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Conical Shaped Monopole Antenna for Multiband Wireless Applications

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Abstract: *In this paper we propose a conical shaped slotted monopole antenna for multiband application. The antenna is small sized, lightweight, and low cost offers multiband operation which is useful for S-band, C-band, and X- band applications. This proposed geometry size is 20 × 20 mm^2 with 1.6mm thickness. Radiating patch is printed on cost effective 1.6mm thick FR4 dielectric material which is fed by 4mm long microstrip line. IE3D is efficiently utilized for designing and analyzing this antenna. Fabricated proposed prototype offers four bands which are 3.35 to 3.75GHz, 5.1 to 5.25GHz, 6.85 to 7.1GHz, and 9.55 to 9.7GHz. These find applications in S, C, and X-bands. Measured results fairly agree with simulated values.*
Index Terms: *Microstrip antenna, Monopole antenna, Multi-bands antenna.*

I. Introduction

The modern wireless applications need antennas which are easily integrate with the other communications systems. To meet this antenna must be of low physical profile, low-cost, and lightweight, with multi-functionality in a single device. To get current and future mobile communications, wireless services, and satellite applications, multiband microstrip patch antennas are used, which must have high performance and good radiation characteristics [1].

Microstrip antennas were designed to get high performance & good radiation characteristics [2-4]. After getting desired performance & good radiation characteristics new challenges to design microstrip antenna were to get low cost, low profile, light weight & it should be easy to integrate with other systems in communication satellites & mobile communication systems [5-6]. After minimizing shape, weight & cost, next challenge is to get multiband and multifunctional antennas i.e. single antenna can be useful for different applications of different frequency ranges. To make antenna work at multiple bands of operation, some portion of the patch is etched [7].

The modern microstrip antennas are used to design for certain applications. For WiMAX ranges G-shaped antenna is used, also to get WiMAX & HIPERLAN applications slot ring antenna is used. To get C-band & WiMAX applications A-shaped antenna is used that shows three bands for satellite communication & mobile communication systems [8]. Based on the background of the A-shaped microstrip antenna this paper proposes one more band in X-band region With WiMAX & C-band ranges. With low cost due to FR4 substrate that are very often to be chosen for RF and microwave circuitry due to their inexpensive market price in comparison with other available substrates[9-12].

For the RF and microwave applications where the losses and dielectric constants are less important, this low cost substrate can be used successfully by replacing other conventional expensive substrates. This proposed antenna is applicable for communication satellites, modern radar communication, microwave devices, mobile phones and for some Wi-Fi devices [13].

In this paper we proposed four bands microstrip antenna. The basic geometry of the antenna is derived from [8]. However, the geometry was modified to offer four bands rather than three bands reported in [8]. Basic geometry of the proposed antenna is given in Section 2. Experimental validations of the simulated geometry are presented in Section 3. Finally, conclusions of the work & possible extension of the work is presented in Section 4.

II. Antenna Geometry

The geometrical layout and design parameters of the proposed Conical Shaped Monopole antenna are shown in Figure 1. The antenna is designed and fabricated on an h = 1.6 mm thick fiberglass polymer resin (FR4) substrate with relative dielectric constant ε_r = 4.4 and loss tangent tanδ = 0.02. The two-sided structure of the antenna consists of a standard 50Ω SMA connector, a microstrip line for feeding, radiating patch on top and reduced rectangular ground plane of 4 × 20 mm^2 on the other side (back). The final geometry structure is achieved by cutting slots and etching out different shapes from rectangular patch.

As stated in earlier paragraphs, the basic geometry is derived from rectangular patch whose dimensions (Length & Width) are calculated from expressions given in [4, 8]. Later various slots are made to obtain multiband operations. The geometry was optimized with the Zeland's IE3D (v.14) which is electromagnetic (EM) software.

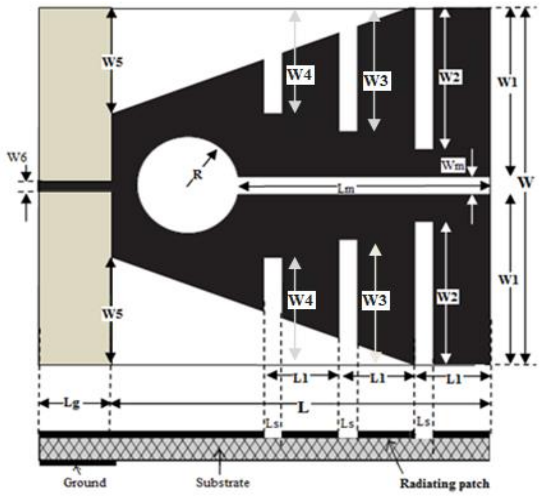


Figure 1: Geometry of the Conical Shaped Monopole Antenna.

Table 1: Parameters of the optimized geometry

Parameter	W	W_1	W_2	W_3	W_4	W_5	W_6	W_m	R	L	L_1	L_m	L_g	L_s	H
Value(mm)	20	9.5	8	7	6	6	0.7	1	2.7	20	4	13.3	4	1	1.6

The antenna is designed and fabricated on h = 1.6 mm thick (FR4) substrate with relative dielectric constant ε_r = 4.4 and loss tangent tan(δ) = 0.02, radiating patch of 20 × 20 mm^2 & ground plane of 4mm long and 20mm wide. Optimized dimensions of the proposed antenna are listed in Table 1.

III. Experimental Validation And Discussions

The proposed geometry (Figure 1) was fabricated for practical validation. The dimensions of the fabricated geometry are as listed in Table 1. Input characteristics of the prototype of the test antenna are measured with the aid of Rohde & Schwarz ZVL network analyzer (R & S, ZVL NA). Photograph with front side and back side of this modified Conical Shaped Monopole Antenna is presented in Figure 2. Front side & back side represents radiating patch of size 20 × 20 mm^2 with different etched shapes & reduced ground of size 4 × 20 mm^2 respectively.

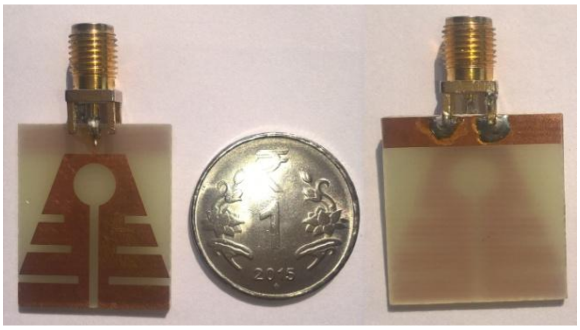


Figure 2: Prototype of the Conical Shaped Multiband Monopole Antenna (left: top view; right: bottom view).

Etching of narrow rectangle strips and cutting circular & triangular shapes from radiating patch are responsible for creating meandered path for the surface currents which supports different resonant frequencies [8]. Photograph of the fabricated prototype is shown in Figure 2. Effect of etching different slots from patch is examined by return loss characteristics. Comparisons in simulated & measured return loss characteristics are presented in Figure 3. From these characteristics (Figure 3) it may be noted that there is a good agreement between the simulated and measured values. Resonating frequencies corresponding to different band are at 3.545, 5.182, 7.1, and 9.636 GHz respectively.

Figure 4 represents gain vs. frequency plot characteristics. The peak gains obtained are 2.12 dBi at 3.545GHz, 2.39 dBi at 5.182GHz, 2.53 dBi at 7.1GHz, and 2.65 dBi at 9.636GHz respectively. These gain values indicate proper operation of the proposed antenna.

Figure 5 shows far field radiation patterns at different resonating frequencies (3.545 GHz, 5.182GHz, 7.1GHz and 9.636GHz). These frequencies are chosen from the bands of operation to demonstrate the working of antenna. From Figure 5, co-polarization patterns are almost symmetric with very low cross polarization levels.

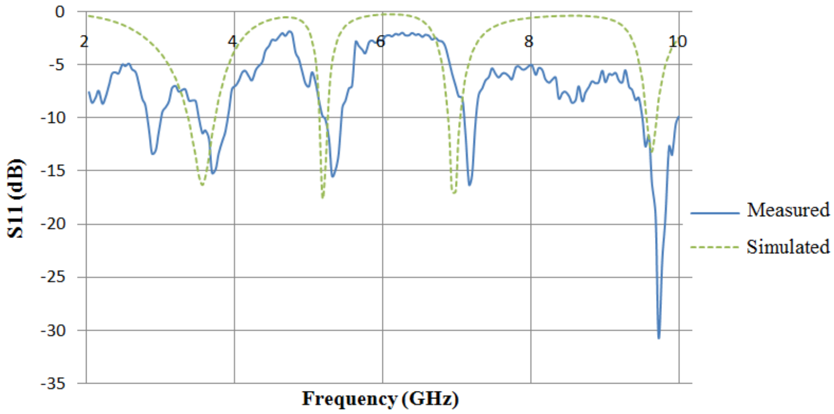


Figure 3: Measured and simulated S_{11} plot of the Conical Shaped Monopole antenna.

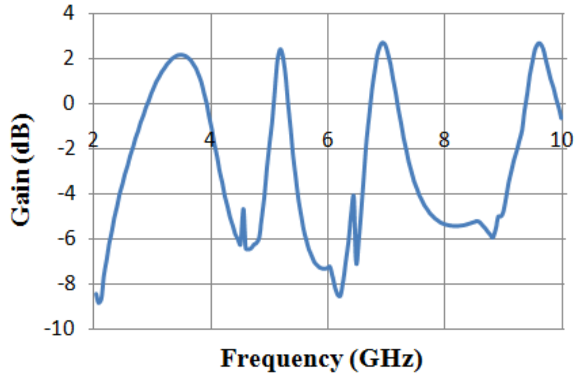
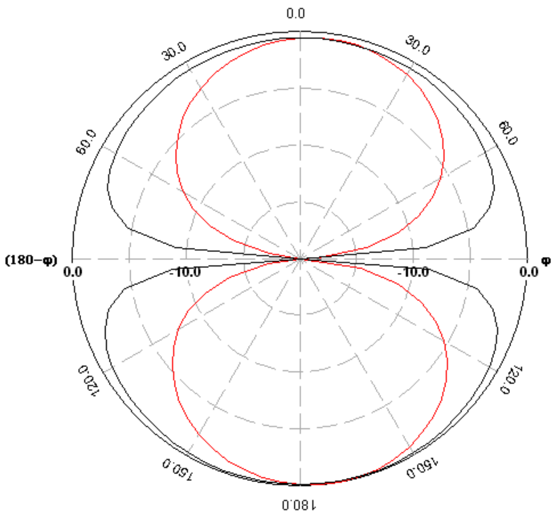
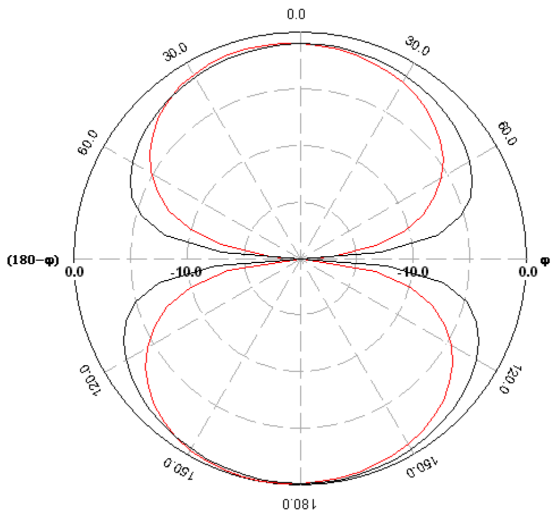


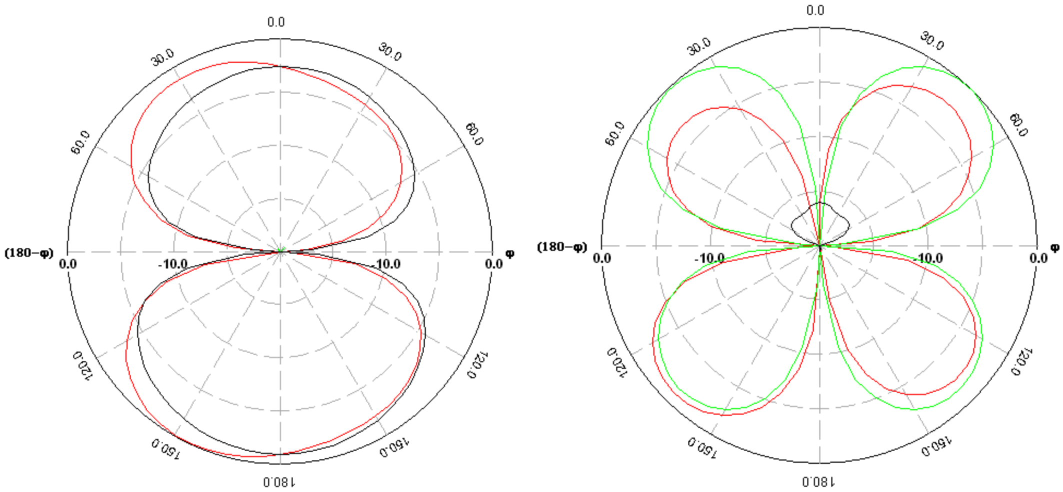
Figure 4: Gain vs. frequency plot of the proposed antenna.



(a) 3.545GHz



(b) 5.182 GHz



(c) 7.1GHz (d) 9.636 GHz

Figure 5: Radiation patterns of proposed antenna for different operating frequencies.

IV. Conclusions

The conical monopole antenna suitable for excitation of multi (four) bands has been fabricated and experimentally analyzed. The multiband capability of the antenna has been achieved with cutting slots of various shapes (rectangular, triangular & circular slots in the radiating patch). Measured results (S_{11}) agree with the simulated values. From the experimental results it is clear that the fabricated prototype offers four bands. They are 3.35 to 3.75GHz (S-band), 5.1 to 5.25 GHz & 6.85 to 7.1 GHz (C-band), and 9.55 to 9.7GHz (X-band). Further work includes the testing of antenna for five bands and flexible variation of bands keeping other bands constant.

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