Design of a dipole tag antenna with a double loop for UHF RFID application

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1. Introduction

Recently, UHF Radio Frequency Identification (RFID) systems have gained great attention due to the advantage of long reading distance. A tag consists of an antenna and an Application Specific Integrated Circuit (ASIC) chip. Designing of an antenna for RFID tag is difficult in matching the antenna impedance with that of a tag chip. Unlike the impedance matching for traditional antennas, the conjugate matching method is used to design RFID antennas to get high power transmission between an antenna and a chip[1]. Since the energy transmission between the chip and the antenna is most important factor to determine the reading distance, a successful antenna design is estimated by the degree of conjugate impedance matching between antenna element and chip[2].

In this paper, a dipole antenna with a double loop is proposed as a tag. The required input resistance and reactance can be easily achieved by adjusting appropriate geometry parameters. The proposed antenna has a great advantage of controlling the antenna impedance under various conditions.

2. Antenna Configuration

The configuration of the proposed antenna using a dipole with a double loop is shown in Fig. 1. A dipole consists of two fan shape loops and two open stubs at the end of the dipole. The widths of S, W1 and W2 are fixed as 1 mm, respectively. Each fan shape loop with outer radius of R1(=11mm) and inner radius of R2(=10mm) is connected to each arm of dipole antenna to increase the reactance of a dipole element. To achieve the conjugate matching with chip impedance, the proposed antenna has a distinct factor of controlling the reactance and the resistance. As shown in Fig. 2, the reactance of an antenna is gradually increased by increasing the outer radius of a fan shape loop. Once the desired reactance value is obtained by controlling the outer radius R1, the resistance can be tuned by adjusting the value of R4 of open stub. Reactance and resistance values for various R1 and R4 are illustrated in Figs. 2, 3, 4, and 5. From the current distribution shown in Fig. 6, we can assure that the tag antenna is operated as a dipole. The proposed antenna is printed on FR4 epoxy substrate (ε_r=4.6, tanδ=0.02) with thickness of 0.4mm. The radiators are made of copper having thickness of 0.47 mil.(=0.012mm), and Impinj class1 gen2, Monza 1 RFID chip[3] with impedance of 33-j112 ohms at 910 MHz is mounted on the antenna terminal. The most beneficial aspect of this design is easy to get a conjugate matching to a tag IC by adjusting R1 to have required reactance and to adjust R4 to have necessary resistance of the antenna[4]. The overall dimension of the proposed tag antenna is 67 mm × 47 mm. The design parameters are optimized at 910 MHz and listed in Table 1. The fabricated antenna is shown in Fig. 7.

3. Experimental results

The simulated resistance and reactance of the proposed antenna are 33 ohms and 113 ohms, respectively as shown in Fig. 8. The -10 dB impedance bandwidth as shown in Fig.4 is 38 MHz (892 MHz ~ 930 MHz) which covers the whole Korean UHF RFID band (908 MHz ~ 914 MHz). Performances of designed RFID tag antenna measured in an anechoic chamber are given in Table. 2. The maximum reading range is 5.29 m at 890MHz and the average reading distance is around 5 m over the Korean UHF RFID band.

4. Conclusion

The proposed antenna has the impedance bandwidth of 38 MHz (892 MHz ~ 930 MHz) for S_{11} less than -10 dB and the power transmission coefficient of 0.999 at 910MHz. Measurement shows that the average reading distance is around 5m under the condition that the reader power is 27 dBm and gain of the reader antenna is 6dBi. The proposed antenna is compact in size (67 mm × 47 mm) and has the merit of easy conjugate matching by adjusting the inner radius of a fan shape loop and the radius of an open stub.

Acknowledgement

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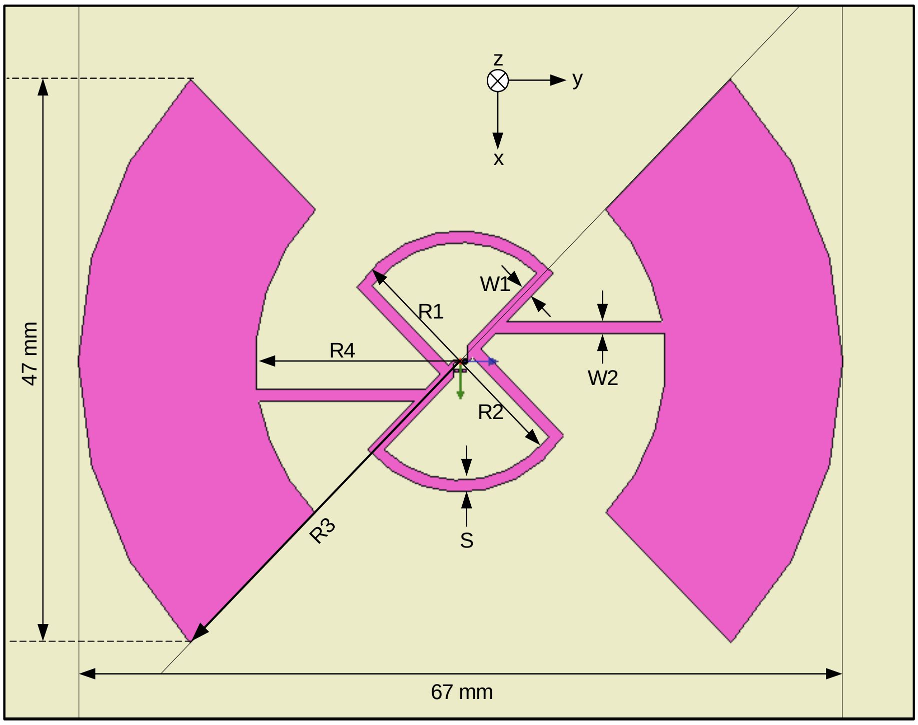

Fig.1 Configuration of the tag antenna

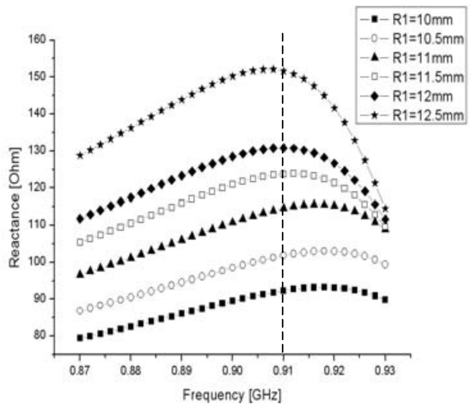

Fig.2 Reactance of the proposed antenna for variation in R1

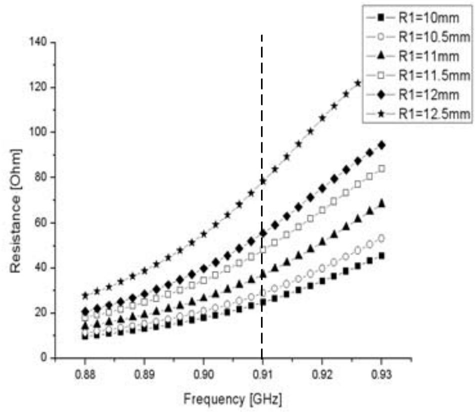

Fig.3 Resistance of the proposed antenna for variation in R1

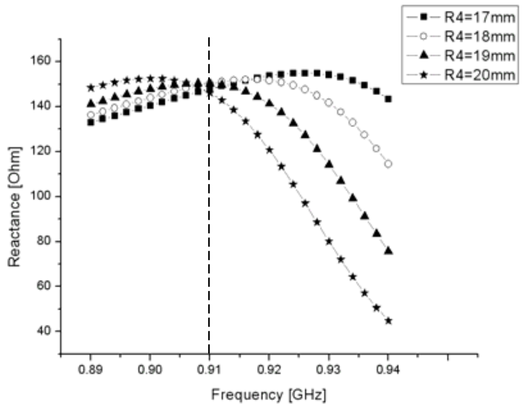

Fig.4 Reactance of the proposed antenna for variation in R4

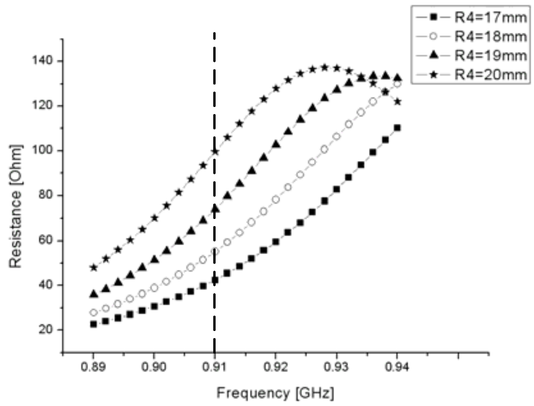

Fig.5 Resistance of the proposed antenna for variation in R4

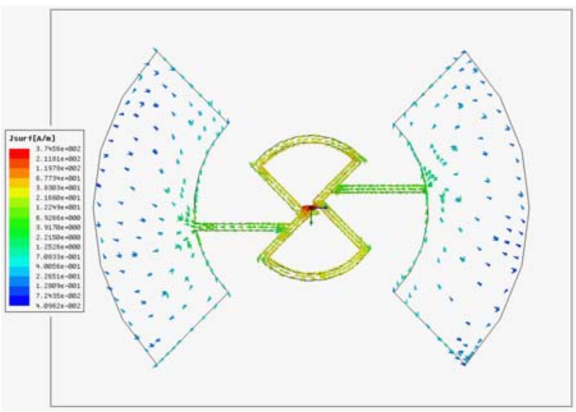

Fig.6 Current distribution of the proposed antenna at 910MHz

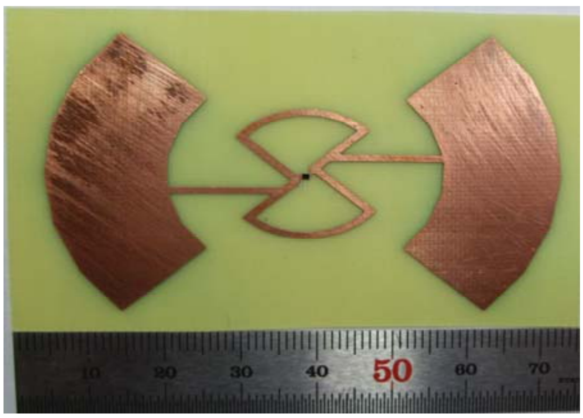

Fig.7 Photography of the fabricated tag

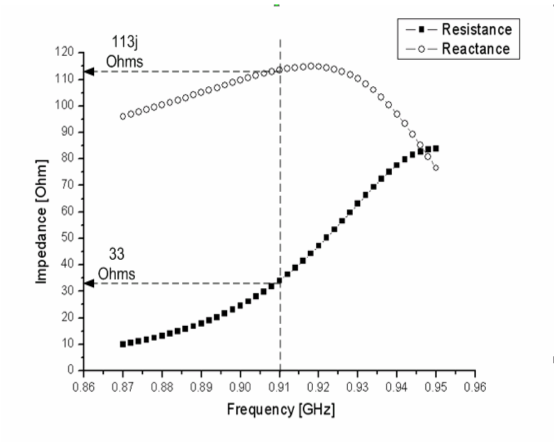

Fig.8 Resistance and reactance of the proposed antenna

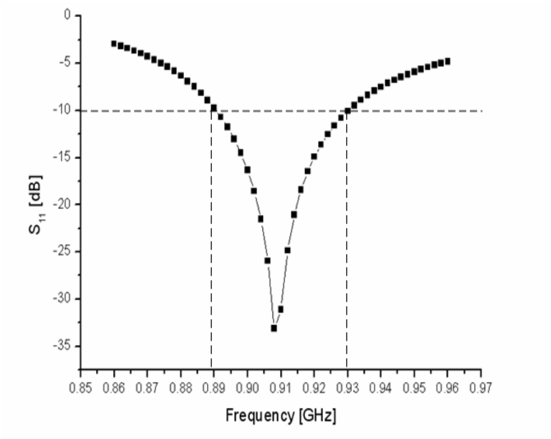

Fig.9 Calculated S_{11} characteristics of the proposed antenna

Table 1. Design parameters of the proposed antenna [unit : mm]

R1	**R2**	**R3**	**R4**	**S**	**W1**	**W2**
11	10	18	33.5	1	1	1

Table 2. RFID tag antenna performance measured in an anechoic chamber
[Reader output power : 27 dBm , Gain of reader antenna : 6 dBi]

Frequency [MHz]	**Wakeup sensitivity [dBm]**	**Calculated reading distance [m]**
860	-8.2	3.19
870	-9.9	3.87
880	-11.9	4.77
890	-12.9	5.29
900	-12.7	5.11
910	-12.5	4.94
920	-11.7	4.88
930	-11.5	4.31
940	-10.5	3.80
950	-9.6	3.39
960	-8.8	3.06

References

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