A Low Cost Dual Band Antenna for Bluetooth, 2.3 GHz WiMAX and 2.4/5.2/5.8 GHz WLAN

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ABSTRACT
A low cost, dual band antenna has been proposed and studied in this paper. The antenna consists of two elements- a T-shaped element and an F-shaped element. A microstrip feed line with a characteristic impedance of 50Ω has been used to feed the T-element which is responsible for the generation of the higher band of operation. The F-element is placed on the other side of the dielectric and is coupled with the T-element to generate a lower band of operation. Thus, together the two elements generate a dual band performance. Besides, the design has been simplified by doing away with shorting pins and complicated geometries- one of the major disadvantages in existing dual band antenna designs. Furthermore, the dimensions of the two elements have been optimized so that the overall size of the antenna is considerably reduced. Return loss plots, radiation pattern and other antenna parameters have been studied thoroughly and also compared with existing designs to prove that the proposed antenna is a promising design for wireless systems using WiMAX, Bluetooth and also for WLAN applications.

General Terms
Microstrip Patch Antenna, Dual Band Antenna

Keywords
Antenna, Dual Band, WiMax, Bluetooth, WLAN

1. INTRODUCTION
Wireless communications has seen an explosive growth in recent years due to an ever increasing market demand for smaller and better wireless devices. Also, since FCC allowed potential users to make unlicensed use of medical, industrial and scientific frequencies, engineers are constantly trying to achieve size reduction of multiband and broadband antennas for applications that communicate over short distances. A common example is that of the wireless local area network (WLAN) which is a flexible data communication system implemented as an alternative to wired LAN.

WLANs combine connectivity and user mobility by making use of radio frequency technology to transmit and receive data over the air. As a result, they are becoming increasingly popular in a number of vertical markets such as retail, healthcare, warehousing, manufacturing and academia and are being widely recognized as a reliable, cost effective solution for wireless high speed data connectivity for a broad range of systems that make use of hand-held terminals for real-time transmission of information to centralized hosts for processing.

Various WLAN antennas designs have been proposed in the literature [1] - [12]. It suggests the use of one monopole for the lower band and another for the higher band of WLAN systems. However, this results in a large antenna size due to the large length of the monopole resonating in the lower band. To achieve a compact size antenna, a method of bending this monopole to different shapes has been used. In [1], [2] modified T-shaped elements have been used in the antenna design with radiator size of14.5 × 10.6 mm2 and 26 × 10 mm2 respectively. Coplanar Waveguide (CPW) feeding technique has been used to excite a T-shaped stub with a radiator size 23 × 13 mm2 in [3] and a beveled rectangular metal patch with a large radiator of area 30 × 26 mm2 in [4]. In [5] and [6] antenna of size 50 × 19 mm2 has been designed using a combination of slots and slits in the radiating patch and the ground plane. An E-shaped patch is used in [7] and [8].In [9] and [10] use elements with L and inverted L-shape to design radiators. A combination of L and E-shape elements is used in [11]. An interesting technique of using a rectangular monopole and a conductor-backed plane for band broadening is used in [12]. The smallest size achieved in this design was about 11.3*8 mm^2.This is still larger than the 11*6.5 mm^2 size of our proposed antenna.

In this paper, a very low cost compact dual band antenna for the 2.3GHZ WiMax, Bluetooth and WLAN operating bands of 2.4, 5.2, 5.8 GHz is proposed. A microstrip fed T-shaped element and a ground shorted F-shaped element have been used to achieve dual band operation. The antenna is designed and studied with the high performance full-wave electromagnetic (EM) field simulator Ansoft HFSS software. The paper is organized as follows. In Section II, information about wireless standards is provided. In Section III the details of the proposed antenna are presented. This is followed by Section IV where Parametric Study of the antenna has been given. Results and discussion on the proposed antenna design have been presented in Section V. In Section VI Conclusion has been given followed by references.

2. WIRELESS TECHNOLOGY STANDARDS
The proposed antenna is compatible with the following Wireless Technology Standards.

WiMax: WiMax (Worldwide Interoperability for Microwave Access) is a wireless communication standard widely used as an alternative to cable and DSL. IEEE std 802.16 defines the frequency bands for WiMax usage. Three WiMax bands 2.3/2.5/3.5GHz (2300-2400, 2500-2700, 3400-3600 MHz) are widely used. WiMax is deployed all over the world and the usage of bands differs from each country.

Bluetooth: Bluetooth is a wireless communication standard used for communication over short range distances. Bluetooth is a very popular technology standard and can be find in many electronic devices. Bluetooth operates in the range of 2.4GHz (2400-2483.5MHz).

WLAN: WLAN systems represent an attractive way of setting up computer networks in locations where cable installation may be expensive or impossible. They provide high data applications and this is one of the reasons why big attention is paid to WLAN equipment manufacturers. WLANs operate in the unlicensed 2.4 GHz (2400-2484 MHz) and the 5GHz band- 5.2GHz (5150-5350 MHz) and 5.8GHz (5725-5825MHZ). Some of the popular WLAN standards as follow:

2.1 802.11a

This is a 5 GHz radioband physical layer standard which specifies eight available radio channels with a maximum link rate of 54 Mbps per channel. As the distance between the radio access point and the user increases, the data rate decreases.

2.2 80211b

This is 2.4 GHz radioband physical layer standard which specifies three available radio channels and a maximum link rate of 11 Mbps per channel. Again, the data rate decreases with an increasing distance between the access point and the user.

2.3 802.11g

This physical layer standard for WLAN specifies three available radio channels in the 2.4 and 5 GHz radio band with a maximum link rate of 54 Mbps per channel and with the use of Orthogonal frequency-division multiplexing (OFDM). Now-a-days, dual band WLAN systems combining the IEEE 802.11a/b/g standards are be- coming more attractive [**?**]. Hence, to satisfy the need of wireless communications, it is necessary to design compact high performance antennas with 2.4/5 GHz dual band operation and excellent radiation characteristics.

3. ANTENNA DESIGN

The geometry of the proposed antenna is shown in Fig. 1. A microstrip feed line of 50 Ω impedance is used to feed the antenna. The antenna consists of a ground plane of 40x20 mm2 and a radiator of 11 × 6.5 mm2 with overall dimensions of 40 × 30 × 0.8 mm3. The radiating element which is fed directly is similar to letter T and is referred as T-element and the element which is connected to ground plane is referred as the F-element. The T- element is fed by the 50 Ω microstrip feed line. The F-element surrounds the T- element and is shorted to the ground plane.

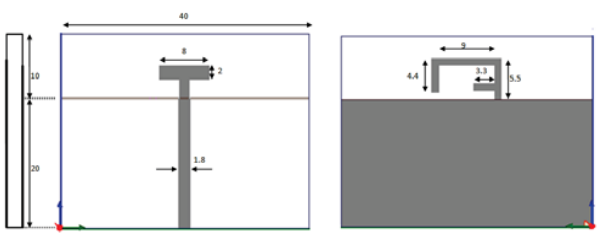


Fig. 1. Design of the Proposed Antenna

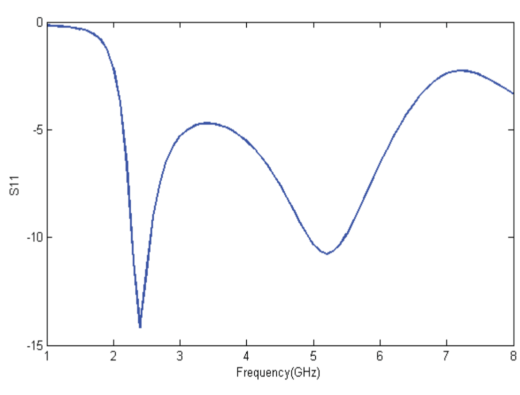
The antenna has been designed on a substrate of relative permittivity 3.5 and loss tangent 0.02. The T element generates a band at 5.2/5.8 GHz for the higher band of WLAN systems while the F element generates a band at 2.4 GHz for the lower operating frequency of Bluetooth, 2.3GHz band of WiMax and WLAN devices. The re- turn loss plot of the proposed antenna has been shown in Fig. 2. As can be seen from the return loss plot, two bands are generated- one covering the 2.4 GHz band of WLAN applications and the other covering the higher 5GHz band. The radiation pattern is presented in Fig.4. It can be seen from the figure that it is omnidirectional in nature. Also the proposed antenna has a very compact radiator area of only 71.5mm^2 and overall area 1200 mm^2 with a very good performance.

4. PARAMETRIC STUDIES

To observe the effect of various dimensions of the antenna on the two resonant frequencies a detailed parametric study was performed using Ansoft HFSS. To understand the impact of the radiating elements on the resonating frequencies, the design is simulated with the T-shape element alone and a single band was obtained at 6.5 GHz. The S11 plots have been shown in Fig. 2. When the F-element was added, a second resonant mode was obtained at 2.4 GHz also shifting the higher frequency to around 5.2 GHz. The Current distribution results are shown in Fig. 5. It shows that at 2.4 GHz, the current was mainly on the F-element which show that T-element is the resonating element at 2.4 GHz. At 5.2 GHz, a high current was observed on the T-element which confirms that F-element is responsible for that band.

The antenna design parameters such as f3 and f4 are varied and the effects are studied. The value of f3 was varied and returns loss plots as shown in Fig.5 (a) were observed for various values of f3. It can be clearly seen that with a decrease in the value of f3, the resonant frequencies of both the upper and the lower band changed with the higher band frequency showing a considerable change. Also, the matching for the upper band improved significantly and the bandwidth also increased by a large amount. Hence, f3 can be used to achieve a coarse tuning of both the bands.Fig.5 (a) also show that the resonant frequency of 5.8 GHz was obtained while varying this length.

The S11 plots for variation in the value of f4 are shown in Fig.5 (b). As the value of f4 increased, a good return loss was observed while maintaining both the resonant frequencies constant. Thus, this dimension could be changed to get the required matching without disturbing the operating frequency.



(a)

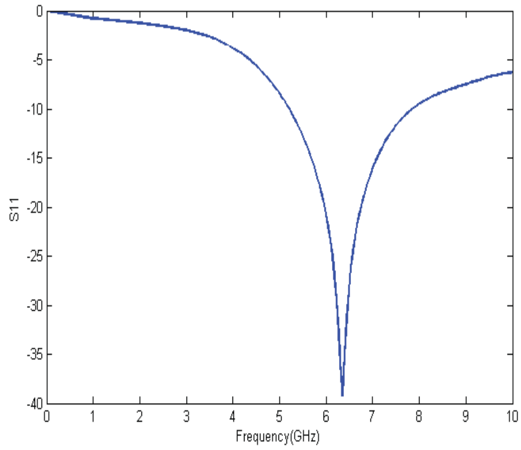


Fig. 2. Return Loss plot for the proposed antenna (a) with T and F elements (b) Only with T element

5. RESULTS AND DISCUSSION

Ansoft HFSS has been used to obtain the S11 and radiation pattern. The simulation results of the return loss have been shown in Fig 2. The bandwidths (S11 < −10 dB) for the lower band is 0.31(2.27- 2.58) GHz and for the higher band is 0.57(4.92-5.49)GHz. Thus, the lower band covers 2.3GHz WiMax, Bluetooth, 2.4GHz band of WLAN and upper frequency band covers the 5 GHz band of WLAN systems are covered. Additionally, the antenna can be tuned to other frequencies for dual band operation by merely changing the dimensions.

Radiation pattern shows that the proposed antenna has an omnidirectional radiation pattern at both the lower as well as the higher frequencies. Radiation pattern at 2.4 GHz and 5.2 GHz are shown in Fig 4. The efficiency at 2.4 GHz and 5.2 GHz are 89% and 87% respectively. The compact size of the antenna enables the designer to integrate it with miniatured devices. Also the simple design reduces the cost of fabrication of antenna.

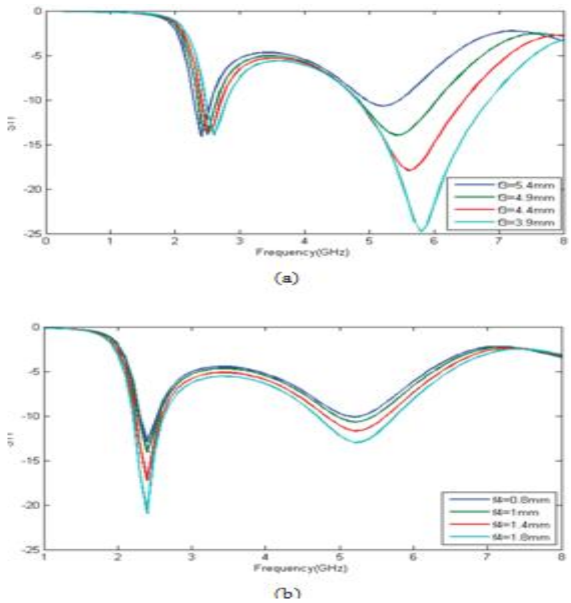


Fig. 3. Return Loss with variation in the length of (a) f3 (b) f4

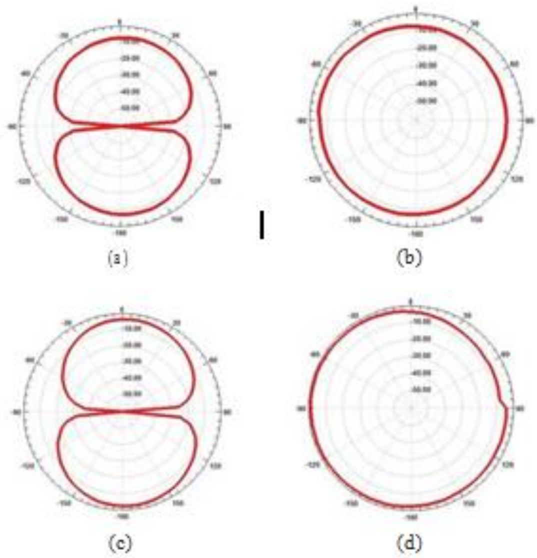
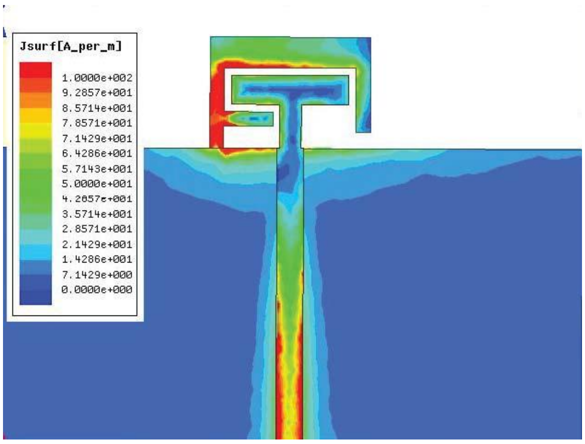
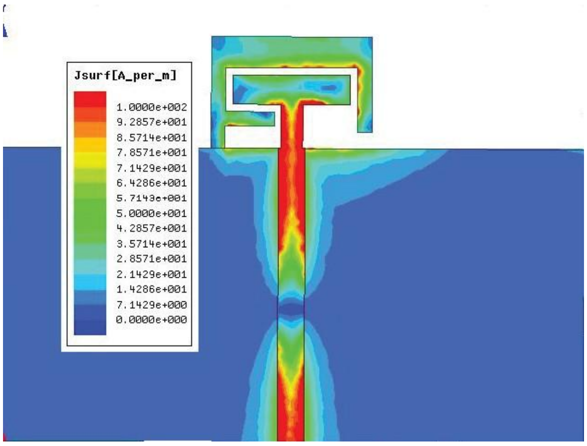


Fig. 4. Simulated Radiation pattern: (a)E-plane pattern at 2.4 GHz (b) H- plane pattern at 2.4 GHz (c) E-plane pattern at 5.2 GHz (d) H-plane pattern at 5.2 GHz



(a)



(b)

Fig. 5. Current Distribution Plots (a) at 2.4GHz and (b) 5.2GHz no., pp.66, 70, 11-13 May 2012

6. CONCLUSION

A low cost compact dual band antenna for 2.3GHz band of WiMax, Bluetooth and 2.4, 5.2 and 5.8 GHz WLAN applications has been designed and studied. The proposed antenna design is compared with the dual band antenna designs available in literature. The antenna has a compact radiator of area 11 × 6.5 mm2 featuring a T-element and a F-element resonating at 5.2/5.8 and 2.4 GHz respectively. A thorough parametric study reveals that these two frequency bands can be tuned independently by adjusting certain dimensions of the antenna. Thus, by carefully adjusting the key dimensions of the antenna a dual band performance can be obtained at other frequencies. The reflection coefficient S11 and radiation pattern plots for the two frequencies have been studied. These results have shown that the design is a very promising candidate for WiMax, Bluetooth and WLAN applications.

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