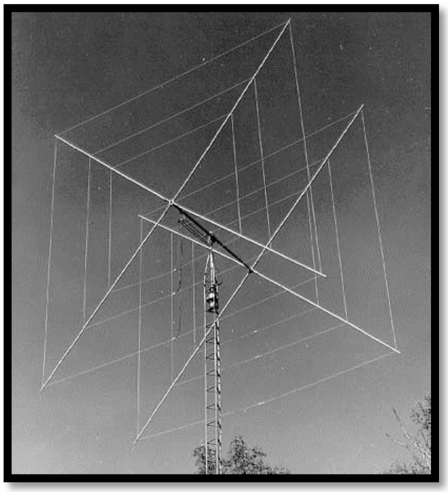
BUILD A HIGH PERFORMANCE TWO ELEMENT TRI-BAND CUBICAL QUAD

By Bob Rosier – K4OCE



INTRODUCTION

Lots of DX can be worked with a dipole at the QRP level, however, a beam will obviously give you additional gain as well as more directivity. The Cubical Quad has the advantage of being not only multi-band, but in my experience is equal to a 3 element Yagi in performance. It is also something that you can construct yourself. At the end of this article, I go into some detail as to how to "fine-tune" the antenna. Some may not have the test equipment or knowledge to perform these tests. It is not absolutely necessary to go through all of these extra steps so long as you carefully cut each wire to the lengths shown in Table B. In other words, careful construction will result in a fine working antenna, just not finely-tuned.

THEORY AND GENERAL INFORMATION

Assume a loop of wire resonant at 14.1 MHz and fed with 75 ohm cable. With no reflector (or at reflector spacing greater than λ/4) the impedance of this loop is approximately 140 Ω. Therefore, the ratio of impedance i.e. SWR = $\frac{140}{75} = 1.86/1$. If a reflector (typically 3 % longer than driven element) is placed at a distance of approximately 1 foot from the driven element, the impedance of the loop is approximately 40 ohms, and the ratio of impedances i.e. SWR = $\frac{75}{40} = 1.87/1$. The point of the above example is that the spacing is not critical relative to impedance since the worst case (for any given frequency) results in an SWR of less than 2/1. For this reason, one should concentrate on forward gain and front-to-back ratio and then match as closely as possible with λ/4 stubs or direct feed. The author does not recommend a 3 gamma match system unless good test equipment is available and time to perform a good weather proofing job on the match system (if a match is ever obtained !). Aluminum arms are not recommended because of the large capacitive loading effect which must occur at the insulating joints, and boomless quads are not recommended because of the mechanical problems. The front-to-back ratio vs reflection length (fixed frequency) curve is relatively broad whereas the gain vs reflector length curve is rather sharp. For this reason, tuning should be for maximum forward gain.

CARBON FIBER POLES

Carbon can exist in several different structural forms, so this has caused a lot of confusion about its conductivity. Carbon fibers have several advantages which include high stiffness, high tensile strength, high chemical resistance, high temperature tolerance, low thermal expansion, inexpensive, and very light weight. Each pole weighs only 10 ounces. That is amazing that all 8 poles needed for a 10-15-20 cubical quad only weigh 5 pounds. In doing research on these poles, I found several sources stating that carbon fiber poles should not be used on a cubical quad because they are conductive, but these poles are so perfect for quad applications, I thought I would do some additional research on my own. I am a volunteer for home schooling for some high school kids in Chemistry, Physics, and Mathematics. We just completed Chemistry so fresh in my mind was the fact that on the Periodic Chart, carbon is considered to be a non-metal. With four valance electrons (electrons in outer shell), it can neither donate electrons nor accept electrons, it can only share electrons in a covalent bond with other atoms. Because of this, carbon itself does not conduct electricity. Carbon atoms can, however, bond together with other carbon atoms and form other structures called allotropes. Diamonds and graphite are two examples. Diamonds are insulators, but the carbon atoms in graphite bond in such a way that “free” electrons result making it a good conductor. If poles have graphite in them, they will be conductive. I found some information from a manufacturer of carbon fiber and he said that “if our customers want to reduce the conductivity of carbon fiber products, we use special epoxy resin to mix with the carbon fiber.” So, the poles can be conductive or non-conductive, and the problem is determining which are non-conductive.

Pole Markings

Carbon fiber pole

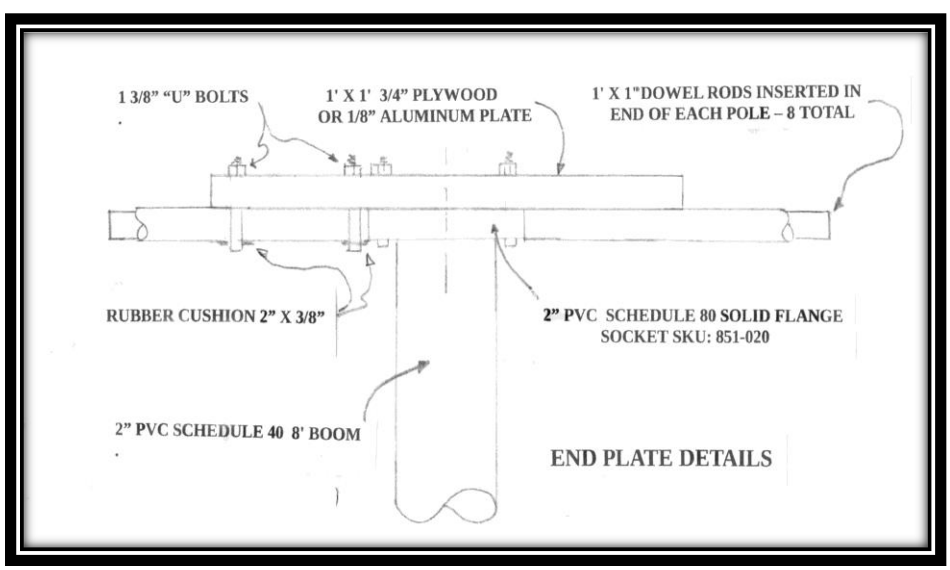
Cross-section of poles

When searching for carbon fiber poles, I came across one on Ebay that stated “CARBON 99%.” The seller couldn’t verify conductivity, but since they only cost $10 I ordered one so that I could do some testing. The result of every test on this particular pole showed it to be non-conductive. I sanded off the surface to be sure there was not a layer of insulated material, and when applying a voltage across different sections, the results in all cases were the same….. zero current flow. I also used a grid-dip meter (GDO) set at 28 MHz and I slipped a section of the pole right over the GDO coil with absolutely no movement in the meter reading.

<u>CONSTRUCTION DETAILS</u>

The following information is based on an 8’ boom length, two commercial end spiders (an “X-shaped” cross member) or two 1’ square end plate (wood or aluminum) for mounting the fiberglass arms.

Commercial Spider Arms OR Wooden End Plate and Boom



Each of the 8 fiberglass poles need to be 13 foot in length in order to accommodate the largest 20 meter loops. The Ebay vendor where I purchased the poles is “mysweethouse” and the product was “Telescopic Stream Pole Spinning Freshwater Fishing Rod Fiberglass 2.7m-7.2m”, and choose the 7.2 m length (23 ½ feet). Although you only need 13 feet, you will be removing the four smaller sections that are not needed. Eight sections will be glued together with epoxy. Sections do fit tight, so you could make a portable Quad and not glue the sections. Perhaps just using hooks where the wires could hang. When collapsed, the poles are only 24 ½” long and a carrying bag is included. The poles are also long enough for a 30 meter should you be so inclined (16’ poles). Adding 12 meters might be a good idea too (7’ poles).

1. Put the pole arms and spider (or end plate) on a convenient flat surface. After assembling the spider or plate and fiber poles, drill three of the four holes based on the dimensions in Table A. Mount the hardware as shown in Fig. 1 at the three points on each pole for a total of 18. The fourth corner can be taped down during measurements.

TABLE A

1/8” Cable Clamp

LOCATION OF HOLES TO BE DRILLED IN FIBERGLASS POLES FOR 1/8” WIRE CABLE CLAMPS: MEASURE FROM THE CENTER OF THE END PLATE

DRIVEN ELEMENTS:	20 meter: 12’ 4”	15 meter: 8’ 4 5/8”	10 meter: 6’ 1 ¾”
REFLECTOR ELEMENTS:	20 meter: 12’ 8 ¾”	15 meter: 8’ 7 ½”	10 meter: 6’ 4”

2. Make up an assembly similar to Fig. 2 for the coax feed. Note the use of special solder lugs which have a straight-through hole. The use of the female coax connector instead of hard wiring is recommended for the following reasons:

   a) It allows substitution of a two turn loop for later use with a grid-dip oscillator to check resonant frequency.

   b) It eliminates the pull of heavy coaxial cable on the driven element during its mounting to the boom.

   c) It allows easy replacement of coax cable in future years or a troubleshooting aid in case of coax trouble

   d) Short coax lengths can be added to a coax relay should one be used instead of multiple coax cables

3. Using Beldon #8000 hard drawn copper wire or equivalent, lay out the wire evenly around the arms. Cut the element wires 2 feet longer than the lengths given in Table A. If you are not planning to “fine-tune” the antenna, you can cut each wire as close as possible to the Table B dimensions.

TABLE B
TRI-BAND QUAD DRIVEN AND REFLECTOR LENGTHS

BAND	20	15	10
DRIVEN ELEMENT	69’8”	47’4”	34’8”
REFLECTOR	72’	48’8	35’8”

Wrap and solder one end of the wire for the driven element to one of the special lugs (a permanent connection). Loop the wire through the 3 cables clamps installed in Step 1. After adjusting each loop so that the feed point is in the center, temporarily secure the fourth point of each loop with tape. *If you are* *__not__ doing the "fine tuning", pull the wires snug (not too tight), solder, and permanently mount the last cable clamp as in Fig. 1.*

4. Repeat Step 3 for the reflector but refer to Fig. 3 for the method of closing the loop. *Again, if you are __not__ doing the "fine tuning," you can made this a permanent connection by soldering the wire, and then drill the hole for the last (fourth) clamp….then skip to step 9 for feed line information..*
5. Fasten the cable tie on the three corners of each loop as given in Fig. 4 and dimensions from Table A.
6. Mount the reflector and driven elements to the boom. Spacing should be 8 feet, but 7'-9' is OK.
7. Temporarily raise the antenna as high as possible with the feed point still accessible.
8. Connect a 2 turn loop (Fig. 5) and couple the grid-dip oscillator (GDO) near the loop. Check the resonant frequency of each driven element for each band, verifying the GDO frequency against the station receiver.
9. Shorten each loop until the desired resonant frequency is reached. Connect the coaxial cable. If three different feed lines are employed (recommended), use RG8 on 20, RG-11 on 15, and a λ/4 5'6" stub of RG-11 in series with any length of RG-8 for 10 meters. If 5'6" seems short for λ/4 on 10, it must be remembered that the RG-11 velocity of propagation constant is equal to 0.66. Run an SWR curve to insure correlation. To eliminate the cost of 3 runs of coax, a 3:1 coax relay can be used with RG-8. You should still use RG-11 λ/4 stub for 10 meters. The feed point impedance will be off a bit on 15 meters, but only resulting in a little loss of transfer power.
10. With a field strength meter permanently placed at least 100 feet, set the frequency of the exciter to the resonant frequency of the antenna. With the antenna pointed towards the field strength meter, continuously monitor the signal strength as the reflector loops are shortened until the point of maximum gain is reached. Permanently solder all loops.
11. Pull the loops snug (not too tight), determine the location of and drill the fourth hole for each loop and mount the final cable clamp as shown in Fig. 1.
12. Raise the antenna into the air as high as possible, work 300 countries!

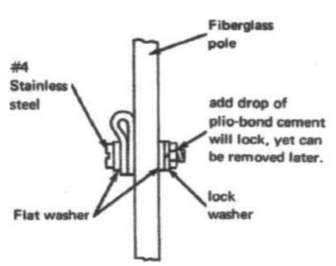


FIGURE 1

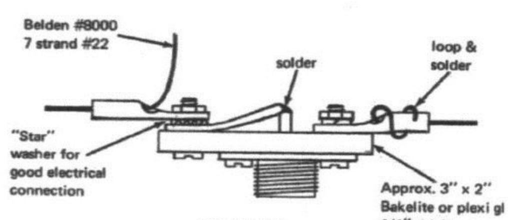
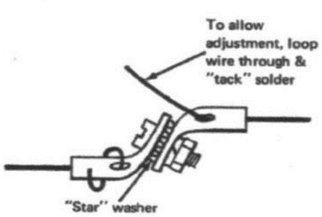


FIGURE 2



REFLECTOR ELEMENT

FIGURE 3

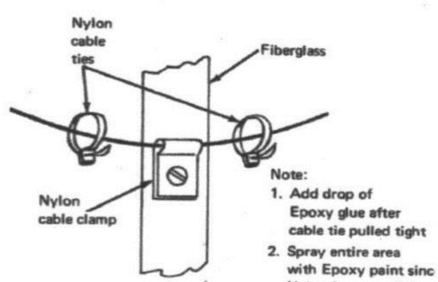


FIGURE 4

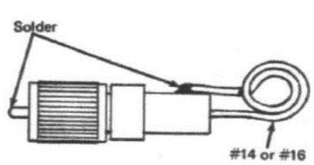


FIGURE 5