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A COMPACT FOLDED PRINTED DIPOLE ANTENNA FOR UHF RFID READER

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Abstract—A compact printed dipole antenna for UHF RFID reader is presented. The peak gain of the printed dipole antenna is 2.07 dBi, which is higher than traditional UHF RFID antenna. The proposed antenna occupies a volume of $65 \times 30 \times 2\,\mathrm{mm}^3$ and the radiator is composed of two rectangular patches etched with folded slit. The radiation element of the dipole antenna is fed by $50\,\Omega$ coaxial line. Measured results indicate that the proposed antenna has a good impedance matching characteristic at 905–935.5 MHz (return loss less than 10 dB). In addition, the effect of some parameters on the performance of the proposed antenna is also discussed in this article. This printed dipole antenna will be applicable for future RFID systems.

1. INTRODUCTION

In recent years, radio frequency identification (RFID) has been widely used in service industries and material flow systems as an automatic identification tool. A typical radio frequency identification system is made up of three components: 1) an electronic data carrying device called RFID tag is combined with an antenna. The tag is usually a microchip and contains the item to be identified, 2) a reader that communicates with the tag antenna by means of electromagnetic waves, 3) a host data processing system embodies the information of the identified item and communicates with other remote data processing systems [1]. The RFID system [2–11] covers frequency bands of low-band range 100–500 kHz, high frequency 13.56 MHz and microwave band range 860–960 MHz, 2.45 GHz and 5.8 GHz [1]. Of the microwave bands, 860–960 MHz is assigned as ultrahigh frequency

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(UHF) band for global use according to ISO 18000 standard. The most highlighted applications that utilize the UHF band RFID technology are merchant flow tracking and stock control. Owing to its long reading range and high reading speed, there has been more and more research into the design of UHF RFID tag antenna [9]. Most applications require that the tags be compact in size, low cost and easy to fabricate. As good candidate, the printed dipole antenna satisfies all these need. Additionally, the far-field radiation pattern of the dipole antenna is omnidirectional in the whole band on the H-plane so that it can keep consistent readability in different angles. In theory, the total effective length of radiating arms is usually as half as that of the operating wavelength. Therefore, reducing the size of the dipole antenna is an interesting topic in the practical applications. It is a feasible method of making radiating arms folded. According to [12], the resonant frequency of the meander antenna is independent of its geometry. Increasing the total wire length in the meander antenna of fixed height will lower its resonant frequency. When the meander antennas of different configurations are adjusted at the same resonant frequency, they present identical EM behavior.

A software application that is designed read data from a contactless data carrier (transponder) or write data to a contactless data carrier, requires a contactless reader as an interface. In this article, a compact folded printed dipole antenna is proposed for UHF RFID reader. To realize 922 M resonant frequency, etching folded slits in the radiating patches of the proposed antenna is adopted as a method of reducing the size of RFID antenna. Compared with [13], each radiating arm of the proposed antenna is bent into G-shape and it can achieve more compact size. Though the structure of G-shape is widely used in the applications of WLAN and 2G wireless communication systems, it is rarely studied in dipole antenna. In this article, this structure is first introduced as a new method of reducing the size of dipole antenna. It satisfies miniaturization in future RFID systems.

2. ANTENNA CONFIGURATION

Figure 1 shows the geometry of the proposed antenna. The dipole antenna mainly consists of two radiating arms separated by a 0.5-mm width slot. At the end of the slot, there is a 1-mm wide shorting strip which connects two radiating arms. Without folded slit, the proposed antenna is a simple dipole antenna which occupies a volume of $65 \times 25 \times 2\,\text{mm}^3$. Each radiating arm is bent to form a shape resembling the letter G in the opposite direction. The width of the radiating arms

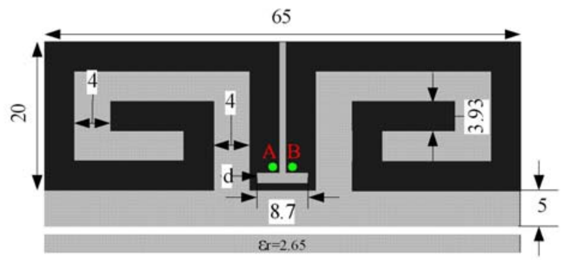

Figure 1. Geometry of the proposed printed dipole antenna.

is fixed at 3.93 mm as an optimized result. The antenna is fed by 50-Ω coaxial cable, with central conductor and outer sheath soldered to the points A and B respectively. Apparently, the proposed dipole antenna is symmetrical in shape so that the points A and B can be designated vice versa [14]. Note that there is a volume of $65 \times 5 \times 2\,\mathrm{mm}^3$ substrate behind the radiating arms. Not only can it be used to fix the antenna but also fine-tune the operating frequency. This point will be discussed in the following text.

It should be specially mentioned that the shorting strip is used to adjust the inductive reactance to compensate for capacitive coupling between the two radiating arms according to [14]. The value of the distance (d) between points A, B, and the shorting strip is fixed at 1 mm to achieve a good impedance matching.

The length of the conventional dipole antenna is about half the resonant wavelength and is 162 mm working at 922 M. The size of the proposed antenna reduces about 60% comparing with conventional dipole antenna. When each radiating arm is bent into L-shape according to [13], the total length of the dipole antenna will be about 86 mm, which is about 32.3% larger than the proposed antenna. Consequently, the structure of G-shape is valid as a method of reducing the size of dipole antenna.

3. RESULTS AND DISCUSSION

Figure 2 shows the photograph of the proposed antenna. The antenna is simulated by HFSS and its return loss is measured using Wiltron 37269A network analyzer. As shown in Figure 3, the proposed antenna has an impedance bandwidth (defined by 10 dB return loss) from 905 MHz to 935.5 MHz, which covers UHF RFID band. It is noted that there is a difference between simulation and measurement results in the lower band. I think it is mainly due to the length of the branch

Figure 2. Photograph of a working sample fed by 50-Ω coaxial cable.

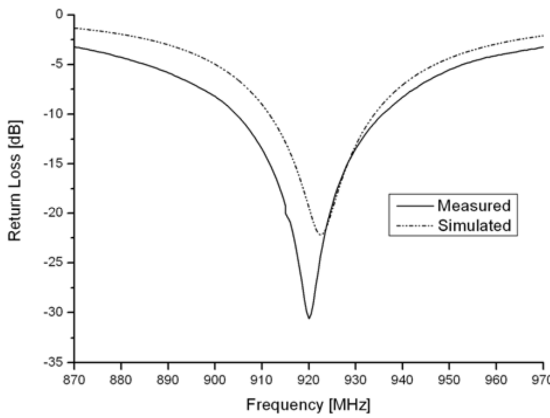

Figure 3. Measured and simulated return losses of the proposed antenna.

of coaxial line, which appears the tip of the coaxial line. This length will be added to the total length of the radiating arm, which leads to the resonance frequency move to lower band, and causes the differences between simulation and measurement in the lower band.

There is additional substrate behind the radiating arms. It is usually used to fix the antenna. At the same time, altering the width (wg) of substrate can influence the resonant frequency. Figure 4 presents that the resonant frequency at $wg = 5\,\mathrm{mm}$ is lower than that at $wg = 0\,\mathrm{mm}$. Therefore, changing the value of wg can fine-tune the operating frequency. Figure 5 shows the impedance variation with shorting stub and no shorting stub.

The radiation characteristic is studied for the proposed antenna.

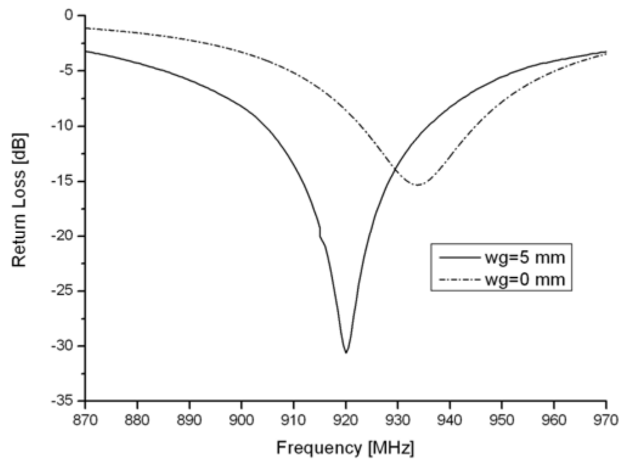

Figure 4. Return losses for the proposed antenna when $wg = 5\,\text{mm}$ and $wg = 0\,\text{mm}$.

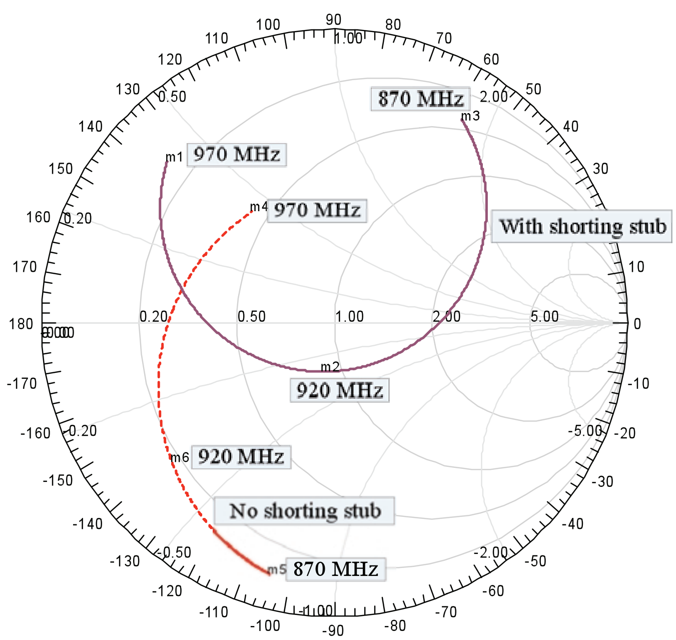

Figure 5. The impedance variation with shorting stub and no shorting stub.

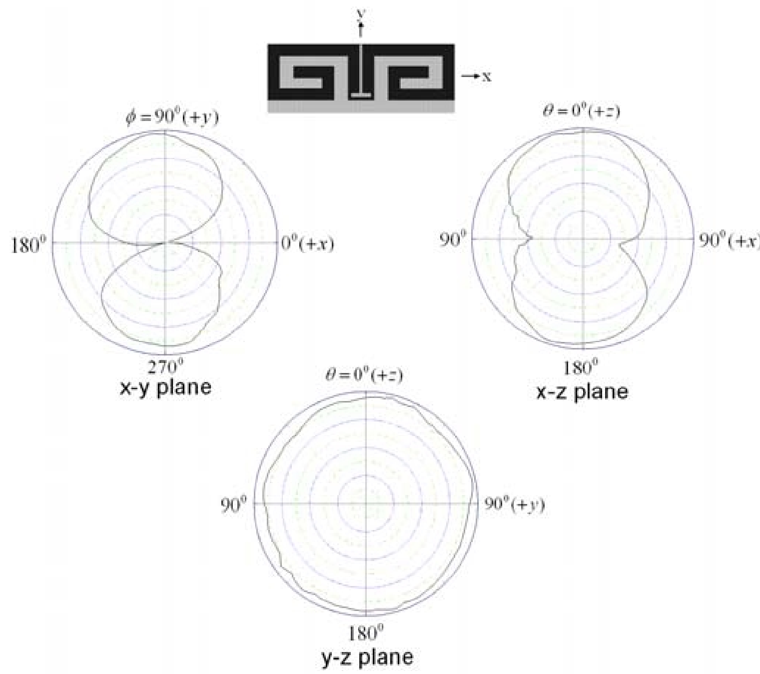

Figure 6. Measured radiation patterns at 922 MHz for the proposed antenna.

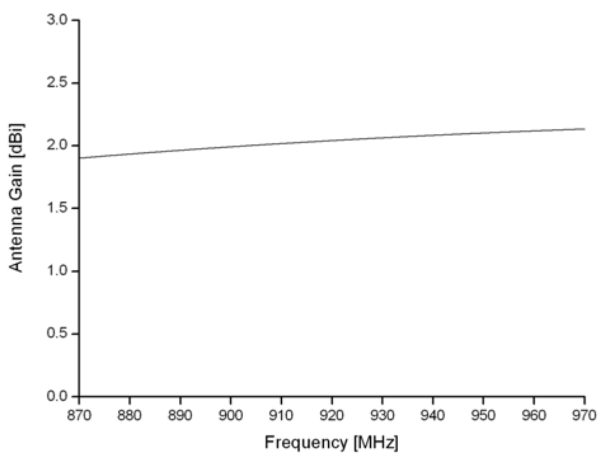

Figure 7. Measured gain of the proposed antenna.

Figure 6 plots the measured far-field radiation patterns at 922 MHz. Clearly, the E-plane pattern is dipole-like and H-plane pattern is close to omnidirection, which are similar to the conventional dipole radiation characteristics. Shown in Figure 7 is the measured gain of the proposed antenna. The peak gain of the printed dipole antenna is 2.07 dBi, which is much higher than [15], meaning that the proposed antenna has a good directional characteristic. meaning that the proposed antenna has a good directional characteristic.

4. CONCLUSION

A printed dipole antenna for UHF RFID reader has been proposed, constructed, and tested. The proposed antenna mainly comprises two radiating arms and a shorting strip. Each radiating arm is bent into G-shape to obtain a compact size. The peak gain of the printed dipole antenna is higher than traditional UHF RFID antenna, and the proposed antenna has good omnidirectional-radiation characteristics. Furthermore, this antenna has many advantages such as easy fabrication and low cost. Therefore, it is suitable for UHF RFID systems.

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