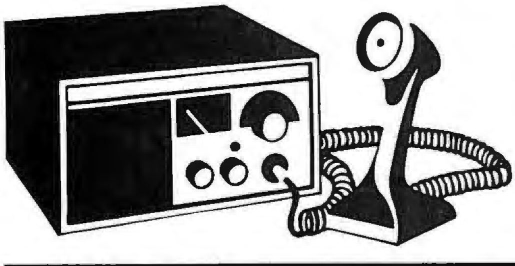


CB Scene

By Len Buckwalter, K10DH

HANDLING THE VSWR PROBLEM

A WHILE AGO I attended a meeting of microwave engineers. Up front, a speaker slashed the blackboard with a piece of chalk and said, "You've got to get rid of the *vizz war*!"

On another occasion, I heard an avionics technician, wriggling out of the fuselage of a light plane, exclaim triumphantly, "We just got rid of the *vizz war*!"

Of course, vizz war is not the latest skirmish to be debated at the United Nations. It's the way the "in crowd" pronounces VSWR, voltage standing wave ratio, sometimes called just plain SWR.

Most of the time, VSWR is as interesting to contemplate as a bubble surfacing in a pool of lava. It rarely intrudes if a CB system is comprised of standard components, in which a transceiver with a 50-ohm output impedance is connected to a 50-ohm transmission line that's hooked up to a 50-ohm antenna. There's a perfect match all around and r-f power flows smoothly from one to the other. But no marriage is forever perfect, as an escalating vizz war will indicate. Gradually, the coaxial jacket cracks, corrosion creeps into conductors and connectors, wires short out, a cold solder joint develops ohmic resistance, rust prevents a lug from making firm contact with ground or a base mount becomes isolated from a car's sheet metal. More dramatically, a heavy ice storm can cause radials to fall off, or a 200-pound bird comes to roost on your antenna. Any one of these troubles will draft you into fighting the vizz war.

Measurements. Since manufacturers appear to sell more SWR meters (also called "reflectometers") than any other CB accessory, they're worth a close look. Measuring an antenna's SWR (with a reflectometer) is a clever tactic, because troubleshooting an antenna system with other instruments would require the resources of a NASA laboratory. You can put an r-f wattmeter on the transceiver output, but all it reveals is how much power is being delivered to the coaxial cable. Finding out if that power is being efficiently radiated by the antenna is another matter.

Ohm's Law doesn't really help because most operators lack the gear needed to measure the parameters of an antenna system operating at 27 MHz. For example, if your rig puts out 4 watts into a 50-ohm load, Ohm's Law says that the antenna current would be 300 milliamperes (mA). But an r-f ammeter that could accurately read 300 mA is priced beyond the means of many CBers. So unless you have access to fancy r-f instrumentation, a low-cost SWR meter is the most practical way to monitor impedance matches.

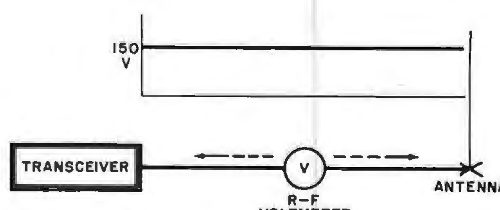
Since a transceiver should have its output circuitry factory-tuned for 50-ohm loads, one doesn't expect much of an SWR ripple where the transceiver meets the coaxial cable. The feedline itself should not produce a mismatch, because standard lines, such as RG58/U, display a constant 50-ohm impedance regardless of length when terminated with a 50-ohm load. If you suspect something's amiss in the transmitter tuning, connect an r-f wattmeter and a 50-ohm dummy load to the rig's output with short pieces of coax. The output should nudge close to the 4-watt limit of the FCC. Use the procedure in the manufacturer's instruction manual to peak the output to the legal limit. (Remember to keep away from the frequency-sensitive controls, as these can only be adjusted by a technician with a valid FCC Commercial license. If in doubt, check with a tech.)

The happiest situation occurs when all the power delivered to the feedline is coupled to the antenna and radiated into space. In this ideal system, an r-f voltmeter placed across the transmission line, as shown in Fig. 1, will indicate a constant voltage anywhere along its length. With nary a voltage ripple, the line is said to be "flat." But the ravages of time and the elements eventually disturb this placid relationship.

The result is graphically shown in Fig. 2. Instead of accepting and radiating all the r-f power, the antenna bounces back part of the signal into the feedline. Two waves now travel on the line: a forward wave and a reflected one. The reflected wave opposes and cancels a portion of the forward wave, setting up a standing voltage wave. The r-f voltmeter will reveal this. Let's assume that voltmeter *M1* is put across the line at the point of maximum voltage (also called a loop or antinode) and reads a potential difference of 200 volts. The second voltmeter, *M2*, is placed across the line at the point of minimum voltage (called a node) and reads 100 volts. The standing wave ratio or SWR is then V_{max}/V_{min}, 200/100, or 2 (also expressed as 2:1 or "two-to-one"). If the two voltage extremes were 400 and 40 V, the SWR would be 10.

CSWR. We've been measuring voltage along the transmission line, but the same relationships hold for cur-

Fig. 1. In a perfectly matched system, the r-f voltage is constant all along the feedline.



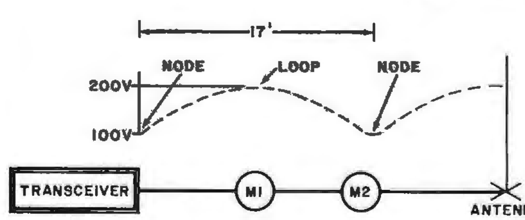


Fig. 2. When impedance mismatch occurs, standing wave appears on the transmission line. In the example shown here, the SWR is 2.

rent distribution. Current standing wave ratio is also meaningful. Incidentally, the loops (or nodes) in Fig. 2 are a half-wavelength apart from each other, or about 17 feet (approximately 5.5 m) at CB frequencies.

No practical system is perfect. An SWR of 1 occurs only in engineering textbooks. An acceptable ratio is 2 or less, but even at 2 the power loss is only 0.2 dB, or about 11%. That's much less than the 1-dB drop that occurs on a 50-foot (15-m) length of RG58/U from the transceiver to the roof. It's not worth trying to lower your SWR from 1.5 to 1.4, as power losses are small below 2 or 2.5. You should be wary, however, of an SWR of 3 because it usually means that something is drifting into the trouble area.

Losses due to high SWR pick up when it runs much above 3. At this value, about 25% of your power never makes it into the antenna. About half your r-f power is wasted when the SWR increases to 12. This is not as dramatic as it sounds. Losing half your power may seem like a lot, but that's only a 3-dB drop in signal strength (other things being equal) or about half an S unit.

SWR produces more serious effects than power loss. It can raise the voltage across the output circuitry to a critical value. Final transistors can blow out—as often happened in the early solid-state rigs. Today, however, engineers produce active devices with a high degree of SWR immunity. A high SWR can also heat up coaxial cables to the melting point, but this rarely happens at 4-watt CB power levels.

Besides keeping a watchful eye over your transceiver output stage, there's another advantage to monitoring the SWR of your system—it telegraphs the condition of your antenna system. While you sit comfortably at your operating position, you can judge how well your antenna is standing up to the hail and sleet storm raging outside. Any abrupt change in SWR warrants an inspection upstairs.

A typical SWR meter (Fig. 3) samples radiation traveling in two directions on a short piece of transmission line. Inside the cabinet, two "directional couplers" (short lengths of wire) run parallel to the line. A switch connects either pickup wire to a meter (through a diode rectifier, which converts the r-f signal to dc). When the switch is in the FORWARD position, the meter gives a relative indication of

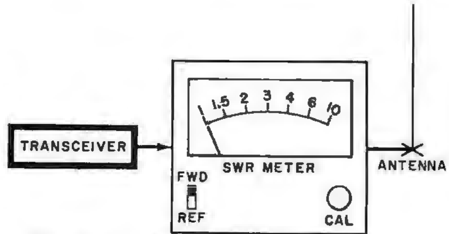


Fig. 3. An in-line reflectometer indicates the impedance match.

the strength of the wave traveling from the transmitter towards the antenna. You then adjust a calibrating pot to bring the needle to exactly full scale (using an unmodulated carrier). To read SWR, the switch is thrown to REFLECTED, which connects the meter to the other directional pickup. This samples the wave going back down the line from the antenna towards the transmitter. The meter indicates SWR directly, and some models are also calibrated in "Percent Reflected Power."

Many SWR meters have negligible insertion loss, so they can be left inline for continuous monitoring. Others, however, have built-in dummy loads and no output jacks. These should be used only for peaking adjustments, as described above. Some models have limited power-handling capacities, but this is almost never a problem at CB power levels. Check the manufacturer's literature for details.

If your system's SWR reads suspiciously high after the antenna has been in service for a while, look for the trouble spots mentioned earlier. High SWR on a brand-new installation, might have some other cause. If you soldered coax connectors onto the cable yourself, doublecheck your work. When the coax was routed from the antenna to the rig, was it bent sharply? Did a nail or staple accidentally puncture the insulating jacket? If the antenna was positioned close to a large mass of metal, its feedpoint impedance might have been altered. At a base station, proximity to a large TV mast with a group of guy wires can cause this effect. Sheet-metal ducts, plumbing, metal flashing, or electrical cables can also create problems. Try to keep the antenna at least a half-wave (about 17 feet or 5.5 m) away from any large amount of metal.

Never try to reduce SWR by fiddling with transceiver controls. You might cause an apparent drop in SWR, but a better match is not obtained, merely a drop in transceiver output. Once the rig is optimized for 50-ohm loads, as described above, don't touch its innards anymore. ◈