Volume 9, Issue 6
December 2020

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

Design of Flower Shaped Antenna for Medical Applications

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ABSTRACT

In a medical world, the wearable planar antenna is high in demands these days and its advantages motivate the researcher to work in these field. These antennas also increased the utility of wireless body area network (WBAN). An isolated accessing unit and body embedded unit is very helpful in the medical application as in insulin injectors, glucose monitoring, active tremor control therapy and endoscopy. Body insert able devices are widely researched now days as they are helpful in monitoring purpose. Wearable antennas can be embedded into human body or placed over the skin to make communication system between body and biotelemetry system. Isolate accessing systems facilitate the detection of diseases. It reduces the hospitalization period. Use of flexible material for wearable antenna is in trends. In this proposed work, we have designed a novel circular flower structured micro strip antenna with compact ground plane. HFFS simulator is used to design the proposed antenna. Successive second iterations are performed to achieve the gain of 2.8 dB, 4.56 dB and 6.43 dB. Furthermore, microstrip feed is utilized to obtain efficient results. Return loss of 24.90 dB, -12.6 dB and 12.3 dB achieved in the present work. The proposed design gives better result in terms of gain, spectrum, radiation pattern, directivity, axial ratio, return loss. Proposed design finds its application in UWB, K/Ku band employments.

Keywords: Wireless Body Region Network, Flexible antenna, Planar Antenna, Wearable Antenna

1. INTRODUCTION

To monitor our health and sending a biological signals, wearable devices plays an important role in biological communication. The requirements for these devices are small in size, flexible in design, robust, reliable, cheap and low maintenance requirements. Antenna in these devices plays a vital role. To Achieve these requirements many research work is done to minimize its size using various different techniques in the designing of these antennas. Wearable antenna has great future as wireless technologies are emerging in our day to day life very efficiently. This Wireless Biological Antenna System has potential to create medical facilities to the next level as it creates a opportunity for real time health care and fitness monitoring system. With the development of wearable antenna, patch antenna is designed with using flexible substrate for all such reason the textile substrate is widely using day by day [1]. Bandwidth and efficiency of planner antenna is depends upon the substrate permittivity and substrate height [2]. The textile substrate is made up of polymer thread and metal thread. Both have minimal dielectric constant because of this reason the losses due to surface wave reduces as well as impedance bandwidth of an antenna increases [3]. Other technology like Electromagnetic Band Gap structure, Artificial magnetic Conductor and High Impedance Structure design also give good results as a wearable antenna [4]. Metamaterial also improves the radiation properties of antenna and reduces the size of antenna [5]. In [6] small size antenna is designed for glucose monitoring purpose which is operated in MICS and ISM bands. Using the Simulation code and Swarm Optimization algorithm these antennae made to operate in dual band. The real time measurement is done in Gel which shows the same electrical properties as human body. The authors [7] presented a low profile antenna and measure the effects of EM waves on human body mainly on head and shoulder. They applied the DGF expansion and FDTD to calculate its effects on human body and it is operated in MICS Bands. The authors [13] presented an antenna operated in ISM Bands and designed using IE3D Software with FR4 substrate. It is a V-shaped monopole antenna with coplanar waveguide fed and it can be mounted on top of human tissues such as muscle, fat cells and skin. In [8] implantable antenna of size 27 mm X 14 mm X 1.27 mm is designed. It is wideband antenna can be used for neural recording with high data rate. It resonates at 433.9 MHz frequency and 542.4 MHz, these frequencies are near to the MICS bands (402-405 MHz). The measurement is done in tissue mimic solution. In [9] a magnetic induction link system with the human body is presented. They designed the transmitter and receiver module separately and then combined them properly to form a system. Magnetic antenna seems less fussy then electrical antenna and their battery life also increases by less power consumption. In [10] an ingestible capsule endoscope system is presented. To achieve wideband author introduced a spiral structure with thick arm in the structure. These are used to send the high quality biological image of internal body. The measurement is done using a human phantom. In [11] a small antenna which operated in the Med Radio band (401-406 MHz) is proposed. It is meant for ingestible capsule endoscopy. The FE simulation is done with the assumption that the capsule is surrounded by human tissues. In [12] presented antenna is designed by taking copper tape as a radiating patch, substrate of jeans material had been taken and a ground. The value of dielectric constant is 1.68 is for jeans material, loss tangent is 0.01 and thickness is 1mm. High bandwidth is achieved using Slots in the designed. The antenna shows a good results and high gain with and without body phantom. In [13] presented a dipole antenna designed in diamond shaped. It is a wearable antenna provides a good

Volume 9, Issue 6
December 2020

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

bandwidth and efficiency as compared to traditional antenna. To provide the suppleness antenna is constructed and formulated on textile. In [14] presented a patch antenna of polygon shaped with circular slots in between the structure. It is operated in GSM 900 and GSM 1800 bands. They have used copper tape as a radiating patch and a jeans material as a substrate and ground. The substrate has dielectric constant value 1.7 and the value of loss tangent is 0.025. In [15] presented a wearable antenna that is small in size and shows a wide bandwidth. The antenna is designed using a jeans substrate and patch of copper tape. In [16] presented a small antenna using a monopole concept is designed and a portion of human arm is placed at antenna location. Phantom section is selected wisely for the simulation in Computer System Technology (CST) microwave studio. The antenna shows a wide bandwidth and good efficiency. In [17] proposed a flexible conformal antenna using jeans as substrate and copper tape as metallic radiator. In these antenna the Slot and truncation both techniques is introduces in the design to improve its bandwidth characteristics. The dielectric constant value of the design is 1.76 and the value of loss tangent is 0.078. The Return Loss is -21 dB. The result is simulated in the existence of human body that consists of skin fat and muscles for wider range of frequency. The gain at frequency 3.0 GHz is 2.74 dB and at 7.0 GHz and 9.0 GHz gain is 4.17 dB and 4.07 dB respectively. In [18] designed an antenna using jeans substrate and copper tape. It's a monopole structure Operated at GSM and ISM bands. The antenna of dimension 150×150 mm2 is stacked with 3 X 3 EBG array. In the present scenario of application in wireless system, compact and efficient antennas are recognized as one of the best candidate for different communication equipment. To accommodate the growing numbers of subscriber we need aerial with small size, structure and broad spectrum characteristics. Micro strip patch aerial is the common choice for academician, engineer due to its several advantages, such as: a) Simple to design and implement, size, light density, cheap etc. Micro strip antenna find application in various field, satellite, celluar , Missile, radar etc. narrow spectrum, Medium propagation efficiency, small gain are some drawback of micro strip [19]. The above mention hurdles are overcome by designing a wideband spectrum patch antenna. Utilizing a several methods like introducing a numerous feeding technique, implementing distract slot arrangement, implementing innovative aerial patch stint pin [20]. Gupta S et.al proposed a flower wideband spectrum antenna. The simulation and experimental outcome levels that the projected antenna achieved an excellent performance [21]. The outcome proposed a microstrip antenna operating at K/Ku range. The simulation results show that the suggested structure achieved a gain of 3.1 dBi and 4.31dBi with propagation performance of 86% and 75% [22]. In this work circular shaped patch antenna is simulated and fabricated. The proposed antenna operates at dual band and finds its application in Global positioning system [23]. The author designed a rectangular resonator based flower structure. The proposed antenna is operating at 0.92 THz with gain of 12.786 dB [24]. The author proposed circular structured microstrip antenna, operating at multiband. The outcome shows the performance of the designed antenna is better as compared with the conventional aerials [25]. In [26] structured patch is designed and fabricated, operating at 2.2 GHz to 2.6 GHz. The experimental results reveal that the as compares to the conventional E shaped antenna propose design achieved a compact structure. In this work L structure microstrip aerial is implemented. The outcome of study shows enhancement in spectral performance [27]. The authors designed a Z- Shaped microstrip aerial functioning at 1.64 GHz-3.16 GHz .However, it is noted that the structured of the projected designed is heavy and complex [28]. In this work Seirpinsky Slotted antenna is simulated and fabricated. The antenna shows an excellent performance at 2.45 GHz and finds its utilization in medical applications [29]. In the projected work, we have designed circular flower shaped micro strip aerial operating in the wide band spectrum. The range of wide band is from 12.3 GHz to 17.1 GHz. The projected antenna holds the advantages of micro strip antenna and can be used in medical applications.

2. WIRELESS BODY REGION NETWORK

In recent years, for medical applications this type of antennas is widely used for the detection and treatment of various diseases [30]. In Body area network system the antenna used to radiates electromagnetic waves to the body and then the electromagnetic waves returned after coincide with nuclei it is called as nuclear magnetic resonance signal which carry the information related to the change in structure of nuclei and then we compare those signal with the healthy body NMR signal and diagnosis [31]. The purpose of health care monitoring systems is to provide the information related to the internal body to the server system. Health monitoring system consists of various components as shown in figure 2 [32].

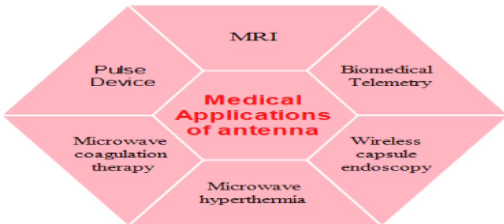

FIG.1. ANTENNAS IN DIAGNOSIS OF VARIOUS MEDICAL APPLICATIONS

Volume 9, Issue 6
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ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

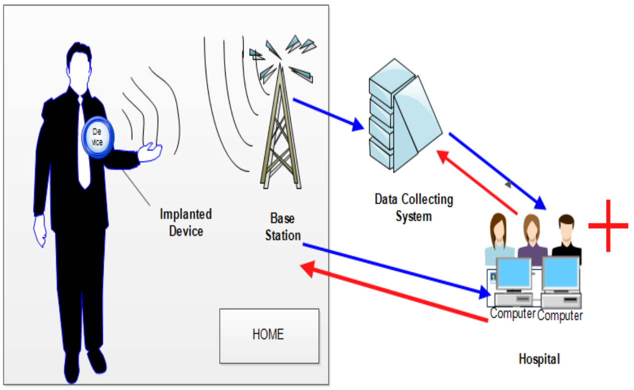


FIG. 2. GENERAL HEALTHCARE SYSTEM IN WIRELESS BODY REGION NETWORK.

In this figure base station consists of control system, a receiver system and internet. This station helps to communicate with other devices, channel for the propagation of signal, human body, insulators that helps to reduce the adverse effects of EM waves on body tissue, Implantable antennas that helps in diagnosis and treatment although we have different kind of antenna used in these field as shown in figure 3, electronics system and power supply to helps in communication and signal conversion process and health care monitoring system [33-34].

The requirement for the wearable antenna is as mention below:-

- Must have high bandwidth to transmit good quality of signal
- Efficiency of antenna should be good for high data rate transmission.
- The dielectric constant of antenna should be high so that according to the electrical property of the body antenna performance will change.
- The size of capture antenna should be small.

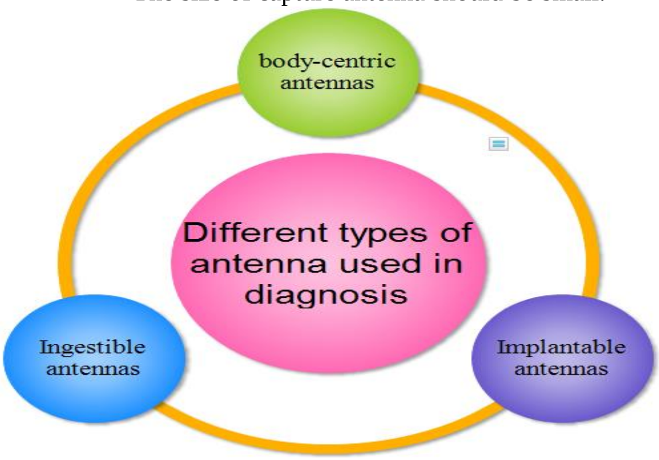


FIG.3. DIFFERENT KIND OF ANTENNAS FOR DIAGNOSIS

3. DESIGN METHODOLOGY OF PROJECTED ANTENNA

There are various technology introduced and used day by day to enhance the efficiency of wearable antenna, to reduce the size of antenna, to overcome adverse effects of these antenna on body and to achieve the required feature of the wearable antenna. Let discuss the various design technology used in wearable antenna and there features in brief. The antenna is completed at second iteration. The suggested flower shaped circular Mirostrip patch antenna is implementing on FR4 substrate having dialectical 4.4. Taking loss tangent as 0.02. The proposed antennas have 8 circular flower appeared to it. The impedance matching is achieved by introducing an abridged ground fact. The size of the antenna is 14*14*1.6 mm2. The feed lines of the projected structure are analyzed and length and width of 1 mm and 2 mm is considered. Figure.4 indicates the proposed antenna and the parameter used in this work is indicated in table.1. [35]

$$kS = 2.01 \qquad (1)$$

K is the wavenumber, and S is the hexagon side. The resonant frequency (Fr) is determined from Equation 2.

$$f_r = \frac{k_{nm}\, c}{2\pi a_e \sqrt{\varepsilon_r}} \qquad (2)$$

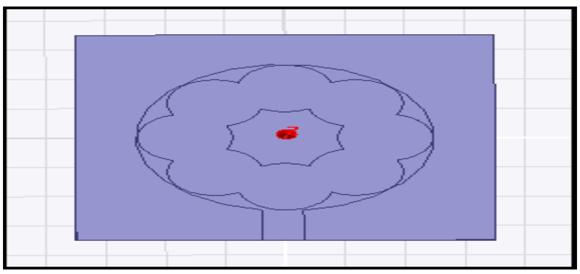
Where k_{nm} is n order derivative, a is the radius, ε_r is the permittivity.

The fr of a hexagonal antenna is given as :

$$f_r = \frac{k_{nm}c}{2\pi(0.9094\, S)\sqrt{\varepsilon_r}} = \frac{1.1k_{nm}c}{2\pi S\sqrt{\varepsilon_r}} \qquad (3)$$

TABLE.1: ANTENNA PARAMETERS

S.No	Parameters	Dimension
1.	Sub Width(W)	80mm
2.	Sub Length (L)	80mm
3.	Gnd (W*L)	80*80mm^2
4.	Patch height(H)	25mm
5.	Coaxial feed Line Height(h)	5mm



Volume 9, Issue 6
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ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

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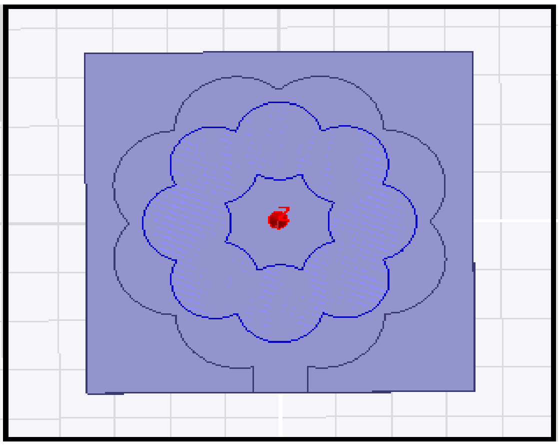


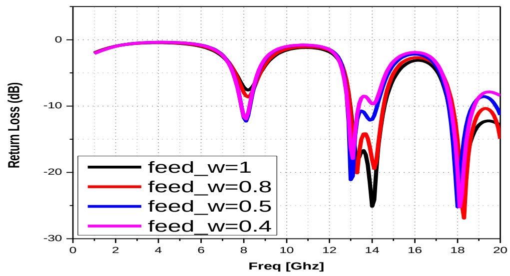
(b)

FIG.4. a) FIRST ITERATION b) SECOND ITERATION

4. SIMULATION OUTCOME:

The planned design is designed by high-frequency structure simulator (HFSS). Different parameters are analyzed to get improved results.

The results attained through the simulation are as follows: Return loss shows the energy loss in the signal imitated through a discontinuity in the antenna is given in fig.5. From fig 5 we can observe that if the return loss will greater the power transfer towards the load will maximum. The return loss is -12 dB, 25 dB and -23 dB at 8 GHz, 14 GHz and 18.1 GHz for first iteration and for second iteration 24.90 dB, -12.6 dB and 12.3 dB at 12.3 GHz, 15.1 GHz and 17.1 GHz.



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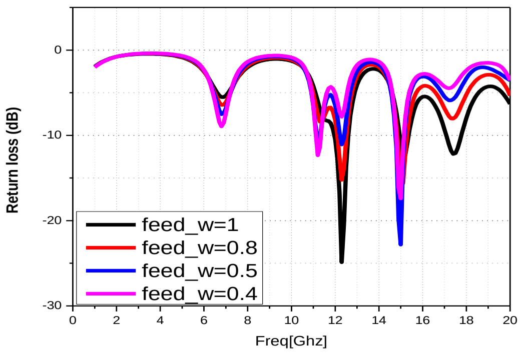

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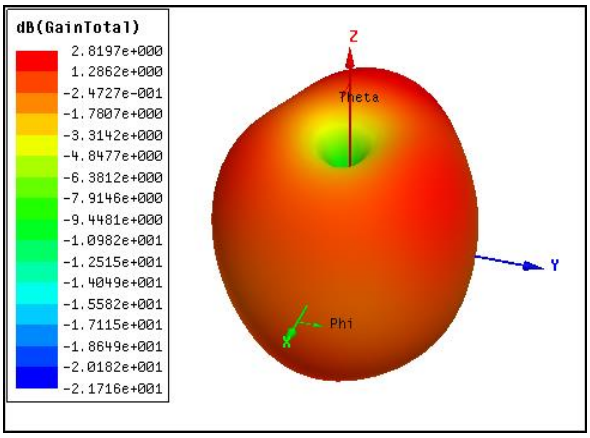
Fig.5. RETURN LOSS a) FIRST ITERATION, b) SECOND ITERATION

Gain identifies the amount in which an antenna establishes the radiated wave on a particular trajectory relative to the reference antenna. The gain obtained at 12.3 GHz frequency is 2.8 dB, at 15.1 GHz is 4.56 and at 17.4 GHz is 6.43 dB indicated in fig.6 (a), (b) and (c).



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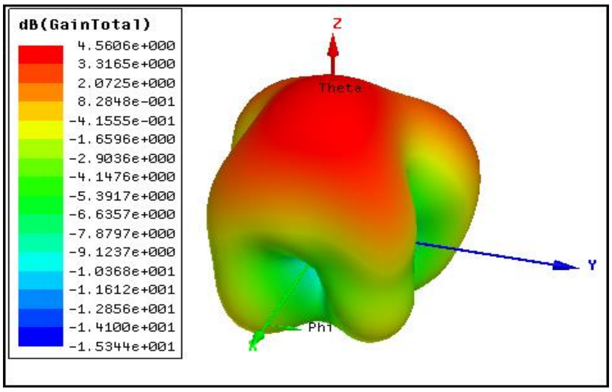

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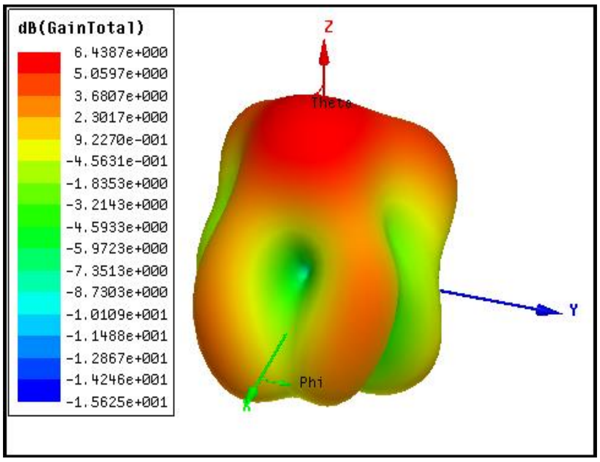
ISSN: - 2306-708X



(c)

FIG.6. GAIN a) 12.3 GHz, b) 15.1 GHz and c) 17.4 GHz

The graph of smith chart for the proposed antenna is given in figure 7.The genuine value of aerial impedance is shown by the smith chart. It may be helpful to examine transmission lines by figure out them in vector network analyzer (VNA).

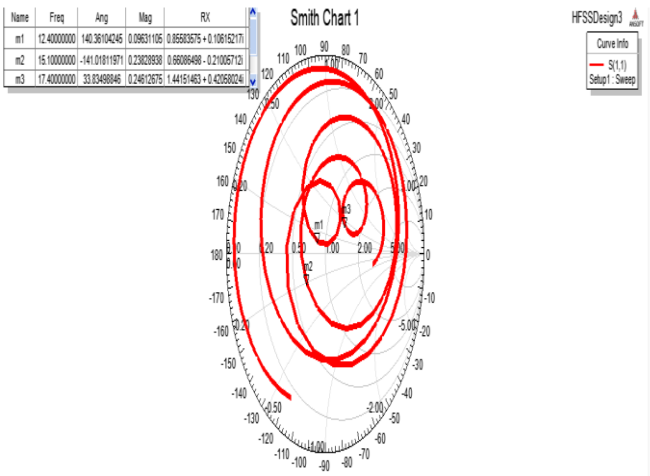


FIG.7. SMITH CHART

Voltage wave standing ratio (VSWR) determines the stationary wave set on the antenna due to the difference. The range of VSWR is from 1 to 2. It shows that the aerial imitated the less amount of energy. In this design, 1.22 is the value of VSWR at 12.5 GHz. The graph of frequency v/s VSWR of the designed work is shown in fig.8.

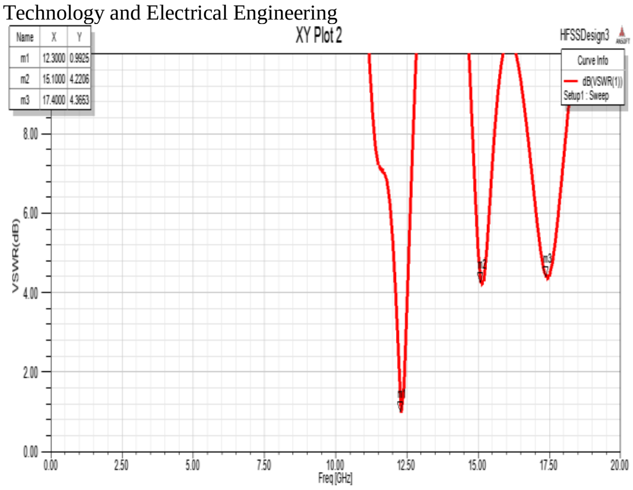


FIG.8. VSWR

Amount of phase noise is known as group delay. It is the appropriate time for a wave to travel over a test antenna as a part of reappearance. In calculating the delay, it is required to show the gap utilize for the evaluation. The proposed design group delay is shown in fig.9.

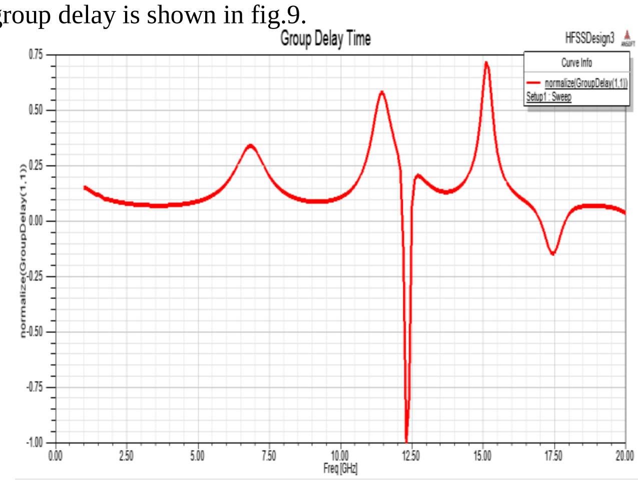


FIG.9. DELAY

5. CONCLUSION:

A basic geometrical plan of flower shaped micro strip antenna has been suggested and the simulated element with corrected parameters has been designed effectively. The structural standards along with promulgation characteristics of projected design has been studied by mathematical simulation and verified by conducting several simulations. The presentation of eight wide circular segment openings on eight corners of the antenna and a wide hexagonal space in center form the receiving device to distant spectrum bands precisely K and Ku band. Besides the proposed receiving wire shows extensively balanced radiation designs with steady gain over the bands of spectrum functioning and the relating radiation powers are equitably satisfactory. Simulation results of the proposed design show that the triple band flower shaped

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

antenna may be the best option for the Ku and K band for satellite purpose. Table.2 indicates the assessment in regards to projected antenna with diverse parameters. It is concluded that antenna dimension and patch are compact. Hence, the proposed design works better for higher frequencies with improved return loss, bandwidth, gain and directivity. The wearable device is a miracle in the field of medical applications. The textile antenna adds the flexibility to the structure of the antenna. The antenna with textile substrate and metamaterial concepts has some advantages and disadvantages of its structure. The implementation of these wireless antennas in medical field to diagnose the disease and for the treatments of disease is easier and comfortable. The research on these fields are improves day by day as these antenna plays an important role in cure of various disease in this digital Era. It is a good option to take the planar patch antenna for design wearable devices. It is easy to fabricate and have low profile. In addition to this the jeans substrate added advantages with its design to be flexible and conformal. When these are put on human body it a shows adverse effects on human tissue that leads to health risks. So it's a challenge to minimize the SAR. With the metamaterial concept the SAR can be improves at the rate of antenna structure size and complexity of the antenna structures. The antenna performance its robustness and deformation like wrinkling, wetting and bending in practical simulation is also challenge for the researchers. We have to investigate more too full-filled it's all requirements.

TABLE. 2. COMPARISON BETWEEN DIFFERENT PARAMETERS.

Reference	Size(mm)	S-Parameter(dB)	Gain (dB)	Application
[36]	28*40mm^2	-19dB, -16dB,-24dB	4.1dB	ISM
[37]	10×4×10×2 mm^2	-18dB, -17 Db	4.9 dB	WLAN/Wi-MAX/ISM
[38]	27*60mm2	-10 dB and -20 Db	2.19 dB	Wi-Max
Proposed work	14*14* 1.6 mm^2	-24.90 dB, -12.6 dB and 12.3 dB	2.8 dB, 4.56 dB and 6.43 dB	K, KU band and GPS application

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