

# Design and Performance analysis of a LPDA in VHF range for observing Solar Radio Bursts

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**ABSTRACT:** We have made an endeavour to monitor the solar activities by constructing a Log Periodic Dipole Array (LPDA) antenna at Kalyani, West Bengal for observing solar bursts in the frequency range of 50 to 300 MHz. This paper highlights the design considerations and the performance characteristics of the fabricated antenna. The given specifications and the distinctive values of scale factor as well as spacing factor determine the design of the LPDA. A reasonably low SWR (usually not more than 2 to 1) is revealed by this LPDA over a broad band of frequencies. The important advantage of LPDA is that in the design band its performance is efficiently frequency-independent along with radiation pattern (therefore gain). The constructed antenna would be very useful for discovering and recording solar radio performances because of its wideband operation, simple fabrication and low cost.

**KEYWORDS:** LPDA, design constants VSWR, solar radio burst

## I. INTRODUCTION

The LPDA is a coplanar linear array, with criss-crossing of the dipoles as shown in Figure 1. Though an LPDA consists of a large number of dipoles, only a few of them are active at a fixed frequency with the longer dipole acting as a reflector and the shortest dipole acting as the directors [1-4]. Phase reversal of currents in adjoining elements, results in highly directive broadside beam pattern ensuring high directivity and front-to-back ratio over a very wide range of frequency [1-8].

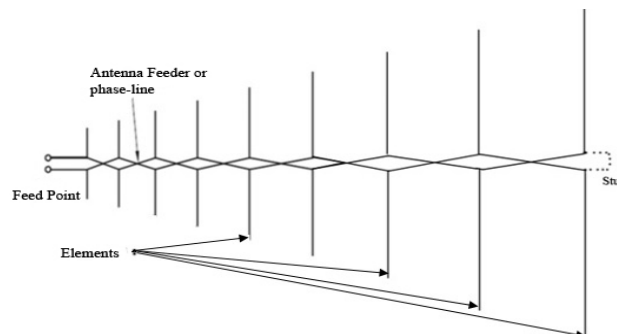


Fig. 1 Log Periodic Dipole Array showing the criss-crossing of feed lines

## II. PROPOSED ANTENNA SYSTEM & DESIGN STEPS

The scaling factor  $\tau$  is one of the most important parameter that expresses the LPDAs. The space between the elements decreases with increase in frequency. Moreover we should be cautious with the parameter  $\alpha$  because if it is set to a

value which is too small or too large it will cause destruction of the impedance bandwidth of the antenna. The design of the LPDA antenna is based on this characteristic and this feature allows alterations in frequency to be made without immensely affecting the electrical operation. The design dimension of the constructed LPDA is shown in Figure 2(a) and the simulated antenna is shown in Figure 2(b). It consists of a pair of pair of dipole elements connected in zigzag fashion and thus acts as a transmission line.

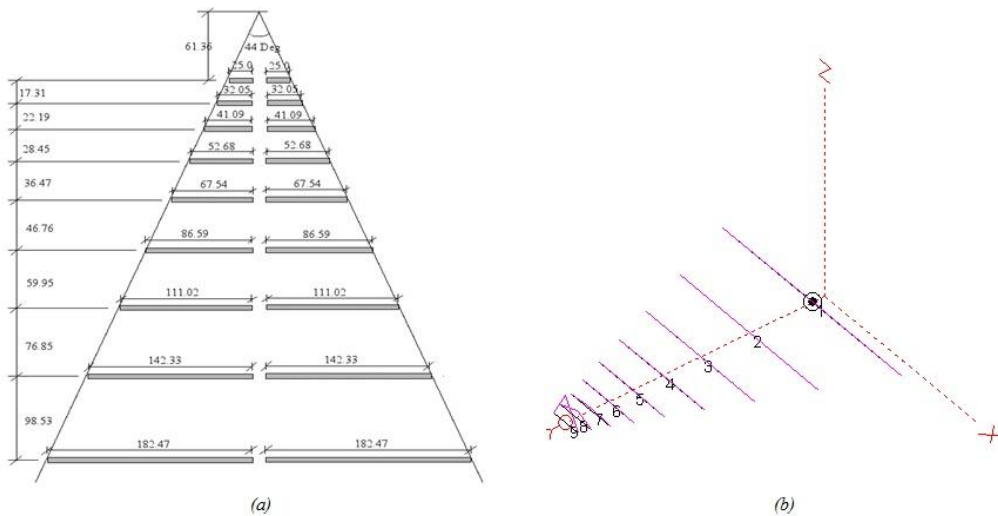


Fig. 2 (a)Design details of the log periodic antenna (50-300 MHz) (b) Simulated Antennas

As the elements with dimensions roughly half-wave lengths provide most of the radiation so the region where these elements take place is called “active region” [3, 4]. The specifications of the LPDA for calculating the length of the dipole from apex and element separation distance are presented in Table 1 while some of its important physical properties are given in Table 2.

TABLE 1: LENGTH OF THE DIPOLE FROM APEX AND ELEMENT SEPARATION DISTANCE

Length of the Dipole from Apex(cm)		Element Separation Distance (cm) $D_{n,n+1} = \text{Spacing between the } n\text{th and } (n+1)\text{th element}$	
R <sub>1</sub>	61.36	D <sub>1,2</sub>	17.31
R <sub>2</sub>	78.67	D <sub>2,3</sub>	22.19
R <sub>3</sub>	100.86	D <sub>3,4</sub>	28.45
R <sub>4</sub>	129.31	D <sub>4,5</sub>	36.47
R <sub>5</sub>	165.78	D <sub>5,6</sub>	46.76
R <sub>6</sub>	212.54	D <sub>6,7</sub>	59.95
R <sub>7</sub>	272.49	D <sub>7,8</sub>	76.85
R <sub>8</sub>	349.34	D <sub>8,9</sub>	98.53
R <sub>9</sub>	447.87		

TABLE 2: PHYSICAL PROPERTIES OF THE LPDAS

Specifications	Particulars
Frequency Range	50-300MHz
Polarization	linear
Number of dipoles	nine
half of the apex angle	22°
Height	447.87cm
Width	364.94cm

### III. SIMULATION RESULTS

We have simulated the antennas with the aid of EZNEC software and it was regarded under free space. The simulations were utilised in obtaining the performance properties of the LPDA antenna and it was considered under free space.

Figure 3 gives the comparison of Fr/Back/Fr/Rear (dB) and max gain (dBi) with frequency. Gain is increasing from 200 MHz to 250 MHz and maximum gain is obtained at 250 MHz. Maximum Front/ Rear is found at 100 MHz. After 100 MHz Front/ Rear is diminishing. Figure 4 shows the variation of SWR with frequency from 50 MHz to 300 MHz. At 50 MHz, SWR is maximum. Similarly SWR is minimum at 100 MHz.

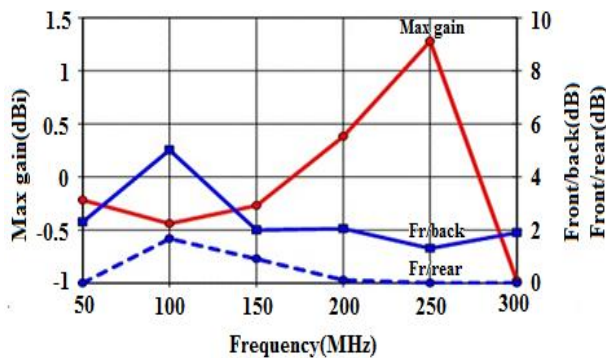


Fig. 3 Comparison of Fr/Back/Fr/Rear (dB) and Max Gain (dBi) with frequency

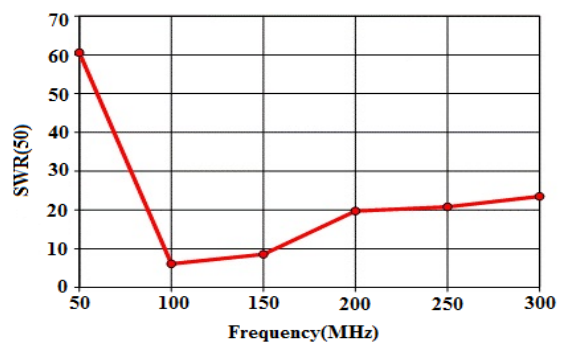


Fig. 4 Variation of SWR with frequency from 50 MHz to 300 MHz

### IV. RECORDED BURSTS

For recording solar radio signals, the instruments we used are Log Periodic Dipole Array at Kalyani (22.98°N, 88.46°E) in the Department of Physics, University of Kalyani, in West Bengal including a Digital Storage Oscilloscope (DSO) GDS-1000 Series. The LPDA, we used, can receive solar signals in the frequency range from 50 MHz to 300 MHz. The DSO is connected to a computer containing signal analysis software, which digitalizes the constantly varying solar radio signal voltages, creates a data set out of it and stores the data set in the form of CSV (comma separated values) file in the computer.

Figure 5 reveals solar signal amplitude vs. time plot, obtained from the one hour data recorded on February 7, 2013, the day in which no significant bursts were recorded. From the graph plot, we can see that, the amplitude has an average value of 0.001 volt, with few peaks at 0.002 volt. This can be considered as the *quiet sun component* of solar radio emission.

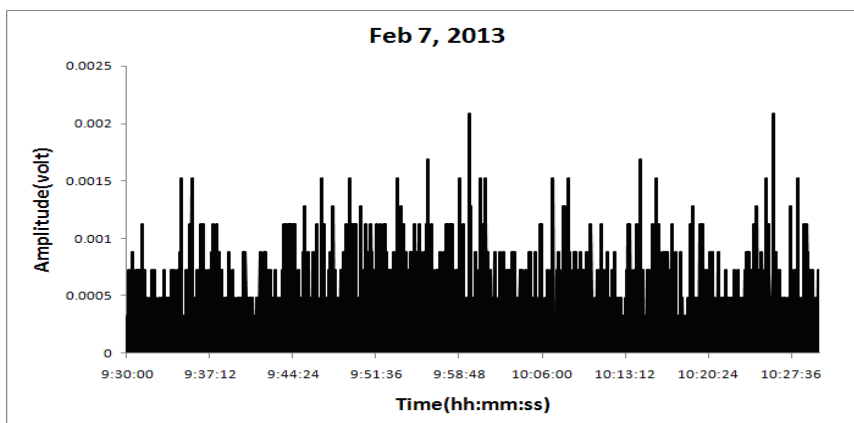


Fig.5 Solar signal variation data on the day in which no burst was observed

Figure 6(a) and 6(b) shows the one hour plot obtained on February 26, 2013 and on February 28, 2013, 5:30 UT and 6:00 UT onwards respectively. From the plot of February 28, we can see that the amplitude level remained at about 0.05 volt with a sudden increase to about 0.25 volt from 6:18 UT to 6:21 UT. We considered this event as a burst of duration 3 minutes. Clearly the burst component has amplitude 100+ times greater than the quiet sun component. We can consider this as the *active sun component* of radio emission which are associated with sunspots and flare activity. Similarly, we recorded many more radio burst, having different amplitudes and durations. Some bursts occurred for duration as long as 30 minutes as that on February 26, 2013, 5:30 UT onwards.

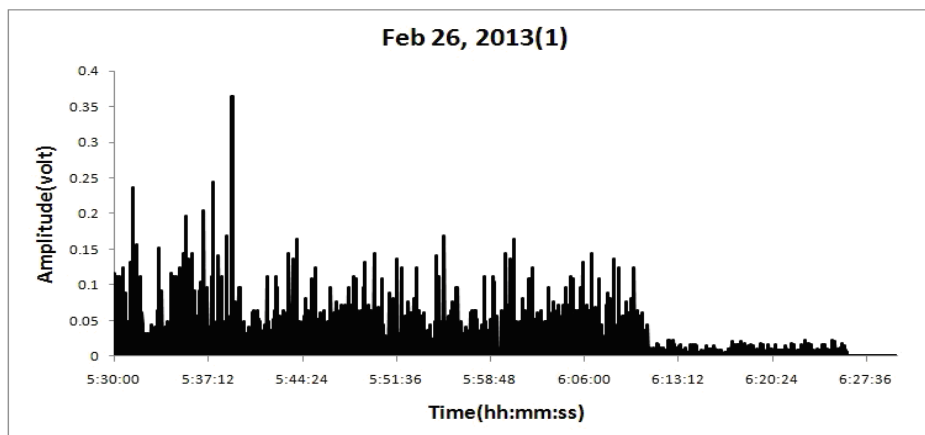


Fig. 6(a) Bursts obtained on February 26, 2013

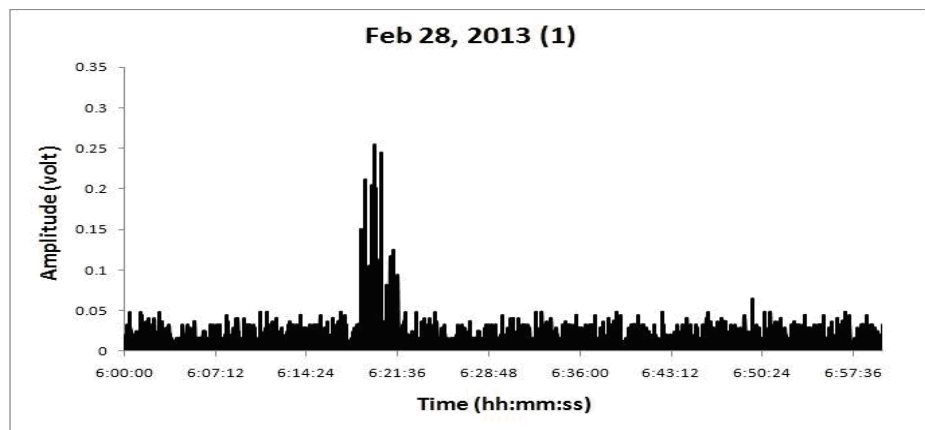


Fig. 6(b) Bursts obtained on February 28, 2013

## V. CONCLUSION

The LPDA consists of a system of driven elements; but not all of them in the system are active on a single frequency of operation. We have presented here the design and simulated performance analysis of front/back ratio and SWR LPDA antenna at 50MHz – 300MHz. The LPDAs we have designed is appropriate for high forward gain, good front-to-back ratio, and low VSWR. The research of Space Weather utilizing the nature of low-frequency solar radio bursts and their potential is enormous [3]. Moreover, Space Weather is the study of the circumstances in the solar wind that can influence life on the surface of the Earth, especially the increasing technologically advanced devices that are part of today’s life. Solar radio observations are important to such phenomena as they normally initiate as events in the solar atmosphere, comprising flares, coronal mass ejections and shocks which generate electromagnetic and particle radiations that influence the Earth. LPDA antenna can be predominantly used for all this purposes very accurately.

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