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Research Article

High-Gain Rectangular Patch Microstrip Antenna for IEEE 802.11 b/g Applications

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Abstract

Increasing demand for microstrip patch antennas, especially in microwave applications, due to its compactness, ease of fabrication, low cost, etc. gives rise to the research studies on the related area. In this study, rectangular shaped microstrip patch antenna is designed and simulated for Bluetooth applications. The antenna consists of rectangular shaped patch that is loaded with rectangular slots with different lengths, FR-4 substrate with 1.6 mm thickness and ground with reduced length. The designed antenna is simulated using CST MWS software to investigate S11, gain, VSWR parameters. Microstrip line feeding technique with discrete port is used to feed the antenna. According to the results, lower and higher frequency bands of the antenna are 2.24 GHz – 2.62 GHz with 2.48 GHz center frequency (15.3% bandwidth) and 5.80 GHz – 5.99 GHz with 5.90 GHz center frequency (3.22% bandwidth), respectively. Gain values at 2.4 GHz, 2.5 GHz and 5.9 GHz frequencies can be given as 3.45 dBi, 3.58 dBi and 4.93 dBi, respectively. S11 values at 2.4 GHz, 2.5 GHz and 5.9 GHz frequency bands are -16.64 dB, -18.00 dB and -15.11 dB. VSWR values of the antenna for 2.4 GHz, 2.5 GHz and 5.9 GHz can be given as, 1.35, 1.29 and 1.43 respectively. As a result, the proposed antenna has high gain and wide low frequency band. It can be used for Bluetooth/ Wi-Fi applications and IEEE 802.11 b/g standards are also supported by the antenna.

Keywords: IEEE 802.11 b/g, rectangular patch antenna, Bluetooth Antenna, Wi-Fi Antenna, 2.4/2.5 GHz antenna design

IEEE 802.11 b/g Uygulamalarına Yönelik Yüksek Kazançlı Dikdörtgen Yama Mikroşerit Anten Tasarımı

Öz

Mikroşerit yama antenlerin kompakt olması, imalat kolaylığı, düşük maliyeti vb. gibi avantajları, bu antenlere olan talebin, özellikle mikrodalga uygulamalarında, artmasına dolayısıyla mikroşerit antenlere yönelik bilimsel araştırmalarda artışa sebep olmuştur. Bu çalışmada, Bluetooth uygulamaları için dikdörtgen yama mikroşerit anten tasarlanmış ve simüle edilmiştir. Anten, üzerinde farklı uzunluklarda dikdörtgen yarıklar kullanılmış dikdörtgen yama, 1,6 mm kalınlığında FR-4 alt taş ve dikdörtgen zeminden oluşmaktadır. Tasarlanan anten, S11, kazanç, VSWR parametrelerini incelemek için CST MWS yazılımı kullanılarak simüle edilmiştir. Anten, mikroşerit hat besleme tekniği kullanılarak beslenmiştir. Sonuçlara göre antenin düşük ve yüksek frekans bantları 2,48 GHz merkez frekansı ile 2,24 GHz – 2,62 GHz (%15,3 bant genişliği) ve 5,90 GHz merkez frekansı ile (%3,22 bant genişliği) 5,80 GHz – 5,99 GHz olarak elde edilmiştir. 2.4 GHz, 2.5 GHz ve 5.9 GHz frekanslarında kazanç değerleri sırasıyla 3.45 dBi, 3.58 dBi ve 4.93 dBi olarak verilebilir. 2.4 GHz, 2.5 GHz ve 5.9 GHz frekans bantlarında S11 değerleri -16.64 dB, -18.00 dB ve -15.11 dB'dir. Antenin 2.4 GHz, 2.5 GHz ve 5.9 GHz frekanslarındaki VSWR değerleri sırasıyla 1.35, 1.29 ve 1.43 olarak verilebilir. Sonuç olarak önerilen anten yüksek kazanca ve geniş düşük frekans bandına sahiptir. Anten, IEEE 802.11 b/g standartlarını destekler. Dolayısıyla Bluetooth ve Wi-Fi uygulamalarında kullanılabilir.
Anahtar Kelimeler: IEEE 802.11 b/g, dikdörtgen yama anten, Bluetooth anten, Wi-Fi Anten, 2.4/2.5 GHz anten tasarımı

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1. Introduction

Due to the recent developments in microwave and millimeter wave component technology replacement of new wireless structures with existing ones [1]-[5] is a requirement to keep up with developing new technological progress. Increasing usage of microstrip patch antennas is one of the example of the mentioned circumstance. Microstrip patch antennas have been used commonly in microwave applications such as global positioning system, radar, mobile and satellite communication applications due to outstanding features such as ease of fabrication with printed circuit technology, operating at various frequency bands, reduced dimension and lightweight [6]-[8]. However, it is compelling to obtain desired antennas for researchers because of drawbacks of the microstrip antennas [9], [10].

Insufficient gain, low efficiency, narrow bandwidth and high cross polarization can be given as some of the examples of those drawbacks [6], [8]. To reduce those drawbacks, in literature, there are several works on the microstrip patch antennas. 2x2 circular microstrip antenna array that operates at 2.4 GHz resonance frequency is proposed by G. S. Shravan, L. Sai Suhas, N. G. Hemanth Kumar, S. Vinay and N. G. Girish Kumar. According to the simulation results in the study, gain is 6.71 dBi at 2.4 GHz resonance frequency. Simulation results and fabricated antenna results are very close to each other. Finally the proposed antenna is compared with rectangular patch antenna array [11]. A dual broadband antenna that supports IEEE 802.11 ac/b/g/n standards is proposed by Merih Palandöken. The proposed antenna consists of two split ring resonators those are interspaced and electrically small. The antenna work at 2.3 GHz – 3 GHz at 2.65 GHz and 4.7 GHz – 6 GHz at 5.35 GHz resonance frequencies. Gain values of the antenna can be given as 4.76 dBi, 2.9 dBi and 2.44 dBi at 2.4 GHz, 5.2 GHz and 5.8 GHz, respectively. In the study, simulation results and fabricated antenna measurements have enough consistency with each other [12].

Three antennas with different geometrical values are investigated by C. Baytore et al. Aim of the study is that to present a designing way of existing microstrip patch antennas in the literature that support WLAN 802.11 ac/b/g/n standards according to the new technological standards with low fabrication cost [13]. 4x1 rectangular microstrip array antenna is designed by I. Atas, T. Abbasov and M. B. Kurt with 11.3 dBi gain. S11 and VSWR parameters are -28.91 dB and 1.2 [14]. Circular slotted rectangular microstrip patch antenna that operates at 2.4 GHz – 3.5 GHz WLAN/WiMAX applications is proposed by S. E. Bayer Keskin and C. Güler. Two resonance frequencies of the antenna can be given as 2.59 GHz and 3.34 GHz. Gain of the resonance frequencies are 2.17 dBi and 2.18 dBi for 2.59 GHz and 3.34 GHz, respectively [15]. Wideband patch dipole antenna is designed by A. Sondaş. Bandwidth of the antenna is 2.36 GHz – 3.67 GHz and its gain is obtained as 2.36 dBi [16]. Split ring antenna that operates at 2.4 GHz/ 5.2 GHz frequency bands is designed by S. C. Başaran. The designed antenna can be used for WLAN applications [17]. Compact dual band planar antenna has been designed for 2.4 GHz/5.2 GHz/5.8 GHz WLAN applications by P. Nayak. Lower and higher frequency bands of the designed antenna are 2.27 GHz – 2.58 GHz and 4.92 GHz – 5.49 GHz, respectively [18].

The rest part of the presented paper is organized with the geometrical model of proposed antenna including geometrical parameters in Section II. Simulation results of the designed antenna are given in Section III. The proposed rectangular shaped microstrip antenna is compared with several antennas in the literature in Section IV and the results of the study are summarized in Section V.

2. Material and Method

In this paper, rectangular patch microstrip antenna is proposed for Bluetooth/Wi-Fi applications at 2.4 GHz and 2.5 GHz frequency bands. The geometrical parameters and corresponding values of the antenna are given in Figure 1 with the values in Table 1. To obtain desired antenna parameters, rectangular shaped slots with different lengths are loaded on the patch and length of the ground is reduced. Thickness of all the rectangular shape slots is the same and 2.50 mm. Annealed copper with 0.035 mm thickness is used as ground and patch materials. FR-4 with 1.6 mm thickness is used as substrate material. In the study, after the design procedure, the antenna is simulated using CST MWS software. To feed the designed antenna, microstrip line feeding technique with discrete port is used.

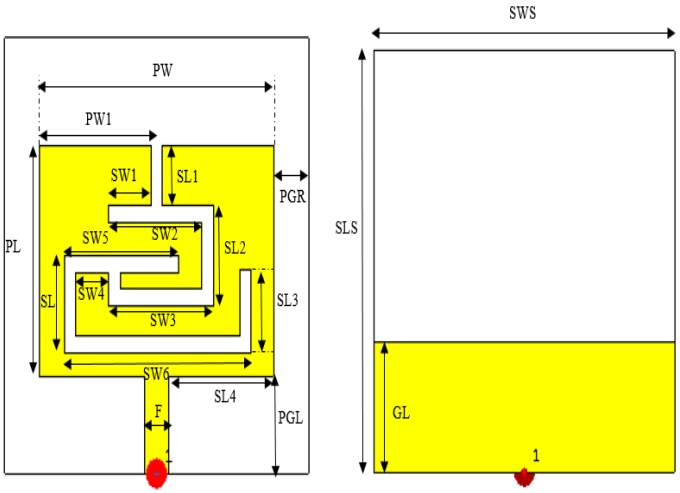

Figure 1:Geometrical Parameters of the Designed Antenna

Table 1: Geometrical Parameters of the Designed Antenna (mm)

PW	50.00	SW4	7.00
PW1	23.75	SW5	24.50
PL	34.50	SW6	40.00
PGR	7.50	SL	14.50
PGL	14.50	SL1	9.00
SW1	9.00	SL2	15.00
SW2	20.00	SL3	12.50
SW3	22.50	SL4	22.50
F	5.00	SLS	65.00
GL	20.00	SWS	65.00

3. Results and Discussion

3.1. Results

According to the simulation results, antenna operates as dual band rectangular patch microstrip antenna. Bandwidth and resonance frequency values of low frequency band are 2.24 GHz – 2.62 GHz (380.7 MHz) and 2.48 GHz with -18.18 dB S11 parameter, respectively. On the other hand, bandwidth and resonance frequency values of high frequency band are 5.99 GHz – 5.80 GHz (192 MHz) and 5.90 GHz with -15.13 dB S11 parameter, respectively. VSWR parameters of the antenna are 1.28 and 1.43 for 2.48 GHz and 5.9 GHz, respectively.

Farfield parameters at 2.4 GHz, 2.5 GHz and 5.9 GHz are summarized in Table 2. Also, 3D radiation patterns for 2.4 GHz and 2.5 GHz are given in Figure 3 and Figure 4.

Table 2: Parameters of the Proposed Antenna

Frequency (GHz)	Gain (dBi)	VSWR	S11 (dB)
2.4 GHz	3.45	1.35	-16.64
2.5 GHz	3.58	1.29	-18.00
5.9 GHz	4.93	1.43	-15.11

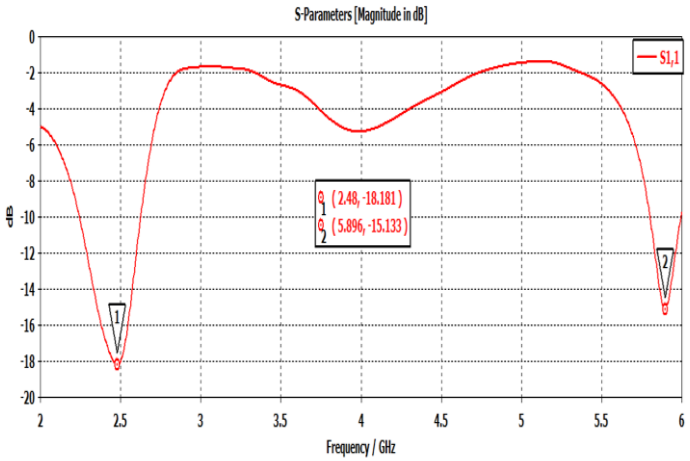

Figure 2: S11 Graph of the Designed Antenna

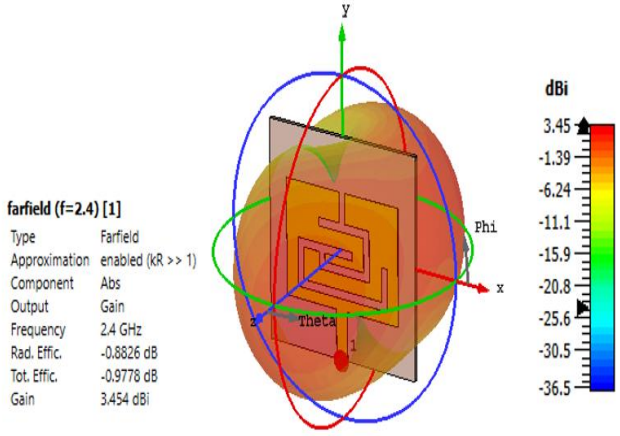

Figure 3: Simulated 3D Radiation Pattern at 2.4 GHz of the Proposed Antenna

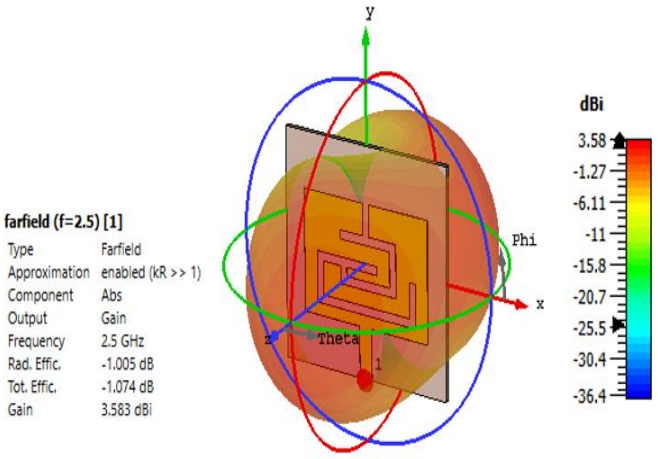

Figure 4: Simulated 3D Radiation Pattern at 2.5 GHz of the Proposed Antenna

3.2. Discussion

Table 3: Comparison of Antennas

Reference	Frequency (GHz)	Gain (dBi)	S11 (dB)
[19]	2.45 3.7 5.8	-1.24 -2.59 -0.45	-27 -28 -27
[20]	2.4	3.93	-17.29
[21]	2.5 5.8	1.37 3.9	-29.9 -15.16
This work	2.4 2.5 5.9	3.45 3.58 4.93	-16.64 -18.00 -15.11

Proposed rectangular shaped microstrip antenna has high gain and wide bandwidth in low frequency band. According to the results, the proposed antenna outperformed of similar microstrip patch antennas because of its outstanding features such as high gain, dual band operation and wide bandwidth. Also the proposed antenna is appropriate for Bluetooth/Wi-Fi applications.

4. Conclusions

In this study, rectangular shaped microstrip patch antennas is designed using rectangular slots with different lengths for IEEE 802.11 b/g applications. The designed antenna is simulated using CST MWS software. According to the simulation results, gain values of the antenna are 3.45 dBi, 3.58 dBi and 4.93 dBi at 2.4 GHz, 2.5 GHz and 5.9 GHz respectively. The simple structured small antenna can easily integrated to the small projects such as Bluetooth/Wi-Fi applications.

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