ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.12

Synthesis of Shaped Beams Patterns using Amplitude Control Method

S.Ramesh Babu[1], Dinesha.P[2], A.Sudhakar[3]
Assistant Professor[1], Professor[2, 3]
Department of ECE
RVR & JC College of Engineering, Andhra Pradesh, India[1, 3]
Dayananda Sagar College of Engineering, Karnataka, India[2]

Abstract:
This paper presents an amplitude control method of Woodward-Lawson technique to find out the required amplitude distribution to realize desired shaped beams like ramp and Stair-step patterns over desired angular sectors. A linear antenna array of Patch antennas is modeled using CST Microwave studio for the generation of desired shaped beams like ramp and stair-step patterns. It is observed from the results amplitude control method considered in the present paper becomes exact for larger arrays and there exists a deviation from the desired shape from small arrays. The designed data obtained for the generation of required shaped beams is highly useful for modern radar applications and point to point communications.

I. INTRODUCTION

Any specified pattern can be realized from arrays of radiating elements by designing either one of the space distribution, amplitude distribution, phase distribution or all of them. In practice one of the above distribution functions is designed keeping the others fixed. The determination of all the above distribution functions for a desired beam shape becomes very complex. When the spacing of the radiating elements in the array is uniform and less than $\lambda/2$, more number of elements is required to produce a desired beam shape. Moreover, realization is highly involved as there are some mutual coupling effects.

To overcome such effects it is sometimes useful to design the arrays with element spacing as variable. Design of such arrays is reported by Andreasen [1]. Meher et al. [2] carried out some studies on the effects of random removal of elements on the radiation patterns. The limiting bounds of the radiation beams are determined while restricting side lobe levels. Various methods of non uniform spacing are reported by several authors [3–5]. All these methods are found to be suitable to control beam width and side lobe levels of narrow beam in one way or other. But for the synthesis of shaped beams like ramp and stair-step patterns, the design of space function is highly involved. In view of the above fact, it is of interest to go for the amplitude control as well as phase control method for realization of any desired beam shape. Several authors [6–9] reported on the realization and synthesis of various beam shapes. As the methods reported are not giving the optimized shaped beams such as ramp and stair-step patterns, alternative approach is considered in the present work. In the case of amplitude only control method a number of aperture distributions were considered for fixed spacing elements and by introducing fixed phase. Commonly assumed aperture distributions are found to be uniform, circular, hyperbolic, parabolic, sinusoidal, etc. These distributions produce narrow beams with symmetric side lobe structures varying levels between 13.5 to 30 dB. To generate specified beam shapes these distributions are not suitable. It is therefore essential to design amplitude distribution that gives desired beam shapes. After carrying out intensive studies, it is found that Woodward method is suitable to produce shaped beams like ramp and stair-step patterns under amplitude control methodology. In the present work, array of helical antennas is considered and desired shaped beams are synthesized by introducing optimally designed amplitude distributions.

II. WOODWARD LAWSON METHOD OF SYNTHESIS

In this method of synthesis the desired radiation pattern to be generated is sampled at appropriate points. Each pattern sample corresponds to a source current of uniform amplitude and phase. When the antenna is excited with such current it produces the field strength equal to the magnitude of the desired radiation pattern at the sample point. The overall pattern is the sum of the fields at each point. The discrete elements of an array are placed in equal and specified spacing. The pattern of each sample is written as

$$f_m(u) = a_m \frac{\sin\left[\frac{N-1}{2} kd\left(\sqrt{1-u^2} - \sqrt{1-u_m^2}\right)\right]}{N-1 \sin\left[\frac{1}{2} kd\left(\sqrt{1-u^2} - \sqrt{1-u_m^2}\right)\right]}$$

The resultant array factor is

$$E(u) = \sum_{m=-M}^{M} a_m \frac{\sin\left[\frac{N-1}{2} kd\left(\sqrt{1-u^2} - \sqrt{1-u_m^2}\right)\right]}{N-1 \sin\left[\frac{1}{2} kd\left(\sqrt{1-u^2} - \sqrt{1-u_m^2}\right)\right]}$$

The excitation level of each element of the array at its location is equal to the value of the specified pattern at the sampling points. In other words

$$a_m = E(u = u_m)_d \quad (3)$$

The sampling points are taken at

$$\theta_m = cos^{-1}\left[m\frac{\lambda}{(N-1)d}\right] \quad (4)$$

This expression is written in terms of θ as $\theta = \sin^{-1}u$.

Once the coefficients *am* are determined the discrete current/voltage excitation of each element is reduced to the following form

$$a(x_m) = \frac{1}{N}\sum_{m=-M}^{M} a_m e^{-jkx_m\sqrt{1-u_m^2}} \quad (5)$$

Where *xm* indicates the position of each element. From the amplitude levels obtained using Woodward method, the ramp and stair-step patterns over desired angular sector can be obtained.

III. SYNTHESIS OF LINEAR PATCH ANTENNA ARRAY TO GENERATE RAMP PATTERNS

The elements in the array are excited using Woodward amplitude control method. In this method the elements are excited with unequal amplitude coefficients with constant phase to generate the ramp pattern. The excitation coefficients necessary for the generation of ramp pattern are listed in Table 1. Attenuators close to the desired amplitude levels are chosen and connected to the corresponding feed cables. In this measurement the feed of the array consists of one 1: 2 and two 1: 4 power dividers with standard attenuators. Cables of the same length are used to excite the elements of the array in same phase for the generation of ramp pattern using amplitude control method.

Table.1. Position and amplitude level of each element in the array.

Element Number	Element Location (mm)	nplitude Level	mplitude Level (Normalized)	ttenuators used [dB]
1	−87.5	0.8	0.28	6
2	−62.5	1.6	0.55	3
3	−37.5	2.4	0.83	1
4	−12.5	2.9	1	0
5	12.5	2.9	1	0
6	37.5	2.4	0.83	1
7	62.5	1.6	0.55	3
8	87.5	0.8	0.28	6

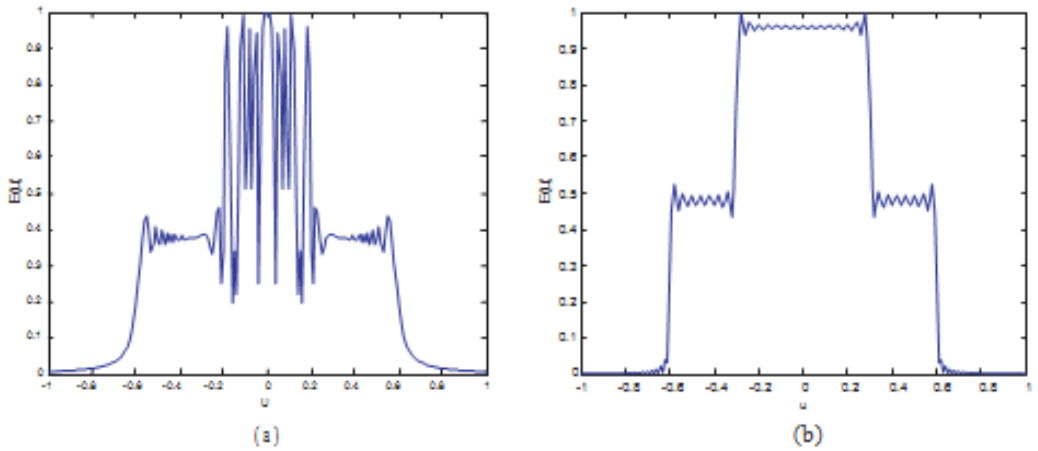

Figure.1. Stair step patterns for array length of (a) 50, (b) 200.

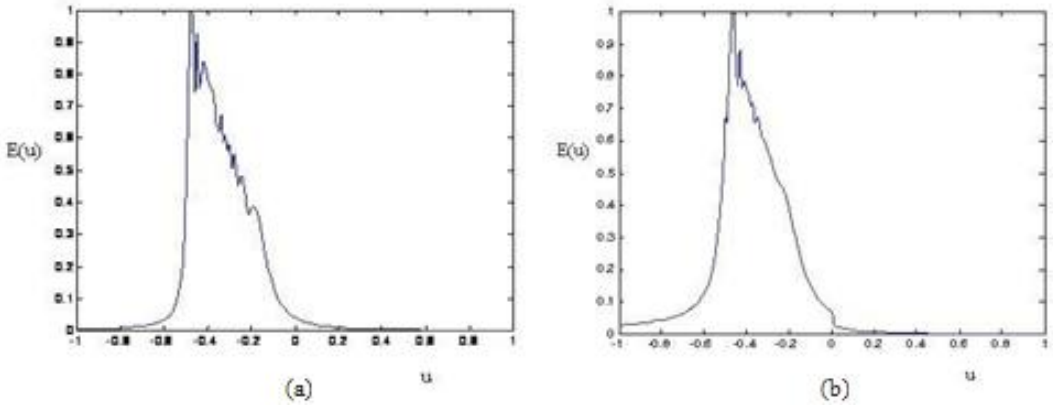

Figure.2. Ramp patterns for array length of a) 50 b) 200

IV. RESULTS AND CONCLUSION

In this paper, an array of patch antennas is synthesized to generate shaped beam patterns using amplitude control method. Woodward-Lawson method of amplitude control technique is used to generate complex shaped beams like ramp and stair-step patterns. From Equation (5), the amplitude coefficients necessary to generate various shaped beams are obtained. Excitation coefficients are obtained for arrays with number of elements 50 and 200 and the corresponding stair-step and ramp patterns generated are shown in Figs. 1 and 2. Maximum radiation is directed perpendicular to the axis of the array for all the beams. There are no side lobes immediately surrounding the main beam as in conventional methods. The boundaries of the covered and uncovered regions are clearly separated. Ripples of the main beam are less in arrays with large number of elements. The stair- step pattern is symmetrical around the center of the array. The ramp pattern is nonsymmetrical about the center of the array.

V. REFERENCES

[1]. Andreasen, M. G., "Linear arrays with variable inter element spacing," *IRE Trans. on Antennas and Propagation*, Vol. 10, 137–143, March 1962.

[2]. Maher, T. M. and D. K. Cheng, "Random removal of radiators from large linear arrays," *IEEE Trans. on Antennas and Propagation*, 106–116, March 1963.

[3]. Ma, M. T., "Another method of synthesizing non uniformly spaced arrays," *IEEE Trans. on Antennas and Propagation*, Vol. 13, 833–834, September 1965.

[4]. Schuman, H. K. and B. J. Strait, "On the design of unequally spaced arrays with nearly equal side lobes," *IEEE Trans. on Antennas and Propagation*, Vol. 16, 493–494, July 1968.

[5]. Serevor, M. G. and G. S. Sanyal, "Position modulated phased array space factor considerations," *IEEE Trans. on Antennas and Propagation*, Vol. 27, No. 3, 373–378, May 1979.

[6]. Guney, K. and S. Basbug, "Interference suppression of linear antenna arrays by amplitude-only control using a bacterial foraging algorithm," *Progress In Electromagnetic Research*, Vol. 79, 475–479, 2008.

[7]. Basu, B. and G. K. Mahanti, "Fire fly and artificial bees colony algorithm for synthesis of scanned and broadside linear array antenna," *Progress In Electromagnetics Research B*, Vol. 32, 169–190, 2011.

[8]. Li, R., L. Xu, X.-W. Shi, N. Zhang, and Z.-Q. Lv, "Improved differential evolution strategy for antenna array pattern synthesis problems," *Progress In Electromagnetics Research*, Vol. 113, 429–441, 2011.

[9]. Mandal, A., H. Zafar, S. Das, and A. Vasilakos, "Modified differential evolution algorithm for shaped beam linear array antenna design," *Progress In Electromagnetics Research*, Vol. 125, 439–457, 2012.