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DESIGNING THE ANTENNA FOR ISM BAND APPLICATION

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ABSTRACT

Breast cancer is the most common cancer among women according to WHO. However, early diagnosis is the most important parameter to detect and interfere with cancer tissue. Some of methods for breast cancer detection are X-ray mammography, MRI ultrasound and microwave imaging, etc. Microwave imaging to detect breast cancer is a promising method to show a potential for detecting malignant tumors in the breast. In this work, a 3D breast structure has different permittivity and conductivity is modeled in HFSS by using Finite Element Method (FEM) to solve electromagnetic field values and a micro strip patch antenna operating at 2.45 GHz is designed and substrate material is FR4 (ε_r=4.4F/m). The antenna is best suited because it possesses a wide input bandwidth, stable radiation patterns and a good front-to-back ratio. In order to obtain high resolution, accurate images the antennas must be able to radiate signals over a wide band of frequencies while maintaining the fidelity of the waveform over a large angular range. This process depends on overcoming three problems: Achieving high resolution, overcoming the high attenuation in human tissue, to permit the detection of relatively deep-seated tumors, preventing reflections from skin, bones and other anatomical features (clutter) obscure the signals from tumors.

Keywords: Micro strip patch antenna, breast cancer, cancer detection, HFSS;

I. INTRODUCTION

The current Indian population is 1,270,272,105 (1.27 billion).The incidence of cancer in India is 70-90 per 1, 00,000 populations. And cancer prevalence is established to be around 2,500,000 (2.5 million) with over 800,000 new cases and 5, 50,000 deaths occurring each year. More than 70% of the cases present in advanced stage accounting for poor survival and high mortality. About 6% of all deaths in India are due to cancers which contribute to 8% of global cancer mortality. There are many factors to affect this such as life-style, foods, contamination, stress and undefined things. Breast cancer type is the most common cancer type among women. A lot of women suffer from this disease in the worldwide and have many unreturned problems because of not to diagnose early. The most important process before healing is early diagnosis. Early diagnosis has vital importance is reason to return life for many sufferers. Different techniques are currently used to detect breast cancer, e.g., X-ray mammography, ultrasound, magnetic resonance imaging (MRI), microwave imaging, etc. However, they have some negative and undesired sides. Especially for younger women, these methods are not preferred because of ionized radiation. So, microwave Imaging techniques are developed. Microwave imaging is the technique used to sense a

Given object by means of examining microwave pulses. It has been recently proved that it is much useful by providing excellent diagnostic capabilities in several areas which includes civil and industrial engineering and biomedical engineering. Microwave Imaging is the most important technique which offers comprehensive descriptions for the proposed short-range microwave imaging including reconstruction procedures & imaging systems and apparatus enabling.

It creates a path to the researcher to use microwaves for diagnostic purposes in a wide range of applications. The research in the area of application for microwaves in biomedical imaging and diagnostics still exists due to the field remains with many uncharted areas. Even though in the field of medical imaging the microwave community has so far limited contributions, with the exception of magnetic resonance imaging (MRI) systems. In the last two decades, to detect breast cancer mammography has emerged as the golden standard methodology. But still it has some demerits like invasive detection, compression of the breast tissues, radiation and discomfort to the patient which should be rectified and can be rectified in the proposed microwave imaging methodologies.

The microwave imaging in the medical field is an acquisition of human body parts by using electromagnetic waves for cancer detection especially in the microwave region. Experimental studies made on the human tissues show significant contrast in dielectric properties between the malignant tumors and normal fatty tissue at microwave frequencies. Main aim in the microwave imaging is to achieve non-ionizing detection, increased the sensitivity of tumors specific to malignancies and gives comfort to the patient.

In digital mammogram, images are composed by applying the concentration of X-rays over a breast using illumination process. The concentration of X-ray will give white region for fibro glandular tissues and black region for breast tissues. Maximum part of the fatty breast consists of fibro glandular regions. So the discovered tumor part using X-ray Illumination is also gives white regions. It not shows much difference between the breast tumor and breast fatty tissues. This is the one main disadvantage of the mammogram methodology. To

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detect cancerous breast tissue, (Wang & Huang, 2012) designed a MIMO antenna structure and evaluated microwave imaging results. To obtain microwave imaging by radiating into breast tissue, a single layer micro strip patch antenna structure was designed. In this paper, inset fed antenna structure as a rectangular micro strip patch antenna is used for the purpose of microwave imaging over detecting cancerous tissue into breast structure and so, a simple 3D breast structure is modeled to define cancerous tissue. 3D breast structure is designed and implemented in HFSS by using Finite Element Method (FEM). ISM band which is used commonly is preferred for investigation. In this work, better simulation results are obtained by modifying ground plane and slotting on micro strip patch. The antenna structure operating at 2.45 GHz is placed under breast skin and differences between electromagnetic field values according to simulations results are evaluated via graphics. Section 2 explains basic antenna design, section 4 and 5 explain simulation & results and conclusion, respectively.

II. ANTENNA DESIGN & IMPLEMENTATION

2.1 Microstrip Patch Antenna Design Procedure

The three essential parameters for the design of a rectangular Microstrip Patch Antenna are:

2.1.1 Frequency of operation (FO)

The resonant frequency of the antenna must be selected appropriately.

2.1.2 Dielectric *constant of the substrate (εr):*

The dielectric material selected for my design is FR4 which has a dielectric constant of 4.4. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

2.1.3 *Height of dielectric substrate (h):*

For the microstrip patch antenna to be used in medical application, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.5 mm.

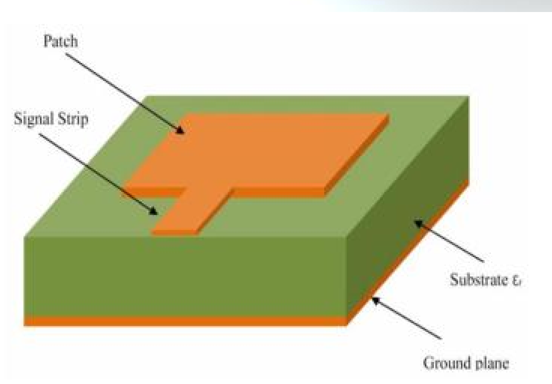

Fig 1: Rectangular micro strip patch antenna

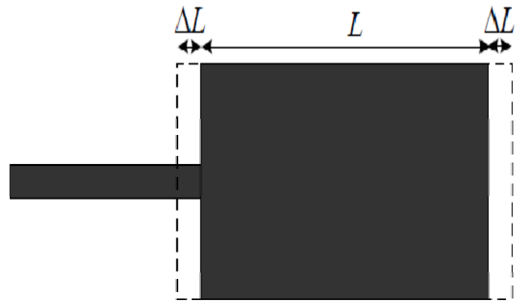

Fig 2: Basic structure of micro strip patch

Step 1: Calculation of the Width (W): The width of the Microstrip patch antenna is given

$$w = c/2fo\sqrt{}(\epsilon r+1)2m$$

Step 2: Calculation of Effective dielectric constant (εreff): the effective dielectric constant as:

$$\epsilon reff = \epsilon r+1/2+\epsilon r-1/2(1+12h/w)^{-1/2}$$

Step 3: Calculation of the Effective length ($Leff$): gives the effective length as:

$$\mathrm{Leff} = c/2fo\sqrt{\varepsilon\, reff}$$

Step 4: Calculation of the length extension (ΔL): the length extension as:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

Step 5: Calculation of actual length of patch (L): The actual length is obtained by re-writing as:

$$L = L_{eff} - 2\Delta L$$

2.2 Antenna Methodology

Body area network (BAN) consists of wearable or implantable sensors that can establish two way wireless communication with a controller node that could be either worn or located in the vicinity of the body which has been properly considered the design phase of antenna. For wearable sensors nodes, the antennas adjacency to the body and more precisely its location (e.g. head, chest, waist and wrist) and distance to the body surface can affect the radiation pattern, radiation efficiency, and resonance frequency. This could directly impact communication link between the sensors and communication node in the body area network. But better results are obtained only by placing in chest.

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The difficulties arise from the X-ray mammography is the small intrinsic contrast between diseased and normal tissue at X-ray frequencies. Breast compression is required to reduce image blurring and to create uniformity of tissue between the source and receiver located on breast. The association of X-ray mammography with uncomfortable or ionizing radiation may reduce patients' compliance with screening recommendations. These concerns motivate to develop the microwave imaging technique for detecting breast cancer is the significant contrast in the dielectric properties at microwave frequencies of normal and malignant tissue

Two different methods of active microwave imaging techniques exploit the contrast in dielectric properties: Tomography methods and backscatter methods. The goal of microwave tomography is the recovery of dielectric properties of the object from measurements of microwave energy transmitted through the object. The challenge of it involves the solution of an ill conditioned nonlinear inverse scattering problem. As a result, these are inherently limited by vulnerability to small experimental uncertainties and noise. Furthermore reconstruction, the inverse scattering problem requires image reconstruction algorithms that may be computationally intensive.

Considering the backscatter methods, it uses the measured reflected signals to interfere the locations of significant microwave scatters. Scattering arises from significant contrasts in dielectric properties. This is unsuccessful because a single antenna location was used to transmitting and receiving, eliminating the possibility of spatially focusing the signal. Without the spatial selectivity obtained by focusing, the tumor signature can be easily masked from adjacent breast regions. The relative arrival times and amplitudes of the backscattered signals provide information that is used to determine the location. It only seeks the location of strong scattered rather than attempting to completely reconstruct the dielectric properties.

2.3 Antenna Geometry

The planar monopole antenna with various design parameters were constructed, and the numerical and experimental results of the input impedance and radiation characteristics are presented. The simulated results are obtained using the Ansoft simulation software high-frequency structure simulator (HFSS). The basic antenna structure consists of a square patch, a feed line, and a ground plane. The square patch has a width W. The patch is connected to a feed line of width W_f and length L_f.

The optimal dimensions of the designed antenna are as follows:

Wsub= 12 mm, L sub = 18 mm, W = 10 mm, Wf= 2 mm, Lf= 7 mm, LPS = 2 mm,LS3 = 5 mm, WS2=6mm, LS2 = 1 mm, WS1 = 2 mm, LS1 = 3 mm, WS = 1 mm, LS = 2 mm, WP = 1 mm, LP = 2:5 mm, WP1 = 3 mm, LP1 = 2 mm, WP2 = 10 mm, LP2 = 3:5 mm, LgS= 4:5 mm, and Lgnd= 3:5 mm.

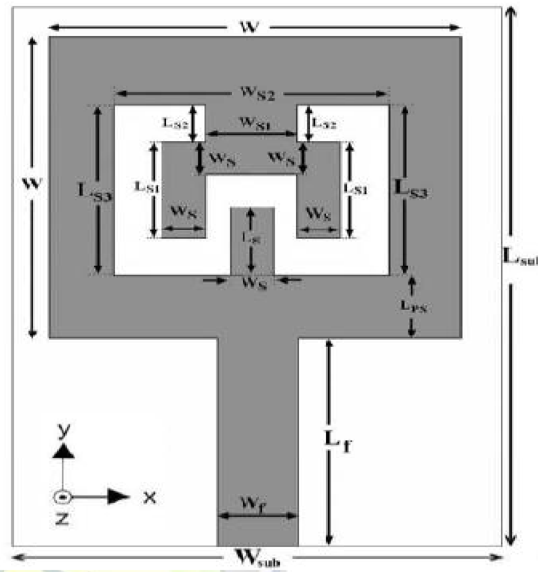

Fig 3: Antenna Geometry using HFSS

The current concentrated on the edges of the interior and exterior of the W-shaped slot. As a result, the desired high attenuation near the desired frequency can be produced. The variable characteristics can be achieved by carefully choosing the parameters (LS1 and WS2) for the W-shaped slot. In this structure, the width WS2, is the critical parameter to control the bandwidth. On the other hand, the center frequency of the notched band is insensitive to the change of WS2.The resonant frequency of the band is determined by LS1.

2.4 The Finite Element Method

Ansoft HFSS utilizes the 3D full-wave Finite Element Method (FEM) with adaptive meshing to compute the electrical behavior of high-frequency and high-speed components. It can be used to calculate antenna parameters such as S Parameters, radiation pattern, gain, current distributions, fields, efficiency etc. The Finite Element Method is well-established and widely used for the time-harmonic solution of Maxwell's equations. The unstructured nature of the time domain version of FEM gives a clear advantage over numerical computational methods in modeling complex antenna geometries.

The main idea behind the FEM is to solve Boundary Value Problems (BVP)'s governed by a differential equation and a set of boundary conditions. The interpolation or shape functions must be a complete set of polynomials. The accuracy of the solution depends, among other factors, on the order of these polynomials, which may be linear, quadratic, or higher order. Christo Ananth et al. [5] discussed about E-plane and H-plane patterns which forms the basis of Microwave Engineering principles.

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2.5 Antenna Design Methodology

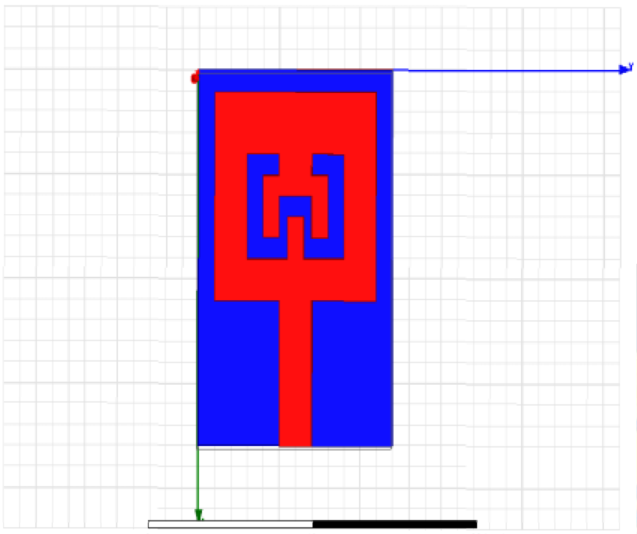

Fig 4: Top view of the proposed antenna model

The fig 4. Shows W slot patch antenna model used for the ISM band application.

2.5.1 Selection of Materials

Substrate Material - FR4 (εr=4.4)
Ground Material - Pec (εr=4.4)
Patch Material - Pec (εr=4.4)

2.5.2 Feeding Method

Micro Strip Line Feed

To design the rectangular micro strip patch antenna the measurement takes are given below.

Lg=18mm, Wg=12mm, Hg=-0.05mm
Ls=18mm, Ws=12mm, Hs=1.5mm
Lp=10mm, Wp=10mm, Hp=1.033mm

Where

Lg -Refers to the Length of the Ground Material,
Wg-Refers to the Width of the Ground Material,
Hg -Refer to the height of the Ground Material.
Ls-Refers to the Length of the Substrate Material,
Ws -Refers to the Width of the Substrate Material,
Hs -Refer to the height of the Substrate Material.
Lp - Refers to the Length of the Patch Material,
Wp -Refers to the Width of the Patch Material,
Hg -Refer to the height of the Patch Material.

2.5.3 Types of Feeds

a) Feed 3D

L_{3f}=7mm, W_{3f}=2mm, H_{3f}=1.033mm

b) Feed 2D

W_{2f}=2mm, H_{2f}= -1.5mm

Where

L_{3f} - Refers to the Length of the 3D Feed,
W_{3f} - Refers to the Width of the 3D Feed,
H_{3f} - Refers to the height of the 3D Feed.
L_{2f} - Refers to the Length of the 2D Feed,
W_{2f} - Refers to the Width of the 2D Feed,
H_g-Refers to the height of the 2D Feed.

The substrate thickness of the proposed antenna model is about 1.5mm. And the patch thickness is considered as about 1.033mm. The thickness of the ground is about -0.05mm.

2.6 Fabricated Antenna

Fig 5: Fabricated antenna

The feeding method of this antenna is a co-axial feed line.

III. SIMULATION AND RESULTS

3.1 Return Loss

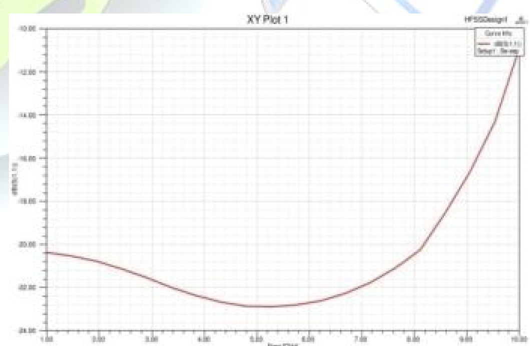

Fig 6: Return Loss Plot

Based on the design parameters proposed antenna was first modeled and simulated using Ansoft simulation software High-Frequency Structure Simulator (HFSS) and its characteristics were analyzed. Measured return loss curve of proposed antenna

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is shown in Figure Has < -10 dB return loss from 4.5GHz to 11.6 GHz.

3.2 Y Parameter

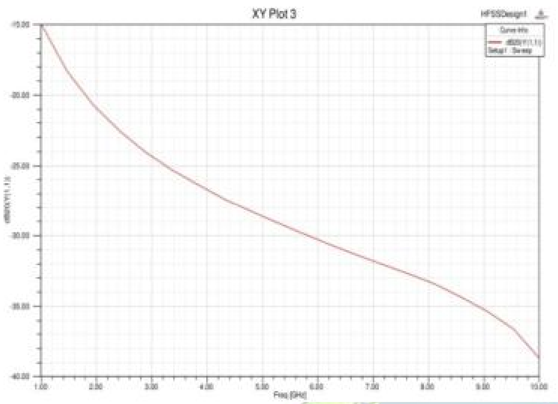

Fig 7: Y Parameter Plot

Measured Y parameter plot for the proposed antenna achieves a better result in the frequency range 4.5GHz to 11.6 GHz.

3.3 Z parameter

Fig 8: Z Parameter Plot

Measured Z-Parameter plot for the designed antenna has nearly 50 ohm impedance for majority of the region (real part) and the reactive part at almost zero.

3.4 VSWR

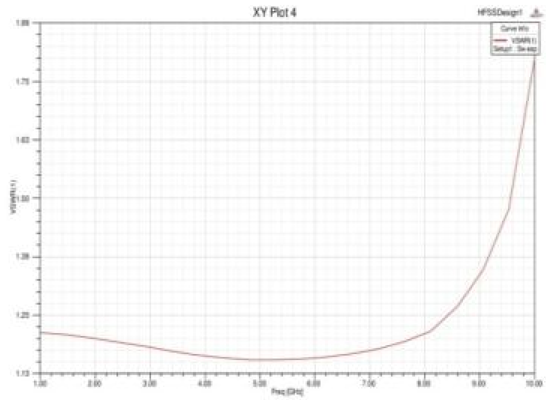

Fig 9: VSWR Plot

Measured VSWR for the proposed antenna are shown in figure 6.6.from the figure measured VSWR =~ 1 from 4.5GHz to 11.6 GHz show that antenna has good performance in minimizing standing waves with better impedance matching.

3.5 Zo Parameter

Fig 10: Zo Parameter Plot

3.6 Radiation Pattern

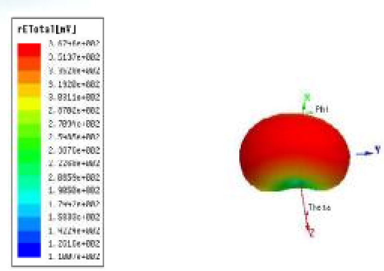

Fig 11: The Radiation Patterns in the Azimuth Plane (X-Y Plane)

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The Measured radiation patterns of the designed antenna are shown in figure11.As seen the radiation patterns in the azimuth plane (x-y plane) are Omni-directional.

3.7 Comparison between the W Shape Patch and Rectangular Antenna

PARAMETERS	RECTANGULAR PATCH	W SHAPE PATCH
Height of the substrate (mm)	1.5	1.5
Relative permittivity (Ɛr)	4.4	4.4
Patch Width(mm)	30	10
Patch Length(mm)	20	10
Ground Width(mm)	50	12
Ground Length(mm)	50	18
Return Loss(dB)	-15.1874	-22.8911
VSWR(dB)	1.4214	1.1544
Resonance Frequency (GHZ)	2.54	2.54

IV CONCLUSION AND FUTURE WORK

The influence of the human body on the radiation pattern of a wearable antenna for different antenna locations on the body surface was studied. Other than the location of the antenna, other factors consider in our study were antenna separation from the body surface (0 to 20mm range) the antenna gain pattern depends on the exact location and distance of the antenna from the body. Intelligent antenna design is the key to establish communication links to adequate range and acceptable quality. Also the deeply seated tumors of less than 0.5mm were detected successfully in the frequency range 4.5GHz to 11.6 GHZ. While investigate SAR issues for wearable node communication, the microstrip patch antenna design was modified by including band gap to achieve better results. Because the specific absorption ratio of human body and the distance between the antenna and tumor will affect the accuracy of detection. Further experimental studies and comparison with phantom models are required to validate the results obtained here.

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