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Bob Zepp: A Low Band, Low Cost, High Performance Antenna

This antenna array provides a switchable, 4-direction, vertically polarized, full-azimuth-coverage high gain antenna for 160 meters and a bidirectional horizontal antenna for 40/75/80 meters. In Part 1. Bob takes us through the early development stages of his antenna.

In the Feb 2010 issue of *QST* I presented "The Curtain-Zepp."[1] That wire antenna array was supported by two 140 foot Douglas Fir trees, which provided bidirectional gain on the three low bands: 160, 80/75 and 40 meters. It has proven to be a very effective antenna on all these bands. This paper presents a revised version of the Curtain Zepp. In addition, several steps leading to the final design are presented, therefore this paper describes several possible low-band antenna configurations, from the simplest to the more complex Bob-Zepp. An antenna builder could also use these steps as a progression to more complex and more effective arrays as confidence is gained at each step. This, in effect, is what I did in the development of this array over an eight year period.

The Bob-Zepp is also scalable for higher frequencies. For example, instead of 160/80/40 meters, it could be configured as an 80/40/20 meter or even a 40/20/10 meter array, the latter would be about 30 feet high and 40 feet long. *EZNEC* or a similar design tool would be required to optimize such alternate designs. Also, the dimensions are not critical. The mini Bobtail configuration "wants to work." Optimization should be done using modeling tools.

Advantages of the final version:

1) Bidirectional horizontal gain (dBd) for 80/75/40 meters.

[1]Notes appear on page 48.

Photo A — Here is the antenna feed point. The ladder line from the shack (not visible in this photo) comes to the pole from the left, then down to the tuner box. The coax and control cables are fed though buried electrical conduit. You can see a corner of my outdoor patio, where the tuner box serves as a convenient summer serving table.

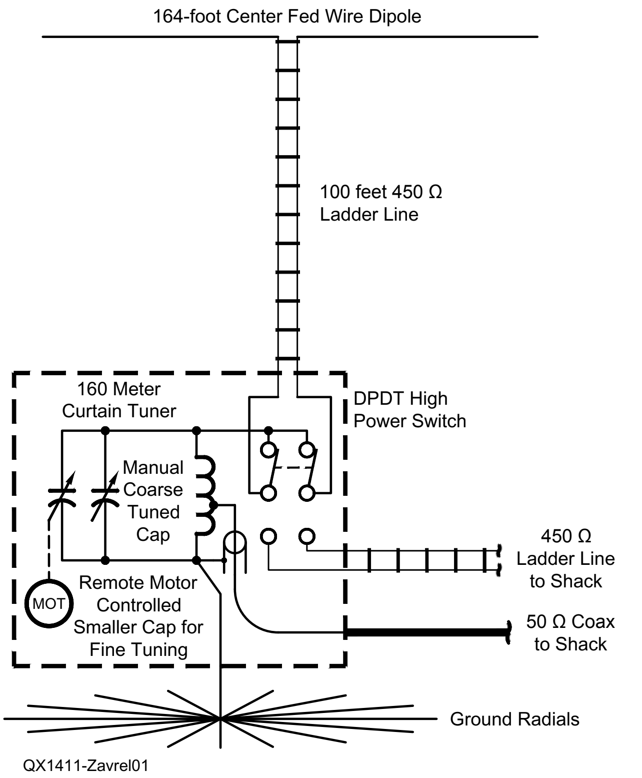

Figure 1 — Step 1: An extended double Zepp on 40 meters, a dipole on 75/80 meters, and top-loaded vertical for 160 meters. and three plots showing azimuth vs. gain on the three bands.

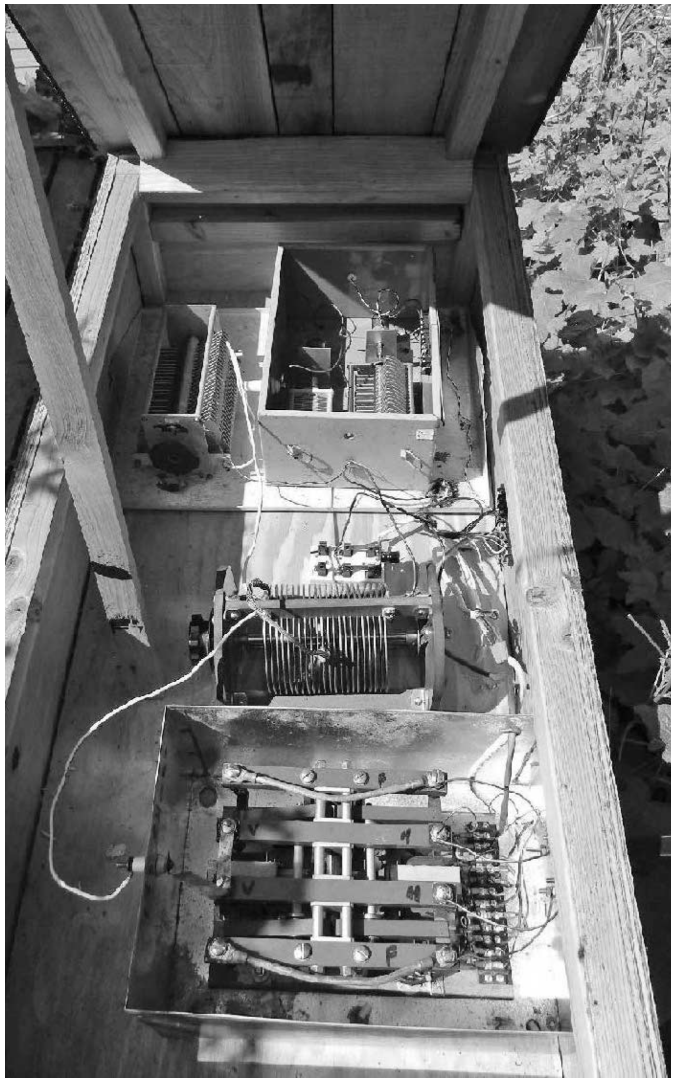

Photo B — This photo is a view of the tuning networks inside the tuning box from Photo A. Near the bottom of the photo you can see my heavy duty antenna transfer switch. This was surplus from a high power AM broadcast facility. Vacuum switches or high voltage ceramic switches can also be used.

2) Vertically-polarized, switchable all-azimuth coverage gain antenna for 160 meters.

3) Minimal ground radial system (6 short wires only on the fed element).

4) Two or optional four-support system.

5) Inexpensive wire construction that can be supported by trees.

6) All tuning and switching performed at near-ground level and with remote control from the shack.

The final version also includes some techniques that may be useful for a wide variety of antenna applications outside of the Bob-Zepp. For example:

1) Gain optimization of a horizontal antenna using "drooping" vertical end loading.

2) Suggestions on dressing open wire feed-lines that feed wire antennas prone to wind movement (tree supported).

3) Developing an end-fire pattern from a Bobtail antenna, first bidirectional, then switchable mono-directional.

4) Considerable information on using quad-style loop parasitic elements with ground-mounted verticals.

5) An alternative method for implementing a remote control motor-driven variable inductor.

The First Three Steps

There are two main differences between the original and this antenna: horizontal polarization on 80/75 meters and a four-directional vertical polarized capability on 160 meters. On 80 meters the low elevation angle gain with the old vertical curtain array was comparable with a more optimized horizontal configuration. Furthermore, band-switching and tuning involved a rather complex circuit for vertical polarization on 80/75 meters. After extensive modeling with *EZNEC* and lots of experimentation, I settled on the addition of two end-fire configurations that provide mono-directional "east" and "west" patterns for 160 meters.

Switching back to the old curtain configuration, a third north-south bidirectional pattern emerges, providing full-azimuth coverage from the one single antenna (not to mention an excellent bidirectional horizontal antenna for 80/75 and 40 meters)! So this new array can be considered a vertical polarized directional array with full azimuth coverage on 160 meters and a high gain bidirectional horizontal polarized array for 80/75 and 40 meters. This array is supported by the same two trees and is the same size as the Curtain-Zepp.

In addition, a reflecting loop in back of the broadside curtain, supported by two other trees forms a unidirectional 160 meter array with substantial gain toward Europe, the Middle East and East Africa, all very difficult paths from Oregon on the low bands. This loop can be detuned remotely to rees-

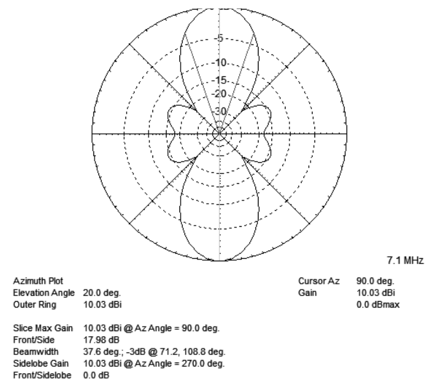

Figure 2 — This azimuth versus gain *EZNEC* pattern plot shows the 40 meter dipole.

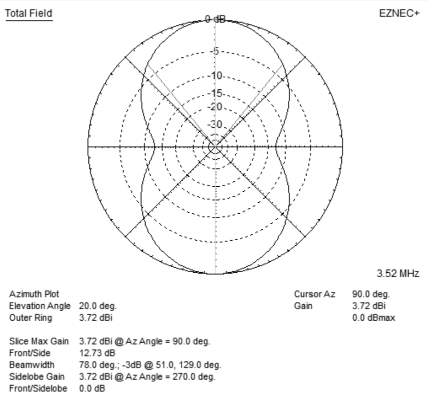

Figure 3 — This azimuth versus gain *EZNEC* pattern plot shows the 80 meter dipole.

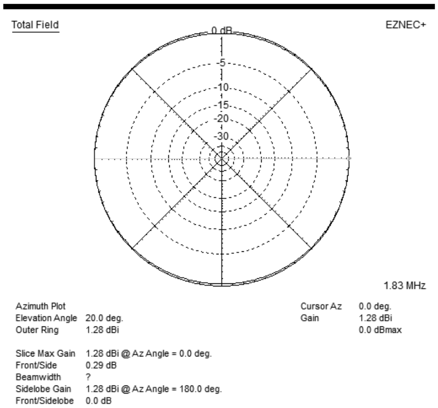

Figure 4 — Here is the azimuth versus gain *EZNEC* pattern plot for the 160 meter top loaded vertical.

Photo C — Here is my preferred method of vertical ladder line mounting. Coming down from the antenna feed point, the ladder line is fed through a plastic electric fence insulator (at the top right corner of the photo) to allow it to move up and down with the wind. Placing this guide for the line about 8 feet high prevents the line from becoming entangled with garden plants and people. Near the bottom of the photo, a ¼ inch nylon nut and bolt fasten the line to a rubber bungee cord, which is then fastened to a heavy weight on the ground. The rest of the secured line is then fed to the tuning box. Note that this photo shows an older version of the tuning box on the left. Photos A and B show the current tuning box.

tablish a bidirectional pattern for coverage of the south-west Pacific. So on 160 meters, four separate mono-directional patterns are available. The loop was intentionally made smaller than a full size 160 meter reflecting loop. Two inductors are included in the loop to optimize its functions as a director or reflector. There will be more on optimizing loops in Part 2, in the Optimizing Loop Parasitic Elements section.

Note: I use azimuth directions north, south east and west in this paper for simplicity. Of course this array can be oriented in any configuration. My "north" is actually at 30° azimuth, directly toward Europe from my QTH. Therefore, "east" is 120°, south is 210°, and west is 300°.

Step 1:

Tree supported extended double Zepp antennas have been my default favorite antenna on 40 meters for over 20 years.[2] Therefore this was my starting point: a 164 foot wire, center fed with 450 Ω ladder line, strung at a height of about 100 feet between two trees. This also forms a very effective "long dipole" on 75/80 meters. The ladder line is fed to a rack in my shack, where tuners achieve a perfect match anywhere in the 80/75/40 meter bands. On these bands it forms a north-south bidirectional pattern. It can also be fed as a short dipole on 160 meters. A 160 meter vertical can be created by breaking the ladder line near ground level, shorting the ladder line wires, and feed it against the ground as a familiar "T" antenna. This requires a second transmission line (coax) fed from the shack, and of course the required tuning and switch-

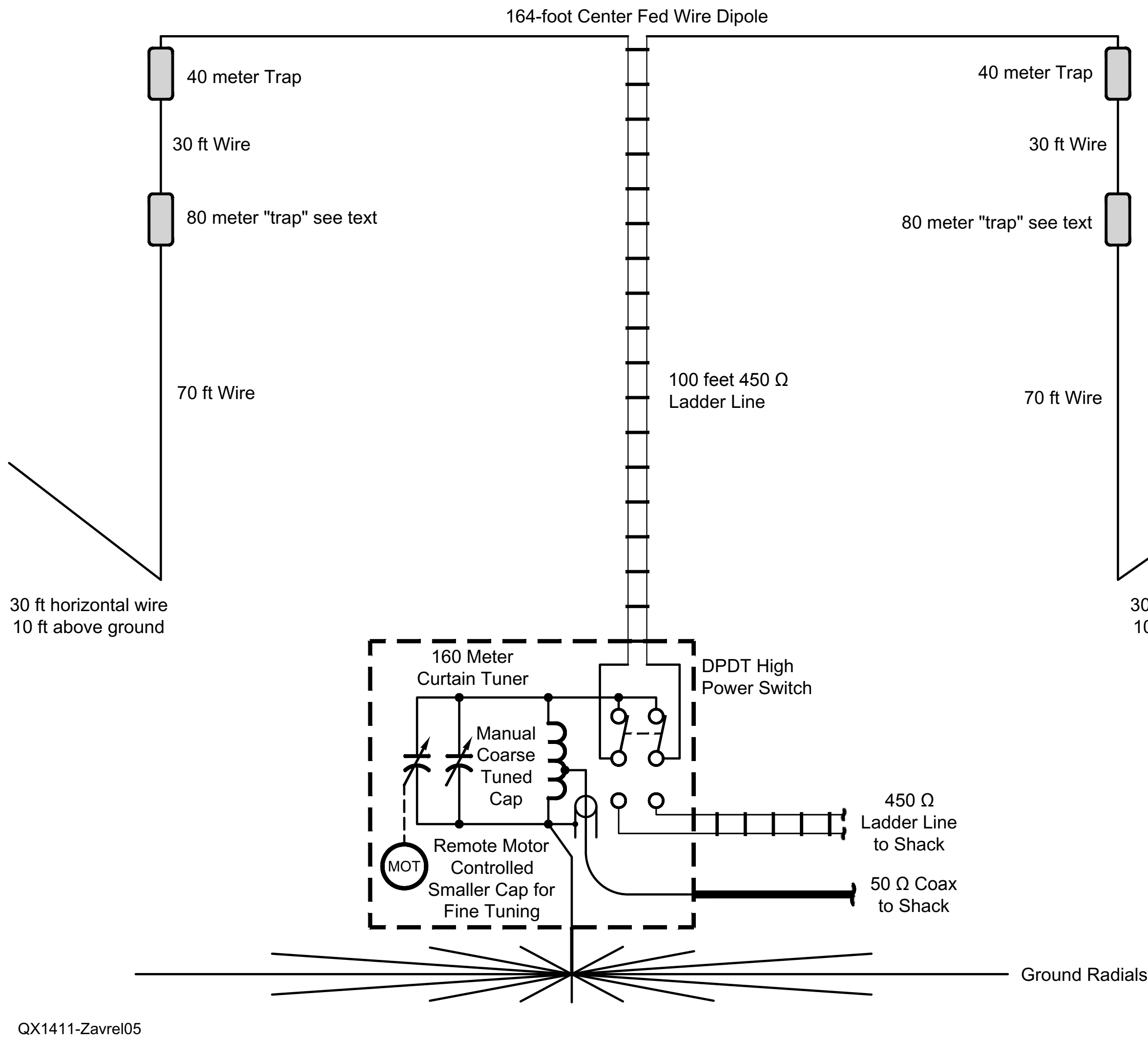

Figure 5 — Step 2: An extended double Zepp on 40 meters, extended dipole on 75/80 meters and a bidirectional curtain for 160 meters.

ing circuitry at the base. This antenna is very effective on 160 meters as a single-element monopole. On 160 meters, the horizontal wires form a capacitive hat, thus moving the current maximum away from the base to near the top of the vertical element (shorted ladder line). This increase in base-fed impedance lowers the effect of ground loss on efficiency and thus this vertical needs only a modest ground radial system. I use only four 50 foot radials and a 6 foot copper ground rod. Figure 1 illustrates this arrangement. Figures 2, 3 and 4 show the *EZNEC* patterns for the 40 and 80 meter horizontal configurations and the 160 meter vertical.

Photo A shows the antenna feed point. The ladder line from the shack (not visible in this photo) comes to the pole from the left, then down to the tuner box. The coax and control cables are fed though buried electrical conduit. This tuner box doubles as a food serving table for summer outdoor activities, when the low bands are dead! It is *imperative* that all such tuning points be secured from people and animals when the array is in use!

Photo B is a view of the tuning networks inside the tuning box. Near the bottom of the photo you can see the antenna transfer switch. This was surplus from a high power AM broadcast facility. Vacuum switches or high voltage ceramic switches can also be used.

Photo C shows my preferred method of vertical ladder line mounting. Coming down from the antenna feed point, the ladder line is fed through a plastic electric fence insulator (at the top right corner of the photo) to allow it to move up and down with the wind. Placing this guide for the line about 8 feet high prevents the line from becoming entangled with garden plants and people. A ¼ inch nylon nut and bolt fasten the line to a rubber bungee cord, which is fastened to a heavy weight on the ground. The rest of the secured line is then fed to the tuning box, which houses the heavy transfer switch. Ladder line with braided wire is preferred for this section of the line rather than solid copper wire.

Step 2

I want vertical gain on 160 meters! If we drop vertical wires from the horizontal wire ends, an array that resembles a Bobtail Curtain emerges. In addition traps, for 40 and 80/75 meters are also included to maintain the extended double Zepp response on 40 meters and optimize broadside gain on 80/75 meters. My original array was configured as a curtain for both 160 and 80/75 meters. Modeling and on-air testing both indicated that returning to horizontal polarization on 80/75 meters would be to my advantage. To use horizontal polarization on 80/75 meters, a second set of traps are required, since the vertical wires provide an undesirable pattern on that band. This

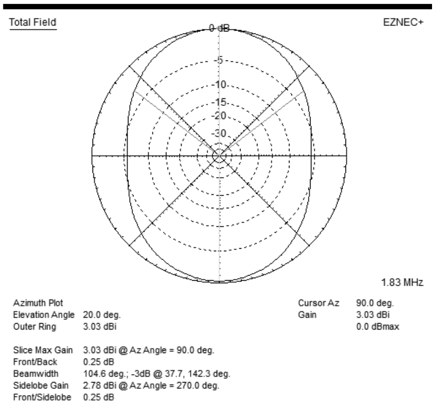

Figure 6 — This plot shows the 160 meter bidirectional curtain north/south pattern.

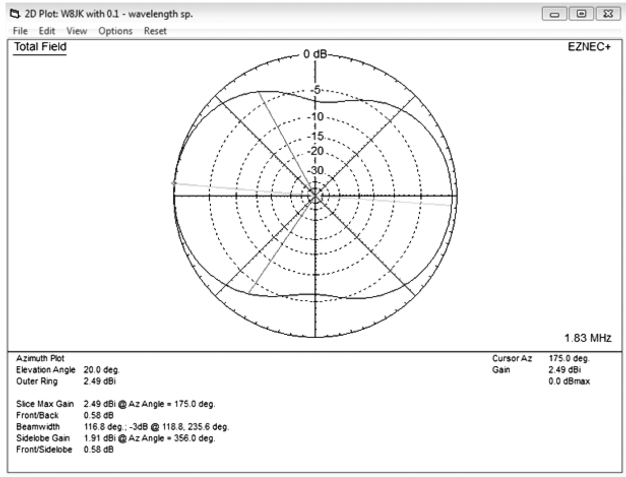

Figure 7 — Here is the plot showing the east/west pattern formed when the new array is fed with the ladder line, identical to the feed method on 40/80/75 meters, but the result is a two-element end-fire bidirectional vertical array.

modification also greatly simplified the tuning and switching requirements at the base of the array, freeing expensive components that would prove far more useful in the more complex arrays that follow.

By moving the 75/80 meter traps "down" the end vertical elements, the broadside gain increases over a simple 164 foot dipole, until reaching a point where further lowering of the traps begins reducing the gain. This point is about 30 feet below the tops of the vertical wires, the "sweet spot" for 80/75 meters. The 80 meter traps use a rather high C/L ratio since higher inductance proved to be a disadvantage for all patterns on 160 meters. The 80 meter traps use 200 pF capacitors and 9.5 µH inductors. The 40 meter traps use 40 pF and 13 µH components. I use high voltage doorknob capacitors (at least 10 kV), and wind #10 insulated copper wire on ABS pipe sections with the capacitors placed inside the pipe and a pipe cap on top to keep the inside of the pipe (and capacitors) dry. Also, I drilled small drainage holes in the bottom of the ABS to avoid condensation inside the traps.

Finally, for 160 meters, low horizontal "capacitive boots" are placed at the bottoms of the vertical wires. Since the vertical end wires are effectively top fed vertical elements, the loading lines perform the identical function of capacitive hats in base fed verticals. That is why I call them "capacitive boots." These have the effect of optimum placement of the RF current along the array elements for maximum gain of the array. This completes the tri-band bidirectional array. The result is a north/south bidirectional array with more gain on 80/75/160 meters.

As mentioned before, the 160 meter curtain is configured by shorting the ladder line leads together at the base and feeding it as a vertical against the ground, resembling a full-sized Bobtail Curtain. On 160 meters, however, if we feed this array with the balanced ladder line at the center of the horizontal wire

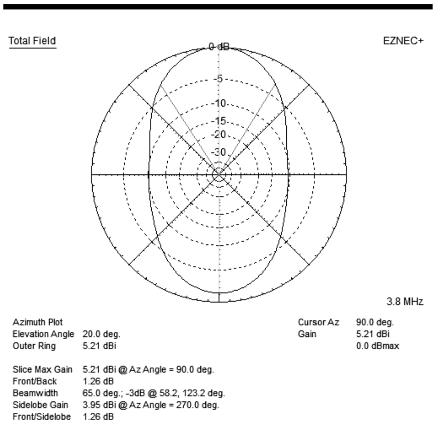

Figure 8 — This plot shows the higher broadside gain realized on 75 meters, resulting from optimum placement of the 80/75 meter traps. The 40 meter response is essentially identical to the plot shown in Figure 7.

(again, like a dipole), the array dimensions are conducive to forming a two-element vertical end-fire array (east/west) on 160 meters! Thus, on 160 meters we now have two orthogonal bidirectional patterns for full-azimuth coverage *in addition* to the Bobtail bidirectional pattern. Of course, the end-fire configuration is also tuned in the shack for a perfect match. The result is that we can switch between two bidirectional 160 meter patterns (north/south or east/west) simply by changing the way we feed the array! Figure 5 illustrates this construction.

Figure 6 shows the 160 meter bidirection curtain north/south pattern. Figure 7 shows the east/west pattern formed when the new array is fed with the ladder line, identical to the feed method on 40/80/75 meters, but the result is a two-element end-fire bidirectional vertical array. Finally, Figure 8 shows the higher broadside gain realized on 75 meters resulting from optimum placement of the 80/75 meter traps. The 40 meter response is essentially identical to the pattern shown in Figure 7.

In Part 2 of this article, I will describe how the end-fire radiation pattern can become a switchable dual mono-end-fed directional array. This will increase the gain in these two directions. I will also describe the remaining steps to design the complete Bob-Zepp antenna.

Bob Zavrel, W7SX, is an ARRL Life Member, Technical Advisor and Amateur Extra class licensee. He has been licensed since 1966. His primary interest in Amateur Radio is low band DXing and designing and building antennas, tuners, and amplifiers. Bob holds 5BDXCC, 5BWAZ (200), has 334 mixed, and 324 CW entities confirmed. Previous call signs include WN9RAT, WA9RAT, WA9RAT/HR2 and SV1/W7SX.

Bob has a BS in Physics from the University of Oregon and has worked in RF engineering for over 30 years. He has five patents, and has published over 50 papers in professional and Amateur Radio publications, including the first block diagram of an SDR receiver in 1987. He was involved with the first generation of RF integrated circuits for cellular phones, and worked extensively with DDS, WLAN and passive mixer development. Bob is currently an RF Research and Development Engineer for Trimble Navigation with a primary focus on high precision GPS, down to mm accuracy.

Notes

[1]Bob Zavrel, W7SX, "The Curtain Zepp — A Bidirectional Antenna for 160, 80 and 40 Meters," Feb 2010 *QST*, pp 36 – 39.

[2]Bob Zavrel, W7SX, "Maximizing Radiation Resistance in Vertical Antennas," Jul/Aug 2009 *QEX*, pp 28 – 33.