INTERNSHIP REPORT

NPHSAT SYSTEMS PVT L TD

KANURU, VIJAYAWADA, ANDHRA PRADESH, INDIA 520007.

Submitted by:

S.GOWTHAM SAI **URK18AE009**

Under The Guidance of

Dr.V.PRAVEEN NAIDU, DIRECTOR & CEO,

NPHSAT SYSTEMS PVT LTD.

& Dr.JIMS JHON WIESLY,

Head of the Department,

Department Of Aerospace Engineering,

KITS, Coimbatore

Submitted to

DEPARTMENT OF AEROSPACE ENGINEERING

KARUNYA INSTITUTE OF TECHNOLOGY AND SCIENCES

(Declared as Deemed-to-be-under Sec-3 of the UGC Act, 1956)

Karunya Nagar, Coimbatore, INDIA- 641114.

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NPHSA
Small Satellites

NPHSAT SYSTEMSPVT.LTD.
Manikya Nagar, Kanuru,
i•y• wada - 520007. A.I?, India
Ph: 85008 87418
Email: nphsat18@gmail.com
website: www.nphsat.com

Date: 20-05-2020

NPHSAT/19-20/HRD/INT/KU01

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Mr. SOMAROUTU GOWTHAM SAI, Student of Karunya University, has successfully completed internship with NPHSAT SYSTEMS PVT LTD, during the period from **20/04/2020 to 20/05/2020.**

During the course of internship, SOMAROUTU GOWTHAM SAI has shown great amount of responsibility, sincerity and a genuine willingness to learn and zeal to take on new assignments & challenges. In particular‘, his coordination skills and communication skills are par excellence and his attention to details is impressive.

We wish all the very best for his futui‘e.

5|2020

NPHSAT SYSTEMS PRIVATE LIMITED

(Dr. Praveen Naidu Vummadisetty)
Founder, Director and Chief Engineer

DECLARATION

I **S GOWTHAM SAI** of B.Tech 2nd year in Aerospace Engineering at Karunya Institute of Technology and Sciences, Coimbatore, hereby declare that this internship has been carried out in NPHSAT SYSTEMS PVT LTD, Vijayawada for a period of one month under the valuable guidance of Dr.V.PRAVEEN NAIDU, DIRECTOR & CEO and the report has been submitted in partial fulfilment for the requirement of B.Tech curriculum.

Place: Vijayawada.

Date: 16/11/2020.

S GOWTHAM SAI
URK18AE009

ACKNOWLEDGEMENT

First of all I would like to thank KARUNYA INSTITUTE OF TECHNOLOGY AND SCIENCES for guiding and granting us the permission to carry out an internship at the **NPHSAT SYSTEMS PVT LTD,** Kanuru, Vijayawada, and Andhra Pradesh.

I extend my sincere heartfelt gratitude to the Director& CEO, **Dr.V.PRAVEEN NAIDU** for allowing me to carry out my internship at NPHSAT SYSTEMS.

It has been my great fortune to have **Mr.HARANATH**, senior electronics engineer for carrying out the internship and guiding us to improve our technical skills.

I also thank senior electrical engineer, **Miss.JAYALAKSHMI**, for her guidance and support.

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CHAPTER 1

INTRODUCTION

1.1 ABOUT NPHSAT SYSTEMS PVT LTD

NPHSAT SYSTEMS PVT LTD. is a First Aerospace STARTUP in Andhra Pradesh, INDIA. It is specializing in the design, development and production of small satellites namely Can-Sat, Cube-Sat, Pocket Cube-Sat, Tube-Sat, Sun-Sat and mobile phone antennas, satellite antennas, printed compact multi frequency antennas for all portable wireless applications, UWB antennas, RF power dividers, Telescopes and Robotic systems. With corporate headquarters based in Vijayawada, Andhra Pradesh, INDIA, and a production office in the Machilipatnam, Andhra Pradesh, INDIA. NPHSAT is able to offer superior service and support to customers around the world. NPHSAT provides customers with complete small satellites and antenna system products, product development and services that maximize the technical and commercial benefits for their customers with cost, performance, quality and reliability requirements [1].

1.2 ABOUT INTERNSHIP PROGRAM

Program Name: OSIP 2020

Program Duration: 4 Weeks

Technology Tracks: Small Satellite Design, RF Antenna Design, AutoCAD for Electronics, Satellite Data Analysis

TOPICS COVERED DURING INTERNSHP

MODULE 1:

Briefing about the training program, introduction to CubeSat, basics of electronics, electromagnetics, antennas, wireless communication topics related to CubeSat, learn common point and difference between CubeSat and other type of satellites, identifying the CubeSat components, basic information and mission specifications and software installation.

MODULE 2:

CubeSat antenna design and understanding ground station antenna design (communication between satellite and ground station, system architecture communication protocol) (using HFSS/CST, ADS tools).

MODULE 3:

CubeSat outer body design using CAD tools, understanding about Structural system design (CAD, vibration test, etc.), and how to develop a new mission design, system design & its implementation.

MODULE 4:

Electric Power Subsystem (EPS), design and management (system architecture, power generation, power maintenance, power control, etc.)

MODULE 5:

Analysis of sample real Satellite data using MATLAB Tool with various examples

CHAPTER 2

A BRIEF OVERVIEW OF SMALL SATELLITES

2.1 ABOUT SATELLITES.

In the context of spaceflight, a satellite is an object that has been intentionally placed into orbit. These objects are called artificial satellites to distinguish them from natural satellites such as Earth's Moon.

Satellites are used for many purposes. Among several other applications, they can be used to make star maps and maps of planetary surfaces, and also take pictures of planets they are launched into. Common types include military and civilian Earth observation satellites, communications satellites, navigation satellites, weather satellites, and space telescopes. Space stations and human spacecraft in orbit are also satellites.

Satellites can operate by themselves or as part of a larger system, a satellite formation or satellite constellation.

Satellite orbits vary greatly, depending on the purpose of the satellite, and are classified in a number of ways. Well-known (overlapping) classes include low Earth orbit, polar orbit, and geostationary orbit.

A launch vehicle is a rocket that places a satellite into orbit. Usually, it lifts off from a launch pad on land. Some are launched at sea from a submarine or a mobile maritime platform, or aboard a plane (see air launch to orbit).

Satellites are usually semi-independent computer-controlled systems. Satellite subsystems attend many tasks, such as power generation, thermal control, telemetry, attitude control, scientific instrumentation, communication, etc.

Figure 1 A TYPICAL view of CUBE SAT IN SPACE

2.2 CLASSIFICATION OF SATELLITES.

Satellite types according to mass:

- Large satellites: More than 1,000 kg.
- Medium-sized satellites: 500-1,000 kg.
- Small satellites:
  - Mini satellite: 100-500 kg.
  - Micro satellite: 10-100 kg.
  - Nano satellite: 1-10 kg.
  - Pico satellite: Less than 1 kg.
  - Femto satellites: less than 10g.
  - Atto satellites: 1g-10g.
  - Zepto satellites: 0.1g-1g.

2.3 CUBE SATS.

A CubeSat (U-class spacecraft) is a type of miniaturized satellite for space research that is made up of multiples of 10 cm × 10 cm × 10 cm cubic units. CubeSats have a mass of no more than 1.33 kilograms (2.9 lb.) per unit, and often use commercial off-the-shelf (COTS) components for their electronics and structure.

CHAPTER 3

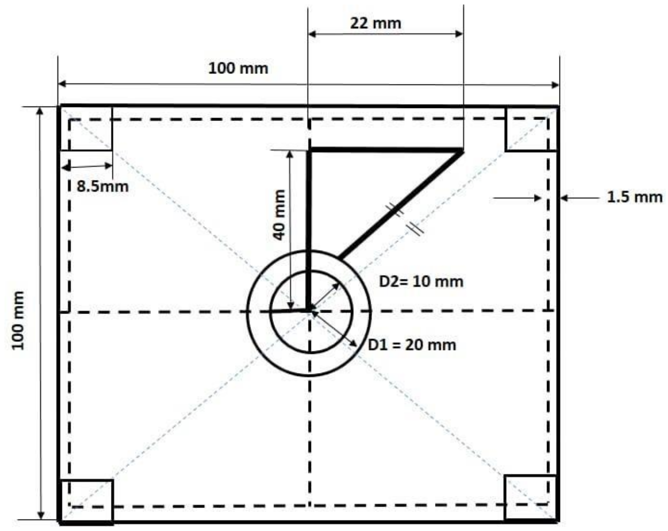
DESIGNING AND MODELLING A CUBESAT FRAME

3.1 CUBESAT STRUCTURE

As for all space missions, including cube sat, the structure is one of the main satellite subsystems. In principle, the purpose of the structural subsystem is to provide a simple and robust structure that shall survive launch loads and provide a suitable environment for the operation of all subsystems. Furthermore, the structure mechanically supports all other spacecraft subsystems, attaches the spacecraft to the launch vehicle, and provides for ordnance-activated separation. Generally, structural design shall aim for simple load paths, simplified interfaces, and easy integration.

The design of space structural systems is dictated by mass, stiffness, and strength requirements. On the one hand, stiffness is required to ensure the survivability of the instrumentation; on the other hand, by reducing the weight, it is possible to increase the payload, which extends the mission goals and also reduces the launch cost. The structural and mechanical parts of a satellite generally represent a large percentage of its mass, and therefore, it is important to choose the proper material and structural configuration to minimize mass. Finally, cube sat design is bound by the general constrains and requirements of stiffness. [2]

3.2 CUBESAT STRUCTURE DESIGN



The design process of the structure is an iterative process as is the case with the other subsystems. The process accounts for the upcoming necessary changes evolving from the interaction between the subsystems. Using the above design plan the structure was modelled and assembled using SOLIDWORKS.

Steps involved for modelling the structure.

- Making the 2d plan form.
- Extruding the structure accordingly.
- Make all the sides and save as different parts.
- Open solid works assembly and assemble all the sides

Different structures were made as case studies using the same methodology.

CHAPTER 4

MICROSTRIP PATCH ANTENNAS

4.1 INTRODUCTION

In telecommunication, a microstrip antenna (also known as a printed antenna) usually means an antenna fabricated using microstrip techniques on a printed circuit board (PCB). It is a kind of internal antenna. They are mostly used at microwave frequencies.

4.2 MICROSTRIP ANTENNAS

Microstrip antennas have profound applications especially in the field of medical, military, mobile and satellite communications. Their utilization has become diverse because of their small size and light weight. Rapid and cost effective fabrication is especially important when it comes to the prototyping of antennas for their performance evaluation. As wireless applications require more and more bandwidth, the demand for wideband antennas operating at higher frequencies becomes inevitable. Inherently microstrip antennas have narrow bandwidth and low efficiency and their performance greatly depends on the substrate parameters i.e. its dielectric constant, uniformity and loss tangent

CHAPTER 5

DESIGN METHODOLOGY FOR CIRCULAR PATCH

5.1 FORMULA.

The procedure assumes that the specified information includes the dielectric constant of the substrate (εr), the operating frequency (fr) and the height of the substrate (h). To find the actual radius 'a' of the patch.

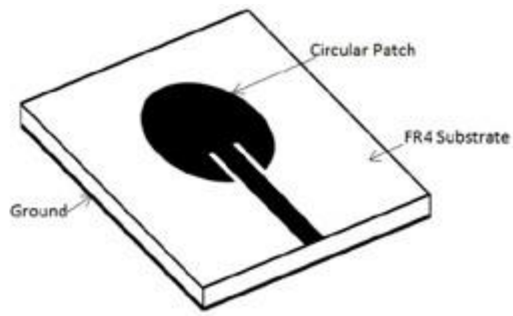


Figure 2 A TYPICAL view of CIRCULAR MICROSTIP PATCH ANTENNA

ACTUAL RADIUS (a) = $\frac{F}{\sqrt{\{1+\frac{2h}{\pi\varepsilon rF}(\ln\frac{\pi F}{2h})+1.7726)\}}}$

Whereas F = $\frac{8.791\times10^{9}}{f_r\sqrt{\varepsilon_r}}$

In the above equations we should remember that the operating frequency Fr should be taken in Hertz (Hz) and the height of the substrate h should be taken in Centimetres (cm).

5.2 CALUCULATIONS

From the formula provided above we can calculate the effective radius of the circular micro strip patch antenna.

Consider, f_r= 2.4GHz

And $\varepsilon_r = 4.4$

After calculating we get

Radius of the patch (a) = 16.9mm

5.3 MODELLING IN THE HFSS13.0 ENVIRONMENT

Modelling of the micro strip patch is done in ANSOFT HFSS 13.0 software. The model contains a PATCH, GROUND PLATE and SUBSTRATE.

The antenna is designed for the band width frequency of 2.4GHz and di-electric constant of 4.4

5.3.1 MODELLING OF SUBSTRATE.

- Create a box from origin using below parameters.
- Position: 0, 0, 0.
- X size: 67.9 mm.
- Y size: 67.9 mm.
- Z size: 1.6 mm.

5.3.2 MODELLING OF GROUND PLATE.

- Create a box from origin using below parameters.
- Position: 0, 0, 0.
- X size: 67.9 mm.
- Y size: 67.9 mm.
- Z size: -0.1 mm.

5.3.3 MODELLING OF PATCH.

- Create a cylinder using below parameters.
- Position: 33.8, 33.8, 1.6.
- Radius: 16.9 mm.
- Height: 0.1 mm.

5.3.4 MODELLING OF CUT.

- Create a box using below parameters.
- Position: 32.3, 16.9, 1.6.
- X size: 3 mm.
- Y size: 16 mm.
- Z size: 0.1 mm.

5.3.5 MODELLING OF FEED.

- Create a box using below parameters.
- Position: 32.8, 0, 1.6.
- X size: 2 mm.
- Y size: 34 mm.
- Z size: 0.1 mm.

After creating CUT, a Boolean subtract operation is done (PATCH-CUT).

After creating FEED, Boolean unite operation is done (PATCH+FEED).

Rename the final one as PATCH.

5.4 MATERIALS AND COLOURS

There are several material data available in library out of those materials, this modelling contains the following materials. The material properties that are predefined for as per the standards.

SUBSTRATE	-	FR4 EPOXY.
GROUND	-	COPPER.
PATCH	-	COPPER.

The colours for the parts is give as following.

SUBSTRATE	-	GREY.
GROUND	-	REDDISH BROWN.
PATCH	-	REDDISH BROWN.

CHAPTER 6

DESIGN METHODOLOGY FOR RECTANGULAR PATCH

6.1 FORMULA.

The procedure assumes that the specified information includes the dielectric constant of the substrate (ε_r), the operating frequency (fr) and the height of the substrate (h). To find the LENGTH AND WIDTH of the patch.

$$\text{Width, } W = c \frac{c}{2f_0\sqrt{\frac{(\varepsilon r+1)}{2}}}$$

Where, f_0= resonating frequency

C = speed of light ($3x10^8$ m/s)

ε_r = relative permittivity of the di-electric substrate.

Calculation of Effective Dielectric constant

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-0.5}$$

Where, h = height of substrate

W = calculated width

ε_r = relative permittivity of the di-electric substrate.

Calculation of Effective Length

$$L_{eff} = c \frac{c}{2f_0\sqrt{\varepsilon_{eff}}}$$

Where, f_0= resonating frequency; C = speed of light ($3x10^8$ m/s) ε_r

= relative permittivity of the di-electric substrate.

Calculation of Length extension ΔL

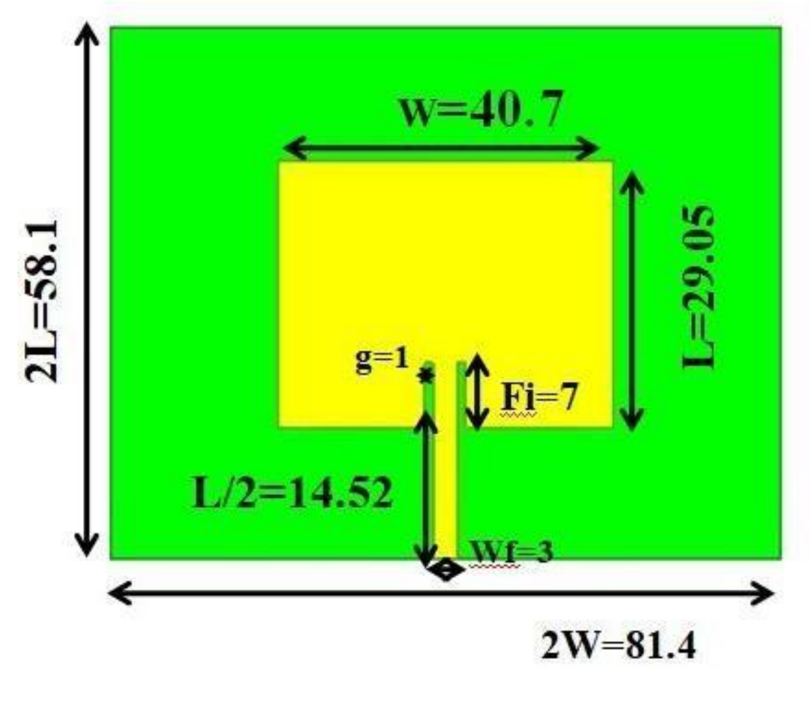
$$\Delta L = \frac{(\varepsilon_{eff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{eff} - 0.258)(\frac{W}{h} + 0.3)}$$

Calculation of Length extension ΔL

$$L = L_{eff} - 2\,\Delta L$$

Where, L_{eff}= calculated effective

ΔL = length extension



6.2 MODELLING IN THE HFSS13.0 ENVIRONMENT

Modelling of the micro strip patch is done in ANSOFT HFSS 13.0 software. The model contains a PATCH, GROUND PLATE and SUBSTRATE.

The antenna is designed for the band width frequency of 2.4GHz and di-electric constant of 4.4. The following data provides the dimensions and positions for the model.

6.2.1 MODELLING OF SUBSTRATE.

- Create a box from origin using below parameters.
- Position: 0, 0, 0.
- X size: 51.8 mm.
- Y size: 81.4 mm.
- Z size: 1.6 mm.

6.2.2 MODELLING OF GROUND PLATE.

- Create a box from origin using below parameters.
- Position: 0, 0, 0.
- X size: 51.8 mm.
- Y size: 51.8 mm.
- Z size: -0.1 mm.

6.2.3 MODELLING OF PATCH.

- Create a box from origin using below parameters.
- Position: 0, 0, 0.
- X size: 29.05 mm.
- Y size: 40.7 mm.
- Z size: 0.1 mm.

6.2.4 MODELLING OF CUT.

- Create a box using below parameters.
- Position: 36.575, 38.2, 1.6.
- X size: 7 mm.
- Y size: 5 mm.
- Z size: 0.1 mm.

6.2.5 MODELLING OF FEED.

- Create a box using below parameters.
- Position: 36.575, 39.21, 1.6.
- X size: 21.52 mm.
- Y size: 3 mm.
- Z size: 0.1 mm.

6.3 MATERIALS AND COLOURS

There are several material data available in library out of those materials, this modelling contains the following materials. The material properties that are predefined for as per the standards.

SUBSTRATE	-	FR4 EPOXY.
GROUND	-	COPPER.
PATCH	-	COPPER.

The colours for the parts is give as following.

SUBSTRATE	-	GREY.
GROUND	-	REDDISH BROWN.
PATCH	-	REDDISH BROWN.

CHAPTER 7

REMOTE SENSING

7.1 INTRODUCTION

Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites. Remote sensors collect data by detecting the energy that is reflected from earth. These sensors can be on satellites or can be mounted on an aircraft.

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation, especially the Earth. Remote sensing is used in numerous fields, including geography, land surveying and most Earth science disciplines (for example, hydrology, ecology, meteorology, oceanography, glaciology, geology); it also has military, intelligence, commercial, economic, planning, and humanitarian applications.

In current usage, the term "remote sensing" generally refers to the use of satellite- or aircraft-based sensor technologies to detect and classify objects on Earth, including on the surface and in the atmosphere and oceans, based on propagated signals (e.g. electromagnetic radiation). It may be split into "active" remote sensing (such as when a signal is emitted by a satellite or aircraft and its reflection by the object is detected by the sensor) and "passive" remote sensing (such as when the reflection of sunlight is detected by the sensor). [3]

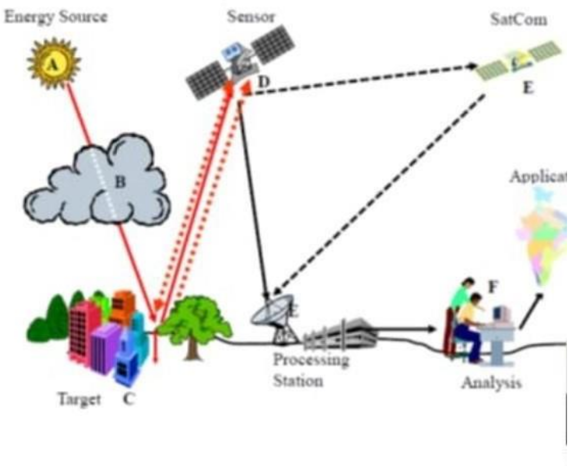


Figure 3 REMOTE SENSING

7.2 INDIAN REMOTE SENSING PROGRAMME

India's remote sensing program was developed with the idea of applying space technologies for the benefit of human kind and the development of the country. The program involved the development of three principal capabilities. The first was to design, build and launch satellites to a sun synchronous orbit. The second was to establish and operate ground stations for spacecraft control, data transfer along with data processing and archival. The third was to use the data obtained for various applications on the ground.

7.3 IRS DATA APPLICATIONS:

Data from Indian Remote Sensing satellites are used for various applications of resources survey and management under the National Natural Resources Management System (NNRMS). Following is the list of those applications:

- Space Based Inputs for Decentralized Planning (SIS-DP)
- National Urban Information System (NUIS)
- ISRO Disaster Management Support Programme (ISRO-DMSP)
- Biodiversity Characterizations at landscape level- http://bis.iirs.gov.in
- Pre-harvest crop area and production estimation of major crops.
- Drought monitoring and assessment based on vegetation condition.
- Flood risk zone mapping and flood damage assessment.

- Hydro-geomorphological maps for locating underground water resources for drilling well.
- Irrigation command area status monitoring
- Snow-melt run-off estimates for planning water use in downstream projects
- Land use and land cover mapping
- Urban planning
- Forest survey
- Wetland mapping
- Environmental impact analysis
- Mineral Prospecting
- Coastal studies
- Integrated Mission for Sustainable Development (initiated in 1992) for generating locale-specific prescriptions for integrated land and water resources development in 174 districts.
- North Eastern District Resources Plan (NEDRP)- www.nedrp.gov.in

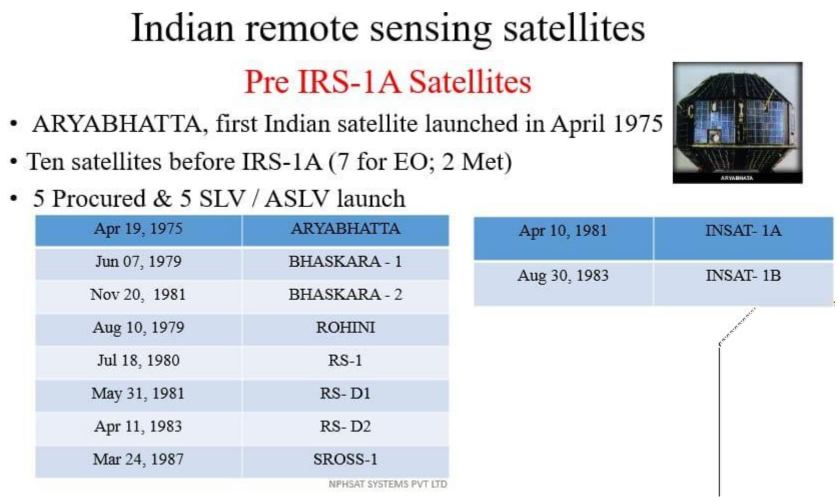


Figure 4 INDIAN REMOTE SENSING SATELLITES

Figure 5 IRS-1A

The initial versions are composed of the 1 (A, B, C, D). The later versions are named based on their area of application including Ocean Sat, Carto Sat, and Resource Sat. Some of the satellites have alternate designations based on the launch number and vehicle (P series for PSLV).IRS-1A is the first earth orbit application satellite carried 4-band multispectral camera (3 no s).

Early IRS Multispectral Sensors

- 1st Generation : IRS-1A, IRS-1B
- 2nd Generation : 3 tier image (WiFS/AWiFS), SWIR band ; IRS-1C/1D, Resourcesat-1/2

Mission	IRS-1A	IRS-1B	IRS-1C	IRS-1D
Weight (kg)	975 kg	975 kg	1250kg	1250kg
Onboard power	600 Watts	600 Watts	809 Watts/(9.6 sqm)	809 Watts/(9.6 sqm)
Payloads, (Solid State Push Broom Camera)	LISS-1 (72.5 m) LISS-2A , 2B (36.25 m)	LISS-1 (72.5 m) LISS-2A , 2B (36.25 m)	WiFS (189 m) LISS-3 (23.6m) & PAN (<6m)	WiFS (189 m) LISS-3 (23.6m) & PAN (<6m)
Onboard TapeRecorder	-	-	62 Gb	62 Gb
Launch /	Mar 17,1988	Aug29,1991	Dec 28, 1995	27 Sep 1997
Mission Completion	Jul 1996	Dec20,2003	Sep 21, 2007	Jan 2010
Orbit # (ht km)	904 km	904 km	817 km	817 km

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Figure 6 IRS DETAILS

In the above picture, WiFs – wide field sensor

AWifs – advanced wide field sensor

LISS – linear imaging self-scanning sensor

PAN sensors in IRS 1C and 1D are the sensors used to send panchromatic images. These satellites will be having 2 cameras front and back to capture the same image and combine them to acquire good resolution.

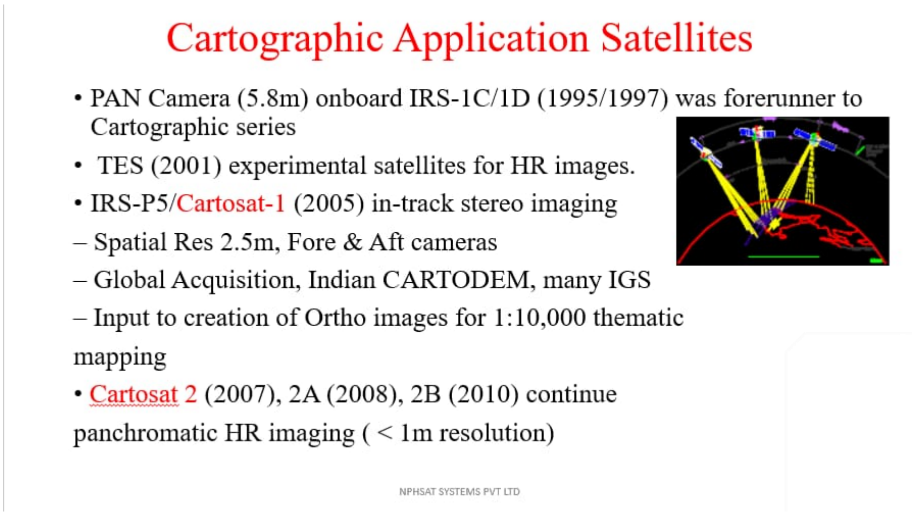

Figure 8 CARTOGRAPHIC APPLICATION SATELLITES (CARTOSATS)

7.4 CARTOSATS

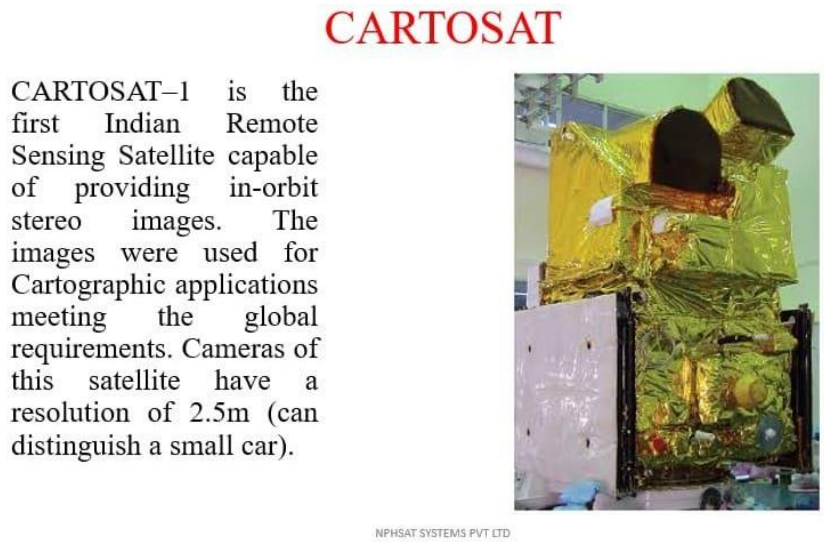

Figure 9 CARTOSATS

The Cartosat satellites are a series of Indian optical earth observation satellites built and operated by the Indian Space Research Organisation (ISRO). The Cartosat series is a part of the Indian Remote Sensing Program. They are used for Earth's resource management, defence services and monitoring. This is a major remote sensing satellite used for monitoring forests and land etc. It is having a good resolution of 2.5 meters.

CARTOSAT gives PAN Images and Resource sat gives multispectral images.

CHAPTER 8

CRYPTOGRAPHY

8.1 INTRODUCTION

Cryptography is a method of protecting information and communications through the use of codes, so that only those for whom the information is intended can read and process it. The prefix "crypt-" means "hidden" or "vault" -- and the suffix "-graph" stands for "writing." Cryptography is the study of secure communications techniques that allow only the sender and intended recipient of a message to view its contents. ... When transmitting electronic data, the most common use of cryptography is to encrypt and decrypt email and other plain-text messages.

Encryption processes:

Transforming data using the algorithm to make it unreadable to anyone except those possessing the key.

Through the insecure channel there may be a chance of third party (hacker) entering into the system and the data can be stolen. But if we have a "key, it is very hard to hack the data. Only the person who knows the key can get access of data.

8.2 LIGHT WEIGHT CRYPTOGRAPHY

Lightweight cryptography is an encryption method that features a small footprint and/or low computational complexity. It is aimed at expanding the applications of cryptography to constrained devices and its related international standardization and guidelines compilation are currently underway.

It endorses algorithms which are best suited for constrained environment. For e.g. RFID Tags, sensors, contactless smart cards etc.

8.3 CASE STUDY

This is the case where the temperature data on mars is sent back to ground station. Using an existing cipher (LiCi) for encryption and decryption by a 128 bit key. The encryption is done using hexadecimal pattern.

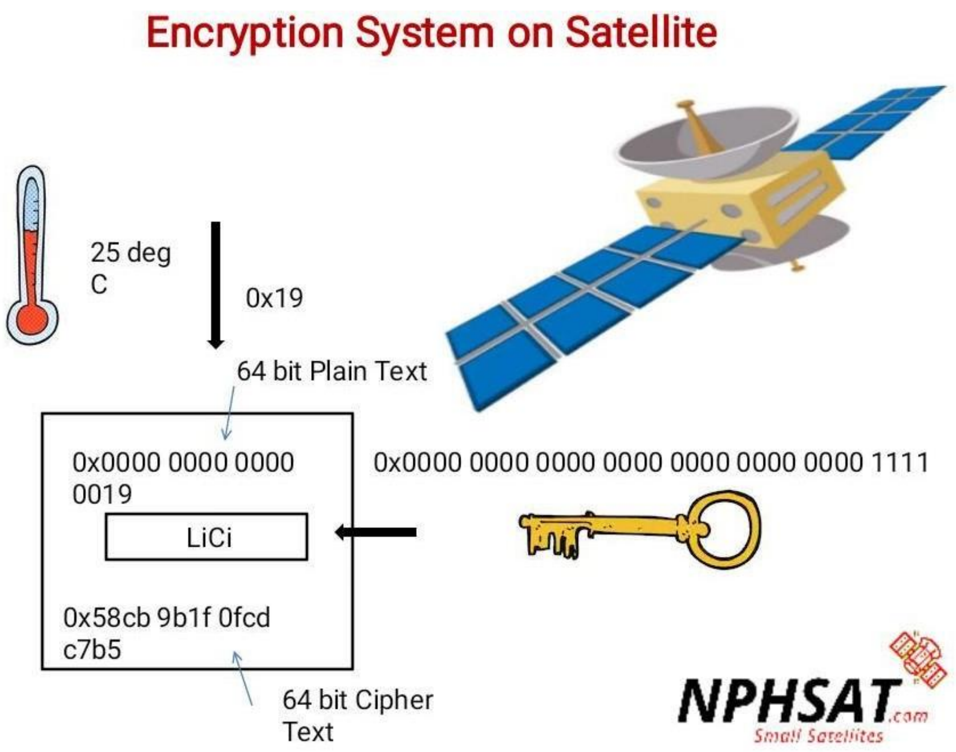

Figure 16 ENCRYPTION SYSTEM ON A SATELLITE

This encrypted data is sent to the ground station along with the key in the format of cipher text. This text is decrypted using the key and data is acquired from the cipher text.

CHAPTER 9

SOLUTION AND RESULTS

9.1 MODELS

Some of the results were calculated for four types of micro strip patches Namely-

- Rectangular micro strip patch with a cut.
- Rectangular micro strip patch without a cut.
- Circular micro strip patch with a cut.
- Circular micro strip patch without a cut.

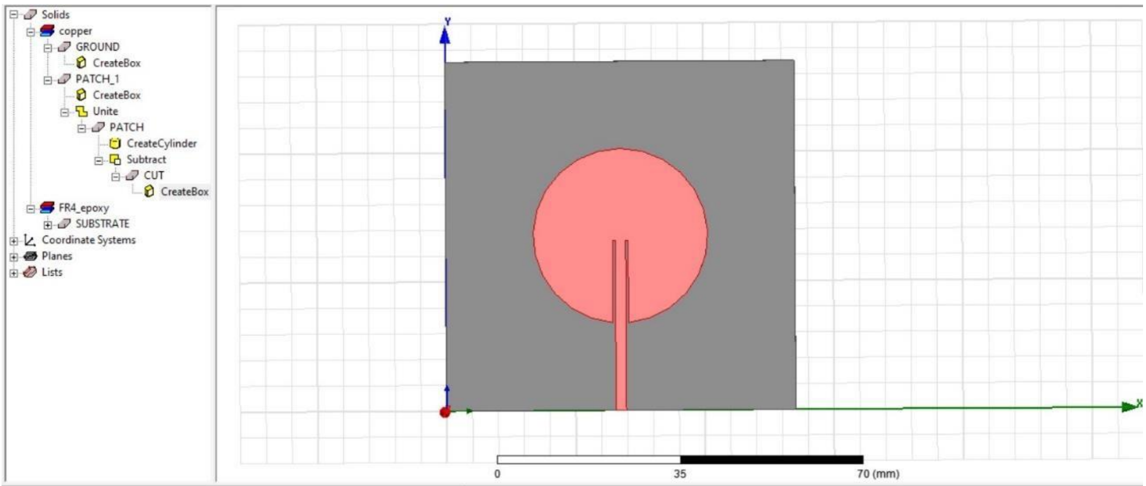

Figure 17 CIRCULAR PATCH WITH A CUT

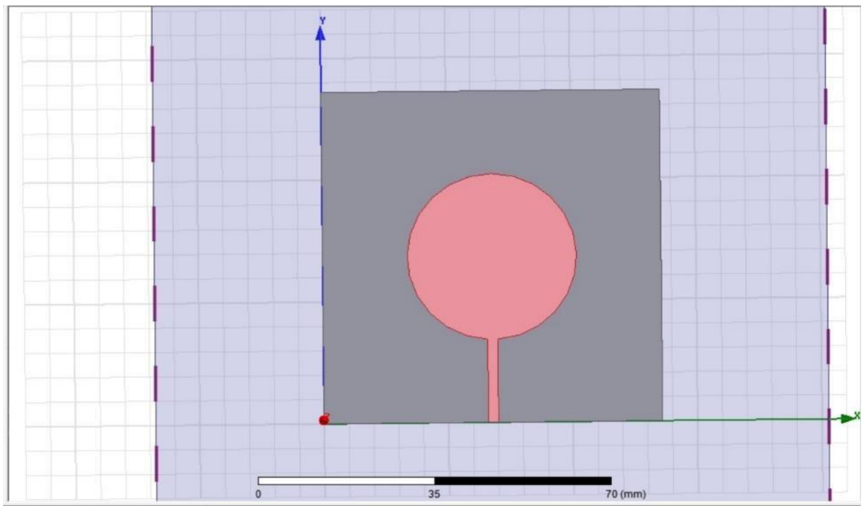

Figure 18 CIRCULAR PATCH WITHOUT A CUT

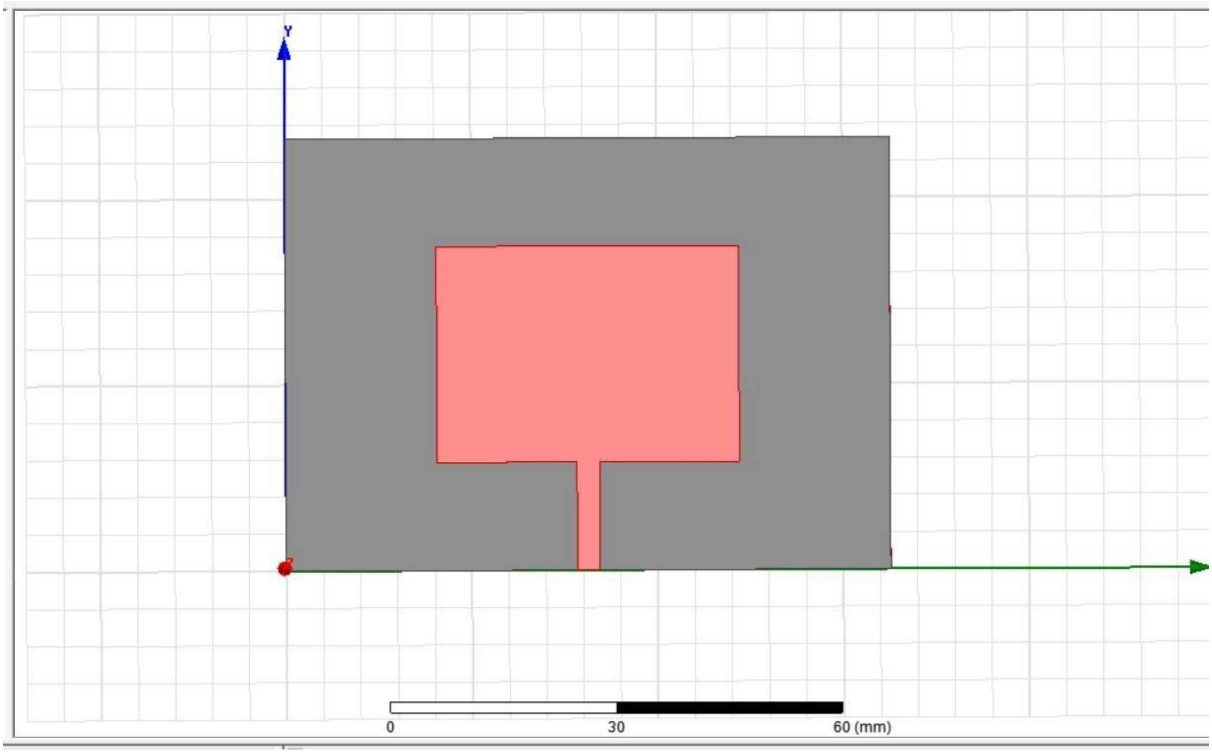

Figure 19 RECTANGULAR PATCH WITHOUT A CUT

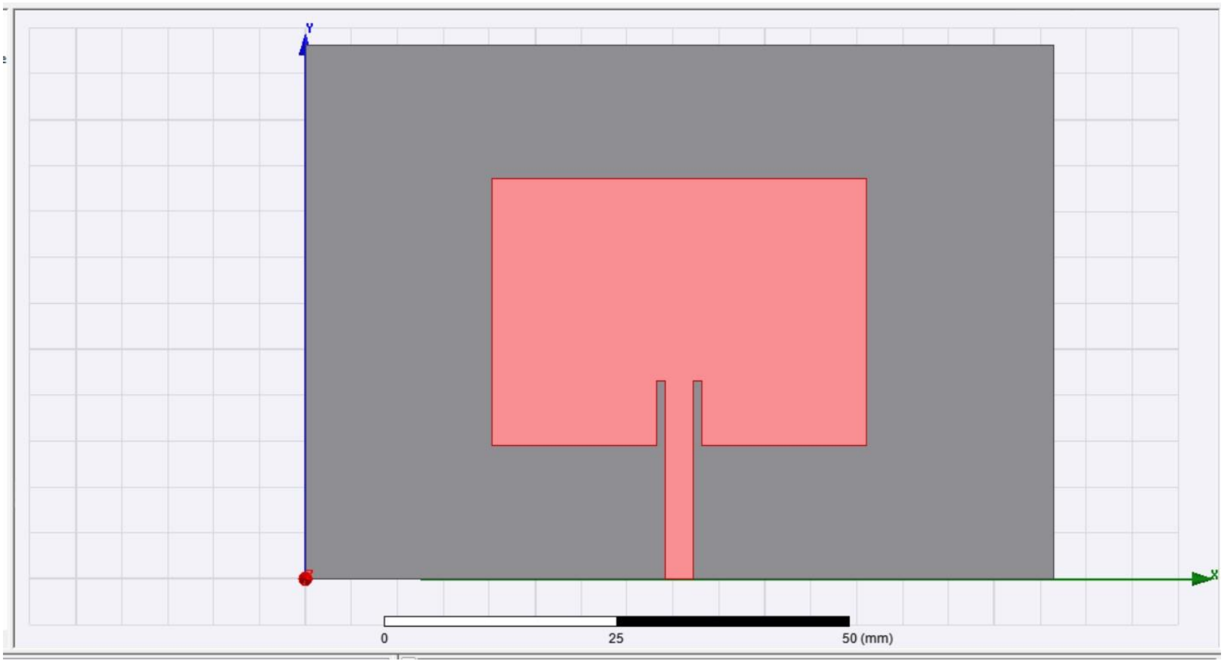

Figure 20 RECTANGULAR PATCH WITH CUT

9.2 COMPARISION TABLE

A comparison between the J-surf contour, FREQ vs. VSWR and FREQ vs. S Parameter of different micro strip patches is tabulated below.

9.2.1 S-PARAMETER vs. FREQ (Hz)

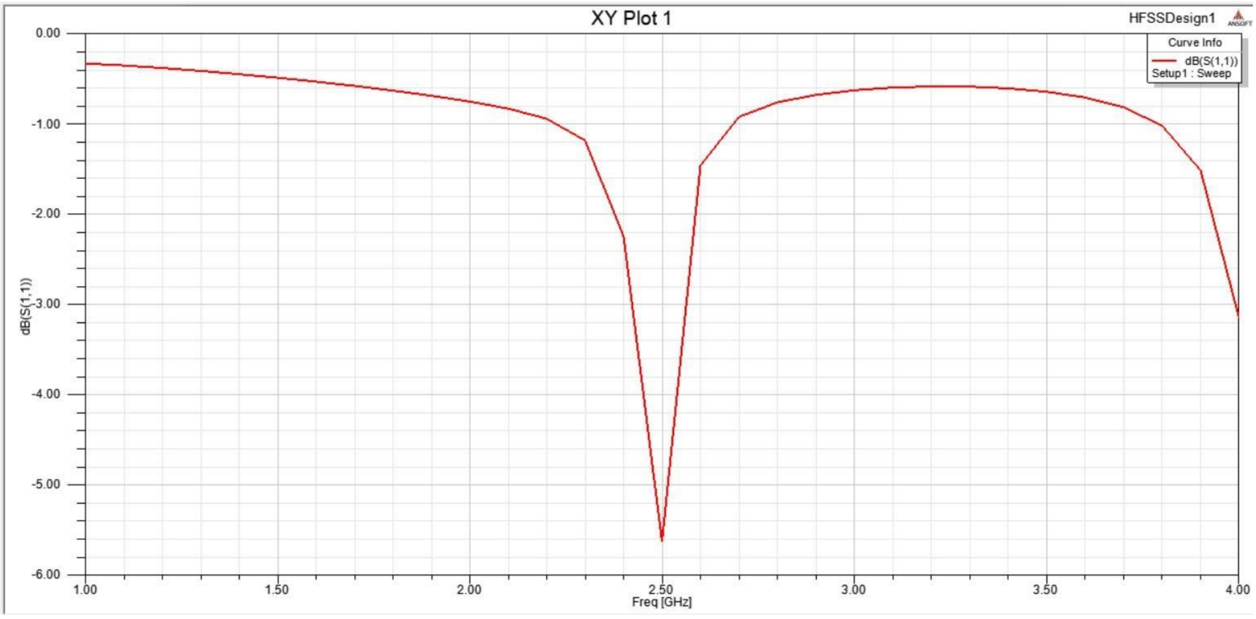

Figure 21 S-PARAMETER OF CIRCULAR PATCH WITH CUT

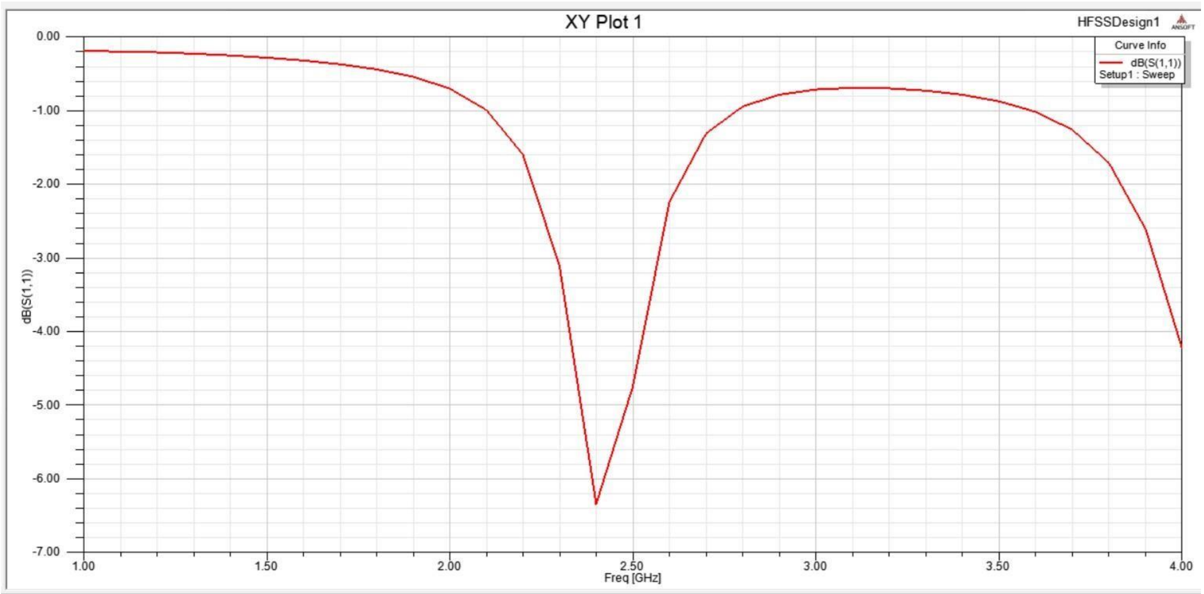

Figure 22 S-PARAMETER OF CIRCULAR PATCH WITHOUT CUT

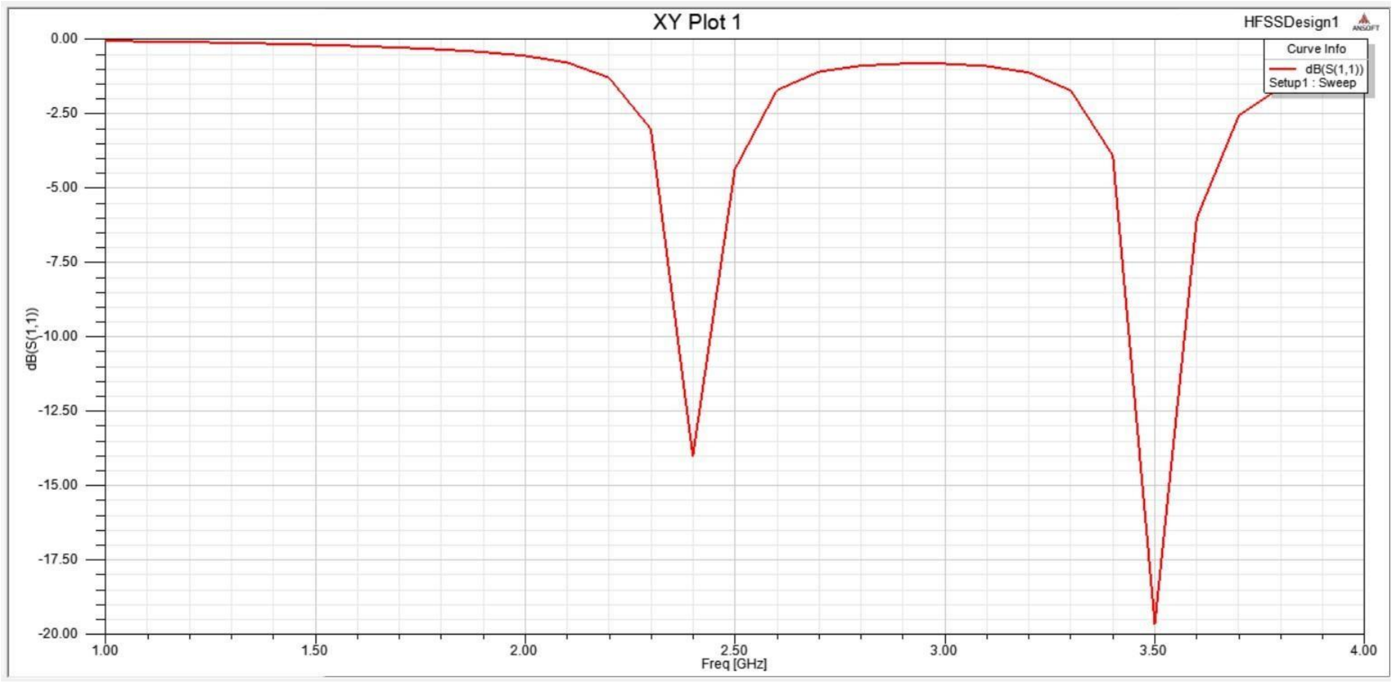

Figure 23 S-PARAMETER OF RECTANGULAR PATCH WITH CUT

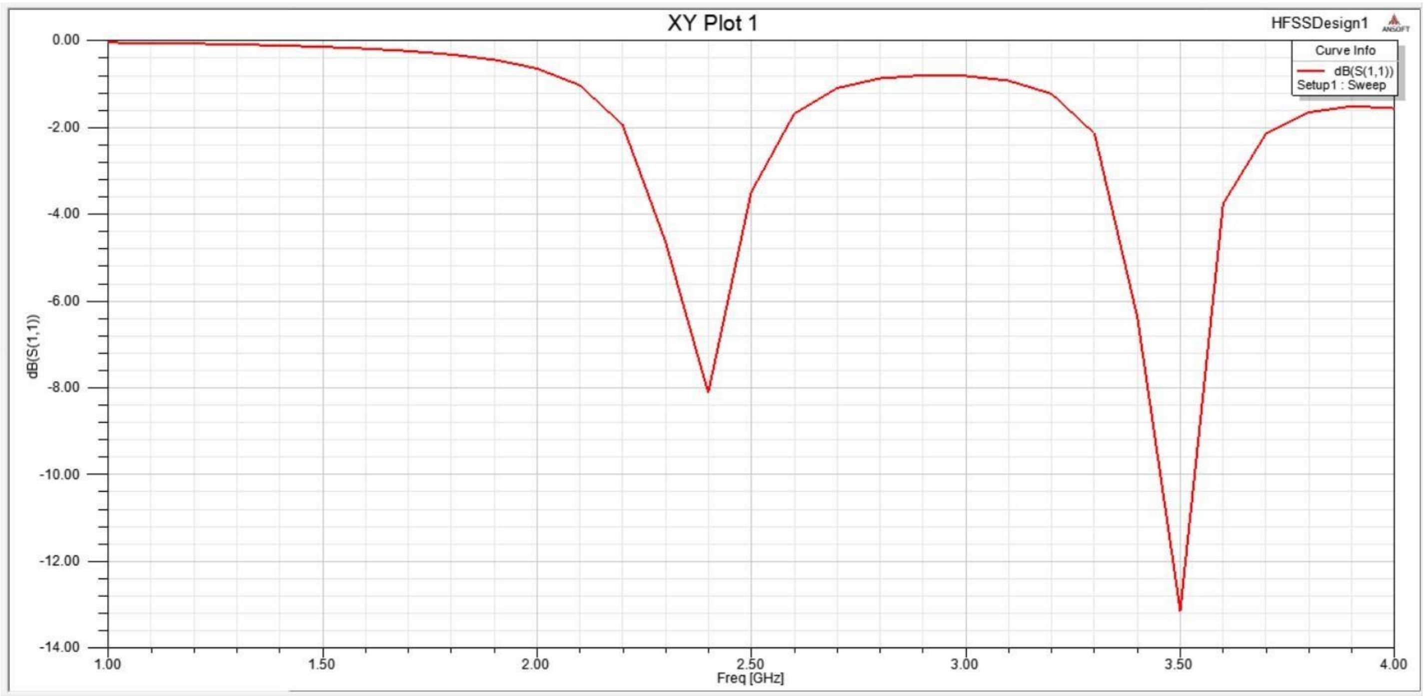

Figure 24 S-PARAMETER OF RECTANGULAR PATCH WITHOUT CUT

9.2.2 VSWR-PARAMETER vs. FREQ (Hz)

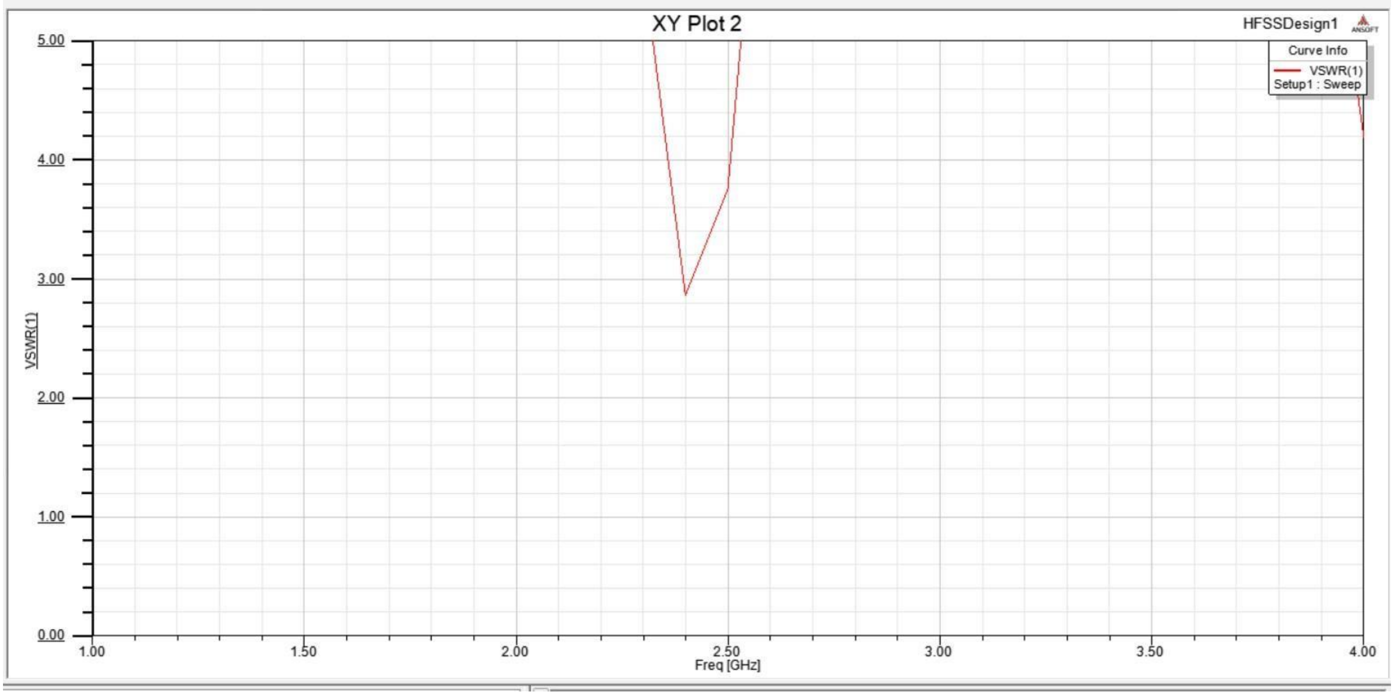

Figure 25 VSWR-PARAMETER OF CIRCULAR PATCH WITH CUT

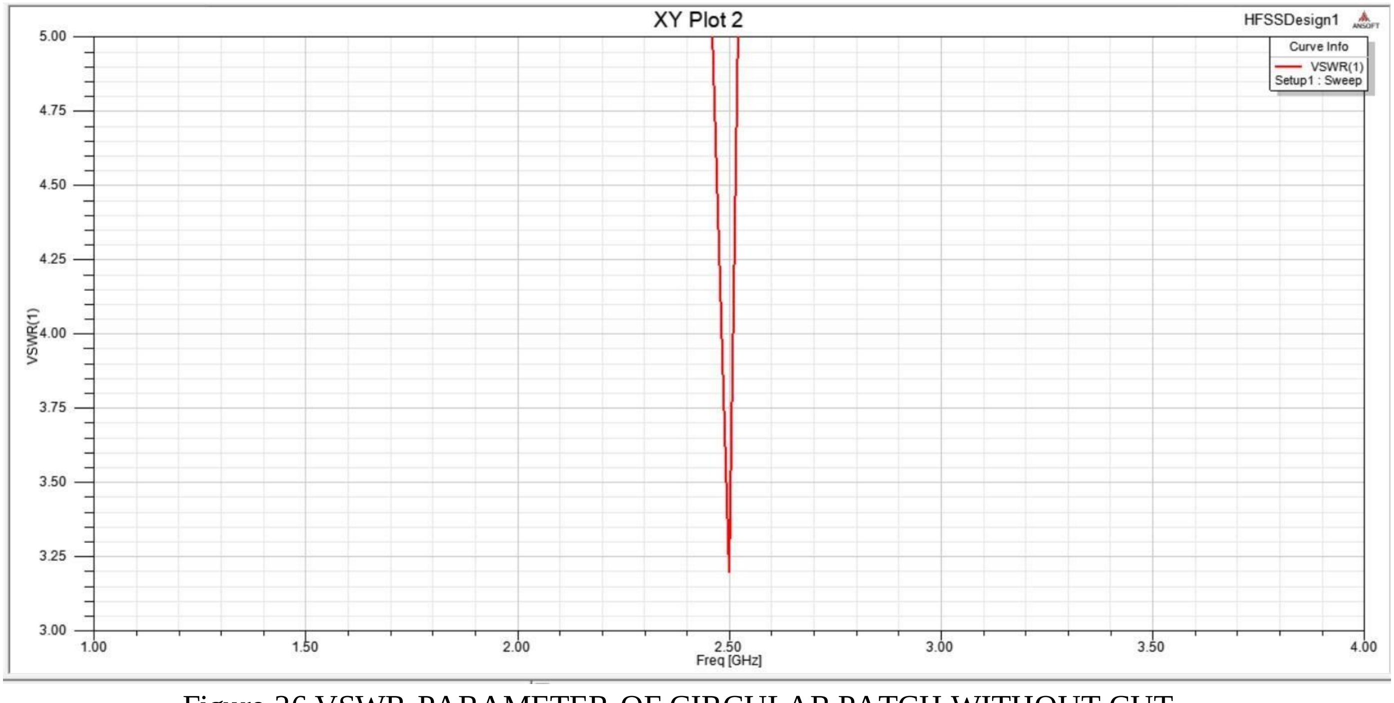

Figure 26 VSWR-PARAMETER OF CIRCULAR PATCH WITHOUT CUT

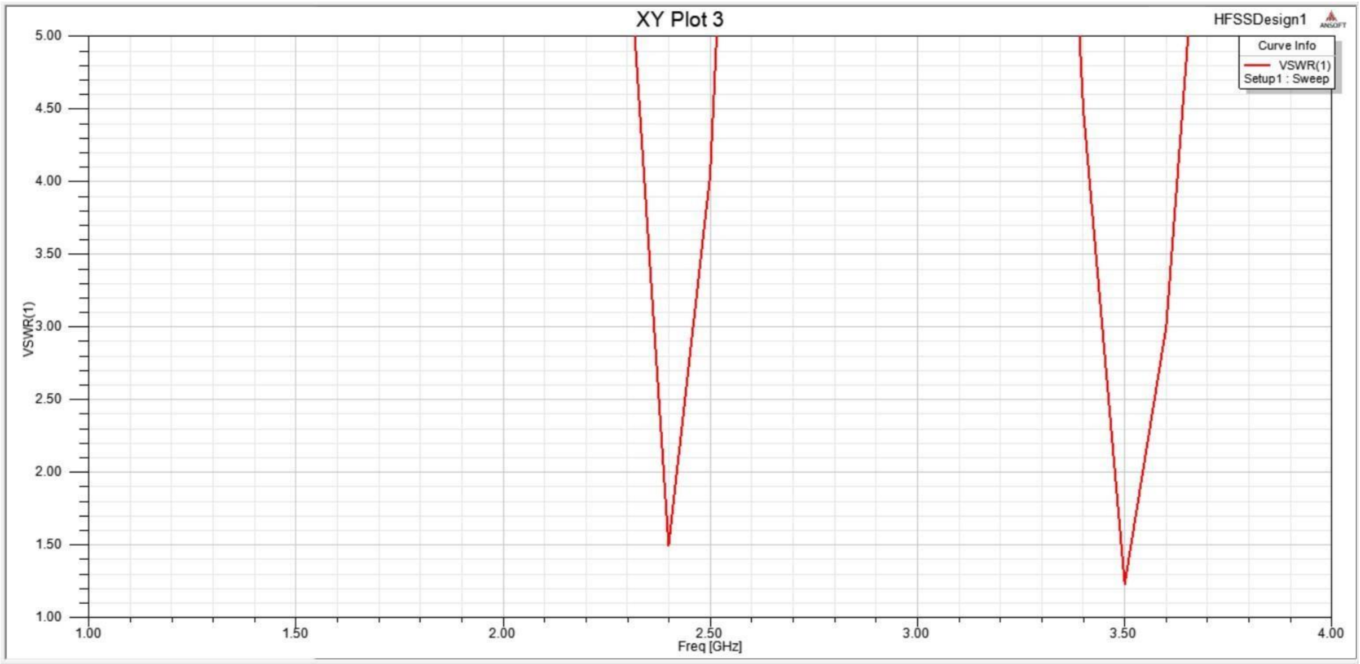

Figure 27 VSWR-PARAMETER OF RECTANGULAR PATCH WITH CUT

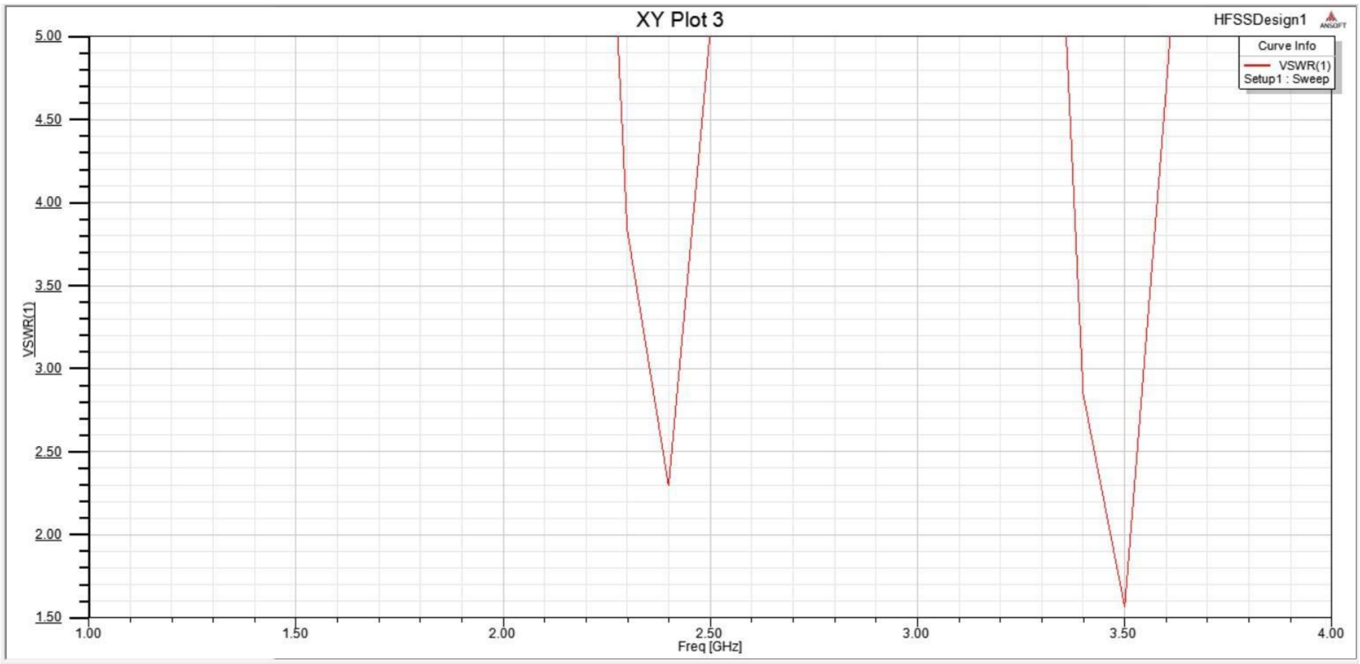

Figure 28 VSWR-PARAMETER OF RECTANGULAR PATCH WITHOUT CUT

9.2.3 J-surf contours

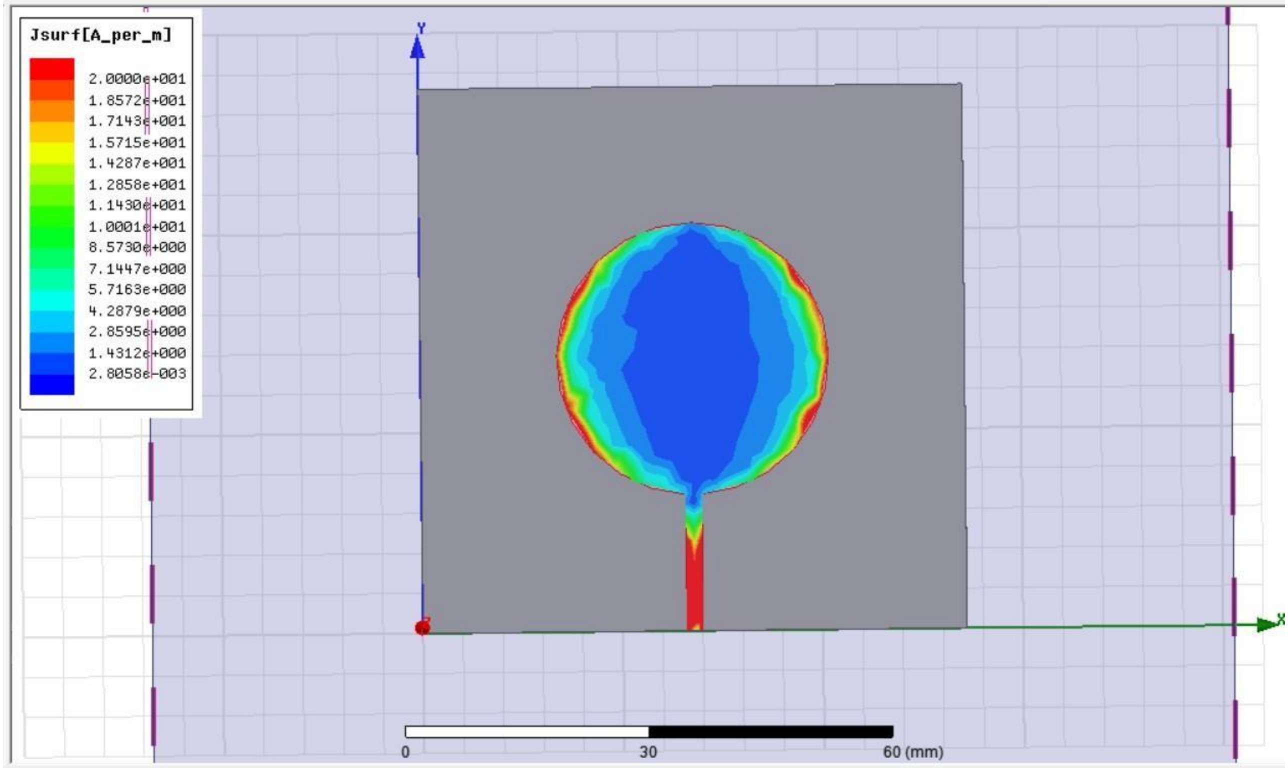

Figure 29 J-surf CONTOUR OF CIRCULAR PATCH WITHOUT CUT

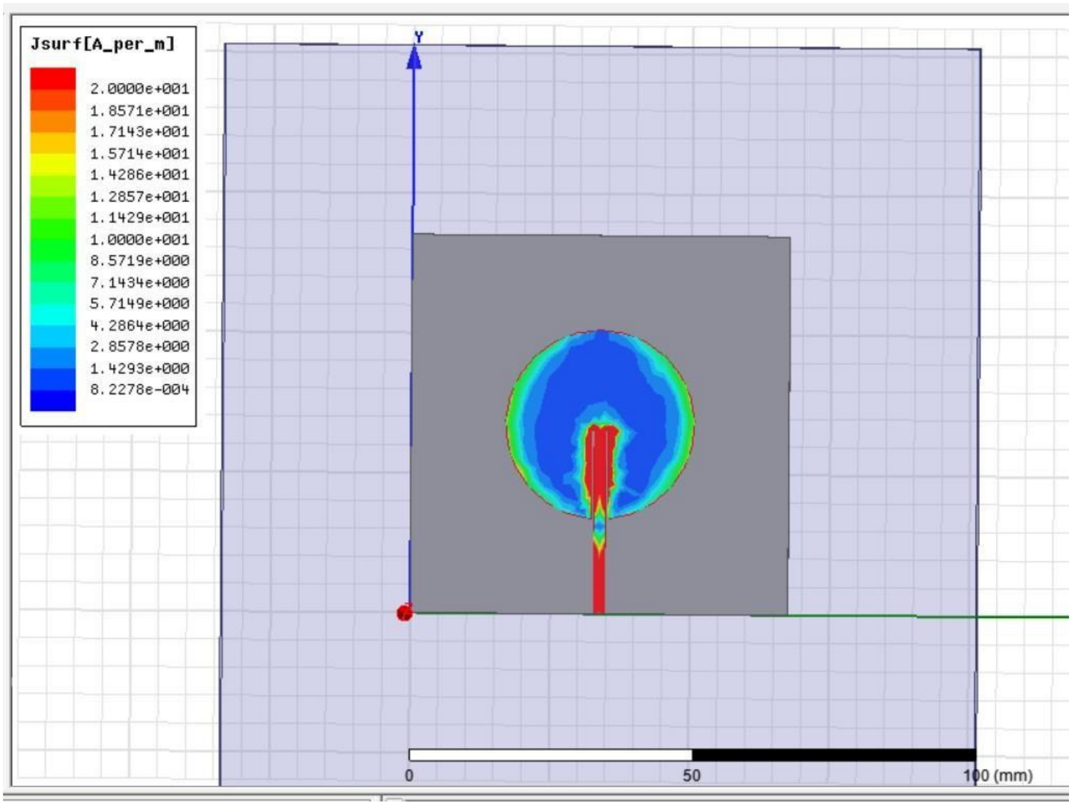

Figure 30 J-surf CONTOUR OF CIRCULAR PATCH WITH CUT

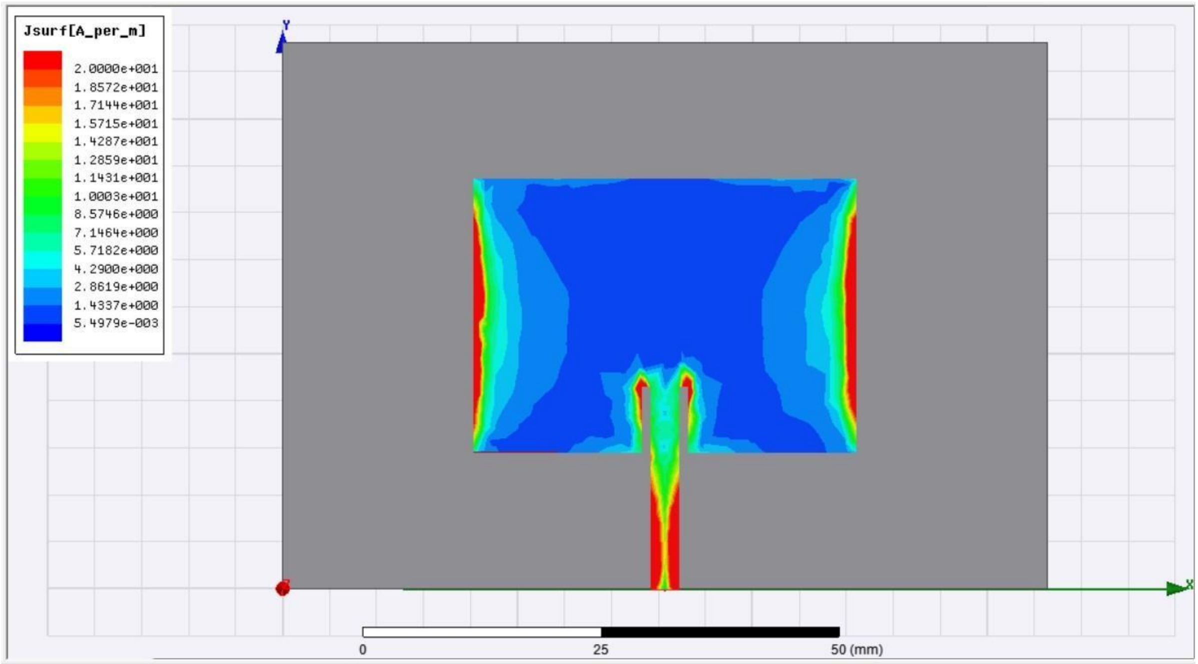

Figure 31 J-surf CONTOUR OF RECTANGULAR PATCH WITH CUT

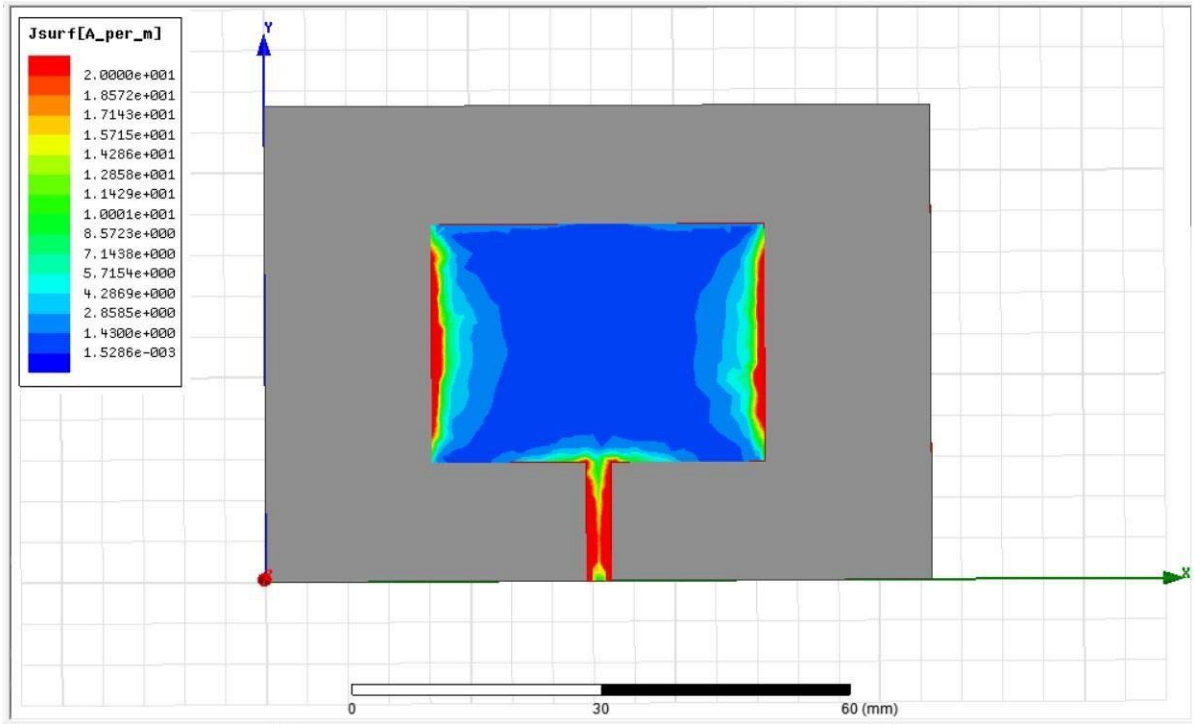

Figure 32 J-surf CONTOUR OF RECTANGULAR PATCH WITHOUT CUT

9.3 RESULT AND DISCUSSION

The CubeSat design was done using the SOLIDWORKS and also using Fusion 360.The design case studies were done by modelling different base structures and outlines.

Different types of microstrip patch antennas were designed and simulated using ANSOFT HFSS software. It is observed in j-surf contour that the rectangular patch antenna with cut propagates or radiates decently as it has the more perimeter covered there by having better surface current distribution.

The Voltage Standing wave Ratio (VSWR) and s- parameter graphs shows how efficiently the designed antenna works and these graphs also shows the resonant frequency at which antenna is responding for the given bandwidth.

The MALAB results were of the satellite image taken from google maps and is processed to get the number of tree crowns. This analysis is very useful to know the amount of trees present in an area and to know the tree densities.

This internship on CubeSats was very useful. I learnt a new software to design the antennas. Antennas plays a very important role in satellite through which all the communication will be carried out. And the Principle component analysis algorithm used to analyse the tree density can also be used in NDT crack detection as it basically uses edge detection technique. Finally, this internship helped me a lot to improve my knowledge in satellites which will be useful in my future studies.

REFERENCES

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