U-Shaped Microstrip Patch Antenna for WLAN/WIMAX Applications

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Abstract:A full-duplex radio design communication systems design based on the WiMax/WLAN antenna. The design an antenna in this report presented a triple-band operation with significant impedance bandwidth for WLAN/WiMAX system. The designed antenna having the compact size of 10 x 26 mm2 and shaped of antenna is U-shaped. The overall performance of the antenna three different bands 1) band-1:- 2.40 to 2.53 GHz, 2) band-2:-3.40 o 3.60 GHz and 3) band-3:- 5.00 to 6.00 GHz, these bands cover the WiMAX (2.5, 3.5, 5.5) and WLAN (2.4, 5.2, 5.8) bands. Here HFSS simulator used to simulate and validate the results. By combining the performance of complete WLAN/WiMAX antenna with MIMO antenna, the proposed MIMO antenna with wide operating frequencies 2.4 GHz. Thus the simulation results along with the given parameter values show that the antenna can simultaneously operate over WLAN, WiMAX and MIMO frequency bands.

Keywords: *WLAN, WiMAX,LTE, MIMO*

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1 Introduction

An antenna has very important and indispensable part in WCS. It's coupling device among transmitter and receiver. It's a device radiating or receiving radio waves. Nowadays there is an increasing demand for the antenna with the multiband operation. Hence it has attracted many research scholars to do research for advanced types of antenna. Microstrip patch antenna has the number of advantages and extraordinary features than the conventional antennas. With regards to their geometrical shapes and practical applications, microstrip patch antennas are very efficient and useful. There are dissimilar types of antennas like loop antenna, a reflector antenna, aperture antenna, lens antenna, microstrip patch [Deschamps GA, Sichak W, 1953]. Among them, microstrip patch antenna is one of most versatile and conformal antenna. It is easy to design and fabricate.

The concept and fundamental idea of microstrip antenna were created [Deschamps GA, Sichak W, 1953]. A flat aerial that can be used in Ultra High frequency (UHF) range was invented and patented [Gutton H, Baissinot G, 1955]. Through continued research, a thorough and detailed study of microstrip antenna was made only in the year 1970s. By the year 1970, the microstrip antenna had become very popular. That led to the rapid growth of microstrip patch antenna technology. The first practical microstrip antennas were developed [Byron EV, 1972]. In the meantime, the microstrip patch antenna with various geometrical shapes was invented [Howel, JQ, 1972].

Mobile communication, wireless interconnects, wireless local networks (WLANs) and phone advances make one in every out of the first rapidly developing in markets today. Actually, these applications need antennas. What's extra the mobile handsets are demanding that those are little, light-weight and minimal. These requests are dry spell an on the improvement of the low-profile inner antenna with unrivaled execution. This being the situation, transportable antenna innovation has completely developed along the edge of mobile and cell advancements. It is critical to have the legitimate antenna for a devices.

Nowadays microstrip patch antennas are commonly used for commercial purposes. They can fix an external of aircraft, satellites, spacecraft, automobiles, missiles, even mobile phones [Bahramzy, Pevand, et al., 2015]. A microstrip antenna comprises of dielectric substrate which has transmitted patch side of a dielectric substrate and opposite side have a ground plane.

They also provide better efficiency and more bandwidth, but the size of antenna is large. The size of antenna can be concentrated based on thin substrates whose dielectric coefficient value is high. However, these antennas are less efficient because they produce greater losses [Zhang, Shuai, et al., 2017].

Further, they work on smaller bandwidth. Furthermore, compared to conventional antennas, the microstrip antennas have many advantages. They can be used for many applications that work over a wide frequency range.

Some of important advantages of microstrip patch antenna are as follows. They can be made conformal planar and non-planar surfaces because of its low weight, little volume and thin profile shape. These antennas can fabricate using modern printed-circuit technology. Their fabrication cost is low and mass production of these antennas can be easily done. These antennas can produce mutually linear and circular polarization. They can certainly combine using heat up integrated circuits. Greater directs can be achieved by using arrays of microstrip elements. The Feeding methods of microstrip antennas are defined in four types. The antenna used such feed line like microstrip feed, coaxial feed, aperture coupled feed and proximity coupled feed [Okazaki H, Kawai K, Fukuda A, Furuta T, Narahashi S, 2010].

[Yuan, Bo, et al.., 2012] Given the design of an internal antenna for multi-band for cell phone applications. Two antenna segments are framed on both base and best of a similar substrate and unite by metallic stick to get the multi band characteristics.

A Multi-band FPMA has been proposed for mobile handset. Here designed the pleated planar monopole antenna that includes the low rated profile about one twentieth of the wavelength lowermost in operational frequency. Result successfully bring out by utilizing a bent radiating patch which is in rectangular shape and an inverted l-shaped ground plane.

A novel minimal antenna working at DCS, GSM, PCS and IMT2000 groups has been presented by Peng Sun et al. With a delicately coupled ground branch, the reception apparatus proposed here spreads each of the 2G and 3G remote correspondence groups.

Best conferred a multiband round shape monopole antenna. The monopole which is in round shape shows more extensive impedance bandwidth and enhanced example execution. [Ravichandran, G., 2015] Conferred a double recurrence reception apparatus landed to a conservative microstrip patch antenna stacking couple of tight openings near to its emanating edge. Two working frequencies display parallel polarization planes (PPP) and the comparative radiation qualities.

[Zheng, M., Wang, H., &Hao, Y., 2012] Planned a published double monopole band antenna for 2.4/5.2GHz WLAN get to the point. Trident monopole antenna includes the vocal support for 2.4 GHz band (2.42.484GHz) process and the two side arms for 5.2 GHz band (5.155.35GHz) operation.

Two folded wide-band CPW-encouraged adjusted Koch fractal printed opening reception apparatus, appropriate for WLAN, WiMAX processes is proposed by Krishna et al. Here working repeat of a three-sided space antenna transported around Koch cycle system realizing a limited antenna.

A minimized double band planar antenna has been proposed by [Morishita, H., H. Furuuchi, and K. Fujimoto., 2002]. Its Limited Ground CPW fed, double monopole band setup. A double band process accomplished stacking the wide monopole receiving wire with"V"-molded cover.

[Hayashida, Shogo, et al., 2002] Exhibited smaller uniplanar antenna to the applications of a WLAN. To the dual band antenna, acquired to adjusting one of the parallel portions an opening line, consequently creating two diverse current ways. Antenna vibrates with the two groups to 2.20 to 2.50 GHz and 5.00 to 10.00 GHz with countless coordinating, countless radiation attributes & reasonable gain.

[Ban, Yong-Ling, et al., 2013] Proposed a planar wind line radio wire involving three extended strips for down-profile either DCS or PCS and GSM or WLAN triple-band process of the cellphones. The strips planned fill in quarter-wavelength design at 900 and 1800 MHz, independently, and covering GSM/DCS/PCS/GSM and WLAN gatherings.

[Kingsley S., 2005] Antenna proposed here occupies a very small area on the chip. The compact antenna is having a driven arm connected with a ground arm and by adjusting the antenna, which are to be printed in both the bottom layer and the top layer of a chip.

[Ban, Yong-Ling, et al., 2013] A folding monopole or dipole or loop antenna wire proposals special preferences more than a routine PIFA and monopole antenna to a portable cell gadget. The future antenna has four resonances in which there are three of them are 0.5, 1 & 1.5 modes. Antenna proposed here is folded dipole which is in 2 mode, which has not been accounted for in this way, is excited and used.

[Ishimiya, Katsunori, Chi-Yuk Chiu, and Jun-ichi Takada. 2013] The antenna here gives an answer to planar continuous metal-rimmed handsets can be worked in five wireless announcement bands.

Here they described in what way dielectrics can be used to recover the performance of the electric antennas of small design, as well as defining techniques to the integrate antenna, with radio to create an antenna module.

[Konya, Shohei, et al. 2011], here they had measured the input impedance for the balanced Antenna by using return loss (s-parameter) method

[Collins, B. S., et al., 2006], characterize the other multi band antenna consolidating an adjusted feed system which indicates significant resistance from the typical ground plane impacts and focuses the best approach to the novel based antenna designs which can be moved between stages with almost no adjustment.

[Okazaki, Hiroshi, et al., 2007] Different reconfigurable RF front-end engineering for upcoming devoid of band cell phone terminals were proposed. The solitary way to design the utilization of the single-band device with the circulated reconfigurable coordinating systems which can possibly accomplish the ideal RF front-end to the transmission side.

The first phase in the confirming proposed engineering, a reconfigurable quad-band PA design is likewise introduced. The 1W-class PA design utilizing micro electro mechanical system switches and low temperature co-fired ceramic technology gets more extreme power included productivity more noteworthy than 44% in the 0.9, 1.5, 2.0, to 2.6-GHz bands.

[Gorbachov, Oleksandr, 2011] Movement towards the higher data rates and capacities with respect to sight and multimedia applications, arrangement to different facilities (text, audio, video) to various wireless values to a similar gadget require incorporated design that work over numerous principles, can without much of a stretch be reused, and accomplish most extreme equipment part at least power utilization.

The antenna performance [Deschamps GA, Sichak W, 1953] is a need to make a self-resonant and self-immune antenna, as there might be some impact on antenna performance because of the style and its geometry and the presence of other antennas for WLAN, WiMAX, and GPS or for MIMO functionality. It has led to an increase in the complexity of the antenna along with the commercial pressures to make cheaper models that occupy less volume in the handset.

2 ANTENNA STRUCTURE

The design of single component is appeared given underneath and different measurements the patch antenna. The patch antenna was planned based on TLM. The width of patch is ascertained to begin with, given by,

$$W = \frac{c}{2f}\sqrt{\frac{2}{\epsilon_r+1}} \quad (1)$$

Where, εr substrate of dielectric constant, W patch width.

As a result of bordering impact, the antenna appearances bigger than the physical measurements. ΔL produces this results in account and can processed to

$$\Delta L = 0.412h\frac{(\epsilon_{eff}+0.3).\left(\frac{W}{h}+0.264\right)}{(\epsilon_{eff}-0.258).\left(\frac{W}{h}+0.8\right)} \quad (2)$$

Where, h substrate height and ε_{eff} actual dielectric constant assumed:

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left\{1+12\frac{h}{W}\right\}^{-\frac{1}{2}} \quad (3)$$

When height (h) has reached out by every side of patch, the compelling length is given,

$$L_{eff} = \frac{c}{2f\sqrt{\epsilon_{eff}}} \quad (4)$$

L is Length of Patch resonant given by,

$L=L_{eff}$(length of dielectric constant) –2Δ (5)

The dielectric substrate Duroid and height have values respectively εr = 2.2, h = 1.57 in mm utilized.

3 SIMULATION AND ANALYSIS

This research focused on design, simulate U-shaped slot triple band for WLAN/WiMax application that will operate in a frequency range 2.5 GHz until 6.5 GHz. All design and prototype of the antenna in this research were constructed using HFSS software.

A result of measurement in this research was focused on three main things which are reflection loss, gain, and SAR value. In this chapter, all the research background simulation results and related facts to proof present study is valuable and usable for further work regarding this research were discussed by detail. The simulation parameter and antenna dimensions of designed patch antenna mention below in Table I.

Table I: Dimension of antenna designed.

Parameters	Unit(mm)	Parameters	Unit(mm)
L_{p1}	1.0	L_g	3.6
L_{p2}	9.0	L_{g1}	2.5
L_{p3}	11.9	L_f	22.7
W_{p1}	1.0	W_{g1}	0.7
W_{p2}	2.6	W_{g2}	5.0
W_{p3}	1.8	W_g	10.0
L_{p1}	1.0	L_g	3.6

The design is optimized using HFSS software. As discussed earlier, slotted antenna with high dielectric material is difficult to match with the 50 ohm line, and hence standard inset length is optimized after cutting the slot. At 2.4 GHz, the electric field is much concentrated on the smaller slot in the patch. In the proposed model we increase the size and change the position of the optimized slot [Sahota, Kamal, 2010].

A. *SIMULATIN DESIGN*

This section tackles the design problems in microstrip antenna and improved the results. Our final design is compact and covers the wireless applications.

Step 1: Starting with new dimensions, we consider an antenna operating at 2.45 GHz, corresponding to the centrally placed wireless applications. The equations of previous section are applied to the smaller antenna.

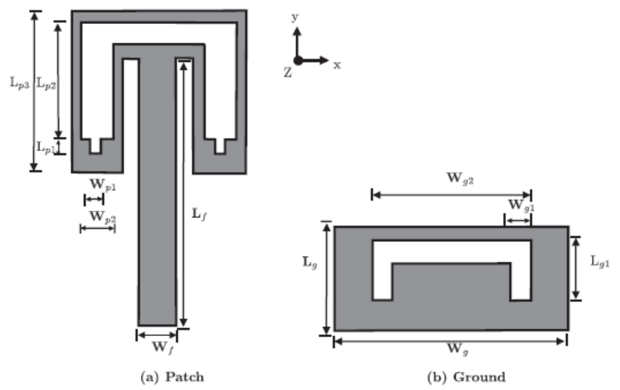

Figure 1: Geometry of the antenna [Kunwar, A., Gautam, A. K., &Rambabu, K. (2017)].

The dimensions of ground are L= 26 mm and W= 10 mm for operation, substrate dimension is L=52 mm and W=20 mm and Patch dimension is L=26 mm and W=10mm and Z=1.6 at 2.45 GHz in the wireless application. The width of the feed line (input port) can be varied to obtain impedance matching.

Step 2: Substrate we are using FR4 epoxy as a substrate.

Step 3: Line-feed rectangular patch on a grounded substrate at 2.45 GHz. The dimensions of a simple rectangular patch on a grounded substrate were obtained from the formulas. We consider a simple line-feed rectangular patch at 2.45 GHz and a substrate with €r = 4.4 and height 1.6 mm.

Step 4: Design: A 1.6 mm FR4 epoxy substrate with copper coating on both sides is easily available. The antenna was simulated in HFSS for an operating frequency of 2.45 GHz.

Step 5: The designed antenna has a compact size of 10x 26 mm^2. The proposed antenna consists of an inverted U-shaped slot radiator and a defected ground plane.

B. *RESULT ANALYSIS AND DISCUSSION*

This research focused on design, simulate WiMAX/WLAN antenna for various application that will operate in a frequency range 2.5 GHz, 3.5 GHz and 5.5 GHz. All design and prototype of the antenna in this research were constructed using HFSS software.

A result of measurement in this research was focused on three main things which are reflection loss and radiation pattern. In this chapter, all the research background simulation results and related facts to proof present study is valuable and usable for further work regarding this research were discussed by detail.

The figures of the S11 parameter are shown below in figure 2 and this S11 plots are generated based on the resonance frequency at 3.5 GHz, 3 GHz & 5.8 GHz and 2.5 GHz, 3.5 GHz and 5.5 GHz respectively.

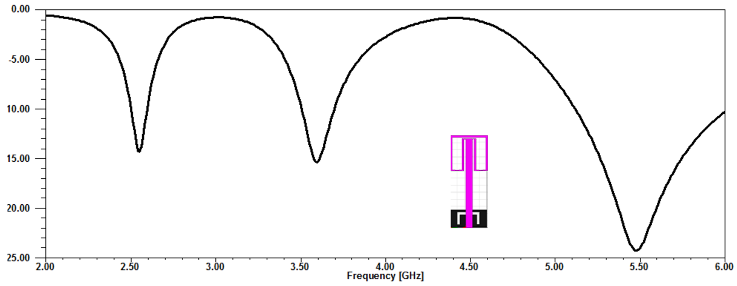

Figure 2: Return Loss [dB] over frequencies for complete antenna of WiMax/WLAN antenna on HFSS.

To achieve the triple-band operation for WLAN/WiMAX applications, the antenna return loss [dB] are shown in figure 2. The final figure 5.3 demonstrates that the additional inverted-U slot on the radiating patch of the antenna provides another resonance.

The simulations of antenna showed that the slot on the ground plane is just accountable for the impedance matching. To study the connection between resonant frequencies and important parameters of designed antenna as well as operating principle. Lastly. Figure 3 observed the single resonant mode seems at about 2.4 GHz because of the radiating patch size improvement and additional inverted-U slot.

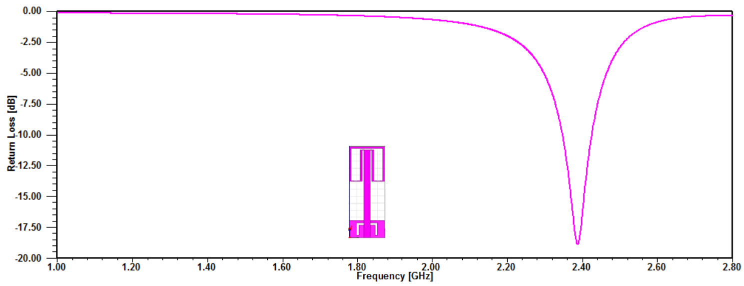

Figure 3: Return Loss [dB] over frequencies for MIMO antenna on HFSS for mobile antenna.

The radiation characteristics of the designed design are simulated with HFSS simulator and for brevity the radiation patterns are given at the central operating frequency in each band. Nearly omnidirectional patterns are achieved in H-plane (phi=90 degree) and E-plane (phi=0 degree) with HFSS simulators at all three frequencies. Figure 4 (a)–(c) shows the 2-D far-field radiation patterns at central frequencies of 2.5 GHz, 3.5 GHz and 5.5 GHz respectively.

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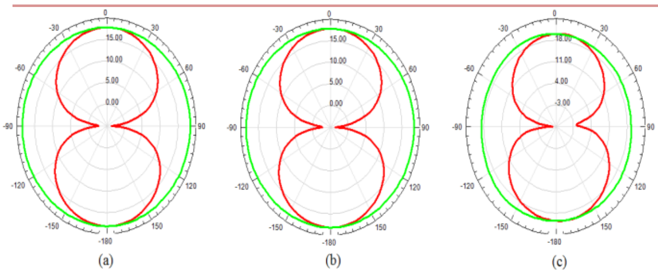

Figure 4: Radiation patterns of the designed antenna (a) 2.5 GHz (b) 3.5 GHz and (c) 5.5 GHz resonance frequencies, H-Field (Red line) and E-Field (Green line).

The radiation characteristics of the MIMO design antenna are simulated with HFSS simulator at the central operating frequency at 2.4 GHz band. The achieved patterns are based on H-plane (phi=90 degree) and E-plane (phi=0 degree) with HFSS simulators at MIMO band frequencies. Figure 5 shows the 2-D far-field radiation patterns at frequency of 2.4 GHz.

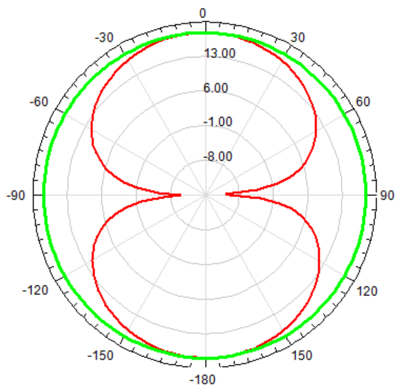

Figure 5: Radiation patterns of the MIMO antenna at 2.4 GHz resonance frequencies, H-Field (Red line) and E-Field (Green line).

4 CONCLUSION

A WiMax/WLAN capable to provide the three numbers of bands under various smartphone applications. By combining the performance of complete WLAN/WiMAX antenna with MIMO antenna, the proposed MIMO antenna with wide operating frequencies 2.40 GHz, but WiMAX have different operating frequencies 2.50 GHz, 3.50 GHz and 5.50 GHz. The current simulated result with given antenna performance parameter are defined based on S11 (return loss) parameter and radiation pattern.

The modified microstrip WLAN/WiMAX and MIMO antenna with an inverted U-shaped patch is successfully designed and simulated. The experiments are accepted for validation the design concept and method, showing good arrangements of the simulations. The proposed antenna features compact size, good triband operating bandwidth and stable radiation patterns indicating it can be a good candidate for WLAN/WiMAX applications.

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