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Design and Simulation Based Studies of a Dual Band Antenna for WLAN/WiMax Application

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ABSTRACT--*In this rapid changing world in wireless communication systems, multiband antenna has been playing a very important role for wireless service requirements. Rectangular line slot designs of a dual band patch antenna have been investigated in this paper. By using rectangular line slot patch geometry dual band operation has been obtained. The patch antenna is simulated by Ansoft HFSS and antenna magus software which is finite element method based simulators. After the antenna performance characteristics such as, input impedance, return loss, polar plot are obtained.. This observation has provided us sufficient insight to optimize the antennaparameters to meet the design requirements. The proposed designs of the antenna operate in 2.4 GHz band which is common to all two designs but the second operating band is different. By varying the slot broadness the second frequency band can be shifted.IEEE802.11b (2.45 GHz), IEEE802.11y (3.2 GHz) andIEEE802.11a(5.775 GHz) standards which would allow WLAN operation. This patch antenna has been intended to be used in portable devices that demand miniaturized constituent parts.*

Keywords— Patch antenna, slot, dual band, gain, directivity.

I.INTRODUCTION

The use of multiband antennas in portable devices like mobile phone, laptop, gaming console etc. is inevitable now-a-days. Due to the concept of miniaturization the size of these devices is shrinking rapidly. Consequently, the antennas must become smaller to fit inside them. This paper aims at presenting three miniaturized dual band u-slot patch antennas for WLAN application. The paper also confirms the technique of shifting resonance frequency by varying the u-slot broadness. Besides, the gain and directivity have been improved in two designs of the patch antenna. Apart from it, emphasis has been given to the miniaturization. At the end, the balance between the dimension and performance of the antenna has been carefully established by parametric study. For brevity, the results of parametric study have been omitted in this paper. A simple patch antenna with basic rectangular patch operates in a single frequency band. A patch antenna intended to operate at a center resonance frequency fr mounted on a substrate having dielectric constant εr would have length L and width W of the patch as found from the following equations neglecting the fringing effect.

$$L = \frac{c}{2\,fr\sqrt{\xi r}}$$

$$W = \frac{c}{2\,fr}\sqrt{\frac{2}{\xi r + 1}}$$

A basic single band rectangular patch antenna can be modified into a multiband antenna by introducing slots in the patch. The shapes and position of the slot play an important role in determining the resonance frequency.

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The slot shapes like C, E, F, H, L, V, U and many others are well known.

Sometimes, more than one slot of different shapes is used in the same patch for desired performance. The u-slot was introduced in a paper published in 1995 and the antenna showed wideband behaviour and was linearly polarized . Although the initial investigations of u-slot patch antenna were based on air and foam substrate, later it was found that the antenna retained its wideband characteristic when material substrate was used instead of air and foam substrate. Initially, u-slot was regarded as a mean of achieving only wideband characteristic rather than multiband characteristic of the patch antenna. Interestingly, subsequent researches revealed that wideband characteristic can be modified to multiband characteristic by intelligent placement of u-slot, thereby perturbing the surface current flow in the patch Not only the band characteristic but also the polarization characteristic can be altered by manipulating u-slot. The antennas investigated in and exhibited circular polarization. Moreover, u-slot patch antenna with reconfigurable polarization has been reported recently In that paper, PIN diodes have been used to change the length of the u-slot arms, which alters the polarization state of the antenna and it can switch between linear and circular polarization. Besides, the antenna can also switch between right hand and left hand circular polarization. All theseresearches have unveiled different interesting aspects of slot patch antenna.It is now well established fact that by using slot patch geometry multiband characteristic can be obtained. Therefore, slot patch geometry is now regarded as a general template which can be customized to best suit therequirements. The proposed antennas in this paper are three specific cases of the dual band characteristic of a general slot patch antenna template.

II.ANTENNA DESIGN PARAMETERS

The structure of the proposed antenna is shown in Figure 1 below. For a rectangular patch, the length L of the patch is usually 0.3333 λ0< L < 0.5 λ0, where λ0 is the free-space wave length. The patch is selected to be very thin such that t << λ0 (where t is the patch thickness).The height h of the dielectric substrate is usually 0.003 λ0 <= h <= 0.05 λ0 (Balanis, 2005).

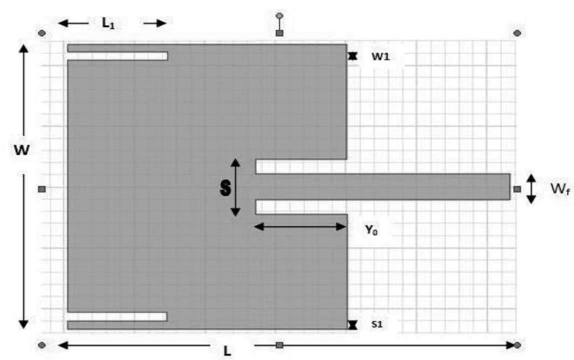

Fig:1Geometry of Proposed Dual Band Antenna

III. PHYSICAL PARAMETERS OF ANTENNA

Step 1: Calculation of the Width (W): The width of the Microstrip patch antenna is given by:

$$W = \frac{\lambda o}{2}\left[\frac{\xi r + 1}{2}\right]^{-\frac{1}{2}}$$

Step 2: Calculation of Effective dielectric constant (εreff): Equation gives the effective dielectric constant as:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2}\frac{\varepsilon_r - 1}{2}\frac{1}{\left(1 + 12\frac{h}{w}\right)^{\frac{1}{2}}}$$

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Step 3: Calculation of the Effective length (Leff): Equation gives the effective length as:

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$$

Step 4: Calculation of the length extension (ΔL):

$$\Delta L = 0.412h \frac{(\varepsilon_{eff} + 0.3)}{(\varepsilon_{eff} - 0.258)} \frac{\frac{w}{h} + 0.264}{\frac{w}{h} + 0.8}$$

Step 5: Calculation of actual length of patch (L): The actual length is obtained by re-writing Equation as:

L = Leff - 2 ΔL

Step 6: Determination of feed point location (fx,fyfz,) : A Micro strip feed line is to be used in this design. As shown in Figure 1, the feed point location is given by the co-ordinates (fx , fy,, fz) from the origin. The united feed line-patch excited by the lumped port where the input impedance is 50 ohms for the resonant frequency. Hence, a hit and trial method is used to locate the feed point. For different locations of the feed point, the return loss (R.L) is compared and that feed point is selected where the R.L is most negative (below -10 dB). There exists a point along the length of the patch where the R.L is minimum.

Design of Dual Band Microstrip Patch Antenna	
Width of the Patch(W)	46.9 mm
Effective dielectric constant of the Patch,(εeff)	2.2922
Length of the Patch(L)	39.6 mm
Input Resistance of the Patch(Rin)	50 Ω
Width of slots(w1)	1.4 mm
Length of slots(L1)	14.2 mm
Width of non-radiating edge(s1)	1.4 mm

Table 1:.Design parameter of Proposed Dual Band Antenna

IV.SIMULATION SETUP AND RESULTS

The software used to model and simulate the microstrip patch antenna is HFSS software. HFSS software is a full-wave electromagnetic simulator based on the finite element method. It analyzes 3D and multilayer structures of general shapes. It has been widely used in the design of MICs, RFICs, patch antennas, wire antennas, and other RF/wireless antennas. It can be used to calculateand plot the S parameters, VSWR, current distributions as well as the radiation patterns.

V.RESULTS AND DISCUSSION

Return loss is important parameter for calculating the bandwidth of the antenna. The solutionfrequency is selected as the one at which the return loss is minimum. Here we are getting dual band graph one at 2.45 GHz and the other at 3.2 GHz.

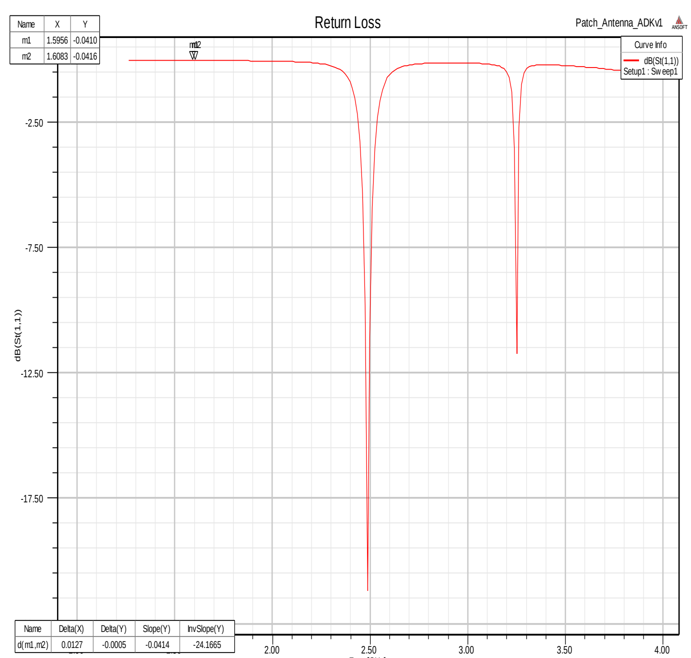

Fig. 3 Measured Return Loss (-28db at 2.45GHz && -16.6db at 3.45GHz)

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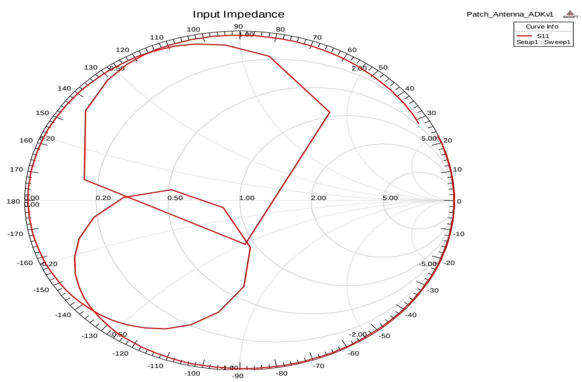

Fig 4. Input Impedance in smith chart

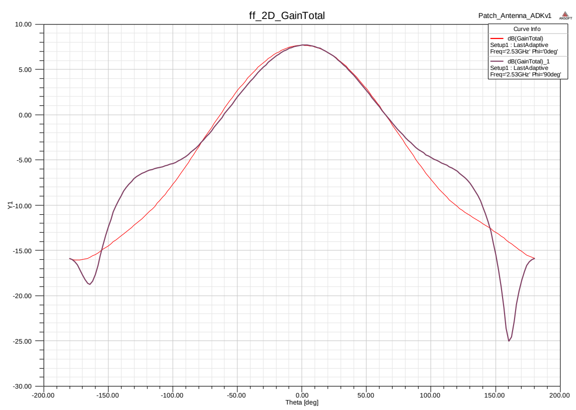

Fig 5. 2D gain of Proposed Dual Band Antenna

Standards/ Antennas (Centre Resonance Frequency)	Bandwidth (MHz)	Resonance Frequencies (|S11| dB)	Gain (Resonance Frequency)
IEEE802.11y (3.675 GHz)	50	-10	3db
IEEE802.11b (2.45 GHz)	83	-10	3db
Proposed Antenna-2.45GHz	90	-28	7.685db
Proposed Antenna 3.65GHz	120	-16.6	7.58db

Table 2: Comparison with standard values

VI. CONCLUDING REMARKS

Rectangular line slot designs of a dual band slot patch antenna have been proposed for WLAN application. They are dimensionally small and have impressive performance characteristics as pointed out in this paper. Even though this paper presents simulation based results, the use of HFSS software for simulation ensures that there would not be large discrepancies between the simulated and measured results in case the proposed antennas are fabricated and measured. Being powerful and commercial software, HFSS is capable of delivering accurate simulation results. Besides, numerous simulations have been performed to confirm the results and the accuracy settings of the software have been carefully set up to minimize the approximation errors.

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