Chapter 4
Azimuth and Elevation Patterns for Log Periodic Dipole Array in VHF Range Associated with Two Satellites

4.1 Introduction

The simulation of Azimuth and Elevation pattern for Log Periodic Dipole Array (LPDA) in VHF range at Kalyani, West Bengal has been analyzed for observing solar radio bursts. The structure is devised so as to make it an excellent wind proof system consisting of two logarithmic periodic dipole antennas which cross each other and are positioned in the north-south and east-west directions respectively. The alterations of vertical along with the horizontal azimuth patterns and gain for diverse frequencies are analyzed in details. Moreover the variation of elevation patterns at 163° and 167° azimuth along with gain for different frequencies have been analyzed. The LPDA was first introduced by Raymond DuHamel and Dwight Isbell [1] at the University of Illionis, and in the year 1960 Isbell illustrated the first log-periodic dipole array. Thereafter, Carrel investigated the LPDA and found out its radiation pattern, input impedance, etc., by means of a digital computer [2]. If the LPDA’s input impedance is represented as a function of frequency, it will appear to be repetitive. Azimuth is a horizontal angle, which we normally measure from the true north whereas the elevation angle is a vertical angle, which ranges from 0 degree (horizon) to 90 degree (zenith). On incising the 3D pattern throughout an orthogonal plane i.e. the X-Z plane or the Y-Z plane, elevation plane pattern is got. The azimuth plane pattern is got on incising the 3D pattern all throughout the horizontal X-Y plane.

Antenna plays an indispensable part in determining the direction of the azimuth as well as elevation plane patterns. In this chapter the findings of simulation of azimuth and elevation patterns of radiation which are associated with log periodic dipole array (LPDA) are exemplified. So as to study about radiation from antennas, it is required primarily to specify the coordinate systems for explaining the antenna and the correlated electromagnetic fields. The greatly recognized coordinate structure for this kind of assignment is the spherical coordinate system as at a particular localized source of electromagnetic emission or the electromagnetic fields decay inversely with radial distance when it is at a substantial distance from the antenna [3-6]. The ordinary spherical coordinate mechanism is made up of three factors like radial distance, azimuth and elevation angles. A straight line from the origin to the point and Z-axis forms an angle known as the elevation angle while the projection of the referred line in the X-axis and X-Y plane creates the azimuthal angle.
4.2 Polarization

The orientation of the field vector (magnetic or electric field vector) of an electromagnetic wave is known as polarization. It is generally explained by an ellipse. The antenna that originates the waves into space establishes the primary polarization of a radio wave. An antenna will create an E.M wave that changes periodically as it progresses through space. An alteration in polarization may occur by the environment through which the radio wave passes on its way from the transmit antenna to the receiving antenna. Linear and circular polarization is normally employed in specific cases of elliptical polarization. The field vector shares the similar plane with linear polarization. If a wave moving “outward” alters “up and down” in time with the electric field always in one plane, that wave (or antenna) is called linearly polarized. It is vertically polarized as the wave shifts upwards and downwards only. Vertically or horizontally polarized wave means that the field vector is vertical or horizontal relating to the ground. The wave rotates with the progress of time as it passes through space, so the wave is elliptically polarized. The wave is identified as circularly polarized provided the wave rotates in a circular way. The electric field vector is seen as spinning in a circular way around the path of propagation, creating a complete turn in case of every individual RF cycle and so it is circularly polarized.

The rotation may be right-hand or it may also be left-hand. The polarization in same plane to the polarization being said about is co-polarization. As for illustration, in case the antenna’s fields are horizontally polarized, the co-polarization is also horizontally polarized. Cross polarization is that polarization which is in an orthogonal position to the polarization when the fields of an antenna are seen to be horizontally polarized, so it is acknowledged as vertical polarization. There are certain antennas which are susceptible to typical sorts of E.M waves. The practical inference of this notion is that antennas with the same polarization give the best transmission or reception path. We can take into consideration antennas that generate and are sensitive to linearly polarized waves. If a linearly polarized E.M wave shifting up and down or vertically is originated by a linearly polarized antenna, an excellent receiver of that electromagnetic wave will resemble a new antenna which is linearly polarized in an alike way i.e. vertically polarized. Linear polarization also consists of the chance of the electromagnetic waves moving “right to left” (horizontally) as well. Frequently antennas can simply be physically rotated to make them horizontally or vertically polarized, even though this may not always be the finest choice. The electromagnetic waves radiated by the circularly polarized antennas spin clockwise or counterclockwise depending on the built up. Hence an identical sort of polarized antenna should be employed to find these signals.

This direction of rotation is generally distinguished by left circular polarization or right circular polarization. It is to be remembered that antenna’s polarization is not at all times anything about the size or shape of the antenna. A dipole is normally designated
as vertically polarized because the manner a dipole is usually employed, that is, it is kept vertically, however the antenna is linearly polarized. Similarly, antennas that are circular in their built up do not have to be circularly polarized. Many circular patches are linearly polarized while other rectangular patches are circularly polarized. These illustrations are simple explanation of the fact that the polarization state of an antenna is not associated to its shape.

4.3 Antenna Radiation Patterns

When a signal is fed into the antenna, it emits radiation which is circulated in space in a distinct manner. The antenna’s radiation features shown graphically as a function of space coordinates is the antenna radiation pattern [7]. In the majority of cases the pattern of radiation is determined in the zone of far-field and radiation features comprise of power flux density, radiation intensity, field strength, directivity, phase or polarization. The spatial allocation of emitted energy as a function of the spectator’s position by the side of a path or surface of constant radius is the most important radiation characteristic. To elucidate the radiated power in the far-field area nearly the antenna, two types of radiation patterns are generally employed [8,9]. The magnitude of magnetic together with electric field represented as a function of the angular space is called as field pattern while the square of the magnitude of magnetic along with electric field represented as a function of angular space is known as the power pattern. The E-plane encompasses the E-field vector which is not only the electric field but also the way of the greatest radiation. At ninety degrees to the E-plane, there is the H-plane which encompasses the magnetic field (H-field) vector and direction of highest emission. The distribution of radiation pattern is dependent on the purpose for which an antenna will be utilized.

The three dimensional pattern is decomposed into two orthogonal patterns in E-field and H-field planes where the Z-axis is the line connecting the transmitting and receiving antennas and perpendicular to the radiating apertures. The 3-D graphical demonstration of an antenna’s radiation far-off from the origin is its radiation pattern. In fact, the antenna pattern becomes three dimensional as the antenna emits energy in all directions, at least to some limit. It also represents the manner in which the antenna discharges energy into space. The azimuth plane pattern is determined when the measurement is made covering the complete X-Y plane about the antenna under experiment. Elevation plane is the plane which is in the Y-Z plane, where Φ = 90 degrees. The pattern of elevation plane comprises the whole Y-Z plane about the antenna under experiment. The azimuth and elevation plane patterns which are together known as the antenna patterns are normally described as plots in polar coordinates. This provides us the capacity to simply imagine how the antenna emits in each direction when the antenna was mounted for recording the radio burst data.
4.4 Simulation Results

The time-shared LPDA have been designed and built at Kalyani (22.98°N, 88.46°E) in the Department of Physics, Kalyani, West Bengal [10]. The variation of vertical and horizontal azimuth patterns at different frequencies is shown in Figure 4.1 and Figure 4.2 respectively. On the other hand, Figure 4.3 and Figure 4.4 illustrate the variation of Gain with azimuth angle at various frequencies for vertical and horizontal azimuth pattern analysis respectively. The variation of elevation pattern corresponding to azimuth at 163° and 167° for different frequencies are shown in Figure 4.5 and Figure 4.6 respectively. Figure 4.7 and Figure 4.8 reveal the variation of gain with elevation angle at 163°, 167° azimuth and different frequencies for analyzing the elevation pattern. The antenna is simulated under free space using EZNEC software. According to the location of the LPDA, two important satellites viz., 95 E NSS – 6 (Elevation 62.1°, Azimuth true 163.6°) and 93.5E INSAT – 3A (Elevation 62.5°, Azimuth true 167.2 °) are considered.

4.4.1 Azimuth and Elevation Pattern Analysis

In this chapter the simulated performance analysis of the azimuth and elevation radiation patterns as well as the variations of gain of LPDA in between 50MHz - 300MHz have been observed. The significant benefit of LPDA is that within the design band its performance may be effectively frequency independent along with radiation patterns and hence the gain. The LPDA has significantly high directivity as well as front-to-back ratio over very broad range of frequencies [11]. Constant radiation patterns are established by conducting experiments within the entire working frequency bands [12]. Figure 4.1 shows the variation of vertical azimuth pattern at frequencies of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz, respectively whereas in Figure 4.2 the alteration of horizontal azimuth patterns at diverse frequencies is presented. On the other hand, Figure 4.3 demonstrates the variation of gain with azimuth angle and Figure 4.4 presents some other interesting characteristics. When the elevation patterns are considered some interesting changes are also noted which we have presented in Figures 4.5 to 4.8. In Figure 4.5, the variations of elevation pattern are shown at 163° azimuth for different frequencies of 50 MHz, 100 MHz, 150 MHz, 200 MHz, 250 MHz and 300 MHz respectively. The variation of elevation patterns at 167° azimuth at different frequencies is depicted in Figure 4.6. Figure 4.7 exhibits the variation of gain with elevation angle at 163° while Figure 4.8, on the other hand, shows the variation of gain with elevation angle at 167° azimuth. It is observed that the elevation patterns for an antenna above ground and in free space are different (Figures 4.5-4.8), but the azimuth patterns are similar.
Figure 4.1 The variation of vertical azimuth patterns at frequencies of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz respectively
Figure 4.2 The variation of horizontal azimuth patterns at different frequencies of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz respectively
Figure 4.3 The variation of gain with azimuth angle corresponding to: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz for vertical azimuth pattern analysis.
Figure 4.4 The variation of gain with azimuth angle corresponding to: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz for horizontal azimuth pattern analysis
Figure 4.5 The variation of elevation patterns at $163^\circ$ azimuth for different frequencies of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz respectively
Figure 4.6 The variation of elevation patterns at 167° azimuth and different frequencies of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz respectively
Figure 4.7 The variation of gain with elevation angle at 163° azimuth and different frequencies of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz for elevation pattern analysis
Figure 4.8 The variation of gain with elevation angle at 167° azimuth and different frequencies of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz respectively for elevation pattern analysis.

4.5. Conclusion

The EZNEC software has proved to be very effective to optimize the length of the elements and to study the activities such as radiation patterns and gain for the designed
antenna. The recommended antenna would be very helpful for identifying and recording solar radio observations due to its especially broadband operation, low cost, easy fabrication and good radiation patterns [13]. It may also be useful occasionally to plot the antenna patterns in cartesian (rectangular) coordinates, particularly when there are numerous side lobes in the patterns and where the heights of these side lobes are essential. In this chapter it is considered that the uniformity to the edge in reality provides a more negative outcome for the side lobes [14].

References