A

PROJECT REPORT

ON

"Microstrip Patch Antenna for Breast Cancer Diagnosis at 2.5 GHz"

Submitted for partial fulfillment of award of

<u>BACHELOR OF TECHNOLOGY</u>

Degree In

Electronics & Communication Engineering

By

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Candidate's Declaration

I hereby declare that the work which is being presented in this dissertation entitled as **"MICROSTRIP PATCH ANTENNA FOR BREAST CANCER DIAGNOSIS AT 2.5 GHz"**, towards the partial fulfillment for the award of Degree of Bachelor of Technology in Electronics & Communication Engineering, submitted in the Department of Electronics & Communication Engineering, Institute of Engineering & Technology, Bundelkhand University, Jhansi, is an authentic record of my work, under the kind guidance of **Er. Saiyed Tazen Ali**, Lecturer, Department of Electronics & Communication Engineering, Institute of Engineering & Technology, Bundelkhand University, Jhansi.

I have not submitted the matter embodied here for the award of any other degree.

Date**: 28 MAY 2024** **NAKUL SHARMA** **(201361031029)**

Certificate

Certified that group has carried out the project work presented in this report entitled "**MICROSTRIP PATCH ANTENNA FOR BREAST CANCER DIAGNOSIS AT 2.5 GHz**" for the partial fulfillment for the award of degree of **Bachelor of Technology** from Bundelkhand University, Jhansi. The work is carried out by Students themselves and the contents of the work do not form the basis for the award of any other degree to the candidate or to anybody else.

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Certificate

Certified that Group has carried out the Project work presented in this report entitled "**MICROSTRIP PATCH ANTENNA FOR BREAST CANCER DIAGNOSIS AT 2.5 GHz**" for the partial fulfillment for the award of degree of **Bachelor of Technology** from Bundelkhand University, Jhansi. The work is carried out by Students themselves and the contents of the work do not form the basis for the award of any other degree to the candidate or to anybody else.

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NAKUL SHARMA

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Abstract

Among the most common invasive diseases affecting women worldwide is breast cancer. These days, breast cancer affects an increasing number of women annually. Although these methods have limits, the following are the primary techniques used for the identification of breast tumours: mammography, biopsy, computer-aided detection, and magnetic resonance imaging. Micro strip antennas are wearable, practical, planar, and simple to produce. They have some appealing qualities and characteristics, but they also have certain clear drawbacks that must be considered before using them. The wearable antenna's wearable bending in two dimensions demonstrates its adaptability for electronic wearables. Antenna operating in the ISM band is ideal for use in biological fields. Antennas using radiation patches may operate in the broad ISM band of 1.9–2.5GHz or 5.3–5.6GHz, which is used for wearable biomedical applications. Due to its low Specific Absorption Rate (SAR), silk substrate is used in the suggested antenna and is applied to the breast in order to identify breast cancer tumours. Both in and out of regions impacted by cancer, Microstrip Patch Antenna were taken into consideration and examined. It was discovered that the gain and electrical conductivity performance changed because cancer cells are tissues with a higher water content. Convenient software, such as the CST Studio suite or CST ANSYS software, will do the analysis for the antenna simulation. We'll measure and tabulate the simulated outcomes.

CHAPTER-1

INTRODUCTION

Cancer is a disease that develops when aberrant cells grow out of control and quickly spread to other parts of the body, harming healthy organs. Usually, it begins anywhere in the body and develops into a solid tumour. Among the most common invasive illnesses affecting women worldwide is breast cancer. These days, breast cancer affects an increasing number of women every [6]. In addition to causing mortality, breast cancer may also result in additional severe consequences in the liver, brain, lungs, and bones. Early diagnosis of tumours that cause breast cancer is crucial for ensuring vital, appropriate, and successful therapy. It is well acknowledged that breast cancer is the most common kind of cancer worldwide, and the sooner it is discovered, the better. Currently, X-ray imaging, often known as Xray mammography, is the most widely used method of detection. But because of the limitations of X-ray mammography, scientists began looking for a brand-new, cutting-edge tool to help with breast cancer early detection [1]. Microwave imaging works by employing low power electromagnetic radiation at microwave frequencies to light the target and then observe its inside components. Microwave imaging has been used for the diagnosis of breast cancer for a very long time. One common technique for detecting and confirming the presence of breast tumours is to use microwave radiation. This may be classified into two types: tomography and radar-based. An antenna is a conductive metallic device used for sending and receiving electromagnetic waves, or radio waves, which are often used for signalling or communication.

Transmitter and receiver antennas are the two basic types of antennas. Radio waves are sent and received with the intention of broadcasting or communicating information at the speed of light. One transmitter is utilised to radiate towards the breast during the initial stage of tomography, and many antennas are positioned around the breast to collect diffracted and dispersed waves at the same time [3]. A 2-

D or 3-D picture of the breast is obtained by a few operations carried out based on the data acquired.

Microwave imaging based on radar is another technique used to identify breast cancer. at order to apply this technology, a single ultra-wideband (UWB) antenna must be used to send a brief pulse to the breast, receive the dispersed signal back, and repeat the process at different places around the breast [7]. The presence of a tumour will be indicated if the scattering intensity was high. Comparing this approach to the tomography microwave imaging method, more comprehensive information is offered. However, there are some restrictions since the UWB antennas need to approve the resolution level. Therefore, low side lobes, low mutual coupling, and wide fractional bandwidth are the main attributes that need to be taken into account [6]. In addition, the metallic sensors need to be positioned in a medium that is almost same in permittivity to the breast tissue in order to reduce reflection between the breast surface and the open space. The application of the matching media around the patient's breast is challenging in real life, however. As previously mentioned, there are many primary methods for detecting breast tumours, including mammography, biopsy, computer-aided detection, and magnetic resonance imaging. However, each of these methods has its limits. Micro strip Patch Antenna (MSPA) is another technology that may be used to get around these systems' limitations.

These parameters are sometimes also referred to as antenna properties or characteristics:

- Radiation Intensity
- Directivity and Gain
- Input Impedance
- Effective Length
- Bandwidth
- Effective Aperture
- Antenna polarisation
- Radiation Efficiency
- Antenna Radiation Pattern.

1.1. Problem Statement

One of the worst illnesses is cancer, particularly when it progresses to a malignant state, takes over the body, and spreads to other organs [12]. It occurs when a cell's development process goes awry, and even with the availability of contemporary tools, it has been difficult to identify for years. Breast cancer is one of the most frequent types of cancer in the world, taking the lives of many women. As a result, there is a need to address this issue, discover a treatment, and—above all—develop a method for detecting the disease. Numerous years of study have shown that the key to treating cancer is to catch it early, before it spreads to other organs and becomes uncontrollably aggressive. Numerous techniques, including mammography, MRIs, and ultrasounds, have been proposed for the detection of these tumours. However, the limitations of these technologies, primarily related to poor contrast, make it difficult to detect the cancer early and decrease the likelihood of a successful cure [3]. This study looks at the use of microwave imaging, which has shown to be a potential method of cancer diagnosis when combined with radar-based approaches and microwave tomography.

1.2. Various Types of Antennas

1.2.1. Wire antennas

- Examples: Loop antenna, monopole, dipole, helix.
- Typically used for personal usage in vehicles, buildings, ships, planes, and spacecrafts etc.

Fig1.1: Dipole antenna

1.2.2. Aperture Antennas

- Examples: Waveguide opening, horn antennas.
- Typically used in spacecraft and aeroplanes, these antennas allow for flush mounting.

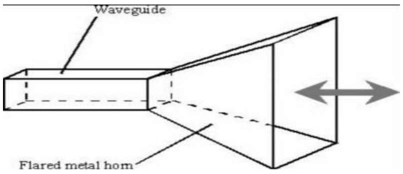


Fig1.2: Horn antenna

1.2.3. Reflector Antennas

- Examples: Corner reflectors, parabolic.
- These high-gain antennas are often used in satellite tracking, microwave transmission, and radio astronomy.

Fig1.3: Reflector antenna

1.2.4. Lens Antennas

- Lenses that are concave, convex, convex-convex, and convex plane. Typically, extremely high frequency applications employ these antennas.

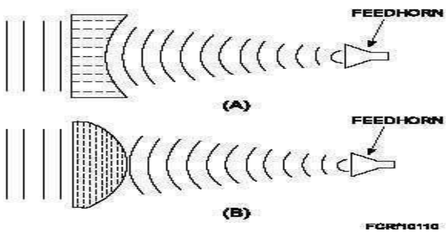


Fig1.4: Lens antenna

1.2.5. Microstrip Antennas

- A metallic patch above a ground plane that is formed like a rectangle, circle, etc. used in automobiles, mobile phones, satellites, aeroplanes, and other objects.

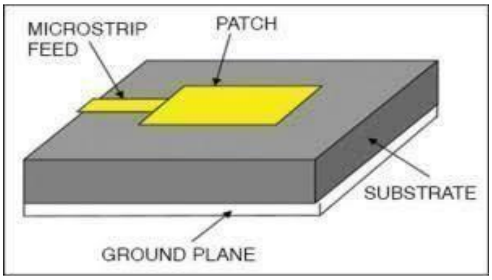


Fig1.5: Microstrip antenna

1.2.6. Array Antennas

- Microstrip patch array, aperture array, slotted wave guide array, and Yagi-Uda antenna.
- Applied for high gain uses with supplementary benefits like adjustable radiation.

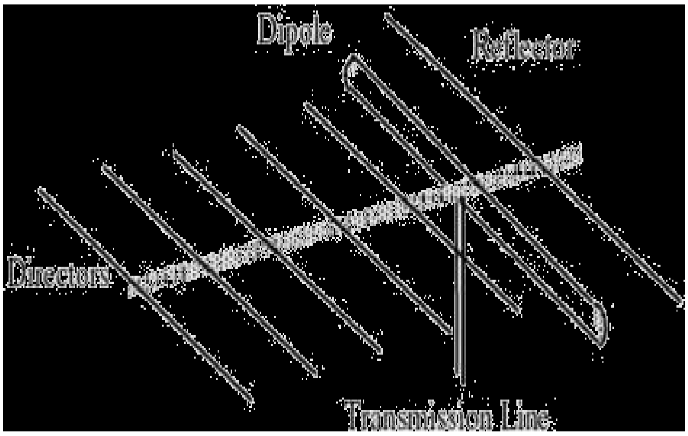


Fig1.6: Yagi-Uda antenna

1.3. Antenna Parameters

1.3.1. Return Loss

Another means of conveying mismatch is the return loss. The power reflected by the antenna and the power put into it from the transmission line are compared using a logarithmic ratio expressed in dB [6]. The following describes the connection between SWR and return loss.

$$\text{Return Loss} = -20\log_{10}\left(\frac{\text{VSWR} - 1}{\text{VSWR} + 1}\right)\text{dB}$$

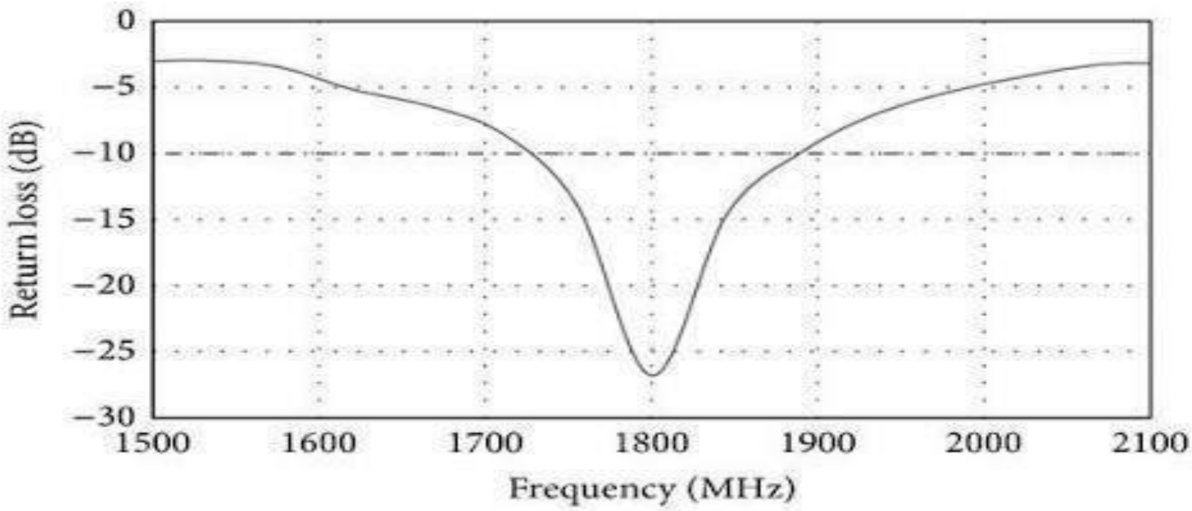


Fig1.7: Example plot for return loss

1.3.2. Band Width

The range of frequencies that an antenna can properly function across is referred to as its bandwidth. The number of Hz for which an antenna will have an SWR less than 2:1 is known as the antenna's bandwidth [6]. Another way to express the bandwidth is as a percentage of the band's centre frequency.

$$B = 100*\frac{(FH-FL)}{FC} \tag{1.2}$$

Where

FH -Highest frequency in the band

FL is the lowest frequency

FC is the centre frequency

Thus, the relationship between bandwidth and frequency is constant. The bandwidth would vary based on the central frequency if it were stated in absolute frequency units. Different antenna types have varying bandwidth restrictions.

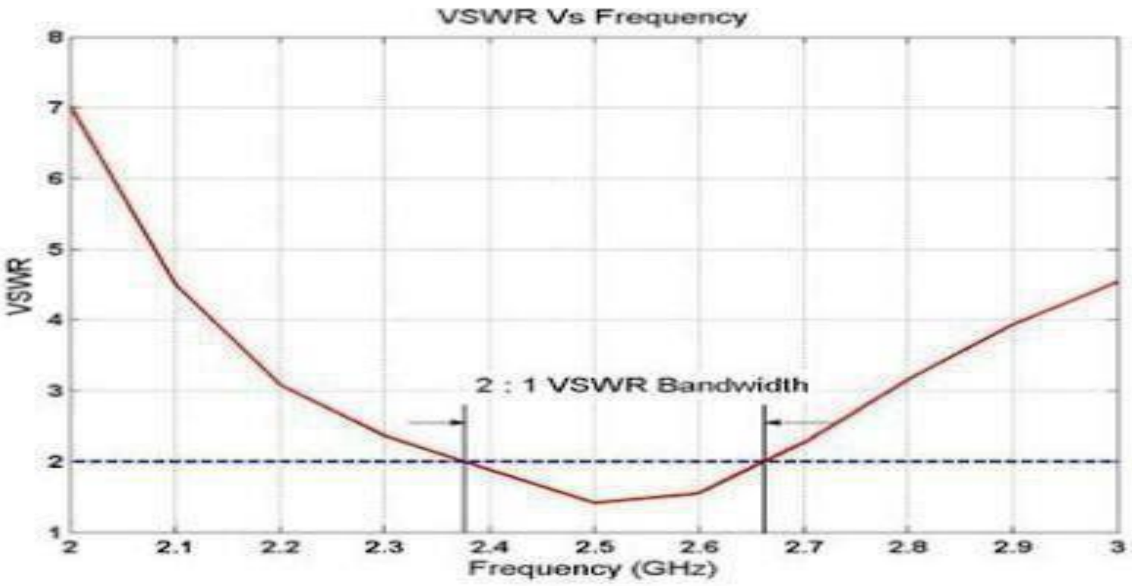


Fig1.8: Example plot for band width

1.3.3. Directivity

The capacity of an antenna to concentrate energy in a certain direction during transmission or to better accept energy from a specific direction during reception is known as directivity. The radiation beam may be focused in the desired direction in a static environment by using the antenna's directivity [5]. On the other hand, an omni-directional antenna is one that radiates equally in all directions in a dynamic system where the transceiver is not stationary.

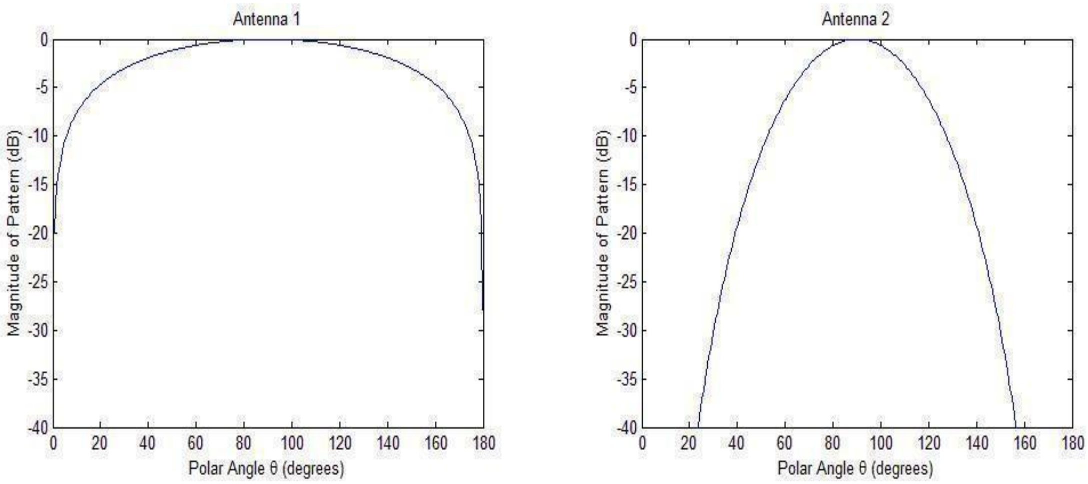


Fig1.9: Example plots of radiation pattern of antennas with higher directivity

1.3.4. Gain

Gain is a dimensionless ratio rather than a number that can be expressed in terms of a physical quantity like a watt or an ohm. Gain is expressed in terms of a typical antenna. The isotropic antenna and the resonant half-wave dipole antenna are the two most often used reference antennas. In any direction, the isotropic antenna transmits equally effectively. Although there are no true isotropic antennas, they provide helpful and straightforward theoretical antenna designs that may be used to compare actual antennas. In some directions, any actual antenna will emit more energy than in others [6]. It must emit less energy in other directions as it cannot produce energy and hence radiates the same overall power as an isotropic antenna. The amount of energy emitted in a direction relative to the amount of energy an isotropic antenna would radiate in the same direction when driven with the same input power is known as the antenna's gain in that direction. Typically, the only gain that matters to us is the maximum gain, or the gain in the direction where the antenna emits the highest power. The notation for an antenna gain of 3dB relative to an isotropic antenna is 3dB [1]. When comparing different antennas at a single frequency or over an extremely narrow frequency range, the resonant half-wave dipole might be a helpful benchmark. It takes many dipoles of varying lengths to compare the dipole to an antenna throughout a frequency range. The notation for an antenna gain of 3 dB relative to a dipole antenna is 3dB.

Technically speaking, again transfer technique is the process of determining gain by comparing the antenna being tested to a recognised standard antenna that has a calibrated gain. The three antennas approach is an additional technique for calculating gain. When three random antennas are measured at a known set distance apart to determine the broadcast and received power at the antenna terminals.

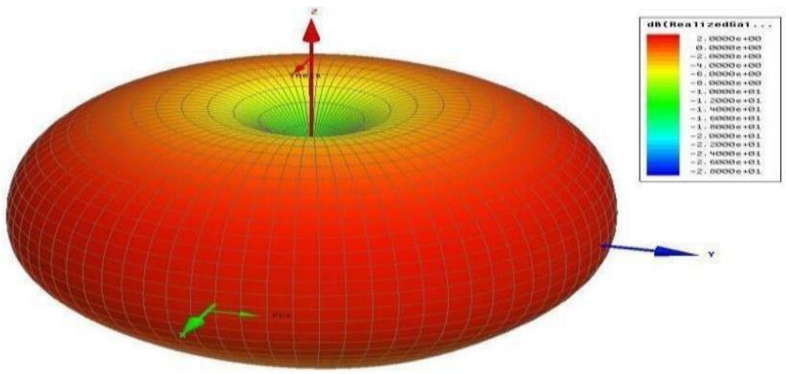


Fig1.10: Example gain pattern of an antenna

1.3.5. Radiation Pattern

The relative intensity of the radiated field at a fixed distance and in different directions from the antenna is described by the radiation, also known as the antenna pattern [4]. Since the radiation pattern also represents the antenna's receiving characteristics, it also functions as a reception pattern. Although the radiation pattern is three-dimensional, the measured radiation patterns are often a two-dimensional slice in the vertical or horizontal planes of the three-dimensional pattern. There are two formats available for these pattern measurements: rectangular and polar.

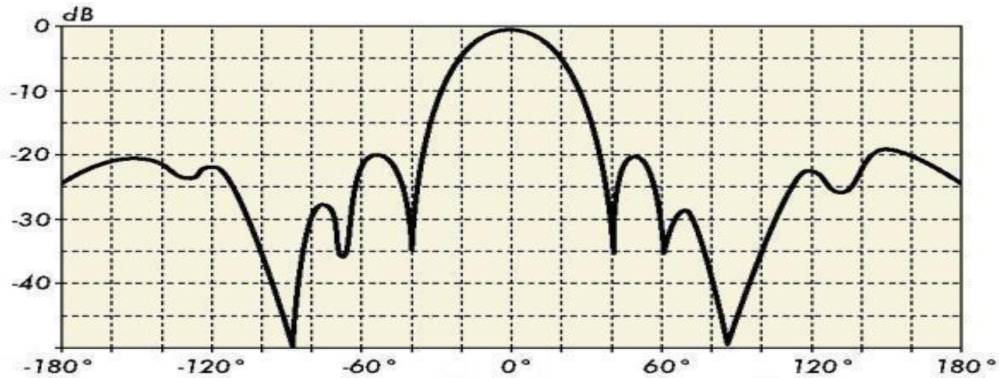


Fig1.11: Example for rectangular plot representation of radiation pattern

Almost all systems of coordinates are polar. By projecting points along a rotating axis (radius) to an intersection with one of multiple concentric circles, points are identified in the polar coordinate graph.

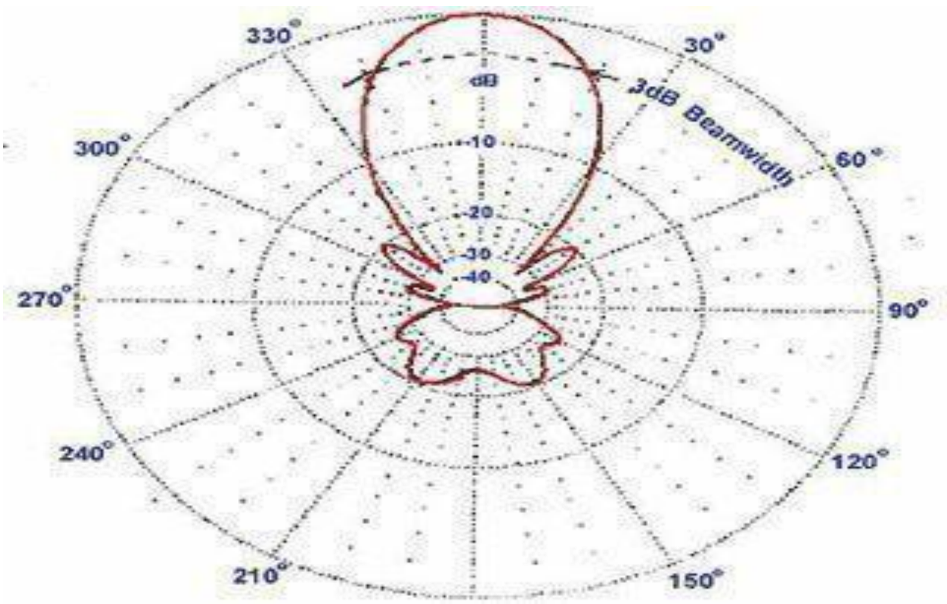


Fig1.12: Example for polar plot representation of radiation pattern

1.3.6 Logarithmic

The concentric circles are graded and uniformly spaced in the linear coordinate system. A linear plot of the signal's power may be created using such a grid. The concentric grid lines of the logarithmic polar coordinate system are spaced at regular intervals based on the signal's voltage logarithm. The logarithmic constant of periodicity may have a range of values, and the projected patterns' appearance will depend on this decision.

1.3.7 Polarization

The direction of an electromagnetic wave's electric field is known as polarisation. An ellipse is often used to describe polarisation. Linear polarisation and circular polarisation are two examples of elliptical polarisation special instances. The antenna determines a radio wave's initial polarisation. The electric field vector in circular polarisation seems to be spinning with circular motion around the direction of propagation, completing one complete turn for each RF cycle, in contrast to linear polarisation where the electric field vector always remains in the same plane. Either the right or left hand may rotate in this way. One of the design options accessible to the designer of an RF system is the selection of polarisation.

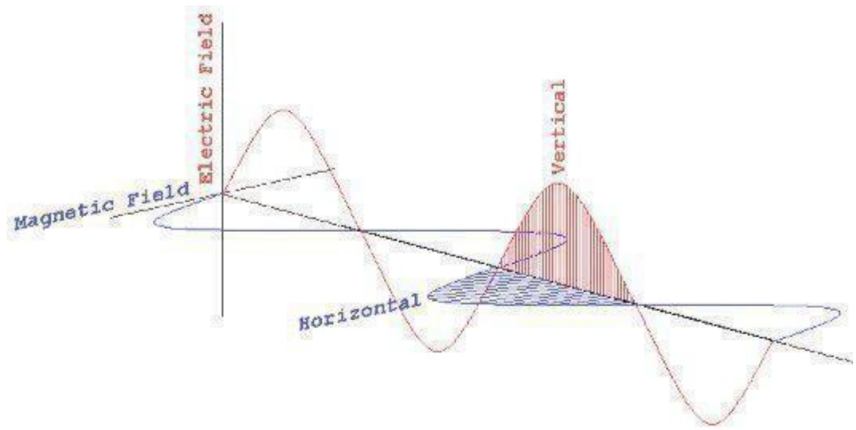


Fig1.13: Example figure for polarization

1.3.8 Polarization Mismatch

A transmit and a receive antenna must have the same axial ratio, the same polarisation sense, and the same spatial orientation in order to transfer the greatest amount of power between them. There will be less power transmission between the two antennas if they are not aligned or have different polarisations. The efficiency and performance of the system as a whole will decline due to this decrease in power transmission. A polarisation mismatch loss occurs when physical antenna misalignment occurs between the linearly polarised transmitter and receiving antennas.

1.4. Structure Of Micro-Strip Patch Antenna

A device called a microstrip patch antenna is composed of many pieces, including substrate, ground, patch, feed line, and source. Positioned on the dielectric material, the metallic patch is held up by the ground plane. Photo etching is the method used to establish feeding lines and radiating patches on dielectric material. A conducting substance, such as silver, copper, aluminium, etc., makes up the ground plane. Depending on the use, the substrate might be square, round, or rectangular in form.

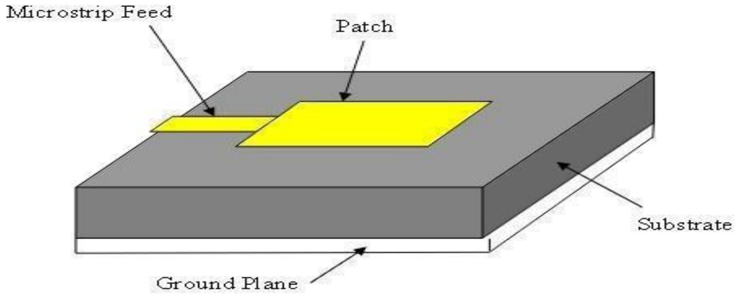


Fig1.14: Structure of Micro Strip Patch Antenna

The ground plane, which is made up of a conductor, comes first. The substrate component, which contains the dielectric, comes in second, followed by a conductor that symbolises the metal patch. The ground plane and the substrate are positioned above one another in the antenna's design. They are just the same size. An antenna is a conductive metallic device used for sending and receiving electromagnetic waves. Radio waves are often used for signalling or communication. In the medical industry, antennas have been used generally and in the treatment of cancer in particular. In general, antennas may be employed as communication or therapy devices. Radio Frequency Identification (RFID) has been utilised in medical implants, monitoring systems, and microwave imaging. It has also been used for diagnosis and treatment, and sometimes merely for information transfer. Transmitter antennas and receiver antennas are the two basic types of antennas.

Radio waves are sent and received with the intention of broadcasting or communicating information at the speed of light. The metal patch component, on the other hand, is almost half the size of the other two. An electromagnetic field is created during the transmission of radiofrequency energy into space. An antenna experiences an induced voltage when the travelling electromagnetic field reaches the receiving antenna.

Wireless technologies are incorporated into implanted antennas to enable physicians to continuously monitor the patient's body and identify cellular changes, including the transformation of cells into malignant tumours. Furthermore, there are internal and exterior antennas, and the position of the antenna determines its form. In order for antennas to function, electricity must be supplied to them via a copper cable known as the feeder [2]. Because the feeder is connected to the metal patch, the antenna's initial component and a conductor, voltage and current will manifest themselves. The voltage will almost reach zero as it approaches the antenna's midway point, and the current will be zero at its ends. A little metal patch will cause an open circuit, which means there won't be any electricity flowing.

1.5 Micro -Strip Patch Antenna in Breast Cancer

With the use of microwave imaging, breast cancer may be found early. Studies are conducted on the micro-strip patch antenna's capacity to detect breast tumours because of its properties, which include tiny size, light weight, low profile, and cheap production cost [8]. As a result, the micro-strip patch antenna became operational and helpful for imaging, helping to both pinpoint the suspicious lesion in the breast for a biopsy procedure and assist in the early identification of cancer. Wearable technology refers to the integration of electrical and computer technologies into clothing [4]. It is appropriate for daily wear. These gadgets include headgear, watches, eyeglasses, earrings, and textiles. These gadgets are multifunctional; in addition to functioning as a computer and cell phone, they may also be used as sensors, trackers, or even scanning machines [13]. It is seen as a significant advancement in the ubiquitous computing movement, which allows information access for all users anywhere. Wearable technology has a wide range of applications overall. Prior to being released to the public, many gadgets were used in military technology. The performance of a microstrip patch antenna is more versatile for biomedical applications. When radio waves are converted into electrical currents and voltages and vice versa, antennas may be regarded of as a kind of "transducer." More precisely, they are gadgets designed to effectively emit or absorb electromagnetic radiation in a predetermined way [8].

1.6. Applications Of Microstrip Patch Antenna

Recently, the medical industry has begun using micro-strip antennas for imaging, diagnosis, and therapy. Furthermore, the ability to make contact between the human body and skin is made possible by the micro-strip antenna's flexibility [9]. Because MSPA patches may blend in with microwave circuits, they are ideal for a variety of applications, including navigation systems, wireless local area networks, and biomedical applications.

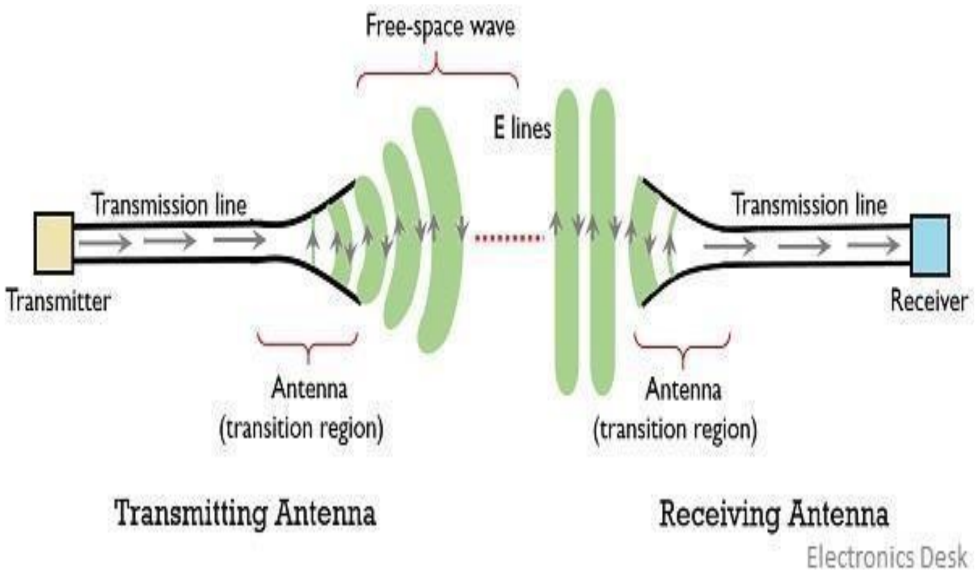


Fig1.15: Transmitting and Receiving Antenna.

An antenna is a device that uses electromagnetic waves to send and receive messages. Because it can convert between electrical signals and electromagnetic radiation to function as both a transmitter and a receiver at the same time, it is sometimes referred to as a transducer device. The transmission line's journey from the transmitter to the receiver is explained in Figure 2.1, which also illustrates how it links to wireless space and cables, respectively. In general, antennas have been used in medicine, especially in the treatment of cancer in particular [2]. In general, antennas may be employed as communication or therapy devices. Radio Frequency Identification (RFID) has been utilised in medical implants, monitoring systems, and microwave imaging. It has also been used for diagnosis and treatment, and sometimes merely for information transfer.

These days, the main goals of antenna development are to minimise antenna size and reduce complexity [14]. The Wireless Body Area Networks (WBANSs) study aims to establish a connection between the human body and electronic devices. It employs techniques similar to those found in wireless systems and consists of a group of small nodes that are fitted with a sensor, such as a motion detector, and a wireless device [9]. Since it is well known that the frequency of the microwave band rises in the human body, Specific Absorption Rates, or SARs, are often used to test wireless equipment and protect the body from radio wave exposure. Communication patch antennas are employed because of their small size, simple construction, and high gain; nevertheless, patch antennas are limited by their strong back radiation. Flexible antennas with compact size, minimal effect on human body, and lower SAR are always preferred in WBAN.

1.7. Advantages Of Micro Strip Patch Antenna

When constructed using the traditional micro strip manufacturing method, MSPA is very easy to produce. Circle polarisations, frequency agility, dual characteristics, feed line flexibility, and beam scanning are all readily achieved with these patch antennas. Compact design, low mass, good gain, low cast, low weight, and low profile. Microwave Integrated Circuits Can Easily Be Integrated with It. It is compatible with both circular and linear polarisation. Microstrip patches come in three distinct shapes: square, triangular, and rectangular. They are easily etched. ability to operate at two and three frequencies. Greater Flexibility in Microstrip Patch Antenna for Biomedical Applications MSPA's performance Because these patches may blend in with microwave circuits, they are ideal for use in wireless local area networks, navigation systems, and biomedical applications, among other applications.

This chapter covered the project's problem statement, types of antennas, antenna parameters, the structure of the microstrip patch antenna, the use of the microstrip patch antenna in breast cancer research, applications, and benefits of the microstrip patch antenna.

CHAPTER -2
LITERATURE SURVEY

Literature Review on Brest Phantom Cancer Tumour Detection Using Micro Strip Patch Antenna.

Circular Patch on Body Antenna for Breast Cancer Detection by Dhrubo Ahmad, Rajan Kumar Brahmadatta, Sushree Nibedita Sahu, B. Dayanand, S. Subhaj, Maidul Islam Sarder, Sk. Subrata Saha, Garima Singh, Rajeev Tiwari, and Chethan Vishnu (2019) IEMANTENNA International Elect To identify malignant tumours presence, two types of breast phantoms were created: Donetsk breast phantom and heterogeneous breast phantom. While calculating the values of the two phantom S11s, their values were as follows: s11 = -8. 49 and -8. beats per minute (bpm) from 66 at rest to 154 during the exercise with 43 dB, respectively, while the first one shifted from -12. 73dB to 12. 47dB. For the simulated and measured antenna mentioned in the intended article, flying performance must be high, S11 should be as close to 0 centimetre as possible, radiation pattern should be as uniform as possible and fair gain across the operating band must be provided. Pertaining to the want set by the customer, evidences are required to be supported by comparing the category in the design part with other customer wants.

The article under analysis is titled “Time of Arrival Data Fusion Method for Two-Dimensional Ultrawideband Breast Cancer Detection” written by Yifan Chen, an author being a member of the IEEE, and his co-authors (2021). This paper demonstrates a new approach in applying microwave imaging equipment, termed as ultrawideband (UWB) imaging system, for detection of breast tumours. The information obtained from an array of TOA readings could be used to identify the location and presence of small and asymptomatic malignant formations. Thus, to estimate the IR components of each sensor, it is proposed to apply the generalised sequence CLEAN (GS-CLEAN) technique dividing the matrix into portions that are less than the length of the sounding pulse. This new deconvolution method addresses an inverse problem to reconstruct the morphological/dielectric profiles, and time delays of unknown tumours, and it works well without losing much information when a picture carries almost continuous data. To anticipate where dominating scattering sources such as malignant tumours might appear the TOA data fusion step is then applied. Moreover, to understand both electrical and morphological features of the tumour using data gathered from each antenna element, we employ entropy-based approaches. Preliminary studies using the method in two dimensions – 2-D analysis and simulations – indicate that it will be possible to discover minor cancerous tumours in the breast with the created system.

Elsherif et al., 2020 Breast Cancer Early Detection with Microchip Patch Antenna Thus, the detection of cancerous tissue at an early stage is very important. Despite this, there are limitations associated with current methods of breast cancer detection. Therefore, methods for microwave imaging (MWI) were developed. MWI methods are quite interesting and I believe they have a great potential. This paper presents the design and enhancement of a rectangular microstrip patch antenna (RMPA) for breast cancer detection. Further, breast phantom was constructed with and without cancer using Computer Simulation Technology Microwave Studio (CST-MWS). The results showed that the current density, magnetic field, electric field, and power loss density were increased to 30 A/m2, 10 A/m, 1800 V/m, and 100,000 W/m3 respectively when the breast tumour was lodged. These findings show that the RMPA that has been described here can achieve higher sensitivity for breast tumour detection than the other designs reported in the literature.

IEEE Miniature planar UWB MSPA implanted on breast skin to detect cancer tumour. Kaeli, et al. (2019) Miniature Planar Ultra- Wide – Band Microstrip Antenna for Breast Cancer Detection. The antenna operates at 6 GHz. mammaries are situated 5 to15 cm apart from each other. This research provides details of identification of a tumour at thirteen different sites within a compact and dense mammary gland of a human being using only four 1. 5 GHz meander line microstrip patch antennas for breast cancer diagnosis. The medical profession may use this developed arrow band microstrip medical antenna for breast cancer detection uses.

“Design of Microstrip Patch Antenna to Detect Breast Cancer,” Vinoth Kumar et al. (2018) April 2020 issue of ICTACT journal on microelectronics Rectangular MSPA that was used in the design, simulation, fabrication, and validation of S11 value which is -18. 91 dB at 2. 4 GHz. A phantom without tumour has VSWR of 1. 11, whereas one with a tumour has a 1. 45 VSWR. The goal for the design of the antenna is to achieve high isolation, low profile, minimum cost and relatively simple to fabricate. For the radio frequency ranging between 2 and 12 GHz the dimensions of the antenna in the vertical and the horizontal directions are 34 mm and 36 mm respectively. Using the CST modelling technique, a truncated rectangular form of the antenna is developed. This new deconvolution approach aims to solve an inverse problem to reconstruct the morphological/dielectric properties and time delays of the unknown tumours and works well with almost continuous image data.

Shanmuganantham et al. (2018) proposed a study and design of an SRR loaded ACS-Fed Multiband Koch star and Minkowski Curve Fractal-Patch Antenna. The antenna is printed with a 1. 6 mm thickness mounted on a 12 mm x 20 mm Flame Retardant-grade 4 dielectric substrate having a relative permittivity of 4. 4. To achieve multiband quality, a split ring meta material resonator is fixed at the back side of the FR4 and multiple fractal shapes are placed on the face side of the rectangular patch resonator. This makes it possible to obtain additional resonances. At Multi Vendors, the antenna plan for WLAN IEEE802. 11/ Radio Frequency Identification/ satellite/ microwave relay/ HYPERLAN 2/ Radar band at 2. 55 GHz, 3. 17 GHz on S band, 5. 46 GHz, 6. 51 GHz on C band, and 10. X band at 37 GHz. The following is a summary of the intended antenna's simulation and measurement result: high flying performance, ideal S11, correct radiation pattern, and reasonable gain over the operating frequency range. These should be supported by comparing the category in the design part with other customer wants.

The studies on Circularly-Polarized SIW Cavity-Backed Filtennas were recommended by Huayan Jin et al. (2017). Substrate integrated waveguide cavity-backed structure is suitable for generating circularly polarised antennas because SIW is a low loss, low profile multi-mode resonator. When introducing the CP patches into SIW cavities, filtering responses may be created with the help of electric and magnetic coupling between the patch and SIW cavity as well as the modes of the SIW cavity at the same time. By applying these filtering techniques, three examples of SIW cavity-backed filtennas are designed and analysed. A cavity-backed patch filtenna with a wideband single-layer dual-CP SIW and an out-of-band rejection level over 13 dB is achieved. Radiation nulls are achieved by the mixed coupling between the patch and the cavity as well as the TE110 mode of the SIW cavity. In our next work, we further utilize the modified perturbations to reduce the frequency of the SIW cavity's TE220 mode and optimize the side roll-off of the high band.

Wang Wenlei, et al. (2015) In the corner-excited square SIW cavity operating at the degraded TE120/TE210 modes, a dual-CP SIW cavity-backed filtenna is designed.

These two SIW cavity modes may be divided to generate the CP radiation with the help of slot perturbation. By adding a square CP patch one can significantly enhance the AR bandwidth. Hence, the multimode SIW cavities and patch antennas should be employed to design the filters with a broader bandwidth and a high level of filtering. Table I also provides a comparison between the three suggested filtennas and previously reported CP filtennas. Out of all the options, Antenna I, a single-fed dual-CP filtenna, has certain benefits because of its small size, single-layer structure, and wide operating frequency range. It is a 2 × 2 CP filtenna. Antenna II has less intricate design, wide working band, high gain, excellent filtering capabilities, as no extra filtering circuits are required.

Md. Adasan Kabir et al “Microstrip Patch Antenna for Breast Cancer Detection,” 2021. The 5th International Conference on Electrical Information and Communication Technology (EICT) will take place on December 17–19, 2021. The reflection coefficient of Model 1’s breast phantom fluctuated between 17. 50214 to 17. for Model 1 they varied from 537977dB and for Model 2 from -40. 260902 to -39. 904223dB. The simulated study of the proposed antenna for tumour localization using CST Microwave Studio shows very good reflection coefficients. In analysing the reflection coefficient data obtained from the four antennas, the outcome of the work may contribute toward establishing a portable medical device that can be used to screen breast cancer at home.

Sushmitha K. and others (2021) International Conference on Applied Artificial Intelligence and Computing (2022): A microstrip patch antenna is defined in this work as having a truncated rectangular shape for breast cancer detection (ICAAIC). In designing the antenna, it is desired that the structure must have high isolation, low profile, low cost and easily fabricated. For radio frequencies ranging from 2 to 12 GHz, the dimensions of the antenna are 34 mm vertically and 36 mm horizontally. An antenna with a truncated rectangular form is designed and analyzed using the CST modelling technique. The antenna is resonant at 7 GHz for the frequency range of 2 GHz to 12 GHz, and the reflection coefficient is less than -28. This antenna was designed using the FR4 substrate which has a permittivity of 4. 3. A patch antenna with a length of 18 mm and a width of 11 mm was employed for evaluation of the gain, directivity and the S parameter. This built narrow band microstrip medical antenna may be used by the medical profession to detect breast cancer.

Wang Shih-Chang et al. (2018) “Detection of Two-Dimensional Ultrawide band Breast Cancer Using Time of Arrival Data Fusion Method” IEEE Antennas and Propagation Transactions, October 10, 2007 Two-dimensional UWS imaging aimed at identifying breast cancer. The received signals are then processed through the GSCLEAN algorithm individually for each of the sensors. In this paper, the procedure of developing a microstrip antenna with a defective ground structure (DGS) for a microwave imaging system operating at 2. In this paper the effectiveness of using 45GHz for the detection of breast tumours is discussed. Introducing dielectric substrates and microstrip feed inset with grounding patches at 2. At 45 GHz operating frequency, four types of microstrip patch antennas have been developed.

Electric and magnetic fields for the proposed microstrip antenna with DGS for breast cancer detection, Kho. J. Annie and others 2019. This paper presents a microstrip antenna with defective ground structure (DGS) for an imaging system at 2. This work aims to detect breast tumours using 45 GHz. Using dielectric substrates, FR4 (r = 4. 4 F/m), four various types of microstrip patch antennas have been designed using microstrip feed inset with grounding patches at 2. 45 GHz operating frequency. The electric (E), magnetic (H), and current densities are employed to quantify the results. To assess the antenna, a three-dimensional breast model with a defined conductivity and dielectric value is employed. The results show that in comparison with other suggested antennas, the antenna with design structure Design 4 gives good Intensities values of both E and H fields respectively with the tumour present. This gives voltages of 7083 V/m and 35. 5 A/m and the respective values without the tumour are 7186 V/m and 35. 8 A/m.

"Microstrip Antenna for Tumour Detection SAR Analysis," Yusnita Rahaya et al. (2019), IEEE 7th International Conference on Smart Instruments, Measurements and Applications (ICSIMA, 2021) S11 antenna parameters on a 4x4 array have an operating frequency of 4.9 – 6.4 GHz and an antenna parameter of -37.50 dB. The figure derived from head simulation data at 2.44 GHz, -14.50 Db. Initial two-dimensional (2-D) analysis and simulations show that it is possible to use this method to identify tiny cancerous tumours in the breast using the created system. The antenna's design aims to provide strong isolation, low profile, cheap cost, and ease of fabrication. At radio frequencies between 2 and 12 GHz, the antenna's vertical and horizontal lengths are 34 and 36 mm, respectively. The antenna with a truncated rectangular form is constructed using the CST modelling approach.

S. Bhavani et al. (2021) "Wearable Microstrip Circular Patch Antenna for Breast Cancer Detection" USNC - URSI Radio Science Meeting and 2021 International Symposium on Antennas and Propagation. For two diameters, 50 and 60 mm, Circular MSPA has been developed and produced with maximum SAR values. The antenna provides excellent return loss and increased bandwidth. It follows FCC guidelines for design. Wearable jeans are more flexible and used as a substrate in medical applications. Ashiqur, Md. Mamum Ur Rashid, et al. (2019) Four Flexible Microstrip Patch Antennas for Rahman Breast Cancer Detection and Tumour Localization International Conference on Electronic, Chemical, Materials, Computer, and Communication Engineering (IC4ME2). The use of microwave imaging as an imaging technique for breast cancer early detection is being investigated. The electrical characteristics of the breast cancer vary significantly from those of healthy breast tissue when subjected to electromagnetic radiation. This study aims to identify breast cancer. We investigate the capacity of a UWB microstrip antenna operating at 6 GHz to detect tumours. using a simple cone-shaped model. The tissues of the tumour, fat, and breast skin make up this model. The investigation is conducted based on several distances between the breast model and the patch antenna. To provide us with a thorough understanding of the idea under study, simulation and measured findings are provided. These include the antenna's reflection coefficient, gain, and radiation pattern as well as the current density in the breast skin, fatty tissue, and tumour.

This chapter included the literature review of the microstrip patch antenna's ongoing projects related to the detection of breast cancer tumours.

CHAPTER – 3
SOFTWARE

3.1 About Software

Fig3.1: CST Studio Suite

Computer Simulation Technology (CST) is a leading provider of electromagnetic simulation software. CST develops and markets CST Studio Suite, a high-performance 3D electromagnetic (EM) simulation tool that enables engineers and researchers to analyse and optimize the electromagnetic behaviour of their devices and systems. Here are some key points about CST:

1. CST Studio Suite:

   CST Studio Suite is the flagship product of CST. It is a comprehensive software package for simulating electromagnetic fields in various applications, ranging from antennas and RF/microwave components to high-frequency electronics, signal integrity, and more.

2. Electromagnetic Simulation:

   CST Studio Suite is designed for solving complex electromagnetic field problems. It uses various numerical methods and algorithms to simulate the behaviour of electromagnetic waves and their interaction with structures and materials.

3. Applications:

CST Studio Suite is widely used across different industries, including telecommunications, automotive, aerospace, electronics, healthcare, and more. It plays a crucial role in the design and optimization of a broad spectrum of devices and systems.

4. Features:

The software offers a range of features for modelling, simulating, and analysing electromagnetic phenomena. It includes tools for parametric analysis, optimization, co-simulation with other engineering disciplines, and post-processing of simulation results.

5. User Interface:

CST Studio Suite provides a user-friendly interface that allows engineers to set up simulations, define materials, and analyse results efficiently. The software supports both time-domain and frequency-domain simulations.

6. Versatility:

One of the strengths of CST Studio Suite is its versatility. It can handle a wide range of electromagnetic problems, from static and low-frequency simulations to high-frequency and microwave applications.

7. Education and Research:

CST software is often used in academic institutions for educational purposes and in research institutions for cutting-edge research in electromagnetics. It helps researchers explore new ideas and validate theoretical concepts through simulation.

8. Integration with Other Tools:

CST Studio Suite can be integrated with other simulation tools and engineering software, allowing for co-simulation with thermal analysis, structural analysis, and other disciplines to provide a more comprehensive understanding of a system's behaviour.

9. Support and Training:

CST provides technical support and training to help users make the most of their software. This support includes documentation, webinars, and direct assistance from CST's support team.

10. Industry Recognition:

CST Studio Suite has gained recognition in the electromagnetic simulation community and is widely used by engineers and researchers globally. Its accuracy and efficiency make it a valuable tool for designing and optimizing a variety of electromagnetic devices and systems.

It's important to note that details about CST may evolve over time, and users should refer to the official CST website or contact CST directly for the latest information.

3.2. History And Achievements

History:

CST was founded in 1992 by Dr. Martin Timm and Dr. Manfred Leidl in Darmstadt, Germany. The company initially focused on developing simulation software for electromagnetic applications. CST Studio Suite, the flagship product of the company, was developed and released. This software became widely recognized for its capabilities in electromagnetic simulation [6]. CST expanded its presence internationally, establishing offices and partnerships in various countries to serve a global customer base. In 2016, CST became part of Dassault Systèmes, a major software company known for its 3D design and engineering solutions. This acquisition aimed to strengthen Dassault Systèmes' portfolio in electromagnetic simulation.

Achievements:

- Industry Adoption:

CST Studio Suite gained widespread adoption in industries such as telecommunications, automotive, aerospace, electronics, and healthcare for its advanced electromagnetic simulation capabilities.

- Versatility and Accuracy:

The software has been recognized for its versatility, handling a wide range of electromagnetic problems, from low-frequency to high-frequency applications. Its accuracy in simulating complex electromagnetic phenomena has contributed to its success.

- Contributions to Research:

CST Studio Suite has been used in numerous research projects and academic studies, contributing to advancements in electromagnetics and related fields.

- Integration with Other Tools:

The software's ability to integrate with other engineering tools and simulation disciplines has been an important factor in its success, allowing for more comprehensive analysis in multi-physics simulations.

- Continued Development:

CST has continued to invest in the development of its software, introducing new features, capabilities, and improvements in successive versions of CST Studio Suite.

- Educational Initiatives:

CST has supported educational initiatives by providing software licenses to universities and educational institutions, helping train the next generation of engineers and researchers.

- Industry Partnerships:

The company has formed partnerships with various industry players, collaborating on joint projects and ensuring that CST Studio Suite remains at the forefront of electromagnetic simulation technology.

3.3. Three Layers of Breast

- Skin
- Fat

- Tissue

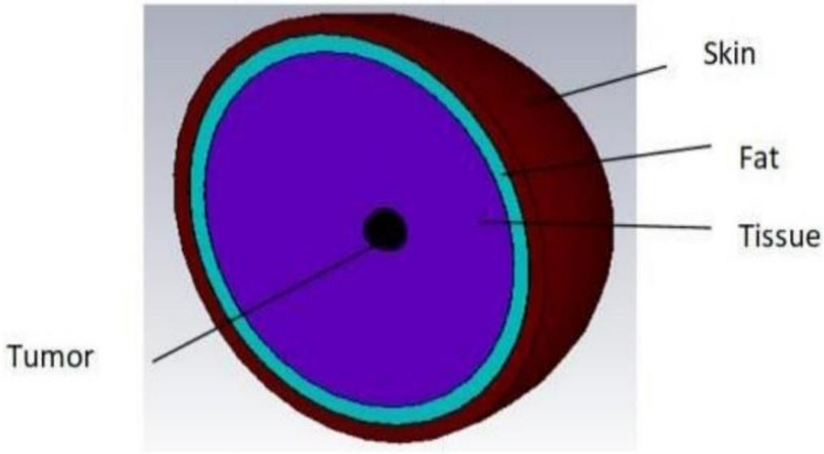


Fig3.2: Breast Layers

The phantom includes features imaged in the breast of a female, including fibre lesions, tumours of varying sizes, and microcalcifications [6]. Additionally, the phantom was used to evaluate the detectability thresholds, depth resolution, and sensitivity of lesion detection using various imaging modalities.

The phantoms cover the four breast density classes offered by the American College of Radiology:

(a) fatty
(b) fibro-glandular fragments
(c) unevenly distributed
(d) highly concentrated

3.4. 3-D Antenna Array Design

A 3D antenna array was created at Duke University with the goal of detecting cancer early on. Following an evaluation of the antennas' performance, the simulated scattered field information of the little cancer, and the parameters already established for the other components, they concluded that the clinical microwave imaging array is definitely capable of screening the malignancy. The inversion of their previously established technique at Duke University is also conceivable, as shown by the successful inversion of phantoms in earlier experimental data using a 3D imaging system.

Furthermore, all that will need to be done is complete the hardware system's implementation, design the prototype, and begin clinical testing.

Their main difficulties stemmed from the assumption that the antenna would radiate in free space, which is what most academics take into account while creating a stationary 3D array antenna [6]. Nonetheless, radiation should be directed towards the tumour while developing an antenna for breast cancer detection so that it can mimic the tumour's dielectric characteristics. On the other hand, the breast cancer antenna has to be enhanced in order to radiate straight into material with greater dielectric. Furthermore, sampling resolution must be taken into account since the antenna provides the capacity to determine the field distribution characteristics inside the imaging volume, which will be necessary to modify the dielectric properties of the region it radiated in [11]. Thus, it is preferable to enhance the covered area by adding more antennas. Furthermore, it is not desirable since adding more antennas would result in a higher coupling between them.

Furthermore, a few detrimental consequences of the mutual impedance on the antenna's operation, such the shifting of the resonant frequency, change the radiation pattern and lower matching performance. Additionally, because of their placements, each antenna in the array has a distinct influence from those effects [5]. As a result, in order to improve and evolve the design, the array must be designed in a manner that reduces the mutual coupling between the antennas and repeats modelling and measurements [15]. As shown in Figure 3.4, they created a tapered patch-imaging chamber that is simpler for the client to utilise. The chamber is made of six arrays of patch antennas that are encased in a lossless dielectric material [10].

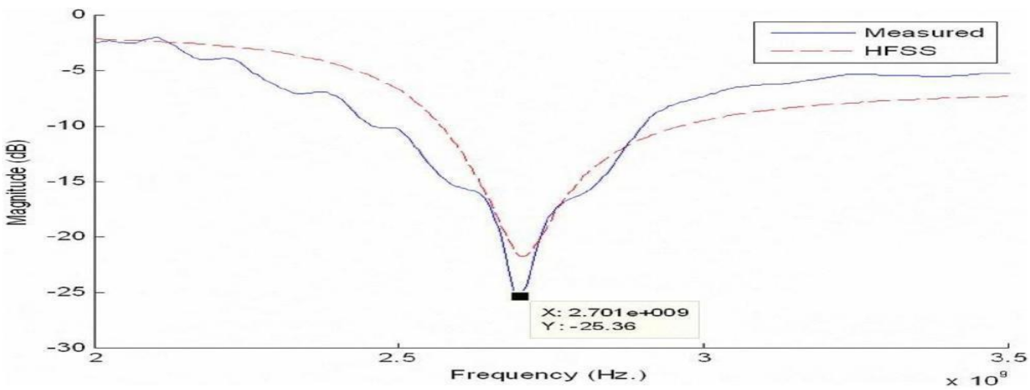


Fig3.3: Return Loss Comparison

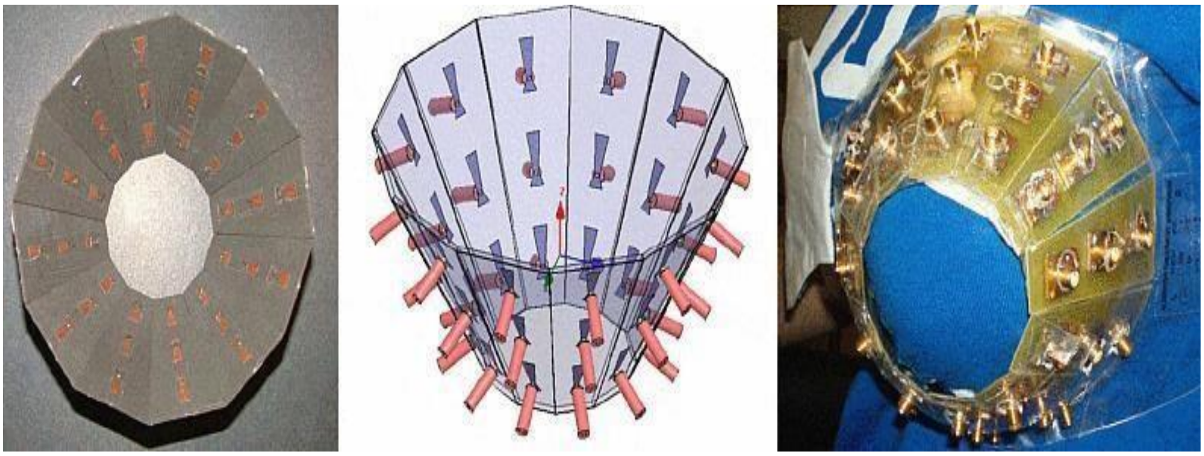


Fig3.4: Imaging Chamber and The CST Model

The return loss for the CST simulation is shown in Figure 3.4.

CST simulation software is dependable because it simulates the CST in a way that is comparable to the actual measurement for the operational antenna.

The model of a healthy breast and a breast with a cancer, which was built based on the dielectric characteristics of both, are shown in Figure 3.6.

Figure 3.7: Antenna radiation diagram.

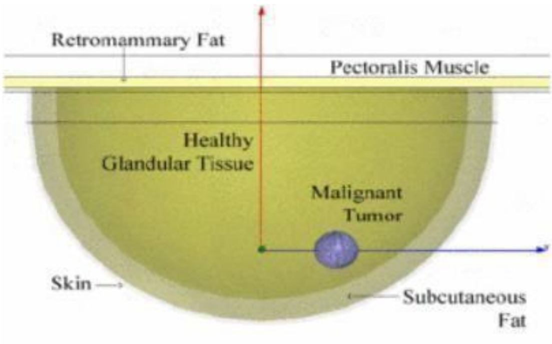


Fig3.5: Human Breast Model

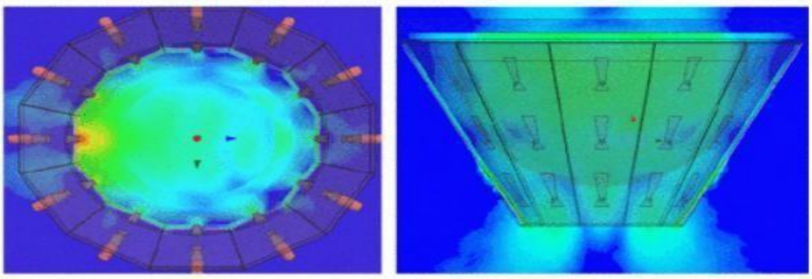


Fig3.6: Antenna's Radiation in The Breast Model

3.5. Feeding Techniques of Microstrip Antenna

There are several sorts of feeding mechanisms for microstrip patch antennas. Electromagnetic coupling is used to send power to the patch antenna without the need for any connections. Coaxial probe feeding, feeding with microstrip line and aperture or proximity coupling methods are the feeding techniques involved.

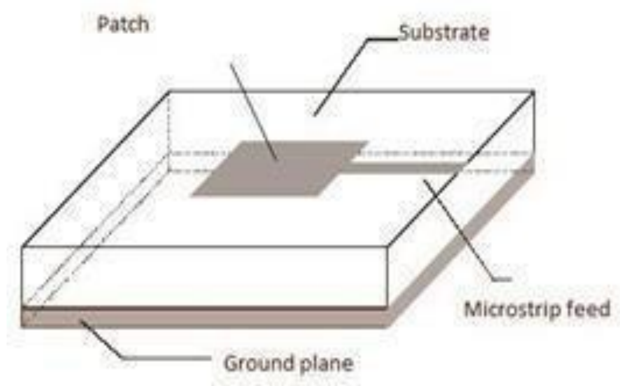


Fig3.7: Microstrip line

The conducting strip is immediately linked to a microstrip patch, which is used in the microstrip line feeding method [2]. The conducting element may be cut on the same substrate, which is a benefit of this approach. As shown in figure 3.8, the conducting element width is less than the patch antenna.

A coaxial connection is used in the coaxial probe feeding method, as shown in figure 3.9. The coaxial connector's core is attached to the patch antenna, while its other conductor is attached to the patch antenna's ground. One of the main problems with this is that it is hard to design. As seen in fig. 3.10, the proximity coupled feeding approach places the patch element above the substrate and the input feed between two substrates.

Microstrip Line Feed: In this configuration, a conducting strip is joined straight to the Microstrip patch's edge. The conducting strip is shorter than the patch. In order to create a planar structure, the feed may thus be etched on the same substrate. Feeding strategies may aid in limiting nutrient intake excess. Feeding techniques include time- and food-restricted feeding, as well as free-choice feeding. Allowing your pet to eat whenever they like increases the danger of overindulging in nutrients. This is known as free-choice feeding.

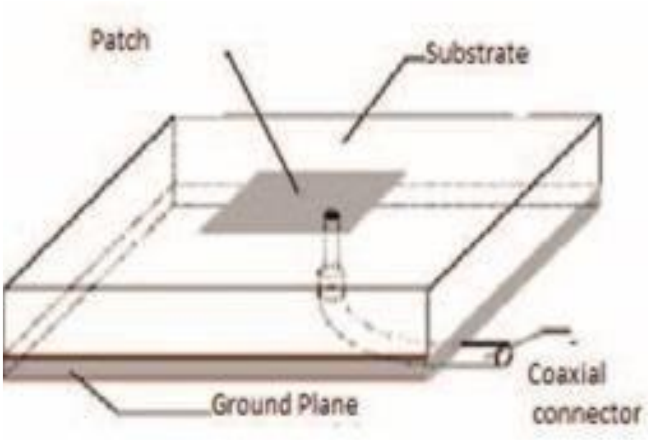


Fig3.8: Coaxial probe feed Design of Microstrip Rectangular Patch Antenna for Cancer Detection

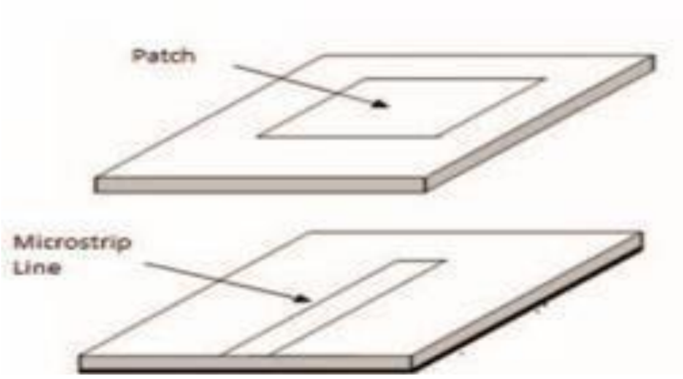


Fig3.9: Proximity coupled feed

The radiating patch in an aperture linked feed is maintained between the ground plane, which may be related via a slot, and the microstrip feed line. The patch element and the ground are kept apart by the slot. These variations depend on width and length. This method is used to enhance the simulation's outcome.

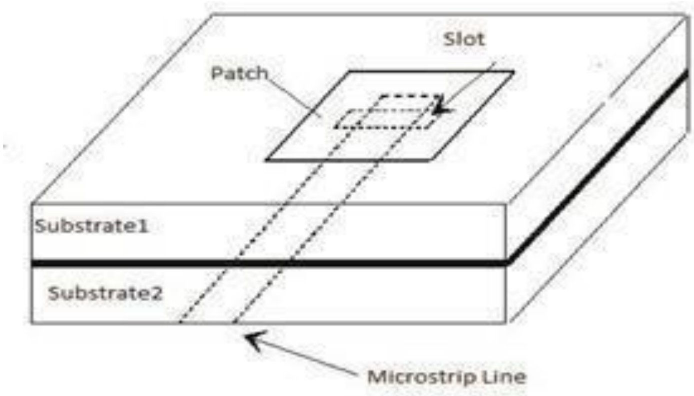


Fig3.10: Aperture coupled feed

All six of the aforementioned processes will be included in some capacity in every CST simulation. Although following these stages exactly is not required, it is excellent modelling practice to follow them consistently from model to model.

3.5.1 Initial Step

Making the physical model that a user wants to evaluate is the first step in building a CST model. The 3D modeller in CST may be used to create this model. A user may design a structure with changeable geometric dimensions and material attributes using the fully parametric 3D modeller. That is why a parametric structure comes in particularly handy when the final dimensions are unknown or the design has to be "tuned." As an alternative, a user may import 3D structures from mechanical drawing programmes like autoCAD®, Pro/E®, and SolidWorks®. Imported structures, however, are not parameterizable upon import since they lose any "history" of their creation. The imported geometry must be manually changed by the user in order to enable parameterization of the structure, should that be required.

3.5.2 The Second Step

Usually, the designation of "boundaries" comes next. Boundaries are applied to surfaces of 3D objects or specially constructed 2D (sheet) items. Users are advised to carefully read this document's section on boundaries since they have a direct bearing on the solutions that CST offers.

3.5.3 The Third Step

Applying the excitations (or ports) comes next once boundaries have been allocated. Similar to boundaries, the quality of the findings that CST will provide for a certain model is directly influenced by the excitations. Users are therefore once again urged to carefully read this document's section on excitations. Although creating and using excitations correctly is crucial to getting the most accurate CST results, there are a few handy guidelines that a user may adhere to. In the section on excitations, these guidelines are explained.

3.5.4 The Fourth Step

To develop a solution setup, boundaries and excitations must first be established. The user will choose a frequency for the solution, the desired convergence criterion, the number of adaptive steps to be performed to the maximum, the frequency range across which the solution is wanted, and the specific solution and frequency sweep technique to employ during this phase.

3.5.5 The Fifth Step

The model is prepared for analysis when a CST user has finished the first four phases. An analysis's time needed depends mostly on the model's shape, how often solutions are found, and the computing power that is available. A solution may take a few seconds, an overnight run, or the time it takes to grab a cup of coffee. Utilising CST's remote solution feature to transfer a specific simulation run to a different computer nearby the user's location is often advantageous. By doing this, the user's PC will become freer to be utilised for other tasks.

3.5.6 The Sixth Step

After the solution is complete, the user may further process the output. Plotting the fields within and outside of the structure or looking at the S-parameters of the device that was modelled are two easy ways to postprocess data. The distant fields that an antenna creates may also be examined by users. Basically, any S, Y, or Z parameter or field quantity may be plotted in the post-processor. In addition, families of curves may be produced after the analysis of a parameterized model.

Solution Types:

The kind of solution that CST must compute must first be specified by the user. Three different kinds of solutions are offered:

1. Driven Modal
2. Driven Terminal
3. Eigen mode

By clicking on CST in the main menu bar, choosing Solution type, and choosing the appropriate kind from the menu, one may choose the solution type. Three sorts of solutions exist for CST. The majority of CST simulations have historically used the Driven Modal solution type, particularly those involving passive, high-frequency structures like transmission lines, waveguides, and microstrips.

Driven Terminal Mode, the newest solution type, is employed in simulations that deal with signal integrity. Multi-conductor transmission line models are often included in these simulations. Similar mathematical computations are used by the driven modal and driven terminal solution types to solve a given issue. The kinds of outcomes that a user may get distinguish the two sorts of solutions.

The driven modal solution type simulations produce S-matrix solutions, which will be represented in terms of the waveguide modes' incident and reflected powers. But terminal voltages and currents are used to represent the S-matrix provided by the driving terminal type.

The findings of the eigen mode solver will be expressed in terms of the resonances or eigen modes of the specified structure. The fields at each resonance as well as the resonances' frequencies will be provided by this solution.

Boundaries in CST:

Boundaries in the context of CST serve two primary functions:

One of two goals is to:

1. Develop an open or closed electromagnetic model
2. Reduce the electromagnetic or geometric complexity of the model.

Limitations may be established in an open or closed model. A closed model is essentially a solution volume or structure from which energy may only exit via an applied port. This may be a cavity resonator for an Eigenmode simulation. This might be a waveguide or another completely enclosed structure for a driven modal or terminal solution. An electromagnetic model that is open to the emission or radiation of electromagnetic energy is called an open model. Typical instances include an antenna, a printed circuit board, or any other object not contained in a closed cavity.

Although the majority of CST simulations work with open models, CST starts with the assumption that every model is closed. CST makes the assumption that a perfect electric conductor boundary coats or covers every exterior surface of the solution area.

The default ideal electric conductor boundary must be overwritten by a boundary that the user specifies on the exterior surfaces in order to produce an open model.

Boundaries are utilised in CST for a second reason: to reduce the geometric/electromagnetic complexity of a particular structure or model. These limits are only appropriate for usage on a symmetry plane or internally inside a model. They ought to be used on certain surfaces of 3D objects or on specially made 2D sheet items. Boundaries are highly helpful, but if they are used improperly, they might have unexpected consequences, thus one should take care while applying them.

Boundaries on the outside surfaces of the solution space are a feature of every CST model that a user builds. This directly stems from the need for the user to indicate whether a certain model is open or closed. Therefore, on all outside surfaces of any given CST model, there will always be either Radiation, Conducting, or Perfectly Matched Layer Boundary. Finite conductivity, impedance, and ideal electric conductor are examples of conducting boundaries.

Simplifying boundaries, however, is not a feature of all CST models. Users should be careful not to apply arbitrary or improper bounds to their models when utilising boundaries to make them easier.

Software selection, symmetrical antenna arrays, the three layers of the breast, D-antenna array design, feeding techniques for microstrip patch antennas, and general steps in microstrip strip patch antenna design were all covered in this chapter.

CHAPTER - 4

METHODOLOGY

4.1 Motivation

When cancers are discovered early on, many lives may be spared and there may be a chance for recovery. Because most monitoring devices are complex, not universally accessible, and non-mobile, many patients find routine check-ups to be inconvenient. Additionally, micro-strip antennas are used in imaging, diagnosis, and therapy in the medical industry because they are effective and adaptable [1]. Breast cancer is the most prevalent kind of cancer worldwide, and early detection is key to treatment success. It is simpler and more certain to remove the tumours in the early stages of breast cancer.

4.2 Aim

Our project's goal is to develop a micro strip patch wearable antenna that will enable early, inexpensive, and quick detection of breast cancer. The screen will also be used to display the tumour at an early stage.

4.3. Objectives

1. What role will the antenna play in breast cancer detection.
2. Examining the current MICS and ISM band antenna technique.
3. Research many alternatives to use microwave imaging for breast cancer screening.
4. Using the knowledge gained to create a micro strip patch antenna array prototype.
5. Following the acquisition of data for actual human tissues.
6. In the lab, we can verify the effectiveness of this outcome.

4.4. Wearable Technology

Wearable technology refers to the integration of computer and electrical components into clothing. It is appropriate for daily wear. These gadgets include headgear, watches, eyeglasses, earrings, and textiles. These gadgets are multifunctional; in addition to functioning as a computer and a mobile phone, they may also be used as sensors, trackers, or even scanning equipment. It is seen as a significant advancement in the ubiquitous computing movement, which allows information access for all users anywhere. Wearable technology has a wide range of applications overall. Prior to being released to the public, many gadgets were used in military technology. Next, applications in the fields of education, gaming, music, fitness, and health are shown. These wearable gadgets' primary purpose is to provide the features required for everyday living.

4.5. Wearable Antenna Design Challenges

Every job has limitations, thus in order to get the desired results, it must be assessed and examined [16]. Among the primary causes of these constraints are the lossy conducting materials present in the human body, which presents the following difficulties:

4.5.1. Size Restrictions

Due to the relationship between antenna size and performance, size limitations occur. Consequently, increasing the size of the antenna is necessary to achieve a larger bandwidth and reducing the dielectric constant will improve performance. This is accomplished by increasing the substrate's thickness. computer, but it may also function as a tracker, a sensor, or even a scanning tool. It is seen as a significant advancement in the ubiquitous computing movement, which allows information access for all users anywhere. Wearable technology has a wide range of applications overall. Prior to being released to the public, many gadgets were used in military technology.

4.5.2. The Battery's Life

Because significant performance, speed, and quality require power, the battery will eventually run out. In addition, the size of the battery in some wearable antennas may be problematic because it may impair the performance of the sensor. As a result, a larger battery will be needed to power the small sensors in order to create an efficient system that can complete the required task.

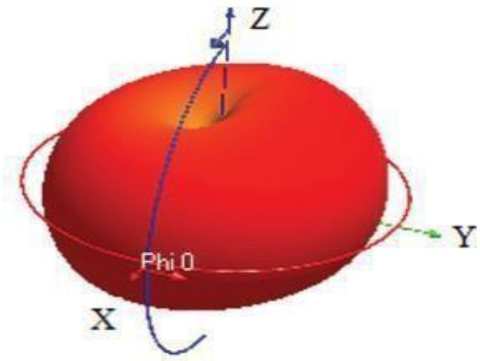


Fig4.1: Radiation Pattern

4.5.3. Lossy Environment and Multipath Losses

The relative motion between the transmitter and receiver may also lead to power spectrum widening in a multipath fading scenario. In addition, other users in the system may interfere with the wireless channel, which is the over-the-air communication between a transmitter and a receiver. The mechanics of reflection, diffraction, and scattering from structures, buildings, and other barriers present in the propagation environment are the source of these multipaths. Line of sight (LOS) and non-line of sight (NLOS) pathways are often used to characterise multipath propagation. Fading is brought on by destructive interference and may make a radio signal too faint to receive well in certain places. Because of this, multipath interference or multipath distortion are other names for this phenomenon. When an RF signal from a transmitter travel over two or more paths to reach a receiver, multi-path interference occurs. Usually, there are many indirect channels brought on by reflections in addition to the direct one. Reflections inside a room may be caused by walls, people, furniture, and other things.

Because the human body is made of lossy conducting material, which dissipates energy, installing an antenna in the body will alter its behaviour and radiation pattern, as shown in the following examples.

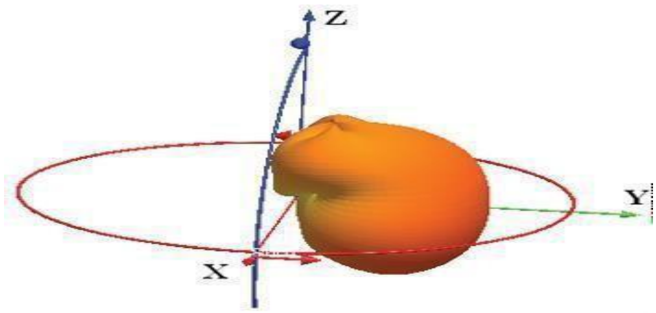


Fig4.2: Defected Radiation Pattern

The two pictures are clearly different from one another. Figure 4.1 displays a radiation pattern determined by CST, whereas Figure 4.2 depicts an antenna embedded in a human head model's skin.

4.6. Existing Methodology

A Micro Strip Patch Antenna was designed, measured, simulated, fabricated and validated with and without tumour. Experiments the Return loss, SAR Value (Specific Absorption Rate), VSWR (Voltage Standing Wave Ratio), Gain, Directivity, results through Network Analyzer. A Micro Strip Patch Antenna was designed, measured, simulated, fabricated and validated with and without tumour. Antenna Frequency Between 10 to 25 GHz or 5.6 – 5.9 GHz. Experiments the Return loss, SAR Value (Specific Absorption Rate), VSWR (Voltage Standing Wave Ratio), Gain, Directivity, results through Network Analyzer.

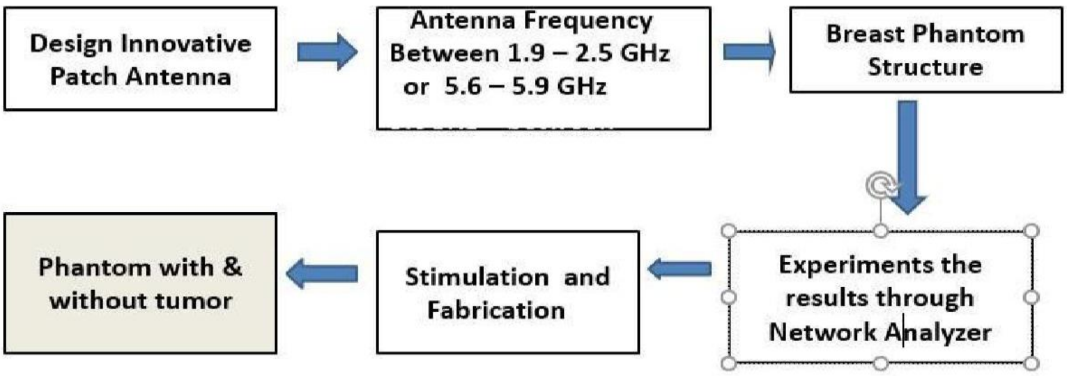


Fig4.3: Block Diagram of Existing Method

In this Chapter discussed about the Motivation, Aim and Objective of the Project, Wearable Technology for Antenna, Wearable Antenna Design Challenges and Existing Methodology.

CHAPTER - 5

PROPOSED ANTENNA DESIGN MODEL

5.1. Proposed Design of Antenna

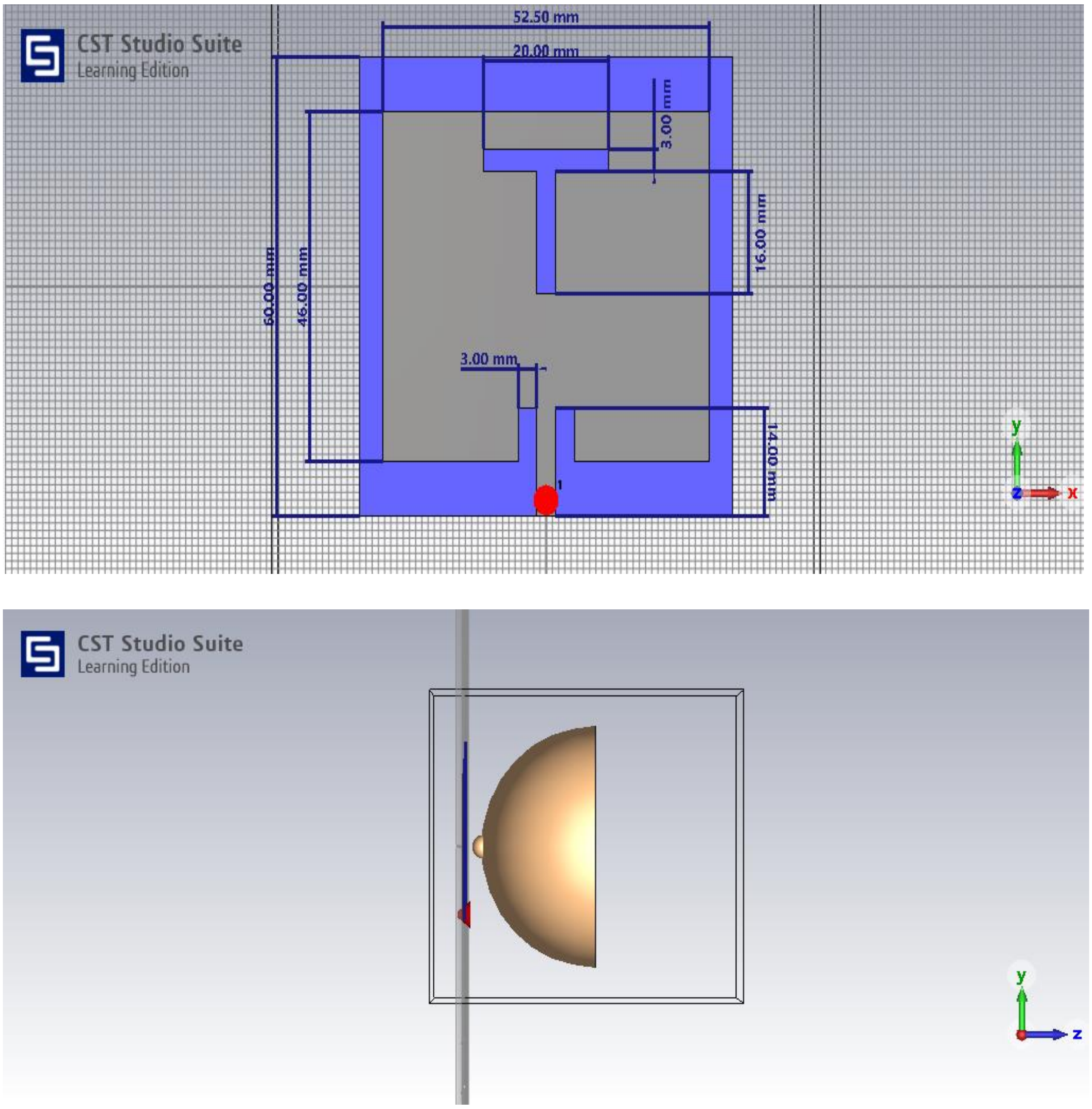


Fig5.1: Antenna proposed design

The image depicts a simulation setup in CST Studio Suite for diagnosing breast cancer using a microstrip patch antenna operating at 2.5 GHz. The patch antenna is positioned 2 mm away from a simulated breast phantom model. This close proximity allows the antenna to effectively transmit and receive electromagnetic waves through the breast tissue, facilitating the detection of anomalies such as tumours. The simulation aims to analyse the antenna's performance and the interaction of the electromagnetic waves with the breast tissue, which can be crucial for non-invasive, early-stage breast cancer detection using microwave imaging techniques.

5.2 Fabricated Antenna (Hardware)

Figure 5.2: Fabricated Antenna Front View

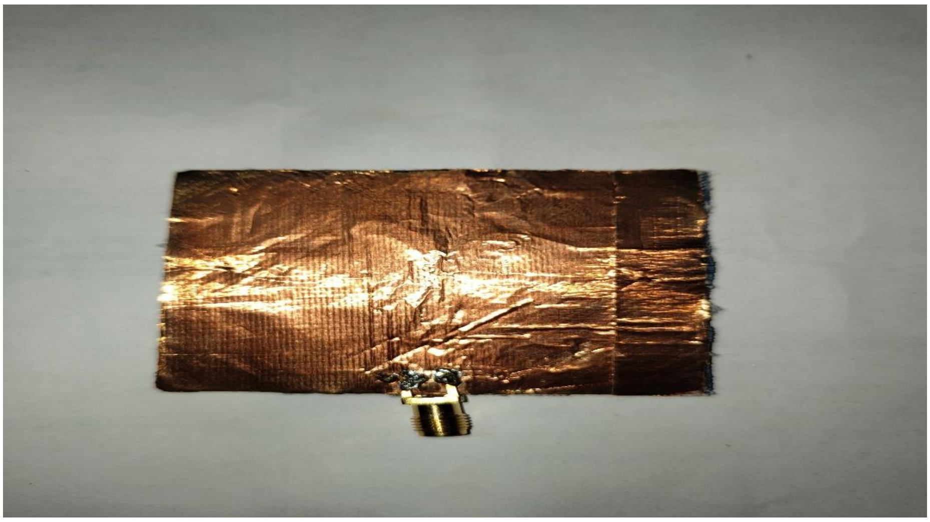


Figure 5.3: Fabricated Antenna Back View

The width w of the radiating MSPA is computed using equation

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

where c is the velocity of light, ε_r is dielectric constant of the substrate and f_0 is the resonant frequency of antenna.

Resonant frequency, the effective length

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

This is Proposed Design of Microstrip Patch Antenna with Tumour. Frequency of the Antenna is 2.5 GHz. Through this can find S Parameter Plot, Voltage Standing wave Ratio Maximum unambiguous range, Front-to-back ratio, Gain Plot, Directivity Plot, S Parameter Chart etc.

Table 5.1: Proposed Antenna Parameters

Source: Self-Generated

Parameters	Values
Substrate Thickness	1 mm
Ground and Patch Thickness	0.038 mm
Patch length	46.0 mm
Patch width	52.5 mm
Substrate Epsilon (ε)	1.7
Substrate Tan delta	0.024
Tumour radius	3mm
Breast radius	60 mm

Table 5.2: Dielectric properties of Breast Phantom Structure

Source: Self-Generated

Material	Permittivity ‘ε_r’ (F/m)	Electrical Conductivity ‘σ’ (S/m)	Density (kg/m^3)	Thickness ‘t’ (in mm)
Skin	35.93	3.72	1100	2
Fat	4.9	0.15	910	3
Muscle	48.49	4.96	1040	5
Tumour	54.9	4	1058	2.5

5.3. S_{11} Parameter Plot of Proposed Design

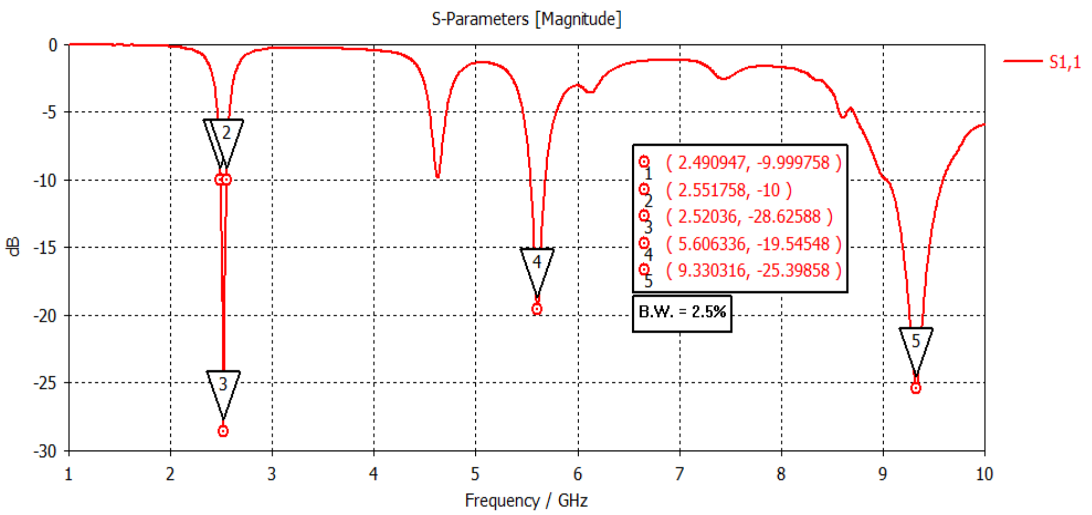


Fig5.4: S_{11} Parameter Plot of Proposed Design

The S-parameters graph shows the S11 reflection coefficient of the microstrip patch antenna across a frequency range of 1 to 10 GHz. Key resonance dips occur at 2.49 GHz, 2.52 GHz, 5.06 GHz, and 9.33 GHz, indicating frequencies where the antenna efficiently radiates, with minimal reflection. The deepest dip at 2.52 GHz (S11 ≈ -28.63 dB) suggests optimal performance around this frequency, aligning with the intended 2.5 GHz operation. The bandwidth (B.W.) is marked as 2.5%, signifying a narrow operational range around the resonant frequency. This performance is crucial for precise and reliable breast cancer diagnosis using microwave imaging. Low Bandwidth is acceptable in this case because we have a high Directivity of more than 8 dBi and also the antenna will be placed close to the breast so it will not affect our results.

5.4. VSWR of Proposed Design

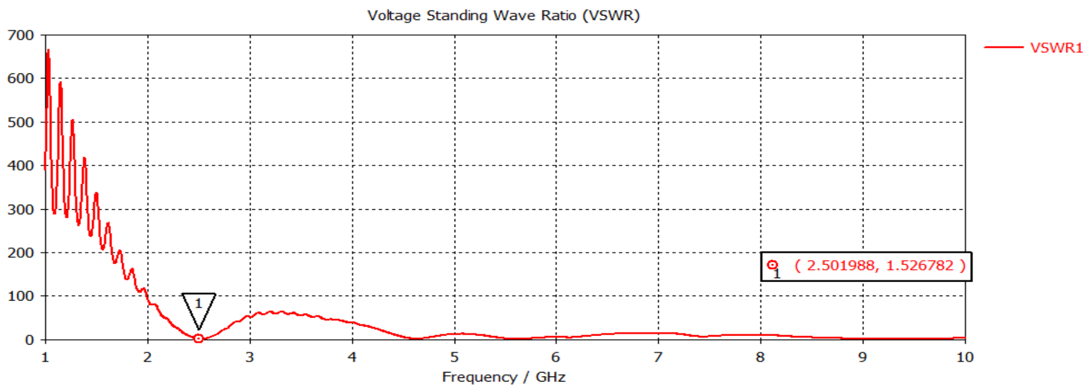


Fig 5.5: VSWR Plot

The VSWR (Voltage Standing Wave Ratio) graph displays the performance of the microstrip patch antenna over a 1 to 10 GHz frequency range. A significant dip is observed at 2.50 GHz with a VSWR value of 1.53, indicating optimal impedance matching and minimal reflection at this frequency. A VSWR close to 1 signifies efficient power transfer from the antenna to free space, reducing signal loss. The graph confirms that the antenna performs best around 2.5 GHz, the target frequency for breast cancer diagnosis. This low VSWR at the operational frequency ensures effective signal penetration and reliable imaging results.

5.5. Y-Parameters of Proposed Design

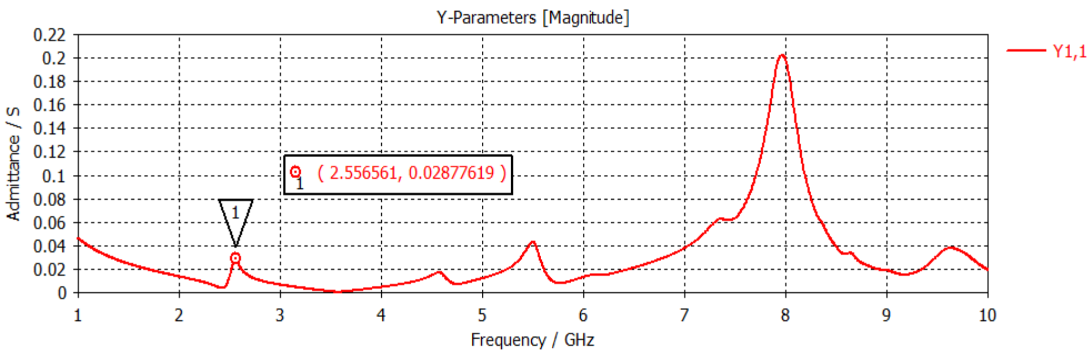


Fig 5.6: Y-Parameters

The image depicts the admittance (Y-parameters) graph of a microstrip patch antenna designed for breast cancer diagnosis at 2.5 GHz, simulated using CST Studio Suite. The graph shows the admittance magnitude versus frequency, ranging from 1 to 10 GHz. At approximately 2.56 GHz, the admittance is marked at around 0.02878 S, indicating a point of interest for diagnosis. The antenna's Y1,1 parameter reveals its performance across the frequency spectrum, with significant peaks, especially near 8 GHz, suggesting resonant frequencies that are crucial for its operation in medical diagnostics applications.

5.6. Z-Parameters of Proposed Design

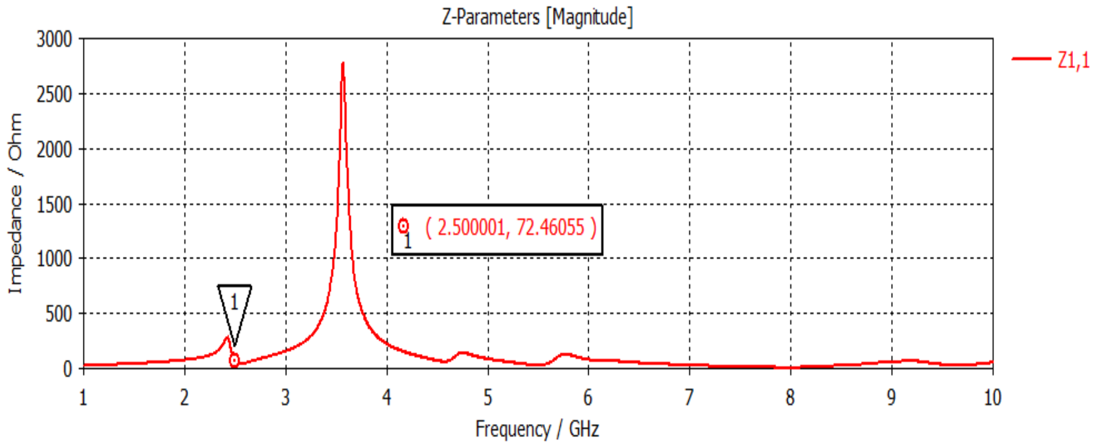


Fig 5.7: Z-Parameters

The image displays the impedance (Z-parameters) graph of a microstrip patch antenna designed for breast cancer diagnosis at 2.5 GHz, simulated using CST Studio Suite. The graph plots impedance magnitude versus frequency, spanning from 1 to 10 GHz. At 2.5 GHz, the impedance is marked at approximately 72.46 ohms, highlighting a key operational point for the antenna. The Z1,1 parameter shows a significant peak around 2.5 GHz, indicating resonance and optimal performance for diagnostic purposes. Other frequencies exhibit lower impedance values, which are crucial for understanding the antenna's efficiency and effectiveness in medical diagnostic applications.

5.7. Maximum Gain over Frequency of Proposed Design

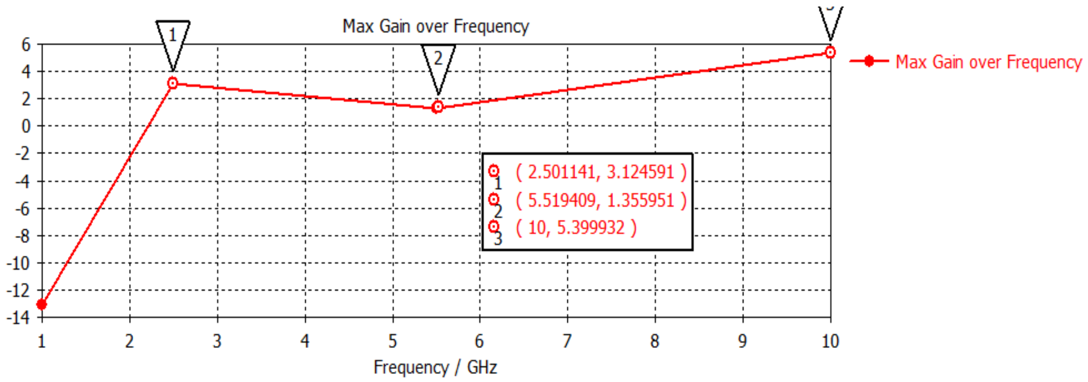
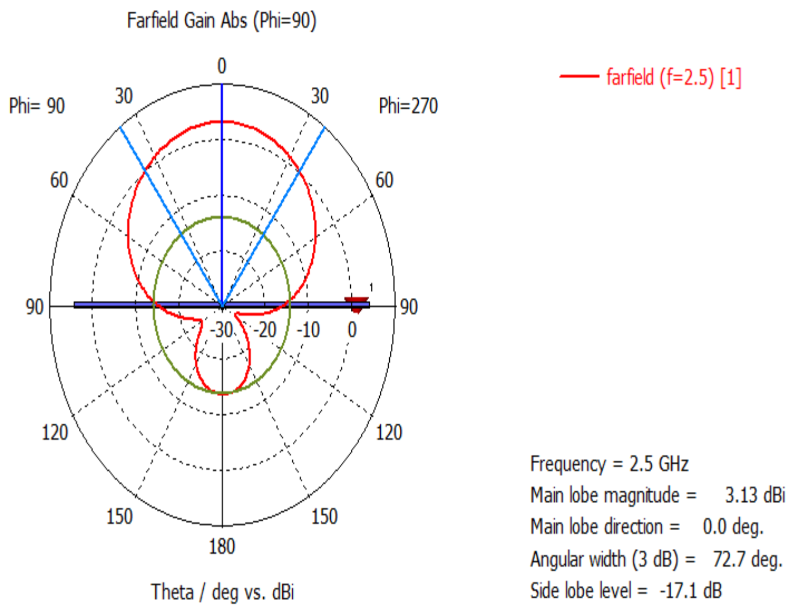


Fig 5.8: Max Gain over Frequency

The image displays the maximum gain over frequency graph for a microstrip patch antenna designed for breast cancer diagnosis, simulated in CST Studio Suite. The graph shows the antenna's gain performance across a frequency range from 1 to 10 GHz. At the target frequency of 2.5 GHz, the antenna achieves a gain of 3.125 dBi. Other notable points include a gain of 1.356 dBi at 5.519 GHz and 5.399 dBi at 10 GHz. This gain variation helps in understanding the antenna's efficiency and effectiveness at different frequencies, crucial for ensuring reliable tumour detection through optimal electromagnetic field propagation.

5.8. Gain of Proposed Design



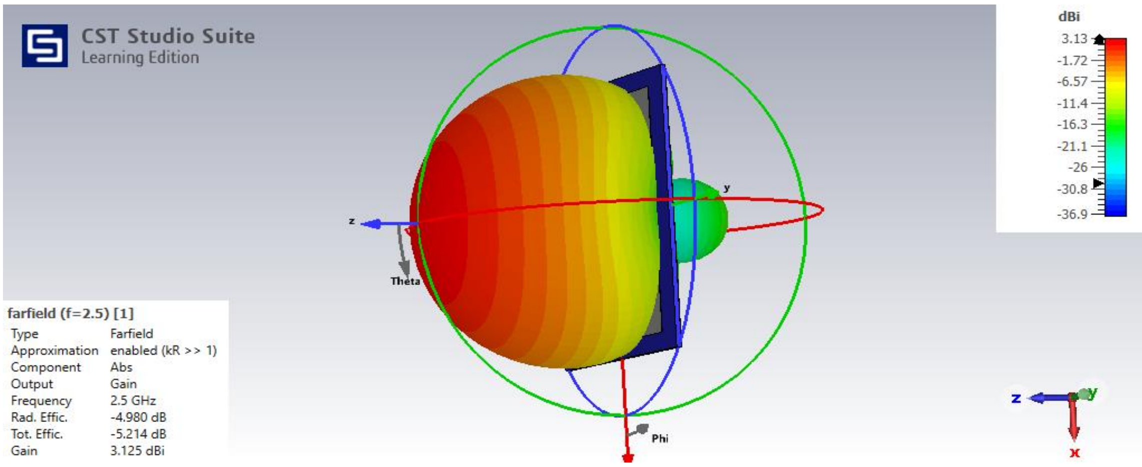
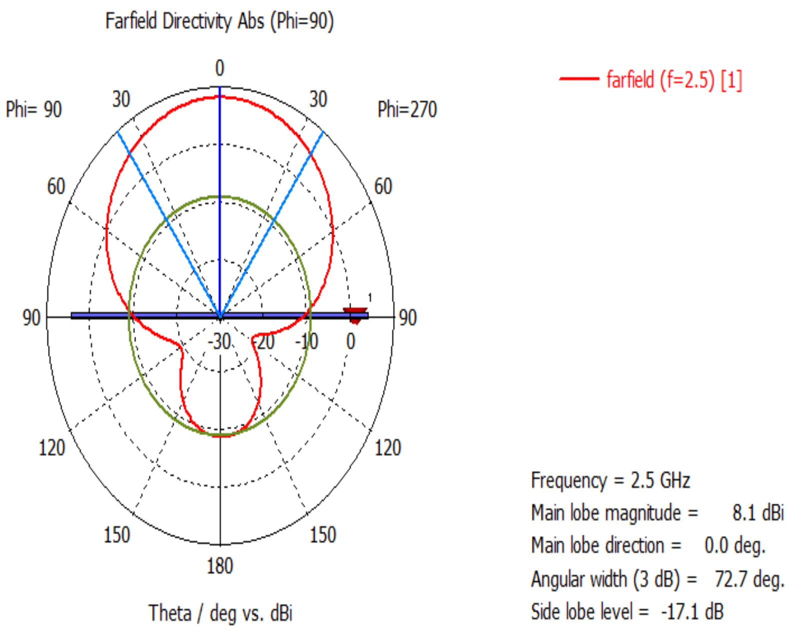


Fig 5.9: 1-D Gain chart and its 3-D pattern

The image displays the far-field radiation pattern of a microstrip patch antenna designed for breast cancer diagnosis at 2.5 GHz, simulated using CST Studio Suite. The antenna's gain is 3.125 dBi, which indicates the efficiency of the antenna in directing the radiated power. The radiation pattern shows the distribution of the radiated energy in different directions, with the maximum gain occurring in the direction normal to the patch. The total and radiation efficiencies are -5.214 dB and -4.980 dB, respectively, which reflect losses due to dielectric, conductor, and other factors. This information is critical for evaluating the antenna's performance in medical applications.

5.9. Directivity of Proposed Design



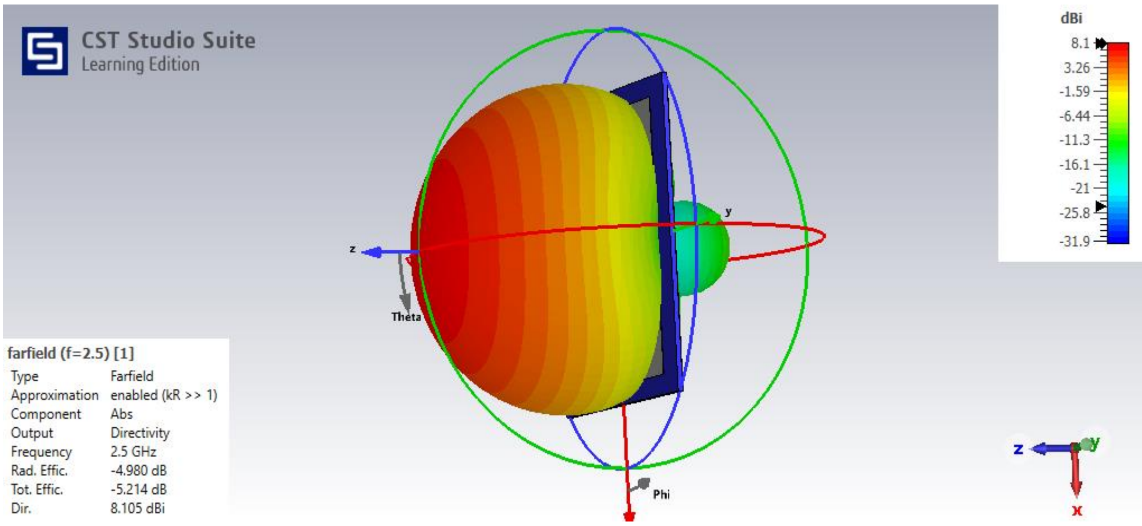


Fig 5.10: 1-D Directivity chart and 3-D farfield pattern

The image shows the directivity pattern of a microstrip patch antenna for breast cancer diagnosis at 2.5 GHz, simulated with CST Studio Suite. The directivity is 8.105 dBi, indicating the antenna's ability to focus energy in a specific direction. This is higher than the previously observed gain, highlighting the antenna's directive capabilities despite losses. The radiation efficiency is -4.980 dB and the total efficiency is -5.214 dB, reflecting the power lost due to various inefficiencies. The pattern shows maximum radiation perpendicular to the patch, essential for effective breast tissue penetration in diagnostic applications.

5.10. E-Field Pattern of Proposed Design

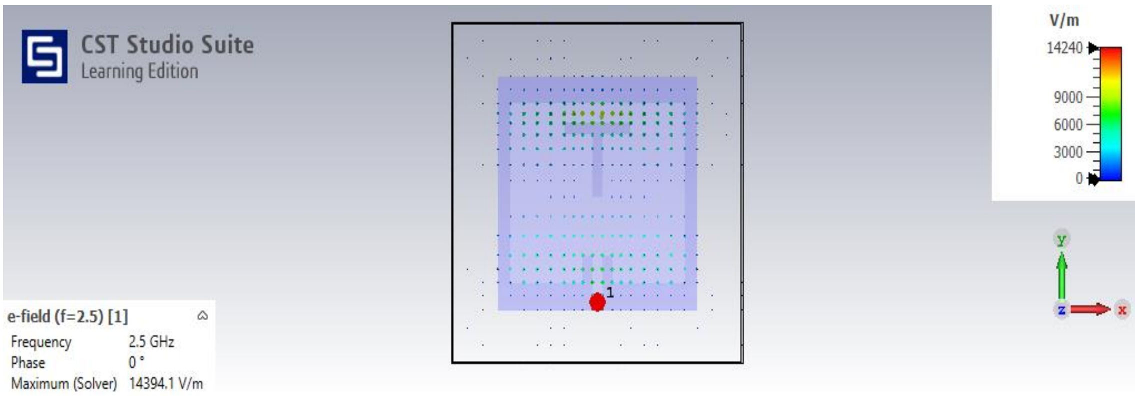


Fig5.11: E-Field Pattern

The image presents the electric field (E-field) distribution of a microstrip patch antenna simulated at 2.5 GHz using CST Studio Suite. This visualization is crucial for evaluating the antenna's performance in breast cancer diagnosis. The E-field pattern illustrates how the electric field propagates across the antenna surface, with a maximum intensity of 14943.1 V/m. The simulation aids in identifying regions of strong and weak electric fields, ensuring optimal antenna design for detecting cancerous tissues. The E-field distribution provides insights into the antenna's ability to generate sufficient field strength for effective tumour detection in the breast phantom.

5.11. H-Field Pattern of Proposed Design

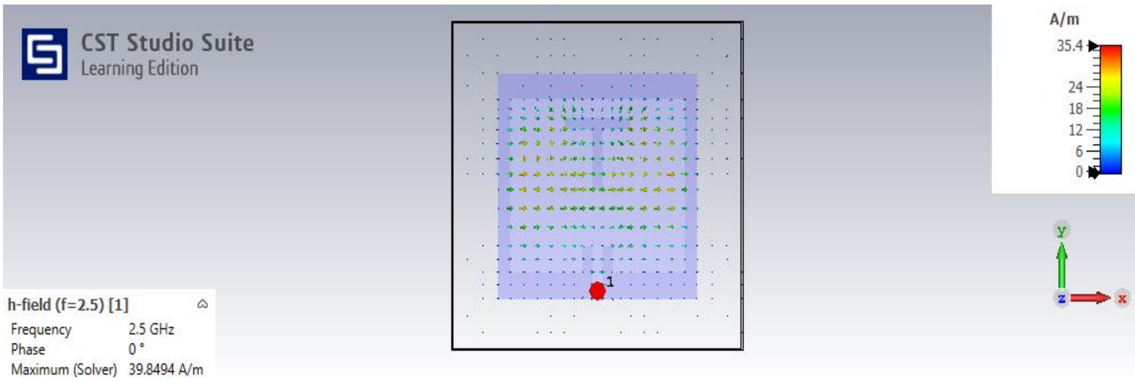


Fig5.12: H-Field Patterns

The image presents the H-field (magnetic field) distribution pattern of a microstrip patch antenna designed for breast cancer diagnosis at 2.5 GHz, simulated using CST Studio Suite. The field plot, shown in a 2D plane, illustrates the magnetic field strength across the antenna's surface. The colour scale indicates the intensity of the H-field, with a maximum value of approximately 39.85 A/m at 2.5 GHz and a phase of 0 degrees. The visualization helps in understanding the magnetic field distribution and the antenna's performance, which is critical for ensuring effective operation in medical diagnostic applications.

5.12. Surface Current of Proposed Design

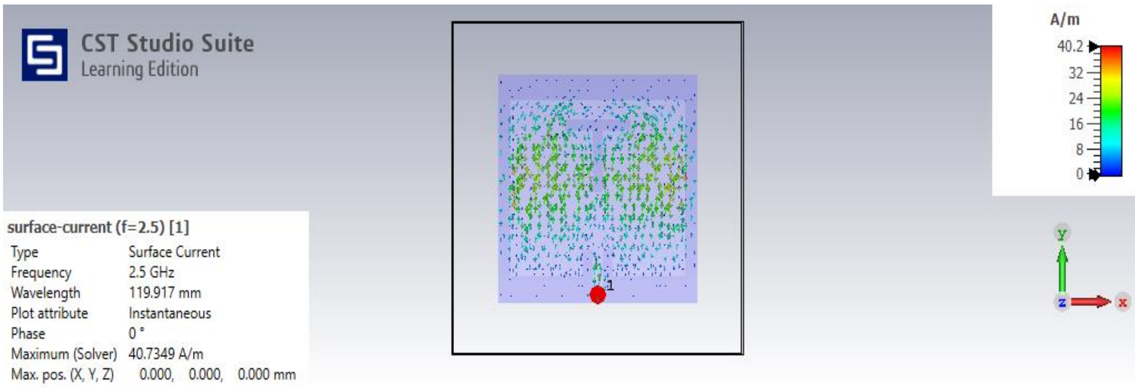


Fig5.13: Surface Current

The surface current distribution of the antenna is visualized. The simulation indicates the current's magnitude and distribution across the antenna surface, essential for assessing its performance in detecting cancerous tissues. The frequency of 2.5 GHz corresponds to a wavelength of 119.917 mm. The maximum surface current magnitude is 40.7349 A/m. This detailed analysis helps in optimizing the antenna design for accurate and efficient breast cancer detection through non-invasive electromagnetic methods.

5.13. Current Density of Proposed Design

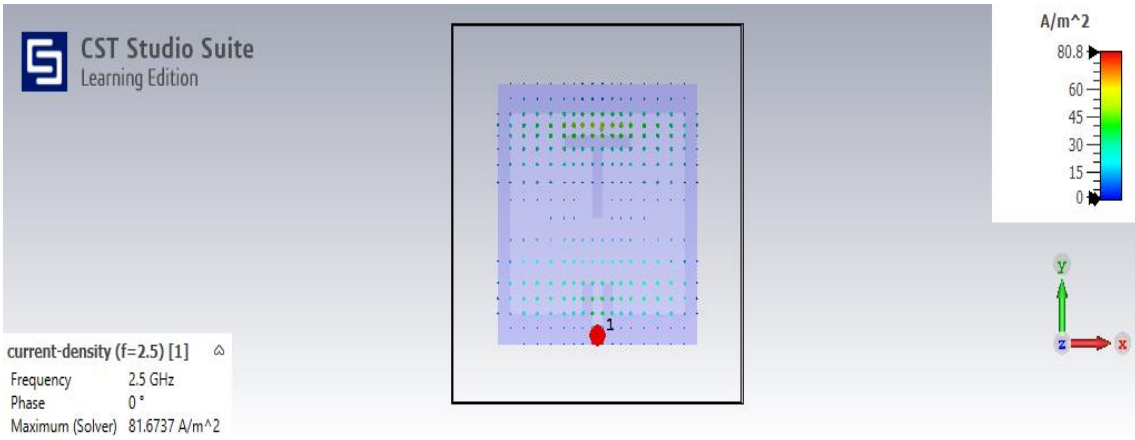


Fig5.14: Current Density

The current density distribution across the antenna is shown, with a maximum value of 81.6737 A/m^2. The colour scale on the right indicates varying levels of current density, highlighting areas of high (red) and low (blue) intensity. This antenna aims to detect cancerous tissues by analysing the differences in electromagnetic wave interaction with healthy and cancerous tissues, leveraging the high sensitivity of the antenna to changes in permittivity and conductivity within breast tissue.

Table 5.3: Various 1-D and 3-D Results

Source: Self- generated

S. No.	Results	Values
1	Resonant Frequency	2.5 GHz
2	Return Loss (f=2.5 GHz)	-28 dB (approx)
3	Bandwidth (f=2.5 GHz)	2.5% (approx)
4	VSWR (f=2.5 GHz)	1.53
5	Y-Parameter (f=2.5 GHz)	0.029 Admittance/S
6	Z-Parameters (f=2.5 GHz)	72.46 Impedance/OHM
7	Gain (f=2.5 GHz)	3.125 dBi
8	Gain (f=5.5 GHz)	1.36 dBi
9	Gain (f=10 GHz)	5.4 dBi
10	Directivity (f=2.5 GHz)	8.1 dBi
11	E-Field (f=2.5 GHz)(max)	14394.1 V/m
12	H-Field (f=2.5 GHz)(max)	39.894 A/m
13	Surface Current (f=2.5 GHz)(max)	40.7349 A/m
14	Current Density (f=2.5 GHz)(max)	81.6737 A/m^2

In this chapter we saw the proposed antenna design in CST with all its parameters such as its S_{11} parameter graph, Y and Z parameters graphs, VSWR graph and various field patterns like farfield directivity, gain, E-field, H-field, Surface Current, Current Density etc.

CHAPTER - 6

RESULTS & CONCLUSION

6.1 Simulated SAR Values without and with Tumour

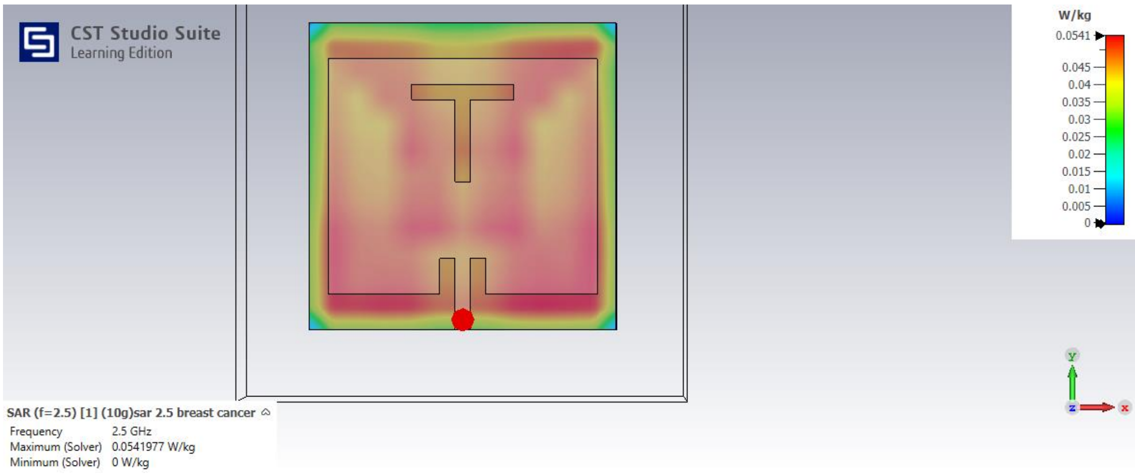


Figure 6.1: SAR result without tumour

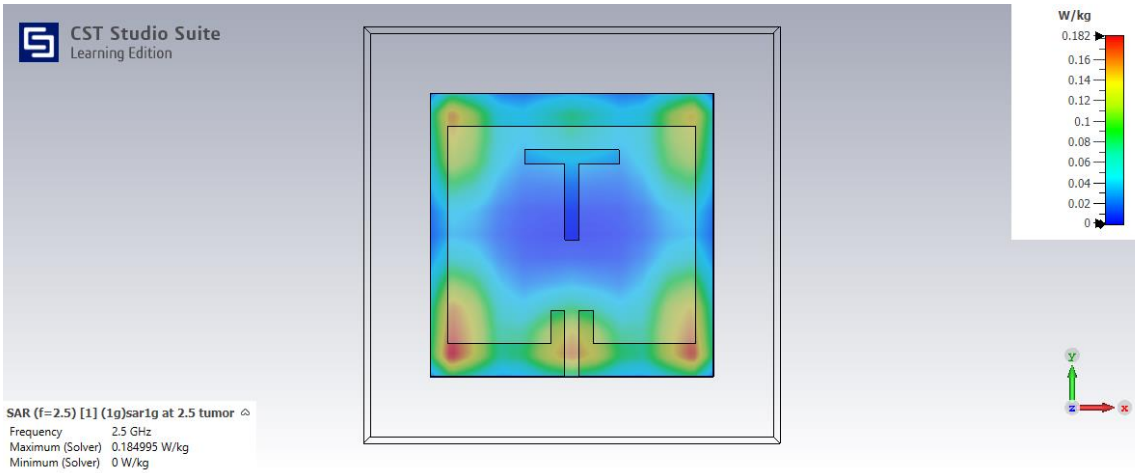


Figure 6.2: SAR result with tumour

The images depict simulations from CST Studio Suite, showcasing a microstrip patch antenna designed for breast cancer diagnosis at a frequency of 2.5 GHz. The first image shows the Specific Absorption Rate (SAR) distribution in a breast phantom without a tumour, while the second image shows the SAR distribution with a 2.5 cm radius tumour.

In the first image (without tumour), the SAR distribution is relatively uniform across the breast phantom, indicating no significant variations in tissue properties. The maximum SAR value is 0.0148974 W/kg, as indicated in the simulation results.

In the second image (with tumour), the SAR distribution changes notably. The presence of the tumour causes localized variations in the SAR values, reflecting the different electromagnetic properties of the tumour compared to the surrounding tissue. The maximum SAR value increases to 0.0149785 W/kg, highlighting the higher absorption in the region where the tumour is located.

These simulations illustrate how the microstrip patch antenna can be used for detecting breast cancer by identifying changes in the SAR distribution caused by the presence of a tumour. The higher SAR values around the tumour region indicate increased electromagnetic absorption, which can be used as a diagnostic indicator in breast cancer detection. This method provides a non-invasive approach to cancer diagnosis, leveraging the differences in electromagnetic properties between healthy and cancerous tissues.

6.2 Change in Farfield Directivity Values of antenna without and with Tumour

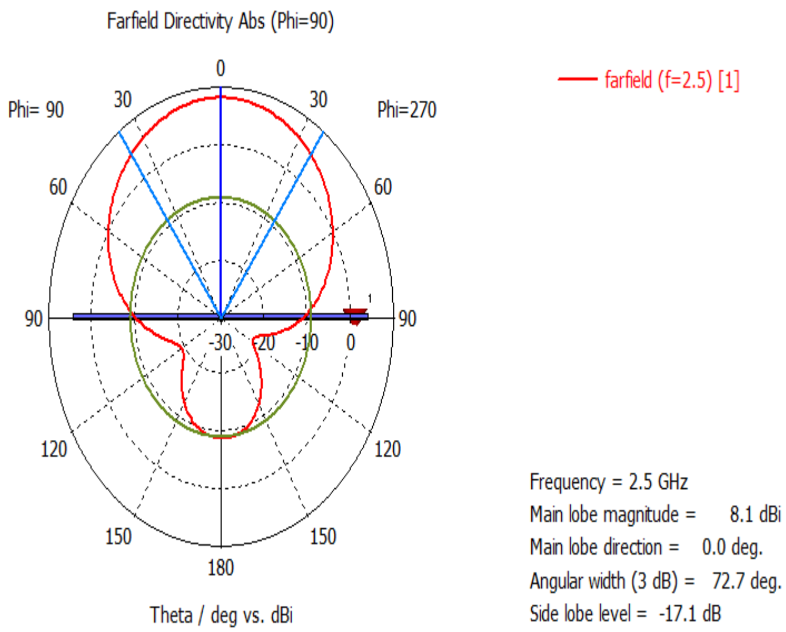


Figure 6.3: Farfield Directivity chart without Tumour

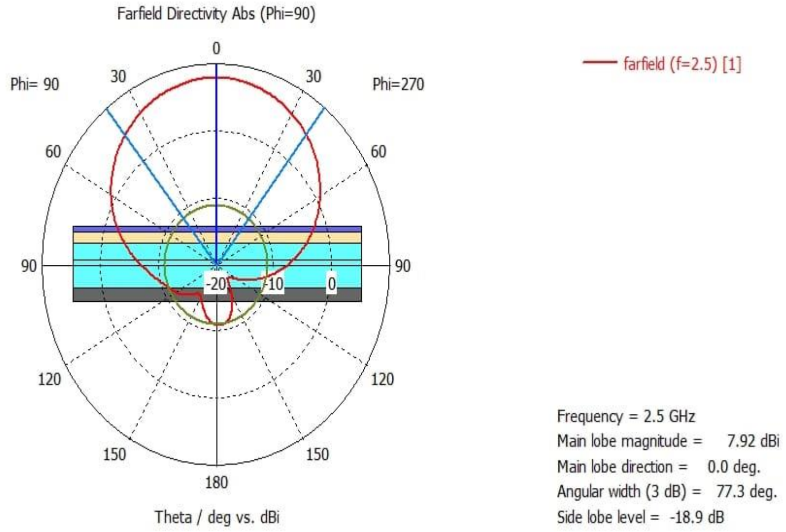


Figure 6.4:Farfield Directivity chart with Tumour

The image depicts the far-field directivity pattern of a microstrip patch antenna used for breast cancer diagnosis. After placing a tumour inside the breast phantom, the directivity chart shows the antenna's radiation characteristics. The main lobe magnitude was 8.1 dBi (without tumour) and 7.92 dBi (with tumour), directed at 0 degrees with an angular width of 72.7 degrees (without tumour) and 77.3 degrees (with tumour) at the 3 dB point. The side lobe level was -17.1 dB (without tumour) and -18.9 dB (with tumour), indicating minimal interference from side lobes. This pattern helps evaluate the antenna's effectiveness in detecting tumours by focusing energy towards the targeted region, enhancing diagnostic accuracy.

Conclusion

Antennas' general operation was recognised. 2.5 GHz was used in the design and fabrication of the microstrip patch antenna for the purpose of detecting breast cancer tumours. The S Parameter Plot Graph displayed the difference between the two conditions: with and without tumours. The main factors that impact design and applications—like SAR, VSWR, Return Loss curves, Radiation Patterns, Directivity, and Beamwidth, among others—were examined, and their consequences were comprehended. By simulating the patch antenna using CST, the required degree of optimisation was attained. It was determined that the software outcomes we got were consistent with the outcomes that were theoretically expected.

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Appendix

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ORIGINALITY REPORT

16%	11%	9%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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