# A little about SWR.

**My world is not perfect, and neither are my antennas, so now it is important to discuss what can go wrong.**

**No discussion about antennas would be complete without a word or two about SWR. The Standing Wave Ratio will be explained somewhere much later in this site, but I suspect that you have the idea from somewhere that the SWR must be 1:1 for a perfect antenna. Actually, that is not true. It is true that a low SWR is good, but many radio amateurs attempt to match their perfect antennas (with a 36 Ohm impedance) to a high quality coax that has an impedance of 50 Ohms and expect to get an SWR of 1:1. That just should not happen. The problem here is that most rigs and most coax are not manufactured for a 36 Ohm impedance. There should be some manufacturer somewhere in the world who makes a rig with 36 Ohms, but I do not know of any. I only know of the ones who use 50 Ohms, and that does not match a vertical antenna.**

**The formula for non-reactive SWR has two possible formulas. Choose the one that gives you an answer that is greater than 1.**

**SWR = Z load / Z coax**

**or**

**SWR = Z coax / Z load**

**Lets find the SWR of a 50 Ohm coax hooked to a 36 Ohm vertical antenna. I will use both of the formulas to show you what happens if you choose the wrong one.**

**SWR = Z load / Z coax = 36 Ohms / 50 Ohms = 0.72, which is less than 1.**

**SWR = Z coax / Z load = 50 Ohms / 36 Ohms = 1.38, which is more than 1.**

**In this example, you should choose the answer which is greater than 1, which is 1.38. This will become 1.38 to 1 or can be written 1.38:1. 1.38 is almost 1.4, so I will say that this SWR is 1.4 to 1. The conclusion here is that a perfect vertical antenna with a perfect ground connected to a perfect 50 Ohm coax will have a SWR of 1.4 to 1.**

**This is a critical idea. If your vertical antenna has a SWR less than 1.4 to 1, or more than 1.4 to 1, something is not perfect. A 1:1 SWR is not a good sign.**

**So, why is a 1:1 SWR not a good sign? To get a 1:1 SWR means that the antenna system has 50 Ohms of resistance and is being used with 50 Ohm coax. The radiation resistance is supposed to be 36 Ohms with a vertical antenna, not 50 Ohms. Somehow, the antenna system has gained an extra 14 Ohms. (50 Ohms minus 36 Ohms equals 14 Ohms.) Where can an antenna system get an extra 14 Ohms? The easiest way to increase the resistance of an antenna system is to have a bad connection or a bad solder joint. The next easiest way to get extra resistance in an antenna system is to have a poor ground system.**

**The efficiency of a vertical antenna system with extra resistance in it will be lower than a perfect system. Let's do the math again.**

**Efficiency = Radiation resistance * 100 / sum of all the resistances in the antenna and ground.**

**Efficiency = 36 ohms * 100 / 50 Ohms = 72 %**

**This means that the 1:1 SWR antenna system is losing 28% of its power and transmitting only 72% of its power.**

**Just a little more math.....**

**Remember when we looked at both of those graphs, and found that 55 radials each 0.288 wavelengths long would give us 80% efficiency? You can use the 36 Ohms and the 80% to find out what the total resistance is in the whole system. You can use the formula for efficiency and turn it around (transpose it) to find that total resistance, then use that total resistance in the SWR formula.**

**Efficiency = 36 Ohms / the Total resistance . . . so, Total Resistance = 36 Ohms / 0.8 = 45 Ohms Calculating the SWR of an 80 % efficient antenna looks like this.....**

**50 Ohms / 45 Ohms = 1.11, or 1.11: 1 SWR.**

**That sure looks perfect, but it is only 80 percent efficient!**

**80%? That really does not look good, but it is not as bad as it looks.**

**One more look at math.......What is 80% in Decibels?**

**dB = 10 times log 10 (power ratio)**

**Where the power ratio is 0.8. (because 80% is equal to 0.8)**

**Decibels = -.969**

**The Decibel calculation of 80% efficiency turns out to be slightly less than 1 dB! I think I can live with a 1 dB loss in my ground system.**

## This is a good place to put it all together.

**Actually, you might want to know the value of efficiency VS. Decibels so you can make a better estimation of how many radials you really need. This information comes from the same two graphs at the Stepper web site found on another page in this web site.**

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**Efficiency | decibels | # of radials | wave length | SWR**

| | | | | |
|---|---|---|---|---|
| 90% | -.457 dB | 120 radials | 0.40 wl | 1.25 : 1 |
| 80 % | -.969 dB | 45 radials | 0.24 wl | 1.11 : 1 |
| 70 % | -1.54 dB | 22 radials | 0.16 wl | 1.02 : 1 |
| 60 % | -2.21 dB | 7 radials | 0.06 wl | 1.20 : 1 |
| 50 % | -3.01 dB | 4 radials | 0.03 wl | 1.44 : 1 |
| 40 % | -3.97 dB | no info | no info | 1.8 : 1 |
| 30 % | -5.23 dB | no info | no info | 2.4 : 1 |
| 20 % | -6.99 dB | no info | no info | 3.6 :1 |
| 10 % | -10.0 dB | no info | no info | 7.2: 1 |

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**It is difficult to know if your antenna is really doing a good job from "on the air" reports from other amateurs. The following paragraph is an example of a standard automotive system on UHF or VHF.**

**You can see that at 50% efficiency an automotive 50 Watt transmitter will be putting out 25 Watts which beats any standard handheld transmitter at UHF or VHF. Using the formulas for efficiency and SWR as shown above, the SWR for a 50% efficient antenna is 1.44, which looks pretty good for an automobile system. While this system is not very good at all, the operator will possibly think that her/his system is doing fine because everyone says the signal gets into the repeater "full quieting".**

**I hope you can see that a poor antenna can do an OK job and the operator will never suspect that the antenna is not really doing all it can do. In fact, the operator is likely to think the antenna is quite good. This is where bad information gets its start and intelligent people get the wrong idea!**