Implementation of Compact Ultra wide Band Antenna Design for Breast Cancer Tumor detection

K.S. Chakradhar, V. Malleswara Rao

Abstract*: One of the applications of UWB antenna is for detecting a cancer tumor according to breast cancer model system. The absolute dimensions of antenna are 44x30mm2 having a thickness of 1.6 mm. It involves Ultra wide band of 80% frequency range of 3 GHz–12 GHz for the FCC band. The proposed antenna resulted high gain and omni-directional radiation patterns and a considerable impedance matching. The optimized functioning of the antenna is illustrated by the simulation results. This antenna has been implemented in a designed system model with dielectric properties of a human breast capable to detect peculiar bodies. The tumor is detected and examined by the received Proportions and Positional coordinates, accessed by the application of UWB antenna. The accurate position coordinates of the tumor inside the breast are obtained at the places with the least Specific absorption rate (SAR). The antenna was used to localize the tumor precisely which shows the excellent functioning of the antenna and device. The proposed device is simulated by using Ansoft HFSS software and also CST Microwave studio simulator developed the breast model.

***Keywords* : Breast cancer, CST, HFSS, UWB antenna.**

I. INTRODUCTION

In recent years, much ground work and research were done for the purpose of detection of cancer tumors involving microwave based technologies and techniques. These include meager extents of microwave energy radiation which is intended for transmission through breast tissue. The detection is possible because of the dissimilarity between the dielectric properties of normal and effected breast tissue. Along with it micro wave based techniques are inexpensive, quick and can be easily carried. Breast cancer is one of the most common cause of death in women in the world. A significant amount of cases can be resolved and cured if they were detected early. In this process of detection, the Mammogram has a vital role of utilizing the difference between the scattering cross-section of healthy and abnormal tissues to X-rays. However, this process has considerable limits [1]. In recent times, a different approach has been set up for using microwave imaging since it has the potential benefits of affordable cost and increased safety and higher availability [2] [3]. The difference between the dielectric constant of effected and healthy tissues is microwave imaging technique primary principle [4]. The tumour is detected from the signals which are obtained by the antenna. These days new interests are being put forward for the techniques which involve UWB signals to serve the purpose of breast cancer tumour detection [5] [6].

II. BREAST CANCER DETECTION SYSTEM

Around the world, nearly 14 million people cancer cases were detected of which 8..2 million people died based on statistics in the year 2012 [7]. Annually 100,000 people are diagnosed with breast cancer in India alone. According to ICMR, in women the most common type of cancer is recorded as breast cancer [8].In [11], the antenna consists of a CPW Antenna is designed for son input impedance, fed with an SMA connector. The antenna is designed using FR-4 substrate for resonant frequency 5.48 GHz.The dielectric properties comprise conductivity (σ) and relative permittivity (ε). Water is a important constituent in the determination tissue permittivity [12]. The tissues with less proportion of water have higher permittivity in comparison to tissues with higher water content [10]. As it turns out, at the frequency of microwave radiation, a higher level of absorption means the substance is having greater conductivity or reduction microwave energy while its propagating through the substance The normal tissues possess 10% less electrical properties than tissues effected with cancer Tumors [12].Three sorts of imaging were proposed for diagnosing breast cancer [9]: active, passive and hybrid. An Active microwave imaging is explored as an imaging modality for early detection of breast cancer. The electrical properties of cancer tumor are quite different from that of healthy tissue with exposure to microwave radiation. In the process of Vascularisation, Tumours have a greater temperature than normal breast tissue. This property is used for passive micro wave imaging [9]. The benefits of Ultra sound and microwave imaging are used by hybrid microwave imaging. Microwaves are propagated through breast tissue then, ultrasound transducers are used to determine the signals and localise tumours with processing of high resolution images [13].

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A. Basic Breast Model

In this work female breast structure is modeled as a basic breast structure. The cancer infected breast tissue assumed as a spherical body which is kept in a typical breast tissue.
The parameters like permittivity & conductivity differ from substance to substance so these properties are used to measure the values of magnetic and electric fields of the substance. so each structure having different permittivity & conductivity values have various electromagnetic values which enable us to identify cancer infected tissue. The cancer infected breast tissue values of Permittivity and conductivity are 50 (F/m) and 4 (S/m). The normal breast skin values of permittivity and conductivity are 36 (F/m) and 4(S/m), respectively while normal breast tissue values of permittivity and conductivity are 9 (F/m) and 0.4(S/m).

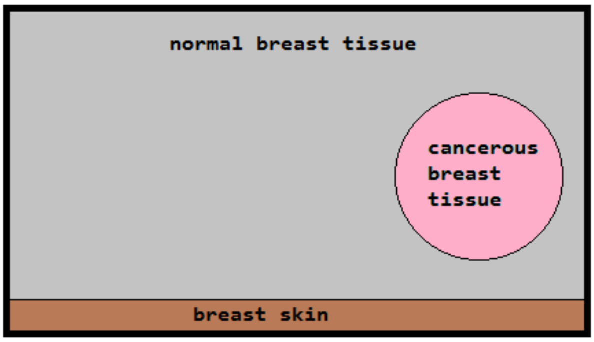

Fig. 1. Basic Structure of Breast Phantom

III. ANTENNA STRUCTURE AND MECHANISM OF UWB ANTENNA

Because of the Ultra-wideband characteristic slot antenna have received more attention towards wireless communication. These are accepted for wideband and volume-limited applications. The Ultra Wide Band antenna structure is shown in Figure 2. This antenna is printed by used with material a substrate(FR-4) thickness of 1.6 mm and ε (relative permittivity)- 4.4. The device consist 2-layers (bottom layer and top layer). The bottom is ground layer there are with width L2 and length L1. The microstrip antenna is the top layer.

The dimension thickness, length and width of antenna have 1.6mm, 44 mm and 30 mm. The device (antenna) is fed through a matched with 50 ohm microstrip line. Table.1shows the antenna dimensions. It radiation pattern antenna has an omnidirectional. The designed antenna can be appeared with curves, edges and different strategies. It has a truncated ground so that contribute the other frequencies. These features make the UWB antenna a good candidate for microwave medical imaging application.

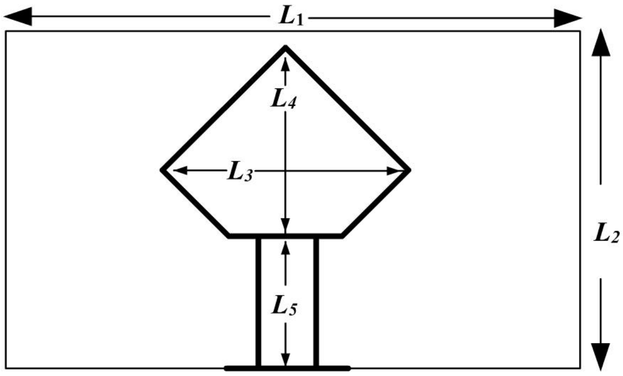

Fig.2(a). Structure of the Top View of UWB Antenna.

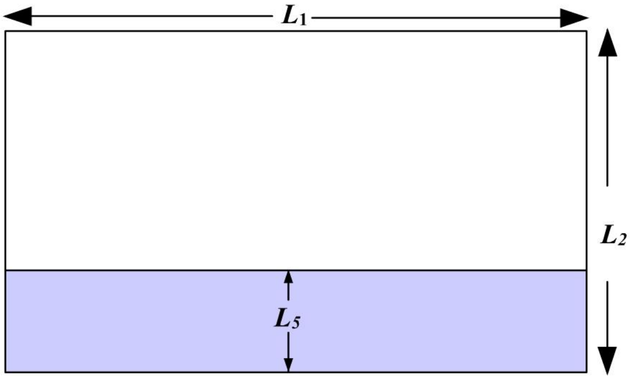

Fig.2(b). Structure of the Bottom View of UWB Antenna.

Table.1. Dimensions for UWB Antenna

Sides	*Length (mm)*
L_1	43
L_2	29
L_3	22
L_4	21
L_5	8.4
L_6	7.7

A) Antennas Simulation

The simulation is carried out to verify the analysis by using proper dimensions calculated for the specifications. The proposed antenna structure is shown in Figure 3 & 4 and simulated with HFSS. The device dimension are shown in Table 1.

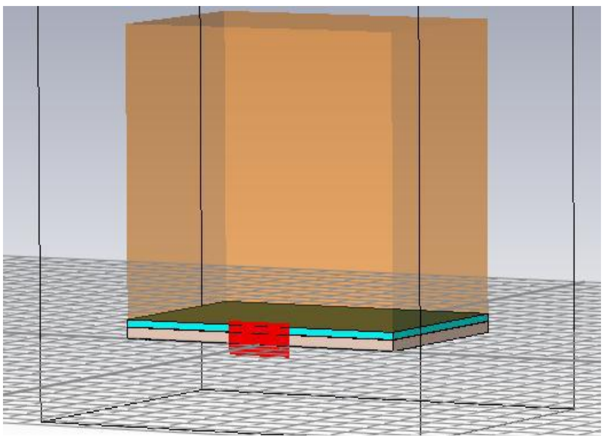

Fig.3. Antenna on breast model without tumor

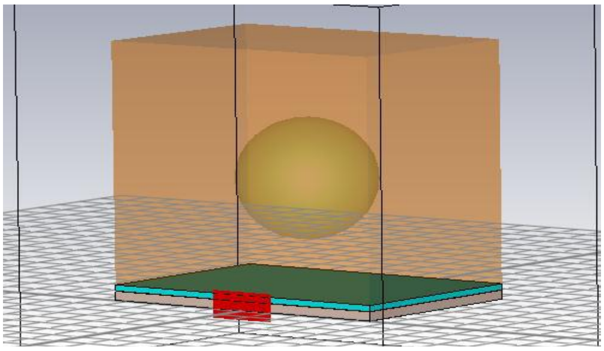

Fig.4. Antenna on breast model with tumor

B) Fabrication of Antennas

To verify the analysis of fabricated antenna by using proper dimensions obtained from simulation. The Antenna is fabricated on Substrate FR-4 material with dielectric constant (€r) 4.4. The fabricated structure of projected antenna is shown in Figure 5, 6 & 7.

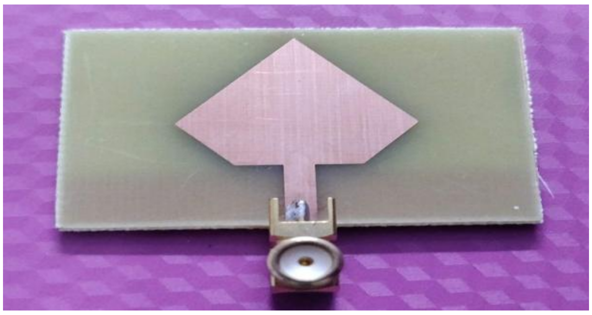

Fig.5. UWB Antenna front view

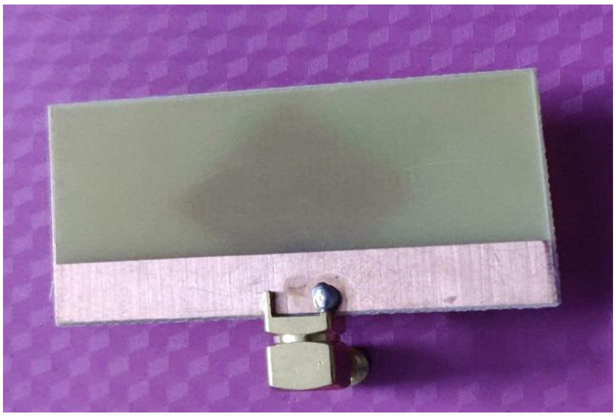

Fig.6. UWB Antenna back view

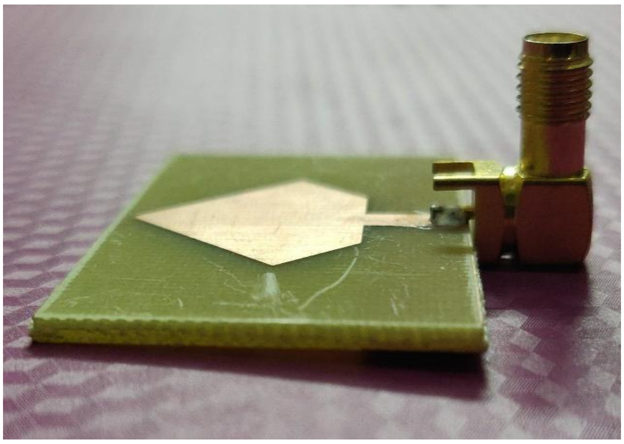

Fig.7. UWB Antenna side view

C) Phantom Fabrication Creation

The breast phantom is created with a circular shape plastic container with diameter is 125 mm,1mm thickness and 100mm height filled with oil a relative permittivity of 4 and containing water with relative permittivity of 81. The created breast phantom provides good representation in terms of electric parameters. Observe that the relative permittivity of an actual breast tissue is 5 and a malignant breast tumor is 50 respectively in the range of microwave frequency. Figure.9 depicts phantom created by using different materials.

Fig.8. Practical tumor and breast phantom Antenna on breast model without tumor

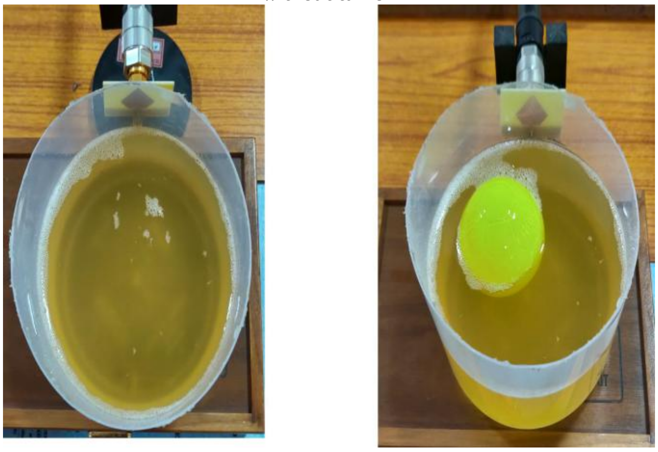

Fig.9. Breast Phantom UWB Antenna top view with and without tumor

Fig .10 Experimental set-up Breast Phantom UWB Antenna with and without tumor connected to Vector Network Analyzer (VNA)

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IV. RESULTS

Both simulation and practical results are carried out to verify the above analysis. The proposed antenna is simulated with HFSS and measured on Vector network analyser. Figure 11 shows the simulated S11 return loss, which measured -10 dB at bandwidth are 2.3GHz-12.2GHz, which covers an ultra-wideband.

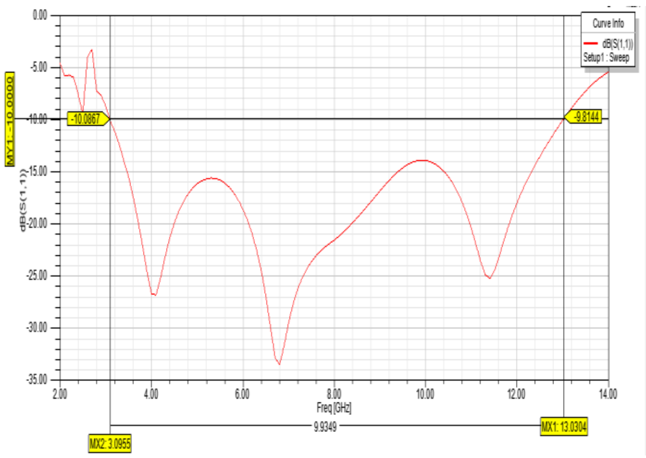


Fig 11 Return loss in free space of the Breast Tumor Detection UWB Antenna in HFSS

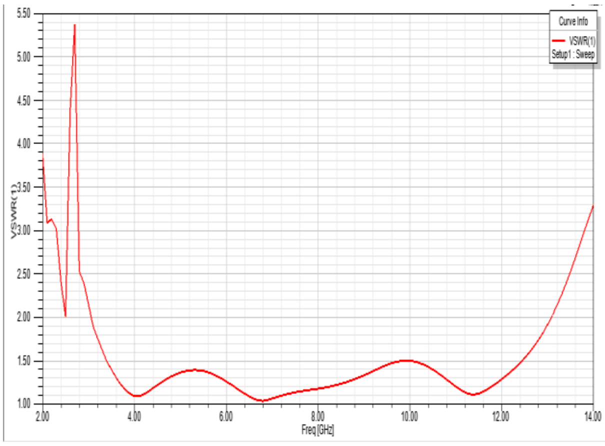


Fig.12. VSWR in free space of the Breast Tumor Detection UWB Antenna in HFSS

The VSWR of antenna results is shown in figure.12 and is obtained at less than 2 from 2.3GHz to 12.2GHz, which covers an ultra-wideband.

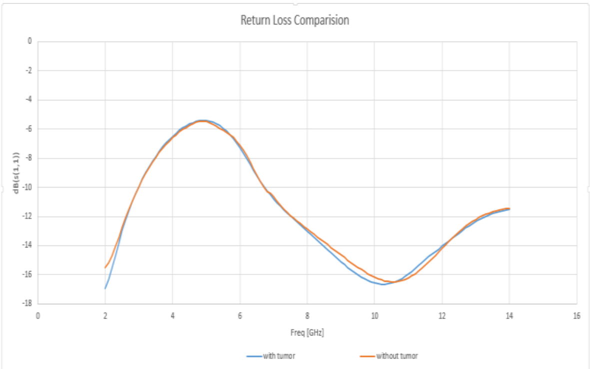
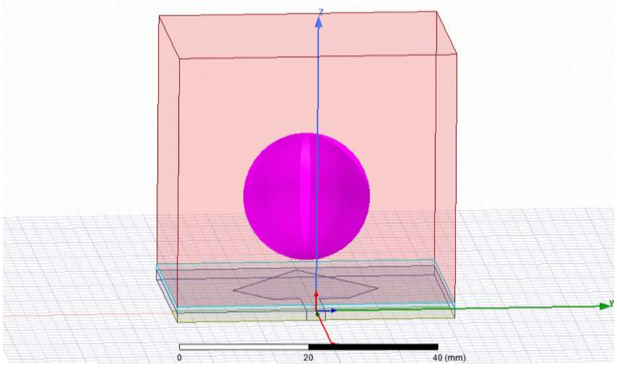


Fig.14 Comparison Return Loss with Breast Model with and Without Tumor

A) Breast Tumor Model with Tumor and Antenna with different dielectric constant



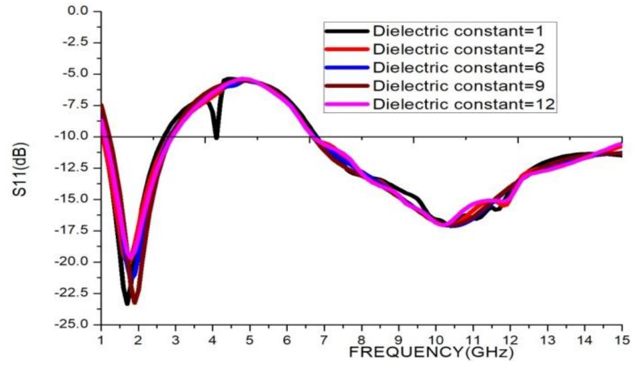
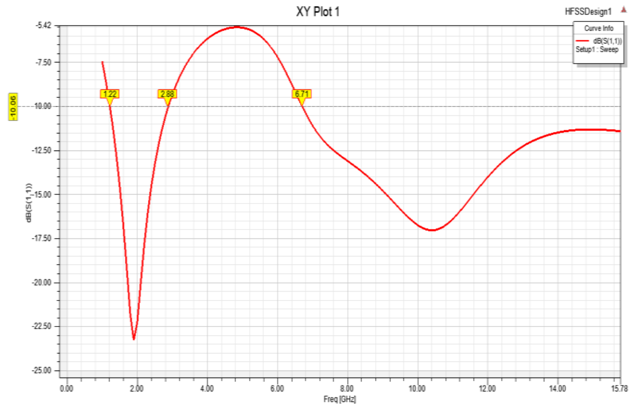
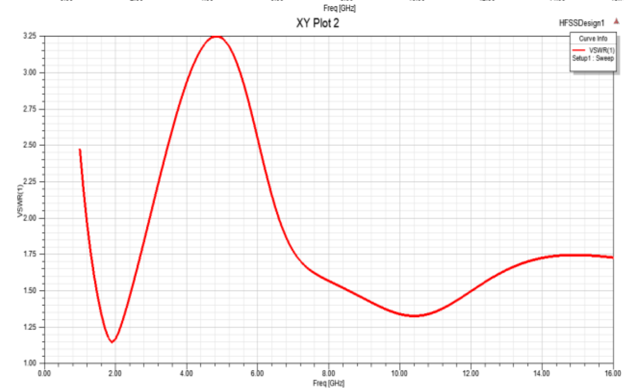


Fig.15 Comparison Return Loss with Breast Model with different Dielectric constants

i) Dielectric constant =9





ii) Dielectric constant = 12

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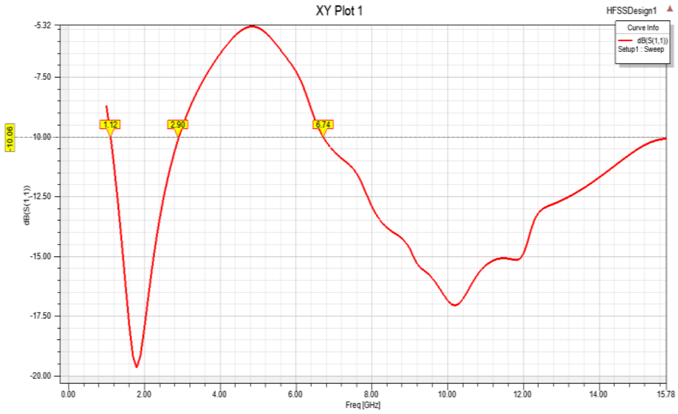
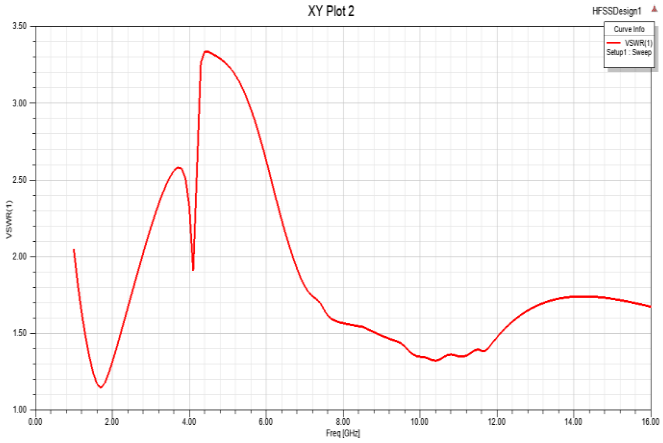
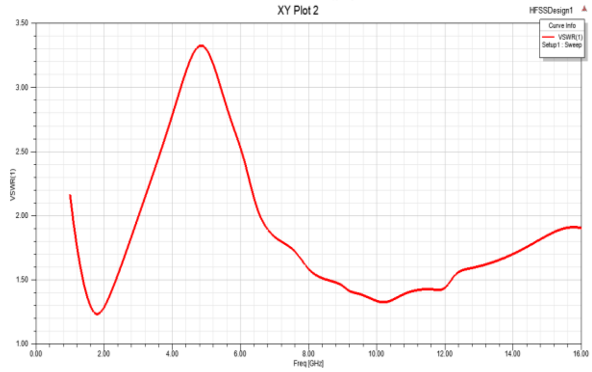
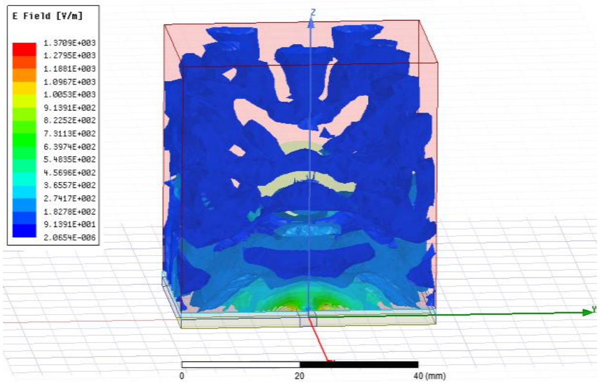
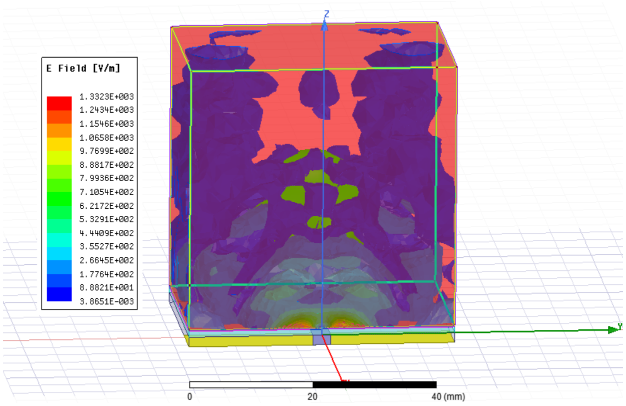


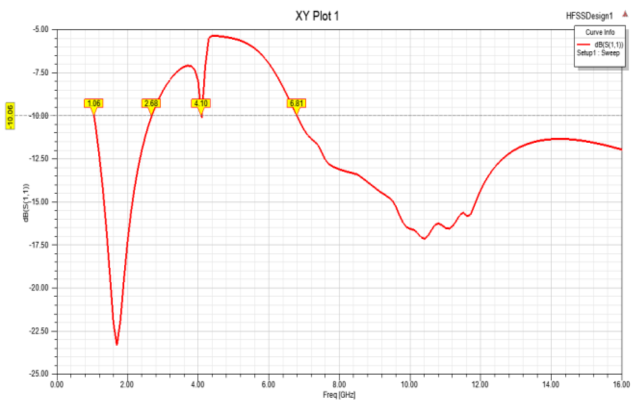




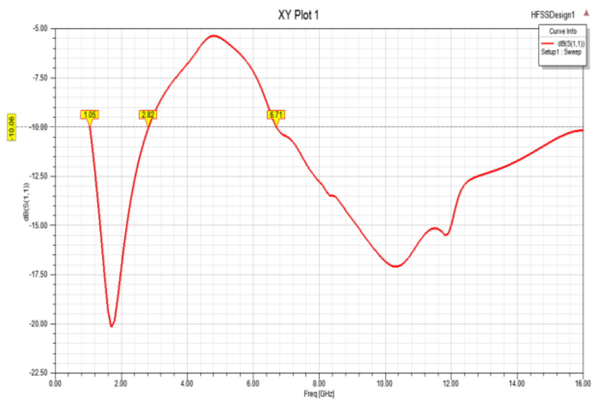


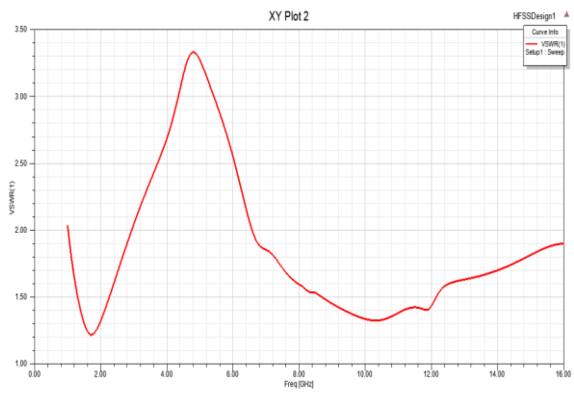


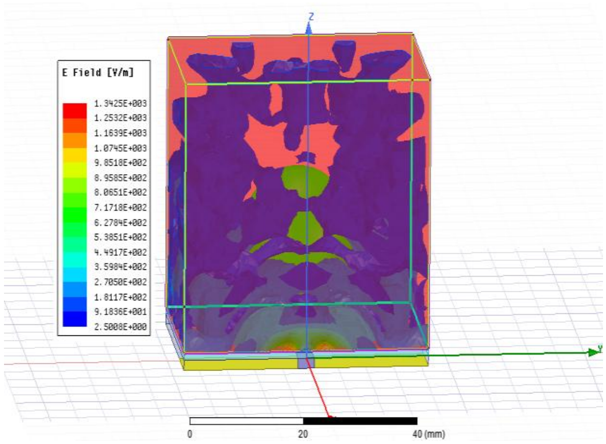
iii) Dielectric constant =1



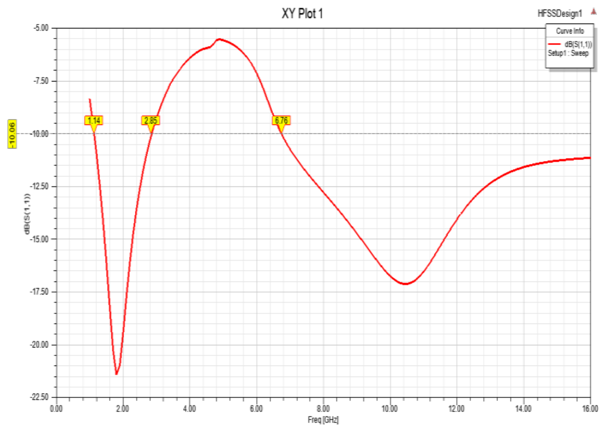
iv) Dielectric constant =2

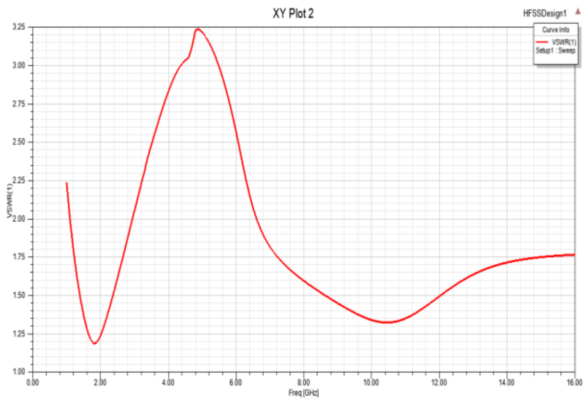






v) Dielectric constant =6





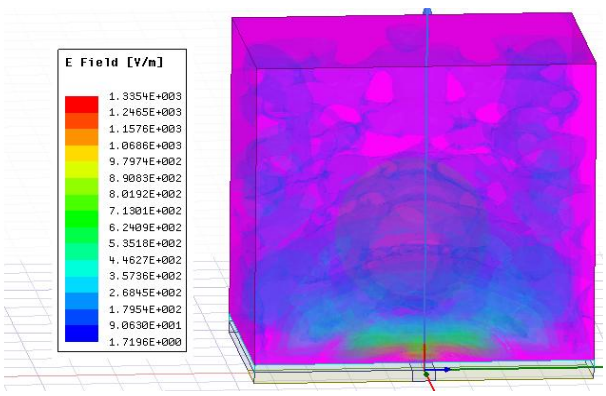
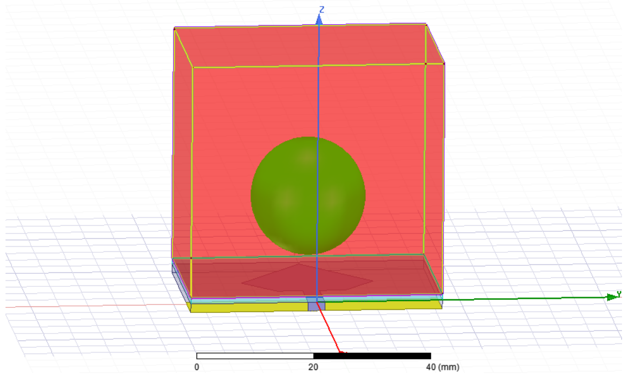
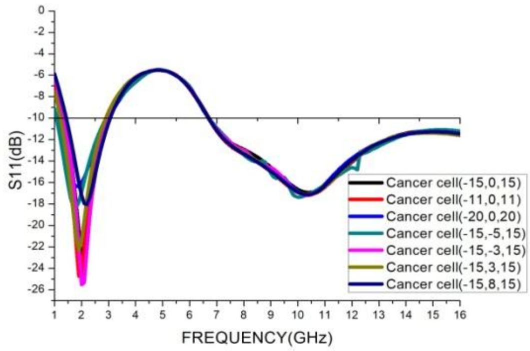


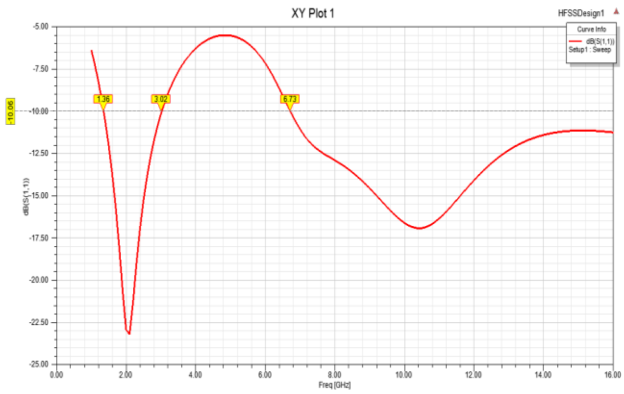
Fig .16 Return Loss, VSWR and field distribution of with different Dielectric constants

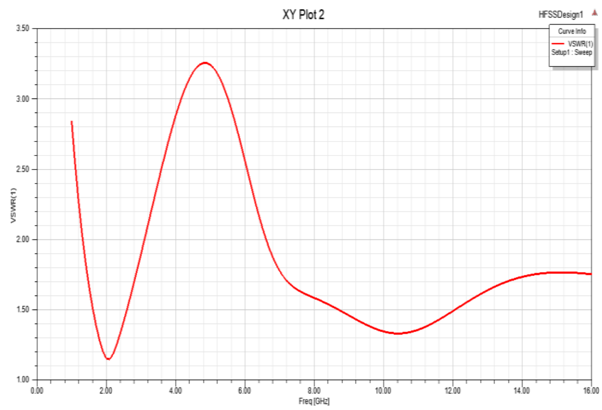
B) SAR for Breast Tumor Model with Tumor at different cell positions





1.Cancer cell position(-15,0,15)





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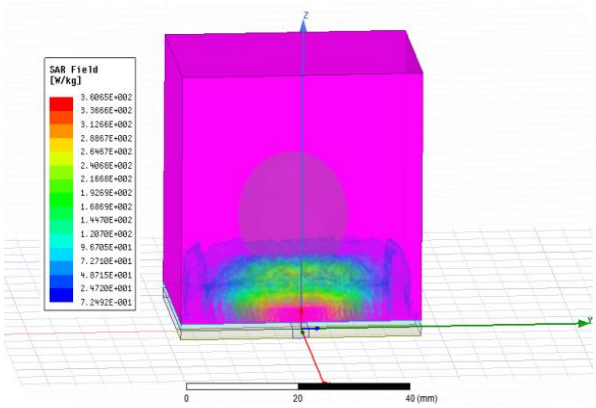
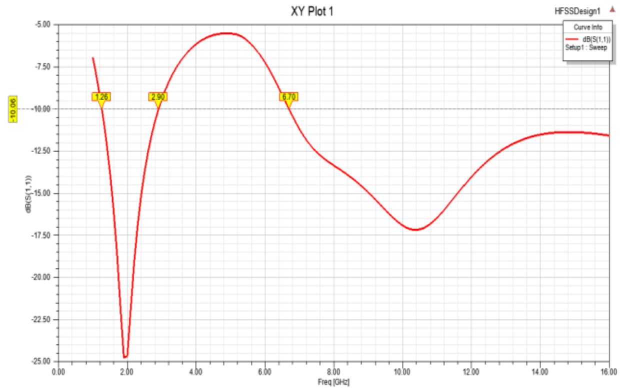
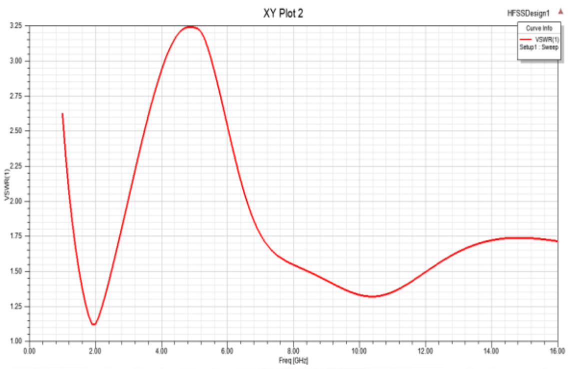
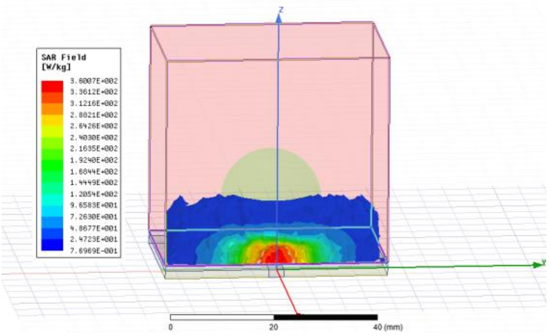


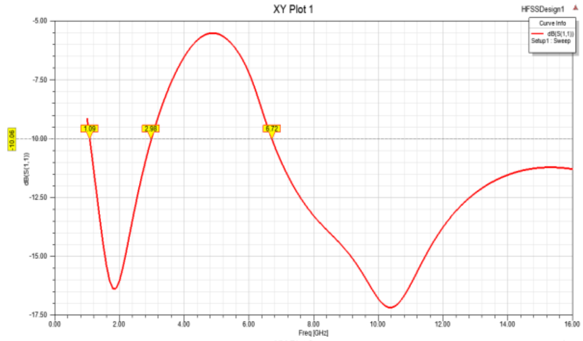
2. Cancer cell position(-11,0,11)

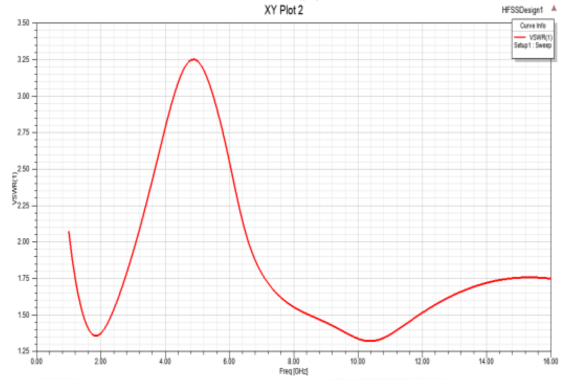


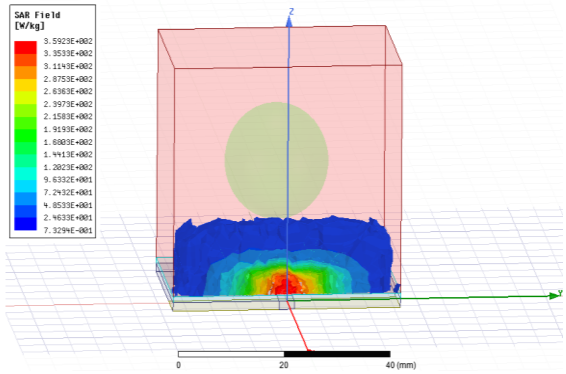




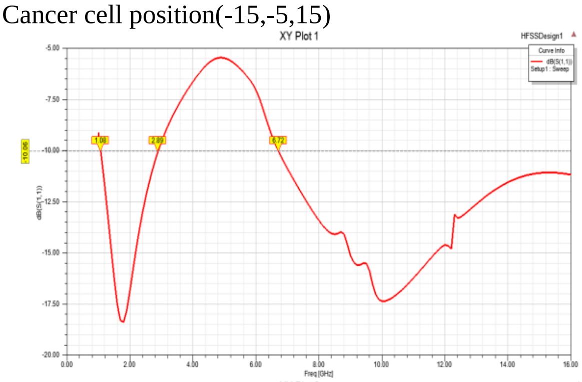
3. Cancer cell position(-20,0,20)

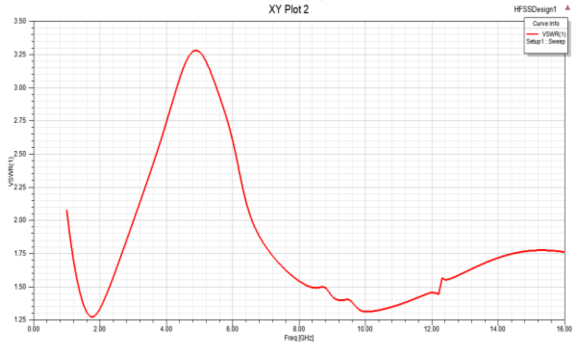






4. Cancer cell position(-15,-5,15)





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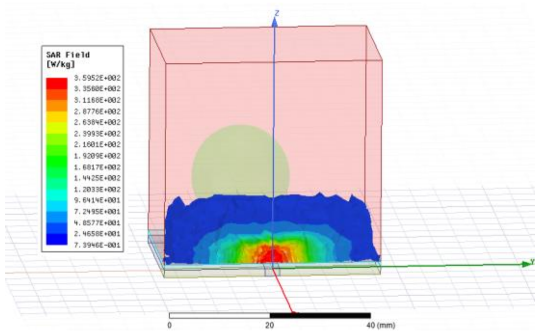
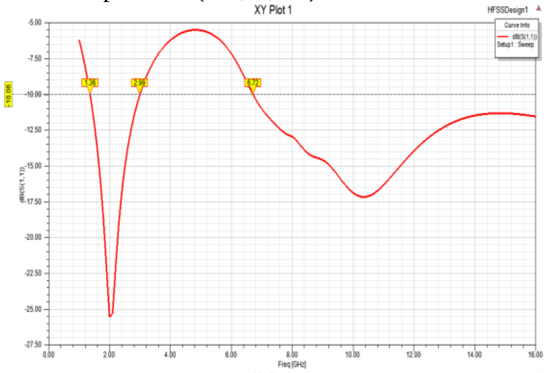
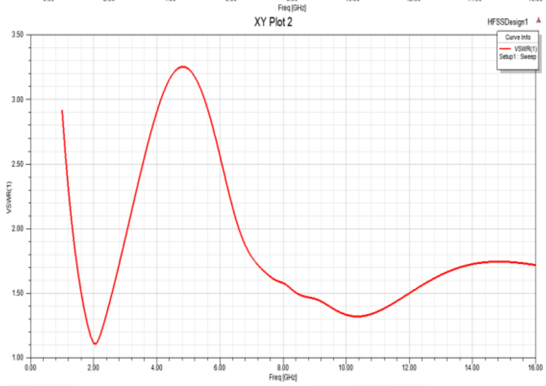
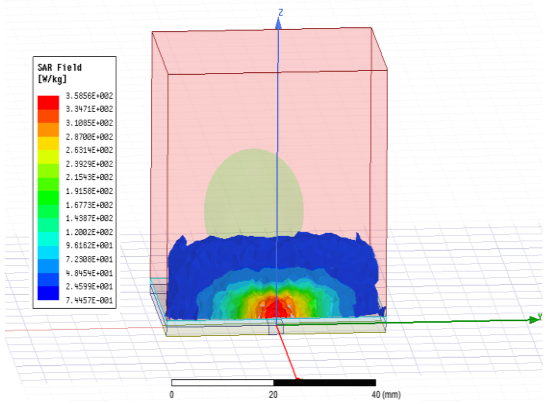


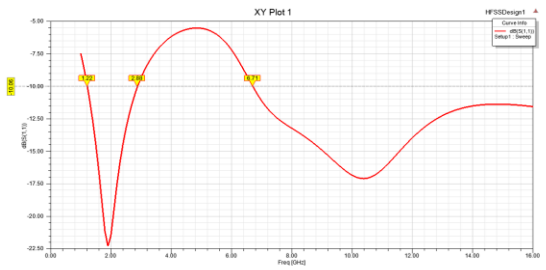
5. Cancer cell position (-15,-3, 15)

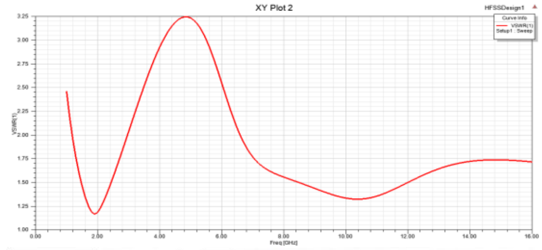


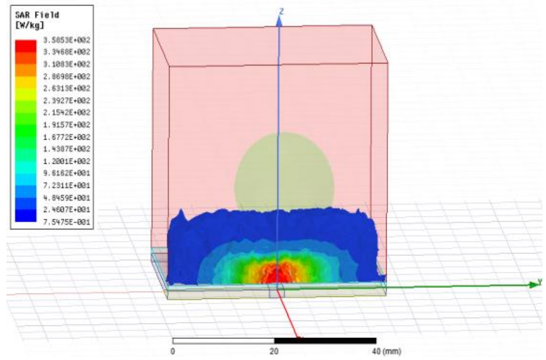




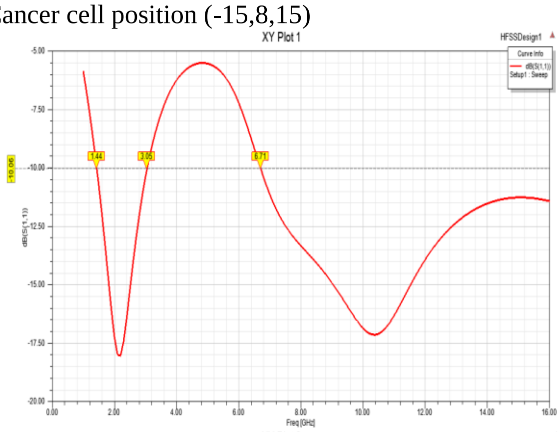
6. Cancer cell position (-15, 3, 15)

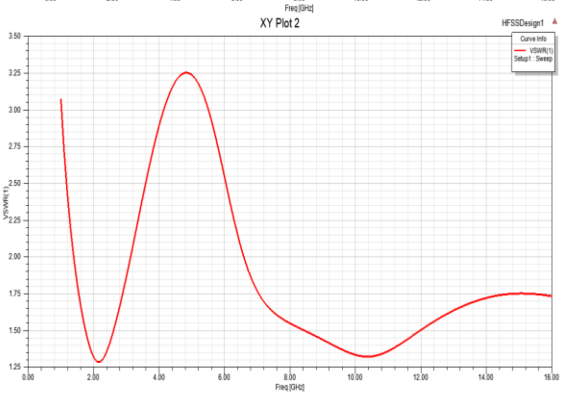






7. Cancer cell position (-15,8,15)





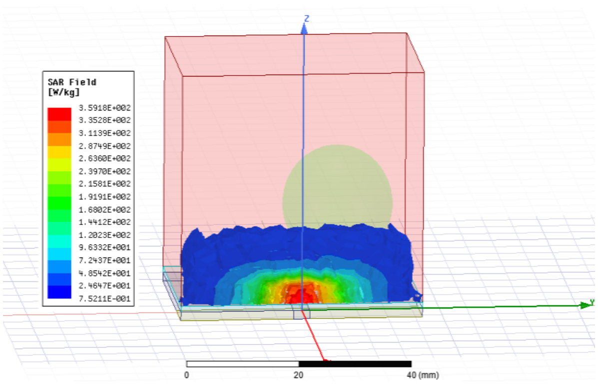


Fig.17 SAR for Breast Tumor Model with Tumor at different cell positions

Table:2. Comparison of different parameters at different cancer cell positions.

S.No	Cancer cell position	Return loss (in dB)	Resonant Freq (In GHz)	VSWR	SAR (W/Kg)
1	(-15,0,15)	-23.15 -17.26	2.1 10.45	1.15 1.41	0.724
2	(-11,0,11)	-24.81 -17.34	1.97 10.32	1.11 1.32	0.769
3	(-20,0,20)	-16.86 -17.42	1.91 10.40	1.35 1.26	0.732
4	(-15,-5,15)	-18.42 -17.49	1.78 10.00	1.27 1.31	0.739
5	(-15,-3,15)	-25.25 -17.48	2.00 10.41	1.1 1.4	0.744
6	(-15,3,15)	-22.46 -16.45	1.98 10.43	1.17 1.32	0.754
7	(-15,8,15)	-17.15 -18.127	2.2 10.4	1.28 1.32	0.752

The antenna is modeled on Ansoft HFSS software and gain of the antenna was found slightly more than 8 dBi at central frequency 6 GHz. A prototype of the patch antenna is designed with a substrate FR-4 and thickness 1.6 mm for the practical realization. The VNA E 5071C vector network analyzer was used for practical measurements.

V. CONCLUSIONS

In this design of a pentagon patch antenna for breast cancer detection, directly way on human breast model. In the simulation it has chosen different dielectric constants and observed return loss and VSWR using HFSS software and fabricated with substrate FR-4 with relative permittivity (ε_r) 4.4 and 1.6 mm thickness also the varied at different cell positions. It is pointed out that there is a frequency shift between the normal breast model and the one simulated with tumor. The pentagon patch antenna measured on a normal breast phantom. It is clear, that is a good concurrence between the simulated and measured results.

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