Optimising Efficiency and Gain of UHF-RFID Tag with Increased Read Range.

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Abstract- **Radio frequency identification (RFID) has become one of the fastest growing wireless technologies. An RFID system is a real-time processor that enables the information stored on a tag to be tracked and exchanged remotely with an RFID reader. The goal of this paper is to present the investigations and design of RFID antenna for applications as a tag in the UHF band ranging from 860 to 960 MHz. The antenna models presented are based on a triangle shape design with good gain that is designed and analyzed. To obtain an optimum peak gain, the effects of slots are investigated. The physical parameters of the novel structure as well as its partial ground plane are analyzed and optimized using Ansoft HFSS simulation software package and MATLAB. Return loss (S11), directivity and gain are carried out. The results show that the proposed antenna has good impedance and radiation characteristics over the required UHF bandwidth. The return loss of the optimized antenna is below 10 dB over the UHF frequency band and increase read range about 12.77 m. The proposed antenna is very promising for various modern communication applications.**

***Keywords*: Radio frequency identification (RFID), High Frequency structure simulation (HFSS) . Ultra High Frequency (UHF).**

I. INTRODUCTION.

Automatic identification procedures have become very popular, such as Signature Capture, Magnetic Stripe Readers, Optical Character Recognition, Biometric Technologies, Barcodes and Radio Frequency Identification (RFID) have become the critical components in the operation of various industries and business processes. These technologies are able to identify people, products, codes, serial numbers, rapidly and accurately. Due to their low cost and ease of implementation, they have been the primary means of identifying products in retail industry. However, the main disadvantage of barcode technology is the limited information capacity, very short reading range and the need for a line-of-sight reading arrangement. In fact, due to the line-of-sight requirement, reading barcodes is a time-consuming process. As well, the printed barcode sticker must be placed on the outside of a product, where it is subject to wear and tear. Barcode tags also have no read/write capability, thus the information written on a printed barcode sticker cannot be changed. These drawbacks make barcode technology unsuitable for many modern applications.

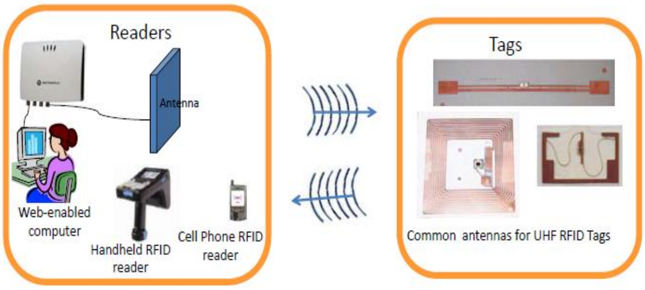

Fig. 1. The main components of a typical RFID system [1].

The basic RFID system as shown in Fig. 1, consists of two components: (i) the transponder (or tag) that is located on the object to be identified as well as (ii) the reader (or transceiver) that is designed to communicate with the tag by performing either a read or a write/read operation. The RFID system operates as follows: The reader broadcasts signals via its attached antenna. The tag receives these signals and responds by either writing the received data into the IC memory or replying with another signal that contains some data, usually the identity code or a measurement value [2]. In addition, the tag may rebroadcast the signal to the reader with a predetermined time delay.

A reader is basically a radio frequency (RF) transmitter and receiver, controlled by a microprocessor or digital signal processor. An RFID reader emits electromagnetic signals where an RFID tag draws power from it. This power is then used to energize the microchip's circuits.

One of challenge in designing a RFID system is to design compact, low-cost, small size antennas and increase read range. The microstrip is considered a good candidate for RFID applications because it is low profile, etched on a single substrate and can provide the feature of multi-band operation.

In this paper, an triangle-shaped antenna with good gain for RFID tag and wireless communications is designed to resonate on the Ultra High Frequency (UHF) RFID bands of 860 MHz-960 Mhz. The effects of adding slots are investigated. The theoretical simulations are performed using Ansoft HFSS simulation software package and MATLAB software.

II. RFID DESIGN AND EQUIVALENT CIRCUIT

A tag normally consists of a chip and an antenna. In passive tags, the energy required to drive the chip comes

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from the interrogation system itself. A backscattering modulation is achieved when the microchip acts as a switch, to match or mismatch its terminal impedance to the antenna [2]. The impedance matching between tag antenna and chip is very important thing. In order to realize the maximum power transmission reflected from tag, the tag antenna has to conjugate a match to the chip. Fig. 2, shows the equivalent circuit of tag. The chip impedance Z_L is given by $R_L + jX_L$ and the antenna impedance Z_A is given by $R_A + jX_A$. When $Z_L = Z_A$, the maximum transmitted power Pt by a tag can be expressed as below [3].

$$P_t = \frac{1}{2}|I|^2 . R_A \quad (1)$$

since $Z_L = Z_A^*$.

$$I = \frac{V}{2R_A} \quad (2)$$

Substituting (2) for (1) we get

$$P_t = \frac{1}{2}\left|\frac{V}{2R_A}\right|^2 . R_A = \frac{V^2}{8R_A} \quad (3)$$

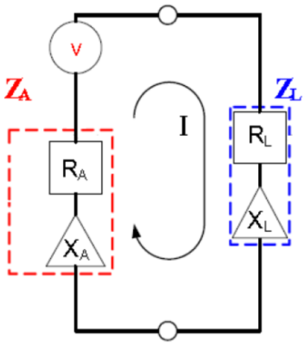

Fig. 2. The equivalent circuit of tag.

III. Optimization of UHF RFID Tag design

A considerable amount of work have been dedicated to the understanding and design of a tag antenna for UHF worldwide RFID applications. The results obtained are shown in last section. They show the basic physical and electrical parameters to be considered when designing a tag antenna that relies on the backscattering method. A simulated model is presented.

One of challenges in designing a RFID system is to design compact, low-cost, small size antennas and increase read range. The microstrip is considered a good candidate for RFID applications because it is a low profile, etched on a single substrate and can provide the feature of a multi band operation.

IV. Antenna Design

The configuration of the proposed antenna is shown in Fig. 3, The antenna is designed on a low cost FR4 substrate with ε_r =4.4and thickness of 1.6 mm. The structure of proposed antenna is shown in Fig. 3,. The antenna consists of two triangular sections. Two triangular sections are incorporated in the design to increase the antenna gain value. The antenna is mainly determined by the two triangular sections. The geometric parameters are adjusted carefully and final optimized antenna dimensions as shown in Fig. 3, the physical size of antenna is 8.02 mm × 40 mm. The proposed design is single layered, via-free and can therefore be easily fabricated at a very low cost [5].

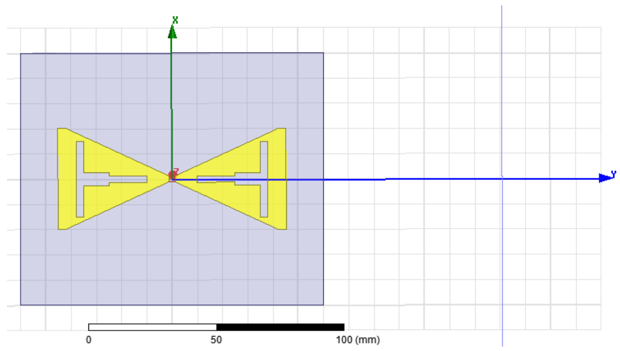

Fig. 3. Geometry Structure of proposed UHF RFID tag antenna in (mm).

V. Simulated Results of Proposed Antenna

The design of the proposed antenna has been done by the proper selection of the loading left handed elements. This has been checked by using electromagnetic full wave simulation (HFSS).

A- Antenna Return Loss

The simulated reflection coefficient of the proposed antenna is shown in Fig. 4,.It is obvious that the reported antenna can operating band is at centered 900 MHz with -17.68 dB and bandwidth which extends from 827 MHz to 978 MHz. So, it is quite clear that this operating band meets the design requirements of UHF RFID standard operating frequency.

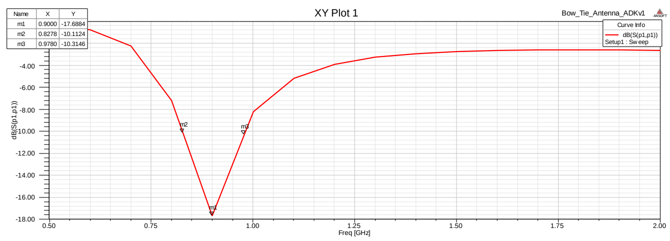

Fig. 4. Microstrip antenna return loss of a proposed UHF RFID tag antenna.

B- Radiation Pattern in 3D

The antenna radiation performance at the operating band has been checked by investigating the radiation pattern at UHF frequency. It is obvious that the antenna has an Omni-directional radiation pattern with maximum radiation in Z direction, perpendicular to the antenna. Such a radiation pattern is appreciated in the RFID applications. For investigation of the polarization properties of the antenna, Fig. 5, at the UHF frequency, the result can be observed is better.

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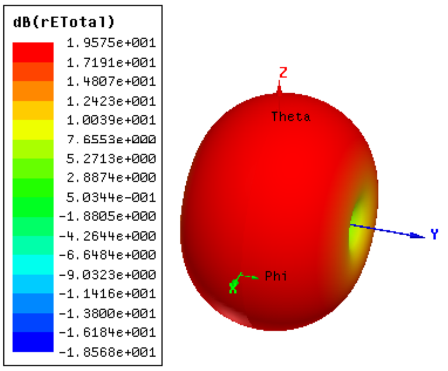

Fig. 5. 3D radiation pattern of the proposed UHF RFID tag antenna.

C- Gain and Directivity

The designed antenna radiates in broadside direction with gain of 2.11 dB and the directivity of 2.17 dB. Gain and Directivity 3D far field plots are given below in Fig. 6, the antenna is good gain and directivity for RFID applications.

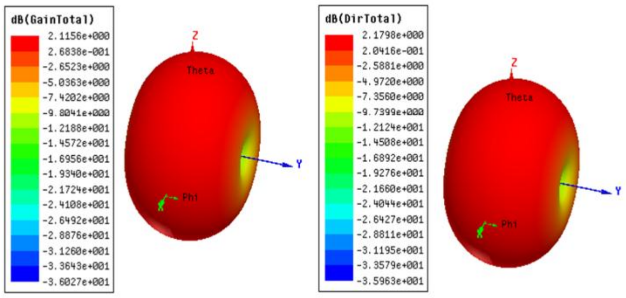

Fig. 6. Gain and directivity of the proposed UHF RFID tag antenna.

E- Current distribution

Fig. 7, illustrates the current distribution of RFID tag antenna. It is clear from the Fig. that the amount of current declines at the start and edge of triangle. Fig. 7 shows the current distribution pattern at UHF band. The red arrows show the strongest current distributed in patch of antenna.

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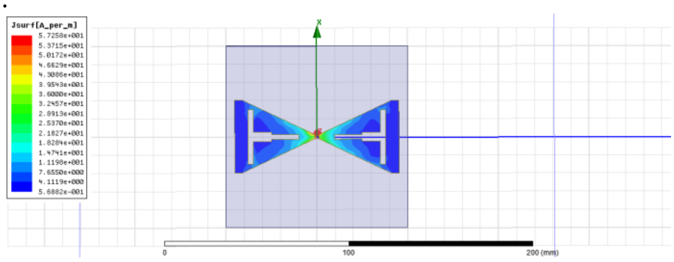

Fig. 7. Average current distribution of the UHF RFID tag antenna.

VI. MAXIMUM READ RANGE OF PROPOSED RFID

Form results proposed tag antennas is a perfect choice for RFID application due to the following features, a low profile and small size has been obtained with respect to a conventional rectangular patch or mended dipole antenna. and conformability. The bandwidth can be increased by adding slots but it affects efficiency of the antenna. The tag antenna use two triangular sections are incorporated in the design to increase the antenna gain value.

The tag read range is defined as the maximum distance at which the RFID reader can detect the RFID tag. The reader has a higher sensitivity than the tag and as a result the read range can be considered as the tag response threshold. Furthermore, the read range is also dependant on other factors such as tag orientation and environmental losses. The read range is calculated using the Friis free-space equation [4].

$$r = \frac{\lambda}{4\pi}\sqrt{\frac{EIRP\ G_t\tau}{P_{th}}} \qquad (4)$$

Where the EIRP = 3.3 W for Europe and = 4 W for USA. after substitute by parameters and tag antenna (gain of the reader = 0.941, gain of the tag = 2.11, $\lambda = 0.327$ m, P_t = 1W, $P_{th} = 35\ \mu W$, EIPR = 4 W for USA), then the maximum read range is = 12.77 m.

VII. CONCLUSIONS

A compact Tag antenna for UHF-RFID applications has been presented in this paper. The proposed radiating structure is a triangular geometries antenna which takes. This way, a size reduction and has been obtained with respect to a conventional antennas. The simulation results to achieve high gain, and good VSWR for RFID applications, this proposed antenna model is cost, effective, high efficiency and read range. The optimum design parameters (dielectric material=FR4, height of the substrate = 1.6 mm), and operating UHF have been used to achieve the compact dimensions and high radiation efficiency is 96%. It provides a return loss was below 10 dB -17.68 dB) for UHF band, gain of 2.11 dB, and directivity is 2.17 dB, is achieved over the complete frequency band, the antenna can be realized with conventional printed circuit board techniques. The proposed is increase read range about 12.77 m. it can be easily fabricated at a very low cost. The antenna is thin and compact with the use of low dielectric constant substrate material. These features are very useful for worldwide portability of wireless communication equipment.

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