Journal of Medical Systems (2019) 43: 177
https://doi.org/10.1007/s10916-019-1314-5

PATIENT FACING SYSTEMS

Breast Cancer Detection Using Adaptable Textile Antenna Design

Dhamodharan Srinivasan[1] · **Mohanbabu Gopalakrishnan**[1]

Received: 8 March 2019 / Accepted: 25 April 2019 / Published online: 9 May 2019

Abstract

In the field of medicinal applications, early / (Timely) detection of Breast cancer is a key diagnosing process which provides effective medical treatment and also reduces women mortality. Due to the advancement and growth of medical sciences, efficient antennas are needed for imaging, diagnosing and providing superior treatment to the patients. Since tumor is tiny in size at the early stage, the knowledge of its precise location is chiefly required. For this purpose several antennas with high accuracy are designed. Among them, Flexible antenna has several advantages compared to other antennas. The main advantage of flexible antenna is its simple construction, high gain and cost-efficiency. The proposed research work implements a novel flexible antenna for detection of early breast cancer, with and without tumor application. In the study, (for the sake of comprehensive analysis and accuracy / familiarity / simplicity), Jean material is used as dielectric substrate with dielectric constant 1.7. The flexible antennas are designed with a slot loaded over the patch and with ground plane that are made up of copper as the conducting material. The jeans cloth material with 1 mm thickness is considered as a substrate, which is to be placed on the breast surface. Co-axial feeding method is chosen for the proposed antenna which improves the antenna performance. In addition to this, the antenna is a wearable textile type designed for ISM (Industrial, Scientific and Medical) band 2.4 GHz applications. The antenna is simulated using HFSS (High Frequency Structure Spectrum) software. From the simulation analysis, Return loss (S_{11}), Gain in dB, Radiation pattern, axial ratio (AR) and VSWR are obtained and analyzed. Finally, the simulation results are compared with the existing methodologies.

Keywords Flexible antenna · Breast cancer detection · ISM band · Jeans material · HFSS software

Introduction

Breast cancer is an invasive disease which develops / originates from rapid growth of breast tissues, and is one of the crucial health problems to women in today's modern world. Globally, it is prone to spread in a fast manner, accounting for 25% of all cases. The lump is different from normal breast tissue and it is an important symptom of cancer occurrence. In most of the cases women can feel such lumps by themselves. The World Health Organization (WHO) has reported most of women deaths are caused due to severity of the breast cancer. To reduce and wind up this problem, the proposed work has identified early detection as the most significant factor to improve the survival rate. Incidentally, this factor drives fast an urge to explore trustworthy, comfortable and highly efficient technical tools for early detection of breast cancer with and without tumor.

Conventionally, X-ray mammography is a common technique which is employed for effective screening modality and detection of breast cancer at an earlier stage. While fulfilling the purpose, this technique lacks with the following limitations / constraints:

- It has difficulty in the detection of breast cancer at earlier stage.
- The performance efficiency is not up to the mark in case of women with dense breasts.
- It faces hindrance in the detection of tumor which is located near the chest wall or the underarm.
- It is possible to destroy healthy tissue when using ionizing X-ray process.
- Cost wise this is an expensive process.

This article is part of the Topical Collection on *Patient Facing Systems*

✉ Dhamodharan Srinivasan
dhamu20@gmail.com

[1] Department of ECE, SSM Institute of Engineering and Technology, Dindigul, India

For bio-medical applications, microwave imaging technique has a significant presence and has potential information about physiological and anatomical structure of human tissues. This system allows non-destructive tissues owing to non-ionizing nature of microwaves. The successful imaging system can effectively avoid mechanical issues of scanning antenna. Multivariate data, which contains information about breast tissues, provide clear idea in subsequent stages of treatment by doctors. This multivariate information is collected from position of scanning antenna which changes from time to time. But, it is practically difficult during the time of surgery. In recent years, breast self-examination programs are introduced for detection of cancer at its earlier stage. Because, cancer is caused at any time irrespective of the patient's age. Moreover, most of the women have a fear over the cancer treatment process. Many of the medical researchers involve in motivating women to be aware of the breast cancer and, provide them with counseling guidance for prevention of breast cancer.

Antenna is a significant technical evolution tool which is applied in many practical applications including medical implants, microwave imaging, hyperthermia treatments and wireless monitoring applications. The primary objective of recent antenna research is developing a compact antenna with miniature size. But, the above mentioned medical applications are still using bulky antenna system which reduces the antenna's actual efficiency and applicability of high potential applications. The early detection of breast tumors without using any harmful radiations method was an attractive one in the past decades.

There are several kinds of antennas algorithms and techniques developed by expert researchers. However, each method has its own advantages and disadvantages and few are confined to certain applications. Recent growth in medical field requires flexible antenna for providing better treatment for patients without any risk during surgery. Flexible antenna or body-worn antennas are unlike the other techniques which make the possibility of concealing the methodology that often frightens patients while discreetly furnishing additional support. In addition, unobserved monitoring systems are necessary in the involuntary treatment and dementia care, where the patients may disconnect suspicious equipment devices.

In welfare industry, wearable sensors are available being helpful in providing on-body sensing with unnoticeable information. The lack of personnel nursing homes is a crucial problem while giving treatment to old patients instantly. In this situation, instead of human tangency, improved technological equipment will help and take care of certain monitoring responsibilities. Thus, equipment monitoring system saves time of the physicians for providing better treatment further. In order to provide better assistance, technology must be improved which can create a feeling of security, sensing of breathing, body temperature, sleep or body limb movement. Also, regular actions, for instance, can help in spontaneous welfare monitoring. The sensors could monitor certain exercises that are practiced but not too hard training is performed in the rehabilitation process.

The advanced development of antenna technology urges wireless communication technology in human life, particularly in the medical field. For example, wearable textile antenna is used for health welfare monitoring of vital signs of wearer like heart rate, temperature, respiration rate, military application, mobile communication, monitoring the actions of a flight pilot or a truck driver. Therefore, flexible wearable system requires integration of flexible antennas in order to give seamless wireless connectivity, operating in specific frequency bands. It is extremely demanded by today's information-oriented society.

During the past decade, smart fabrics or e-textiles were a growing field, especially for wearable system applications. The real-time use of flexible textile antennas was well suited as they could integrate into clothing, depending upon material characteristics. Hence, the indispensable need of wearable antenna was designed using flexible conductive material both in patch and ground plane, and flexible dielectric materials. The proposed research work is carried out by designing the flexible low-cost antenna for breast cancer detection at its earlier curable stage. The proposed antenna employs relevant applications so that it can detect early breast cancer with tumor and without tumor. Here wearable jeans material is utilized as a dielectric substrate with dielectric constant of value 1.7. The flexible antenna is designed in the form of a sandwich model, with slot loaded over patch and with ground plane that are made up of copper as conducting material. Jeans cloth material of 1 mm thickness is used as a substrate. Co-axial probe feeding method is used as a feeding for the antenna, which is also like a wearable textile antenna, designed for an ISM (Industrial, Scientific and Medical) band 2.4GHz applications. The experimentation is done in simulation environment by using HFSS (High Frequency Structure Simulator) antenna software tool. The performance of the proposed approach is analyzed in terms of antenna parameters such as Return loss (S_{11}), Gain in dB, Radiation pattern, axial ratio (AR) and VSWR. The advantage of using HFSS software is that it can automatically generate solution process for difficult problem since it uses an accurate mesh analysis.

The main considerations for wearable materials are small size, flexibility, robustness, and they require low power while providing comfort to the wearer. Moreover, an ISM (Industrial, Scientific and Medical) device does not need high power for transmitting signal to the receiver and also has longer battery life time. For designing flexible antennas, textile wearable materials are more attractive than others. The reason behind that is fabric antennas can be easily incorporated into the clothes material. An efficient high gain flexible antenna can be designed using cloth material fabrication by combining

ISM technology with textile technology. The flexible wearable antenna could be seamlessly integrated with jeans cloth material.

The remaining parts of this research work are organized as follows: In Section II, relevant papers and literatures related to the proposed work are analyzed and referred. These papers discuss the merits and demerits of several existing designed antennas. The proposed implementation is described in Section III. Experimentation prototype and results are discussed in Section IV. Section V is the conclusion part containing the summary of this research done.

Related works

In this section, recently publicized and relevant papers for the proposed work are discussed. Amadaouch [1] et al. had presented a high gain impedance matching antenna system with overall size of 35 mm × 20 mm × 1.6 mm based on Ultra-wide band (UWB) [2] for locating a tumor cancer. The proposed antenna (which antenna is referred here?) is characterized with 120% of ultra wide band and frequency range of 3–12 GHz for FCC band. The antenna system with dielectric properties of a human breast is used to identify strange objects. Subsequently, the size and location of tumor coordinates, corresponding to maximum value of SAR is found. The rectangular ring shaped UWB antenna is planar with compact design and its radiation pattern is appropriately placed in the target. Through the result, it is confirmed that maximum value of coordinates of SAR can be used for indicating / identifying the exact location of a tumor.

Bahrami [3] et al. designed a single and dual polarization antenna system which takes inhomogeneous multi-layer model of human breast for wireless UWB. The designed flexible antenna is operating in 2–4 GHz with reflection coefficient below −10 dB. The proposed miniaturized antenna has the size of 20 mm × 20 mm with two flexible conformal 4 × 4 UWB antenna arrays. Further, single and dual polarization is used for radar based breast cancer detection. Miniature antenna is mainly in contact with biological tissues having different polarization due to its electrical characteristics of biological tissues. These two arrays of antenna permit to transmit maximum power for wearable flexible applications.

Liting Wang [4] et al. had implemented a UWB MIMO antenna that can cover frequency range from 2.3 GHz to 12.2 GHz and also has a high resolution. The spacing between two antennas is zero, which indicates that grounds of antenna are common being connected in central point. Thus, results in getting a coupling loss below −15 dB.

Kaabal [5] et al. developed a new antenna which has polygon printed with low dielectric FR4 substrate, fed by 50 Ω feed line and partial ground plane in another side. In addition, designed compact antenna has UWB with global interoperability for microwave access and WLAN with dual band notched characteristics. The ring slot and EBG (Electromagnetic Band Gap) structure is added in antenna which improves the antenna performance. It has superior pulse preserving capability with reduction of group delay less than 1 ns. The error associated with antenna is reduced due to its small size of 28 × 20 mm^2. Among the several methods available to detect breast cancer, microwave imaging technique is safer than X-ray.

Microwave imaging system is an (innovative / flexible / alternative /) approach for detection of breast cancer tissue using EM (Electro Magnetic) signal. The radio frequency interaction between EM signal and breast tissue has been highly significant and remarkable. Selvaraj [6] et al. had proposed a study of effect of EM wave interaction between transmitting device and the breast tissue. The antenna has wide bandwidth of 4.284–13.628 GHz. The power absorbed and SAR (Specific Absorption Rate) with an average mass of 1 g and 10 g is presented at different frequencies, sizes and distance of tumor. Thus, the result confirms that with an increase in power absorbed and SAR value the frequency and size of the tumor is also increased. Yet, the power absorbed and SAR value can be decreased by changing the distance between transmitting device and breast. The SAR of 1 g mass tissue can be used effectively to detect the exact location of tumor in breast tissue. Taylor [7] et al. discusses the topic of image generation technology with pixel acquisition time.

Cancer is a vulnerable health disease compared to various kinds of disease. Lung cancer is the leading cause of all cancers. Sushmita Asha [8] et al. investigated design and analysis of Microstrip patch antenna for Lung tumor. The proposed system? comprises a microstrip patch antenna modeled on Computer simulation technology (CST). The detection of Lung cancer can be done by analyzing current density of lung with and without tumor. Under this system, the frequent variation in current density, E-field and H-field are measured. Shrestha [9] et al. suggested a flexible microstrip antenna for breast cancer imaging, diagnosing and furnishing proper treatment. The designed antenna is placed on a human body which is in direct contact with the skin. Approximately, microstrip antenna has 0.25 mm thickness, 32 mm × 31 mm dimension with the frequency range of 2.45 GHz. The analytical experimental results use skin phantoms and compared with other existing techniques. Katbay [10] et al. suggest a miniaturized microstrip antenna for breast tumor detection in order to quantify the imaging of inhomogeneous tissues. The microstrip antenna is placed in contact with the breast model which investigates the presence of malignant tissue.

In practice, there are several kinds of antenna namely circular patch antenna, t-shaped antenna, t-slotted antenna, microstrip antenna, slotted rectangular antenna and so on that are designed and used for suitable applications.

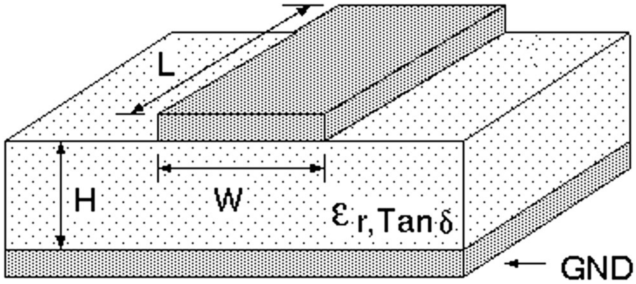

Fig. 1 Proposed flexible wearable textile antenna for breast cancer detection

Vidyasree [11] et al. recommend a new method which uses several kinds of microstrip antennas such as circular microstrip patch antenna using FR-4 substrate, slot antenna, rectangular patch antenna, hemispherical antenna array, Pentagonal patch antenna at different frequencies in order to detect breast cancer efficiently.

Susila [12] et al. present a slot loaded rectangular microstrip patch antenna which is implemented using cost effective RT rogers 5880 lossy substrate. It comprises horizontal narrow slots with radiating element and a ground plane. The antenna is simulated separately using breast phantom with and without tumor and variations are measured. The proposed antenna performance is evaluated both in E-field (25,167 V/m) and H-field (129 A/m). Gupta [13] et al. introduced a planar antenna for detection of tumor by measuring current density. The antenna is designed by T shaped Rectangular Microstrip patch antenna (RMPA) for ISM band 2.45 GHz. At each resonant frequency, antenna is simulated simultaneously confirming attainment of very low loss at the frequency of 32.2 dB. Current density and SAR model are evaluated which is 1288A/m2 and 3.10*105 respectively.

Among various microstrip patch antennas and fractal antennas, Al Habsi [14] et al. proposed a new microstrip-fed Vivaldi antenna having more advantages than other antenna methodology. It is quite easy to fabricate, design and simulate when compared with other methods. The proposed approach is also used to measure antenna crucial parameters such as impedance matching of antenna, radiation property, gain, return loss, VSWR and other characteristics. Hammouch [15] et al. proposed a smart UWB antenna system for bio-medical applications, particularly for breast cancer detection. The antenna is designed with specifications of FR-4 substrate with thickness of 1.58 mm and permittivity of 4.3 in an operating frequency of 2.96–10.68 GHz. Finally, all simulation numerical values are compared with two different electromagnetic solvers.

Amanath Ullah [16] et al. had presented an optimal and designing process of 3D antenna in context with affordability to provide primary health observation without any health risk. The proposed three dimensional antenna used folded radiating structure for clinical diagnosing purpose. The antenna operated at the frequency of 1.67–1.74 GHz and radiating structure of $40 \times 25 \times 10.5$ mm^3 with the gain of 5.2 dB. Here, two types of prototype antenna structure were utilized for the detection of malignant tumor in breast phantom model. The entire process was done by applying feasible signal processing technique. Singh [17] et al. had proposed a novel compact dual-band textile printed slot antenna with partial ground plane, in which substrate was taken from jeans fabric material whereas patch and ground plane were made from copper tape material.

The antenna typically attained bandwidth efficiency up to 46% (i.e) 3.01–5.30 GHz and had a high gain of 5.7 dB. Finally, the comparison was done with other existing fabricated prototype. The designed antenna is applicable for WiMAX, WLAN and X-band with corresponding frequency range of 3.85 GHz, 5.35 GHz and 12 GHz respectively. Rahman [18] et al. had introduced an improved Microwave imaging technique using a compact UWB antenna with an array of sixteen antennas. The proposed Bi-static radar based imaging system comprised two omni-directional antenna which minimized the antenna size and the computational complexity. The size of antenna was 20×14 mm^2 at operating frequency range of 4 to 6 GHz. This research involved development of a wearable antenna, 'one time use clinical bra', which detected unwanted growth inside the breast at early stage. Moreover, the method handled biodegradable organic material as research materials which normally do not cause any environmental pollution. Due to the advantages of flexible nature of antenna it is easy to insert inside the bra. Through practical experimentation, it was ensured that the proposed system could attain efficiency above 70%. Foroutan [19] et al. had suggested a new methodology, active sensor for the measurement of array antenna based microwave tissue imaging system. The sensor integrated a printed slot antenna, low noise amplifier (LNA) and active mixer, inter sensor separation distance between antenna is 12 mm. The overall sensor system had a bandwidth of 3GHz to 7.5 GHz. The intermediate frequency between the antennas was 30 MHz. In addition, the sensor could be controlled by bias-switching circuit.

Alternatively, Microwave sensors-based breast cancer detection was proposed in the paper [20]. Generally, the

Table 1 Design parameters and dimensions of the proposed antenna

Parameters	Symbol	Dimensions
Relative permittivity of the substrate	ε_r	1.7
Thickness of the dielectric substrate	h	1 mm
Length of the patch	L	46 mm
Width of the patch	W	53 mm
Length of the substrate and ground	Lg	80 mm
width of the substrate and ground	Wg	80 mm
Feed location	(x_0, y_0)	(1,7)

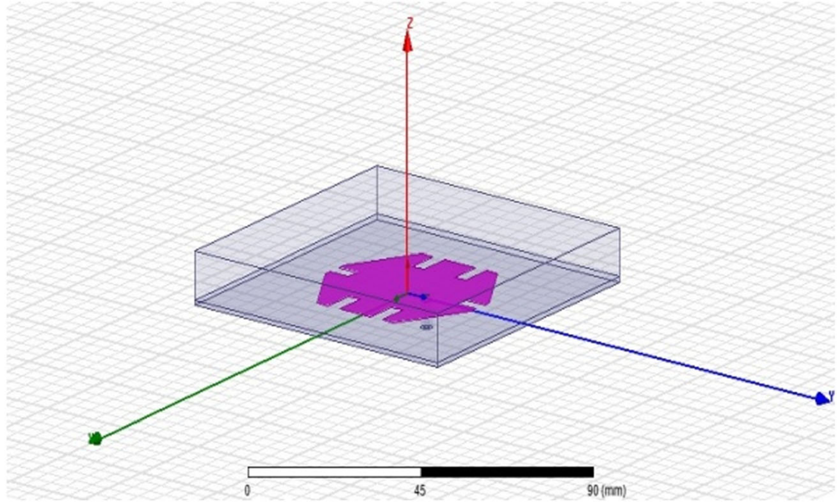

Fig. 2 Designed antenna using ANSYS HFSS software tool

performance of Microwave imaging approach depends on how quality information is contained within scattering data. Owen Mays [21] et al. had applied TSVD (Truncated Singular Value Decomposition) technique that evaluated information in a scattering scenario simultaneously. And compact, shielded array of miniaturized patch antennas are anatomically diagnosed using the numerical breast phantom. The simulation result analyzed that the mixed polarization configuration improved the information quality when compared to the uniform polarization configurations. In the paper [22] et al. had proposed a novel antenna array design that effectively detected the breast cancer at risk-free curable stage.

Other than microwave imaging technique, radiometry, a non-invasive and sensitive method, otherwise called as microwave thermography, helps to find out cancer detection at its curable stage. D Srinivasan [23] et al. compared various antenna and their parameters used for early detection of breast cancer.

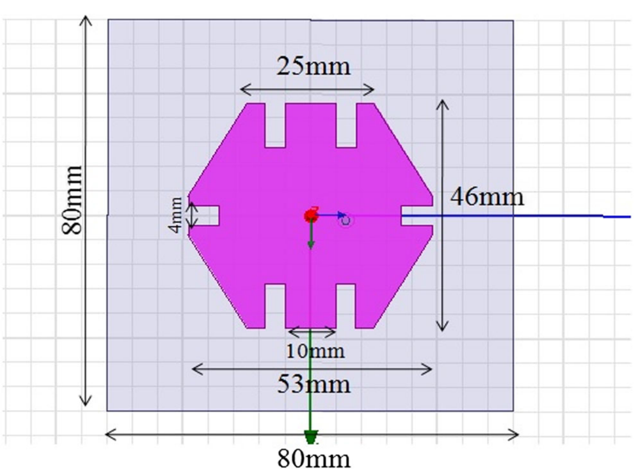

Fig. 3 Dimension representation of proposed textile wearable antenna

Motivation and problem formulation

Globally, breast cancer is one of the major invasive health problems for women and percentage of death has been increasing year by year. Several algorithms and techniques are developed in order to reduce the death rate. The effectiveness of breast self examination can reduce women mortality. Several programs are being conducted and information is provided to women on practicing breast self examination test. Breast cancer is a widespread kind of tumor diagnosed in women world-wide. Hence, it is essential to detect it in curable stage as early as possible. Unfortunately, it is a paramount cause of cancer death in women. Therefore identification and prevention is an indispensable task. The monitoring of breast cancer is actually getting medical information of asymptomatic and apparently healthy women for cancer in an attempt to achieve at earlier stage. Another reason for cancer occurrence is uncontrollable growth and aging of population as well as prevalence of established risk factors like overweight, physical inactivity and environmental changes owing to urbanization and economic development. To control amount of death due to breast cancer, the proposed work implements low cost flexible antenna to detect breast cancer with and without tumor application. For antenna, wearable jeans material (1 mm thickness) is used as dielectric substrate with dielectric constant of 1.7. In this research work, antenna is designed like a sandwich model with slot loaded over patch and with ground plane, made of copper as conducting material. Co-axial feeding method has been adopted for antenna feeding. The designed antenna is also like a wearable textile antenna with ISM (Industrial, Scientific and Medical) band at 2.4 GHz applications. The proposed antenna can be simulated and implemented in both software and hardware. The simulation is done using HFSS (High Frequency Structure Spectrum) software and parameters such as S_{11} Return loss,

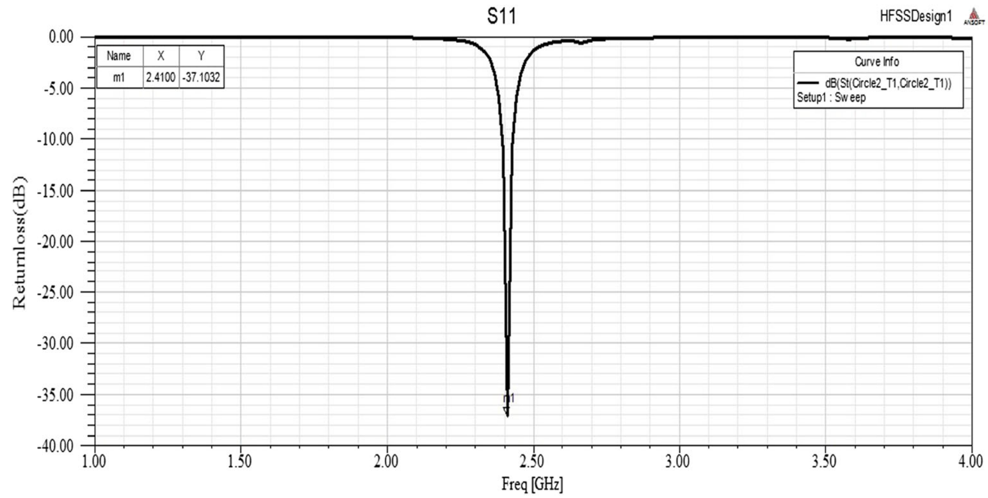

Fig. 4 Simulated return loss (S_{11}) versus frequency of antenna

Gain in dB, Radiation pattern, axial ratio (AR). Through the process / simulation VSWR are obtained as result.

Proposed implementation

In this section, the proposed flexible antenna designing process and implementation are explained in detail. Figure 1 below represents the proposed flexible textile antenna:

Antenna design and configuration

The proposed antenna is a thin hexagonal patch printed on a Jeans substrate having a thickness of h = 1 mm. The antenna design requires permittivity or dielectric of the substrate, length, width of the patch and ground plane. Of these, major role of the antenna is the permittivity of the substrate ε_r i.e., 1.7 for jeans cloth. The effective dielectric constant ε_{reff} of the antenna is calculated in two different cases depending on the ratio of patch width (w) and substrate thickness (h), either less than or greater than unity. The eqs. 1.a and 1.b represent these two cases:

Case: 1 If $\left(\frac{w}{h}\right) < 1$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{-1}{2}} = 1.66 \quad (1.a)$$

Case: 2 If $\left(\frac{w}{h}\right) > 1$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{-1}{2}} + 0.04\left(1 - \left(\frac{w}{h}\right)\right)^2 \quad (1.b)$$

where,

w represents width of the patch
h represents thickness of the substrate

The length and width of patch antenna is determined by using the following steps:

Step: 1.

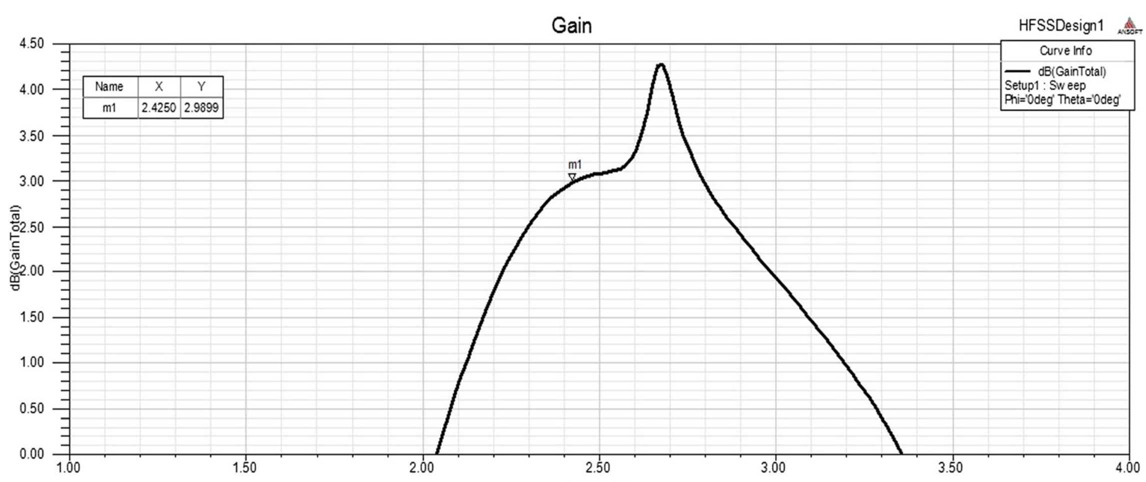

Fig. 5 Stimulated gain versus frequency of designed antenna in 2D

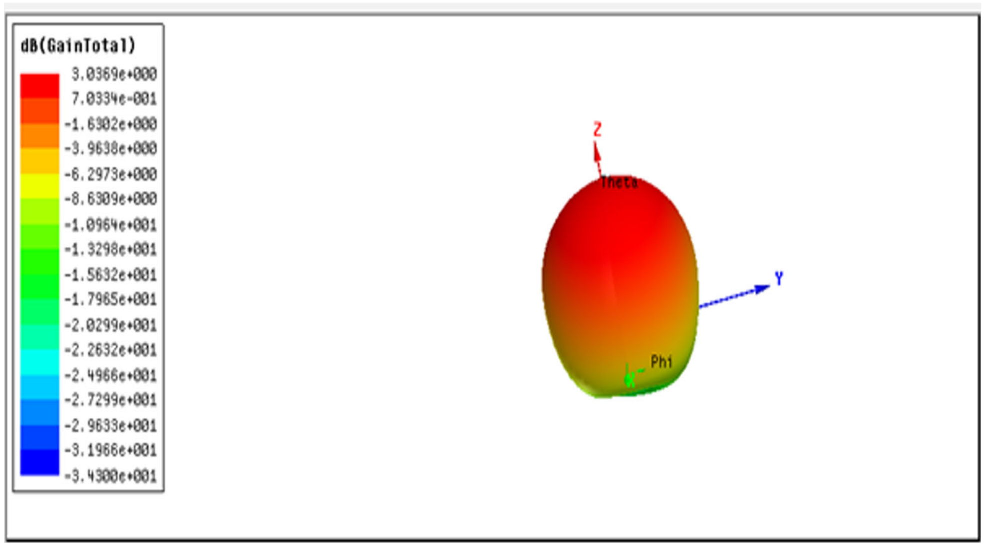

Fig. 6 Stimulated gain versus frequency of designed antenna in 3D

The width of antenna patch (w) can be calculated as

$$w = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}} = 53mm \tag{2}$$

Where.

c Velocity of EM wave ($3 * 10^8$ m/s)
f_0 Resonant frequency = 2.45 GHz
ε_r Relative permittivity of the jeans cloth.

Step: 2.

The effective dielectric constant (ε_{eff}) can be calculated from the eq. (1).

Step: 3.

The effective length (L_{eff}) is calculated as

$$L_{eff} = \frac{c}{sf_0\sqrt{\varepsilon_{eff}}} \tag{3}$$

Step: 4.

Antenna length extension (ΔL) is calculated as

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

Step: 5.

Then Length of patch

$$L_{eff} - 2\Delta L = 46\ mm \tag{5}$$

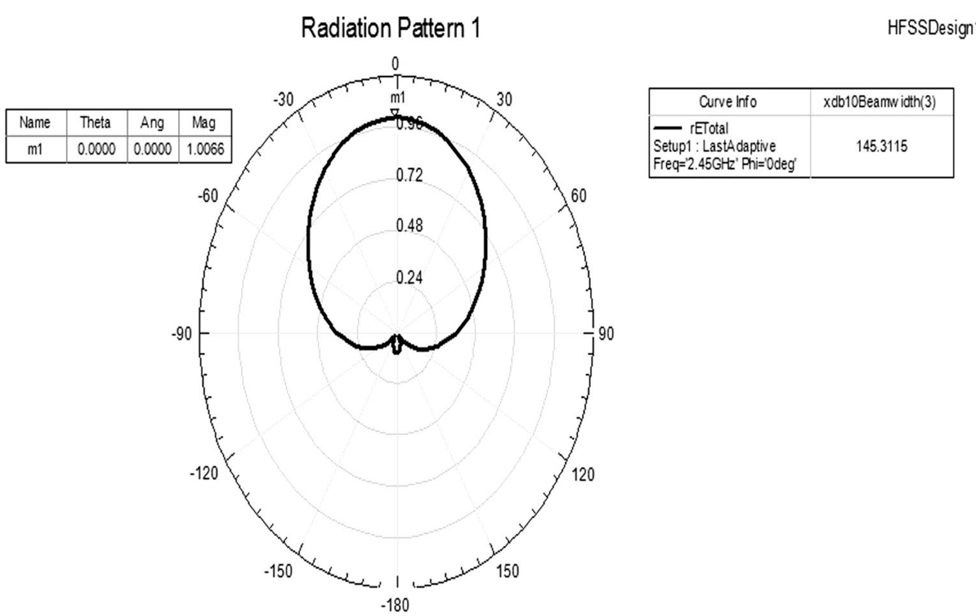

Fig. 7 Overall radiation pattern of proposed textile antenna

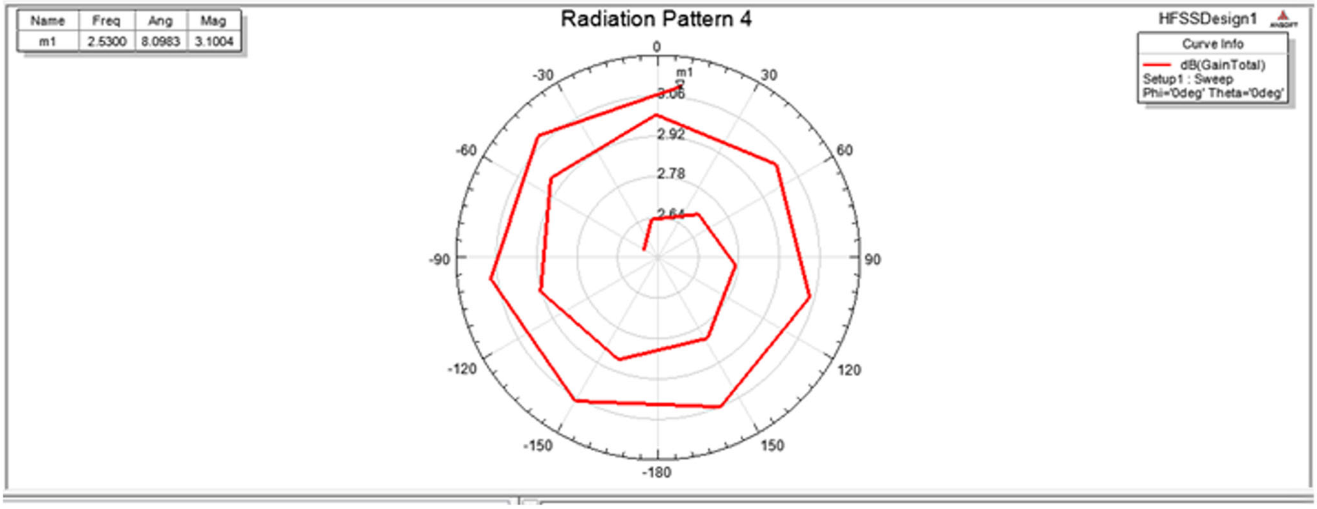

Fig. 8 Radiation pattern of proposed antenna in terms of gain

Table 1 shows the modeled antenna design specifications clearly.

The designed flexible textile antenna is fabricated on 40×40 mm^2 with jeans substrate material which looks like a sandwich model with slot loaded over patch and with ground plane. The co-axial feeding method has been followed at location of (1, 7) for antenna at ISM band operating frequency at 2.4 GHz. The jeans textile material is used as substrate and for conducting (patch and ground) part is fabricated by using copper conducting material. Jeans material is used as it has crucial characteristics like thickness, relative permittivity and using only 1 mm thickness. The realistic purpose of using jeans material is its convenience when it is incorporated into the clothing. The simulation experiment is accomplished in HFSS software. The height and width of substrate and ground designed to have equal dimension as 80 mm.

Experimental results and discussion

In this section, the performance results of the proposed antenna are analyzed through simulation by HFSS software whereas the real time hardware implementation will be discussed in future. The proposed antenna designed by using the ANSYS HFSS software is shown in fig. 2. HFSS tool is used for designing different types of antennas and also for designing RF electronic circuit elements like power dividers, couplers and filters. The geometrical design, its material properties and the desired output frequency are specified. For the given design, HFSS software automatically generates a solution process and accurate mesh analysis. Important parameters for the analysis namely return loss (S_{11}), gain, radiation pattern and VSWR are duly considered.

The figure above shows the geometric design of the flexible software antenna. The performance of the proposed antenna depends on the return loss$|S_{11}|$. More than $-35dB$ is

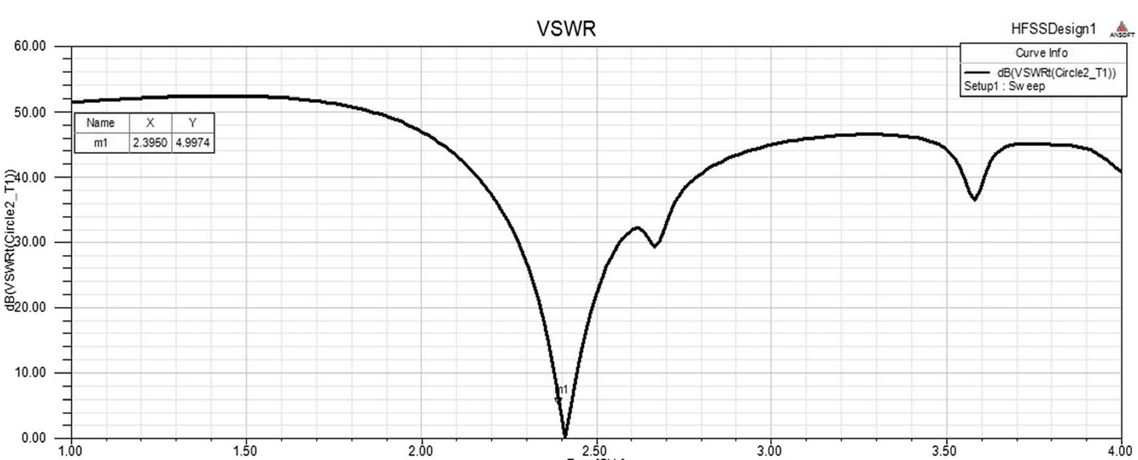

Fig. 9 Representation of voltage signal noise ratio (VSWR) of antenna

Fig. 10 Axial ratio

achieved and as the return loss of the antenna increases, performance of the antenna also increases. Figure 3 clearly illustrates the two dimensional representation of the proposed antenna.

Now, the antenna performances are discussed with their important parameters.

(i) Return loss (S_{11})

Figure 4 shows the simulated return loss of wearable textile antenna within ISM band frequency range. Through the simulation, it is shown that return loss (S_{11}) is attained with / at less than −35 dB.

(ii) Simulated Gain

The proposed designed antenna is tested by tuning different frequency ranges and corresponding gains are noted down. The maximum gain attained is near 3 dB. The simulation result shows that designed antenna has low power consumption due to large gain. Figure 5 shows the plot of gain versus frequency of the proposed wearable textile antenna. The gain of the antenna, measured in both two dimensional and three dimensional ways, are shown in fig. 5 and fig. 6 respectively.

(iii) Radiation Pattern:

Figure 7 shows that overall radiation pattern of designed antenna is measured at different frequencies. Through simulation it is shown that the radiation pattern of antenna is about 145.3115 dB which is somewhat perfect value for medical diagnosis. The proposed antenna has an Omni directional property which is necessary for patient's comfort. When a patient wears a textile antenna it can be adjusted in any orientation. Figure 8 shows radiation pattern of proposed antenna in terms of desired gain:

Moreover, antenna has voltage signal to noise ratio (VSWR) whose value is 1.029 shown by varying different frequencies in fig. 9.

The Axial ratio of antenna is represented in terms of XY plot which is given in fig. 10. The designed antenna has the value of axial ratio as 35 dB which can be measured at different frequencies which is clearly shown in the graph.

Conclusion

This research work is carried out for designing and implementing an innovative low cost textile wearable antenna for breast cancer detection at earlier stage. The designed antenna can be applied both at the earliest stage of detection of breast cancer with and without tumor applications. For this research work, wearable jeans material is used as dielectric substrate with dielectric constant value of 1.7. The antenna is a framework of sandwich model, with slot loaded over patch. The ground plane material is made up of copper as conducting material. The jeans cloth with 1 mm thickness is taken for breast cancer analysis whereas co-axial probe feeding method has been used as feed to the antenna. It is also like a wearable antenna, which is mainly designed for ISM (Industrial, Scientific and Medical) band 2.45 GHz applications. The performance of designed antenna is analyzed through ANSYS HFSS (High Frequency Structure Spectrum) software in terms of Return loss (S_{11}), Gain (dB), Radiation pattern, axial ratio (AR) and VSWR.

(Through the analysis of the results / The (simulation) results prove that the designed antenna has more advantages in terms of applications, cost and time.)

Compliance with Ethical Standards

Conflict of Interest This paper has not communicated anywhere till this moment, now only it is communicated to your esteemed journal for the publication with the knowledge of all co-authors.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Amdaouch, I., Aghzout, O., Naghar, A., Alejos, A. V., and Falcone, F., Breast tumor detection system based on a compact UWB antenna design. *IEEE Progress Electromagnet. Res. M.* 64:123–133, 2018.
2. Song, H., Kubota, S., Xiao, X. and Kikkawa, T., Design of UWB antennas for breast Cancer detection. IEEE, International Conference on Electromagnetic in Advanced Applications (ICEAA), 978–1–4673-9810-7, 2016.
3. Bahrami, H., Porter, E., Santorelli, A., Gosselin, B., Popovic, M. and Rusch, L.A., Flexible sixteen antenna Array for microwave breast Cancer detection. IEEE Transactions, 36th international conference of the IEEE engineering in medicine and biology Society, 1558–4615, 2014.
4. Wang, L. and Huang, B., Design of Ultra-WidebandMIMO antenna for breast tumor detection. Hindawi Publishing Corporation, International Journal of Antennas and Propagation, Article ID 180158, 2012.
5. Kaabal, A., El Halaoui, M., Ahyoud, S., and Asselman, A., Dual band-notched WIMAX/WLAN of a compact Ultrawideband antenna with spectral and time domains analysis for breast Cancer detection. *IEEE Progress Electromagnet. Res. C* 65:163–173, 2016.
6. Selvaraj, V., and Srinivasan, P., Interaction of an EM wave with the breast tissue in a microwave imaging technique using an ultra-wideband antenna. *Biomed. Res.* 28(3):1025–1030, 2017.
7. Taylor, Z. D., Singh, R. S., Bennett, D. B., Tewari, P., and Kealey, C. P., THz medical imaging: In vivo hydration sensing. Ieee Transactions on Terahertz Science and Technology 1(1), 2011.
8. Asha, J. M. S. and Kumar, K. M., Design and analysis of microstrip patch antenna for lung tumor. International Research Journal of Engineering and Technology (IRJET) 4, (4), 2017.
9. Shrestha, S., Agarwal, M., Ghane, P. and Varahramyan, K., FlexibleMicrostrip antenna for skin contact application. Hindawi Publishing Corporation, International Journal of Antennas and Propagation, Article ID 745426, 2012.
10. Katbay, Z., Sadek, S., Lababidi, R., Perennec, A. and Roy, M. L., Miniature antenna for breast tumor detection. IEEE 13th International New Circuits and Systems Conference, 978–1–4799-8893-8, 2015.
11. Vidyasree, K., Mannisha, M., Nagaveni, T. S., Nandhini, B. M. and Kumar, H. V., Breast cancer detection using microstrip patch antenna. International Journal of Advance Research, Ideas and Innovations in Technology 4(3), 2018.
12. Susila, J. J. and Fathima, H. R., A slot loaded rectangular microstrip patch antenna for breast Cancer detection. International Research Journal of Engineering and Technology (IRJET) 4(4), 2017.
13. Gupta, H. K., Sharma, R., and Thakre, V. V., Breast cancer detection by T-shaped slotted planner antenna. *Ind. J. Sci. Technol.* 10(8): 0974–6846, 2017.
14. Habsi, S. A., Ruzaiqi, T. A., Hadharami, K. A., and Gopinathan, S. T., Development of antenna for microwave imaging systems for breast cancer detection. *J. Molec. Imag. Dynam.* 6(2):2155–9937, 2016.
15. Hammouch, N. and Ammor, H., Smart Uwb antenna for early breast Cancer detection. ARPN Journal of Engineering and Applied Sciences 13(11), 2018.
16. Ullah, M. A., Alam, T., Aam, M. S., Kibria, S. and Islam, M. T., A unidirectional 3D antenna for biomedical microwave imaging based detection of abnormality in human body. Springer, 1–6, 2018.
17. Rahman, A., Isam, M. T., Singh, M. J., Kibria, S. and Akhtaruzzaman, M., Electromagnetic performances analysis of an ultra-wideband and flexible material antenna in microwave breast imaging: To implement a wearable medical bra. Research Gate, 978–1-5090-6005-4, 2017.
18. Foroutan, F., and Nikolova, N. K., Active sensor for microwave tissue imaging with bias-switched arrays. Journal of sensors 18(5), 2016.
19. Wang, L., Microwave sensors for breast Cancer detection. IEEE 18(2), 2018.
20. Mays, R. O., Behad, N. and Hagness, S. C., A TSVD analysis of the impact of polarization on microwave breast imaging using an enclosed Array of miniaturized patch antennas. IEEE Antennas And Wireless Propagation Letters 14, 2015.
21. Khan, M. A. and ul Haq, M. A., A novel antenna Array design for breast Cancer detection. IEEE Industrial Electronics and Applications Conference (IEACon), 978–1–5090-0926-8, 2016.
22. Afyf, A., Bellarbi, L., Riouch, F, Errachid, A. and Sennouni, M. A., Flexible antenna Array for early breast Cancer detection using radiometric technique. IEEE, International Journal Of Biology And Biomedical Engineering, Volume 10, 2016.
23. Srinivasan, D., Gopalakrishnan, M., and Srinivasan, D., A survey on antennas used for early detection of breast cancer. *Int. Conf. Energ. Commun. Data Anal. Soft Comput. (ICECDS), Chennai* 2017:1736–1739, 2017.