International Journal of Bio-Science and Bio-Technology
Vol.8, No.5 (2016), pp. 201-210
http://dx.doi.org/10.14257/ijbsbt.2016.8.5.18

Brain Tumor Detection by Microwave Imaging using Planner Antenna

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Abstract

This paper presents the research work about the detection technique for brain tumour by microwave imaging. Slotted RMPA (Rectangular Micro-strip Patch Antenna) and Modified Ground Plane ultra wide band antenna has been proposed which is having the frequency range from 6GHz to 10GHz. In this work bandwidth achieved by the proposed antenna is approximate about the frequency of 4GHz that is large enough for early detection of brain tumor. Single layer brain phantom model is developed using CST-MWS which is an approximate model of the brain in which sphere is considered as a brain. The dielectric permittivity of the phantom brain model is 45.8 and its conductivity is .77s/m. Proposed antenna is placed in contact with the phantom brain having a cubical tumor of 5mm^3 with dielectric constant 54.2 and conductivity 2.62s/m. current density is increased approximate two times compare to the cases when brain having no tumor and SAR of the system is also considerably increased. The result shows the better improvement as compared to the previous results proposed by several researchers time to time.

***Keywords**: Rectangular Micro-strip Patch Antenna (RMPA), SAR, Brain Phantom model, Cancer tissue*

1. Introduction

Micro-strip Patch Antennas are uses because of their compact design, easy construction, considerable gain and directivity. Its bandwidth is increased by the applying different method to the patch antenna like by applying different type of slot to the antenna and also by applying different type of different ground structures like H,E dumbbell shape *etc*. Planner antenna is easy to fabricate and it is easily mountable to any surface that's why these antennas are increasing their popularity in today's microwave world [1-3]. As a new option microwave imaging is a new and safer technique in comparison to the X-ray mammography in the paper gauss Newton algorithm is used to solve the problem [4].In the paper [5] demonstrated a human head model and simulated it for brain tumor detection. The detection of brain tumor is based on the analyzing the scattering parameter of human head model with and without tumor. In this research paper ultra wide band antenna was used which had the frequency range from 2.6GHz to 13.1GHz. UWB Vivaldi antenna [6-8] with different substrate can be used for brain cancer detection. In this work a phantom model is proposed with dielectric properties of a brain. A UWB Vivaldi antenna has been put in contact with the human head model and specific absorption rate [SAR] by electromagnetic wave is calculated. It is found that SAR is much greater in human head with tumor as compared to the human head without tumor. Holographic microwave imaging array technique [9] can also be used for brain tumor detection. This analysis is based on microwave holographic technologies. Microwave

ISSN: 2233-7849 IJBSBT

tomography imaging [10] can be used in brain tumor and breast cancer detection. Algorithm of structural inversion with all boundaries defined breast cancer detection , but in case of brain tumor detection inversion problem is more complicated due to the skull as it produce higher noise. This method is applied to the two dimensional slices created from a database of three dimensional MRI phantom images. In [11], the wideband compact tapered micro-strip feed antenna is proposed for brain tumor detection. Antenna is placed in liquid of high coupling capacity that is use in high level signal penetration into the antenna in brain is tested using a suitable model of head. Smart Antenna array [12] is designed and fabricated for brain tumor detection, array consist of Vivaldi antenna array of three antenna and a brain model having different four layers is created and simulated with radius of 5mm tumor is modeled and signal is input to the brain having tumors and reflected signals from tumors studied analysis of reflected signal shows that array of antenna can be used to detect the brain tumors. Simple half oval patch antenna [13,15] used for the breast cancer imaging over a wide bandwidth. MRI technique is most painful and having various disadvantages of x-ray wave interfacing directly to the human body. In this research author designed array of oval patch antenna that can be fit into the chamber of breast. In the paper antenna is placed to different location in the chest to find out differences in the scattered signal.

Microwave Imaging is a technique that is used to detect the hidden object using an electromagnetic wave in microwave region (300MHz to 300GHz). Microwave imaging also used for medical application. Any part of the body that is to be examined interface by electromagnetic wave, then the reflected wave from body part is compared to input wave and the changes in the two wave will be examined to detect the tumor on the body part. Property of reflected Signal is also depends upon the environment on which the experiment is performed like the temperature, humidity *etc* .The tumor have very different electrical properties like in breast or brain tumors (higher dielectric permittivity and higher conductivity).

2. Proposed Antenna Design

Proposed antenna is designed by using CST-Microwave Studio simulation software and all the important terms like reflection coefficient, SAR, current density are displayed with the help of figures and tables.The antenna sizes are an important in the design process. Firstly the Rectangular Micro-strip Patch Antenna as shown in Figure 1 is designed for one of the frequency of the UWB and then applied the different DGS method to enhance the bandwidth of the system. The Length and Width of Micro-strip Patch Antenna has been calculated by formula given in reference book [14]. Initially the microstrip antenna is designed for the frequency 4GHz and the antenna is resonated at particular frequency. After that The Ground plane is modified to achieve the ultra wide band performance of the antenna as shown in Figure 2.

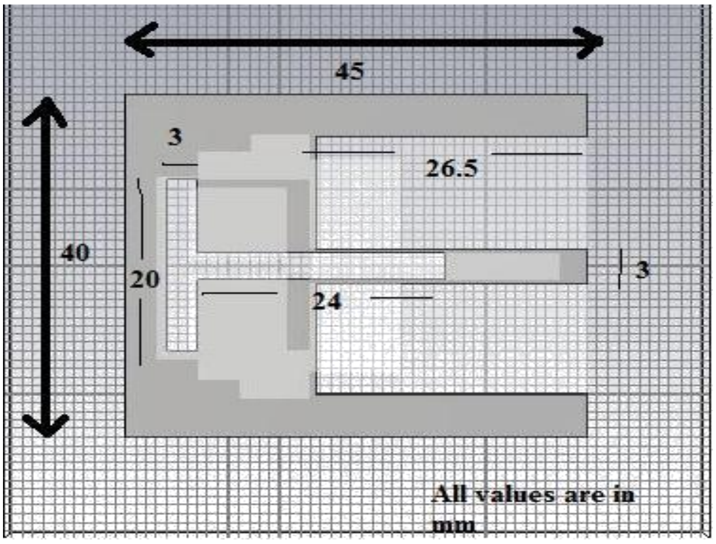

Figure1. Front View of Modified Ground Plane RMPA

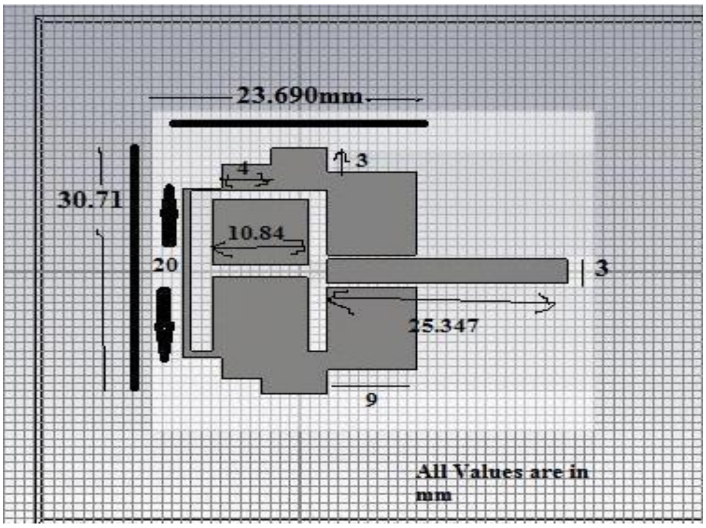

Figure 2. Modified Ground Plane of the Patch Antenna

The dimensions of the microstrip patch antenna has been calculated for particular frequency by the standard formulas given below, and further length and width of DGS structure and slots are finding by hit and trial methods dimension are stored for the best result. Width of Rectangular Microstrip Patch Antenna has been calculated by [14].

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\epsilon r+1}} \quad (1)$$

Where
f_r = resonant frequency of the patch antenna and
ϵ_r = dielectric constant of material used

Effective dielectric constant to find out the effective length of the micro-strip patch antenna has been calculated by

$$\epsilon_{ff} = \frac{\epsilon r+1}{2} + \frac{\epsilon r-1}{2}\left[\sqrt{\frac{1}{\frac{12h}{w}+1}}\right] \tag{2}$$

Where h=height of substrate and
w=width of rectangular micro-strip patch antenna.

Fringing field length for calculating the effective length of the rectangular microstrip patch antenna

$$\Delta L = 0.412h\left[\frac{(\frac{w}{h}+.264)}{(\frac{w}{h}+.80)}\right]\left[\frac{(\epsilon ff+.3)}{(\epsilon ff-.258)}\right] \tag{3}$$

Length of microstrip patch antenna has been calculated by

$$L = \frac{c}{2fr\sqrt{\epsilon_{ff}}} \tag{4}$$

Effective length of the rectangular microstrip patch antenna has been given by

$$L_{eff} = L - 2\Delta L \tag{5}$$

3. Discussion and Simulation Result

Proposed Micro-strip Patch Antenna with A-shaped Slot and modified ground plane has been designed as shown in Figure 1 and Figure 2 respectively. Proposed designs of both antennas are simulated in CST-MWS studio. Figure 3 shows that reflection coefficient of the proposed slotted antenna is 47.87dB at frequency 6.8GHz. All the parameter like current density and SAR are calculated for lowest reflection coefficient. It is shown that antenna is working fine from approximately 6GHz to 10GHz and its approximate bandwidth is 4GHz. The current density is 756.4A/m2 as shown in the shown in the Figure 4. SAR produced by the proposed antenna is $2.53X10^6$ W/m3 clear from Figure 5.

Now in next section the brain phantom model is designed by CST-MWS. Brain phantom model is represented by a sphere with 10mm centre radius and 5mm top and bottom radius, its dielectric permittivity=45.8 and conductivity=.77s/m .A Cancer Tissue is assumed by a cube of 5mm side face it dielectric properties are ,Dielectric Constant =54.06 and Conductivity =2.62s/m.

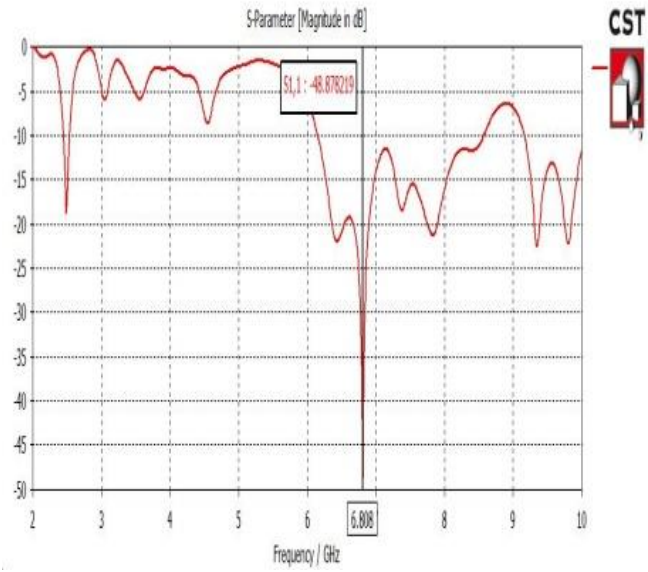

Figure 3. Return Loss of the UWB Antenna

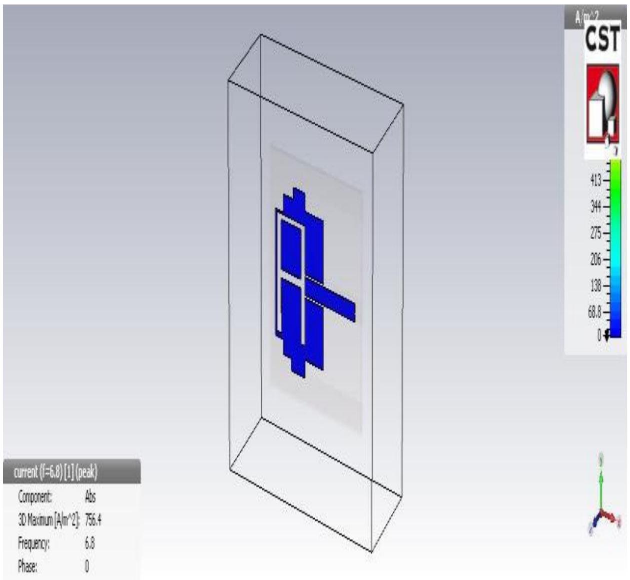

Figure 4. Current Density of UWB Antenna is 756.4A/m^2

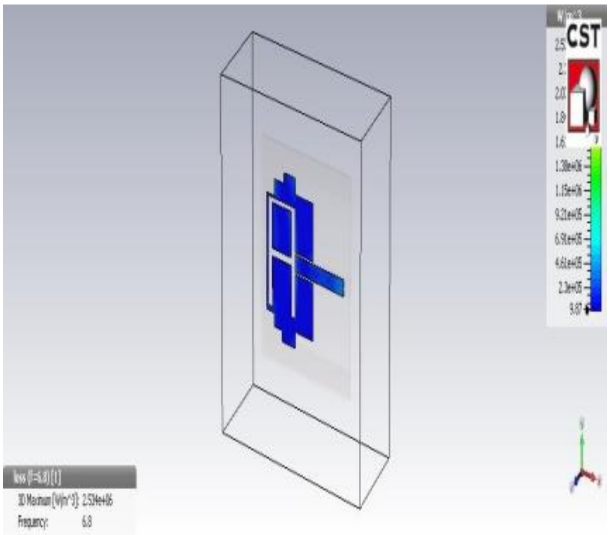

Figure 5. Specific Absorption Rate Produced by Antenna is $2.53X10^6$ w/m^3

Now Antenna is placed in contact with brain phantom model and all parameter of the system will discuss, results are compared with the model when brain model with tumor is placed with antenna.

There are two different cases for detection of tumor

Case-I Brain Phantom model without tumor UWB antenna in its contact

Case-II Brain Phantom model with tumor and UWB antenna in its contact

These two cases are demonstrated as

3.1 Case-I Brain Phantom model without tumor:

Brain phantom model is represented by a sphere with 10mm centre radius and 5mm top and bottom radius, its dielectric permittivity=45.8 and conductivity=0.77s/m.brain phantom model without tumor is placed close to the antenna and by simulation all results like return loss, current density and SAR of the configuration is calculated.

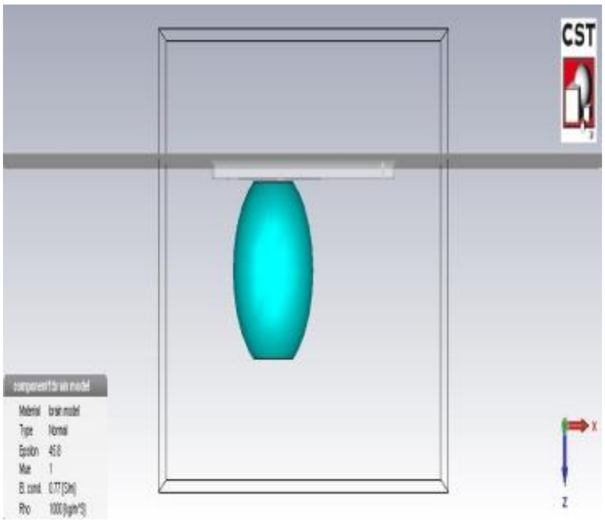

Figure 6. Top View of the Brain Phantom Model with Antenna

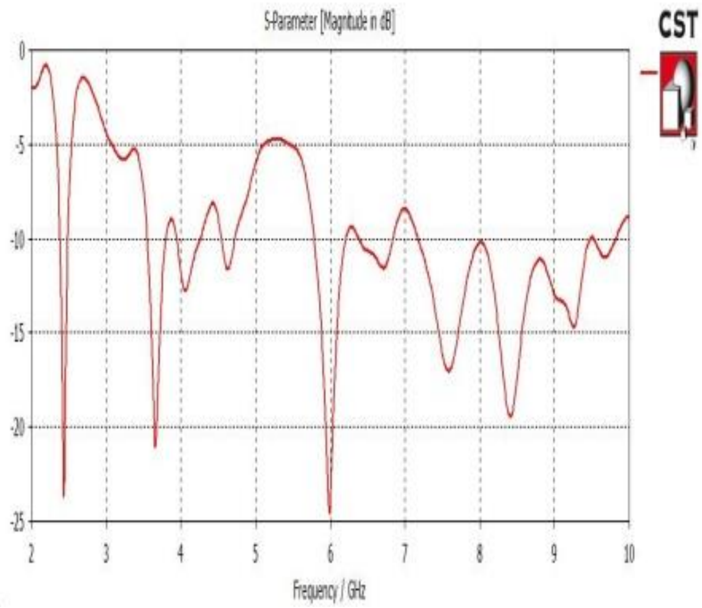

Figure 7. Return loss of Brain Phantom Model with UWB Antenna

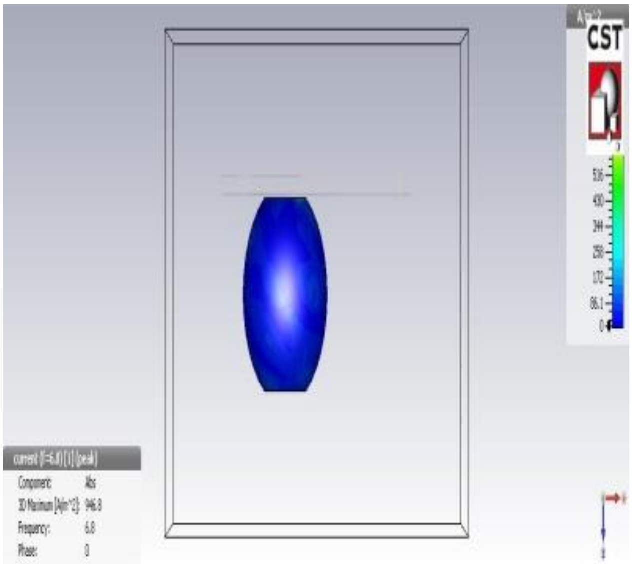

Figure 8. Current Density of RMPA with UWB Antenna

Table 1. Shows the Results of Brain Phantom Model with Ultra Wide Band Antenna

Bandwidth(GHz)	SAR(W/m^3)	Current density(A/m^2)
04	3.874*10^6	946.8

Figure 6 shows the brain phantom model with antenna on the top and Figure 7 shows the reflection coefficient of the phantom model with antenna .Current density is much higher it is 946.8A/m^2 .It should be the desirable results when the antenna used with brain phantom model as clear from Figure 8.

3.1.1 Case-II Brain Phantom model with tumor:

A Cancer Tissue is assumed by a cube of 5mm side face. It is defined by the higher dielectric Constant =54.06 and Conductivity =2.62s/m. Antenna is placed in contact with this configuration and simulation result will display by the figures below and also given in Table 2.

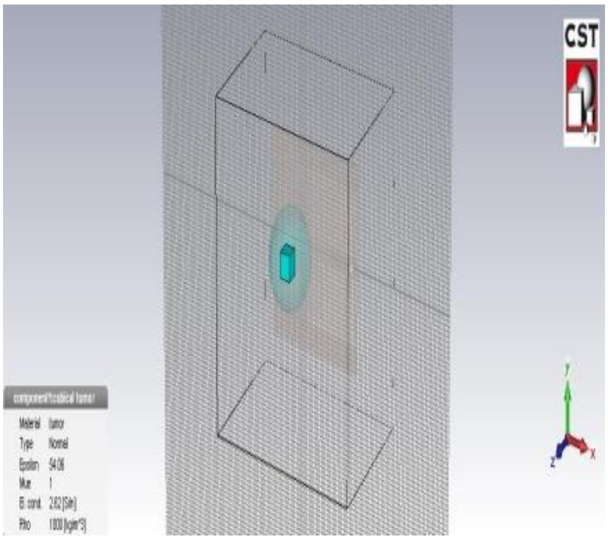

Figure 9. Top View of the Brain Phantom Model with Cancer Tumor

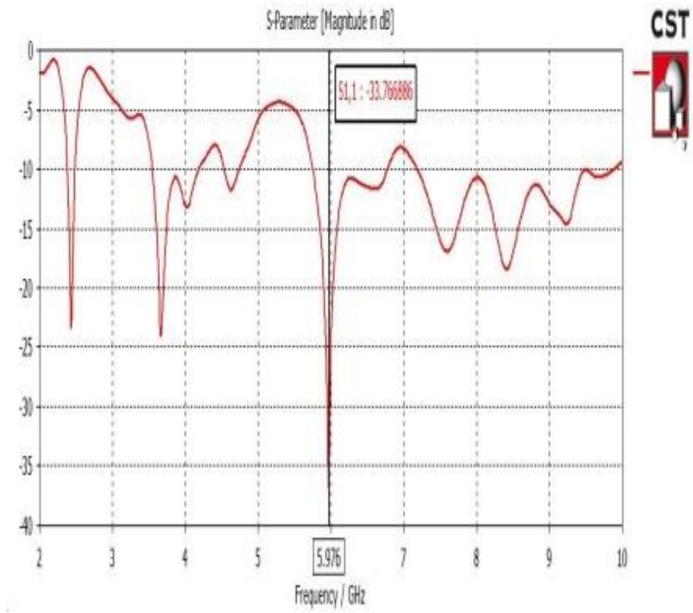

Figure 10. Return Loss of Brain Phantom with Cancer Tumor in the Center

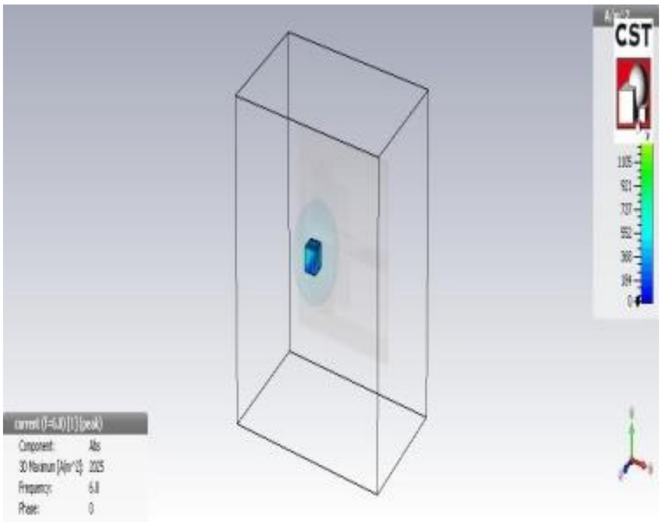

Figure 11. Current Density of System with Tumor in the Center is 2025A/m^2

Figure 9 describes the brain phantom model with cancer tumor at the center of the UWB Antenna. Figure 10 shows the reflection coefficient produced by brain phantom model with tumor. Figure 11 shows the current density produced by the brain phantom model with tumor and it is

2025 A/m^2. This value of current density is greater as same compared to the brain model without tumor.

Table 2. Shows the Results of Brain Phantom Model with Tumor

Bandwidth(GHz)	SAR(W/m^3)	Current density(A/m^2)
04	4.05*10^6	2025

It is clear from the analysis of both the cases discussed above that losses are increased when the brain phantom model is subjected to the tumor because of more current signals reflected from tumor. All Results also clear from the Table-1 and Table-2. It has been observed from above results that current density of the brain phantom model having tumor is more than two times as compared to the brain phantom model not having tumor. This is the great achievement of this research work that current density increased more than two times so that antenna sensivity is

Also increased, increased sensivity of the system can also be used for early detection of brain tumor.

5. Conclusion

From our proposed research work, it can be analyzed that brain tumors can be easily detected by the ultra wide band antenna. It is observed from the results that antenna current density is increased when antenna is placed in contact with the brain compared to the antenna placed away from the brain. Specific Absorption Rate is also increased with the presence of tumor in the Ultra wide band antenna. In this paper antenna is also make wideband by the use of defect ground structures in ground plane of the antenna, as compared from the very few papers available in this area the result is highly improved shown by the result discussion, figure and tables. Future work is suggested to design more realistic brain model. One can use the multilayer brain model to approach the reality of the brain phantom model.

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