Implantable Antennas for Wireless Biomedical Devices

MINI PROJECT REPORT

Submitted in partial fulfilment of the requirements for the award of the

degree of

BACHELOR OF TECHNOLOGY

in

ELECTRONICS & COMMUNICATION ENGINEERING
by

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NEW DELHI – 110063

June 2022

CANDIDATE'S DECLARATION

It is hereby certified that the work which is being presented in the B. Tech Minor project Report entitled **"Implantable Antennas for Wireless Biomedical Devices "** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** and submitted in the **Department of Electronics & Communication Engineering** of **BHARATI VIDYAPEETH'S COLLEGE OF ENGINEERING, New Delhi (Affiliated to Guru Gobind Singh Indraprastha University, Delhi)** is an authentic record of our own work carried out during a period from **January 2018 to May 2018** under the guidance of **Rajiv Nehra, Designation.**

The matter presented in the B. Tech Mini Project Report has not been submitted by me for the award of any other degree of this or any other Institute.

This is to certify that the above statement made by the candidate is correct to the best of my knowledge. He/She/They are permitted to appear in the External Mini Project Examination

MR. RAJIV NEHRA	**Mrs. KIRTI GUPTA**
PROFESSOR	**Head, ECE**

The B. Tech Mini Project Viva-Voce Examination of

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has been held on 21st June 2022.

(Signature of External Examiner)

Project Coordinator **Project Coordinator**

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INTRODUCTION:

Implanted biomedical devices are witnessing great attention in finding solutions to complex medical conditions. Many challenges face the design of implantable biomedical devices including designing and implanting antennas within hostile environment due to the surrounding tissues of human body. Implanted antennas must be compact in size, efficient, safe, and can effectively work within adequate medical frequency bands.

Implantable antennas must be biocompatible in order to Preserve patient safety and prevent rejection of the implant. Furthermore, human tissues are conductive, and would short-Circuit the implantable antenna if they were allowed to be in direct contact with its metallization. Biocompatibility and prevention of undesirable short-circuits are especially crucial in The case of antennas that are intended for long-term implantation.

Recently the interest in implantable devices for biomedical telemetry has significantly increased. Among the different components of the implantable device, the antenna plays an important role in the wireless data transmission. These devices are intended to provide cost-efficient and long-term monitoring of vital signs in patients with chronic diseases without the need for an implantable battery.

Implantable antennas inside the human body have two types of biomedical applications. They are **BIOTELEMETRY and BIOMEDICAL THERAPY**. Biotelemetry can build a wireless communication link between human body and outside environment. Biomedical therapy includes treatment of diseases and monitoring of various physiological parameters.(WBAN) wireless body area network is the health care monitoring system which uses implantable devices inside the human body.

A wireless body area network (WBAN) connects independent nodes(sensors) that are situated in the clothes, on the body or under the skin of a person. The network typically expands over the whole human body and the nodes are connected through a wireless communication channel.

LITERATURE SURVEY:

Implantable medical devices are a growing technology with a high potential for improving patients' life and the quality of healthcare in society. Issues related to patient safety limit the maximum allow-able power incident on the implantable antenna. The Specific Absorption Rate (SAR) (the rate of energy deposited per unit mass of tissue) is generally accepted as the most appropriate diametric measure, and compliance with international guide-lines is assessed. For example, the IEEE C95.1-1999 standard restricts the SAR averaged over any 1 gram of tissue in the shape of a cube to less than 1.6 W/kg (SAR 1.6 1 , g max ≤ W/kg).

Recent advances in the technology of implantable-medical-device electronics have led to ultra-small designs for Implantable medical devices. The aim is to reduce the size of the antenna at a given operating frequency, while still maintaining adequate electromagnetic performance.

If operated continuously, the implantable medical device's transceiver will consume significant energy, and reduce the lifetime of the implantable medical device. For this purpose, a transceiver with dual-band operation May be used, such as the commercially available Zarlink ZL70101 transceiver. The system uses two frequency Bands, one for “wake-up” and one for transmission. The trans receiver stays in “sleep mode” with low power consumption (1 µW) until a “wake-up” signal is sensed in the 2450 MHz ISM Band.

IMPLANTABLE ANTENNA

The design of a specific radiator is the key aspect of an implantable device working in a WBAN of a few meters range. Characteristics such as radiation efficiency, bandwidth, the coupling with the lossy biological tissues and the use of the available volume are essential for the data communication.

BASE STATION

A general Base Station comprises several sub-systems a control module to drive the entire system and to store the measurements and receiver module including antennas. An internet modem (or any other device to connect to the data collecting system).The sensitivity of the receiver, the performance of its antennas (in terms of directivity, efficiency, polarization) and its portability are of fundamental importance for the realization of a system that targets real life applications.

CHANNEL PROPAGATION

The analysis of the EM propagation from the implant to the Base Station is another important aspect. The study of the multi-path propagation of the radiated EM waves and the scattering because of the nearby objects is necessary. This analysis, together with the design of antennas for the Base Station, can noticeably improve the performances of the entire system.

INSULATION

The presence of a biocompatible insulation is mandatory for any implantable device so as to avoid any adverse reaction of the living tissues. Such an insulation is of paramount interest from the antenna point of view, as the human body is an “hostile” environment for the Radio Frequency (RF) radiation. In fact, insulating layers, either placed around the antenna or on the surface of the human skin, enhance the EM transmission from an implantable radiator to the Base Station.

BIO SENSOR

The bio-sensors and/or bio-actuators determine the application of an implantable device and its placement in the human body. Monitoring devices (for instance measuring temperature, pH, glucose, etc.) or active system (drug delivery apparatus) are nowadays being investigated for implantable applications.

Implantable antenna must be biocompatible in order to preserve patient safety. Human tissues are conductive, and would short circuit the implantable antenna if they were allowed to be in direct contact with its metallization. Most widely used approach, metal radiator is separated from human tissues to cover the structure with a super strate dielectric layer.

PROPOSED METHODOLOGY:

Ansys HFSS is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit boards.

once we have got it installed on your system. Depending upon the version you are using and the thing you are designing (Filter, Resonator, Antenna etc), we saw videos on YouTube. It being a simulator takes a lot of time in giving results (depending on the number of passes, complexity of your structure etc.)

The first step we learnt this software is to get in touch with concepts like return loss, feeding methods and studied the basic terms and installed the software.

Once we have completely implemented the given instructions by our mentor and obtained the result, we learnt the most of it. Now kept adding new features to our structure and kept observing the changes in results.

The work on software is simple drag and drop.There are certain software related concepts which we figure out while using. However in case of any doubt just googled it and finally completed the design and stimulated graph with help of our mentor.

TABLE I

PARAMETER VALUES OF PROPOSED ANTENNA

Parameter	Value (mm)
L	8.615
W	7.43
ℓ_t	6
ℓ_0	3.615
L_t	2.5
S	0.11
W_t	0.5

TABLE II

THE DIELECTRIC & CONDUCTIVE PROPERTIES OF HUMAN TISSUES AT 433.92 MHZ

Tissues	ε_r	σ (S/m)
Stomach	67.2	1.01
Colon	62.0	0.87
Small Intestine	65.2	1.92
Muscle	56.9	0.8

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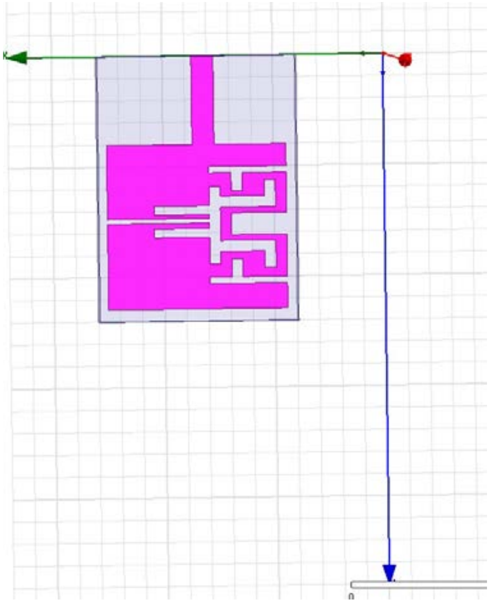

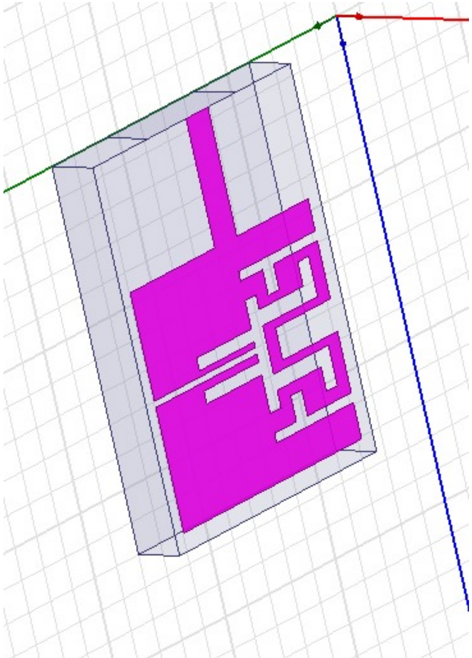

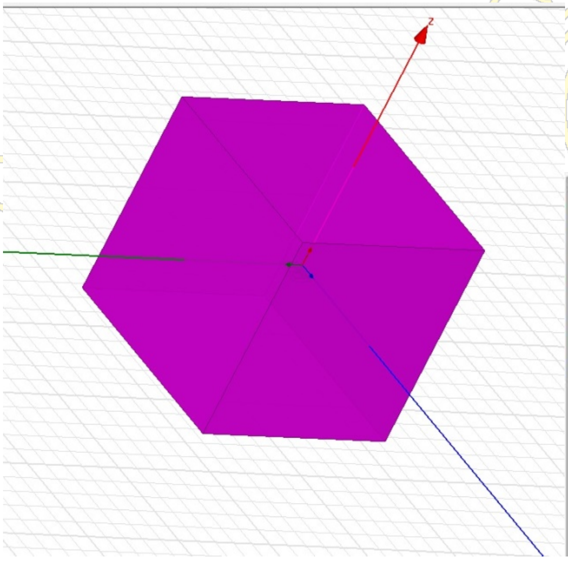

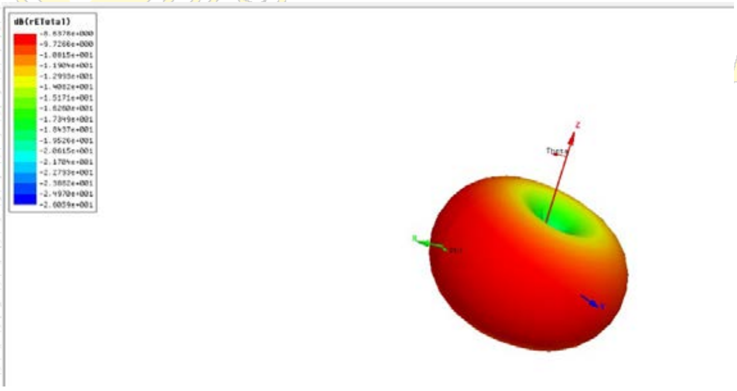

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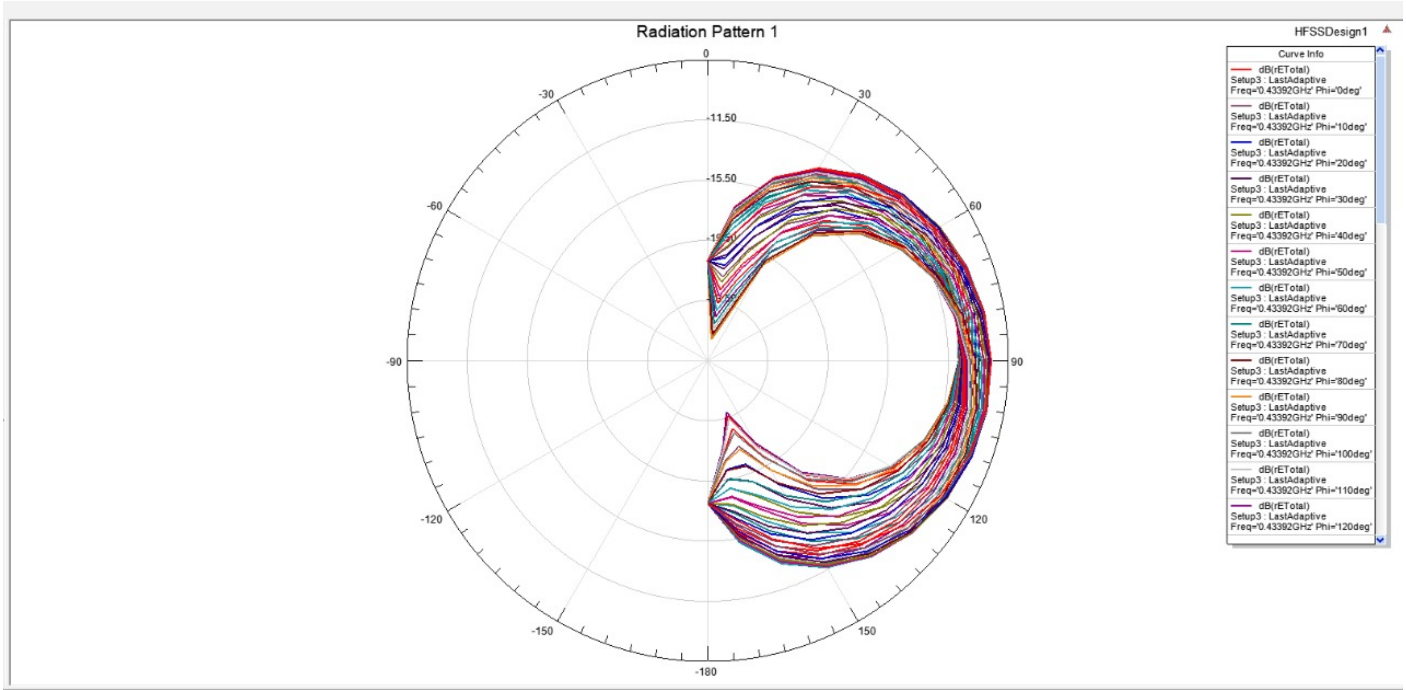


RESULTS:

The outcome of our project was developing an implantable antenna for wireless biomedical devices which operate at very low frequency, typically at medical implant communications service (MICS) band (402-405 MHz) or medical device radio communications service band (Med Radio, 401MHz – 406MHz).

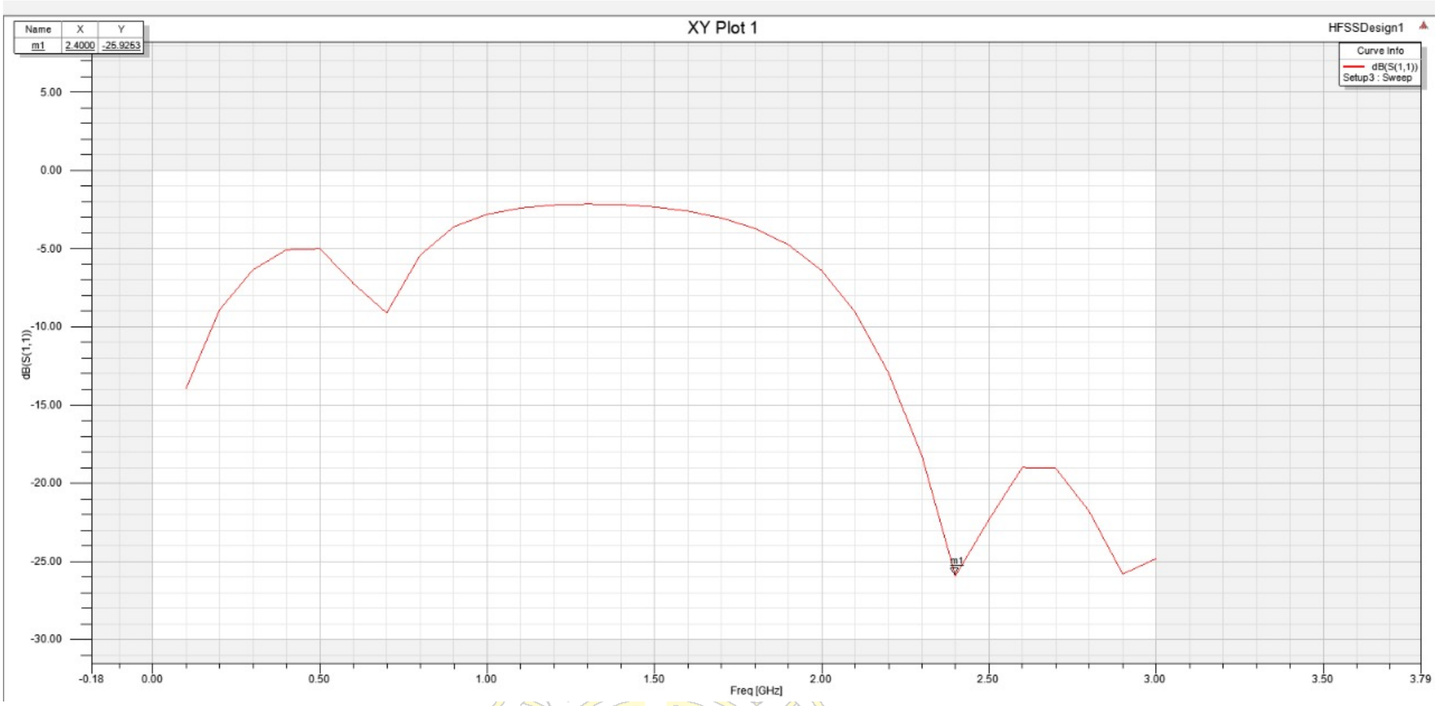
In this project next we changed the parameters of our antenna in the software to check whether it is safe for implantation in human body or not. We have designed it in a way that it matches the safety limits as defined by SAR (specific absorption ratio) and SA (specific absorption) standards and do not increase the body temperature by more than 1 or 2 degree Celsius. We have simulated the model at different frequencies and changing parameters to make it more usable. Working in a suitable biomedical band requires an efficient compact antenna that fits inside or around implanted device.

There is an urge for installing an implantable antenna capable of allowing multi or broadband data transmission, taking into consideration the attenuation due to body heterogeneous tissues which causes reduction in both efficiency and bandwidth. The major challenge was that the implanted antenna is heavily miniaturized which leads to an electrically small size antenna, thus suffering from decreasing of its radiation performance. The solution to such a problem was to achieve a good compromise between size and radiation characteristics.

The design goal of the antenna is to have a compact size and sufficient resonance and radiation characteristic at 433.92 MHz. The antenna is fabricated on FR4 substrate with relative permittivity 4.4 and thickness 1.6 mm.

Four different locations inside the human phantoms have been targeted for the investigation purposes: Muscle, stomach, colon and small intestine.

The solution frequency was reached 2.4 Ghz, which is provided by government for medical Bluetooth transmissions.



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