

## THE HALF WAVE DIPOLE (HERTZ ANTENNA)

The dipole antenna dates back to the early RF experiments of Heinrich Hertz in the late 19<sup>th</sup> century. It consists of a conductor that is broken in the center so that RF power can be applied to it. One can think of the half wave dipole as an open circuited transmission line that has been spread out, so that the transmission line can radiate a signal into space.



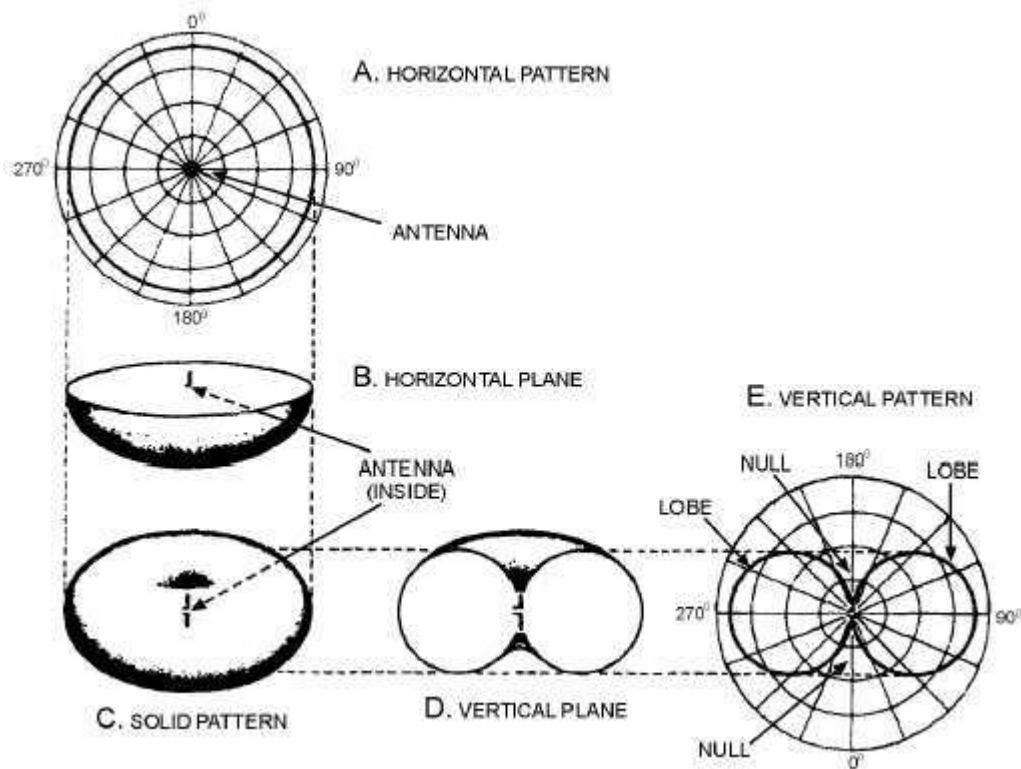
A dipole can be any length, but it most commonly is just under 1/2 wavelength long. A dipole with this length, known as a resonant or half wave dipole, has an input impedance that is purely resistive and lies between 30 and 80 ohms, which provides a good match to commercially available 50 ohm coaxial cables as well as commercial transmitters and receivers, most of which have 50 ohm output and input impedances. The length of a dipole can be approximately determined from the following formula:

$$l = 468/f$$

where:

l is the length in feet and  
f is the frequency in MHz.

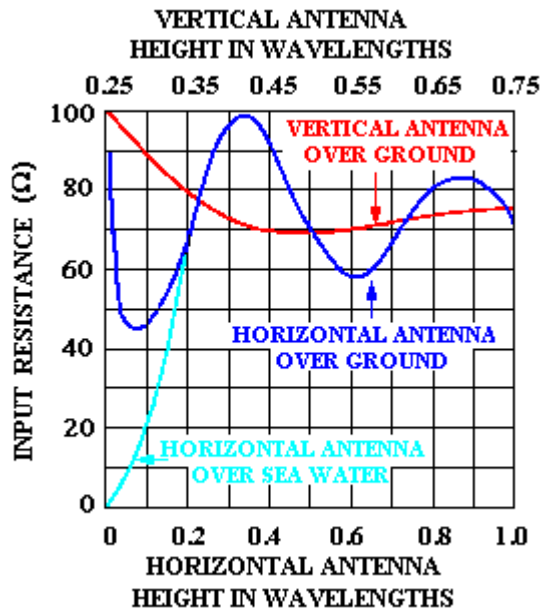
The radiation pattern of a  $\lambda/2$  dipole in free space is shown below



The 3-dimensional radiation pattern in free space is a fat doughnut with the dipole piercing its central hole. Notice that unlike an isotropic radiator that radiates equally well in all directions, the dipole radiates more RF in some directions than others. This means that the dipole has a gain or directivity over an isotropic radiator of approximately 2.1 dB. That means that the radiation from the dipole is 2.1 dB stronger in the direction of maximum radiation than the radiation from an isotropic radiator in the same direction, when both antennas are fed with the same amount of RF power..

The input impedance of a dipole antenna also depends on its electrical length. When the antenna is approximately an odd multiple of a half wavelength long, the input impedance is resistive and lies between 50 and 200 ohms. For antennas that are an even number of half wavelengths long, the input impedance is resistive and extremely high, between 1000 and 50,000 ohms.

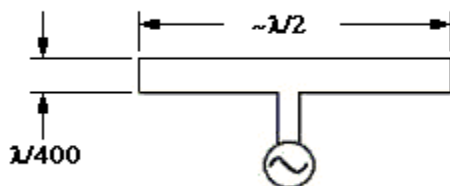
The chart below shows the effect of ground on the input impedance of a dipole.



As a horizontal antenna is brought closer to the surface of the earth, its input resistance decreases at first because the electric field is being shorted by the ground. As the antenna is brought closer, the input resistance will rise again because increases in ground loss resistance overwhelm the decrease due to shorting of the electric field. Over a good conductor such as sea water, the input resistance drops steadily as the antenna is lowered, reaching a value of zero when the antenna touches the water's surface.

As a horizontal dipole is raised above the ground, the input resistance increases until a maximum value of approximately 90 ohms is reached at a height of  $3/8 \lambda$ . As the antenna is raised even higher, the input resistance slowly oscillates around the free space value of 73 ohms. Most dipoles in actual installations show an input resistance of 50 to 75 ohms, depending on the location.

There is a variation of the  $\lambda/2$  dipole known as the folded dipole that is often used for FM and TV reception. A diagram of the folded dipole is shown below.



The folded dipole is the same overall length as the  $\lambda/2$  dipole, but has a second conductor connected to the first only at the ends, and separated from it by

approximately  $\lambda/400$ . The input impedance of the folded dipole is approximately 300 ohms, which is a perfect match to TV twin lead and to the input of the TV set. The folded dipole also has a larger bandwidth than the regular dipole, which is important for proper TV reception.

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