Design and Analysis of a Compact Triple Band Printed Monopole Antenna for Wireless Applications

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***Abstract*— Wireless communication systems have made tremendous development during the modern days. In consideration with the current advancement in the wireless networks it has become an unavoidable fact that an efficient interoperable antenna has to be developed so that it can be accommodated in handy devices making itself work both on WLAN and WiMAX. To simulate, fabricate, and analyze the multi frequency printed monopole antenna applied to both WLAN and WiMAX systems is proposed in this paper. The antenna structure is simple, and the size is 34 × 18 mm^2. The proposed microstrip fed antenna mainly comprises a fork-shaped strip that is etched on a modified rectangular ring and the rectangular- defected ground plane. To experimentally analyze the characteristics of this antenna, the design and the measurement have been completed. Good antenna performance has been obtained.**

The proposed Compact Triple Band Printed Monopole Antenna will be designed and simulated using 3D Electromagnetic (EM) Simulation tool of CST Microwave Studio. The operating frequency of this antenna is 2.40–2.71, 3.31–3.79, and 5.13–5.91 GHz, which can cover almost all WLAN and WiMAX bands.

Keywords— Antenna; communication; WiMAX;

I. INTRODUCTION

The Wireless Local Area Network (WLAN) requires the antenna to operate at 2.4-2.484, 5.15-5.35, and 5.725-5.825 GHz and the worldwide interoperation for microwave access (WiMAX) requires the antenna to operate at: 2.5-2.69, 3.4-3.69, and 5.25-5.85 GHz. These have attracted high attention and have been widely applied in portable wireless communication devices like mobile phone and PDAs. The monopole antenna has the characteristics of low cost, light weight, less fragile, and low profile. Thus, many designs of dual or multiband antennas have been proposed to the applications of WiMAX and WLAN.

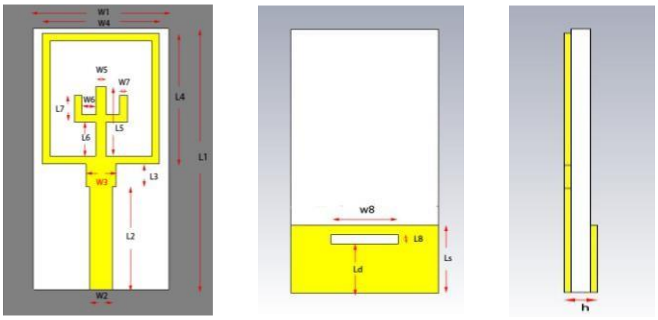
Many antennas, such as the G-shaped antenna, the inverted L-shaped strip antenna, and the 9-shaped antenna, cover only WLAN bands. Antennas that are designed to satisfy the requirement of WLAN and WiMAX system have a drawback that these antennas have a relatively larger in size. A new microstrip-fed modified rectangular ring antenna is presented for WLAN and WiMAX applications. It has a smaller size than the antennas mentioned above. By introducing a modified rectangular ring strip and adding a fork shaped strip and a defected ground, a significant triple band is obtained, which can satisfy both WLAN and WiMAX system.

The main focus of this paper is to simulate, fabricate and analyze the Compact Triple Band Printed Monopole Antenna. The proposed antenna is to be fabricated and measured. The measured results are to be compared simulated data for its agreement. To present the Details of design, parameter studies, and experimental results such as |S11| curves, radiation patterns, and antenna gains.

II. THEORY AND PROPOSED ANTENNA

The antenna proposed is the Compact Triple Band Printed Monopole Antenna mainly comprising of a fork-shaped strip that is etched on a modified rectangular ring and the rectangular- defected ground plane. The operating frequency of the antenna to be in the ranges 2.4–2.484, 5.15–5.35, and 5.725–5.825 GHz which is the required frequency of operation for the WLAN/WiMAX devices.

Fig. 1 shows the geometry of the proposed printed monopole antenna. The compact radiator is connected with a 50-Ω microstrip line and is composed of a modified rectangular ring and a fork-shaped strip. These elements with a defected ground are fabricated on a dielectric substrate of FR4 with length L1 = 34 mm and width W1 = 18 mm. To obtain better antenna performance, W2 is fixed at 3 mm as the thickness of the substrate h is 1.6 mm and the relative permittivity of the substrate is 4.4. The parameters of the designed antenna are simulated and optimized by 3D Electromagnetic (EM) Simulation tool of CST Microwave Studio and are demonstrated in Table I. Based on these dimensions, the antenna was fabricated and Measured. Fig. 2 shows the fabricated prototype of the antenna. To have a further understanding of the radiation mechanism of this multifrequency antenna, the design process is presented in Fig. 3 and its corresponding |S11| curves are presented in Fig. 4. Antenna I is a modified rectangular ring printed monopole antenna, which has a strip printed under the rectangular ring. It is a common compact antenna with a simple structure and has two operating bands 2.43–2.84 and 5.21–5.47 GHz. By attaching a fork-shaped strip, another resonant mode is excited, which makes the antenna achieve three bands. Three frequency bands of Antenna II are observed as follows: 2.41–2.70, 3.32–3.72, and 5.39–5.74 GHz. To make the antenna achieve better impedance matching at higher band, a rectangular slot is etched on the ground plane. The simulated |S11| curve in Fig. 4 shows that Antenna III is able to achieve three resonant bands of 2.40– 2.71, 3.31–3.79, and 5.13–5.91 GHz, which can cover almost all WLAN and WiMAX bands. The designed antenna is shown in the Fig. 1 and the parameters of the designed antenna is shown in the table 1.



Front view Rear view Side view

Fig 1. Configuration of the proposed antenna

Parameter	Size (mm)	Parameter	Size (mm)
L_1	34	W_1	18
L_2	13.4	W_2	3
L_3	3	W_3	4
L_4	17	W_4	15.5
L_5	9	W_5	1.4
L_6	4.4	W_6	1.8
L_7	2	W_7	1
L_8	1.2	W_8	8.2
L_s	8.7	h	1.6
L_d	6.3	a	1

Table 1 Parameters of the proposed antenna

III. RESULTS AND DISCUSSIONS

The parameters like S-parameter (Fig. 1), VSWR (Fig. 3), gain, directivity and current distribution was measured. It can be observed that desired antenna performance has been established in the operating frequency range.

From the surface current distributions at center frequencies of the three bands it can be observed that at the lower and higher band, the current concentrated on the rectangular ring and the strip under it. The current distribution reveals that the rectangular ring and the strip play an important role in the generation of the two resonant modes of the lower band and higher band. At the middle band, the current is significantly distributed along the fork-shaped strip. It can be concluded that the fork-shaped strip excites a new resonant mode at 3.5 GHz. The study of current distributions also validates the antenna analysis above.

Some important parameters are investigated in order to achieve independent frequency control. It was noted that, with the increase of L4, the lower and higher band shift left while the middle band is almost invariable.

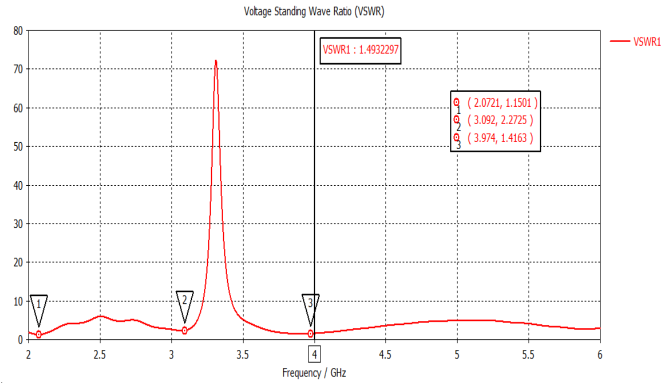


Fig 2. VSWR

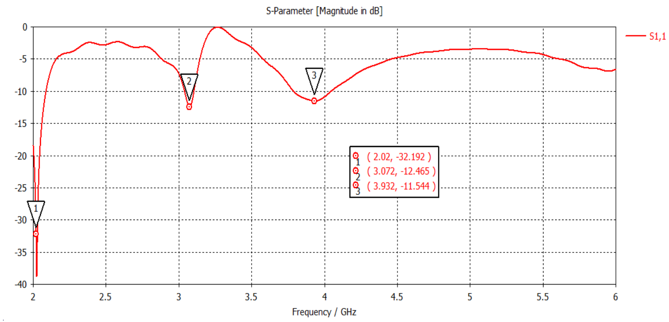
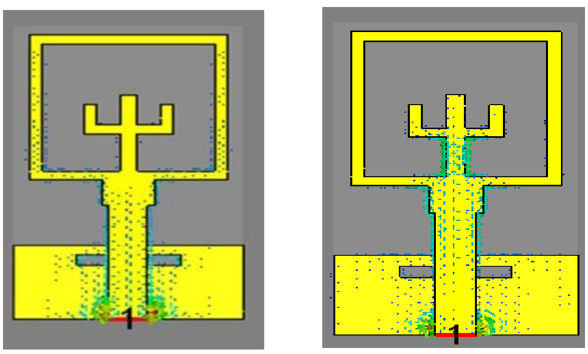


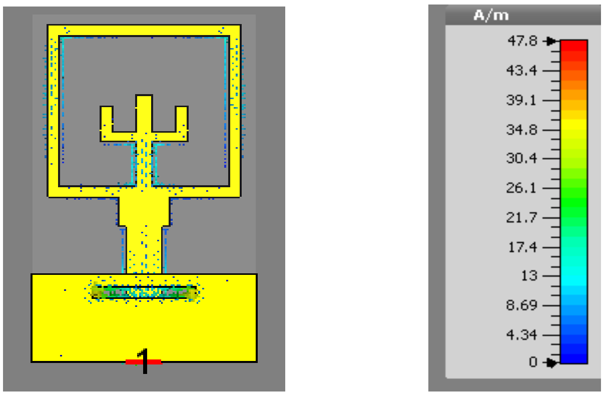
Fig 3. S-parameter

By optimizing the values of L4 and L7, the operating bands can be tuned, respectively. An important parameter analysis of W8 is also carried to analyze the effect of the rectangular slot. It was also realized that by increasing the length of the rectangular slot, the higher band becomes wider. It means that by increasing the length of the slot, the proposed antenna can achieve better impedance matching at the higher band. To cover the desired band, W8 is fixed at 8.2 mm.



(a) (b)

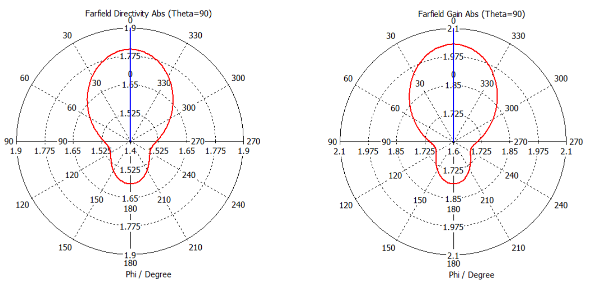
Fig 4. Current distributions at (a) 2-3 GHz (b) 4-5 GHz



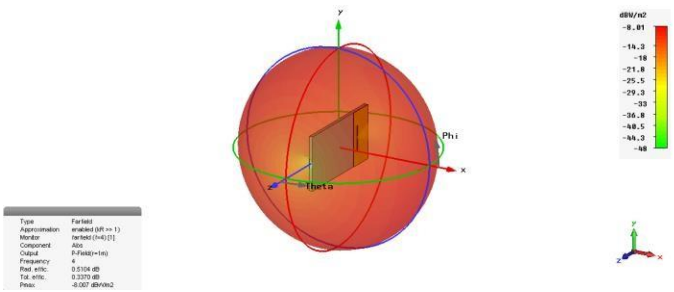
(c)

Fig 4. Current distributions at (a) 5-6 GHz

Furthermore, Directivity, gain and radiation pattern of the antenna has been indicated to show the better performance of the designed antenna.

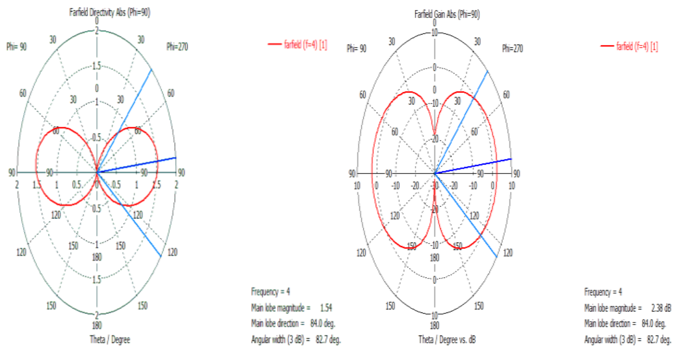


(a) (b)



(c)

Fig 5. (a) Directivity, (b) Gain at Theta= 90°, (c) Radiation Pattern.



(a) (b)

Fig. 6 (a) Directivity, (b) Gain at Phi= 90°

Fig 5 (a) & (b) shows the Directivity and gain with theta set at 90°. The radiation pattern of the antenna is shown in the Fig. 5 (c). similarly the gain and directivity obtained with Phi =90° is shown in the Fig 6 (a) & (b)respectively.

IV. CONCLUSION

A compact printed monopole antenna is designed for WLAN and WiMAX system. By etching a rectangular slot in the ground plane and adding a fork-shaped strip in a modified rectangular ring, the antenna can produce three resonant modes for desired applications.

Reasonable S_{11} parameters below -10dB has been obtained in the frequency ranges 2.41–2.63, 3.39–3.70, and 4.96–6.32 GHz. The VSWR values obtained are 15, 2.2, 1.4 respectively in the three bands. Omnidirectional radiation patterns, reasonable gains, small size, and easy fabrication make the antenna a suitable candidate for WLAN/WiMAX applications.

V. REFERENCES

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