DG8SAQ VNWA3 Vector Network Analyser

A compact and versatile unit that measures S parameters, VSWR, reactance and Q up to 1.3GHz

PHOTO 1: The front panel of the VNWA3 with transmit (TX) connector of the left and receive (RX) connector of the right.

INTRODUCTION. Vector network analysers have become very popular with radio amateurs, particularly in the last few years with the introduction of low cost, PC-based designs. However, many of these are meant for use up about 200MHz, making them unsuitable for UHF. Determining UHF network performance requires access to a network analyser with a much higher frequency range. Even relatively small changes in cable length can translate to large phase changes in UHF networks. The VNWA3 is claimed to work from 1kHz to 500MHz with a 90dB dynamic range, falling to 50dB at up to 1.3GHz, with some response still possible to about 1500MHz.

Designed by Tom Baier, DG8SAQ **[1]** and produced commercially by SDR-Kits **[2]**, the VNWA3 is the latest version of this small but versatile network analyser. It is able to measure S parameters, VSWR, reactance, Q, and time domain for 'distance to fault' and cable impedance measurements. Add to this the ability to import and export Touchstone format files and it becomes apparent that this is a very powerful instrument for the design and verification of electrical networks. The analyser front panel is shown in **Photo 1**.

The VNWA3 can also be used as a basic signal generator and spectrum analyser, although these two functions are rather more limited in their scope.

The VNWA3 is available only as an assembled and tested unit. The review sample came with an optional carry case, SMA calibration kits (more on these later in the review), SMA test cable and adapters. A comprehensive set-up and operating manual is included. An expansion board, to increase the versatility of the VNWA3, will be available later in the year.

I am fortunate to have my own Hewlett Packard 8753C vector network analyser and S parameter test set, but this combination is large and heavy – definitely not a portable setup. When *RadCom* asked me if I would like to review the new DG8SAQ VNWA3, I immediately accepted the offer as I had already been thinking about purchasing something similar for use in the field, having tried a number other small analysers. I was particularly keen to see how well the VNWA3 results compared with my own analyser.

The VNWA3 weighs just 350g and is 104mm wide by 80mm deep and 46mm high. It is powered from the host computer using the mini-USB-B connector and takes up to 500mA at 5V.

BRIEF DESCRIPTION. There have been three versions of the VNWA. The original, version 1, uses an LPT (parallel) interface to the host computer whilst version 2 uses a USB interface. Version 3, described in this review, also uses a USB interface, but the housing has been newly redesigned and now includes facilities to add an expansion board (not yet available) to allow simultaneous S11 and S21 measurement display. All three versions use the same RF signal path processing circuits.

Construction uses a single PCB with surface mount components. The PCB is soldered into a wrap-around brass screen. A folded, anodised, aluminium outer cover then completes the assembly. Two SMA sockets on the front of the analyser provide the transmit and receive ports whilst a mini USB socket allows connection to the host computer. A red LED, visible through a hole on the rear panel, indicates that the unit is powered. **Photo 2** shows the rear panel of the analyser.

The VNWA uses two Analog Devices AD9859 direct digital synthesisers (DDS). One is used to generate an RF test signal (stimulus) whilst the second generates the test receiver local oscillator signal. These DDS chips specify a maximum 400MHz core clock frequency. However, in this application, both chips are overclocked to permit coverage to 1300MHz. With such a wide frequency range the DDS outputs would suffer from 'drop outs' in the output frequency range due to aliasing. To eliminate the need for extensive anti aliasing filters the two DDSs core clock frequencies are dynamically switched, during the frequency sweep, to provide an effective 'fill in' of the dropout frequencies. This is an established technique that works extremely well in this application.

The stimulus signal is applied to a resistive 50Ω RF bridge and then to the network under test. Any reflected RF returns to the bridge via the Tx port and into the balanced mixer where it is mixed down with the output from the LO DDS to a low IF of between 1 and 12kHz. This is processed by the built-in CODEC before being passed over the USB connection to the host computer for further IF DSP processing and display. A sample of the mixed RF and LO is also processed and passed to the other audio channel of the sound card as the reference signal.

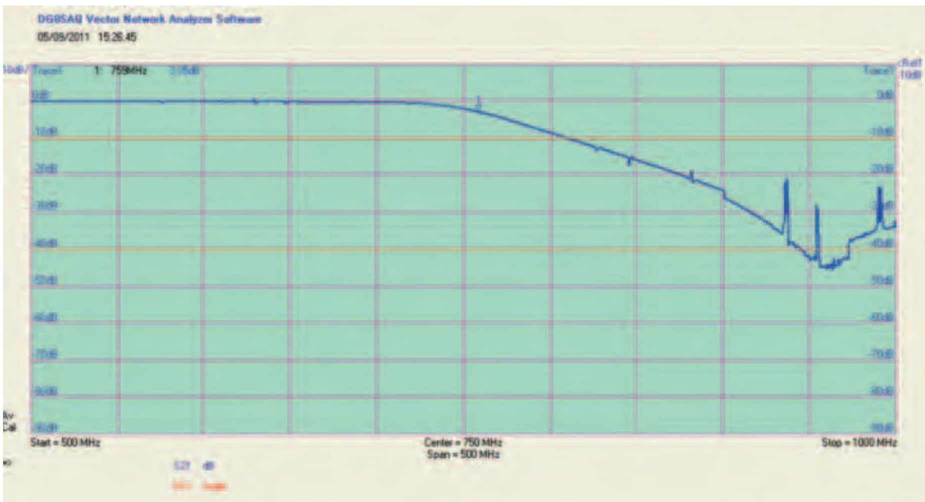

FIGURE 1: Frequency response of a 750MHz low pass filter acquired with the VNWA3.

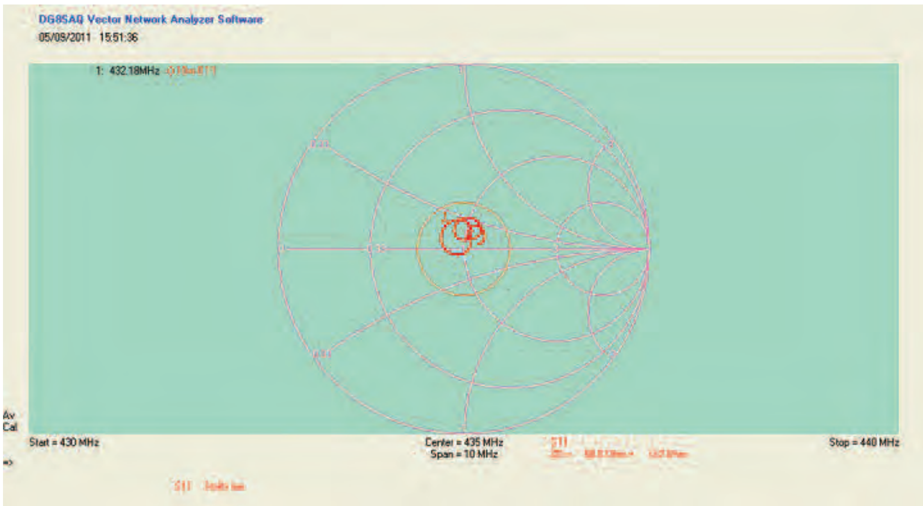

FIGURE 2: Smith Chart plot of a 432MHz Yagi acquired with the VNWA3.

PHOTO 2: Rear panel of the VNWA3 showing the mini USB connector and the red power LED.

TABLE 1: Network measurement results.

	10MHz	50MHz	144MHz	432MHz	1300MHz
VNWA |Z|	100.1Ω	94.1Ω	48.8Ω	10.3Ω	3.7Ω
VNWA X	2.15nF	102pF	23.7pF	17.9pF	2.5nH
HP5753C |Z|	100.2Ω	89.6Ω	50.1Ω	9.5Ω	0.3Ω
HP8753C X	2.4nF	104.6pF	23.1pF	16.5pF	1.9nH

|Z| = Impedance
X = reactance, displayed as equivalent capacitance or inductance.
This is a common way of displaying results on commercial analysers.

When the VNWA is used to make through (transmission) measurements, RF from the network under test enters the Rx port where it is mixed with the LO DDS signal. The resultant low frequency signal is amplified, processed in the USB CODEC and then passed via a CMOS switch over the USB connection to the host computer for IF DSP processing. The CMOS switch is necessary because the host computer sound card has just two channels. One of these is required as a permanent reference channel input. Reflected and Through measurements cannot be performed simultaneously as there is only one other audio channel available. By switching (multiplexing) the reflected and through measurements, these can be displayed and then viewed as required. The new expansion board will overcome this limitation by supplying a second sound card within the VNWA.

A combination of falling output levels from the two DDS with increasing frequency and the use of 500MHz mixers means that although the VNWA will work effectively to over 1300MHz, best performance is obtained up to about 500MHz. The resistive bridge uses miniature SMD resistors and should be good to well in excess of 1300MHz.

In order to get meaningful measurements with a network analyser it is necessary to calibrate it. This is usually done using a 'calibration kit'. A calibration kit consists of a short, open, termination (load) and through adapter using the appropriate type of connector for the analyser. It also needs to be either male or female, depending on the gender of the connector or cable to be used. Optional SMA calibration parts are available for purchase with the VNWA3. The review unit was supplied with Amphenol calibration types in both male and female SMA. There was also a very useful data sheet included giving the measured delay through each of these parts so that the calibration plane position can be moved as required.

RESULTS WITH THE VNWA. In order to obtain the best results from (any) VNWA the user should be familiar with transmission and reflection of signals in a network. A working knowledge of S (scattering) parameters is also desirable. With this knowledge the VNWA becomes one of the most powerful pieces of test equipment that the radio amateur (or professional) can have available to them.

The following measurements were made using the review VNWA3 and my Samsung N110 netbook computer running the usual Intel Atom processor. No problems with speed were experienced during the tests although the processor was working very hard at times.

As an illustration, **Figure 1** shows the frequency response from a 750MHz low pass filter whilst **Figure 2** shows a Smith Chart representation of the match between 430 and 440MHz on a Maspro 8-ele Yagi. For convenience the plot was taken at the input end of the coaxial feeder. Normally the cable would have been normalised out of the match by doing a calibration at the end of the cable where it connects to the Yagi. Although there isn't space to show the results here, I also had the chance to try out the VNWA3 time domain reflectometer mode, which worked well.

What is likely to be of equal interest is a comparison in accuracy between the VNWA3 and an expensive vector network analyser. For this review I assembled a simple network termination consisting of a 100Ω chip resistor connected in parallel with a 10pF chip capacitor. These were soldered at the end of a short length of microstrip transmission line on an FR4 PCB. Both chip components were high precision 0603 size surface mount parts. An SMA edge connector allowed connection between the microstrip and the coaxial connecting cable. My Hewlett Packard HP8753C network analyser, HP85046A S parameter test set, HP85052 3.5mm calibration kit and HP test cable cables were used for the comparison measurements.

The results from these measurements, at several spot frequencies, are shown in **Table 1**.

IMPRESSIONS OF THE VNWA3. This is a very versatile instrument. It should provide the radio amateur with the means to test and measure the impedance and transmissions characteristics of almost any circuit or network up to at least 500MHz with good accuracy and from 500 to 1300MHz with sufficient accuracy to give a good indication of circuit performance.

I was a little disappointed with the software interface. I found it was not very intuitive to use and I spent quite some time searching the interface for some of the measurement facilities. Having said that, once you become familiar with the interface it then becomes a lot easier (and quicker) to use.

My comparison of the VNWA3 results against those from my own HP network analyser system showed the accuracy of the VNWA3 compared well up to 500MHz. At the higher frequencies the limiting performance is mainly due to 'spikes' in the DDS local oscillator output, together with the reduced performance of the mixers above 500MHz.

Much of the accuracy of any analyser measurement will depend on the quality of the calibration kit used and the amount of care taken during calibration. If you are going to order one of these excellent analysers, make sure you either have access to a good calibration kit, or order the VNWA3 with the calibration kit option.

I would like to thank Jan Verduyn of SDR-Kits for the loan of the review VNWA3. The basic instrument is available from SDR-Kits for £400 and an analyser in presentation case, complete with short SMA cable, calibration kit and USB lead costs £456. And yes, I bought the review analyser!

WEBSEARCH

[1] DG8SAQ – www.mydarc.de/dg8saq
[2] SDR-Kits – www.sdr-kits.net