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Strawberry Shaped Patch Antenna for Biomedical Applications

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Abstract
The design of a strawberry-shaped antenna for biomedical applications is presented in this work. The suggested antenna has a small footprint, measuring 22X26mm2. Testing is conducted using both jeans and fr-4 substrates. CST Microwave Studio is used for the antenna's complete design and modeling. To find any tissue anomalies, this antenna is tested on phantoms of the lung and brain. It was evident from the simulation findings that the reflection coefficient changed both with and without tissue defects. Slots are inserted in the patch and ground to produce an impedance bandwidth of 3.1–10.6 GHz. With a gain of 4.8 dBi, an 82% radiation efficiency, and a peak reflection coefficient of -32 dB, the suggested antenna performs well.

Keywords: Bio medical, Patch Antenna, Strawberry, UWB.

Introduction
Tomography techniques that are frequently used and all-purpose include computed tomography (CT-Scan), positron emission tomography (PET), magnetic resonance imaging (MRI), and each one provides specific information about the blood samples of the imaged tissue and can diagnose conditions like ischemia, infarction, metabolism, malignancies, and hypoxia. Using a non-radiative technique, microwave imaging is a secure clinical imaging approach that uses the signal reflected by the examined tissue to identify tumours, insufficiencies, and diseases. Due to its affordability for construction and maintenance as well as its adaptability to various situations [1–12], this imaging technique can be utilised to assess the acute and chronic functioning as well as pathological states of soft or hard tissues.

There are many UWB antennas that have been developed and produced for MWI applications [4, 6, and 8]. These antennae have the ability to picture the liver [11], heart [1], breast [6], lung [10], brain [8], bone [9], and lung [10]. Similar to other imaging techniques like MRI, microwave imaging techniques frequently use conformal antennas [12–13], which can improve the system's built-in capabilities for the intended application. In this study, we will investigate the construction of an ultra wideband antenna in the form of a strawberry that will be used to test tumour detection on inhomogeneous lung and brain tissues. Comparative analysis has also been done on the S11 results of the antenna using the jeans and fr-4 substrates. Antenna and phantom simulations, as well as analysis and comparison of the results, have all been done using CST Studio Suite.

Design and Simulation
A 22X26X1.6 mm3 ultra wideband monopole antenna has been created for this study. By using line feed, partial ground, and slot in the ground, the intended antenna bandwidth has been reached. The given antenna will be mounted on a FR-4 substrate with electrical characteristics of 4.3 & 1.7. A schematic of the two substrates-based developed antenna is shown in Figure 1. A design based on the use of a circular monopole antenna was initially taken into consideration. We were successful in obtaining the appropriate antenna size in order to maximise manufacturing field homogeneity, accomplish the desired bandwidth, and operate at maximum efficiency. The pyramidal structure of 1, 2, and 3 circles, as well as 4 minor slots, are incorporated in a regular geometry

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pattern to create the strawberry shape. Upon that top of the fruit, a leaf structure and radius are designed. To improve bandwidth, a small slot is inserted in the feed of the antenna with jeans substrate. Table 1 provides information on the antenna's, dimensions and performance traits.

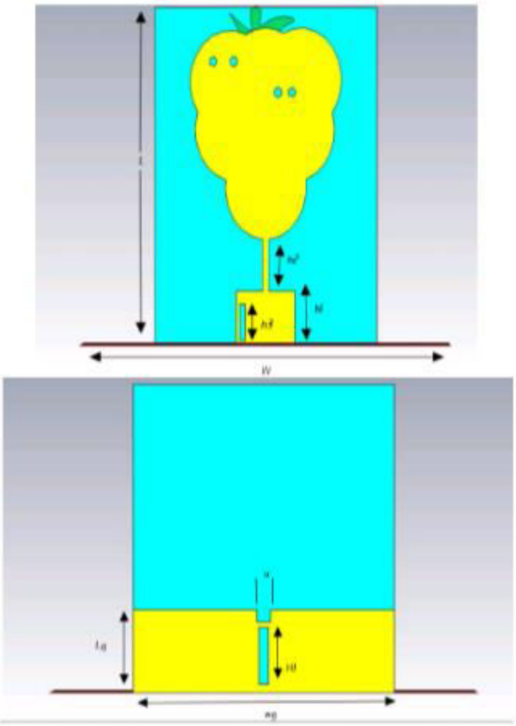

Fig1. Top and bottom views of the antenna

Table 1. Optimized Dimensions of Strawberry antenna

Brain Phantom Design

A 22X26X1.6 mm3 ultra wideband monopole antenna has been created for this study. By using line feed, partial ground, and slot in the ground, the intended antenna bandwidth has been reached. The given antenna will be mounted on a FR-4 substrate with electrical characteristics of 4.3 & 1.7. A schematic of the two substrates-based developed antenna is shown in Figure 1. A design based on the use of a circular monopole antenna was initially taken into consideration. We were successful in obtaining the appropriate antenna size in order to maximise manufacturing field homogeneity, accomplish the desired bandwidth, and operate at maximum efficiency. The pyramidal structure of 1, 2, and 3 circles, as well as 4 minor slots, are incorporated in a regular geometry pattern to create the strawberry shape. Upon that top of the fruit, a leaf structure and radius are designed. To improve bandwidth, a small slot is inserted in the feed of the antenna with jeans substrate. Table 1 provides information on the antenna's dimensions and performance traits.

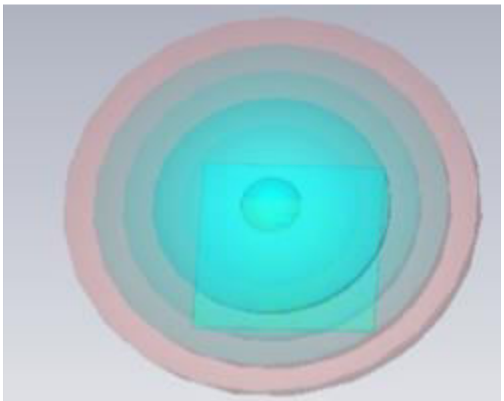

Fig.2. six layers of brain tumour

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

Fig.3. 6 layer's; electrical characteristics

In light of a significant rise in incidence and death, lung cancer detection is currently a more essential study area. It appears as a result of unchecked cell proliferation in lung tissues. As a result, hundreds of thousands of individuals pass away annually. Surgery can be used to treat cancer when it is found early on. In this research, a five-layer lung phantom is created utilizing CST microwave studio, as seen in figure 4.

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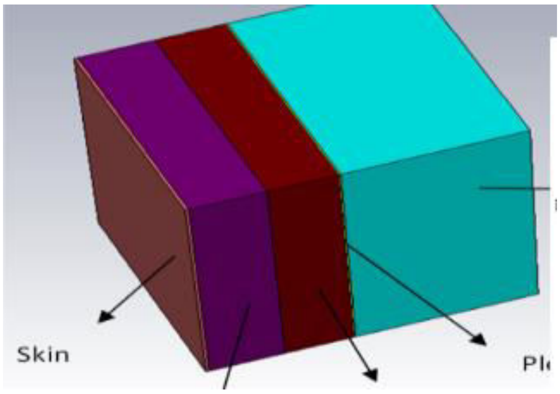

Fig. 4 Phantom of one lung

SIMULATION RESULTS

The brain phantom's skin is covered with an antenna, and CST Microwave Studio is used to replicate the process. The antenna (jeans) return loss measurements are -25.8 dB and -32.4 dB, respectively, with tumour (See figure 5). Tumors have high density features, which reduce return loss. Figure 6 displays the S11 findings of the antenna utilising Fr-4. Table III lists the various antenna output parameters while evaluating the brain.

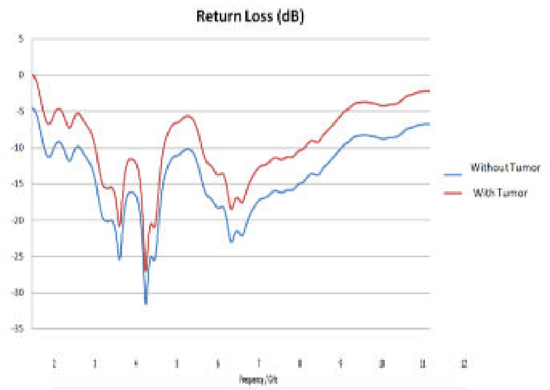

Fig. 5. Return loss (dB) due to antenna on brain phantom(jeans)

Tumor Status	Return loss (dB)	E-field (V/m)	VSWR	SAR (W/Kg)	Gain (dB)
Presence	-27.34	7402	1.89	1.0236	3.56
Absence	-31.7	5210	1.26	0.0986	4.86

Table 2. various antenna output parameters

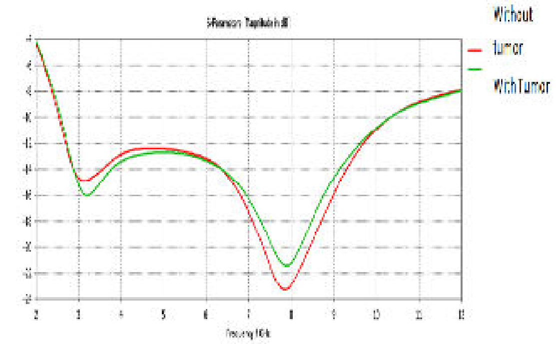

Fig. 6. Return loss (dB) due to antenna on brain phantom (fr-4)

Figure 7 shows the results of simulating an antenna on a lung phantom with and without tumour using CST microwave studio.

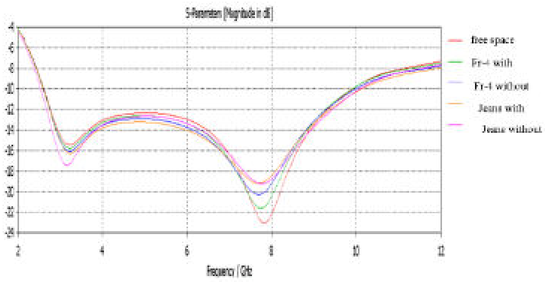

Fig. 7. Antenna on lung phantom results in return loss (dB).

Conclusion

The detection of lung and brain tumours using a strawberry shaped patch antenna was given in this research. In order to give flexibility for on-body medical applications, these antennas are designed to get around the limitations of the standard methods. A comparison of the results is made between suggested antennas and proposed antennas with brain and lung models. Because a wearable application is the primary goal of antenna design, a substrate with a dielectric constant of 1.7 denim was selected another substrate fr-4 is also tested. Using CST Microwave studio, all simulations are completed.

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