# DESIGN AND DEVELOPMENT OF NEAR-FIELD ANTENNA FOR RFID APPLICATIONS

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***Abstract:*** Radio-frequency identification (RFID) is an expanding technology that enables radio detection and recognition of the objects associated with an identification code carried by an electronic chip which is attached to tag. RFID belongs to group of technologies which is referred as Automatic Identification and Data Capture (AIDC). AIDC methods automatically identify the objects, collect the data, and analyze the data from the object. RFID's being extensively used in different kinds of applications and is one of the most promising in the field of IOT (Internet of Things). The design of the RFID system deals with mainly two components which are RFID tag and the RFID reader, both the system contains an antenna in it. The Near-field reader antenna is designed for UHF Gen-2 item-level tagging systems. And it is optimized to read near-field tags placed on products with a variety of packaging options. The near-field antenna for the RFID applications is designed for a particular range of frequency band using a tool called CST and it will be fabricated on a Printed Circuit Board (PCB) for the required specifications.

***IndexTerms –*** RFID, Near-Field Spiral Antenna, VSWR, Return loss, CST tool

## I. INTRODUCTION

Radio Frequency Identification uses electromagnetic fields, which automatically identify and track the tags which are attached to the objects. RFID system consists mainly two components a RFID tag and a RFID reader. The tag contains electronically-stored information and it can be either passive tags or active tags. Passive tags collect energy from a nearby RFID reader's interrogating radio waves whereas active tags have their local power sources like battery. Unlike barcode, the tag need not be within the line of sight (LOS) to the reader. The reader antenna transmits the electromagnetic energy to activate the tags. The reader converts the radio waves to more usable form of data information collected from the tags. The reader antenna should be designed with low profile and realize attenuations.

The fields surrounding an antenna are broadly divided into three principle regions: reactive near-field region, radiating near-field (Fresnel region) and far-field (Fraunhofer region). The immediate vicinity of antenna there is a reactive near-field region, where the fields are predominately reactive fields, the E and H fields are out of phase by 90º to each other and the boundary of this region is given as

$$R < 0.62 \sqrt{(D^3/3)} \quad (1)$$

The radiating near-field region is a region where the radiation field predominates. The E and H fields are in phase, but angular field distribution is still dependent upon the distance from the antenna. The operating distance R of radiating near-field antenna is given as

$$R < 2D^2/\lambda \quad (2)$$

Where D is the diametric size of near-field antenna, and $\lambda$ is the wavelength of electromagnetic wave at 865-868MHz. As the high frequency RFID system, the field energy of UHF RFID system couples strongly in near-field with short distance. So the surrounding environment has little effect on UHF RFID system which works in near-field manner.

Far-field or Fraunhofer region is a region surrounding the reactive and radiating near-field regions, which extends to infinity and represents the vast majority of the space the wave usually travels. The entire field radiates and the angular field distribution is essentially independent of the distance from the antenna which can be approximated with spherical wavefronts. Since it is very far from the antenna, its size and shape are not important and approximate it as a point source. The electric and magnetic fields are in phase, perpendicular to each other and perpendicular also to the direction of propagation.

## II. LITERATURE REVIEW

In this paper an antenna array comprising of four dipoles are used, which can be switched via reconfigurable feeding network that strengthens the intensity of a magnetic field in a near-field zone and improve the far-field gain for the RFID applications [1].

The design of large loop type antennas for ultra-high frequency near-field radio frequency identification readers is a challenge due to the inherent limitation of loop type antennas, which can overcome by the development of the zero- phase-shift-line loop antennas for Ultra High Frequency near-field RFID systems [2].

In this paper a review of ultra-high frequency RFID Antennas are explained. The ultra-high frequency Radio Frequency Identification antennas deployed in recent years are fixed reader antennas and hand-held reader antennas. The development trends of UHF RFID antennas are with respect to application point of view and its technical challenges [3].

Planar 2-element Yagi array with a parasitic element loaded with self-oscillating switching circuit can also be used as RFID reader antenna. Theoretical concept of a wirelessly reconfigurable antenna, where wirelessly powered switches on parasitic elements are controlled by modulating signals embedded into an antenna transmission. The difficulty with practically implementing this concept is need for an additional protocol overhead to control the switches and the complexity of such intelligent switches [4].

The Dipole Spiral antenna structure was used to produce for the RFID application. An innovative approach of chip less RFID Tag was introduced using conductive ink technology and paper substrate to produce a typical RFID tag. So, the replacement of EMF coil (conductive material) is done here, which eliminate the loss that occurs in the tag [5].

A novel near-field UHF RFID receives a lot of attention as a possible solution for item level tagging system. The near-field UHF RFID concept is to make UHF RFID system work at short distances and on different objects as reliably as LF/HF RFID. In most of the near field RFID applications, the interaction between the RFID reader and tags is based on inductive coupling. The limitations of RFID systems are that they do not operate at short distances (near-field). To overcome this problem, RFID reader antenna for simultaneous near-field and far-field operations at UHF band is explained in this paper [6].

Here the use of simple transmission lines as near-field antenna for UHF Radio Frequency Identification (RFID) applications. The limitation of the reading or identification zone to the near-field region of the antenna is a challenging problem in UHF RFID application. Several solutions have been proposed during past years but most of them are more complicate and expensive in the final implementation. A transmission line concept will show that is possible to achieve the limitation of the reading zone in a simple and effective way by using a simple antenna or coupling mechanism system between RF signal generated by RFID reader and UHF RFID Tag [7].

The Confinement of detection region is a critical issue for some important RFID applications, where the coarse location of the object is required along with its identification. In the UHF band, it's a challenge to confine antenna radiation to reasonably sharp interrogation volumes < 10 $\lambda^3$, without resorting to physical barriers. A novel approach for RFID reader radiating structures that self-confine tag detection to a desired volume, by avoiding undesired readings outside the interrogation volume was proposed in this paper [8].

The near-field coupling RFID system has steady performance in any environment and quite fit for item-level tagging system. The near-field coupling antenna is based on near-field antenna, which has bending folded-dipole structure for antenna size-reduced and impedance increased. For reducing effect of surrounding objects and antenna size-reduced, a near-field antenna of UHF RFID systems is researched , which works in magnetic field coupling manner and operates on near-field of antenna[9].

## III. METHODOLOGY

The antenna is designed for the operation that enable reading of an Item Level Tag which works with UHF Gen2 RFID tags that incorporate an inductive near-field component with high performance, low cost antenna solution which can be mounted top or bottom of the table. The proposed methodology is depicted in the below flowchart, here the Spiral Antenna is designed which operates at the frequency band of 865-868 MHz. The design parameters like length, width and thickness of ground, substrate and antenna are formulated. The orientation, shape and feeding technique of an antenna is designed using CST tool. The designed spiral antenna is then analyzed with respect to VSWR, Return loss and other specification required.

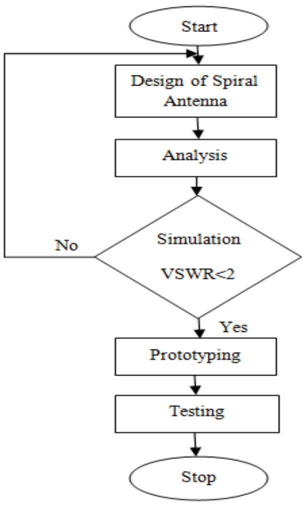


Fig 1: Flow chart of proposed methodology

## IV. DESIGN OF SPIRAL ANTENNA

Spiral Antenna belongs to the class of frequency independent antennas which operate over a wide range of frequencies. Spiral type planar inductors are widely used in the design of power amplifiers, oscillators, microwave switches, combiners, and splitters, RFID applications. The proposed antenna has advantages of its easy gain, simple structure, higher space utilization, improved radiation efficiency, pattern control with a small antenna size and which operates at the range of 865-868 MHz.

The frequency band is 865-868 MHz, So the resonant frequency is at 866.5 MHz

$$\text{Wavelength } \lambda = \frac{c}{f_r} \ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

$$\lambda = 346.2 \text{ mm}$$

The Length of outer square is given by

$$L = L_{eff} - 2\Delta L \ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

$$\text{Where, } L_{eff} = \frac{c}{2*fr\sqrt{Ereff}} \text{ and } \Delta L = h*[\frac{0.412[E_{reff}+0.3]*[\frac{W}{h}+0.264]}{[E_{reff}-0.258]*[\frac{W}{h}-0.8]}]$$

So, L = 82.35 mm

The Width of outer spiral is given by

$$W = \frac{c}{2fr}\sqrt{\frac{2}{Er+1}} \ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

W= 105.3 mm

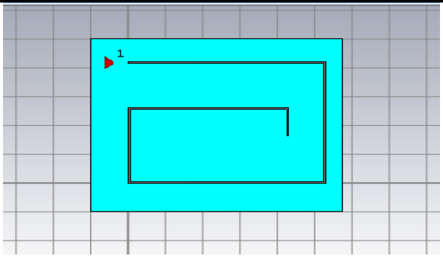

Fig 2: Proposed spiral antenna

### V. SIMULATION RESULTS

CST MICROWAVE STUDIO (CST MWS) is a powerful tool for the 3-D electromagnetic simulation of high frequency components. CST offered unparalleled performance, making first choice in technology leading research and development departments. And user-friendly and enables to choose the most appropriate method for the design and optimization of devices operating in a wide range of frequencies. It offers accurate, efficient computational solutions for electromagnetic design and analysis.

A radio transmitter or a receiver to deliver power to an antenna, the impedance of the radio and transmission line must be well matched to the antenna impedance. The Voltage Standing Wave Ratio (VSWR) is a parameter which measure how well the antenna impedance is matched to the radio or transmission line it is connected. The Voltage Standing Wave Ratio is an indication of the amount of mismatch between an antenna and the feed line connecting to it. VSWR is a real and positive number, the smaller the VSWR is the better the antenna is matched and more power is delivered. The range of values for VSWR is from 1 to infinity, but VSWR value below 2 is considered suitable for most antenna applications and the antenna can be described as having a good match.

$$VSWR = \frac{1+|r|}{1-|r|} \quad (6)$$

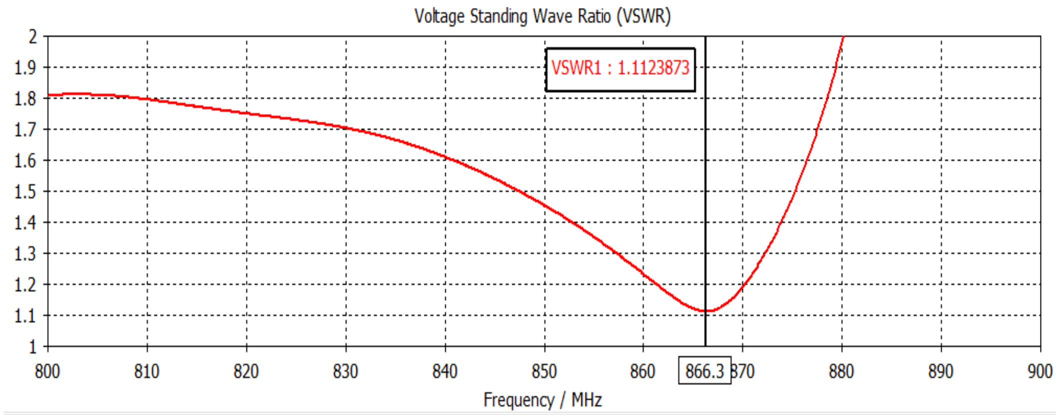


Fig 3: VSWR of spiral antenna

Return Loss (RL) is another specification of interest for an antenna design that indicates the proportion of radio waves arriving at the antenna input that are rejected as a ratio against those that are accepted. It is specified in decibels (dB).

$$RL = -20 \log \left[\frac{VSWR-1}{VSWR+1}\right] \quad (7)$$

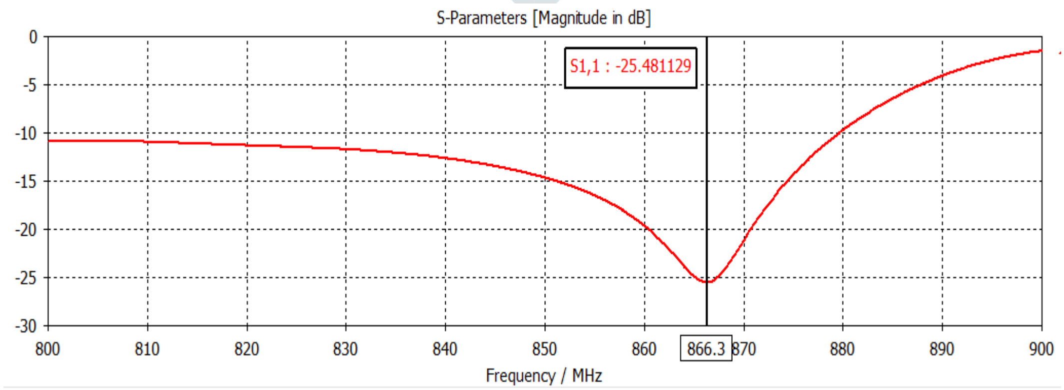


Fig 4: Return loss of spiral antenna

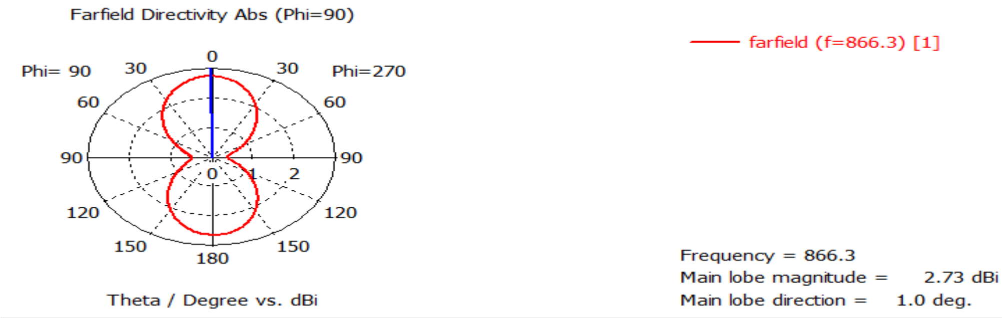


Fig 5: Far field of spiral antenna

## VI. CONCLUSION

The near-field square spiral antenna for RFID application for the range of 865-868 MHz with VSWR 1.11 and Return loss of -25 dB is designed using CST tool and it is analyzed through network analyzer. The designed antenna will be developed on a Printed Circuit Board and tested further.

## VII. REFERENCES

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