Alexandria Engineering Journal (2017) xxx, xxx–xxx

HOSTED BY

Alexandria University

Alexandria Engineering Journal

www.elsevier.com/locate/aej
www.sciencedirect.com

ORIGINAL ARTICLE

Design of hexagon shape bow-tie patch antenna for implantable bio-medical applications

N. Mahalakshmi [a,*], A. Thenmozhi [b]

[a] Vickram College of Engineering, India
[b] Thiagarajar College of Engineering, India

Received 23 December 2016; accepted 23 January 2017

KEYWORDS

Implantable bio-medical applications;
Patch antenna hexagon;
CPW feed;
Phantom model;
Industrial;
Scientific and medical (ISM)

Abstract This paper presents a novel hexagon shape bow-tie antenna for implantable bio-medical application at a frequency ranging from 2.4 GHz to 2.48 GHz of ISM band. In order to achieve high frequency response the proposed antenna is designed with CPW feed. Alumina ceramic (Al_2O_3) is used as the substrate material with 1 mm thickness and the dielectric constant is 9.8. The proposed antenna has the total size of $10 * 10 * 1$ mm which is located at human tissues such as muscle, fat and skin and some of the parameters such as gain, return loss, radiation pattern and VSWR are measured. The main advantage of the proposed system is it has reduced size with increased accuracy. The proposed antenna possesses the return loss of −29 dB at 2.43 GHz. Thus the proposed hexagon shape bow-tie antenna can be employed for several implantable applications.

1. Introduction

Nowadays, there is an increasing need for diagnostic and therapeutic functions which are provided by Implantable Medical Devices (IMDs). With the help of integrated implantable antenna the bidirectional telemetry operation is done between exterior monitoring equipment and implantable medical device in a wireless manner. The implantable antenna comprises an advantage of creating such technology very attractive since it possesses the capability to be handled remotely. It is essential to study the biological property of the human tissues while implementing the implantable antennas within a human body because the human tissues lead a crucial role. This implantable antenna is fitted at the chest simply under the collar bone.

By varying the frequency, the conductivity and relative permittivity of the human tissues also vary. In implantable antenna design, the patch designs are much important because of its shape and flexibility [1]. Through the MICS band and the ISM band, the communication is accomplished at the frequency between 402.0 MHz to 405.0 MHz and 2.4 GHz to 2.48 GHz respectively [2]. The cables are removed because of the wireless links. Thus the operations are simplified by the way cost-effective communication is achieved [6]. The experimental and numerical studies of implantable patch antennas are much interesting which attract particular scientific interest [8].

In past few years due to the advancement in technology compact communication devices are produced which comprise compact antennas. The power is transmitted through the antennas which have less focus. For constant wireless

* Corresponding author.
E-mail address: ece.nmaha@gmail.com (N. Mahalakshmi).
Peer review under responsibility of Faculty of Engineering, Alexandria University.

http://dx.doi.org/10.1016/j.aej.2017.01.028
1110-0168

Please cite this article in press as: N. Mahalakshmi, A. Thenmozhi, Design of hexagon shape bow-tie patch antenna for implantable bio-medical applications, Alexandria Eng. J. (2017), http://dx.doi.org/10.1016/j.aej.2017.01.028

applications the design of low profile antenna is essential. The microstrip patch antennas are employed for a wide range of applications such as biomedical applications, communication systems and satellite applications and it is also required to transfer power.

The coplanar waveguide (CPW) feed is used in the proposed system because this CPW feed can minimize the back radiation and respond at the range of high frequency. The total size of the antenna is about $10 * 10$ mm with 1 mm thickness. Design and analysis of a novel hexagon shape bow-tie antenna are proposed with human phantom models such as muscle, fat and skin along with its relative dielectric permittivity, electrical conductivity and mass density and some of the parameters such as gain, return loss, radiation pattern and VSWR are measured [9]. The measured return loss is −29 dB at the frequency of 2.43 GHz. The size of the muscle, fat and skin is 8 mm, 4 mm and 4 mm respectively.

2. Antenna design

Fig. 1 demonstrates the configuration of the proposed antenna. The resonant frequency of proposed antenna is 2.43 GHz. The area of the alumina ceramic (Al_2O_3) is $10 * 10$ mm with 1 mm thickness on which the antenna is printed. It has the relative permittivity of 9.8. The width of the transmission line is 1 mm with 0.25 mm distance between two strips. The antenna is fed through the coplanar ground plane [11]. The design of hexagon shape bow-tie antenna is done for ISM band (2.4–2.48 GHz) bio medical operations [12]. Dimensions of the proposed antenna are given in Table 1.

The flow of design requirements [5] is showed as flowchart in Fig. 2.

Design of parametric model for skin, fat and muscle is done as per their relative dielectric constant of human tissues [13], which is shown in Table 2. And the thickness of human tissues is shown in Table 3 [14].

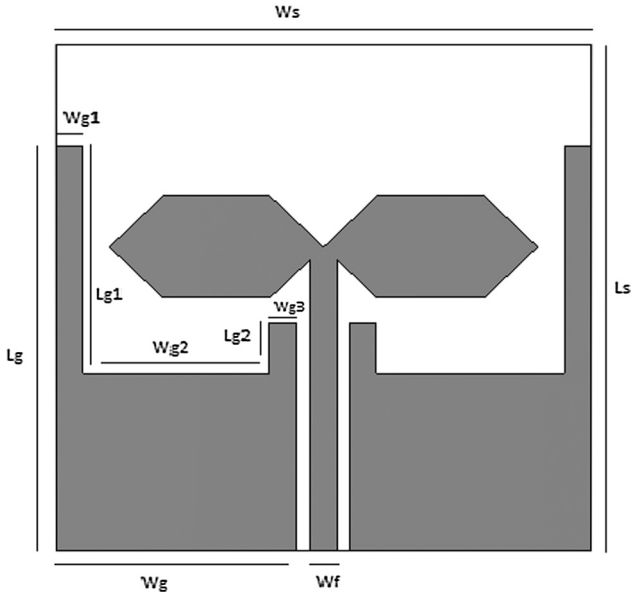

Figure 1 Geometry view of proposed antenna.

Table 1 Dimensions of proposed antenna.

Ws-width of the substrate	10 mm
Ls-lengtrh of the substrate	10 mm
Wg-width of the ground	4.5 mm
Lg-length of the ground	8 mm
Wf-width of the feed	0.5 mm
Wg1	0.5 mm
Lg1	4.5 mm
Wg2	3.5 mm
Lg2	1.5 mm
Wg3	0.5 mm

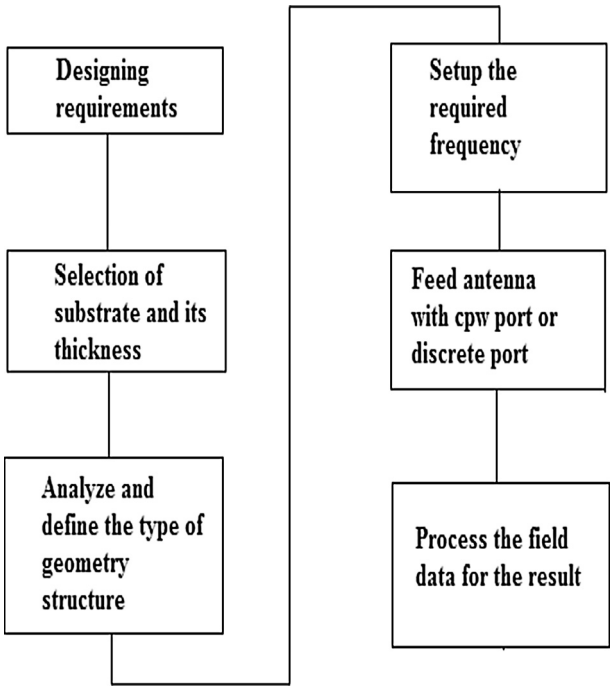

Figure 2 Flowchart for proposed system.

Table 2 Electrical properties of human tissues.

Tissue	Permittivity	Conductivity
Skin	$\varepsilon_r = 38$	$\sigma = 1.46$
Fat	$\varepsilon_r = 5.28$	$\sigma = 0.10$
Muscle	$\varepsilon_r = 52.7$	$\sigma = 1.73$

The proposed hexagon shape bow-tie antenna with phantom model [4] is demonstrated in Fig. 3.

2.1. Simulation result

The antenna parameters such as return loss, VSWR, radiation pattern and gain, are measured from CST (computer simulation technology).

Please cite this article in press as: N. Mahalakshmi, A. Thenmozhi, Design of hexagon shape bow-tie patch antenna for implantable bio-medical applications, Alexandria Eng. J. (2017), http://dx.doi.org/10.1016/j.aej.2017.01.028