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Design of a Hexagonal Labyrinth Implantable Antenna for Biotelemetry Applications

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ABSTRACT

The health care industry is continuously revolutionizing and advancing towards developing more efficient system suitable for physical body . Today implantable devices became a more interesting topic in health care services which primarily started with the pacemakers. Since then it's continuously evolving thanks to its non-invasive nature, instant monitoring and diagnosis, and periodic simulation. during this work, a completely unique Hexagonal Labyrinth implantable antenna has been proposed for medical applications to be operated in medical band. The biocompatible polyamide substrate (r = 4.3 and tan□ = 0.004) with 0.05 mm thickness has been used as both substrate and superstrate. The proposed antenna is featured with excellent miniaturization with the size of 6× 6×0.1 mm3 by employing circular maze shaped structure in radiator. The performance of the proposed antenna was evaluated by placing during a realistic human model using HFSS. The simulated results for the gain and reflection coefficient exhibited reasonable agreement. the security of the antenna was verified consistent with the IEEE SAR regulation. The analysis of the link budget revealed that the antenna can perform reliable wireless communication.

INTRODUCTION

The evolution in our world is running very fast because of the rapid development of scientific research methods and tools. The base for such evolution is the human needs in different life styles including health and entertainment etc. There is no doubt in that the health has the priority over most other needs because it relates directly to human life. It attracts a lot of research funding and has a very active market. Consequently, researchers in both academic and industrial sectors are very interested in designing and developing health tools and medical devices to be more reliable, safer and more comfortable.

Some of the medical devices can be implanted inside the human body for different purposes, such as monitoring, drug delivery or specific stimulation. The first successful implanted device inside the human body was a pacemaker in 1960. This step opened a hot topic for researchers to investigate and develop many more implantable devices. Medical devices designed for implantation purposes require several considerations from different scopes such as medical, biology, electrical engineering or mechanical engineering requirements. Electrical engineering plays a significant role in developing such devices in terms of various aspects including powering and communication systems. Since these aspects are very essential for any implantable device, researchers spend great efforts to exploit the optimum solution such that the devices can work reliably and safely.

Due the electromagnetic properties of the human body, implantable systems face more challenges and difficulties in designing antennas than conventional wireless

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communication systems. Unlike free space, human body tissues are lossy and have relative permittivity. Therefore, the antenna requires the compliance with many conditions, standards and requirements such as: size, radiation performance, frequency of operation and SAR.

RELATED WORK

Mohammed Z. Azad et al proposed a miniature implanted Hilbert inverted-F antenna design at the 1.575 GHz global positioning system (GPS) frequency, which may be wont to track thesituation of its user, e.g., the elderly with declining brain (Alzheimer's disease).
BehailuKibret et al propose to use the physical body itself as an antenna by feeding an RF current into the tissues. especially , this paper studies the scenario when the RF current is fed by a small toriodal inductor that's implanted and clamped round the tissues within the ankle. The frequency range of 1-70 MHz is taken into account , which incorporates the resonance frequency of the physical body .
Zhu Duan et al proposed a completely unique differentially fed dual-band implantable antenna for the primary time for a totally implantable neuro-microsystem. The antenna operates at two center frequencies of 433.9 MHz and 542.4 MHz, which are on the brink of the 402-405 MHz medical implant communication services (MICS) band, to support sub-GHz wideband communication for high-data rate implantable neural recording application. the dimensions of the antenna is 480.06 mm 3 (27 mm × 14 mm × 1.27 mm). The simulated and measured bandwidths are 7.3% and 7.9% at the primary resonant frequency, 5.4% and 6.4% at the second resonant frequency.
AsiminaKiourti; et al study the planning and radiation performance of novel miniature antennas for integration in head-implanted medical devices operating within the MICS (402.0-405.0 MHz) and ISM (433.1-434.8, 868.0-868.6 and 902.8-928.0 MHz) bands.
Chin-Lung Yang et al proposes a completely unique antenna for dental implants. The proposed antenna are often attached to minimally invasive biomedical devices to watch health conditions. supported a mixture of Archimedean spirals and a Hilbert-based curve, this 3D folded antenna was embedded on a ceramic denture (ZrO 2), and operates within the medical radio (MedRadio) band.
Farooq Faisal et al developed a miniaturized novel-shape dual-band implantable antenna operating within the industrial, scientific, and medical bands (902-928 MHz and a couple of .4-2.4835 GHz) for battery-powered implants.
Matthew K. Magill et al presented a compact printed meandered folded dipole with a volume of 114 mm 3 suitable for implantation during a range of various body tissue types with diverse electrical properties for operation within the 2.36-2.4 GHz MBAN and a couple of .4-GHz ISM bands
Muhammad Zada et al presents a miniaturized triple band implantable antenna system for multiple biotelemetry applications, which operates at the economic , scientific, and medical (ISM) band (902-928 MHz and 2400-2483.5 MHz) and therefore the midfield band (1824-1980 MHz).
Wen Lei; et al proposed a ground radiation antenna with circularly polarized (CP) properties for biomedical applications. A square ground with alittle clearance is implemented within the proposed antenna. Reactive components are included to

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understand the impedance matching, also as those requirements for the generation of CP waves.

P. Soontornpipit et al design a microstrippatch antenna for communication with medical implants within the 402-405-MHz Medical Implant Communications Services band. Microstrip antenna design parameters are evaluated using the finite-difference time-domain method, and are compared to measured results.

S. AbdollahMirbozorgi et al present a completely unique , fully-integrated, low-power full-duplex transceiver (FDT) to support high-density and bidirectional neural interfacing applications (high-channel count stimulating and recording) with asymmetric data rates

PROPOSED ANTENNA

In this work, a novel Hexagonal Labyrinth implantable antenna has been proposed for medical applications to be operated in medical band. The biocompatible polyamide substrate (r = 4.3 and tan□ = 0.004) with 0.05 mm thickness has been used as both substrate and superstrate.

The proposed antenna is featured with very good miniaturization with the dimensions of 7 × 7×0.1 mm3 by employing circular maze shaped structure in radiator.The dimensions and geometry of the proposed antenna are illustrated in Fig. 2. The radiating patch are shown in Fig. , respectively. The meandered structure in the patch are responsible for the antenna miniaturization and BW enhancement.

A coaxial feed with a diameter of 0.3 mm, located on the right side of the ground plane, is used to excite the antenna. Isometric and side views of the designed antenna are presented in Fig, respectively. The radiating patch is employed on a FR4 (r = 2.9 and tan□ = 0.0025) material with a thickness of 0.05 mm, which serves as a substrate and superstrate The impedance BW is tuned to cover the AR BW (3 dB) by adjusting a relevant parameter of the design. The dimensions of the proposed antenna are 6*6*0.05 = 1.8 mm3; thus, its volume is smaller than those of the antennas reported in the literature. The proposed antenna is optimized using a slotting technique in the patch and the ground plane to achieve optimum radiation performance, significant CP behavior, and an impedance-matched resonance with the miniaturized structure in the respective operating bands.

The proposed antenna is initially designed and analyzed in the center of a homogeneous skin phantom (HSP) of dimensions 100 mm*100 mm * 100 mm, as shown in Fig. The permittivity and conductivity values assigned to the skin phantom are r = 41.33, 38 and 0.872 S/m, and 1.45 S/m at frequencies of 928 MHz and 2.45 GHz, respectively. The antenna is set at the center point of the skin phantom and the separation distance from the air to the antenna in this case is 50 mm. Similarly, the distance between each edge of the antenna and radiation boundaries is greater than 3/4 at 928 MHz.

SIMULATION RESULTS

CONCLUSION

A miniaturized dual-band CP antenna was designed and experimentally validated for WCE applications. The optimum performance and miniaturization of the antenna were achieved via the introduction of slots in the radiating patch. The surface current distribution was visualized to confirm the circular polarization of the antenna. The impedance BW and AR BW of the antenna covered the desired frequency bands. The performance of the proposed antenna was evaluated by placing in a realistic human model using HFSS. The simulated results for the gain and reflection coefficient exhibited reasonable agreement. The safety of the antenna was verified according to the IEEE SAR regulation. The analysis of the link budget revealed that the antenna can perform reliable wireless communication.

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