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Null Steering In Linear Arrays for Multiple Null Positions

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***Abstract** In the current article, the linear array null pattern synthesis for beam forming applications is presented using the novel social group optimization algorithm(SGOA) . As a part of the simulation, the circular array of 24 element length is considered with a spacing of inter-elements of 0.5 λ is considered. These patterns are synthesized for null steering and side lobe level (SLL) optimization. Strategy of designing arrays with single and multiple nulls are presented in more robust manner in which the width of the beam and SLL are also included for objectives of design.*

Keywords : Beam forming, Null positioning , SGOA.

I. INTRODUCTION

Now a day's challenge of the modern telecommunications is the ever-growing subscribers number. This is in conflict with the limited spectrum available with the provider. With the available resources, the capacity which is proportional to the number of users served in a sector of the cellular station is limited. With the increasing number of users, it is always an inconceivable task to detect signal coming in a particular direction. In addition to these, the environment is more polluted with several other factors like fading and co-channel interference. In order to overcome these, the solution lies in application of adaptive antenna arrays for such environment. Such radiating element consists of more than one similar type of antennas that are electrically connected with each other. These adaptive arrays are designed, so as to suppress the interference signal that leads to improved signal reception characteristics. Hence, the objectives of such array synthesis are to generate radiation patterns that are completely defined by the null steering and null positioning.
The fundamental construction blocks of null placement and beam steering Null placement and beam steering are the fundamental building blocks of beam forming. Beam forming technique accepts desired signal that is arriving at an angle known as direction of arrival (DOA) of desired signal and suppresses the interference signal from other directions. Beam steering involves in directing the main beam of the required signal to the DOA while nulls are positioned in the interference signal DOA.

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Several synthesis techniques are proposed that effectively design the arrays for increasing the SNR in multipath environment. In this paper, one such technique known as amplitude only using SGOA is proposed. The simulation-based experiments are carried out to meet several challenges like observing narrow single and multiple nulls under constrained and unconstrained conditions.
The framework of the simulation experimentation is explained in the subsequent sections and divided into eight cases. SGOA is used for synthesis process.

II. PROBLEM FORMULATION

Array design formulation for the corresponding fitness formulation for the desired objectives are presented in this Section as follows.

(A) Array factor formulation

Linear array design problem involves in generating optimal set of design parameters like amplitudes or inter-element spacing or both that yields main beam of the required signal to the DOA while nulls are positioned in the interference signal DOA predefined BW. Array factor of LA is

$$AF(\theta)=2\sum_{n=1}^{N} A_n \cos[\mathrm{kd}_n \cos\theta+\beta_n] \qquad -(1)$$

Here
N relates to element n and to element n=1,2 ..... N
k is the amount of the wave specified as 2Π/λ
θ is the angle of observation
A_n relates to the nth element's excitation amplitude
d_n refers to the distance between the reference point and the nth component
The description of this array factor is given in previous Chapters. In brief the optimization problem involves in determining the vector I of size N=12 in order to acquire the required pattern of radiation. This is given as

$$I=[I_1, I_2, \ldots\ldots I_{24}] \qquad -(2)$$

The longitudinal length between two sequential elements is maintained uniformly at λ/2.

III. FITNESS FORMULATION

For objectives such as single or multiple narrow nulls and desired SLL, the formulation of the fitness function is given as

$$f1 = \max(\text{null\_depth} + \text{AF}(\theta = \theta_{null(n)})) \quad if\ \text{AF}(\theta = \theta_{null(n)}) > -50$$
$$= 0 \qquad\qquad \text{otherwise}$$
-(3)

$$f2 = SLL_{desired} + \max(\text{SLL}_{\theta=-\pi/2 to \pi/2})$$
-(4)

IV. RESULTS AND DISCUSSIONS

The experimentation with simulation is carried to demonstrate the null steering mechanism and capability of the algorithm for linear arrays. In this regard, a 12-element linear array is chosen. In order to demonstrate the null steering capability, the experimentation is divided into two cases. In the first case single nulls at different positions contrary to the side lobes of the uniform distribution are considered as the deign targets. As part of the second case, multiple nulls are considered two different locations as two different scenarios. The corresponding results are presented in the subsequent Sections.

(A) Case-1: Single null positions

As discussed earlier, in this case single nulls at different locations are considered as deign objectives. The considered null positions are 14^0, 24.5^0, 48.25^0, and 66.25^0 which are relevant to the lobe on the left peaks of the uniform LA.

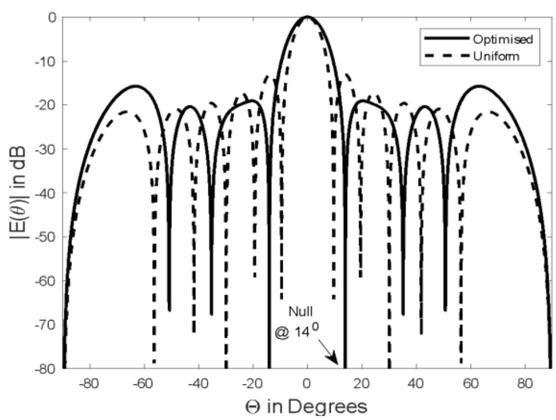

Fig1 (a): Non-uniform amplitude distribution of LA with null at 14°

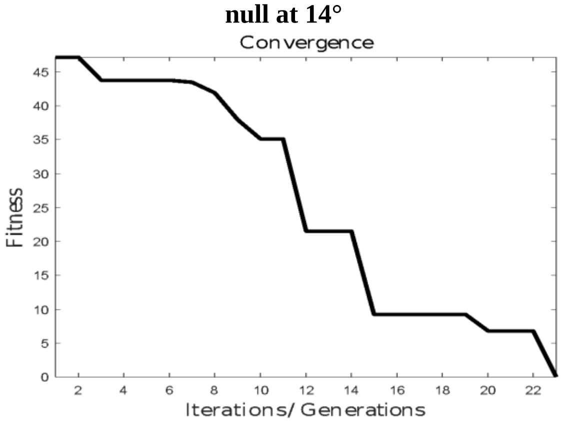

Fig.1 (b): Non-uniform amplitude distribution of LA with null at 14°

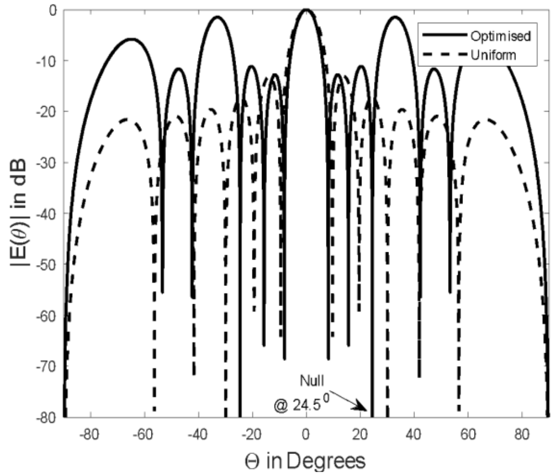

Fig.2 (a): Non-uniform amplitude distribution of LA with null at 24.5°

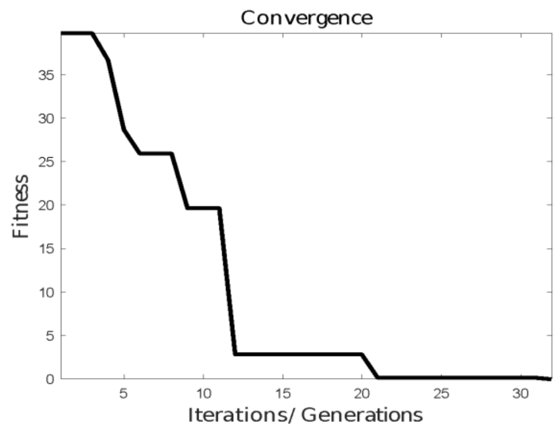

Fig.2 (b): Non-uniform amplitude distribution of LA with null at 24.5°

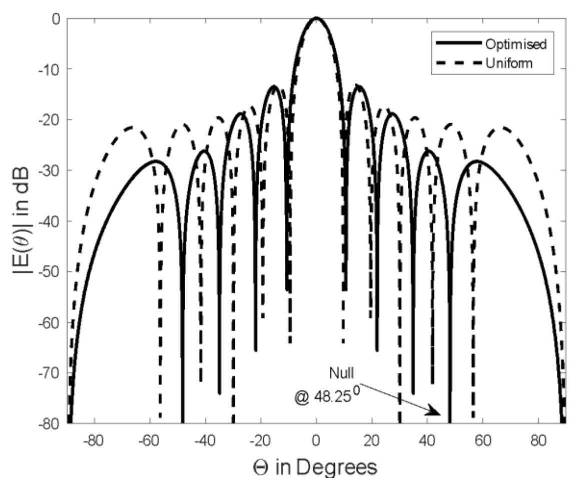

Fig.3 (a): Non-uniform amplitude distribution of LA with null at 48.25°

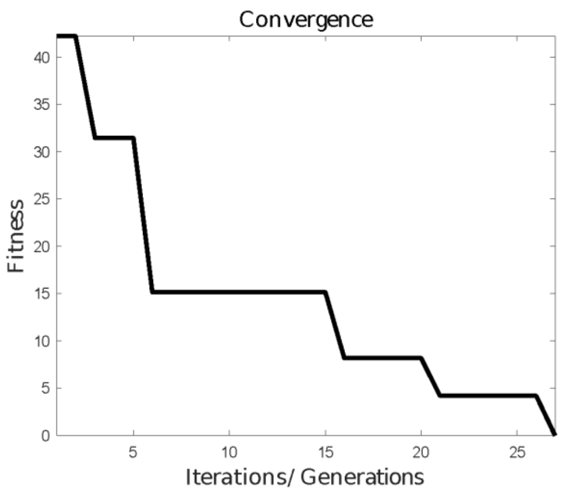

Fig.3 (b): Non-uniform amplitude distribution of LA with null at 48.25°

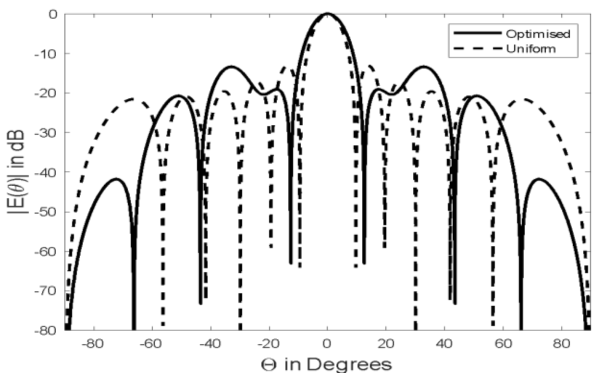

Fig.4 (a): Non-uniform amplitude distribution of LA with

null at 66.25°

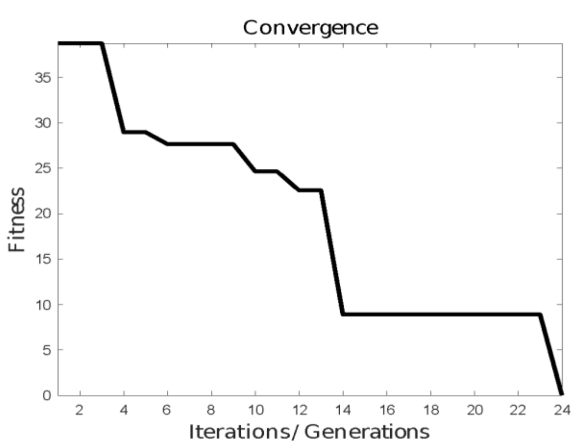

Fig. 4 (b): Non-uniform amplitude distribution of LA with

null at 66.25°

(A)Case-2: Multiple null positions

Multiple nulls will be regarded in this situation. The phenomenon of multiple nulls are chosen to be a combination of two previously described positions. In this regard, a combination of two edge nulls and in between median nulls are taken, and radiation patterns accordingly are determined and presented in Fig. 6.5 and Fig.6.6. Along with the radiation patterns, appropriate convergence plots are also provided.

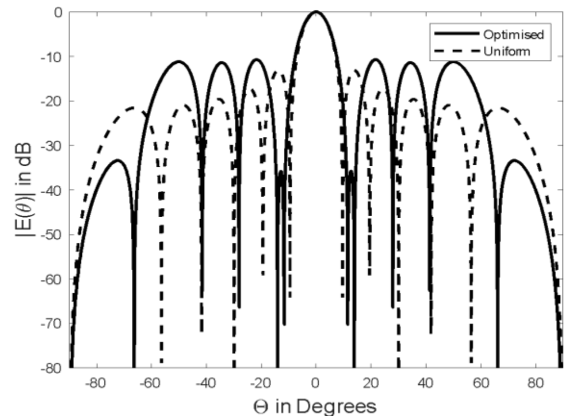

Fig. 5 (a): Non-uniform amplitude distribution of LA with null at 14° & 66.25°.

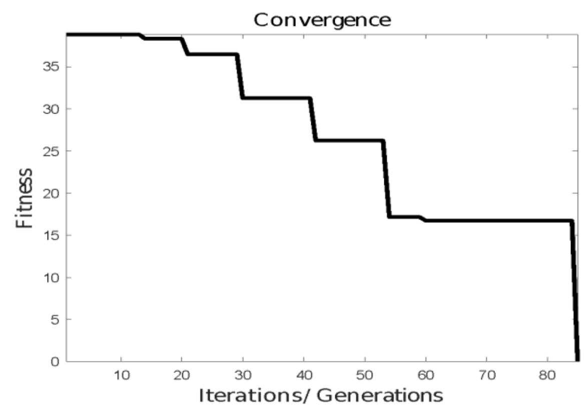

Fig. 5 (b): Non-uniform amplitude distribution of LA with null at 14° & 66.25°.

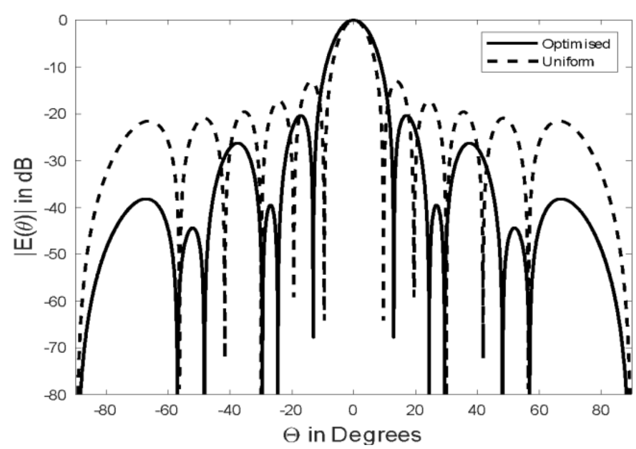

Fig. 5 (b): Non-uniform amplitude distribution of LA with null at 14° & 66.25°.

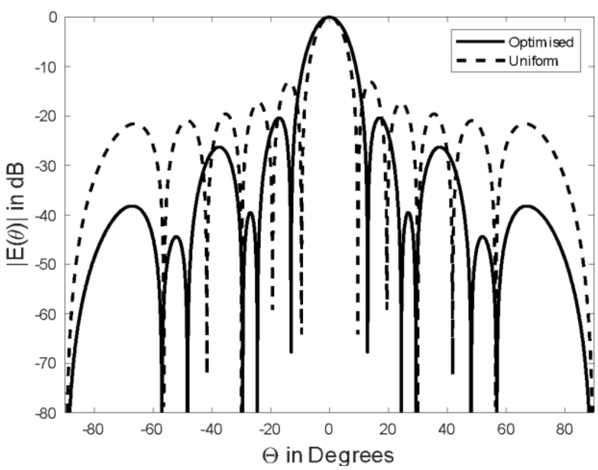

Fig. 6 (a): Non-uniform amplitude distribution of LA with null at 24.5° & 48.25°

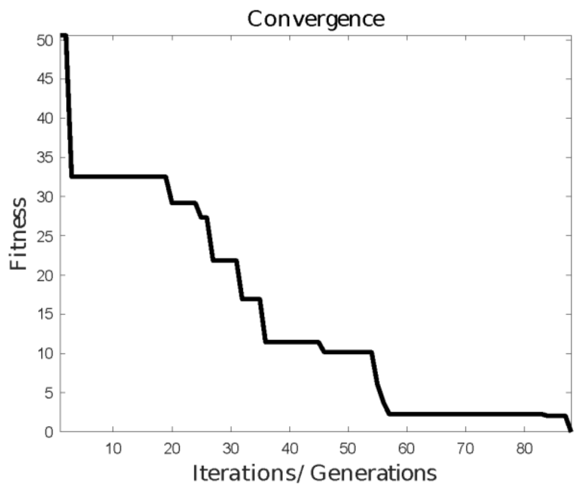

Fig. 6 (b): Non-uniform amplitude distribution of LA with null at 24.5° & 48.25°

V. CONCLUSION

The design of NULA with the objectives of single and multiple nulls is implemented in this paper . The robust design includes nulls along with the SLL and controlled BW. The choice of the null position describes the experimentation process which is supposed to be appropriate to evaluate the algorithm's efficiency.

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