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. The antenna 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 2.42 GHz (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 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 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 microstrip line. The remaining design parameters are given in Fig. 1.

The proposed antenna has two resonant paths, one in the folded strip (Lα) of the radiating element and the other (Lβ = N) in the protruding stub of the ground plane. The length of the resonant path in the folded strip is Lα = 29.8 mm, which is 0.23λ1 at the first resonant frequency of 2.42 GHz (f1 = 2.42 GHz). Similarly, the length of the second resonant path in the protruding stub of the ground plane is Lβ = N = 12 mm, which is 0.23λ2 at the second resonance frequency of 5.81 GHz (f2 =
Design of a printed dual band monopole antenna for WLAN and RFID applications with a protruding stub in the ground plane

5.81 GHz). By properly varying the lengths $L_{\alpha}$ and $L_{\beta}$, we can fix the antenna resonance at 2.42 GHz and 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. RESULTS AND DISCUSSION

Figure 2 shows the comparison of the simulated and measured graphs of the reflection coefficient ($|S11|$) (dB) of the 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 good agreement between the measured and simulated reflection coefficients ($|S11|$) (dB). With the measurement, the first resonance occurs at 2.42 GHz having the reflection coefficient value of -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 measured reflection coefficients ($|S11|$) (dB) of the proposed dual-band monopole antenna for WLAN and RFID applications.](image1)

Figure 3 shows the comparison of the simulated and measured reflection coefficients ($|S11|$) (dB) graphs varying $M$ when $N=12$ mm and $P=4.8$ mm.

![Fig. 3. Simulated gain (dBi) vs. frequency of the proposed antenna.](image2)

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 $(N = 12 \text{ mm})$ and $(P = 4.8 \text{ mm})$ 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 $M$ when $N=12$ mm and $P=4.8$ mm.](image3)

Fig. 5 shows the variation of the length $N$ of the protruding stub in the ground plane when the other parameters such as $(M = 8 \text{ mm})$ and $(P = 4.8 \text{ mm})$ 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 5.81 GHz.

![Fig. 5. Simulated reflection coefficient ($|S11|$) (dB) graphs varying $N$ when $M=8$ mm and $P=4.8$ mm.](image4)
Fig. 5. Simulated reflection coefficient ($|S_{11}|$) (dB) graphs varying N when M=8 mm and P=4.8 mm.

Fig. 6 shows the variation of the length P of the radiating element 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 ($f_2$) moves towards left but the performance degrades at P=8.8 mm.

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 are shown in the Fig. 7 and Fig. 8 respectively. The H-plane radiation pattern is purely omni-directional at all the simulated frequencies. In the E-plane, the radiation patterns are like a small dipole leading to a bi-directional radiation pattern. The E-plane radiation pattern is directonal along 90° and 270° respectively. In the E-plane, the radiation patterns remain roughly a dumbbell shape like a small dipole leading to a bidirectional pattern. 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 simple microstrip fed folded strip monopole antenna with a 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 bandwidth stable radiation pattern and appropriate gain characteristic in the RFID and WLAN frequency ranges. Consequently, the proposed antenna is expected 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.

REFERENCES

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


Rajneesh Mishra, Electronics & Communication Engineering Department, Sri Ram Institute Of Technology, Jabalpur, India, +918853473379.

Ravi Mohan, Electronics & Communication Engineering Department, Sri Ram Institute Of Technology, Jabalpur, India

Sumit Sharma, Electronics & Communication Engineering Department, Sri Ram Institute Of Technology, Jabalpur, India.