AN102
Understanding Vector Network Analysis

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Abstract:

This paper is meant assist in the operation and understanding of the VIA Bravo Family of products.

Understanding the Display and its Readings:

The VIA Bravo display provides graphical and numerical results on measurements made on antennas, cables, or electrical components. Figure 1 is the basic display layout for the VIA Bravo.

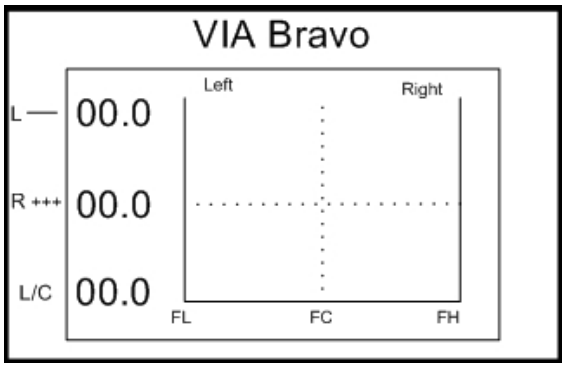

Figure 1

Left Represents the unit of measure of the selected test on the Left vertical axis plot.

Right Represents the unit of measure of the selected test on the Right vertical axis plot.

L Numeric readout of the Left Plot center frequency measurement or in the EXAM/PLOT mode displays the measurement at the cursor frequency. The Left Plot is denoted by a single line on the graph.

R Numeric readout of the Right Plot center frequency measurement or in the EXAM/PLOT mode displays the measurement at the cursor frequency. The Right Plot is denoted by a hashed line on the graph.

L/C Numeric display of the inductive or capacitive component of the measurement. For SWR measurements, L/C is the calculated “Q”.

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FL – FC – FH Denotes the center frequency and the frequency sweep range displayed.

FC Center Frequency of the measurement sweep.

FL Represents the lowest frequency of the sweep.

FH Represents the highest frequency of the sweep.

Tests:

Resistance Measured in Ohms. This test measures the series or parallel resistive component of the antenna and/or feed line. Resistance is the property of resisting or impeding the flow of AC and DC signal current.

Reactance Measured in Ohms. Reactance is the property of resisting or impeding the flow of AC current that is not accounted for by Resistance in an antenna or device under test. There are two types of reactance, inductive and capacitive. Inductive is denoted by a positive reactance, and capacitive is denoted by a negative reactance.

Impedance Measured in Ohms. The impedance of the antenna or device under test should match the design of the system at the center or resonant frequency. Impedance is the combined effect of resistance and reactance.

Impedance (Phase) Angle Measured in degrees. This test determines whether the antenna or device measured is reactive at the measured frequency. A positive angle means the circuit is inductive, and a negative angle identifies the circuit is capacitive.

SWR Usually, SWR is defined as the ratio of the maximum radio-frequency (RF) voltage to the minimum RF voltage along the line. The SWR has to be at an acceptable level across the frequency band. 1:1 is considered the ideal reading but is not usually attainable.

Return Loss Measured in decibels (db). There is a direct relationship between Return Loss and SWR. Return Loss is the amount of signal reflected back towards the transmitter expressed in decibels (db).

General Notes:

Why should the user care about resonance?

For good power transfer, cable impedance should match the antenna impedance and transmitter impedance. In addition, the antenna should be close to resonant at the frequency of interest. When the reactance of an antenna is not zero, the current either leads (capacitive) or lags (inductive) the voltage waveform, which results in a lower power factor and lower transmitted power. Thus, having the reactance (series) near zero (near resonant) is desirable for good transmitter efficiency.

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Why not just use the SWR measurement?

SWR gives impedance matching information, but it is missing the resonance information.

Testing an Antenna:

Vector Impedance Measurements Most antenna systems are 50 Ohms. This includes the output impedance of the transceiver, the impedance of the feeder cable, and the impedance of the antenna. An antenna is resonant at the frequency(s) where the Impedance (Phase) Angle is equal to zero (0). Refer to the system or radio specifications for operating requirements. The antenna Impedance should be at or near the manufacturer's specification (usually 50 Ohms) across the frequency band of interest. See Figure 2.

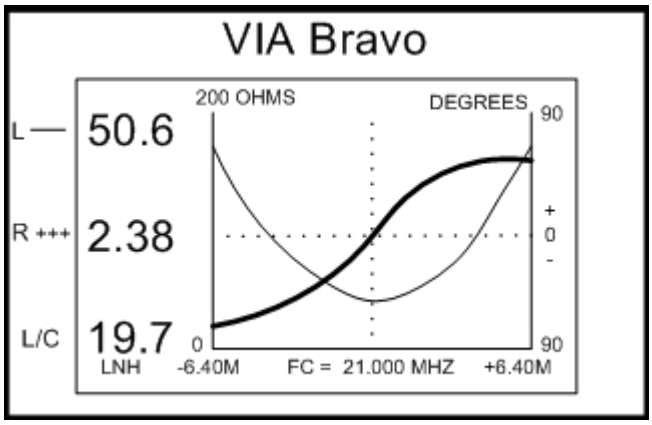

Figure 2

In Figure 2, Impedance is on the Left Plot and Impedance (Phase) Angle is on the Right Plot (thick line). The center is set at the resonant frequency (FC) of the antenna at 21 MHZ, and the Sweep Range is set at 12.80 MHz (6.40 MHz below FC and 6.40 MHz above FC). The Impedance (Z) of the device under test is 50.6 Ohms at the center frequency, and the Impedance (Phase) Angle is 2.38 degrees at the center frequency. This Impedance Angle reading means that the device is inductive rather than capacitive at the center frequency. A negative Impedance Angle reading would identify the device as being capacitive. The L/C reading of 19.7 nH (nano-henry) is the device's inductive measurement at the resonant frequency. Depending on the system specifications, these reading may be perfectly acceptable.

Feed cables will modify the Impedance (Z) total of the antenna. This modification of the readings can be eliminated by using the cable null feature of the VIA Bravo.

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By default, the VIA Bravo calculates the Resistance and Reactance as two series elements. The user may change the Bravo's settings to calculate the Resistance and Reactance as parallel elements instead.

SWR and Return Loss Measurements
SWR and Return Loss are scalar measurements, that is, they do not have any resonance information. This type of testing is a rough indication of system match. It was a popular way to measure antennas because the SWR meters were so much cheaper than vector (non-scalar) measuring systems. Although SWR measurements are useful in testing antennas, the Vector Impedance readings provide the most information for testing antennas, cables, and electrical devices because SWR and Return Loss do not show where the antenna is resonant. See Figure 3 for an example of the of the SWR plot.

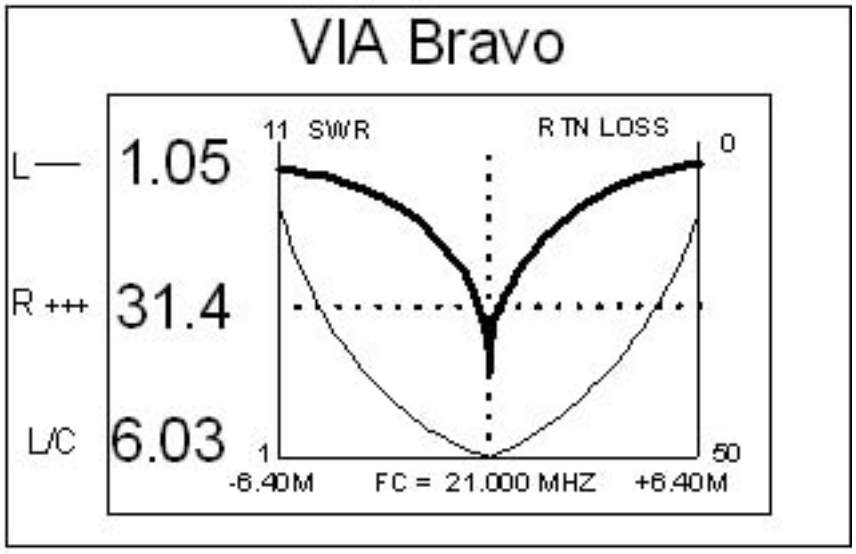

Figure 3

In the Figure 3, the SWR, on the left plot, is 1.05:1. In this example, the minimum SWR occurs at the resonant frequency (same antenna shown in Figure 2), but this will not hold true for most cases. The Return Loss, on the right plot (thick line), is 31.4 db. L/C is the Q measurement, which is 6.03. It should be noted that SWR and Return Loss have a direct relationship. The center frequency and sweep width are the same as in Figure 2. Refer to the manufacturer's specifications for SWR and Return Loss requirements for each antenna.

Exam Plot In the Exam Plot mode, the plot is frozen and a cursor appears at the center frequency point. The user can now move the cursor up and down the plot using the FREQ up and down keys. By moving the cursor up and down the plot, the VIA Bravo will display the selected test measurements and frequency at the location of the cursor.

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