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EVALUATION AND DEVELOPMENT OF A CPW-FED ANTENNA OPERATING IN THE ISM BAND FOR USE IN HEALTHCARE

Dr. ROSI. A, SANIYA SALIM, SHILPA ALIYAS, SHELJA JOSE
Department of Electronics and Communication Engineering,
Indira Gandhi Institute of Engineering And Technology Nellikuzhi P.O, Kothamangalam, Ernakulam (Dist) Pincode 686691

Abstract

The purpose of this study is to build a patch antenna that may be implanted for use in biomedical applications that operate in the ISM band (2450 MHz), which stands for the industrial, scientific, and medical band. The proposed antenna has a total dimension of 16 × 16 × 1 mm3, and its thickness is 1 mm. Additionally, this antenna is embedded in a substrate made of Teflon, which has a dielectric constant value of 2.1 and a loss tangent of 0.00028. Simulation of the proposed antenna is carried out with the help of CST simulation and measurement. The antenna parameters exhibit favourable outcomes, including a decrease in return loss, an impedance matching that is flawless, and an improvement in gain. When compared with existing conventional antennas, the suggested antenna demonstrates superior accuracy and performance.

Keywords: Implantable antenna; Coplanar waveguide feed; ISM band biomedical applications

1. Introduction

IMDs, which stand for implantable medical devices, have been receiving an increasing amount of attention in the area of medical diagnosis and therapy in recent times [1]. It is necessary that the transmitter specification be able to work in the ISM band, which has a frequency range that falls between 2400 MHz and 2480 MHz [2]. The transmitter specification is a key design feature of IMD. The size of the implanted antenna is much smaller than that of conventional antennas, which are used for broad wireless applications such as mobile phones. The implantable antenna is comparable to conventional antennas. Adding another layer of complexity to the situation is the fact that these implant antennas will be installed inside of a complicated lossy environment [3]. For the aim of medical applications like as balloon angioplasty or hyperthermia, as well as certain sensing applications, a number of researchers have been concentrating their efforts on implantable antennas. When it comes to both scenarios, the functioning of antennas revolves around their narrow field, and they are able to cover a certain distance throughout the course of propagation, which is not a disadvantage [4]. This study offers a monopole antenna in the form of a loop that is intended for implantable biomedical applications in the frequency range of 2.4–2.48 GHz, which is classified as the ISM band (which stands for industrial, scientific, and medical communication). High frequency response is achieved by the use of CPW feed in the construction of the patch antenna. The antenna is 16 millimetres in length, 16 millimetres in width, and 1 millimetre in height. The suggested system has a number of advantages, the most important of which is that it has a very minimal size consumption and that it has greater accuracy[10]. Measurements are taken of the antenna's properties, including return loss, voltage standing wave ratio (VSWR), radiation pattern, and gain, after the planned antenna has been analysed using a single layer, also known as muscle.

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Therefore, the suggested antenna is used for a variety of applications that include implantability. As a result of implanted wireless connections, wires are no longer required, processes are simplified, and ultimately, the cost effectiveness is reduced [5–9].

2. Antenna design

To respond to the high frequency range and to limit the back radiation of an antenna, the suggested system is developed using CPW feed. This allows it to respond to the high frequency range. All things considered; the volume of an antenna is rather tiny. Following this, the antenna is created and analysed using a human phantom model, which includes features such as skin, fat, and muscle, along with their relative dielectric permittivity, electrical conductivity, and mass density. Additionally, we examine the properties of an antenna, including return loss, voltage standing wave ratio (VSWR), radiation pattern, and gain [8]. At a frequency of 2.45 GHz, the return loss value that was achieved is 37 dB. Coplanar waveguide is the method of feeding, and in this particular instance, CPW (Coplanar waveguide) feed is proposed for high frequency response [9]. This allows for an increase in the accuracy of the proposed system, as well as a reduction in the back radiation of the antenna. Additionally, the proposed system is analysed with human tissues such as muscle, considering their relative dielectric constant. The length of the muscle in this instance is eight millimetres. To biomedical applications, a unique Coplanar Waveguide fed folding type antenna has been constructed at the ISM band frequency, which ranges from 2.4 to 2.48 frequencies. To design the suggested antenna, Teflon was used. The dielectric constant was set at 2.1, the tand value was set at 0.00028, and the thickness was set at 1 mm. As can be seen in Figure 1, the total dimensions of this antenna are 16 millimetres by 16 millimetres by 0.8 millimetres. First, the antenna is constructed as a planar structure, which is a mix of loop and monopole antennas, and then it is folded. This is done in order to ensure that the channel and stage of external currents are altered appropriately, resulting in unidirectional radiation and a compact size. The cancellation of the backward radiation and the achievement of impedance matching are both results of this mechanism.

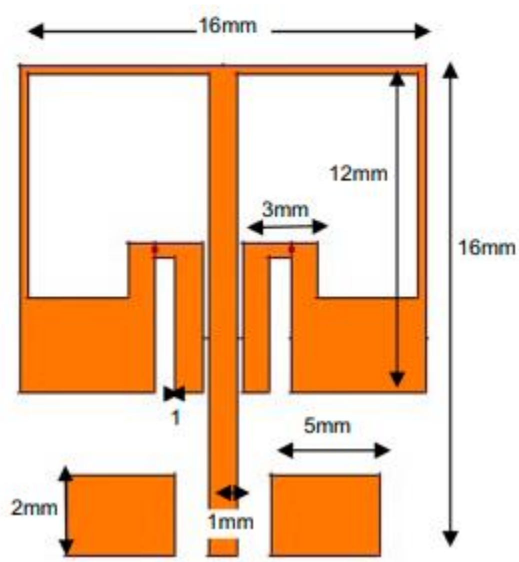

Figure 1 Proposed antenna structure.

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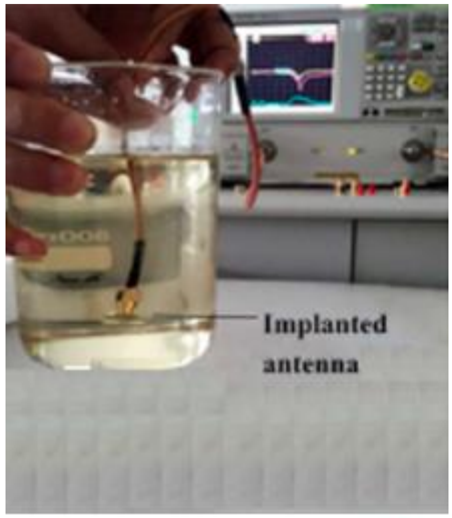

Figure 2 Measurement setup model.

Table 1 Electrical properties of muscle tissue.

Tissue	Permittivity	Conductivity
Muscle	$\varepsilon_r = 52.7$	$\sigma = 1.73$

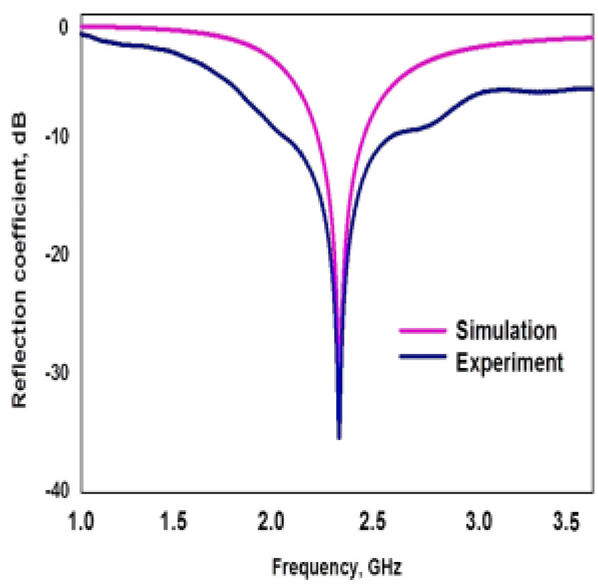

Figure 3 Return loss of proposed antenna.

During the process of developing the fundamental theory of the tiny ray characteristics and modelling of the human body, an analysis of antennas on lossy cases was carried out. For us, this method of identifying major difficulties is connected to implanted antennas, which serve as a firm basis for the subsequent work

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that will be presented, so providing a clear image. It was determined, for example, that biocompatible lagging is of the utmost importance.

Taking this into mind, we have developed and implemented a number of different physiological and mathematical models that demonstrate that the suitable choice of insulating layers will greatly increase the emission competence.

Taking into account the design of implantable antennas, packaging constraints, and technological obstacles, theoretical inputs will be required. Teflon substrate is used in the fabrication of the proposed antenna construction. Once the body has been infected, it functions more effectively than when it was created utilising dielectric later. The dielectric substrate thickness and the finite coplanar waveguide structure are two factors that need to be taken into consideration in order to guarantee the efficiency and practicability of the design.

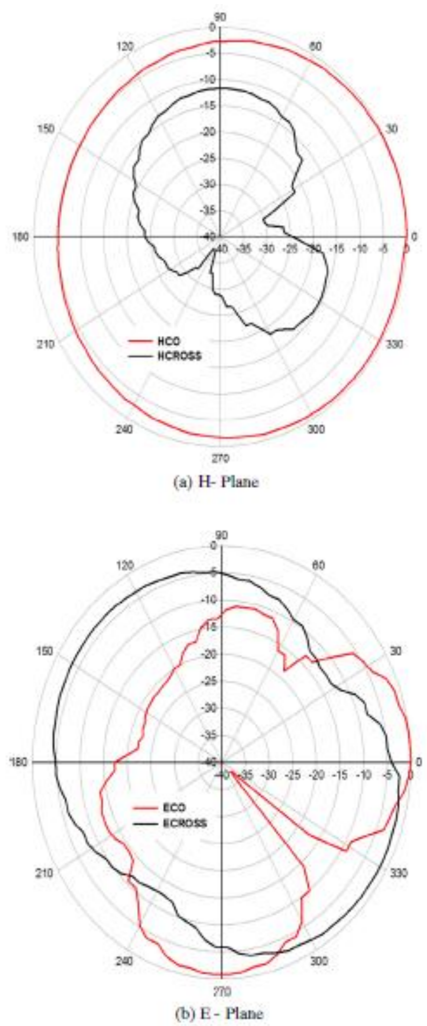

Figure 4 XY plane (a) H–Field (b) E–Field.

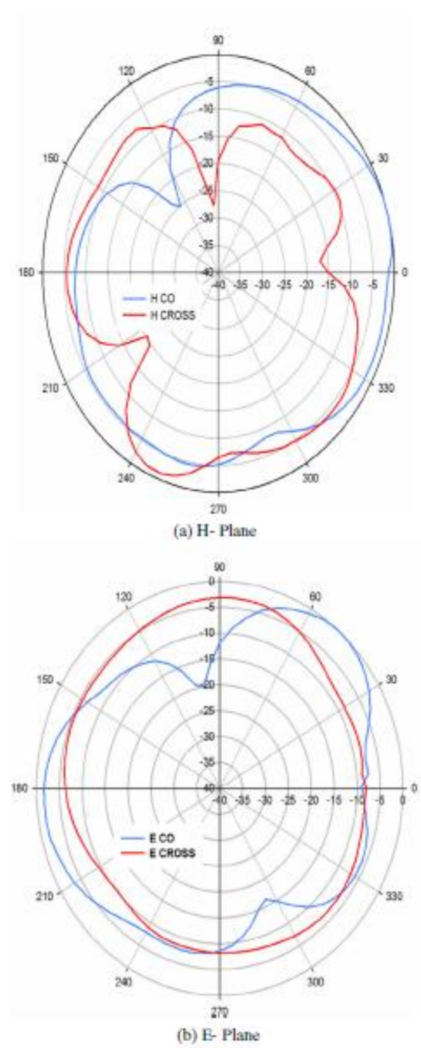

Figure 5 XZ plane (a) H–Field (b) E–Field.

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3. A system for detection

The early detection of congestive heart failure may be accomplished with the help of an implantable CPW supplied antenna by the monitoring of the buildup of fluid in the lungs. With the help of this antenna, a radar-based microwave system that is comprised of Agilent heart failure detecting technology and an adjustable platform is constructed from a portable transceiver that was produced to order. An artificial human torso phantom has been used to evaluate a life-size human torso anatomical model of the whole system. This model includes a realistic representation of the cardiovascular organs, including the ribs, fat, heart, lungs, and stomach capacity.

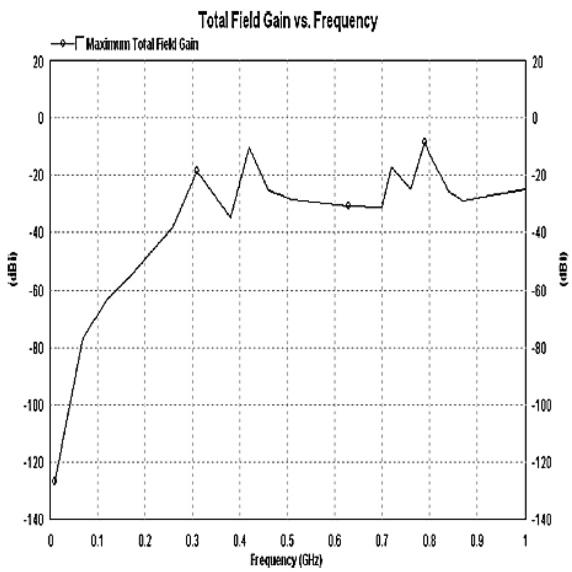

Figure 6 Gain vs. frequency.

When the measurements were being taken, the antenna and the phantom were separated by a distance of fifty millimetres. In order to do a scan of the torso, it is manually moved in increments along the x and y axes. The notion of a virtual antenna array, which is used in the detection method, is the sole element that is required. The total number of scanning positions that were done was 63. These positions included three displacements with a step length of Θy = 30 mm (horizontal scan) and 21 displacements with Δx = 10 mm (vertical scan). In order to get a picture of the lungs, the measurements were repeated as part of two vertical scans. It is dispersed over the frequency range that a pulse frequency of 158 samples, which are sent via the transceiver, grows continuously from 0.5 to 1 GHz.

In order to produce a picture of the time domain frequency domain data distribution switches and scatters inside the body, the model first compiles the data and then combines them with their respective counterparts. The case of a healthy lung to the left and right pictures acquired in the fair distribution of the reflected signals suggests that there is a resemblance between the two. Skin and ribs of the air interface are most likely to be affected by the strongest dispersed signals. It is recommended that a little quantity of water, about fifty millilitres, be introduced into the left lung in the event of an early heart failure.

In light of the fact that the radiation does not have a pencil beam antenna, the picture of the right lung is affected by the addition of the left lung to the water. Nevertheless, it is evident that it is in the lungs as a result of heart failure; the inclusion of fluids in order to identify any irregularity is referred to as processing.

4. Results and discussion

A CPW feed has been built into the proposed system so that it can respond to the high frequency required. The distance between the grounds and the feeding line is 0.5 millimetres, and this distance has been optimised based on the results of simulations that have been carried out using computer simulation technology (CST). Following the completion of the design restrictions, the proposed antenna is put through its paces using a single layer human tissue model, as seen in Figure 2. The results of this test are presented in Table 1, along with the relative dielectric constant and conductivity values. Individual human tissues have a thickness of eight millimetres.
The features of the proposed CPW-fed antenna's return loss are shown in Figure 3, which shows both the simulated and measured values. The fact that the resonance frequency and the bandwidth of the antenna are both completely evident is shown by the fact that the result is one that is relatively precise. The impedance bandwidth of a CPW supplied monopole antenna is broader, which allows it to span the stunned state that was discovered via experimentation. A representation of the proposed 50 X matching bandwidths in the resonant frequency may be identified in Figure 3. The XY radiation patterns for both the E-plane and the H-plane patterns are shown in Figure 4a and 4b respectively. The XZ radiation patterns for both the Efield and the H-field patterns are shown in Figure 5a and 5b respectively. It is possible to note that the results of the agreement between the E plane and the H plane are reasonably satisfactory.
One possible explanation for the little disparity is that the edges of the conductor simulation are to blame. The antenna is positioned in the centre of the VNA surface, with the direction of the antenna being directed towards the surface of the earth and the distance of the antenna ground plane located along the Z-direction. With the help of the graph, it is possible to see that the gain of the antenna stays relatively unchanged over the whole frequency range of the resonant band. In addition to this, it is important to notice that the gain energy value has not changed. Figure 6 illustrates the gain of the folded type antenna that is fed by CPW frequencies.

5. Conclusion

A unique miniaturised antenna that is suitable for use in biological applications has been suggested in this investigation. The loop structure is used in order to achieve the miniaturised size of 16 millimetres by 16 millimetres by one millimetre In addition, the suggested antenna has the capability of reducing its size by truncating the diagonal corner as well. It is suggested that an antenna with a return loss of 37 dB be used here. The selection of the substrate material allows for gain to be attained since the Teflon substrate has a higher dielectric constant. As a result, miniaturisation is also accomplished in this research. In the ISM band, which ranges from 2.4 to 2.48 GHz, the suggested antenna is constructed. As a candidate for the area of biomedical engineering applications, it is appropriate for further consideration.

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