Product Review and Short Takes from *QST* Magazine

August 2007
Product Reviews:

Short Takes:

Three Antenna System Measurement Devices

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QST *Technical Editor*

Since this is the annual antenna issue, we thought we'd take the opportunity to look over several new antenna related test systems. We've already looked at some related devices, including a collection of hand-held portable antenna analyzers in May 2005 *QST* and a pair of antenna analyzers with graphical readout in November 2006.[1,2] In January 2006, it was the Array Solutions PowerMaster wattmeter, followed by the Alpha 4150 power meter in July.[3,4] It shouldn't be a surprise that both manufacturers and Product Review editors commit so much time to this product area — knowing how your antenna is acting and how much power your radio is putting into it are perhaps the most important factors behind successful station operation.

This time we will look at units in both the analyzer and power meter camps, but all have a bit new to add to the mix. You may want to look over the earlier reviews as part of your assessment of these units to decide which type best fits your application requirements. We describe each below — in alphabetical order.

[1]J. Hallas, "A Look at Some High-End Antenna Analyzers," Product Review, *QST*, May 2005, pp 65-69. *QST* Product reviews are available on the Web at **www.arrl.org/members-only/prodrev/**.
[2]J. Hallas, "Antenna Analyzers with a Different View," Product Review, *QST*, Nov 2006, pp 70-74.
[3]M. Wilson, "Array Solutions PowerMaster Wattmeter," Product Review, *QST*, Jan 2006, pp 70-72.
[4]J. Carcia, "Alpha Power 4510 Wattmeter," Product Review, *QST*, Jul 2006, pp 62-64.

ARRAY SOLUTIONS AIM4170 ANTENNA ANALYZER

The AIM4170 is an enhanced version of the antenna impedance meter designed by Bob Clunn, W5BIG, and presented in a recent *QST* construction article.[5] You may want to scan that article before you read further. This model extends the frequency range to 0.1 to 170 MHz from the HF-only version described in *QST*. The unit attaches to your PC with a serial cable, or to a USB port with an optional adapter and cable. Calibration loads are provided to allow easy setup using menu items on the PC. A BNC coax connector on the front of unit is used to connect to the sample to be tested, and that's all that happens at the AIM4170, the rest is done from the PC.

[5]B. Clunn, "An Antenna Impedance Meter for the High Frequency Bands," *QST*, Nov 2006, pp 28-32.

What's it Do?

A 61 page manual is included on the CD-ROM provided with the unit, as well as a 10-page *Quick Start* guide. Operation is very straightforward. You just tell the software what you want to measure, the desired frequency range and resolution and the type of display — rectangular coordinates or Smith chart — and out it comes.

As noted in Table 1, the accuracy is exceptional and caused us to go back and check the calibration of our reference loads to make sure we were getting the whole story. Note that while some antenna analyzers are designed to give you a quick answer at a single data point while at the top of your tower, the AIM4170 is really more of a laboratory instrument designed to give you a whole suite of data from the bottom end of your feed line. The manual offers two methods of modifying the output to transform the data to what would be seen at the antenna. There is room for both types of analyzers, in my opinion, in the serious amateur's station inventory.

Bottom Line

High accuracy, ease of use and multiple output parameters make the AIM4170 a great addition to your home laboratory.

Figure 1 shows the default output, and it looks a bit overwhelming until you decide to select the parameters of interest. Once you deselect the parameters you don't want to look at, it becomes very manageable as shown in Figure 2. In addition to the plotted data, a click on any frequency will provide you with the tabular data for that frequency on the right hand side of the screen.

Setting Your Tuner

A great application for some analyzers

Table 1
Array Solutions AIM 4170 Antenna Impedance Meter, serial number 202

Manufacturer's Specifications	*Measured in the ARRL Lab*
Frequency range: 0.1-170 MHz.	As specified.
Frequency accuracy: Not specified.	2.3 ppm (after warm up).
Impedance range: 1-2000 Ω.	Better than 5-1000 Ω.
Impedance accuracy: 1 Ω ±5% 0.1-60 MHz; 10% 60-170 MHz.	See Table below.
Drift: 30 ppm.	4.2 ppm in 30 min.
Output power: 20 µW max, load not specified.	15 µW into 50 Ω.
Power requirements: 250 mA, 6-15 V dc.	250 mA at 13.8 V dc.
Size (height, width, depth): 2 × 5 × 4 inches.	
Price: AIM4170, $495; USB adapter and cable, $14.	

Impedance and SWR Measurements

Load	*Frequency*	*Array Solutions AIM4170*	*Agilent 4291B (reference)**
50 Ω, (1:1 SWR)	3.5 MHz	50.1+*j*0.1 Ω, (1.0:1)	50+*j*0 Ω**
	14 MHz	50.1+*j*0.1 Ω, (1.0:1)	50+*j*0 Ω
	28 MHz	50.0+*j*0.1 Ω, (1.0:1)	50+*j*0 Ω
	50 MHz	50.1+*j*0.1 Ω, (1.0:1)	50+*j*0 Ω
	144 MHz	49.9+*j*0.1 Ω, (1.0:1)	50+*j*0 Ω
5.0 Ω, (10:1 SWR)	3.5 MHz	5.0+*j*0 Ω, (9.9:1)	5.1+*j*0.0 Ω
	14 MHz	5.0+*j*0.3 Ω, (10.0:1)	5.1+*j*0.2 Ω
	28 MHz	5.1+*j*0.4 Ω, (9.6:1)	5.1+*j*0.4 Ω
	50 MHz	5.1+*j*0.7 Ω, (9.7:1)	5.2+*j*0.7 Ω
	144 MHz	5.2+*j*1.7 Ω, (9.5:1)	5.2+*j*1.9 Ω
25 Ω, (2:1 SWR)	3.5 MHz	25.3–*j*0.1 Ω, (2.0:1)	25.1+*j*0 Ω
	14 MHz	25.3+*j*0.2 Ω, (2.0:1)	25.1+*j*0.2 Ω
	28 MHz	25.3+*j*0.3 Ω, (2.0:1)	25.1+*j*0.4 Ω
	50 MHz	25.2+*j*0.4 Ω, (2.0:1)	25.1+*j*0.7 Ω
	144 MHz	25.5+*j*0.9 Ω, (2.0:1)	25.2+*j*2.0 Ω
100 Ω, (2:1 SWR)	3.5 MHz	101+*j*0.2 Ω, (2.0:1)	100–*j*0.2 Ω
	14 MHz	101–*j*0.5 Ω, (2.0:1)	100–*j*0.9 Ω
	28 MHz	101–*j*0.4 Ω, (2.0:1)	101–*j*1.8 Ω
	50 MHz	101–*j*1.0 Ω, (2.0:1)	99.9–*j*3.1 Ω
	144 MHz	100–*j*3.5 Ω, (2.0:1)	99–*j*8.9 Ω

Load	*Frequency*	*Array Solutions AIM4170*	*Agilent 4291B (reference)**
200 Ω, (4:1 SWR)	3.5 MHz	202–*j*0.7 Ω, (4.1:1)	201–*j*1.2 Ω
	14 MHz	202–*j*2.3 Ω, (4.0:1)	201–*j*4.8 Ω
	28 MHz	201–*j*2.1 Ω, (4.0:1)	200–*j*9.4 Ω
	50 MHz	202–*j*4.2 Ω, (4.0:1)	199–*j*16 Ω
	144 MHz	201–*j*12 Ω, (4.0:1)	189–*j*45 Ω
1000 Ω, (20:1 SWR)	3.5 MHz	1030–*j*16 Ω, (20:1)	998–*j*33 Ω
	14 MHz	999–*j*19 Ω, (20:1)	981–*j*127 Ω
	28 MHz	986–*j*14 Ω, (20:1)	935–*j*239 Ω
	50 MHz	1000–*j*39 Ω, (20:1)	825–*j*373 Ω
	144 MHz	935–*j*191 Ω, (20:1)	373–*j*476 Ω
50 – *j*50 Ω, (2.62:1 SWR)	3.5 MHz	48.5–*j*45.4 Ω, (2.4:1)	50–*j*47 Ω
	14 MHz	47.0–*j*51.2 Ω, (2.8:1)	48–*j*52 Ω
	28 MHz	50.1–*j*47.0 Ω, (2.5:1)	51–*j*48 Ω
50 + *j*50 Ω, (2.62:1 SWR)	3.5 MHz	50.5+*j*49.0 Ω, (2.6:1)	52+*j*50 Ω
	14 MHz	51.2+*j*47.5 Ω, (2.5:1)	53+*j*48 Ω
	28 MHz	62.3+*j*50.1 Ω, (2.4:1)	65+*j*51 Ω

Notes

*The SWR loads constructed in the ARRL Lab were measured on an Agilent 4291B Impedance Analyzer by ARRL Technical Advisor John Grebenkemper, KI6WX.

**An HP 11593A precision termination was used for the 50 Ω tests. This termination has a wide frequency range.

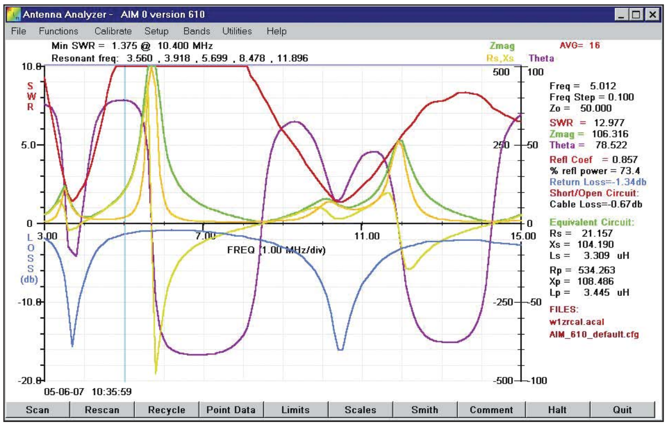


Figure 1 — AIM4170 default output with plots of almost all possible outputs in living color.

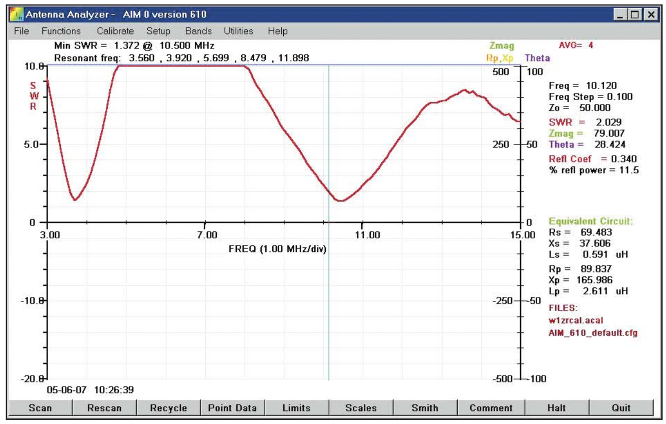


Figure 2 — AIM4170 output with just an SWR plot. Seems a bit easier to grasp.

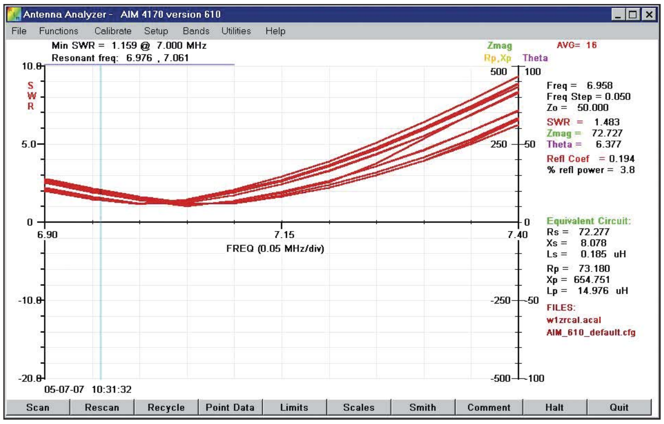


Figure 3 — Family of curves as I adjusted my tuner for an SWR of less than 2:1 over the 40 meter CW segment.

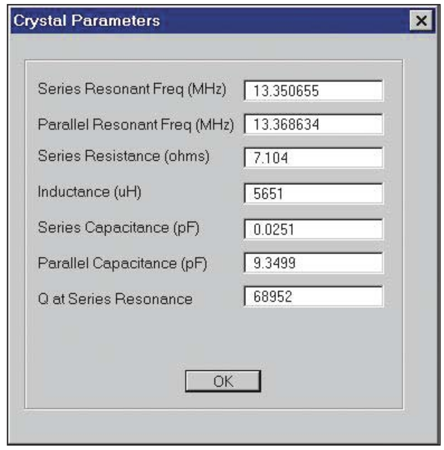


Figure 4 — AIM4170 output while measuring crystal parameters.

Some Notes on Impedance Measurement

What most folks who use antenna analyzers are interested in is the direct reading of the instrument. You hook it to your coax, and it tells if the antenna on the other end is too long or too short, or where it actually resonates, and what the impedance is (at the end of the coax). You can also use one with an antenna tuner to determine nearly correct settings without applying full transmitter power. Similarly, you can use one to test the performance of your antenna tuner.

However, to test the analyzer itself, typically a series of known resistors is attached to the analyzer using short connections and a connector adapter or two. As can be seen from past *QST* Product Reviews of antenna analyzers, this approach works quite well at HF. At VHF, however, there can be a significant problem due to a change in what is known as the *plane of measurement*. Simply stated, the plane of measurement is the point at which the actual measurement is made. This is important because if a coax is connected to an impedance other than its characteristic impedance, the impedance seen at the other end is generally something quite different.

While 2 inches of connector adapters may not seem like much, they can produce quite a change in measured impedance from the actual values connected to the other end. The ideal way to make such measurements is to "calibrate" the test setup by measuring an open circuit and a short circuit, at the same point at which you want to measure your impedance and then correct for the change imparted by the connector adapters. Although you can do this manually, the AIM 4170 does this for you, so it removes the effects of connectors and cables from the measurement you really want to make. All of the other antenna analyzers currently on the market do not have this feature, so you would have to make the correction by hand to get the most accurate numbers.

All of this doesn't really matter to most folks because they are making measurements near an antenna's resonance where the impedance change is small. It is helpful for users to be aware of this, and to make sure it is accounted for in situations in which the impedance you are measuring is quite different from the feed line you are using.

— Michael Tracy, KC1SX, ARRL Laboratory Engineer

is presetting your antenna tuner, avoiding interference on frequency and reducing the strain on your transceiver and tuner. I found that with some practice, and by not having excessive resolution to slow the processing, I could use the swept function to set my tuner to cover a range of frequencies. Figure 3 shows the family of curves as I adjusted the tuner to have an SWR less than 2:1 over the CW portion of the 40 meter band with my center-fed Zepp.

What Next?

The manual describes many possible applications, including measuring crystal parameters — so don't just think antennas. This is a measurement tool that can be used for a number of other applications as well. For example with a BNC-to-clip lead adapter, it becomes an easy matter to measure the reactance of components to determine their value. Perhaps even more importantly, it is now easy to locate the parallel resonance of an RF choke, or the series resonance of that bypass capacitor, for example.

Did I say crystal? If you're trying to make a crystal lattice filter, select a crystal for your QRP net frequency, or just find out what the story is with that box of strangely marked surplus crystals you couldn't leave behind at a hamfest, just clip one on, select CRYSTAL mode and see the story as shown in Figure 4. One caution, the analyzer asks for the crystal frequency before it starts. If you put in a frequency very different from the actual frequency, it will give you data that looks real but isn't. The easy solution is to do an impedance scan at narrow resolution (I found 0.010 kHz steps worked well) and the real resonant frequency will be obvious.

The AIM4170 software and documentation has undergone several updates and revisions since introduction, and new versions are available by download. It's worth checking the Array Solutions Web site periodically to see what's new. All in all, this appears to be a very useful and accurate station accessory.

Manufacturer: Array Solutions, 350 Gloria Rd, Sunnyvale, TX 75182; tel 972-203-2008; **www.arraysolutions.com**

Table 2
TelePost Model LP-100, serial number 260

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency range	1.8-54 MHz.
Power range	0.05-3000 W (peak).
Power requirement	11-15 V dc, 160 mA.
PEP measurement	Active.*

Size (height, width, depth): Controller, 2.75 × 6 × 6 inches; weight, 3 pounds.
Price: LP-100 kit version, $310; factory assembled, $410.
Add $25 for Type N connectors instead of the standard UHF type.

Actual Forward Power	Measured Peak Power (W)			
Frequency (MHz)	*2*	*14*	*28*	*50*
5 W CW	5.0	4.8	4.8	5.0
5 W 50%	5.0	4.7	4.9	5.1
100 W CW	100	98	97	100
100 W 50%	99	98	96	100
100 W Two-Tone	–	93	–	–
1 kW CW	980	990	1000	–**
1 kW 50%	1040	1050	1100	–
SWR Accuracy				
1:1 SWR	1.0:1	1.0:1	1.1:1	1.1:1
2:1 SWR	2:1	2:1	2:1	2:1
Insertion Loss (dB)	<0.1	<0.1	<0.1	<0.1

Notes
*For PEP monitoring, *Active* indicates that a circuit requiring external power is used.
**A 1000 W amplifier for 6 meters was not available at the time of testing.
– Not measured.

TELEPOST LP-100 HF DIGITAL VECTOR WATTMETER

The LP-100 wattmeter is an enhanced version of the design Larry Phipps, N8LP, described in the Jan/Feb 2006 issue of *QEX*.[6] This unit is an autoranging in-line wattmeter, available either as a kit or as a factory assembled and tested unit. (We opted for the factory assembled version.) The LP-100 is specified to operate from HF through 54 MHz at power levels from 50 mW to 3000 W (peak). While the unit can operate under PC control, and can provide plots and additional output formats using the PC, it can also perform its basic functions as a standalone unit.

A Plain Old Digital Wattmeter — Plus

The in-line directional coupler assembly that goes between your transmitter and antenna system is in a separate enclosure that can be mounted conveniently away from your operating position where you would likely want the meter display unit. This avoids the need to run extra antenna feed line cable to your operating position. The supplied cables are 6 feet long, but longer lengths can be accommodated if the calibration procedure is redone.

The interesting twist with this wattmeter is that in addition to providing power and SWR indication, it can also provide a measurement of impedance in both magnitude and phase and resistive and reactance units. I don't think I've previously encountered a wattmeter with this capability — hence its name *Vector Wattmeter*. As noted in the documentation, the meter does not know the sign of the reactance (or phase angle). For any situation I've encountered, the sign can readily be determined by noting the

[6]L. Phipps, "The LP-100 Wattmeter," *QEX*, Jan/Feb 2006, pp 3-13.

Figure 5 — The LP-100's front panel readout can display power in dBm and return loss in dB in addition to power in watts and SWR. In the vector mode, the display shows impedance. The top line is magnitude and phase, and the bottom line shows resistive and reactive components.

Bottom Line

The LP-100 is an accurate high-resolution in-line power meter with flexible output formats and the added output of vector impedance data, so you know what's happening out there.

change in reactance upon a slight (make sure there's no zero crossing) upward shifting of frequency. If the reactance goes up, it's inductive — down it's capacitive.

Measuring complex impedance at transmit power levels has a subtle advantage over the typical flea power antenna analyzer. Those can sometimes give false readings caused by strong local signals being picked up by the antenna you are trying to measure. This is a chronic problem for those living near broadcast stations, especially if trying to take data on large lower frequency HF antennas.

But Wait — There's More!

Many hams will be happy just displaying an accurate indication of the power and SWR. The FAST/SLOW button affects the way the numerical readout responds. Pressing this button toggles among FAST, PEAK-HOLD and TUNE modes. PEAK-HOLD shows the highest level reached during an interval — very handy, especially for SSB operators who sometimes get nervous if they aren't sure they are getting all the peak power that they paid for. TUNE is intended for adjusting a power amplifier with a pulser and locks the bargraph in the high power range to prevent range hunting.

For those who like to think in terms of other units, choices include power measured in dBm (decibels referenced to a milliwatt) and *return loss* (ratio of reflected to outbound power in decibels) in place of the usual SWR. See Figure 5 for an example of this display.

The power range is automatically set to provide appropriate significant digits and to set the top of the bargraph range. Calibration is adjustable in 0.1% steps, if you have access to a more accurate calibration standard. The calibration is also temperature compensated and can be calibrated on a band by band basis to improve accuracy. There is also a mode that can be used as a field strength meter.

An SWR alarm can be set to disable the PTT or your amplifier key line and alert you if antenna system SWR exceeds a preset value. Standard choices are off, 1.5, 2, 2.5 and 3, but the user can program any value from 1:1 to 5:1. The alarm threshold is adjustable to prevent false alarms when energy from another transmitter is picked up by the antenna (at a multitransmitter contest station or Field Day site, for example).

A calibrated field strength mode is also provided. It has a range of –15 to +33 dBm.

The LP-100 has Software, Too!

Operating software, available from **www.telepostinc.com**, provides a screen indicating what's happening. The full display is shown in Figure 6. Once you have selected the outputs and settings you want, you can change the screen to show just the bargraphs. The graphs can then be moved to an unused

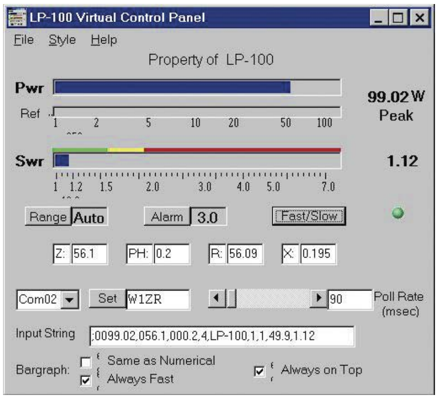


Figure 6 — LP-100 *Virtual Control Panel* software display. Once you set the parameters, a smaller version of the display can be selected.

corner of your PC display and you can keep an eye on operation at the same time that you operate your logging and control program.

There is also a separate plotting routine that can be used to generate SWR or impedance plots. The plots can be automatically generated through a second serial connection to the radio, so that the plot program can send frequency and PTT commands to the radio as it collects impedance data from the LP-100.

Impedance plots include an algorithm that determines the sign of the reactance at each measurement point providing a true measure of the impedance for each. The output format can be selected to show R ±*j*X, (R represents the resistive part of the impedance, *j*X the reactance, positive for inductive, negative for capacitive), or magnitude and phase angle. Other plots include Smith chart, return loss and reflection coefficient. Additional features are under development.

Documentation

A 37 page manual is downloadable from the TelePost Web page. It serves as an assembly manual for the kit version as well as an operation manual for the completed unit. The instructions are clear and straightforward, describing hardware and software operation.

A look at the assembly instructions gives us a glimpse of the kit version, even though we didn't order that one. The few surface mount parts come preassembled. The remaining parts seem to be the through-hole mounting type that most of us prefer. Assembly seems straightforward. Don't expect a *Heathkit* type manual with a separate step for each connection, though. This appears to be a kit intended for the experienced home constructor. For example: "Install all of the .01 µF caps (marked 103), in groups of about 6."

The LP-100 firmware, software and documentation is updated regularly to improve operation or add features. Firmware updates are downloaded from the TelePost Web site (using a proprietary loading routine e-mailed to purchasers) and installed from your PC using supplied software. We updated our LP-100 firmware to the latest version, and the process was painless.

Manufacturer: TelePost, 49100 Pine Hill Dr, Plymouth, MI 48170; tel 734-455-3716; **www.telepostinc.com**.

WAVENODE WN-2 STATION MONITORING SYSTEM

The WaveNode WN-2 is an updated version of the WN-1 we reviewed in October 2004.[7] During lab testing, we noticed that this model has improved accuracy. Another major difference is that the WN-2 includes an LCD numerical and bargraph display — the WN-1 had output just via a computer. The WN-2 can thus be operated as a standalone unit, although it clearly shows its stuff when computer connected. In addition, responding to the trend in PC ports, the WN-2 has a USB connection in place of the WN-1's connection to a parallel (printer) port.

The normal LCD display function (Figure 7) provides an output of both peak and average power and SWR for any of the four power sensors (see below). A bargraph indicating real time power output is shown simultaneously. In addition, the unit can be set to alarm on high SWR and trip a relay that could be used to disable a linear amplifier, for example. Even without a connected computer, this display can show you much of what's happening through the WN-2.

Check Your Operating System

You will want to connect your WN-2 to

[7]J. Hallas, W1ZR, "WaveNode WN-1 Station Monitoring System," Product Review, *QST*, Oct 2004, pp 71-74.

Figure 7 — The WN-2's numerical readout shows peak power, average power, SWR and sensor (up to four sensors can be connected at one time), as well as a bargraph for power output.

Bottom Line

The WN-2 provides a wide range of station information in flexible ways. The ability to simultaneously monitor up to four radios makes it particularly useful for some station configurations.

Table 3
WaveNode WN-2 (no serial number)

Manufacturer's Specifications	*Measured in the ARRL Lab*
Frequency range	Sensor dependent.
Power range(s)	20/200/2000 W (HF-1 sensor).
Power requirement	9-16 V dc, 200 mA.
PEP measurement	Active.*

Size (height, width, depth): Controller, 1.875 × 6.25 × 5.5 inches; weight, 3 pounds.
Price: WN-2 System (includes one sensor, cable and software), $385; additional sensors, $55 to $88 each, depending on model.

Actual Forward Power	**HF-1 Sensor Measurement**			
Frequency (MHz)	***2***	***14***	***28***	***50***
5 W CW (avg)	4	4	4	2
5 W CW (peak)	4	5	5	3
5 W 50% (peak)	4	5	5	3
100 W CW (avg)	97	104	103	102
100 W CW (peak)	97	104	103	102
100 W 50% (peak)	99	104	105	103
100 W Two-Tone (peak)	–	100	–	–
1 kW CW (avg)	990	1050	1100	–**
1 kW CW (peak)	990	1050	1100	–
1 kW 50% (peak)	1040	1100	1170	–
SWR Accuracy (worst case)				
1:1 SWR	1.0:1	1.0:1	1.0:1	1.1:1
2:1 SWR	2.3:1	2.0:1	2.1:1	2.0:1
Insertion Loss (dB)	<0.1	<0.1	<0.1	<0.1

Notes
*For PEP monitoring, Active indicates that a circuit requiring external power is used.
**A 1000 W amplifier for 6 meters was not available at the time of testing.
– Not measured.

a PC though, to use its advanced functions and measurement capabilities. I confirmed that the WN-2 software won't work on old clunker PCs such as the one in my shack that runs on *Windows 98*. If your shack is as computer challenged as mine, the WN-1, with connectivity via the parallel port, is still available and is less expensive. It may be worth a look if you don't need the front panel LCD. The WN-2 is specified to work with newer versions of *Windows*, and came up just fine on the new laptop loaned by my wife Nancy, W1NCY, running *Windows XP*. Perhaps the requirement for USB-2 support is the actual limitation. In any case, modern PCs should be compatible.

Multiple Sensors Supported

As is the case with the WN-1, multiple sensors are available, and there is room to plug in up to four in at a time. HF (to 60 MHz) sensors are available in ranges 0 to 60 W (LP-1), 0 to 2000 W (HF-1) and 0 to 8000 (!) W (HF-8KW), neatly lining up with the recent trend of "HF" transceivers covering through 6 meters. They also offer a UHF-1 sensor covering 140 to 460 MHz at a power range of 0 to 500 W and a UHF-2 that covers 120 to 170 MHz at up to 2000 W. It is handy that the sensors are compatible between units, so if you bought some for your WN-1, they will work with your new WN-2 as well.

Operating with Just One

The screen shot in Figure 8 shows the basic screen with input from the single HF-1 sensor we obtained with the unit (your choice of a single sensor is supplied with the unit). It shows the power and SWR in terms of both average and peak levels for sensor number one. For the figure, I was sending alternating dots and dashes into a dummy load, and inserted some mismatch by adjusting my

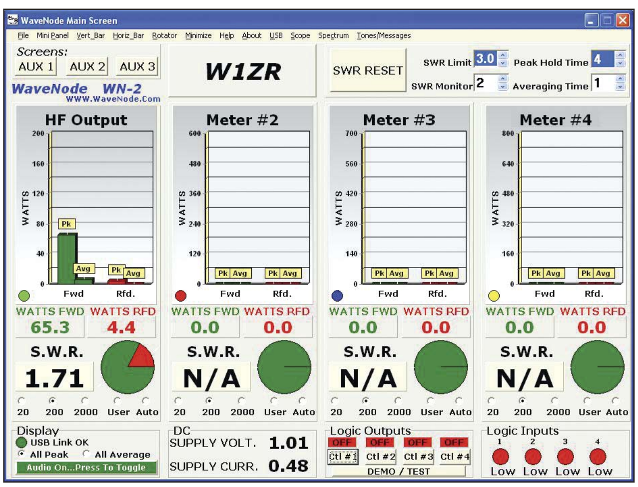


Figure 8 — This screen allows you to monitor the WN-2 with up to four sensors connected simultaneously. In this case there is just one active HF sensor.

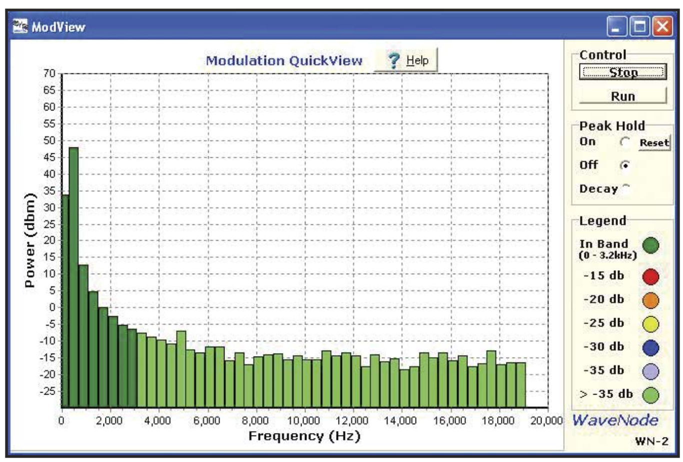


Figure 9 — Spectral analysis of typical SSB modulation as sampled on coax sensor.

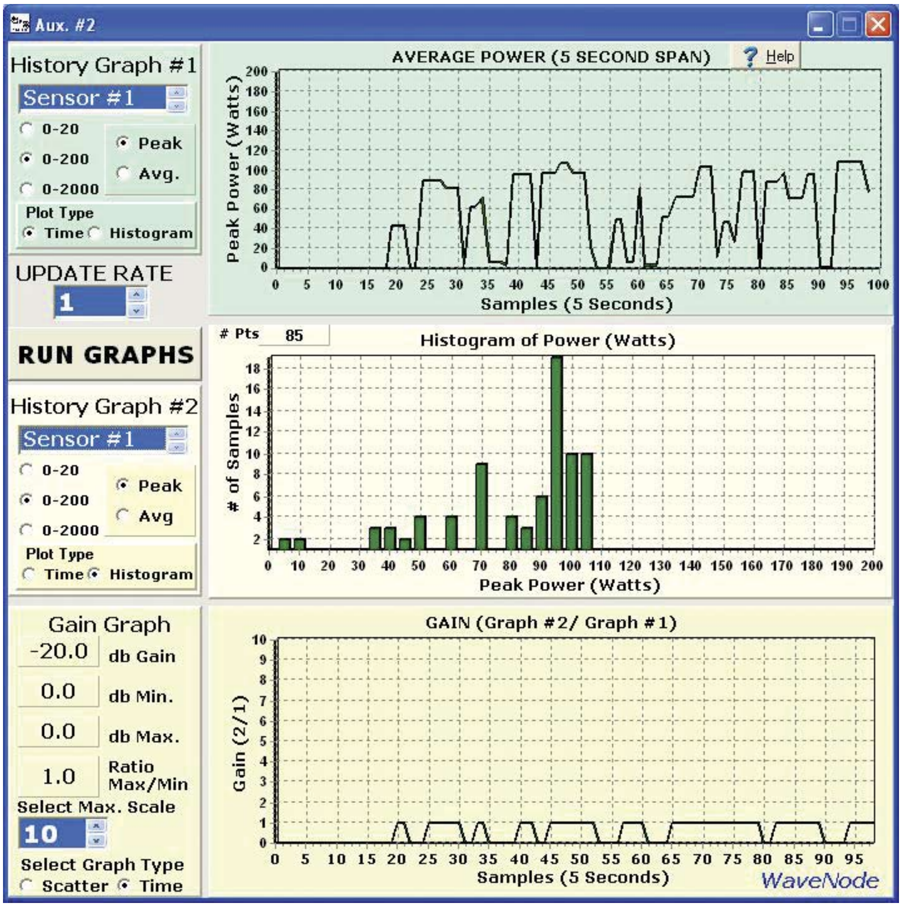


Figure 10 — WN-2 power graphic display. The upper plot is a running view of average output power, the middle a histogram of quantity of samples in each power bin. The bottom gain chart requires a second sensor.

tuner to give a reflected power reading.

WN-2 makes it easy to make to a plot of SWR versus frequency to record and characterize antenna operation. Just click on AUX 3 and an SWR plot appears. Select the desired frequency range and sample spacing. The software prompts you to transmit a signal at each selected frequency. Be sure to set your radio inside the band edges even if it asks you to transmit at 7000 kHz, for example.

Another interesting new feature of the WN-2 is the capability to serve as a digital oscilloscope and spectrum analyzer to allow examination of the RF modulation waveform and frequency content of a transmitted signal. This function provides a graphical output that indicates transmit intermodulation products in real time, providing a way to make sure you are putting out a clean signal. Figure 9 shows a view of the digital spectrum analyzer function observing a 100 W SSB transmission.

Why not Use More?

The power of the WN-2 shows up during monitoring of multiple transmitters, or monitoring multiple points within a transmitting system, all at the same time. Routines provided in the software package provide operations, such as gain calculations, that can be conducted on the multiple sets of data.

Those with a single sensor can still perform many interesting studies. Figure 10 shows a plot indicating average power over time, a good way to get a feel for how your speech compressor is acting. The middle chart provides a histogram showing the number of samples at each of the power ranges. The lower GAIN plot can be used with two sensors, for example with one on each side of a linear amplifier, to automatically determine the gain.

For the WN-1 review we had two sensors, and it was quite handy to have one on each side of a linear amplifier to see just what was happening. Additional sensors can be left in the lines to V/UHF radios, or other HF station equipment, to provide indication whenever those units are used without having to change any cabling or settings.

Other Modes

As with the WN-1, this unit can make other measurements and perform related logic. A 16 pin expansion connector provides four analog and four logic inputs, and four logic outputs. These can be used for remote control of monitored systems. If you power your WN-2 via your radio equipment power supply, you can monitor supply voltage at the same time you perform other functions. There is provision to power a transceiver from the power supply connected WN-2 and then both voltage and current can be monitored. The documentation leaves it to you to figure out how to make the connections, so we didn't. All dc and logic data is shown at the bottom of the main display screen.

Documentation

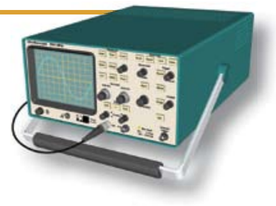
The primary operating and setup documentation for the WN-2 is provided via the HELP button on the main display screen. Somewhat overlapping choices of HARDWARE HELP and SOFTWARE HELP are provided, each including extensive information on most aspects of operation. While extensive help screens are very commendable, it would be nice if an expanded and printable version were also available on the supplied CD and WaveNode has indicated that they will do so. Specialized detailed documentation for applications such as rotator control, or use with Bird power measurement equipment, is provided via files on the supplied CD.

Manufacturer: WaveNode, PO Box 111404, Campbell, CA 95011; tel 408-933-8059; **www.wavenode.com**.

Strays

DENNY SMITH, W4FVQ

Ham radio bug: **Denny Smith, W4FVQ, of Covington, Kentucky, installed a Yaesu FT-100D transceiver (and 95 A alternator) in his restored 1971 VW Beetle. His VHF/UHF arrays for 50 MHz through 2.3 GHz are in the background.**



TinyCAD

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Creating a legible schematic has always been a challenge for me! My freehand sketches seem to wander all over the paper and get messy after a few sessions with the eraser and pencil. In the last couple of years, I noticed that several free or low-cost electronic CAD software packages are available to download. So, when I needed to produce a schematic, I would try a different program. Finally, my trials turned up a software package developed by Matt Pyne called *TinyCAD*. I tried it; I liked it!

Why I Like *TinyCAD*

I enjoy *TinyCAD* because it installed without a hitch and it is easy to use! After quickly reading the supplied help screens, I was ready to draw my first schematic. The result — a legible, editable, printable and exportable schematic — was produced with minimal effort and on a short learning curve. Even better, this is a completely *free* software tool. Obviously, I am a happy *TinyCAD* user. I think the best way to show you why is to describe my experiences with the software.

Using *TinyCAD*

My first *TinyCAD* project was to draw the power supply of a Hallicrafters SX-110 receiver that I was attempting to restore. I started *TinyCAD* and searched the symbol libraries for the appropriate components. All were there, except for the power transformer and rectifier tube. So, my first task was to create those two symbols.

I created the power transformer symbol by duplicating an existing symbol and adding an additional output using the component library editor. The rectifier tube symbol required me to use the New Symbol function and the component editing functions to draw the symbol and save it in an existing library. In a few minutes, both new symbols were available to add to my drawing.

To start drawing, I selected the power transformer symbol and placed it on the drawing pane (see Figure 1). I added the desired reference, T5, in the component tool. Then I selected and placed the rectifier tube symbol and added the reference attribute and the name (component value or type). I quickly selected and added and identified the resistors, capacitors, the power plug, the power switch and a couple of ground symbols.

Next, I connected the components with the "Wire" tool. When I moved the cursor to the starting component pin, a red circle appeared. When I clicked on the circle, that connection was added. As I moved the cursor to the second component, a blue line was drawn, following my cursor. Another circle, another click and the two components were connected by that blue line. Of course, all connections are not straight lines. When needed, a turning point can be established with a quick click, and the line continues in the new direction.

I completed the drawing by annotating the transformer windings and adding a note about the power switch, using the "Text" tool. Then, I decided to re-size a couple of components — just to improve the appearance. I selected the whole drawing and centered it in the drawing pane, using the "Drag Block" function. For the final touch, I completed Design Details (drawing name, my name and the date). Then I saved the file in my SX-110 Receiver folder.

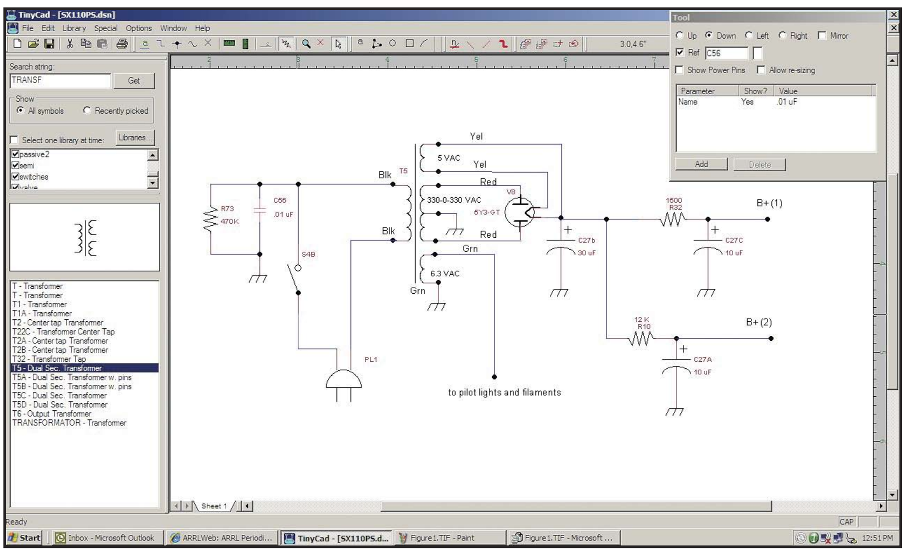

Figure 1—A *TinyCAD* screenshot. The schematic drawing is in the main frame. The drawing position can be adjusted with the scroll bars at the bottom and right side of the screen. The image size can be changed with the zoom function. The tool popup is used to change symbol orientation, adjust symbol size and manage component attributes. To the left of the drawing frame is the symbol and library toolbar. In this screenshot, I used the search string to search for "Transfor." All libraries were searched and the results are listed in the bottom pane. I selected one result and the corresponding symbol is displayed in the preview pane, immediately above the results pane.

Using the Drawing

I printed the completed drawing to a file in my SX-110 restoration binder. I also exported the drawing as an image file and created a parts list text file. After that, I imported both the image file and the parts list in my SX-110 Restoration Notes, a *Word* document.

Additional Features

I have barely scratched the surface of *TinyCAD* functionality. I used only two of the 14 libraries of schematic symbols. I haven't touched the special functions or the advanced features like netlist generation for PCB layout or *SPICE* analysis.

Want A Copy?

TinyCAD can be yours within minutes. All you need is an Internet connection. The *TinyCAD* software and other information, like the FAQ and links to the user group, are available from the developer's project Web site at **http://TinyCAD.sourceforge.net**. It's astonishing that such a powerful piece of software is offered free of charge. Try it yourself and see! QST