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Microstrip Antenna with a Defective Ground Structure (DGS) Motor for Wireless Fidelity Applications (Wi-Fi) at 2.4 GHz

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Abstract— Wireless fidelity (WiFi) is a wireless connection using radio technology so that the wearer can transfer data quickly and securely. However, at a certain distance, there is a decrease in signal speed on WiFi as happened to the Tursina rental located in Pasar Baru. When away from WiFi, the internet speed will decrease and the connection becomes unstable. Therefore, an antenna that has a high gain is needed in the form of a microstrip antenna with a working frequency of 2.4 GHz. This final project aims to design a microstrip antenna with the Defected Ground Structure (DGS) method for wireless fidelity (WiFi) applications at a frequency of 2.4 GHz, as well as analyze antenna parameters such as return loss, VSWR, bandwidth, gain, and radiation patterns. Where the antenna design uses CST Studio Suite 2019 software. After the simulation results are as desired, then fabrication or antenna manufacturing is carried out. The simulation results after optimization are return loss -40.79 dB, VSWR 1,019, Bandwidth 543.9 MHz, the gain of 1,312 dBi, and bidirectional radiation patterns. After the simulation is carried out, then the next is the fabrication or manufacture of antennas. In microstrip antenna measurements, the fabrication results using the Vector Network Analyzer show return loss values of -16.07 dB and VSWR 1,375. the measurement results of the fabricated antenna already meet the specifications of a good antenna for WiFi applications.

Keywords- **Microstrip Antenna, *Defected Ground Structure, Wireless Fidelity.***

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I. Introduction

Telecommunications technology is now very rapidly increasing. This is evidenced by the method of data transfer that is usually through cables, while nowadays it can be done with air media (without cables). One technology that is now widely used is Wireless fidelity (Wi-Fi) which uses a working frequency of 2.4 GHz by the IEEE 802.11 standard [1]. Wireless fidelity (Wi-Fi) is a wireless connection using radio technology so that the wearer can transfer data quickly and safely [7]. However, in some places there are still some obstacles or problems that interfere with the speed of accessing the internet using Wi-Fi signals, To overcome this problem, an antenna that has a high gain is needed. Because with high gain, users can access a faster and more stable internet. In addition, Wi-Fi signal strength is not the same in every place, so it is possible that there are several places where the signal is weak, requiring a high-gain antenna. Microstrip antennas are one of the most popular types of wireless antennas used today. The advantages of microstrip antennas are easy to fabricate, cheap, efficient, thin small, and easy to integrate with other devices. In addition, the disadvantages The problem with microstrip antennas is that they have low gain [2]. One way to overcome low gain is to use the Defected Ground Structure (DGS) method. The DGS method applied in this antenna design is by modifying the ground plane on the microstrip antenna. Various forms of DGS include circles, spirals, dumbbells, and split ring resonators. The form of DGS that will be designed is Split ring resonator (SRR). The use of SRR in microstrip antennas is one solution to meet current needs because it can increase gain. Almost similar research has been conducted by Fitri Yuli Zulkifli, Eko Tjipto Rahardjo, Muhamad Asvial, and Djoko Hartanto, who discussed the development of a two-element stacked microstrip antenna with the application of a trapezoid-shaped Defected Ground Structure. This design produces an antenna with an increase in gain of 0.6 dB [15]. In addition, in research conducted by G. Viswanadh Raviteja, B. T. V Madhan, M. Kshetra Sree, N. Avinash, and P. R.S. Naga Surya, which discusses Gain and Bandwidth Considerations for Patch antennas. Microstrip antenna using U-shaped and Quad L-shaped slots with DGS and parasitic elements for WiMax/Wi-Fi applications. This design produces an antenna with a gain increase of 7.24 dB [12].

II. Method

In this research, we will design a patch-shaped microstrip antenna. Before starting the design process, we need to understand the specifications of the antenna to be designed and calculate the dimensions of the patch antenna. Research Flow In designing this final project, there are several steps that will be explained. The flowchart shows several stages in the antenna design process, including stages that include calculations of operating frequency, antenna dimensions, VSWR, gain, and mathematical calculations for return loss. The second stage involves calculating the width and length of the patch and the diameter of the ground plate. Furthermore, in the first and third steps, the dimensional design of the antenna is performed using CST 2019 software.

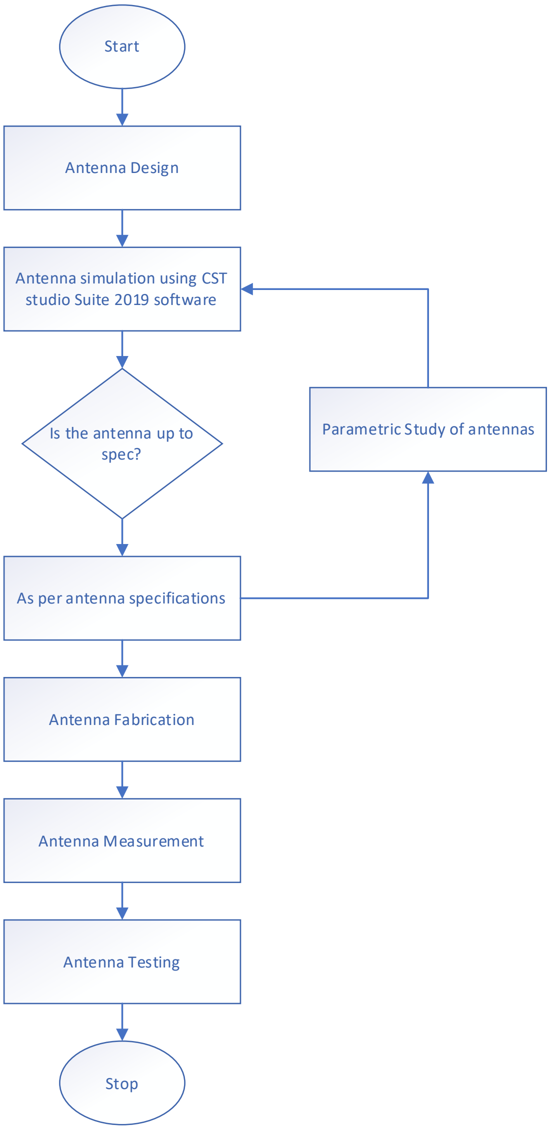

Fig.1 Research Flow

Antenna Dimensions

TABLE I ANTENNA DIMENSIONS

Parameters	**Size (mm)**
LongPatch (Lp)	26.6
WidthPatch (Wp)	26
Long *Feed1* (Lf)	12
WidthFeed1 (Wf)	4.5
Long *Feed2* (Lf2)	17.5
Wide Feed2 (Wf2)	10

After doing the calculations to determine the dimensions of the antenna patch can be seen in the table above. Patch Length (Lp) Patch Width (Wp), Feed1 Length (Lf), Feed1 Width (Wf), Feed2 Length (Lf2), Feed2 Width (Wf2). Antenna Design In this study, a microstrip antenna with a patch shape will be designed. Before designing the antenna, we must first know the specifications of the antenna to be designed and calculate the dimensions of the antenna with a patch.

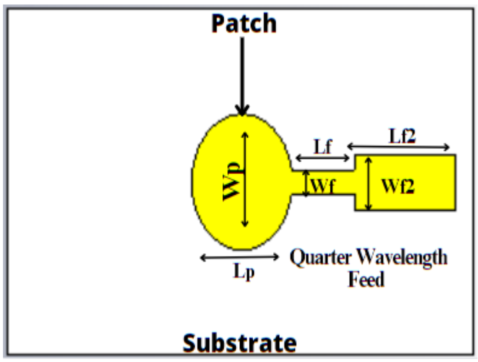

Fig. 2 Patch Antenna Design

TABLE II REFERENCE ANTENNA SIZE

Parameters	L	W	Lp	Wp	L1/Lf	SW1/Wf	L2/Lf2	SW2/Wf2
value	83	56	22	18	11.3	3.9	18.1	9.0
Parameters	S1	S2	W1	W2	G1	G2	G3	
value	20	10	2	2	1	2	2	

Before designing a microstrip antenna, it is necessary to determine the size of the antenna to be designed first. Where is the size of this antenna based on the journal (reference) "Tri-Band Defected Ground plane Based Planar Monopole Antenna for Wi-Fi/WiMAX/WLAN Applications" by Aneri Pandya, Trushit Upadhyaya, and Killol Pandya. The design and size of the reference antenna can be seen in Fig 2 and table 2.

III RESULT AND DISCUSSION

Parametric study a parametric study is a process carried out to obtain the desired antenna parameters, the aim is to see changes from the microstrip antenna design made, such as changes in patch, ground plane, slot, or other parameters. This parametric study is done by reducing or increasing the size of the antenna design. The figure above shows the antenna design made. Where when the antenna is without DGS, the return loss value is far above -10 dB. When the antenna is with DGS, the return loss value is below -10 dB, besides that, it turns out that when adding DGS, besides Wi-Fi, other bands are also produced, namely WiMAX at a frequency of 3.5 GHz and WLAN at a frequency of 5.1 GHz.

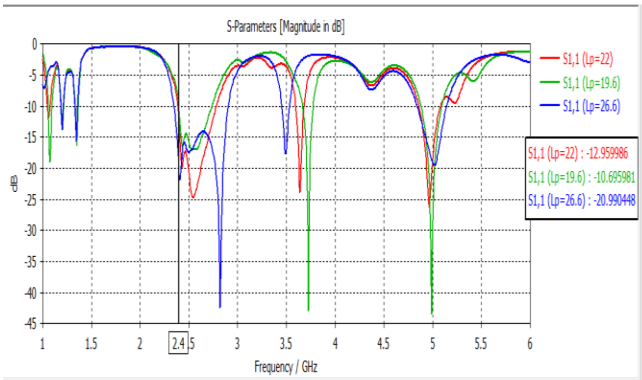

Fig. 3 Simulation results of Return Loss 1 Lp

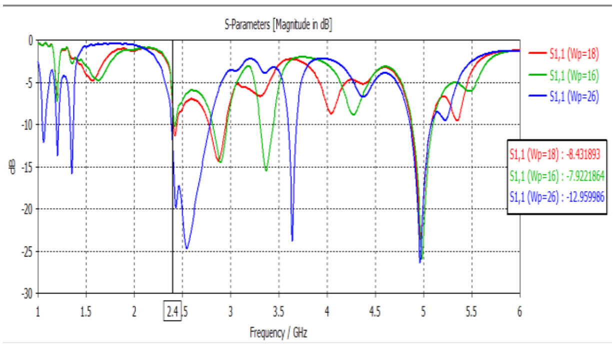

Fig. 4 Simulation results of Return Loss Wp

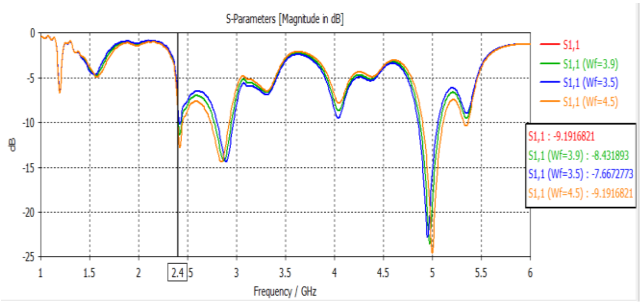

Fig. 5 Simulation results of *Return Loss* Lf

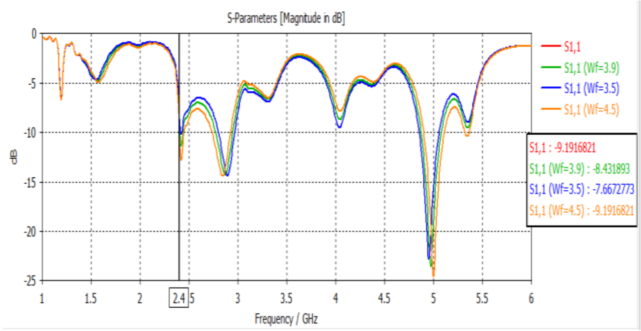

Fig. 6 Simulation results of Return Loss Wf

After getting the size where as seen in Fig 3 in graph S1.1 the value of return loss is -12.95 dB. After increasing the size of the patch length by 26.6 mm, it can be seen in graph S1.1 that the return loss value becomes -20.99 dB and after reducing the size by 20.6 mm the return loss value becomes -10.69 dB. To see the effect of the patch width size (Wp) where the initial size is 18 mm and at this size the results obtained have not reached specifications. Then changes were made to the patch width including values of 16 mm and 26 mm. The simulation results can be seen in Fig 4. After simulation, it is found that the patch width (Wp) affects the return loss value. In Figure 3.27 with the value of Wp = 18 mm (initial size) has a return loss of -8.43 dB, the value of Wp = 16 mm has a return loss of -7.92 dB, and the value of Wp = 26 mm has a return loss of -12.95 dB. So, a good return loss value is when the value of Wp = 26 mm. So it can be concluded that the higher the Wp value, the higher the return loss value and vice versa. The initial size of the feedline1 length (Lf) is 11.3 mm, then a size change is made to the feedline1 length which aims to determine whether there is a change in the simulation results if the feedline1 length is changed. It can be seen in Fig. 5 the simulation results of the effect of changing the size of the feedline1 length. In the addition of Lf size, the return loss is getting higher and vice versa in the reduction of Lf size, the return loss value is getting lower. It can be seen in Fig. 5 when Lf = 12 produces a better return loss and has increased, compared to when the values of Lf = 11 and Lf = 11.3. Changing the width of the feedline1 (Wf) also affects the return loss value. In Fig. 6, it can be observed that when the size of the

to the width of the feedline1 the resulting return loss value will be greater.

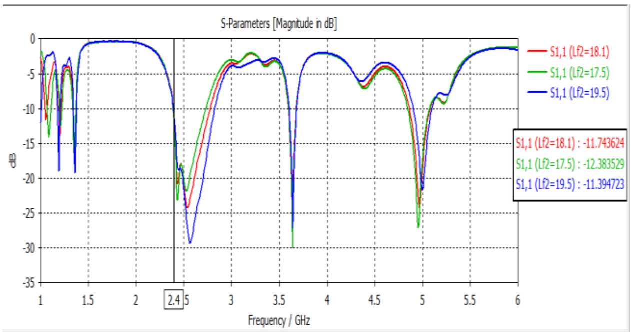

Fig. 7 Simulation results of Return Loss Lf2

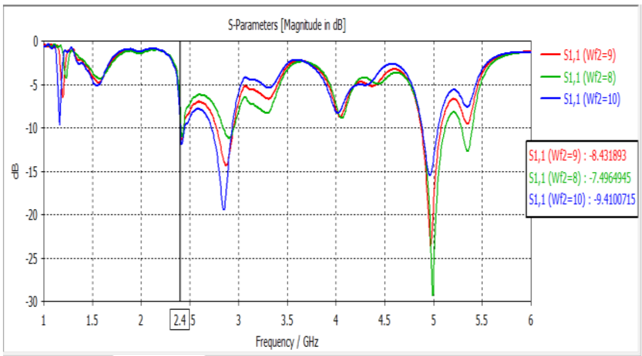

Fig. 8 Simulation results of Return Loss Wf2

In Fig 7 it can be seen that the return loss value changes at Lf2, where the initial size is 18.1 mm. Then changes are made to the length of the feedline2 to 17.5 mm and 19.5 mm. from these changes in value there is a change in the return loss value. After simulation, it is found that the length of feedline2 (Lf2) affects the return loss value. The higher the Lf2 value, the lower the return loss value and vice versa. In Fig. 7 with an Lf2 value of 17.5 mm, it has good results compared to the others with a return loss value of 12.38 dB.

The effect of changing the width of the feedline2 (Wf2) can be seen from the simulation results in Fig. The initial value of the Wf2 size is 9 mm, then after changing the width of the feedline2 with a value of 8 mm and 10 mm. As the width of the feedline2 (Wf2) increases, the return loss value also increases.

Fabricated Antenna After obtaining the optimal antenna design, the next step is to fabricate the antenna Patch Length (Lp) Patch Width (Wp), Feed1 Length (Lf), Feed1 Width (Wf), Feed2 Length (Lf2), Feed2 Width (Wf2).

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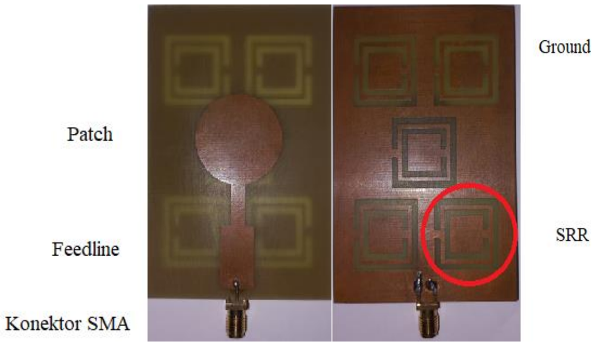

Fig. 9 Fabricated Antenna

After all the antenna processing is complete, measurements are then taken on the antenna that has been made. At the return loss and VSWR measurement stage using a Keysight E5071C Vector Network Analizer (VNA) for the results The return loss measurement can be seen in Fig 10 and the VSWR (Voltage Standing Wave Ratio) value in Fig 11.

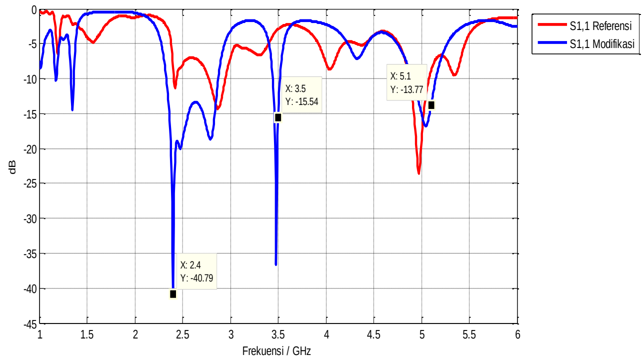

Fig. 10 Return Loss Comparison

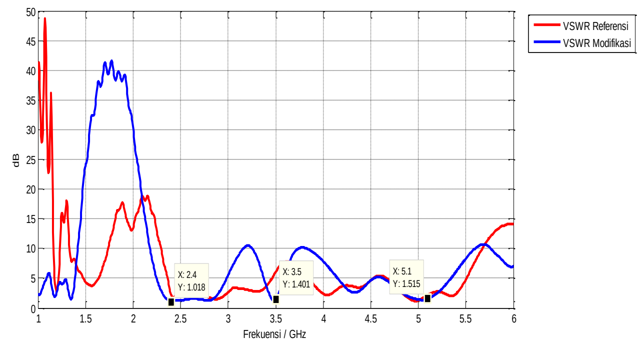

Fig. 11 VSWR Comparison

Fig. 10 displays the return loss values where there are differences caused during fabrication. This antenna can also work at WiMAX frequency 3.5 GHz and WLAN frequency 5.1 GHz with return loss values after modification of 15.54 dB and 13.77 dB and VSWR values at WiMAX frequency 3.5 GHz and WLAN frequency 5.1 GHz after modification of 1.401 and 1.515 in Fig 11.

TABLE II

COMPARISON OF MODIFIED AND FABRICATED REFERENCE ANTENNAS

No.	Antenna Parameters	Reference Antenna Results	Modified Antenna Results	Fabrication Result
1	*Return loss* (dB)	-8.43	-40.79	-16.07
2	VSWR	2.21	1.018	1.375
3	*Bandwidth* (MHz)	30.6	543.9	498
4	*Gain* (dBi)	-0.817	1.309	-

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

IV Conclusion

Design of Microstrip Antenna with Defected Ground Structure (DGS) Method for WIRELESS Fidelity (Wi-Fi) Application at 2.4 GHz Frequency with return loss level -16.07 dB, VSWR 1.375, bandwidth 49.8 MHz, and has a unidirectional radiation pattern. The connectivity value or network quality produced by the microstrip patch antenna is relatively good.

Acknowledgment

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