

BRAIN TUMOR DETECTION ANALYSIS AND IMPLEMENTATION USING MICROSTRIP PATCH ANTENNA

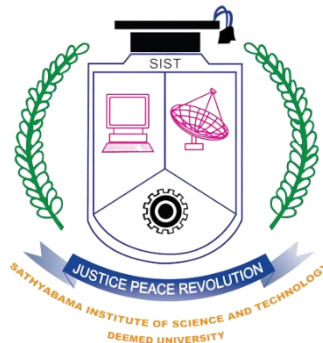
A Project Report Phase – II

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Electronics and Communication Engineering

by

G V LOHITH REDDY (39130263)

KONCHADA PAVAN (39130235)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

APRIL - 2023



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Accredited with "A" grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in

DEPARTMENT OF ELECTRONICS AND COMMUNICAITON ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report Is the bonafide work of **G V LOHITH REDDY (39130263), KONCHADA PAVAN (39130235)** who carried out the project entitled "**BRAIN TUMOR DETECTION ANALYSIS AND IMPLEMENTAION USING MICROSTRIP PATCH ANTENNA**" under our supervision from July 2022 to April 2023.

Internal Guide

Dr. I REXILINE SHEEBA, M.E., Ph.D.

Head of the Department

Dr. T. RAVI, M.E., Ph.D.,

20.04.23

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

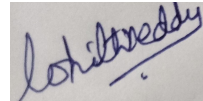
WE **G V LOHITH REDDY AND KONCHADA PAVAN** hereby declare that the Project Report entitled “**BRAIN TUMOR DETECTION ANALYSIS AND IMPLEMENTATION USING MICRSTRIP PATCH ANTENNA**” done by us under the guidance of **Dr. I REXILINE SHEEBA, M.E., Ph.D.** submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

DATE: 20.04.23

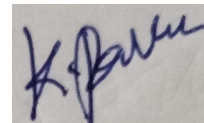
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SIGNATURE OF THE CANDIDATES

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ABSTRACT

The microstrip antenna is a convenient, planar, easy-to-fabricate antenna with some attractive attributes and features, as well as some distinct limitations. These are becoming increasingly useful because they can be printed directly onto a circuit board and are ease, have a position of safety and are effectively manufactured. As the textile material and radiation patch shape provide the antenna a wide working band 1.9-2.5GHz or 5.3-5.6GHz which is an ISM band used for wearable biomedical applications. The interaction between the human head and antennas needs to be taken into account, since wearable devices have to be functional, and at the same time, guarantee biological compatibility. The main objective was to compare the antenna parameters and the impact on the measured SAR of such antennas as functions of the slot configuration in the ground plane and patch and the antenna's location. Although all antennas suffered from change in their performance when brought near the head model, SAR is effectively reduced. The analysis for antenna free space propagation with and without phantom simulation is done by using HFSS (HIGH FREQUENCY STRUCTURE SIMULATOR V 17.0) software.

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CHAPTER 1

INTRODUCTION

1.1 MICROSTRIP PATCH ANTENNA

An antenna that is formed by etching out a patch of conductive material on a dielectric surface is known as a patch antenna. The dielectric material is mounted on a ground plane, where the ground plane supports the whole structure. Also, the excitation to the antenna is provided using feed lines connected through the patch.

As it is formed using a microstrip technique by fabricating on a printed circuit board thus is also known as Microstrip antenna or printed antenna.

Generally, patch antennas are considered as low-profile antennas and are used for microwave frequency applications having frequency greater than 100 MHz

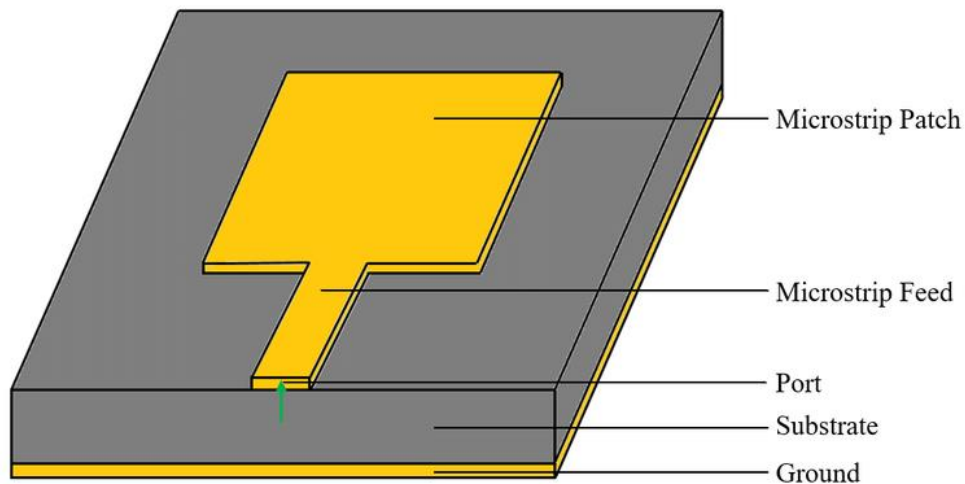


Fig:1.1: Basic Micro strip patch antenna

1.1.1 Working of Microstrip Patch Antenna

A microstrip or patch antenna operates in a way that when current through a feed line reaches the strip of the antenna, then electromagnetic waves are generated.

The waves from the patch start getting radiated from the width side. But as the thickness of the strip is extremely small thus the waves that are produced within the substrate get reflected by the edge of the strip. The continuous structure of the strip along the length does not permit the emission of radiation.

Furthermore, on experiencing a sudden discontinuity in the structure of the patch, radiations are again emitted from the second width side of the patch.

As this discontinuous structure favours reflections, thus the patch antenna radiates only a small fraction of supplied incident energy.

This makes the antenna inefficient, that rather displaying the characteristics of a good radiator, it somewhat acts as a cavity.

The low radiating ability of microstrip antenna allows it to cover the only small distances of wave transmissions like local offices, stores or any indoor locations. As such inefficient transmission is not supportable at a centralized location in an extremely large area.

1.1.2 Various Structure of Microstrip Patch Antenna

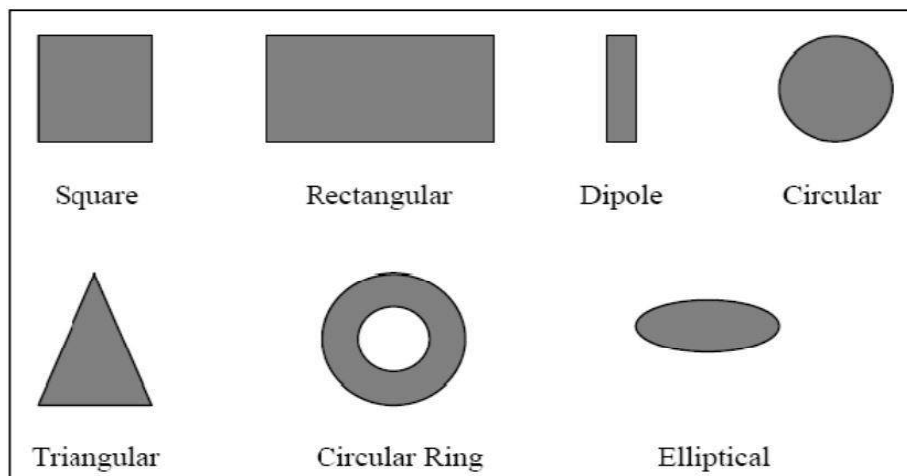


Fig:1.2: Types of structure in antennas

1.1.3 Various Feed Methods

There are mainly four basic methods for the feeding to these antennas

1.3.3.1 Probe Coupling Method

The Coupling of power of the microstrip patch antenna can be done by probe feeding method. The inner conductor of the probe line is connected to patch lower surface through slot in the ground plane and substrate material.

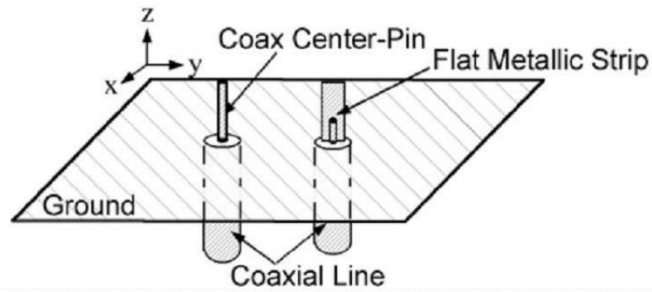


Fig:1.3: Probe Coupling Method

1.1.3.2 Strip Line Feeding Method

Using microstrip line can give excitation to the antenna as shown in the below figure. This method is very simple to design and fabricate. But this technique suffers from some limitations. If substrate thickness is increased in the design, then the surface waves and the spurious radiation also increase.

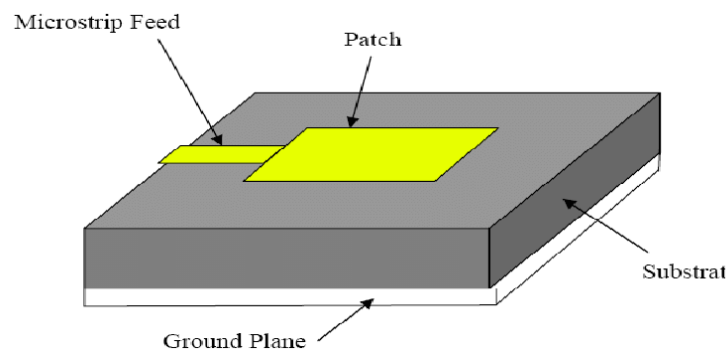


Fig:1.4: Strip Line Feeding Method

1.1.3.3 Aperture Coupled Microstrip Feed Method

This method employs ground plane between two substrates. A slot will be placed on the ground plane and feed line will be placed on lower substrate. This will be electromagnetically connected to patch on the upper substrate through the ground plane slot.

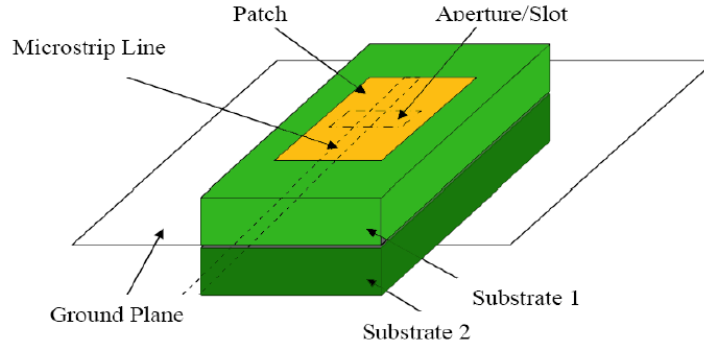


Fig:1.5: Aperture Coupled Microstrip Feed Method

1.1.3.4 Proximity Coupling Method

This method can be employed, where two or multilayer substrate configuration is considered. Generally, in this configuration, microstrip line will be placed on lower substrate and the patch element will be placed on the upper substrate. Other name for this feeding is electromagnetically coupled feed.

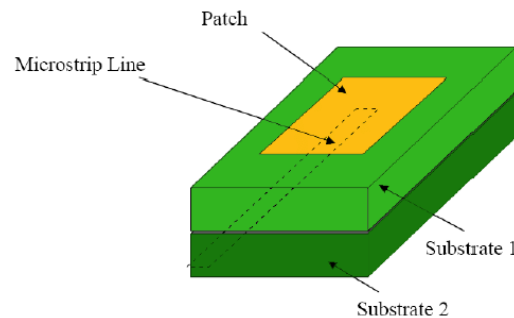


Fig:1.6: Proximity Coupling Method

1.1.4 Benefits of Microstrip Patch Antenna

A microstrip antenna is a versatile, low-cost antenna that can be manufactured easily and produces high-quality signals. Its benefits include low manufacturing cost, lightweight, and directivity.

1.1.5 ADVANTAGES AND DISADVANTAGES OF MICROSTRIP ANTENNA

Microstrip patch antennas are expanding in popularity for use in remote applications because of their position of safety structure. Therefore, they are extremely compatible for embedded antennas in handheld wireless devices such as cellular

phones, pagers etc. The telemetry and communication antennas on missiles need to be thin and conformal and are often Microstrip patch antennas. Another area where they have been used successfully is in Satellite communication. Some of their principal advantages are: It is lightweight, low volume and thin profile configuration. These make them to be easily incorporated into any package. It has a low-profile planar configuration that can be easily made conformal to host surface which fits the shape design and needs of modern communication equipment. It can be made compact for use in personal mobile communication.

The microstrip antenna shape flexibility enables mounting them on a rigid surface which makes them mechanically robust. Using printed-circuit technology leads to a low fabrication cost hence can be manufactured in large quantities. It upholds both straight polarization and round polarization. They acknowledge for double and triple recurrence activities and can be handily incorporated with microwave coordinated circuits (MICs) on a similar substrate. Microstrip patch antennas also have a number of disadvantages as compared to conventional antennas. Some of their major disadvantages discussed are: It operates over narrow bandwidth. Low efficiency and low gain while compared with conventional antennas. Extraneous radiation from feeds and junctions and relatively poor radiation efficiency as it radiates only in half-space. It also has low power handling capacity and high loss resulting from surface wave excitation

1.2 BIOMEDICAL ANTENNA

Biomedical antennas are used in biomedical wireless devices. They are categorized as on-body, in-body, and off-body devices. In each of these categories, the antenna requirement and the propagation environment are significantly different from each other and the conventional wireless communication environments. With the advancement of technology, there is a lot more attention now given to the devices that improve or monitor our health which are worn or implanted inside the body. Therefore, wireless connectivity is essential to the functionality of these devices. As the body is considered a harsh environment for antennas, the design of antennas for these devices requires great knowledge of electromagnetism, propagation, antenna design, and interaction of the electromagnetic field with the body. These devices may be used in

our everyday life, or they might be used in controlled environments such as hospitals or rehab centers.

1.2.1 Biomedical Antenna Parameter

The antennas, in general, are characterized by parameters like gain, Input impedance, directivity, radiation pattern, effective area and polarization properties.

1.2.1.1 Return Loss

It is the measure of loss of power in the signal reflected by a transmission line to a load. The two major cause of return loss are discontinuity and impedance mismatching and it is expressed in decibel.

Table 1.1: Return loss and its meaning

RETURN LOSS IN dB	MEANING
0	100% reflection, no power into the antenna, all reflected back
1	80% reflection, 20% power into the antenna
2	63% reflection, 37% power into the antenna
3	50% reflection, 50% power into the antenna
5	32% reflection, 68% power into the antenna
6	25% reflection, 75% power into the antenna
8	16% reflection, 84% power into the antenna
10	10% reflection, 90% power into the antenna
15	3% reflection, 97% power into the antenna
20	1% reflection, 99% power into the antenna

1.2.1.2 Reflection Loss

Reflection loss results in the part of energy being reflected back to the source and it can be caused due to discontinuity or impedance mismatch. Reflection loss in transmission line is the ratio of the incident power to the reflected power. It is expressed in dB.

$$R_L \text{ (dB)} = 10 \log \left[\frac{1}{1 - |S_{11}|^2} \right] \quad (1.1)$$

1.2.1.3 Attenuation Loss (AL)

It is a natural consequence of signal transmission over long distances. The extent of attenuation is usually expressed in units called decibels (dBs).

$$AL \text{ (dB)} = 10 \log \left[\frac{1 - |S_{11}|^2}{|S_{12}|^2} \right] \quad (1.2)$$

1.2.1.4 Insertion Loss

This loss can be caused by connectors and it is the ratio of received signal power to inserted signal power at the end of the cable. There will be rise in temperature of the cable by rise in level of insertion loss.

$$IL \text{ (dB)} = 20 \log \left[\frac{1}{|S_{12}|} \right] \quad (1.3)$$

1.2.1.5 VSWR

VSWR can be expanded as voltage standing wave ratio. It is a measure of how efficiently the RF power is transmitted from power source. If the given signal is completely radiated by the antenna without any reflection, then the antenna has a unit value of VSWR. The numerical value of VSWR ranges from 0 to 1 and so the antenna has no impedance mismatch.

$$VSWR = \left| \frac{1 - \Gamma}{1 + \Gamma} \right| \quad (1.4)$$

1.2.1.6 Gain

Antenna Gain is the measure how strong the signal of an antenna can transmit or receive in a particular direction.

$$Gain = \frac{\text{Total Power Radiated}}{\text{Input Power}} \text{ (dB)} \quad (1.5)$$

1.2.1.7 Directivity

Directivity is the measure of the antenna's radiation pattern in a particular direction.

$$D = \frac{A_e 4\pi}{\lambda^2} \quad (1.6)$$

1.2.1.8 Efficiency

From the obtained value of gain and directivity the efficiency of the antenna is calculated and it is expressed in terms of percentage (%). The Efficiency of the antenna is usually measured in an anechoic chamber.

$$\eta = \frac{\text{Gain}}{\text{Directivity}} \times 100\% \quad (1.7)$$

1.2.1.9 SAR

Specific absorption rate (SAR) is the measure of the allowable level of EM radiation to be produced by communication antenna in wireless devices. In antenna transmit power is lowered when SAR is too high. It is a measure of the rate at which energy is absorbed by the human body when exposed to a radio frequency electromagnetic field. It is defined as the power absorbed per mass of tissue and is expressed in units of watts per kilogram (W/kg).

1.2.1.10 Smith Chart

A Smith chart is a circular plot with a lot of interlaced circles on it. When used correctly, matching impedances, with apparent complicated structures, can be made without any computation. The only effort required is the reading and following of values along the circles.

The Smith chart is a polar plot of the complex reflection coefficient (also called gamma and symbolized by Γ). Or, it is defined mathematically as the 1-port scattering parameter s or s_{11} .

A Smith chart is developed by examining the load where the impedance must be matched. Instead of considering its impedance directly, you express its reflection coefficient Γ_L , which is used to characterize a load (such as admittance, gain, and transconductance). The Γ_L is more useful when dealing with RF frequencies.

1.2.1.11 Surface Current

The surface current antenna is an actual electric current that is induced by an applied electromagnetic field. The surface current is denoted using the letter J . The surface current density is defined as a vector whose magnitude is the electric current

pre-cross-sectional area at a given point in space. The current is the amount of charge per unit time that flows through a unit area of chosen cross section. The SI unit used to measure the surface current density is amperes per square meter.

1.3 TUMOR

A tumor is a solid mass of tissue that forms when abnormal cells group together. Tumors can affect bones, skin, tissue, organs and glands. Many tumors are not cancer (they're benign). But they still may need treatment. Cancerous, or malignant, tumors can be life-threatening and require cancer treatment.



Fig:1.7: basic brain tumor

1.3.1 Types of Tumours

- **Cancerous:** Malignant or cancerous tumors can spread into nearby tissue, glands and other parts of the body. The new tumors are metastases (mets). Cancerous tumors can come back after treatment (cancer recurrence). These tumors can be life-threatening.

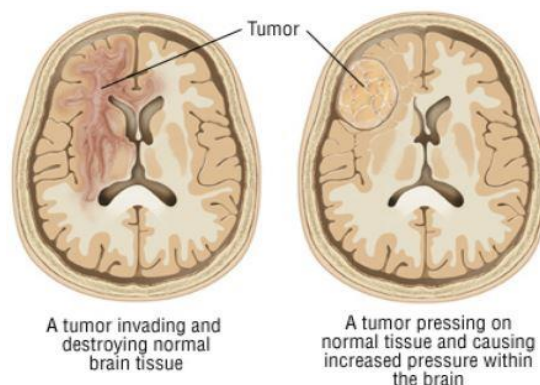


Fig:1.8: Effect of Cancerous tumor

- **Noncancerous:** Benign tumors are not cancerous and are rarely life-threatening. They're localized, which means they don't typically affect nearby tissue or spread to other parts of the body. Many noncancerous tumors don't need treatment. But some noncancerous tumors press on other body parts and do need medical care.

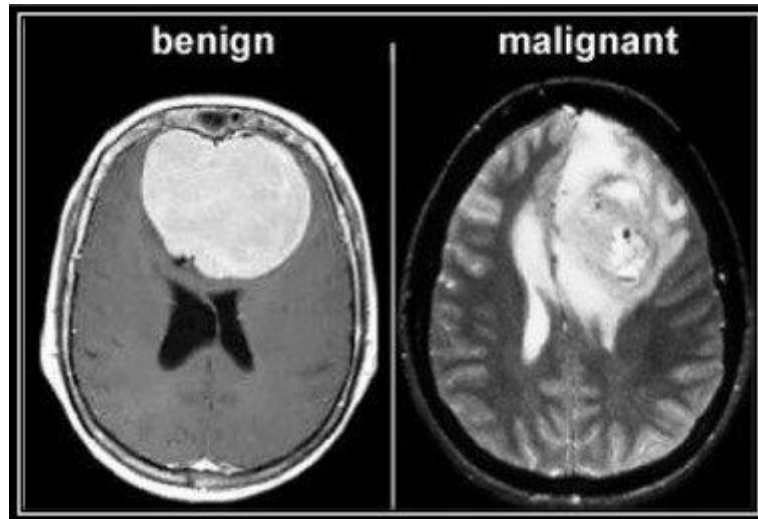


Fig:1.9: Effect of Noncancerous tumor

- **Precancerous:** These noncancerous tumors can become cancerous if not treated.

1.3.1.1 Types of malignant tumors

- Bone tumors (osteosarcoma and chordomas).
- Brain tumors such as glioblastoma and astrocytoma.
- Malignant soft tissue tumors and sarcomas.
- Organ tumors such as lung cancer and pancreatic cancer.
- Ovarian germ cell tumors.
- Skin tumors (such as squamous cell carcinoma).

1.3.1.2 Types of benign tumors

- Benign bone tumors (osteomas).
- Brain tumors such as meningiomas and schwannomas.
- Gland tumors such as pituitary adenomas.
- Lymphatic tumors such as angiomas.

- Benign soft tissue tumors such as lipomas.
- Uterine fibroids.

1.3.1.3 Types of Precancerous tumors

- Actinic keratosis, a skin condition.
- Cervical dysplasia.
- Colon polyps.
- Ductal carcinoma in situ, a type of breast tumor.

1.3.2 What causes a tumor

Your body is constantly making new cells to replace old or damaged ones that die off. Sometimes, the cells don't die off as expected. Or, new cells grow and multiply faster than they should. The cells start to pile up, forming a tumor.

- In India, every year 40,000- 50,000 patients are diagnosed with a brain tumor. Of these 20 percent are children.
- The American Cancer Society's estimates for brain and spinal cord tumors in the United States for 2022 include both adults and children.
- About 25,050 malignant tumors of the brain or spinal cord (14,170 in males and 10,880 in females) will be diagnosed. These numbers would be much higher if benign (non-cancer) tumors were also included.
- About 18,280 people (10,710 males and 7,570 females) will die from brain and spinal cord tumors.

1.4 SUMMARY

This chapter explains the microstrip patch antenna in biomedical application. Which is created by etching a patch of conductive material onto a dielectric surface, mounting it to a ground plane, and supplying feed lines for excitation. There are numerous feeding techniques. Microstrip patch antennas have advantages such as low production costs, lightweight, and directivity. Cancer tumor and cancer less tumor also explained in this chapter. The existing methodology for this analysis is carried out in the next chapter.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE SURVEY

Md. Ahasan Ibna Aziz et.al (2018) Lengths of ground patch had been considered as the key parameter to achieve optimum antenna performance in terms of reflection coefficient (S_{11}). To detect the brain tumor in human head, a six layered human head model was considered and the proposed antenna was located at 20mm distance from human head. Brain tumor presence indicated by lowered reflection coefficient values compared to higher values recorded by brain tumor absence. The biocompatibility analysis of the head tissue was determined used CST MWS software

D. F. Moná et.al (2018) presented an accurate and simple method to model the transition between a probe-fed microstrip antenna and a microstrip circuit, assembled in a back-to-back configuration. with the aid of a full-wave electromagnetic simulation tool the two-port s-parameter matrix of the transition was calculated. This information was used to determine the antenna input impedance (Z_A) that enforces a given impedance (Z_{in}) after the transition. To showcase the applicability and validate the proposed method a co-designed gps active integrated antenna was designed and manufactured.

Bayer S et.al (2018) investigated for the brain shifted compensation, another state-of-the-art interventional imaging modality c-arm CT was rarely studied in this context. due to the lack of clinical data, a suitable anthropomorphic deformable phantom was indispensable. The purpose of this studied was to describe and determine the characteristics of a multimodal deformable brain phantom made out of polyurethane and ceramic composite bone material. The phantom was made of six parts: skin, skull, brain, blood vessels, ventricles and an inflatable tumor. Fluid could be filled into the blood vessels, the ventricles and the tumor in ordered to simulate the brain shifted phenomenon. such an anthropomorphic phantom was both visible with MR and c-arm CT scanner. In ordered to evaluate the clinical relevance of our

phantom, we induce deformations with different degrees by in- and deflated the embedded tumor in 5 steps. Both MR and c-arm CT (cone beamed CT) images were acquired in each stepped. The induced deformation was estimated by performing mono-modal deformable registration with symmetric normalization method (SYN) both on MR and cone beamed CT (CBCT) acquisitions. The maximum displacement estimated with MR and CBCT pair was 29.6mm and 28.1mm. This result correlates the clinical findings.

Tulsi Chowdhury et.al (2019) discussed and implemented on antenna to detect brain tumor which operates at industrial, scientific and medical (ISM) band (2.4-2.4835GHz). The antenna was a wearable on body pentagon shaped micro stripped patch antenna which had a dimension of 33 X 23 X 1mm. It was very favorable for on body appliances because of its compact size. The antenna used FR-4 lossy as its dielectric substrate with a thickness of 0.8 mm and copper for patch and ground, each having a thickness of 0.1 mm. A human head phantom model was also being designed to get more idealistic values of the antenna parameters when placed above the head phantom model. The head phantom contains six homogenous layers which were skin, fat, skull, dura, CSF (Cerebrospinal fluid) and the brain. A tumor of size 5 mm was designed having a relative permittivity of 50 and conductivity of 1.58 S/m. Input signal was being radiated into phantom model and the response was being recorded by the receiver antenna. The antenna monitors the radiation pattern, voltage standing wave ratio (VSWR) and the returned loss of a normal head model and then later compares these parameters with a head model containing a benign tumor of size 5 mm. The parameters measured were safe and operates at ISM band. Under IEEE standard safety regulation, the specific absorption rate of a brain should be within 1.6 W/kg and the designed model obtained a SAR of 0.36 W/kg which was harmless for human body.

Hongxin et.al (2020) developed a 5G 5mmillimeter wave band appeared in the public view because of its wide bandwidth, narrowed beamed and strong detection ability, in order to make use of more extensive spectrum resources. To meet the need of 5G and the curiosity inspired by all kinds of 5G devices used patch antennas

learned in the project, we decided to design antennas for 5g millimeter wave n258 band. The performance of two antennas fed by rectangular microstrip patch and coaxial cable is compared, in order to figure out which kinds of feeding way could benefit more in the antennas of 5g devices. The simulation results showed that coaxial cable patch antenna had a higher operating frequency band, which covers 24.71ghz-27.32ghz, and microstrip line patch antenna had a higher radiation gain. Besides, the directivity and the radiation efficiency of these two patch antennas shows slight difference which points out that there was only minute difference in terms of transmission efficiency.

Jing Sun et.al (2020) demonstrated a 1×4 microstrip antenna array based on SICL (substrate integrated coaxial) transmission line structure was designed in this paper. The antenna array operates in the x-band (8-12Ghz) and consists of a SICL-based t-type power divider, a SICL-microstrip line adapter, and a circularly polarized microstrip antenna unit. The power divider designed by SICL transmission line technology had low loss and good shielding performance, and could realize an ultra-wide working bandwidth. And the microstrip circularly polarized antenna unit was fed by h-type slot coupling, and had the characteristics of wide working bandwidth, high gain and good circular polarization. After arrayed, it could be seen from the simulation results of HFSS that the 1×4 antenna array had good radiation characteristics in the working frequency band of 8-12Ghz, achieving an impedance bandwidth of 20.5% and the main lobe gain of 12.17db.

Zabed Iqbal et.al (2021) proposed A single-layer, dual-mode circular microstrip patch antenna was presented to achieve reconfigurable radiation patterns with high mode purity. The broadside radiation pattern was achieved by a central circular patch, whereas conical radiation pattern was realized through a concentric shorted ring patch. With the simultaneous excitation of the two operating modes, the proposed antenna could generate self-scanning and self-nulling radiation patterns. The proposed antenna was fabricated and tested. Simulated and measured results showed that the antenna produces stable broadside and conical radiation patterns with high mode purity at the design frequency of 10Ghz.

Hao Zhang et.al (2021) proposed a new microstrip patch antenna with wideband harmonic suppression was presented in this paper. Compared to the traditional patch antenna, a dual-point feeding technique was adopted in our patch antenna design. This feeding method was able to excite the fundamental tm_{10} mode and controlled the higher ordered harmonics at the same time. Detailed analysis for the harmonic modes controlled was provided, and the performance of the antenna was simulated and optimized. It was indicated that the designed patch antenna not only had a good radiation pattern and stable gain at the working frequency f_0 , but also could achieve the harmonic suppression up to $2.8f_0$ with resorting to the proposed dual-point feeding method. Simulated and measured results were given, well validating the feeding approach.

Shakthi Sharuni et.al (2022) developed a rectangular microstrip patch antenna using HFSS with an operating frequency of 7.3 GHz to diagnose brain tumor. The antenna was designed using Rogers RO3003 substrate material. In this paper, the antenna's dimensions were 31.68 X 31.01 X 0.75 mm³, with a rectangular feedline being used to feed the radiating patch. With six layers of fat, dura, brain, skin, CSF (cerebrospinal fluid), and the brain phantom was constructed using HFSS software. In that same human brain, the tumor of radius 1.5 mm was implanted. The antenna was evaluated both with and without a tumor on a brain phantom to detect a tumor.

Balamurugan Velan et.al (2021) developed Head imaging technique plays a vital role in the detection of an affected brain, such as strokes cancerous tumours caused by trauma. Current systems require the patient to be transported to the imaging device which increases the time taken to apply treatments, which leads to the patient's conditions to be worsen. The antenna is designed in 3-D dimension with a wideband and unidirectional properties. The lower microwave frequencies are used in the antenna to detect size, location and intensity of the tumour. This microwave imaging technique will not harm the tissues. The concept has been validated through experimental data collection in image generation, and is capable of capturing images

in less than a minute. A simplified head phantom was developed gathering the data and proved that the system was capable of locating targets with dielectric properties similar to brain tumors and bleeds.

Yusnita et.al (2021) developed an antenna microstrips for the detection of tumors in the breast and brain have been designed. 4x4 array antenna using Kapton Polyimide flexible substrate ($\epsilon_r = 3.5$) is used for breast tumor detection which works at a frequency of 4.9 GHz - 6.4 GHz. The use of this flexible material is so that later the antenna can be bent and adjust to the shape of the breast. Meanwhile, the microstrip antenna with a pentagonal patch used to detect brain tumors can work at a frequency of 2.4 GHz - 2.4835 GHz using the FR-4 substrate ($\epsilon_r = 4.3$). This flexible antenna measures 20x25 mm² with a thickness of 0.05 mm, while the antenna on the FR-4 has a thickness of 1.6mm with dimensions of 46x40x1.65 mm³. The flexible antenna simulation results show that the reflection point (S11) parameter is -37.50 dB with a SAR of 1.5565 W/kg. While the S11 of -14.50 dB at 2.44 GHz with a SAR of 0.03866 W/kg is obtained on the FR4 antenna. The two SAR values obtained in this simulation do not exceed the maximum set standards.

T. Jayanthi et.al (2019) SoftWear antenna is an arrangement of Wearable and textile antenna properties which is flexible in two dimensions. Softwear antenna serves as element of clothes and it should not affect the wearer by means of any radiation persevere in it. It is deliberate in such a way to perform in close propinquity to human body antenna substrate made of fabrics. This paper gives evidences about those for the design and development of softwear textile antenna. Nowadays wireless technology has challenges to construct a device with compact size, lightweight, low profile and ease in its fabrication. A right choice for such type of antenna is a softwear microstrip patch antenna. Wireless Body centric communication is also possible in this Type which uses the frequency of Industrial, Scientific, Medicine meant by ISM band (2.45 GHz). This soft wear antenna using polyester substrate was fabricated and its S11 and VSWR was measured using network analyzer.

I. Rexiline Sheeba et.al (2019) developed a hexagonal patch antenna with jean substrate operating in industrial, scientific and medical band was presented. Two step methodologies are recommended. Simulated antenna results indicate the tumor detection present in skin and breast by observing the changes in the gain and current density of the skin and breast with and without tumor. An experimental set up was introduced, in which the proposed antenna was kept under various temperature and the changes in the performance of the antenna was noted and tabulated. With respect to time a change in shift of frequency was observed. With and without tumor was assumed with pieces of uniformly shaped ice cubes in the experimental analysis. In simulation the presence and absence of tumor is 20.3 A/m² and 19 A/m² and gain as 7.20 and 7.25 dB was noted in breast model in CST. And the existence of the tumor is 25.9 A/m² and the nonexistence of the tumor is 21.1 A/m² and the gain is 6.91 dB for with and without tumor is 6.95 dB is noted using CST. The fabricated and measured result of the proposed softwear antenna and the experimental verification has been done.

R. Raihan et.al (2017) developed a wearable pentagon shaped microstrip patch antenna which operates at Industrial, Scientific and Medical (ISM) band (2.4–2.4835GHz) for detecting brain cancer. ISM band is selected for its flexibility toward larger bandwidth. The antenna is designed with a feature that its thickness and dimension is small which makes it practically wearable on human head. Taking into consideration of the patient safety the antenna is surfaced on the human head phantom model which consists of six homogeneous layers that are skin, fat, skull, Dura, cerebrospinal fluid (CSF) and brain respectively using CST microwave studio. The designed wearable antenna observes the return loss, voltage standing wave ratio (VSWR), Radiation pattern in human head phantom model and the results are compared with cancerous tumor consisting head model that carries a 5 mm tumor inside human brain. It is prevised that the proposed antenna is to be functioned in ISM band under IEEE standard safety regulation.

The following problems have been identified from the above literature survey:

- Low reflection coefficient
- Perfect impedance match
- Low operating power
- Low SAR value (below 1W/kg)
- To design antenna with size reduced as much as possible

2.2 SUMMARY

The listed literature survey was referred and problems have been identified in overall existing methods. The patch antenna design and the drawbacks in the implementation have been analyzed and to be overcome in the proposed work and the implementation of the phantom in different methodologies have been taken into account in the proposed work.

CHAPTER 3

PROPOSED SYSTEM

3.1 Hilbert Curve

- Hilbert curve fractal geometry was first proposed in the year 1891 named after the german mathematician 'David Hilbert' as space filling curve. Hilbert curve geometry in antenna design has been configured to reduce the size of antenna as well as to get multiple resonances. Total length of the Hilbert curve increases when increasing the iteration stage, while keeping the overall space of the entire geometry fixed. This phenomenon mainly stems from electrical miniaturization of the geometry.
- A Hilbert curve is part of the family of plane-filling curve. It is commonly used to transform multi-dimensional data to a single dimension.
- A kind of space-filling curve defined by David Hilbert in 1891.

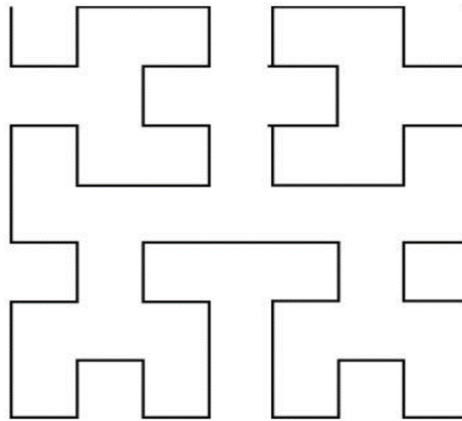


Fig:3.1: Hilbert curve

- The usefulness of fractal Hilbert curves in antenna geometry is explored here for the first time. Apart from being simple and self-similar, these curves have the additional property of approximately filling a plane. These properties are exploited in realizing a “small” resonant antenna. This approach has resulted in an antenna size smaller than $\lambda/10$ and still resonant, with performance comparable to a dipole whose resonant length is close to $\lambda/2$. Numerical predictions of the input impedance of the antenna have been compared with experiments. The effect of additional

fractal iterations on the reduction of the resonant frequency has been studied. The radiation characteristics of the antenna at the resonant frequencies provided show that this is very similar to the dipole characteristics

- There is a formula for Hilbert's space filling curve in space filling curves by Hans Sagan... If we write $t \in [0,1)$ in its base four expansion,

$$t = 0.4^1 q_1 4^2 q_2 4^3 q_3 \dots$$

$$h(t) = \sum_{n=1}^{\infty} \frac{(-1)^{e_{0j}}}{2^j} \text{sign}(q_j) \left(\frac{(1-d_j)q_j - 1}{1-d_j q_j} \right) \quad (3.1)$$

Where e_{kj} denotes the number of k s preceding q_j and $d_j = e_{0j} + e_{3j} \mod 2$ and $\text{sign}(x)$ is 1 if x is positive, 0 if x is zero and -1 if x is negative (though q_j is never negative).

3.2 BLOCK DIAGRAM

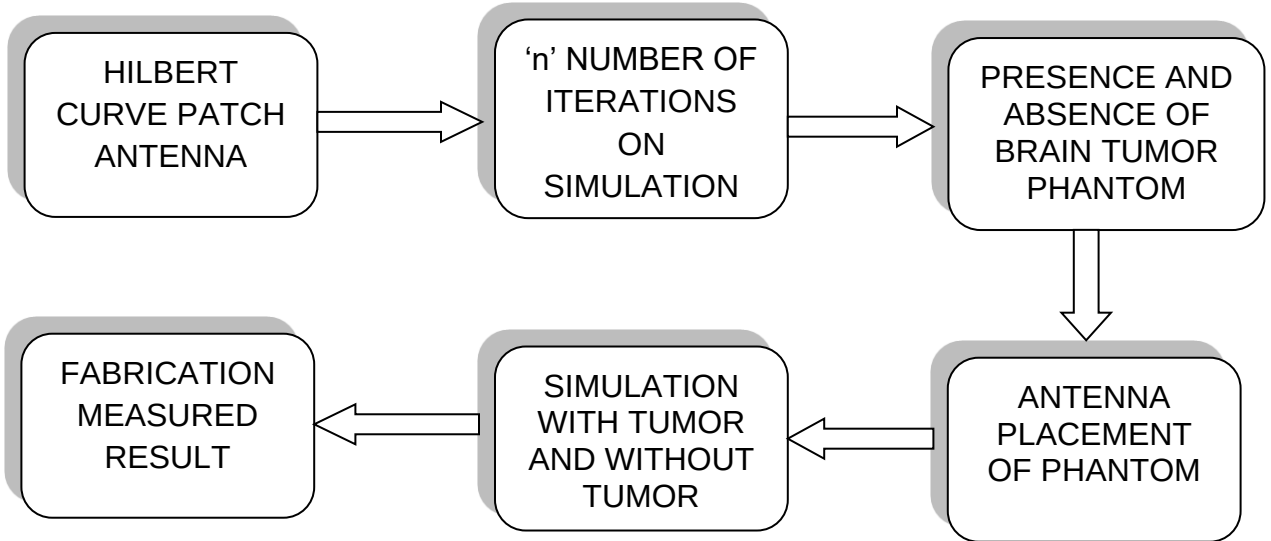


Fig:3.2: Block diagram of proposed work

3.3. Proposed Antenna design

Since the antenna is designed based on square patch antenna, hence the design calculation of square patch is applicable. To obtain the dimensions of patch antenna we need to specify the dielectric constant and the desired frequency.

We proposed the square patch antenna because of it is easy to access the even

distribution process, we can predict reflection coefficient in an easy manner.

3.3.1 Square Patch Antenna

- Wavelength

Wavelength is the distance between identical points in the adjacent cycles of a waveform signal propagated in space or along a wire.

$$\lambda = \frac{c}{f} \text{ mm/sec} \quad (3.2)$$

- Length and Width

The length and width mean the horizontal and vertical length of the antenna. The larger the trace width is, the lower the impedance will be. The thinner the trace width, the more impedance is offered. Increasing the board thickness increases the impedance while reducing it will decrease the impedance

$$L=W= \frac{\lambda}{2} \sqrt{\frac{2}{\epsilon_r}} \text{ mm} \quad (3.3)$$

- Fringing effect

The bending of the electric flux lines towards the edge of parallel plate capacitors is known as fringing. Fringing is frequently referred to as the "edge effect.". In most capacitors, the flux lines are homogeneous and parallel.

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} \quad (3.4)$$

- Thickness

It gives the height of the substrate and it give potential strength to the antenna to hold

$$h = \frac{0.0606\lambda}{\sqrt{\epsilon_r}} \text{ mm} \quad (3.5)$$

- Ground and Substrate Dimensions

Substrate is a base or container on which microstrip patch (metallic sheet) antenna is fabricated and it plays important role in microstrip antenna functioning. The substrate in microstrip antennas is principally needed for the mechanical support of the antenna. To provide this support, the substrate should consist of a dielectric material, which may affect the electrical performance of the antenna, circuits and transmission line. A substrate must, therefore, simultaneously satisfy the electrical and mechanical requirements, which is sometimes difficult to meet.

The Ground Plane its principal purpose is to allow the flow of return current there should be a minimum of interruptions to it, and for this reason ground planes are more successful on a multilayer board where an entire layer can be devoted, one to the power plane and one to the ground

$$L_g = L + 6h \text{ mm} \quad (3.6)$$

$$W_g = W + 6h \text{ mm} \quad (3.7)$$

- Feed

The antenna feed system or antenna feed is the cable or conductor, and other associated equipment, which connects the transmitter or receiver with the antenna and makes the two devices compatible

$$L_f = \frac{\lambda_g}{4} \text{ mm} \quad (3.8)$$

$$W_f = \frac{2h}{\pi} \left\{ (B - 1 - \ln(2B - 1) + \left(\frac{\epsilon_r - 1}{2\epsilon_r}\right)) \right\} \times \left\{ \ln(B - 1) + 0.39 - \left(\frac{0.61}{\epsilon_r}\right) \right\} \quad (3.9)$$

$$B = \frac{60\pi^2}{Z_0\sqrt{\epsilon_r}} \quad (3.10)$$

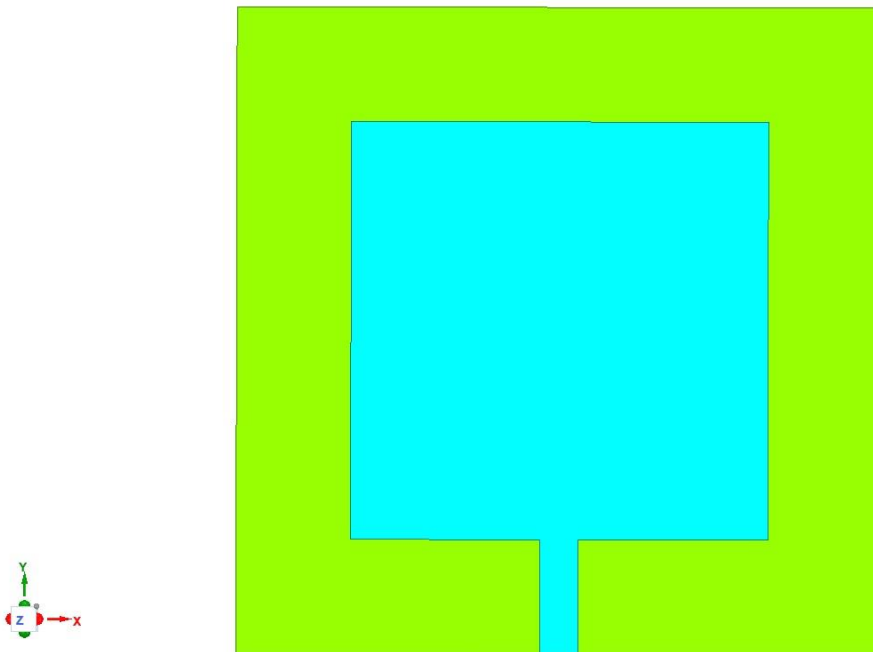


Fig:3.3: Square Patch Antenna

3.4 ANTENNA OPTIMISATION

Antenna optimization aims at creating advanced and complex electromagnetic devices that must be competitive in terms of performance, serviceability, and cost effectiveness. This process involves selection of appropriate objective functions, design variables, parameters, and constraints. In most antenna optimization problems, several goals must be satisfied simultaneously in order to obtain an optimal solution. As these objectives are often conflicting, no single solution may exist that is best regarding all considered goals. Here we have used different optimization on ground to get the desired ISM frequency for biomedical application.

3.4.1 Square patch antenna without optimization

Here the square patch antenna is placed on a ground without any optimization.

Table 3.1: Design Specification

	Length	Width	Height
Patch	37.2 mm	37.2 mm	-
Ground	57.6 mm	57.6 mm	-
Substrate	57.6 mm	57.6 mm	3.4 mm

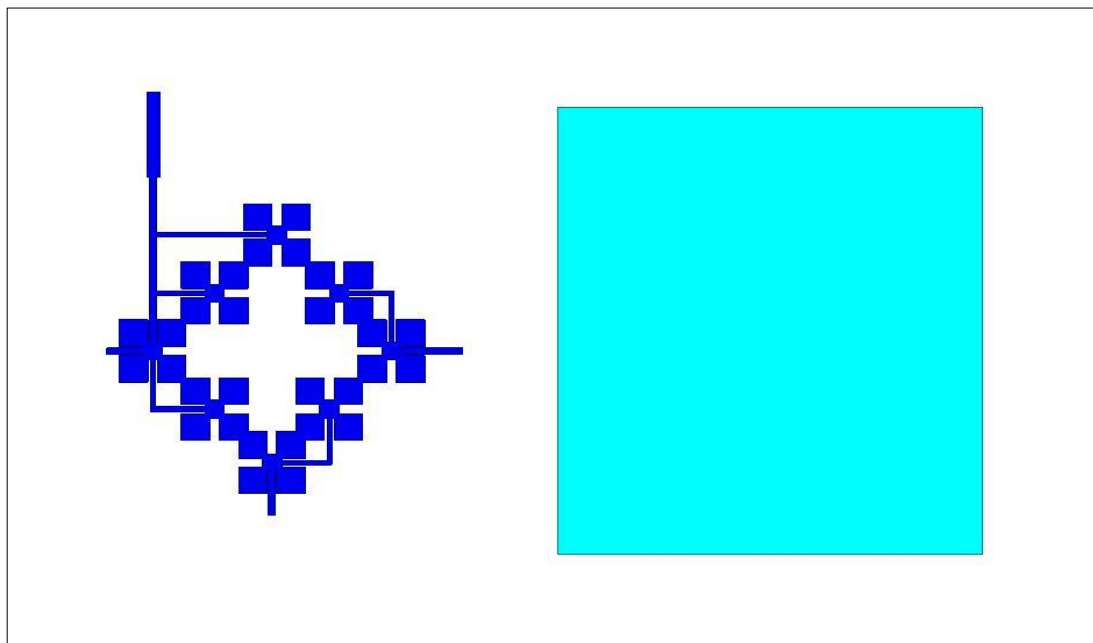


Fig:3.4: structure of square patch antenna without optimization

3.4.2 Square patch antenna with parallel quarter wave transmission grounding method

Here the square patch antenna is placed on a ground with parallel quarter wave transmission optimization.

Table 3.2: Design Specification

	Length	Width	Height
Patch	37.2 mm	37.2 mm	-
Ground	9.5 mm	57.6 mm	-
Substrate	57.6 mm	57.6 mm	3.4 mm

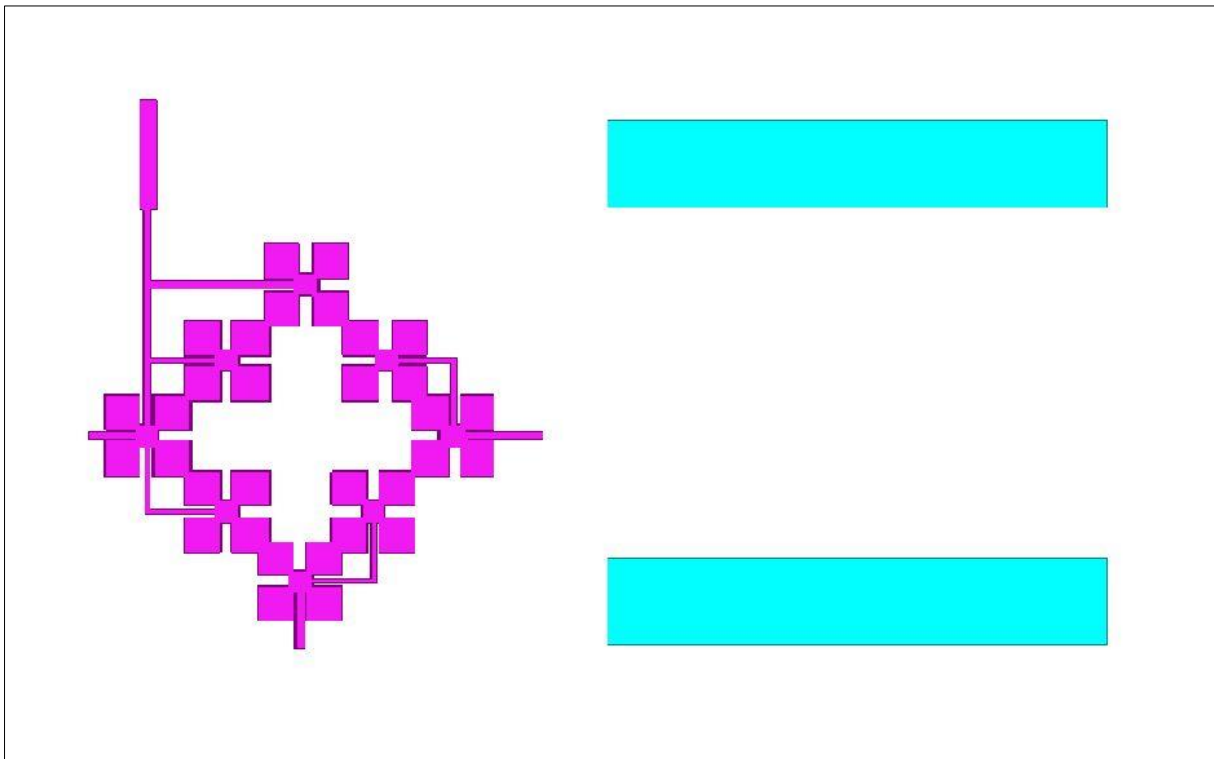


Fig 3.5: structure of square patch antenna with parallel quarter wave transmission grounding method

3.4.3 Square patch antenna with quarter wave transmission grounding method

Here the square patch antenna is placed on a ground with quarter wave optimization.

Table 3.3: Design Specification

	Length	Width	Height
Patch	37.2 mm	37.2 mm	-
Ground	9.5 mm	57.6 mm	-
Substrate	57.6 mm	57.6 mm	3.4 mm

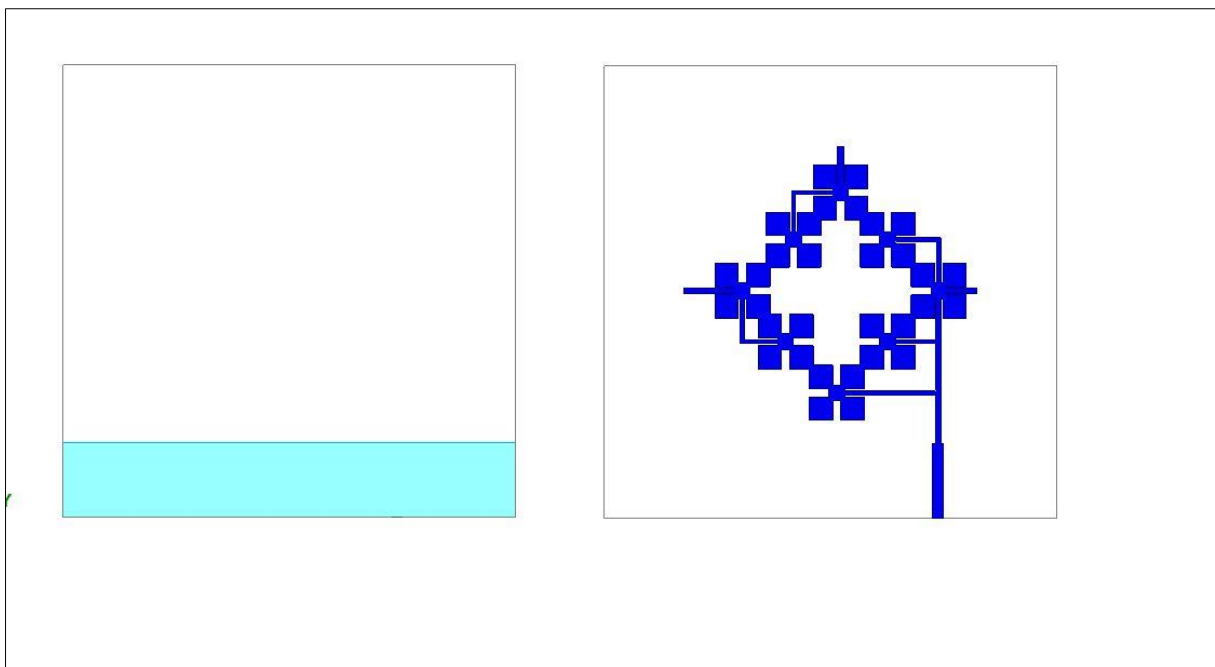


Fig:3.6: Structure of square patch antenna with quarter wave transmission grounding method

Table 3.4: Comparison return loss, gain, directivity

Parameters	No optimization	Parallel Quarter wave	Quarter wave
Working Frequency (GHz)	1.9	2.3	2.4
Return Loss (dB)	-27.2221	-11.8887	-38.0513
Gain (dB)	Max: -4.8 Min: -20.5	Max: 4.321 Min: -12.686	Max: 5.5 Min: -11.9
Directivity (dB)	Max: 5.7 Min: -11	Max: 5.082 Min: -11.925	Max: 5.7 Min: -11.7

3.5 PERMITTIVITY AND ELECTRIC CONDUCTIVITY

3.5.1 Permittivity

A measure of the ability of a material to interact with an electric field and became polarized by the field, so that the field within the material was weaker than the field in the absence of the material. The permittivity of a material was the product of the dielectric constant of the material and the permittivity of a perfect vacuum, which was defined have been about 8.854×10^{-12} farad per meter

3.5.2 Electric conductivity

Conductivity was measured by the ease at which an electric charge or heat could pass through a material. A conductor was a material that gave very little resistance to the flowed of an electric current or thermal energy.

Table 3.5: Properties of brain tissue

Tissue	Source	Permittivity	Elec. Cond. (S/m)
Brain	Cerebellum	8.98E+1	7.90E-1

3.6 BRAIN TISSUE CREATION

Modeling and simulation of the presented approach were performed in High frequency simulation software (hfss). Simulation models consisting of a part of the brain, an antenna, and a tumor were developed in hfss. A part of brain tissue was been designed and given properties like permittivity and elec. Cond. (s/m).

3.6.1 Creating the brain part without tumor

A part of brain tissue was been designed and given properties like permittivity and elec. Cond. (s/m). The brain permittivity was 8.98×10^1 and elec. Cond. (s/m) was 7.90×10^{-1} . Placing the antenna near the brain and analyzing we would get returned loss.

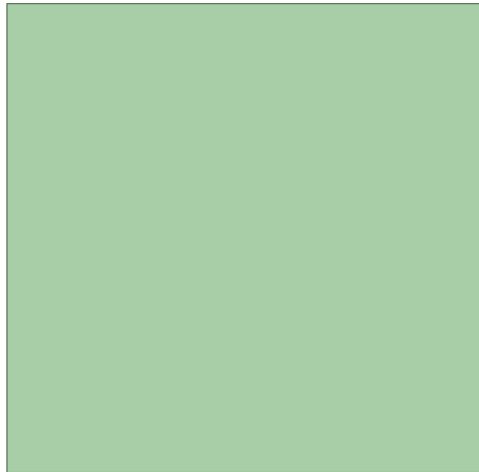


Fig:3.7: Brain phantom

3.6.2 Creating the brain part with tumor

A part of Brain tissue is been designed and given the properties like Permittivity and Elec.Cond.(S/m). another brain tissue was also designed and inserted a 1mm size tumor inside of it. The brain permittivity is 8.98×10^1 and Elec.Cond.(S/m) is 7.90×10^{-1} .

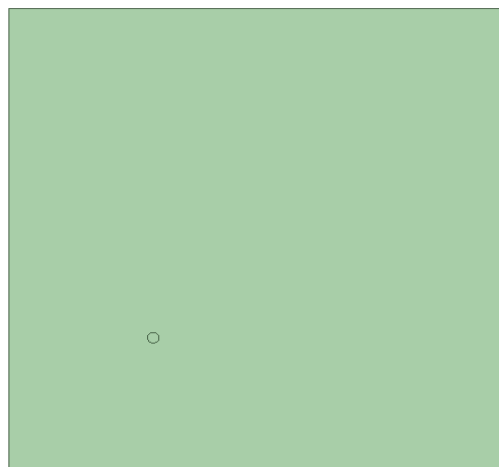


Fig:3.8: Brain phantom with tumor

3.7 SUMMARY

By implementing Hilbert curve in the patch and implementing iteration in the ground plane structure and optimization in the length and width of the ground plane. An optimized output is compared in table 3.1. It is observed that quarter wave performance gives the best optimization to implement on brain phantom. Further High-frequency simulation software (HFSS) was used to create simulation models of a tumor, an antenna, and a portion of the brain. It was possible to construct a brain phantom with the given permittivity and electric conductivity parameters. Also, a brain phantom with a tumor was made. The simulated results and analysis have been discussed in the next chapter.

CHAPTER 4

SIMULATED RESULTS

Various antenna parameters of the antenna are measured and recorded. Now these antenna parameters are analyzed. The parameter to be analyzed are return loss, VSWR, gain, directivity, efficiency, power, radiation intensity, SAR and average current surface.

4.1 COMPARISON OF S11 PARAMETER

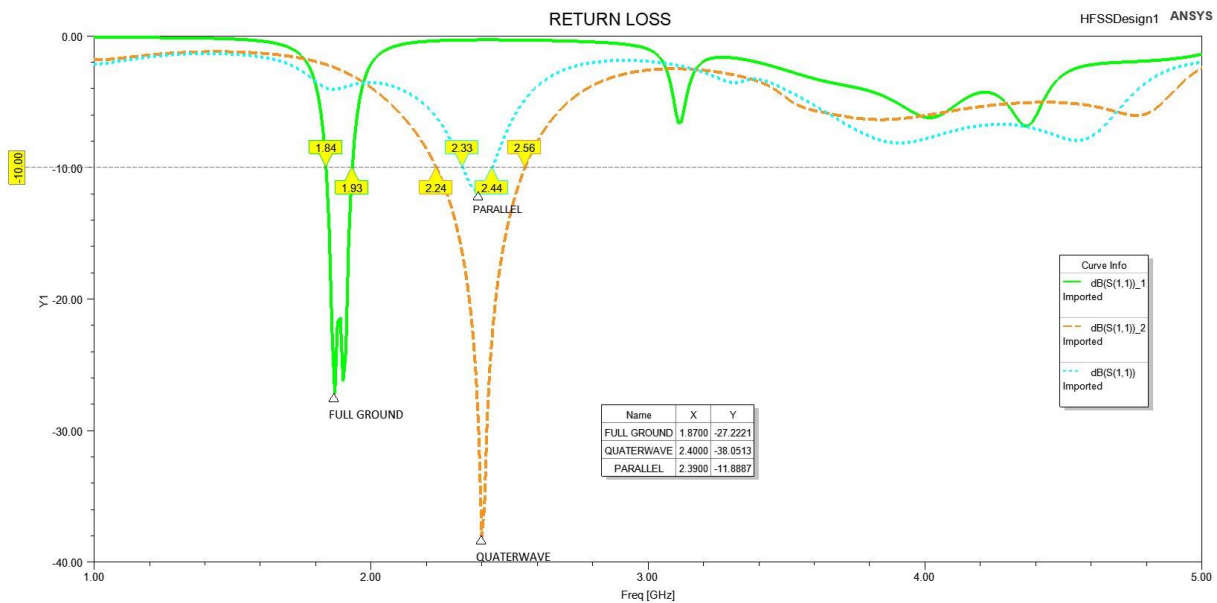


Fig:4.1: Comparison of return loss with different optimizations

Table 4.1: Return loss for different optimizations

Parameters	No optimization	Parallel Quarter wave	Quarter wave
Return Loss (dB)	-27.2221	-11.8887	-38.0513
Working Frequency (GHz)	1.9	2.3	2.4

Return loss is a parameter which indicates the amount of power that is “lost” to the load and does not return as a reflection. Hence the RL is a parameter to indicate how well the matching between the transmitter and antenna has taken place. For an ideal antenna, the expected return loss should be below -10dB.

In this return loss and working frequency comparison graph between different optimization methods, we got different outputs. Here, for all the return loss is less than -10 dB but the quarter wave optimization antenna provides a better return loss compared to others, hence the quarter wave antenna works perfectly at our proposed resonance frequency 2.4GHz. Hence our final proposed antenna is a quarter wave ground antenna, which now we will measure and record the different parameters and analyze all reports

4.2 SIMULATED RESULTS FOR ANTENNA

4.2.1 Voltage Standing Wave Ratio (VSWR)

Voltage Standing Wave Ratio or VSWR is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to. VSWR is directly related to return loss and reflection coefficient. Higher VSWR means a higher reflection coefficient which in return causes maximum

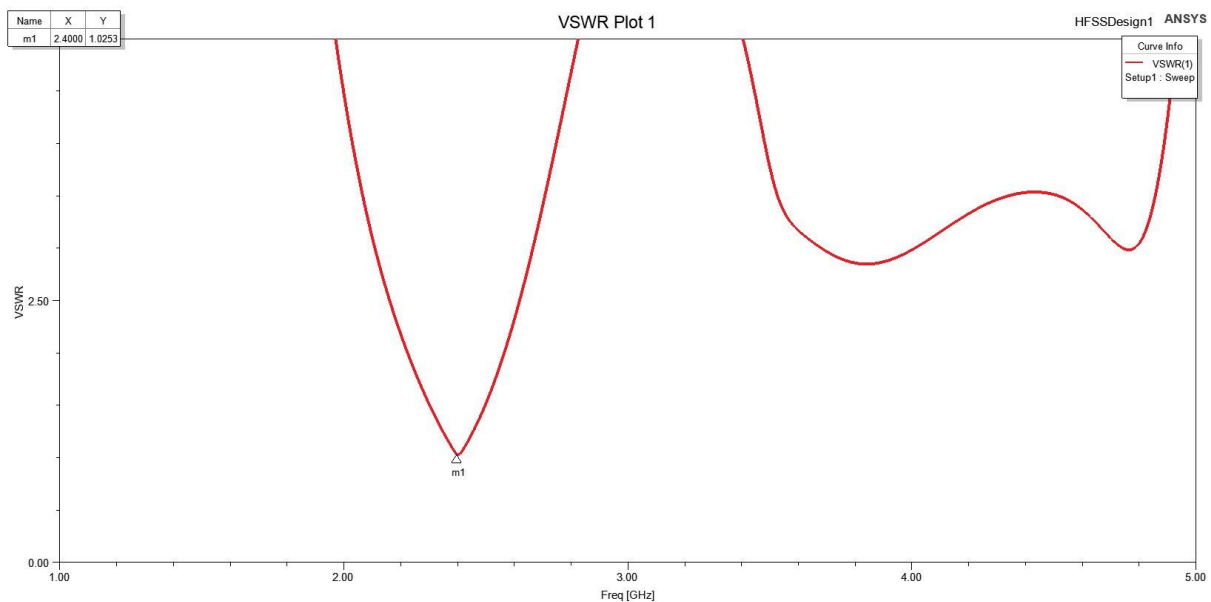


Fig:4.2: VSWR

reflection loss. For example, VSWR of 4 has 36% of the power delivered to the receiver

being reflected antenna. Hence VSWR of 1(perfectly matched) to 2 is ideal and a VSWR of less than 3 is acceptable during antenna design. In addition to reflection loss, VSWR incorporates insertion loss as well. From the above graph, it is concluded that the VSWR of our proposed antenna shows the best figure of 1.0253.

4.2.2 Antenna Gain

The term antenna gain describes how much power is transmitted in the direction of peak radiation to that of an isotropic source. Antenna gain is specified in the antenna specification sheet because it takes into account the actual losses that occurred. For

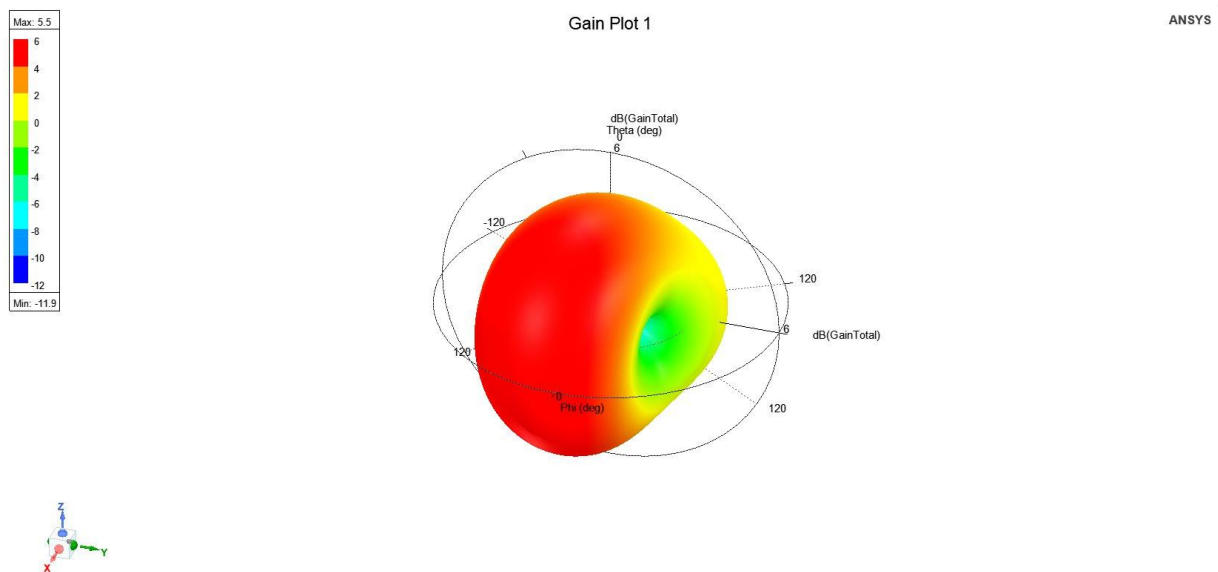


Fig:4.3: Gain

example, antenna with 3dB gain means that the power received far from the antenna will be 3dB higher than what would be received from the lossless isotropic antenna. The real antenna gain is as high as 40-50dB in large dish antenna. Here the proposed patch antenna shows a gain of 5.5dB.

4.2.3 Directivity

Directivity is a fundamental antenna parameter. It is the measure of how 'directional' an antenna radiation pattern is. An antenna that radiates equally in all directions would have effectively zero directionality, and the directivity of this type of antenna would be 0dB. Increased directivity implies a more

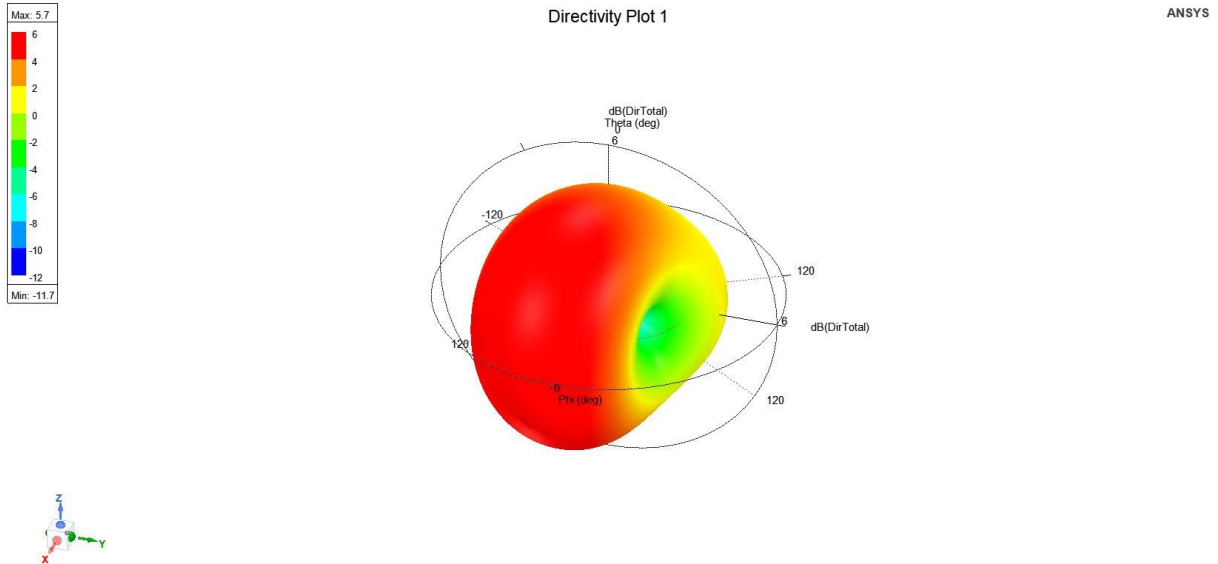


Fig:4.4: Directivity

focused or directed antenna. Larger antennae such as horn antenna and dish antenna have a directivity of range 10-40dB whereas short dipole antenna has a directivity of 1.76 dB. The directivity of the patch antenna ranges from 2 to 10 dB. Hence patch antennas are mostly used in Bluetooth, Wi-Fi, and ZigBee applications. Here the Square patch shows the directivity value of 5.7dB.

4.2.4 Efficiency

4.2.4.1 Physical Efficiency

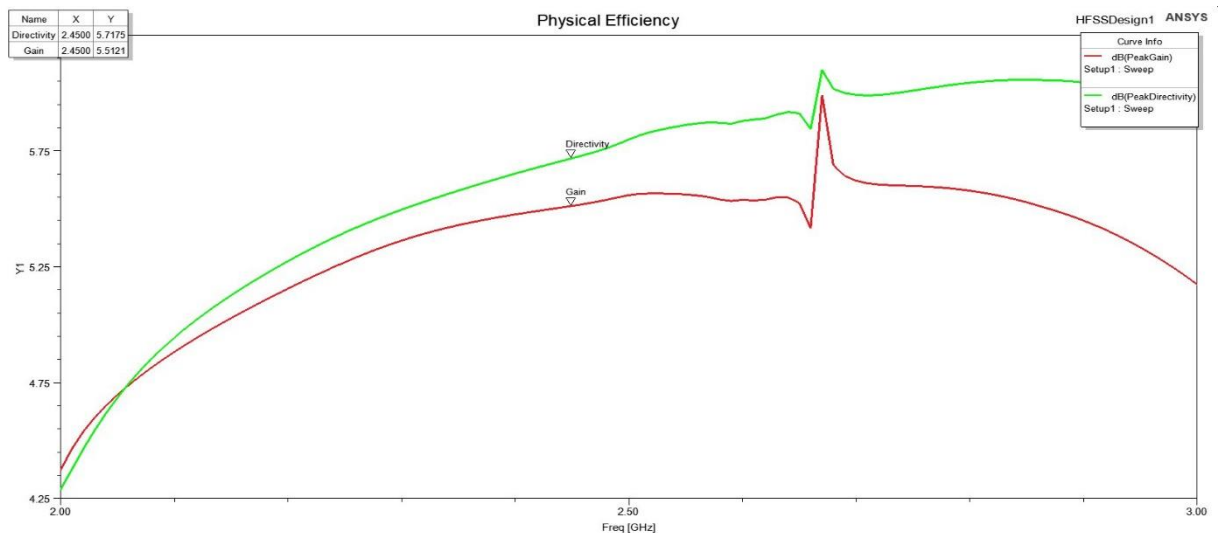


Fig:4.5: Physical efficiency

4.2.4.2 Radiation Efficiency

The efficiency of an antenna is the ratio of the power delivered to the antenna relative to the power radiated from the antenna. A high-efficiency antenna has most of the power present at the antenna's input radiated away. A low-efficiency antenna has most of the power absorbed as losses within the antenna or reflected away due to impedance mismatch.

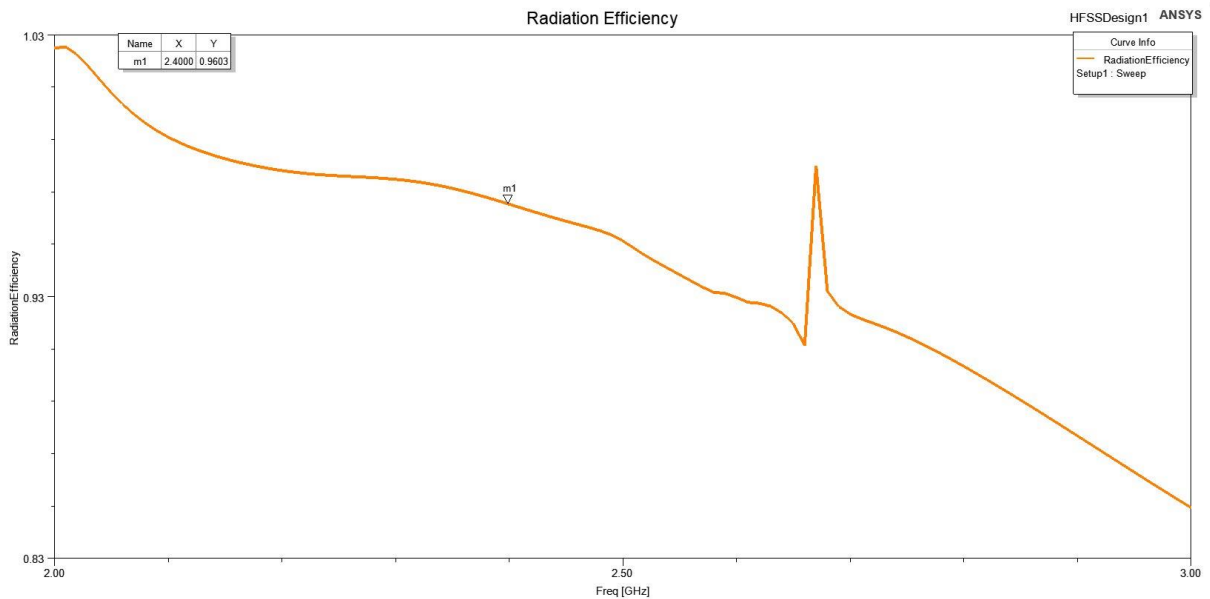


Fig:4.6: Radiation Efficiency

From the obtained value of gain and directivity, the efficiency of the antenna is calculated and it is expressed in terms of percentage (%). The efficiency of our proposed antenna is 96.03%, which means that the antenna is working perfectly without giving any harm to the patient.

4.2.5 Power

Power means the difference between accepted power and radiated power. For our antenna the power is 0.176.

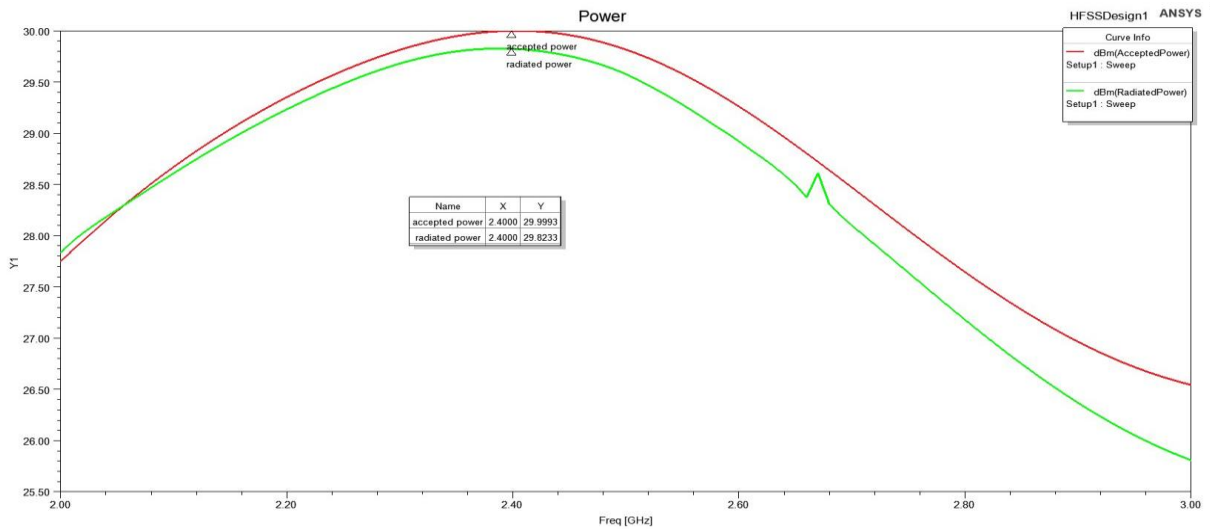


Fig:4.7: Power

4.2.6 Radiation Intensity

Radiation intensity is defined as the power per unit solid angle. Radiation emitted from an antenna which is more intense in a particular direction, indicates the maximum intensity of that antenna. The emission of radiation to a maximum possible extent is nothing but the radiation intensity.

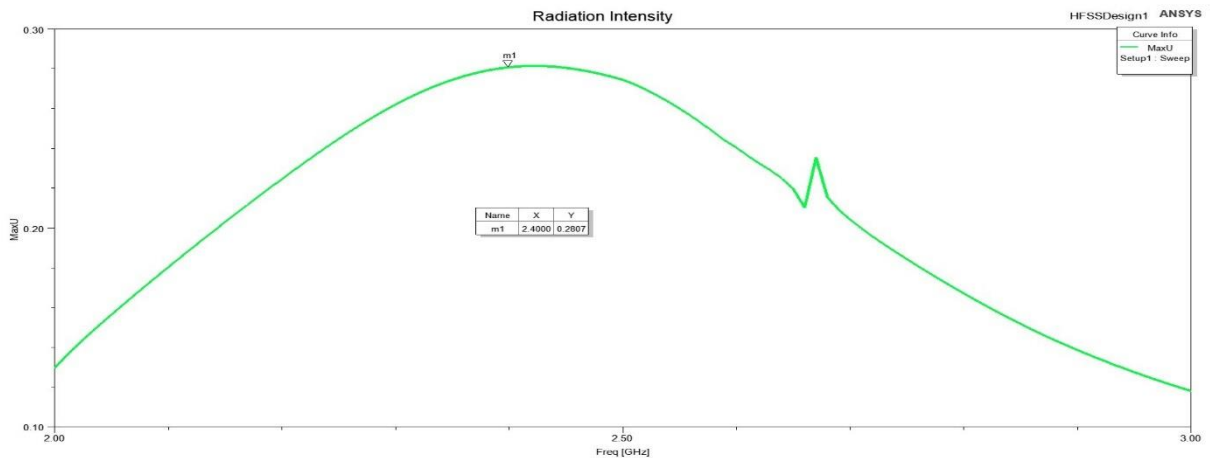


Fig:4.8: Radiation Intensity

4.2.7 SAR

Specific absorption rate (SAR) is the measure of the allowable level of EM radiation to be produced by communication antennae in wireless devices. In an

antenna transmit power is lowered when SAR is too high. It is a measure of the rate at which energy is absorbed by the human body when exposed to a radio frequency electromagnetic field. It is defined as the power absorbed per mass of tissue and is expressed in units of watts per kilogram (W/kg). For India, it is 1.6 W/Kg and for our proposed antenna it is 0.1621911 W/Kg, which is way less than the limit, so our antenna is working perfectly without emitting any harmful radiation.

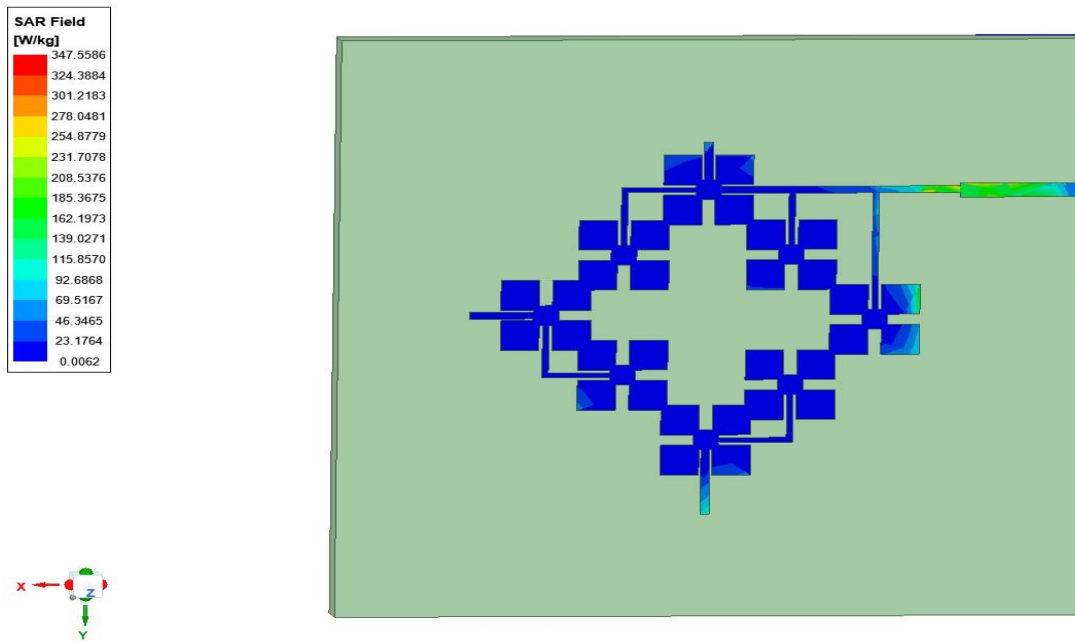


Fig:4.9: SAR Field of patch antenna

4.2.8 Average Current Surface

The surface current antenna is an actual electric current that is induced by an applied electromagnetic field. The surface current is denoted using the letter J . The surface current density is defined as a vector whose magnitude is the electric current pre-cross-sectional area at a given point in space. The current is the amount of charge per unit of time that flows through a unit area of the chosen cross section. The SI unit used to measure the surface current density is amperes per square meter. The average current surface for this antenna is around 8.3 amps/meter, which is less than 10 amps/meter, so our proposed antenna is perfectly matched.

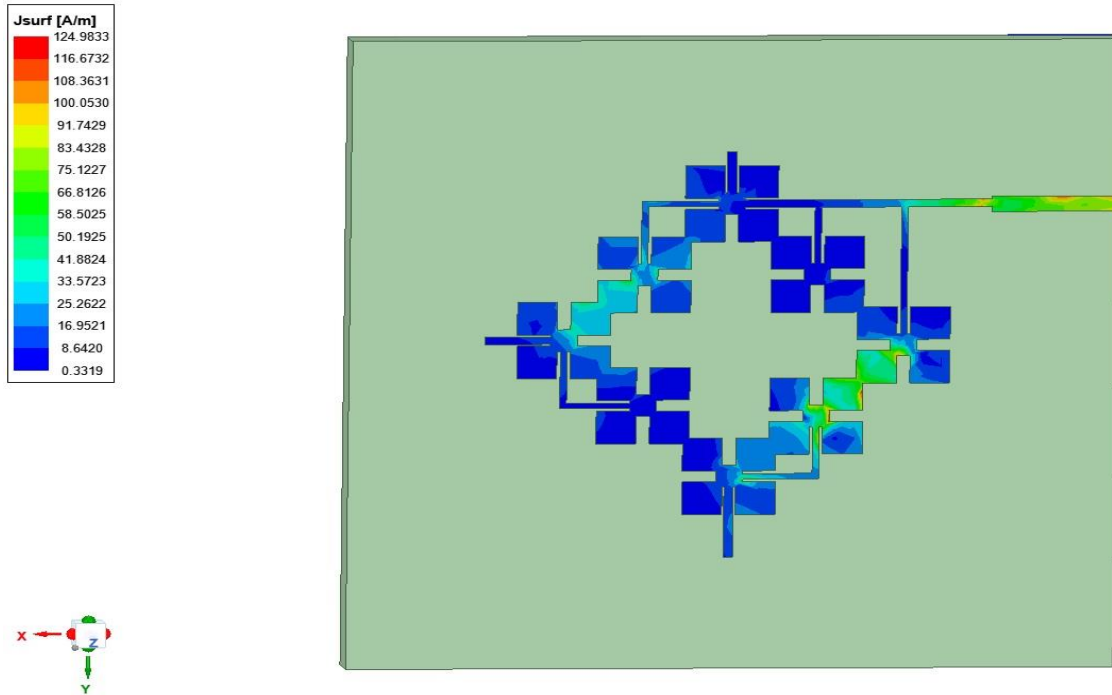


Fig:4.10: Average Current Surface Field

4.3 SIMULATED RESULTS WITH PHANTOM

4.3.1 Brain phantom without tumor using proposed microstrip antenna

Placing the antenna near the brain and analyzing we will get return loss of different values in each case. For the simulation without a tumor, we will get a return loss of -17.9 dB.

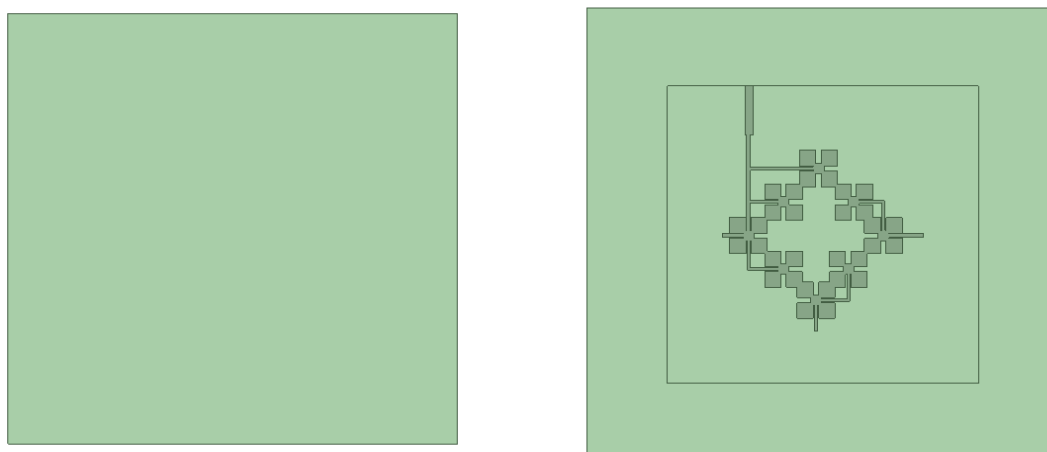


Fig:4.11: Antenna placed on Brain phantom

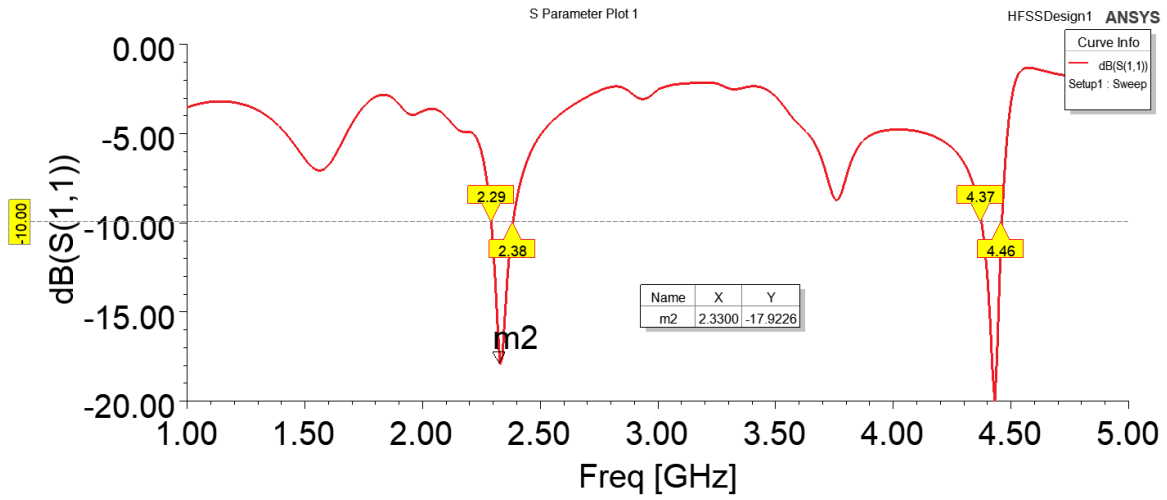


Fig:4.12: Return loss for Antenna placed on Brain phantom

4.3.2 Brain phantom with tumor using proposed microstrip antenna

Placing the antenna near the brain and analyzing we will get return loss of different values in each case. For the simulation with the tumor, we will get a return loss of -19.0008dB.

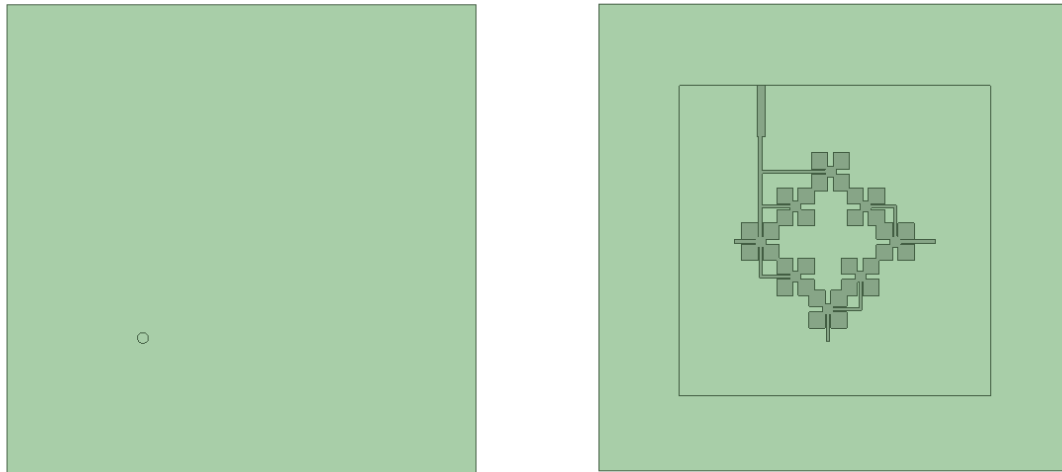


Fig:4.13: Antenna placed on Brain Phantom with tumor

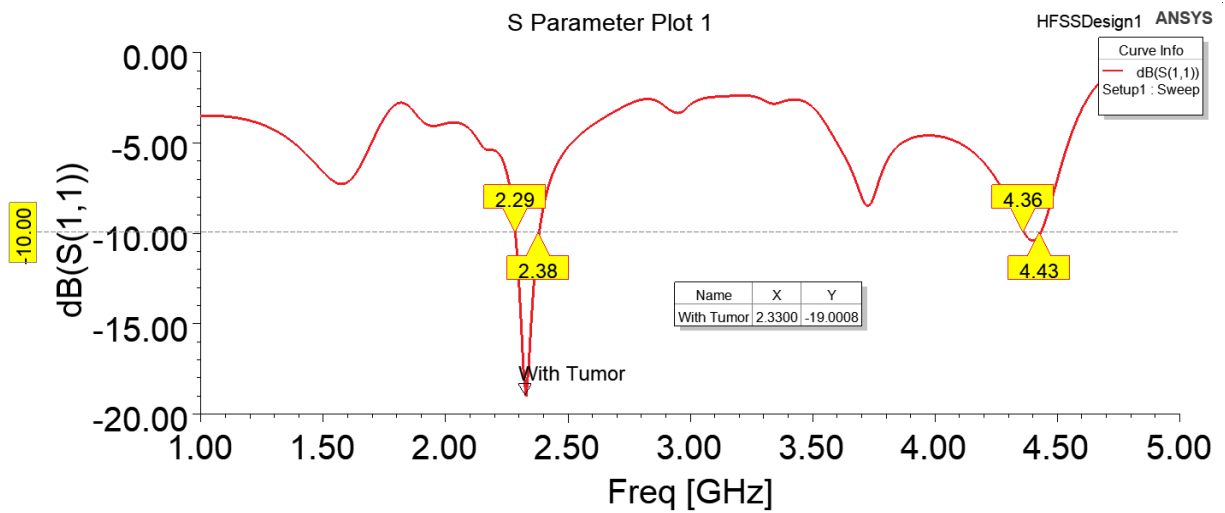


Fig:4.14: Return loss for Antenna placed on Brain phantom with tumor

4.3.3 Comparison of operating frequency and return loss

Here the antenna selected to be placed along the head model. it can be seen that when the antenna is brought near the human head there is a considerable change that occurs in the antenna's performance. The resonant frequency and return loss values get changed the antenna is kept near the high permittivity structured human head phantom model.

Table 4.2: Frequency comparison

TYPE	FREQUENCY	RETURNLOSS
Free space	2.40 Ghz	-38.55
Without tumor	2.33 Ghz	-17.92
With tumor	2.33 Ghz	-19.00

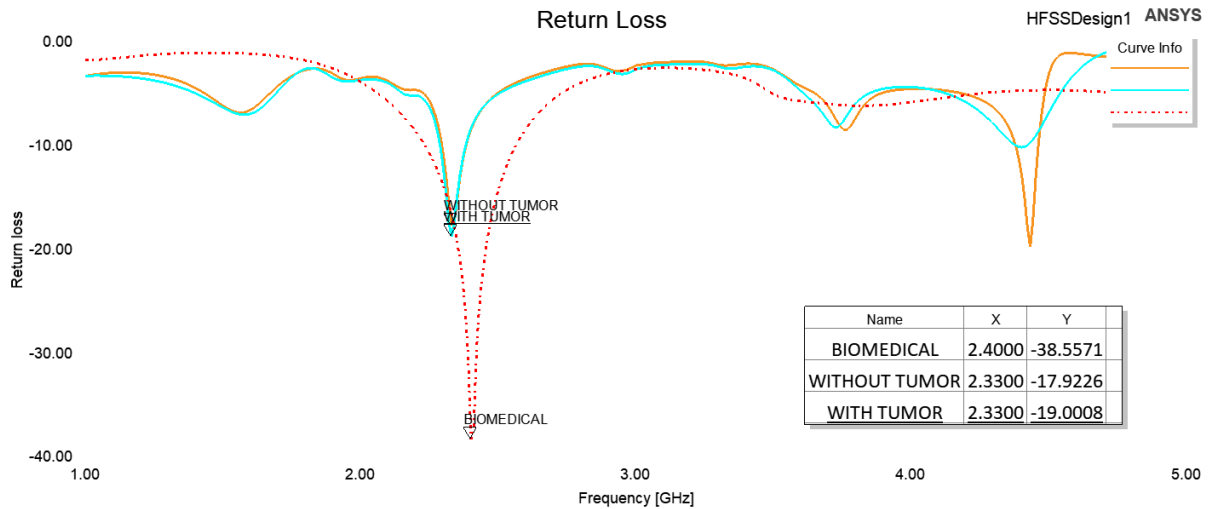


Fig:4.15: Return loss comparison

4.4 SUMMARY

Various parameters were used to measure the performance of an antenna. The parameters include return loss, voltage standing wave ratio (VSWR), gain, directivity, efficiency, power, radiation intensity, and specific absorption rate (SAR). From the output, it concluded that the proposed antenna is working perfectly without giving any harm to the patient and to test this, artificial analysis is also performed by creating a brain phantom and tumor phantom, and then return loss is analyzed for this artificial analysis and found the antenna is working according to the requirement.

CHAPTER 5

CONCLUSION

Thus, the implementation of the Hilbert curve in the radiating patch using an iterative method has resulted in optimized outputs with improved working parameters such as S11, gain, and directivity. Through extensive testing and analysis, it was observed that the quarter-wave optimization technique provided the best optimization for implementing brain phantom analysis.

Phantom models were created, with and without tumors in the brain, using their respective permittivity values. The antenna's performance was analyzed in free space propagation and on the brain phantom in the absence and presence of propagation. It was noted that the proposed antenna showed variations in the S11 parameter, indicating its ability to detect the presence of a tumor.

Overall, the proposed antenna was found to be working perfectly at the frequency of 2.4 GHz, without emitting harmful radiation. The results of this study suggest that the Hilbert curve implementation in the radiating patch using an iterative method is a promising approach for developing high-performance antennas for medical applications, especially in the detection of brain tumors. Further research can explore the potential of this approach in other areas, such as wireless communications and IoT devices.

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