ISSN 2286-4822
www.euacademic.org

EUROPEAN ACADEMIC RESEARCH
Vol. XII, Issue 2/ May 2024

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Dual-band Microstrip Patch Antenna with Optimized Coverage and Bandwidth for WLAN Applications

SAIFULLAH
MUHAMMAD SOHAIL
MUZAMMIL BUKHARI
Department of Physics, University of Baluchistan, Quetta, Pakistan

Abstract:

Microstrip Patch Antennas (MPA) typically used in modern WLAN routers. A Dual-band Microstrip Patch Antenna (MPA) is presented which is optimized for WLAN bands (2.4 GHz and 5 GHz). High Frequency Structure Simulator (HFSS) is used for structure design and results. The simulation results reveal better VSWR, bandwidth and return loss values for both of bands. The proposed antenna operates on resonating frequencies of 2.4 GHz and 5 GHz with a return loss of 24 dB and 25 dB respectively. The bandwidth for 2.4 GHz is 340 MHz and for 5 GHz band it is 290 MHz which very much meets the IEEE 802.11 standards for dual-band WLAN antenna. Usually, MPAs come in various shapes but the proposed antenna is rectangular shape with a size of 70x60 mm² and thickness of 1.6 mm. Fr4-epoxy is used as dielectric substance which is an ideal choice for MPAs having dielectric constant of 4.4. Feedline for the proposed antenna is a microstrip line of 50 ohms. Overall, this dual-band MPA provides good impedance bandwidths in dual bands to make it a stable, versatile and an effective device.

Keywords: Microstrip patch antenna (MPA), HFSS, WLAN, return loss, VSWR

I. INTRODUCTION

Wireless communication is a common way to transmit data in a local area network specifically known as WLAN. In last two decades, the Wi-Fi technology has greatly advanced to more speedy data transferring rate, with this advancement the local area wireless communication network has also progressed, and the market demand of wireless appliances is incredibly increasing [1]. The most crucial WLAN standard is Wi-Fi 6 which is required for all current mobile devices and Internet of Things (IoT) gadgets. The wireless router is an essential gadget in the WLAN system which is used to connect a variety of portable devices [2]. Wireless routers are extensively asked for wireless connectivity in educational institutes, offices, homes, factories, etc. Wi-Fi 6 antennas, which play a significant role in wireless router performance, have been studied for many years. As wireless communication services and standards continue to grow, the design of WLAN antennae is encountering new challenges and demands such as low profile, High gain, Compactness, and multiband properties [3]. Microstrip Patch antennas are gaining popularity and attraction in the research field because of their lightweight, compactness, low cost of fabrication, and conformability. With the development of wireless communication bandwidth enhancement and transmission coverage are some important pursuits [6]. They have been broadly utilized in WLAN systems such as Radio Frequency Identification (RFID), mobile phones and WLAN routers, Global Positioning System (GPS), and several other applications [5]. The analysis of multiband and miniaturization of the antenna is gained significant importance. Besides smaller size, low profile, lightweight and low cost which fulfil the requirement of miniaturization. The MPAs lag in longer transmission coverage and broader bandwidth. Therefore, the dual-band characteristics of the antenna are essential to be explored and optimized [1]. At the moment, in wireless local area network extensive research on dual-band patch antennas is undergoing. Several types that operate in two bands are being proposed, which include inverted-F planer antennas, Quasi-Yagi antennas and dipole antennas. These antennas have basic construction and cheap manufacturing cost making them appropriate for use with WLAN devices. MPA research is mostly aimed at small scales, broadband, multi-polarization, multiband (2.4 GHz and 5GHz) and high gain. But they still encounter limitations in long-range transmission coverage and bandwidth [8].

This paper is created to support two Wi-Fi frequency bands (2.4 GHz and 5 GHz), seeks to optimize the coverage and bandwidth of a dual band microstrip patch antenna making it suitable for the needs of different countries. Many researchers have worked on designing dual-band Wi-Fi antennas, and you can find their achievements in TABLE I .

TABLE I. Comparison Table of Reputed Dual Band WLAN Antennas with Proposed Design

Preceding studies	Area(mm^2)	Resonance Frequencies
[1]	216	2.4/5.2/5.8GHz
[2]	960.75	2.4/3.5 GHz
[3]	9261	2.5/3.5 GHz
[4]	4200	3.48/5.35 GHz
[5]	720	2.4/5.6 GHz
[6]	7200	2.29/3.34 GHz
[7]	600	2.4/5.0 GHz
[8]	600	2.4/5.2 GHz
[9]	3600	2.4/5.5 GHz
[10]	2500	1.57/5.8 GHz
This work	4200	2.4/5.4 GHz

In our current study, we employed simulation software HFSS and analytical modelling. The research was carried out using these methodological approaches. The data collection methods involved the utilization of microstrip circuit design. The optimized wireless local area network microstrip antenna was developed through the application of rectangular patch design equations and analytical methods. The research was conducted rigorously and can be reproduced through simulation and analytical modelling, representing a standard methodology in our research domain. The second part of our work outlines the configuration for antenna miniaturization design. Subsequent sections demonstrate antenna geometry and simulated results, with the conclusion provided in the final section.

II. ANTENNA DESIGN PROCESS

A) Antenna Characteristics:

The current Microstrip Patch Antenna (MPA) is designed for application in both 2.4GHz and 5GHz wireless local area network scenarios. The presence of a metallic ground surface can impact the resonance frequency, necessitating an optimal impedance match to ensure that the antenna, when mounted on a metallic surface, doesn't compromise its performance by reflecting the user's signal. In the MPA system, continuous orientation is required, making directional antennas impractical as they focus on electromagnetic energy in specific directions. To address the limitation in range due to gain, our work focuses on enhancing the power transmission coefficient, gain, and impedance bandwidth of the microstrip patch antenna. This improvement aims to satisfy the conditions of the maximum power transfer theorem, leading to an enhancement in both gain and impedance bandwidth.

B) Proposed Antenna Structure:

The configuration of patch and ground plane of the suggested microstrip patch antenna is illustrated in Figure 1 (a) and (b).

(a) (b)

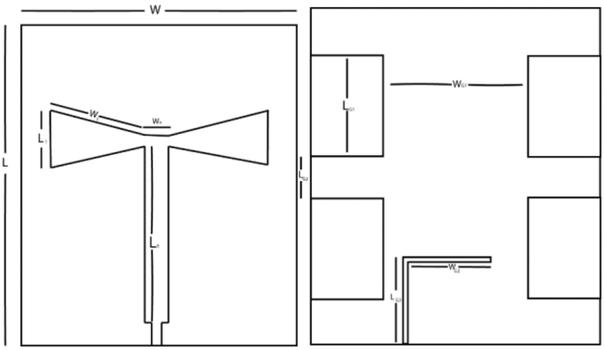

Figure 1 (a) Patch (b) Ground

The antenna's dimensions are provided in Table II. We conducted simulations for the proposed design using the HFSS software and acquired the corresponding results.

TABLE II. The Dimensions of the Antenna (mm)

L	70	L_{G3}	18
W	60	W_0	6
L_0	40.35	W_1	21
L_1	11.7	W_{G1}	
L_{G1}	21	W_{G2}	17.2
L_{G2}	8		

III. SIMULATION RESULTS

The microstrip patch antenna design in Figure 2 was simulated using the high-frequency simulation software HFSS. Upon completing the antenna design phase, we obtained simulated results for the proposed microstrip patch antenna, including metrics such as return loss, VSWR, radiation pattern, 3D polar plot, and gain.

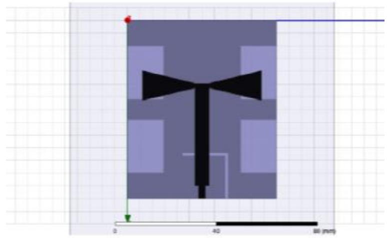

Figure 2 Microstrip Patch Antenna design

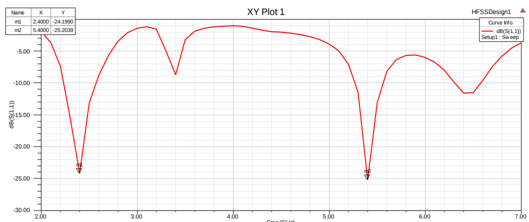

Figure 3 Optimized S_{11} Parameter

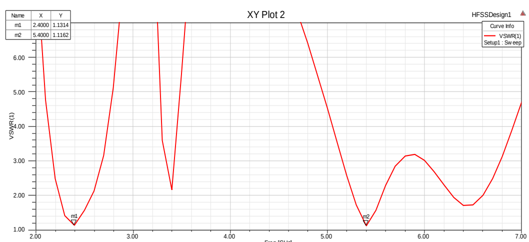

Figure 4 VSWR

In Figure 3, it is evident that the designed Microstrip Patch Antenna (MPA) exhibits a return loss of –24.1990 dB at the resonant frequency of 2.4 GHz and –25.2039 dB at resonant frequency of 5.4 GHz. Additionally, the antenna's bandwidths can be observed from Figure 3. To calculate the bandwidths of the dual-band MPA, the following formula is utilized:

Bandwidth = High Frequency − Low Frequency

Substituting the values into the equation:

Bandwidth for lower band=0.3367 GHz ≈ 340 MHz

Bandwidth for upper band= 0.296 GHz ≈ 290 MHz

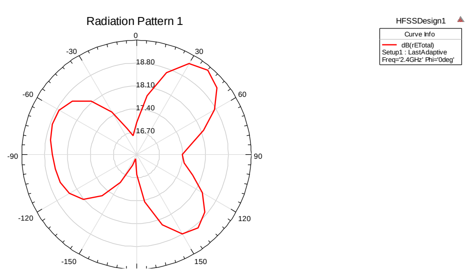

Figure 5 2D Radiation Pattern

In Figure 4, the VSWR is depicted, revealing the minimum value of 1.1314 at 2.4000 GHz and 1.1162 at 5.4000 GHz. Figures 5 and 6 present the 2D radiation model and 3D polar plot, respectively. The radiation configuration indicates the direction in which electromagnetic waves emanate from the antenna. To achieve this, we set the solution frequency to 2.4GHz with an exceptionally high number of passes (20) and the highest delta S of 0.02.

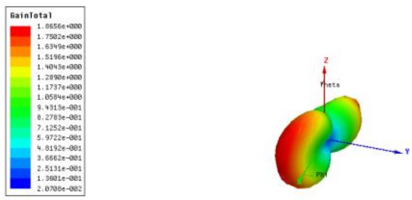

Figure 6 3D Polar Plot

IV.CONCLUSION

The crafted antenna effectively satisfies the criteria for a dual-band WLAN antenna. The S11<-10dB band aligns precisely with the specified frequency band of IEEE 802.11, demonstrating robust radiation performance across the two frequency bands. The proposed antenna exhibits a VSWR of 1.1314 at 2.4000 GHz and 1.1162 at 5.4000 GHz, indicating acceptable performance. The design of the Microstrip Patch Antenna (MPA) was replicated using HFSS simulation software. In this antenna, a microstrip feed line is employed to achieve a bandwidth of 340 MHz and 290 MHz at the desired resonant frequencies of 2.4GHz and 5GHz. The recommended microstrip antenna boasts a compact profile, rendering it small, easy to fabricate, and is fed by a 50-ohm microstrip feed line, making it an attractive choice for both current and future WLAN applications.

REFERENCES

[1] Ghaffar, A., Li, X. J., & Seet, B. C. (2018, August). Compact dual-band broadband microstrip antenna at 2.4 GHz and 5.2 GHz for WLAN applications. In *2018 IEEE Asia-Pacific Conference on Antennas and Propagation (APCAP)* (pp. 198-199). IEEE.

[2] Zheng, X., & Tang, L. (2022, August). Design of dual band microstrip antenna based on electromagnetic band gap structure. In *2022 20th International Conference on Optical Communications and Networks (ICOCN)* (pp. 1-3). IEEE.

[3] Ali, I., & Chang, R. Y. (2015, September). Design of dual-band microstrip patch antenna with defected ground plane for modern wireless applications. In *2015 IEEE 82nd Vehicular Technology Conference (VTC2015-Fall)* (pp. 1-5). IEEE.

[4] Kaur, J., & Khanna, R. (2014). Development of dual-band microstrip patch antenna for WLAN/MIMO/WIMAX/AMSAT/WAVE applications. *Microwave and Optical Technology Letters*, *56*(4), 988-993.

[5] Xu, X., Liu, G., & Jiang, T. (2021, October). Research and Design of Dual Band Microstrip Antenna for WLAN. In *2021 IEEE 9th International Conference on Computer Science and Network Technology (ICCSNT)* (pp. 85-88). IEEE.

[6] Deepa, M., Reba, P., Annalakshmi, H., & Suthindhira, S. (2023, February). Design and Fabrication of Dual band Slotted Microstrip Patch Antenna-3.5 Ghz and 2.4 Ghz. In *2023 International Conference on Intelligent Systems for Communication, IoT and Security (ICISCoIS)* (pp. 208-211). IEEE.

[7] Pandey, A., Singhania, C., & Mishra, R. (2016, October). Design of a compact dual band meandering line monopole antenna for WLAN 2.4/5.0 GHz applications. In *2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES)* (pp. 830-833). IEEE.
[8] Chang, M. C., & Weng, W. C. (2011, July). A dual-band printed dipole slot antenna for 2.4/5.2 GHz WLAN applications. In *2011 IEEE International Symposium on Antennas and Propagation (APSURSI)* (pp. 274-277). IEEE.
[9] Dadgarpour, A., Zarghooni, B., Denidni, T. A., & Kishk, A. A. (2015). Dual-band radiation tilting endfire antenna for WLAN applications. *IEEE Antennas and Wireless Propagation Letters*, *15*, 1466-1469.
[10] Liu, H. W., Qin, F., Lei, J. H., Wen, P., Ren, B. P., & Xiao, X. (2014). Dual-band microstrip-fed bow-tie antenna for GPS and WLAN application. *Microwave and Optical Technology Letters*, *56*(9), 2088-2091.