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Detection of kidney cancer using Circularly polarized patch Antenna

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***Abstract*— In this project, a technique for the early detection of kidney cancer was proposed. The technique depends upon the use of an antenna and a model for the human head. The reflection coefficient (S11) was found for two cases: with and without tumor in the head model. The large increase of S11 due to the presence of the tumor provides a good indication for cancer detection. It also gives an idea about the size of the cancer. The antenna used is a hexagonal microstrip patches. The antenna operates at Industrial Scientific and Medical (ISM) frequency 2.4 GHz. It was designed on Rogger substrate of relative permittivity 4.3 and thickness of 1.6 mm. Specific absorption rate (SAR) was calculated and found to be within the safe limit. HFSS tool use to evaluate a performance of designed antenna.**

Keywords—antenna,patch,tumor,reflection coefficient,resonant frequency

INTRODUCTION

In the current society, the people living on the earth are being troubled with several diseases. Based on the statistics, 1/2th of humans are harmed by diseases and have medicines in an unavoidable situation for their survival. The doctors and the hospitals are increasing day by day and each day brings a new disease. To handle these kinds of diseases, doctors need some special automation tools for prediction and to make their tasks easier. To enhance the advanced prediction based on a patient's care, medical innovation is to be enhanced in the form of automated tools. This is essential to improve the efficiency of doctors/technicians and also to minimize the death rate and reduce the suffering of the patient.

Based on the estimation of the World Health Organization (WHO), cancer was the second foremost mortality caused in people all around the world. The most cancer-affected people are under 70 years of age in the year 2015. Population growth, ageing, economic development, and change in lifestyle are the reasons for these cancer occurrences. Brain cancer/tumor is the most significant disease that has risen vigorously in recent decades in the world. Malignant is one type of brain tumor that is caused rarely for adults in 1–2%. Based on the GLOBOCAN 2012, the survival rate of brain cancer is minimum and it impacts people's quality of life, mortality rate, and economic costs. Kidney cancer, also known as renal cancer, is a type of cancer that originates in the cells of the kidneys, which are responsible for filtering waste products from the blood and producing urine. There are several types of kidney cancer, including:

Renal cell carcinoma (RCC): This is the most common type of kidney cancer, accounting for about 90% of cases. RCC originates in the cells that line the small tubes within the kidneys that filter blood and remove waste.

Transitional cell carcinoma: This type of kidney cancer originates in the lining of the renal pelvis, which is the area where urine collects before being transported to the bladder.

Antennas can play a role in cancer and tumor detection through a technique called microwave imaging. Microwave imaging is a non-invasive imaging technique that uses antennas to transmit and receive electromagnetic waves at microwave frequencies. When the waves encounter biological tissue, they are reflected or absorbed, depending on the tissue's dielectric properties.

Tumors and cancerous tissue have different dielectric properties than healthy tissue, which can be detected through microwave imaging. By analyzing the reflected or absorbed waves, it is possible to create an image of the tissue, including any tumors or cancerous growths.

One of the advantages of microwave imaging is that it is non-invasive and does not use ionizing radiation, unlike some other imaging techniques such as X-rays or CT scans. This makes it safer for patients, especially for repeat imaging sessions.

Microwave imaging is still a developing technology and is not yet widely used in clinical practice for cancer and tumor detection. However, research is ongoing to improve the sensitivity and specificity of microwave imaging and to develop practical systems for clinical use.

In addition to microwave imaging, other antenna-based techniques such as radiofrequency ablation (RFA) and microwave ablation (MWA) are used in cancer treatment. These techniques use antennas to deliver high-frequency energy to the tumor, which heats and destroys the cancerous tissue.

Some of the medical devices can be implanted inside the human body for different purposes, such as monitoring, drug delivery or specific stimulation. The first successful implanted device inside the human body was a pacemaker in 1960. This step opened a hot topic for researchers to investigate and develop many more implantable devices. Medical devices designed for implantation purposes require several considerations from different scopes such as medical, biology, electrical engineering or mechanical engineering requirements. Electrical engineering plays a significant role in developing such devices in terms of various aspects including powering and communication systems. Since these aspects are very essential for any implantable device, researchers spend great efforts to exploit the optimum solution such that the devices can work reliably and safely.

Due the electromagnetic properties of the human body, systems face more challenges and difficulties in designing antennas than conventional wireless

communication systems. Unlike free space, human body tissues are lossy and have relative permittivity. Therefore, the antenna requires the compliance with many conditions, standards and requirements such as: size, radiation performance,
frequency of operation and SAR.

Medical electronic devices can be classified into two categories depending on the protocol and standards that these devices use. The first category is Wireless Medical Telemetry Services (WMTS) for wearable devices. The second category is Medical Implant Communications Service (MICS) which was allocated by the European Telecommunications Standards Institute (ETSI) for implantable devices. The frequency band allocation for MICS is 402 MHz to 405 MHz [41]. The Industrial, Scientific, and Medical (ISM) bands (433.1-434.8 MHz, 868-868.6 MHz, 902.8-928 MHz, and 2400-2500 MHz) are also suggested for implantable medical device biotelemetry in some countries, especially for subcutaneous application.
reference polarisation is usually the co-polarisation

abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

A. Survey

Mohammed Z. Azad et al proposed a miniature implanted Hilbert inverted-F antenna design at the 1.575 GHz global positioning system (GPS) frequency, which can be used to track the location of its user, e.g., the elderly with declining mental capacity (Alzheimer's disease). A detailed parametric study of the antenna design is performed by considering it to be implanted within a human muscle model.

Behailu Kibret et al propose to use the human body itself as an antenna by feeding an RF current into the tissues. In particular, this paper studies the scenario when the RF current is fed by a tiny toriodal inductor that is implanted and clamped around the tissues in the ankle. The frequency range of 1-70 MHz is considered, which includes the resonance frequency of the human body.

Zhu Duan et al proposed a novel differentially fed dual-band antenna for the first time for a fully implantable neuro-microsystem. The antenna operates at two center frequencies of 433.9 MHz and 542.4 MHz, which are close to the 402-405 MHz medical implant communication services (MICS) band, to support sub-GHz wideband communication for high-data rate implantable neural recording application. The size of the antenna is 480.06 mm 3 (27 mm × 14 mm × 1.27 mm).

Asimina Kiourti; et al study the design and radiation performance of novel miniature antennas for integration in head-implanted medical devices operating in the MICS (402.0-405.0 MHz) and ISM (433.1-434.8, 868.0-868.6 and 902.8-928.0 MHz) bands. A parametric model of a skin-implantable antenna is proposed, and a prototype is fabricated and tested.

Chin-Lung Yang et al proposes a novel antenna for dental implants. The proposed antenna can be attached to minimally invasive biomedical devices to monitor health conditions. Based on a combination of Archimedean spirals and a Hilbert-based curve, this 3D folded antenna was embedded on a ceramic denture (ZrO 2), and operates within the medical radio (MedRadio) band

Farooq Faisal et al developed a miniaturized novel-shape dual-band implantable antenna operating in the industrial, scientific, and medical bands (902-928 MHz and 2.4-2.4835 GHz) for battery-powered implants. The Rogers ULTRALAM (ε r = 2.9 and tanδ = 0.0025) liquid crystalline polymer material with 0.1 mm thickness is used as both the substrate and superstrate.

Matthew K. Magill et al presented a compact printed meandered folded dipole antenna with a volume of 114 mm 3 suitable for implantation in a range of different body tissue types with diverse electrical properties for operation in the 2.36-2.4 GHz MBAN and 2.4-GHz ISM bands. Its performance was verified and compared against that of a wire dipole and slot loaded monopole antenna in an implant phantom testbed containing tissue equivalent liquids representing body tissues with high and low water content.

Muhammad Zada et al presents a miniaturized triple band implantable antenna system for multiple biotelemetry applications, which operates at the industrial, scientific, and medical (ISM) band (902-928 MHz and 2400-2483.5 MHz) and the midfield band (1824-1980 MHz). These bands are intended for the function of data telemetry, wireless power transfer, and power saving.

Wen Lei; et al proposed a ground radiation antenna with circularly polarized (CP) properties for biomedical applications. A square ground with a small clearance is implemented in the proposed antenna. Reactive components are included to realize the impedance matching, as well as those requirements for the generation of CP waves. Simulations are conducted within a single-layer tissue model to evaluate the antenna's performance.

P. Soontornpipit et al design a microstrip patch antenna for communication with medical implants in the 402-405-MHz Medical Implant Communications Services band. Microstrip antenna design parameters are evaluated using the finite-difference time-domain method, and are compared to measured results.

Asimina Kiourti; et al address numerical versus experimental design and testing of miniature implantable antennas for biomedical telemetry in the medical implant communications service band (402-405 MHz). A model of a novel miniature antenna is initially proposed for skin implantation, which includes varying parameters to deal with fabrication-specific details.

Fa Wang et al present a wide frequency range, low cost, wireless intracranial pressure monitoring system, which includes an implantable passive sensor and an external reader. The passive sensor consists of two spiral coils and transduces the pressure change to a resonant frequency shift. The external portable reader reads out the sensor's resonant frequency over a wide frequency range (35 MHz-2.7 GHz

B. Proposed Antenna

- This work presents compact and hexagonal antenna for high the detection of kidney cancer.

- The antenna is designed on the Rogger substrate having a compact dimension of 80 × 60 × 0.857 mm3.

C. ANTENNA DESIGN AND OPERATIONAL MECHANISM

Antenna design plays a vital role in determining its performance. Microstrip patch antenna is simpler to construct as it provides easy feeding and has low profile when compared to other type of antennas. It has a patch supporting radiation, along with a ground plane and the substrate. In the proposed designs the ground plane is made of copper and Rogger material is used for making the substrate. The patch can be of any shape, here the shape of patch chosen to be rectangle instead of circular because it provides high gain.The antenna has slots within the patch and is provided with an inset feed. The antenna design parameters are calculated using various formulae . In order to get efficient radiation, a practical rectangular patch width *W* can be given as,

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\varepsilon_r+1}}$$

where *fr* is the antenna's resonant frequency and *c* is the speed of light in vacuum. The effective dielectric constant *εreff* is expressed as,

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12\square}{W}}}\right)$$

where h is the substrate height, the effective length Leff is obtained as,

$$L_{eff} = \frac{c}{2fr\sqrt{\varepsilon_{reff}}}$$

Patch's actual length is estimated using the equation 4

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

where Δ*L* is extension length of the patch and is given by,

$$\Delta L = 0.412h\frac{\left(\varepsilon_{reff}+0.3\right)\left(\frac{W}{h}+0.264\right)}{\left(\varepsilon_{reff}-0.258\right)\left(\frac{W}{h}+0.8\right)}$$

There are number of feeding techniques present in operating an antenna such as aperture-coupled coaxial feed, proximity-coupled feed, inset feed, microstrip feed, and coplanar waveguide feed. Any of these techniques can be used ensuring the efficient power transfer between the radiating structure and feeding structure.

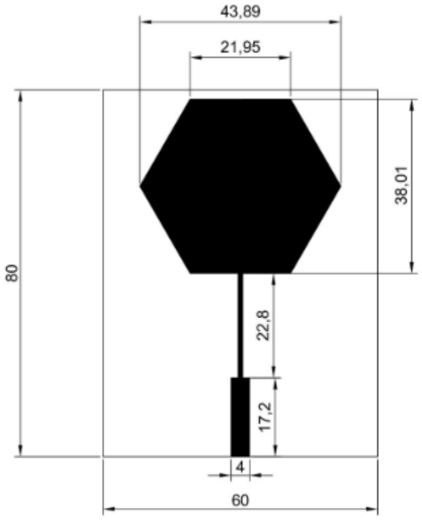


Figure 3.1 Proposed antenna

The length and width of the ground plane are 60 × 80 mm. The height of the substrate is chosen as 0.8 mm. The slot width and length are 21.95 mm and 38.01 mm respectively. The overall length of the feed line is 40 mm as shown in Fig. 3. These design parameters are calculated using the above mentioned formulae and the proposed antennas are connected with 50Ω transmission feed line.

D. Simulation Results

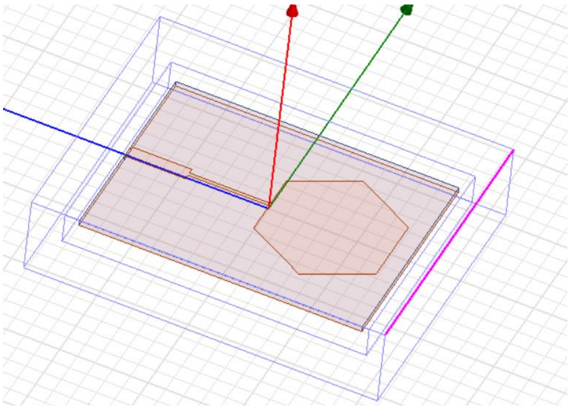
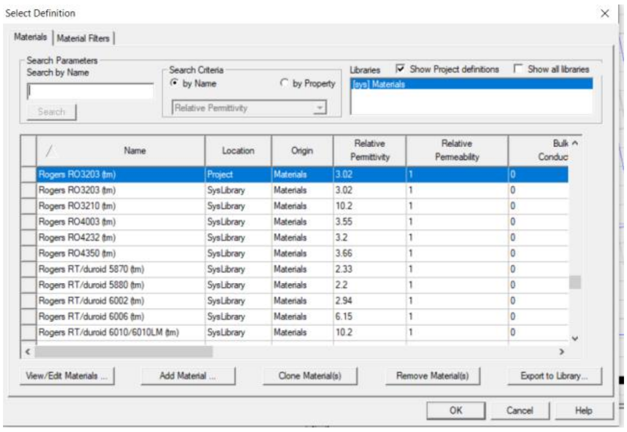


Fig Proposed structure

The above figure shows the radiating element design of proposed antenna. In radiator , the hexagon cuts are created to tuned for the required frequency . The radiator is formed a Rogger substrate.



☑ Show Project definitions ☐ Show all libraries

[sys] Materials

Name	Location	Origin	Relative Permittivity	Relative Permeability	Bulk Conduc
Rogers RO3203 (tm)	Project	Materials	3.02	1	0
Rogers RO3203 (tm)	SysLibrary	Materials	3.02	1	0
Rogers RO3210 (tm)	SysLibrary	Materials	10.2	1	0
Rogers RO4003 (tm)	SysLibrary	Materials	3.55	1	0
Rogers RO4232 (tm)	SysLibrary	Materials	3.2	1	0
Rogers RO4350 (tm)	SysLibrary	Materials	3.66	1	0
Rogers RT/duroid 5870 (tm)	SysLibrary	Materials	2.33	1	0
Rogers RT/duroid 5880 (tm)	SysLibrary	Materials	2.2	1	0
Rogers RT/duroid 6002 (tm)	SysLibrary	Materials	2.94	1	0
Rogers RT/duroid 6006 (tm)	SysLibrary	Materials	6.15	1	0
Rogers RT/duroid 6010/6010LM (tm)	SysLibrary	Materials	10.2	1	0

Fig Material design

The above figure shows rogger substrate design for proposed antenna design. By using film technology the proposed antenna mounted on Rogger substrate .

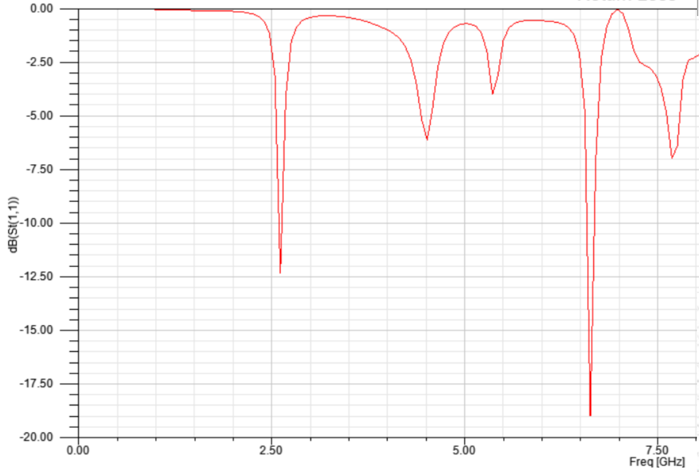


Fig Return loss

The above figure shows the return loss analysis of proposed antenna. The proposed antenna achieved a RL of -13 with the tuned frequency .The effect of creating various slots analysed for different cuts in a radiating elements.

Fig 3D Gain

Figure shows the gain analysis of proposed antenna. The proposed model achieved a gain values of 6.7 for the tuned frequency. The average values of gain achieved about 6 in the rogger substrate.

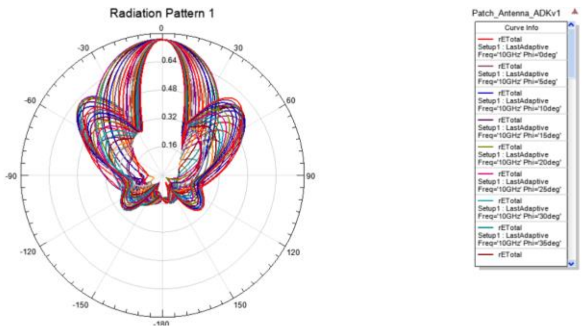
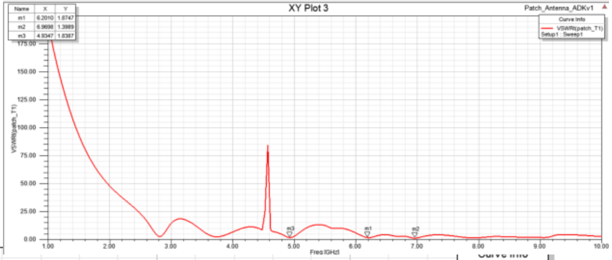


Figure : Radiation pattern of proposed antenna



Name	X	Y
m1	6.2010	1.8747
m2	6.9698	1.3989
m3	4.9347	1.8387

Figure : VSWR measurement

Table shows the performance comparison of proposed antenna. Compared to other design ,the proposed antenna shows higher gain ,RL and VSWR results.

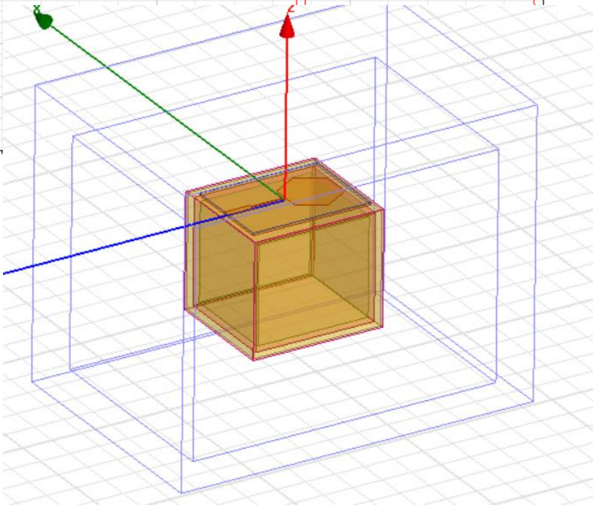


Fig Proposed structure

The above figure shows the radiating element design of proposed antenna. In radiator , the hexagon cuts are created to tuned for the required frequency . The radiator is formed a Rogger substrate. Also, the antenna is placed above the brain model.

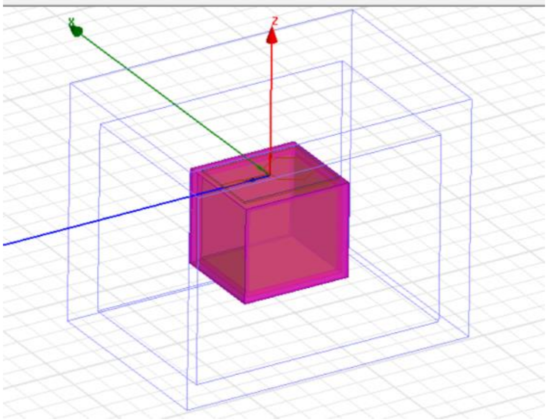


Fig Material design

The above figure shows brain model designed for simulation .

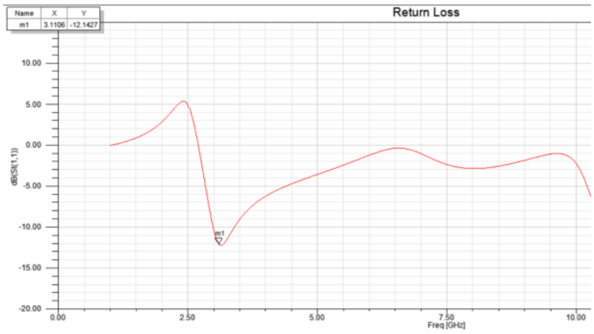


Fig Return loss

The above figure shows the return loss analysis of proposed antenna. The proposed antenna achieved a RL of -13 with the tuned frequency .The effect of creating various slots analysed for different cuts in a radiating elements.

Fig 3D Gain

Figure shows the gain analysis of proposed antenna. The proposed model achieved a gain values of 6.8 for the tuned frequency. The average values of gain achieved about 6 in the rogger substrate.

Parameter	Normal region	With cancer
RL	-11.9	-12.14
Gain	6.52	6.4
VSWR	1.6	1.9

E. Conclusion

A reconfigurable hexagonal antenna was designed for kidney cancer detection. A corporate feeding network was designed to match the antenna to the feeding source. The complex of designing radiator is reduced due to the hexagonal structure. S11 was found for the antenna array on head phantom with and without tumor. The radiation pattern and S11 were measured in free space. This enables early detection of kidney cancer.

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