LIGHT WEIGHT ROVER RADIATORS

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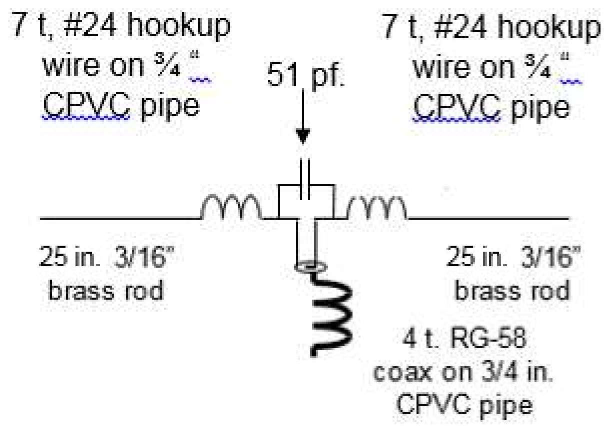
When hams think of going roving, a detriment is often the thought of erecting antennas sometimes on tall mobile towers and with long booms. This series for the most popular rover bands are light weight, small antennas that can be supported by PVC pipe. The antennas are constructed such that, if desired, they can easily be placed in carry-on luggage for transporting. These antennas are not meant to be left outside exposed to UV rays, but if it is desired to use one on a permanent base, the PVC can be substituted with solar resistant PVC or electric fence post. As first stated, they are to be used for rover operation and then taken in out of the Sun. Antennas are described for the 4 most popular VHF/UHF bands that are used for contesting; 6 m, 2 m, 1.25 m, and 70 cm.

6 METERS

First, and usually the largest and heaviest antenna taken on rover trips, is the 50 MHz antenna for 6 meter operation. The antenna as described herein is a loaded dipole which is implemented by adding loading coils to each radiating element on both side of a center conductor for the dipole. While this does shorten the length of the antenna, there will obviously be some gain loss due to the decreased aperture area of a shortened dipole compared to a full length dipole. For an approximation of the gain loss, the length of the shortened dipole can be compared to a full length dipole determined from $5600/F_{MHz}$. In this case, this length is 112 inches. This shortened antenna is 50 inches in length, so the approximate gain loss is: 10 log (50/112) = -3.5 dB. Since low signal to noises ratios are the situation where the small changes in the S/N is discernable, normally a 3 dB change, either + or -, is necessary for the human ear/brain processor to detect that there has been a change. As often is the case for 50 MHz operation, signal to noise ratios are often 30 to 40 dB; i.e. not a weak signal situation!

As shown in the drawing, in order to compensate for the added inductance in each leg of the dipole, a 51 pf. DM capacitor was added between the two sides of the dipole. Although this has not been implemented, it should be easy enough to replace the PVC center insulator with a PVC 4-way and configure a Turnstile antenna to yield an excellent circular pattern. Four of these stacked up a tower leg would produce ~6 dB omnidirectional gain which is approaching the gain of a small yagi. Note that this antenna weighs only 10.4 ounces, barely over ½ lb.

50 MHz Mini-Dipole, 10.4 oz.



Frequency, MHz	SWR
50.0	1.4:1
50.2	1.1:1
50.4	1.0:1
50.6	1.3:1
50.8	1.6:1
51.0	2.1:1

Figure 1 - 50 MHz LOADED DIPOLE

Each side of the loaded dipole is made from 1/8 inch brass tubing. At one end of the tubing, a ½ inch copper tube cap with a hole in the center to allow passage of the brass tubing to be passed through the copper tube cap and soldered to the tube cap with about 1/8 inch of brass tubing extending beyond the ½ inch tube cap. Soldered to this brass tubing, 27 inches of insulated hookup wire is soldered to the brass tubing. The ½ inch copper just slide inside of a ¾ inch length of PVC pipe that is 6 inches in length. A small hole is drilled in the ¾ inch PVC pipe 3 ½ inches from the end of the PVC pipe to allow passage of the hookup wire, so the hookup wire is fed inside of the PVC pipe and through this hole. After pulling the hookup wire taught, the brass tubing is held in place in the 6 inch length of PVC pipe, and the hookup wire that passes to the outside of the PVC pipe is then wound around the exterior of the PVC pipe to form a coil. A PVC pipe cap for ¾ inch PVC with a hole in the center of the cap is then slide over the 6 inch length of PVC pipe to keep the brass tubing centered inside of the 6 inch length of PVC pipe.

At that point, the hookup wire is wound around the PVC pipe to form the loading coil on that side of the dipole. Seven turns of the hookup wire provides about the amount of inductance for the coil. Placing a brass wood screw at the end of the coil nearest the center of the antenna gives a protrusion to terminate the coil. However, in order to obtain the minimum SWR at the desired frequency, in this case 50.4 MHz, the spacing of the turns on the coil is varied to “tweak” in the coil. To hold the turns of the coil in place, the coil is then sprayed with clear, Krylon spray. The Krylon spray will change the dielectric of the coil, so it’s best to let the Krylon particially dry and then adjust the spacing once again. After this partially dry’s, then spray the coil again with another coat of Krylon and readjust the spacing between the turns for the minimum SWR at the desired frequency. After a couple of coats of Krylon, then allow this coil to dry and harden with the dielectric of the Krylon included.

Attach an alligator clip to the brass wood screw using a solder terminal. Now, the dipole antenna can be attached to the center insulator which connects to the RG-58 coax feed line. In order to further reduce the SWR, a capacitor is place between each side of the dipole. This process permits the dipole to be disassembled into two lengths that are 27 inches long so that the dipole can be broken in half to place inside the carryon luggage and taken on an airplane. When assembling the antenna for operation, it’s a simple matter to slide the two side of the dipole into the center insulator, clip the alligator clips to brass screws on the center insulator, and be assured that the SWR is minimum at the design frequency.


Figure 2 – DETAILS FOR THE 50 MHz LOADED DIPOLE

2 METERS

Probably the most popular band for roving is 2 meters. Following is an easy to construct, 2 meter loop. The center part of this antenna is a ¾ in. copper pipe T available at a home supply or hardware store. These stores normally have a copper plug, not and end cap but a plug that just slides in both ends of the T fitting. Before soldering the plugs in the T-fitting, drill a hole in the center of each plug sufficiently large to accommodate a #10 length of bare, copper wire. Straighten a 43 inch of #10 wire and then mark the center of this length of wire using a black "Sharpie." Now, on each side of the center mark, make another mark around the wire that is 1 ¼ inches from the center mark.

Drill a hole in the center of two copper plugs that each fit inside the copper pipe T connector and pass the #10 wire through these holes. Using the marks that are spaced 1 ¼ inches from the center mark as guides, pass the length of #10 wire through the holes in the plugs and solder this wire in place. Then make two marks on the #10 wire that are spaced 11 ¼ inches apart to form one side of the loop as shown in the image below. Using a vise or edge of a table, bend the #10 at 90 deg. on each side of the center T to form the horizontal loop. Then, make two more marks on the #10 wire that are 10 7/8 inches from the 90 deg. bend that was just made. Again, using a table edge or vise, make two more 90 degree bends so that these loop ends are facing each other. This completes the loop of the loop antenna, so the remaining task is to feed RF to this radiator with a low SWR.

A classical Delta Match is used due to its ease of construction and the ability to achieve a low SWR. Two 4 ¼ lengths of 1/8 inch brass rod are used for the Delta feed arms, but solid copper wire could be used as a substitute. Solder a solder lug on one end of each of the feed arms. Now solder the feed arms to the #10 wire used for the loop at a distance of 5 inches from the center of the copper T connector, making these feed arm points 10 inches apart and soldered to the loop just over ½ inch from the 90 deg. bend in the loop. After inserting a 10 inch long piece of ½ inch PVC pipe in the center of the copper T, then drill a couple of holes in each side of this PVC pipe, and attach the solder lugs to the PVC pipe using brass wood screws making sure the wood screws do not touch each other inside the ½ inch PVC pipe.

The next task is to cut a piece of RG-58 coax cable that is electrically ½ wavelength long. To assist in this the brief discussion that follows alludes to why it’s much easier to cut a transition line that is ¼ wavelength long instead of ½ wavelengths long. Looking at the image below, the SUM and DIFFERENCE of two sin waves summed together are shown on the same graph. The more bold line shows the SUM, in dB’s, over an angle of 90 deg. from 135 deg. to 225 deg. Looking at the center of the SUM plot, moving from this center amplitude to the 135 deg. and 225 deg. points on the X-axis shows a 3 dB variation in amplitude which isn’t much of a change. Moving from the center of the SUM plot at 180 deg. to ± 7 deg., 173 to 187 deg.,produces minimal change in amplitude, almost too small to measure but certainly less than a 1 dB amplitude change. However, the DIFFERENCE pattern changes almost 10 dB from -25 dB to -15.5 dB. This is a much more dynamic change and much easier to detect than the change in the SUM pattern. A ± 3 dB change in the DIFFERENCE pattern shows an angular change on the X-axis from 178 deg. to 182 deg.

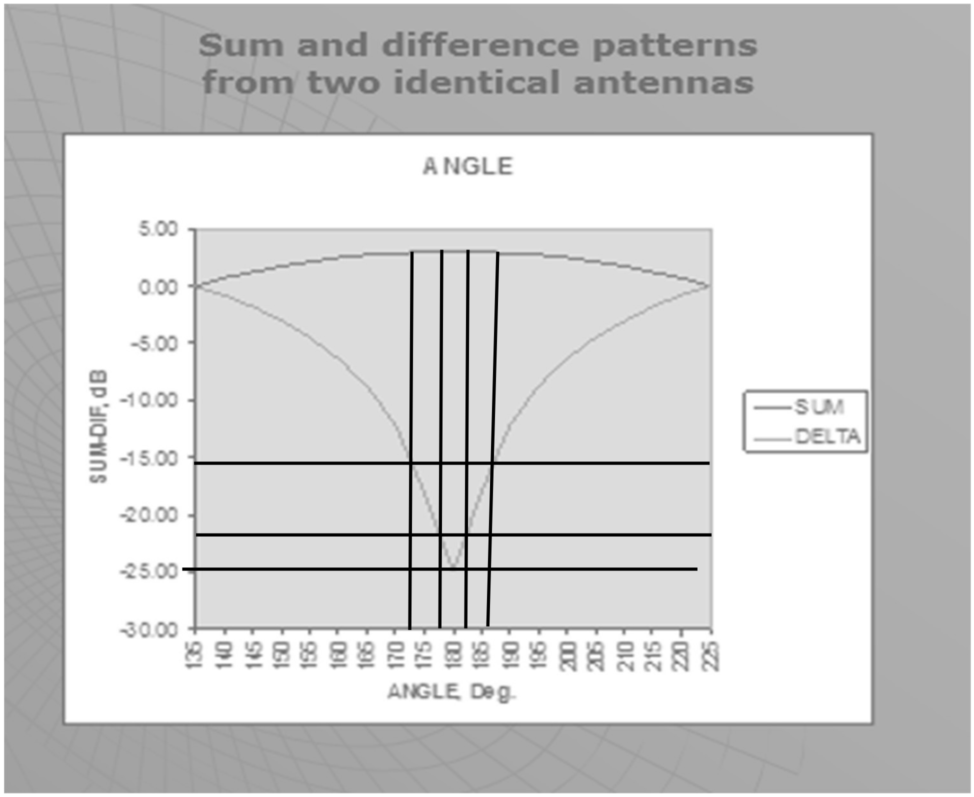


Figure 3 - SUM AND DIFFERENCE PATTERNS FOR A SINE WAVE

This characteristic alludes to must more precise measurements of coax transmission lines. The diagram below shows setup for cutting a coax line to 90 deg. or λ/4 long. The Thru Line connects the signal source to a

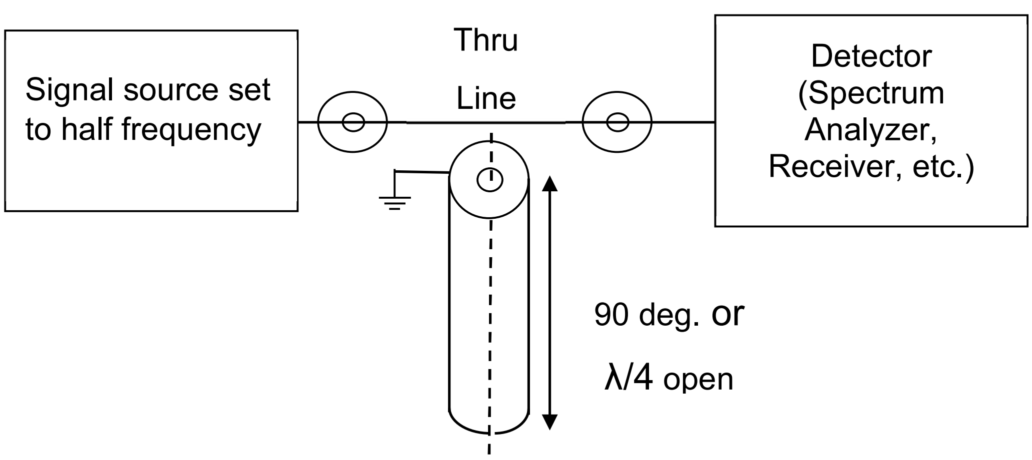


Figure 4 - TEST SETUP FOR CUTTING 90 DEG. LINE LENGTHS

detector, a spectrum analyzer etc., and the quarter wave open line, the part where the shield around the center conductor forms the coax, is connected to the Thru Line with the other end open. With this set up, a signal applied to the top of the Thru line travels down the open line to the far end, an open circuit, and all of the signal is reflected back up the line. Since this introduces another 90 deg. phase shift in the signal, now the open line presents a signal across the Thru line that is the same amplitude but shifted 180 deg. in phase, producing a null or minimum at the detector. This way, the coax line can be precisely cut to 90 deg. or λ/4 in length since the null is very sensitive to the length of the line.

However, it is simple enough to cut the λ/4 at half the frequency, or 72 MHz. Since this line is to be used at two times the frequency for which it is cut, now the line is precisely λ/2 at 144 MHz, exactly what is desired. One of the 4 ¼ in. brass rods is soldered to the loop at the 100 ohm impedance point of the loop on the positive part of the sine wave illuminating the driven element of the antenna, and the other 4 ¼ in. brass rod is soldered to the loop on the negative part of the sine wave at the 100 ohm impedance point. So, stray reactances cancel each other out. For the λ/2 wave line, the impedance at one end is presented to the other end of the λ/2 wave coax and shifted 180 deg. in phase, yielding two 100 ohm impedances in parallel and in phase, so this is presented to the coax feed line as 50 ohms with no reactance producing a low SWR for the antenna. The remainder of the antennas are all fed with Delta matches with the feeder lines soldered to the radiation elements.

144 MHz loop, 10.4 oz.

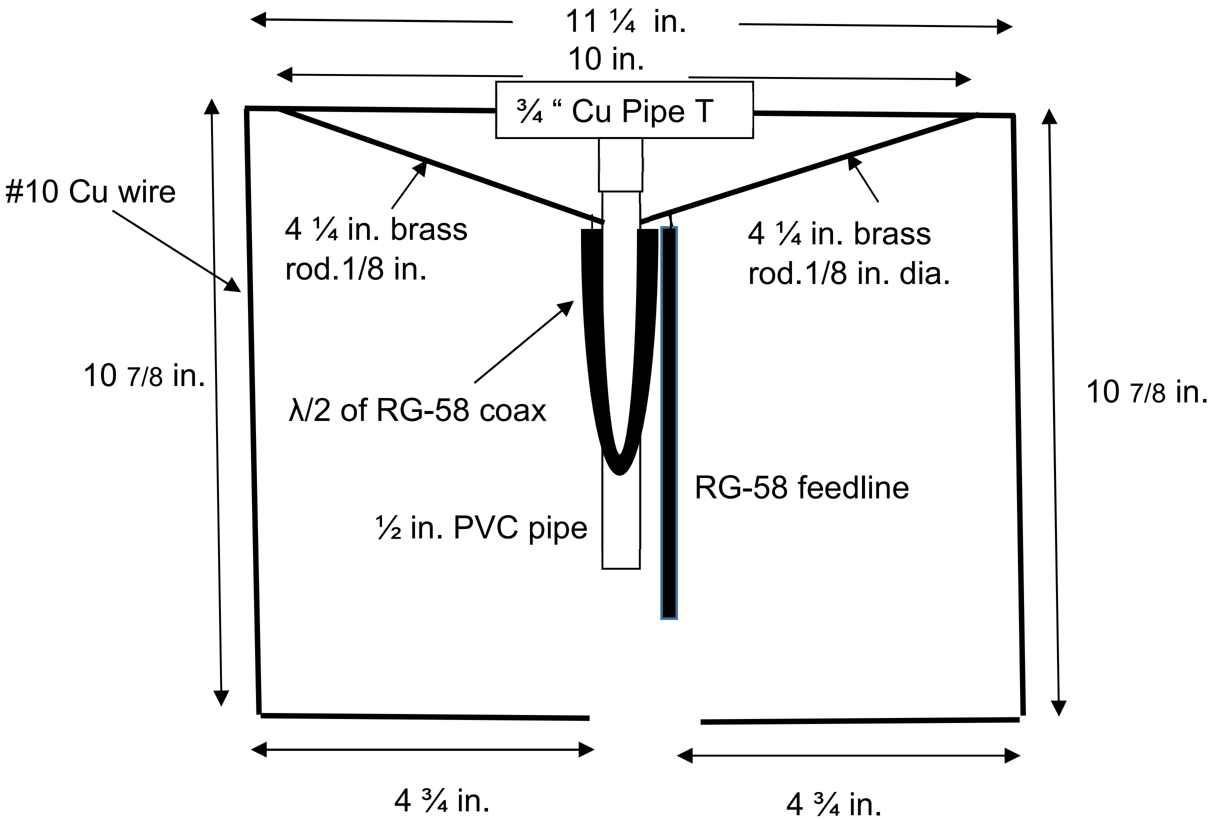


Figure 5 - DIMENSIONS FOR 2 METER LOOP

The following page shows an image of the actual loop antenna, and this antenna is fed with a Delta two brass feeder lines and a half wave length of RG-58 coax.

Figure 6 - TWO METER LOOP IMAGE

222 MHz loop, 8.1 oz.

The 222 MHz loop is identical except the dimensions are scaled for the shorter wavelengths as is the half wave coax line for the Delta match. The dimensions are shown on the following page with the image following that.

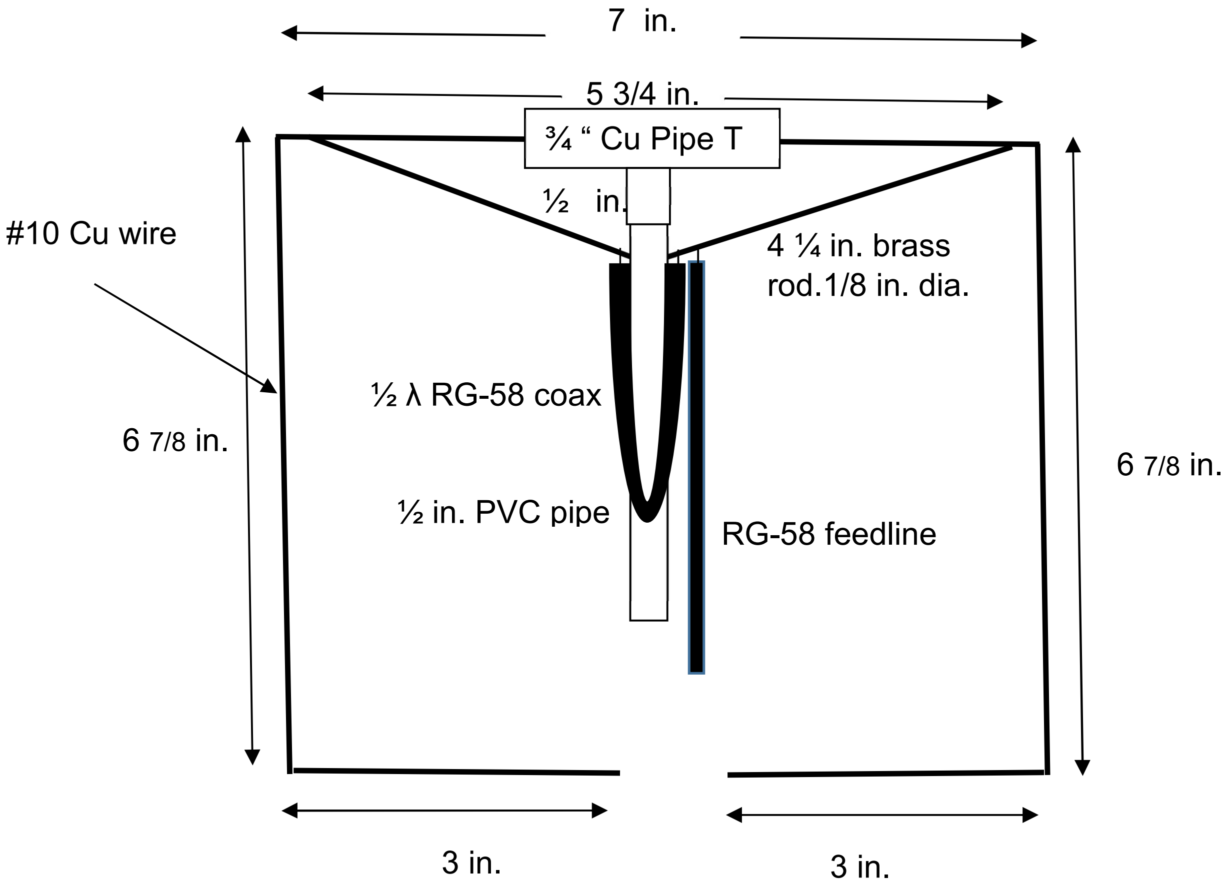


Figure 7 - DIMENSIONS FOR 222 MHz LOOP

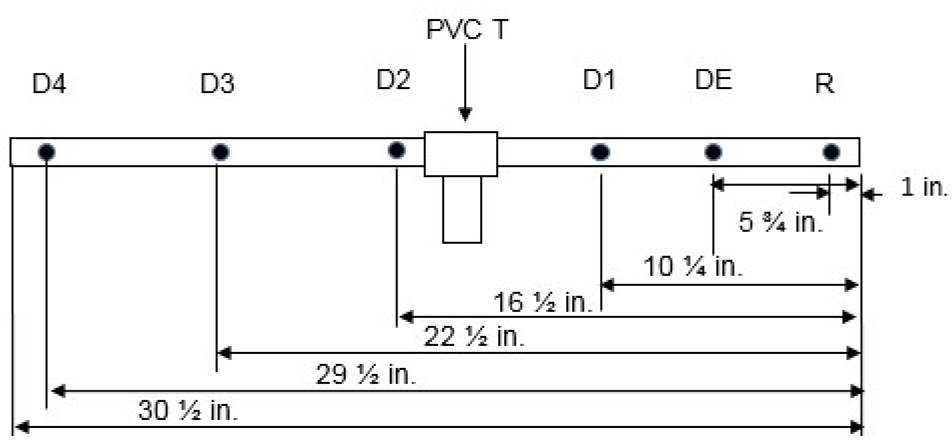
Figure 8 - 222 MHz LOOP MOUNTED ON MAST

The I.F. radio is attached to the mast a couple of feet below the antenna and is resting on a shelf consisting of a 2 in. by 2 in. piece of angle aluminum attached to the mast with a U-bolt.

432 MHz 6 ele. Yagi, 15.3 oz.

Since the 432 wavelengths are so small, it now is feasible to construct a small lightweight yagi on a short length of PVC pipe. This antenna is constructed such that the boom can be divided in two with a PVC T connector and joined with a single machine screw. This allows the antenna to be separated in two lengths that can be inserted in a back pack for Man Portable operation to locations that are inaccessible by a motor vehicle. This back pack with antennas and an Icom 705 is shown later in this paper.

A properly designed Yagi of this boom length results in 8 dB gain for the antenna. The dimensions are shown below. One thing to note is the weight of each of these antennas which each contribute to the total weight for the man portable operations.



Boom = 3/4 in. PVC pipe

Element	Element Spacing, in.	Element Length, in.						
Reflector	0.00	13.51						
Driven ele	5.71	13.25						
D1	10.13	12.36						
D2	15.45	12.00						
D3	21.69	11.74						
D4	28.18	11.12						
	30.18 in.		=	2.515	ft.	=	1.1620	λ

weight = 15.3 oz.
Freq = 432 MHz

Figure 9 - DIMENSIONS FOR COMPACT 432 MHz YAGI

Again, the feed element for this antenna is a Delta match, and a close up of the feed element is shown on the following page along with the antenna separated into two lengths of the boom when detached into two lengths, and a close up view of the Delta match is shown.

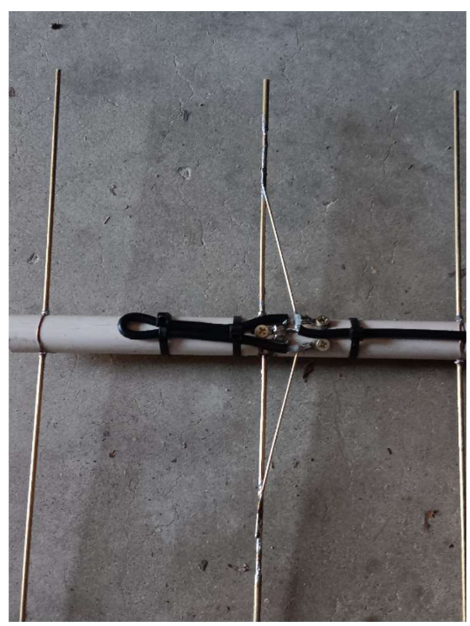


Figure 10 – 432 MHz YAGI DISSASSEMBLED INTO TWO PARTS AND DETAILS OF DELTA MATCH FOR DRIVEN ELEMENT

The full length of the assembled yagi is shown below along with the procedure for attaching the brass elements to the PVC boom with a short length of wire soldered to the element.

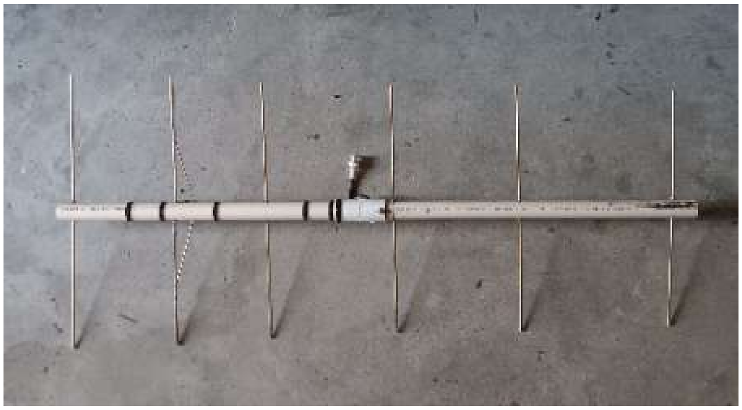


Figure 11 - FULL LENGTH OF 432 YAGI ON A 2.5 FT. BOOM

MAN PORTABLE BACK PACK

Since a number of good operating sites for roving aren't accessible by motor vehicle, these antennas were designed as very light weight antennas with the portability in mind; i.e. a light weight back pact to can be carried to locations accessible only by hiking to the site. As shown in the image, this back pack contains antenna for 6 m., 2 m., 222 MHz, and 432 MHz, as well as an End Fed Half Wave for the HF bands. The total weight for these items is just under 10 lbs. including the Icom 705. Although there's room in the back for a battery, the size and the weight is left to the discretion of the individual depending on their desire for shorter or longer operating periods.

The Icom 705 radio is placed inside of the back pack, an Explorer Modular Backpack available at Gigaparts and other suppliers. Also, a short length of RG-8X is placed inside along with an End Fed Half Wave antenna for HF operation in case the operator wants to pass out contacts for Summits On The Air (SOTA).

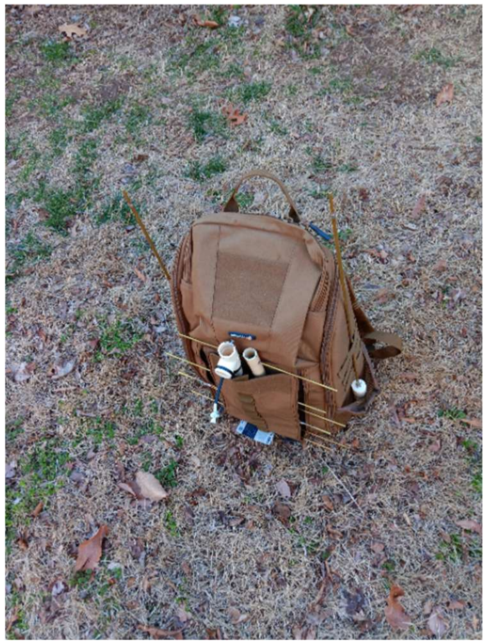


Figure 12 - BACK PACT FOR TRANSPORTING HAM RADIO EQUIPMENT FOR HF THROUGH 432 MHz, INCLUDING RADIO, FEEDLINE, ANTENNAS FOR ALL BANDS, AND MASTS, WEIGHT ~10 LBS.

Also, since many folks carry a “walking stick” as they hike, this hiking stick doubles as a mast. To guy the mast, plastic tent stakes are attached to the walking stick/mast with kite line to guy the mast. The mast itself is PVC pipe used for electrical conduit as this pipe has thicker walls and is more UV resistance. The mast in the “walking stick” configuration is shown below.

Figure 13 - WALKING STICK/MAST FOR MAN PORTABLE OPERATION TO LOCATIONS AVAILABLE ONLY BY FOOT

The tent stakes are fastened to the pole with Velcro straps went hiking to the operating site.

RELATED APPLICATIONS

Since this paper describes the procedure for cutting exact λ/4 transmission lines to length, this technology can be applied to other ham radio activities. The first that is presented is for the Turnstile Antenna. While most hams use a loop or Halo antenna for omin-directional coverage, these antennas typically have 2 or 3 dB (or more) gain variation in the azimuth pattern. On the other hand, the Turnstile is nearly uniform in its azimuth pattern. The Turnstile is implemented by mounting two dipole antennas at 90 degrees to each other and fed 90 deg. out of phase. The diagram below shows this configuration.

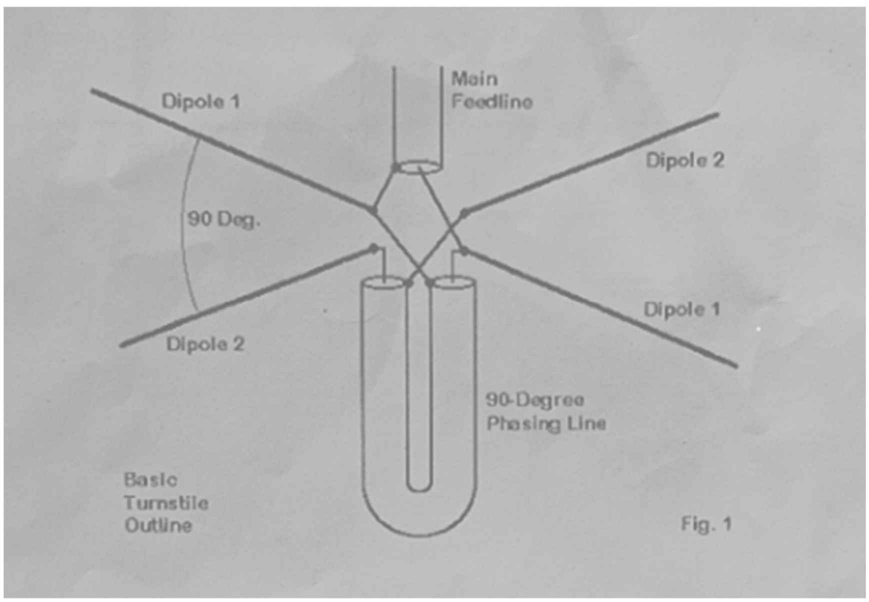
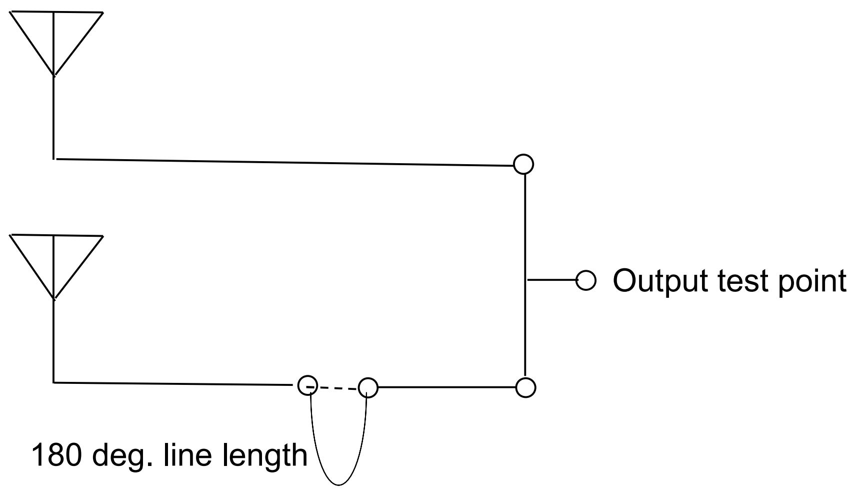


Figure 14 - TURNSTILE ANTENNA

Now the 90 deg. phasing line can be cut with precision a truly circular pattern.

Another capability for the Turnstile is to produce an omni-direction, gain antenna. Using a mast or a tower leg, four of the Turnstiles can be stacked to compress the vertical pattern similar to what TV stations use for their transmitting antennas. Four of these Turnstiles stacked up a tower leg will produce 6 dB of gain minus any loss in the power splitter feeding the four antennas.

Another application for precision transmission line lengths is for stacking antennas. Referring to Fig. 3 for the SUM and DIFFERENCE patterns, it can be seem that the SUM pattern is very broad. For stacking two yagis, for example, the objective is to obtain the maximum gain with the spacing of the two yagis. Instead of trying to stack and measure a few tenths of a dB for the sum signal from the two antennas, a more precise method is to use the DIFFERENCE signal of the combined antennas. To accomplish this, first the two antennas are spaced at what the user “thinks” is the proper spacing. The diagram below depicts how this is implemented.



Each antenna is connected to the Output Test Point with two equal lengths of coax where the voltage or signal strength is measured. One of the antennas has a junction point such that a 180 deg. additional length of coax can be inserted. Now, the signal from the two antennas indicates the DIFFERENCE pattern since the two signals are the same amplitude and 180 deg. out of phase which is a very sharp indication. The spacing between the two antennas is adjusted for minimum signal, and then the 180deg. phase shift line is removed leaving the two antennas SUMMED for maximum signal which is the optimum spacing.

In summary, these very light weight antennas are sufficiently rugged for roving operation, can be transported in a car or in carry-on luggage, and can provide radio, antennas, mast, feedline, and coax for about 10 lbs. weight. As many commercials state, “Batteries Not Included.”

K4QF