Tech Note - Theory - 15 More VSWR

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Q: What is VSWR?
A: In the real sense, it is nothing!

The forward wave or transmitter output is real, it can be measured and quantified.

The reflected wave is real, it can also be measured and quantified. VSWR is merely a ratio between the two wave levels, enabling us to see the degree of mismatch between the line and load. (Reflections, ARRL, Walt Maxwell, Chapter 8, Section 8.2)

There are some amateurs who are unable to see this concept and regard SWR as a live serpent with a fanged head at both ends, that must be brought under control at all cost or life on the air will not be possible.

There is a common misconception that reflected power is lost. If it were lost there would be no measurable VSWR at the input end! The impedance is altered at the end of the feedline from what it would normally be if it were matched.

It is easier to measure the VSWR than some of the other qualities (such as the impedance of the antenna) that enter into transmission line computations. VSWR is a convenient basis for working with lines. The greater the VSWR is, the greater is the mismatch between line and load (antenna). In practical lines the power loss in the line itself increases with frequency and VSWR.

Adjustment of antenna matching systems requires some means either of measuring the input impedance of the antenna or transmission line, or measuring the standing wave ratio. Various SWR bridge methods are suitable for either measurement.

Since the development of the simple reflectometer, it has become a very popular item even though it's accuracy will leave a great deal to be desired. The importance of VSWR is the fact that it can be very easily measured experimentally.

A mismatched transmission line for the HF bands of operation is not necessarily a deterrent to proper station performance.

One of the widest spread misconceptions in amateur radio circles is that high VSWR causes lost power.

WRONG! If the line attenuation is low with a matched line to load, then the line loss with a mismatched load, will in all likelihood be barely perceptible with a mismatch.

If under matched conditions the line loss is the order of 0.2 dB, VSWR values as high as 5:1 are not to be worried about as far as VSWR line losses are concerned. For most amateur station situations, high VSWR is relatively unimportant, provided the feedline can be matched properly to the transmitter/filter assembly. Only at vhf and above does high VSWR really become significant. The reason is simple. At VHF-UHF, even when properly matched, line losses are far greater than at HF.

Reasons for having a low VSWR at HF:

1. To provide a proper termination for a low pass filter.
2. To allow the transmitter to load correctly.
3. To avoid the need for an ASTU or transmatch.

Feedline choices: two principal methods of feeding an antenna with tuned or resonant transmission line, and with a flat or non-resonant line. Whether the line is considered tuned or flat is determined by the VSWR.

If the VSWR is low (1.5 or less) the line is considered flat. A higher VSWR makes the lines impedance vary along its length, and the line is said to be resonant.

There are distinct advantages in both types of feeding systems. Whether flat line or tuned line is used to feed an antenna will be determined in great measure by the frequency range over which the antenna must operate, and by the extent of antenna variation with change in frequency.

In an open wire line, radiation losses are negligible if the load is balanced, the wires are the same size and the line is properly installed. This results in equal but 180 degree out of phase currents in each wire of the transmission line providing near cancellation of radiation from the line.

Conductor losses are greater in lines of lower impedance because for a given voltage at the input end, the current which flows is greater (denser electron movement). A higher current means I R losses are increased, unless the conductor sizes are increased proportionally!

Dielectric losses and possible damage increase rapidly with high VSWR,(especially in coax). The higher the impedance of the line the greater will be the voltages and corresponding dielectric losses. With open wire line, this is not a problem. However with flat 300 ohm ribbon type line, from dry to damp results in a wide antenna to feedline impedance excursion. This can be a very serious problem.

Feeding an Antenna. How? Either voltage or current feed may be resorted to. Since the voltage and current STANDING WAVE of an antenna are 90 degrees out of phase with one another, we have maximum current existing at the point where the voltage is minimum. The particular point where power is introduced into the antenna determines whether it is voltage or current fed. Voltage loops (maximums) exist at the ends of a full wave antenna, or at halfwave intervals along the antenna. Current loops exist at odd multiples of a quarter wave length from the end or at the grounded end of a quarter wave length vertical antenna. An antenna has a high impedance at current nodes and voltage loops and a low impedance at current loops and voltage nodes.

In a properly matched line the voltage and current are in phase(forward or incident power), throughout the line. The length is not critical for low VSWR or a good match etc.

When transmitter power is fed to the antenna, the current in the Rr is in phase with the applied voltage, while the current in the inductive or capacitive portion (reactance) is 90 degrees out of phase with the applied voltage. Thus the phase relationship between current and voltage in a tuned circuit or antenna element can be anything between zero and plus or minus 90 degrees. depending on the ratio of resistance (Rr) and reactance.

Because of this, impedance is always expressed in two parts, resistive and reactive. An impedance having a resistance of 75 ohms and an inductive reactance of 50 ohms is more conveniently written as 75 +j50 ohms the +j or -j would indicate whether the impedance was inductively or capacitively reactive. This is a kind of shorthand used to mathematically describe the situation and the beginning amateur should not allow himself to be intimidated by what appears at first hand to be very complicated.

EFFECT OF VSWR:

The power lost in a line is least when the line is terminated in a resistance equal to it's characteristic impedance, and increases with an increase in the standing wave ratio. This is because the effective values of both current and voltage become larger as VSWR becomes greater. The increase in effective current raises the ohmic losses in the conductors, and the increase in effective voltage increases the losses in the dielectric.

The increased loss caused by a VSWR greater than 1 may or may not be serious. If the VSWR at the load is not greater than 2, the additional loss caused by the standing waves, as compared with the loss when the line is perfectly matched, does not amount to more than about ½ dB even on very long lines. Since ½ dB is an undetectable change in signal strength, it can be said that from a practical standpoint a VSWR of 2 or less is, so far as losses are concerned, is every bit as good as a perfect match.

On lines having low losses when perfectly matched, a high standing wave ratio may increase the power loss by a large factor. However, in this case the total loss may still be inconsequential in comparison with the power delivered to the load. A VSWR of 10 on a line having only 0.3 dB loss when perfectly matched will cause an additional loss of 1 dB. This loss would produce a just detectable difference in signal strength!

For the "purists" among us, this would not be acceptable. They would be required to spend many dollars, on extremely low loss feedlines, with on the air results not justifying this expensive move. Hopefully this little essay has allayed the fears of the newcomer that achieving an SWR of 1:1, on HF is not really all that important. It may make a nice topic of conversation or a fine "brag point" but in the end you will enjoy the on the air activities more, knowing that you can spend your money where it counts! ***

*** Any copy of the ARRL Antenna Handbook.