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Design and Implementation of Printed Monopole Antenna for ISM Band

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Abstract

Monopole antennas have several advantages but for their narrow bandwidth. Broadband planar monopole antennas have all the advantages of the monopole in terms of their cost, and ease of fabrication besides, yielding very large bandwidths. This paper focuses on designing and simulating printed monopole antenna for ISM band resonant frequency of 2.4 GHz. Design and simulation by using IE3D and hardware implementation by using double sided copper clad on FR4 substrate. For many applications large bandwidth is required. Various planar configurations such as circular, triangular, rectangular and square monopoles have been studied. More recently, it has been shown that, although the square monopole (SM) provides smaller BW than the circular monopole (CM), its radiation pattern suffers less degradation within the impedance BW. It has been observed that printed rectangular monopole antennas are small in size and simple in design and fabrication because of high operating frequency but its performance is very good for ISM band and multiband applications.

Keywords: ISM Band, Impedance bandwidth, Microstrip patch antenna, Printed monopole, , Square monopole.

Introduction

This paper focuses on the software simulation and hardware fabrication of printed monopole antennas. Monopole is a ground plane dependent antenna that must be fed single-ended. 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 size of the ground plane influences the gain, resonance frequency and impedance of the antenna.

Modern and future wireless systems are placing greater demands on antenna designs. 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. The impedance BW achievable for the quarter wave monopole antenna is dependent on the radius of the cylindrical stub, and increases with increased radius. This is true up to a point where the stepped radius from the feed probe to the cylindrical element becomes abrupt.

Planar monopole antennas have long been used in mobile communications. Several planar monopoles such as circular, elliptical, square, rectangular, hexagonal and pentagonal, have been analyzed, providing wide impedance BW.

The industrial, scientific and medical (ISM) radio bands are radio (portions of the radio spectrum) reserved internationally for the use of radio frequency (RF) energy for industrial, scientific and medical purposes other than telecommunications [2]. ISM band frequency spectrums are 915 MHz (902–928 MHz), 2.4 GHz (2400–2483.5 MHz), and 5.7 GHz (5725–5850 MHz) bands. ISM band is unlicensed band. It is required to design antenna for ISM band with improved bandwidth in order to get complete utilization of ISM band.

Design Specifications

The three essential parameters for the design of a square printed monopole antenna 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

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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.

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

Square monopole antenna having patch dimension of 40x40 mm, ground dimension of 100x20 mm, p=2 mm and substrate of dimension 100x100 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.

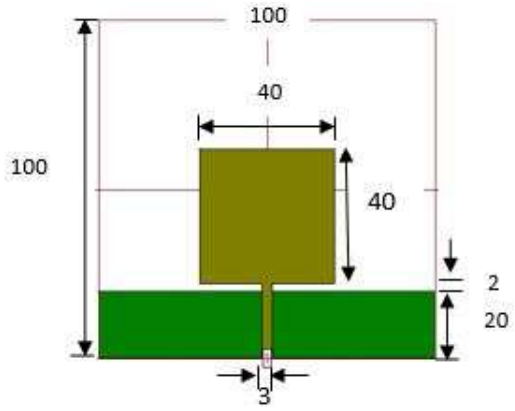

Fig. 1: Square Monopole Antenna geometry

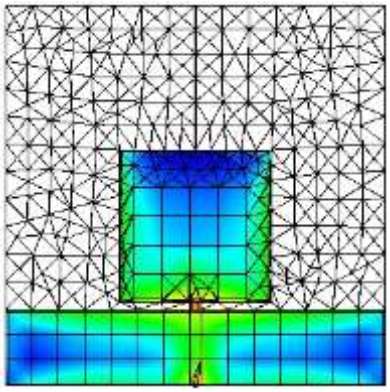

Fig. 2: Current distribution in patch antenna

Results

In this design Square monopole antenna having patch dimension of 40x40 mm, ground dimension of 100x20 mm, p=2 mm and substrate of dimension 100x100 mm was designed. After designing and simulating printed monopole for ISM Band, the desired frequency of 2.4 GHz is achieved with a bandwidth of 1.485 GHz as shown in fig. 3 and fig. 4. The figures below show the gain v/s frequency response of a printed monopole antenna and radiation pattern as shown in fig. 5.

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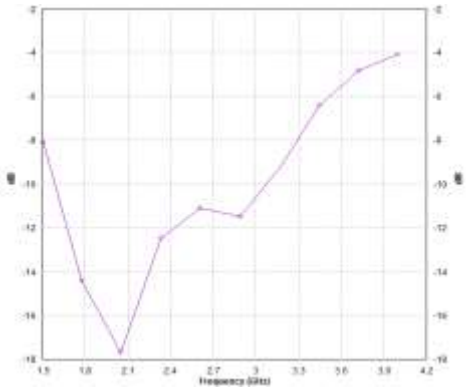


Fig. 3: Frequency v/s Gain S_{11}(dB) Plot

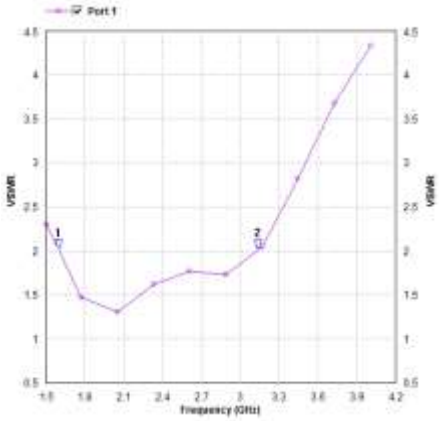


Fig. 4: Frequency v/s VSWR Plot

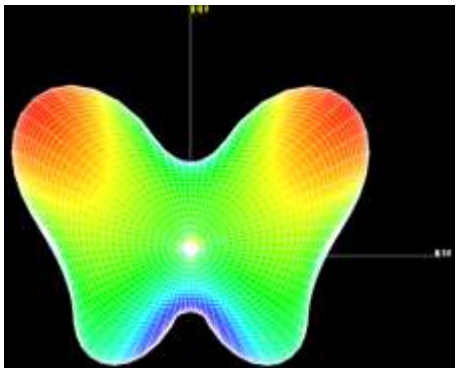
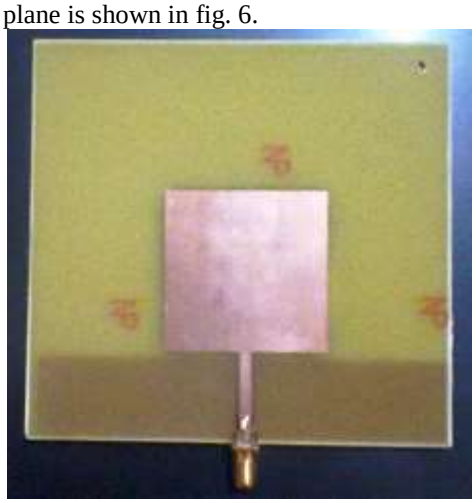


Fig. 5: 3D Radiation pattern cut into 2D polar pattern

After designing and simulating proposed printed monopole antenna, next part is to implement this printed monopole antenna on hardware, so that it can be analyzed whether this antenna can be used practically or not. Printed Monopole antenna 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 shown in fig. 6.



Conclusions

Depending upon the assessment of this design we make the conclusion of our work. The overall working of antennas was understood. The major parameters (such as VSWR plot, 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 the desired frequency and power levels. Several patch antennas were simulated (using IE3D) and the desired level of optimization was obtained. It was concluded that the hardware and software results we obtained matched the theoretically predicted results.

After designing basic monopole antenna of square shape lower edge frequency of 1.6 GHz and bandwidth of 1.485 GHz was obtained which includes ISM Band of resonant frequency 2.45 GHz.

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