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Fabrication of Low-Cost Antenna for RFID Applications

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ABSTRACT

The design and the fabrication of RFID-Radio Frequency Identification device performs with low microwave frequency range and also obtained with low cost production of the antenna design. Here in the proposed antenna design, developed with the purpose to minimize the amount of the cost of both substrate as well as the conductive Ink printing technology. The main motive of this technology is brought up here to see that the current density flow distribution in antenna structure to be restricted by eliminating excess of the metal material respectively. A typical Square Spiral Dipole Antenna designed structure is proposed and to be induced in this paper. The proposed antenna is designed for RFID systems, is observed at the operational frequency bandwidth of 2.4 GHz for VSWR < 2 from the reference of simulation model. And at the model representation of the prototype, the operating frequency is measured at 2.3GHz by the input given 800mA to 1A respectively. Even though the Spiral Antenna design is considered to be complex, still it has been used for wide ranges of RF applications, but also considered to give the desired resulting frequency and radiation pattern. Several aspects make the paper material an outstanding component as a low-cost substrate for radio frequency identification (RFID) and other RF applications. Paper substrate is an organic-based substrate, is universally available, highly demanded and the mass production of paper has made to be one of the cheapest material.

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

1. INTRODUCTION

Radio Frequency Identification (RFID) is growing as a major technology for identification and tracking things around the world. In general, a term RFID refers to describe a system that transmits the identity of an object wirelessly by using radio waves. A typical RFID system is based on three components which are RFID tag, RFID reader, and an antenna. RFID does not require line-of-sight to operate. The RFID has got an ability to read many tags which comes in range to the reader, so it is not necessary for each tag to radiate separately by the reader. The main goal of the RFID system is to carry the signal on a tag (which is transponder) that can be received by the transceiver wirelessly. The applications are numbers when its comes with RFID, which are significantly used for Identifying goods, locations, animals, and even people. The RFID tags comes in various sizes and shapes, for example paper sticker just like barcode tags, plastic Credit card, plastic capsules. The process of fabrication deals in simple method, where in the proposed work, the paper substrate was significantly utilized for many considerations. And of course as a conductive material for designing antenna, rather than fabrication on a semiconducting material, the electric conducting Ink is used for printing the design. This fabrication of system has brought up for the evolutionary achievement for low cost production and manufacturing the RFID tag respectively [1][2]

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1.1. RFID tag

Generally, RFID tag is broadly classified into two which are, passive, semi-passive and active tags. The passive tags Passive tags have no battery. Instead, they draw power from the reader, which sends out electromagnetic waves that induce a current in the tag's antenna. Semi-passive tags use a battery to run the chip's circuitry, but communicate by drawing power from the reader. Active RFID tags have a transmitter and their own power source (typically a battery).

The power source is used to run the microchip's circuitry and to broadcast a signal to a reader (the way a cell phone transmits signals to a base station). As per the proposed system in this paper, the Active RFID tag is designed and fabricated in paper substrate using conductive Ink respectively. In order to overcome current flow distribution with the dielectric loss and so this system of novelty innovation is executed. The tag is designed accordingly with a small power source to support the application which is implemented.

1.2. RFID reader

An RFID reader is a network connected device (fixed or mobile) with an antenna that sends power as well as data and commands to the tags. The RFID reader acts like an access point for RFID tagged items so that the tags' data can be made available to business applications. A transmitter/receiver that reads radiates the contents of RFID tag. It can be also referred as "RFID interrogator". The maximum distance covered between the reader's antenna and the tag varies depending on application. For other applications, passive RFID tags can be radiated up to approximately 10 feet away, while active tags with batteries can be radiated several hundred feet from the reader.[4][5][2]

1.3. Paper substrate

It has been known that the invention of printed circuits on boards (PCB) has brought about tremendous advances to modern electronics. Now a day, with more care raised in the complicated and energy-consuming fabrication processes of conventional electronics, various attentions have been made to find an additive way to make electronic components on any required substrates, exclusively those flexible ones. Among the many efforts ever made, functional inks based on organic substances, polymers, nanoparticles, thin-film semiconductors etc [13]. have been developed for manufacturing flexible electronics, which extremely contributed to the development of antennas, transistors, solar cell, radio frequency identification (RFID), flexible displays, electronic clothes, sensors and so forth.

1.4. Conductive Ink

Enormous efforts have also been made to find highly conductive inks, so as to perform direct writing of flexible circuit. So far, many currently available electrical inks are still not conductive enough. To further improve their electrical conductivity, loading nanoparticle to the base material is an important approach. However, some basic issues still remain. For instance, such composite inks conductivity is heavily dependent on the particles loading ratio and bonding mechanism after solidification. So far, there still lacks of a reliable way which is capable of directly writing out electronic circuits, just like printing a picture on paper via a desktop printer in office. [1][6][5].

1.5. Specification of Antenna design

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

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

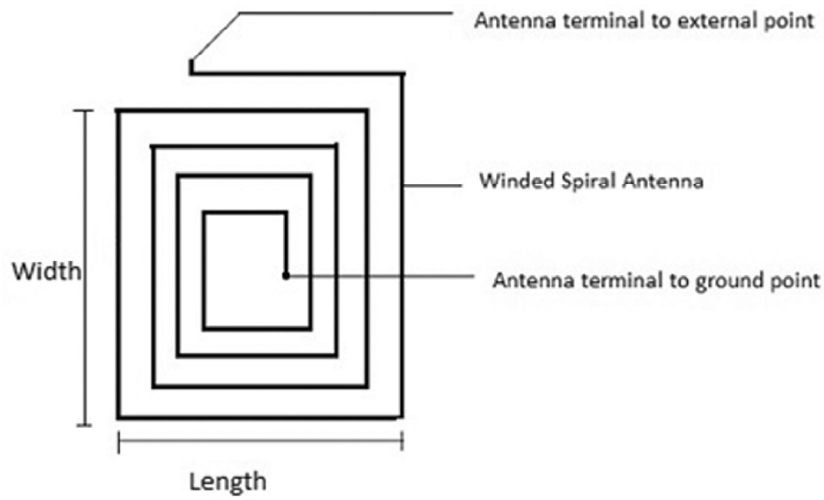


Figure 1: Model diagram of Planar Spiral Antenna

the radiation pattern, impedance and polarization remain virtually constant over a large bandwidth. Fig. 1 shows the diagram of model antenna taken for the experimental concept. The number of turns of the spiral is also considered as a design parameter. [1] [3] [4].

2. PROPOSED WORK

General considerations on the paper based antenna and simple design involves with various steps and techniques. The most of the existing antenna with the meander line for the RFID system have the current cancellation on adjacent meandered sections which reduces the effective length of the radiator, thus these often have poor radiation, e.g. low antenna efficiency, therefore it is approached with square spiral structure to avoid such conditions. The dimensions of the central part of the antenna were reduced while a spiral shape was almost maintained [5]. In particular, with the purpose of further reducing the dimensions of the overall structure while following the ink optimization technique already developed.

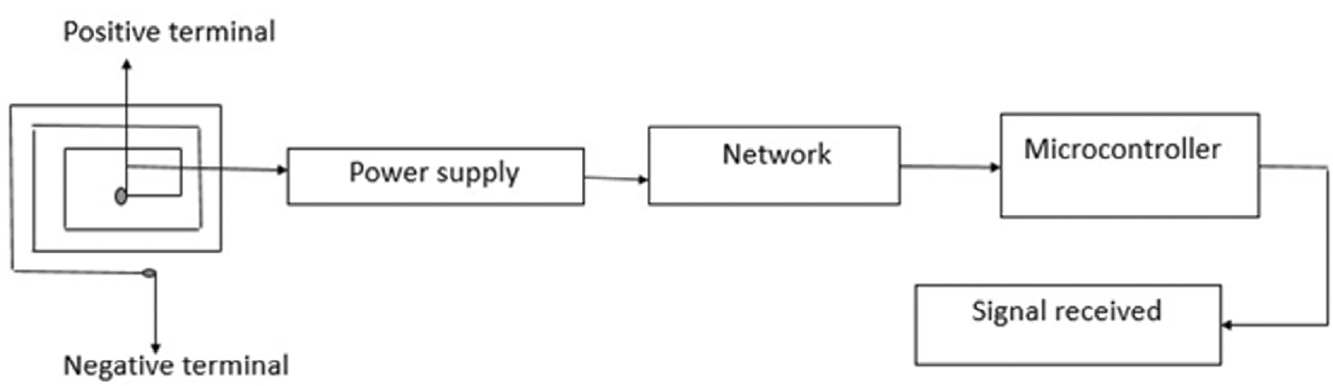


Figure 2: Block diagram of Complete RFID System

Table 1
Simulation Parameter

	Specifications				
Type of Antenna	*Length* x *Width*	*No. of Windings*	*Thickness*	*Length of terminal*	*Frequency*
Spiral Dipole Antenna	4 mm × 4 mm	Three	0.05 mm	0.9 mm	2.4 GHz

2.1. Simulation process

As observed from the simulation process, as per the dimension configuration which is shown in the Table 1., since the total length of the antenna is electrically full wavelength of the resonant frequency, the current distribution on the radiator is not uniform likely an ideal small loop with uniform current. By reason of this, the radiation patterns of the proposed antenna are asymmetric about 1~2 dB. However, the proposed antenna has a smaller size by applying the spiral dipole structure than the existing antennas in size reduction which is significant for the RFID transponder antennas. The simulated planar spiral antenna substrate as shown in the Fig. 3. is received with the return loss at 2.4 GHz, as shown in Fig.4. The simulated and measured radiation patterns obtained for the frequency is 2.4 GHz which is shown in the Fig. 5, and it is found that the proposed antenna radiates in 90deg broadside direction and achieved VSWR < 2. And in order to completely eliminate the dielectric material, a planar square spiral patch antenna is proposed and simulated. 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).

Accordingly, the simulation is observed with the measured parameters as shown in the Table. 1, where the simple spiral antenna is designed at the length and width of 4mm × 4mm. The winding of antenna is specified to show that occurrence of current contributes to yield an identical magnetic dipole and therefore, the current cancellation happens to be much less. [6, 2].

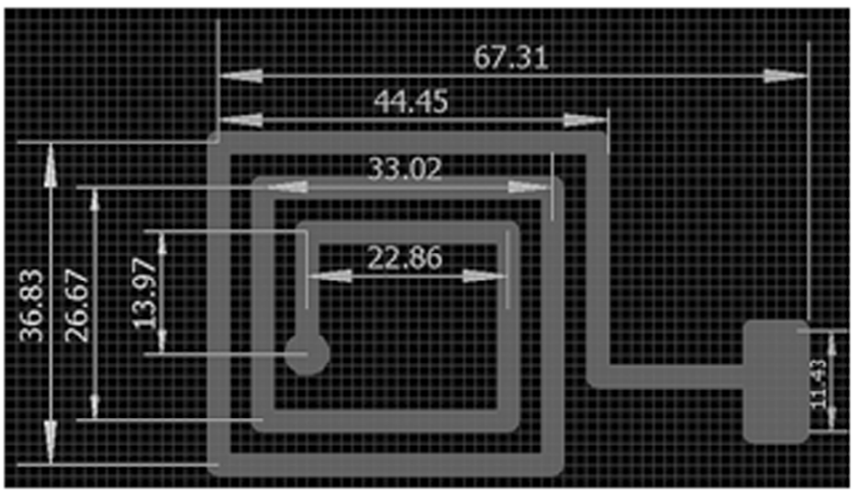


Figure 3: Spiral Antenna substrate

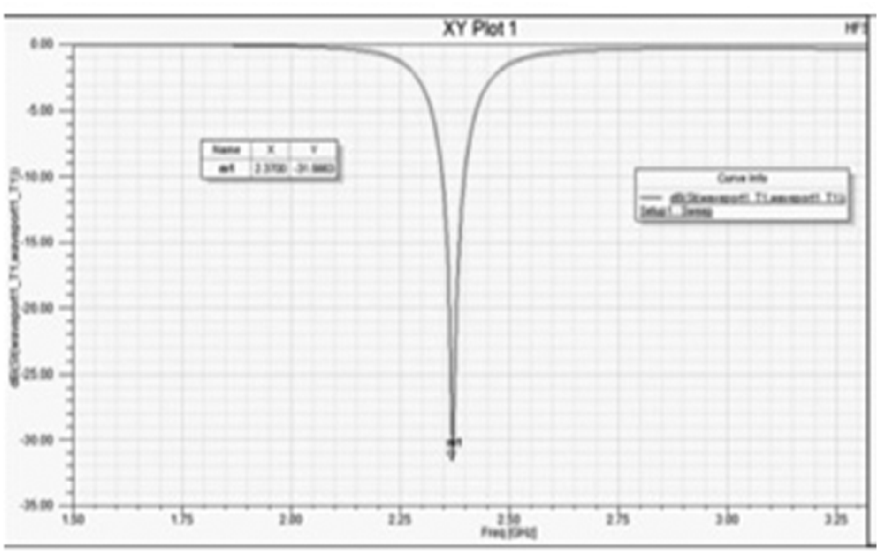


Figure 4: Return loss

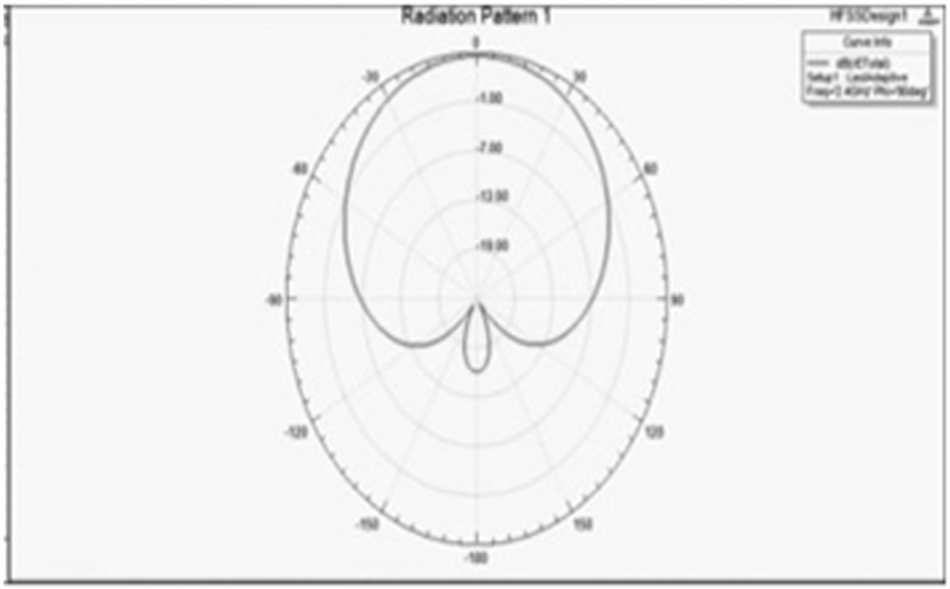


Figure 5: Radiation Pattern

2.3. Prototype Model of Rfid Reader

The system of RFID reader is designed according to the block diagram representation shown in figure 2, and the model of designed spiral antenna was fabricated by the parameter specification given in the Table 2, and designed accordingly on low dielectric material, to be flexible. The size of the antenna is 2.5 cm × 2.5 cm in physical length and designed accordingly, the thin copper wired is winded around by the scale measurement of 25mH.

Here it utilized the PIC (Peripheral Integrated Circuit) microcontroller to check for the response of the antenna Tag information as shown in fig. 6, of prototype model of RFID Antenna [4][7-12].

From the experimental setup, the output is observed and received up to 2.3GHZ, with the input given from 800mA to 1A. The block diagram, Figure 2, shows the overview set of the functional unit of the prototype in the experiment, where in the external terminal is given to the power supply and further the output is observed and obtained as shown in Figure. 6. respectively. Fabricated antenna by copper coil, illustrates actually to show that how a simple RFID system works. And the system is compared with the fabricated antenna using Electrically conductive ink.

Table 2
Specifications of design principle of RFID reader

	Specifications				
Type of Antenna	*Substrate*	*Conducting Material*	*No. of windings*	*Length × Width*	*Input given*
Spiral dipole antenna	Flexible transparent sheet	Copper Coil	Five	2.5cm × 2.5cm	800mA to 1A

2.3.1. Working principle of RFID reader

Here the system was designed accordingly where the RFID system basically consists of RFID tag, RFID reader and an interface system as shown in the figure 6. The RFID tag contains an Integrated antenna, which is used to transmit the data stored to the RFID reader. Here the designed reader (which is copper coil) coverts the radio waves to a more usable data and then the information stored collected from the tag is transferred through a communication Interface (microcontroller) where, the data stored is analysed.

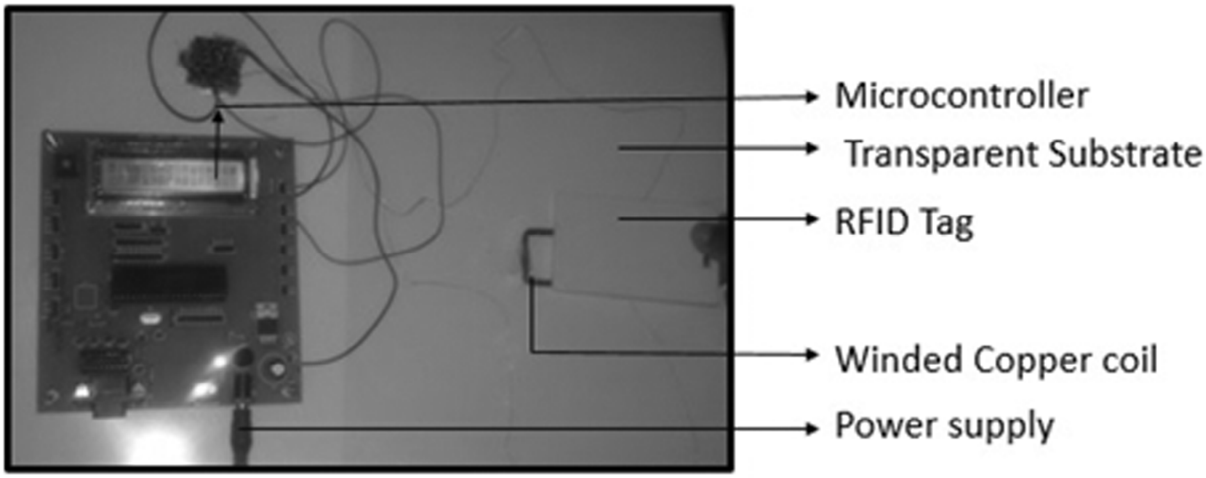
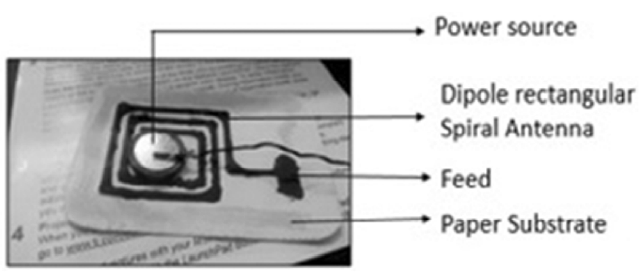


Figure 6: RFID Reader Antenna

3. PROPOSED WORK-FABRICATION OF PLANAR SPIRAL ANTENNA BY CONDUCTIVE INK:

The proposed experiment for designing the spiral antenna on a paper substrate, here it was implemented by designing the particular antenna structure using the appropriate dimension shown as in the Table 3.

From the illustration shown, 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 chart paper of thickness 3 mm. The paper was chosen to present the less dielectric loss value. The antenna printed on a flat sheet using electrically conductive ink as shown in the Fig. 7, 8, thus, the electric conductive ink is used here to completely avoid the electric and magnetic field effects and its loss.



Figur 7: Active Tag antenna

Figure 8: Folded RFID Tag

Table 3
Specification of fabricated RFID Tag

		Specification of Fabricated Tag Antenna			
Substrate material	*Thickness*	*Conductive material*	*Spacing length between each winding*	*Type of Antenna*	*Total length tag*
Paper	3mm	Conductive Ink	1.27mm	Rectangular spiral dipole antenna	67.37mm
		Length and width of Spiral windings			
Length	L1 = 22.86mm		L2 = 33.02mm		L3 = 44.45mm
Width	W1 = 13.97mm		W2 = 26.67mm		W3 = 36.83mm

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 3.0volts 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. [7][8].

4. CONCLUSION

The experimental proposal deals with the small sized spiral dipole antenna for RFID reader purpose. For the expected application of the wide ranges of RFID systems, such as a supply chain integration, industrial automation, track and trace, and so on, the small and adequate printed antenna is required. The antenna is designed to have the spiral structure than the meander structure. In spiral antenna structure, the current cancellation on the antenna is much less than compared in the meander structures. The proposed antenna is designed for RFID Tag, to have the operating frequency bandwidth of 2.4 GHz. This antenna is fabricated on the simple paper substrate, to be utilized as an antenna RFID tag application for identifying purposes. Therefore, it is clear that the proposed tag antenna can provide a compact transponder in the RFID systems. Moreover, Paper substrate material and conductive Ink technology have been used to guarantee mechanical flexibility and low production costs of antenna.

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