I. INTRODUCTION

Radio frequency principle is the basis for automatic identification technology using RFID. It identifies automatically stationary and moving targets, efficiently get target information and data by a storage displacement encoder which is part of RFID tag circuit. The RFID tag circuit utilizes radio frequency signals and spatial coupling and transmission characteristics. RFID technology blending with the internet and wireless communication network has numerous applications which can successfully and efficiently replace the bar code systems. The immediate and apparent advantages are long read distance, rapid reading and writing and non-visible identification. The broad applications like logistics supply chain, production automation, traffic management, military and public information services.

RFID tag antenna is highly sensitive to the surrounding environment [1], where it is attached and brings an enormous impact on its performance. Inevitably in various occasions identifying metal objects is the objective such as motor vehicle, weapons, cylinders, containers so on. The ordinary UHF tags could not serve the purpose as it effects Impedence matching, radiation efficiency and directivity [2]. Hence it has a direct say on the reading range obviously it limits the applications pertaining to logistics industry. So the need arises to design anti metal RFID tags to perform better on the metal surface.

The existing design methods of RFID tag are as follows: (1) modifying the distance between the tag antenna and the metal surface; (2) inventing electromagnetic wave absorbing film [3]; (3) utilizing electromagnetic band gap (EBG) structure [4]; (4) utilizing unique metal tag antenna design methods. Adjusting the distance will increase the size of the antenna. It is not advantageous because there is no uniform method of adjustment. Most of the high frequency electromagnetic wave absorbing film costs a lot. So it’s not an economical way to be widely used in the UHF band. EBG structure can inhibit a particular band of electromagnetic wave propagation to reduce the sidelobe level and increase the gain, but the structure of production is too complicated. So it is not helpful to production.

Here an anti-metal tag antenna structure which employs a microstrip antenna model where the embedded feed is to adjust the antenna impedance by changing the dimensions of the open circuited stub are considered. Thus there would be a focus on maximizing the transmission efficiency by optimizing antenna Impedence. The remainder of this paper is organized as follows. In Section II, we describe the tag antenna model. In Section III, a new tag antenna structure is presented. Simulation results are shown in Section IV. At last, we conclude in Section V.

II. PREVIOUS WORK

This session describes the details about previous works of UHF RFID tag antenna. The resonant frequency used in base paper is 920MHz. [5]. A new anti-metal tag antenna with open-circuited stub embedded feed. Its reflection loss S11 is less than -15 dB at 920 MHz. It has a planar structure, including thin and low cost. Its maximum reading distance is more than 2.5 m. The proposed tag antenna can be used in the metal object management.

III. MICROSTRIP PATCH ANTENNA DESIGN

A. Tag Antenna Model

Currently, there are two kinds of popular metal tag antenna design methods: the short stub structure [6], [7] and the open stub structure [8], [9]. Compared to the metal tag antenna with the short stub structure, the metal tag antenna with the open stub structure can realize a big reactance value.

We consider the microstrip antenna as the antenna model and propose a new metal tag antenna with the open stub structure. On one side of the dielectric substrate whose thickness is much smaller than a wavelength, we cover the metal radiation sheet whose length is shorter than a half wavelength in the dielectric substrate. On the opposite side of the dielectric substrate, we cover the thin metal layer as a ground plane to form a microstrip antenna. The microstrip antenna is small, has a light weight and is easy to be made. Since we take the metal ground plane into consideration, when we put the antenna on metal surface, its performance will improve significantly.

A microstrip patch antenna is designed on the bases of three essential parameters for the design, one is operating Frequency or resonant frequency (fr), two is dielectric constant of a substrate (Ɛr), and third important one is height of the dielectric substrate (h). The calculation of the patch antenna is given below with the mathematical design equations [10].

B. Mathematical Design Equations:

The width of the Microstrip patch antenna is given by,

$$W = \frac{c}{2\pi f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \quad \text{(1)}$$

The effective dielectric constant is as follows,
The length extension is given as,

\[ \Delta L = h \times 0.412 \left( \frac{W}{\varepsilon_{eff} + 0.3} \right) \]

The actual length of the patch is obtained by,

\[ L = \frac{c}{2f \varepsilon_{eff}} - 2\Delta L \]

The length of the ground plane and substrate is,

\[ L_g = 6h + L \]

The width of the substrate and ground plane,

\[ W_g = 6h + W \]

Where,

\( c \) => Speed of light.
\( \varepsilon_r \) => Dielectric constant of the substrate.
\( \varepsilon_{eff} \) => Effective dielectric constant.
\( f_r \) => Resonant frequency.
\( h \) => Height of the substrate.
\( \Delta L \) => Extension of the patch length.

IV. TAG ANTENNA STRUCTURE

Using above said essential parameters the patch width (W) and length (L) is calculated along with the ground or substrate of width (Wg) and length (Lg) as shown in the mathematical equations. The UHF RFID antenna is simulated with the 3D full wave electromagnetic software Ansys HFSSv15 [11].

Two-dimensional geometry of the tag antenna is shown in Fig. 1. Top view and bottom view of the proposed tag antenna are shown in Fig.1(a) and Fig.1(b), respectively. The existing tag antenna is shown in Fig.1(c) [8]. Three-dimensional structure of the proposed tag antenna, which consists of an antenna radiating surface, a stub and a metallic ground plane. We choose an FR4 substrate whose relative permittivity is \( \varepsilon_r = 4.6 \). The size of the substrate is \( L_0 \times W_0 \times H_0 = 140 \text{mm} \times 40 \text{mm} \times 2 \text{mm} \), where \( L_0, W_0 \) and \( H_0 \) denote the length, the width and the thickness of the tag antenna, respectively.

![Fig. 1(a): Three-dimensional geometry of tag antenna](image)

![Fig. 1(b): Top view of tag antenna.](image)

![Fig. 1(c): Bottom view of tag antenna.](image)

V. SIMULATION RESULTS

All the below described Simulations results are carried out using Ansoft HFSSv15 simulation tool which is a high performance full wave electromagnetic (EM) 3D field simulator. Ansoft HFSS can be used to calculate parameters such as return loss, gain, directivity, band width, VSWR, radiation pattern and polar plot. The resonant frequency is set at 920MHz.

We use the electromagnetic simulation software HFSS15 as simulation tool. Simulation parameters are defined as follows: 920 MHz is the center frequency, 620 MHz~1220 MHz is the scanned region, and a metal plane attached on the surface of tag antenna is of size 200 \times 200 \text{mm}^2.

With the optimal size, the proposed tag antenna radiation pattern at 920 MHz is shown in Fig.3. We can see that the XOZ plane is equivalent to the plane of \( \varphi = 0^\circ \) and the YOZ plane is equivalent to the plane of \( \varphi = 90^\circ \) in figure 4.

![Fig. 3: Radiation Pattern of 0 degree.](image)
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Fig. 4: Radiation Pattern of 90 degree.

Fig. 5: 3D Polar plot

We also find the antenna has good directivity features in the semicircle of E plane and H plane. The three-dimensional antenna pattern is shown in Fig.5. The measured S11 values are shown in Fig.6.

Fig. 6: S11 value

VI. CONCLUSION

This paper proposed UHF RFID microstrip patch antenna with 920MHz as the center frequency, appropriate gain and directivity, minimal return loss with good bandwidth. The above issues are addressed with a novel approach. In this paper, a metal tag antenna is considered with open stub, its reflection loss S11 is less than -21.0499 dB at 910 MHz. It has a planar structure, including thin and low cost.

The analysis, design of UHF RFID patch antenna with open stub is simulated successfully using Ansys HFSS v15 tool. These characteristics satisfy the requirements of RFID applications and hence can be used for RFID systems in 900MHz – 920MHz range.

REFERENCES


