Body Implantable G-shaped patch antenna operates in MICS band

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***Abstract*— This paper describes a novel design of G-shaped micro strip patch antenna within the MICS (402.0-405.0MHz) band. The Performance of designed antenna is analyzed in free space as well as inside in human phantom model with different conducting material. In this design, the height of the antenna is considered as 1.5mm from the ground plane. At resonance frequency of 404 MHz the S11 parameter is obtained in free space is -16.35 dB for conducting material of Gold and -15.66 dB is inside human phantom model. FR4 is used as substrate material. The Specific absorption Rate (SAR) is also found to be 0.0134 W/kg after implemented inside the human phantom model. VSWR and directivity has been analyzed also.**

Keywords — ***Implantable Antennas, MICS band, G- shape, Farfiled, Return Loss, VSWR, SAR.***

I. INTRODUCTION

In the fast-changing global world, IMDs has a significant role and remarkably popular for maintaining safety and security of patients. Some benefit of IMDs are like diagnostic, monitoring temperature and so on [1]. It can be implemented in human body through surgical operation [2]. Besides these biomedical sensors has significant role in bio telemetry sector. These sensors recover functional limitations with the sufficient existence interstitial. And at the result these can get efficient and effective output [3].

Medical implantable devices are allowed various frequency band. Most of the medical application are in MICS(401-406MHz) band [4]. Industrial Scientific and Medical (ISM) band(2.4-2.4835GHz) is used for PIFA (planer Inverted F-antenna), circular, square and many more types of antennas[4]. For the wireless communication, a low-profile antenna is required which supports multiband and wideband operations. Planar Inverted-F Antenna is met these requirements. This antenna is compact, has minor inverted radiation and has quarter-wavelength patch [5].

Millions of people now-a-days rely on implantable medical devices for surviving and developing standardization of their lives [6]. Moreover, it's challenging for such type of prototype fabrication of miniature antenna to provide them with tolerance of the potential experimental vs numerical inconsistencies [1]. Biomedical sensors also play a significant role in this field. Though this sensor has specific limitations with the availability of interstitial fluid which encompass it, it helps to operate successfully [7].

In this work a G-shaped patch antenna has designed with 404MHz of resonance frequency for medical applications. Return loss (S11), Directivity, VSWR and SAR are observed by changing different conducting material. Radiation pattern and antenna performance in far field region is also observed.

II. EXPERIMENTAL DESIGN

To design the antenna, three-layer structure is used and that are ground layer, substrate layer and the microstrip patch layer. Antenna is designed in free space. To get the MICS frequency band, the antenna is optimized by length, width, and also slot size.

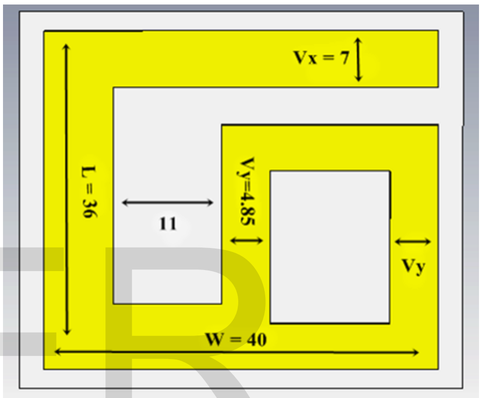

Fig.1. Designed G-shaped Antenna

The patch of the G-shaped antenna is designed width of 40mm and the length is 36mm.Each layer thickness is designed with 0.5mm. For designing the Antenna FR-4 substrate material is used. The patch material is considered as copper, aluminum and gold for performance analysis.

The antenna is designed by CST Microwave studio which is performed in free space. By changing the substrate and patch material performance is measured in the free space.

TABLEI. I ANTENNA SIZE PARAMETER

Parameter and size for G-shaped	
Parameter	**Size**
W	40mm
L	36mm
Mt	0.5mm
Wf	5.6mm
H	1.5mm
Gp	12.2mm
Vx	7mm
Vy	4.85mm

III. SIMULATED RESULT

In CST microwave studio the input impedance was set to 50 ohms to observe the performance of antenna. The initial frequency was taken from 0 to 2GHz.

A. Simulated Result for G-shapde Antenna (free space)

For G-shaped antenna S_{11} parameter is observed in the figure-2 and the value of S_{11} is obtained -16.12dB, -16.23dB, and -16.35dB respectively for the conducting material of copper, aluminum and gold. Here the substrate material is used FR-4. The reflected power from the antenna is known as the S_{11} and the value is always should be less than -10dB.

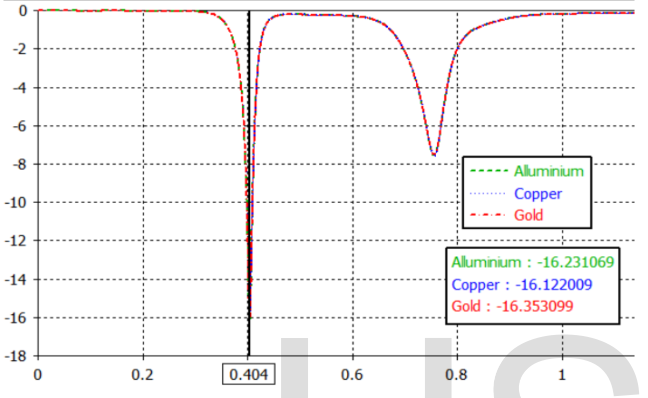

Fig. 2. S11 parameter of G-shape antenna in free space

The polar view of the G-shaped antenna is shown in figure-3. Main lobe of an antenna means the maximum power containing of this lobe. There are also side lobe of an antenna. Here is shown the polar view and main lobe magnitude of aluminum material. The main magnitude of the lobe is 1.89 dBi and the main lobe direction is 100.0 degree.

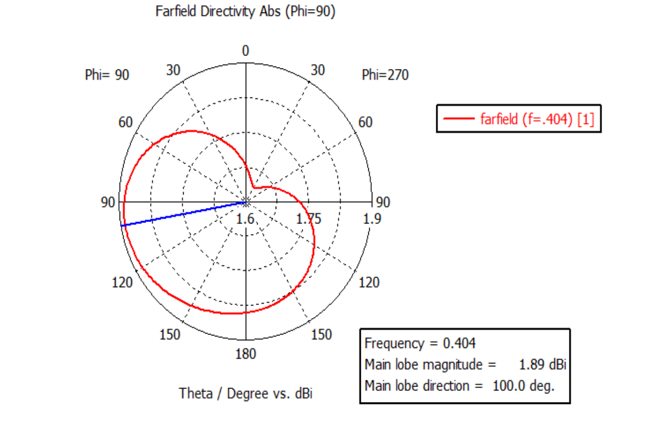

Fig. 3 Polar view of G-shaped antenna

The Far-field radiation pattern is shown in figure-4. For all the conducting material Far- field region are almost same. The directivity of the G-shaped antenna is found 1.952dBi. Total efficiency of this antenna is observed -36.62 dBi.

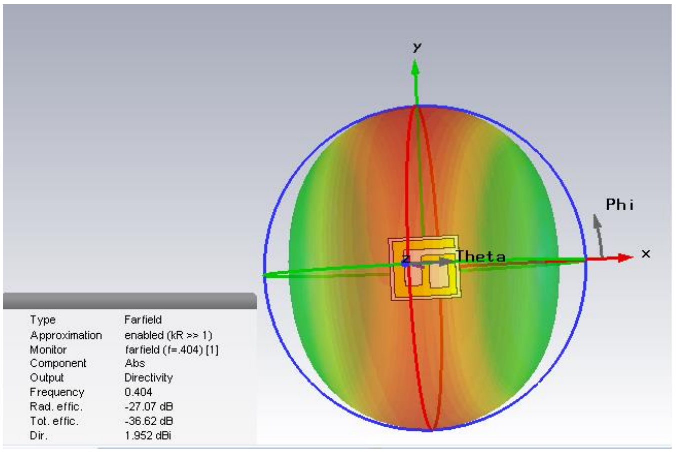

Fig. 4. 3D view of Far-Field Region of the G-shaped antenna (in free space)

VSWR (voltage standing wave ratio) is observed 1.358 at resonance frequency of 404 MHz in figure-5. By changing the conducting material, we found almost same result. VSWR means the function of reflection coefficient. It is measured by the flowing equation.

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

VSWR is always a real and positive number for antennas [8].

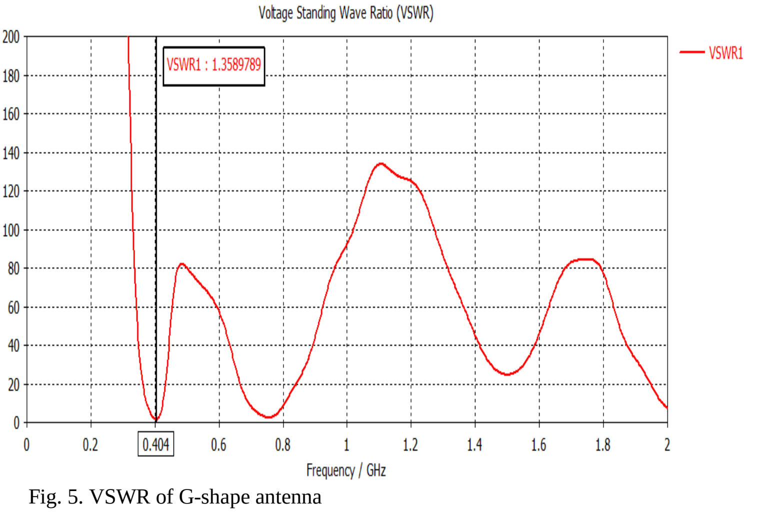

Fig. 5. VSWR of G-shape antenna

B. Simulated G-shaped Antenna in Phantom Model

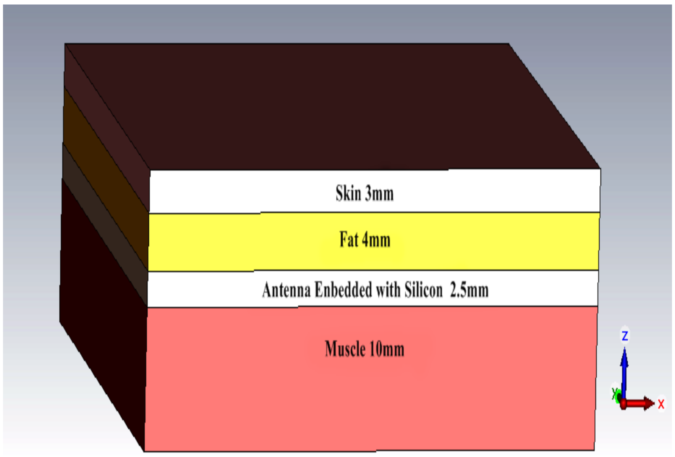

Fig. 6. G-shaped Antenna inside human phantom model

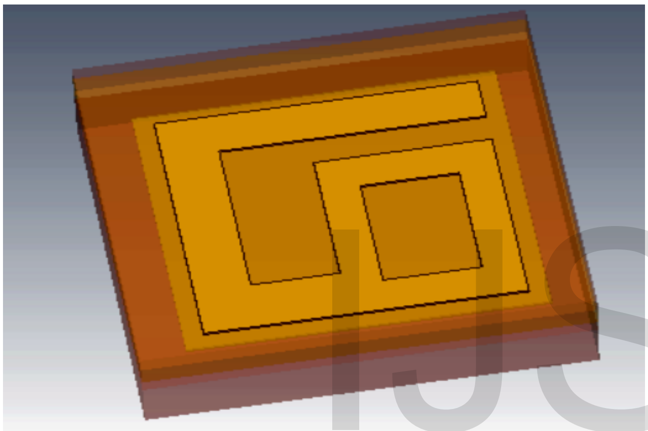

Fig.7 Antenna inside in human tissue model

In figure-6 and figure-7 it can be seen that the designed antenna is implanted into human phantom model which consist of 3mm Skin, 4mm Fat and 10mm Muscle. It has been observed that the S11 parameter is obtained -15.66dB inside human tissue which shown in Fig-8. Here the substrate material is used FR-4 also. The resonance frequency of the G shaped antenna is 404 MHz, which is in MICS band.

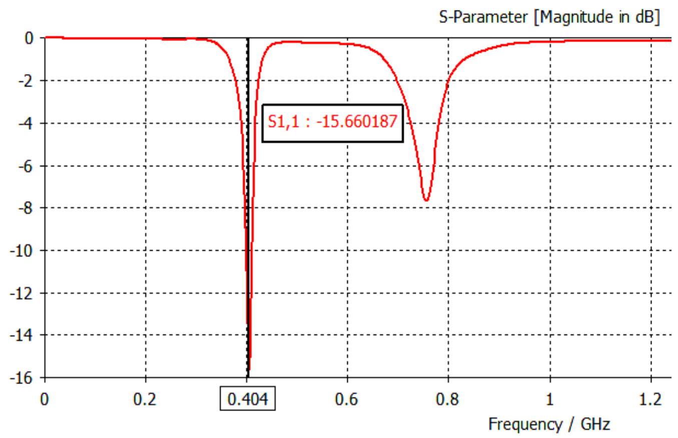

Fig 8. S11 parameter of G-shaped antenna into human phantom model (Muscle)

The bandwidth of the antenna can also be calculated by drawn a straight line at -10dB. From figure-8 the bandwidth is found 5MHz (403MHz- 408MHz).

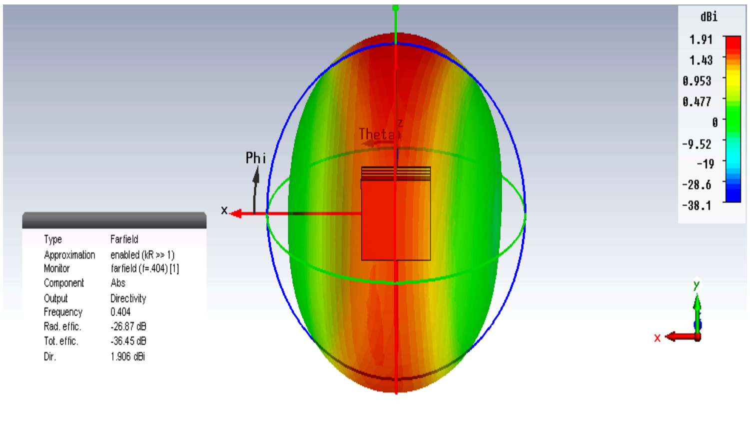

Fig 9. Far –field Radiation Pattern view (in 3D) of the antenna on phantom model for muscle.

3D view of Far-Field Region of the G-shaped antenna is shown in figure-9. Here the directivity if the antenna is observed 1.906 dBi. The total efficiency is found -36.45 dBi. For all the conducting material, far-field region are observed. The directivity for other conducting material are closed to this result.

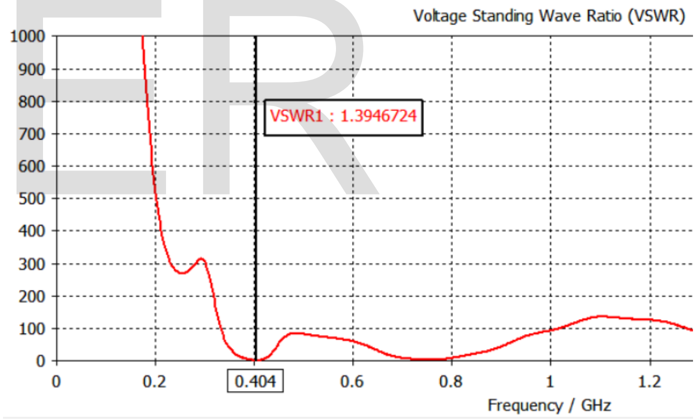

Fig 10. VSWR plot of the antenna on phantom model for Muscle.

In figure-10 the VSWR is found to be 1.3946 at resonant frequency of 404 MHz which is below the acceptance value of 2.

Specific Absorption Rate (SAR)

The SAR is measured on Human Phantom Model (Muscle), as seen in figure-11. The Standards for SAR calculation was regulated by IEEE C95.3-2002 standard, where the1-g average SAR should not be exceeded 1.6 W/kg as given by FCC and ICNIRP guidelines.

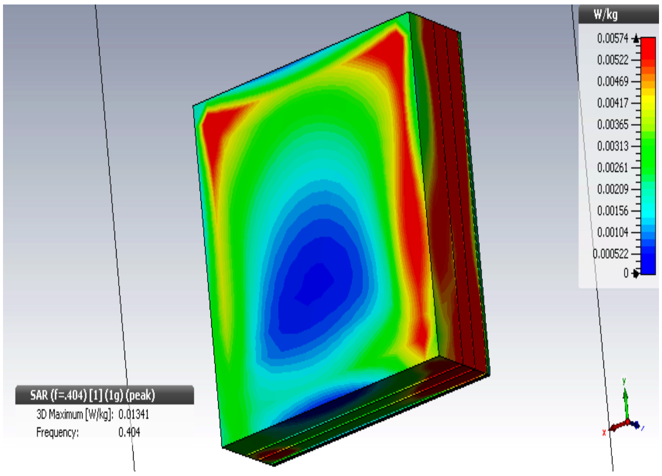

Fig 11. SAR distributions for an input of 1 mW on human phantom model (Muscle).

After implanted inside Human Phantom model (Muscle) it has been observed that the SAR is found to be 0.0134 W/kg which is below the mark to fulfill the ICNIRP and FCC guideline regarding safety issue.

TABLE II
Performance analysis of G shape antenna

G-shaped antenna		
Substrate material	**Conducting material**	**S11**
FR-4	Copper	-16.12
	Aluminum	-16.23
	Gold	-16.35

Table II is shown which conducting material gives the better performance at the resonance frequency. It is noticed that Gold gives the better performance inside the human phantom muscle model.

IV. CONCLUSIONS

A G-shaped patch antenna is designed in this research for biomedical application. This designed antenna is implantable in human Phantom body model (muscle) to test the workability in bio environment. The return loss is measured -15.66dB inside human tissue at the resonant frequency of 404 MHz. Voltage Standing Wave Ratio (VSWR) is found to be 1.3946 which were also very good to support the criteria of the in body biocompatible antenna. Far-field radiation pattern & Specific Absorption Rate (SAR) of 0.0134 W/kg showed the directivity & safety measurement of the antenna which is very much satisfactory in biomedical applications.

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