Vertical antenna ground system experiment No. 5

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The purpose of this experiment was to evaluate the relative performance of several different elevated radial arrangements for a 1/4-wave vertical.

The "standard" elevated radial scheme has four or more radials elevated above ground by 4' to 10' with the base of the vertical also elevated so that the radial fan or screen is essentially flat. However, for a variety of practical reasons somewhat different radial configurations are often used and it is of some interest to see what effect these variations have on the performance of the antenna.

Description of the experiment

All the experimental runs were done with four 35' radials (except as noted), the length of the vertical set to 34' and a test frequency of 7.2 MHz. The antenna, including radials, was isolated from ground and a common mode choke (balun) used in the feedline.

Measurements of S21 (transmission gain) and Zi (feed-point impedance) were made for each test configuration.

The following radial configurations were used:

1) Radials and vertical base elevated at 48" above ground.

2) The far end of the radials at 48" but the base at ground level.

3) A "gullwing" configuration as suggested by Dean Straw, N6BV, in his Antenna Compendium #6 article "Antennas Here Are Some Verticals On The Beach" and later extensively modeled by Al Christman, K3LC, where the base was at ground level, the radials rising from the base at a 45 degree angle until they reached 48" above ground and the rest of the radials beyond this point were kept at 48" to the far ends.

4) The base elevated to 48" but the far ends of the radials elevated at 12". (remains to be done!)

5) Radial lengths cut to 17.5' (1/8-wavelength). Radial and base height set to 48". Antenna resonated with an inductor.

6) Radials lying on the ground surface and the antenna base at ground level.

Experimental results

The experimental results are summarized in table 1. The values for |S21| are were normalized by setting the value for configuration 1 to 0 dB and the rest the difference between them and configuration 1. Configuration 4 has not been run yet but will be in the near future. A line of data from an earlier experiment has been added for comparison purposes.

Table 1
Experimental results

configuration number	|S21| normalized [dB]	Zi [Ohms]	test configuration
1	0	39 + j 6.3	base and 4 radials elevated at 48"
2	-0.47	36 + j 6.2	base at ground level, radials ends at 48"
3	-0.65	29 - j 11	gullwing, base at ground level radial ends at 48"
4	tbd	tbd	base at 48", radial ends at 12"
5	-0.36	39 + j 0.9	base and radials at 48" radial length = 17.5' 2.2 uH inductor to resonate
6	-5.19	132 + j 22	base and radials on ground surface, four 35' radials
from an earlier experiment	-1.79	51 + j 1	base and radials on ground surface, four 21' radials

For configuration 1, the current division between the radials was measured. Those results are summarized in table 2.

Table 2
Measured current division between radials, normalized to 1A total base current.

Radial number	normalized current [A]
1	0.249
2	0.269
3	0.260
4	0.221

Comments

The most important observation is that radically changing the radial geometry does not seem to have a major impact on |S21|.

Cutting the radial lengths in half (configuration 5) and adding a small loading inductor reduced the gain by only 0.4 dB. The use of shorter radials has been suggested by Weber (K5IU) and Moxon (G6XN) to either make the radial screen footprint smaller and/or reduce asymmetry in the current division between radials.

I was surprised to see that the gain reduction for the gullwing configuration (configuration 3) was slightly worse than simply running the radials straight up to the far end (configuration 2). It may have something to do with the higher feedpoint impedance in configuration 2. In the case of the gullwing, the radials rise rapidly near the vertical resulting in some cancellation between the vertical and radial currents depressing the feed-point resistance. We see a similar effect in top-loaded antennas with sloping wires. But this is just speculation! From the standpoint of keeping the radials above head height for safety reasons, the gullwing is more attractive than just sloping up the radials. For mechanical reasons there are advantages to keeping the base at ground level.

In any case, anything done to get the radial wires away from ground makes a great improvement as can be seen from configuration 6, where the radials are lying directly on the ground surface. Even using shorter, resonant radials on the ground surface is not nearly as effective as simply elevating the radials. Modeling and other experimental work shows that you don't have to get very high to make a substantial improvement but greater heights are used for safety reasons to keep the radials above head height.

One thing missing from this experiment was the use of more than 4 radials. An earlier experiment which compared 4 elevated radials to 8 in configuration 1, showed very little difference in |S21| (about + 0.2 dB) from doubling the radial number. The advantage of more radials is not in additional gain but rather in

reduced radial current asymmetry and a lower Q (more bandwidth) for the antenna.