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Reducing Side Lobes of Antenna Array by The Binomial Method

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***Abstract*- This paper explores optimization and synthesis of linear, which prints antennas arrays. The developed synthesis bases on an optimization binomial method. The objective of this paper is to adapt the binomial method to reduce the side lobe level. The application of this formalism gives terrific results.**

***Index Terms*- antenna array synthesis, antenna printed, binomial method, optimization, radiation pattern, side lobes.**

I. INTRODUCTION

Today, the antennas have become an indispensable tool for any radio link, for example satellite, radar and radio. That is, they allow the posting of fields of their metal supports and radiation in space.

The development of new telecommunications networks architectures, base stations providing a dynamic reconfiguration and coverage satellite tracking systems scrolling, require major technological developments in these antennas. It becomes imperative in the sense of having antennas wide field and radiation opening to allow significant pointing. Furthermore, it affect without significantly increasing losses by deformation of the radiation pattern. In addition to that, Printed antennas are designed to meet the requirements of this technological development, and tended to the miniaturization of electronic devices or telecommunications systems. With their small size, performance, flexibility, they make them particularly adaptable to mobile equipment (satellite, airplane, boat). Which means that, flexibility allows them to mix imported form of surface (flat or formed). These antennas have proven their effectiveness and have tended to replace conventional antennas permanently. Besides, their networking association are the subject of extensive research, and high performance to achieve specific functions. Moreover, numerous types of applications such as misalignment, electronic scanning and rejection jammers output of variable shapes or directions of radiation patterns. In other terms, the operation takes place by adjusting the parameters of number, spatial position of the sources, amplitude and phase of the supply characteristic, the elementary source.

In the field of printed antenna array, the synthesis problem concerns more specialists, Which, estimates the variations in amplitude phase and the spatial distribution of radiating elements to get fixed constraints radiation (reduction of side lobes). The purpose of the study is to find the optimal combination of these parameters. So that, the array meets the needs of the user in a precise specification.

For synthesis of the radiation pattern of antenna arrays, different overall analytical methods and numerical optimization (Fourier, Woodward-Lawson, relaxation, Newton, combined gradient, genetic algorithm, simulated annealing algorithm, Minmax, etc...) were developed and implemented [1-7].

In this article, we present the binomial method that will be applied to the synthesis of the radiation pattern of the linear patch antenna array.

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II. PROBLEM OF SYNTHESIS

Consider an array of antenna consisting of N number of elements. It assumes that the antenna elements are symmetric about the center of the linear array as shown in figure 1.

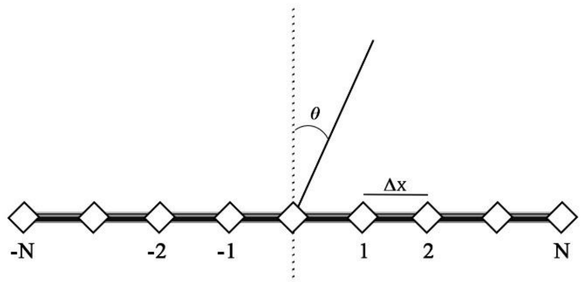

Fig.1. Symmetric linear array

The far field array factor of this array with an even number of isotropic elements can be expressed as [6],[8]:

$$Fs(\theta) = \frac{f(\theta,\varphi)}{Fsmax}\sum_{i=1}^{p} W_i cos(K_0 X_i sin\theta + \psi_i) \quad (1)$$

$$W_i = a_i exp(j\psi_i) \quad (2)$$

Where a_i is amplitude of amplitude of n^{th} element, θ is the angle from broadside and X_i is the distance between position of nth element and array center.

The directivity pattern f (θ, φ) is a function of two angular directions θ and φ. If φ is fixed, the diagram f (θ,φ) may be shaped in the plane E or H. For reasons of convenience, we are interested in the synthesis of linear array in the plane φ = 0. In the case of an even number of elements (2N+1) and a symmetrical spatial distribution [1], the array factor for normalized directivity pattern is:

$$Fs(\theta) = \frac{f(\theta)}{Fsmax}\sum_{i=1}^{N} a_i cos(K_0 X_i sin\theta + \psi_i) \quad (3)$$

The main objective of this work is to find an appropriate set of required element amplitudes and that achieves interference suppression with maximum side lobe level reduction and narrow main beam width.

III. BINOMIAL METHOD

In order to increase the directivity of an array of its total length, it needs to be increased. In this approach, number of minor lobes appears are undesired for narrow beam applications. It has been found that number of minor lobes in the resultant pattern increases; whenever, spacing between elements is greater than λ/2, which is per demand of modern communication, where narrow beam (no minor lobes) is preferred. It is the greatest need to design an array of only main lobes.

The ratio of power density of main lobe to power density of the longest minor lobe is termed side lobe ratio. A particular technique is used to reduce side lobe level, which is called Tapering. Since currents/amplitude in the sources of a linear array is non-uniform, it is found that minor lobes can be eliminated, in case of the center element radiates is more strongly than the other sources. Therefore, tapering need to be done from center to end radiators of same specifications [9]. The principal of tapering are primarily intended to broadside array but it is also applicable to end-fire array. Binomial array in 1929, where amplitude of the radiating sources are arranged according to the binomial expansion. That is, minor lobe appearing in the array need to be eliminated, the radiating sources must have current amplitudes proportional to the coefficient of binomial series, i.e.

$$(1+x)^n = 1 + (n-1)x + \frac{(n-1)(n-2)}{2!}x^2 + \frac{(n-1)(n-2)(n-3)}{3!}x^3 \pm \cdots \quad (4)$$

Where n is the number of radiating sources in the array.

INTERNATIONAL JOURNAL OF MICROWAVE AND OPTICAL TECHNOLOGY,
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For an array of total length (nλ/2), the relative current in the nth element form the one end is given by

$$(1+x)^n = \frac{n!}{r!\,(n-r)!} \qquad (5)$$

Where r=0, 1, 2, 3.., and the above relation is equivalent to what is known as Pascal's triangle.

IV. MICROSTRIP PATCH ANTENNA RESONATING AT 5.86GHz

The proposed microstrip patch antenna is shown in Figure2. For improved adaptation, two slots and two cuts are introduced on the patch. In this design the substrate is Arlon45. The substrate height is 1.6mm, the dielectric constant is 3.2 and the loss tangent is 0.018. The dimensions of our antenna are optimized by using CST Microwave Studio tool.

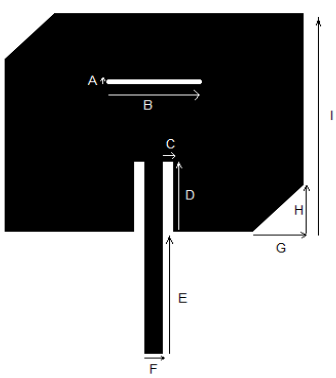

Fig.2. Top view of our patch antenna resonating at 5.86GHz, (A = 0.2 mm, B = 2.75mm,C = 0.69 mm, D = 5 mm, E = 7.95 mm, F =1.02mm, G=H = 3.1 mm and I = 17.66mm).

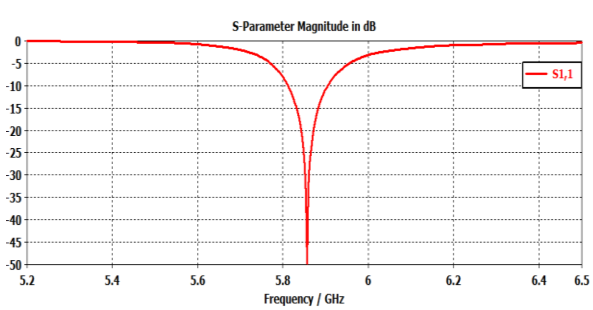

Fig.3. Simulated return loss of the patch antenna resonating at 5.86GHz.

Figure 3 shows that the antenna has a good adaptation (around -50dB) at the resonant frequency (5.86GHz).

V. ANTENNA ARRAY: UNIFORM DISTRIBUTION

On the basis of this analysis, we have chosen as optimum separation distance 0.7 λ0. Because for this the antenna array has good performance, the side lobes and the coupling between the antennas have been reduced [10].

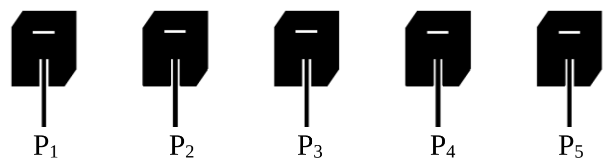

Fig.4. Linear microstrip array of five elements.

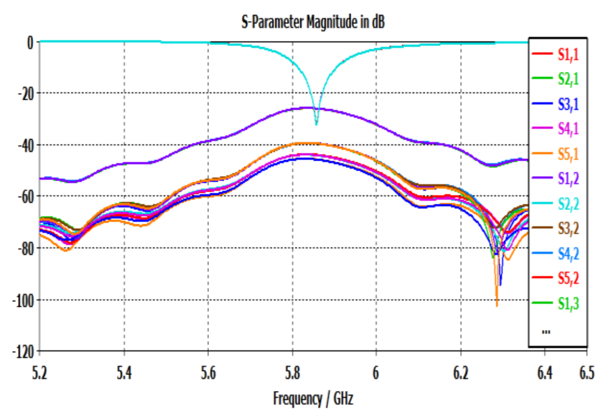

Fig.5. Scattering parameters of array antenna

The mutual coupling is due to the simultaneous effects of radiation in free space and propagation of the surface waves. The important factor should be considered in the calculation of network characteristics. Figure 5 shows that the coupling between the network elements is reduced.

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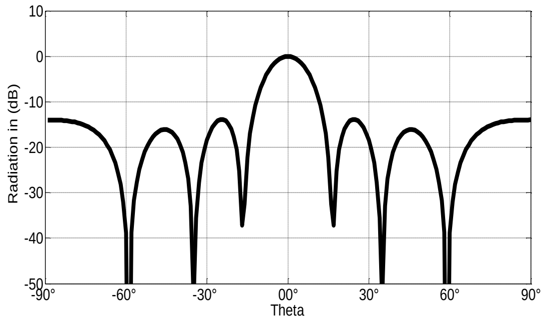

Fig.6. Radiation pattern of symmetric antenna array using uniform distribution ($P_1=P_2=P_3=P_4=P_5=1A$).

In Figure 6, we can see the radiation pattern of symmetrical array by using uniform distribution. The side lobe level is lower than -12.9dB, which indicates the existence of parasitic radiation. That will influence the reliability of these antennas. As a result, to reduce the side lobe level, in next section we use the binomial method.

VI. ANTENNA ARRAY: BINOMIAL METHOD

The side lobe level in uniform distribution may pick up interfering signals, and increase the noise level in the receiver. One possible solution is to change the power distribution networks of array antenna by using binomial approach.

Figure 7 shows the radiation pattern of antenna array with or without binomial distribution. We can see that the side lobe reduction is about -28.3dB.

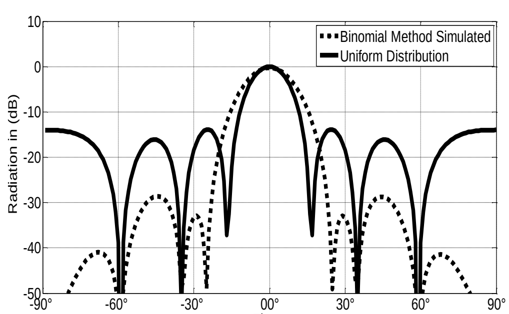

Fig.7. Radiation pattern of symmetric antenna array (for binomial method $P_1=P_5=0.7A$, $P_2=P_4=1.5A$, $P_3=2A$).

Figure 8 illustrate the comparison between theoretical and simulated radiation pattern of antenna by using binomial method. That is, we can see the agreement of both results.

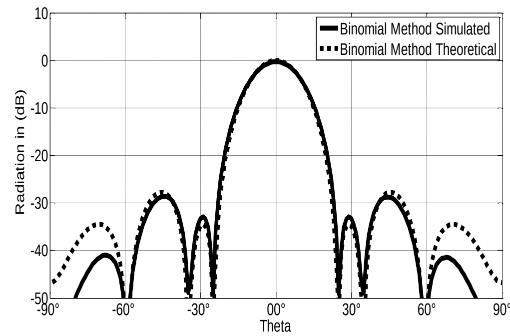

Fig.8 Comparison between binomial method simulated and theoretical.

VII. CONCLUSION

The microstrip planar antenna arrays with binomial technique concept have been studied in this paper with the objective to reduce the side lobe level. Also the comparison results of uniform and binomial distribution show that the side lobe reduction is about -28.3dB. The theoretical radiation patterns show the agreement with simulations. That is, the side lobe level was suppressed.

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