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RESEARCH ARTICLE

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DESIGN OF A BINOMIAL ARRAY OF 4-ELEMENTS RECTANGULAR MICROSTRIP PATCH ANTENNA WITH HIGH GAIN FOR 2.4 GHZ APPLICATIONS

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ABSTRACT

A binomial array of 4-elements rectangular microstrip patch antenna has been designed and simulated at 2.4 GHz using HFSS (high frequency structure simulator) software. The binomial array is a non-uniform array which reduces the side lobes and enhances the gain. The bandwidth is improved. The simulated results the high gain 15.95 dB at 2.4 GHz, large bandwidth 1.39 GHz and beamwidth 44^0 have been obtained. The other characteristics like scattering parameter and radiation pattern are presented. The obtained results are compared with published results of Yahya [1] uniform-based array.

I. INTRODUCTION

Microstrip patch antennas play a very significant role in the field of wireless communications [1-6], which are very simple in the construction using a conventional microstrip fabrication technique. A microstrip antenna consists of a conducting patch on a ground plane separated by a dielectric substrate. Low dielectric constant substrate is generally preferred for maximum radiation. Two most serious limitations of microstrip antennas are its low gain and narrow bandwidth.

In the recent years the development in the communication systems required the development of low cost, minimal weight, and low profile antennas that they are capable of maintaining high performance over a wide spectrum of frequencies. There is a fundamental relationship between the size, bandwidth, and efficiency of an antenna. As antennas are made smaller, either the operating bandwidth or the antenna efficiency must decrease. The gain is also related with the size of the antenna, that is smaller antennas typically provide lower gain than the larger antennas.

Microsrtip antenna arrays are very versatile and are used among other things, to synthesize a required pattern that cannot be achieved with a single element. In addition, they are used to scan the beam of an antenna system, increase the directivity and perform various other functions which would be difficult with any single element. The elements can be fed by a single line or by multiple lines in a feed network arrangement.

Yahya [1] has designed and simulated a uniform-based array of 4-elements rectangular microstrip patch antenna and compared the results with a single element and an array of two elements. The results show that the value of side lobe is more in 4 element array than 2 element array.

In this proposed paper, we intend to reduce the side lobes and enhance the gain by using Binomial array approach. Binomial arrays do not exhibit any minor lobes provided the spacing between the elements is equal or less than one-half of a wavelength [2].

II. DESIGN PROCEDURE

One of the essential parameters for the design of a rectangular microstrip patch antenna is the frequency of operation (f_0). The operation frequency selected for our design is 2.4 GHz. The value of substrate parameters are relative dielectric constant (ε_r) to be 2.2 and the substrate thickness (h) to be 1.6 mm. Then we evaluated the length and width of the patch.

A. Binomial Array Design

We used the same height of the dielectric substrate (h), the dielectric material and the dimensions of the single patch antenna at the frequency of operation (f_0) to design the binomial array of 4-elements rectangular microstrip patch antenna.

- The width of the patch W = 49.411 mm.
- Length of the patch L = 41.356 mm.

The binomial array of 4-elements rectangular microstrip patch antenna has been designed by using HFSS software (Fig.1), the inner elements arranged to form like a 3element array. The currents in this array are not equal i.e., the current ratio is 1:2:1, so that this array is called a non-uniform array. As illustrated in Fig.1, the microstrip feedlines are designed for the non-uniform amplitude excitations i.e., the current amplitude is 2I in the middle elements with respect to the current amplitude I in the side elements.

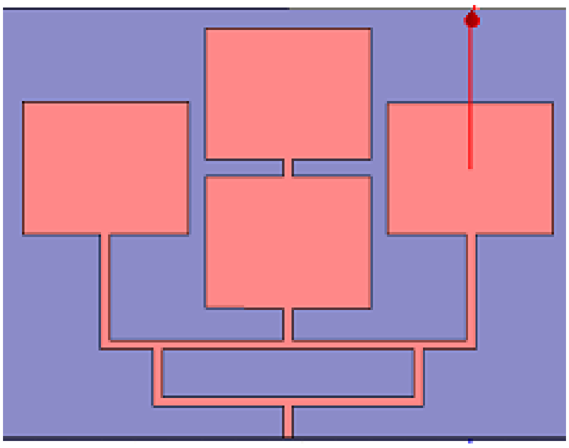

Fig.1 Binomial array of 4 elements microstrip patch antenna.

III. RESULTS

In this paper we designed a binomial array of 4 elements rectangular patch antenna and simulated by using HFSS software. We obtained scattering parameter S_{11} (dB) (Fig.2), 2D radiation pattern (Fig.3) and gain G (dB) versus theta (Fig.4). We observed the simulated results of gain (dB) versus frequency (GHz) and 3D- polar form of radiation pattern.

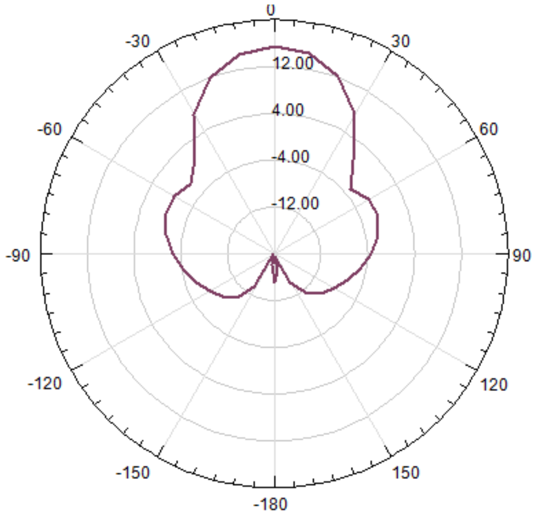

Fig.3 Radiation Pattern

IV. DISCUSSION OF RESULTS

The characteristics in terms of scattering parameter S11 and radiation pattern are shown in the Fig.2 and Fig.3. The value of S11 is less between 1.9 GHz to 3.29 GHz. This means that return loss is less between these frequencies. The radiation pattern is shown in Fig.3 i.e., the pattern of radiation is broadside. Fig.4 shows the gain is maximum 15.95 dB at θ = 00, φ = 00. The obtained gain is 2.75 dB more as compared to Yahya [1]. The beamwidth is 44 degrees that mean the coverage area is large. Side lobes are negligible as shown in Fig. 4. The bandwidth is 1.39 GHz measured from the simulated results.

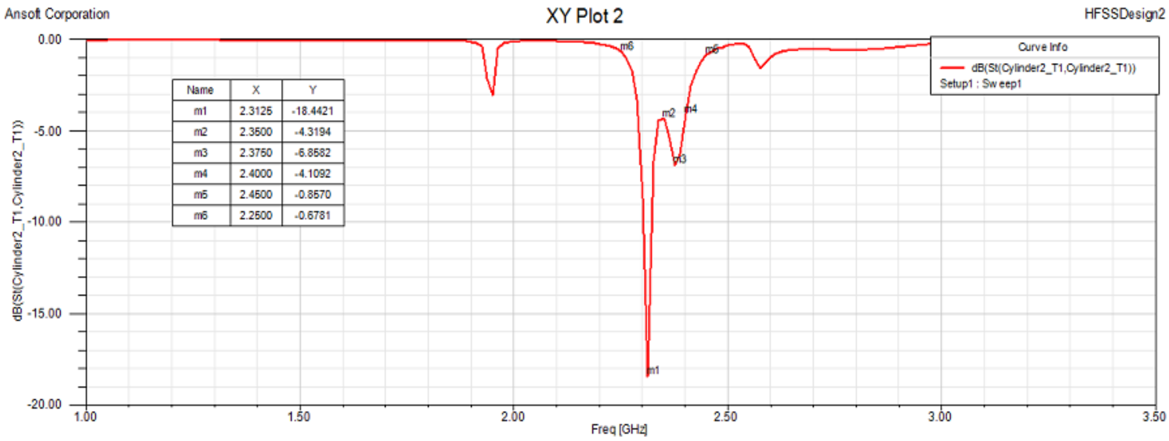

Fig.4 Scattering Parameter S_{11} (dB) versus frequency (GHz).

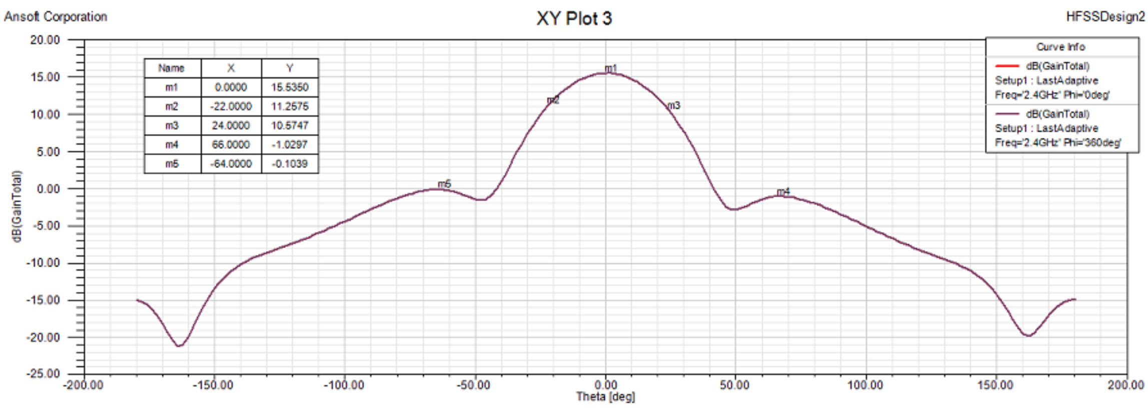

Fig.4 Gain (dB) versus Theta (degree) at $\varphi = 0^0$

V. CONCLUSION

The binomial array of 4-elements rectangular microstrip patch antenna has been designed and simulated by using HFSS to reduce the side lobes and enhance the gain at 2.4 GHz. The high gain is obtained 15.95 dB and the large bandwidth is 1.39 GHz. This array can be operated between the frequency rage1.9GHz to 3.29 GHz. The beamwidth is wider that can be used for large coverage areas as for the application of search radar.

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