Journal of Current Research in Engineering and Science
JCRES
Bi-Annual Online Journal (ISSN: 2581 - 611X)

VOLUME:8, ISSUE:1, FEBRUARY 2025, PAPER NUMBER:06

EXPLORATION OF H-SHAPED MICROSTRIP PATCH ANTENN FOR WEARABLE TECHNOLOGY IN THYROID CANCER CELL DETECTION

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EXPLORATION OF H-SHAPED MICROSTRIP PATCH ANTENNAFOR WEARABLE TECHNOLOGY IN THYROID CANCER CELL DETECTION

ABSTRACT -- This paper presents the design of an H- shaped microstrip patch antenna to estimate the SAR(Specific immersion Rate) for thyroid gland cancer cell discovery. This antenna is flexible and applicable for wearable operations. The performance of an antenna can exhibit variability when positioned over the human thyroid gland. Measuring parameters such as return loss, gain, and VSWR is a standard practice in the field. There are different kinds of the antenna but microstrip patch antenna provides low cost, low volume, featherlight etc. FR-4, known for its dielectric properties, is employed as a substrate to address issues related to low gain and high return loss.The patch captain is made up of bobby material to form a flexible antenna. The proposed antenna design provides a high SAR value of 0.0199 W/ Kg for 1g of towel with a excrescence. Since cancer cells contain further water content the performance of colorful parameters can be changed in the proposed antenna design. The gain value of the proposed antenna is 6.36 dB at GHz. The thyroid gland model of proposed H- shaped and H shaped perpendicular niche antennas are designed using CST(Computer Simulation Technology) microwave oven plant tool.

Keywords --- Voltage Standing Wave rate, Return Loss, Gain, Specific immersion Rate

I. INTRODUCTION

The thyroid gland, located in the neck just below the larynx or voice box, comprises two lobes connected by a structure known as the isthmus, resembling a butterfly in shape. Thyroid cancer originates in this gland when healthy cells undergo mutations and form a tumor mass [1]. Thyroid gland cancer can potentially spread throughout the neck and to other parts of the body, with distinct differences between normal cells and thyroid cells observable under a microscope[2].For cancer detection, wearable microwave imaging devices equipped with flexible antennas are employed [4]. The Metal Composite Embroidery Yarn (MCEY), a polyester substrate, is utilized for detecting FM signals. The MCEY is embroidered with a Multi Resonant Folded Dipole (MRFD) and integrated into a jacket as a wearable antenna.

When the antenna is positioned near the human body, its efficiency and operating frequency are adversely affected due to the human body's high permittivity [8]. Textile antennas exhibit lower return loss at lower frequencies. For protection and consistency, flexible foam is employed as a protective material [9] [10]. The Specific Absorption Rate (SAR) measures the amount of power absorbed by human tissue. SAR values can be determined by placing the antenna in various positions over a sample volume, typically 1g or 10g of tissue, using the following formula:

$$SAR = (\sigma E^2) / (2\rho) \quad (1)$$

Where σ represents tissue conductivity (S/m), E is the electric field strength within the tissue (V/m), and ρ denotes mass density (Kg/m3) [5]. Antennas designed with polydimethylsiloxane (PDMS) are flexible and can be modified by dielectric permittivity. Sealed antennas are manufactured to integrate this substrate, resulting in improved radiation characteristics due to their soft and flexible nature [6].

Wearable antennas using fabric substrates can assess the dielectric constant using microstrip patch radiators, making them suitable for various wearable applications. The multilayer weaving technique involves weaving a cotton substrate with multiple layers of yarn, allowing for variation in skin, fat, and muscle thickness depending on the body part [3].

II. LITERATURE REVIEW

J.Jenisha and K.Madhan Kumar [1]This paper introduces the design of a circular microstrip patch antenna, aimed at evaluating the Specific Absorption Rate (SAR) for the detection of thyroid gland cancer cells. This antenna stands out for its flexibility and suitability for wearable applications, making it an ideal candidate for medical diagnostic purposes. When placed directly on the thyroid gland in humans, its performance exhibits variability. To gauge its effectiveness, various parameters such as return loss, gain, and VSWR are measured. This study highlights the potential of the circular microstrip patch antenna in the context of thyroid gland cancer detection, emphasizing its flexibility, suitability for wearables,and its performance characteristics.

Dr.P.A.Harsha Vardhini et.al, The growing prevalence of various frequency bands in mobile and wireless communication has sparked a demand for antennas that can efficiently operate across multiple frequency ranges. With the increasing popularity of portable handheld devices, there is also a heightened need for compact and small antennas.This research project focuses on the development of a multi-band antenna tailored for use in portable communication devices.The antenna serves as an embedded solution for accommodating a wide range of frequency bands. Specifically, a microstrip multiband antenna has been designed and analyzed using CST Microwave Studio software.

R. Kiruthika et.al, This paper presents the design and analysis of a Microstrip Patch antenna intended for radar applications. Microstrip patch antennas come in various shapes, and this study explores conventional shapes, including Rectangular, Triangular, and Circular Microstrip patch antennas. The antennas are specifically designed to resonate at the X-band frequency range, which spans from 8 to 12 Ghz and finds widespread use in radar applications. The chosen substrate for these antennas is the cost-effective FR4 (Flame Retardant) Epoxy material. To analyze and evaluate the performance of these antennas, the study employs Ansoft HFSS (High-Frequency Structural Simulator) Version 12 software.

Kumar Mohita,et.al, This research paper focuses on the comparative analysis of three distinct feeding methods—co-axial probe, microstrip line, and co-planar feeding—applied to a thermally stable resonator antenna (TSRA). The study begins by developing

nanoparticles through a suitable synthesis process and then mixing them based on their temperature coefficients to achieve thermal stability. The microwave dielectric constant (εr) and permeability (μr) have been determined using the Nicholson-Ross-Weir conversion method. Subsequently, a thermally stable cuboid-shaped resonator antenna was designed using this nanoparticle composition. The study then explores the use of these three different feeding techniques and compares the resulting characteristics and performance of the antenna. The objective is to evaluate and contrast the features and performance of the TSRA under different feeding methods, shedding light on the most effective approach for this specific antenna design.

Manjunath G,et.,al, This paper introduces a novel design approach for a circular microstrip patch antenna, utilizing a substrate sandwiching technique to enhance the antenna's bandwidth. The proposed antenna has been specifically developed to operate at 2.7GHz in the S-band frequency range, and its design and analysis were carried out using the High-Frequency Structural Simulator.In this study, the circular patch antenna is designed on two different substrates, namely FR4 epoxy and RT Duroid 5880™, with the actual antenna fabricated on a three-layer FR4-epoxy substrate. The research primarily investigates the impact of dielectric constant and substrate stacking on the performance of the antenna system, and the results obtained from the simulator are thoroughly analyzed. The outcome of this analysis indicates a notable enhancement in the antenna's bandwidth. With the application of a three-layer substrate stacking, the antenna's bandwidth has expanded by a factor of 2.5, with a 10 dB return loss and a directive gain of 4.7dBi.

III. ANTENNA'S TECHNIQUE IMPLEMENTATION

A microstrip patch antenna incorporating an inset feed technique has been employed to enhance return loss, and its performance has been simulated when placed on the thyroid gland. This antenna operates within the 2.45GHz ISM (Industrial, Scientific, and Medical) frequency range and exhibits a return loss of -14dB at 2.45GHz [1]. An innovative Z-shaped wearable patch antenna has been developed, with a frequency band of 2.5GHz. Utilizing a silk substrate, this antenna reduces the SAR (Specific Absorption Rate) value. The antenna design yields a gain value of 1.67dB, and its performance is contingent on the presence or absence of thyroid cancer [2].

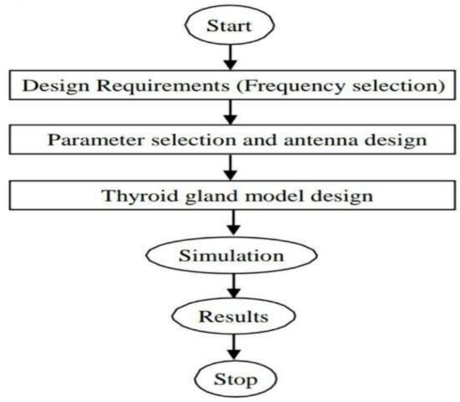


Fig.1. Data Flow Diagram

A multilayered woven textile with coaxial feeding has been designed for wearable applications operating at 2.45GHz. The SAR value varies across different body regions, with a simulated SAR value of 0.0164W/Kg detected at the arm [3].

This approach leverages various antenna designs and frequencies, emphasizing the impact of these designs on SAR values and their suitability for wearable applications.Based on the literature review provided, it is evident that various wearable antennas have operated within the ISM band. In contrast, our designed H-shaped microstrip patch antenna operates within a higher frequency range, spanning from 10.846GHz to 16.452GHz. For its substrate material, we have employed FR-4 (Flame Retardant).

The primary objective of this H-shaped microstrip patch antenna design is to assess a range of antenna performance parameters, including gain, VSWR

(Voltage Standing Wave Ratio), return loss, directivity, E-field, H-field, and to observe the specific absorption rate within human thyroid tissue.

As depicted in Fig.1, a data flow graph illustrates the interaction between the designed antenna and a human thyroid gland model, both of which were developed using CST software. Notably, the designed antenna's operational frequency spans from 10.846GHz to 16.452GHz. This innovative approach ventures beyond the typical ISM band, operating at higher frequencies while utilizing FR-4 as the substrate material, and aims to comprehensively evaluate the antenna's performance in conjunction with its impact on specific absorption rates within the human thyroid tissue.

IV. THYROID GLAND MODEL DESIGN:

The H-shaped microstrip patch antenna, designed for a frequency range spanning from 10.846GHz to 16.452GHz, features specific materials for its components. Copper (annealed) is employed for the ground, patch, and FR-4 (Flame Retardant) as the substrate, consisting of fiberglass and epoxy resin to facilitate communication between the ground and patch.

The patch is positioned above the substrate and is constructed using copper (annealed) material. To create slots and modify the design, sections are marked and subsequently cut using nickel (lossy) material.

V. H-SHAPE MICROSTRIP PATCH ANTENNA:

The H-shaped microstrip patch antenna encompasses essential components, including the ground, substrate, patch, and microstrip line feed. The dimensions for the width and length of the microstrip line feed are 4mm and 17mm, respectively. Both the ground and substrate share the same dimensions of 24mm in width and 30mm in length. The ground has a thickness of 0.05mm, while the substrate utilized in this antenna is 1.40mm thick.

Fig. 2 illustrates the design of the H-shaped microstrip patch antenna, which incorporates three sets of patches, each with unique dimensions:

1. The left patch has a width and length of 22mm and 14mm, with a thickness of 0.05mm.

2. The center patch features dimensions of 6mm in width and 9mm in length, with a thickness of 0.05mm.

3. The right patch measures 22mm in width and 14mm in length, with a thickness of 0.05mm.

Both slot 1 and slot 2 are identical in terms of their dimensions, differing only in their positions. The width, length, and thickness of both slot 1 and slot 2 are consistent at 14mm, 16mm, and 0.05mm, respectively

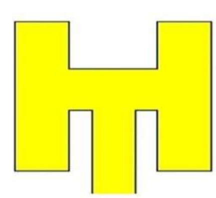


Fig.2. H-shape microstrip patch antenna

This antenna design and its constituent components are instrumental in achieving the desired performance within the specified frequency range.

VI. VERTICAL SLOT H-SHAPE MICROSTRIP PATCH ANTENNA:

The vertical slot H-shaped microstrip patch antenna is an extension of the original design, maintaining the same dimensions for its key components, which include the ground, substrate, patch, and feed. The antenna retains the dimensions of the H-shaped microstrip patch antenna mentioned earlier.In this modified design, the vertical H-shaped antenna incorporates two vertical slots, one in the left patch and another in the right patch. These slots are created using a material known as nickel (lossy) to remove the highlighted portions. Fig. 3 provides a visual representation of the vertical slot microstrip patch antenna.

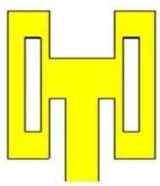


Fig.3. Vertical slot H-shape microstrip patch antenna

This modification introduces vertical slots into the original H-shaped microstrip patch antenna, and these slots share identical dimensions while serving specific design purposes.

VII. THYROID GLAND MODEL DESIGN:

Thyroid cancer specifically affects the thyroid gland, a small gland located at the base of the neck. Fortunately, most cases of thyroid cancer are treatable. To explore the potential of using the designed H-shaped wearable microstrip patch antenna for identifying the presence of cancer cells within the thyroid gland, various performance parameters need to be evaluated. Notably, the antenna's placement should result in a high Specific Absorption Rate (SAR).

This paper outlines the development of a human thyroid gland model consisting of six layers, including skin, fat, muscle, bone, thyroid, and tumor. The primary aim is to quantify the amount of radiation absorbed by the human thyroid gland, which can be expressed in terms of SAR.

The SAR is calculated both with and without the presence of a tumor.The average mass density and conductivity values for these layers are as follows: skin (ρ = 1100; σ = 5.0138), fat (ρ = 1100; σ = 0.1), muscle (ρ = 1060; σ = 1.705), bone (ρ = 1810; σ = 0.32), thyroid (ρ = 1050; σ = 1.469), and tumor (ρ = 2050; σ = 6). These values are integral to determining the SAR within the thyroid gland model.

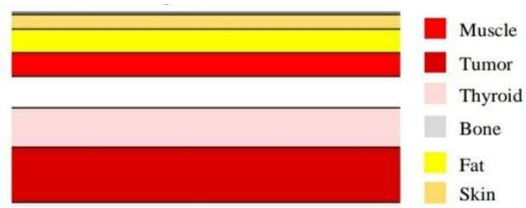


Fig.4. Human thyroid gland model

Furthermore, the thickness of each layer varies, with skin, fat, muscle, bone, thyroid, and tumor layers having thicknesses of 1mm, 4mm, 6mm, 9mm, 13mm, and 18mm, respectively. This comprehensive thyroid gland model is essential for assessing the impact of the antenna's performance and SAR values in both the presence and absence of a tumor, contributing to the understanding and potential diagnosis of thyroid cancer.

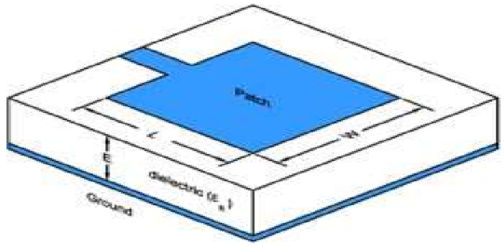
In this research project, we have developed both an H-shaped microstrip patch antenna and an H-shaped microstrip patch antenna with a vertical slot. The purpose of these designs is to assess various key parameters, including gain, VSWR (Voltage Standing Wave Ratio), return loss, and Specific Absorption Rate (SAR). These evaluations are conducted using a thyroid gland model, both with and without the presence of a tumor.

The primary objective of this study is to comprehensively analyze how these antennas perform and the resulting SAR values within the thyroid gland model. This investigation provides insights into the potential application of these antennas for diagnosing thyroid conditions, particularly the presence of tumors.

VIII. DESIGN METHODOLOGY

CST Microwave Studio is a specialist tool for the 3D EM simulation of high frequency factors. It enables the fast and accurate analysis of high frequency (HF) bias similar as antennas, pollutants, couplers, planar andmulti-layer structures. Besides the flagship module, the astronomically applicable time- sphere solver and the frequence- sphere solver, CST offers farther solver 3 modules for specific operations. At first, we've designed a Square Microstrip Antenna.

To make it to serve better for both multiband operation we've considered a Fractal structure. similar that it can serve as a reconfigurable antenna. Square is chosen as the base structure by considering the formula listed below



The Width of Rectangular Patch is calculated using equation

$$w = \frac{c_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

- ✓ W - Width of the patch
- ✓ c_0-Speed of light
- ✓ ε_r-substrate dielectric constant
- ✓ f_r- Frequency of Resonance

IX. TUMOR DESIGN MODEL

Fig 6 and 7 depict the H-shaped Microwave Photonic Antenna (MPA) in two configurations: without a tumor layer and with a tumor layer. The design of the H-shaped MPA involves maintaining a separation of 1mm between the antenna and the six layers.

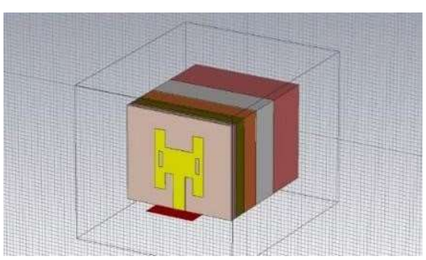


Fig.6. Without tumor layer

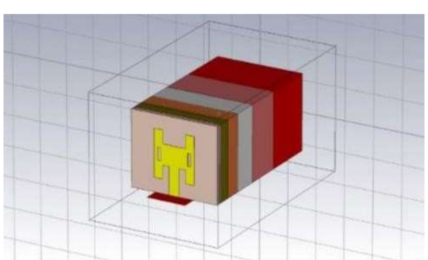


Fig.7. With tumor layer

X. RESULTS OF H-SHAPE MICROSTRIP PATCH ANTENNA

Without Tumor- 2.92 (-32.365-s11, Gain- -20.4 dB, VSWR-1.049, Directivity-5.4 dBi, Bandwidth-3.5585 GHz).With Tumor- 2.86 (-25.499-s11, Gain- -20.6 dB, VSWR-1.112, Directivity-5.05 dBi, Bandwidth-3.4933 GHz)

Fig.8.**FREQUENCY- 2.92 GHz**

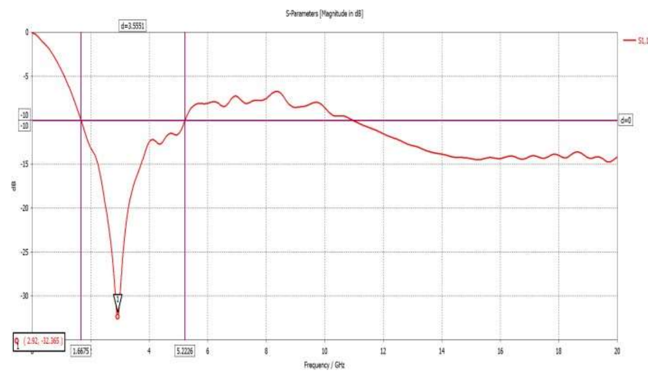


Fig.9.The simulated Fractal Microstrip Patch Antenna VSWR (Voltage standing wave Ratio) is shown below.

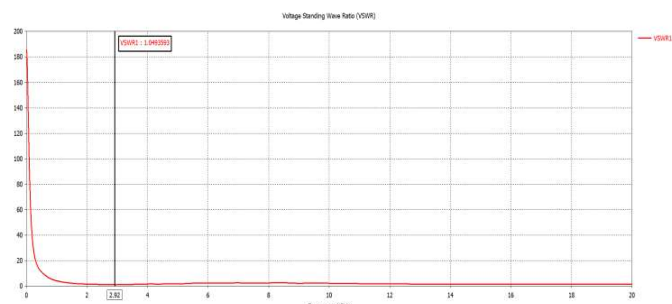


Fig.10.The simulated Fractal Microstrip Patch Antenna Directivity at 2.92 GHz is shown below

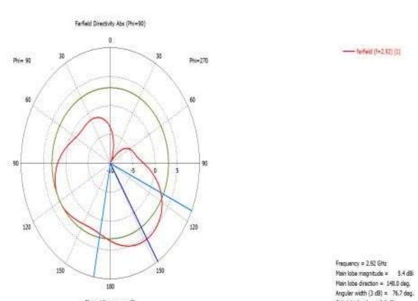


Fig.11.FREQUENCY- 2.86 GHz

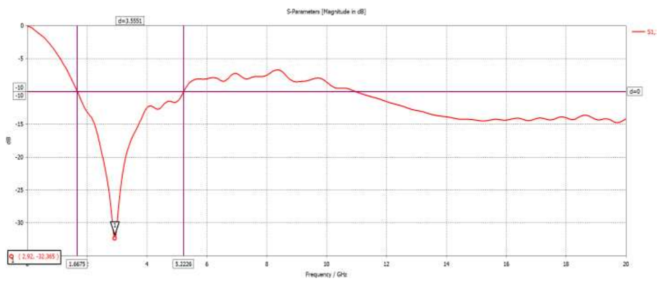


Fig.12.The simulated Fractal Microstrip Patch Antenna VSWR (Voltage standing wave Ratio) is shown below

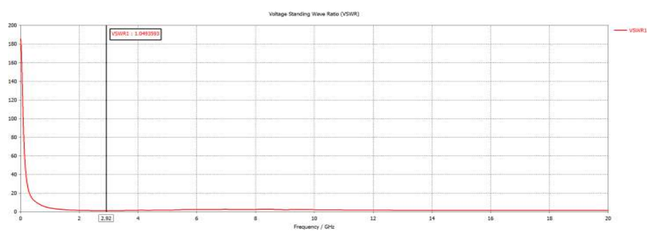
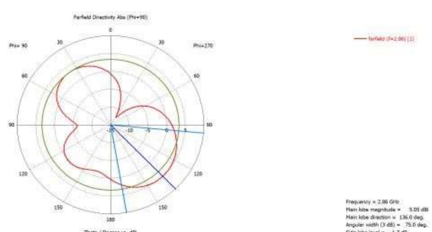


Fig.13.The simulated Fractal Microstrip Patch Antenna Directivity at 2.86 GHz is shown below



XII.SIMULATED RESULTS

Parameters	2.92 GHz (Without tumor)	2.86 GHz (With tumor)
S11(dB)	**-32.365**	**-25.499**
VSWR	**1.049**	**1.112**
Bandwidth(GHz)	**3.5585**	**3.4933**
Gain(dBi)	**-20.4**	**-20.6**
Directivity(dB)	**5.4**	**5.05**

CONCLUSION

This research paper focuses on the design and evaluation of two types of microstrip patch antennas: the H-shape microstrip patch antenna and the H-shape microstrip patch antenna with a vertical slot. These antennas are designed with the specific purpose of assessing the Specific Absorption Rate (SAR) for the detection of thyroid gland cancer cells and are simulated using CST (Computer Simulation Technology) tools.The choice of the H-shaped microstrip patch antenna design is motivated by its similarity in shape to the human thyroid gland. The human thyroid gland model developed for this study incorporates six distinct layers, including skin, fat, muscle, bone, thyroid, and tumor.

The research aims to investigate and compare the performance of these antennas in the context of the human thyroid gland, particularly in scenarios with and without the presence of a tumor. The evaluation of SAR is crucial for understanding how these antennas can contribute to the detection of thyroid gland cancer cells.

In the future, there is potential for further development of the proposed antenna to enable tumor identification in various parts of the body. Additionally, the antenna's design may evolve to incorporate different shapes and frequencies, with the aim of achieving improved overall performance and diagnostic capabilities.

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