ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 8, August 2015

Multiple Parameter Optimization of Antenna Array Using GA for Desired Results

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Abstract : **Genetic Algorithm is used for Linear Antenna Array Optimization by simultaneously optimizing two input parameters. It is performed on 16 element array. Reduction of SLL and nulls in desired directions are achieved in this paper. In single parameter optimization , nulls were at -55dB. It has been found that the better nulls of -62dB occurs in desirable directions when excitation amplitude and phase are optimized simultaneously.**

Index Terms : **Simultaneous Optimization, Excitation, Sidelobe level ,Genetic Optimization**

I. INTRODUCTION

Linear Antenna Arrays are used to optimize antenna array factor. 16 Antenna Arrays are used to achieve the results. The antenna array output depends on three input parameters, i.e. Excitation Amplitude , Excitation Phase and Element Spacing. By adjusting these input parameters using GA the desired pattern can be achieved. Simultaneous Optimization of two parameters using Genetic Algorithm is performed in this paper to achieve the desired results.[1-4]. There are total of five parameters which are required to arrange the antenna pattern properly as : Geometrical configuration (Linear, rectangular, circular, spherical), distance between the elements (element spacing) , Excitation amplitude of the elements, Excitation phase of the elements, pattern of the elements. [2]GA is the random search method used to optimize the radiation pattern. It is capable of solving complicated problems easily and is much reliable. GA works on the principle of Darwinian Theory. [5]This theory is said to be as Reproduction in which, genetic information of existing individual is copied to the new individual. It consists of mainly three steps : Selection , Crossover and Mutation. In selection process GA chose the best fitness function from the desired individuals. Crossover consists the interchanging of genes between two individuals. In mutation process , new individual being created from parent individual by randomly mutating.[6-7] It produces changes, which can be gradual or violent.

The paper is organized as follows. The problem formulation is presented in Section 2. The results and discussions are given in Section 3 followed by conclusion in Section 4.

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II. PROBLEM FORMULATION

Problem of multi parameters has been ignored till now and this is taken up in this paper. In simultaneous optimization of two parameters the main motive is to reduce the SLL and to have better nulls in the desired directions. In simultaneous optimization of two parameters firstly excitation phase and element spacing are optimized and excitation amplitude is kept constant. In second case, excitation amplitude and element spacing are optimized and excitation phase is kept constant. In third case, excitation amplitude and excitation phase are optimized and element spacing is kept constant. Array Factor is the geometrical representation of radiation pattern.

The array factor is given as follows:

$$AF(\theta)=2\sum_{n=1}^{N} I(n)\cos[kz(n)\cos(\theta)+\phi(n)] \quad [8]$$

Where

N=number of elements;

Z(n)=distance of the nth element from origin;

I(n)= amplitude excitation of the nth element;

Φ(n)= phase of the nth element.

K=2*pi/λ wave numbers

Range of Excitation Amplitude is taken from 0.2 to 1, Excitation Phase from 0° to 180° , and Element Spacing between two adjoining elements from 0.3λ to 0.7λ, where n is number of antenna elements .The experiment is conducted 10 times. The average of the 10 results are taken for analysis and comparison.

III. RESULTS AND DISCUSSIONS

In this paper, results of the following cases are obtained and analysed :

Case 1 : Optimization of single parameter namely : element spacing, excitation amplitude and excitation phase.

Case 2 : Optimization of two parameters namely excitation phase and element spacing , excitation amplitude and element spacing , excitation amplitude and excitation phase.

In these cases , sidelobes range is from [1° 88°] and [94° 181°] and the null directions are in 81° and 99°.

These results are presented in the form of plots and tables as shown below:

A. Optimization of array factor by adjustment of element spacing.

The results are presented in fig. 1.1 .In this case deep null of -40 dB occurs at 81° and 99°. Here two bands of sidelobes are there in which near by lobes are at -15 dB from [78 to 82] and [91 to 93] and from [75 to 80] and [95 to 100] are at -25 dB and far away lobes from [0 to 74] and [101 to 181] are below -30 dB.In this optimization of element spacing is done by keeping excitation amplitude one and excitation phase zero.

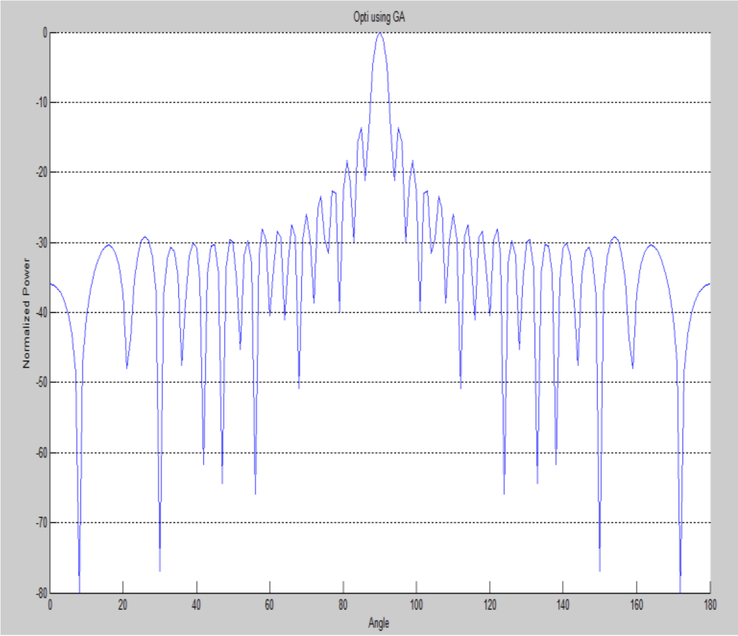

Fig 1.1 Antenna Array Optimization Using Genetic Algorithm for element spacing

B. Optimization of array factor by adjustment of feed current amplitude.

The results are presented in fig. 1.2 . Here nulls are at -53dB at 81° and 99°. Here sidelobes are below -25dB but near by lobes are at -16dB. In this excitation amplitude is varied and excitation phase is kept zero , and values of element spacing are taken from first result.

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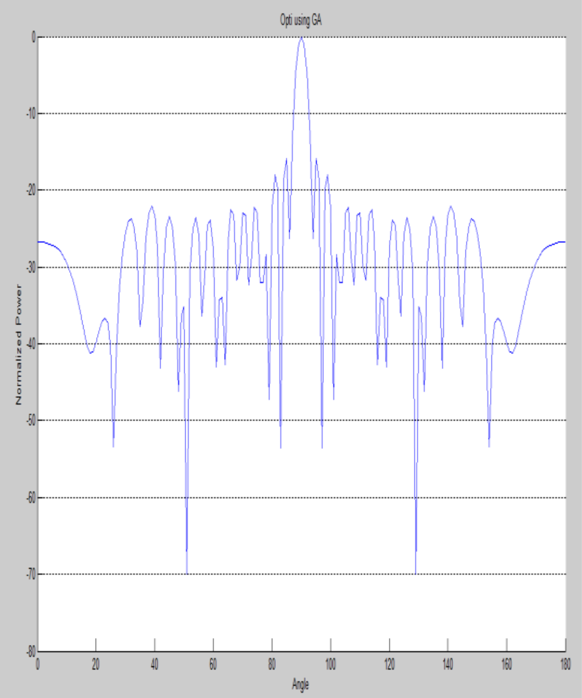

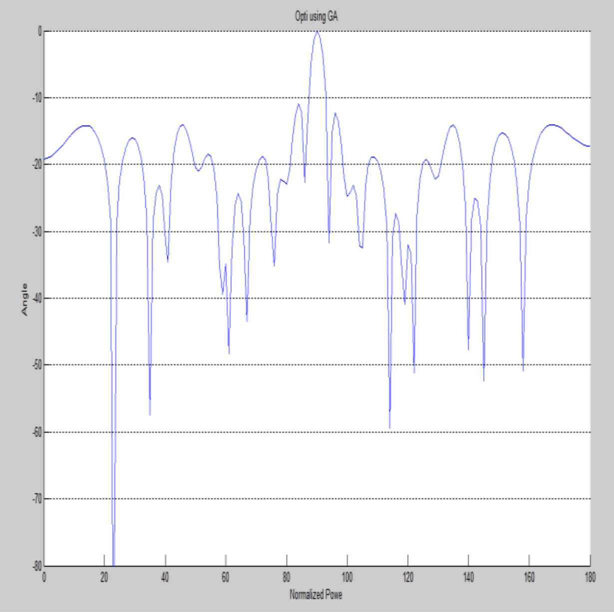

Fig 1.3 Antenna Array Optimization Using Genetic Algorithm for excitation phase

Fig 1.2 Antenna Array Optimization Using Genetic Algorithm for excitation amplitude

C. Optimization of array factor by adjustment of feed current phase.

The results are presented in fig. 1.3 . Here nulls are at -23dB and -25dB at 81° and 99°. Here near by lobes are below -12dB , middle lobes are at -23dB and far away lobes are at -15dB.In this excitation phase is varied and values of excitation amplitude and element spacing be from previous results.

Table 4.1

Results obtained after averaging the values obtained by repeating the experiment 10 times in single parameter optimization

Sr. No.	Element Spacing	Excitation Amplitude	Excitation Phase
1	0.47	0.75	4.08
2	1.45	0.76	4.41
3	2.43	0.61	6.04
4	3.42	0.61	4.11
5	4.41	0.69	4.84
6	5.41	0.61	3.64
7	6.40	0.47	5.43
8	7.37	0.60	3.72
9	8.35	0.75	3.16
10	9.34	0.54	3.09
11	10.34	0.75	4.47
12	11.34	0.43	5.20
13	12.34	0.62	4.57
14	13.36	0.47	3.61
15	14.42	0.59	4.50
16	15.55	0.75	4.22

D. SIMULTANEOUS OPTIMIZATION OF EXCITATION PHASE AND ELEMENT SPACING

The results are presented in fig. 1.4 .In this deep null of -25 dB occurs at 81° and 99°. Here two bands of sidelobes are there are there in which , from 0° to 55° and from 125° to 180° Azimuth angle the value of sidelobe level is near -16dB. For 56° to 65° and 115° to 124° Azimuth angle the value of sidelobe level is near -36dB i.e. -34dB to -38dB. For 66° to 79° and 100° to 114° Azimuth angle the value of sidelobe level is below -20dB.

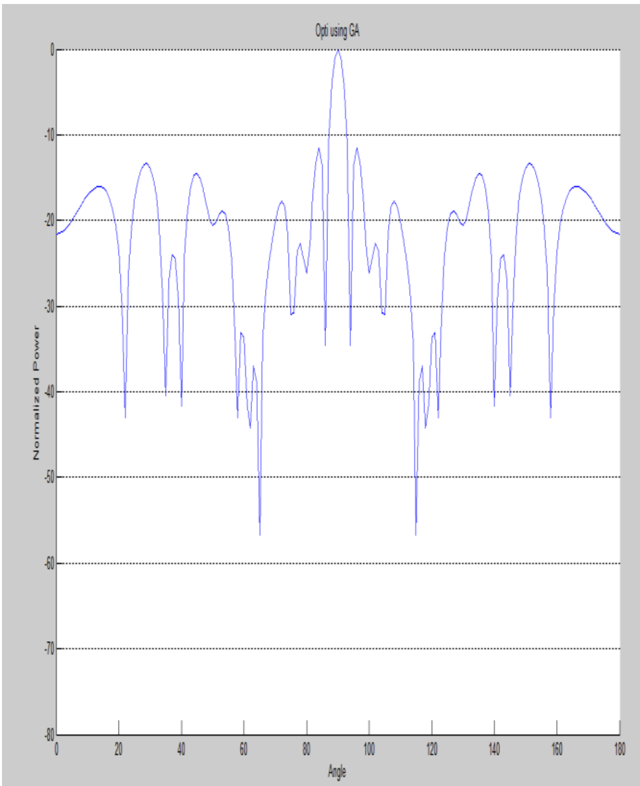

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Fig 1.4 Antenna Array Optimization Using Genetic Algorithm for simultaneous excitation phase and element spacing

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E. SIMULTANEOUS OPTIMIZATION OF EXCITATION AMPLITUDE AND ELEMENT SPACING

The results are presented in fig. 1.5 .In this deep null of -42 dB occurs at 81° and 99° angle. Here two bands of sidelobes are there in which , from 0° to 20° and from 161° to 180° Azimuth angle the value of sidelobe level is below -20dB. For 21° to 76° and 102° to 160° Azimuth angle the value of sidelobe level is below -25dB . For 77° to 88° and 95° to 101° Azimuth angle the value of sidelobe level is below -15dB.

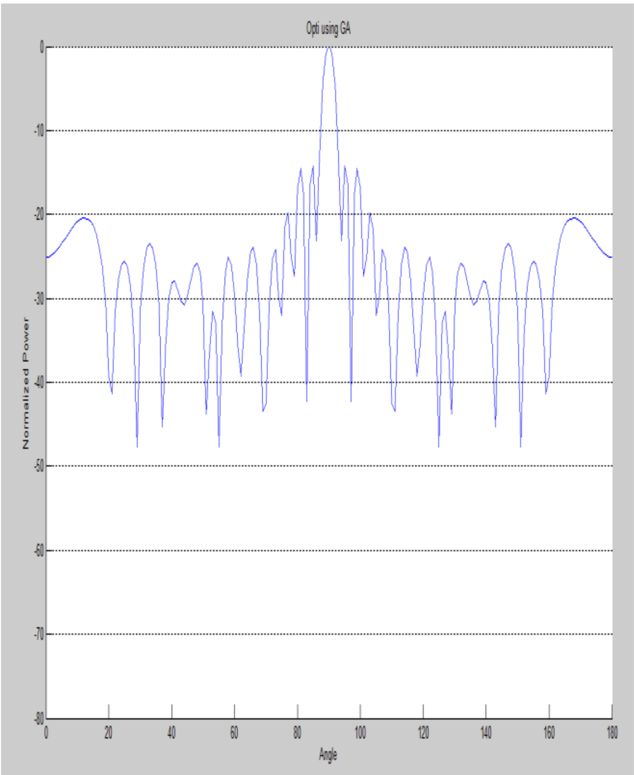

Fig 1.5 Antenna Array Optimization Using Genetic Algorithm for simultaneous excitation amplitude and element spacing

F. SIMULTANEOUS OPTIMIZATION OF EXCITATION AMPLITUDE AND EXCITATION PHASE

The results are presented in fig. 1.6 .In this deep null of -55 dB occurs near 81° and 99°. Here two bands of sidelobes are there in which , from 0° to 20° and from 160° to 180° Azimuth angle the value of sidelobe level is below -23dB. For 21° to 37° and 143° to 159° Azimuth angle the value of sidelobe level is near -30dB . For 38° to 50° and 130° to 142° Azimuth angle the value of sidelobe level is near -30dB. For 51° to 88° and 94° to 129° Azimuth angle the value of sidelobe level is above -20dB..

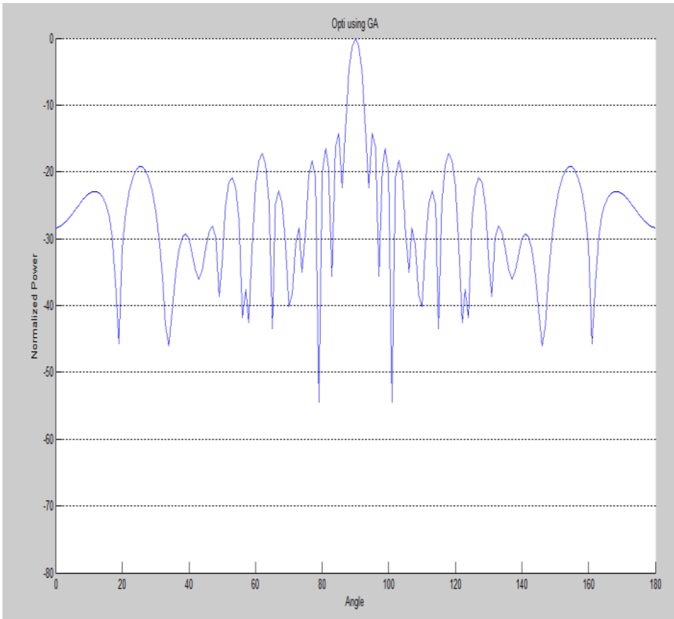

Fig 1.6 Antenna Array Optimization Using Genetic Algorithm for simultaneous excitation amplitude and excitation phase.

Table 4.2

Results obtained after averaging the values 10 times for simultaneous two parameter optimization

Sr. No	Case1 ExcitationAmplitude	Case1 ExcitationPhase	Case2 Excitation Amplitude	Case2 Element Spacing	Case3 Excitation Phase	Case3 Element Spacing
1	0.39	0.14	0.46	0.34	0.14	0.49
2	0.38	0.37	0.44	1.30	0.39	1.34
3	0.66	0.21	0.33	2.30	1.11	2.30
4	0.30	0.54	0.48	3.30	0.27	3.30
5	0.44	0.18	0.39	4.30	0.49	4.30
6	0.58	0.47	0.47	5.30	0.33	5.30
7	0.50	0.48	0.35	6.30	0.31	6.30
8	0.36	0.32	0.30	7.30	0.19	7.30
9	0.28	0.90	0.39	8.30	0.53	8.30
10	0.39	0.65	0.37	9.30	0.92	9.30
11	0.43	0.55	0.36	10.30	0.62	10.30
12	0.70	0.65	0.56	11.30	0.48	11.30
13	0.35	0.44	0.40	12.30	0.28	12.30
14	0.44	0.26	0.51	13.30	0.29	13.30
15	0.40	0.37	0.30	14.30	0.41	14.30
16	0.46	0.37	0.36	15.30	0.44	15.30

From case 1 of element spacing and case 2 of excitation phase and element spacing ,in case 1 deep null of -40 dB occurs at 81° and 99° both and in case 2 deep null of -25 dB occurs at 81° and 99° both. In case 1 SLL is -30dB and in case 2 SLL level is -36dB which is better in both cases than single parameter optimization as shown in fig. 1.1 and 1.4 respectively. In this simultaneous optimization is better in case of SLL and slightly poor in case of null directions. If null required at lower position then it is better in null positions also. Further in case 1 of excitation amplitude and case 2 of excitation amplitude and element spacing ,in case 1 SLL reduction is -25dB and in case 2 SLL reduction is -32dB and null directions are at -53dB in case1 and in case 2 these are at -42dB as shown in fig. 1.2 and 1.5 respectively. Here also the case arises in which SLL is better than single parameter optimization but nulls are slightly poor as compared to case 1. But for lower level of null positions they are better than case 1. In case 1 of excitation phase there is only SLL reduction of -25dB and in case 2 of excitation amplitude and excitation phase SLL is -30dB and in case 1 null directions are at -23dB and -25dB at 81° and 99° and in case 2 deep null of -55dB as shown in fig 1.3 and 1.6 respectively. In this case for simultaneous optimization both SLL and null positions are better than single parameter optimization. From single parameter optimization, excitation amplitude optimization is better in case of null positions and in SLL reduction element spacing optimization is better. It concludes that simultaneous optimization of excitation amplitude and excitation phase is better than all other techniques. From all these analysis , it can be concluded that simultaneous two parameter optimization is better than the single parameter optimization.

IV. CONCLUSION

In this paper , single parameter optimization and multi parameter optimization in case of Antenna Arrays are presented. Sidelobes band selected is from [1° 88°] and [94° 181°] and the null directions are in 81° and 99°. From the analysis it can be seen that in case of single parameter optimization , excitation amplitude optimization is better in case of null positions and in SLL reduction element spacing optimization is better . In simultaneous two parameter optimization, excitation amplitude and excitation phase is better than all other techniques.

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