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Design and Analysis of Patch Antenna for Bone Cancer Detection

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Abstract:
Cancer is a unregulated cell growth in the human body which is the potential threat to the human kind. The bone cancer is one doesn't give clue for the cause will occur anywhere in the bone. The cure of bone cancer depends on the tumor type, localization, size, and other factors. Existing bone cancer detection methods are hold a series and lengthy process and highly expensive also failed to detect the cancer at the early stages. This paper presents a patch antenna for bone cancer detection which operates at 5.7GHz. An ultra-wideband (UWB) antenna is designed using full wave electromagnetic solver, IE3D simulator. Designed antenna is fabricated on FR4 substrate with dielectric constant of 4.4, loss of tangent is 0.01 and thickness of 1.6mm using Printed Circuit Board (PCB) technology. The antenna has delivered a optimal performance in terms of functional parameters including return loss, radiation pattern, gain and current distribution in a compact size.

Keywords: Bone cancer; patch antenna; ultra-wideband; return loss; micro strip line.

I. INTRODUCTION

Cancer is a group of diseases involving abnormal cell growth with the potential to invade or spread to other parts of the body [1]. Not all tumors are cancerous; benign tumors do not spread to other parts of the body. Cancer is one of the main health challenges. Statistics reveal that around 13.2 million deaths of cancers are expected in 2030[4-6]. The National Cancer Institute, United States, estimates that by the end of 2018, there will have been 3,450 new cases and 1,590 deaths from cancer of the bones and joints. In adults, over 40% of primary bone cancers are chondrosarcomas. This is followed by Osteosarcomas (28%), Chondrosarcoma (10%), Ewing tumors (8%) and malignant fibrous histiocytoma/ fibro sarcoma (4%). The estimated number of cancer cases and deaths are listed in below table 1.

Table.1. Estimation of cancer cases and Deaths

Cancer	Estimated cases		Estimated Deaths	
	Male	Female	Male	Female
Pancreas	29,200	26,240	20,170	19,420
Liver	30,610	11,610	15,870	7,130
Lung	1,21,680	1,12,350	86,930	72,330
Breast	2,550	2,66,120	430	40,000
Thyroid	13,090	40,900	830	1,060
Eye	2,130	1,410	130	180
Intestine	5,430	5,040	640	570
Brain	13,720	10,160	8,090	6,230
Bone	1,940	1,510	830	630

In this paper, a micro strip patch antenna is proposed to detect the bone cancer in simple structure. Simulation is done using full wave simulator, IE3D and fabricated through PCB technology. The antenna is operated in ISM band which is used commonly preferred for investigation. A parametric study is carried out for the better simulation results by modifying the structure. The antenna structure obtained at 5.7 GHz is placed under bone and the return loss parameter S11 is observed for an antenna dimensions are changed. The paper is structured as follows: Section II Design of Patch Antenna, Section III Result and Discussion, Section IV Conclusion

II. DESIGN OF PATCH ANTENNA

A. *STRUCTURE OF PATCH ANTENNA*

The basic structure of a patch antenna is given in Fig.1. A Patch antenna is made up of two parallel conductors that are separated by a dielectric substrate. The lower conductor usually acts as a ground plane and the upper conductor is a patch, therefore such antennas are also called patch antennas.

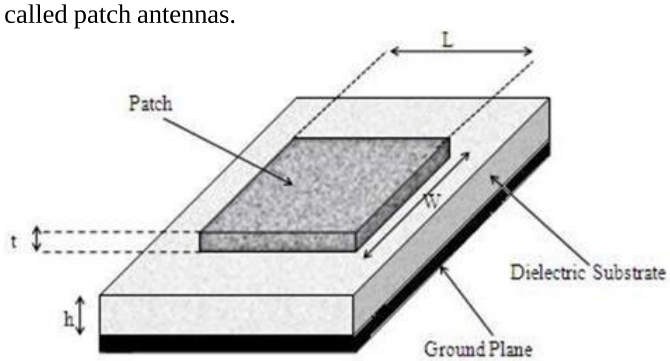

Figure.1. Basic Structure of a Patch Antenna

The rectangular patch excited in its fundamental mode has a maximum directivity in the direction perpendicular to the patch (broadside). The patch can be of various shapes such as rectangular, circular, square, elliptical, dipole and triangular among others but regular shapes are generally used to simplify analysis and performance prediction. Substrate properties such as dielectric constant and thickness are important considerations in the design of micro strip antennas [11-13].

B. DESIGN EQUATION

The proposed antenna is fed with a micro strip feed line and works in the 5.7 GHz band. The designing has been be done with the help of the following formulae [2]:

The width w of the patch is calculated by

$$(W) = \frac{c}{2fc\sqrt{\frac{\varepsilon r+1}{2}}} \quad \textbf{(1)}$$

Effective dielectric constant

$$(\varepsilon_{reff}) = \frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r+1}{2}[1+\frac{12h}{w}]^{-1/2} \quad (2)$$

Effective length--

$$(L_{eff}) = \frac{c}{2f_c\sqrt{\varepsilon_{reff}}} \quad (3)$$

Delta length

$$(\Delta L) = 0.412 \times \frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

Actual length

$$(\text{L})=L_{eff} - 2\Delta L \quad (5)$$

C. ANTENNA GEOMETRY

The structure of the designed and optimized antenna is given in *Fig*.2. It consist of radiating element and substrate (FR4) It can also be observed that for impedance matching, the width of the feed line has been kept at a value greater than its length. A rectangular structure is illustrated with the following dimensions: the total width of the rectangle is 30.2mm; total height is 28mm; the side of the square block is 18mm. Return loss of the antenna 1 is shown in *Fig.3.* The antenna exhibits -17.8 dB at 6.8 GHz. The idea of the antenna is to make the antenna radiate at 5.7 GHz for Bone Cancer Detection system.

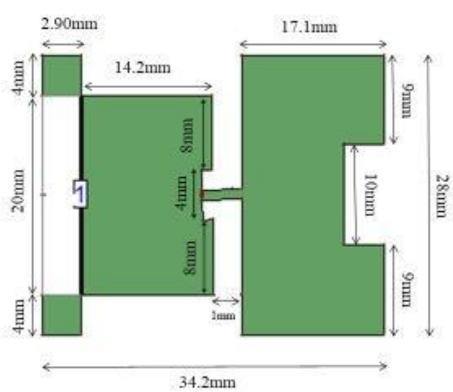

Figure.2. Geometry of proposed Patch antenna 1

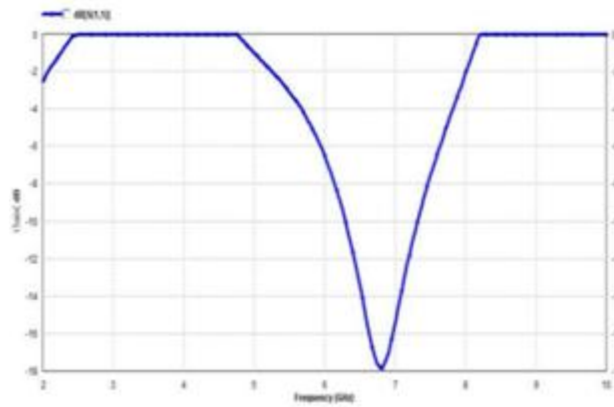

Figure.3. Return loss of proposed patch antenna 1

A deep parametric analysis is carried out to tune the antenna for the desired frequency. After much iteration the antenna geometry is modified as shown in *Fig 4*. It is added some capacitance to improve the frequency. In turn the inductance will be reduced to map with the capacitance which will ensure the larger bandwidth with deep attenuation. Also, the structure ensures the frequency shift in pass band.

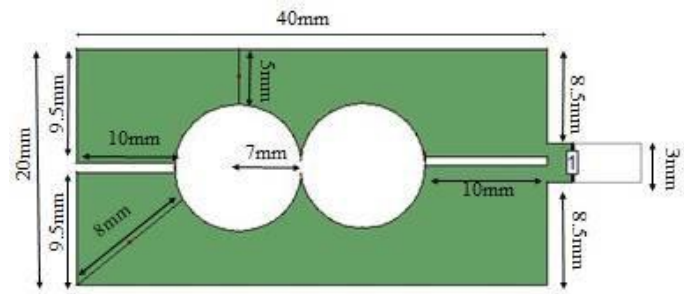

Figure.4. Geometry of proposed patch Antenna 2

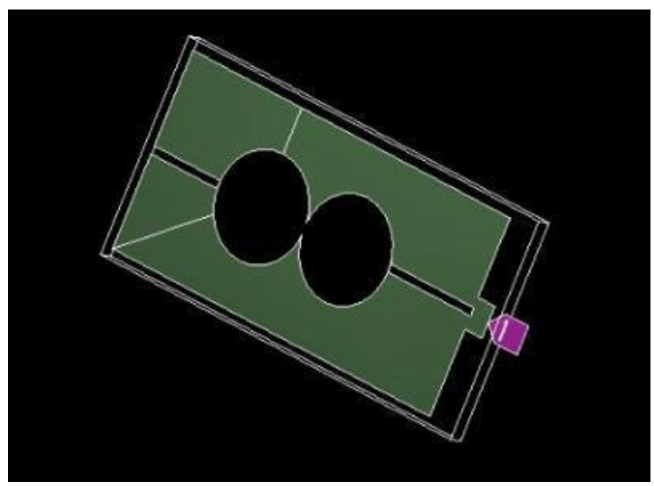

Figure.5. 3D view of proposed patch Antenna 2

The antenna dimensions are given; the total width of the rectangular block 40mm and length 20mm.The 3D view of proposed patch antenna 2 is shown in *Fig.5*; the arrow indicates the structure represent the port.

III. RESULTS AND DISCUSSIONS

The designed patch antenna for bone cancer is an new kind of attempt to detect the bone cancer at the early stages with less cost. Return loss of the proposed antenna as shown in *Fig.* 6.

The antenna obtain the better return loss of -25 dB at 5.7 GHz.

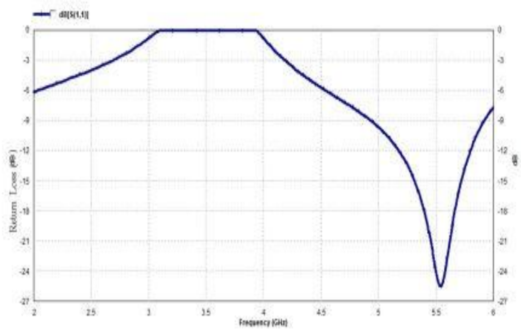

Figure.6. Return loss of proposed patch antenna 2

The snapshot of fabricated patch antenna is shown in *Fig.7* (a) and *Fig.7 (b)* where a 50Ω transmission lines are extended to accommodate the SMA connectors to connect to the Scalar Network Analyzer for measurement. The proposed antenna model is fabricated for real time operations using micro strip technology.

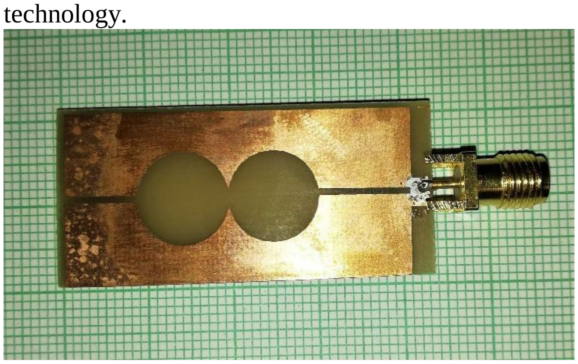

Figure.7.(a): A Snapshot of Fabricated Antenna Top View

Figure.7.(b): A Snapshot of Fabricated Antenna Bottom View

Table.2. Summary of the Obtained Results

SI.NO	PARAMETERS	ANTENNA2
1	Center frequency(GHz)	5.7
2	Return loss(dB)	25
3	Radiated power(w)	0.004793
4	Antenna efficiency (%)	47.935
5	Gain (dBi)	3.405
6	Directivity (dBi)	6.5993

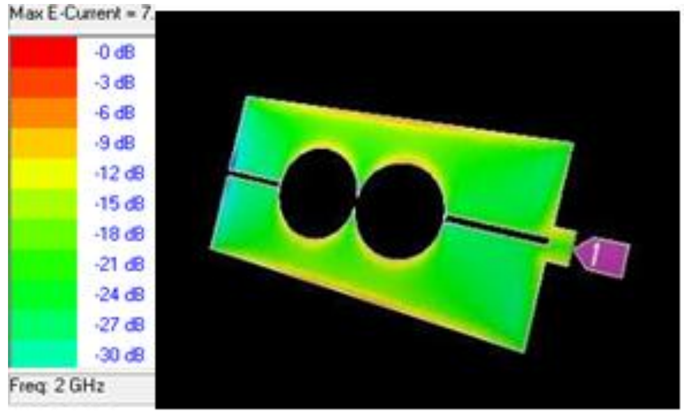

Figure.8. Current distribution of proposed patch antenna 2

Fig. 8 shows the three dimensional view of current distribution of proposed antenna2 .The light blue colour shows -33dB maximum current, second yellow colour shows -12dB medium current and green colour shows the minimum current in the range of -15 to -27 . The radiation pattern of corresponding antenna is shown in *Fig. 9*. The antenna has acceptable direction pattern of 6.59 dBi over most of the UWB considered as preferred for imaging applications. The obtained results are tabulated in the table 2. The antenna shows optimal performance in terms of physical and functional parameters. The antenna is compact having the size of 20(length) x 40 (breadth) x 1.6 (thickness) mm3. The antenna would be developed in printed Circuit Board (PCB) technology with the copper coating for 35 microns. The fabricated antenna will be tested with the help of Scalar Network Analyzer (SNA).

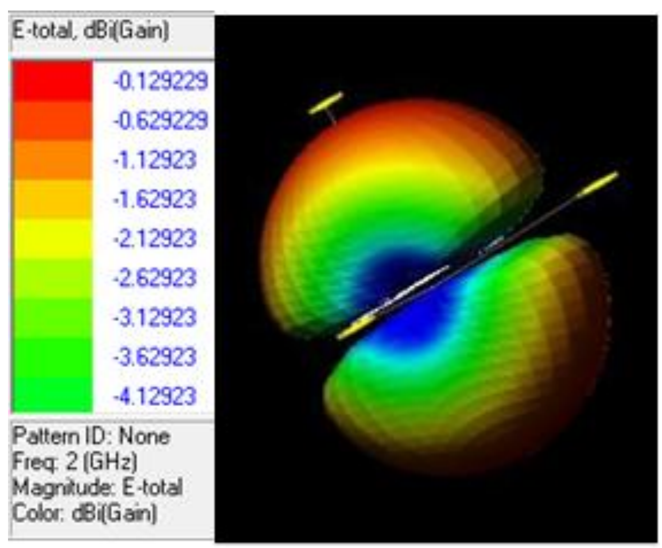

Figure.9. Radiation Pattern of proposed patch Antenna 2

The designed antenna will be used in the UWB tomography system which is shown in *Fig.*10 to identify the bone cancer. The experimental system is organized with impulse generator, a sampling oscilloscope, an antenna and switching matrix [14-16]. The sampling oscilloscope has been composed with a main frame and the wideband of two channel test set. Using this system an impulse signal is used to generate from the impulse signal used to generate from the impulse generator is transmitted by the antenna into object-under-test and then scattered field is acquired again by the antenna [17]. The acquired signals are then sampled and digitized by the sampling oscilloscope. The switching matrix is being used in order to select different transmitting and receiving antenna pairs. Now the synchronization between the transmitter and receiver modules is achieved by connecting the trigger output of impulse generator with the trigger input of two channel test set [18].

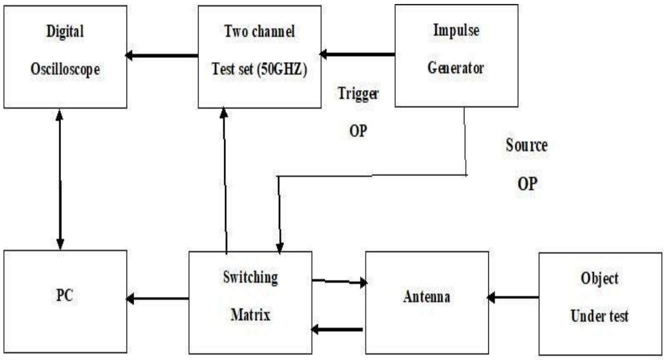

Figure.10. Block diagram of UWB tomography system

IV. CONCLUSION

Research on bone cancer is now being done at many medical centres, university hospitals, and other institutions across the nation. In this paper, the design of patch antenna in the UWB range for bone cancer detection is presented. This antenna has simple structure and compact design and represents a better return loss of -25dB at 5.7GHz. By adjusting rectangular edges in the polygon one could able to tune the antenna for the desired frequency with improved performance. The main intension of the development of the patch antenna is mainly for minimizing the cost and time for detecting the bone cancer. In summary, the final antenna structure has good UWB characteristics with better return loss with moderate gain and can also suitable for microwave imaging system.

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