MICROWAVE WEARABLE ANTENNA FOR TUMOUR SENSING ANALYSIS SYSTEM

M. Thenmozhi, S. Ranjitha, Mrs. Shankari

Student, ECE, Prince Shri Venkateshwara Padmavathy Engineering College, Tamilnadu, India
Student, ECE, Prince Shri Venkateshwara Padmavathy Engineering College, Tamilnadu, India
Assistant Professor, ECE, Prince Shri Venkateshwara Padmavathy Engineering College, Tamilnadu, India

ABSTRACT

A compact 3D stacked patch antenna is designed for microwave head imaging application. Stacked patch technique is utilized to achieve unidirectional radiation pattern and folding technique is used to achieve resonance at lower frequency that are the requirements for imaging system. Shorting wall is introduced to minimize the overall antenna structure. For multiband operation the frequency range is selected from 0-10 GHz. The resonant frequency selected for my design is 2.55GHz. The operating frequency of the proposed antenna is suitable for human brain imaging. The sensor characteristic of the proposed antenna is affiliated via connection with the imaging entity, miniaturized dimension and high radiation efficiency. Raster scanning is deployed to achieve the 2D image of the target phantom and it is shown that the proposed highly directional antenna can detect tumour inside the human brain phantom.

Keyword: - *Microwave imaging, Human head, three dimensional antenna, and miniaturization etc..*

---

1. INTRODUCTION

Microwave imaging technique is recently given higher priority due to its low cost, portability and side effect minimization nature compared to other existing solutions. The frequency specification for human head imaging is from 1-4 GHz. In Microwave imaging, the antenna is the key element for connection between the head and the back end of the microwave imaging system. The dimension and radiation characteristics of the antenna control the overall microwave imaging performance greatly. To test the capability of the system to detect brain injuries, a low-cost mixture of materials that emulate the frequency-dispersive electrical properties of the major brain tissues across the frequency band 1–4 GHz are used to construct a realistic-shape head phantom.

1.1 Dielectric Resonator Antenna

A dielectric resonator antenna (DRA) with dual-polarization characteristics is de- signed for use in a three-dimensional (3-D) microwave to mography system to collect co-polar and cross-polar responses. The broadside radiation and dual polarization are achieved by exciting the fundamental mode of the DRA as well as by using two elements of the DRA that are perpendicular to each other[3]. Compared to the conventional rectangular DRA, the proposed antenna is reduced in size by a factor of 6.7. The proposed DRA offers a measured bandwidth of 72% (2.6–5.52 GHz). The performance and radiation characteristics of the antenna are verified experimentally. The existing DRA antenna provides increased return loss, and VSWR. Gain total is also considerably needed to be increased. Frequency coverage is only for three frequency bands are generated. The drawbacks present in the above antenna can be identified as Less reception of due to high return loss due to single patch antenna are used for each individual device.

1.2 Objectives

The proposed antenna is a single band antenna that can be used for biomedical purposes. The proposed antenna meets its objectives, they are- to achieve VSWR less than 2, to obtain optimum return loss and radiation pattern and to determine and compare the performance of microstrip patch antennas with microstrip feed line and coaxial feed line techniques.

2. DESIGN OF THE 3D STRUCTURE

The proposed microstrip patch antenna is analysed based on the transmission line model and uses all of the empirical equations and this model is based on for simulations. This model represents the microstrip antenna by two slots of width W and height h, separated by a transmission line of length L. The microstrip is essentially a non -homogenous line of two dielectrics, typically the substrate and air. The resonant frequency of the antenna must be selected appropriately. For multiband operation the frequency range selected is from 0-10 GHz. Hence the antenna designed must be able to operate in this high frequency range. The resonant frequency selected for this design at 2.55GHz. The resonance frequency for this dimension can be roughly calculated by using the formula given below .

$$f_r = \frac{c}{\left[x\sqrt{2(\varepsilon_r + 1)}\right]}$$

equation 1

The dielectric material selected for our design is ‘Air’ which has a dielectric constant of 1.00059. A substrate with a low dielectric constant has been selected. Since it increased the bandwidth of the antenna. Dielectric constant of the substrate is 2.2.The height h of the dielectric substrate is usually 0.003λ.

2.1Geometry of Antenna

In this Figure 2.1 shows the proposed antenna which indicates the radiator fed with microstrip feed line. The radiator consists of slot along with the feed in the radiating edge. These slot with the feed reduce the return loss to a greater extent.

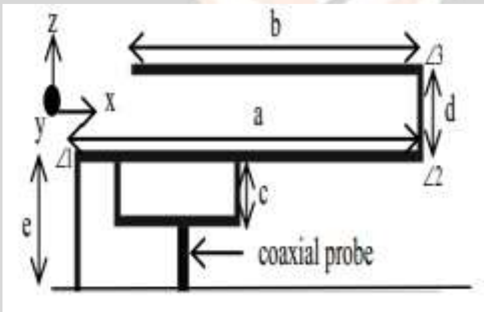

Fig-1: Antenna geometry

The dimensions for the iteration are given as
a=length of the patch
b=width of the patch
c=length of the lower patch
d=length of the folded structure
e=length of the shorting wall

Table-1: Structure of design parameters

a	b	c	d	e
25	20	3	4.5	6

coaxial probe feeding reduces the spurious radiation occurred by other feeding method; hence it is applied to the design structure .In this structure is built at the centre of a square shaped ground plane. To reduce the overall size of the antenna. A shorting wall is extended until the ground plane of the antenna which makes the antenna to resonate at a lower frequency .The lower patch is U-shaped and directly connected with the coaxial probe. The placement of the coaxial probe is crucial relative to the lower patch and optimized to achieve desired performance. Then the upper patch needs to be set over the corners of the U-shaped lower patch. The structure is symmetrical at the xz-plane. The proportion of coupling between the two patches can be used to tune the resonance frequency of the structure. To achieve higher gain, both patches are stacked at a position to achieve high directivity normal to the ground plane of the antenna. With the change in the size of the rectangular patch, the radiation pattern of the antenna changes gradually. The rectangular patch actively couples with the U-shaped patch hence passively coupling with the coaxial probe beneath the lower patch, the reactance decreases at the feeding point with the increment in resistance of the input impedance. Through parametric studies, it can be observed that "*a*" plays an important role in tuning the resonance frequency of the antenna. The coupling effect between the U-shaped patch and the lower part (before bending) of the rectangular patch cancels the reactance in between which results in increment in the real impedance.

3. RESULTS AND DISCUSSIONS

The software used to model and simulate the microstrip patch antenna in CST is a high performance full wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantages of the familiar micro soft graphical user interface. It has been used to calculate and plot the S11 parameters, VSWR, current distributions as well as the radiation pattern.

3.1 Return Loss

Figure 2 shows the proposed microstrip patch antenna with slot using microstrip feed line as a feeding technique, which gives the return loss or reflection coefficient value as -37 dB in the frequency range of 2.55 GHz.

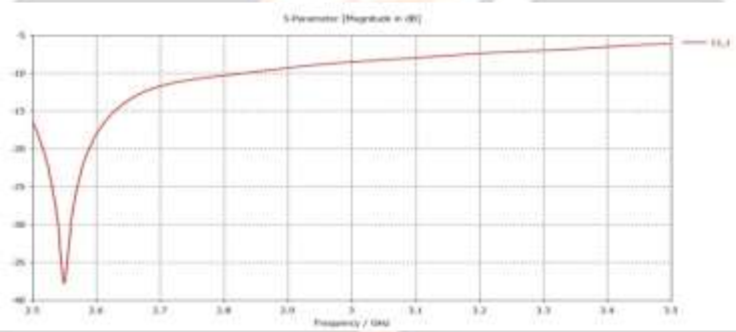

Fig-2: Return loss

3.2 VSWR

The transmission feed used in design to have a frequency range of 2.7 GHz is selected and frequency points are selected over this range to obtain accurate results.
The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum energy transfer from the feed line to the antenna to be possible.

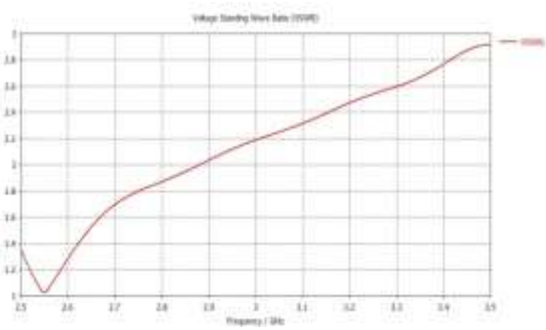

Fig-3: VSWR

Figure 3 shows that the desirable VSWR (<2) is achieved in the frequency range 0 to 10 GHz

3.3 Radiation pattern

Graphical representation of the spatial distribution of the radiation from an antenna is represented as a function of angle. The proposed antenna is showing Bi directional pattern. The radiation field of the microstrip patch antenna is shown in figure 4 which is determined using either an "electric current model" or a "magnetic current model". In the electric current model, the current in is used directly to find the far field radiation pattern.

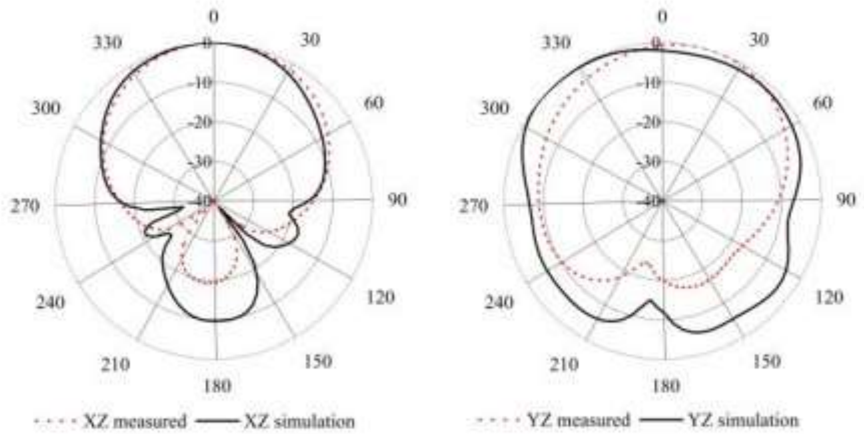

Fig-4: 2D-Radiation Pattern

The radiation field of the microstrip patch antenna is shown in figure 4 which is determine using either an "electric current model" or a "magnetic current model". In the electric current model, the current in is used directly to find the far field radiation pattern.

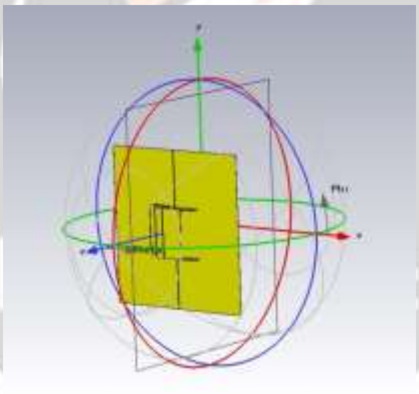

Fig-5: 3D-Radiation Pattern

The radiation field of the microstrip patch antenna is shown in figure 5 which is determined using either an "electric current model" or a "magnetic current model". In the electric current model, the current in is used directly to find the far field radiation pattern. If the substrate is neglected (replaced by air) for the calculation of the radiation pattern, the pattern may be found directly from image theory. If the substrate is accounted for and is assumed infinite, the reciprocity method may be used to determine the far-field pattern.

3.4 Input and Output port signals

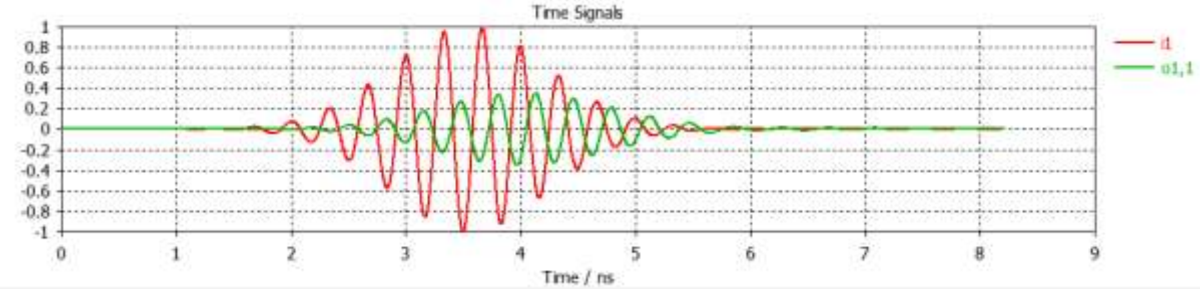

Fig-6: Input and Output port signal

Here input signal amplitude will be 2 volts. Output signal amplitude will be 0.8 volts.

3.5 Human head phantom used for tumour detection

A human head phantom model is also being designed to get more idealistic values of the antenna parameters when placed above the head phantom model. The head phantom contains six homogenous layers which were skin, fat, skull, dura, CSF (Cerebrospinal fluid) and the brain. A tumour of size 5 mm is designed having a relative permittivity of 50 and conductivity of 1.58 S/m. Input signal is being radiated into phantom model and the response is being recorded by the receiver antenna. The antenna monitors the Radiation pattern, Voltage Standing Wave Ratio (VSWR) and the Return loss of a normal head model and then later compares these parameters with a head model containing a benign tumour of size 5 mm. The parameters measured are safe and operates at ISM band. Under IEEE standard safety regulation, the Specific Absorption Rate of a brain should be within 1.6 W/kg and the designed model obtained a SAR of 0.5 W/kg which is harmless for human body.

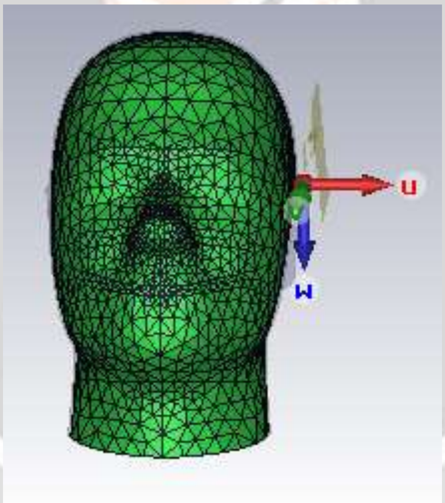

Fig-7: Head model without tumour

Here the proposed antenna is used for brain tumour sensing analysis based on the specific absorption rate calculated in the CST software.

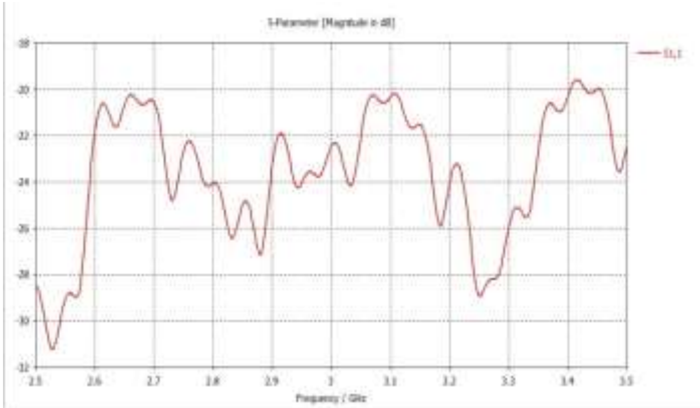

Fig-8: S Parameter for without tumour

It is a measure of the rate at which energy is absorbed by the human body when exposed to a radio frequency (RF) electromagnetic field. It can also refer to absorption of other forms of energy by tissue, including ultrasound. It is defined as the power absorbed per mass of tissue and has units of watts per kilogram (W/kg).
SAR is usually averaged either over the whole body, or over a small sample volume (typically 1 g or 10 g of tissue). The value cited is then the maximum level measured in the body part studied over the stated volume or mass. SAR measures exposure to fields between 100 kHz and 10 GHz (known as radio waves).It is commonly used to measure power absorbed from mobile phones and during MRI scans. The value will depend heavily on the geometry of the part of the body that is exposed to the RF energy, and on the exact location and geometry of the RF source. For normal human being the SAR level should be at or below 1.6 watts per kilogram (W/kg) taken over the volume containing a mass of 1 gram of tissue that is absorbing the most signal and the average time of SAR limit is 6 minutes.

In figure 8,the S-parameter for the human head without tumour is analysed to be -31dB at the operating frequency 2.55GHz and the maximum magnitude is -20 dB over the frequency range of 2.5 to 3.5 GHz

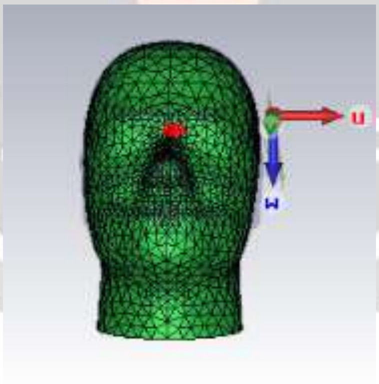

Fig-9: Head model with tumour

In figure 10, the maximum value of s-parameter for the human head with tumour is analysed to be -10 dB for the frequency range of 2.5 to 3.5 GHz.

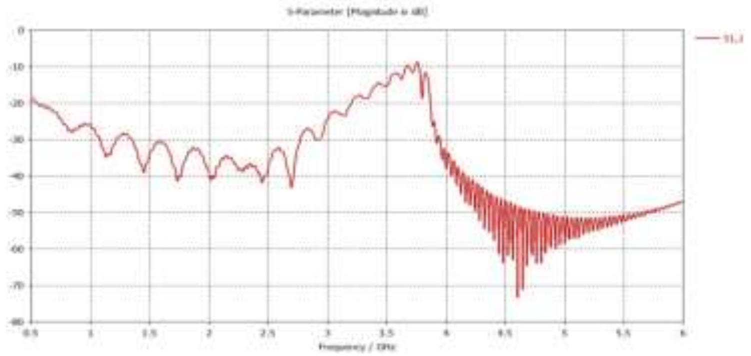

Fig-10: S Parameter with tumour

Hence the brain tumour is analysed by using the proposed antenna by means of S-parameters and SAR(specific absorption rate)

In every antenna design, simulation is always an important step. All the study of parameter can be predicted before it is to make changes. Simulation is done using CST. All of the shapes shown in this section are simulated. The simulated results are compared. The results investigated in this section for the design are return loss, VSWR and radiation pattern. By varying these widths of the slot, length of the slot, feed and feed position of S-parameter variation is studied for the slotted patch antenna. The characteristics of proposed antennas have been investigated through different parametric studies using CST simulation software. The proposed antenna have achieved stable radiation pattern and satisfied return loss. This antenna design can be used for multiband applications.

3.6 Discussion

In every antenna design, simulation is always an important step. All the study of parameter can be predicted before it is to make changes.

Simulation is done using CST. All of the shapes shown in this section are simulated. The simulated results are compared. The results investigated in this section for the design are return loss, VSWR and radiation pattern. By varying these widths of the slot, length of the slot, feed and feed position of S-parameter variation is studied for the slotted patch antenna.

The characteristics of proposed antennas have been investigated through different parametric studies using CST simulation software. The proposed antenna have achieved stable radiation pattern and satisfied return loss. This antenna design can be used for multiband applications.

6. CONCLUSIONS

A patch antenna in the radiator and partial ground plane has been designed and simulated. The proposed antenna exhibits five bands, it supports for 2.55 GHz, as well as good radiation properties. Therefore this antenna suitable for Super High Frequency application are other biomedical applications that works in these frequencies. Patch antenna for single band frequency applications with SISO technique is simulated.

5. REFERENCES

[1] B. J. Mohammed, A. M. Abbosh, S. Mustafa, and D. Ireland, "Microwave system for head imaging," *Instrumentation and Measurement, IEEE Transactions on,* vol. 63, pp. 117-123, 2014.

[2] o. N.-I. R. H. IEEE Standards Coordinating Committee 28, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz*: Institute of Electrical and Electonics Engineers, Incorporated, 1992.

[3] A. Sabouni and A. Kishk, "Dual-polarized, broadside, thin dielectric resonator antenna for microwave imaging," *Antennas and Wireless Propagation Letters, IEEE,* vol. 12, pp. 380-383, 2013.

[4] A. T. Mobashsher, A. M. Abbosh, and Y. Wang, "Microwave system to detect traumatic brain injuries using compact unidirectional antenna and wideband transceiver with verification on realistic head phantom," *MicrowaveTheory and Techniques, IEEE Transactions on*, vol. 62, pp. 1826-1836, 2014.*Propagation Letters, IEEE,* vol. 12, pp. 380-383, 2013.

[5] X. Li, M. Jalilvand, Y. L. Sit, and T. Zwick, "A compact double-layer onbody matched bowtie antenna for medical diagnosis," *Antennas and Propagation, IEEE Transactions on,* vol. 62, pp. 1808-1816, 2014.

[6] A. T. Mobashsher and A. Abbosh, "Slot-loaded folded dipole antenna with wideband and unidirectional performance for L-band applications," *Antennas and Wireless Propagation Letters, IEEE,* vol. 13, pp. 798-801, 2014.62, pp. 1808-1816, 2014.

[7] S. Ahdi Rezaeieh and A. Zamani, "3-D Wideband Antenna for HeadImaging System with Performance Verification in Brain Tumor Detection," *Antennas and Wireless Propagation Letters, IEEE,* vol. 14, pp. 910-914, 2015.