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A Dual Band Microstrip Double Slot Antenna for Wi-Fi and WIMAX Applications

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***Abstract*— In this paper a dual band microstrip slotted antenna is proposed. This antenna has a simpler structure than other antennas designed for realizing dual band characteristics. Simulation studies of the proposed structure are studied and analyzed using High Frequency Structure Simulator (HFSS) software. The design antennas are then fabricated and tested using Vector Network Analyzer. We obtained good results in testing. The radiating patch is placed on a FR-4 dielectric substrate (=4.3, tan δ = 0.02) with conducting ground. The Co-axial feeding technique is used. In the Operating frequency range of 2.4-2.48 GHz, have a return loss of less than -10 dB for Wi-Fi applications. Operating frequency range of 2.66-2.77 GHz, 4.28-4.4 GHz and have a return loss of less than -10 dB for WIMAX applications.**

***Keywords*: Slot antenna, , WIMAX, Wi-Fi, Return loss.**

I. INTRODUCTION

In modern wireless communication systems, multiband antenna has been playing a very important role for wireless service requirements. Wireless fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WIMAX) have been widely applied in mobile devices such as handheld computers and intelligent phones. These two techniques have been widely recognized as a viable, cost-effective, high-speed data connectivity solution, enabling user mobility. A compact dual band microstrip slot antenna is proposed for Wi-Fi and WIMAX applications. The antenna consists of a coaxial feed, a substrate, a ground plane, and patch on which some simple slots are etched. The rectangular and trapezoid slots are able to achieve dual frequencies and also provide a broadband operation at high frequency. IEEE 802.16e WIMAX standards consist of 2.6 GHz (2.6–2.7 GHz), 4.2 GHz (4.2-4.4 GHz) frequency bands and Wi-Fi of 2.4-2.48 GHz frequency bands. With the rapid development of the modern wireless communication system, antenna design has turned to focus on wide multiband and small simple structures that can be easy to fabricate. The proposed antenna (shown in Fig.1.) can be considered to achieve multiband just through etching slots on the patch, so it can be much easier to fabricate.

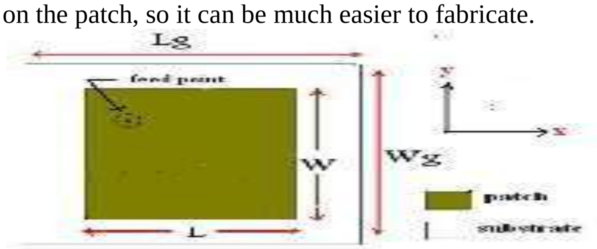

Fig. 1. Proposed Microstrip Slot Antenna

The antenna consists of a substrate, and a ground plane, patch on which some simple slots are etched. The rectangular and trapezoidal slots are able to achieve dual frequencies and also provide a broadband operation at high frequency. The additional resonant mode is excited with the use of a pair of symmetrical horizontal strips embedded in the rectangular slot. Compared to the other antenna, the dual band double slot antenna not only achieves coaxial feed, but also has a rather simple structure that is easy to fabricate. Meanwhile, the measured results represent that the antenna shows a good multiband characteristic to satisfy the requirement of WIMAX in the 2.6-2.7 GHz & 4.2-4.4 GHz bands and Wi-Fi in 2.4 GHz. Operating at frequency of 2.6 GHz with permittivity of 4.4 of tangent loss of 0.02 (H=1.6 mm). The dimension of proposed antenna is 35×30×1.6 mm. Details of the antenna design are described in this paper, both simulated and measured results are presented. The measured results show good agreement with the simulated ones.

The dual band micro strip double slot antenna have good radiation characteristics and gains in the two operating bands, so it can emerge as an excellent candidate for multiband generation of wireless. The antenna gain must be a peak value of 3 dBi at 2.6 GHz, 6 dBi at 4.3 GHz, and 9 dBi at 4.4 GHz respectively.

II. THE DESIGN OF TRAPEZOIDAL SLOT ANTENNA

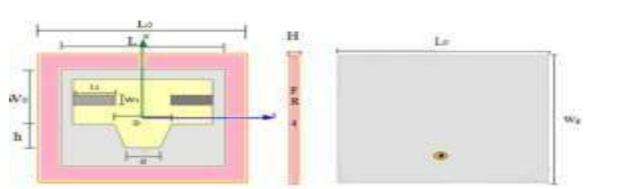

Fig. 2. Simulated Microstrip Antenna (Top & Back View)

Fig. 3. Photograph of Fabricated Antenna (Top & Back View)

The configuration of the dual band slot antenna (shown in Fig. 2) is designed and fabricated (shown in Fig. 3) on a substrate with FR4, relative permittivity of 4.4, and a loss tangent of 0.02. The entire size of the antenna is only 30×35×1.6 mm. Without loss of generality, a 50 Ω coaxial feed with a inner radii of 0.5 mm is adopted for centrally feeding the antenna at one side of the substrate.

The microstrip slot antenna, is to operate in the frequency of 2.6 GHz effectively, the f_r is chosen as it. So the width of the patch is selected from equation(1).

$$W = c/2f_r\sqrt{(\varepsilon_r+1)/2} \quad (1)$$

As the inclusion, the dielectric property of the air present in substrate, the ε_{eff} is calculated.

By making these calculations, the dimensions of the slot antenna are finalized as in table-1 after the trial and error methods in simulation (shown in Fig. 3).

TABLE-1. Dimensions of Proposed Antenna

Parameter	Dimensions (mm)
L_1	9
L_0	30
L	35
W_0	14
W_1	3
W_g	44.6
L_g	39.6
D	18
d	3
H	1.6

III. EMBEDDED STRIPS

The embedded strips in the slot mainly generate the middle frequency. Similarly the current centralizes in the region nearby the trapezoidal slot that generates the highest frequency. By adding a pair of symmetrical horizontal strips to the slot, the middle frequency can be achieved. Adjusting the length and width of the strip makes changes in the domain of current distribution so that the resonance performance can be quite influenced. It can be seen that as the length L1 of strip increases, the second and third resonances shift toward the lower side. The strip width W1 has much effect on the return-loss characteristics apparently, and an optimum coaxial radius of 0.5 mm is selected for achieving good impedance matching of the antenna. Similarly, the height of trapezoid slot affects impedance matching at the highest resonant frequency, and the length of upper bottom controls impedance matching.

As frequency increases, currents are located in a smaller region of the ground plane. The current flows mainly along the edge of the rectangular slot. It justifies that the lowest resonant frequency is generated by etching the rectangular slot on the patch. The current flows along the edge of the ground plane upward to the upper side of the rectangular slot. Therefore, the embedded strips in the slot mainly generate the middle frequency. Similarly the current centralizes in the region nearby the trapezoid slot that generates the highest frequency. By adding a pair of symmetrical horizontal strips to the slot, the middle frequency can be achieved. Adjusting the length and width of the strip makes changes in the domain of current distribution so that the resonance performance can be quite influenced. .

IV. FEEDING TECHNIQUE

Although the numbers of feeding techniques are available for micro strip patch antenna, the coaxial feed is selected to achieve the good impedance matching to 50 . The feeding points are selected from the following equations:

$$X_f = L/2\sqrt{\varepsilon_{reff}}$$

$$Y_f = W/2$$

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V. SIMULATED ANTENNA

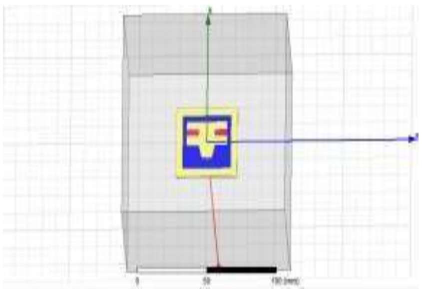

Fig. 4. Designed Microstrip Slot Antenna for 2.6 GHz

In designing Dual-Band rectangular and trapezoidal microstrip slot antenna using HFSS software, we simulate with analysis method and the advantage of fast, easy and output with graphical interfaces. The design of antenna follows four types of setup namely, planar EM design setup, model setup, excitation setup and analysis setup.

This setup involves the Ansoft designer. This involves the creations of substrate, ground, patch and slots. Also creation of infinite conductivity is involved in this method. The positions values are calculated by using the formulas for width, length. Here the material for substrate is taken as FR4-epoxy which has dielectric constant as 4.4.

TABLE–2 Special Features Of Proposed Antenna

Operating frequency	2.6 GHz
	4.4
Tan	0.02
H	1.6

VI. SIMULATED RESULTS

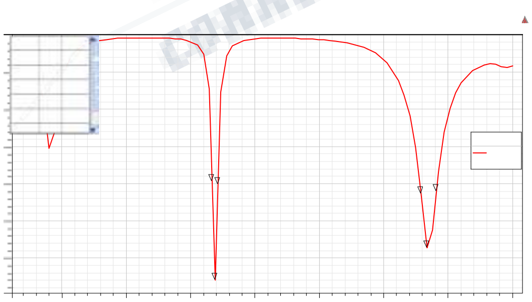

Fig. 5. Return Loss

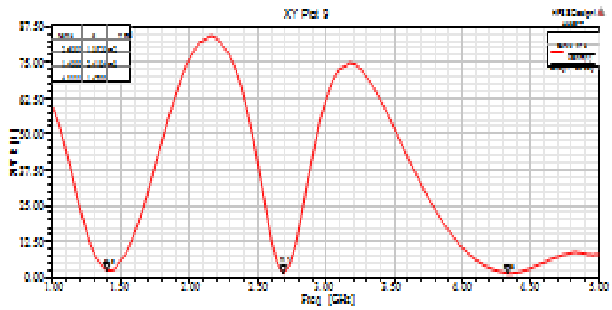

Fig. 6.VSWR

In designing the microstrip antenna using HFSS, we obtain VSWR less than 2(shown in Fig. 6). In designing the microstrip antenna using HFSS, we

obtain VSWR less than 1.05 for 4.7 GHz and 2.6 GHz. At operating frequency 2.6 GHz, corresponding value is 1.4.

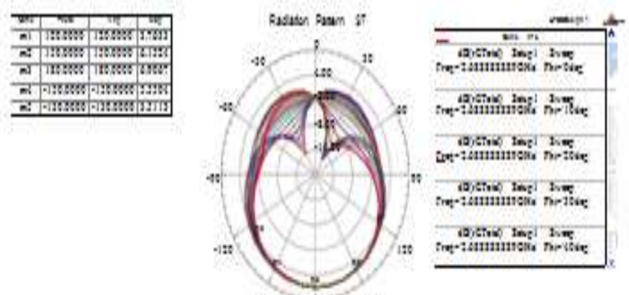

Fig. 7. Radiation Pattern At 2.6 Ghz

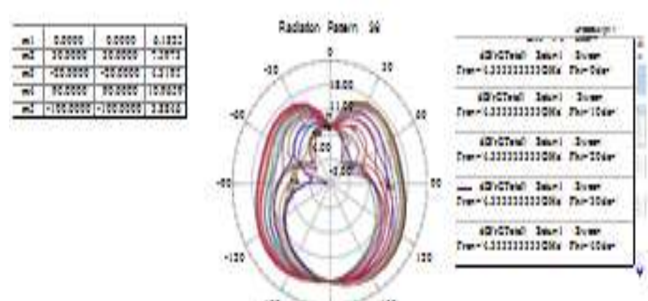

Fig. 8. Radiation Pattern At 4.4 Ghz

At our operating frequency 2.6 GHz, we get 1.3 as our value and for 4.3 GHz is 1.4. Also we determined the radiation pattern for every degree.

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VII. TESTED RESULTS

The following (Fig. 9, Fig. 10, Fig. 11, Fig. 12) figures are obtained from Vector network analyzer.

Fig. 9. Return Loss

The maximum returnloss of -32.2 dB is obtained at 4.7 GHz.

Fig. 10. Return Loss with Different Connector

By changing the radius of the connecters the Wi-Fi bands can be achieved.

Fig. 11.VSWR

The VSWR of 1.05 is obtained at 4.7 GHz.

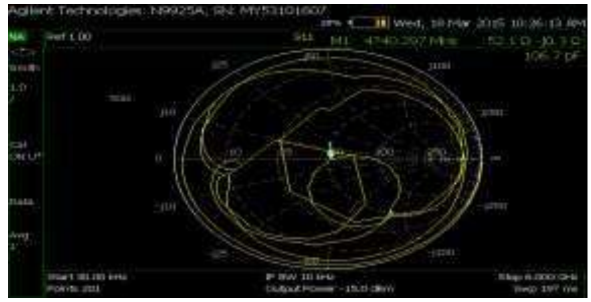

Fig. 12. Impedance Matching

The impedance matches to 50 ohms after the trial and error method in feed positions. At the frequency 4.7 GHz the impedance matching have been performed very well. Good impedance matching will lead a good performance.

The comparison between simulated and measured return loss characteristics of the proposed antenna obtained by using HFSS ver. 13 and the vector network analyzer. Apparently, the measured return losses below -10 dB bandwidths range from 2.4–2.48 GHz, 2.6-2.7 GHz, and 4.2-4.4 GHz (refer Fig. 9 and Fig. 10) with the relative bandwidth of 12.2 %, 22.3 % and 33.2 % respectively, which show approximate agreement with the simulated results. The differences may be due to the effect of the SMA connector and mismatching tolerance. Illustrates the current distribution of the proposed antenna at different frequencies. As frequency increases, currents are located in a smaller region of the ground plane. As the current flows mainly along the edge of the rectangular slot. It justifies that the lowest resonant frequency is generated by etching the rectangular slot on the ground plane. In the current flows along the edge of the strips upward to the upper side of the rectangular slot.

VIII. CONCLUSION

The measured results show that the obtained impedance bandwidths are 22.2% (2.6–2.8 GHz), and about 33.2% (4.2-4.5 GHz), respectively, good enough for Wi-Fi and WIMAX applications. In addition, the proposed antenna has good radiation characteristics and gains in the three operating bands, so it can emerge as an excellent candidate for multiband generation of wireless. The antenna gain had a peak value of 3 dBi at 2.6 GHz, 6 dBi at

4.3 GHz, and 9 dBi at 4.4 GHz, respectively. Thus the designed antennas have the scope of emerging research in future in the applications of Wi-Fi and WIMAX. In this paper, we designed a low-cost UWB dual band micro strip double slot antenna is fabricated on FR4 substrate and measured with vector network analyzer. The measured results have good agreement with simulation. Thus, this antenna can be very much used in Wi-Fi and WIMAX applications. In this paper a compact dual band microstrip slotted antenna for Wi-Fi and WIMAX applications is presented. Compared to many antennas proposed earlier, this antenna is designed based on a rather simple structure and suitable for all frequency bands of Wi-Fi and WIMAX applications. The proposed antenna can be considered to achieve multiband just through etching slots on the patch, so it can be much easier to fabricate

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