The Half Square Antenna

BY BEN VESTER,* K3BC

WITH THE sunspot cycle on a downtrend, and the 5-band DXCC award as bait, considerable interest has arisen in DX and antennas for the lower frequency ham bands. My attempts to get a decent 80-meter DX antenna have gone through an evolutionary cycle with a lot of iterative tries and with steadily improving results. The half-square antenna that is the latest of these has some interesting properties and gives about as many "dBs per buck" as any I've seen.

Before describing this configuration, it might be interesting to cover briefly the different antennas tried which didn't work as well. My available options were set up by (1) a yard full of tall trees and (2) very little money to spend. The first antenna was an inverted V hung on the 75-foot tower (23 m). This is really a quite good antenna – primarily because it has the high current part of the antenna at the highest support point. It provided a standard against which all succeeding antennas were checked. The next step was to add a parasitic element (director) which didn't seem to help at all. This is perhaps not so surprising with the ground so close. Viewed simply, normal parasitic coupling is dependent upon a fair proportion of the current in the driven element being coupled to the parasitic element. When they are both close to the ground, the reverse polarity of the image of the driven element starts to couple heavily to both the driven element and the parasitic element, making it practically impossible to get the desired parasitic current at any useful spacings.

This effect has been shown experimentally to be less with closed-loop type antennas such as the quad. Based on this supposition, I next constructed a 2-element quad, supported at the corners by ropes tied off to trees. With only 75-foot trees and the consequent sag, the bottom was only about 6 feet (2 m) off the ground. However, the quad did work, had an acceptable feedpoint impedance, and gave a few dB (about 1/2 an S unit) improvement over the inverted V on European contacts. Obviously, the only useful low-angle radiation in this antenna came from the upper half of it, the lower half serving to feed or excite the upper half. A major problem with the quad was keeping it up. It had to be very tightly stretched between trees to keep it from sagging to the ground and as a result the wire often broke.

To try another tack which would avoid the parasitic coupling problem, I tried an 8JK array with four half-wave elements, all elements being fed. With the span of this being so long and with lots of high-voltage points which had to be kept from touching the trees, I only managed to get it to a height of about 40 feet (12 m). The signal-report results with this were essentially identical to the quad on the path to Europe. The horizontal beamwidth was noticeably less than the quad. It probably would have done better if I could have gotten it to 75 or 80 feet in height.

The next antenna tried was the so-called bobtail which is shown in Fig. 1. This is a broadside vertical array with approximately twice the current in the center leg as the two outer legs and with current distribution in the horizontal wires which tend to cancel horizontally polarized emission.[1] A major reason for trying this was my frustration with trying to use the maximum available height of the trees and still be able to feed the antenna and keep the high-voltage points clear of the tree branches. I had avoided vertical antennas before

* 4921 Bonnie Branch Road, Ellicott City, MD 21043.

[1] [EDITOR'S NOTE: While complete cancellation of the horizontally polarized component occurs at a point broadside to the array, some radiation from the flat-top portion will exist at other angles. This is because of incomplete cancellation of the components from the opposite ends of the flat top.]

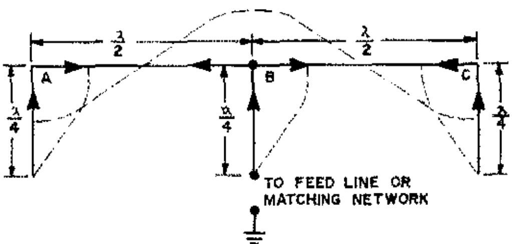
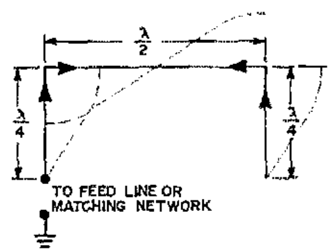


Fig. 1 — Bobtail array. The dotted lines show the approximate current distribution along the antenna and the arrows indicate the relative directions. With this array, the high-current points occur at the highest points on the antenna.

Fig. 2 — The "half-square" evolved when one leg broke off the bobtail. The input impedance of both the bobtail and half-square antenna is very high, which eliminates the need for an elaborate ground system at the feed point. Either a parallel-tuned circuit or a quarter-wave transformer can be used to match to a 50-ohm feed line.



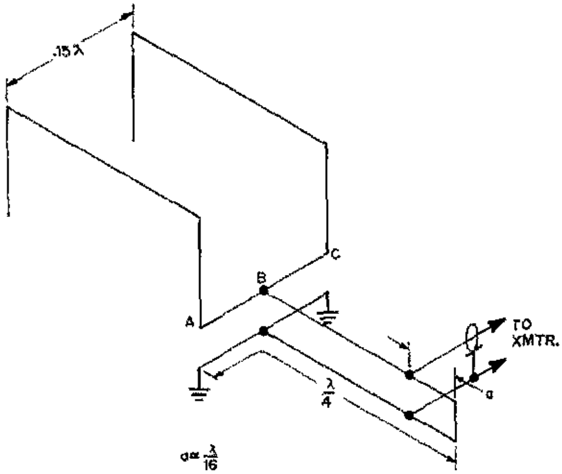


Fig. 3 — Two-element half square array gives greater gain and a very wide bandwidth.

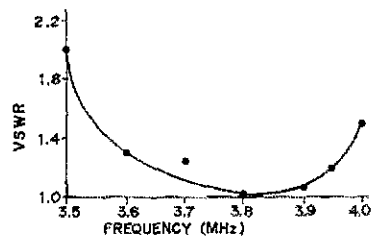


Fig. 4 — Measured SWR of the antenna shown in Fig. 3.

because of the difficulty in getting a good low-loss ground. Also, the trees looked like great vertically polarized rf energy eaters. The bobtail is particularly nice for tree hanging since its highest support points (A, B, and C in Fig. 1) are all at low impedance and looked as if they could be directly slung over a tree limb with no insulators. It is fed from the bottom at a high-impedance point so the ground system doesn't need to be as good as it does with low-impedance feedpoints. Also, like the inverted V, the bobtail has its maximum current at the highest support point. It can be excited from a parallel-resonant tank circuit or a quarter-wavelength stub.

The bobtail has been an outstanding performer for me. It's at least an S unit better than the inverted V and works great on DX paths to the Far East (JA, KG6, and VS6). I put up two of these at right angles and found their interaction to be practically nil even though their center legs are quite close. When switching, I ground the feed point of the one not in use.

The Half-Square Antenna

With such fine results, I thought I had the ultimate "tree-hung" antenna. However, after a particularly bad storm, I noticed that one leg of

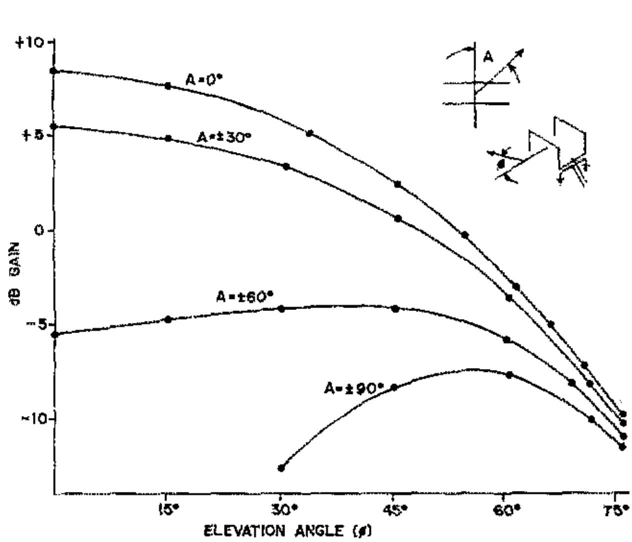


Fig. 5 — Computer-pattern plot for a two-element half square array with 0.15-wavelength spacing between elements. The angles referred to in the drawing are shown in the inset.

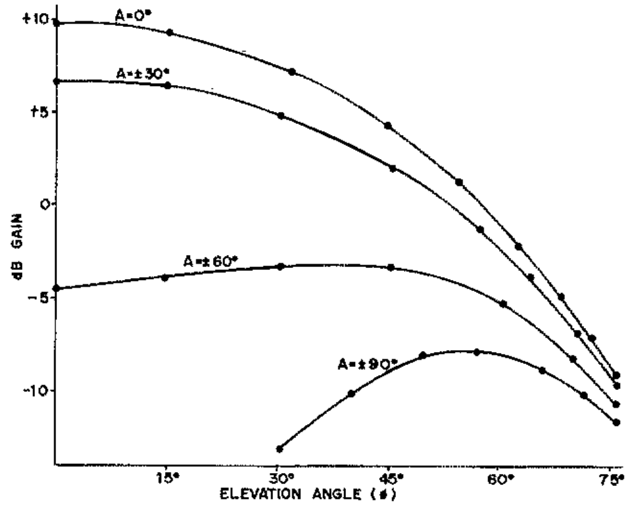


Fig. 6 – Computer-pattern plot for the antenna of Fig. 5 with 0.25-wavelength spacing.

the bobtail had broken off and yet the antenna feed impedance hadn't changed noticeably. Furthermore, the results compared with the inverted V seemed about the same as the full bobtail. Fig. 2 shows the configuration. It is a two-element (instead of 3) vertical broadside array with the same current in both legs. It has all the advantages of the bobtail except that the radiation from the horizontal part of the antenna doesn't cancel as well in all directions and some end-fire, horizontally polarized energy does spill off. This might be considered an advantage or a disadvantage, depending on whether you're seeking coverage or discrimination! In discussing this with Ed Watters, WA3LGX, he pointed out the kinship this antenna has with the bisquare array. It's sort of half of a bisquare laid sideways with the ground image antenna making up the other half. That, plus it's obvious shape, led me to dub it the half-square antenna.

After using a single half-square for awhile, I decided to add another element with about 0.15-wavelength spacing. With the new element in place, I made a check to see what parasitic coupling there might be between elements. With several hundred watts fed into the driven element there was no evidence of rf on the parasitic element (using a neon bulb). This was a very gross measurement which tended to confirm what was expected; the very close proximity of the antenna to ground tends to reduce greatly parasitic coupling to a nearby element. I hope to devise a means of measuring this coupling more accurately since I'm still puzzled that it should appear so small.

Having had to tear down the 8JK antenna to get enough wire for this antenna, as a first try for feeding it I just used the 8JK open-wire line and stub match as it existed. The one wavelength of wire for each element was taken directly from the 8JK also. Fig. 3 shows the configuration. Unlike the 8JK, which was narrowband (centered around the middle of the band), this configuration gave the very flat SWR shown in Fig. 4 – on the first try! The SWR was not very different whether the feed-line stub was connected to point A, B, or C (Fig. 3). B gives a bidirectional characteristic while connection to A or C gives some unidirectivity. I'm still suspicious of the wide bandwidth and suspect the two elements may be different effective lengths, giving a stagger-tuned effect. If the spacing between these two were increased to a quarter wave and fed at point A or point C, it should theoretically add another couple of dB gain and give a more significant front-to-back ratio than with the 0.15-wavelength spacing. WA3LGX plugged the dimensions and shape of this antenna into a generalized computer program he has developed for wire antennas and got the curves shown in Figs. 5 and 6. Fig. 5 defines the forward pattern for 0.15-wavelength spacing assuming a perfectly conducting earth. Fig. 6 is for quarter-wave spacing. The actual patterns will be modified at angles below 10° to 15° by the earth's resistivity[2] as is the case with any vertical antenna. The 0.15-wavelength spaced antenna was used for some time and consistently gave better results than the bobtail on the path to Europe.

I've taken one other step beyond the 2-element array and added another element at 1/8-wavelength spacing (see Fig. 7). The extra element is fed, like the other two, with an extension of the same open wire line. This antenna is considerably quieter (less QRN) than any of the other 80-meter antennas I have and has better than 1/2 an S unit advantage over the bobtail on European signals. It doesn't require any retuning to cover the whole band.

With these antennas not insulated at their support points, one might expect some effects when the tree sap rises or in wet conditions. I haven't been able to notice any differences from dry weather to monsoon-type rains or wet snow covering everything. The trees are slightly over 1/4-wavelength high on 80 meters. Considered as

[2] *The ARRL Antenna Book*, 12th edition, p. 46.

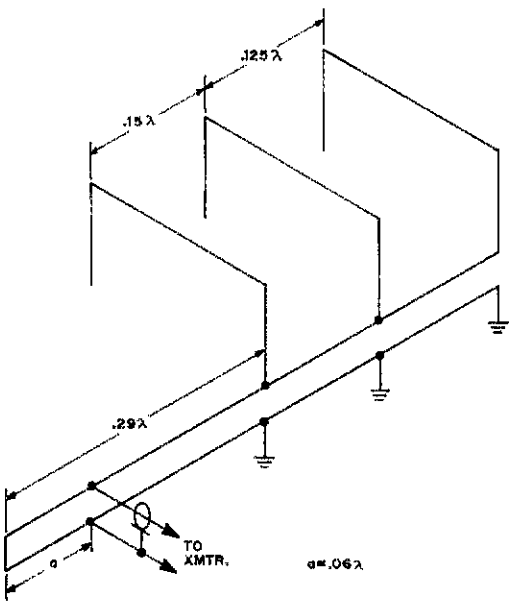


Fig. 7 — A three-element half-square array.

antennas or absorbers, they would look like grounded 1/4-wavelength vertical radiators. The vertical sections of the half-square antenna that run close to the trees are just the opposite. That is, at the bottom of the antenna the voltage is high and at the top, the voltage is low. This should minimize coupling to the trees, as opposed to, for example, using 1/4-wavelength grounded verticals for the antenna elements.

160-Meter Operation

Now if you look closely, you can see that the 80-meter half-square whether 1, 2 or 3 elements, should make a good antenna for 160 meters. Each element is 1/2-wavelength long on 160 meters, voltage fed on the end, and the high current part of the antenna is at the maximum height. True, a higher impedance part of the antenna touches the tree, but you can't have everything free! While I haven't managed to work any DX with the few watts I have available on 160 meters, I can *hear*

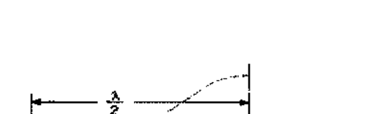


Fig. 8 — Any of the antennas mentioned can be bent as shown in order to keep the current loops at the upper corners.

Central European ham stations quite well on this band for the first time ever at this location. Of course, a different stub or tuning arrangement is necessary for getting a low SWR on 160 meters. I just unshorted the stub and put a tapped coil (about 14 microhenries) in series with the coax feed line to tune it.

Construction Details

These antennas were all built with No. 14 soft-drawn copper wire. The elements are pulled over the top limbs of trees that have approximately the correct spacing and tied to nylon strings at about shoulder level. If your trees aren't a full quarter wave high, the extra wire can be stretched out parallel to the ground at each end as shown in Fig. 8. Note that you still get the maximum current point at the highest support point you have.

The best technique I've found for getting a line over the highest tree is to use a fisherman's casting reel (I use a Zebco 202) with an 8-pound nylon line and a 1- or 1-1/2-ounce sinker. The reel is put in the RELEASE position and a sling shot is used to shoot the sinker and line over the desired tree. This is a very accurate technique and you can easily put a line over 90-foot trees. The light fishing line is used to pull over a heavier line. It's a good idea to paint the sinker a bright color since the line is almost invisible. You can waste a lot of time looking for the sinker at the end of the line.

Be sure to leave enough droop in the horizontal section of the antenna to allow for tree motion in high winds. The open-wire feed line used for the harness and stub sections is made with the same No. 14 wire spaced 3-1/2 inches (9 cm).

I think the avid Field Day or camping fan will notice the obvious advantages of the half-square antenna for that type of operation. It uses minimum materials, goes up very quickly, will really put out a booming signal on 80 meters, and can be taken down in just a few minutes. You can also make good use of the fishing rod in between your turns at the key. QST

It Seems . . .

(Continued from page 9)

of both Canadian and U.S. members, some $4,500 for operation of the Region II organization. Other societies in this hemisphere contribute also, though not anywhere near the same amount (because of the considerably smaller number of members). The funds are used for administrative costs of bulletins, secretarial service, etc., and for travel of members of the Executive Committee to annual meetings. The purpose remains closer liaison between our organized groups for a stronger amateur radio — one better able not only to retain our bands at future frequency conferences, but enhancing the likelihood of some additional hf space to provide for growth. Your support of ARRL, therefore, is truly support of amateur radio worldwide.