K4HJU

Amateur Radio
Austin, Texas

Some Musings

Voltage Standing Wave Ratio Facts & Thoughts

Rev 0.03
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A Work in Progress

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1. Introduction

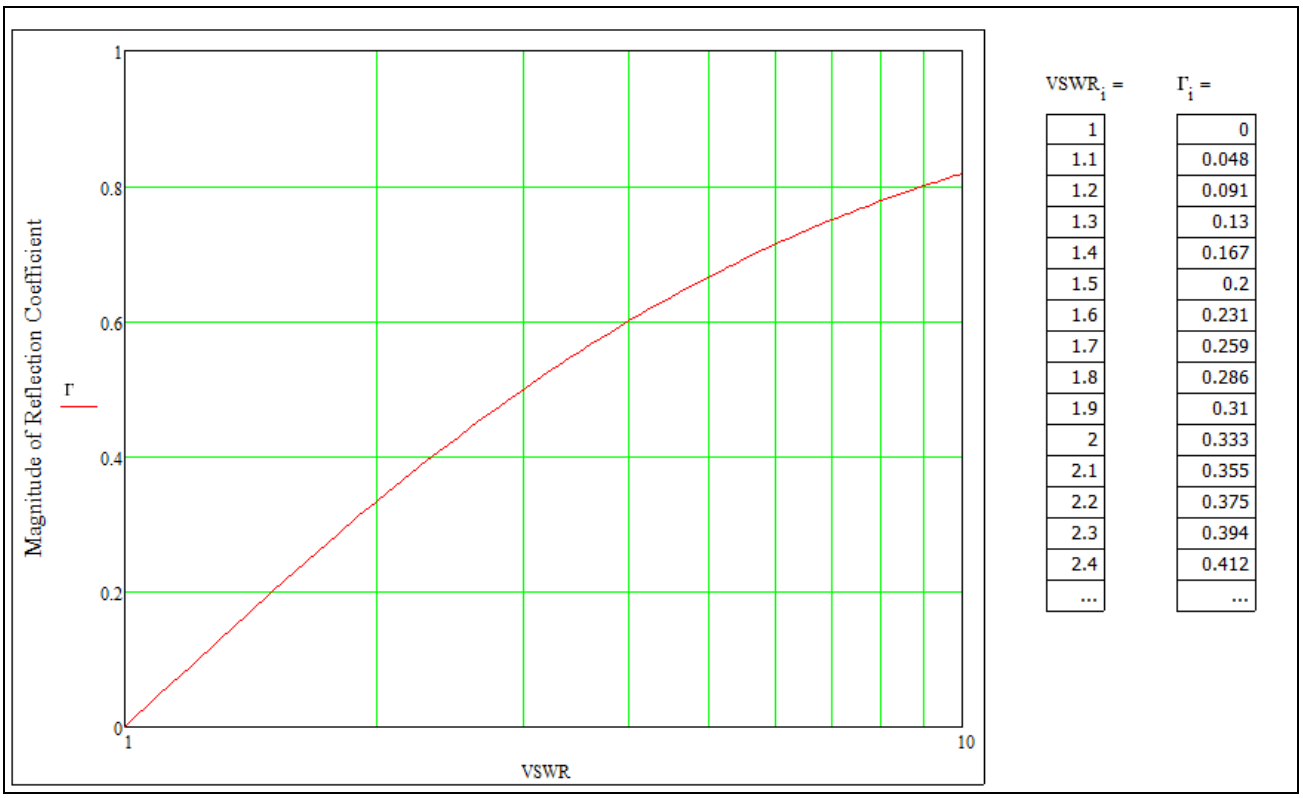
The voltage standing wave ratio (VSWR) has been a very useful parameter in ham radio applications. It is relatively easy to measure and can provide effective confidence in tuning antenna systems. With that said there is a lot that is left unknown when only the VSWR of a given system is determined. This musing will look at some of the aspects hidden behind the VSWR wrapper. For example a wide range of load impedance values can give the same VSWR value. This will be looked at in detail in what follows.

2. VSWR to Magnitude of Reflection Coefficient

The magnitude of the reflection coefficient can be calculated from the VSWR.

$$|\Gamma| = \frac{VSWR - 1}{VSWR + 1}$$

Where $|\Gamma|$ (gamma) is the magnitude of the complex reflection coefficient and can have any value between 0 and 1. VSWR is the voltage standing wave ratio and can have any value between 1 and infinity. Performing this calculation for a range of values of VSWR yields.



$VSWR_i$ =	Γ_i =
1	0
1.1	0.048
1.2	0.091
1.3	0.13
1.4	0.167
1.5	0.2
1.6	0.231
1.7	0.259
1.8	0.286
1.9	0.31
2	0.333
2.1	0.355
2.2	0.375
2.3	0.394
2.4	0.412
...	...

Figure 2-1 VSWR to $|\Gamma|$

This yields the magnitude of Γ; however a Γ with any phase angle is possible, we do not have not have a full description of the situation. It is interesting to look at the possible values for the reflection coefficient and thus the apparent load. For a given load the reflection coefficient and thus the VSWR can be determined. If there is a transmission line of the system characteristic impedance between the load and measurement the

VSWR and the magnitude of the reflection coefficient will be the same as when measured at the load; however the phase angle of the reflection coefficient will be different depending on the length and propagation velocity of the line. I will call this the apparent load. Figure 2-2 shows calculated values for several discrete values of VSWR on the Smith Chart.

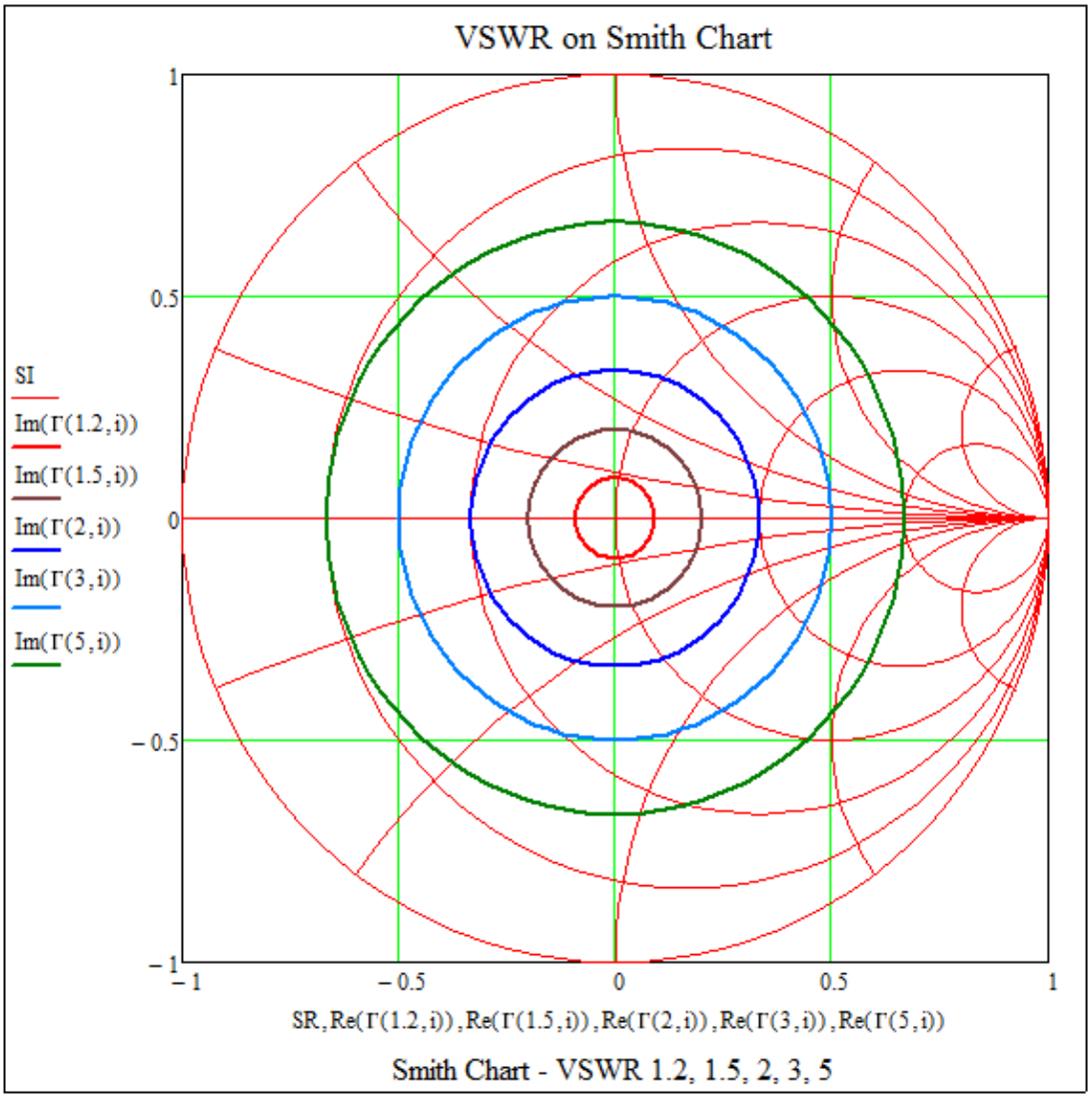


Figure 2-2 Plots for VSWR on the Smith Chart

Notice that each value represents a circle on the Smith Chart and therefore a range of impedance vales for each VSWR value. To get an idea of the range impedance values that result, calculations of the values are presented in Figure 2-3 with real and imaginary parts of the complex impedance presented on separate charts. These calculations are based on a 50 ohm system.

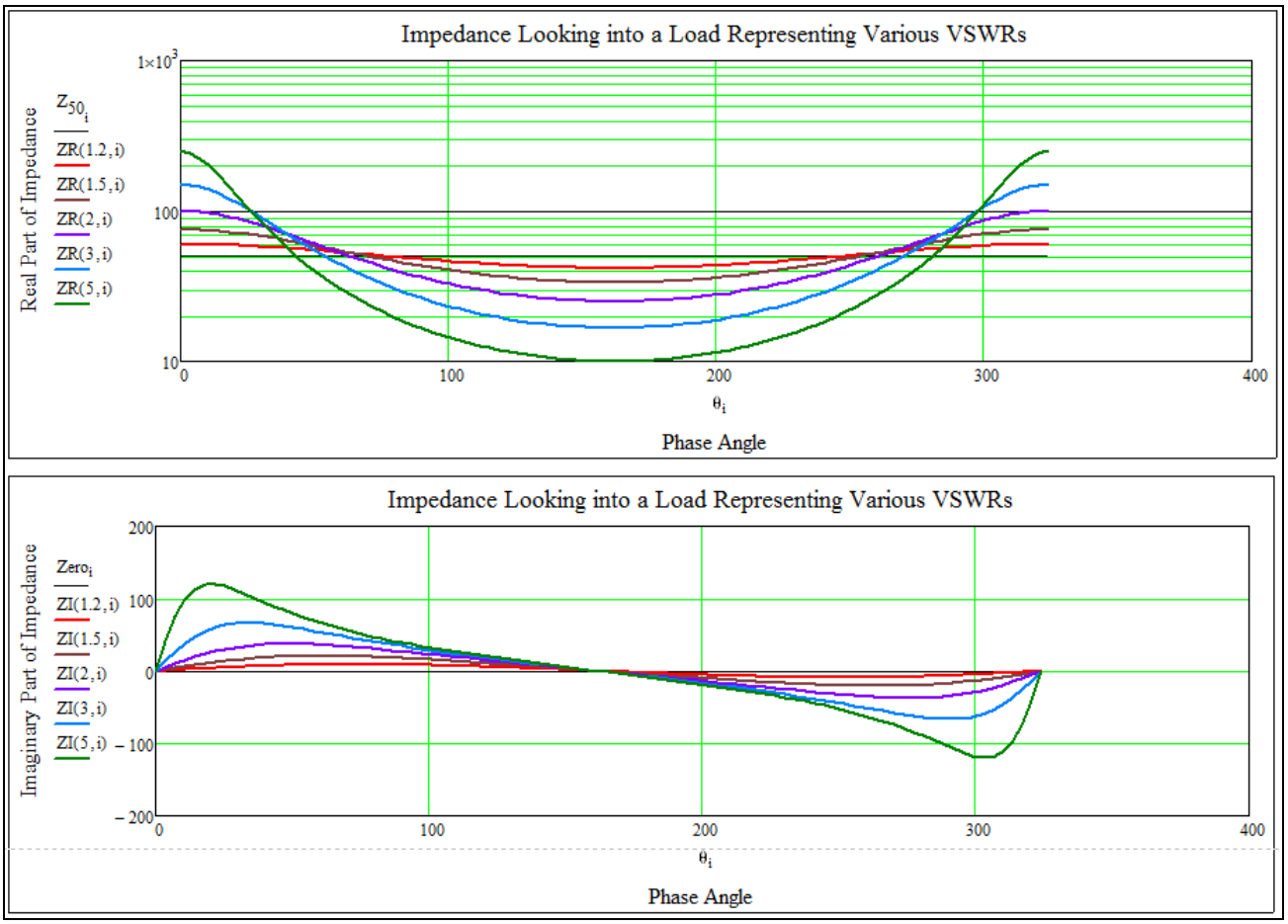


Figure 2-3 Possible Impedance Values for Selected VSWR Values

Another way of presenting this information is to plot the imaginary vs. the real part of the impedance as shown in Figure 2-4.

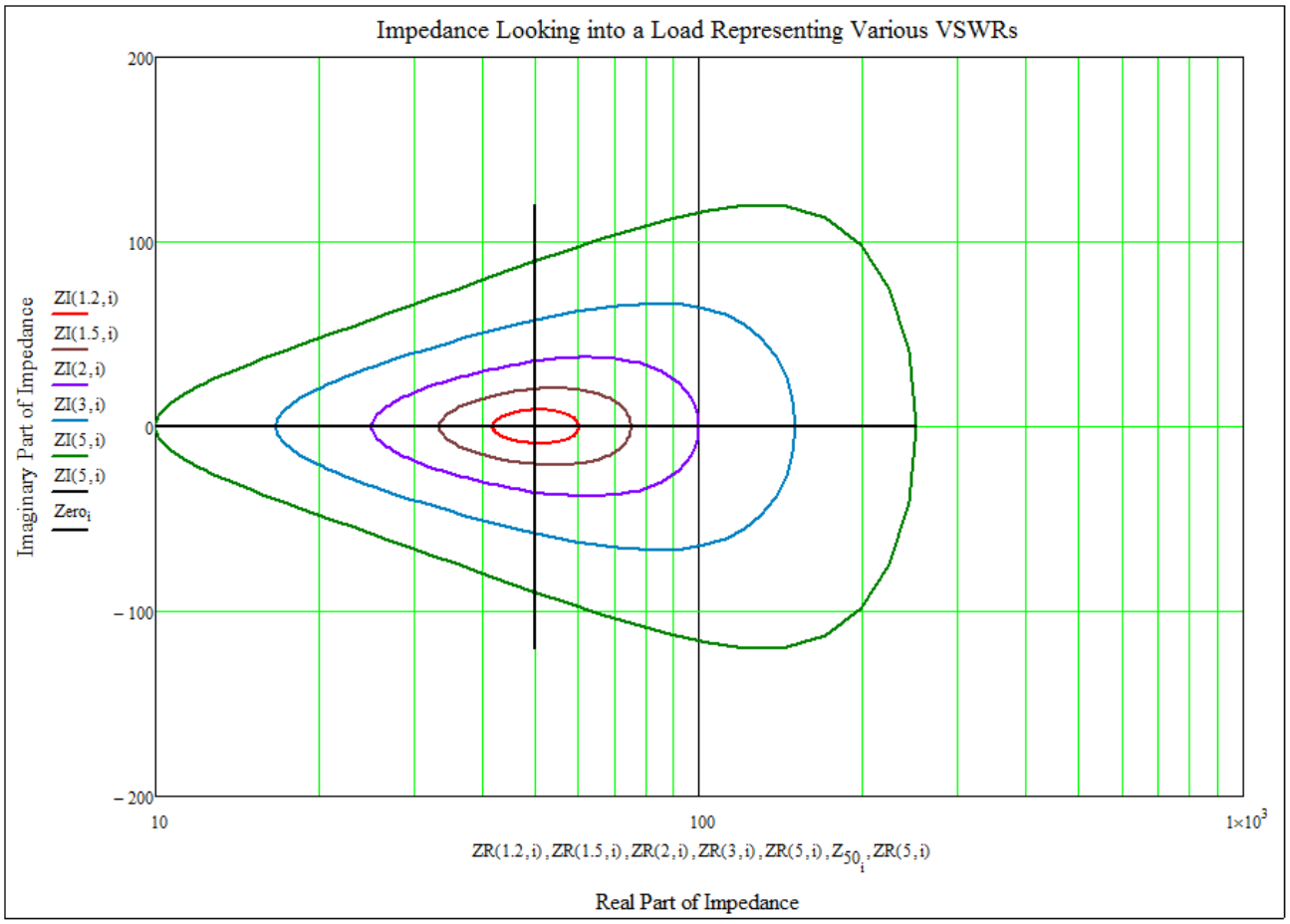


Figure 2-4 Imaginary vs. Real Part of the Impedance

3. Magnitude of Reflection to VSWR

Of course one can go the other way and calculate the VSWR from the magnitude of the reflection coefficient. this is given by:

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

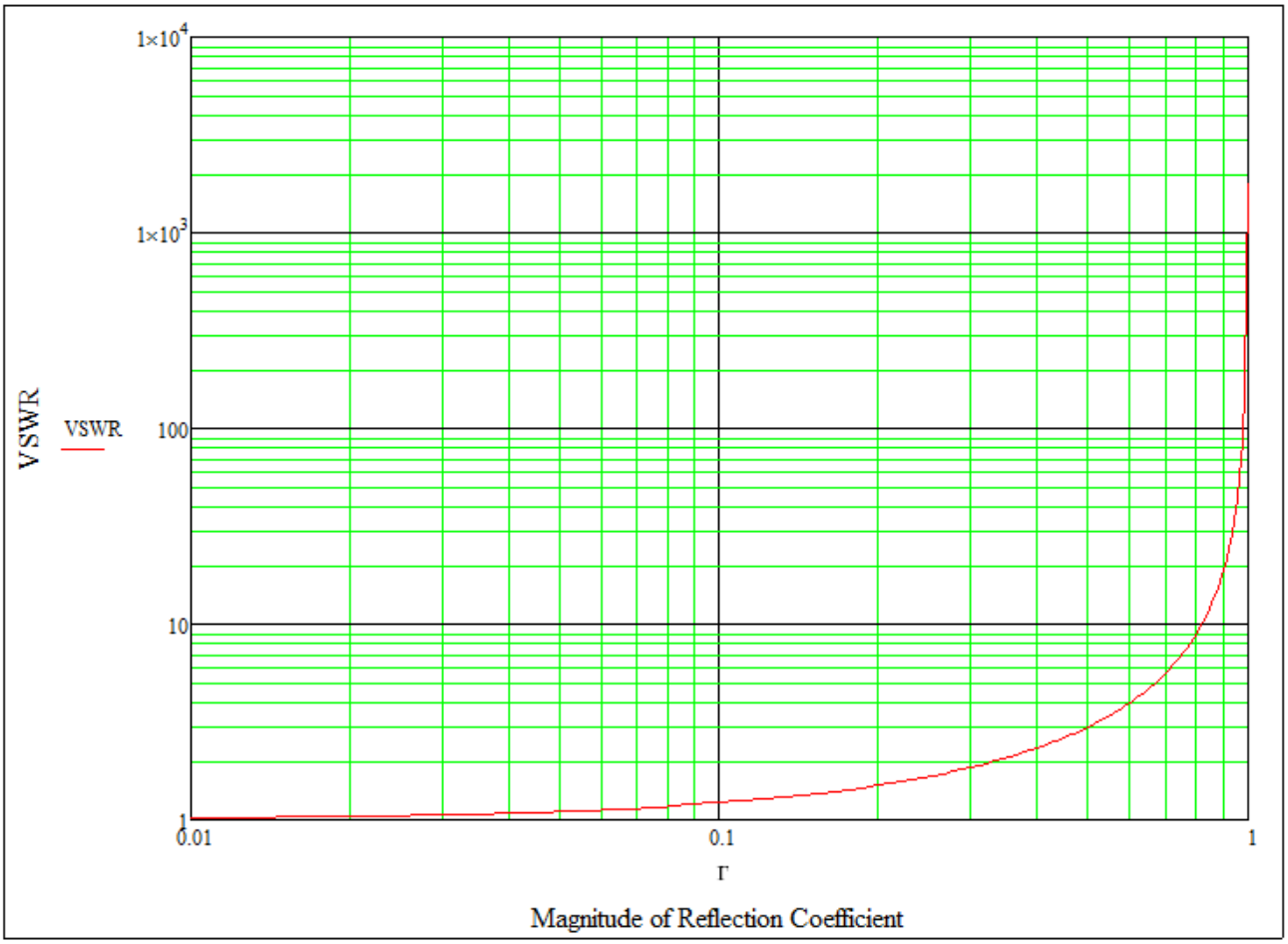


Figure 3-1 Chart of VSWR vs. Magnitude of Reflection Coefficient

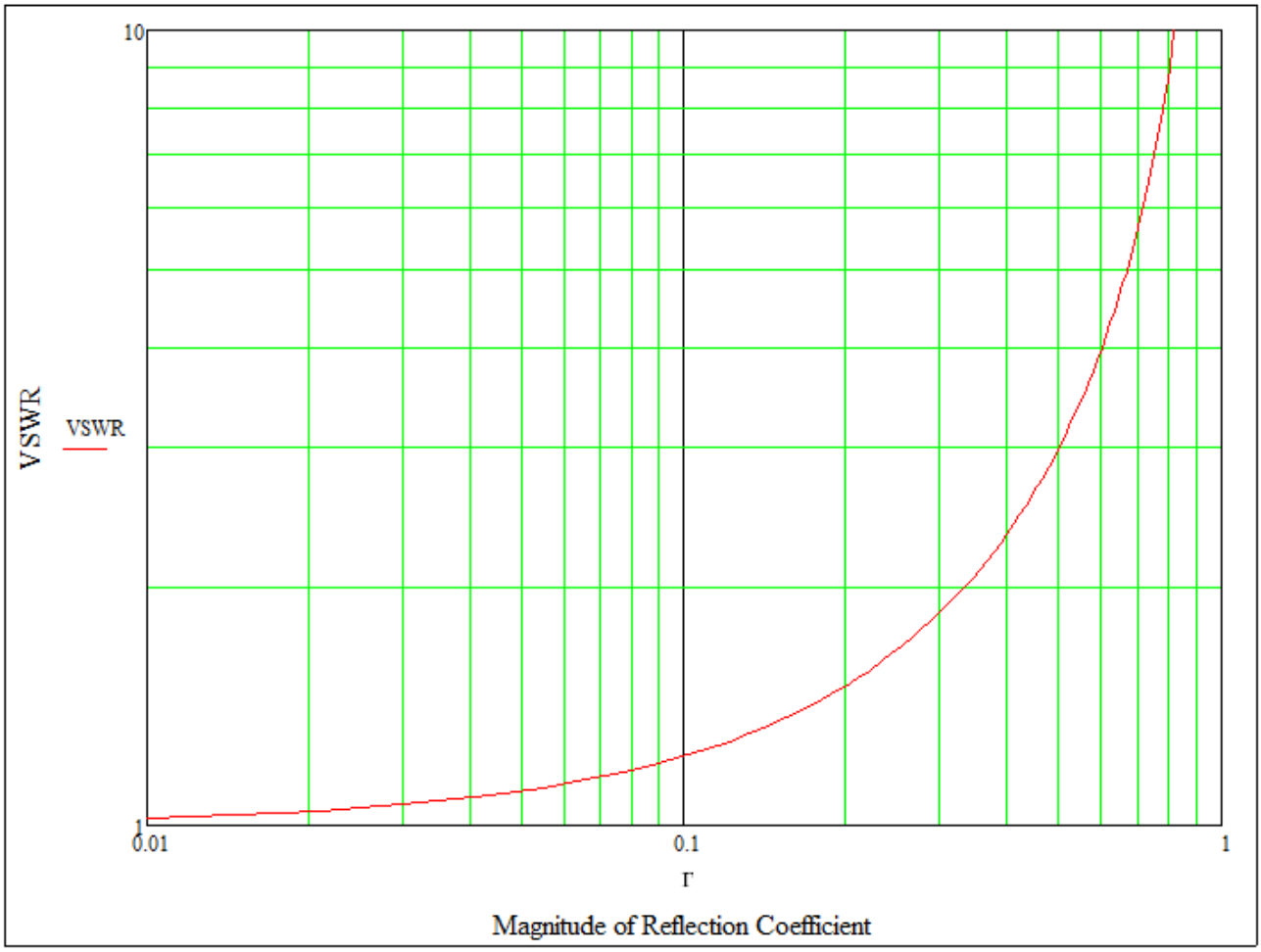


Figure 3-2 Expanded Chart of VSWR vs. Magnitude of Reflection Coefficient

4. Discussion

From the above it can be seen that considerable information is missing from the VSWR value that would be very useful in many situations. Nevertheless, in a number of circumstances, the VSWR value can quite useful by itself. One example when tuning a load and when the VSWR goes below some value, one can consider the load tuned. Many times this all that is needed and with various tuners all that is needed. In these circumstances one has no idea what he is compensating for with the load and may not care.

There are times that one wants provide a specific solution to a load problem. In this case it becomes important to go the complex reflection coefficient and calculate the exact parameters need. Fortunately today this is not quite the burden it used to be, particularly for general ham or experimenter. In addition to the Vector Network Analyzer that out of reach of many hams, there are a number less expensive instruments dedicated to these types of measurements. At last Γ is available to the masses.

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