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Design and analysis of the Flexible Antenna behavior for Microwave Imaging of breast cancer

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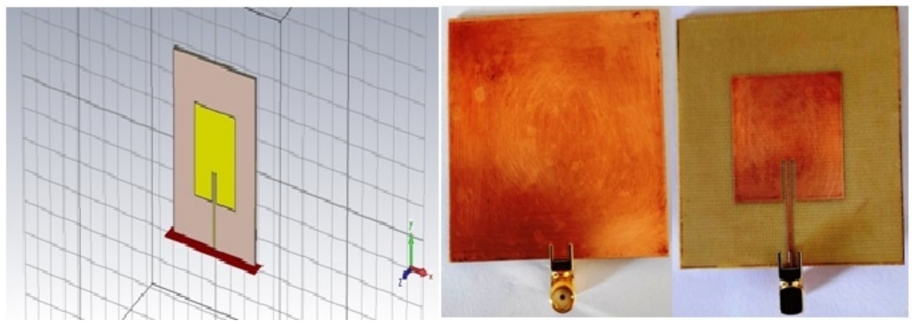
ABSTRACT



Microwave imaging has more advantages as compared to previous techniques because of its compact size, low profile, and ease of integration with a variety of medical devices. This research presents a detailed investigation of the design, assessment, and characterization of a microstrip patch antenna for biomedical purposes. Many antennas are equipped with high precision and gain for breast cancer detection at an early stage, but versatile microstrip patch antenna efficiency is better compared to other antennas. The jeans material is used for this purpose as a dielectric constant (4.7) as a 1.6 mm thick dielectric substrate. This wearable antenna is made for 2.45 GHz applications and utilizes the co-axial feeding technology of the conducting type for the optimum antenna output. CST software is used to simulate this antenna, and the simulation results are contrasted with previously measured metrics including return loss (**$S_{1,1}$**), VSWR, gain in dB, and directivity (D).

Keywords: Breast cancer detection, CST software, Flexible antenna, Jeans material, Microwave imaging.

INTRODUCTION

The breast cancer is known to be the most prevalent among all other cancer types in the women i.e. the maximum number of cancer incidences observed in women are of breast cancer.[1] The second-most typical kind of cancer worldwide responsible for maximum incidences and deaths combined, behind lung cancer, is breast cancer. Recent statistics shows that the incidence of most commonly diagnosed cancers worldwide were female breast (2.26 million cases, 11.7% of total incidences) which leads to high cancer related death due to breast cancer (680,000, 6.9%).[1] Early diagnosis of the cancer is the prime factor for saving the life of cancer patients.[2] Among various diagnostic techniques, microwave imaging is the emerging technique for diagnosis of cancers including breast cancer. The development of antenna for microwave imaging is one factor for successful application of diagnostic technique. Furthermore, due to their small size, low profile, low manufacturing cost, dependability, simplicity of fabrication, and ease of integration with wireless technology equipment, microstrip patch antennas are attractive for applications such as high-performance aircraft, spacecraft, satellite, missile, and embedded applications. However, they have low power, high Q, and low radiation efficiency in addition to a relatively restricted frequency spectrum. A microstrip patch antenna's name is derived from the shape of the radiating patch. Radiating patches can be square, rectangle, circle, ellipse, triangle, hexagonal ring, and ring sectors in addition to other shapes. Square, rectangular, and hexagonal microstrip patch antennas are easy to design and evaluate all of the antenna's characteristics. One can feed a microstrip patch antenna in a variety of ways. The most often used types include aperture coupling, coaxial probes, and microstrip lines. The procedures come in contacting and non-contacting forms. A microstrip line is employed in the contacting approach to deliver RF power directly to the radiating patch. In the non-contacting condition, power is transferred between the microstrip line and the radiating patch through electromagnetic field coupling. The hexagonal patch antenna design that is being suggested uses a microstrip line feed. In the contacting method known as a microstrip line feed, a conducting strip considerably narrower than the patch is employed (the width should be less than

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the patch thickness). The antenna is easy to design, match, and construct because its designed impedance is 50 Ohm. It is necessary to adjust the patch's feed line positioning to accommodate the impedance. A ground plane and a radiating patch are attached to one side of a dielectric substrate in a microstrip patch antenna, and the radiation of the antenna comes from fringing fields that exist between the patch's and the ground plane's edges. If we detect cancer at an early stage then we can increase the survival rate because breast cancer is not a curable disease, for this paper discusses work identified at an early stage with comfortable and highly efficient methods to detect with and without tumors. Flexible antenna design for breast cancer early detection using microwave imaging. In current technology, Mostly we are using flexible Antennas because of their high gain, low manufacturing cost, easy availability, lightweight, and easy fabrication. In the current scenario, Breast cancer is most dangerous in women (99%) as well as men also (1%) and on average one woman is suffering in every seven women. For the earlier identification of breast cancer, many techniques like X-ray mammography, ultrasound (US), magnetic resonance imaging (MRI), etc. were used,[3] but they have some drawbacks and these all methods das ionizing radiation due to this reason not preferred to younger women, The malignant tumor and the benign tumor are contrasted using dielectric contrast in the microwave imaging approach. Through such contrast distribution maps, the electrical characteristics of interested tissue, such as dielectric properties, permittivity, or conductivity, are used to determine the pathological differentiation of benign tumor tissue from normal breast tissue. The fundamental concept behind employing a microwave imaging system to find breast cancer detection is to send electromagnetic waves coming from a transmitting antenna to the breast and collect the reflected waves at a receiving antenna reflected from the breast. Identifying malignant tissue's location, volume, etc., is vital to understanding the differences between electric and magnetic fields.[4] In contrast to prior methods like Position emission tomography, Magnetic Resonance Imaging (MRI), ultrasound, and X-ray mammography, newer methods are now employed (PET). All the above, the X-ray mammography technique is the most popular method with low-energy X-ray and also, detects early-stage cancer but has many drawbacks, like exposure to radiation, overtreatment, and invasive testing due to false-positive results. In the mammography procedure unpleasant breast tightness while being examined.[5] Ultrasound technique has painless, false radiation exposure and 17% has a false-negative rate but it uses sound waves to interrogate for internal structure, due to low resolution, it does not differentiate between the benign cell and malignant cell. Microwave imaging techniques das overcome all previous techniques, such as radiation exposure, low resolution, radiation exposure, false indications, higher cost, time taking, and patient discomfort. The microwave imaging technique is a fast, index-pensive, noninvasive, convenient, and safe imaging method for rapid diagnosis of breast cancer. Microwave imaging identifies the presence and location of significant dielectric scatters within the breast. The microwave imaging technique has a very important role in biomedical applications, it has potential information related to the structural and physiological makeup of human tissues. It enables non-destructive tissues to interact with microwaves in a non-ionizing way. The imaging procedure avoided all mechanical problems of scanning the antenna. Treatment by Doctors at many stages has multiple data available which gives clear information about the idea of tissues but from time to time information has been changed due to the position of the scanning antenna. For this solution, Breast self-examination programs have been developed to find breast cancer early because it can strike anyone at any age. Many academics urge women to learn about breast cancer and offer strategies for protection from breast cancer because most women have a great deal of worry around the cancer treatment procedure.[6] An antenna is the most important evolution tool for many applications, including the medical industry, microwave imaging, wireless monitoring, etc. The main objective of developing a small antenna was to make it modest in size, however, we were employing a large antenna system, which lowers antenna efficiency in applications with a lot of potential. Various sorts of antenna approaches and algorithms are currently being explored, but each one has advantages and disadvantages that are related to particular applications. The flexible patch antenna is necessary for today's medical industry and security needs to provide top-notch care for any patient receiving treatment without surgery. Specific Absorption Rate (SAR) numbers used in microwave imaging should not be higher than exposure levels that could injure tissue. According to the IEEE and the Internal Commission on Radiation Protection from Non-Ionizing Radiation. The ICNIRP value is defined as 2W/kg with an average mass of 10 g, however, the maximum SAR value stipulated in IEEE C95.1:1999 recommendations states that a mass of 1 g should produce 1.6 W/kg of power. various factors, including the distance between antennae matching the human body, antenna strength, antenna type, and antenna radiation power intensity. Instead, additional variables including frequency, intensity, near-field or far-field, as well as the reflection, absorption, and dielectric characteristics of various tissues and scattering affect the value of SAR. As the beast gets bigger and farther away from the broadcast antenna, the SAR value will decrease. The SAR value will increase in tandem with an increase in tumor size and frequency[6]. This paper presents a bendable antenna that can come into contact with flesh. Due to its small and flexible nature, it fits inside the Bra surface. From the last decade, E-textiles, often known as smart fabrics, are extensively used in wearable system applications. Flexible textile antennas were well suited for use in real-time because, depending on the material, they could be incorporated into clothing. Because of this, elastic conductor material was used in the ground plane and patch of the wearable antenna as well as flexible dielectric materials. Designing a flexible, cheap antenna for earlier breast cancer detection, and the treatable stage is how the planned research is carried out. The suggested antenna makes use of pertinent applications to both early breast cancer with and without a tumor can be seen.[7]

RELATED WORKS

In this paragraph, recent publications and related work papers are discussed. Srinivasan Dhamodharan et al. have designed employing a flexible textile antenna to detect breast cancer, with an overall size of 28.45 mm × 28.45 mm × 1.6 mm. and Amadaouch et al. proposed a high gain impedance matching based antenna technology for ultra-wideband (UWB) for finding a cancerous tumor whose size is 35 mm × 20 mm× 1.6 mm. a frequency range of 3-12 GHz and an ultra-wideband of 120 percent define the proposed antenna. To detect unusual objects, It uses an antenna with the same dielectric characteristics as a human breast. the size and position of the tumor coordinate matching the highest SAR value were noted.[8]

Bahrami et al. created a single and dual-polarization antenna system for wireless UWB using an inhomogeneous multi-layer human breast model. The flexible antenna is operationally designed at 2-4 GHz with a coefficient of reflection below 10 dB. With two versatile conformal 4 x 4 UWB antenna arrays, the suggested miniature antenna has a size of 20 mm x 20 mm. Additionally, Dual and single polarisation are used to find breast cancer using radar. Given that organic tissues have electrical properties, Most of the time, the tiny antenna makes contact with polarised biological tissues. These two arrays of antennas allow maximum power transmission for versatile wearable technology.[9]

Liting Wang et al. have developed a UWB MIMO antenna with a high resolution and 2.3 GHz to 12.2 GHz is the frequency range. Since there is no space between two antennas, the antenna ground is often attached near the middle. The coupling loss is, therefore, less than 15 dB.[10]

A new polygon-printed antenna was created by Kaabalet et al. with an FR4 substrate with low dielectric, 50 feed lines are used to feed the other side, and an incomplete ground plane. Additionally, the built-in tiny antenna features dual band-notched WLAN capabilities and global microwave communication interoperability, and UWBIt has an exceptional capacity for pulse preservation and a group delay reduction of < 1 ns. Owing to its small size of 28 mm2 × 20 mm2, the error associated with the antenna is minimized. The microwave imaging technique is better than X-ray, among the many approaches used to detect breast cancer.[11]

Selvaraj et al. offered an examination of the impact of the electromagnetic wave interaction between the breast tissue and the transmitting equipment. The antenna's bandwidth is very broad between 4.284 and 13.628 GHz. With a mean 1 g and 10 g mass, the absorbed power and SAR (Specific Absorption Rate) are displayed at various tumor frequencies, sizes, and distances. As a result, the findings show that the frequency and size of tumors rise along with an increase in SAR value and power absorbed.[12]

For lung cancer, a Microstrip patch antenna was created and studied by Sushmita Asha and colleagues. A patch antenna with microstrips created using computer simulation technologies is the suggested framework. By contrasting the lung density today with and without a tumor, lung cancer can be diagnosed. The frequency of the current density, H-field, and E-field variations are measured by this system.[13]

A flexible microstrip antenna for breast cancer imaging was developed by Shrestha et al, diagnosis, and appropriate therapy. The integrated antenna is situated atop a person's body that is close to the skin. The frequency range of the microstrip antenna is 2.45 GHz, estimated thickness of 0.25 mm, and dimensions between 32 and 31 mm.[14]

To quantify the imaging of inhomogeneous tissues, Katbay et al. propose a miniaturized micro-strip antenna for breast tumor detection. The microstrip's antenna is close to the breast model that examines the existence of cancerous tissue. The microstrip's antenna is positioned close to the breast model that investigates malignant tissue presence. Numerous antenna types, such as circular patch antennas, t-shaped antennas, t-slotted antennas, microstrip antennas, slotted rectangle antennas, and others are constructed and employed in real-world applications.[15]

Vidyasree et al. provide a novel approach for the accurate detection of breast cancer that makes use of numerous types of miniature antennae, including Cylindrical micro-strip patch antennas on FR-4 substrate, slot antennas, and rectangular patch antennas with a pylon at various frequencies.[16]

A rectangular microstrip patch antenna with slot loading is presented by Susila et al., This is carried out utilizing reasonably priced 5880 lossy substrates from Rogers Technology. It has a radiating part with small horizontal slots and a plane on the ground. It has thin, horizontal slots and a radiating section, the antenna is simulated separately and differences are calculated.[17]

Gupta et al. brought in a planar tumor antenna identification by detecting current density. The antenna is a 2.45 GHz ISM band rectangular T-shaped Micro-strip patch antenna, with a loss of just 32.2 dB is simultaneously confirmed by simulating the antenna at resonance frequency.[18]

Al Habsi et al. claim that a brand-new micro-strip led Vivaldi antenna provides greater benefits than previous antenna technologies. In comparison to other methods, it is quite simple to produce, construct, and simulate. The suggested approach is frequently used to assess critical antenna characteristics, including, among other things, Gain, return loss, VSWR, antenna impedance matching, and radiation properties.[19]

A clever UWB antenna setup for biological uses, specifically to find breast cancer, was demonstrated by Hammock et al. The antenna is built using requirements for an FR-4 substrate with 4.3 permittivities and a 1.58 mm thickness that operates between 2.96 and 10.68 GHz.[20]

Amanath Ullah et al. proposed an efficient and creative method of the 3D antenna in the backdrop to provide primary health observation without causing any health risks. In the suggested triangular antenna, a radially folded structure was utilized the medical diagnostic reasons. The antenna had a radiating structure that measured 40x25x10.5 mm3 and had a gain of 5.2 dB between 1.67 and 1.74 GHz.[21]

Singh et al. suggested a new, small, dual-band, partially-ground-planed textile printed slot antenna, where the copper tape was used to make the ground plane and patch and denim fabric was used as the substrate. The antenna typically has a high gain of 5.7 dB and up to 46 percent (3.01-5.30 GHz bandwidth efficiency) efficiency.[22]

Rahman et al., employing a sixteen-antenna array on a lightweight UWB antenna, implemented an enhanced microwave imaging technique. There were two omnidirectional antennas in the proposed Radar-based imaging technology that is bistatic reducing the difficulty of the algorithm and the antenna's size. At an operating frequency range of 4 to 6 GHz, the antenna size was 20 x 14 mm^2.[23]

A new technique, an array antenna-based active sensor for measuring a microwave tissue imaging device was suggested by Foroutan et al. Low Noise Amplification, a printed slot antenna, and an active mixer are built into the sensor and The spacing between the antennas between each sensor is 12 mm. The entire sensor network's bandwidth ranges from 3 GHz to 7.5 GHz and 30 MHz was the frequency between the antennas.[24]

Result and Discussion

This paragraph discusses the suggested flexible patch antenna and the use of formulas in design. Figure 1 represents the flexible patch antenna designed in this study. The structural dimensions and flexible patch antenna using CST software are depicted in Table 1.

We were successful in developing an ISM band-capable patch antenna. These implanted antennas were constructed using superfluous components to increase their functionality.

Each detection technique was tested using these four parameters:-

1) Sensitivity= $\frac{\text{Malignant tumors detected}}{\text{Total number of patients with malignant tumor}}$

2) Specificity= $\frac{\text{Patients having benign tumors}}{\text{Total numbers of patients with benign tumors}}$

3) Positive Predictive= $\frac{\text{Number of patients correctly diagnosed to have malignant tumors}}{\text{Total numbers of positive diagnosis}}$

4) Accuracy= $\frac{\text{Number of patients correctly diagnosed}}{\text{Total number of patients}}$

The schematic illustration of the flexible patch antenna being proposed with its dimensions is shown in Figure 1. The abbreviation of the dimensions with its description is shown in Table 1.

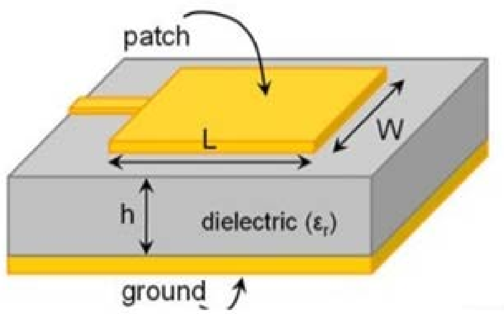


Figure1. Flexible patch antenna

To develop the suggested flexible Patch antenna, every formula is employed.

Step: 1 Width of the antenna patch (W) from the following equation (1).

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

Step: 2 To determine the effective length (L_{eff}), we must first calculate the Effective Dielectric Constant (ε_{eff}) from Equation (3) and plug it into Equation (2).

$$L_{eff} = \frac{C}{2f_0\sqrt{\epsilon_{eff}}} \quad (2)$$

Deciding on the Best Dielectric

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} + (1+12\frac{h}{w})^{-1/2} \quad (3)$$

Step :3 As shown below, the fringing length (L) is calculated. eq.

$$\Delta L = 0.412\frac{(\varepsilon_{eff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{w}{h}-0.8)} \quad (4)$$

Step:4 Length of the path in reality (L)

$$L = L_{eff} - 2\Delta L \quad (5)$$

Calculating the Length of the Inset from eq. (6)

$$F_i = \frac{6h_s}{2} \quad (6)$$

Where,

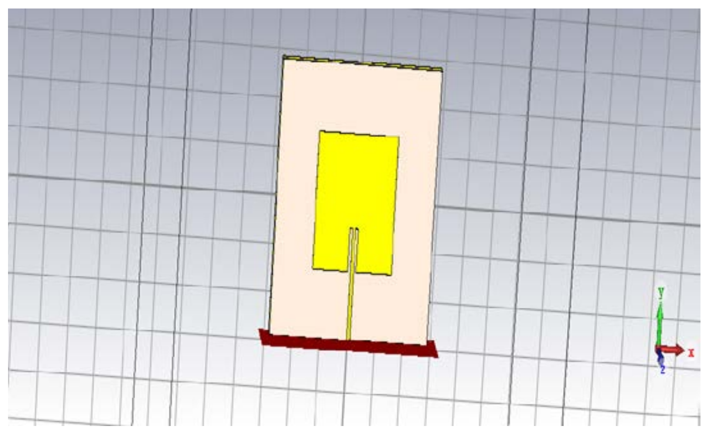
w The area covered by the patch

h Thickness of the substrate

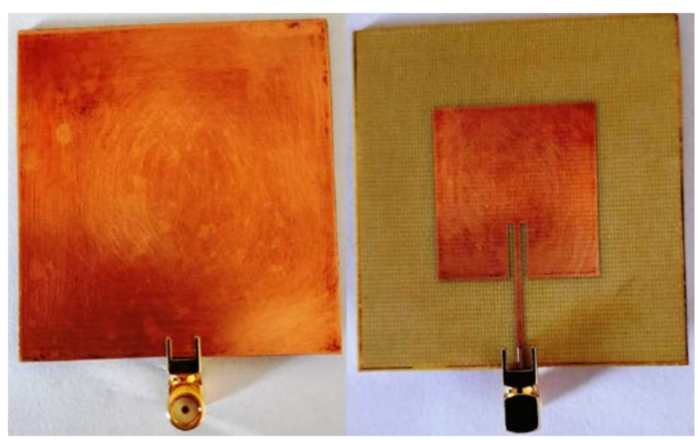
f_0 Resonance frequency f_0= 2.45 GHz

ε_r permittivity relative.

c = 3×10^8 $^m/_s$



Simulated Antenna



Hardware Antenna Structure

Figure 2. A proposed antenna's dimension representation and hardware antenna structure

The simulation results for the flexible patch antenna were modeled through CST software. utilizing the CST software instrument, which is used to simulate the simulation process for developing different antenna types, this program produces outcomes automatically. Directivity, gain, return loss, bandwidth, and VSVR are important properties. This suggested flexible patch antenna is printed on a denim substrate with a 0.035 mm thickness. The substrate's (substrate εr =4.7) dielectric permittivity is utilized in this antenna's design. The simulated directivity of a flexible patch antenna is shown in Figure 3 (D), as can be seen from the graph. In comparison to the previous finding, directivity (D)= 6.36 dBi was high.

The Figure 4 displays Gain (dB). We simulated and tested the needed constructed antenna throughout a range of frequencies, and for all corresponding results, we were able to get a 3.4 dB maximum gain. This demonstrates that the design and the simulated antenna have minimal power use as a result of the high gain. Return Loss (S_{11}) Figure 5 represents the return loss within the frequency spectrum of the ISM (Industrial, Scientific, and Medical) band of the versatile patch antenna that is appropriate for finding breast cancer. Bandwidth B= 58.8 MHz shows the same figure.

Figure 6 depicts a simulated flexible patch antenna's voltage standing wave ratio (VSWR), which has a value of 1.1889728.

Table 1. Dimensions and design criteria for the proposed antenna

Parameters	Dimensions (mm)
The area covered by the patch (w)	28.45
Patch size (L)	28.45
Patch length (Fi)	7
Width of the patch feed line (w_f)	1.157
Feed not needed for feed (Gpf)	1
Substance and field size (Lg)	2*L
Surface and field size (wg)	2*w
Height of the dielectric substrate (hs)	1.6
The adaptability of the substrate, in general(ε_r)	4.7

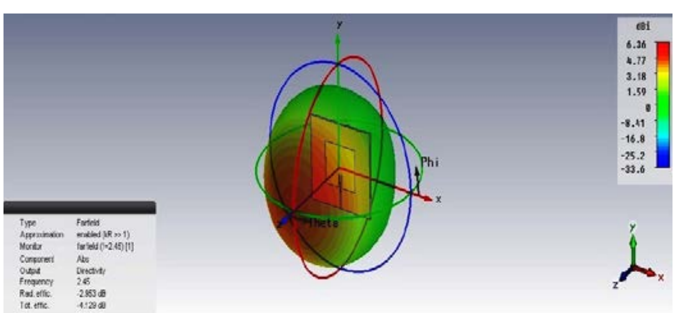


Figure 3. Directivity (D) = 6.36 dBi

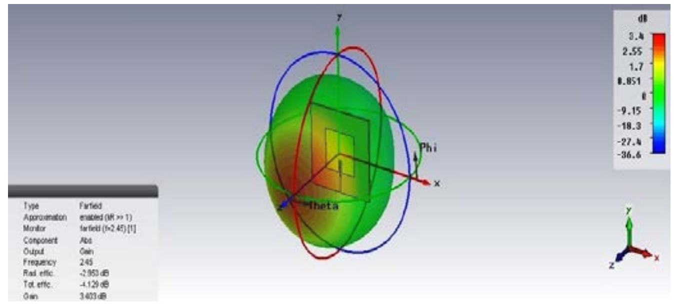


Figure 4. Gain (G) =3.4 dB

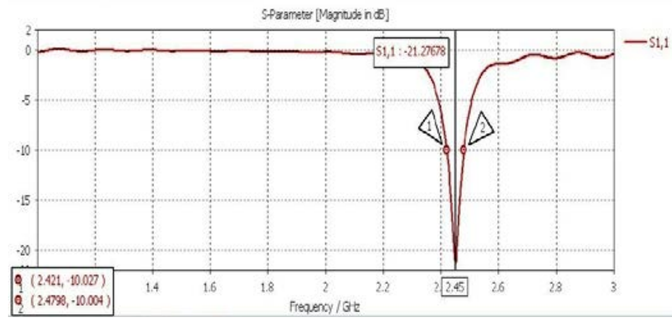


Figure 5. Return loss($S_{1,1}$) =-21.27678 dB, Bandwidth (B) = 2.4%

The Bandwidth can be calculated as below eq.

$$B = \frac{(f_H - f_L)}{f_C} \times 100\%$$

$$B = (f_H - f_L) \ \ Hz$$

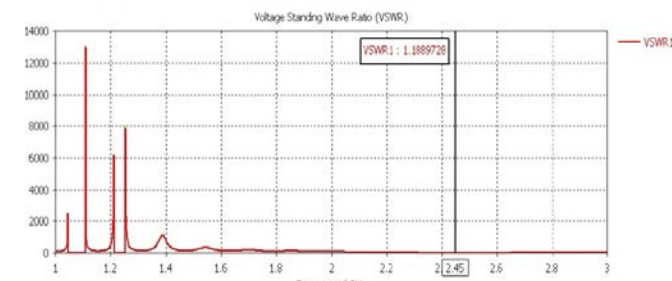


Figure 6. VSWR(S) =1.1889728

Table 2. Comparisons between various antenna design parameters

Parameters	**Previous Results**	**Current Results**	**Advantage**
Size	53 mm ×46 mm ×1 mm	28.45 mm ×28.45 mm ×1.6 mm	Decreases
Cost	More	Less	Decreases
Gain(dB)	3	3.4	Increase
Directivity(dB)	Not mention	6.36	Good
VSWR	Less than 2	Less than 2	Good
Return loss ($S_{1,1}$)	Less than -10 dB	Less than -10 dB	Good

Conclusions

This work designs and implements a flexible patch antenna for inexpensive jeans fabric wearable antenna that can be utilized for breast cancer detection at an earlier stage. We can infer from the research and simulated results that the designed antenna has numerous benefits in terms of inexpensive price, small size, and excellent effectiveness. The developed antenna can be used with sensors and equipment in biomedical applications to monitor illness and healthcare quality by transmitting data collected by sensors to target devices to detect trends and forecast the severity of diseases or problems. When an antenna is constructed, it's also made sure that the materials used won't harm the host's body in any way.

Conflict of Interest

Authors declare that there is no financial constrain or conflict of interest for publication of this work.

References

1. 1. B.S. Chhikara, K. Parang. Global Cancer Statistics 2022: the trends projection analysis. *Chem. Biol. Lett.* **2023**, 10 (1), 451.
2. P. Mittal, S. Singh, A. Singh, I.K. Singh. Current advances in drug delivery systems for treatment of Triple negative breast cancer (TNBC). *Chem. Biol. Lett.* **2020**, 7 (1), 1–12.
3. S. Markkandan, C. Malarvizhi, L. Raja, J. Kalloor, J. Karthi, R. Atla. Highly compact sized circular microstrip patch antenna with partial ground for biomedical applications. *Materials Today: Proceedings*, **2021**, 47, 318-320.
4. N.K. Nikolova. Microwave imaging for breast cancer. *IEEE Microw. Mag.* **2011**, 12 (7), 78–94.
5. A.M. Hassan, M. El-Shenawee. Review of electromagnetic techniques for breast cancer detection. *IEEE Rev. Biomed. Eng.* **2011**, 4, 103–118.
6. D. Srinivasan, M. Gopalakrishnan. Breast Cancer Detection Using Adaptable Textile Antenna Design. *J. Med. Syst.* **2019**, 43 (6).
7. V. Selvaraj, P. Srinivasan. Interaction of an EM wave with the breast tissue in a microwave imaging technique using an ultra-wideband antenna. *Biomed. Res.* **2017**, 28 (3), 1025–1030.
8. I. Amdaouch, O. Aghzout, A. Naghar, A. V. Alejos, F. Falcone. Breast tumor detection system based on a compact UWB antenna design. *Prog. Electromagn. Res. M* **2018**, 64, 123–133.
9. H. Bahramiabarghouei, E. Porter, A. Santorelli, et al. Flexible 16 antenna array for microwave breast cancer detection. *IEEE Trans. Biomed. Eng.* **2015**, 62 (10), 2516–2525.
10. A.B. Muhajr, J.F. Mahdi, M.A. Khadhim. Design of Ultra-Wideband MIMO Antenna for Breast Tumor Detection. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, 881 (1).
11. A. Kaabal, M. El halaoui, S. Ahyoud, A. Asselman. Dual band-notched WIMAX/WLAN of a compact ultrawideband antenna with spectral and time domains analysis for breast cancer detection. *Prog. Electromagn. Res. C* **2016**, 65, 163–173.
12. V. Selvaraj, P. Srinivasan. Interaction of an EM wave with the breast tissue in a microwave imaging technique using an ultra-wideband antenna. *Biomed. Res.* **2017**, 28 (3), 1025–1030.
13. J.M.S. Asha, K.M. Kumar. Design and analysis of microstrip patch antenna for lung tumor. *Int. Res. J. Engin. Technol.* **2017**, 4(4), 3330-3334.
14. S. Shrestha, M. Agarwal, P. Ghane, K. Varahramyan. Flexible Microstrip Antenna for Skin Contact Application. *Int. J. Antennas Propag.* **2012**, 2012, 1–5.
15. Z. Katbay, S. Sadek, R. Lababidi, A. Perennec, M. Le Roy. Miniature antenna for breast tumor detection. In *Conference Proceedings - 13th IEEE International NEW Circuits and Systems Conference, NEWCAS 2015*; **2015**; pp 978–1– 4799–8893–8.
16. J.D. Allin, S. Gopika, S.M. Sobiya, K.R. Manusa. Breast Cancer Detection Using Patch Antenna. *2nd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation, ICAECA 2023*. 2023.
17. J.J. Susila, H.R. Fathima. A Slot Loaded Rectangular Microstrip Patch Antenna for Breast Cancer Detection. *Int. Res. J. Eng. Technol.* **2017**, 4 (4), 3394–3397.
18. ,et al. Breast Cancer Detection by T-Shaped Slotted Planner Antenna. *Indian J. Sci. Technol.* **2017**, 10 (8), 1–7.
19. S. AlHabsi, T. ARuzaiqi, K. AlHadharami. Development of Antenna for Microwave Imaging Systems for Breast Cancer Detection. *J. Mol. Imaging Dyn.* **2016**, 06 (02), 2155–9937.
20. N. Hammouch, H. Ammor. Smart UWB antenna for early breast cancer detection. *ARPN J. Eng. Appl. Sci.* **2018**, 13 (11), 3803–3808.
21. M.A. Ullah, T. Alam, M.S. Alam, S. Kibria, M.T. Islam. A unidirectional 3D antenna for biomedical microwave imaging based detection of abnormality in human body; *Microsystem Technologies*, **2018,** 24, 4991-4996.
22. Z.D. Taylor, R.S. Singh, D.B. Bennett, et al. THz medical imaging: In vivo hydration sensing. *IEEE Trans. Terahertz Sci. Technol.* **2011**, 1 (1), 201–219.
23. A. Rahman, M.T. Islam, M.J. Singh, S. Kibria, M. Akhtaruzzaman. Electromagnetic Performances Analysis of an Ultra-wideband and Flexible Material Antenna in Microwave Breast Imaging: To Implement A Wearable Medical Bra. *Sci. Rep.* **2016**, 6, 978–1–5090–6005–4.
24. F. Foroutan, N.K. Nikolova. Active sensor for microwave tissue imaging with bias-switched arrays. *Sensors (Switzerland)* **2018**, 18 (5), 1447.