EXPERIMENT NO. 2

Design of Half-wave dipole and Quarter-wave monopole antenna

Aim : To design and compare the performance of half-wave dipole and quarter-wave monopole antenna.

Software Tool: 4nec2 (Numeric Electromagnetic Coder)

Theory

The half-wave dipole antenna is just a special case of the dipole antenna. The term "half-wave" means that the length of this dipole antenna is equal to a half-wavelength at the frequency of operation. a simple half-wavelength wire fed at the center as shown in Figure 1:

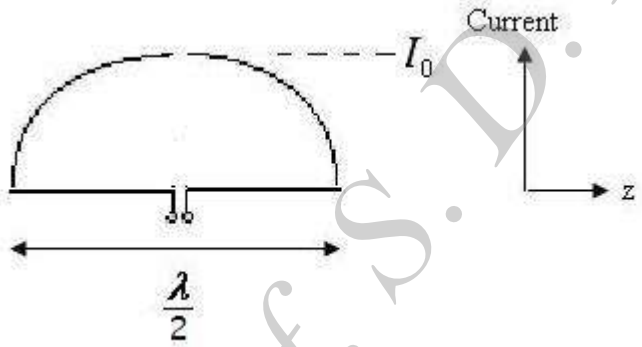


Fig.1 Half-wave dipole configuration with typical current distribution

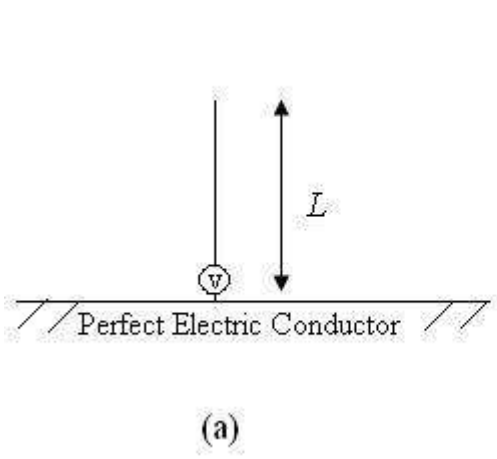
The input impedance of the half-wavelength dipole antenna is given by Zin = 73 + j42.5 Ω. The fields from the half-wave dipole antenna are given by:

$$E_\theta = \frac{j\eta I_0 e^{-jkr}\cos\left(\frac{\pi\cos\theta}{2}\right)}{2\pi r\sin\theta}$$

$$H_\phi = \frac{E_\theta}{\eta}$$

The directivity of a half-wave dipole antenna is 1.64 (2.15 dB). The HPBW is 78 degrees. In viewing the impedance as a function of the dipole length, it can be noted that by reducing the length slightly the antenna can become resonant. If the length of a dipole is reduced to 0.48λ, the input impedance of the antenna becomes Zin = 70 Ω, with no reactive component. This is a desirable property since the antenna will be better matched to the radio (transmitter or receiver), and hence is often done in practice for thin dipoles. The radiation pattern remains virtually the same.

A monopole antenna is one half of a dipole antenna, almost always mounted above some sort of ground plane. The case of a monopole antenna of length L mounted above an infinite ground plane is shown in Figure 2(a).



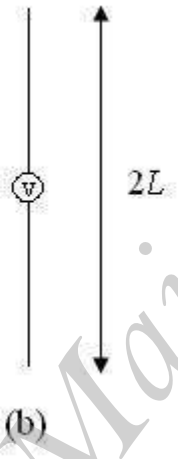


Figure 2. (a) Monopole above a PEC Figure 2. (b)equivalent source in free space

Using image theory, the fields above the ground plane can be found by using the equivalent source (antenna) in free space as shown in Figure 2(b). This is simply a dipole antenna of twice the length. The fields above the ground plane in Figure 2(a) are identical to the fields in Figure 2(b). The monopole antenna fields below the ground plane in Figure 2(a) are zero.

The radiation pattern of monopole antennas above the ground plane are also known from the dipole result. The only change that needs to be noted is that the impedance of a monopole antenna is one half of that of a full dipole antenna. For a quarter-wave monopole (L=λ/4), the impedance is half of that of a half-wave dipole, so, Zin = 36.5 + j21.25 Ω. This can be understood since only half the voltage is required to drive a monopole antenna to the same current as a dipole (think of a dipole as having +V/2 and -V/2 applied to its ends, whereas a monopole antenna only needs to apply +V/2 between the monopole antenna and the ground to drive the same current). Since, Zin = V/I, the impedance of the monopole antenna is halved.

The directivity of a monopole antenna is directly related to that of a dipole antenna. If the directivity of a dipole of length 2L has a directivity of D_1 [decibels], then the directivity of a monopole antenna of length L will have a directivity of D_1+3 [decibels]. That is, the directivity (in linear units) of a monopole antenna is twice the directivity of a dipole antenna of twice the length. The reason for this is simply because no radiation occurs below the ground plane; hence, the antenna is effectively twice as "directive".

Monopole antennas are half the size of their dipole counterparts, and hence are attractive when a smaller antenna is needed. Antennas on older cell phones were typically monopole antennas, with an infinite ground plane approximated by the shell (casing) of the phone.

(Students are supposed to attach the output pages here).

Observations:

Sr. No.	Parameter	Half-wave dipole	Quarter-wave monopole
1	Gain		
2	HPBW		
3	Impedance		

Conclusion

By performing this experiment, we can design dipole and monopole antennas as well as observe and compare the radiation patterns of dipole and monopole antennas through 4nec2 simulation. From simulation results, we can observe that, directivity of half-wave dipole is approximately 1.64 (2.15 dB) whereas that of quarter-wave monopole is approximately 3.29 (5.18dB).