Antennas with Gain and Bandwidth for 80 and 160 Meters

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On 80 and 160 meters an antenna with even modest gain can give you a very real edge in a contest. Unfortunately, the long wavelength (λ/4 is 70 feet at 3.510 MHz and 134 feet at 1.83 MHz) associated with these bands makes gain antennas very large.

An additional problem is the width of the 80-meter band. It's tough to design an efficient antenna that will work over more than a small portion of the band without retuning. Phased arrays of λ/4 verticals work great but require a great deal of effort, real estate and money to bring on line.

For most of us simple wire arrays, such as the half-square and bobtail curtain, are more practical. When compared to a ground-plane antenna over average ground they have gains of 2.1 dB and 4.6 dB respectively. While useful, both of these arrays have quite narrow SWR bandwidths, typically <100 kHz for SWR <2:1 on 80 meters. While it is possible to make these antennas resonant at multiple points within a band,[1] the SWR between these points will still be high. Various schemes for switching in and out tuner components have also been used. It would be better if we could keep the antenna really simple and still have the gain and bandwidth. Another problem with the bobtail curtain is that it is a full wavelength wide (approximately 280 feet on 80 meters), limiting its use to those with large lots.

The Bruce Array

There is another simple array that has been mostly forgotten by hams. The Bruce array has been around since the '20s.[2-6] This antenna has appeared in the *ARRL Antenna Book* since the first edition in 1939, but the section on the Bruce array has been abbreviated over time leaving out a number of interesting ideas.

A few variations of the Bruce array are shown in **Figure 1**. It is simply a wire one or more wavelengths long, folded so that the currents in the vertical portions are in phase, contributing to radiation and currents in the horizontal portions that tend to cancel. Note that the wire lengths of each side of the squares are 1.05 × λ/4. The square loops in the Bruce behave very much like quad loops—they also have to be made longer for resonance. This is a bi-directional broadside vertical array with all the elements in phase with more or less equal currents. This antenna offers a number of advantages:

- It is only λ/4 high.
- The size can be adjusted to fit the space available.
- It provides substantially greater SWR bandwidth than either the half-square or the bobtail curtain.
- It can be fed at several different points to suit a given installation.
- No ground system is required.

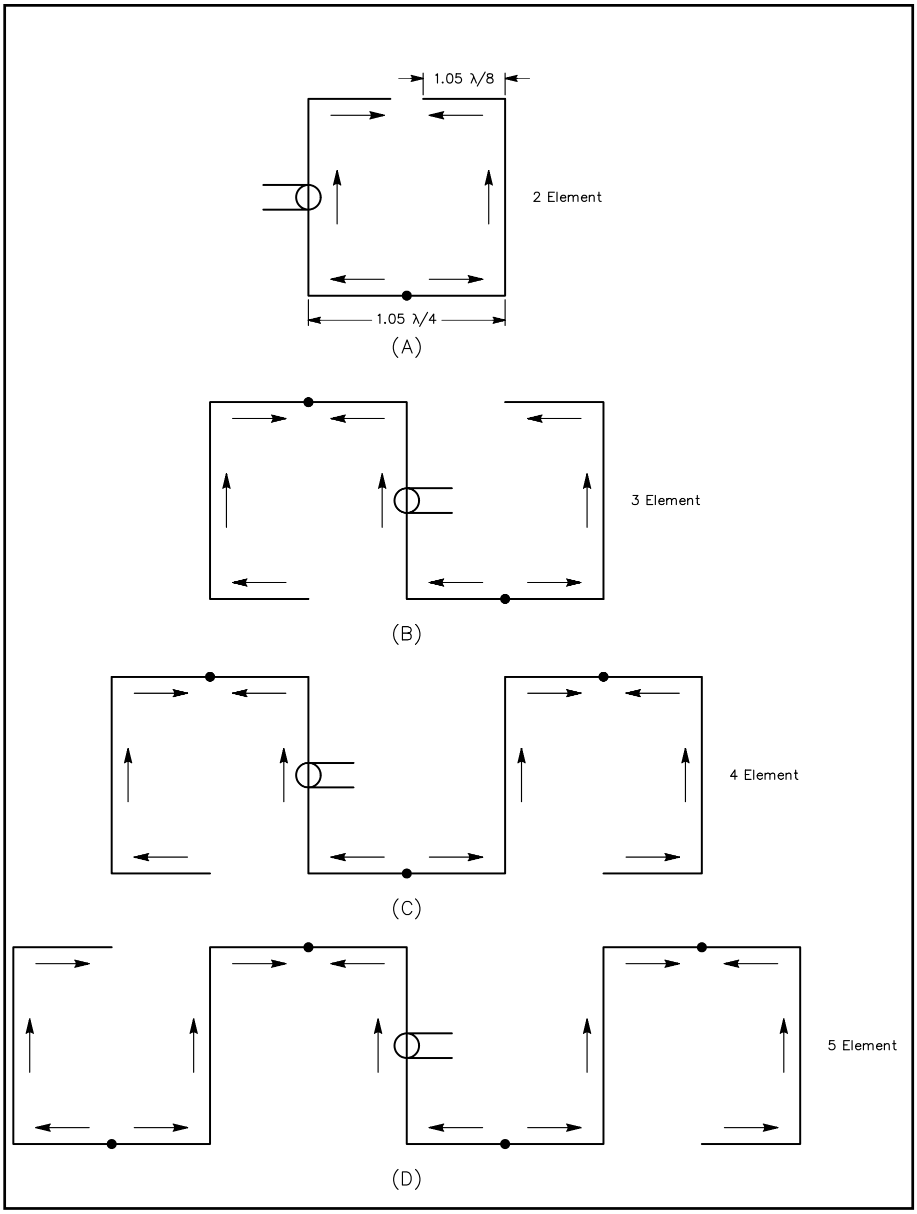

Figure 1—Bruce arrays with 2 to 5 elements. The feed points are nominal. See the text for other feed arrangements.

One comment on ground system requirements. Half-squares, bobtail curtains, Bruce arrays and other nominally ground-independent vertical antennas can all be operated without the usual ground system associated with single verticals. That is not to imply that an extensive ground system under these antennas would not reduce ground losses to at least some degree. As I show later (in **Figure 7**) an extensive ground system can be employed under

[1]Notes appear on page 52.

the Bruce array if you have the space and patience to install one.

Figure 2 is an overlay of the free-space patterns for 2-, 3-, 4- and 5-element Bruce arrays. As you would expect, the wider the array the greater the gain. **Figure 3** shows a pattern comparison between a 4-element Bruce ($^3/_4$-λ wide) and a 3-element Bobtail curtain (1-λ wide). The Bruce has just as much gain but is a full λ/4 shorter (130 feet on 160-meters!).

As you make the Bruce wider (adding more elements) the gain increases, the pattern narrows and side lobes begin to appear. In general more than five elements are not worth the trouble—the pattern is already narrow and the sidelobes are starting to become significant. If you really want even more gain (approximately 3 dB), hang a Bruce reflector about λ/8 behind the main array. Alternatively you could space the second Bruce λ/4 away and drive it with a 90° phase shift. This would produce a unidirectional pattern that could be switched 180°. Of course this is getting away from the idea of

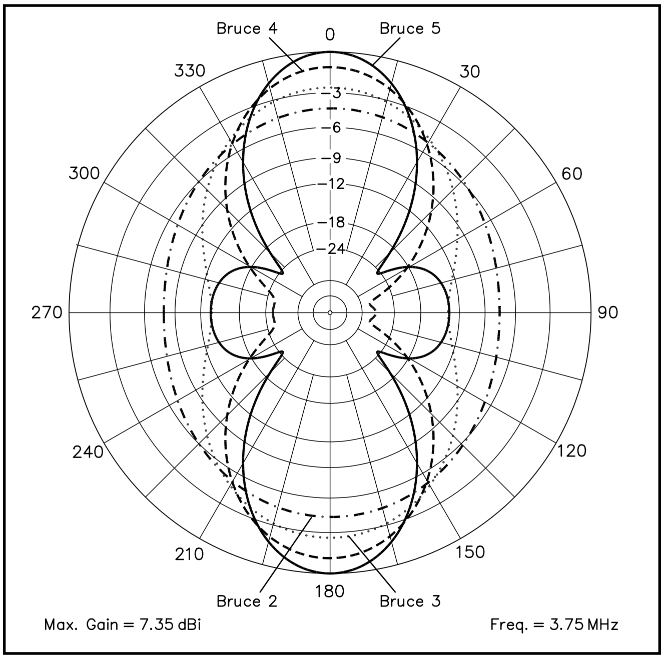

Figure 2—Comparison of free-space radiation patterns for 2 through 5 elements.

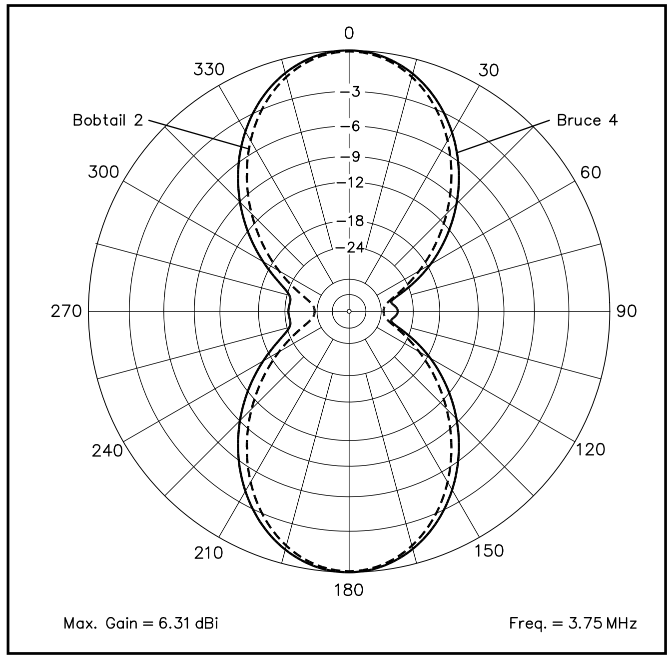

Figure 3—Comparison of free-space radiation patterns between a 4-element Bruce array and a bobtail curtain array.

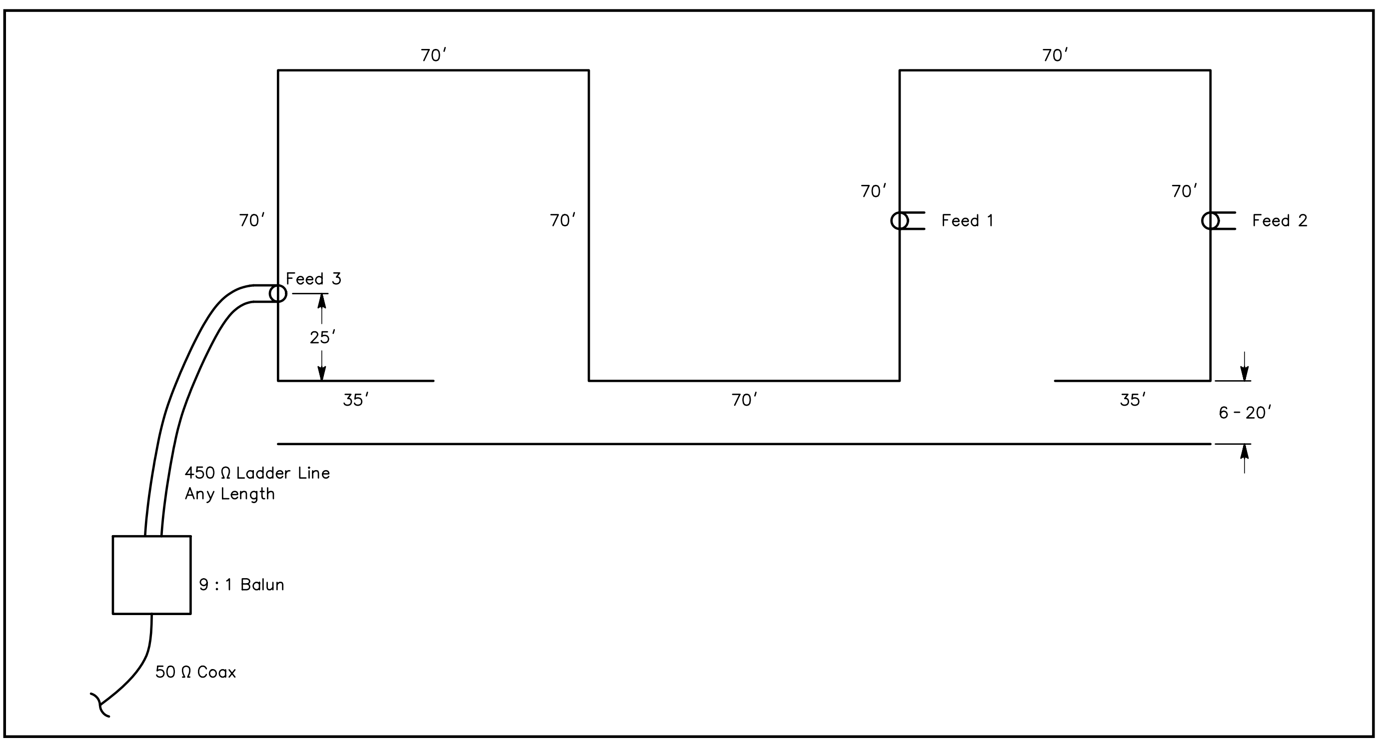

Figure 4—The 80-meter Bruce array employed at N6LF. Alternate feed points are indicated.

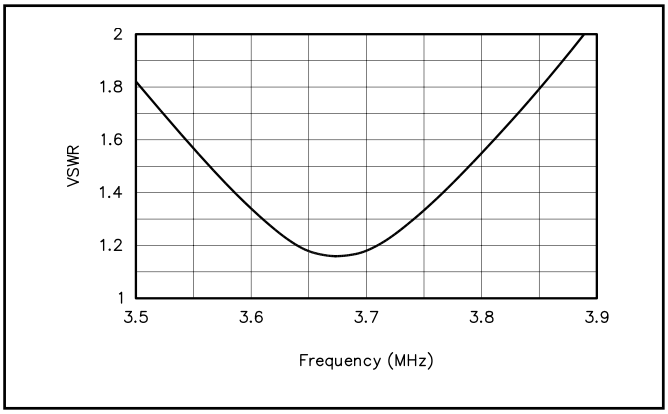

Figure 5—The SWR plot for the N6LF Bruce array.

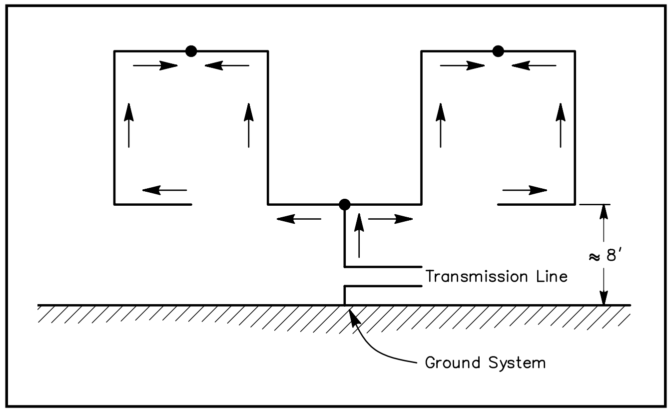

Figure 6—An example of driving a Bruce array against a ground system. This feed scheme produces a very symmetrical pattern with deep nulls off the ends if the array itself is symmetrical.

simplicity that is the basic advantage of the simple version of the Bruce.

I have used the 4-element Bruce array shown in **Figure 4** to good effect. As indicated, the array can be fed at several different points. (I've only shown a few of these.) The impedance at feed-1 and feed-2 is close to 370 Ω—a good match for #16 × 1-inch ladder line.

I chose to feed my antenna at feed-3, slightly off-center from a current maximum. At this point the input impedance is about 450 Ω. This works very nicely using #18 × 1-inch ladder line down to the ground where I connect a 9:1 balun and use 50-Ω coax for the run into the shack. The ladder-line can be any length as it is operated with low SWR.

Figure 5 shows a typical SWR plot that has a 2:1 SWR bandwidth >400 kHz. This covers most of the 75-/80-meter band. The actual bandwidth in a given installation will depend to some extent on the ground characteristics and the height above ground of the bottom of the array.

The gain of this antenna, when compared to a λ/4 vertical with 8 elevated λ/4 radials, is about 4.6 dB—very worthwhile indeed. The pattern is bi-directional with a –3 dB beamwidth of 55°. When fed at one of the inner vertical elements the pattern is very symmetrical. Feeding at one of the outside vertical sections, as I have done, introduces some asymmetry in the pattern but the small side lobe that appears is still 15 dB or more down from the main lobe.

Like the half-square and the bobtail curtain, the Bruce antenna has deep nulls off the ends and is relatively insensitive to the presence of a metal tower off the ends. If you space the outside elements 10 feet or more away from the tower you can use a tower (or towers!) as supports without degrading the pattern greatly. In my case I used a very tall (100 feet to the support point) fir tree at one end and a 95-foot pole at the other end.

One of the nice things about the Bruce antenna is that there are several other ways it can be fed. For example, if you already have a vertical with a ground system you can simply hang the Bruce over the ground system and feed it as you did the vertical (see **Figure 6**). The feedpoint impedance will be 200 to 400 Ω and may be reactive. This method of feed was used in the original versions of the Bruce array but they seem to have been forgotten by hams.

An alternative feed arrangement would be to use an elevated radial system as shown in **Figure 7**. A minimum of two radials are needed, but you could use more (just as you would for a ground-plane vertical). The dimensions shown in Figure 7 are for phone band (75-meter) operation.

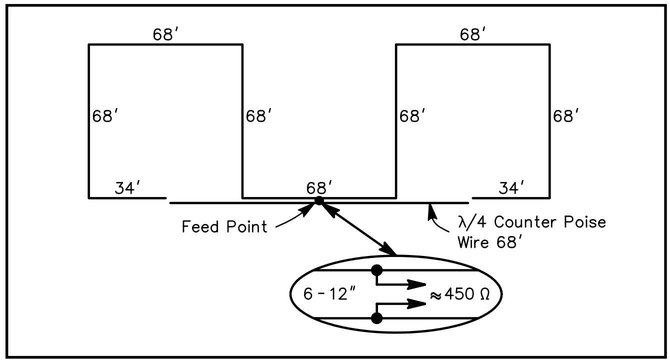

Figure 7—A 75-meter Bruce array driven against an elevated radial system. As few as two radials can be used. More radials will reduce ground losses somewhat.

Conclusion

If you have a couple of supports from which to hang an array, then you should give the Bruce array some consideration. It is very simple and flexible and is one of those antennas that just seems to "want to work."

I noticed that the dimensions are not critical. If you have some height but not enough width, you don't have to make the bays square—you can make the vertical sections taller and the horizontal sections shorter. Conversely, if you have plenty of width but not enough height, you can use shorter vertical sections and longer horizontal sections. Variations of up to ±20% in the height-to-width ratio have little effect on the gain and general performance.

Good luck! I'll listen for your thunderous 80-meter signal in the next contest.

Notes

[1] *ARRL Antenna Book*, 18th Edition, pp 6-13 - 6-16.
[2] Oswald, *Transatlantic Telephone Service*, Bell System Technical Journal, 1930, p 287.
[3] *Admiralty Handbook of Wireless Telegraphy*, 1931, pp 820-821.
[4] E.J. Sterba, *Directional Transmitting Systems*, IRE Proceedings, Volume 19, Number 7, July 1931, p 1202.
[5] *The "Radio" Antenna Handbook*, 1936, pp 57-58.
[6] *Admiralty Handbook of Wireless Telegraphy*, Volume 2, section 46.

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