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Balanced RFID Tag Antenna Mountable on Metallic Plates

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Abstact

A novel balanced tag antenna for radio frequency identification (RFID) system is presented. The radiating elements of two planar inverted-F antennas (PIFAs) are inductively coupled by the feed loop with out of phase. The balanced structure provides smaller degradation of performances when an RFID tag is mounted on the various sizes of metal plates. The HFSS simulator is employed to analyze the proposed antenna in the design process and to compare with measured results.

Introduction

Radio frequency identification (RFID) has attracted considerable press attention in recent years since it is an automatic identification method for efficiently tracking and managing of individual consumer goods, relying on storing and remotely retrieving data in an RFID chip. An RFID system mainly consists of the reader, tag, and host computer. Both the tags and the readers have their own antennas because they are both radio devices. A passive RFID tag does not contain its own power source. Therefore, reader antenna sends a radio signal into the air to activate the tag, then it listens for a backscatter from the tag, and reads the data transmitted by the tag. In general, tags are mounted on many different objects such as paper, glass, plastic, wood, metal, and the human body. Objects can exhibit a wide range of behavior characteristics in relation to RF that is dependent on their material composition. An object can be RF transparent, RF absorbing, RF reflecting, or exhibit a combination of the three. Therefore, the tag antenna has to be designed and optimized for a particular platform [1]. In this paper, a passive RFID tag antenna at UHF (915MHz), which is mountable on a metallic object, is presented. Tag antennas have to be designed to enable passive tags to be activated near and on metallic objects without severe degradation of the performance. Several antenna structures mountable on metallic objects are presented [2]-[4]. In this paper, a novel balanced tag antenna with two PIFAs is proposed. The inductively coupled feeding method [5] is applied to obtain out of phase between two PIFAs and an impedance matching with the microchip simultaneously. The proposed antenna is simulated to analyze by HFSS simulator. A prototype of the proposed antenna is fabricated and measured.

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Design and Results

Fig. 1 shows the structure of the proposed tag antenna. The proposed tag consists of a microchip, feed loop, radiators (two PIFAs) with the shorting plate, FR4 layer, air layer, and ground plane. Overall size of the antenna is $46 \times 54 \times 3\ mm^3$. The feed loop is electrically connected to the microchip, and inductively coupled to the radiator. The feed loop is also suitable for conjugate matching with the microchip. The real and imaginary part of the antenna input impedance can be controlled by the gap between the radiator and feed loop and a radius of the loop, respectively. This inductively coupled feed is very useful for impedance matching of the tag antenna. The microchip has the characteristic impedance about (10-j150 [Ω]) at 915MHz and located on center of the feed loop. Fig. 2 shows the current distribution of the proposed antenna. Two PIFAs are fed by out of phase with the loop. Each shorting plate for two PIFAs is located at the edge of the radiator so that the maximum and minimum point of the electric field can build up on center of the radiator, simultaneously. Therefore, the polarization of the antenna is the same direction as Y-axis. Since the proposed antenna can reduce the induced current on the ground plate compared with the conventional PIFAs, the degradation of the antenna performance by metallic objects can be mitigated. Fig. 3 and 4 represent characteristics of the impedance and the radiation patterns when antenna is mounted on the different size of metal plate (mounted on free space, 0.5λ and 1.0λ). The impedance and resonant frequency are slightly varied as shown in Fig. 3. Variation of bandwidth (VSWR< 3) is only 1MHz from 11MHz to 12MHz, and the resonant frequency is changed within 3MHz. Fig. 4 represents that the main beam direction is not steered by metallic plates. Table 1 presents the maximum reading distances of tag and shows that the proposed tag antenna with the balanced feeding structure can be mounted on metallic objects without severe degradation of the performance.

Conclusions

The balanced RFID tag antenna mountable on metallic plates is proposed. The radiator of two PIFAs is inductively coupled out of phase with the feed loop. The proposed antenna mounted on a metallic object has smaller degradation of performance compared with conventional PIFA structures. It is verified by measuring the maximum reading range on metallic plates.

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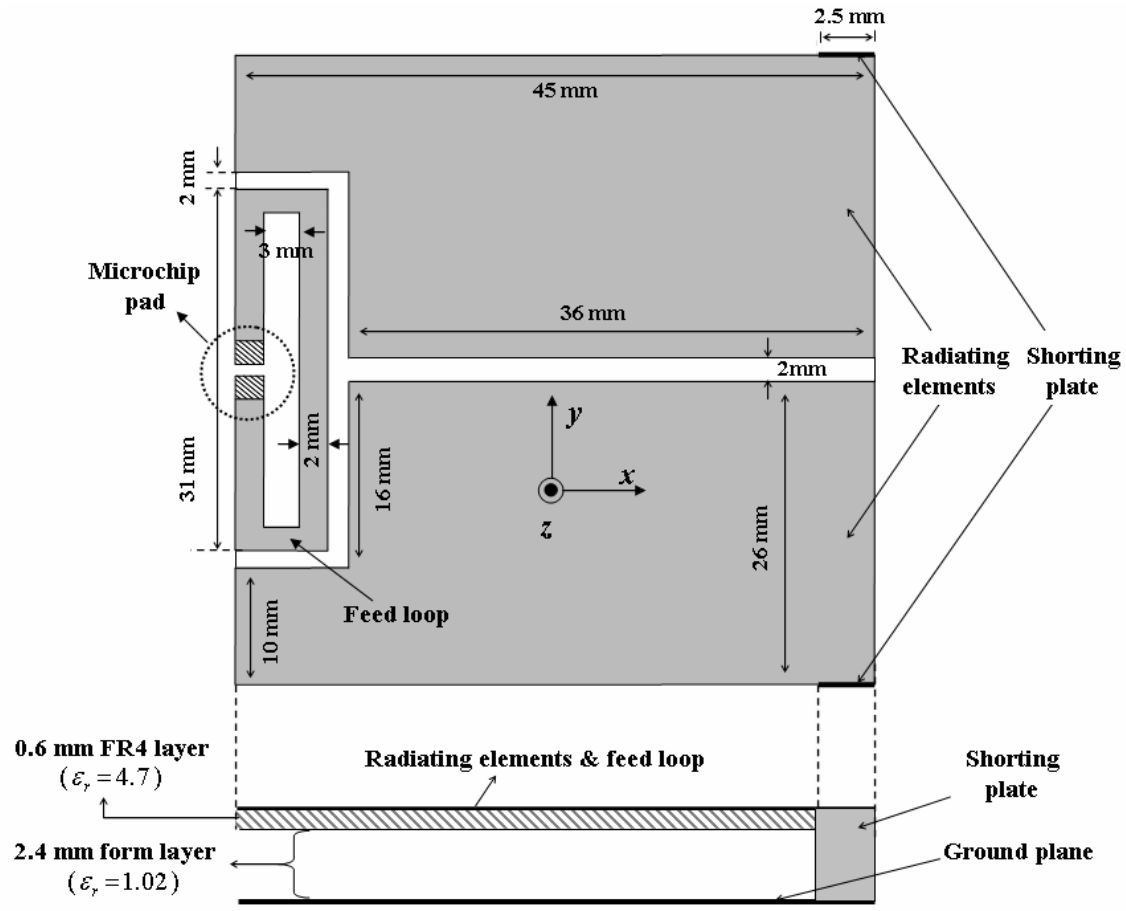


Fig. 1 Structure of the proposed antenna

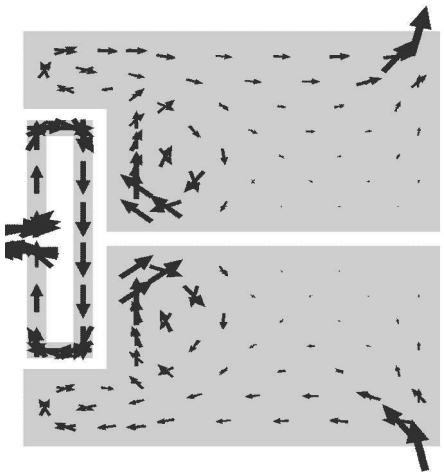


Fig. 2 Calculated currents at 915MHz

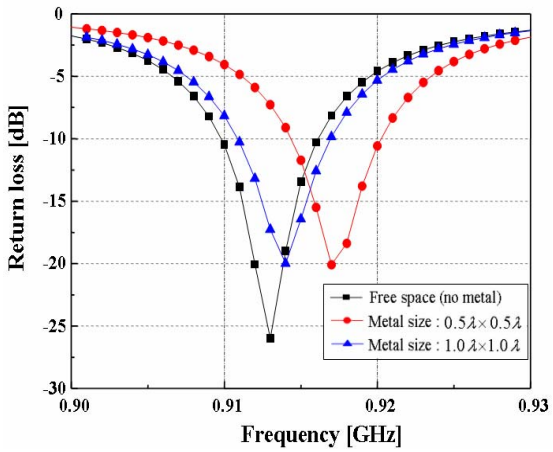
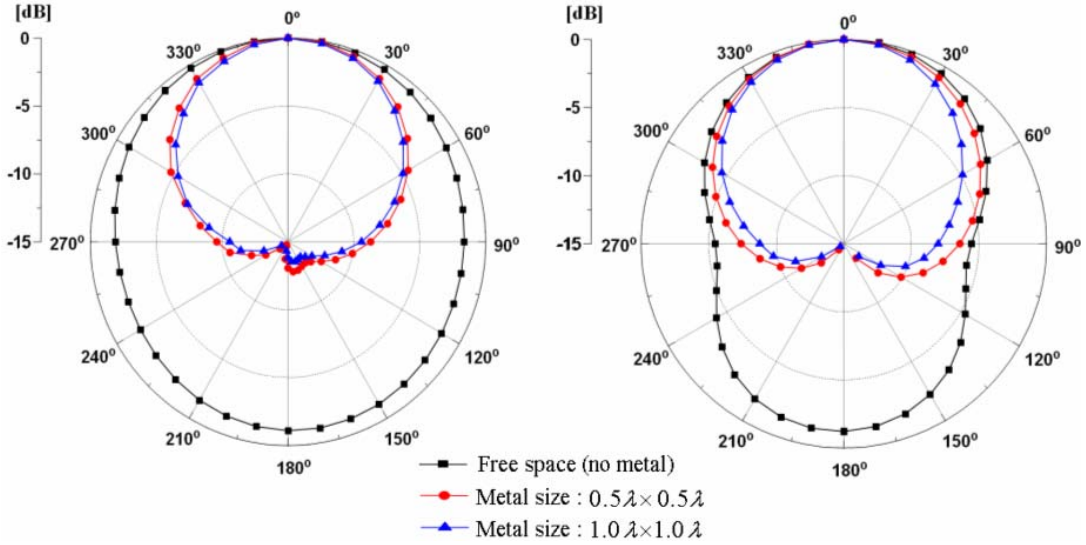


Fig. 3 Calculated return loss by HFSS



(a) (b)

Fig. 4 Calculated radiation pattern by HFSS at 915MHz: (a) Y-Z plane (b) X-Z plane

Table 1 Measured maximum reading distances of tag mounted on metal object

Metal plate size	Maximum reading distance[m]
Free space(no metal plate)	5.1
0.5 λ × 0.5 λ	5.0
1.0 λ × 1.0 λ	4.7