Design and Realization of Ultra Wide-Band Implant Antenna for Biotelemetry Systems

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Abstract

The aim of this study is to design of a small size implantable antenna involving Industrial, Scientific and Medical (ISM) (2.4 GHz-2.48 GHz) band. The goal of designing antenna is to obtain physiological information pertaining to person. Simulation measurements of antenna were obtained in body ambient by making the design of antenna with CST Studio Suite programme. Then, in vitro measurements were performed on antenna by making an artificial material, which shows electrical features of human skin tissue, to verify measurement results. Obtained measurement results and simulative results are in accordance.

1. Introduction

Antennas are going to be more important in medical area with wireless communication in the recent years. It is planned to develop life standards of people by granting them more relaxed life in the area of health with the help of technological developments. Hence there are many studies related to the remote patient monitoring developed for this purpose. The area of usage of telemetry systems widespread to meet the needs required remote monitoring of communication between the patient and base station [1, 2]. In recent years, ingestible antennas have began to place in literature as well as implantable antennas among antennas used telemetry systems [3]. The goal of this study was to designed the antenna that can be used in wireless telemetry systems.

Wireless data telemetry applications such as in brain and in cardiac pacemakers, in artificial eyes, in nerve stimulators, in implantable glucose sensors, in cochlear implants and in such similar areas getting extensive interest in implantable antennas. Wireless data transmission at the implant between the patient and base station that allows communication continuous monitoring of physiological parameters such as the glucose, blood pressure and temperature is very important for early diagnosis of diseases [4, 5, 6].

Implantable antenna design is quite challenging because of constraints as antenna size, low power requirements and biocompatibility with the body. The body tissue temperature can be added also on these mentioned constraints. Because the human body consist of many loss media that have electrical properties, it seems interesting to distinguish these electrical properties. The electrical properties are characterized by dielectric measurements such as relative permittivity, conductivity, dielectric loss tangent and penetration depth. In other words, electrical properties of human body tissues such as relative permittivity and conductivity are frequency dependent. Therefore, antenna which is placed in tissue is designed in accordance with the electrical properties of the tissue.

In this study, we are intended an implantable antenna design that is placed under human skin tissue. To test the antenna in-vitro tissue, mimicking gels were made that show relative permittivity and conductivity of human skin tissue for ISM band. To create required gels, we have used agarose, deionized water, NaCl, oil, sugar and pril chemicals. The gels were obtained by mixing different proportions of different chemicals for human skin tissue samples [7]. Skin samples with different content were produced to see the performance of the antenna. Then, designed antenna is placed under skin tissue and the antenna measurement results have been obtained. The measurements were obtained from 1 GHz to 5 GHz frequency range. The results obtained is seen to be in consistancy with simulation results in the interested frequency range.

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2. Material Characterization

Gels, exhibiting similar electrical properties of the tissues have an important role in the characterization of implantable devices and these gels are used to examine interaction between electromagnetic wave and biological tissues. These materials can be used in electromagnetic absorption, hyperthermia, microwave imaging systems, and determinate of the distribution of SAR and characteristics of the antenna for cell phone as well [8,9].

Tissue mimicking gels, which have electrical properties of human skin are compatible to ISM band. Samples with properties of human skin tissues were made of by stirring in accordance with the rates given in Table 1. Samples of skin are homogeneous. Percent of the value of content and the amount of gels are shown in Table 1 for tissue and frequency. Figure 1 depicts skin mimicking gels prepared for ISM band. The skin samples are named as Skin1 and Skin2 because their contents are different.

Frequency	Gels	Ingredients (%)
ISM	Skin1	Sugar 56.18%, NaCl 2.33%, Deionized water 41.49%, Agarose for 1 g in 100 ml solution
ISM	Skin2	Oil 40%, Deionozed water 58%, Pril 2%, Agarose for 1.4 g in 100 ml solution, NaCl 0.3 g for 100 ml solution

Table 1: Recommended Ingredients for Human Skin Tissue

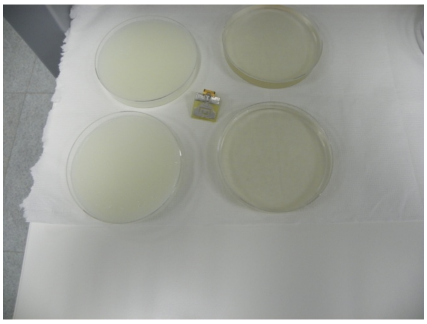


Fig. 1. Samples of human skin tissue and implant antenna

Skin mimicking gel has been chosen according to its electrical properties, which are interesting frequency for antenna characterization. We have considered electrical properties of skin mimicking gels with respect to [4,7,9].

3. Antenna Design

The two most important parameters are the antenna location and the frequency range for the design of an implantable antenna system. Type of antenna should be selected in terms of the interested aims. Frequency is a measure of penetration of antenna size and power of antenna radiating out of the body. The power absorption losses in human body is depending on the frequency. These dependencies are the characteristics of the tissues indeed.

In the content of study, firstly, the parameters of the antenna is calculated and numerical models for the first design was produced in the frequency range. In the first case, the antenna is in air, then the antenna has been analyzed according to the functionality in human skin tissue. Fig. 2 and Fig. 3 depict simulation model of the antenna and fabricated implanted antenna, respectively. Considered antenna has dimensions of 20mm × 20mm × 1.5mm.

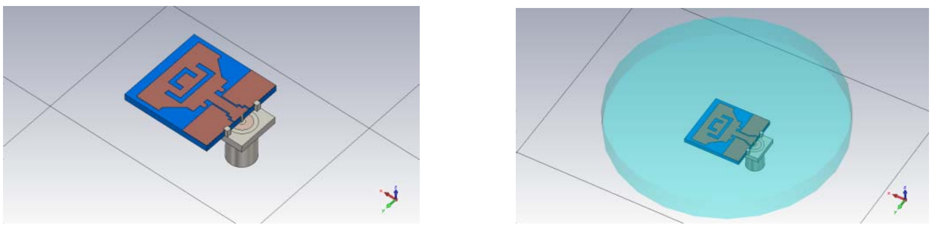


Fig. 2. Antenna Simulation Model

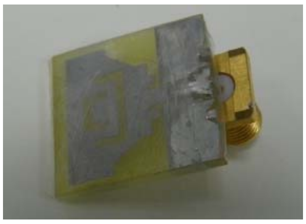


Fig 3. Fabricated antenna

To verify the simulation results, implantable antenna is fabricated and embedded in human skin mimicking gel. Measurement setup and implantable antenna are shown in Fig. 4. Antenna measurement is performed with Agilent Technologies E8362C PNA network analyzer in TUBITAK Antenna Test and Research Center. Simulation and measurement result of the antenna is examined in air and in human skin mimicking gel. Then these results were compared, Figure 5, 6. The discrepancies between simulation and measured data are originated from the dielectric properties of the samples. These samples were made for ISM band. But, in the simulation studies the electrical parameters of these samples are used at the interesting frequency range.

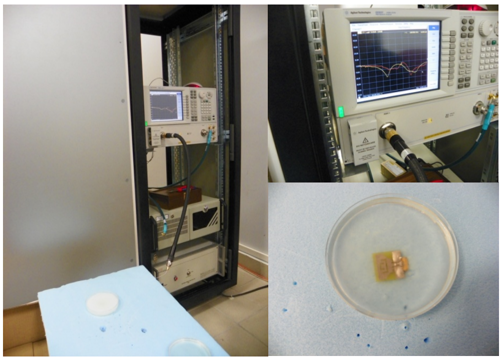
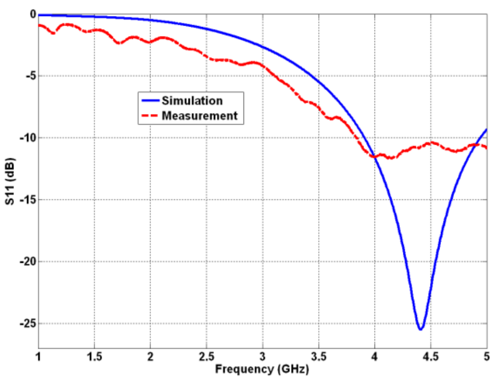


Fig. 4. Measurement setup and antenna embedded in the skin mimicking gel.



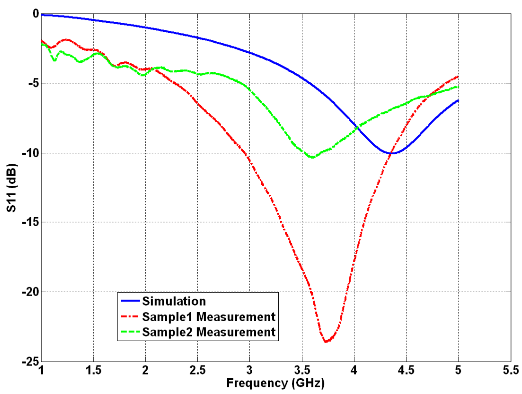


Fig 5. Return loss of the antenna in air

Fig 6. Return loss of the antenna in skin mimicking gels

The measurements were merely performed on the skin tissue for in-vitro testing at ISM band. In Fig. 6, Sample1 and Sample2 expression are used for Skin1 and Skin2, respectively.

The functionality of the antenna in body is also affected by electrical properties of fat, muscle and bone tissues not only the skin tissue. Figure 7 show antenna simulation model and return loss in body environment. Therefore, the functionality of the antenna affects the electrical properties of other tissues.

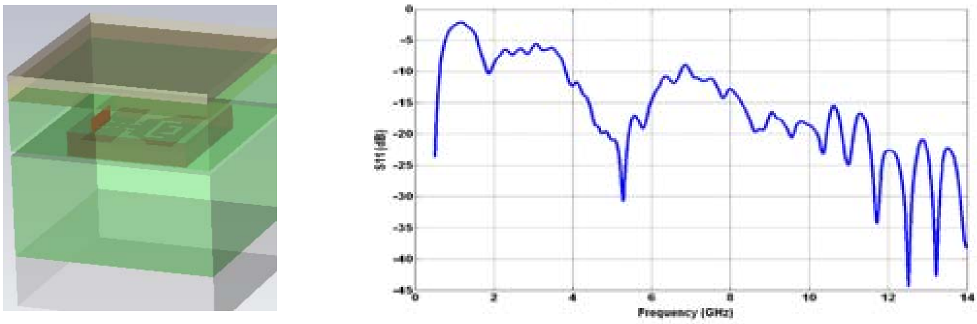


Fig 7. Implant antenna in body and return loss

4. Conclusion

In this study, we have designed a small size implantable antenna in ultrawideband applications involving ISM (2.4 GHz- 2.48 GHz) band for biotelemetry communications. The antenna was designed CST Studio Suite software taking into account the frequency range and the media of the antenna. ISM band is one of the selected frequency range that used to stimulate the implantable device. To test implantable antenna in-vitro were made tissue mimicking gels that resemble electrical properties of human skin tissue. The obtained measurement results of simulation were confirmed by using gels features of the human body tissues in ISM band. The fisrt measurement is performed in air and then in the skin mimicking gel for the ISM band. Return loss of the antenna is measured with an E8362C PNA network analyzer. We have seen that differences exist between the measurement and simulation results. The reason of the difference can come from the neglection of the encapsulation material of the gels, the different electrical properties of the resembled skin mimicking gel in the interesting frequency range or from the thicknesses of the gels. Also the electrical properties of the gels were not measured and considered in the scope of this work.

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