Low Cost High Performance VHF Dipole Array

This project will provide you with a VHF high band antenna that can be adjusted for an omni directional pattern with 6dB gain over a dipole or a directional pattern with 9dB of gain. The antenna has upwards of 20MHz band width at the 2:1 VSWR points which will cover the 2m amateur band through RR frequencies and higher, or about 142 to 162MHz.

The key design criteria for this antenna was to use common hardware store components and repeatability so the builder can duplicate the design without any complex test equipment.

The exposed dipole array is common in high performance VHF/UHF base station and repeater use because it packs the most omni directional gain for the number of elements.

Most dipole array projects I have seen require complex metalwork, welding or matching networks which are beyond the abilities of most hobbyists. This antenna uses no special matching and wide bandwidth is achieved using large diameter elements made from 3/4” copper water pipe. Some information for this project was plagiarized from antenna brochures, other articles and updated with a few of my ideas.

Some designs space the dipoles about 1/4 wavelength out from the mast while others use less than 1/8 wavelength spacing. I have several VHF dipole array examples from DB Products, Cushcraft and Maxrad that use very close spacing, so I used their dimensions.

You will need the following parts and substitutions can be made if common sense is used. Most parts can be purchased from Home Depot and Radio Shack.

- 3/4” rigid copper water pipe, 12ft.
- 1/2” PVC pipe T, qty 4.
- 1” to 1/2” PVC T, qty 4.
- 1/2” schedule 40 PVC pipe, 24” long.
- PVC pipe cement.
- SS hose clamps, 3/4” to 1 3/4” size, qty 8.
- RG-59 coaxial cable, 30ft.
- PL-259 connector, RS cat# 278-205, qty 8.
- UG-176 (adapter for RG-59) RS cat# 278-204, qty 8.
- PL-259/SO-239 “T” adapter, RS cat# 278-198, qty 3.
- SO-239 double female adapter, qty 3.
- 1 1/4” to 1 3/8” OD steel fence post 21ft long. You can substitute two 10ft heavy duty TV masts.

Start by cutting the 1/2” PVC pipe into four 6” lengths. Deburr the ID and OD of each end.

Next cut the 1” to 1/2” PVC Ts as shown to make the element mast clamps. I used a table saw and temporarily connected two T’s with one of the 1/2” PVC sections to make it easier to handle. You can simply cut the PVC T with a hacksaw to achieve the same result.

The picture on the right shows the desired cut on the 1” to ½” PVC T.

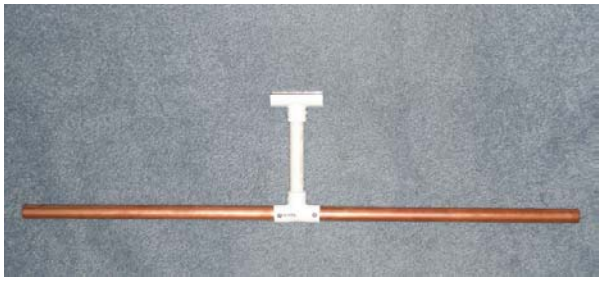

Next cut the 3/4” copper pipe into eight 18” long sections, preferably with a tubing cutter. The tubing cutter will leave the ends slightly tapered which will make it easier to force into the PVC Ts. If a saw is used you will need to deburr and file a slight taper on one end of each pipe. The 18” length is slightly longer than needed to allow removal of the end that gets pounded with a hammer during assembly to the PVC T’s.

The OD of the copper pipe is slightly larger than the ID of the 1/2” PVC T and the T should be warmed with a heat gun or hair dryer to soften slightly before inserting the copper pipe. I successfully pounded several pipes into PVC T’s without any problem but one PVC T finally cracked, so warming is a good idea. Warming the copper pipe may also benefit if the parts are very cold.

Start by placing the warmed PVC T on a hard floor as shown below and center the tapered end of the copper pipe in one side of the T. Using a medium size sledge hammer or large rubber mallet, carefully hammer the copper pipe into the PVC T until it bottoms out in the T. Check the progress every few blows to make sure the pipe doesn’t go past the stop ridges inside the T.

To insert the other half of the dipole element, place previously installed copper pipe side on the hard floor with the PVC T facing upward. It takes a little balancing to hold the joined sections while pounding the second copper pipe in and another set of hands would be helpful. You may have to warm the PVC T again before this step. Make sure the two copper elements are going together concentrically by looking down the side of the pipes as they go together.

Now that you have successfully joined the copper pipes to the PVC T you can cement the 6” long PVC section and 1” to 1/2” cut T as shown below.

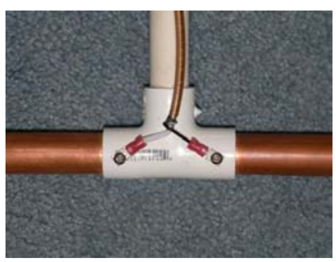


The picture also shows the coax attachment screws, which will be drilled and threaded into the copper pipe at this point. I used 6-32 and 4-40 will work fine as will self tapping metal screws. A good spot to drill is 3/8” in from the edge of the PVC T.

At this point its good to trim the elements to 16 1/4” (153MHz) or attach an antenna analyzer and custom tune if desired. I found 16 1/4” about right for the completed antenna to cover the 141 to 161MHz range. If custom tuned, the element must be clamped to a mast and a short length of 50ohm coax must be used to the antenna analyzer.

Any bare leads from the coax connected to the elements are considered part of the antenna and I used 1 1/4” of exposed center conductor and ground wire to the center of the lugs.

The example below shows a 50ohm test cable attached for tuning.



Now its time to make the phasing harness using 75ohm coaxial cable. RG-59 is a convenient size since there are readily available adapters for PL-259 connectors. I have since found type F female T adaptors from L-com and will be using them with RG-6 and compression type F connectors on my next version.

The length of each harness section will vary depending on the type and brand of cable. You must either verify the velocity factor of the cable from the mfr’s specifications or measure the final length using an antenna analyzer.

The phasing sections will be odd multiples of 1/4 wavelength in coax and four cables will be 3/4 wavelengths long (cable "A") and two cables will be 5/4 wavelengths long (cable "B") in coax. These lengths were chosen based on the separation of the dipoles on the mast and the most appropriate number of odd quarter wavelengths needed to reach the elements. The total length will also include the connector and T adaptors.

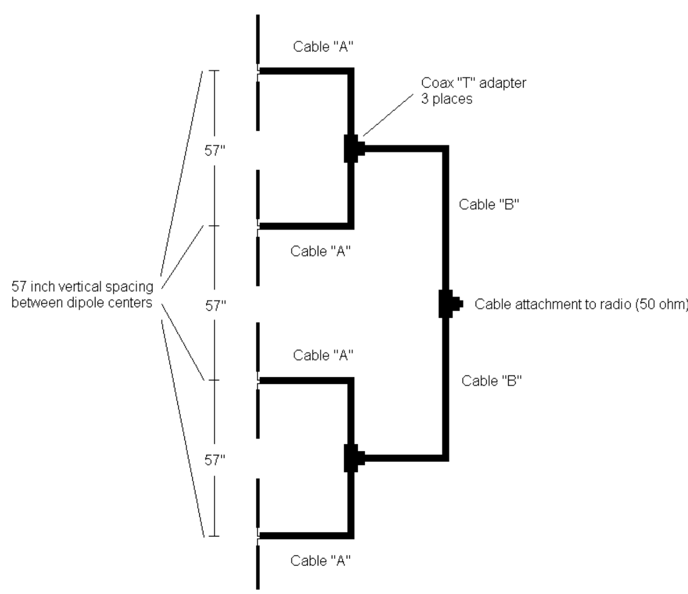
To find the dimensions to make your cables, divide 2952 by the design center frequency of the antenna, then multiply by the velocity factor, then multiply by 3 to get the 3/4 wavelength pieces (cable "A") or by 5 to get the 5/4 wavelength (cable "B") pieces.

For example: 2952 / 153(MHz) = 19.29" X .83 (Belden 1505A velocity factor) = 16.01" (one quarter wavelength in coax) X 3 = 48.04" for cable "A" or X 5 = 80.07" for cable "B".

Remember the connectors including "T" adaptors will be part of this length, so measure accordingly. You can subtract about 3/4" from the cable length for each PL-259 interface to a "T" adaptor with female sides and about 1 3/4" for the male "T" adaptor side with double female adaptor.

Cable "B" has connectors on both ends and cable "A" will have a connector on one end with the opposite end terminating in lugs at the dipoles. The center conductor and ground leads to the dipoles should be about 1 1/4" long. I like to solder a wire to the braid for the ground lead because it will be easier to weatherproof with RTV later. Exposed braid will wick water under the cable jacket and cause premature failure.

The diagram below illustrates the phasing harness placement for cable "A" and cable "B" with attachments to the dipoles and coaxial "T" adaptors.



The dipoles attach to the mast using two hose clamps per dipole as shown below.

The polarity of the dipoles must be consistent, so make the connection to the top element of each dipole with the coax center conductor and the coax shield to the bottom element.

This picture shows an almost completed antenna with all 4 dipoles arranged on the same side of the mast for 9dBD gain in a directional pattern. The phasing harness will tape or Ty-rap to the mast with excess cable folded into loops on the back side of the mast.

For omni directional coverage arrange the dipoles around the mast so they each cover a compass heading 90 degrees apart from each other. For example, if the top element faces north, the next one down will face east, next below that will face south and the bottom dipole will face west. You can aim the top dipole in the direction of your weakest signals.

I would recommend painting the elements and PVC components to prevent corrosion and deterioration of the PVC from UV. Fence posts come in 21ft lengths and would be a good choice for mast material. The fully assembled antenna pictured on the previous page is using two Radio Shack 10ft TV masts, which seem adequate for the job unless the antenna will live in a very high wind area.

Three or four SS hose clamps will easily hold the 20ft long antenna mast to another support pipe. Some tower legs are around 1 1/4” OD (Rohn 25 series) and the dipole elements can clamp right to the tower leg without a separate mast.

This antenna project can be modified to use other hardware and aluminum tubing for the elements or other methods of holding the dipoles from the mast can be considered. As long as the dipole element OD is close to 3/4” copper pipe and the spacing from the mast is not changed, you can use the basic dimensions listed here.

I used Belden 1505A (RG-59 equivalent) because it has a full braid that is easy to solder. Some newer foam type RG-59 has only a few strands of braid over foil and would be difficult to solder on the PL-259s. I think a better approach would be to use type F connectors and type F T’s which are available from L-com (part # BA132) and Pasternack. You can also use RG-6 or RG-11 for lower loss.

I encourage you to experiment, improve the design and share your findings.