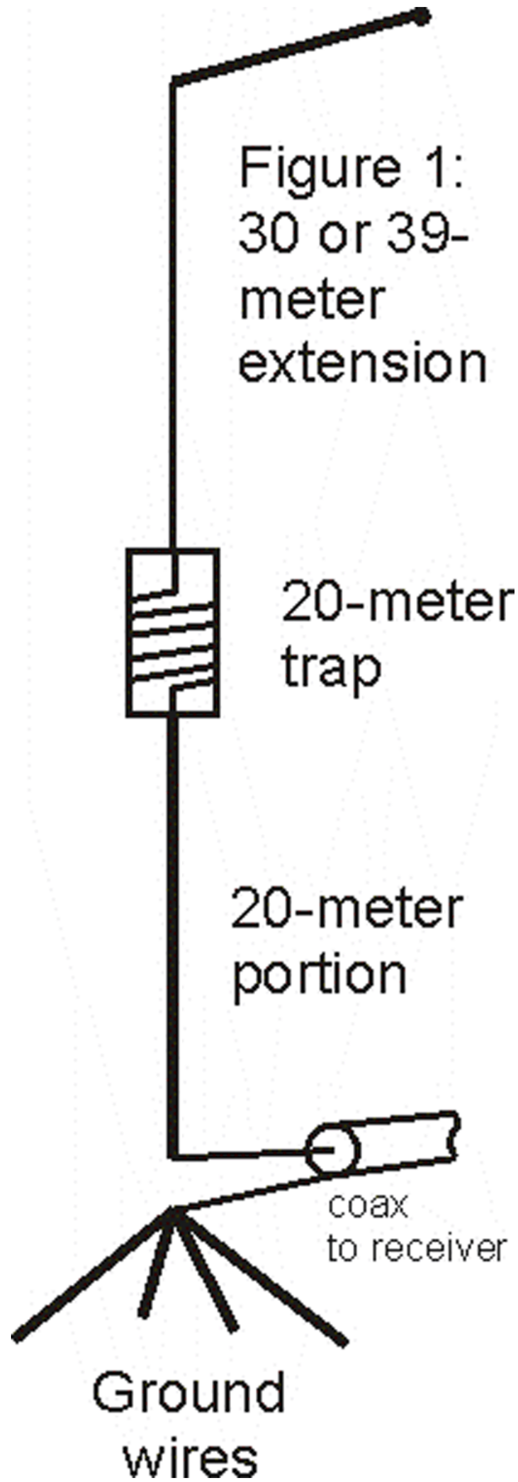
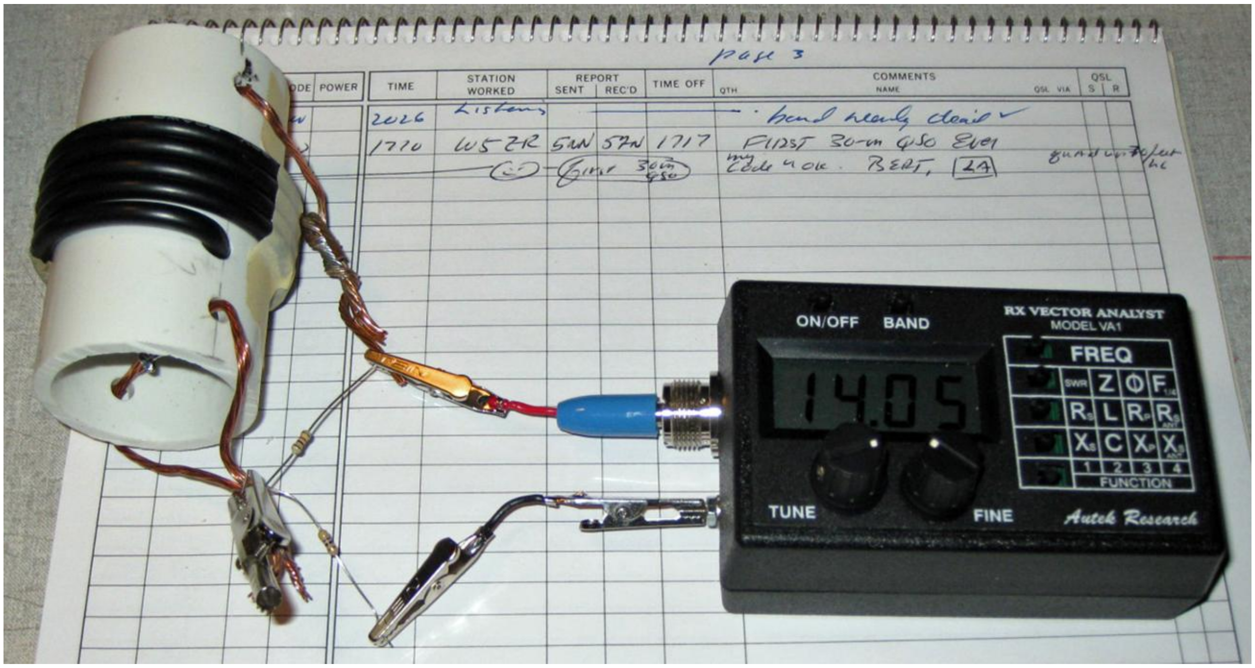
A 20- & 30- or 20- & 39-Meter Trap Antenna

By Phil Anderson, WØXI



I received an email from a crystal set enthusiast, wondering if the helical antenna I wrote about in the September issue would work for the AM broadcast band too? The helical was designed as a dedicated and shortened 20-meter (14 MHz) antenna, and as such, wouldn't be very effective for 0.5-1.5 MHz reception. A decent antenna for that band needs to be much longer. Being an amateur radio operator and an HF shortwave crystal set enthusiast, it accrued to me that it would be fun and doable to design a 20 & 30 or 20 & 39 meter vertical antenna, featuring a coaxial trap to isolate the 20-meter portion. The design process and specs follow.

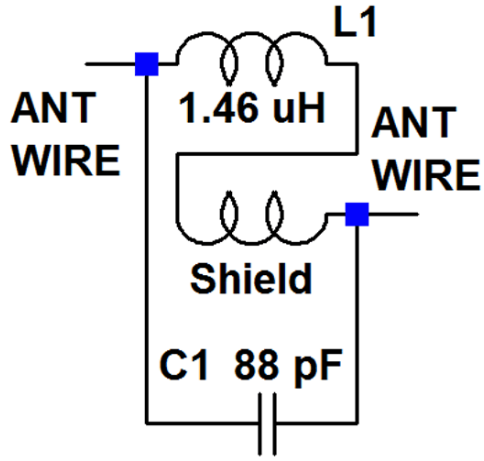
The layout of the antenna is depicted in Figure 1. Starting at ground, a number of 16.6 foot radials are run out across the ground and a copper ground rod is driven into the ground and attached to the radials. The base portion for 20-meters consists of 16.6 feet of antenna wire (or small pipe) and the trap. The trap is smaller than the graphic shows, consisting of a 1.92-inch dia. 3.5 inch long piece of PVC pipe with 4.5 snug wound turns of Beldon 8262 RG58-C/U coax. A sufficient length of wire is added above the trap to bring the antenna into resonance at the midpoint of the 30 or 39 meter.



The purpose of the trap is to electrically isolate the 20 meter resonant base wire from the additional wire added above the trap for a second band. A picture of the assembled trap and its schematic are show in Figures 2 and 3. The trap is a parallel tuned circuit consisting of the wound coaxial inductor and the paralleled capacitance due to the length of the coax. A discrete capacitor in not needed (see reference 1).

The capacitance per foot for Beldon 8262 is 30.8 pf. My Coax Trap Calculator (reference 2) indicated 5.0 turns are required for resonance at 14.05 MHz, producing a parallel trap with 1.457 uH of inductance and 88 pF of capacitance.

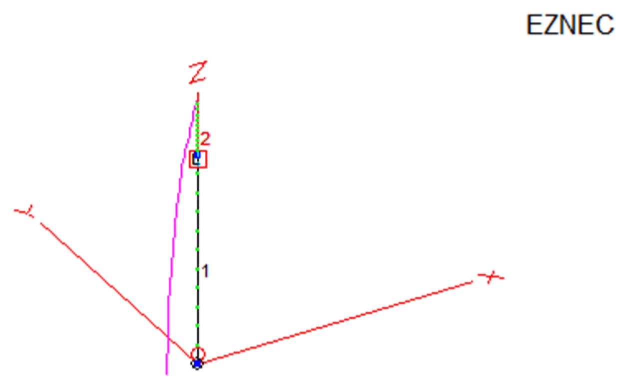
Figure 3: Trap Wiring



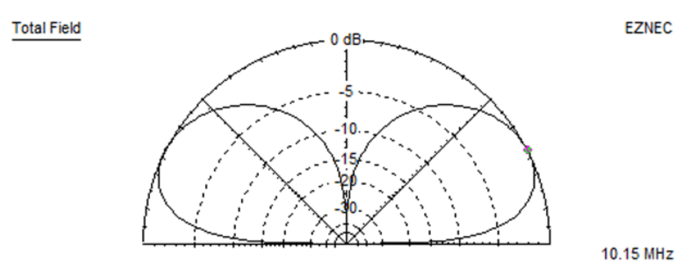
I measured the impedance of the trap with a 50 ohm load from 13.5 to 14.2 MHz in 100 kHz steps, using my Autek Research VA-1 Vector Analyzer. Because the impedance at resonance is high, I had to – as recommended in the analyzer manual – parallel the trap with a 1K resistor in order to obtain R, X, L, and C readings. First pass results are shown in Table 1. Note that the trap resonated at about 13.85 MHz. This is the frequency, where the trap impedance switches from inductive to capacitive as the frequency is increased. I was then able to tune the trap to 14.05 Mhz by spreading out the top of the left most turn about one coaxial diameter thickness.

		Table 1:			
	Table 1: Impedance Values of 20-M Trap				
	Taken with Autex VA-1 Vector Analyzer				
F	SWR	R	X	L	C
[MHz]	[ratio]	[ohms]	[ohms]	[uH]	[pF]
13.5	17.2	851	88	4.01	
13.6	16.7	836	79	0.93	
13.7	16.8	829	59	0.69	
13.8	16.4	823	42	0.58	
13.9	17.3	865	-64		177
14.0	17.6	878	-90		127
14.1	17.6	846	-105		107
14.2	17.4	849	-129		82
coax adjusted for resonance at 14.05:					
14.05				0	0

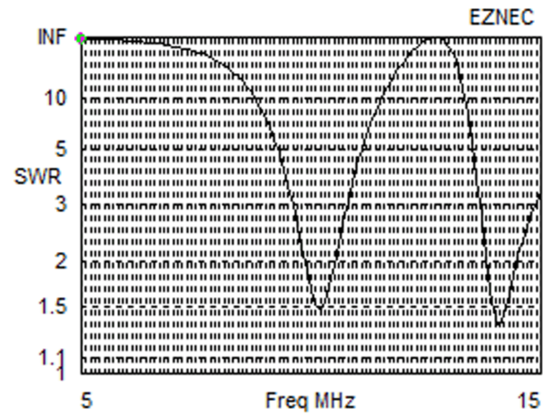
I modeled the 20-30 antennas with my EZNEC 5.0 program, which runs on my Del-XPS 420 with Vista Home Edition (reference 3). The resulting antenna and trap are shown in Figure 4 at right. I set the length of the 20-meter section (wire 1) at the base as 16.6 feet and an initial value for the top section (wire 2) at 4 feet. EZNEC provides for trap entries too, and that is shown as the small box between wires 1 and 2. The curved line from top to bottom denotes the current distribution when driven with a 10.125 MHz source.



The resulting antenna elevation pattern is shown at right, Figure 5. *See J K Fenton's "Antenna Tutorial" article in this issue for how to read this plot.* It's a typical plot for a simple vertical antenna, even though we obtained it by combining two sets of wires with the trap. The plot for 20-meter operation is identical.



EZNEC provides for a frequency sweep presentation for SWR, as shown at right, Figure 6. With the simulation you get to see at what frequencies the antenna is resonant. Clearly, we can see the low standing wave ratios (SWRs) for 10.125 (30 meters) and 14.05 MHz (20 meters).



Calculations & Adjustments

It is well known that the resonant length of a quarter-wavelength vertical antenna (or half of a dipole) in feet can be calculated as follows:

$$\text{length} = \frac{234}{f}, \text{ where f is the frequency in MHz and length is in feet.}$$

That's where the 16.6 feet came from for the 20-meter base section. The trap values, obtained from the Coaxial Trap Calculator were used for entry of the trap parameters for EZNEC. I then adjusted the length of wire 2 until the SWR was minimal at 10.125 MHz, obtaining about 3.4 feet for the 30-meter add-on section and 14 feet for the 40-meter add-on. <u>The 14 feet is noteworthy</u>. One might expect the total length for a stand-alone 40-meter antenna to be twice that of the 20 meter, given the equation above. However, with our trap antenna, the trap is tuned for 14.05 MHz which is not resonant but inductive for lower frequencies used. For example, the 2.6 missing feet (16.6-14 feet) for our 40-meter version is provided by the impedance of the trap for 40-meters. Cute huh?

Here's another tidbit. If one tries to string out 234 feet less 16.6 feet of wire for the AM broadcast band at 1 MHz and attach it to the top of our trap antenna, the addition badly detunes the use of the antenna for 20-meters. Actually this only happens when the top wire is L-shaped, which it usually is "Cause we don't have any 234 foot trees about!" If a large portion of that wire is running parallel to the ground and say up only 50 feet or so, too much capacitance is added to the antenna and the 20-meter section is no longer resonant. It also has an odd near vertical (NVIS) elevation pattern.

References

(1) Robert C. Sommer, N4UU, “Optimizing Coaxial-Cable Traps,” QST, December, 1984. This article includes the derivations for the equations used in some current web coax trap calculators. It is an outstanding article (including the math)!

(2) Tony Field, VE6YP, “Coaxial Trap Calculator,” www.qsl.net/ve6yp

(3) Roy Lewallen, W7EL, EZNEC Antenna Modeling Software,

www.eznec.com