ANTENNAS FOR BIO-MEDICAL APPLICATIONS : A REVIEW

[1]**T. Pavani,** Department of ECE, GRIET, Hyderabad, India
[2]**Ch. Komali,** Department of ECE, GRIET, Hyderabad, India
[3]**G. Sowmika,** Department of ECE, GRIET, Hyderabad, India
[4]**Y. Rajasree Rao,** Department of ECE, LORDS Institute of Engineering and Technology, Hyderabad, India

ABSTRACT

Micro strip patch antennas plays vital role in biomedical applications as they are low profile. These antennas are used in countless bio medical applications. These days patch antennas become popular for health monitoring. Implanted, BWCS and RFID sensors are few applications in which patch antenna is a key element. This paper discusses a review of various micro strip antennas and techniques for biomedical applications.

Keywords: Biomedical, RFID, BWCS, Antennas, Micro-Strip.

REVIEW OF ANTENNA FOR BIOMEDICAL APPLICATION

An implanted antenna prototype has been design using planner inverted antenna (PIFA)which is modified into conformal antenna for glucose sensing, which works over the MICS bandwidth (402-405) GHz. The prototype consists of antenna, battery and a Tran's receiver which is completely insulated using PEEK material. The comparison of simulated and measured results is listed in table1. The prototype has been tested in the base station provided by Zarlink and communication tested at anechoic chamber and the prototype has shown good results [1].

Table.1. Comparison of simulated and measured results

Simulated values	Measured value
εr=57.1	εr=57.068
Tanδ=0.0622	Tanδ=0.673

A flexible folded slot dipole implanted antenna has been designed which operates in the ISM band at 2.45 GHz, it is H- shaped slot cavity antenna, it has two dual band implantable which work in the MICS and ISM band and is embedded in PDM. The antenna has been tested in MSL2450 which mimics the dielectric characteristics of human muscle tissue. The reflection co-efficient in planar and bent state, Electric-field and gain have been evaluated. A good agreement has been found between the stimulations and measurements for the planar state antenna. In addition, Specific Absorption Rate (SAR) measurements indicate that the antenna meets the required safety regulations [2].

A U- shaped micro strip patch antenna with a meandered slot is designed for bio-medical applications; it operates at 2.45 GHz frequency. In the designing of this antenna two designs of the patch are introduced with and without meandered slot, when stimulated both the results have been compared and the antenna with meandered slot have shown Better performance for biomedical applications. The antenna was fabricated on the FR4 substrate and the stimulations were carried out on FDTD based Empire Xcel simulator [3].

A reconfigurable antenna which is printed in spiral shape monopole and with a compact structure is designed for biomedical applications where the configuration is altered by usage of embedded microwave switches to operate on different frequencies depending on the state of the switch. This antenna can operate over the MICS (402-405) GHz ad the ISM (24-25) GHz frequency range. The size of the antenna is 32mm*50.3mm*1.8mm and it has been fabricated on FR4 substrate. The simulations and measurements are in good agreement [4].

A microstrip line-fed flexible antenna is designed which operates in the UWB (3.1-10.6 GHz) frequency range, the resonant frequency is 5.93 GHz. It is a lower sensitive to angular misalignments and higher fidelity which is best suited for biomedical applications. The size of the antenna is 40mm*40mm*1.4mm with an FR4 substrate and copper patch material. Table 2 describes dielectric values of human tissue at different frequencies. The calculations and the measurements are performed using CSTMW studio and the SAR distribution of antenna is analyzed, and it is compactible for practical use [5].

Table.2 Dielectric values of human muscle tissue in different frequencies

Frequency (GHz)	$\boldsymbol{\varepsilon r}$	$\boldsymbol{\partial}$ $(\boldsymbol{S/m})$
5	49.5	4.04
5.93	48.3	5.12
6	48.2	5.23
7	46.9	6.46

A dual-loop antenna with ultra-wideband has been designed for biomedical as well as industrial scientific use, which operates in the ISM (2.4 -2.483) GHz frequency range, it is used in wireless endoscope applications. The antenna consists of two identical loops located symmetrically around the centre, a feeding Patch at the centre of the loop and a parasitic Patch connected to the other loop. The ultrawide band is achieved by adding two rectangular patches at the centre of these loops and rotating feed direction by 90 degrees. The simulations are performed on pork in the ultrawide band of 124% is obtained as measured [6].

A novel circular polarised antenna has been proposed at (902-928) Hertz which is position fed and short slow wave concept is utilised to achieve miniaturised centre shifted from 1.936 Hz to 882.5 megahertz with 54.4% miniaturization and to obtain the compact size of antenna 13mm*13mm*13mm. Bandwidth of 18.2 is realised with |s11| below -10 DB. The simulation realised gain is -32 DB in pork and skin mimicking gel. Hence it is proved that circular polarisation can be used for bio-medical applications [7].

A single fed microchip circular polarised antenna has been designed and demonstrated operated over the ISM frequency of (2.42 - 2.486) GHz .The design utilises the capacitor for loading on the radiator. A square Patch antenna with centre square slot helped the antenna for good size reduction and good polarisation purity. The stimulations have been done on two models- cubic skin phantoms and guv voxel human body. Stimulations and measured impedance in cubic skin Phantom 7.7 and 10.2 respectively, the communication between the CP antenna and external antenna have been performed [8].

A novel differentially fed dual implantable antenna is designed for implantable neuro microsystem for the first time. The antenna operates at two centre frequencies 433.9MHz and 542.4 MHz which is close to the MICS (402-405) MHz frequency range and the size of the antenna is 27mm*14mm*1.27mm. The stimulation is carried in a tissue mimicking solutions, stimulation and measurement bandwidth are 7.3% and 7.9% at first resonant. The Dimensions of the proposed antenna are given in table 3. The communication between external half wavelength dual band dipole and the implanted antenna has been obtained [9].

Table. 3. Dimensions of the proposed antenna

Symbol	Value (mm)
L1	13.1
L2	13.2
S	0.5
S1	0.3

S2	0.9
W	1.0
W1	1.4
W2	1.22

A multi-polarization reconfigurable antenna is designed with four dipole radiators and body-centric wireless communication system (BWCS) has been designed for bio medical applications where, multi-dipole antenna with switchable 0, 45, 90,-45 linear polarisation for mismatching and the multipath distortion in BWCS. Is achieved the 4 dipole radiates are placed at 45 degrees the antenna has impedance bandwidth of 34% from 2.2 -3.16 Hz. The communication link has shown great link due to the configurability [10].

A single-fed Patch antenna operates at operating at a frequency 2.4GHz ISM frequency is designed for biomedical applications the stimulations are done at the on the skin mimicking gel and pork measured impedance bandwidth of 5.45% and 5.69% axial bandwidth ratio of 10% is achieved with the Patch antenna and has a bandwidth of 2.46 Hz. It is observed that it as highest wide band of all reported results [11].

RFID enable sensor has been used for the biomedical monitoring of the antenna here the inkjet printing technology is also used RDF antenna design and integration of sensor has been done in the antenna. Preliminarily Embodiments showed that the RFID enable sensor is good for wireless body area networks [12].

Here an inverted F-dual implantable antenna is optimised to operate in medical device radio communication services (401-406MHz) and ISM bandwidth (902-928MHz). Artificial neural network (ANNs) are used reduce the size of the original design. With the dielectric parameters as inputs the antenna is tested using COMSOL Multiphysics and the resonant frequency, bandwidth and return losses are evaluated [13].

A implantable patch antenna has designed for biomedical applications which operates in the ISM frequency (2450 MHz) the dimensions of the antenna are 16mm*16mm*1mm , it is embedded in Teflon substrate have a di-electric constant of 2.1.The stimulations and measured using CST and the antenna has shown better results when compared to the conventional antennas [14].

A novel coplanar waveguide fed implantable crossed-type triangle slot antenna is design which operates in the ISM band having a centre frequency of 2450MHz. The dimensions of the proposed antenna are 10mm*12mm*0.65mm. The stimulations are evaluated on the human body tissue model, the communication link has been tested between the implanted antenna and external antenna, the stimulated and the measured bandwidths are 7.9% and 8.2% respectively. The antenna has shown very good results with respect to other parameters like Size reduction, lower S11, better impedance matching, and high directivity over other implanted antennas [15].

A novel wide band antenna filled with high dielectric material (A mixture of paraffin and titanium oxide (TiO_2) is used for biomedical applications which operates in the frequency range of (2 – 6) GHz. The antenna has been tested in layers skin and muscle .The results have shown a great benefit of 4 GHz of bandwidth and (5-8)dB of gain [16].

CONCLUSION

This paper gives a review of the design of various micro strip patch antennas for biomedical applications. The planner inverted antenna (PIFA), flexible folded slot dipole, U- shaped micro strip and single-fed Patch antenna were used for biomedical applications. Reconfigurable antenna which is printed in spiral shape monopole, dual-loop antenna, circular polariZed antenna, inverted F-dual implantable antenna and coplanar waveguide fed implantable crossed-type triangle slot antenna were used as implantable antennas. By different feed techniques, slots, and metamaterials and with circular polarization compact antennas have been designed for biomedical applications and implantable applications. The combination of the above techniques will be implemented in future work.

This paper presents a review on various techniques used to design microstrip patch antenna for different wireless communication systems operating at various frequency bands. The use of slotting, stacking, defected ground structure, shorting pin, metamaterial loading can be used to enhance the performance parameters of microstrip patch antenna. The antenna parameters such as gain, bandwidth and directivity can be enhanced by optimizing the physical dimensions of antenna as well as by changing the length and width of slots. Metamaterial on other hand found very useful to design compact microstrip antennas. In future research work, the combination of these techniques can be used to design and enhance the performance of different microstrip antennas for various wireless communication systems.

ACKNOWLEDGMENT

This work was supported by the TEQIP-III, JNTUH, India, under Grant (CRS/2019/ECE/09).

REFERENCES

1. F. Merli, L. Bolomey, E. Meurville and A. K. Skrivervik, "Implanted antenna for biomedical applications," 2008 IEEE Antennas and Propagation Society International Symposium, San Diego, CA, 2008, pp. 1-4, doi: 10.1109/APS.2008.4619064.

2. M. L. Scarpello et al., "Design of an Implantable Slot Dipole Conformal Flexible Antenna for Biomedical Applications," in IEEE Transactions on Antennas and Propagation, vol. 59, no. 10, pp. 3556-3564, Oct. 2011, doi: 10.1109/TAP.2011.2163761.
3. S. Sukhija and R. K. Sarin, "A U-Shaped Meandered Slot Antenna for Biomedical Applications," *Progress In Electromagnetics Research M*, Vol. 62, 65-77, 2017.
4. M. Salim and A. Pourziad, "A Novel Reconfigurable Spiral-Shaped Monopole Antenna for Biomedical Applications," *Progress In Electromagnetics Research Letters*, Vol. 57, 79-84, 2015.
5. A. Biswas, A. J. Islam, A. Al-Faruk and S. S. Alam, "Design and performance analysis of a microstrip line-fed on-body matched flexible UWB antenna for biomedical applications," 2017 International Conference on Electrical, Computer and Communication Engineering (ECCE), Cox's Bazar, 2017, pp. 181-185, doi: 10.1109/ECACE.2017.7912902.
6. J. Shang and Y. Yu, "An Ultrawideband Capsule Antenna for Biomedical Applications," in IEEE Antennas and Wireless Propagation Letters, vol. 18, no. 12, pp. 2548-2551, Dec. 2019, doi: 10.1109/LAWP.2019.2942842.
7. L. Xu, Y. Guo and W. Wu, "Miniaturized Circularly Polarized Loop Antenna for Biomedical Applications," in IEEE Transactions on Antennas and Propagation, vol. 63, no. 3, pp. 922-930, March 2015, doi: 10.1109/TAP.2014.2387420.
8. C. Liu, Y. Guo and S. Xiao, "Capacitively Loaded Circularly Polarized Implantable Patch Antenna for ISM Band Biomedical Applications," in IEEE Transactions on Antennas and Propagation, vol. 62, no. 5, pp. 2407-2417, May 2014, doi: 10.1109/TAP.2014.2307341.
9. Z. Duan, Y. Guo, R. Xue, M. Je and D. Kwong, "Differentially Fed Dual-Band Implantable Antenna for Biomedical Applications," in IEEE Transactions on Antennas and Propagation, vol. 60, no. 12, pp. 5587-5595, Dec. 2012, doi: 10.1109/TAP.2012.2209197.
10. H. Wong, W. Lin, L. Huitema and E. Arnaud, "Multi-Polarization Reconfigurable Antenna for Wireless Biomedical System," in IEEE Transactions on Biomedical Circuits and Systems, vol. 11, no. 3, pp. 652-660, June 2017, doi: 10.1109/TBCAS.2016.2636872.
11. Z. Yang, S. Xiao, L. Zhu, B. Wang and H. Tu, "A Circularly Polarized Implantable Antenna for 2.4-GHz ISM Band Biomedical Applications," in IEEE Antennas and Wireless Propagation Letters, vol. 16, pp. 2554-2557, 2017, doi: 10.1109/LAWP.2017.2732460.
12. Li Yang, R. Vyas, A. Rida, J. Pan and M. M. Tentzeris, "Wearable RFID-enabled sensor nodes for biomedical applications," 2008 58th Electronic Components and Technology Conference, Lake Buena Vista, FL, 2008, pp. 2156-2159, doi: 10.1109/ECTC.2008.4550284.
13. A. Djellid, L. Pichon, S. Koulouridis, and F. Bouttout, "Miniaturization of a PIFA Antenna for Biomedical Applications Using Artificial Neural Networks," *Progress In Electromagnetics Research M*, Vol. 70, 1-10, 2018.
14. S. Ashok Kumar, M. Arun Raj, T. Shanmuganantham,Analysis and design of CPW fed antenna at ISM band for biomedical applications,Alexandria Engineering Journal,Volume 57,Issue2,2018.Page723727,ISSN11100168,https://doi.org/10.1016/j.aej.2017.02.008.(http://www.sciencedirect.com/science/article/pii/S1110016817300704).

15. AshokKumar,Srinivasan; Shanmuganantham,Thangavelu.International Journal of Microwave and Wireless Technologies; Cambridge Vol. 6, Iss. 2, (Apr 2014): 167-172.DOI:10.1017/S1759078713000883
16. S. Sarjoghian, M. H. Sagor, Y. Alfadhl and X. Chen, "A 3D-Printed High-Dielectric Filled Elliptical Double-Ridged Horn Antenna for Biomedical Monitoring Applications," in IEEE Access, vol. 7, pp. 94977-94985, 2019, doi: 10.1109/ACCESS.2019.2928629.