OPTIMIZATION OF NESTED SLOT RFID TAG ANTENNA USING PSO ALGORITHM

A Dissertation Submitted in Partial Fulfillment of the Requirement for the Award of the Degree of

MASTER OF ENGINEERING

In

Wireless communication

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DECLARATION

I, Garima hereby declare that the work presented in this thesis entitled "**Optimization of nested slot RFID tag antenna using PSO algorithm**" in partial fulfillment of the requirement for the award of degree of Master of Engineering submitted at Electronics and Communication Engineering Department, Thapar University, Patiala is an authentic record of work carried out under supervision of Dr. Surbhi Sharma Assistant professor, Electronics and Communication Engineering Department , Thapar University, Patiala from July 2015 to July 2017. The matter presented in this has not been submitted either in part or full to any other university or institute for the award of any other degree.

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CERTIFICATE

It is certified that the work contained in the thesis titled "**Optimization of nested slot RFID tag antenna using PSO algorithm**" by Garima [801563004] has been carried out under my supervision and that this work has not been submitted elsewhere for any other degree.

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ABSTRACT

These days, there is a developing interest for solid resources security and administration in different businesses. One of the advances that made this idea feasible is known as Radio Frequency Identification (RFID). It is Automatic distinguishing proof innovation which utilizes radio frequency electromagnetic fields to recognize objects conveying labels (tags) when they approach a reader. RFID technology is known for its support in automation and tracking as being more competent to barcode system and has been approved for worldwide deployment. Different tag antennas are designed depending upon the applications. Here an inverted S-shaped nested slot RFID tag antenna and its 2^{nd} order fractal RFID tag antenna is designed at operating frequency 0.91 GHz.

With the advancement in the field of wireless communication system led to increase constraints on antennas. To achieve the desired goal, antennas designs are typically improved by some cumbersome hit- trial and error strategies. So the need for improved antenna design solution is fulfilled by the amalgamation of electromagnetic simulators with various optimization methods. A new methodology based on optimization is introduced for a nested slot RFID tag antenna to get the desired results of antenna minimization and conjugate impedance matching.

In order to design a RFID tag antenna and its 2^{nd} order Minkowski Fractal tag Antenna which would have a perfect impedance matching with the tag chip, our work presents the particle swarm optimization strategy integration with CST Microwave Studio and MATLAB. This type of proposed design do not require any additional loading or matching network and thus yielding smaller antenna size and relatively lower implementation cost when compared to conventional tag antenna.. The goals for the optimization is to get the perfect conjugate input impedance with the chip impedance and the miniaturization of the RFID tag antenna design and the results are successfully achieved.

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LISTS OF ABBREVIATIONS

RFID	Radio Frequency Identification
RF	Radio Frequency
UHF	Ultra High Frequency
IC	Integrated Circuit
EA	Evolutionary Algorithm
GA	Genetic Algorithm
ACO	Ant Colony Optimization
ABC	Artificial Bee Colony
PSO	Particle Swarm Optimization
MATLAB	Matrix Laboratory
CST	Computer Simulation Technology
VBA	Visual Basic for Application
EM	Electro-Magnetic
IIF	Identify Friendly Feo
ID	Identification
EPC	Electronic Product Code
ISO	International Standard Organization
PC	Personal Computer
AC	Alternating Current
EMF	Electromotive Force
SIM	Subscriber Identity Module
CCD	Charge Couple Device
QR	Quick Response
OCR	Optical Character Recognition
MRZ	Machine Readable Zone
HF	High Frequency
LF	Low Frequency
SHF	Super High Frequency
VLF	Very Low Frequency
EHF	Extremely High Frequency
MF	Medium Frequency

VHF	Very High Frequency
GSA	Gravitational Search Algorithm
DE	Differential Evolution
PBIL	Population Based Incremental Learning
RA	Reference Antenna
FA	Fractal Antenna
FEM	Finite Element Method
IE3D	Integral Equation three Dimensional
CPW	Co-planer Waveguide
ISPO	Intelligent Single Particle Optimization
BPSO	Binary Particle Swarm Optimization
WCDMA	Wideband Code Division Multiple Access
CP	Circularly Polarized
SAR	Specific Absorption Rate
PIFA	Planar Inverted F-Antenna
MWS	Microwave Studio
IABC	Improved Artificial Bee Colony
GPS	Global Positioning System
PRC	Power Reflection Coefficient
PTC	Power Transmission Coefficient
GUI	Graphic User Interface
HFSS	High Frequency Structural Simulator
ASCII	American Standard Code for Information Interchange
BBO	Biogeography Based Optimization
GABC	Guided Artificial Bee Colony
WIMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Networks
HIPERLAN	High Performance Radio Local Area Network
PCB	Printed Circuit Board
SLL	Side Level Loop
RPSO	Real Number Particle Swarm Optimization
SGA	Stud Genetic Algorithm
MOM	Method of Moments

NM	Nelder Mead
FDTD	Finite Difference Time Domain
LTE	Long Term Evolution
FR4	Forgotten Realms 4
IFS	Iterative Function System

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CHAPTER I

INTRODUCTION

A standout amongst the most intriguing developments of the wireless technology is the Radio Frequency Identification (RFID). RFID is a contactless programmed identification method which utilizes RF signals. In 1948, H. Stockman presented a idea of identification of articles and remote control of gadgets [1]. After the enormous endeavours delivered in the 1970s by the advancement of microelectronic technology and the proceeding with development of the most recent decade, RFID is presently turning into an inescapable technology in regular day to day existence [1]. It required significant measure of investment before the technology progressed to current level and now identification of articles and remote control of gadgets has turned out to be extremely prevalent in co-ordinations, logistics, stock and inventory administration and bioengineering applications[2],[7]. It additionally helps in giving robotized wireless identification, electronic toll gathering, and resource identification, tracking capability, access control, retail item management and vehicle security and being more powerful than the scanner tag framework (barcodes). It has demonstrated a business overall organization following frequency allocation in the UHF band, extending from 0.860 GHz to 0.960 GHz. These days a great deal of researchers everywhere throughout the world, are confronting the test to create empowering innovations for the Internet of Things worldview.

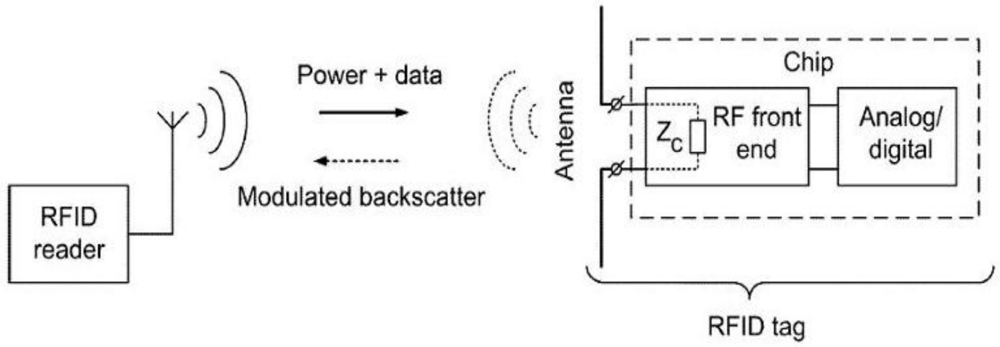


Figure 1.1: Elements of RFID System [2].

A fundamental RFID framework involves a unit of radio scanner, called reader, and an arrangement of wireless transponders, meant as labels/ tags as shown in the figure 1.1. The tag incorporates a microchip transmitter having read/write memory and an antenna. The vitality required to drive the microchip originates in inactive tags from the interrogation framework itself. The microchip goes about as a change, to match or crisscross its internal load with antenna in order to accomplish a backscattering modulation [2]. Here the antenna prerequisites are fundamental to optimize the RFID framework power performance, particularly for aloof designs where the main vitality source is the approaching reader vitality. The antenna architect is gone up against the two note worthy issues. The first one is the miniaturization of antenna , which restricts to the coveted property of moderately high gain and the second is the way that the tag antenna must be conjugate coordinated to the impedance (i.e. capacitive reactance) of the IC.

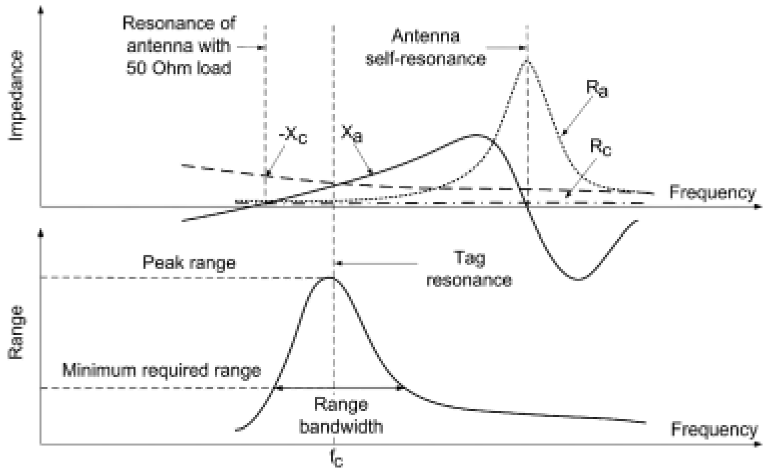


Figure 1.2: Relationship between tag impedance, chip impedance and range as a function of frequency [2].

The first one could be settled by choosing the printed structure state in such a way that it would be improvable regarding its size. The second one can be fathomed by different method one is by modifying the geometry of the antenna by means of the conventional experimentation strategy or by utilizing an algorithm of optimization [3].

As per the overview, the complex matching techniques utilized as a part of RFID tag systems can be arranged into the accompanying classes [4]

(i) Adding matching network or the stub lines between chip and the proposed antenna.

(ii) Implementing the antenna inductively or capacitively with open or short stub line to modify the input impedance so as to guarantee $Z_A = Z_C^*$

(iii) Reconfiguring the antenna parameters, for instance utilizing an average balanced dipole antenna, a nested, embeddings the antenna in a recessed cavity, formed slot and open complementary split ring resonator etc.

Each above technique needs the inclusion of extra components and portrayed by a bigger region as contrasted with traditional designs. In this work another philosophy is discovered to configuration tag antenna working with conjugate matching with the tag chip. The philosophy depends on tuning of antenna parameters to differ its input impedance at the operating frequency till it achieves the conjugate of the impedance of the tag chip.

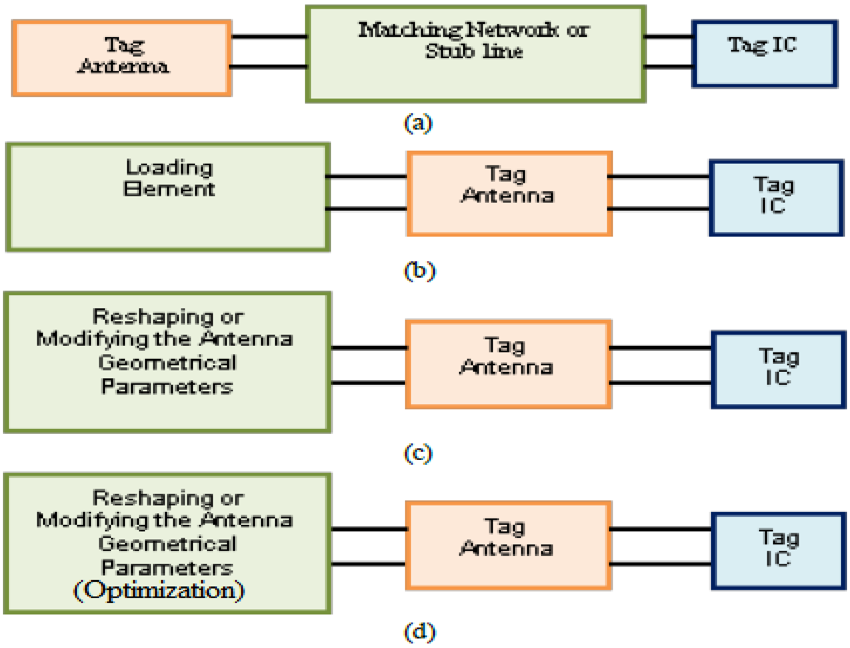


Figure 1.3: Different Matching Strategies for RFID (a) Using stub line/Matching network. (b) Using Loading Components. (c) By modify or reshaping the antenna design. (d) Tuning the antenna through Optimization [4].

The system is improved further to configuration a scaled down antenna under conjugate matching condition by presenting fractal geometry on the proposed tag as depicted below Chapter III taken after by applying PSO procedure to address the resultant antennas optimization area through interfacing between MATLAB and CST software. There are diverse Evolutionary algorithms (EA) appropriate for these RFID frameworks, for example, Genetic algorithms (GA), (ACO) Ant colony optimization, artificial bee colony algorithm (ABC), The PSO Algorithm is most famous nature inspired and promising algorithm in taking care of different optimization issues in the field of science and designing, with this exceedingly multi dimensional and multi target issues can be understood. PSO is a Global optimization EA in view of the development, insight and social conduct of the swarms which guide themselves specifically heading in the search space so as to satisfy their necessities.

To spare the time, the designing of RFID Structure and Optimization process is implemented simultaneously through the interfacing between the two softwares MATLAB and the commercial electromagnetic software CST Design Studio. This sort of interfacing requires a scripting dialect interface named as VBA script. The MATLAB commercial electromagnetics solver interface ends up plainly basic in number of utilizations one such instance is numerical optimization. So, our work procedure comprises of the following steps:

- First step is interfacing between MATLAB and CST to exchange the data and files between these two software.
- Design the proposed RFID tag antenna and modified fractal tag antenna in CST MWS environment.
- Optimization of these two proposed design through PSO Algorithm using first step.

1.1 Radio Frequency Identification (RFID)

The RFID is an identification system based on the Automatic identification technology which utilizes radio-frequency electromagnetic fields in distinguishing objects through the tag connected to them [2]. The only thing required for communication is radio correspondence between the tag and the reader. Information (like identification number) incorporated into the electronic chip of the RFID tag can be gathered by the reader. This reader can likewise change the substance of the tag memory. However, RFID can't be lessened to one technology. RFID utilizes a few radio frequencies as appeared in figure 1.10 and many sorts of tag exist with various specialized techniques and power supply sources.

1.1.1 RFID History

1. RFID was first utilized amid World War II in 1940, to recognize planes (IFF). The goal was to utilize the plane's radar signal to peruse an identification number keeping in mind the end goal to recognize whether they were partners or adversaries.
2. During the 1960-70s, RFID systems were as yet considered a mysterious technology utilized by the armed force to control access into touchy ranges (atomic plants and so on).
3. Technological improvements prompt the making of detached inactive tags in 1980. This technology implied we never again required the vitality to be implanted into the tag. Therefore the cost of the tag and its upkeep could be essentially lessened.
4. Standardization for the interoperability of RFID gear started in 1990.

5. The Massachusetts Institute of Technology (MIT) in 1999, made the Auto-ID research center - had practical experience in programmed identification (including RFID).
6. The MIT Auto-ID research center in 2004 turned into the worldwide EPC, a life form responsible for advancing the EPC standard.
7. RFID innovations are currently broadly utilized as a part of every mechanical division (aviation, car, co-ordinations, transport, wellbeing, life, etc.).From 2005, ISO partook in building up specialized and handy standards that let to have a high level of interoperability or compatibility.

1.1.2 A Basic RFID System

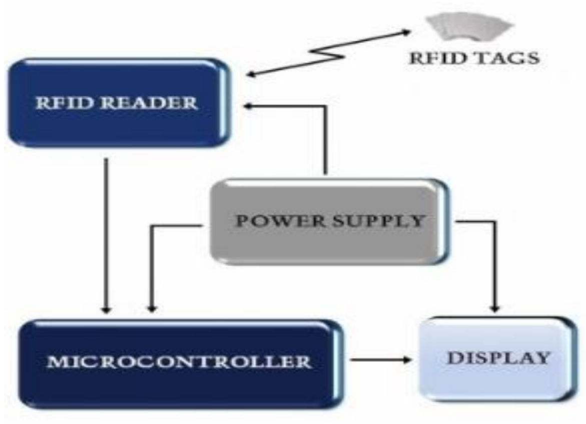


Figure 1.4: The block diagram of Basic RFID System.

The Three main Components required for a RFID System are:

- A RFID tag: It comprises of a microchip made up of silicon connected to a miniaturized antenna and mounted on a substrate and typified in various materials like plastic or glass shroud and with an adhesive on the posterior to be joined to objects. An example for RFID tag is shown in the figure 1.5.

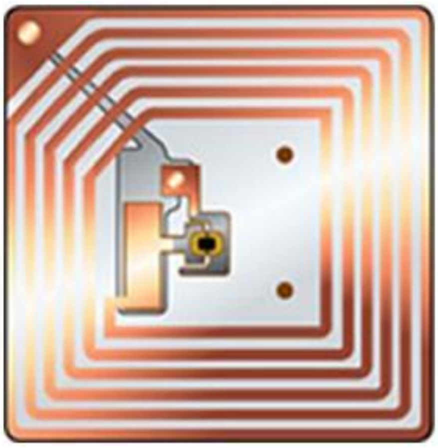


Figure 1.5: An example of RFID Tag.

- A Reader**:** This comprises of a scanner having antennas that will act as a trans-receiver and this will in charge of correspondence with the tag and gets the data from the tag. Example of A reader is depicted as in figure 1.6 below.

Figure 1.6: An Example of RFID Reader.

- A Processor or a Controller: This could be a host PC attached to a Microprocessor or microcontroller which process the reader information.

1.1.3 Various Types of RFID Systems

- The Active RFID Framework: These frameworks are having the tag which has its own energy source like a battery[2], [7] . The main imperative being the life span of the power gadgets. They can be utilized for bigger separations and to track the high esteem products such as vehicles.
- The Passive/Inactive RFID Framework: These are frameworks where the tag gets control through the exchange of energy from a reader antenna to the tag antenna [2], [7]. These types of systems are utilized for small range transmission. Here we are for the most part worried about the detached/inactive RFID framework as it is most broadly utilized as a part of consistent applications like in retail advertise associations.

A short thought regarding the working of the Passive RFID Systems are detailed as:
The tag can be fuelled either utilizing enlisting inductive coupling technique or EM wave capture strategy. Following details gives a chance to have short information about the framework utilizing above two techniques.

- The Passive RFID utilizing an Induction coupling method**:** In these systems, the reader controls the RFID Tag through the technique of an inductive coupling. As the reader comprises of a curved wire associated with an AC power supply to such an extent that a MF is conformed to it. There will be a increase in the reader coil's current as By the ideals of Lenz law a MF produced by the reader coil get restricted by the Tag coil's MF and the reader captures this current as the load data. This type of framework is reasonable for small separation correspondence. Further with the Rectifiers and Filters the AC voltage over the tag coil can changed to DC.

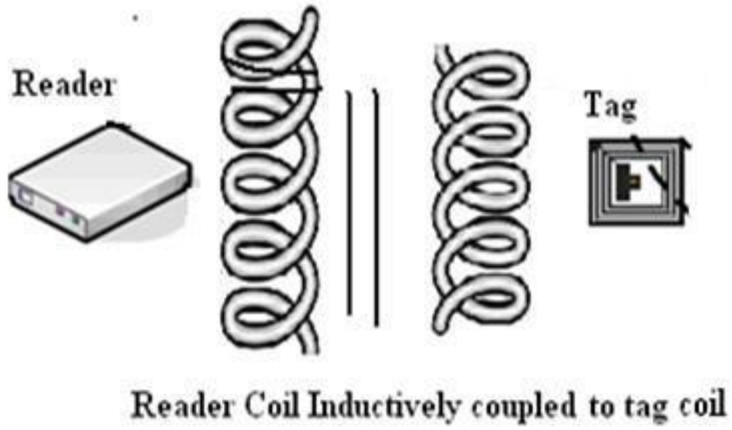


Figure 1.7: A Passive RFID utilizing an Inductive Coupling Technique.

- A Passive RFID utilizing an EM wave propagation method**:** In this, the EM waves are transmitted by the reader antenna which is received by the tag antenna. Now to get the DC control this voltage is filtered and rectified. The Received signal gets reflected back at the recipient as the antenna is kept at various impedances. The reader receives this reflected signal and observes it.

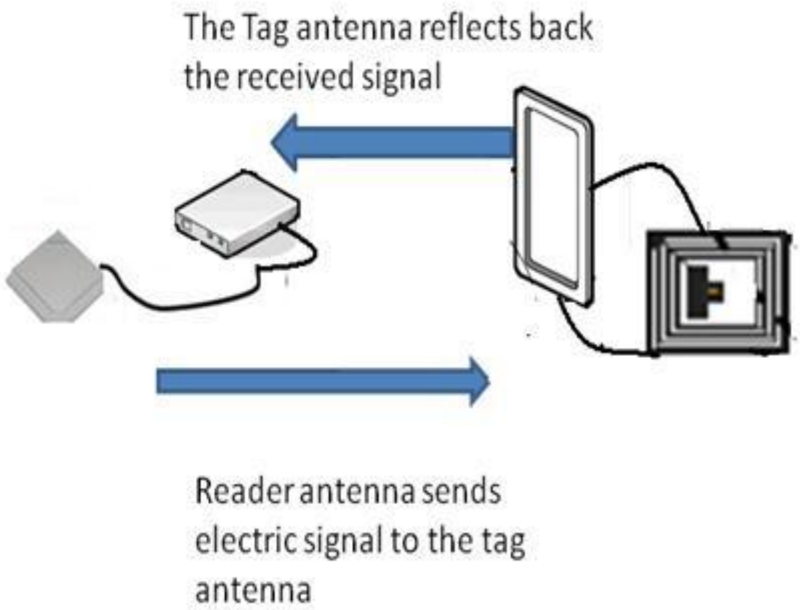


Figure 1.8: A Passive RFID utilizing an EM-wave transmission.

An Idea about the working of the Active RFID System: The reader in the active RFID framework transmits the signals utilizing an antenna to the tag. Tag gets this transmitted data and re-transmits it back alongside the data in its cache. The reader gets this signal and sends it to the micro-processor for additionally handling.

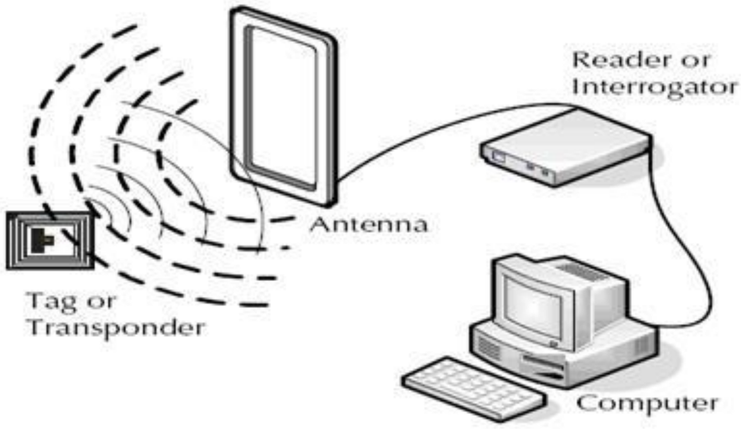


Figure 1.9: An example of Active RFID system

From Identification to RFID Electronic identification is separated into two sections:

a. Contact Identification: Alludes to frameworks with correspondence guaranteed by electric contacts. The two primary cases of contact identification are:
   - Memory: incorporates inserted memory works on modules with various structures and sizes.
   - Smart cards: the most renowned savvy cards are Visas, credit/debit cards, SIM Card or standardized savings card.
b. Contactless Identification: We can isolate contactless identifications into three sections as:
   - Line of sight - this sort of connection requires an immediate vision between the identifier (tag) and the reader (CCD Camera, laser, and so forth.) The most well known innovation is straight scanner ta g(barcode) and 2D codes (PDF417, QR Code, and so forth.). The OCR (Optical Character Recognition) is likewise generally utilized (examine MRZ (Machine Readable Zone) on international IDs or National Identity Card).
   - Infrared link - this sort of connection permits a high rate of information, a high directivity and an awesome range. These frameworks additionally require coordinate perceivability.
   - Radio frequency link - this sort of connection empowers correspondence between the identifier (tag) and a reader, without requiring direct perceivability. It is additionally conceivable to control the synchronous nearness of different identifiers.

1.1.4 Features of RFID Tags

1. RFID tags ordered into with electronic chip[2] (tags containing antenna and an incorporated circuit) or without an electronic chip (RF barcode tag).

2. Active/passive RFID tags[7].
3. RFID tags are separated into six unique classes[2].
4. Read only or read/write tags.

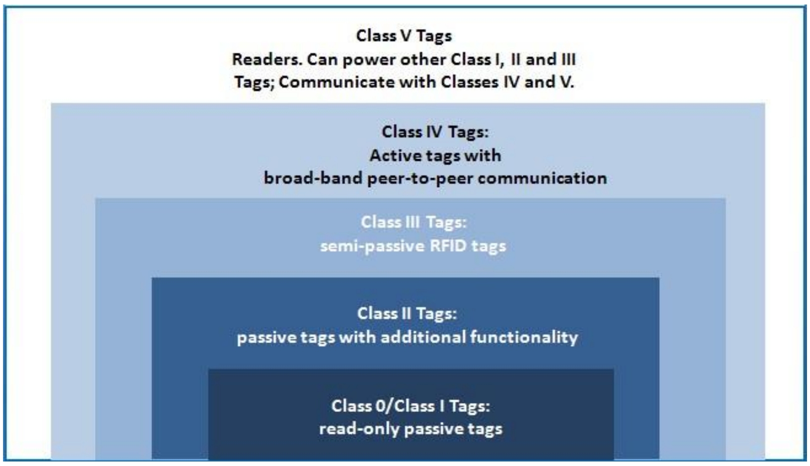


Figure 1.10: Classification of Classes of RFID tags [2].

1.1.5 The Frequency Spectrum for RFID systems

The RFID systems are seems to be non specific smaller range systems. They don't require any license for using these frequency bands [1],[2].

- LF: It includes the low frequency range from 125 KHz to 134.2 KHz.
- HF: It includes the high frequency range from 13.56 MHz.
- UHF: It includes the ultra high frequencies from 860 MHz - 960 MHz.
- SHF: It includes the super high frequency range above 2.45 GHz.

The Frequency spectrum with the various frequency bands that the RFID applications can utilize is shown in figure 1.11.

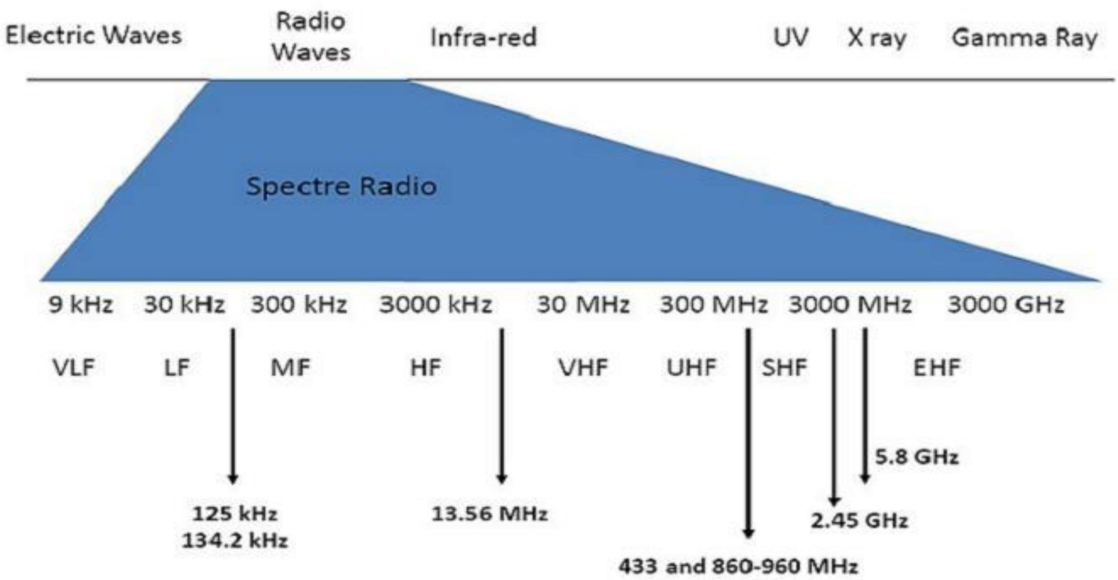


Figure 1.11: RFID Frequency Spectrum [2].

The utilizations of various LF, HF and UHF RFID tags

- The RFID low frequency tags are very much adjusted for the applications of co-ordinations and traceability. Glass tags are light in weight and small in size. A Wide range of material are utilized by these tags like metals, plastics etc.
- The RFID high frequency tags are also utilized as a part of applications for traceability and co-ordinations. For example spiral antenna printed or scratched on adaptable substrates for HF band.

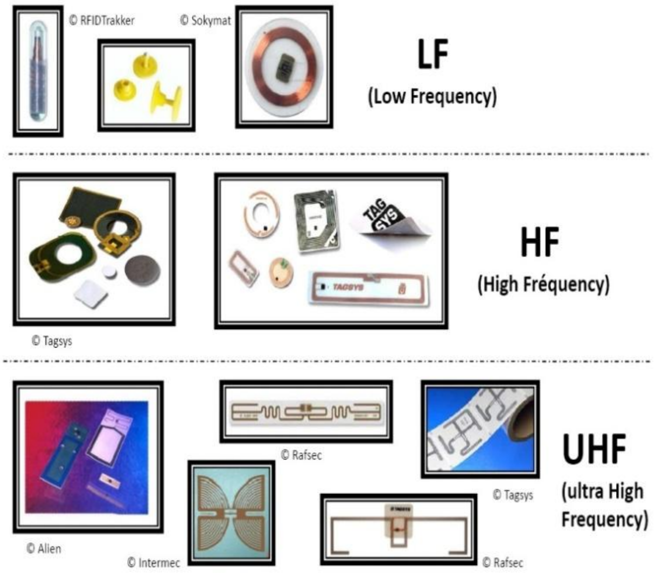


Figure 1.12: Different Types of antenna used in Different frequencies.

- The RFID ultra high frequency tag has a dipole like antenna scratched/imprinted on any sort of substrate. The readability of such tag is 3m to 6m or even 8 meters. Particular antenna configuration is needed for metallic or wet situations.

1.1.6 RFID Applications

Different applications based in RFID systems are listed below [8][9].

1) A RFID Based Attendance System: Keeping up and checking a database for individuals from a institute/foundation, utilizing RFID system. The essential thought includes every individual working in the establishment having their own id’s and when these cards are swiped through the reader, the individual's information is coordinated with the database of the current system and thus the individual’s attendance is checked.
2) RFID Technology for Device Control and Authentication in Industries [2],[9]: The system is intended to give security in an association by enabling just the approved people to get to the protected range. The primary need is the security in any association. The approved people are doled out with RFID tags that permit them into the secured premises

Figure 1.13: RFID Applications [8],[9].

3) RFID Technology for Books Tracking in Libraries: Looking and course of action of lost books is a troublesome assignment frequently completed by the library faculty. Numerous a times Librarians hectically look the misplaced books or books wrongly put by the library clients and students in the library of a school, office or school. Furthermore, frequently discover this assignment exceptionally troublesome. To defeat this issue, a RFID based shrewd book tracking system has been produced for checking the books in the library through wireless communication between the RFID reader and the books. This system comprises of RFID tag and RFID reader to recognize the data about the books set in the library.

Figure 1.14: RFID Technology for Books Tracking in Libraries.

4) RFID Technology for Intelligent Tollgate System [2]: The proposed system plays out the accompanying activities, for example, recognizing, charging and representing vehicles as they go through a toll entryway inside the frequency extend between 30 kHz and 2.5GHz. In this system, a RFID tag is customized with the vehicle proprietor's data in the frame with an EPC (electronic product

code) that can guarantees to read the information at specific separations and identifies the vehicle keeping in mind the end goal to enhance a transaction.

5) RFID Technology for Authentication of Passport Details: A Passport system can wind up noticeably sufficiently keen by the usage of RFID innovation to it. In this system, international ID benefit issues RFID tag to qualified native, this contains travel permit points of interest like name, address, nationality, visa number, and other pertinent information. during the time of validation, the RFID card reader peruses that data and contrasts it and the information put away in the identification database. In the event if it observes to be coordinated, at that point it will take into consideration facilitates priority, else it alarms the experts as fake subtle elements.

Figure 1.15: RFID Technology for Authentication of Passport Details.

6) RFID based Automatic Door Lock System: The Basic need of security can be accomplished by outlining different entryway doors locks, for example, mechanical locks or electrical locks. These sort of entryway locks are outlined with at least one keys, yet to lock a vast territory different locks are required. The conventional locks are substantial heavy and that are not solid as they can harm essentially by utilizing a few apparatuses. Electronic locks are better finished mechanical locks, to resolve the security issues that are associated with the mechanical locks, Lately every gadget utilizes advanced innovation. For instance, distinguishing proof of advanced gadget utilizing token, entryway lock system utilizing computerized innovation, programmed entryway opening and closing, automatic door lock systems, and so forth. These sorts of systems are utilized for controlling the development of an entryway without utilizing a key.

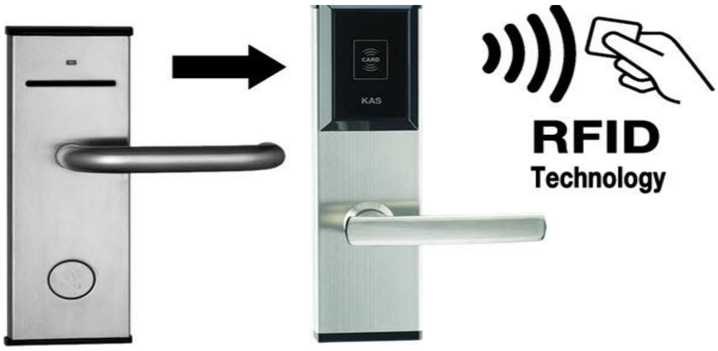


Figure 1.16: RFID based Door Lock System.

We know that for RFID systems there is a criterion of complex conjugate matching condition. The methodology used in our work to meet these criteria is through the optimization. The detailed concepts of optimization is depicted in the below subpart.

1.2 Optimization Techniques

With the advancement in the field of wireless communication system prompted increment limitations on antennas. The optimization is essential as it offers more dependable outcomes and higher possibility of determining best design parameters when connected to a given designed issue in electromagnetics. Various distinctive algorithms has exploded each year to satisfy the popularity for vigorous optimization techniques[6], for example, Genetic algorithm (GA), Gravitational search algorithm (GSA), Particle swarm optimization (PSO), differential evolution (DE), Biogeography based Optimization (BBO), Population based incremental Learning (PBIL), Ant Colony Optimization (ACO), Artificial Bee Colony (ABC) etc [3],[5],[6],[10]-[14].

The most mainstream nature inspired global evolutionary algorithm is the particle swarm optimization (PSO) among them. In 1995, Eberhart and Kennedy had developed the Particle Swarm Optimization algorithm (PSO) [15], PSO is based on the intelligence of the swarms as it simulates the social system behaviour such as a school of fish and rush of winged animals[16]. In this a swarm searches for sustenance, along with its people spread in nature and they independently move around. They even reports to its neighbours, whenever one of them discovers digestible. Then these would be able to approach the wellspring of sustenance, as well.

In PSO, the swarm's particles (people) in a search space (G) of n-dimension are simulated [17]. The (p) particle has position of (p.g) $\in G \subseteq R$ n and a velocity of (p.v) $\in$ R n. In PSO, initially the position and velocity of people are arbitrarily instated. In each progression, firstly the particle's velocity is refreshed and afterwards position is being updated. Subsequently, every (p) particle has a cache of its best position denoted as [best (p) ∈ G]. The particle moreover knows an arrangement of topological neighbours denoted by N(p) to understand the social segment. Every particle can speak to its neighbours, so that the best suited position discovered so far by any component in neighbours is referred to every one of them as [best(N(p))]. The best (Pop) is the best position got by any person in the population. For changing the velocity, either best(Pop) or best(N(p)) is utilized in PSO. The algorithm will unite quick and yet may locate the global ideal less most likely, if it depends on the global best position. On the off chance that, then again, neighbourhood communication is utilized, the merging pace drops however the global optimum is discovered more probable.

```
Algorithm : X ⋆ ← PSO Optimizer f(x) pn
Input: f(x): function to be optimize
Input: pn: the size of population
Data: Pop: the population  of particle
Data: i:  the count variable
Output: X ⋆ : the ideal value found
1.  Begin
2.  Pop ← create Pop(pn)
3.    while terminateCriteria() do
4.          for i ← 0 up to length(Pop) − 1 do
5.                Pop[i] ← PSOrefreshed(Pop[i],Pop)
6.      return best(Pop).X
7.  End
```

Figure 1.17: Algorithm of PSO.

1.2.1 PSO Implementation

The principle stride that helps the engineer and planner to utilize the plan arrangement is with the help of PSO. These strides will incorporate both preparatory strides before coding and also those steps which will be used to go to an optimized arrangement by an optimizer [20]. These means are recorded underneath.

1) Define the Optimization Problem: While this may appear glaringly evident to the reader, deciding the ideal design that will meet the require criteria after limiting the quantity of factor can be a significant test for numerous applications. To meet outline criteria, this progression involves a building judgment for picking a legitimate plan. However to decrease the optimization dimensionality, it has a lesser number of improvement parameters.
2) Define the Search Space: After indication of the proposed design and its specification variables, the subsequent stage includes the constraining for every enhancement parameter. Once more, a trade off ought to be needed between a broad range as well as

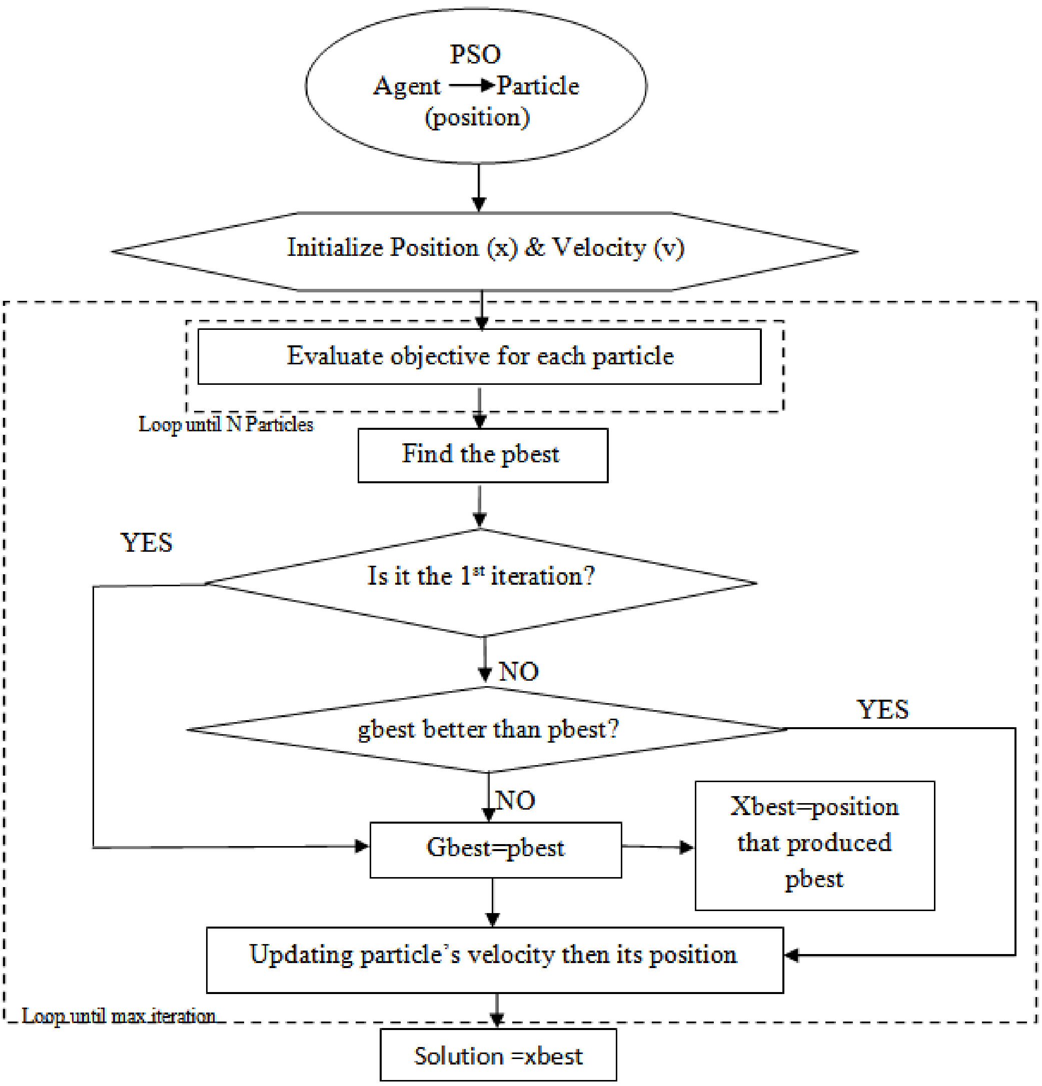


Figure 1.18: Flow chart of the Particle Swarm Optimization Algorithm [18][19].

a restricted range for every factor. A broad range will compound the convergence rate while a constrained range lessens plan adaptability. In this way, the engineer must pick an maximum range (xmax,n) and a minimum range (xmin,n) for the (N) number of parameters that are going for optimization with the end goal that it adjusts these two restricting prerequisites and here n = 1, ... , N.

3) Define Objective Function: This progression is among the most imperative step for any of the optimization procedure, as a poor calculation of the objective function can truly impede the capacity for the optimizer to perceive prevalent designs. The connection between the physical framework and optimizer is characterize by the objective function and normally depicts its execution with a solitary number. The function ought to give a decent portrayal of the execution of the desire performance characteristics. For example, if we want the maximization of the received power for a specific direction, at that point we may prescribe the utilization of the gain in that specific course as the objective function. However, there is not all in one inclusive

function that applies to all situations, and normally unique objective functions should be deliberately created for various streamlining ventures. For EM issues, this is likewise the most computationally escalated stride and a intelligent formulation for its assessment that can facilitate the enhancement procedure.

4) Initializing the Particle’s Locations as well as Velocities: This progression starts the arrangement of ventures towards the execution of the algorithm. To meet the above purpose, we randomly introduce every particle all through the search space with a uniform distribution. Likewise, there is randomly creation of velocity with a uniform distribution from (- vmax, vmax). At this stage, every location of the particles turns into the pBest for every particle as the particle has not having a past history.
5) Systematically Searching the Search Space: There are a few segments in this progression that ought to underlined, and the core of the optimization algorithm is situated at this stride. This systematic looking is executed by flying the (M) number of particles into the search space utilizing the accompanying sub-steps. Eventually, these sub-steps are repeated in the accompanying request to get the convergence.
    a) Calculate the Swarm objective: Utilizing the objective function characterized in step third, we assess the every swarm’s particles objective.
    b) Updating the Best positions: Supplant the past pBest as well as gBest location with the present position, If the value of the objective is superior to both the past pBest as well as gBest location.
    c) Particle’s position and Velocity Updating: As the present location has assessed, we coordinate the particle’s velocity as Equation 1.1[16],[20].

$$\vec{v} \qquad \vec{v} \qquad \vec{p} \quad \vec{x} \qquad \vec{g} \quad \vec{x} \qquad (1.1)$$

Where, $\vec{v}$ is the velocity, is the inertial weight at k, $\vec{p}$ is the area of the pBest , $\vec{g}$ is the area of the gBest, $\vec{x}$ is the ith particle present location, c1 and c2 are called acceleration weights (usually value taken is 2), and are uniformly appropriated scalar random variables lies under {0; 1}. the subscript i and the superscript k are assigned to ith particle and the kth iteration respectively. With the help of the refreshed velocity of the particle, the position is refreshed by [16],[20]

$$\vec{x} \qquad \vec{x} \qquad \vec{v} \tag{1.2}$$

Commonly, it is a standard to utilize the value of Δ t = 1, and many references utilize this value. With the refreshed position ,the succession is rehashed again by assessing its newly rehashed position and so forth. These are the essential steps for executing PSO. It ought to likewise be noticed that a particle can go outside the search space and thusly a boundary criteria is regularly connected with the objective function assessment.

As our work methodology includes the optimization through the PSO Algorithm of the proposed antenna design and the modified fractal antenna design in association with the interfacing of two software MATLAB and CST MWS. So, for the above strategy we should know about the interfacing concepts too as depicted below.

1.3 Interfacing between MATLAB and CST

MATLAB [32] has become a ubiquitous math, data manipulation, signal processing, and graphics software package. Engineers use its powerful functions for analysis and design in many areas including antenna design. MATLAB is general-purpose software, so many arcane applications, like antenna design, are done using special purpose commercial software. Although these packages can model very complex electromagnetic systems, they lack some of the powerful analysis tools in MATLAB. Using MATLAB to control these commercial electromagnetics solvers creates a powerful tool for design, analysis, and control. There are a number of applications where a MATLAB-commercial electromagnetics solver interface is critical. Numerical optimization is one example.

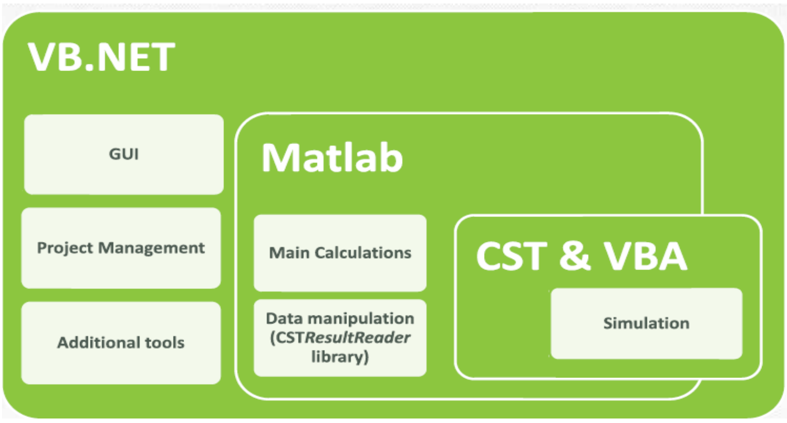


Figure 1.19: VBA Interfacing Architecture [21].

Interfacing of MATLAB and CST Studio gives us background information on data exchange and close integration between these two programs In order to do interfacing between MATLAB and CST, the concept of client and server comes into picture. Both the software can act as server and client depending upon the application. Here we are controlling CST using MATLAB, so CST will act as server and MATLAB as client [32],[33]. CST offers Command Line option for invoking VBA via external programs (Windows, MATLAB etc).

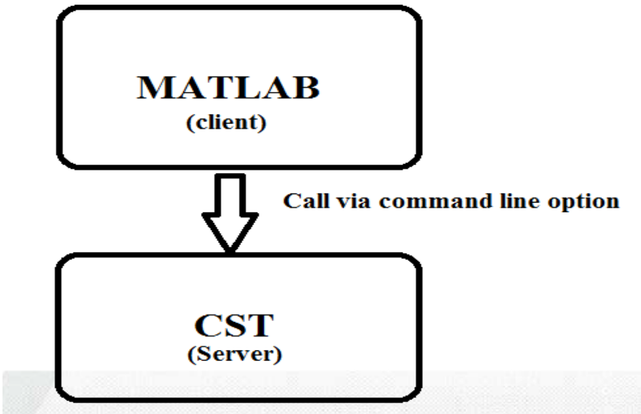


Figure 1.20: Calling CST using MATLAB [32], [33]

MATLAB can control some commercial software via a scripting language. A script is a text file containing instructions written in a scripting language. The commands in the script are executed when the scripting language opens the file. VBA is widely used and Microwave Studio and Ansoft HFSS have VBA editors built in. It is a good idea to get familiar with the VBA editor in the software package before attempting to interface with MATLAB. Commands that call various functions in the commercial software are placed in the *.bas file using the VBA editor. Types of commands include building geometry, passing variables, and engaging the main software engine. The proposed design described in the chapter III uses MATLAB to control Microwave Studio via a VBA script. Microwave Studio generates a huge number of files with each run. The relevant ASCII files are shown in Table 1.1. Again, all the files have the same name but a different extension. The S11 data written by Microwave Studio for use by MATLAB is written in the garima^d1(1)1(1).sig file.

S.NO.	File name	contents
1.	rfid.m	MATLAB m file
2.	rfid.txt	ASCII file with variable values
3.	rfid.bas	VBA program
4.	rfid.mod	Microwave Studio model file
5.	rfid^d1(1)1(1).sig	File containing 11 *s* data

Table 1.1: Relevant MATLAB-Microwave Studio computer file [21]

There are various different methods to call the CST Studio from within the matlab[21]:

1) Using the command Line Option: In this method, for launching CST from MATLAB using command line and for instructing CST, use a VBA file [22]. The following command are used for command line option and for opening an existing file :
   - ("c:\program files(x86)\CST STUDIO SUITE 2014\CST DESIGN ENVIRONMENT.exe-m\c:\test1.bas")

2) Using CST Studio command: In this method, the commands that need to be executed in CST are contained in a MATLAB .m file. In the Matlab program commands are executed for opening models, start and quit solver and saving the results, the commands used are:
   - mws = invoke(cst, 'OpenFile', 'file_path.cst')
   - solver = invoke(mws, 'Solver');

The VBA program has two parts. The first part reads the data from the garima.txt data file generated by MATLAB. Once the data is read, then the Microwave Studio model file is opened using the command.

- openfile("d:<dir>\rfid.mod")

The model with the previously stored dimension values appears on the computer screen. In order to change the dimension values, they must be stored in the model file using the following commands.

- invoke(mws, 'StoreParameter','L', ii)
- invoke(mws, 'StoreParameter','W', iii)
- Next, the data is saved and the model rebuild using,
- invoke(mws, 'Rebuild');
- solver = invoke(mws, 'Solver');
- invoke(solver, 'Start');
- release(solver);
- release(mws);

The picture of the model on the screen is redrawn to reflect the new dimension values. Finally, the solver (in this case, the transient solver) is started and the results saved through the commands, When the solver finishes and the data is stored, control returns to MATLAB and the Microwave Studio window closes. The Microwave Studio window will reopen every time the program is called from MATLAB.

In our work, we have use the "resultreader.dll" directory for importing and exporting of our files with MATLAB and CST. This type of linking of the softwares is needed to spare our time. It is a flexible procedure and we don’t have to update the proposed design manually. This seems to be a best methodology for the futuristic algorithms (which are not included in CST till now).

1.4 Outline of the Thesis

The report is organized as follows:

The Chapter I describes us the brief introduction about RFID System, RFID Tags and their types , about reader and RFID Applications and most importantly the PSO Optimization using MATLAB-CST interfacing.

Chapter II describes the Literature survey being studied. In which we surveyed different RFID antenna Designs at different frequencies utilizing various strategies depending upon the application.

In Chapter III, The proposed methodology is being described. The various mathematical formulas and specifications of proposed antenna and its modified Fractal antenna are employed. Optimization goals and the formulations regarding these are shown in this.

In Chapter IV, The Optimized geometric parameters and simulated results of both the proposed and modified Fractal antenna are been displayed. This chapter also compares the optimize simulated results of both the proposed designs.

The last Chapter V, summaries our work that this new methodology of antenna design is been carried successfully. Basically, this section concludes our work along with its future scopes.

CHAPTER II

LITERATURE SURVEY

Naji, D. K., J. S. Aziz, and R. S. Fyath *et al*[4]: Another improvement based-system for scaling down RFID label reception apparatus is presented. This paper describes, PSO procedure in association with CST Microwave Studio. EM test system is being utilize to plan a scaled down fractal antenna having flawless impedance coordinating with the label chip. The plan does not require any extra stacking or coordinating system and subsequently yields moderately bring down cost and littler reception apparatus estimate contrasted and ordinary label antenna frameworks. A mix of two target capacities identified with power reflection coefficient and reception apparatus region are utilized for enhancing the antenna. The outline approach is connected to a third order Minkowski fractal nested slot patch antenna and yields 90% territory diminishment contrasted and the reference (non-fractal) partner.

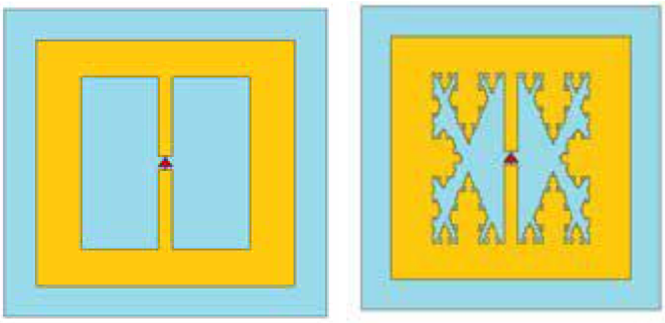


Figure 2.1: (a) H-shaped nested slot RFID Tag Antenna (b) 3rd Order Minkwoski Fractal RFID Tag Antenna [4].

Marrocco, Gaetano *et al* [1]: The RFID, in light of the reader worldview, is rapidly saturating a few parts of regular day to day existence. The EM research basically concerns the outline of the tag antennas which are having high effectiveness and little size, and suited to impedance coordinating to the inserted gadgets. Beginning from the accessible however divided open writing, this paper introduces a homogeneous overview of applicable procedures for the outline of UHF passive tag antennas. Specific care is taken to delineate, inside a typical system, the essential ideas of the most-utilized plan designs. The outline strategies are represented by methods for some non-commercial cases.

Haupt, R. L *et al* [21]: This paper gives subtle elements on the best way to utilize MATLAB to control some business electromagnetics programming bundles. FEKO is an illustration that can be straightforwardly called from MATLAB. Other business programming, for example, CST Microwave Studio and Ansoft HFSS, require a scripting dialect interface. A case of an outline of an inset rectangular patch antenna is introduced utilizing an immediate call to FEKO and a Visual Basic for Applications interface to CST Microwave Studio are displayed.

Rao, K.V. Seshagiri, P.V. Nikitin, and S.F. Lam *et al* [2]: In this paper, a review of antenna plan for passive radio frequency identification (RFID) tags is introduced. We talk about different necessities of such plans, plot a non specific outline prepare including range estimation methods and focus on one pragmatic application: RFID tag for box tracking in distribution centers. A stacked meander antenna plan for this application is portrayed and its different viable perspectives, for example, affectability to manufacture process and box substance are broke down. modeling and simulation results are likewise introduced which are in great concurrence with estimation information.

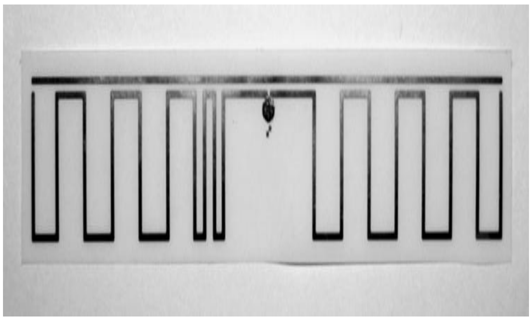


Figure 2.2: Prototype of RFID tag with loaded meander antenna [2].

Goudos, K. Sotirios, K. Siakavara, A. Theopoulos, E. E. Vafiadis, and J. N. Sahalos *et al* [13]: This paper describe a new planar spiral antenna associated with meander lines and loads for inactive RFID tag application at ultra-high-frequency band are planned and enhanced utilizing the worldwide (gbest) (GABC) guided Artificial Bee Colony calculation. The GABC is enhanced Artificial Bee Colony calculation, which incorporates gbest arrangement data into the inquiry condition to enhance the misuse.

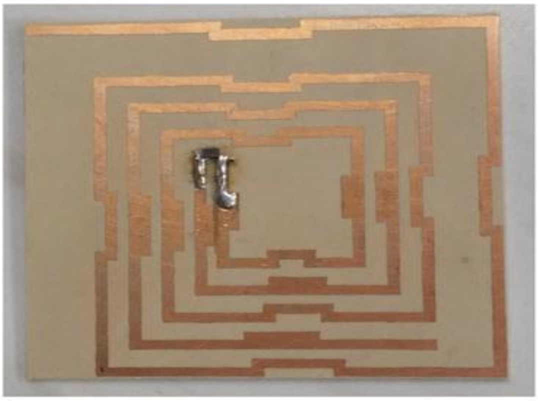


Figure 2.3: Optimized New Planar Spiral Antenna with Meander lines[13].

The improvement objectives are antenna parameters minimization, pick up amplification, also, conjugate coordinating. The antenna measurements were improved and assessed in conjunction with business programming FEKO. GABC is contrasted and other well known calculations. The advancement comes about created demonstrate that GABC is capable improvement calculation that can be effectively connected to tag antenna outline issues.

Goudos, Sotirios K., Katherine Siakavara, and John N. Sahalos *et al* [12]: This letter presents, another planar spiral antenna for inactive RFID application at UHF band and improved utilizing the Artificial Bee Colony calculation. The streamlining objectives are antenna estimate minimization, conjugate coordinating, maximization gain and the boost of the read extend. The antenna measurements were streamlined also, assessed utilizing ABC in association with business EM programming. The correlations of the outcomes acquired by ABC to particular ones of other prominent transformative calculations demonstrate that ABC can be productively connected to tag antenna plan issues. To approve the hypothetical outcomes, composed RFID tags were manufactured, and their perusing effectiveness was assessed tentatively. The consequences of recreation and those got by means of estimations demonstrate that the method for the outline of inactive RFID tag antennas is productive, as the antennas with measurements less than 3 cm, pick up that achieves the estimation of 1.6 dBi, and around 6 m read extend were gotten.

Figure 2.4: Fabricated Spiral RFID Tag Antenna[12].

Lu, J. H., and G. T. Zheng *et al* [28]: For RFID systems at UHF band, a new planar broadband circular tag antenna is proposed. By including a couple of T-curve molded strips and parasitic stride strips, The multi-full modes excitations can reach up to estimation with the working half-power band which covers the required data transfer capacity for overall UHF RFID (860-960 MHz) framework i.e. from 848 to 963 MHz,. Also, the deliberate read range of this outline comes to be 3.8 m, and shows a great unidirectional radiation design.

Popržen, Nemanja, and M. Gaćanović *et al* [26]: This report will depict the hypotheses and methods for contracting the measure of an antenna using fractals. Fractal antennas can get radiation pattern and input impedance like a more extended antenna, yet take less region due to the many forms of the shape. Fractal antennas are a genuinely new look into zone and are probably going to have a promising future in numerous applications.

Ukkonen, Leena, L. Sydänheimo, and M. Kivikoski *et al* [9]: Handheld passive RFID reader units at UHF turn out to be progressively essential frameworks in supply chain, stockroom and retail location administration. Imperative necessities for this reader unit are ergonomic size, weight, adequate battery life and appropriate read extend for the coveted applications. Likewise, ease of use of the reader unit as far as perusing bearings and introductions of labels has to be considered. This paper shows an execution examination of minimized handheld RFID reader antennas for UHF band. The proposed reader antennas are intended to be joined either inside the reader unit or into an outer module of antenna. The finite element method (FEM) is used to enhance the antenna design.

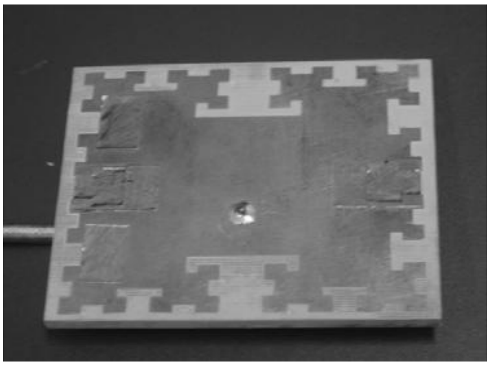


Figure 2.5: A proposed Fractal Patch Antenna [9].

The resonant frequency and transmission capacity qualities are broke down utilizing displayed and measured outcomes all antennas displayed in the paper are pertinent to a handheld RFID reader unit.

Kazanc, Onur, C. Dehollain, and F. Maloberti *et al* [10]: For conveyed control in remotely-controlled sensor frameworks, the ideal coordinating between tag antenna and incorporated circuit is pivotal. The strategy amplifies on conjugate coordinating the antenna with inductive reactive impedance with an IC having capacitive reactive impedance. Acquiring the coveted conjugate impedance by the natural antenna impedance is the requirement of an impedance coordinating system. This empowers completely coordinated sensor frameworks with further scaling down. In this review the design of a meandered slot antenna with GA optimization for an operation frequency of 2.45 GHz is proposed. Examinations on imperatives constraining the power interface productivity amongst reader and tag antenna at framework level layout conceivable plan activities and offer ascent to the plan stream of the antenna. Reproduction comes about on the proposed engineering confirm the execution of the composed scaled down antenna.

Figure.2.6: Optimized Antenna Design for Chip Impedance of 15-j250Ω [10].

Singh, Archana, and M. Kumar Singh *et al* [23]: In Modern time of innovation bunches of research is going ahead in the Wireless Technology. Fractal is a recursively created structure having self-comparable shape, which implies that a portion of the parts have an indistinguishable shape from the entirety question yet at various scale. The self-closeness property of fractals if a little piece of a fractal is amplified, more highlights that are reminiscent of the entire can be seen. Accomplishment of fractal possesses property of expanding electrical length of antenna to a great extent and 65% size decrease accomplished contrast with a customary Microstrip antenna at same resonance frequency. Tag and reader are the fundamental two segments which includes in the execution of RFID. A label comprises of an antenna and a programmable chip. Fundamentally a rectangular patch antenna has intended to resound at 1.03 GHz. Presentation of a botanical formed fractal into essential rectangular patch antenna in the primary emphasis which reverberates at 0.72 GHz and further in second cycle it resounds at 0.636 GHz. result demonstrates the augmentation in electrical length of microstrip antenna and shifting of operating frequency.

Shafie, S. Nuha, I. Adam, and P. J. Soh *et al* [24]: This work exhibits a novel tri-band Minkowski planar antenna, utilizing an altered planar monopole-shaped ground plane. The fractal structure is favorable in creating numerous resonances, while the changed ground plane was observed to be fit for upgrading every bandwidth. Use of the Minkowski fractal structure was moreover fruitful in diminishing the arm length and therefore, sideways size of the planned antenna. The proposed antenna was intended to successfully bolster WiMAX, WLAN and HiperLAN applications, at frequencies of 2.3 GHz, 2.45 GHz and 5.2 GHz, individually. The execution properties of the antenna, for example, return losses, radiation pattern and gain were dictated by simulation. A customary Minkowski antenna with full ground plane was additionally intended to give legitimate benchmarking of the change level given by the adjusted ground plane.

Suganthi, S., K. S. Tharini, P. S. Sarankumar, S. Raghavan, and D. Kumar *et al* [25]: This paper portrays the plan and simulation of novel microwave patch sort Minkowski planar fractal antennas utilizing IE3D electromagnetic simulation software. The fractal structure is beneficial in creating various resonances or upgrading bandwidth. Fractal antenna is involved components designed after self-comparable plans. Self-comparability of the fractal shape can be converted into its electromagnetic conduct. Fractal antennas are exceptionally old in idea and new in outline for broadband applications. Numerous discontinuities in the structure help in emanating higher frequencies. Both scaling down and broadband scope are the incredibly achievable figures this sort. This paper proposes the outline and simulation of four phases of antennas and the execution qualities of these four antennas have been accounted for in this paper.

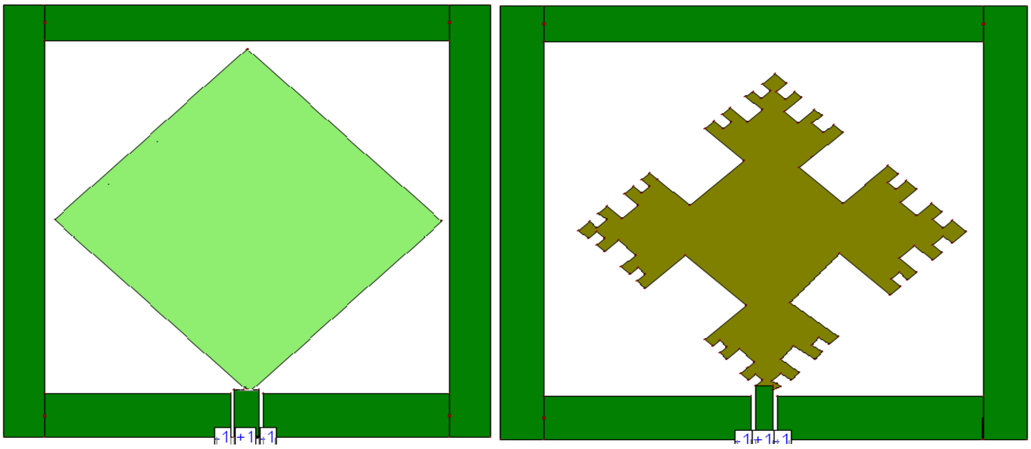


Figure 2.7 (a) Planar Patch Antenna (b) and its Fractal Patch Antenna[25].

Li, H. H., X. Q. Mou, Z. Ji, H. Yu, Y. Li, and L. Jiang *et al*[11]: A novel tri-band CPW-fed antenna intended for RFID applications is detailed. Constrained to 30 × 30 mm^2 territory on a PCB with Er=4.4, the antenna has four U-formed, two F-molded and two L-molded openings as extra resonators to accomplish multi-band operation. The intelligent single particle optimization (ISPO) algorithm is utilized to decide the streamlined space arrangement for the best return loss at 0.92, 2.45, furthermore, 5.8 GHz at the same time. The execution of the planned antenna was described through simulations utilizing the limited finite element technique.

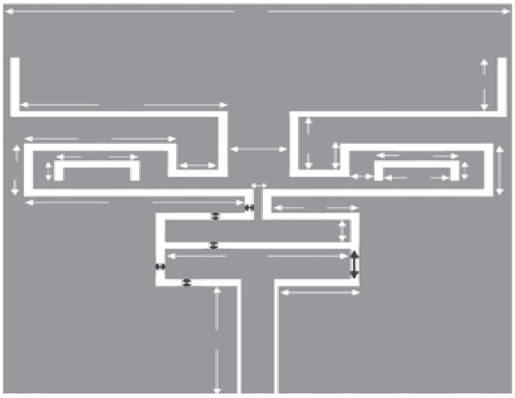


Figure 2.8: Geometry of proposed tri-band Antenna [11].

Marrocco, Gaetano *et al* [7]: This paper addresses the outline of passive and semipassive transponder antennas for radio frequency identification applications including the human body as the protest be tagged or bio-checked. A planar tag antenna geometry, that depends on a suspended patch fed through a nested slot and can have sensors and hardware is here presented. Rules for conjugate impedance coordinating are given for various types of microchip transmitters, inside power restrictions and in addition space requirements. At last, the antenna coordinating execution is tentatively assessed using a body-tissue ghost.

Calabrese, Claudio, and Gaetano Marrocco *et al* [12] : This letter presents a planar antenna format suited to Sensor-RFID creation. The geometry depends on a meandered-slot profile on a suspended patch and allows to host sensors and gadgets in a little space. The accessible geometrical parameters are upgraded by methods for a Genetic Algorithm (GA) strategy meant to augment the antenna acknowledged gain. The antenna exhibitions are examined through illustrations and models.

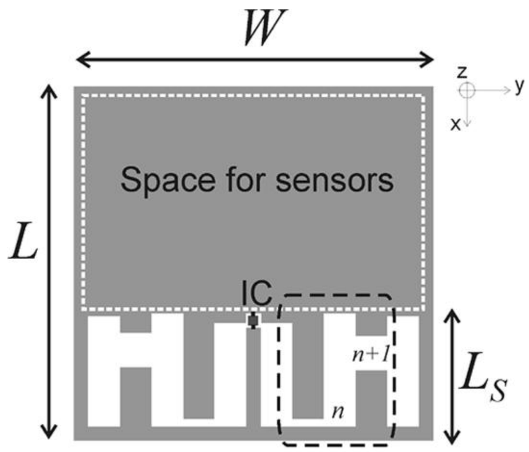


Figure 2.9: A Meander slot line Tag Antenna [12]

Wen-bo, Zeng, Li Xiang-yang, and Liu Ji-xiang *et al* [8]: A comb formed slot RFID tag antenna is exhibited in this paper. The antenna is explored numerically and approved tentatively. The parametric reviews are directed to research the impact of the geometrical parameters on the input impedance of the antenna. The antenna model joined to a copper plate accomplishes great impedance qualities over both the UHF RFID band of 902 MHz to 928 MHz and additionally microwave RFID band of 2.4 GHz. In addition, the most extreme reading scope of the tag model utilizing the proposed antenna and a microchip of ATA5590 achieves 5.2 meters and 2.6 meters, individually.

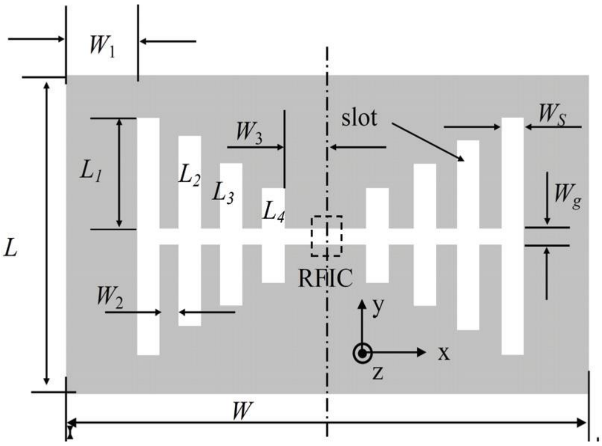


Figure.2.10: A comb shaped multi-slot RFID Tag Antenna [8].

Martinez, Marcos, and Daniel van der Weide *et al* [27]: We show a completely printable, orientation free, planar, single layer, chipless RFID tag. The tag comprises of a roundabout patch with numerous discretized round space resonators settled in it. This layout diminishes the aggregate size of the tag since the discrete roundabout space resonators reverberate at a lower frequency than consummate roundabout resonators for a similar diameter.

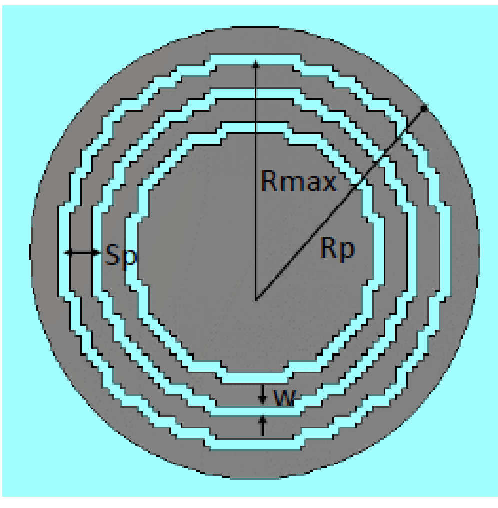


Figure.2.11: Structure of proposed circular slot RFID tag antenna [27].

Reader's unpredictability is lessened has the tag is polarization autonomous, enhancing the tags coherence from various points concerning the reader antenna. Its single layer attributes make this tag a potential possibility for conductive ink printing. The frequency band is inside16-14 GHz.

Jin, Nanbo, and Y. R. Samii ***et al*** **[15]:** The PSO is a global evolutionary algorithm (EA) in view of the swarm behaviour in the nature. The paper represents advances in applying a flexible PSO to binary, real number, single-objective and also to multi-objective optimizations for antenna designs, with a randomized Newtonian mechanics display created to portray the swarm conduct. The design of non-periodic (non-uniform and diminished) antenna exhibits is introduced for instance for the use of the PSO engine. Specifically, so as to accomplish an enhanced peak side lobe level (SLL), component position in a non-uniform cluster are advanced by real number PSO (RPSO).

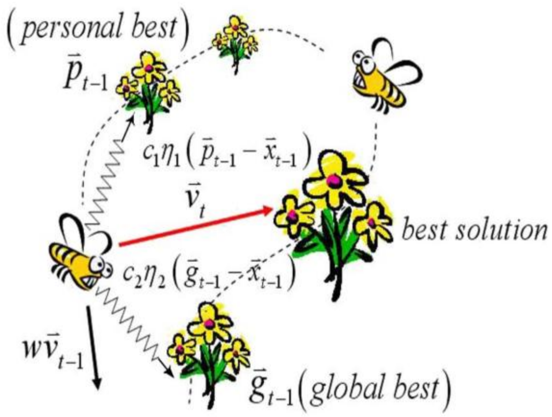


Figure 2.12: The PSO mechanism for finding highest flower density [15].

Then again, in a diminished array, the ON/OFF condition of every component is controlled by binary PSO (BPSO). Optimizations for both non-uniform clusters and diminished arrays are additionally extended to multiobjective cases. Thus, non-dominated plans on the Pareto front empower one to accomplish other design factors than the peak SLL. Upgraded antenna arrays are compared to periodic and beforehand introduced non-periodic arrays. Chosen outlines created and measured to approve the adequacy of PSO in useful electromagnetic issues.

Ramna, A. S. Sappal ***et al*** **[16]:** Particle swarm optimization is a famous optimization calculation utilized for the outline of microstrip patch antenna. The paper provides layout of probe fed rectangular microstrip patch antenna for WCDMA utilizing delicate processing strategy, (PSO). A substrate with dielectric steady of 4.4 and tallness

1.588kmm has been utilized for the plan of microstrip patch antenna. PSO has been utilized to improve the parameters like patch length, width and feed position at resonant frequency off 1.95 GHz utilizing Sonnet 13.52.

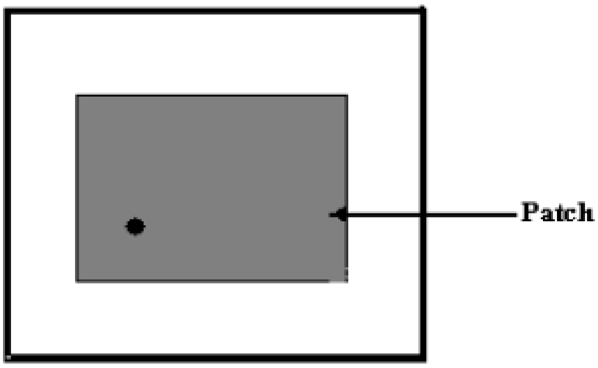


Figure 2.13: Top view of the Probe Fed Rectangular Microstrip Patch Antenna [16].

Choudhury, Balamati, S. Thomas, and R. M. Jha *et al* [5]: Portrays different strategies accessible for delicate processing to handle extensive, nonlinear issues in electromagnetics and antenna framework. Delicate registering strategies vary from hard computational techniques, and they don't depend on stringent scientific mathematical formulas yet rather depend on copying organic frameworks, for example, human intelligence, foraging behaviour and genetic inheritance. These techniques are valuable in versatile antenna arrays, space/air vehicles and metamaterials.

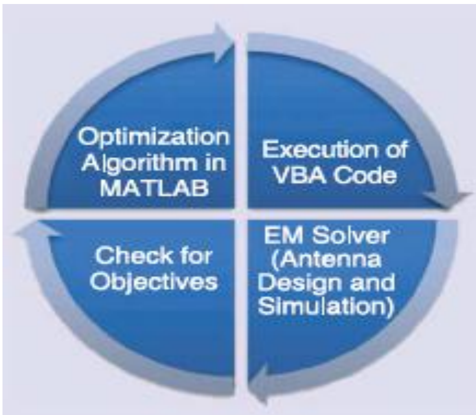


Figure 2.14: Sequence of various Stages of Optimization problem [5].

Zich, R. E., M. Mussetta, F. Grimaccia, R. Albi, A. Carbonara, P. D'Antuono, T. Guffanti, and E. Zucchelli *et al* [6]: In today's world, there has been an expanding consideration regarding some novel evolutionary procedures, such as Ant Colony Optimization (ACO), Biogeography Based Optimization (BBO), Stud Genetic Algorithm (SGA), Population-Based Incremental Learning (PBIL) and Differential Evolutions (DE). The layout of a microwave filter, a planar array and a curved reflect array are here tended to keeping in mind the end goal to look at their exhibitions on benchmark EM optimization issues. Results demonstrate that a few methods (DE, BBO, SGA) are especially successful in managing antenna optimization.

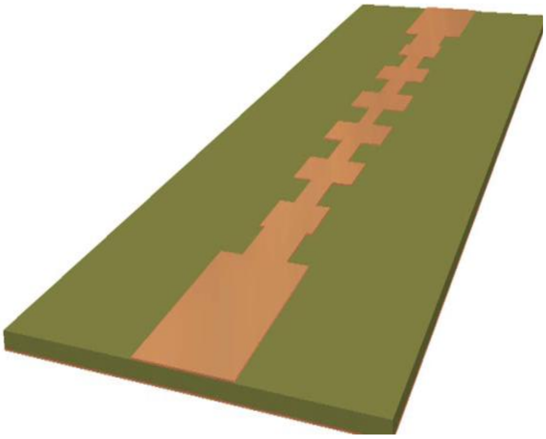


Figure 2.15: Proposed Microstrip Filter design[.6]

R. Samii, Yahya, J. M. Kovitz, and H. Rajagopalan ***et al*** **[20]:** This paper outlines the essential components inalienable in current optimization methods ordinarily connected to antenna designs and shows their viability by applying particle swarm optimization (PSO), a nature-inspired worldwide optimization procedure, to novel antenna designs arrangements in remote correspondences. The idea of the PSO system is quickly presented and a diagram of the essential parameters that are used is abridged. Next, an execution system joining PSO with numerical calculations for electromagnetic solutions, to be specific the finite element method (FEM) and the method of moments (MoM), is talked about. In both acknowledge (PSO-FEM and PSO-MoM), the PSO procedure drives the design factors, for example, the antenna measurements, geometrical components and so on. and the full-wave electromagnetic investigation motors assess the fitness function for the streamlining agent. Advanced antenna design including a multiband handset antenna and an E-molded patch antenna for circularly polarized (CP) applications are displayed. Estimation consequences of model optimized outlines are appeared to show the functionality and viability of the methodologies displayed in this paper.

Montaser, M. Ahmed, K. R. Mahmoud, and H. A. Elmikati ***et al*** **[22]:** In this paper, the cooperation of a planar inverted-F antennas array, mounted on a portable handset, with a human hand-head apparition is examined in the 1.9 GHz band. The mixture approach including the particle swarm optimization (PSO) and Nelder-Mead algorithm (NM) is considered to enhance the intricate excitations of the versatile array components in a shared coupling environment for variety of beamforming synthesis. Firstly, the effect on the handset radiation qualities of the human hand-head is contemplated. Then, the spatial-top specific absorption rate (SAR) estimations of 2-and 4-component PIFA arrays for portable handset in the region of a human hand-head are assessed numerically for different situations. The antenna is dissected totally utilizing finite difference time domain (FDTD) strategy while the association is performed utilizing the CST Microwave Studio software.

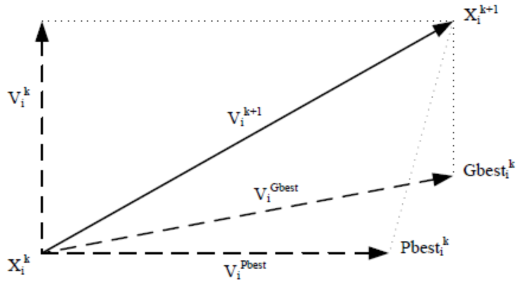


Figure 2.16: PSO search mechanism in multidimensional search space [22]

M. N. Alam *et al* [17]: In this work, a calculation for traditional particle swarm optimization (PSO) has been talked about. Additionally, its codes in MATLAB condition have been incorporated. The adequacy of the calculation has been examined with the assistance of a case of three variable optimization issue. Additionally, convergence characteristic for the calculation has been examined.

Lee, Kyounghwan, Y. Kim, and Y. C. Chung *et al* [18]: This paper displays an outline mechanization technique to enhance RFID tag antenna design with a genetic algorithm (GA) connected with an EM commercial simulation program MWS (microwave studio) produced by CST Co. The MWS test system program is exceptionally notable program for antenna layout. The GA is customized with MATLAB and connected with MWS to get the aftereffects of RFID tag antenna reenactment. The visual basic application (VBA) script dialect is utilized to connect and execute amongst GA and MWS program. The test outcomes getting from the MWS recreation program gone to the GA, and GA streamlines the design naturally.

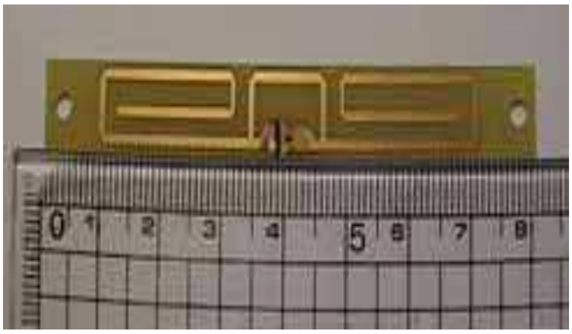


Figure 2.17: An example of the Optimized RFID Antenna and Parameters [18]

Wakrim, Layla, S. Ibnyaich, and M. M. Hassani *et al* [19]: Nowadays, the interest for remote devices that help multiband frequency has expanded. The coordination of such technology in mobile communication system has prompted an awesome request in growing miniaturized antenna with multiband operation, which can work in the required framework. the paper represents a novel sort planar inverted F antenna (PIFA) with gridded ground plane structure and covering cells is exhibited. By controlling the covering size, we enhance the characteristics of the proposed antenna. This antenna is produced to accomplish multiband operation with miniaturization and great performance. The particle swarm optimization (PSO) is utilized to a PIFA antenna to dispose of the restrictions of single band operation via looking the ideal limitation and length of straight openings on the ground plane to give tri-band operation. This PIFA antenna can be incorporated to work for a few portable applications as Bluetooth/WLAN,WIMAX, and 4G (UMTS2100, LTE). The upgraded antenna is reproduced by both Ansoft HFSS and computer simulation technology microwave studio (CST MWS) as far as -parameters. A decent assention between recreated performances by both software sorts is accomplished. A parametric report is made to break down the effect of different PIFA parameters on the working frequency and the reflection coefficient keeping in mind the end goal to upgrade the antenna performances. In these frequency groups, the antenna has about omni-directional radiation pattern.

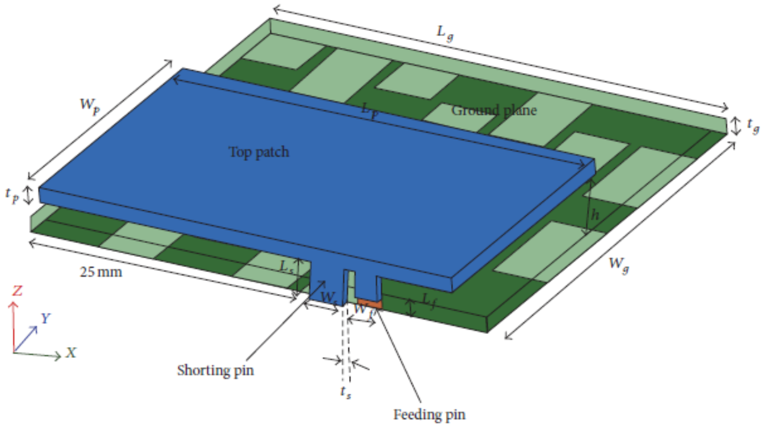


Figure 2.18: The Geometry of the proposed tri-band PIFA RFID Tag Antenna [19]

Goudos, K. Sotirios, K. Siakavara, and J. N. Sahalos *et al* [3]: This paper outlines, a new planar spiral antennal for passive RFID tag application at UHF band and optimization is presented using artificial bee colony (ABC) algorithm. Here the improved ABC (I-ABC), which is an improved version of the original ABC algorithm is applied as it produces the best solution, inertia weight and acceleration coefficients to modify the search procedure. The optimization objectives are minimization of antenna, gain maximization and complex conjugate impedance matching. The antenna geometrical parameters were optimized and assessed using I-ABC in conjunction with commercial EM software. The I-ABC and the original ABC algorithm comparison has been discussed. The obtained comes about demonstrate that both algorithms are effective optimizers that can be efficiently applied to label (tag) antenna design problems. I-ABC creates preferred outcomes over the original ABC algorithm regarding solution precision and achievement rate. RFID tags with dimensions under 38cm,achieves the maximum gain of estimation 1.46 dBi and reading distance more than 10 m.

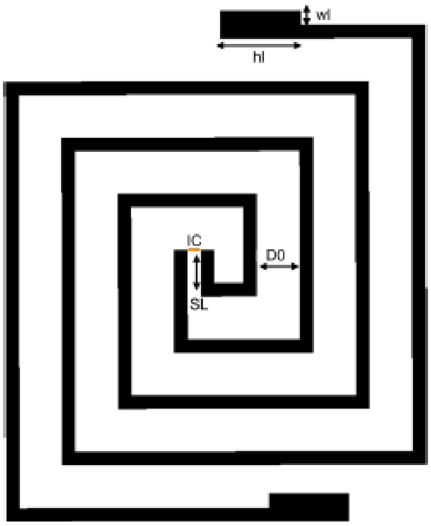


Figure 2.19: Load ended spiral RFID Tag Antenna [3].

Marrocco, Gaetano *et al* [29]: New meander line antennas with enhanced gain are presented as low-profile self-resonant tags for application in inactive RFID. Antenna geometrical parameters are advanced by genetic algorithm considering the conductor losses. Cases are exhibited for application at 869 MHz with antennas of various materials and sizes.

Palazzi, Valentina, P. Mezzanotte, and L. Roselli *et al* [30]: This paper displays a novel minimized dual-layer harmonic tag in paper substrate, in light of an arrangement of settled annular spaced antennas. The inactive tag is invested by a signal at fo = 1.2 GHz and the received signal transmitted back to the reader is changed over to 2fo= 2.42 GHz all together for the framework to be resistant to clutter returns. The frequency transformation is performed by a solitary Schottky diode frequency doubler, which demonstrates a hypothetical transformation loss of 13 dB at the yield frequency of 2.4

GHz for an accessible power of – 10ndBm. Furthermore, a taper annular slot antenna has been proposed to build the operational bandwidth capacity.

Björninen, Toni, and L.Ukkonen *et al* [31]: A miniaturized slot antenna on a high-permittivity ceramic Barium Titanate (BaTiO3) substrate for metal mountable inactive UHF RFID tags is displayed. The tag has a size of 0.09λ×0.09λ, basic structure in view of just a solitary conductor layer, and it accomplishes aggressive execution against cutting edge.

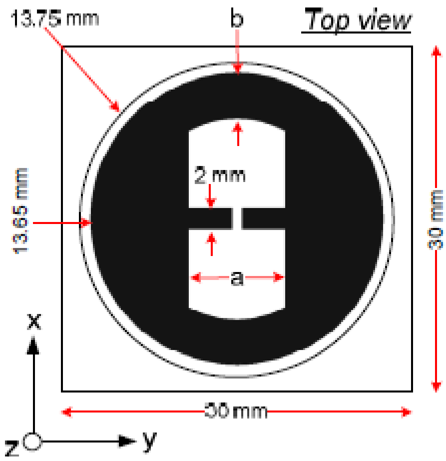


Figure 2.20: Small slot RFID Tag Antenna [31].

CHAPTER III

METHODOLOGY AND DESIGN ANALYSIS

3.1 Proposed Methodology

To achieve the perfect conjugate matching of impedances between the proposed tag antenna and the chip ($Z_A = Z_C^*$), PSO algorithm which seems to be the most popular nature inspired global evolutionary algorithm is used through the linking of MATLAB and CST. This proposed methodology is shown in the flow chart below.

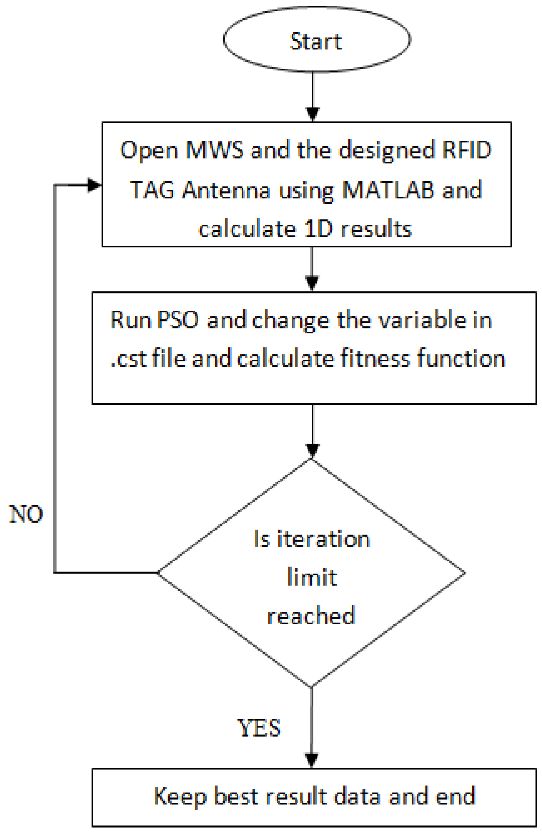


Figure 3.1: Flow chart for PSO Aalgorithm implemented on the Nested Slot RFID Tag Antenna through MATLAB-CST Interfacing [20].

3.2 RFID Tag Antenna and Fractal Tag Antenna Design

RFID technology is known for its support in automation and tracking as being more competent to barcode system and has been approved for worldwide deployment [3]. Major design challenges concerning to RFID technology are small size antennas and conjugate impedance matching to IC chips having capacitive impedance[1],[2]. For our problem an inverted S-shaped nested slot RFID Tag antenna is designed and further optimization is being performed. A nested slot structure is used as it offers ability to tune the impedance of tag antenna by modifying six slot parameters to achieve conjugate impedance matching. An inverted S-Shaped nested slot RFID Tag antenna is depicted as in figure 3.2. The nested slot antenna is consider as a reference proposed antenna which consist of a patch antenna on which slots are implemented on FR4 substrate of thickness 0.8mm having the relative permittivity of 4.3 and dielectric loss tangent of 0.025. The basic analytical (approximated) equations are used to determine the initial values of the geometrical parameters of the patch antenna working at a operating frequency of 0.91GHz.

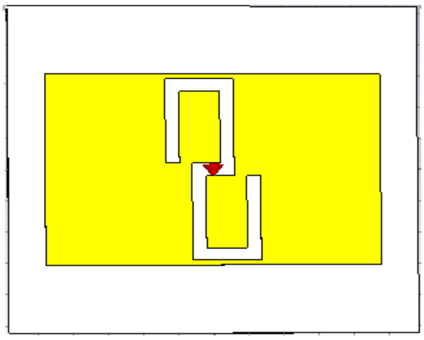


Figure 3.2: Inverted S-Shaped Nested Slot RFID Tag Antenna [33].

The parameters for the tag antenna are the ground/substrate length L, the ground/substrate width W, patch length Lp, patch width Wp, slot length Ls, slot width Ws, gap length and width are Lgap and Wgap respectively as shown in the figure 3.3.

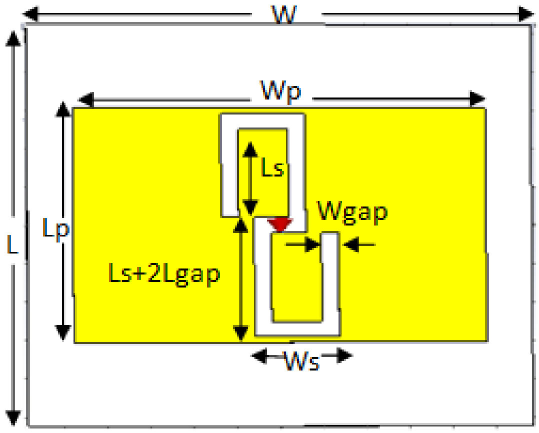


Figure 3.3: Specification of the Design antenna [33].

Other geometrical parameters are scaled from each other. Lgap and Wgap remain fixed at 4mm the equations 3.1 to 3.4 describe the relation between the geometrical parameters with each other are given as [4]:

(3.1)

(3.2)

(3.3)

(3.4)

Where the parameters such as Klp, Kwp ,Kls , Kws are the scaling factors related to the lengths and widths of the patch and slot. Further to minimize the design the fractal shape is being considered and for this four other parameters related to the fractal slots length and slots width required are Kla, Klb, Kwa and Kwb respectively.

S.NO	**Antenna parameters**	**Data**
1	Resonant frequency(f_r)	0.91GHz
2	Dielectric constant(ϵ_r)	4.3
3	Substrate thickness(h)	0.8mm
4	Gap length (Lgap)	4mm
5	Gap width (Wgap)	4mm
6	Metal thickness (copper)(t)	0.035mm

Table 3.1: Known RFID Tag Antenna Parameters [33]

Here the patch works as a coupling element between the reader and the chip [1]. The slot line implemented on patch acts as a impedance transformer to offer inductive reactance as tag is required to be matched to the chip impedance [1]. The parameters Ls and Ws can be varied to achieve inductive coupling and the gap ‘Lgap x Wgap’ acts as a coupling capacitance so impedance can be tuned to achieve conjugate impedance matching [4].

There is a limit for the upper and lower bound of the slot length Ls and width Ws in order to prevent failure in the geometrical configuration of antenna during optimization process given in equations [3.5],[3.6],[3.7].

(3.5)

(3.6)

(3.7)

To simulate the radiation performance a lumped element corresponding to the tag chip is added in series with the discrete port of 50 Ω to ensure the complex conjugate matching condition. This lumped element has a 12Ω resistance in series with two 0.22nF capacitors to get a total of 12+j150 Ω same as that of the equivalent tag chip of Monza 4 series having a minimum power threshold of P_{th} –17.4dBm.

3.3 Minkwoski Fractal Techniques

In these recent years of wireless communications, there has been an expanding requirement for more miniaturized and compact communications systems. Similarly as the larger hardware has developed to transceivers on a solitary chip. As of now, numerous versatile communications systems utilize a basic monopole with a coordinating circuit. Be that as it may, if the monopole were short contrasted with the wavelength, the radiation resistance diminishes, the reactive energy increments, and the radiation efficiency would diminish [23]. Thus, the coordinating hardware can turn out to be much entangled. As an answer for limiting the antenna configuration while keeping high radiation efficiency, fractal antennas can be actualized. Fractals are a space-filling shape, which means electrically expansive elements can be proficiently pressed into little regions [23]. The word fractal originates from Latin fractus, which implies broken lines [24]. Mandelbrot, who initially presented this idea, characterized a fractal as an unpleasant or divided geometric shape that can be further subdivided into parts, each of which is a diminished size duplicate of the entirety. He has researched the connection amongst fractals and nature utilizing revelations made by Gaston Julia,Felix Hausdorff and Pierre Fatou [24]. He demonstrates that numerous fractals exist in nature and can be utilized to precisely display certain phenomena. Likewise, he acquaints new fractals to show more intricate structures, including trees and mountains that have a characteristic self-similitude and self-partiality in their geometrical shape. Fractal ideas have been connected to many branches of science and designing, including fractal electrodynamics for radiation, scattering, and propagation. Fractals can be arranged in two classifications: deterministic and random [24]. Deterministic, for example, the Sierpinski gaskets and the von Koch snowflake are those that are produced of a few downsized and turned duplicates of themselves. Such fractals can be created utilizing PC designs requiring specific mapping that is rehashed again and again utilizing a recursive algorithm. Random fractals likewise contain components of randomness that permit recreation of regular wonders. Fractal geometries are created in an iterative mold, prompting self-comparative structures. The state of the fractal is shaped by an iterative scientific process. This procedure can be depicted by an iterative function system (IFS) algorithm [26]. This iterative era strategy is introduced in Fig. 8. The fractal antenna has a substantial effective length, as well as the forms of its shape can create a capacitance and inductance that can coordinate the antenna to the circuit. Higher order fractal antennas abuse the space-filling property and empower scaling down of antennas. The fractal structure is worthwhile in producing various resonances.

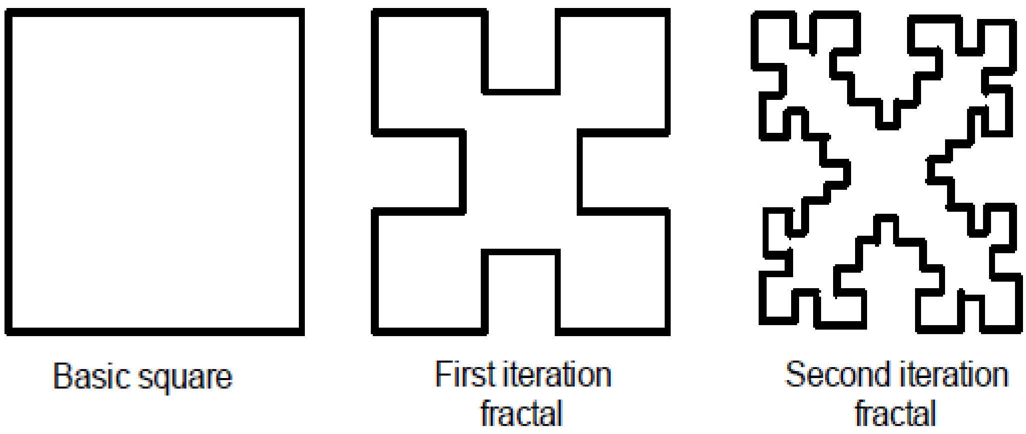


Figure 3.4: The Iterative Fractal Generation Technique [26].

Fractal antennas can go up against different shapes and forms [26] utilizing diverse fractal techniques, for example, Koch fractal technique, Minkowski loop, Sierpinski sieve, Hilbert curve Tree structure, fractal arrays etc.[9][24],[25],[26].

Advantages:

- Miniaturization of design.
- Better information impedance coordinating wideband/multiband(use one antenna rather than numerous)
- Frequency autonomous (steady execution over a huge range of frequency)
- Lessened mutual coupling in fractal array antennas.
- The fractal structure is also valuable in producing different resonances

Disadvantages:

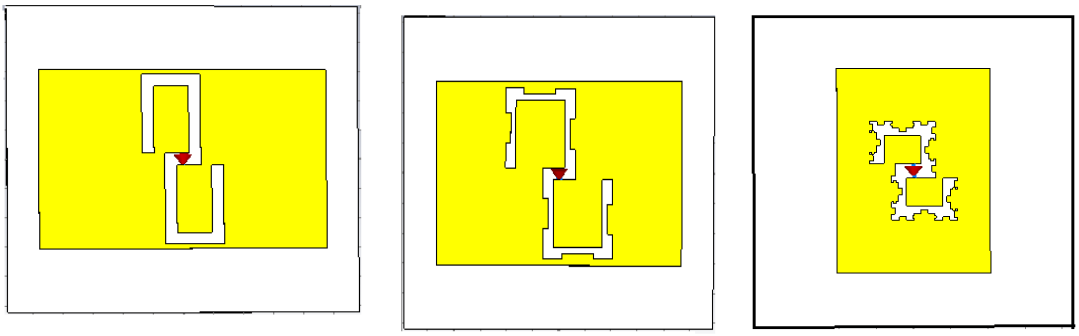
- Lower the gain parameter
- Complex structure
- Numerical constraints
- The benefits start to lessen after initial couple of iterations.

For the above advantages, fractal antennas are chosen as to exceptionally reduced the design size, or for multiband or wideband applications[24].

Applications:

- Cellular telephone and location services such as GPS, the global positioning satellites.
- microwave communication
- reconfigurable systems
- Military applications and so on.

For the scaling down of RFID tag antenna and to get the conjugate impedance matching effortlessly the Minkowski fractal technique is been utilized here. In Minkowski Fractal technique Fractal Geometries are created utilizing an iterative procedure that prompts self-comparable and self-fondness structures.



(a) (b) (c)

Figure 3.5: The Iterative Fractal Generation of the designed antenna. (a) Proposed Tag Antenna design. (b)1st order Minkowski Fractal Antenna (c) 2^{nd} order Minkowski Fractal Antenna [33]

The last fractal geometry is a curve with an interminably many-sided hidden structure to such an extent that, regardless of how nearly the structure is seen, the key building blocks can't be separated as they are scaled variants of the initiator. Fractal geometries are utilized present the structures in nature, for example, trees, mountain ranges, blossoms, winged animals ,plants, mists, waves etc.[23]. It must be symmetrical about a point, and it must act naturally comparable, having a similar fundamental appearance at each scale that makes it must be fractal. The fractal geometry characterizes a structure with long lengths that fit in a minimal region. This characteristic of fractals can be utilized to configuration scaled down antennas because of their decreased physical lengths. The state of the fractal is shaped by an iterative numerical process. This procedure can be depicted by an iterative function system (IFS) algorithm. The different orders of inverter S-shaped nested slot fractal RFID Tag antenna is depicted in the figure 3.5.

3.4 PSO Optimization

In RFID systems, the input impedance (Z_A) should be conjugate coordinated with the chip impedance (Z_C) so that the maximum power can be received. These Aantennas are required to be optimized as in passive tag antennas operational power is utilized from reader antenna [1],[2],[4],[14]. Several optimization algorithms for solving antenna design problem have been proposed[10]-[14].Here Particle Swarm Optimization (PSO) algorithm has been used to optimize antenna geometry of RFID tag design in order to get the desired results as it is most promising nature inspired optimization algorithm.for this the concept for conjugate matched impedance should be acknowledged.

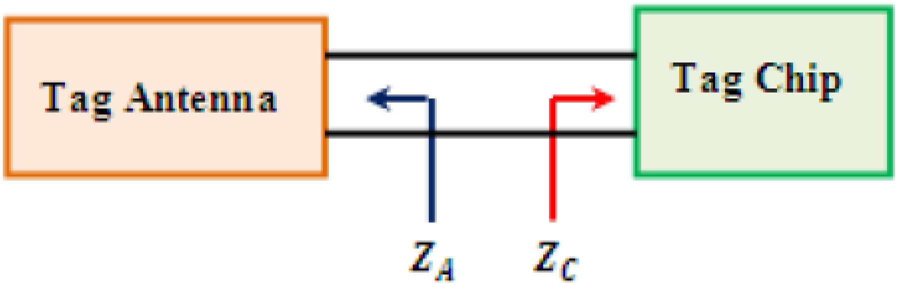


Figure 3.6: Simplified Block Diagram of a Tag Antenna and a Tag Chip [4]

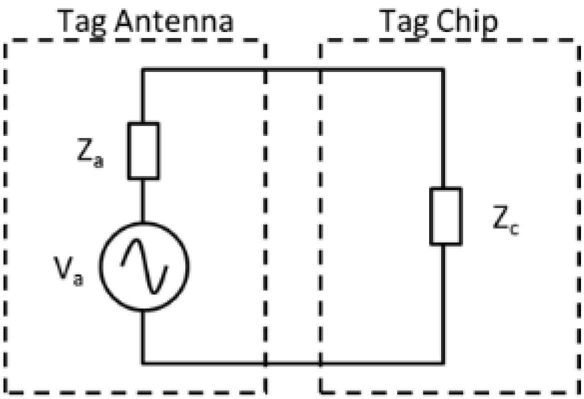


Figure 3.7: Equivalent circuit of RFID tag with chip [4]

The total chip power received is given as [4]:

$$P_C = \left(1-|S|^2\right) P_A \tag{3.8}$$

Where P_A is the power collected by tag antenna, S is the complex reflection coefficient and is given as:

$$S = \frac{\left(Z_A - Z_C^*\right)}{\left(Z_A + Z_C\right)} \tag{3.9}$$

Whenever, $Z_A = Z_C^*$ Then S should be zero and this condition is known as the ideal impedance matching. The chip input reactance is comes out to be capacitive as the chip includes an energy storage stage. So, the chip impedance can be described as:

$$Z_C = R_C + jX_C \tag{3.10}$$

Where X_C is a negative term. So, for the condition of conjugate impedance matching, the Z_A must be inductive and represented as:

$$Z_A = R_A + jX_A \tag{3.11}$$

With X_A is a positive term.

The Power Reflection Coefficient (PRC) $|S|^2$ or PRC is given as [4]:

$$PRC = 10Log\left|\frac{(Z_A - Z_C^*)}{(Z_A + Z_C)}\right|^2 \tag{3.12}$$

$$= 10\log\left|\frac{(R_A + jX_A) - (R_C + jX_C)^*}{(R_A + jX_A) + (R_C + jX_C)}\right|^2 \tag{3.13}$$

$$= 10Log\left|\frac{(R_A - R_C) + j(X_A + X_C)}{(R_A + R_C) + j(X_A + X_C)}\right|^2 \tag{3.14}$$

Also, The Power Transmission Coefficient is defined as [2]:

(3.15)

Also, = 1 - PRC

The last equation is used to estimate the PRC at the resonant frequency f_r= 0.91GHz. Here we are taking the chip impedance of 12- j150 Ω. So to get the impedance coordination condition i.e. $Z_A = Z_C^*$ the input impedance of the tag antenna should be 12+ j150 Ω which would be our main goal of optimization. So, the goal becomes the minimization of the fitness function so its value lies in 0 and 1. The equation for the fitness function F(x) for proposed tag antenna can be written as:

$$F(x) = \left((PRC)_{fr} - (PRC)_{Th}\right).u(t) \tag{3.16}$$

Also, $0 < F(x) < 1$,

$$u(t) = \begin{cases} 1; if\ (PRC)_{fr} > (PRC)_{Th} \\ 0; else \end{cases} \tag{3.17}$$

Where the PRC_{fr} is the value of (PRC) power reflection coefficient at the resonant frequency 0.91GHz, PRC_{Th} is the value of (PRC) power reflection coefficient at the threshold and u(t) is the unit step function. For finishes the optimization process the value of F(x) should tends towards zero. For the fractal tag antenna optimization the fitness function can be extended as:

$$F(x) = PRC_{Obj} + Area_{Obj} \tag{3.18}$$

Where, $$PRC_{Obj} = (PRC_{fr} - PRC_{Th}) \cdot u(PRC_{fr} - PRC_{Th}) \tag{3.19}$$

$$Area_{Obj} = \left(\frac{A_F}{A_P} - 1 \right) \tag{3.20}$$

Also, $A_F < A_P$

The terms A_P and A_F represents the area of proposed antenna and the area of 2nd order Minkwoski fractal tag antenna respectively. To optimized the proposed tag antenna total 15 number of particles are used which optimized the six geometrical parameters(L, W, Klp, Kwp, Kls, Kws) and for fractal tag antenna its particle number increases from 15 to 20 in order to optimized the ten geometrical parameters(L, W, Klp, Kwp, Kls, Kws, Kla, Klb, Kwa, Kwb). Further there should be a certain criteria to stop the optimization process. The criteria followed is that whenever the value of PRC_{fr} goes lower or equal to PRC_{Th} i.e the u(t)=0, the optimization process will stop. The value taken for PRC_{Th} is -20dB. Here the goal will not only to minimize the tag antenna or conjugate matching of impedances but also for a design that yields $PRC_{fr} \leq PRC_{Th}$.

For optimization, it is required to set particular ranges for lower and upper bounds of the parameters which are going to be optimized to ensure the boundary conditions. The lower and upper bounds for parameters are described in the tables [3.2] and [3.3].

S.NO	**Antenna parameters**	**Range(mm)**
1	Substrate length (L)	95 – 105
2	Substrate width(W)	115 – 125
3	Klp	0.4 - 0.9
4	Kls	0.1 - 0.4
5	Kwp	0.4 - 0.9
6	Kws	0.15 - 0.55

Table 3.2: Parameter ranges for optimization of proposed RFID Tag antenna [33]

S.NO	Antenna parameters	Range(mm)
1	Substrate length (L)	40 - 105
2	Substrate width(W)	50 - 125
3	Klp	0.4 - 0.9
4	Kls	0.1 - 0.4
5	Kwp	0.4 - 0.9
6	Kws	0.15 - 0.55
7	Kla	0.1 – 0.2
8	Klb	0.45 - 0.55
9	Kwa	0.1 – 0.2
10	Kwb	0.45 - 0.55

Table 3.3: Parameter ranges for optimization of 2^{nd} order fractal RFID Tag antenna [33].

CHAPER IV

RESULTS AND PERFORMANCE PARAMETERS

The electromagnetic properties of both of the tag antennas (proposed and fractal antennas) are simulated successfully through MATLAB –CST interfacing. the table [4.1] and [4.2] shows the optimized geometrical parameters of the RFID tag antenna and its fractal antenna respectively.

S.NO	Antenna parameters	Value(mm)
1	Substrate length (L)	104.70
2	Substrate width(W)	117.12
3	Klp	0.5835
4	Kls	0.3770
5	Kwp	0.8191
6	Kws	0.1585

Table 4.1: Optimized Parameters of proposed RFID Tag Antenna [33]

S.NO	Antenna parameters	Range(mm)
1	Substrate length (L)	53.99
2	Substrate width(W)	56.70
3	Klp	0.75
4	Kls	0.13
5	Kwp	0.69
6	Kws	0.43
7	Kla	0.14
8	Klb	0.48
9	Kwa	0.10
10	Kwb	0.48

Table 4.2: Optimized Parameters of 2nd Order Minkowski Fractal RFID Tag Antenna [33].

The PRC (Power Reflection Coefficient) are also investigated for both the proposed antennas and Fractal antenna. The value for the PRC comes out to be -40.8dB and -22.2. dB respectively at the resonant frequency of 0.91GHz.The figure [4.1] and [4.2] shows the S_{11} dB value after the implementation of conjugate matching and their values are -8.8 dB and -9. 8dB. The figure [4.3] and [4.4] represents the input resistance and reactance for the designed antenna and modified FA as a function of frequency. From these figures we can observed that a good complex conjugate impedance matching has achieved. Along with the conjugate impedance matching there are also variations in other performance parameter of these two antennas that is in gain, efficiency, size, bandwidth and reading range etc. it is noted that after introducing the fractal geometry, there is a decrease in the gain, directivity and size of the antenna. The gain and directivity of proposed RFID antenna seems to have a value of -3.65dB and 5.77dB. However after the fractal geometry it goes lower and values comes out to be -20dB and 3.1dB. Directivity is as shown in the figures[4.5],[4.6].

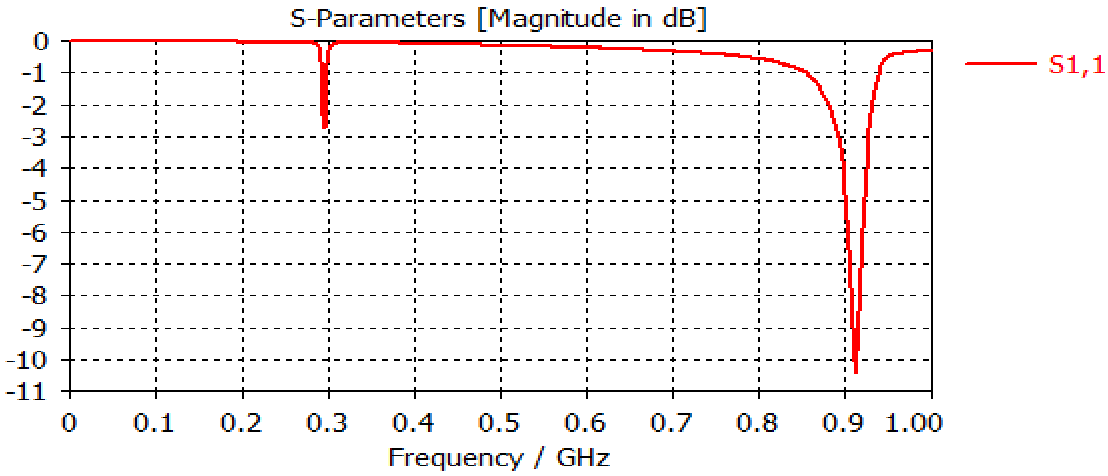


Figure 4.1: S_{11} (dB) for Proposed Antenna [33]

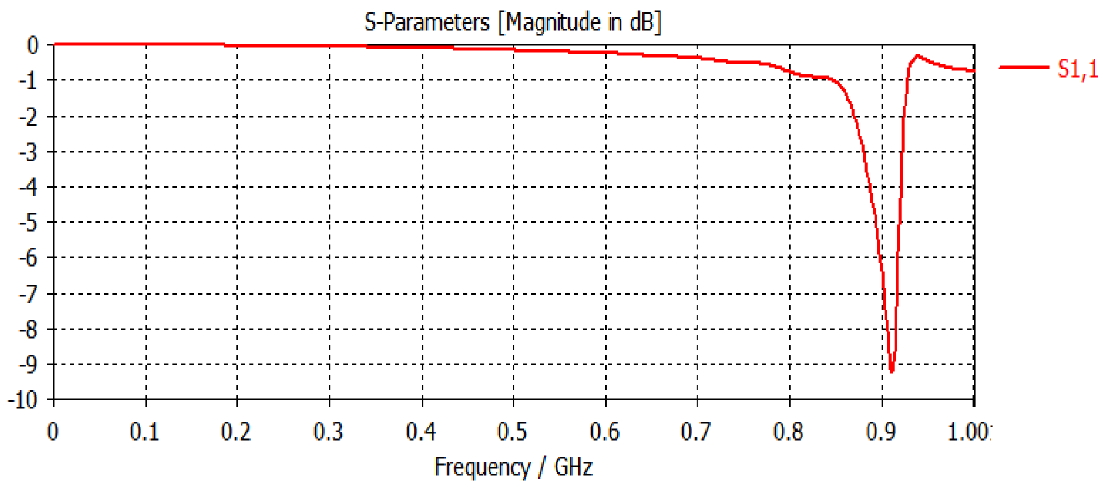


Figure 4.2: S_{11} (dB) for Fractal Antenna [33]

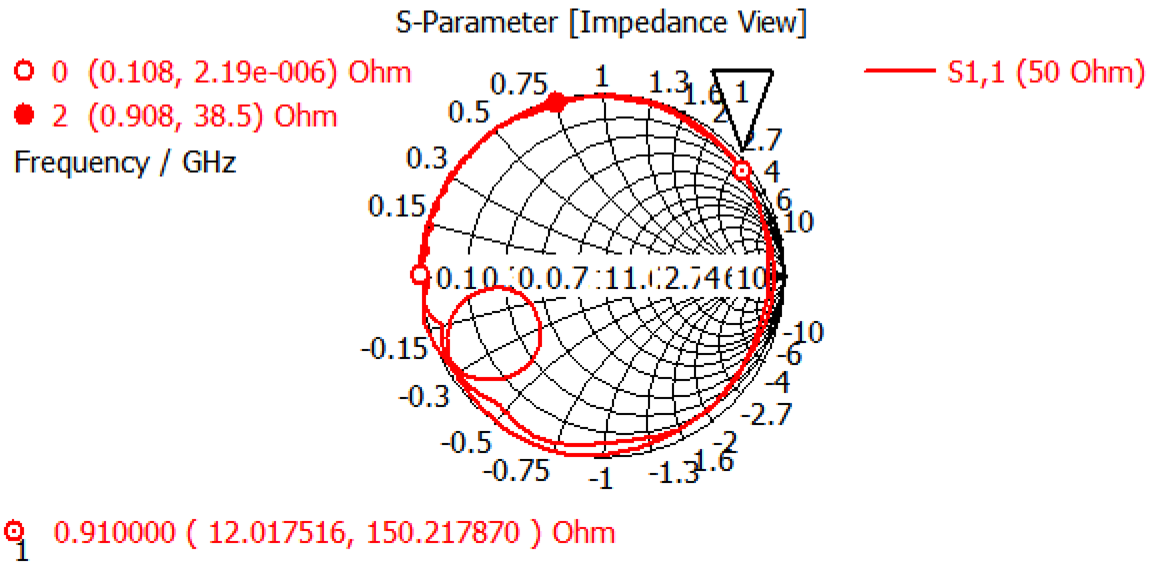


Figure 4.3: ZA for proposed Antenna [33]

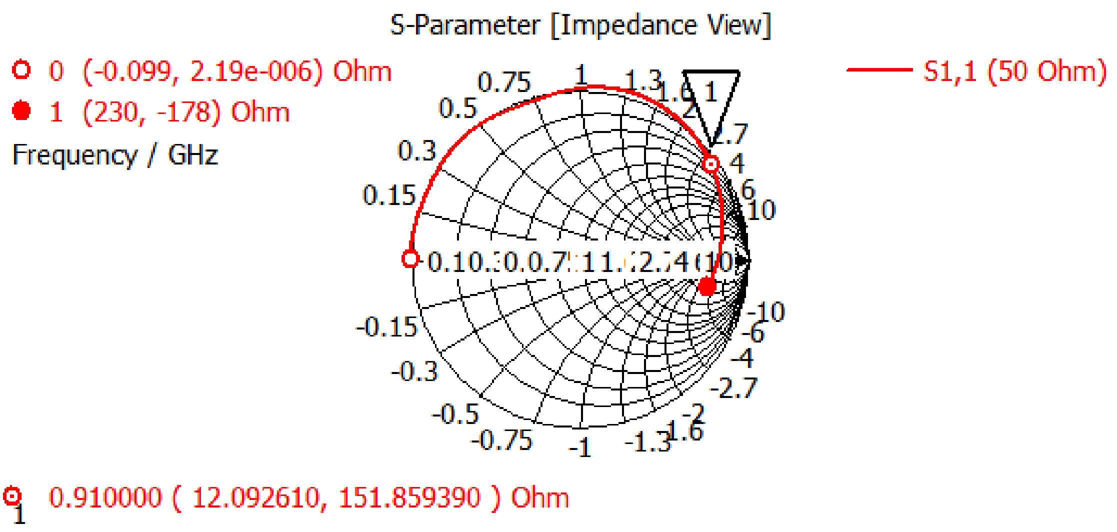


Figure 4.4: ZA for Fractal Antenna [33]

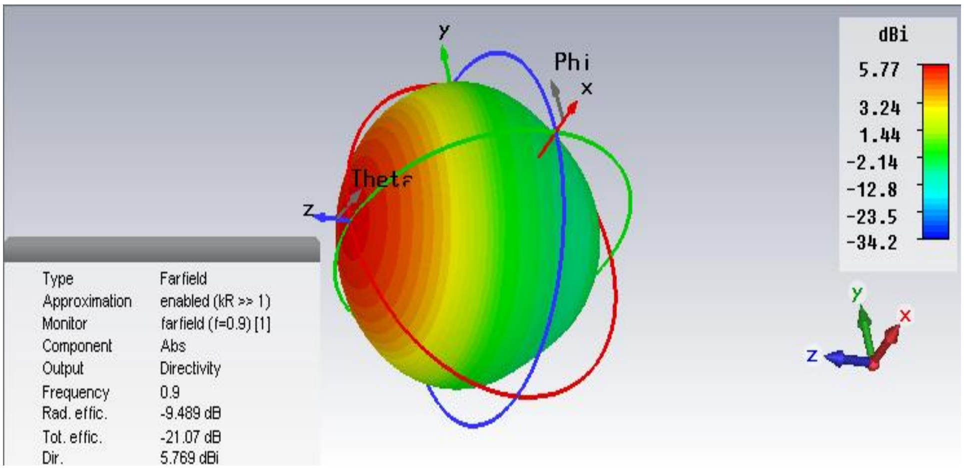


Figure 4.5: Directivity for Proposed Antenna [33].

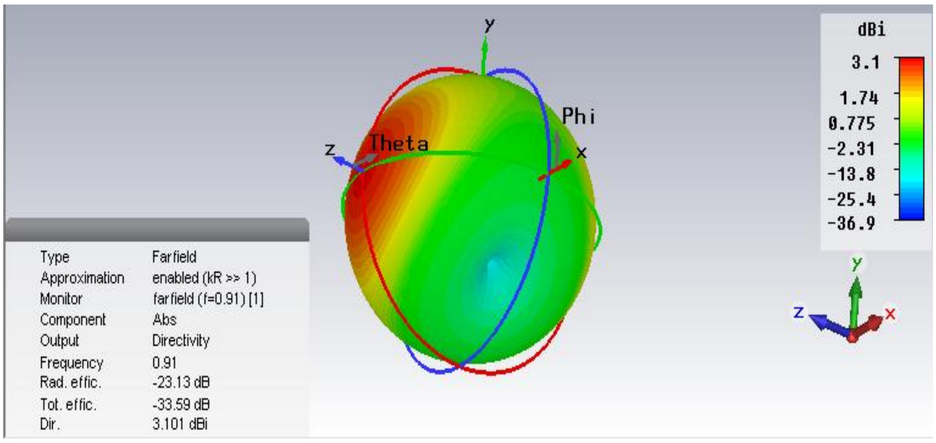


Figure 4.6: Directivity of FA [33]

The results for the tag resistance and reactance for the proposed antennas are also simulated through MATLAB and comes out as depicted in figure 4.7, 4.8, respectively.

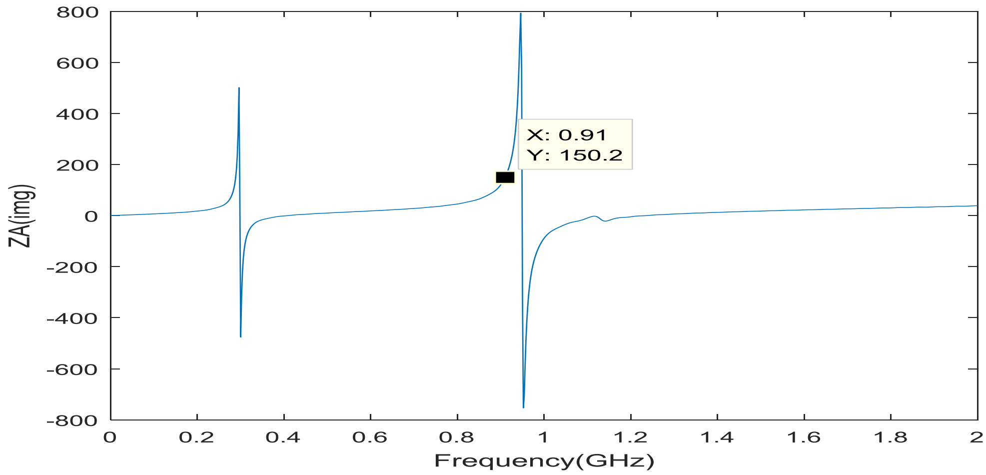


Figure 4.7: ZA (img) i.e. Reactance for PA [32].

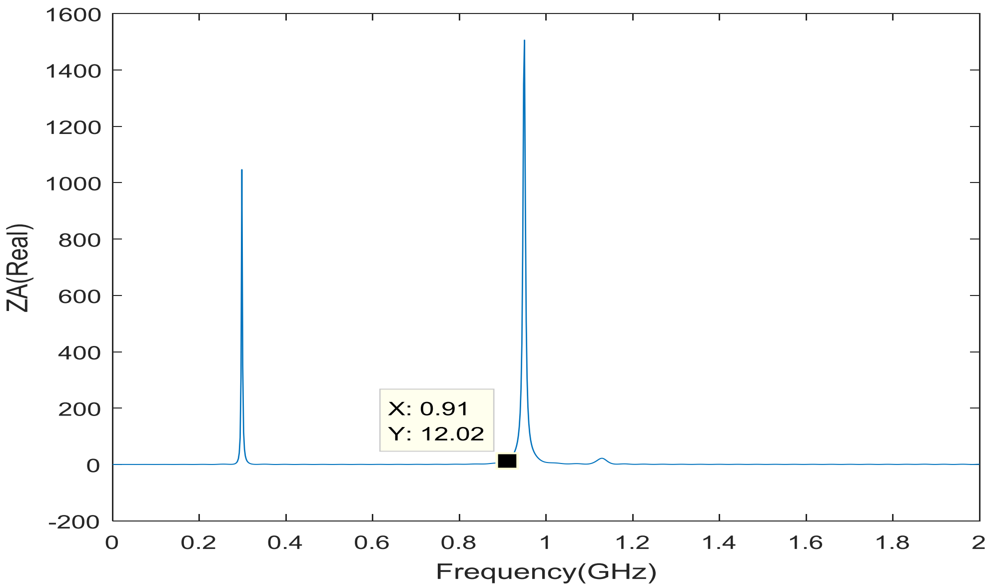


Figure 4.8: Z_A (real) i.e. Resistance for PA [32].

It is also observed as that both of the RFID tag antennas are working across a band of 890-930MHz that is comes under the standard European ISM band of 860-960MHz. From the reading range formulas as depicted below it is observed that the reading range (r)of the FA also decreased(as gain is decreased)[2].

(4.1)

Where, λ denotes the wavelength, P_{r} and G_r represents the power and gain of the reader whereas, G_t is the tag gain. The term (P_r. G_r) represents EIRP (Effective Isotropic Radiation Power) of the reader whose value is 4W. P_{th} depicted here represents the minimum threshold power of chip and is value of the PTC. From above the read range comes out to be 3.5m and 1.3m for proposed and Fractal antenna respectively.

The surface current effect of these two RFID antennas are also investigated and the computed results for the surface current over antennas are shown in figures [4.11],[4.12]. From the above results, the efficiencies are also investigated and noted to be increased in modified fractal design. From these above figures it is worth noted that the Fractal antenna has almost omni-directional radiation pattern. The value for its fitness function for proposed design is 0.1 and for Fractal antenna design its value comes out to be 0.9. and both lies in the range {0,1}.

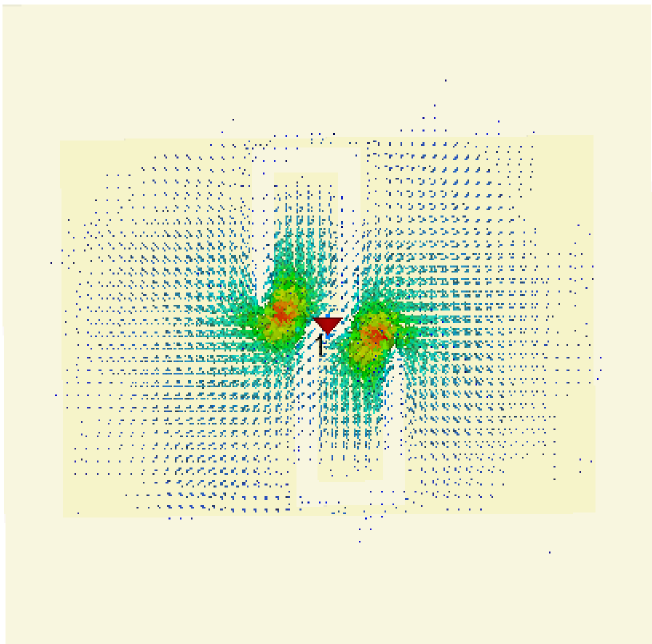


Figure 4.9: Surface Current for Proposed Tag [33].

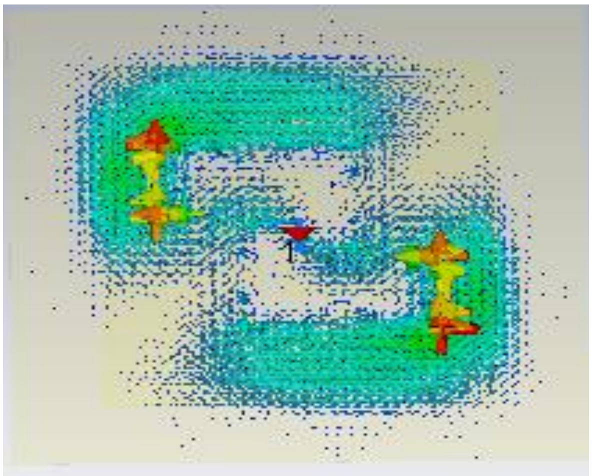


Figure 4.10: Surface Current for Fractal Tag [33].

S.No.	Parameter	Proposed Antenna	Fractal Antenna
1	PRC (dB)	-40.8	-22.26
2	PTC ( )	0.994	0.99
3	(m)	3.5	1.3
4	R_A (Ω)	12	12
5	X_A (Ω)	150.2	151.8
6	η (%)	-21.07	-33.59
7	Bandwidth(MHz)	36	42
8	F_L	893	880
9	F_H	929	922
10	A(mm^2)	12262.4	3061.2
11	ΔA(%)	-	75
12	G_t (dB)	-3.6	-20

Table 4.3: Comparison of Various Parameters for PA and FA.

The summary for the results related with both the PA and FA are given in the table [4.3]. As our work presents a metal tag antenna design so because of conductor losses and imperfections, the half power bandwidth specification is taken in such types of tag antennas.[4],[28]. The bandwidth for the PA comes out is 36 MHz. and the bandwidth for the FA is 42 MHz. The Fractal antenna has a reduction of 75% in area as compared to the proposed tag antenna design. In Ideal case for the perfect impedance matching, the PTC should be equal to 1. As depicted in above table the value of PTC for both the antennas comes out to be 0.99. That means our designs almost attain the ideal condition and got perfect impedance matching condition.

CHAPTER V

CONCLUSION AND FUTURE SCOPES

In our work we have optimized the inverted S-shaped nested slot tag antenna design and its miniaturized 2nd order Minkowski Fractal nested slot tag antenna design for RFID applications in UHF band. As the passive RFID tag antenna does not have any power of its own so it makes use of reader energy and should transfer maximum power to the chip which needs antenna to have impedance complex conjugate to the chip impedance. Hence Optimization is needed to make the two impedances complex conjugate to each other. The PSO technique along with the MATLAB-CST linking is used to miniaturize the design and for perfect conjugate matching of the input tag impedance to the chip impedance that is 12+j150Ω. Further, the fractal concept is introduced to get the improved performance of the proposed nested slot antenna. The fractal design offered a reduction of the 75 % in area as compared to the Proposed antenna.

This antenna design methodology of applying different algorithm on design through interfacing between the two software MATLAB and CST can be applied to the any structure and configuration with other futuristic algorithms (which are not included in CST itself) like ABC, ACO, Wind driven optimization algorithm etc. As the MATLAB-CST interfacing allows us a greater flexibility in data manipulations and signal processing. It is also an efficient method which saves both time and cost. This is because there is no requirement of additional matching network and we do not have to manually sweep the geometrical parameters.

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[2] Garima , Bansal A. And Sharma S., “ Study of a RFID Tag Antenna using PSO Optimization through MATLAB-CST linking”, IEEE Indian Antenna Week Conference 2017, Pune, June 2017.

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