A HIGH GAIN DUAL ISM BAND MONOPOLE PRINTED ANTENNA FOR WLAN APPLICATIONS WITH OMNIDIRECTIONAL RADIATION PATTERN

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Abstract: Due to very high traffic in 2.4 GHz WLAN band, dual WLAN band antennas are in great demand. Printable planar antennas are the best choice in this regard due to low-profile structure as it can be best fitted in handheld devices. Antennas designed on FR4 substrate is an added advantage due to low fabrication cost. A dual band monopole antenna is suggested for potential application in wireless communication in 2.4 GHz and 5.8 GHz ISM band. It is a low profile planar antenna fabricated on FR4 substrate of dielectric constant 4.4 and width of 1.6mm. It consists of a rectangular ground plane and a semicircular patch printed on opposite sides of the substrate. The antenna resonates at 2.45 GHz and 5.8 GHz with the bandwidth of 300 MHz and 450 MHz respectively. The antenna shows positive gain and good radiation patterns at these two frequency bands. A prototype of the antenna is fabricated. Measured and simulated data are in good agreement.

Keywords: *ISM Band, High Gain, WLAN, Microstrip Antenna.*

I. INTRODUCTION

2.4 GHz ISM band became one of the major research interests because of its use in so many applications like Wi-MAX/RFID/ZigBee/WPAN/Bluetooth/WLAN etc [1]. Because of the heavy traffic at 2.4 GHz, the demand of 5.8 GHz band is increasing day by day. 5.8 GHz band can be used in WLAN/ HIPERLAN/ Wi-MAX/IEEE 802.11p communications etc as specified by the ITU and radio spectrum allocation regulation [2]. Planar antennas are the best suited candidate for use in hand held mobile communication devices. Planar antenna can be integrated with the main circuit board by the printed circuit board technology and this is the greatest advantage of planar antenna. Especially planar antennas fabricated on low cost FR4 substrate of thickness 1.6 mm, is in great demand, because of the very low fabrication cost [3-7]. Planar antennas also consist of some major drawbacks like low bandwidth and gain. Efforts have been done to overcome these drawbacks.

In In this respect a planar monopole antenna is proposed to cover both the ISM band of 2.4 GHz and 5.8 GHz. The proposed monopole antenna is a simple, compact and low profile. The antenna is designed in Ansoft Designer Software. Several simulations have been done to optimize the antenna characteristics. Overall dimension of the optimized antenna is 55mm×22mm×1.6mm. Low cost FR4 of dielectric constant 4.4 and thickness of 1.6 mm, is used as the dielectric substrate. A prototype of the antenna design has been fabricated using printed circuit board technology. It is found that measured data validates the simulated results.

II. ANTENNA DESIGN

Top view and side view of the antenna design is shown is Fig-1 and Fig-2 respectively. It consists of a metallic radiating patch and metallic ground plane, printed on opposite sides of the dielectric substrate. Due to the fact that the monopole antenna has the ground connected directly to one side, the ground plane is no longer necessary. That means there is no ground plane just under the metallic patch.

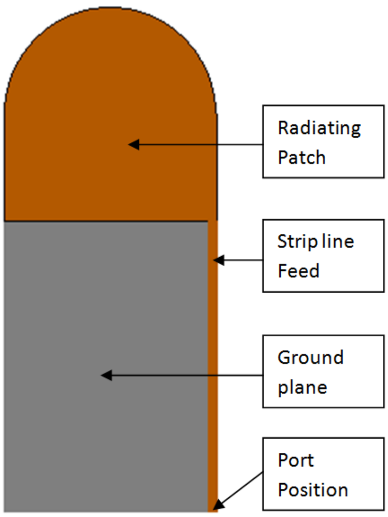

Fig-1: Top view of the antenna design

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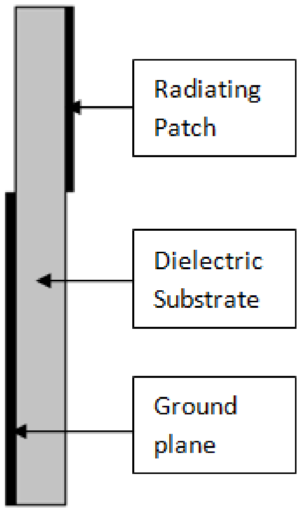

Fig-2: Side view of the antenna design

Shape of the ground plane is rectangular of dimension 22 mm × 33 mm. Patch is a combination of a rectangle of size 22 mm×11 mm and a semicircle of radius 11mm. This combination of rectangle and semicircle is acting as active element. Microstrip line feed technique is used to provide excitation to the radiating patch as indicated in Fig-1. The microstrip line is connected to one of the corners of the patch. Dimension of the microstrip line is 1mm x 33mm. Overall dimension of the optimized antenna is 55mm×22mm×1.6mm.

III. ANTENNA FABRICATION AND MEASUREMENT

A prototype of the optimized antenna is fabricated using printed circuit board technology. Fabrication is done on low cost FR4 substrate of dielectric constant 4.4 and loss tangent 0.02. Thickness of the substrate is 1.6 mm. Copper is used for the metallic patch and ground plane. Standard 50Ω SMA connector is used for the feeding port. Front view and back view of the fabricated antenna is shown in Fig-3 and Fig-4 respectively.

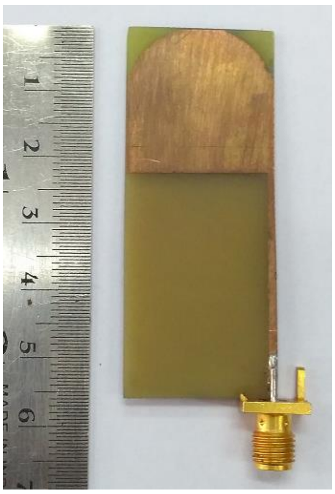

Fig-3: Front view of the fabricated antenna

Fig-4: Back view of the fabricated antenna

Reflection coefficient of the fabricated antenna has been measured by Vector Network Analyzer (VNA) manufactured by Rohde and Schwarz (model no ZNB20). Test antenna is connected to the VNA via high quality coaxial cable supplied by Rohde and Schwarz. Before connecting the antenna the VNA is calibrated to nullify the coaxial cable impedance. After the calibration is done antenna is connected via the coaxial cable and SMA connector. Then Reflection Coefficient measurement is done on the VNA. Antenna gain and radiation pattern is measured by standard microwave test bench. Microwave test bench setup consist of a microwave source, a power meter and two horn antenna. First a horn antenna is connected to the microwave source and another horn antenna is connected to the power meter. This two horn antenna is positioned face to face and power reading is noted in the power meter. Then the receiving horn antenna connected to the power meter is removed and test antenna is connected to the power meter. By comparing this power reading with the former (horn to horn) power reading, actual gain of the test antenna have been measured.

IV. RESULTS AND DISCUSSION

Simulated and measured Reflection Coefficient vs Frequency plot has been shown in Fig-5. It is observed that simulated and measured results are in good agreement. But the resonant frequency in the measured data shifts little bit towards the higher frequency. This might be explained due to the dependencies between the dielectric constant with the frequency over 2 GHz in the case of the low-cost FR4 PCB. But still the fabricated antenna operates in the required band of 2.4 GHz and 5.8 GHz. From simulation data it is observed that the antenna resonates at 2.45 GHz for the 2.4 GHz band with bandwidth of 300 MHz (2.3 GHz to 2.6 GHz). In measurement it is found that the antenna resonates at 2.5 GHz with bandwidth of 520 MHz (2.31 GHz to 2.83 GHz). For the 5.8 GHz band simulation shows that the antenna resonates at 5.8 GHz with the bandwidth of 450 MHz (5.55 GHz to 6 GHz). During measurement it is found that the fabricated antenna resonates at 5.85 GHz with the bandwidths of 1400 MHz (5.3 GHz to 6.7 GHz). So the fabricated antenna covers the 2.4 GHz band (2.4 GHz to 2.5

GHz) and 5.8 GHz band (5.725 GHz to 5.875 GHz). Simulated vs measured gain plot has been shown in Fig-6. From Fig-6 shows that simulated vs measured gain is in good agreement. Simulated peak gain at 2.5 GHz and 5.85 GHz are 3.5 dBi and 3.1 dBi respectively. Measured gain at 2.45 GHz and 5.9 GHz are 3 dBi and 3.15 dBi respectively.

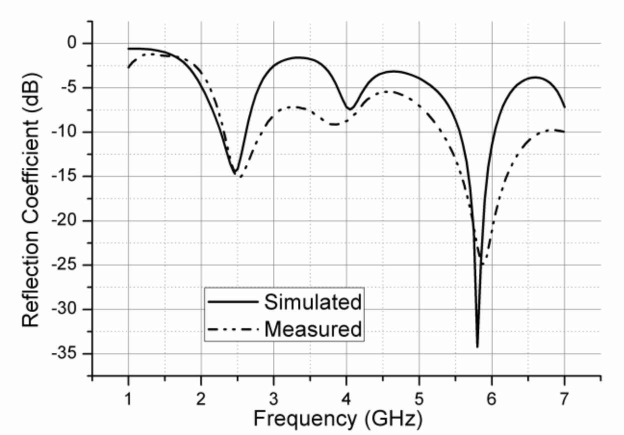

Fig-5: Simulated and measured Reflection Coefficient vs Frequency plot.

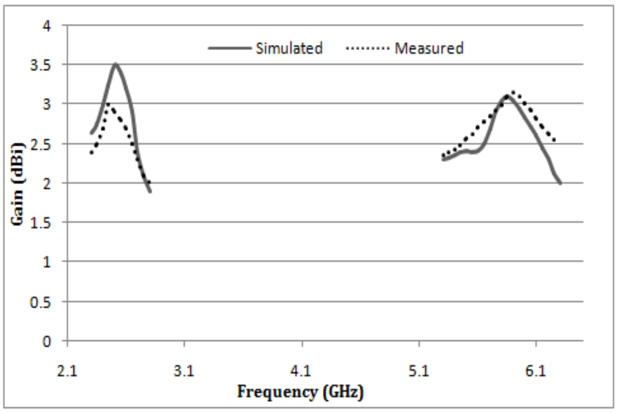

Fig-6: Simulated and Measured Gain vs Frequency plot

Simulated and measured 2D radiation patterns are shown in Fig-7 and Fig-8 for 2.45 GHz and 5.8 GHz respectively. Both simulated and measured normalized E field patters for E plane(Co-pole) and H plane(Cross-pole) are shown. It is observed that measured results are in good agreement with simulated result. Simulated 3D radiation patterns are shown in Fig-9 and Fig-10. From 2D and 3D radiation pattern, it is observed that, in both the frequencies the antenna shows good omnidirectional radiation pattern which is very attractive for wireless communication applications.

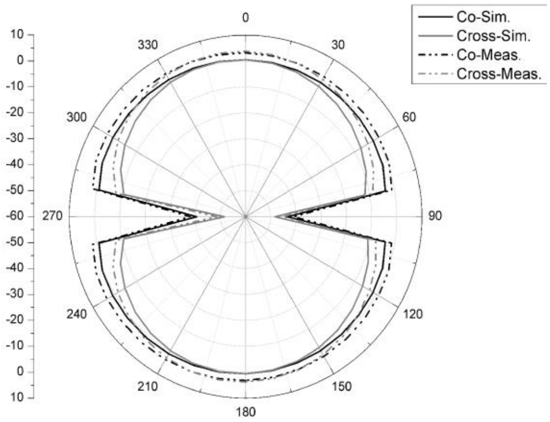

Fig-7: Simulated and measured radiation pattern at 2.45 GHz.

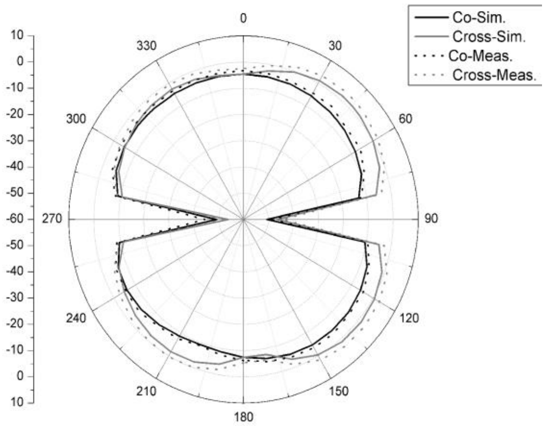

Fig-8: Simulated and measured radiation pattern at 5.8 GHz.

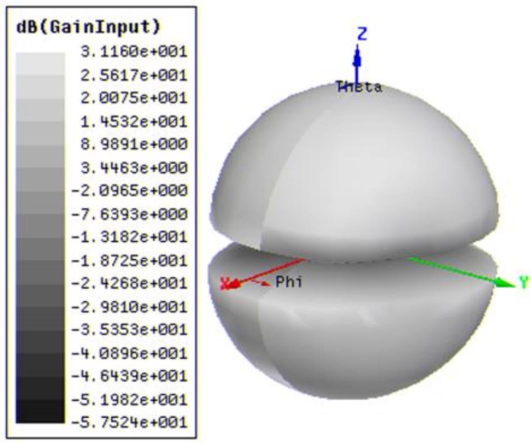

Fig-9: Simulated 3D radiation pattern at 2.45 GHz.

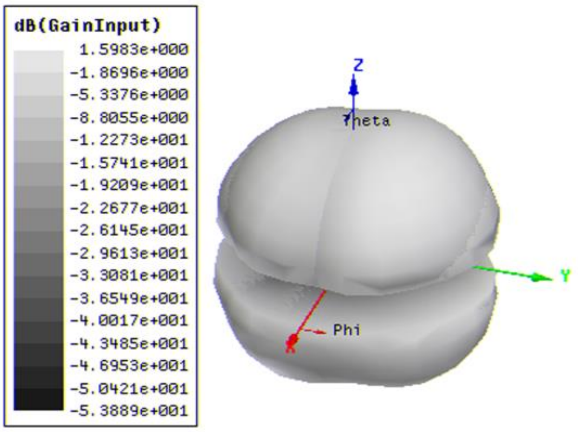

Fig-10: Simulated 3D radiation pattern at 2.45 GHz

VI. CONCLUSION

A dual ISM band antenna is presented. The antenna operates over 520 MHz and 1400 MHz bandwidths at 2.4 GHz and 5.8 GHz band respectively. The antenna shows good positive gain and omnidirectional radiation patterns at these two frequencies. Achieved percentage bandwidths of the fabricated antenna at these two bands are respectively 20.8% and 23.9%. Peak gain of 3.5 dBi and 3.1 dBi are achieved at the 2.5 GHz and 5.85 GHz respectively. All of these have been achieved in a simple design and by means of low fabrication cost. Hence this proposed antenna is a very good candidate for ISM band wireless communications like Wi-Fi/WLAN etc.

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