Build a 2-Meter Quadrifilar Helix Antenna

Step-by-step instructions make this circularly polarized antenna easy to construct.

David P. Finell, N7LRY*

This quadrifilar helix antenna (QHA) is circularly polarized, has excellent beam-shaping capabilities, and is independent of a ground plane. It is suited for both terrestrial and space operations. This half-wavelength, half-turn QHA with a 2.6 to 1 aspect ratio, should provide a nominal 4.5 dBi of gain in a spheroid radiation pattern. The antenna consists of a pair of one-wavelength perimeter, rectangular half-turn helical loops oriented 90° to each other on the same axis and fed in phase quadrature. The circular polarization direction is opposite to the twist direction of the helical elements.

Materials for the QHA

(4 feet) 6061 ¼-inch aluminum rod
(12 feet) ½ × ⅛ aluminum bar/strap; plain aluminum or a softer alloy works better for forming the straps
(20) ¼ × 28 stainless-steel nuts
(8) ¼ × 28 stainless-steel lock nuts
(4) ¼-inch ring terminals
(1) 1-inch PVC end cap
(1) 2-inch PVC coupler
(1) 2-inch PVC end cap
(3 feet) 2-inch PVC schedule 40 pipe
(6 inches) 1-inch PVC schedule 40 pipe
(6 feet) RG-58 solid core dielectric (not foam)
Antenna connector (your choice) for RG-58 cable
Dielectric grease or No-Ox™ compound
Epoxy
PVC cement
Heat-shrink tubing

Assembling the QHA

Figure 1 shows the antenna helical loop configuration minus the support infrastructure or feed network. Please read these assembly instructions thoroughly before starting to build the antenna.

I designed the antenna using the metric system of units, but specified some components in US customary units, where applicable. I used RG-58 for my convenience, but you can use other coax cables provided that the impedance is 50 Ω, and you account for the velocity factor when measuring lengths for phasing loops. See the sidebar for a list of materials. Follow these step-by-step instructions.

***Second-place winner in the 2017 *QST* Antenna Design Competition, 6 Meters and Higher Frequencies category**

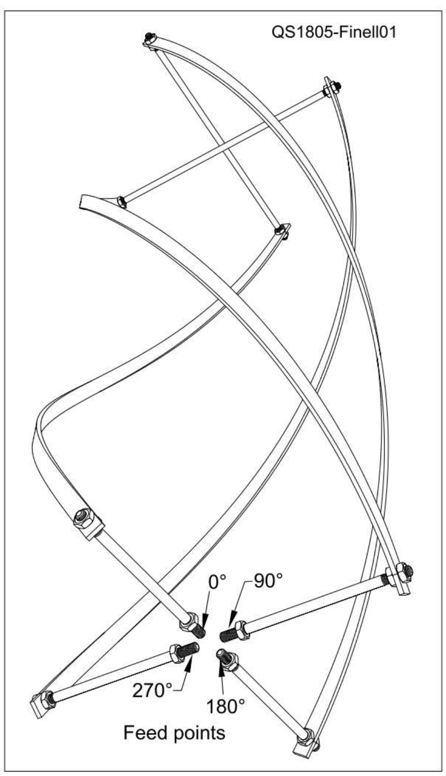

Figure 1 — This sketch of the QHA shows the location of the feed points.

Feed-Point Assembly — Steps 1 to 7

1) Cut the aluminum rod into four 13-centimeter sections and two 28-centimeter sections.

2) On the aluminum rod sections, cut 0.7 inch of ¼ × 28 threads on each end.

3) Drill or punch four ¼-inch holes evenly spaced at 90° to each other in the side of the 1-inch PVC cap so the opposite holes align and are all in the same plane. The holes should be roughly midway between the open and closed end. Use Figure 2 as a reference for how the completed feed point looks.

4) Drill or punch four ¼-inch holes evenly spaced at 90° to each other. The 2-inch PVC coupler is one-quarter the distance from one lip and on the same plane. When the 2-inch coupling and the 1-inch cap are centered and on the same axis, the holes should align.

5) Insert the four 13-centimeter aluminum rods into the holes of the 2-inch PVC coupling to form an **X**.

6) Place one ¼ × 28 nut on the end of each 13-centimeter rod.

7) Orient the 1-inch PVC cap at the junction of the four 13-centimeter rods on the inside of the 2-inch PVC coupling and secure it temporarily with four ¼ × 28 nuts. This will be the feed point for the antenna.

Figure 2 shows the assembly with a ¾-inch end cap, but I found that a 1-inch end cap provides better separation between converging elements and is easier to assemble.

Figure 2 — The completed feed-point assembly.

“The antenna consists of a pair of one-wavelength perimeter rectangular half-turn helical loops oriented 90° to each other on the same axis and fed in phase quadrature.”

Making the Helical Elements — Steps 8 to 17

8) Cut four strips of ½ × ⅛ inch aluminum, each 32 inches long.

9) Punch or drill ¼-inch holes centered ½ inch from each end of the four aluminum strips prepared in step 8.

10) Lay two of the cut and punched aluminum strips next to each other.

11) Place a ¼ × 28 nut on each end of the 28-centimeter rods and finger-tighten to the base of threads.

12) Place one end of an aluminum strip on one end of a 28-centimeter aluminum rod and loosely secure it with a lock nut. The aluminum strip must be able to pivot freely. There is no need to tighten the lock nut into the nylon lock portion of the nut at this time. They will be removed in a future step.

13) Place another aluminum strip on the opposite end of the aluminum rod and secure in the same way as step 12.

14) Secure the remaining 28-centimeter rod to the opposite ends of the aluminum strips used in steps 12 and 13. You should end up with a rectangle made from the 28-centimeter aluminum rods on top and bottom, and aluminum strips on the sides.

15) Find an old board, block, box, or book (a telephone book works great). This will be used to raise one of the aluminum rod ends of the rectangle off the ground.

16) As shown in Figure 3, hold one aluminum rod end of the rectangle in your hands while standing on the other end of the rectangle on top of the book or block from step 15 and twist the rectangle to the right, while pushing down. This will cause the helices to form from the aluminum strips for a right-hand polarized antenna. The antenna circular polarization is opposite to the helix screw sense. Ensure that the ends of the strips pivot freely and the aluminum rods stay parallel to the ground and in vertical alignment. When the strips are shaped properly, they will form a half-turn symmetrical double helix with a diameter roughly equal to that of the aluminum rods. The aluminum rods will be parallel and separated by approximately 26 inches. You may need to slightly over-bend so the helices stay in the desired shape.

17) Remove the formed helices from aluminum rods and repeat steps 12 to 16 with the two remaining aluminum strips. Remove those formed helices from aluminum rods as well.

Top Preparation — Steps 18 to 32

18) Align the 2-inch PVC cap, and drill or punch holes at 90° intervals similar to those made previously, so opposing holes are in alignment but do not intersect with holes that are at 90°. Leave about ¼-inch separation (see Figure 4). When the 28-centimeter rods are passed through the holes, they must not touch and should have about ¼-inch of clearance. These are the same rods that were used to form the helices.

Figure 3 — Hold one aluminum rod end of the rectangle in your hands while standing on the other end on top of the book, and twist the rectangle to the right while pushing down.

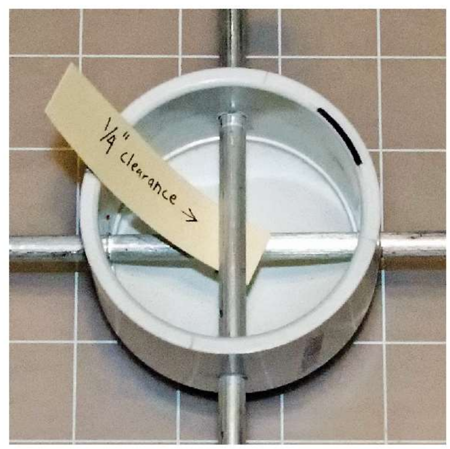

Figure 4 — The rods at 90° orientation are displaced so there is a ¼-inch gap between them.

19) Center the aluminum rods in the cap so that the same length is protruding from all sides of the cap. This configuration will make a symmetrical **X**. Epoxy the rods at the PVC hole junctions so they are secured in their centered position.

“When the strips are shaped properly, they will form a half-turn symmetrical double helix with a diameter roughly equal to that of the aluminum rods.”

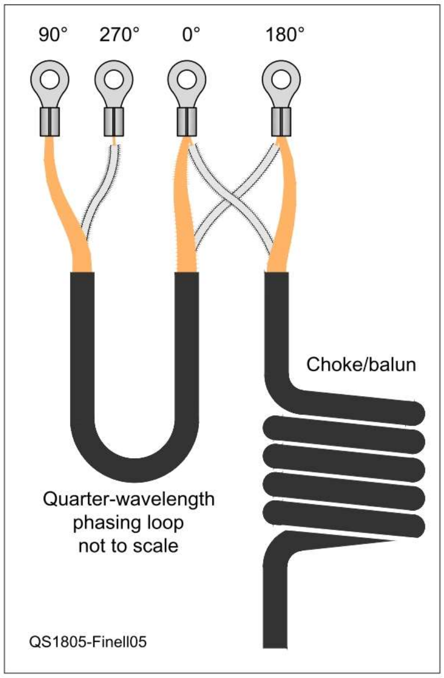

Figure 5 — Connections for the four feed terminals. Note the balun/choke on the feeding cable.

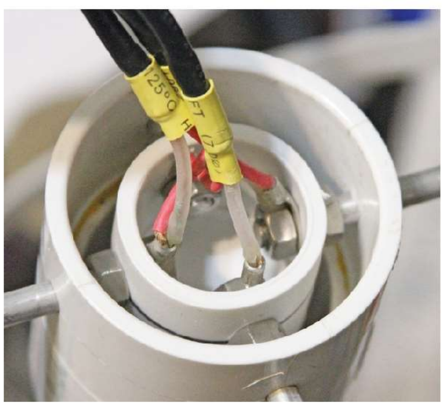

Figure 6 — Feed-point connections.

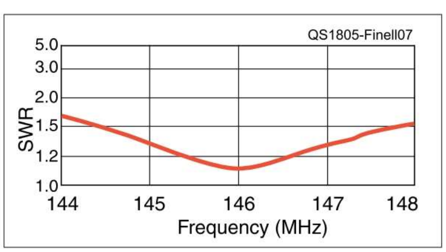

Figure 7 — The SWR is lowest at the band center and is well behaved across the 2-meter band.

20) Cut a length of RG-58 to 13 inches, or 33 centimeters. This is the quarter-wavelength phasing loop length for solid dielectric. Foam dielectric will have a different velocity factor, so the length will differ. If you choose coax other than RG-58, ensure that the velocity factor of the coax is taken into account when making the quarter-wavelength phasing loop.

21) Strip back about 1½ inches of outer sheath. Separate the shield from the dielectric over this 1½ -inch end while avoiding cutting any of the strands. Strip about ¼ inch of dielectric from the end of the coax. Place about a 1-inch length of heat-shrink tubing over the shield and a short piece over the transition from the sheath to the other heat-shrink covering the length of shield. Terminate both leads with ¼-inch ring terminals. Repeat this with the other end but delay terminating with the ring terminals until the next steps.

22) Cut a length of RG-58 about 3 to 6 feet in length. This is your antenna feed line. Prepare one end as in step 21, without ring terminals.

23) Connect shield to center and vice versa of the feed line and unterminated end of the phasing loop as shown in Figure 5, and terminate the remaining ends as shown with ring terminals in Figure 6.

24) Make a choke/balun coil of three to five turns about 1½ to 2½ inches in diameter in the feed coax, close to the feed point and phasing loop. One method to accomplish this is to punch or drill a ¼-inch hole about ½ inch from each end of a 2½-inch-long piece of 1-inch PVC pipe. Thread your feed line into one end of the pipe and through the first hole. Wrap your turns of coax around the pipe and thread through the second hole. Make your coil spacing as tight as possible. Some balun adjustment may be necessary to achieve optimum results.

25) Connect the four phase-ring terminals to the antenna feed point in a configuration where each loop feed-point connection is fed 0°, 90°, 180°, and 270° around the feed point. The direction or sense you choose, clockwise or counterclockwise, will determine which end the QHA radiates.

26) Cut a 2-foot length of 2-inch PVC pipe to form the center mast between the top and bottom of the antenna. This can be adjusted slightly for the design or style of the couplers and end caps. It is better to cut slightly long, then trim as needed. Adjust the length so the helical elements will form a virtual cylinder that is not bowed outward or inward.

27) Assemble the antenna so that the feed-point cross section and the top cross section are on opposite ends of the 2-foot PVC pipe, and are in alignment. It is a good idea to do a dry-fit assembly to ensure all parts fit properly before cementing any PVC parts.

28) Ensure one stainless-steel ¼-28 nut is threaded on each outer end of the aluminum rods.

29) Attach the straps to the ends of the rods so they twist 180° around the antenna from the top to bottom cross sections.

30) Apply No-Ox™ compound to the ends of the rods and straps.

31) Secure the straps to the ends of the rods with the ¼-28 stainless-steel lock nuts.

32) Terminate the end of the feed line with your choice of RG-58 connector.

If you have followed the instructions correctly, your antenna should resemble the image in the lead figure. The

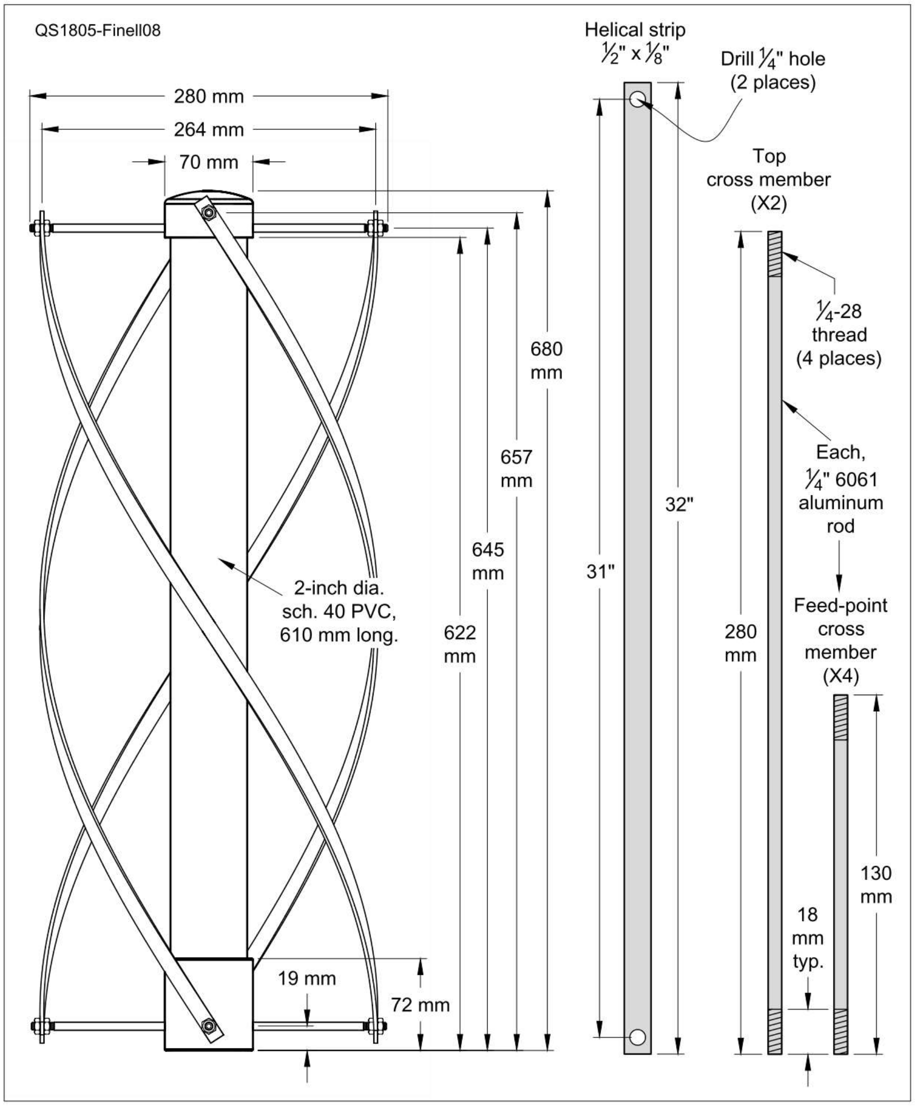

Figure 8 — The QHA dimensions following assembly (left), and the dimensions of the QHA components (right). [The top cross member and the feed-point cross member component dimensions are not to the same scale.]

SWR performance is shown in Figure 7. Finished QHA dimensions are on the left side of Figure 8. The QHA component dimensions are on the right side of the figure. Note that the top cross member and the feed-point cross member component dimensions are not to the same scale.

End Notes

I have used this antenna for many years and have also compared it against commercially designed omnidirectional antennas, including many that were much larger. It has consistently performed with the best of them. This antenna was designed with a center frequency of 146 MHz, but I have used it successfully to receive 137 MHz WEFAX images as well as receive commercial broadcast TV. I hope that you have as much success with this antenna as I have.

I would like to thank Dr. Kilgus of Johns Hopkins University for the theory behind an outstanding antenna and Walt Maxwell, W2DU (SK), for making the theory easy to understand.

All photos by the author.

David P. Finell, N7LRY, was exposed to radios and gadgets by his dad, Paul Finell, W7EFQ, who was a very active ham. David joined the Air Force in 1988 as a wideband electronics technician and worked in broadcast studio engineering with video production systems. He designed CATV head end systems, and retired as the NCOIC of radio and television systems for what was called HQ Air Force News Agency. While in the Air Force, David earned an associate degree in electronic systems technology from the Community College of the Air Force. Later, he earned an associate degree in art from Northwest Vista Community College, then graduated cum laude from UTSA with a Bachelor of Fine Arts. David volunteers as a guest lecturer at local ham club meetings and hamfests. He enjoys homebrewing and building kits, and is currently building a low-power software-defined radio. You can reach David at **dfinell@satx.rr.com**.

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