

Design and Performance Measurement of a Miniaturized Implantable PIFA Antenna for Biomedical Applications

Nasim Al Islam and Farhadur Arifin

Abstract—An implantable PIFA (Planar Inverted F Antenna) antenna for biomedical applications is proposed in this study. The main notability of this design refers to its subtle dimension, flexibility and subordinate thickness that makes it perfectly suitable for implementing inside human or animal tissues for Wireless Body Area Networks (WBAN). The antenna is aimed to operate in the Industrial, Scientific and Medical (ISM) band (2.4–2.4835 GHz). The thickness of this antenna is only 0.735 mm, which implies that this antenna is suitable to perform under bent conditions. The antenna offers a compact design with a dimension of 9.48 mm × 7.8 mm × 0.735 mm (54.348 mm³). Copper and Rogers R03010 are chosen as the patch material and substrate material accordingly. The antenna is encapsulated inside biocompatible material Rogers R03010 for safety concern inside skin or muscle tissues. Several types of analysis and performance measurement of this antenna have been done by using CST Microwave studio in both planar and bent conditions by maintaining the electrical properties of human skin tissues. Specific Absorption Rate (SAR) and thermal loss are evaluated to comply with the antenna safety issues. For proving biocompatibility and versatility of this antenna, performance analysis by changing different patch materials and substrate materials have been done after putting the antenna inside different human tissue models. Finally, the antenna is fabricated on a FR4 substrate and its performance is measured using Agilent Technologies E5071C Network Analyzer.

Keywords— PIFA; ISM Band; Implantable Antenna; Human Body Model;

I. INTRODUCTION

Implantable devices have been developed enough to enhance patients nursing quality and to affirm patients safety now a days. In this modern era, it is impossible for most patients to afford long-term hospital stays due to financial confinements, work and other reasons, even though their health status must be monitored in a real-time or short periodic time mode. In order to keep pace with the technological advancement in healthcare sector, remote diagnostic systems

can play emergent role by coordinating with wireless communication technology. Thus, implantable antenna is becoming a vital part of portable medicinal devices focusing on real-time monitoring [1].

Miniaturization is a key challenge to be proficient for implantable medical devices in the human body. For designing implantable antenna, variation of electromagnetic properties in the vicinity of human tissue is to be considered. These properties alter the antenna characteristics such as resonance frequency and impedance matching [2-3]. It is also necessary to encapsulate the antenna with biocompatible material to ensure the protection of human tissue from radiation [4].

Wireless Body Area Network (WBAN) provides connectivity between different nodes of body with the help of sensors or antenna to a remote health monitoring system through wireless communication channel. WBANs supporting healthcare applications are in early development stage but offer important commitments at monitoring, diagnostic and therapeutic levels. With the use of RF technology, data recorded by the implanted antenna can be transmitted wirelessly to the receiving end which results in an effective healthcare monitoring system. However, in this structure, the data exchange capability is limited and the range between internal and external system is confined. Also in practical cases, for establishing communication of WBAN via implantable antenna is always a tough task due to the miniaturized size of biomedical devices and noisy surrounding environment [5]. This is where the main motive of this research work comes in.

For the communication of biomedical antenna, several bands are mostly considered like Wireless Medical Telemetry Service (WMTS), Medical Implant Communication Service (MICS) and Industrial, Scientific and Medical (ISM). Wide variety of frequencies offered by these bands facilitate the significant advances in wireless medical technologies. ISM band has been chosen for our work due to its flexibility to work with gigahertz range frequency bandwidth, which allows to reduce the wavelength [6-7].

With the revolutionary development in the field of biomedical implants like cardiac defibrillators [8-10], cochlear implants and brain neurostimulators [11] etc. can be easily manipulated by using RF technology. Recent researches in the design of implantable antennas cover several factors like size

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Design Of Pifa Antenna For Medical Applications

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Design Of Pifa Antenna For Medical Applications:

Antennas for Industrial and Medical Applications with Optimization Techniques for Wireless Communication S.

Kannadhasan,R. Nagarajan,2024-12-30 The text begins by covering the fundamental concepts and new advances in the field of antenna theory antenna hardware and propagation It further explains the designing of metamaterials microstrip patch antennas for medical applications photonic crystals of millimeter wave signals for 5G communications dual band miniaturized circular antennas for wireless networks and ultra thin compact flexible antennas for wearable applications This book Presents the design and development of S shaped and T shaped microstrip path antennas for industrial applications Highlights the use of W shaped and metamaterials microstrip patch antennas for medical applications Covers photonic crystals of millimeter wave signals for 5G communications Showcases the importance of compact and wideband slot antenna for wireless communications Illustrates the design of an ultra thin compact flexible antenna for wearable applications It is primarily written for senior undergraduates graduate students and academic researchers in the fields of electrical engineering electronics and communications engineering antenna design and microwave engineering

Design and Optimization of Wearable, Implantable, and Edible Antennas Kavitha, K.,Sabapathy, Thennarasan,Rajeshkumar, V.,2024-08-16 The demand for integration of smart devices into our daily lives has led to a pressing challenge the effective design and optimization of antennas for wearable and implantable applications As our reliance on interconnected devices grows so does the need for antennas that transcend their conventional roles and adapt to the diverse dynamic needs of users Addressing these challenges is vital considering the unique demands imposed by this technology ranging from size constraints to energy efficiency biocompatibility and signal integrity Design and Optimization of Wearable Implantable and Edible Antennas is an innovative work that confronts these challenges head on In this exploration the book sheds light on the evolving landscape where electromagnetic research intersects with the demands of human life As antennas seamlessly weave into attire revolutionize healthcare through implants and even find their place in edibles this book serves as a guide for academic scholars researchers engineers and students navigating the intricate terrain of antenna engineering

Biomedical Antenna Technology Akinola Segun Ayokunle,Indrasen Singh,Vivek Rajpoot,Ajay Kumar,2025-11-11 This book is a compelling and comprehensive guide to the dynamic world of antennas tailored for healthcare With its practical case studies forward looking perspectives and a keen focus on the potential of 6G wireless communications this book serves as an indispensable resource driving the advancement of wireless technologies in the realm of biomedical applications ultimately transforming the future of healthcare The authors bridge the gap between complex scientific concepts and practical applications making this book accessible to healthcare professionals researchers students and anyone interested in understanding how antennas play a pivotal role in transforming the landscape of healthcare technologies The book delves into the principles of different types of antennas such as microstrip patch antennas dipole antennas helical antennas and

planar inverted F antennas explaining how each one serves a specific purpose in healthcare Offers a comprehensive exploration of antennas designed explicitly for healthcare applications Covers various types of antennas including principles design optimization and practical case studies Written in non specialists terms making content easily accessible to a broad audience

Antenna Design for Narrowband IoT: Design, Analysis, and Applications Pattanaik, Balachandra, Saravanan, M., Saravanakumar, U., T R, Ganesh Babu, 2022-03-11 In internet of things IoT applications wireless connectivity is a key factor particularly those that need to be in transition or where wired communication is not effective or practicable For top notch connectivity of the Narrowband IoT NB IoT standard the 900MHz frequency is generally used by most of the vendors The radiation quality not only depends on the antenna geometry but on immediate surroundings Additionally the IoT product itself and the user of the product can strongly affect the resulting radiation pattern and other characteristics of the antenna On the other hand a suitable antenna should also have high efficiency and adequate bandwidth covering the desired frequency range To take these effects into consideration the whole IoT product must be included in the antenna simulations

Antenna Design for Narrowband IoT Design Analysis and Applications provides the antenna design concept for narrowband internet of things applications performs a detailed analysis of the antenna and discusses the various antenna design concepts and structures Covering a range of topics such as antenna design and antenna measurement systems this book is ideal for industry professionals research scholars academicians professors and students

Manufacturing Engineering and Materials Science Abhineet Saini, B. S. Pabla, Chander Prakash, Gurmohan Singh, Alokesh Pramanik, 2023-11-15 This book which is part of a two volume handbook set gives a comprehensive description of recent developments in materials science and manufacturing technology aiming primarily at its applications in biomedical science advanced engineering materials conventional non conventional manufacturing techniques sustainable engineering design and related domains

Manufacturing Engineering and Materials Science Tools and Applications provides state of the art research conducted in the fields of technological advancements in surface engineering tribology additive manufacturing precision manufacturing electromechanical systems and computer assisted design and manufacturing The book captures emerging areas of materials science and advanced manufacturing engineering and presents the most recent trends in research for emerging researchers field engineers and academic professionals

Novel Wearable Antennas for Communication and Medical Systems Albert Sabban, 2017-09-29 Wearable antennas are meant to be incorporated as part of clothing or placed close to the body Wearable antennas can be used in countless communication applications including tracking and navigation medical applications imaging and detection RFID mobile computing and public safety The book Novel Wearable Antennas for Communication and Medical Systems discusses the challenges and technology to develop compact efficient wearable antennas The book begins by presenting elementary communication electromagnetics and antenna topics needed for engineers and students that do not have a background in design principles and features of antennas printed antennas wearable antennas and compact antennas

for communication and medical applications Throughout the book each chapter also covers sufficient mathematical details physical details and explanations to enable the reader to follow and understand the topics presented New topics and design methods in the area of wearable antennas metamaterial antennas active printed antennas and fractal antennas for communication and medical systems are presented and discussed throughout the book The book presents computed and measured results in the vicinity of the human body The book also covers topics such as RF measurement techniques measurement setups and design considerations The antennas developed and analyzed in this book were designed and optimized by using 3D full wave electromagnetics software

Wearable Systems and Antennas Technologies for 5G, IOT and Medical Systems Albert Sabban, 2020-12-08 Due to progress in the development of communication systems it is now possible to develop low cost wearable communication systems A wearable antenna is meant to be a part of the clothing or close to the body and used for communication purposes which include tracking and navigation mobile computing and public safety Examples include smartwatches with integrated Bluetooth antennas glasses such as Google Glass with Wi Fi and GPS antennas GoPro action cameras with Wi Fi and Bluetooth antennas etc They are increasingly common in consumer electronics and for healthcare and medical applications However the development of compact efficient wearable antennas is one of the major challenges in the development of wearable communication and medical systems Technologies such as printed compact antennas and miniaturization techniques have been developed to create efficient small wearable antennas which are the main objective of this book Each chapter covers enough mathematical detail and explanations to enable electrical electromagnetic and biomedical engineers and students and scientists from all areas to follow and understand the topics presented New topics and design methods are presented for the first time in the area of wearable antennas metamaterial antennas and fractal antennas The book covers wearable antennas RF measurements techniques and measured results in the vicinity of the human body setups and design considerations The wearable antennas and devices presented in this book were analyzed by using HFSS and ADS 3D full wave electromagnetics software Explores wearable medical systems and antennas Explains the design and development of wearable communication systems Explores wearable reconfigurable antennas for communication and medical applications Discusses new types of metamaterial antennas and artificial magnetic conductors AMC Reviews textile antennas Dr Albert Sabban holds a PhD in Electrical Engineering from the University of Colorado at Boulder USA 1991 and an MBA from the Faculty of Management Haifa University Israel 2005 He is currently a Senior Lecturer and researcher at the Department of Electrical and Electronic Engineering at Kinneret and Ort Braude Engineering Colleges

Handbook of Biomedical Telemetry Konstantina S. Nikita, 2014-07-28 A must have compendium on biomedical telemetry for all biomedical professional engineers researchers and graduate students in the field Handbook of Biomedical Telemetry describes the main components of a typical biomedical telemetry system as well as its technical challenges Written by a diverse group of experts in the field it is filled with overviews highly detailed scientific analyses and

example applications of biomedical telemetry The book also addresses technologies for biomedical sensing and design of biomedical telemetry devices with special emphasis on powering integration issues and materials for biomedical telemetry applications Handbook of Biomedical Telemetry Describes the main components of a typical biomedical telemetry system along with the technical challenges Discusses issues of spectrum regulations standards and interoperability while major technical challenges related to advanced materials miniaturization and biocompatibility issues are also included Covers body area electromagnetics inductive coupling antennas for biomedical telemetry intra body communications non RF communication links for biomedical telemetry optical biotelemetry as well as safety issues human phantoms and exposure assessment to high frequency biotelemetry fields Presents biosensor network topologies and standards context aware sensing and multi sensor fusion security and privacy issues in biomedical telemetry and the connection between biomedical telemetry and telemedicine Introduces clinical applications of Body Sensor Networks BSNs in addition to selected examples of wearable implantable ingestible devices stimulator and integrated mobile healthcare system paradigms for monitoring and therapeutic intervention Covering biomedical telemetry devices biosensor network topologies and standards clinical applications wearable and implantable devices and the effects on the mobile healthcare system this compendium is a must have for professional engineers researchers and graduate students

Advanced Radio Frequency Antennas for Modern Communication and Medical Systems Albert Sabban, 2020-09-23 The main objective of this book is to present novel radio frequency RF antennas for 5G IOT and medical applications The book is divided into four sections that present the main topics of radio frequency antennas The rapid growth in development of cellular wireless communication systems over the last twenty years has resulted in most of world population owning smartphones smart watches I pads and other RF communication devices Efficient compact wideband antennas are crucial in RF communication devices This book presents information on planar antennas cavity antennas Vivaldi antennas phased arrays MIMO antennas beamforming phased array reconfigurable Fabry Perot cavity antennas and time modulated linear array

Array and Wearable Antennas Puran Gour, Nagendra Singh, Rajesh Kumar Nema, Ravi Shankar Mishra, Ashish Kumar Srivastava, 2024-03-20 The text highlights the designing of efficient wearable and textile antennas for medical and wireless applications It further discusses antenna design for the Internet of Things biomedical and 5G applications The book presents machine learning and deep learning techniques for antenna design and analysis It also covers radio frequency micro electromechanical systems and nanoelectromechanical systems devices for smart antenna design This book Explores wearable reconfigurable antennas for wireless communication and provide the latest technique in term of its structure defective ground plane and fractal design Focuses on current and future technologies related to antenna design and channel characterization for different communication links and applications Discusses machine learning techniques for antenna design and analysis Demonstrates how nano patch antenna resonates at multiple frequencies by varying the chemical potential Covers the latest antenna technology for microwave

sensors and for fiber optical sensor communications It is primarily for senior undergraduate graduate students and academic researchers in the fields of electrical engineering electronics and communications engineering *Wearable and Neuronic Antennas for Medical and Wireless Applications* Arun Kumar,Manoj Gupta,Mahmoud A. Albreem,Dac-Binh Ha,Er. Mohit Kumar Sharma,2022-04-29 WEARABLE AND NEURONIC ANTENNAS FOR MEDICAL AND WIRELESS APPLICATIONS This new volume in this exciting new series written and edited by a group of international experts in the field covers the latest advances and challenges in wearable and neuronic antennas for medical and wireless applications Antenna development and engineering is changing at a rapid pace and it is incredibly important that engineers scientists and students in the field have a valuable reference work to consult Students are able to use this book as a learning tool and professors and industrial short courses are able to use it as a textbook Covering all of the advances and developments of wearable and neuronic antennas for medical and wireless applications this outstanding new volume offers information not available anywhere else in any other format Covering new research and development of antenna designs never seen before this volume written and edited by a team of experts in the field breaks new ground offering new solutions to engineering and scientific problems to experts in the field while providing the full theoretical and conceptual background for the practical applications Whether for the veteran engineer or scientist the student or a manager or other technician working in the field this volume is a must have for any library *Antennas and Wireless Power Transfer Methods for Biomedical Applications* Yongxin Guo,Yuan Feng,Changrong Liu,2024-03-14 Antennas and Wireless Power Transfer Methods for Biomedical Applications Join the cutting edge of biomedical technology with this essential reference The role of wireless communications in biomedical technology is a significant one Wireless and antenna driven communication between telemetry components now forms the basis of cardiac pacemakers and defibrillators cochlear implants glucose readers and more As wireless technology continues to advance and miniaturization progresses it s more essential than ever that biomedical research and development incorporate the latest technology Antennas and Wireless Power Transfer Methods for Biomedical Applications provides a comprehensive introduction to wireless technology and its incorporation into the biomedical field Beginning with an introduction to recent developments in antenna and wireless technology it analyzes the major wireless systems currently available and their biomedical applications actual and potential The result is an essential guide to technologies that have already improved patient outcomes and increased life expectancies worldwide Readers will also find Authored by internationally renowned researchers of wireless technologies Detailed analysis of CP implantable antennas wearable antennas near field wireless power and more Up to 100 figures that supplement the text Antennas and Wireless Power Transfer Methods for Biomedical Applications is a valuable introduction for biomedical researchers and biomedical engineers as well as for research and development professionals in the medical device industry 4th International Conference for Innovation in Biomedical Engineering and Life Sciences Fatimah Ibrahim,Juliana Usman,Mohd Yazed Ahmad,Norhamizan Hamzah,2024-03-21 This

book reports on engineering methods and technologies for biomedical applications It covers sensors and devices for biological and medical purposes along with their fabrication and testing and advances in engineering technologies such as autonomous systems which can support life science and healthcare in the era of industry 4.0 Based on the proceedings of the 4th International Conference for Innovation in Biomedical Engineering and Life Sciences ICIBEL 2022 held on December 10-13, 2022 in Kuala Lumpur, Malaysia, this book provides researchers and professionals with a timely snapshot of current issues and challenges in the broad field of biomedical engineering. It is aimed at inspiring future research and fostering interdisciplinary and international collaborations in this field and relating ones.

Internet of Things Enabled Antennas for Biomedical Devices and Systems Praveen K. Malik, Prasad N. Shastry, 2023-04-30 The book consists of the latest research in biomedical and communication integration. It discusses the fabrication and testing outcomes of the Internet of Things enabled biomedical applications. The book focuses on recent advances in the field of planar antenna design and their applications in space communication, mobile communication, wireless communication, and wearable applications. Planar antennas are also used in medical applications in microwave imaging, medical implants, hyperthermia treatments, and wireless wellness monitoring. This book presents planar antenna design concepts, methods, and techniques to enhance the performance parameters and applications for IoT and device-to-device communication. It provides the latest techniques used for the design of antennas in terms of their structures, defected ground, MIMO, and fractal design. This book also addresses the specific steps to resolve issues in designing antennas and how to design conformal and miniaturized antenna structures for various applications.

Printed Antennas Praveen Kumar Malik, Arshi Naim, Ramendra Singh, 2022-12-15 This collection covers different printed microstrip antenna designs from rectangular to circular, broadband, dual band, and millimeter wave microstrip antennas to microstrip arrays. It further presents a new analysis of the rectangular and circular microstrip antenna efficiency and surface wave phenomena. The book covers the latest advances and applications of microstrip antennas. Discusses methods and techniques used for the enhancement of the performance parameters of the microstrip antenna. Presents low power wide area network (LPWAN) proximity coupled antenna for Internet of Things applications. Highlights a new analysis of rectangular and circular microstrip antenna efficiency and surface wave phenomena. Showcases implantable antennas, H-shaped antennas, and wideband implantable antennas for biomedical applications. Printed Antennas discusses the latest advances such as the Internet of Things for antenna applications, device-to-device communication, satellite communication, and wearable textile antenna in the field of communication. It further presents methods and techniques used for the enhancement of the performance parameters of the microstrip antenna and covers the design of conformal and miniaturized antenna structures for various applications. It will serve as an ideal reference text for senior undergraduates, graduate students, and researchers in fields including electrical engineering, electronics, and communications engineering, and computer engineering.

Bioelectronics and Medical Devices Garima Srivastava, Manju Khari, 2021-12-15 This new volume

provides an abundance of information on new biomedical applications being used today The book covers a wide range of concepts and technologies discussing such modern technological methods as the Internet of Things e pills biomedical sensors support vector machines wireless devices image and signal processing in e health and machine learning It also includes a discussion on software implementation for the devices used in biomedical applications The different types of antennas including antennas using RF energy harvesting for biomedical applications are covered as well **Wideband RF**

Technologies and Antennas in Microwave Frequencies Dr. Albert Sabban, 2016-06-10 Presents wideband RF technologies and antennas in the microwave band and millimeter wave band This book provides an up to date introduction to the technologies design and test procedures of RF components and systems at microwave frequencies The book begins with a review of the elementary electromagnetics and antenna topics needed for students and engineers with no basic background in electromagnetic and antenna theory These introductory chapters will allow readers to study and understand the basic design principles and features of RF and communication systems for communications and medical applications After this introduction the author examines MIC MMIC MEMS and LTCC technologies The text will also present information on meta materials design of microwave and mm wave systems along with a look at microwave and mm wave receivers transmitters and antennas Discusses printed antennas for wireless communication systems and wearable antennas for communications and medical applications Presents design considerations with both computed and measured results of RF communication modules and CAD tools Includes end of chapter problems and exercises **Wideband RF Technologies and Antennas in Microwave Frequencies** is designed to help electrical engineers and undergraduate students to understand basic communication and RF systems definition electromagnetic and antennas theory and fundamentals with minimum integral and differential equations Albert Sabban PhD is a Senior Researcher and Lecturer at Ort Braude College Karmiel Israel Dr Sabban was RF and antenna specialist at communication and Biomedical Hi tech Companies He designed wearable compact antennas to medical systems From 1976 to 2007 Dr Albert Sabban worked as a senior R D scientist and project leader in RAFAEL **Intelligent Data Communication Technologies and Internet of Things** Jude Hemanth, Robert Bestak, Joy

Long-Zong Chen, 2021-02-12 This book solicits the innovative research ideas and solutions for almost all the intelligent data intensive theories and application domains The proliferation of various mobile and wireless communication networks has paved way to foster a high demand for intelligent data processing and communication technologies The potential of data in wireless mobile networks is enormous and it constitutes to improve the communication capabilities profoundly As the networking and communication applications are becoming more intensive the management of data resources and its flow between various storage and computing resources are posing significant research challenges to both ICT and data science community The general scope of this book covers the design architecture modeling software infrastructure and applications of intelligent communication architectures and systems for big data or data intensive applications In particular this book

reports the novel and recent research works on big data mobile and wireless networks artificial intelligence machine learning social network mining intelligent computing technologies image analysis robotics and autonomous systems data security and privacy

Low-Visibility Antennas for Communication Systems Albert Sabban, 2015-09-18 Low visibility antennas have many attractive features such as being low profile flexible lightweight small volume and low cost *Low Visibility Antennas for Communication Systems* provides explicit guidelines for the development of these antennas Offering valuable insight into emerging antenna technologies the book Introduces the fundamental t

Smart Antennas Praveen Kumar Malik, Joan Lu, B T P Madhav, Geeta Kalkhambkar, Swetha Amit, 2022-02-03 This book presents the latest techniques for the design of antenna focusing specifically on the microstrip antenna The authors discuss antenna structure defected ground MIMO and fractal design The book provides the design of microstrip antenna in terms of latest applications and uses in areas like IoT and device to device communication The book also provides the current methods and techniques used for the enhancement of the performance parameters of the microstrip antenna Chapters enhance the knowledge and skills of students and researchers in the latest in the communications world like IoT D2D satellite wearable devices etc The authors discuss applications such as microwave imaging medical implants hyperthermia treatments and wireless wellness monitoring and how a decrease in size of antenna help facilitate application potential Provides the latest techniques used for the design of antenna in terms of its structure defected ground MIMO and fractal design Outlines steps to resolve issues with designing antenna including the latest design and design parameters for microstrip antenna Presents the design of conformal and miniaturized antenna structures for various applications

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