International Journal of Engineering, Science and Mathematics
Vol. 7 Issue4, April 2018, (Special Issue NCIME)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed
Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

ANTENNA ARRAY FOR MICROWAVE IMAGING TO DETECT BREAST CANCER

M.VIJAY, G.PARAMESWARAN, S.SIVASAKTHI, D.MARAN

ASSISTANT PROFESSOR, DEPARTMENT OF ECE, TRP ENGINEERING COLLEGE, TRICHY

ABSTRACT

Microwave imaging for breast cancer detection is based on the contrast in the electrical properties of healthy fatty breast tissues. This paper presents an industrial, scientific and medical (ISM) bands comparative study of five micro strip circular- rectangular patch antennas for microwave imaging at a frequency of 3-4 GHz. The choice of one antenna is made for an antenna array composed of 6 antennas for a microwave breast imaging system. Each antenna element is arranged in a circular configuration so that it can be directly faced to the breast phantom for better tumour detection. This choice is made by putting each antenna alone on the Breast skin to study the electric field, magnetic fields and current density in the healthy tissue of the breast phantom designed and simulated in a soft High Frequency Simulation Software (HFSS).

Index Term - ISM band, circular- rectangular patch, circular array, microwave breast imaging, tumour detection, HFSS.

INTRODUCTION

Breast cancer is the most prevalent type of cancer among females in the globe [2][3] which is generally a fast cell growth within the breast tissue, usually in the epithelium of the lobules and ducts. It can also circulate to other parts of the human body if it is a metastatic breast cancer [4][5]. These cancer cells can propagate to other parts of the body, such as liver, lungs, bones and brain. The cancer cells divide up and become taller out of control, thus forming new tumour Even though the new tumours are getting bigger in another part of the body, it is still always a breast cancer. Since the last medical examination of breast cancer in 2008, cases of this type of cancer are rising by more than 20%, with 14 % of mortal cases[2]-[7].

In 2012, 1.7 million women were diagnosed with breast cancer all over the world [7]. This tumour is now considered as the most commonly diagnosed tumours among women and an inevitable concomitant of death with 522 000 death cases. To downsize the risks of breast cancer mortality, we should diagnose the appearance of the malignant tissue in healthy tissues and treat this serious illness in its early stages. To quickly identify the presence of breast tumour, we are going to proceed with the study of microwave breast imaging (MBI).This technique has been widely used especially for biomedical diagnosis[9]-[10]. The principle behind the MBI consists of using a transmitter microwave signal to emit signals inward the breast and receivers to detect those emitted signals after they interact with the breast. In the presence of a tumour, usually with higher dielectric properties than those of the other tissues of the breast, the amount of signal energy scattered by the tumour is higher than the one scattered by the fabrics of a normal breast with no tumour. A model of breast close to the real human breast should be modelled using the A sys HFSS software with a semi-spherical geometric shape. The different dielectric properties of the mammary tissues that make up the breast model should be close to the real breast properties [11]. In this paper, we present the design of an inset-fed circular rectangular patch antenna for microwave imaging using a 3-4GHz signal.

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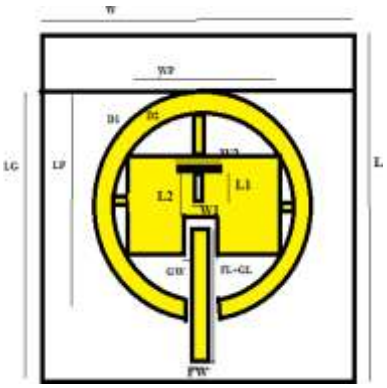

Figure 1: Antenna design parameters

Table 1: Electrical property of breast tissue

BREAST TISSUE	DIELECTRIC	CONDUCTVITY
Healthy tissue	36	4
Skin	9	0.4
Tumor	50	4

MICROWAVE SYSTEM

A. Antenna design

The antenna is a key element in the microwave imaging system. To perfectly detect the tumour, an adapted antenna is required. Our antenna design strategy starts with a basic circular rectangular inset-fed micro-strip patch antenna resonating at 2-5GHz with a total dimension of 37.26x28.82mm on an substrate ROGERS RT/DUROID 5880(tm)with a relative permittivity of 4.4, a width of 65.4mm, a length of 88.99mm, and a thickness of 1.588mm.

Table 2: Antenna Parameters used.

Antenna parameters	Value (mm)	Antenna parameters	Value (mm)
W	65.4	W_2	11.26
L	88.99	W_p	37.2
L_G	63.151	L_1	3.99
D_1	57.483	L_2	13.8
D_2	52.483	G_L	9.57
L_p	28.82	G_W	1
W_1	4	F_L	20
F_W	3.03		

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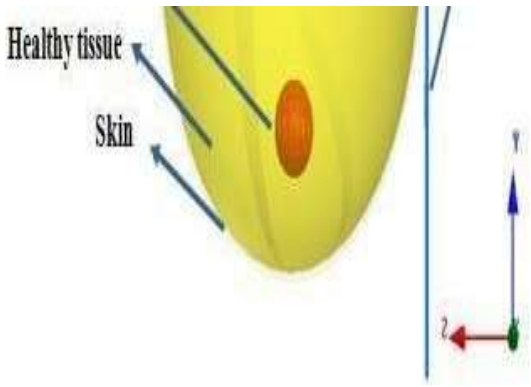


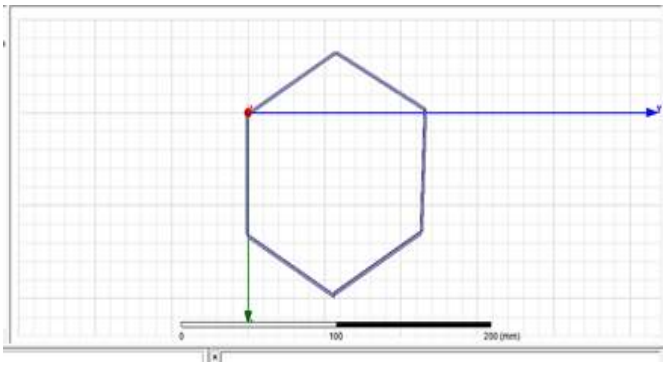
Figure 2: antenna on breast model.

B. Breast phantom design

Different designs of breast phantoms have been used by researchers [12]-[13]-[14]-[15]. All these phantoms are characterized by essential electrical properties which are the relative permittivity and conductivity [5]- [16]. An extended research has proved that there is an important contrariety between healthy and malignant breast tissue properties, specifically in the microwave frequency.
In this paper, however, we adopted a hemispherical shape to model the breast phantom composed of a skin with an outer radius of 70 mm and a thickness of 2mm, a Fatty tissue named healthy tissue with a 68-mm outer radius and a spherical tumour placed in the middle of the breast with a 10-mm radius.

C. Antenna Array

In this section, we study the feasibility of a circular antenna array. To improve the performance of the microwave imaging system, we have chosen to put our circular rectangular patch antenna in front of the simplified breast model to nearly end up in the form of a half sphere to permit more antennas to be placed in the network. We have arranged the array in a circular configuration where 6 antennas are used nearly close to each other, connected to the Lumped ports



(a)

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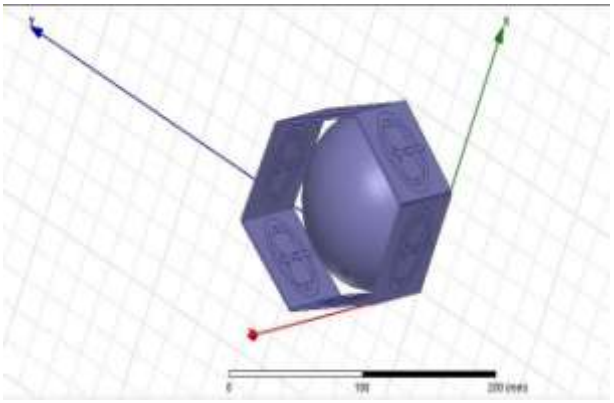

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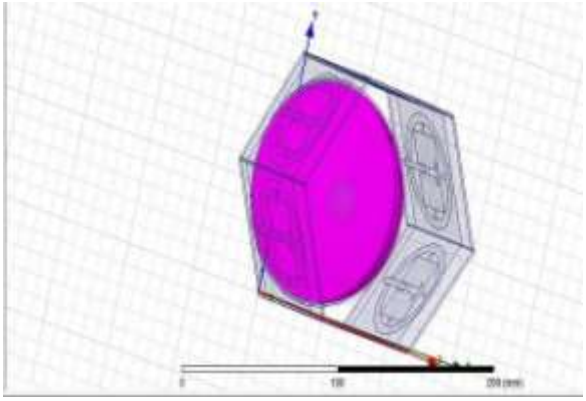

(c)

Figure 3: (a)antenna array, (b)array on breast model without tumour (c) array on with tumour`

SIMULATION RESULTS

The simulation results of the antenna array reveal that it successively performs the radiation pattern in the resonance frequency of 3-4GHz with a peak of 12.23 dB compared with the element antenna with 1.94dB.
The mutual coupling between antennas which shows that they are nearby S21, S31, S41, S51 and S61 and in the desired frequency their maximum part is below - 51dB.
Accordingly, it is clear that this antenna array is adequate for use in the microwave breast imaging (MBI). All the antennas are connected through wave guide ports of 50- ohm impedance. For all the radiators, a discreet port is attached to the feeding point acting as a waveguide port.
We can define the term mutual coupling as the situation when two or more neighbour antennas come close to each other. While one antenna transmits a part of energy, another receives it; and both exist in transmitting and receiving mode. Among the annular array configuration in transmitting mode, the antenna used to radiate a part of energy which is received by the other is known as mutual coupling. Mutual coupling decreases when the distance between neighbour antennas increases.

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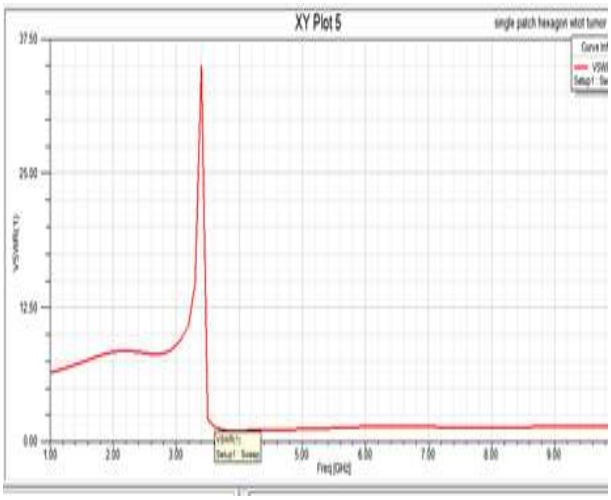

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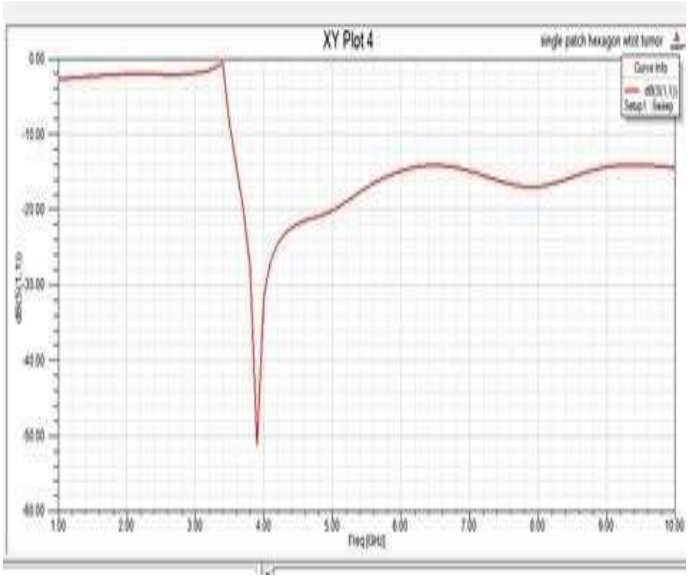

(b)

Figure 4: (a) VSWR, (b) S-parameter.

CONCLUSION

In our Design, We have used 6 patches for the circular array but as of existing array for microwave imaging 8 patches have been used for creating the circular array. This makes power consumption much low as possible. The S-parameter of 8 patches was -31dB and now S-parameter of our design is -51 dB. This is because of substrate Rogers RT/duroid5880(tm) and the patch of rectangle is change into Circular-Rectangular patch. The usage of Circular-Rectangular patch have made our antenna efficiency more even better.

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