A crossed-dipole turnstile antenna for 2-meter ARDF

I came up with this antenna design for use with hidden transmitters on international-rules ARDF events. The rules call for an omnidirectional horizontally-polarized transmitting antenna at a height of two to three meters above ground level. Here in Southern California we have typically used vertical polarization in the past. This same antenna could be used for satellite or space communications as well with the addition of an appropriate reflector.

The electrical design is a classic crossed-dipole with 75-ohm phasing section. W4RNL has an excellent article on the electrical characteristics of this antenna with schematics and patterns online here. This basic design has a slight mismatch due to the difference between the 36-ohm characteristic impedance of the antenna and the 50-ohm feedline. This results in an SWR of about 1.3 to 1.

The parts used are relatively inexpensive. It will probably be cheaper to build several antennas at once due to the burden of buying some items in small quantities.

Parts:

- 2 ea. 1 1/4 inch trade size PVC pipe caps
- 2 inches long 1 1/4 inch trade size PVC schedule 40 plastic pipe

- 1 ea. 1/4-20 eyebolt
- 2 ea. 1/4 inch internal star lockwashers
- 2 ea. 1/4-20 hex nuts
- 2 ea. 36 inch long 1/8 inch diameter uncoated bronze welding rod (see text)
- 4 ea. 8-32 x 1 inch long hex spacers (see text)
- 4 ea. 8-32 x 3/4 round-head machine screws
- 4 ea. 8-32 KEPS nuts
- 4 ea. #8 locking solder lugs [Mouser 534-906]
- 5 ea. ferrite cores [Mouser 623-2643002402]
- 16 inches RG-179 75-ohm teflon coaxial cable [Mouser 566-83264]
- RG-58A/U coaxial cable of desired length for feedline (see text)
- Suitable connector for your radio to fit above cable
- Cable ties
- Heat-shrink tubing
- Silicone sealant
- PVC solvent cement

Mechanical assembly

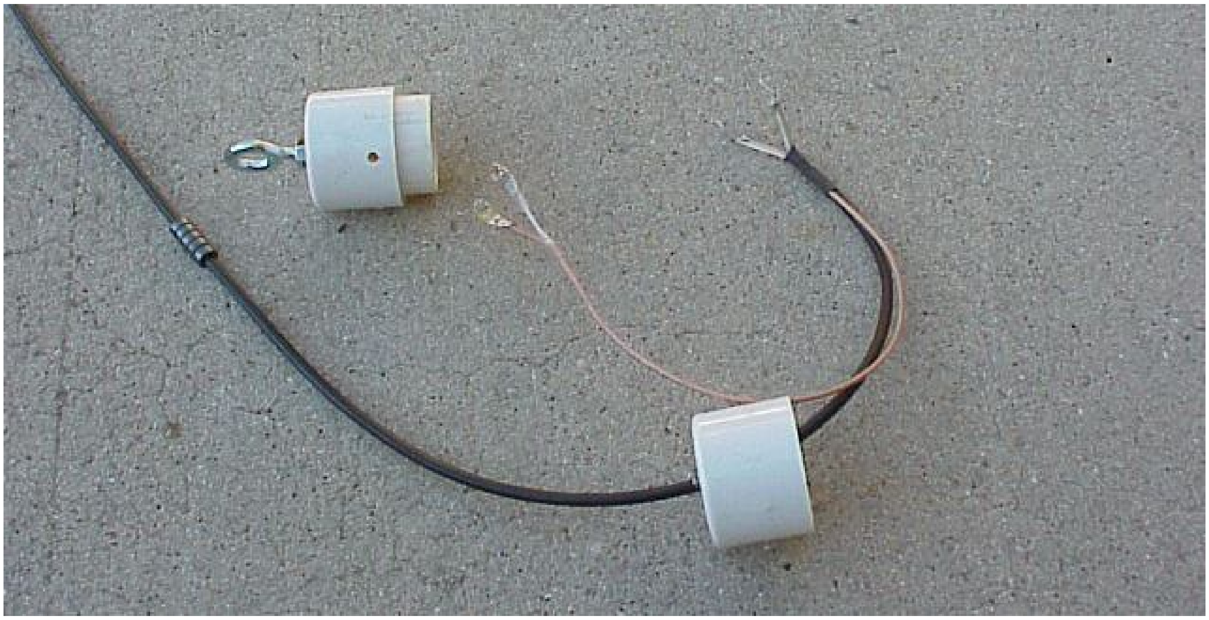
The case of the antenna is made from PVC plumbing pipe and fittings.

Case preparation

1. Drill a 1/4 inch diameter hole in the center of each end cap.
2. Cut a piece of pipe approximately two inches long. Fit it snugly into one of the end caps. There should be about a half inch protruding.
3. The next step is drilling the element holes at 90 degree spacing around the circumference of the end cap. Aligning these can be tricky, but the following shortcut works well. Cut a narrow strip of paper long enough to wrap around the end cap at least once. Make a mark on the paper where it overlaps. Remove it from the end cap and fold it in half, aligning the marks. Then fold in half again. Unfold and make a mark at each crease. Now re-wrap it around the end cap and transfer the marks to the end cap. They will be at 90-degree spacing. Mark the end cap in four places, 3/8 of an inch from the lip of the cap where the pipe protrudes.

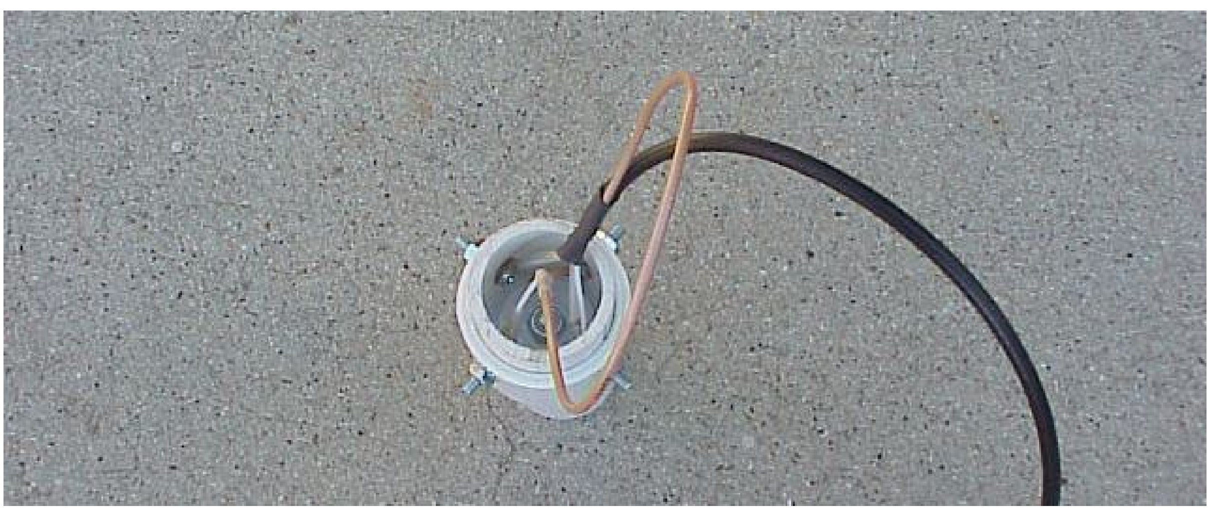
   Drill four 11/64 or #16 clearance holes for 8-32 bolts at the marks, going through both the end cap and the pipe snug-fit inside. It is not necessary to glue the pipe to the cap. The bolts will hold them together.

4. Thread a nut and lockwasher on to the eyebolt. Apply a small amount of silicone sealant to the threads and push the eyebolt through the hole in the top of the end cap/pipe assembly. Thread a second lockwasher and nut on from the inside and tighten with a socket wrench.



Wiring

1. Thread five ferrite beads on to the jacket of the RG-58 feedline.
2. Thread the feedline through the center hole of the other end cap.
3. Prepare the matching section of RG-179 by stripping both ends and separating the braid from the center conductor. Stripped length should be 1 1/4 inches on both ends, with 13 1/2 inches of jacketed cable inbetween. The velocity factor of RG-179 is 0.69. If you substitute a different cable, adjust accordingly for a 1/4 wave section.
4. Attach solder lugs to one end of the cable, insulating with heat shrink tubing.
5. Prepare the end of the RG-58 feedline in a similar manner, stripping 1 1/4 inches and separating the braid and center conductor.
6. Solder both the shields of the RG-58 and the matching section to a solder lug, insulating the shielding with tubing.
7. Similarly, solder both center conductors to a solder lug.



Case Assembly

1. Using longnose pliers, thread the two lugs on the loose end of the RG-179 phasing section through two holes 180 degrees apart from each other. Secure in place with KEPS nuts. Tighten the nuts securely while holding the screw head from turning. Take care with the center conductor as it is rather fragile.
2. Similarly, secure the two lugs on the feedline/phasing combination through the two remaining holes.
3. Secure a cable tie to the feedline below the point where the jacket is removed to act as a strain relief.
4. Carefully fold the RG-179 cable into the pipe, watching for possible shorts.
5. Press the end caps together on the pipe and perform an ohmmeter check. You should see continuity between the two studs connected to the shield braids 90 degrees apart from each other, and continuity between the two center conductor studs, also 90 degrees apart. The pairs should not be shorted to each other.
6. If all checks out, spread a blob of silicone sealant around the cable tie on the feedline to seal against moisture, apply some solvent glue to the protruding pipe and quickly push the two end caps together until they butt against each other. Hold in place for a minute or two until the cement hardens.

Element assembly

The elements are made from 1/8 inch diameter bronze rod, commonly available at welding shops. This material comes in 36 inch lengths and is referred to as material 15, uncoated. I have used it for making numerous antennas and other projects. At one time it was sold by the piece. The last time I went to purchase it, I was told that it was only sold in sealed containers by the pound. One pound has eight pieces, enough to make four antennas. Apparently the vendor wants to ensure that the buyer receives warning notices about the dangers of welding, etc. and thus it is now only sold in sealed containers. Your experience may vary. Similar material is likely available at hobby and hardware stores at higher cost, but you won't have to buy a pound of it for one antenna. The 1/8 diameter material is a slip-fit inside the 8-32 spacers. Cut the rods exactly in half, yielding two rods 18 inches long. This length plus the added length of the spacer and the case gives a good match in the 2-meter amateur band.

On my first production run of these antennas, I purchased plated brass spacers. I inserted the rod about 3/8 inch into the spacer and soldered them in place. The Mouser part number for these spacers is 534-1474E. A substantial amount of heat and a good flux is required. Consider the use of a torch if you have one. Take care not to get solder into the opposite end of the spacer where it will attach to the antenna case.

When making another batch, I found that the local supplier only had aluminum spacers in stock. Soldering aluminum is problematic at best. As an experiment, I used a prick punch and hammer to crimp the spacers on to the elements. I found this to be very strong and not have the problems of solder wicking into the remaining threads. Over time this method may develop issues with elements becoming loose but so far it looks very good. I made six crimps to each spacer, three near the center and three near the end on alternate faces of the spacer. The Mouser part number for aluminum spacers is 534-2219.

Final Assembly

1. Slide the ferrite beads down the feedline until the center bead is 19 1/2 inches from the element studs. Secure the beads in place with cable ties above and below. The beads act as a choke balun.
2. Attach a connector to the other end of the feedline to match the one on the radio with which you will be using the antenna (PL-259, BNC, etc.) The feedline length is not critical. Note that ARDF rules specify a height of two to three meters above the ground, and the pattern will be distorted if the antenna is too close to the ground, so it's better to be a little long than a little short.

3. Thread the elements on to the studs. You may want to put plastic balls or wire-nuts on the ends of the elements to reduce the possibility of injury if someone were to run into the antenna.
4. Hang the antenna away from obstacles using the eyebolt, check SWR and performance. Note that the design SWR is about 1.3 to 1.

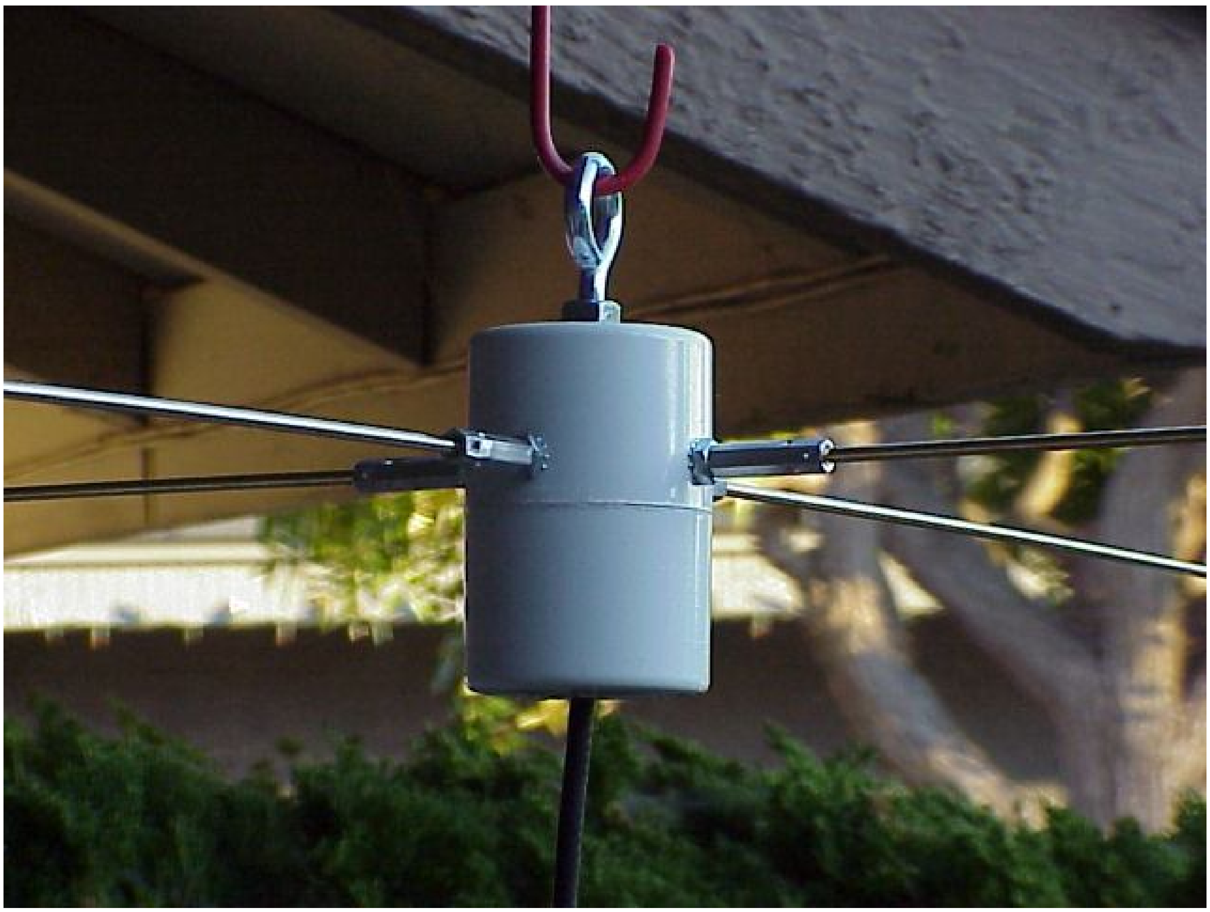
Improvements and options

Note that the materials and dimensions in inches are based on what is commonly available in the USA. Metric hardware could certainly be used. There is nothing special about the dimensions other than the element and phasing section lengths.

There is no reason that the same antenna could not be adapted for other bands, just scale appropriately.

If you choose to paint the housing to reduce visibility, consider the use of some of the newer spray paints designed for plastics. Regular paint doesn't adhere well to PVC. You might also want to mask off a small area around each element stud. I'm not sure of the RF characteristics of paint.

There is a huge variety of configurations available in the way of PVC pipe fittings. Alternative mounting options like a threaded pipe mount from below as opposed to or in addition to the eyebolt are possible.



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