Design of a printed dual band monopole antenna for WLAN and RFID applications with a protruding stub in the ground plane

Rajneesh Mishra, Ravi Mohan, Sumit Sharma

Abstract— Design of a simple and compact microstrip fed folded strip monopole antenna with a protruding stub in the ground plane for the radio frequency identification (RFID) and wireless local area network (WLAN) is presented. Theantenna has two resonant paths, one in the radiating element (folded strip) and other in the protruding stub of the ground plane,it supports two resonances at 2.42 GHz and 5.81 GHz which are the operating frequency band for RFID and WLAN. Effectively consistent omnidirectional radiation pattern have been observed in both the frequency band from both simulation and experimental results. The measured percentage fractional bandwidth of the printed monopole antenna at 2.42GHz (2.06 GHz to 2.82 GHz) is 32.97, and at 5.81 GHz (5.56 GHz to 6.15 GHz) is 10.12. the proposed antenna is simple and compact in size providing broad band impedance matching, consistent radiation patterns and appropriate gain characteristics in the RFID and WLAN frequency ranges.

***Index Terms*—compact microstrip, fed folded strip monopole antenna, RFID and WLAN frequency.**

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. Compact printed monopole antennas are indispensable for the application in wireless local area network (WLAN), ultra-wideband (UWB) and radio-frequency identification (RFID) applications. Along with the compact size, the antenna shouldbe 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 stripmonopole 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 inthe ground plane. It supports two resonances at 2.42GHz and 5.81 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 feedline. The dual-band performance can be easily obtainedfor this type of antenna by fine-tuning the lengths of the two resonantpaths in the folded strip and the protruding stub in the ground plane.

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II. ANTENNADESIGN

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 1.6mm 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 DBMA is 3 mm, same as that of the width of the microstripline. The remaining design parameters are given in Fig.1.

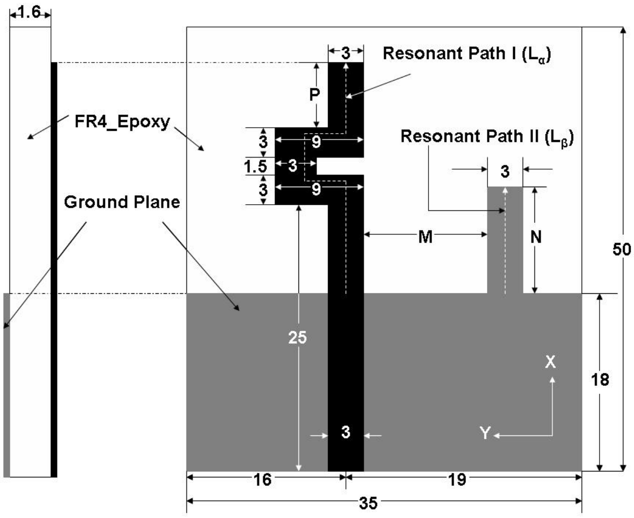

Fig. 1. Geometry of the proposed antenna with M= 8mm, N=12 mm andP=4.8 mm.

The proposed antenna has two resonant paths, one in the folded strip (L_α) of the radiating element and the other (L_β= N) in the protrudingstub of the ground plane. Thelength 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 2.42 GHz (f_1 = 2.42 GHz).Similarly, the length of the second resonant path in the protruding stub of the ground plane is L_β= N= 12 mm, which is $0.23\lambda_2$, at the second resonance frequency of 5.81 GHz (f_2 =

5.81 GHz). By properly varying the lengths L_α and L_β, we can fix the antenna resonance at 2.42 GHzand 5.81 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. RSEULTANDDISCUSION

Figure 2 shows the comparison of the simulated and measured graphs of the reflection coefficient (|S11|) (dB) ofthe proposed antenna. The reflection coefficient measurement was performed by using Rohde and Schwarz ZVA24 vector network analyser. From the graph, it is quite clear that there is reasonably goodagreement between the measured and simulated reflection coefficients (|S11|) (dB). With the measurement, the first resonance occurs at 2.42 GHz having the reflection coefficient valueof -40.42 dB with percentage fractional bandwidth (FBW) of 32.97(2.06 GHz to 2.82 GHz), and the second resonance occurs at 5.81 GHz having the reflection coefficient value of -20.19 dB with percentage FBW of 10.12. (5.56 GHz to 6.15 GHz).

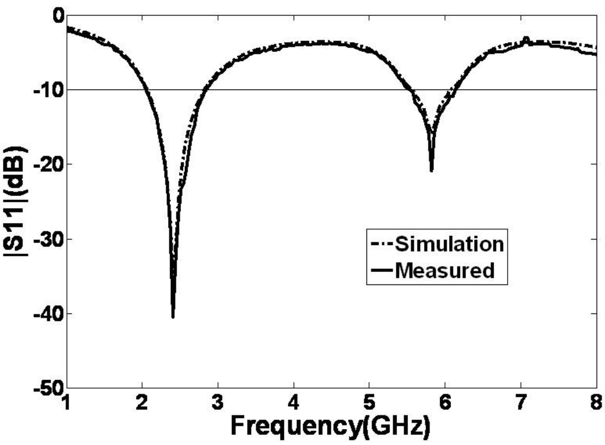

Fig. 2.Comparison of the simulated and the measured reflection coefficients (|$S11$|) (dB) of the proposed dual-band monopole antenna for WLAN and RFID applications.

Fig. 3 show the simulated antenna gain (dBi) vs. frequency for the folded-stripmonopole antenna with a protruding stub in the ground plane.the measured peak gain in dBi of the proposed antenna. The measured peak gain at2.42 GHz is 3.71 dBi, and the measured peak gain at 5.81 GHz is 3.56 dBi. The measured peak gain is almost consistent in the frequency range of 2.06 GHz to2.82 GHz, and the average peak gain in sthis frequency range is 3.73 dBi. Similar situation can be seen in the frequency range of 5.56 GHz to 6.15 GHz. The average measured peak gain in this frequency range is approximately 3.61dBi.

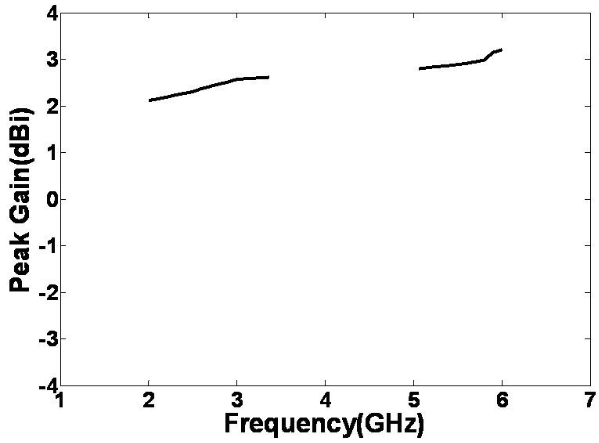

Fig. 3. Simulated gain (dBi) vs. frequency of the proposed antenna.

Fig.4 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 (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 5.81 GHz, but the performance degrades at M=10 mm and 12 mm.

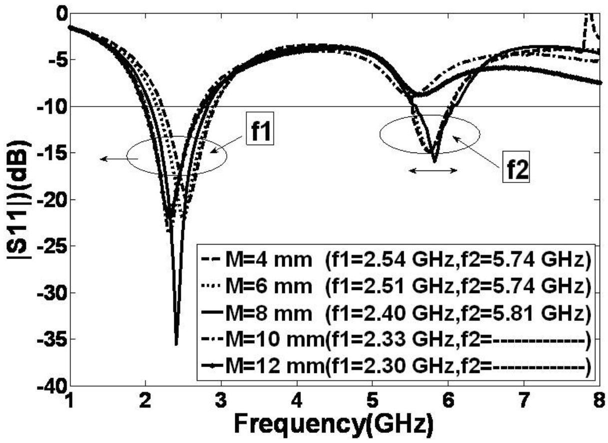

Fig. 4. Simulated reflection coefficient (|$S11$|) (dB) graphs varying M whenN=12 mm and P=4.8 mm.

Fig.5 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 itis clearly visible that when N increases from 8 mm to 16 mm,the first resonant frequency (f_1) moves towards left, whichmeans that the first resonant frequency (f_1) decreases with theincrease of the distance M. But on the other hand, the secondresonant frequency (f_2) is remaining static at 5.81 GHz.

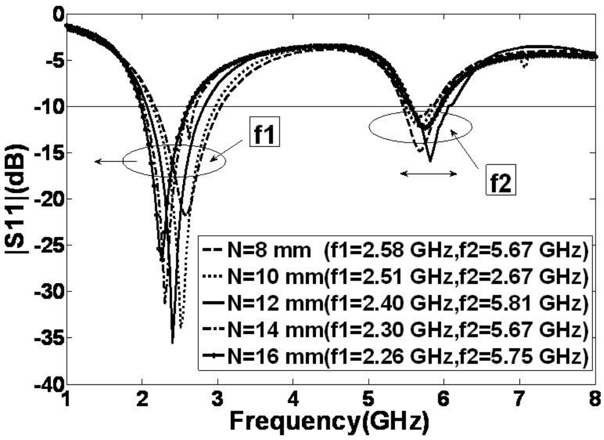

Fig. 5. Simulated reflection coefficient (|$S11$|) (dB) graphs varying N whenM=8 mm and P=4.8 mm.

Fig.6 shows the variation of the length P of the radiatingelement when the other parameters such as (M =8 mm) and (N =12mm) remain constant. From the graph it is clearly visible that when P increases from 0.8 mm to 8.8 mm, the firstresonant frequency (f_1) moves towards left, which means thatthe first resonance frequency (f_1) decreases with the increaseof the distance M. But on the other hand, the second resonantfrequency (f_2) is also decreases with the increase of P, whichmeans the second resonant frequency (f_2) movers towards leftbut the performance degrades at P=8.8 mm.

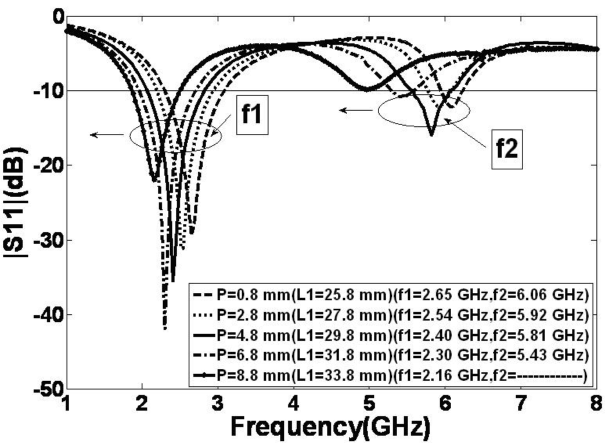

Fig. 6. Simulated reflection coefficient (|$S11$|) (dB) graphs varying P whenM=8 mm and N=12 mm.

The E-plane (xz-plane) and H-plane (yz-plane) radiation patterns from the IE3D simulation [7] of the folded stripmonopole antenna with a protruding stub at 2.42 and 5.81 GHzare shown in the Fig. 7 and Fig. 8 respectively. The Hplaneradiation pattern is purely omni-directional at all thesimulatedfrequencies. In the E-plane, the radiation patternis like a small dipole leading to a bi-directional radiationpattern. The E-plane radiation pattern is directional along $90^0$and 270^0 respectively. In the E-plane, the radiation patternsremain roughly a dumbbell shape like a small dipole leadingto bidirectional patterns. Hence, this proposed folded stripmonopole antenna with a protruding stub demonstrates aconsistent radiation pattern in the desired band of frequencies.

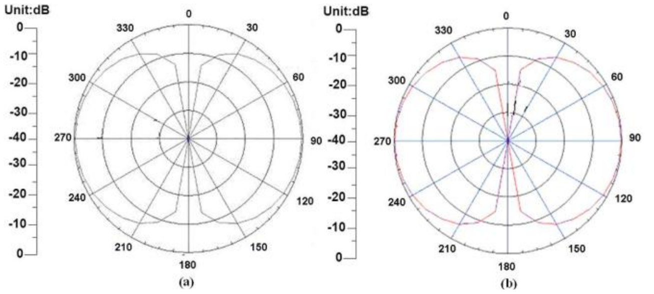

Fig. 7. Simulated E-plane (xz-plane)(Co-pol) radiation patterns at (a) 2.4GHz and (b) 5.8 GHz.

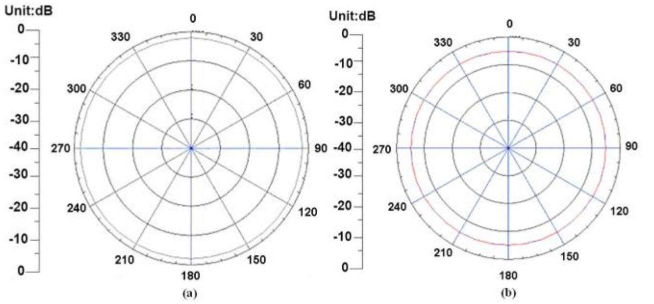

Fig. 8. Simulated H-plane (yz-plane)(Co-pol) radiation patterns at (a) 2.4GHz and (b) 5.8 GHz.

IV. Conclusion

A simple microstrip fed folded strip monopole antenna witha protruding stub in the ground plane for RFID and WLAN operations has been presented. Satisfactory dual-band operation for WLAN and RFID applications is easily achieved by the proposed antenna. The proposed antenna has the advantages of simple structure, easy fabrication, low cost and compact size, showing good dual band operating bandwidthand stable radiation pattern and appropriate gain characteristic in the RFID and WLAN frequency ranges. Consequentlythe proposed antenna isexpected to be a good candidate for RFID and WLAN wireless communication system.

Appendix

Appendixes, if needed, appear before the acknowledgment.

Acknowledgment

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ... .” **Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page**.

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