DESIGN OF A NOVEL RECTANGULAR MICROSTRIP PATCH ANTENNA FOR DETECTING BRAIN CANCER

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Abstract - *Antennas are essential component of any wireless communication. An antenna is a transducer that converts electrical signals to electromagnetic waves and radiates into free space. At first, a compact microstrip patch antenna is designed with the FR-4 substrate loaded over the patch and with the partial ground. Next the antenna is surfaced on the human head phantom model which consists of six homogeneous layers that are skin, fat, skull, dura, cerebrospinal fluid and brain. Then the antenna is simulated upon the human head phantom and the variations in the electric field, magnetic field, return loss and specific absorption rate are measured. It is simluated using the CST Microwave Studio.*

Keywords: Gain, VSWR, Return loss, SAR.

1. INTRODUCTION

Cancer is one of the most complicated disease that even leads to death if it is not identified at the earlier stage. Statistics reveal that around 13.2 million death of cancer are expected in 2030[2]. There are number of brain diseases which if not detected at the early stage, might end up resulting in premature death. Detection of brain cancer can be done in various ways and usually depends on the stage in which the cancerous tumors are traced. Basic method like x-ray mammography, ultrasound, computed tomography (CT) scan, magnetic resonance imaging (MRI) scan and biopsy are used in detecting tumors in the initial stages. These limitations have motivated researches to develop a more effective, low-cost diagnostic method and involving lower ionization for cancer detection. In this proposed work, first the micro strip path antenna is designed and simulated over the computer simulation technology[7]. Next the brain phantom with tumor at six different location & without tumor at six locations are designed with appropriate dimensions using computer simulation technology. Brain tumors are abnormal growth of cells in the brain. Although such growths are popularly called brain tumors, not all brain tumors are cancer. Cancer is a term reserved for malignant tumors. Malignant tumors can grow and spread aggressively, overpowering healthy cells by taking their space, blood, and nutrients. They can also spread to distant parts of the body. Like all cells of the body, tumor cells need blood and nutrients to survive[5]. Tumors that do not invade nearby tissue or spread to distant areas are called benign. In general, a benign tumor is less serious than a malignant tumor. But a bengin tumor can still cause many problems in the brain by pressing on nearby tissue. Tumors that start in the brain are called primary brain tumors. A tumor that starts in another part of the body and spreads to the brain is called a metastatic brain tumor.

2. LITERATURE REVIEW

M. A. Shokry et.al [5], reported that the antenna is operating at a band from 3.3568-12.604 GHz in free space and from 3.818 to 9.16 GHz on the normal head model. The antenna has dimensions of 44x30mm^2. It is fabricated on FR4-substrate with relative permittivity 4.4 and thickness 1.5mm It is simluated using the CST Microwave Studio. The simulated antenna shows -10dB for 4.031GHz

From the above literature review it is found that the proposed antenna provides maximum return loss. Our antenna is miniaturized size with covering the entire desired working frequency band by adding some perturbation structure on the antenna structure.

3. PROPOSED METHOD

3.1 ANTENNA DESIGN

The Microstrip patch antenna has ground, substrate, patch and feeding techniques. The substrate of the antenna is FR-4. The ground and patch of the antenna is copper annealed. The slot of the antenna is nickel. The length of the substrate is mm and the width of the substrate is mm and the thickness of the substrate is 1mm. The back side of the substrate contains the partial ground plane. The length of the ground is mm and the width of the ground is mm and the thickness of the ground is mm. The other side of the substrate contains the patch. The length of the patch is mm and the width of the patch is mm and the thickness of the patch is 1mm. The proposed antenna is fed with the microstrip line feed. The length of the feed is mm and the width of the feed is mm and the dimensions of the proposed antenna are shown in Table 1.

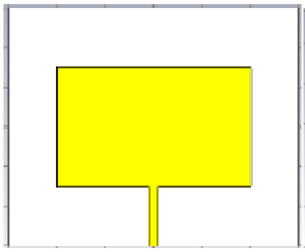


Fig 1.Without slot

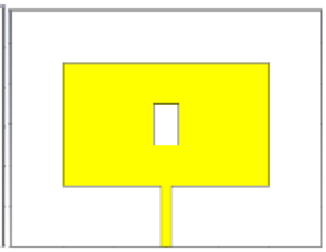


Fig 2.Center slot

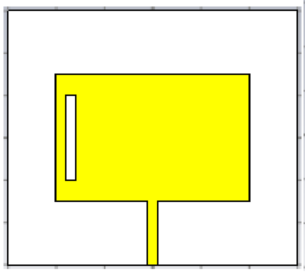


Fig 3.Vertical slot

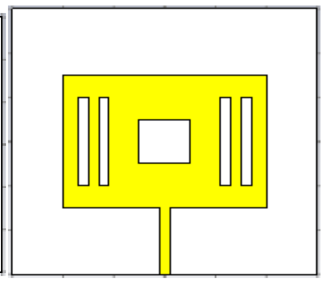


Fig 4.Four vertical and center slot

Table 1. Dimensions of RMSPA

SI NO	Antenna Specifications	Dimensions in mm
1	Thickness of the ground	0.03
2	Width of the ground	60
3	Height of the ground	60
4	Thickness of the substrate	1.56
5	Width of the substrate	60
6	Height of the substrate	60
7	Thickness of the patch	0.03
8	Width of the patch	40
9	Height of the patch	30
10	Width of the feed	1
11	Height of the feed	15
12	Width of the center slot	10
13	Height of the center slot	10
14	Width of the vertical slot	2
15	Height of the vertical slot	20

3.2 BRAIN PHANTOM DESIGN

A brain phantom is designed by considering a sphere as a brain and a tumor. The permittivity of the brain is 43.22 F/m and its conductivity is 1.29 S/m. The permittivity of the tumor is 54.2 F/m and its conductivity is 2.62 S/m.

In our proposed work, first the antenna is designed and simulated over computer simulation technology. Next the brain phantom is designed with the appropriate dimensions using the computer simulation technology. Then the proposed antenna is simulated upon the brain phantom with and without tumor separately and it is found that the return loss, current density and specific absorption rate has been drastically increased in the presence of tumor within the brain. The steps involved in proposed method is shown in fig.5

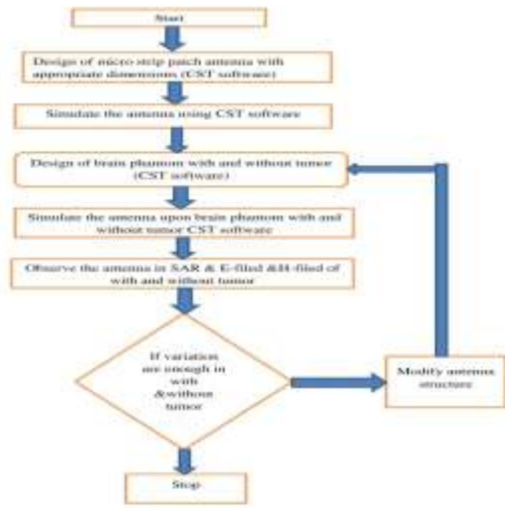
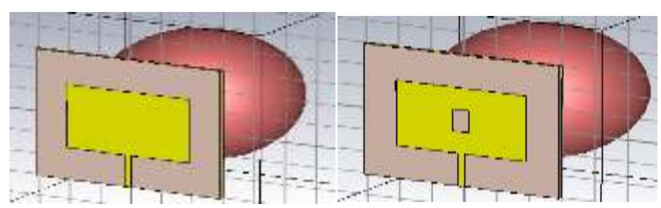
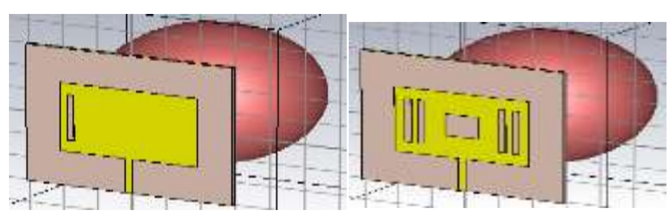


Fig 5. Steps involved in proposed work

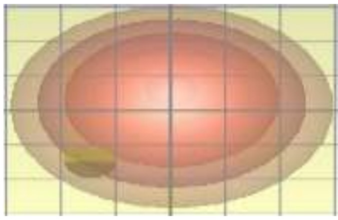
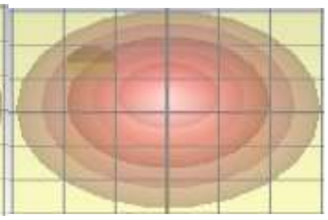


(a) (b)

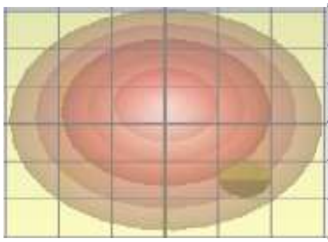
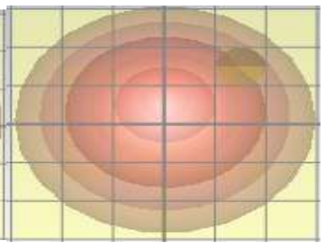


(c) (d)

Fig 6. Shows the brain phantom without tumor

(e) (f)

(g) (h)

Fig 7. Shows the brain phantom with tumors

Table 2. Geometrical measurement of antenna

TISSUE	PERMITTIVITY	CONDUCTIVITY	DENSITY
Skin	45	0.73	1090
Fat	5.54	0.04	910
Skull	5.6	0.03	1850
Dura	46	0.9	1130
CSF	70.1	2.3	1005.9
Brain	43.22	1.29	1030

4. RESULTS

4.1 BRAIN PHANTOM WITHOUT TUMOR-WITHOUT SLOT

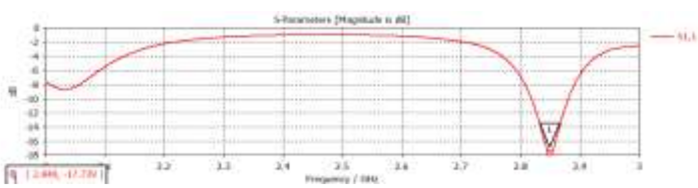


Fig 4.1.1 Return loss at 2.84GHz – without tumor

Fig 4.1.1 shows the return loss value of -17.739 at 2.84GHz in the absence of tumor

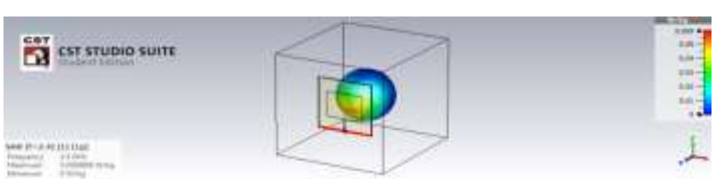


Fig 4.1.2 SAR at 2.4GHz – without tumor

Fig 4.1.2 shows the SAR value of 0.059 W/kg at 2.4GHz for 1 gram tissue in the absence of tumor

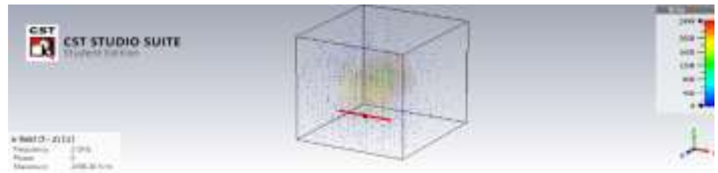


Fig 4.1.3 E-field at 2.4GHz – without tumor

Fig 4.1.3 shows the E-field value of 2560V/m at 2.4GHz in the absence of tumor.

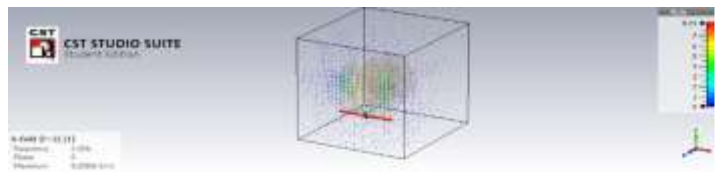


Fig 4.1.4 H-field at 2.4GHz – without tumor

Fig 4.1.4 shows the H-field value of 8.20 A/m at 2.4GHz in the absence of tumor.

4.2 BRAIN PHANTOM WITHOUT TUMOR- CENTER SLOT

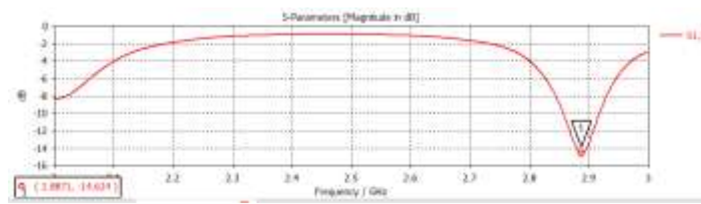


Fig 4.2.1 Return loss at 2.88GHz – without tumor

Fig 4.2.1 shows the Return loss value of -14.62GHz at 2.88GHz in the absence of tumor

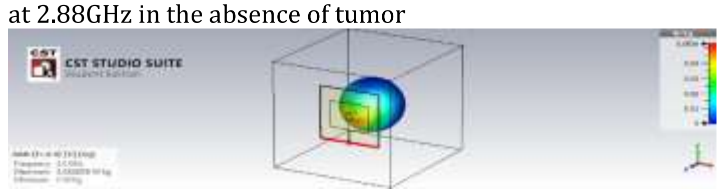


Fig 4.2.2 SAR at 2.4GHz – without tumor

Fig 4.2.2 shows the SAR value of 0.0526 W/kg at 2.4GHz for 1 gram tissue in the absence of tumor

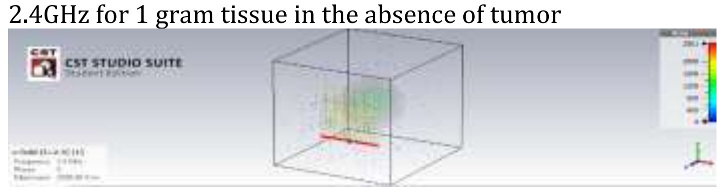


Fig 4.2.3 E-field at 2.4GHz – without tumor

Fig 4.2.3 shows the E-field value of 2560V/m at 2.4GHz in the absence of tumor

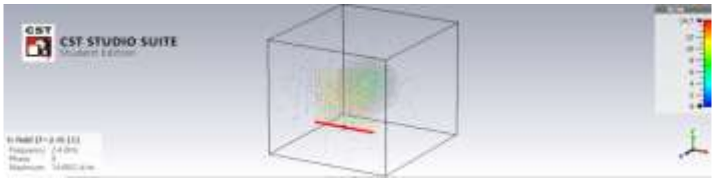


Fig 4.2.4 H-field at 2.4GHz – without tumor

Fig 4.2.4 shows the H-field value of 8.20 A/m at 2.4GHz in the absence of tumor

4.3 BRAIN PHANTOM WITHOUT TUMOR- VERTICAL SLOT

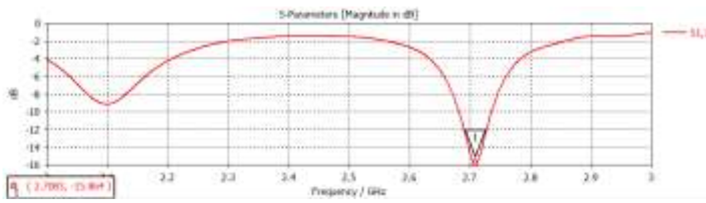


Fig 4.3.1 Return loss at 2.88GHz – without tumor

Fig 4.3.1 shows the Return loss value of -15.864GHz at 2.7083GHz in the absence of tumor

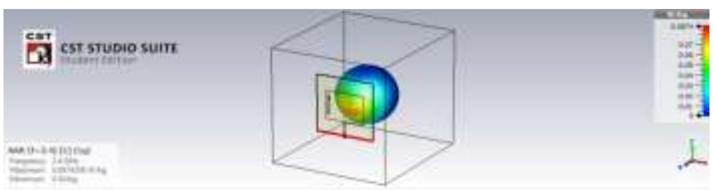


Fig 4.3.2 SAR at 2.4GHz – without tumor

Fig 4.3.2 shows the SAR value of 0.0874 W/kg at 2.4GHz for 1 gram tissue in the absence of tumor

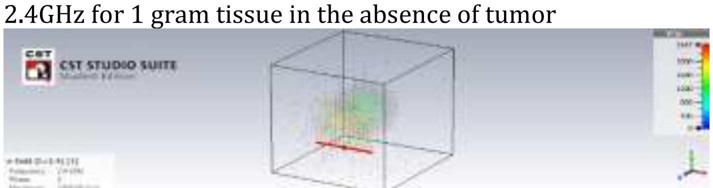


Fig 4.3.3 E-field at 2.4GHz – without tumor

Fig 4.3.3 shows the E-field value of 2466V/m at 2.4GHz in the absence of tumor

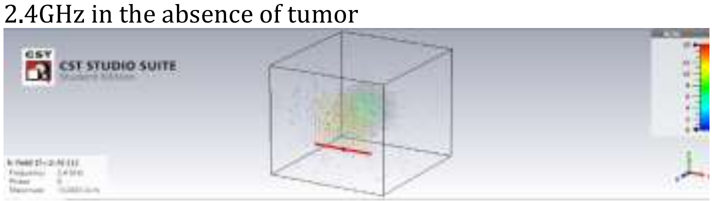


Fig 4.3.4 H-field at 2.4GHz – without tumor

Fig 4.3.4 shows the H-field value of 15.04 A/m at 2.4GHz in the absence of tumor

4.4 BRAIN PHANTOM WITHOUT TUMOR- VERTICAL AND CENTER SLOT

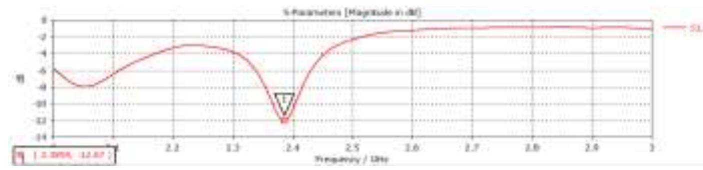


Fig 4.4.1 Return loss at 2.88GHz – without tumor

Fig 4.4.1 shows the Return loss value of -12.07GHz at 2.38GHz in the absence of tumor

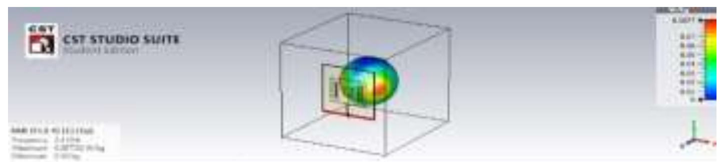


Fig 4.4.3 E-field at 2.4GHz – without tumor

Fig 4.4.3 shows the E-field value of 4431V/m at 2.4GHz in the absence of tumor

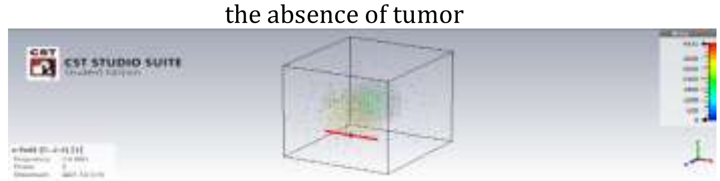


Fig 4.4.4 H-field at 2.4GHz – without tumor

Fig 4.4.4 shows the H-field value of 33.2 A/m at 2.4GHz in the absence of tumor

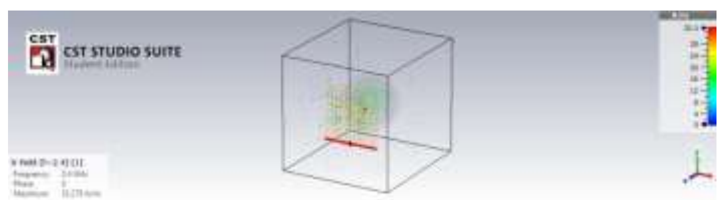


Fig 4.5.1 Return loss at 2.838GHz – with tumor

Fig 4.5.1 shows the Return loss value of -28.002GHz at 2.838GHz in the presence of tumor

4.5 BRAIN PHANTOM WITH TUMOR-WITHOUT SLOT

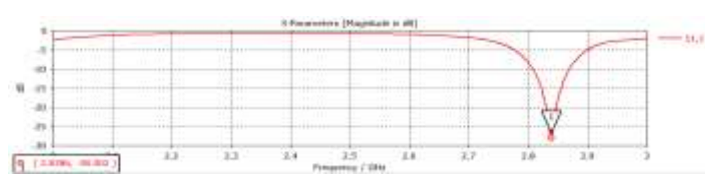


Fig 4.5.1 Return loss at 2.838GHz – with tumor

Fig 4.5.1 shows the Return loss value of -28.002GHz at 2.838GHz in the presence of tumor

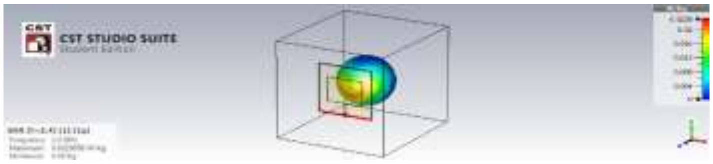


Fig 4.5.2 SAR at 2.4GHz – with tumor

Fig 4.5.2 shows the SAR value of 0.0228 W/kg at 2.4GHz for 1 gram tissue in the presence of tumor

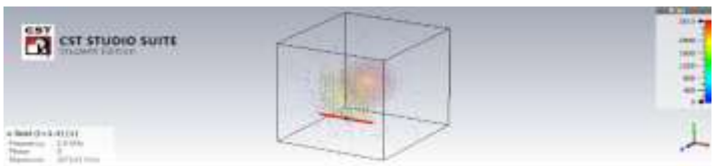


Fig 4.5.3 E-field at 2.4GHz – with tumor

Fig 4.5.3 shows the E-field value of 2618.41V/m at 2.4GHz in the presence of tumor

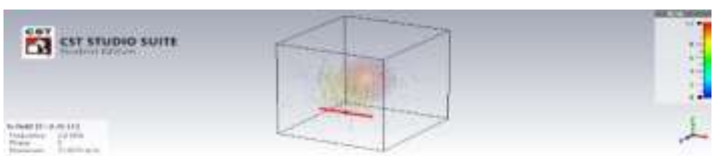


Fig 4.5.4 H-field at 2.4GHz – with tumor

Fig 4.5.4 shows the H-field value of 11.02 A/m at 2.4GHz in the presence of tumor

4.6 BRAIN PHANTOM WITH TUMOR- CENTER SLOT

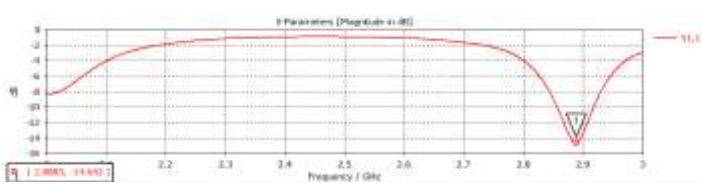


Fig 4.6.1 Return loss at 2.88GHz – with tumor

Fig 4.6.1 shows the Return loss value of -14.62GHz at 2.88GHz in the presence of tumor

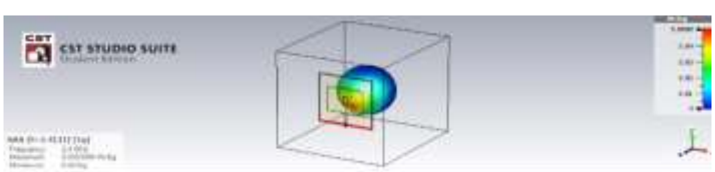


Fig 4.6.2 SAR at 2.4GHz – with tumor

Fig 4.6.2 shows the SAR value of 0.0505 W/kg at 2.4GHz for 1 gram tissue in the presence of tumor

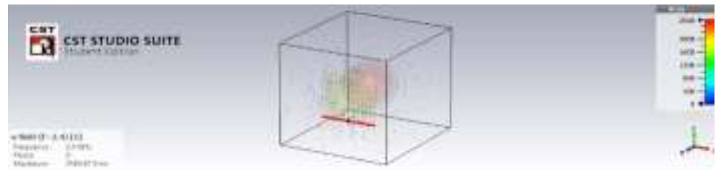


Fig 4.6.3 E-field at 2.4GHz – with tumor

Fig 4.6.3 shows the E-field value of 2560.47V/m at 2.4GHz in the presence of tumor

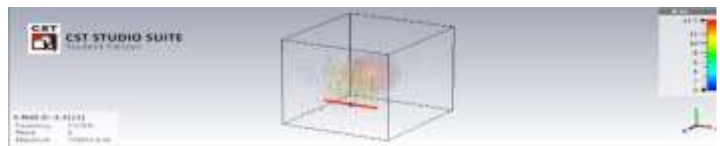


Fig 4.6.4 H-field at 2.4GHz – with tumor

Fig 4.6.4 shows the H-field value of 14.69 A/m at 2.4GHz in the presence of tumor

4.7 BRAIN PHANTOM WITH TUMOR- VERTICAL SLOT

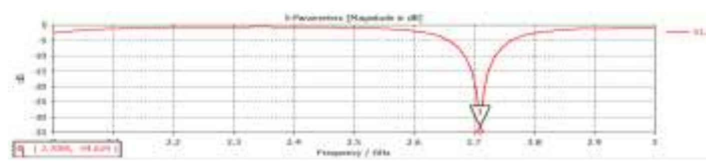


Fig 4.7.1 Return loss at 2.70GHz – with tumor

Fig 4.7.1 shows the Return loss value of -34.61GHz at 2.70GHz in the presence of tumor

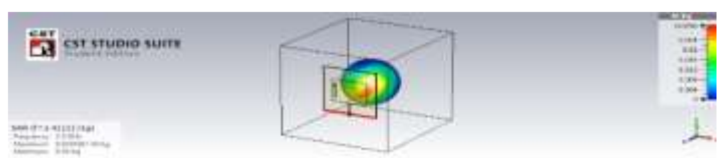


Fig 4.7.2 SAR at 2.4GHz – with tumor

Fig 4.7.2 shows the SAR value of 0.029 W/kg at 2.4GHz for 1 gram tissue in the presence of tumor

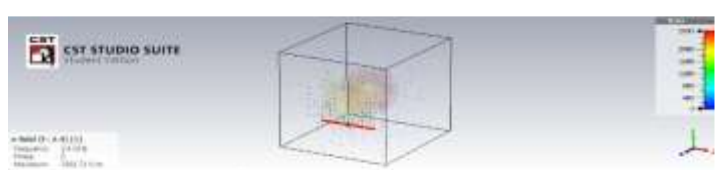


Fig 4.7.3 E-field at 2.4GHz – with tumor

Fig 4.7.3 shows the E-field value of 2592.73V/m at 2.4GHz in the presence of tumor

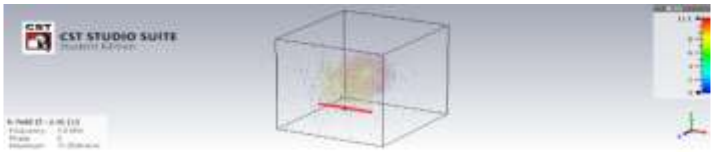


Fig 4.7.4 H-field at 2.4GHz – with tumor

Fig 4.7.4 shows the H-field value of 11.05 A/m at 2.4GHz in the presence of tumor

4.8 BRAIN PHANTOM WITH TUMOR- VERTICAL AND CENTER SLOT

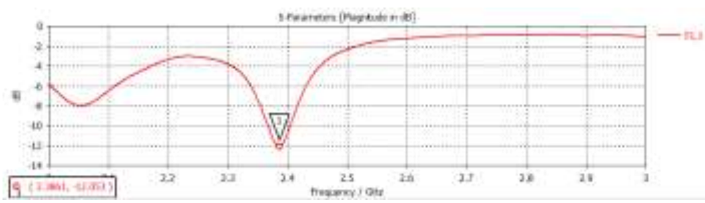


Fig 4.8.1 Return loss at 2.38GHz – with tumor

Fig 4.8.1 shows the Return loss value of -12.053GHz at 2.38GHz in the presence of tumor

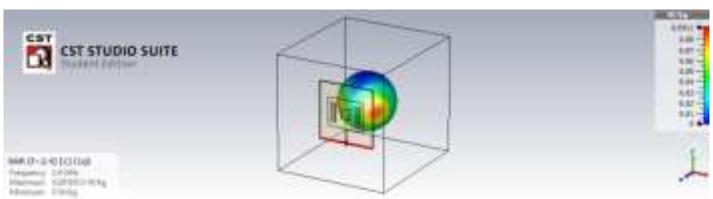


Fig 4.8.2 SAR at 2.4GHz – with tumor

Fig 4.8.2 shows the SAR value of 0.091 W/kg at 2.4GHz for 1 gram tissue in the presence of tumor

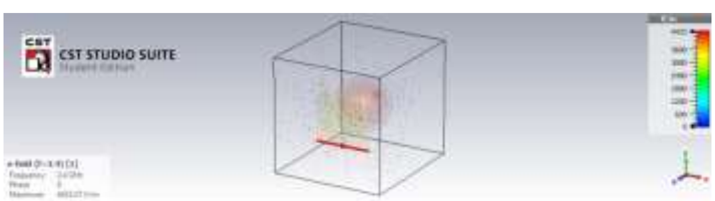


Fig 4.8.3 E-field at 2.4GHz – with tumor

Fig 4.8.3 shows the E-field value of 4422.07V/m at 2.4GHz in the presence of tumor

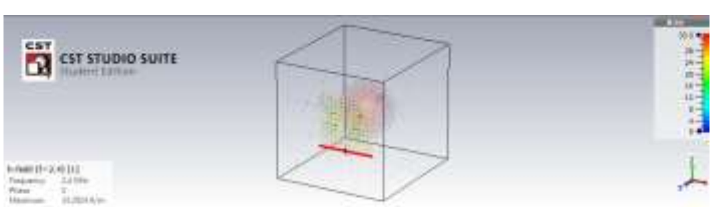


Fig 4.8.4 H-field at 2.4GHz – with tumor

Fig 4.8.4 shows the H-field value of 33.2 A/m at 2.4GHz in the presence of tumor

5. CONCLUSION

The conception and simulation of rectangular microstrip patch antenna was successfully designed using the computer simulation tools. The frequency band used for the antenna is 2 – 2.483GHz. The performance of the proposed antenna is evaluated based on the variations in magnetic field, electric field, return loss and SAR of the antenna after simulated upon the brain phantom with and without tumor. It is found that the antenna when simulated upon the brain phantom with tumor has a return loss of -34.61GHz which is higher than that of the brain without tumor. The specific absorption rate of 0.0505 W/kg for 1 gram tissue which is higher than that of the brain without tumor.

ACKNOWLEDGMENTS

I would like to thank almighty God for his grace and also my guide Dr K. Madhan kumar, assistant guide Mustafa Nawaz S.M, and my parents as well as my friends for their consecutive support and guidance.

6. REFERENCES

[1] Adhitya Satria Pratama, Basari, Muhammad Firdaus S. Lubis, Fitri Yuli Zulkifli, Eko Tjipto Rahardjo," A UWB Antenna for Microwave Brain Imaging", 978-1-4799-8897-6/15/$31.00c 2015 IEEE.

[2] Haoyu Zhang, Brian Flynn, Ahmet T. Erdogan, Tughrul Arslan, "Microwave Imaging for Brain Tumour Detection Using an UWB Vivaldi Antenna Array", 2012 Loughborough Antennas & Propagation Conference.

[3] Smita.A.Nagtode, Bhakti B. Potdukhe, Pradnya Morey," Two dimensional Discrete Wavelet Transform and Probabilistic Neural Network used for Brain Tumor Detection and Classification", 978-1-5090-2541-1116/$31.00 © 2016 IEEE.

[4] N. Mahalakshmi , A. Thenmozhi, "Design of hexagon shape bow-tie patch antenna for implantable bio-medical applications", Alexandria Engineering Journal (2017) 56, 235–239.

[5] Eng. M. A. Shokry*, Prof. Dr. A. M. M. A. Allam ," UWB Antenna for Brain stroke and Brain Tumour Detection", 978-1-5090-2214-4/16/$31.00 ©2016 IEEE.

[6] Asma Lak and Homayoon Oraizi," Evaluation of SAR Distribution in Six-Layer Human Head Model", International Journal of Antennas and Propagation (2013).

[7] Haoyu Zhang, Ahmed O. El-Rayis, Nakul Haridas, Nurul H. Noordin, Ahmet T. Erdogan, Tughrul Arslan," A Smart Antenna Array for Brain Cancer Detection", 2011 Loughborough Antennas & Propagation Conference.

[8] Mariusz wozniak,Adrian durka ,marek bugaj, rafal przesmychi,leszek nowosielski and marian wnuk, " Designing and Optimization of Microstrip Rectangular Patch Antenna to Work on Human Body,MIKON 2012, 19th Internation Conference on Micro, Radar Wireless Communication, May 21-23,Warsaw, Poland.

[9] A. Afyf, L. Bellarbi, F. Riouch, A. Errachid, and M. A.Sennouni," Flexible Antenna Array for Early Breast Cancer Detection using Radiometric Technique", international journal of biology and biomedical engineering Volume 10, 2016.

[10] Suriya, Nandhini R, Leepika M, Praveen SR," Microstrip Patch Antenna for brain tumour detection", International Journal of Scientific Research and Review Volume 7, Issue 3, 2018.