

Design Rectangular Patch Microstrip Antenna With Rectangular Slot On 2.4 GHz Ground plane For Wifi Application

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Abstract—This study aims to design a rectangular patch microstrip antenna design with a rectangular slot on the 2.4 GHz ground plane for Wi-Fi applications using CST Studio Suite 2019 software and on antenna measurements using Vector Network Analyzer. Some of the antenna parameters produced are return loss, bandwidth, VSWR, radiation pattern, and gain. This antenna has a rectangular patch shape and a ground plane that has a rectangular slot. The antenna is designed on a circuit board (PCB) with a permittivity of 4.6 and a thickness of 1.6 mm. The antenna is designed based on the characteristics of several antenna parameters, namely having a return loss of 10 dB, a gain value of ≥ 1 dB, and VSWR < 2 dB. After several simulations, the results at the frequency of 2.4 GHz obtained a return loss value of -14.84 dB, bandwidth of 53 MHz, VSWR value of 1.442, a gain of 2.063 dBi, and had a Unidirectional radiation pattern. The measurement of the microstrip antenna fabricated using the Vector Network Analyzer shows a return loss value of -11.68 dB, and VSWR of 1.747 dB.

Keywords— Antena microstrip, patch rectangular, WiFi, CST Studio Suite 2019.

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I. INTRODUCTION

In wireless communication systems, antennas are needed in the process of transmitting data from the air, so that electromagnetic waves can be emitted and received effectively. Wireless technology continues to evolve to meet the needs of telecommunications users [1]. One of the wireless communication technologies is *Wireless Local Area Network* (WLAN) which is applied to the local area for example in one building or one office. There are two frequency allocations used, namely 2.4 GHz and 5 GHz. The 2.4 GHz frequency is used by the IEEE 802.11 protocol standard for *wireless fidelity* (Wi-fi) [2][7]. Wi-fi signal strength varies from place to place, so there may be some places where the signal is weak and requires a high-gain antenna. In designing such antennas, the size and cost of manufacture must also be considered [3].

An antenna is an electrical device that can convert electrical signals into electromagnetic waves and then emit them into free space or vice versa, which captures electromagnetic waves from free space and converts them into electrical signals. Antennas are also classified as transducers because they can change a form of energy to other forms of energy. The antenna is one of the components or elements Most important in a circuit and electronic devices related to radio frequencies or electromagnetic waves. Several important

antenna parameters become benchmarks in antenna performance, namely radiation pattern, polarization, gain gain, and directivity. For the antenna to work properly, these parameters must get optimal values [2]. Microstrip antenna is the most suitable antenna used in telecommunications devices today because of its adequate shape and size. Then this microstrip Antenna is suitable

used for wifi technology to be more effective and efficient [4].

Microstrip antenna technology can provide a solution because it is one type of antenna that has many functions, including wireless communication, has a small and lightweight shape, works at a specified frequency, and is low cost. Microstrip antennas have three components: conducting *patch*, substrate, and *ground plane*. [5]. The *patch* and *ground plane* can be modified by adding some form of slot[10]. The modified microstrip antenna with added slots affects the inductive coupling that is transmitted from the plug to the slot: the greater the inductive coupling, the less the quality of an antenna. Increasing the gain value and bandwidth of the antenna is done by modifying the antenna microstrip with added slots on the *patch* or *ground plane*[6].

II. METHOD

In this final project, a microstrip antenna with a *rectangular patch* shape will be designed. Before designing an antenna, we must first know the specifications of the antenna to be designed and the calculation of the dimensions of the antenna with *rectangular patches*.

A. Research Flow

In the design of this final project, several stages will be described. The flow chart illustrates several phases in antenna design. That is the phase that sums the operating frequency, antenna dimensions, VSWR, gain, and mathematical calculations for return loss, then the second phase calculates the width and length of the patch and the diameter of the ground plate. Furthermore, in the first and third steps, antenna dimensions were designed using CST 2019 software[11].

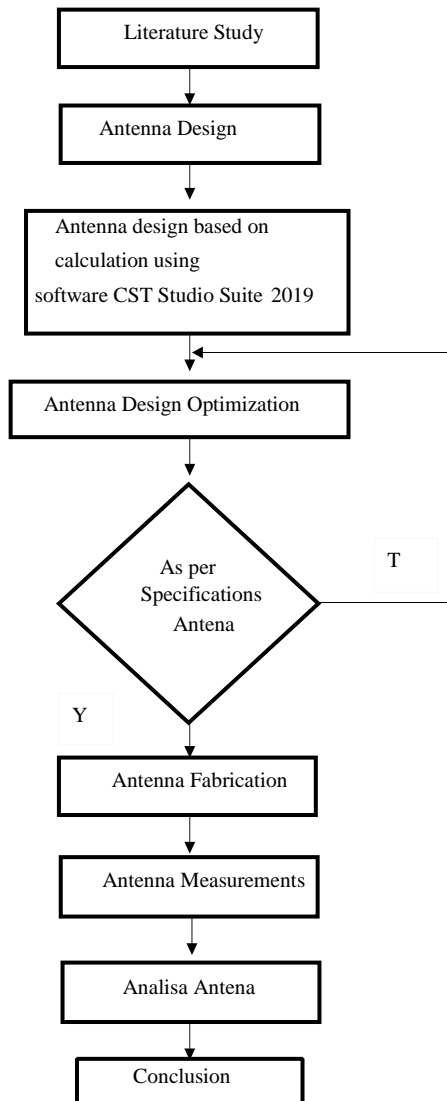


Fig.1 Research Flow

B. Antenna Dimensions

Table 1. Antenna Dimension

Parameter	Size (mm)
Wide Patch	37.3
Long Patch	28.7
Wide stripline	5.82
Big Inset feed	10.7
Width notch	1.1
Wide ground	46.9
Long ground	38.3

Microstrips with slots added to the *patch* or *ground plane* [5][8][9].

After doing calculations to determine the dimensions of the antenna, the patch can be seen in the table above. There are patch width, patch length, stripline width, feed inset size, notch width, ground width and ground length.

C. Antenna Design

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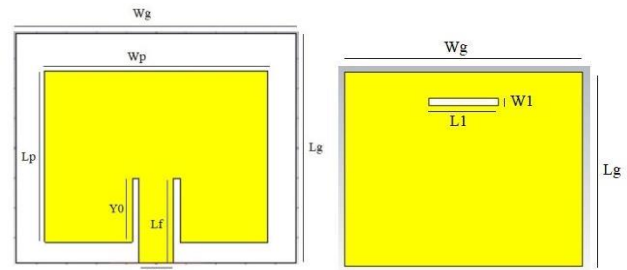


Fig. 2 Rectangular Patch Antenna Planning

The antenna to be made is a microstrip antenna in the form of a *rectangular patch* with a working frequency of 2.4 GHz for wifi applications with a gain value to be obtained is ≥ 1 dB. The type of substrate used is FR-4 (*lossy*) with a specification of the dielectric constant is 4.6, a characteristic impedance is 50ohm and a thickness is 1.6 mm. For the *ground plane* material used is *copper* with a thickness of 0.035 mm which can be seen in Fig 2.

III. RESULT AND DISCUSSION

A. Studi Parametric

A parametric study is a process carried out to obtain antenna parameters that match the desired, the aim is to see changes in the design of the microstrip antenna, such as changes in *patches*, *ground planes*, slots, or other parameters. This parametric study is done by reducing or increasing the size of the antenna design.

Changes in *ground plane* and substrate size affect *return loss* and VSWR. If the size is increased, the *resulting return loss* and VSWR value will be smaller. As seen in Fig 3 in chart S1.1

(23). Where after increasing the size of the ground and substrate length by 1.1 mm which can be seen in graph S1.1 (24) and increasing the length of the ground and substrate size by 2 mm, seen in graph S1.1 (25).

In Fig 4, there is a decrease in VSWR value when increasing the size of the ground and substrate lengths. In graph S1.1 (23) after increasing the size of the ground and substrate length by 1.1 mm, it can be seen in graph S1.1 (24) and increasing the length of ground and substrate size by 2 mm, seen in graph S1.1 (25).

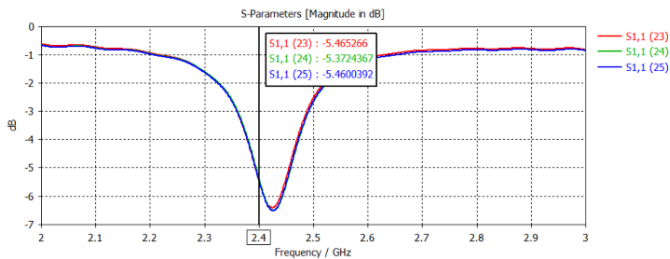


Fig. 3 Change in Ground and Substrate Size on Return Loss

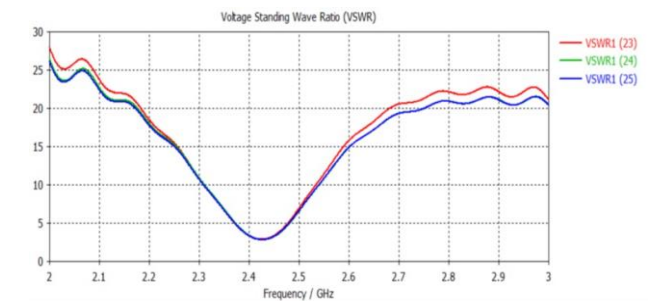


Fig. 4 Change of Ground and Substrate Size on VSWR

After getting the maximum *ground plane* size, it is tried to change the patch size, to get a better parameter value as expected. It can be seen in Fig 5, 3 attempts are shown. However, it can be seen in Fig 5 that the increase in *patch* size makes a frequency shift Work is very quickly shifted to the left, which means that the shift is getting closer to the desired work frequency.

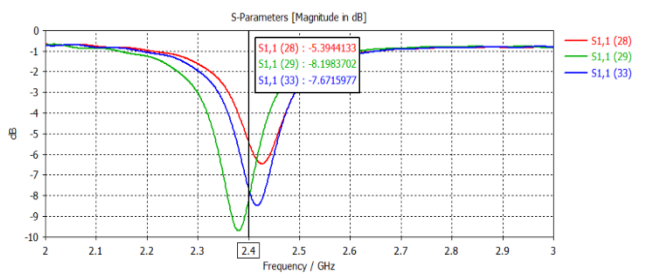


Fig. 5 Patch Size Changes

Next, perform optimization or parametric studies to several antenna elements by changing the size or dimensions. Here what is changed is the size of the slot on the antenna. The simulation results can be seen in Fig 6.

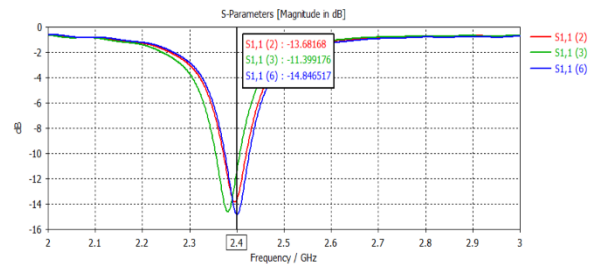


Fig. 6 Slot Simulation Results

In increasing the slot size, there is a change in return loss. Where, when the slot size is 1.15 mm produces a smaller return loss value than when the slot size is 0.6 mm or 0.9 mm. However, you must conduct parametric studies in order to produce even better parameters such as bandwidth, gain and so on.

After parametric studies, the most optimal design and simulation results were obtained. Next, compare the antenna before and after optimization. The goal is to see that antenna optimization produces more results than the antenna before Optimization. Here's what the antenna design looks like optimum after parametric studies and antenna simulation results after optimization can be seen in Fig 7.

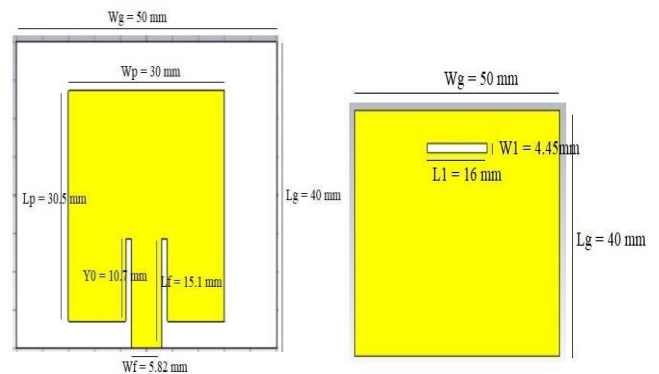


Fig. 7 Antenna Design After Optimization.

B. Fabricated Antenna

After getting the optimal antenna design, the next step is antenna fabrication, the plate used is aluminum with a width of 37.3mm, length of 28.7mm, stripline width of 5.82mm, Inset feed size of 10.7mm, notch width of 1.1mm, ground width of 46.9mm and ground length 38.3mm. The antenna uses SMA port 50 Ω, the fabrication results are shown in Fig 7.

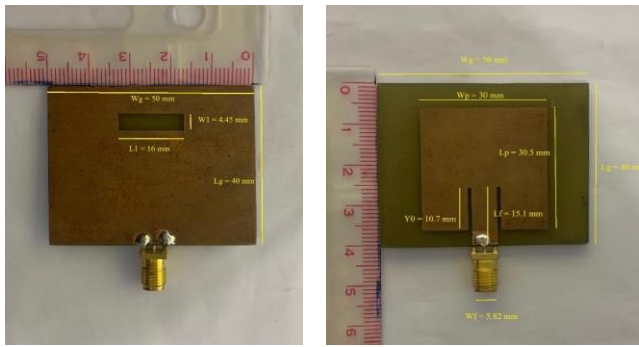


Fig. 8 Fabricated Antenna

After all the antenna work processes are complete, then measurements are made on the antenna that has been made. At the stage of measuring return loss and VSWR using Keysight E5071C Vector Network Analyzer (VNA) for return loss measurement results can be seen in Fig 9 and VSWR (Voltage Standing Wave Ratio) values in Fig 10.

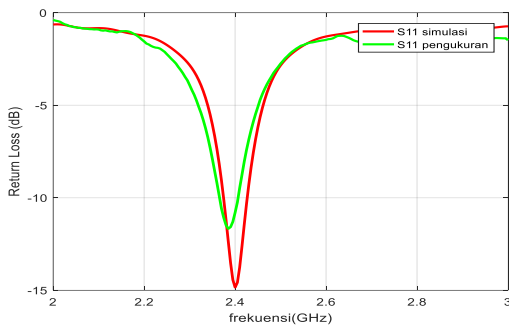


Fig. 9 Comparison Return Loss

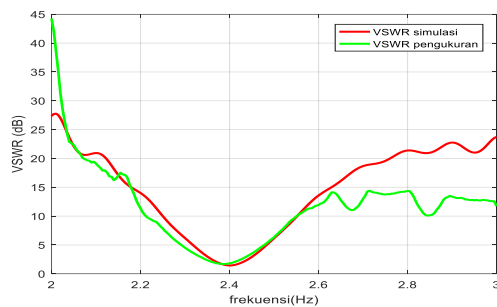


Fig. 10 VSWR Comparison

Fig. 9 displays the return loss value where there is a difference caused during fabrication. The return loss value at the frequency during simulation was -14.85 dB while at the time of measurement, it was -11.68 dB and the VSWR value at the time of simulation was 1,442 and at the time of measurement it was 1,747 at Fig 10.

From the comparison table, it can be seen that the results of antenna simulation that have been optimized are much better than fabricated antennas. Although the measurement results are not very good, they are still in the specifications of microscopic antennas for Wi-Fi applications.

TABLE II COMPARISON OF OPTIMIZED AND FABRICATED ANTENNAS

No	Parameter	Simulation Results Antenna Optimasi	Measurement Result Fabrikasi
1	Working frequency	2,4 GHz	2,4 GHz
2	Return Loss (dB)	≤-10	≤-10
3	Bandwidth (MHz)	53	45
4	VSWR	1,442	1,747
5	Gain (dB)	2,063	-
6	Polaradiasi	Unidirectional	Unidirectional

CONCLUSION

Rectangular patch microstrip antenna with a rectangular slot on 2.4 GHz ground plane for Wi-Fi applications with return loss rate of -11.68 dB, VSWR 1,747, gain 2,063 dBi, and has unidirectional radiation pattern. The connectivity value or network quality produced by rectangular patch microstrip antennas is good.

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