Side Lobe Levels Reduction in Broadside Linear Antenna Array Using Chaotic Optimization Algorithm

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Abstract—in this paper chaotic optimization [14] algorithm method is used for the synthesis of broadside linear antenna array. In this paper optimum value of current in each antenna element is determined which produces radiation pattern with minimum side lobe level. Optimization is done using MATLAB. Chaotic Optimization [14] algorithm which enables search in broader space along randomly generated directions to produce new generations. This approach includes two searches, first is a global search and another is local search. This improves the performance greatly to achieve the maximum reduction in side lobe level with minimum function calls.

Keywords: Antenna array, Chaotic [14], global search, local search, cost function, fitness function.

I. INTRODUCTION

With the advent of technology and recent developments in communication, wireless communication has reached to new level. Recent updates in wireless communication were not possible without application of smart antennas. Use of smart antennas is one of the vital characteristic that has led to third and fourth generation standard developments. However, smart antenna theory always driven by the Antenna array and so do the wireless communication. With antenna pattern synthesis there comes speed and robustness to the existing system thereby improvising transmission parameters [3]. Along with this radio wave propagation is a matter of research that accounts to faster and reliable transmission, since wireless is generated from the roots of radio communication. Radio communication was first came into existence in December, 1901 when Guglielmo Marconi successfully received the first transatlantic radio message [1]. The message under radio communication was letter ‘S’ which is considered as the most significant approach in developments of radio communication.

However, there is a long way to go and research will contribute entirely for new upgrades in it. The primary objective of this work is to study the effect of linear array antenna on the communication channel and then the optimization of a linear array antenna using chaotic algorithm for side lobe level reduction thereby improving the communication.

A. Antenna Array

An antenna array [5] is a set of N spatially separated antennas. Most commonly antenna with N=2 elements are considered as array of antenna. An array of antenna can have number of elements which may include several thousand elements. . An antenna array is preferred over single antenna as it has ability to filtrate the intentional electromagnetic radiation in the air.

Consider a linear array of n isotropic elements of equal amplitude and separated by distance d. The total field E at a far field point P in the given direction φ is given by,

$$E = 1 + e^{j\psi} + e^{2j\psi} + e^{3j\psi} + \cdots \ldots \ldots \ldots \ldots \ldots + e^{(n-1)j\psi}$$

Where Ψ is the total phase difference of the fields from adjacent sources. It is given by;

$$\psi = 2\pi\left(\frac{d}{\lambda}\right)cos\phi + \alpha$$

α is the phase difference between excitation current of adjacent element of antenna array.

The basic setup of an arbitrary antenna array is shown in Figure 1

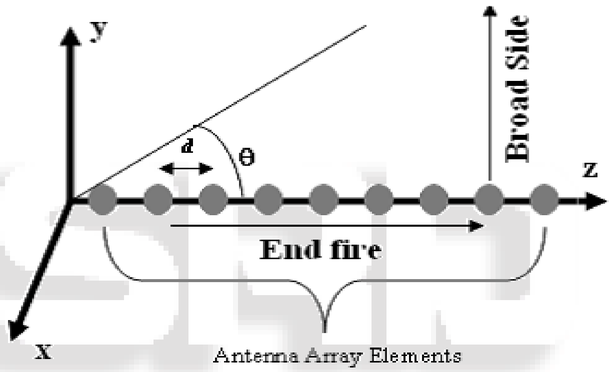

Fig. 1: Antenna Array

The array factor for, N number of elements

$$AF = \sum_{n=1}^{N} E_n = \sum_{n=1}^{N} {e_n}^{jk}$$

Where $E_n = {e_n}^{jK}$ and K= (nkdcosθ + β_n) is the phase difference. βn is the phase angle. The antenna array can be used to:

1) It increases the overall gain of the transmission.
2) It helps to determine the direction of incoming

signals

1) Maximize the Signal to Interference Plus Noise Ratio (SINR)
2) "Steer" the array so that it is most sensitive in a particular direction
3) Cancel out interference from a particular set of directions
4) Provides diversity reception

II. OPTIMIZATION TECHNIQUES

The side lobe level reduction is the prime motive of the system. The optimization of the antenna current of each element is required to reduce the side lobe level. Let the initial antenna current is [I1 I2 ……. In], then the field due all antennas may be given as

H=H1+H2+H3+……Hn;

Where Hi is the magnetic field due to ith node of antenna array.

Hi α Ii

The normalized H will contain the information of beam pattern As1, As2, As3…… is side lobe levels in beam pattern, then the objective is minimize the cost function given as below

C.F. =maximum ([As1, As2…]),

Chaos states disorder and irregularities within a system. In order to enforce non-chaotic behavior, it is imperative to design a control of chaos. Two possibilities exist in order to accomplish a system that does not converge to an attractor or diverge to an edge .The first possibility is to detect whenever a chaotic system is about to arise and design a feedback system in order to bypass the chaotic region In order to find the global minima, the population needs not converge, but stay robust. Robustness is critical in order to map the solution space. Even when the objective function has converged, the ordering of the individual solutions is diverse. Therefore the approach proposed is to keep the solutions diverse throughout the evolution, by generating a distance between the solutions spread instead of the objective function of the solution. In order to do this, intelligence has to be incorporated within the solutions. The overriding approach is to incorporate population dynamics within the solutions in order to organize a feasible propagation approach.

Chaos theory stipulates that the emergence of chaoticbehavior is invariably linked to initial conditions of the system. When observing all EA's, it becomes clear that little attention is paid to the initial conditions like population. The overriding approach is to have apopulation created using random generation, which thesearch heuristic will guide towards the global minima.The fallibility of this approach is that a lot of emphasis

The processes required to have a controlled propagation is described in the following sections. The methodology introduces the approach in terms of discrete optimization, specifically permutation based as a means to describe the different processes initial Population.The procedure of the chaotic optimization is given below.

1) *Initial Population:* An initial generation on N no. of population is generated randomly in the search space.
2) *Global Search:* Random search is done for different values of current and a particular space is fixed.
3) *Population Propagation:* Here the propagation of population from one search to another is done.
4) *Local Search:* Systematic search is done in that space which is fixed by the global search and a best value is selected.
5) *Dynamic Replacement:* In every iteration the last best value is compared with the previous best value if the current value is better than the previous then it is replaced by it, otherwise the previous value is kept intact.
6) *Generation:* The solution iterates for N no. of generations and the top ranked value is printed as the final result.

III. SIMULATION RESULT

Using Chaotic optimization [14] Algorithm, better results are obtained as shown in figures as compared to result obtained by genetic Algorithm. [11]

Technical Specifications:-

1) Number of elements(N)- 5
2) Spacing between elements(in cm)- 5
3) Excitation current in element(amp)- 1
4) Phase among elements(in radian)- 0
5) Operating Frequency (in GHz)- 2.4

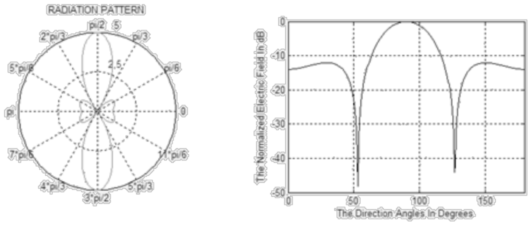

Fig. 3:Un-optimized Radiation pattern.

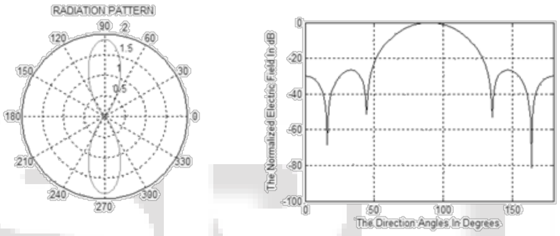

Fig. 4: Optimized Radiation pattern using Genetic Algorithm

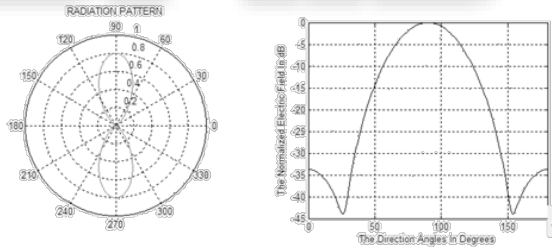

Fig. 5: Optimized Radiation pattern using CHAOTIC Optimization Algorithm.

S.NO	Parameters	Without Optimization	G.A.	Chaotic
1.	side lobe level	-12.041dB	31.573dB	- 35.732dB
2.	directivity	10.364	10.633	10.709

Table. 1: Comparison of Side lobe level with previous work

IV. CONCLUSION

In this paper chaotic optimization algorithm [14] method using MATLAB codes is used to obtain maximum reduction in side lobe level relative to the main beam. This work shows that the significant reduction of side lob levels with the use of optimization method gives better values of side lobes levels as compare to genetic algorithm. There is a significant reduction of -28dB to -38dB in this work, which is better than genetic algorithm.

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