Making Better Homebrew Traps from Coax

Improving the mechanical design of coax traps built on a PVC coil form. The benefits: greater bandwidth, lighter weight, lower cost and easier fabrication.

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In recent years antenna traps made from coaxial cable have become popular for use in homebrew antennas. The traditional coax trap is made from a few turns of coax wound solenoid fashion on a hardware store PVC form to eliminate the coil and capacitor of a discrete component antenna trap. It relies on the natural distributed capacitance and inductance of a short length of coax.

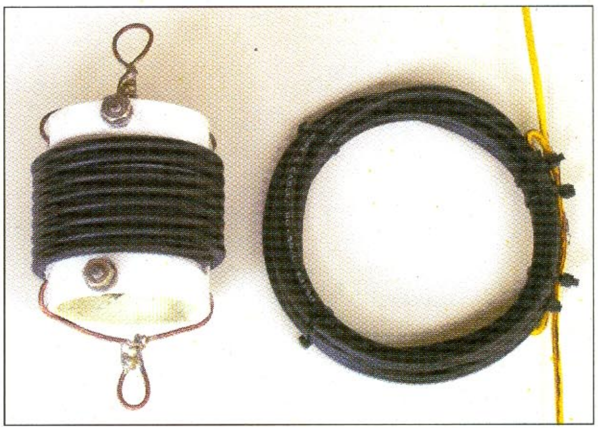

Figure 2 — Common PVC form trap compared to the 40 meter version described in this article.

To make this style of trap, all one needs is a length of coax, a PVC pipe form and a little hardware. These are readily available at local electronics or hardware stores. Discrete coils and capacitors are more difficult to find and to make into traps. These factors, as well as the reduced cost, are no doubt the main reasons for the popularity of coax traps.

Figure 1 is a simplified drawing of the traditional homebrew coax trap built on a PVC form. Figure 2 compares it to the version that will be presented in this article, a no-form scramble-wound trap.

Another Approach

I do not propose in this article to reinvent the wheel. The theory and practice of traps made from coax are well documented in many ham articles.[1,2] Here I merely offer two mechanical improvements to the common PVC form design, along with step-by-step instructions on how to make such a trap.

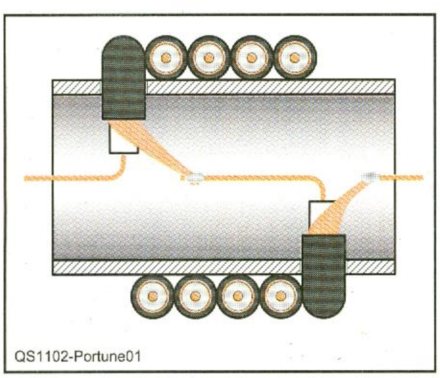

Figure 1 — Traditional configuration of a solenoid wound coax trap.

Both these modifications are applicable to other configurations and bands. The first increases the resultant trapped antenna bandwidth by using higher impedance coax for the traps. The second makes coax traps easier to construct and lower in cost by eliminating the PVC coil form completely. I evolved both methods simply because the familiar configuration has always seemed lacking in these ways.

The magic of a coax trap happens because of a crossover connection at the ends of the coil of coax. We connect the center conductor at one end to the braid of the other. The remaining ends then go to the antenna. See Figure 3.

The reason for the crossover connection is clever. It causes RF in the antenna to traverse the trap twice. On the outside it encounters inductance. On the second pass, on the inside of the coax, it encounters distributed capacitance. These two reactances are in parallel, forming a parallel tuned circuit. They replace the coil and capacitor of a discrete trap.

[1]Notes appear on page 48.

Trap Bandwidth

As attractive as this style of trap may be for ease of construction and economy, it does have a small drawback — lower Q than discrete LC traps. Many articles point this out. This is why some home builders still prefer separate coils and capacitors, for they do produce higher Q. Here's why. With discrete components one can choose optimum values. We are free to select an LC ratio that will achieve high Q.

In a coax trap we can't. There's just one length of each coax type and coil configuration on a specific frequency that will make a trap. That fixed length unfortunately has too much capacitance and too little inductance to yield the Q of a discrete LC trap. It's just the basic physics of coax traps. Very roughly, the typical discrete LC trap has twice to three times the inductance and only a third to a half the capacitance of a coax trap — a higher LC ratio.

The Downside of Low Q

Low Q is not ideal simply because a trap with a higher Q affords a higher working bandwidth to the antenna. I realize that common wisdom might suggest the opposite. For haven't we always heard: *The higher the Q, the narrower the bandwidth*? Yes, that is true for antennas, but not for traps.

Traps present a high impedance at resonance, which prevents RF from passing through to the ends of the antenna. At the resonant frequency they are efficient. But off resonance, their trapping action rapidly decreases as the overall impedance of the parallel tuned circuit diminishes. In any case though, a higher Q trap will maintain a higher impedance off the resonant frequency than will a low Q trap.

So what do we do about the low Q of a

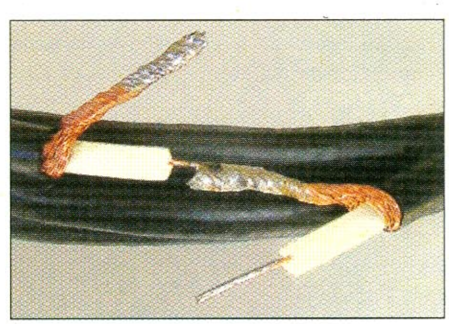

Figure 3 — Coax ends at the crossover connection.

Figure 4 — Test traps: RG-62 (left), RG-59 (top) and RG-58 (bottom). Two of each type were used for testing.

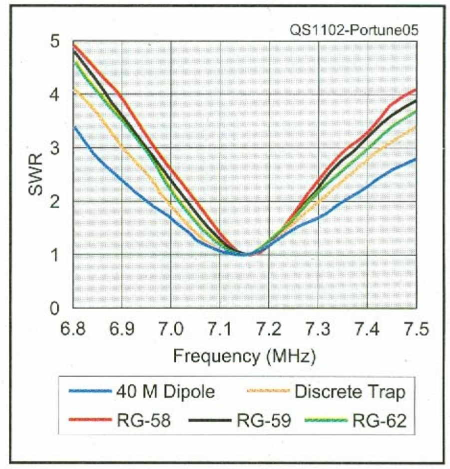

Figure 5 — Bandwidth of 40 and 80 meter trapped dipole with traps made from different impedance coax types, compared to a basic dipole without traps. Also shown is the same dipole with discrete commercial traps.

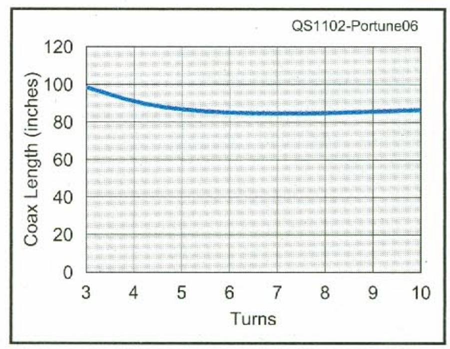

Figure 6 — The number of turns on a trap is almost irrelevant for the fixed length of coax required for the trap.

coax trap? The first improvement of this article is to use coax with less natural distributed capacity, that is, with a higher characteristic impedance (Z_0). 50 Ω coax, such as RG-58, as many articles suggest, is not the optimum choice for coax traps. RG-59, a 75 Ω coax, is better. Still better is RG-62. This not so common coax has a Z_0 of 93 Ω. It was promoted some years ago by IBM for use in their computer networks. While it has generally fallen out of fashion for that use, it is still commonly available. Table 1 compares the important properties of the most common coax types.

Lower capacitance will of course now require more inductance in the trap — a longer piece of coax — to produce resonance. But that's exactly what we want, a higher LC ratio — higher Q — greater operating bandwidth.

To verify how great the benefit is, I made three 40 meter trap sets of the modified design of this article from RG-58, RG-59 and RG-62. See Figure 4. I also tested the antenna with some commercial discrete LC traps I had on hand. I did it one evening as an outdoor club project that everyone enjoyed. Many had never seen home made antenna traps.

I took a reading on each pair in a two band 40-80 meter dipole at a height of 24 feet. All traps had five turns, only the coil diameter was different. I also measured the basic 40 meter dipole without traps. Additionally, I tested the antenna with a pair of commercial discrete LC traps I had on hand as well as a home-brew trap of the common PVC form configuration.

With the traps installed one pair at a time, I plotted the SWR across the 40 meter band using an MFJ-259 antenna analyzer. See Figure 5. The data were normalized to an SWR of 1:1 and a frequency of 7.15 MHz to make the comparisons more evident. The actual traps were very close, though. I fed the antenna through an electrical half wavelength of LMR-400 low loss coax and a choke balun. These precautions essentially eliminated the feed line from the tests.

Here are my conclusions. As I discovered, and you can see, much of the bandwidth of a trapped antenna is not based on trap characteristics but on the antenna itself. Yes, it is evident that a higher impedance coax does improve the bandwidth. It is also clear that a discrete LC trap is a little better. But after my tests it was evident to me that trap bandwidth is really not a major concern. That's why lower Q coax traps perform quite favorably compared to discrete LC traps. And higher impedance coax is still the best idea, though the difference is only modest.

Trap Mechanical Design

Here's the second mechanical improvement of this article. It to me this one is a much more significant improvement. To eliminate calculations while you're making coax traps I recommend a freeware computer program by VE6YP available at **www.qsl.net/ve6yp/index.html**. It quickly computes all the parameters for traps made from common coax. I discovered the improvement while learning to navigate the program. I was surprised to find that one can completely eliminate the need for the PVC coil form.

Once you're familiar with the program, calculate the parameters for several traps on the same frequency using the same coax type. Change only the coil diameter. You will probably be surprised to observe that the length of coax hardly changes for a wide range of diameters, and therefore turns. The effect is evident in Figure 6. The reason is simple. For the fixed length required to make a trap from a given coax and coil configuration, as the diameter goes up the number of turns goes down. It's just simple trigonometry. This made me realize that it is the length of the coax in a trap that primar-

Table 1

Comparison of the Key Characteristics of Common Coaxial Cables

Type	*LMR-400*	*RG-58*	*RG-8*	*RG-59*	*RG-6*	*RG-11*	*RG-62*
Z_0 (Ω)	50	50	50	75	75	75	93
Capacitance (pF/foot)	23.9	28.3	30.8	20.5	18.6	20.6	13.5
Diameter (inches)	0.41	0.19	0.40	0.24	0.27	0.40	0.24

Figure 7 — A no-form coax antenna trap No-form traps have four very real advantages: They are easy to make with a whole number of turns, they are lighter in weight, lower in cost and simpler to fabricate.

ily determines the trap's resonant frequency, not the number of turns or the coil diameter.

So if turns and coil diameter do not matter, why then even bother with a coil form? The PVC form is actually doing nothing but adding weight, cost and construction difficulty. Therefore, the second improvement of this article is to wind coax traps as no-form bundles and secure them with tie wraps. Many will recognize that this is like using a bundle of coax to form a balun. [Note that in the balun case, the form actually improves the bandwidth by reducing the distributed capacitance between the turns. — *Ed.*]

To me these are significant improvements compared to the common PVC form design. Expanding a little, with a rigid coil form you'll often end up needing a fractional number of turns. With a no-form coil you can always achieve a whole number of turns. This is very convenient, for the end connections will now be close together. This permits a much easier crossover connection than on a PVC form trap. See Figure 3.

Second, the savings in weight are substantial. This is desirable with respect to the stress on an antenna. For example, an RG-58 PVC form 40 meter trap on a 2¼ inch form weighs 5 ounces. Its no-form equivalent only weighs 2 ounces with pigtails attached. Similar weight savings exist for RG-59 and RG-62.

Cost reduction isn't as great, but is still significant, in that many builders finish their PVC form traps with stainless steel or brass screws, nuts and washers, plus wire terminals. The add-ons for a no-form trap are only two crimp butt splices, some small tie wraps and two short wire pigtails.

Lastly, fabricating a no-form trap is much easier. Just solder the ends together, form a tight bundle, add some tie wraps and two pigtails, and you're done.

Let's Make a No-Form Trap Antenna

Here is the step-by-step procedure to fabricate RG-62 no-form traps and make a dual band 40 and 80 meter dipole.

Input the coax data from Figure 3 into the trap design program. See Figure 8. For RG-62 do not specify a coax type. Just enter the listed diameter of 0.24 inches and the capacitance of 13.5 pF per foot. If you wish you may add this data to the configuration file of the program for later use.

Cut the specified length of RG-62. The program value will typically be a few inches too long. This is due to the shorter physical length of the no-form trap coil. My initial resonant frequency was roughly 6.8 MHz. This is handy, though, as it permits pruning.

Remove 1 inch of the jacket from both ends of the coax. Separate and twist together the shield strands to expose the center conductor and dielectric. Note the direction that the coax naturally tends to bend and twist both strand sets together outward in the same direction. This makes the crossover connection a little easier.

Remove ⅝ inch of the dielectric to fully expose the center conductor. Form a tightly spaced five turn bundle of the coax. Ignore the number of turns and the diameter of the trap specified by the program. Remember, they are essentially irrelevant. Position the ends of coax to the outside of the bundle as shown in Figure 3.

Solder the center conductor of one end of the coax directly to the braid of the other as shown in Figure 3. Lightly secure the bundle with about four temporary tie wraps. Now, before connecting anything to the trap, measure the resonant frequency. Suspend it with a non-metallic cord at least a foot from any nearby object. Use a dip meter or an MFJ-

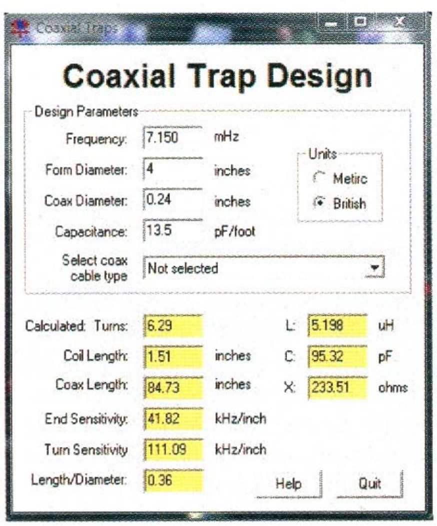

Figure 8 — Sample display of the output of the VE6YP trap design program with data for RG-62 at 7.15 MHz.

Give it a Try

Here is a suggestion for an experiment. The characteristic impedance of coax is a logarithmic function of the ratio of outer to inner conductor diameter and the properties of the dielectric between them. For a given shield diameter, the smaller the inner conductor, the higher the Z_0. See Figure A.

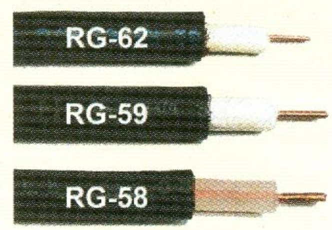

Figure A — Center conductor sizes. Outer diameter is scaled to equal size.

Since the amount of coax needed to make a trap is not large, one could remove the outer jacket and braid from a length of RG-62 and add some additional dielectric, perhaps in the form of flexible plastic tubing. Then replace the outer conductor with the braid from a larger coax type and then the jacket with heat shrink tubing. You'd then likely need to experimentally determine the length required for a trap from this coax, in that you would not now easily know the characteristic impedance. The length of coax will be significantly longer than for unmodified RG-62. The author would appreciate hearing about your experiences.

Hamspeak

Coax — Coaxial cable. Kind of unbalanced transmission line in which one conductor is a wire in the center of a dielectric with a circular cross section. The dielectric is surrounded by a tubular conductor, often made of flexible braid. Some cable types, the outer conductor is covered by a protective insulating jacket.

Resonant frequency — The frequency at which a circuit of a resistor, capacitor and inductor has an impedance that is only resistive. The inductive and capacitive reactances are equal and opposite.

Trap — Parallel resonant circuit used to electrically isolate sections of an antenna to provide resonant operation on more than one frequency range.

259/269 with optional dip coils.

Do not attempt to dip a trap with anything connected to it, or with it installed in an antenna. Once installed in the antenna, make frequency adjustment by changing the antenna wire lengths, not the traps

Progressively now, shorten the coax an inch or two at a time until the trap is resonant at the center of the band (7.15 MHz). One inch equals roughly 100 kHz in this case. Keep the trap bundle secured with temporary tie wraps while dipping.

Cut two pigtails of single-conductor stranded insulated hook-up wire of the same gauge as the antenna wire roughly 8 to 12 inches in length. Strip ¼ inch from the ends and solder these to the remaining coax ends. Insulate these connections with small pieces of heat-shrink tubing. Now install two tight permanent tie wraps roughly 2 inches from the crossover connection on both sides.

Permanent tie wraps should be the black UV stabilized type, specified for outdoor use. White or colored tie wraps deteriorate quickly in sunlight.

Fold back the pigtails and secure them on the opposite side of the crossover connection with two more tight permanent tie wraps. See Figure 9. This provides strain relief for the traps in the antenna. It is more than adequately strong. Some may wish to add additional strain relief using a short piece of plastic or PVC pipe.

Weatherproofing the Traps.

It is essential to protect the crossover connection from the weather to keep the coax from wicking up moisture and degrading. I coat the entire trap. Clear hardware store RTV 100% silicone sealant is completely satisfactory, though it is messy to apply.

To keep things tidy I employ a trick suggested on an artist's Web Site for making flexible molds. 100% silicone sealant can be thinned to brushing consistency with ordinary paint thinner or turpentine. A 50/50 mix paints on easily. It does take longer to cure if thinned, but it eventually does. Curing time is really not a problem though up on an antenna. Make up only the amount you need; it does not store well.

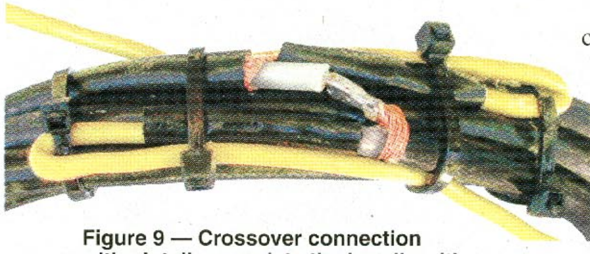

Figure 9 — Crossover connection with pigtails complete the bundle with permanent tie wraps. Remove any temporary tie wraps. Finally, weather proof the trap as described in the text.

Inserting Traps Into an Antenna

At first I was perplexed about how to insert no-form traps into an antenna. For a PVC form trap, by using two loops of heavy solid wire, some screws and a couple of crimp type ring terminals, one easily accomplishes this. But it is also easy with no-form traps. Simply use crimp butt splices between the pigtails and the antenna wires. I have had many in service for extended periods with no weatherproofing whatsoever. Or you may coat them with silicone sealant. You can also strain-relief the butt splices by tying a small loop of the antenna wire around them. This isn't necessary, though.

For determining the lengths of your antenna wires, refer to the many published articles on trapped antennas in the ham literature. Again, it has not been the object of this article to reiterate coax trap design and practice, but merely to offer two simple mechanical improvements to their physical design.

However, the basic idea is this. Start by cutting the innermost dipole according to the classical 468/f MHz formula. Add the traps and then also add about 80% of the remaining wire that would have been required for a single band (lower frequency) outer dipole. Because of the resulting inductance of the traps on the lower frequency, the outer dipole will need to be somewhat shorter. Adjust first the length of the highest frequency dipole and then work outward.

Overall, no-form coax traps are easier to make, less expensive and lighter. Also, if made from higher characteristic impedance coax, namely RG-62, coax traps have moderately better bandwidth than other kinds of traps.

Notes

[1]A Buxton, W8NX "Two New Multiband Trap Dipoles," *QST,* Aug 1994, pp 26-29.

[2]A Buxton, W8NX "An Improved Multiband Trap Dipole Antenna," *QST,* Jul 1996, p 32.

ARRL Member John Portune, W6NBC, received a BSc in physics from Oregon State University in 1960, his FCC Commercial General Radiotelephone license in 1961 and his Advanced class amateur license in 1965. He spent five years in England as G5AJH and upgraded to Amateur Extra class in 1985. John retired as a broadcast television engineer and technical instructor at KNBC in Burbank and then from Sony Electronics in San Jose, California.

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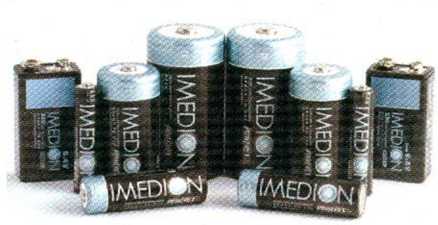

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