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DESIGN AND SIMULATION OF MICRO STRIP PATCH ANTENNA FOR C BAND APPLICATIONS

Keerthana R[1], Harshitha B[2], Madhushree S Shet[3], Anusha N S[4], Hanumanthappa Magalada[5]

[1]Keerthana R, Final Year BE Student, Dept. of ECE Engineering, PESITM College, Karnataka, India.
[2]Harshitha B, Final Year BE Student, Dept. of ECE Engineering, PESITM College, Karnataka, India.
[3]Madhushree S Shet, Final Year BE Student, Dept. of ECE Engineering, PESITM College, Karnataka, India.
[4]Anusha N S, Final Year BE Student, Dept. of ECE Engineering, PESITM College, Karnataka, India.
[5]Hanumanthappa Magalada, Assistant professor, Dept. of ECE Engineering, PESITM College, Karnataka, India

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Abstract - *Micro strip Patch Antenna plays an important role in designing antennas due to its low cost, light weight, simple in construction, ease of analysis and fabrication. The antenna is radiated with the help of micro strip line feed. Proposed Micro strip Patch Antenna for C Band Applications operate at frequency range of 4-8GHz. The design has been devised using woven fiberglass cloth substrate (FR4) with a Dielectric constant =4.4(ε_r), having a width of W=22.82mm and length of the patch L=17.45mm.The patch dimensions are calculated, simulated and optimized using HFSS Software. After simulation of rectangular micro strip patch antenna, the characteristics such as return loss, bandwidth and radiation patterns are calculated. The favorable frequency of the antenna is 4-8 GHz and can be used for satellite communication, microwave communication, cell phone antennas and GPS antenna.*

***Key Words*: C band, HFSS software, return loss, bandwidth, radiation pattern.**

1. INTRODUCTION

Antenna is a transducer designed to transmit or receive electromagnetic waves. Micro strip antennas have several advantages over conventional microwave antenna and therefore are widely used in many practical applications. It consists of a radiating patch on one side of dielectric substrate (Ɛr≤10), which has a ground plane on other side. [20]

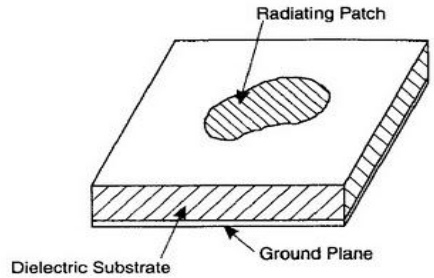


Figure 1(a): Micro strip patch antenna configuration[19]

Micro strip antennas are characterized by a larger number of physical parameters than are conventional microwave antennas. They can be designed to have many geometrical shapes and dimensions. [19]

1.1 Micro strip Patch Antenna

In Micro strip antenna, the electromagnetic (EM) wave fringe off the top patch into the substrate, reflecting off the ground plane and radiates out into the air. Radiation occurs mostly due to fringing field between the patch and ground. The radiation efficiency of the patch antenna depends largely on the permittivity (εr) of the dielectric. Micro strip antenna is also referred as a patch antenna. It consists of a very thin metallic strip (patch) placed a small fraction of a above a ground plane. The Micro strip patch is designed so its pattern maximum is normal to the patch (broadside radiator). This is accomplished by properly choosing the mode (field configuration) of excitation beneath the patch. In designing Micro strip antennas, a number of substrate can be used. The dielectric constant of the substrate usually ranges of $2.2 \leq \varepsilon r \leq 12$. Thick substrates whose dielectric constant is in the lower range is the most desirable for antenna performance because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space.[20]

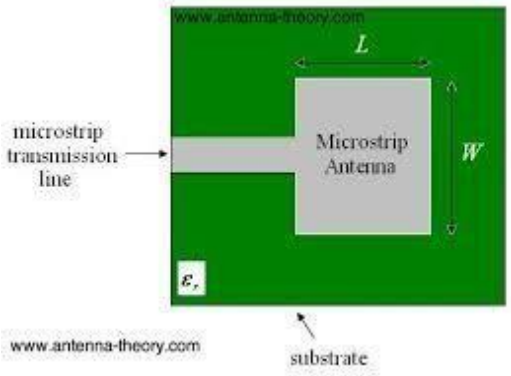


Figure 1(b): Structure of rectangular micro strip patch antenna

1.2 Micro strip line feed

A conducting strip is connected directly to the edge of the Micro strip patch as shown in Figure. The conducting strip is smaller in width as compared to the patch.. So this is easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. The advantage of this feeding

method is that the feed can be etched on the same substrate to provide a planar structure. [20]

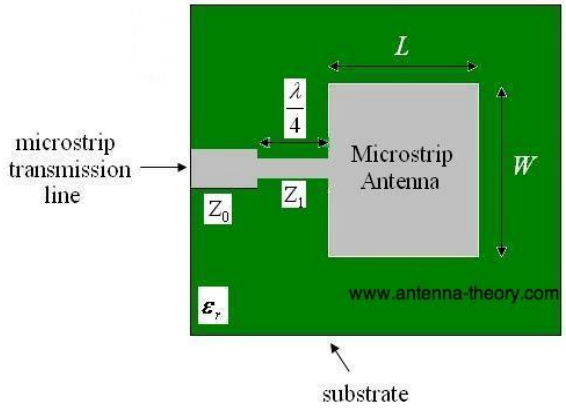
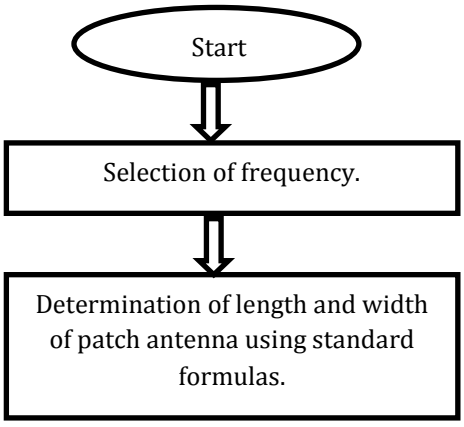


Figure 1(c): Micro strip line feed patch antenna[19]

The C band is a designation by the Institute of Electrical and Electronics Engineers (IEEE) for a portion of the electromagnetic spectrum in the microwave range of frequencies ranging from 4.0 to 8.0 GHz. It is used in many satellite communications transmissions, Wi-Fi devices, cordless telephones as well as in surveillance and weather radar systems. The transmitter signal energy is sent into space by a transmitting antenna; the RF signal is picked up from space by a receiving Antenna in satellite communication. The voltage is induced into the receiving Antenna (a conductor), as the electromagnetic field arrives at it. The RF voltage induced are then passed into the receiver and converted back into the transmitting RF information.[20] The Antenna must be able to radiate efficiently so the power supplied by the transmitter is not wasted. An efficient transmitter must have exact dimensions. The choice of antenna selection is based on the requirements of the application such as frequency band, gain, cost, coverage, weight, etc. In this paper, Micro strip patch antenna for C band application is designed and simulated using High Frequency Structure Simulation (HFSS) Software. The proposed patch antenna resonates at 4.2 GHz and 5.8GHz frequency.

2. METHODOLOGY



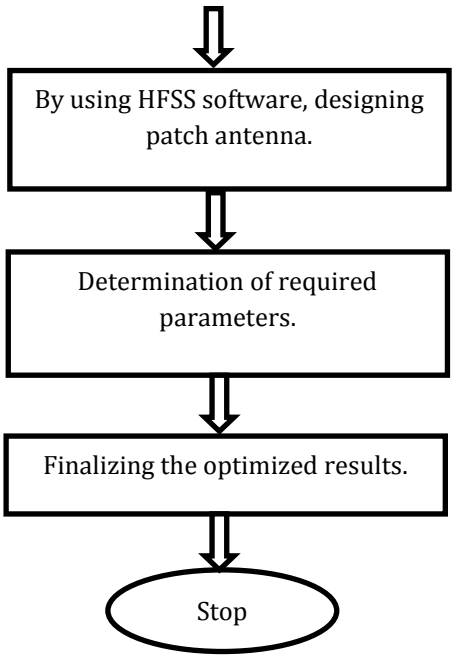


Figure 2(a): Design flow of Micro strip Patch Antenna

Before the selection of frequency, knowing the technologies used in related field is important.

2.1 Literature Review

1. Lukas et all worked on Broadband, Micro strip, Shaped Beam, C-Band Antenna for Application in Wireless Lan, A design and performance of the C-band, broadband, micro strip patch antenna for application in wireless LAN is presented. The antenna operates in C-band and support broadband outdoor operation complied with IEEE 802.1 la standard (primary application). Use of this antenna in system complied with IEEE 802.16 standard is also possible (secondary application). [1] Low-cost substrates and mechanical design was applied with little compromise of electrical and field parameters.

2. Naser Ojaroudi Parchin, et all worked on Recent Developments of Reconfigurable Antennas for Current and Future Wireless Communication Systems, in 2019 showed that With the use of active materials such as microelectro mechanical systems (MEMS), varactor or p-i-n (PIN) diodes, an antenna's characteristics can be changed through altering the current flow on the antenna structure. If an antenna is to be reconfigurable into many different states, it needs to have an adequate number of active elements.[2]

3. A. Naga Jyothi et all worked on Design of Micro Strip Stacked Patch Antenna in C-Band for Satellite and Radar Communications in 2019. An analytical model of Edge Feed Micro Strip Stacked Patch Antenna (EFMSSPA) with twin slots operating at

5Ghz frequency is proposed and this lies within the microwave C-band (4-8 GHz).[3]

4. Haleh Jahanbakhsh Basherlou, Yasir Yasir et all worked on Recent Developments of Reconfigurable Antennas for Current and Future Wireless Communication Systems, in 2019 showed that With the use of active materials such as microelectromechanical systems (MEMS), varactor or p-i-n (PIN) diodes, an antenna's characteristics can be changed through altering the current flow on the antenna structure. If an antenna is to be reconfigurable into many different states, it needs to have an adequate number of active elements.[4]

5. Akshay kumar, et all ,2019, worked on Micro strip patch antenna for C band satellite application. C band antenna has been designed and simulated. The returned signal loss and radiation pattern for far field has been proposed. The software results introduced that the C Band patch antenna attain a high return loss beyond 24 dB. This antenna can therefore facing the different requirements for satellite based Military Communication applications and is mainly focused over the voice as well as data Communication. The dimension of the proposed C band micro strip antenna is 40X40mm which is fabricated using copper. The side width of the patch antenna is 1.72mm and it is fed with 50 and feed line is connected to standard connector.[5] The design of the patch antenna is proposed using done by ansoft HFSS software.

6. Satyendra Kumar et all worked on Irregular M Shape Micro strip Patch Antenna using U slots technique for enhancing bandwidth for broadband and fed by Micro strip line using coaxial probe and also for C band applications in 2019.[6]

7. Md. Ashraful Haque, et all worked on a Modified E-Shaped Micro strip Patch Antenna for C Band Satellite Applications a new structure of modified E shaped MPA has been designed and proposed which covers almost entire C frequency band (4 GHz to 8 GHz) of satellite communication with standard gain. Rogers RT5880 (lossy) is used as dielectric substrate material having dielectric constant of 2.2 [7], all performance parameters of the proposed antenna have been estimated by using Zealand IE3D simulation software.

8. Nikita Saxena, et all in 2018 worked on Design and Analysis of Multi Band antenna for S and C Band, a rectangular Micro strip Patch multiband antenna has been designed. The parameters of the micro strip patch antenna have been optimized to obtain the multi band characteristics at 2.379 GHz, 2.45 GHz, 3.75 GHz, 4.46 GHz, 5 GHz and 6.25 GHz. All the six frequencies can cater to wireless networking applications. The frequencies between 5 GHz and 6.25GHz fall in the C band. The designed antenna uses the inset feed line technique for feeding the patch of the antenna. The antenna has been implemented on RT Duroid as the substrate which has 2.2 as its dielectric constant[8]

9. Uzma Uddin et all worked on Design and Analysis of Micro strip Patch Antenna and Antenna Array for Vehicular Communication System in 2018. The design and performance analysis of a rectangular micro strip patch antenna and its array in E and H plane. The antenna is designed at a centre frequency of 5.9GHz for Wi-Fi applications.[9]

10. Ribhu Abhusana et all worked on broadband micro strip patch antenna in 2017 for wireless communication that works at 2.4 GHz with gain 11 dB for outdoor place. wide band width and low power handling capacity can be overcome through an array configuration and slotted patch. A rectangular patch is used as the main radiator. It also has a wide angle of beam in its radiation pattern.[10]

11. Divesh Mittal, Aman worked on micro strip feed compact rectangular antenna woven fiberglass cloth substrate (FR4) having depth of 0.157 cm with a dielectric constant of (Ɛr= 4.4). propounded antenna has resonant frequency of 5.54 GHz for C band applications in 2017. A small rectangular slot has been added within the patch to increase the bandwidth performance of the antenna.[11]

12. A Anusha U et all in 2017, worked on Compact Micro strip Antenna for C Band Applications. A compact micro strip antenna for C band application is proposed. It is inferred that a properly designed E shaped antenna with micro strip line feed provides a bandwidth of 5.25GHz by reducing the ground plane and cutting slots on the arm of E shaped patch. The substrate is kept 1.6mm.[12] The antenna is suitable for C band applications such as Wi-Fi, satellite communications.

13. K. Dinakaran et al, worked on Micro strip PatchAntenna and simulated by using HFSS antenna simulation software in 2016 .The proposed antenna is capable of operating in the C band having frequency range of 4 GHz – 8 GHz. This is operating in the frequency of 5.4 GHz which is implemented in Wi-Fi communication in the IEEE 802.11 standard.[13]

14. Shivani Soni, Kundan Singh worked on dual frequency patch antenna for C band focusing on 5 and 8 GHz frequency band in 2015. Simulation is done using IE3D software for various parameters. Proposed antenna gives dual band operation and shows good bandwidth and simulated results for two frequency bands. Incorporating slots to the radiating patch of the

micro strip antenna enhance the multi-band performance and maintain the antenna's thin profile characteristic. [14]

15. Afridi in 2015 worked on Micro strip patch antenna designing at 2.4 GHz frequency. Biological and chemical research. simple micro strip patch antenna consists of metallic patch and ground between which is a dielectric medium called the substrate. A Simple micro strip patch antenna is designed in CST Microwave studio at resonant frequency of 2.4GHz.[15]

16. Babu lal Sharma et all worked on Frequency Reconfigurable Micro strip Patch Antenna for S-band and C-band application in 2015. In this there are two switches (copper strip) are placed on the slot at the ground plane to produce three different frequency bands at 3.06, 3.26 for (S Band) and 4.27GHz(C-Band) respectively. The proposed antenna is simulated using FR-4 substrate with permittivity 4.1 and substrate thickness 1.5mm.[16]

17. Adegoke et all in 2014 worked on Analysis and design of rectangular micro strip patch antenna at 2.4GHz WLAN applications. Internal coupled-fed dual-loop antenna integrated with a USB connector for mobile handset is presented. The antenna integrates with a protruded ground, which is extended from the main ground plane of the mobile handset to accommodate a USB connector functioning as a data port of the handset.[17]

18. M.Venkata et al in 2012 Worked on Micro strip Patch Antenna for C-band Radar applications with Coaxial fed. The optimum dimension of elliptically polarized patch antenna on RT- duroid substrate for C band Radar applications has been investigated. The performance properties are analyzed for the optimized dimensions and the proposed antenna works well at the required 7 GHz frequency.[18]

19. Indrasen Singh et al in 2011 worked on, Micro strip Patch Antenna and its Applications: a Survey. A theoretical survey on micro strip patch antenna is presented. Some effect of disadvantages can be minimized. Lower gain and low power handling capacity can be overcome through an array configuration. Some factors are involved in the selection of feeding technique. Particular micro strip patch antenna can be designed for each application and different merits are compared with conventional microwave antenna.[19]

20. Jagdish. M. et al worked on, Design Development of Antenna for TV Transmission for Connecting Outdoor Broadcasts Van to the Studio for Rural Areas in 2010. The purpose was to enhance the bandwidth performance up to the wideband level. The theoretical analysis is presented , including resonating frequency and substrate parameters influence on the antenna performance. The substrate thickness and loss is taken as the most significant design parameters. Designed Micro strip rectangular patch Antenna employed dielectrics as FR4 PCB. Patch fed via a semi rigid coaxial cable. One side fully copper plated PCB acts as ground plane for the patch.[20]

2.2 Selection of frequency: Particular frequency should be selected for designing antenna. Here we are selecting frequency between 4-8GHz say 4 GHz.

2.3 Determination of length and width of patch antenna using available standard formulas: To determine the length, width and other parameters of Micro strip patch antenna. using available standard formulas.

2.4 By using HFSS software, design of patch antenna: HFSS (high frequency structure simulator) software is used to design the antenna where simulation is done.

2.5 Determination of required parameters: By using different parameters we can build and simulate antenna.

2.6 Finalizing the optimized results: Once the optimum result is obtained from simulation, we can go for fabrication process.

3. MODELLING AND ANALYSIS

Block Diagram

3.1 Antenna Design considerations:

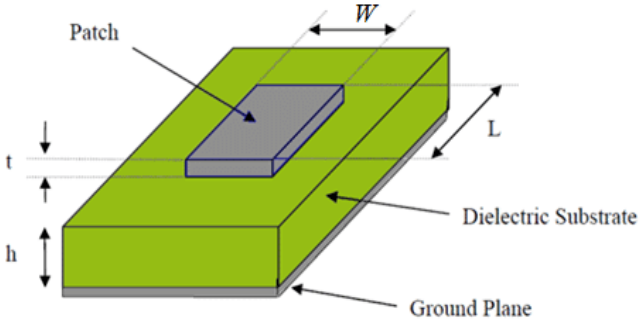


Figure 3(a): Micro strip patch antenna design

The structure of the Micro strip patch antenna consists of a thin square patch of length (L) and width (W) on one side of a dielectric substrate (ε_r) and ground on the other side.

The three essential parameters for design of a rectangular Micro strip Patch Antenna.

- Frequency of operation (f_0)= 4GHz
- Dielectric constant of the substrate (ε_r)= 4.4
- Height of the dielectric substrate(h)= 1.5mm.

A Micro strip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side.

An individual micro strip antenna consists of a patch of metal foil of various shapes on the surface of a PCB (printed circuit board), with a metal foil ground plane on the other side of the board. Most micro strip antennas consist of multiple patches in a two-dimensional array.

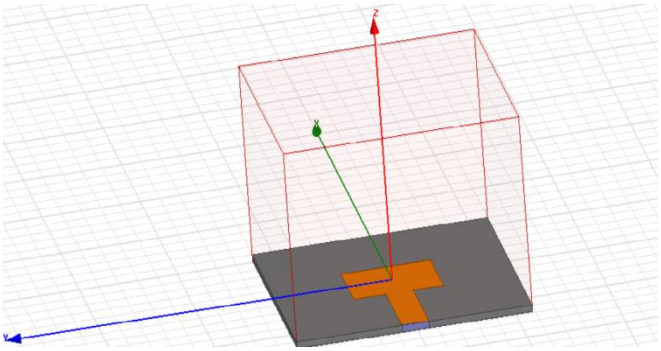


Figure 3(b): Micro strip Patch Antenna Model

3.2 Antenna formulae:

The following formulas are used for the determination Width, Length and bandwidth of the micro strip patch antenna.

W.K.T,

• Dielectric constant = 4.4.

• Frequency (fo) = 4 GHz.

• Height (h) = 1.5mm.

• Velocity of light (c) = 3x10^{8}m s-1.

1. Elemental width (w):

W=C/(2fo)[(£r+1)/2]-½.....(1)

W=3×10^8/(2×4×10^9)[(4.41+1)/2]-½

W=22.81mm.....(2)

2. Effective dielectric constant (ε_{eff}):

ε_{eff} =((£r+1)/2) +((£r-1)/2)[1+(h/w)]-½.....(3)

ε_{eff} =((4.4+1)/2)+((4.4-1)/2)[1+(1.5/22.81)]-½

ε_{eff} =3.971.....(4)

3. Extension length (Δl):

Δl=0.412h{[((εeff+0.3)(w/h+0.264)/
[((εeff-0.258)(w/h+0.8)]}.....(5)

Δl=6.87081×10-¼.....(6)

4. Elemental length (L):

L=[C/2fo(εeff)½]-2Δl.....(7)

L=17.45mm.....(8)

5. Bandwidth (BW):

for 5.84GHz,

BW=f2-f1GHz

BW=5.8178-5.7815

BW=36.3MGHz.....(10)

for 4.2GHz,

BW=f2-f1GHz

BW=4.2288-4.1671

BW=61.7MGHz.....(11)

4. RESULTS AND DISCUSSION

A micro strip patch antenna as shown in the Figure 4 has been designed with FR4 epoxy substrate with ϵ_r = 4.4 and the thickness of the substrate is 1.5mm.

The dimensions of micro strip rectangular patch antenna are as follows

L_s = 60mm, W_s = 60 mm,
L_p = 17.45 mm, W_p = 22.82 mm,
L_f = 22 mm, W_f = 6.9 mm, L_g = 60 mm.

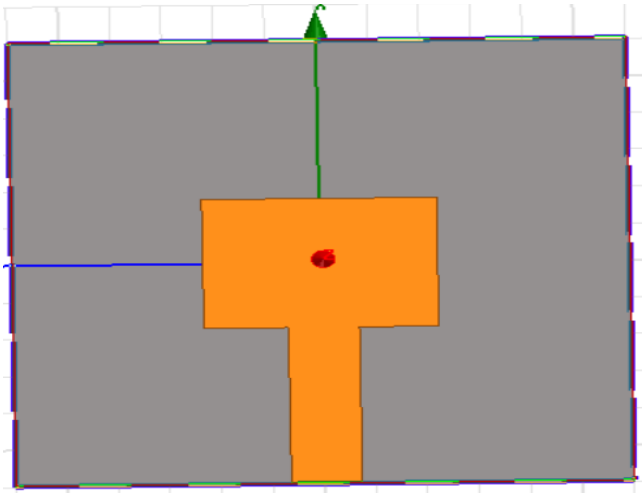


Figure 4(a): Micro strip rectangular patch antenna model.

The resonating frequency plot for design of rectangular micro strip patch antenna for C band applications is as shown below.

The antenna operates at 4.2 GHz with return loss of -16.26 dB and 5.8GHz with return loss of -26.5244 dB

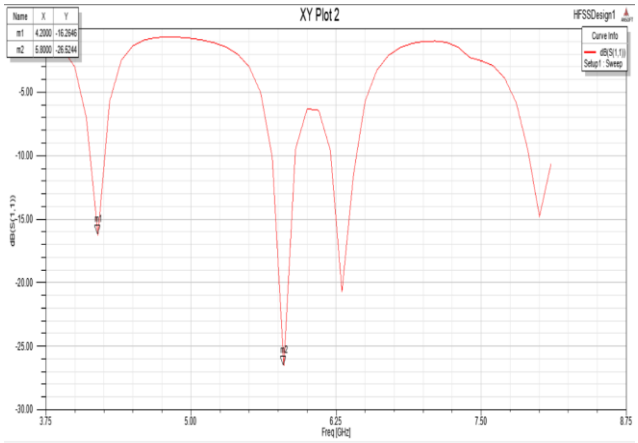


Figure 4(b): Reflection coefficient(dB)against Frequency of micro strip patch antenna.

The simulated radiation patterns of the proposed antenna is shown in Figure.

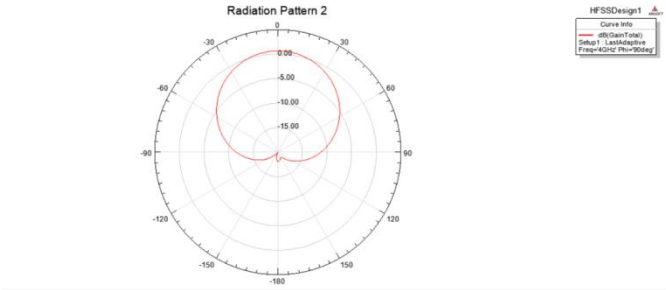


Figure 4(c): Simulated radiation pattern of proposed antenna

5. CONCLUSION

A micro strip patch antenna for C band application has been presented. A micro strip patch antenna has been designed with FR4 epoxy substrate with ϵ_r = 4.4 and the thickness of the substrate is 1.5mm. The proposed antenna provides a bandwidth of 36.3MHz for 5.8GHz and 61.7MHz for 4.2GHz. However, the performance of the micro strip patch antenna provides better result in terms of the return loss and radiation pattern.

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