Chapter 3

Study of Magnetic Field and Some Important Antenna Parameters in Azimuth and Elevation Pattern Analysis

3.1 Introduction

Log Periodic Dipole Array (LPDA) is comprised of two crossed logarithmic periodic dipole antennas, arranged in north-south direction and east-west direction. In this chapter the study of magnetic field and some important antenna parameters in Azimuth and Elevation pattern analysis for a frequency range of 50MHz – 300MHz are presented. An appreciably excessive directivity, front-to-back ratio, broadband function, subsidized cost, simple fabrication and good radiation patterns across wide frequency made the LPDA antenna very convenient for watching solar radio observations. In this chapter, for the analysis of Azimuth and Elevation patterns the simulations of magnetic (H) field (A/m RMS) and other significant antenna parameters of LPDA are illustrated. From the observations it comes to a conclusion that LPDA is the simplest antenna which may be suitably used for the purpose. LPDA is employed in broad band communication in VHF to UHF band [1-4]. Not only the LPDA antenna’s input impedance but also the gain changes regularly in the logarithm of the frequency. The basic thought is that a slowly expanding periodic structure array emits mainly when the array elements (dipoles) are close to resonance so that with alterations in frequency the active (radiating) region shifts throughout the array. For a specified frequency, the elements with lengths near to half wavelength resonate [5]. The longest dipole resonates at the lowest frequency ($f_L$) and the shortest dipole resonates at the highest frequency ($f_U$) of working. The radiating or active area moves throughout the construction characterized by changing frequency. The dipole elements whose wavelengths are $\lambda/2$ at the resonant frequency constitute the active region and almost all the antenna currents are focused in this region [5, 6]. Only 2 or 3 are active at any specified frequency in the operating range though an LPDA consists of a huge number of dipole elements. The residue elements of the array which consist of directors and reflectors are regarded as parasitic. The LPDA antenna is greatly directional in its radiating and receiving patterns in consequence of the actions of the directors and reflectors. It is essential at first to specify the coordinate system for elucidating the antenna and the related electromagnetic fields so as to facilitate the discussion about radiation from antennas. The usual coordinate system for this type of task is the spherical coordinate system comprised of a radial distance, an elevation angle and an azimuth angle.
3.2 Azimuth and Elevation

These are angles by which we denote a particular position in an antenna's radiation pattern. Azimuth is determined clockwise from true north to the position on the horizon beneath the object but elevation is measured vertically from that location situated on the horizon to the object. 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 degrees (horizon) to 90 degrees (zenith). To describe the apparent place of an object in the sky, compared to a particular observation point azimuth and elevation angles are used. The azimuth angle is described as the angle from the positive x-axis in the direction of the positive y-axis, to the vector's orthogonal projection onto the xy plane. The azimuth angle ranges from –180 and 180 degrees. The angle of elevation is indicated as the angle from the vector's orthogonal protrusion on the xy plane in the direction of the positive z-axis to the vector. The elevation angle varies between –90 and 90 degrees. These definitions presume that the bore sight direction is the positive x-axis. The observer is ordinarily seen on the earth’s surface, but not at all times. The rotation of the whole antenna around a vertical axis is denoted as azimuth which is a side to side angle. Normally we let loose the chief mount bracket and sway the whole dish all the way in a round way like a 360 degree circle. From the definition it is seen that the north, east, south and the west are 0 degree, 90 degrees, 180 degrees and 270 degrees accordingly. Rarely north may be 360 degrees.

Elevation denotes the up-down angle between the beam pointing direction, exactly in the direction of the satellite, and the local horizontal plane. The elevation angle is only a few degrees when a dish is pointed low down near the horizon. At lesser elevation angles i.e. smaller than 5 degrees at C band and 10 degrees at Ku band, the way across the atmosphere is greater and the signals are diminished by rain attenuation and rain thermal noise. Especially during hot humid weather scintillation also takes place. These results in increase and decrease in the signal level every several seconds for many hours, similar to the twinkling of a star. The angle of elevation is at ninety degrees if the dish is in the upward direction. Locations close to the equatorial region may necessitate that the elevation angle may be 90 degrees in case the longitude of the satellite is identical to the location’s longitude. Figure 3.1 exemplifies the finding out of Azimuth from the north. This can also rarely be determined from the south point of the horizon throughout the east.
Figure 3.1 Determination of azimuth from the north point (occasionally also observed from the south point) of the horizon throughout the east; altitude representing the angle above the horizon

Figure 3.2 Illustration of azimuth angle, zenith angle and elevation angle
The zenith, azimuth and elevation angles are illustrated by Figure 3.2 whereas Figure 3.3 explains the elevation and zenith angles as well as the protrusion of area at ninety degrees to incident rays on a smooth surface. Azimuth is determined from the north point (occasionally from the south point) of the horizon about the east whereas altitude signifies the angle above the horizon. The horizontal coordinate scheme resembles a celestial coordinate structure that utilizes the observer’s local horizon as the elementary plane. This coordinate arrangement segregates the sky into the upper and lower hemispheres. In the upper hemisphere objects are seen and in the lower they are invisible. The division of hemispheres is done by the great circle, also called rational or celestial horizon. The lower as well as upper hemispheric poles are identified as the nadir and zenith respectively. Altitude is recognized as the elevation which is the angle created by the spectator's local horizon and the object. For visible objects it is an angle ranging from 0 degrees to 90 degrees. The angle of the object with reference to the horizon is the azimuth, usually determined from the north advancing in the direction of the east. For example, exceptions are ESO's FITS standard which is calculated from the south proceeding towards the west, or the FITS convention of the SDSS in which it is determined from the south progressing towards the east. Sometimes while computing these coordinates, zenith distance is employed instead of altitude. The zenith distance and the altitude go together.
3.3 Simulation Results

Figure 3.4 Magnetic (H) field (A/m RMS) in Azimuth pattern analysis at different frequency of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz respectively
Figure 3.5 Magnetic (H) field (A/m RMS) in Elevation pattern analysis at different frequencies of: (a) 50 MHz (b) 100 MHz (c) 150 MHz (d) 200 MHz (e) 250 MHz (f) 300 MHz, respectively.

The designed time-shared LPDA was simulated using EZNEC software and considered under free space. In Figure 3.4 and Figure 3.5 the variation of magnetic (H) field (A/m RMS) in Azimuth & Elevation pattern analysis [7, 8] at different frequencies are shown. Figure 3.6 shows the variation of R, X, reflection coefficient, return loss and
SWR vs. frequency (MHz) in Azimuth pattern analysis while Figure 3.7 shows the variation of R, X, reflection coefficient, return loss and SWR vs. frequency (MHz) in Elevation pattern analysis.

![Figure 3.6](image)

**Figure 3.6** Variation of (a) R(ohm), (b) X(ohm), (c) Reflection Coefficient, (d) Return Loss (dB) and (e) SWR (50) vs Frequency (MHz) in Azimuth pattern analysis
Figure 3.7 Variation of (a) R(ohm), (b) X(ohm), (c) Reflection Coefficient, (d) Return Loss (dB) and (e) SWR (50) vs Frequency (MHz) in Azimuth pattern analysis
3.4 Conclusion

Here the simulated performance study of the magnetic field, variation of R and X, reflection coefficient, return loss, VSWR of LPDA at 50MHz – 300MHz have been depicted. The LPDA demonstrates a comparatively low SWR (generally not more than 2 to 1) over a wide band of frequencies. A significantly high directivity and front-to-back ratio across a very wide frequency range is shown by the LPDA [9, 10]. The recommended antenna would be very essential for monitoring solar radio observations because of its broadband operation, low cost, easy fabrication, and good radiation patterns [11, 12]. The EZNEC software is employed to optimize the length of the elements and to investigate the distinguishing features of the devised antennas, for example return loss, and gain.

References