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Analysis of Microstrip Patch Antennas for Detecting Brain Cancer

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***Abstract*: This papers represents a various micro strip patch antennas which operates at different bands for detecting brain cancer. The antennas are designed with a feature that its thickness and dimension is small which makes it practically wearable on human head. The antennas are designed on the different substrates with the thickness of 0.8 mm and the relative permittivity of 4.3 F/m. Taking into consideration of the patient safety the antenna is surfaced on the human head phantom model which consists of six homogeneous layers that are skin, fat, skull, Dura, cerebrospinal fluid (CSF) and brain respectively using CST microwave studio. The designed antennas observes the return loss, voltage standing wave ratio (VSWR), Radiation pattern in human head phantom model and the results are compared with cancerous tumor consisting head model that carries a 5 mm tumor inside human brain.**

***Keywords*: Directivity, Gain, Return loss, Bandwidth**

1. Introduction

In modern days microwave imaging has achieved much popularities and interests in the medical applications. And that results in, microwave imaging has become integral diagnosis tool to detect brain cancer. [1], [2] The main interest of this work is developed because of the antenna which is low profile, non-invasive, omni directional and compact in size compared to other medical diagnosis tools like Magnetic resonance imaging (MRI), computed tomography (CT) scan. The major principle of working is based on the difference of electrical properties such as permittivity, conductivity of the tissue that are used to pathological identification between the cancerous tumor and healthy tissue of human head [3]. Cancerous brain tumors can be regarded as the most deadly and dangerous diseases in medical science. It is an anomalous and inestimable growth of the tissue in the brain. The factors to decide the state of tumor are like its size, its location and its state of development. Benign and malignant are two types of tumor. Benign tumor is referred as noncancerous tumor which is not dangerous and the growth of the tissue is very slow. Beside malignant tumor is a cancerous tumor which is considered as lethal, dangerous, unstable, spread out to the nearby tissue very rapidly and it has secondary stage [4]. In modern days the advancement in technology compact communication devices are produced which incorporate compact antennas. Micro strip patch antennas are employed as it has large range of use in medical application [5]. In this paper for micro strip patch antenna, coplanar wave guide (CPW) feed is used. There are two layer microstrip patch used in this antenna. It consists of a ground plane and a upper patch [6]. Though the thickness of the antenna is very low but the result accuracy is high. Design and analysis of a novel pentagon shaped microstrip patch antenna is proposed with human head phantom model consisting layer skin, fat, skull, Dura, Cerebrospinal fluid (CSF) and brain respectively with its relative dielectric permittivity, electrical conductivity and mass density and some of the parameters such as return loss, radiation pattern, gain, directivity and voltage standing wave ratio (VSWR) are measured using CST microwave studio [7].The human head phantom model the measured return loss (S11 parameter) is -30.99 dB at the frequency of 2.448 GHz to cover the Industrial, Scientific and Medical(ISM) band.

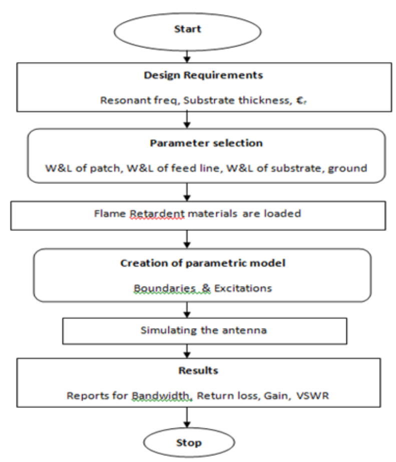

Fig. 1. Data flow diagram

2. Methodologies

Fitri Yuli Zulkifli (2015) proposed an ultra-wide band (UWB) antenna which operates in UWB range (i.e. 3.1–10.6 GHz). The proposed antenna is a printed dipole-like fed by a coplanar waveguide because it provides high frequency response. The antenna is numerically simulated using CST Microwave Studio 2014 and experimentally measured near to a semi-solid head-equivalent phantom, particularly S11 and radiation pattern on xy- and yz-plane at 5.8 GHz.

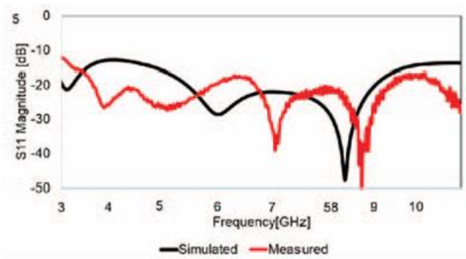

Fig. 2. Shows the S11 characteristics

The simulated antenna shows the return loss of -45dB and the measured antenna shows the return loss of -49dB. Haoyu Zhang (2012) proposed an Ultra wide-Band (UWB) Vivaldi Antenna array and is used for microwave imaging based brain cancer detection. A cancerous brain model which consists of a 5 mm tumour and four layers is simulated with CST Microwave Studio. The input pulse is radiated into brain model and the pulse response is recorded by the receiver antenna. The analytical signal function has been employed to eliminate the noise and the scanning method is applied for microwave imaging. The image processing result shows a good agreement with the actual tumour location in the brain model.

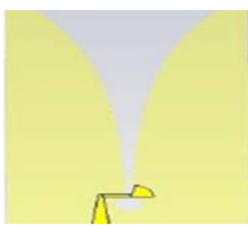
Fig. 3. Vivaldi antenna

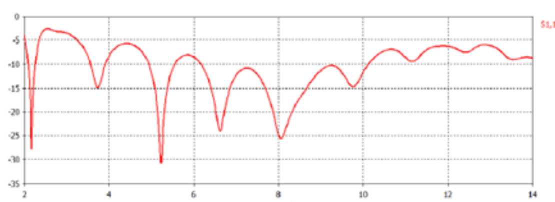
Fig. 4. The simulated antenna produces the return loss of -32dB

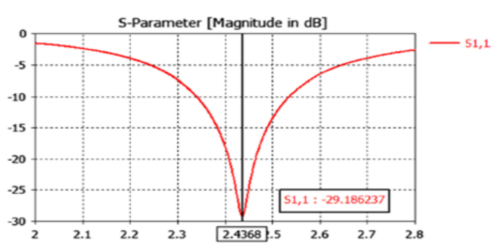

Fig. 5. S- Parameter characteristics

Thenmozhi (2017) presents a novel hexagon shape bow-tie antenna for implantable bio-medical application at a frequency ranging from 2.4 GHz to 2.48 GHz of ISM band. In order to achieve high frequency response the proposed antenna is designed with CPW feed. Alumina ceramic Al2O3Þ is used as the substrate material with 1 mm thickness and the dielectric constant is 9.8. The proposed antenna has the total size of 10 * 10 * 1 mm which is located at human tissues such as muscle, fat and skin and some of the parameters such as gain, return loss, radiation pattern and VSWR are measured. The main advantage of the proposed system is it has reduced size with increased accuracy. The proposed antenna possesses the return loss of -29 dB at 2.43 GHz.

The Fig. 5 illustrates the simulation result of return loss of about -29 dB at 2.43 GHz which is lower and it is essential for bio-medical application. The antenna simulates a lower return loss of -29 dB at 2.43 GHz. This is sufficient for the biomedical application. Shokry (2016) proposed UWB Pentagon antenna and is designed to detect brain stroke and brain tumour. It 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 44x30mm2. It is fabricated on FR4-substrate with relative permittivity 4.4 and thickness 1.5mm. The antenna is simulated on the CST Microwave Studio and measured using the network analyzer. There is a good agreement between the measured and simulated results of the return loss of the antenna on human's head and head phantom.

Table 1
Electrical properties of human head model

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

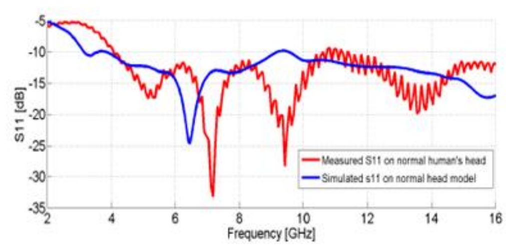

Fig. 6. Return loss of antenna on human head model

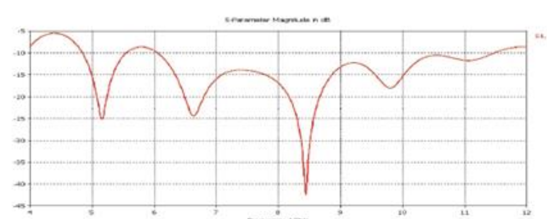
Fig. 7. Return loss characteristics

Haoyu Zhang (2011) proposed a smart antenna array and fabricated for brain cancer detection. The smart antenna array is composed of three ultra-wideband vivaldi antennas. A brain model with 4 layers is created and simulated with the CST Microwave Studio. A radius of 5mm tumor model is placed into the white matter close to the skull. A short pulse is transmitted into the brain and the reflected signals are detected by one or more receiver antennas placed in different positions. Analysis of the reflected signals shows that using a smart antenna array based imaging system can be used for brain cancer detection.

Leepika (2018) proposed a compact wearable micro strip patch antenna and is used for the determination of brain tumor. 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 analyze 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 tumor is detected by determining the specific absorption rate.

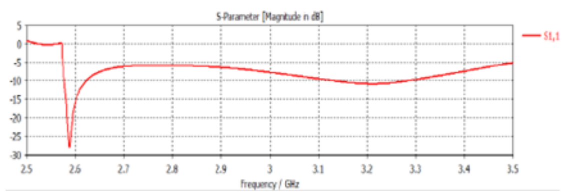

Fig. 8. Return loss characteristics

The proposed antenna possesses the return loss of -29 dB at 2.58 GHz. Annakamatchi (2018) proposed a spiral shaped patch wearable antenna has a compact size for biomedical applications. The increasing introduction of new technologies and services, the antenna is an essential part of the wireless body-centric network to operate at different frequencies. For Bio medical applications the design considerations of antenna are often hidden, small in size, and light in weight. The wearable antenna is made up of fleece substrate material with the dielectric constant of 3.2 and permittivity of 1. The proposed antenna is successfully simulated using CST Microwave Studio (CST MWS) to operate at the frequency of ISM band.

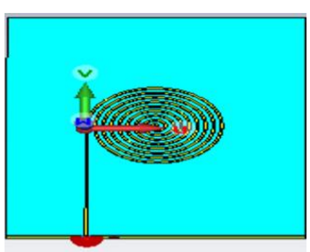
Fig. 9. Design of spiral shaped patch antenna

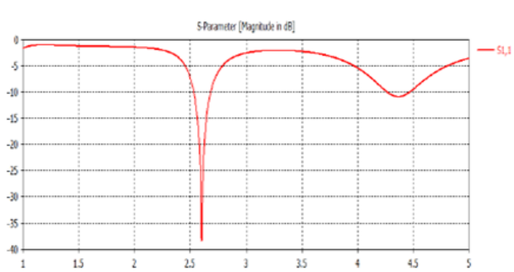

Fig. 10. Frequency response of the spiral shaped patch antenna

The Fig. 10, shows return loss obtained by the proposed antenna for ISM band is -38dB. Raimi Dewan(2014) proposed a leaf-shaped dual band dipole textile antenna for on-body application. The antenna is designed to operate at Ultra High Frequency (UHF) range frequency at 1.8 GHz and 2.6 GHz. Denim substrate was used as the material due to its robustness, flexibility and lightweight. The antenna design is simulated, optimized and analyzed using Computer Simulation Technology (CST) Microwave Studio software and Voxel. Copper tape and Shield IT fabric were used as conductive elements. The proposed antenna is compact in size and flexible materials. Results in terms of return loss, bandwidth, radiation pattern, as well as gain are presented to validate the performance of the antenna.

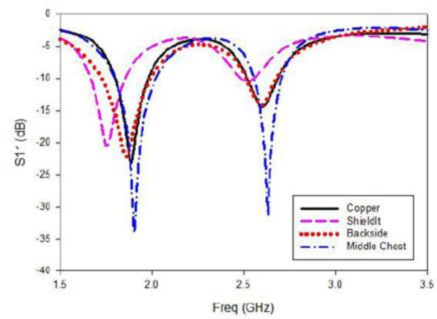

Fig. 11. Return loss characteristics

Saroja Meenakshi (2016) proposes the design and development of circular patch built on multilayer substrate having FR4 and Velcro material and it resonates at 2.45GHz and 5GHz. Body area network (BAN) technology, is a wireless network technology of wearable computing devices targeted at monitoring physiological conditions surrounding patient that has a capability to process and communicate data of heart beat, body temperature and blood pressure. Body Area Network devices along with the help of wearable antennas are embedded inside the human body in a fixed position. A return loss of -30dB and -16.2dB is observed at 2.45GHz and 5GHz respectively.

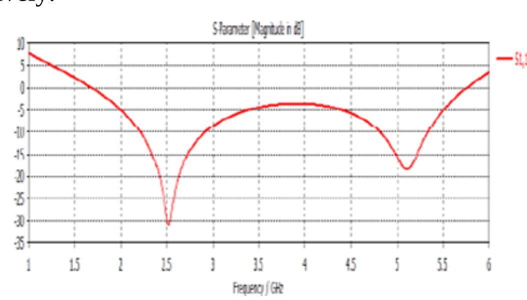

Fig. 12. Simulated return loss of dual band button antenna

Zakir Ali (2104) proposes a novel structure of wearable antenna used for clothing materials, suitable for wearable application has been presented. The substrate of the designed antenna was made of textile material, while radiating element and ground plane are made out of copper tape. To design a novel wearable flexible antenna which has high gain, efficiency, good return loss. Improvement in the design is done by increasing the electrical length and area without increasing the size of the antenna.

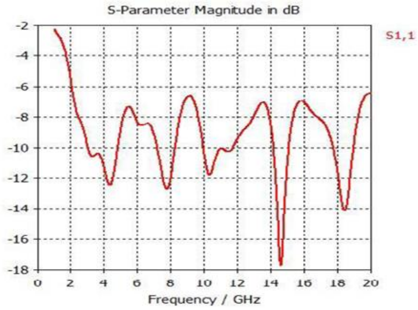

Fig. 13. S11 plot of the proposed antenna

Rahim (2017) proposes the design and development of bow-tie antenna performance made of three different flexible materials as the substrates. The antenna performance is address in terms of S11 and radiation pattern. The flexible antenna performance is simulated in free space condition and compared to the antenna performance in on-body environment. The aim of this research is to choose suitable flexible dielectric substrate which sustains its performance under on-body environment. The results of this research could provide guidance and has significant implication for future development of wearable electronics especially in medical monitoring application.

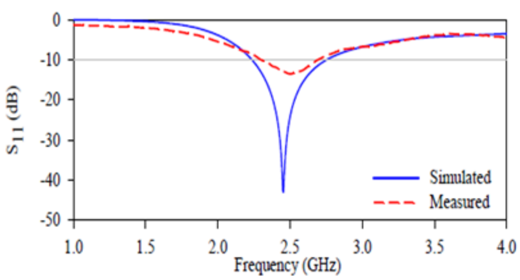

Fig. 14. Simulated and measured results of S11 of bow-tie antenna

3. Result and discussion

In this paper, the different antennas structures such as microstrip patch antenna, half-wave dipole antenna, vivaldi antenna, PIFA antenna, array antennas design were analyzed. From the observation it is inferred that rectangular slot microstrip patch antennas provide less return loss.

4. Conclusion

In this survey paper, various antennas designs were analyzed. From the observation it was found that rectangular microstrip patch antenna produced a lower return loss of -45dB

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