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Microwave Antenna for Brain Tumour Sensing Research System using Image Processing

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Abstract:- A 3D smicrostrip spatch santenna is designed using the computer simulation technology software. Along with sit the head phantom is screated. Then a tumour of 4mm3 is placed sinside sthe shead sphantom. This stumour sintroduced based on the relative permittivity. By susing Human Head Imaging the size of the antenna and other parameters are introduced. The antenna is placed side of the head, then a RF signal is sent to through the antenna. A reflecting beam is placed on the other side of the head, these reflecting signals are received by the antenna substrate. The results are based on the specific absorption rate (SAR). During the simulation the results of SAR with tumour and without tumour are compared.

Keywords- RF, HHI, CST, SAR.

I. INTRODUCTION

A microstrip antenna has a metal sheet on the surface of the printed circuit board, on the side it has a ground plate. Through the transmission lines it is connected to a transmitter or a receiver. The RF current is applied to the antenna and the ground plane. The patch antenna is a broadband wide bean antenna that is inserted into the etching process of the metal antenna element attached to a dielectric substrate.

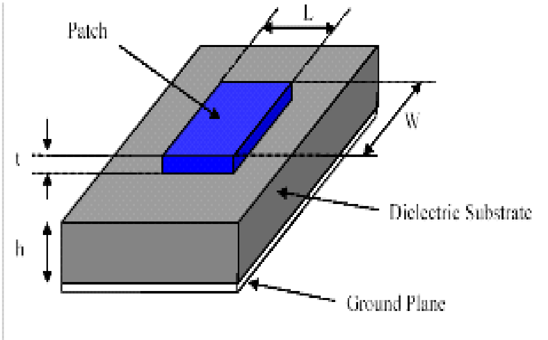

Fig 1. Microstrip antenna

A microstrip antenna has a dielectric substrate which is rectangular or circular or square in shape. Generally the rectangular one is considered, since it has high directivity gain. On the top of the substrate a patch is placed which is made of copper. The patch has a length “L”, width “W”,and thickness “t”. The substrate has a height “h”. and the bottom of the antenna is grounded. There are two types of feeding techniques, contacting and non contacting type. In the contacting type the feed is directly attached to the patch, where as in non-contacting type the feed is given either by electrically or magnetically. The contacting type consists of microstrip feed line and coaxial feeding techniques. But in the proposed design, we considered the coaxial feed, since it is accurate in impedence measurements. In the proposed antenna design the shape of the patch is U-shaped, since it is helpful in current losses. A signal is sent from the antenna through the brain and it reaches through to the other side. On the other side there is a reflector beam, which reflects back the signal and the reflected signal is collected by the antenna and it is analysed by the vector network analyser.

II. LITERATURE SURVEY

There are several types of antenna which had been proposed earlier. For example, the UWB (Ultra-Wide Band) antenna which has a return loss of -49 dB which was proposed by Fitri Yuli Zulkifi. This model is used to detect whether the cancer is present or not. A UWB Vivaldi antenna is used in this design. Based on the S11 parameters the antenna is simulated. The operating frequency is 5.8GHz. The software used for tis process is CST. The only disadvantage of this type is more radiation.

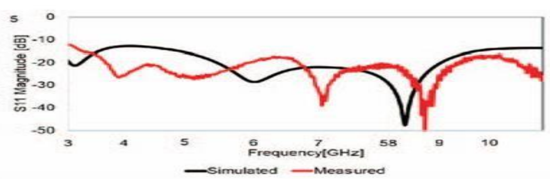

Fig 2. The S11 parameters.

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The another type of the antenna is the hexagon novel antenna which operates at a frequency of 2.4 to 2.48GHz. In this type based on the return loss, VSWR, radiation pattern Are measured. It has -29dB return loss at 2.43 GHz. In the biomedical applications the return loss should be minimum. His antenna was proposed by Thenmozhi. The results of this type are accurate. The dimensions of the antenna are $10*10*2mm^3$. the advantage of this system is , it has a very compact size.

	Electric permittivity	*Electric conductivity*
Brain	49.7	0.59
Skull	17.8	0.16
Skin	46.7	0.69

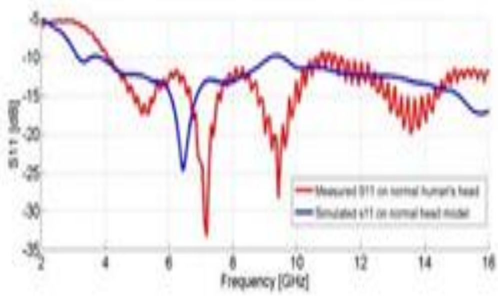

Fig. 3. Return loss

Haoyu Zhang designed an antenna for the detection of the brain cancer. It is an array of 3UWB Vivaldi antenna. The head phantom is created using the computer simulated technology software. It consists of 4 layers. The microwave signals are transmitted into head and reflected back signals are detected by the receiver antenna.

A compact wearable patch antenna was proposed by Leepika to determine the brain tumour. This is used at lower frequencies, since are used at a complicated part of the human body. The dimensions of the antenna are $26*26*5mm^3$. These cancersi are detected based on the specific absorption rate. The operating frequency used is 2.7GHz range which has a reflection loss of -29dBs at 2.7Ghz.

A spiral shape antenna was proposed Annakamatchi which can operate at two different frequencies. The substrate is made with fleece. The substrate has a dielectric constant of 3.3 and permittivity of 1.0. this proposed system is designed using CST and the results were also obtained.

Another type of antenna is the shape of a leaf, which is a dual band antenna which has ultra-high frequencies. It ranges from 1.9 GHz to 2.6GHz. The results are executed using the computer simulation technology software. The results are obtained using return loss, radiation pattern, and bandwidth and are successfully processed.

The next type of antenna is a circular patch antenna which is designed on a multilayer substrate. The operating frequency is 2.5 GHz to 5GHz range. This is proposed to detect the blood flow and heart monitoring. The return loss of 30dB is obtained at 2.5 GHz.

The next proposed antenna is a bowtie antenna in which the substrate is made of 3 different type of materials. The antenna is determined based on the S11 parameters and radiation pattern. The working of this type of antenna is compared, When it is in the free air condition and when it is used on the human parts. This type of antenna has more applications in the medical field and in the electronic industries.

The novel antenna which is a wearable one that is used for the clothing has been implemented. In this the ground and the radiating substances are made up of copper for better conductivity. This antenna has a good amount of a gain, returnloss and efficiency. But the antenna is very large which is the only disadvantage in this model.

III. DESIGN OF THE PROPOSED 3-D STRUCTURE

Microstrip feeding technique reduces non-essential radiations produced by another feeding method; therefore, it applies to the design structure. In addition, thanks to the direct connection of the transmission line to the substrate and the patch, impedance matching is facilitated. The lower microwave frequency range depends to a large extent on the total size of the radiating structure. As frequency is reduced, the size of the antenna is reduced. To effectively obtain a low frequency and a miniature size of the antenna, it is necessary to use a folding technique. Figure 1 shows the dimensional shape of the proposed antenna. The proposed substrate is made in the centre of the rectangular plant. The size of the antenna is reduced by connecting a short circuit that is elongated to the ground that will resonate at low frequencies. The width of the short-circuit wall has the equal parameters of radiation plane. The lower patch of the antenna is in the shape of Ü" and is connected to the coaxial feed probe. To have a reduced inductance, the length of the probe must be lowered.

The length of the lower patch is $x = 55.4$ *mm*. The resonance frequency is calculated by using

$$f_r = \frac{c}{L^{x\sqrt{2(\epsilon_r+1)}}}$$

Copper material which is used to make the short circuit is having a length of 2.50mm. The substrate which is present in the model is air; therefore, the structure in the crude copper ground and has a support by the pin which is used for short circuiting

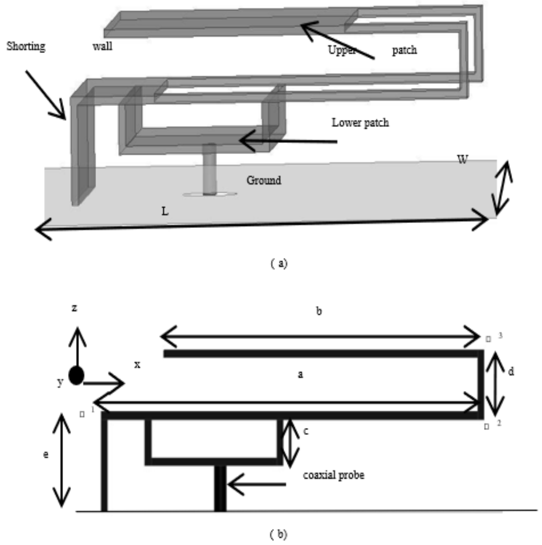

Fig. 2., (a) Proposed Design of antenna, (b) Proposed side view

C=speed of light
f_r=frequency of the resonance band
$\mathcal{E}_r$=relative permittivity
X=length of upper patch

TABLE I

Parameters of the proposed design

a	25	c	5	e	5	L	80
b	25	d	4.6	f	25	W	80

The height of the designed structure is 10.50mm. The probe height is reduced to 3.0mm in order to obtain the smaller size. Figure 1 (b) describes the proposed side 2D side view. The antenna consists of a short circuit wall, a lower patch and an upper patch. When you bend the points, you will get a short-circuit wall supplied with the top piece. Then, at the corners U patch, upper patch is being placed. Around the XZ plane the structure is nearly equal and symmetric in shape. The upper part has a rectangle shape, held by the folded extensions of the lower part. Due to the design parameters, there is no gap among the patches. The height of the square of the floor is equal to total height of antenna. The resonance frequency of the antenna can be modified by using the coupling relationship between the patches. When two patches are attached in one position to have a high directivity, normal to the ground plane of the antenna, then gain is obtained. The patch is actively combined with to the U patch; Therefore, passive coupling with the coaxial probe located below the lower patch will decrease the reactance at the supply voltage point by increasing the resistance of the impedance. The length of the patch has a crucial role in changing the resonance frequency. The impedence can be increased by the coupling between the lower patch and the U-shaped patch and thus results in cancellation of the reactance among them

The computer simulation technology software, is a electromagnetic full wave estimator for the 3D model of the antenna. It also has a very good user interface. CST is used to calculate the parameters such as S11, resonance frequency and electric and magnetic fields. HFSS is a electromagnetic simulator that will analyze the 3D and multilayer structures. CST was the first to use the finite element method (FEM) for the simulation of MS through the development or implementation of technologies such as the Tangent Vector Finite Element, the adaptive mesh and the adaptive Lanczos-Pade (ALPS) scan. S11 parameters, radiation pattern and voltage standing wave ratio are detected by using this method.

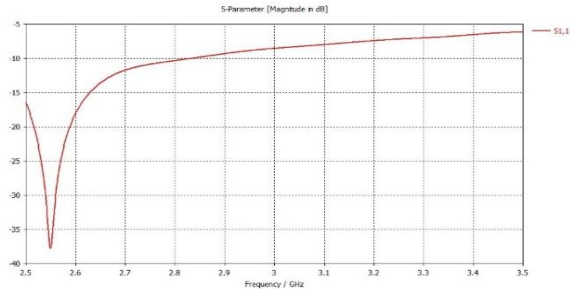

Fig 3. Return loss.

Due to the discontinuity of the transmission line or the optic fiber, there will be a power loss. This is called Return loss. -37 dB in the 2.55 GHz frequency range. The transmission speed used in the design is selected to have a frequency range of 2.7 GHz. When the transmitter is attached to antenna by the help of a feedline, the impedance and the feedline should match for the energy to be maximum.

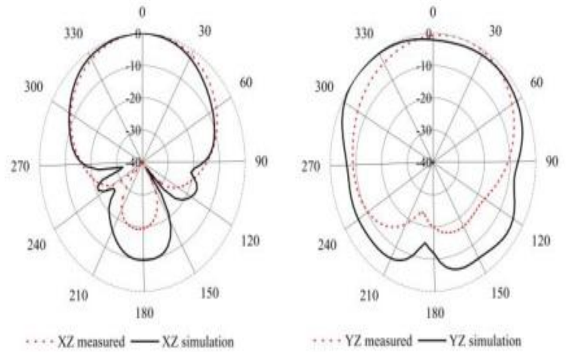

Fig 4. Radiation Pattern.

Figures 3 and 4 illustrate the radiation pattern of the patch antenna. These radiation patterns are estimated using the electric and magnetic current model. The far field is found by the use of the incoming source current. But both the magnetic current model and electric current model will gives the equal output for the far field radiation pattern. At the resonance frequency of the cavity patch pattern every incoming current is measured in the presence of the substrate. Fig 5 shows the 3D radiation pattern of the antenna around at the radius r, at an angle theta. Figure 6 and 7 shows the human head phantom of the 3d structures. One is the head without tumour and the others the head with tumour.

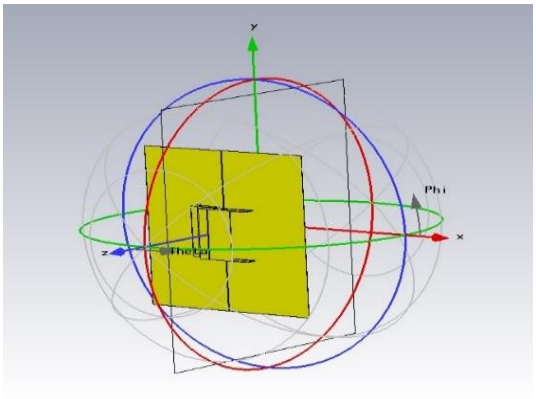

Fig 5. 3Dimensional Radiation Pattern.

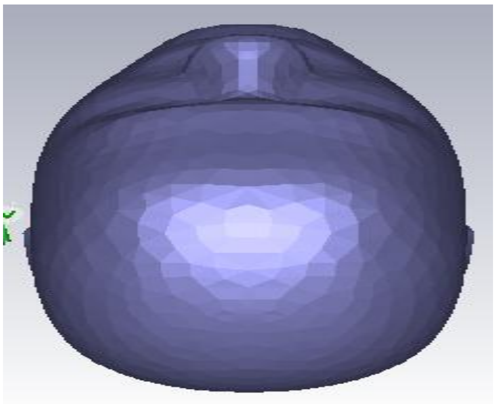

Fig 6. Skull without tumour modelling.

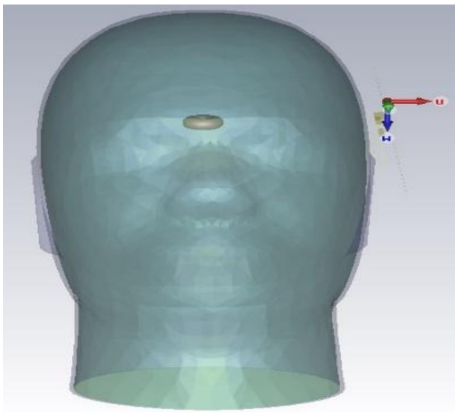

Fig 7 Skull with tumour modelled.

IV. DESIGN PROCEDURE FOR THE SIMULATION

In the process of creating the antenna and using it on an human head phantom there involves 6 steps in implementing the computer design model they are as follows.

1. Creating a 3D geometry

The human head phantom image can be obtained from the preloaded libraries of the software. But the antenna is to be designed according to the design which we have discussed earlier This is done using the CST simulator. The 3D head model is imported from the library files of the software which are integrated in the software.

2. Assign sboundaries

The boundaries are used to measure the 2D results. The head image consists of the many internal layers. The radiation has to travel through the head which should have the prescribed boundaries that are to be estimated at the time of the simulation.

3. Assign sexcitations

After boundaries are applied, excitations are done, which have a greater contact with the output. The excitations are used to determine the exact results at the time of post processing. These excitations have a greater impact on the simulation results. There are many rules that are to be followed during the excitation process. These are mentioned in the separate section in the software.

4. Setup sthe ssolution

During this step, the required operating frequencies are assigned and the parameters of the antenna are given, so the design of the folded structure is made possible. And also the 3-D head image is also inserted in the simulator for the sweep methodologies.

5. Solve

The analysis of the 3D geometry depends upon the time stipulated. The output is calculated in a minute time as soon as possible the results are displayed in the output screen. It is possible to run the simulation that is on the other computer from the one we are currently using. This helps us to reduce the time. This is helpful in running of of storage in the user computer.

6. Post process the results

When the above four procedures are completed, post processing is to be analysed. The compaction in the design, resonance frequencies and the type of the computer that the user uses takes a longer time to be simulated. The post processing is calculated in a very less interval of time. The post processing results are displayed in the output screen. It is possible to run the simulation on the other computer from the one that we are using. This helps us to reduce the time. It also helps us to view the results on the other screens.

V. RESULTS

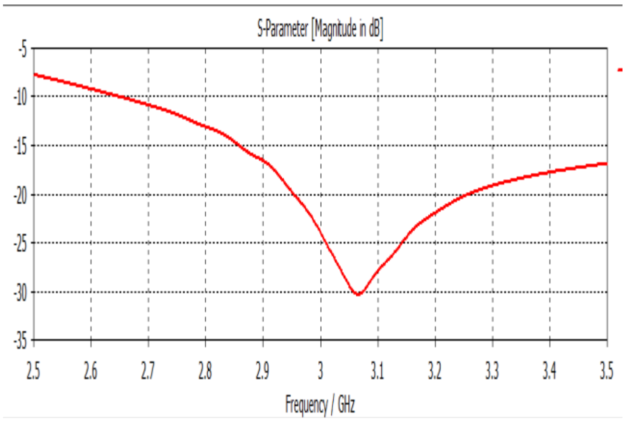

Fig 8. S-parameters without tumour

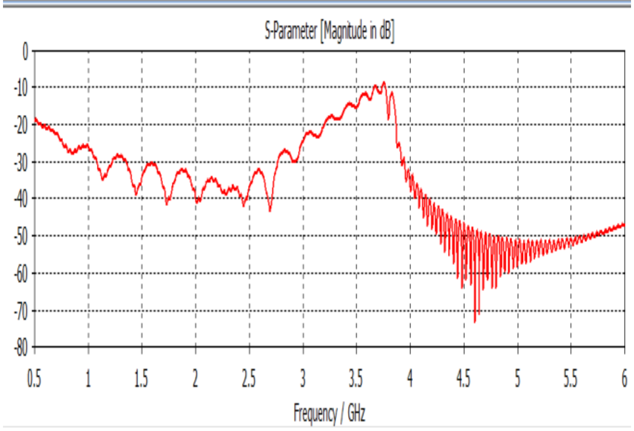

Fig 9. S-parameters with tumour

The Figure 8,9 Shows the S parameters of the brain. In the first case i.e. S-parameters without tumour, the graph is linear, but in case of the S-parameters with the tumour, there are a lot of distortions in the reflected signal. Generally, S11 parameters are used to re

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SAR Calculation Results
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Powerloss density monitor used: loss (f=3.25) [1] at 3.25 GHz
Power scaling [W] : None
Stimulated Power [W] : 0.5
Accepted Power [W] : 0.495295
Average cell mass [g]: 0.239004
Averaging method: IEEE/IEC 62704-1
Averaging mass [g]: 10

Entire Volume:

Min (x,y,z) [mm]: -458.62, -474.741, -774.741
Max (x,y,z) [mm]: 833.36, 774.741, 474.741
Volume [mm^3]: 2.22313e+009
Absorbed power [W]: 9.91352e-008
Tissue volume [mm^3]: 5.24992e+006
Tissue mass [kg]: 5.24992
Tissue power [W]: 8.46537e-008
Average power [W/mm^3]: 1.61248e-014
Total SAR [W/kg]: 1.61248e-008

Fig 10. SAR without tumour.

Figure 10 shows the SAR value of the phantom brain. When there is no tumour, it shows the lower specific absorption rate.

Figure 11 shows the SAR value of the Phantom brain. When there is a tumour, it shows the higher specific absorption rate

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SAR Calculation Results
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Powerloss density monitor used: loss (f=2.7) [1] at 2.7 GHz
Power scaling [W] : None
Stimulated Power [W] : 0.5
Accepted Power [W] : 0.499974
Average cell mass [g]: 0.0543158
Averaging method: IEEE/IEC 62704-1
Averaging mass [g]: 10

Entire Volume:

Min (x,y,z) [mm]: -458.62, -474.741, -774.741
Max (x,y,z) [mm]: 833.36, 774.741, 474.741
Volume [mm^3]: 2.13909e+009
Absorbed power [W]: 3.01756e-005
Tissue volume [mm^3]: 5.24992e+006
Tissue mass [kg]: 5.25
Tissue power [W]: 2.87697e-005
Average power [W/mm^3]: 5.48003e-012
Total SAR [W/kg]: 5.47995e-006

Fig 11. SAR with brain tumour.

VI. CONCLUSIONS

Thus, the tumor was detected and patch antenna is designed which can be used up to 2.7GHz frequencies. The proposed antenna has five bands, supports 2.55 GHz, Hence this antenna is used in the biomedical applications in super high frequencies. A patch antenna is simulated for single frequency band applications with the SISO technique.

VII. FUTURE WORK

To compare the loss of feedback and the VSWR value of a microstrip patch antenna with microstrip line technique and microstrip patch antenna with coaxial power line in a frequency range between 2 and 4 GHz. And design this ground plane Microstrip antenna patch using the microstrip feed method. The results of the studies were also used to propose a methodology to design other frequency bands.

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