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Optimization of Log Periodic Dipole Array using Genetic Algorithm: A Review

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Abstract: This paper emphasis on the optimization of Log Periodic dipole array using Genetic Algorithm. The algorithm can be implemented on the physical size of the antenna and its gain. The proposed design is being compared with the conventional LPDA design in terms of length, diameter and spacing between dipole elements. The results reveal that the presented approach may improve the antenna gain and reduce its dimensions. The size of the antenna can be reduced up to 12% as compared to the conventional design. Also the gain can be improved from 9.1, 9.5, 9.2 and 8.5 dB to 10.7, 11.2, 9.9 and 9.1 dB for the desired communication bands. That is why; this approach makes an antenna an attractive choice for wireless applications.

Keywords: Genetic Algorithm (GA), Optimization Techniques, Log Periodic Dipole Antenna (LPDA).

I. INTRODUCTION

The key component of any wireless communication system is antenna. It is necessary to design an antenna which is small in size and efficient in terms of its gain. The goal of small size and high gain can be achieved by means of Genetic Algorithm (GA), Particle Swarm Optimization (PSO) and its variants, e.g., Quantum PSO.
This paper presents the design of an LPDA which can be implemented at WiMAX, GSM-I, GSM-II and WiFi wireless communication bands. Genetic Algorithm (GA) and Method of Moment (MoM) has been used to compress the size of LPDA in terms of its number of elements

The optimization of LPDA has two major objective functions.
The design procedure is as follows:

1) First step is to make use of conventional techniques to optimize LPDA and analyse the response in terms of gain.
2) In the second apply Genetic Algorithm to optimize LPDA.

II. DESIGN AND OPTIMIZATION OF LPDA

A. Conventional Approach
LPDA has number of dipole elements L_i where i=1,2,..n showing that largest and smallest elements mounted on a common feed network. The length, diameter and spacing of each element are different from the other elements. The schematic diagram of LPDA is shown in Fig.1.The smallest dipole element L_n is fed with a sinusoidal current of form $i(t)=A\sin(\omega t)$ where maximum value of i(t) is assumed to be unity.

The basic design equations to determine LPDA parameters are given below:

$$\sigma = \frac{d_n}{2L_n}$$

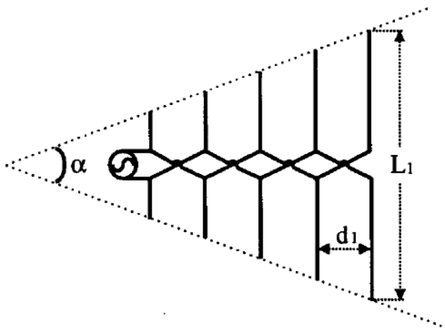

Fig.1. Geometry of LPDA

$$L_{n+1} = L_n \times \tau$$

$$X_n = h_n \times \tan(\alpha)$$

$$\alpha = \tan^{-1} \frac{(1-\tau)}{4\sigma}$$

Where σ, L, α and X represent the spacing factor, length, angle that bounds the dipole length and spacing between La and Ln elements.
The initial response of LPDA is observed against the conventional design using $\tau=0.9$, $\sigma=0.16$, N=10, Ln/dn=125 and $z_0=50\Omega$ respectively.

The length of the first dipole is supposed to be half of the wavelength. The length of the first dipole is $L_1=\lambda_{ref} \times 0.5$ where λ_{ref} can be calculated from reference frequency which is 400MHz in present case. It is essential to calculate current across each dipole element .This can be done after knowing Z_{ij} and Y_{ij} of the feeder line.

B) Genetic Algorithm to optimize LPDA
The algo generates a population of points at each iteration. The best point in the population approaches an optimal

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solution. It is used to select the next population by computation which uses random number generators.

The initial step in the implementation of GA algorithm is to create random population which consists of length, diameter and spacing of each element. The next step is to create chromosome vector which comprises of length (10 length genes), diameter (10 diameter genes) and spacing between consecutive elements (9 spacing genes).All these parameters can be optimized in chromosome vector.

$$C = [L_1, L_{2,\ldots\ldots}L_{10}\, d_1, d_2\ldots\ldots d_{10}, x_1, x_2, \ldots\ldots x_9)$$

For optimization process the cost function can be written as

$$\text{Cost} = \frac{\sum_{f_l=1}^{f_h} \text{Gain}(f_l)}{f_h - f_l}$$

Where f_l = Lower frequency Bands
f_h= Higher frequency Bands

The cost function is required to determine the optimized gain of the function. The cost function is being compared with the initial gain at the end of each iteration. It is essential to see whether the gain has been improved or not.

III. NUMERICAL OPTIMIZATION OF LPDA

In order to do numerical optimization of LPDA MATLAB has been used. A GA is required to optimize routines to a compiled version of the NEC (Numerical Electromagnetic Code). There may be the variation in element length, spacing and radius of each element. Fig.2 represents the flow chart of GA algorithm.

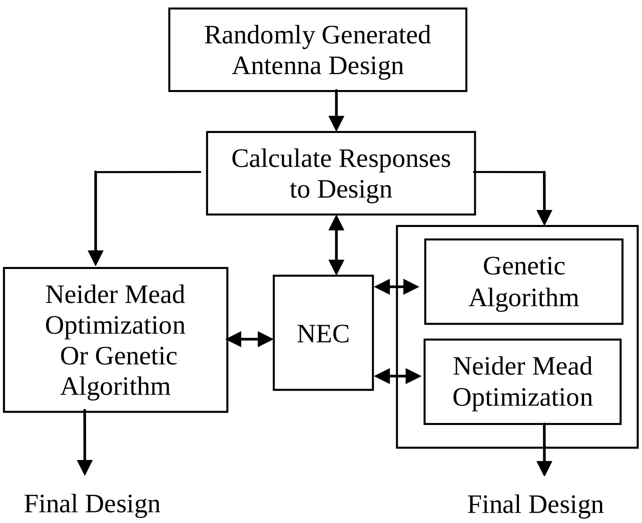

Fig.2

Table I represents initial and optimized parameters of the proposed antenna against the improved gain.

TABLE I

Element #	L_n (m)	d_n (m)	X_n (m)	L_n opt. (m)	d_n opt. (m)	X_n opt. (m)
1	0.375	0.003	0.12	0.3675	0.0029	0.0975
2	0.3375	0.0027	0.108	0.3275	0.0026	0.0868
3	0.3038	0.0024	0.0972	0.2914	0.0023	0.0772
4	0.2734	0.0022	0.0875	0.2594	0.0021	0.0687
5	0.246	0.002	0.0787	0.2309	0.0018	0.0615
6	0.2214	0.0018	0.0709	0.2055	0.0016	0.0544
7	0.1993	0.0016	0.0638	0.1829	0.0015	0.0485
8	0.1794	0.0014	0.0574	0.1627	0.0013	0.0431
9	0.1614	0.0013	0.0517	0.1448	0.0012	0.0384
10	0.1453	0.0012	0.0465	0.1289	0.001	0.0234

IV. RESULTS

The results reveal appropriate improvement as compared to conventional design. Also Genetic Algorithm took less time in computation of parameters than Particle Swarm Optimization (PSO) and Quantum Particle Swarm Optimization (QPSO).

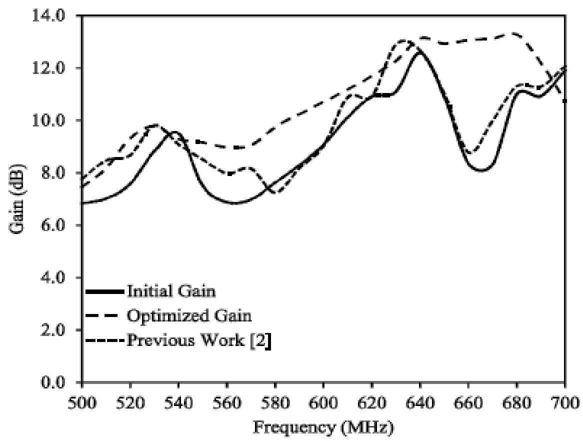

Fig.3 Initial and Optimized Gain for WiMAX

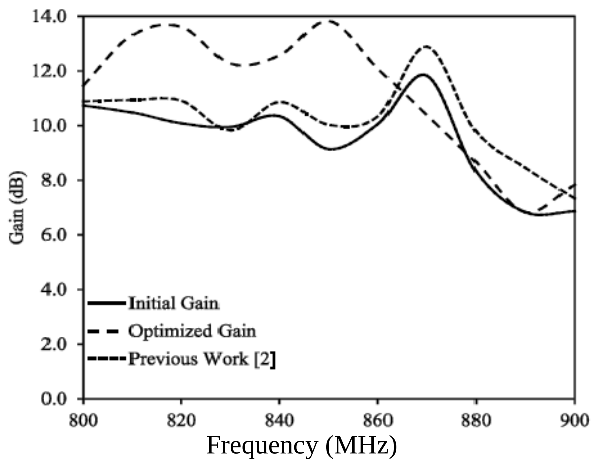

Fig.4 Initial and Optimized Gain for GSM-I

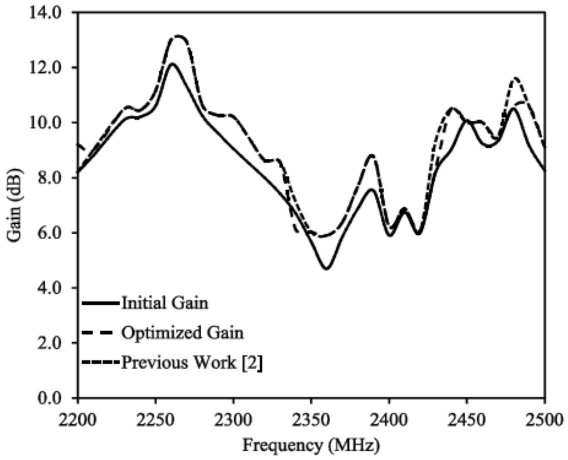

Fig.5 Initial and Optimized Gain for WiFi

It has been observed that GA requires less time in computation and by implementation of this algorithm the overall size of the antenna can be reduced up to 12% of the original size. That's why antennas are compact in shape and size and are quite compatible with gadgets.

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