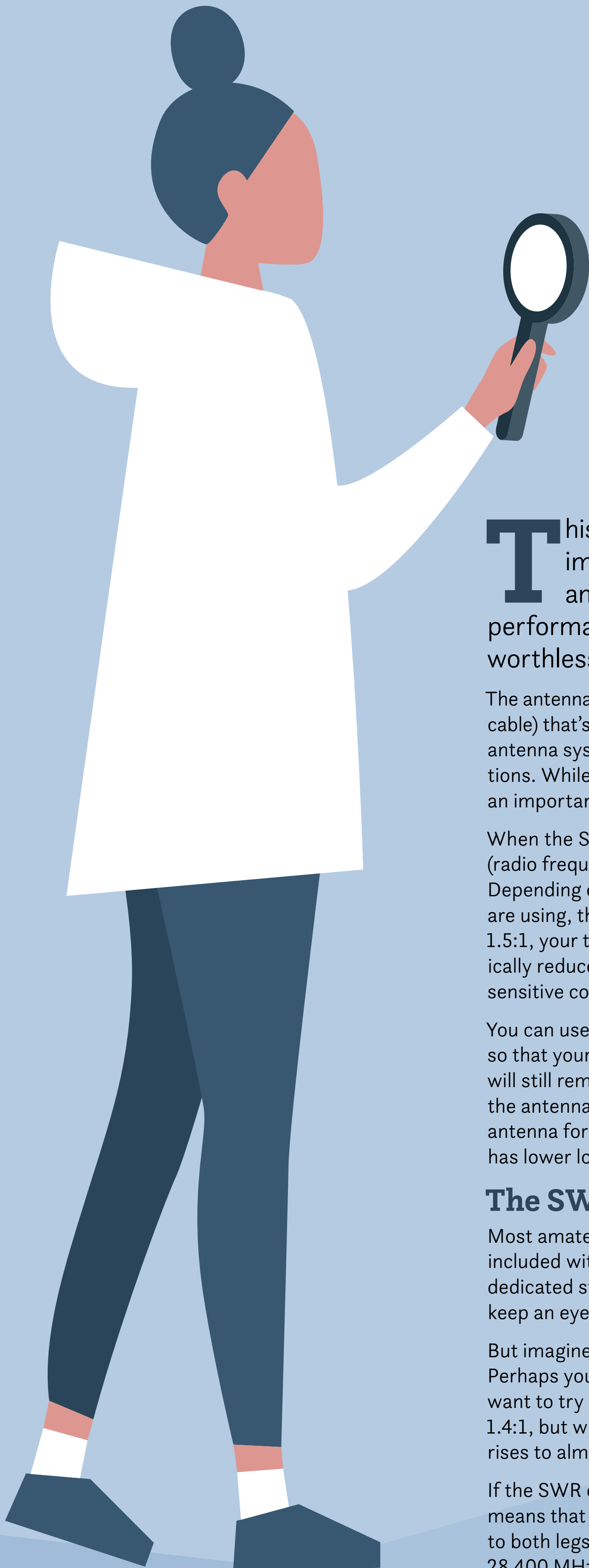

Analyzing Your Antenna System

This may come as news to some readers, but the most important part of any amateur radio station is its antenna system. You can buy the most expensive, high-performance transceiver ever made, but it will be virtually worthless if your antenna system is defective.

The antenna system consists of the antenna itself and the feed line (such as a coaxial cable) that's between it and your radio. Some hams judge the performance of their antenna systems by the standing wave ratio (SWR) readings they see in their stations. While it's true that SWR is only part of the antenna-performance story, it is an important part.

When the SWR becomes higher than about 2:1, a significant portion of the RF (radio frequency) energy generated by your transceiver can be lost in the feed line. Depending on the frequency you are transmitting at and the type of feed line you are using, the loss can be quite high. In addition, when the SWR rises above about 1.5:1, your transceiver may begin to automatically reduce its output to prevent damage to sensitive components.

You can use an antenna tuner to lower the SWR so that your transceiver is satisfied, but the SWR will still remain elevated between the tuner and the antenna. The solution there is to adjust the antenna for a lower SWR, or use a feed line that has lower loss characteristics, or both.

For More About SWR and Antenna Tuners

The January/February 2021 issue of *On the Air* features articles on "Untangling SWR" and "Antenna Tuners: Making a Match," with fundamental information on both topics.

The SWR Meter Approach

Most amateurs monitor their antenna system SWR by using either the meters included within their transceivers, SWR meters within external antenna tuners, or dedicated stand-alone SWR meters. Any of these will do a fine job of helping you keep an eye on the health of your antenna system, at least as it concerns the SWR.

But imagine that you have a wire dipole antenna that you use on the 10-meter band. Perhaps you operate SSB at about 28.400 MHz much of the time, but now you want to try digital modes below 28.100 MHz. The SWR at 28.400 MHz is a nice 1.4:1, but when you dip down to 28.100 MHz, your meter tells you that the SWR rises to almost 3:1.

If the SWR of a dipole antenna goes up when the frequency goes down, it usually means that you need to make the antenna longer. By adding equal lengths of wire to both legs of the antenna, you can effectively "shift" the 1.4:1 SWR you saw at 28.400 MHz so that it is present at 28.100 MHz instead.

Above, left to right: An MFJ analyzer doing a frequency sweep to find the lowest SWR. ■ A RigExpert AA-600 analyzer doing an SWR sweep through a broad range of frequencies. ■ The NanoVNA sells for less than $100. ■ The Comet CAA-500 Mark II analyzer offers a mechanical meter and a graphic display.

Let's say you get two 1-foot lengths of wire and attach them to the ends of your antenna. You return to your station, transmit a low-power signal at 28.100 MHz and see what the SWR meter has to say. According to the meter, the SWR has gone down to 2:1. That's an improvement, but it isn't good enough. It looks like you'll have to add more wire and try again.

When you return to your radio and try another test, your meter now tells you that the SWR has *increased* at 28.100 MHz! What happened? Did you add too much wire this time?

Back and forth you go, cutting wire and taking SWR readings. You'll find the SWR sweet spot eventually, but it could be a tedious exercise. Wouldn't it be so much easier if you could see the SWR response of your antenna at all frequencies, from one end of the band to the other, with just one measurement?

Introducing the Antenna Analyzer

Antenna analyzers are battery operated, low-power transmitters controlled by microprocessor circuitry. They can generate signals at any HF frequency, and some models work at VHF and UHF as well. An analyzer will measure your antenna system SWR at any frequency within its range. It will show you the SWR at a specific frequency, and more sophisticated models can sweep through many frequencies and display graphic plots that show where the SWRs are highest and lowest.

In our dipole antenna example, an antenna analyzer would allow you to quickly see the SWRs at frequencies above and below your 28.100 MHz target. If you are using an analyzer with a sweep display, you'd instantly see whether your low-SWR frequency is below 28.100 MHz, which means you added too much wire, or above, which means you need to add more. The SWR performance of your antenna will be shown in its entirety — right before your eyes — with a single measurement.

An antenna analyzer can do more than measure SWRs. It will also show you the electrical characteristics of your antenna system — its total impedance and the resistive and reactive values that make up that impedance. A full discussion of this function is well beyond the scope of *On the Air* magazine, but it is important for hams who design or modify antenna systems, or build devices such as antenna tuners.

An analyzer can also tell you how much RF you're losing in your feed line. This is an easy function to use. One method is to disconnect the feed line at your antenna, go back inside your station, attach the analyzer to the feed line, and select the function and the frequency of interest. You'll immediately see a number such as 3 dB (decibels). This means that your feed line will lose up to 3 dB of RF energy at the frequency you've selected. (By the way, this isn't a good result; it means you're losing 50% of your power in the feed line!)

A few analyzers can even help you find a defect in your coaxial cable. They have what are known as TDRs — *Time Domain Reflectometers* — functions that will send a pulse through the cable and measure what happens as the signal bounces back. If there is a problem such as a bad connection, the analyzer will tell you the approximate distance between the analyzer and the faulty connection.

These are just a few uses for antenna analyzers; there are many more. Put simply, whenever you want to know what is going on in any circuit that handles RF energy, an antenna analyzer is the one of the best tools for the job.

Shopping for Analyzers

Depending on how many features they offer, antenna analyzers can range in price from $100 to more than $400. There are also devices known as *Vector Network Analyzers*, or *VNAs*, that perform many of the same measurements, and there are some VNA models available for less than $100. You may see the terms "antenna analyzer" and "VNA" used interchangeably.

But why purchase an analyzer at all? Sure, it makes antenna setup and adjustment much easier, but you could conceivably save the money and use the more tedious SWR meter approach instead.

Unless you plan to experiment with designing and building your own antennas, you may not get enough use out of an analyzer to justify the investment. On the other hand, though it's a tool that you may not use often, you'll certainly be glad it's there when you need it.

One alternative approach "joint ownership" of an analyzer. If you and four friends contribute, say, $50 each, you can purchase an analyzer that any of you can use when necessary. Amateur radio clubs will sometimes buy test equipment such as antenna analyzers and make them available on loan to members. If your club doesn't do this, you may want to bring up the idea!