Semiconductor Optoelectronics, *Vol. 42 No. 2 (2023), 1582-1593*
https://bdtgd.cn/

Semiconductor Optoelectronics ISSN: 1001-5868

A 2.4GHz WIRELESS LOCAL AREA NETWORK (WLAN) APPLICATION MICROSTRIP PATCH ANTENNA DESIGN USING HFSS

M.Swapna
Research Scholar, Department of ECE, Chaitanya University (Deemed to be), Hanamkonda, TS, India

Dr.S.Sunil
Assoc.Prof, Department of ECE, Chaitanya University (Deemed to be), Hanamkonda, TS, India

ABSTRACT
In this paper, HFSS software is used to create a rectangular microstrip patch antenna. The developed antenna is suitable for Wireless Local Area Network (WLAN) and has a resonant frequency of 2.4 GHz. This study presents the suggested antenna's design considerations as well as its simulated performance. The FR-4 Epoxy material, which has a dielectric constant of 4.4 and a thickness of 1.5mm, was used to create the design.
Antennas are essential to communication. Nowadays, microstrip patch antennas are very popular because to their simplicity in design and construction. An improved multiband octagonal patch antenna is presented in this thesis and is best suited for X, Ku, K, Ka, Q, and U-band applications. A short rectangular strip is inserted into an octagonal patch antenna to create this tiny micro strip antenna. The feed position affects the octagonal patch's resonance frequency. On a Rogers RT/duriod substrate with a dielectric constant of 2.2 and a thickness of 1mm, the antenna has been planned and modelled.The proposed antenna is then built based on the HFSS simulation software's modelling of the design. The manufactured results were obtained by manufacturing the MSA, and they are displayed in the study. The proposed antenna's low profile and clearly defined structure make manufacture simple, and it is also well suited for WLAN use.
Keywords: HFSS, WLAN, microstrip patch antennas, Fixed satellite service

INTRODUCTION
In the 1950s, micro strip antennas were initially developed. But printed circuit board (PCB) technology wasn't invented until the 1970s.The advantages of MSA, such as their light weight, low profile, low cost, planar configuration, and many more, led to their widespread use from that point on.[1] Multiple-input multiple output (MIMO) systems, vehicle collision avoidance systems, surveillance systems, direction finding, radar systems, remote sensing, missile guidance, broadcast radio, mobile systems, GPS, satellite communication, television systems, MSAs, and so forth all make use of MSAs [2].
A metallic patch on a grounded substrate is what makes up a micro strip antenna, also known

as a patch antenna. These have a low profile, can conform to planar and non-planar surfaces, are simple and inexpensive to make thanks to recent advances in printed circuit technology, are naturally robust when mounted on rigid planes, are similar to MMIC (Monolithic Microwave Integrated Circuit) designs, and are very clever in terms of resonant frequency, polarization, pattern, and impedance positions. These antennas can be found on the exterior of high-performance vehicles, satellites, missiles, aircraft, spacecraft, cars, and even handheld mobile phones. Here, we are using the X, Ku, K, Ka, Q, and U-bands to analyze the performance of an octagonal patch array.

There seems to be little question that micro strip patch antenna will continue to find various applications in the future due to its many distinctive and alluring qualities. Lightweight, low profile, simple construction, compact, and conformability to mounting framework are some of its characteristics. [2] [3]. In this design, our main focus is on a rectangular microstrip patch antenna, which comprises of a patch with dimensions of [L1] and [W2]. The suggested antenna operates at the 2.4GHz (2400-2484MHz) WLAN frequency, which is based on IEEE 802.11b for WLAN applications [2][3]. FR-4 Epoxy is the substrate material, and it has permittivity, or a dielectric constant, that is within the specified range of 2_r12of. [4][5]

A groundplane is located on the opposite side of a dielectric substrate and an emit patch is located on the single face. Adirecting substance like copper or gold is used in the fix. As a result of the nearest fields between the fix edge and the ground plane, small scale strip fix radio wire emerges. A thick dielectric consistency is desirable for a good receiving wire because it provides higher performance, better radiation, and greater transmission capacity.

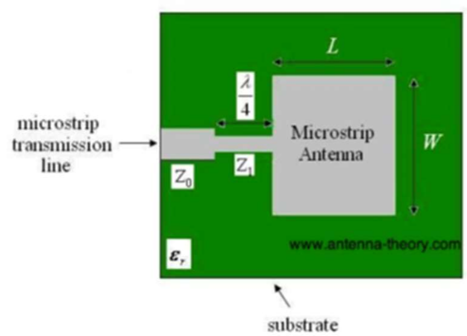


Fig.1 Microstrip Antenna

An important component of correspondence frameworks are reception devices. A receiving device is used to modify an RF flag, moving along a conductor, focused on an EM wave in empty space. Receiving equipment demonstrates a characteristic called as correspondence, which denotes that a radio line will maintain the same characteristics whether it is transmitting or receiving. The microstrip patch antenna model is shown in Fig. 1.

Literature Review

M. Sekhar et al. [1] described the Triple Frequency Patch Antenna and mentioned that it can be applied to applications in the X, Ku, and K bands. This small-scale strip receiving apparatus is obtained by enclosing a tiny rectangular strip in a circular ring patch of radio wire. According to J.L.N. Swathi et al. in their description of the 2-Port Penta Band, Deca Frequency Antenna's HFSS method, their suggested antenna can be employed with 10 separate operating frequencies while operating at five bands.

Antenna Design

The ground, substrate, and patch layers make up a microstrip patch antenna. Where the radiation happens, there is a metallic patch on the earth.

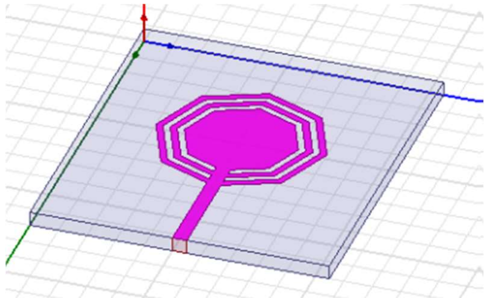


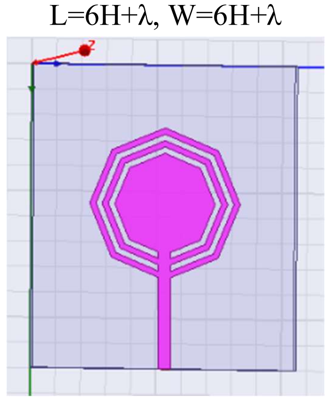
Fig: Proposed antenna model

The resonant frequency for the lowest order mode of a normal octagon patch antenna can be approximated by the equation KS=2.01 where S is the side of the octagon patch antenna and K is a constant number depending on the type of mode. The feed position affects the octagonal patch's resonance frequency. This patch antenna's emission pattern offers good directivity (gain).

A. Ground Plane

An electrically conducting surface known as a ground plane is typically connected to electrical ground. The phrase has two separate meanings in two different areas of electrical design. An earth-like object, such as the Earth, which is connected to the transmitter's ground wire and serves as a radio wave reflector, is referred to as a groundplane in reception apparatus theory. We are giving the ground a perfect E. The ground measures 162 mm in length and 162 mm in width.The following formula is used to determine length and width:

$$L=6H+\lambda, W=6H+\lambda$$



B. Substrate

A fixed reception device is a narrowband, wide-shaft receiving wire that is made by machining the radio wire component design in metal and adhering it to a shielding dielectric substrate, like a printed circuit board, with a constant metal layer adhered to the opposite side of the substrate that frames a ground plane. The FR4_Epoxy material is used as the substrate. The substrate has a 20mm height. The substrate is 162 mm in length and 162 mm in breadth.

$$H=\frac{0.3\times C}{2\times\pi\times F\times\sqrt{E}}$$

C. Patch

Printed circuit sheets are typically made using identical materials and lithography techniques to the way a fix receiving wire is typically generated on an adhesive substrate.A conducting or radiating element is patch. This gave the patch optimum E material. The patch formula for a hexagonal side is

$S=C/(23.1033\times\sqrt{E})$

D. Feed

Receiving wire support refers to the parts of the reception system that feed the radio waves to all of the receiving wire's ruins, or when accepting radio waves, the wires gather the nearby radio waves, change them to an exciting stream, and then send them to the collector.Radio wires typically consist of a feed, extra-reflecting or telling structures, and the micro strip feed, which varies in length and breadth.

PROPOSED ANTENNA GEOMETRY

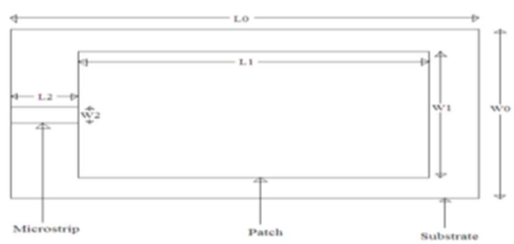


Table I design parameters of rectangular MSA

Parameters	Values (in mm)
H	1.5
L0	47.04
W0	38.48
L1	38.04
W1	29.48
L2	5.2
W2	1

The suggested antenna geometry, which includes a dielectric substrate, patch, and microstrip feed line, is shown in Fig. The FR-4 Dielectric substrate with the above-described dimensions is used to isolate the rectangular patch from the ground plane. Table I, on the other hand, displays the pertinent design parameter values for the suggested antenna.

DESIGN OF PROPOSED ANTENNA

An antenna is often a metallic device used to transmit or receive radio waves. Due to its low profile and high cost of production, small scale strip radio wire with a metallic fix on a grounded substrate is used in government and commercial applications. It is used to transfer electric and magnetic energy from a transmitting source to a receiving wire or from a receiving device to a recipient. The implementation of the Micro strip repair radio wire serves as a benchmark for remote correspondence systems and is still going strong in meeting the evolving needs of the new wave of receiving wire innovation. The reception system is initially described with just one component. The 4 component cluster radio wire is indicated for further pick up improvement. The receiving wire parameters, including as pick up, VSWR, and return misfortune, are extended at the same working repetition.

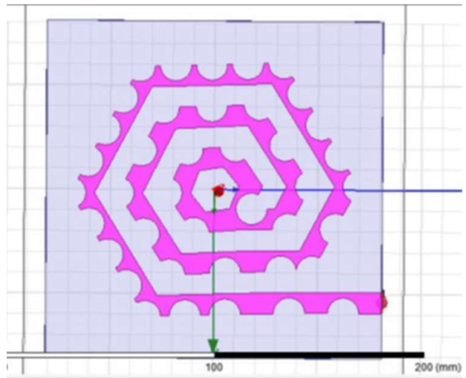


Fig. Pentagonal spiral microstrip antenna

A reception device consists of a leading patch with any planar or non-planar geometry on a single section of an electrical substrate, with a ground plane on the other side and excitation provided by a tiny strip of support as shown in the picture. Lumpedport excitation is employed. Give the radio wire some additional radiation. The constructed receiving wire operates in the 2.4 GHz ISM band with a periodicity of 1 to 5 GHz. This recurrence is studied in applications for the L, S, and C bands.

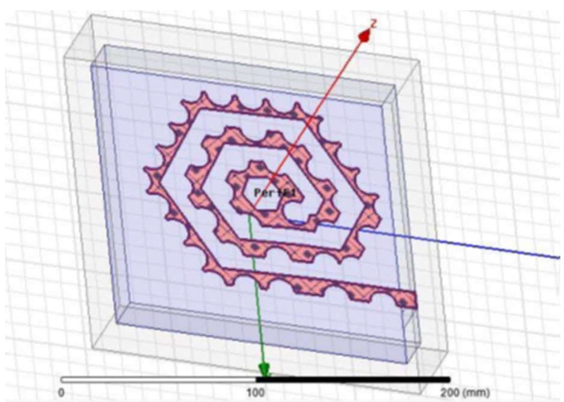


Fig. Pentagonal spiral microstrip antenna – Side View

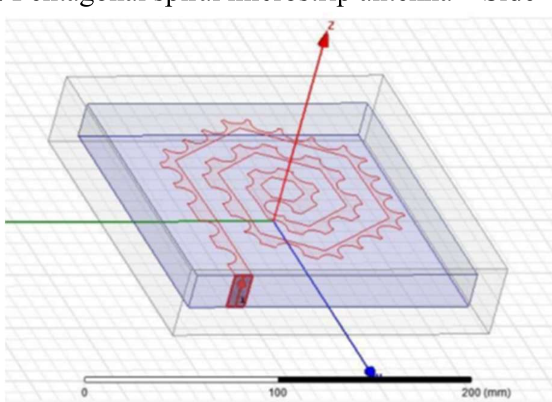


Fig. Providing input to Pentagonal spiral microstripantenna

The antenna is designed using HFSS (High Frequency Structural Simulator) Software 15.0. For an efficient gain, the width of octagonal patch antenna becomes

$$w = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \times \sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$L = \frac{1}{2 f_r \sqrt{\varepsilon_{eff}} \sqrt{\varepsilon_0 \mu_0}} - 2\Delta L$$

Where

$$\Delta L = 0.41h \frac{\varepsilon_{eff} + 0.3}{\varepsilon_{eff} - 0.258} * \frac{\left(\frac{w}{h} + 0.264\right)}{\left(\frac{w}{h} + 0.8\right)}$$

And

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\frac{h}{w}}}$$

Where, fr =resonant frequency (in Hz), L=length of patch (in mm),W=width of patch (in mm), h=height of substrate (in mm) and εr=relative dielectric constant. Basically h/w<< 1for better gain and bandwidth.

To achieve better performance, slot should be introduced into patch.The slot isof0.5 mm wide which is inserted into the patch as shown in the figure. Single slot were arranged to improve the overall performance in the proposed Design.

HFSS Simulation Results

This antenna is planned and enhanced with the aid of HFSS 15.0.

Return Loss

The reflection coefficient, also known as the return misfortune, or amount of power reflected off the radio cable, is discussed in S11 and is depicted in Fig. 4. It is clear that the impedance bandwidth covers the X, Ku, K, Ka, Q, and U bands with frequencies of 8.2GHz, 11.4GHz, 21.9GHz, 28.9GHz, 37.7GHz, 40.9GHz, and 45.8GHz and a return loss of -21.79dB, -15.87dB, -23.83dB, -17.71dB, -26.15dB, -39.69dB, -15.

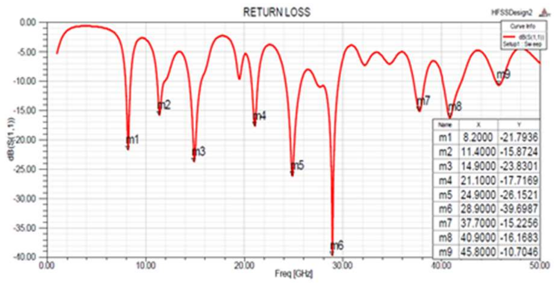


Fig. Returnloss for proposed multi band octagonal patch antenna model

VSWR

Radio reappearance control transmission quality from a power source, via a broadcast line, and into a mound is gauged by VSWR. The values for VSWR are displayed in Figure below.
The antenna's Voltage Standing Wave Ratio (VSWR) is 1.17, 1.38, 1.13, 1.31, 1.10, 1.02, 1.41, 1.36, and 1.82 for frequencies of 8.2GHz, 11.4GHz, 14.9GHz, 21.1GHz, 24.9GHz, 28.9GHz, 37.7GHz, 40.9GHz, and 45.8GHz, respectively.

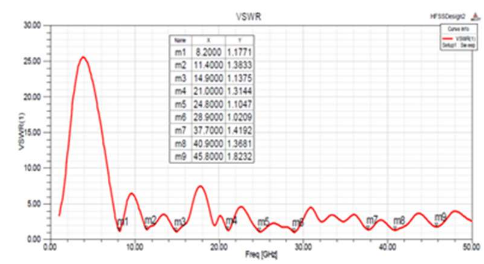


Fig.: VSWR for proposed multi band octagonal patch antenna model

GAIN

It is clear as the relationship between the power transmitted by the antenna from a source located on the beam axis of the antenna and the power transmitted by a lossless antenna. The intended antenna is depicted in Figure with a steady gain of 7.40 dB, and the individual gains are depicted in Figures.

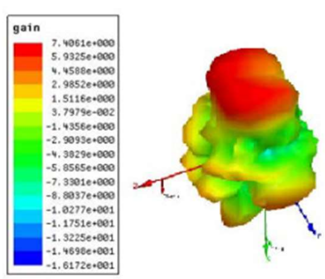


Fig.: Overall gain for proposed multi band octagonal patch antenna model

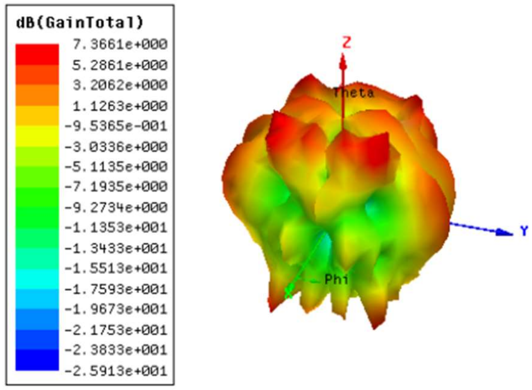


Fig: Gain at 8.2GHz

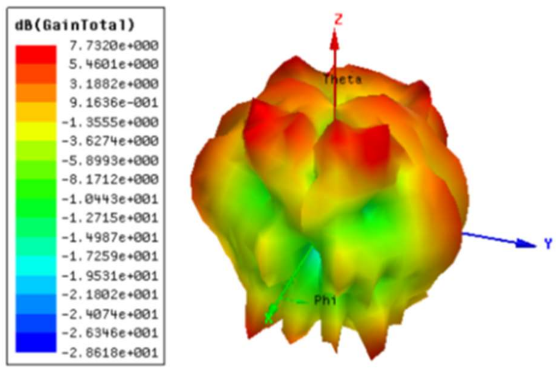


Fig: Gain at 11.4GHz

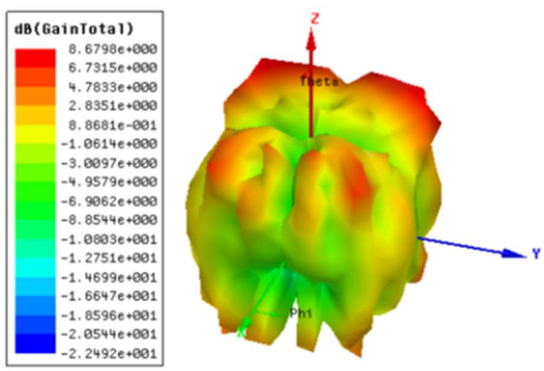


Fig: Gain at 14.9GHz

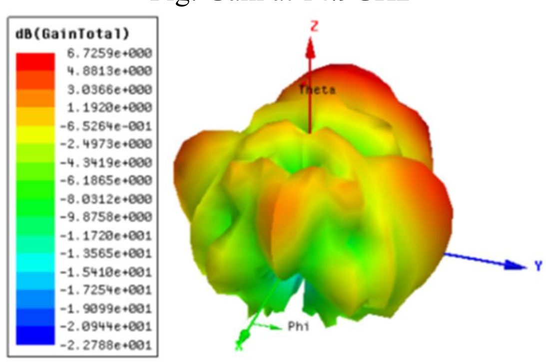


Fig: Gain at 21.1GHz

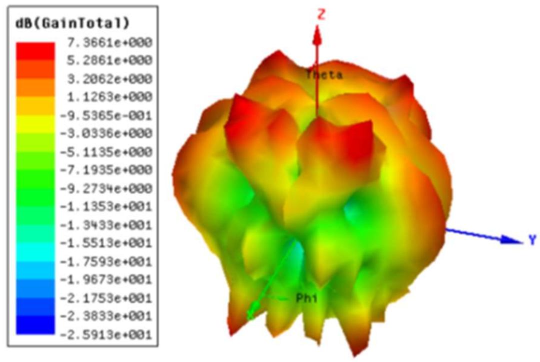


Fig: Gain at 24.9GHz

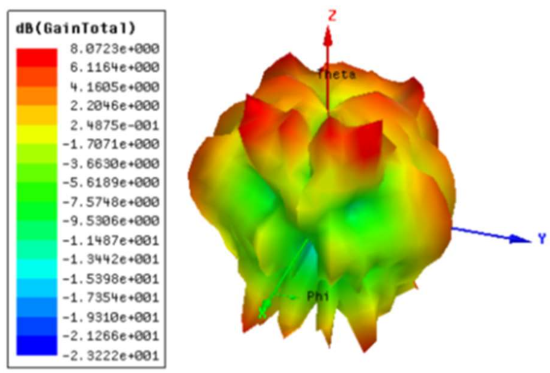


Fig: Gain at 28.9GHz

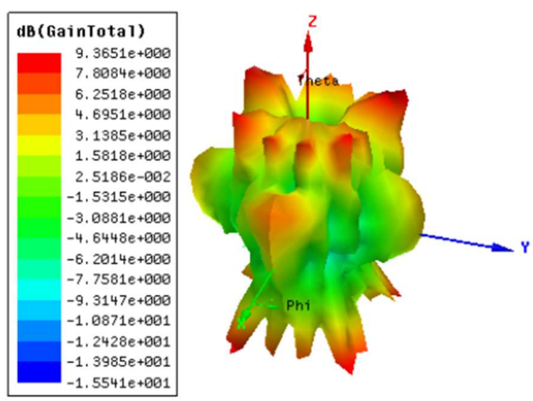


Fig: Gain at 37.7GHz

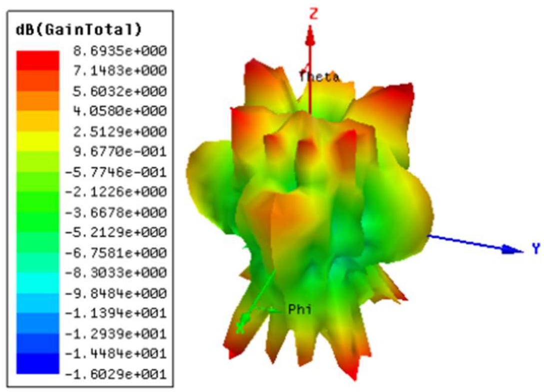


Fig: Gain at 40.9GHz

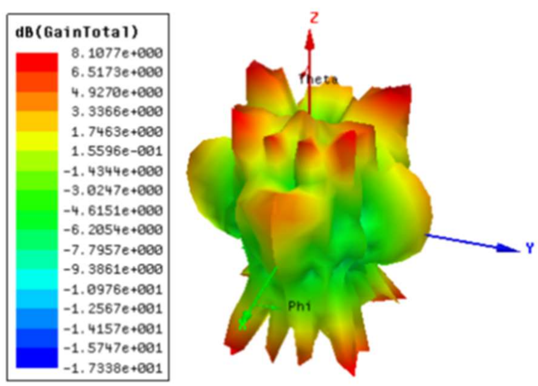


Fig: Gain at 45.8GHz

RESULT ANALYSIS

The measured results are compared with simulation results and observed that good treaty between measured (fabricated) and simulated results. The below tables represent the comparison.

S.No	Frequency in GHz	Return loss in dB	VSWR	Gain in dB	Band
1	8.2	-21.79	1.17	7.36	X
2	11.4	-15.87	1.38	7.73	X
3	14.9	-23.83	1.13	8.67	Ku
4	21.1	-17.71	1.31	6.72	K
5	24.9	-26.15	1.10	7.36	K
6	28.9	-39.69	1.02	8.07	Ka
7	37.7	-15.22	1.41	9.36	Q
8	40.9	-16.16	1.36	8.69	U
9	45.8	-10.70	1.82	8.10	U

S.No	Frequency in GHz	Return Loss in dB	VSWR	Band
1	8.2	-20.91	1.09	X
2	11.4	-15.12	1.27	X
3	14.9	-22.81	1.03	Ku
4	21.1	-17.04	1.23	K
5	24.9	-25.45	1.08	K
6	28.9	-37.41	1.12	Ka

7	37.7	-15.05	1.35	Q
8	40.9	-16.14	1.41	U
9	45.8	-10.12	1.79	U

CONCLUSION

The multiband octagonal patch antenna that has been designed is small and has the ability to operate in the X, Ku, K, Ka, Q, and U bands. The suggested octagonal patch antenna can be utilised for X-band military applications like missile management, airborne tracking, and Intelsat, INSAT, AsiaSat, and Galaxy in the C-band. According to the ITU, the Ku band is divided into numerous sectors that are divided into topographical regions. Broadcast satellite service (BSS), wireless communication, and satellite altimetry are examples of fixed satellite service (FSS), which also includes television broadcasting. A combinational analyzer was used to measure the proposed antenna after it had been constructed, simulated, and measured using HFSS 15.0.

At 2.4GHz, the suggested antenna has a return loss of -12.0505 dB. HFSS simulation software has been used to simulate the planned MSA. The microstrip feed line of this antenna also introduces a significant amount of bandwidth to attain the ideal resonant frequency of 2.4GHz. The designed MSA is optimised to cover WLAN, as was already described. The suggested antenna is a low profile antenna, making it very small, simple to construct, and supplied by a microstrip feed line, making it a desirable structure for both present and future WLAN applications.

REFERENCES

[1] Bhavanam, S. N. and Kalyan, R. S. Design of a novel coaxial feed triple frequency patch antenna with slots and shorting pin. Procedia Computer Science 85 (2016) 345-351.

[2] Vasujadevi, M. and Madhav, B.T.P. Shiva Skandan Maple leaf shaped array antenna for multiband applications. International Journal of Engineering and Technology (UAE), 2018.

[3] Chakrabarti, S. and Chakraborty, A. Dual-band dual sense microstrip antenna with improved characteristics. Electronics Letters 54 (20) (2018) 1149-1150.

[4] Liu, X., Wu, Y., Zhuang, Z., Wang, W. and Liu, Y. A Dual-Band Patch Antenna for Pattern Diversity Application. IEEE Access 6 (2018) 51986-51993.

[5] Vasujadevi, M., Naga Kishore, B.S., Batchu, M. and Prasanna Kumar, A. Performance optimization of multiband microstrip patch antenna by incorporating EBG structures. Journal of Advanced Research in Dynamical and Control Systems, 2017.

[6] Tanish Narang; Shubhangi jain; "Microstrip Patch Antenna- A Historical Perpective of the Development",Conference on Advances in Communication and Control Systems 2013 (CAC2S 2013)..

[7] Ogunlade Michael Adegoke; Ismael Saad Eltoum; "Analysis and Design of Rectangular Microstrip Patch Antenna AT 2.4GhzWLAN Applications", International Journal of Engineering Research &Technology (IJERT) ISSN: 2278-0181Vol. 3 Issue 8, August – 2014.

[8] J. R. James, P.S. Hall. Handbook of microstrip antennas, I.E.E. Electromagnetic Waves Series 28- Peter Pereginus LTD, 1989.

[9] C. A. Balanis, "Antenna Theory-Analysis and Design," 2nd ed., J. Peters, John Wiley and Sons, pp. 728-730.

[10] Girish Kumar, K.P. Ray, "Broadband microstrip antennas", Aretch House 2003.

[11] R.J. Mailloux, J.F. Mcllvenna and N.P. Kemweis-Microstrip Array Technology IEEE Transactions on Antennas and Propagation, Vol. 29, No.1, January 1981.

[12] Ansoft Corporation, HFSS User's Guide, version 10 &12, Ansoft Corporation, Pittsburgh, CA,20

[13] Nandini Ammanagi, Rahul Khadilkar, Akash Harwani, Disha Budhlani, Disha Dembla; "Comparison of the performance of Microstrip Antenna at 2.4GHz Using Different Substrate Materials", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3, Issue-4, April 2014.