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# A compact CPW-Fed Tri-Band antenna for WLAN/WiMAX applications

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## Abstract

In this paper, A novel compact co-planar waveguide (CPW)-fed tri-band antenna with dual band-notched characteristic is proposed. This antenna consists of a circular element, two inverted L-shaped slots, and a T-shaped slot etched into the circular element, which lead to the desired high attenuation at the two notch frequencies: 2.56 GHz – 3.25 GHz and 3.8 GHz – 4.96 GHz. The proposed tri-band antenna is CPW-fed and printed on an low-cost FR-4 substrate with only 20 mm × 28 mm surface area. The antenna is successfully simulated by the full-wave electromagnetic (EM) simulator HFSS and measured to cover the bandwidth for WLAN and WiMAX (2.40 GHz – 2.54 GHz, 3.24 GHz – 3.76 GHz, 4.96 GHz – 6.65 GHz) applications. Experimental results show that, the proposed tri-band antenna is obtained with promising performances, including omnidirectional radiation patterns and stable gains across its whole operation bands.

## Keywords

CPW-Fed, Microstrip Antenna, Tri-Band Antenna, WLAN/WiMAX

## 1. Introduction

In modern wireless communication systems, such as Wireless Local Area Networks (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX), many interests are concentrated on antennas with multiple operation bands, compact sizes, omnidirectional radiation patterns, and sufficient impedance bandwidths, etc. In order to meet this immediate need, a large variety of multi-band antennas have been developed [1]–[23]. In [1], a tri-band antenna is designed using a novel asymmetric ring structure. Tri-band fractal antenna is developed in [2] for RFID applications. Modified swastika shape patch is employed to realize a tri-band antenna in [3]. In [4] and [5], co-planar waveguide (CPW)-fed antennas are used for WLAN and WiMAX applications. In [6], spline-shaped antenna is developed for dual-band Wi-Fi applications. Recently, the design methods of using slot antennas [7]–[14] and monopole antennas [15]–[23] to satisfiy multi-band requirements are widely investigated. Although wideband [24], [25] or ultra-wideband (UWB) [26]–[29] antennas can cover all the operation bands in WLAN/WiMAX communication systems, frequency interference cannot be avoided.

The antennas in [1]–[29] have their own merits, however, they also suffer from some drawbacks. For example, the presented antenna in [1] is complicated in structure. The design procedure of the proposed antenna in [15] is complex, and the third band cannot cover the WLAN operation band. The proposed antennas in [6], [13], and [14] are dual-band antennas which can not satisfy all the WLAN and WiMAX operation bands. The overall dimensions of the proposed antennas in [3], [7]–[11], and [19] are large, which may limit their integration with future miniaturized portable devices in wireless communication systems.

In this paper, a novel compact CPW-fed tri-band antenna with slots characteristics is proposed. The proposed antenna is composed of a circular radiator with two inverted L-shaped slots and a T-shaped slot. It is able to generate three separate impedance bandwidths to cover the 2.4, 5.2, and 5.8 GHz

WLAN operation bands and the 3.5 and 5.5 GHz WiMAX operation bands. The antenna is designed and optimized by using the full-wave electromagnetic (EM) simulation tool ANSYS HFSS V13. In addition, the antenna is with extremely simple structure which incarnates the suitability of the tri-band antenna for WLAN and WiMAX applications. Moreover, the antenna is very compact which occupies only 20 mm × 28 mm. Detailed design procedures of the proposed tri-band antenna and the simulated and measured results are exhibited and discussed.

## 2. Antenna Design

The specific configuration of the proposed CPW-fed tri-band antenna is shown in Fig. 1. The antenna consists of a circular element with two inverted L-shaped slots and a T-shaped slot. The antenna is designed on a 1.6 mm-thick low-cost FR-4 substrate with a relative permittivity of 4.4 and a loss tangent tanδ = 0.02. A 50 Ω CPW transmission line with a signal strip width of 3.0 mm is attached to the circular patch, and the gap between the fed-line and the co-planar ground plane is 0.38 mm.

The design procedures of the presented tri-band antenna can be expresses as follows. First, the proposed antenna is excogitated as a circular element unit with a straight line (antenna 1 exhibited in Fig. 2) to generate one wideband resonant elements operating at about 2.9 GHz – 6.6 GHz. Thus, antenna 1 exhibited in Fig. 2 comes into being.

Secondly, a T-shaped slot is etched into the circular patch of antenna 1 to make the wideband with one notched band at about 3.8 GHz – 4.96 GHz. Antenna 2 and its return loss are depicted in Fig. 2. By turning the dimensions of the T-shaped slot, two resonant modes at about 3.5 and 5.5 GHz are excited.

Finally, two inverted L-shaped slots are etched into antenna 2 to compose the proposed antenna (antenna 3 shown in Fig. 2) to produce another notched band at about 2.56 GHz – 3.25 GHz.

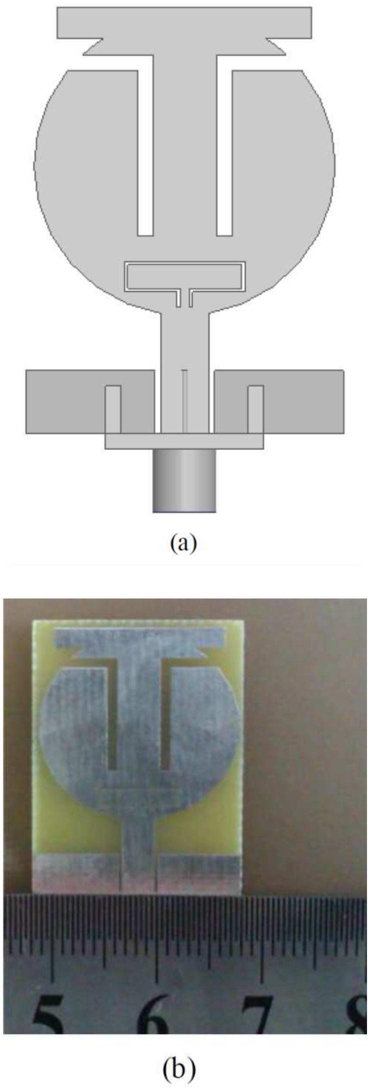


***Fig. 1.*** *(a) Specific configuration of the proposed tri-band antenna. (b) Photograph of the proposed tri-band antenna.*

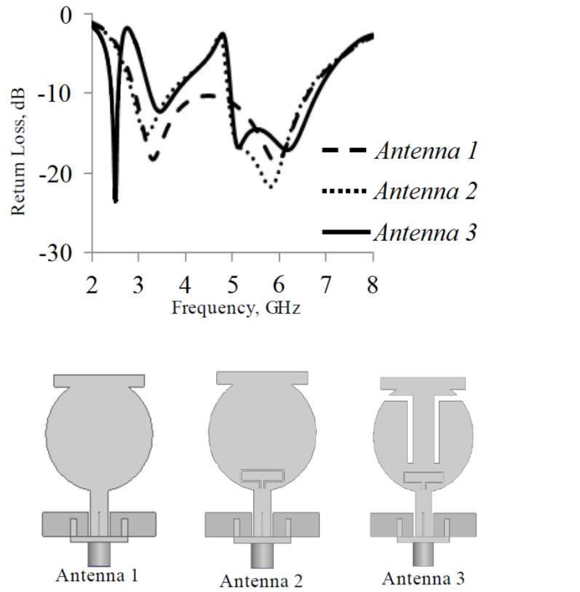


***Fig. 2.*** *Simulated return losses of various antennas involved.*

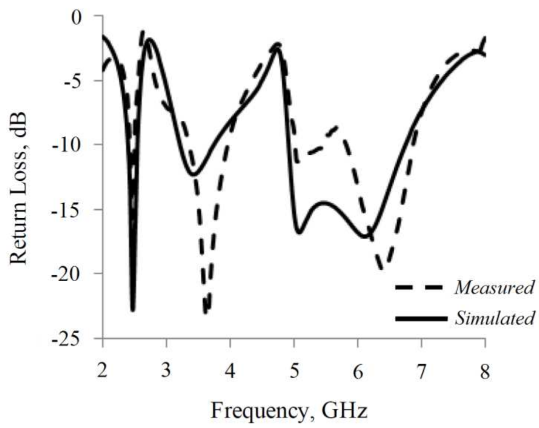


***Fig. 3.*** *Simulated and measured return losses of the proposed tri-band antenna.*

By adjusting the parameters of the T-shaped and L-shaped slots, it can produce three different bands centred at about 2.45, 3.5 and 5.5 GHz respectively, which cover WLAN 2.4 GHz, 5.2 GHz, and 5.8 GHz operation bands and WiMAX 2.5 GHz, 3.5 GHz, and 5.5 GHz operation bands.

## 3. Results and Discussion

Based on the above-mentioned design method, a tri-band antenna prototype is fabricated and measured. The simulation works are carried out by using the EM simulator ANSYS HFSS V13, and the measurements are performed in an Anechoic Chamber with an Agilent E8362C.

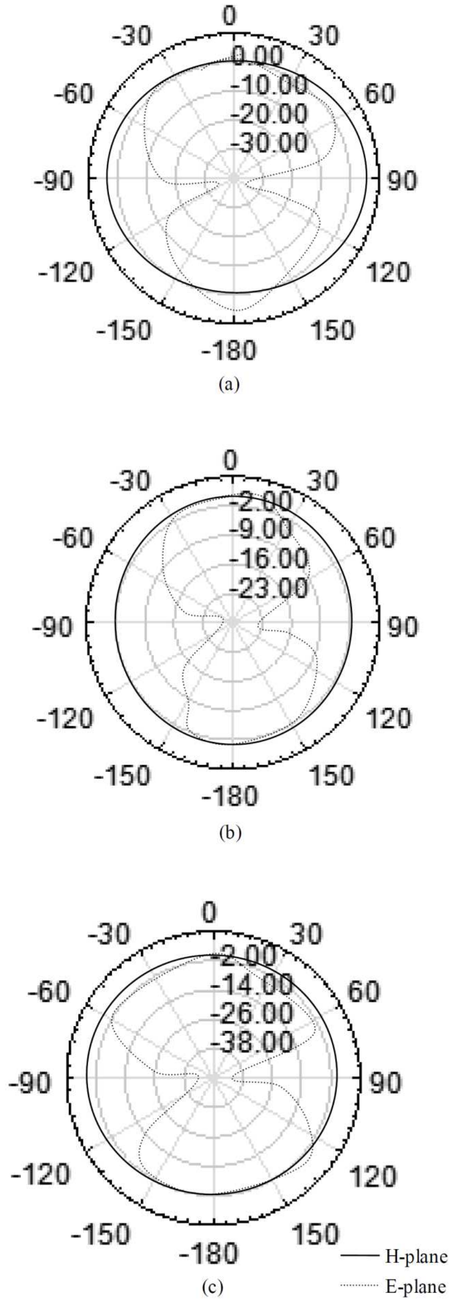


*Fig. 4. Measured radiation patterns of the proposed tri-band antenna at (a) 2.4 GHz, (b) 3.5 GHz, and (c) 5.5 GHz.*

Fig. 3 shows the simulated and measured reflection coefficients ($|S_{11}|$). It is observed that the measured and simulated results are in good agreement. The measured -10 dB impedance bandwidths for the lower band is 140 MHz (2.40 GHz – 2.54 GHz), and the middle and the upper bands are 520 MHz (3.24 GHz – 3.76 GHz) and 690 MHz (4.96 GHz – 6.65 GHz), respectively, which cover all the WLAN and WiMAX operation bands.

The measured far-field radiation patterns of the proposed antenna at 2.4 GHz, 3.5 GHz and 5.5 GHz are exhibited in Fig. 4. The radiation patterns are nearly omnidirectional in the H-plane (YOZ) and the radiation patterns in the E-plane (XOZ) are almost bidirectional.

Finally, the measured peak gains of the proposed antenna across the three bands are illustrated in Fig. 5. The average peak gains of the proposed antenna have values of 1.78, 2.27 and 3.63 dBi at about 2.40 GHz – 2.54 GHz, 3.24 GHz – 3.76 GHz, 4.96 GHz – 6.65 GHz, respectively. And stable gain variation can be observed.

Table 1 gives a comparison of the proposed tri-band antenna with some reported works of the same applications. From Table 1, It can be observed that the proposed tri-band antenna realizes tri-band performance capable of WLAN and WiMAX applications on a low-cost substrate with a compact circuit size as well as sufficient impedance bandwidths.

***Table 1.** Comparison of the proposed tri-band antenna with other reported works.*

| Refs. | Bandwidth (GHz) | Applications | Size ($mm^2$) |
|---|---|---|---|
| [3] | 2.28–3.23/3.28–3.94/5.05–6.17 | WLAN/WiMAX | 40 × 40 |
| [4] | 2.39–2.54/3.37–3.73/5.02–6.19 | WLAN/WiMAX | 30 × 27 |
| [5] | 2.39–2.69/3.38–3.73/5.0–5.99 | WLAN/WiMAX | 30 × 18 |
| [7] | 2.28–2.58/3.38–3.66/5.07–5.86 | WLAN/WiMAX | 40 × 40 |
| [8] | 2.37–2.72/3.39–4.07/4.92–6 | WLAN/WiMAX | 42 × 25 |
| [10] | 2.24–2.58/3.02–3.66/5.62–6.21 | WLAN/WiMAX | 35 × 30 |
| [11] | 2.01–2.85/3.12–3.79/5.09–6.03 | WLAN/WiMAX | 54 × 55 |
| [18] | 2.4–2.74/3.41–3.75/5.24–5.88 | WLAN/WiMAX | 30 × 20 |
| [19] | 2–2.89/3.18–3.95/4.7–5.95 | WLAN/WiMAX | 30 × 40 |
| [20] | 2.33–2.51/3.25–3.82/4.83–8.4 | WLAN/WiMAX | 20 × 30 |
| This work | 2.4-2.54/3.24-3.76/4.96-6.65 | WLAN/WiMAX | 20 × 28 |

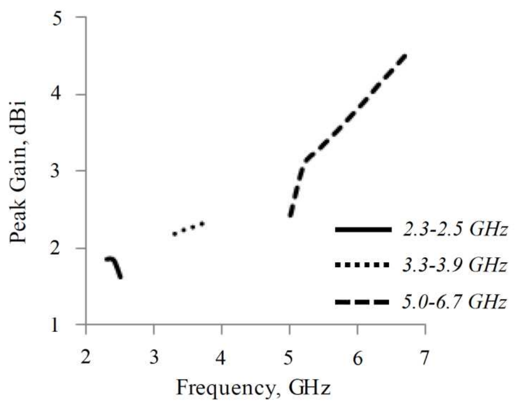


*Fig. 5. Measured peak gains of the proposed tri-band antenna at three operation bands.*

## 4. Conclusion

In this paper, a novel and compact CPW-fed tri-band antenna with T-shaped and L-shaped slots is proposed. A wideband antenna with dual band-notched characteristics can generate triple bands to meet WLAN and WiMAX applications. The antenna has a small size of only 20 mm × 28 mm and is simple in structure. Measured and simulated results exhibit that the tri-band antenna can excite three bands covering the 2.4/5.2/5.8 GHz WLAN and 2.5/3.5/5.5 GHz WiMAX bands, and exhibit omnidirectional radiation pattern performance in the H-plane. All this demonstrates that it is quite suitable for WLAN and WiMAX wireless communication systems.

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