A Compact and Wideband UHF Tag Design Based on Artificial Transmission Line

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Introduction : A passive anti-metal RFID tag antenna is proposed in this paper with the artificial transmission line to reduce the size. The coupled capacitance and inductance are introduced by the four metal parts at corners and interfingers, which determines the resonating frequency, and four square slots are used to fine-tune the resonant frequency. Shorting walls are attached at edges to modulate the surface current path and extend the working band. The proposed antenna topology has a low profile of 27mm × 17.9mm × 1.6mm (0.0823λ × 0.0550λ × 0.0049λ@915 MHz). Simulation and measured results can meet the engineering requirements with an efficient reading area of 1.1 meters under an EIRP of 630mW when tested on a 20cm × 20cm metal plate.

Antenna structure

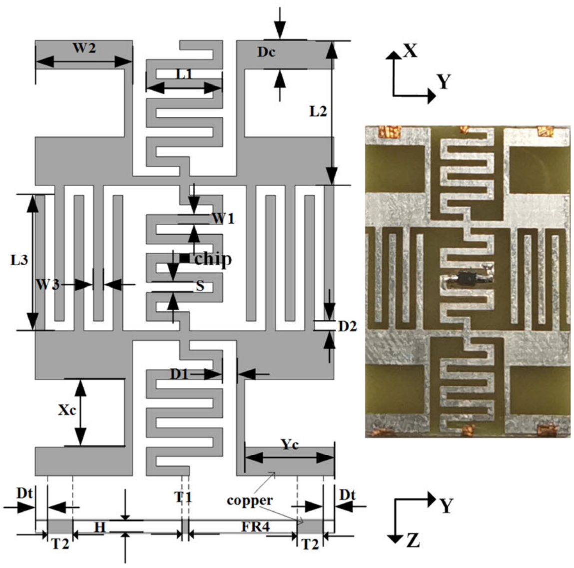
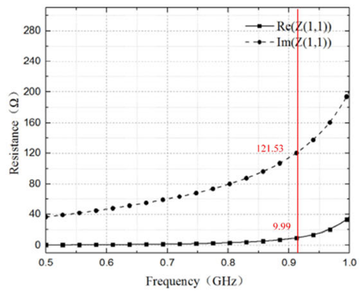


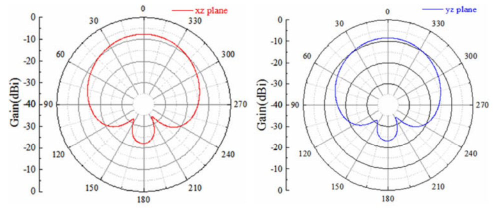
Fig. 1 shows the configuration of the tag antenna.

The upper metal surface adopts artificial transmission line structure as a whole. Bending the microstrip line can reduce the size and introduce the inductance to meet the impedance match. The middle bending strip can also help to suppress the harmonic surface wave, and thus reducing interference on signals. The coupled capacitive and inductive effects of the artificial transmission line will be brought by the metal parts at corners and the middle interfingers. Both of the them can act as the capacitors with the small sizes.

The four metal corners are cut with a slot. Changing the design parameters of them can help to determine the resonating frequency. The copper foil attached on the side edges can play as shorting walls to modulate the surface current path and extend the working bandwidth. The width (T2) of the copper foil on the four corners is essential to guide the current path. The middle shorting wall with the width of T1 on both sides can compensate the current path to maintain the uniformity of the gain performance. The four corners of the shorting walls are the main current paths, and the middle shorting walls are auxiliary current paths. It can extend the working bandwidth. The antenna has been fabricated and measured. Its performance are shown in Fig. 2.

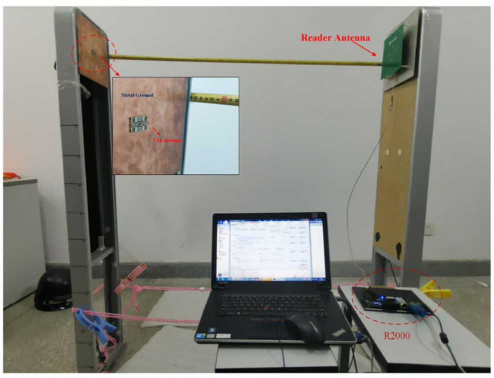


(a)



(b)

Fig. 2 shows the simulation results of the proposed antenna.
(a) input impedance (b) radiation patterns at 0.915GHz



(a)

Fig.3 shows practical test of the tag antenna

To achieve a high responding efficiency, the input impedance is required to be conjugated with the chip impedance. This anti-metal RFID tag antenna takes Monza R6-P chip as the source. The chip is placed in the central position of the antenna with an impedance of (12.28-j *122.03) Ω at 915 MHz. By optimizing the design parameters of L1 and W1 , we obtained the simulated result of the antenna impedance with (9.99 + j *121.53) Ω at 915 MHz. Fig. 2 shows the simulated far-field pattern with a maximum gain of -7.6 dBi with satisfaction to the requirements. We can also see that the proposed tag antenna reaches a uniform radiation gain performance at both the xz and yz planes.

Table I shows the comparisons with some other anti-metal tags

	Power (EIRP)	Tag Dimension(λ^3)	Metal plate Size (cm^2)	Max. Read Distance (m)
This work	630mW	0.0823 × 0.0550 × 0.0049	20 ×20	1.1
[6]	3.28W	0.1156 × 0.1156 × 0.0046	20 ×20	5
[9]	4W	0.0925 × 0.0520 × 0.0092	16 ×16	1.5
[10]	4W	0.0751 × 0.0405 × 0.0069	20 ×20	~5.2

The responding performance of the proposed tag antenna has been tested with an in-lab measurement setup. The tag is placed in the middle of the metal plate with a size of 20cm × 20cm. A circularly-polarized reader antenna with a gain of 8 dBi is used for transmitting and receiving signals. It is controlled by the Impinj 2000 reader, with an input power of 28 dBm. The maximum reading distance of the tag antenna is measured under the working frequency range between 900 MHz and 930MHz, which can reach above 0.9 meters with a broad working band. The maximal effective reading distance appears at 915 MHz with 1.1 meters, which can meet the practical application requirements.We can see that this tag antenna has the advantages of small size, low profile and long reading distance when compared with other existed anti-metal tags.

Conclusion

In this paper, a compact and wideband RFID anti-metal tag antenna is proposed. Coupled capacitance and inductance are introduced from the metal parts and interfingers. Bended strips and metal ground are used to reduce the antenna size and shield the influences from other metal substrates. By optimizing the structure design parameters, the resonating frequency and the surface current can be modulated to achieve a high radiation performance. The metal shorting walls are also employed to extend the working band. Simulated results show that this antenna has a good impedance match with the chip and excellent far field radiation performance. The responding effects of this tag antenna are tested and verified in lab, and achieves the requirements for practical applications. The proposed tag antenna can be fabricated on the common PCB substrate of FR4 with low cost.

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