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DESIGN AND IMPLEMENTATION OF MICROSTRIP PATCH ANTENNA USING METAMATERIALS FOR BIOMEDICAL APPLICATIONS

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ABSTRACT

In this workcircularmicrostrip patch antenna using rectangular spilt ringmetamaterial unit cell is designed, simulated and analyzed. The rectangular split ring metamaterial unit cell and conventional circular microstrip patch antenna are designed using FR-4 substrate with dielectric constant 4.4. The overall dimensions of conventional circular microstrip patch antenna and rectangular split ring metamaterial unit cell are 62X36X1.6mm^3, 20X20X1.6mm3respectively. Then designed metamaterial unit cell is loaded on the ground plane of conventional circular microstrip patch antenna is resonated from 2.34GHz to 3.4GHz with overall bandwidth of 200MHz. Simulated results include bandwidth gain VSWR and radiation pattern. The proposed circular patch Antenna is compared with the conventional circular patch antenna, which shows the significant miniaturization as compared to conventional circular patch antenna hence the proposed antenna shows good results and it is well suited for biomedical application wireless devices.

***Keywords**:CircularMicrostrip patch antenna,Rectangular split-ring,biomedicaldevice, Bandwidth*

I. INTRODUCTION

In Recent years, need for the deployment of wireless telemetry systems in medicine has significantly increased due to necessity for early diagnosis of diseases and continuous monitoring of physiological parameters.Microwave antennas and sensors are key components of these telemetry systems since they provide the communication between the patient and base station.Nowadays, the major microwave applications in the medical field are in data telemetry, medical diagnosis and treatment (see in Figure 1.1).

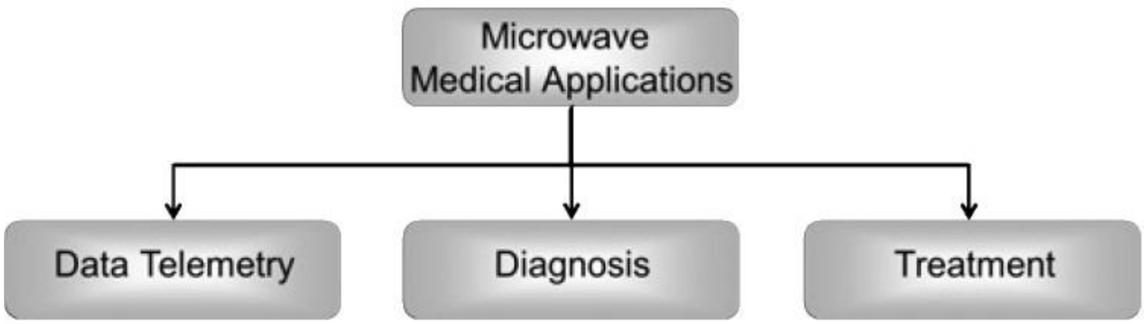

Figure1: Three major medical applications

Data telemetry: Data telemetry refers to wireless data transmission using microwaves between implanted medical devices (IMDs) and external devices. Due to the rising demand of health care products, IMDs have gained much interest for healthcare providers. Examples are: bladder stimulators and pacemakers, glucose monitoring for diabetics, which are widely usedwith the use of traditional IMDs, the wires used to connect to the devices for the diagnosis signals increase the pain and risk of infection in the patients. With the help of wireless link, the continuous monitoring of the state of implanted devices can also be achieved.

Medical diagnosis using microwaves: The applications for medical diagnosis are used in the detection of breast cancer, stroke, water accumulation in human body, etc. Among these, one of the most important applications of medical diagnosis is the detection of breast cancer, which is the most dangerous form of cancer among women. Approximately one million women around the world suffer from breast cancer. Therefore, technologies with high accuracy and sensitivity to detect the presence of tumors are required. An almost pain-free examination with a short examination time and a portable apparatus is especially desirable for the detection of early-stage breast cancer.

Medical treatment using microwaves: Medical treatment using microwaves is based on using the heat generated by microwave radiation to increase the local temperature to destroy the abnormal tissues (e.g. malignant tissues). This technique is more sensitive and effective compared to ionizing radiation (i.e. X-ray) and chemical toxins (i.e. Chemotherapy).

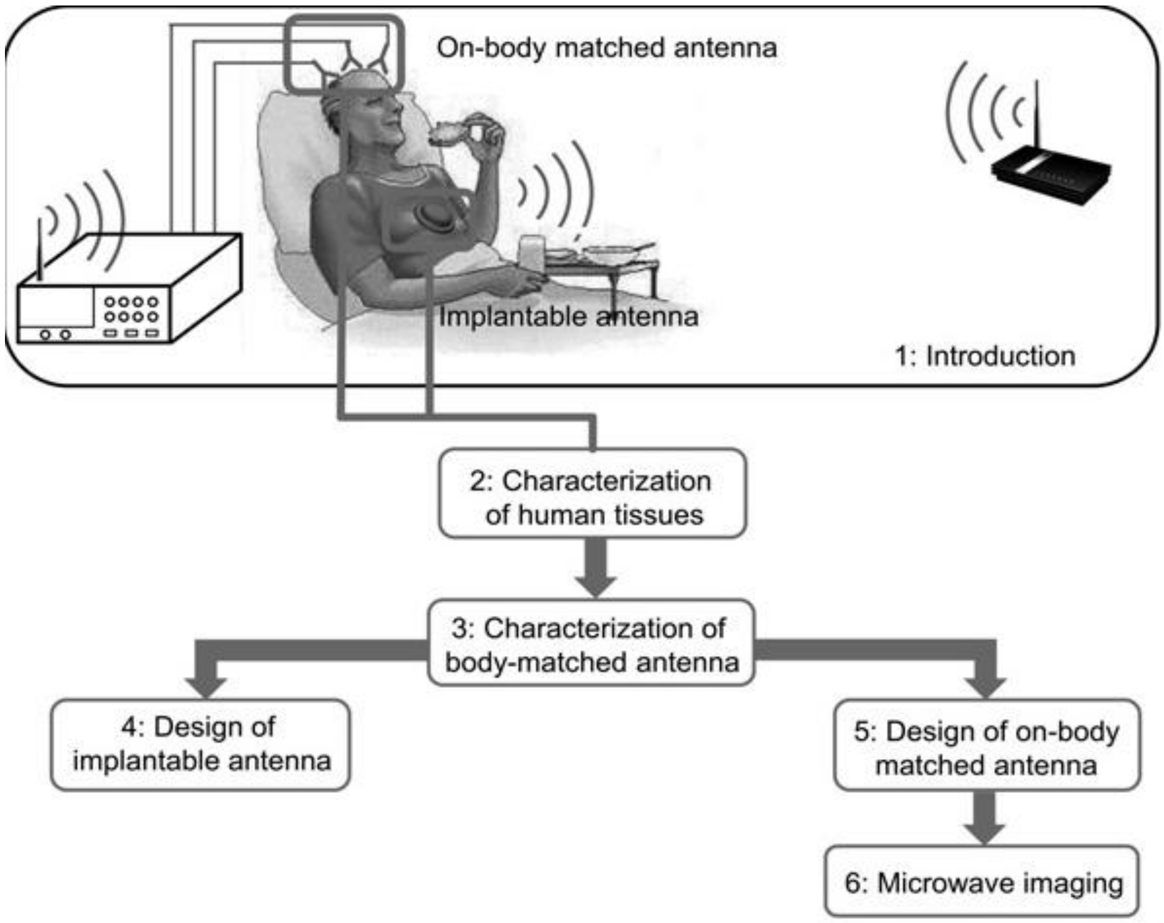

Figure 2: Vision of the telemedicine for nursing home residents using microwaves and the goal as well as organization of the work to realize these applications.

Telemedicine refers to the use of telecommunication for the transmission of health information to deliver clinical healthcare from a distance .A vision of the future telemedicine for a healthcare system for nursing home residents using microwaves is illustrated in Figure 2. The medical diagnosis system serves to monitor health problems such as stroke for prompt diagnosis and treatment. On the other hand, the data transmission between IMDs and external devices are performed simultaneously. In this way, the combination between medical diagnosis and data telemetry using microwaves contributes very positively to the existing healthcare services. In the data telemetry of this healthcare system, the physiological data (temperature ,blood pressure, glucose concentration) or vital signs (such as respiration ,heart beating, etc.) are monitored by sensors integrated on the implants .The implants are wirelessly powered by an antenna at a certain frequency(usually very low frequency in the MHz range). The wireless data transmission between implants and external medical devices is performed at a high frequency (in the GHz range) at the medical center, the received data is forwarded to the healthcare practitioner to evaluate the patient's status. In the case where abnormalities are detected, the doctor is immediately informed so that necessary actions can be initiated in time. The vision shown in Figure 2 is the development of suitable antennas for IMDs and medical diagnosis using radar imaging. For such applications, the antenna for radiating and receiving the signals is the governing factor of the SNR of the overall system.

Metamaterials are artificial materials which have the electromagnetic propertiesthat may not be found in nature. The unusual properties of a metamaterial have led to thedevelopment of metamaterial antennas, sensors and metamaterial lenses for miniature wireless systems which are more efficient than their conventional counterparts. Metamaterialsexhibita very sensitive response to the strain, dielectric media, chemical and biological sensing applications. The design concept of metamaterial circular microstrip patch antennas in ISM band is presented by using FR4 substrate with 4.4 dielectric constant and result shows well suited for biomedical applications.

II. RECTANGULAR SPLIT RING METAMATERIAL STRUCTURE (RSRM):

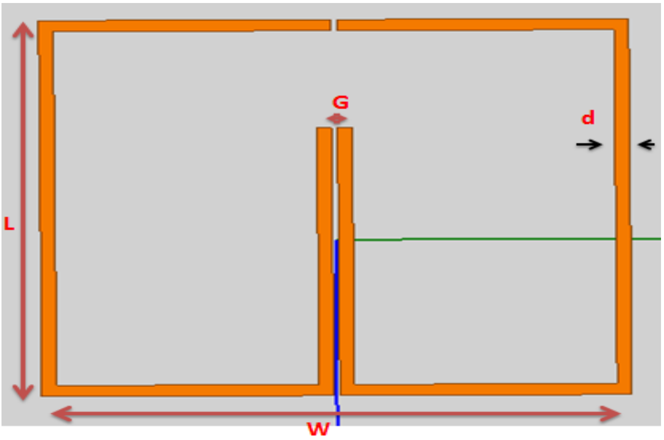

Figure3: RSRM Unit Cell

An attractive properties of metamaterial is that plane wave propagating in the media would there phase velocity antiparallel with group velocity so that media would support backward waves. In this paper we proposed a periodic rectangularsplit ring resonator structure (SRSM) a unit cell is depicted in figure 3.This metamaterial SRSM unit cell is composed of two nested spilt rings, which are etched on a FR4 substrate of a dielectric constant of 4.4. The dimension of the unit cell is shown in table 1. The resonance frequency of this rectangular split ring unit cell structure depends on the gap dimension (*g*). By increasing the gap, the capacitance in LC circuit model of the unit cell decreases. The decrement of the capacitance, results the increment of the resonance frequency of the structure.

Parameters	Dimensions(mm)
Length of the substrate	30
Width of the substrate	30
Length of rectangle split ring , L	20
Width of rectangle split ring, W	20
Thickness, d	0.03
Gap, G	0.2
Distance between the split ring	0.2

Table1: Dimensions of RSRM

In all of the previous work, slot loaded miniaturized patch antennas were used in biomedical applications. Such patch antennas were never extended and analyzed by metamaterialstructure.Hence here we designed rectangular split ring metamaterial structure and it loaded on ground plane of the conventional circular microstrip antenna so that we achieved 75% of size reduction and good amount of bandwidth and gain for biomedical and wireless applications.

III. ANTENNA DESIGN

A. Conventional Microstrip Patch Antenna

In this paper we proposed a circular microstrippatch antenna having radius 16.3mm using Fr-4 substrate with 4.4 dielectric constant and having thickness of the substrate 1.6mm .The overall dimension of the circular microstrip patch antenna are shown in table2.and conventional circular microstrip patch antenna as shown in figure 4 .

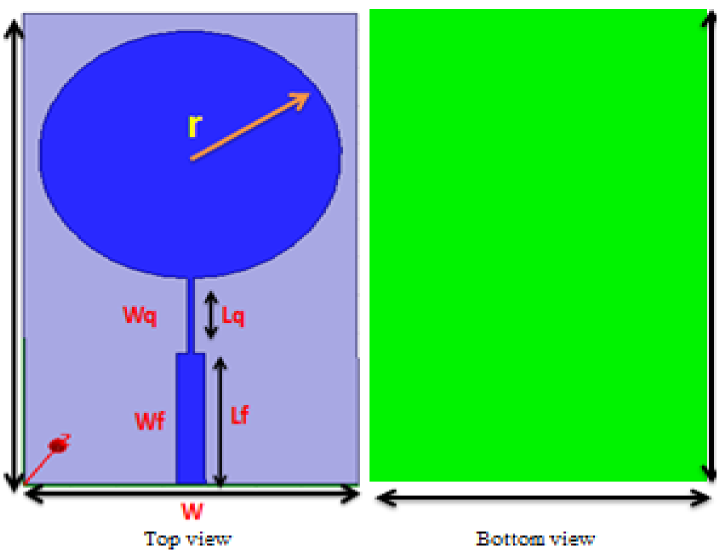

Figure4: Conventional CircularMicrostrip Patch Antenna top view

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Parameter	Dimensions (mm)
Radius, r	16.3
Length of the substrate, L	62
Width of the substrate, W	36
Quarter wave length of thefeed line, Lq	10
Quarter wave Width of the feed line, Wq	0.7
Length of thefeed line, Lf	17.11
Width of the feedline, Wf	3.059
Thickness of the substrate	1.6

Table2: Dimensions of the Conventional Microstrip Patch Antenna

B. MetamaterialMicrostrip Patch Antenna

In this work designed rectangular split ring metamaterial structure loaded on the ground plane of the conventional circular microstrip patch antenna so that we etched the RSRM structure on the ground plane of the conventional microstrip patch antenna, so that RSRM structure is actively coupled with conventional circular microstrip patch antenna hence it shows that the antenna miniaturized to 75% of size reduction as compared to conventional circular microstrip patch antenna, and it supported 200MHz bandwidth as well as 2.4dB gain more than conventional microstip patch antenna bandwidth and gain was 100MHz, 2dB respectively. The designed metamaterial circular microstrip patch antenna is shown in figure 5.after that by varying the width and gap of the metamaterial structure parametric studies was done for the better improvement of bandwidth and gain and efficiency for biomedical applications. so that here we simulated and compared conventional microstrip antenna result with proposed met material micro strip patch antenna.

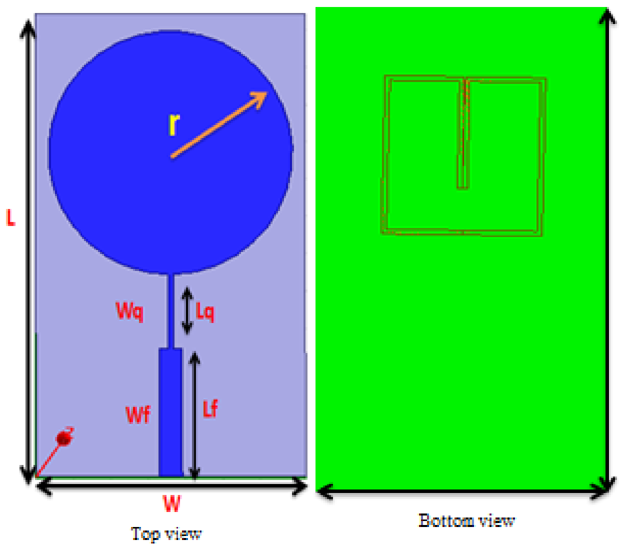

Figure5: Metamaterial Circular Microstrip Patch Antenna top and bottom view

IV. RESULTS:

In this section we are presenting the design and simulated results for the conventional microstrip patch antenna as well as metamateialmicrostrip patch antenna , in the following section first we presented all the conventional

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antenna results like scattering parameter, bandwidth, gain, VSWR, radiation pattern after that we presented our proposed metamaterialmicrostrip patch antenna for the same parameter like scattering parameter, bandwidth, gain, VSWR, radiation pattern, then we summarized the result in table 3

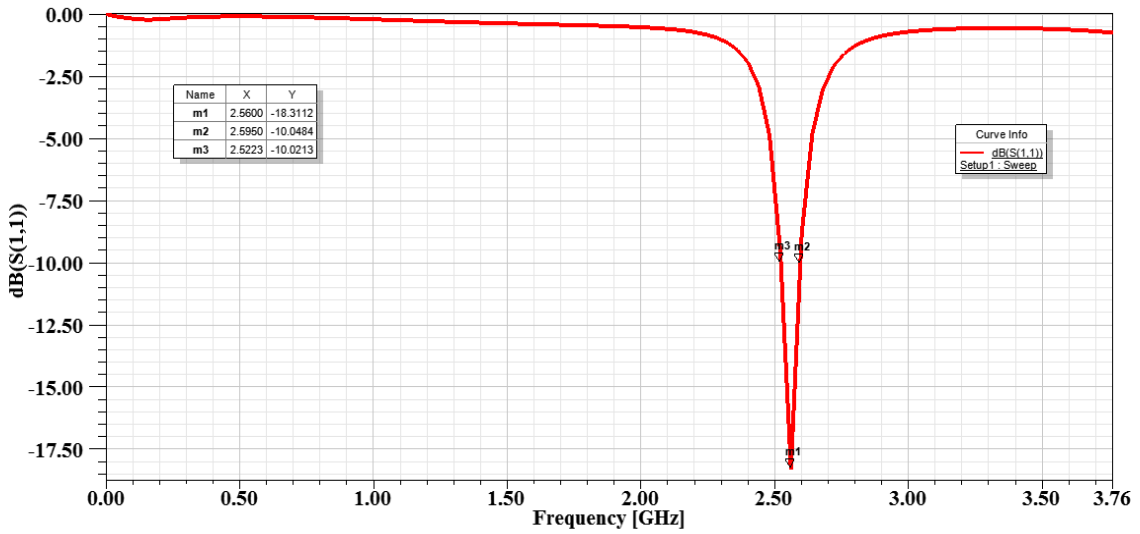

Figure6: Reflection coefficient of conventional microstrip patch antenna

Figure 6 shows the reflection coefficient conventional microstrip patch antenna is that -18.31dB at 2.56GHz and it supported bandwidth 100MHz.

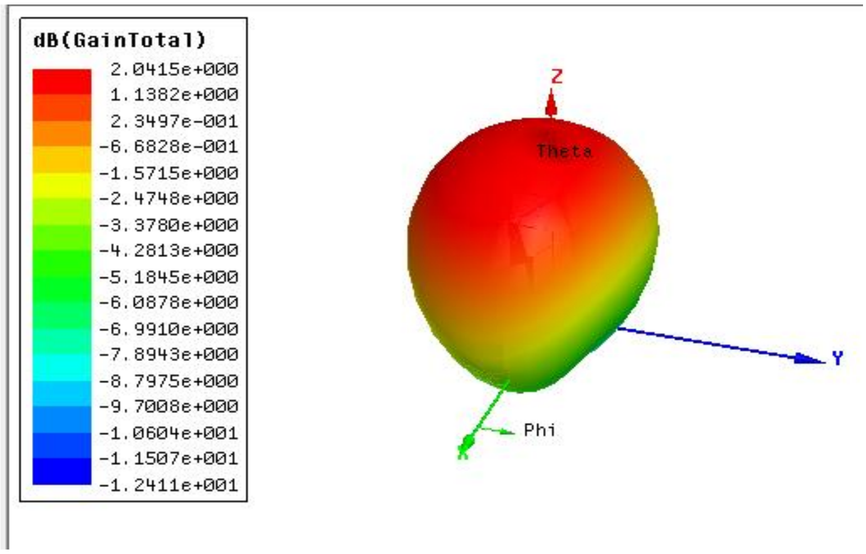

Figure 6: 3D gain pattern of conventional microstrip patch antenna

Figure 6 show that conventional microstrip patch antenna supported gain is about 2dB, and figure 7 show the VSWR of conventional microstrip patch antenna is 1.27.

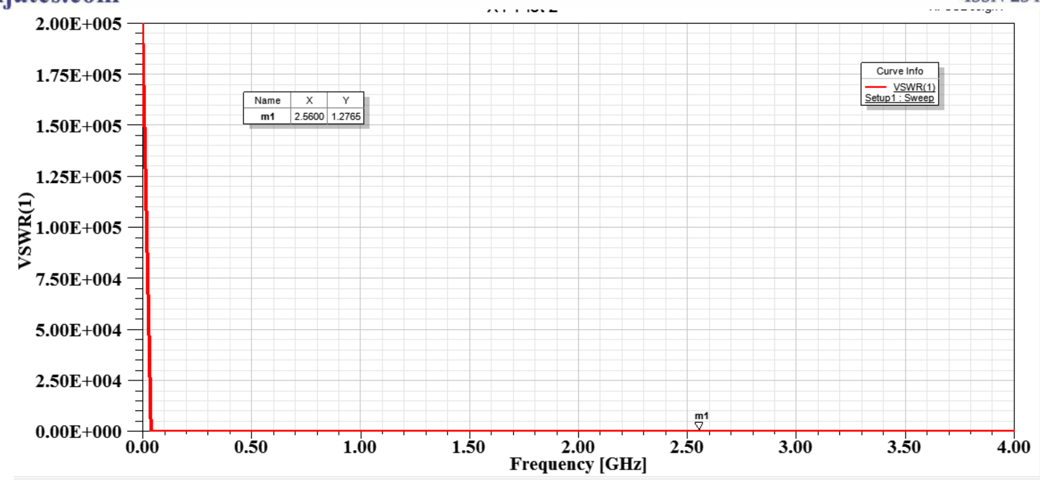

Figure7: VSWR of conventional microstrip patch antenna

The radiation pattern and current distribution pattern of conventional circular microstrip patch antenna are shown in figure 8 and figure9 respectively. And figure 10 shows the proposed metamaterial circular microstrip patch antenna reflection coefficient bandwidth here the proposed antenna resonate a dual band frequencies are 2.32GHz and 3.4GHz with supported 200MHz bandwidth, so that as compare with conventional microstrip patch antenna we achieved 75% of size reduction as well as increased in bandwidth and it resonate at dual frequencies. Figure 11 show the gain parameter of the proposed antenna is 2.4dB hence proposed antenna gain improvement far better than conventional microstrip patch antenna. Figure 12 and figure 13 shows the VSWR and radiation pattern of the proposed metamaterial circular microstrip patch antenna.

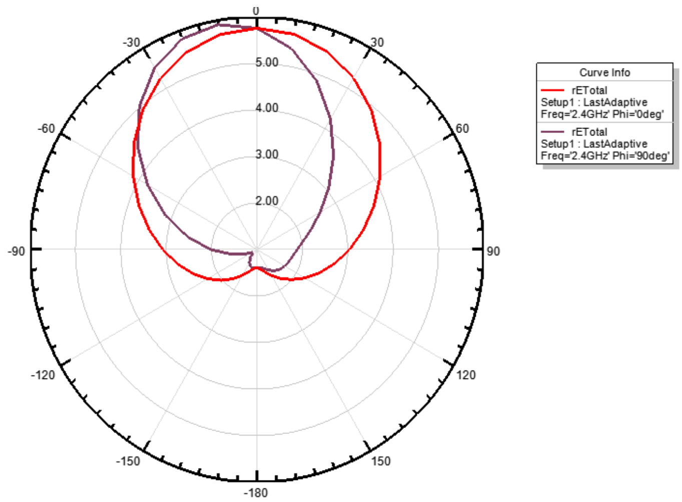

Figure 8: Radiation pattern of conventional microstrip patch antenna

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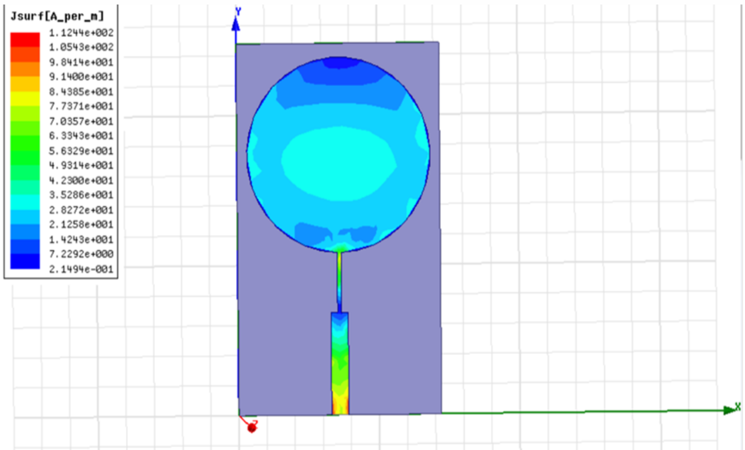

Figure 9: Current distribution of conventional microstrip patch antenna

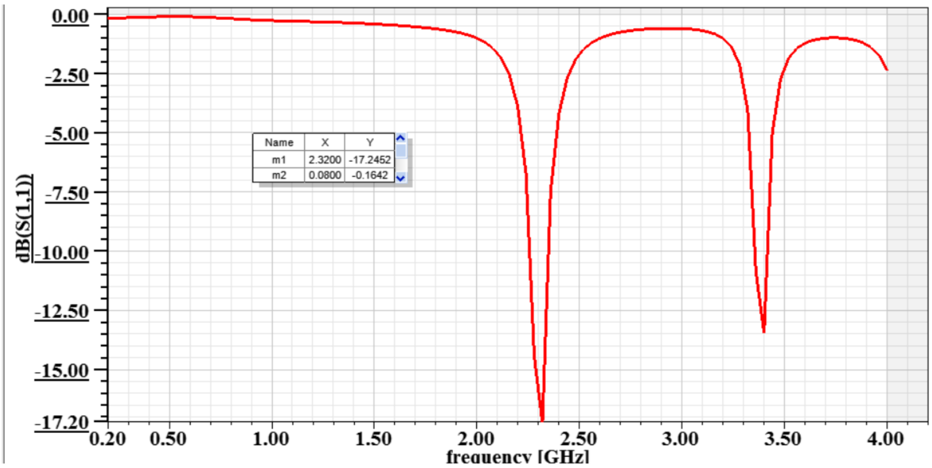

Figure 10: Reflection Coefficient ofMetamaterialmicrostrip patch antenna

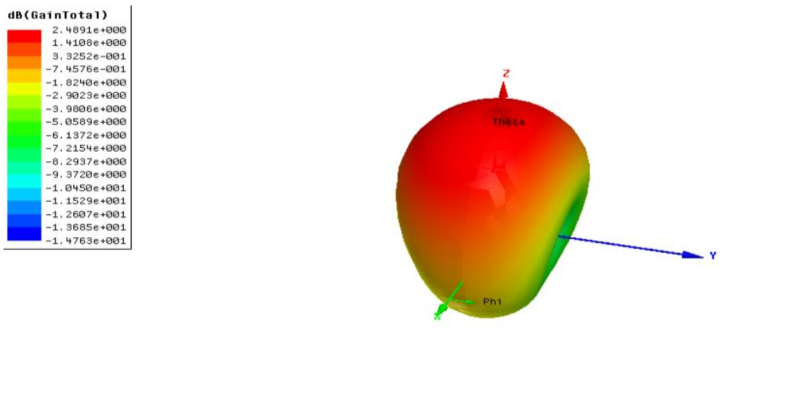

Figure 11: 3D gainpatternofMetamaterialmicrostrip patch antenna

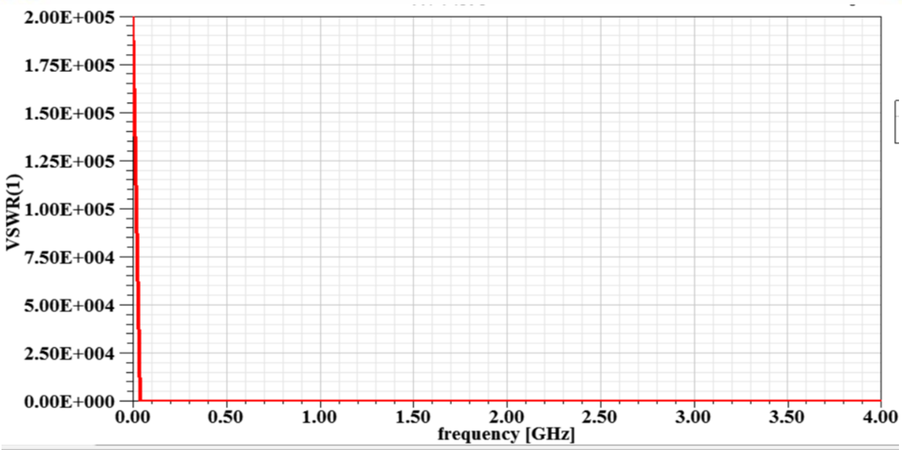

Figure 12: VSWRofMetamaterialmicrostrip patch antenna

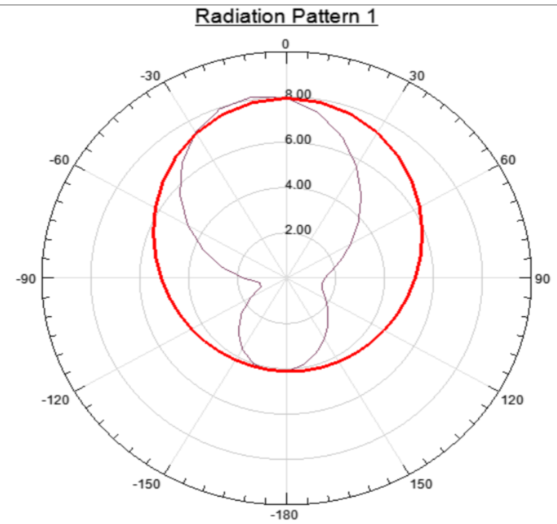

Figure 13: Radiation patternofmetamaterialmicrostrip patch antenna

Parameters	Conventional Antenna	Proposed Antenna
Resonating Frequency	2.56GHz	2.32GHz, 3.4GHz
Reflection Coefficients	-18.31dB	-17.20dB, -13dB
Bandwidth	100MHz	200MHz
Gain	2.0dB	2.4dB
VSWR	1,21	1.21

Table 3: Compression of conventional and proposed microstrip patch antenna

V. CONCLUSION

A new antenna has been designed and simulated using rmetamaterial at the frequency range of 2.3GHz-3.4GHz. Bandwidth of 200MHz.Theproposed Circular microstrippatchantenna with metamaterial gives a multiband operation compared to conventional microstrip patch antenna.Byanalyzing the simulation result, it is found that the bandwidth and gain is also increased by using metamaterial structure. Further the size of antenna is also reduced. Such a compact multiband microstrip antenna is well suited for biomedical and wireless applications.

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