Effects of Number of Radials on Portable Vertical Antenna Performance

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SUMMARY

During the development of the Ventenna HFp portable vertical antenna, we did a great deal of experimentation with radial quantity, configuration, and length. Those experiments led us to the conclusion the three tuned radials presented the optimum compromise between antenna efficiency and portability.

DETAILED DESCRIPTION

The primary problem we addressed was making a vertical antenna as portable as possible, while at the same time meeting a minimum, but high, efficiency standard. The standard we have long used on the Ventenna concealed VHF and UHF antennas is –20 dB return loss on a network analyzer, which is equivalent to less than 1.2:1 VSWR. That seemed like a reasonable goal for the HFp antenna as well.

After some initial experimentation and data collection, as well as researching a number of sources, including the HF Pack group, we concluded that *tuned* radials (that is, the radial length is specific for each frequency band) offered substantial efficiency advantage. Bonnie Crystal, KQ6XA, reports that for a *single* dragging counterpoise, shortening the radial from 10%-25% from a quarter wave is desirable. We found that with more than one radial, shortening was indeed more efficient, but to a lesser extent. Our research showed that 5%-10% shortening with multiple radials produced optimum results.

Having reached that conclusion, we set about to determine the optimal number of radials for efficiency vs. portability. Unlike Bonnie's research for pedestrians dragging a counterpoise, ours focused on fixed portable operation. In all cases, the radials were made using insulated 22-awg wire, laying directly on the ground. Actual ground conductivity was not measured.

One Tuned Radial

We began our experimentation using one tuned radial. We found that a reasonable match was indeed possible, but not as good as we were seeking. On 40m, the best return loss we were able to implement was -9.2 dB (approximately 2.05:1 VSWR). Photo 1 shows the display from our network analyzer with one tuned radial (approximately 90% of one-quarter wavelength).

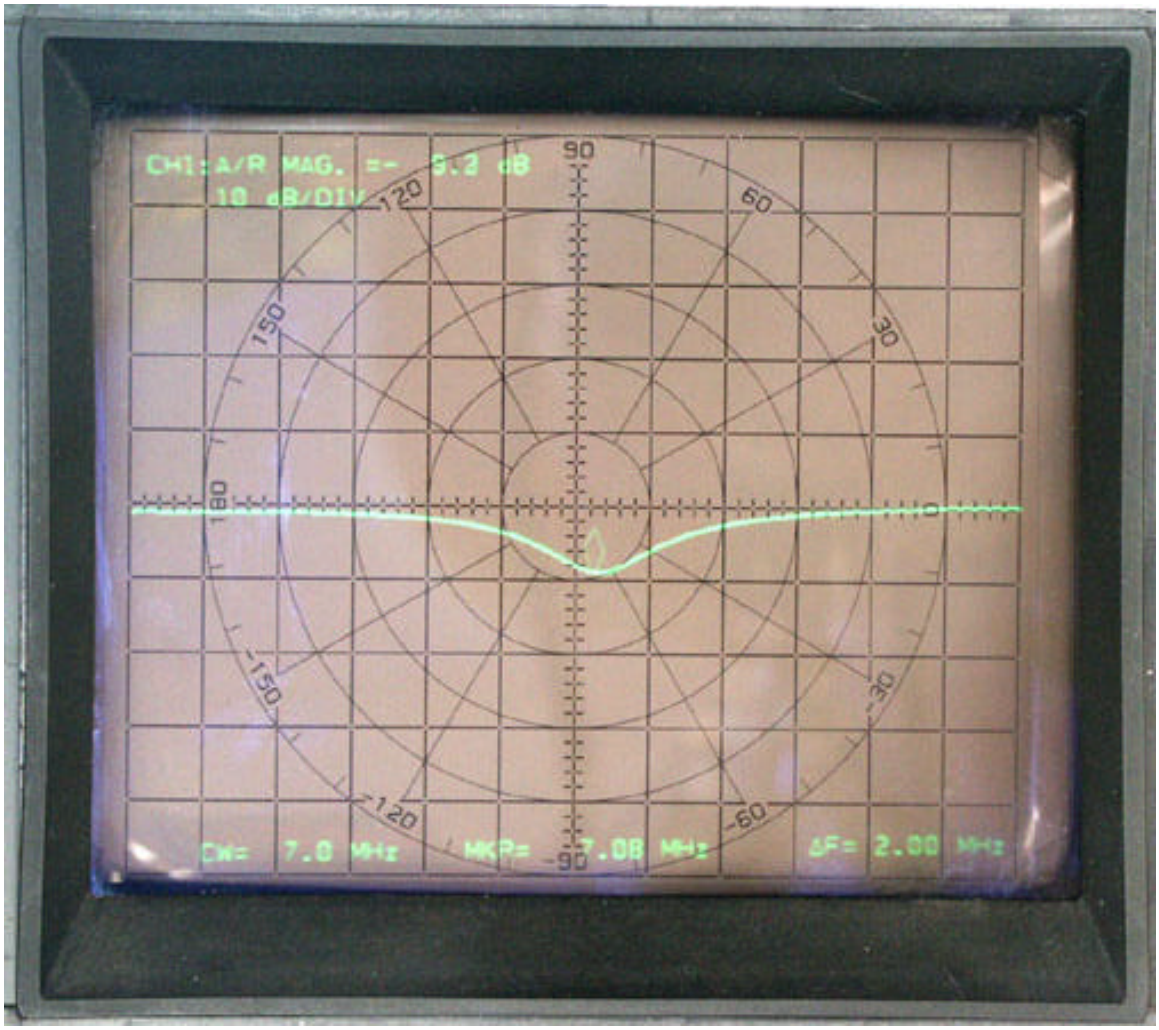

Photo 1: Network analyzer display at 7.080 MHz with one radial, of length 90% of a quarter wavelength

Two Tuned Radials

Adding a second tuned radial, situated 180° from the first produced a measurable improvement in return loss. Photo 2 shows the network analyzer display with two radials, each 90% as long as a quarter wavelength. The return loss has now improved to -13 dB, which is roughly equivalent to a VSWR of 1.58:1 — a much more usable figure with modern solid-state radios than a single radial.

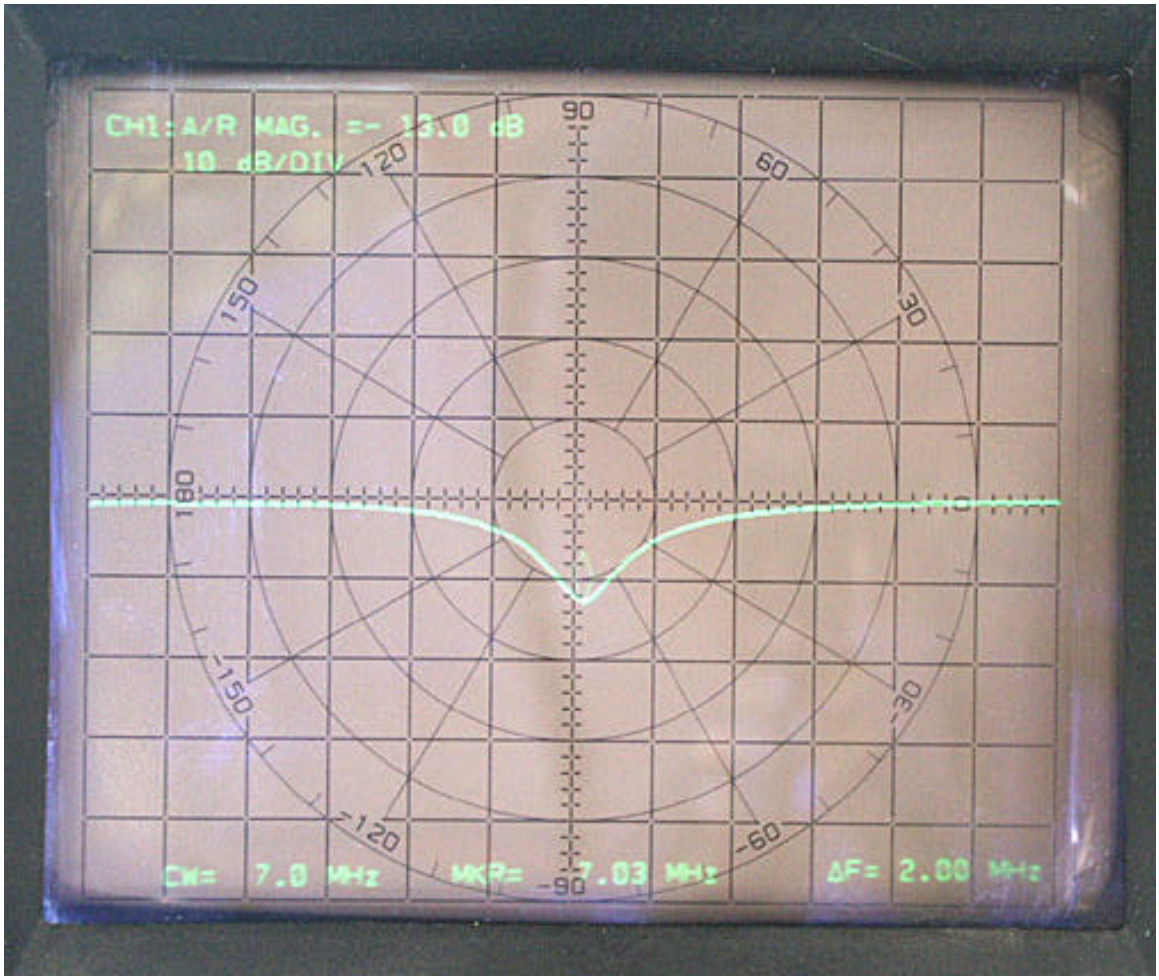

Photo 2: Network analyzer display at 7.030 MHz with two radials, of length 90% of a quarter wavelength

Three Tuned Radials

With this encouraging result, we added a third radial. The radials were dispersed symmetrically, at 120° separation. This made a substantial improvement over the single tuned radial. We also discovered that running the feedline parallel with, and in close proximity to one radial produced the greatest return loss.

The results of this final configuration produced a whopping -31.7 dB return loss, shown in Photo 3! This equates to a VSWR of 1.05:1! We added a fourth wire, and as you would expect with a 1.05:1 VSWR using three, little change was noticed. So, we suspended our tests, concluding that three tuned radials offered the best combination of antenna efficiency and portability.

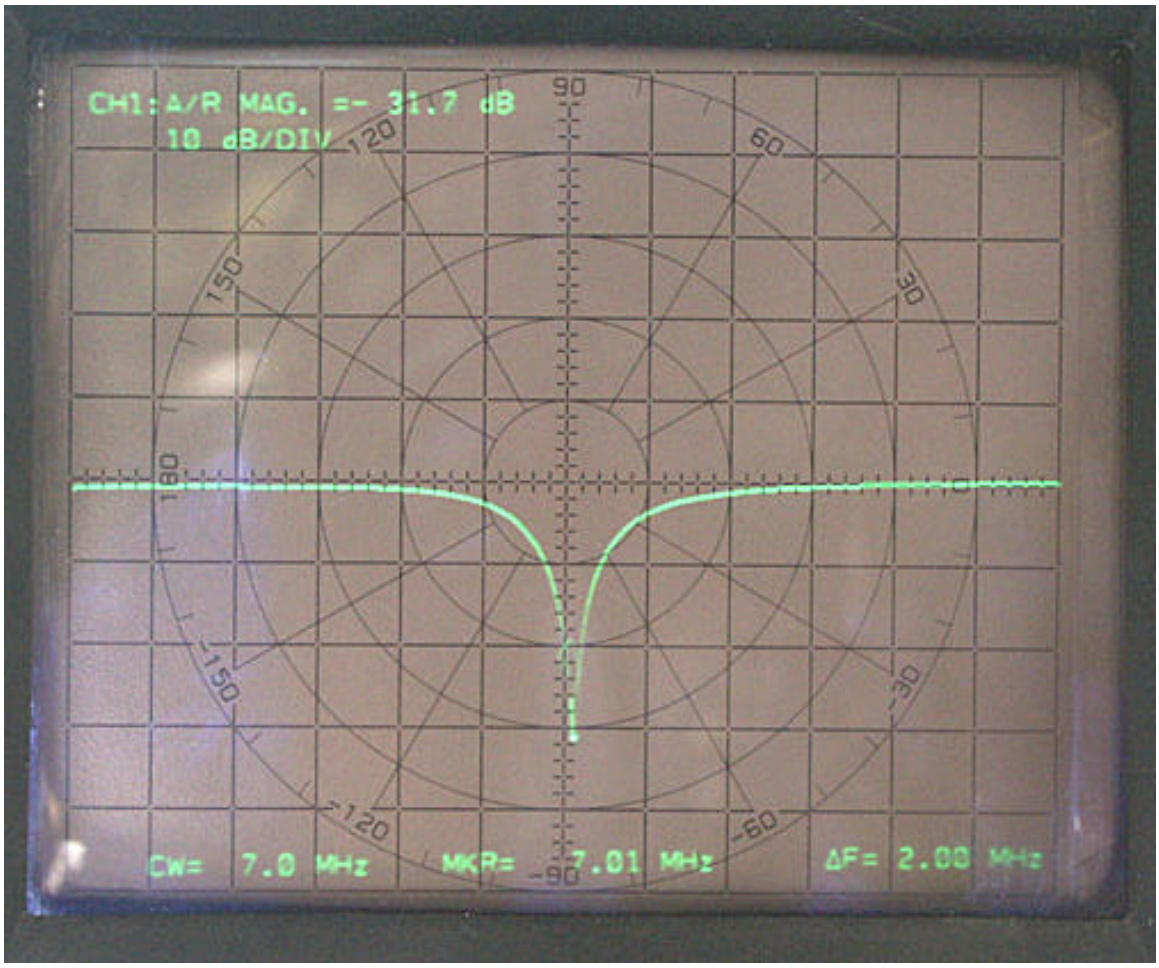

Photo 2: Network analyzer display at 7.010 MHz with three radials, of length 90% of a quarter wavelength

CONCLUSION

We concluded that three tuned radials, symmetrically spaced with the coaxial feedline running coincident with one of the radials produced the best return loss, while still maintaining portability and set up ease.

We also experimented with the vertical radiator raised approximately 40 inches above ground, and the radials sloping downward, away from the antenna. This produced noticeable changes in the length of the radiator, but little noticeable change in the length of the radials, except 17m and 20m.

With these empirical results in hand, we designed the radial system for the HFp such that the three radials were wound on reels with tuning markings. Thus, it's quite easy to unwind just enough radial to tune to the desired band in a matter of seconds. Of course, you could unwind the radial wire all the way and leave it there for each band, with reduced efficiency.

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