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A Rose Garden Array

An empirical study of elevated, sloping radials in a phased vertical array.

Jack Falker, W8KR

Figure 1—The ComTek Systems hybrid quadrature phasing coupler at the center of the array.

Every November, after our roses are put to bed for the Minnesota winter, my garden sprouts a 20 meter 4-square phased vertical array. I've been experimenting with elevated ground planes ever since my wife talked me into selling my 80 foot tower and Yagi several years ago, on the grounds that I was getting too old for climbing.

Horrors, you say! How could a DXer of nearly 50 years give up his tower and beam? Well, I have to admit to thinking long and hard about that. But I recognized that my summers were increasingly spent on my roses (more than 100 at the moment) and less on DXing. So the idea of giving up the tower after so many years, and doing something different with vertical antenna technology in the winter months, was kind of exciting. I also recognized from my early years in the hobby that the old saying, "A vertical antenna is one that radiates equally poorly in all directions," is just not correct for vertical antennas with extensive radial systems. This is especially true if you provide some gain and front-to-back ratio with multiple elements and appropriate phasing. [For optimum low-angle results, the ground conductivity must be relatively high in the area around the antenna for up to a few hundred feet—not a condition found everywhere.[1]—*Ed.*]

I started with a simple 20 meter $^{1}/_{4}$ λ ground-plane, elevated about 6 feet, with 12 sloping quarter wave radials. That turned out to be a better antenna than I expected. It was pretty competitive in most CW pileups, particularly with the linear on line. Unfortunately, it clearly didn't have the "ears" for the really long haul stuff, such as long path to VK or the Middle East.

I started reading about phased arrays and the radial systems necessary to create a low-loss ground. Since this array was going to be in my garden and, by definition, go up in the fall and down in the spring, there was no way it could be a ground-mounted system with the several hundred radials required at ground level. In reading the literature, especially the excellent book, *ON4UN's Low Band DXing*,[2] I became increasingly fascinated by the fact that a vertical antenna elevated $^{1}/_{4}$ λ needed four or even fewer radials. Now, $^{1}/_{4}$ λ of elevation on the low bands is a very big deal, but on 20 meters and above, it's not that hard to imagine. I talked to some low-bander friends who said they were getting good results on 80 meters at elevations of 10 feet (0.038 λ) with only four radials. I also learned that WWV uses nine radials elevated $^{1}/_{4}$ λ for each of their vertical antennas.

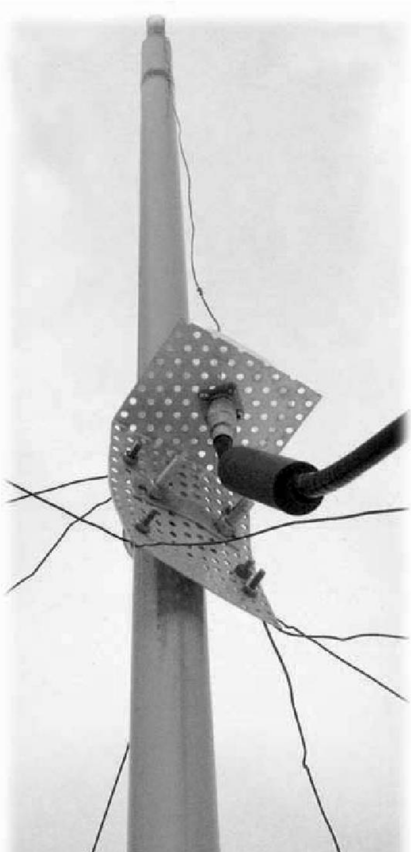


Figure 2—A ferrite-bead 1:1 current balun is at the base of each element.

The Past is Prologue

My memory flipped back to my earliest days of DXing in Detroit. In 1955, Karl, W8GB (SK), virtually ruled the low end of 40 CW every night with his homebrew 807s running 150 W, and his three-wire vertical with four radials elevated about 8 feet (0.061 λ) off the corner of his garage on a tiny city lot. (The three wire, 7 MHz vertical is featured in my very dog-eared copy of the 1955 *ARRL Antenna Book.*) Karl worked a lot of DX we kids couldn't

[1]Notes appear on page 31.

even hear until I emulated his antenna on the corner of my dad's garage. The difference was that my three-wire vertical was for 20 meters, which made my four radials, elevated 8 feet (0.122 λ), twice as high, relatively. I earned DXCC with that antenna and my Hallicrafters SX-71 and Heathkit DX-100 combo, before heading off to college in 1958.

Design to Fit

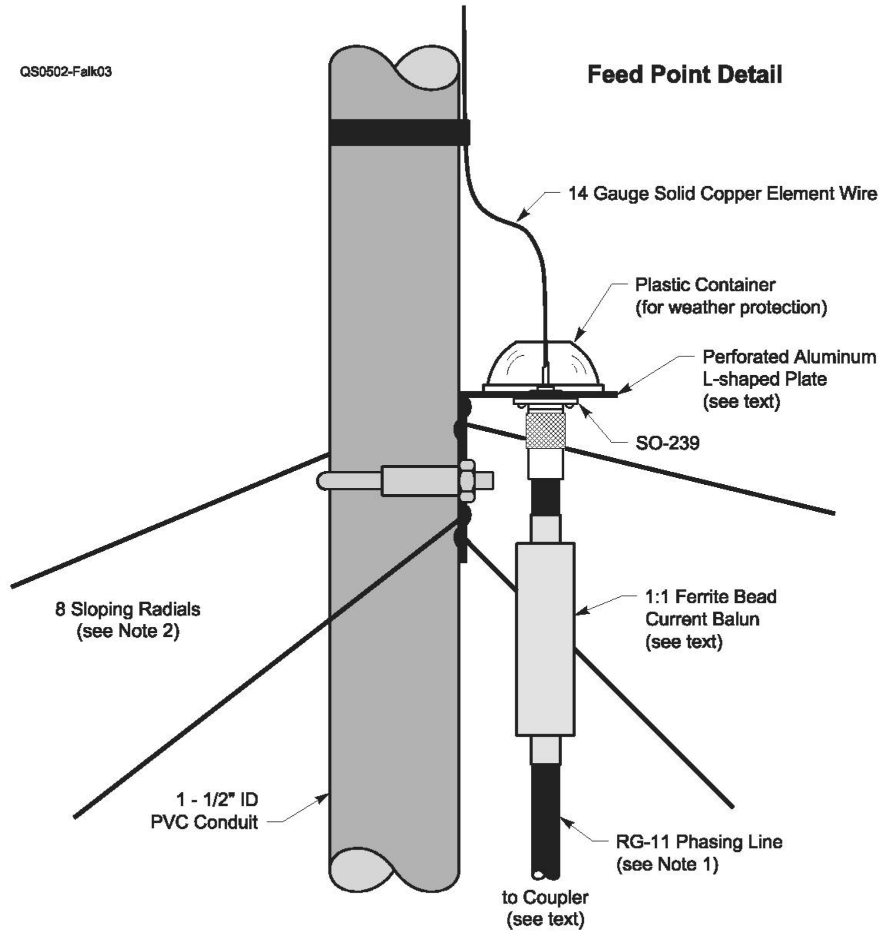
With all that empirical evidence and some encouragement from current literature, I set out during the winter of 2001-2002 to design an elevated phased array for the fall of 2002. I had visions of big rolls of coax, toroids and relays, until Bob, WØBV, showed me a little box containing a hybrid quadrature phasing coupler made by ComTek Systems.[3] This device, shown in Figure 1, is based on a Collins-defined phasing method. The hybrid quadrature coupler is discussed in some detail, including schematic and formulas, in *ON4UN's Low Band DXing*.[4] ON4UN also devotes significant discussion to the performance of the ComTek coupler on these pages.

While I'm game for just about any antenna construction project, my lack of test equipment and experience in building this kind of gear, plus my desire to get something on the air that fall, convinced me that using a phasing "module" was the right decision for my project. Just building the four antennas with their interconnected radial system offered enough construction fun!

I got in touch with Jim, K4SQR, at ComTek and ordered an ACB-4 Hybrid Coupler, designed for the middle of the 20 meter CW sub-band. In addition to the coupler and in-shack control box, Jim supplied all of the custom-cut RG-11 coax cable phasing lines, complete with a ferrite-bead 1:1 current balun for each line. The baluns (Figure 2) are necessary at the feed points (detailed in Figure 3) of elevated vertical arrays to reduce RF currents on the coax shield. For those who might plan to make their own phasing lines, note that the baluns can affect the electrical length of the lines, requiring additional measurements and/or experimentation. Balun kits are available both from ComTek and The Wireman.[5]

Putting it Together

With the *guts* of the system in hand, I set out to build four antennas from my junk box/pile. I wanted something that would be attractive and very modular for annual assembly, disassembly and storage. Those nice blue fiberglass quad arms



Notes:

1. Phasing lines are RG-11, with .78 velocity factor.
   Length in feet = .78 × (234/f)
   Each phasing line has 1:1 current balun at feed point (see text)
2. Each element uses 8 elevated, sloping radials.
   L = length in feet = 234/f
   Radials are connected together, where they cross.
3. Elements are 14 gauge solid copper.
   L = length in feet = 234/f
   Wire is taped to fiberglass poles and PVC tubing.
4. S = element spacing in feet = 246/f
   D = diagonal spacing = $\sqrt{S^2 + S^2}$

Figure 3—Details of each element feed point.

I had been saving for more than 30 years came to mind, but they were only 13 feet long, so I needed something to lengthen them. PVC 1½ inch ID conduit filled the bill. With a little duct tape as a shim around the base of each quad arm, they slip nicely into the conduit, which also serves as a mounting base for each antenna. I taped 1/4 λ of #14 solid copper wire to each quad arm to form the vertical elements. An L-shaped piece of perforated aluminum (left over from an old linear amplifier project) makes up a little mounting platform for an SO-239 coax connector, leaving lots of holes for stainless-steel screws to connect 1/4 λ radials made of the same #14 wire. This is all U-bolted to the PVC at the right spot to accommodate the full 1/4 λ of radiating wire. Each SO-239 is covered with a little plastic baby food container (from the grandkids) to keep the snow off.

Each antenna is mounted on an 8 foot steel fence post (which freezes solid in the ground around here) and is elevated to about 8.5 feet (0.13 λ). Eight radials are then attached to each vertical, with several doubling as guy wires. As you can imagine, 32 sloping radials create a bit of a maze within the square, but that's important. Broadcast engineering literature tells us that these radials should be

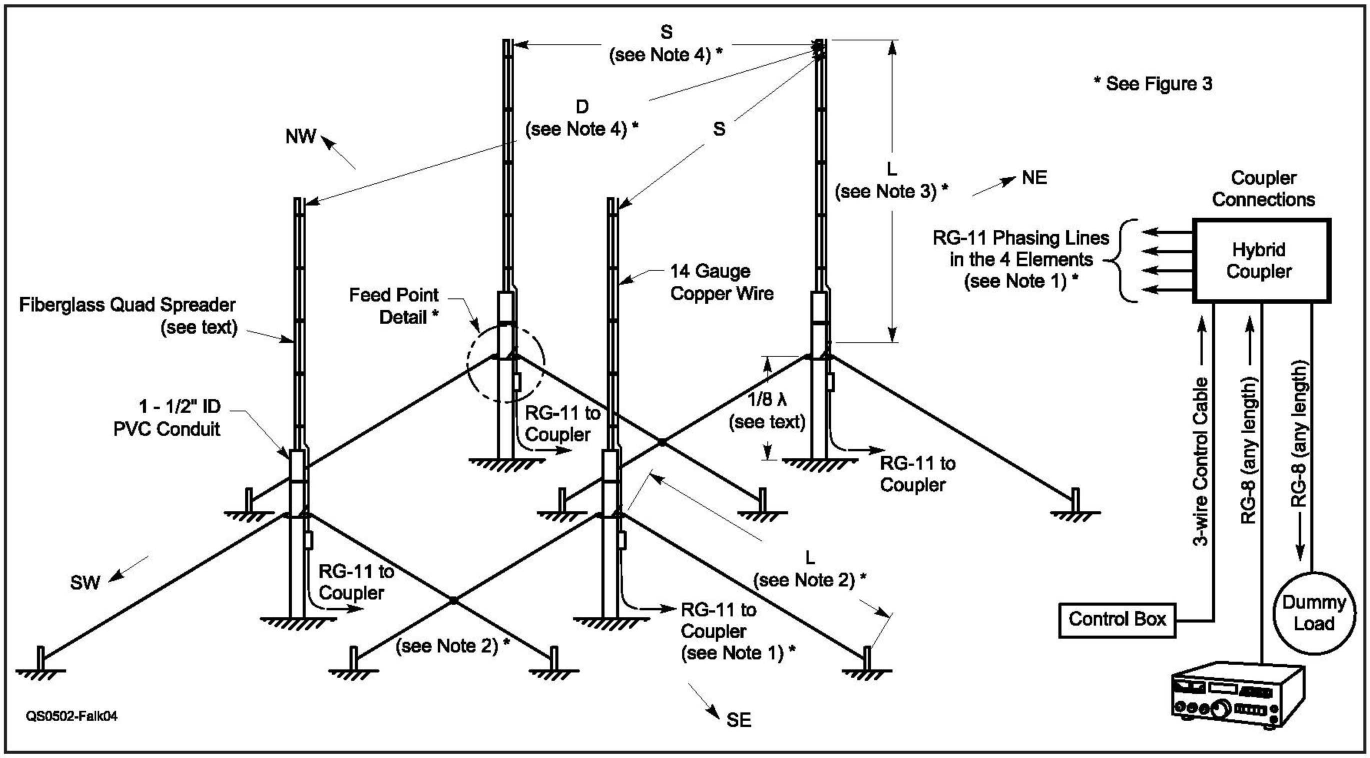


Figure 4—Drawing of the entire array.

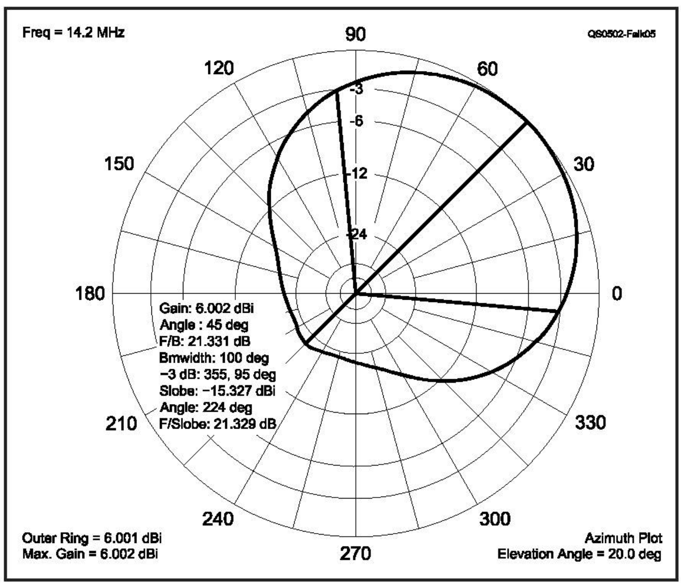


Figure 5—*ELNEC* plot of antenna azimuth pattern.

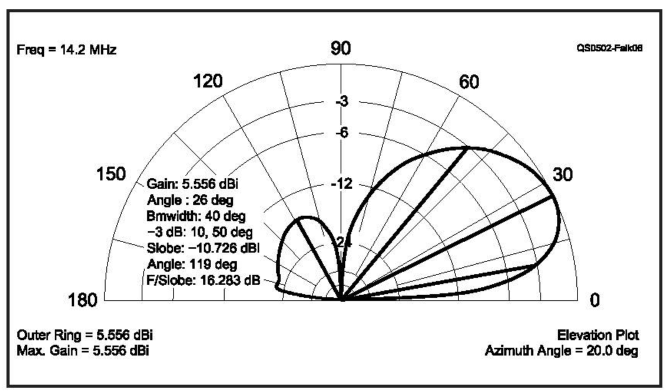


Figure 6—*ELNEC* plot of antenna elevation pattern.

interconnected wherever they cross within the square. This results in each antenna being connected to all the others, thereby creating a very uniform ground screen. In my mind, interconnection compounds the effectiveness of the radials. I'm tempted to try 12 radials per antenna, to make 48 in the maze, but I have a hunch (and *ON4UN's Low Band DXing* confirms) it won't make a difference, or perhaps even be a negative.

The hybrid coupler module is mounted in the center of the square with the four phasing lines running to it. The coupler also has to be elevated because if it is much lower than the antennas the phasing lines won't reach it. In addition to the phasing lines, three other cables attach to the coupler: the 52 Ω transmission line from the shack (any length), the control cable to switch antenna directions and another 52 Ω line running to a dummy load, either at the antenna or in the shack. The array is shown in Figure 4.

The purpose of the dummy load is to dissipate *dumped* power at port four of the coupler, which occurs if all four port impedances are not the same. In other words, if something happens to one of the antennas, causing it to not be resonant at the same frequency, its impedance will differ from the other three elements. As a consequence, power will be dissipated in the dummy load resistor.[6]

In that regard, the final step in building the array is to measure power to the

Figure 7—W8KR in the midst of his rose garden array—it's winter in Minneapolis.

dummy load with a wattmeter. I found it easiest to run a piece of coax back to a dummy load in the shack where I can measure power to the load a couple of times a year, just to make sure nothing has changed. ComTek indicates that dumped power of 5% or less of transmitter power is considered normal. Note that if you were to build a separate enclosure to keep the coupler and the dummy load out of the weather, the extra run of coax could be eliminated. ON4UN shows just such an arrangement in his book.

How Does it Play?

My experience with big towers and beams tells me that this dog hunts on 20 meters. I measure this by what I hear and how many times I need to turn on my linear to crack a pileup, which is not very often. This antenna has great *ears* and performance on the longest hauls because its radiation takeoff angle is low. The longer the haul the better the front to back: 20 to 25 dB (by my S-meter observations), dropping to around 15 dB on short-haul, ie, higher-angle signals. The *ELNEC*[7] plots, shown in Figures 5 and 6, indicate a forward gain of 5 to 6 dB over a single vertical, front-to-back of 21 dB; and a takeoff angle of 26°. That's about how it feels on the air. It isn't a Yagi at 70 feet, but you don't have to climb it, it's inexpensive, and it goes up and down with minimal effort. Figures 7 and 8 provide the two-season view of the multifunction backyard.

One final note: We feed lots of birds in the rose garden during the winter and deer wander around the feeders at night. I've noticed that the birds are smart enough to fly around the maze of radials in the square. However, the other night I watched as a deer wandered into the radial maze. Had she been startled it could have been a mess but, as I held my breath, she backed her way out slowly. Now, if I could just keep them out of there in the summer!

Special thanks to Bob Garwood, WØBV, for his help in drawing the schematic of the array, and to my son, John Falker, for taking the high resolution digital pictures for this article.

Figure 8—Summer in Minneapolis and it's back to a rose garden!

Notes

[1]*The ARRL Antenna Book, 20th edition*, Chapter 3, pp 11-15. Available from the ARRL Bookstore for $39.95 plus $8 shipping in the US, $10 elsewhere. Order number 9043. Telephone toll-free in the US 888-277-5289, or 860-594-0355; **www.arrl.org/shop/**; **pubsales@arrl.org**. Compare your ground conductivity in Figure 19 to that of Minneapolis to get an idea of relative performance.

[2]J. DeVoldere, *ON4UN's Low Band DXing*, available from the ARRL Bookstore for $19.95 plus shipping. Order number 7040.

[3]ComTek Systems, tel 704-542-4808; **www.comteksystems.com**.

[4]*ON4UN's Low Band DXing*, Chapter 11, pp 14-15.

[5]The Wireman, **www.thewireman.com**.

[6]*ON4UN's Low Band DXing*, Chapter 11, p 14.

[7]*ELNEC* has been superseded by *EZNEC*, available from Roy Lewallen, W7EL, at **www.eznec.com**.

Jack Falker, W8KR, was first licensed in 1954 in Detroit, Michigan as W8SRK. He began DXing and building antennas in 1955. Jack spent more than 40 years in the practice and teaching of corporate finance and now owns his own investment practice in Minneapolis, Minnesota, where he and his family have lived since 1977. He is a graduate of the University of Michigan and the University of Detroit, with BA and MBA degrees. He is a life member of ARRL. Jack can be reached by e-mail at **jack@falkerinvestments.com**.