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IMPLEMENTATION OF ISM BAND ANTENNA USING PRINTED MONOPOLE

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ABSTARCT:
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. For many applications large bandwidth is required. Recently, many techniques to tailor and optimize the impedance BW of these antennas have been investigated. These include the use of bevels, slots and shorting posts. The radiation performance is also shown to be acceptable over a wide range of frequency. Various planar configurations such as circular, triangular, rectangular and annular ring monopoles have been studied. Combinations of shorting pin and optimization of the feed point location can achieve very compact configurations. Also these antennas can provide band-notching characteristics. These antennas have been reported to provide multi band characteristics too. 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: *Printed Monopole Antenna; Microstrip antenna; ISM Band*

1. INTRODUCTION

Wireless communications have become popular worldwide owing to their major advantages such as installation speed and simplicity, installation flexibility, reduced cost of ownership and scalability. The use of the 2.4 - 2.4835 GHz Industrial Scientific and Medical (ISM) band[1] has a role to play in wireless communication's expansion counting numerous applications such as 802.11b Wireless Local Area Network (WLAN), cordless telephone, Digital European Cordless Telecommunications (DECT) and home RF. The main reasons for the growth of the 2.4 GHz ISM band is the fact that it is available worldwide and that it is unlicensed. However, the low data rates (11 Mbps or 80 MHz bandwidth) primarily and the interference in second place had pushed WLAN technologies to move to the 5.15 - 5.35 GHz ISM band [4][8][9]. This band offers 54 Mbps data rate with 200 MHz bandwidth, availability in both North America and Europe and less interference.

One of the challenges nowadays is the development of small, integrated, low cost antennas with favorable characteristics operating in these ISM bands. However, a future challenge will be the development of single element integrated antennas operating in both 2.4 and 5.15 GHz ISM bands[5][9]. It's well known that the overall size of the antenna is related to the wavelength of operation.

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. A planar monopole may be realized by replacing the wire element of a conventional monopole with a planar element. The planar element is located at a distance 'h' above the ground plane. The replacing of wire element with planar element, with various shapes, increases the surface areas of the monopoles, there by having a direct impact on BW.

Several planar monopoles such as circular, elliptical, square, rectangular, hexagonal and pentagonal, have been analyzed, providing wide impedance BW. Among all these configurations, the circular monopole and the

elliptical monopole fed along the major axis were reported to yield maximum bandwidth. More recently, it has been shown that, although the square monopole provides smaller bandwidth than the circular monopole, its radiation pattern suffers less degradation within the impedance BW. Planar monopole antennas can be optimized to provide extremely wide impedance BW with acceptable radiation performance. They can be developed to cover frequency ranges from GSM900/NADC through GSM1800/PCS1900, IMT-2000, the 2.45GHz and 5.8GHz ISM bands and including UWB (1.9GHz – 10.6 GHz).
The broadband planar monopoles can also be understood by considering it as a modified MSA. In MSAs increasing the substrate height or decreasing the substrate dielectric constant increases the BW. Now, if a rectangular patch without the substrate is fed by a coaxial feed with a perpendicular ground plane, it will result into effective dielectric constant of one and a substantial increase in height h. Both these factors will yield a large BW.

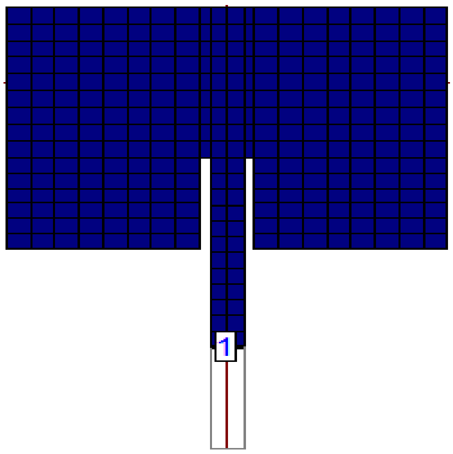

Fig. 1 Geometry of Monopole Antenna

2. METHODOLOGY

1. **Calculation of Dimension:** Dimensions of monopole antenna is calculated by analytical method according to the operating 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 observe the various parameters such as current distribution, radiation pattern, gain v\s frequency plot, VSWR etc.
4. **Observation:** Observe the result and various parameters obtained in the above step and check whether the required parameters and operating or resonance frequency is achieved or not if not then again vary the parameters, dimensions and shape of monopole antenna and then design and simulate the structure again for observations as in step 2 and 3.
5. **Hardware Implementation:** If the desired parameters and results are satisfied then implement the structure on hardware, design micro-strip monopole antenna structure as per the design in software.
6. **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. Fig. 2 shows a flowchart with the principal steps of the proposed methodology.

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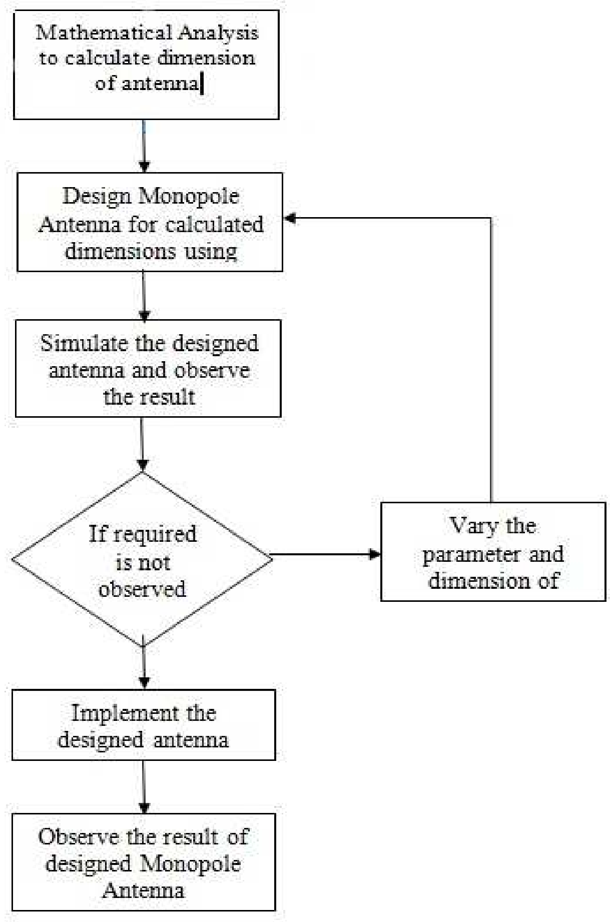

Fig. 2 Flowchart of antenna design

3. DESIGN SPECIFICATION

The three essential parameters for the design of a rectangular Micro-strip Patch 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 Silicon which has a dielectric constant of 3.4. 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 1.54 mm.

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4. DESIGN STEPS

Step 1: Calculation of dimensions and parameters

For a planar monopole antenna, the lower frequency corresponding to VSWR = 2 can be approximately calculated by equating its area (in this case, a rectangular disc monopole) to that of an equivalent cylindrical monopole antenna of same height L and equivalent radius r, as described below:

$$2 \pi r L = W L \quad \ldots\ldots\ldots\ldots\ldots \text{(i)}$$

which gives

$$r = W / (2 \pi) \ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

$$L = 0.24 \lambda F \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

Where,

$$F = (L / r) / (1 + L / r) = L / (L + r) \ldots\ldots \text{(iv)}$$

the wavelength λ is obtained as:

$$\lambda = (L + r) / 0.24 \ldots\ldots\ldots\ldots\ldots \text{(v)}$$

Therefore, the lower frequency f_L is given by:

$$f_L = c / \lambda = (30 \times 0.24) / (L + r)$$

$$= 7.2 / (L + r)\ GHz \ldots\ldots \text{(vi)}$$

Equation (3.6) does not account for the effect of the probe length p, which increases the total length of the antenna thereby reducing the frequency. So, this equation is modified to

$$f_L = 7.2 / (L + r + p)\ GHz \ldots\ldots\ldots\ldots\ldots\ldots \text{(vii)}$$

Where, L, r and p are in mm

Step 2: Software simulation

i. Define basic parameters for simulation such as the dielectric constant of different layers, the units and layout dimensions, and metal types among other parameters.
ii. To draw the antenna layout.
iii. Select the feed location and type of feed.
iv. The next step is to run the simulation. However, before that, let us first mesh the structure; this mesh is used in the Method of Moment (MoM) calculation.

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v. Observe the result for various parameters such as radiation pattern, current distribution, gain v/s frequency plot, resonance frequency and bandwidth.

Step 3: Hardware Implementation

i. Implement the designed antenna on dielectric substrate over infinite or finite ground plane.
ii. Attach the feed port to the antenna.
iii. Observe the result for above designed parameters that are mentioned in software simulation.

Step 4: Comparison of Result

Both software simulation and hardware result will be observed and tabulated. On the basis of software and hardware results obtained; comparative study of the results with other methods, antenna studied in literature survey and then conclusion will be deduced.

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5. CONCLUSION

In this paper, we have investigated printed monopole antennas, which is basically a printed micro-strip antenna with etched ground plane for ISM Band and multi-band applications. Printed monopole antennas are less fragile, planar and can be integrated with the integrated circuits unlike monopole antennas which have non-planar or protruded structures above the ground plane. Printed monopole antennas are studied first for such application. Then monopole antennas for high gain and high bandwidth are studied. It has been concluded that the printed monopole antennas are one of the versatile candidates for ISM band applications as well as it can be used for various Wireless Applications such as Wi-Max.

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