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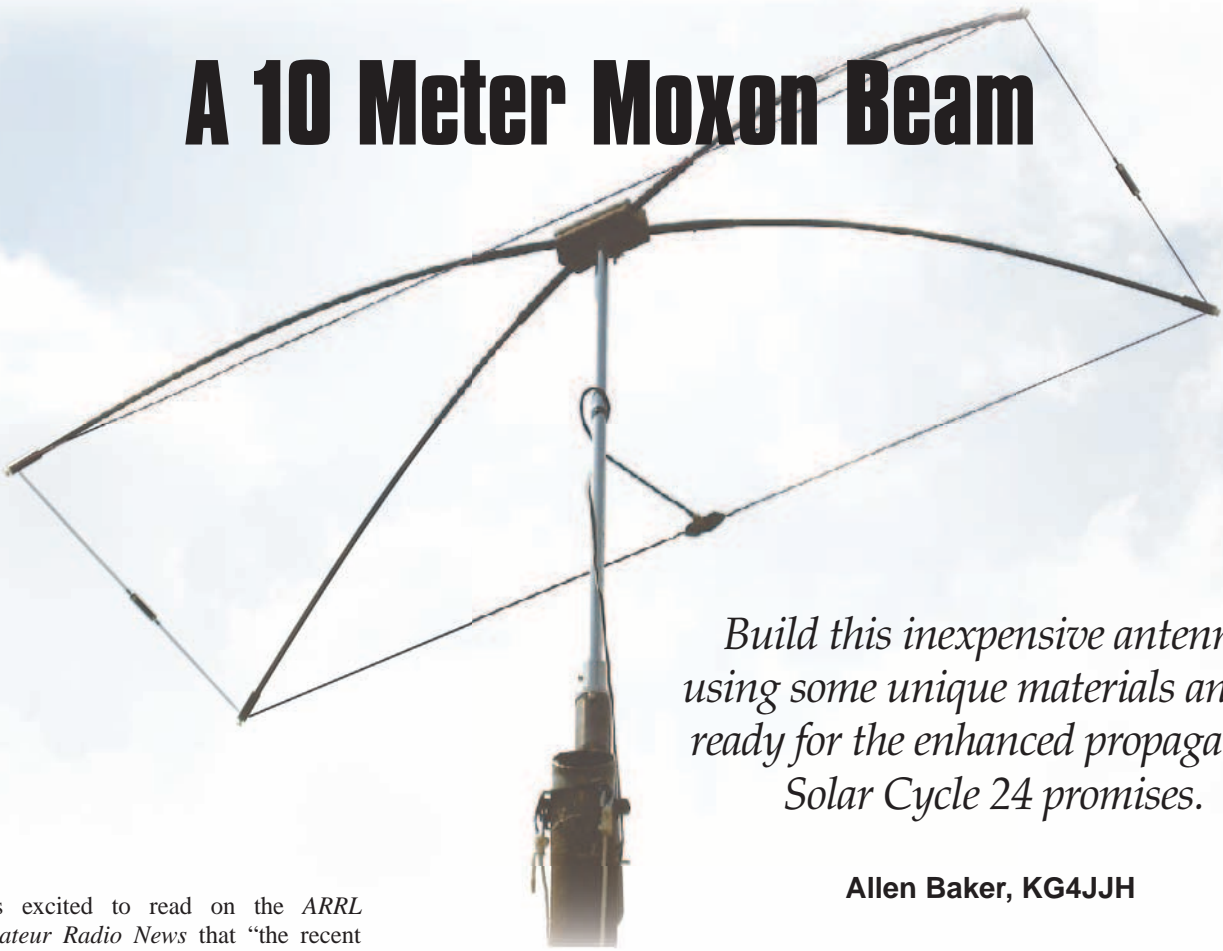
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# A 10 Meter Moxon Beam



*Build this inexpensive antenna using some unique materials and be ready for the enhanced propagation Solar Cycle 24 promises.*

**Allen Baker, KG4JJH**

I was excited to read on the *ARRL Amateur Radio News* that “the recent appearance on the sun of two so-called ‘backward sunspots’ may mean solar cycle 23 is drawing to a close and Cycle 24 now is under way or soon will be.”<sup>1</sup> During the peak years of solar cycle 23, some years back, I consistently made worldwide contacts on 10 meter PSK31 using 5 W to an attic mounted Moxon rectangle.

The Moxon rectangle was developed by Les Moxon, G6XN, as a derivative of the VK2ABQ square, with further refinements to natural beam dimensions by L. B. Cebik, W4RNL (SK).<sup>2</sup> The antenna is essentially a two element Yagi with the element ends folded toward each other. It has about the same gain, a higher front to back (F/B) ratio, direct 50 Ω feed and is approxi-

mately 30% smaller than the usual two element Yagi.

For this Moxon Beam or *MoxBeam* project, I describe a portable version of my attic antenna that is built from composite lumber, fiberglass tubing, and Home Depot wire for about \$75. Your efforts will be rewarded with a 7 pound antenna that, if mounted 25 feet above typical ground, delivers up to 11.3 dBi gain, and has a 40 dB F/B ratio (see Figure 1), a 19° take-off angle and a turning radius of 6.5 feet. For amateurs interested in other bands, I have prepared a table of construction dimensions and performance details for the 6 through 20 meter amateur bands using the same technique. This information, along with additional drawings and photos is available at the *QST* binaries Web site.<sup>3</sup>

## Construction

### Hub

You may have seen the new composite lumber that is used to build outdoor decks. At least one company offers this material in dimensional sizes such as nominal 2 × 4 inch. It is an ideal material for building the antenna hub.<sup>4</sup> It saws and drills as easily as wood but is impervious to weather extremes. It has low thermal expansion and contraction and is ultraviolet protected. The smallest piece available is 12 feet long and, according to my local lumber yard, it is expensive at \$26 each. You only need an 8 inch piece for this design and the same hub dimensions can be used for all bands, or you can make

18 hubs. You may be as lucky as I was and find a free scrap at a construction site. All required materials are listed in Table 1.

Print a full size template of the hub (see Figure 2) and temporarily fasten it to the composite material using a glue stick. Mark a centerline down the length of the material and use it to line up the template. Using a table or miter saw, cut two 20° angles on each end to form a “V” along the centerline (see Figure 3). The total length should

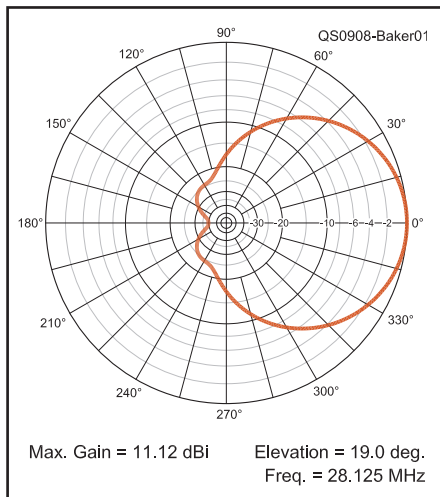
<sup>1</sup>Notes appear on page 36.

**Table 1**  
**10 Meter MoxBeam Materials List**

Qty	Description	Source	URL
1	Hub, Trex composite lumber	Home Depot	<a href="http://homedepot.com">homedepot.com</a>
2	½" OD × 8' fiberglass tubing*	Max-Gain	<a href="http://mgs4u.com/fiberglass-tube-rod.htm">mgs4u.com/fiberglass-tube-rod.htm</a>
4	¾" OD × 8' fiberglass tubing*	Max-Gain	<a href="http://mgs4u.com/fiberglass-tube-rod.htm">mgs4u.com/fiberglass-tube-rod.htm</a>
33'	#14 PVC insulated stranded wire	Home Depot	<a href="http://homedepot.com">homedepot.com</a>
4	Nylon screw ⅝"-18 × ½"	Ace Hardware	<a href="http://acehardware.com">acehardware.com</a>
1	Budwig HQ-1	RF Connection	<a href="http://therfc.com/antacc.htm">therfc.com/antacc.htm</a>
1	Thumb screw, stainless, ¼"-20 × 1½", #91745A546	McMaster-Carr	<a href="http://mcmaster.com">mcmaster.com</a>
1 box	Ring terminal #34540, 16-14 gauge	Ace Hardware	<a href="http://acehardware.com">acehardware.com</a>
4	Nylon screw and nut, 6-32 × ½"	Ace Hardware	<a href="http://acehardware.com">acehardware.com</a>
1 pk	Quick release button, stainless, #92988A510.	McMaster-Carr	<a href="http://mcmaster.com">mcmaster.com</a>

\*Max-Gain Systems will cut tubing to specification, which can significantly reduce shipping charges





**Figure 1 — 10 meter MoxBeam azimuth plot at a height of 25 feet over typical ground.**

be 7½ inches from end to end. Extend the spreader hole centerlines down the ends and mark the centers. The angles on the ends make drilling the spreader holes easy. By clamping the piece on its end you automatically get the required 20° spreader angle. I find it helpful to drill an ⅛ inch pilot hole first and then enlarge it to the final diameter.

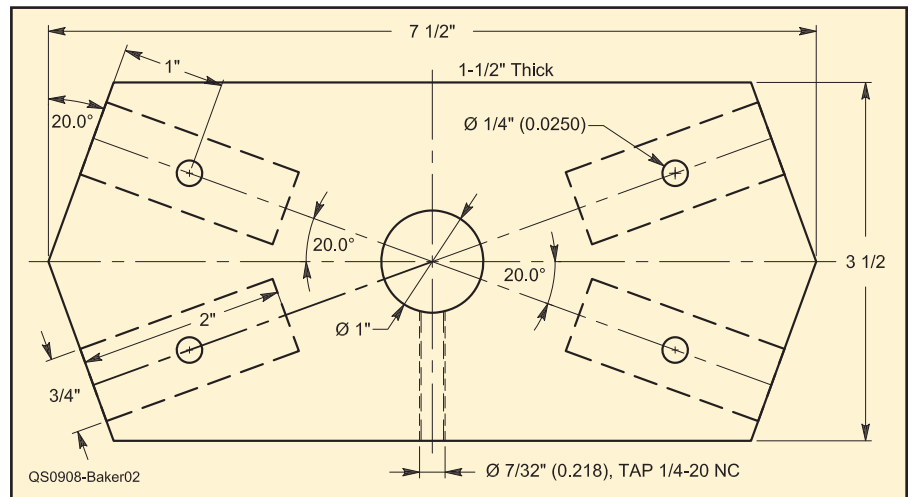
Using a drill press with a ¾ inch Forstner bit, drill a 2 inch deep hole at each location. Trial fit a piece of ¾ inch OD tubing to ensure that the insertion depth is 2 inches. Next, drill a 1 inch diameter hole in the hub center for the mast. A tapped hole on the side allows the hub to be secured to the mast with a ¼-20 × 1½ inch thumb screw. And last, drill four ¼ inch holes on the top of the hub for the spreader quick release buttons. If desired, remove sharp corners using a file or router with a round over bit. The hub material can be painted, but the manufacturer recommends that you let it weather for 8 to 12 weeks, and then use any paint or stain that adheres well to wood.

### Spreaders

The 83 inch long spreaders (see Figure 4) are made from ¾ inch and ½ inch outside diameter (OD) fiberglass tubing (⅛ inch wall). Cut four 61 inch long pieces of ¾ inch OD tubing (Figure 4, dimension S2), and four 28 inch long pieces of ½ inch OD tubing (Figure 4, dimension S3). On one end of the ¾ inch OD tubing, drill a 1⅞ inch hole through one wall, 1 inch from the end. Deburr the inside of the hole with a round file and insert a quick release button. Insert the ½ inch tubing into the other end of the ¾ inch tubing with a 6 inch overlap. Fasten the tubes with a 6 × ½ inch thread-cutting screw in the center of the overlap.

### Corner Clamps

The four corner clamps (see Figure 5)



**Figure 2 — Template of MoxBeam hub. If printed full size (see Note 3), this can be used as a cutting template.**



**Figure 3 — Preparing a hub on a table saw using a printed template.**

are made from ¾ inch OD (⅛ inch wall) fiberglass tubing. Cut four pieces, 2½ inches long. Using scraps from the spreaders, cut four 1 inch long pieces of ½ inch OD fiberglass tubing. Roughen the inside of the ¾ inch tubing with a tubing brush. Then, glue the ½ inch OD tubing inside the ¾ inch OD tubing, flush with one end, using fiberglass epoxy. Allow 24 hours for the glue to set and then remove any excess dried glue inside the ¾ inch tubing with a ½ inch Forstner bit. Next, tap the inside of the ½ inch tubing using a ⅝ NC-18 tap. The last step is to drill an ⅛ inch diameter hole all the way through both tubes, ½ inch from the flush end. Use a countersinking bit to smooth the edges and prevent chafing the wire insulation. A ⅝ NC-18 × ½ inch long nylon hex head screw is then screwed into the threads. When a wire element is threaded through the ⅛ inch hole the nylon screw is tightened enough to hold the wire, and the corner clamps become part of the element assembly.

### Elements

The elements are cut from regular Home

Depot 14 gauge THHN insulated wire that was left over from dipole construction. This *machine tool wire* (MTW) has 0.015 inches of PVC insulation plus a 0.005 inch outer nylon jacket. I initially suspected that the nylon jacket affected the insulation's dielectric constant because the first set of elements I made had a resonance that was considerably lower than the model indicated (*EZNEC4 4.0* includes the effects of wire insulation).<sup>5</sup> Closer inspection, however, revealed that the ½ inch metal screws used to attach the elements to the insulators were to blame. The metal screws were replaced with nylon and the element resonance was on target.

The insulator ends are terminated with ring terminals by crimping and soldering. The feed point ends are soldered to a Budwig HQ-1 center insulator as shown in Figure 6. Mark the wire corners with a permanent marking pen and place marks ⅜ inch on either side of the corner mark. This will allow you to center the corner clamps on the corners. Trim the wire to length leaving ¼ inch of wire insulation stripped off for connecting the ring terminals. This gives ⅞ inch of additional length from the end of the wire to the tip of an Ace Hardware 16 to 14 gauge ring terminal. Check the ring terminals that you intend to use and adjust the wire lengths as needed to meet the dimensions.

First, trim ¾ inch off both sides of the Budwig wires for a total end-to-end length of 5 inches. For the driven element, solder a ring terminal on the end of the wire. Place the ring terminal on a metal measuring tape (cloth tapes can stretch) with the terminal tip on zero and clamp the measuring tape and terminal in a vise. While keeping constant tension on the wire and tape, measure out 1 foot 10⅞ inches (see dimension details on the binaries Web site) and mark the wire. Continue measuring to 7 feet 10⅞ inches and mark the wire, recheck the measurement



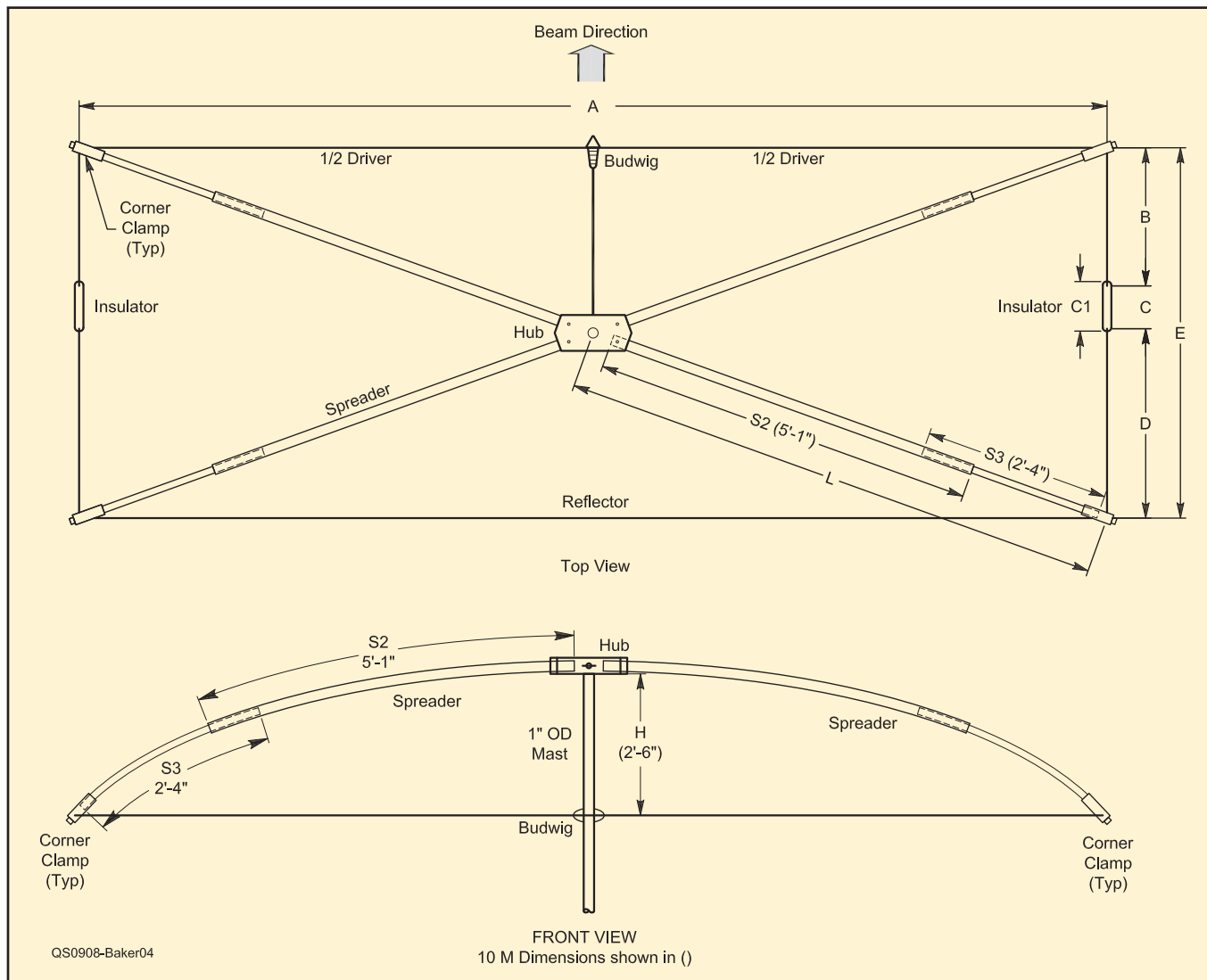


Figure 4 — Dimensioned drawing of the 10 meter MoxBeam.

and cut. Slip on a corner clamp and then a 2 inch length of  $\frac{1}{4}$  inch OD heat shrink. Trim 1 inch of insulation from the wire and wrap the stripped wire around the Budwig wire. Adjust until the element wire insulation just touches the Budwig wire and solder. Slide the heat shrink tubing over the solder joint and shrink. Center the corner clamp between the marks and tighten the nylon screw finger tight, then tighten  $\frac{1}{2}$  turn with a wrench. Don't over tighten as it doesn't take much torque to secure the wire. Repeat this procedure for the other half of the driven element.

The reflector is longer than the driver and has no Budwig connector. Solder a ring terminal on the end of the wire. Using the clamping method mentioned above, measure out 2 feet  $\frac{3}{16}$  inches and mark the wire. Continue measuring to 16 feet  $9\frac{1}{16}$  inches and mark the wire, recheck the measurement and cut. Slip on two corner clamps, strip  $\frac{1}{4}$  inch of insulation and solder a ring terminal on the end. Measure 2 feet  $\frac{3}{16}$  inches from the tip of the second ring terminal and mark

the location of the second clamp. Center the corner clamps between the marks and snug the nylon screws.

### Insulators

The insulators provide the required spacing between the driver and reflector elements. Cut two strips,  $\frac{1}{2}$  inch wide  $\times$   $4\frac{3}{4}$  inch long, from plastic screen base material (used for screened-in porches). This material is stable, flexible and light weight. The element ring terminals are fastened to the insulators using 6-32 NC  $\times$   $\frac{1}{2}$  inch nylon screws and nuts. It is important not to use metal screws here as it extends the element lengths and detunes the antenna. Mount the element terminal rings so that the tip-to-tip measurement is  $4\frac{1}{16}$  inches.

### Assembly

Assembly of the MoxBeam requires no tools and can be completed in less than 5 minutes. Place the hub on the ground and plug each spreader into the hub. Rotate the spreaders until the quick release buttons snap

into the hub holes. Lay the wire elements out and slip the corner clamps over the spreaders, flexing the spreaders up as you progress.

There is sufficient tension created by the elements to hold the corner clamps on the spreaders and keep the feed point taut. Flip the antenna over, place it on the mast and tighten the thumbscrew to lock it in place. The 6 and 10 meter versions can also be installed with the spreaders flexed upward.

Due to higher lateral forces on the spreaders, the 12 through 20 meter versions must be installed with the elements flexed downward. Connect the coax feed line to the Budwig center connector and secure the coax to the mast. Adjust the coax for minimum pull or sag on the driven element. I often include a 1:1 choke balun, to prevent common mode current on the coax shield, by strapping it to the mast. Disassembly requires a small diameter rod to depress the spreader quick release buttons in order to remove the spreaders from the hub.

For portable use, the antenna can be hung from a convenient tree limb. A 1 inch OD



wooden dowel inserted in the hub with an eye hook screwed into the top serves as a convenient tie point. The bottom of the dowel is used to suspend the weight of the coax before it is connected to the feed point. Strings tied to opposite ends of two spreaders allow the beam to be rotated from the ground.

Another method I find useful is to mount the smaller antennas with the spreaders flexed upward on a painter's extendable pole. With the acme threads extending past the top of the hub, a short length of wooden extension pole is screwed into the threads using a plastic coupling. The feed line is then secured to the pole, providing support for the antenna feed point. This setup works well while camping by securing the painter pole mast to the camper using plastic conduit clamps.

## Modeling, Measuring, and Testing

A modeled azimuth plot for a 25 foot elevation over average ground is shown in Figure 1. Maximum in-band gain is 11.28 dBi at 28.0 Hz dropping to 10.05 dBi at 29.0 MHz. The peak F/B of 39.66 dB is achieved at 28.125 MHz, and the 50  $\Omega$  SWR minimum occurs at 28.25 MHz. The antenna's response favors the lower end of the band to cover the CW, digital, and SSB modes up to 28.7 MHz with a 1.5:1 SWR bandwidth. If you wish to alter the response or use different wire I suggest validating any changes with an antenna modeling program.

Builders who want to check the outline dimensions of their finished antenna should understand that the corner clamps alter these dimensions slightly. By securing a  $\frac{3}{4}$  inch section of the elements at an angle, the

clamps shorten the antenna length by approximately  $\frac{3}{4}$  inch and increase the width by  $\frac{1}{16}$  inch on the 10 meter version. *EZNEC* modeling shows that this dimensional change does not significantly affect overall performance.

With the 10 meter MoxBeam installed at an elevation of 25 feet, an MFJ-259B antenna analyzer was used to compare the actual and modeled 50  $\Omega$  SWR. The antenna SWR curve compared very favorably with the modeled data. I tuned across the band and heard several stations on CW and a few PSK signals.

Jim Innis, K5SP, of Gainesville, Texas was coming in loud and clear at S-8 and we had a nice chat on PSK. Afterwards, I rotated the antenna 180° and his signal dropped to S2. Using the traditional 6 dB per S-unit approximation, this works out to 36 dB, which is very close to the modeled F/B of 39 dB at this height and frequency. Subsequent testing a few weeks later yielded several solid PSK contacts during the New England QSO Party.

All MoxBeams use a dielectric constant of 6 for the wire insulation in the *EZNEC* models with the exception of the 6 meter version. This version repeatedly came up with a 1 MHz lower measured resonant frequency than the models indicated. A quick search on the Internet revealed that the dielectric constant can even change with wire insulation color. An e-mail to (since deceased) L. B. Cebik, W4RNL, provided some much needed assistance with this mystery, for which I am grateful: "The most likely answer is that the insulation of the Home Depot wire is changing its dielectric properties in the upper HF range. PVC and other insulating plastics in the same general range often have additives to

improve their durability or some other property such as fire retardation, and these materials can alter the dielectric properties, especially in frequency regions that go untested, since they fall

outside the wire's intended use."

Although increasing the dielectric constant helped somewhat, I still couldn't get enough change to match the actual antenna. I ended up by leaving the dielectric constant at 6 and increasing the insulation thickness from 0.020 to 0.031 inches. The antenna (made with red insulation wire) was trimmed to the new dimensions and the resulting SWR curve was finally on target.

## Final Notes

The Moxon rectangle is a proven performer with decent gain and a great F/B ratio, and the 10 meter MoxBeam makes a terrific directional beam. If you are anxious and don't want to wait for the next solar cycle peak, you can get on the air now on any band from 6 through 20 meters using the techniques and information supplied in this article.

Ten meters is a fascinating band to work. At solar cycle peaks the band comes alive with extremely long distance signals that refract from the F2 layer. Even in times of solar minimum when F2 is rarely available, 10 meters still has some long-distance capabilities due to sporadic E propagation.<sup>6</sup> This small antenna will provide hours of fun, and, because it's portable, you can use it just about anywhere. If you make use of the latest rugged and weatherproof materials, the 10 meter MoxBeam will soon become one of your favorite antennas.

## Notes

<sup>1</sup>ARRL *Amateur Radio News*, "Backward sunspots may herald start of Solar Cycle 24," Aug 30, 2006; [www.arrl.org/?article=6730](http://www.arrl.org/?article=6730).

<sup>2</sup>L.B. Cebik, W4RNL (SK), "Moxon Rectangles"; [www.cebik.com/moxon/moxpage.html](http://www.cebik.com/moxon/moxpage.html).

<sup>3</sup>[www.arrl.org/files/qst-binaries](http://www.arrl.org/files/qst-binaries).

<sup>4</sup>"Trex Traditional Railing," Trex Company (available at Home Depot); [www.trex.com](http://www.trex.com).

<sup>5</sup>Several versions of *EZNEC* antenna modeling software are available from developer Roy Lewallen, W7EL, at [www.ez nec.com](http://www.ez nec.com).

<sup>6</sup>[en.wikipedia.org/wiki/10\\_meters](http://en.wikipedia.org/wiki/10_meters)

*Photos by the author.*

ARRL member and General class licensee Allen Baker, KG4JJH, received his license in 2000, fulfilling a lifelong dream of becoming a ham. He holds a BS in Industrial Engineering from Tennessee Tech and works as an Instrumentation and Controls Engineer for the company that operates the US Department of Energy weapons plant in Oak Ridge, Tennessee. Allen is active on SSB and in digital modes, enjoys the challenge of working low power (QRP) and loves to experiment with antennas and radio gear. He can be reached at 211 Brochardt Blvd, Knoxville, TN 37934 or at [kg4jjh@arrl.net](mailto:kg4jjh@arrl.net). **QST**

Figure 5 (right) — Close-up view of one of the corner clamps.

Figure 6 (below) — The center insulator and coax fitting adapted from a Budwig antenna insulator.

