TECHNOLOGY SPECIAL

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COMMUNICATIONS & TECHNOLOGY

DECEMBER 2020

Wishing You a Happy and Healthy Holiday Season!

CONTENTS

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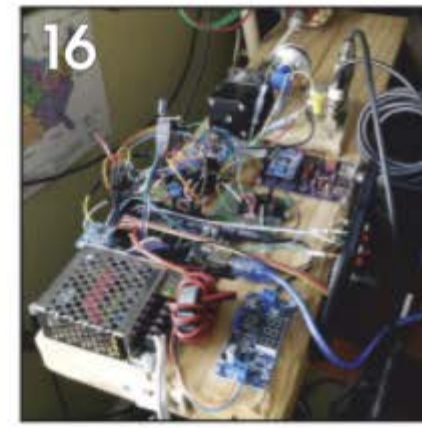
COVER: SEASON'S GREETING FROM *CQ*!

CQ sends its best wishes for a happy and healthy holiday season and new year, especially after this year. We hope the holiday scene on our cover gets you ready for the night St. Nick slips down the chimney and gives you wonderful electronic delights that will keep you busy all year round. Whether it is a new radio, accessory, antenna, or a subscription to your favorite ham radio magazine (hint, hint!), we wish each and every one of you a great, healthy and prosperous new year.



FEATURES

TECHNOLOGY SPECIAL: Ham radio has driven technological innovation for over a century thanks to tinkerers searching for a new way to get their signals out farther. This month, *CQ* shines a spotlight on innovations in antennas and antenna accessories. You can read all about it on pages 10, 12, 16, 25, 28, 39, 44, 64, 68, and 87.

COLUMNS

DEPARTMENTS

Technology Special:

Here's a low-profile 5-band antenna for 20-10 meters that is fed with a single feedline and requires no tuner, built around a commercially-available 20-meter vertical.

The Texas Star Multi-Band Antenna

Five Bands, One Feedline, No Tuner

BY GENE HINKLE,* K5PA

The Texas Star 5-band vertical antenna (*Photo A*) was designed to provide a 20- to 10-meter band antenna with the following goals:

1) Coverage of 20, 17, 15, 12, and10 meters without the need for an antenna tuner
2) Stealthy profile that blended into surrounding areas
3) Easy setup without the need to climb any structures
4) Efficient design, and
5) Built from readily available parts

The 5-band antenna was built upon the COMTEK COM-20VA vertical antenna for the 20-meter band (available from DX Engineering). By starting with a base design that was strong structurally, additional cross-arms were added at the upper and lower portion of the antenna. These provided a mechanical structure that could support wire elements cut to the other four bands. The cross-arms gave an appearance of a star, thus providing the name, the Texas Star. Although the COMTEK antenna was used in the base design, equivalent parts could be substituted. The full materials list is provided in *Sidebar 1*.

Since the antenna was a vertical with four additional elements, it was essential to add radials at the base of the vertical support to provide an efficient ground system. Twenty (20) wires, each 20 feet long, were added to the base of the antenna. The number and length of the wires were sufficient to provide a good ground system for efficient operation. During modeling, I studied using 16, 32, and 64 radials but found 20 to be a good compromise.

Design

The antenna was modeled using EZNEC[1] and AutoEZ[2] antenna design software. First, the antenna was modeled as a 20-meter vertical with ground radials. The standard formula for a quarter-wave vertical was used as a starting point for the lengths, 234/f, where f is the frequency in MHz. For a frequency of 14.2 MHz, this equated to a length of about 16.5 feet.

Once the vertical element and ground wires were modeled, the antenna exhibited the impedance and pattern expected of a vertical.

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Photo A. The Texas Star is a 5-band vertical that requires no tuner and has a single feedline. The central antenna element (a COMTEK COM-20VA 20-meter vertical) supports two sets of cross-arms for additional band elements. (All photos and drawings courtesy of the author)

Next, single wire elements were added around the vertical antenna support to provide coverage for the 17-, 15-, 12-, and 10-meter bands (*Photo B*). Each element was offset from the center element by 12 inches. It was expected that with the added vertical elements and the dual, 24-inch cross-arms, the overall length would have to be adjusted to maintain the desired impedance and VSWR.

Figure 1 shows the model for the antenna with the central 20-meter element and the four surrounding elements. The ground radials can be clearly seen under the vertical elements.

Frequency sweeps of the antenna model provided both VSWR graphs and antenna patterns. The VSWR plot is shown in *Figure 2*. The measurements were taken 3 feet from the base of the antenna. The VSWR would be less at the far end of the coax connecting to the station due to line losses. The element interactions resulted in small length changes from that of a single vertical element.

The plots suggested the element lengths were slightly short and should be adjusted a few inches to obtain a minimum VSWR in the center of each band. After building the antenna and adjusting these elements, the optimum lengths were found to put the VSWR within the desired range. This demonstrated the need to use slightly longer elements so they could be adjusted to bring the VSWR of each band into the required frequency range. I will describe my wire fold-back technique in the antenna adjustment section.

Materials List - The Texas Star HF Antenna

Line #	Part No.	Description	Qty Needed	Where Used
1	COMTEK 20VA or Equiv., DXE P/N COM-20VA, See Note 1	Complete 20-meter vertical antenna kit with base plate attachment to a galvanized pipe	1	20-meter vertical kit with mounting plate
2	Local Hardware Store	Channel aluminum, 48" x1" x1" (cut each in half to make 2)	2	Cross arms mounting to vertical
3	DXE-SAD-100A	Saddle clamp, 1-inch U-Bolt, 1/4-20 inch thread, stainless steel / aluminum, natural	2	Used to secure cross-arms to vertical 1-inch O.D. tubes
4	DXE-SAD-075A	Saddle clamp, 3/4 inch U-Bolt, 1/4-20 inch thread, stainless steel / aluminum, natural	n2	Used to secure cross-arms to vertical 0.75-inch O.D. tubes
5	DXE-RADW-500	Element wire using: radial wire, 14 AWG stranded copper, UV-resistant black PVC insulation, 500-foot length. Need 58 feet long for 4 elements.	58 feet	Wire for each of 4 elements
		Radial wire, 14 AWG stranded copper, UV-resistant black PVC insulation, 500-foot length. Need 20-foot length X20 = 400 feet	400 feet	Wire for 20 radial wires
6	The Wireman #815	3/32" UV-resistant Dacron® double weave rope. 260-pound break strength.	100	Need additional amount during antenna tuning to raise and lower elements.
7	MFJ-16A06 or equiv.	Egg insulator for vertical elements	4	Insulators for each of 4 elements
8	DXE-RADP-3	Radial plate, stainless steel, 1/8 x 11-5/8 inch square, pre-drilled, 60 holes, includes 20 sets SS hdwr.	1	Radial plate
9	Local Hardware Store	Misc., tie wraps (UV resistant), solder lugs, electrical tape, flat black paint, etc.	1	Misc. hardware
10	Local Hardware Store	Vertical support, galvanized pipe 1-1/2 feet x 48 inches	1	Mounting pole
11	Local Hardware Store	Concrete for base, 1 bag	1	Secure mounting pole in ground

Note 1: The COMTEK COM-20VA full parts list is available from the DX Engineering website.
Note 2: All DXE part numbers can be located on the DX Engineering website.

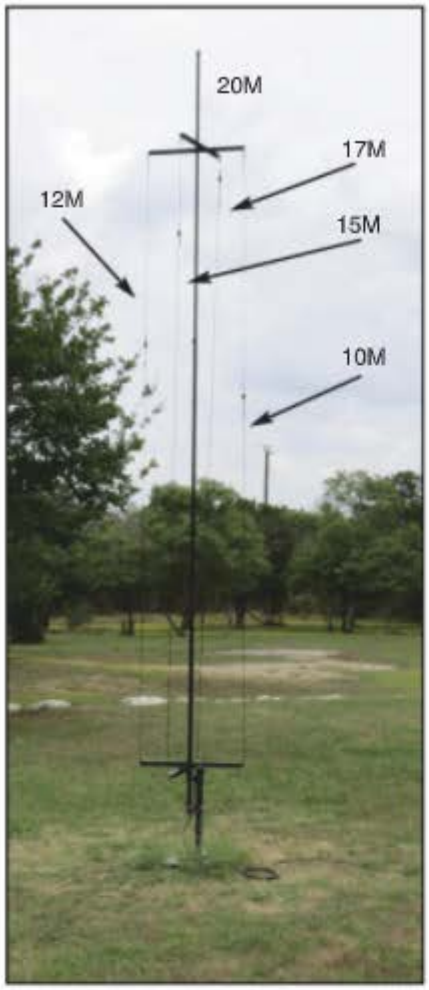


Photo B. After the cross-arms have been attached, wires cut to each additional band are installed between the top and bottom cross-arms.

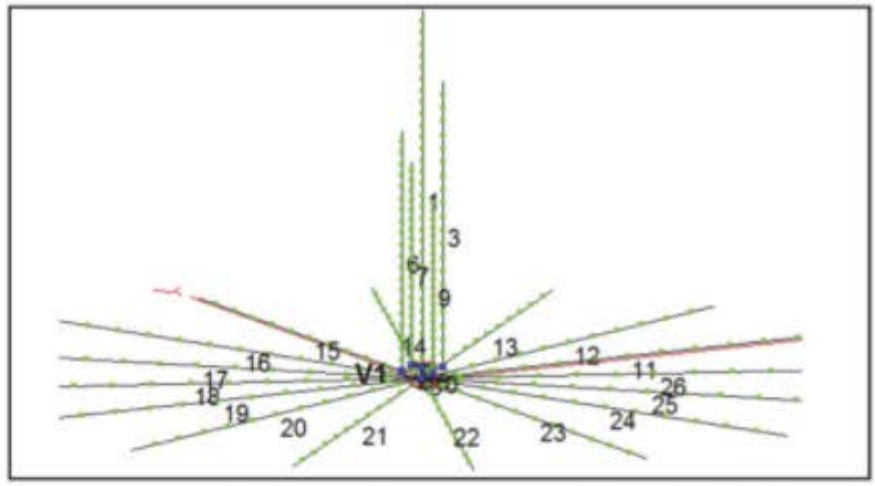


Figure 1. EZNEC Model of the Antenna Elements.

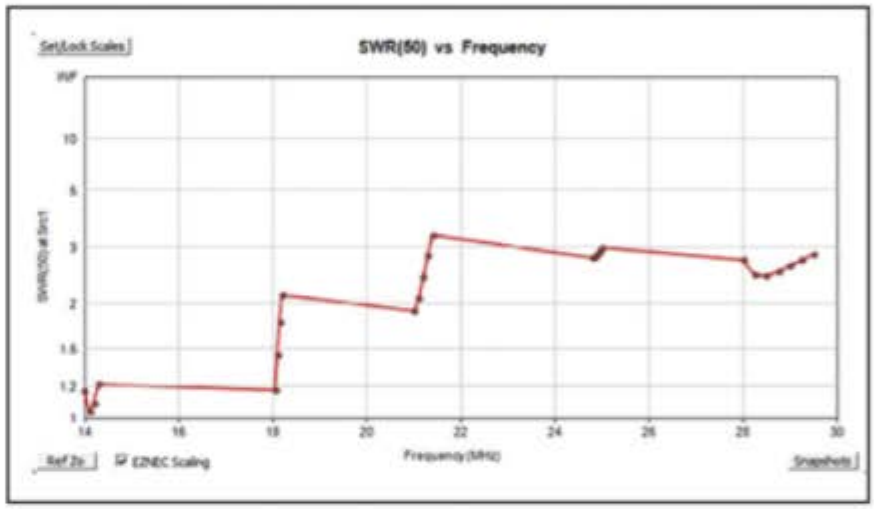


Figure 2. EZNEC model VSWR plots across all five bands at the antenna base prior to tuning.

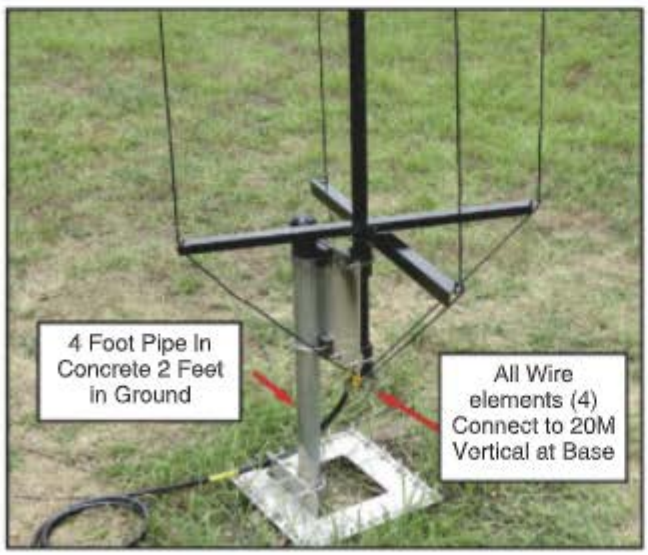


Photo C. Base connections of four wire elements to the central 20-meter element, which is mounted to a pole cemented into the ground.

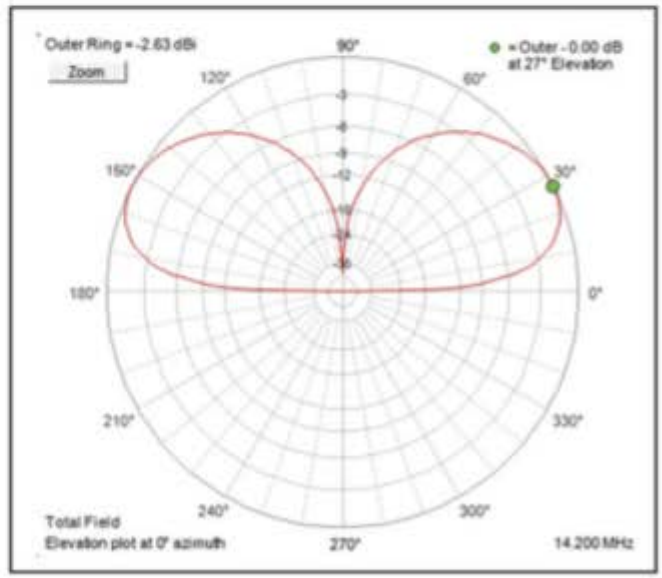
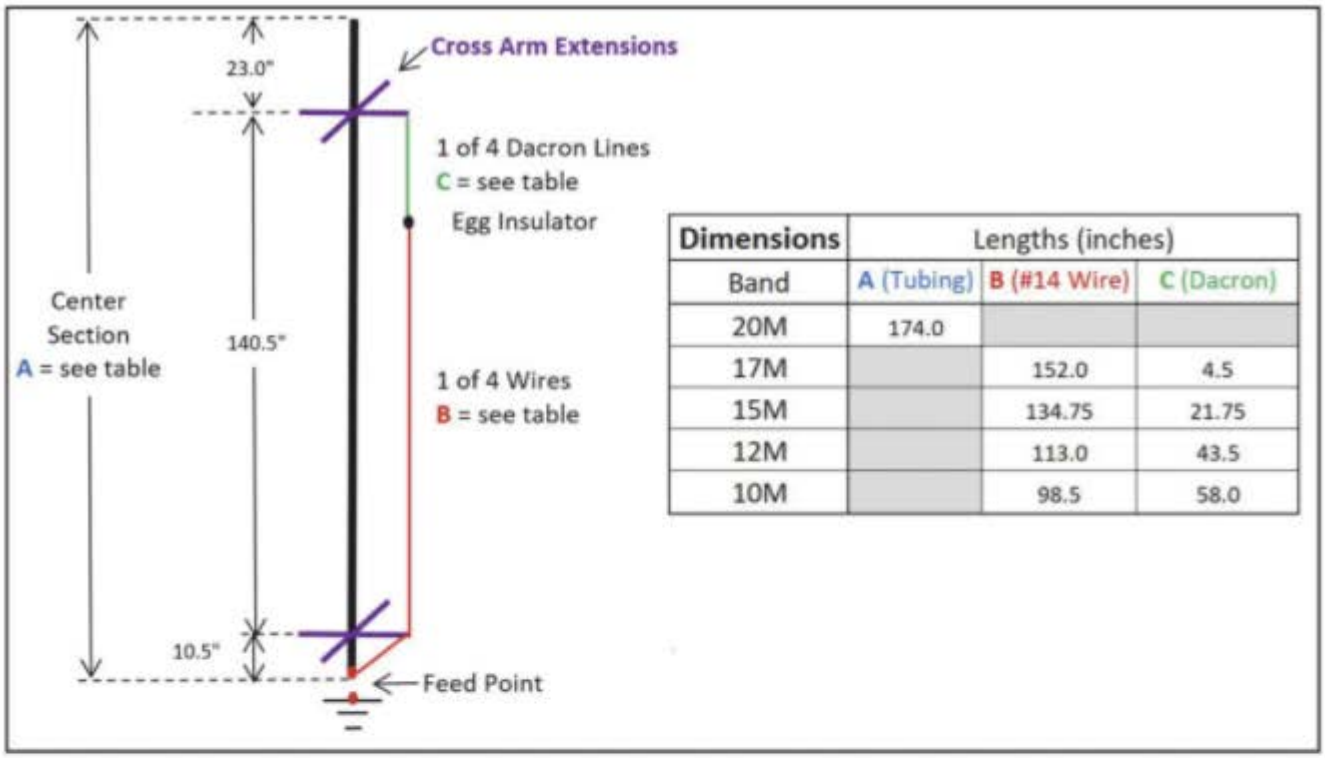


Figure 3. Typical EZNEC elevation plot for the 20-meter band.



Dimensions	Lengths (inches)		
Band	A (Tubing)	B (#14 Wire)	C (Dacron)
20M	174.0		
17M		152.0	4.5
15M		134.75	21.75
12M		113.0	43.5
10M		98.5	58.0

Figure 4. Dimensions for the 20-meter element and 17-, 15-, 12-, and 10-meter elements.

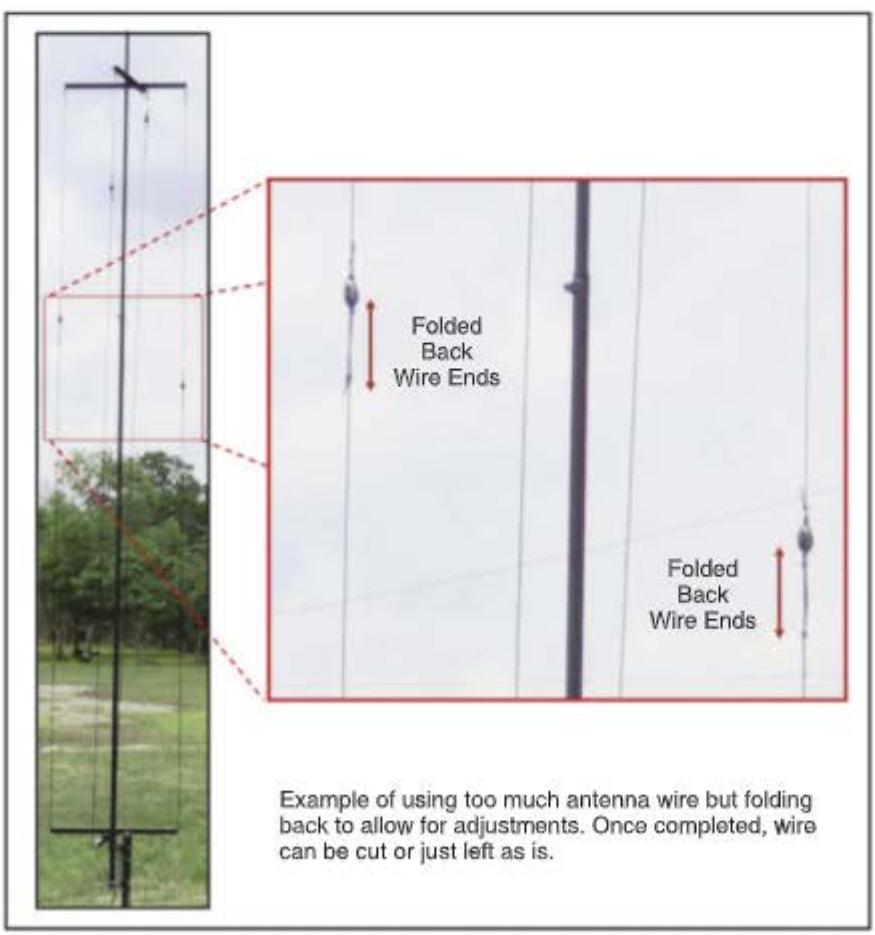


Figure 5. Wire fold-back technique used during tuning.

The pattern for the 20-meter band is shown in *Figure 3*. Using the modeling software, all azimuth and elevation patterns across all bands were obtained. There were some minor effects of element interactions between bands resulting in slight changes to the pattern at the higher bands.

Antenna Drawings

After I modeled the design and verified performance, an initial set of dimensions were derived as a starting point to build the antenna. To simplify the mechanical drawing, I drew a single element hanging from the cross-arms. Each arm was 24 inches in length, center-mounted to the central vertical section using a special "saddle clamp." An antenna dimension table was then used to record the lengths of each elomont. The dimensions included the central 20-meter element, the wire lengths, and Dacron® cord on a band-by-band basis are shown in *Figure 4*. The table lists my final lengths. When building this antenna, the lengths should be increased by 12 inches so the elements can be tuned to frequency by trimming the length. It is always easier to trim the length than to replace the whole element.

List of Materials (see Sidebar)

The detailed list of materials is included in the sidebar. Many of the items can

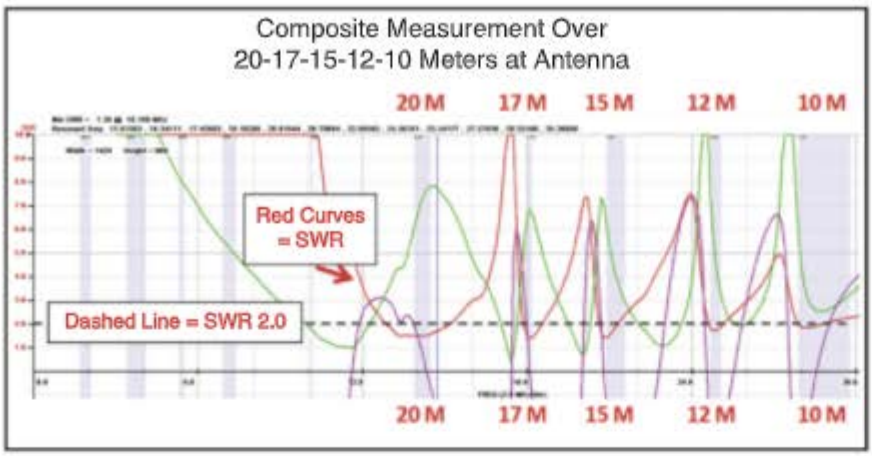


Figure 6. Impedance (green) and VSWR (red) measurements of the completed antenna.

be conveniently purchased through DX Engineering as their part numbers are included (e.g., COM-20VA). However, there are many sources for these materials including the amateur junk box. The DXE part numbers are provided to document the specifications for this design.

I should emphasize the importance of using the part numbers for the saddle clamps listed in the materials list (P/N DXE-SAD-100A and DXE-SAD-075A). These saddle clamps were enablers in the design because they provided the mechanical attachment of the cross-arms (L-brackets) to the upper and lower (1-inch and 0.75-inch O.D.) central vertical antenna tubes. These saddle clamps were critical for allowing the correct amount of force to be exerted around the tube without crushing it. Do not substitute these clamps unless you can guarantee similar attributes (precision and even force) around the tubes. If a non-compliant clamp was used and it crushed the outside diameter of the tubing, the tubing might fail during windy conditions.

I also used four ceramic egg insulators, one at the top of each vertical element, to attach to the Dacron cord that hangs from the upper cross-arms. Ceramic glass, egg insulators were specified to reduce the chance of an insulator breaking and causing the wire element to fall to the ground. Since the upper vertical elements are at a high impedance point, there will be high voltage if moderate RF power is delivered to the antenna. I used a ceramic glass insulator for that reason.

I also used flat black spray paint to coat the aluminum vertical tubing and the cross-arms. I found that, when viewed from afar, the flat black color keeps the antenna very stealthy. Alternately, camouflage spray paint may be available from your local hardware store.

Antenna Adjustments and Measurements

An antenna analyzer, AIM 4170D, was used to measure antenna impedance across the 20- to 10-meter bands. All measurements were made 3 feet from the antenna's base.

Figure 5 shows the antenna wire fold-back technique used for tuning the wire elements. The 20-meter band vertical center tube section was first adjusted for length to obtain a minimum VSWR at mid-band, 14.2 MHz. Next, the 17-meter wire length was adjusted, then 15-meter, 12-meter, and finally the 10-meter-band element. Since the wires were folded back, it was possible to repeat this process in each band, making minor length adjustments, with the goal of minimum VSWR.

The composite sweep across the HF spectrum is shown *Figure 6*. The 20-, 17-, 15-, 12-, and 10-meter bands are highlighted with the goal of less than 2:1 VSWR on all bands. The VSWR measurements were made at the base of the vertical; additional line losses from the antenna to the transmitter will lower the VSWR measured in actual use.

Making the Connections

Photo B shows the cross-arms that were physically attached to the 20-meter radiator element. That meant they were part of this element that resulted in slight shortening of the antenna. The lower cross-arms were at the current maxima of the vertical so higher current flowed through them. Whereas the upper cross-arms were at voltage maxima. Therefore, ceramic egg insulators were used as part of the upper structure.

Photo C shows how all the outer elements for 17-10 meters were attached to the base of the 20-meter vertical. All elements are driven by the transmitter in parallel. Also shown is the base plate mount to the galvanized pipe and the radial plate for attaching the ground radial wires.

Summary

All of the design criteria cited at the beginning of this article were met. The antenna is a joy to use. I integrated the antenna into a remote radio application that used the no-tuner requirement to simplify the system design that provided safe operation for multiple users. In addition, since the radiation patterns favored low angle-of-arrival signals, the antenna provided good DX performance.

The AutoEZ file for the antenna model is available on the author's website.[1] The filename is: "Texas Star 20-10 Meter 5-Band Vertical K5PA Hinkle.weq".

References:
1. <www.k5pa.com>
2. <https://eznec.com>
3. <https://ac6la.com/autoez.html>