

High Gain Printed Monopole Antenna for Wireless Applications

Mr. Rohit Sharma¹, Mr. Mohd Farhan², Dr. Balaji G. Hogade³

Department of Electronics and Telecommunication
rohitsir91@gmail.com¹, far786686@gmail.com², bghogade@gmail.com³

Abstract— It has been observed that printed monopole antennas are simple in design and fabrication because of high operating frequency, 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 and studying the radiation patterns for the array of 5 elements, 9 elements and 16 elements to improve its directive gain. For many applications a high gain and directive antenna is required. We are using the rectangular shaped elements in our array as its performance is very good for applications in ISM band and multiband wireless applications.

Keywords— ISM Band, Impedance bandwidth, Microstrip patch antenna, Printed monopole, antenna array, directivity.

INTRODUCTION

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 directive gain or directivity of the antenna is influenced by number of elements in the antenna array.

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 perfect 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)

Design Specifications:

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

Frequency of operation (f_0): 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.

Dielectric constant of the substrate (ϵ_r): 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 has been selected since it reduces the dimensions of the antenna.

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.

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.

DESIGN STEPS

Rectangular monopole antenna array having patch dimension of 40x120 mm, ground dimension 400x20 mm for 5 elements antenna array, $p=3$ mm and substrate of dimension 400x200 mm for 5 elements 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.

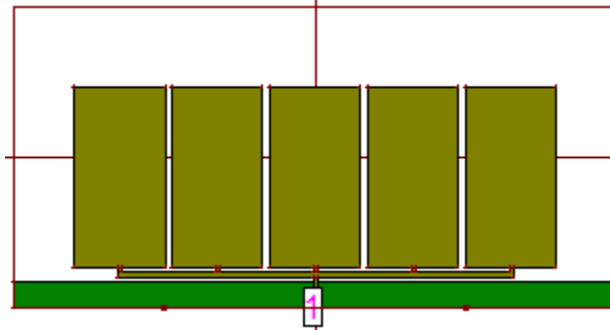


Fig. 1: Geometry of Rectangular Monopole Antenna Array of 5 Elements

Rectangular monopole antenna array having 9 elements each having patch dimension of 40x120 mm, ground dimension of 500x20 mm, $p=3$ mm and substrate of dimension 500x200 mm is to be design as shown in fig. 2.

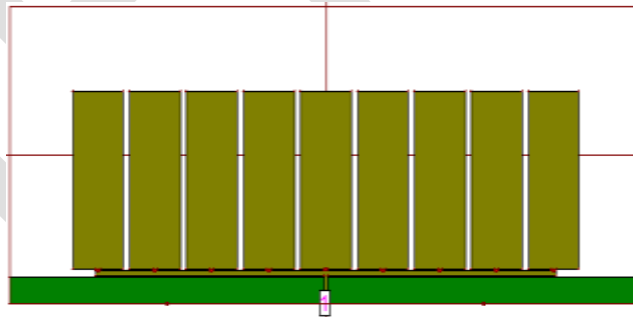


Fig. 2: Geometry of Rectangular Monopole Antenna Array of 9 Elements

Rectangular monopole antenna array having 16 elements each having patch dimension of 40x120 mm, ground dimension of 700x20 mm, $p=3$ mm and substrate of dimension 700x200 mm is to be design as shown in fig. 2.

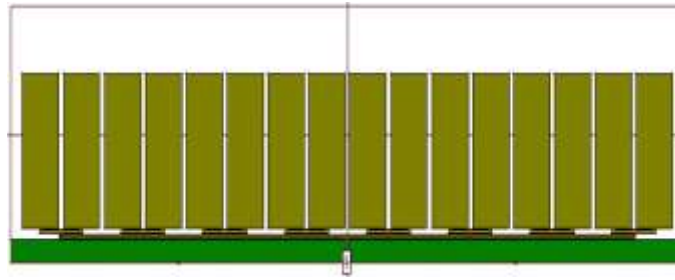


Fig. 3: Geometry of Rectangular Monopole Antenna Array of 16 Elements

RESULTS

1. In design of Fig. 1 rectangular monopole antenna array for 5 elements having patch dimension of 40x120 mm, ground dimension of 400x200 mm, $p=3$ mm and substrate of dimension 400x200 mm was designed. After designing and simulating the antenna frequency range of 780-990 MHz is achieved. The directivity of this antenna can be inspected by studying the radiation pattern in Fig. 5
2. In design of Fig. 2 rectangular monopole antenna array for 9 elements having patch dimension of 40x120 mm, ground dimension of 500x200 mm, $p=3$ mm and substrate of dimension 500x200 mm was designed. After designing and simulating the antenna frequency range of 1.5-1.7 GHz is achieved. The directivity of this antenna can be inspected by studying the radiation pattern in Fig. 6
3. In design of Fig. 3 rectangular monopole antenna array for 16 elements having patch dimension of 40x120 mm, ground dimension of 700x200 mm, $p=3$ mm and substrate of dimension 700x200 mm was designed. After designing and simulating the antenna frequency range of 2-2.7 GHz is achieved. The directivity of this antenna can be inspected by studying the radiation pattern in Fig. 6

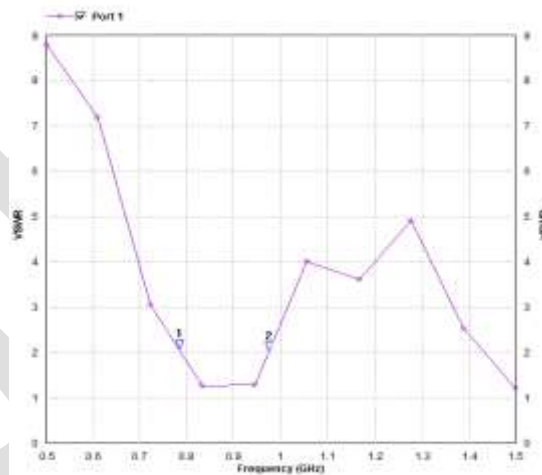


Fig. 4: Frequency v/s VSWR plot for five element antenna array

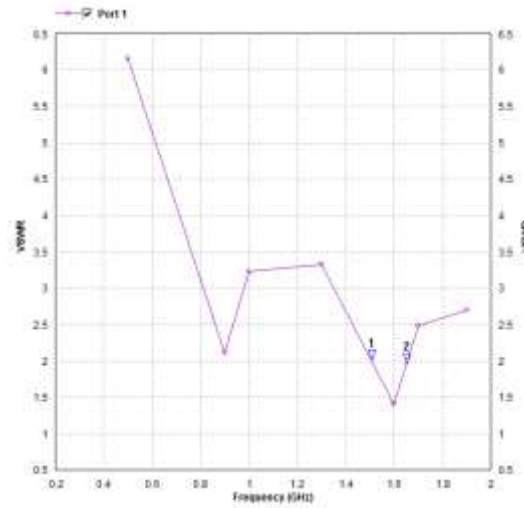


Fig. 5: Frequency v/s VSWR plot for nine element antenna array

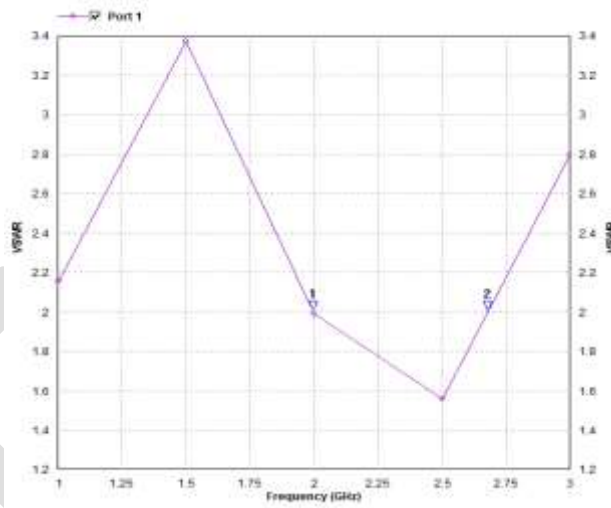


Fig. 6: Frequency v/s VSWR plot for sixteen element antenna array

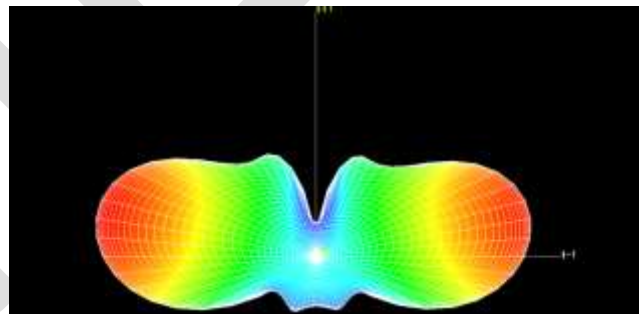


Fig. 6: 3D Radiation pattern cut into 2D polar pattern for five element patch

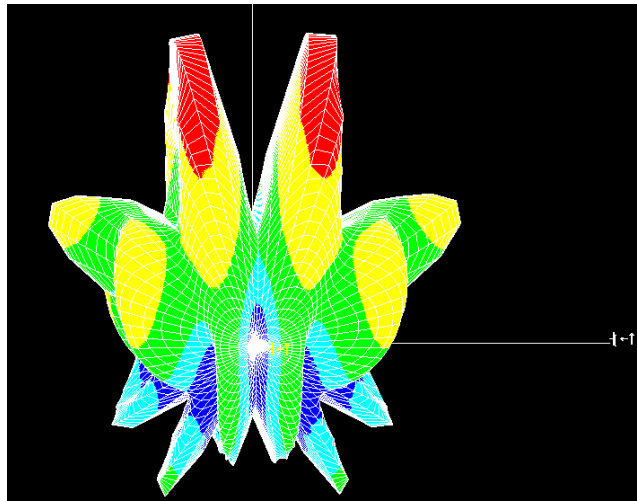


Fig. 7: 3D Radiation pattern cut into 2D polar pattern for nine element patch

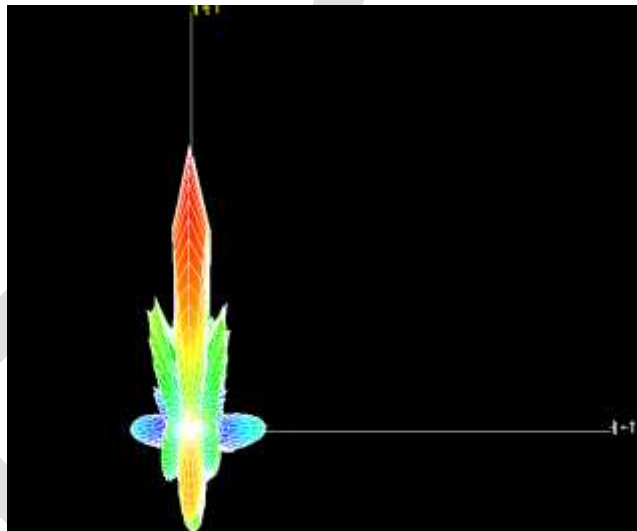


Fig. 7: 3D Radiation pattern cut into 2D polar pattern for sixteen element patch

After designing and simulating proposed printed monopole antenna patch for five, nine and sixteen elements, next part is to implement these printed monopole antennas on hardware, so that it can be analyzed whether these 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 three antenna designs we make the conclusion of our work. The overall working of antennas was understood. The major parameter (such as VSWR 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 comparison of radiation pattern for 5 elements patch antenna, 9 elements patch antenna and 16 elements. We could observe that the radiation pattern appears more directive in 16 elements antenna array. This shows that when the number elements in the array are increased from 5 to 16 the radiation pattern becomes highly 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.

ACKNOWLEDGEMENT

I would like to thank my guide Dr. B. G. Hogade from Terna College of Engineering and my college ARMIET for their support and guidance.

REFERENCES:

- 1) Ahmed Al-Shaheen "New Patch Antenna for ISM band at 2.45 GHz" ARPN Journal of Engineering and Applied Sciences VOL. 7, NO. 1, January 2012.
- [9] Rajasree Hazra, Chandan Kumar Ghosh, and S.K. Parui "P-shaped Wearable Antenna for ISM band at 2.45 GHz" International Journal of Innovation and Applied Studies ISSN 2028-9324 Vol. 4 No. 3 Nov. 2013.
- [10] P. Jithu, A. Paul, V. Pithadia, R. Misquitta, U. P. Khot "Dual Band Monopole Antenna Design" P. Jithu et.al / International Journal of Engineering and Technology (IJET) Vol 5 No 3 Jun-Jul 2013.
- [11] Sarawuth Chaimool and Prayoot Akkaraekthalin "A Compact Dual-band Printed Dipole Antenna Based on Fractal Feature in ISM Band".
- [12] P. Misra, A. Tripathy, N. Singhdeo "A Planar Monopole Antenna for Dual band Application" International Journal of Scientific & Technology Research Volume 1, Issue 2, March 2012.
- [13] S. M. Naveen, R.M. Vani, P.V. Hunagund "Compact Wideband Rectangular Monopole Antenna for Wireless Applications" Wireless Engineering and Technology, 2012,3,240-243.
- [14] G. Tsachtsiris, C. Soras, S.A. Kotsopoulos and V. Makios "Analysis and design of a Koch monopole printed on a PCMCIA card for the 2.4 GHz ISM band" 8th COMCON International Conference on Advances in Communications and Control, June 2001, Crete, Greece.
- [15] S.H. Hwang, J.I. Moon, W.I. Kwak and S.O. Park "Printed compact dual band antenna for 2.4 and 5 GHz ISM band applications" ELECTRONICS LETTERS 9th December 2004 Vol. 40 No. 25
- [16] Yanyan Zhang, H. Y. David Yang "An Ultra Small Integrated Monopole Antenna using High-Density Periodic Substrate Metallization"
- [17] Yi Ye Sun, Sing Wai Cheung, Tung Ip Yuk "An ISM/UWB antenna with offset feeding and slotted ground plane for body-centric communications" Journal Electrical and Electronic Engineering 2013; 1(2): 45-50.
- [18] Nader Behdad, "A Tutorial on Simulation of a 2.4 GHz Patch Antenna using IE3D" EEL 6463, Spring 2007.
- [19] C. A. Balanis, "Antenna Theory: Analysis and Design", 2nd Ed. Wiley India Pvt. Limited, 2007.
- [20] Girish Kumar, K. P. Ray "Broadband Microstrip Antennas" pp 205-376