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Binomial Array of Three Elements Microstrip Antenna for Sidelobe Reduction

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Abstract: *A binomial array of 3-elements rectangular microstrip patch antennas has been designed and simulated at 2.4 GHz using HFSS (high frequency structure simulator) software for the side lobes reduction and gain improvement. This array of 3-elements is also designed to reduce the size of the array by a pair of inner elements of a binomial array of 4-elements of rectangular microstrip patch antennas is replaced by a single element. This array is a non-uniform array because the currents in these 3-elements of the array are not equal. The microstrip feed lines are designed for the non-uniform amplitude excitations. The simulated results are compared with published results in reputed journals. The simulated result of side lobe is -7.57 dB which is negligible. The beam width of the main lobe is 30^0 and the gain is 14.04 dB. Other characteristics like radiation pattern (2D and 3D), scattering parameter (S_{11}), and bandwidth have also been presented. This array can be used for the various applications like surveillance radar, mobile communication, satellite communication etc.*

Keywords: *Binomial array, Microstrip antenna, HFSS, Sidelobe reduction, Non-uniform array, Radiation pattern*

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I. Introduction

The arrays of microstrip patch antennas [1-12] are designed to increase the directivity, gain and bandwidth, which would be difficult with a traditional microstrip patch antenna. As elements in the linear array are increased, sidelobes are also formed which degrade the antenna performance. Binomial arrays do not exhibit any minor lobes provided the spacing between the elements is equal or less than one-half of a wavelength. These arrays are called non-uniform arrays because the elements in the array are having non-uniform amplitude excitations.

Yahya [5] has designed and simulated the 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 were shown that the value of side lobe is more in the 4-elements array than the 2- elements array. Pradeep et al [10] have designed a binomial array of 4-elements rectangular microstrip patch antenna to reduce the value of side lobes that occurred in Yahya [5].

In this proposed paper, it is intended to further reduce the values of side lobes and the beamwidth of the main lobe and to improve the gain by designing 3-elements binomial array of rectangular microstrip patch antennas with microstrip line for nonuniform amplitude excitations.

II. Research Method

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

Binomial Array Design:

The same height of the dielectric substrate (h), the dielectric material and the same dimensions of the single patch antenna at the frequency of operation (f_0 =2.4 GHz) are used to design of a binomial array of 3-elements rectangular microstrip patch antenna.

- The width of the patch W = 49.411 mm.
- Length of the patch L = 41.356 mm.
- The height of the substrate h = 1.6 mm
- The relative permittivity ε_r = 2.2
- Spacing between elements: 30 mm

The binomial array of 3-elements rectangular microstrip patch antenna (Fig.1) has been designed by using HFSS software. A pair of inner elements of a binomial array of 4-elements of Pradeep et al [10] is replaced by a single element to form a 3-element array to further reduce the values of side lobes. The currents in these 3-elements of the array are not equal i.e., current ratio is I: 2I: I, so that this array is a non-uniform array. As illustrated in Fig. 1, the microstrip feed lines are designed for the non-uniform amplitude excitations.

III. Results and Discussion

In this proposed paper, a binomial array of 3-elements rectangular microstrip patch antenna has been designed and simulated by using HFSS software. The scattering parameter S_{11} (dB) [Fig. 2], gain (dB) versus theta (degree) [when spacing between elements is 30 mm (Fig. 3) and when spacing is 60 mm (Fig. 4)], 2D radiation pattern (Fig. 5), gain G (dB) versus frequency (GHz) (Fig. 6) and 3D – polar form of radiation pattern (Fig. 7) have been obtained.

The characteristics in terms of scattering parameter S_{11} and gain versus theta are shown in the Fig. 2 and Fig. 3. The value of S_{11} is less between 2.1 GHz to 2.6 GHz. This means that return loss is less between these frequencies. The lowest value of S_{11} is -16.82 dB at 2.31 GHz and -3.11 dB at 2.4 GHz. Fig. 3 shows that the high gain is obtained 14.04 dB at $\theta = 0^0$, $\varphi = 0^0$ which is 0.84 dB more as compared to Yahya [5] a uniform-based array of 4-elements rectangular microstrip patch antenna. The side lobe is negligible [-7.57 dB when the spacing between the elements is 30 mm (Fig. 3)] as compared to -3.42 dB [when the spacing is 60 mm (Fig. 4)] and -0.1dB (a binomial array of 4-elements Pradeep et al [10]) and 2.93 dB Yahya [5]. The beamwidth is 30^0. The radiation pattern is shown in Fig. 5 i.e., the pattern of radiation is broadside. The bandwidth is 0.9 GHz which is obtained from Fig. 6. The 3D-polar form of radiation pattern is shown in Fig. 7 which is more directional.

IV. Figures And Tables

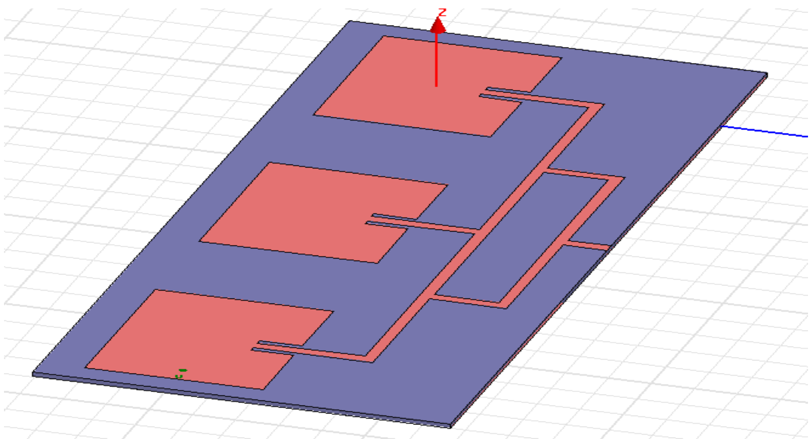

Fig.1 Structure of a binomial array of 3-elements rectangular microstrip patch antenna

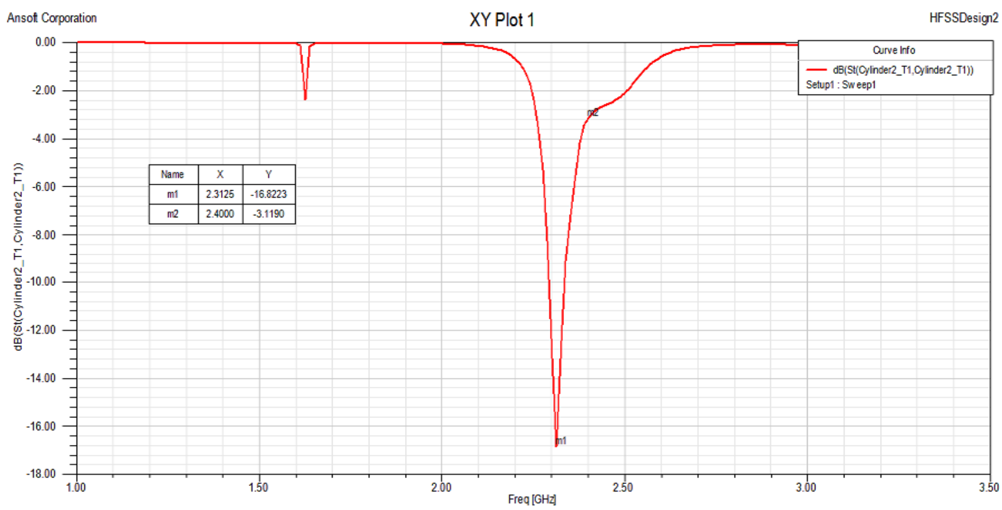

Fig. 2 Scattering parameter S_{11} (dB) versus frequency (GHz)

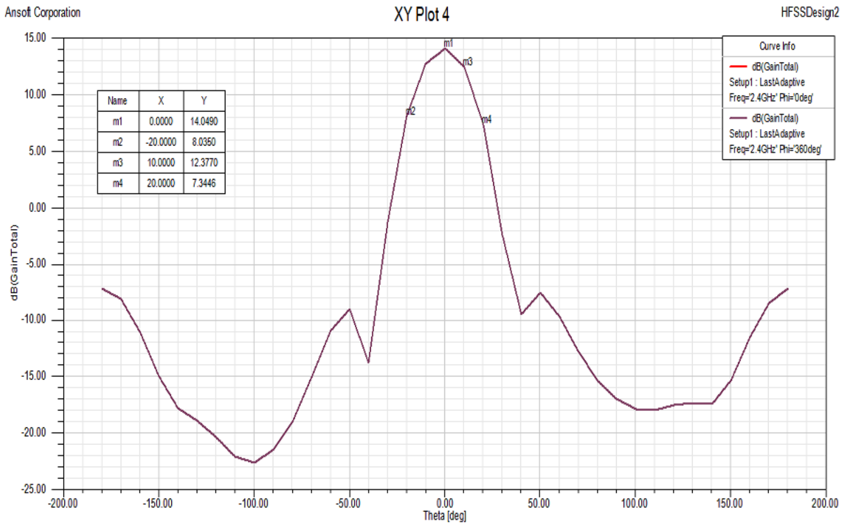

Fig. 3 Gain (dB) versus theta (degree) [when the spacing is 30 mm between the elements]

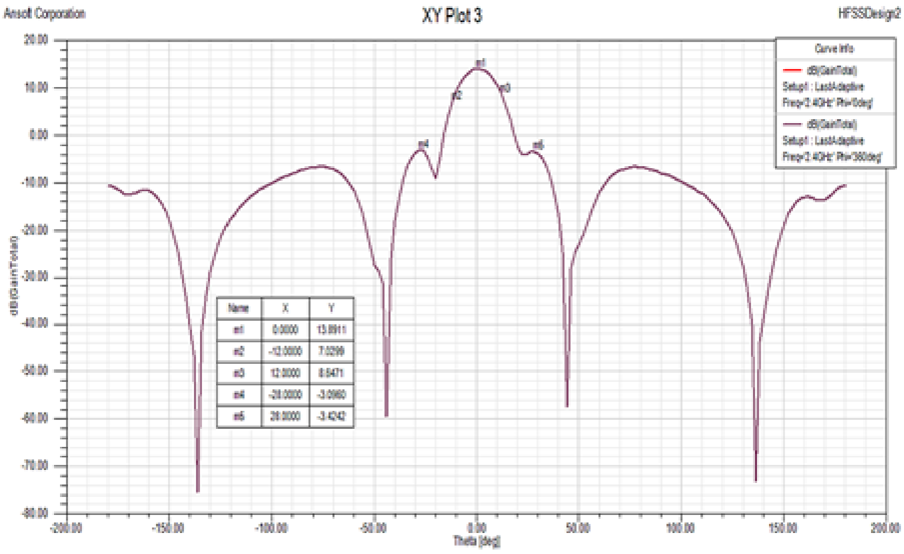

Fig.4 Gain (dB) versus theta (degree) [when the spacing between elements is 60 mm]

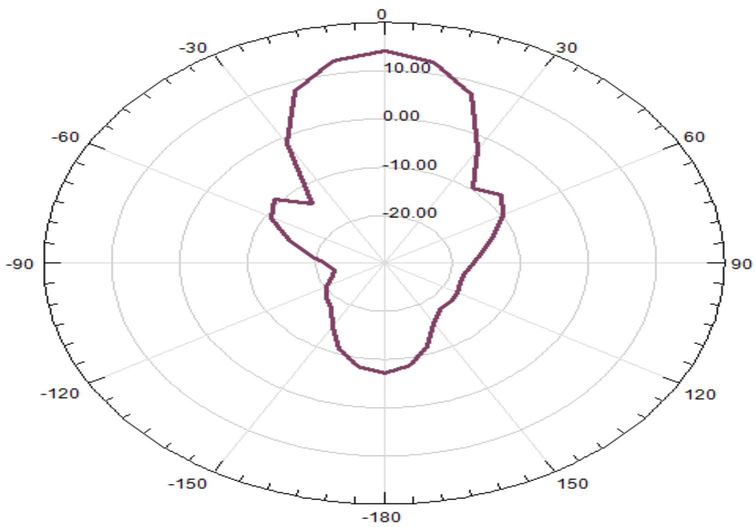

Fig. 5 Radiation pattern (2D-polar form)

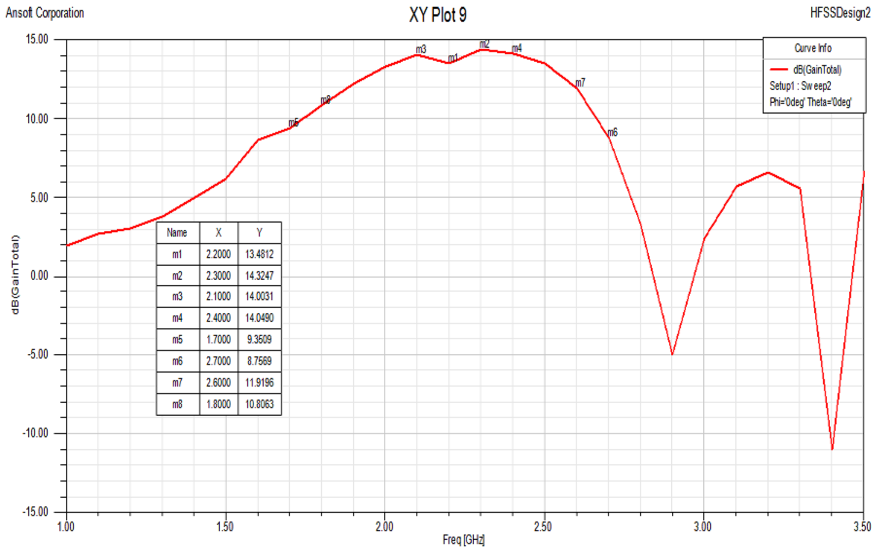

Fig. 6 Gain (dB) versus frequency (GHz)

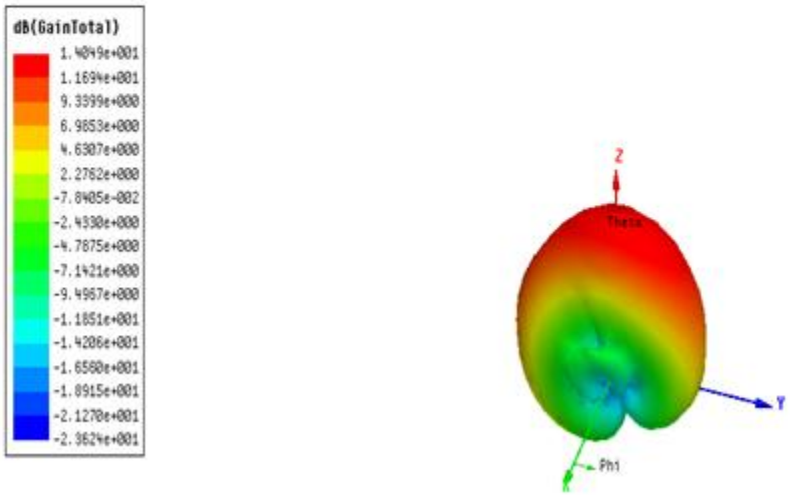

Fig. 7 Radiation pattern (3D-polar form)

Table 1: Comparison of results of proposed paper with published papers listed in reference

Parameters	Yahya [5]	Pradeep [10]	Ching [12]	Proposed Paper
S_{11} (dB)	-22 dB	-18.44 dB	-25 dB	-16.82 dB
G (dB)	13.2 dB	15.95	10.9 dB	14.04 dB
HPBW		44^0	47.5^0	30^0
Bandwidth		1.39 GHz	0.92 GHz	0.90 GHz
Side lobe	2.93 dB	-0.13 dB		-7.57 dB

Table 1 shows the summary of the results of proposed paper and its comparison with the results of published papers listed in the reference. The side lobe is -7.57 dB which is negligible. HPBW is 30^0 which is narrower.

V. Conclusion

The binomial array of 3-elements rectangular microstrip patch antenna has been designed and simulated by using HFSS software to reduce the side lobes, beamwidth of the main lobe and to enhance the gain at 2.4 GHz. With the simulation, the high gain 14.04 dB and bandwidth 0.9 GHz have been obtained. The obtained gain is higher about 0.84 dB as compared toYahya [5] a uniform-based array of 4-elements rectangular microstrip patch antenna. This binomial array can be operated between the frequency ranges from 1.75GHz to 2.65 GHz with high gain. The pattern of the radiation is broadside. The beamwidth is narrower and the side lobe is neglible than other published results summarized in table 1. The radiation pattern of a binary array of 3-elements rectangular microstrip patch antenna is more directional than a binomial array of 4- elements rectangular microstrip patch antenna [10]. This array can be used for the various applications like surveillance radar, mobile communication, satellite communication etc.

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