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Spiral Micro-Strip Patch Antenna using Coaxial Probe Feeding Technique to Operate in MICS-Band

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Abstract: Various types of micro strip antennas that can be used for several applications in medical implanted communication systems. This paper presents the design of a spiral micro-strip patch antenna to operate at frequency range of 402-405MHz. This antenna, based on a thickness of 1mm Rogers-RO3210(tm) substrate with a dielectric constant of approximately 10.2 with a probe feed and has a partial ground plane. The antenna performance characteristics is analyzed using parameters like antenna input impedance, reflection coefficient, Return Loss, 3D Gain and current density are obtained. The results obtained in the present work and compared with Pichitpong Soontornpipit[2].

Keywords: MICS (Medical Implanted Communication Service), Micro Stripe Patch Antenna, HFSS (High Frequency Structure Simulator), Rogers-RO3210(tm).

I. INTRODUCTION

International Labour Organisation, which was setup in 1919 as a part of League of Nations has also made suggestions on Social Security, Conditions of work, Health, safety & welfare of labourers and employees. Antennas play a very important role in the field of wireless communications [1] [3]. Some of them are parabolic reflectors, patch antennas, slot antennas, and folded dipole antennas with each type having their own properties and usage. It is perfect to classify antennas as the backbone and the driving force behind the recent advances in wireless communication technology [3]. Micro-strip antenna technology began its rapid development in the late 1970s. By the early 1980s basic micro strip antenna elements and arrays were fairly well establish in term of design and modeling. In the last decades printed antennas have been largely studied due to their advantages over other radiating systems, which include: light Weightiness reduced size, low cost, conformability and the ease of integration with active. A Micro-strip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Fig.1. The patch is generally made of conducting material such as copper or gold. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. Micro-strip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane.

In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a micro-strip line or probe feed. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the micro-strip line and the radiating patch this includes proximity feeding and aperture feeding. Micro-strip antennas are characterized by a larger number of physical parameters than conventional microwave antennas [7],[8]. They can be designed to have many geometrical shapes and dimensions but rectangular and circular Micro-strip resonant patches have been used extensively in many applications. In this paper, the design of probe feed rectangular micro-strip antenna is for satellite applications is presented and is expected to operate within 402-405MHz frequency span [3]. This antenna is designed on a double sided Rogers-RO3210(tm) and its performance characteristics which include reflection coefficient, Return Loss, 3D Gian and current density are obtained from the simulation.

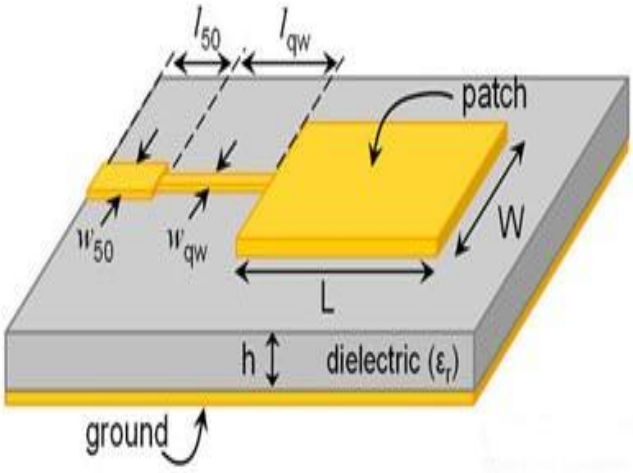

Fig. 1. Rectangular Micro-strip Antenna.

In this paper, a low profile implantable patch antenna design has been performed. The design is carried out in HFSS EM tool with the design consideration like boundary conditions of human biological system. Reports in terms of S11, 3D Gain and radiation pattern are used for analysis. Further, the paper is organized as follows simulation description of the proposed design is discussed in section-II. Description of the geometry is presented in section-III. Brief reports presenting to the antenna design along with analysis is presented in Section-IV. Overall conclusion is mentioned in Section-V.

II. ANTENNA GEOMETRY

The structure of the proposed antenna is shown in Fig. 2 below a rectangular patch of dimension 26.6mm×21mm and 26.6 mm x 16.6 mm is designed on one side of an Rogers-RO3210(tm) substrate of thickness 1 mm and relative permittivity 10.2. and the ground plane is located on the other side of the substrate with dimension 26.6 mm x 19.6 mm and 35mm x 25 mm. In this paper antennas are designed by using HFSS (High frequency Structure simulator) Software. There are three essential parameters for design of a coaxial feed rectangular micro strip Patch Antenna [4]-[7]. Firstly, the resonant frequency (f_0) of the antenna must be selected appropriately. The frequency range used is from 402-405MHz and the design antenna must be able to operate within this frequency range. The resonant frequency selected for this design is 402 MHz. Secondly, the dielectric material of the substrate (ε_r) selected for this design Rogers-RO3210(tm) which has a dielectric constant of 10.2.

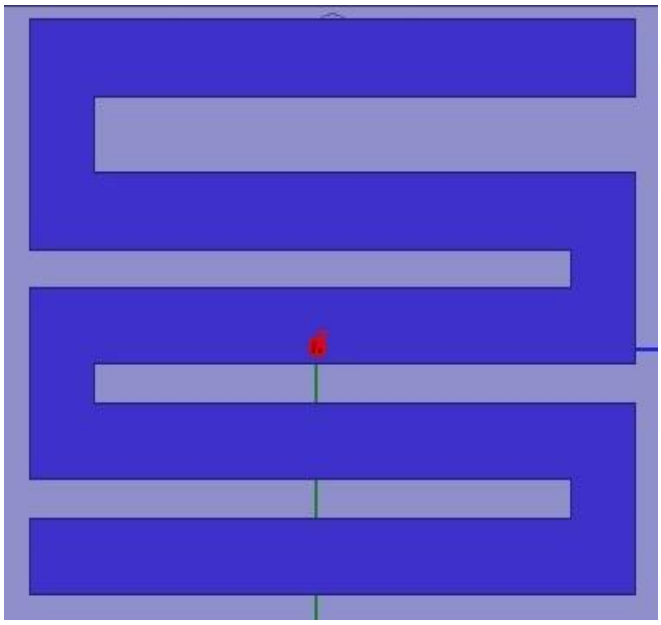

Fig.2. Proposed Rectangular Micro-strip Antenna.

The dielectric constant of the substrate material is an important design parameter. Low dielectric constant is used in the prototype design because it gives better efficiency and higher bandwidth, and lower quality factor Q. The low value of dielectric constant increases the fringing field at the patch periphery and thus increases the radiated power. The proposed design has patch size independent of dielectric constant. So the way of reduction of patch size is by using higher dielectric constant and Rogers-RO3210(tm) is good in this regard[13]. Lastly, substrate thickness is another important design parameter. Thick substrate increases the fringing field at the patch periphery like low dielectric constant and thus increases the radiated power. The height of dielectric substrate (h) of the micro strip patch antenna with coaxial feed is to be used in MICS-band range frequencies. Hence, the height of dielectric substrate employed in this design of antenna is h= 1mm.

III. PROPOSED ANTENNAS

The proposed antenna is simulated in HFSS environment and is presented as shown in fig.3.

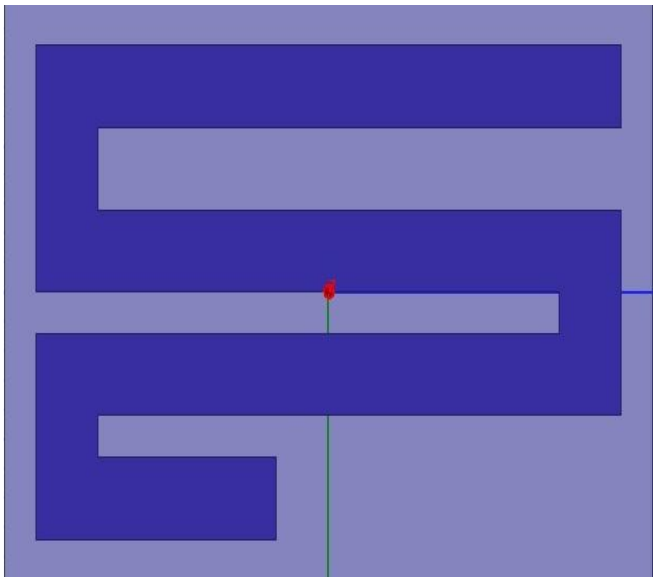

Fig.3. Proposed Rectangular Micro-strip Antenna.

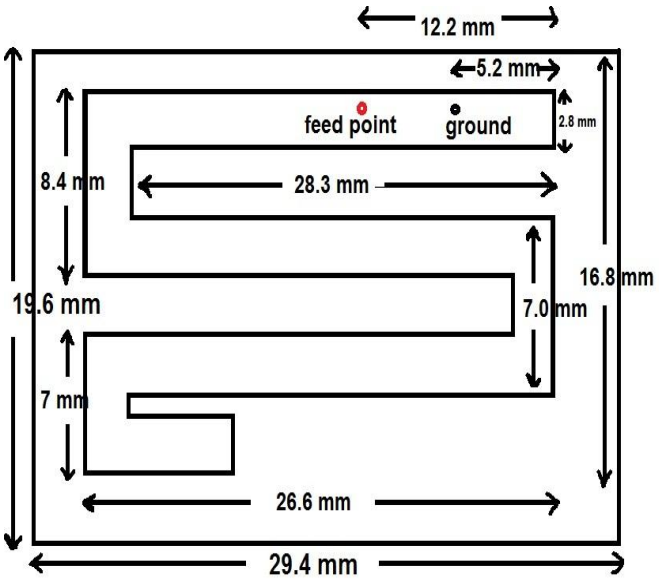

Fig.4. Proposed Rectangular Micro-strip Antenna Design.

The proposed antenna is subjected to several modifications in terms of layers distribution like single and three layers form. The analysis of these two is carried out in two cases.

Case-1 deals with single layer form while the analysis of 3 layers is discussed in case-2. However case-2 has another 4 variations with respect to the material forming the three layers[14]. A thorough discussion of the corresponding cases wise results are discussed as follow.

TABLE I: Cases Details

S.No	Type	Layers
1	Case-1	Free Space
2	Case-2	Skin, Fat & Bone
3	Case-3	Skin, Fat & Heart
4	Case-4	Skin, Fat & Kidney
5	Case-5	Skin, Fat & Skull

In the above rectangular patch antennas are satisfy the MICS (402-405MHz) band. The Spiral Rectangular patch has advantages over a micro strip antenna, specifically, smaller dimensions and higher radiation efficiency. In that considerations Fig4 has smaller dimensions. Below mentioned results all are taken for Figs.5 to 7.

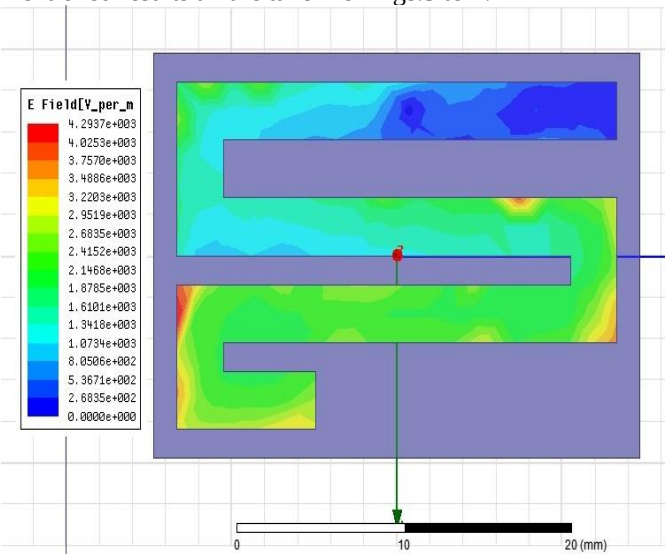

Fig.5.Current Flow in Designed Antenna.

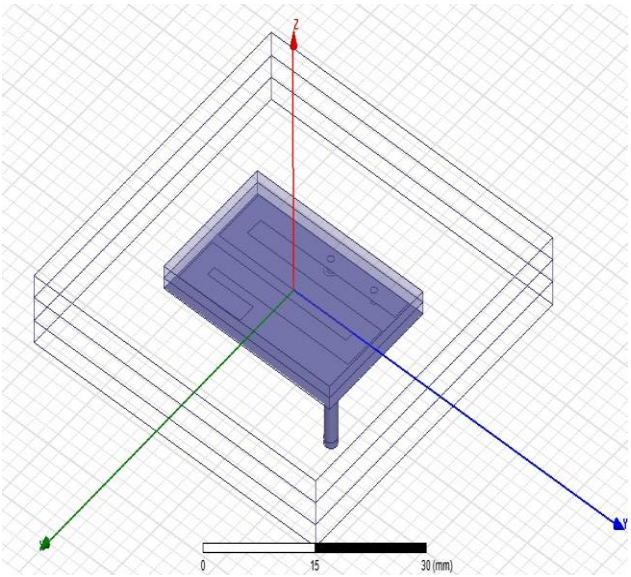

Fig.6.Proposed antenna within the Three layers.

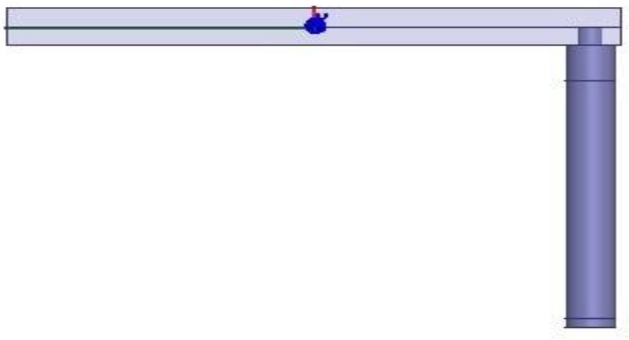

Fig.7. Side view of proposed antenna.

Case-1: Proposed Antenna Within The Single Layer: The reflection coefficient (S11) frequency response of the Spiral Micro strip patch antenna is presented in Figs. 8 to 10. The antenna Return loss at 402 MHz with -13.90dB reflection coefficient. The proposed PIFA is matched at MICS frequency limit at 402-405 MHz

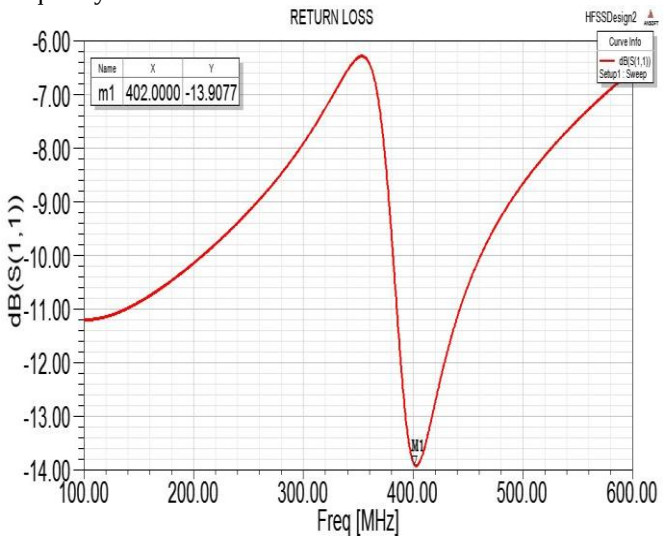

Fig.8. Return loss (Frequency = 402MHz & Total Gain = -13.90 dB).

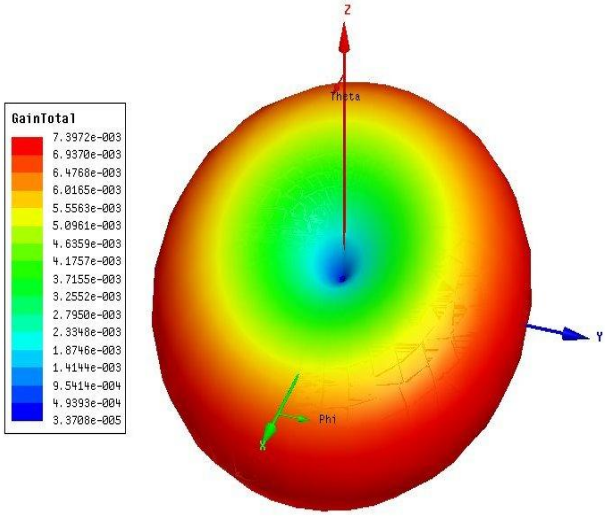

Fig.9. 3D Gain patch Antenna.

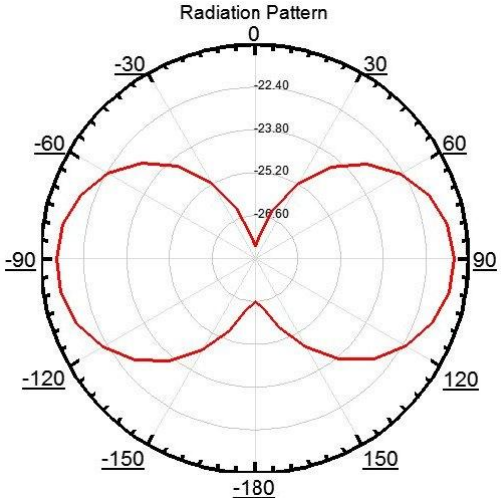

Fig.10.Radiation pattern Antenna.

Case-2: Proposed Antenna for three layers (Skin, Fat & Bone): The reflection coefficient (S11) frequency response of the Spiral Micro strip patch antenna in Figs.11 to 13. The antenna Return loss at 402 MHz with -29.39 dB reflection coefficient. The proposed Antenna is matched at MICS frequency limit at 402-405 MHz.

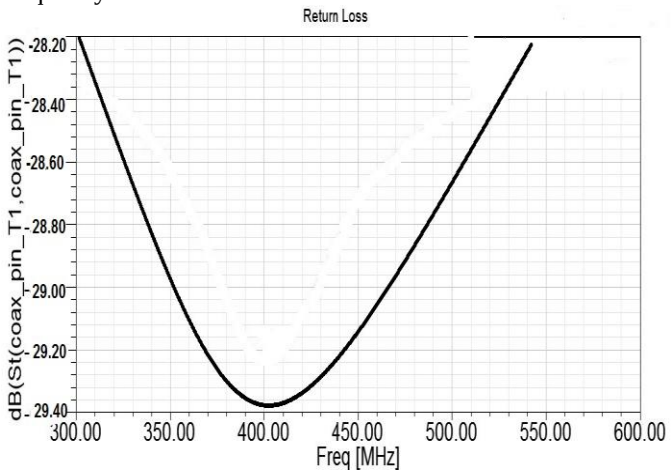

Fig.11.Return loss (Frequency = 402MHz & Total Gain = -29.39 dB).

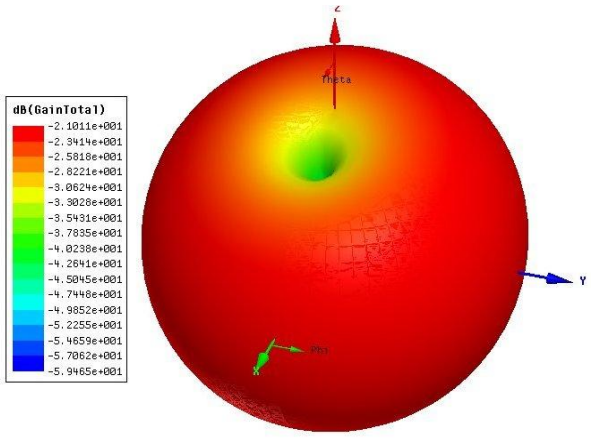

Fig.12. 3D Gain of Antenna - at 402MHz.

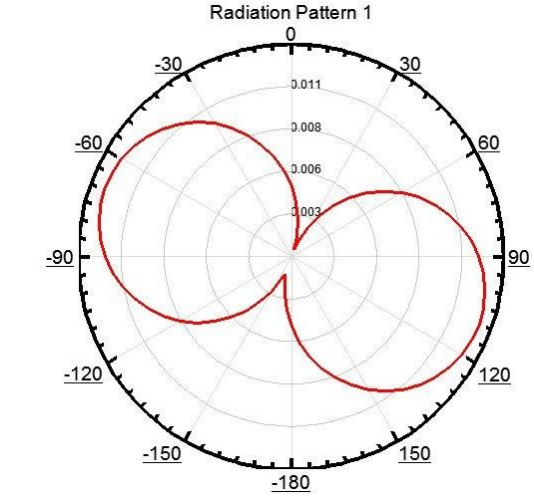

Fig.13. Radiation pattern of Antenna.

Case-3: Proposed antenna for three layers (Skin, Fat & Heart): The reflection coefficient (S11) frequency response of the Spiral Micro strip patch antenna is presented in Figs.14 to 17. The antenna Return loss at 402 MHz with -2.69 dB reflection coefficient. The proposed Antenna is matched at MICS frequency limit at 402-405 MHz.

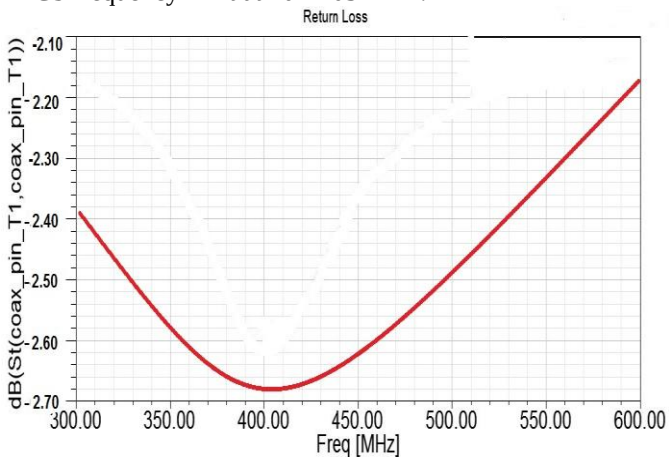

Fig.14. Return loss (Frequency = 402MHz & Total Gain = -2.69dB).

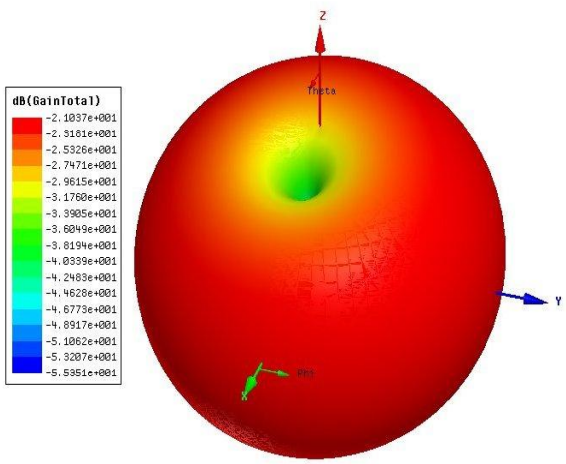

Fig.15. 3D Gain of Antenna - at 402MHz.

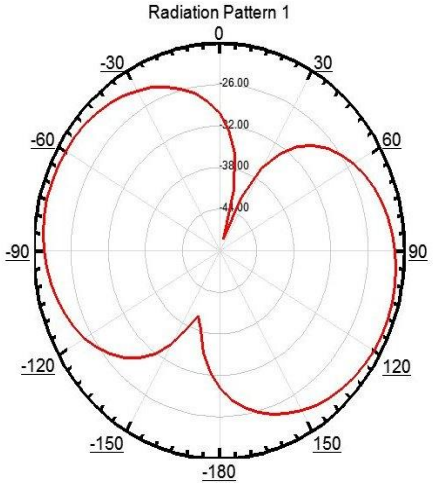

Fig.16. Radiation pattern of Antenna.

Case-4: Proposed antenna For Three Layers (Skin, Fat & Kidney): The reflection coefficient (S11) frequency response of the Spiral Micro strip patch antenna is presented in Figs. 17 to 19. The antenna Return loss at 402 MHz with -8.39 dB reflection coefficient. The proposed Antenna is matched at MICS frequency limit at 402-405 MHz.

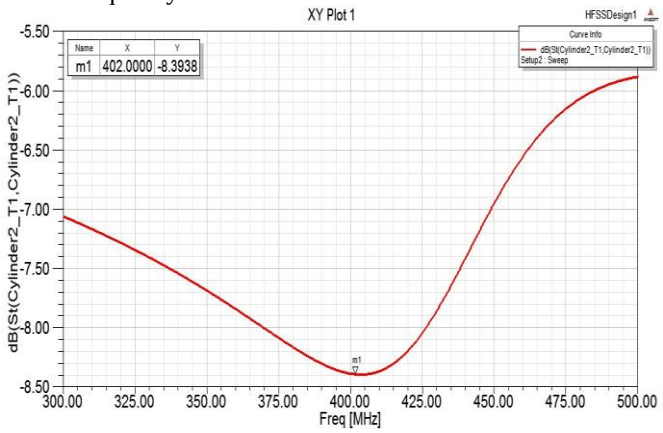

Fig. 17 Return loss (Frequency = 402MHz & Total Gain = -8.39 dB).

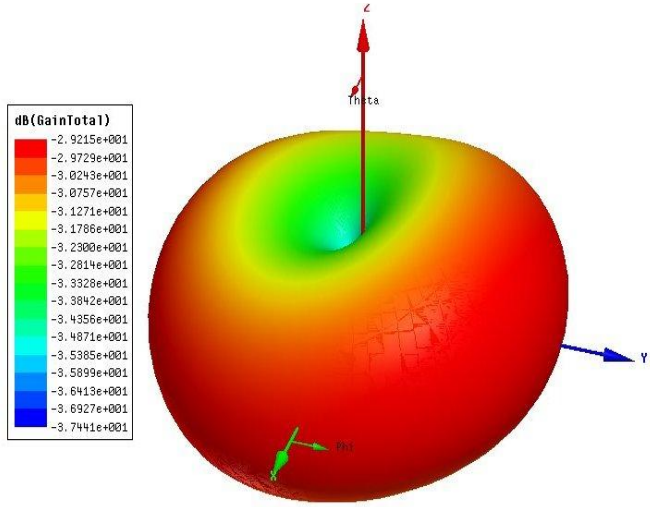

Fig.18. 3D Gain of Antenna - at 402 MHz.

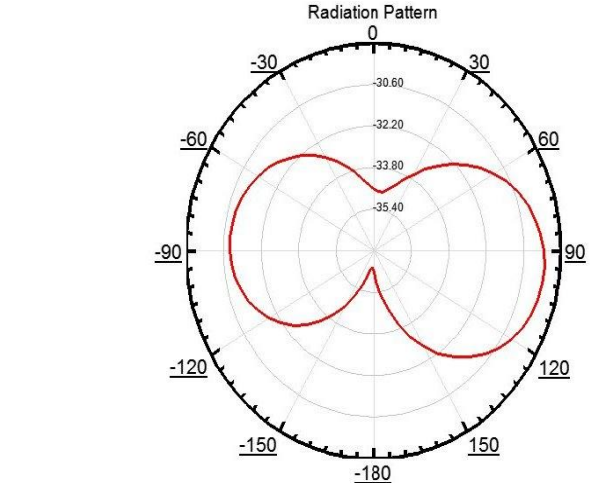

Fig.19. Radiation pattern of Antenna.

Case-5: Proposed Antenna For Three Layers (Skin, Fat & Skull): The reflection coefficient (S11) frequency response of the Spiral Micro strip patch antenna is presented in Figs. 20 to 22. The antenna Return loss at 402 MHz with -8.39 dB reflection coefficient. The proposed Antenna is matched at MICS frequency limit at 402-405 MHz

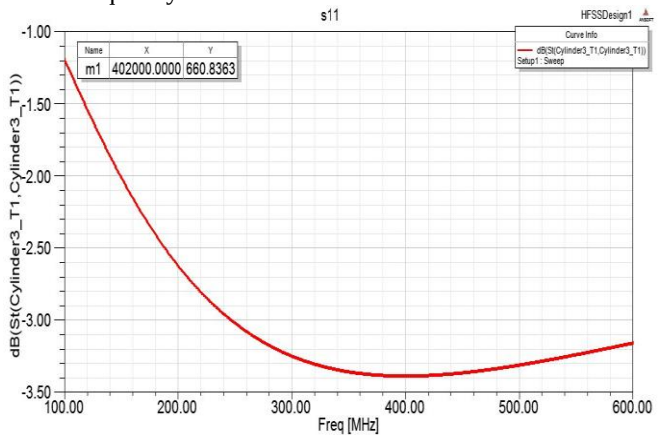

Fig.20. Return loss(Frequency = 402MHz & Total Gain = -8.39 dB).

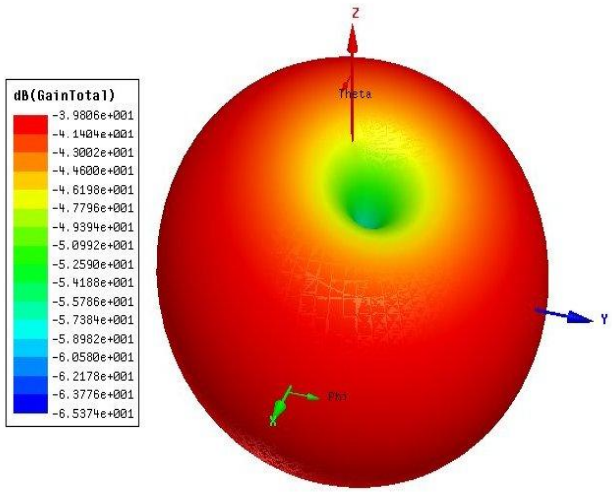

Fig.21. 3D Gain of Antenna - at 402 MHz.

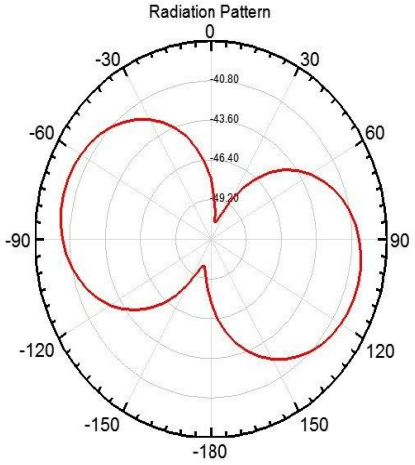

Fig.22. Radiation pattern of Antenna.

TABLE II: Analysis of Different Parameters or Case 2 & 3

PRAMETER	SKIN FAT BONE	SKIN FAT HEART
Max U	2.296e-007(W/sr)	2.28123e-007(W/sr)
Peak Directivity	0.00918138	0.0088826
Peak Gain	0.00792386	0.00787646
Peak Realized Gain	2.89E-06	2.87E-06
Radiated Power	0.000314256(W)	0.000322738(W)
Accepted Power	0.000364129(W)	0.000363964(W)
Incident Power	1(W)	1(W)
Radiation Efficiency	0.863036	0.886729
Front to Back Ratio	1.00985	1.00681
Gain	-29.39	-2.69
Frequency	402 MHz	402 MHz

TABLE III: Analysis of Different Parameters Or Case 2 & 3

PRAMETER	SKIN FAT KIDNEY	SKIN FAT SHULL
Max U	2.27971e-007(W/sr)	2.31026e-007(W/sr)
Peak Directivity	0.00887157	0.00913932
Peak Gain	0.00785201	0.00791689
Peak Realized Gain	2.86E-06	2.90E-06
Radiated Power	0.000322924(W)	0.000317663(W)
Accepted Power	0.000364854(W)	0.000366713(W)
Incident Power	1(W)	1(W)
Radiation Efficiency	0.885076	0.866245
Front to Back Ratio	1.00679	1.00972
Gain	-8.39	-8.39
Frequency	402 MHz	402 MHz

IV.CONCLUSION

Spiral micro stripe antennas are used for communication with medical devices has been analyzed in the range of 402-405 MHz. Based on this paper spiral antenna is designed and several observations were made. We designed a spiral-type micros trip at 402–405 MHz, Which are well matched to the surrounding biological tissues. Although the radiation patterns are similar to each other, the Spiral has advantages over a micro strip antenna, specifically, smaller dimensions and higher radiation efficiency. So this antenna can be easily fabricated on substrate material due to its small size and thickness. The simple feeding technique used for the design of this antenna make this antenna a good choice in many communication systems.

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Dr. S. Mishra has completed his Ph.D in (Electronics&Communication Engineering) from Biju Patnaik University & Technology, Odisha and M.Tech (Electronics System and Communication) from NIT Rourkela, Odisha. He has published research papers in different national and international in journals. Presently he is Professor and Head of the Electronics and Communication Engineering department in Centurion University of Technology and Management, Bhubaneswar. His research areas are soft computing, signal processing and image processing.