High Directivity Passive UHF RFID Tag with Dual-radiating-body Antenna

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Introduction

Most antennas that are commonly used in RFID tags exhibit almost omnidirectional radiation patterns to allow for the effective link of arbitrary positioned RFID tags with respect to the reader orientation. Nevertheless, due to the low directivity of these radiators, they often suffer from relatively short reading ranges. In some RFID applications in which the tag and the reader antenna placement is fixed, like conveyor belts or loading docks, having a rugged antenna with high directivity value can be extremely appropriate since the reader power consumption would be minimized and the range would be drastically enhanced. In this paper, we propose for the first time a dual-radiating-body RFID tag that features high directivity and increased range for particular RFID applications.

A Novel "Dual radiating body" RFID antenna

A directivity-enhancement technique that has been proposed in the past consists of adding loading (parasitic) bars to a dipole structure in order to distort the radiation pattern toward a more directed shape [1]. The directivity improvement achieved is minimal, being usually less than 2.0 dBi, mainly due to the weak coupling. Typically, an inductively-coupled RFID tag structure consists of a feeding loop with two terminals and a radiating body. The two terminals of the loop are connected to the IC and the feed "communicate" with the antenna body through mutual coupling. In this paper we are proposing a tag antenna design characterized by two symmetrically placed radiating bodies as shown in Figure 1. For validation purposes and without loss of generality, the prototype commercial chip impedance was Z_{IC}=30-j172 Ω.

The design procedure starts with the appropriate selection of the IC-mounting loop size, with the purpose of matching the IC's imaginary part of the impedance. Further on, a proper distance between this loop and the folded dual radiating bodies is selected as a first step toward the chip resistance matching. This resistance can hardly reach high values: the shape of the two folded arms has been optimized in order to obtain the resistance value needed for the matching. Meander lines are utilized on both sides of the feeding loop for miniaturization purposes. Each radiating element is strongly coupled with the feeding loop and

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the direction of the excited currents on the arms is antisymmetric allowing for the effective operation of each, radiating body as a dipole.

The prototype antenna was inkjet printed on a paper substrate [2] with a Dimatix 2800 printer. The photograph of the printed dual-body antenna with a mounted IC is illustrated in Figure 1. The radiation pattern shown in Figure 2 proves that the radiating energy is focused directionally in a dumbbell shape. The gain achieved is 5.03 dBi. Figure 3 depicts the antenna input impedance plot: the impedance of the proposed antenna is 29.1+j175.2 Ω at 915 MHz. The simulation result in Figure 4 verifies the effective radiation performance around 915 MHz with a power radiation coefficient of 0.96. The key performance characteristics of the dual-radiating-body RFID tag antenna are summarized in Table 1 where τ is the power transmission coefficient between the tag antenna and the RFID IC chip and P_{th} is the threshold or minimum power needed to activate the RFID IC chip. From measurement, the maximum read range has been calculated to be equal to 16.5 m with a reader antenna linearly polarized according to the following formula

$$r_{\max} = r_{ref}\sqrt{\frac{P_{\max}}{P_{ref}}}$$

where $r_{\max}$ is the maximum read range and r_{ref} is the actual distance between the reader and the tag antenna. The reference power P_{ref} transmitted by the reader antenna is at 20% of the maximum allowed power $P_{\max}$ (an EIRP of 4 W)[3] to reduce the effective reading range in the measurement in order to minimize the interference from the surrounding environment. With a circularly polarized reader antenna the theoretical range is estimated to be 11.7m and the measurements, carried out in an outdoor environment, showed a range of 10.4 m. Although the reading range is shorter compared with a linear polarized antenna, the circular polarized reader antenna is rugged due to the fact that the performance is not affected by the physical placement angle of the antenna.

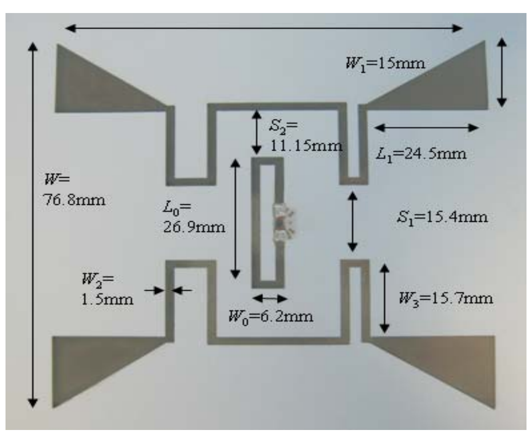


Figure 1: Photograph of the dual-radiating-body RFID antenna inkjet printed on paper

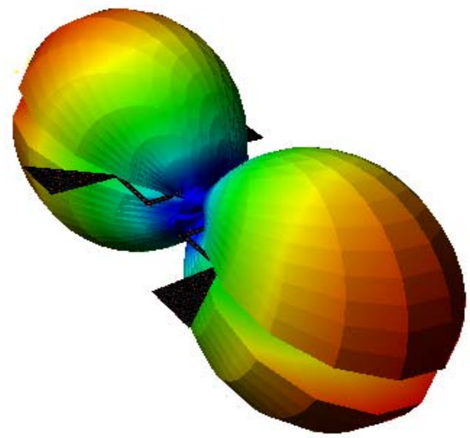
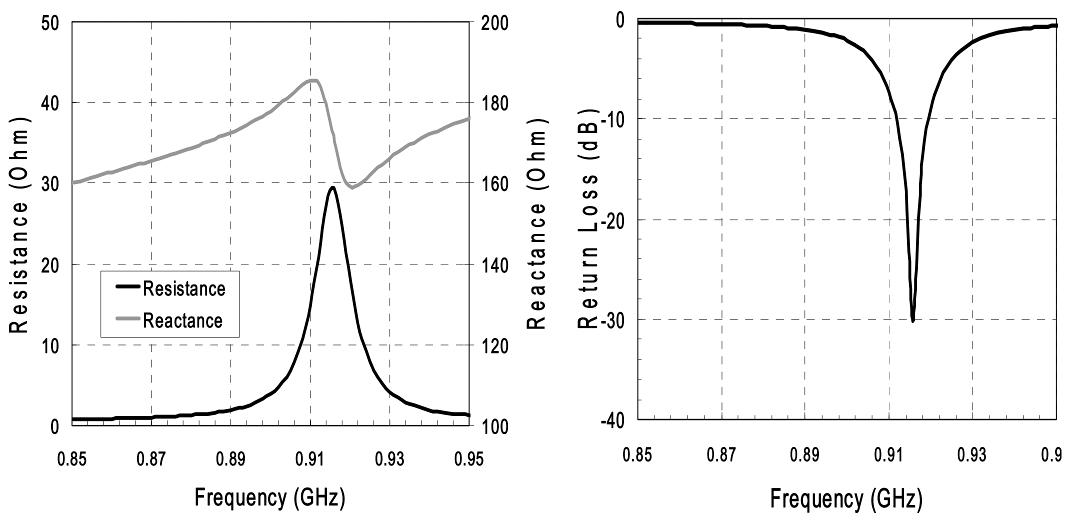


Figure 2: Plot of the far-field radiation pattern.



(a) (b)

Figure 3: Resistance and reactance and return loss plots of the dual-radiating-body antenna: (a) resistance (b) reactance.

Table 1: Dual-radiating-body RFID tag key parameters

EIRP	Gain (G)	Antenna (Z_{ant})	Chip (Z_{IC})	τ	P_{th}
4 W	5.03 dBi	29.1+j175.2 Ω	30-j172 Ω	0.99	-15 dBm

Conclusion

A novel dual-radiating-body antenna for UHF passive RFID tags has been proposed for particular RFID applications in which high directivity and high reading range is required. Inductively-coupling technique has been used to match the antenna tag impedance with the impedance of a commercial IC chip. The calculated and measured maximum read range fairly agrees with each other proving the good impedance matching achieved demonstrating ranges in excess of 10m for conveyor belt applications.

Acknowledgment

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