Design and Miniaturization of Vehicle Mount Bi-polar Antenna for Jamming Applications

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Declaration

I certify that this research work titled "*Design and Miniaturization of Vehicle Mount Bi-polar Antenna for Jamming Applications"* is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources has been properly acknowledged / referred.

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Acknowledgements

I am thankful to my Creator Allah Subhana-Watala to have guided me throughout this work at every step and for every new thought which You setup in my mind to improve it. Indeed I could have done nothing without Your priceless help and guidance. Whosoever helped me throughout the course of my thesis, whether my parents or any other individual was Your will, so indeed none be worthy of praise but You.

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ABSTRACT

Design and Miniaturization of Vehicle Mount Monopolar Antenna for Jamming Applications

A monopole type antenna has been designed as a optimum one in this study . The type is selected in such a way that the design parameters have not been much affected . As this antenna is vehicle mounted , so research has been carried out to minimize the effect of wind onto it. I use the knowledge obtained from the study to design the optimal antenna which have better wind resistance and longer lifecycle. Therefore, the current design approach of the antenna is based on with new type of antenna and is optimized for gain , radiation efficiency and is Omni-directional . Antenna is designed in CST at 130-180 MHz frequency and wind analysis is carried out in Comsole software before the finalization of hardware.

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CHAPTER 1

INTRODUCTION

Technically, an antenna is an electrical device which produces electromagnetic radiation pattern in the space which surrounds it on excitation. Antenna is usually a collection of one or different conductors which are electrically connected to each other either in order to transmit or receive in any direction. It is an electrical device that redirects guided EM energy during the transmission line to radiate electromagnetic energy in free space. There are many variations of antennas and the main are transmitting and receiving one. Another use of antenna is as an impedance transformer. Functionality, shape, size and directivity give rise to various types of antennas. Antennas are used as a bridge between transmitter and receiver as by alternating magnetic fields generated.

By shapes, Antennas are classified as aperture antenna, loop antenna, monopole antenna , dipole antenna and array antenna.

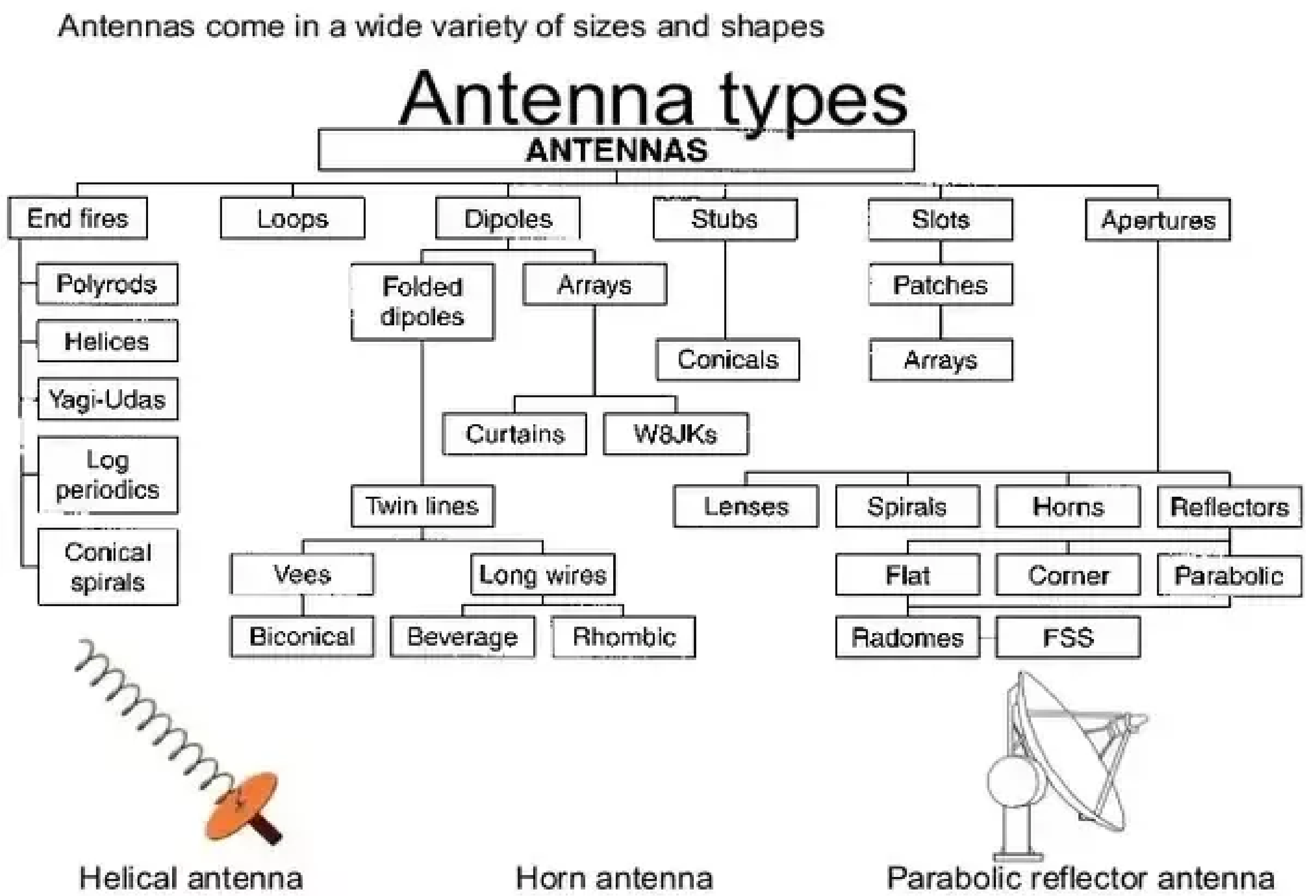

Figure 1.1: Types of Antennas

Based on directional properties , classification of antennas are shown in above figure .

Antennas Parameters

- Gain
- Bandwidth
- Radiation Pattern
- Radiation Efficiency
- Directivity
- Polarization

❖ Effective length

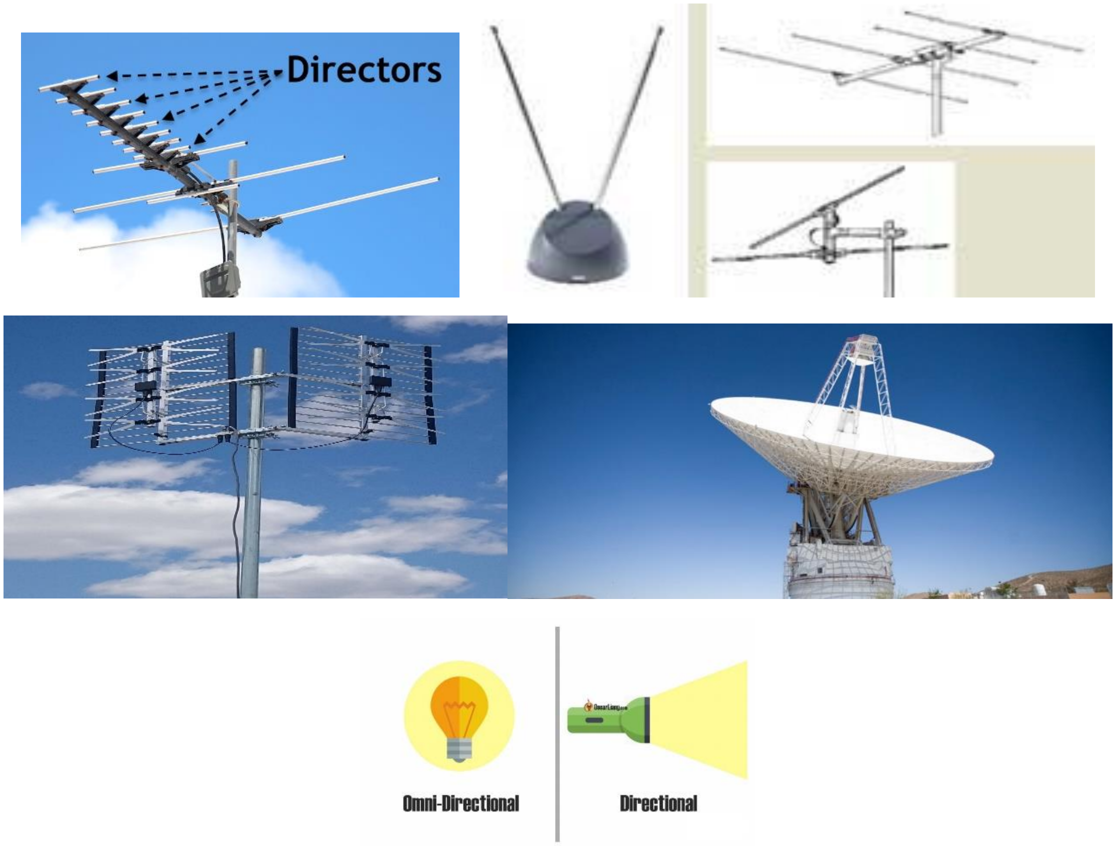

Figure 1.2: Classification on the basic of Shapes

If an antenna give radiations in all directions , its isotropic antennas while if its giving in a specific direction , its directional.

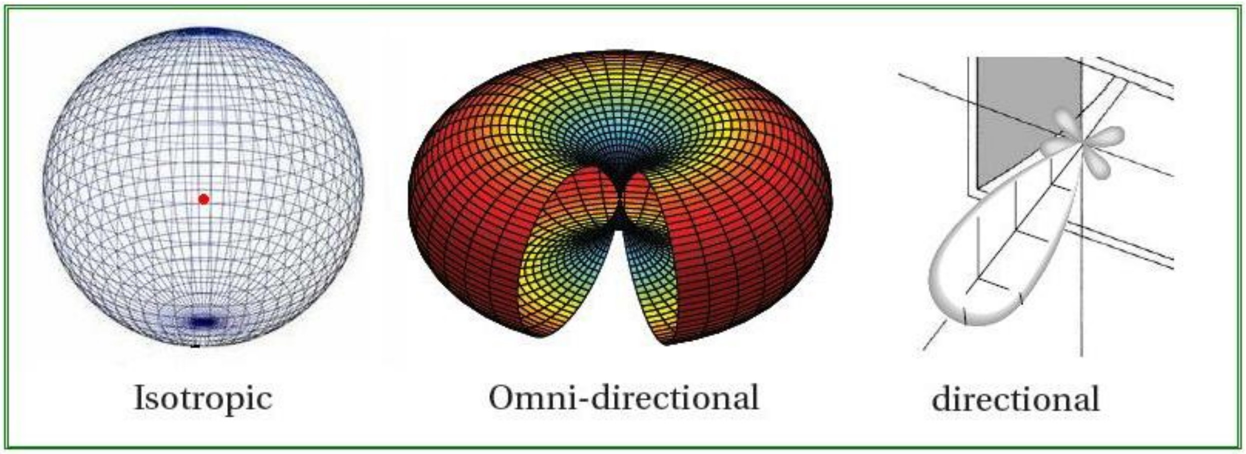

Figure 1.3: Isotropic and Directional antenna's pattern

1.1 Overview

Antenna, at the frequency of 130-180 MHz is already designed in dipole shape. As it is vehicle mounted, So, different parameters are playing the role in its design. Wind is the main design parameter to be taken into account as when the speed of vehicle increases significantly, it starts to vibrate and de-shape. Because of that, Signal get distorted. Monopole type antennas gives us an option to optimize efficiency with the minimal size. Because of this reason, they are being used widely now.

1.2 Problem Definition

The main objective of thesis is to design an antenna that is built having minimal wind effect and operate between 130-180 MHz. HFSS is required to simulate it first before fabrication of its hardware. CST was used for the same reason. Different antenna types and shapes were taken into consideration to reach the conclusion of shape and type to be used. Challenge was to design the antenna with minimal shape (Length and width) so as to have a lesser wind effect as compared to that already present.

1.3 Proposed Application

Because of wide range research and development, It was required to design the antenna with maximum efficiency, smaller size, optimized design and efficient approach. Having an antenna already present, Antenna is designed based on ground with the use of GI sheet as ground. Vehicle body will be used when to be used on vehicle. Legs on which antenna is having ground base are bearing weight of whole design.

1.4 Proposed Approach

Thesis was completed by keeping in mind the following approach.

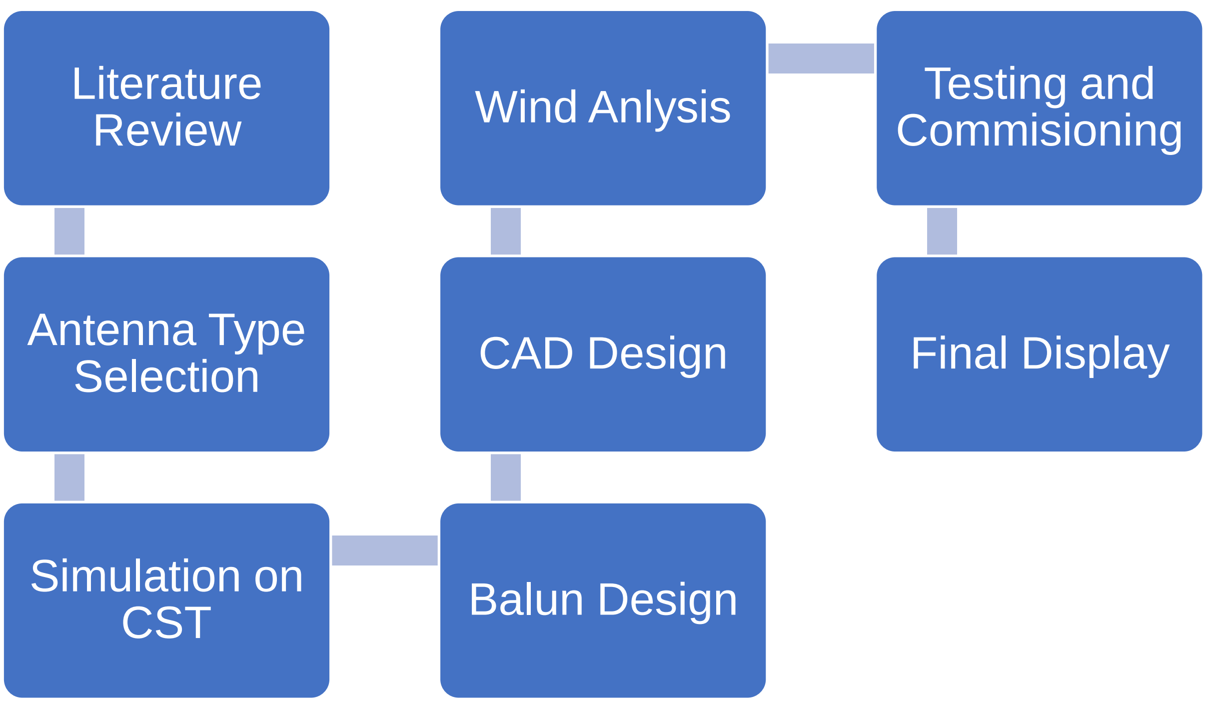

Figure 1.4: Complete Thesis Flowchart

The complete timeline of thesis is progressed in such flow. Starting from literature review to finalization of design.

1.5 Objectives

Objectives of thesis are enlisted below.

1.5.1 Academic Objectives

- Learning how dipole type antenna works.
- Composing the design of dipole and monopole antenna in CST.
- Analyzing wind effect of antenna .
- Watching the parameters of antenna on CST like gain , realized gain , efficiency and direction.

1.5.2 Application / End Goal Objectives

Final objective is to design antenna with 130-180 MHZ frequency , Gain of greater than 2 , Maximum of 0.6m of length , maximum of 100mm of diameter , linear polarization and Omnidirectional pattern.

CHAPTER 2

LITERATURE REVIEW

Research & development have been made for the betterment of wireless communication system. Latest methods have been approached to frame efficient antennas for mobile and other handheld devices. An unfailing and efficient technique have also been in use that is monopole radiation antennas.

2.1 Techniques for Mobile Antennas

Efficiency of wireless antennas may be enhanced by different methods, different applications can be used on some varieties of wireless devices. This thesis will only discuss different technique that can be applied on vehicle mounted antennas . Some techniques are to be discussed in details.

2.2 Techniques for Vehicle Mounted Antennas

Vehicle-mounted antennas used for wireless communications normally operate at a power level of two watts or less. The wireless antennas are typically fixed on the roof, trunk or rear window of a car or truck.

Studies show that, in order to be exposed to RF levels that are to be approached the safety limits , it is needed to remain near to a vehicle-mounted wireless antenna for a little time. Studies have also proved that the metal body of mobile vehicle can effectively contribute to safety measures of riders. Perfect installation of a vehicle-mounted antenna to ensure the maximum impact of safety is a good way to minimize exposure. Some companies recommend that antennas should be fixed either in the center of the roof of vehicle or center of the trunk of a vehicle. A minimum distance of one to two feet is recommended as a preventive measure over debate of concerns expressed over the commonly used rear-window mounted wireless antennas.

From the data researched till now, perfectly-installed, vehicle-mounted, personal wireless antennas consuming till 2 watts of power give a consequence of maximum exposure levels in or near the vehicle taking in consideration that the transmitting antenna is 6 inches or more from riders of vehicle .

2.2.1 Shapes of Antennas

Ground Radiation antennas are having variation in shapes . They can be planer antennas they can be loop type used in wireless communication devices Because of its many factors like lesser visibility, cheap, fine integration with electronic circuits of various feed types, less heavier, ease of manufacturing etc. Each shape have its own characteristics having an option of improvement using different methods. The primary thing to be use in of ground Radiation antennas are of microwave frequencies due to short wavelengths and low profile give rise to their use in commercial as wel as domestic sector.

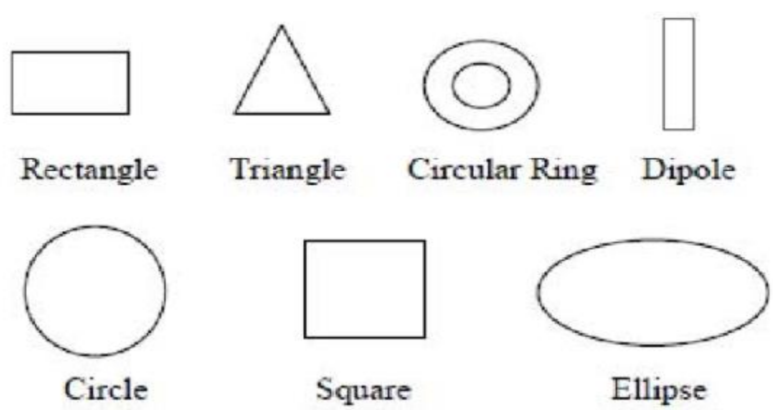

Figure 2.1: Various Antenna Shapes

Monopole antenna is very important type of antenna & they are having a very important role in today's wireless communication systems. Now we will discusss monopole antenna , their radiation efficiency and other parameters.

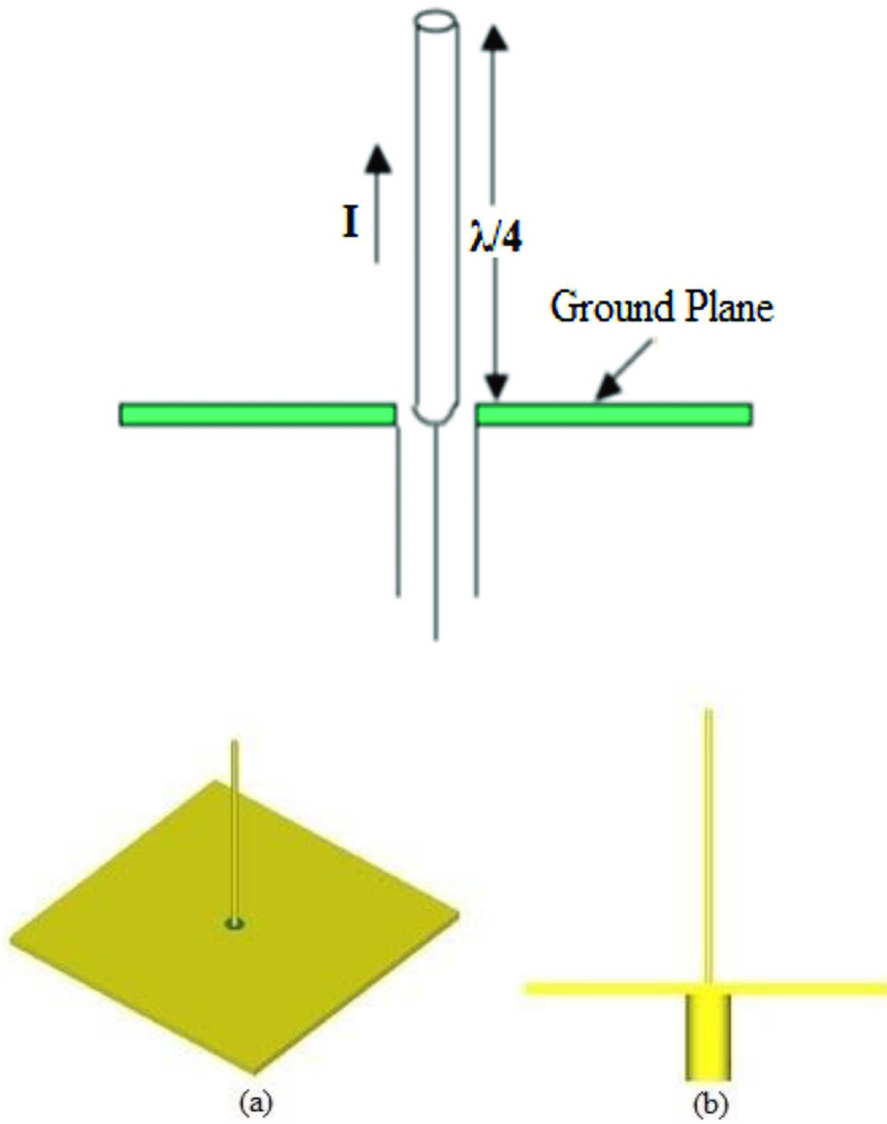

Figure 2.2: Monopole Antenna with different shapes

Above these the mostly used shapes of ground Radiation antennas are as follow:

The input impedance of the monopole antenna has both reactive and resistive components. Its resistive components will govern the power radiated by antenna. The factor of complex part govern that the imaginary parts of these poles are for the power loss by radiation and by dielectric and conduction losses. Shape of their model govern the real part and antenna poles.

2.2.1.1 Planer Inverted F Antennas (PIFA)

Planer inverted F antennas resonates at 1/4 wavelength and has much greater SAR properties because of which they are smaller in size and are used in mobile phones and mostly the antenna in PIFA is parallel to ground plane . PIFA is widely used in wireless communication & is printed using microstrip antenna technique . Mostly , technique is a choice for modern RF electronics.

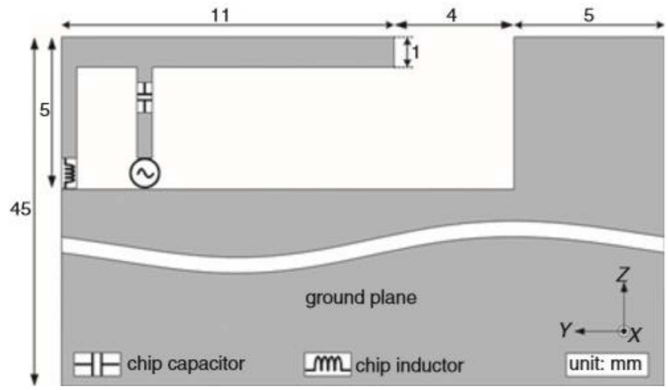

Figure 2.3: Patch Antenna in rectangle shape

2.2.1.2 Loop Type Ground Radiation Antenna

Much consideration has been given to Loop type ground radiation antenna as they are efficient and having good properties. The antennas are the consequence of varying feeding mechanisms of the ground plane of a mobile device. Different feeding techniques of Ground Radiation (GRadiAnt) are elaborated upto some extent here. Loop type antenna has not yet been as extensively considered as PIFA. EM theory is the basis of operation mechanism of the loop type antenna. The analysis may not be used to some designs of loop antenna.

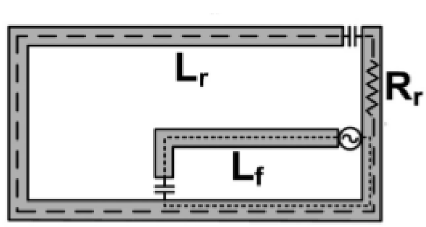

Figure 2.4: Ground Antenna in the shape of Loop

2.2.1.3 Microstrip Patch Antenna

Microstrip antennas (Printed Antennas) usually known as copper strips printed or fabricated on PCB. Microstrip antenna contains strips of metal (in some cases strips are of copper tapes) . Microstrip antennas are of use in last ten years because of their tiny shape and planar profile they may be used in covering of any object as they are easy to manufacture.

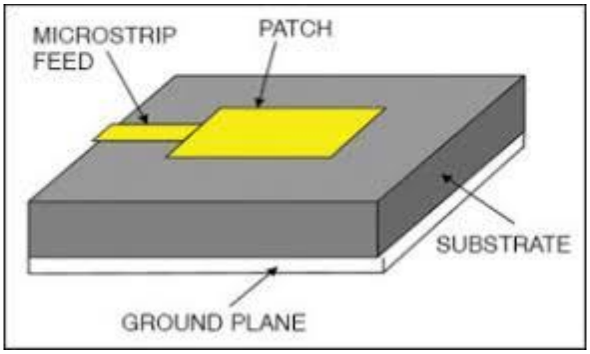

Figure 2.5: Ground Antenna in the shape of Loop

2.3 Other Characteristics of Monopole Antenna

2.3.1 Material

The material which I use is copper made monopole and GI made ground plane . Aluminium and Teflon are also used as they are readily common and not much expensive . FR4 is used as substrate material in Balun Design.

2.3.2 Antenna Thickness

Thickness of monopole antenna used is 2mm sheet designed in pole shape.

2.3.3 Feed

N type male connector is used to give feed to antenna at its base.

2.3.4 Ground

Because of property of enhanced radiation pattern and bandwidth , Whole plane ground is used made-up of GI.

CHAPTER 3

ANTENNA DEVELOPMENT AND DESIGN

3.1 Software

Prior to manufacturing of hardware antenna and its prototype , its simulations were conducted in Computer Simulation Technology (CST). Its very easy software in use and we can design and simulate antenna in it as per our own choice and optimize it as required.

3.1.1 Computer Simulation Technology (CST)

CST is high frequency software for simulation system. Antenna domain of this software is used . It gives the results almost same as in real hardware design. Antenna is designed as per specifications here, simulated it and optimize it as per own need.

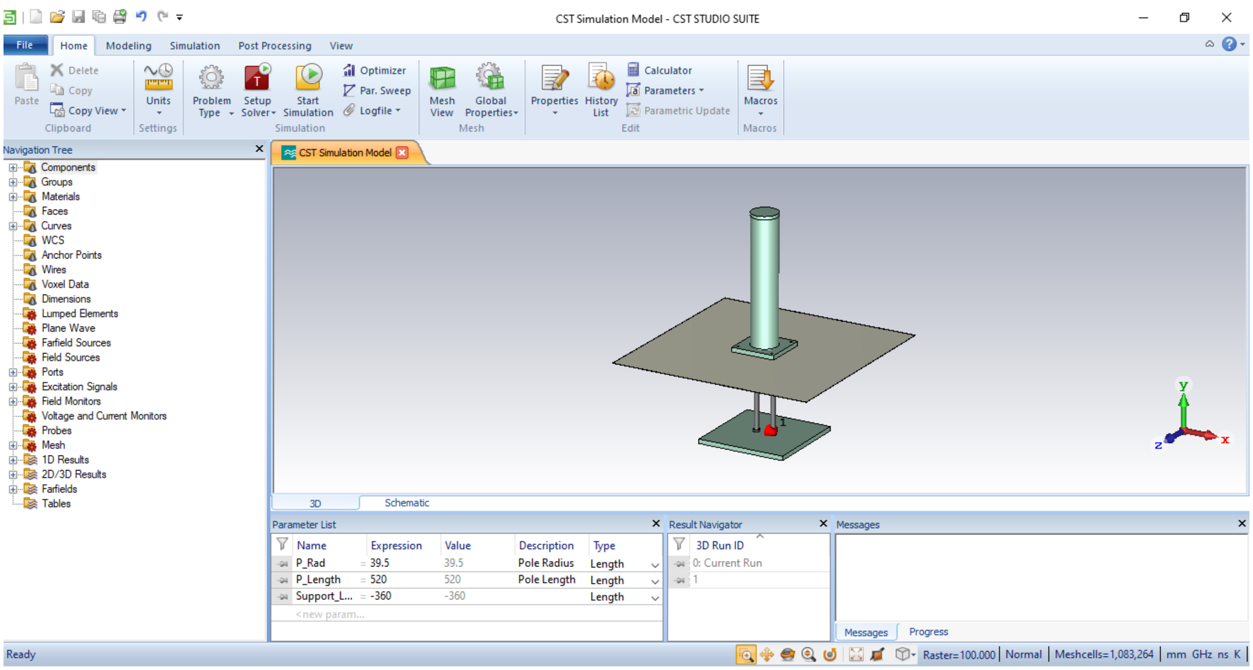

Figure 3.1: CST Environment

3.2 Fabrication

Proposed antenna is manufactured after taken/selection of material. Carefully manufactured pole and ground with very minute tolerance. Weight of antenna and ground plane was also taken into consideration during selection of material as it was to be mounted on vehicle.

Figure 3.2: Manufacturing of Monopole Antenna

3.3 Measurements of Simulations

Every aspect of parameter was considered while designing of antenna into software as very minute mistake can lead of re-manufacturing of antenna. Different designs of antenna and Balun was selected, optimized before going for final manufacturing. Even the screws to be used later for attaching the parts was mentioned in simulation so as to get the best possible results. Different Parameters like return loss , efficiency , frequency and radiation pattern was analyzed in the results of simulations.

3.4 CST Design

Thesis were gone through various stages before finalization of final design. Parameters which affect the design were taken into account to get the best possible and optimized results. All the elements were ensured to be connected properly, best material used and were given proper attention during design to make it feasible to fabricate.

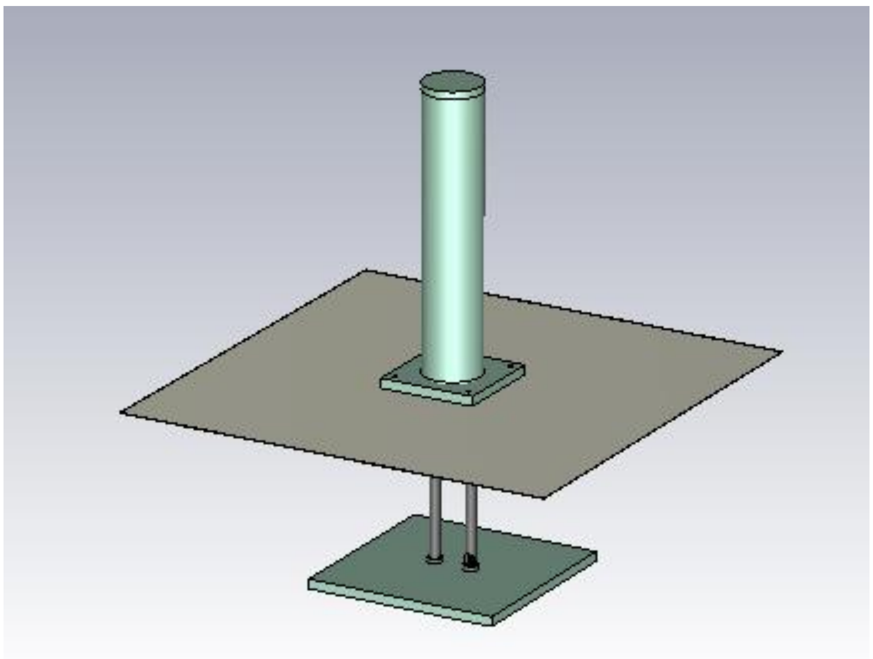

Figure 3.3: Monopole antenna design in CST

3.4.1 Design of Monopole Antenna

Before reaching the final results , different designs were considered which were discarded later .

Best and optimized results were reached as follows:

3.4.1.1 Design without Nylon Casing

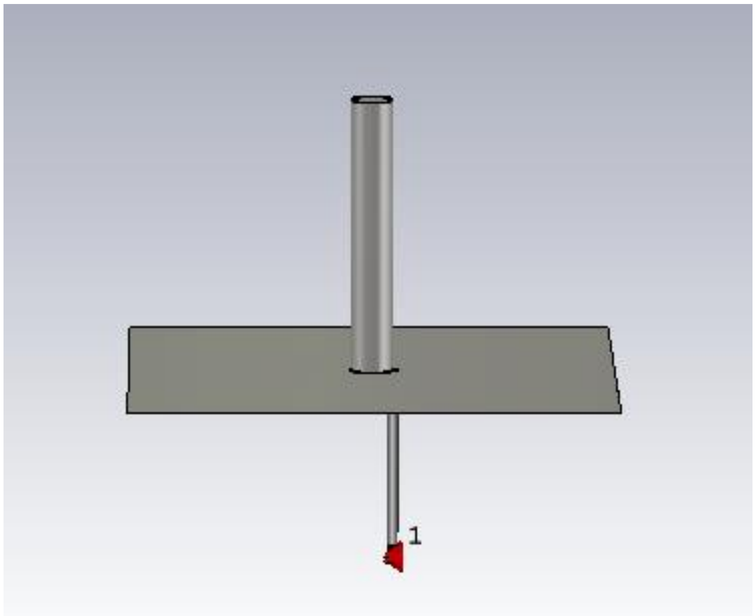

Figure 3.4: CST Design without Nylon Casing

Nylon casing were used after design were finalized which also have a little effect on S11 value . S11 value before installing Nylon casing were:

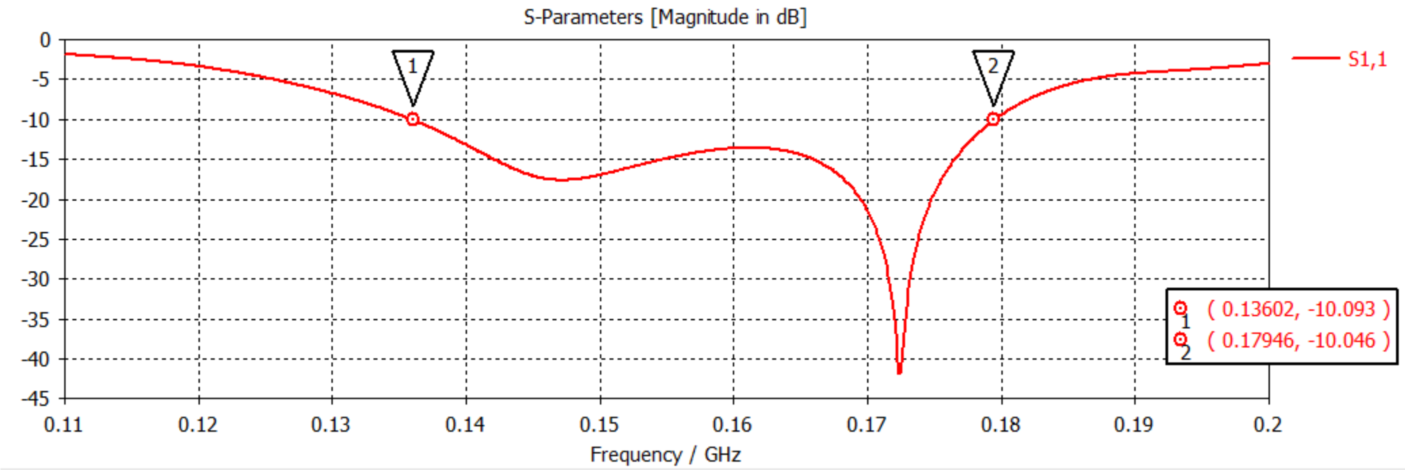

Figure 3.5: S_{11} plot for CST Design without Nylon Casing

3.4.1.2 Design with Nylon Casing

Nylon casing were used in CST after finalization of antenna. It reduces return loss (S11) to some extent but results were still acceptable as casing was very necessary to use and without it, antenna on vehicle doesn't seems feasible as it will contribute to more wind effect .

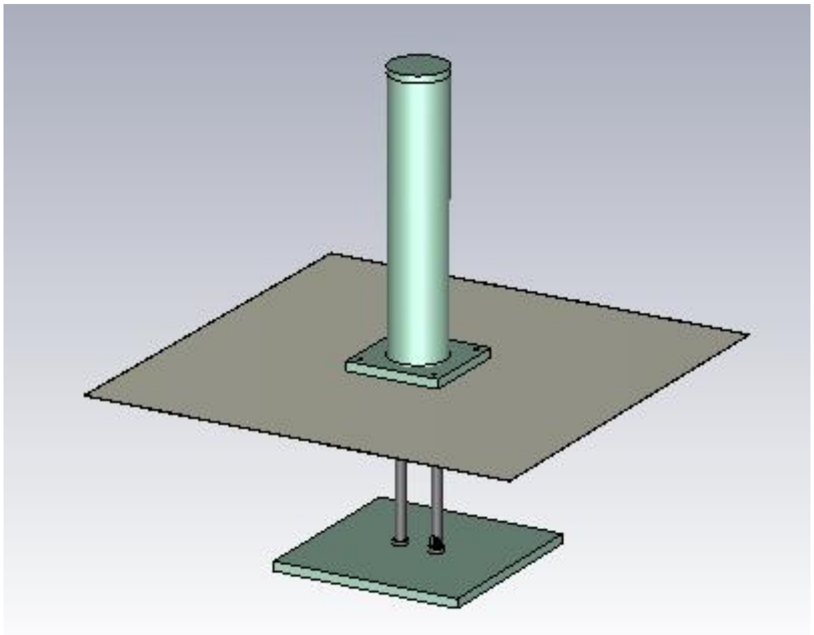

Figure 3.6: CST Design without Nylon Casing

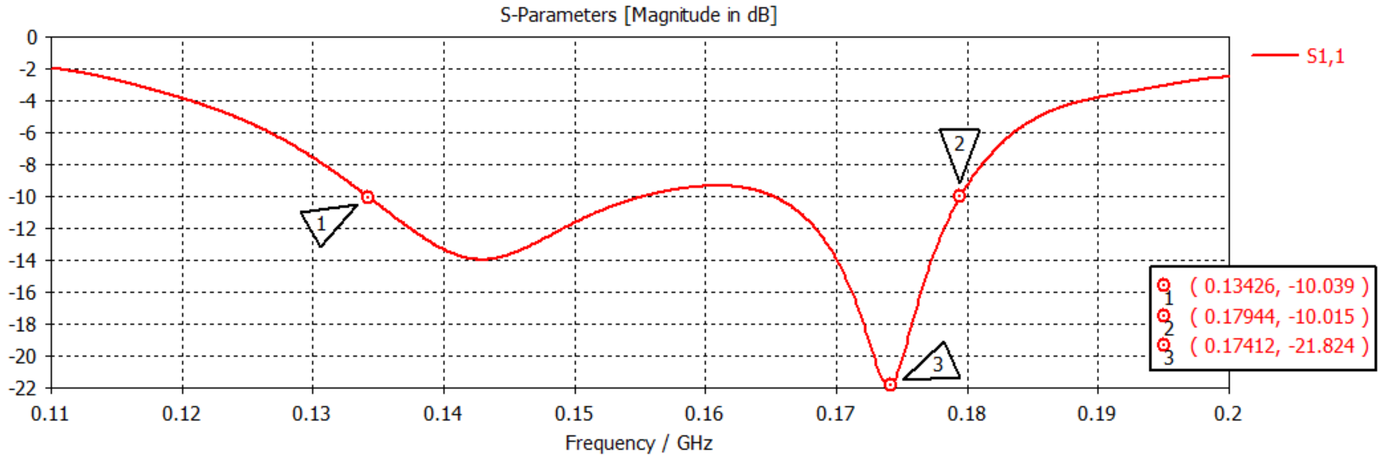

Figure 3.7: S_{11} plot for CST Design with Nylon Casing

Resonant frequency reduces to -21.8 dB when nylon casing is used.

3.5 3D Polar Plot

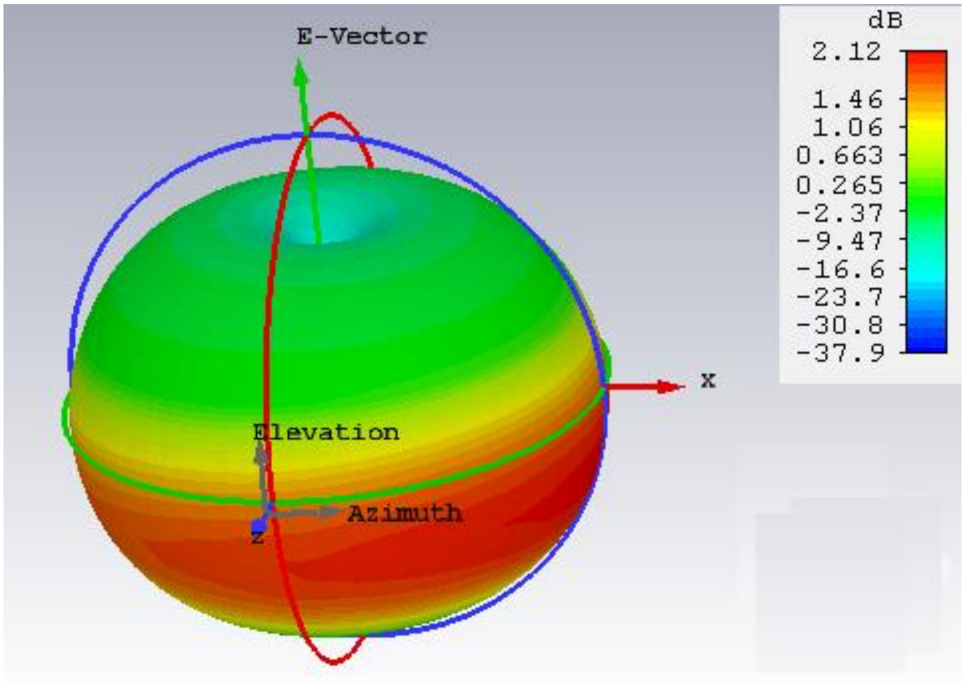

Figure 3.8: 3D Polar Plot

2.12 dB gain has been achieved using this design.

3.6 Calculations

3.6.1 Dimensions of the proposed antenna

Following are the dimensions of designed antenna.

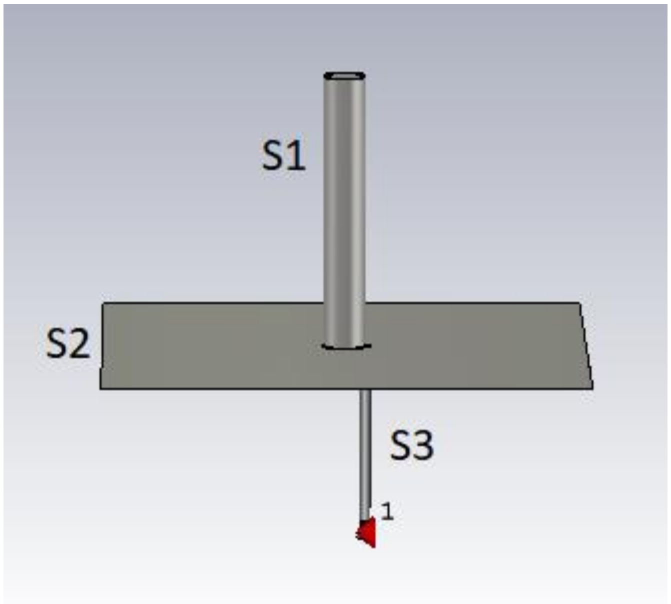

Figure 3.9: Dimensions of Designed Antenna

Length Measurement of Antenna
S1=520mm
S2=920mm
S3=360mm

Table 3.1: Dimension Values

Length Measurement of Antenna	Width Measurement of Antenna
S1 = 520 mm	Diameter = 79 mm
S2 = 920 mm	W = 1mm
S3 = 360 mm	Outer diameter = 11 mm

Table 3.2: Labeling the Dimensions

CHAPTER 4

ANTENNA FABRICATION AND RESULTS

Antenna Measurements are taken from Vector Network Analyzer. Network analyzers are of two types , Scalar and Vector. The scalar network analyzer gives specifically the same information as a swept spectrum analyzer with a return loss as other vector network analyzer or VNA. Vector analyzers measure both magnitude and phase of the response, to which we can calculate other information too using other tools.

4.1 Antenna Measurement and Results

Figure 4.1: Results and Measurements on Vector Network Analyzer

Figure 4.2: Results and Measurements on Vector Network Analyzer

4.1.1 S_{11} Plot of Monopole Antenna with Nylon

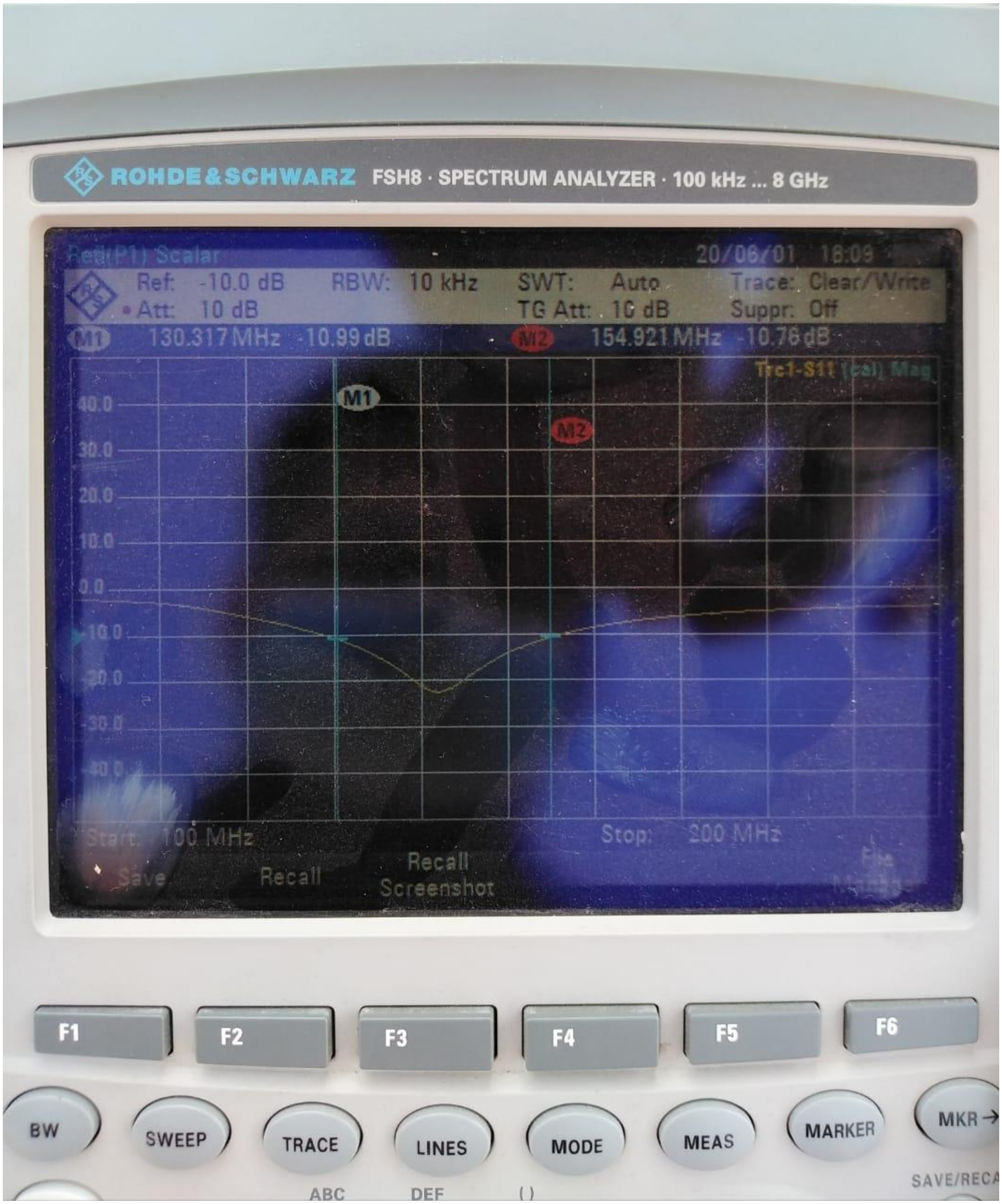

Figure 4.3: S_{11} Plot of Antenna with Nylon

In figure 4.3 S_{11} plot frequency having the return loss more than -10 dB that means that it is at operating frequency. The dip is of 26 MHz (130 MHz to 156 MHz) frequency with a return loss of approximately of -22 dB. This S_{11} shows the values of Antenna resonance.

4.1.2 Radiation Pattern

2D Radiation pattern shows the power radiated by an antenna as a function of direction away from the antenna.

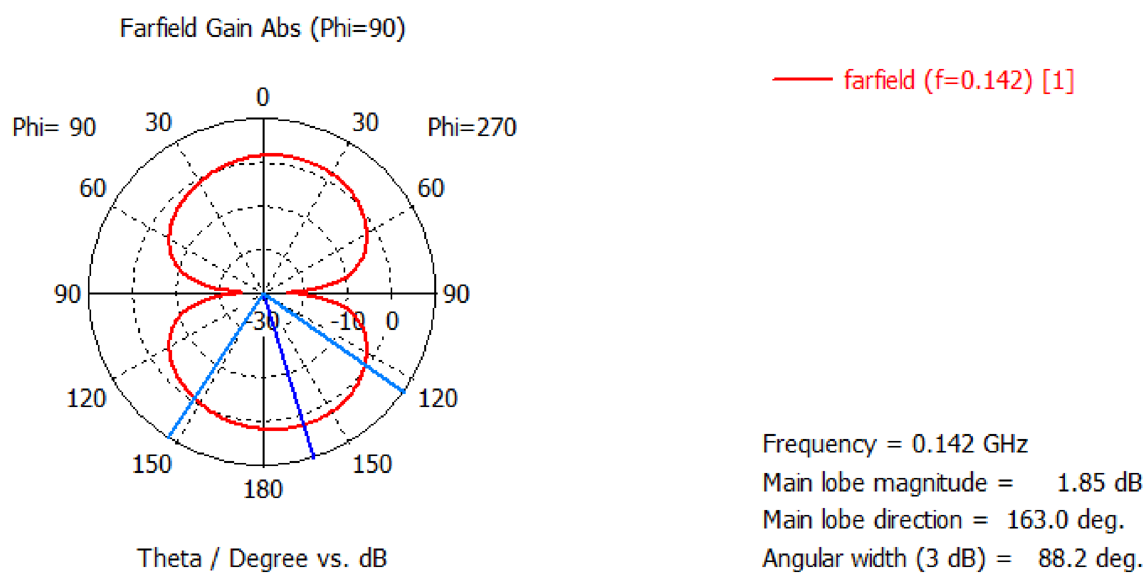

Figure 4.4: 2D Radiation pattern of Monopole Antenna without Casing

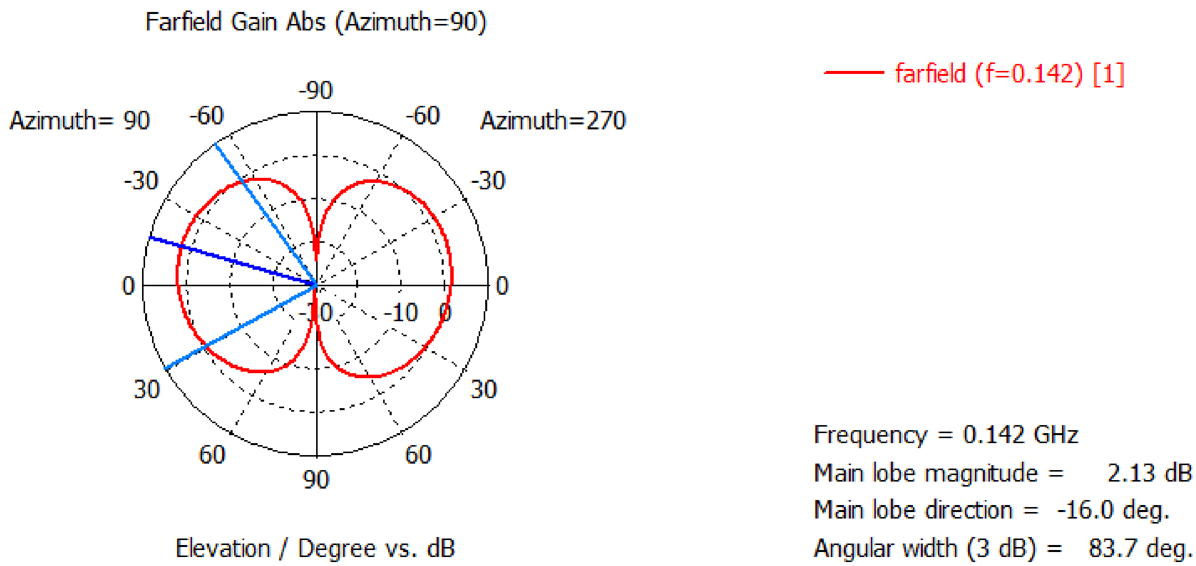

Figure 4.5: 2D Radiation pattern of Monopole Antenna with Nylon Casing

4.2 Antenna Fabrication

Initial design of the antenna was finalized on CST and then the Balun of Designed antenna is fabricated from National Institute of Electronics (NIE).

Figure 4.6:Fabricated Balun

4.3 Application

Keeping in view the operating frequencies of antenna. It can be used as jammer for frequency of 135-155 MHz & 165-180 MHz.

4.4 Stiffness Ratio

Stiffness ratio has been calculated to determine the wind effect on antenna. COMSOL Multiphysics software is used for the same purpose. Antenna design is made on software and stiffness ratio was calculated that how much stiffness it can withstand.

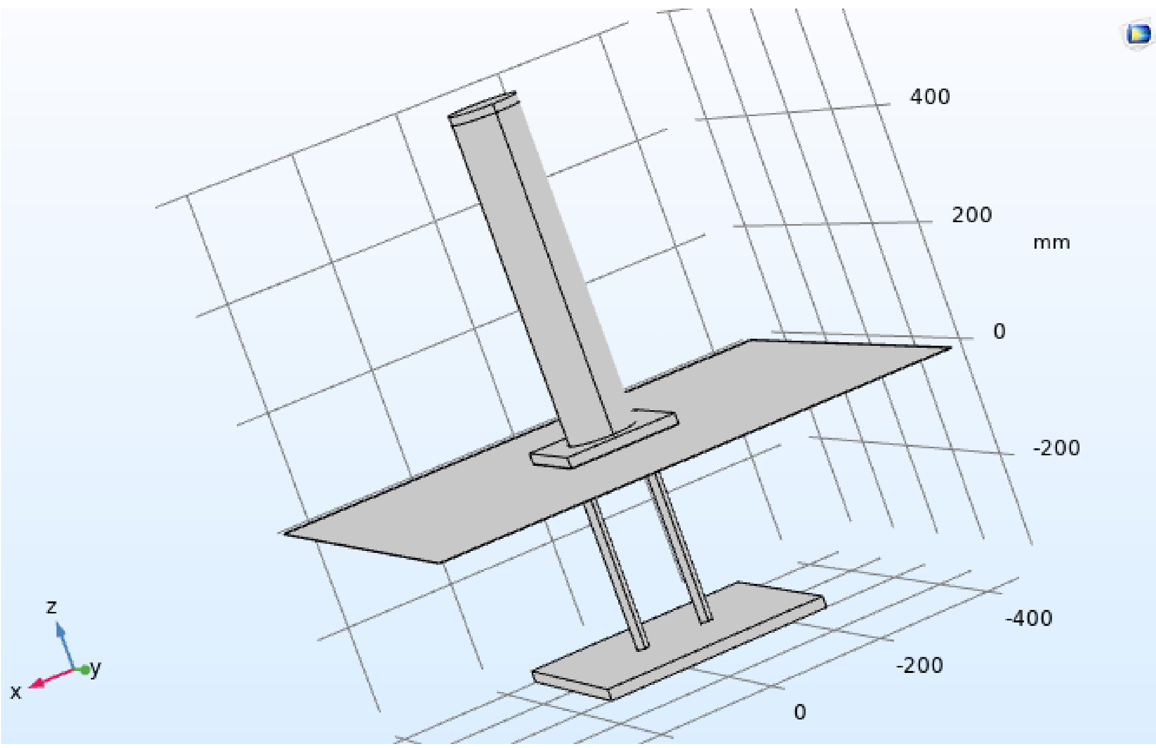

Figure 4.7: Design on COMSOL MULTIPHYSICS

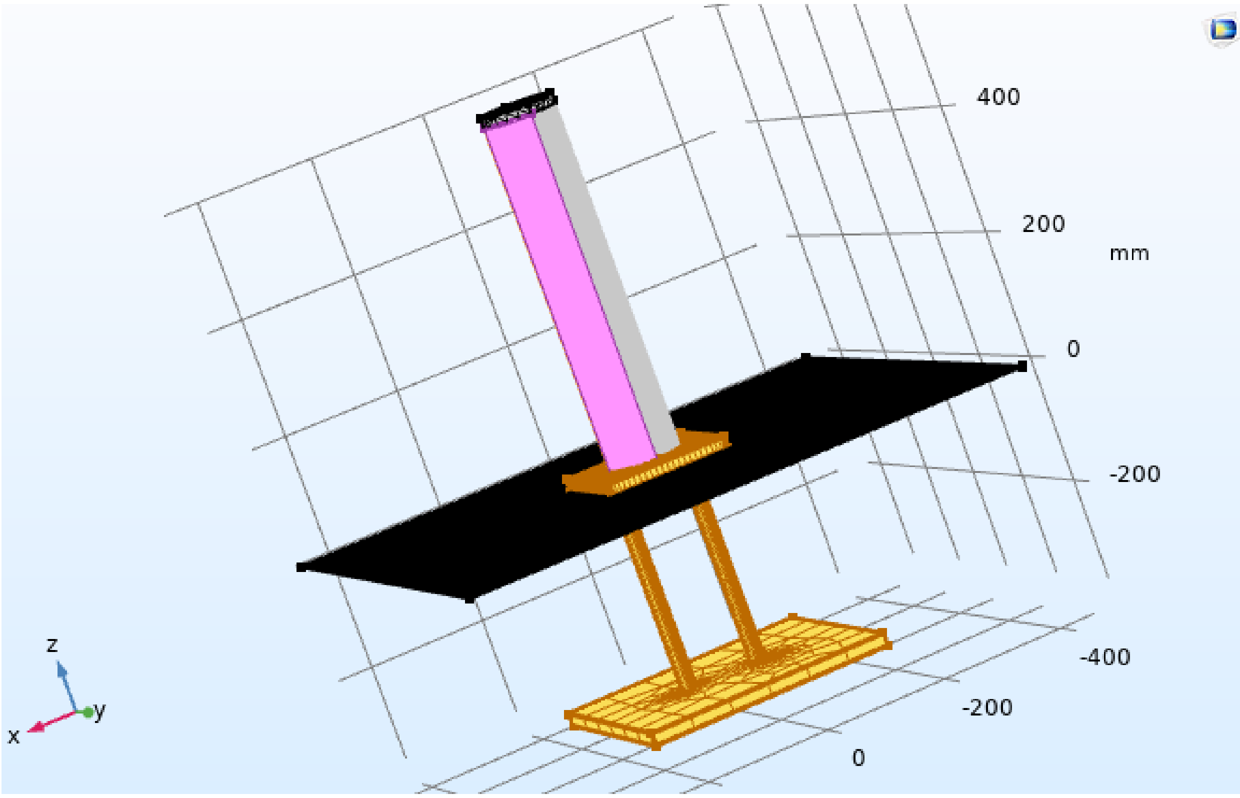

Figure 4.8: Parameter Sweep diagram of antenna

On computing the wind effect , a value of $8x10^6$um was simulated .

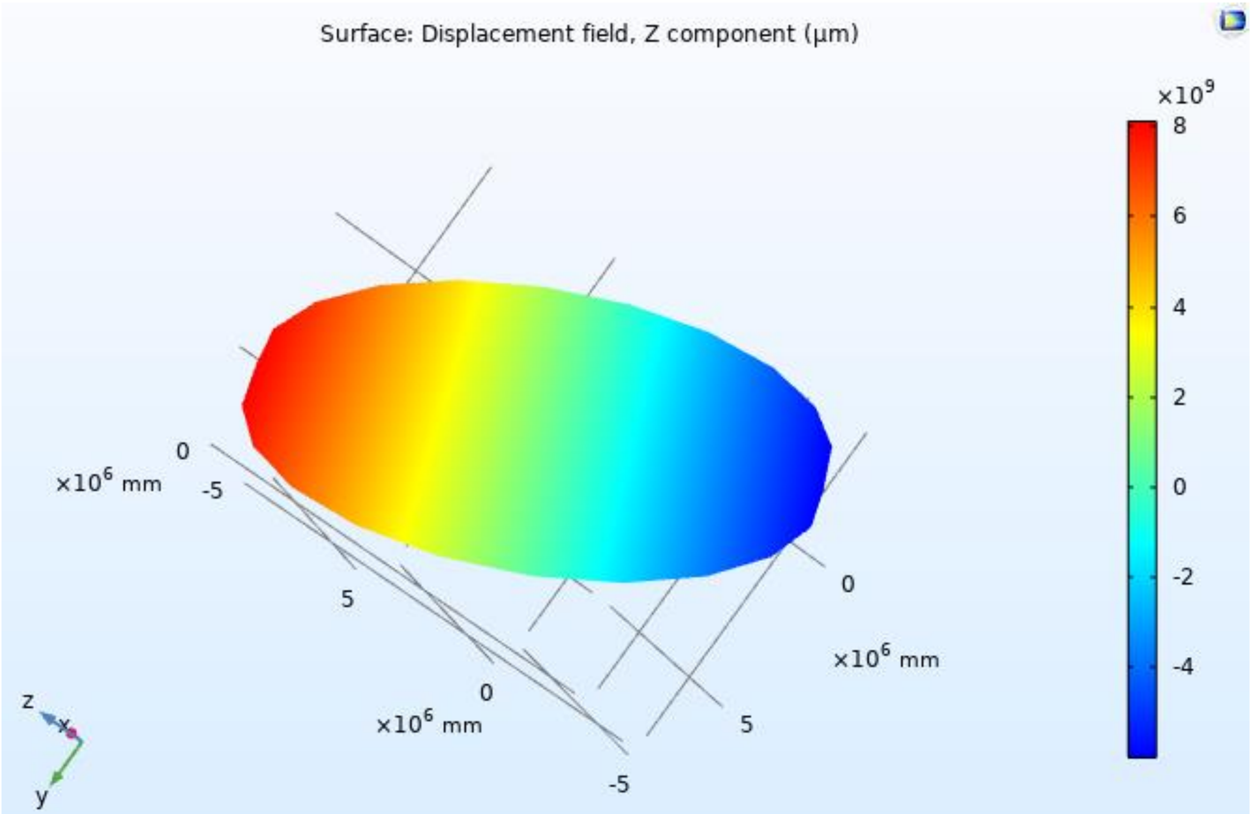

Figure 4.9: Simulated Graph of Antenna for Wind Analysis

Stiffness ratio calculated is 2.82×10^{-6} .

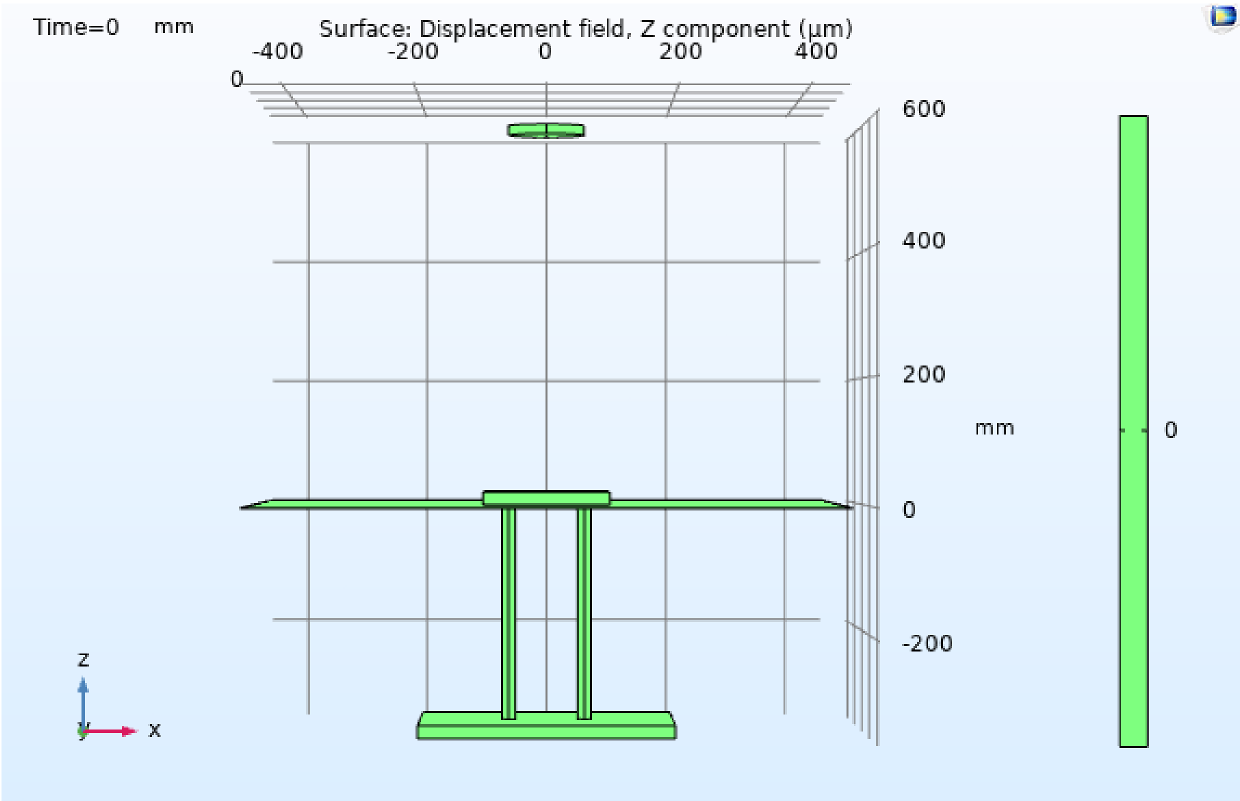

Figure 4.10: Displacement field at Surface, Z component

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

5.1 Conclusions

We can conclude that by the application of an antenna is designed for frequency of 135 MHz to 155 MHz & then for 165 MHz to 180 MHz. Following conclusions can be drawn from this research work:

- Simulation in CST gives near to accurate results.
- Monopole antenna have gain, radiation efficiency and power almost equal to dipole but its size is comparatively less than dipole.
- Monopole antenna has much lesser wind effect than dipole or any other type antenna.
- Use of Teflon give maximum efficiency than any other material in antennas.
- Monopole antenna is less expensive in manufacturing and most suitable antenna type.

5.2 Future Work

- We can enhance the compactness of antenna by making the changes in dimensions.
- Other types of antenna can be tested for gain and other parameters to reduce shape and having less wind effect.
- More bands can be achieved by having variable loops.
- Antenna can be made reconfigurable so that antenna can be dynamically changing its radiation properties.

CHAPTER 6

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