I J C T A, 9(37) 2016, pp. 569-576

Design and Fabrication of Low-cost RFID Antenna on a Paper Substrate using Conductive Ink Technology

Iswarya A.[*] and B. Priyalakshmi[**]

Abstract: In this proposed paper, design and implementation of RFID System Access Device involves with the integration of a RFID Tag and a Microcontroller, which results in producing a simple way of system to access the authorized person by the information stored. The proposed RFID tag emerge with conductive ink printing technology which is fabricated on low-cost paper substrate, subjected to replace with the EMF coil to produce a Chipless RFID Tag. And as concerned with the RFID reader, a Arduino microcontroller is used, so as to store the data as well as to radiate the RFID tag respectively. The main motive of this system device, recreates the RFID system for the low-cost production which is evolved with the simplest architecture.

Keywords: RFID-Radio Frequency Identification, RFID Tag, RFID Reader, Spiral Dipole Antenna, Arduino, Conductive Ink and Paper substrate.

1. INTRODUCTION

Today, RFID technology has moved from ambiguity into standard applications that speed the handling of manufactured goods materials and many other system applications. The RFID system helps to automatically identify humans, animals, or any objects by means of radio wave. RFID allows identification from a distance, and unlike earlier bar-code technology. RFID tags support a major set of different IDs than bar codes and can consolidate the additional data such that manufacturer, products, and even measuring devices for environmental factors such as temperature. Moreover, RFID systems can discover many different tags located in the same general area without human support. RFID drives as a major technology promoter for identifying and tracking goods and assets around the world. It can assist hospitals to get an expensive equipment instantly to improve patient care, pharmaceutical companies to reduce counterfeiting [3]. It also promises to enable new ability in the supply chain business by tracking goods from the point of manufacture through to the retail point of sale.

2. RFID-RADIO FREQUENCY IDENTIFICATION

Radio-frequency identification (RFID) detail of an object (typically referred to as an RFID tag) can be applied and put together into a product for the purpose of identification and tracking used by radio waves. Some tag can be radiated from meters away. Basically, the RFID systems consists of an radiating antenna and a transceiver, which reads the radio frequency and transfer the information stored to a processing device, and a transponder, or tag, which is an integrated circuit containing the RF circuit and information to be transmitted. Radio frequency identification, or RFID, is collection of technologies that use radio waves to automatically identify people or objects. There are several methods of identification, but it is to store a serial number that identifies a person or object.

[*] PG Scholar, Department of Telecommunication Engineering, SRM University, Kattankulathur, Kanchipuram District. *Email: ashu.pagat@gmail.com*

[**] Assistant Professor, Department of Telecommunication Engineering, SRM University, Kattankulathur, Kanchipuram District. *Email: priyalakshmi.b@ktr.srmuniv.ac.in*

3. RFID TAG

RFID Tag is an ID (Identification) system that uses radio frequency identification devices for identification purposes. An RFID tag system contains the tag itself, a read/write device, and a host system application for data collections, processing and transmission. In correspondence with power suppliers, RFID tags can be classified into passive, active, and semi-passive. Passive tags, which has no internal power source and no radio transmitter [1, 2, 4]. The internal circuits are driven by the rectified energy from the electromagnetic wave sent from a reader. Semi-passive tags have local battery, but the power output from the battery exclusively supplies the operation of the internal circuit, and the energy for sending out data is still derived from the interrogation signals transmitted by the reader. Active RFID tags have an internal power source and a transmitter that can proactively transmit signals. Semi-passive and active tags can offer longer operation range, higher data rate and larger memories than passive ones.

4. RFID Reader

An RFID reader is actually a radio frequency (RF) transmitter and receiver, controlled by a microprocessor or digital signal processor. The reader, using an inbuilt antenna, receives data from tags then passes the data to a host system (computer) for processing. Readers can be fixed in a stationary position; for example, beside a conveyor belt in a factory or dock doors in a warehouse, portable (integrated into a mobile computer that also might be used for scanning bar codes), or even embedded in electronic equipment such as print-on-demand label printers [7, 8, 9].

5. Functions of RFID

The Information is transmitted to and received from RFID tags by a reader used with radio waves. In passive systems, which are the most common, an RFID reader transmits an energy field that “wakes up” the tag and provides the power for the tag to operate. With active systems, a battery in the tag is used to boost the effective operating range of the tag and to offer additional features over passive tags; such as, temperature sensing. All the data stored is collected from tags and then transferred through familiar communication interfaces (cable or wireless) to computer systems in the same way that data scanned from bar code labels is collected and transferred to computer systems for interpretation, storage, and action [4-7].

6. MICROCONTROLLER

As per the proposed system design is concern, an ATmega328 microcontroller which is used in RFID reader and it consists 28-pins. The pin configuration of the Arduino Uno board is shown in the figure. 1. It consists of 14-digital i/o pins. Wherein 6 pins are used as pulse width modulation o/ps and 6 analog i/ps, a USB connection, a power jack, a 16MHz crystal oscillator, a reset button, and an ICSP header. Arduino board can be powered either from the personal computer through a USB or external source like a battery or an adaptor. This board can operate with an external supply of 7-12 V by giving voltage reference through the IORef pin or through the pin Vin. [3, 5, 8, 9]

A. Digital Pins

The digital Input pins comprises of 14-digital I/O pins, each pin take up and provides 40mA current. Some of the pins have special functions like pins 0 & 1, which acts as a transmitter and receiver respectively. For serial communication, pins-2 & 3 are external interrupts, 3, 5, 6, 9, 11 pins deliver PWM o/p and pin-13 is used to connect LED.

- **Analog i/ps:** It has 6-analog I/O pins, each pin provides a 10 bits resolution.
- **Aref:** This pin gives a reference to the analog i/ps.
- **Reset:** When the pin is low, then it resets the microcontroller.

The main advantage of the Arduino technology is you can directly load the programs into the device without the need of a hardware programmer to burn the program. This is done because of the presence of the 0.5KB of boot loader, that allows the program to be dumped into the circuit.

B. Power Supply

As of the whole product design of RFID system is concerned with Active RFID tag and RFID Reader. The RFID tag antenna is in build with a 3.0V power source which is specified as mentioned in the table. And the RFID Reader uses the Arduino Uno and the power supply is specified in the Table 1 and 2.

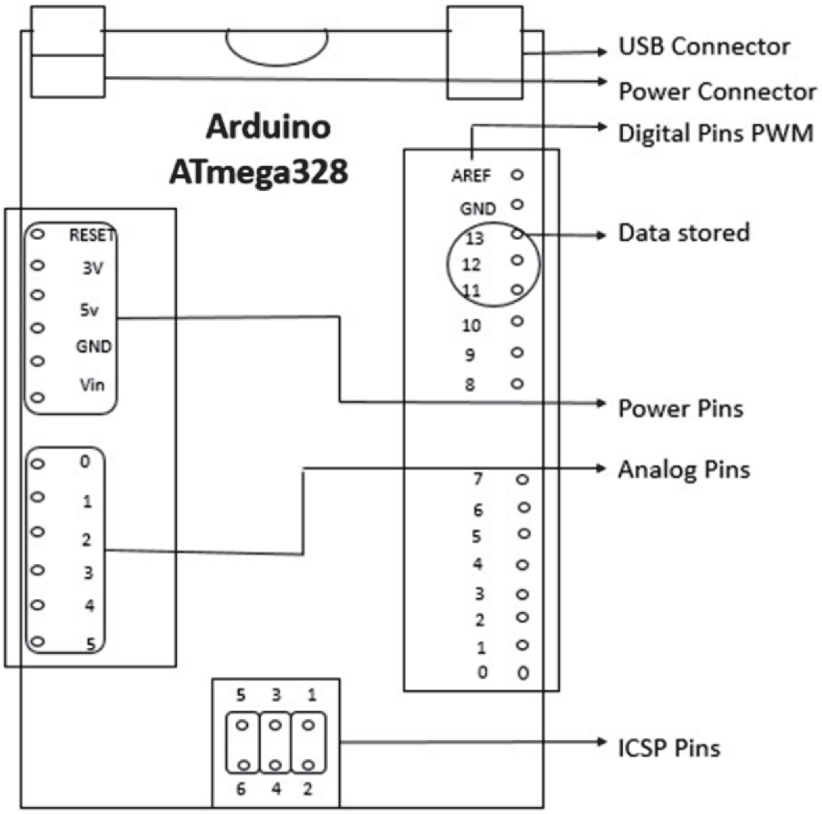

Figure 1: Representation of Arduino Pin diagram

Table 1
Power supply specification of RFID tag

Type of battery	*Lithium coin*
Voltage	3.0 V
Capacity of battery	240 mAh
Weight of battery	3.0 grams

Table 2
Power supply specification of RFID reader

Microcontroller	*AT mega 328*
Input voltage driven	+5 V
DC current per I/O Pin	20 Ma
DC current for 3.3V Pin	50 Ma
Adapter power source	12 V to 1 A

7. PROPOSED EXPERIMENTAL WORK

A. Design of Tag Antenna for RFID System

In this proposed antenna design of Square Spiral antenna, which is considered as one of the types of Dipole antenna. Since the spiral antenna is utilized in the wide range of RF applications, and so it is observed to be used in the design and fabrication [1].

This type of the Spiral antenna belongs to the class of frequency independent antenna, which operates over wide range of frequencies that can be either low or more of high of UWB Frequencies, and therefore the radiation pattern, impedance and polarization remain virtually constant over a large bandwidth. Figure 2 shows the diagram of model antenna taken for the experimental concept.

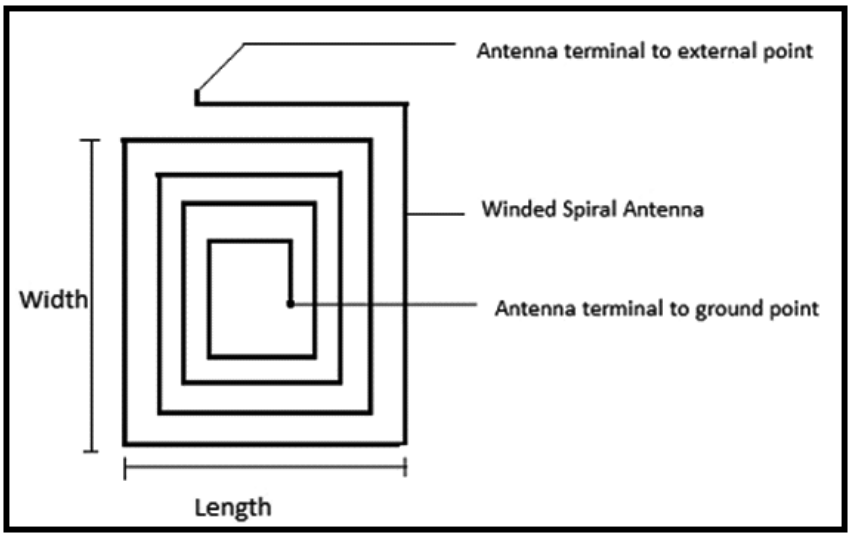

Figure 2: Planar Square Spiral Antenna

B. Discussion of Simulation Process and Results

From the simulation process, the main part of creating this technique is to replace the electric and magnetic fields as the radiating element at the ground plane (in the substrate). The simple spiral antenna is designed at the length and width of 6 mm × 6 mm as shown in Figure 3(a). The simulated planar spiral antenna substrate as shown in the Figure 3 is received with the return loss at 910 MHz GHz, as shown in Figure 3(b). The simulated and measured radiation patterns obtained which is shown in the Figure 3(c), and it is found that the proposed antenna radiates in E- and H-plane direction and achieved VSWR < 2.

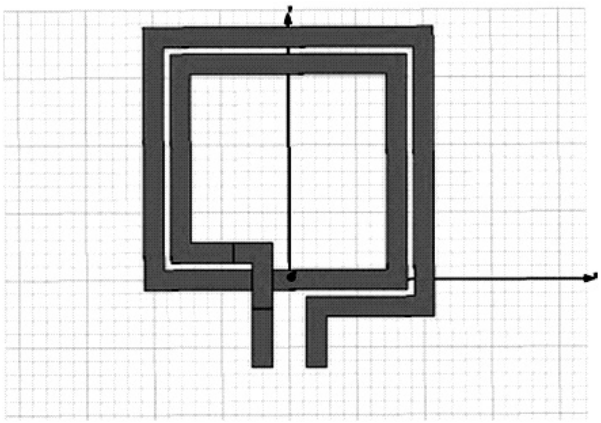

Figure 3: (a) Spiral Antenna Substrate

C. Fabrication for tag antenna by conductive ink

The proposed experiment for designing the spiral antenna on a paper substrate, here it is implemented by designing the particular antenna structure using the appropriate dimension shown as in the Table 3. From the above illustration in order to face the low-cost features, so the EMF induction is replaced by the conductive ink technology in the RFID Tag, therefore the (chipless RFID) Spiral antenna is fabricated on a classical paper of thickness 4 mm. The paper was chosen to present the less dielectric loss value, as shown in the Figure 4. The antenna printed on a flat sheet using electrically conductive ink as shown in the Figure 5, thus, the electric conductive ink is used here to completely avoid the electric and magnetic field effects and its loss.

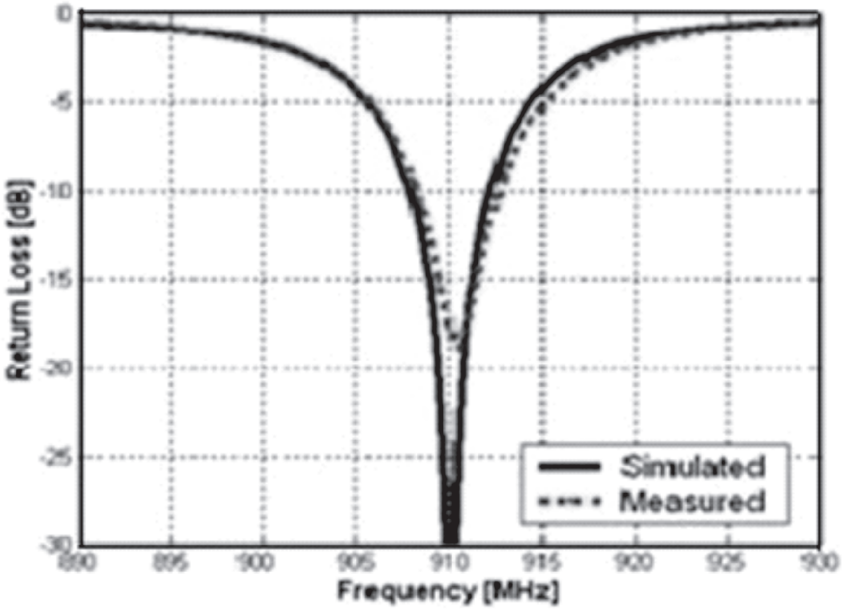

Figure 3: (b) Return loss

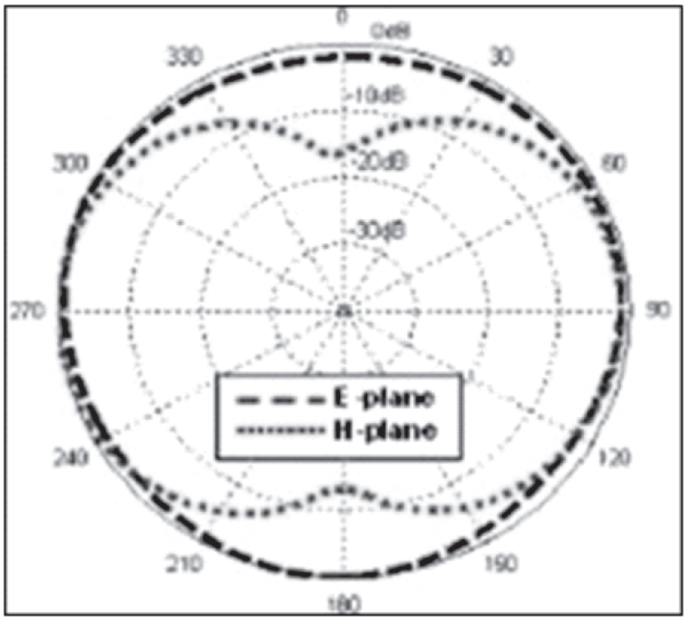

Figure 3: (c) Radiation pattern

As seen in the Figure 4, generally there are two types tag antennas which are active tag and passive tag. As per the functional system of the application concerned, the design of active tag is used, in which

it contains an internal battery of 3.0 volts of capacity 240 mAh and do not require power from the reader. And as it is mentioned earlier, the EMF coil is replaced by creating the Chipless Active RFID Tag for various RFID applications.

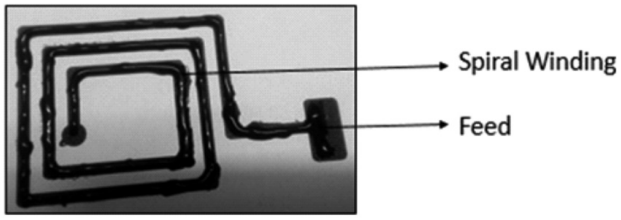

Figure 4: Printed Planar Spiral Dipole Antenna

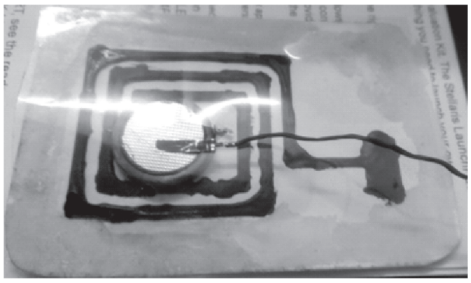

Figure 5: RFID Tag (Transponder)

Table 3
Specification of Fabricated RFID Tag Antenna

Specification	*Measured Factors*		
Substrate material		Paper	
Thickness		4 mm	
Conductive Material		Electric conductive ink	
Length of spacing $L_1 = L_2 = L_3$		1.48 mm	
Length of Feed		14.53 mm	
Length	L_1 = 25.86 mm	L_2 = 35.02 mm	L_3 = 46.45 mm
Width	W_1 = 11.97 mm	W_2 = 12.4 mm	W_3 = 34.93 mm

D. Proposed Structure and Design of the RFID Hardware Device

The working process begins when the designed RFID Tag comes in the range of RFID reader system, then the reader to which the RFID tag connected, radiates and transmits the signal to the tag Antenna. The functional units are connected according to the reference of the block diagram shown in the Figure 7, where Arduino microcontroller-power and Analog inputs are interfaced to the LCD shield Digital power and Analog inputs respectively. The A_0 pin from LCD Shield is taken out as the terminal point to receive the signal radiated from the RFID tag. Finally, the output is obtained at 2 × 16 LCD screen, which is driven from the ATmega microcontroller.

E. Design of RFID Reader

According to the system design concern, RFID Reader operates at 3.0 V. Here in the system design, the input is driven from 12 V to 1 A. The reader is having Arduino ATmega microcontroller, so it is used to program at ISCP pins consisting of V_{CC}, RESET, SCK, MISO and MOSI pins , where the necessary program is written in MISO and MOSI pins respectively. And the required data for the product system to

be displayed is stored in 13th, 12th and 11th pins from the DIGITAL PWM. For to display the data given, the Arduino microcontroller is interfaced with the LCD button shield. When the Tag transmits the signal, the A_0 pin which is in the LCD button shield, receives the transmitted signal from the Tag antenna.

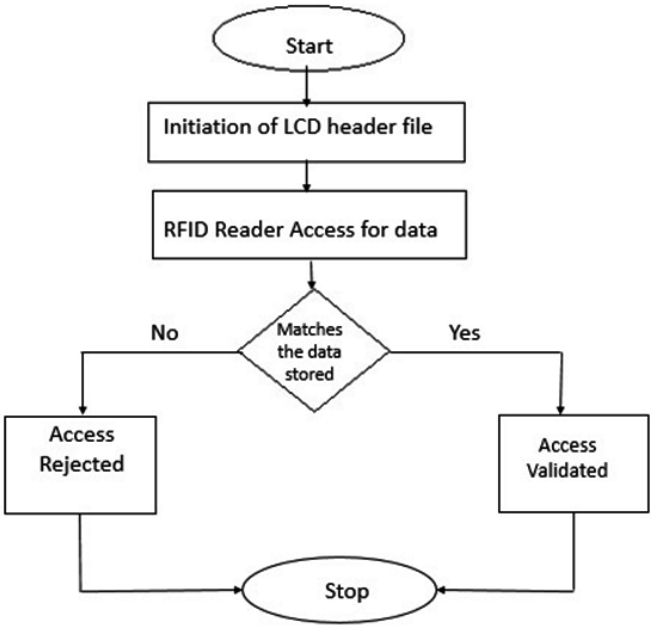

Figure 6: Flow Chart

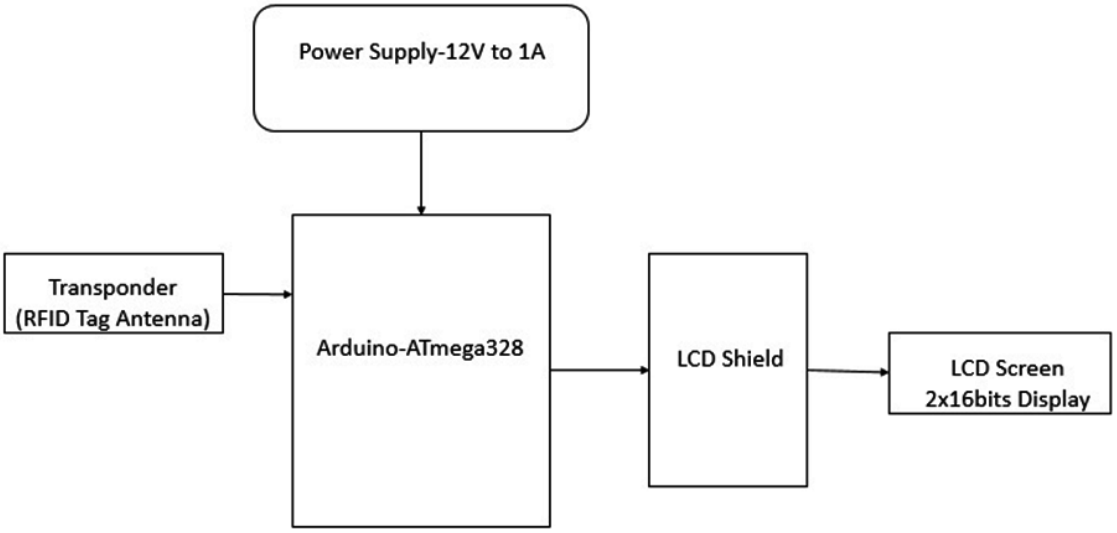

Figure 7: Architecture of proposed system device

F. Working of the System Device

The RFID reader operates at +5V, so when the power supply is given, with the reference of the flow chart shown in Figure 6, the reader indicates that the user is ready to access. As soon as the power connection is verified by the RFID reader, the LCD screen is displayed with the message "WELCOME TO STUDENT ACCESS SYSTEM", with some delay again there a message is displayed as "System is ready to be used". After all the above process, RFID reader validates the user to access the system. Now the reader is asked to user for the response by displaying a message as "Please punch your Card". When the user follows to the command as per the RFID reader, the reader responses with the messaged displayed as "Validation accepted". Thus, a simple student system access product is produces this way.

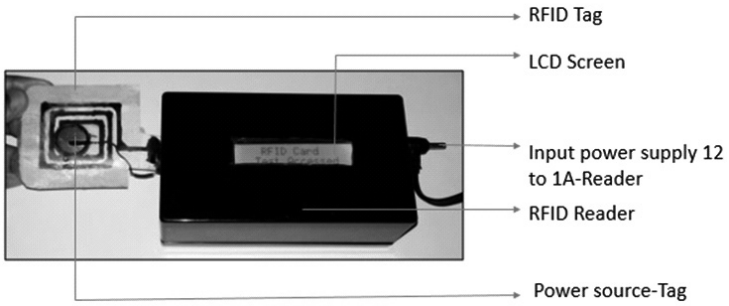

Figure 8: RFID system accessing device

8. DISCUSSION AND RESULTS

As shown in the Figure 8, RFID student Access device which is able to identify authorized persons and with that concern, this RFID device was successfully developed, which is shown in the figure.7. The major contribution of this work deals with integration of Chipless RFID tag on paper substrate by conductive technology and the RFID reader with Arduino microcontroller respectively. The system methodology represents to get accessed by the authorized person by simple low-cost RFID device. And this methodology guides to produce a better quality product for the student attendance entry.

9. CONCLUSION AND FUTURE ENHANCEMENT

As a vital and integrated part of the radio-frequency identification (RFID) system, RFID tag and RFID reader have been received much attention over years, and their design is very urgent and significant. Here in this project, the major contribution is the integration of the RFID tag and RFID reader for the Simple system access. The proposed tag design is concern with replacing the Electric and Magnetic coil, so it is achieved by creating a new evolution of RFID Tag on paper substrate model by conductive Ink technology. Also the RFID Reader involves by immerging a simplest way of storing and reader the data from the Tag by using the Audrino microcontroller. Thus, furthermore development can be done with this design structure according to the application requirement.

References

1. Meenakshi Sharma, Adil Siddiqui "*RFID Based Mobiles: Next Generation Applications*", 0781-424456, 2006 IEEE.
2. Gong Haibo, Wu Yuesha, Liu Yichang, "*2.45 GHz-band Reader Antenna Based on High-impedance Surface*", 2010 International Forum on Information Technology and Application.
3. R. Bhattacharyya, C. Floerkemeier and S. Sarma , "*RFID Tag Antenna Based Temperature Sensing in the Frequency Domain*", 2011 International Conference on RFID.
4. Kihun Chang, Sang-il Kwak, and Young Joong Yoon, "*Small-sized Spiral Dipole Antenna for RFID Transponder of UHF Band*", Dept. of Electrical and Electronic Eng., Yonsei Univ., Seoul, Korea, IEEE, 2005.
5. Kharrat, P. Xavier, T.-P. Vuong, J.-M. Duchamp, "*Low-Loss Paper Substrate for Printed High Efciency Antennas at 2.45 GHz*", IEEE Antenna and Wireless Propagation 2015.
6. Li Yang, Amin Rida, Rushi Vyas, and Manos M. Tentzeris, "*RFID Tag and RF Structures on a Paper Substrate Using Inkjet-Printing Technology*", IEEE Transactions On Microwave Theory and Technique.
7. Adam C. Siegel, Scott T. Phillips, Michael D. Dickey, Nanshu Lu, Zhigang Suo, "*Foldable Printed Circuit Boards on Paper Substrates*", WILEY-VCH VERLAG 2009–28-35.
8. Mi Jung Kim, Choon Sik Cho, and Jaeheung Kim, "*A Dual Band Printed Dipole Antenna with Spiral Structure for WLAN Application*", IEEE Microwave and Wireless Components Letters, VOL. 15, NO. 12, December 2005.
9. G. Orecchini, F. Alimenti, V. Palazzari, A. Rida, "*Design and fabrication of ultra-low cost radio frequency identification antennas and tags exploiting paper substrates and inkjet printing technology*", IET Microwaves, Antenna and Propagation –993-1001.