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PERFORMANCE ANALYSIS OF MICROSTRIP PATCH ANTENNA USING BINOMIAL SERIES EXPANSION

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ABSTRACT
This paper proposes a single microstrip patch antenna (MPA) in the presence and absence of ground plane (GP) using binomial series expansion. The coefficients of binomial series expansion are employed. The proposed antenna is designed to serve for satellite service. The antenna is designed and simulation is performed by ADS software. The primary objective is to increase the directivity. FR4 substrate is used as the dielectric material. The performance measures like directivity, gain and efficiency are compared. The performance analysis of MPA residing and not residing on the GP is simulated and results are validated.

Keywords: Antenna, binomial, Directivity, gain, efficiency

I. INTRODUCTION
Antenna are the crucial components in communication system. Antenna employs electromagnetic radiation for the transmission purpose. Antenna can be in any shape. Antenna acts as a transducer converting RF fields into alternating current or vice-versa. The detail study on antenna, antenna shapes and the parameters for performance analysis can be viewed in [1, 2, and 3]. In the literature study, there is only limited study on antenna design with GP using binomial series. But the proposed design focuses on the design of MPA in the presence and absence GP.

Kavitha etal focussed on the optimization in linear arrays using binomial method. The objective of their work is the reduction of side lobe level using binomial series. It also studied the relation between the coefficients of binomial array and the current amplitude. It also depicts the technique to minimize the side lobe level there by increasing the directivity of antenna. The expression for the current in the nth element is included in the study, from which the Pascal's triangle can be brought into picture [4].

Hamid [5] compared the characteristics of radiation pattern of the patch antenna under uniform, Tchebscheff and binomial amplitude for X-band radar working receivers. An array of 1 x 10 antenna array elements are designed for that studied and simulated at 9.5 GHz. The spacing between the elements are considered as 0.5 λ, 0.6 λ, 0.8 λ, and 0.9 λ. The antenna parameters for different spacing are investigated. These antenna structures are designed and simulated using ADS software. For the work, RT Duroid is used as the dielectric material. Also, in that work along with patch a λ/4 transformer is employed. Direct feeding is used for the excitation purpose. [5] showed that binomial method performs better than uniform and Tchebyscheff.

Aziz etal proposed a mathematical model and system level model for the representation of MPA. In that work the optimization is carried out using MATLAB tool to reduce the side lobes and to analyze the radiation pattern. The performance characteristics are analysed by taking the radiation pattern, reflection coefficient, operating frequency and minimization of side lobes into account [6].

Rinkee and Girish [7] proposed an antenna linear broadside to compare and relate the impact of number of elements in the array, spacing between the elements in the array and its radiation characteristics. 4NEC2 is the simulation software employed. In that work 10 elements are considered in an array and the spacing is varied from 0.1λ to 2 λ in steps of 0.02 λ. the maximum achieved gain here is 12.8 dBi. Out of these spacing variations the one with the best result is found to be 0.82 λ. and the maximum achieved gain is greater in this case[7].

Aras [8] proposed a linear and planar array for lower side lobe level. Tapered patch width technique and series width type of feeding is employed in that paper. In this paper seven element arrays with U-shaped slot is compared with conventional array elements [8].

II. Binomial Expansion Method
The binomial series refers to the algebraic expansion of powers of the binomial. Any expression in binomial with highest power can be solved easily using binomial series or theorem. The detailed study on Binomial series can be viewed in [9]. The expansion for binomial series is

$$(1+x)^n = 1 + \frac{nx}{1!} + \frac{n(n-1)x^2}{2!} + \cdots$$

In the design of an antenna, n indicates the number of radiating sources in an array. The proposed focuses only on single radiating source, so only first coefficient in the binomial series is taken into account. In order to reduce the side lobes, directivity of an array has to be improved by increasing the total length of the array. The radiation pattern with no minor lobes or less minor lobes is preferred. A linear array is considered because the amplitude of the sources is said to be a non-uniform form which the minor lobes can be eliminated. The amplitude of the radiating sources is proportional to the coefficient of the binomial series. The distance between elements is fixed as λ/2. For an n-element array, the current in the n^{th} element is

$$\frac{n!}{r!\,(n-r)!}$$

From the above relation Pascal's triangle is obtained. Symmetric elements in antenna placed are at a distance of λx.

III. ANTENNA DESIGN

The antenna is designed under two cases, the single patch antenna in the truancy of GP and the patch antenna residing on the GP. The single MPA in the truancy of GP used for fixed satellite service application. The results presented in the table 1 which is taken from the research article [6] are used for the proposed single MPA which is residing and not residing on GP

Table 1: Design Parameters

Parameter	Dimension of the patch (mm)
Lp	14.6
Wp	14.6
Lg	14.6
Wg	6.5
Ls	2.8
Wc	3

The structure of single MPA in the truancy of GP and residing on the GP is given below in Fig. 3.1 and 3.2 respectively.

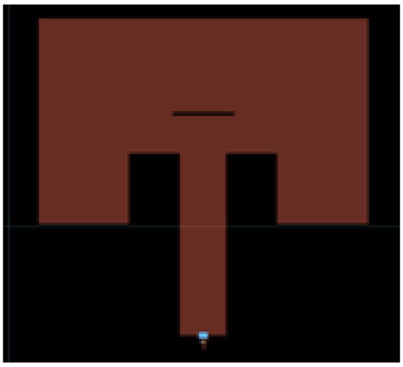

Fig 3.1 MPA in the truancy of GP

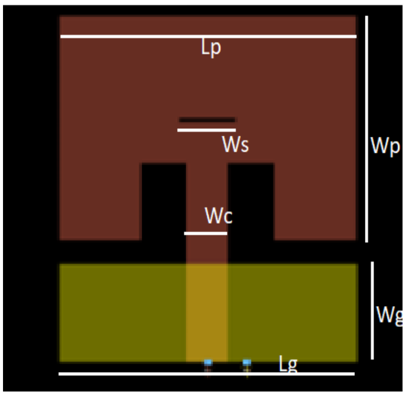

Fig 3.2 MPA residing on GP

MPA residing on GP is applicable for like broadcasting satellite service. The antenna proposed is designed with FR-4 dielectric material. The antenna is designed and is simulated using ADS software. Microstrip line feeding is applied in this design. The blue colour dots indicate the ports placed for excitation.

IV. SIMULATION RESULTS

4.1 MPA in the Truancy of GP

For the proposed MPA design simulation is performed. The results are recorded based on return loss, directivity and gain.

The results of design of MPA in the truancy of GP are presented as first. The results of design of MPA residing on GP are given later.

4.1.1 Return Loss of MPA in the Truancy of GP

The return loss of MPA in the truancy of GP is showed below in the Fig. 4.1. The return loss is obtained as -10.999 dB at 14.38 GHz

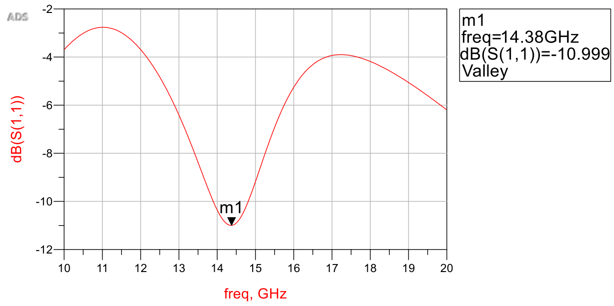

Fig. 4.1 Return loss of MPA in the truancy of GP

4.1.2 Directivity of MPA in the Truancy of GP

The simulated directivity of MPA in the truancy of GP is obtained below in Fig. 4.2. From the graph the directivity is well obtained.

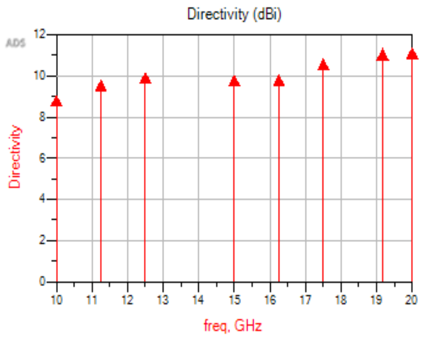

Fig. 4.2 Directivity of MPA in the truancy of GP

4.1.3 Gain of MPA in the Truancy of GP

Gain of MPA in the truancy of GP is obtained as in Fig. 4.3. From the graph it is observed that the gain is fall in expected range of the result well obtained.

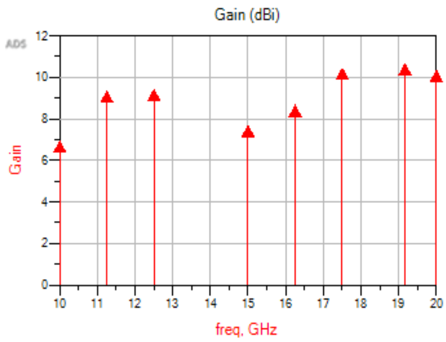

Fig. 4.3 Gain of MPA in the truancy of GP.

4.2 MPA Residing on GP

For the MPA residing on the GP, the following simulated results are obtained.

4.2.1 Return loss of MPA Residing on GP

For MPA residing on the GP the return loss is depicted below in the Fig. 4.4. The return loss is -34.449 dB at 12.57 GHz and -32.805 dB at 17.38 GHz

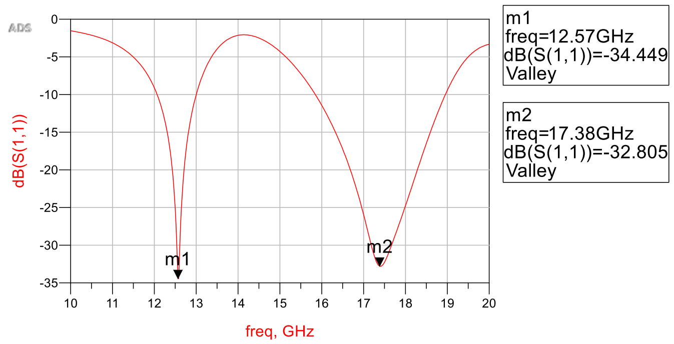

Fig. 4.4 Return loss of MPA residing on GP

4.2.2 Directivity of MPA in the Truancy of GP

The Directivity of MPA in the truancy of GP is obtained in Fig. 4.5. From fig 4.5, it is observed that the directivity is well obtained.

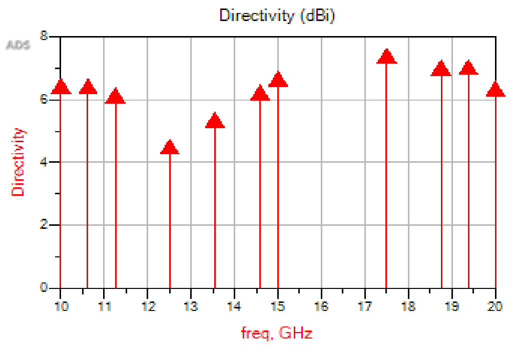

Fig. 4.5 Directivity of MPA residing on the GP

4.2.3 Gain of MPA in the truancy of GP

Gain of MPA in the truancy of GP is depicted below in Fig. 4.6. From Fig. 4.6 it is clear that the Gain is well obtained.

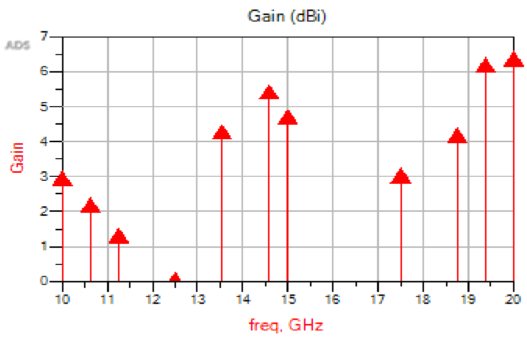

Fig. 4.6 Gain of MPA in the truancy of GP.

V. COMPARISON

5.1 Comparison on Return Loss

Fig. 4.1 and 4.2 depicts the return loss in case of MPA residing on GP has better than return loss of MPA in the truancy of GP. And also, the number of operating frequencies is two for MPA residing on GP and one for MPA in the truancy of GP.

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5.2 Comparison on Directivity

The comparison between frequency and directivity for the MPA residing and not residing GP is presented below in the Fig. 5.1. From the graph it is found that the MPA in the truancy of GP has a maximum directivity of 11.37 dB and the MPA residing on GP has maximum directivity of 7.643 dB. So, it can be concluded that MPA in the truancy of GP has better directivity than MPA residing on GP

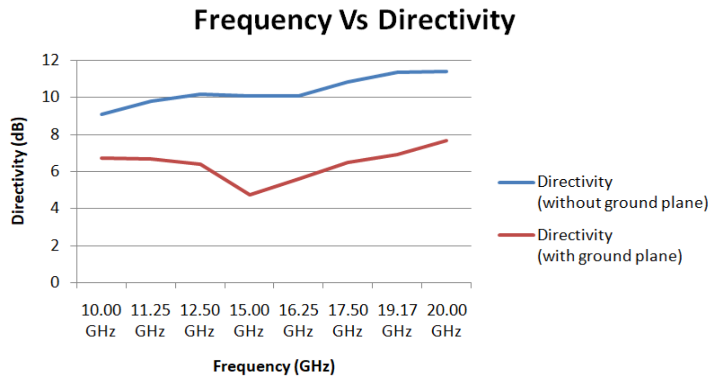

Fig. 5.1 Comparison on Directivity

5.2 Comparison on Gain

The comparison between frequency and gain for the MPA residing and not residing GP is depicted below in the Fig. 5.2. From the graph it is showed that the MPA in the truancy of GP has a maximum Gain of 10.66 dB and the MPA residing on GP has maximal gain of 6.5 dB. So, it can be concluded that MPA in the truancy GP has better gain than MPA residing on the GP

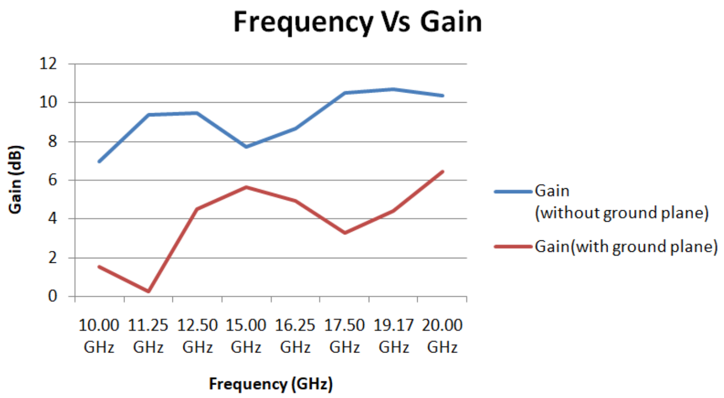

Fig. 5.2 Comparison on Gain

5.3 Comparison on Radiation Efficiency

The comparison between frequency and radiation efficiency for the MPA residing and not residing on the GP is presented below in the Fig. 5.3. From the graph it is showed that the MPA in the truancy of GP has a maximum radiation efficiency of 91.827 % and the MPA with GP has maximum radiation efficiency of 100 % dB. So, it can be concluded that MPA residing on GP has better radiation efficiency than MPA in the truancy of GP

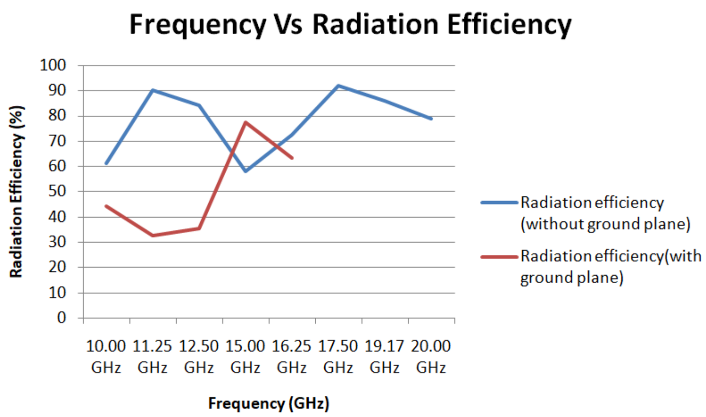

Fig. 5.3 Frequency Vs Radiation Efficiency plot

VI. CONCLUSION

In the work, antenna is designed which is residing and not residing on the GP using first coefficient in binomial expansion. The simulation has been done using ADS software. The performance measures like return loss, directivity and gain are obtained. It is found that the return loss is less in case of MPA in the truancy of GP when compared with the return loss of MPA residing on the GP. Similarly, the directivity and gain are better in MPA in the truancy of GP in comparison with MPA residing on the GP. For future study, an array of antennas is employed and its various antenna parameters will be validated.

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