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Dual Band Microstrip Patch Antenna for WiMAX and WLAN Applications

M. Haroon Tariq, Saba Rashid and **Farooq A. Bhatti**

Department of Electrical Engineering, Military College of Signals (MCS), National University of Sciences and Technology (NUST), Rawalpindi, Pakistan

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Abstract

A dual band microstrip patch antenna has been designed for technology oriented requirements of high speed wireless local area networks (IEEE 802.11a standard) and other communications systems covering the 5.15-5.825 GHz band. Three parallel slots have been introduced in the radiating patch to get the maximum current distribution on the surface. The position of center arm is set to get the radiation pattern in desired outward direction. The effects of various dimensional parameters were analyzed to get the optimized performance of the presented antenna. FR-4 substrate has been used for cost estimation whereas size reduction and enhanced gain of the structure was another challenge. To meet this challenge impedance is matched while maintaining the width of transmission line and also addition of slots is responsible for enhanced performance of antenna. The simulated results are good in agreement with measured results making antenna to be used for WiMAX and WLAN applications.

Keywords*: Antenna, microstrip antenna, dual band, WiMAX, WLAN*

1. Introduction

Wireless communication has evolved a lot in the last couple of decades. The demand for wireless LAN equipment has increased up to the mark. Wireless channels for frequencies operating bands of the targeted environment must be better understood before designing a new WLAN system [3]. The 2.4GHz ISM band is license free, that is the reason most of WLAN devices suffer interference from devices which use the same frequency band. This ISM band is utilized by IEEE 802.11b and 802.11g standards. 5GHz is used by IEEE 802.11a standard which is cleaner to support high speed WLAN [2]. This means that it has interference free spectrum so its productivity increases. The possibility of data collisions is less so we can stay connected. Laptops, mobile phones, PDAs, and all the other wireless communication gadgets, all use antennas for transmission and reception of radio waves. For such applications, microstrip patch antenna will be a good candidate due to its low profile, low cost and compatibility characteristics. Although there is a tradeoff between gain, bandwidth and the specifications mentioned above. Techniques like substrate thickness, partial ground, meandering, inset feed etc, have been proposed to address these issues. To get the maximum gain at desired frequency and for equal and concentrated electric field distribution, different slots were placed. The size and positions of these slots is adjusted to get the required results.

In this paper, a slotted microstrip patch antenna has been designed for WiMAX and WLAN applications.

Simulation were carried out on commercially available High Frequency Structure Simulator (HFSS), measured results were taken using Agilent Network Analyzer and Anechoic Chamber. The proposed work is presented in different sections. Section-II is describing the antenna geometry and in Section-III modeling of structure is discussed. Comparison of measured and simulated results is presented in Section-IV, whereas Section-V concludes the paper.

2. Design Geometry

The design geometry of antenna is shown in Fig. 1. Antenna has ground plane of dimensions 50x35mm^2. The substrate selected for the design is FR-4 Epoxy having relative permittivity of 4.4 and loss tangent 0.02 with dimensions of 50x35mm^2. Substrate properties such as surface finish and the fabrication processes such as metallization and definition determine the accuracy of line width and gap width, and ultimately circuit performance. For optimum performance, microwave substrates should have low loss tangent to reduce dielectric loss and a uniform, isotropic dielectric constant to minimize circuit impedance changes. Patch of the antenna is excited with wave port through transmission line which is keeping the impedance of the patch 50Ω. Different slots were placed with different positions to get the desired frequency band.

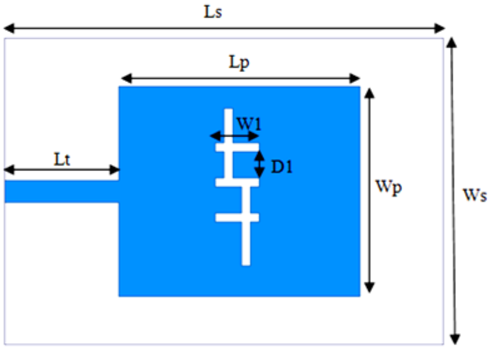


Fig.1 Antenna geometry

3. Modeling of the antenna

The proposed geometry of antenna is shown in Fig. 1. The impedance of the antenna was matched at 50Ω while changing the width of the transmission line. Notching of frequency for the desired band was achieved by the movement in the radiating edges of the patch. The frequency of operation of the patch antenna is determined by the length of the patch [11]. The microstrip antenna should have a length equal to one half of a wavelength within the dielectric (substrate) medium [6].

Table 1 Dimensions of the Proposed Antenna

Parameter	Dimension (mm)	Parameter	Dimension (mm)
Ls	50	Lp	27.5
Ws	35	Wp	24
Lt	13	W1	5
D1	3	Wt	2.5

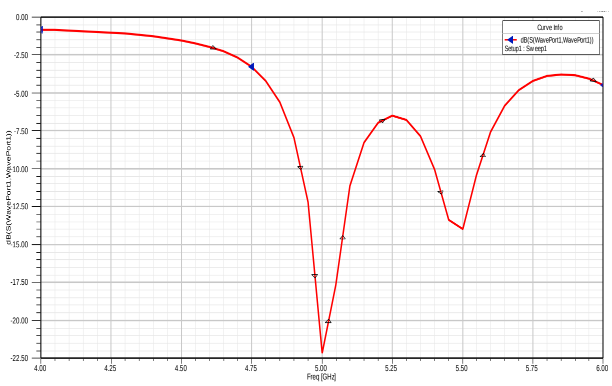


Fig.2 Return loss at 5GHz

The width of the microstrip antenna controls the input impedance. Larger widths also can increase the bandwidth. For a square patch antenna fed in the manner above, the input impedance will be of the order of 300 Ohms. By increasing the width, the impedance can be reduced. However, to decrease the input impedance to 50 Ohms often requires a very wide patch antenna, which takes up a lot of valuable space.

The voltage reflection coefficient will be -1. When this occurs, the voltage and current are out of phase. Hence, at the end of the patch the voltage is at a maximum (say +V volts). At the start of the patch antenna (a half-wavelength away), the voltage must be at minimum (-V Volts). Hence, the fields underneath the patch will resemble that of above, which roughly displays the fringing of the fields around the edges. After achieving the return loss in figure 2 all gain was lost, according to figure seems that it splits into two direction and we have to get those beams merged and will have maximum gain in one direction.

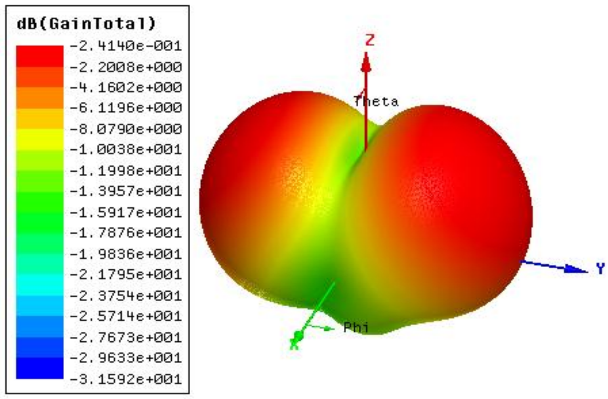


Fig.33-D gain at 5GHz

Microstrip antennas are planar resonant cavities that leak from their edges and radiate [9]. We can utilize printed circuit techniques to etch the antennas on soft substrates to produce low-cost and repeatable antennas in a low profile. For that purpose current distribution was observed on the patch, it was making two areas.

To get this problem solved a slot was placed in area of the patch where current concentrated region could be joined. The effect was null in case of return loss whereas there was slight increase in the gain.

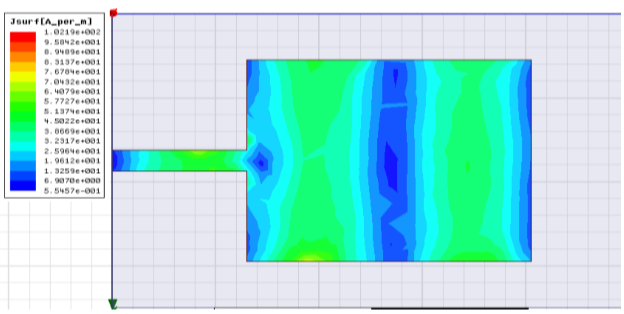


Fig.4 Current distribution at 5GHz

Consider the top view of a patch antenna, shown in the Fig. 4. Note that the current at the end of the patch is zero (open circuit end), the current is maximum at the center of the half-wave patch and zero at the beginning of the patch. The current is low at the feed while is maximum at center of the patch.

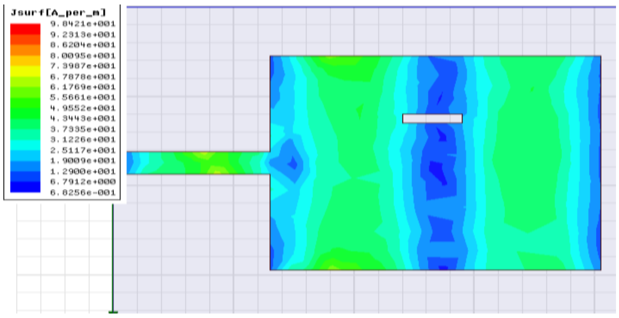


Fig.5 Current distribution after placing slot

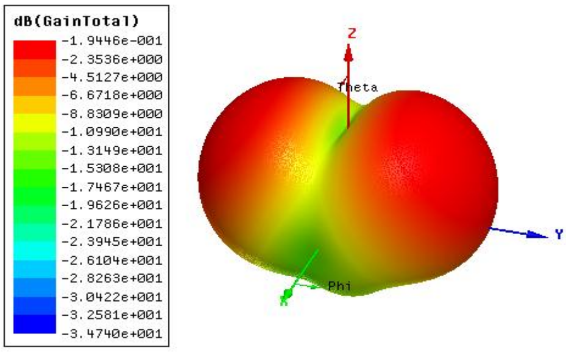


Fig.6 Gain after placing slot

Just to observe and get some higher changes in the gain three slots of same lengths and widths were placed with equal distance from each other. The gain of the antenna increased up to 2.7dBi.

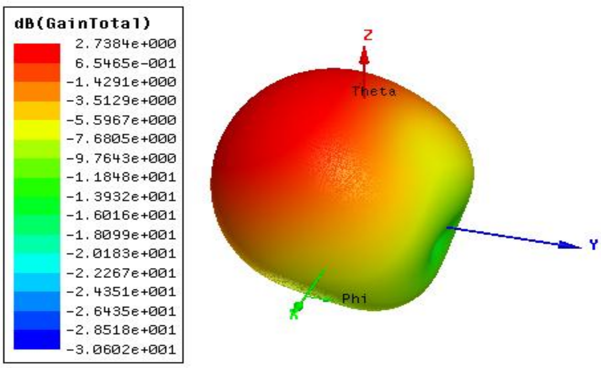


Fig. 7 Gain after three slots

But this time there was a shift in the frequency band and also the angle of directivity was shifted. To tackle these issue two perpendicular slots were placed and their position was changed with parametric analysis. Whereas for different positions; results of antenna for both of the slots were observed.

The slots introduced in parallel act like an inductor and the center arms of the patch act like a capacitor. The inductance will increase as the width of the parallel slots is increased similarly increasing the width of the centered slots will increase the capacitance. A local inductive effect is produced by the force of surface current to flow around the slots [2].

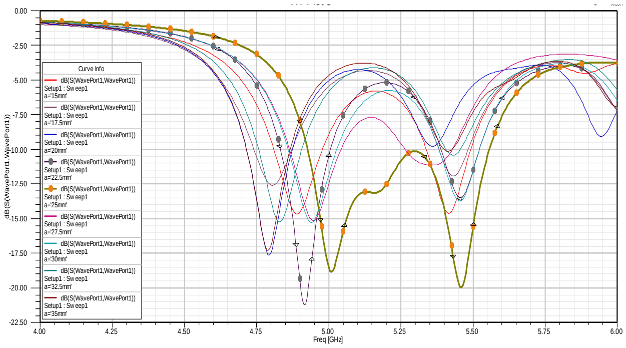


Fig.8 Return loss for slot1 from 15m to 35mm with step of 2.5mm

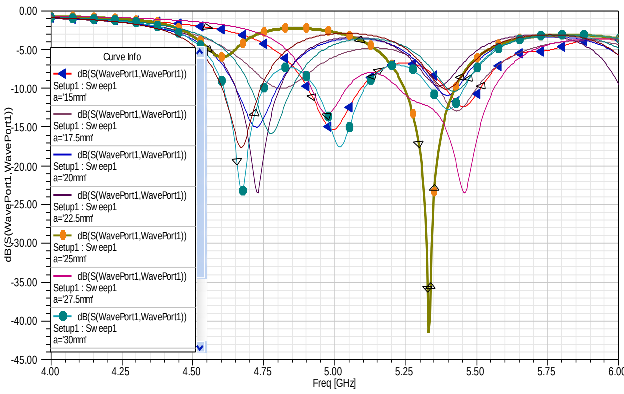


Fig.9 Return loss for slot2 from 15m to 35mm with step of 2.5mm

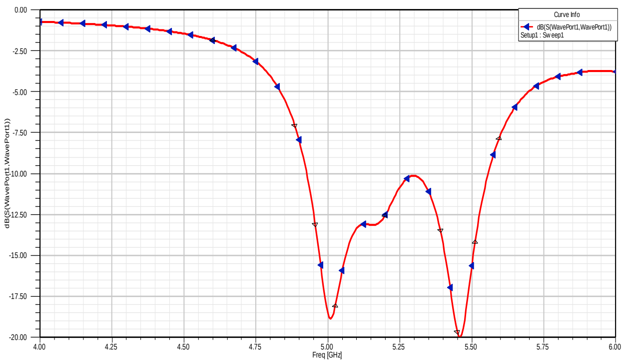


Fig. 10 Return loss after placing slot1 at 25mm and slot2 at 28mm

For first slot the position selected was 25mm because for all other values it was not operating at required frequency band. Second slot was placed at 28mm, although for some other values like 15mm and 27mm return loss was -10dB but maximum transmission could be possible observed was for the position at 28mm. Required results were achieved by placing these slots on the positions mentioned above.

It is the fringing fields that are responsible for the radiation. Note that the fringing fields near the surface of the patch antenna are both in the +y direction. Hence, the fringing E-fields on the edge of the microstrip antenna add up in phase and produce the radiation of the microstrip antenna. The current adds up in phase on the patch antenna as well; however, an equal current but with opposite direction is on the ground plane, which cancels the radiation.

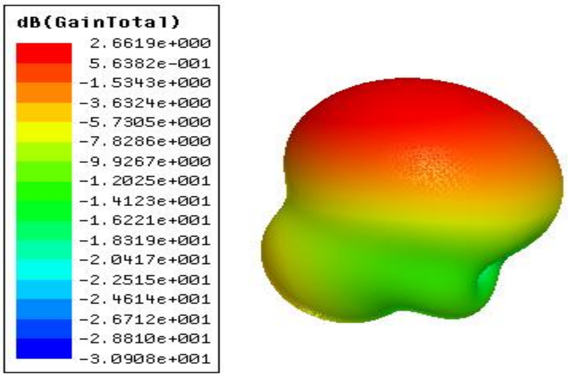


Fig.11 Gain of antenna after placing slot1 at 25mm and slot2 at 28mm

The rectangular patch when excited has a maximum directivity in the direction perpendicular to the patch in its fundamental mode of operation. While moving towards lower elevations its directivity decreases from broadside. Directivity is defined by a reference of isotropic source which radiates in all directions in equal amount [8].

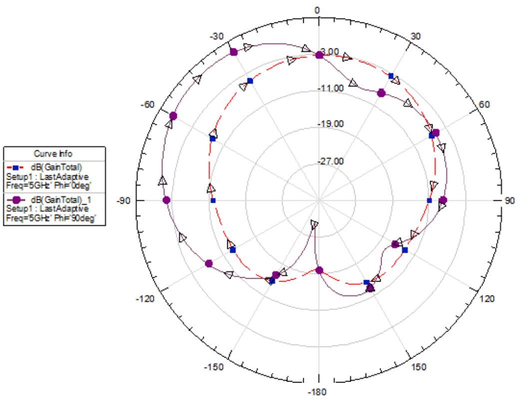
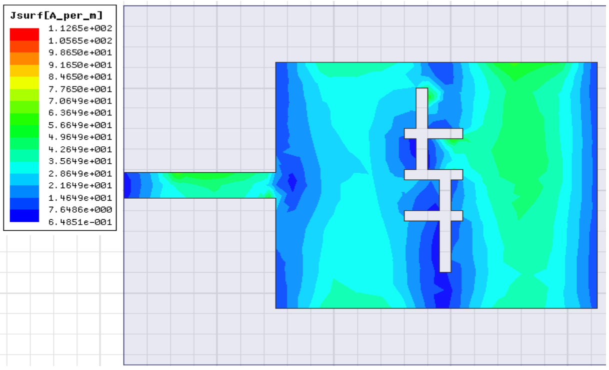


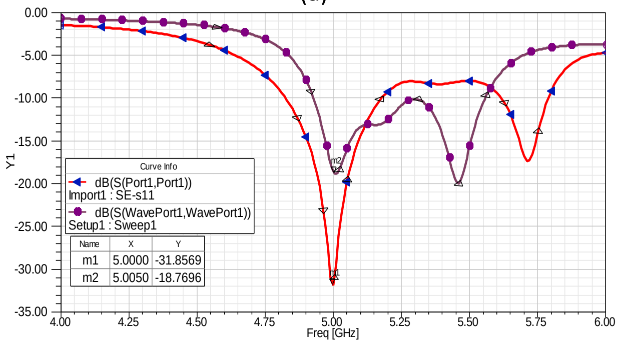
Fig. 12 Radiation pattern at 5GHz for phi is 0^0 and 90^0

4. Results and measurements

Return loss, VSWR were measured with Vector network analyzer and radiation pattern was measured from anechoic chamber. Measured results showed that the return loss is below -10dB and VSWR is below 2 for the whole bandwidth and it means antenna is operable in required frequency band.



(a)



(b)

Fig. 13 Comparison of measured and simulated return loss of the structure

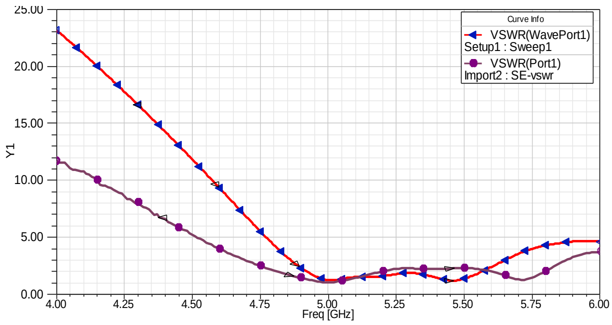


Fig. 14 Measured and simulated VSWR both are below 2

Conclusion

A compact low profile Microstrip patch antenna has been designed on FR-4 substrate with dual frequency bands at 5GHz. The wireless 802.11a standard for WLAN runs in the 5 GHz spectrum, from 5.15-5.825 GHz, at data speeds up to 54 Mbps. Antenna is integrated with SMA 50Ω connector to get the measured results from Network analyzer and anechoic chamber. The measured and simulated results are in good match. Gain of the antenna is 2.7dBi and impedance bandwidth is fulfilling the requirements for the WiMAX 5.2GHz and WLAN (5.15-5.35) GHz frequency bands.

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