

Research/Technical Note

Implantable CPW fed M Shaped Antenna for Biomedical Applications

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Abstract: Implantable medical device has become very popular in medical sector for proper diagnosis and treatment. If, this devices are wireless, then it will very effective for remote communication. For this wireless communication, antenna is a suitable thing. So, this paper presents the design Implantable CPW fed M-shaped antenna for biomedical applications. Coplanar waveguide fed technique is used with ground plane in this antenna. The antenna is designed by Alumina ceramic (Al_2O_3) substrate and Copper ground plane with dimensions ($8\text{mm} \times 7\text{mm} \times 0.85\text{mm}$) and Silicon material of 0.1mm thickness is used as a coating for human body safety. This antenna works under 2.42 GHz resonate frequency of ISM band (2.40-2.48 GHz). The bandwidth percent of the antenna at -10dB is 7.66%. The return loss characteristic of the antenna is -56.96 dB. Based on the conductivity and permittivity of different tissue (such as: Muscle, Fat, Skin) a simple 3D human body phantom structure is designed for implantation of CPW fed antenna. The antenna is designed and simulated with the help of CST software. The antenna parameters such as: Return loss, Smith Chart, VSWR, Gain, SAR have been discussed in the paper.

Keywords: Implantable Antenna, Coplanar Waveguide (CPW), ISM Band, Biomedical Applications, Specific Absorption Rate (SAR), CST Software

1. Introduction

At presents, Different diseases such as: Diabetic, High per tension, Cancer, Heart attack etc have become a part of some human life. Old aged people suffer from these diseases very much. Regularly checkup is the best treatment of these diseases. But, Regularly checkup is very painful for old aged people at hospital or to the doctor. The implantable device has become an effective solution for these problems. Because, implantable device is that device which collects information from patient's body and sends it to external device by wirelessly [1, 2]. This wireless communication is done by antenna. In this case, Small implantable device is implanted inside human body very easily. For this small device, small antenna is much suitable. Antenna have been used in many medical applications such as: Biomedical telemetry, Wireless capsule endoscopy, Hyperthermia treatments, Microwave imaging, Microwave coagulation therapy [3-5]. The Industrial

scientific and medical (ISM) band (2.40–2.48 GHz) is allocated by FCC for medical applications. This band gives higher bit rates and high frequency [6, 7].

Recently, Implantable antenna have been reported by some researchers. In paper [8], an implantable medical antenna was proposed, which operating at 2.45GHz of ISM band. The bandwidth of this antenna was 40.3 MHz. An implantable dual spiral antenna has been proposed in the frequency 2.41 GHz of ISM band. The total size of this antenna was ($30\text{mm} \times 30\text{mm} \times 1.6\text{mm}$). The return loss of this antenna was -26 dB at 2.41 GHz [7]. A rectangular shaped implantable antenna were presented at 2.46 GHz of ISM band. The dimension of this antenna was ($17.635\text{mm} \times 17.325\text{mm} \times 1.3314\text{mm}$). The return loss of this antenna was -46.42 dB at 2.46 GHz [6]. Most of the implantable antennas proposed in literature have large size and complex shape. It is very difficult to implant into the human body for large size. So, Main purpose of this research is to reduce the size of antenna as much as possible at

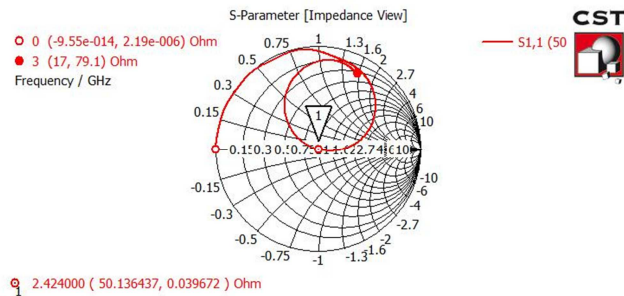


Figure 4. Smith Chart for 2.42 GHz.

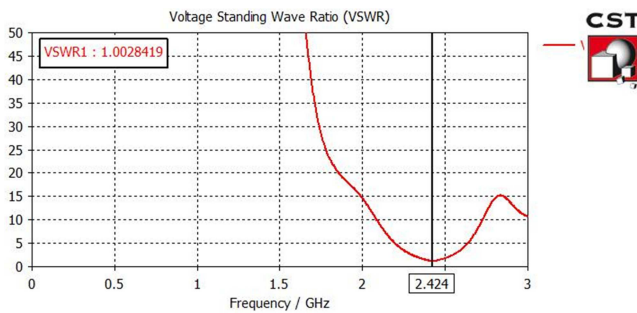


Figure 5. Voltage Standing Wave Ratio (VSWR) for 2.42 GHz.

From Figure 3 it can be seen that the resonant frequency of the antenna is 2.42 GHz and return loss is -56.9607 dB. Bandwidth of antenna can be calculated from return loss graph. The bandwidth is 185.6 GHz (2.5158-2.3302 GHz) covering the ISM band (2.40 - 2.48 GHz). The bandwidth percent of the antenna at the standard value -10 dB is 7.66%.

The smith chart represents how the antenna impedance varies with frequency. The smith chart plot of the proposed antenna shown in Figure 4. From the simulation result, It is clear that, the impedance value is 50.1364+0.0396 ohm at 2.42 GHz.

The voltage standing wave ratio (VSWR) is the measure of how well the antenna terminal impedance is matched to the characteristic impedance of transmission line. VSWR of the proposed antenna is shown in Figure 5. The VSWR of the proposed antenna is 1.0028 at resonant frequency 2.42 GHz. Which is suitable for this antenna.

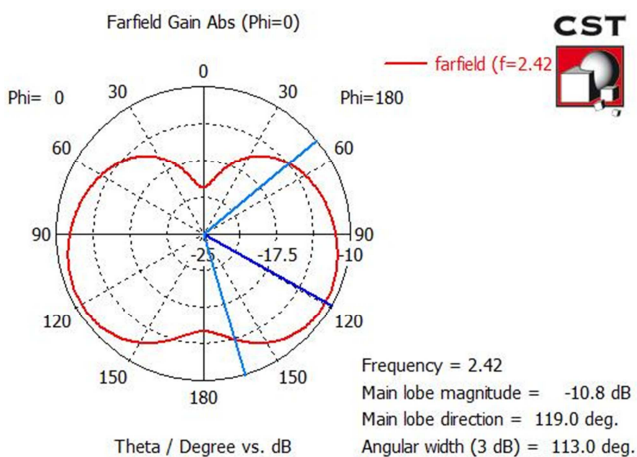


Figure 6. E plane gain for 2.42 GHz.

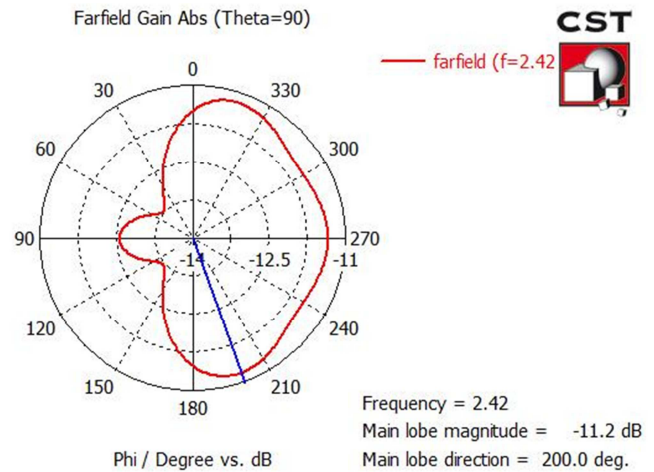


Figure 7. H plane gain for 2.42 GHz.

Frequency = 2.42
Main lobe magnitude = -11.2 dB
Main lobe direction = 200.0 deg.

Figure 7. It can be seen that at frequency 2.42 GHz, E plane gain is -10.5 dB and H plane gain is -11.2 dB. Main lobe direction is 119 degrees at 2.42 GHz for E plane and 200 degrees at 2.42 GHz for H plane.

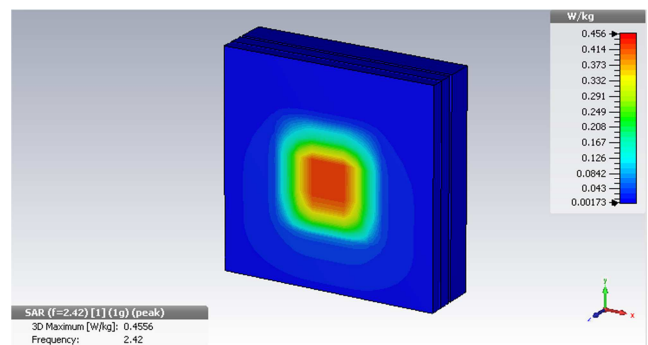


Figure 8. 1-g averaged SAR for 2.42 GHz.

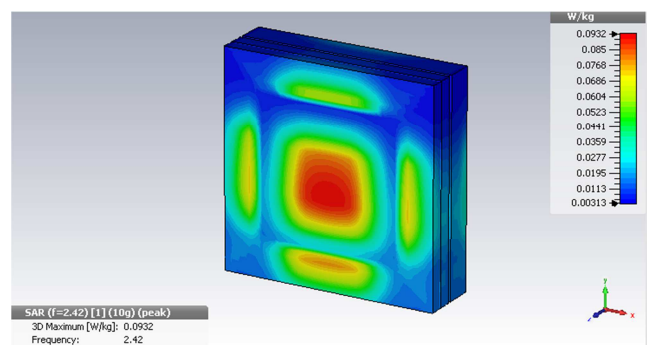


Figure 9. 10-g averaged SAR for 2.42 GHz.

Specific absorption rate is a measure of how much transmitted RF energy is absorbed by human tissues. IEEE C95.3-2002 standard says that for an input power of 2mW, the 1-g averaged SAR should not exceed 1.6 W/kg as given by FCC and ICNIRP guidelines for public exposure [6].

In this research, 1-g averaged SAR (in Figure 8) is 0.456 W/kg and 10-g averaged SAR (in Figure 9) is 0.0932 W/kg

for an input power of 2mW.

4. Conclusion

The Implantable CPW fed M-Shaped antenna has been designed for biomedical application with dimensions of (8mm × 7mm × 0.85 mm) in the ISM band (2.40-2.48 GHz). This antenna have been simulated in (60 mm × 60 mm) bio-tissue. The designed antenna resonates at 2.42 GHz and provides a bandwidth of 185.6 MHz. Due to its wideband property, this antenna can be used for remote distance health monitoring system. Size reduction and biocompatibility are main focus of this antenna design. For size reduction, high dielectric material is used and for biocompatibility the antenna is encased in a biocompatible material. Considering all these factors the antenna is designed using Alumina Ceramic (Al₂O₃) substrate inside human body phantom model and silicon coating of 0.1 mm is used as a biocompatible material for human body safety. Due to superior permittivity of the Alumina ceramic substrates, implantable antenna exhibits lower return loss (-56.961 dB), good VSWR, better impedance matching with CPW structure. Therefore, the proposed antenna is proper structure for ISM band frequency of biomedical engineering.

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