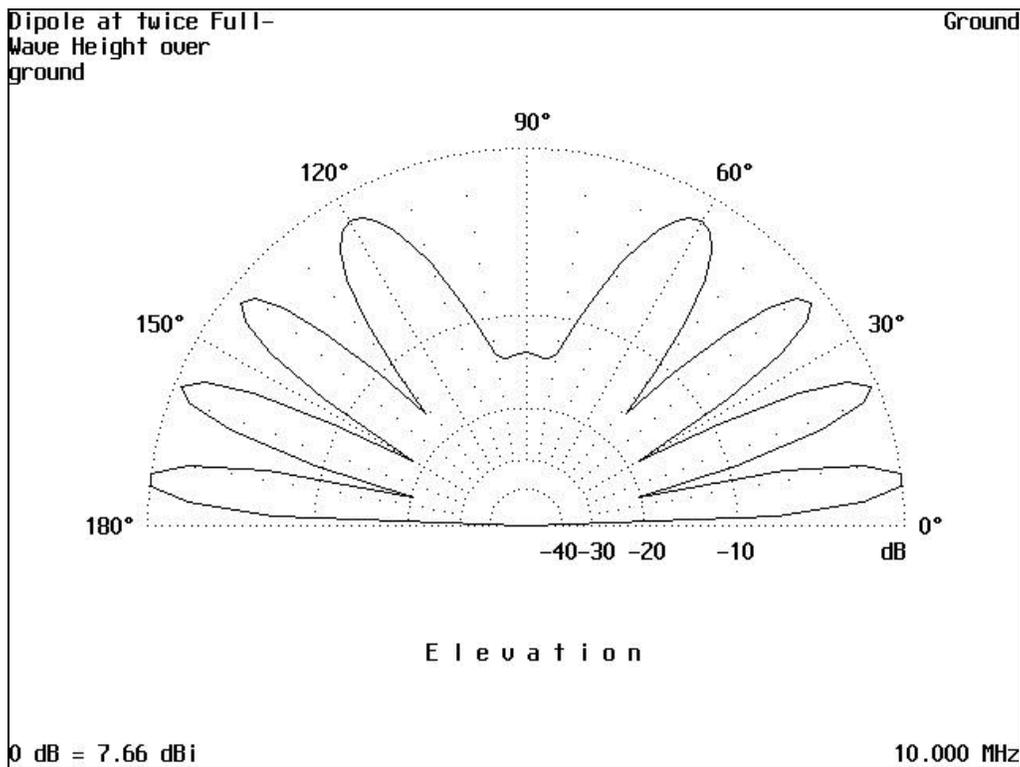


# HFp Antennas

## Dipole Antenna Radiation Patterns

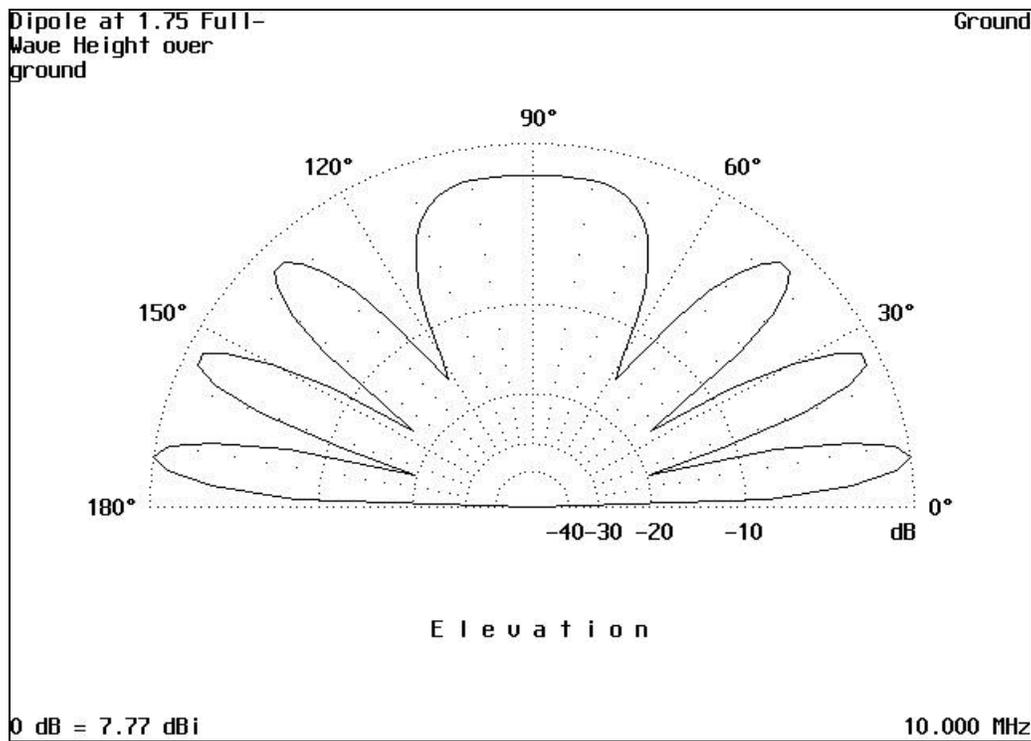
Much confusion exists about the radiation patterns of antennas. In particular, the horizontal dipole is misunderstood by most who use it. It is generally assumed that a horizontal dipole has a radiation pattern which aims most of its signal toward the horizon, perpendicular to the line of the antenna. As we will see here, that is only true in one particular circumstance, and, even then, not quite an accurate picture.

Following is a series of dipole radiation pattern plots, produced by a popular antenna modeling program. The first shows a dipole at an elevation of two wavelengths above a standard earth ground model.



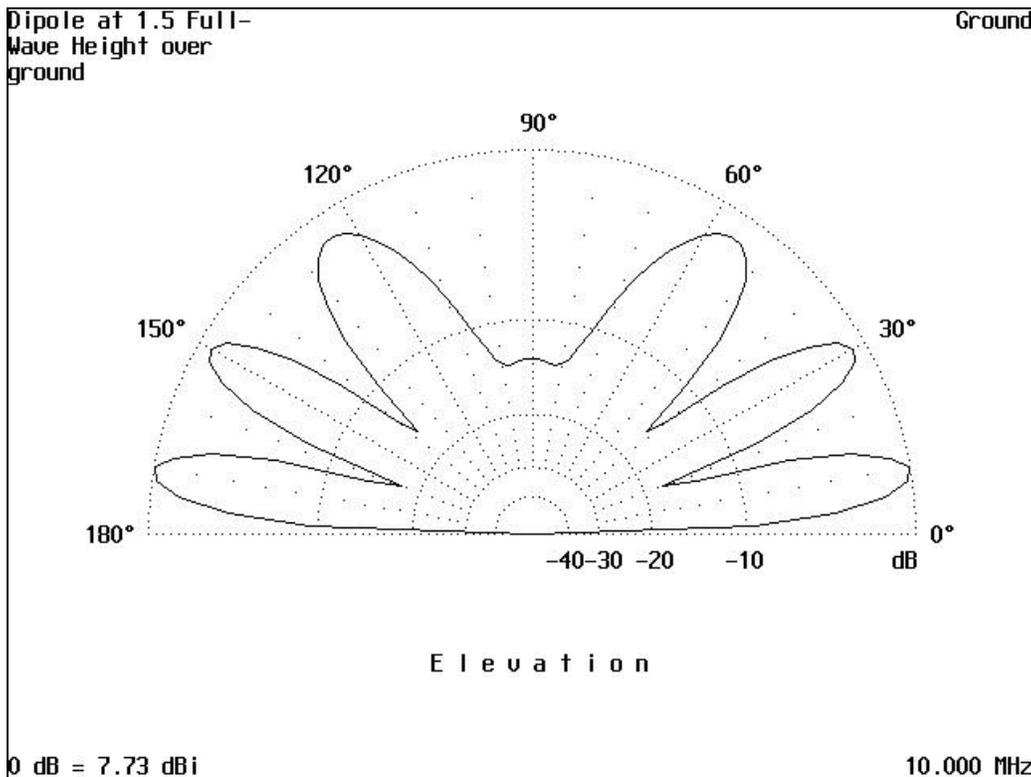
Note the multiple lobes at varying elevation angles above the horizontal. These lobes represent a division of the radiated energy, so that much energy is sent off at angles which may not be helpful to the particular communication in progress. In addition, the nulls represent angles at which no energy is transmitted. Depending on the height of the ionosphere, and the location of the distant target station, the null may exist at the precise angle necessary to effect the desired contact.

The next plot shows the dipole at 1.75 times the wavelength above the earth.

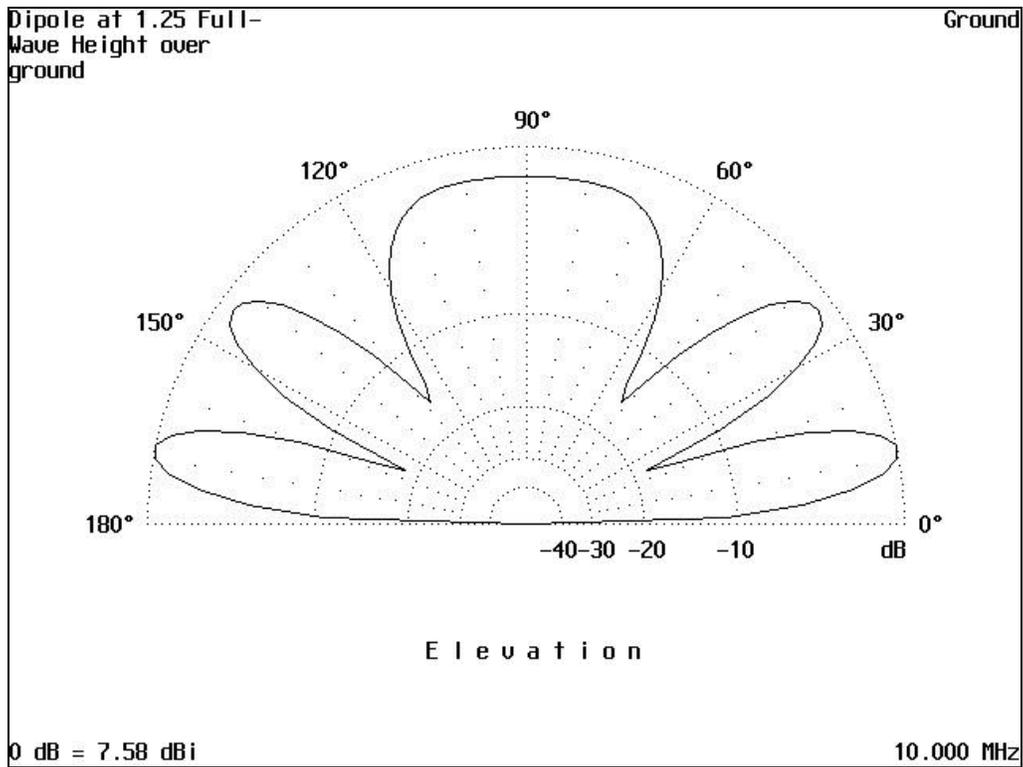


There are fewer lobes and fewer nulls, but they are still present. In addition, two of the upper lobes have moved up and merged to produce a single, wide lobe aimed straight up.

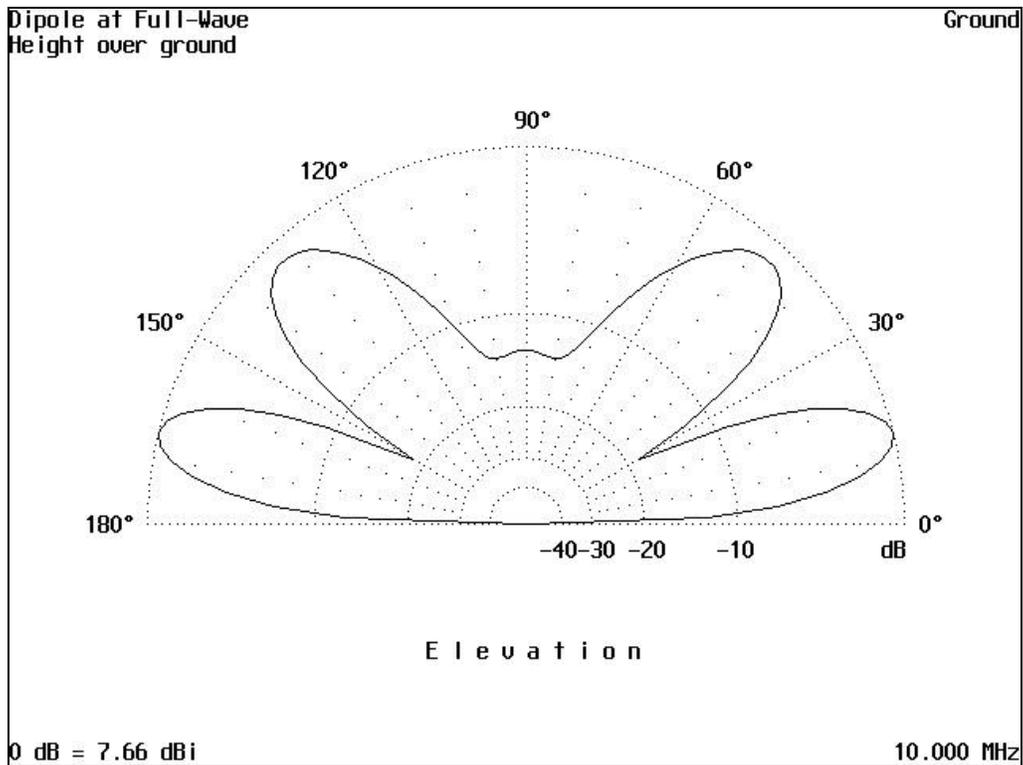
Next is the dipole at 1.5 wavelengths elevation.



Again, fewer nulls and lobes, but still not necessarily concentrating the energy in the desired direction. Next is the dipole at 1.25 wavelengths high.

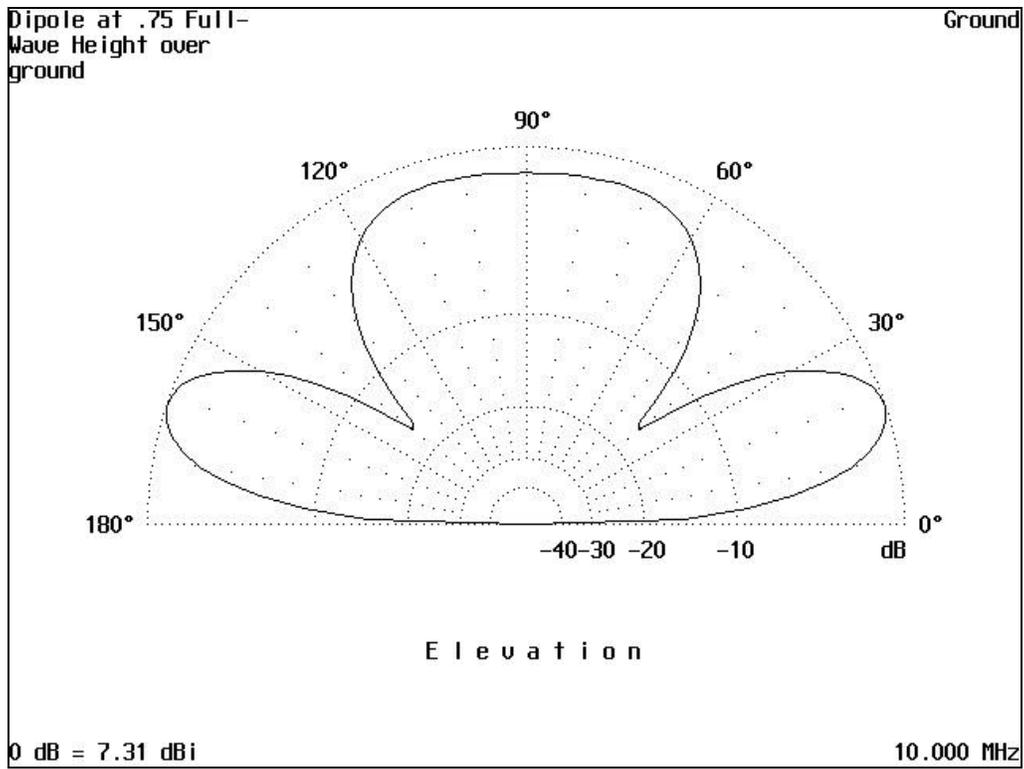


The large vertical lobe is back, and the nulls and lobes are fewer, but still not the expected pattern. Next is the dipole at 1 wavelength high.

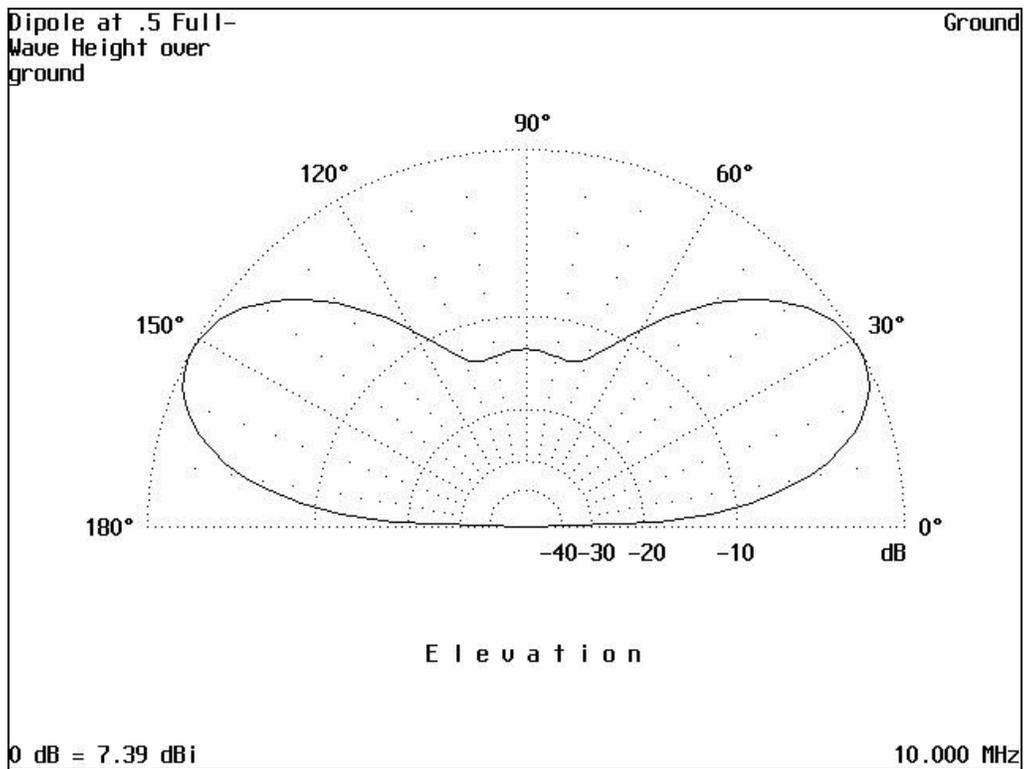


By now, we should be noticing a sequence to the patterns. As we lower the antenna, the lobes move higher, combine and disappear.

Next is the dipole at .75 wavelength.

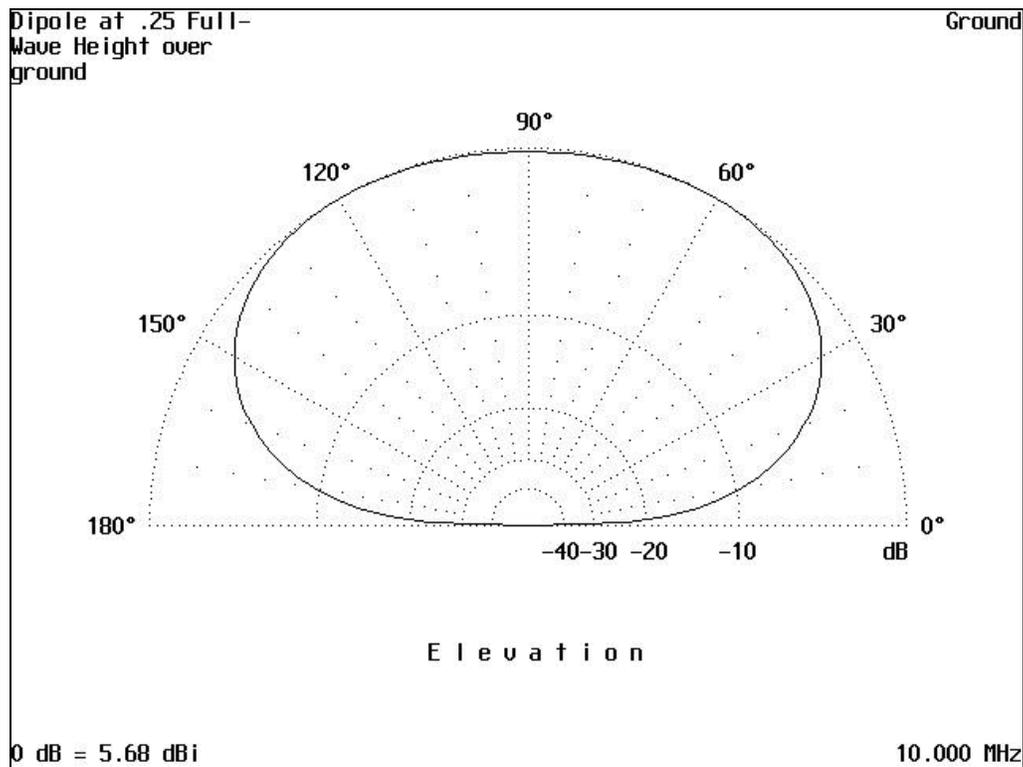


And, the dipole at .5 wavelength over the ground.



Finally we see a pattern that looks somewhat like what we expected. But, notice that, rather than the energy being directed at the horizon, the peak of the pattern is elevated at about a 30 degree angle (actually 28 degrees). However, the lobe is broad enough so that there is considerable signal strength from about ten degrees to about 55 degrees elevation - the 6 dB down points on the lobe. Remember that 6 dB represents one "S" unit on the signal level meter of most HF receivers. Thus, for a quite broad range of elevation angles, and for a correspondingly broad expanse of geographical area covered by the signal reflected off the ionosphere, there is substantial signal strength.

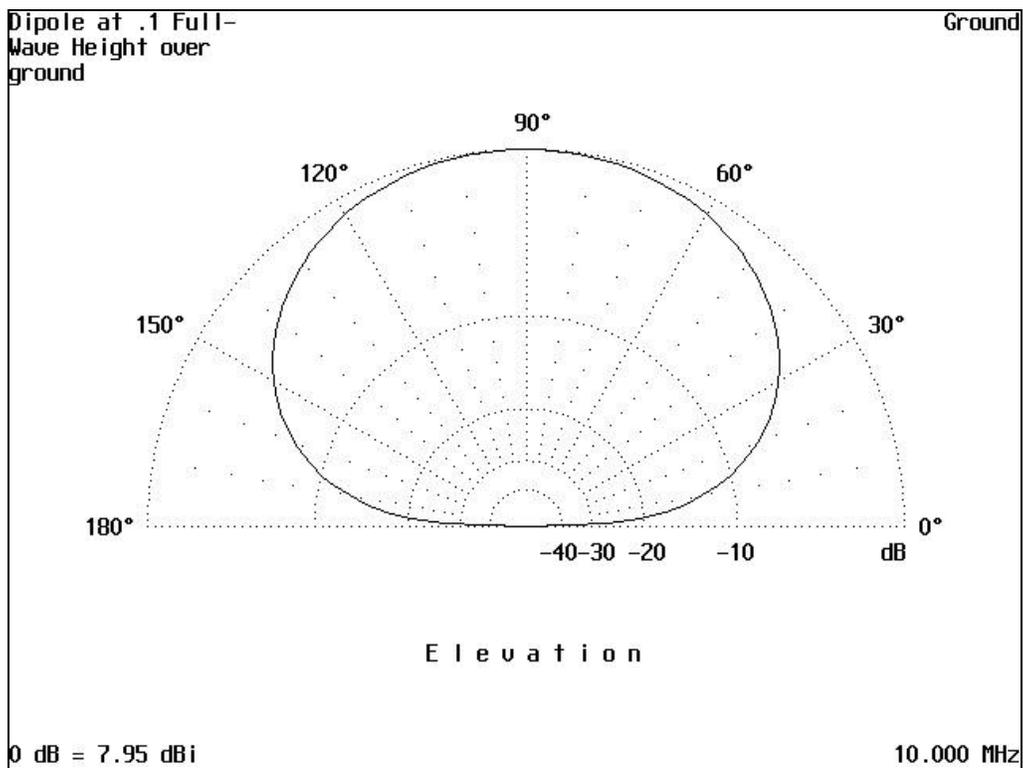
As we continue to lower the dipole, we continue to see the now familiar raising and combining of the lobes, until, at .25 wavelength, the lobes have combined to produce a single broad peak, aimed straight up.



Clearly, this is not going to make for great DX communications, with most of the energy concentrated above the 30 degree elevation angle. But, notice that there is still considerable energy directed even as low as 15 degrees – the 6 db down point.

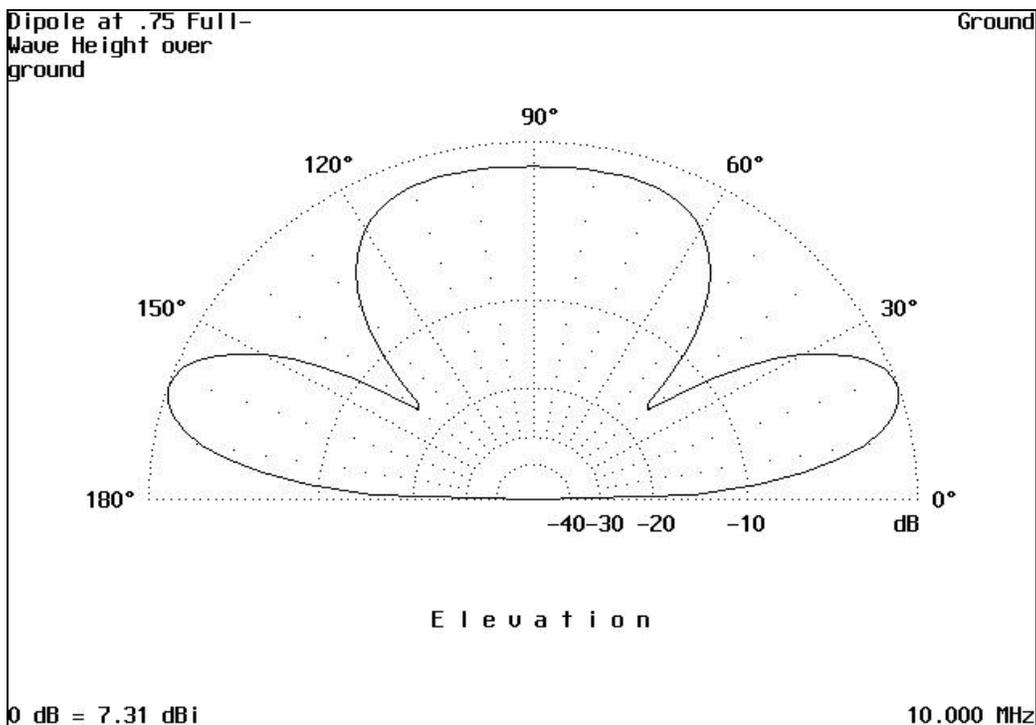
This is the radiation pattern which is normally used for NVIS operations. NVIS stands for Near Vertical Incidence Skywave. Below a certain critical frequency (which depends on the density of the ionization in the ionosphere), a signal directed straight upward will be reflected back down into an area near the transmitter. This can allow communications within a 100-200 mile radius of the transmitter – the area normally skipped over by signals transmitted from the dipole at lower radiation angles (generated by higher positions above ground). NVIS antennas are normally elevated at about .1 to .25 wavelength above the ground.

The next plot shows the dipole at .1 wavelength.



At .1 wavelength, we see the single lobe even more tightly pointed up, with the 6 dB points now at about 25 degrees. This appears to be a very good NVIS antenna. But, as we will shortly see, there is another factor involved – the antenna’s impedance.

Before we leave the NVIS discussion, lets go back and look at the .75 wavelength elevation pattern.



Notice that this pattern has both the low-angle lobes and a broad vertical lobe. The vertical lobe is about 2 dB below the low-angle lobes – an almost insignificant difference in signal strength. It may be that a dipole at .75 wavelength height over ground is the best of all possible setups, providing both DX communications and NVIS communications at the same time.

## Dipole Impedance

One other factor should be discussed – the antenna feed point impedance. A dipole’s impedance varies according to its height above the ground. The following chart shows the variations in impedance as the dipole is lowered from .5 wavelength above ground to .1 wavelength. For each calculation, the antenna’s length was adjusted for best SWR, using 50 Ohms as the reference impedance. The calculated dipole was modeled using #12 wire for the elements.

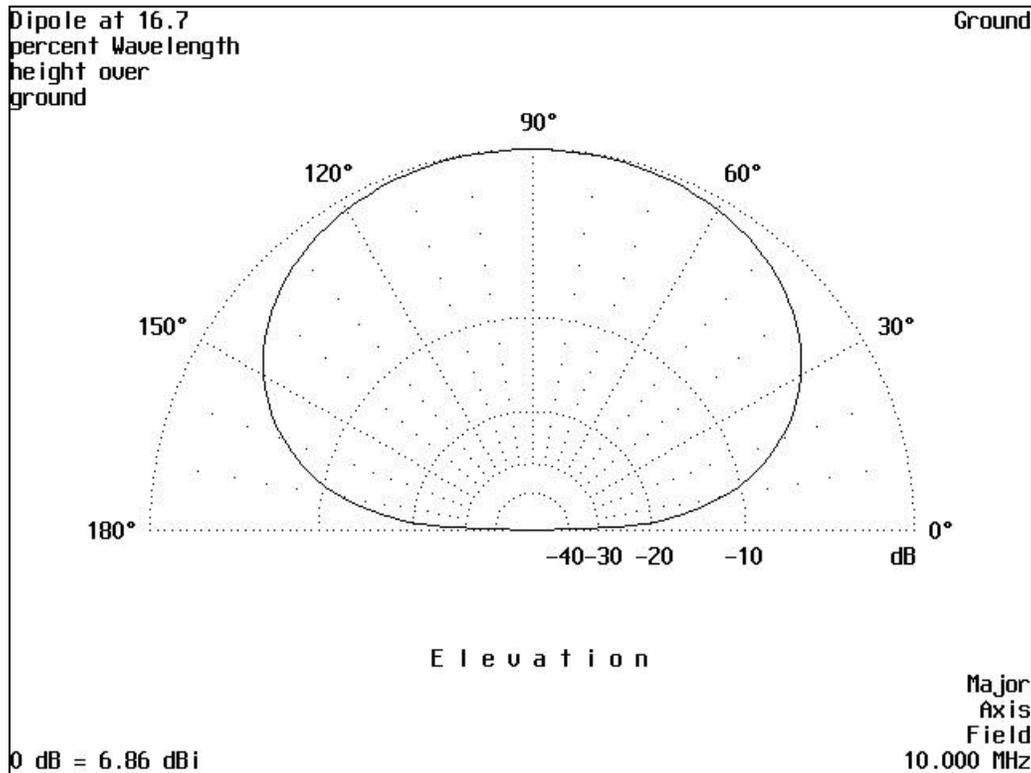
<b>Dipole Impedance versus height</b>		
<b>(Antenna adjusted for best SWR)</b>		
<b>% W/L</b>	<b>Feed Z</b>	<b>SWR</b>
50	70.4	1.41
45	81.8	1.64
40	92.0	1.84
35	96.9	1.94
30	93.9	1.88
25	82.5	1.65
20	64.5	1.29
15	43.0	1.16
10	21.9	2.28
5	6.6	7.58
1	1.2	41.67

## The Best Dipole Setup

Note that, somewhere between 20% and 15% wavelength height, the dipole’s impedance crosses 50 Ohms. If we specifically calculate for the 50 Ohm point, we discover that, at a height of 16.7 % wavelength, with a length of 47.4 % wavelength, we get an antenna setup which exactly matches 50 Ohms. The following chart shows the 16.7 % / 47.4 % dimensions for various Ham frequencies in the HF bands.

<b>Best Dimensions (Feet)</b>		
<b>Freq (MHz)</b>	<b>16.70%</b>	<b>47.40%</b>
3.6	45.7	129.6
3.8	43.3	122.8
7.2	22.8	64.8
10.125	16.2	46.1
14.1	11.7	33.1
14.3	11.4	32.4
18.125	9.1	25.7
21.25	7.7	22.0
24.5	6.7	19.0
28.5	5.8	16.4
29.5	5.6	15.8

The radiation pattern for a dipole set up according to the 16.7% / 47.7% chart looks like this:



This is not the ideal DX antenna, but it does provide good signal strength at reasonably low angles (6 dB down at 20 degrees elevation angle). It is essentially the same pattern as the .25 wavelength height dipole, but with the benefit of being matched to 50 Ohms. In addition, it provides a very broad NVIS signal lobe. This looks like a good compromise between both modes, and is fairly easy to set up on frequencies above 10 MHz. At lower frequencies, the height above ground becomes a problem to achieve with a reasonable support structure.

## The HFp Dipole

For the HFp Dipole, the element length is set according to the element chart in the Dipole instructions. The 16.7% wavelength antenna height for each band is listed here:

- 80 Meters (3.6 MHz) – 45.7 Ft. high
- 75 Meters (3.8 MHz) – 43.3 Ft. high
- 40 Meters (7.2 MHz) – 22.8 Ft. high
- 30 Meters (10.125 MHz) – 16.2 Ft. high
- 20 Meters CW (14.1 MHz) – 11.7 Ft. high
- 20 Meters SSB (14.3 MHz) – 11.4 Ft. high
- 17 Meters (18.125 MHz) – 9.1 Ft. high
- 15 Meters (21.25 MHz) – 7.7 Ft. high
- 12 Meters (24.5 MHz) – 6.7 Ft. high
- 10 Meters low (28.5 MHz) – 5.8 Ft. high
- 10 Meters high (29.5 MHz) – 5.6 Ft. high

## Conclusions

A dipole antenna in free space exhibits a feed impedance of 72 Ohms, and has a doughnut-shaped radiation pattern. But, as the dipole is brought close to the earth, the radiation pattern changes, and the feed point impedance also changes. An awareness of these changes can help ease the task of setting up a dipole for communications. And, careful selection of the dipole's position above the ground can make its impedance exactly match the impedance of the feed line used.

For me, one of the fun aspects of antennas is that they are still “magical”. There is a lot of art involved in their design, setup and operation, compared to much of digital electronics, where it is almost literally “plug-and-play”. But, at the same time, when you are trying to make an HF contact, the “magic” can quickly turn to frustration when things don't work as expected. Perhaps this discussion will help reduce some of the frustrations, let you make that rare DX contact, and bring back some of the “magic”. I had fun creating this report, and I hope you have fun using it!

73,

John, WB4YJT

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