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***Research Article***

# Design and Interpretation of Microstrip Patch Antenna Operating at 2.4GHz for Wireless WI-FI Application

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**Abstract**

With the renewed and changing technology in recent years, wireless communication has increased its importance in engineering, communication, transportation and almost every field. In this study, a Wi-Fi antenna with 2.4 GHz operating frequency, which is one of the leading studies of antenna technology, which can be used in wireless communication technology, has been designed. Wi-Fi antenna is very important for this technology, which has become indispensable for everyone today. To design the Wi-Fi antenna, the operating frequency specified in the IEEE 802.11 standards has been taken into account. While choosing the antenna model, micro-strip antenna was preferred due to its geometry, lightness, low production cost and compactness. While designing the antenna, CST Microwave Studio program was used and necessary measurements were made. While designing the antenna, FR-4 substrate with a dielectric coefficient of 4.3 and a thickness of 1.6 mm was used. Copper was used as the material for the ground and patch parts. As a result of the design, most of the intended goals were achieved. Graphs were analyzed from the CST microwave studio program. When the required S parameter value is examined; The antenna obtained as a result of this study operates in the 2.26 GHz-2.38 GHz band range, which is the targeted frequency of 2.4 GHz. The Wi-Fi antenna obtained in this study; return loss value is 25.90dB and gain value is 4.66 dBi. These results are acceptable according to the standards.

**Keywords:** Wi-Fi Antenna, Microstrip Patch, Return Loss, IEEE 802.11, Antenna Design

# Kablosuz WI-FI Uygulaması için 2.4GHz'de Çalışan Mikroşerit Yama Anten Tasarımı ve Yorumlanması

**Öz**

Son yıllarda yenilenen ve değişen teknoloji ile kablosuz iletişim mühendislik, iletişim, ulaşım ve hemen her alanda önemini artırmıştır. Bu çalışmada, kablosuz iletişim teknolojisinde kullanılabilecek anten teknolojisinin önde gelen çalışmalarından biri olan 2.4 GHz çalışma frekansına sahip bir Wi-Fi anteni tasarlanmıştır. Günümüzde herkes için vazgeçilmez hale gelen bu teknoloji için Wi-Fi anteni oldukça önemlidir. Wi-Fi anteni tasarlanırken IEEE 802.11 standartlarında belirtilen çalışma frekansı dikkate alınmıştır. Anten modeli seçilirken geometrisi, hafifliği, düşük üretim maliyeti ve kompaktlığı nedeniyle mikro şerit anten tercih edilmiştir. Anten tasarımı yapılırken CST Microwave Studio programı kullanılmış ve gerekli ölçümler yapılmıştır. Anten tasarlanırken dielektrik katsayısı 4,3 ve kalınlığı 1,6 mm olan FR-4 substratı kullanılmıştır. Zemin ve yama parçaları için malzeme olarak bakır kullanılmıştır. Tasarımın bir sonucu olarak, amaçlanan hedeflerin çoğuna ulaşıldı. Grafikler, CST mikrodalga stüdyo programından analiz edildi. İstenilen S parametre değeri incelendiğinde; bu çalışma sonucunda elde edilen anten, hedeflenen frekans olan 2.4 GHz olan 2.26 GHz-2.38 GHz bant aralığında çalışmaktadır. Bu çalışmada elde edilen Wi-Fi anteni; geri dönüş kayıp değeri 25.90dB ve kazanç değeri 4.66 dBi'dir. Bu sonuçlar standartlara göre kabul edilebilir niteliktedir.

**Anahtar Kelimeler:** Wi-Fi Anteni, Mikroşerit Yama, Dönüş Kaybı, IEEE 802.11, Anten Tasarımı.

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# 1. Introduction

In digitalizing and developing world, the importance of wireless communication has increased day by day when it says 3G, 4G and the latest technology 5G [1]. The fact that wireless communication has become so widespread has revealed the need for equipment to be used in this technology [2-5]. The elements found in the past began to become unable to meet the needs, and there was a need for a better version to be revealed instead. One of the most widely used areas of wireless communication is WLAN systems [6-7]. Antennas are the most important parts required for data transfer in this system. Many studies have been carried out in order to meet the needs and make adequate transfer [8-10].

One of the most important features suitable is small size antenna design. Palandöken et al. A compact antenna design operating in 2.4, 5.2 and 5.8 GHz (WLAN) and 3.5 and 5.5 GHz (WiMAX) frequency bands compatible with 802.11.ac/n standards has been realized. The proposed metal antenna is made of a 0.5 mm thick copper plate with a compact overall physical size of 20 mm x 30 mm. It meets the desired features in terms of size [11]. This technology requires high-performance antennas [12]. It should also be cost-effective and easy to manufacture. In line with this definition, microstrip antenna, which is the most advantageous option that meets the demand, has been discussed. Rachmansyah et al designed the flattest microstrip patch antenna known. The gain value of this antenna is 11dBi [13]. The main problem of microstrip antennas is narrow bandwidth. In order to solve this problem, Haydar Ahmet, Y. Teşneli and N. Berna Teşneli compared the results using different feeding methods and analyzed the most appropriate feeding that could be used in the designed model. Coplanar feeding was the best feeding method with 60% bandwidth [14]. Afridi et al., on the other hand, designed an antenna with a gain value of 8.27 dBi and a return loss value of 21.29 dB, but with a very low bandwidth [15]. Another method to solve this problem is to open slots on the antenna. Raad H. Thaher and Zainab S. Jamil made parametric studies on the antenna in their study and opened slots in certain areas. The antenna they designed works in 2.4/5.8 GHz bands for Wi-Fi/WiMAX applications. The resulting return loss is 32.77 dB at 2.4 GHz at 7.4% bandwidth and 25.955 dB at 5.8 GHz with 8.17% bandwidth [16]. Looking at the study of Ali Hanafiah Rambe et al, the gain value of this antenna operating in the range of 2,404 GHz- 2,482 GHz is 6 dBi and the return loss value is 13.75 dB [17]. IEEE 802.11 standards were taken into account while doing all these studies. IEEE 802.11 standards are the general name of the developed wireless networks. 802.11 standards represent protocols created over WLAN within the local network. In this study, the dimensions of the antenna were changed, parametric studies were carried out and the most ideal dimensions were tried to be obtained by open slots on the selected surface [18]. It is aimed to design the most suitable microstrip antenna in terms of return loss and antenna gain. As a result of the simulations, the graphics were examined and interpretations were made [19].

The paper is structured as follows. In Chapter 2, a discussion will be made about the design of the designed antenna, its dimensions, feeding methods, and the preferred application for simulation. In Chapter 3, simulation results of the designed antenna are presented. In chapter 4, literature comparison is made and the difference between antenna and past is presented. In the last chapter, chapter 5, the general summary of the study is explained.

# 2. Material and Method

## 2.1. Proposed Antenna Design

There are 3 important parts of the antenna while designing a micro-strip antenna. Ground -- Patch – Substrate. While designing the antenna, the first step is to make the ground layer, which is the conductive layer. The ground material of the antenna we designed is copper and its thickness is 0.035mm. This layer must be conductive. The second layer is the substrate layer. The material FR4 was chosen for this layer. Its dielectric coefficient is 4.3 and its thickness is 1.6 mm. Generally, FR4 material is used in antenna designs. The other layer is the patch part. The patch layer is the layer on which the antenna radiates. This part should be conductive. Choosing copper was deemed appropriate. Its thickness is taken as 0.035 mm. It is aimed to bring the antenna to the desired frequency by making changes on this layer. After the necessary parametric analyses were made, it took the shape shown

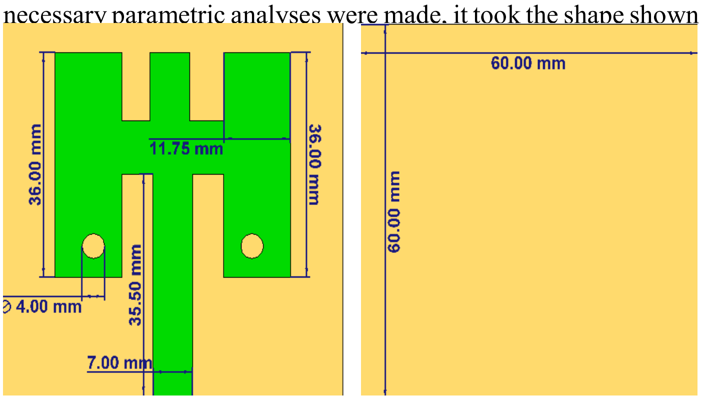


Fig. 1 Proposed antenna design

## 2.2 Proposed Antenna Feed

There are many feeding methods for the designed antennas. Micro-strip feed line is used for the antenna it was designed in this article. Optimal results were observed with this feeding [20]. The input impedance between the feed line and the antenna should be normalized. The normalized result is the input impedance of 50 ohms, because this value is the internationally accepted value. It is an important value for the proper integration of the antenna and the feed line.

## 2.3 Simulation and Measurement

The CST microwave studio program was used to design the antenna. The S (1, 1) gain return loss radiation pattern graphics of the designed antenna were examined and the results were interpreted.

*Table 1. Design parameters of proposed antenna*

| PARAMETER | MEASUREMENT |
|---|---|
| Left of Patch | 36 mm |
| Right Top of Patch | 11.75 mm |
| Radius of Slot | 2 mm |
| Length of Feed | 7 mm |
| Height of Feed | 3 mm |
| Length of Ground | 60 mm |
| Height of Ground | 60 mm |
| Thickness of Substrate | 1.6 mm |
| Thickness of Ground | 0.035 mm |
| Thickness of Patch | 0.035 mm |

# 3. Result and Discussion

## 3.1. Result

The results of the simulations of the antenna was designed in the CST microwave studio program were examined. The necessary results and graphics for the antenna are given below.

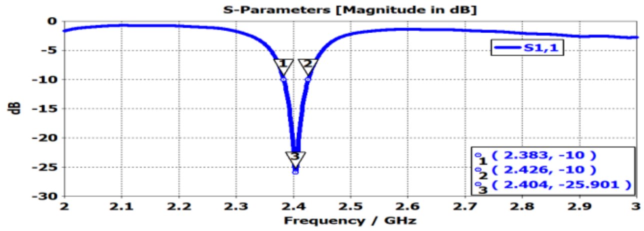


Fig. 2 Return loss of proposed antenna

The S parameter graph of the designed antenna is shown in Figure 2. According to the graph it was examined, the Wi-Fi antenna operating frequency has a return loss value of 25.90 dB. 25.90 dB return loss value is a very good result for the antenna. ($S11 \leq -10$ dB). The operating frequency range of the designed antenna is 2.382 GHz – 2.426 GHz.

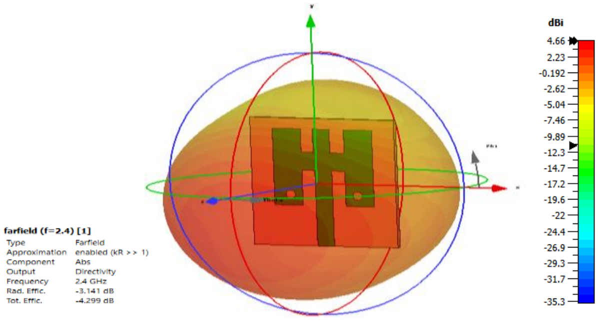

Fig. 3 Radiation Pattern of proposed antenna

It was obtained the gain of the antenna it was designed as 4.66 dBi as given in Figure 3.

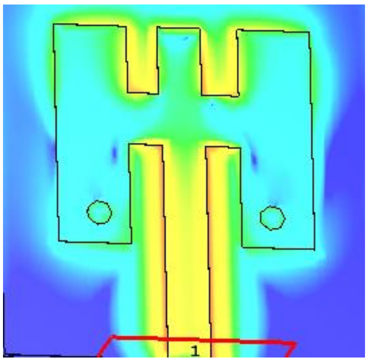

Fig. 4 Current Density of proposed antenna

The surface current density simulation results of the antenna designed in the study are shown in Figure 4 at 2.4GHz. When look at the simulation result, it is observed that this density decreases as to go to the edges where the current density is high along the supply line.

### 3.2. Discussion

The relevance of wireless communication in the globe is growing by the day in such times when everything is linked and digitalized. Many research have been conducted in order to reduce the hurdles to wireless communication improvement. The greatest examples in the research are Wi-Fi antenna designs. Wi-Fi antennas are in high demand now, and in the future, as the Internet becomes increasingly important. The operational frequency of the antenna created is that of Wi-Fi. It has a unique structure and has a lower surface area than other instances in the literature. Materials with a low cost of production are utilised. This has been demonstrated through trials and simulations. Because the return loss is so good, it may be employed in antenna designs that require it.

# 4. Conclusion

In this study, a Wi-Fi antenna operating at 2.4 GHz was obtained by using a microstrip patch antenna. Microstrip feeding was used as feeding and waveguide port assignment was made. The return loss value of the designed antenna was measured as 25.90 dB. The antenna operates between the frequency values of 2.382 GHz – 2.426 GHz. Proposed antenna gain has a value of 4.66 dBi. Optimum values were observed by performing various parametric studies. The studies and the results obtained were shown and evaluated. As a result of this study, an antenna with the desired values was observed.

## 5. Acknowledge

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