A Review On Designing Of Implantable 3d Dental Antenna

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Abstract—This paper presents the designing of compact high gain implantable dental antenna with a large bandwidth. The 3D folded antenna is based on a combination of Archimedean spirals & a Hilbert-based 3D folded fractal structure. Due to its compactness the antenna can be implanted in the human body easily & is used to communicate with external devices. In this paper we design such an antenna for dental applications.

Keywords:- 3D Antenna, Reference Antenna, Hilbert fractal, Archimedean spirals.

I. Introduction

Compact implantable antennas are very useful in medical field & can be implanted in the human body easily & hence a bio-communication system is developed between these antennas & exterior instruments [1]. This makes the continuous monitoring of physiological parameters possible which in turn sense the disease at early stage & hence the disease can be treated [2] [3]. The main components of this system are – A compact 3D antenna & a RF-front end. This Rf-front end collects the biological information & transfer it to exterior device & vice-versa.

Two bands are specified by the Federal communications commission (FCC) – Medical implant communications service (MICS) band at 402-405 MHZ & MedRadio band at 401-406 MHZ [4]. Size of the antenna should be very small for dental implantation. So various miniature techniques can be used. e.g. Space filling geometries such as fractal hilbert curve [5][6]. But these decrease the efficiency & increase the power consumption. So a technique can be used which retains the high gain & efficiency by maintaining effective radiation. So a 3D structure can be used which gives the high gain with smaller size.

Also bandwidth is an important factor. To remove the frequency variations after implantation the bandwidth should be ideal & broad. The desired antenna design can be divided in to two parts. At first, the first resonant mode operating at certain frequency is selected & is designed as the reference antenna. Then the impedance bandwidth is further increased while the same volume is maintained & a new radiator structure, that generates the second resonance mode is combined with the first reference mode to increase the bandwidth [7].

II. Antenna Designing

The antenna designing can be done in two steps. First the reference antenna can be designed & then the broadband antenna which is our final antenna can be designed.

Reference Antenna designing: Substrates are very important in case of implantable antennas. These should be selected according to our aim. i.e. the size should be selected according to practical dimensions of the dentures involved and the material properties of the environment in which the antenna is to be implanted. Two commonly used materials for dental implants are – Alumina ($_{Al2o3}$) & Zirconium dioxide (Zro_2). Zro_2 has an advantage that it has a high dielectric constant & is biocompatible [8]. Now once the substrate is selected, the reference antenna can be designed easily. The size is selected according to our problem. e.g. if we want to make the antenna for molar teeth then we have to select the size according to the dimensions of molar. The molar size of an average asian person is 8*11.5*8 $mm^{3.}$ We can assume it like a rectangular cube. The feed port is base on the design of PIFA [6]. This is based on the Hilbert-shaped fractal geometry & there is a grounded shorting pin next to the feed port shown in fig (1) [7].

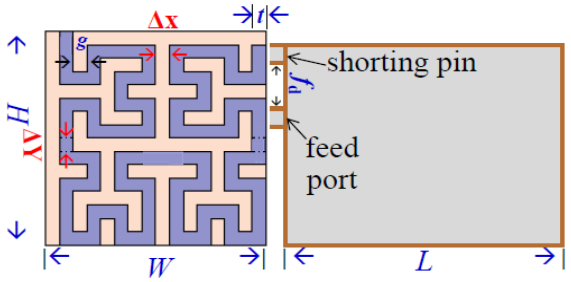

Fig. 1: Architecture of reference antenna

To extend the effective current path of radiator, & in turn reducing the operation frequency of antenna, the shorting pin near the feed port is grounded. All this leads to Antenna miniaturization. The order of the hilbert curves are then adjusted for minimum frequency. Once the order is determined, the line width & the gaps of the Hilbert geometry are also determined. Also the operation frequency can be adjusted. In this way, the reference antenna can be designed. This reference antenna is delicate & has to be protected & also the frequency can be shifted due to bio-medical environment. Obviously we don't want the fluctuations in our set frequency. So we add an upper lid to Zro_2 . This upper lid covers the four sides of the tooth but not the tongue side & the bottom portion of the tooth. This is called modified antenna & is shown in fig (2) [7].

Broadband antenna designing: The reference antenna has been designed. Now we have to increase the bandwidth for broadband designing. This can be done by creating a second resonant mode near the first mode with a compact form factor, & then the two frequencies can be combined to create a wide band.

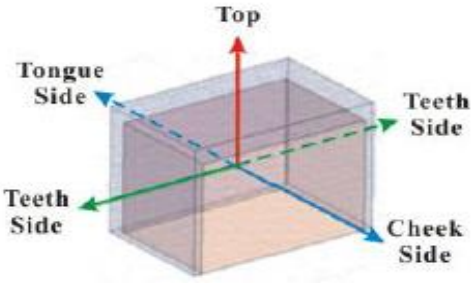

Fig. 2: Modified dental substrate model

The reference antenna's metal microstrip structure can be modified by inserting an Archimedean spiral between the two Hilbert fractal parts to combine the different modes [9].

Fig (3) [7] shows the modified structure of the antenna, fig (4) [7] & fig (5) [7] shows the structure of spiral radiator & fractal radiator respectively.

The advantage of combining the fractal components with the spirals is that - the dual modes occur at close frequencies & hence they can be combined to form a wideband.

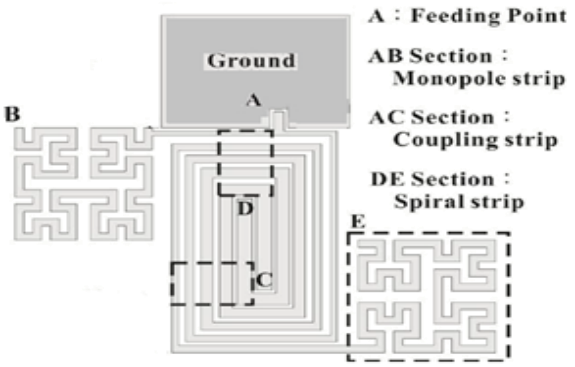

Fig. 3: Modified broadband antenna

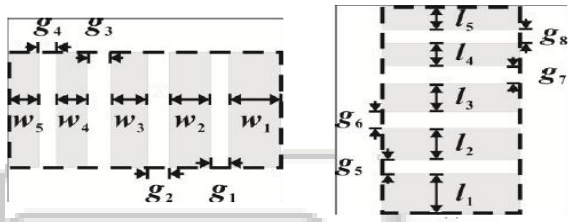

Fig. 4: Structure of spiral radiator

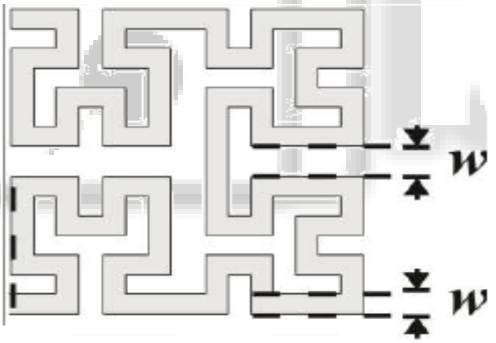

Fig. 5: Structure of fractal radiator

& fig (6) [7] shows the 3D schematic of the entire modified antenna.

Fig. 6: 3D schematic of the broadband antenna

This antenna can be labeled as MHSA (Modified Hilbert-spiral antenna). BY carefully adjusting the line widths & gaps between the spirals, the bandwidth can be improved significantly. This is our desired antenna. In this designing the fabrication differences like adhesive tightness & flexible printed circuit board (FPCB) are also need to be considered. By doing this the bandwidth further increase. Hence we got an antenna with a high gain & broad bandwidth.

III. Conclusion

A compact implantable 3D dental antenna has been designed in this paper. The design is based on the Hilbert-type fractal & Archimedean spirals. The advantage of 3D design is that it provides high gain, broader bandwidth & miniaturized area & volume. Broader bandwidth helps in avoiding the frequency fluctuations after installing the antenna in oral cavity. The antenna is feasible & is shown to be promising in future work.

References

[1] T. W. Berger, M. Baudry, R. D. Brinton, J.-S. Liaw, V. Z. Marmarelis, Y. A. Park, B. J. Sheu, and A. R. Tanguay, Jr., "Brain-implantable biomimetic electronics as the next era in neural prosthetics," Proc. IEEE, vol. 89, pp. 993–1012, Jul. 2001.

[2] 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. Instrumentation and Measurement, vol. 54, no. 1, pp. 61–72, Feb. 2005.

[3] C. M. Furse, "Design of an Antenna for Pacemaker Communication," Microwaves RF, vol. 39, no. 3, pp. 73–76, Mar. 2000.

[4] FCC MedRadio Specification. Available online: http://wireless.fcc.gov/ services/index.htm?job=service_home&id=medical implant.

[5] M. Z. Azad and M. Ali, "A miniaturized Hilbert PIFA for dual band mobile wireless applications," IEEE Antennas Wireless Propag. Lett., vol. 4, pp. 59–62, 2005.

[6] M. Z. Azad, M. Ali, "A New Class of Miniature Embedded Inverted-F Antennas (IFAs) for 2.4 GHz WLAN Application," IEEE Trans. on Antennas and Propagation, vol. 54, no. 9, Sep. 2006, pp. 2585.

[7] Chin-Lung Yang, Chi-Lin Tsai & Sheng-Hao Chen, "Implantable high-gain dental antennas for minimally invasive biomedical devices," IEEE 2013.

[8] C. Lin, N. Zhang and Q. Shen, "Studies on Al2O3/ZrO2/Al2O3 High K Gate Dielectrics Applied in a Fully Depleted SOI MOSFET," Metals and Materials International, v. 10, no 5, pp. 475-478, 2004.

[9] J. Kaiser, "The Archimedean Two-Wire spiral antenna," Antennas and Propagation, IEEE Transaction on, Vol. 8, pp. 312-323,1960.

