A Printed Monopole Antenna with a Protruding Stub in the Ground Plane for Dual Band WLAN and RFID Applications

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Abstract— Design of a simple microstrip fed folded strip monopole antenna with a protruding stub in the ground plane for the application in the WLAN and RFID is presented. The antenna has two resonant paths, one in the radiating element (folded strip) and other in the protruding stub in the ground plane, supports two resonances at 2.41 GHz and 5.82 GHz, which are the center frequencies of the WLAN and RFID. Effectively consistent radiation pattern and large percentage bandwidth has been observed. The percentage bandwidth at 2.41 GHz (2.07 GHz to 2.84 GHz) is 32.98 and the percentage bandwidth at 5.82 GHz (5.54 GHz to 6.14 GHz) is 10.13. The proposed antenna is simple and compact in size providing broadband impedance matching, consistent radiation pattern and appropriate gain characteristics in the RFID frequency range.

***Keywords*—Monopole antenna, RFID and WLAN.**

I. INTRODUCTION

In recent years, the technologies of wireless communication systems have been rapidly growing demands for greater capacities broadband service to support wireless devices. Antennas as one of the crucial components of these communication systems. A printed monopole antennas are indispensable for the application in wireless local area network (WLAN) and radio-frequency identification (RFID) applications. Along with the compact size, the antenna should be low cost, light weight, less fragile, low profile, and finally, the fabrication methodology should be simple. Many compact printed monopole antennas were fabricated for wireless applications and reported in the literature [1-6]. Our intention here is to design a microstrip fed folded strip monopole antenna, which can be used simultaneously for WLAN as well as RFID systems.

In this paper, a simple new printed microstrip fed folded strip monopole antenna (FSMA) with a protruding stub in the ground plane for the simultaneous applications in the WLAN and RFID is presented. There are two resonant paths in the proposed antenna, one in the folded strip and the other in the protruding stub in the ground plane. It supports two resonances at 2.41 GHz and 5.82 GHz, which are the center frequencies of the WLAN and RFID. The antenna is constructed by a non-conductor backed folded strip with a microstrip feed line. The dual-band performance can be easily obtained for this type of antenna by fine-tuning the lengths of the two resonant paths in the folded strip and the protruding stub in the ground plane.

II. ANTENNA DESIGN

The dual-band monopole antenna (DBMA) with a microstrip fed folded strip and a protruding stub in the ground plane is printed on the FR4 substrate of relative permittivity 4.4 and thickness 1.6 mm as shown in the Figure 1. A 50-Ohm microstrip line is used for the excitation. The folded strip width and protruding stub width of the proposed dual band monopole antenna is 3 mm, same as that of the width of the microstrip line. The remaining design parameters are given in Fig.1. The proposed antenna has two resonant paths, one in the folded strip (L_α) of the radiating element and the other (L_β) in the protruding stub of the ground plane. The length of the resonant path in the folded strip is L_α = 29.8 mm, which is $0.23\lambda_1$, at the first resonant frequency of 2.41 GHz (f_1 = 2.41 GHz).

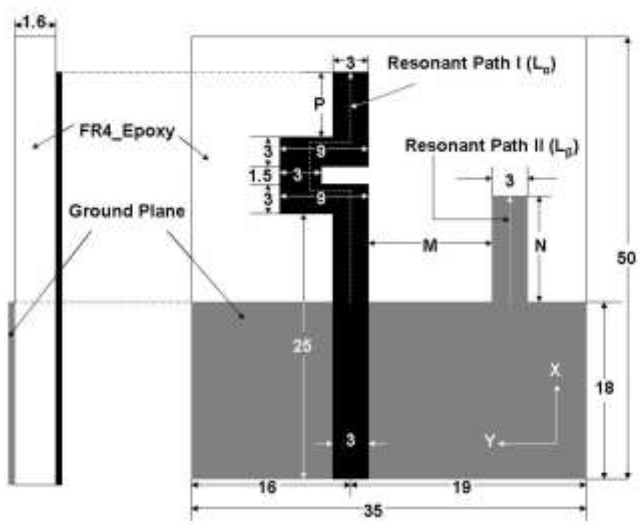

Fig. 1 Geometry of the proposed antenna with M= 8 mm, N=12 mm and P=4.8 mm.

Similarly, the length of the second resonant path in the protruding stub of the ground plane is L_β=12 mm, which is $0.23\lambda_2$, at the second resonance frequency of 5.82 GHz (f_2 = 5.82 GHz). By properly varying the lengths L_α and L_β, we can fix the antenna resonance at 2.41 GHz and 5.82 GHz, respectively. The overall adjustments of the geometrical parameters are done for the improvement of impedance bandwidth in the 2.4 GHz and 5.8 GHz bands. The full wave simulator IE3D [7] is used to simulate the proposed antenna.

III. RESULT AND DISCUSSION

Fig. 2 shows the comparison of the simulated reflection coefficient (|$S11$|) (dB) and the measured reflection coefficient (|$S11$|) (dB) of the folded strip monopole antenna with a protruding stub in the ground plane. The reflection coefficient measurement was done by using the Rohde and Schwarz ZVA24 vector network analyzer. From the graph it is quite clear that there is reasonably good agreement between the measured and the simulated reflection coefficients (|$S11$|) (dB). The experimental lower and upper cut off frequencies are quite clearly matching with the simulated lower and upper cut off frequencies and confirm good fabrication quality of the fabricated prototype. With the measurement, the first resonance occurs at 2.41 GHz having the reflection coefficient value of -40.47 dB with percentage bandwidth of 32.98 and the second resonance occurs at 5.82 GHz having the reflection coefficient value of -20.19 dB with percentage bandwidth of 10.13. Hence, from the experimental results, it is clear that the fabricated prototype can be used for the dual band WLAN and RFID applications around 2.4GHz and 5.8 GHz.

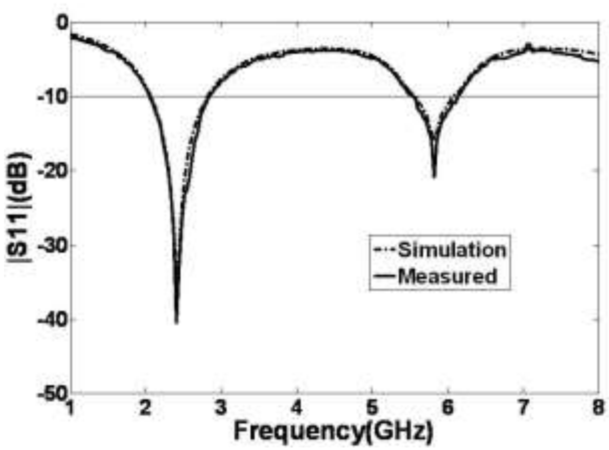

Fig. 2. Comparison of the simulated and the measured reflection coefficients (|$S11$|) (dB) of the proposed dual-band monopole antenna for WLAN and RFID applications.

Fig. 3 and Fig. 4 show the simulated antenna impedance vs. frequency and the gain (dBi) vs. frequency for the folded-strip monopole antenna with a protruding stub in the ground plane.

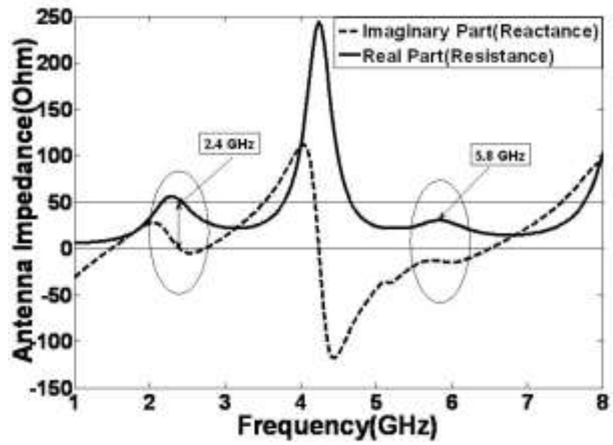

Fig. 3. Simulated antenna impedance (Ohm) vs. frequency of the proposed antenna.

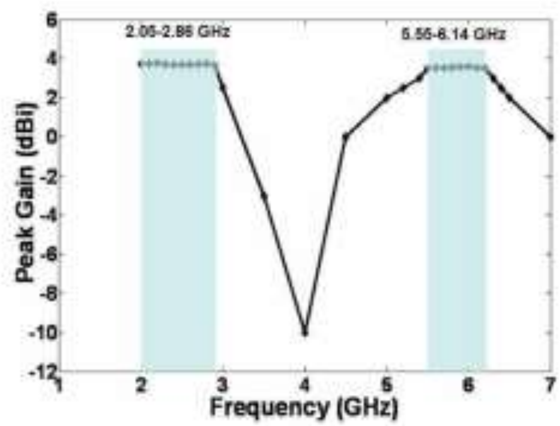

Fig. 4 Simulated gain (dBi) vs. frequency of the proposed antenna.

In Fig. 3, the simulated variation of the antenna input impedance versus frequency of the folded-strip monopole antenna with a protruding stub in the ground plane can be seen. At the resonance frequency of 2.41 GHz and 5.82 GHz , the average value of the resistance (real part) is approximately 50-Ohms and the average value of the reactance (imaginary part) is 0-Ohms signifies the adequate impedance matching occurs at the two desired resonant frequencies. The Fig.4 depicts the variation of peak gain in dBi of the proposed monopole antenna with the frequency. The peak gain increases smoothly with the frequency. The gain at 2.41 GHz is 3.68 dBi and the gain at 5.82 GHz is 3.58 dBi. The proposed antenna provides sufficient and appropriate gain required for the operation in the WLAN and RFID (2.4 GHz and 5.8 GHz) band.

Fig.5 shows the variation of the distance M between the folded strip of the radiating element and the protruding stub in the ground plane when the other parameters such as (N=12 mm) and (P=4.8 mm) remain constant. From the graph it is clearly visible that when M increases from 4 mm to 12 mm, the first resonant frequency ($f1$) moves towards left, which means that the first resonant frequency ($f1$) decreases with the increase of the distance M. But on the other hand, the second resonant frequency ($f2$) is remaining static at 5.8 GHz, but the performance degrades at M=10 mm and 12 mm.

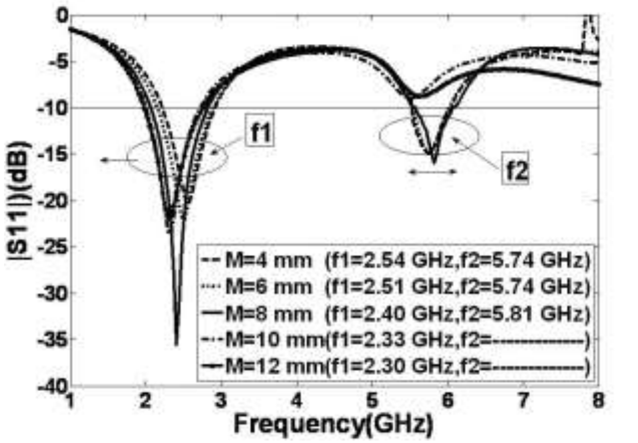

Fig. 5 Simulated reflection coefficient (|$S11$|) (dB) graphs varying M when N=12 mm and P=4.8 mm.

Fig.6 shows the variation of the length N of the protruding stub in the ground plane when the other parameters such as (M =8 mm) and (P =4.8 mm) remain constant. From the graph it is clearly visible that when N increases from 8 mm to 16 mm, the first resonant frequency (f_1) moves towards left, which means that the first resonant frequency (f_1) decreases with the increase of the distance M. But on the other hand, the second resonant frequency (f_2) is remaining static at 5.8 GHz.

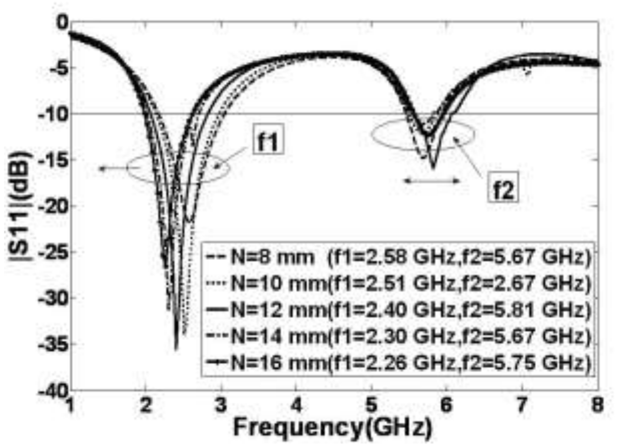

Fig. 6 Simulated reflection coefficient (|$S11$|) (dB) graphs varying N when M=8 mm and P=4.8 mm.

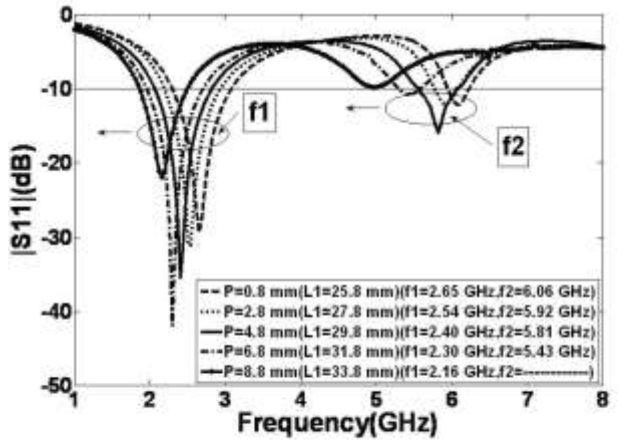

Fig. 7 Simulated reflection coefficient (|$S11$|) (dB) graphs varying P when M=8 mm and N=12 mm.

Fig.7 shows the variation of the length P of the radiating element (means also the total length of the folded strip (L_1) when the other parameters such as (M =8 mm) and (N =12 mm) remain constant. From the graph it is clearly visible that when P increases from 0.8 mm to 8.8 mm, the first resonant frequency (f_1) moves towards left, which means that the first resonance frequency (f_1) decreases with the increase of the distance M. But on the other hand, the second resonant frequency (f_2) is also decreases with the increase of P, which means the second resonant frequency (f_2) movers towards left but the performance degrades at P=8.8 mm.

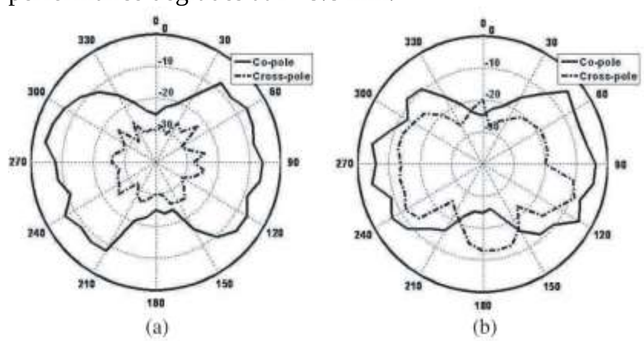

Fig. 8 Simulated E-plane (xz-plane)(Co-pol) radiation patterns at (a) 2.41 GHz and (b) 5.82 GHz.

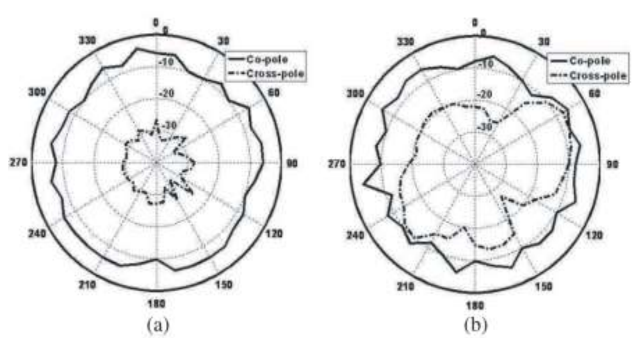

Fig. 9 Simulated H-plane (yz-plane)(Co-pol) radiation patterns at (a) 2.41 GHz and (b) 5.82 GHz.

The E-plane (xz-plane) and H-plane (yz-plane) radiation patterns from the IE3D simulation [7] of the folded strip monopole antenna with a protruding stub at 2.41 and 5.82 GHz are shown in the Fig. 8 and Fig. 9 respectively. The H plane radiation pattern is purely omni-directional at all the simulated frequencies. In the E-plane, the radiation pattern is like a small dipole leading to a bi-directional radiation pattern. The E-plane radiation pattern is directional along 90^0 and 270^0 respectively. In the E-plane, the radiation patterns remain roughly a dumbbell shape like a small dipole leading to bidirectional patterns. Hence, this proposed folded strip monopole antenna with a protruding stub demonstrates a consistent radiation pattern in the desired band of frequencies.

IV. CONCLUSION

A printed monopole antenna with a protruding stub in the ground plane for dual band WLAN and RFID is designed. Satisfactory dual band operation for WLAN and RFID application can be easily achieved by the proposed antenna. Two distinct operating bands which can meet all the requirements for WLAN and RFID standard are obtained, ranging from 2.07-2.84 GHz and 5.54-6.14 GHz. The proposed antenna is simple and compact in size providing broadband impedance matching, consistent radiation pattern and appropriate gain characteristics in the WLAN and RFID frequency range.

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