Implementation of The Novel MSP Dielectric Antenna Design on Effective Prediction of Breast Cancer

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Abstract: Breast cancer is a type of cancer which can be formed in the cells inside the breast. Early diagnosis of the breast cancer is still a hard method for the clinical experts. Several traditional techniques are there for the detection of the cancer but all of them are not an efficient one. By all those techniques early diagnosis of the cancer is somewhat a questionable one. So, search for an efficient technique for the process of the effective imaging is needed. Microwave imaging is a hopeful method for the early prediction of the tumor or the carcinoma. In this paper, a 3D breast structure having different permittivity and conductivity is arranged in HFSS by using the Adaptive Finite Element Method (AFEM) is needed to solve the electromagnetic field values and a micro strip patch antenna operating at 2.45 GHz is designed with the help of the substrate material, FR4 . Here, the patch geometry i.e. the design and the ground plane can be changed. The rectangular micro strip antenna structure is then investigated to provide microwave imaging with a view to diagnose breast cancer very earlier. Here, different antenna designs are evaluated by modifying the ground plane and slotting on the micro strip patch.

Index Terms: Adaptive Finite Element Method, Breast cancer, Breast model, Microwave imaging, Mutual Coupling, Radiation pattern, Rectangular micro strip patch antenna, Return Loss.

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1. INTRODUCTION

THE Microwave images are the mapping of the random distributions electrical range in the body. Various tissues and their electrical properties might be associated to the physiological behavior. The detection of Cancer with the microwave imaging depends on the differentiation in the corresponding electrical properties. The dielectric properties of the tissue in the region of the microwave depend on ion concentration, molecular constituents, and the concentration of the free water, consequent temperature and the mobility of the charges. The microwave imaging technique for detecting the breast cancer is the important variation in the dielectric properties of the breast tissues condition normal, benign and the malignant at the frequency of microwave. Additionally, reduction of microwave in normal condition is extremely low as much as necessary to create proliferation of the signal possible over the huge breast volume. Also microwave mechanism is simply a non-ionizing, non-invasive and eradicates the irritating breast tissue compression. The physical convenience and small size of the breast is related to the other internal organs which is a complementary advantage. The main aim is to apply this microwave technology for the purpose of the detection of the cancer.

Detection of breast cancer using Microwave:

The detection of early stage breast cancer will help the patients for the effective medication. But many of them move for the X-ray mammography. But it has a lot of side effects to the patients. Because, early diagnosis is not possible in X-ray mammography. This method can face the difficulty in imaging women with dense breasts which gives an unclear image. So the patients search for the different imaging techniques or else move on to the tissue biography. These X-ray mammography drawbacks can initiate the way clear for the motivation of the complementary development of breast imaging mechanism for the effective diagnosis and breast cancer recognition. The perfect selection tool is the one which has no side effects to the patients, cost efficient, easily available, sensitive to the cancer cells, simple and non-invasive to execute and also offer simple way to understand the cancer blockage. To detect the early minimal range of the cancer cells, a contrast of exposure between the normal, benign and the malignant tumor has to be done. At the microwave frequencies the ability and the sensitivity to distinguish minute tumors is the dielectric dissimilarity among the breast tissues malignant and normal. A breast tissue that is malignant shows the evidence of the increased amount of the water at ease on comparing with the usual tissues and therefore there is an increase in the dielectric constant value. There are three techniques of breast imaging using microwave. They are hybrid, active and passive methods.

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Passive Microwave imaging:

The theory of this function relies that the cancer tissue exposes high level of the temperature when compared to that of the normal tissue. Here, the radiometer is used for the detection of the difference in the temperature in the breast. Images display the temperature measured. During diagnosis, the actual breast size and the lesion formed on the breast size will be compared to express the severity of the disease.

Hybrid Microwave Imaging Hybrid approach:

In this technique also, microwaves can be used. Because of malignant breast tissue's high conductivity, excess energy gets accumulated in the tumors which lead to the discriminating lesions heating. The tumors will get expanded and the pressure waves are generated, which will be identified by the use of an instrument called ultrasound transducers. The two methods of image restoration is used here such as scanning thermo-acoustic tomography (SIT) and the computed thermo acoustic tomography (CIT).

Active Microwave Imaging

Two active microwave imaging classifications are deliberated in this. Confocal Microwave Technique (CMT) uses the method of backscatter to deduce the significant microwave scatters' location. The breast then gets enlighten in the highlighted area. The scattered waves tell about the range of the disease. The technique of MTI pose an inverse problem of scattering at which the breast is enlighten by using microwave transmitter, and the fields that are scattered are computed at a several locations, clearly express the shapes of the breast size and the lesion size.

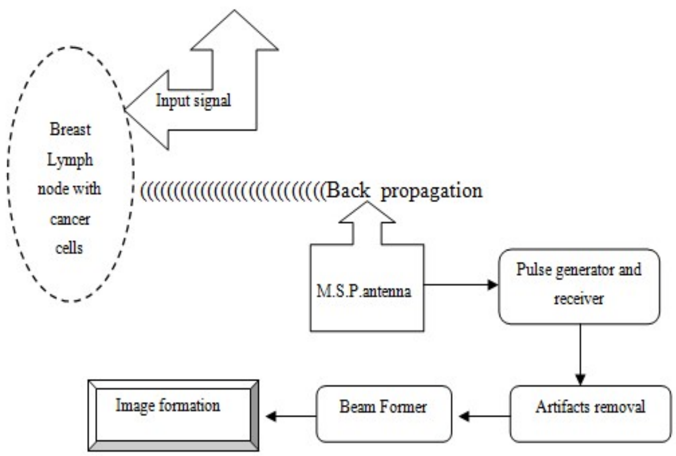

***Fig. 1**. Process of imaging in Micro strip Patch (MSP) antenna*

2 RELATED WORKS

Elham et al (2019) [1] proposed about the two time-reversal (TR) based algorithms performances which are decomposition of the time reversal operator and time-reversal multiple signal classification for the detection of breast cancer over UWB microwave image which assess their application. Wang et al (2018) [2] proposed about the microwave antenna of wideband for the purpose of health microwave breast imaging. A number of simulations were conducted for the validation of proposed antenna scheme. The outcomes reveal that the presented antenna scheme has some potential for the microwave imaging system application for the recognition of breast lesions. Ren et al (2018) [3] proposed about the FRET strategy with F19 fluorescence proteins for the effective identification of the tumor. Akinci et al (2019) [4] proposed about the use of the dissimilarity agents that increases the dielectric properties of malignant tissue in a selective manner. Conversely, both field measurements that were multi-static will be collected after and before the contrast agent administration. Afterwards, the Green's function of the breast that were homogeneous will be predictable through the back-propagation of the dielectric magnetic field and after that phantoms of breast could be obtained in the form of the 3D measurements. Akki et al (2019) [5] proposed about the modeling of Multi-physics to learn the cold stress and tissue compression influence on improving the detection of breast tumor with the use of microwave radiometry. Avsar et al (2019) [6] anticipated the breast model that were double layered with a globular swelling and were located in the layer of fibro-glandular was made with the utilization of software CST microwave studio. This will be embedded in the canola oil for declining the signals that were distorted among the receiving and transmitting antennas. Shere et al (2019) [7] proposed about the clinical study of multicentre for estimating the micrima radio wave capability in the breast imaging system. (MARIA®) which in turn helpful in the detection of lesions present in symptomatic breast. Hidayat et al (2019) [8] proposed about the THz imaging simulation which was performed by means of the micro strip linear antennas array for the detection of breast cancer. The transmitter as source and THz receiver waves which are alienated for a 4.5 mm distance. An entity, with the breast cancer, is modeled by the taking into account three tissue layers with special values of the conductivity and permittivity. Mukherjee et al (2019) [9] proposed about the thermal therapy applications which is established by scheming the rates of specific absorption which related with the electromagnetic fields that were time-reversed. The results of simulation can explicate the robustness and feasibility of this method. A time domain pulsed dimension scheme is urbanized for the conduction of research to measure and detect the heat fascinated by the multiple and single tumors in an uncomplicated phantom of breast. Lin et al (2019) [10] proposed about the strategy of a dipole antenna handheld for a compacted thermo acoustic system of imaging. Azeez et al (2019) [11] proposed about the Triband E-Shaped Wearable Dipole Antenna with Low SAR for the application of IoT. Kibria et al (2019) [12] proposed the microwave breast tumor detection system is iteratively presented by precise (CF-DAS) coherence factor delay and sum process. CF-DAS is a data independent one that makes it steady in piercing surroundings. On the other hand, the techniques of data adaptive have offer important development by the enhancement of image quality within a microwave tomography. Golnabi et al (2019)[13] proposed the Microwave Tomography with the Technique Soft Prior Regularization for the purpose of the Evaluation in MRI-Derived Anatomically-Realistic arithmetical Breast Phantoms. Amdaouch et al (2019) [14] proposed about the algorithm of Confocal microwave imaging for the detection of breast cancer as per the corrugated high directive Vivaldi pulses of antenna. O'Loughlin et al (2018) [15] proposed about the Specificity and Sensitivity for the purpose of the viewing the use of Diverse Experimental Breast Phantoms based Patient-Specific Microwave Imaging. Saied et al (2018) [16] projected the radar based microwave development head imaging process for the detection of tumors, other anomalies, and strokes in the brain. The algorithm of imaging depends on the microwave imaging in space-time algorithm (MIST) that was proposed earlier and was introduced for the recognition of breast cancer. The data that is simulated will be attained from the wearable array of antenna system and was processed with the modified algorithm termed MIST.

Sadaati et al (2018) [17] proposed Immuno sensing of the protein CA 15-3 breast cancer tumor a carbohydrate antigen 15.3 with the use of new nano-bioink: A novel policy for proteins screening in bio-fluids human by the technology pen-on-paper. Wang et al (2012) [18] proposed about the aim of the Antenna Ultra-Wideband MIMO for the Detection of Breast Tumor.

3 PROBLEM STATEMENT

In spite of latest development in the imaging method, imaging of the dense breast is very tricky. There are lots of imaging problems in the thick breast owing to a huge percentile of the belongings of using other techniques there will be a chance of missing carcinomas of early stage of the cancer. New techniques of imaging like magnetic resonance imaging, thermography, computed tomography, transillumination, radionuclide imaging and ultrasonography are used now a days for the detection of the breast cancer. But there also many side effects like irritation and compression on breast, radiation effects etc. So to overcome all kinds of the problem a need for an effective imaging method for the purpose of the detection of the breast cancer is necessary.

4 PROPOSED METHODOLOGY

Here is the proposed method which is based on the Enhanced delay and Sum algorithm. The micro strip patch antenna method for the effective identification of the breast cancer is explained here. The figure 2 represents the FR-4 sheet. FR4 stands for Flame Retardant 4. FR4 is made from the matting of fiber glass that impregnated by the resin epoxy. FR4 is a cheaper material. Not just for patch antenna, mostly, FR-4 substrate is used for the low frequency designs because it is easy and economical and is market available. The material is known to keep its elevated mechanical values and qualities of electrical insulating at both humid and dry circumstances. The following attributes, with the characteristics of good fabrication, provide grade utility for a wide range of mechanical and electrical uses. The laminates of glass epoxy grade designations are: FR-4, FR-5 and FR-6, G-10, G-11. FR-4 is the most widely used grade and is a material that is common for a printed circuit boards. The figure 3 represents the implementation of various methods for the effective identification of the breast cancer.

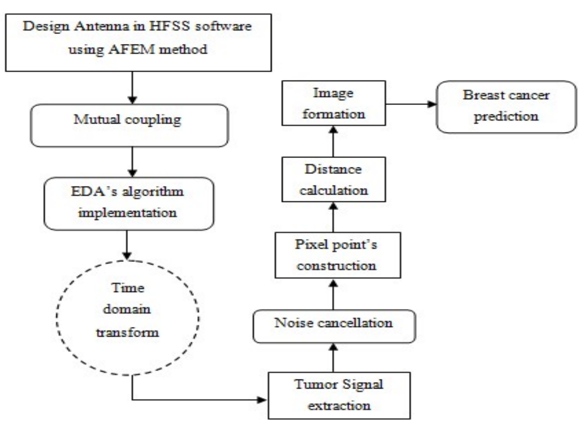

Fig. 2. *Schematic representation of the proposed methodology*

Fig. 3. *FR-4 sheet used for antenna fitting*

Antenna design:

The three dimensional structures with finite element modeling is nowadays significant in the antenna field and other electromagnetic wave domain. For finest design of the small patch antenna, it is required that the plane of ground must be better on comparing patch dimensions by about 6 times. The figure 4 represents the design of our proposed antenna model. The figure 5 represents the general breast model with the proposed antenna device

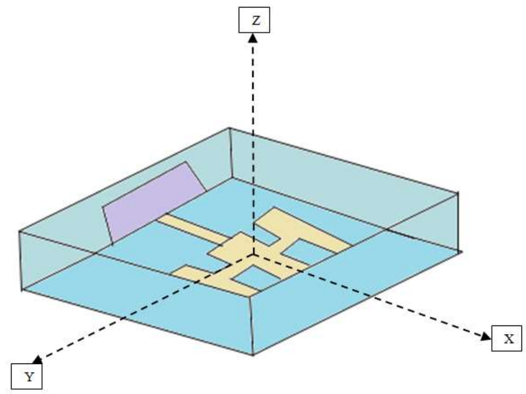

Fig. 4. *Proposed novel MSP Dielectric antenna*

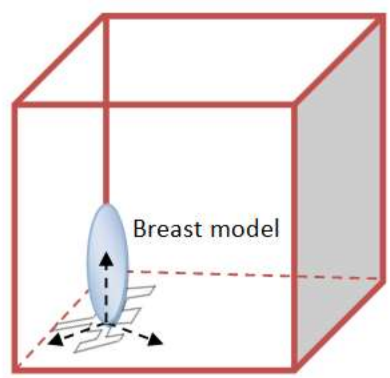

Fig.5. *General Breast model with the proposed antenna device*

Mutual coupling:

The vital necessity of coefficient reflection, of a transmitter for satisfactory representation is usually less then -10dB. But in breast cancer detection case more than one transmitter which can be placed over the breast is needed so as to enhance the image declaration. On rising antenna elements number, there is a possibility of receiving more imaging data from various breast locations. Although this might be an exclusive one as two successive antennas distance will get reduced, the mutual coupling between the antennas will get increasing.

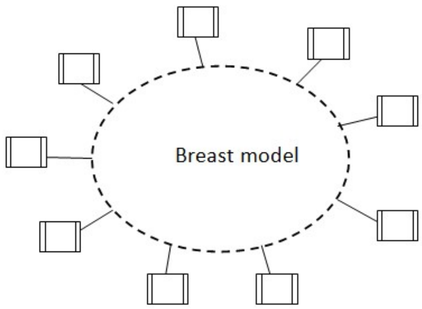

Fig. 6. *Mutual coupling of the antenna device*

The electromagnetic interaction between the two consecutive antenna elements is called as the mutual coupling. Increase in mutual coupling will affects the antenna array in the several ways: voltage gets changed characteristic of the antenna gets varies Changes the radiation pattern. Therefore, 90% of power is being transmitted to the breast which results in apparent examination in the breast. The figure 6 represents the coupling of the antenna device for receiving the signals.

Implementation of the EDA's algorithm:
The enhanced algorithm EDAS exploits an extra factor of weighting quality, on comparing standard EDAS. A QF (quality factor) can interpret as a algorithm quality factor. It is intended in three stages. First each focal point, curve of energy collection is plotted during the coherent signal summation. Such curve example is computed at a tumor response's focal point. After that, the curve of energy collection is being rescaled by the process of normalization which is the standard deviation of energy. Normalization is performed in fact with the use of multiplication by 1/(1 + σe), as in this case the equal energy in all radar signals that are considered. Equalization, more closely look like the preferred case of equal energy. The main process involved here is the process of normalization and equalization. During the focusing process, the point of focal gets moved randomly in the breast, which results in spatial shaft process of light get form. At every location, every time related reaction are integrated and summed. The process of integration is performed on the windowed signal, along with integration window length is selected in relation to the bandwidth system. A (3D) three-dimensional scattered energy map is formed in this way. The main EDAS algorithm advantage is its effortlessness, sturdiness, and with a small time for computation. The given focal point's scattered energy with the breast volume that will be uttered as, $e(x,y,z)=\int_{n}^{i}(\sum_{i=1}^{M} W_i(x,y,z) * Y_i(t - t_i(x,y,z))^{\wedge}2)dt$

Time domain transforms:
The frequency domain information of the normal breast and the tumor affected breast was attained by the simulation process through using the software simulation. Then the breast image is converted into the time domain. Then the time domain transforms are determined. Here, the hamming window is used for the process of the transformation of the image.

$$W(H_m) = \alpha - \beta$$

Tumor signal extraction:
On the subtraction of the tumor time domain reply from the normal breast tissue the signal of tumor is extracted. This provides the tumor response in time domain.

$$T_i(x,y)t = NB_i(x,y)t - TEB_i(x,y)t$$

Noise cancellation:
During the simulation process, reflection is regular because of the environment and antennas which are added into the preferred signal. This unwanted signal is referred as noise. It is significant for noise removal as the main purpose is of the reconstructing image. So as to decrease the noise, response of tumor from the antenna array is averaged initially in excess of the antenna elements total number n. Hence, this method is conceded out by summing all the signals received of all antennas after which, the result is divided by antennas total number of n array.

5. RESULTS

In this approach, values of electromagnetic field on the breast tissue are evaluated without tumor growth and with tumor growth, and the following evaluations are presented and discussed. In total there are five structures of antenna, which can be presented by altering the slotting and ground plane on micro strip patch. In this part, the results of proposed antenna performance are estimated in the course of simulation by using software HFSS. The projected antenna is intended by software ANSYS HFSS. HFSS tool is a kind of the tool used for designing different types of the antennas. The geometrical plan, its properties of material and the preferred frequencies of output are specific. On behalf of the design given, the software HFSS generates a solution process automatically and interconnect analysis accurately.

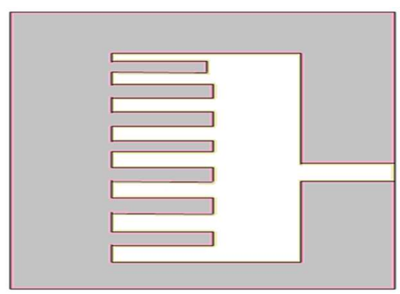

Fig. 7. *Antenna 1*

The Figure 7 shows the antenna 1 which has the modified ground plane. The Dimensions of customized ground plane can be 34 mm for y axis and50.2 mm for X axis. The novel antenna is perfectly placed on the micro strip. Basically this antenna posses a comb like structure.

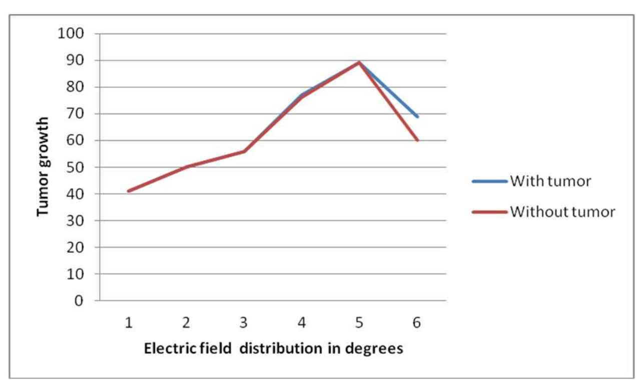

Fig. 8. *Graphical representation of the performance of Antenna 1*

The figure 8 represents the performance of the antenna 1. Here the blue line represents the electric field into the tumor breast tissue and red line represents the values of electric field into the breast tissue with no tumor. The Figure 9 shows the antenna 2 which has the modified ground plane. The common antenna is perfectly located on the micro strip.

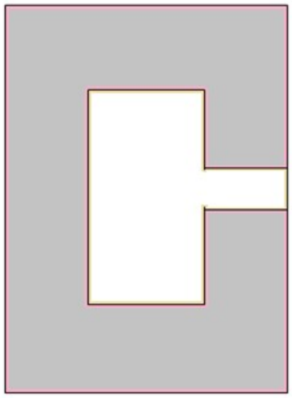

***Fig. 9**. Antenna 2*

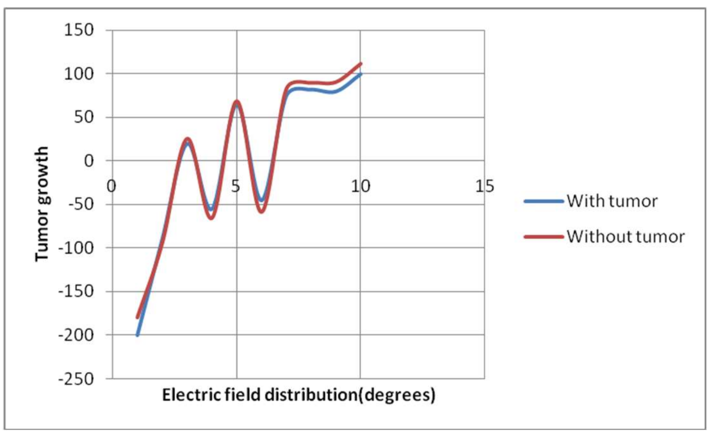

***Fig.10.** Graphical representation of the performance of Antenna 2*

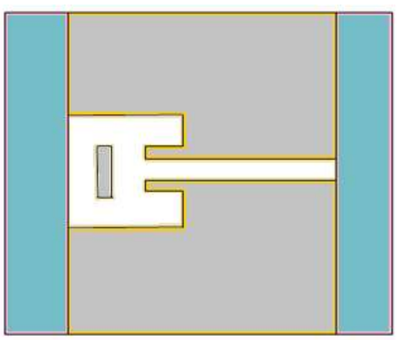

***Fig.11.** Antenna 3*

The figure 10 represents the performance of the antenna 2. Here in the blue line represents the electric fields into the breast tissue having tumor and red line represents the values of electric field into the breast tissue with no tumor. Circle at graph signify the simulation results of the differentiation of the tumor and non-tumor cells. The Figure 11 shows the antenna 3 which has modified ground plane. Dimensions of the modified ground plane can be 54 mm for y axis and 67.2 mm for X axis. The novel antenna is perfectly placed on the micro strip. The figure 12 represents the performance of the antenna 3. Here the blue line represents the electric fields into the breast tissue with tumor and red-line represents the values of electric field into the breast tissue with no tumor. Circle on the graph represents the simulation results of the differentiation of the tumor and non-tumor cells.

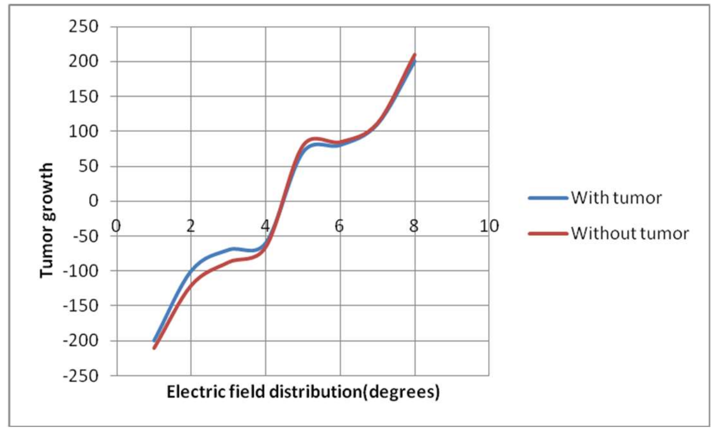

***Fig.12.** Graphical representation of the performance of* Antenna 3

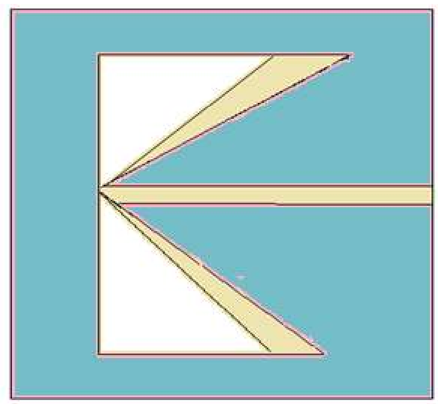

***Fig.13.** Antenna 4*

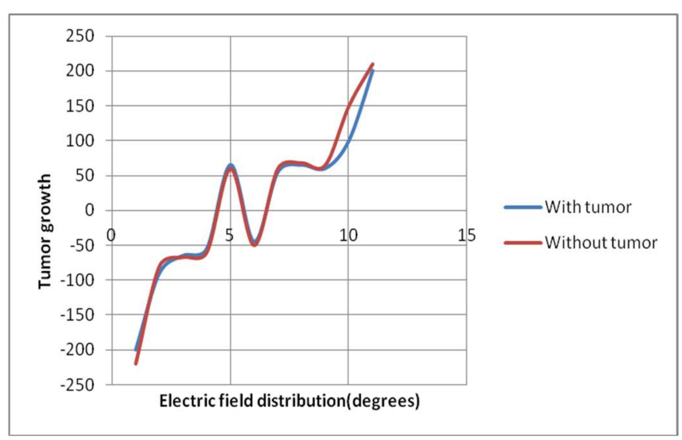

***Fig.14.** Graphical representation of the performance of Antenna 4*

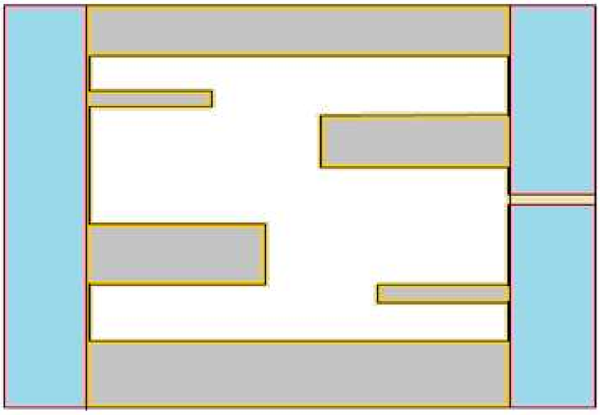

Fig.15. *Antenna 5*

The Figure 13 shows that the antenna 4 it which has the adapted ground plane. The Dimensions of modified ground plane can be 18 mm for y axis and 32.1 mm for X axis. The novel antenna is perfectly placed on the micro strip. The figure 14 represents the performance of the antenna 4. Here the blue line represents the electric fields into the breast tissue having tumor and red-line represents the values of electric field in the breast tissue with no tumor. Circle lying on the graph signifies the simulation results of the differentiation of the tumor and non-tumor cells. The Figure 15 shows that the antenna 5 which has the modified ground plane. The Dimensions of modified ground plane can be 55 mm for X axis and 15 mm for y axis. The novel antenna is perfectly placed on the rectangular micro strip. The figure 16 represents the performance of the antenna 5. Here the blue line represents the electric fields into the breast tissue with tumor and red line represents the electric field values into the breast tissue without tumor. Circle on the graph represents the simulation results of the differentiation of the tumor and non-tumor cells. Among the proposed 5 antenna's Antenna 5 shows better performance when compared to the other four antennas.

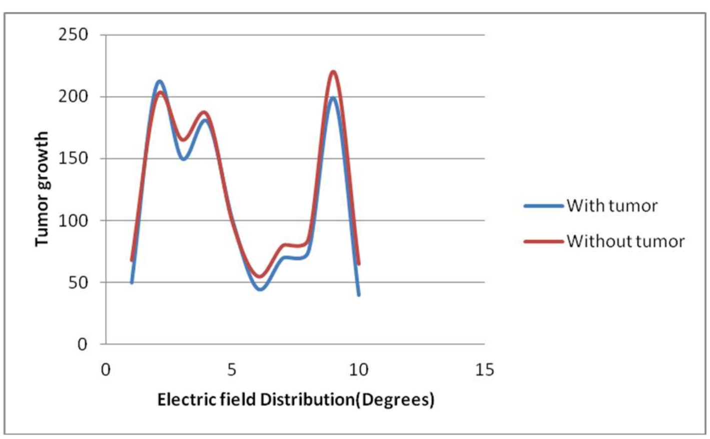

Fig. 16. *Graphical representation of the performance of Antenna 5*

Due to the better performance of the Antenna 5, (determined by its speed) the antenna 5 model will undergo simulation and further process. Now, the antenna performances were narrated with their significant factors. (i) Return loss: Fig 17 depicts the return loss simulated in the proposed antenna micro strip in frequency range of ISM band. During the simulation, it is exposed that return loss is obtained under 40 dB. (ii) Simulated Gain: The proposed antenna designed is tested in fine-tuning diverse ranges of frequency and gains that are corresponding will be distinguished. The attained maximum gain is near 6 dB. The result of simulation represents that antenna designed has small consumption of power because of huge gain. (iii) Radiation Pattern: Through simulation it is revealed that the antenna's radiation pattern is 149.3220 dB and is a bit a perfect value for medicinal analysis. The antenna proposed has belongings in Omni directional that is essential for patients' soothe. While a patient wear a proposed transmitter this might be accustomed in any direction.

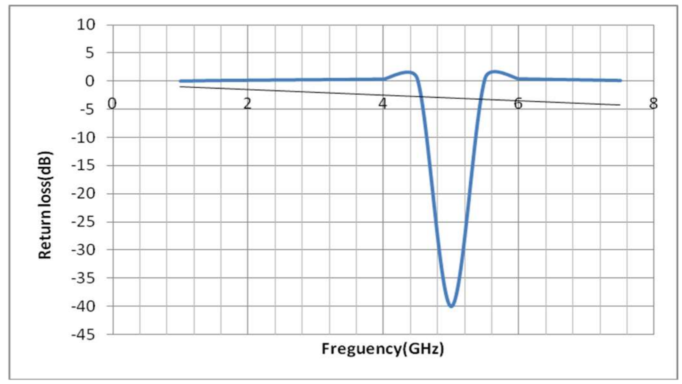

Fig. 17. *Frequency vs. return loss*

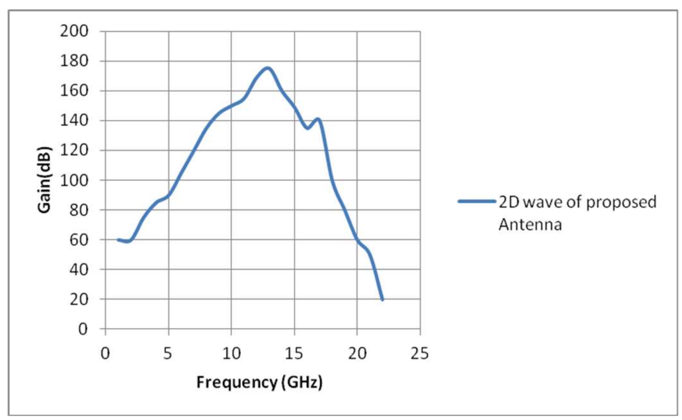

Fig.18. *simulated antenna gain vs frequency of 5 in 3D*

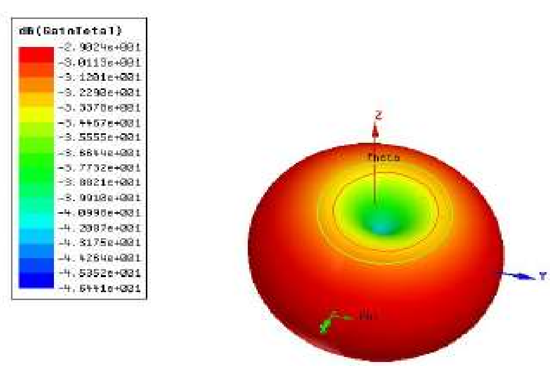

Fig. 19. *simulated gain vs frequency of the antenna 5 in 2D*

The figure 18 represents the gain vs frequency values of the antenna 5. The figure 19 represents the gain vs frequency values of the antenna 5. This indicates that the gain versus frequency plot of the projected micro strip antenna. The antenna gain considered in both three dimensional and two dimensional behavior are shown in figure 18, figure 19 correspondingly. The fig 20 represents radiation pattern of the Antenna 5. This reveals that the general radiation designed antenna pattern which is measured at various frequency level.

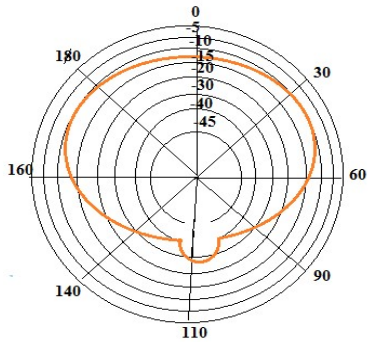

Fig. 20 *The proposed antenna 5 radiation pattern*

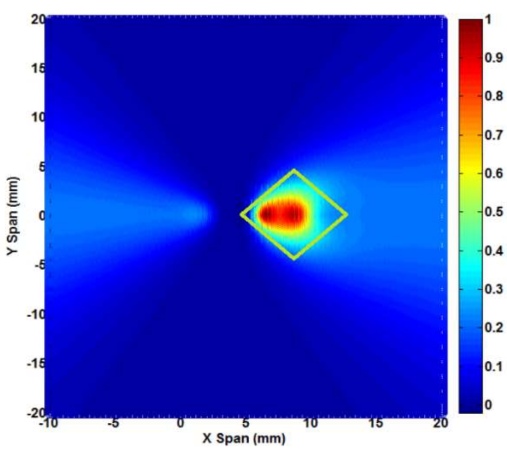

Fig. 21. *Image with 8th power intensity*

The figure 21 represents the image with 8th power intensity value is preferred for the detection of the breast cancer.
The figure 22 represents the calculation of the cancer area by using formulae then the result shows the patient having 7mm tumor growth.

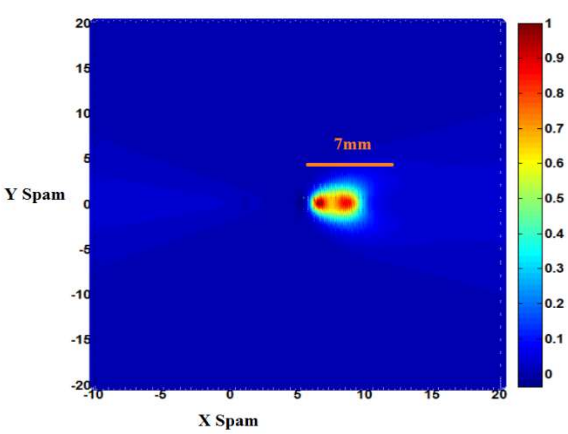

Fig. 22. *Distance calculation*

6 CONCLUSION:

The five different kinds of antenna are designed, and then the performances of the antennas are evaluated. The result shows antenna five has better performance when compared to other antennas. The proposed antenna 5 array is placed around the breast. Simulation results are obtained by 7 mm size of the tumor. Exact results are obtained by the back scattered data which can be observed in the proposed antenna by adjoining the breast at different locations. The reply of tumor signal is separated by the subtraction of tumor affected tissue in a time domain response on behalf of normal breast tissue. The region under the breast is separated for obtaining points. Each antenna to the focal point distance can be intended by using the enhanced sum and delay method. This delay and sum data is used further for the purpose of getting the intensity value. These values help us in the prediction and localization of the area of the tumor.

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