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Extend the Matching Range of Your 80 m Antenna

An inexpensive, easy and accurate way of broad-banding an antenna.

I prefer to use resonant antennas, but 80 m presents special problems. It's an extremely wide band, and it is very difficult to build a reasonable antenna with SWR better than 2:1 across its entire range. My antenna is resonant near the low end of the band (see **Figure 1**). I need to stretch its operating area up to the 75 m area for the few phone contests I like to run every year. For these few contest opportunities I just can't justify purchasing an expensive high power antenna tuner.

However, today's tools allow us to build our own tuners, designed for our own situation, and do it in an elegant manner.

Tools Required for the Job

You will need two important tools to design your own antenna matching unit.

1) A modern antenna analyzer capable of saving its output as a Touchstone file (such as the Rig Expert AA series). The output file must contain the real and imaginary impedance values for each frequency measured. If your analyzer (such as an MFJ-259) cannot save a Touchstone file, you can type the file yourself, see **Appendix 1**.

2) The program *SimSmith* by Ed Harriman, AE6TY, is available as a free download from **www.ae6ty.com**. You can learn all about this program in online YouTube videos **[1]**. You really don't need to learn a lot about it to design your tuner.

You start by sweeping your analyzer through the range of the band you want to match, then saving your Touchstone file. Then you tell *SimSmith* to load the file. As shown in **Figure 2**, you can also tell *SimSmith* to generate 2:1 and 3:1 SWR circles. You can see here that only the bottom 100 kHz of the band is inside the 2:1 circle. That's not too good.

The beauty of this solution becomes evident as the program not only allows you to sweep the frequency of the antenna trace, but allows you to build a matching circuit

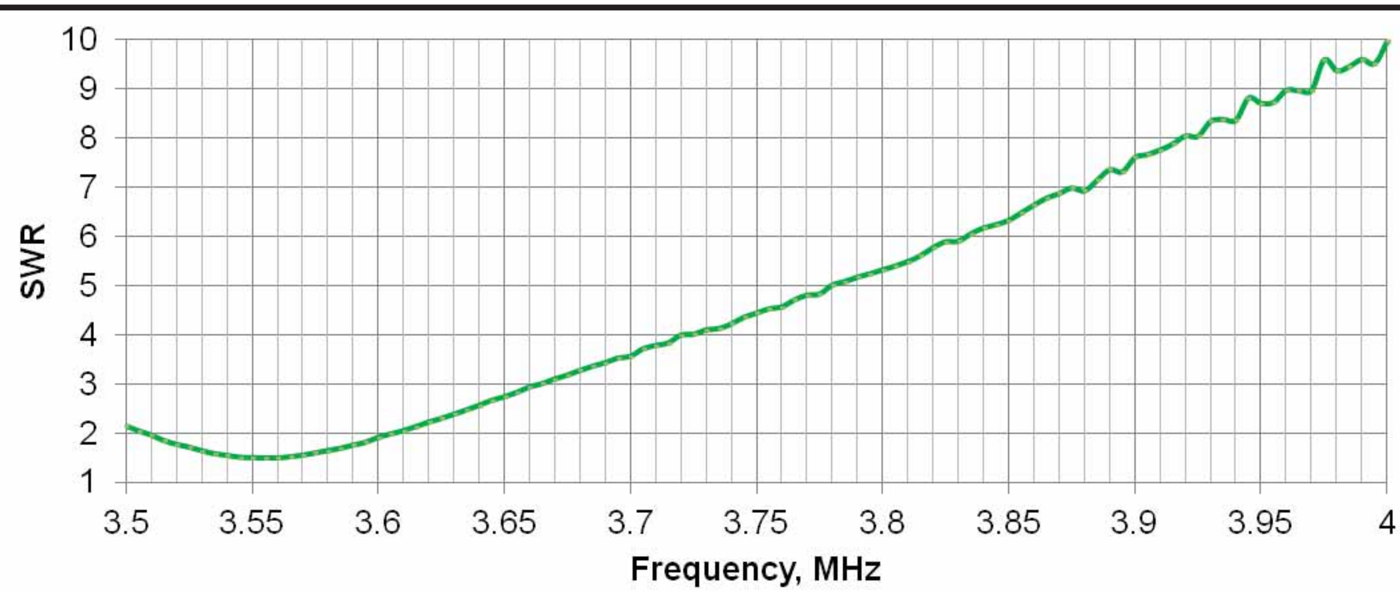

Figure 1 — An 80 m antenna resonant at low end of the band.

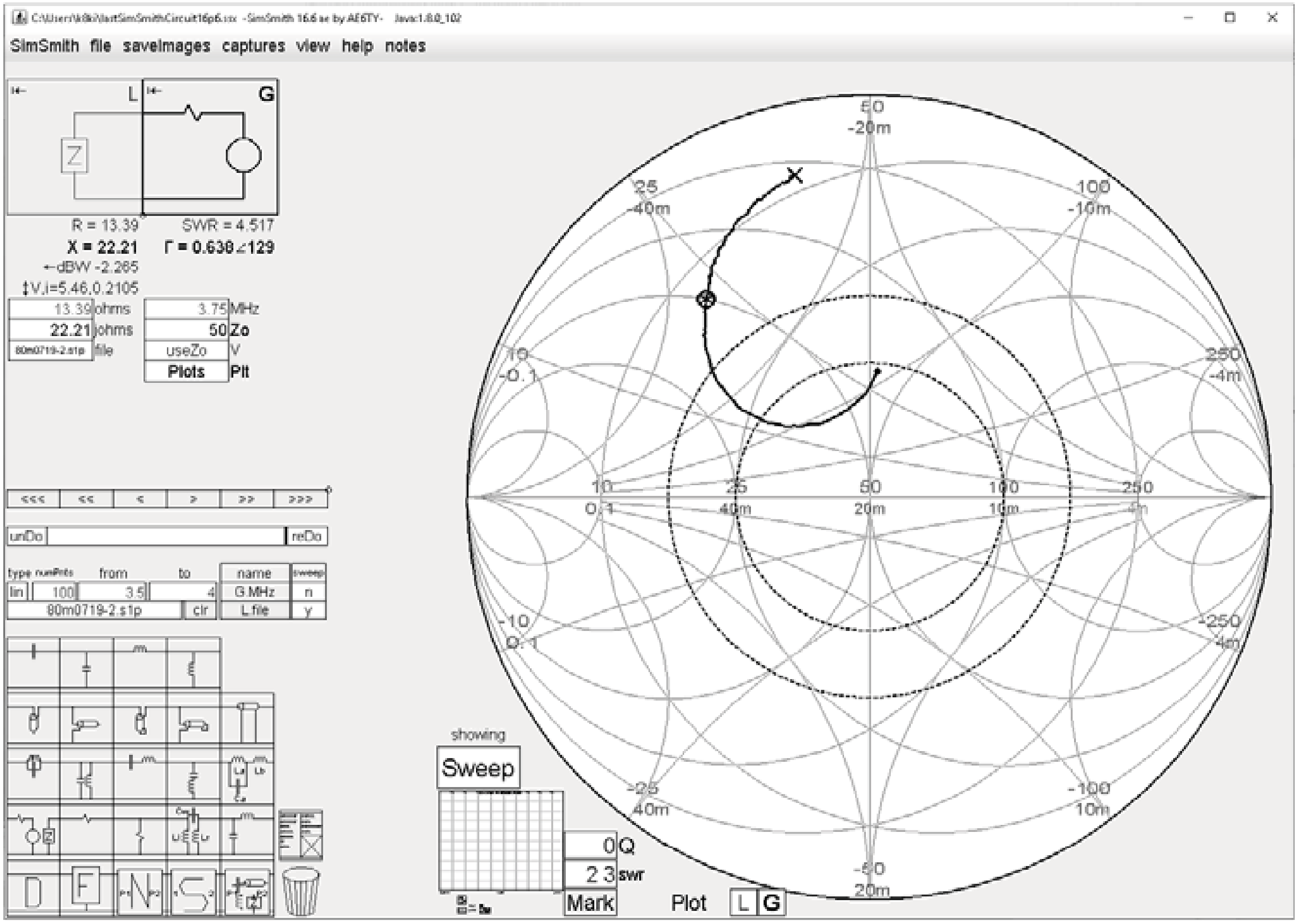

Figure 2 — Impedance trace for 80 m antenna using *SimSmith*.

whose values you can also sweep with a mouse.

You can see a capacitor tuner in the simulated circuit at the upper left corner of **Figure 3**. **Figure 4** shows the result of adding simply a shunt capacitor, connected in the antenna line at the back of your rig. In the Figure 3 Smith Chart graphic, you can see the original antenna trace, as well as the rotated rendition of it as the capacitor is tuned. Here the capacitor is set to 961 pF, optimal to this situation. We now have a circuit that stays inside the 2:1 SWR circle from 3500 to 3825 kHz, and it is done with one capacitor with a couple of connectors and a box (**Figure 5**).

The Concept of Good Enough

Luckily, this problem was solved with just a single inexpensive component. Other situations may also involve a second component, either capacitive or inductive, but those components are almost always going to be small and easy to find or build. More importantly, the aim was not to find the perfect 1:1 solution, but rather to find one that is more universal. That is, one that maximizes the frequency span where the SWR is workable. Very many rigs today have built-in tuners that can easily handle a 2:1 SWR, but maybe not 3:1. If that is your case, your rig can now tune the major part of the 80 m band, which is good enough.

Well, Did It Work?

The trace of Figure 4 shows the circuit response after the capacitor was inserted. It is virtually identical to the simulation of Figure 3. The solution will indeed work, but two other issues must be taken into account to work in the real world.

1) The capacitor must be able to withstand the voltage impressed upon it by the transmitter, as well as the high SWR on your transmission line. See **Appendix 2** for the calculation of the required breakdown voltage.

2) The capacitor must be temperature-stable under the worst conditions. Do not use capacitors with X7R temperature profiles. You must use NP0 capacitors. Perfect capacitors do not dissipate any heat, but our real-world capacitors have an Equivalent Series Resistance (ESR) that does cause them to heat up. Get capacitors with the lowest ESR you can find.

In a first experiment I used a 2 kV, 1000 pF, X7R capacitor with significant ESR. At 660 W, its temperature rose 40 °F. Of course the match flew off the chart. I replaced it with a 2 kV, 1000 pF, NP0, surface mount capacitor with the lowest ESR I could find. Of course it cost ten times as much as the first capacitor, but at 900 W, the temperature rose only 10 °F, and the match didn't budge. Pass! The finished project is shown at Figure 5.

Conclusions

1) Modern antenna analyzers and software offer solutions we couldn't dream of just a short time ago. Use them.

2) Don't try for perfect, single point solutions. "Good enough" swept solutions are far more universal and useful.

3) Use components made for the job. If the job is temperature critical (it always is), use NP0 capacitors with the lowest ESR you

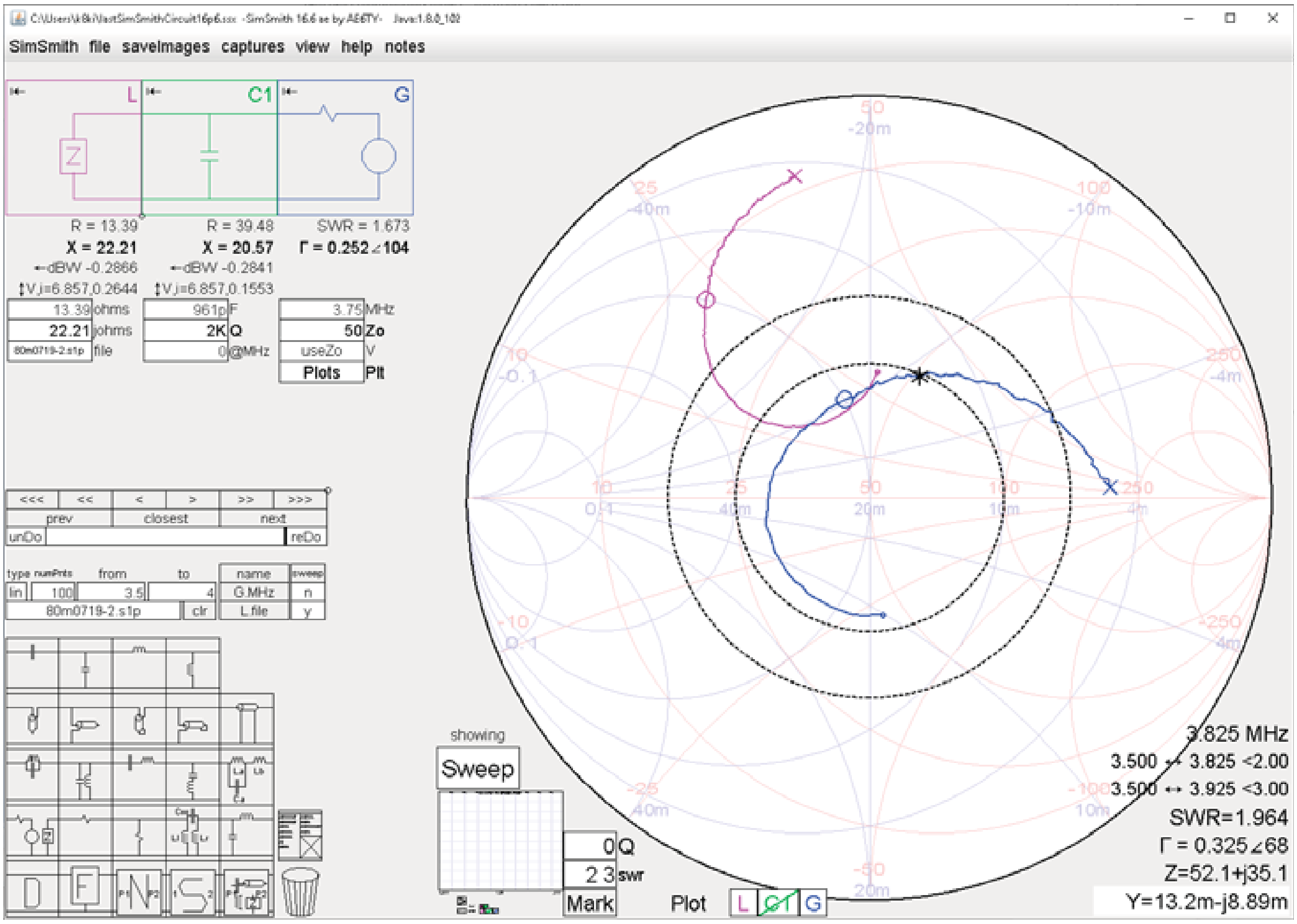

Figure 3 — Sweeping a matching circuit.

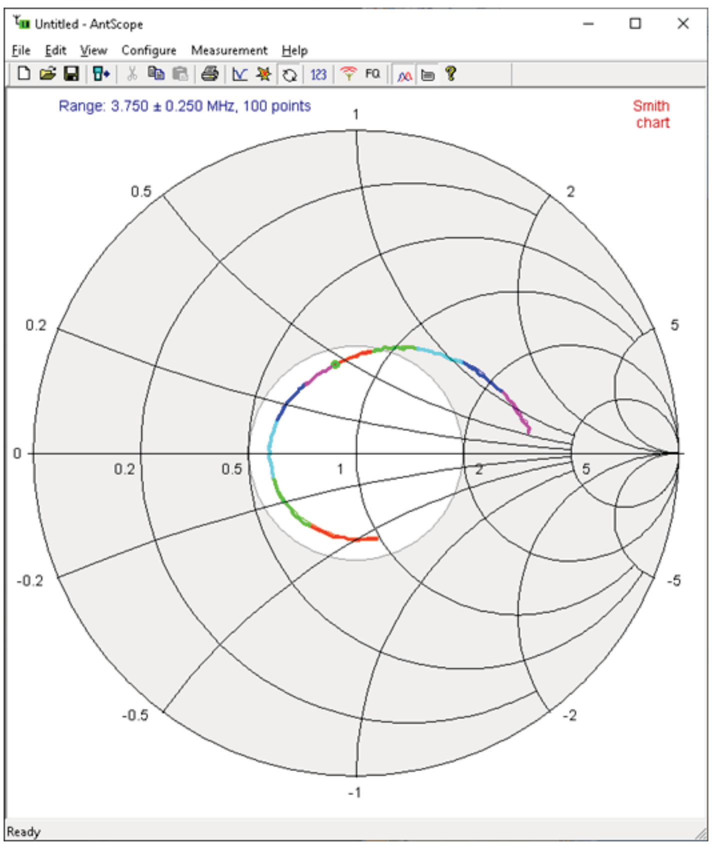

Figure 4 — Antenna sweep with tuner Installed.

Figure 5 — This 80 m tuner uses a single capacitor.

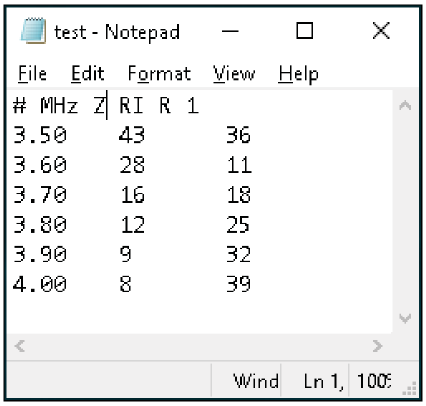

Figure 6 — Touchstone file entered every 100 kHz.

can find. Of course you need ample voltage breakdown headroom as well.

Appendix 1 — Construct Your Own Touchstone File

You can make your own Touchstone file if you have an analyzer such as a MFJ-259, as shown in **Figure 6**. You just open the Windows *Notepad* text processor and enter the first line exactly as shown. It is important that the last number in the first line is a 1, to show the values are normalized to 1 Ω Here I used the *R* and *X* values from my analyzer, except they were spaced every 100 kHz. The fields are: frequency in MHz, the real component of the impedance, and then the imaginary part. Use the Tab key to separate the fields on each line, and a Return at the end of the line. Finally, save the file to something like *test.s1p*. Be sure to use the file suffix *s1p*, and not *txt*.

As you can see in **Figure 7**, the curve is not nearly as smooth as in Figure 3, but your tuning result will be very close. In this case the solution was a 1000 pF capacitor for both 101 points and 6 points of data.

Appendix 2 — Calculation of Voltage Across the Capacitor

An amplifier at 1500 W working into a 50 Ω load will generate:

$$V_{RMS} = \sqrt{PR} = \sqrt{1500 \times 50}$$
$$= 274$$

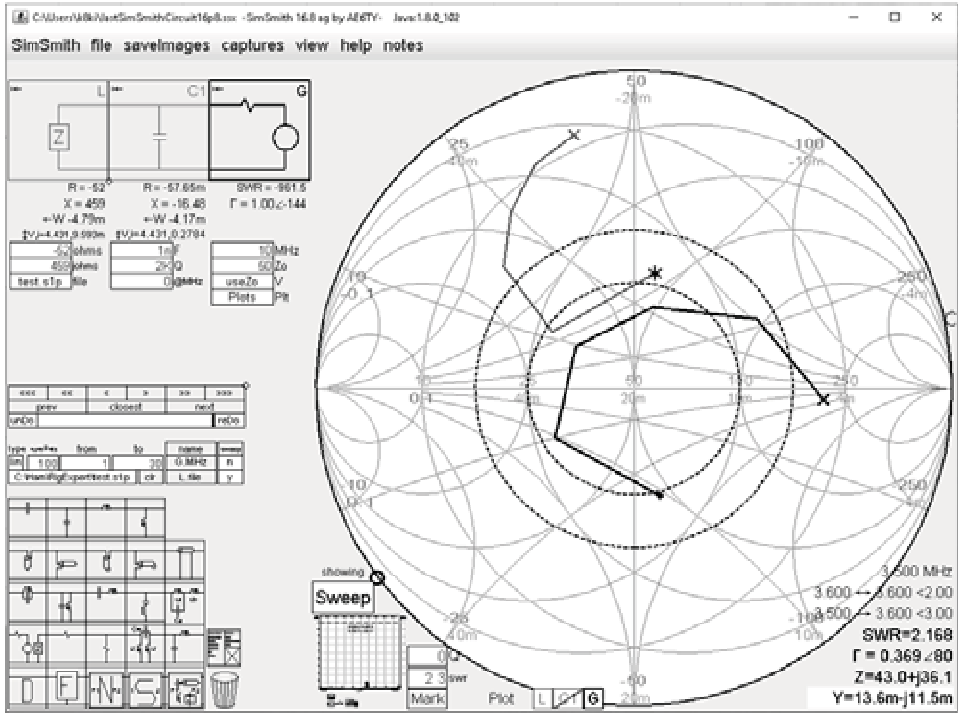

Figure 7 — *SimSmith* solution every 100 kHz instead of every 5 kHz.

The total voltage across a shunt capacitor is:

$$2\sqrt{2} \times 274 \ \mathrm{V}_{RMS} = 774 \ \mathrm{V}_{\text{P-P}} .$$

The peak transmission line voltage is much higher than this with a high SWR on the line. We can calculate the impact from:

$$SWR = \frac{|V_{max}|}{|V_{min}|} = \frac{1+|\Gamma|}{1-|\Gamma|} .$$

Now for SWR=10, we solve for $|\Gamma| = 9/11$, so that

$$V_{max} = (1+|\Gamma|) \times 774 \ \mathrm{V}_{\text{P-P}}$$
$$= (1+9/11) \times 774 = 1408 \ \mathrm{V}_{\text{P-P}} .$$

Thus a 2 kV-rated capacitor would give acceptable margin. NP0 and low ESR capacitors are readily available from distributors. Surprisingly, surface mount capacitors as small as size 1812 will meet the specification. Of course larger ones will work as well.

Bob DePierre, K8KI, spent a career in the USAF, and the last 16 years as VP Engineering at the Q-Track Corp. He earned a BSEE at Notre Dame and MSEE at the University of Florida. He is currently president of the North Alabama DX Club. Now mostly retired, Bob enjoys spending time with his new granddaughter, Diana. He has been licensed since 1962.

Notes

[1] See for example **https://www.youtube.com/watch?v=Xf_S2IT4_JE&t=5s**