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Design of MicroStrip Patch Antenna for 2.4GHz Application

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***Abstract*: The designed Antenna operates at a frequency of 2.4 GHz Using FR4 material as a substrate which has the dielectric constant of 4.4(ε_r).The designed Antenna can be used for WLAN application and ISM (industrial, scientific and medical). The antenna is designed using ANSYS HFSS V19 simulation software. The designed antenna has low profile, low cost, easy fabrication and good isolation. The designed antenna provide return loss less than -10dB. The parameters such as return loss, VSWR (voltage standing wave ratio), gain, radiation pattern has been simulated and analyzed.**

***IndexTerms*— Patch Antenna, Multi-Slot, Return Loss, gain, HFSS (High Frequency Structural Simulation).**

I. INTRODUCTION

In the past decade, the world has shifted from 2nd Generation to 5th Generation wireless mobile systems. As well the increase in the growth of mobile users, smartphones, internet of things connections, cellular video consumption, and network speed improvements are projected to increase the data traffic in 5 years by seven times. So there has been a need for a compact miniaturized antenna which can occupy lesser space with adequate performance[1]. The antenna that we need for this purpose must be lightweight and small in size with ease of fabrication.

Microstrip Patch Antenna is an integral part of the reduced wireless system. These antennas are narrowband antennas in the order of 1-5%. Numerous techniques have been accomplished in the past three decades to enhance the bandwidth of the Microstrip Patch Antenna. These techniques can be frequency selective surface impedance matching networks, parasitic or multiple resonators, the modification geometry of the radiating element, and the use of a substrate of low dielectric constant or the increase in the thickness of the substrate. Microstrip Patch Antenna is currently used in nearly all wireless systems with every recent advancement in printed circuit technology as illustrated in Fig.1.A[2]. The motive of the Microstrip patch antenna is to radiate and receive electromagnetic energy in the microwave range and it plays a crucial role in a wireless communication application. The operation and performance of a Microstrip patch antenna are based on the geometry of the printed patch and the material characteristics of the substrate against which the antenna is printed.

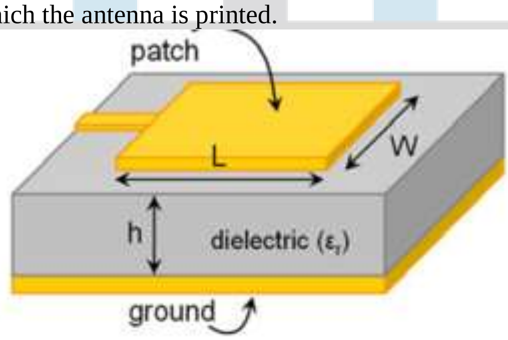

Fig.1 Antenna structure for Microstrip patch

Microstrip patch antenna has a radiating patch on one face and a ground plane on the other of a dielectric material. For a representative performance in the analysis, the radiating patch's fundamental shapes are rectangular, square, circular, and triangular. Microstrip antennas are put to use in mobile and satellite communication, GPS, RFID, Wi-Max, Wi-Fi, medical applications, 5G applications, and even military applications such as rockets, radar, aircraft missiles, and so on. Because of its lighter weight, lower volume, conformal design, minimal cost, and simplicity of manufacture and integration. Microstrip antennas are broadly used in today's wireless communication systems. As a result of these tempting qualities, microwave and wireless experts have increased their research on Microstrip antenna design. However, it has the drawback of having a low gain and a limited bandwidth. Researchers have centered their efforts on overcoming these drawbacks, proposing and investigating several viewpoints such as probe-fed antennas, patch antennas with thick substrates electrically, stacked shorted patches, and slotted patch antennas. Due to their ease of design, production, and analysis, Square, rectangular, and circle patches are the most common[3], [4].Their radiation properties, particularly for low cross-polarization radiation, are fascinating.

By making the slots in the ground as well as on the patch with appropriate dimensions, the antenna may be reduced and the bandwidth enhanced[5], [6]. A compact Microstrip antenna design is also suggested in this study. The proposed antenna resonates at a frequency of 2.4 GHz with return loss of -33dB, Gain of about 6.7dB. Also, the suggested antenna's radiation characteristics are evaluated using HFSS(High-Frequency Structure Software 19).

Section II depicts the proposed antenna's design, while Section III describes the simulation findings, including the reflection coefficient, VSWR, Radiation pattern, and Gain of the proposed model. In Section IV, the study's findings are compared to those of previous research, and the study's conclusion is provided in Section V.

II. DESIGN PROCEDURE FOR ANTENNA

The first part of creating a Microstrip antenna is to select an appropriate frequency and substrate. The proposed rectangular patch's resonance frequency (f) was chosen to be 2.4 GHz. A 50Ω-microstrip wire is used to feed the designed RMA antenna. Analytical models for scaling antenna designs such as rectangular, circular, and triangular exist[7]. Several parameters such as dielectric constant ($\varepsilon_r = 4.4$) resonant frequency (f=2.4 GHz), and substrate thickness (h=1.6 mm) are taken when developing the proposed RMA. The substrate selection is censorious in the design of the RMP antenna. Substrate parameters such as dielectric constant and thickness have an effect on the antenna's impedance bandwidth performance, as well as the resonant frequency and impedance matching[8], [9]. Because of its electrical properties, affordability, and availability, FR4 is employed as a substrate in the making of the proposed antenna. In this proposed concept, the ground plane is placed lower the substrate materials.A lumped port is used to excite the antenna in this proposed construction. Table 1 shows the substrates measurements. Table.2 indicates the exact parameters of the proposed patch antenna, and Fig. 2 shows the layout of the proposed antenna.

TABLE I.FR4 SUBSTRATE PARAMETER

S.No.	FR4 substrate parameter	Value
1	Loss tangent(δ)	0.02
2	Dielectric constant (ε_r)	4.4
3	Dimensions (mm2)	55 x 55 x 1.6
4	The thickness of the substrate (h)	1.6

Using the transmission-line concept, we created a rectangular Microstrip patch antenna in the first section[10], [11]. The antenna dimension may be calculated using the provided formulae[12]–[14].

A. The patch's height (h) is determined as follows:

The formula is used to calculate the patch's height.

$$h = \frac{0.3c}{2\Pi f\sqrt{\varepsilon_r}} \qquad (1)$$

The speed of light is denoted by C. which is 3.0 x 10^8 m/s,

ε_r is the dielectric substrate, which in this case is 4.4,

and the height in millimeters (mm), which in this case is 1.6 mm.

B. The patch's width (W) is calculated as follows:

The formula is used to calculate the patch's width.

$$w = \frac{c}{2f}\sqrt{\left(\frac{2}{\epsilon_{r+1}}\right)} \qquad (2)$$

W stands for width in millimeters (mm)

C. The effective dielectric constant is calculated ($\boldsymbol{\varepsilon_{eff}}$)

The effective dielectric constant is an elemental quantity to consider when making a rectangular-patch antenna. Because of the fringing effect, some waves traveling in the direction of the ground plane from the radiating patch penetrate the substrate. The value of dielectric materials differs depending on the medium. The value of the effective dielectric constant must be calculated when an electromagnetic wave travels. The effective dielectric constant is calculated using the equation below:

$$\varepsilon_{\mathrm{eff}} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}} \qquad (3)$$

$\varepsilon_{\mathrm{eff}}$ = The effective dielectric constant

h= Patch height, w= Patch width

D. Extension of the patch length calculation (ΔL)

Length add-on refers to the additional length at the patch's end caused by the fringing field running down its length. The formula for calculating it is as follows:

$$\Delta\mathrm{L} = 0.412\frac{[\varepsilon_{eff}+0.3][\frac{W}{h}+0.264]}{[\varepsilon_{eff}-0.258][\frac{W}{h}+0.8]} \qquad (4)$$

Where ΔL= Extension of the patch length in millimeters,

h and w the patch's height and breadth,
and ε_{eff} is effective dielectric constant of the given substrate which is unit less.

E. Effective length of the patch (L eff).

The provided formula is used to calculate the patch's effective length (L eff).

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{eff}}} \quad (5)$$

F. Calculation of the patch's real length (L);

The provided formula is used to calculate the actual length L of the patch.

$$L = L_{eff} - 2\Delta L \quad (6)$$

G. Calculation of the ground plane dimensions;

The formula is used to get the actual length of the patch,

$$Lg= L + 6h \quad (7)$$

$$Wg=W+6h \quad (8)$$

L and W are the patch antenna's length and width, respectively.

III. PROPOSED ANTENNA DESIGN AND PARAMETERS

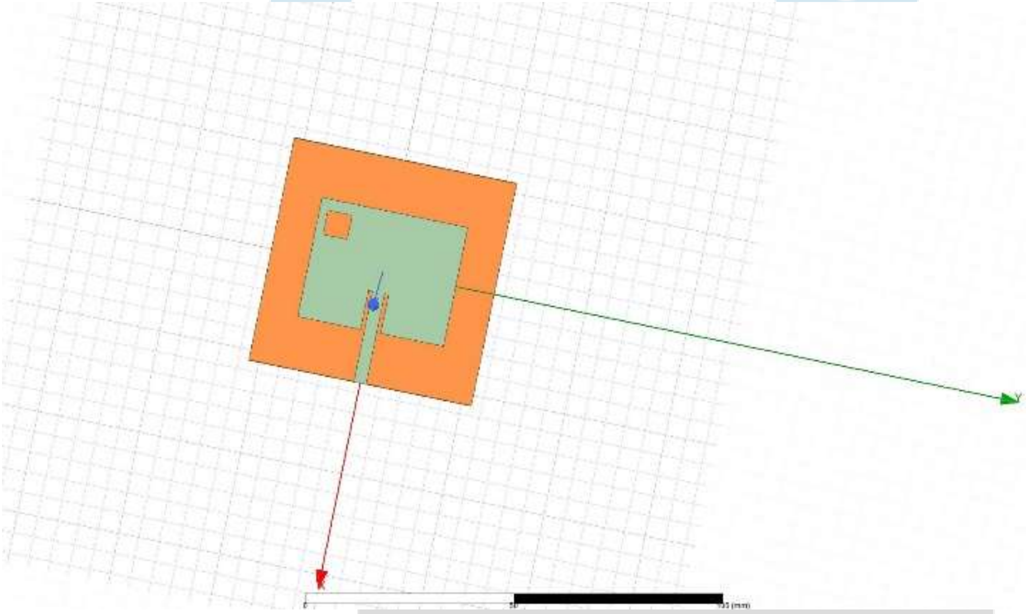

Fig.2 Suggested antenna design

TABLE II. ANTENNA DESIGN PARAMETERS

S. No	Proposed Antenna Dimensions	Value (Unit mm)
1	gw	55
2	gl	55
3	pw	29.4
4	pl	36
5	h	1.6
6	fw	27.5
7	fl	1.5

8	ffl	3
9	cw	14.7
10	cl	2.5
11	ccw	9.6
12	ccl	5
13	pow	27.5
14	py	3
15	sw	55
16	sl	55

IV. SIMULATION RESULTS AND DISCUSSION

The Ansoft HFSS version 19.0 simulator is used to create, simulate, and optimize the suggested structure. Return Loss Plot with Lumped Ports, VSWR, reflected power, and gain of the suggested microstrip patch antenna is shown in Figure. The antenna resonates in the defined x band reference range. As illustrated in Fig.3, a microstrip patch antenna resonates at 2.4GHz with a return loss of -33dB. Fig. 4 depicts the antenna's VSWR plot which values in the middle of 1 and 2 for every resonant frequency. The simulated return loss and VSWR findings support the suggested Microstrip patch antenna's high performance.

A. Simulated Return Loss of Microstrip Patch Antenna

How well the antennas are matched is determined by the amount of return loss. S11 provides the antenna insertion loss. Insertion loss is proportional to the antenna input power. Antennas radiate successfully over a restricted frequency range in general. At these frequencies, the radiated energy would virtually match the input capacity, resulting in an extremely low reflected power. The value of return loss less than -10dB serves as the criterion for selecting a frequency band. The recommended antenna resonates at 2.4 GHz with the return loss of -33 dB.

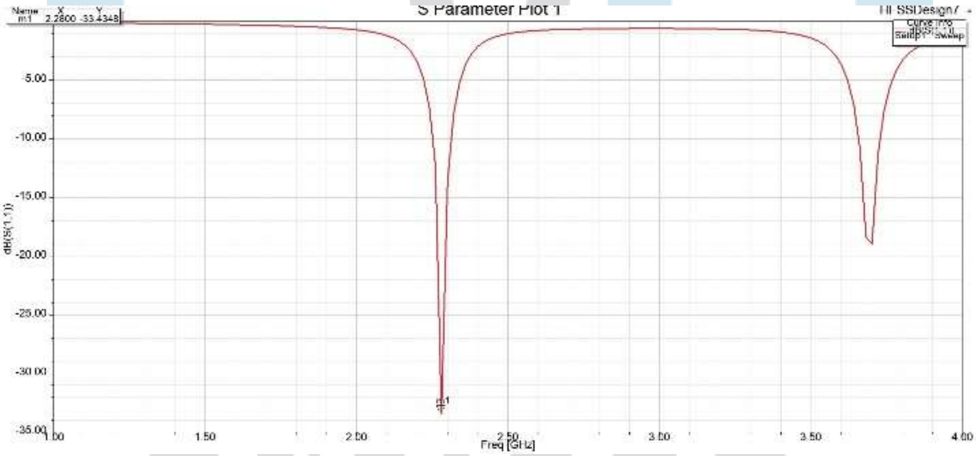

Fig.3 Microstrip patch antenna Return loss (S11)

B. Simulated Microstrip Patch Antenna VSWR

In the case of antennas, the VSWR is generally positive. The lower the VSWR, the better the antenna matches the transmission line and gets more power. At the absolute least, the VSWR is set to 1.0. The antenna is not reflecting any power in this situation, which is perfect. In this study as indicated in Fig.4, the VSWR value is 0.3.

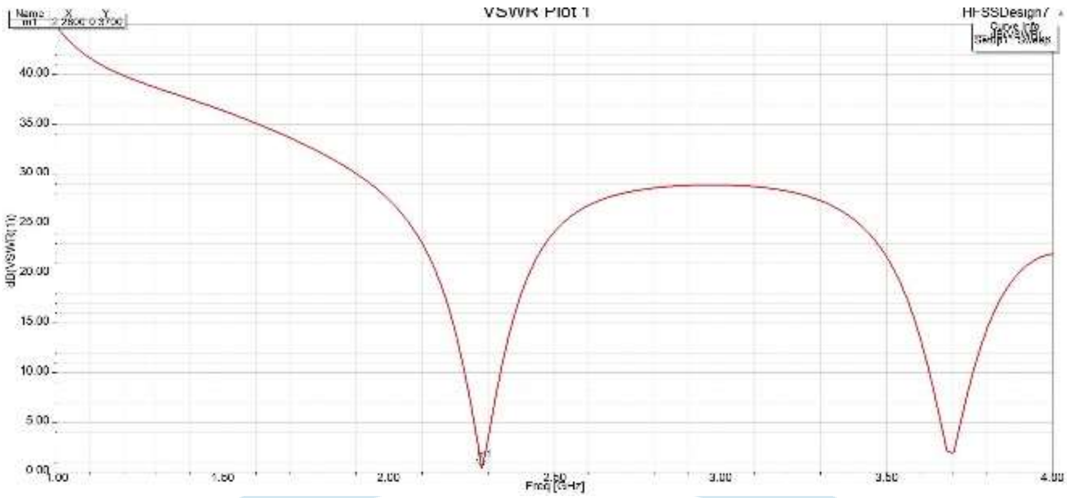

Fig.4 VSWR of the proposed Microstrip patch antenna

C. Simulated Microstrip Patch Antenna 2D gain

Gain is a decibel-based measurement. As a result, an anisotropic area's gain is defined as the entire amount of power provided to it. This antenna, as shown in Fig.5, has a gain of 6.7 dB at the resonance frequency of 2.2 GHz.

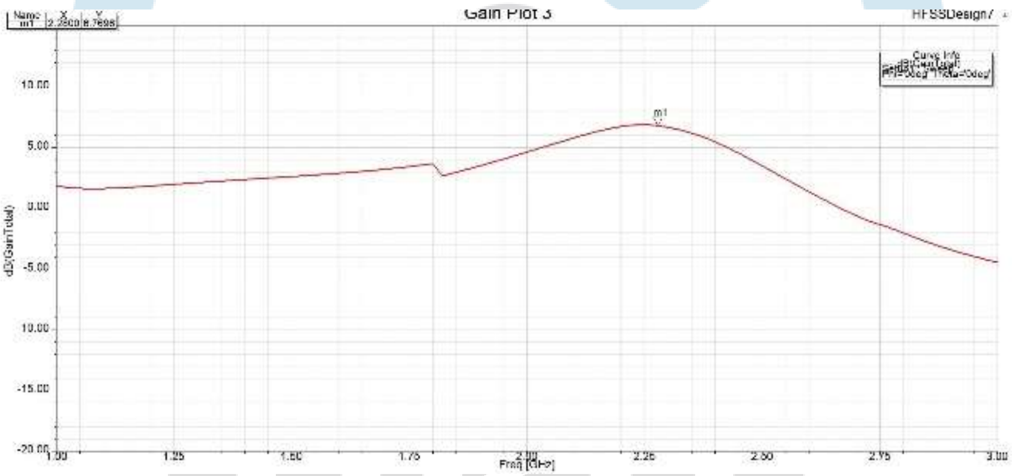

Fig.5 Microstrip patch antenna Gain versus frequency

D.Proposed Microstrip Patch Antenna Radiation Pattern

The patch antenna's 2D radiation pattern is shown.

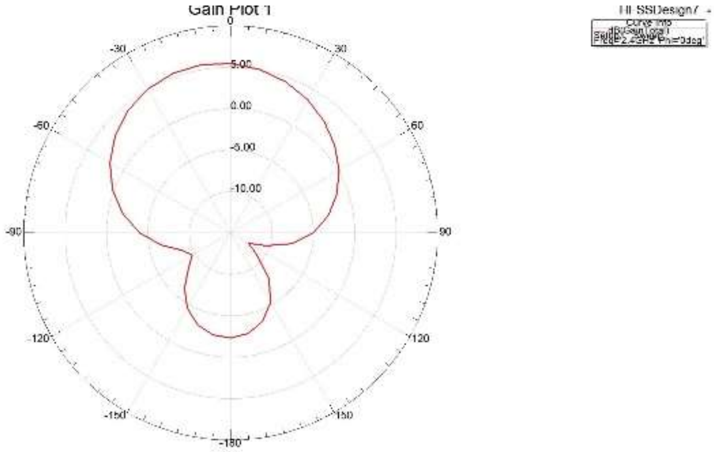

Fig.6 Microstrip patch antenna E-plane 2d gain

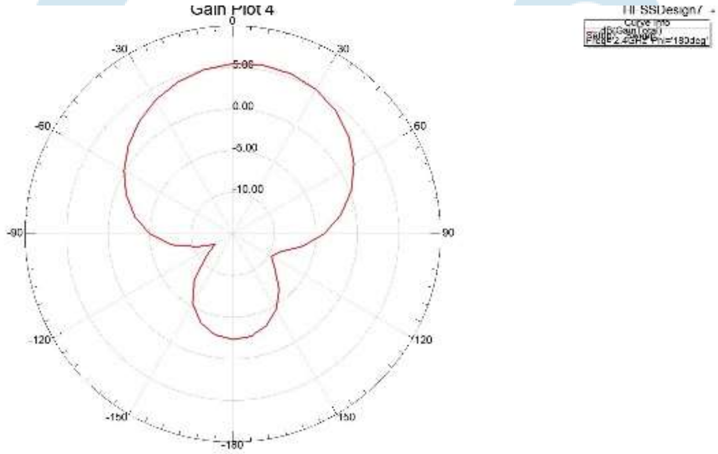

Fig.7 Microstrip patch antenna H plane 2d gain

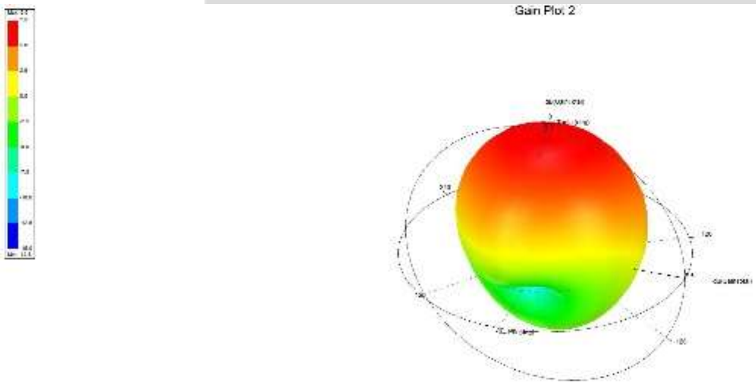

Fig.8. Microstrip patch antenna 3d gain

V. COMPARISION OF RESULTS

By comparing the suggested antenna results to the existing antenna, we can conclude that the proposed antenna is smaller and produces better results as shown in Table III.

TABLE.III: COMPARISON BETWEEN EXISTING METHODAND PROPOSED METHOD

References	Operating Frequency (in GHz)	Return Loss(dB)	Gain(dB)	Dimension (in mm)
[15]	2.4	-23	4.22	76 x 57.8
Proposed Antenna	2.4	-33	6.7	55 x 55

VI.CONCLUSION

In this Article, a method for constructing a high gain rectangular Microstrip patch antenna for 2.4 GHz applications is provided. The antenna resonates at 2.4 GHz with a return loss of -33 dB and a VSWR of 0.3. The patch antenna recommended has a good radiation pattern and a gain of 6.7dB. The antenna's construction is relatively low profile, measuring 55x55x1.6 mm.

REFERENCES

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[1] “Antenna Theory: Analysis and Design - Constantine A. Balanis - Google Books.”

[2] “Antenna Theory and Design - Warren L. Stutzman, Gary A. Thiele - Google Books.”

[3] M. A.-Biol. Chem. Res and undefined 2015, “Microstrip patch antenna− designing at 2.4 GHz frequency,” *academia.edu*

[4] “Design of Rectangular Microstrip Patch Antennas for the 2.4 GHz Band - 百度文库.”

[5] M. Karthick, “Design of 2.4GHz patch antennae for WLAN applications,” *2015 IEEE 7th National Conference on Computing, Communication and Information Systems, NCCCIS 2015*, pp. 1–4, Oct. 2015, doi:0.1109/NCCCIS.2015.7295902.

[6] M. S. Islam, M. T. Islam, M. A. Ullah, G. K. Beng, N. Amin, and N. Misran, “A Modified Meander Line Microstrip Patch Antenna with Enhanced Bandwidth for 2.4 GHz ISM-Band Internet of Things (IoT) Applications,” *IEEE Access*, vol. 7, pp. 127850–127861, 2019, doi: 10.1109/ACCESS.2019.2940049.

[7] L. C. Paul, S. S. A. Ankan, M. M. Alam, M. Z. Mahmud, and P. K. Paul, “A Compact Slotted Circular Patch Antenna for 5G Applications,” *Proceedings of International Conference on Electronics, Communications and Information Technology, ICECIT 2021*, 2021, doi: 10.1109/ICECIT54077.2021.9641253.

[8] R. Azim *et al.*, “A multi-slotted antenna for LTE/5G Sub-6 GHz wireless communication applications,” *International Journal of Microwave and Wireless Technologies*, vol. 13, no. 5, pp. 486–496, Jun. 2021, doi: 10.1017/S1759078720001336.

[9] M. Munde, S. P. Singh, A. Singh, D. Upadhyay, and S. Pal, “Design and Fabrication of Microstrip Patch Antenna at 2.4 Ghz for WLAN Application using HFSS,” *Article in IOSR Journal of Electronics and Communication Engineering*, 2021, Accessed: Jul. 02, 2022. [Online]. Available: https://www.researchgate.net/publication/351618826

[10] E. Aravindraj and K. Ayyappan, “Design of slotted H-shaped patch antenna for 2.4 GHz WLAN applications,” *2017 International Conference on Computer Communication and Informatics, ICCCI 2017*, Nov. 2017, doi: 10.1109/ICCCI.2017.8117773.

[11] S. M. Ali, V. Jeoti, T. Saeidi, and W. P. Wen, “Design of compact microstrip patch antenna for WBAN applications at ISM 2.4 GHz,” *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 15, no. 3, pp. 1509–1516, Sep. 2019, doi: 10.11591/ijeecs.v15.i3.pp1509-1516.

[12] K. Anusury, S. Dollapalli, H. Survi, A. Kothari, and P. Peshwe, “Microstrip Patch Antenna for 2.4GHz Using Slotted Ground Plane,” *2019 10th International Conference on Computing, Communication and Networking Technologies, ICCCNT 2019*, Jul. 2019, doi: 10.1109/ICCCNT45670.2019.8944653.

[13] T. Katajamäki, “A compact dual-band phased array antenna for outdoor WLAN,” *IEEE Vehicular Technology Conference*, vol. 59, no. 1, pp. 59–63, 2004, doi: 10.1109/VETECS.2004.1387912.

[14] I. J. Gupta, J. A. Ulrey, and E. H. Newman, “Antenna element bandwidth and adaptive array performance,” *IEEE Antennas and Propagation Society, AP-S International Symposium (Digest)*, vol. 1 B, pp. 295–298, 2005, doi: 10.1109/APS.2005.1551548.

[15] V. K. kumar, “IEEE SPONSORED 2 ND INTERNATIONAL CONFERENCE ON ELECTRONICS AND COMMUNICATION SYSTEM(ICECS 2015) Design and Analysis of Microstrip Patch Antenna for 2.4GHz ISM Band and WLAN Application.”