Antenna Analyzers — the Basics

What antenna analyzers do, and why you might want one.

Just a few of the numerous brands and models of antenna analyzers that are available for purchase.

Joel R. Hallas, W1ZR
QST Contributing Editor

If you're a typical ham, with a modern transceiver and a working antenna, you may wonder why you might need an antenna analyzer. After all, your transceiver likely reports your antenna's SWR (standing wave ratio) every time you key up — what more do you need? I can't argue with that logic, as long as that's the only antenna you want, and as long as it keeps working the same way.

On the other hand, your transceiver's SWR indicator will provide little or no help if you are trying to characterize an unmatched antenna or are trying to adjust an antenna that starts out resonant on a frequency outside an amateur band.

What Antenna Analyzers Don't Do

Let's start with a disclaimer — antenna analyzers do not analyze an antenna's performance! Antenna analyzers might be better called antenna *impedance* analyzers, because that is what they really measure. In fact, the typical antenna analyzer can't really tell if it's hooked to an antenna system or some other kind of two-terminal network such as the input of a filter, a resistor, inductor, capacitor, or some combination. As we will discuss, that may be one of its charms.

Why You Need One

An antenna analyzer comes into its own if you are trying to develop, build, or adjust an antenna so that it will work on the frequencies you want. This is because antennas often start out tuned to frequencies outside of the desired amateur band or segment, so your transceiver's SWR indicator may not be able to provide enough information to tell you what to do next, or how the antenna needs to be adjusted.

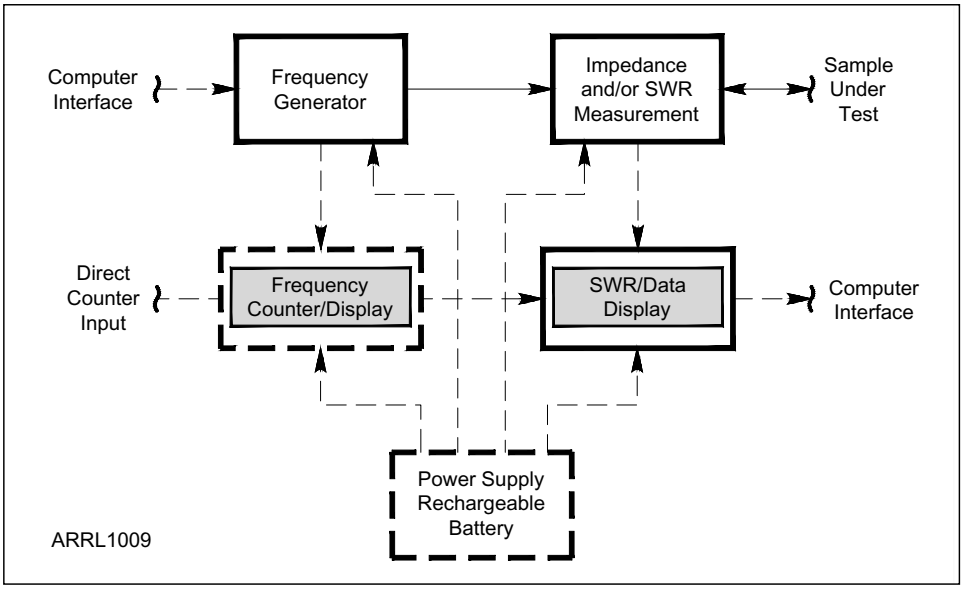

Figure 1 — Block diagram showing the elements of typical antenna analyzers. The items shown with dashed lines may not be part of every model, resulting in a wide range of capabilities, features, and prices.

What's Inside an Antenna Analyzer

What makes an antenna analyzer different from other instruments is the way that it is packaged. It is a self-contained device that measures the SWR — and with some analyzers, impedance — without the need for a radio transmitter. This is because it has a built-in low-power signal source in a compact enclosure along with built-in measurement and display subsystems.

The built-in signal source is a major element of its usefulness. Because the signal source is at such a low level, it can operate

on any frequency within its range, whether within an amateur band or not, without interfering with other services.

While the detailed implementation of different models offer quite different features, the basic architecture offers some significant advantages:

- A transmitter-based measurement system can be used only on authorized operating frequencies for your license class. The antenna analyzer, on the other hand, can be used to take data on any frequency within its operating range.
- The low signal intensity allows taking of data without causing interference to other users of the frequency.
- The self-contained, and often self-powered, device can be easily used at the antenna location, perhaps on the top of the tower, making antenna adjustments easier to accomplish.

As with all design choices, there are a few possible disadvantages as well.

- The most significant potential disadvantage is a downside of the low power measurement approach. If you have the analyzer connected to an antenna that happens to be picking up the signal from a strong nearby transmitter, such as an AM broadcast transmitter, the coupled energy can interfere with the measurements. This is not a problem for most users, but it easily can be for you, particularly if you're in a metro area near a broadcast transmitter — ask other local hams about their experience with such analyzers.
- Compared to most laboratory bench measurement systems, the information displays of compact handheld units are limited in size. This is usually not a major problem, but may be an issue in bright sunlight or other conditions. You just can't fit 10 pounds of display in a 5 pound bag!

There is a wide range of features that may or may not be part of a given antenna analyzer, explaining the perhaps five-to-one variation in prices among different models. Figure 1 shows a generic block diagram applicable to all antenna analyzers that I can think of. The solid boxes and lines are absolutely required, while the dashed lines represent components that may be included, depending on model (and price).

Frequency Generator. A major differentiator between units is the covered frequency range. Some units cover just MF through HF, perhaps 1 to 30 MHz, while others extend the range on each end, perhaps resulting in a range as wide as 0.1 to 600 MHz.

Obviously the complexity and cost of covering such a wide range will add considerably to the expense, so it is good to have an idea of your requirements before you select a unit. In making your selection, keep in mind that the more flexible analyzers can be useful far beyond just measuring antennas. Virtually all can be used as bench signal generators, and for other lab uses within their limitations.

Analyzers that can measure the real and imaginary components of impedance ($R \pm jX$), rather than just SWR, can be used to measure all manner of circuits and components on the bench, as well as antennas in the field.

Note that impedance measurements taken at the end of a mismatched transmission line will not be the same as the impedance at the antenna. However, software such as *TLW* can be used to translate the data to that at the antenna, if the transmission line electrical length is known.[1, 2]

Antenna analyzers might be better called antenna impedance analyzers, because that is what they really measure.

Frequency Counter/Display. The frequency accuracy and read-out resolution of the generator may be equally important. The units with analog dials are most useful if a separate calibrated receiver can be used to check their actual frequency while making measurements. This may reduce a unit's utility for field operation.

The more capable units measure and indicate frequency directly with a built-in frequency counter, or generate the frequency using a calibrated frequency synthesizer — either method is a worthwhile improvement for most applications. Keep in mind, however, that the usefulness is only as good as the accuracy of the counter or synthesizer, and its resolution (number of digits).

Almost as important is the ability to set the frequency to any desired value and have it stay there. Being able to read to 1 Hz is not very useful if the tuning knob changes frequency so quickly that setting to within 50 kHz of the desired frequency is all you can do. Similarly, if the frequency drifts that much between setting and reading the results, the high resolution is of little benefit.

A major side benefit offered by some units with built-in frequency counters is that they can be used to measure the frequency of other sources as well. If the unit can also serve as a standalone laboratory frequency counter, its value to you will be much higher, unless you already have a separate counter.

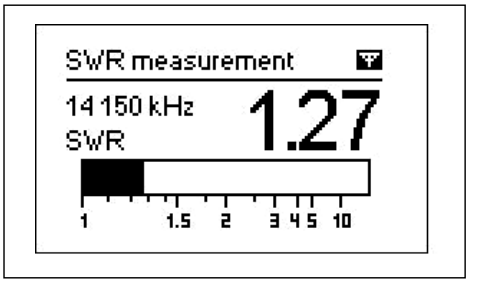

Figure 2 — The "basic" SWR display of the author's RigExpert AA-54 antenna analyzer. Note that in addition to a digital SWR value, shown to hundredths, it indicates measurement frequency and provides a calibrated bar graph to facilitate making adjustments.

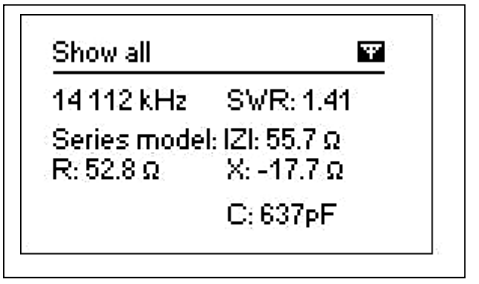

Figure 3 — The RigExpert AA-54 single frequency impedance display. Note that in addition to the SWR, it shows the magnitude of the impedance, the resistive and reactive part of the impedances, and even calculates the value of equivalent capacitance at the measurement frequency.

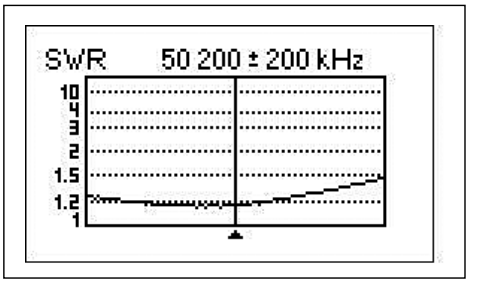

Figure 4 — The RigExpert AA-54 in swept frequency analysis mode. Note that in one view, the operator can see the center tuned frequency and the bandwidth of the antenna system.

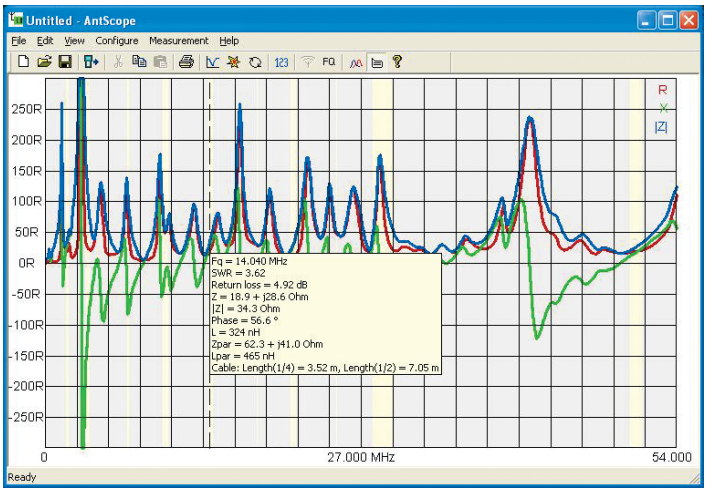

Figure 5 — Plot of impedance versus frequency, as seen on a PC using RigExpert *AntScope*, shows much better resolution than available on the smaller handheld screen. While the screen looks busy, any individual plot can be displayed by itself, and the box shown provides the details of the data at whatever frequency the dashed-line cursor is set to.

Impedance Measurement. As noted, the basic antenna analyzer measures standing wave ratio, an important parameter of an antenna system. In many cases, that's all you need or desire, and any more information can be a distraction. On the other hand, if a new system is not well matched to the impedance its radio wants to see, the details of the actual impedance of the termination can be an aid in designing a matching network.

SWR/Data Display. The nature of the display system will make a considerable difference in the precision, resolution, and thus usefulness of the data. Digital systems generally have the edge. On the other hand, most people find it easier to adjust systems while watching the pointer movement of an analog meter. Some digital displays include a bar graph option (see Figure 2) that can work well if it responds quickly enough. In addition to SWR, antenna analyzers often display detailed impedance data as shown in Figure 3.

A whole different dimension is provided by analyzers that provide not just data at a particular frequency, but graphical data as the frequency is swept across a range (see Figure 4). This can be very useful for adjusting antennas or other networks, such as filters. Some units provide this capability on the small screen of the analyzer, while others allow connection to a PC that has software loaded to allow analysis on the computer screen (see Figure 5). In some cases the data can be saved in the analyzer and examined in detail on the PC after coming down from the top of the tower.

Power Supply, Rechargeable Battery. For the casual user, there is nothing wrong with running the analyzer from a few AA batteries purchased from the corner drug store. Many units provide the capability to use rechargeable batteries and a separate power supply.

Where to Go Next

In this short article, we have just scratched the surface of what antenna analyzers are and what can be done with them. A book could be written on this topic, and, in fact, I did that. *Understanding Your Antenna Analyzer* is available from the ARRL bookstore or your retailer.[3] Another good source of information can be obtained from reading the *QST* Product Reviews of the analyzers you have under consideration. All reviews since the 1980s are available to members on the ARRL Product Review web page.[4]

Notes

[1] *TLW* (*Transmission Line for Windows*) software is included on the CD-ROM supplied with *The ARRL Antenna Book*, 23rd Edition. Available from your ARRL dealer or the ARRL Bookstore, ARRL Item no. 0444. Telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop**; **pubsales@arrl.org**.

[2] J. Hallas, W1ZR, "I Know What's Happening at the Shack — What's Happening at the Other End of my Feed Line?" *QST*, Feb 2007, p 63.

[3] J. Hallas, W1ZR, *The ARRL Guide to Antenna Tuners*. Available from your ARRL dealer or the ARRL Bookstore, ARRL Item no. 0984. Telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop**; **pubsales@arrl.org**.

[4] **www.arrl.org/product-review**

You can reach *QST* Contributing Editor Joel Hallas, W1ZR, at **w1zr@arrl.org**.

For updates to this article, see the *QST* Feedback page at www.arrl.org/feedback.

Did you enjoy this article? Cast your vote at www.arrl.org/cover-plaque-poll

New Products

Portable Torsion Bar Key from W1SFR

The TBP (Torsion Bar Portable) key from Steve Roberts, W1SFR, features a contact system said to allow the key lever to make a "softer" contact, allowing the very slightest movement when the contact post hits the stainless contact. That is said to make the key feel less mechanical, and also allow quieter operation. The torsion system allows very close contact spacing. Keys are made by hand and feature exotic wood finger pieces with a mother-of-pearl dot on each finger piece. Price: $175. Also available are the TBKII, a single lever key ($265), and the TBSK, a torsion bar straight key ($175). For more information, visit **w1sfr.com**.