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Analysis of Radiation Pattern of a Log Periodic Dipole Antenna in VHF Frequency

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ABSTRACT: In this paper the functioning of a Log Periodic Dipole Antenna (LPDA) in VHF frequency range (30 - 300 MHz) is depicted. We made an endeavor in designing a LPDA that suits the criteria, specification and is practical. The LPDA, comprising of nine elements, accomplishes a gain higher than 10 dBi with low noise amplifier. In the paper the analysis, design, and simulation of log periodic dipole antenna (LPDA) is represented We can conclude that the log-periodic dipole antenna (LPDA) is the simplest antenna having consistent bandwidth and gain estimates.

I. INTRODUCTION

Scientific and technological improvements in solar behavior, particularly in solar radio bursts, have generated a requirement of building log periodic dipole antenna (LPDA) to monitor this occurrence in radio region. Principally antennas are used to transmit or receive electromagnetic waves. The features in both are similar due to the theory of reciprocity. Amongst the kinds of antennas, LPDA have drawn a great deal of interest recently because of the broadband frequencies. In modern times, logarithmically periodic antennas have been extensively employed because of their frequency response attributes, simplicity of design and directivity [1-3].

II. LOG-PERIODIC DIPOLE ARRAY

In case of wideband applications, the Log-Periodic Dipole Antenna (LPDA) has been usually employed. Log-periodic antennas fall under the class of frequency independent antennas offering bandwidth more than 10:1. The log-periodic array structure was initially launched by Raymond DuHamel and in the year 1960 Isbell established the earliest log-periodic dipole array. The electrical attributes of the antenna, specifically, the input impedance, the gain, etc., vary periodically in the logarithm of the frequency domain. This antenna is well-known as log-periodic array. The fundamental idea is that a slowly escalating periodic structure array emits mainly efficiently when the array elements (dipoles) are close to resonance in order that with alteration in frequency the active (radiating) region shifts all along the array. It is established that for a specified frequency, the elements with lengths near to half wavelength resonate. The longest dipole resonates at the lowest frequency (f_L) of operation. Moreover at the highest frequency (f_U) of operation, the shortest dipole is seen to resonate. It has been monitored that the maximum radiation all along the direction of the shortest dipole with a good input match is attained if the feed line is criss- crossed among the dipoles. The longer dipole performs as a reflector and the shortest dipole as directors. A phase shift of 180° is initiated by criss-crossing the transmission line which helps in setting up the right phase of the currents on the dipoles in order that the maximum is all along the direction of the smallest dipole, which is fairly the same to how the reflector and directors perform in a Yagi-Uda array. The active or radiating region shifts along the structure along with altering frequency. The active region includes dipole elements, the wavelengths of which are $\lambda/2$ at the resonant frequency. Furthermore nearly all the antenna currents are focused in this region. The residual elements of the array are regarded as parasitic consisting of directors and reflectors. Following the actions of the directors and reflectors, the LPDA antenna is extremely directional in its radiating and receiving patterns. Moreover the phase reversal of currents in adjoining elements, finally effects in extremely directive broadside beam pattern rising from the direction of the smallest element in the array. LPDA possess high directivity and high front-to-back ratio over an extremely broad frequency range. The log-periodic dipole array is a coplanar linear array of progressively gaped dipoles of uneven heights. These dipoles are

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fed by a twisted balanced transmission line of distinctive impedance Z_0, which in turn is loaded by termination impedance. Even though an LPDA includes a huge number of dipole elements, only 2 or 3 are active at any specified frequency in the operating range [4-7]. The fundamental structure of a LPDA is depicted in Figure 1.

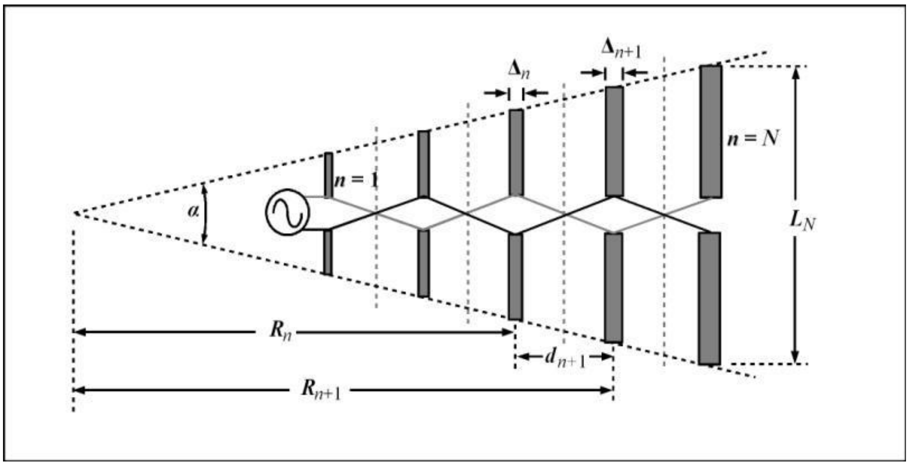

Fig. 1 Basic Structure of a LPDA

III. DESIGN STEPS AND NECESSARY EQUATIONS

The design parameter τ is a geometric constant close to 1.0 which is utilized to calculate the element lengths L and element spacing d. That is $L_2=L_1\tau$, $L3=L_2\tau$……………$L_n=L_{n+1}\tau$, $L_{n+1}=L_n\tau$ in which L_{n+1} is the longest element length, L_1 is the shortest element length. In the same way, $D_{2,3}=D_{1,2}\,\tau$,$D_{3,4}= D_{2,3}\,\tau$, $D_{4,5}= D_{3,4}\,\tau$……………….. $D_{8,9}= D_{7,8}\,\tau$, $D_{n,n+1}= D_{n-1,n}\,\tau$.. In case of distinctive designs,α acquires values between 10° - 45° and τ alters from 0.7 to 0.95. There is a relation between the values of α and τ. As α enhances, the corresponding τ values diminishes, and vice versa. Larger values of α or smaller values of τ effect in more compact designs which need smaller number of elements separated by larger distances. In comparison, smaller values of α or larger values of τ need a huge number of elements that are nearer together. The values of τ and σ ascertain the gain of the antenna. Select τ and σ to offer a required gain. $0.7\leq\tau\leq0.98$ and $0.5\leq\sigma\leq\sigma opt$. The value of σ_{opt} can be computed by the following formula $\sigma_{opt}=0.258\tau-0.066$.

Here, R_n = Distance from apex to the nth dipole elements
R_{n+1} = Distance from apex to the(n+1)th dipole elements
τ = Scaling factor (<1) which decides next geometrical freq.
σ = Spacing factor which decides the distance between successive dipoles.
σ' =Mean spacing factor
σ_{opt} = optimum Spacing factor
α = half of the apex angle
L = Boom length
N = Total Number of elements in an array

The significant design equations are given below

1. $\tau = \dfrac{L_n}{L_{n+1}} = \dfrac{R_n}{R_{n+1}} = \dfrac{D_n}{D_{n+1}}$

2. $\alpha = \tan^{-1}\left(\dfrac{1-\tau}{4\sigma}\right) \Rightarrow \sigma = \dfrac{1-\tau}{4\tan\alpha}$

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3. Log (f_U)-Log (f_L) $=(N-1)Log\left(\frac{1}{\tau}\right)$

4. $L=\left[\frac{\lambda_{\max}}{4}\left(1-\frac{1}{B_s}\right)\cot\alpha\right]$

5. $\sigma=\frac{R_{n+1}-R_n}{2L_{n+1}} \Rightarrow L_{n+1}=\frac{R_{n+1}-R_n}{2\sigma}$

6. $\sigma'=\frac{\sigma}{\sqrt{\tau}}$ 7. $\sigma_{opt}=0.258\tau-0.066$

IV. SIMULATION RESULTS

In this paper we have analysed the E&H plane Radiation patterns of LPDA at 60 and 120MHz, depicted in Figure 2 and Figure 3 respectively. The Variation of Front to Back Ratio, Gain, VSWR with frequency (MHz) are illustrated in the Figure 4, Figure 5 and Figure 6 respectively .The performance attributes of the LPDA antenna were acquired with MATLAB simulations and it was regarded under free space. We have chosen the lower analyze frequency as 50 MHz and the upper analyze frequency as300 MHz.

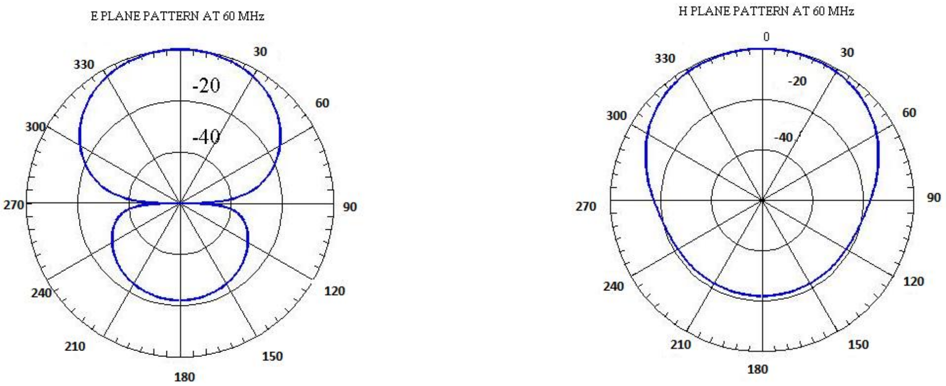

Fig. 2 E and H plane Radiation pattern for 60 MHz

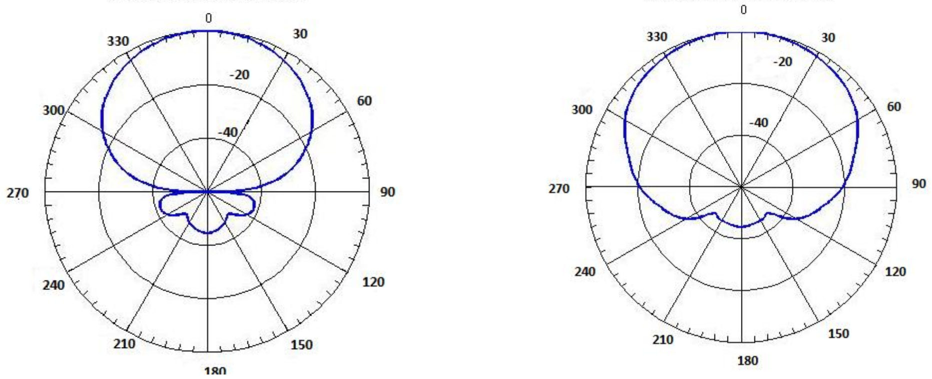

Fig. 3 E and H plane Radiation pattern for 120 MHz

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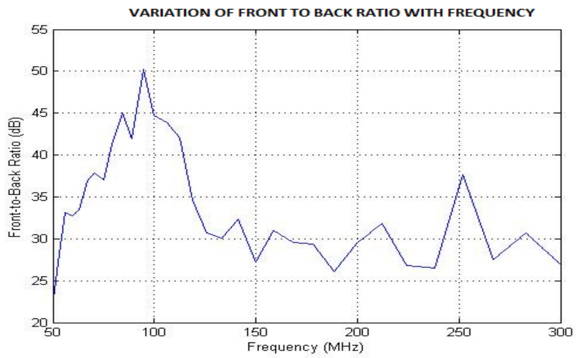

Fig. 4 Variation of Front to Back ratio with frequency

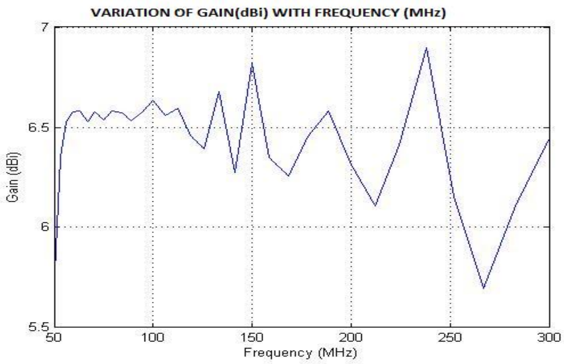

Fig. 5 Variation of Antenna Gain with frequency

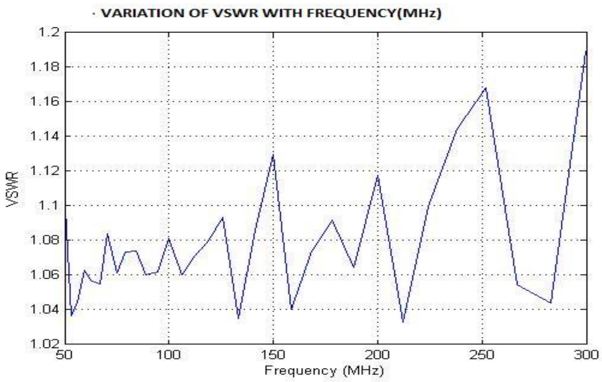

Fig. 6 Variation of VSWR with frequency

V. DISCUSSION

The design and simulated performance study of radiation pattern, front to back ratio, Gain, VSWR of LPDA at 50MHz – 300MHz has been depicted. The performance attributes of LPDA antenna were acquired with MATLAB simulations. The LPDA demonstrates a moderately low SWR (generally not larger than 2 to 1) over a broad band of frequencies. Its benefit is that within the design band its performance is basically frequency-independent, comprising radiation resistance (thus VSWR) and radiation pattern (therefore gain and front-to-back ratio). LPDA possess high directivity and front-to-back ratio over an extensive frequency range

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