DESIGN OF A 2D PLANAR SENSOR ANTENNA FOR LOCALIZATION OF RFID TAG

Dissertation submitted in fulfilment of the requirements for the Degreeof

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By

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DECLARATION BY THE SCHOLAR

I hereby declare that the work reported in the M.tech dissertation entitled **"DESIGN OF A 2D PLANAR SENSOR ANTENNA FOR LOCALIZATION OF RFID TAG"** submitted at **Jaypee University of Information Technology, Wakhnaghat India,**is an authentic record of my work carried out under the guidance of **Dr. Ashwani Sharma.** I have not submitted this work elsewhere for any other degree or diploma.

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CERTIFICATE

This is to certify that the work reported in the M.tech project dissertation entitled"**DESIGN OF A 2D PLANAR SENSOR ANTENNA FOR LOCALIZATION OF RFID TAG**"*which is being submitted by* ***Archana Thakur*** *in fulfilment for the award of Masters of* Technology in Electronics and Communication Engineering by the Jaypee University of Information Technology, is the record of candidate's own work carried out by her under my guidance. This work is original and has not been submitted partially or fully anywhere else for any other degree or diploma.

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ABSTRACT

Localization and orientation of search coil is presented. Localization of planar antenna with eight coil design was demonstrated in various researched papers. Application based on localization are virtual bronchoscopy system, tracking of eye and others. These eight coils were employing with different frequency range from 3-100khz. For the excitation of eight coils different feeding port had been used. This problem can resolved by using only single frequency which ultimately minimizes the number of feeding port. Using time division approach instead of frequency division approach, better results has achieved by using the switching network for the same eight array coil but with different approach . While comparing the initial approach with our proposed approach , the postion and orientation error results are more in frequency division approach. From analysis results, it is observed that our proposed approach having 60% of accuracy in results whereas only 30% is observed in the initial approach.

LIST OF ACRONYMS & ABBREVIATIONS

AOA	Angle of arrival
DOA	Direction of arrival
DOF	Degree of freedom
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
LBS	Location Based Service
LM	Levenberg Marquardt method
MATLAB	Matrix Laboratory
MSC	Magnetic Source Constraint
NFC	Near Field Communication
PCB	Printed Circuit Board
PDF	Partial Differential Equation
RFID	Radio Frequency Identification
SSC	Scleral Search Coil
UHF	Ultra High Frequency

VB	Virtual Bronchoscopy
WCE	Wireless Capsule Endoscopy

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CHAPTER-1

INTRODUCTION

Location finding was probably among one of the oldest problems faced by the human species. The early hunters and gatherers, after having successfully chased their prey, needed to find a way back to their camp. Those people had acquired some remarkable skills in finding their way through the wilderness. Such skills have now long been forgotten and only a few people remain that are familiar with them. One way people were able to navigate was using the orientation of stars on the night sky. This method has proven to be very successful at night and in the absence of clouds. However, during the day this method was useless and we are all well aware of the fact that we cannot rely on clear skies. The invention of the compass was a big improvement, since it allowed people to navigate at anytime and anywhere.

Nowadays we have the luxury of electronics and the Global Positioning System (GPS) has become the method of choice for navigation. In fact with our increased mobility navigation is still one of the tasks we perform regularly. Some even need to do so on a daily basis. GPS has greatly simplified our navigation problem and its popularity can be seen from the car navigation systems that are being used. People that are using printed maps are becoming rarer day by day.

Advancement in electronics and the changing nature of the modern societies have also led to a desire for navigation on a smaller scale. Generally there is an increase in interest in location aware services. Such services adapt their functionality and processes based on their location. For example one can think of an application of mobile phones that shows weather information for the area where the devices are located actually. While this application does not require accurate location estimate and there are a lot of applications and services that would be benefitted from a location estimate with low accuracy. For rescue squats like fire fighters are able to locate persons in a building with an accuracy of 1 meter could save a life. But also in less extreme cases would an accurate location estimate be really useful, for example finding someone in big crowded market place.

1.1 LOCALIZATION

Presently, one of the wireless technology that is location based service (LBS) emerging as an developing technology for the application like mapping, navigation, tracking of motion, location position and others. There are mainly two types of localization i.e. outdoor localization and indoor localization. Indoor localization enabled devices or system do help the rescuers and residents hit upon their positions yet discover the shortest access in accordance with break out of the building, the place the thick, dark smoke blocks their subject concerning vision. This Wireless localization is less costly as compared to other means of indoor localization. It may be able to grant higher insurance concerning the whole building and room. To find localization in outside environment, GPS is preferably used. For this 24 satellites are used by the GPS which provides whole coverage of world with 1-5 meters region. The GPS transceiver chip is of less cost[1].

The question arises why this dissertation work emphasize more on indoor localization as the outdoor localization is having more advantages and is the leading one?

The performance of GNSS (Global Navigation Satellite Systems) is not satisfactory inside the building because the signal can't penetrate into dense material, thick forests, building wall. Although in the future GNSS will be more reliable, promising and massive and having the ability by employing the acceptable precision for outside environment[2]. The indoor surroundings lacks a system as it possesses the worthy performance parameters on outside GNSS in terms over global coverage, excessive accuracy, low latency, higher availability, integrity is excessive . Like indoor settings, absolute outdoor environments are no longer properly included by GNSS and fit in accordance with insufficient views in accordance with the open sky. Hence, for outdoor environments 'GNSS challenged' has become a targeting position system. Precisely speaking, that land survey goals after describing all positioning methods are relevant according to challenging environments – even which even including GNSS approaches suitable for such environments. For simplicity however, the term indoor positioning is kept throughout this dissertation.

1.2 APPLICATIONS

- **Catheter Position Tracking**

Catheters are medical devices which can be inserted in the body to treat diseases or to perform a surgical procedure. Catheters can be inserted into a body cavity, duct, or vessel. They allow drainage, administration of fluids or gases, access by surgical instruments, and also perform a wide variety of other tasks depending on the type of catheter [3].

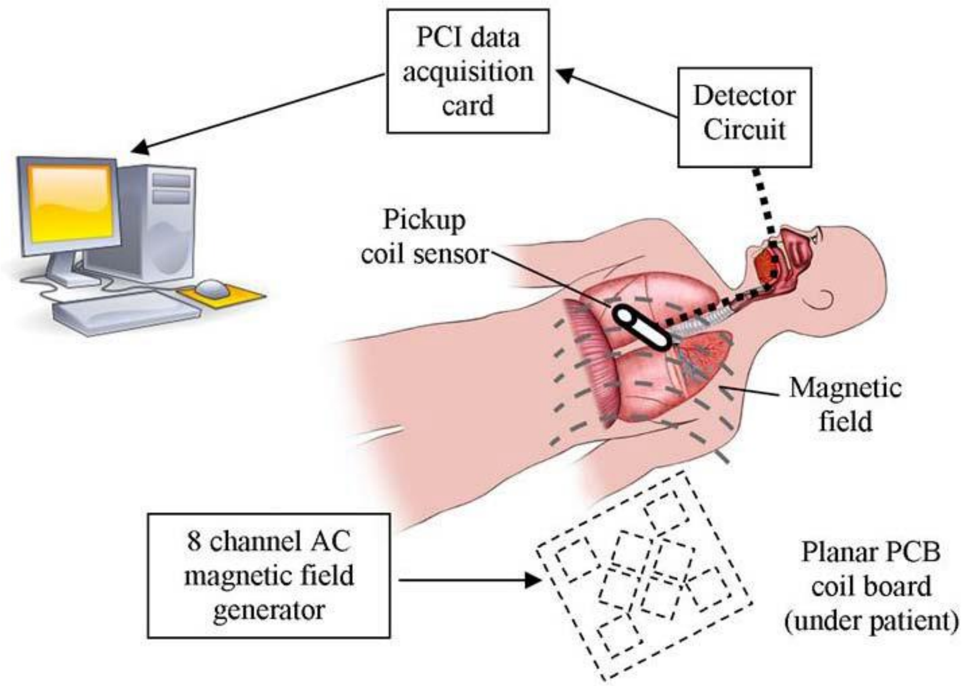

Fig. 1.2: position tracking of Virtual bronchoscopy[6]

A set of magnetic coils placed below a patient generates an ac magnetic field which is detected by a sensor which in turn is processed to determine an estimate of the sensor's position.[4]

Due to Virtual bronchoscopy (VB), the feasibility of detecting chest diseases has turned from imaginary form to real world . The technical advances construction this feasible then provides the function regarding VB among the assessment concerning a variety over neoplastic then non-neoplastic processes. In the medical evaluation over pulmonary disease, fiberoptic bronchosopy is a critical tool between the diagnosis concerning a range concerning heart diseases Stability[5]

The improvement concerning a system because of finding out position then orientation of a catheter of vivo.The instant medical utility is because pulmonary catheter localization in virtual bronchoscopy. Make use of 30 khz frequency , an configuration of coil in planar form so that the movement of the catheter can be determined. By measured induced voltage in the pickup coil prompted by way of an organize of magnetic sources at a number of frequencies, position then orientation by using a nonlinear equations. The hardware system consists on an eightcoil array regarding transmitting coils, an 8 mm receiver coil, and related amplifiers calculates the function or orientation using MATLAB.

- . **MOBILE ROBOT**

Nowadays, Mobile Robot (MR) is widely used in various fields, such as military,industrial, agricultural and many other applications. Imagine the face of warfare with autonomous robotics: Instead of our soldiers returning home in flag-draped caskets to heartbroken families, autonomous robots—mobile machines that can make decisions, such as to fire upon a target, without human intervention—can replace the human soldier in an increasing range of different missions These robots would be 'smart' enough to make decisions that only humans now can; and as conflicts increase in tempo and require much quicker information processing and responses [6]. Its small size enables it to enter buildings and report on possible occupants. It uses cameras and other sensors

Figure 1.1. Pioneer 2 with Sick Laser Range Finder, RFID reader and two antennas (left).[7]

The Radio Frequency Identification (RFID) technology is used to improve the localization of mobile robots and persons in their environment. They used a mobile robot equipped with RFID antennas to determine the locations of RFID tags attached to objects in an indoor environment. The robot consists of an off-the-shelf Pioneer 2 robot equipped with a laser range scanner and two RFID antennas. The antennas are mounted on top of the robot and point approximately 45 degrees to the left and to the right with respect to the robot. To use these antennas for estimating the locations of objects, a sensor model that describes the likelihood of detecting an RFID tag given its location relative to one of the antennas.

- **NEAR FIELD COMMUNICATION (NFC)**

NFC and mobile payments has been grouped together with the aid of analysts, pundits, researchers and shops on the grounds of the short-range wireless technology. The 6131 nokia model started in 2007 is the first phone made by use of NFC. In auto industry, BMW has formed an NFC-enabled auto authorization so that it executes unlocking an automobile, and however additionally help to book or get right of entry to hotels car while you're traveling [8].

NFC has attracted considerable attention recently. The technology widely used to wirelessly transfer power and information between Transmitter (Tx) and Receiver (Rx) is known as inductive near-field coupling. A fulfilled RFID consists over Reader and Transponder is called RF tag. The reader sends a radio signal about a definitive frequency conducted together with a short amount of electric power to the transponder, between system according to the circuit inside transponder in conformity with ship outdoors the ID articles stored. Then the reader do catch the ID code being despatched from transponder.

For instance, the RFID system employs inductive coupling within Reader (Tx) and Tag (Rx) structures. Consideration of coil is only because of it's low cost.,the Tx is loacted at origin yet the Rx coil may stand placed somewhere inside the running place for the ease over motion tracking. The Rx coil have induced power due to the oscillation produced by Tx coil .Rx will have allocation about magnetic field in the location. In RFID, the Tag antenna is producing magnetic-field (H-field)oscillating near in the Reader antenna where they are tuned according to chosen frequency over operation[9]. Since a intense magnetic coupling between the Tx and the Rx is desired, antennas producing high H-fields among theirs near-field zones are favorably used. Being a mean virtue solution, coil antennas are broadly adopted at the Tx then the Rx aspects into inductive coupling systems. Analogous to a loosely magnetically collective transformer, the Tx coil antenna induces voltage V_{ind} between the Rx coil antenna. For wireless charging ,the Rx is placed at stationary position with respect to the Tx. Also beneficial for the mobile objects to track their motion like capsule endoscopy, motion tracking, RFID and others.

- **AID FOR DIFFERENTLY ABLED PERSON**

Figure: 1.3Visually impaired people to navigate environment [10]

Indoor localization is to use one or more sensors such as cameras, magnetic sensors, etc., to automatically determine the location of a robot or a person in real time in an indoor environment. Finding the position, location of a visually impaired person can help him/her to get the designed places, and this ability of free navigation is important for a normal social life. Important places in a building include restrooms, stairs, elevators, public electronic terminals, and building entrances and exits. The usual way for visually impaired people to navigate indoor environments is by memorization, which means, by remembering the already traveled route and recalling it when they come to the same place the second time .

Localization working as a aid for differently abled person by providing them full support of controlling actions .

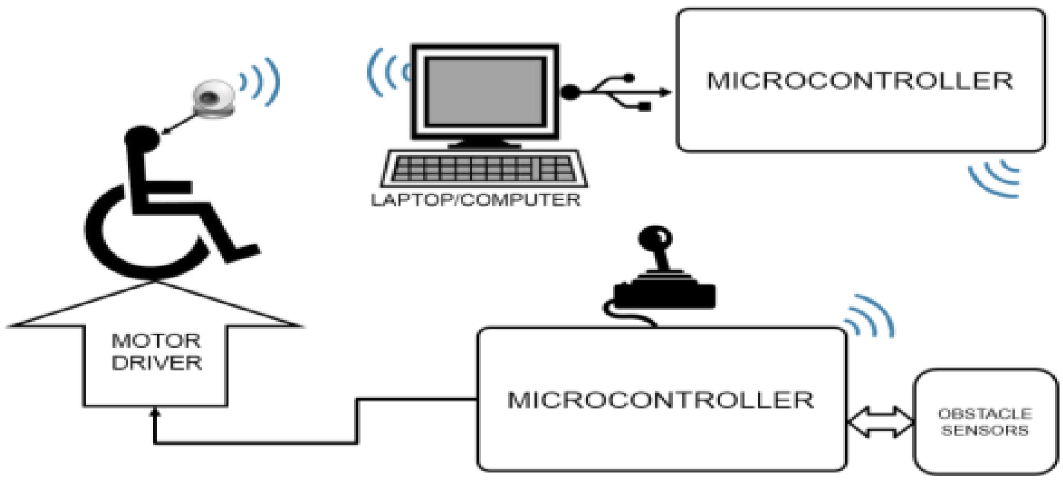

Figure.1.4 Block diagram of Eye directive wheel system [11]

The eye directive wheel chair, helps person suffering from the chronic disease ,blindness. There are a range of interfaces which because of wheelchair are accessible among the market, still they are stay under-utilized, the reason being the ability, idea presence required for functioning them.. In this model, the eye sight tracking wheel chair was proposed. Instead of taking the advice from someone, a person can locate itself according to his wish.. When eye focuses in one particular direction , captured image by camera mounted on the eye will send the data to laptop. After further processing, the signal received by the chair performs the task i.e., now user moves his eyes balls left (move left), correct (move right), away (move forward) among every cases halo chair pleasure stop. Also, sensors are linked to the arduino microcontroller to provide crucial feedback because of good action of the wheelchair to ensure the user’s safety. In case of tired vision, this chair also enable joystick for free movement[11]

1.3 PREVIOUS SURVEY

This[12] paper starts with an overview introducing the available technologies for localization with a focus on radio frequency based technologies. The current and main functions concerning RFID localization in a variety of industries are summarized. Moreover, RFID localization algorithms are reviewed, categorised to multilateration, Bayesian inference, nearestneighbor, proximity,and kernel-based lesson methods.Also,they showed a localization analys was utilizing inactive RFID technology and it demonstrated that objects be able remain effectively localized the use of either multilateration or Bayesian generalization methods. The survey additionally discusses the challenges or future lookup about RFID localization.

In this paper(13) they analyzed whether recent Radio Identification (RFID) technology could be used to improve the localization of mobile robots and persons in their environment. They studied the problem of localizing RFID tags with a mobile platform that is equipped with a pair of RFID antennas. They presented a probabilistic measurement model for RFID readers that allow us to accurately localize RFID tags in the environment. They also demonstrated how such maps can be used to localize a robot and persons in their environment. Finally, They presented experiments illustrating that the computational requirements for global robot localization could be reduced strongly by using RFID information with laser data..

This paper[14] examined the applicability of direction-of-arrival (DOA) estimation methods to the localization and tracking problems of passive RFID tags. Different scenarios of stationary and moving targets are considered. In this paper, they examined the applicability of a two-antenna array structure for the localization and tracking tracking of passive RFID tags. By simply comparing the phase of the matched filtered output at each bit interval, it had been demonstrated through analysis and simulation experiments that it achieves high DOA estimation accuracy for the localization and tracking of closely spaced items. In addition, incorporating observations over multiple frames or multiple positions can significantly improve the DOA estimation performance.

This paper [15] presented new experimental results of angle of arrival (AoA) measurements for localizing passive RFID tags in the UHF frequency range. The localization system is based on the principle of a phased array with electronic beam steering mechanism. This approach had been successfully applied within a UHF RFID system and it allowed the precise determination of the angle and the position of small passive RFID tags. The work showed that the angle determination with such a system was quite accurate. With the receiver system precise measurements of the angle of arrival with small errors could be achieved over a scan angle of ±45 degrees.

This paper [16] presented a novel method for the localization of a passive radio frequency identification (RFID) tag in a 2-D space. First, we show that the position of the tag can be estimated as the intersection of two orthogonal lines, which are determined by the weighted integrals of the magnetic flux density created by the tag. To measure them, we developed a square magnetic sensor composed of six coils: four rectangular coils, a set of four bow-tie-shaped coils connected in series, and a square coil. Using this sensor with side lengths of 200 mm, an RFID tag was localized in a 180 mm square domain with an average error of 5.1 mm. Using the sensor with side lengths of 400 mm, the RFID tag was also localized in a 300 mm square domain with an average error of 1.8 mm.

In this paper [17], they proposed a novel method for localizing a magnetic dipole directly. They pointed out that Euler's equation, a widely used MSC-PDE (magnetic source-constraint partial differential equations)., does not take electromagnetic constraints of the magnetic field into account. Then, they derived new MSC-PDEs, the general solution of which is equal to the magnetic field created by the magnetic dipole. By applying the weighted integral method to the MSC-PDEs, the magnetic dipole can be localized from the line integrals or surface integrals of the magnetic field, while Euler's equation requires volume integrals. The numerical simulation and experiments showed that the proposed method with a circular magnetic sensor array is better than the previous methods, regardless of the SNR and the results in a shorter search and rapid localization for avalanche rescue.

In paper[18,]To obtain high precision magnetic intensity signals, a special function fitting method wss proposed based on the AC coupling signals between the generating and sensor coils, which made the hardware circuit simpler. Then, based on the threeaxis magnetic dipole model, a novel localization and orientation algorithm was proposed that uses several mathematic equations to directly calculate the position and orientation parameters of the object, and these parameters are optimized with LM method. Comparing with other techniques, this method was much simpler, faster and more applicable. Finally, a complete system is designed and realized with the specific generating and sensing circuits. The real experimental results show that the positioning accuracy is within 1mmand orientation accuracy is within 0.7 . degree.

In paper [19] , to further increase the speed of magnetic tracking and simplify the computing algorithm is presented. For this purpose, we suggest making the magnetic field rotate continuously by using a pair of excitation coils that are in space and phase quadrature. It was found that the resulting excitation field rotates elliptically at any position in the near-field region. Thus, the sensor sees a rotating field as though a properly oriented equivalent pair of excitation coils situated just around the sensor's center produced it. At any position, the "excitation ellipse" has a unique set of parameters: the aspect ratio, size, phase, and orientation. These parameters can be related in a simple manner to the excitation field at the origin. As a result, information about the sensor's position and orientation can easily be extracted from the sensor's output. Preliminary experimental verifications made with the help of standard lock-in amplifier have shown the resolution of about 1 mm in a 3.6 m range

In this paper(9), a planar multi-loop reception apparatus is proposed to be utilized as a part of inductive coupling frameworks working at 13.56 MHz yet aimed to tackle angular misalignment trouble with the aid of exploiting a magnetic-field forming concerning 3 orthogonal H-field components within a target area. The antenna be able consequently rule planar receiving coils concerning any orientation within the surroundings.At first, the H-field circulations of different mixes of spatially disseminated curls were examined for the H-field shaping in the close field, which advanced into the proposed antenna comprising about six spatially distributed coils into a double sided PCB because of easy fabrication at mean cost, the place four coils contribute by having lateral H-field parts (Hx and Hy)other two in framing pivotal H-field segment (Hz); the orthogonality.. The layout was once simulated to make out the claims yet consequences corroborated with the analysis. The design is viewed as a proper antenna candidate because of wireless powering applications, e.g., RFID, clinical implants, NFC where collectors can be fueled in any introduction inside the objective region.

This paper [20] showed a simple algorithm and a compact sensor for localization of a magnetic dipole. First, they derived an explicit localization formula, where the dipole position, irrespective of its posture, is directly reconstructed from the magnetic field and its spatial gradient tensor. Then, they developed a sensor unit consisting of three orthogonal loop coils, three orthogonal planar gradiometers, and three orthogonal coaxial gradiometers, for measuring the magnetic field, non-diagonal, and diagonal components of the gradient tensor, respectively. Localization experiments are conducted, where the maximum error is about 7 mm when the source-sensor distance is from 80 to 140 mm.

This paper[21] proposed a simple sensor and algorithm to estimate the position of the magnetic field source from the spatial gradients of a field for localization of RFID tags. For the near field, they showed the azimuth and the elevation angle of the source were directly reconstructed by planar coils in a restricted situation where the posture and the depth of the tag were fixed. For the far field, they showed that a certain combination of the first order spatial gradients and the field values determined the azimuth and the elevation angle, whatever the posture of the tag.

In paper [22] presented methods of localization using cooperating landmarks (beacons) that provide the ability to measure range only. If the positions of the beacons were known, measurements from multiple beacons could be combined using probability grids to provide an accurate estimate of robot location. This estimate could be improved by using Monte Carlo techniques and Kalman filters to incorporate odometry data. Range measurements with expected error on the order of 6 feet were used to generate position estimates with expected error on the order of a foot or less. The beacon technology used in this paper is continually improving, one manufacturer has told us that the most recent systems provide an expected error of about one foot. This increased performance should yield future position estimation systems with expected errors on the order of a few inches.

This paper [23] presented a overview of the localization systems for robotic endoscopic capsules, for which the motivation, challenges and possible solutions of the proposed localization methods were also discussed. Although many localization methods have been proposed as reviewed in this study, none of them could offer a complete solution to address the challenging capsule localization problem. To date, a commercial WCE(wireless capsule endoscopy) can only provide rough 2D position information.

This paper [24]provided a noniterative solution to determine the six degree-of-freedom (6- DOF) position and orientation of a wireless capsule endoscope being actuated by a rotating magnetic dipole. Non-iterative solutions in the past have only been used to locate immobile objects. They experimentally demonstrated that our algorithm calculates the 6-DOF position and orientation of capsules that are truly stationary as well as those that are operated in the “step-out” regime, where the magnetic field is rotated too quickly for the capsule to rotate synchronously, but the capsule does undergo chaotic movement. The method was experimentally verified and was found to result in sufficiently small errors to be used by existing magnetic-actuation methods

In paper[25]They have developed a novel tracking technique due to the unnecessary irradiation of healthy tissues by measuring measure tumour positions directly and continuously with high resolution in space and time. The method can also be used to survey and monitor the patient positioning. The proper functioning of our method has been technically demonstrated with the help of phantom irradiation with protons. Implementation into the clinical environment is now beginning. In the laboratory, it has been shown that the system achieves a high spatial accuracy at a high repetition frequency.

In Paper [26] novel system and method for magnetic tracking of a single subminiature coil is described. The novelty of the method consists in employing a large, 8 *8 array of coplanar transmitting coils. This allows us to always keep the receiving coil not far from the wide, flat transmitting array, to increase the signal-to-noise ratio, and to decrease the retransmitted interference. The whole transmitting array, 64 coils, is sequentially activated only at the initiation stage to compute the initial position of the receiving coil. The redundancy in the transmitters number provides fast and unambiguous convergence of the optimization algorithm. At the following tracking stages, a small (8 coils) transmitting subarray is activated. The relatively small subarray size allows us to keep a high update rate and resolution of tracking. For a 50-Hz update rate, the tracking resolution is not worse than 0.25 mm, 0.2 rms at a 200-mm height above the transmitting array's center. This resolution corresponds to an approximity 1-mm, 0.6 tracking accuracy.

In paper[27], new scleral search coil (SSC) tracking approach employing a planar transmitter has been developed theoretically and tested experimentally.A thin and flat transmitter is much more convenient in installation, operation, and maintenance than the conventional large cubic one. A planar transmitter also increases the mobility of SSC systems, simplifies their accommodation in a limited clinical space, enables bedside testing, and causes no visual distractions and no discomfort to the users. Moreover, it allows tracking not only the SSC orientation, but also its location, which is very important for many medical and scientific applications. The suggested approach provides the speed and precision that are required in SSC applications. The experimental results show that it can be used for the diagnosis of vestibular disorders. The tracking precision is in good agreement with its theoretical estimation. The experimental results show that it can be used for the diagnosis of vestibular disorders: typical random orientation errors are 3 millidegrees rms, and typical random location errors are 6 μm rms. These errors are in good agreement with their upper bounds that have been found theoretically λR = 4.4 millidegrees and σR = 9 μm correspondingly. The result obtained in this paper for tracking precision can be further improved by increasing the radius of the transmitting coils and increasing the excitation frequencies.

In paper [28], they presented a new approach for the magnetic tracking of eye motion in small, fast-moving animals. They employed a thin, flat magnetic tracking transmitter instead of the conventional bulky, cubic-shape transmitting frame. The new transmitter enables convenient access to the tracked animal, causes no visual distractions, and occupies much less space. They also employed a tiny solenoidal search coil instead of the conventional scleral search coils. Such a small solenoidal search coil attached laterally to the eye does not limit the peripheral field of view and allows the animal to perform its standard behavioral tasks. The flat transmitter comprises eight transmitting coils that allow us to monitor not only the orientation of a search coil but also its location. To test the efficiency of the new approach, they measured the location and orientation of the solenoidal search coils attached to the eyes and head of an archer fish during swimming, targeting, and shooting. The size of the coils attached to the fish eyes was 2 mm in diameter and 2 mm in length, and the size of the coil attached to the fish head was 4 mm in diameter and 4 mm in length. The transmitter size was 60 cm *60 cm 2 cm. At a 25 cm from the transmitter, they obtained the tracking resolution of 3 millidegree and 8.3 m rms for a 200-Hz bandwidth. Such a performance is good enough to precisely monitor the fastest component in the fish eyes movements. The fish with the search coils on the eyes and head correctly hits the target up to 20 times during an experimental session, which is similar to the shooting rate of the fish without the search coils. This implies that our new design does not introduce much discomfort for the fish.

In paper(3)They introduced the assessment about an electromagnetic function monitoring system for usage along virtual bronchoscopy systems. Their longevity system utilises a planar magnetic coil array then commercially reachable inquire coil sensors.Test comes about demonstrate the Electro magnetic tracking to be in the scope of 1-1.5mm, which is practically identical to both business and research frameworks. A novel fiducialfree enrollment technique is actualized to lessen blunders coming about because of mistaken milestone distinguishing proof regularly connected with point-based enlistment.After enlistment, there is great understanding between the deliberate position of the sensor test amid endoscopic route and the lung aviation routes as pictured in a phantom 3D model..

This paper(29)introduced an electromagnetic system because of five degrees over freedom location and orientation sensing along application of a virtual bronchoscopy system.Planar attractive source curls were made on printed circuit sheets for reproducibility and minimal effort producing.. The precise magnetic discipline of each coil is deliberated the usage of a filament-based approach. A consistent ac current amplifier is utlized to drive each coil at any frequency or a synchronous demodulator calculates each companion magnetic field Extensive checking out together with twins separate techniques has proven the precision over the system to be between 1 and 2 mm. The utilization of a novel closed loop coil driver has been found to offer magnificent attractive field dependability and critical decrease in crosstalk obstruction.

1.3 OBSERVATION AND MOTIVATION

The paper demonstrated in the literature survey from paper 1 to 13 gives a clear view that location,orientation,motion track,velocity of a target won't be achievable with better precision until we have single coil. Applications like capsule endoscopy, magnetic tracking of eye motion can't be achievable with rough approximations. Therefore, it can be seen from paper 14 to 20 how the evaluation of novel tracking in a breathing lung model has taken place and there is a need of spatially distributed coils. By employing a planar antenna design which consist of the arrangement of eight coils it is possible to have postion,orientation of the object possible with good results. All the eight coils are working on frequency division approach where all coils are excited by different frequency that is 3-100khz.Here,a question arises that why they have used only eight number of coils in the design? To find the location and orientation of the tag, we require five parameters to be sort out first. Therefore by using at least five equations five coils are needed. But they are resulting in multiple location due to which a nonlinear least squares algorithm is confused to find the exact location of the target.Hence, eight number of choice is the optimal choice.

Beside advantages ,there is also some disadvantages of this approach. The main lack points are the requirement of of eight feeding port for eight coils working on different frequency.

1.6 CONTRIBUTION

The contribution of this research is to provide a single frequency instead of multiple frequency.In the arrangement of eight coils,it required eight number of switching network.Also,this has different feeding port for the excitation of coil,which generally makes the design very complex.Therefore, our research proposes to have only single port for the feeding point which ultimately reduces the number of ports for the operation.Less number of switches can be achieved by grouping the coils for different time slots. Same design of planar eight coils will be used but only for single frequency.

CHAPTER-2

FREQUENCY DIVISION APPROACH FOR TRANSMITTING ANTENNA

In paper[3],multi frequency was applied to eight coil array structure ranging from 3-100khz. Excitation of coils due to the different frequency produced the induced voltage at the search coil. Therefore, location and orientation of search coil could be sort out with respect to the eight coil array structure. This design of eight coil had been practiced in many papers for localization and orientation by using multiple frequency. So, multiple frequency have been benefited for the application like capsule endoscopy, human eye tracking and others.

2.1 DESIGN

- This design consist of eight coils which are symmetrical to each other and the arrangement is done in the form of spatially distributed form.
- Planar design of coil is preferred because

  1 It require less volume as compared to three dimensional antenna .

  2 It reduce the complexity.

  3 It is not costly.
- For this, design coil antenna is considered because of it's low cost and for strong magnetic field in near field communication coil antenna is preferably used.
- Here, all the eight coils are working on different frequency, ranging from 3-100khz.
- Therefore, all coils require different feeding network for their excitation.
- To operate these coils feeding network are used that is this design required eight number of feeding port for eight different coils.
- 25 Multi turns coil are being used over here.

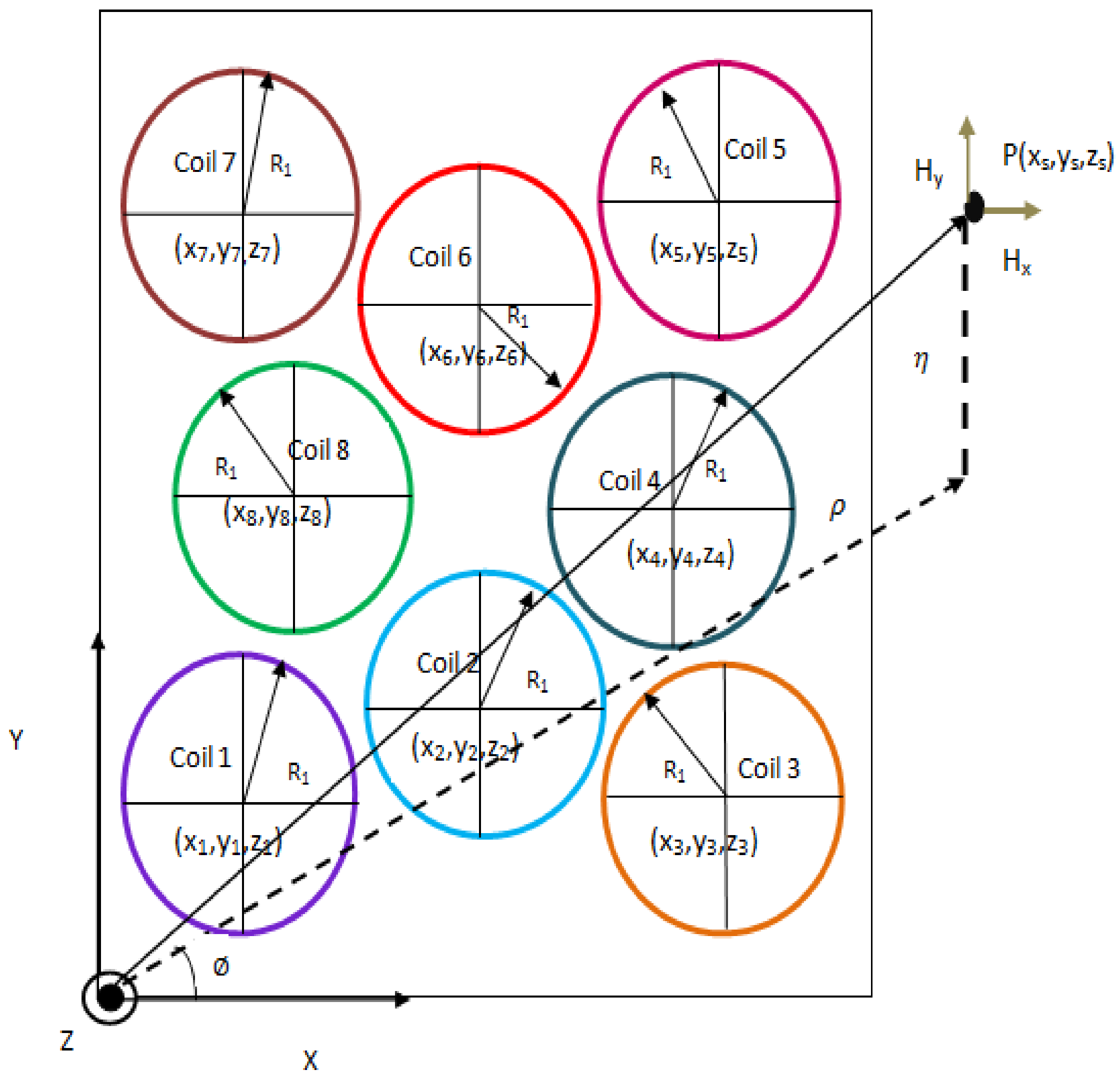

Figure-2.1 Planar eight coil design

- Here ,eight coil design is considered to be the optimal choice with 30cm *30cm of array layout and 250 mA current in each coil.
- While exciting these coils on different frequency, it will generate induce voltage in the search coil. This induced voltage help us to determine the location and orientation of the search coil.

2.2 ANALYTICAL MODELING

In the cartesian coordinate given below, inductive coupling between the transmitter and receiver is shown. In figure 4.2,transmitter coil (xt, yt, zt) is located at (0,0,0,). The radius of transmitter coil is r_t , I_t is total current amplitude of coil, and number of turns Tt each having current it, hence It = Tt . it. The magnetic field originating from transmitter induce the voltage at receiver.

According to Faraday's law,

$V_{ind} = u_0.\ j2\pi f.\ N_{Rx}.\ A_{Rx}.\ H$ - (1)

The analysis of H field distribution at receiver for random location is shown below[9]

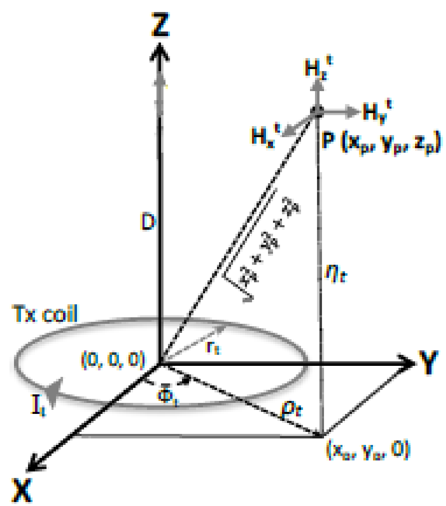

Figure 2.2 Transmitter and receiver are inductively coupled

At random observation point P (xp, yp, zp) of receiver ,H-field due to transmitter coil will be analysed by solving the following equations. The relative parameters Ø, η and ρ are defined as

$$\rho_t = \sqrt{\left((x_p - x_t)^2 + (y_p - y_t)^2\right)}$$

$$\eta_t = z_p - z_t$$

$$\emptyset_t = tan^{-1}\left[\frac{y_p - y_t}{x_p - x_t}\right] \quad (2)$$

The three H-field component H_X, H_Y, H_Z are shown below

$$H_x{}^t = H_\rho{}^t cos(\emptyset_t)$$

$$H_y{}^t = H_\rho{}^t sin(\emptyset_t)$$

$$H_\rho{}^t = \frac{I_t e^{j\theta_t} \eta_t}{2\pi\rho_t\sqrt{(r_t + \rho_t)^2 + \eta_t{}^2}}\left[\frac{r_t{}^2 + \rho_t{}^2 + \eta_t{}^2}{(r_t - \rho_t)^2 + \eta_t{}^2} E(k) - K(k)\right]$$

$$H_z{}^t = \frac{I_t e^{j\theta_t}}{2\pi\sqrt{(r_t + \rho_t)^2 + \eta_t{}^2}}\left[K(k) + \frac{r_t{}^2 - \rho_t{}^2 - \eta_t{}^2}{(r_t - \rho_t)^2 + \eta_t{}^2} E(k)\right] \quad (3)$$

$$\kappa = \sqrt{\frac{4r_t\rho_t}{(r_t+\rho_t)^2+\eta_t{}^2}} \quad (4)$$

Where K(k) and E(k) are the complete elliptic integrals of the 1st and 2nd kind respectively.

To find the induced voltage due to three H-field component can be calculated as

$$V_{ind} = v_x \Big|_{Hx} + v_y \Big|_{Hy} + v_z \Big|_{Hz} \qquad (5)$$

$$V_{ind} = u_0 . T_k . f. (H_x \sin(Ø) \cos(\phi) + H_y \sin(Ø) \sin(\phi) + H_z \cos(Ø)) \qquad (6)$$

Where T_k is the sensitivity of the sensor coil, 0.1 V/Hz T−1 (volts per Hertz per tesla)

Once the induced voltage has been calculated, the position and orientation can be determined by using a nonlinear least squares algorithm iteratively with the Levenberg–Marquardt method.

Now the calculations is to be done for position and orientation Error.
The position error between the real sensor location (x_r,y_r,z_r) and the calculated position (x_c, y_c, z_c) to be determined.

$$X_p = ((x_c - x_r)^2 + (y_c - y_r)^2 + (z_c - z_r)^2)^{1\backslash 2} \qquad (7)$$

Similarly ,orientation error can be find out as

$$e_o = (Øc - Ø_r) + (Øc – Ø_r) \qquad (8)$$

and the distance from the sensor to the coil array is

$$d = (x_r^2 + y_r^2 + z_r^2)^{1\backslash 2} \qquad (9)$$

2.3 RESULTS

- Using nonlinear least squares algorithm to find the localization and orientation

To check whether the algorithm is performing or not,we have considered the random location of search coil within in the operating region of the multi coil antenna design . At the output we found that for seven voltages, the best Curve fitting of measured and predicted induced voltage is observed to find the localization of search coil. From the result,it has been observed that V7 and V8 contribute for having maximum induced voltage.

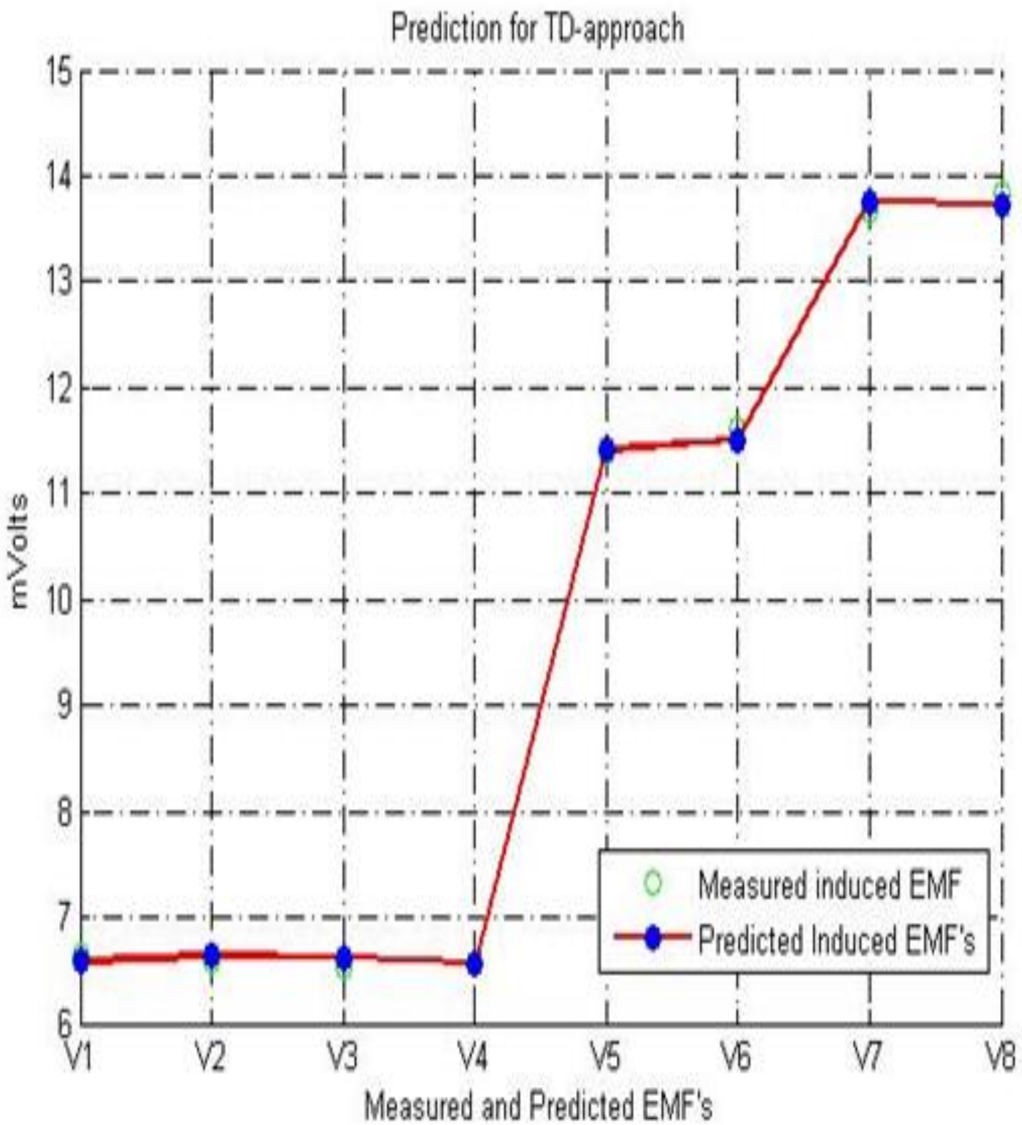

Figure 3.6 Curve fitting of measured and predicted value of induced voltage

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This algorithm provide outcome of best curve fitting and histogram of residuals. The histogram of residuals giving the count of distribution of error for different voltages.

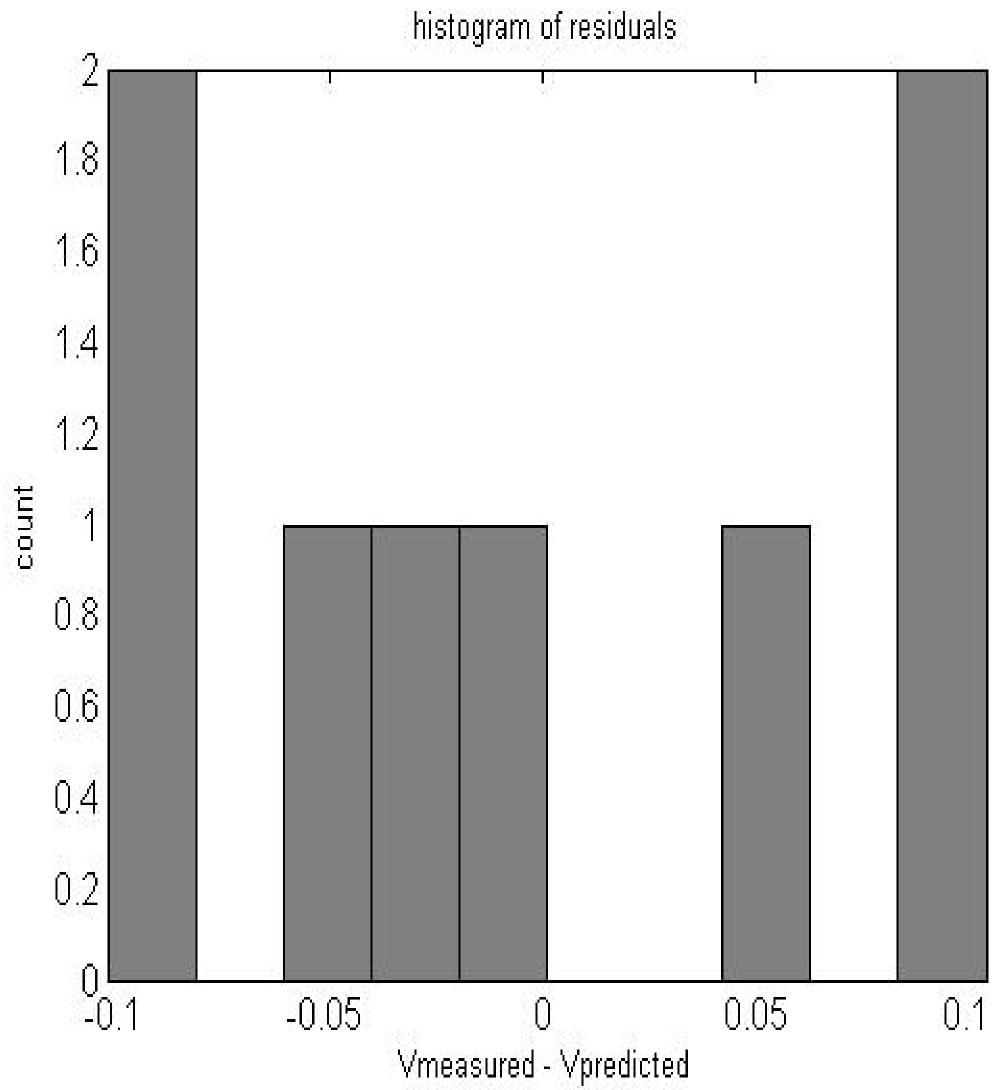

Figure 3.7 Histogram of residuals

- **Position and orientation error**

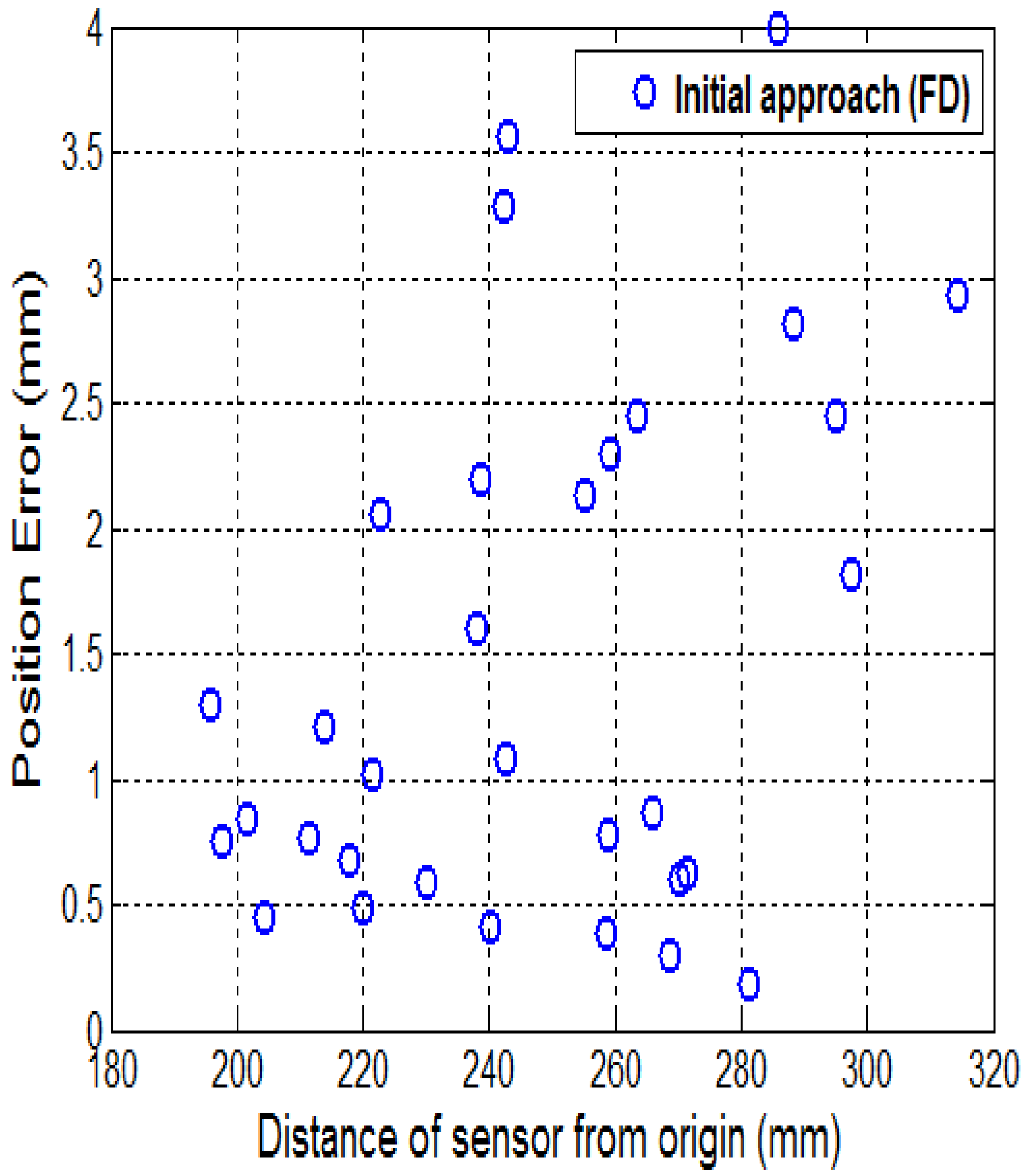

Figure 3.8 orientation error of frequency division

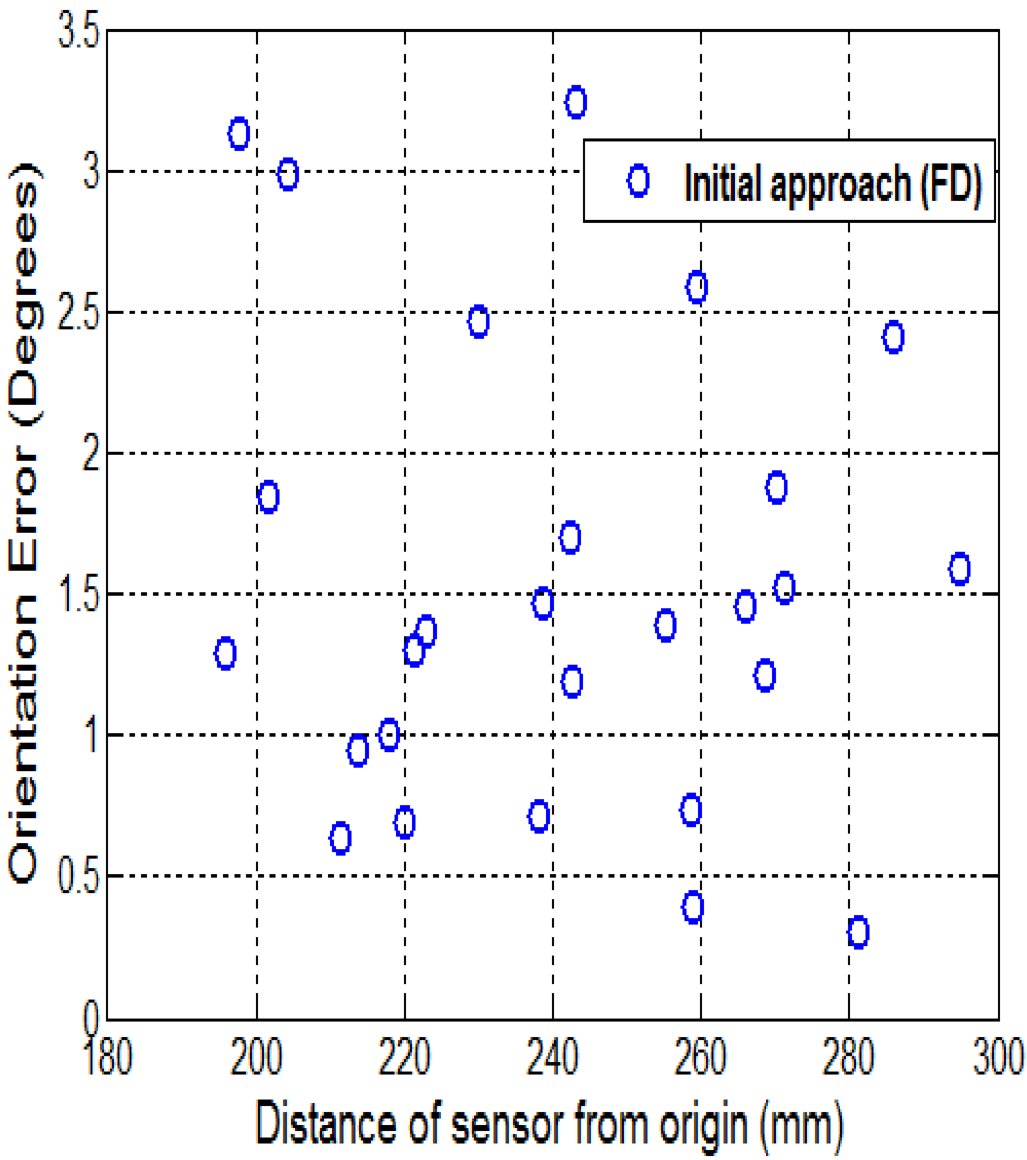

Figure 3.9 orientation error of frequency division

Table: POSITION AND ORIENTATION MEAN ACCURACY

Scheme	Mean $\mathbf{e_p}$ (mm)	Standard Deviation $\mathbf{e_p}$ (mm)	Mean $\mathbf{e_0}$ (Deg)	Standard Deviation $\mathbf{e_o}$ (Deg)
FD-Approach	1.4666	1.0618	1.5351	0.8139

From the results , the distribution of position and orientation error with respect to the distance from the sensor is observed.While taking trial of 100 points for testing, it has been observed that only 32 points exhibit with less error. The table shows mean and standard deviation error of position and orientation for frequency division approach which can be calculated by using equation (7), (8),(9).

This approach is working for eight different frequency by having eight different port. This problem can tackled for the same design by using Time division approach. In our proposed approach all the coils will be excited by using switching network where each coil will get excited in different time slots.

CHAPTER-3

TIME DIVISION APPROACH FOR TRANSMITTING ANTENNA

As discussed in the previous chapter that for eight coils, they needed eight different feeding port and switching network. This may increase the complexity due to multiple frequency problem, and by feeding them independently. The problem can be demonstrated by using single frequency instead of eight different frequency by having only four feeding port as compare to eight feeding port. Also, minimizes the number of switches.

3.1 DESIGN :

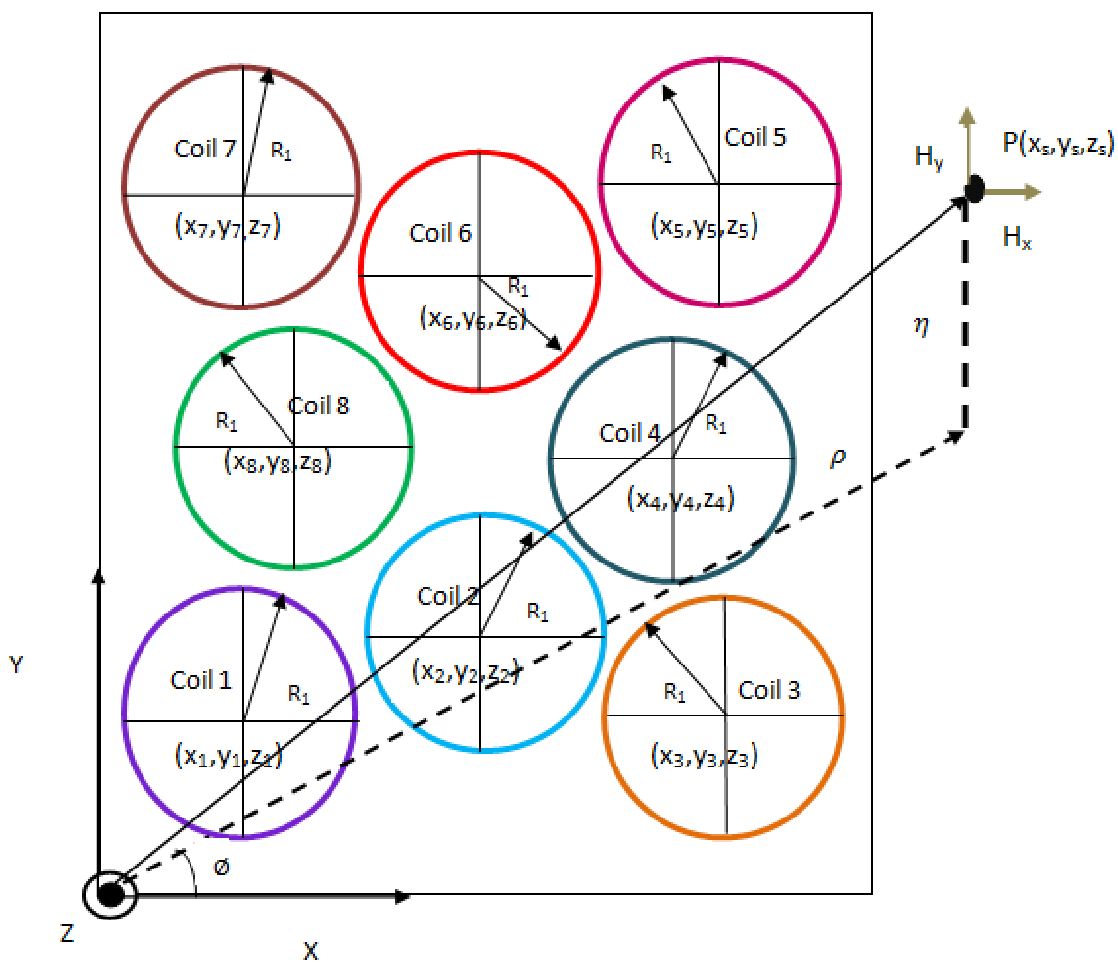

Figure-3.1 Coordinate system for tracking algorithm, where the sensor the is placed at position (x_s,y_s,z_s)

- By using only single frequency, all coils can be excited by making an arrangement and grouping of coils.
- Now, reducing the number of port to feed the single frequency.
- Minimized the number of switches according to grouping of coils.
- This approach also using the inter coil connection.
- By using the switching network, it enables us to understand the working of eight coils in the different time slots.

3.2 EVOLUTION OF DESIGN

By grouping the coils in different time slots enable us to understand the working of Time division approach. Various combinations of coils had been researched and in many cases it was found that they all were not working fully for the all location of search sensor coil.

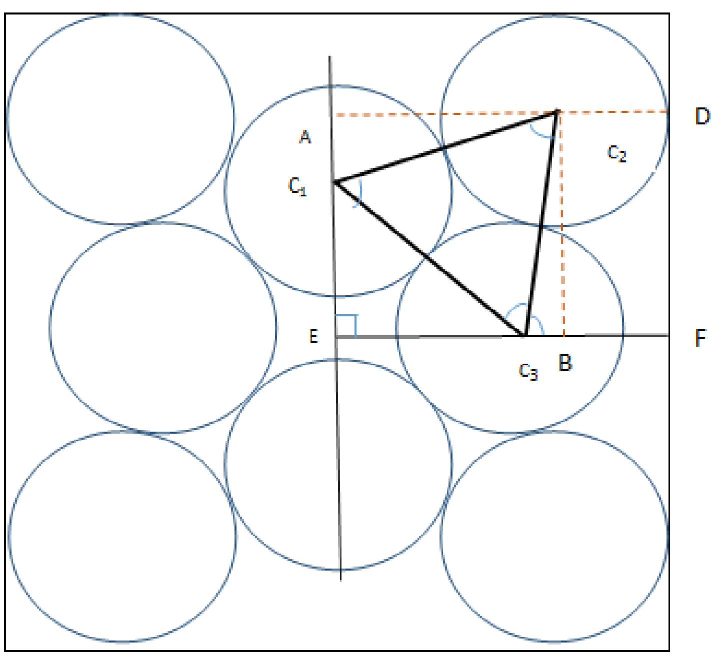

Figure 3.2 the each coil radius =5cm observed

Before move further, the radius of eight coil to be known first. The layout of coil array consist 30*30 cm of side length. From the diagram of eight coils ,it can be seen that all eight are forming their mirror image on opposite side. Let the radius of each coil is r. Here, C_1C_2= C_3C_2= C_1C_3=2r and triangle C_1C_2 C_3 forming an equilateral triangle.

We have,

EF=EC_3+ C_3B+BF -(1)

EF=sqrt(2)*r +2*r*cos(75) +r -(2)

Given EF=15cm,then r=5 cm -(3)

Therefore, radius is 5cm for 30cm array layout of eight coils.

By using two only two switches for different groups of coils ,it won't become possible to achieve the location at each point. Then, next come to the grouping of three coils,in this arrangement ,it is possible to have the location of searching coil correct but there are various symmetrical point occurring in the resultant output. Let's have one example of three switches (1,2,8),(3,5,6) and (4,7) having different combination of coils.Therefore it comes to our knowledge that by making group of three coils for three switches which are symmetrical to each other gives the multiple locations for the search coil.The following table showing the seven states for three switches, using 2^N-1 where N=3 we have seven different states and the off state has not been considered. For the excitation of coil,100khz frequency is considered.

STATE	SWITCHES		
	SW_1	SW_2	SW_3
	(1,2,5,6)	(4,7)	(3,8)
1	ON	ON	ON
2	ON	OFF	OFF
3	OFF	ON	OFF
4	OFF	OFF	ON
5	ON	ON	OFF
6	ON	OFF	ON
7	OFF	ON	ON

Figure 3.3 Grouping of coils for three switches

So we have tried for another one that is grouping of four coils.In this arrangement of coils,the coils are arranged in such a manner that there is no possibility of symmetrical location by making grouping the two coils which are adjacent to each other

.For four number of switches ,we have fifteen combinations out this we have tried first for seven states which didn't give best results for the location of search coil.Then take eight number of switches, this also didn't work. Similarly,moving for the next trial until we reach with better accuracy. We found best results for eleven states.

STATE	SWITCHES			
	SW_1 (1,2)	SW_2 (5,6)	SW_3 (4,3)	SW_4 (8,7)
1	ON	ON	ON	ON
2	ON	OFF	OFF	OFF
3	OFF	ON	OFF	OFF
4	OFF	OFF	ON	OFF
5	OFF	OFF	OFF	ON
6	ON	OFF	ON	OFF
7	ON	OFF	ON	ON
8	OFF	ON	ON	OFF
9	OFF	ON	OFF	ON
10	ON	ON	ON	OFF
11	OFF	ON	ON	ON

Figure 3.4 an arrangement made by using four switches

3.3 PLANAR MULTI COIL ANTENNA REALIZATION

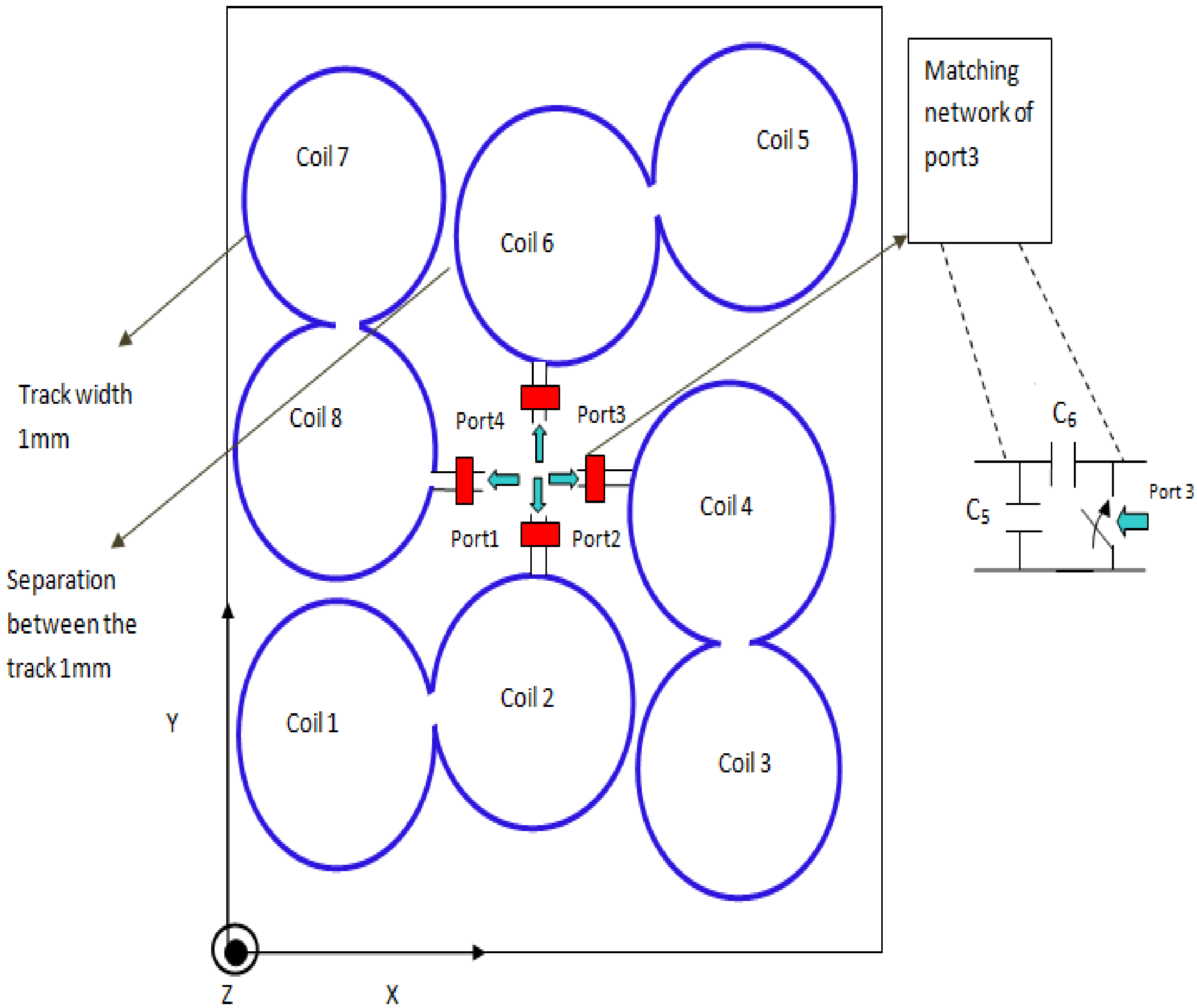

Figure 3.5 Multi coil antenna realization in PCB

As in the frequency division approach, all the coils was excited within the frequency range of 3-100khz. Using single frequency 100khz to be used in the printed circuit board design. The proposed multicoil antenna realization having four ports using single frequency. As already mentioned that we are using four switches for eight coils. In the arrangement , grouping of two adjacent coils have been shown. Each two grouping coils are arranged in series and they are formed on the top view of PCB. Using the same parameters as used in the frequency division approach,current in each coil is 250 mA. The total turns in a coil is 25. Therefore ,the total current $I_i=i*N_i$. The grouping of coil (1,2) ,(3,4),(5,6),(7,8) have been shown.The width of track is 1mm and the separation between the track is 1mm to avoid the short circuit.

For maimum power transfer to the antenna at 100khz, impedances at Port1,Port2,Port3 and Port4 Have to be matched to 50 ohms using L-section matching networks each consisting of two capacitors, C1 and C2 at Port1, C3 and C4 at Port2, C5 and C6 at Port3, C7 and C8 at Port4.

3.4 RESULTS

- Using nonlinear least squares algorithm to find the localization and orientation

To check whether the algorithm is performing or not,we have considered the random location of search coil within in the operating region of the multi coil antenna design . At the output we found that for eleven voltages, the best Curve fitting of measured and predicted induced voltage is observed to find the localization of search coil. From the result,it has been observed that V8 contribute for having maximum induced voltage.This algorithm provide outcome of best curve fitting and histogram of residuals. The histogram of residuals giving the count of distribution of error for different voltages.

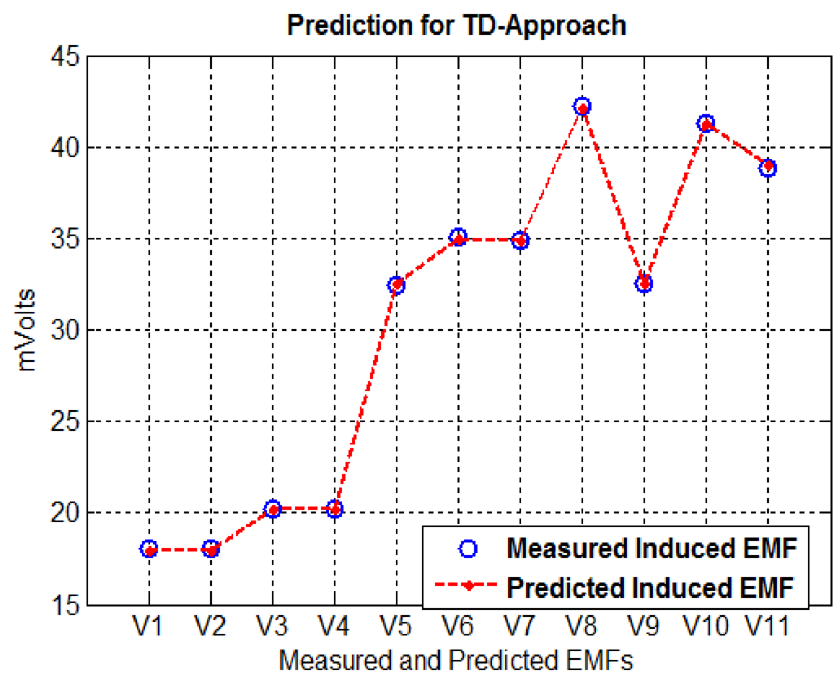

Figure 3.6 Curve fitting of measured and predicted value of induced voltage

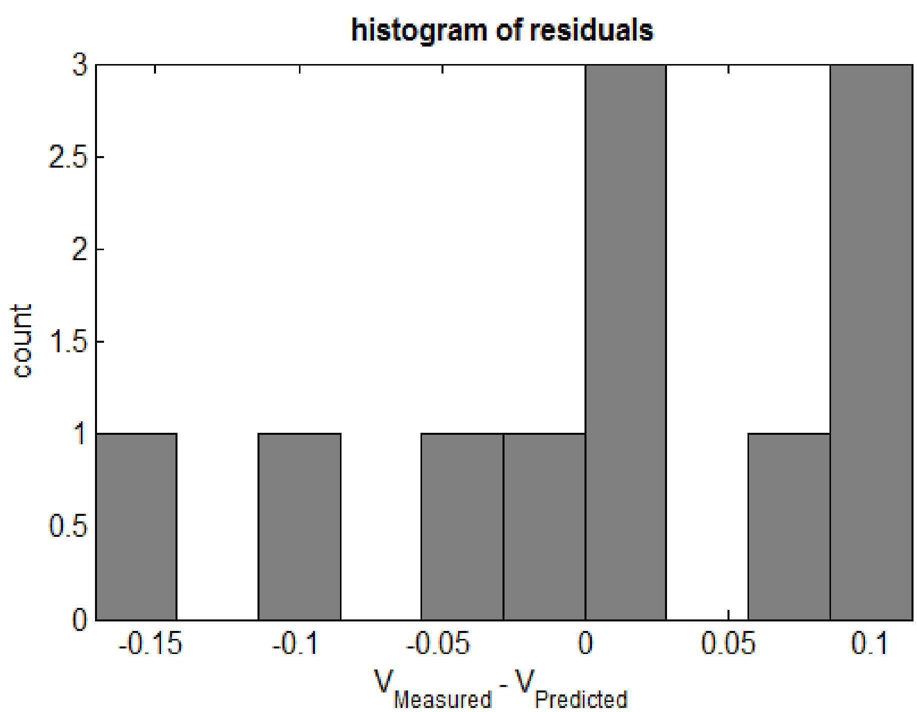

Figure 3.7 Histogram of residuals

- **Position and orientation error**

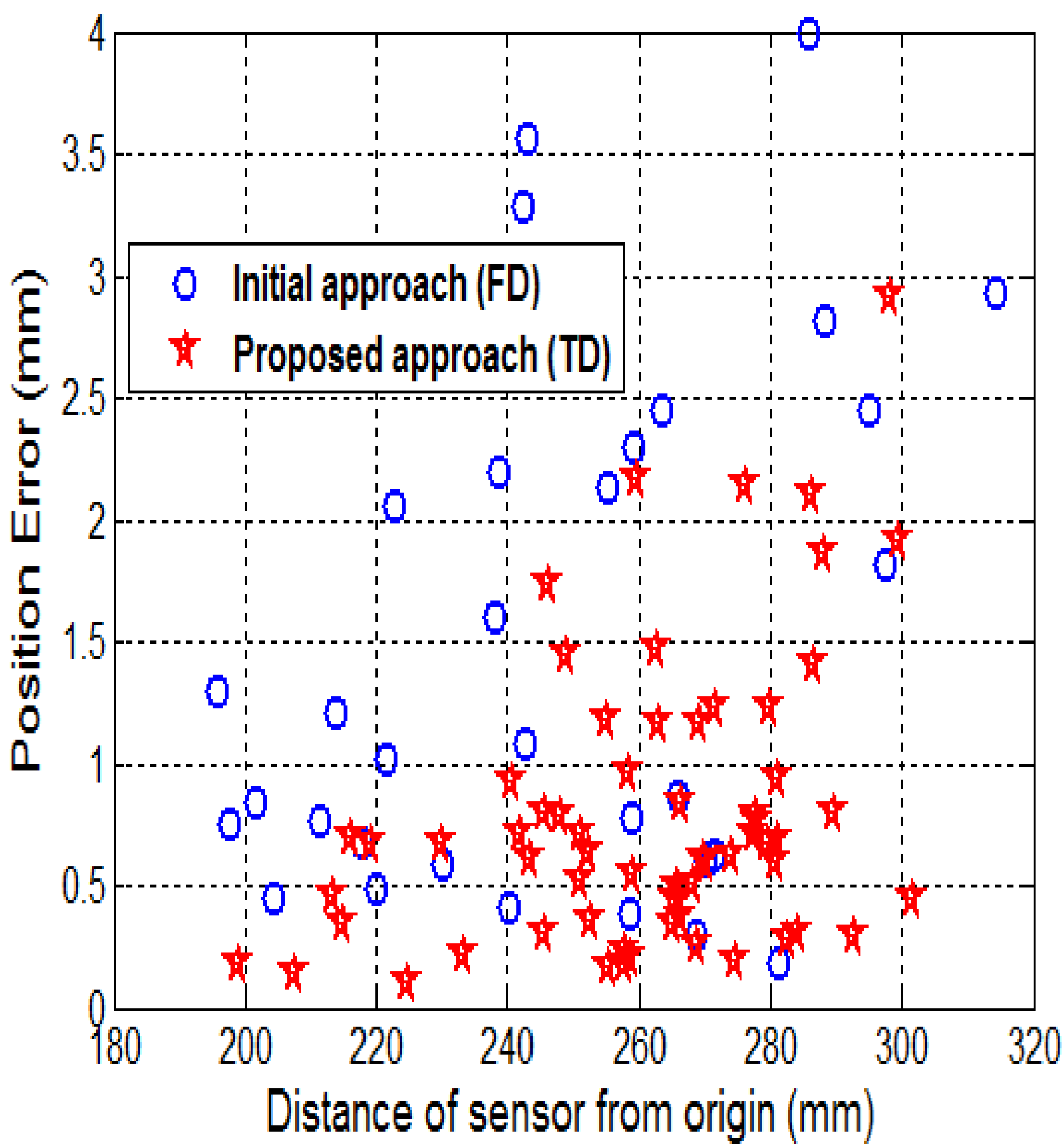

Figure 3.8 Comparison of orientation error of frequency division with time division approach

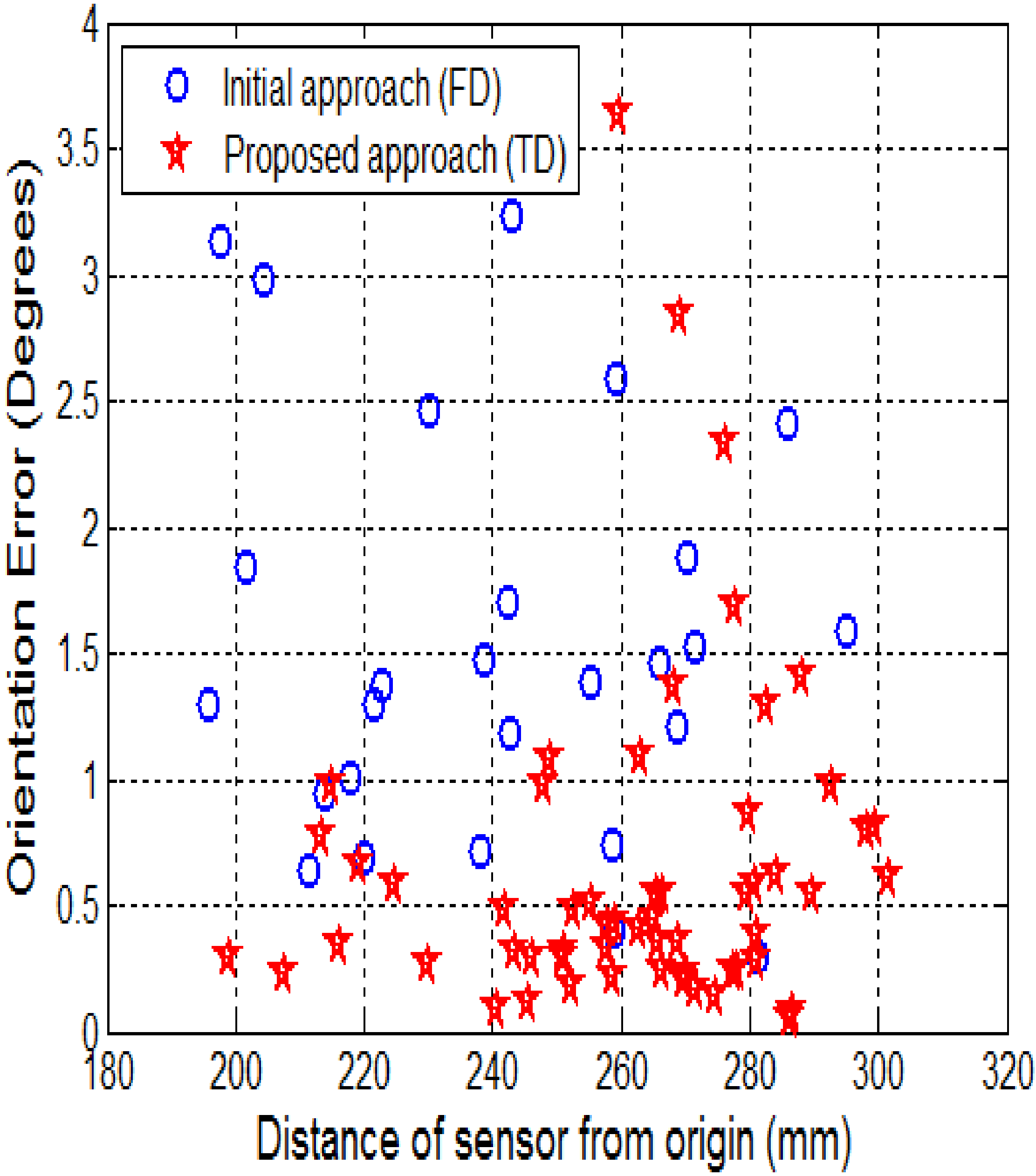

Figure 3.9 Comparison of orientation error of frequency division with time division approach

POSITION AND ORIENTATION MEAN ACCURACY

Scheme	Mean e_p (mm)	Standard Deviation e_p (mm)	Mean e_0 (Deg)	Standard Deviation e_o (Deg)
FD-Approach	1.4666	1.0618	1.5351	0.8139
TD-Approach	0.7949	0.5932	0.6526	0.6597

From the results, it has been observed that while comparing the initial approach with our proposed approach, the number of accuracy of position and orientation of frequency division approach is less seen as that of time division approach. While taking trial of 100 points for both cases, it has been observed that only 63 points having less error in time division approach as compare to frequency division approach which is having only 32 points with less error. Even from the table shown above , the mean and standard deviation error of position and orientation of frequency division approach having more numerical values as that of our proposed approach. Therefore ,it has been observed from the above results that time division approach is the optimal choice for the design of eight coil array which was earlier working on frequency division approach. Only 30% accuracy results found for the initial approach. Our research for the proposed approach provide 60% best accuracy result.

CHAPTER -4

CONCLUSION

By using 100 testing points for both cases, it has been observed that only 63 points having less error in time division approach as compare to frequency division approach which is having only 32 points with less error. The mean and standard deviation error of position and orientation of frequency division approach having more numerical values as that of our proposed approach. Therefore ,it has been observed from the above results that time division approach is the optimal choice for the design of eight coil array which was earlier working on frequency division approach. Only 30% accuracy results found for the initial approach. Our research for the proposed approach provide 60% best accuracy result.

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