Dual Band Antenna Design with Improved Result for Mobile and Satellite Application

Bindita Sahu[1], Prof. Prashant Jain[2]
[12]*Department of Electronics and Tele-Communication Engineering,*
Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India

Abstract-*A novel and compact dual band antenna design for mobile and satellite application is proposed and studied in this paper. The proposed antenna consists of a ground plane having square slot with a rectangular patch at the centre, which is printed on the top of the substrate. A simple 50Ω microstrip line having width 3.08mm is used to excite the parasitic patch from the backside of the substrate. Through some changes like reduction in ground slot, variation in the slots at patch and by impedance matching, gain and bandwidth of the proposed antenna is improved. The proposed antenna is simulated by HFSS program using finite element method .The simulated antenna have two band, radiates over 1.77-2.24GHz and 3.40-4.12GHz frequency ranges. The proposed antenna is capable of covering multiple mobile communication bands (DECT,PCS,PHS), WiMAX band and fixed satellite application.To prove that the proposed design is a promising candidate for the aforementioned wireless technologies,important antenna parameter such as return loss, radiation pattern,peak gains and VSWR in the operating bands have been simulated and studied in detail.*

Keywords- *DECT, PCS, PHS, Worldwide interoperability for microwave access(WiMAX),Fixed Satellite*

I. INTRODUCTION

Microstrip antennas are widely used in many applications due to their low profile, low cost, light weight and ease of fabrication. The advantages of the microstrip patch antenna are same like of printed circuit board technology such as low fabrication cost, size reduction and bandwidth enhancement. Because of these advantages, making microwave patch antennas is a popular choice in communication, radar, medical applications and electronically scanned array application.

It is desired to have a dual band or multiband characteristics in some applications. WiMAX, WLAN [3], satellite communication andfor many applications, dual band/triple band design is definitely necessary so that these designs with compact patch size are urgently required.These characteristics can be obtained by coupling multiple radiating elements or by using tuning devices such as varactor diodes [12,13]. However these methods make antenna more complicated. Embedding a slot in the patch as the structure proposed in which the radiating patch includes a pair of slots[1,4] is alsoanother method to achieve the dual band characteristic in a microstrip antenna. A dual band antenna is created, in [9] by a triangular shaped patch and a pair of additional arms at the two corners of the patch. Most widely used techniques for dual band characteristic are inserting slots on ground plane and patch such as parasitic structures of inverted U shape and fork like shape and pair of L-slot on ground plane [6], etching two slots of U like shape on ground plane [7], T-slotted ground plane with T-shaped microstrip feed line [8]. Dual band operations are obtained by implementing a rectangular ground plane and fork like patch [9], by etching two annular ring slots on ground plane [10], disc shape patch etched with cross shape slot [11].

This paper uses the structure proposed in [1] as a reference antenna. A compact dual band antenna fed by microstrip line consisting of a ground plane with square slot and a double slotted rectangular patch in the centre is presented.By matching the impedance through feed line and properly choosing the dimensions and locations of the ground slot and patch slot, a good performance of bandwidth enhancement andimproved gain are obtained.The proposed antenna is designed to cover digital enhance cordless telecommunication system (DECT) (1800-1900MHz) [14], personal communication system (PCS) (1850-1900MHz) [15], personal handy phonesystem (PHS)

(1880-1930MHz), worldwide interoperability for microwave access (WiMAX) (3.3-3.6GHz), and fixed satellite (space to earth) (3600-4200MHz) [16]communication bands. The impedance bandwidth is 23.78% and 19.24% for first and second band respectively calculated from simulated results, which is greater than of the reference paper. A detailed simulation is conducted and described to understand its behavior and to optimize for improved gain and wider bandwidth.

II. Antenna Design

In this paper a rectangular patch antenna along with slotted ground and fed by microstrp line located at back side of the substrate has been proposed. Return loss, bandwidth and gain achieved after simulating the proposed antenna in HFSS

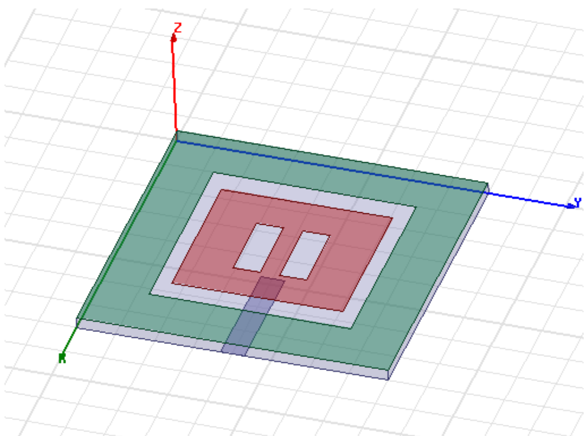
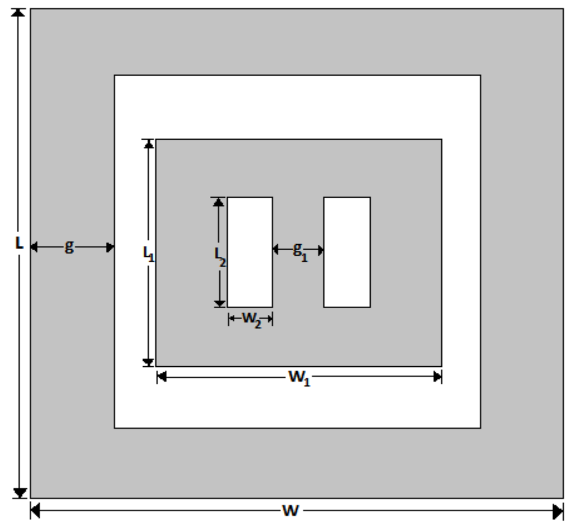
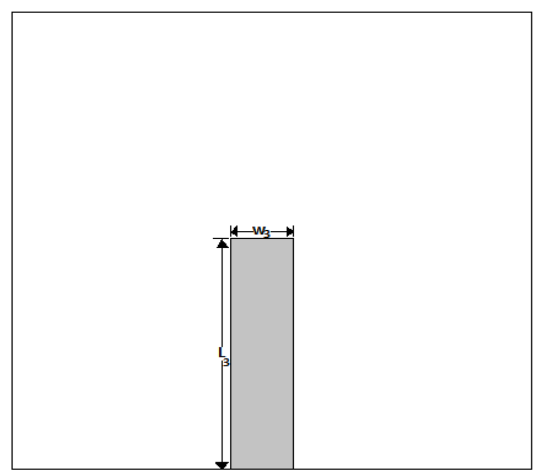


Fig.1 - Structure of the proposed dual band antenna.

software. The geometry of the dual band microstrip fed antenna is illustrated in Fig. 2. Here is the proposed antenna having square slot and rectangular parasitic patch fed by microstrip line. The total area of the proposed antenna is 40×40 mm^2. This antenna is fabricated on FR4 dielectric substrate with a permittivity of 4.4 and a thickness of 1.6mm. It has a simple configuration,the top side consists of slotted ground and parasitic patch in the centre and bottom side has a microstrip line with the length L_3 (16mm) and width W_3 (3.08mm). The parasitic patch, L_1 (20mm) long and W_1 (22mm) wide has two vertical slots of length L_2 (9.5mm) and width W_2 (3.5mm). The gap between two slots is g_1 (2.5mm). The optimized dimension of the ground slot is 26×26mm^2. Compared to the designed antenna in [1], the proposed antenna has better bandwidth and improved return loss. The proposed model is shown in the Fig. 1. Table 1 shows the design parameters of the proposed antenna with optimized values.



(a) Top view



(b) Bottom view

Fig. 2 - (a) Top view (b) Bottom view of the proposed antenna with rectangular parasitic patch

Table .IDesign Parameters With Optimized Values For Proposed Antenna

Parameter	Value(mm)	Parameter	Value(mm)
L	40	g	7
W	40	g1	2.5
L1	20	W1	22
L2	9.5	W2	3.5
L3	16	W3	3.08

III. Parameter Study

The prototype of the proposed slot antenna with optimal geometrical parameters as shown in Fig. 2 is simulated and discussed. In this section, a parameter study is carried out to understand the effects of various parameters to optimize the performance of final design. Fig. 3 shows the simulated return loss of the proposed antenna with different ground slot sizes. As we can see in the graph the resonant frequency is decided by the ground slot size. In the proposed antennawe have chosen g=7mm (ground slot 26×26mm), because it is seen that this dimension results in best return loss from others, which is -49.5dB for first band and -45dB. While in the reference paper g=4.27mm is given (ground slot 31.46×31.46mm), which gives worse resultthan proposed, about -26dB return loss for the first band and -34dB for the second band.

An important feature of the proposed antenna is the influence of impedance matching caused by the coupling effects between the slot and the feed structure. For this reason the effects of the length L_3 = 16.5,16,15.5,15 and 14mm on the performance of the proposed antenna are also studied and presented in Fig. 4. Large change in reflection coefficient at

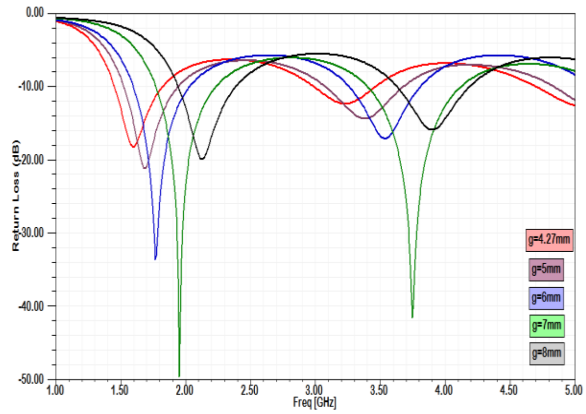


Fig. 3 – Simulated Return Loss of the proposed antenna with different ground slots size

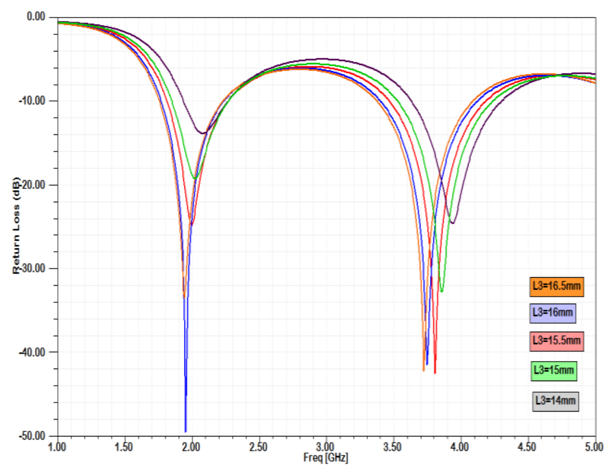


Fig. 4 – Simulated Return Loss of the proposed antenna with different L_3

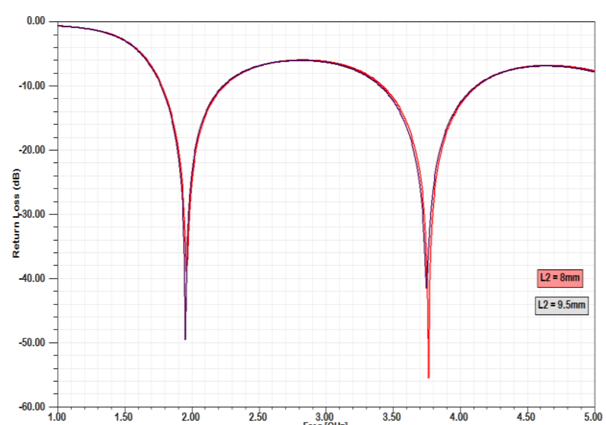


Fig. 5 – Simulated Return Loss of the proposed antenna with different L_2

the first band due to the variation of L_3 is observed while at the second band it remains same for the different L_3. The combination of improved return loss and bandwidth can be noticed at L_3=16mm, so that chosen for the proposed antenna while for the reference antenna it is 14mm.

Fig. 5 demonstrates the simulated return loss of the proposed antenna for two values of L_2. It is from the simulated result shown that antennas having L_2= 9.5mm and 8mm both give improved result at same resonant frequencies. For L_2 = 9.5mm the values of return loss are -49.5dB and -41.47dB and for L_2= 8mm they are -55.5dB and -40dB respectively at lower resonant frequency and upper resonant frequency. Hence we have seen that both the value optimized the result any of them can be chosen according to the need of the application. The gap between two identical slots is also changed, because there should be a particular combination of gap and slot size for the improved result. A parameter analysis has been done above, by investigating the effects of various parameters and optimized performance of the proposed antenna is obtained, by varying one of the parameters at a time and keeping the others as constant. Larger return loss indicates higher power being radiated by the antenna which eventually increases the gain.

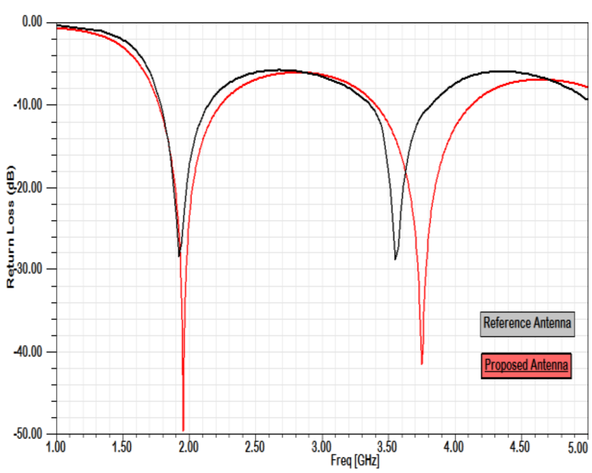
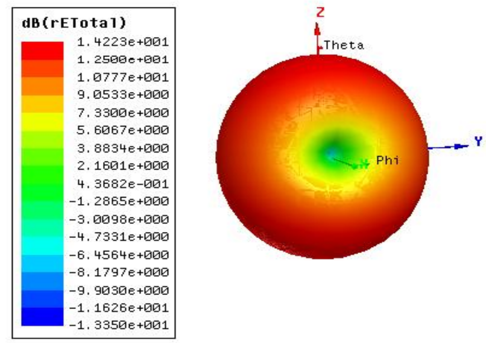
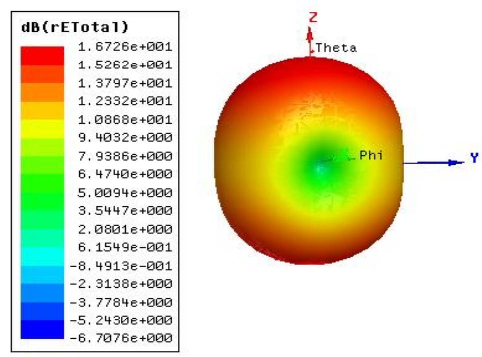


Fig. 6 – Comparison between Simulated Return Loss of the Proposed Antenna and Reference Antenna

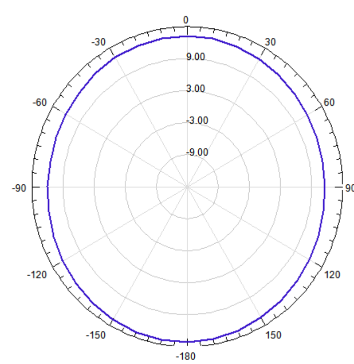


(a)

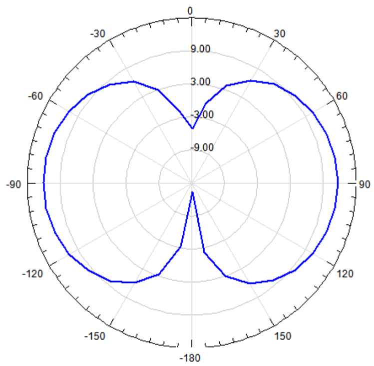


(b)

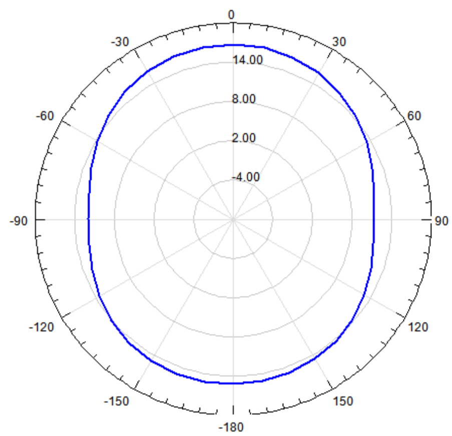
Fig.7 - 3D plot of radiation pattern of the proposed antenna at frequency (a)1.95GHz (b)3.75 GHz



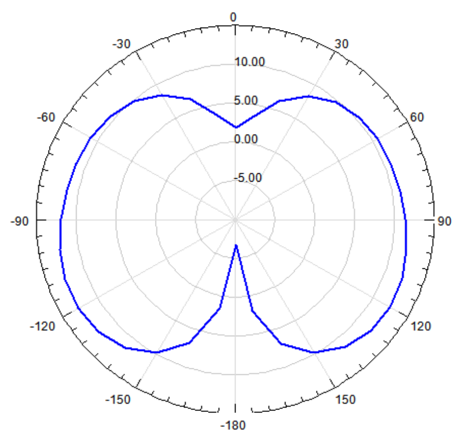
(a)



(b)



(c)



(d)

Fig. 8 E field pattern of the proposed antenna at frequency (a) 1.95GHz and (c) 3.75GHz and H field pattern of the proposed antenna at frequency (b) 1.95GHz and (d) 3.75 GHz

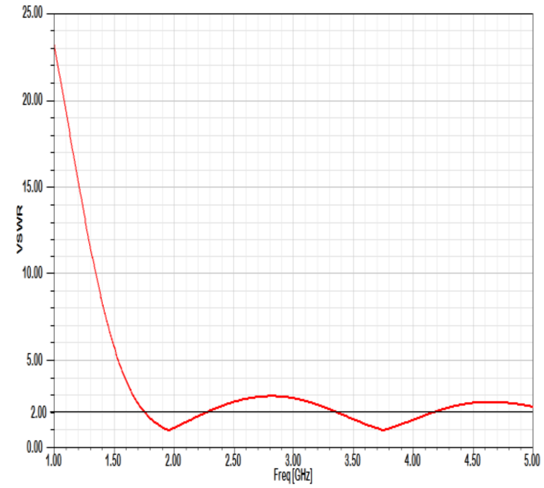


Fig. 9 – VSWR of the proposed antenna

IV. Simulated Results

According to the design results above, the proposed antenna is fabricated in case of g =7mm, L_3=16mm and L_2=9.5mm. The two frequency band is generated ranging from 1.77GHz to 2.24GHz and 3.40GHz to 4.12GHz. To obtain the improved gain and enhanced bandwidth these dimensions for the proposed antenna have chosen.

The Fig. 6 shows comparison between simulated results of proposed antenna and reference antenna. The bandwidths of the first and second band for the proposed antenna are 465MHz and 723MHz respectively, which are greater than the bandwidths for the reference antenna that is 450MHz for the first band and 430MHz for the second band. The return loss values at first and second resonant frequencies are -49.5dB and -41.5dB respectively. While in the reference paper the return loss values were -25dB and -27dB for first and second resonant frequencies respectively.

The measured radiation pattern in the E plane (yz-plane) and H plane (xy-plane) are plotted in Fig.8. Nearly omni-directional and bidirectional patterns have been observed in yz plane (Fig. a and c) and xy plane (Fig. b and d) respectively for both the frequencies. In Fig.8(a) for 1.95GHz frequency E field radiation pattern has maximum magnitude 14.13dB, in the direction of 180 degree. For the same frequency H field radiation pattern has maximum magnitude 12.06dB, in the -90 degree direction and minimum magnitude in 180 degree direction. Fig.8(c) for 3.75GHz frequency E field radiation pattern has maximum magnitude 16.73dB, in the direction of 0 degree. For the same frequency H field radiation pattern has maximum magnitude 13.00 degree in 120 degree and -120 degree direction and same as the above minimum magnitude in 180 degree direction. The 3D plot of the radiation pattern is shown in the Fig.7(a) and Fig.7(b) for the two frequency 1.95 GHz and 3.75 GHz respectively.

For all communication devices the VSWR is an important parameter. It can measure that how well an antenna is matched to the cable impedance where the reflection, $|\Gamma| = 0$. This means that all power transmitted to the antenna and there is no reflection. The simulated result of Voltage Standing Wave Ratio, (VSWR) is shown in Fig.9. It is observed from the figurethat for our two frequency bands 1.77GHz-2.24GHz and 3.40GHz-4.12GHz the proposed antenna is showing good matching and at resonant frequencies 1.95GHz and 3.75GHz, the VSWR value is obtained is 1.0.

V. CONCLUSION

By properly choosing the suitable slot shape and tuning other dimensions the design with enhanced bandwidth and improved return loss is obtained. The impedance bandwidth and return loss are 23.78% and 49.5dB for the first band and 19.24% and 41.5dB for the second band respectively. VSWR of the antenna is found below 2 for the two frequency ranges. In addition, the proposed antenna exhibit stable and nearly omni-directional far-field radiation pattern over the two operating bands with the simple structure. So this antenna can be extensively used for multiple communication bands (DECT,PCS,PHS), WiMAX band and for the fixed satellite application.

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