A Literature Review On Time Modulation Antenna Array Using Evolutionary Computing Tools

Mr. P.V.K.DURGA PRASAD[1], PhD Scholar, CUTM, Paralakehmundi, India, prasad2977@gmail.com

Dr. S.S.NAYAK[2], Professor, CUTM, Paralakehmundi, India, ssnayak@cutm.ac.in

Dr. P.S.R. CHOWDARY[2], Professor, Raghu Institute Of Technology, Visakhapatnam, India, sathishchowdary@ieee.org

Abstract -Array synthesis using evolutionary computing algorithms involves in determining the appropriate non-uniform distribution of current excitation on each element of the array. However, implementation of the non-uniform distribution is a cumbersome task. Recently, the time modulation(TM) of the uniform current distribution is capable of providing excellent desired radiation features with ease. This paper thoroughly revised the latest and contemporary research in the field of time modulation schemes managed by the evolutionary computing tools for the synthesis of various types of antenna arrays.

***Keywords* —Antenna arrays, time modulation, uniform distribution, evolutionary algorithms, non-uniform amplitudes.**

I. INTRODUCTION

Now-A-Days technology in an antenna design goes viral in wireless communication systems. Generally antenna is a metallic device which is used to transmitting or getting radio waves.[1] Antenna is the midway structure linking free-space and a guiding device. To improve the overall system performance, we design an antenna full fill the system requirements. Early days antennas are designed by single elements. Single element antenna is not sufficient to achieve high directivity and gain for long distance communication also it has no control on SLL and BW.

To overcome these drawbacks antenna arrays were developed. In antenna arrays there are multiple stationary and similar radiating elements. In end to end connections like wireless, radar in addition to mobile applications these arrays are play a key role for modification. Collective operation of all elements in array acts as a single element antenna there by absorbed the emission to one direction, which is sought-after by the above mentioned applications.[1] In Recent trends main characteristics for wireless communication systems are side lobe level, beam steering and good directivity.

II. ARRAY OPTIMIZATION

Optimization could be the technique of obtaining most competitive follow contingent a few restraints. It is usually defined as minimizing or maximize a serve as referred to as purpose a well known depends upon initialize devise variables.[2] Completely the above-mentioned variables are self sustaining of one another or could have relative addiction upon a few restraint. Irrespective of procedure or technique worn, the ultimate intention of optimization has at all times been to one widen the specified result or diminish the hassle prescribed. For an array optimization we have three basic parameters to vary those are amplitude, phase and the place of the antenna array. These three parameters are named as degree of freedom.[3]

These characteristics of uniform antenna arrays are equal for all the elements. The advantage of these characteristics have narrow beamwidth(BW) and simplicity in implementation as all the elements are uniformly excited. The required SLL is to be below -20dB for many wireless applications. A good technique for reducing the SLL is non uniform excitation but suffers from enhanced beamwidth (BW). Among the above considerations we want to achieve narrow beam width and very low side lobe levels, then we want to control the amplitude and also the spacing distance between the elements non uniformly.[4]

Geometry of array refers to the geometrical distribution of elements in the array. Basing on this, the arrays are classified as one dimensional (1D), two dimensional(2D) and three dimensional(3D). In the linear array, arrangement of all elements is in the form of straight line manner.[4]

Planar arrays are two dimensional(2D) which are circular and rectangular or arbitrarily arranged along a plane. The examples of three dimensional (3D) arrays are cylindrical arrays, conical and triangular prism shaped arrays.[4] Array factor is the important parameter for all types of arrays. The position in the array elements, amplitude weights and the phase excitation are the basic functions of the array factor.

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ARRAY SYNTHESIS TECHNIQUES:

The array factor of linear and circular array configuration is a function of element current excitation amplitude and its relative phase along with spacing between the elements. Hence it can be described as follows

$$AF(\phi) = f(I, d)$$

These parameters are called design parameters and are adequate to dictate the radiation pattern of the array. The general practice is to apply non-uniform distribution of one or more combinations of these parameters for array synthesis while the other unused parameters are defined with uniform distribution. Amplitude is only technique in which non-uniform amplitude distribution is considered leaving the remaining two parameters at constant value. The overall excitation of the amplitude is the combination of vector size with equal number of elements in the array. represented as I

$$I = [I_1, I_2, I_3, I_4, \ldots I_n \ldots\ldots I_N]$$

I_n is the total excitation of the amplitude in the n elements. While spacing on the elements and the excitation of phase for each element is constant and given by d,

$$d=\lambda/2a$$

In space (position) only technique, non-uniform space function is used to describe the vector of element positions in the array. In this technique the amplitude and phase excitation current are uniformly distributed. This is explained as

$$d=[d_1, d_2, d_3, \ldots d_n \ldots\ldots d_N]$$

d_n refers to the position of the n^{th} element from the reference point in the array. The corresponding current excitation and the phase of each element is given as

$$I = 1 \text{ and } \phi = 0$$

Phase only synthesis technique involves in non-uniform distribution of phase among the elements of the array keeping the other parameters constant. In this technique, the vector representing the non-uniform phase distribution of array elements is given as

$$\Phi = [\phi_1, \phi_2, \phi_3, \ldots\ldots \phi_{n\ldots\ldots}, \phi_N,]$$

Φ_n refers to the phase excitation of the n^{th} element while the

$$d=\lambda/2 \text{ and } I = 1.$$

For an Amplitude-space synthesis technique we have amplitude and distance is non-uniformly distributed in addition to phase maintained at constant value.

$$I = [I_1, I_2, I_3, I_4, \ldots I_n \ldots\ldots I_N]$$

$$d=[d_1, d_2, d_3, \ldots d_n \ldots\ldots d_N]$$

$$\text{and } \phi = 0$$

Amplitude-phase control technique considers uniform space distribution with non-uniform amplitude and phase of excitation current, This is given as

$$I = [I_1, I_2, I_3, I_4, \ldots I_n \ldots\ldots I_N]$$

$$\Phi = [\phi_1, \phi_2, \phi_3, \ldots\ldots \phi_{n\ldots\ldots}, \phi_N,]$$

$$\text{and } d=\lambda/2$$

For all the above cases the following range for non-uniform distribution is implied

$$-\Pi \leq \Phi \leq \Pi,$$

$$0 \leq d \leq 2\lambda \text{ and } 0 \leq I \leq 1$$

Each technique has unique strategy in controlling the radiation pattern. The non-uniform amplitude function has better control on the SLL whereas the non-uniform space function has better control on the BW. The shape and position of the main beam can be easily manipulated using the non-uniform phase control. Depending upon the multiple objectives a combination of these parameters can be employed for better optimization

❖ ***EVOLUTIONARY COMPUTING TOOLS:***

In cellular telecommunications an evolved receiver is definitely an antenna devised comprehensively or considerably by an automated CPU design program that fact uses an evolutionary set of rules[5].This complicated operation antiquated utilized in latest agedness to make a few antennas for mission-critical applications involving rigorous, contrary, or significant radioactivity patterns for which not one of the quite a few existing antenna types are adequate. The computer prioritize starts amidst straight forward antenna shapes, and after that adds or modifies elements within a pickup incidental habit to build a number new candidate antenna shapes. These are after which evaluated to figure out how thoroughly they satisfy the aim requirements, and a numerical record is computed for every. By the use of in response to that deal with such a lot of evolutionary tools perform. To development of an antenna lot for devaluation of side lobe level, beam width keep watch over a range of algorithms admire GA,DE, FPA, APSO,FF etc., are developed. In these developed algorithms a brief introduction of FPA algorithm is followed[9].

Flower Pollination Algorithm

Introduction:

Flower pollination algorithm is a nature inspired meta heuristic algorithm developed by Xin She Yang in 2013. It is based on the pollination process of flowers. Flower pollination is a process in which plants reproduce. In flower pollination, the male particles known as pollen grains travel toward the female part of the flower known as stigma.[9] Now, pollination of flowers can be classified into two types:

Local Pollination
Global Polination

In local pollination, pollen grains travel to the stigma of either the same flower or to a different flower present in the

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same plant. Global pollination, the pollen grains travel to different flowers of different plants but the plants are of same species.[9]

In addition, certain natural agents known as pollinators are responsible for the transfer of pollen grains. These pollinators can be abiotic which include natural elements like wind and water or biotic which includes insects traveling to different flowers for nectar.[9]

If pollination occurs through abiotic means, it is known as abiotic pollination and if it occurs through biotic means, it is known as biotic pollination.[9]

Flower pollination is developed based on the above process. In Flower Pollination algorithm, the process is considered to be Local Pollination or Global Pollination based on the switching probability.

Abiotic pollination is considered as Local Pollination and biotic and cross pollination are considered as Global pollination.

The basic steps involved are based on rules that are as follows:

1. Movement of pollen carrying pollinators obeys Levy flights, and biotic and cross-pollination are considered as global pollination.
2. Abiotic and self-pollination are used for local pollination.
3. Flower constancy which is proportional to the similarity of two flowers can be considered as the reproduction probability.
4. Switch probability p [0, 1] controls the local and global pollination. Physical proximity and factors such as wind, bias the pollination activities towards local pollination.

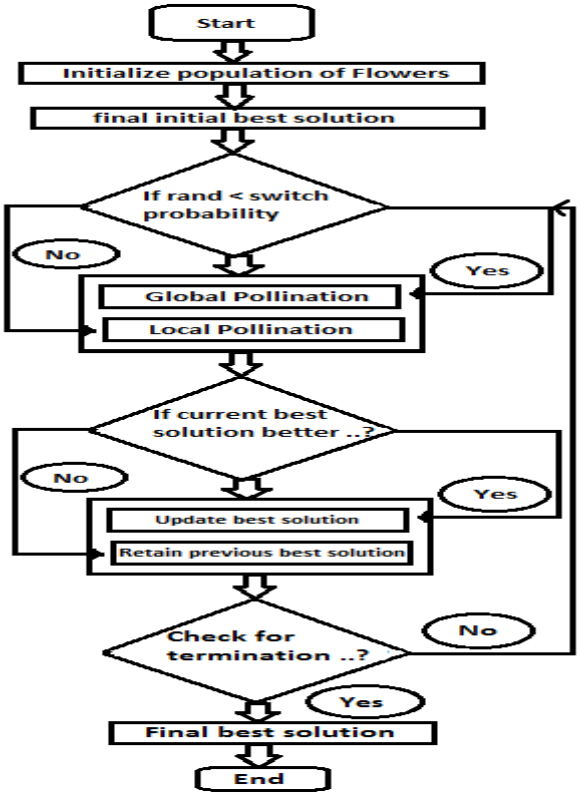

Fig1: Flowchart for FPA alogirthm [9]

FPA	ANALOGY
Aim=optimal reproduction of plant	**Aim= Optimize the objective function**
Pollen/flower	**Antenna Excitation's**
Population(N)	**Number of solution(N)**
Generation	**Iteration**

While (t < M Maximum Generation)
for(i=1:N)
if rand < P,(Global pollination)
Global pollination via insects and
animals.
else(Local Pollination)
Local pollination via self pollination
end if
Find new pollen
If new pollen is found, then update
it in population
end for
Find current best pollen
end while
Best pollen found after all generation
	while (t < M Iteration)
	for (i=1:N)
	if rand < P,(Global Solution)
	Global solution via step size.
	else(Local Solution)
	Local solution via update of each
	solution
	end if
	Calculate new among all solution
	If new solution is find, then update
	it in solution
	end for
	Find current best solution
	end while
	Best solution found iteration

FPA Analogy with Antenna

III. TIME MODULATION ANTENNA ARRAYS

In present research work in time modulation antenna arrays is to get effective realization of reduction of side lobe levels in the long distance sequences. These time modulated arrays have the basic feature of design time with the degree of freedom.[5] Compared to the conventional side lobe levels these Time modulated arrays have greater flexibility to reduce ultra low level side lobes when we maintain dynamic range ratio process.[5] When we maintain time modulation process is on switching manner in prearranged sequences then automatically antenna filters and get reduced the side lobe levels[5]. In conventional side lobe levels we have the error tolerances which are easy for levels reduction without difficult manner. While the existence of multi amplitude side band signals based time modulated array designing is difficult. The direct optimization of the switch on time sequence of each array element in time modulated array perform through various evolutionary computing tools[5].

When we control the pulse sequences in radio frequency switches we obtain radiation pattern in an easy way, which is an advantage of time modulated array. When we place a proper null in radiation diagram then it will have impact to reduce the interferences along with beam steering.

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The main shortcoming of time modulated arrays is that there are many side band signals separated at multiples of the modulation frequency.[6] To overcome this drawback so many evolutionary algorithms are latterly considered. For an array synthesis we add another dimension as time along with three steering parameters which gives an excitation for low side lobe levels to reduce.[6]

TIME MODULATION LINEAR ANTENNA ARRAY:

In the time switched array we use N elements which are having identical space between each. Every single element has the rapid condition of radio frequency switching. These type of arrays is used to transmit a pulses of rectangular manner including a pulse repetition frequency prf =1/Tp, where Tp is no. of repetitions of the pulse.[7-8]

This approach of time modulated array antenna with the reference of figure 2 shows that linear switching array topology. Each switches combined with the feed network to the summing network.[7-8]

If each switch of elements are resolved then array behaves with uniform element amplitude weighting which looks like normal linear array.[7-8] To arrange an effective time average highlight function across the face of the array, the elements of the array might be switched on for a cycle corresponding to a ordinary element amplitude weight.[7-8]

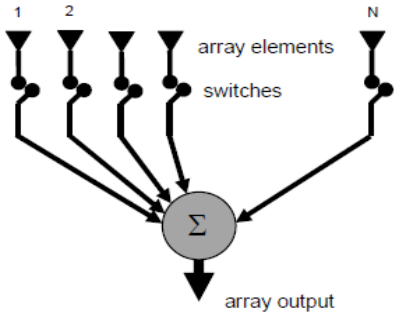

Fig 2. Time-switched array[5]

Time modulated circular antenna array:

As compared to the linear array antennas we have an advanced feature of a single direction exposure in invariant beam pattern and the azimuth plane angle.[10] These advanced features will make circular antenna as a best choice for finding radar and wireless communication systems. But the drawback of circular arrays is to get high side lobe levels. For this reason researchers developed different approaches to reduce these side lobes in the circular array antennas.[10]

Though, the side lobe levels (SLLs) of circular arrays habitually are relatively high, making them incompatible for some of these applications. In the past decades, antenna designers have developed several approaches to produce low side lobes in circular arrays.[10]

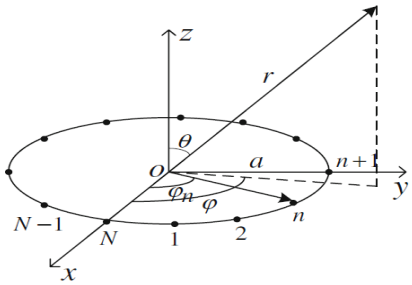

Fig.3 N-element circular array

IV. LITERATURE SURVEY

1)W. H. Kummer, A. T. Villeneyve," Ultra-Low Sidelobes from Time-Modulated Arrays" 1963 [5]

In this paper author described about the ultra low side lobes based time modulated antenna arrays design approach based on radio frequency switching which are programmed in a prearranged sequence. And the experimental results under an eight element slot array designing for reduction of side lobes be present in this paper. Author can consider an initial with 30db side lobe reduction of about 40db sequential switching.

2) Shiwen Yang, Yeow Beng Gan, "Sideband Suppression in Time-Modulated Linear Arrays by the Differential Evolution Algorithm" 2002 [6]

In this paper author working shows that in time modulated antenna arrays the suppression of the sideband radiation pattern by using differential evolution (DE) algorithm. And to observe that by re-arranging the static excitation amplitudes as well as the switch-on time intervals of each element significantly which can reduce the sideband level of a time modulated linear array.

3)William C. Barott,, and Braham Himed,," Time Modulated Array Pattern for Sidelobe Blanking in Spectrometry and Radar". 2014 [7]

In this paper author described about the TM applied to an array pattern by alternating a beam former between the set of beam forming coefficients. The coefficients are selected in such a way that signals arriving in the sidelobes are BPSK modulated by beam switching. This technique provides sidelobe blanking using a single beam former, which is simpler than the other approaches. In this paper authors Proposed the methods of array synthesis along with an example of 32-element linear array.

4) M. A. Hannan1, L. Poli1, P. Rocca1, A. Massa Pulse Sequence Optimization in Time-Modulated Arrays for Secure Communications, 2016 [8]

In this paper author described about the pulse sequence optimization in time modulation linear arrays. For securing communication we periodically modulate pulse sequences. These pulse sequences can control switching of the array optimizing by using Genetic Algorithm. This will

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minimizes the distortion on the transmitted signal along undesired directions.

5) V. V. S. S. S. Chakravarthy, P. S. R. Chowdary, Ganapati Panda "On the Linear Antenna Array Synthesis Techniques for Sum and Difference Patterns Using Flower Pollination Algorithm" 2017 [9]

In this paper author says that an array synthesis technique for summing and difference pattern using flower pollination algorithm. By using this algorithm we have an impact of reduction in side lobe levels and beam width of an antenna. For an antenna array side lobe problem, the population-based evolutionary computing techniques are best suited. In this paper author additionally shows that amplitude spacing methods this will estimate the weight of the each objective. Author compares flower pollination algorithm to genetic algorithm and particle swarm optimization. Among those flower pollination algorithm shows effective for sum and difference pattern.

6) Weilong Liang, Zhao Wu and Li Zhang "Multiobjective Optimization Design of Time-Modulated Concentric Circular Ring Arrays"2018[10]

In this paper author specified multi objective approach based on generalized differential evolution algorithm is proposed for optimizing the time-modulated array. Different from the single-objective optimization, which optimizes a weighted sum of the peak sidelobe level and the peak sideband level of the array, the multi objective algorithm treats the peak sidelobe level and the peak sideband level as in this paper author take 2 distinct objectives that are to be optimized alternatively. Furthermore, not only one outstanding optimization result can be acquired but also a set of solutions known as Pareto front is obtained by using the GDE3 algorithm, which will guide the design of time-modulated array more effectively. Users can choose one appropriate outcome which has a suitable trade off between the PSLL and the PSBL. This approach is illustrated through a time-modulated concentric circular ring array (CCRA). The optimal parameters and the corresponding radiation patterns are presented at last. Experimental results reveal that the multi objective optimization can be an effective approach for the TMA synthesis problems.

V. CONCLUSION

The evolutionary computing tools are capable of providing solution to antenna array design problem with excellent convergence features. The Time Modulation Scheme is capable of preserving the advantages of uniform distribution while the corresponding algorithm significantly plays the role of achieving the desired radiation characteristics. The review on the TMA expressed similar outcomes from vast literature cited.

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