Onco-Trace: A Non-Invasive Technique to Detect Breast Cancer Tumors Using Copper Based Microstrip Patch Antenna

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Abstract
Among the most prevalent invasive illness that impact women worldwide are breast cancer. These days, breast cancer affects an increasing number of women each year. Due to their limitations, the primary methods for detecting breast tumors are magnetic resonance imaging, computer-aided detection, biopsy, and mammography. A wearable, practical, planar, and simple-to-fabricate antenna with some appealing qualities and characteristics but also some clear limitations is the solution to these restrictions on the use of micro strip antennas. Flexibility for wearable electronics is demonstrated by the wearable antenna's wearable bending in two dimensions. Applications in biomedicine are best suited for an antenna operating in the ISM band. Wearable biomedical applications use the ISM band of 1.9-2.5GHz or 5.3-5.6GHz, which radiation patches offer as antennas. The silk substrate is applied to the breast in order to identify breast cancer tumors because silk has a low specific absorption rate. Microstrip Patch Antennas were examined both in and out of cancer-affected regions. The gain and electrical conductivity performance were discovered to alter because cancer cells are tissues with a higher water content. The CST Studio suite or HFSS ansys software will be employed for the convenient examination of the antenna simulation. The results of the simulation have been quantified and tabulated also using network analyzer, the falsified findings have been proposed.

Keywords: Breast Cancer, Non-invasive, Low cost, Microstrip Patch Antennas

1. INTRODUCTION

Cancer, a disease identified by the uncontrolled growth of abnormal cells, can rapidly spread throughout the body, damaging healthy tissues. Often originating as a solid tumor, it can develop anywhere in the body. Breast cancer, a particularly prevalent invasive malignancy among women worldwide, is increasingly affecting a growing number of individuals each year. This condition can lead to severe complications in various organs, including the brain, lungs, liver, and bones, ultimately resulting in death. Early detection of tumors is crucial to ensure timely and effective treatment. Globally, breast cancer has marked as one of the most common forms of cancer. The earlier this disease is identified, the better the prognosis. Mostly, X-ray mammography is the commonly used technique for breast cancer detection. However, because of the inherent limitations and negative undesired sides of X-ray mammography, researchers are actively making progress in their exploration's technologies for earlier detection. For several years, microwaves have been employed for breast cancer detection. Microwave imaging utilizes low-power electromagnetic waves at microwave frequencies to illuminate the target tissue and visualize its internal structures. By radiating microwaves into the breast, researchers can assess the presence of tumors. This technique can be broadly categorized into two approaches: tomography and radar-based methods. An antenna, typically constructed from a conductive metallic material, is a device designed to transmit and receive electromagnetic waves, primarily radio waves, for communication or signal transmission. Antennas are divided into two primary types: transmitting antennas and receiving antennas. These devices facilitate the transmission and reception of radio waves at the speed of light, enabling the communication and broadcasting of information. In the tomography approach, a single transmitter radiates microwave signals toward the breast, while there are several antennas placed around the breast to receive the scattered and diffracted waves. By analyzing the received data, researchers can generate two-dimensional or three-dimensional images of the breast tissue.
As previously discussed, traditional methods like mammography, biopsy, computer-aided detection, and magnetic resonance imaging have limitations. To address these shortcomings, microstrip patch antennas (MSPAs) offer a potential solution
To determine whether or not there are any malignant tumors present, two varieties of breast phantoms were developed. The first phantom S11 value was -12.73 dB, then it changed to 12.47dB. The second phantom S11

value went from -8.49 to -8.43dB. We simulated and measured all the constraints of the proposed antenna to achieve high-flying performance, a very desirable S11, a supreme radiation pattern, and fair gain across the operating band. Evidence must be provided by comparing the design part's category to a range of clients [1]. To ascertain whether or whether there were any malignant tumors present, two varieties of breast phantoms were developed. The values of the first and second phantom S11 altered from -12.73 dB to -12.47 dB and -8.49 dB to 8.45dB, respectively.

There must be proof that the design portion falls into a different category for different types of clients [2]. In order to detect breast cancer, this study uses only four meander line microwave with an operating frequency of 1.5 GHz to locate tumors at 13 distinct locations deep within a thick human breast. Breast cancer detection is one medical use for this narrow band microstrip medical antenna design [3]. Applications and Measurements (ICSIMA) With a working frequency of 4.9 to 6.4 GHz, the S11 antenna parameter on a 4x4 antenna array is -37.50dB. The simulation results on head showed a value of -14.50 dB at 2.44 GHz. The developed system may detect tiny breast malignant tumors using this method, according to preliminary two-dimensional (2-D) analysis and simulations. The antenna is designed to have strong isolation, be low-profile, inexpensive, and easy to manufacture. This antenna operates at radio frequencies between 2 and 12 GHz and has vertical and horizontal lengths of 34-36 mm. The truncated rectangular shaped antenna is constructed using the CST modeling technique [4]. For two diameters, 50 and 60 mm, circular MSPA with maximum SAR values has been designed and constructed. The antenna achieves good return loss and increased bandwidth. It was created using FCC guidelines. For medical applications, wearable jeans serve as a more flexible substrate [5]. Using the GS-CLEAN algorithm, to handle the signals that each sensor receives. This paper presents Four different types of microstrip imaging systems with working patch antennas at a frequency of 2.45GHz are presented in this paper on the design of microstrip antenna with defective ground structure (DGS) for the detection of breast tumors in microwaves was created with microstrip. Four feed-insets with grounding patches employing dielectric substrates running at 2.45 GHz [6]. A microstrip patch antenna is described in this study as having a truncated rectangular shape. The antenna is designed to have strong isolation, be low-profile, inexpensive, and easy to manufacture. This antenna operates at radio frequencies between 2 and 12 GHz and has vertical and horizontal lengths of 34 and 36 mm, respectively. The truncated rectangular antenna is constructed using the CST modeling technique. The antenna resonates at 7 GHz and has a reflection coefficient of less than -28 for the frequency range of 2 GHz to 12 GHz. The substrate of this antenna is FR4, which has a permittivity of 4.3. A rectangular patch antenna of 18 mm in length and 11 mm in width was utilized to determine several characteristics, including the S parameter, gain, and directivity. This design is narrow [7]. The construction of a microstrip antenna with a defective ground 1111 structure (DGS) for the imaging system's breast tumor detection at 2.45GHz is presented in this work. employing dielectric substrates, FR4 (ɕr = 4.4 F/m), four different types of microstrip patch antennas have been constructed employing microstrip 21 feed inset with grounding patches at 2.45GHz operating frequency. The electric (E), magnetic (H), and current density intensities are used to gather the data. A 3D breast model construction with a particular dielectric value and conductivity is used to analyze the antenna. The findings demonstrate that an antenna with a well-designed structure may provide good E and H field intensities when the tumor is present, yielding values of 7083 V/m and 35.5 A/m, respectively, compared to other suggested antennas, the presence of tumor is 7186 V/m and 35.8 A/m [8]. The use of microwave imaging as an imaging technique for breast cancer early detection is being investigated. The electrical characteristics of the breast tumor differ significantly from those of healthy breast tissue when subjected to electromagnetic radiation. The purpose of this paper is to investigate if a UWB microstrip antenna running at 6 GHz may detect malignancies with the help of utilizing a straightforward cone-shaped model. The skin, fat, and tumor tissues of the breast make up this model. The study is conducted using a variety of distances between the breast model and the patch antenna. Results of simulation and measurement are provided to provide a thorough understanding and shade of light of understanding including the antenna's radiation pattern, gain, and reflection coefficient with current density of the breast skin, fatty tissue, and tumor [9].

2. Breast cancer in Asian countries

An estimated one in eight women will receive a breast tumor diagnosis at some point in their entire life, and over 310,000 new cases of invasive breast tumor detected this year. Were you aware that your race affects such risks? Approximately 11% of Asian/Pacific Islander women will develop breast cancer in their lifetime, comparable to 12% of Black women and 13% of white women. The incidence of breast cancer is increasing, despite Asian women having slightly lower rates than women of other races. Asian women's breast cancer incidence rose 1.4% between 1999 and 2018. Chinese, Korean, Vietnamese, South Asian, and Filipina people were the most at risk. Additionally, Asian women's risk factors for breast cancer differ from those of women of other ethnicities.

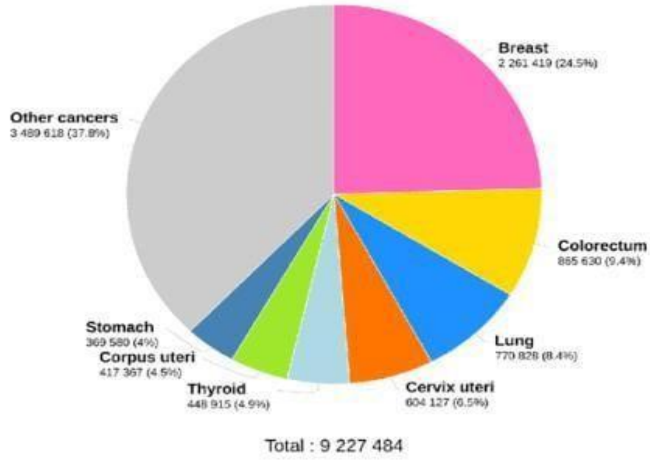


Fig 1. WHO pie chart about breast cancer statistical analysis.

3. Methodology

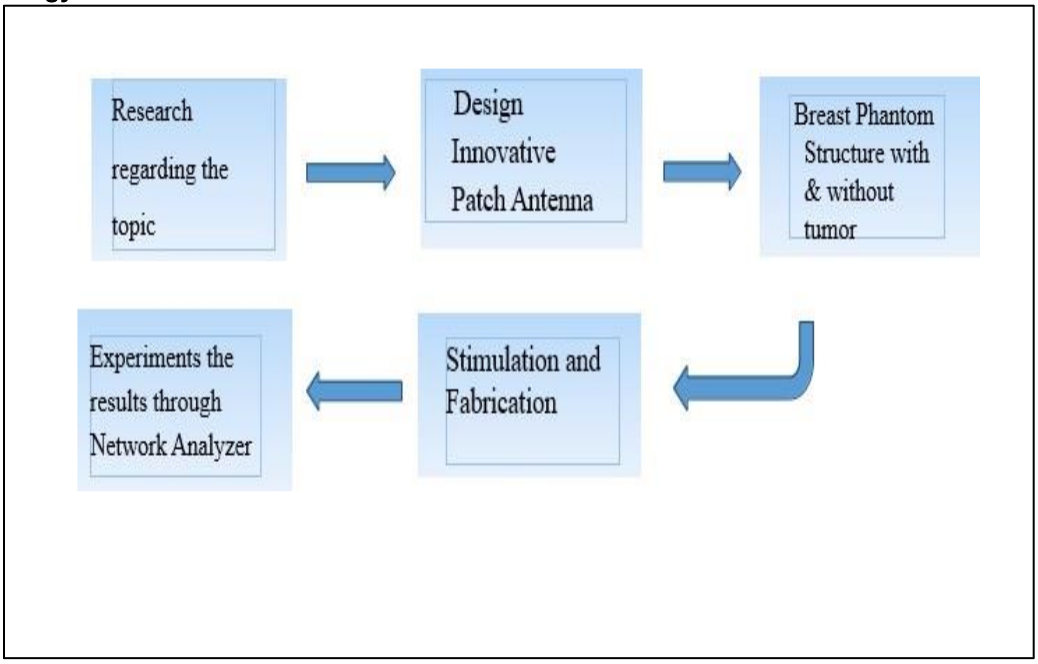


Fig 2. Scheme of proposed work flow

Hardware Elements

The presented system uses a Microstrip Patch Antenna (MSPA) for non-invasive breast cancer detection. For the purpose of detecting anomalies like tumors, the MSPA is a customized antenna designed to send and receive microwave signals that can pass through breast tissue. The signals that the antenna receives are captured and digitalized by the Vector Network Analyzer (VNA), enabling in-depth examination. A phantom, which mimics human breast tissue, is used to calibrate and certify the system in order to guarantee accuracy during testing. Advanced software such as CST Studio Suite, which aids in antenna design, and a number of signal processing algorithms that reduce noise, improve signal quality, and examine the relationship between signals and breast tissue are used to process the raw data from the VNA. After the Following data processing, a screen displaying the tissue's classification—such as benign or malignant—is presented. To make well-informed diagnostic decisions, medical professionals utilize this information. Therefore, by integrating accurate antenna technology, advanced signal processing, and professional analysis in an intuitive interface, the system presents a promising approach for early breast cancer diagnosis.

Antenna Design

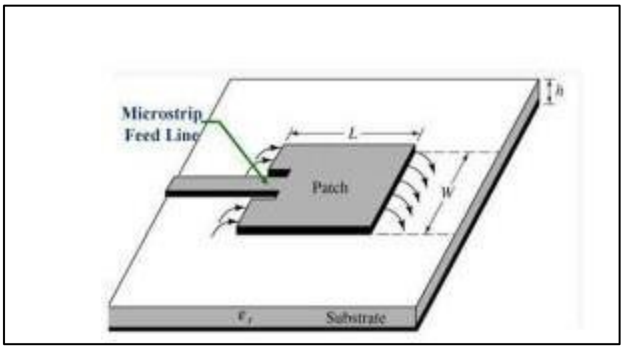


Fig 3. Microstrip Antenna Design

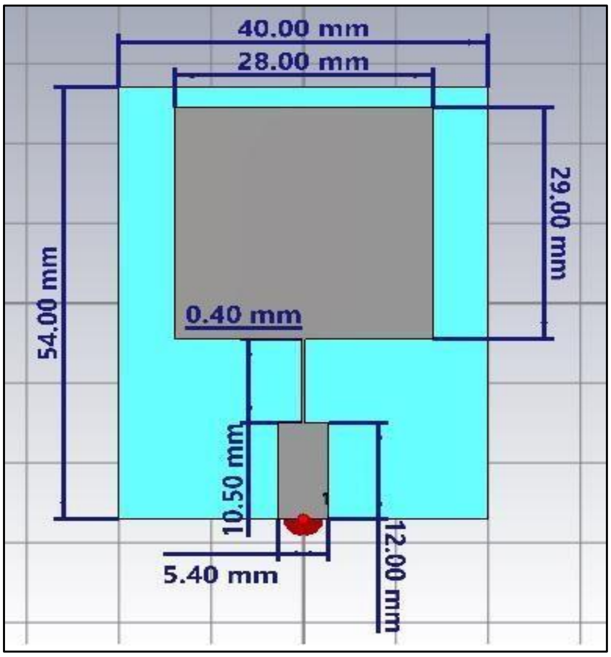
The following diagram illustrates how to model a patch antenna's length, width, dielectric constant, and computation of the necessary structures. The substrate, ground, patch, feed line, and source are the several components that make up the MSPA. For the antenna to radiate properly, all of those are given specific dimensions. These antenna measurements match those shown in the table. Software known as CST (Computer Simulation Technology) is used to simulate the antenna at a resonance frequency of 2.45GHz. A single patch antenna that resonates for the same resonant frequency is utilized in this instance.

This antenna design uses FR4 epoxy for the substrate and copper for the patch and ground. Instead of being transmission fed, the feed line is inset fed because it improves antenna performance. The radiation box is sufficiently large because it is the cause of the return loss. Lastly, the fabricating equipment operates under specific conditions to build the antenna. To find L and W, most people use the formulas derived from the patch's fundamental resonant mode, which is the half-wavelength mode. Equation (1) is used to find the patch width (W) once the ideal resonant frequency and dielectric constant are known.

$(W) = C/(2f_o)\sqrt{2/(\epsilon_r+1)}$ I

where fr is the antenna's resonance frequency, ϵr is the substrate dielectric constant, $3*10^8 m/s$, and C is the speed of light. Once the width has been considered in the order determined, further elements need to be taken into account in order to precisely determine the patch's length. These parameters consist of the antenna length extension, effective length, and effective dielectric constant. These are necessary for matching impedance and more accurate design. Using Equation (2), the effective dielectric constant (ϵeff) was determined.

$\varepsilon_{reff} = (\varepsilon_r+1)/2 + (\varepsilon_r-1)/2\,[1+12h/W]^{(-1/2)}$ II



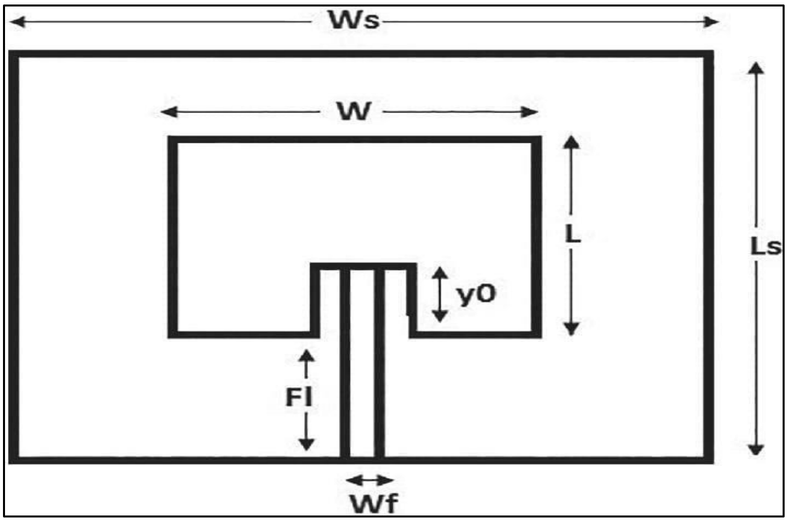


Fig 4. Design of Microstrip patch antenna

Parameters	Dimension
Ws	40mm
Ls	54mm
W	28mm
L	29mm
Wf	5.40mm
Fl	10.50mm
y0	0.40mm

Table 1. Proposed antenna design parameters

Microstrip antenna implementation

There are numerous methods to feed microstrip patch antennas. Through electromagnetic coupling, electricity is sent to the patch antenna without the need for any connections. Coaxial probe feeding, feeding using a microstrip line and aperture, and proximity coupling are the methods used for feeding. The conducting strip is immediately connected to a microstrip patch, which is used in the microstrip line feeding technique. One benefit of this method is that it allows the conducting part to be cut on the same substrate. The patch antenna is wider than the conducting element. Coaxial connectors are used in the coaxial probe feeding technique. The patch antenna is connected with coaxial connector's core, and the patch antenna's ground is connected with coaxial connector's other conductor. One of the main problems with this is that it is hard to design. The patch element is positioned above the substrate in the proximity linked feeding technique, with the input feed situated between two substrates. Microstrip Line Feed: This kind involves a conducting strip that is attached straight to the microstrip patch's edge. In order to create a planar structure, the feed might be etched into the same substrate where strip is narrower than the patch. Feeding techniques can aid in limiting the consumption of surplus nutrients. Feeding techniques include food-restricted feeding time-restricted feeding and free-choice feeding. Because free-choice feeding gives the pet unlimited access to food, It is more likely that they will the will consume too many nutrients.

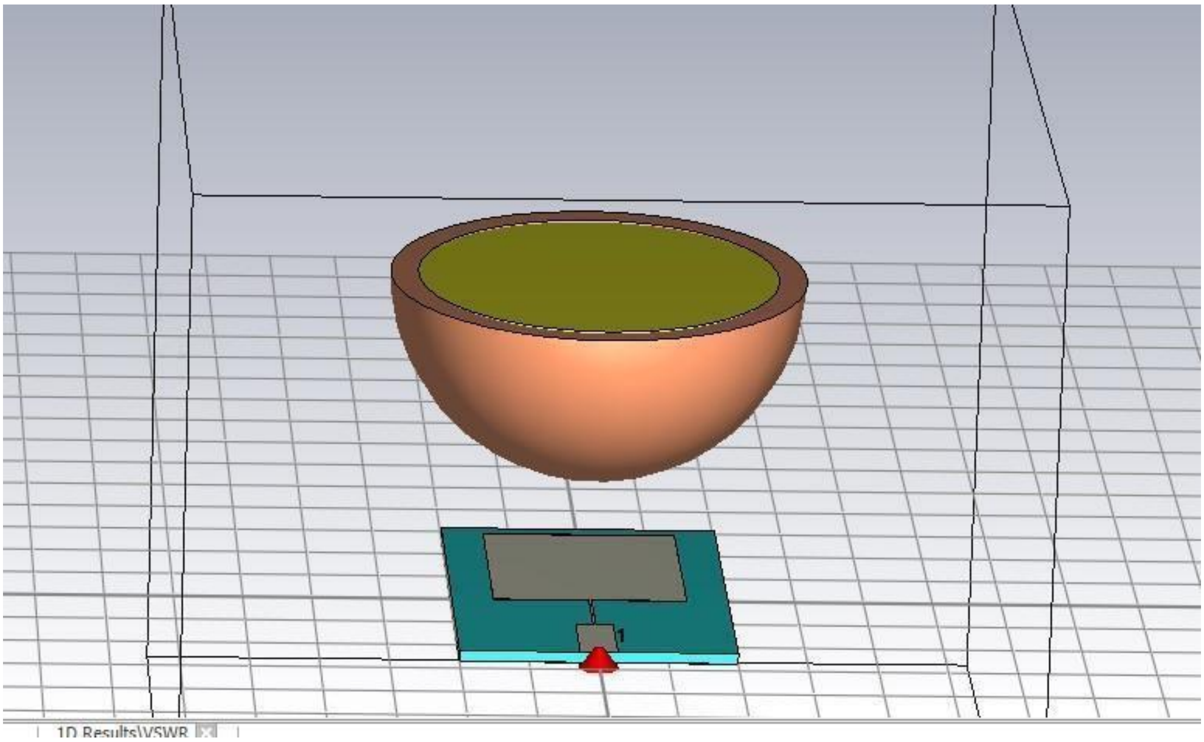


Fig 5. Simulated feeding techniques of Microstrip antenna in CST

Breast phantom design

To assess the feasibility of the suggested antenna for breast cancer detection, a variety of breast phantoms were constructed. The dielectric characteristics of biological tissues are frequently described using the Cole-Cole and Debye models. Both theories advance our knowledge of the interactions between biological tissues and electromagnetic fields. As demonstrated, our model was utilized in conjunction with the IT'IS material parameter database to ascertain the dielectric properties of the glandular, fat, and breast skin tissues throughout the targeted frequency range. The literature made assumptions about the tumor's characteristics. For electromagnetic simulation and analysis, the well-known program Computer Simulation Technology (CST) was utilized. As seen in the picture, the antenna design was first evaluated on a breast model (Model A) that was tumor-free, and subsequently on a breast model (Model B) that had a tumor with a 5 mm radius. To ensure the antenna's test capacity to detect cancers in various locations, a second tumor with a 2 mm radius was added to Model B and placed in a new location to form Model C. Lastly, a square tumor (Model D) was added to see how it influenced the antenna's performance.

Tissue	Permittivity (F/m)
Skin	36.7
Fat	4.84
Tumor	54.9

Table 2. Breast phantom design parameters

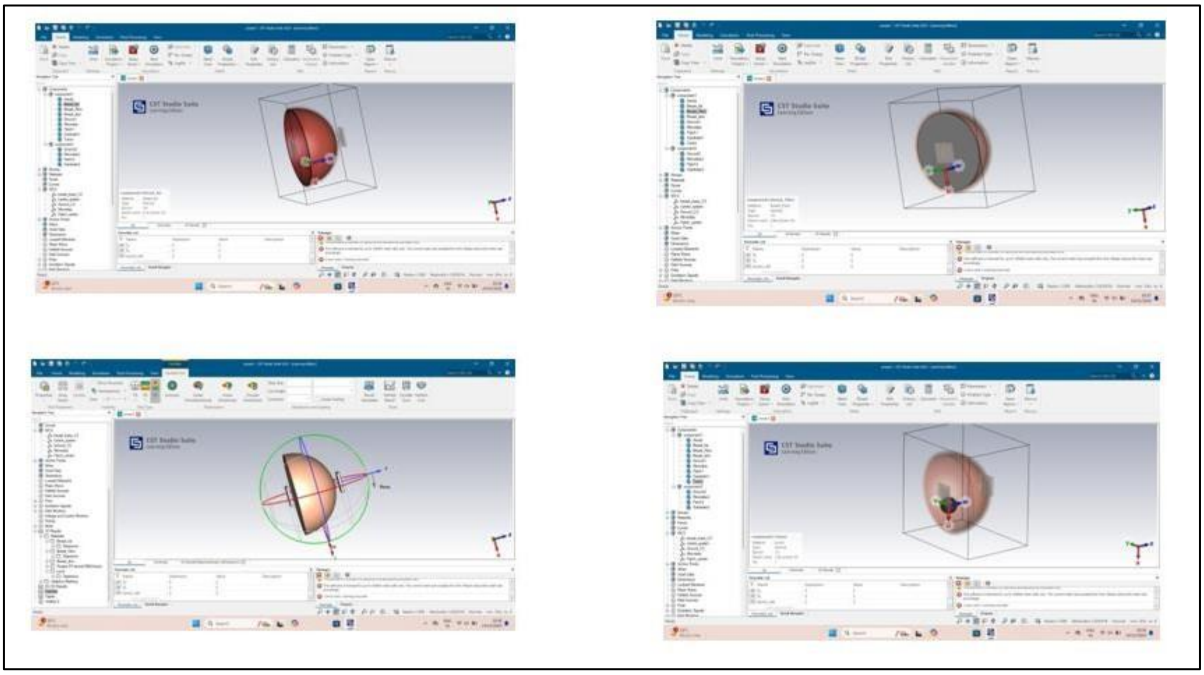


Fig.6. Respectively: A: Structure of Breast Phantom with Breast fat, B:. Structure Breast fibroadenoma, C: Structure of Breast Phantom with far field, D: Structure of Breast Phantom with Tumor.

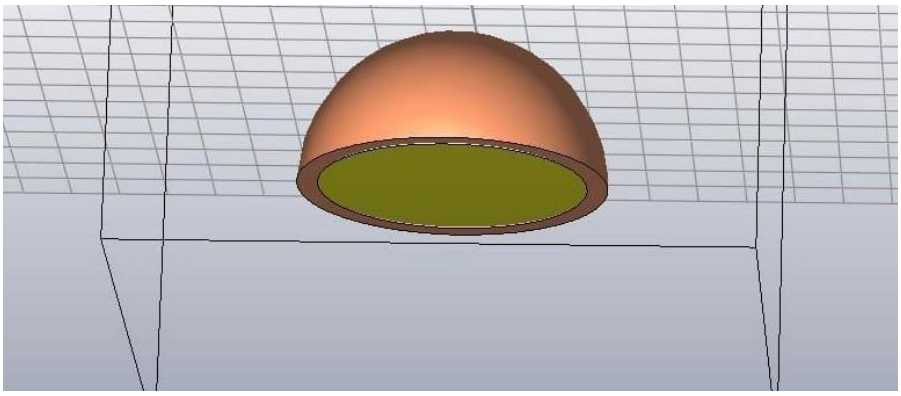


Fig 7. Simulated phantom without tumor

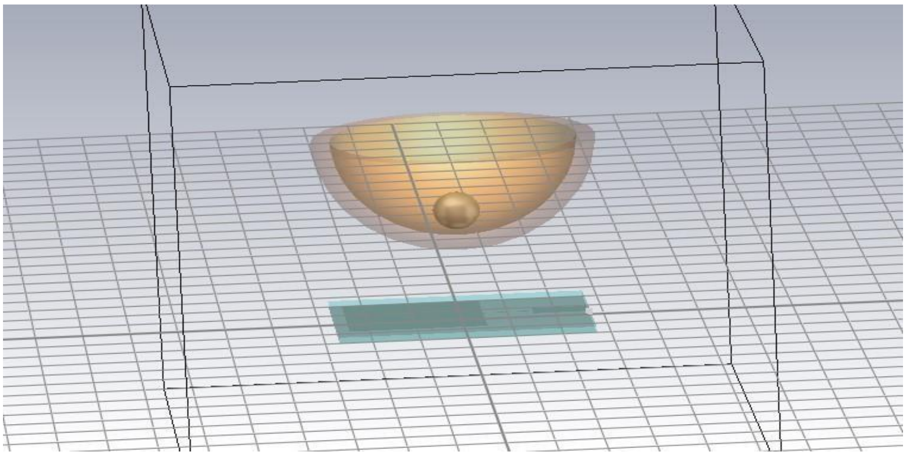


Fig 8. Simulated phantom with tumor

S parameter plot

S-parameters provide a detailed description of how energy can flow via an electrical network. The use of scattering parameters, which only examine voltage and current at the input and output ports, to characterize a complex network as a "black box" S11 is the input port. The voltage reflection voltage gain is S12, and the reverse output port voltage is 18. S21 represents the gain's forward reflection voltage coefficient. The symbol for the coefficient is S22 reflection coefficients and transmission gains from the matrix on both sides. The energy flow across the network has been mentioned in depth by S-parameters. Main parameters are used to describe a complicated network as a "black box" because they simply look at the voltage and current at the input and output ports. The input port is S11. The reverse output port voltage is 18 and the voltage reflection voltage gain is S12. The forward reflection voltage coefficient of the gain is denoted by S21. The coefficient is represented by the symbol S22. Transmission gains and reflection coefficients from the matrix on both sides. S-parameter, which expresses a range of electrical characteristics of the network's constituents (capacitors, inducers, and resistors), including gain, return loss, wave ratio (VSWR), reflection coefficient, and others, can be used to determine the S parameters of a two-port network using b1=S11*a1 + S12*a2, where a1 and a2 are the complex excitations in volts that occurred on Port 1 and Port 2, respectively.

VSWR plot

S-parameters clarify the input-output relationship between ports (also called terminals) in an electrical system. For instance, if we have two ports (ingeniously called Ports 1 and 2), S12 represents the power transformation. S21 displays the electricity that travelled from Port 1 to Port 2. Keep in mind that every signal that the antenna receives is transmitted to the radio, which must separate the LoRa signal from the noise produced by all of the other signals. Therefore, the ideal antenna would have a low S11 (below -10dB) at 868MHz and a high (around 0dB) at all other Transmission lines and radios must be properly matched to the antenna's impedance in order for an antenna to receive power from a radio (transmitter or receiver). The VSWR characteristic gauges how well the antenna matches impedance with the radio or transmission line it is attached to. The amount of power Standing Wave Ratio (SWR) is an acronym that is commonly used to refer to this measurement. The power reflected by VSWR is shown by the coefficient. Voltage fluctuations brought on by the antenna are known as VSWR. Proportion between the line's highest and lowest voltages. by the total and the power that is represented. Features of networks of referenced reflections in terms of S-parameters. A wide range of electrical components (such as resistors, capacitors, and inducers) can be expressed using the following formula, which describes the voltage components from the forward power: return loss, voltage radiation pattern standing wave ratio (VSWR), reflection coefficient, gain (all forms of electromagnetic energy are combined to form gain), and amplifier stability.

Radiation Pattern

All electromagnetic energy types are together referred to as the electromagnetic "spectrum." Electromagnetic energy includes microwaves and radio waves that are released by transmitting antennas. All of these are referred to as "radiofrequency" or "RF" radiation or energy. They offer a greater gain in horizontal directions and are frequently utilized for emergency radio, automobiles, and GPS applications. Energy is mostly received and transmitted from a single direction using directional antennas. The oscillation rate of electromagnetic radiation spectrum, or electromagnetic radio waves, from frequencies as high as 300 GHz to 9kHz. To produce heat, radio frequency devices use low-frequency electromagnetic waves at safe levels. The layers of your skin are deeply penetrated by this heat. There, it promotes the growth of new skin cells. Additionally, the therapy promotes the synthesis of elastin and collagen. The radiation pattern, referred to as the antenna pattern, is a graphical representation of the radiation attributes of the antenna as a function of space. To put it a different way, the antenna's pattern shows how energy is sent into or received from space.

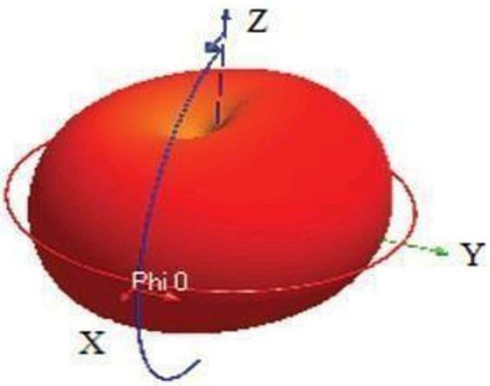


Fig 9. Radiation Pattern

Directivity plot

Directivity is a basic antenna characteristic which measures how "directional" an antenna's radiation pattern is.

An antenna that radiates uniformly in all directions would have a directivity of 1 (or 0 dB) and a directionality of nearly zero. The scaling of the magnitudes so that the greatest value of the radiation pattern's magnitude equals one is the only distinction between a normalized radiation pattern and a radiation pattern. While the denominator of this directivity equation only represents the "average power emitted over all directions," the most significant value of F serves as the numerator. The directivity of the antenna can be calculated by simply dividing the average of the radiated power by its peak. The following is a mathematical representation of the directivity (D) formula:

$$D = \frac{1}{\frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi}|F(\theta,\phi)|^2 \sin\theta d\theta d\phi}$$

S parameter chart

The ports (or terminals) of their interactions are described by S-parameters. For example, if there are two ports (smartly named Port 1 and Port 1, for Port 2), S12 denotes 2 an electrical system and the input-output of the electricity that was sent from Port 2. Power has been moved from Port 1 to Port 2, according to the signal S21. SNM is frequently used to show the electricity that has been sent from Port M to Port N in a multi-port network where we may supply voltage. Generally speaking, a port is current. Thus, the radio system with two radios (radios 1 and 2) would be the two port terminals that supply power to the two antennas in a communication. S11 would therefore be the radio 1's attempt to communicate its power. The linear properties of RF electronic circuits and components are expressed using S-parameters, also known as S-matrix or scattering parameters. The S-parameter matrix can be used to compute the phase group delay, gain, loss, impedance, and voltage standing wave ratio, among other properties of linear networks. An S-Curve graph, a project management tool, allows one to track the evolution of a project's components over time. It has the ability to track all relevant project parameters, such as labor hours, man-hours, and cost. The S-Curve graph shows these resources plotted against time.

With tumor S parameter plot

S-parameters describe the input-output system. For instance, S12 shows the power port transferred from Port 2 -Port 1 when there is a relationship between ports (or two ports, cleverly termed terminals) in Port 1 and Port Electrical 2. S21 claims that Port 2's electricity was transferred. In a multi-port network where SNM typically shows the power sent from Port M to Port N in 1. Any place that can deliver voltage and, consequently, current might be considered a port. The radio terminals that supply power to radios (radio 1 and radio 2) and the two antennas would comprise a two-port communication system. Therefore, S11 would be the power attempt for radio 1. The Active S-Parameter is calculated with the following formula i.e. (S11*a1 + S12*a2)/a1.

Fabrication of antenna

A printed circuit board (PCB) antenna must be fabricated using a few crucial processes. The antenna's layout, comprising the ground plane, feedline, and patch, is first saved as a Gerber file. The next step is to choose an appropriate FR4 substrate with the required thickness and dielectric constant. Copper cladding on the FR4 substrate is the initial phase in the PCB manufacturing process. Copper is patterned using photolithography, which uses a photoresist and etching technique to create the antenna design. The copper traces become thicker and more conductive after electroplating. For insulation and to avoid solder bridges, a solder mask is used. The feedline connection is soldered to the patch using the correct methods, such as joining a coaxial wire or microstrip line, after holes are created for it. To assess performance, the constructed antenna is placed on a ground plane or test fixture. Gain, radiation pattern, impedance matching, and return loss are among the characteristics that are assessed via network analyzer or comparable devices. The design is iteratively improved based on these measurements, and the manufacturing and testing procedures are repeated until the required performance is attained. The choice of FR4 substrate, careful feedline design for maximum efficiency and impedance matching, appropriate soldering methods for dependable connections, and precise testing and measurement to confirm performance and pinpoint areas are crucial elements for improvement.


Fig 10. Fabricated prototype front view of proposed antenna


Fig 11. Fabricated prototype back view of proposed antenna

Synthesis of Breast Phantom

After about half an hour of boiling agar powder in water, glycerol preservative was added, and then a mixture of wheat flour was added to the mixture. To simulate a tumor, The boiling mixture was transferred into a mold that held a piece of metal. After that, the mixture was left to cool to ambient temperature. The model's base diameter is 8.5 cm and its top diameter is 4.25 cm at room temperature. The model is displayed.

Fig 12. Synthesis of breast phantom with and without tumor

4. Results and Discussion

Unit Test Cases

The discussed Antenna model is simulated in CST Studio suite, the tumor-free and tumor-containing phantoms' respective VSWR values are 1.07 and 1.20. As shown in Table, the measured VSWR values using CST with tumor indicate that the tumor in the phantom causes the reflection to increase. The S parameter values for the tumor-containing and tumor-free phantoms are -28.50 and -25.21 respectively. As can be seen in the table, the S parameter values obtained wit with tumor reveal that the tumor in the phantom increases the reflection. The simulation output values of S11 Parameters are described in the below table.

Condition	Obtained Values
Output of VSWR without tumor	1.07
Output of VSWR with tumor	1.20
Output of S11 without tumor	-28.50
Output of S11 with tumor	-25.21

Table 3. Antenna Design simulation output values of S11 Parameters

Integration Test Cases

Test Outcomes via VNA:

The purpose of the Network Analyzer is to measure the practical values while the simulated MSPA is maintained between 1.5 cm - 2.5cm the existence of a tiny metal fragment trapped in a phantom tumor, respectively. The findings indicate that the tumor raises the return loss of the S11 tumor to -25.21dB, which is the reason for the reflection. The findings unequivocally demonstrate that the phantom included a foreign body. The difference between with and without tumor design is depicted in the graph. -28.50GHz without tumor x axis, -25.21GHz with tumor x axis. This is the Microstrip Patch Antennas proposed design graph, both with and without a tumor. 2.45 GHz is the antenna's frequency. S Parameter Plot, Voltage Standing Wave Ratio, Gain Plot, Directivity Plot, and S Parameter Chart may all be found with this. Comparison graph between with tumor and without tumor mentioned below.

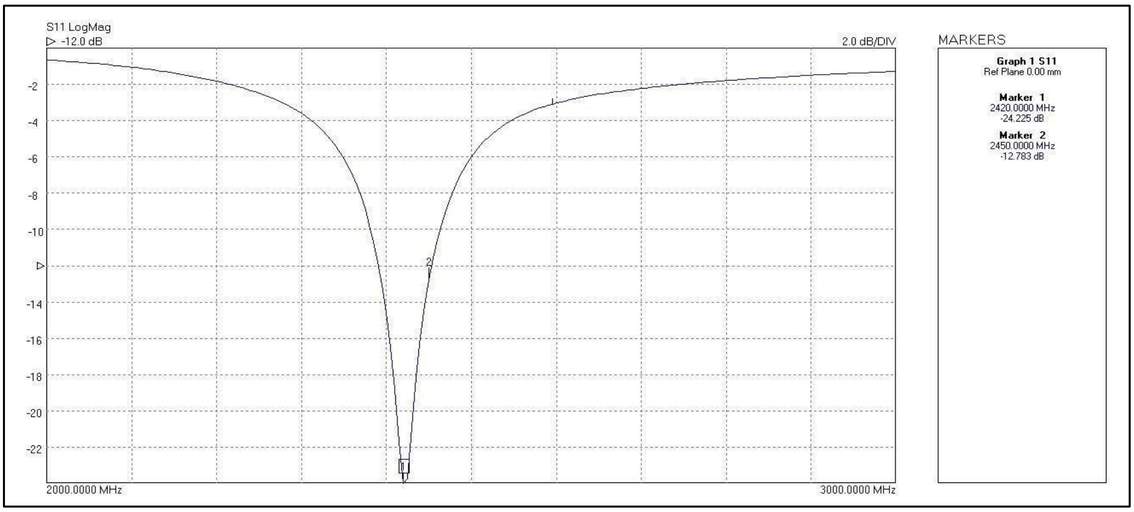


Fig 13. Output of S11 without tumor in VNA

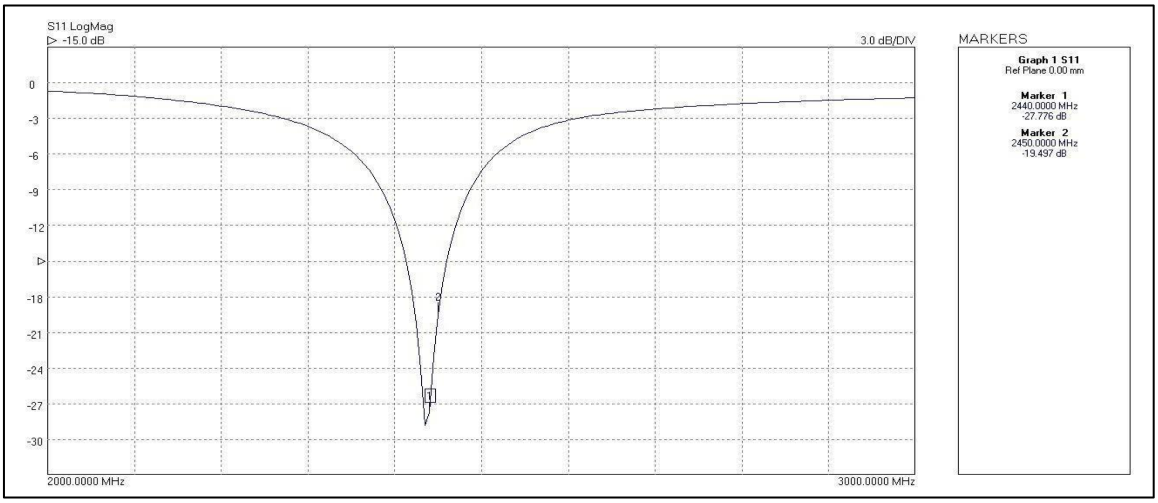


Fig 14. Output of S11 with tumor in VNA

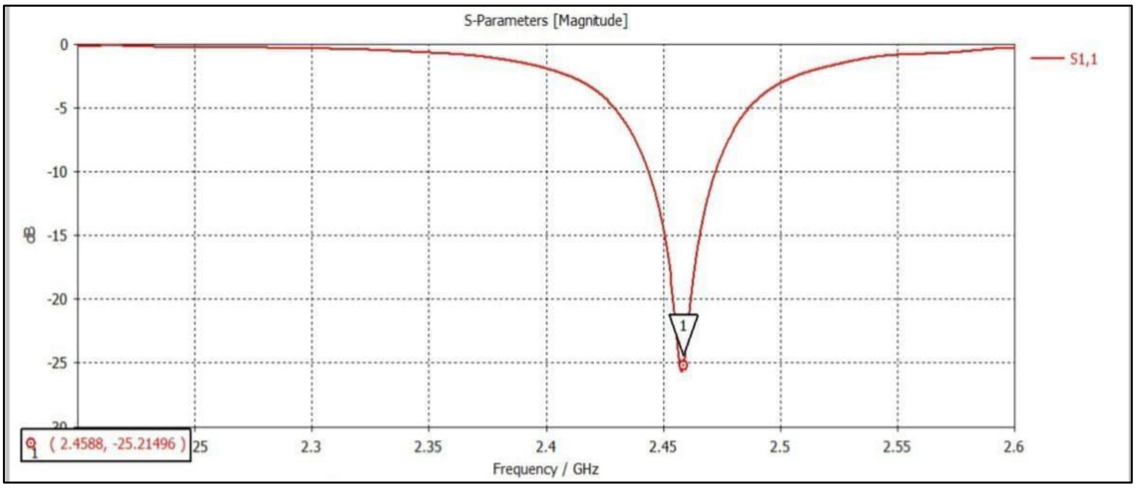


Fig 15. Output of S11 with tumor

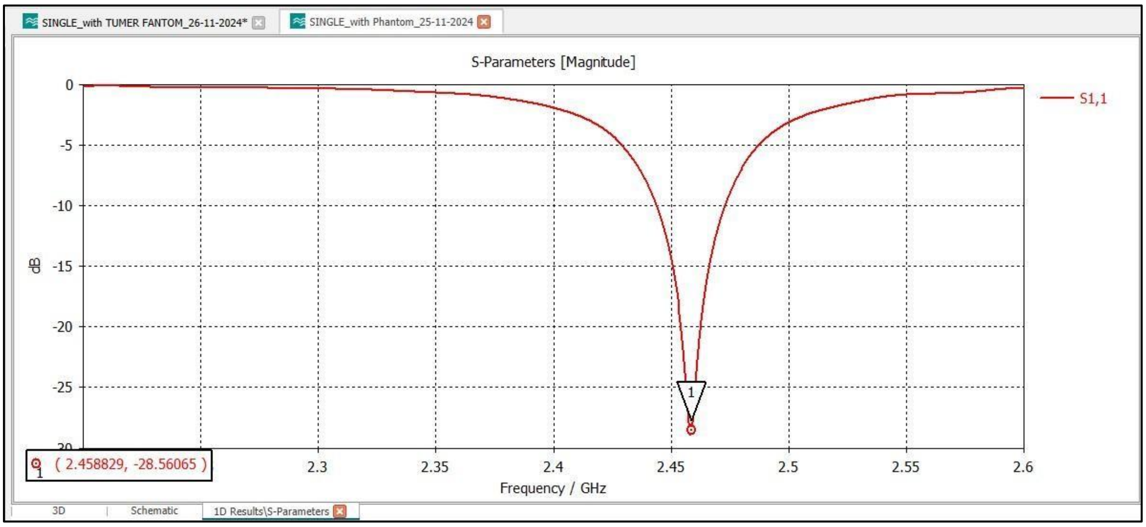


Fig 16. Output of S11 without tumor

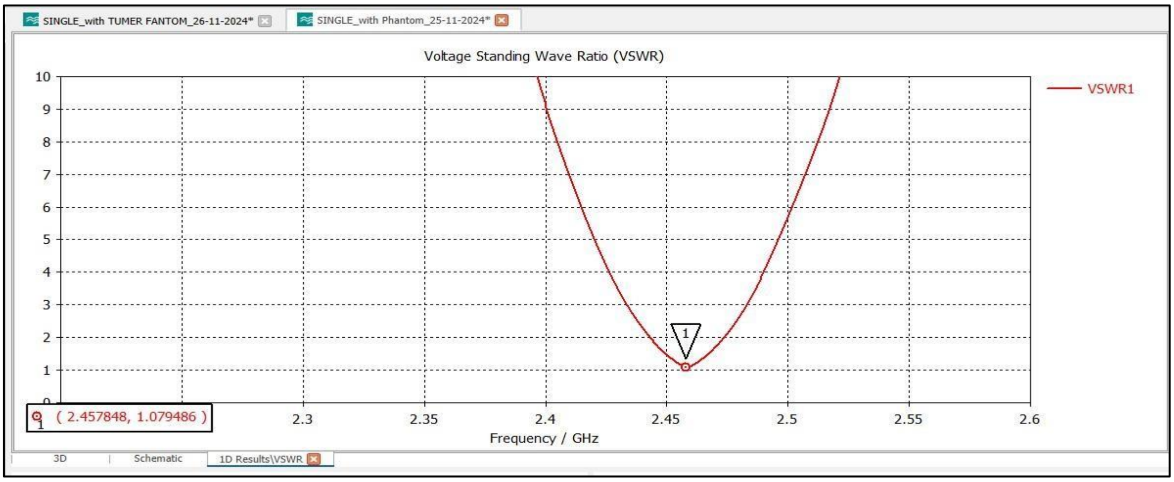


Fig 17. Output of VSWR without tumor

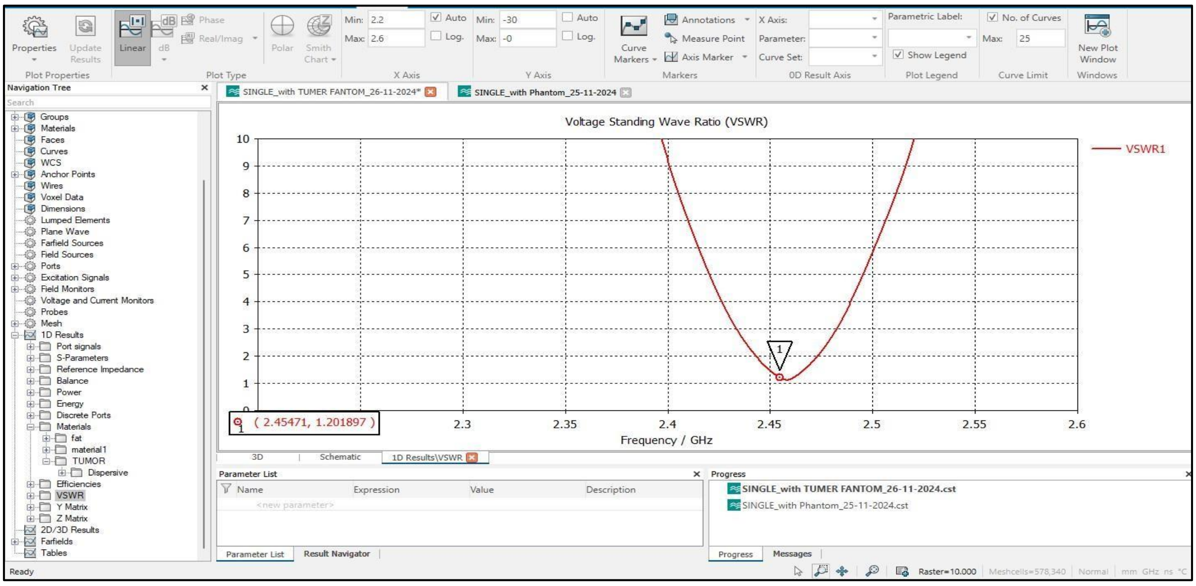


Fig 18. Output of VSWR with tumor

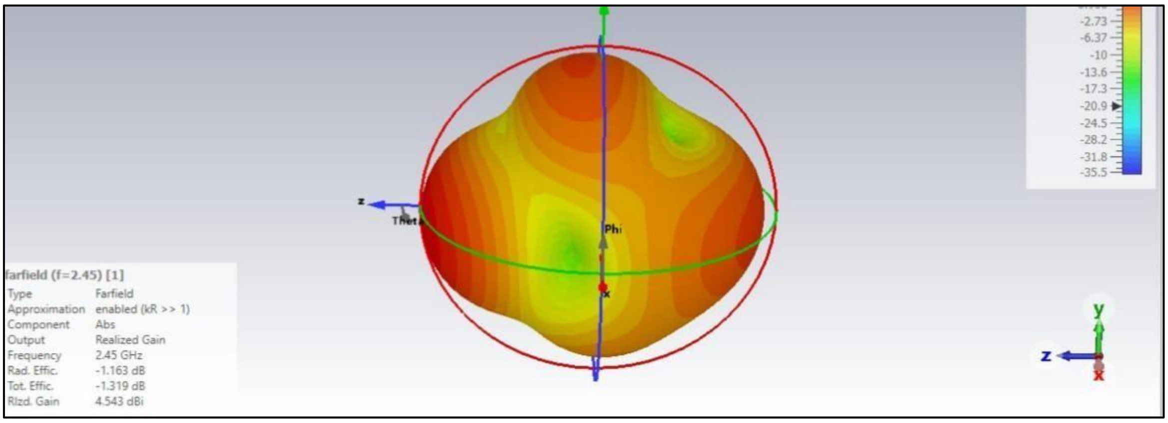


Fig 19. Radiation pattern with tumor

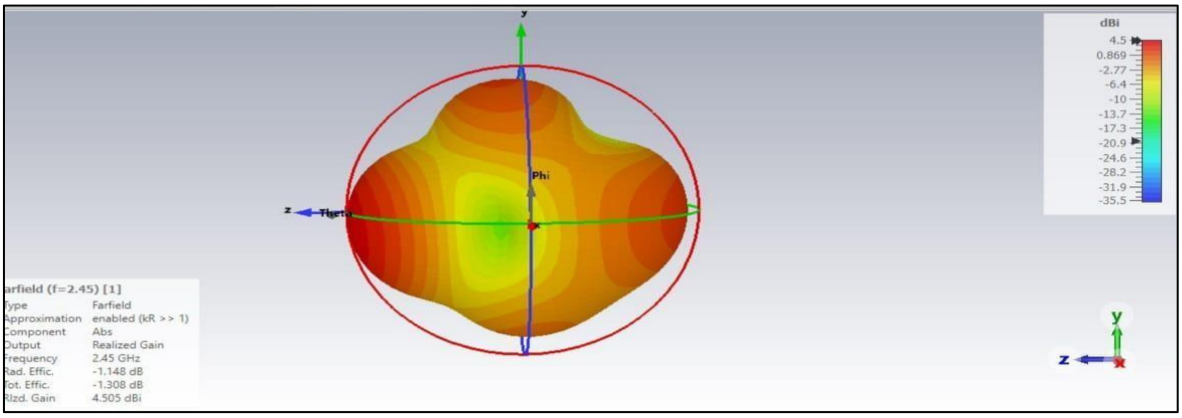


Fig 20. Radiation pattern without tumor

Testing and validation of Fabricated antenna using VNA

The MSPA's construction, which uses a traditional microstrip fabrication technique, is extremely straightforward. Broad band width, feed line flexibility, beam scanning, frequency agility, dual frequency operation, dual characteristics, and circular polarizations are all readily acquired from these patch antennas. A ground plane is located on one of the substrate's sides of the MSPA. The substrate may be quartz, rubber, benzocyclobutene, or another material. For communication engineers, MSPA's performance and advantages—Low profile, low weight, good gain, compact design, and inexpensive cost—make them ideal. These patches may blend in with microwave circuits, making them ideal for broad categories of applications, including navigation systems, cell devices, biomedical applications, and WLAN applications. One of the sides' ground planes is made of a conducting substance, such as copper, aluminum, silver, etc. A patch less than the substrate as well as and fed with a micro strip line is located on the opposite side. The substrate's thickness has no bearing on the directivity. Based on the use, the substrate may be square, elliptical, rectangular, or circular in shape. As previously discussed, traditional methods like mammography, biopsy, computer-aided detection, and magnetic resonance imaging have limitations. To address these shortcomings, microstrip patch antennas (MSPAs) offer a potential solution.

As calculated at the intended operating frequency of 2.45GHz, the MSPA's gain achieved is 3.79dB. The figure depicts the planned simulated antenna. The suggested antenna's 3D directivity is 5.80dB, VSWR 1.02 indicates that there is virtually little reflection, and the resonant frequency of 2.48GHz is likewise satisfied. The return loss, which is -25.214dB, indicates that theory and reality are in harmony. The constructed antenna is brought in for examination.

Fig 21. Testing of Fabricated antenna using VNA

Parameters	Results
Frequency	2.45GHz
Substrate	FR4
Height	1.60mm
size	28l*29b
Thickness	1.6m
Dielectric	4.4
Return loss	-25.214(with tumor)
Gain	3.79dB
Directivity	5.80dB
Difference in graph	3dB

Table 4. Obtained results for taken parameters

5. Conclusion

A 2.45–27 GHz microstrip patch antenna for breast cancer tumor detection was successfully designed and fabricated as a result of a complete understanding of antenna function. In order to provide the best possible performance for medical diagnostic applications, this antenna was painstakingly constructed to function efficiently within the specified frequency range. The electromagnetic behavior of the antenna was simulated using the CST Studio Suite, which made it possible to precisely optimize its crucial design parameters. The antenna's appropriateness for tumor identification was confirmed by the S-parameter plot graph, which clearly separated the response changes between situations with and without tumors. In order to guarantee low signal reflection and ideal impedance matching, other crucial characteristics were assessed, including the Voltage Standing Wave Ratio (VSWR), return loss, and impedance analysis using Smith charts. Directivity and radiation patterns were investigated to verify

The antenna's capacity to efficiently concentrate energy into particular areas—a critical function for identifying anomalies in breast tissue—was verified by analyzing radiation patterns and directivity. In order to reduce energy attenuation brought on by dielectric and conductive material losses, loss curves were examined. The reliability of the design was demonstrated by the simulation results, which agreed with theoretical predictions. The antenna's performance was verified using a network analyzer after construction, ensuring that it matched the simulated outcomes. With the manufactured antenna demonstrating encouraging promise for efficient breast cancer tumor identification, this study emphasizes the critical role that modeling and optimization play in building high-performance antennas for biomedical purposes.

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