A SUMMARY OF SWR AND CALCULATIONS

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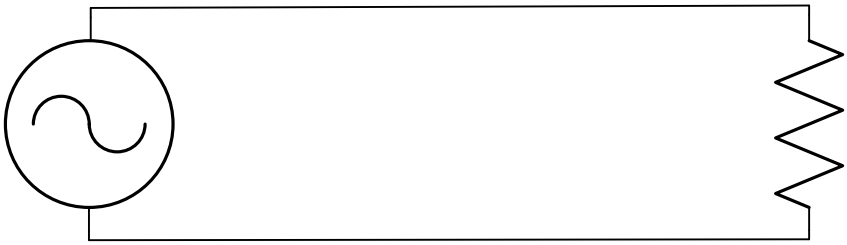
This paper is a summary of information on SWR contained in the *ARRL Antenna Book*, *Understanding Your Antenna Analyzer* by ARRL, the R.L. Drake Co. SWR CALCULATOR, and an outstanding article in November 2006 QST by Darrin Walraven K5DVW entitled *Understanding SWR by Example*.

The purpose of my paper is to hit some of the highlights of SWR contained in the previously listed references in a very simplistic manner for the purposes of stimulating understanding of the commonly referred term SWR and providing sources for further reading. I am not an expert and do not pretend to be an expert in this field.

To begin let's consider the circuit of an rf signal generator, transmission line, and a resistive load.



If we assume the load is a purely resistive load R, the transmission line has characteristic impedance Z_0, and the signal generator has impedance Z. If $Z=Z_0=R$, we have a matched system and the signal is completely carried along the transmission line and then completely absorbed or transmitted to the load. This is the unrealistic ideal that all power generated by our transmitter is absorbed and radiated by our antenna. If the voltage were measured at any point on the transmission line the voltage would be the same as the voltage at the corresponding point on the signal generated sine wave. If $Z_0 \neq R$, then the generated signal is not completely absorbed by the load or antenna and the unabsorbed signal is reflected back down the transmission line. The original signal and the reflected signal interact altering the voltage and current on the transmission line in relation to the signal generated. As an index of many of the properties of a mismatched system we define the Voltage Standing Wave Ratio (VSWR) or simply SWR to be

SWR = maximum voltage ⁄minimum voltage = $E_{max}/E_{min} = I_{max}/I_{min}$

In the matched system $E_{max} = E_{min}$ and SWR = 1 or the ratio is 1 to 1. The term "level" comes from the level voltage in the matched system. In terms of power with P_f =power in the forward wave and P_r = power in the reflected wave we have

SWR = $(1 + \sqrt{\frac{Pr}{Pf}})/(1 - \sqrt{\frac{Pr}{Pf}})$.

As an example suppose P_f = 100 watts and P_r =10 watts. Here (P_r / P_f) = 0.1 and SWR = $(1 + \sqrt{0.1})/(1 - \sqrt{0.1})$ = 1.92 . . . . . or approximately 2 to 1. We could have 300 out and 30 back or 800 out and 80 back and the ratio is still 0.1 which still gives an SWR = 1.92 approximately. This and other similar calculations give us a feeling for the significance of various values of SWR. Further if the SWR at the load is not greater than 2 to 1, the additional loss caused by standing waves as compared with the loss when the line is perfectly matched, does not amount to more than about ½ db loss, even on very long lines. From a practical standpoint in the HF bands, an SWR of 2 to 1 or less is as good as a perfect match. The one catch here is manufacturers of modern transmitters use protection circuits which reduce power before an SWR of 2 to 1.

Now consider the SWR CALCULATOR chart provided by the R.L. Drake Company for the Drake W4 wattmeter. This table has columns for forward power, VSWR, and reflected power and enables us to graphically determine the third value given the other two values. For example if we have 200 watts forward and 20 watts reflected power, by drawing a straight line between the two values we find the VSWR to be 1.92 as expected. Similarly if we have an output of 100 watts and a VSWR 1.5 to 1, we expect to have 4 watts reflected power. This chart provides a convenient way to relate these values.

I hope that you have found my paper helpful and useful.