Building Coaxial Cable Traps

Introduction

This page describes the design and construction materials I used to build a coaxial cable trap. A coaxial cable trap is a parallel resonant circuit that is usually inserted in an antenna element to enable multiband operation. In this case, I wanted to build a 40 meter (7.150 MHz) trap for use in an 80/40 meter vertical antenna.

Coaxial cable traps have become popular in recent years, mainly because they are easy to build, easy to adjust, inexpensive, and coaxial cable is usually far easier to obtain than discrete capacitors and inductors. Since coaxial cable is always designed for outside use, the trap is inherently weather-resistant, except for the connections at the ends. When the trap is constructed from larger diameter coax, such as RG-213, the trap should be able to handle full legal power (1500 watts). Traps constructed from smaller cable, such as RG-58, should be able to accept 600 watts (on the lower HF bands).

Trap Design

The trap physical design will be substantially influenced by the design of the antenna using the trap. As mentioned earlier, the antenna in this case is an 80/40 meter trap vertical. A 40 meter trap is located at the top of a quarter wave 40 meter vertical. The top of the trap supports a whip, which is sized to bring the whole antenna into resonance on 80 meters.

The trap will be inserted as a series element in the vertical antenna. That is, the two sections of the antenna are separated from each other by the trap. The trap must be part of an insulated assembly that attaches the top whip to the bottom portion of the vertical. The electrical connection between section is made through the trap.

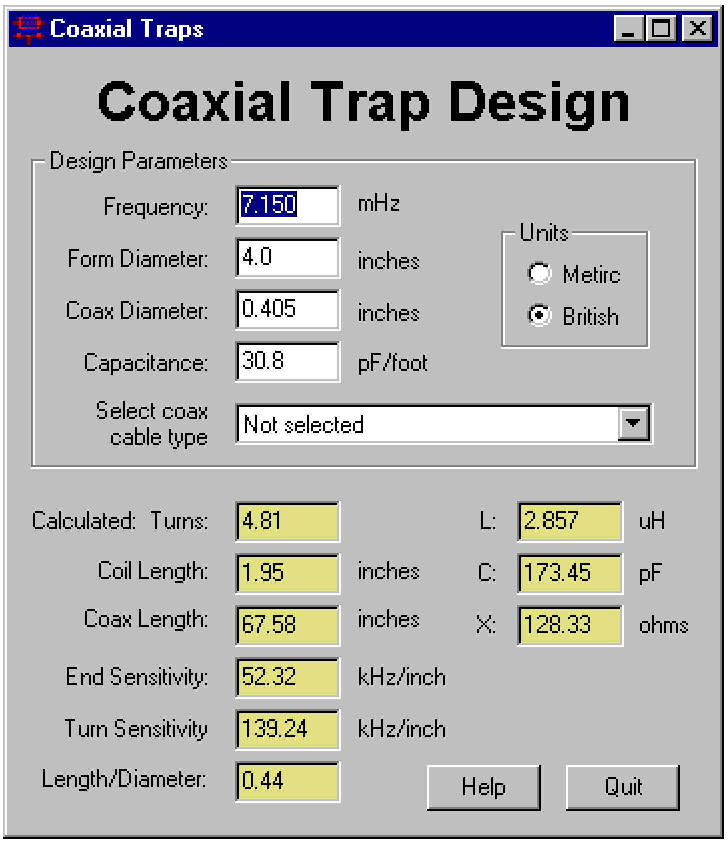
The vertical itself is constructed from aluminum tubing. I have found that Texas Towers is a good source of tubing, in a complete range of diameters. I decided to use a piece of fiberglass tubing as an insulated segment/spacer between the top and bottom sections of the vertical. I get my fiberglass tube from Max Gain Systems, a supplier of fiberglass used in amateur radio applications such as quad spreader arms.

I selected a 1.5 inch diameter fiberglass tube as the center support of the trap, and the linkage between the bottom and top sections of the antenna. The bottom section would telescope on the outside of the fiberglass, meaning that it was 1.625 (1 5/8) inches in outside diameter. The inside diameter is 1.5 inches, which will be a snug fit over the fiberglass tube.

The top whip is much smaller in diameter. The outer diameter of the largest whip section is 1 inch. This transition is accomplished by telescoping a smaller fiberglass tube inside the 1.5 inch tube. The details of the transition will be described with the antenna description on another page. The important point for the purposes of this page is that the trap must be built to surround a 1.5 inch section of fiberglass tubing.

In order to be able to handle 1500 watts, the trap would be built from RG-213 coax. While I could have wound the coax directly on the 1.5 inch fiberglass tube, that would have created a trap which is much longer than its diameter. The length to diameter ratio for an *optimized* trap (from the reference cited above) should be approximately 0.450. This results in the shortest length of coax in the trap, which helps reduce loss. Specifying a frequency of 7.150 MHz, RG-213 coax (0.405 inch diameter and 30.8 pf/ft), and a 1.5 inch diameter form resulted in a design using 78 inches of coax and almost 13 turns. Multiplying the 13 turns by the coax diameter of 0.405 inches results in an overall trap length of 5.2 inches. Since the form is 1.5 inches in diameter, the length to diameter ratio is approximately (5.2 / 1.5), which equals 3.4. Obviously 3.4 is not very close to the optimized ratio of 0.450. In order to reduce the ratio down towards 0.450, the length must go down, and the diameter must go up. (the length and number of turns were calculated by the *Coaxial Trap Design* software)

A common cylindrical form for winding large coils is 4 inch diameter PVC pipe. The software was again executed, but this time with a form diameter of 4 inches. The coax length now dropped to 67.5 inches, and the number of turns was reduced to 4.8. The new coil length was 1.95 (4.8 X 0.405) inches. The length to diameter ratio is (1.95 / 4), which equals 0.485. This value is very close to the suggested ratio of 0.450. This seemed like a good design to build.



Screen Capture of the Coaxial Trap Design Program

The software informed me that I needed 67.5 inches of RG-213 coax wound on a 4 inch diameter form. The software allowed for 1 inch of coax on each end to be used to make the trap connections. The coil length would be approximately 2 inches. A trap built from this specification should be able to handle 1500 watts of power, and it will have a length to diameter ratio very close to the suggested optimum value.

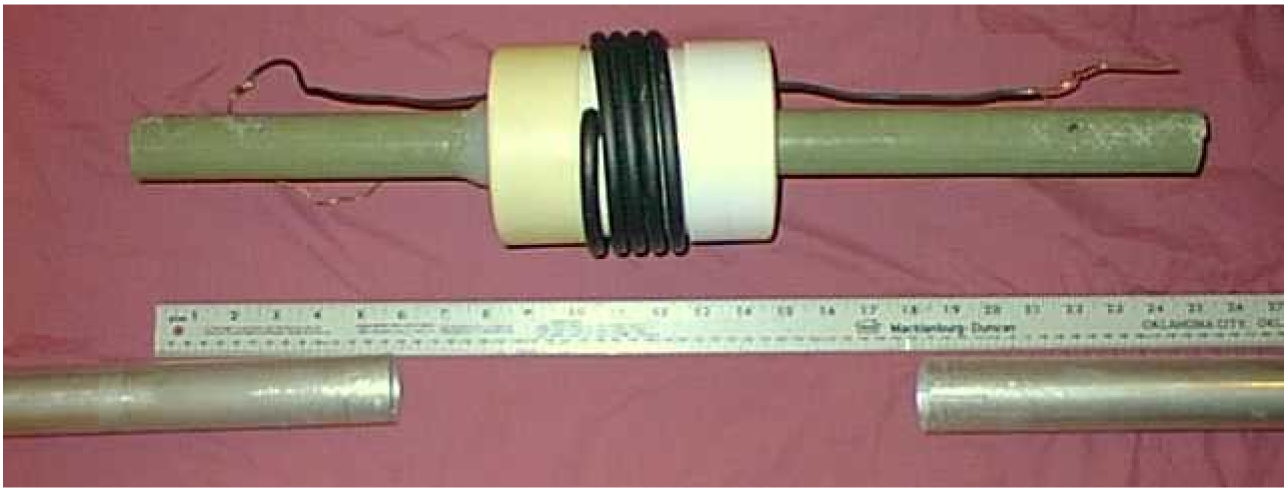
Trap Construction

I selected *schedule 20*, 4 inch diameter PVC pipe, which is the lightest (thinnest wall) commonly available stock.

NOTE: pipe size is usually specified by inside diameter. This means that a 4 inch schedule 40 pipe will have an outside diameter of around 4.5 inches. Since I used schedule 20 pipe, the actual diameter was 4.1875 inches. I ran the program with 4.0 inches, which is an error. When the program was run with the new form diameter, the coax length changed by 0.6 inches. I suspect that I didn't notice this when building the traps because I had far more length issues with the ends of the cable. This error got lost in that slop. The moral of the story is to be sure to measure your form, and use the actual value. Thanks to Bruce, N9BX, for bringing this to my attention.

The 4 inch PVC pipe would be held coaxially around the 1.5 inch fiberglass center support tube with a pair of PVC end caps, drilled in their center to accept the 1.5 inch tube. Let's get down to the step by step details.

The 1.5 inch fiberglass tube is 2 feet (24 inches) long. This length was selected so that there would be a 1 foot (12 inch) middle section of fiberglass with 6 inches of overlap with the aluminum tubing on each end. The 4 inch diameter PVC pipe length was determined by adding the inside length requirements of the end caps to the 2 inches required by the trap. This length was 4.5 inches. I used a 1.5 inch diameter hole saw to create the required holes in the center of the end caps. The overall length of the trap, from end cap to end cap, was 6 inches. The trap could be located in the exact middle of the 24 inch fiberglass tube, with 3 inches between the end of the aluminum tubing and the end cap. The layout of the trap relative to the fiberglass center tube and the aluminum tubing is shown in the following picture.



Prototype Coaxial Trap

It was clear that I would not be able to make a good electrical connection with only 1 inch of stripped and dressed cable inside of the trap. I found that I needed approximately 3 inches inside of the form in order to have enough exposed braid and center conductor to make connections between the ends and the antenna. I decided to arrive at any length adjustment by simply building a trap according to the design values (but with the 3 inch end length within the PVC form) and then to use a *grid dip meter* to measure the actual resonance. If the resonance was off, the coax length would be adjusted. In the end, the coax I used was 68 inches long. Of course one really should measure the resonance of each trap since coax can vary in important parameters such as velocity factor by as much as 10 percent. The relative compression of the turns will also change the resonance point. That's why I decided to *trap* the coax between the end caps, so that the turns would be tightly compressed and held in place by the end cap edges. It was my hope that this would lead to a tightly controlled coil length. I built six of these traps, and a prototype, and although I individually measured each trap to be sure that the resonance point was 7.150 MHz, I found that once I had the dimensions established, each trap was physically identical to the others. The coax did come from one roll, where one assumes that relative variation is minimized.

The total cost of 68 inches of coax and 4.5 inches of 4 inch diameter PVC pipe is around $3.00 (USD). This low cost makes it quite affordable to experiment with the design, and I certainly built several traps until I really understood the process, and got the resonant frequency correct. I then went into *mass production* mode, and built the 6 traps used in my vertical array.

Trap Coil and Wiring

Trap/Fiberglass Interface

Dipping the Trap

The left picture shows the 4.5 inch section of schedule 20 PVC pipe with the trap coax wound around it. RG-213 coax has an outside diameter of 0.405 inches. I drilled a 3/8 inch (0.375) hole in the pipe, then deliberately tilted the drill to create an elongated and beveled hole in the pipe. This hole allowed the relatively rigid coax to make a more angled (from perpendicular) entrance into the pipe while still being basically a tight fit. Within the pipe, I used cable ties to hold the ends of the coax from slipping out of the pipe. The coax ends were stripped before they were placed within the pipe. As the picture shows, one end center conductor is connected to the other end braid to create the parallel resonant circuit. The remaining center conductor and braid are the input and output terminals of the trap. In the final versions, I coated all exposed wiring with a product called *Liquid Electrical Tape*. This is a thick, black, liquid which can be applied to electrical connections. It dries quickly, and creates a form-fitting electrical insulator and weather barrier. I connected #12 solid wire to the trap, and brought those wires out of the trap, through holes in the PVC end caps.

The center picture shows the 1.5 inch hole in an end cap, and how the trap is placed on the fiberglass tube. I first glued the top end cap to the fiberglass tube with an adhesive caulk. After this glue dried, I liberally coated the junction between the fiberglass and the end cap, as well as the hole for the trap wire, with flexible silicon caulk. The idea here is to shed rain and moisture away from the trap. Of course it is impossible to keep water out of the trap. The best that one can do is to discourage it, and an important part of water management is to drill a *weep hole* in the bottom PVC end cap. This allows any accumulated water, or condensed moisture, to drain out of the bottom.

When the trap was assembled, stainless steel machine screws were used to fasten the end caps to the pipe. Silicon caulk was applied around the area where the coax entered the pipe. This completed the assembly of the trap.

The right picture shows a trap being tested for the desired resonant frequency with an MFJ-269 antenna analyzer being used as a *dip meter*. MFJ sells an accessory attachment that allows the analyzer to be used as the classic grid dip meter. The sense coil is inserted into the center of the trap to measure the resonant frequency.

Conclusion

The traps were very easy to build, and my verticals do operate as expected on 80 and 40 meters. I am concerned, however, about the performance issues which have been raised. These traps are very close to the optimum length to diameter ratio, which is just the dumb luck of my particular combination of frequency, coax, and the use of 4 inch PVC pipe. In many cases, coaxial traps shown in print are built from thinner coax (RG-58), and have a very poor length to diameter ratio. I would like to think that I'm doing that best that I can with this style of trap, and that converting to discrete components (coils and capacitors) would not make a measurable difference. If that proves to be incorrect, I believe that I could still use the PVC pipe and end cap construction to weather protect the discrete parts. I would expect that the coil would be around 2 inches in diameter, and would surround the 1.5 inch fiberglass tube. The capacitor would be placed in the same cylindrical volume.