e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 1, April 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

6381 907 438 6381 907 438 ijmrset@gmail.com www.ijmrset.com

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

Miniaturized Spiral Antenna with Multiband Capability for Implantable Biotelemetry Devices

G. Nithya, M. Mohanapriyaa, G. Vinoth

Assistant Professor, Department of Electrical Science, Adithya Institute of Technology, Coimbatore, Tamil Nadu, India

ABSTRACT: Antenna-enabled biotelemetry is a key component in Implantable medical devices for wireless communication with the external environment. In this communication, we present a compact spiral-shaped implantable antenna with multiband characteristics for biotelemetry applications. The proposed antenna has the following operational bands: industrial, scientific, and medical (ISM) (902-928 MHz), (2400–2483.5 MHz). This antenna consists of a radiating element, substrate, and ground plane. In order to achieve a more-compact size for the implantable antenna meandered structure is used. Rogers 6010 (εr = 10.2, tan δ = 0.0025) is used as a dielectric material for the substrate layers. A 50 Ω coaxial feed having a radius of 0.3 mm is used for the excitation of the antenna. In this design, the surface area and small size of the antenna are optimized through meandered line slotting technique so that the antenna has the smallest possible size and good radiation performance. The antenna systems were designed, simulated, and analysed using the CST studio 2010.

KEYWORDS: Radio frequency, Medical applications, Wireless capabilities, Implantable antennas, Wireless communication, Healthcare costs, Biomedical telemetry, Wireless healthcare, Patch designs.

I. INTRODUCTION

Radio frequency/microwaves technology plays a significant role in modern medicine, aiding in disease prevention, diagnosis, and therapy through various applications like imaging and cancer treatment. Wireless capabilities enhance patient care and comfort, reducing the invasiveness of medical instruments and enabling remote monitoring of implantable devices. Implantable medical devices, such as pacemakers and glucose monitors, utilize wireless communication for monitoring and treatment within the body.

Economically, wireless implantable devices reduce healthcare costs by facilitating disease prevention and enabling home-based care. However, designing implantable antennas poses challenges due to size restrictions and the need for robust communication links. This multidisciplinary thesis focuses on analysing, designing, and characterizing implantable antennas for data telemetry, addressing issues like biocompatibility and patient safety.

The advancement of wireless healthcare relies on overcoming limitations such as low data rates and resolution in lower frequency bands, leading to a preference for higher ISM bands in certain wireless medical implants. Patch designs offer flexibility in antenna design, and recent research has proposed various implantable antennas for telemetry applications. For instance, an implantable antenna designed for wireless power transfer at the 900MHz ISM band demonstrates promising characteristics, including a small volume and high gain.

Ultimately, wireless healthcare holds the promise of improving monitoring accuracy and patient comfort while offering valuable diagnostic and treatment information for better healthcare outcomes.

II. RELATED WORK

In paper [1], Muhammad Zada and Hyoungsuk Yoo developed a miniaturized triple band implantable antenna system operating at ISM and midfield bands for biotelemetry applications. It includes two implantable devices, offering deep tissue and skin implantation options, with a record-small size of 21 mm. In paper [2], The communication presents dual-band antenna systems designed for skin implantation, operating at 915 and 2450 MHz ISM bands, exhibiting efficiency and compactness. System A, suitable for surface-based studies, occupies a volume of 344 cubic mm, while System B, intended for depth-based implantation, has a volume of 406 mm3. Both systems integrate antennas,

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

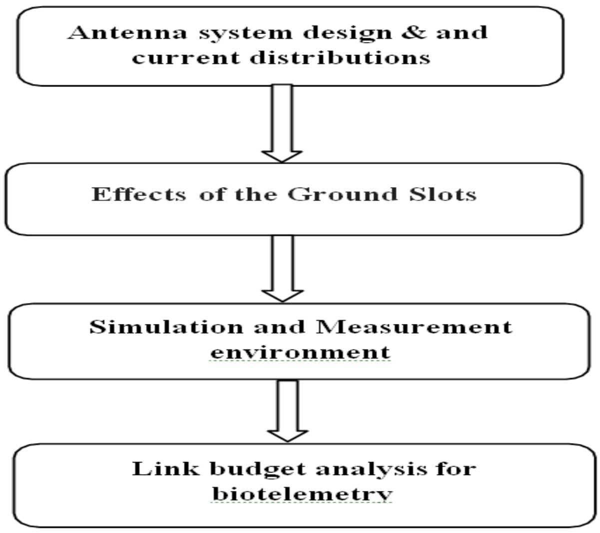
electronics, and batteries on a Rogers 6010 substrate, featuring small volumes and satisfactory peak gain values. The paper [3] describes the design of a miniaturized dual-band implantable antenna for wireless communications. Operating at MICS (402–405 MHz) and ISM (2.40–2.48 GHz) bands, the spiral dipole antenna is designed on a Rogers 3010 substrate with a Parylene-C insulating layer. Incorporating offset feeding and inductive loop loading achieves dual-band performance, improving impedance matching for both resonances.

In paper [4], they introduces a differentially fed dual-band planar antenna for medical implant communication, operating at MICS (402–405 MHz) and ISM (2400–2480 MHz) bands. The antenna achieves a compact design with a volume of 642.62 cubic mm. Symmetrical features like meandered strips, shorting pins, notches, and slots facilitate dual-band operation and improve resonance tuning for both bands. From paper [5], Two skin-implantable biotelemetry devices feature a planar inverted-F antenna (PIFA) operating across five bands, including MICS and ISM. Link budget analysis guided algorithm configuration for optimal device operation. Simulated in various environments, the devices, with volumes of 617 and 510 cubic.mm respectively, integrate storage batteries, controlling electronics, and bio-sensors. The compact antenna, employs a serpentine radiating patch and a ground plane with a "hook-shaped" slot for miniaturization.

III. PROPOSED ALGORITHM

The proposed system discusses the pivotal role of antennas in achieving robust communication links and miniaturization in implantable devices with telemetry capabilities. Recent advancements in spectrum allocation have spurred research on optimized implantable antennas. The thesis aims to provide design guidelines for such antennas, evaluating existing solutions and formulating efficient design strategies. Various electromagnetic characteristics and challenges are discussed, including miniaturization techniques and the need for compliance with safety regulations. The state of the art in implantable antennas is reviewed, categorized into groups based on design considerations and integration with packaging. Miniaturization techniques are explored, highlighting the challenges posed by the dimensions of traditional antennas in low-frequency bands allocated for medical implants. Patch designs are identified as a key solution for achieving miniaturization while maintaining electromagnetic performance. The design and simulation of antenna systems are conducted using advanced software tools, considering realistic environments such as implantation in anatomical models. Measurements are performed in saline solutions and human head phantoms to evaluate antenna performance. Overall, the paragraph provides a comprehensive overview of the design, simulation, and measurement aspects involved in developing implantable antenna systems for biotelemetry applications.

IV. BLOCK DIAGRAM



International Journal Of Multidisciplinary Research In Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

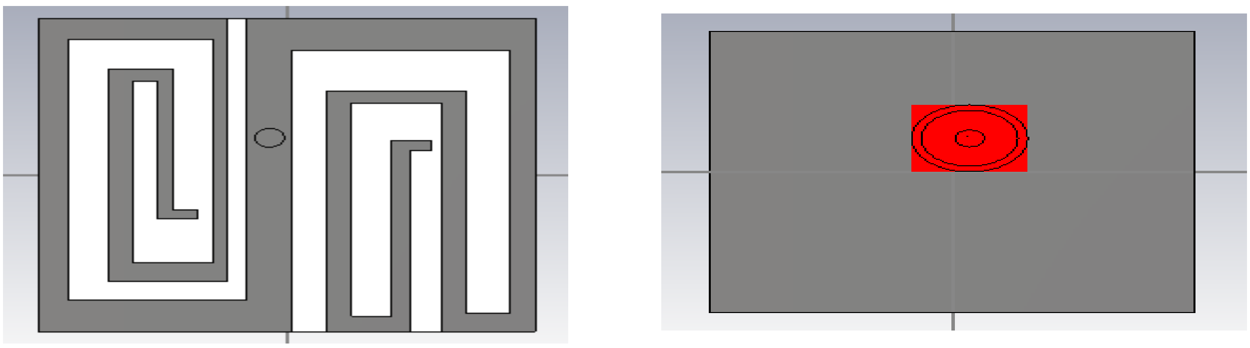
V. PROJECT IMPLEMENTATION

This proposed antenna consists of a superstrate, radiating element, substrate, and ground plane. The ground plane has a length of 10mm and the substrate has same length as ground plane**.** Longer effective current-flow paths excited on the radiating patch can reduce the resonance frequency, and achieve a more-compact size for the implantable antenna. For this purpose, meandered structure is used here. Substrate material should be inert to body and should reduce coupling with body. This designed antenna is slot less and a via less ground plane. PEC is used as a conductive material. Rogers 6010 (εr = 10.2, tan δ = 0.0023) is used as a dielectric material for both the superstrate and substrate layers. The thickness of the substrate is 0.635mm. A 50 Ω coaxial feed having a radius of 0.3 mm is used for the excitation of the antenna. In this design, the surface area and small size of the antenna are optimized through meandered line slotting technique so that the antenna has the smallest possible size and good radiation performance. The antenna systems were designed, simulated, and analyzed using the CST studio 2010.

IMPLEMENTATION ASPECTS:

To improve gain:
We can reduce the 90 degree bends as much as possible.
Without using vias.
To get multiband:
Resonators with different radiating stubs and slots.
To improve bandwidth
Defective Ground Structure (DGS).
Electro-magnetic Band Gap structure (EBG).

But if the DGS is used there will be a back-radiation, it will harm the human tissue. SAR value will increase. For implantable antenna 1.6 W/kg is the SAR limits for 1g of tissue. By increasing the stub width, the antenna shift at lower frequency and also by truncating the edges of the stubs both frequency (i.e. 900 MHz and 2.4GHz) has a good impedance matching. However, we found that the 2.4 GHz ISM band is more sensitive to the variations in length of the left side stubs and also 900MHz frequency is more sensitive to the variation in length and width of the right side stubs.



(a) (b)

Figure 1-Proposed antenna (a) front view (b) bottom view

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

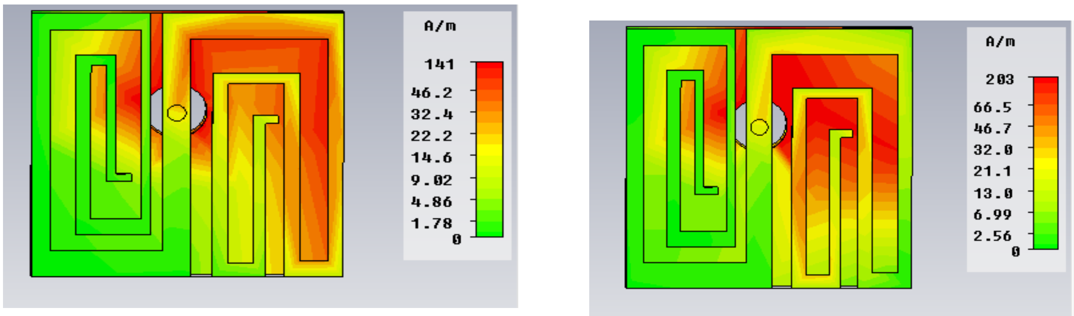
International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

VI. RESULT

SURFACE CURRENT



(a) (b)

Figure 2 Surface current distribution for (a) 900MHz (b) 2.4GHz

Figure 2 show that the current distribution for both resonant frequency. By increasing the length of the current flow path both frequency shift to the left side. The two resonant bands can be shifted by changing the feed point from this position. Most of the implantable antennas are integrated with a shorting pin between the ground and the patch layer. The proposed antenna has a small size; therefore, this technique is not applied here to avoid the complexity in the fabrication process. The PEC components have a negligible effect on the performance of the antenna in systems. This is because the antenna has a flat ground plane with no slots, thereby reducing the effect of backward radiations.

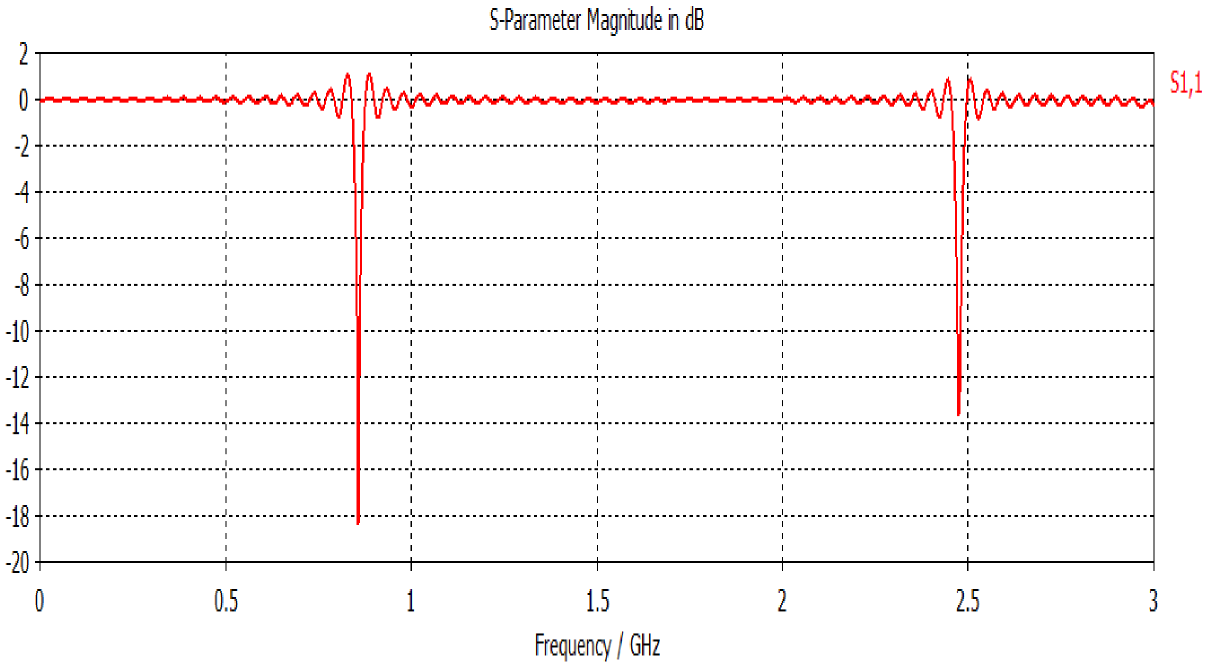
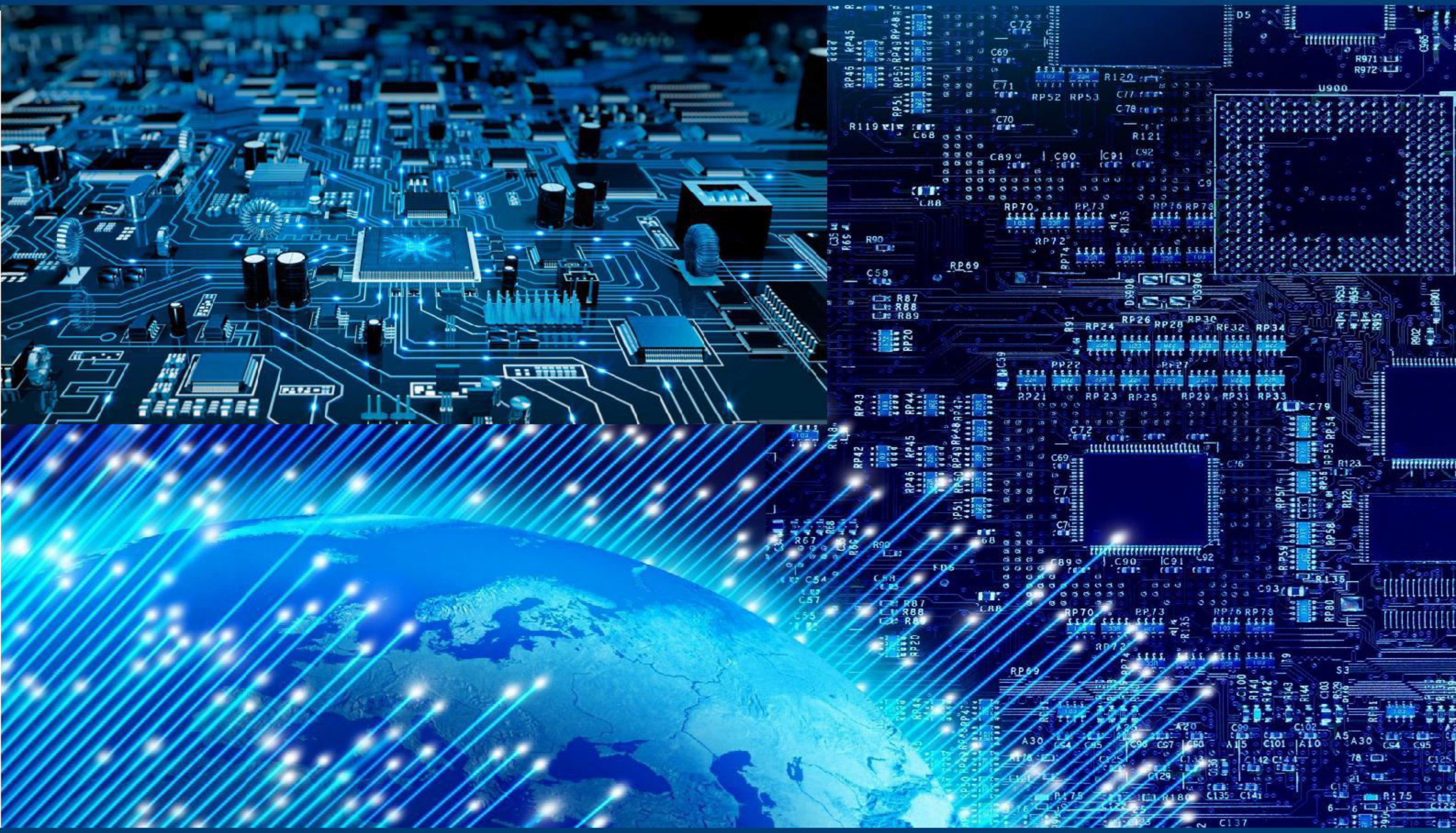


Figure 3-S-parameter for proposed antenna

Figure 3 show the S11 parameter for the proposed antenna, we can observed that both the frequencies (i.e. 900MHz and 2.4 GHz) radiates at -18dBi and - 13dBi.The S11 parameter show the return loss of the proposed antenna. This proposed antenna is perfectly radiates at the frequency of 900 MHz and 2.4GHz.

REFERENCES

1. Muhammed Zada and Hyoungsuk Yoo, "A Miniaturized Triple-Band Implantable antenna system for Bio-Telemetry applications," IEEE Transactions on Antennas and Propagation 66(12):7378 – 7382, October 2018
2. S. A. A. Shah and H. Yoo, "Scalp-implantable antenna systems for intracranial pressure monitoring," IEEE Trans. Antennas Propag., vol. 66, no. 4, pp. 2170–2173, Apr. 2018
3. Y. Cho and H. Yoo, "Miniaturized dual-band implantable antenna for wireless biotelemetry," Electron. Lett., vol. 52, no. 12, pp. 1005–1007, May 2016.
4. Y. Liu, Y. Chen, H. Lin, and F. H. Juwono, "A novel differentially fed compact dual-band implantable antenna for biotelemetry applications," IEEE Antennas Wireless Propag. Lett., vol. 15, pp. 1791–1794, 2016.
5. S. M. Huang, M. R. Tofighi, and A. Rosen, "Considerations for the design and placement of implantable annular slot antennas for intracranial pressure monitoring devices," IEEEAntennas Wireless Propag. Lett., vol. 14, pp. 1514–1517, 2015
6. H. Y. Lin, M. Takahashi, K. Saito, and K. Ito, "Performance of implantable folded dipole antenna for in-body wireless communication," IEEE Trans. Antennas Propag., vol. 61, no. 3, pp. 1363–1370, Mar. 2013.
7. Kiourti and K. S. Nikita, "Miniature scalp-implantable antennas for telemetry in the MICS and ISM bands: Design, safety considerations and link budget analysis," IEEE Trans. Antennas Propag., vol. 60, no. 8, pp. 3568–3575, Aug. 2012.
8. Gani and H. Yoo, "Multi-band antenna system for skin implant," IEEE Microw. Wireless Compon. Lett., vol. 26, no. 4, pp. 294–296, Apr. 2016.
9. G. Zheng, R. Shankaran, M. A. Orgun, L. Qiao, and K. Saleem, "Ideas an challenges for securing wireless implantable medical devices: A review,"IEEE Sensors J., vol. 17, no. 3, pp. 562–576, Feb. 2017.
10. P. C. M. Soontornpipit and C. C. You, "Design of implantable micro strip antenna for communication with medical implants," IEEE Trans. Microw. Theory Tech., vol. 52, no. 8, pp. 1944–1951, Aug. 2004



INTERNATIONAL JOURNAL OF
MULTIDISCIPLINARY RESEARCH
IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com