Microstrip Patch Antenna for brain tumour detection

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Abstract— *A compact wearable microstrip patch antenna is used for the determination of brain tumour. This antenna is designed at a lower frequency since it is used at a very sensitive part of the body. A microwave wearable antenna is made to analyse the radiation over the body in order to detect the tumor in that particular region. A multiband frequency antenna is designed so that two different applications can be used at two different frequencies. The proposed antenna is designed at a frequency of 2.7 GHZ. The dimension of the antenna is 25 × 25 × 10.5 mm3. The tumour is detected by determining the specific absorption rate. It is the power absorbed per mass of tissues and has units of watts per kilogram. The SAR for the head phantom with tumour and without tumour is determined and then the result is analysed.*

Keywords— **head phantom, SAR, lower frequency.**

I. Introduction

Microwave Imaging in medical field is one of the important diagnosing mechanisms available and it is widely used due to its low side effects and also low cost [4]. The microwave imaging is used to view the internal structure of the body with less radiation using low frequencies. The frequency specification for head imaging ranges between 0.7-6GHz. One important factor for head imaging is the high directivity and gain. These microwave imaging techniques have the capability to penetrate into the dielectric materials. The head imaging is used to detect the location of the tumour. Brain is the most sensitive part of the human body, so the radiations should be as low as possible.

A compact microstrip antenna design is to be used in brain tumour detection. The reduction in size is also a considered in the designing of the antenna, which would be easily integrated into the system [5]. The width of the patch is selected in such a way that, it has good radiating efficiency. The dimension and radiation characteristics of the antenna can give an overall good performance of the microwave imaging. The microstrip antenna is of low cost, easy to integrate and also have low profile.

The proposed system is used to detect the tumour by the specific absorption rate. Antenna is the element which is used to transmit and receive the radiations. The specific absorption rate for a normal human range between 1.7-2.7W/kg , whereas if a tumour is present in any part of the brain. The specific absorption rate will be greater than 2.7W/kg.

II. Design of antenna and discussions

A. EXISTING METHOD

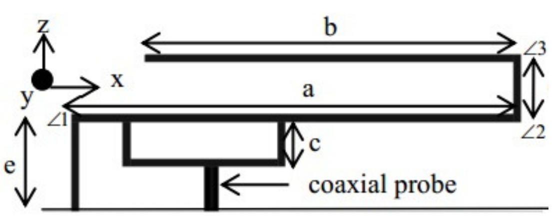
The most common methods of detecting brain tumour is by using MRI scan which uses a strong magnetic field about 0.2-3 tesla which aligns proton spins. It also produces the wave frequency which has varying magnetic field. In CT scan, the density of tissue is measured from the calculation of attenuation coefficient. The x-rays emitted from the machine passes through the biological matter. The recorded attenuation values are used to build 3D representation. Both the methods have disadvantage of patients exposed to high radiations. There are always chances of cancer from excessive exposure to radiations. These methods are not usually used for children and pregnant women.

B. PROPOSED METHOD

In this a microstrip patch antenna is used to detect the brain tumour. Since this antenna is used in the most sensitive part of the body it is designed with a minimum frequency of 2.7GHZ. This method uses specific absorption rate to detect the brain tumour. Specific absorption rate is the amount of energy absorbed by the body when exposed to radio frequency electromagnetic field. It is defined as the power absorbed per mass of tissues and has units of watts per kilogram. For a normal human brain, it is said that the SAR is 1.7-2.7 W/kg. But for a brain with tumour the SAR is greater than 2.7 W/kg. We use an artificial head phantom and the tumour is created as a material with a dielectric constant of 67 and thickness of 5mm.The SAR without the tumour is calculated and it is compared with the SAR with tumour. The simulation is done by using CST software. This method can be used to detect tumour cells in any part of the body. Since the system is built from 3D printing parts and custom-made components it is flexible and can be adjusted for head shapes and size. Another advantage is that it is smaller in size and the method is carried out easily when compared to the convention methods.

C. DESIGN OF ANTENNA

Coaxial probe feeding reduces the spurious radiation occurred by other feeding method; hence it is applied to the design structure. By decreasing the length of the probe, this inductance can be controlled. The frequency used here is very low since it is used on the most sensitive part of the body. The excessive radiation sometimes leads to cancer. To achieve low frequency folding technique may be used [1]. The lower patch is U shaped and directly connected with the coaxial cable [1]. The proposed antenna which indicates the radiator fed with microstrip feed line. The radiator consists of slot along with the feed in the in the radiating edge. These slot with the feed reduce the return loss to a great extent. The proposed antenna is designed by cutting single patch to make it a patch antenna. Cutting of patches in antenna increases the current path which increases the current intensity, and in turn increases the efficiency [6]. The basic structure of antenna consists of ground plane, substrate, patch and feed line. The transmission line is the preferred method of analysis for calculating the various dimensions of the microstrip patch antenna. The transmission line model is applicable to infinite ground planes only.



However, for practical considerations it is essential to have a finite round plane. It has been shown by that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater the patch dimensions by approximately six times the substrate thickness all-round the periphery. The FR4 epoxy substrate material is used here because of its good mechanical properties making it a deal for wide range of electronic component applications. The current concentration is minimized by keeping them at a distance from the feeding point. The upper patch is rectangle shaped, held by the bended extensions from the lower patch. A substrate with a low dielectric constant has been selected, since it increases the bandwidth of the antenna. The design parameters are obtained from the formulae

Width of the antenna (W) = $\dfrac{c}{2fo\sqrt{\dfrac{(\epsilon_r+1)}{2}}}$

Effective dielectric constant (ϵ_{reff}) = $\dfrac{\epsilon_r+1}{2}+\dfrac{\epsilon_r-1}{2}(1+12\dfrac{h}{w})^{\frac{1}{2}}$

Effective length (L_{eff}) = $\dfrac{c}{2fo\sqrt{\epsilon_{reff}}}$

Length (L)= $L_{eff}-2\Delta L$

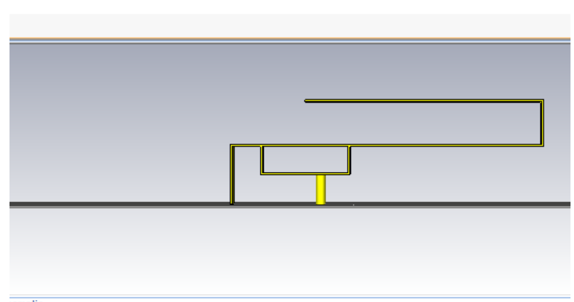
Length of the ground (L_g) = 2* L

Width of the ground (W_g) = 2* W

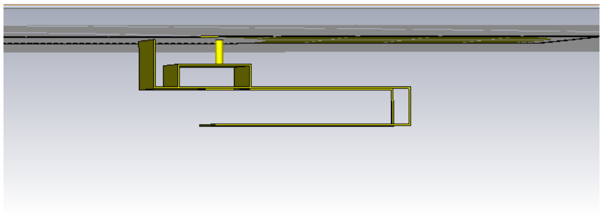
TABLE 1

Structure Design parameters of antenna (in millimeters)

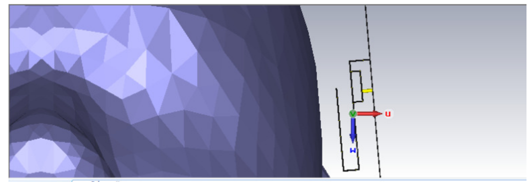
A	20	c	3	e	6	L	80
B	25	d	4.5	f	25	W	80



(a)



(b)



(a)

Fig1. Configuration of the proposed 3D structure (a) The side, (b) 3D view

For the microstrip patch antenna to be used in multiband applications, it is essential that the antenna is not bulky. Hence the essential parameter such as frequency of operation is 2.7 GHz and dielectric constant of the substrate is 2.2. The resonant frequency of the antenna must be selected appropriately. The antenna designed must be able to operate in this high frequency range. The resonant frequency which is selected for this design is 2.7GHz. The simulation is done by using CST Studio Suite (2014). It is based on Finite Element Method. It offers efficient and accurate computational solution for electromagnetic design and analysis.

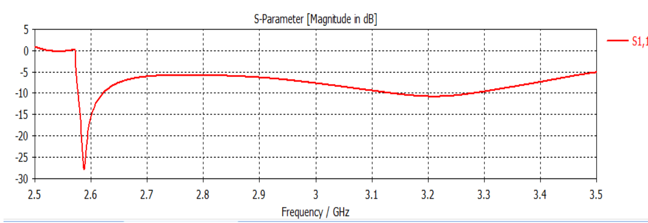


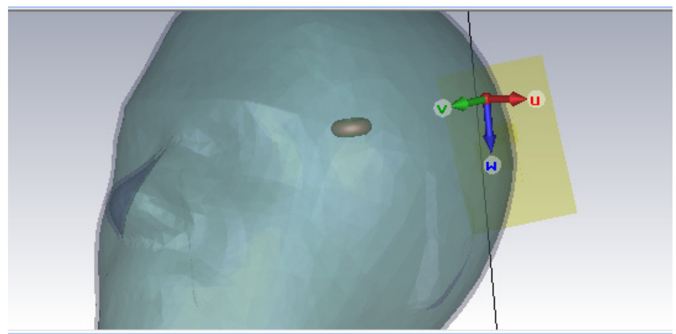
Fig 2. Return loss

TABLE 2

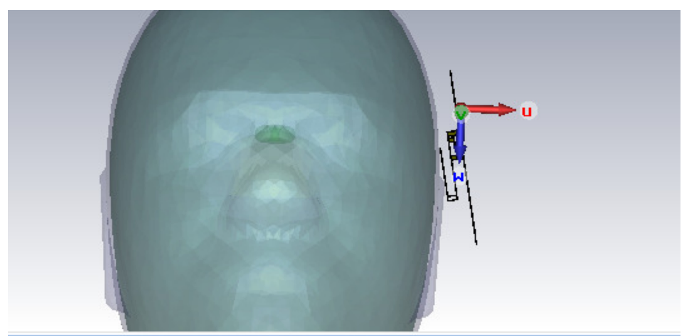
Dielectric properties of brain phantom.

Material	Dielectric constant	Thickness (mm)	S m-1
Skin	38	1	1.61
Grey matter	45	60	2.03
Tumor	67	5(sphere radius)	2.30

A 3D structure of the head phantom is imported from the CST software and the antenna that has been designed is placed close to the 3D structure and the specific absorption rate is calculated(SAR) for 10g of tissue is calculated. And now a tumor is created in the form of a material with a dielectric constant of 67 and thickness of 5(sphere radius). The proposed antenna is similarly placed near the head phantom and the SAR is calculated.



(b)



(c)

Fig 3. 3D head phantom (a) Without tumor, (b) With tumor, (c) tumor with antenna

For the brain without tumor SAR obtained for 10g tissue is found to be 1.817e-001 and for the brain with tumor which was created with as a material with dielectric constant mention in TABLE 2, the SAR obtained is 5.571e-005. This shows that brain with tumor radiates more when compared to the one without tumor. And the report and calculation of SAR is mentioned below.

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
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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
Max. point SAR [W/kg]:	0.00610628
Maximum SAR (10g) [W/kg]:	5.57132e-005
Maximum at (x,y,z) [mm]:	72.3735, 109.285, -155.927
Avg.vol.min (x,y,z) [mm]:	58.8969, 95.8084, -157.738
Avg.vol.max (x,y,z) [mm]:	85.8501, 122.762, -130.785
Largest valid cube [mm]:	23.6305
Smallest valid cube [mm]:	21.4984
Avg.Vol.Accuracy [%]:	0.01
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Calculation time [s]:	12

(a)

Powerloss density monitor used: loss (f=2.7) [1] at 2.7 GHz	
Power scaling [W] :	1 Accepted
Stimulated Power [W] :	1.08815
Accepted Power [W] :	1
Average cell mass [g]:	0.239004
Averaging method:	IEEE C95.3
Averaging mass [g]:	10
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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]:	5.09969e-006
Tissue volume [mm^3]:	5.24992e+006
Tissue mass [kg]:	5.24992
Tissue power [W]:	4.42625e-006
Average power [W/mm^3]:	8.43108e-013
Total SAR [W/kg]:	8.43108e-007
Max. point SAR [W/kg]:	0.000427947
Maximum SAR (10g) [W/kg]:	1.8171e-005
Maximum at (x,y,z) [mm]:	71.3366, 129.978, -130.292
Avg.vol.min (x,y,z) [mm]:	59.2084, 117.849, -142.42
Avg.vol.max (x,y,z) [mm]:	83.4649, 142.106, -118.164
Largest valid cube [mm]:	32.7161
Smallest valid cube [mm]:	21.5443
Avg.Vol.Accuracy [%]:	0.01
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Calculation time [s]:	2

(b)

Fig 3. Report of SAR calculation (a) With tumor, (b) Without tumor

III. Conclusions

Brain is an important part of human being and reasons of brain tumor is unpredictable. The methods that are being used to detect brain tumour include MRI scans, CT scans. But these methods have many disadvantages. A wearable antenna is designed with a minimum frequency of 2.7 GHz.. The SAR for module without tumor is said to be lesser than the module with tumor. When SAR was calculated it was found to be 1.81e-005 W/kg for without tumor and 5.571e-005 for with tumor.CST Studio Suite is used for investigating different parametric studies of the proposed antenna. This can also be used for different multiband applications.

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