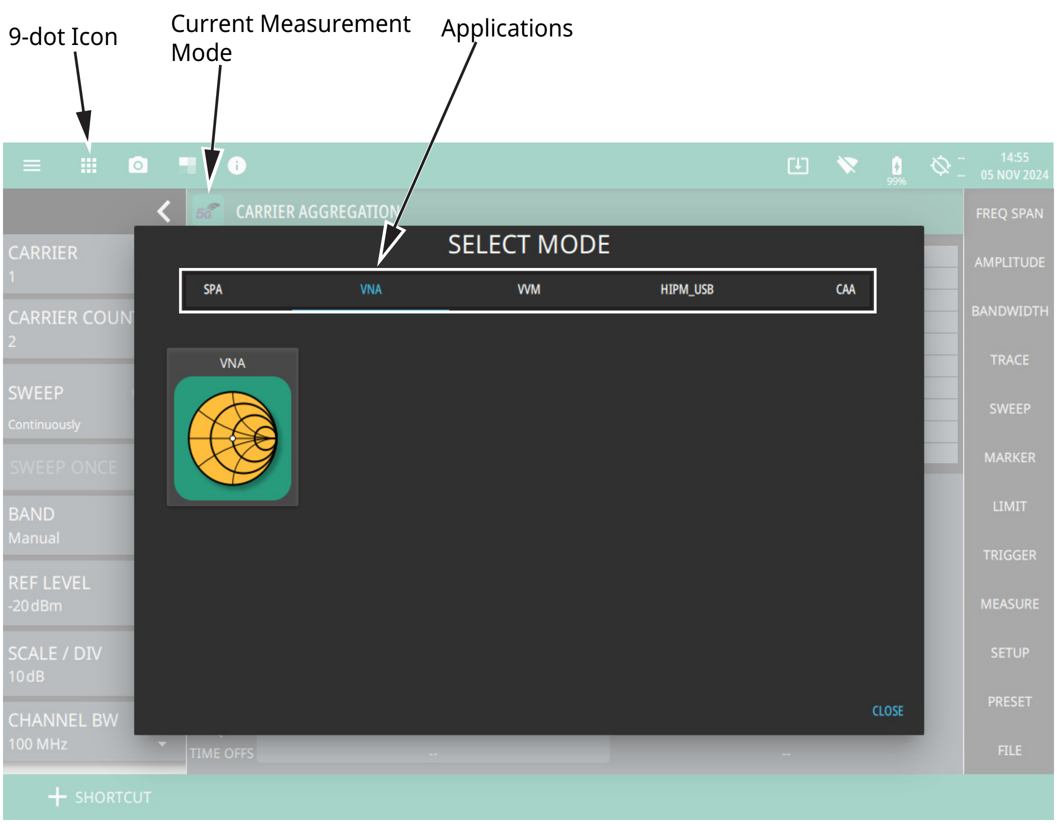


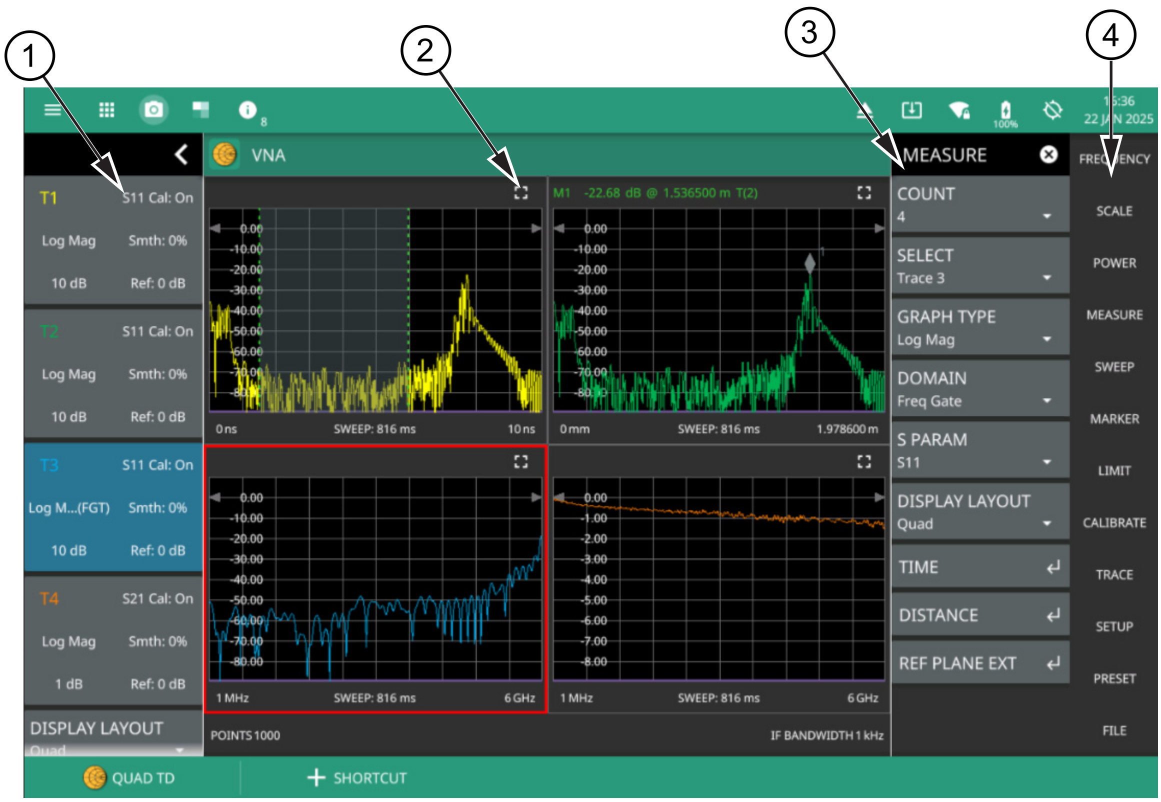
Figure 2-1. Instrument Application and Corresponding Mode(s)

VNA Display Overview

The Site Master VNA display mainly consists of a status panel, main menu and a graphical representation of an active measurement.

The VNA mode supports six different trace layouts you can select from MEASURE > DISPLAY LAYOUT. The Figure 2-2 shows the quad display layout representing all four traces. The status panel displays the individual trace cards that consist of cal type, graph type, smoothing, resolution and reference level. Additionally, if the domain is set to frequency gating, 'FGT' is included in parentheses, next to graph type.

You can view any desired trace in full screen by pressing the maximize icon as shown in the figure below.

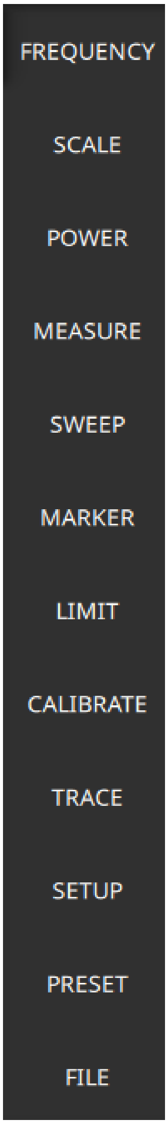


1. The status panel features an individual trace card displayed for each trace along with display layout and frequency reference tiles. See "Status Panel" on page 2-5.
2. Maximize icon allows you to expand an individual trace to carry on detailed analysis of the selected S-parameter. The expanded graph can be minimized by pressing the minimize icon (not shown in the figure).
3. Measure menu facilitates the selection of number of active traces, graph type, domain, S-Parameters, display layout and so on. See "MEASURE Menu" on page 3-13.
4. The main menu is the primary access point for all instrument controls and measurement selections. See "Main Menu" on page 2-4.

Figure 2-2. Vector Network Analyzer Quad Display Layout

2-3 Main Menu

The main menu is the primary access point for all instrument controls and measurement selections. The main function for each main menu button is described below.



FREQUENCY: Contains all frequency control settings such as center frequency, start and stop frequency and span. Refer to Section 3-2 "Setting Frequency Parameters".

SCALE: Provides access to resolution settings including reference level, graticule scale settings. Refer to Section 3-3 "Setting Scale Parameters".

POWER: Provides access to power and receiver calibrations. You can turn in source level power by turning PORT 1 CAL toggle. Refer to Section 3-4 "Setting Power Parameters".

MEASURE: Provides access to supported graph types and selecting the display layout, domain, S-parameters. Refer to Section 3-5 "MEASURE Menu".

SWEEP: Provides access to segmented sweep and trigger settings. Refer to Section 3-6 "Setting Sweep Parameters".

MARKER: Used to enable and set all marker-related parameters and provides access to the marker table and functions. Refer to Section 3-7 "Setting Up Markers".

LIMIT: Provides controls for setting up limit lines and limit alarms. Refer to Section 3-8 "Setting Up Limit Lines".

CALIBRATE: Provides access to start calibration, selecting cal methods and cal medium and so on. Refer to Section 3-10 "CALIBRATE Menu".

TRACE: Provides access to select trace math options and smoothing. Refer to Section 3-11 "Setting Trace Parameters".

SETUP: Measurement controls for setting up advanced measurements. Refer to Section 3-12 "SETUP Menu" on page 3-72.

PRESET: Opens the PRESET menu with selective trace, marker, limits, and measurement preset commands, or an all inclusive analyzer preset command. Refer to Section 3-13 "Presetting the Analyzer".

FILE: Used to save and recall instrument setups and measurements, limit lines, and screen images. Also provides access to save on event controls. Refer to Section 3-14 "Saving and Recalling Measurements" on page 3-75.

Figure 2-3. Main Menu

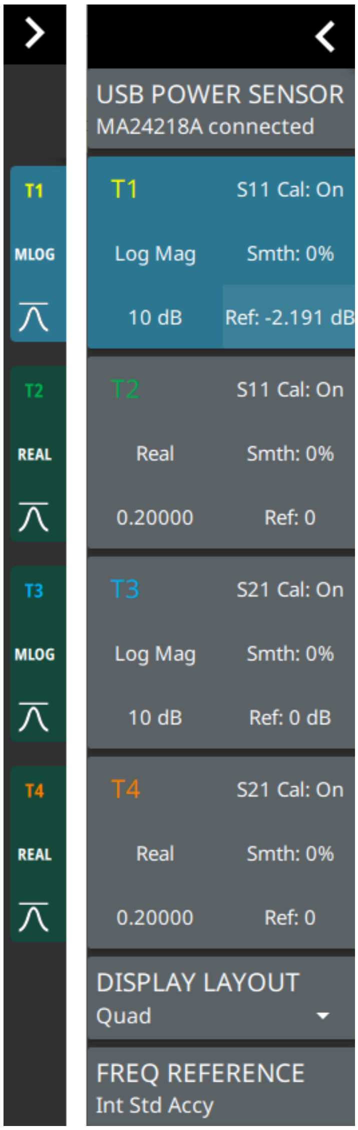
Using Menus

Instrument setup, control, and measurement functions are performed through the use of menus. Menu behaviors are summarized below:

- Selecting a main menu button opens an associated menu.
- The name of the button pressed in the main menu is reflected in the title bar of the resulting menu.
- Menu buttons can change for various measurement settings, instrument setup parameters, and measurement views.
- Selecting the corresponding main menu button for a menu closes the menu.
- Touching status data, a parameter field, or label in the display area opens the corresponding menu and the associated keypad for editing that parameter setting.
- Selecting Accept, Cancel, or the X in the upper right corner closes the menu or keypad.

2-4 Status Panel

The status panels and features illustrated in this section are unique to the vector network analyzer and to the particular measurement and view that is selected. Below is the vector network analyzer status panel with the corresponding minimized status panel icons.



Go to MEASURE > COUNT to activate required number of traces. If count is set to 4 all four traces are activated in the status panel.

USB POWER SENSOR: Displays the model number of the USB power sensor when connected to the instrument.

T1: Represents the first trace consisting of the selected S-parameter, graph type, smoothing percentage, resolution and reference level values.

T2: Represents the second trace consisting of the selected S-parameter, graph type, smoothing percentage, resolution and reference level values.

T3: Represents the third trace consisting of selected the S-parameter, graph type, smoothing percentage, resolution and reference level values.

T4: Represents the fourth trace consisting of selected the S-parameter, graph type, smoothing percentage, resolution and reference level values.

DISPLAY LAYOUT: Select any one of following display layouts:

- Single: Displays the active trace at full size in the sweep window.
- **Horizontal Split**: Displays 2 active traces in the sweep window, with the sweep window divided horizontally into 2 equal rectangles.
- Vertical Split: Displays 2 active traces in the sweep window, with the sweep window divided vertically into 2 equal rectangles.
- **Horizontal Triple**: Displays 3 traces in the sweep window, with the sweep window divided horizontally and vertically so that 2 equal rectangles share the lower half of the window, and one wide rectangle occupies the upper half of the window.
- **Vertical Triple**: Displays 3 traces in the sweep window, with the sweep window divided horizontally and vertically so that 2 equal rectangles share the left half of the window, and one wide rectangle occupies the right half of the window.
- **Quad**: Displays 4 traces in the sweep window, with the sweep window divided horizontally and vertically into 4 equal rectangles.

Refer to Section 3-5 “MEASURE Menu” on page 3-13 to access DISPLAY LAYOUT menu.

FREQ REFERENCE: Indicates the current frequency reference source of Internal High Accuracy, Internal Standard Accuracy, or External. The instrument automatically selects the frequency reference in the following order of priority: external and then the internal time base.

Figure 2-4. Vector Network Analyzer Status Panel with Minimized Status Panel Icons

Refer to Chapter 3 for VNA measurement setup.

2-5 VNA Fundamentals

This section includes Vector Network Analyzer measurement capabilities and instrument architecture information. It also describes calculating and displaying S-parameters, and describes using markers to provide additional measurement information.

VNA is Vector Network Analyzer or Vector Network Analysis. The MS2085A/89A Site Master is a Vector Network Analyzer that measure the magnitude and phase characteristics of 1-port or 2-port networks, including cables, antennas, filters, isolators, attenuators, and amplifiers. The Vector Network Analyzer compares the signal that leaves the analyzer port (the reference signal) with either the signal that is transmitted through the test device (the transmitted signal) or the signal that is reflected from the input or the output of the test device (the reflected signal).

Compared to a Scalar Network Analyzer (SNA), a VNA has the added capability for measuring phase characteristics. While phase measurements are important in themselves, the availability of this phase information unlocks many new features for complex measurements. These features include Smith Charts, Time Domain, and Group Delay. Phase information also allows greater accuracy through vector error correction of the measured signal.

A VNA can have 1-port only, in which case it measures only reflection signals. A VNA can have 2-ports, in which case it can measure both reflection and transmission. A 2-port VNA can also have two different capabilities: 1-path 2-port, or full-reversing. The 1-path 2-port design allows reflection measurements only at one of the two ports and allows transmission measurements only in one direction.

The MS2085A/89A Site Master is a two-port, 1-path VNA instruments that allow S_{11} and S_{21} measurements with a single connection.

2-6 S-Parameters

To simplify the description of the types of measurements a MS2085A/89A Site Master VNA can make, the reflection and transmission measurements are defined in terms of scattering parameters, or S-parameters. For a 2-port and 1-path network, two fundamental S-parameters can be measured, and they are defined as SXY. For a 2-port VNA, measurements of signals leaving Port 1 are called forward measurements, and those leaving Port 2 are called reverse measurements. Signals that leave and return to the same port are designated reflection measurements, and those that leave one port and return to another port are designated transmission measurements.

S-parameters are an abbreviated designation for these measurements, and are used as shown in the following list:

- S11: Forward Reflection
- S21: Forward Transmission

The first number (X) in SXY is the port number into which the signal is being injected, and the second number (Y) is the port number from which the signal is leaving. The S-parameter is a ratio of these two signals.

Additional Examples:

S11: Forward Reflection represents the measurement in which the signal leaves port 1 and is reflected back to port 1.

S21: Forward Transmission represents the measurement in which the incident signal is transmitted from port 1 and is received at port 2.

User: Custom user-defined S-parameters can be selected from the list of options included in the numerator and denominator submenus, in addition to user-defined S-parameter power source port.

Table 2-1. User-Defined Numerator/Denominator Combinations

Denominator	Numerator			
	A1	**B1**	**B2**	**1**
A1	$\frac{A1}{A1} = 1$	$\frac{B1}{A1}$ S11 Forward Reflection	$\frac{B2}{A1}$ S21 Forward Transmission	$\frac{1}{A1}$
B1	$\frac{A1}{B1}$	$\frac{B1}{B1} = 1$	$\frac{B2}{B1}$	$\frac{1}{B1}$
B2	$\frac{A1}{B2}$	$\frac{B1}{B2}$	$\frac{B2}{B2} = 1$	$\frac{1}{B2}$
1	$\frac{A1}{1} = A1$	$\frac{B1}{1} = B1$	$\frac{B2}{1} = B2$	$\frac{1}{1} = 1$

S21 (Ext. Sens): Forward Transmission represents the measurement in which the signal leaves port 1 and is transmitted to port 2. In this case an external USB power sensor is used as port 2.

2-7 VNA Architecture

A VNA can have only 1-port, in which case it measures only reflection signals. A VNA can have 2-ports, in which case it measures both reflection and transmission. A 2-port VNA can also have two different capabilities: 1-path 2-port, or full-reversing. The 1-path 2-port design allows reflection measurements only at one of the two ports and allows transmission measurements only in one direction. With Options 904/906 the MS2085A/89A Site Master is a 1-path 2-port, VNA that allows S_{11} and S_{21} measurements with a single connection.

The Figure 2-5, shows how S_{11} and S_{21} are generated by a forward sweep (signal directed from Port 1).

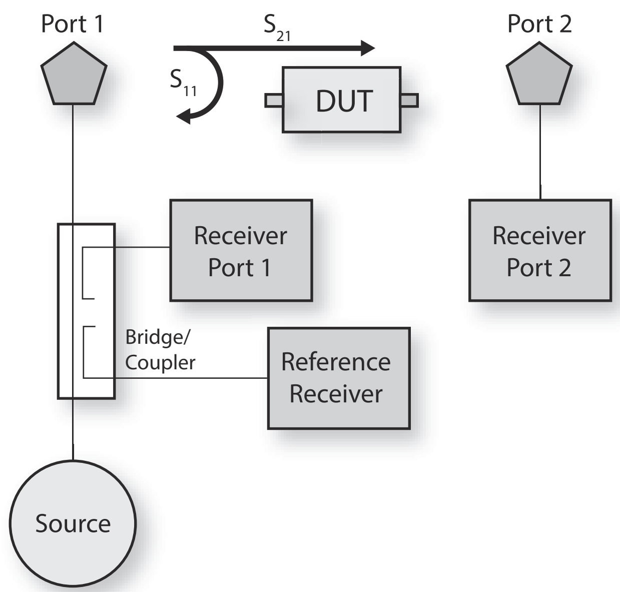


Figure 2-5. MS2085A/89A Site Master VNA Block Diagram

2-8 Calculating and Displaying S-Parameters

S-parameters are typically measured as the ratio of two complex voltage levels, one measured by the port receiver, and one measured by the reference receiver. S-parameters therefore consist of unitless complex numbers.

Depending on the application, S-parameters can be displayed in many ways and can be used to calculate other parameters. S-parameters consist of real and imaginary numbers. More typically, however, they are represented as magnitude and phase. In most cases, the magnitude is displayed in dB (this term is often called log magnitude). We can display phase as "linear phase". With phase, we cannot tell the difference between one cycle and the next. After going through 360 degrees, we are back to where we began. We can display the measurement from –180 degrees to +180 degrees, which keeps the display discontinuity removed from the important 0 degrees area used as the phase reference.

The Site Master supports the following display types. Each type is associated with a particular S-parameter, $S_{xy} = S_{Real} + jS_{Imaginary}$ (where j is the square root of –1).

Table 2-2. Log Magnitude

$$\text{LogMagnitude(dB)} = 20\text{Log}_{10}|S_{xy}|$$

Application Notes

To measure return loss at Port 1 (or Port 2), use the Log Mag display with S_{11}.

To measure the gain or loss in a DUT that is connected between Port 1 and Port 2, use the Log Mag display with S_{21}.

Table 2-3. Log Magnitude / 2

$$\frac{\text{LogMagnitude}}{2}\text{(dB)} = 0.5 \times 20\text{Log}_{10}|S_{xy}|$$

Application Note

For measuring 1-port cable loss, use S_{11} with the Log Mag/2 display type to account for the round trip signal path through the cable. When using reflection data to measure cable loss, the end of the cable must be shorted or must be a perfect open.

Table 2-4. Real and Imaginary

$$\text{Phase(degrees)} = \text{Tan}^{-1}\left|\frac{S_{Imaginary}}{S_{Real}}\right| \times \left(\frac{180}{\pi}\right)$$

SReal = Real S-parameter

SImaginary = Imaginary S-parameter

Table 2-5. SWR

$$SWR = \frac{(1 + |S_{xx}|)}{(1 - |S_{xx}|)}$$

Application Note

SWR, or Standing Wave Ratio, is a measure of the reflection from the DUT input port or output port, and it must be used, therefore, with S_{11}.

Table 2-6. Group Delay

Group Delay (sec) = rate of change of phase over a specified frequency aperture

Application Note

Group Delay is a measure of the time delay of the signals that are propagating through the DUT versus frequency (using S_{21} or S_{12}). Group delay is a good measure of phase distortion through the DUT.

Table 2-7. Smith Chart

Smith Chart = graphical tool for plotting impedance or admittance data versus frequency

Application Note

Use Smith Chart with $S_{11}$to plot the input or output impedance of the DUT.

Use the Inverted Smith Chart to plot admittance data.

2-9 Extracting More Information by Using Markers

An S-parameter can be displayed in different formats, as already described. The Site Master also allows you to extract information from the trace by using 8 markers. By default, the marker presents the trace point information using the graph type format, thereby providing additional flexibility in analyzing S-parameter VNA data. For example, if the graph type is SWR, then the marker readout is in SWR. You can set the marker type to be something other than the graph type. Refer to

For any graph type that the trace may have, the markers can be used to extract data in any of the following formats:

- Log Magnitude (dB)
- SWR
- Phase (deg)
- Smith Chart
- Group Delay (sec)
- Real
- Imaginary: Z_{in}= R + jX
- Real Impedance
- Imaginary Impedance
- Inverted Smith
- Log Magnitude/2 (dB)
- Linear Polar
- Log Polar
- Unwrapped Phase
- Linear Magnitude (dB)
- Z- Magnitude

2-10 Bias Voltage

Another important feature of a VNA is the ability to provide DC bias voltage at the RF port. Bias on the RF cable is useful for operating TMA components that are being tested. Refer to Section 3-12 “SETUP Menu” on page 3-72.

Chapter 3 — VNA Calibration and Measurements

3-1 Introduction

This chapter describes some of the VNA measurements that can be made with the Site Master. It includes both 1-port and 2-port measurements (coaxial and waveguide) and features the key considerations that you are required to make regarding calibration types, IF Bandwidth (IFBW), power levels, graph types, and graph formats.

3-2 Setting Frequency Parameters

Frequency-related parameters are set using the “FREQUENCY Menu” on page 3-3. The tuning frequency range can be entered in several different ways depending upon what makes the most sense, either for the user or for the measurement. The center frequency and span can be specified, the start and stop frequencies can be entered.

Entering Start and Stop Frequencies

The frequency settings are displayed along the bottom of the VNA graph. These parameters can be accessed directly by touching the values displayed or via the FREQUENCY menu. To enter start and stop frequency follow the steps below:

1. Touch FREQUENCY on the main menu.
2. Select START FREQUENCY to open the start frequency parameter entry keypad.
3. Enter the desired start frequency and choose an appropriate unit from the list of available frequency units (Hz, kHz, MHz, and GHz) displayed along the right edge of the keypad.
4. Touch ACCEPT to set the start frequency or cancel the entry by pressing CANCEL.
5. Select STOP FREQUENCY to open the stop frequency parameter entry keypad.
6. Enter the desired stop frequency and choose an appropriate unit from the list of available frequency units (Hz, kHz, MHz, and GHz) displayed along the right edge of the keypad.
7. Touch ACCEPT to set the stop frequency or cancel the entry by pressing CANCEL.

Note	To quickly move the start or stop frequency value up or down, press + or – buttons to increment or decrement the frequency, respectively. You can also change the frequency by sliding the slider to the left or right. Refer to your instrument’s user guide for detailed information about operating the touch screen.

The current settings are shown along the bottom of the VNA graph.

Entering Center Frequency

1. Touch FREQUENCY on the main menu.
2. Select CENTER FREQUENCY to open the center frequency parameter entry keypad.
3. Enter the desired center frequency and choose an appropriate unit from the list of available frequency units (Hz, kHz, MHz, and GHz) displayed along the right edge of the keypad.
4. Touch ACCEPT to set the center frequency or cancel the entry by pressing CANCEL.

Note	To quickly move the start or stop frequency value up or down, press the + or – buttons to increment or decrement the frequency, respectively. You can also change the frequency by sliding the slider to the left or right. Refer to your instrument’s user guide for detailed information about operating the touch screen.

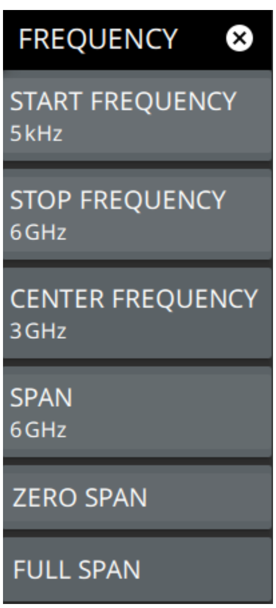
The center frequency will be set to exactly the middle of the start and stop frequencies. The current settings are shown along the bottom of the VNA graph.

Setting the Span

1. Select FREQUENCY on the main menu.
2. Select SPAN to open the span frequency parameter entry keypad.
3. Enter the desired span frequency and choose an appropriate unit from the list of available frequency units (Hz, kHz, MHz, and GHz) displayed along the right edge of the keypad.
4. Touch ACCEPT to set the span frequency or cancel the entry by pressing CANCEL.
5. To select full span, press the FULL SPAN. Selecting full span overrides any previously set start and stop frequencies.
6. Select ZERO SPAN to set the span frequency to zero.

Note	To quickly move the span value up or down, press the + or - buttons to increment the span. You can also drag the span using the slider or by pinching the trace in or out. Refer to your instrument's user guide for detailed information about operating the touch screen.

FREQUENCY Menu



START FREQUENCY: Sets the start frequency in units of Hz, kHz, MHz, or GHz. If you enter a start frequency that is higher than the currently-set stop frequency, and if CAL = On, then the start frequency is set to the same value as the stop frequency. If you enter a start frequency that is higher than the currently-set stop frequency, and if CAL = Off, then both start and stop frequency are set to the new frequency.

STOP FREQUENCY: Sets the stop frequency in units of Hz, kHz, MHz, or GHz. If you enter a stop frequency that is lower than the currently-set start frequency, and if CAL = On, then the stop frequency is set to the same value as the start frequency. If you enter a stop frequency that is lower than the currently-set start frequency, and if CAL = Off, then both stop and start frequency are set to the new frequency.

CENTER FREQUENCY: Sets the center frequency of the sweep range. The current span setting will remain constant or will be adjusted to accommodate the start and stop frequency range of the instrument. The center frequency can also be dragged on the display when DRAG/PINCH toggle is on.

SPAN: Sets the sweep frequency range. The current center frequency will remain constant and the start and stop frequencies will be adjusted to accommodate the new range. Selecting the plus (+) or minus (–) control increments or decrements the span value.

ZERO SPAN: Sets the instrument start and stop frequency to the center frequency. The span will be set to zero.

FULL SPAN: Sets the instrument to a full span that sweeps the instrument from 5 kHz to maximum frequency range depending on the frequency option purchased.

Figure 3-1. FREQUENCY Menu

3-3 Setting Scale Parameters

The SCALE parameters corresponds to the y-axis display. The instrument supports both log units (such as dBm and dBV) and linear units of scale (such as volts or watts). Amplitude-related parameters are set using the “SCALE Menu” on page 3-4.

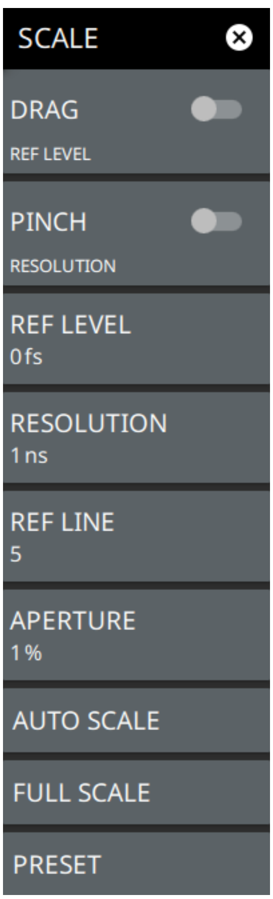
Setting Resolution and Reference Line

This setting applies to most analyzer modes of operation and allows you to set the y-axis graticule scale for log-based units only.

1. Select SCALE > RESOLUTION.
2. Enter the desired number
3. Select SCALE > REF LINE
4. Enter the desired number

SCALE Menu

Access the SCALE menu from the main menu.



DRAG: Toggles the touchscreen drag feature on or off. When toggled off, the reference level will not change when dragging the display. This can be useful when dragging markers.

PINCH: Toggles the touchscreen pinch feature on or off. When toggled off, the resolution will not change when pinching the display. This can be useful when dragging markers.

REF LEVEL: The reference level is the top graticule line on the measurement display. If the reference level offset is not zero, the offset reference level is displayed at this location. Selecting the plus (+) or minus (–) control increments the value by 10. The plus/minus (+/-) button on the keypad toggles between positive and negative values.

RESOLUTION: Sets the number of units that are displayed between horizontal reticle lines. Units depend upon frequency, time, and distance settings. The default resolution is 10 dB.

REF LINE: Sets the horizontal graph reticle at the reference level. The reference line is indicated by a yellow line with small triangle heads on both sides. Reference line is 9 by default is 9 and the max is 10. The position is adjusted based on the set value.

APERTURE: Aperture percentage is available only when the GRAPH TYPE is set to GROUP DELAY. Group delay is a measurement of “Change in phase / change in frequency.” The aperture setting is used by the Site Master to determine how large a change in frequency to use in this calculation.

AUTO SCALE: Adjusts the resolution and reference level so that the active trace for the current measurement is shown in the middle of the display.

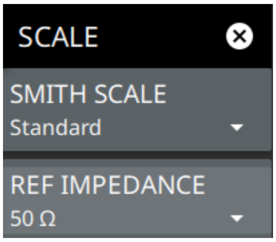
FULL SCALE: Sets the resolution to 10 dB and reference level to zero.

PRESET: Presets all the scale parameters.

Figure 3-2. SCALE Menu

SCALE Menu (Smith Chart)

To access Smith Chart's SCALE menu go to main menu, MEASURE > GRAPH TYPE > Smith.



SMITH SCALE: Allows expansion and compression of the scale with respect to the reference impedance. Select any of the available expand and compress options to view the smith chart in a desired manner.

REF IMPEDANCE: Sets the reference impedance as either 50 ohms or 75 ohms.

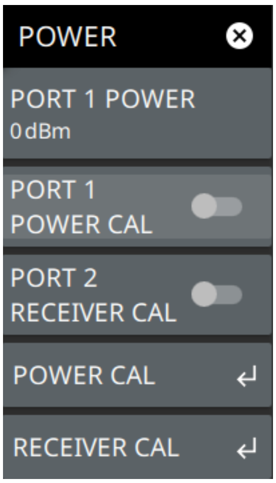
Figure 3-3. SCALE Menu (Smith Chart)

3-4 Setting Power Parameters

The Site Master VNA mode's power parameters are set using the "POWER Menu" on page 3-6.

POWER Menu

Access POWER menu from main menu. It enables port 1 calibration setup in addition to power and receiver calibrations.



PORT 1 POWER: Sets the Port 1 power in dBm. It is 0 dBm by default.

PORT 1 POWER CAL: This toggle is off by default and is turned on once the power calibration is applied at Port 1.

PORT 2 RCEIVER CAL: This toggle is off by default and is turned on once the receiver thru calibration is applied at Port 2.

POWER CAL: Opens"POWER Calibration" submenu.

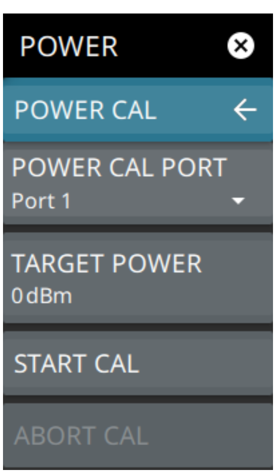
RECEIVER CAL: Opens"RECEIVER CAL" submenu.

Figure 3-4. Power Menu

POWER CAL

To access power calibration submenu, go to main menu, POWER > POWER CAL.

The objective of the power cal is to improve the accuracy of the power delivered to the device under test (DUT) beyond that provided by the factory ALC calibration (0.1 dB vs. on the order of 1 dB). This is useful if a preamplifier or other network is needed between the test port and the DUT. The exact loss/gain of that network over frequency can be corrected for. The power in this context refers to signal amplitude at the fundamental frequency. Power calibration in the VNA mode is a crucial step to ensure accurate measurement of the scattering parameters (S-parameters) of DUT. This process involves setting the correct power levels for the VNA signal output and measuring the resulting signals accurately.



POWER CAL PORT: MS2085A/89A Site Master supports Port 1 only.

TARGET POWER: Sets the power level target for the flat power correction calibration on Port 1.

START CAL: Starts the power cal.

ABORT CAL: Cancels the power cal.

Figure 3-5. POWER CAL Submenu

POWER Calibration

Follow the steps below to perform power calibration on Port 1:

1. Touch FREQUENCY on the main menu and adjust the start and stop frequency values according to the operating range of the USB power sensor.
2. Select POWER menu on the main menu.
3. Select POWER CAL submenu.
4. Select TARGET POWER to enter the target power to set reference to port 1 power.
5. Select START CAL and follow the on-screen CAL WIZARD.
6. Select MEASURE at the end of each step to proceed to the next step in the sequence.

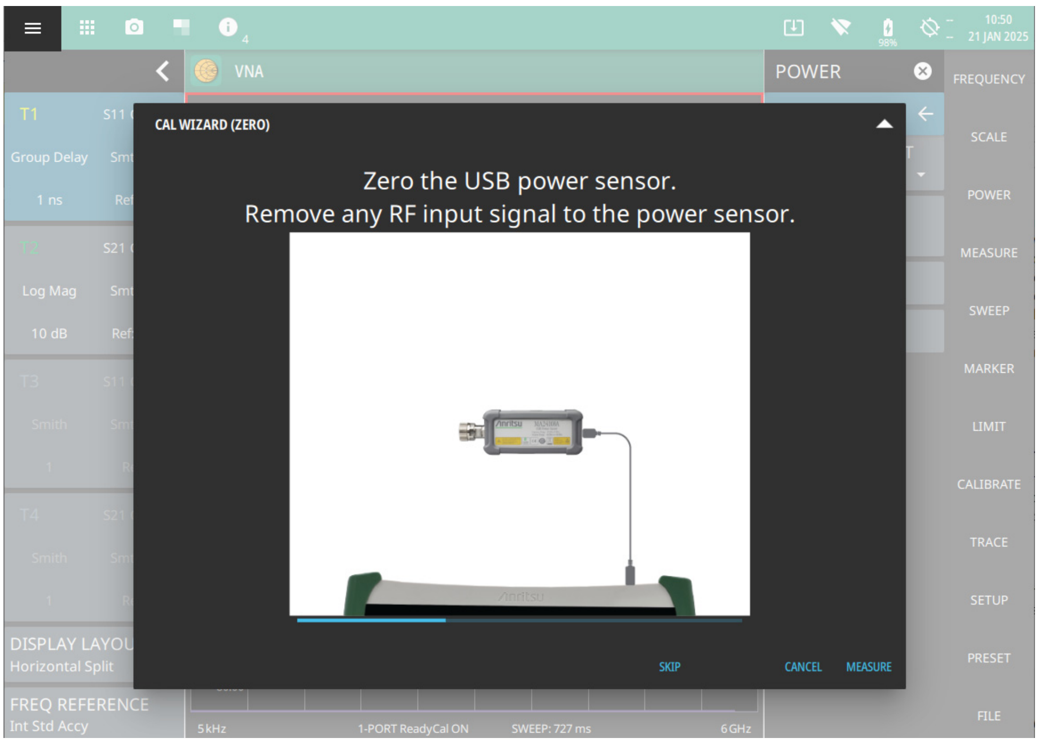


Figure 3-6. Power Calibration - ZERO

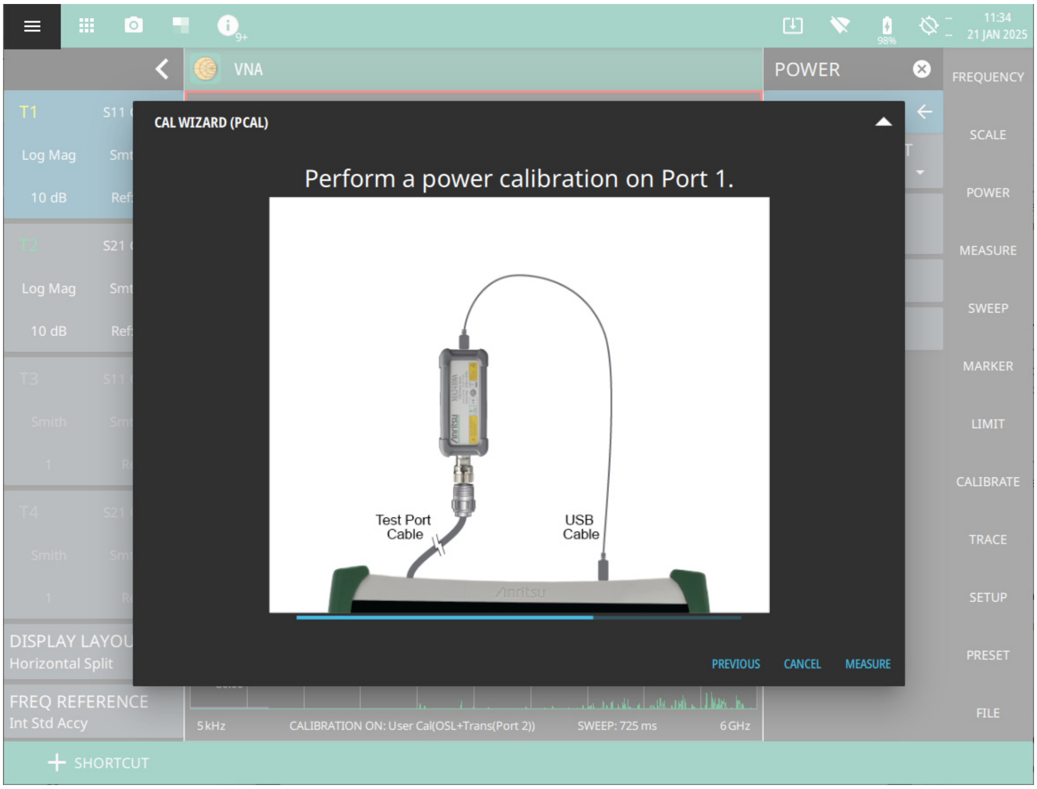


Figure 3-7. Power Calibration - PCAL

7. Select APPLY to apply the power calibration on Port 1.

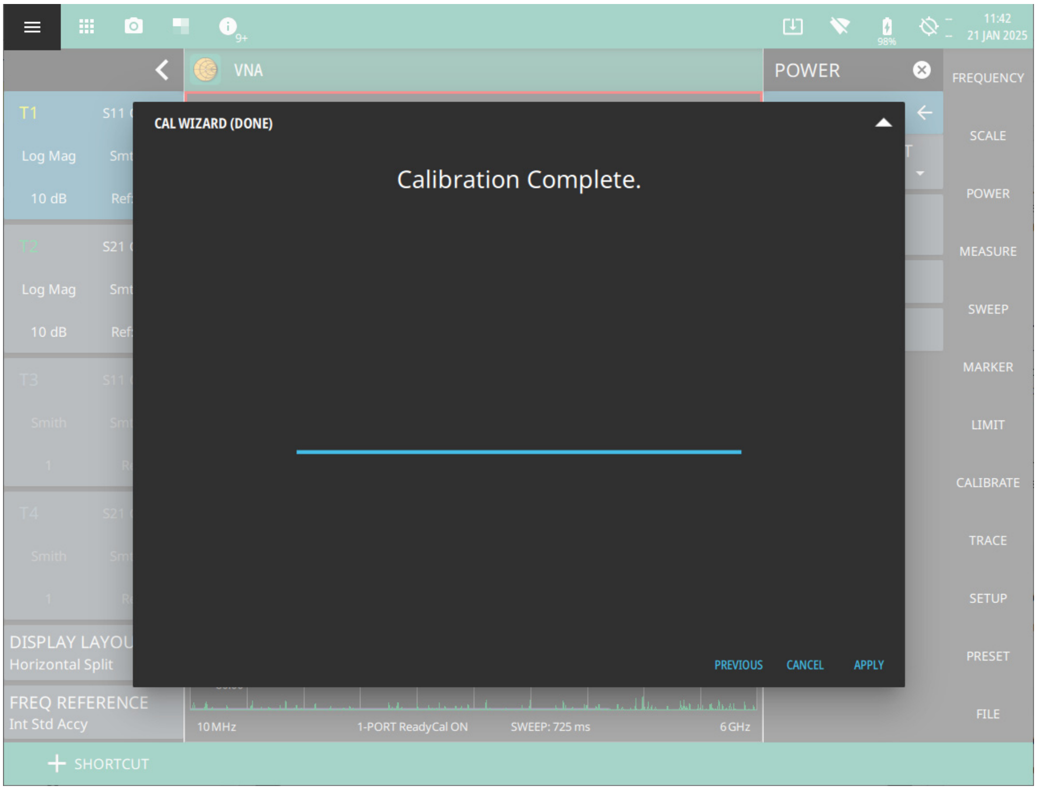
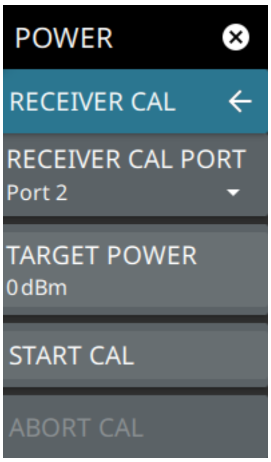


Figure 3-8. Power Calibration - Done

RECEIVER CAL

To access receiver cal submenu go to main menu, POWER > RECEIVER CAL.

The concept of the receiver cal is to take a known source power at some source reference plane and transfer that knowledge to the receiver at a desired receiver reference plane. If it is convenient to use the test port as the source reference place, the built-in factory ALC calibration can be used to establish the power knowledge. If this is not convenient (because of frequency translation or some other network is required, or greater accuracy is needed), then a power calibration can be performed with the help of a GPIB-controlled power meter or USB power sensor to better establish that power knowledge.



RECIEVER CAL PORT: Receiver cal port is Port 2 by default.

TARGET POWER: Sets the Port 2 target power in dBm.

START CAL: Starts receiver calibration process.

ABORT CAL: Aborts the power calibration process.

Figure 3-9. RECEIVER CAL Submenu

RECEIVER Calibration

Follow the steps below to perform receiver thru calibration on Port 2:

1. Touch FREQUENCY on the main menu and adjust the start and stop frequency values if needed.
2. Select POWER > RECEIVER CAL submenu.
3. Select TARGET POWER to enter the target power to set Port 2 power.
4. Select START CAL and follow the on-screen CAL WIZARD.
5. Select MEASURE to proceed to the next step in the sequence.

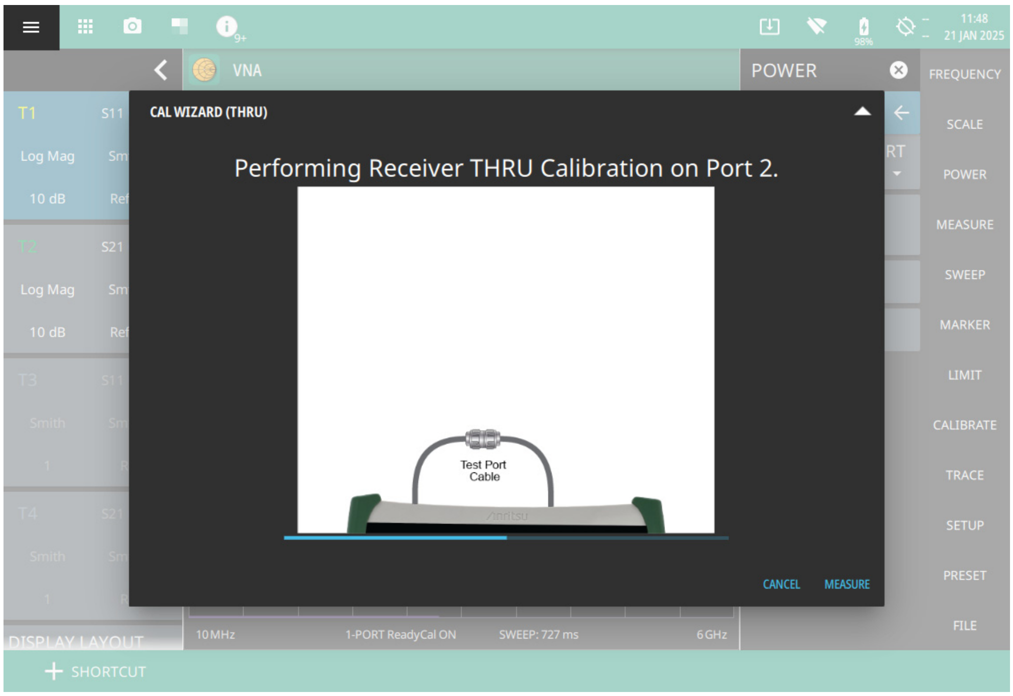


Figure 3-10. Receiver Calibration - Thru

6. Select APPLY to apply the thru calibration on Port 2.

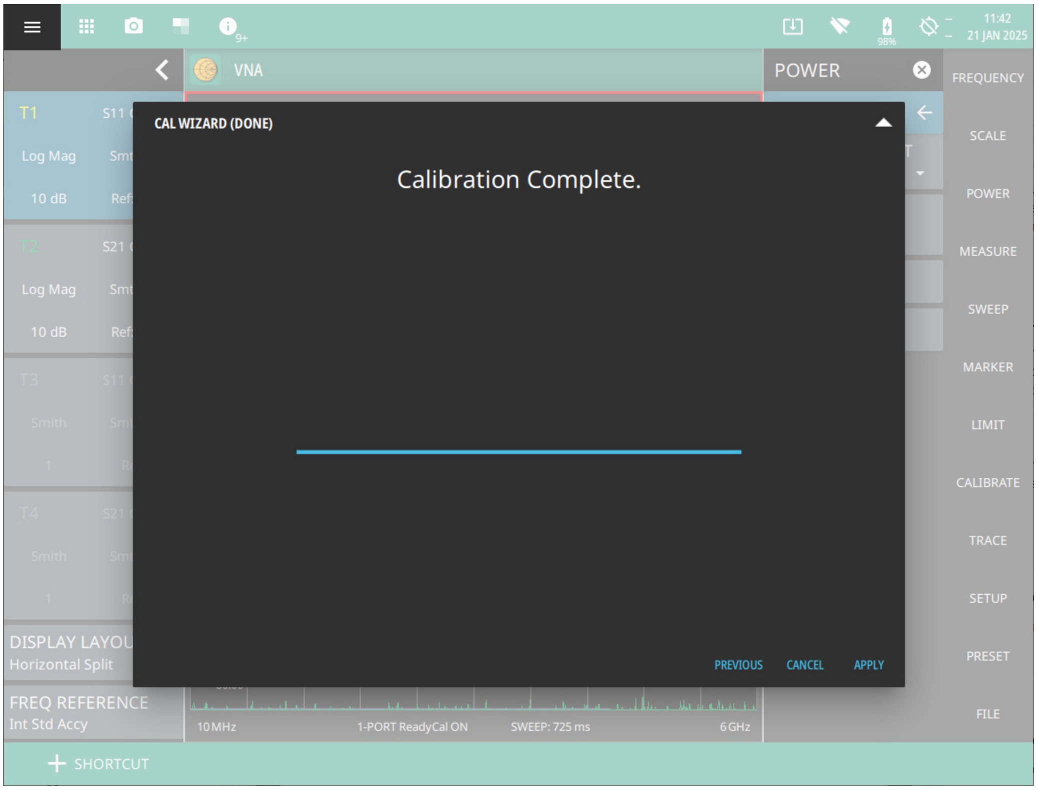
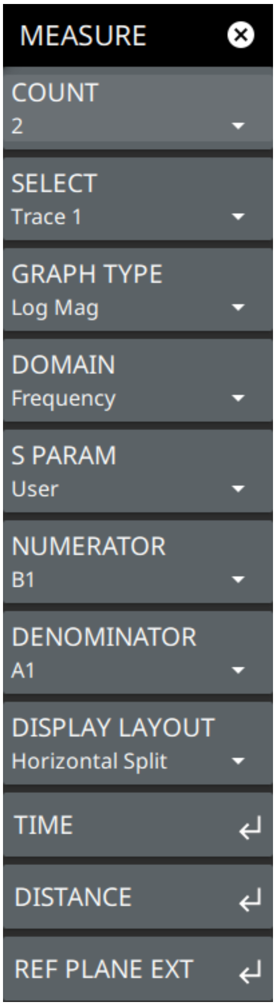


Figure 3-11. Receiver Calibration - Done

3-5 MEASURE Menu

From the main menu select MEASURE menu to choose an appropriate graph type, domain, S-Parameters, display layout. MEASURE menu includes sub menus such as TIME, DISTANCE and REF PLANE EXT



COUNT: Selects the number of trace count. Maximum of 4 traces are supported.

SELECT: Selects the number of active traces to be displayed on the sweep window.

GRAPH TYPE: Selects any of the following graph types for an active trace:

- **Log Mag:** Log magnitude is used to measure return loss at Port 1 (or Port 2), or gain or loss in a DUT that is connected between Port 1 and Port 2.
- **SWR:** Standing wave ratio (SWR) is used to measure the reflection (S_{11}) from the DUT input port or output port.
- **Phase:** Use the Phase or Unwrapped Phase measurement to display the phase in degrees of S_{xy}. The Phase measurement is contained within a vertical scale of ±180º, whereas the unwrapped phase displays the linear phase without wrapping it at the 180 degrees transitions**.**
- **Smith:** Smith chart is a plot of input and output impedance of the DUT using S_{11} versus frequency.
- **Group Delay:** Group Delay graph type is a measure of the time delay of the signals that are propagating through the DUT versus frequency (using S21). Group delay is a good measure of phase distortion through the DUT. Group delay is equal to rate of change of phase over a specified frequency aperture.
- **Real:** Real graph type denotes real part of the complex S-Parameter S_{xy}.
- **Imaginary:** Imaginary graph type denotes imaginary part of the complex S-Parameter S_{xy}.
- **Imaginary Imp:** An imaginary graph in the context of a Vector Network Analyzer (VNA) typically represents the imaginary component of complex impedance or reflection coefficients (S-parameters) as a function of frequency. This type of graph is useful for analyzing how the reactive components (inductive and capacitive) of a device under test (DUT) behave over a specified frequency range.
- **Inverted Smith:** An inverted Smith chart is a variation of the traditional Smith chart used in RF and microwave engineering for displaying complex impedance and reflection coefficients in a more intuitive way, particularly for certain types of analysis.
- **Log Mag/2:** Measures 1-port cable loss, using S11 to account for the round trip signal path through the cable. When using reflection data to measure cable loss, the end of the cable must be shorted or must be a perfect open.
- **Linear Polar:** Linear polar graph typically refers to a graphical representation of complex impedance or reflection coefficients (S-parameters) in a polar coordinate system. This representation is useful for visualizing how the impedance of a device changes with frequency or how it behaves in response to varying input signals.
- **Log Polar:** A log polar graph is a specialized type of graphical representation used in Vector Network Analyzers (VNAs) to display the magnitude and phase of S-parameters, particularly useful for analyzing wide-ranging values of impedance or reflection coefficients across a frequency spectrum.
- **Unwrapped Phase:** The unwrapped Phase graph removes the wrapping and plots the phase linearly. Unwrapped phase is obtained by counting the number of transitions of the phase measurement.
- **Linear Mag:** A linear magnitude graph in a Vector Network Analyzer (VNA) is a straightforward representation used to visualize the magnitude of S-parameters (scattering parameters) over a specified frequency range. This type of graph is particularly useful for assessing the performance of RF and microwave components, such as antennas, filters, and amplifiers.

Figure 3-12. MEASURE Menu

- **Z-Magnitude:** A Z-magnitude graph in a Vector Network Analyzer (VNA) displays the magnitude of impedance (Z) as a function of frequency. This type of graph is useful for analyzing how the impedance of a device under test (DUT) varies with frequency, providing insights into the performance characteristics of RF and microwave components.

DOMAIN: Selects any one of the following domain options:

- **Frequency**: Sets the x-axis of the active trace to frequency domain.
- **Time:** Sets the x-axis of the active trace to time domain. Note that time domain is available when Time Domain with Gating Option 2 is installed.
- **Distance:** Sets the x-axis of the active trace to distance domain. Note that distance domain is available when Time Domain with Gating, Option 2 is installed.
- **Freq Gate**: Sets the x-axis of the active trace to frequency gate domain. Note that frequency gate domain is available when Time Domain with Gating Option 2 is installed. Note that status panel indicates '(FGT)' next to the selected graph type only if Domain is set of Freq Gate.

S PARAM: Selects any one of the following S-Parameter options:

- **S11**: Set the measurement to S_{11} Forward Reflection (receive at Port 1, transmit from Port 1).
- **S21:** Sets the measurement to S_{21} Forward Transmission (receive at Port 2, transmit from Port 1).
- **User:** Sets the user-defined S-Parameters by choosing a combination of available numerator and denominator values. For example, if numerator is set as B1 and denominator is set as A1 the instrument measures the S11 forward reflection. See Table 2-1.
- **S21 (Ext. Sens)**: Forward Transmission represents the measurement in which the signal leaves port 1 and is transmitted to Port 2. In this case an external USB power sensor is used as Port 2.

NUMERATOR: Selects any of one of the following as numerator:

- **A1:** Denotes the reference signal from source Port 1.
- **B1:** Denotes the received power into Port 1.
- **B2:** Denotes the received power into Port 2.
- **One:** Denotes the number 1 as the numerator.

DENOMINATOR: Selects any of one of the following as numerator:

- **A1:** Denotes the reference signal from source Port 1.
- **B1:** Denotes the received power into Port 1.
- **B2:** Denotes the received power into Port 2.
- **One:** Denotes the number 1 as the denominator.

DISPLAY LAYOUT: Selects any of the following display layouts:

- Single: Displays the active trace at full size in the sweep window.
- **Horizontal Split**: Displays 2 active traces in the sweep window, with the sweep window divided horizontally into 2 equal rectangles.
- Vertical Split: Displays 2 active traces in the sweep window, with the sweep window divided vertically into 2 equal rectangles.
- **Horizontal Triple**: Displays 3 traces in the sweep window, with the sweep window divided horizontally and vertically so that 2 equal rectangles share the lower half of the window, and one wide rectangle occupies the upper half of the window.
- **Vertical Triple**: Displays 3 traces in the sweep window, with the sweep window divided horizontally and vertically so that 2 equal rectangles share the left half of the window, and one wide rectangle occupies the right half of the window.
- **Quad**: Displays 4 traces in the sweep window, with the sweep window divided horizontally and vertically into 4 equal rectangles.

TIME: Opens the "TIME Menu" on page 3-15.

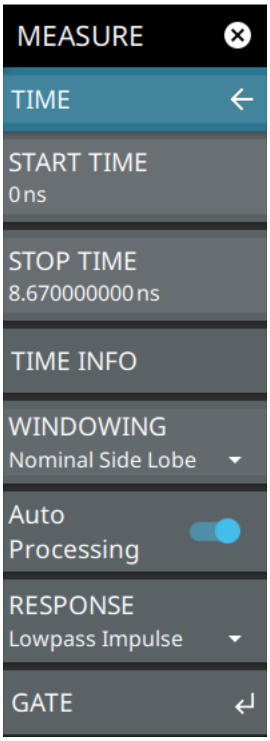
DISTANCE: Opens the "DISTANCE Menu" on page 3-18.

REF PLANE EXT: Opens the "REF PLANE EXT Menu" on page 3-19.

Figure 3-12. MEASURE Menu

TIME Menu

To access TIME submenu go to main menu MEASURE > TIME.



START TIME: Sets the start time in seconds (s), milliseconds (ms), microseconds (μs) and nanoseconds (ns).

STOP TIME: Sets the stop time in seconds (s), milliseconds (ms), microseconds (μs) and nanoseconds (ns).

TIME INFO: Displays time resolution and maximum usable time for both reflection and transmission.

WINDOWING: Selects one of the following windowing for the measurement:

- **Rectangular**: Rectangular windowing shows the highest side lobe levels (worst) and the greatest main lobe resolution (best).
- **Nominal Side Lobe:** Nominal side lobe windowing shows lesser side lobe levels than rectangular windowing (good) but lower main lobe resolution (very good).
- **Low Side Lobe:** Low side lobe windowing shows less side lobe levels than nominal windowing (very good) but lower main lobe resolution (good).
- **Minimum Side Lobe**: Minimum side lobe windowing shows the lowest side lobe levels (best) but the least main lobe resolution (worst).
- **Kaiser-Bessel:** Kaiser-Bessel windowing shows lower side lobes, but a wider main lobe width for larger Beta values.
- **Dolph-Chebyshev:** Dolph-Chebyshev windowing shows the parameterized side lobe level and a wider main lobe width.

AUTO PROCESSING: Lowpass processing is used to transform frequency domain data to time data (or distance data), when auto processing is turned on. Bandpass processing gets activated when auto processing is turned off, especially for band-limited sweeps with starting frequency not near DC (Such as for waveguide devices). Refer to "Site Master Implementation" on page 4-1 for more information.

RESPONSE: Sets the response to any one of the options mentioned below:

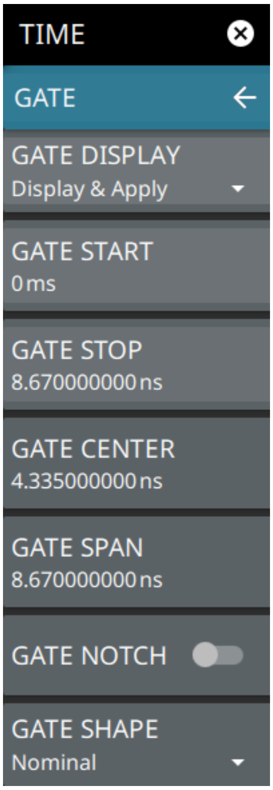
- **Lowpass Step**: Sets the response of the low pass time or distance domain to step response.
- **Lowpass Impluse**: Sets the response of the low pass time or distance domain to Impulse response.
- **Bandpass Standard**: Sets the response of the band pass time or distance domain to standard Impulse response.
- **Bandpass Phasor**: Sets the response of the band pass time or distance domain to Phasor Impulse response.

GATE: Opens the "GATE Menu" on page 3-16.

Figure 3-13. TIME Menu

GATE Menu

To access GATE submenu go to main menu, MEASURE > TIME > GATE. Figure 3-15 illustrates the applied gate display of the active trace (T1) set in time domain.



Gate Display: Sets the gate function status to one of the following options:

- Hide: When selected, the gate is not displayed on the screen nor applied to the data.
- Display: When selected the gate shape is displayed on the screen but the gate filtering is not applied to the data.
- Display & Apply: When selected, the gate shape is displayed on the screen, and the gate filtering is applied to the data.

GATE START: Sets the Gate Start value. The units will differ depending on the selected Domain. Refer to Section 3-5 "MEASURE Menu" on page 3-13 for information about domain options.

GATE STOP: Sets the stop Gate in either time or distance units, depending on whether the active trace is in the Time Domain or the Distance Domain. In time domain, the units are in seconds (s), milliseconds (ms), microseconds (μs). In distance domain, the units are in meters (m), centimeters (cm), or millimeters (mm).

GATE CENTER: Sets the GATE CENTER in either time or distance units, depending on whether the active trace is in the Time Domain or the Distance Domain.

GATE SPAN: Sets the GATE SPAN in either time or distance units, depending on whether the active trace is in the Time Domain or the Distance Domain.

GATE NOTCH: When GATE NOTCH is set to OFF, the polarity of the Gate is set to keep everything between start and stop. When the GATE NOTCH is set to ON, the polarity of the Gate is set to reject everything between start and stop.

GATE SHAPE: Selects any one of the gate shape value:

- **Maximum:** Sets the gate shape value to maximum.
- **Wide:** Sets the gate shape value to wide.
- **Nominal**: Sets the gate shape value to nominal. The nominal gate shape is the default shape.
- **Minimum:** Sets the gate shape value to minimum.

Figure 3-14. GATE Menu

Note that the gate shape is analogous to the window selection. If the data are truncated with a sharp gate (minimum, related to rectangular window), then maximum resolution is used in determining the gate, but ripple is introduced in the frequency domain. For more gradual gates, the resolution decreases in separating defects, but the size of the artifacts that are added to the frequency domain data also decreases. The window and gate shapes cannot be selected entirely independently because they interact through the transform. In particular, the use of a very sharp gate with a low side lobe window can lead to large errors. The following table shows the recommended combinations.

Table 3-1.

Window / Gate	Minimum	Nominal	Wide	Maximum
Rectangular	OK	OK	OK	OK
Nominal	OK	OK	OK	OK
Low side lobe		OK	OK	OK
Minimum side lobe			OK	OK

Note	Gate Display options in the Gate menu are only available if DOMAIN is set to TIME or DISTANCE.

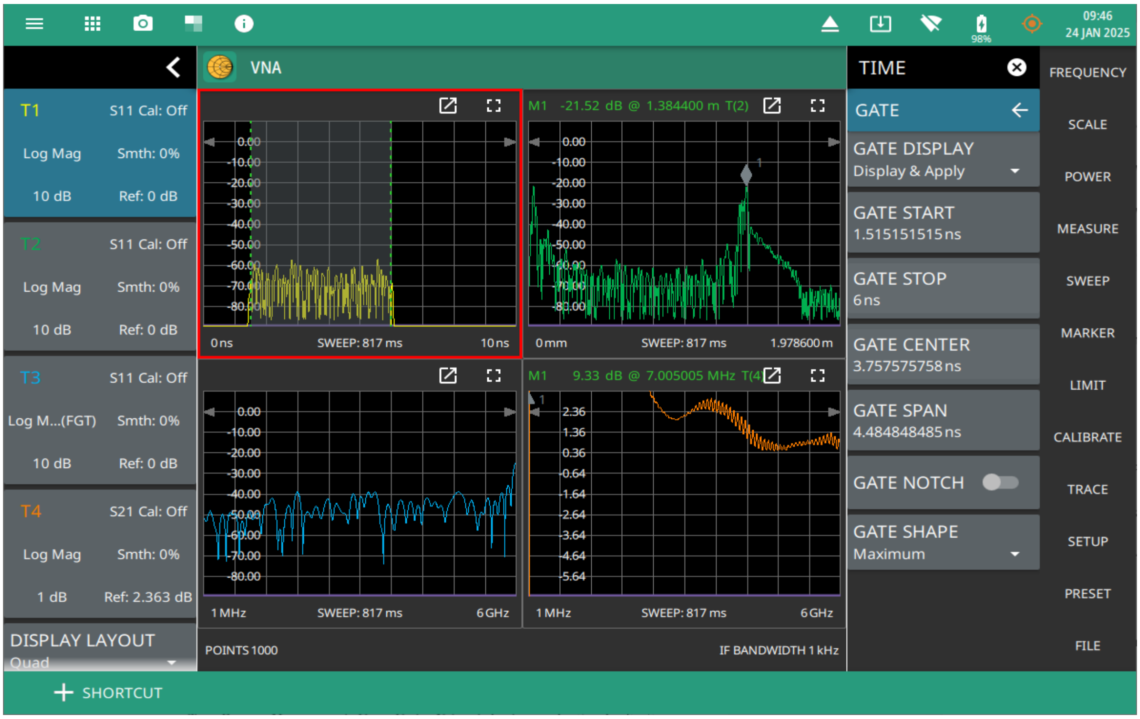
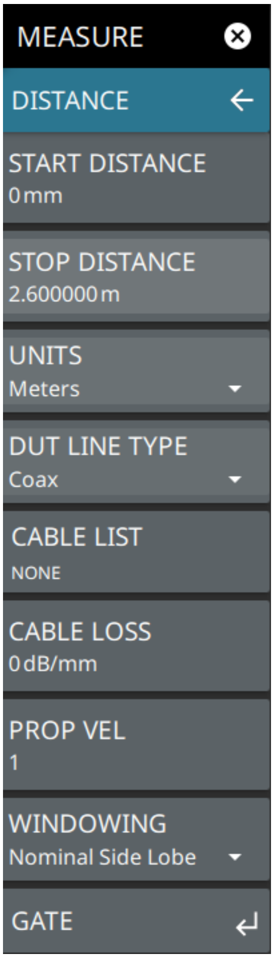


Figure 3-15. Applied Gate Display in Time Domain

DISTANCE Menu

To access DISTANCE submenu, go to main menu, MEASURE >DISTANCE.



START DISTANCE: Sets the start distance value when distance domain is selected.

STOP DISTANCE: Sets the stop distance value when distance domain is selected.

UNITS: Select the desired measurement type from the following list:

DUT LINE TYPE: Selects either one of the DUT line type:

- **Coax**: Sets the DUT LINE TYPE as Coax.
- **Waveguide:** Sets the DUT LINE TYPE as Waveguide.

CABLE LIST: Opens the standard or user cable list.

CABLE LOSS: sets the cable loss coefficient from 0.000 dB/m to 5000 dB/m.

PROP VEL: Sets the propagation velocity for the selected cable using the keypad.

WINDOWING: Selects the desired measurement view from the following list:

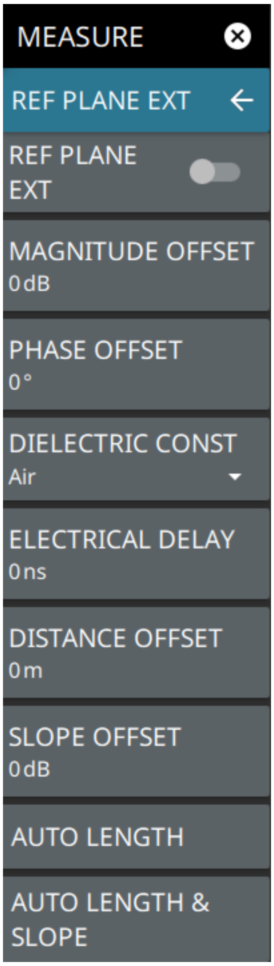
- **Rectangular**: Rectangular windowing shows the highest side lobe levels (worst) and the greatest main lobe resolution (best).
- **Nominal Side Lobe:** Nominal side lobe windowing shows lesser side lobe levels than rectangular windowing (good) but lower main lobe resolution (very good).
- **Low Side Lobe:** Low side lobe windowing shows less side lobe levels than nominal windowing (very good) but lower main lobe resolution (good).
- **Minimum Side Lobe**: Minimum side lobe windowing shows the lowest side lobe levels (best) but the least main lobe resolution (worst).
- **Kaiser-Bessel:** Kaiser-Bessel windowing shows lower side lobes, but a wider main lobe width for larger Beta values.
- **Dolph-Chebyshev:** Dolph-Chebyshev windowing shows the parameterized side lobe level and a wider main lobe width.

GATE: Opens the “GATE Menu” on page 3-16.

Figure 3-16. DISTANCE Menu

REF PLANE EXT Menu

To access Reference Plane Extension submenu, go to main menu, MEASURE > REF PLANE EXT.



REF PLANE EXT: Turns on or off the reference plane extension for Port 1.

MAGNITUDE OFFSET: Sets the reference plane extension loss (magnitude offset) on the given channel and port. For transmission S-Parameters this will shift the measurement of the given port by the magnitude offset. For reflection S-Parameters this will shift the measurement of the given port by 2x the magnitude offset. For Site Master applications, only port 1 is available.

PHASE OFSET: Sets the reference plane extension phase offset in degrees for the given channel and port. For Site Master applications, only port 1 is available.

DIELECTRIC CONST: Sets the reference plane extension coaxial or waveguide line dielectric constant type as follows:

- Air
- Microporus
- Other
- Polyethylene (This is the default constant for coaxial line type)
- Teflon

ELECTRIC DELAY: Sets the reference plane extension time (electrical delay) on the given channel and port. For Site Master applications, only port 1 is available.

DISTANCE OFFSET: Sets reference extension distance offset for the given channel and trace.

SLOPE OFFSET: Sets the reference plane extension slope offset for the given channel and port in dB/GHz. For reflection S-Parameters, the slope will be 2x dB/GHz due to the round-trip nature of the measurement. For Site Master applications, only port 1 is available.

AUTO LENGTH: Auto Length refers to an automated feature that adjusts the measurement reference point based on the physical length of the cables or fixtures connected to the DUT (Device Under Test).

AUTO LENGTH & SLOPE: Slope refers to the rate of change in the measured parameter (such as impedance or reflection coefficient) as a function of frequency. Understanding this slope is crucial for analyzing the behavior of a Device Under Test (DUT) across a frequency range.

Figure 3-17. REF PLANE EXT Menu

3-6 Setting Sweep Parameters

Sweep parameters are set using the "SWEEP Menu" on page 3-22.

DATA POINTS

The number of data points determines the number of display points in the trace that are generated from the measurement data. The data points can be user defined. The range is between 2 and 16,001 for both Standard and Flex calibrations.

The snap data points ensure that all points in the sweep are calibration measurement points rather than interpolated points. The data point can be changed with the calibration enabled, but it will always snap to the nearest calibrated data point. The Start/Stop frequencies cannot be changed when the calibration is started.

Once the calibration is complete, the unit will return to the data point and Start/Stop frequencies that were in place at the start of the cal. The number of points and Start/Stop frequencies can be changed with the calibration enabled, with each frequency point being interpolated from the flex cal.

The default data point setting is 1000. This is recommended for most measurements. Increasing the data point increases the resolution of the measurement but slows down the sweep speed. The increased resolution can be helpful in DTF, as it enables increased distance coverage for the same distance resolution.

1. Select SWEEP on the main menu to open the "SWEEP Menu" on page 3-22.
2. Select DATA POINTS and enter the desired number using the numeric keypad.

RUN/HOLD

RUN/HOLD is used to start and stop line sweeping. When in hold mode, the RF output can be set on or off.

1. Select SWEEP menu from main menu to open the "SWEEP Menu" on page 3-22.
2. Select RUN/HOLD submenu to set the sweep either in Run or Hold mode.
3. When in Hold mode, toggle the HOLD RF MODE to enable or disable the RF output.

SWEEP TRIGGER

Sweep Trigger sets the VNA sweep mode to single or continuous. In single sweep mode, each sweep is initiated by SWEEP ONCE submenu.

1. Select SWEEP on the main menu to open the "SWEEP Menu" on page 3-22.
2. Select SWEEP TRIGGER and select Single or Continuous.
3. When in single sweep mode, press SWEEP ONCE to start one line sweep.

SWEEP TYPE

Vector Network Analyzers use different sweeping techniques to measure the characteristics of DUTs. Two common methods are linear sweep and segmented sweep.

A linear sweep involves measuring the S-parameters of a DUT across a specified frequency range in a continuous manner. The frequency is incremented in equal steps (linear increments) throughout the sweep.

A segmented sweep allows the user to define specific frequency segments of interest within a broader frequency range. The VNA measures only these segments rather than performing a continuous sweep across the entire range. Site Master VNA mode supports Frequency-Based Segmented Sweep

In many applications, having a simple list of frequencies where the step size between points is uniform is not adequate. The DUT specifications may have specifications in certain bands and certain specific frequencies that must be tested, there may be certain communications bands that must be tested, or there may be certain spot frequencies that are of interest for troubleshooting or analysis.

For these cases and others, segmented sweep allows one to put together a very arbitrary list of frequencies to sweep as well as having some control of instrument behavior that is distinct at these different points and/or segments. The entire sweep is broken into segments (a segment may contain one or many points) and in each segment, one can independently control the following:

- IF bandwidth
- Sweep Averaging
- Port 1 Power

The frequency of the segments is always monotonically increasing (within a segment and between segments). Plotting is based on the frequency of the particular point. Using segmented frequency-based sweep you can create multiple linear segments each with its own independent start and end frequencies.

1. Select SWEEP on the main menu to open the “SWEEP Menu” on page 3-22.
2. Select SWEEP TYPE and select LINEAR or SEGMENTED. Refer “SEGMENT SWEEP” on page 3-23 for detailed information about segmented sweep.

Note USER CAL must be turned off to set the SWEEP TYPE to SEGMENTED.

RF Immunity

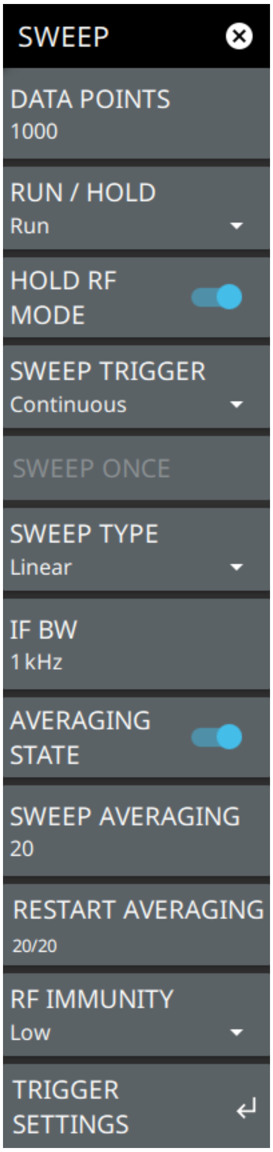
The RF Immunity setting provides a way to protect the instrument from stray signals generated by nearby or co-located transmitters that can affect measurements. Interfering signals can make the measurement look better or worse than it is. To improve the instrument’s ability to reject unwanted signals, you can set the RF immunity to high. However, sweep speed may be slowed as a result.

The RF immunity default setting is low, which makes the instrument more susceptible to interfering signals during a measurement, but optimizes sweep speed. This is appropriate when the instrument is used in an environment where RF noise is not of great concern.

1. Select SWEEP on the main menu to open the “SWEEP Menu” on page 3-22.
2. Select RF IMMUNITY and select either High or Low.

SWEEP Menu

Access SWEEP menu from main menu.



DATA POINTS: Sets the number of data points to be included in the sweep. You can set any number of data points from 2 up to 16001. The larger the number of data points, the slower sweep speed. Data Points is disabled if sweep type is set to Segmented, but is available in “SEGMENT SWEEP” on page 3-23.

RUN/HOLD: Sets the sweep to either Run or Hold.

HOLD RF MODE: Toggles RF power transmitted from Port 1 when the instrument is put in Hold mode. The RF power can be set either to stay on or to be turned off during Hold. The default setting is for the RF to stay on during Hold, which helps to stabilize the instrument temperature.

SWEEP TRIGGER: Switches between single and continuous sweeping. Note that continuous is the default setting.

SWEEP ONCE: Gets enabled when the SWEEP TYPE is set to Single.

SWEEP TYPE: Selects the SWEEP TYPE as Linear or Segmented.

SEGMENT SWEEP: Opens “SEGMENT SWEEP” on page 3-23. A segmented sweep allows defining the number of data points used at each sweep segment. Adds frequency-based segments within the frequency range of the instrument.

IF BW: Sets intermediate frequency (IF) bandwidth. Select 10 Hz for the maximum dynamic range; select 100 kHz for the maximum speed. IFBW is disabled if sweep type is set to Segmented, but is available in SEGMENT SWEEP submenu.

AVERAGING STATE: Enables sweep averaging when toggled. Notice that the averaging state is included next to the graph type displayed on the top left corner of sweep window.

SWEEP AVERAGING: Sets the number of sweeps to be used for averaging.

RESTART AVERAGING: Restarts sweep averaging if AVERAGING STATE is turned on.

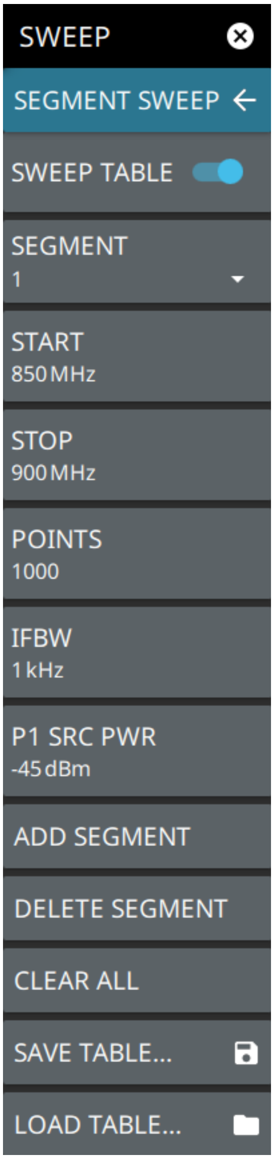
RF IMMUNITY: Sets the RF immunity to either low or high. By default, RF immunity is low. RF immunity is disabled if sweep type is set to Segmented.

TRIGGER SETTINGS: Opens the “TRIGGER SETTINGS” on page 3-25.

Figure 3-18. SWEEP Menu

SEGMENT SWEEP

To access segment sweep go to main menu, SWEEP > SWEEP TYPE > Segmented > SEGMENT SWEEP. You can create frequency-based segmented sweeps to analyze a designated portion of the trace with specific number of data points, Port 1 source power and IFBW



SWEEP TABLE: Displays sweep segments table displayed under the VNA graph. Note that a table entry denoting the segment index of the active trace with full span is available by default.

SEGMENT: Selects one of the added segment, the default value is 1 and a maximum of 100 segments can be added.

START: Sets the start frequency of the segmented sweep within the frequency range of the instrument.

STOP: Sets the stop frequency of the segmented sweep within the frequency range of the instrument.

POINTS: Sets the number of data points. Minimum is 2 and maximum is 16,001 points.

IFBW: Sets the intermediate frequency (IF) bandwidth. Maximum is 1000 kHz and minimum is 0.01 kHz.

P1 SRC PWR: Sets port 1 source power.

ADD SEGMENT: Adds a new frequency-based segment at the end of the active segment or the given segment index. To add a segment make sure to set the stop frequency less than the maximum frequency range of the instrument.

DELETE SEGMENT: Deletes an active segment.

CLEAR ALL: Clears all the added segments except the default segment.

SAVE TABLE: Saves the sweep segment table. Segmented sweep tables are saved as segmented sweep file with.sgs extension.

LOAD TABLE: Loads the segment table (.sgs) saved either internally or on to external USB memory device.

Figure 3-19. SEGMENT SWEEP Submenu

Adding Segmented Sweep

Segmented sweeps are multiple segments defined with different start and stop frequencies, along with varying number of points for each segment. Increase the number of data points to enhance the resolution and the dynamic range for the defined segments. By default, a segment covering the operating range of the instrument is available in the SWEEP SEGMENTS table displayed below the graph.

Follow the steps below to add a new segment:

1. Select SWEEP > SWEEP TYPE > Segmented > SEGMENT SWEEP.
2. From SEGMENT SWEEP menu select STOP or simply touch the stop frequency of the segment listed in segment table, to set the stop frequency of the default segment below the operating range of the instrument.
3. Select ADD SEGMENT to add a new sweep segment.

A new segment is added after the default segment covering the full operating range of the instrument. The new segment starts with the stop frequency of the previous segment, incremented by 1 Hz and ends with the stop frequency incremented by 2 Hz. The active segment is highlighted by the shaded region as shown in Figure 3-20.

4. Select DELETE SEGMENT to delete an unwanted segment.

Note	The default segment cannot be deleted. Once, the calibration is applied, the added segments cannot be deleted. To delete a segment, go to main menu, PRESET > PRESET MODE to disable the calibration.

5. Select SAVE TABLE to save sweep segments table as.sgs file.
6. Select LOAD TABLE to recall .sgs file saved in the instrument.

The active segment is highlighted as shown in Figure 3-20.

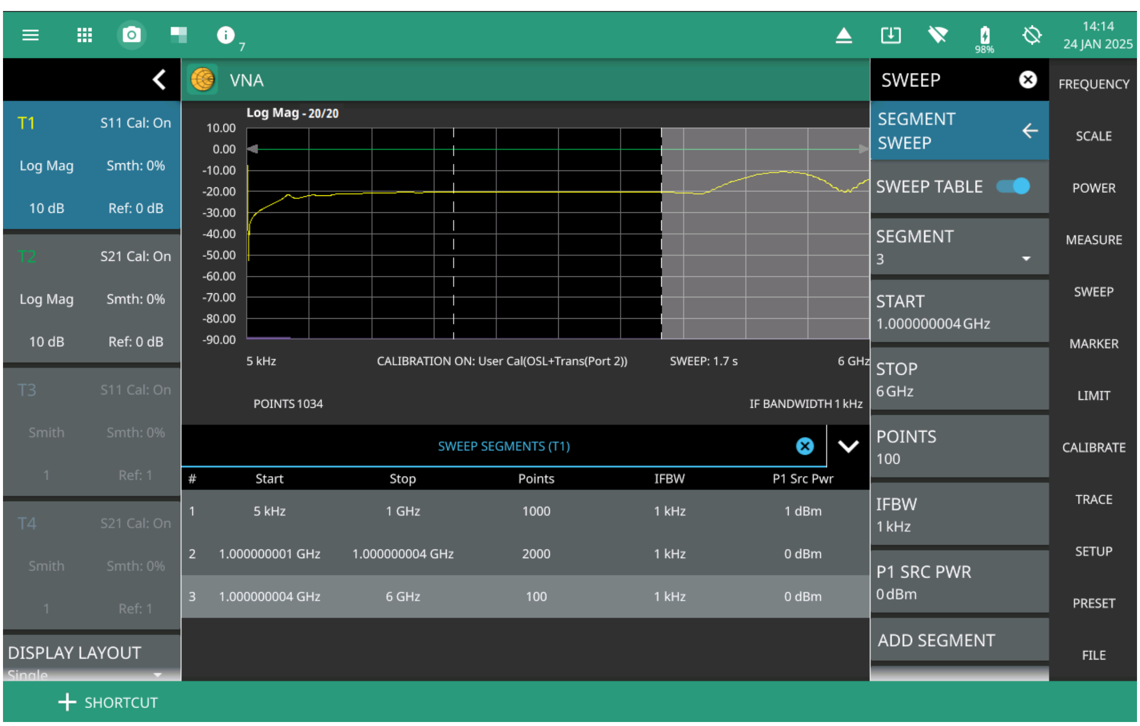
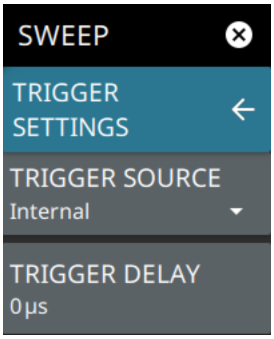


Figure 3-20. Segmented Sweep

TRIGGER SETTINGS

To access TRIGGER SETTINGS submenu go to main menu SWEEP > TRIGGER SETTINGS.



TRIGGER SOURCE: Trigger source indicates whether or not to look for a trigger condition before making measurements. Sets the trigger source as one of the following:

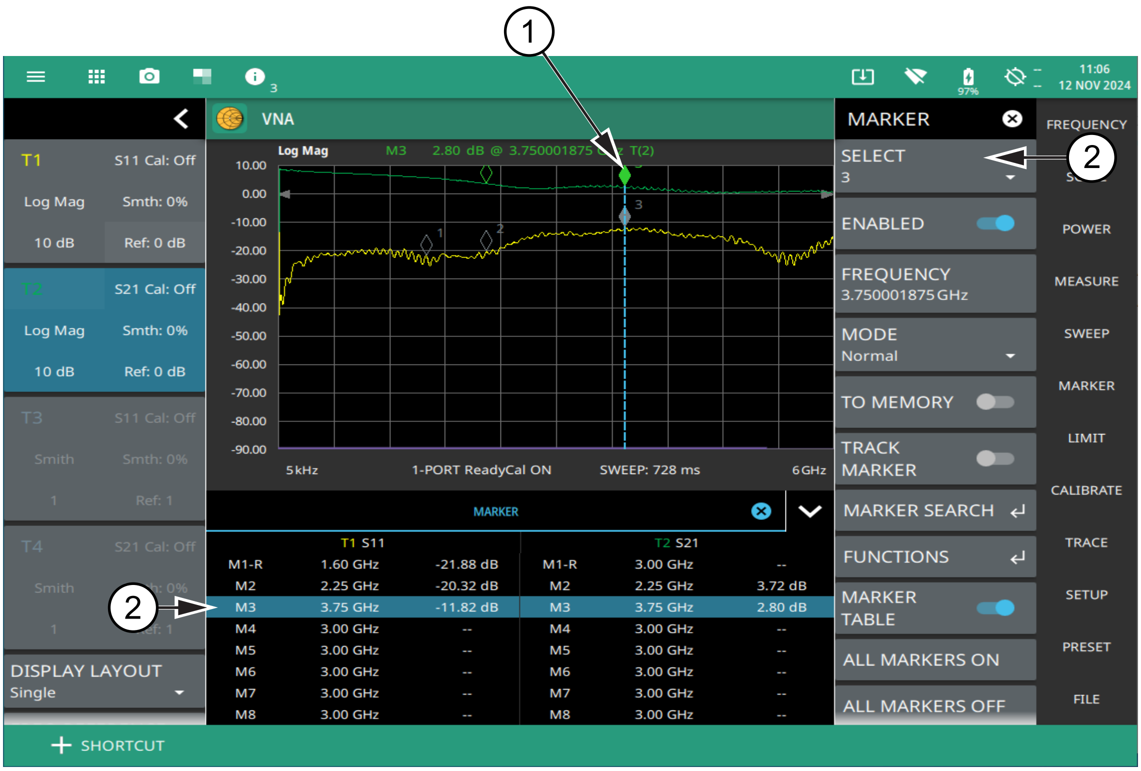
- **Internal:** Internal trigger source performs continuous sweeping by default. But can be sweeped once if the SWEEP TRIGGER is set to Single.
- **External Port 1:** A TTL signal applied to the selected External Trigger SMA input connector causes a single sweep. After the sweep is complete, the resultant trace is continuously displayed until the next trigger signal is received.
- **External Point Port 1:** The external point trigger will enable a sweep to the next point. For example if there are 10 points, each trigger will trigger a sweep to the next point. The 11th trigger will sweep the 1st point.

TRIGGER DELAY: Sets the amount of time that the analyzer waits to begin a measurement after a trigger signal is received. Negative trigger delay effectively moves the trace to the right so you can observe the activity before the trigger event.

Figure 3-21. TRIGGER SETTINGS

3-7 Setting Up Markers

The vector network analyzer supports 8 markers. Marker parameters are set using the “MARKER Menu” on page 3-28. Refer to Figure 3-22 when working with this section.



1. The status panel provides quick access to common VNA settings. Refer to “VNA Display Overview” on page 2-3.
2. Marker located on trace. The active marker is indicated with solid green fill, other markers will show with a hollow fill, fixed markers show as a green X. The dashed vertical line is attached to the active marker and facilitates touch operations. Either the marker or the line can be dragged into position, and either can be double tapped to open a number of peak search options.
3. Selected marker in the MARKER menu and in the MARKER table. The marker table shows all of the marker parameters and measurement values. You can edit marker parameters from the marker table as well as from the MARKER menu.

Figure 3-22. Markers and Marker Table

Placing a Normal Marker

1. Select MARKER to display markers. If markers were off, Marker 1 will automatically be made active at the current center frequency.
2. Select another marker using MARKER > SELECT, then select one of 8 available markers. If the marker was off, the marker will be made active and placed at the center frequency. If the marker was on, it will be made the active marker. You can enable all 8 markers and place them separately on traces.
3. Place a marker by first selecting it as the active marker, then do one of the following:
   - **a.** From MARKER menu enter the appropriate frequency using FREQUENCY submenu. The frequency can be entered manually or adjusted by using the slider or the + and – buttons to move the marker to the left and right.
   - **b.** Drag the marker on the trace (note that anywhere on the vertical dashed blue line can be touched to drag a marker's position).
   - **c.** Use the MARKER SEARCH submenu to search for the peak marker to automatically find signal peaks (refer to "MARKER SEARCH" on page 3-29).

Placing a Delta Marker

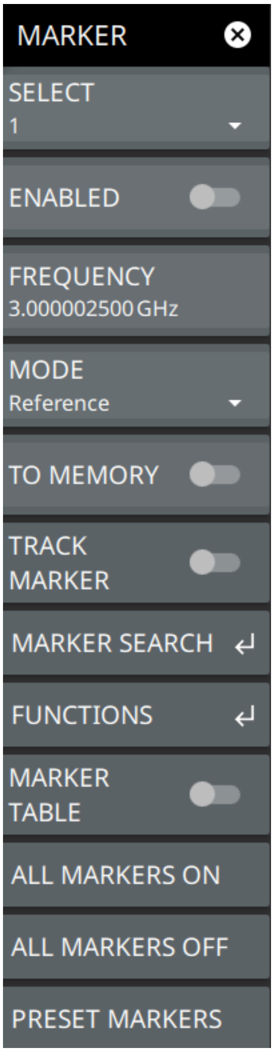
When a delta marker is on, its position data is relative to its reference marker. For example, if Marker 2 is set as a delta marker, the delta reference is set to Marker 1. To set a delta marker and its reference:

1. Activate either a normal or fixed marker and place it in a reference location as described previously.
2. Activate a delta marker using MARKER > SELECT > Marker #, then select MODE > Delta.
3. Place the active delta marker by doing one of the following:
   - **a.** Enter a new FREQUENCY value.
   - **b.** Drag the marker on the trace (note that anywhere on the vertical dashed blue line can be touched to drag a marker's position.
   - **c.** Use the MARKER SEARCH menu and the desired peak search function to automatically find signal peaks (refer to "MARKER SEARCH" on page 3-29).

A delta marker is labeled with a green delta symbol between each marker number. For example, delta Marker 2 relative to Marker 1 is displayed as "M2Δ1". If another marker is desired to be the reference marker, select the delta marker as the active marker and then use DELTA REFERENCE > Marker # to select the desired reference marker number.

MARKER Menu

The Vector Network Analyzer supports 8 markers. Marker 1 is always the reference marker. Markers 2-8 can be either be Normal or Delta markers. The delta marker is always relative to marker1.



SELECT: Selects one of the 8 markers. Marker 1 is selected by default.

ENABLED: Enables the selected marker. When the toggle is off, the marker is disabled and not shown on the top of the sweep window.

FREQUENCY: Sets the marker frequency. For delta markers, the frequency is relative to the reference marker. Change the marker frequency by dragging it to the desired location. You can also change the marker frequency by pressing the FREQUENCY button and changing it manually using the keypad controls.

MODE: Sets the current active marker as a reference (standard) marker or a delta marker relative to Marker 1. Marker 1 is always a reference marker:

- **Normal:** A Normal marker is also known as a tracking marker. The frequency is fixed but the amplitude value varies from sweep to sweep. It measures the absolute value of the marker.
- **Delta (Δ):** A Delta (Δ) marker displays the delta frequency and amplitude between itself and a reference marker. If Marker 1 is selected to be a Delta marker, then Marker 2 is turned on as a reference marker for Marker 1 and it becomes a Normal marker at the same location.

TO MEMORY: If there is a trace in the memory the TO MEMORY toggle will allow the user to save the marker into the memory trace. If the memory trace is not displayed the marker will moved into the memory trace and also not be displayed. Active markers will follow the active trace and the same with memory traces. If there is no trace in memory the toggle will not work. An error message will be displayed in the notifications bar.

TRACK MARKER: Allows the user to track the marker. For example if the user searched peak and changed the graph and used the track marker it will return to the peak.

MARKER SEARCH: Opens the “MARKER SEARCH” on page 3-29.

FUNCTIONS: Sets the position of markers by either moving to left, right or center. There is a capability to set the marker to left most or right most end of the sweep window. For more information about using marker functions, refer to “MARKER FUNCTIONS” on page 3-30.

MARKER TABLE: Toggle on or off the marker table displayed below the sweep window. Refer to “MARKER TABLE” on page 3-31 for additional information.

ALL MARKERS ON: Turns all markers on, but markers will retain their last frequency position once re-enabled.

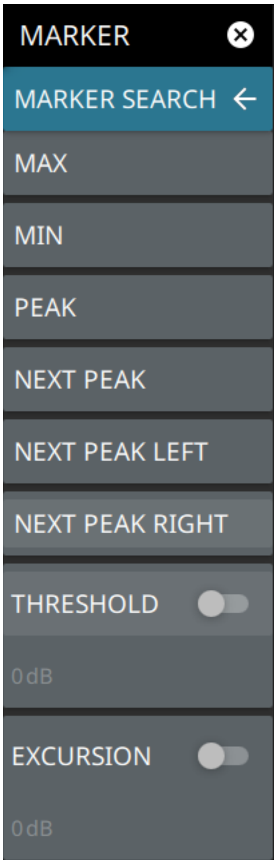
ALL MARKERS OFF: Turns all markers off, but markers will retain their last frequency position once re-enabled

PRESET MARKERS: Presets marker selections to default values.

Figure 3-23. MARKER Menu

MARKER SEARCH

Access MARKER SEARCH submenu from MARKER menu.



MARKER SEARCH: Returns to the main MARKER menu.

MAX: Press MAX button to move the active marker to the maximum point on the active trace.

MIN: Press MIN button to move the active marker to the minimum point on the active trace

PEAK: Moves the selected marker to the highest peak.

NEXT PEAK: Moves the selected marker to the next highest peak regardless of location.

NEXT PEAK LEFT: Moves the selected marker to the next peak left of its current position.

NEXT PEAK RIGHT: Moves the selected marker to the next peak right of its current position.

NEXT POINT LEFT: Moves the selected marker one display point to the left of its current position. Useful for fine tuning the position of a marker.

NEXT POINT RIGHT: Moves the selected marker one display point to the right of its current position. Useful for fine tuning the position of a marker.

THRESHOLD: If turned on, sets the threshold that a peak has to achieve to be considered a peak. The default is 0 dB, the min is -200 dB and max is 100 dB.

EXCURSION: If turned on, sets the excursion value that a peak amplitude must rise and fall over the peak threshold to qualify as peak.

Figure 3-24. MARKER SEARCH

MARKER FUNCTIONS

Access FUNCTIONS submenu from MARKER menu

MKR TO START: Press to set the active marker to the start frequency of the SPAN..

MKR TO STOP: .

MKR TO CENTER: Moves the selected marker to the highest peak.

MKR TO REF MKR: Moves the selected marker to the next highest peak regardless of location.

MKR TO LEFT: Moves the selected marker to the next peak left of its current position.

MKR TO RIGHT: Moves the selected marker to the next peak right of its current position.

START TO MKR: Moves the selected marker one display point to the left of its current position. Useful for fine tuning the position of a marker.

START TO MKR: Moves the selected marker one display point to the right of its current position. Useful for fine tuning the position of a marker.

CENTER TO MKR: If turned on, sets the threshold that a peak has to achieve to be considered a peak.

REF MKR TO MKR: If turned on, sets the excursion value that a peak amplitude must rise and fall over the peak threshold to qualify as peak.

Figure 3-25. MARKER FUNCTIONS

MARKER TABLE

The Marker Table is displayed below the sweep window. The table is automatically sized to display all 8 markers that are turned on. The table displays marker frequency/distance, amplitude, and delta information for delta markers. The selected marker is displayed with a highlighted background. Table controls are located on the right of the header. Select the down or up arrow to collapse or expand the table, press X to close the table.

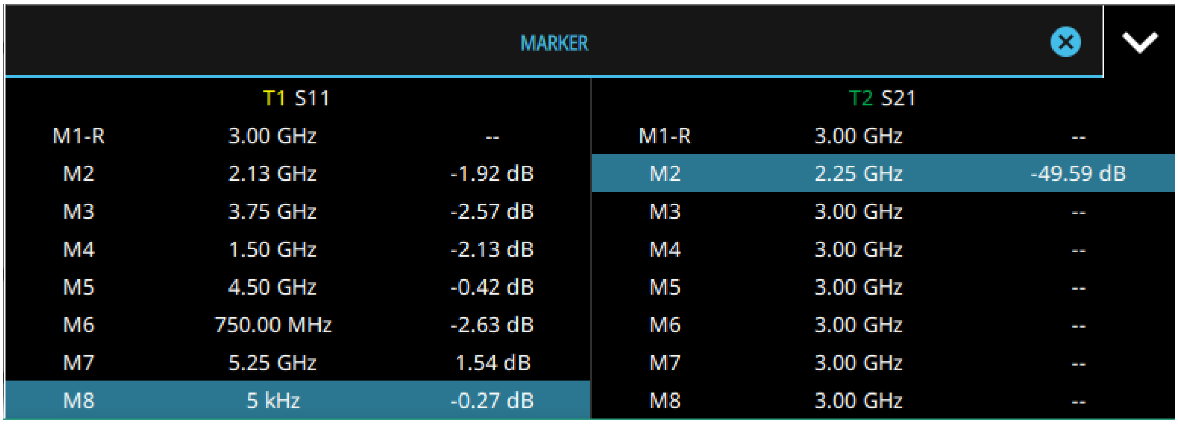


Figure 3-26. Marker Table

You can select and change the marker parameters by selecting the marker from either the MARKER menu or the MARKER table.

The currently selected marker's value is shown at the top left of the sweep window with its current amplitude and frequency values. The selected marker is highlighted on the trace display.

3-8 Setting Up Limit Lines

Limit lines allow you to monitor when trace data crosses a defined line. Two types of limit lines can be specified: lower limit lines and upper limit lines. Limit lines are used for visual reference or for pass/fail criteria using the limit alarm and upper/lower limits. Selecting the LIMIT on the main menu displays the LIMIT menu.

Overview of limit lines:

- Each measurement has a unique limit line.
- The color of the limit line changes to red when a measurement trace exceeds a limit and when LIMIT TEST is enabled, the limit pass/fail result is displayed in the upper right of the measurement data.
- Limits set beyond the current amplitude range are displayed at either the top or bottom of the graticule.
- The limit line amplitude is stored when a limit line is turned off.
- Limit lines must either be all single limit lines or all segmented limit lines. They cannot be mixed, but you can have a single segment as upper or lower limit lines.
- PRESET LIMITS will turn off the limit line display, limit alarm and Pass/Fail message, and reset upper and lower limits to their default values.

Single Limit Lines

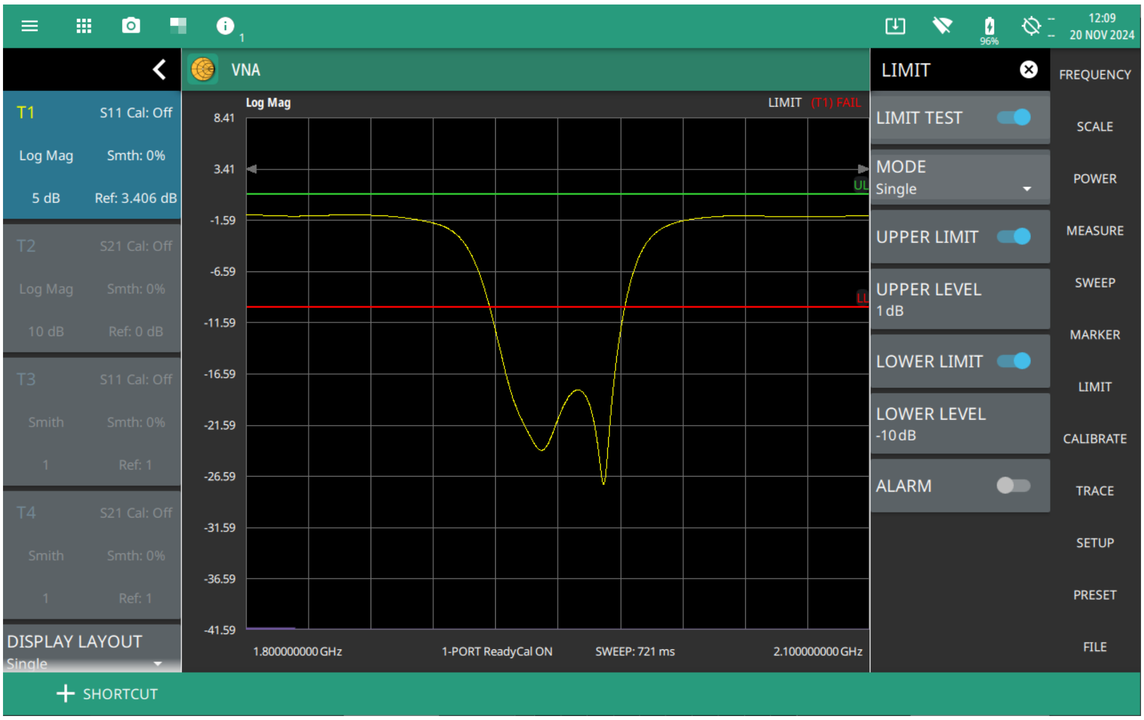
To enable a simple upper or lower limit lines:

1. Select LIMIT on the main menu.
2. Toggle UPPER LIMIT or LOWER LIMIT on or off.
3. Select UPPER LEVEL or LOWER LEVEL to edit the limit line amplitude, or use the touch screen to drag the limit line up or down.

   A single limit line extends over the entire displayed range of the sweep, independent of the start/stop settings of the sweep. For a single limit line, the amplitude for the start/stop points is the same. Upper limit lines are labeled with a “UL”, and lower limit lines are labeled with an “LL”. Limit lines are displayed in green so long as the limits are not reached or exceeded. When a limit is exceeded (upper or lower), the limit line or segment turns red. Any portion of the measurement trace touching or exceeding a limit also turns red, while portions of the trace within limits remain in the default yellow color.

Figure 3-27 shows single upper and lower limit lines with the lower limit failing the limit test.

Each limit line can consist of a single segment, or as many as 40 segments across the entire frequency span of the instrument. These limit segments are retained regardless of the current frequency span of the instrument, which allows the configuring of specific limit envelopes at various frequencies of interest without having to re-configure them each time the frequency is changed. Limit line parameters are set using the "Segmented Limit Lines" on page 3-34.



1. Limit points are shown as gray circles. The active point is filled in gray. Points can be dragged into position or set discretely using the frequency and amplitude settings in the.
2. The limit line shown here is a simple upper limit line. The limit line color is green when the trace does not cross the limit line, and the limit line color turns red when the trace crosses it.
3. The limit test pass/fail status is also shown in green or red color at the top of the display. The limit test is applied to the active trace, indicated here by T1.

Figure 3-27. Simple Limit Line

Segmented Limit Lines

Segmented limit lines need not be continuous or connected as a single limit line. If any of the segments fail the limit test, the entire upper or lower limit fails the test. Additionally, segments can be added in any order and are not necessarily sequential from left to right or as all upper or all lower in sequence (i.e., segment 1 and 10 can be upper limits.

To enable segmented limit lines:

1. Select LIMIT on the main menu.
2. Select MODE and select Segmented. The segmented LIMIT menu will be shown (use the MODE selection to change between single or segmented limits).
3. Select SEGMENT TYPE and select Upper or Lower.
4. Toggle UPPER LIMIT or LOWER LIMIT on or off.

   A single limit line segment is placed over the entire displayed range of the sweep, independent of the start/stop settings of the sweep. A segmented limit line can be divided into connected or disconnected segments with different start/stop frequency values (X1/X2) and corresponding start/stop amplitude values (Y1/Y2).
5. Select SEGMENT and select a segment number and make it the active segment. The active segment is shown in blue color.
6. Select X1 to set the start frequency of the active segment.
7. Select Y1 to set the start amplitude of the active segment.
8. Select X2 to set the stop frequency of the active segment.
9. Select Y2 to set the stop amplitude of the active segment.

Note	Limit lines segments cannot be moved by using the touch screen.

Figure 3-28 shows a single segment limit line.

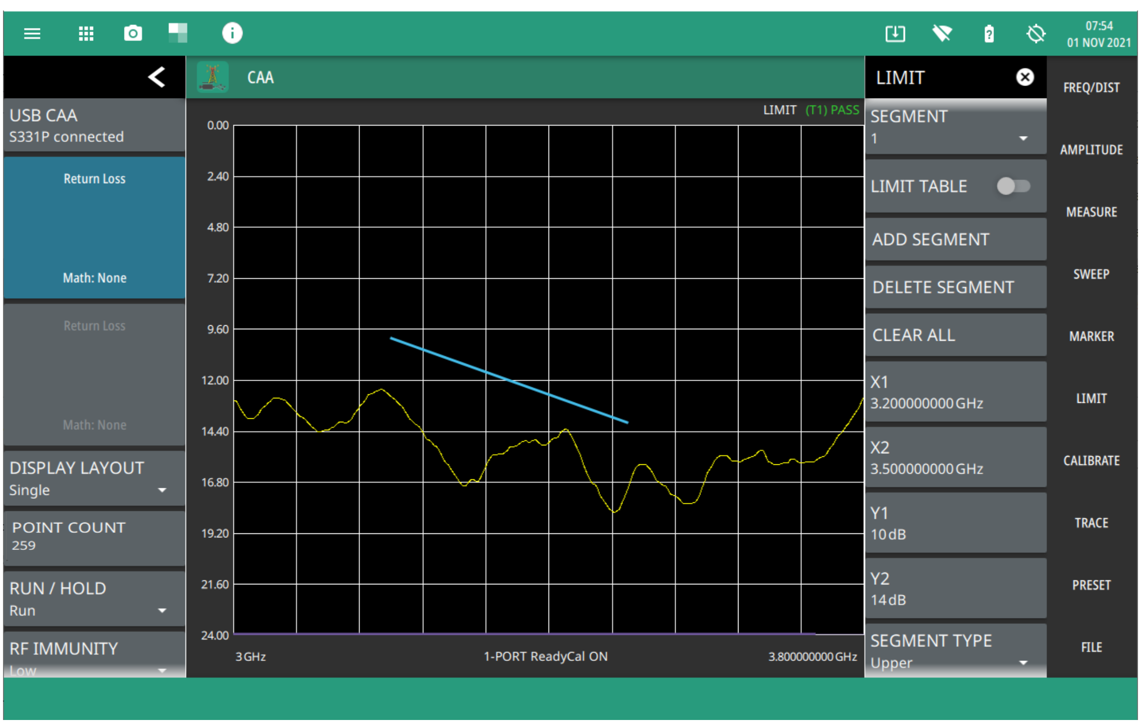


Figure 3-28. Single Segment Limit Line

10. Select ADD SEGMENT to add a new segment, then press SEGMENT TYPE to set it as an Upper or Lower segment.

    A new segment is added after the currently set active segment and existing segment numbers are incremented by 1. The new segment starts from the stop point of the previous segment and ends at the start point of the next segment of the same type (upper or lower), or to the end of the sweep range if there are no following segments. Figure 3-28 shows three upper segments where the active segment 2 was added by making segment 1 active, then pressing ADD SEGMENT. The new segment was added and connects the end point of segment 1 and start point of segment 3.

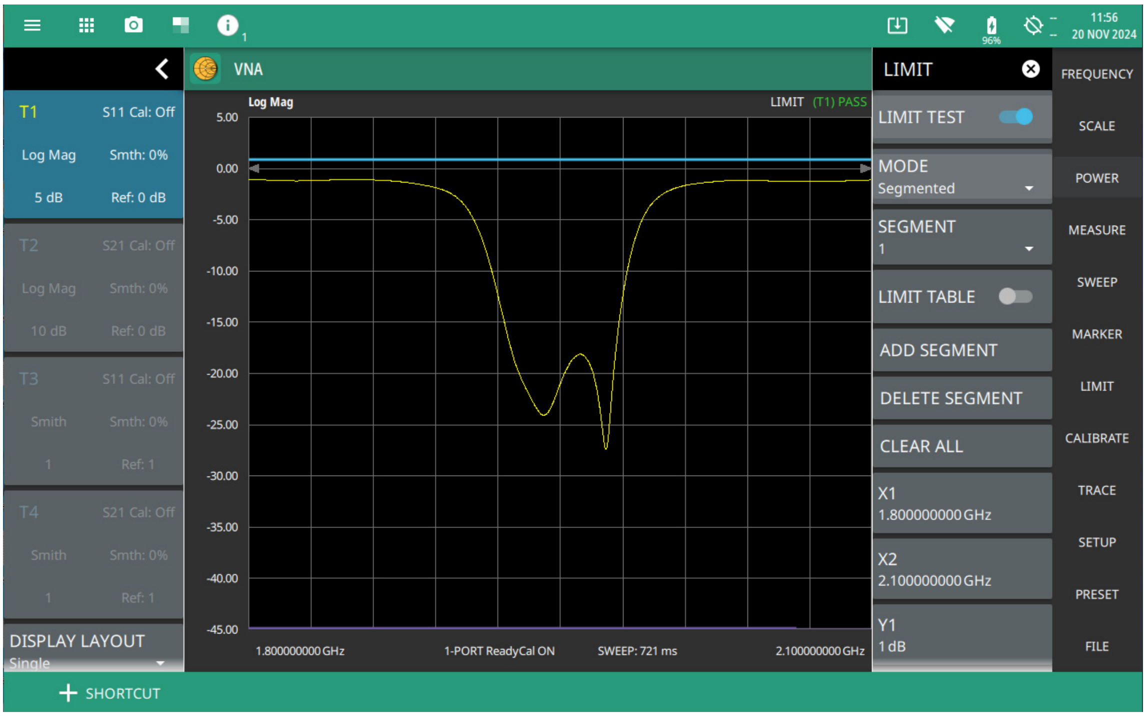


Figure 3-29. Single Segment Limit Line

Segments are added, set as upper and lower, and their start and stop points are edited to create a complex pass/fail limit test. Figure 3-28 shows several upper and lower segmented limit lines with the lower limit failing.

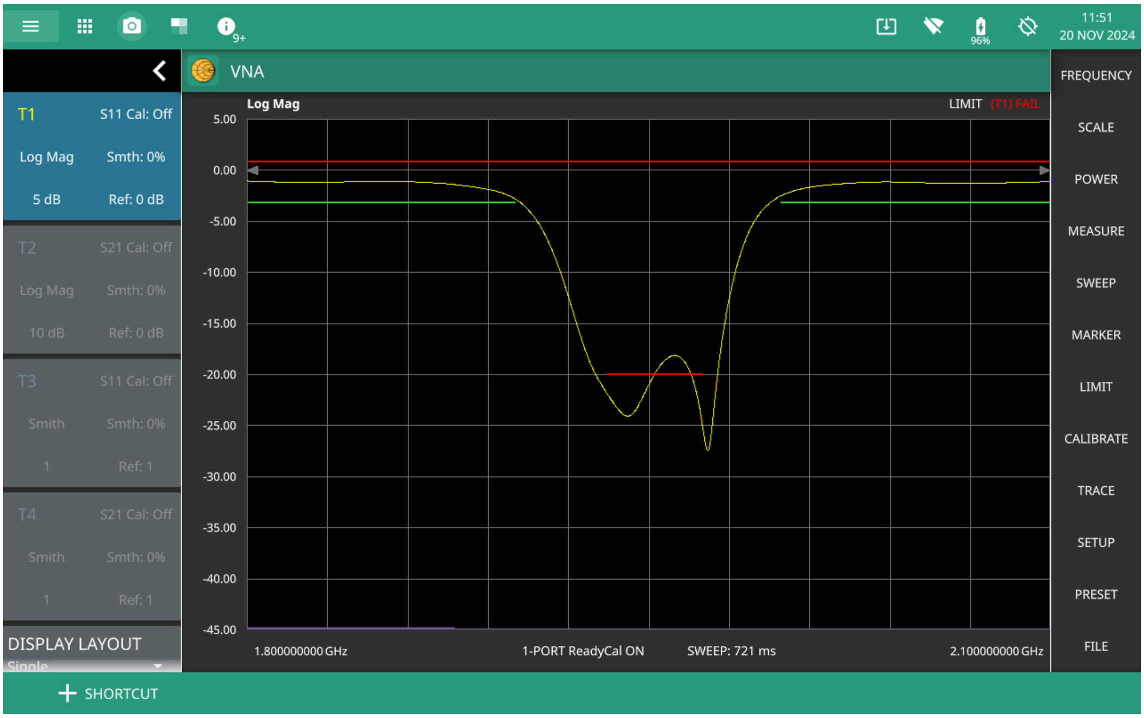


Figure 3-30. Complex Segmented Limit Lines

Limit Table

A limit table can be displayed for segmented limit lines by toggling LIMIT TABLE on or off. The limit table is useful when creating very complex limit lines as you can directly select the limit segment to make it active and edit any of its parameters (start and stop points and its type) right from the table. Figure 3-31 shows segmented limit lines with the limit table enabled. The lower segment is failing the limit test.

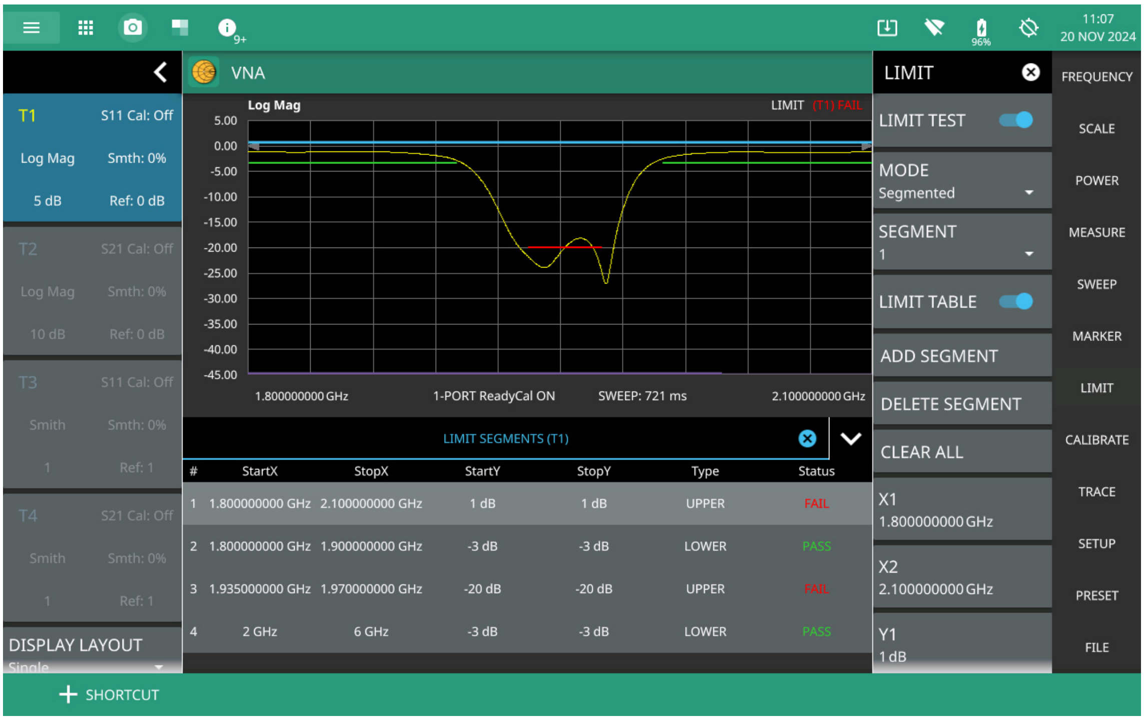


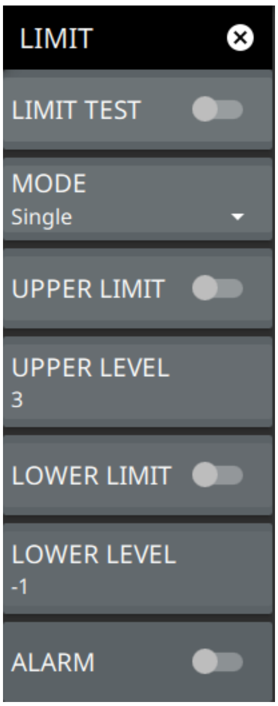
Figure 3-31. Limit Table

Limit Alarm

Select the LIMIT > ALARM to toggle the audible limit test alarm on or off.

LIMIT Menu (Single)

Two types of limit lines can be specified, lower limit lines and upper limit lines. Limit lines can be used for visual reference only, or for pass/fail criteria using the limit alarm. Limit alarm failures are reported whenever a signal is above the upper limit line or below the lower limit line. Limit lines cannot be used with Smith Chart or Polar graphs. Each limit line can consist of a single segment, or as many as 40 segments across the entire frequency span of the instrument. These limit segments are retained regardless of the current frequency span of the instrument. Limit segments allow the configuring of specific limit envelopes at various frequencies of interest without having to reconfigure them each time that the frequency is changed.



LIMIT TEST: Selects UPPER or LOWER limit line for editing.

MODE: Sets the limit mode to either Single or Segmented. If the mode is set to Segmented you can add a limit segment by using custom values for X and Y axes.

UPPER LIMIT: Activates the upper limit when turned on.

UPPER LEVEL: Sets the upper limit value of the data point of active trace.

LOWER LIMIT: Activates the lower limit when turned on.

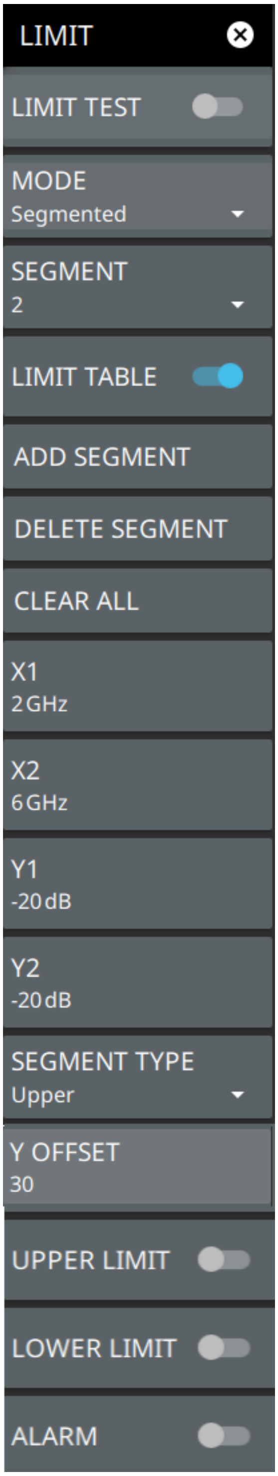
LOWER LEVEL: Sets the lower limit line value of the data point of the active trace.

ALARM: This setting is for toggling the alarm function on or off for the currently active limit line. When on, an alarm beep will occur when a data point exceeds the limit.

Figure 3-32. LIMIT Menu (Single)

LIMIT Menu (Segmented)

If the limit MODE is set to Segmented you can add a segmented limit by using custom values for X (frequency) and Y (amplitude) axes.



LIMIT TEST: When toggled on, a PASS or FAIL message is displayed at the top of the scale to indicate whether the trace touches or exceeds the limit line (FAIL).

MODE: Sets the limit line to single or segmented. Limit line segments are independent of each other and are defined by a start point and an end point. A maximum of 42 limit line segments can be defined. Both the upper and lower limit line segments for a measurement trace must be of the same type: either both are single, or both are segmented; however, you can create just one limit line segment as upper or lower to cover the entire measurement. If using single limit lines, see “LIMIT Menu (Single)” on page 3-38.

SEGMENT: Selects one of the limit line segments and makes it active.

LIMIT TABLE: Toggle on or off the limit table displayed below the screen. The limit table is only available when segmented limit lines are used. The limit table provides an easy to use interface for editing limit line segments. Refer to “Limit Table” on page 3-37 for more info.

ADD SEGMENT: Adds a limit line segment after the current active segment. All segment numbers after the current active segment will be incremented.

DELETE SEGMENT: Deletes the currently active segment. All segment numbers after the current active segment will be decremented.

CLEAR ALL: Removes all segments and does not store any segment information.

X1: Edits the start X value (frequency or distance) of the active limit line segment.

X2: Edits the stop X value (frequency or distance) of the active limit line segment.

Y1: Edits the start Y value (amplitude or phase) of the active limit line segment.

Y2: Edits the stop Y value (amplitude or phase) of the active limit line segment.

SEGMENT TYPE: Toggles the active limit line segment to upper or lower limit.

Y OFFSET: Applies an amplitude offset to all upper limit line segments. The offset value must not offset any upper limit line segments outside of the full scale amplitude for the measurement.

UPPER LIMIT: Toggles all of the upper limit line segments on or off.

LOWER LIMIT: Toggles all of the lower limit line segments on or off.

ALARM: When toggled on, an audible alarm sounds a repeating beep when the trace touches the limit line.

Figure 3-33. LIMIT Menu

3-9 Calibrations Considerations

Various 2-port calibrations are available in VNA Mode. Transmission response is the simplest and requires only one connection during calibration, but it does not correct for test port match errors. 1-Path 2-Port calibration requires four calibration connections and corrects for the transmit port match, but does not correct for the receive port. Full 2-port calibration requires seven calibration connections and corrects for both test port match errors. The full 2-port calibration technique offers the most accuracy.

For accurate results, the MS2085A/89A must be calibrated at the ambient temperature after allowing for warm-up time (10 minutes) and before making any measurements. The instrument must be recalibrated whenever the setup frequency changes, whenever the ambient temperature changes by an amount that has more than likely rendered the calibration invalid, or whenever a test port extension cable is added, removed, or replaced. For an example of measurement improvement after calibration, refer to "Only one calibration is available at one time. Performing a new calibration overwrites any existing calibration. You can, however, store a measurement setup, which also stores the calibration. You can therefore have multiple calibrations available (as long as the calibration settings and conditions continue to apply). Refer to Chapter 3, "VNA Calibration and Measurements" to deep dive into CALIBRATE menu that includes calibration methods and setup options." on page 3-40.

Calibration data are saved when you save a Setup file. When you recall a setup, the calibration remains valid if instrument conditions (such as temperature) remain within the calibration tolerance.

Calibration Data and Indications

When you perform a calibration, the correction coefficients are calculated for specific S-parameters (depending on the type of calibration chosen) and for instrument settings (frequency range, number of points, and power level). The term "calibration correction" refers to the measurement correction coefficients that are applied to measurements as a result of your calibration.

When calibration is completed it applies to all S-parameters. For example, if a Full S_{11} (1-port) calibration is performed, then only traces that measure S_{11} have a valid calibration. For those traces, the calibration status is displayed as S11 Cal: On in the trace card of the status panel. All other traces that do not measure S_{11} will displayed as S11 Cal: Off to indicate that no valid calibration is available for those traces. The calibration status is off by default. The calibration correction can also be turned off manually by toggling off the USER CAL under the CALIBRATE menu. In that case, the calibration status is shown as CAL: OFF for all traces that have valid correction data available.

When you have INTERPOLATE set to off, you cannot modify the frequency range or the source power level, or increase the number of points. You can, however, decrease the number of points without forcing the calibration to become invalid.

If you reduce only the number of points, then the frequency range is not changed. The MS2085A/89A finds a subset of the original points in the sweep that can be used. You can therefore notice that the instrument may not use the exact number of points that you have entered. It picks a specific number of points that allow the calibration correction to continue to be valid. Data points can be set using DATA POINTS under SWEEP menu.

If INTERPOLATE is set to on, then you can reduce the frequency range and modify the number of points without invalidating the calibration. In that case, the calibration coefficients are regenerated (interpolated) to match the new settings.

Only one calibration is available at one time. Performing a new calibration overwrites any existing calibration. You can, however, store a measurement setup, which also stores the calibration. You can therefore have multiple calibrations available (as long as the calibration settings and conditions continue to apply). Refer to Chapter 3, "VNA Calibration and Measurements" to deep dive into CALIBRATE menu that includes calibration methods and setup options.

3-10 CALIBRATE Menu

Access CALIBRATE menu from main menu to mainly perform calibration, access cal setup and choose a calibration method and so on.

START CAL: Begins VNA calibration.

CAL SETUP: Opens "CAL SETUP" dialog. Provides the predefined set of parameters needed to start calibration.

TYPE: Selects any one of the following calibration types, see "TYPE" on page 3-43:

- OSL
- OSL +Trans (USB Sen)
- OSL + Trans (2-port)
- Trans (USB Sen)
- Trans (2-port)
- iOSL (not available when LINE is set to Waveguide)
- iOSL + Trans (USB Sen) (not available when LINE is set to Waveguide)
- iOSL + Trans (2-port) (not available when LINE is set to Waveguide)
- Reflection Response

LINE: Sets the cable type to either Coax or Waveguide.

METHOD: Selects any one of the following calibration methods:

- **SOLT:** Short-Open-Load-Thru calibration method is default when LINE is set to Coax. The load behavior largely sets the directivity terms, the short and open together largely determine source match and reflection tracking and the thru largely determines transmission tracking and load match. See "SOLT Calibration" on page 3-50.
- **SSLT:** Short-Short-Load-Thru calibration method is default when LINE is set to Waveguide. It differs from an SOLT calibration by the differing offset lengths between two shorts which are used to help define reflection behavior instead of an open and short. See "SSLT Calibration" on page 3-54.

MODE: Selects the calibration mode as either Standard or Flex.

PORT 1 DUT: Selects an appropriate PORT 1 DUT connector. Not available when TYPE is set to any one of the ICN51A InstaCal calibration types.

PORT 1 CAL KIT: Selects an appropriate PORT 1 CAL KIT connector. Not available if THRU DEVICE is set to User Offsets and when TYPE is set to any one of the ICN51A InstaCal calibration types.

THRU DEVICE: Selects the thru device as either PORT 1 CAL KIT or User Offsets. Enter the LINE LENGTH and LINE DELAY, when THRU DEVICE is set to User Offsets.

INTERPOLATE: Turns on/off data interpolation. If the toggle is turned off, the calibration data will not be interpolated from one point to another. This means the user cannot change the frequency. When it is turned on, the unit will take the data and allow the user to change the frequency because it will interpolate the data between two points.

USER CAL: Enables user calibration when toggled on.

THRU UPDATE: Opens the calibration wizard to allow calibrating the Thru component without repeating the entire calibration sequence.

CAL INFO: Displays the active cal settings and current instrument settings. See "CAL INFO" on page 3-66.

Figure 3-34. CALIBRATE Menu

CAL SETUP

In order to perform a proper calibration, several parameters must be set before the calibration procedure is started. These parameters are: TYPE, LINE, METHOD, MODE, PORT 1 DUT, PORT 1 CAL KIT and THRU DEVICE as shown in Figure 3-35. To access Cal Setup window, press the CAL SETUP submenu from CALIBRATE menu.

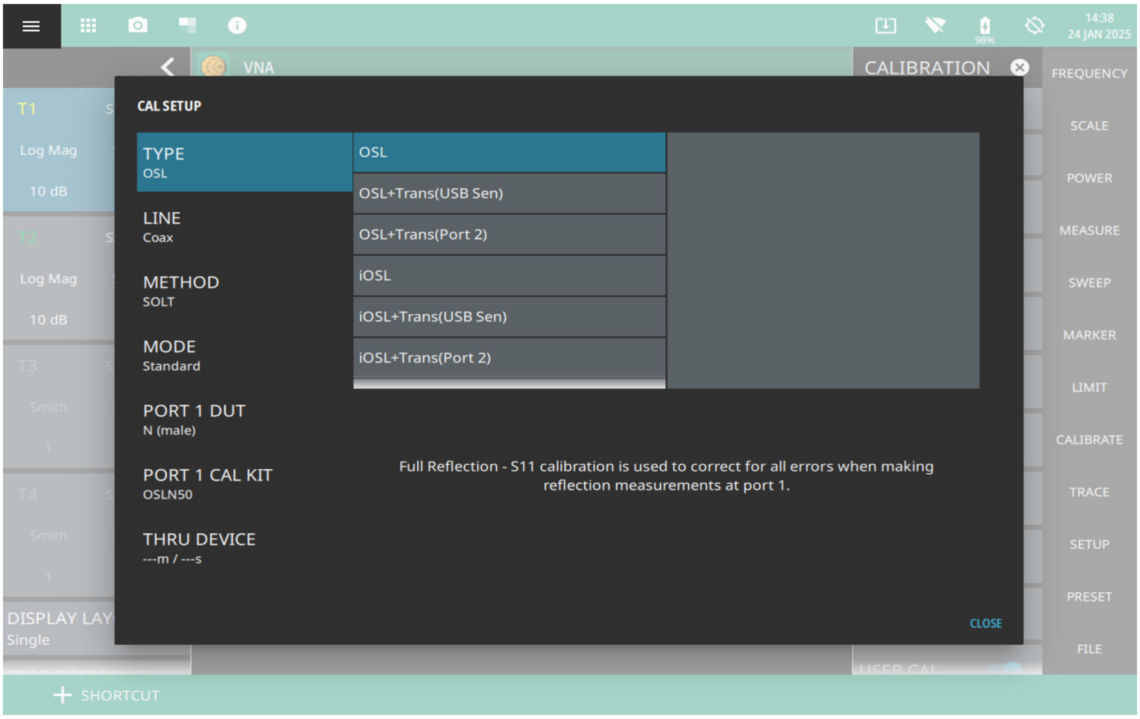


Figure 3-35. CAL SETUP Window

TYPE

MS2085A/89A Site Master supports the following calibration types in VNA mode as shown in Figure 3-35.

Refer to Cable Antenna Analyzer (CAA) Measurement Guide (PN: 10580-00493) for detailed information on each calibration type except Reflection Response. Some of the calibration types are option dependent, please refer to your instrument's technical data sheet for the list of available options.

OSL (Open-Short-Load): For all measurement except Transmission (USB Sensor), you can manually calibrate the unit using an external precision OSL calibration kit.

OSL +Trans (USB Sen): The combined calibration type OSL + Trans (USB Sen) allows the instrument to be calibrated once for all the supported measurement types, eliminating the need to re-calibrate when switching from one type of measurement to another, such as return loss to transmission.

OSL + Trans (2-port) (Option 21): OSL + Transmission (2-Port) type involves calibrating the port one with OSL and then calibrating the transmission from port 1 to port 2. The cable used to connect the two ports would be normalized.

Transmission (2-Port) (Option 21): The 2-port transmission measurement is used to verify the performance of tower-mounted amplifiers, and duplexers, and to verify antenna isolation between two sectors. The excellent dynamic range makes it suitable for repeaters as well. The second port is a selective receiver which provides up to 100 dB dynamic range which makes it possible to test the band pass filters common on many networks.

iOSL : The system will automatically switch between open, short and load during the calibration process. Note that this calibration type is only available when InstaCal ICN51A is connected and LINE is set to Coax.

iOSL + Trans (USB Sen) : The system will automatically switch between and open, short and load. ICN51A InstaCal is used in this type instead of traditional OSL. External USB power sensor is necessary to carry out this calibration type. Note that this calibration type is only available when InstaCal ICN51A is connected and LINE is set to Coax.

iOSL + Trans (2-port) (Option 21): Just like OSL+ Trans (USB Sen) the iOSL + Trans (2-Port) uses the ICN51A instead of a traditional OSL. The system will automatically switch between and open, short and load. Note that this calibration type is only available when InstaCal ICN51A is connected and LINE is set to Coax.

Reflection Response: This calibration type simply performs normalization for Port 1. This cal type requires one connection to Port 1 reflection measurements only. Connect Open or Short on Port 1, load connection can be skipped, but if used, will improve the effectiveness of this calibration.

Follow the steps below to perform Reflection Response calibration:

1. Select FREQUENCY on the main menu and adjust the start and stop frequency values if needed.

   If the active calibration mode is Standard and USER CAL is on, a warning message is displayed informing you that USER CAL must be turned off. You can use the Flex calibration mode to allow frequency changes with USER CAL on.

2. Select CALIBRATE on the main menu and ensure USER CAL is off.
3. Go to TYPE drop-down and select Reflection Response.
4. Select MODE and select either Standard or Flex.
5. Select START CAL and follow the on-screen CAL WIZARD.

6. Select MEASURE at the end of each step to proceed to the next step in the sequence.

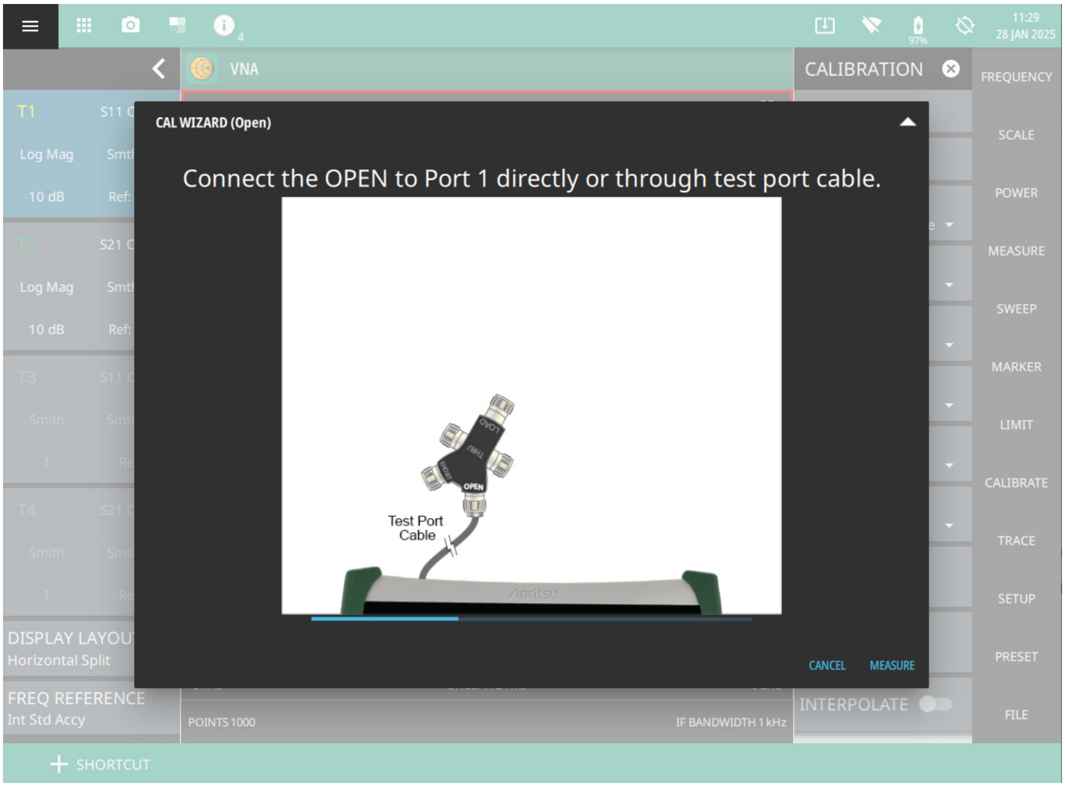


Figure 3-36. Reflection Response Calibration - Open

7. Select SKIP as connecting the Port 1 to LOAD is optional, but if used, will improve the effectiveness of this calibration.

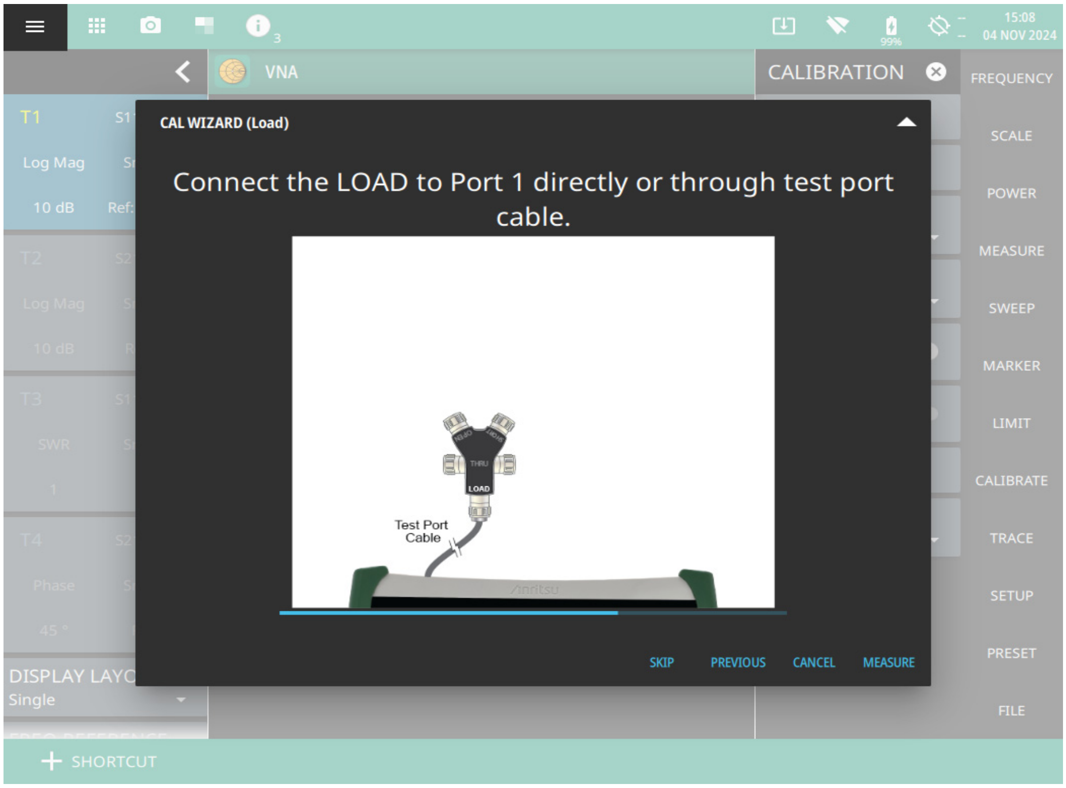


Figure 3-37. Reflection Response Calibration - Load

8. When done, touch APPLY.

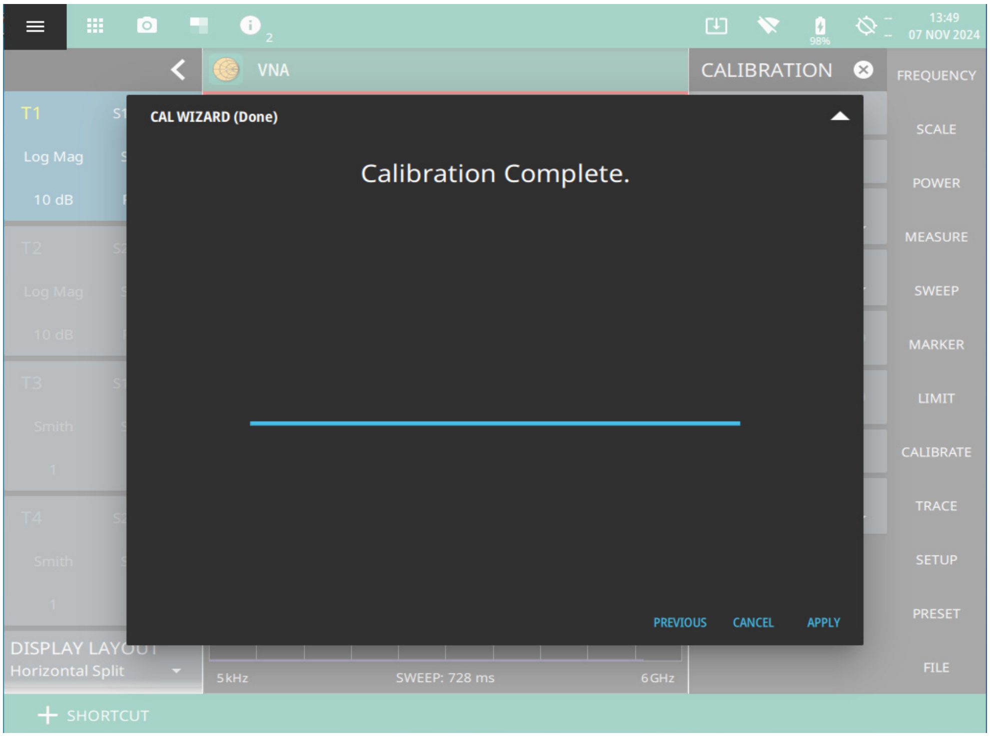


Figure 3-38. Reflection Response Calibration - Done

9. When calibration has completed, the user cal status message will display as follows:

   CALIBRATION ON: User Cal (Reflection Response) for Standard calibration mode
   CALIBRATION ON: iUser Cal (Reflection Response) for Flex calibration mode

Figure 3-39 illustrates the reflection response of S11 forward reflection.

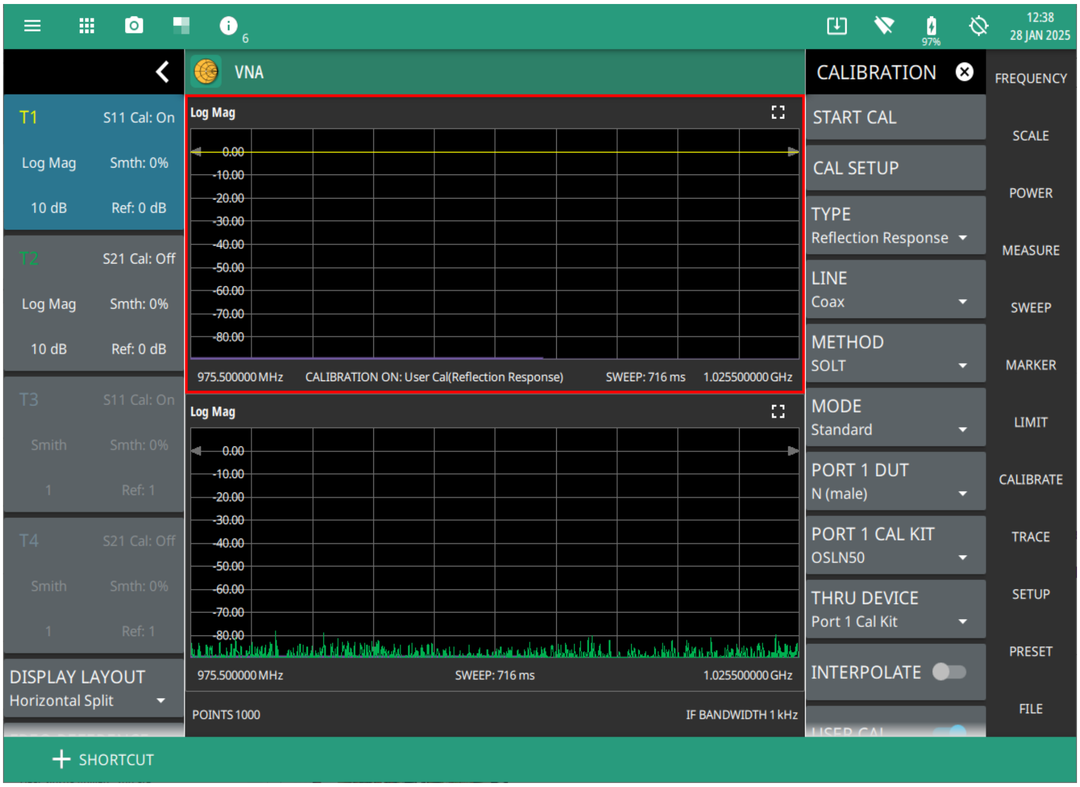


Figure 3-39. Reflection Response Calibration, Standard Cal

Notice that when the Site Master is connected with ICN51A InstaCal and if TYPE is set to any one of the calibration types such as iOSL, iOSL + Trans (USB Sen) and iOSL + Trans (Port 2), the PORT 1 DUT and PORT 1 CAL KIT parameters disappear from Cal Setup window as shown in Figure 3-40. Also notice that InstaCal calibration types are not available when LINE is set to Waveguide, as shown in Figure 3-40.

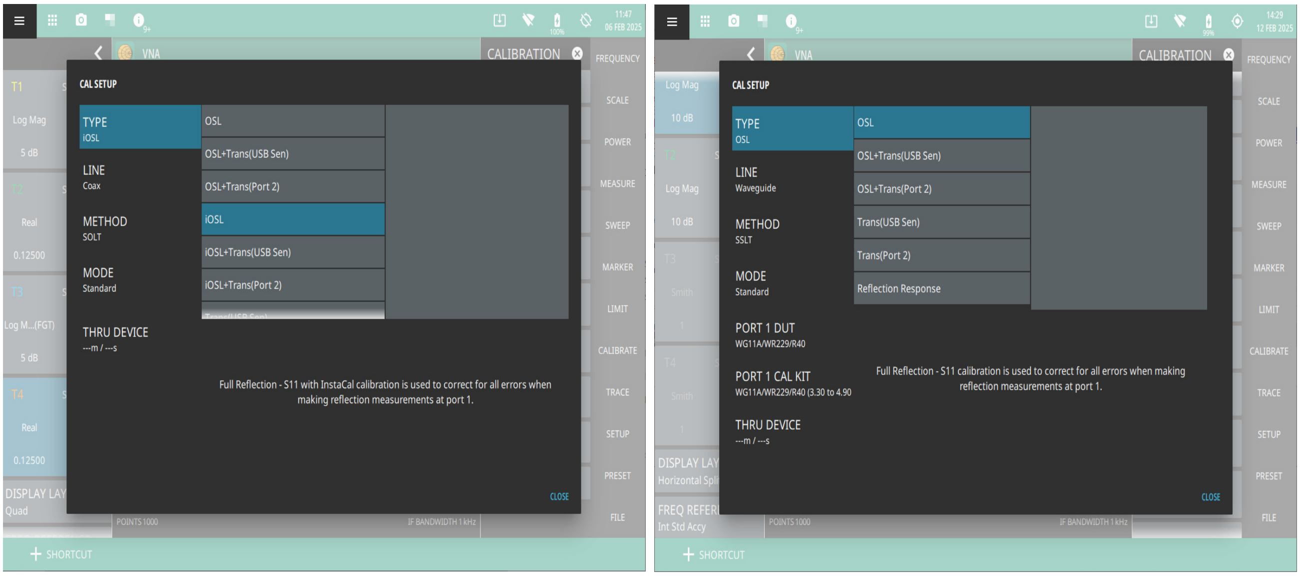


Figure 3-40. CAL SETUP Window - TYPE

LINE

The Site Master supports measurements and calibrations for both coaxial and waveguide media. In the Cal Setup window, set the LINE to either Coax or Waveguide before starting the calibration. Figure 3-41 shows the selection window for the Line, within the CAL SETUP window.

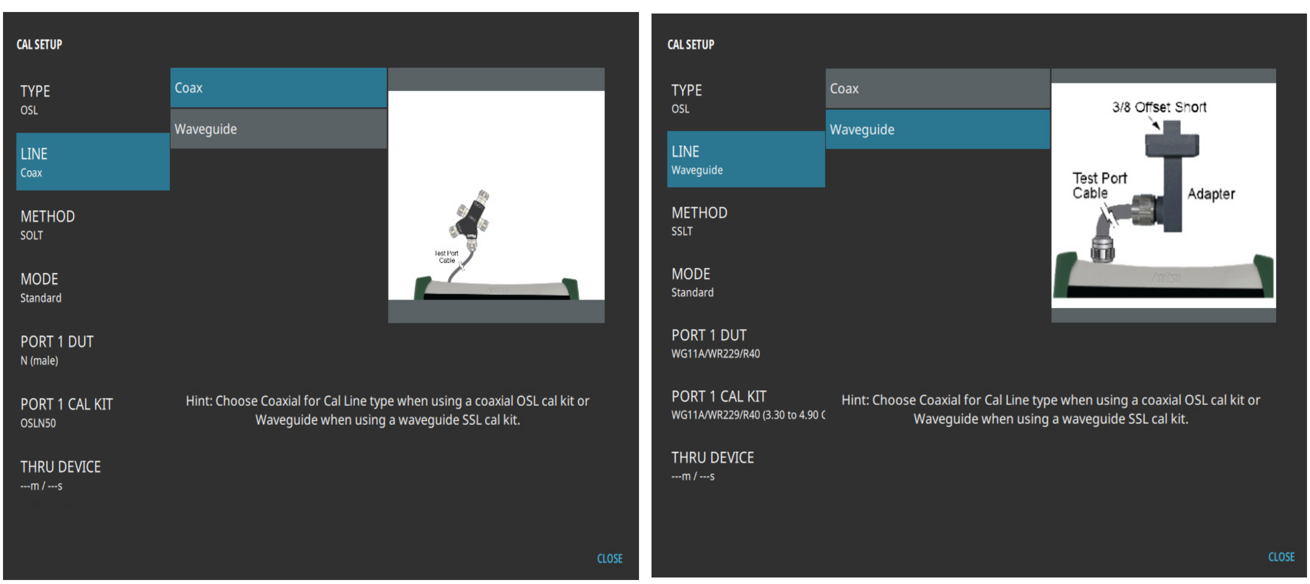


Figure 3-41. Cal Setup Window - Coaxial Line (left) and Waveguide Line (right)

CALIBRATION METHODS

In Vector Network Analyzer, calibration is required when the test port cable or adapters have been changed or when no valid calibration is available (Cal: Off). The following sections describe how to perform calibrations.

Note	If a Test Port Extension Cable is to be used (this is recommended), then it must be connected to the Site Master before calibration.

For coaxial line types, the calibration method that is most commonly used is the Short, Open, Load, Thru method, or SOLT. For waveguide line types, the calibration method that is most commonly used is the Offset Short 1 (1/8th wavelength), Offset Short 2 (3/8th wavelength), Load, Thru method, or SSLT. Use METHOD to set the appropriate method for the type line being used during the calibration and measurements, as shown in Figure 3-42

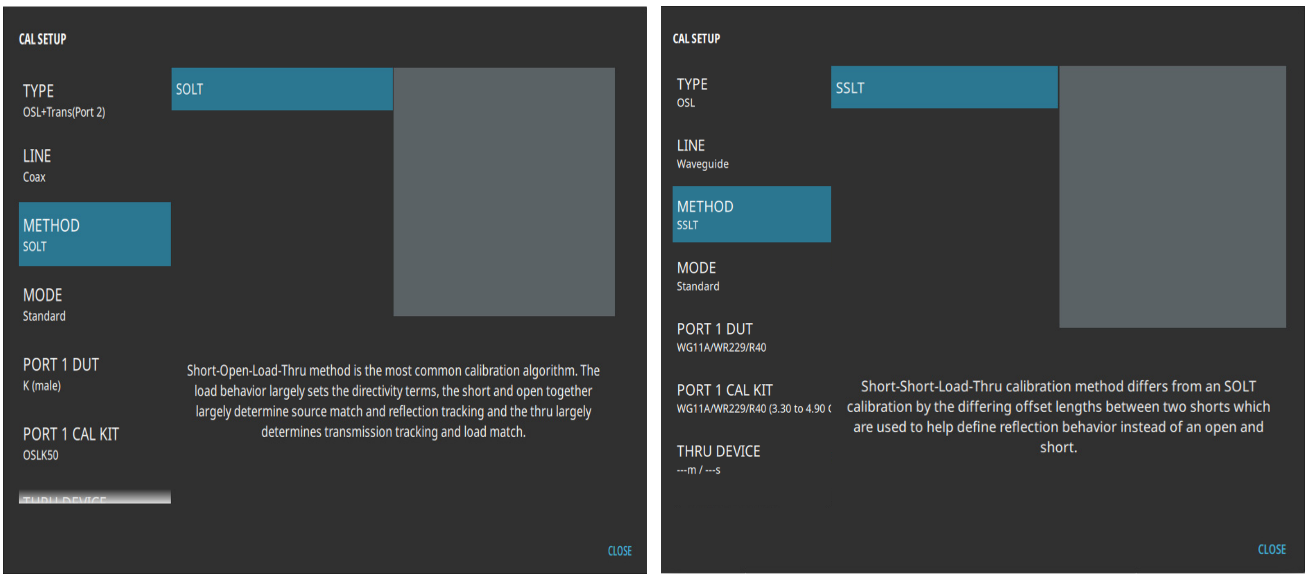


Figure 3-42. Cal Setup Window - SOLT Method (left) and SSLT Method (right)

You can manually calibrate the instrument or use the ReadyCal factory calibration for quick measurements. The instrument automatically applies the default ReadyCal to all vector network analyzer measurement types. The instrument needs to be manually re-calibrated if a test port cable is used and has been replaced, or when changing frequency in Standard Cal Type (not in Flex Cal).

To manually calibrate the instrument:

1. Select FREQUENCY from the main menu and enter the appropriate frequency range.
2. Select POWER menu from main menu to set PORT 1 POWER level.
3. Select CALIBRATE on the main menu and press CAL SETUP to make changes to the setup as needed. Refer to "CAL SETUP" on page 3-42.
4. Press START CAL from CALIBRATE menu. Note that INTERPOLATE and USER CAL toggles cannot be turned on before calibrating the instrument.
5. Confirm the calibration status of the appropriate S-Parameter by verifying the cal status displayed as ON in the status panel. This indicates that calibration has been applied to the appropriate S-Parameter. By default the trace card in the status panel shows the cal status as off, indicating either the calibration is not applied or inappropriate S-parameter has been selected.

SOLT Calibration

Follow the steps below to perform SOLT calibration method:

1. Select FREQUENCY on the main menu and enter the appropriate frequency range.

   A warning message will be displayed informing you to turn off USER CAL in order to change the active calibration type.

2. Select CALIBRATE on the main menu and ensure USER CAL is off.
3. Select TYPE and choose a desired cal type for example, OSL + Trans (Port 2).
4. Select LINE and select Coax. The cal method for coaxial media is SOLT by default.
5. Select MODE and select either Standard or Flex.
6. Select START CAL and follow the on-screen CAL WIZARD.
7. Select MEASURE at the end of each step to proceed to the next step in the sequence.

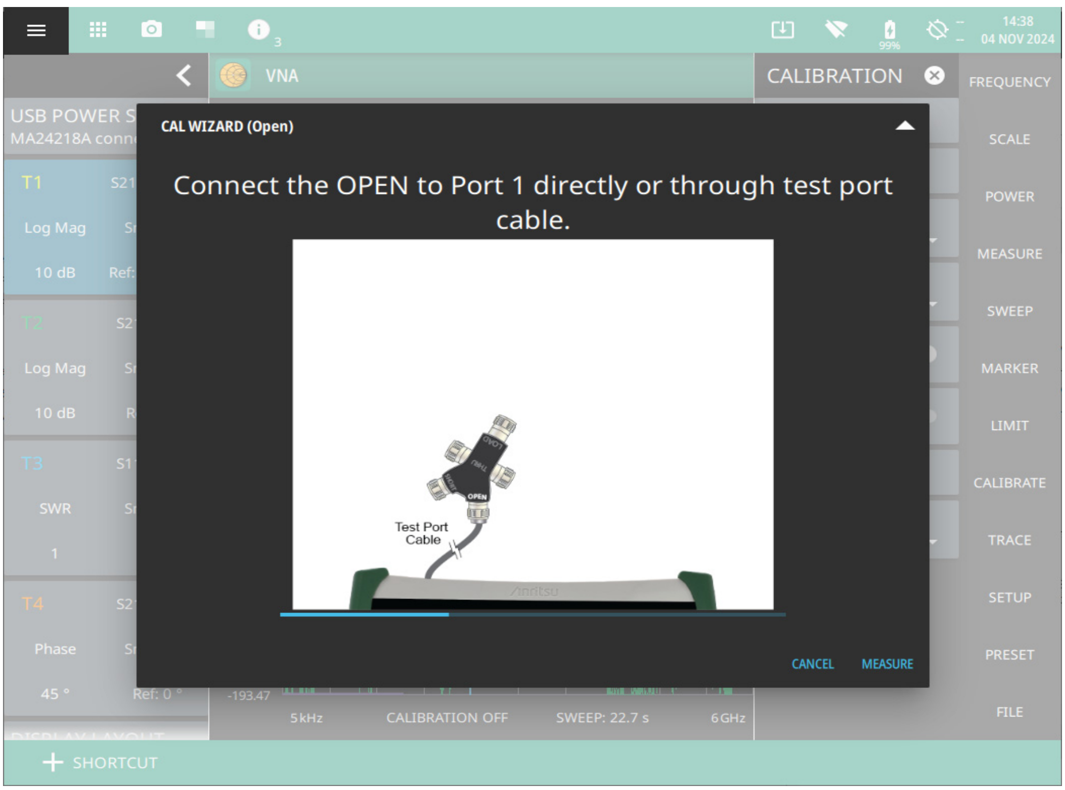


Figure 3-43. SOLT Calibration Method- OPEN

Figure 3-44. SOLT Calibration Method- SHORT

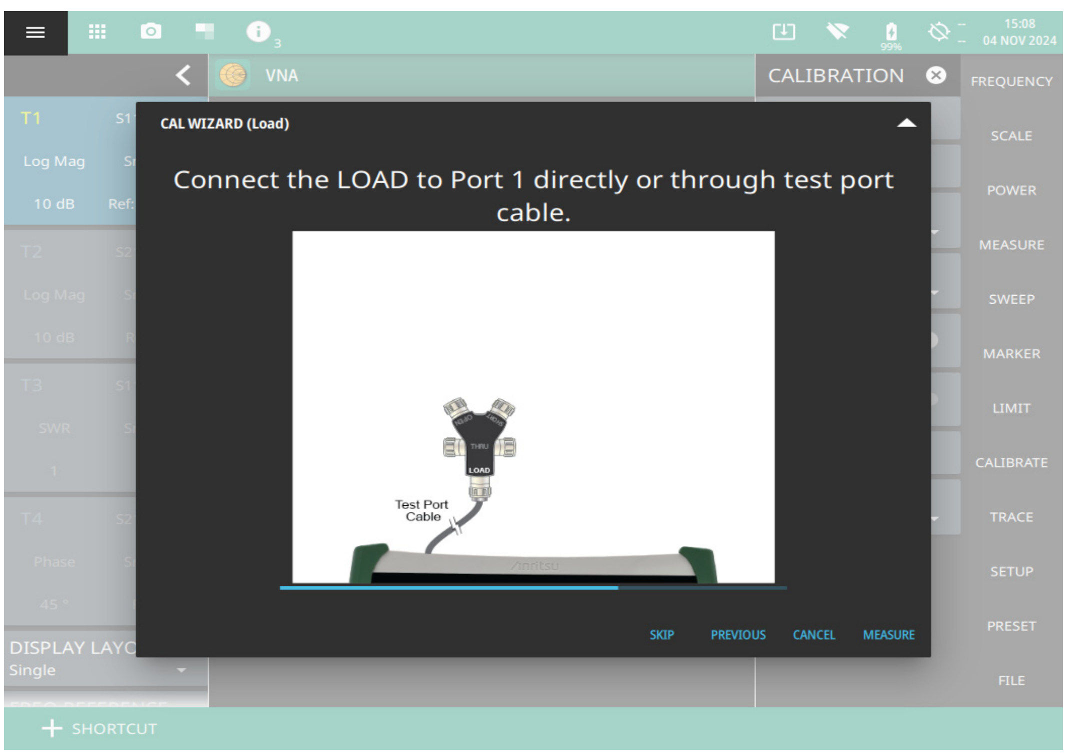


Figure 3-45. SOLT Calibration Method - LOAD

8. When done, touch APPLY.

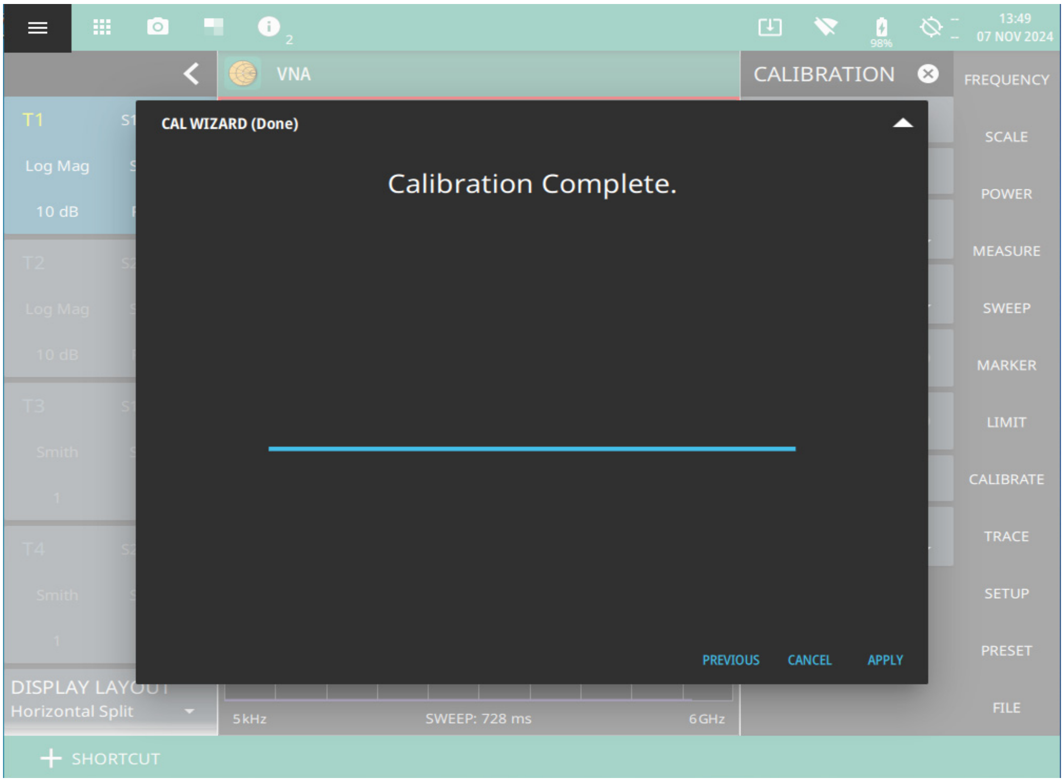


Figure 3-46. SOLT Calibration Method - Done

9. When calibration has completed, the user cal status message will display as follows:

   CALIBRATION ON: User Cal (OSL + Trans (Port 2)) for Standard calibration type
   CALIBRATION ON: iUser Cal (OSL + + Trans (Port 2)) for Flex calibration type

Figure 3-47 illustrates S21 forward-path transmission measurement of coaxial media, after applying standard OSL + Trans (Port 2) calibration.

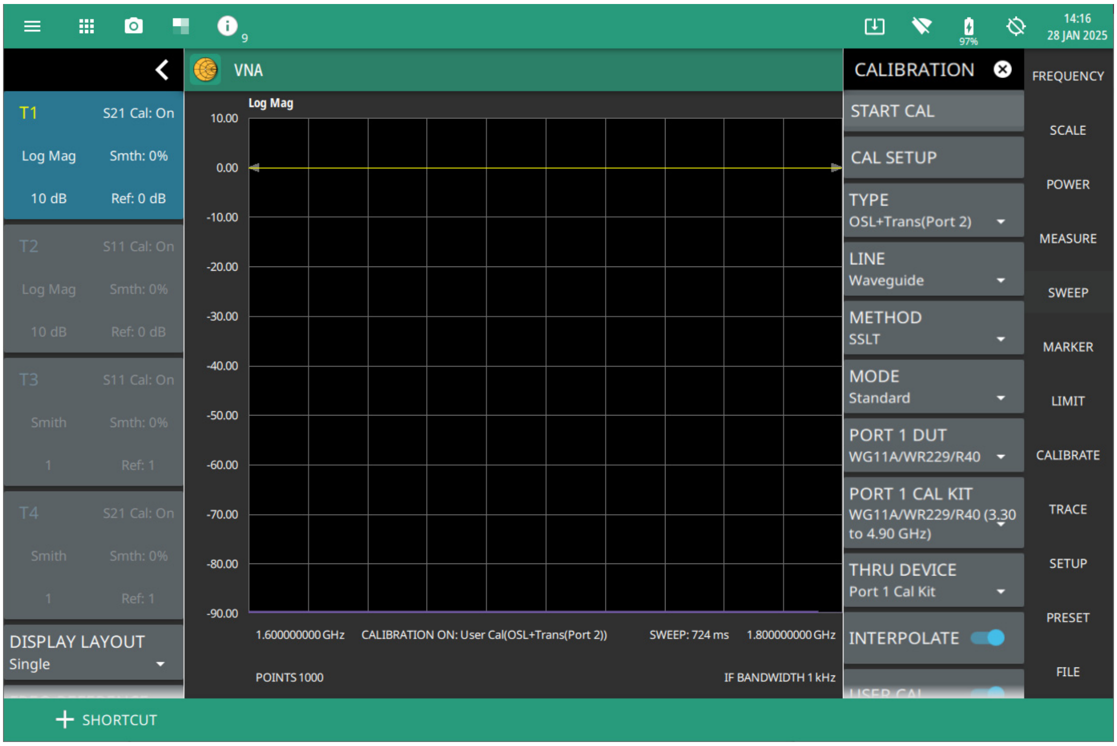


Figure 3-47. SOLT Calibration Method, Standard Cal

SSLT Calibration

Follow the steps below to perform SSLT calibration method:

1. Select FREQUENCY on the main menu and adjust the start and stop frequency values if needed.

   A warning message will be displayed informing you to turn off USER CAL in order to change the active calibration type.
2. Select CALIBRATE on the main menu and ensure USER CAL is off.
3. Select TYPE and choose a desired cal type for example, OSL + Trans (Port 2).
4. Press LINE and choose Waveguide. The cal method for waveguide media is SSLT by default.
5. Select MODE and select either Standard or Flex.
6. Select START CAL and follow the on-screen CAL WIZARD.
7. Select MEASURE at the end of each step to proceed to the next step in the sequence.

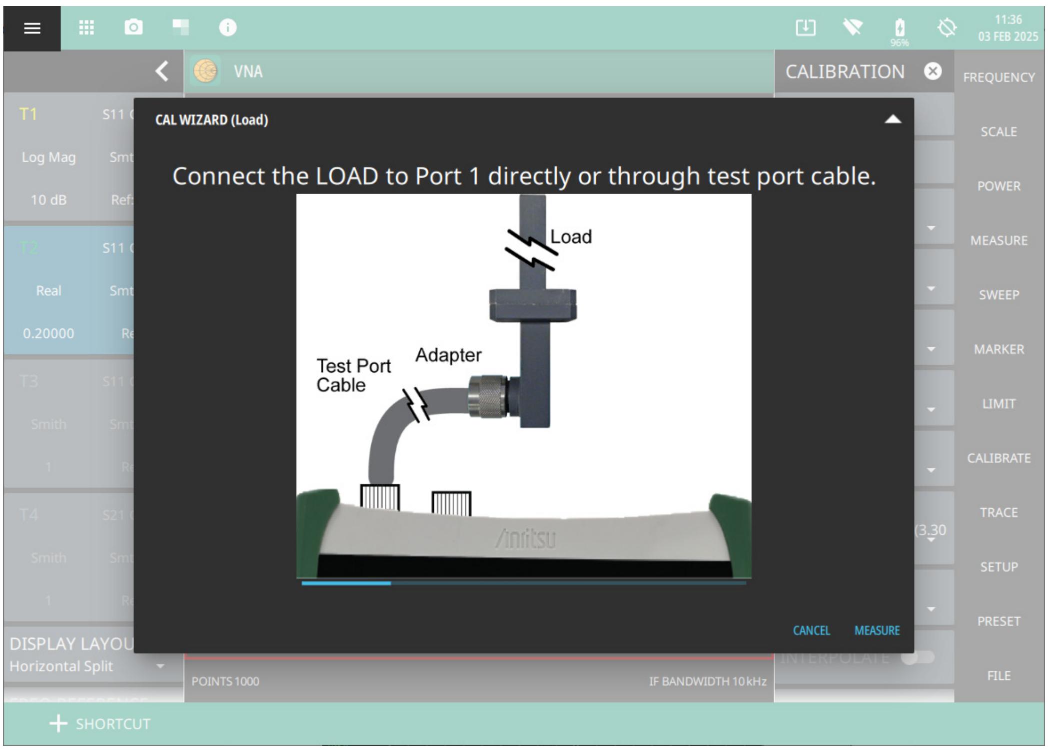


Figure 3-48. SSLT Calibration Method - Load

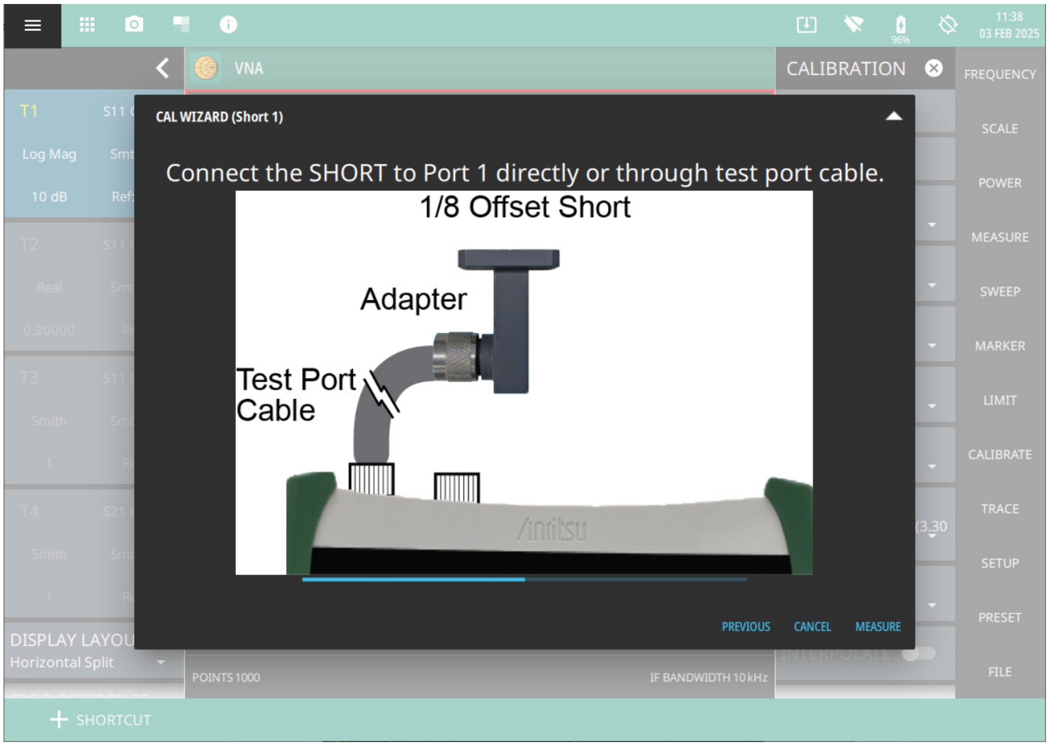


Figure 3-49. SSLT Calibration Method - Short 1

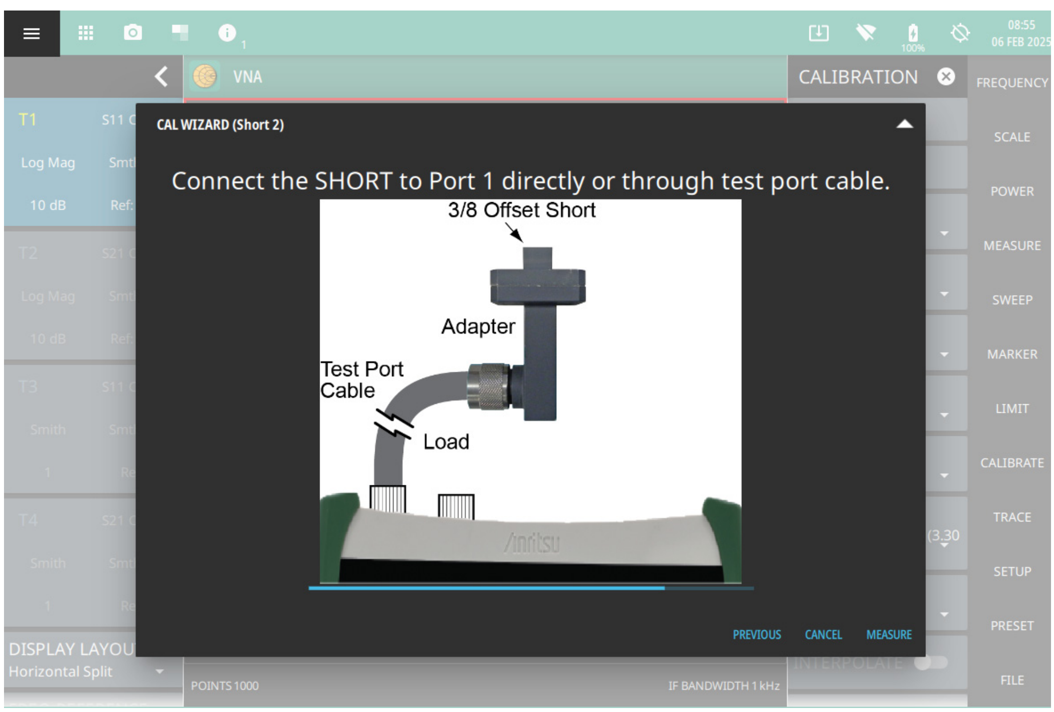


Figure 3-50. SSLT Calibration Method - Short 2

8. When done, touch APPLY.

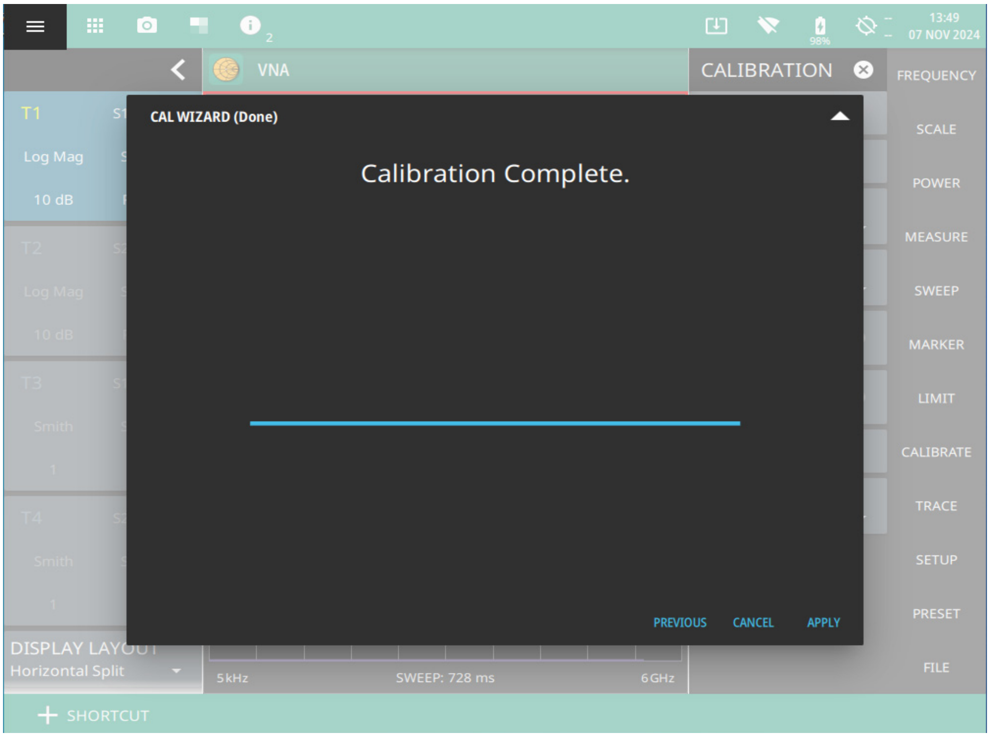


Figure 3-51. SSLT Calibration Method - Done

9. When calibration has completed, the user cal status message will display as follows:

   CALIBRATION ON: User Cal (OSL + Trans (Port 2)) for Standard calibration type
   CALIBRATION ON: iUser Cal (OSL + Trans (Port 2)) for Flex calibration type

Figure 3-52 illustrates S21 forward-path transmission measurement for waveguide media, after applying standard OSL + Trans (Port 2) calibration.

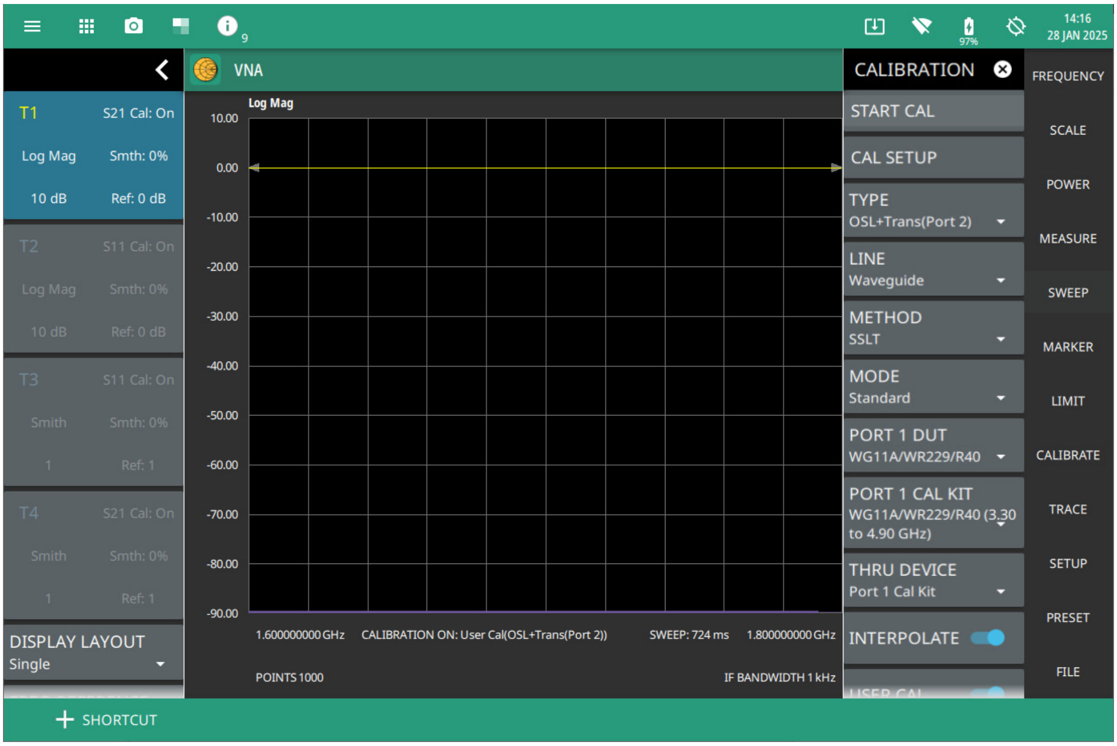


Figure 3-52. SSLT Calibration Method, Standard Cal

MODE

The available calibration modes are Standard Cal and Flex Cal. Standard Cal applies to the currently set frequency range. Changing either the Start or Stop Frequency setting requires turning off User Cal, in which case the factory default 1-Port ReadyCal will apply to all measurement types except Transmission (USB Sensor). You may subsequently re-calibrate the instrument as appropriate.

Flex Cal calibrates the instrument over the entire frequency range and interpolates data points if the frequency range is changed. This method saves time as it does not require the user to re-calibrate the system for frequency changes. The trade-off is fewer data points and less accuracy when compared to Standard Cal.

Table 3-2 lists the main characteristics of the Standard and Flex calibration types. If you do not expect to change the frequency range often, Standard Cal is recommended for best accuracy.

Table 3-2. Summary of Calibration Types

Calibration Mode	Characteristics
Standard Cal	Need to re-calibrate if frequency changes. This will provide the best accuracy. Recommended for reporting.
Flex Cal	No need to recalibrate if frequency changes. Recommended for troubleshooting.

PORT 1 DUT AND PORT 1 CAL KIT

For the most accurate calibrations, you must select the connector of the DUT that will be attached to Port 1 of the instrument. After you select the DUT connector, you must then select the desired calibration kit that will be used for the Port 1 correction. If you do not select a desired calibration kit, then the analyzer defaults to one of the built-in kits.

Figure 3-54 shows the selection window for the Port 1 DUT connector. For easier identification of the DUT connector, a representative picture is shown for each selection. After a connector is chosen, the Port 1 Cal Kit selection is updated in order to list only the available calibration kits that are associated with the selected DUT connector. Figure 3-54 also shows an example of the selection of calibration kits that are available for the K (female) coaxial DUT connector.

For each coaxial kit in the list, the values of the Offset Lengths for the Open, Short, and Thru (if applicable) are listed. The Capacitance and Inductance values for the Open and Short are also listed, as shown in Figure 3-54. For waveguide calibration kits, the Cutoff Frequency and the Offset Short 1 and Short 2 lengths are listed, as shown in Figure 3-54.

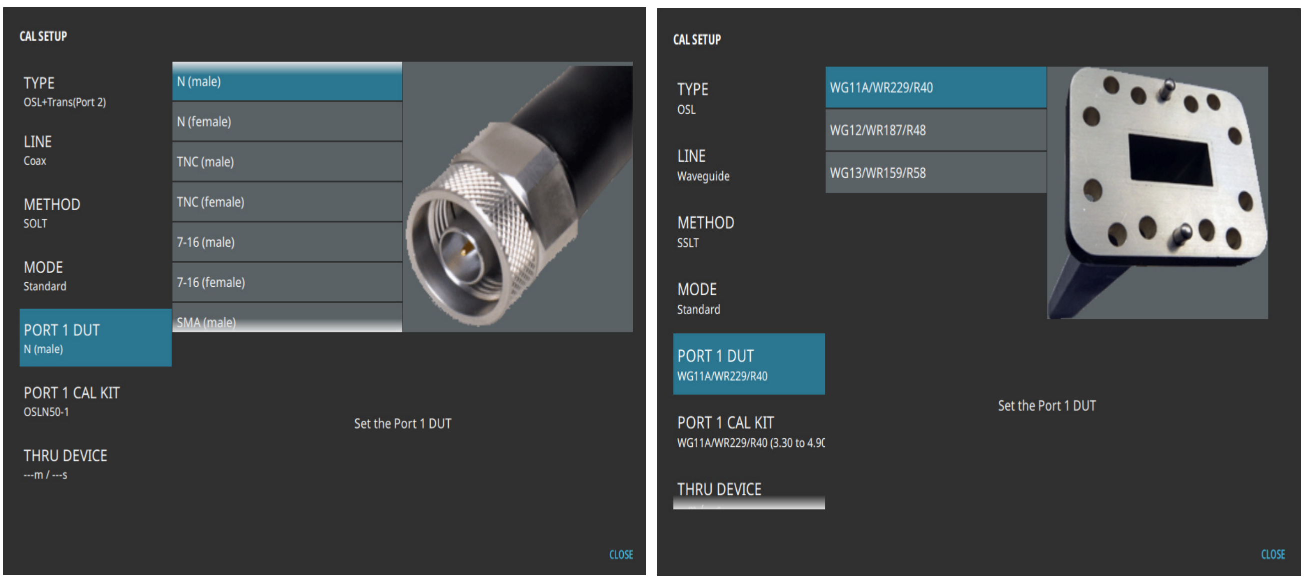


Figure 3-53. Cal Setup Window - Coaxial Port 1 DUT (left) and Waveguide Port 1 DUT (right)

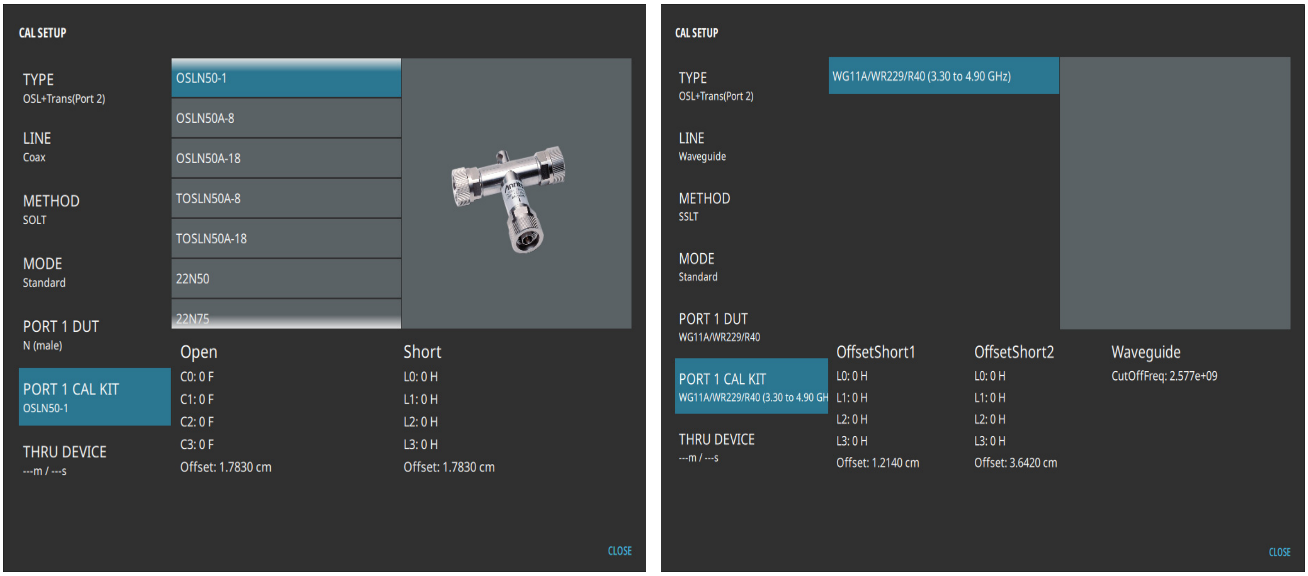


Figure 3-54. Cal Setup Window - Coaxial Port 1 CAL KIT (left) and Waveguide Port 1 CAL KIT (right)

The selection list for DUT connectors includes all of the common connectors that you may encounter. Table 3-3, "Coax DUT Connectors and Cal Kits" on page 3-61 and Table 3-4, "Waveguide DUT Connectors" on page 3-61 provide complete list of Coax and Waveguide connectors and corresponding calibration kits that are selectable through the Cal Setup window.

Table 3-3. Coax DUT Connectors and Cal Kits

Coaxial Connector Name	Available Cal Kits
N (male)	OSLN50, OSLN50-1, OSLN50A-8, OSLN50A-18, TOSLN50A-8, TOSLN50A-18, 22N50, 22N75, 26N50, 26N75
N (female)	OSLNF50, OSLNF50-1, OSLNF50A-8, OSLNF50A-18, TOSLNF50A-8, TOSLNF50A-18, 22NF50, 22NF75, 26NF50, 26NF75
K (male)	OSLK50, TOSLK50A-20, TOSLK50A-40, TOSLK50A-43.5
K (female)	OSLKF50, TOSLKF50A-20, TOSLKF50A-40, TOSLKF50A-43.5
V (male)	TOSLV50A-70
V (female)	TOSLVF50A-70
7/16 (male)	2000-1618-R, 2000-767
7/16 (female)	2000-1619-R, 2000-768
4.3-10 (male)	2000-1915-R
4.3-10 (female)	2000-1914-R
SMA (male)	3650 (male components of kit)
SMA (female)	3650 (female components of kit)
TNC (male)	1091-53, Open
TNC (male)	1091-54, Short
TNC (male)	1015-55, Termination
TNC (female)	1091-55, Open
TNC (female)	1091-56, Short
TNC (female)	1015-54, Termination

Table 3-4. Waveguide DUT Connectors

Waveguide Connector Name
WG11A/WR229/R40 (3.30 to 4.90 GHz)
WG12/WR187/R48 (3.95 to 5.85 GHz)
WG13/WR159/R58 (4.90 to 7.00 GHz)

THRU DEVICE

After you have set up Port 1 DUT and PORT 1 Cal Kits, you must also set the Thru device that is used in the Thru step of the calibration that is being conducted, if applicable. The Thru device accounts for any extra length that is used during the calibration steps (such as an adapter) but is removed for the actual measurement of the DUT. In these cases, if the Thru device length is not accounted for, then the resulting measurements will have an offset error. The Thru device length can be set in units of distance or time, or it can be set to equal the Thru length offset of the cal kits that are used for Port 1, if applicable. Figure 3-55 shows the selection window for the Thru device setting. Press LINE LENGTH to enter the length of the Thru device using the numeric keypad, you can also select appropriate units. Alternatively, you can press LINE DELAY to enter the device length in unit of time.

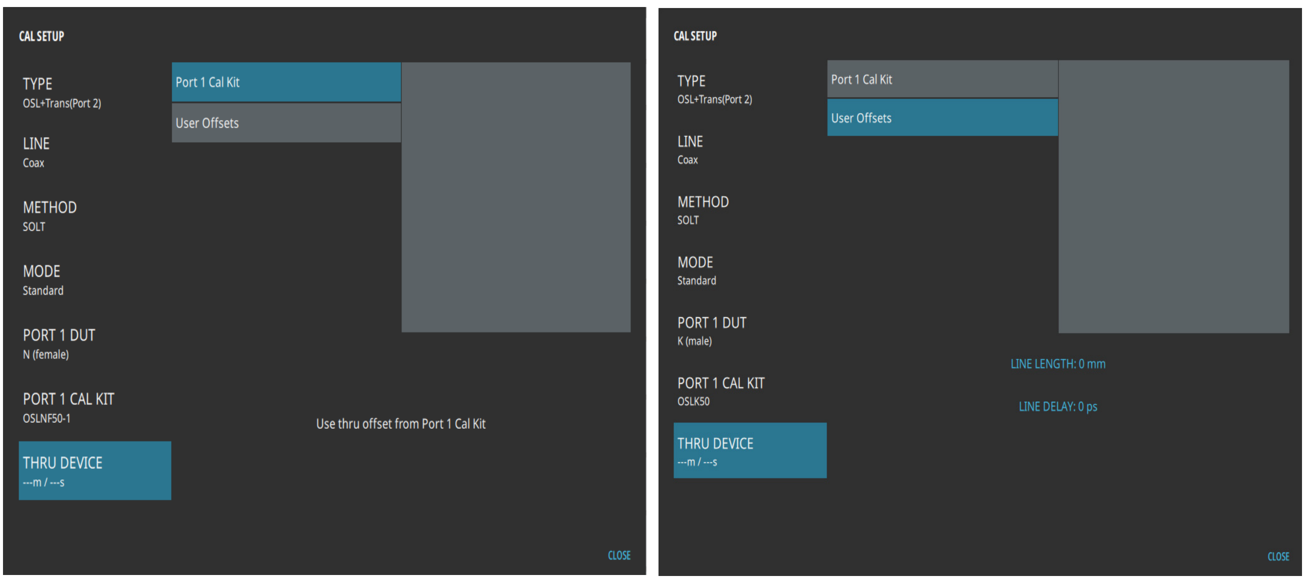


Figure 3-55. Cal Setup Window - Thru Device

INTERPOLATE

If INTERPOLATE toggle is turned off and the current Cal status is on and valid, you cannot modify the frequency range or the source power level, or increase the number of points above 16,001 points (assuming the calibration was performed with 16,001 points or less). Any of these changes will require the USER CAL to be turned off and a new calibration to be performed. You can, however, adjust the number of points from 2 to 16,001 without forcing the calibration to become invalid. To use 2065 points, the number of points must be set to 2065 before the calibration is started. If your current Cal status is on and you turn INTERPOLATE on, you can then change the frequency range (smaller and anywhere within the calibrated range) or modify the number of points without invalidating the calibration. In that case, the calibration coefficients are regenerated (interpolated) to match the new settings. You cannot increase the frequency range, however, beyond the range that was used during calibration. For example, you could perform a calibration from 1 MHz to 6 GHz using 2065 points. With Interpolate toggle on, you could then make a measurement by zooming in on a desired frequency range, 410 MHz to 435 MHz, for example. The trace in your measurement would use the full 2065 points within this much narrower frequency range.

USER CAL

USER CAL toggle in CALIBRATE menu is turned on automatically after the calibration process has been completed successfully. When USER CAL is on, the calibration coefficients are applied to the measured data, resulting in corrected S-parameter data. You can turn USER CAL Off, which results in trace data using uncorrected (or raw) S-parameter data and losing the calibration status.

THRU UPDATE

When measuring the transmission (or insertion loss) response of a DUT, the calibration requires a Thru measurement to be performed. This requires at least one external cable to be introduced into the calibration. The additional cable component is the most susceptible to changes from environmental conditions, such as temperature changes and mechanical flexing. The Thru Update allows you to quickly eliminate the effects of temperature changes or of changes caused by mechanical flexing of the cable without having to repeat the entire calibration process. The Thru update is particularly useful when viewing DUT transmission responses with small scale resolution (0.5 dB/division or less).

Figure 3-56 shows the calibration wizard window depicting the calibration setup and calibration steps.

Figure 3-56. Thru Update - Thru

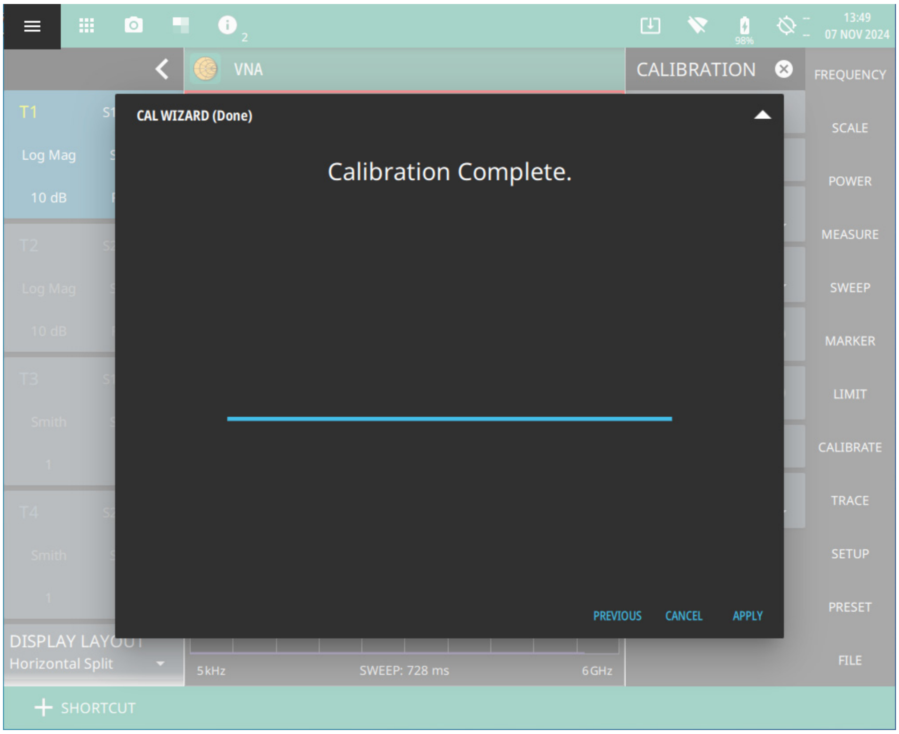


Figure 3-57. Thru Update - Done

CAL INFO

In order to perform a proper calibration, several parameters must be set before the calibration procedure is started. These parameters are: TYPE, METHOD, MODE, LINE, PORT 1 DUT, PORT 1 CAL KIT and THRU device.

To view a summary of these settings, begin from the CALIBRATE main menu and press CAL INFO submenu. A summary of the Active Cal Settings and the Current Settings of the instrument are displayed (see Figure 3-58). Press CLOSE to close the CAL INFO window.

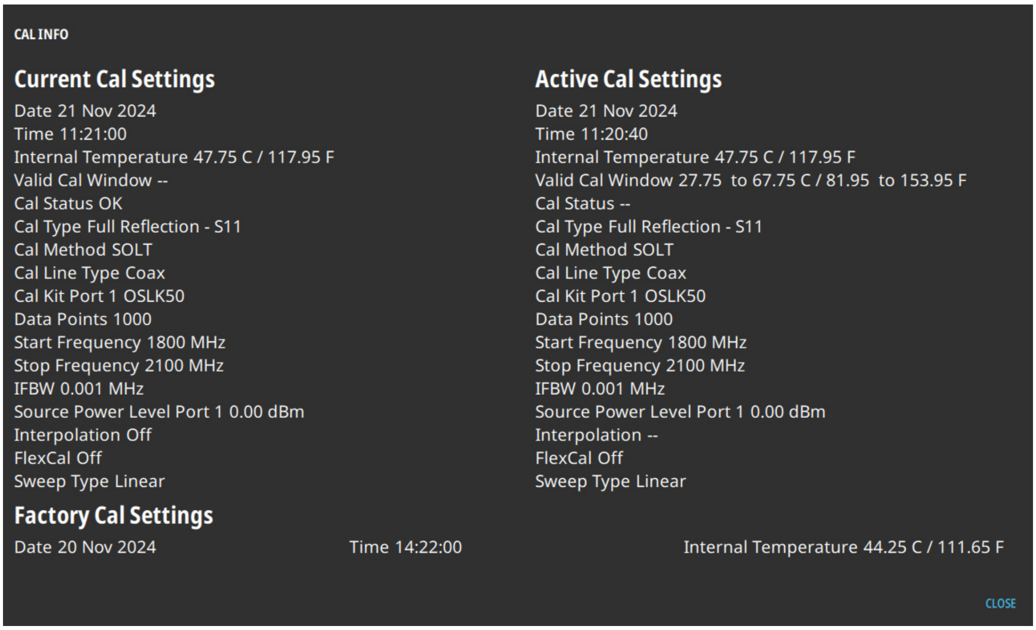


Figure 3-58. CAL INFO Window

The CAL INFO window displays all of the key setup parameters for the calibration. The current settings are shown on the left, and the settings of the instrument at the time of the last calibration are shown on the right.

3-11 Setting Trace Parameters

A trace is a measurement result that can have user-defined attributes assigned to it for display purposes. You can assign the following attributes for a trace: S-parameter, Graph Type, Domain, and Smoothing. Using the Scale menu, you can independently set the scale for each trace.

Overview of traces:

- Recalled measurements (.smvna files) are automatically copied to trace memory and displayed.

Note	Recalled measurements may change the current instrument settings.

- COPY TO MEM will replace whatever is in memory with the live (yellow) trace. The memory trace (purple) is displayed behind the live (yellow) trace.
- The default view is live Trace only. View options (MEMORY DISPLAY) include viewing only the trace in memory or both traces.
- Active markers can be applied to the purple trace memory by pressing MARKER > TO MEMORY (refer to Section 3-7 “Setting Up Markers” on page 3-26).

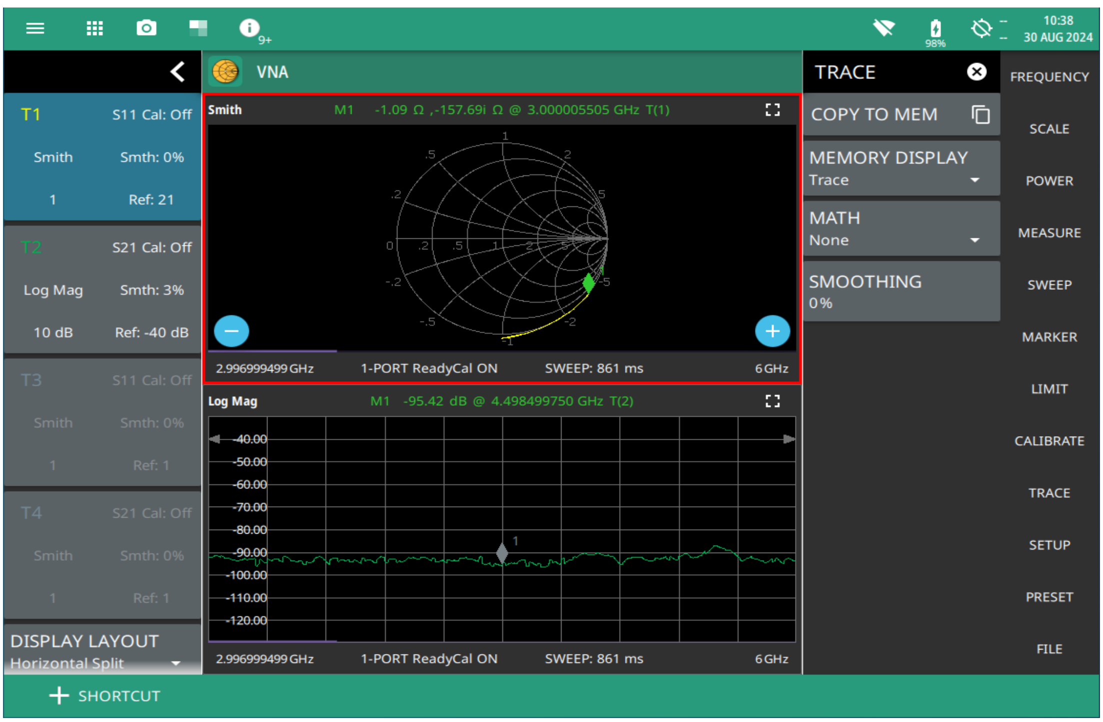


Figure 3-59. Smith Chart and Log Magnitude Display - Trace Menu

MEMORY DISPLAY allows viewing of two traces to compare the trace stored in memory to the live trace. Trace MATH operations include Trace – Memory, Trace + Memory and (Trace + Memory) / 2. Saved traces can also be recalled and compared with the live trace.

Trace Overlay

The examples below illustrate how the trace overlay feature can be used to compare the return loss measurements between two antennas.

1. Connect the first antenna and set up the measurement. .
2. Select TRACE > COPY TO MEM.
3. Remove the first antenna and connect the second antenna.
4. Select MEMORY DISPLAY and select Both. The purple trace from trace memory is displayed along with the live (yellow) trace.

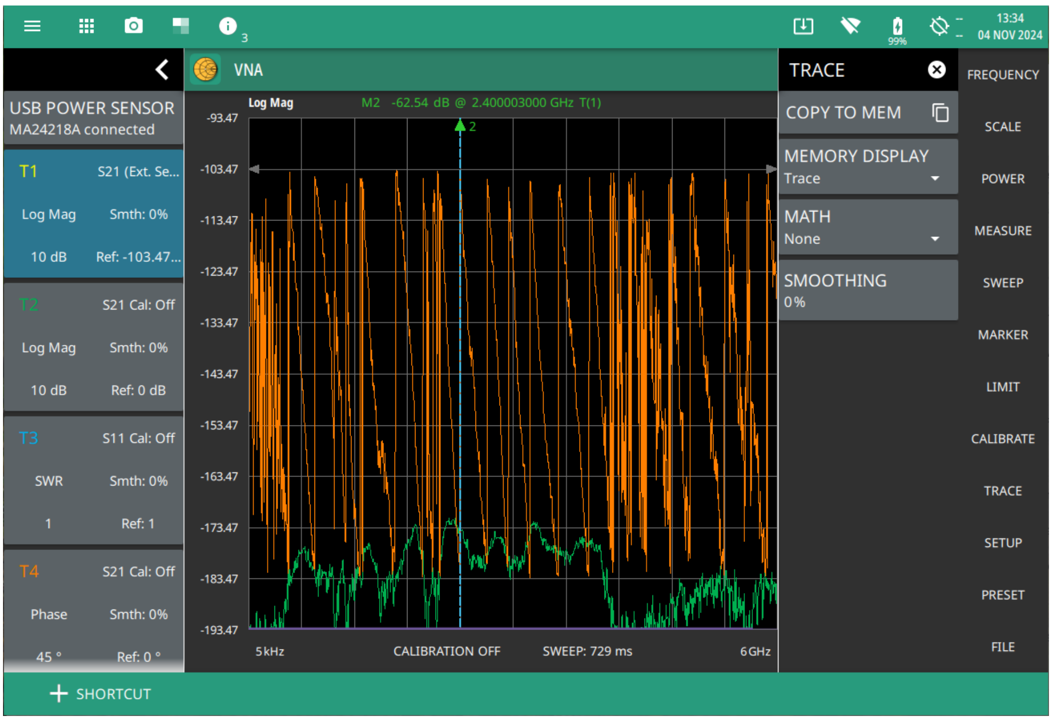


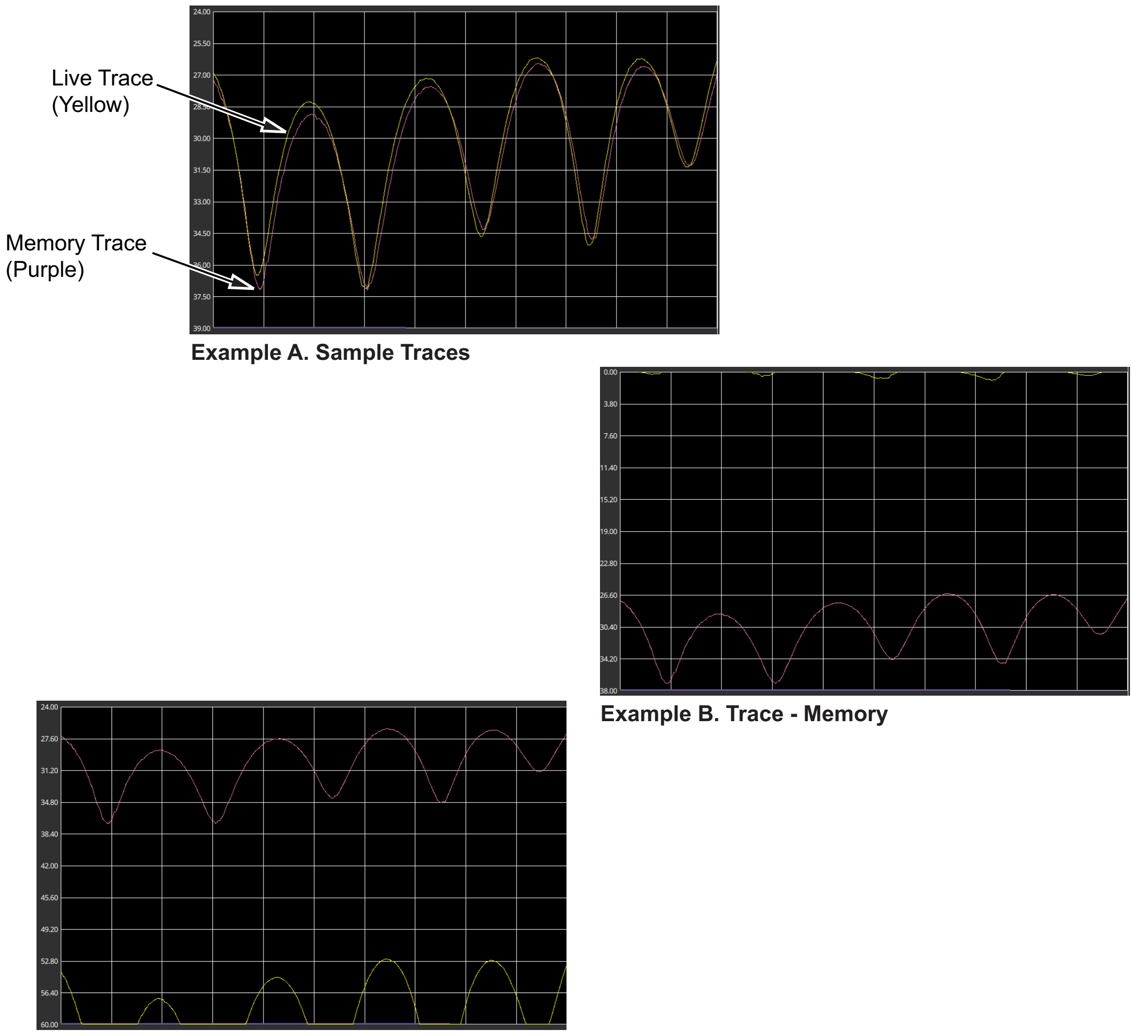
Figure 3-60. Trace Overlay of Two Antennas

Note	The trace from memory can only be displayed if the measurement settings (except for SCALE) have not changed since the trace was copied to memory. If one of the traces is cut off, pressing SCALE > FULLSCALE will adjust the reference level to display both traces.

Trace Math Example

The example below illustrates how the trace math features can be used to compare the phase of two cables.

1. Connect the first cable and set up the measurement.
2. Select TRACE > COPY TO MEM.
3. Remove the first cable and connect the second cable.
1. Select MEMORY DISPLAY and select Both. The purple trace from trace memory is displayed along with the live (yellow) trace.
2. Select MATH and select Trace - Mem or Trace + Mem (Figure 3-61).



Example A. Sample Traces

Example B. Trace - Memory

Example C. Trace + Memory

Figure 3-61. Trace Memory Used to Compare the Phase of Two Cables (see Table 3-5, “Trace Math Details” on page 3-70)

Note

The trace math functions often seem backwards to new users. The points to remember with Trace – Mem, Trace + Mem, are:

The numbers on the y-axis are negative.

The purple trace is added to or subtracted from the live trace. The sum or difference of the live trace and memory trace is displayed in yellow.

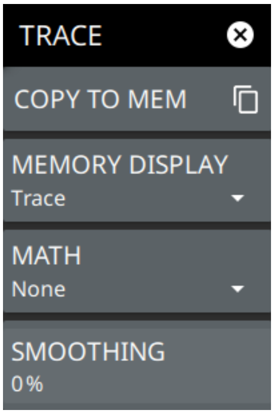
Table 3-5. Trace Math Details

Example from Figure 3-61	Example Description
A. Sample Traces	Shows the live yellow trace and purple memory trace.
B. Trace – Memory	In the Trace - Memory graph, the yellow trace is the result of subtracting the purple trace from the active trace (not displayed in Example B, Trace - Memory, but shown in Example A). Note that the yellow Trace - Memory is at 0 or above (and off the graticule) whenever the yellow trace is above (has a greater value than) the purple trace (refer to A). The two down sloping bumps in Example B are when the purple trace moves above the yellow trace. In Trace - Memory, this results in a negative value that is displayed.
C. Trace + Memory	In the Trace + Memory graph, the yellow trace is the result of adding the purple trace to the active trace (not displayed in Example C, Trace + Memory, but shown in Example A). Note that the yellow Trace + Memory is below 60 (and off the graticule) whenever adding the yellow trace value to the purple trace value is greater than 60 (refer to A).
D. Multiply	Trace data is multiplied by the memory (not shown in **Figure 3-61**).
E. Divide	Trace data is divided by the memory (not shown in **Figure 3-61**).
F. Average	Trace data plus memory divided by two (not shown in **Figure 3-61**).

Refer to "TRACE Menu" on page 3-71 for additional information.

TRACE Menu

Access TRACE menu from main menu.



COPY TO MEM: Copies the currently active trace to memory for use in the display and math and options below.

MEMORY DISPLAY: Selects the trace display options.

- **Trace:** The active trace is shown in yellow.
- **Memory:** The trace stored in memory is displayed in purple.
- **Both:** Displays both the stored trace (purple) if a trace is stored in memory and the current active trace (yellow).

MATH: Select to change the trace math options.

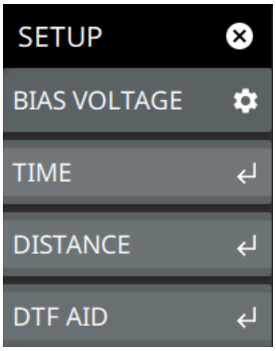
- **None:** The active trace is shown as is with no math functions.
- **Trace + Mem:** Displays the results of logarithmic adding of the active trace and the trace in memory.
- **Trace – Mem:** Displays the difference between the active trace and the trace in memory.
- **Multiply:** Displays the results of logarithmic product of the active trace and the trace in memory.
- **Divide:** Displays the results of logarithmic ratio of the active trace and the trace in memory.
- **Average:** Displays the results of logarithmic average of the active trace and the trace in memory.

SMOOTHING: Sets the smoothing aperture value for specified trace. The range is from 0% to 20%.

Figure 3-62. TRACE Menu

3-12 SETUP Menu

Access SETUP menu from main menu.



BIAS VOLTAGE: The SOURCE button offers several triggering options depending on which view mode the instrument is set.

TIME: Opens "TIME Menu" on page 3-15.

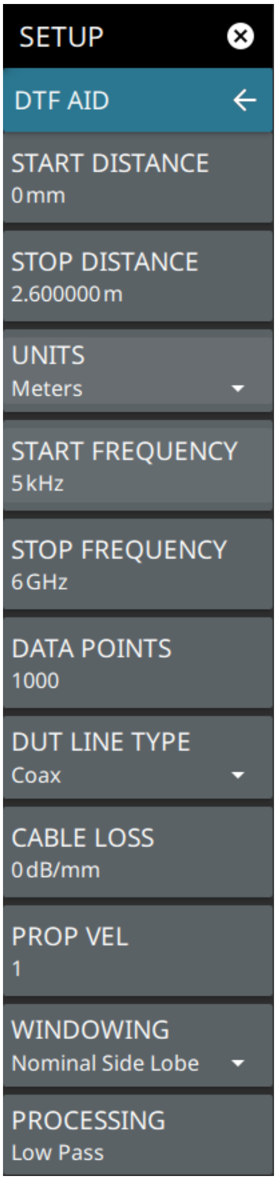
DISTANCE: Opens "DISTANCE Menu" on page 3-18.

DTF AID: Opens "DTF AID Menu" on page 3-73.

Figure 3-63. SETUP Menu

DTF AID Menu

Access DTF AID submenu from main menu, SETUP > DTF AID.



START DISTANCE: Enters a start distance value for the measurement. The start distance must be shorter than the stop distance.

STOP DISTANCE: Enters the stop distance for the measurement. The maximum stop distance is 1500 m.

Note that the maximum distance measurement (from start to stop) is dependent on frequency span and the number of sweep points.

UNITS: Selects distance units of meters or feet.

START FREQUENCY: Sets the start frequency of the sweep range. Selecting the plus (+) or minus (–) control moves the start frequency in discrete steps.

STOP FREQUENCY: Sets the stop frequency of the sweep range. Selecting the plus (+) or minus (–) control moves the start frequency in discrete steps.

DATA POINTS: Sets the number of display point currently measured by the instrument. Note that increasing the number of display points can improve the resolution of measurements in addition to increase in sweep time.

CABLE LIST: Opens a list of available cable specifications. When a cable is selected from this list, propagation velocity and cable loss are automatically set by the instrument. If the preselected values for propagation velocity or cable loss are changed, the analyzer will use "NONE" as the cable type.

CABLE LOSS: Manually enters a cable loss value.

PROP VEL: Manually enters a propagation velocity value.

WINDOWING: Selects the windowing for the measurement:

- **Rectangular**: Rectangular windowing shows the highest side lobe levels (worst) and the greatest main lobe resolution (best).
- **Nominal Side Lobe:** Nominal side lobe windowing shows lesser side lobe levels than rectangular windowing (good) but lower main lobe resolution (very good).
- **Low Side Lobe:** Low side lobe windowing shows less side lobe levels than nominal windowing (very good) but lower main lobe resolution (good).
- **Minimum Side Lobe**: Minimum side lobe windowing shows the lowest side lobe levels (best) but the least main lobe resolution (worst).
- **Kaiser-Bessel:** Kaiser-Bessel windowing shows lower side lobes, but a wider main lobe width for larger Beta values.
- **Dolph-Chebyshev:** Dolph-Chebyshev windowing shows the parameterized side lobe level and a wider main lobe width.

PROCESSING: Selects either low pass or band pass processing method.

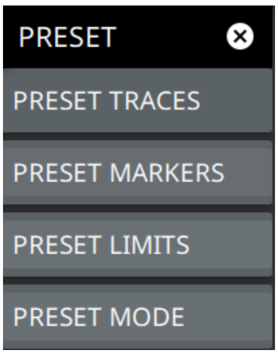
Figure 3-64. DTF AID Menu

3-13 Presetting the Analyzer

The PRESET menu sets certain settings to the default state. Preset only affects the current analyzer settings. Preset does not affect user files or system settings such as networking settings. For other reset options, such as a complete factory reset of the instrument, refer to “Reset Settings” section of the product’s user guide. To recover from system software faults, refer to the product’s user guide for more information.

PRESET Menu

Access PRESET menu from the main menu.



PRESET TRACES: Presets all trace settings to default values.

PRESET MARKERS: Presets all marker settings to default values. Turns off all markers.

PRESET LIMITS: Presets all values on the LIMIT menu to default values. Turns off all limit lines.

PRESET MODE: Presets all of the current analyzer settings to default values.

Figure 3-65. PRESET Menu

3-14 Saving and Recalling Measurements

The instrument can save measurement setups, native trace and CSV trace data, limit line setups, and screenshots. You can recall setup, native trace, and limit line files. For other file operations such as copy, move, and directory management, refer to the product's user guide for more information on file management.

Saving a Measurement

To save a measurement or setup, refer to Figure 3-66:

1. Select FILE > SAVE AS...
2. If desired, press the save location to change the destination.
3. Enter the desired file name using the touchscreen keyboard.
4. Select the type of file to save from the selection list.
5. Select SAVE to save the file.

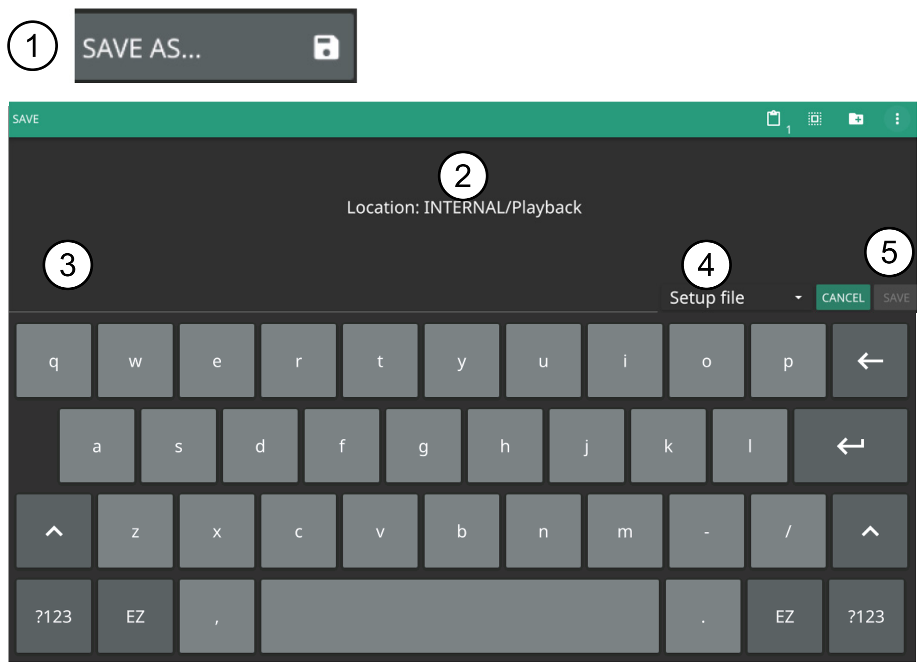


Figure 3-66. File Save As Dialog

Once a file has been saved, the QUICK SAVE feature can be used to quickly save the same type of file with an incrementing number appended to the end of the original file name.

Recalling a Measurement

You can recall a saved setup, native trace measurement, and a limit line. When recalling a setup, the instrument setup and operating state will be restored as it was when the setup was saved. When recalling a trace measurement, the instrument setup and on-screen measurement data will be restored as it was when the trace data was saved.

To recall a measurement or setup, refer to Figure 3-67:

1. Select FILE > RECALL...
2. Select the file location.
3. Use the file type filter to shorten the list if needed.
4. Select the desired file from the displayed list.
5. Select OPEN to recall the file.

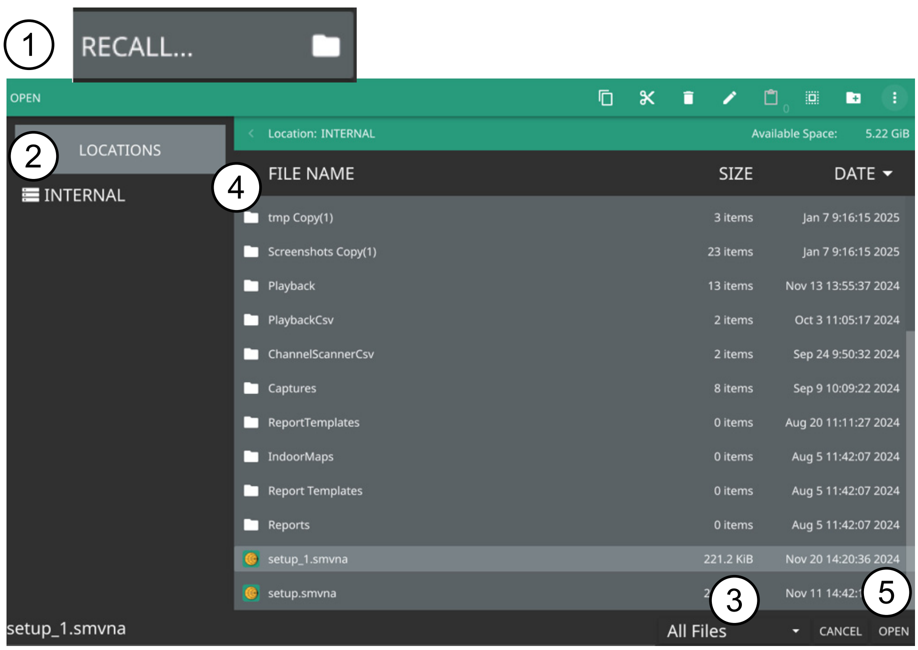
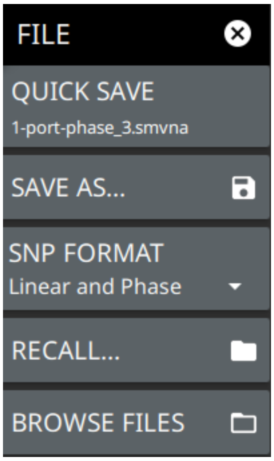


Figure 3-67. File Open Dialog

When a measurement is recalled, the trace or sweep state will be set to hold. To restore active measurements, select SWEEP > RUN/HOLD > RUN.

FILE Menu

Access FILE menu from main menu.



QUICK SAVE: saves a setup file immediately with the name shown in the button. The number in the name is incremented automatically so that the new name is ready for the next setup file to be saved.

SAVE AS: Opens the Save dialog to manually enter a file location, enter a file name, and to set the file type to be saved. Depending on the selected measurement, you can save the following:

- Setup File: Saves the current instrument setup (stp file type).
- Trace File: Saves the measurement (trace or point data) and the current instrument setup (smvna file type).
- Trace + Screenshot: Saves both the current measurement and screenshot files (both smvna and png file types).
- Trace CSV File: (csv file).
- Trace TXT File: Saves both the current measurement and screenshot files (txt file).
- Trace S2P File: Saves the S-parameters from the 2-Port measurements (s2p file).
- Limit File: Saves the current limit line point data (limvna file type).
- Screenshot: Saves a screenshot of the current measurement (png file type).

RECALL: Opens the Recall File dialog to retrieve a file from a desired location. Only supported files will be displayed depending on the currently set measurement. When trace data is recalled, the instrument will change the settings to match the settings of the saved trace. The data will be recalled to the appropriate trace. That trace will be in a Hold mode. To exit the recalled data, simply change the trace mode back to Active.

BROWSE FILES: Opens File Management screen. For more information refer to the product's user guide.

Figure 3-68. FILE Menu

Note	S2P is a standard ASCII text file format that is used for scattering parameters from a 2-Port measurement. This is a subset of SnP (where n equals the number of ports). An S2P file can be used as input for signal analysis. Note The CSV and Text files contain setup information and final formatted data that are shown on the instrument display screen. This file information includes any post-processing that was done on the data (smoothing, trace math, time domain, and so forth). These files contain the data for any traces that are displayed, including the memory traces. They also contain the markers that are turned on when the file is saved.

Chapter 4 — Time Domain, Option 2

4-1 Introduction

This chapter describes the Time Domain Option 2 feature in the Vector Network Analyzer application. General descriptions and examples are presented for time and distance measurements for both coaxial and waveguide media.

4-2 Time Domain Measurements

The Time Domain feature provides the ability to transform the native frequency domain data (that is measured by the VNA) into time domain or distance domain information to help in determining the location of impedance discontinuities. Some typical applications are: distance-to-fault (DTF) in cables and waveguides, characterizing antennas, isolating and analyzing a desired response in a one-port or two-port network, and identifying and analyzing circuit elements.

The relationship between the frequency-domain response and the time-domain response of a network is described mathematically by the Fourier transform. The instrument makes measurements in the frequency domain, then transforms that data into its time-domain response, which can be displayed as a function of time or distance. This computational technique benefits from the wide dynamic range of the instrument (and its measurement data) and from the error correction of the frequency-domain data.

The transformation technique that is used by the instrument (in most cases) is the chirp-Z transform of the available frequency domain data for that parameter. Because the transform simply treats the frequency domain values as input data, any S-parameter can be transformed (including differential S-parameters). The chirp-Z transform is (in a macro sense) very similar to the Fast Fourier Transform with the exception that the output range can be variable. This permits you to zoom in on a specific time (distance) range of interest for the data display. A different algorithm is used with the waveguide dispersive media, where the time-frequency relationship is more complex, but the functionality remains the same.

Two of the fundamental properties of time-domain conversion are resolution and maximum (alias-free) range. Resolution is the ability to resolve one discontinuity from another. Resolution is limited by the frequency span of the measurement. Maximum range defines how far you can see discontinuities on the media you are measuring. Beyond the maximum range, the data just repeats itself, and you start seeing the same discontinuities from closer ranges. The maximum range is determined by the frequency step size.

4-3 Site Master Implementation

The Time Domain implementation in the Site Master is trace based, which makes it very flexible to use. Each of the four traces in the Site Master can be configured independently and can be in the frequency, time, frequency gating or distance domain. Each trace can also be configured to represent any of the S-parameters. The Site Master (as an example) can simultaneously view S_{11} in the frequency, distance, frequency gating, and time domains using four traces. Alternatively, you can view all two of the S-parameters in the distance domain or the time domain or both. This flexibility could be useful when tuning complex filters or analyzing long cable problems with multiple discontinuities.

For example, look at the results of measuring a cable that is 3.05 meters (10 ft) long..

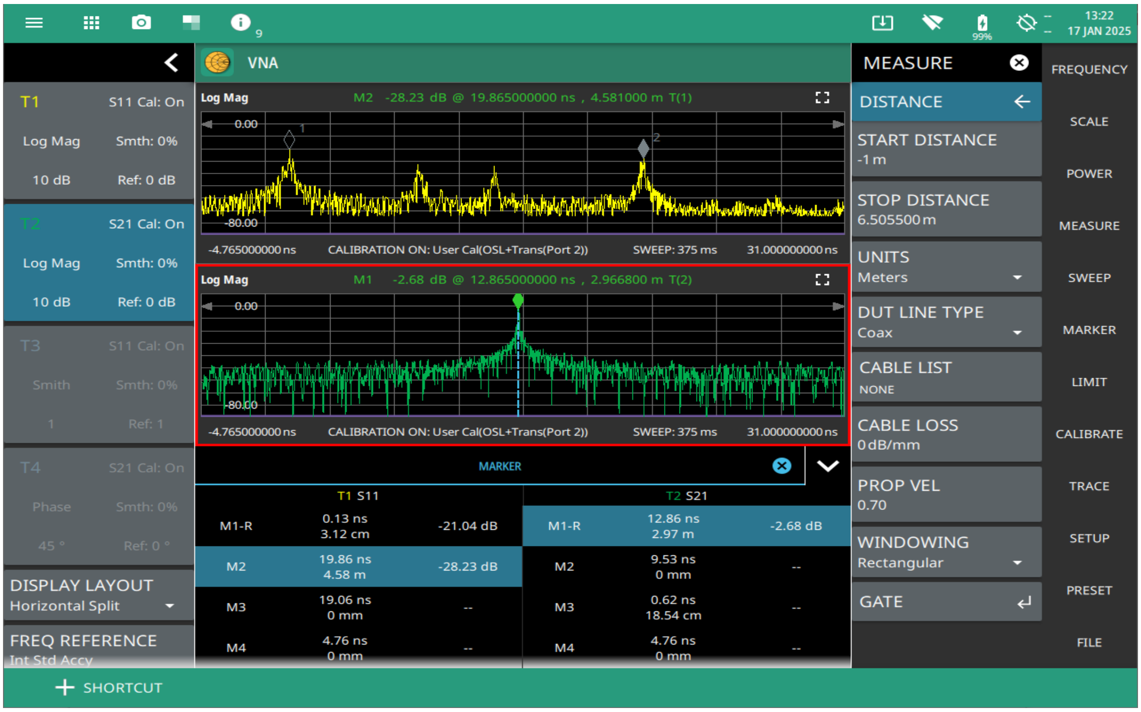


Figure 4-1. Time Domain Measurements of a 3.05 m Cable Showing S_{11} and S_{21}

Take a look at what happens in the distance domain for the same cable. As a user, you want the reflection and transmission measurements to show you where the end of the cable is located. Figure 4-2 shows a measured distance domain response of this cable for both reflection (S11) and transmission (S21). The top trace is the S11 plot showing the reflections from both ends of the cable. The bottom trace shows the transmission S21 measurement with the peak representing the signal received at the end of the cable. Looking at the signal, you can see that the reflection and transmission measurements produced the same result for the length of the cable.

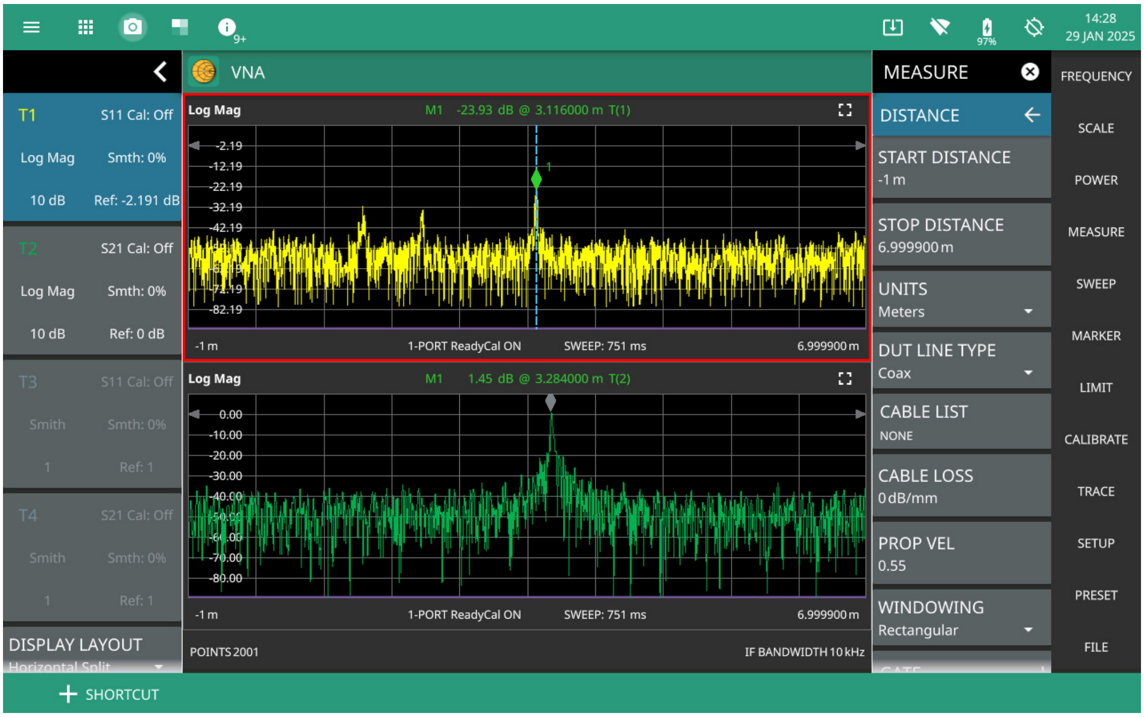


Figure 4-2. Distance Domain Measurements of a 3.05 m Cable Showing S_{11} and S_{21}

Time Domain – Impulse Response

The screen capture in Figure 4-3 shows both frequency and time domain measurements of a Beatty standard (a transmission line with a low impedance section in the middle). The left quadrants shows the frequency response of S_{11} and S_{21}, and the right quadrants show the impulse response of S_{11} and S_{21}. Time domain responses offer insights about the physical characteristics of the DUT.

For example, in the upper right graph, the negative pulse at approximately 1.3 cm is caused by the reflection from the 50 ohm to low-impedance step in the transmission line. A positive pulse at approximately 6.3 cm is caused by the reflection from the low-impedance to 50 ohm step in the transmission line. The bottom right trace shows the impulse response of S_{21} versus distance. A positive pulse at approximately 7.5 cm indicates the total length of the Beatty standard. The pulse amplitude is slightly less than unity because some of the energy from the transmitted impulse was reflected back to Port 1 (the excitation port of S_{21} measurements).

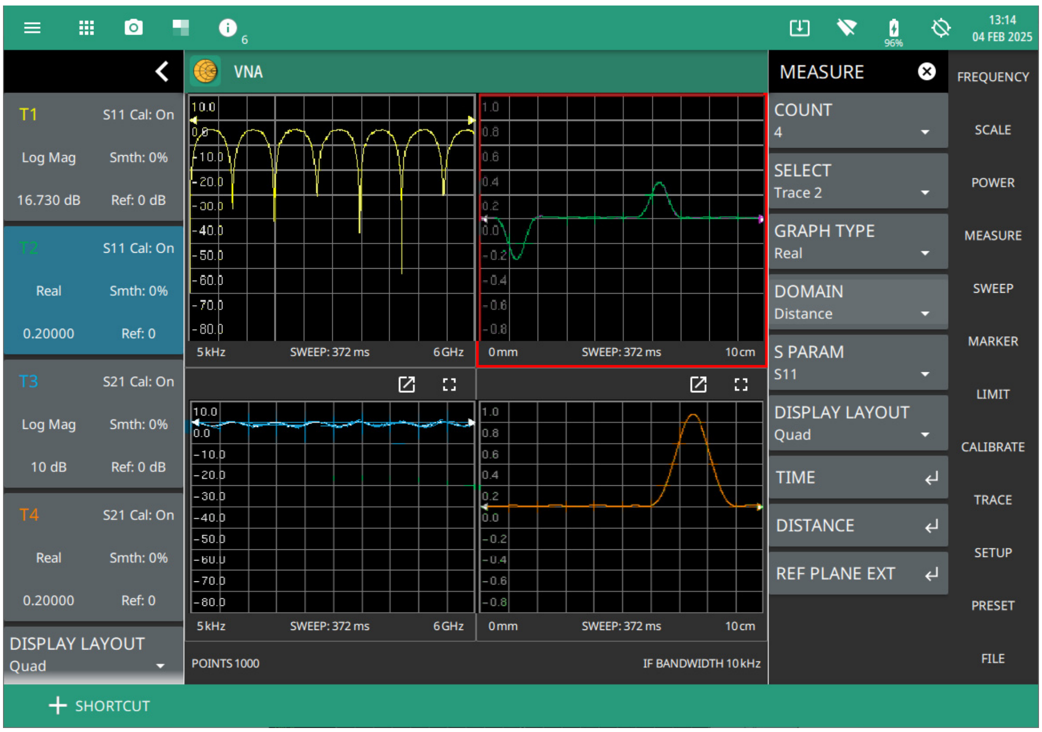


Figure 4-3. Beatty Standard – Frequency Response versus Impulse Response

Step Response versus Impulse Response

The screen capture in Figure 4-4 shows both impulse and step responses of the same Beatty standard. Step responses may seem more intuitive because they are a representation of impedance versus distance. A negative reflection off the leading edge of the low-impedance section of transmission line causes the purple step response to drop down as the step travels through the low-impedance portions of the Beatty standard. A positive reflection off the trailing edge of the low-impedance section of transmission line causes the step response to rise back up. A secondary reflection off the trailing edge eventually brings the step response back to zero. Secondary reflections can be seen with large impedance mismatches such as the Beatty standard.

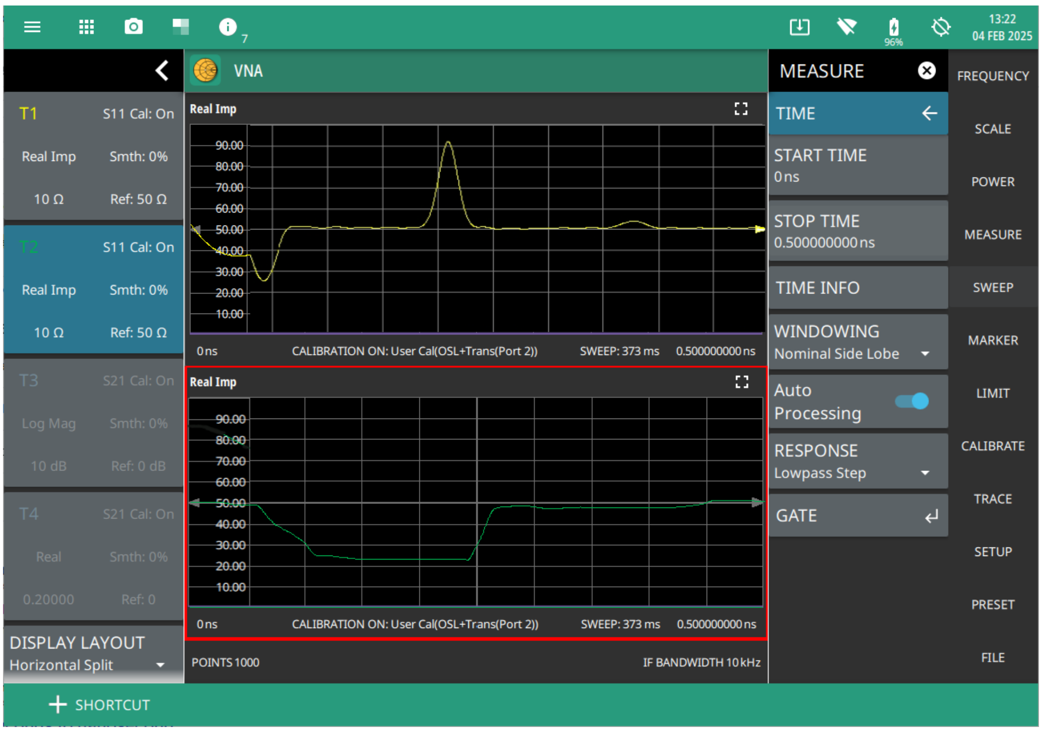


Figure 4-4. Beatty Standard – Impulse and Step Response

Low Pass versus Band Pass

The Site Master uses two types of processing to transform frequency domain data to time data (or distance data). Bandpass processing is the standard processing technique that can be applied to all frequency sweep setups. Only impulse response can be displayed in this mode. Lowpass processing is a technique that can be used only where frequency content that is fairly close to DC is available. This technique creates a pure real transform and can produce a step response in addition to an impulse response. For the same frequency sweep width, lowpass processing produces time (or distance) resolution that is a factor of 2 better than that of bandpass processing.

The Site Master (when Auto Processing in TIME submenu is toggled on) always tries to use lowpass processing whenever the frequency sweep has low frequency content. For band-limited sweeps with a starting frequency not near DC (such as for waveguide devices), the Site Master automatically defaults to bandpass processing.

You can force the instrument to always use bandpass processing by turning off Auto Processing in TIME submenu. For most setups, however, you should take advantage of lowpass processing whenever possible.

The screen capture in Figure 4-5 shows a DUT with return loss measured in lowpass time domain mode using an impulse response.

Figure 4-5. Low Pass Return Loss Using Impulse Response

The same DUT measured with bandpass time domain processing is shown in Figure 4-6.

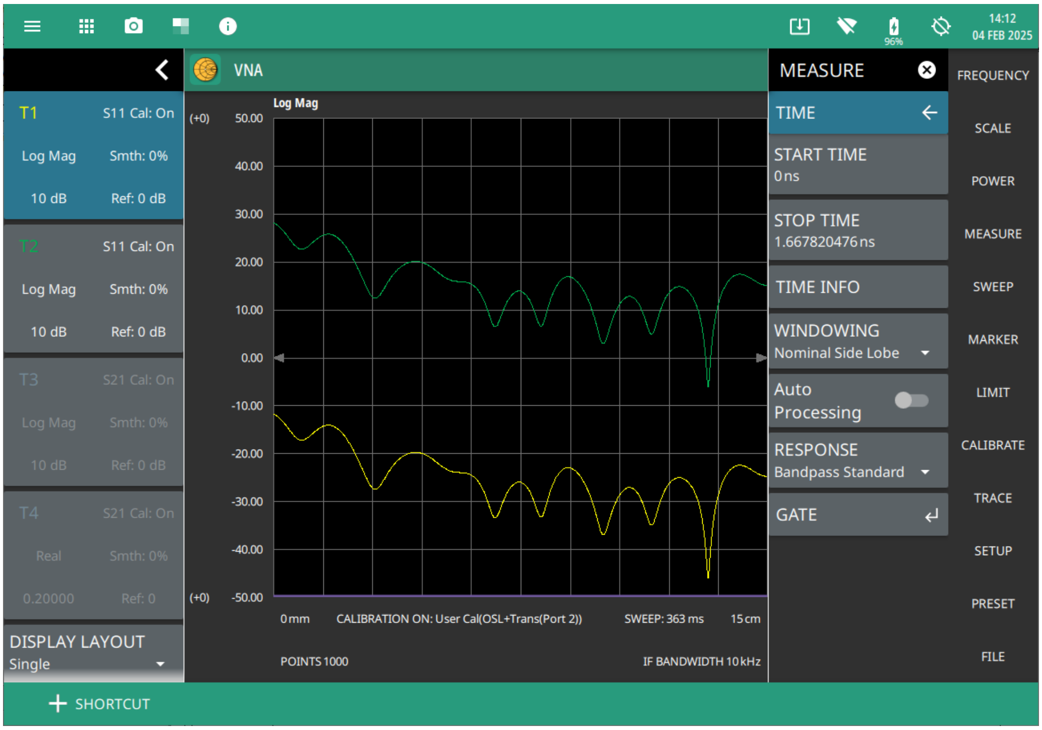


Figure 4-6. Band Pass Return Loss Using Impulse Response

Frequency Gated by Time

Often times, you would like to measure the characteristics of a DUT by connecting to it with a cable. Unfortunately, the cable is not ideal and degrades the measurement of the DUT. Frequency Gated by Time (FGT) is a feature that allows the unwanted characteristics of the devices surrounding the DUT to be “gated” out of the measurement. FGT first transforms the frequency data into the time domain, “gates” out the unwanted time domain data, and then transforms the gated time domain data back into the frequency domain.

The screen capture in Figure 4-7 shows the measurement of a DUT at the far end of a 30 cm cable.

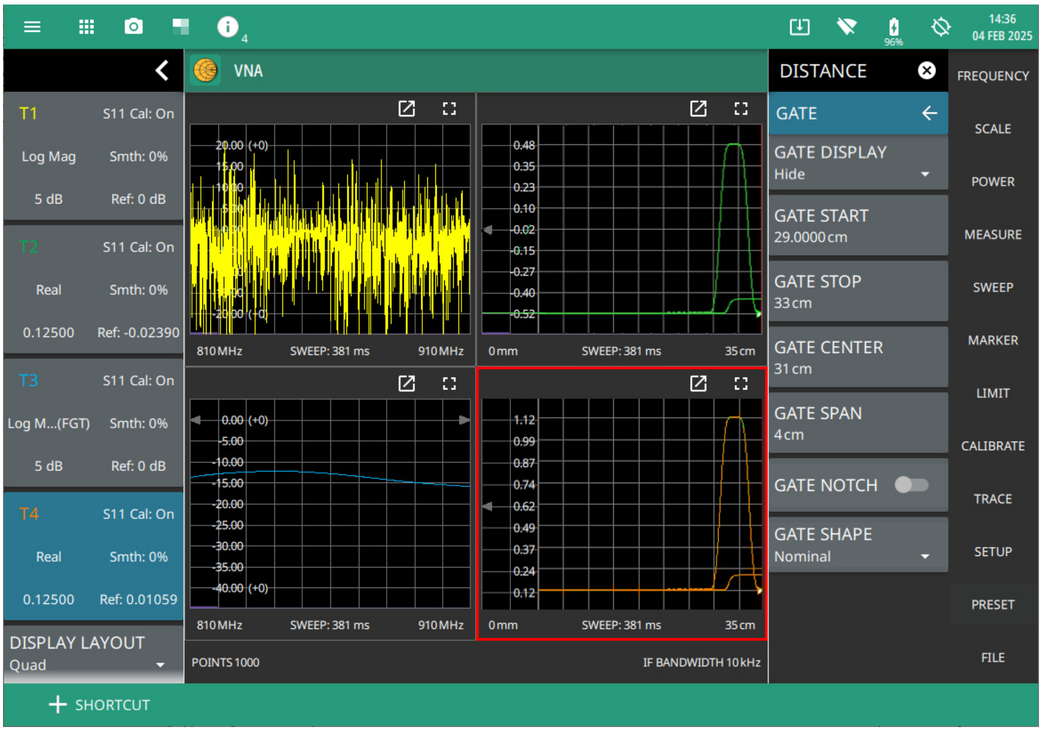


Figure 4-7. DUT at Far End of Cable Measurement – Frequency Gated by Time (FGT)

Another feature that is related by FGT is called GATE NOTCH". Instead of gating the desired portion of the time domain response, notch allows you to suppress an unwanted portion of the time domain response. To turn on GATE NOTCH, from main menu select MEASURE > TIME > GATE >GATE NOTCH.

For illustration purposes, the screen capture in Figure 4-8 places a "notch" on the DUT location, leaving just the cable in the time domain response.

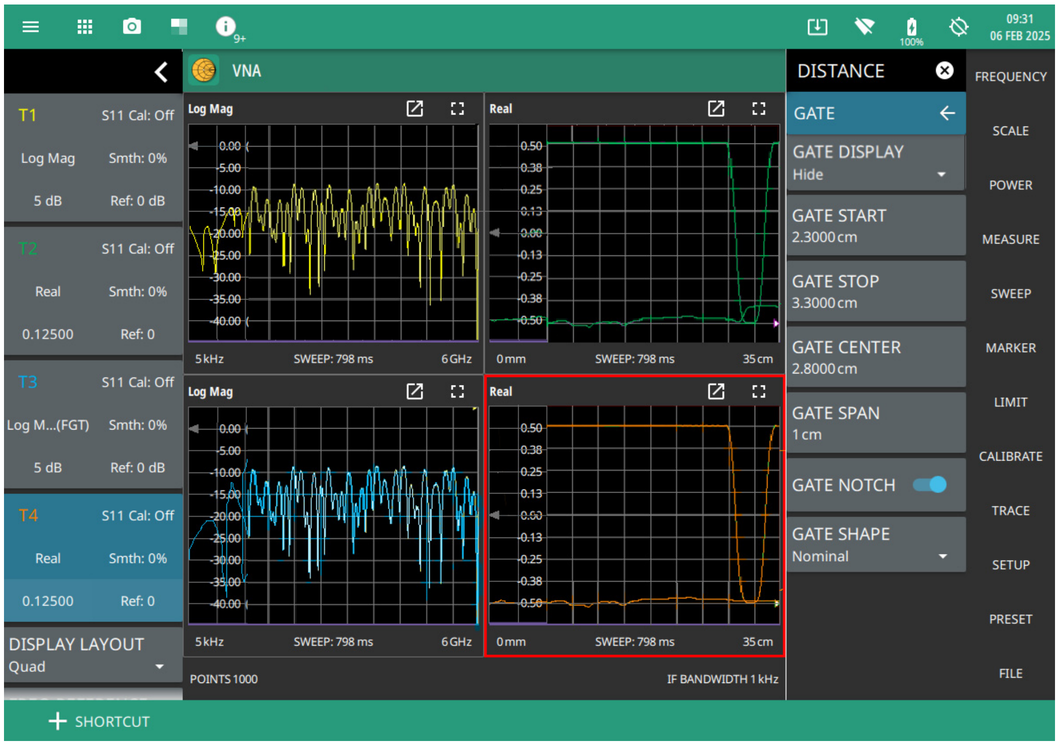


Figure 4-8. DUT at Far End of Cable Measurement – Notch with Frequency Gated by Time

4-4 Windowing

Windowing is a frequency filter that is applied to the frequency-domain data when it is converted to time-domain data. This filtering rolls off the abrupt transition that occurs at the start and stop frequencies. This effectively produces a time-domain response with lower sidelobes. Windowing allows a limited degree of control over the pulse shape, trading ringing (sidelobes) for pulse width. Four different windows are available: Rectangular, Nominal Sidelobe, Low Sidelobe, and Minimum Sidelobe. The Rectangular option provides the narrowest pulse width, and the Minimum Sidelobe option provides the least ringing (fewest sidelobes). For more details on Windowing, refer to Appendix A.

Appendix A — Windowing

A-1 Introduction

The theoretical requirement for inverse FFT is for the data to extend from zero frequency to infinity. Side lobes appear around a discontinuity because the spectrum is cut off at a finite frequency. Windowing reduces the side lobes by smoothing out the sharp transitions at the beginning and the end of the frequency sweep. As the side lobes are reduced, the main lobe widens, thereby reducing the resolution.

In situations where a small discontinuity may be close to a large one, side lobe reduction windowing helps to reveal the discrete discontinuities. If distance resolution is critical, then reduce the windowing for greater signal resolution.

If strong interfering frequency components are present, but are distant from the frequency of interest, then use a windowing format with higher side lobes, such as Rectangular Windowing or Nominal Side Lobe Windowing.

If strong interfering signals are present and are near the frequency of interest, then use a windowing format with lower side lobes, such as Low Side Lobe Windowing or Minimum Side Lobe Windowing.

If two or more signals are very near to each other, then spectral resolution is important. In this case, use Rectangular Windowing for the sharpest main lobe (the best resolution).

If the amplitude accuracy of a single frequency component is more important than the exact location of the component in a given frequency bin, then choose a windowing format with a wide main lobe.

If you are examining a single frequency, and if the amplitude accuracy is more important than the exact frequency, then use Low Side Lobe Windowing or Minimum Side Lobe Windowing.

Rectangular Windowing

Windowing provides best spatial distance resolution for revealing closely spaced events, but the side lobes close to any major event (large reflection) may mask smaller events which are close to the major event. Excellent choice if you suspect multiple faults of similar amplitudes close together.

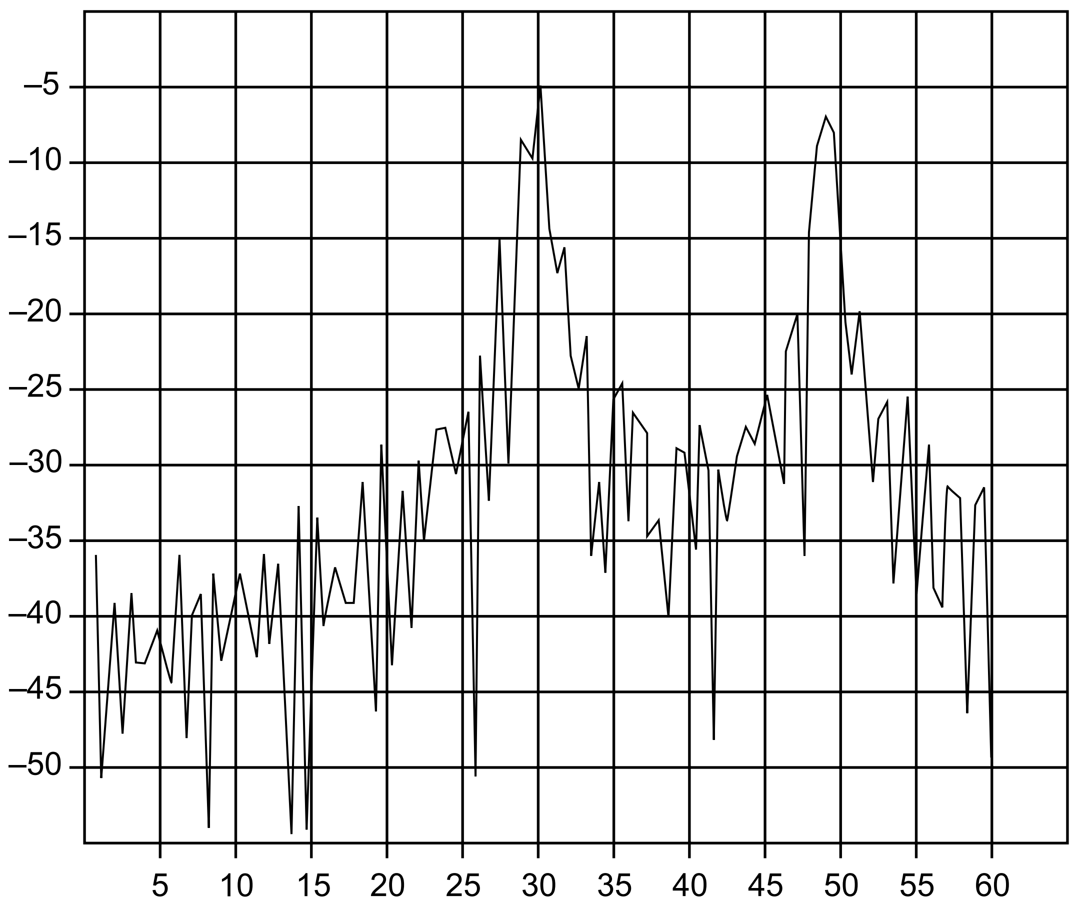


Figure A-1. Rectangular Windowing Example

This Distance To Fault graph has Return Loss (dB) on the vertical scale (y-axis) and distance in feet on the horizontal scale (x-axis).

This view of Rectangular Windowing shows the maximum side lobe display and the greatest waveform resolution.

Nominal Side Lobe Windowing

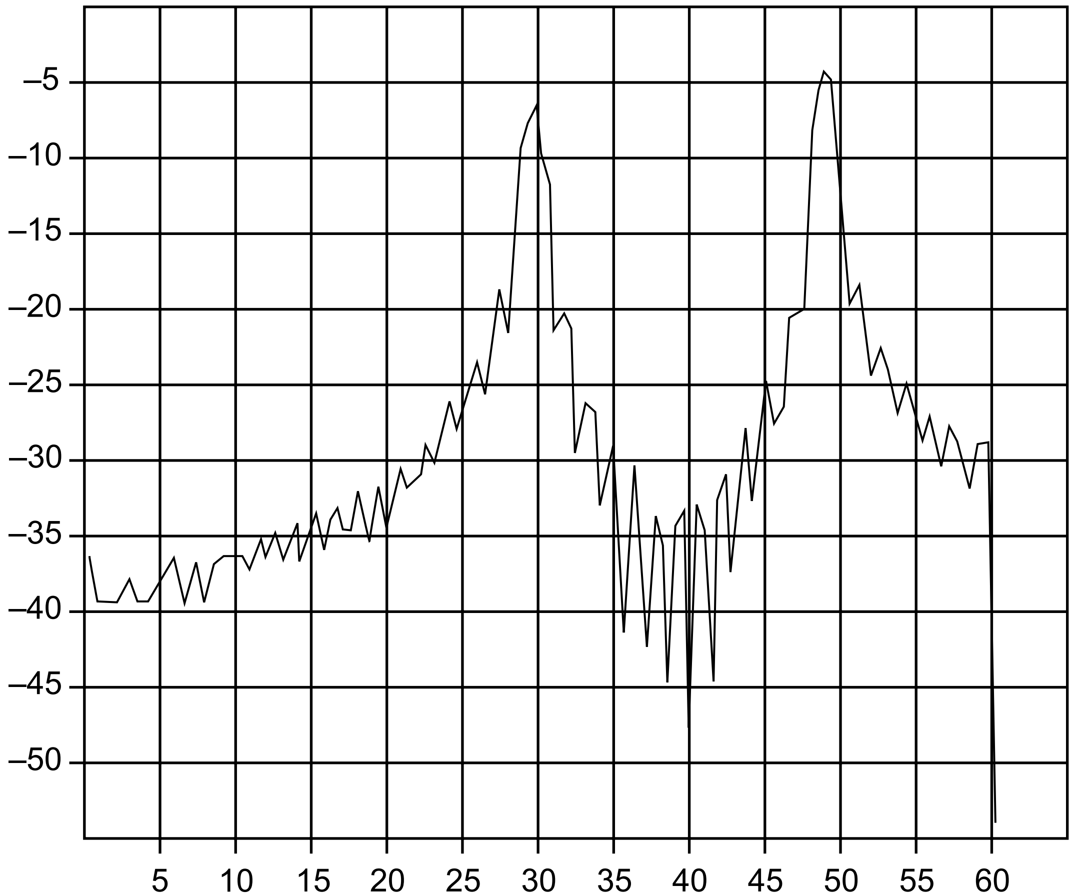


Figure A-2. Nominal Side Lobe Windowing Example

This Distance To Fault graph has Return Loss (dB) on the vertical scale (y-axis) and distance in feet on the horizontal scale (x-axis).

This view of Nominal Side Lobe Windowing shows less side lobe resolution than Rectangular Windowing and more side lobe resolution than Low Side Lobe Windowing. This level of windowing displays intermediate resolution.

Low Side Lobe Windowing

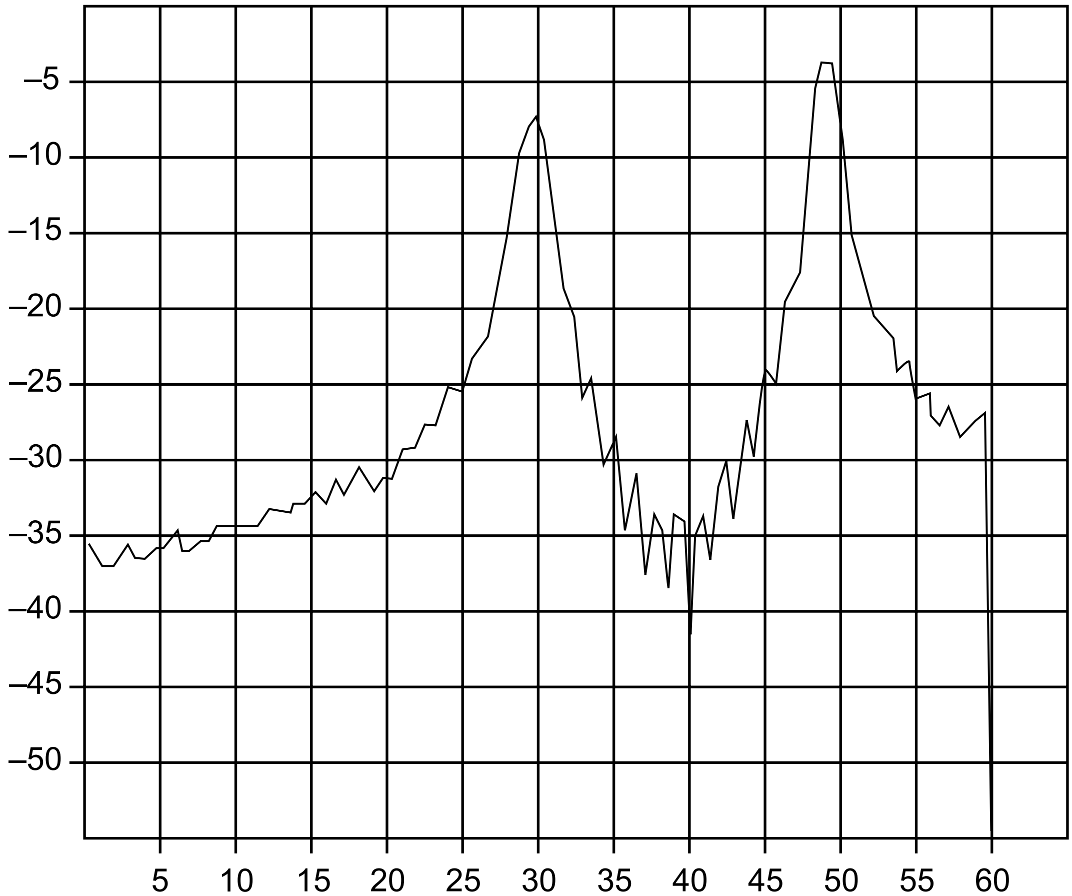


Figure A-3. Low Side Lobe Windowing Example

This Distance To Fault graph has Return Loss (dB) on the vertical scale (y-axis) and distance in feet on the horizontal scale (x-axis).

This view of Low Side Lobe Windowing shows less side lobe resolution than Nominal Side Lobe Windowing and more side lobe resolution than Minimum Side Lobe Windowing. This level of windowing displays intermediate resolution.

Minimum Side Lobe Windowing

This Distance-To-Fault graph has Return Loss (dB) on the vertical scale (y-axis) and distance in feet on the horizontal scale (x-axis).

This view of Minimum Side Lobe Windowing shows less side lobe resolution than Low Side Lobe Windowing and displays the lowest side lobe and waveform resolution.

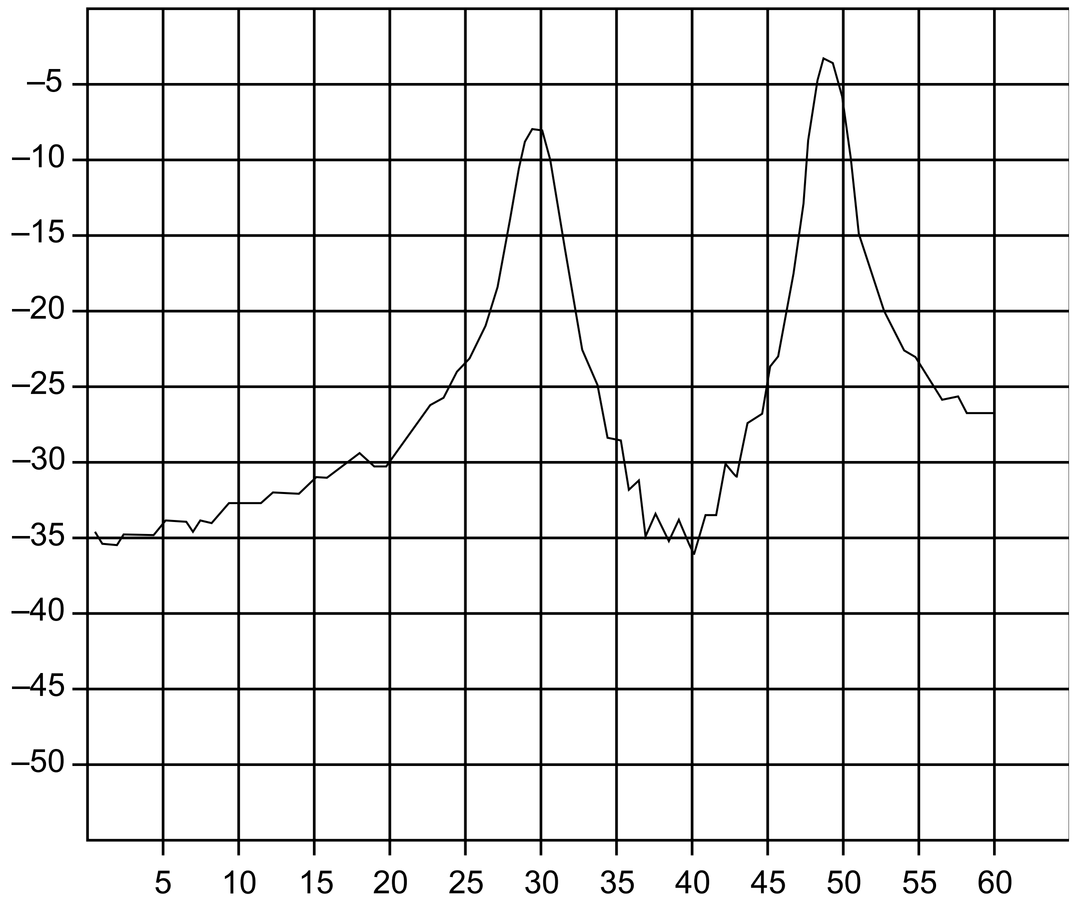


Figure A-4. Minimum Side Lobe Windowing Example

Kaiser-Bessel and Dolph Chebyshev Windowing

For the Kaiser-Bessel window, a larger Beta value leads to lower side lobes, but a wider main lobe width (and hence poorer resolution). For the Dolph-Chebyshev window, the side lobe level is parameterized explicitly (in absolute dB) and a larger value leads to a wider main lobe width as well.

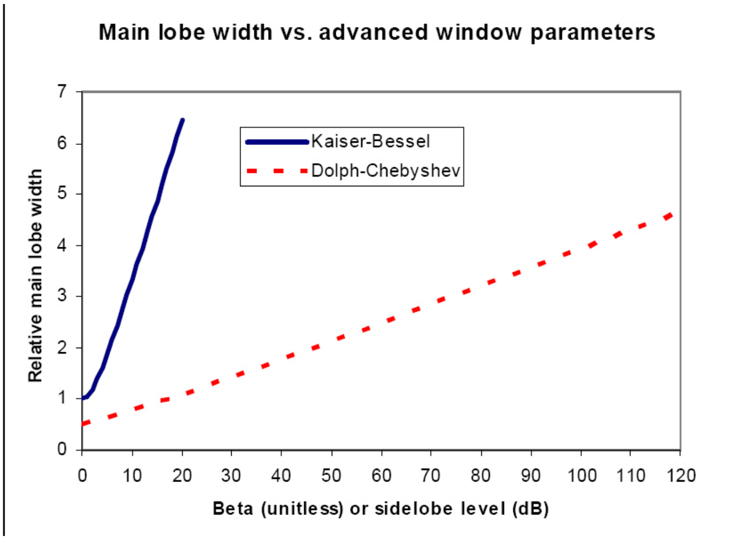


Figure A-5. Kaiser Bessel Windowing Example

Appendix B — Formulas

B-1 Vector Network Analyzer Formulas

The following formulas can be used with the Vector Network Analyzer (Site Master and LMR Master).

Reflection Coefficient

Reflection coefficient is the ratio of the amplitude of the reflected wave to the amplitude of incident wave.

$$\text{Reflection Coefficient} = \rho$$

$$\text{where: } 0 \le \rho \le 1$$

Return Loss

$$\text{Return Loss (dB)} = -20\log|\rho|$$

$$\text{where: } 0 \le \text{Return Loss} < \infty$$

VSWR

$$\text{VSWR} = \frac{(1+\rho)}{(1-\rho)}$$

$$\text{where: } 1 \le \text{VSWR} < \infty$$

Smith Chart

$$\text{Smith Chart: } z = r + jx$$

$$\rho = \frac{(z-1)}{(z+1)}$$

Inverted Smith Chart

$$\text{Inverted Smith Chart: } Y = G + jB$$

Electrical Length

The length of the cable as seen by the electrical signal. The electrical length is always greater than 1 for practical dielectric materials.

$$\text{Electrical Length} = L_{el} = L_{mech} \times \sqrt{\varepsilon}$$

Propagation

Propagation is the propagation velocity expressed as a ratio to the speed of light.

$$\text{Propagation Constant} = vp = \frac{1}{\sqrt{\varepsilon}}$$

$$\text{where:} \quad 0 \le v < 1$$

Cable Loss

$$\text{Cable Loss} = \frac{\text{Return Loss (dB)}}{2}$$

$$\text{Cable Loss Average} = \frac{(\text{Peak} + \text{Valley})}{2}$$

Fault Resolution

Fault resolution (in the distance domain) is the ability of the system to separate two closely-spaced discontinuities. Calculations for distance utilize the speed of light (c), which is 2.99792458×10^8 meters per second (for light in vacuum). F is frequency (in Hertz).

$$\text{Fault Resolution Round-Trip (m)} = \frac{0.5 \times c \times vp}{\Delta F}$$

$$\text{Fault Resolution One-Way (m)} = \frac{c \times vp}{\Delta F}$$

Maximum Horizontal Distance

D_{max} is the maximum horizontal distance that can be analyzed in DTF.

$$D_{max(m)} = (\text{Datapoints} - 1) \times \text{Fault Resolution}$$

Suggested Span

Suggested Span is the span needed to get Max Distance to equal Stop Distance.

$$\text{Suggested Span Round-Trip (Hz)} = \frac{(\text{Datapoints} - 1) \times 0.5 \times c \times vp}{\text{Stop Distance}}$$

$$\text{Suggested Span One-Way (Hz)} = \frac{(\text{Datapoints} - 1) \times c \times vp}{\text{Stop Distance}}$$