Measuring Antennas – Part 2

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The summary from last month's column was:

When measuring the gain of a horizontally-polarized HF antenna over flat terrain at a low elevation angle, it should be equal to the gain when measured at the peak of the main lobe – regardless of the ground parameters.

This month's column continues by looking at non-flat terrain. We'll start with average ground (conductivity = 0.005 S/m and relative permittivity = 13) that slopes down (10 feet down for every 200 feet away from the antenna support). And as last month, we'll use N6BV's HFTA (High Frequency Terrain Analysis) software to compare a 3-element Yagi to a 4-element Yagi. The results of this are as follows:

Gain of 4-element Yagi over 3-element Yagi – average ground and downslope

50 feet high	14 MHz	+1.5 dB at peak of lobe	+1.5 dB at 2°
75 feet high	14 MHz	+1.5 dB at peak of lobe	+1.5 dB at 2°
100 feet high	14 MHz	+1.5 dB at peak of lobe	+1.4 dB at 2°

These results conform to the summary above. I could have continued to look at more scenarios, but I asked myself if anything was going to change based on the results so far. This got me thinking. What would cause one antenna to perform differently than another antenna at low elevation angles compared to the peak of the lobe?

The answer has to be how the free-space H-plane patterns of the two antennas differ. With respect to my results so far, it appears that the difference in the free-space H-plane patterns of the 3-element Yagi and the 4-element Yagi in HFTA was not significant enough to show up in my results.

To try to confirm this, I read through the HFTA documentation. Unfortunately all that's given is the following table.

Free-Space Gain (dBi) and Boomlengths on 20 Meters

Antenna	*Dipole*	*2-Ele.*	*3-Ele.*	*4-Ele.*	*5-Ele.*	*6-Ele.*	*8-Ele.*
Gain	2.15	5.5	7.0	8.5	9.5	11.0	12.0
20 m Boom	–	8'	16'	26'	40'	60'	80'

Next I did a plot in Excel of the gain versus the boom length of the HFTA Yagi antennas. I compared this plot to the plot of gain versus boom length in Figure 2.12 in **Yagi Antenna Design** [note 1]. The two plots compared favorably, so I then looked at the H-plane patterns of the practical 3-element and 4-element designs in **Yagi Antenna Design**. The difference in the half-power H-plane beam widths was on the order of 15° (100° for the 3-element design and 85° for the 4-element design).

My conclusion from this exercise is that I did not see much of a difference in the gain of the 3-element Yagi and 4-element Yagi at the peak of the lobe and at a 2° elevation angle because the H-plane patterns were not different enough – which is what I suspected.

To see a significant difference between the peak lobe gain and the low elevation angle gain, I assumed I'd have to look at two vastly different antennas in HFTA. Going to the extreme, we'll compare the peak lobe gain and the low elevation angle gain of a dipole at three heights to an 8-element Yagi at the same three heights. I estimate the difference in the H-plane beam widths of these two antennas is at least 50°. The antennas will be over flat terrain and average ground. The following table summarizes this exercise.

Gain of an 8-element Yagi over a dipole – flat terrain

height	band	gain of Yagi over dipole	gain of Yagi over dipole	delta
50 feet	14 MHz	+9.2 dB at peak of lobe	+9.8 dB at 2°	0.6 dB
75 feet	14 MHz	+9.5 dB at peak of lobe	+9.8 dB at 2°	0.3 dB
100 feet	14 MHz	+9.7 dB at peak of lobe	+9.9 dB at 2°	0.2 dB

Now we're seeing a noticeable difference in the gain at the peak of the lobe compared to the gain at 2°. And the difference is the largest (at least on 14 MHz) at the lowest height. I also checked using the downslope terrain, and the delta is a couple tenths of a dB worse.

Since the lowest height showed the greatest difference, I did a run with the dipole and 8-element Yagi mounted at 35 feet over flat terrain and average ground. The difference in gain between the dipole and 8-element Yagi at the peak of the lobe compared to the gain at 2° was 1.4 dB. That's a sizeable difference.

It's clear to me now that Mosley has a valid concern when not measuring at the peak of the lobe (as mentioned in last month's column) – but it depends on the free-space H-plane patterns of the antennas. If they're similar enough, my summary at the beginning of this month's column is correct. If they're not, well, watch out.

Although two vastly different antennas will show a difference in gain at the peak of the lobe compared to the gain at a low elevation angle, I believe this could still be a problem with antennas of similar gain depending on how the gain is achieved. I suspect one antenna could have a wide H-plane beam width and a narrow E-plane beam width, while the other antenna could have a narrow H-plane beam width and a wide E-plane beam width.

They then could have similar peak lobe gains, but show different low angles gains. Antennas that might be interesting to look at with respect to this issue are:

1) A single-drive antenna versus a dual-drive antenna

2) A maximum gain Yagi that compromises bandwidth versus a maximum bandwidth Yagi that compromises gain

The bottom line here is to be suspicious of your results if you're measuring gains at low elevation angles in an attempt to validate the gains at the peak of the lobe. And be especially aware of non-flat terrain in between the antennas and ground with different characteristics in between the antennas.

Notes:

1) Dr. James L. Lawson W2PV, **Yagi Antenna Design**, American Radio Relay League, 1986