

Modified Miniature Tri-band CPW-fed Antenna for RFID Applications

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Abstract— A modified tri-band CPW-fed antenna is designed on a PCBoard with $\epsilon_r = 4.4$ for RFID applications. The design is optimized to operate at 0.915 GHz, 2.45 GHz, 3.50 GHz using the finite element method. In this design, two U-shaped branches are added as additional resonators to achieve multi-band operation based on our previous design. Simulation shows that the $30 \times 30 \text{ mm}^2$ antenna achieves less than -10 dB return loss at the targeted frequencies. Furthermore, the antenna achieves less than -8 dB of S_{11} at 5.8 GHz. Simulated current distribution and radiation patterns are given in the paper.

1. INTRODUCTION

Radio frequency identification (RFID) is a contactless automatic identification technology [1]. It has been used extensively in a variety of applications, such as supply chain management, logistics tracking, access control, electronic toll collection (ETC) and public transportation card. RFID can be classified into low frequency (LF), high frequency (HF), ultrahigh frequency (UHF), and microwave RFID systems, according to its use in different frequency bands [2]. UHF RFID frequency band extends from 840 to 960 MHz divided into four world regions: China (840–845 MHz, 920–925 MHz), Europe (865–868 MHz), US (902–928 MHz), and Japan (950–956 MHz) [3]. Furthermore, microwave RFID operation is assigned at 2.45 or 5.8 GHz. Therefore, more and more wireless communications and RFID systems require dual or multi-band antenna designs. Some multi-band antennas have been designed for RFID, such as dual-band antenna with Tree-like fractal structure [4] (842/922 MHz), tri-band fractal tree antenna (3.6/5.8/8.2 GHz) [5], planar inverted F-antenna (PIFA) (433 MHz/912 MHz/2.45 GHz) [6] and meandered dipole antenna [7]. However, most of these antennas are in large size.

In this paper, we propose a modified tri-band CPW-fed antenna which is based on our previous design [8]. Two U-shaped patches are added in the antenna. This paper is organized as follows. Section 2 presents the structure of antenna. Simulated results and discussions are shown in Section 3 and Section 4 concludes this paper.

2. ANTENNA CONFIGURATION

Proposed antenna is implemented on a low-cost FR-4 substrate with dielectric constant $\epsilon_r = 4.4$, loss tangent $\tan \delta = 0.02$ and thickness $h = 1.6 \text{ mm}$ (Fig. 1). The antenna's size is limited to $30 \times 30 \text{ mm}^2$ ($L \times W$). A 50Ω CPW transmission line is used for feeding patch element with a fixed strip $S = 2.6 \text{ mm}$ and a gap distance $G = 0.2 \text{ mm}$ between the feeding line and ground. In order to achieve multi-band performance, the designed symmetric antenna has two U-shaped, four L-shaped and two F-shaped branches. The six branches function as additional resonators to resonate the antenna at multiple frequency bands. Two L-shaped branches ($L_{11} \times W_{13}$) are used to lower the resonant frequencies to the lower bands (0.915 GHz and 2.45 GHz) and two other L-shaped branches ($L_{10} \times W_9$) and two L-shaped branches ($L_1 \times W_3$) are designed for the higher bands (3.50 GHz and 5.8 GHz). Two F-shaped branches are used for compact antenna characteristic. The geometric dimensions for the proposed antenna are given in Table 1.

3. SIMULATED RESULTS

The proposed antenna is simulated by the finite element method (FEM), and the resulting reflection coefficients within the targeted frequency bands are shown in Figs. 2(a)–(d) using the FEM. The proposed antenna achieves less than -10 dB return loss at the targeted frequencies (0.915 GHz, 2.45 GHz, 3.50 GHz). The bandwidths ($\text{VSWR} \leq 2$) are 11 MHz (908 MHz to 919 MHz), 35 MHz (2.435 GHz to 2.470 GHz), 100 MHz (3.50 GHz to 3.60 GHz) respectively. Furthermore, the antenna achieves less than -8 dB of S_{11} at 5.8 GHz.

Table 1: Geometric dimensions of proposed antenna

Parameter	Dimension (mm)	Parameter	Dimension (mm)
W_1	0.5	L_1	8.7
W_2	11.6	L_2	0.5
W_3	4.8	L_3	0.5
W_4	0.6	L_4	0.5
W_5	5.4	L_5	2.3
W_6	13	L_6	1.4
W_7	0.6	L_7	4
W_8	5	L_8	1.5
W_9	2.5	L_9	2
W_{10}	3.8	L_{10}	4
W_{11}	4	L_{11}	4
W_{12}	9	L_{12}	1.5
W_{13}	12.5	W_{14}	8
W_{15}	9		

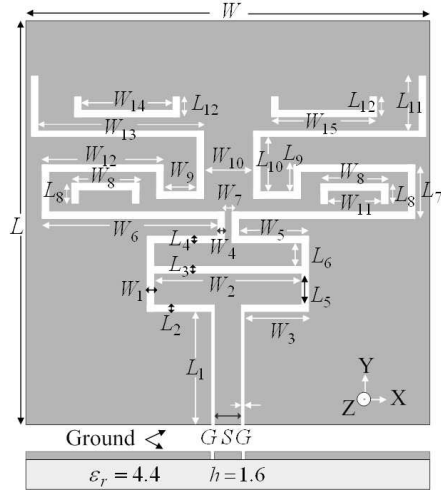
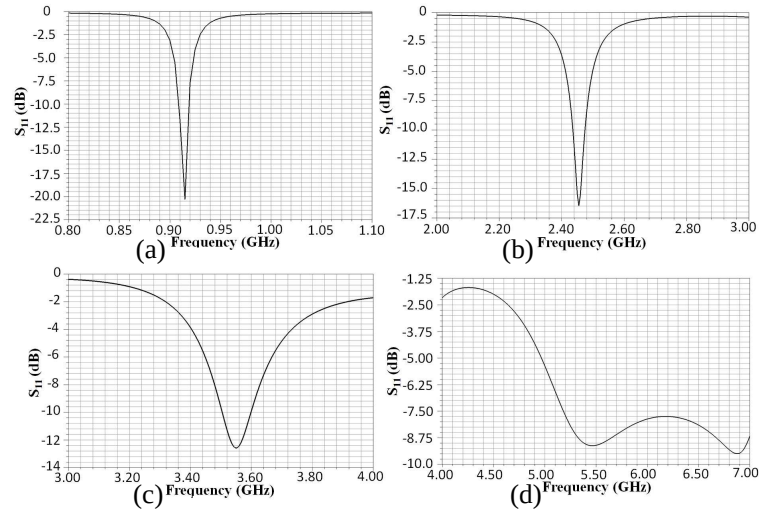


Figure 1: Antenna architecture.

Figure 2: Simulated S_{11} of proposed antenna at four bands obtained by FEM. (a) First band (0.915 GHz); (b) Second band (2.44 GHz); (c) Third band (3.55 GHz); (d) Fourth band (5.80 GHz).

The simulated surface current distributions were analyzed and shown in Fig. 3 for the proposed antenna and antenna without U-shaped branches at operational frequencies of 0.915 GHz, 2.45 GHz, 3.50 GHz and 5.80 GHz respectively. It can be seen in Fig. 3 that antenna with added U-shaped branches has stronger surface current along the meander line at 0.915 GHz and 2.45 GHz respectively, which means that the radiations would be strengthened at these two frequencies. As for the higher two frequency (3.50 GHz and 5.8 GHz), surface current seems to be the same for both antennnas with and without U-shaped branches. It also can be seen that a relative strong surface current is formed along the meander line over L-shaped branches ($L_{11} \times W_{13}$ and $L_{10} \times W_9$) at 0.915 GHz, while most of the surface current concentrates on the two L-shaped branches ($L_7 \times W_6$) and branches (W_7) at 2.45 GHz, and surface current is strong at two L-shaped branches ($L_1 \times W_3$) and slot S at 3.50 GHz. Furthermore, two F-shaped branches ($L_6 \times W_5$) have a relative strong current at 5.8 GHz. Therefore, L-shaped branches ($L_{11} \times W_{13}$) affect the lowest resonant frequency band at 0.915 GHz. With length L_{11} increasing, the lower frequency band will shift to lower frequency with fine-tuning.

Simulated radiation patterns of the proposed antenna in the xz plane ($\phi = 0^\circ$) and the yz plane ($\phi = 90^\circ$) at four targeted frequencies are shown in Fig. 4 (E_θ and E_ϕ). It can be observed

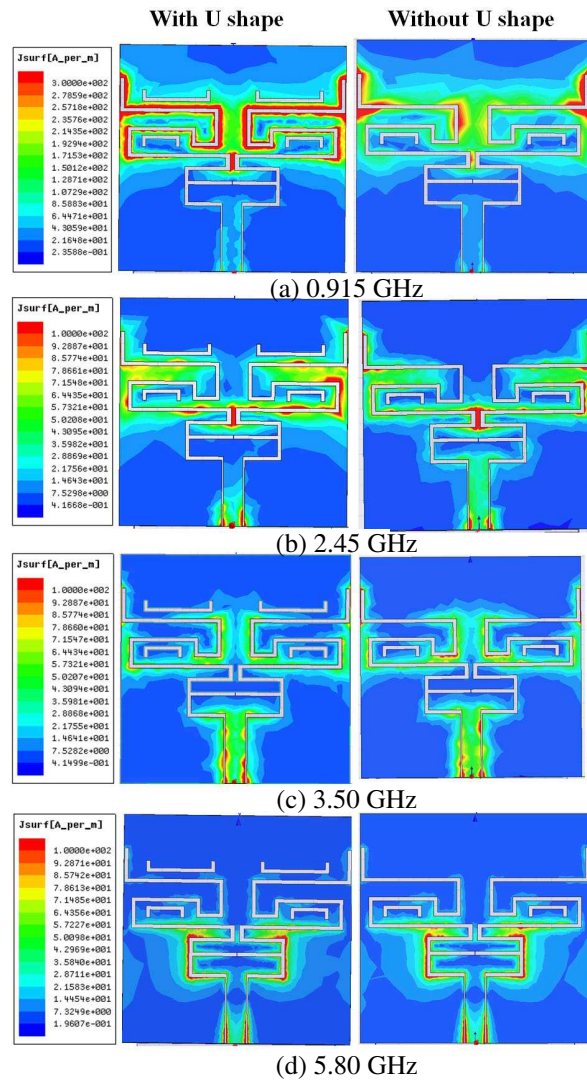


Figure 3: Simulated S_{11} of proposed antenna at four bands obtained by FEM. (a) First band (0.915 GHz); (b) Second band (2.44 GHz); (c) Third band (3.55 GHz); (d) Fourth band (5.80 GHz)

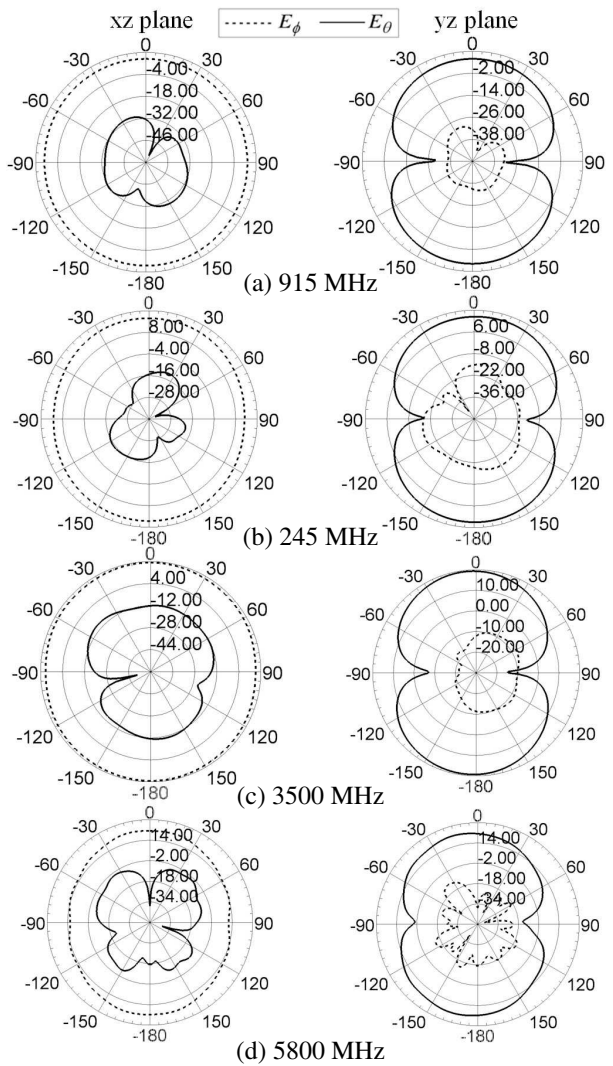


Figure 4: Simulated radiation patterns of proposed antenna at four bands obtained by FEM. (a) First band (0.915 GHz); (b) Second band (2.45 GHz); (c) Third band (3.50 GHz); (d) Fourth band (5.80 GHz).

that radiation patterns of the antenna at 0.915 GHz, 2.45 GHz and 3.50 GHz are omnidirectional in xz plane and quasi-dipole in yz plane. These characteristics may be suitable for RFID applications. Moreover, the simulated peak antenna gains appear to be -11.6 dBi at 0.915 GHz, -1.08 dBi at 2.45 GHz, 2.09 dBi at 3.50 GHz and 5.69 dBi at 5.80 GHz respectively.

4. CONCLUSION

A modified tri-band RFID tag antenna is reported in this paper. Two U-shaped branches are utilized as additional resonators in order to achieve multi-band operation and strengthen the radiation at 0.915 GHz and 2.45 GHz. In the future, by adjusting parameter L_{11} , the designed antenna would be suitable for the combination of the triple-band RFID applications and the multi-band WiMAX/WLAN applications in a single system.

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