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A Technique to Improve Directive Gain of Printed Monopole Antenna for Wireless Application

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Abstract— **Planar monopole antennas have all the advantages of the monopole as they cost less and are ease to fabricate besides, yielding very large bandwidths but the gain and directivity associated with these planar monopole antennas is still a topic of major research. This paper focuses on designing and simulating a high gain printed monopole antenna using the idea of increasing the antenna elements in a linear antenna array .The design and simulation are achieved using IE3D and hardware implementation is done by using double sided copper clad on FR4 substrate. For many applications a high gain and directive antenna is required. We are using the rectangular shaped elements in our array It has been observed that printed rectangular monopole antennas are simple in design and fabrication because of high operating frequency but its performance is very good for applications in ISM band and multiband wireless applications.**

Index Terms—**About four key words or phrases in alphabetical order, separated by commas.**

I. INTRODUCTION

This paper focuses on the software simulation and hardware fabrication of printed monopole antenna and its array. Monopole is single-end fed ground plane dependent antenna. The antenna must have a ground plane to be efficient. Ideally the ground plane should spread out at least a quarter wavelength, or more, around the feed-point of the antenna. The gain, resonance frequency and impedance of the antenna are influenced by size of the ground plane.

Modern and future wireless systems are placing greater demands on antenna designs and shapes. Many systems now operate in two or more frequency bands, requiring dual or triple band operation of fundamentally narrow band antennas[3][4][5][10]. The monopole antennas are convenient to match to 50 ohms, and are unbalanced. The simplest member of the family is the quarter wave monopole above a prefect ground plane. An antenna array is a set of N spatially separated antennas. In general the performance of antenna array increases with number of antennas in the array. Antenna arrays are becoming an increasingly important in wireless communications. The advantages of using antenna arrays:

1) They can provide the capability of a steerable beam (radiation direction change) as in smart antennas.
2) They can provide high gain (array gain) by using simple antenna elements.
3) They provide a diversity gain in multipath signal reception.
4) They enable array signal processing.
5) Maximize the signal to interference plus noise ratio(SINR)

II. DESIGN SPECIFICATIONS

The three essential parameters for the design of a square printed monopole antenna array are as follow:

i). *Frequency of operation (fo):* The resonant frequency of the antenna must be selected appropriately. The ISM Band frequency ranges from 2.4 - 2.4835 GHz. Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for my design is 2.45 GHz.

ii). *Dielectric constant of the substrate (εr):* The dielectric material selected for my design is glass epoxy FR4 substrate which has a dielectric constant of 4.3. A substrate with a high dielectric constant as been selected since it reduces the dimensions of the antenna.

iii) *Height of dielectric substrate (h):* For the microstrip patch antenna to be used in ISM Band Application, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.59 mm.

III. METHODOLOGY

1. **Estimate patch dimension:** Patch dimension of monopole antenna is calculated by using equation of lower edge frequency according to the resonant frequency and required bandwidth and gain.
2. **Design of Antenna:** According to the dimensions and parameters calculated in above step monopole antenna is designed by using IE3D software.
3. **Simulation:** Simulate the above designed antenna by using the IE3D simulator and obtain parameters such as current distribution, radiation pattern, gain v\s frequency plot, VSWR etc.
4. **Hardware Implementation:** If the desired parameters and results are satisfied then implement the structure on hardware, design monopole printed antenna using double sided copper clad.
5. **Observation of hardware result:** After implementing the structure on hardware analyze the result and observe whether the desired parameters are achieved as in software design.

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IV. Design Steps

Rectangular monopole antenna having patch dimension of 30x40 mm, ground dimension of 100x20 mm, p=3 mm and substrate of dimension 80x100 mm is to be design as shown in fig. 1. To design printed monopole antenna steps are mentioned below:
Step 1: Define Basic Parameters.
Step 2: Build the rectangular patch.
Step 3: Build the feed line.
Step 4: Define Port to the antenna for excitation.
Step 5: Preview Meshing and Automatic Edge Cells.
Step 6: EM Simulation.
Step 7: EM Simulation with Current Distribution Data and Pattern Calculation.

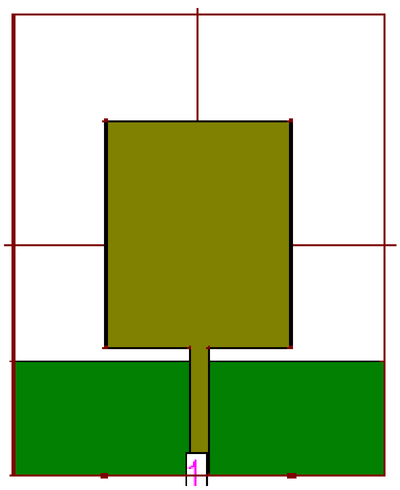

Fig. 1: Rectangular Monopole Antenna geometry for single element

Rectangular monopole antenna array having three elements each having patch dimension of 30x40 mm, ground dimension of 100x20 mm, p=3 mm and substrate of dimension 80x100 mm is to be design as shown in fig. 2.

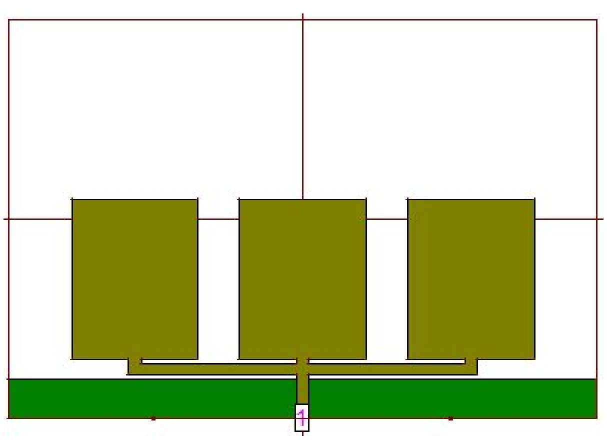

Fig. 2: Rectangular Monopole Antenna Array geometry for three element

V. Results

In design of Fig.1 rectangular monopole antenna having patch dimension of 30x40 mm, ground dimension of 100x20 mm, p=3 mm and substrate of dimension 80x100 mm was designed. After designing and simulating the antenna frequency range of 1.6-3.4 GHz is achieved. The directivity of this antenna can be inspected by studying the radiation pattern in Fig. 5

In design of Fig.2 rectangular monopole antenna array for 3 elements having single patch dimension of 30x40 mm, ground dimension of 100x20 mm, p=3 mm and substrate of dimension 80x100 mm was designed. After designing and simulating the antenna frequency range of 1.9-2.9 GHz is achieved. The directivity of this antenna can be inspected by studying the radiation pattern in Fig. 6

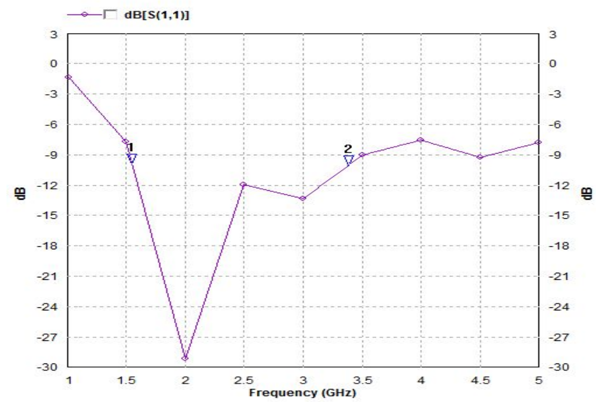

Fig. 3: Frequency v/s Return loss S_{11}(dB) Plot for single element

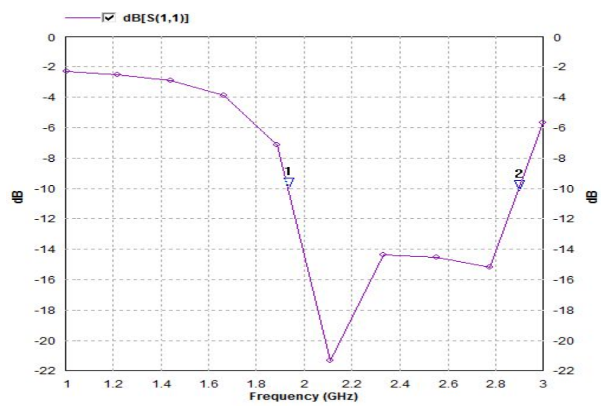

Fig. 4: Frequency v/s Return loss S_{11}(dB) Plot for three elements

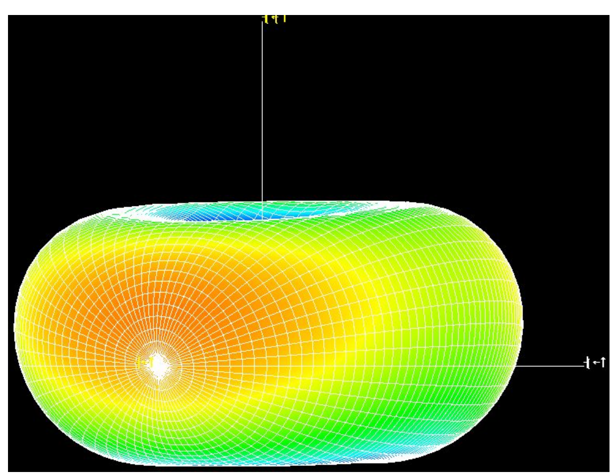

Fig. 5: 3D Radiation pattern cut into 2D polar pattern for single element patch

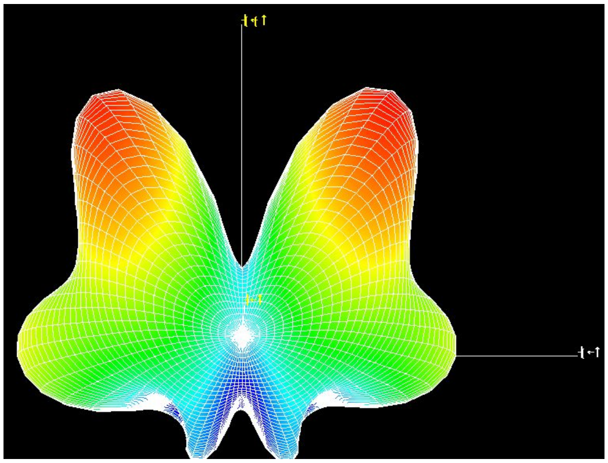

Fig. 6: 3D Radiation pattern cut into 2D polar pattern for three element patch

After designing and simulating proposed printed monopole antenna patch for single and three elements, next part is to implement these printed monopole antennas on hardware, so that it can be analyzed whether this antennas can be used practically or not. Printed Monopole antennas can be designed by using double side copper clad PCB. For this purpose PCB fabrication method to be followed so that printed monopole antenna with finite ground plane is made

CONCLUSIONS

Depending upon the observations of these two designs we make the conclusion of our work. The overall working of antennas was understood. The major parameter (such as S_{11} plot, Radiation Patterns, Directivity and Beamwidth) that affect design and applications were studied and their implications understood. The constructed Printed Monopole antennas operated at expected frequency and power levels. When we observed the radiation pattern for single patch antenna and compared it to radiation pattern for antenna array for 3 elements we could observe that the radiation pattern appears more directive in 3 element antenna array. This shows that when the number elements in the array are increased from 1 to 3 the radiation pattern becomes more directive. This shows that certainly increasing the number of elements in array increases the directivity of the antenna thereby increasing gain. In further observations we would understand this conclusion further by increasing elements in array.

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