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Study of the Implantable Patch Antenna Performance in Medical Application

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Abstract
A novel and small sized implantable antenna has been proposed for scientific industrial & medical (ISM) band applications. The proposed antenna is shaped antenna and it is a circular patch antenna which has been designed based on the previous research articles and the lower size is achieved by implementing different miniaturization techniques. The radiating structure has a circular shaped patch and it has fillet edges with square shape. The back reflections have been avoided by extending the ground plane over the complete plane. The proposed antenna has been structured by using ROGER 3010 substrate which has the thickness of 1.6 mm and dielectric permittivity of 10.2 in order to achieve the geometries of an antenna with rigidity, the proposed structure has been designed. This antenna structure is operated at 2.45 GHz with the most recommended Omni directional pattern that has been used for transmitting with other in body devices.
Keywords*: Bio-medical application; Implantable antenna; 2.45 GHz*

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I. INTRODUCTION

In recent research activities in biomedical applications, an implantable antenna assures the substantial growth in patient's health and their life [1]. The implantable antennas are operated in the range of MICS (401–406 MHz) and ISM band (2.45 GHz) [2], it just a few example of electromagnetic field and radio frequency application. The patch antennas have compact size and low profile so it makes the necessary use of medical implant devices mostly telemetry application the patch antennas place the important role [3–5]. It makes the communication between patients and doctors, so the treatment performance is so easy, the patients need not stay in hospital for week or month. The implantable patch antenna makes the easy communication between doctor and patient.

An implantable antenna is necessary to reduce wave de- cline in complex human environment. While designing wear- able antenna, more attention must be paid on miniaturization. This proposed antenna structure is designed mainly for ISM band applications. One of the issues faced in the use of wearable antennas is the reduction in transmission stretch. This paper depicts the design of low power antenna that will operate in 2.4 GHz ISM band, recommended by ERC [6–8]. In this case the length of the skin and fat is 4 mm and length of the muscle is 8 mm.

Present scenario is the number of heart disease patients increased day to day life. The heart disease is analyzed from the abnormal variation of the ECG signal [9]. ECG is an electronic device used for the graphical representation of electrical activities of the heart variation of human beings. The heartbeat variation vastly depends upon the emotional feeling of the patient, hence this physiological signal or ECG signal monitoring through the wireless network can be done through the bio-sensors and on-body antennas [10,11]. Olden days used them—healthcare and e-healthcare programs for the wireless monitoring of the physiological signal through GSM or WMT service, which is possible only for the gain of antennas to become large value as result the size of the antenna becomes large and the radiation hazard to a human being is large [12,13]. But the proposed antenna operated in a high frequency of 2.45 GHz and 3.5 GHz automatically the size of the antenna becomes small or mm scale, as a result, the radiation hazard to human being minimized. For the long back, the Einthoven established in 1906 the flourishing broadcast of medical signal, and Grim in 1987 transmitted distortion less ECG signal through a wireless medium.

Table:1 Electrical Properties

S.no	Tissues	ετ	σ
1	Skin	38	1.46
2	Fat	5.28	0.10
3	Muscle	52.7	1.73

To discuss the advantage and disadvantages of the literature antennas and also be present the various types of biomedical planar antennas. The theoretical concept of CPW fed PMA for biomedical applications is discussed in Section 1. Section 2 explained the architecture of the proposed design and discussed the dimensions and dielectric substrate material. Experimental and simulated various antenna parametric results are briefly discussed in Section 3. Final Section 4 is the conclusion part of the proposed design.

II. ANTENNA DESIGN

Geometrical view of CPW fed antenna shown in Fig. 1. CPW has one strip conductor and two metallic ground plane and are lied in the equal plain of the substrate material. The main advantages of CPW fed are easy to fabricate, low attenuation and low dispersion characteristics. The CPW al- lowed quasi transverse electromagnetic (quasi-TEM) mode of operation. It does not require any hole and wraparound. The flow of design methodology for this proposed antenna is given below as a flowchart which is given in Fig. 2. The proposed patch antenna is printed on Rogers RO3010 substrate with the thickness of 1.6 mm and which is designed with the human phantom and respective dielectric properties which are tabulated in Table 1.

The total volume of the inverted-S patch antenna is 50X59.5X0.6 mm3. A 50 ω CPW fed line of a single conductor width is 1 mm and the gap is 0.25 mm.

III. RESULTS

An implantable antenna has been designed and antenna parameters are measured and analyzed with network analyzer. The proposed system is simulated by CST (Computer simulation software). The proposed patch antenna is fabricated and tested in human body fluid [Fig. 3]. The ingredients of human body liquids are deionized water, sodium chloride (NACl) and sugar etc. The measured parameters are given below.

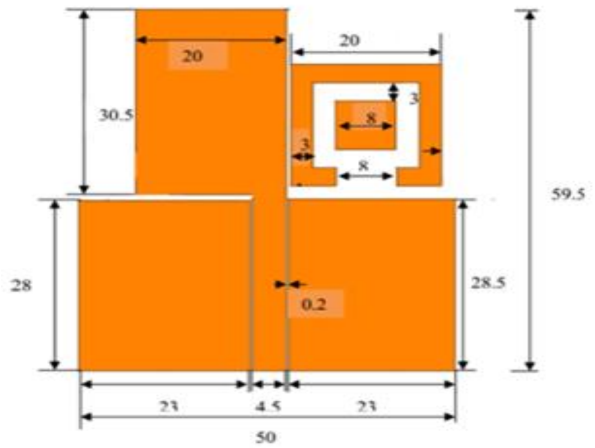

Figure:1 Geometry of Antenna

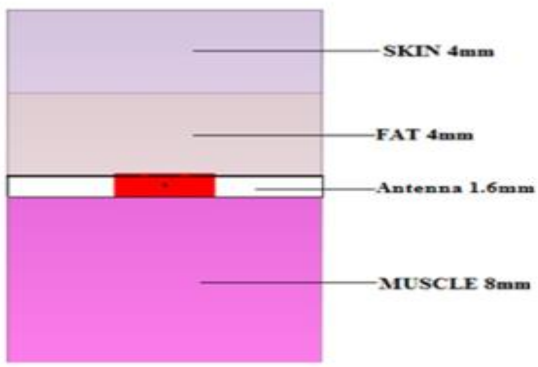

Figure: 2 Setup for Simulation model

IV. DISCUSSION

The reflection coefficient characteristic of presented antenna exhibits a lower value of 36 dB at 2.45 GHz. So it dominantly affects the lower frequency. Few amounts of transmitted power are reflected back to the port so this kind of antenna is absolutely sufficient for implanted cases in the range of ISM band. It shows 1:2 VSWR, so the impedance matching is perfectly matched (see Fig. 4).

The radiation pattern of proposed structure shows gain, E-field & H-field as given in 5. The E field is measured based on theta (θ) value in both 90 and 180. The cross polarization and co polarization levels in E-plane is 3.08 dBi and 1.62 dBi. The total antenna efficiency is 17% in the frequency of 2.45 GHz ISM band. The gain of presented antenna shows 14.7 dBi at the resonant frequency of 2.45 GHz. The EM property of the proposed antenna is clarified to simulate the 3D view at 2.45 GHz.

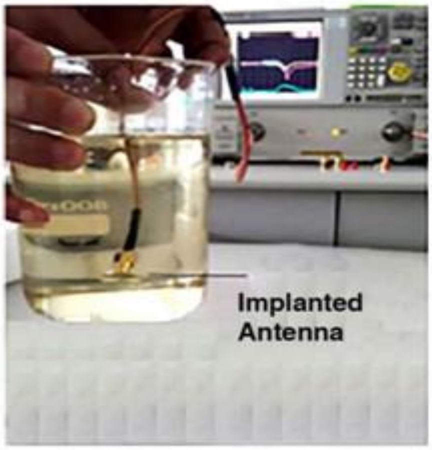

Figure: 3.Eexperimental setup.

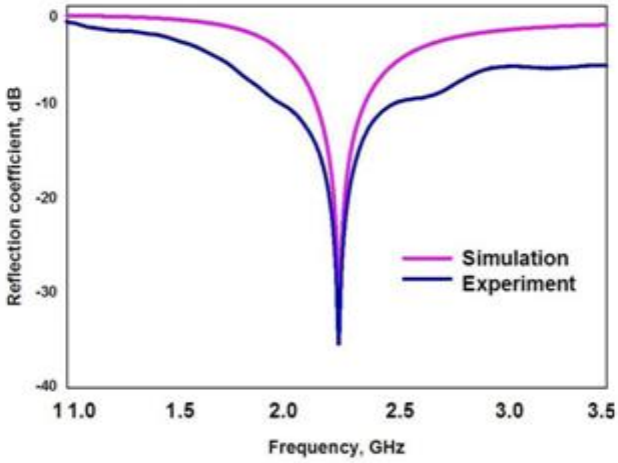

Figure: 4. Reflection coefficient.

The directivity and gain of the proposed antenna are shown in Figs. 6a and 6b. The directivity patterns and gain which are given below are identical to the radiation pattern of the grounded dipole antenna. From underneath mention results are designating the directive pattern and gain, at 2.4 GHz, the values is 14 dBi at 2.45 GHz and measured values are 14.7 dBi at 2.45 GHz.

In this work, the proposed antenna has less size and high performance compared to conventional antennas. However, this maximum level of input power is 2.6 mW and 23.4 mW for the 1g and 10g standards were way higher compared to 3.2 µW (25 dBm), which is the output power of most transmitters in implantable applications [5]. This means that, even though the transmitter produces an output power of 3.2 µW or higher as an input power for the implanted antenna, the SAR values would only reach 1.8 mW/kg for 1g and 0.3 mW/kg for 10g, which are much smaller than the respective IEEE limits of 1.6 and 2 W/kg. Therefore, our presented antenna SAR values should not be a concern in this communication.

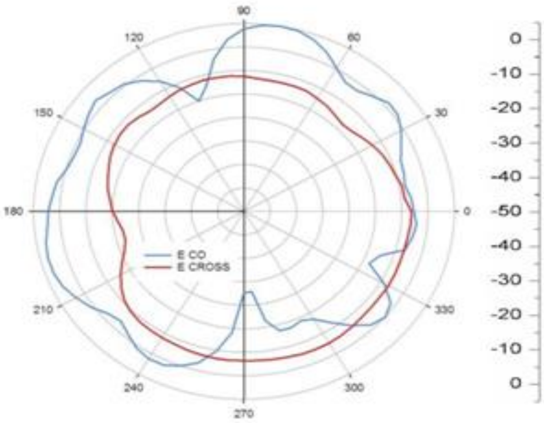

Figure: 5a. Radiation pattern (E-plane).

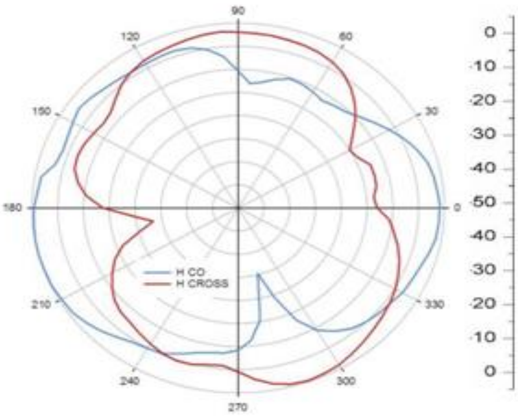

Figure: 5b. Radiation pattern (H-plane).

V. CONCLUSION

In this paper, CPW fed implantable antenna has been presented with 2.45 GHz ISM band frequency for the application of bio-medical industries. It has been observed that the performance of the existing design is suitable for real time application in desired field, while the proposed antenna design is also suitable to be developed in desired application. For the designed structure, the return loss parameter is accurate to the desired frequency range. In future, the results can be improved by developing the antenna in body applications. Based on application, the substrate material can be varied for each antenna. Miniaturization can also be done using different geometries or by varying the antenna parameters.

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