

Dual Frequency Circularly Polarized Microstrip Antenna for RFID Reader Application

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1. Introduction

Recently, the usage of Radio Frequency Identification (RFID) has been increased in order to achieve efficiency in many industries. The RFID system consists of the reader and the tag. The RFID system can be distinguished by the frequency into Low Frequency (125-135 kHz), High Frequency (13.56 MHz), Ultra-High Frequency (850-955 MHz) and microwave (2.45GHz and 5.8GHz) [1].

The RFID system at each frequency band has advantages and disadvantages relative to its capabilities. Since there is no single frequency band which ideal for all applications even within a single industry, a multi-band RFID reader antenna will have an advantage. Due to the random orientation of tags, a circularly polarized RFID reader antenna is desired to get the most efficient communication.

The commercial use of UHF and microwave RFID system in logistics, and supply chain management have become very popular, which made compact handheld reader units become more and more important. The important requirements for this handheld reader unit antenna are small size, light weight and low profile which are features of microstrip antenna.

In this paper a dual-frequency circularly polarized antenna for UHF band (950MHz) and microwave band (2.45 GHz) RFID reader application is proposed and numerically analyzed by using the electromagnetic simulator IE3D [2], [3]. In the numerical analysis, the antenna is located on the infinite dielectric substrate.

2. Design of Proposed Antenna

The simple and fundamental idea in designing a dual-frequency circularly polarized antenna is to design two antennas with the circular polarization characteristics separately, and then combine these two antennas together with a single feed. The square patch microstrip antenna with truncated corner, a well known circularly polarized structure, is used for the UHF band [4]. To keep the antenna structure compact, the slot antenna is used for the microwave band. The slot antenna structure must maintain the possibility of generating circular polarization for the lower frequency. A circularly polarized square ring slot antenna is adopted for this [5].

The truncated corner square patch antenna is designed to have operating frequency around 950 MHz, where perturbation is added on two of its diagonal corner to generate circular polarization. The patch is printed on the dielectric substrate with thickness h of 0.8 mm. The relative permittivity ϵ_r and the loss tangent $\tan\delta$ of dielectric substrate are 3.45 and 0.0027, respectively. The thickness of

conductor t is 0.035 mm.

The square ring slot is chosen for the 2.45 GHz band. By introducing a meandered section at one side of the square ring slot, the circular polarization can occur [5]. With the introduced meandered slot section, the symmetry of the ring-slot antenna is perturbed and the fundamental resonant mode can be split into two orthogonal degenerate resonant modes for CP radiation. To keep maintain the symmetry of the patch, the feed position of the square ring slot structure is modified and the meandered slot position is shifted from that reported in [5].

Figure 1 depicts the geometry of the proposed dual-frequency circularly polarized antenna. The square ring slot is located within a square patch microstrip antenna with perturbation segments. This antenna is fed by an L-shaped probe. Since the two antennas are joined together in parallel, the square ring slot antenna will affect the operation at the 950 MHz band, and vice versa. The impedance behavior of one antenna is affecting the matching to the other antenna. Modified strip line of the L-probe feed is used to meet good matching condition for the two frequency bands. By studying carefully the parameters of the antenna, good impedance matching and low axial ratio could be achieved. To achieve circular polarization characteristic in the 2.45 GHz band, the meandered slot is adjusted. Table 1 shows the parameters of proposed antenna.

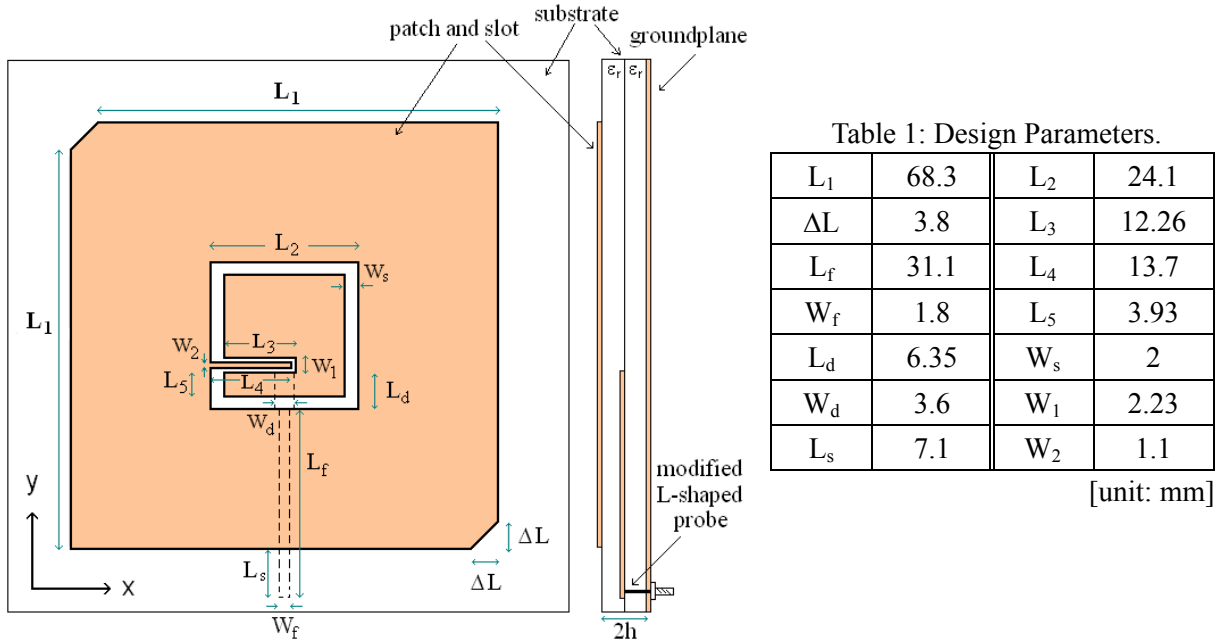


Figure 1: Geometry of the proposed antenna.

3. Simulation Results and Discussion

Figure 2 and 3 show the calculated return loss characteristics of the proposed antenna at 950 MHz and 2.45 GHz band, respectively. After addition of square ring slot, 14 % reduction of the patch length (L_1) is achieved compared with the original truncated corner square patch antenna. The reduction of the patch length is due to that the additional square ring slot lengthens the current path. The calculated axial ratio of the proposed antenna at 950 MHz and 2.45 GHz band are depicted at Figure 4 and 5. The impedance bandwidth of proposed antenna is 10 MHz (945.1 – 955.1 MHz) for lower frequency and 16 MHz (2.443 – 2.459 GHz) for higher frequency. The axial ratio bandwidth of the proposed antenna is 2 MHz (948.5 – 950.5 MHz) for the lower band and 8 MHz (2.447 – 2.455 GHz) for higher frequency band.

The current distributions of the proposed antenna are shown in Figure 6 and 7. The electric field radiation patterns of the proposed antenna at frequency 950 MHz and frequency 2.45 GHz are shown in Figure 8 and Figure 9, respectively. As illustrated in Figure 6, the central small patch is well isolated at the lower frequency. Hence the current distribution on the square ring truncated patch contributes for the radiation in the frequency of 950 MHz. While at the higher frequency, it can be observed in Figure 7 that the radiation pattern is asymmetric. This asymmetry is due to the existence of narrow slit on the left side of the square slot which causes the disturbed current.

4. Conclusion

The design method of dual-frequency circularly polarized microstrip antenna for the RFID reader antenna has been presented. By combining square patch antenna with truncated corner which designed to operate in 950 MHz together with square ring slot antenna which designed to operate in 2.45 GHz, a dual-frequency circularly polarized microstrip antenna has been proposed.

The simulation results have shown that the good antenna performance with return loss less than -10 dB and axial ratio less than 3 dB are achieved in the both 950 MHz and 2.45 GHz band. The impedance bandwidth of this antenna is 10 MHz for 950 MHz band and 16 MHz for 2.45 GHz band. On the other hand, the axial ratio bandwidth is 2 MHz for the lower band and 8 MHz for higher band. The axial ratio bandwidth is still not sufficient for the RFID application. Improving the axial ratio bandwidth is main concern for the future development.

References

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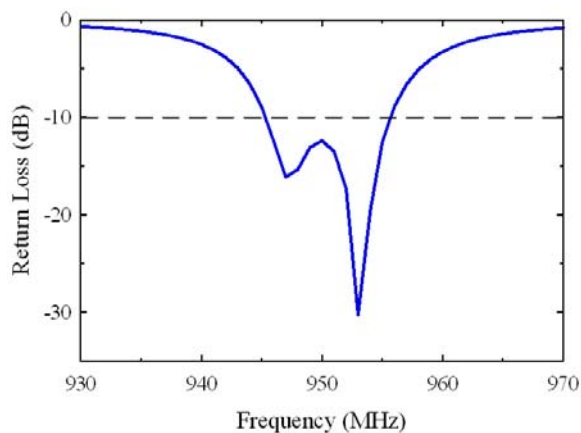


Figure 2: Calculated Return Loss at 950 MHz.

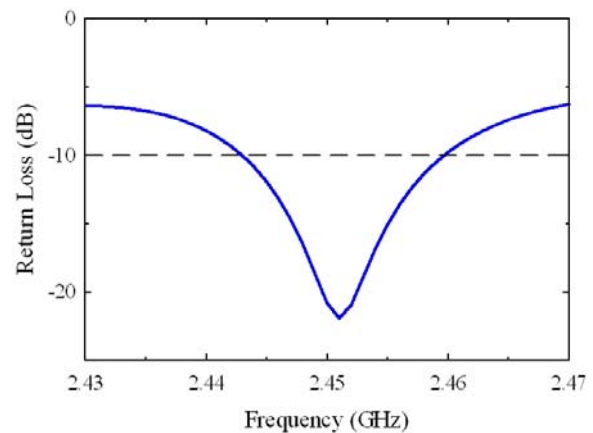


Figure 3: Calculated Return Loss at 2.45 GHz.

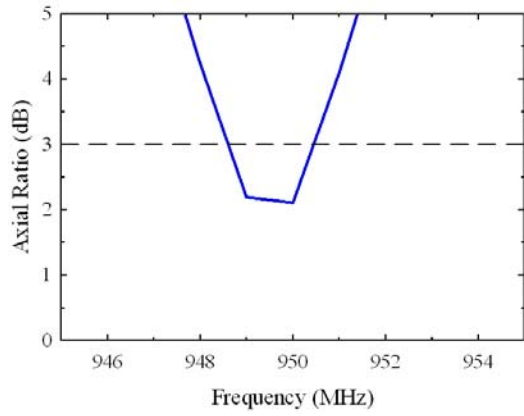


Figure 4: Calculated Axial Ratio at 950 MHz.

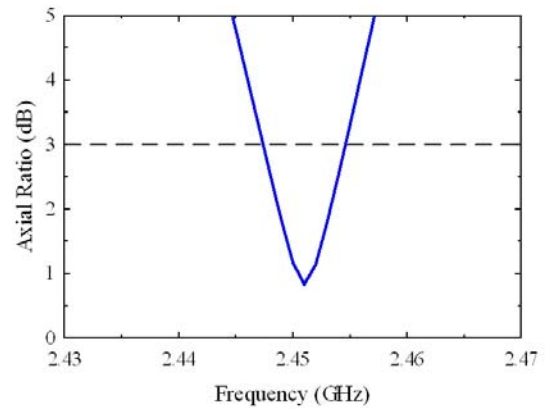


Figure 5: Calculated Axial Ratio at 2.45 GHz.

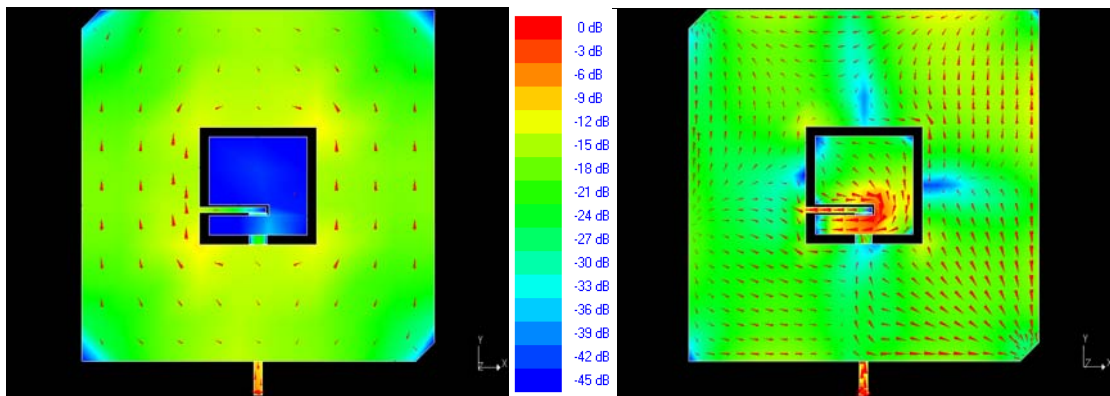


Figure 6: Current distribution at 950 MHz.

Figure 7: Current distribution at 2.45 GHz.

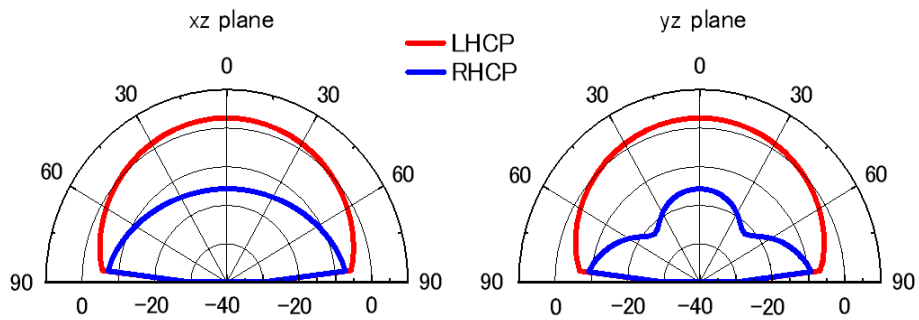


Figure 8: Electric field radiation patterns at 950 MHz.

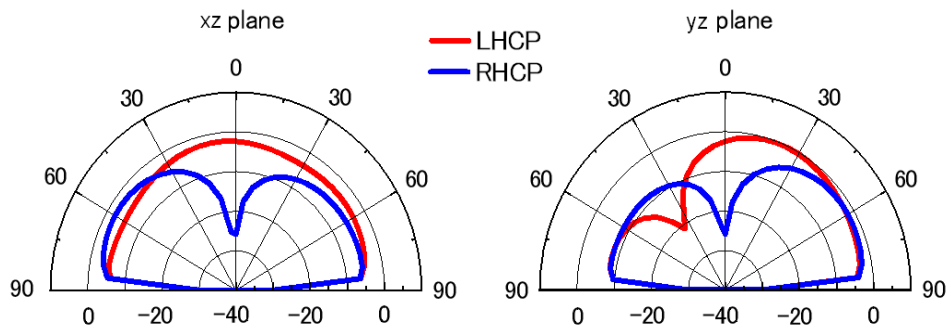


Figure 9: Electric field radiation patterns at 2.45 GHz.