Multiband slotted Elliptical printed Antenna Design and Analysis

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https://doi.org/10.26782/jmcms.2019.08.00031

Abstract

This paper presents the design of elliptical slot antenna for multiband applications. The suggested antenna covers L-band, WIMAX, WLAN and X band. By placing inverted T-shaped stub and three reverse U-shape stubs, the resonating characteristics of the antenna are observed. The resonating frequencies are 1.95, 4.14, 5.05, 5.89 and 9.15 GHz respectively. The designed antenna shows good return loss(S11<-10dB) and compact size which is relevant for most of the wireless applications. Antenna possessing maximum gain of 3.35 dB with efficiency more than 82% in the operating bands. H-plane showing omni-directional radiation pattern and E-plane exhibiting bi-directional radiation pattern. The performance of antenna is analyzed by using HFSS tool.

Key words: Microstrip Antenna, Multi band, T-slot, U-slot.

I. Introduction

At present wireless communication has diligent accomplishment so, the consequent technologies need compact antenna with the multiband aspects to reduce the utilization of more antennas [XIX]. As increasing demand in the electronics and communication systems, there is more demand for wireless systems also. The compact design of antenna operates at different wireless applications such as L-band, WLAN, WIMAX, X-band are proposed by the researchers. The microstrip technology based antennas has more advantages like low cost, low profile, compact
size, easy implementation. If more number of antennas are used electromagnetic interference occurs so, to avoid that, there is a need of multiband antenna design.

Micro strip patch antennas can receive or transmit the electromagnetic waves [XXII,III]. In case of adequate operation of microstrip antenna, the role of feeding is essential to enhance the input impedance matching. The patch antenna has different feeding techniques. Line feed is used because of its benefits like easy to model, easier method to fabricate.

In multi band there are different types of slots are there. T-slot [XXIII], U-slot [XVIII], flared shape with V-sleeve [VII], Y-shape [XXII], multi-fractal structure [I]. A quarter wave length stub is placed near feed T-stub in radiating patch, U-stub near micro strip feed line these stubs directs the antenna to operate at dual band. To improve the bandwidth fork shape slit placed on the ground [X,XIX]. U-strip are placed to produce different multiband and impedance is high at inverted T slot. A C-slot is placed near the inverted T-slot on radiating patch and dual band is produced. Microstrip feed line is used in the design of monopole antenna. Multiband of monopole antenna achieved initially by etching of radiating patch and by inserting the quarter wave in the middle of radiating patch [VII,IV]. Multiband covers the 1.95 GHz L-band used for personal computers, WIMAX at 4.14, lower WLAN 5.5, upper WLAN 5.88 and X-band at 9.15 GHz.

In this paper we mainly discussed about the printed slot antenna for multiband operation and its radiation performance. The inverted T-shape and U-shape printed slot are tested finally with parametric analysis and presented the results in the subsequent sections.

II. Antenna Design

The geometry of the proposed antenna with inverted T-shaped structure is shown in Figure 1. Antenna is printed on FR4-epoxy with relative permittivity 4.4, relative permeability 1 and dielectric loss tangent 0.02.

![Figure 1: Geometry of antenna model, (a) Basic multiband monopole antenna, (b) T-shape slot antenna, (c) U-shape slot antenna, (d) Proposed antenna with dimensions](image-url)
The proposed antenna design has been done in Ansys HFSS with optimization techniques and presented the simulation studies in this work. Figure 1(a) Initially gives the antenna of hexagonal turn shape. The substrate thickness is 0.8 and antenna length $L$ and width $W$ is $W_{sb} \times L_{sb} = 20 \times 20$ mm. The hexagonal shape is inserted with paired ellipse on radiating patch and major radius of ellipse is $MR_1 = 2.2$ mm for wider band width. Figure 1(b) consisting the inverted T-shape slot on top side vertical is fixed on the radiating patch for WIMAX band application. From Figure 1(c) three inverted U-shape stub are used for lower WLAN, upper WLAN and X-band satellite system. Figure 1(d) having rectangular ground of $W_f = 2$ mm. The microstrip feed line 50 $\Omega$ $W_f \times L_f$ antenna covers bandwidth partially. In ground plane for good impedance bandwidth there should be smooth transmission from one resonator to another resonator. The inverted T-slot and U-slot length, width is shown in table 1. In free space electromagnetic (EM) wave is $c = 3 \times 10^8$ where ‘$c$’ is the speed of EM wave.

| Parameter | Dimension (mm) | Parameter | Dimension (mm) |
|-----------|----------------|-----------|----------------|
| $m_1$     | 6.44           | $M_2$     | -2             |
| $m_2$     | 5              | $W_g$     | 20             |
| $m_3$     | 11.8           | $W_a$     | 8              |
| $L_1$     | 4.1            | $w_2$     | 1.25           |
| $L_2$     | 8.11           | $w_3$     | 2.57           |
| $T_1$     | 6              | $M_R_1$   | 2.2            |
| $T_2$     | 2.2            | $M_R_2$   | 8              |
| $t_1$     | 3.56           | $W_f$     | 2              |
| $t_2$     | 11.8           | $L_f$     | 10             |

**Table 1: Dimensions of Antenna**

The central frequency of multiband along with return loss is operated by the length of T-shape inverted stub and different slots.

**III. Results and Discussion**

To demonstrate the compact printed slot design, antenna is fabricated on FR4. The proposed antenna has simulated and measured with return loss, gain total and antenna is having good return loss of -23.51. The proposed antenna has frequency band 1.99-9.15 for L-band frequency band, 1.995-2.0153 for personal computer applications, 4.074-4.27 WIMAX, 4.78-5.48 lower WLAN with return loss -23.59, 5.78-6.019 upper WLAN with return loss -11.02 and 8.97-9.48 X-band used for satellite communication with return loss -14.325 of different multiband wireless application.

The antenna iterations are simulated and presented in the below Figure 2. The proposed antenna simulated values providing reflection coefficient less than -10 dB. The antenna’s resonating frequency at which $S_{11}$ magnitude is obtained with minimum dip.

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Figure 2: Reflection coefficient of antenna iterations

Figure 3: Simulated return loss for proposed antenna

(a)
The E-field co-polarization and cross-polarization and H-field co-polarization and cross-polarization are shown in Figure 4. From the pattern it is observed bi-direction pattern for E-plane and omni-direction pattern for H-plane.

The current distribution shows perfect impedance matching and here it indicates that the current is uniformly distributed over the region. The simulated current distribution at 5 GHz is shown in Figure 5. The E-field distribution over the antenna at 5 GHz is shown in Figure 6.

Figure 4: simulated radiation pattern of E&H plane at (a) 1.9 GHz (b) 5.8 GHz (c) 7 GHz
Figure 5: Current distribution at 5 GHz

Figure 6: E-field distribution at 5 GHz
Antenna radiation pattern with peak realized gain values can be observed from Figure 7. The parametric analysis study for the proposed antenna from 2.2 to 4.4 of radiating ellipse radius is shown in Figure 8. By changing the radius of the ellipse from 2.2 mm to 4.4 mm, the resonant frequency values are derived at 4.4 mm with good return loss of -38.51 dB. The resonant frequency for the 2.2 mm with return loss -12.53 dB, for the 3.2 mm the return loss is -22.8 dB, for
4mm return loss -29.12dB. So, by measuring the all values return loss is high for 4.4mm. The parametric analysis successfully studied

**IV. Conclusion**

In this paper a compact antenna size of 20x20 mm for multiband characteristics have been analysed and demonstrated. The multibands obtained for the proposed antenna are L-band, WIMAX, upper WLAN, lower WLAN, X-band. The simulated antenna shows good impedance bandwidth at resonating frequencies and considerable radiation characteristics. The proposed antenna exhibits good return loss $S_{11} < -10$ dB at operating bands and peak realized gain more than 3.3 dB. Antenna showing excellent radiation efficiency at resonating frequencies, which shows the applicability of the antenna at desired application bands.

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