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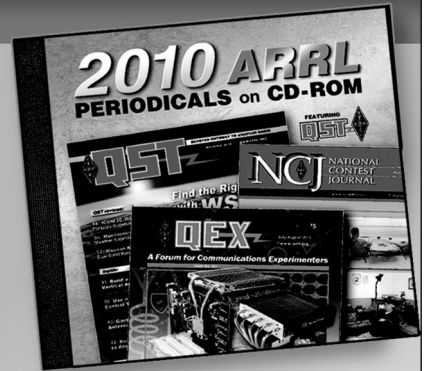
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Array Solutions VNA 2180 Vector Network Analyzer

Reviewed by Phil Salas, AD5X
QST Contributing Editor

In August 2007 *QST*, the ARRL reviewed the Array Solutions AIM 4170 antenna analyzer.¹ The reviewer pointed out that "... the accuracy is exceptional and caused us to go back and check the calibration of our reference loads..." and "... the AIM 4170 is really more of a laboratory instrument..." I couldn't agree more as I've found the AIM 4170 to be indispensable for my home lab work. And while the AIM 4170 has been outstanding in all that it does, I've wanted a two port version so I could design and analyze two port devices. Enter the VNA 2180 Vector Network Analyzer, developed by Bob Clunn, W5BIG, and Array Solutions — the same team that brought the AIM 4170 to market.

What is a Vector Network Analyzer?

A vector network analyzer (VNA) applies an RF signal to the device under test (DUT) and measures the resulting voltages and currents. The word *vector* in its name means the VNA measures both the magnitude *and* phase of these parameters. The term VNA is usually applied to an instrument with separate output and input ports. For convenience, these ports can be labeled A and B. A related instrument, referred to as a vector impedance meter or antenna analyzer, has a single port.

The VNA measures the impedance of antennas or components at port A. Port B provides additional capability for measuring more complex circuits, such as filters and amplifiers, which have separate inputs and outputs.

Measurement accuracy is significantly improved by calibrating the system with loads that have known characteristics. Typically, the calibration procedure uses four items: a short circuit, an open circuit, a resistor and a cable. The open, the short and the resistor are used to calibrate one port and the cable is connected between both ports to calibrate their relative gain and phase. The raw measurement data is compensated



with the calibration data and then used to calculate properties of the DUT. These data are displayed in a variety of ways such as resistance, reactance, SWR, return loss, Smith charts and S-parameters.

S-parameters, or network scattering parameters, are the complex transmission and reflection coefficients of the DUT. Detailed information on S-parameters is beyond the scope of this discussion and the interested reader is encouraged to pursue this subject via Internet sources. For purposes of this review, Port B S21 data (transmission) is displayed as gain/loss in dB, and S11 data (reflection) is displayed as return loss in dB.

VNA 2180 Description

The VNA 2180 is a two port instrument in which Port A is an enhanced version of the AIM 4170 featuring increased frequency range, a higher output signal with a programmable level and the ability to handle a higher interfering signal level while making antenna measurements. The VNA 2180 also has a built-in optically isolated USB interface that reduces the effects of ground loops. As this review focuses on the Port A-to-Port B transmission path capability of the VNA 2180, refer to the AIM 4170 review for the Port A features. The complete VNA 2180 specifications are shown in Table 3.

As with the AIM 4170, the VNA 2180 relies on your computer for calculations,

display and control functions. The software is very intuitive and software updates are readily available. The software has been tested with *Windows 2000, XP* and *Vista*, as well as the 32 and 64 bit versions of *Windows 7*. It requires no installation procedure — it can run directly from a flash drive or CD if desired. You can even download the VNA 2180 manual and software from w5big.com and run the software in demo mode to get a feel for the product prior to purchasing it.

Preparing to Use the VNA 2180

The VNA 2180 hardware is housed in a small metal cabinet with two type N connectors and indicator LEDs on the front. The back panel has a POWER jack, USB jack for connection to your computer and an expansion port for future use. (A six channel multiplexer is available for use in setting up antenna arrays.)

Included with the package are three standard N connector calibration loads (open, short and 50 Ω load — Figure 1), an ac power supply, a 2.1 mm dc cable, two short N male terminated cables and a USB interface cable. An optional universal global power supply is available. The latest software and manual can be downloaded from w5big.com.

Calibration requires no tools or adjustments, and you'll have everything up and running in a few minutes. The VNA 2180 uses N connectors for both Ports A and B, so you may want to purchase appropriate adapters for measurements on devices requiring BNC and UHF connectors. While not absolutely necessary for many lower frequency measurements, for maximum accuracy you'll also want BNC and UHF calibration loads. Fortunately, these are easy to build. See my companion article on the QST-in-Depth website for details on building your own calibration loads.²

Using the VNA 2180

My first project was a low pass filter needed to clean up the square wave output

Bottom Line

The Array Solutions VNA 2180 brings powerful vector network analyzer capabilities to the home workshop. It harnesses the power of your computer for control and display functions, bringing the cost to a level comparable to surplus commercial equipment with unknown issues or accuracy.

¹J. Hallas, W1ZR, "Three Antenna System Measurement Devices," Product Review, *QST*, Aug 2008, pp 67-73. Past *QST* reviews are available to ARRL members at www.arrl.org/product-review.

²See "Building BNC and UHF Calibration Loads for the VNA 2180" available on the ARRL website at www.arrl.org/qst-in-depth.



Figure 1 — The Array Solutions VNA 2180 Vector Network Analyzer is supplied with three calibration loads.

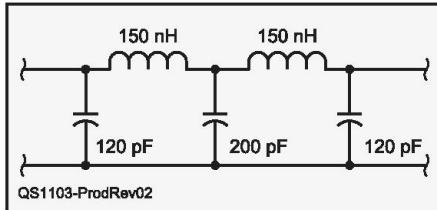


Figure 2 — Low pass filter schematic.

of a 50 MHz TTL clock oscillator for use as a standard signal source for calibrating attenuators. The schematic of the filter is shown in Figure 2.

The VNA 2180 measured filter response is shown in Figure 3, which highlights the ability to set vertical markers on the swept response, as well as to simultaneously display S11 (blue trace) and S21 (green trace). Up to 20 vertical markers can be set. I set markers at the 50 MHz fundamental and 2nd harmonic (100 MHz). The vertical cursor is placed at the 3rd harmonic (150 MHz), where I wanted maximum rejection. Note that if scanning a filter, Port B provides a

50 Ω termination for the filter's output port.

My next project was a resistive 50 dB tap covering 1.8 to 148 MHz to permit looking at transmitter RF output on a spectrum analyzer. The circuit is shown in Figure 4. The two paralleled 16 Ω, 2 W metal film resistors provide the necessary power dissipation for up to a 600 W amplifier.

The VNA 2180 software permits setting an offset attenuation value while simultaneously permitting a fine attenuation range. In this way you can look at fine variations in attenuation, even at the 50 dB tap point. I set an offset of 45 dB with a measuring resolution of 0.5 dB. In my initial circuit, the isolation degraded at higher frequencies because of stray capacitance across the paralleled resistors (even a few picofarads impacts isolation at higher frequencies in a high impedance circuit). I added a 62 pF capacitor across the 50 Ω resistor to compensate for this. Figure 5 shows the final swept response. The three horizontal markers are on the 10, 6 and 2 meter ham bands. Horizontal rulers at -49 dB and -51 dB show that the tap circuit provides 50 dB ±1 dB attenuation in all ham bands through 2 meters.

Next I wanted to characterize a home-made four element crystal filter. I ran two scans. The first (not shown) measured the ultimate rejection of this crystal filter, which is in excess of 100 dB just 5 kHz to either side of the 9.998 MHz center frequency.

The second scan (Figure 6) has a narrowed passband and increased vertical resolution to better see the passband response. The VNA 2180 software calculates the shape factor of the filter for you if you insert horizontal rulers at the desired measuring points. Because the filter loss is approximately 4.5 dB, horizontal rulers were set at

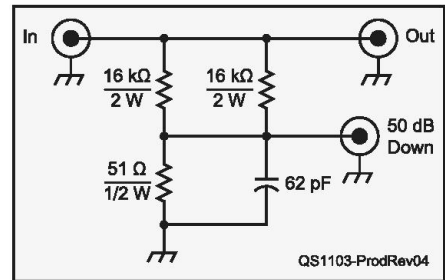


Figure 4 — Schematic of the 50 dB resistive tap. After measuring the initial circuit with the VNA 2180, the 62 pF capacitor was added to compensate for stray capacitance.

-10.5 dB and -64.5 dB so as to calculate the standard 6/60 dB shape factor.

Finally, I looked at a commercially available 40 meter bandpass filter. This type of filter is used in contest environments to protect a receiver from high power adjacent band transmitters and nearby antennas. A broadband scan is shown in Figure 7. This filter has rejection specifications of 42 dB (horizontal red ruler) on 80 meters, and 70 dB (horizontal blue ruler) on 20 meters. Note the simultaneous display of both S11 (dark blue trace) and S21 (dark green trace). Vertical markers are set at 4 MHz and 14 MHz. The vertical cursor is placed within the 40 meter band to show the in band insertion loss (0.430 dB).

Conclusion

The VNA 2180 is a lab grade analyzer that you will find to be an indispensable item for both home and industrial lab environments. With software and firmware updates available for download at no charge, you don't

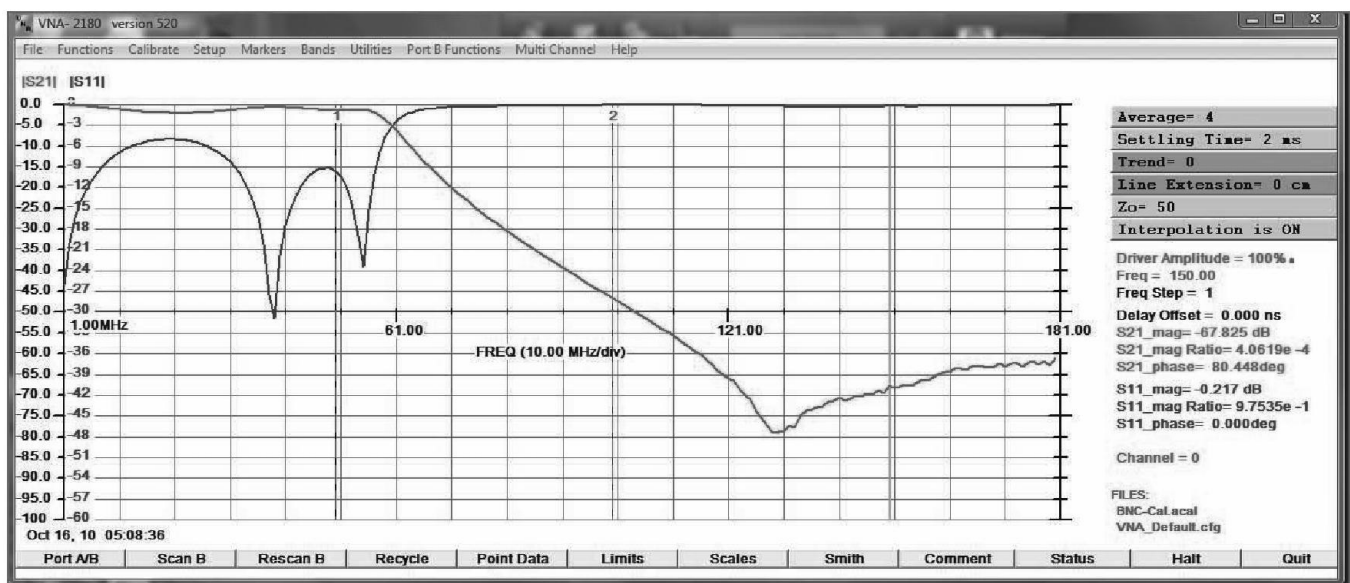


Figure 3 — Low pass filter swept response. Markers are at 50, 100 and 150 MHz.

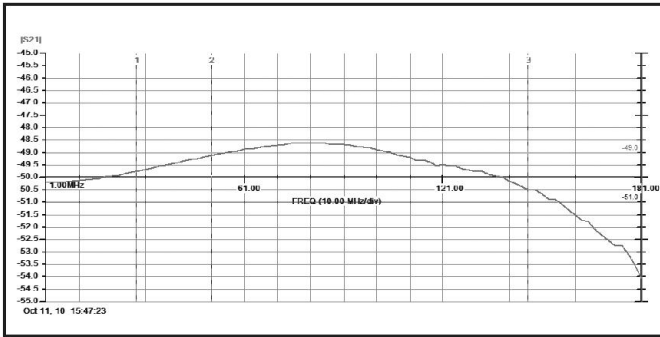


Figure 5 — Sweep of the compensated 50 dB resistive tap. Vertical rulers are on 10, 6 and 2 meters. Isolation at higher frequencies is much improved compared with the original version.

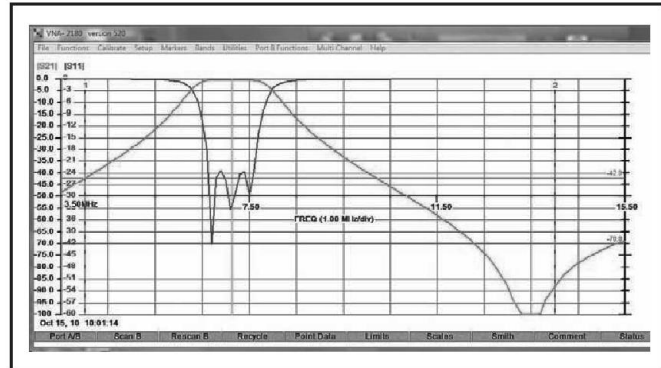


Figure 7 — 40 meter band-pass filter response.

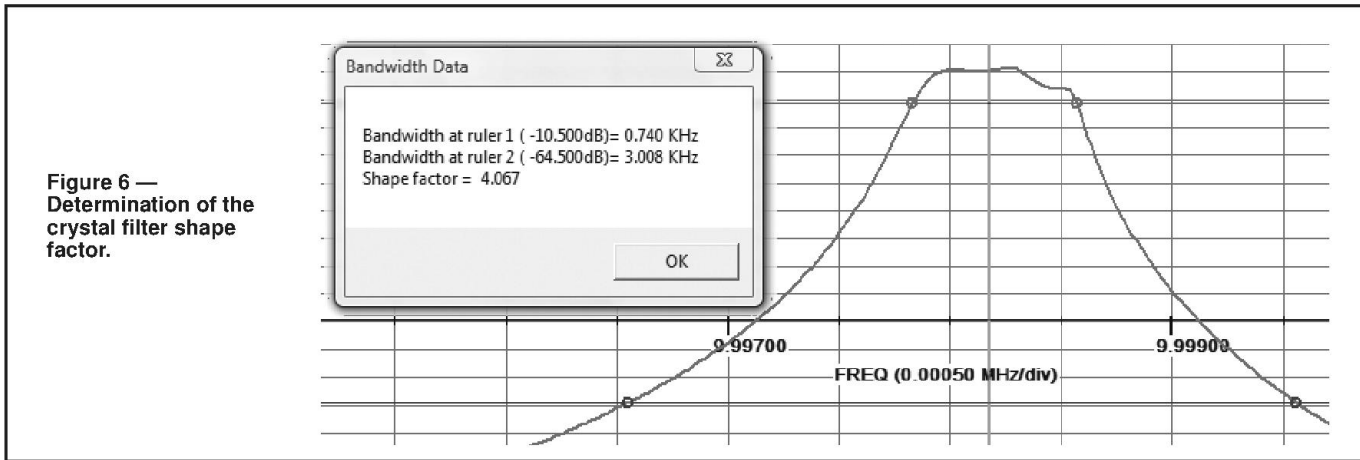


Figure 6 — Determination of the crystal filter shape factor.

Table 3
Array Solutions VNA 2180, serial no. 5107

Parameter	Manufacturer's Specifications
Power requirements:	11-15 V dc, 500 mA max.
Frequency range:	5 kHz to 180 MHz.
Stability:	±25 ppm.
Frequency step size:	1 Hz minimum.
ADC resolution:	12 bits.
SWR measurement range:	1 to 20.
Impedance measurement range:	1 Ω to 5 kΩ.
Accuracy:	±5% to 60 MHz, ±10% to 180 MHz.
Phase angle:	±180° (true phase).
RF output:	+8 dBm max, nominal output Z = 50 Ω.
Spurious output	-30 dBc or better.
Max stray RF input while measuring:	2 V peak (+16 dBm).
Max safe RF input:	5 V peak (+24 dBm).
S21 nominal dynamic range:	100 dB up to 50 MHz, 80 dB to 160 MHz.
Port B nominal input impedance:	50 Ω (return loss >30 dB).
Display: Graphics output on PC. Mouse controlled cursor for digital parametric readout.	
User-specified frequency markers. Audible tone and speech output for SWR.	
Displayed parameters: SWR, S11, Return loss, Z , Phase angle of Z , S21, R _S , X _S , R _P , X _P	
Reactance shown as inductance (μH) or capacitance (pF) according to phase angle.	
Two Smith Charts with zoom, phase offset and markers.	
Data can be referenced to the antenna terminals. Calibration is software controlled.	
Size (height, width, depth):	1.5 × 7 × 5.3 inches.
Price:	\$1495 with standard US ac power supply.

have to worry about product obsolescence. I've only touched on some of the transmission capabilities of this instrument. As an example, group delay measurements permit you to determine the length of cables and potential distortion in filters. There is also an external port with both digital I/O and analog input capability for possible control and monitoring of other accessories. Finally, there is a wealth of measuring and analysis capabilities associated with Port A. Detailed information and the complete manual are available for further investigation at w5big.com.
Manufacturer: Array Solutions, 2611 North Beltline Rd, Suite 109, Sunnyvale, TX 75182; tel 214-954-7140; www.array-solutions.com. Price: \$1495 with the standard US ac supply; \$1524 with the universal global ac supply.

