A Novel Circularly Polarized Dual-band Slot Antenna for RFID Applications

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Abstract—In this paper, a new slot antenna is proposed for dual-band RFID applications. This antenna is designed to covers the frequency of ISM Bands (2.45GHz and 5.80GHz). In this antenna, two squared-slots are used for dual-band characteristic. Furthermore, some perturbations are set on an appropriate location to achieve circular polarization radiation. An L-shaped feed line is used for antenna excitation. The simulations results show that the proposed antenna has good circularly polarized radiations and the 3 dB axial-ratio bandwidth is more than 7.2% and 5.8% for first and second bands respectively. therefor, it is suitable to use for RFID as the reader antenna.

Key words—Slot antenna, circular polarization, dual-band, RFID

I. INTRODUCTION

Automatic identification procedure (Auto-ID) has become very popular in many service industries, purchasing and distribution logistic, manufacturing companies and material flow systems. In past years, barcode labels triggered a revolution in identification. However, barcodes may be extremely cheap, but they cannot be reprogrammed.

Radio frequency identification (RFID) is a contactless method for data transfer in object identification. In fact, this method involves the sending of an interrogation signal from a remote reader to a tag or transponder, and receiving the back-scattered modulated signal from tag. The block diagram of RFID system is shown in Figure 1.

Comparing with barcode and other identification systems, RFID has some advantages of rapid identifying, flexibility and high intelligent degree. Furthermore, it can function under a variety of environmental conditions. RFID systems can be distinguished by their operating frequency ranges. All of frequency ranges for RFID applications can be classified as follows [1].

- Low frequency band: (9-135 KHz)
- High frequency band: (13.56, 27.125, 40.68 MHz)
- Ultra-high frequency band: (433.9, 869, 915 MHz)
- Microwave band: (2.45, 5.8, 24.125 GHz)

As shown in Figure 1, RFID system consists of three components: a small electronic data carrying device including an antenna and a microchip transmitter called a transponder or tag that is attached to the item to be identified, a reader or scanner that communicates with the transponder using radio frequency signals, and a host data processing system that contains the information of the identified item and distributes the information between other remote data processing systems.

Figure 1. Typical schematic RFID system.
II. ANTENNA DESIGN

In this work, to design a dual-band antenna we use two squared-ring slots in ground plane. The geometry of this antenna is shown in Figure 2. The proposed antenna is excited by a microstrip line electromagnetically coupling to two orthogonal sides of the square-ring slots. The squared-slots and microstrip feed line are respectively etched on the two faces of a RT/Duriod 6002 substrate with $\varepsilon_r = 2.94$, $\tan\delta = 0.0012$ and thickness of $h = 0.8\text{mm}$. In fact, the two orthogonal sides of each square-ring slot are excited by the coupling strip in series, and if the slot side lengths are properly selected, the two orthogonal modes of each slot would be excited with the same amplitude and 90 phase difference at a given frequency, which results in a good CP radiation.

For a sole square-ring slot antenna, the resonant slot circumference is about two free-space wavelength multiplied a correction factor mainly considering the effects of substrate permittivity. By several simulated results for the studied a square-ring slot antenna, it is found that the fundamental resonant mode of a sole square ring slot occurs as follows:

$$f = \frac{1.85c}{4L} \left(1 + \varepsilon_r\right)^{0.5}$$

(1)

Where $c$ is the speed of light in free space, $(4L)$ is the mean circumferences of the square-ring-slot and $\varepsilon_r$ is relative permittivity.

For proposed dual band slot antenna in Figure 2, in accordance to (1), the average circumference for designed slots at frequency of 2.45 and 5.80GHz are 48.3 and 20.4mm respectively. However, the simulation results show that these values are changed, to 38.8 and 22mm. Difference between theoretical and simulated results for resonance frequencies is due to elimination of coupling effect between slots in theory analysis.

For circular polarization, we use some perturbations and L-shaped feed line. CP performance with an optimum axial ratio in both frequencies of 2.45GHz and 5.80GHz can be obtained by fine-tuning of $l_1$, $S_1$ and $S_2$. In addition, for a good impedance matching in both of bands, three tuning stubs are used in conjunction with the electromagnetically coupled element (Fig. 2(b)). All of the optimized values for designed antenna in Figure 2, are given as follows:

$L_1 = 38.8$, $L_2 = 22$, $d_2 = 1.5$, $d_1 = 1$, $s_2 = 2.6$, $s_1 = 3$, $l_6 = 35.4$,
$w_6 = 2.8$, $l_5 = 14$, $w_5 = 0.7$, $l_4 = 9.5$, $w_4 = 3.3$, $l_4 = 9.5$,
$w_3 = 2.1$, $l_3 = 5$, $w_3 = 4.2$, $l_3 = 6.7$, $w_1 = 0.85$, $l_1 = 22.7 (\text{mm})$

III. RESULTS

Figure 3 shows the return loss of designed antenna. As shown in this figure, the antenna is excited at 2.45 GHz with a $-10$ dB impedance bandwidth of 500MHz (2.12–2.62GHz) and at 5.8 GHz with an impedance bandwidth of 750MHz (5.37–6.13GHz).

Figure 2. Configuration of proposed antenna. (a) Square-ring-slots (b) Feed line (c) Perspective view

Figure 4 shows the axial ratio of 1st and 2nd modes. As shown in this figure, the axial ratio bandwidth (AR<3dB) for 1st and 2nd modes are 180 MHz (2.40–2.58 GHz) and 350 MHz (5.65–6.00GHz), respectively.

Figure 5 and Figure 6 show the far-field radiation patterns for the E-plane and H-plane of the antenna at two typical frequencies in the operation bands. In order to minimize the interference between the interrogation signal and the back-scattered signal, we have chosen different polarization for two resonance bands. So, in this work, left hand and right hand circularly polarizations are
used for 1st and 2nd modes, respectively. Simulation results show that it is possible to apply the proposed antenna for RFID applications.

**Figure 3.** Simulated return loss of the proposed antenna.

**Figure 4.** Simulated axial ratio of the proposed antenna in (θ=0°). (a) Axial ratio of 1st mode (b) Axial ratio of 2nd mode

**Figure 5.** Simulated radiation pattern of the proposed antenna at 2.45GHz. (a) φ=0° (b) φ=90°

**Figure 6.** Simulated radiation pattern of the proposed antenna at 5.80GHz. (a) φ=0° (b) φ=90°

**IV. CONCLUSION**

The new circularly polarized dual-band slot antenna for RFID Applications has been demonstrated. The proposed slot antenna has a broad CP bandwidth and good impedance matching in both of resonance frequencies. The antenna has been examined numerically using HFSS simulator based on finite elements method. The simulation results show an impedance bandwidth of 500 MHz and 750MHz in 1st and 2nd bands, respectively. Furthermore, axial ratio bandwidths are 180 MHz and 350MHz.

**REFERENCES**


