ULTRA WIDE BAND RADAR BASED BREAST CANCER DETECTION USING STACKED PATCH AND WIDE SLOT ANTENNA

ASWATHY SAM[1] & AMIR ANTON JONE .A[2]

[1,2]Department of Electronics and Communication Engineering, Karunya University, Karunya nagar, Coimbatore
E-mail: aswathy22sam@gmail.com, amir@karunya.edu

Abstract- A wide slot UWB antenna is used for the detection of breast cancer .This method works on the principle of ultra wide band radar imaging technique. In this paper comparing the performance of both stacked patch and wide slot antenna used for the purpose of breast cancer detection. Calculating specific absorption rate of both antenna, when it is placed in a normal tissue and tumors tissue, and comparing its results .And also measuring certain parameters of both simulated and measured results. From this comparative study its clear that wide slot UWB antenna has excellent performance in this UWB frequency range. And also wide slot antenna is three times smaller than stacked patch antenna.

Keywords- *Breast cancer detection, confocal microwave imaging, specific absorption rate ,ultra wide band antenna.*

I. INTRODUCTION

Breast cancer is the most common form of cancer among women. The early detection there is a high chance of successful treatment and long term survival [1] .To reduce the morality of this disease ,it is to be detected early when the cancer is relatively small and has not spread to other parts of the body .The current leading method of detection for this type of cancer is mammography in which the breast is exposed to low-power X-rays [3]. Mammography is the process of using low-energy-X-rays(usually around 30KVp) to examine the human breast and is used as a diagnostic and a screening tool .This method is fraught with problems such as false negative rates ,high false positive rates, and the ionizing nature of X-rays which poses a considerable risk of causing the very cancer it attempts to detect [2],and also this method is very expensive. To provides a safer and /or more accurate method than traditional mammography.

The other method of breast cancer detection is using microwave imaging [2]. The applications of microwave technology were increasing in the field of biomedical engineering for diagnostic purposes. This is based on the dielectric properties this technique promises non destructive evaluation of the biological tissue ,which creates the images related to the electrical properties of the breast tissue[4].From this information we can identify the tissue with malignant tumor, it contains more higher water content than the normal tissue. Due to this strong scattering will take place when microwave hit into the malignant tumor.[4].There are two different approaches that have been proposed in order to image the breast are: Microwave tomography and ultra wide band radar imaging [2] .Both of this method uses antenna arrays.

Microwave tomography[5] is used to provide a complete spatial mapping of the electrical properties in the region of interest .In this method an array of antennas surrounds the region ,out of this one of the antenna is used to transmit a signal, and all other antenna are used to receive the reflected signal. After data has been acquired, it is then compared with received data and the data obtained from simulated model of the region .A numerical model is used to predict how much power is transmitted from the transmit antenna, passes into and reflects from the breast or tumor tissue, and is received by the receiving antenna.

Another method called ultra wide band radar imaging also called confocal imaging. [5]. Unlike microwave tomographic imaging, This method does not provide a complete electrical mapping of the region of interest. Instead it identifies location of significant scattering. This method typically uses a single antenna scanned in a flat array pattern above the breast or a cylindrical array of very small broadband antennas. Two types of imaging can be done in this method [6]. One is planar imaging the patient lies face up, and the antenna is physically scanned in a plane above the breast .Another is cylindrical imaging, the patient lies face down. One of the antenna in the array transmits UWB pluses ,which propagates into the breast, where it is reflected off significant electrical discontinuities ,and is received in parallel by other antennas in the array .By knowing the physical spacing between the array elements, the different delays that occur in between the transmit antenna and receiving antenna can be calculated geometrically.

The received signals are time shifted and added up and integrated to indicate the magnitude of the scattered signal. This is to reduce the clutter ratio [5]. This radar based scheme is used for producing high resolution images without using any algorithms; this is because of the wide band nature of UWB signals [2]. The important part of the breast cancer detection system is the antenna design .To obtain high resolution images ,antenna must be able to radiate signals over wide band frequency .Normally for this scheme array of antennas are used for this size is an important factor. So the antennas geometrical dimensions must be small as possible in order to place maximum number of antennas.

Existing antenna designs used for this breast cancer detection scheme like V-antenna [7] ,bowtie antenna[8], horn antenna[11], oval patch antenna[10], stacked patch antenna. The main problem in these antennas are large in size also have low efficiency and low bandwidth .So in order to improve bandwidth in this paper uses a wide slot antenna for this detection scheme. This antenna is placed in a matching medium its electrical properties are similar to that of the human breast tissue .The size of wide slot antenna is smaller than stacked patch antenna.

The following sections of the paper gives the details of the geometrical design of the stacked patch and wide slot antenna. The performance of the stacked patch antenna and wide slot are compared, and evaluating its results using FEKO software. These will include return loss, radiation pattern, bandwidth, SAR rate.

II. ANTENNA DESIGN

The antenna's used in this paper are:
(i) A stacked patch patch antenna used for the breast cancer detection system.
(ii) A fork-fed wide slot antenna for this detection scheme.

Both these antennas are constructed using substrate Roger duroid with permittivity 10.2.these antennas are immersed in a matching medium ,its dielectic properties like permittivity and conductivity are similar to normal breast tissue .In order to determine the specific absorption rate, antenna is placed above tissue in order to determine how much amount of power is absorbed by the body.

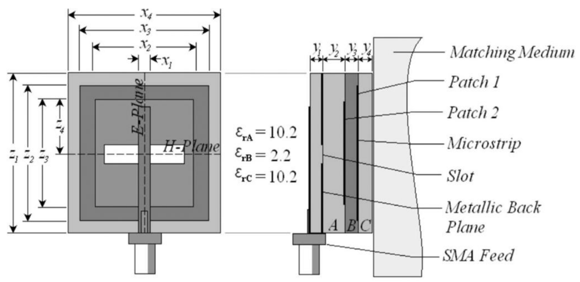


Fig. 1.schematic view of stacked patch.

A. Stacked Patch Antenna

The stacked patch antenna shown in (fig.1) consists of a microstrip line feeding slot, which in turn excites the arrangement of stacked patches. The stacked patch is the modification of the conventional patch antenna. The antenna's popularity is mainly due to its simple design. This stacked patch can obtain wider bandwidth than the traditional microstrip antenna's. This antenna consists of a three dielectric layer ,they are sandwiched between the patches . It has two patches upper and lower patches .The stacked patch antenna is shown in the (fig. 1) with dimensions being : x_1 = .66, x_2 = 6 ,x_3 = 9, x_4 =18 ,y_1 = 0.64 ,y_2 = 1.9 ,y_3 = 0.8 ,y_4 = 1.27 ,z_1 = 18 , z_2 = 6.5, z_3 = 6, z_4 =3.This is simulated using FEKO software.

B. Wide Slot

A wide slot antenna in (fig.2) consists of a wide square slot in one side of the substrate and on other side of the substrate is a forked microstrip feed.Forked feed is used for increasing the bandwidth.The fork like tuning stub here is all positioned within this slot region in the opposite side of wide slot. Due to the coupling between the microstrip line and wide slot is controlled more effectively,which makes possible for the bandwidth enhancement of wide slot antenna. This mechanism is called fork like tuning stub because of the shape of fork.the diamensions of the antenna are: H =14, Y =7, L = 6.5,D = 4, W = 13, X = 10 ,F = 1.25, S = 1.25, l = 2.

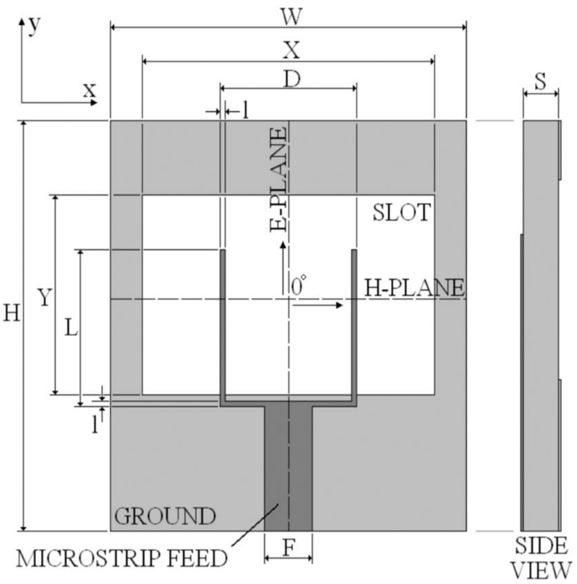


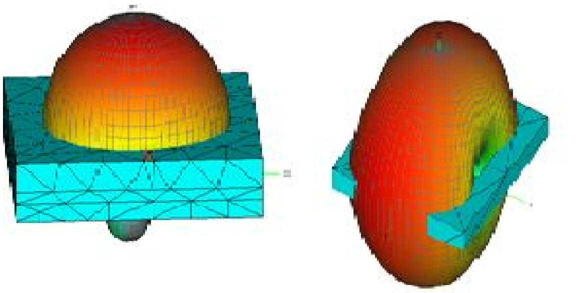
Fig.2 schematic view of wide slot

III. RESULTS

The performance of these antenna's are evaluated using FEKO software .Comparing the radiation pattern, return loss,beamwidth ,bandwidth, and electric field intensity of both antenna's.

C. Radiation pattern

Radiation pattern of the antenna shows the graphical representation of radiation properties of the antenna. The 3D radiation pattern of both antenna is shown in the fig.3.For stacked patch antenna it has directional radiation pattern. That is this antenna radiates power only in one direction. From this pattern in fig.3(i) is clear that maximum radiation occur in forward direction.



(i) (ii)

Fig. 3 Radiation pattern of (i)stacked patch (ii) wide slot antenna

For wide slot antenna pattern in (fig.3(ii)) is an omni directional pattern is obtained .it has a donut shape pattern..

D. Return loss

From the s-parameter graph we can infer that whether the antenna is radiating or not, and also graph tells that how much power is reflected from the antenna. This is called return loss or reflection coefficient.

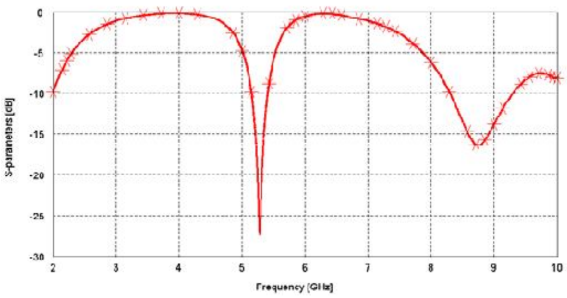


Fig.4 Return loss of stacked patch

Fig.4 shows the return loss of stacked patch ,it is resonating frequency at 5.25GHZ and reflection coefficient is increasing with increasing frequency. At 7.2GHZ the reflection coefficient starts to decrease with increasing of frequency and after reaching the reflection coefficient at 8.7GHZ.By this characteristics of the graph it works in dual band frequency .The return loss of the stacked patch antenna is obtained about -27dB,also it offers good impedance matching. The bandwidth of the antenna describes the range of frequency over which the antenna can properly radiate or receive energy. For stacked patch antenna bandwidth obtained is about 6.51dB.

Fig.5 shows the return loss of wide slot antenna ,it is resonating at 3.75 GHZ, then the reflection coefficient is increasing with increasing of frequency.The whole bandwidth is performing well because the reflection coefficient is <-10dB for entire frequency range. The return loss of wide slot antenna is improved to-34.17dB. And also offers good impedance matching. The bandwidth of wide slot antenna is improve to 13dB by using fork like feed.

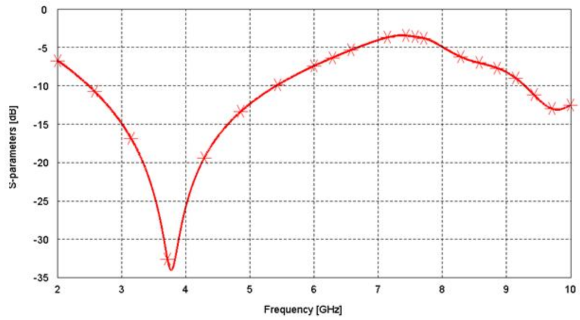
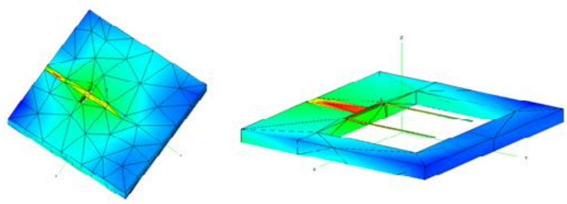


Fig.5 Return loss of wide slot antenna

E. Electric field intensity

It is the amount of electric energy stored in the antenna or region of space per unit volume. Fig.7 shows the current distribution of both antenna. The electric energy through the antenna is uniform for different frequency. Here region where port is giving attains maximum current. Red colour shows maximum current flow. Blue colour shows no current flow means it is dielectric. Maximum current flow occurs in the resonating frequency at 5.25GHZ for stacked patch antenna and at 3.5GHZ for wide slot antenna.



(i) (ii)

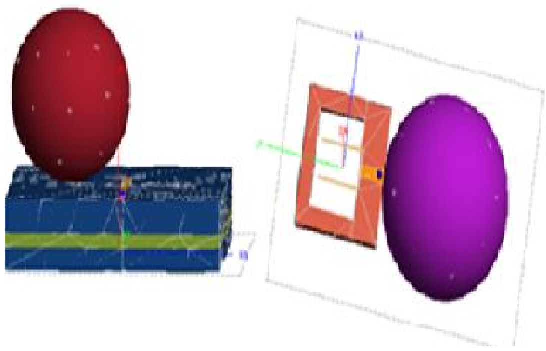
Fig.6 Electric field intensity (i)stacked patch (ii) wide slot antenna

IV. SPECIFIC ABSORPTION RATE

The SAR is an amount of the power absorbed by the medium .For breast cancer detection SAR has a standard limit.SAR can be calculated by the equation [5].

$$SAR=\frac{\sigma E^2}{\rho}\ W/Kg \qquad (1)$$

Where σ is the conductivity of the material in S/m, E is the electric field intensity in V/m. Electromagnetic simulation of normal and abnormal breast, the absorption loss of infected breast is higher than normal breast. For calculating the SAR rate of normal tissue and tumors tissue, for this antenna is attached with a phantom which act as human tissue .Phantom is placed above stacked patch antenna and wide slot antenna in order to measure SAR rate of both normal and infected tissue. The permittivity of normal and tumors tissue is 1:5 ratio .To determine absorption rate ,relative permittivity of normal tissue is ϵ_r =9,for tumor is □r =50,and the conductivity is σ = .4 S/m and for tumor is σ = 9 S/m.



(i) (ii)

Fig. 7 phantom placed above (i) stacked patch (ii) wide slot antenna.

TABLE 1 SAR RATE CALCULATION OF STACKED PATCH

Frequency (GHZ)	Stacked patch	
	Normal tissue	Tumors tissue
2.0	.0123	.05256
3.143	.04633	.0319
4.286	.0893	.1411
5.143	.1562	.717
6.0	.1631	1.019
7.143	.2556	1.0275
8.0	.3217	1.16
9.143	.4156	1.3767
10.0	.5713	2.53

TABLE 11. SAR RATE CALULATION OF WIDE SLOT

Frequency (GHZ)	Wide slot	
	Normal tissue	Normal tissue
2.0	.02216	.2216
3.143	.046	.4933
4.286	.2924	.5667
5.143	.3194	.6532
6.0	.4812	.7234
7.143	.6213	.9743
8.0	.7110	1.213
9.143	1.092	1.525
10.0	1.312	2.21

Table 1 and Table 2 shows SAR rate calculation of normal and tumors tissue for stacked patch and wide slot antenna for frequency 2GHZ to 10GHZ.From these table we can infer that SAR value for infected breast is higher than normal breast tissue, because that tumors tissue contains more water and blood content than normal tissue. The dielectric properties for tumors tissue are five times greater than normal tissue. After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper.

TABLE 111 PARAMETER ANALYSIS

Parameters	Stacked patch	Wide slot
Beam area	326	327
Beam efficiency	.78	.69
Stray factor	.21	.30
Bandwidth	6.1%	13%

TABLE 1V COMPARING SIMULATED AND MEASURED RESULTS OF BOTH ANTENNA

Parameters	Stacked patch		Wide slot	
	simulated results	measured results	simulated results	Measured results
Directivity	2.92	3.44	2.97	3.43
VSWR	1.956	1.96	1.0477	1.0477
Efficiency	35.7%	34%	67.6%	65%
Impedance	56.0	54.56	48.0	46.660
Admittance	.0144	.01756	.02143	.0207

V. CONCLUSION

The performance of UWB radar system for breast cancer detection using wide slot antenna is compared with stacked patch antenna. While comparing the performance of both antenna the return loss is improved to -34Db.by using fork like tuning stub in the wide slot its bandwidth is improved to 13%.The distribution of electric energy is uniform through the antenna. When the electric filed is above 0.02J then the tissue will be burn. The efficiency of stacked patch is 35% and it is improved to 67.9% for wide slot antenna .From this comparative study its clear that size of the wide slot is about three times smaller than stacked patch antenna. While comparing the SAR rate of normal and tumors tissue, The cancerous tissue has higher SAR value in case of both antenna. This wide slot antenna is low profile, easy to manufacture and also for high frequency purpose it is the best choice.

REFERENCES

[1] J.G Elmore and M.B. Barton *et al.*, "Ten year risk of false positive screening mammograms and clinical examinations ",New England J.Med., vol.338, no.16,pp.1089-1096

[2] B.Allen and M. Dohler, Eds.*et.al., Ultra –Wideband Antennas and propagation for Conmmunications,Radar and Imaging*, Chichester, U.K.Wiley,2007

[3] E.Fear,S.C. Hagness, P.Meaney, MOkoniewskij, and M.Stuchly,"Enchancing breast tumor detection with near field imaging,"*IEEE Microwave ,mag.* Vol. 3,no.1 pp.48-56, Mar .2002

[4] W.T Jonies Y.Zhang ,C.Li, and R.L.Jirtle,"The measured electrical properties of breast carcinoma and the surrounding tissues,"*IEEE Trans.Biomed.Eng*.vol.35 no.4,pp,257-263,April 1988

[5] H.M Jafari *et al* .,"A study of ultra wideband antenna for near -field Imaging," *IEEE Trans . Antenna Propag* , vol .55 no.4 ,pp 1184-1188,Apr-2007.

[6] Raquel C.Conceicao ,Martin O Halloran ,Martin Glavin ,Edward Jones ,"Antenna Configuration For Ultra Wide Band Radar Detection Of Breast Cancer", Procedings of SPICE ,vol 7169,1M1-12.

[7] M.Fernandez Pantoja,S.Gonzalez Garcia,M.A .Hernandez-Lopez,A.Rubio Bretones and R.gomez Martin ,"Design of an ultrta –broad-band V antenna for microwave detection of breast tumors " Microw. Opt. Technol. Lett,vol.34, no.3,pp.164-166,Aug,5 ,2002.

[8] C.J.Shannon.E.C.Fear ,and M.Okoniewski,"Dielectric – Filled slot-line bowtie antenna for breast cancer detection,"Electron.Lett ,vol.41,no.7 pp.338-390,Mar. 31,2005

[9] Elizabeth Rufus ,Zachariah C Alex ,and P Vivek chaitanya,"A modified Bow-Tie Antenna for microwave imaging applications",Journal of microw ,Opto and electromagnetic application ,vol 7, pp 115-122,Mar 2008.

[10] J.yuy ,M .Yuan ,and Q.H .Liu ,"A wide band half oval patch antenna for Breast cancer detection",Progress in electromagnetic research ,vol 98,pp 1-13,2009

[11] R.K Amineh , A.Trehan ,and N.K.Nilkolova ,"TEM horn antenna for ultra- Wide band microwave breast imaging,",Progress in electromagnetic research Vol 13,pp 59-75

[12] E.C .Fear and M.A .Stuchly, "Microwave detectionof breast cancer" *IEEE Trans.Microw.Theory Tech*,vol.48,no.11,pt.1,pp.1854-1863,Nov 2000.