Design of Microstrip Patch Antenna for Medical Application Using WBAN

Brindha R[1], Dr.G.Kavithaa[2]

[1]*PG Scholar, Department of Communication Systems, Government college of Engineering – Salem-11, Tamil nadu, India*

[2] *Assistant Professor, Department of Electronics and Communication Engineering, Government college of Engineering – Salem-11, Tamilnadu, India*

Abstract-A Becon Beacon shaped Microstrip patch antenna with wide notched function in WBAN (Wireless Body Area Network) and its performance is vindicated experimentally for ultra-wideband (UWB) medical operations. The antenna is designed over the operating frequency of2.4 GHz-4.5 GHz using the substrate material as FR- 4 which has the dielectric constant of4.3. The designed antenna can be used for ISM (Industrial Scientific and Medical) band and UWB operation. There are a wide range of approaches that have been advanced in the literature by adding to meta- material, all the way from the RF through the split ring resonator which is veritably useful for certain wavelength bands.

The proposed antenna is designed with the purpose of carrying a low SAR module of the human body considering both the electromagnetic effect and the shell model in human tissues. The antenna provides a return loss lower than-20 dB and the gain7 db at frequency of3.45 GHz. The designed antenna has low profile, low cost and good insulation. The antenna is designed by using HFSS simulation software.

1. INTRODUCTION

1.1 OBJECTIVE

Ultramodern trends in technological development have increased demands for multifunctional factors across the diapason. In the radio frequency (RF) governance, wireless dispatches bear effective, reconfigurable, tunable, affordable, and electrically small antennas that can be enforced in decreasingly space- limited bias. In the terahertz band, numerous accoutrements don't respond to in- band radiation and the factors needed constructing complex systems of terahertz bias, similar as lenses, switches, and modulators, don't live. Significant sweats are going into filling this “gap” in the diapason. Also, the arising use of metamorphosis electromagnetic, particularly with regard to cloaking, requires spatial slants that natural accoutrements don't retain. With each of these challenges, contrivers must compromise among size, functionality, complexity, and fabrication cost.

1.2 NEED FOR THE DESIGN

To design a UWB antenna with filtering characteristics, cutting places may be one of the simple, effective, and affordable styles. Antennas with small size and band rejection characteristics are also desirable and seductive. To apply the UWB antennas, a number of styles have been proposed by etching colorful places on either radiation patches or ground aero planes , similar as cube niche, C- shaped niche, pi- shaped niche E-shaped niche, H- shaped niche, and U-shape niche.

Either, combining the C- shaped niche and the U- shaped resonators is also presented to give better filtering function. The disadvantage of these etched places is that they may blunder electromagnetic swells, which will deteriorate the radiation patterns. Therefore, some band- indented UWB (Ultra Wide Band) antennas are realized by using remainders and parasitic rudiments. Still, these antennas are only used either as multiband antennas or as band- indented UWB antennas, independently.

2. LITERATURE REVIEW

J. Mary Sushmitha Asha1, Dr. K. Madhan Kumar, “Design andanalysisof Microstrip Patch Antenna for Lung Tumor”, 2017

Cancer is a serious health problem among various kinds of diseases. More than one in three people will be affected by some form of cancer during their lifetime.Among various types of cancer, Lung cancer is a leading cause of cancer-related death in many countries. In this paper, we have design a lung Tumor which consistsof a Microstrip patch antenna, Lung Model and Tumor in CST. This shows that thetumor present in the lung can be detected by observing the current density of Lung with and Without Tumor. The variations in E-field, H-field, and Current density are measured. It is found that the current density value has been increased twice than that of the brain without tumor, E-field And Magnetic Field value gets reduced in the presence of Tumor.

[2]Tutku Karacolak, Aaron Z. Hood and Erdem Topsakal , "Design of a Dual-Band
Implantable Antenna and Development of Skin Mimicking Gels",2008

In this study, we present a small-size dual medical implant communications service (MICS) (402–405 MHz) and industrial, scientific, and medical (ISM) (2.42.48GHz) band implantable antenna for continuous glucose-monitoring applications. The antenna is optimized for dual-band operation by combining an in- house finite- element boundary integral electromagnetic simulation code and particle swarm optimization algorithm. In order to test the designed antenna in vitro, gels mimicking the electrical properties of human skin are also developed. The optimizedantenna is fabricated and measured in the gel. The simulated and measured bandwidths are found to be 20.4% MICS, 4.2% ISM, and 35.3% MICS, and 7.1% ISM, respectively. Although we have emphasized continuous glucose monitoring throughout this paper, the antenna and skin mimicking gels presented.

[3] Guiping Jin, Chuhong Deng, Yechun Xu, Ju Yang, Shaowei Liao, "Differential
Frequency Reconfigurable Antenna Based on Dipoles for Sub-6GHz 5G and WLAN Applications" ,2019

A new differential frequency reconfigurable antenna based on dipoles is presented in this letter. The basic structure of the proposed antenna consists of two pairs of vertical arms forming two dipoles, the feeding structure, mode switching structure, and PIN diodes. By switching "on" and "off" PIN diodes, the antenna canresonate at two states, and thus work centered at 3.5 and 5.5 GHz, respectively. Though the two states correspond to different resonant modes, the effective radiationparts are the same and the mode switching structure will not contribute to the far field for both states. This results in similar radiation patterns for both states. Besides,the proposed antenna is also simple in structure and wide in bandwidth. The measured -10-dB impedance bandwidths are 2.89 GHz to 4.07 GHz (33%) and 5.1GHz to 6.19 GHz (19.8%) for the two states, respectively.

[4] Zhouyou Ren, Shengjie Wu, Anping Zhao, "Triple Band MIMO Antenna System for 5G Mobile Terminals", 2017

A 4-antenna array for multiple-input multiple-output (MIMO) applications in future fifth generation (5G) mobile terminals is presented in this paper. The antenna array consists of four triple band antennas which can cover 5G new radio (NR) includingn77 (3.3-4.2GHz) and n79 (4.4-5GHz), and 5GHz-wireless wide area network (WLAN) operation in 5.15-5.85GHz. The proposed antenna array was fabricated and measured. The measured total efficiency over 60% and isolation better than 14dB between each port were obtained. Envelope correlation coefficient (ECC) and channel capacity (CC) were also analyzed to evaluate the antenna performance.

[5] Mehmet Ciydem and Emre A. Miran, "Dual Polarization Wideband Sub-6 GHz Suspended Patch Antenna for 5G Base Station" ,2020

This paper presents a simple, compact, low cost, low profile, dual polarization, suspended patch antenna design to operate in 3.3 3.8 GHz band for 5G base stations.Proposed antenna comprises a main radiating patch, a secondary parasitic patch, modified L-probe feeds, and a vertical metal wall. Main patch is capacitive driven by two feeds for dual (±45° slant) polarization. Vertical metal wall is used in order to increase the port isolation. Parasitic patch also helps further improvement of input impedance matching (S11, S22) and port isolation (S21). Prototyped antenna has S1, S22< 10dB and S11, S22 < 5 dB impedance bandwidth of 45% and 36% respectively.Port isolation is S21< 30 dB in desired operating band. Stable and symmetric radiation patterns with half power beam-widths of56° 65° are obtained in E/H- planes. Gain of the antenna is 8.95, 0.25 dBi. Numerical calculations and experimental results are reported and discussed

3. CONCEPTS OF THE PROPOSED METHODOLOGY

The proposed structure is structurally configured by employing system – based cantilevers in the split ring resonator which are designed for the detection of the tumor cell in the lungs at the beginning stage of the cancer. The proposed method provide the medical implant communication service with a small size implantable antenna intended for the detection of assimilated nicotine level in the organ. Three kinds of materials are investigated as electric split-ring resonator (SRR) arrays with different positions of the split. By moving the position of the splitaway from the resonator's center, the SRR exhibits anisotropy, with the dipole resonance splitting into two resonances. The simulation results show a good impedance matching throughout the UWB band except for the narrow notch band close to the resonance frequency of the S-shape SRR. Implantable antennas have been growing rapidly over the past few years with the potential for producing efficient medical treatments and improving the quality of healthcare. The application of implantable antenna builds a communication link between implanted device and outside human body is at the center of academic and technical research in bioengineering and science. Implanting a medical device inside the human body reduces the need for invasive surgical operations as it acts as a body organ for different purposes such as monitoring, treating and diagnosing of some diseases. The implanted antenna is designed to monitor the physiological parametersin human body such as body temperature, blood pressure, glucose level, etc .So the basic idea of implanting medical device is to facilitate patient's life and trying to offer them a better care as it reduces the hospitalization terms and reduces the distance between the patients and their doctors. Many researchers investigated implanted antennas to detect cancer like lungand breast cancer. Antennas used to elevate cancer tissues temperature are positionedinside or outside the patients' body. The shapes of antennas depend on their locations. Some antennas implanted internally and others implanted externally. Nowadays one of the deadly diseases is Lung cancer is a disease that occurs because of uncontrolled cell growth in tissues of the lung. Every year, there are hundred thousands of patients who suffer cancer and many of them do not survive it.When cancer detected in its early stages, it can be removed by an easy surgical operation. This article presents the design, analysis, and fabrication of cupcake ultra-wide band antenna used to detect lung cancer in several stages. The phantom for lung tissues is also formed and simulated on HFSS to test antenna on it.

3.1 LUNG ANATOMY AND LUNG CANCER

There are five layers until reaching to the lung which are skin, fat, muscle, ribs, pleura and the lung. Each lung has an average length of 25 to 35 cm and average width of 10 to 15 cm. The average weight is 0.8 to 1.2 kg. The total air volume of the lungs is about 4 to 6 liters and varies with a person's size, age, gender, and respiratory health. The dielectric properties of the inflated lung for an average frequency ranges from 2 to 14 GHz is εr =17.320292 and σ = 3.284182 S/m. The second layer is the pleura which are double-layered serous membranes that surround each lung to protect it. It's thickness range from 0.2 to 0.4 mm. Its dielectric properties are εr=35.441415 and σ=6.707186S/m. Third layer is muscles of thickness 10 mm and dielectric properties of εr=45.4674187 and σ = 8.235325 S/m.The fourth layer is fatty layer of thickness 10.95mm and dielectric properties of εr=9.353070 and σ =1.317254 S/m. The last layer is skin of thickness 2 mm and dielectric properties of εr=33.036787 and σ =6.273473 S/m [9]. There are two typesof lung cancer: non-small cell lung cancer and small cell lung cancer. Most people diagnosed with lung cancer have non-small cell lung cancer. So in this paper we work on different stages of non-small cell lung cancer.

Table: 1 Different stages of lung cancer

Stage	Description
Stage T1	The tumor exists in the lung only; it doesn't reachthe membranes of the pleura. For T1a: The Tumor is 2cm or less. For T1b:The tumor is larger than 2cm but smaller than 3cm.
Stage T2	The tumor reaches membranes of the pleura. T2a: The tumor is 5 cm or less. T2b: The tumor is larger than 5cm but smaller than 7cm.
Stage T3	The tumor reaches muscle layer and separation distance between two lungs in addition to existence of one or more cancer cells. The tumor is larger than 7cm.
Stage T4	The most advanced stage where the tumor reaches other body organs. The tumor can has any size.

4. DESIGN SPECIFICATIONS

4.1 SOFTWARE REQUIREMENT

HFSS (High Frequency Structural Simulator)

HFSS is a commercial finite element method solver for electromagnetic structures from Analysis. The acronym originally stood for high frequency structural simulator. It is one of several commercial tools used for antenna design, and the design of complex RF electronic circuit elements including filters, transmission lines, and packaging. This software (a soft HFSS) has helped to dramatically reduce the time necessary for designing new connectors. The latest edition has the added capability of Time Domain analysis. This additional tool can help the engineer determine the location within the connector that is causing poor electrical performance. Changes can be made to the software model, and an additional analysis can be performed to determine the effect of the changes. Once again, as pointed out in the previous article, all of this is done before any parts are actually made in the model shop resulting in a significant reduction in development time. HFSS is a high performance full wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation in an easy to learn environment where solutions to your 3D EM problems are quickly and accurate obtained. A soft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. A soft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields

Typical uses include:

Package Modeling – BGA, QFP, Flip-Chip

PCB Board Modeling – Power/ Ground planes, Mesh Grid Grounds, Backplanes Silicon/GaAs-Spiral Inductors, Transformers.

EMC/EMI – Mobile Communications – Patches, Dipoles, Horns, Conformal Cell Phone Antennas, Quadrafilar Helix, Specific Absorption Rate (SAR), Infinite Arrays, Radar Section (RCS), Frequency Selective Surface (FSS)

Connectors – Coax, SFP/XFP, Backplane, Transitions

Waveguide – Filters, Resonators, Transitions, Couplers

Filters – Cavity Filters, Micro strip, Dielectric

HFSS is an interactive simulation system whose basic mesh element is a tetrahedron. This allows you to solve any arbitrary 3D geometry, especially those with complex curves and shapes, in a fraction of the time it would take using other techniques. The name HFSS stands for High Frequency Structure Simulator. Ansoft pioneered the use of the Finite Element Method (FEM) for EM simulation by developing / implementing technologies such as tangential vector finite elements, adaptive meshing, and Adaptive Lancozos - pad Sweep (ALPS).Today, HFSS continues to lead the industry with innovations such as Modesto Nodes and Full wave Spice. A soft HFSS has evolved over a period of years with input from many users and industries. In industry, a soft HFSS is the tool of choice for High productivity research, development, and virtual prototyping.

5. IMPLEMENTATION AND RESULTS

A split ring resonator structure is designed on FR-4 substrate and simulated. A notch is added to the structure at different positions that is to the upper and the lower rectangular shaped slot and the results are observed. The parameters such as frequency coverage, return loss, gain, radiation pattern are measured and tabulated below.

5.1 PROPOSED OUTPUTS

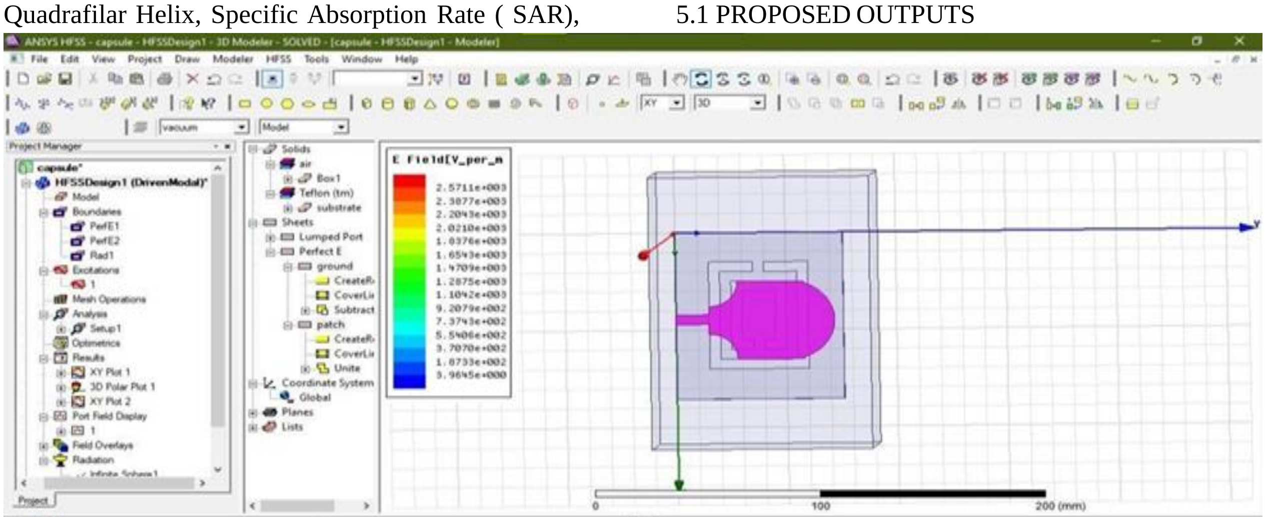

Fig.1 Design of the antenna

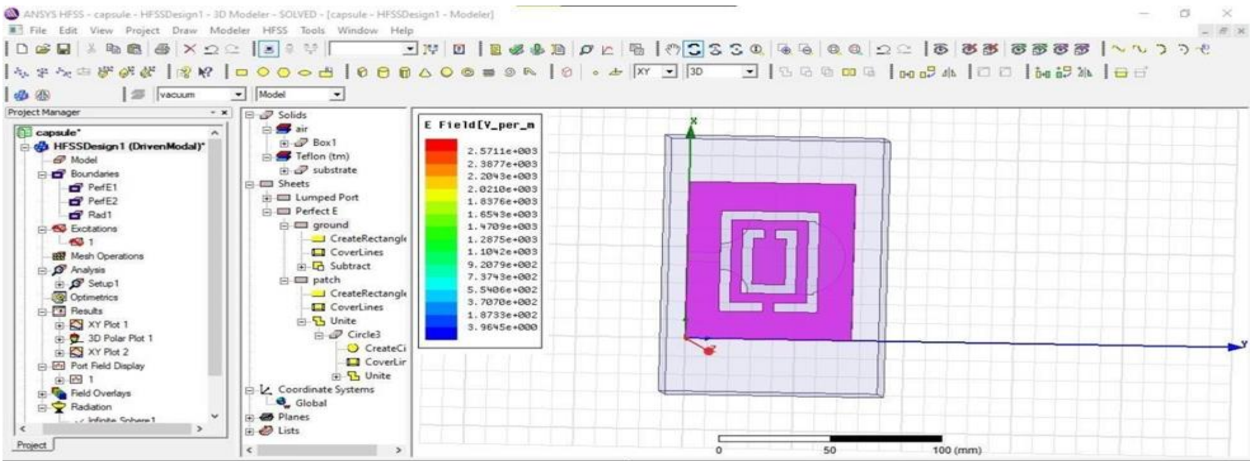

Fig.2 Design of the split ring resonator

The split ring resonator structure is designed with a rectangular shaped slot at bottom side.

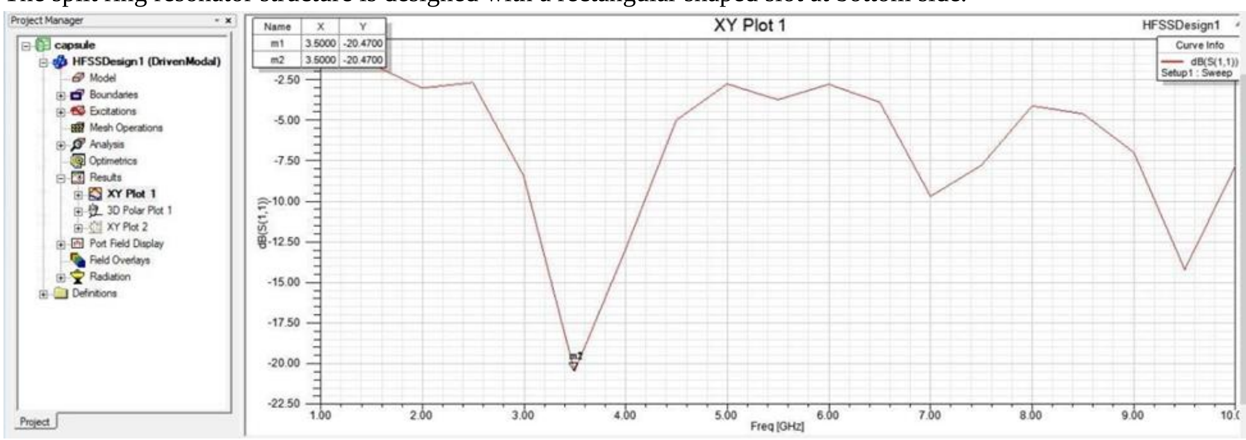

Fig.3 Output of the antenna (S-parameter)

From the above figure, it is observed that the resonant frequency is obtained at 3.5 GHz with a return loss at –22.5 dB.

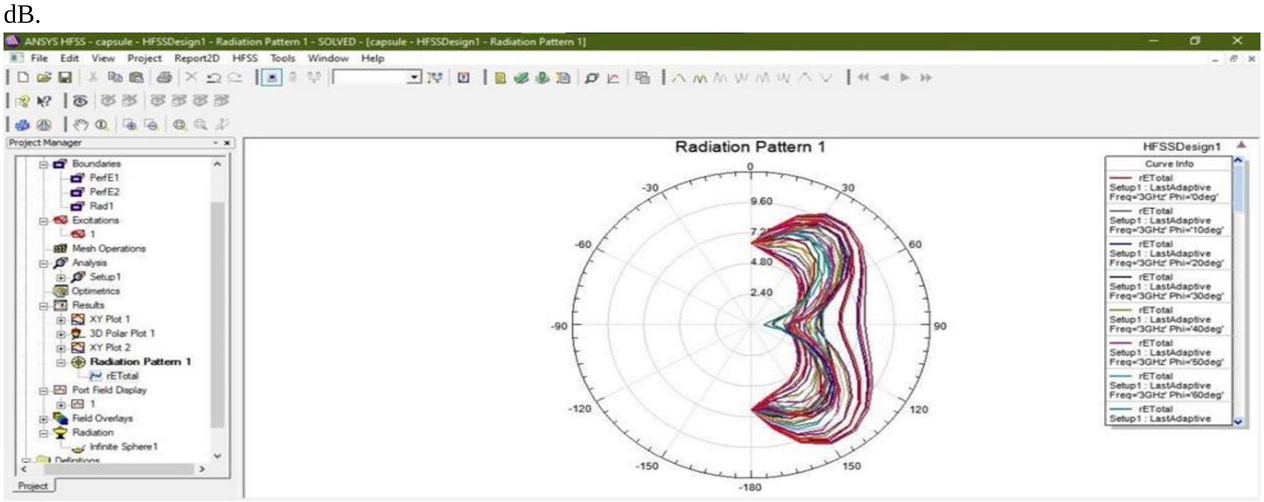

Fig.4 Directivity of the antenna

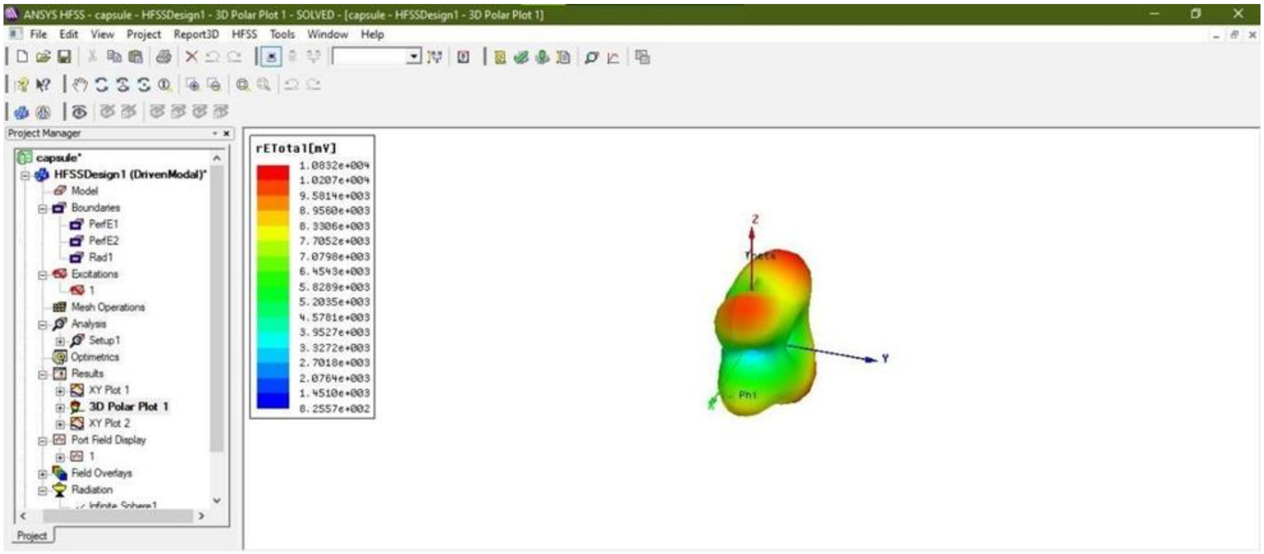

Fig.5 Radiation pattern of the antenna

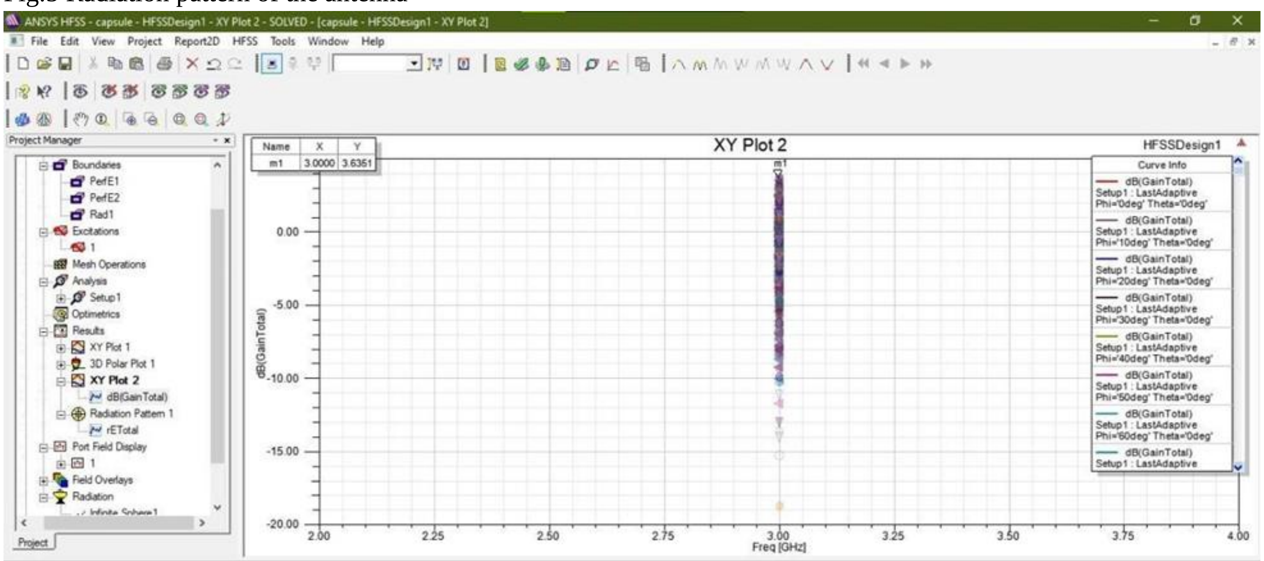

Fig.6 Gain of the antenna

The gain obtained for the split ring resonator structure with rectangular shaped slot is measured as 4.98 dB

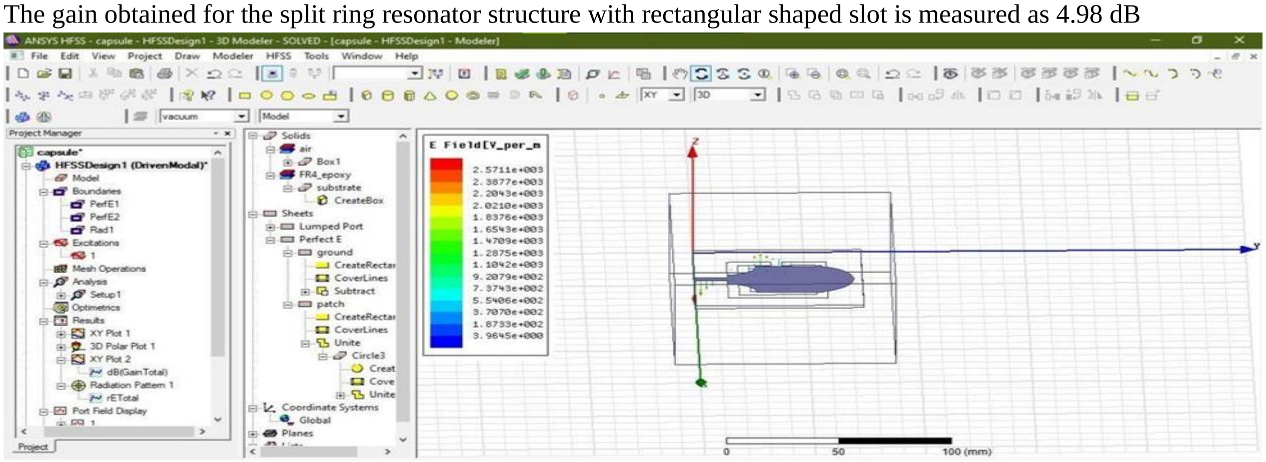

Fig.7 Radiation of the antenna from design

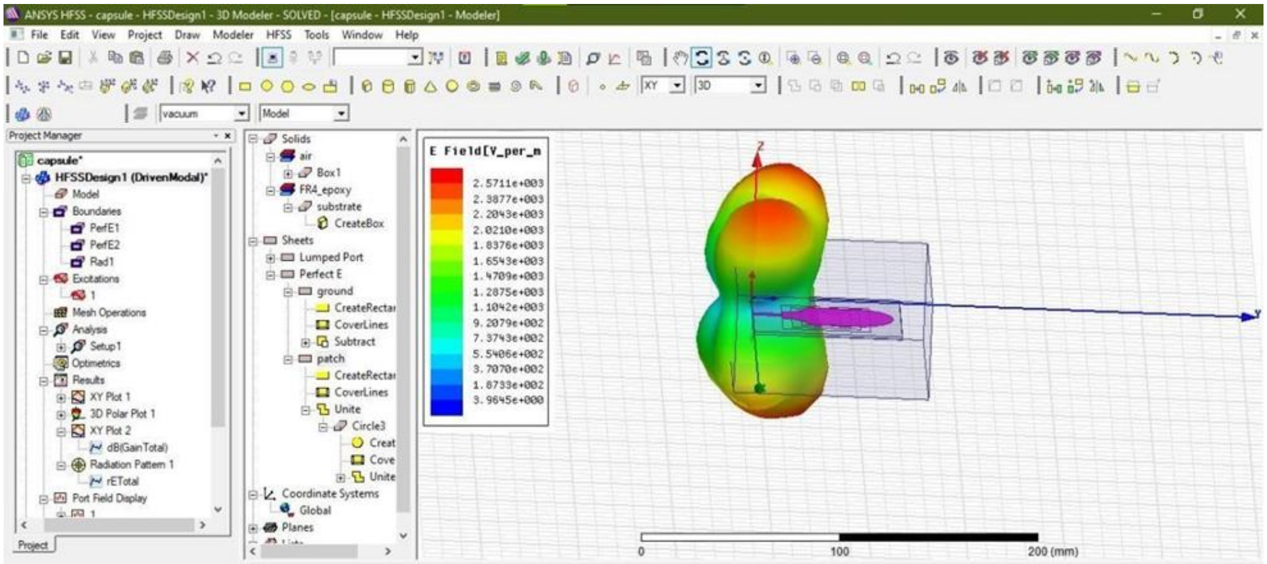

Fig.8 Plot field emission of the antenna

COMPARISON OF THE PROPOSED DESIGN

Table: 2 Comparison of the various substrate materials design

DESIGN MATERIAL	RESONANT FREQUENCY	RETURN LOSS	GAIN
FR-4	3.5GHz	-22.5dB	4.89 dB
TEFLON	6GHz	-13 dB	3 dB
RT-DUROID	4.5GHz	-11 dB	2.3 dB
AIR	5.3 GHz	-17.5 dB	2.1 dB

6. CONCLUSION

The use of S-SRRs energized by contra directional attractive fluxes of a CPW has been illustrated for reconfigurable and tunable operation. To demonstrate the potential application of the proposed structure, a UWB antenna design with tunable notch band for Wi-Max or WBAN services interference rejection has been demonstrated. The design methodology has been validated through electromagneticsimulations.

At long last, in request to show the potential use of the proposed structure, a UWB receiving wire outline with tunable score band for Wi-Max or WBAN administrations obstruction dismissal has been illustrated. The outline philosophy has been approved through electromagnetic reproductions and estimations of manufactured models.

REFERENCES

[1] Hector Kaschel, and Cristian Ahumada, "Design of Rectangular Microstrip Patch Antenna for 2.4 GHz applied a WBAN" IEEE 2018 Res. C, vol. 64, pp. 61– 70.

[2] Malak Y. ElSalamouny ,Raed M. Shubair, "Novel Design of Compact Low- Profile Multi-Band Microstrip Antennas for Medical Applications" IEEE 2018 1569796.

[3] Wahiba Grabssi, Sarah Izza and Arab Azrar, "Design and Analysis of a Microstrip Patch Antenna for Medical Applications" IEEE 2017 vol. 59, no. 10, pp.3556-3564.

[4] K. Ouerghi, N. Fadlallah, A. Smida, R. Ghayoula, J. Fattahi and N. Boulejfen, "Circular Antenna Array Design for Breast Cancer Detection" DOI: 10.1109/SENSET.2017.8125016

[5] May Mohamed Abdelhamid and Prof. Dr. Abdelmegid M. Allam Detection of Lung Cancer Using Ultra Wide Band Antenna DOI: 10.1109/LAPC.2016.7807452

[6] J. Mary Sushmitha Asha, Dr. K. Madhan Kumar, "Design and analysis of Microstrip Patch Antenna for Lung Tumor"

[7] Tutku Karacolak , Aaron Z. Hood and Erdem Topsakal, "Design of a Dual-Band Implantable Antenna and Development of Skin Mimicking Gels DOI: 10.1109/TMTT.2008.919373

[8] P Jin, C H Deng, J Yang, Y C Xu, S W Liao, "Differential Frequency Reconfigurable Antenna Based on Dipoles for Sub-6GHz 5G and WLAN

Applications" IEEE 2019 vol. 7, pp. 56539–56546

[9] Zhouyou Ren, Shengjie Wu, Anping Zhao, "Triple Band MIMO Antenna System for 5G Mobile Terminals " IEEE 2019 18738806/ 86

[10] M. Ciydem , S. Koc, "Dual Polarization Wideband Sub-6 GHz Suspended Patch Antenna for 5G Base Station" IEEE 2015 Vol. 57, No. 3, pp. 603– 607