

Design of compact Implantable Meandered and Sharp Edged Meandered Shaped Antenna for Biomedical Application

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Abstract: *The introduction of Implantable device in the early 1960s, the IMD have become more interesting for Human care services. Currently, the devices designed and proposed to monitor the biological data and signals from inside the human tissue have greater promises. The major contribution to illness is prevention, diagnosis and therapy. The Implantable device in a few days, a miniaturized antenna is proposed to work in the ISM band. The resonant frequency of the antenna design is about 2.4 – 2.5 GHz. A combination of a Meandered and Sharp Edged Meandered shape on a patch design is proposed for biotelemetry applications. The structure of the antenna is designed to meets the satisfied requirements. The simulation is done with CST MW studio is used to calculate the reflection coefficient about -25.941 dB and -31.941 dB between 2.0 GHz to 3.0 GHz. The results obtained with various parameters, the proposed Patch Antenna has a gain which the Meandered is 1.927 dB and the Sharp Edged Meandered Patch is 2.02 dB. The design of a Proposed Antenna is a need because the antennas are operated inside the human body. The proposed design obtains good results towards the requirements.*

Keywords: *Biotelemetry, Triple Meandered Shaped, Sharp Edged Meandered, Implantable Antenna, ISM Band*

INTRODUCTION

Implantable medical antennas are to aid and increase the quality of their daily lives. Radio Frequency-based implantable medical antennas are used in a wide variety of applications like, thermometers, pacemakers, defibrillators and electrical stimulators (FES), the flow of blood and sensing the insulin level [1]. As technology continues to grow, the new IMA are started to expand, and the use of an antenna is increasing rapidly from a large field. Newly, there is no frequency band-approved globally for implantable medical antennas [2].

The environment completely changed with various recommendations, which the (402 to 405) MHz band of frequency is for (MICS), but this proposed structure has been designed for ISM band [3]. The MICS band is organized by the USA (FCC) and the (ERC) European Radio Communications Committee [4]. The (433 to 434.8) MHz and (2.4 to 2.5) GHz (ISM) bands are used for IMA biotelemetry in a few of the countries [4]. The main focus is the MICS band because various benefits are available across the world with a low-cost circuit, power and certainly supports high-data-rate transmission [5]. Some RF critical components based implantable antenna is integration with implantable medical devices, and then the proposed antenna is fit for bidirectional communication with the external monitoring and imaging, controlled equipment [6-8].

Microstrip Patch structures are newly receiving huge attention for IMD and Antenna because the designing processes are easy, flexible, shape thus allows easy miniaturization of the implantable medical antennas [9]. The transmitting process from the human body to the outer world requires a multi-approach. More importantly, this work is towards Implantable Medical Antenna with far-field data telemetry capability [10]. The paper is proposed, simulated and successfully achieved the results. In the existence of the human body, radiofrequency is used to propagate the signals [11]. This radiator embeds with the basic Electronics, Bio-Sensor and Power Supply since they can form the Body Network node [12-14].

1. ANTENNA DESIGN

In the ordering of the proposed paper is designing a small and compact Implantable antenna operates in ISM band. The proposed and suggested antenna is shown in the 3D view of the proposed structure with a Dielectric Substrate FR4 with high permittivity ($\epsilon_r = 4.3$) and the dielectric substrate thickness is 1.6 mm. The Return loss (S_{11}) is called a Reflection Coefficient of the patch antenna must be less than -10dB. The suggested antenna structure, the size of Meandered is a minimum of 24 mm * 22 mm * 1.6 mm (844.8 mm³) which is shown in figure 1 (a). The size of the suggested Sharp Edged Meandered Patch Antenna is about 18 mm * 22 mm * 1.6 mm (633.6 mm³) and it is shown in Fig. 1 (b).

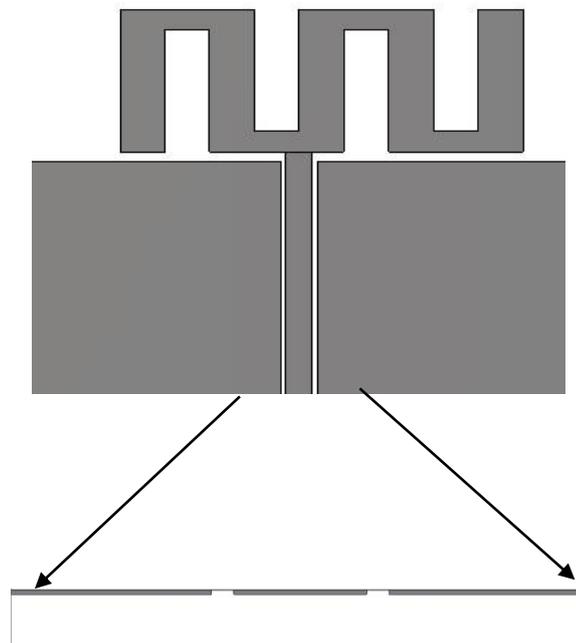


Fig. 1. a. Meandered Shaped Antenna

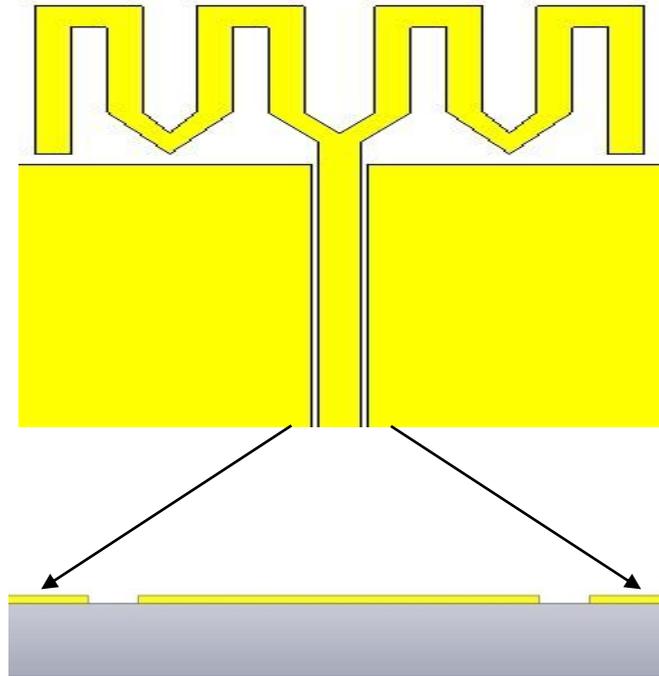


Fig. 1.b: Sharp Edged Meandered Antenna

2. SIMULATIONS AND RESULTS

The medical Implantable antenna is constructed using a coplanar waveguide feed. The Reflection coefficient of the antenna has less than -10dB which will have high Gain. The proposed antenna possesses -25dB at Radiating Frequency when compared with the Meandered structure and Sharp Edged Meandered structure antenna commits to achieve the desired application. Since only the simulated results are displayed here. The measurement of this structure with an insulating layer (using biocompatible material) [15-17] can be done as future work. The feed used in the proposed paper is a coplanar waveguide because the ground layer is imposed on high permittivity substrate which does not affect the human tissue. When the ground layer is below the dielectric substrate, the radiated wave affects the human tissue. Therefore the coplanar waveguide feed is used in the implantable antenna. . The simulations are done in free space because when the Implantable antennas are dipped inside the human body the Gain and Directivity of the proposed antenna is very less because of the resistive characteristics. The comparison between the proposed antennas is done with several parameters such as VSWR, Return Loss, Radiation Pattern, Gain and Directivity.

- Return Loss:

The parameter of the antenna is called a reflection coefficient. The simulated results of the Meandered structure and the Sharp-Edged Meandered structure are compared. The simulated results of the Meandered structure are -25.941 dB and the Sharp Meandered structure has -31.941 dB . The simulated results are obtained and compared. The obtained results are shown in Figure 2 in this paper.

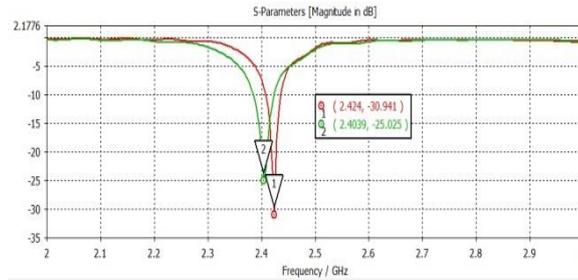


Fig. 2. Return Loss

- VSWR:

The expansion of VSWR is Voltage Standing Wave Ratio. The VSWR of the device in radiating frequency has below 1.5. The VSWR of the designed antenna is compared respectively and shown in figure 3. The measured value of VSWR after simulation, the Meandered Structure has 1.1171 and the Sharp-Edged Meandered structure has 1.0637.

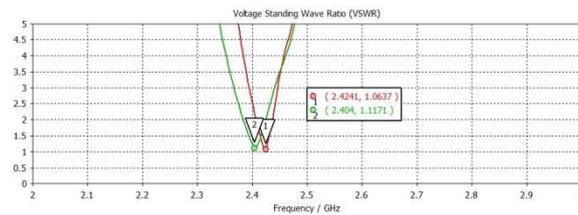
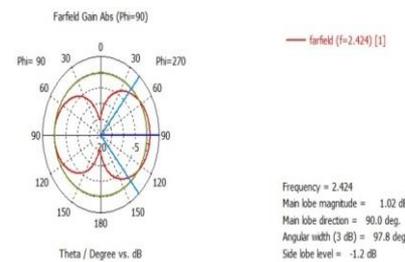


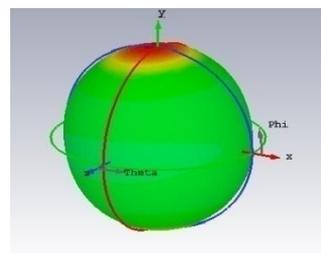
Fig. 3. VSWR

- Radiation Pattern:

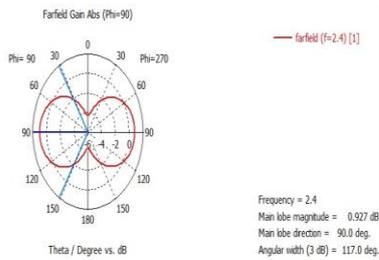
The 3-dimensional pattern and polar plot of the proposed implantable medical antenna are shown in fig. 4 a) and b) respectively. From the Patterns the directivity and Gain are displayed. The main lobe direction of the proposed antennas is shown for 90.0 deg and the main lobe magnitude has 1.05dB and 0.927dB. When compared the two structures the characteristics, radiation efficiency, Gain and Directivity are made compatible for the desired application. The antenna has Directivity which is defined as “the proportion of the radiation intensity of the antenna in a direction from an antenna to the radiation intensity averaged over all the directions.



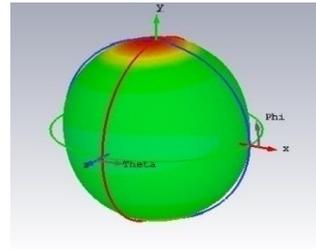
a) E -field



b) H -field



a) E -field

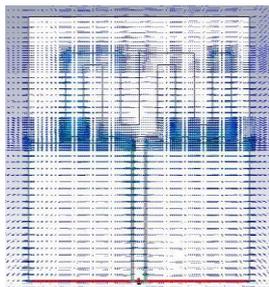


b) H -field

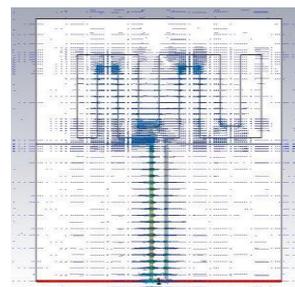
Fig. 4 a) Polar Plot b) 3 D radiation pattern

- E – Field and H – Field Pattern

The plane containing the electric field vector and the direction of maximum radiation is known as the Electric field plane and the Magnetic Field plane is called “the plane containing the magnetic field vector and the direction of maximum radiation. The Peak Electric Field and Magnetic Field value of Meandered shaped is obtained with the phase of 146.25 is $141.4e^{+03}$ V/m and 526.7 A/m. The Sharp Edged Meandered has the Peak Electric Field and Magnetic Field is $155.8e^{+03}$ V/m and 593.1 A/m respectively. The simulated results are shown in figures 5 and 6.



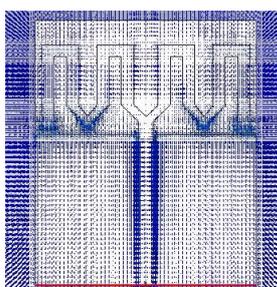
a)



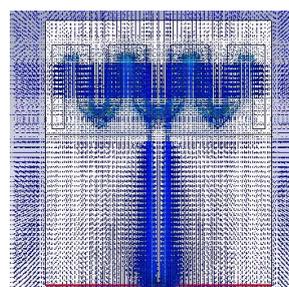
b)

Fig. 5. Current distribution of Meandered Shaped Antenna a) E-Field b) H-Field Pattern

The current distribution towards an antenna is an important parameter for an antenna. The complete report of its amplitude and phase permits the calculation of the Pattern of the proposed Implantable Medical Antenna. There are various numbers of techniques used to measure the current distribution. Therefore, the current distributions of the designed antenna are shown with the results which are simulated. The simulation process uses FDTD (Finite Difference Time Domain) analysis.



a)



b)

Fig. 6. Current distribution of sharp edged Meandered Shaped Antenna a) E-Field b) H-

Field Pattern

3. CONCLUSION

In highly performed antennas in satellite, aircraft and the utilization of the various fields, the low profile, weight, size and performance antennas may be required. The commercial applications are available in huge, such as biotelemetry, mobile radio and without wire connections, which have comparable features and specifications. To accomplish the specification and features the requirement is microstrip patch antennas. A compact rectangular patch with a combination of Meandered shapes is demonstrated for ISM band application. The S_{11} parameter was simulated, which shows the amount of the power mirrored and reflected with effect from the antenna. The designation given to the S_{11} is called a reflection coefficient. The antenna pattern and radiation pattern is “A Pictorial Representation of the radiation properties of the antenna. In huge cases, the antenna pattern is called a far-field region and it is the function of directional coordinates. The Radiation property of the antenna includes power flux density, radiation intensity, field strength, directivity, phase or polarization” of the antenna. The antenna meets the satisfied requirements. The simulation tool CST MW Studio uses FDTD analysis. The FDTD is known as Finite Difference Time Domain and it is defined as an analysis of numerical used for modelling of computational electrodynamics. The Electric field plane is briefed which is “the plane containing the electric field vector and the direction of maximum radiation,” and the Magnetic Field plane is defined by “the plane containing the magnetic field vector and the direction of maximum radiation”, therefore the principal pattern is difficult to illustrate. The content of a Body area Network or Personal Area Network covers a range of requirements and communication needs. Then it can be classified as In-body, On-body and Off-body. The criteria that are mostly considered for the selection of the most appropriate and efficient protocol in this scope are in various forms. The protocols are Data rate, Range, Low Battery power requirements, Safety, Reliability, Security and Data Latency. The simulation in CST MW software led to the reflection coefficient of -25.941 dB and -31.941 dB from 2 GHz to 5GHz. The acquired Gain and Directivity of the proposed Patch Antenna of the Meandered structure is 2.64 dB, 1.927 dBi and the Sharp Edged Meandered Patch is 2.97 dB, 2.02 dBi. To avoid this, the device may be configured with dual-band operation so that it can be operated in one band and put on sleep in another band. However, the proposed system can be modified to operate in the MICS band also in future. The microwave antenna will be used in the future for curing and monitor the patient without wire.

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