Measuring Antennas – Part 1

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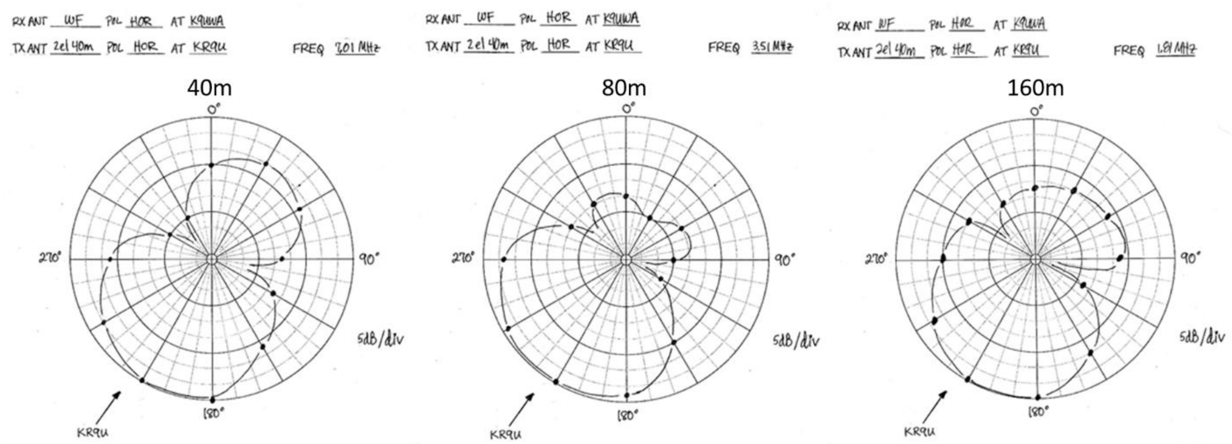
When John K9UWA here in the Ft Wayne area put up his Waller Flag receive antenna at 150 feet for improved receiving capability on 160m (visit http://nx4d10.wixsite.com/waller-flag for more info on the Waller Flag), Jim KR9U and I thought it would be interesting to do azimuth plots of this antenna on 160m, 80m and 40m. Since John mounted his Waller Flag horizontally (like a typical Yagi), we used Jim's 2-element shorty-40 for the transmit antenna to assure horizontal-to-horizontal polarization. The results of our effort are as follows. The patterns are pretty much what we expected for two electrically-small loops fed 180° out-of-phase (which is what the Waller Flag is).



With the Waller Flag at 150 feet, the shorty-40 at 115 feet and the distance between the two at 2.5 miles, it's obvious we measured the azimuth pattern of John's Waller Flag at a very low elevation angle – certainly not in the peak of the main lobe [note 1]. How much do our pattern measurements represent the true far-field azimuth patterns? My guess is it's probably a very reasonable representation. But what's more important to hams is the gain – compared to the gain at the peak of the main lobe, how representative is the gain when it's measured at low elevation angles?

This issue of measuring gain at low elevation angles has been raised before. In the late 1990s Ward Silver NØAX and Steve Morris K7LXC measured and published [notes 2 and 3] gain data on a variety of HF tri-banders. They measured the gain of each tri-bander referenced to a test half-wave dipole antenna. Then they could compare the tri-banders. By the nature of their test set-up (50 foot towers spaced about 1 mile apart), their measurements were also at very low elevation angles – not at the peak of the main lobe. The antenna manufacturer Mosley challenged these results because of not measuring at the peak of the main lobe.

So let's take a deeper look at this. We'll use N6BV's HFTA (High Frequency Terrain Analysis) software to look at the gain difference between a 3-element 20m Yagi and a half-wave dipole, and between a 4-element 20m Yagi and a half-wave dipole. We'll do this at the peak of the main lobe and at a very low elevation angle (per typical in-the-field measurements). We'll look at several different antenna heights, and put the antennas over flat terrain of average soil conditions (conductivity = 0.005 S/m and relative permittivity = 13). The results are as follows.

half-wave dipole

50 feet high	14 MHz	+7.9 dBi at peak	-8.1 dBi at 2^o
75 feet high	14 MHz	+8.1 dBi at peak	-4.6 dBi at 2^o
100 feet high	14 MHz	+8.1 dBi at peak	-2.2 dBi at 2^o

3-element Yagi

50 feet high	14 MHz	+12.5 dBi at peak	-3.3 dBi at 2^o
75 feet high	14 MHz	+12.8 dBi at peak	+0.2 dBi at 2^o
100 feet high	14 MHz	+12.9 dBi at peak	+2.7 dBi at 2^o

4-element Yagi

50 feet high	14 MHz	+14.0 dBi at peak	-1.8 dBi at 2^o
75 feet high	14 MHz	+14.3 dBi at peak	+1.7 dBi at 2^o
100 feet high	14 MHz	+14.4 dBi at peak	+4.2 dBi at 2^o

Going through the math at the peak of the main lobe, the difference in gain between the 3-element Yagi and the 4-element Yagi is 1.5 dB (in favor of the 4-element Yagi) at all heights.

Going through the math at a low elevation angle of 2^o, the difference in gain between the 3-element Yagi and the 4-element Yagi is also 1.5 dB (in favor of the 4-element Yagi) at all heights.

Thus these results for flat terrain and average soil characteristics indicate that measuring an antenna at a low elevation angle is not an issue. Now let's vary the ground conditions, but still use flat terrain. We'll start with very poor soil conditions (conductivity = 0.001 S/m and relative permittivity = 5). The results of this exercise give the same results as over average ground. Regardless of height, the 4-element Yagi has +1.5 dB gain over the 3-element Yagi at both the peak of the main lobe and at the 2^o elevation angle.

Now let's change to salt water (conductivity = 5 S/m and relative permittivity = 80), and still over flat terrain. The results of this exercise also give the same results as over average ground. Regardless of height, the 4-element Yagi has +1.5 dB gain over the 3-element Yagi at both the peak of the main lobe and at the 2^o elevation angle.

In summary, over flat terrain, when you measure the gain of an HF antenna at a low elevation angle, it should be equal to the gain when measured at the peak of the main lobe. Thus you don't have to put up an extremely tall tower to get into the peak of the main lobe.

That's enough for this month. We'll continue next month with the antennas over terrain that is not flat.

Notes

1. The horizontal Waller Flag at 150 feet would have the peak of its main lobe at 32 degrees on 160m, at 22 degrees on 80m and at 12 degrees on 40m. Thus the shorty-40 would have to be at 8250 feet on 160m, at 5333 feet on 80m and at 2812 feet on 40m to measure at the peak of the main lobe of the Waller Flag.
2. NØAX and K7LXC, HF Tribander Performance – Test Methods & Results, Champion Radio Products, 1998
3. NØAX and K7LXC, HF Tribander Performance – Test Methods & Results 2nd Edition, Champion Radio Products, 1999