Novel T-Shaped Planar Dual Band Antenna with Slotted Ground for ISM/WLAN Operations

Anuja Jadhav, Nikhil Borawake, Pradnya Shinde, Vishal Bharate

Abstract - In this paper, we propose a novel T-shaped planar dual band antenna in that two inverted L-shapes are used as additional resonators to produce the lower and upper resonant modes with high return loss. As a result, a dual band antenna for covering 2.4GHz and 5.2GHz ISM/WLAN bands is implemented. The dimension of the antenna is 30x42x1.6 mm^3 and provides an impedance bandwidth of 563.6MHz and 1743.6MHz at lower and upper frequency band respectively. The antenna system shows good radiation patterns as well as good total gains of 9.76dB and 4.28 dB. Detail design criteria with respect to geometrical parameter variation are given. The proposed antenna with relatively low profile is very suitable for multiband mobile communication systems.

Index Terms - dual band antenna, impedance bandwidth, radiation pattern, resonant mode, total gain.

I. INTRODUCTION

Wireless communications have evolved at astonishing rates during the last decade that forced antenna engineering to face new challenges, which include the need of small-size, high-performance, low-cost antennas. Today WLAN used for commercial communication because it provides high speed connectivity and easy access to networks without wiring. In order to satisfy the IEEE 802.11 WLAN standard in the 2.4GHz (2400-2484 MHz) and 5.2GHz (5150-5350 MHz) bands we required multiband antennas. For multiband operation double-T monopole structure[1], wire type strip antenna[2], T-shaped with grounded L microstrip line[3], T-shaped monopole antenna with paired L mirror shaped strips[4], modified T-shaped planer monopole[5], equilateral monopole with modified U-shaped and rectangular monopole[6] and so on has been implemented. However, none of the above available designs can achieve a multiband response with sufficiently large bandwidth and larger return loss. In the literature, implemented designs provide multiband operation but in [1] - [3], [6] has larger ground size and antenna shown in [3] requires a shorting inverted L microstrip line, which increases complexity and fabrication cost as well. Larger size with linear combination of wire type strips [2] is difficult to analysis also it uses CPW feed that little complex than microstrip feed. Design [4] capable to cover WiMAX band along with WLAN but have less return loss that creates problem in tuning of frequency.

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In this paper, we implement multiband antenna for WLAN application. The T-shaped structure which is capable to excite 2.4GHz is modified with paired of unequal L-shaped strips so that mutual coupling among these strips with extended T now also resonate to 5.2GHz and in addition to this semi-circular slot is introduced in ground plane to increase return loss and operating gain over band of operation. Details of antenna design are described, and prototype of proposed antenna for multiband operation have been constructed and simulated.

II. ANTENNA DESIGN

The geometry of proposed antenna is as shown in Fig.1. The proposed antenna can be considered as T shaped monopole and easily fed by a 50 Ω microstrip line of width W2. The antenna is fabricated on FR4 substrate with a thickness of 1.6mm with relative permittivity of 4.4 and loss tangent tanδ= 0.0245. In proposed design, the T-shaped structure controls the lower band at 2.4 GHz frequency of the antenna. On the other hand, mutual coupling between the pair of inverted L-shapes and T-shape is responsible for the antenna's upper band at 5.2 GHz frequency. Notice that the two L-shapes have unequal lengths L4 and L6. This arrangement is for achieving greater return loss at resonant frequency. The return loss enhancement results are demonstrated in the following section. To obtain the desired dual band operation at 2.4GHz and 5.2GHz, several parameters have been adjusted such as width W1, length L4, length L6, length L7 and ground plane length L5 by performing optimization. Ansoft's HFSS software is used to select proper values of parameters. In addition to this, it is observed that the ground plane dimensions affect the resonant frequencies of antenna. Therefore a semicircular slot is introduced in ground plane to increase the return loss further. Due to this it becomes necessary to select the proper ground plane dimensions to achieve desired dual band operation. From the above design process, a dual band antenna for ISM and WLAN application is achieved.

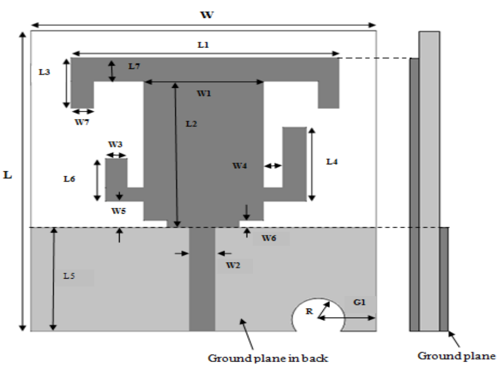

Fig.1. Geometry of proposed antenna

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From optimization process we have selected following dimension of antenna.

Table 1. Antenna dimensions in millimeters.

Dimension	(mm)
L	42
L1	28
L2	19
L3	7
L4	10
L5	18
L6	5
L7	3.5
W	30
W1	12
W2	1.7
W3	2
W4	2
W5	4
W6	0.5
G1	5
R	2

III. PARAMETRIC STUDY

A. *Effect of T-shape and its extension*

The dual mode resonance of antenna is generated by T-shaped with pair of unequal L-shaped strips. As illustrated in [5], the T-shaped is mainly responsible for 2.4GHz band, the width of that affects the bandwidth of bands, we optimize width for various values (L5= 2, 2.5, 3, 3.5, 4mm) and it can be found that with increasing width L5 the bandwidths for. lower band increases and the resonant frequencies of the lower band shifts down, while the bandwidths of the upper band change slightly. Also extension in sides of T-shape increases the current distribution that useful for correct resonant frequencies.

B. *Effect of pair unequal L-shaped strips*

The mutual coupling of pair of unequal L-shaped strips with extended sides of T-shape is responsible for higher resonance mode 5.5GHz. Due to unequal lengths current enter into one side of antenna is greater than other side which leads to excitation to higher frequency. First we kept L4 and L5 of equal length of 13mm then it is observed that the bandwidth of both bands decreases as increase in L5 and simultaneously frequency also shift to lower resonance. Finally by keeping L4 and L5 at different lengths 10mm and 5mm respectively unequal current distribution occurs and that gives higher current distribution to lower resonance while lower current distribution to higher resonance

C. *Effect of slotted ground*

The ground plane dimensions should take into account as they affect the resonance frequency and return loss. We observed ground dimensions verses return loss parameters with ground dimensions varied from 15mm to 30mm. For required frequency we select the proper value of ground and it is L3=18mm.

To increase the return loss we have inserted semi-circular slot in ground. Actually slots in ground disturb the current distribution depending on the size and position. The input impedance and current flow of antenna is then influenced by the disturbance at the current distribution. We insert the semicircular slot of radius R=2mm at a distance of G1=5mm as shown in fig.1.

IV. RESULTS AND DISCUSSION

For the simulation process Ansoft's HFSS11 software which is based on Finite Element Method is used.

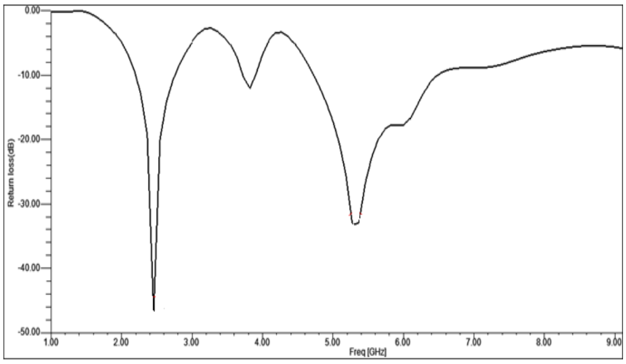


Fig.2 Plot of return loss verses Frequency for proposed antenna.

Table 2. Simulated Return loss and bandwidth at 2.45 and 5.2 GHz frequency.

Resonance Frequency(GHz)	Return loss(dB)	Bandwidth(MHz)
2.45	47	563.60
5.20	33.3	1743.60

Fig.2 shows the simulated return loss for the designed antenna. The characteristics of the proposed antenna have been simulated with the use of HFSS software. As we see from Table 2 we get good return loss for resonance frequencies of2.45GHz and 5.2GHz. At 2.45GHz, return loss is 47dB which we obtained by optimization of length L6, width W1 and also because of semicircular slot in the ground plane. At 5.2GHz, return loss value is 33.3dB which we obtained by optimization of width W1 and insertion of semicircular slot in the ground plane.

Bandwidth achieved for 2.45GHz frequency is 563.6MHz and for 5.2GHz it is 1743.6MHz. These bandwidths essentially cover the entire range for multiband operations of ISM/WLAN.

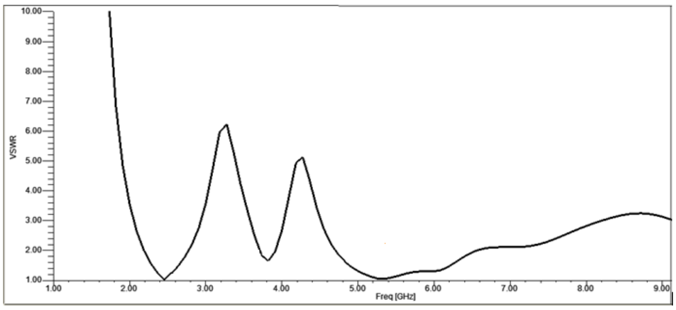
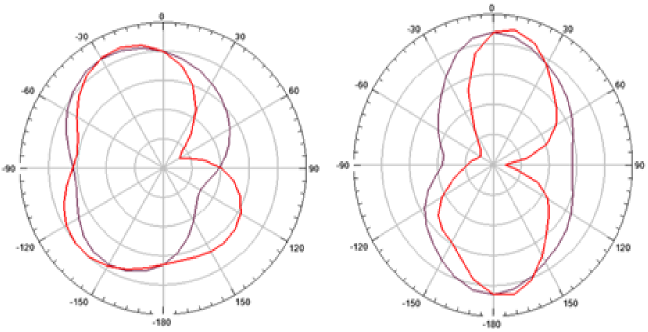


Fig.3 Plot of VSWR verses Frequency for proposed antenna.

Fig.3 shows the VSWR verses frequency plot. VSWR values are ideally 1 for resonance frequencies. For 2.45GHz frequency VSWR is 1.262 and for 5.2GHz frequency VSWR is 1.01.



(a) (b)

Fig.4 Radiation pattern at (a) 2.45GHz frequency, (b) 5.2 GHz frequency.

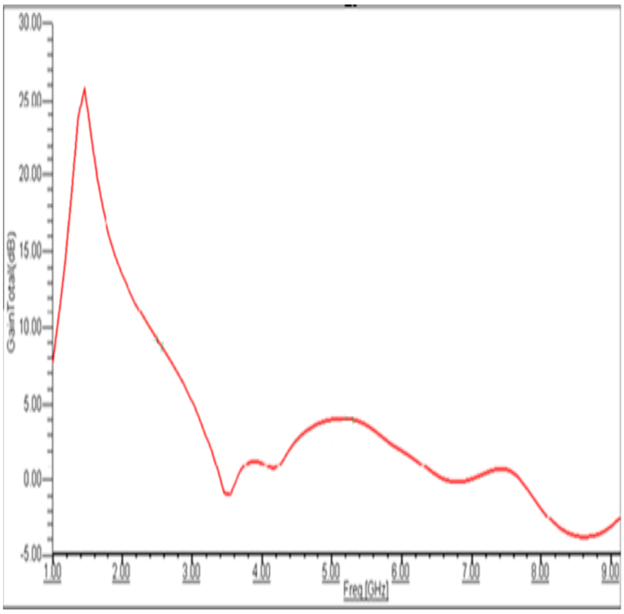


Fig.5 Plot of Total gain verses Frequency

Radiation characteristics of proposed antenna are studied. Fig.4 shows plot of the measured radiation patterns at 2.45GHz and 5.2GHz (center frequencies of the ISM/ WLAN bands) for the proposed antenna studied in Fig.1. Total gain is studied from Fig.5.For frequency 2.45GHz, the antenna gain is about 9.76 dB and for frequency 5.2GHz, the antenna gain is 4.28dB.

V. CONCLUSION

The analysis and design of a multiband antenna is presented. The proposed antenna generates resonant modes covering two operation bands for ISM/WLAN operations with good radiation pattern and maximum total gains. The measured impedance bandwidths are 563.6MHz at lower frequency band of 2.4GHz,and 1743.6MHz at upper frequency band of 5.2GHz.The featured broad bandwidths over two frequency bands and the miniaturized size of the proposed antenna make it very promising for applications in wireless communication and wireless sensing devices.

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