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A Compact Implantable Microstrip Antenna for MICS and ISM Bands

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Abstract: - A wideband implantable microstrip split-ring antenna is proposed for biotelemetry applications. The antenna takes up a miniaturized size of is 388.93 mm3 (17.5 mm × 17.5 mm × 1.27 mm). The proposed antenna provides a wideband operation covering between 402-405 MHz Medical Implant Communication Services (MICS) band, 433-434.8 MHz Industrial, Scientific, and Medical (ISM) bands, simultaneously. The radiating layer of the antenna consists of square split-ring (SR) elements and metallic paths appropriately placed between the rings, which provide both an electrically small structure and wideband frequency response. A shorting pin implemented between the outer ring and the ground plane is also utilized for the antenna miniaturization. In addition, the proposed antenna exhibits uniform radiation pattern at the respective frequency bands.

Keywords: - *Implantable antenna, Industrial, Scientific and Medical (ISM) band, Medical Implant Communication Service (MICS) band, split-ring elements*

I. INTRODUCTION

In recent years, we have witnessed an exponential growth in research focused on developing electronic systems for medical use. Some recent applications include artificial eyes, cochlear implants, brain pacemakers for Parkinson's disease, cardiac pacemakers, implantable drug pumps, nerve signal recorders for use with robotic prostheses, and muscle stimulators. Enabling wireless communication with these devices is paramount in realizing the maximum benefit and convenience of monitoring patients without physical contact and rigorous schedules. One of the emerging electrical engineering applications in medicine is wireless monitoring of physiological parameters of a patient over a distance via biotelemetry systems using radio frequency technology [1, 2]. Medical Implant Communication Services (MICS, 402.0–405.0 MHz) is most commonly used [3] for the technology. The spectrum of 3 MHz allows for 10 channels (a bandwidth of 300 KHz each) in order to support simultaneous operation of multiple implantable medical devices in the same area, and to limit interference from the co-located Meteorological Aids Service band (401-406 MHz). Nevertheless, Industrial, Scientific and Medical (ISM, 433-434.8 MHz) band is also used for the biotelemetry systems for long battery lifetime. While MICS band is used to data transferring and receiving, ISM band is used to send a wake-up signal initiates data transferring with certain time intervals. In implantable systems, the data is first read by the biosensor and then transmitted through the antenna to either an external wearable device or a nearby personal computer. The interface circuit contains a transceiver, a microprocessor, a power supply, operational amplifiers, and mode-switching components [4]. Since these components are relatively small compared to an on board antenna, a traditional antenna for even relatively low frequency operation dwarfs them; therefore, designing very small antennas becomes vital in order to reduce the overall size of the implant device. An implantable antenna must be small in size and light in weight and should easily be integrated with other electronics in the device. The antenna must also radiate outside the body effectively and efficiently while complying with the Federal Communications Commission (FCC) requirements. In addition, placing the antenna inside a biological tissue adds significant complexity to the problem since the antenna now resides in a lossy medium with a very high permittivity such as skin, muscle, blood, and bone. The tissue parameters (relative permittivity (εr), electrical conductivity (σ), and mass density (ρ) depend on the tissue temperature and frequency. Relative permittivity decreases and the conductivity increases as the frequency increases. For these reasons, designing an effective very small size implantable antenna is very challenging and there have been recently presented several implantable antenna designs with different characteristics and target applications [5-9].

In this paper, we propose a novel implantable antenna design based on printed split-ring elements. These elements with inherent μ-negative behavior have recently been used as building blocks of various metamaterial structures, providing highly-resonant frequency responses [10, 11]. We designed various type SR antennas for WLAN applications in our previous designs [12-14]. We employed three additional elements for the design in this study different from the proposed antenna in [12-14]. One of them is superstrate structure. It is chosen same material of the substrate of the antenna and it was used to isolate the antenna copper from the human tissue which is conductive. The other one is shorting pin. It was placed between top copper layer and the ground plane of the antenna like PIFA design and it was used for miniaturization purpose. The third element is feeding structure. While microstrip or CPW feeding technique was used in [12-14], we used probe feeding technique in this design. The proposed implantable antenna consists of split-ring elements and metallic paths inserted between the rings as shown in Fig 1. The compact antenna design provides wideband performance at 400 MHZ with 20% bandwidth and it covers both 402 MHZ MICS band and 433 MHZ ISM bands simultaneously.

II. SPLIT RING IMPLANTABLE ANTENNA DESIGN

A series of parametric studies were carried out to achieve desired antenna performance, particularly for tuning the resonant frequencies and return loss characteristics. In this design process, dimensions of SR elements, dimensions of the substrate, position of the shorting pin and feeding were varied. Analysis and design of the antenna were carried out Ansoft HFSS v.14 based on finite element method and the antenna is simulated in a skin tissue phantom model that its electrical characteristics are εr=46.7, σ=0.69 at the respective frequency bands. As seen in Fig. 1(a), main radiator of the novel implantable antenna design consists of square split-ring elements and ten metallic loadings (S_1-S_{10}) appropriately placed between the rings.

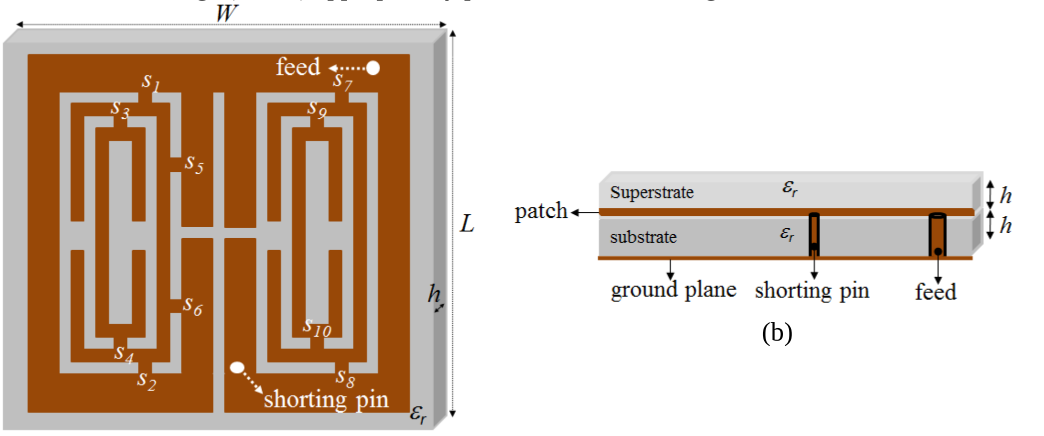

Fig 1. Proposed Implantable SR Antenna (W=L=17.5 mm, h=1.27 mm). a) top view b) side view.

The antenna is fabricated on the Rogers TMM10 substrate with 1.27mm thickness and dielectric constant of ε_r=9.8. A vertical probe placed between the ground plane and outer SR element feeds the proposed antenna. Also, a shorting pin whose position determined by optimization is directly connected between one of the outer SR elements and the ground plane. This pin is used to achieve electrically small antenna structure like PIFA designs. In addition, a superstrate, which is same material of the substrate of the antenna, is used to prevent from contacting human tissue and conducting plates of the antenna as shown in Fig 1(b).The impedance characteristic and return loss performances of the proposed design are shown in Fig. 2 and Fig. 3, respectively. As can be seen from the Fig. 3, the proposed design simulated in skin environment provides a wideband operation at 400 MHz with 20% impedance bandwidths. Thus, the SR implantable antenna covers 402 MHz MICS and 433 MHz ISM bands, simultaneously. In addition, radiation pattern of the antenna for 402 MHz is shown in Fig. 4. As seen, H-plane pattern demonstrates desired omni-directional characteristic and E-plane pattern shows relatively directional behavior.

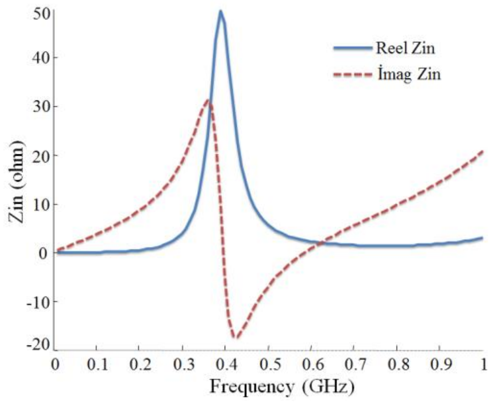

Fig 2. Impedance characteristics of the antenna.

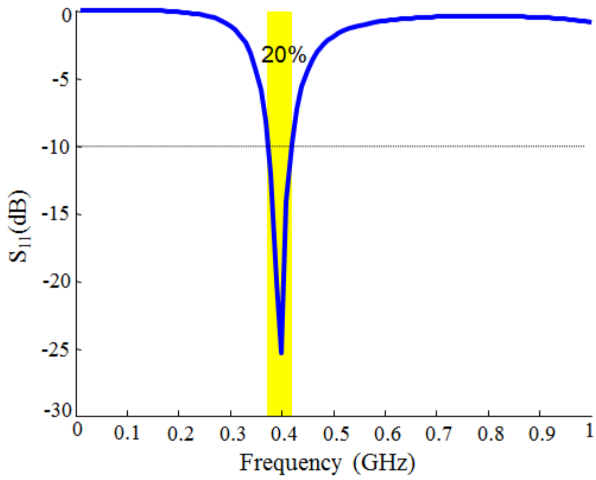

Fig 3. Return loss performance of the antenna.

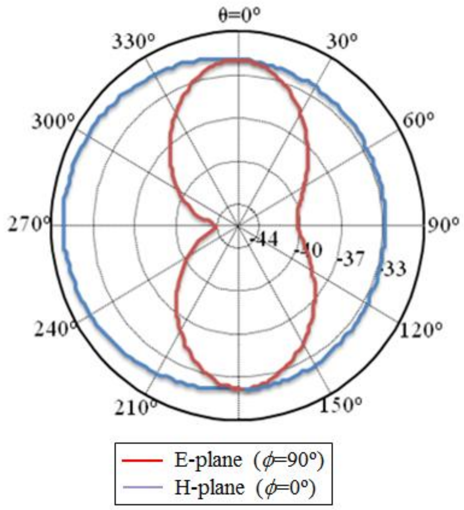

Fig 4. Radiation pattern of the antenna.

III. CONCLUSION

In this paper, we have introduced a compact wideband implantable split-ring antenna for biotelemetry applications. The miniaturization is vital important challenge in designing an implant antenna. The split-ring resonators are used for miniaturization and very compact antenna with 17.5 mm × 17.5 mm × 1.27 mm dimensions is designed in the paper. The compact antenna design provides wideband performance at 400 MHz with 20% impedance bandwidth and covers MICS and ISM bands, simultaneously. All simulations were carried out by means of Ansoft HFSS simulation program.

REFERENCES

[1] W. Greatbatch and C. F. Homes, History of Implantable Devices, *IEEE Eng. Med. Biology Mag.*, 10 (3), 1991, 38-41.

[2] R. D. Beach, F. V., Kuster and F. Moussy, Subminiature Implantable Potentiostat and Modified Commercial Telemetry Device for Remote Glucose Monitoring, *IEEE Trans. Instrument. Meas.*, 48 (6), 2002, 1239-1245.

[3] International Telecommunications Union Radio Communications (ITU-R), Radio Regulations, SA.1346. ITU, Geneva, Switzerland.

[4] R. D. Beach, R. W. Conlan, M. C. Godwin, and F. Moussy, Towards a Miniature Implantable in vivo Telemetry Monitoring System Dynamically Configurable as a Potentiostat or Galvanostat for two- and Three-electrode Biosensors, *IEEE Trans. Instrument. Meas.*, 54 (1), 2005, 61-72.

[5] C. Liu, Y. X. Guo and S. Xiao, Compact Dual-band Antenna for Implantable Devices, *IEEE Antennas and Wireless Propag. Lett*., 11, 2012, 1508-1511.

[6] L.J. Xu, Y. X. Guo, W. Wu, Miniaturized Dual-band Antenna for Implantable Wireless Communications, *IEEE Antennas and wireless Propag. Lett.*, 13, 2014, 1160- 1163.

[7] C. Guo, Y. X. Liu, and S. Xiao, Capacitively Loaded Circularly Polarized Implantable Patch Antenna for ISM Band Biomedical Applications, *IEEE Trans. on Antennas and Propagat.*, 62 (5), 2014, 2407-2417.

[8] L.J. Xu, Y. X. Guo, W. Wu, Miniaturized Circularly Polarized Loop Antenna for Biomedical Applications, *IEEE Trans. on Antennas and Propagat.*, 63 (3), 2015, 922-930.

[9] F. Merli, L. Bolomey, F. Gorostidi, B. Fuchs, J-F. Zurcher, Y. Barrandon, E. Meurville, J. R. Mosig, and A. K. Skrivervik, Example of Data Telemetry for Biomedical Applications: an in vivo Experiment, *IEEE Antennas Wireless Propag. Lett.*, 14, 2015, 783–786.

[10] J. B. Pendry, A. J. Holden, D. J. Robins, W. J. Stewart, Magnetism from Conductors and Enhanced Nonlinear Phenomena, *IEEE Transactions on Microwave Theory and Techniques*, 47 (11), 1999, 2075-2084.

[11] D. R. Smith, W. J. Padilla, D. C. Vier, S. C. Nemat-Nasser, S. Schultz, Composite Medium with Simultaneously Negative Permeability and Permittivity, *Physical Review Letters*, 84 (18), 2000, 4184-4187.

[12] S. C. Basaran, Compact Dual-band Split-ring Antenna for 2.4/5.2 GHz WLAN Applications, *Turkish J. Elec. Engin. Comp. Sci.*, 20 (3), 2012, 347-352.

[13] S. C. Basaran and Y. E. Erdemli, A dual-band Split-ring Monopole Antenna for WLAN Applications, *Microw. Opt. Technol. Lett*., 51 (11), 2009, 2685-2688.

[14] S. C. Basaran, and K Sertel, Dual wideband CPW-fed Split-ring Monopole Antenna with Split-Ring Resonators, *Microw. Opt. Technol. Lett.*, 55 (9), 2013, 2088-2092.