Null Positioning Of Linear Antenna Array Using Evolutionary Algorithm

Smt. S. Aruna [1], Likhita Sai Uppu[2] , Shamshad Begum Shaik[3] and Vamsi Priyanka Thotada[4]

1 Assistant Professor, Dept. of Electronics and Communication, Andhra University College of Engineering,
Visakhapatnam, Andhra Pradesh, India
aruna9490564519@gmail.com

2 Student, Dept. of Electronics and Communication, Andhra University College of Engineering,
Visakhapatnam, Andhra Pradesh, India
ulikhitasai@gmail.com

3 Student, Dept. of Electronics and Communication, Andhra University College of Engineering,
Visakhapatnam, Andhra Pradesh, India
shamshad2995@gmail.com

3 Student, Dept. of Electronics and Communication, Andhra University College of Engineering,
Visakhapatnam, Andhra Pradesh, India
vamsipriyankat@gmail.com

***

Abstract - *In this paper, null steering to reject interference is studied for linear antenna arrays using Bees Algorithm (BA). BA adjusts the amplitude of each radiating element to minimise the total output power in the direction of the interfering signals. Then the null steering algorithm is loaded with MATLAB using amplitude-only in order to facilitate the realization. Numerical examples of Chebyshev pattern with the single and multiple nulls imposed at the directions of interference are given to show the remarkable robustness, accuracy and flexibility of the BA.*

***Key Words*: Bees Algorithm, Null Steering, Linear Antenna Array, Interference suppression, Chebyshev pattern.**

1.INTRODUCTION

The desired signal reception of linear array is improved by placing nulls in the direction of the interfering signal while keeping the direction of the main beam to the desired signal. The increasing pollution of the electromagnetic environment has prompted the study of array pattern nulling techniques. These techniques are very important in radar, sonar and many communication systems for minimizing degradation in signal-to-noise ratio performance due to undesired interference.

The nulling methods are generally based on controlling the complex weights (both the amplitude and the phase), the amplitude-only, the phase-only, and the position only of the array elements. In this paper, null steering is achieved by amplitude control to avoid the non-linearities and approximations as seen in phase control and position control null steering methods. The classical optimization techniques used for antenna array synthesis are likely to be stuck in local minima if the initial guesses are not reasonably close to the final solution. The Bees Algorithm has remarkable robustness over evolutionary optimization techniques such as Genetic Algorithm, Ant Colony Optimization, Particle Swarm Optimization, Differential Evolution. The BA is an optimization algorithm inspired by the natural foraging behaviour of honey bees to find the optimal solution.

2. BEES ALGORITHM

A bee colony can be thought of as a distributed creature that can extend itself so as to utilize a large number of food sources at long distances in multiple directions. The colony tries to attain the most optimal use of colony members by employing more bees for visiting flower areas with more nectar and pollen that can be collected with less effort than the areas with less nectar and pollen.

A certain percentage of the colony is kept as the scout bees which randomly visit flower patches. If these scout bees find a flower patch that has more food than a predetermined threshold, they return to the hive and inform of their finding by performing the “waggle dance” which gives information about direction, distance and quality. After the waggle dance ends, the scout bee goes back to the flower patch with a number of other bees from the colony.

2.1 Algorithm

```
1. Randomly initialize the population
2. Calculate the fitness of the population
3. While stopping criterion is not satisfied
    // Forming the new population
4. Choose the elite bees and the elite sites for
   neighborhood search
5. Choose other sites for neighborhood search
6. Assign bees to the selected sites and calculate their
   fitnesses
7. Choose the fittest bee from each site
8. Recruit remaining bees to search randomly and
   calculate their fitnesses
9. End While
```

2.2 Formulation

If the element amplitudes are symmetrical about the center of the linear array, the far field array factor of this array with an even number of isotropic elements (2N) can be written as

$$F(\theta)=2\sum_{n=1}^{M} a_n \operatorname{Cos}\left(\frac{2\pi}{\lambda}\, b_n\, Sin\theta\right) \qquad (1)$$

where a_n is the amplitude of the nth element, Θ is the angle from broadside, and b_n is the distance between position of the nth element and the array centre. In this particular problem of null synthesizing, we restricted ourselves to find an appropriate set of an to place array nulls at any prescribed directions. Therefore, the following cost function will be minimized by using BA.

$$C=\sum_{\theta=-90^{0}}^{\theta=90^{0}}\left[W(\theta)\left|F_b(\theta)-F_r(\theta)\right|+ESL(\theta)\right] \qquad (2)$$

where $F_b(\Theta)$ and $F_r(\Theta)$ are, respectively, the pattern obtained by using BA and the desired pattern. W (Θ) and ESL(Θ) are included in the cost function to control the null depth level and maximum sidelobe level, respectively

3. TABLES AND FIGURES

Table -1: Element amplitudes for 10 element array

Antenna number in array N	Initial Chebyshev pattern Figure1	Computed with the BA		
		One null Figure 4	Two nulls Figure 5	Three nulls Figure 6
+1	1.0000	0.9695	0.9737	0.6967
+2	0.8780	0.8355	0.9258	0.7418
+3	0.6692	0.7187	0.9395	0.6566
+4	0.4300	0.5281	0.5395	0.4000
+5	0.2575	0.5707	0.5289	0.4026

Table -2: Element amplitudes for 20 element array.

Antenna number in array n	Initial Chebyshev pattern Figure2	Computed with the BA		
		One null Figure7	Two nulls Figure8	Three nulls Figure9
+1	1.00000	1.00000	1.00000	1.00000
+2	0.97010	0.97010	1.03960	0.99274
+ 3	0.91243	0.91243	1.01830	0.99116
+4	0.83102	0.83102	0.89955	0.94345
+5	0.73147	0.73147	0.74706	0.76246
+6	0.62034	0.62034	0.63308	0.59229
+7	0.50461	0.50461	0.53032	0.54667
+8	0.39104	0.39104	0.37235	0.42612
+9	0.28558	0.28558	0.21000	0.21265
+10	0.32561	0.32561	0.28035	0.26785

Table -3: Element amplitudes for 30 element array.

Antenna number in array n	Initial Chebyshev patten Figure3	Computed with the BA		
		One null Figure 10	Two nulls Figure 11	Three nulls Figure 12
+1	1.0000	0.7306	0.8603	0.6088
+2	0.9870	0.9932	0.9816	0.9244
+3	0.9613	0.6001	0.9418	0.9000
+4	0.9238	0.5052	0.9126	0.7976
+5	0.8756	0.5316	0.6511	0.7501
+6	0.8182	0.6069	0.6333	0.6522
+7	0.7532	0.7153	0.5539	0.3036
+8	0.6826	0.6006	0.8937	0.8030
+9	0.6083	0.7194	0.9044	0.7530
+10	0.5322	0.4368	0.9007	0.9076
+11	0.4564	0.5135	0.3444	0.1630
+12	0.3827	0.1767	0.7358	0.8499
+13	0.3127	0.8748	0.6614	0.2181
+14	0.2477	0.2857	0.2607	0.0591
+15	0.4235	0.1441	0.1870	0.3342

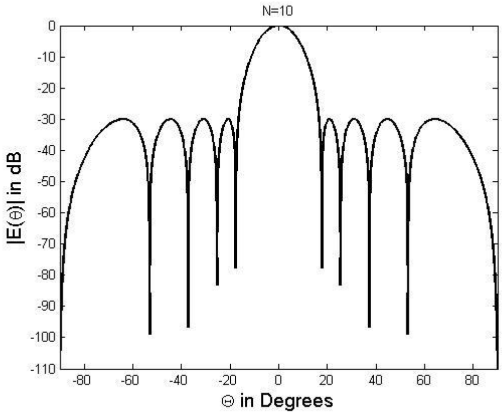

Fig-1: Initial 30dB Chebyshev pattern for 10 elements array.

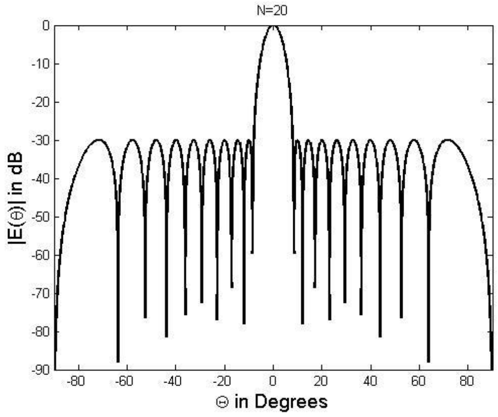

Fig-2: Initial 30dB Chebyshev pattern for 20 elements array

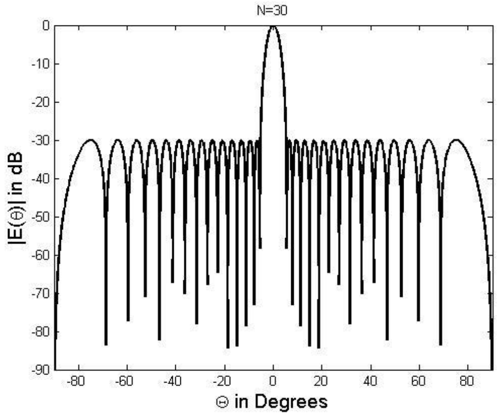

Fig-3: Initial 30dB Chebyshev pattern for 30 elements array.

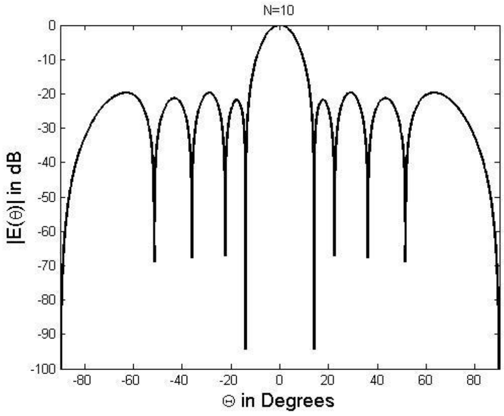

Fig-4: Radiation pattern with one imposed null at 14◦ of 10 element array

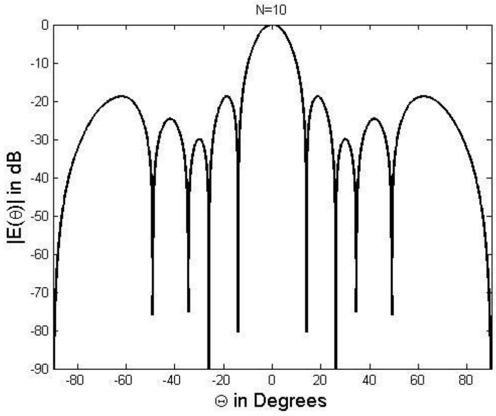

Fig-5: Radiation pattern with double imposed null at 14◦ and 26◦ of 10 element array.

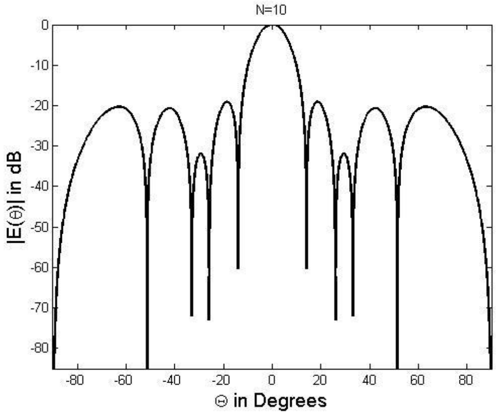

Fig-6: Radiation pattern with triple imposed null at 26 ◦,33 ◦ and 54 ◦ of 10 element array.

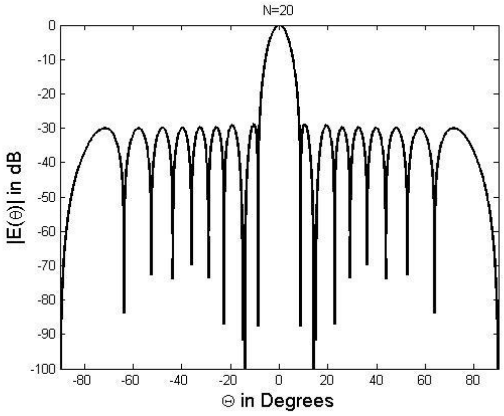

Fig-7: Radiation pattern with one imposed null at 14◦ of 20 element array.

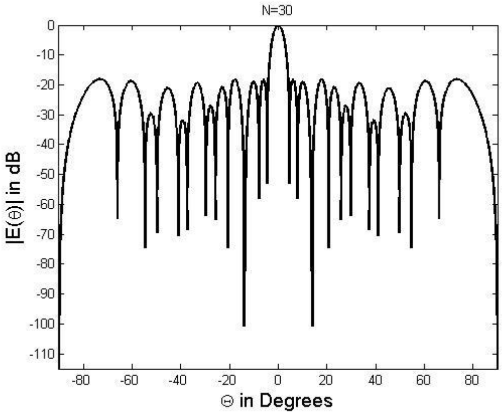

Fig-10: Radiation pattern with one imposed null at 14◦ of 30 element array.

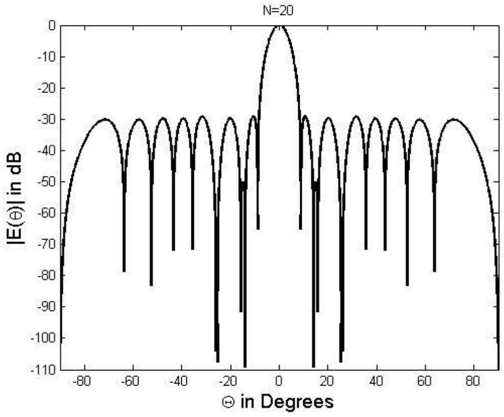

Fig-8: Radiation pattern with double imposed null at 14◦ and 26◦ of 20 element array.

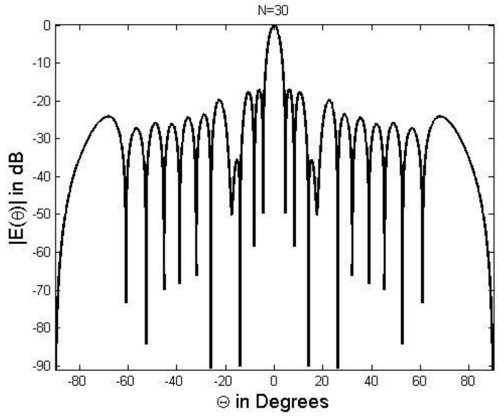

Fig-11: Radiation pattern with double imposed null at 14◦ and 26◦ of 30 element array.

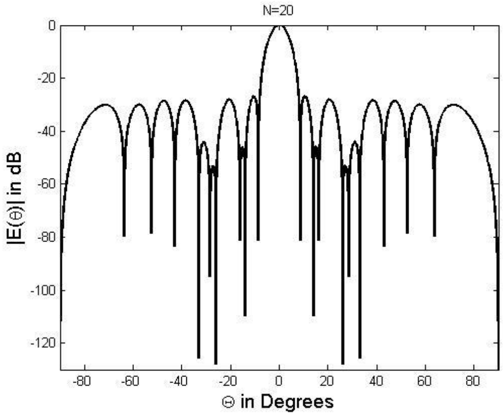

Fig-9: Radiation pattern with triple imposed null at 14◦, 26◦ and 33◦ of 20 element array.

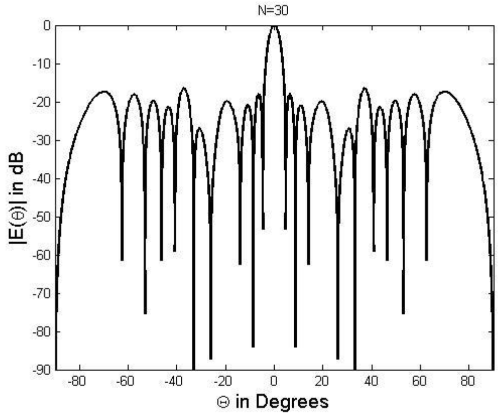

Fig-12: Radiation pattern with triple imposed null at 14◦, 26◦ and 33◦ of 30 element array.

3. CONCLUSION

In this paper, the BA has been used for interference suppression of a linear antenna array by amplitude-only control. The computer simulation results show that the BA is capable of forming single, multiple and broad band nulls to any prescribed directions by controlling the amplitude of each array element while keeping the pattern as close as possible to Chebyshev initial pattern. The BA can also easily be implemented for arrays with complex geometries as well as non-isotropic-elements. Since the BA has good accuracy and does not require complicated mathematical functions, it can be very useful to antenna engineers for the pattern synthesis of antenna arrays

REFERENCES

[1] Steyskal, H., R. A. Shore, and R. L. Haupt, “Methods for null control and their effects on the radiation pattern,” IEEE Trans. Antennas Propagat., Vol. 34, 404–409, 1986.M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

[2] Ibrahim, H. M., “Null steering by real-weight control — a method of decoupling the weights,” IEEE Trans. Antennas Propagat., Vol. 39, 1648–1650, 1991.

[3] Liao, W. P. and F. L. Chu, “Array pattern synthesis with null steering using genetic algorithms by controlling only the current amplitudes,” Int. J. Electronics, Vol. 86, 445–457, 1999.

[4] Shore, R. A., “Nulling at symmetric pattern location with phase-only weight control,” IEEE Trans. Antennas Propagat., Vol. 32, 530–533, 1984.

[5] Haupt, R. L., “Phase-only adaptive nulling with a genetic algorithm,” IEEE Trans. Antennas Propagat., Vol. 45, 1009–1015, 1997.

[6] Ismail, T. H. and M. M. Dawoud, “Null steering in phased arrays by controlling the element positions,” IEEE Trans. Antennas Propagat., Vol. 39, 1561–1566, 1991.

[7] Tennant, A., M. M. Dawoud, and A. P. Anderson, “Array pattern nulling by element position perturbations using a genetic algorithm,” Electronics Letters, Vol. 30, 174–176, 1994.

[8] Liao, W. P. and F. L. Chu, “Array pattern nulling by phase and position perturbations with the use of the genetic algorithm,” Microwave and Optical Technology Letters, Vol. 15, 251–256, 1997.

[9] Hejres, J. A., “Null steering in phased arrays by controlling the positions of selected elements,” IEEE Trans. Antennas Propagation., Vol. 52, 2891–2895, 2004.