Rectangular Antenna Design With 'C' Shaped Radiator Replaced by Helical Antenna for WLAN and WiMAX Applications

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Abstract— *The growth of smart antennas replaced many older technologies. Likewise, this paper presents a study on design of monopole antenna array with multiband multiple-input–multiple-output (MIMO) antenna system for small mobile terminals. Many smart antennas are designed with variable sizes for many different types of uses. In those, each antenna will support particular range of frequency, and some antennas may support few range of frequencies. But the antenna design which is presented in this paper supports five different frequencies. Those are 900, 1800, 2100, 3500, and 5400 MHz, which means, the antenna designed supports five resonant modes. This antenna covers GSM850/900, DCS, PCS, UMTS, WLAN and WiMAX frequency bands.In case of proposed system, a small and compact triple-band microstrip-fed printed monopole antenna for WLAN and WiMAX will be used. The proposed antenna will have a rectangular radiating patch with "L" and "U" shaped slots and ground plane. The proposed antenna is expected to be small when compared to antenna design discussed in this paper. The proposed paper presents a study on a small and compact triple-band microstrip-fed printed monopole antenna for Wireless Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX). The antenna designed in this paper consists of a rectangular radiating patch L- and U-shaped slots. The length of the L and U shaped slots are designed to obtain the required frequency bands—namely, WLAN (2.4/5.2/5.8 GHz) and WiMAX (2.5/3.5/5.5 GHz).*

Keywords— Frequency bands, MIMO, Resonant modes, Radiating element.

I. INTRODUCTION

Nowadays, Wireless terminals that are portable got developed to have numerous functions, even on a smaller handset which supports multiple standards. From this, it is clear that, developing the compact antennas with multiband is necessary to supports MIMO enabled wireless terminals. For the use of MIMO terminals, the design of many antennas have been proposed. In the existing antenna design, dual-element printed monopole antenna is designed, which supports the frequency ranges like GSM850/900, DCS, PCS, UMTS, WLAN and WiMAX frequency bands The existing antenna design is compact and linearly polarized with dual element printed MIMO system; which is developed for supporting the GSM850/900, DCS, PCS, UMTS, WLAN and WiMAX frequency bands.The existing antenna uses an array of two printed monopole which is shown in the figure 1.

The rectangular slot which is designed in the antenna is attached to the ground plane, was used to achieve the low mutual coupling and which is below minus 15dB for all the matched frequency bands. In case of proposed antenna design, to make the antenna design little compact, the shape of the radiators are changed. The antenna design has the rectangular radiating patch which has the shape of L and U slots and the ground plane. This compact antenna design will also supports the frequency bands such as GSM850/900, DCS, PCS, UMTS, WLAN and WiMAX frequency bands, which are supported by the existing antenna design too.

The antenna's wireless communication applications, are required to operate simultaneously for WLAN and WiMAX technology. The spectrum which is specified for WLAN is 2.1, 5.2 and 5.8GHz and for WiMAX at 2.5, 3.5 and 5.5GHz. The low profile multiband antennas which are developed in recent years are relatively large and the desired bandwidths are not provided by them. By using a planar monopole antenna which has the slots on the patch and ground plane is a method of reducing the size and improving the bandwidth. For wireless systems, there are many antenna designs, such as coplanar wave guide fed monopole antenna with slots embedded, slot monopole

Frequency (MHz)	Wireless applications (MHz)
826-1005	GSM 850(824-894) GSM 900 (880-960)
1527-2480	DCS (1710-1880) PCS (1850-1990) UMTS (1920-2170) WLAN (2400-2480)
3439-3690	WiMAX(3400-3600)
5340-5749	WAN(5470-5725)

antenna with rectangular parasitic elements and meandered split ring slot.

In this paper, the antenna which is proposed is a small and low profile and micro strip-fed monopole antenna and is designed for the operation of triple band. The pair of symmetrical 'L' and 'U' shaped slots are used to achieve the triple-band operation of proposed antenna and these slots are used inside the compact patch by a step by step design procedure.

II. ANTENNA DESIGN AND SIMULATION APPROACH

The schematic configuration of the existing rectangular monopole antenna is shown in the figure 1 and that antenna is designed by using HFSS software. The existing antenna design has the 'C' shaped radiator and this proposed antenna has the rectangular radiating patch with a feed line, pair of symmetrical 'L' and 'U' shaped slots and a ground plane. The proposed antenna design is based on a microstrip fed monopole antenna and which has low profile and the design is simple, but the dimensions are relatively large with a quarter guided wavelength at first resonant frequency and some other antennas with these design specifications may not satisfy all the requirements for WLAN/WiMAX applications.

For designing a compact and small antenna which provides the desired performance that includes omnidirectional radiation patterns at WLAN/WiMAX frequency bands, the design procedure which is described below can be used. The patch antenna dimensions were significantly reduced and within the path, the symmetric 'L' and 'u' shaped slots were cut out. Just to provide the desired resonant frequencies, and also based on the expectations. The initial lengths of the slots in each part were selected so that, the total length L_T each their three combinations is about a quarter of the guided wavelength at the desired resonant frequency using the approximate effective permittivity approach. The 'L' shaped slot which is designed in the proposed antenna provides the resonant response at 3.7 GHz (WiMAX band) and this will be provided by that 'L' shaped slot , when the total length of all its parts (L_{p1}+L_{p5}+W_3) is very close to the quarter of a wavelength, in terms of resonant frequency of 3.7 GHz.

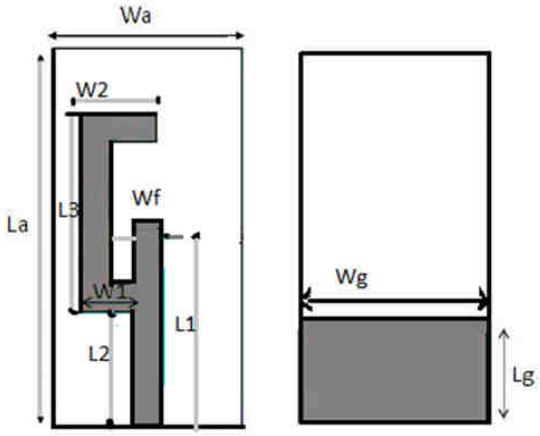

Figure 1:Layout of existing antenna

The 'U' shaped slot which is used in the antenna design, is for mainly controlling the lower resonant frequency, which is approximately a quarter of wavelength at 2.54 GHz. All the dimensions which are explained in this paper is clearly shown in the layout diagram which is show in the figure 1. This layout diagram which is shown in figure 1 is for the existing antenna design.

Table 1: Frequencies supported by the antenna designed.

The antenna which is designed in the existing system supports the frequencies which are mentioned in the table 1. Since the existing antenna design supports five frequency bands such as DCS, PCS, UMTS, GSM, WLAN, WiMAX , the frequency ranges which are supported by these technologies are given in the above table 1. The antenna which is designed will have omnidirectional far field radiation patterns, since the patch with the slots is small and it is not backed by the ground plane. Using the parametric study, the size of the ground plane and the substrates are obtained. Extensive simulation including reflection coefficient, gain and surface current distributions has been performed using the ansoft simulation software high frequency structure simulator (HFSS).

The antenna which is designed using the ansoft simulation software high frequency structure simulator (HFSS) is

shown in figure 2. In the above figure 2 the shape of the radiator is clearly shown as 'C'. the proposed antenna is built on a FR4 substrate which has the permittivity of 4.4, thickness of 1.6mm and a loss tangent of 0.024.

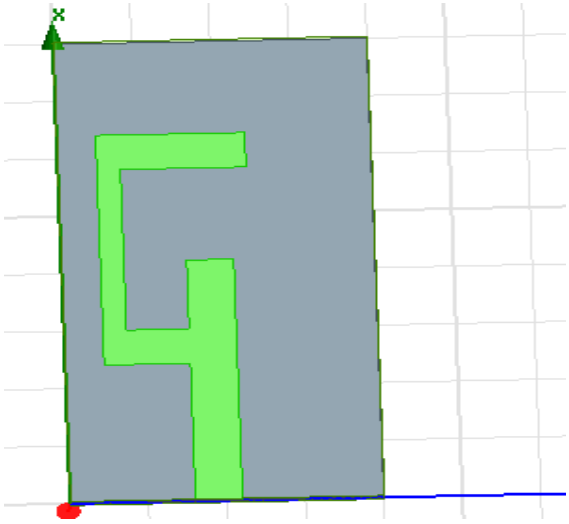

Fig. 2 Design of Existing antenna.

The antenna design consists of several parameters. The ground plane with a size of 30*30mm is designed. To insert the slot in the ground plane, the dimensions are, the lower end width=19.7,length=11.2 from the lower end, upper end width=17.8, length =25 from the lower end connected to the center position of width=26.8, length=17.8 from the lower end. The FR4substrate with thickness 1.6 etched on the upper surface of the ground plane. The round face of the radiator patch of width=7.5mm connected to the other face with a width=6.5mm, resembles like a trapezoidal one with bent junctions. The patch forms round end connected to the feed line with tapered at one end. The antenna is matched with lumped port.

III. RESULT AND DISCUSSION

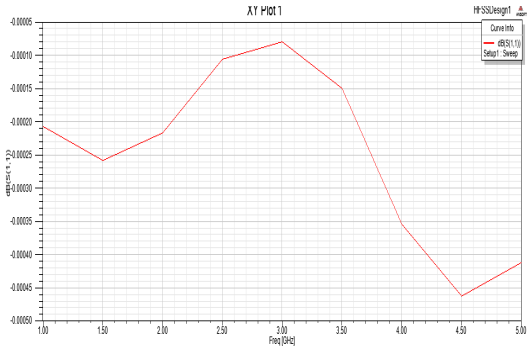

Fig. 3: S parameter graph

The above Figure 3 shows the S parameter graph for the antenna designed above. This S parameter graph is for the frequency 900 MHz and similarly graph for other frequencies which are mentioned above can also be obtained from the same antenna design.

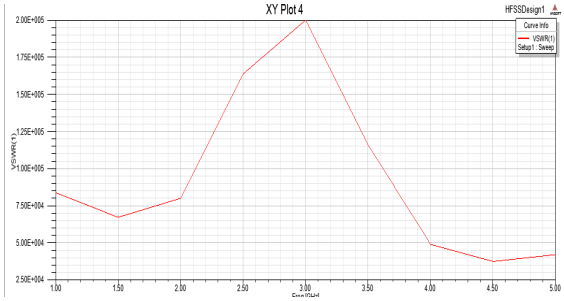

Fig. 4: VSWR Graph

The above Figure 4 shows the VSWR graph for the antenna designed above. This VSWR graph is for the frequency 900 MHz and similarly graph for other frequencies which are mentioned above can also be obtained from the same antenna design. From the above graph it is clear that, the peak value is obtained only at 3GHz. In the figure 5, a wide operating frequency band is obtained by using an ordinary patch antenna. But, in particular at lower frequencies, the frequency band does not cover the desired frequency bands.

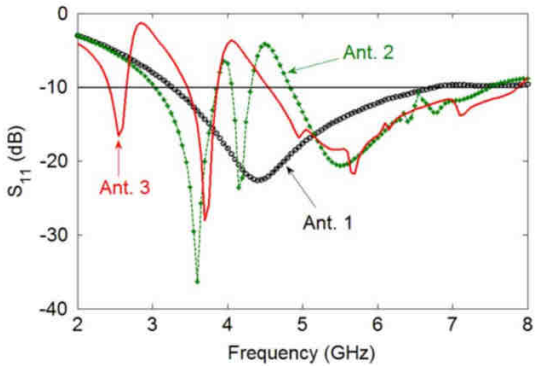

Fig. 5 Simulated S parameter result for designed antenna.

IV. CONCLUSION

In this paper, for triple band operation, the micro strip fed monopole antenna design is presented. The proposed antenna is composed of a pair of symmetrical L and U shaped slots where the existing has the C shaped slots inside the rectangular patch that enables proper adjusting of the resonant bands. The desired operating bandwidths, gain and radiation pattern are obtained in the simulation using the software HFSS for WLAN (2.4/5.2/5.8 GHz) and WiMAX (2.5/3.5/5.5 GHz) applications. The dimension of the antenna is relatively small (15*15*1.6 mm^3) .

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