Analysis and Design of Compact Multiband Printed Monopole Antenna for Wireless Communication System

Ms.Minakshi M. Band[1] Prof. Mahesh M. Kadam[2]
[1,2]Department of Electronics & Telecommunication Engineering
[1]Alamuri Ratnamala Institute of Engineering And Technology A.S Rao Nagar, Sapgaon, Tal Shahapur, Dist.Thane-421601, India [2]Mumbai University, Maharashtra, India

Abstract— With the rapid development of the communication technology, there is a great demand for antennas suitable to operate with dual- or multiband characteristics in wireless communication devices, such as mobile phones and laptops. Printed antennas have been paid great attention in recent years because of their compact size, low profile, light weight, and low cost. Analysis and design of compact multiband printed monopole antenna for wireless communication system is presented. The proposed antenna, at 2.25–2.7GHz, 3.25–3.6Hz, 4.95–6.2GHz, and 7-8GHz, covering the operation bands of Bluetooth, WiMAX, WLAN, and downlink of X-band satellite communication system and will make it a proper candidate for the multiband devices. The antenna is composed of a modified broadband T shaped monopole antenna integrating some band-notch structures in the metallic patch, is excited by means of a microstrip line. To calculate the bandwidth starting frequency (BSF) of the T-shaped broadband antenna, an improved formula is proposed and discussed. The multiband operation is achieved by etching three inverted U-shaped slots on the radiant patch. By changing the length of the notch slots, operation bands of the multiband antenna can be adjusted conveniently. The antenna is simulated in COMSOLMultiphysics and then fabricated and measured.

Key words: Compact Multiband Printed Monopole Antenna, Wireless Communication System

I. INTRODUCTION

For wireless communication systems, the antenna is one of the most critical components. A good design of the antenna can relax system requirements and improve overall system performance. A typical example is TV for which the overall broadcast reception can be improved by utilizing a high performance antenna. An antenna is the system component that is designed to radiate or receive electromagnetic waves.

Antennas are acting as a transducer which is converting electrical signal (current) in to electromagnetic waves and radiating in to free space. Similarly when an electromagnetic wave is hitting on the antenna, voltages and currents are induced. The RF voltage induced are then passed into the receiver and converted back into the transmitting RF information.

Recently, a lot of wideband antennas have been proposed because of the wide operation band and high date rate. To avoid the interference between UWB (ultra wideband) antennas and narrow bandwidth communication systems, antenna designers have proposed several UWB antennas with band-notch characteristics. In this paper, presents compact multiband printed monopole antenna based on the broadband antenna theory and employing band-notch technique. A monopole antenna is one half of a dipole antenna, almost always mounted above some sort of ground plane. Planar Monopole antenna is a good candidate for wireless communication services because of its wide impedance bandwidth, omni directional radiation pattern, compact simple structure and ease of fabrication.

A T-shaped monopole antenna is designed to achieve a broad impedance band-width. Using the techniques suitable to widening of the operative frequency band, three inverted U-shaped slots are etched on the metallic patch to reject the undesired bands; in this way the multiband operation is achieved.

II. BANDWIDTH STARTING FREQUENCY (BSF)

The operation bands of the proposed antenna can be adjusted conveniently by changing the length of each band-notch slot. An improved formula for computing the bandwidth starting frequency (BSF) with higher accuracy is proposed and discussed. Then the broadband characteristic of the T shaped monopole antenna is analysed. Finally, the frequency behavior of the band-notch structures consisting of three inverted U-shaped slots etched on the metallic patch is investigated.

For a broadband antenna, the BSF and bandwidth are two important factors to evaluate its frequency performance. An accurate formula to calculate BSF of a broadband antenna is quite necessary for antenna designers to save simulation time and accelerate the design process. An improved formula to provide a much more accurate prediction of BSF of the T-shaped monopole is:

$$BSF = 72 / (l + r + g)\ \text{GHz} \qquad (1)$$

Where, l denotes the length of the monopole (both the planar monopole and the equivalent cylinder monopole), g denotes the gap between the ground plane and the monopole, and r denotes the radius of the equivalent cylinder monopole. The equivalent radius r is expressed as,

$$r=A / (2\pi l\sqrt{\varepsilon e}) \quad (2)$$

where A denotes the area of the radiant patch and the area of the side face of the equivalent cylinder monopole, εe is the effective dielectric constant of the air-substrate composite dielectric and can be calculated by;

$$\varepsilon e = (1 + \varepsilon r)/2$$

And εr denotes the relative constant of substrate. The parameters l, r, and g appearing in above equation are expressed in millimetres.

However, equation (1) is not accurate enough to calculate the BSF of the T-shaped monopole antenna because the parameter g does not take into account the effect of the two bevel cuts on the feeding gap. Therefore, we propose to replace it by an effective parameter ge defined as follows:

$$ge=g+l-(A/w2) \quad (3)$$

Here w2 denotes the width of the higher edge of the radiant patch, and g, l, and A have the same meanings as in (1), while, $l = l1+ l2$ and $A = w1l1+w2l2$.

Then (3) can be rewritten as,

$$ge=g+l1-(w1l1/w2) \quad (4)$$

The modified formula to calculate BSF of the T-shaped monopole is :

$$BSF = 72(2l1+ l2- (w1l1/w2) + g+((w1l1+ w2l2) /(l1+l2)\sqrt{(2\varepsilon r+2)}))\text{-}1(GHz) \quad (5)$$

After performing some numerical simulations it is found that the values of the BSF calculated by (5) are smaller than the simulated ones. So a calibration factor Fc with its value of 1.145 is introduced. Then (5) can be modified as :

$$BSF = 72\, Fc\, (2l1+ l2- (w1l1/w2) + g + ((w1l1+ w2l2) /\pi\, (l1+ l2)\, \sqrt{(2\varepsilon r+ 2)}))\text{-}1 \quad (GHz) \quad (6)$$

Based on the broadband antenna design, three inverted U-shaped slots are etched on the T-shaped radiant patch to reject the undesired frequency bands, thus achieving the multiband operation. The resonant frequency of each inverted U-shaped slot can be approximately calculated by:

$$Fni=150 / (lni\sqrt{\ }) \text{ GHz} \quad (7)$$

Where Fni denotes the resonant frequency of the ith band notch structure and lni denotes the length, expressed in millimeters of the ith band-notch structure with i = 1, 2, 3. Equation (7) predicts a decrement of the resonant frequency fni as the parameter lni is increased.

III. Antenna Geometry

The geometry and detailed dimensions of the proposed antenna is depicted in Fig. 1 and Table. 1. The antenna consists of dielectric substrate Fig. 2 and a ground plane.

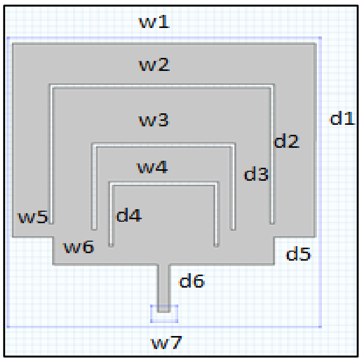

Fig. 1: Antenna Geometry

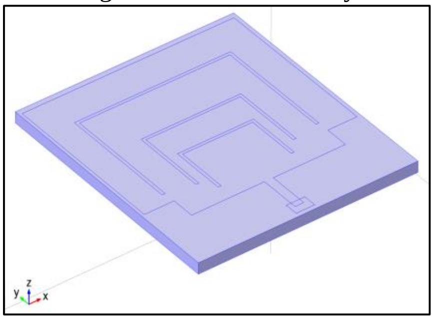

Fig. 2: Substrate

Width	Size(mm)	Depth	Size(mm)
w1	36.88	d1	28.53
w2	26.65	d2	20.44
w3	16.37	d3	12.26
w4	12.17	d4	8.89

w5	5.11	d5	4.04
w6	12.57	d6	7
w7	1.5		

Table 1: Dimensions of Antenna

IV. SIMULATION RESULTS AND DISCUSSION

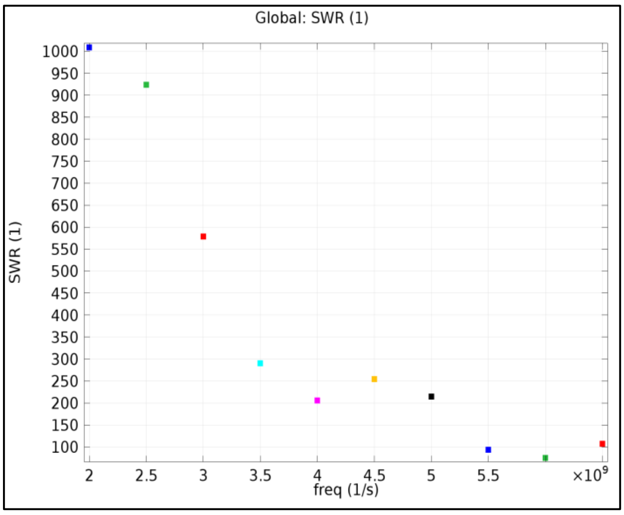

Fig. 3: 1D Plot : Standing Wave Ratio

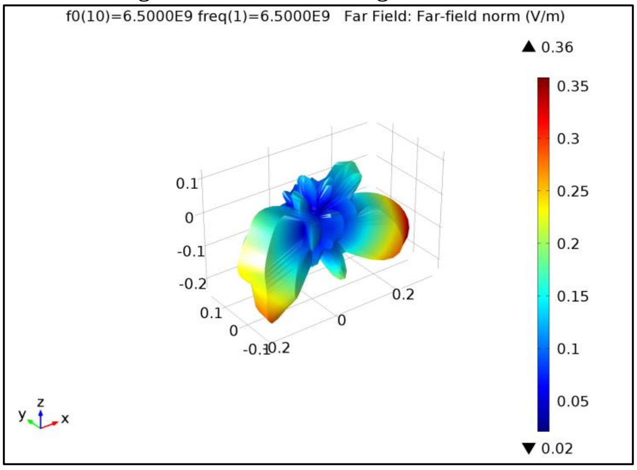

Fig. 4: 3D Plot of Radiation Pattern

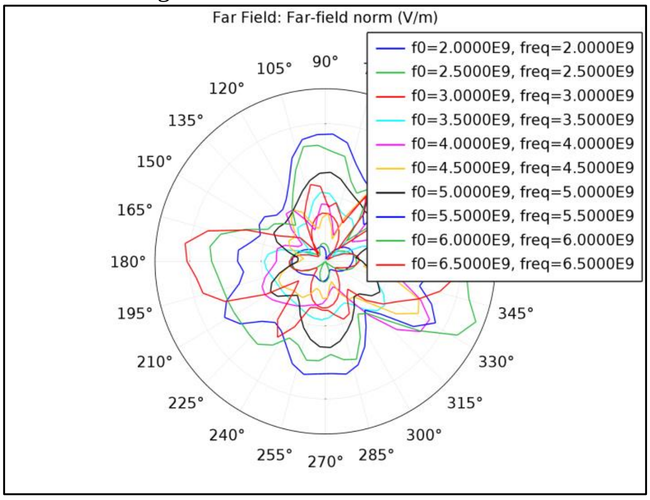

Fig. 5: Polar Plot

The simulated multiband printed antenna gave a resonant frequency of 2.25–2.7 GHz, 3.25– 3.6 GHz, 4.95–6.2 GHz and 7-8 GHz. The simulated Standing wave ratio is shown in Fig 3.The radiation pattern at the different frequencies shown in Fig 4. A polar form of radiation is shown in Fig 5.

V. SIMULATION SOFTWARE

The design was optimized using electromagnetic simulation with the COMSOL Multiphysics®software. The design goal was to maximize the bandwidth. The main reason for choosing COMSOL Multiphysics is that it is based on advanced numerical methods, for modeling and simulating physics-based problems. COMSOL Multiphysics is a finite element analysis.

VI. CONCLUSIONS

A small multi-band compact antenna operates at 2.25–2.7 GHz, 3.25– 3.6 GHz, 4.95–6.2 GHz and 7-8 GHz, covering the operation bands of Bluetooth, WiMAX, WLAN, and downlink of X-band satellite communication system and thus making it a proper candidate for the multiband devices. The antenna characteristic and radiation pattern are satisfactory for most of the wireless system.

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