Design & Simulation of a Planar Monopole Antenna based on Double E & T Shape Slots

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Abstract
This paper presents the design of the multiband microstrip antenna for wireless communication system. The proposed antenna is particularly attractive for WLAN/WiMAX devices that integrate multiple systems. The overall size of the design is 48 mm x 35.2 mm x 1.6 mm with a volumetric size of 2.7 cm³. The proposed designed antenna covers the three frequency bands from 2.3 GHz to 2.8 GHz and from 3.1 GHz to 3.16 GHz (lower-frequency band) and 4.71 GHz to 6.4 GHz (upper-frequency band) such that total bandwidth of the proposed antenna is 2.3 GHz. The parametric study is performed to understand the characteristics of the proposed antenna. Also, good antenna performances such as radiation patterns and antenna gains over the operating bands have been observed. The maximum simulated gain of the proposed antenna is 5.73 dBi at 5.58 GHz band.

Keywords: Monopole Antenna, CPW feeding, WLAN and WiMAX

Introduction
The new technological trend has focused much effort into the design of a Microstrip patch antenna. Advances in wireless communication technologies are placing greater demands on higher antenna impedance bandwidth and smaller antenna size. The microstrip patch antenna is simply a patch which radiates from one face [1, 2]. Bandwidth and efficiency of a Microstrip antenna depends upon patch size, shape, substrate thickness, dielectric constant of substrate, feed point type and its location, etc. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable for higher bandwidth, better efficiency and better radiation, leading to a larger antenna size [3, 4]. These patch antennas are used as simple and for the widest and most demanding applications. Dual characteristics, circular polarizations, dual frequency operation, frequency agility, broad band width, feed line flexibility, beam scanning can be easily obtained from these patch antennas [5]. Some popular antenna designs suitable for WLAN and WiMAX operation for 2.4 GHz band (2.4–2.484 GHz), 5.2/5.8 GHz bands (5.15–5.35 GHz/5.725–5.825 GHz) and 2.5/3.5/5.5 GHz (2500–2690/3400–3690/5250–5850 MHz) bands has been reported in [1-11].

In this paper, a novel approach to achieve a multiband antenna is introduced. The geometry of the proposed antenna is composed of the rectangular patch with a double merged E shape & T shape slots are used to cut the rectangular patch and a small I-shape strip is placed on the radiating sides of the antenna. The impedance bandwidth, gain and radiation characteristics of the proposed planar antennas are examined. The paper is organized as follows: the section 2 presents the antenna design parameters of the printed monopole antenna for multiband operation. After that, results and parameter study of the proposed antennas with a double merged E & T-shape slot structure are described in Section 3. Finally, the paper is summarized in Section 4.

Antenna Structure
The geometry of the proposed triple-band antenna for WLAN/WiMAX applications is shown in Figure 1. The proposed antenna was designed on a low-cost FR4 substrate with height of substrate hsub=1.6 mm, dielectrics constant εr=4.4 and tangent loss tanδ=0.002. A rectangular patch was chosen as the monopole radiation element. The antenna is fed by a CPW transmission-line, which can be easily integrated with other CPW-based microwave printed circuits on the same substrate. The proposed antenna is composed of rectangular patch with double merged E-shape & T-shape slots. The CPW feed was easy to connect to the coaxial cable through a standard 50 ohm SMA connector. The designed structure was designed & simulated using IE3D simulation software based on method of moments (MOM).

The optimized geometric parameters of the proposed antenna are: length of the rectangular patch L=33 mm, width of the rectangular patch W=23 mm, length of the ground plane Lg=11.35 mm, width of the ground plane Wg=14.5 mm, length of the added slot L1=7 mm, length of slot L2=22.3 mm, width of the both slits is W1=11.51 mm, W2=15.21 mm, L3=4 mm, W3=4.2 mm, L4=4.2 mm, W4=2.9 mm. To give feeding to this geometry a feed line of having length Lf=10.2 mm and width Wf=3.9 mm is used. The distance between the ground plane and the rectangular patch is denoted by ‘S’ that this is equal to 1.72 mm and the distance between the feed line and ground plane is denoted by ‘d’ is equal to 1.4 mm. The designed antenna covers the frequency band from 2.3-2.8 GHz, 3.1-3.16 GHz and 4.71 GHz to 6.4 GHz such that total bandwidth of the proposed antenna is 2.3 GHz.

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Simulation Result and Discussions
The simulated return loss and parametric study results for the proposed monopole antenna are obtained. The simulated return loss and gain are presented for the optimized set of antenna parameters. Simulated return loss of the optimized proposed antenna is shown in Figure 2. From the simulated results, it is clear that triple-band operating bandwidths are obtained. The simulated results has a 10 dB impedance bandwidth ranging from 2.3 GHz to 2.8 GHz and from 3.1 GHz to 3.16 GHz and 4.71GHz to 6.4 GHz such that total bandwidth of the proposed antenna is 2.3 GHz with respect to the central frequency. In the first band, the resonant peak of return loss is -20 dBi at 2.5 GHz frequency, in the second band the resonant peak of return loss is -22.4 dBi at 3.12 GHz frequency and in the third band the resonant peak of return loss is -22.3 dBi at 6.32 GHz frequency. Obviously, the proposed antenna has very broader bandwidth which covers the required bandwidths of the IEEE 802.11 WLAN standards in the bands at 2.4 GHz and 5.2 GHz (5150–5350 MHz) /5.8 GHz (5725–5825 MHz) and WiMAX standards in the bands at 2.5 GHz (2.5-2.69 GHz) and 5.5 GHz (5.250-5.850 GHz). The simulated gain of the proposed antenna is shown in Figure 3. The antenna has a maximum gain of about 5.73 dBi at 5.58 GHz frequency with small gain variations in the operating bandwidth. Simulation studies indicate that the maximum antenna radiation efficiency is approximately 85%.

A parametric study is investigated and it demonstrates that the following parameters influence on the performance of the proposed antenna in terms of bandwidth. The parametric study is carried out by simulating the antenna with one geometry parameter slightly changed from the reference design while all the other parameters are fixed. Figure 4 shows the simulated return loss of the proposed antenna as a function of frequency for different shapes. It is observed from the simulation results study that by using only rectangular shape and rectangular shape with T & I shape slots embedded in the patch, triple band is merged into a single band with huge decrease in the bandwidth as compared to the optimum value of the bandwidth. If we add half E-shape with addition to T & I shape slots then results are very much closed to optimized bandwidth of the proposed antenna with small decrease in the bandwidth.

The current distribution pattern showing that how much of the current is flowing in the proposed structure. The maximum current flowing in the proposed structure is 9.0884
A/m. We can see the average current distribution on the surface of the antenna. It is observed that the current is almost maximum at the lower edge of the patch, along the different slots used in the patch and along the feed line.

![Figure 4](image)

**Figure 4** Effect of L₁ & U shape on the proposed antenna

Figure 5 shows the simulated radiation patterns of the proposed dualband CPW-fed monopole antenna at frequency 5.9 GHz. The simulated radiation patterns cut in the Azimuthal (x-y) plane and cut in the elevation plane (y-z) for the proposed antenna is presented in the figure. Similar to monopole kind of antenna, the radiation pattern obtained in the x-y plane are similar to omni-directional. At the above mentioned frequency, nearly figure of eight radiation pattern is obtained in the y-z plane.

**Conclusions**

A new printed antenna have been designed & simulated to achieve the triple-band operation for wireless communication system. The simulated results show that by using proposed designs and tuning their dimensions, operating bandwidth, measured gain and radiation patterns can be obtained for WLAN/WiMAX applications. The simulated results has a 10 dB impedance bandwidth ranging from 2.3 GHz to 2.8 GHz and from 3.1 GHz to 3.16 GHz and 4.71GHz to 6.4 GHz such that total bandwidth of the proposed antenna is 2.3 GHz with respect to the central frequency. The parametric study shows the significant effects on the impedance bandwidth of the proposed antenna. Besides, its triple-band characteristics, the proposed antenna remains compact with a small volumetric size.

![Figure 5](image)

**Figure 5** Simulated radiation patterns at 5.9 GHz for proposed antenna

**References**


