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Research Article

Dual-Band Microstrip Patch Antenna Design for Wi-Fi Applications

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Abstract

In this paper, a microstrip patch antenna working at 2.4 GHz and 5.8 GHz frequencies is designed for use in Wi-Fi applications. The main purpose of the research is to design a compact, easy manufacture, and high-performance microstrip patch antenna. In the antenna, there is a patch with three slots on it as a conductor and the FR-4 substrate under it. Copper is preferred as a conductor in the patch and ground parts of the antenna. The overall dimensions of the antenna are 50 x 50 x 1.6 mm^3. Three rectangular slots were opened in the patch part of the antenna for the antenna to work in the dual-band range. In addition, 50 Ω microstrip feed is used in the antenna. The antenna resonates at 2.41 GHz and 5.8 GHz frequencies. The antennas bandwidth values in the lower (2.4 GHz) and upper bands (5.8 GHz) are 53.6 MHz and 200.4 MHz, respectively. The VSWR values obtained are 1.49 for the 2.41 GHz resonant frequency and 1.08 for the 5.8 GHz resonant frequency, respectively. The directivity graph and radiation properties of the antenna show that the antenna has the desired radiation characteristics. The design of the antenna was made using CST Studio Suite 2020 software.

Keywords: Microstrip Patch Antenna, Wi-Fi, Dual-Band, 2.4/5.8 GHz, Bandwidth.

Wi-Fi Uygulamaları İçin Çift Bant Mikroşerit Anten Tasarımı

Öz

Bu bildiride, Wi-Fi uygulamalarında kullanılmak üzere 2,4 GHz ve 5,8 GHz frekanslarında çalışan bir mikroşerit yama anteni tasarlanmıştır. Araştırmanın temel amacı, kompakt, üretimi kolay ve yüksek performanslı bir mikroşerit yama anteni tasarlamaktır. Antende iletken olarak üzerinde üç slot bulunan bir yama ve altında FR-4 substratı bulunmaktadır. Antenin yama ve toprak kısımlarında iletken olarak bakır tercih edilmiştir. Antenin genel boyutları 50 x 50 x 1,6 mm^3'tür. Antenin çift bant aralığında çalışması için antenin yama kısmında üç adet dikdörtgen yuva açılmıştır. Ayrıca antende 50 Ω mikroşerit besleme kullanılmıştır. Anten 2.41 GHz ve 5.8 GHz frekanslarında rezonansa girmektedir. Alt (2.4 GHz) ve üst (5.8 GHz) bantlardaki anten bant genişliği değerleri sırasıyla 53,6 MHz ve 200,4 MHz'dir. Elde edilen VSWR değerleri sırasıyla 2.41 GHz rezonans frekansı için 1.49 ve 5.8 GHz rezonans frekansı için 1.08'dir. Antenin yönlülük grafiği ve ışıma özellikleri, antenin istenilen ışıma özelliklerine sahip olduğunu göstermektedir. Anten tasarımı CST Studio Suite 2020 yazılımı kullanılarak yapılmıştır.

Anahtar Kelimeler: Mikroşerit Yama Anteni, Wi-Fi, Çift Bant, 2.4/5.8 GHz, Bant Genişliği.

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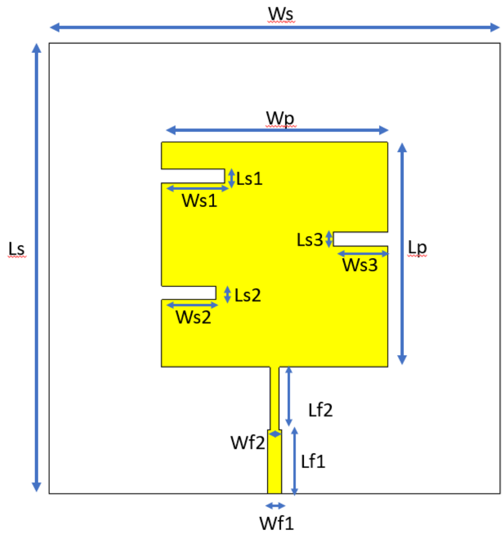
1. Introduction

With the developing technology, the number of more minimal technological devices has increased day by day. With the increase in the number of these devices, the necessity of producing a smaller size, high bandwidth, multi-band antenna that will enable simultaneous communication with more than one device has also emerged in wireless communication. Microstrip antennas are small in size, light in weight, easy to integrate, and inexpensive, making them an ideal choice for dual-band antenna design applications. The microstrip patch antennas generally consist of a flat metallic region referred to as the patch, a dielectric substrate, a ground plane, and a feed supply [1]. With the fast development of new wireless communication protocols, the technological need for mobile devices is growing by the day. Compact size, low profile, and cheap cost are all significant aspects that RF/microwave designers must attain for every wireless component. The antenna is one of the most important components at wireless communication; in addition to physical requirements, high directivity, large gain value, efficiency, and broadband operability of antennas are growing needs of wireless systems. Many strategies have been investigated to meet required specifications, ranging from the inclusion of varied shaped slits or radiating components [2-4] to the use of artificial metamaterials [5-6] and ground plane engineering, as has been done with EBG structures. Generally, a microstrip patch antenna operates in a single frequency range. Multi-band antennas are needed in applications that can work in different frequency channels such as WLAN [7-8]. Today, many new microstrip antennas have been designed and developed to be used in applications such as Wi-Fi/WiMax. The antenna designed in [9] is 44 x 41 mm^2 in size and FR-4 material was used as the substrate. In addition, there are two rectangular slots, one for each patch on the antenna and one on the ground. Although the antenna resonates at 2.5 GHz and 5.8 GHz, the bandwidth values obtained are low compared to their size. The antenna designed in [10] is 70 x 70 mm^2. DGS (Defected Ground Structure) model was used to ensure that the antenna resonates at the desired frequencies. Although the antenna has good gain and bandwidth values for wireless applications, it cannot fully meet the need for smaller microstrip antennas. In [11], a microstrip antenna operating at 2.45 GHz and 5.8 GHz was designed for RFID and WLAN applications. FR-4 material with dimensions of 60 x 70 x 1.58 mm^3 and a dielectric value of 4.4 was used as the substrate for the antenna. Although the antenna operates at frequencies that meet its design purpose, its dimensions are large and the measurement results did not reach as good values as the simulation results. A patch antenna operating at 2.4 GHz and 5 GHz is designed for WLAN applications in [12]. There are star-shaped slots on the patch part of the antenna. FR-4 material with $\varepsilon_r = 4.4$ dielectric value with dimensions of 62 x 64 x 1.6 mm^3 is used in the antenna. The bandwidth obtained for the lower band in the antenna is 65 MHz, and the bandwidth obtained for the upper band is 175 MHz.

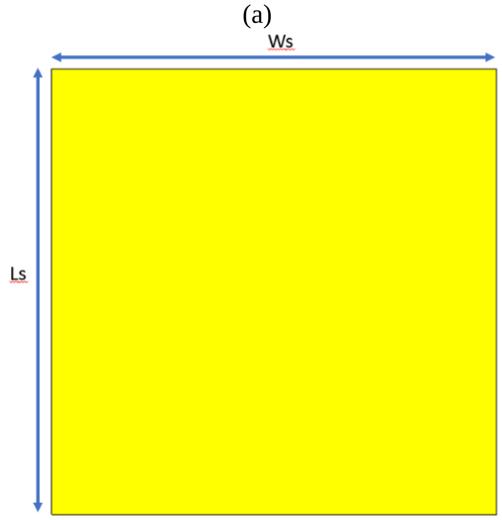
In this paper, a dual-band microstrip antenna resonating at 2.4 GHz and 5.8 GHz frequencies is designed for use in Wi-Fi applications. The overall dimensions of the antenna are 50 x 50 x 1.6 mm^3. Fort he antenna to operate at two different frequencies, 3 slits were opened in the patch part and the effect of these slits on the antenna was observed.

2. Material and Method

The geometric properties and structure of the proposed microstrip antenna are shown in Figure 1. There are 3 slots in the patch part of the antenna. The positions of these slits are clearly shown in the figure. The thickness of FR-4, which is used as a dielectric in the antenna, is 1.6 mm. The dielectric constant of this material is ε_r = 4.3. 50 Ω microstrip feeding line is used as a feeding in antenna. The overall dimensions of the antenna are 50x50x1.6 mm3. 0.035 mm thick copper is used as a conductor in the antenna. Three rectangular slots have been opened in the patch part of the antenna, thus enabling the antenna to operate at 2.4 GHz and 5.8 GHz frequencies. In addition, CST Studio Suite 2020 software was used in the design and simulation of the antenna.



(a)



(b)

Figure 1. Geometry of the proposed antenna. (a) Top view; (b) Bottom view.

The design parameters of the antenna are listed in Table 1.

Table 1. Design parameters of the proposed antenna

Parameter	Value (mm)
Ws-Ls	50
Hs	1.6
Wp-Lp	25
Hc	0.035
Ws1-Lf1-Lf2	7
Ls1-Ls2-Ls3	1.5
Ws2-Ws3	6
Wf1	1.6
Wf2	1

3. Results and Discussion

3.1. Results

The graph of the antenna S1,1 is shown in figure-2. While the bandwidth of the antenna at 2.41 GHz resonance frequency is 53.6 MHz (2.38-2.44 GHz), the bandwidth obtained at 5.8 GHz resonance frequency is 200.4 MHz (5.71-5.91 GHz). These obtained bandwidths and frequency ranges show that the antenna complies with IEEE 802.11 a/b/g standards.

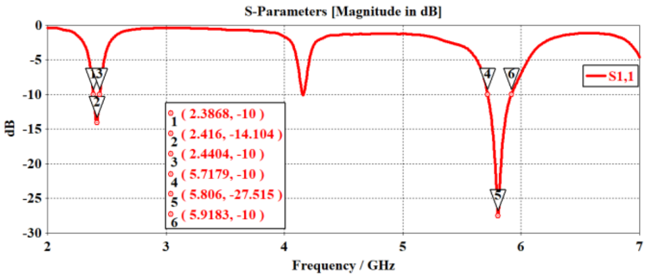


Figure 2. S11 parameter of the proposed antenna

The VSWR graph of the microstrip antenna is shown in figure 3. The VSWR value of the antenna at the 2.41 GHz resonant frequency is 1.49, while the VSWR value at the 5.8 GHz resonant frequency is 1.08. A VSWR value below 2 indicates that the impedance match between the antenna and the transmission line is good. The 1.49 and 1.08 values obtained in the antenna show that a good impedance match is obtained at the resonant frequencies.

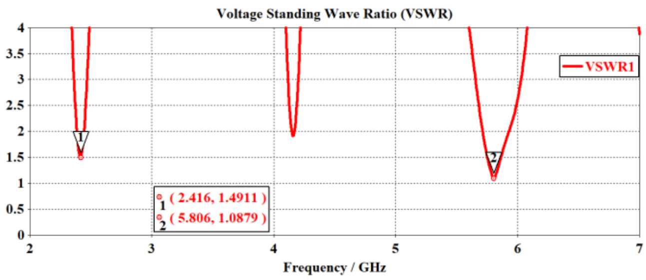


Figure 3. VSWR graph of the proposed antenna

The gain and directivity graph of the antenna is given in Figure 4.

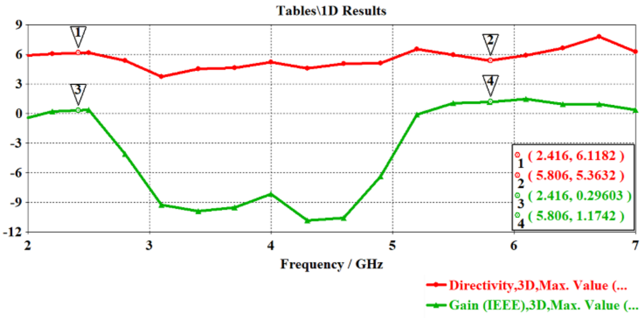


Figure 4. Gain (IEEE) and Directivity graph of the proposed antenna

The radiation pattern shows us the variation of radiation intensity over large distances in different directions of space and which direction radiates better [13]. The 3D radiation patterns of the designed antenna are illustrated in Figure 5a and Figure 5b at the two frequencies.

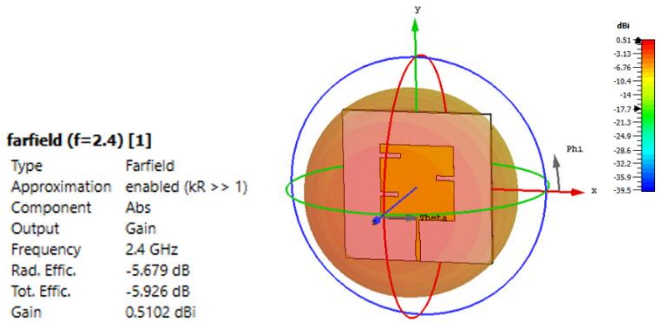


Figure 5a. 3D Radiation pattern of the proposed antenna (at frequency 2.4 GHz)

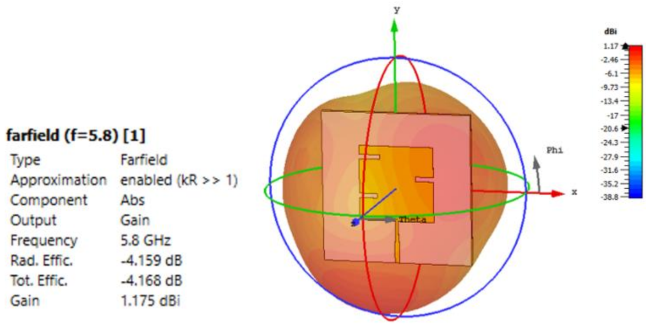


Figure 5b. 3D Radiation pattern of the proposed antenna (at frequency 5.8 GHz)

3.2. Discussion

The values of the important parameters affecting the performance of the microstrip antenna are shown in Table 2.

Table 2. Performance parameters of the proposed antenna

Frequencies (GHz)	2.41	5.8
S11 (dB)	-14.10	-27.51
Bandwidth (MHz)	53.6	200.4
VSWR	1.49	1.08

Considering the dimensions of the antenna, it has the performance to meet the demand. Compared to most antennas designed for similar purposes, it is smaller in size and simpler in production. These features make the antenna preferable in Wi-Fi applications. In addition, due to the simplicity of the design, it can be developed and is easy to manufacture.

4. Conclusion

In this article, a dual-band microstrip patch antenna is designed for use in Wi-Fi applications. A rectangular conductive patch is used in the antenna. Thanks to the three rectangular slots opened in this patch, the antenna can work at both 2.4 GHz and 5.8 GHz frequencies. The S1,1 and VSWR results obtained in the simulation environment show that the antenna meets the IEEE 802.11 standards. The small and simple dimensions of the designed antenna ensure that it is easy to fabricate and can be easily integrated into many systems.

5. Acknowledge

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References

[1] Stutzman, W. L., & Thiele, G. A. (2012). *Antenna theory and design*. John Wiley & Sons.

[2] Göçen, C., Akdağ, İ., Palandöken, M., & Kaya, A. (2020, October). 2.4/5 GHz WLAN 4x4 MIMO Dual Band Antenna Box Design for Smart White Good Applications. In 2020 4th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT) (pp. 1-5). IEEE.

[3] BAYTÖRE, C., GÖÇEN, C., PALANDÖKEN, M., Kaya, A., & ZORAL, E. Y. (2019). Compact metal-plate slotted WLAN-WIMAX antenna design with USB Wi-Fi adapter application. Turkish Journal of Electrical Engineering & Computer Sciences, 27(6), 4403-4417.

[4] Kaya, A. (2014). Diode loaded slot–patch antenna design and analysis for 2.4 GHz transceiver application. Optoelectronics and Advanced Materials-Rapid Communications, 8(November-December 2014), 1205-1212.

[5] Palandoken, M., & Henke, H. (2009, December). Fractal spiral resonator as magnetic metamaterial. In 2009 Applied Electromagnetics Conference (AEMC) (pp. 1-4). IEEE.

[6] Palandoken, M., & Henke, H. (2010, March). Fractal negative-epsilon metamaterial. In 2010 International Workshop on Antenna Technology (iWAT) (pp. 1-4). IEEE.

[7] Sung, Y. (2015). Compact dual-band antenna for 2.4/5.2/5.8 GHz WLAN service for laptop computer applications. *Microwave and Optical Technology Letters*, *57*(9), 2207-2213.

[8] Row, J. S., & Huang, Y. J. (2018). Dual-band dual-polarized antenna for WLAN applications. Microwave and Optical Technology Letters, 60(1), 260-265.

[9] Uqaili, R. S., Uqaili, J. A., Zahra, S., Soomro, F. B., & Akbar, A. (2020). A Study on Dual-band Microstrip Rectangular Patch Antenna for Wi-Fi. Proceedings of Engineering and Technology Innovation, 16, 1-12.

[10] Kaur, J., Nitika, & Panwar, R. (2019). Design and optimization of a dual-band slotted microstrip patch antenna using Differential Evolution Algorithm with improved cross polarization characteristics for wireless applications. *Journal of Electromagnetic Waves and Applications*, *33*(11), 1427-1442.

[11] Karli, R., & Ammor, H. (2015). Rectangular patch antenna for dual-band RFID and WLAN applications. Wireless Personal Communications, 83(2), 995-1007.

[12] Ferouani, S. S., Bendahmane, Z. Z., & Ahmed, A. A. T. (2017). Design and analysis of dual band star shape slotted patch antenna. relation, 8(1), 2.

[13] Fujimoto, K. (2008). Mobile antenna systems handbook. Artech House.