TECHNICAL OVERVIEW

Measure Cable and Antenna Using the N9321/22C Basic Spectrum Analyzer (BSA)

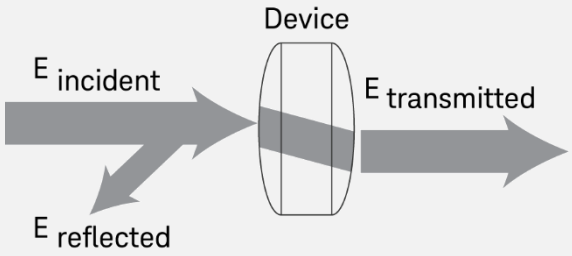
Abstract

In addition to measuring the frequency power characteristics of your device or system with a spectrum analyzer, sometimes you need to evaluate the performance characteristics of antenna, RFID tags, or RF Tx modules, such as their return loss, insertion loss, and VSWR. The Keysight N9321C (9 kHz to 4 GHz) and N9322C (9 kHz to 7 GHz) basic spectrum analyzer (BSA) support those additional measurements using an optional tracking generator (Option TG4/TG7) and reflection measurement (Option RM4/RM7). The built-in bridge in the tracking generator makes the N9321/22C an easy-to-use reflection analyzer.

Introduction

A scalar reflection measurement evaluates how efficiently energy is transferred into a device and reveals the degree of mismatch between a device and a Z0 transmission line (Z0 = characteristic impedance, typically 50 Ω). Not all the energy incident upon a device can be absorbed by the device, and a portion of the energy is reflected back toward the source. We can determine the efficiency of energy transfer by comparing the incident and reflected signals. See Figure 1.

KEYSIGHT TECHNOLOGIES



$$\text{Reflection coefficient } r = \frac{E_{\text{transmitted}}}{E_{\text{incident}}}$$

$$\text{SWR} = \frac{1 + r}{1 - r}$$

$$\text{Return loss} = -20 \log r$$

Figure 1. Reflection measurements

The Benefits of Using the N9321/22C BSA for Cable and Antenna Measurement

The N9321/22C BSA is a multi-use spectrum analyzer. You can easily set it up to cover reflection measurements by adding Option TG4/TG7 and Option RM4/RM7. The benefits of using this solution include:

1. **Simple test setup**

   The built-in VSWR bridge on the tracking generator makes the connection straightforward and eliminates the need for an external bridge (Refer to Figures 2 and 3).

2. **Excellent reliability and repeatability**

   The simple test setup reduces potential measurement error from the cable.

3. **Superior reflection measurement accuracy**

   The N9321/22C BSA reflection measurement mode uses an open-short-load (OSL) calibration procedure, which eliminates system errors better than others that use a single calibration (open or short) procedure.

4. **Simple operation**

   Once the OSL calibration is finished, the N9321/22C BSA is in vector network analyzer mode, therefore, you only need to control the frequency range of interest. The N9321/22C BSA allows you to read both return loss and VSWR.

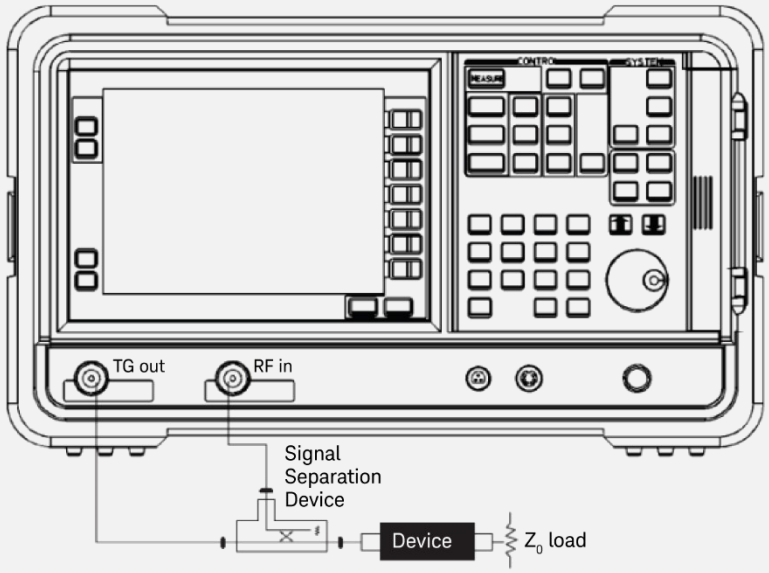


Figure 2. Conventional test setup requires an external bridge

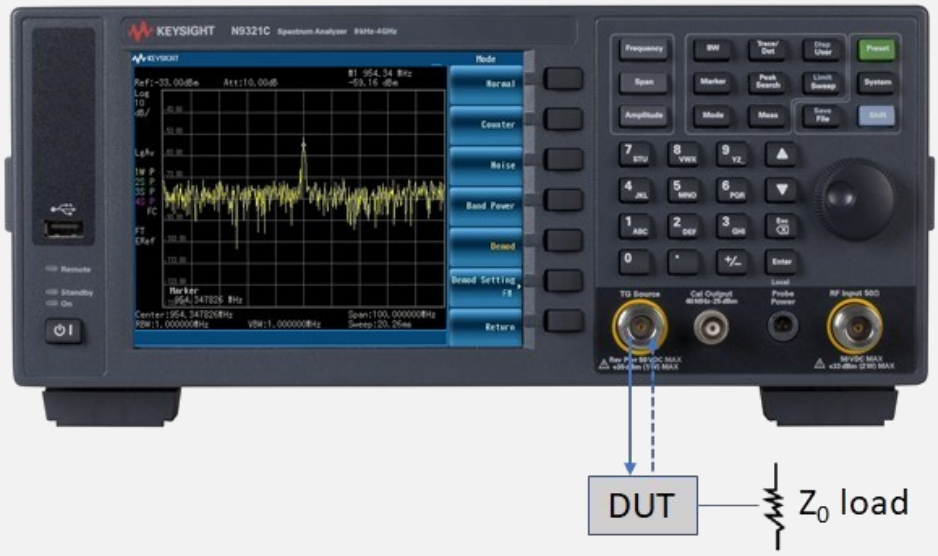


Figure 3. Simple test setup with N9321/22C BSA

Key Specifications of the N9321/22C Tracking Generator and Reflection Measurement Options

Tracking generator (Option N9321C-TG4, N9322C-TG7)	
Frequency	
Range	5 MHz to 4 GHz (TG4), 5 MHz to 7 GHz (TG7)
Resolution	1 Hz
Resolution bandwidth (RBW)	3 kHz to 3 MHz
Output power	
Range	–20 to 0 dBm
Resolution	1 dB
Measurement dynamic range	Max. output power: – DANL with 3 kHz RBW
3-in-1 OSL precision mechanic calibrator (N9311X-201, refer to Figure 4)	
Option RM7	
Frequency range	DC to 7 GHz
Port	Open, short, and load
Directivity	> 40 dB
Reflection measurement (Option N9321C-RM4, N9322C-RM7)	
Frequency	
Range	5 MHz to 4 GHz (RM4), 5 MHz to 7 GHz (RM7)
Resolution	100 kHz
Output power	
−4 to +2 dBm (nominal)	
Trace point	
461	
Return loss	
Range	0 to 60 dB
Resolution	0.01 dB
Accuracy [1]	$20\log_{10}\left(1.1 + 10^{\left(-\frac{D-RL}{20}\right)} + 0.016 \times 10^{\frac{-RL}{20}} + 10^{\left(-3+\frac{RL}{20}\right)}\right)$ (nominal)
VSWR	
Range	1 to 65
Resolution	0.01

1. “D” refers to the directivity of the calibrator; “RL” refers to return loss.

Making a Reflection Measurement with the N9321/22C BSA

Three-step guide to make an accurate reflection measurement:

- Set up the spectrum analyzer's control settings (mode, frequency, RBW, sweep time, etc)
- Calibrate the N9321/22C BSA with the Keysight N9311x-201 OSL calibrator in order to eliminate system error and temperature drift errors
- Re-connect the DUT and read the measurement result from the analyzer

Example: Measuring the return loss and VSWR of an antenna

In this example, the DUT is a Yagi antenna with frequency coverage from 824 to 960 MHz. The demonstration procedures use text in [ ] to indicate a hardkey and { } to indicate a softkey on the N9321/22C spectrum analyzer.

Figure 4. N9311X-201, OSL precision mechanic Calibrator

Step 1. Set up the N9322C BSA

Press [Mode] > {Reflection Measurement} to enter the reflection measurement mode of the N9322C BSA

1. Press [Frequency] > {Start Freq} > [824] > {MHz} to set the start frequency at 824 MHz
2. Press [Frequency] > {Stop Freq} > [960] > {MHz} to set the stop frequency at 960 MHz
3. Toggle {Cal Type} to {Selected} for higher calibration accuracy, comparing to Full band calibration

Figure 5. Reflection measurement mode waiting for OSL calibration

Step 2. Calibrate the N9321/22C BSA with the OSL calibrator

1. Press {Calibrate} to initiate the open-short-load calibration procedure
2. Follow the instrument instructions and connect the open, short, and load port of the calibrator to the TG output port of the N9321/22C BSA
3. Once finished, the instrument displays “Calibrated” on the left upper corner of the display

Figure 6. Performing open-short-load calibration on the N9322C BSA

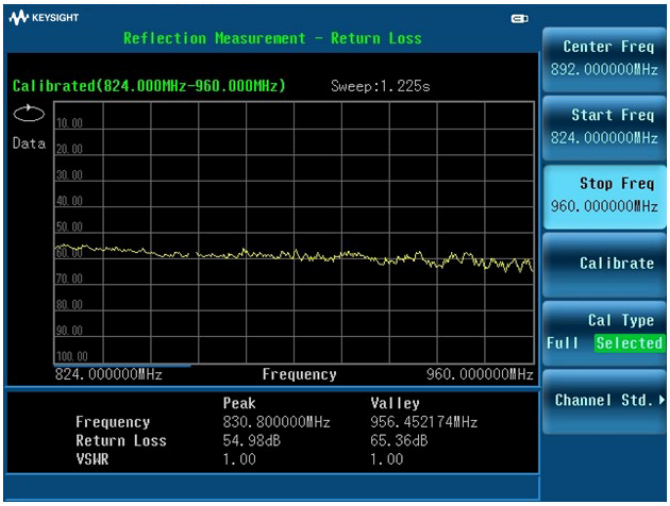


Figure 7. The calibrated N9321/22C BSA ready for measuring return loss/VSWR

Step 3. Connect DUT to the N9321/22C for reflection measurement

1. Disconnect the calibrator from the TG output port of the N9321/22C
2. Connect the DUT to the TG output
3. Press [Amplitude] > {Auto Scale} to optimize the amplitude scale automatically
4. Press [Marker] to turn on the markers to read the points of interest for the frequency, return loss, and VSWR parameters

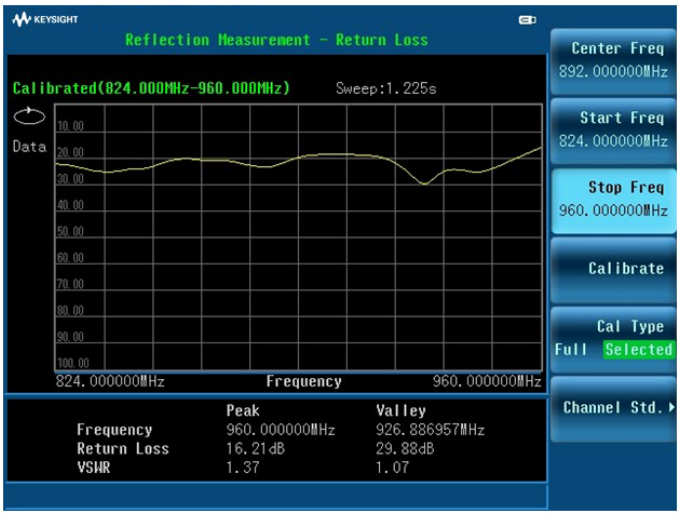


Figure 8. A calibrated return loss measurement across the selected frequency range

Summary

The tracking generator with its built-in VSWR bridge makes the N9321/22C basic spectrum analyzer (BSA) an efficient, reliable, and cost-effective solutions for RF engineers who need to measure both frequency power characteristics and stimulus-response performance of their devices.

Ordering Information

Model number	Description
N9321C	Basic spectrum analyzer, 9 kHz to 4 GHz
N9321C-TG4	Tracking generator, 5 MHz to 4 GHz
N9321C-RM4	Reflection measurement
N9322C	Basic spectrum analyzer, 9 kHz to 7 GHz
N9322C-TG7	Tracking generator, 5 MHz to 7 GHz
N9322C-RM7	Reflection measurement
N9311X-201	3-in-1 precision mechanic calibrator