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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].

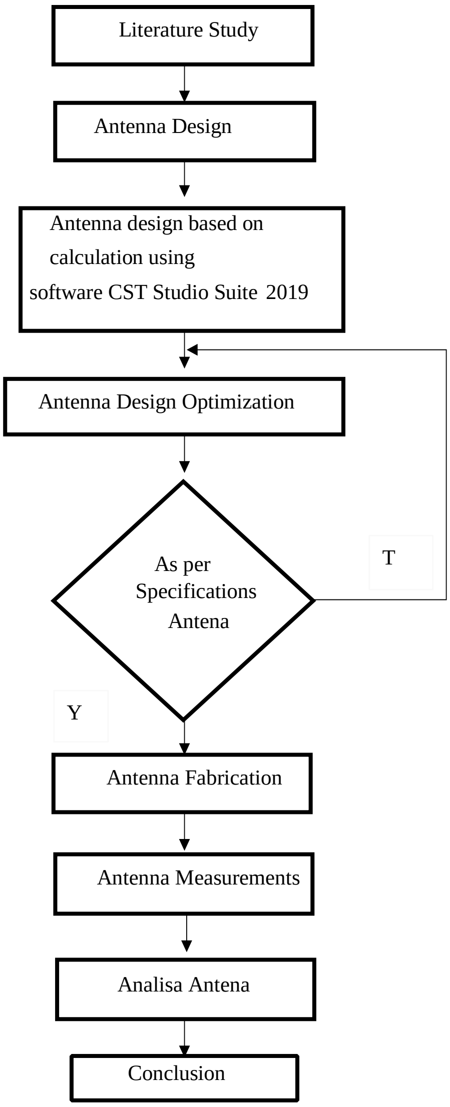

Fig.1 Research Flow

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

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*.

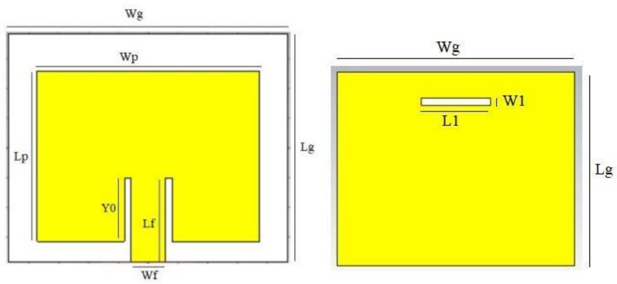

Fig. 2 Rectangular Patch Antenna Planning

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 ≥ 1dB. 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).

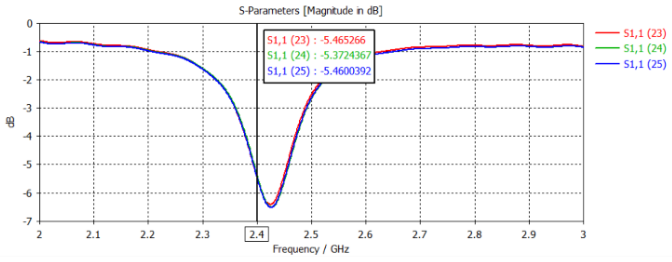

Fig. 3 Change in Ground and Substrate Size on Return Loss

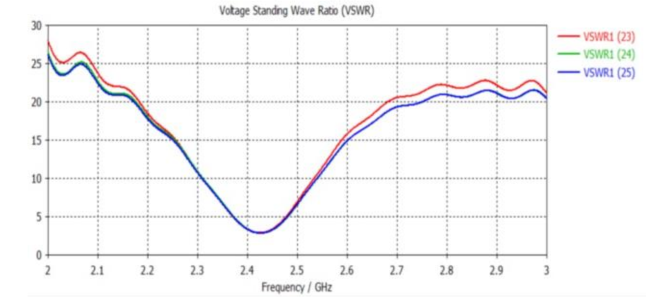

Fig. 4 Change of Ground and Substrate Size on VSWR

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.

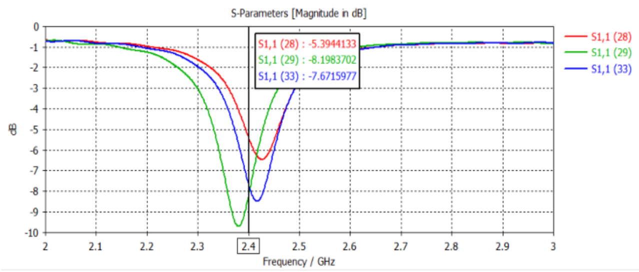

Fig. 5 Patch *Size Changes*

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.

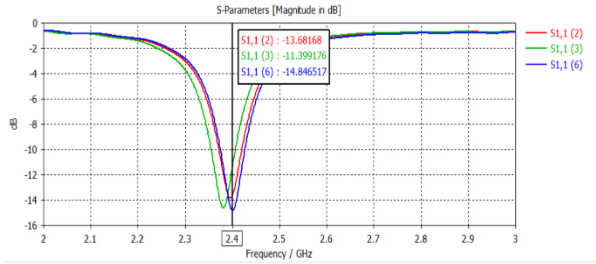

Fig. 6 Slot Simulation Results

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.

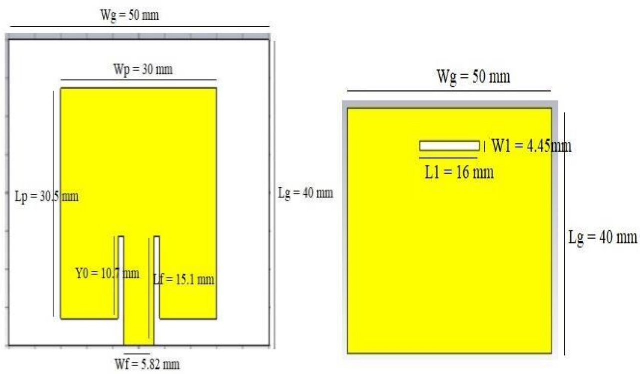

Fig. 7 Antenna Design After Optimization.

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.

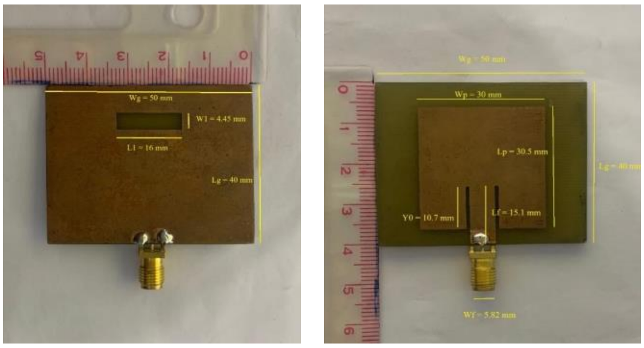

Fig. 8 Fabricated Antenna

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 Analizer (VNA) for return loss measurement results can be seen in Fig 9 and VSWR (Voltage Standing Wave Ratio) values in Fig 10.

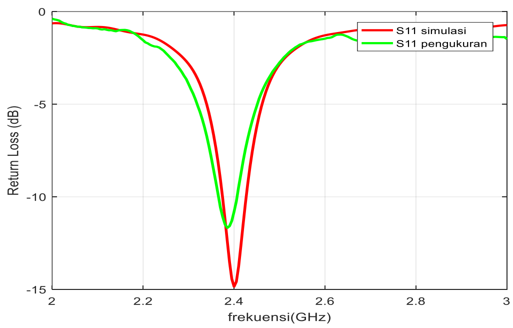

Fig. 9 Comparison Return Loss

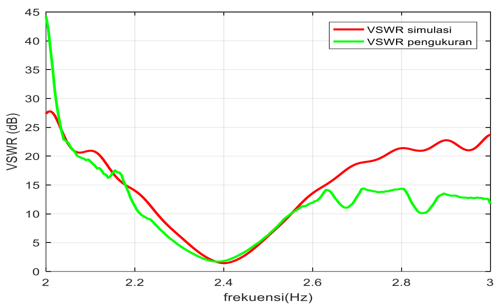

Fig. 10 VSWR Comparison

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.

ACKNOWLEDGMENT

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REFERENCES

[1] Dewiani, E. P. (2019). Design Of Reconfigurable Planar Inverted F Antena For 5G Implementation. *2019 Ieeeint. Conf. Commun. Networks Satell. Comnetsat 2019 - Proc.*(Doi: 10.1109/COMNETSAT.2019.8844073.), Pp. 41–46.

[2] Nandansari, D. (2023). Strategi Pengelolaan Program Siaran Radio Yasmaga FM Ponorogo (Doctoral Dissertation, IAIN Ponorogo).

[3] Al Shifa, A. L. (2020). Perancangan Dan Simulasi Antena Mikrostrip Satu Elemen Berbahan Material Dielektrik Anisotropik Untuk Aplikasi Wifi (Wireless Fidelity) Pada Frekuensi 2400 Mhz. . *In Prosiding Industrial Research Workshop And National Seminar*, (Vol. 11, No. 1, Pp. 613-619)

[4] Murti, P. G. (2019). Antena Mikrostrip Dual Band Bahan Fleksibel Frekuensi 2, 45 Ghz Dan 5, 85 Ghz Untuk Aplikasi Telemedis. *Eproceedings Of Engineering*, 6(2).

[5] Kristiono, A. A. (2020). Perancangan Antena Mikrostrip Rectangled Dengan Teknik Pencatuan Proximity Coupled Pada Frekuensi 3.8 Ghz. *Ejournal Mahasiswa Akademi Telkom Jakarta (Emit)*, 2(2), 1-8.

[6] Saidah, N. &. (2021). Fabrikasi Dan Karakterisasi Antena Mikrostrip Patch Rectangular Dengan Slot Persegi Panjang & Slot T Pada Groundplane Untuk Frekuensi Wifi (2, 4 Ghz). . *Jurnal Matematika Dan Sains*, 1(2), 133-142.

[7] Fikri, A. K. (2020). Potensi Bahaya Menggunakan Wireless Fidelity (Wi-Fi) Public Untuk Keamanan Privasi . *(Doctoral Dissertation, Universitas Mercu Buana Jakarta).*

[8] Handika, D. M. (2022). Rancang Bangun Antena Mikrostrip Patch Circular Untuk Aplikasi 5G. *Data Sciences Indonesia (DSI)*, 2(1), 9-12.

[9] Hardiman., D. M. (2019). Rancang Bangun Antena Mikrostrip Patch Triangular Metode Parasitic Untuk Aplikasi LTE. *J. Teknol. Elektro*, Vol. 9, 109–116.

[10] Saputra, S. H. (2019). Rancang Bangun Antena Mikrostrip Patch Circular Dengan Teknik Linier Array Untuk Frekuensi Wifi 2, 4 Ghz. *Elektrika*, 11(1), 9-14.

[11] Satria, D. D. (2020). DESAIN ANTENA MIKROSTRIP FREKUENSI 329-335 MHZ MENGGUNAKAN APLIKASI CST STUDIO SUITE 2019. *In Prosiding SNITP (Seminar Nasional Inovasi Teknologi Penerbangan)* , (Vol. 4).

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Design and Build Microstrip Antennas *Multiple Input Multiple Output* (MIMO) Wideband Elements For WIFI *Access-point Applications*

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***Abstract*— Technology in the field of telecommunications continues to experience development. One of them is the Multiple Input Multiple Output (MIMO) antenna used in WIFI access point applications using the MIMO technique to increase the need for large amounts of data transfer. In designing and manufacturing MIMO antennas for WIFI access point applications with a size of 110 mm x 112 mm using FR-4 substrate specifications with a thickness of 1.6 mm. The antenna consists of four ports and in each corner of the groundplane there are four slots to achieve good isolation and produce good bandwidth. The antenna simulation produces a bandwidth of 1.0516 GHz with a frequency of 2.4 GHz, return loss -12.78 dB, isolation -16.08 dB, and VSWR 1.53 dB. Meanwhile, fabricated antennas produce bandwidth of more than 100 MHz with a frequency of 2.4 GHz, return loss -13.5 dB, isolation -18.8 dB, and VSWR 1.29 dB. Antenna simulation using the CST Studio Suite 2019 software application.**

***Keywords*—MIMO, WIFI 2.4 GHz,Bandwidth, Isolation, Return Loss, VSWR.**

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I. INTRODUCTION

The existence of antennas in wireless communication systems is important. This is based on the need to communicate and exchange data quickly and easily. One of them is the antenna in the telecommunications world which is starting to be widely implemented, especially in Indonesia is Wi-Fi wireless technology. The 802.11n standard is a standard set by the Institute for Electrical and Electronic Engineers (IEEE) to underlie such technologies. Wi-Fi with 802.11n standard is a standard that works at 2.4 GHz and 5 GHz frequencies and is supported by Multiple Input Multiple Output (MIMO) technology[1].

Multiple-Input Multiple-Output (MIMO) is a wireless technology that uses multiple transmitters and receivers to transfer more data simultaneously. This technology helps enable 802.11n to achieve higher speeds than without 802.11n. To implement MIMO, a device in the form of an access point (AP) is needed for optimal performance and signal coverage[2].

The use of MIMO antennas can effectively increase channel capacity and improve the reliability of wireless communication. However, strong mutual coupling caused between antenna elements will degrade the performance of the MIMO system. In order for the antennas not to affect each other, each antenna must be spaced so that the mutual coupling value is small. In MIMO systems, the effect of mutual coupling effect is kept to a minimum because it affects the performance of each antenna. The longer the antenna distance, the smaller the mutual coupling, but the overall antenna dimensions will be large and difficult to apply to the user's device[3].

To improve high isolation of MIMO for WIFI using an access point by sliding the port on the feed line perpendicular to reduce mutual coupling by moving further and using a slot on the ground plane[4]. Isolation between low antenna elements due to the absence of a slot or lack of a slot. Karena The use of shaped slots on rectangular patches of microstrip antennas can improve the insulation of MIMO antennas[5]. The addition of slots or without slots on the antenna affects the isolation of the antenna, where in theory it is found that high isolation will reduce the value of mutual coupling, which is an effect that causes a decrease in the quality of parameters such as gain, return loss, antenna radiation pattern due to the presence of two or more antennas that are too close together and the presence of slots on the ground plane which will affect the value of mutual coupling.

According to Alishir MoradiKordalivand there is a low insulation value, which will cause a mutual coupling effect on the antenna. Therefore, it is necessary to develop more details, namely by optimizing slot size changes on MIMO antennas for high isolation and increasing antenna gain to reduce the effect of mutual coupling on antennas. To apply it in the field, the author uses a 2.4 GHz Wi-Fi access point device with a larger signal coverage area, where the data taken as research material is based on data simulated using CST Studio Suite 2019 software.

II. METHOD

A. Anntena Design

Antenna design aims to get the desired antenna design. With the design process, it can make it easier to get better design results. As for the design of the antenna design in the final project, the author uses CST Suite Studio software.

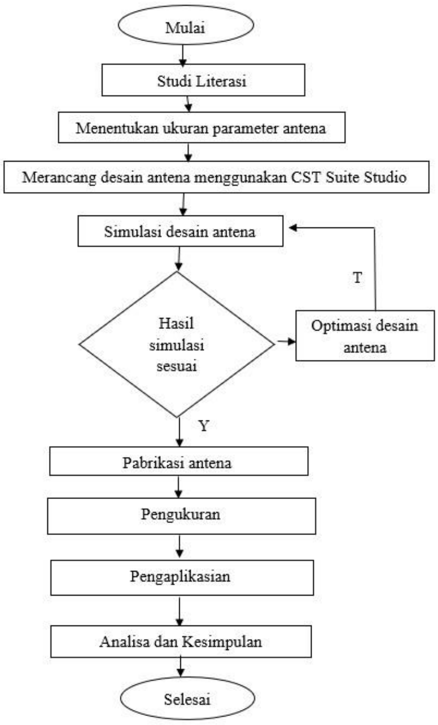

Figure 1 Flowchart antenna planning

The first stage is the literature study stage, at this stage a study of MIMO antennas is carried out along with the antenna parameters and the required literature obtained from final projects, journals, books and article sources from the internet. The second stage is the stage of determining the size of the antenna dimensions, as well as MIMO antenna parameters obtained from literature studies from the internet. The third stage, namely planning to design a MIMO antenna, begins with determining the working frequency of the antenna, the length of the antenna elements and the distance between the elements to the final stage in designing a MIMO antenna according to the literature study obtained. The fourth stage of the simulation stage, at the simulation stage if it meets the desired simulation result target, antenna manufacturing continues, but if the simulation results do not reach the target, an antenna design optimization is carried out. The fifth stage is the manufacturing stage, at this stage the antenna design and fabrication process of the CST Studio Suite software is carried out which before manufacturing, the design results of the CST Studio Suite software, are moved first using eagle software, in this process also obtained the expected parameter results using the software. The sixth stage of the measurement stage, the measurement stage is carried out after the design and fabrication process is complete. The measurement aims to determine the antenna parameters produced as a comparison between the manufactured antenna and antenna simulation in the CST Studio Suite software. The seventh stage of data analysis at this stage is carried out analysis of antenna measurement data obtained.

B. Antenna dimensions

The size of the antenna obtained is the size of the journal entitled "Common Elements Wideband MIMO Antenna System For IFI/LTE Access-Point". The size of the antenna dimensions used is 112 x 110 mm² using the FR-4 substrate type with a thickness of 1.6 mm which has a substrate dielectric constant of 4.3 and a tangent loss of 0.025. The design of the antenna can be seen in figure 2.

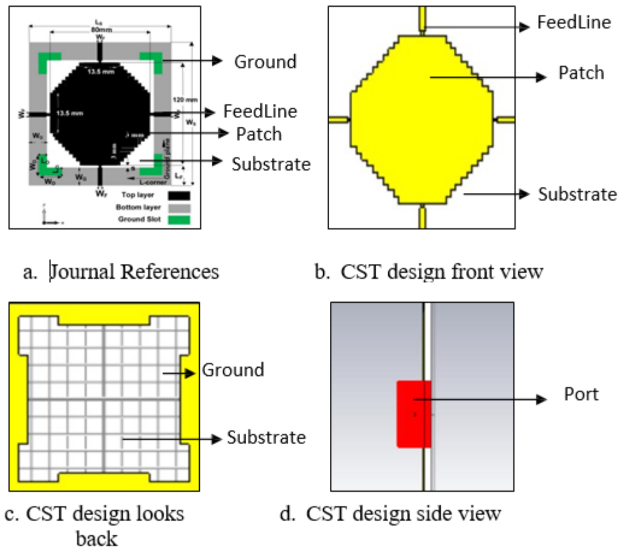

Figure 2 Antenna Design

In figure 2 is a display of antenna design based on references (journals) and the results of modified antenna designs. The size details of the two antenna designs can be seen in table 1.

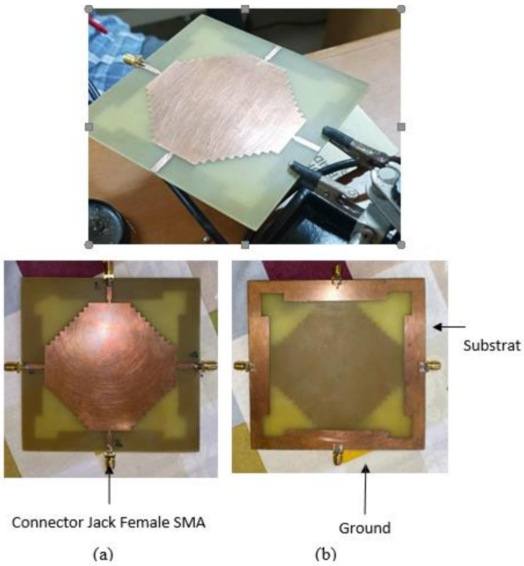

Figure 3 Antenna design offered (a) front view (b) rear view

Table 1 Parameter List Antena

Parameter	Ws	Ls	Wf	Lf	Wd	Ld	h	Wj7
Nilai	112	110	3	13	22	1.5	1.6	38
Parameter	Wg	t	Wt	s	Wp	Wp2	Lp2	Wj8
Nilai	20	0.035	1.5	2	13.5	82	80	32
Parameter	Wj	Sj	Wj2	Wj3	Wj4	Wj5	Wj6	Wj9
Nilai	74	3	68	62	56	50	44	26

ws = lebar substrate
Ls = Substrate Length
Wf = Lebar FeedLine
Lf = Panjang FeedLine
Wd = Lebar Slot
Ld = Panjang Castle
h = Substrate Thickness
Sj = Jarak Back Patch
t = Copper Thickness
Wt = Lebar Transformer
s = Panjang Transformer
Wp = Lebar Patch
Wj5 = Length of Patch 5 Gear
Wj6 = Length of Patch 6 Gear
Wj7 = Length of Patch 7 gear
Wj9 = Length of Patch 9 gear
Wp2= Lebar Ground
Lp2 = Ground Length
Wj = Length of Gear Patch 1
Wj2 = Length of Patch 2 gear
Wj3 = Length of Patch 3 Gear
Wj4 = Length of Patch 4 gear
Wj8 = Length of Patch 8 Gear

Table 2
Design Size Comparison between Reference and Modified Antennas

NO	Size *Substrate/Ground*	Slot Size	
1	length: 110 mm	Referensi (*Paper*)	Modification
2	Wide: 112 mm	Slot length: 1.5 mm	Slot length: 5 mm
3	Thickness: 1.6 mm (*substrate*)	Slot Wide: 22 mm	Slot Wide: 15 mm
4	Thickness: 0.035 (*groundplane*)		

C. *Antenna Fabrication and Measurement*

After getting the optimization results on an antenna and in accordance with the expected specifications, then carry out the manufacturing process and take measurements.

III. Results and Discussion

A. *Studies Parametrik*

Parametric studies are a process carried out to obtain the appropriate antenna parameters. Parametric studies are performed by increasing or decreasing the dimensions of the antenna. This is done to find out changes in antenna design to existing parameters. To see the changes in antenna design can be seen in figure 4 and the simulation results of changes in antenna design can be seen in figures 5 and 6.

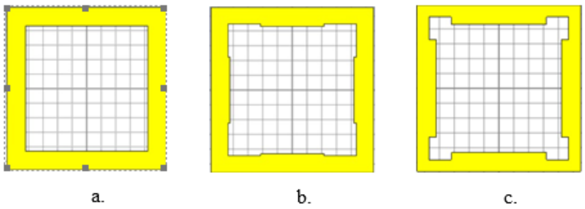

Figure 4 (a). Antenna Without Slot (b). Antenna Reference Slot LD=1.5 WD=20 (c). Slot antenna LD=5 WD=15

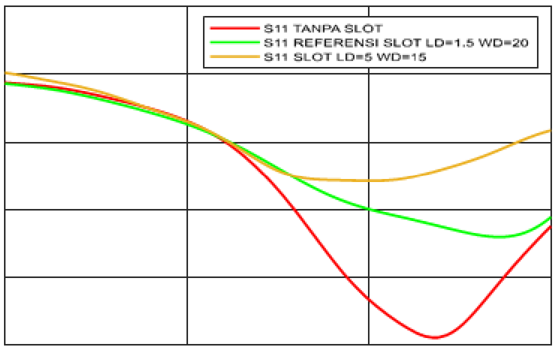

Figure 5 S11 Simulation Results

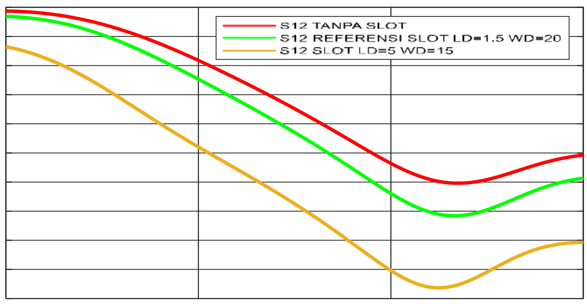

Figure 6 S12 Simulation Results

The Figure 6 shows the change in antenna design to get the appropriate value. Where the slot is set to several shapes and sizes with the same frequency range of 2.4 GHz. In changing antennas without slots, getting a return loss value of -18.72 dB and getting an insulation value of -12.61 dB, whereas in changing the design of antennas without slots, the return loss value meets the criteria because it is still <-10 dB, but the insulation value in changes in antenna design without slots does not meet the criteria because of a good insulation value of <-15 dB. So it can be concluded that in the design of a good antenna that uses slots at the four corners of the *groundplane* with the same size and the same frequency range. Where the greater the length of the slot, the better the value produced.

B. Antenna Optimization Results

After a parametric study, the most optimal design and simulation results were obtained from the modified antenna. Next, compare the reference antenna with the modified antenna. The goal is to see that the modified antenna produces better results than the reference antenna. The following antenna optimization design is shown in figure 7.

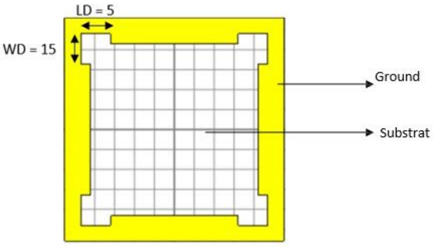

Figure 7 Antenna Optimization Results Design

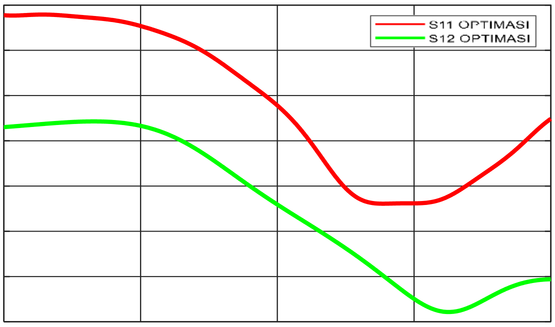

Figure 8 Antenna Simulation Results After Optimization

D. Comparison of Modified Antenna Simulation Results

The measurements carried out aim to compare the results contained in the simulation in CST Studio Suite 2019 with the manufacturing results. The parameters to be compared are return loss, isolation, and VSWR. The measurement results of s-parameters s11 and s12 are shown in figure 9.

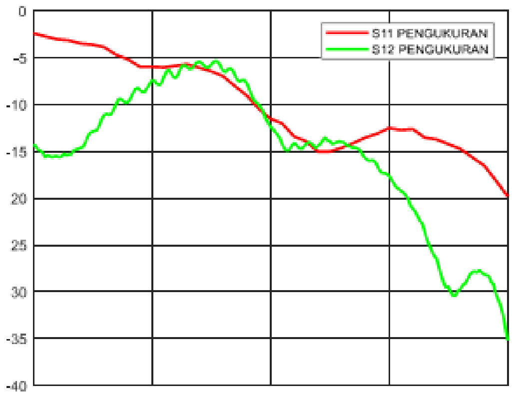

Figure 9 Measurement Results

From the results of measurements that have been carried out, there are several differences in S-parameters between the design results using CST and the manufacturing results. This usually occurs because of changes in the dimensions and permetivity of the antenna material that is fabricated which causes inequality in parameter values from measurement and simulation results.

E. Return Loss Comparison

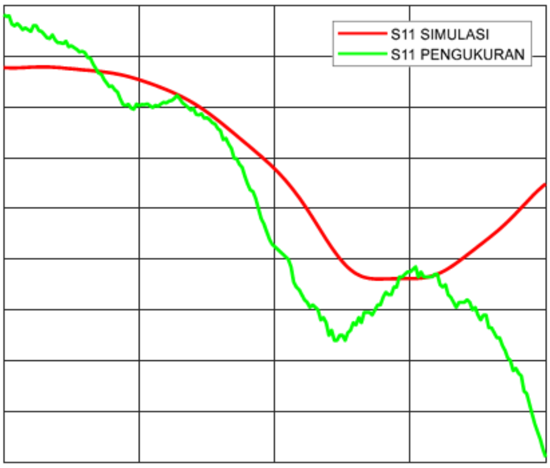

Figure 10 Return Loss Comparison

In the simulation and measurement results, it can be seen that the measurement results have a good depth than the simulation results. It can be seen in figure 10 that the value from the simulation is -12.78 dB with a bandwidth width of 800 MHz which has met the bandwidth criteria for microstrips of 20-40 MHz. As for the measurement results, it gets a value of -13.5 dB with a bandwidth width exceeding 20-40 MHz. The comparison of *return loss* between simulation and measurement can be seen in figure 10.

F. Measurement Comparison of Voltage Standing Wave Ratio (VSWR) Results

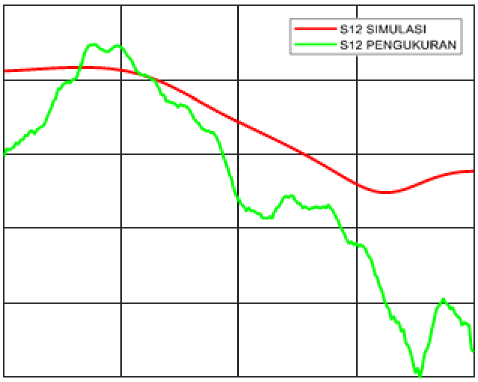

Figure 11 Voltage Standing Wave Ratio (VSWR) Results

In the VSWR results, it can be seen that the measurement results from fabricated antennas are much more constant than those from simulated design antennas. Which results show that the results of the antenna fabrication *match.*

G. Comparison of radiation patterns

The radiation pattern indicates the direction of emission and reception of an antenna. Table 4.1 shows the radiation pattern of the reference antenna with modified antennas in 2D and 3D form. Antenna radiation patterns describe how the antenna radiates energy into free space or how the antenna receives energy. It can be seen that the radiation pattern produced is an omnidirectional radiation pattern, which in the form of this radiation pattern will emit signals in all directions. So this antenna is more intended for wireless communication connections in the room, the antenna is attached to the Wi-Fi router which functions as a reamplifier so that this antenna will work as a transceiver amplifier with a working frequency of 2.4 GHz for wireless LAN.

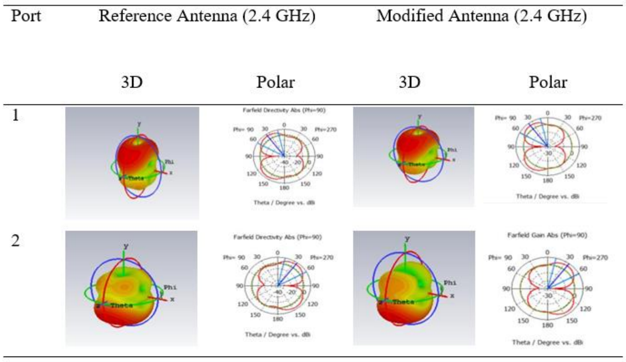

Figure 12 Comparison of radiation patterns

H. Insulation Comparison

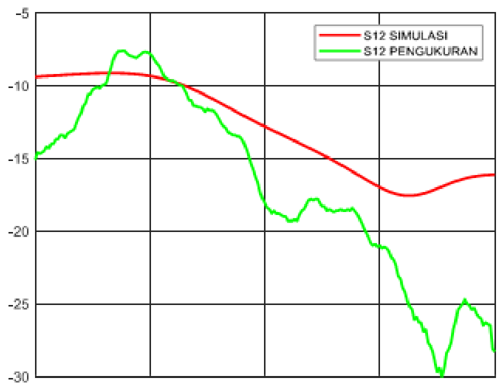

Figure 13 Insulation Comparison

The value of the measurement gets a better value of -18.8 dB while for the simulation it gets an isolation value of -16.08 dB. Where this insulation is used to see the quality of the MIMO antenna and to see the value of the mutual coupling produced.

I. Comparison of Reference Antenna Design, Modification, and Fabrication

Tabel 3 Comparison Table

NO	Parameter	Hasil Referensi (paper)	Hasil Simulasi Referensi	Hasil Simulasi Antena Modifikasi	Hasil Pengukuran
1	Frekuensi kerja (GHz)	2.4	2.4	2.4	2.4
2	Return Loss (dB)	≤ 10	≤ 10	≤ 10	≤ 10
3	VSWR	-	1,361	1,53	1,29
4	Isolasi (dB)	≤ 15	≤ 13,58	≤ 15	≤ 15
5	Gain (dBi)	5,8	6,134	6,142	-
6	Bandwidth (MHz)	1100	2002	1051	>20-40
7	Polaradiasi	Omni directional	Omni directional	Omni directional	-

From table 3 it can be seen that the results from references (journals) that have results that are not much different from the simulation results in CST. And the best value is found in the simulation results of the modified antenna, but there is a narrow bandwidth value, but still in the specification value of 20-40 MHz. Likewise, the measurement results only affect the VSWR value which is better than the modified results.

J. Antenna Application

In the application of the antenna that has been made will be installed on the access point device with a Wi-Fi frequency of 2.4 GHz where the access point gets an internet source from campus fiber optic internet where the fiber terminal is converted into an electrical signal, then sent via LAN cable. Between fiber optic terminals and access points connected using LAN cables. In the design of an antenna that can be used for WIFI as a transmitter is connected to the access point with the help of coaxial cable because the coaxial cable as a cable for connecting antennas, and also a medium for transmitting data and channeling it through electrical signals. Before connecting the access point with the antenna design that the author examined, it was done first to check the default Wi-Fi from the access point.

The results obtained can be seen in the application that has been downloaded on the smartphone, namely the Network Cell Info Lite application. In the application of this final project, several distance comparisons are carried out in checking a network and analyzing how much power is emitted in each distance performed. In the comparison there are distances of 1 meter, 3 meters, and 5 meters in a straight direction, an angle of 30 degrees from the left and right of the antenna whose results can be seen in the table 4.

Table 4 Comparison Table

No	Application	power	Speed Test Result Download Mb/s	Upload Mb/s
1	Access Point Default	-61	12,5	32,5
2	Straight direction distance 1 meter	-48	14,4	40,9
3	Straight direction distance 3 meter	-53	15,5	39,5
4	Straight direction distance 5 meter	-59	13,7	23,6
5	Angle distance 30° to the left 1 meter	-45	15,2	34,6
6	Angle distance 30° left 3 meters	-56	12,3	42,6
7	Angle distance 30° to the left 5 meters	-60	13,5	32,6
8	Angle distance 30° right direction 1 meter	-46	16,7	24,6
9	Angle distance 30° right 3 meter	-57	14,5	34,3

10	Angle distance 30º right direction 5 meter	-61	11,7	23,5

In table 4 there are the results of the application of the default access point, the antenna design access point for wi-fi, where in the application of the default access point the power results obtained are -61 dB with a bandwidth value of 20 MHz at a frequency of 5785 MHz, with a download speed of 12.5 Mbps and an upload speed of 32.5 Mbps. In addition, there are results of comparison of distances from straight directions, An angle of 30 degrees from the right and left of the antenna, where within a distance of 1 meter, a distance of 3 meters and a distance of 5 meters there is the same bandwidth and frequency value, namely with a bandwidth value of 20 MHz and a frequency of 2462 MHz This happens because the antenna used is both using a frequency of 24 MHz, and the bandwidth value obtained is also the same at 20 MHz This happens because bandwidth is a frequency range where the antenna can operates at a value of 20 Mhz.

IV. CONCLUSION

The optimization results obtained from the MIMO Antenna design for WIFI applications of access point devices using CST Studio Suite 2019 software are by adding a slot length of 5 mm and a slot width of 15 mm. The parameter values obtained from the design antenna are return loss of -12.78 dB, isolation value of -16.12 dB, VSWR 1.5 dB, gain of 6.142 dBi, bandwidth width of 1.0516 GHz in the frequency range of 2.4 GHz, and has an omnidirectional radiation pattern. While the value of the manufacturing antenna parameters is a return loss of -13.5 dB, an isolation value of -18.8 dB, and a VSWR value of 1.29 dB. In the application of antennas used for Wi-Fi as transmitters with distance comparisons, different results are obtained where the value of power per distance is different because the longer the distance, the value of power produced or emitted will be smaller or not optimal for a network. Further development is expected to be able to design antennas by conducting even better parametric studies in order to obtain better S-parameters than the results currently obtained.

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REFERENCES

[1] A. Srirahayu, Y. H. Pramono, and M. S. Muntini, “Antena Monopole sebagai Transceiver Wi-Fi Frekuensi 2, 4 GHz pada Saluran Transmisi Silinder (Pipa PDAM),” *Prosiding Pertemuan Ilmiah XXIX HFI Jateng & DIY*, vol. 25, 2015.

[2] I. Amara, “MINI TINJAUAN JARINGAN NIRKABEL,” 2021.

[3] A. B. Adipurnama, H. Wijanto, and Y. Wahyu, “Perancangan dan realisasi antena mimo 4x4 mikrostrip patch persegi panjang 5, 2 ghz untuk wifi 802.11 n,” *eProceedings of Engineering*, vol. 3, no. 1, 2016.

[4] A. MoradiKordalivand, T. A. Rahman, and M. Khalily, “Common Elements Wideband MIMO Antenna System for WiFi/LTE Access-Point Applications,” *IEEE Antennas Wirel Propag Lett*, vol. 13, pp. 1601–1604, 2014, doi: 10.1109/LAWP.2014.2347897.

[5] J. Ren, W. Hu, Y. Yin, and R. Fan, “Compact printed MIMO antenna for UWB applications,” *IEEE Antennas Wirel Propag Lett*, vol. 13, pp. 1517–1520, 2014.

[6] P. Radiasi, “Desain reflektor antena parabola untuk keperluan komunikasi data teresterial pada frekuensi 2, 4 GHz,” 2005.

[7] F. Abdurrahman, “Desain Antena Microstrip Rectangular untuk WIFI pada Frekuensi 2,462 GHz dan 5, 52 GHz,” 2018.

[8] A. H. Rambe, “Antena Mikrostrip: Konsep dan Aplikasinya,” 2012.

[9] M. A. Habib and T. A. Denidni, “Design of a new wideband microstrip-fed circular slot antenna,” *Microw Opt Technol Lett*, vol. 48, no. 5, pp. 919–923, 2006.

[10] T. Aswin, F. Imansyah, J. Marpaung, and R. R. Yacoub, “ANALISIS PENERAPAN ACCESS POINT DALAM RENTANG FREKUENSI 2400–2500 MHz DI BALMON KELAS II PONTIANAK,” *Jurnal Teknik Elektro Universitas Tanjungpura*, vol. 2, no. 1, 2021.

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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.

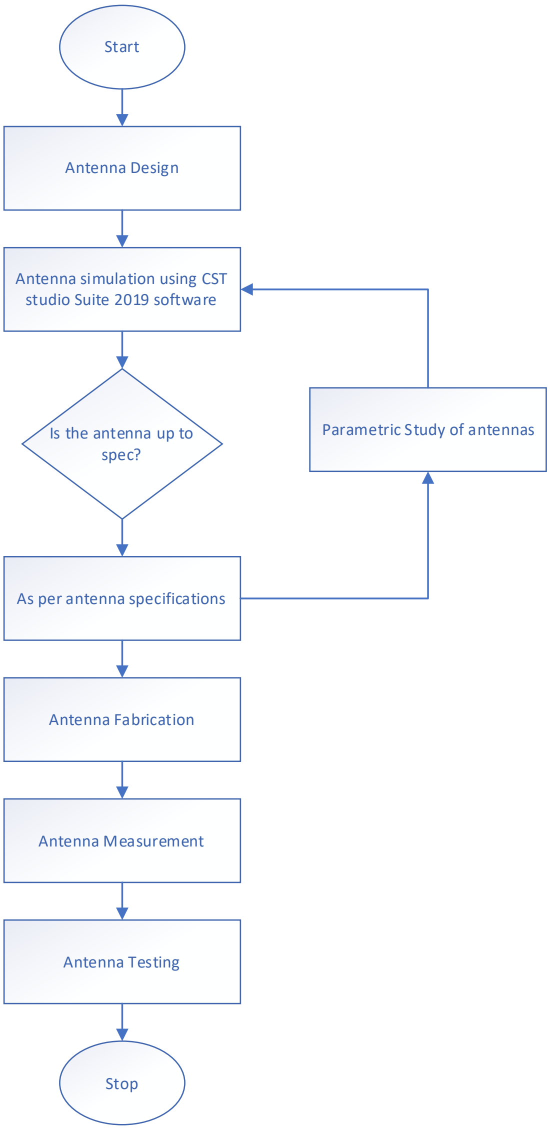

Fig.1 Research Flow

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.

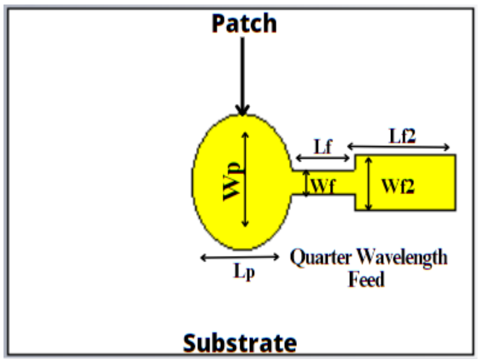

Fig. 2 Patch Antenna Design

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.

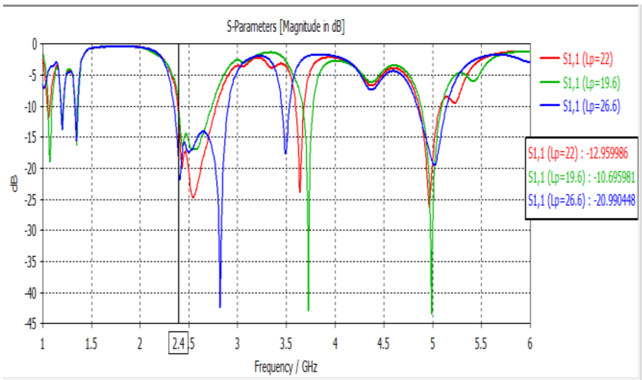

Fig. 3 Simulation results of Return Loss 1 Lp

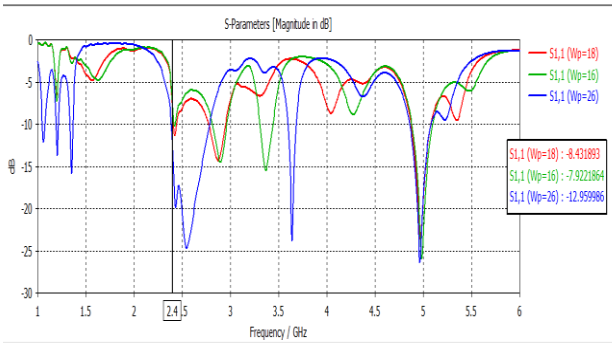

Fig. 4 Simulation results of Return Loss Wp

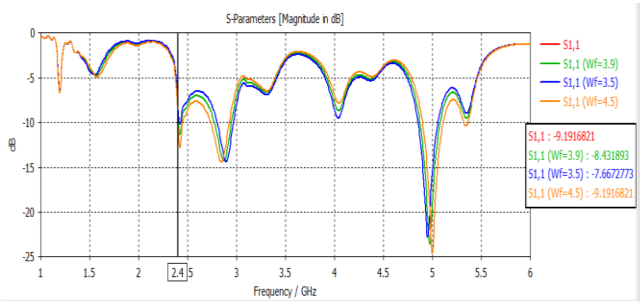

Fig. 5 Simulation results of *Return Loss* Lf

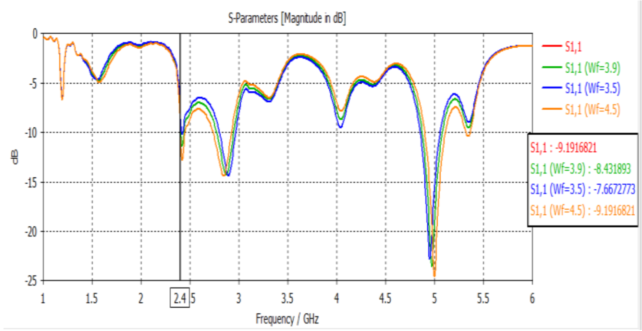

Fig. 6 Simulation results of Return Loss Wf

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.

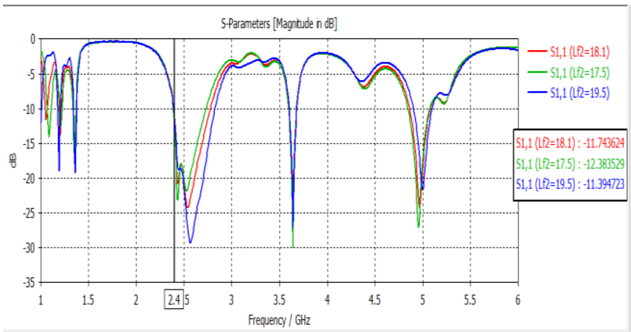

Fig. 7 Simulation results of Return Loss Lf2

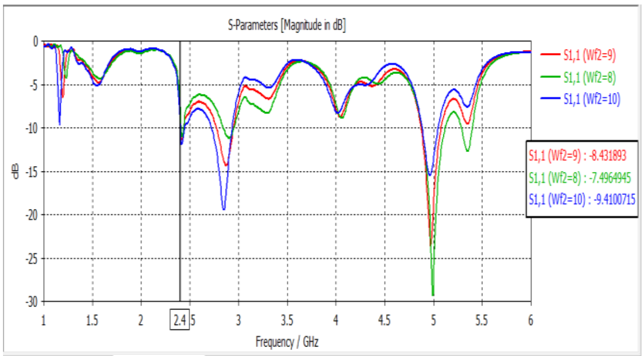

Fig. 8 Simulation results of Return Loss Wf2

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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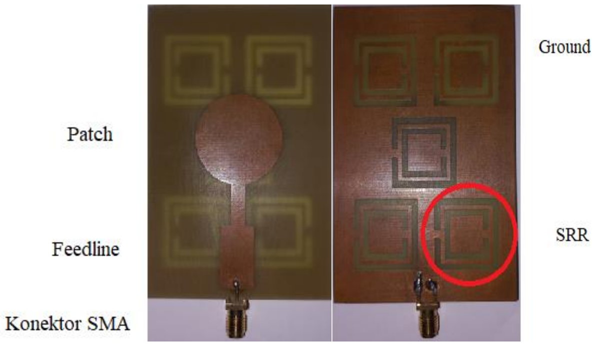

Fig. 9 Fabricated Antenna

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.

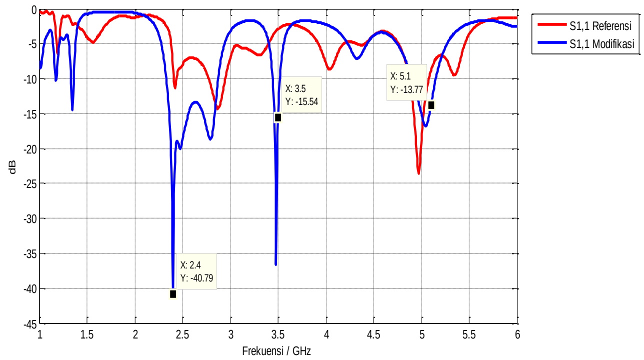

Fig. 10 Return Loss Comparison

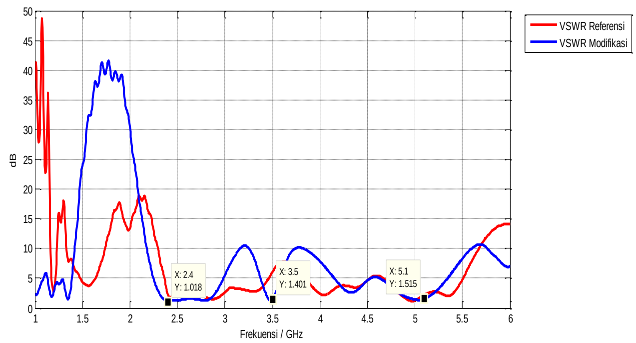

Fig. 11 VSWR Comparison

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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References

[1] Alam, S. (2017). Triangular Microstrip Antenna with Parasitic for *Wireless fidelity* Application. Journal of Electrical Engineering Studies, 2(1), 25-37.

[2] Abdurrahman, F. (2018). Rectangular Microstrip Antenna Design for WI-FI at 2.462 GHz and 5.52 GHz Frequencies.

[AMMAI, L. (2017). MINIATURIZATION OF MICROSTRIP ANTENNA USING *DEFECTED GROUND STRUCTURE* AT FIXED WIMAX FREQUENCY 3.65 GHZ.

[4] Balanis, C. A. (2016). Antenna theory: analysis and design. John wiley & sons.

[5] Budi, I. M., Nugraha, E. S., & Agung, A. (2017). Design and Analysis of Mimo Circular Microstrip Antenna at 2.35 GHz Frequency for LTE Application. Infotel Journal, 9(1), 136-146.

[6] Christyono, Y., Santoso, I., & Cahyo, R. D. (2016). Design of microstrip array antenna at 850 MHz frequency. Transmission: Scientific Journal of Electrical Engineering, 18(2), 87-95.

[7] Nasir, M. (2013). Comparison of WiMax Technology with Wi-Fi. Scientific Journal of MATRIK, 43-52.

[Nugraha, A. S., Christiyono, Y., & Sukiswo, S. (2011). Design and Analysis of Microstrip Antenna with Frequency 850 MHz for Antenna Practicum Application (Doctoral dissertation, Diponegoro University).

[9] Oktavia, H. (2019). Design and Realization of a Quadrilateral Monopole Microstrip Antenna at 546 Mhz Frequency for Dvb-T Applications. Electron: Scientific Journal, 18-28.

[Rahmadyanto, H. (2009). Design of 8-element Triangular Array Slot Microstrip Antenna with Indirect Coupling of Microstrip *Feed* Line for WiMAX CPE Application. Telkom IT Journal.

[11] Rambe, A. H. (2012). Microstrip Antenna: Concepts and Applications.

[12] Raviteja, G. V., Madhan, B. V., Sree, M. K., Avinash, N., & Surya, P. N. (2020). *Gain* and *bandwidth* considerations for microstrip *patch* antenna employing U and quad L shaped slots with DGS and parasitic elements for WiMax/Wi-Fi applications. European Journal of Engineering and Technology Research, 5(3), 327-330.

[13] Setiawan, M. I., Endri, J., & Sarjana, S. (2019). Design of rectangular path microstrip antenna at 900 MHz frequency for GSM application. Respati, 14(2).

[14] Srirahayu, A., Pramono, Y. H., & Muntini, M. S. (2015). Monopole Antenna as 2, 4 GHz Wi-Fi Transceiver on Cylindrical Transmission Line (PDAM Pipe). Proceedings of the XXIX Scientific Meeting of HFI Central Java & Yogyakarta, 25.

[15] Zulkifli, F. Y., Rahardjo, E. T., Asvial, M., & Hartanto, D. (2008). Development of two-element stacked microstrip antenna with the application of trapezoidal *Defected Ground Structure*. Makara Journal of Technology, 12(2), 149577.

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11-Element Yagi Antenna for 1800 MHz Frequency

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Abstract- The need for internet connection is very important because everything is connected to each other with the internet, but due to limitations on access points, many areas are still experiencing difficulties in accessing the internet, one of which is the suburban area. Suburban areas that are indicated to be still difficult to reach due to obstacles from buildings, and the influence of weather. In order for the signal to be reached in this area, an 11-element Yagi antenna with a working frequency of 1800 MHz is needed, which is expected to produce a high gain so that the antenna beam is maximized. This final project aims to design an 11-element Yagi antenna at a working frequency of 1800 MHz, and analyze antenna parameters such as return loss, VSWR, bandwidth, gain, and polaradiation. The design of the yagi antenna uses CST Studio Suite 2019 software. After the simulation results are as desired, the fabrication or manufacture of the antenna is carried out. The simulation results after optimization are -26.00 dB, VSWR 1.10, and gain 12.32 dB. After the simulation is carried out, the next fabrication or manufacture of the 11-element Yagi antenna, the measurement obtained a return loss value of -11.29 dB, and VSWR 1.74, although the measurement results are far from the simulation but the results of this measurement have met the requirements of the antenna specifications.

Keywords- Yagi Antenna, Reflector, Driven, Director, *Return Loss*, VSWR, Polaradiation.

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I. INTRODUCTION

Suburban areas, also known *as* city *suburbs*, are areas of land that are inside a city's periphery or that are somewhat outside of it but can still be divided. Pinggiran kota is a concept of "urban" or "suburban," which is frequently interpreted as "suburbs." [18] Specifically, a suburban or cityscape is a combination of a rural area with a city (urban). In regional terms, a suburban is a region that is divided into or encompasses both rural and urban areas (urban fringe or country side).

In suburban areas, there are still certain areas with relatively unstable and uneven network quality. A few factors that affect the quality of life in suburban areas are as follows: (1) Physical impairment, such as building defects and trees can reduce the quality of signals. Hard building structures or building materials like concrete and wood can weaken soil and reduce the strength of soil that is eroded by erosion. (2) Although suburban areas often have a lower population density than larger cities, the quality of signals may suffer if the number of people using cell phones in a particular region increases. Thin-layer networks can lead to signal density that is more robust and can negatively impact the network's overall performance. (3) In addition, caffeine also lowers the quality of sleep in this area.

In order to resolve this issue, an antenna tuned to 1800 MHz frequency should be used. One type of antenna that is used for long-distance communication is the yagi antenna. Yagi antennas are frequently used in areas where the quality of the antenna's network is unstable because they are versatile.at The maximum frequency of up to 30 GHz and the maximum signal radiation radius of up to 30 km from the base transceiver station. [5]

A few of the studies on Yagi antennas that have already been conducted are based on research conducted by [6] and involve the construction of a 5-element antenna as a 4G signaling antenna at a frequency of 1800 MHz. This type of antenna is used in 4G Telkomsel networks to produce better results in terms of parameters such as return loss, where the return loss of -2.570 dB is reduced to -10.151 dB. This results in a change in which the two return losses are more closely spaced apart and meet the standard for antenna return loss.

The optimal level is at or below -10 dB. Additionally, [15] employed a Yagi 7 Antenna planning elements at a frequency of 915 MHz, resulting in a gain of around 11.45 dB, a bandwidth of -65.9 MHz, and a return loss of 10 dB. In the last test, [13] scanned five antenna elements for 4G LTE repeaters at a 1.8 GHz frequency. The results showed a -28.39 dB return loss, a bandwidth of 280 MHz, and a gain of 10.451 dBi.

II. Method

In this study, 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 perform the calculation of the dimensions of the patch antenna.

A. Research Flow

There are a few steps that will be explained in the final task. A few steps in the antenna design process are shown in the diagram, including those that address the antenna's dimensions, gain, VSWR, frequency of operation, and mathematical return loss. The two layers include the ground plate diameter, the patch length, and the width count. Finally, during the first and second phases, the antenna dimensions are carried out using the software CST 2019.

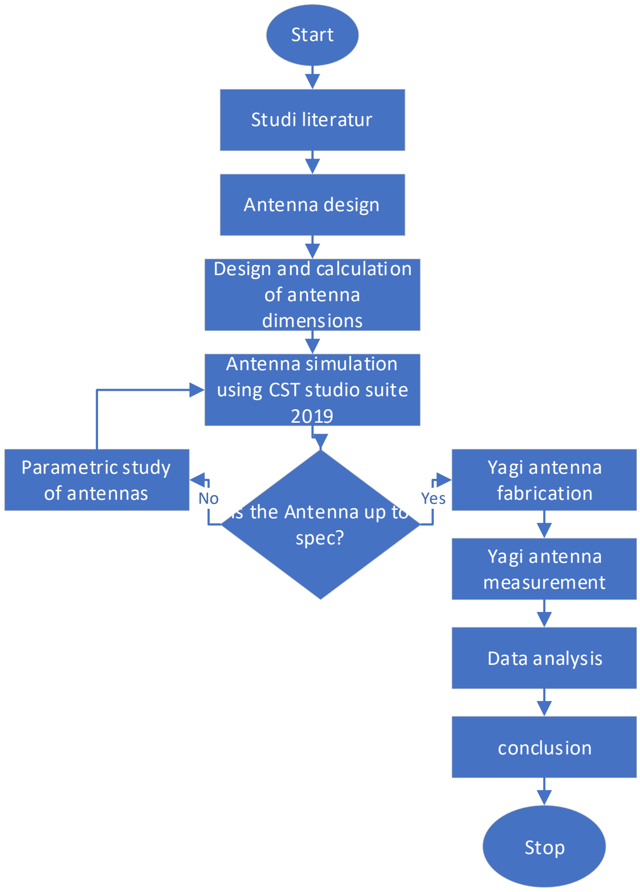

Fig.1 Research Flow

B. Antenna Dimensions

TABLE I
ANTENNA DIMENSIONS

No.	Element Type	Element Length (mm)
1.	Reflector	79.325
2.	Driven	76.82
3.	Director 1	73.48
4.	Director 2	73.48
5.	Director 3	73.48
6.	Director 4	73.48
7.	Director 5	73.48
8.	Director 6	73.48
9.	Director 7	73.48
10.	Director 8	73.48
11.	Director 9	73.48
12.	Reflector to driven spacing	41.75
13.	Spaces driven to directory 1	51.77
14.	Space between directories	51.77
15.	Aluminum diameter	2
16.	Boom diameter	4

After doing the calculations to measure the length of the reflector, driven, and director, the space between the antenna elements determines the dimensions of the antenna patch can be seen in the table above. After obtaining the dimensions of the Yagi antenna, proceed with designing the Yagi antenna design using CST Studio Suite 2019 software.

C. Antenna Design

In this study, a Yagi antenna with 11 elements will be designed. Before designing the antenna, we must first know the specifications of the antenna to be designed and the dimensional calculations of the Yagi antenna.

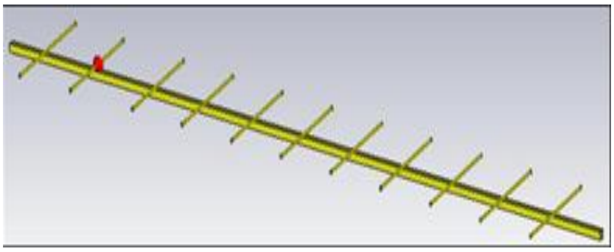

Fig.2 Design of 11-Element Yagi Antenna

After making some size changes to the dimensions of the antenna so that the desired simulation results can be obtained. In the modified antenna, the length of the element and boom is changed according to the previously determined element.

III. Result and Discussion

A. *Parametric Study*

The following are the results of antenna calculations after a parametric study or optimization so as to obtain optimal results where the size will be different from the size in the theoretical calculations obtained and this size will be used for fabrication, can be seen in Table II. The following are the simulation results of the 11-element Yagi antenna parameters that have been carried out parametric studies.

TABLE II
CALCULATION RESULTS OF YAGI ANTENNA ELEMENTS AFTER OPTIMIZATION

No.	Element Type	Element Length (mm)
1.	Reflektor	95.00
2.	Driven	77.00
3.	Direktor 1 - 9	67.00
4.	Spasi driven ke direktor 1	25.00

The following are the results of simulation of the parameters of the 11-element yagi antenna that have been carried out parametric studies.

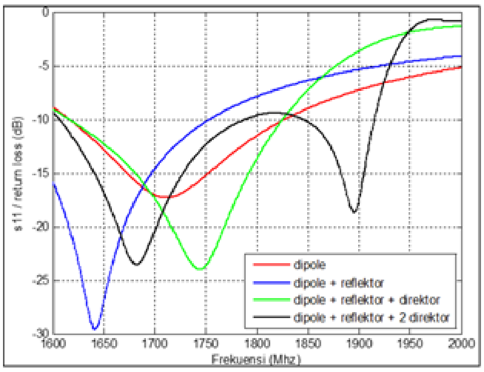

Fig. 3 Return Loss Director 1 than Director 2

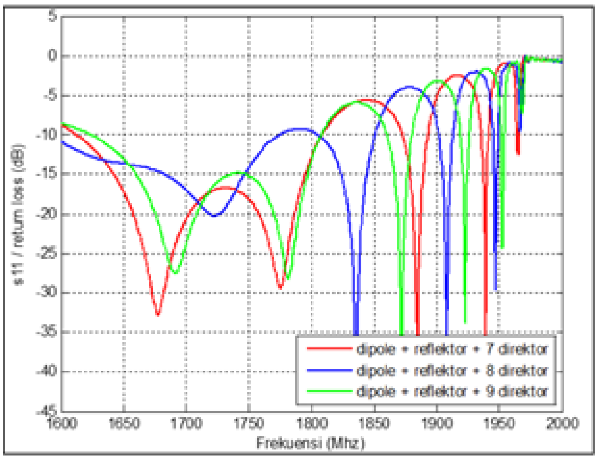

Fig. 4 Return Loss of Director 3, Director 4, Director 5, and Director 6

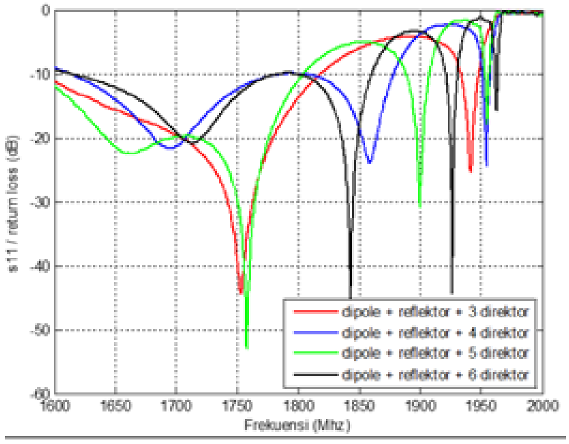

Fig. 5 Return Loss of Director 7, Director 8, and Director 9

Polaradiation Phi (Azimuth) = 0 on an 11-element yagi antenna at 1800 MHz working frequency.

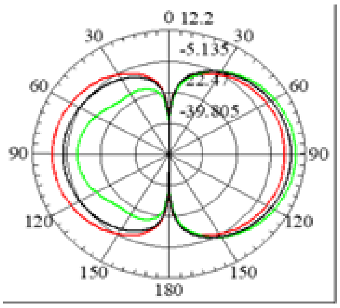

Fig. 6 Phi Polaradiation of Director 1 and Director 2

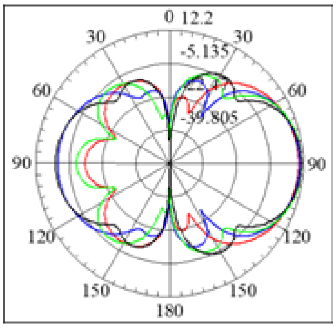

Fig. 7 Phi Polaradiation of Director 3, Director 4, Director 5 and Director 6

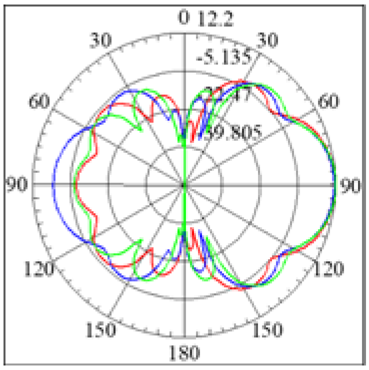

Fig. 8 Phi Polaradiation of Director 7, Director 8, and Director 9

Polaradiation Phi (Azimuth) = 90 on an 11-element yagi antenna at 1800 MHz working frequency.

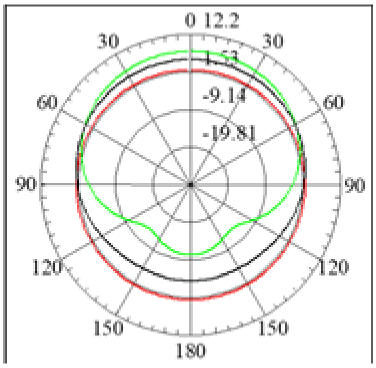

Fig. 9 Theta Polaradiation of Directors 1 and 2

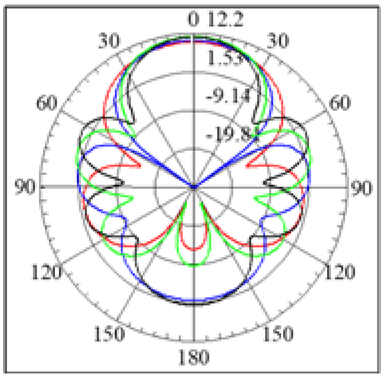

Fig. 10 Theta Polaradiation of Director 3, Director 4, Director 5, and Director 6

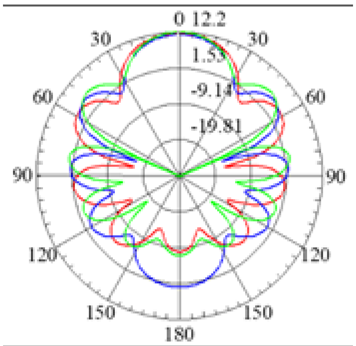

Fig. 11 Theta Polaradiation of Director 7, Director 8, Director 9

B. *Fabricated Antenna*

Fig. 12 Antenna Fabrication

After completing the antenna design, the antenna design is obtained. From the design, fabrication and measurement are carried out to obtain the value of antenna parameters, such as working frequency, return loss, VSWR, gain, bandwidth and radiation pattern shape. In the simulation results that have been carried out, the modified antenna will be compared with the antenna fabricated in this final project to determine the best return loss and VSWR values in the 1800 MHz frequency range.

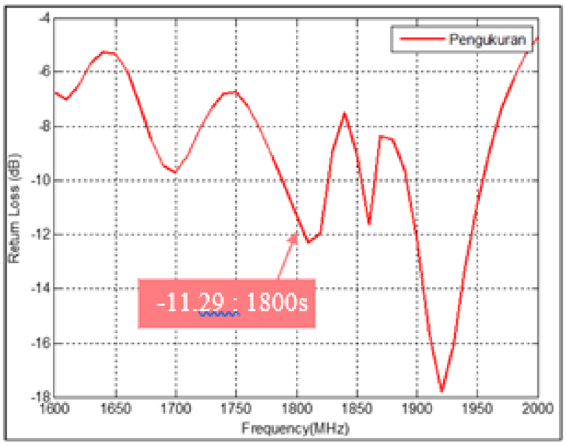

Fig. 13 Return Loss

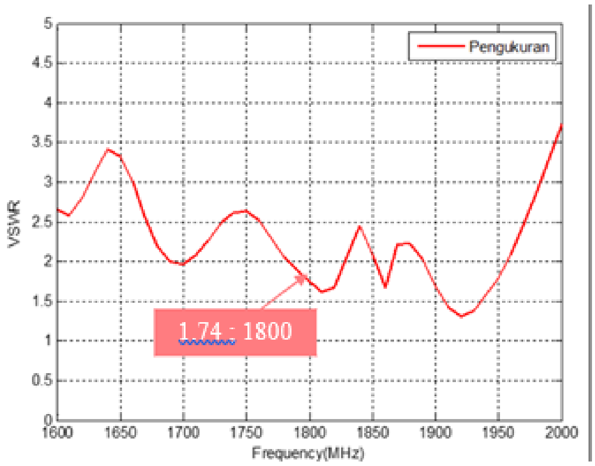

Fig. 14 VSWR

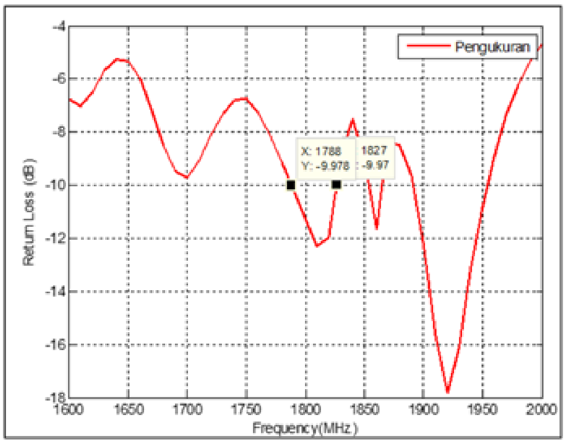

Fig. 15 Bandhwith

TABLE II
COMPARISON OF SIMULATION AND FABRICATION RESULTS

No.	Parameter Antena	Simulation Antenna Results	Fabrication Antenna Results
1.	Frekuensi (MHz)	1800	1800
2.	*Return Loss* (dB)	-26.00	-11.29
3.	VSWR	1.10	1.74
4.	*Bandwidth*	182	39

From Fig 13 the return loss value of the measurement results is -11.29 dB which is still in accordance with the return loss parameter reference which is ≤ -10 and for the VSWR value in Fig 14 is at 1.74 which is still in accordance with the VSWR parameter reference which is 1 ≤ VSWR ≤ 2. The frequency obtained is also in accordance with the working frequency at 1800 MHz. As for the bandwidth in Fig 15, the results obtained are 39 MHz. However, for the results of the return loss and VSWR parameters, the Yagi antenna fabrication can still be said to be as desired.

IV. CONCLUSION

Antenna for working frequency at 1800 MHz, where the return loss value is -26.00, VSWR value 1.10, bandwidth 182 MHz, gain 12.31 dBi, and the radiation pattern formed is unidirectional.

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REFERENCES

[1] Amarulloh. (2019). 433 MHz Yagi Antenna Design (Case Study of 433 MHz Telemetry Signal Amplifier on Unmanned Aircraft). Thesis.

[Balanis, C. A. (2005). Antenna Theory Analysis And Design Third Edition. www.copyright.com.

[Cahyo, R. D., Christyono, Y., & Santoso, I. (2012). Design and Analysis of Microstrip Array Antenna with Frequency 850 Mhz for Antenna Practicum Application. Final Project Seminar Paper.

[Carr, J. J. (2012). Practical Antenna Handbook.

[5] Corputty, R., Muriani, M., & Agustinus Parapaga, T. (2021). Implementation of Signal Booster Antenna in 3G Network QOS (Quality Of Service) Improvement. 03(02).

[Firas, S., & Broto, S. (2020). Design of a 5 Element Yagi Antenna as a 4g Signal Amplifier at 1800 MHZ Frequency. 3(1).

[7] G.S.N., R. (2005). Antennas and Wave Propagation (R. G.S.N, Ed.).

[Gusti, I., Dharmayana, N., Bangun, R., Yagi..., A., Dharmayana, I. G. N., Ardana, I. P., & Widyantara, I. M. O. (2017). Design of Yagi Antenna at 1800 MHz Frequency for Modem Signal Amplification. Electrical Technology, 16.

[Jaya, I., Mustiko, C., & Zainuddin3, A. (2016). Design And Implementation Of 2x5/8λ Telex Antenna For FM Radio Broadcasting System Applications (Vol. 3, Issue 1).

[Jhonson, R. C. (1993). Antenna Engineering Handbook.

[Lubis, A. Z. (2014). Effect of Antenna Position on Wave Signal of Aluminum Yagi Antenna. Dynamic Journal, II (14).

[Nugroho, D. H. T., & Hasan, M. F. (2020). Design of 433 Mhz Yagi Antenna on Automatic Antenna Tracker for Unmanned Aircraft. Journal of Ecotype (Electronic, Control, Telecommunication, Information, and Power Engineering), 7(1), 20-25. https://doi.org/10.33019/ecotipe.v7i1.1390

[13] Padhila, H. (2022). 5 Element Yagi Antenna at 1.8 Ghz Frequency for 4g Lte Repeater Final Project.

[14] Saadilah, A., Imansyah, F., Suryadi, D., Elektro, P. T., & Elektro, J. (2019). Design of an Omnidirectional Modified Yagi Antenna to Improve the Quality of Ultra High Frequency Television Broadcast Receivers.

[Simanjuntak, A. B., Mulyanti, B., Akhmad Juanda, E., Abdulah, A. G., & Supriyadi, T. (2018). Realization of Yagi Antenna for Measurement Objects in Antenna Radiation Pattern Simulation Implementation.

[Soares, D. P. B. (2016). Design of 16-Element Yagi Antenna for 2.4 GHz Wireless LAN Network.

[Surya, F. (2022). Design and Realization of Frying Pan Reflector Yagi Antenna with Working Frequency 2.4 Ghz for WLAN Application. 13-14.

[18] Yandri. (2014). Production Patterns, Distribution and Break-even Point Analysis of the Coconut Shell Charcoal Industry in Suburban Indonesia. Journal of Liquidity, 3(2), 145-155.

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Yagi Antenna With Three Reflector Elements To Amplify 4G Signal In Suburban Area

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Abstract*—Along with the increasing number of cellular telephone users and the high cost of 4G network infrastructure, the investment required to build 4G infrastructure is IDR 278 trillion so that many suburban cellular telephone users (suburban areas) get 4G access with poor network quality. So it requires repeaters as an effective solution with small capital to increase coverage areas in weak signal areas. The Yagi antenna is a suitable antenna for long-distance communication with three reflector elements to strengthen the 4G signal in the suburban area at frequencies of 1710-1880 MHz. The material for making the antenna consists of aluminum pipes as reflector elements and director elements with a diameter of 8.4 mm and wire as a driven element with a diameter of 4 mm. In the manufacture, there is the addition of balun and three reflector elements that can improve the performance of the Yagi antenna parameters. The testing of the Yagi antenna was carried out in two ways, namely the Anechoic Chamber room and the Telecommunication Electronics Lab. For the transmission cable using a sma female connector cable to operate the Anechoic Chamber device appointed female students who have been trained in measurements using Network Analyzer software from the results of manual measurements and Network Analyzer obtained the results of unidirectional radiation patterns, maximum power level of -23.24 dBm, resonant frequency 1809 MHz, Bandwidth 52 MHz, HPBW 250, FBR 12.97 dB, Gain 8.572 dB, VSWR 1.09, and Return loss -26.6 dB design using MMANA-GAL software simulations show that the antenna works at a frequency of 1.800 MHz, antenna impedance 42.84 + j2.906 Ω, VSWR 1.18, Gain 20.66 dB, and FBR 23.77 dB and has a unidirectional radiation pattern.

Keywords*: *4G, Reflector, Yagi Antenna, Network Analyzer

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I. INTRODUCTION

The increasing number of cellular telephone users and the high cost of 4G network infrastructure are based on the required investment of Rp 278 trillion until 2019). [According to the Ministry of Communication and Information (2017), until July 2017, 4G infrastructure has reached 55,701 eNodeBs in Indonesia, the area of Indonesia is not comparable to the ideal needs that should be met resulting in the need for a repeater.

According to Lee et all (2010), repeaters are used as an effective solution with little capital to increase coverage area in weak signal areas. Yagi antenna is an antenna suitable for long-distance communication. [2] According to Lim and Ling (2006), the yagi antenna is used to obtain high gain with a simple design. [In the study of Radiation Patterns Using Modified Design of Yagi-Uda Antenna by using three reflector elements at a frequency of 157 MHz, Thakur, et all [4] (2016) obtained an increase in gain from 6 dB to 8 dB and a narrower HPBW when compared to using one reflector element.[5] The addition of the number of reflector elements makes the unidirectional radiation beam from the Yagi antenna more focused. Based on this, the author raises the title "Yagi Antenna with Three Reflector Elements to Amplify 4G Signals in Suburban Areas".

Previous research conducted by the son titled about the 1.8 GHz Yagi antenna to strengthen 4G signal reception in 2017 This antenna produces less than optimal unidirectional polarisation, antenna gain of 18.86 dB, and HPBW 500[6]. repeaters are used as an effective solution with small capital to increase coverage area in weak signal areas. The Yagi antenna is an antenna that is suitable for long-distance communication in previous studies the Yagi antenna is less than optimal for strengthening 4G networks in suburban areas because there is no addition of reflector elements This antenna produces unidirectional polarization, antenna gain 18.86 dB, and HPBW 500 so it is narrower than the addition of the number of reflector elements on the yagi antenna Further development of additions made by Thakur, et all (2016) improves the performance of the yagi antenna. The study of Radiation Patterns Using the Modified Design of the Yagi-Uda Antenna added three reflector elements at a frequency of 157 MHz and experienced an increase in gain from 6 dB to 8 dB and HPBW The addition of reflector elements makes the unidirectional radiation beam from the yagi antenna more focused [7].

II. THE MATERIALS AND METHOD

The study used a 3-element Yagi antenna in the antenna design and simulation process using MMANA-GAL software and the measurement process was carried out in the Anechoic Chamber room and in the Telecommunication Electronics Lab in the Anechoic Chamber room using Network Analyzer software. The antenna transmission cable connector used is an SMA female connector. in this room also uses the Anechoic Chamber device, measurements of antenna parameters carried out in the Anechoic Chamber room obtained from these measurements are the resonant frequency, bandwidth, return loss, and VSWR. In the Anechoic Chamber room using a frequency of 1800 MHz in the manufacture of yagi antennas, There are two frequency bands in the 4G network, namely the uplink frequency and the downlink frequency. The uplink frequency bandwidth is 75 MHz, namely 1710 MHz - 1785 MHz. The downlink frequency bandwidth is 75 MHz, namely 1805 MHz - 1880 MHz.

In the Telecommunication Electronics Lab room using a dipole antenna as a transmitter with a distance of 1 meter and as a meter spectrum analyzer Yagi antenna measurements in the Telecommunication Electronics Lab. The parameters to be carried out in the room in the communication electronics lab obtained are radiation patterns, antenna gain, HPBW, and FBR in testing radiation patterns in the communication electronics lab room carried out by changing the position of the receiving antenna using a motor control.

A. Antenna Design

In the antenna design process, the antenna design specification process of working frequency, VSWR, Return Loss, and Bandwidth is carried out. Calculating the length of the antenna element and the distance between elements to be simulated using MMANA-GAL software after the antenna design process specifications have been obtained in the next step.

The steps taken in designing and manufacturing the antenna can be described as follows

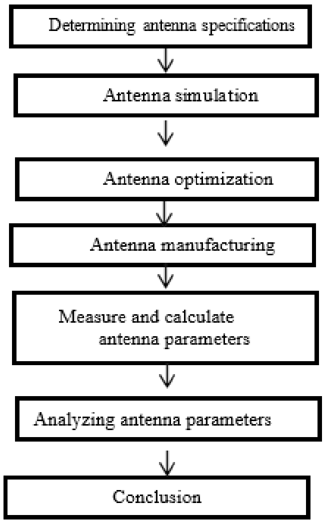


Figure 1. System Block Diagram

B. Antenna Parameters

Before designing the antenna there must be the following predetermined parameters

Table 1 Antenna parameters

No.	Antenna parameters	1710-1880 MHz
1	Resonant Frequency	1800 MHz
2	*Bandwidth*	170 MHz
3	*Return Loss*	≤ -10 dB
4	VSWR	1≤VSWR≤2
5	Impedance of the antenna	50 Ω

In the antenna design process, calculate the size of each antenna element. The first thing to do before calculating the size of the yagi antenna is to know the resonant frequency of the antenna to be made.

$$\lambda = \frac{c}{f} = \frac{3x^{108} m/s}{1800x^{106} Hz} = 0.167m \qquad (1)$$

so,

a. Reflector length
   The length of the reflector element is obtained based on equation 2.3. L reflector= 0.482 x λ
   Reflector L= 0.482 x 0.167 = 0.08049 m
b. Driven length
   The length of the driven element is obtained based on equation 2.1. Ldriven= 0.47 x λ
   Ldriven = 0.47 x 0.167 = 0.07849 m
c. Length of the element director
   The length of the director element is obtained based on equation 2.4. Ldirektor = 0.42 x λ

Ldirector = 0.42 x 0.167 = 0.07014 m

d. Spacing between elements

The width of the space between elements is obtained based on equation 2.5. Space between elements = 0.2 x λ.

Space between elements = 0.2 x 0.167 = 0.0334 m

In the antenna there is a calculation of elements in the yagi antenna there is 1 driven element, 9 director elements of the same size 3 reflector elements of the same size the following table is the result of calculating each element.

Table 2 Calculation results of Yagi antenna elements

No.	Element type	Element length (m)
1	Reflector 1	0.08049
2	Reflector 2	0.08049
3	Reflector 3	0.08049
4	Driven	0,07849
5	Director 1	0,07014
6	Director 2	0,07014
7	Director 3	0,07014
8	Director 4	0,07014
9	Director 5	0,07014
10	Director 6	0,07014
11	Director 7	0,07014
12	Director 8	0,07014
13	Director 9	0,07014
14	Horizontal position (θ) between reflector and R1, Reflector and R3	30^0 and 30^0

C. Tools and Materials

In the process of making antennas, you must pay attention to accuracy and neatness during the fabrication process to get the desired results The materials used in the manufacture of antennas are aluminum pipes for reflector and director elements which have a diameter of 8.4 mm and wire for driven elements has a diameter of 4mm.

The components or materials needed are:

1. Aluminum pipe (8.4 mm diameter) to taste
2. Copper cable (4 mm diameter) special for driven elements to taste
3. Aluminum 0.9 x 1.6 cm to taste
4. 50 Ω coaxial cable to taste
5. BNC *male* connector 1 piece
6. Bolt with 3.5 mm insulator to taste
7. PCB board to taste
8. One telephone rosette
9. Insulation to taste
10. Tin to taste
11. Copper cable (4 mm diameter)

For induction to the *cellphone* to taste the equipment needed to support the process of making this antenna is:

1. Mistar
2. Pencil
3. Markers
4. Hacksaw
5. Drilling machine
6. 3.5 mm drill bit
7. Fine sandpaper
8. Scissors
9. Cutter Knife
10. Glue
11. Solder

III. RESULTS AND DISCUSSION

After carrying out the process of designing and simulating the antenna in Software the fabrication process and the measurement process in the telecommunications lab and the Anechoic Chamber room and the measurement process using Network Analyzer software for the Anechoic Chamber device carried out by *female* students who have been trained. The antenna transmission cable connector is an SMA *female* connector.

A. Yagi Antenna Measurement

Measurements of the yagi antenna were carried out in the Anechoic Chamber room and in the Telecommunication Electronics Lab with the following parameters and using Network Analyzer software. and Anechoic Chamber devices for Anechoic Chamber devices that run students who have been trained

a. Resonant frequency
b. Bandwidth
c. VSWR (Voltage Standing Wave Ratio)
d. Return loss

Measurement in the communication electronics lab. The parameters to be obtained are radiation pattern, antenna gain, HPBW, and FBR. When doing this test, the transmitter used is a dipole antenna.

a. Radiation pattern
b. Antenna gain
c. HPBW (Half Power Beamwidth)
d. FBR (Front to Back Ratio)

B. Yagi Antenna Measurement Results

After the measurement is complete, the parameters determined are Return Loss, Resonant Frequency, VSWR, Bandwidth, Bandwidth, and Gain of the yagi antenna.

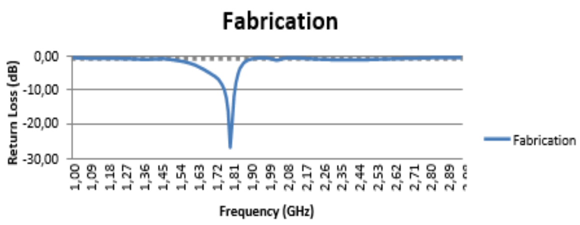
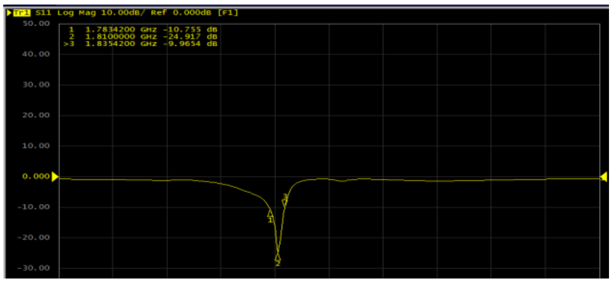


Figure 2 Yagi Antenna Measurement Results

From Figure 2, it is known that the value of the resonation frequency of the yagi antenna is 1.81GHz with a return loss of -26.6 db.

C. Antenna Bandwidth

Lower frequency = 1783 MHz, in the image shown by marker no. 1 Upper frequency = 1835 MHz, in the image shown by marker no.3 Based on equation 2.10, Bandwidth = 1835 MHz - 1783 MHz Bandwidth = 52 Mhz.



D. VSWR (Voltage Standing Wave Ratio)

The ideal VSWR value is 1, the antenna impedance value is the same as the transmission line impedance. The maximum VSWR value that can still be tolerated is 2 because when VSWR is 2, the return loss is -10 dB. An explanation of this return loss value will be explained in the next point.

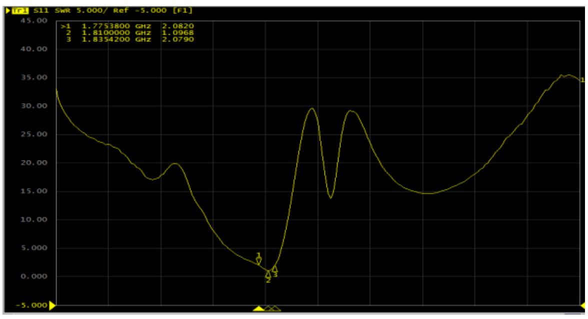


Figure 4 VSWR rounding result

E. Antenna Radiation Pattern

Measurement of radiation patterns in the communication electronics laboratory using a spectrum analyzer measuring device and also using transmitting and receiving antennas with a distance of 1m using a dipole antenna as a transmitter and a yagi antenna as a receiver every antenna position changes the receiving antenna using a motor control.

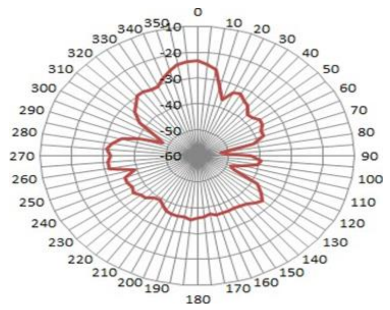


Figure 5. Horizontal polarization of the antenna

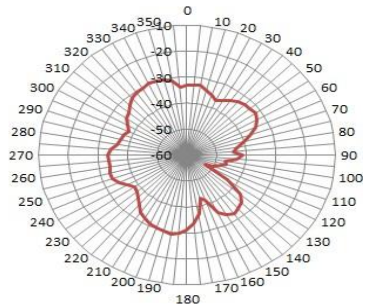


Figure 6. Vertical antenna polarization

F. Antenna Gain

Antenna gain is an antenna parameter that is utilized to amplify 4G signals. The gain of the yagi antenna is done by comparing the power level of the yagi antenna with the dipole antenna as the receiving antenna. The dipole antenna is used as a reference antenna in calculating the gain of the yagi antenna.

Table 3 Antenna gain measurement

No.	Antenna type	Transmitting power (dBm)	Received power (dBm)
1	1800 MHz *dipole* antenna	+0	-47,52
2	1800 MHz yagi antenna	+0	-38,95

G. HPBW (Half Power Beamwidth)

HPBW is the coverage area of an antenna expressed in degrees. HPBW is closely related to antenna gain. HPBW is especially important if the antenna is used for long-distance point-to-point communication. The angular width of the HPBW is the width of the angle formed in the

when the radiation intensity1 of its maximum value or drops 3 dB.

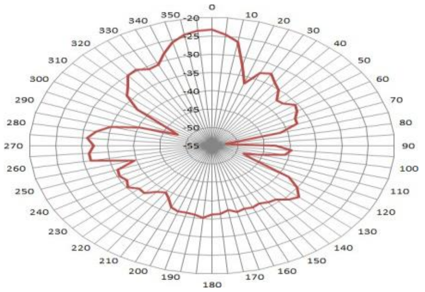


Figure 7 HPBW manufacturing result

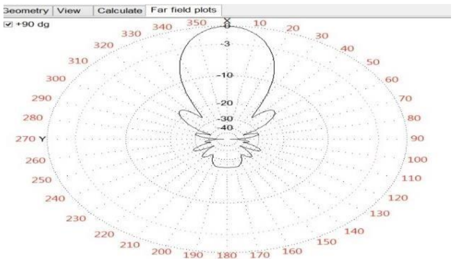


Figure 8 HPBW simulation results

H. Yagi Antenna Parameter Analysis

The resonation frequency is designed at a frequency of 1800 resonation frequency is where the antenna works or gains maximum power after the confirmation process to see its resonation in the Anechoic Chamber. The process of measuring and testing return loss using a Network Analyzer device. To see the resignation using the return loss graph because the smaller the return loss of the antenna, the greater the power emitted or received the test results prove that this yagi antenna has a resonant frequency close to 1810 MHz and the results of the equation obtained that the resonant frequency of the yagi antenna is at a frequency of 1809 MHz. This frequency is slightly different from the initial design of 1800 MHz. This is due to the less neat manual fabrication process.

Bandwidth is the range in a working antenna bandwidth that serves to know the width of a frequency that can be received antenna bandwidth value of 52 MHz this value is different in the bandwich initial frequency of 1710 MHz to 1880 MHz. In general, bandtwich has a band with frequency LTE worth 75 MHz. In LTE use uplink and downlink On uplink has a frequency of 1710 MHz-1785 MHz and a downlink frequency of 1805 MHz - 1880 MHz so that the uplink and downlink frequencies have a frequency of 75 MHz and band gap frequency uplink and downlink (1785 MHz - 1805 MHz) has 20 MHz The antenna frequency range of 1783 MHz - 1835 MHz is still in the bandwidth of uplink and downlink frequencies in LTE technology. The value of vswr ideally is 1 transmission impedance and antenna impedance has the same value if the value of vswr diporeleh 2 can be tolerated when VSWR has a value of 2 then the value of return loss diporeleh by 10 db In the simulation results diporeleh value of 1.09 vswr value is good compared to the simulation results of 1.18.db In the experiment a unidirectional radiation pattern has a large back lobe.

The simulation results are different from the experimental results in the simulation in the form of a unidirectional radiation pattern. good (has a small back lobe). Due to lack of accuracy during the fabrication process.

Radiation patterns that are not in accordance with the simulation are also caused by noise when testing. This noise is caused because the test is carried out in the lab room so the antenna test is affected by reflected waves. This yagi antenna produces a narrow HPBW so that it is more focused to a point. This antenna has a high gain because the narrower the HPBW of an antenna, the higher the gain. HPBW and gain values are inversely proportional

Gain is an amplifier on the signal on the test antenna carried out in the communication electronics lab using a dipole antenna as the received power level of the yagi antenna is -38.95 dBm and the received power level of the dipole antenna is -47.52 dBm. From the measurement results, the gain value of this antenna is 8.572 dB. This result is smaller when compared to the simulation results, where the simulation results obtained are 20.66 dB.

HPBW is the large coverage area of the antenna expressed in degrees. HPBW is related to antenna gain The HPBW angle has a wide angle formed when the radiation intensity is ½ when the maximum value drops by 3db HPBW this rounding result has a better or more focused value compared to the simulation results. HPBW from simulation results is 300

FBR (Front to Back Ratio) Is the ratio between the main lob and back lobe FBR = power in the direction 00 - power in the direction 1800 = -23.24 dBm - (-36.21dBm) = -12.97 dB Return Lossb Is back attenuation. Return loss serves to check the loss of transmitter power and know the value of power received on the yagi antenna as a receiver. return loss measurement chart, a good antenna has a return loss value below -10 dB. The return loss value is known from the VSWR value. The return loss value of the simulation results is not displayed by the software but uses the formula.

IV. CONCLUSIONS

The antenna design and simulation process uses MMANA-GAL software and uses a frequency of 1800MHz from the simulation results obtained antenna impedance of 42.84 + j2.906 Ω, VSWR 1.18, Gain 20.66 dB, and FBR of 23,77 dB and has a unidirectional radiation pattern and in calculations carried out manually and using a Network Analyzer the radiation pattern is unidirectional, the maximum power level is -23.24 dBm, the resonant frequency is 1809 MHz, Bandwidth is 52 MHz, HPBW is 250, FBR is 12.97 dB, Gain is 8.572 dB, VSWR is 1.09, and Return loss is -26.6 dB. With the addition of the reflector element on the antenna, it results in an increase in resonation impedance.

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After completing this journal, a new chapter in life will begin that is not the end. Without the help of others, I as a writer would not have been able to complete my journal.

The author would like to thank the lecturers who have been involved in this research so that this journal is completed properly in accordance with what we want. The author really hopes for constructive and useful input and criticism because of the lack of everything that does not complete the preparation of this diary so that the author can learn and perfect it. The author of this journal hopes that readers will find it useful.

REFERENCES

[1] Balanis, Constantine A. 2005. Antenna Theory Third Edition: Analysis and Design. Arizona: Jhon Wiley & Sons Inc.

[2] Dharmayana, I.G.N., at all. 2017. "Design of Yagi Antenna at 1800 MHz Frequency for Modem Signal Amplification". Electro Technology. 16 (1), 75-83

[3] Harsono, Nonot. 1993. Communication Circuits and Systems. Surabaya: PES-ITS

[4] Kustiwan, Iwan. 2014. Module 1: City Planning. Open University Repository

[5] Lee, Youngki, et all. 2010. "Design of Wideband Indoor Repeater Antenna With High Isolation for 3G Systems". IEEE Antennas and Wireless Progation Letter. 9, 697-700

[6] Lim, Sungkyun and Ling, Hao. 2006. "Design of a Closely Spaced, Folded Yagi Antenna". IEEE Antennas and Wireless Progation Letter. 5, 302-305

[7] Putra, Teguh An Nur. 2017. 1.8 GHz Yagi Antenna to Strengthen 4G Signal Reception. Diploma 3 Telecommunication Program PNP: Unpublished Final Project

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Design and Build of a Blynk-Based Automatic Cat Food and Drinking Water Dispenser

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Abstract — **There are many people who like to keep cats. When keeping cats, the things you need to pay attention to are eating and drinking so that the cat's health is maintained. As it should be, food and drinking water must be given according to the dosage. However, if the cat owner is outside the house, it will make it difficult for the owner to feed and drink it. Through this final project, cats can eat and drink at any time by implementing the Internet of Things called an automatic dispenser. Automatic food and drinking water dispenser uses *NodeMCU8266, 2 servo motors, 2 ultrasonic sensors, HX711 load cell and Blynk software*. The Blynk software functions to display the on/off switch, the distance the cat is approaching, the amount of food and drinking water available in the cat food and drinking water dispenser which is connected via *nodeMCU8266* which can be accessed on the cat owner's smartphone. If the food and drinking water is less than capacity, a notification will immediately appear on the cat owner's smartphone and email.**

***Keywords*— CAT, *Ultrasonic Sensor, Servo Motor, Load Cell HX711, NodeMCU8266, Blynk, IOT*.**

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I. INTRODUCTION

In Indonesia, many people already have cats as pets. This is common in all levels of society. Cats are popular pets because they are easy to care for, cute, reduce stress and reduce feelings of loneliness at home[1]. Animals also need nutrition from their food, including pets. The focus of raising animals, especially cats, is to feed them twice a day, morning and evening.

Although many are interested in keeping cats, some owners have jobs that require them to be out of the house for longer periods of time. However, this does not make it difficult for them to keep cats. Not being home often often makes them late or even forget to feed their cats. Cats need to eat and drink to live. Regular feeding is important for a cat's health. Irregular feeding can impact a cat's digestion and health[2].

Cat owners often entrust their animals to pet shops at high costs for convenience[3]. Pet Shop is a pet and food sales company that also offers feeding for pets. However, the problem is the incorrect feed dosage. The problem faced by pet shops when the number of pets entrusted to them increases is that they require additional employees to care for and feed the animals. This requires large costs in one day of care. Cat owners cannot take their pets to the pet shop.

The author will design a tool to control pet eating and drinking remotely via IoT. Implementation of an IoT-based automatic pet fideer that makes it easier for cat owners to provide food and drinking water according to the daily dose. The Blynk application will provide notifications if food and drinking water have run out.

II. METHODS AND MATERIALS

A. Method

In this research, the cat's instinctive testing method for approaching proper eating and drinking was used to determine the suitability of the system's work with the simulation that will be made. And electronic components are needed, namely an MCU 8266 node, servo motor, HX711 load cell and ultrasonic sensor.

B. Material

1. *Arduino IDE*

Arduino IDE is open-source software used to write C and C++ programming languages. Used to create programs on NodeMCU ESP8266. Creation in NodeMCU ESP8266 is called sketch. The Arduino IDE has a black message box for status display. In this software, at the bottom right it will display the board that has been configured with the COM ports used. Its purpose is to check syntax errors in the sketch that has been created. If there are no syntax errors, it will be compiled into the language. Upload is a function to send a compiled program to the Arduino module.[2]

Figure 1. Arduino IDE

2. *NODEMCU 2866*

NodeMCU is an open-source IoT platform. NodeMCU is a board that combines the ESP8266 with microcontroller features, Wi-Fi access, and a USB to serial chip. For programming, you only need to use the same USB data cable as the Android charger. Some of NodeMCU's features include open source, low cost, smart, interactive, and Wi-Fi active.[4]

Figure 2. NodeMCU esp8266

3. *Ultrasonic sensor*

Ultrasonic sensors convert sound into electrical quantities or vice versa using ultrasonic waves of up to 20 frequencies. The working principle of an ultrasonic sensor is to measure the time the wave travels from the transmitter to the receiver with a frequency of 000 Hz.[5]

Figure 3. Ultrasonic Sensor

4. *HX711 load cells*

The function of the load cell sensor is a sensor that reads the weight of objects, this sensor is usually used for scales. In the process of reading the load cell sensor, there is a calibration process which functions to check the level of accuracy of the load cell sensor reading.

Figure 4. HX711 load cells

5. *Servo motors*

Servo motors are a type of DC motor with a feedback system and consist of a DC motor, gear, control and potentiometer. The servo motor does not stand alone, but is supported by other components in one package. Servo motors are used in making robots, especially as leg drivers because they have large power and torque to move heavy loads. The servo motors commonly used on robots are usually 180º servo motors.[6]

Figure 5.Servo Motors

6. *Blynk Software*

Blynk is a platform for controlling Arduino, Wemos D1, NodeMCU 8266, Raspberry Pi, and similar devices via applications on iOS and Android with an internet connection[7]. With this application, users can control remotely without time limits as long as they are connected to the internet.[2]

Figure 6.Blynk Software

C. Block diagram

This research has a block diagram shown in the image below:

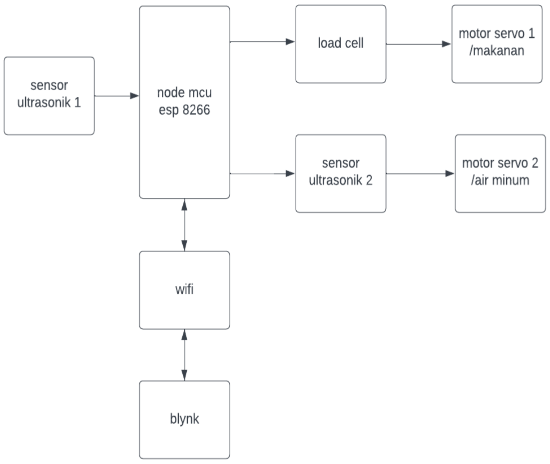

Figure 7. Block diagram

The block diagram above explains the design and construction system that uses software*Blynk*and two sensors. The two sensors are the distance sensor and the weight sensor. The distance sensor used is an ultrasonic sensor and the weight sensor used is a load cell with an HX711 module. Both sensors function to provide notifications to the Blynk software when the food and drinking water in the place has run out and see how many grams of food and drinking water are left. When the notification appears, it will activate the program on the NodeMCU and will become a link to the Blynk application. Then the servo motor will act as a driver which will open and close the dispenser for the cat to eat and drink

D. Image Design

The main components in the cat food and water dispenser system are NodeMCU esp 8266, HC-SR04 ultrasonic sensor, and HX711 load cell, servo motor. An ultrasonic sensor is placed in front of the cat's food and drink container as a device that measures the distance the cat approaches the dispenser. Meanwhile, under the food and drink containers, a load cell is also placed to measure the availability of food and drinking water. And the servo motor is placed under the food supply funnel and on the drinking water tap.

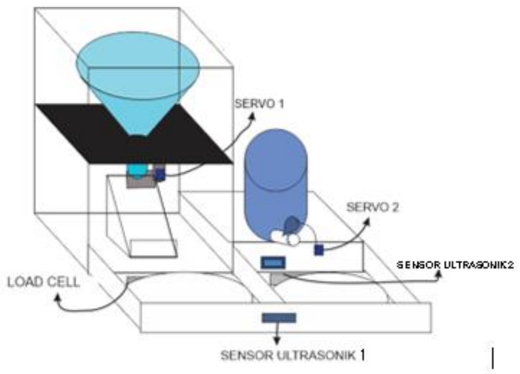

Figure 8. Design

E. Network design

To provide a clearer picture of the automatic cat feeding and drinking system circuit, you can see the picture

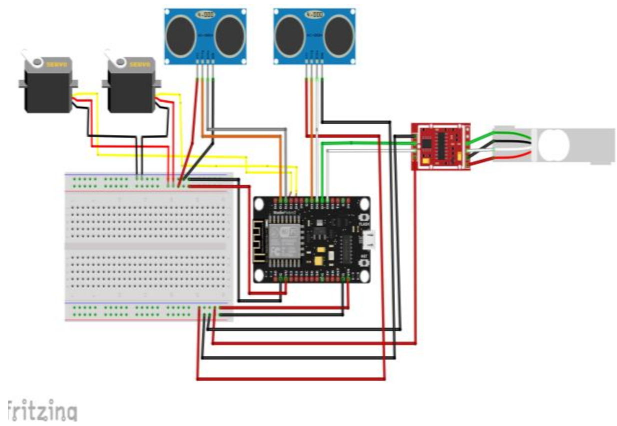

Figure 9. Automatic Cat Feeding Schematic

Table 1. Pin component connection

No	NodeMCu	Motor servo1	Motor servo2	ultrasconic Sensor1	load cell 1	ultrasonic sensor2
1	vcc 5V	vcc	vcc	vcc	vcc	vcc
2	gnd	gnd	gnd	gnd	gnd	gnd
3	d1	signal control				
4	d2		signal control			
5	d3			Triger		
6	d4			echo		
7	d5					triger
8	d6					echo
9	d7				DT	

F.Flow chart

In this research there is a flowchart of how the tool works in the image below:

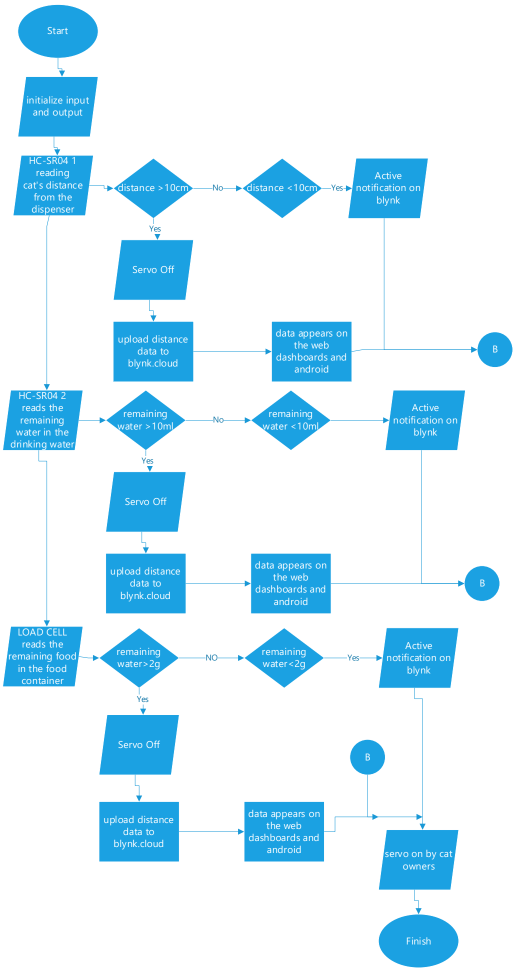

Figure 10. Flow chart

III. RESULTS AND DISCUSSION

A. *Load Cell Testing*

The cat food system is run by utilizing a load cell sensor to weigh the load on the available food capacity, data obtained by the NodeMCU 8266 Cat drinking water system. Load cell testing is carried out by comparing the readability of the scales on the Arduino Ide serial monitor. Data collection was carried out by weighing the weight by comparing the error.

Table 2.Comparison and percentage of load cell errors

NO	Digital scales (grams)	Load cell (gram)	Error (%)
1	30	30.12	0.4
2	12	12.13	1
3	1	1.11	1
4	0	0.11	1

The load cell sensor is capable of weighing loads quite well with the error range that occurs based on research being from 0.4% to 1%. System testing is carried out by setting several load conditions to facilitate the system testing process. From the results obtained, when the detected load weight is 30 grams and 12 grams, there is no scaleFood notification.

B. *Ultrasonic Sensor Testing 1*

The livestock drinking water system is run by utilizing the HC-SR04 ultrasonic sensor as a tool that detects the volume of water in the cat's drinking water container.

Table 3. Comparison and percentage of ultrasonic sensor error 1

No	Measuring Glass (ml)	Sensor Utrasonic (ml)	Error (%)
1	150	150	0
2	120	123	2.5
3	88	88.6	0.6
4	19	19.7	3

From the table it can be seen that the HC-SR04 ultrasonic sensor is capable of measuring and detecting distance quite well with the error range that occurs based on research being from 0% to 3%.

C. *Ultrasonic Sensor Testing 2*

The livestock drinking water system is run by utilizing the HC-SR04 ultrasonic sensor as a tool that detects the water level in the water tank and cat drinking water containers.

Table 4. Comparison and percentage error of ultrasonic sensors 2

No	Ruler Measurement (cm)	Sensor Utrasonic (cm)	Error (%)
1	14	14.88	6.2
2	12	12.88	7.3

So from comparing the results measured by the sensor and the calculations, it can be seen that the sensor can read the distance well so that the system can run well.

D. *Cat Food System*

The cat food system can be seen on the web dashboard and Android application on the cat owner's smartphone.

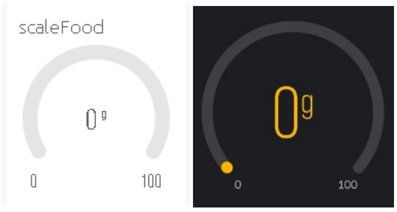

Figure 11. Dashboard on the blynk application

The system that has been created is also able to provide a warning to the cat owner's smartphone when the food available in the container is less than 3 grams in capacity. This warning is given via notification on the cat owner's smartphone.

Figure 12. Food Notifications

When the notification arrives on the cat owner's smartphone, the cat owner can immediately open the smartphone application to click ON in the Food section and click OFF again if the food has reached the weight of the cat's food dose.

E. Cat Drinking Water System

The cat's drinking water system can be seen on the web dashboard and Android application on the cat owner's smartphone.

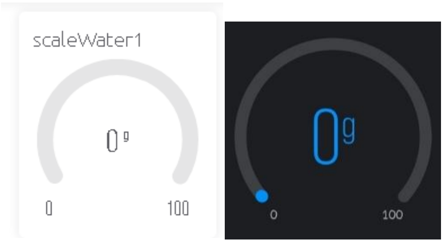

Figure 13. Dashboard on the Blynk Android application

The system that has been created is also able to provide a warning to the cat owner's smartphone when the water available in the container is less than 20ml capacity. This warning is given via notification on the cat owner's smartphone.

Figure 14. Android blynk application notifications

When the notification arrives on the cat owner's smartphone, the cat owner can immediately open the smartphone application to click ON on the water section and click OFF again if the water has reached the volume of the cat's drinking dose.

F. Cat Distance System

The cat distance system can be seen on the web dashboard and Android application on the cat owner's smartphone.

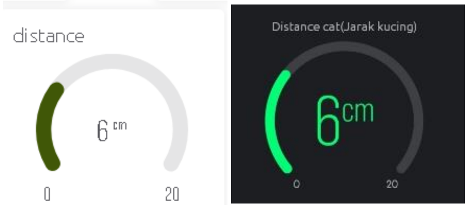

Figure 15.blynk dashboard on android

The system that has been created is also able to provide a warning to the smartphone of the cat owner approaching the dispenser less than 10cm away. This warning is given via notification on the cat owner's smartphone.

Figure 16. Notification of cat approaching

When the notification arrives on the cat owner's smartphone, the cat owner can immediately open the smartphone application to check whether the cat's food and drinking water supplies are still available or not. If one of the food or drink supplies is not available, the cat owner can click ON on the food and water section and vice versa.

IV. CONCLUSION

Based on the results and discussion of the system that has been created, the following conclusions are obtained:

1. A food and drinking water monitoring system to determine the availability of cat food and drinking water can be designed and built by utilizing the NodeMCU module as a device that processes input from the servo motor, HC-SR04 ultrasonic sensor, load cell sensor in the system by sending data to the Blynk platform for connection. with the internet and the cat owner's smartphone.
2. The communication process between the microcontroller and the internet network by utilizing the NodeMCU 8266 module, the WiFi network is used to communicate with the internet, in this case a smartphone, website or localhost using internet protocols such as TLS and HTTP.

3. Servo motor for opening and closing system for cat food and drinking water. And in the blynk servo application it is implemented in the form of an ON and OFF switch to automatically open the cat's food and drink. Load cell sensor for weighing cat food left in the food container. Two HC-SR04 ultrasonic sensors are implemented in the system. monitoring and controlling the availability of drinking water in the cat's drinking container and detecting the distance of the cat approaching the dispenser.

THANK-YOU NOTE

Thank you to the parties involved in assisting this research and most importantly to the parents for their prayers and supervisors who have guided this research so that the author can complete this research.

REFERENCE

[1] Salim C, Lestari D, Mico G, Meilita IT, Saputra O, Therry C, Sinatra JA, Soesanto VM. UNIVERSE ARTIFICIAL PETS. InSETI International Conference 2023 Nov 23 (Vol. 1, No. 1, pp. 46-49).

[2] AB Pradana, S. Jinan, A. Pramesti, and JT Putra, "Design of an Automatic Cat Feeder Using an Ultrasonic Sensor Based Microcontroller,"*Infotronik J. Teknol. Inf. and Electron.*, vol. 6, no. 1, p. 42, 2021, doi: 10.32897/infotronik.2021.6.1.668.

[3] Belshaw Z, Robinson NJ, Dean RS, Brennan ML. Motivators and barriers for dog and cat owners and veterinary surgeons in the United Kingdom to using preventative medicines. Preventive veterinary medicine. 2018 Jun 1;154:95-101.

[4] U. Khair and T. Sabrina, "Automatic Cat Feeding Tool Based on Arduino Uno in Pet Shop,"*Sebatik*, vol. 23, no. 1, pp. 9–14, 2019, doi: 10.46984/sebatik.v23i1.437.

[5] TWO Putri and MA Darmawan, "Prototype of Remote Control System for Cat Feed and Cage Doors,"*Sutet*, vol. 12, no. 1, pp. 21–30, 2022, doi: 10.33322/sutet.v12i1.1664.

[6] WT Arifin Bisri, "Design of an Automatic Feeding Device for Pet Cats Using Arduino Uno,"*TESLA J. Tech. Electro*, vol. 23, no. 1, p. 34, 2021, doi: 10.24912/tesla.v23i1.9288.

[7] KY Triastuti*et al.*, "Design of a Feeding and Health Condition Monitoring System for Animals Based on an Android Application," Semin. Nas. Has. Ris., no. Ciastech, pp. 293–300, 2019.

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Water Quality Monitoring System and Automatic Filter System Based on the Internet of Things

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***Abstract*—PDAM's peak usage of clean water means that water supply to customers often stops due to insufficient distribution of discharge and pressure. To overcome the problem of insufficient water flow, the community provides a water storage tank consisting of a ground water tank and an over head water tank. PDAM water received by the public through distribution pipes has the potential to be contaminated due to the entry of pollutants from repair activities and pipe leaks. These pollutants will accumulate in the tank, causing the water quality to decline and no longer comply with the established quality standards. To prevent accumulation of pollutants in the tank, before using it, the water should be filtered first. An automatic filtration system with monitoring of turbidity and water levels is a technology that can make people's work easier and the quality of the water used is in accordance with drinking water quality standards. Data obtained from turbidity and water level sensors can also be monitored via the IoT platform. The test results of the turbidity and water level sensors have a low error so that the designed tool can be used to monitor turbidity, water level and automatic filter systems. Sending data so that it can be displayed on IoT platforms such as Blynk has also been successfully created. From 10 attempts, the Water Level Sensor gave an average error of 0.78%.**

***Keywords*—Internet of things, turbidity, water level, filtration, automatic**

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I. Introduction

Water is one of the basic human needs which has an important role in the body's metabolic processes. Water consumed by humans must meet quality standards so that it is not dangerous to health [1]. In Indonesia, drinking water quality standards are regulated by Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Implementing Regulations of Government Regulation Number 66 of 2014 concerning Environmental Health [2].

Communities, especially those in urban areas, obtain clean water from PDAM (Regional Drinking Water Company) which is channeled through distribution pipes to residents' homes. The water that reaches these houses has a high chance of being contaminated with pollutants originating from rust from old metal pipes, mud that enters during repairs to the distribution pipe network and pipe leaks which result in the entry of dirty water or sewer water into the distribution network [3].

Apart from water quality not meeting quality standards, the water flow reaching customers also fluctuates, especially during peak usage hours, which can result in the supply of clean water stopping in certain areas. As a solution, many people use holding tanks. From the service pipe, water enters the ground water tank and is then pumped to the over head water tank. Water stored in tanks usually accumulates contaminants in it such as particles and microorganisms which can reduce the quality of the water [4]. The characteristics of water that does not meet quality standards are an unpleasant odor, an unpleasant taste and visible turbidity due to the presence of sediment [5]. The public is strongly advised to carry out regular checks. However, this will become a boring routine activity and is rarely done by the community so that the water consumed no longer meets quality standards.

Turbidity is a condition where the transparency of a liquid is reduced due to the presence of dissolved substances. Based on SNI 06-6989.25-2005 concerning water and waste-Part 25, turbidity is tested with a nephelometer using the principle of the light intensity of the test sample being absorbed and refracted, compared to the light intensity of the standard suspension. In developing turbidity sensors, this method is often used [6].

To remove contaminants in water, you can pass the water through a filter tube containing filter media such as active sand, silica sand and activated carbon. Filter media that has been used for a long time will experience blockages which will affect the quality of the filtering results. To clean it, wash and replace the filter media [7]. Many automatic water filter systems have been developed nowadays so that they are easy and do not require user intervention [19].

The current trend of monitoring water quality is carried out continuously and in real time, using more than one sensor, an automatic control system and a wireless data collection mechanism [8]. For example, water sensors and ultrasonic sensors transmit data using a wireless gateway into the consumer network. Meanwhile, the ATmega 328P controller board is used to send data to the cloud server [9]. The data storage server will manage all water quality monitoring data, collect data, analyze and submit data to a web-based dashboard. This system allows water storage tank owners to access water quality conditions and levels via the internet [10]

Another example of monitoring water quality can also use ZigBee 802.15.4 which consists of several sensors and wireless communication networks, a 74HC14 inverter and mobile communications (GSM) [11],[15],[16]. The system can use water level sensors, turbidity sensors, temperature sensors, pH sensors and dissolved oxygen sensors [12],[20]. This system is more complicated in terms of microcontroller input and output communication because the algorithms and analysis are carried out to monitor water quality as a whole, such as water level, temperature and water pH. The information storage system obtained in the database can be accessed via a web-based monitoring service using GSM [13]. GSM technology has the advantage of being able to send data without an internet connection.

It is important to consider the cost and complexity of the water quality control and monitoring system architecture [14]. In this research, what was created was a water quality monitoring system, especially the turbidity of the water in the tank, which was equipped with an automatic filter system as seen in Figure 1 and Figure 2.

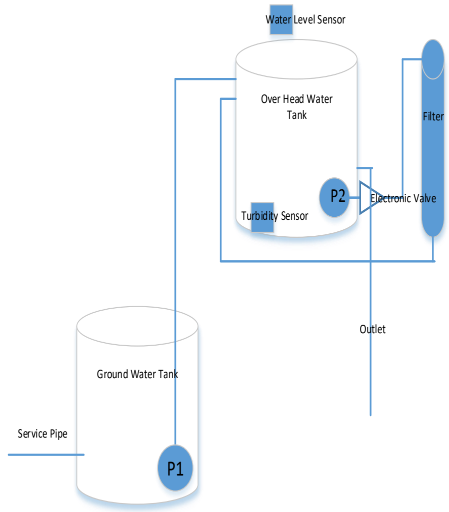

Fig 1. Monitoring and Filter System

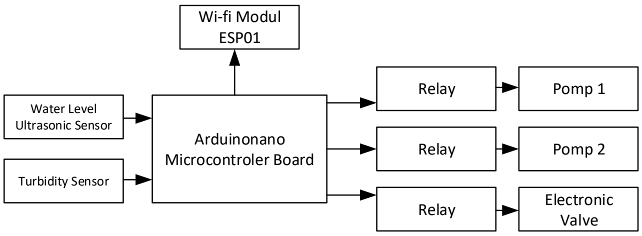

Fig 2. Electronic Controller Block Diagram

In this system, water can be seen being pumped from the bottom tank to the top tank. If the water in the over head water tank decreases, the water is automatically pumped to the over head water tank. In the over head water tank there is a turbidity sensor. If the turbidity of the water in the tank has passed the quality standards, then the water is pumped into the filter tube. The filtered water is returned to the over head water tank. All sensor data is processed by the microcontroller on the Arduino Nano board. After processing, a decision is obtained to activate the pump which was explained previously. Sensor data can be sent via the ESP01 wifi module.

The pump used to move water from the ground water tank to the over head water tank uses a submersible pump which has a voltage of 220 volts with a flow rate of 75 liters/minute (P1). In the filtration process, a submersible pump (P2) is used to pump water out of the tank. This pump is a pump that can be placed in water and has a voltage of 12 volts with a flow rate of 1.3 liters/hour. The gateway created in this system uses ESP01 as a microcontroller link to the cloud server. The cloud server used is the Blynk IoT platform. Blynk is an IoT platform that can control electronic devices remotely using IOS and Android applications, provides a dashboard that can create graphs, store and display sensor data and provides libraries for Arduino, ESP826, Raspberry pi, SparkFun and others [17].

II. THE MATERIAL AND METHOD

The flowchart of the monitoring and control system algorithm for the water filtration process can be seen in Figure 3. From Figure 3, it can be seen that the turbidity and water level sensors read the data. If the turbidity level is < 3 NTU, then pump 2 is on and if not, then pump 2 is off. Furthermore, if the water level read by the sensor is > 150 cm, then pump 1 is on. If the water level is <5 cm, then pump 1 stops. Next, the data is sent to the cloud server.

If the water in the tank is read by the sensor > 3 NTU, the pump will work by pumping water out of the tank into the filter tube. While the filtration process is in progress, the turbidity sensor can continuously update the turbidity value of the filtered water in the tank. The system will stop if the sensor reads a turbidity level < 3 NTU, which indicates the filtration process has been completed.

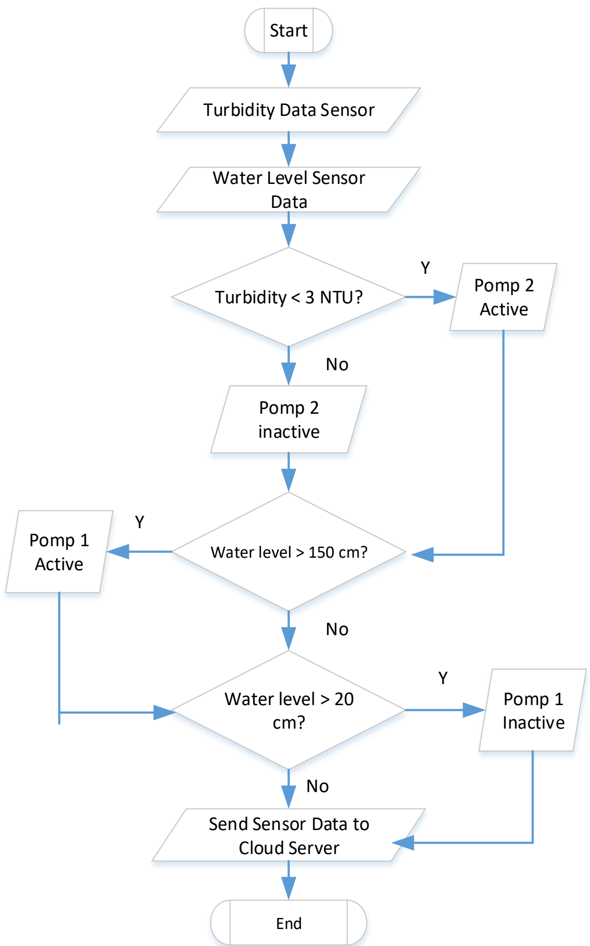

Fig 3. Flowchart of web based monitoring automated water filtration system

III. RESULT AND DISCUSSION

The results of the turbidity sensor experiment can be seen in Table 1 and it can be seen that in experiment 1 it can be seen that the higher the turbidity, the smaller the voltage produced [18]. The trend of the data that comes out can be seen in Figure 4, resulting in the following linear equation:

$$Y = -0.0366x + 5.0203$$

Tabel 1.
Experiment Result

No Experiment	Turbidity NTU	Output (Volt)
1	1.55	4.96
2	1.76	4.96
3	2.30	4.94
4	3.26	4.90
5	4.65	4.85
6	15.45	4.45
7	20.34	4.28
8	32.20	3.84
9	35.30	3.73
10	44.21	3.40

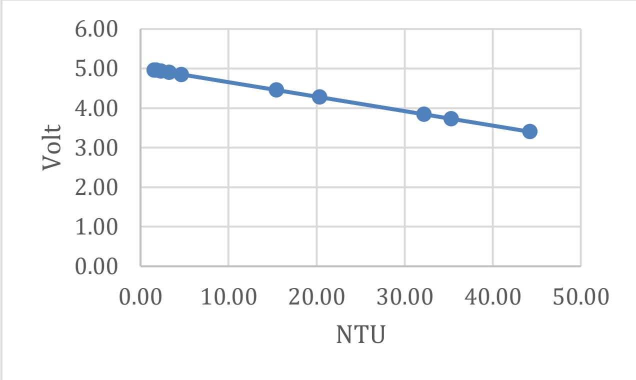

Fig 2. Measurement Results Graph

The experimental results for the water level sensor can be seen in Table 2 and Figure 5. Based on Table 2 and Figure 5, it can be seen that the error rate for the water level read by the sensor is in the range of 0.06% to 1.52%. The resulting equation from the graph formed is:

$$y = 0.9933x + 0.0658$$

Table 2.
Water Level Sensor Test Results

No Experiment	Real Water Level (cm)	Water level read by sensor (cm)	Error (%)
1	3	3.05	1.52
2	6	6.03	0.43
3	9	9.01	0.06
4	12	11.99	0.12
5	15	14.97	0.23
6	18	17.95	0.30
7	21	20.93	0.36
8	24	23.91	0.40
9	27	26.88	0.43
10	30	29.86	0.45

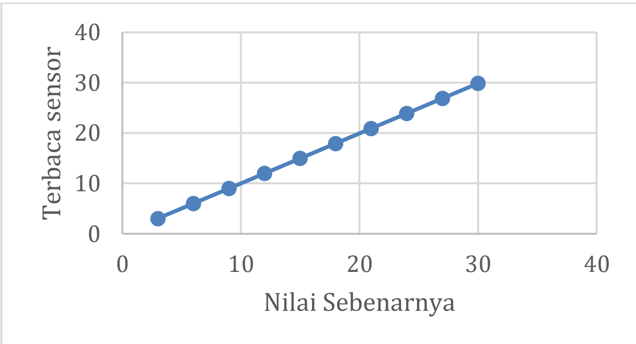

Fig 5. Water Level Sensor Experiment Results

The resulting data from sensor measurements is sent to the Blynk IoT platform server using the HTTP request format. Turbidity sensor data goes to datastream V0 while water level sensor data goes to datastream V1 on the Blynk platform. All data is displayed on the dashboard with chart and gauge widgets as shown in Figure 6.

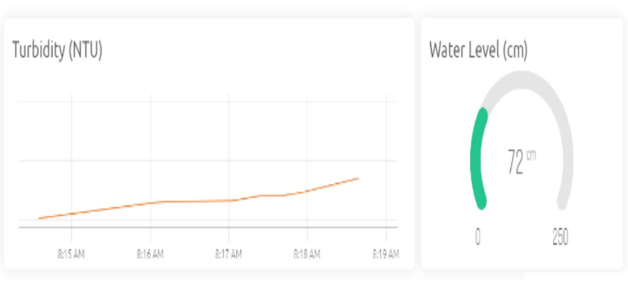

Fig 6. Appearance of the Blynk Application

IV. CONCLUSION

Turbidity sensors, water level sensors and pump automation systems that have been designed can be used for web-based monitoring and control systems. The data sent can be viewed on the Blynk IoT platform without experiencing any problems. From 10 attempts, the Water Level Sensor gave an average error of 0.78%.

REFERENCES

[1] J.D. Miller, C.L. Workman, S.V. Pancang, G.Sneegas, E.A. Adams, S.L. Young, A.L. Thomson, "Water Security and Nutrition: Current Knowledge and Research Opportunities," Advances in Nutrition, Vol. 12, Issue 4, pp 2525-2539, November 2021.

[2] Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2023 Tentang Peraturan pelaksanaan peraturan Pemerintah Nomor 66 Tahun 2014 Tentang Kesehatan Lingkungan.

[3] C.M. Fontanazza, V. Nataro, V. Puleo, P.Nicolosi, G. Freni, " Contaminant Intrusion Through Leaks In Water Distribution System: Experimental Analysis," in Proc Engineering, CCWI, 119, 2015, pp 426-433.

[4] I. Slavik, K.R.F. de Oliveira, P.Cheung, W. Uhl, " Water Quality Aspects Related to Domestic Drinking Water Storage Tanks and Consideration in Current Standards And Guidelines Throughout The world – A Review, " Journal if Water and Health 18(4), 2020, pp 439-463.

[5] M.B. Addsie, Evaluating Drinking Water Quality Using Water Quality Parameters And Esthetic Atrributes, Air, Soil and water Research, 15(3), 2022, pp 1-8.

[6] SNI 06-6989.25-2005 tentang air dan limbah-Bagian 25.

[7] A. Cescon, J.Q. Jiang, "Filtration Process and Alternative Filter Media Material in Water Treatment," Water, MDPI, 12, 3377, 2020, pp 1-20.

[8] M. Miller, A. Kisiel, D.C. Lech, I. Durlik, T. Miller, " IoT in Water Quality Monitoring-Are We Really Here?," Sensors, MDPI, Vol.23, Issue 2, 2023, pp 1-12.

[9] B.A. Jerom, R. Manimegalai, "An IoT Based Smart Water Quality Monitoring System using Cloud", 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), no. 7, 24-25 February, Vellore India, 2020.

[10] Maneesha V. Ramesh, K. V. Nibi, Anupama Kurup, Renjith Mohan, A. Aiswarya, A. Arsha, P. R. Sarang, "Water Quality Monitoring and Waste Management using IoT", 2017 IEEE Global Humanitarian Technology Conference (GHTC), no. 7, 19-22 October, San Jose CA USA, 2017.

[11] T. Perumal, M.N. Sulaiman, C.Y. Leong, " Internet of Things (IoT) Enabaled Water Monitoring System, " Electronics (GCCE), IEEE 4th Global Conference on 2015, Oct 27, pp 86-87.

[12] N.R. Moparthi; Ch. Mukesh; P.V. Sagar, "Water Quality Monitoring System Using IOT", 2018 Fourth International Conference on Advances in Electrical Electronics Information Communication and Bio-Informatics (AEEICB), no. 5, 27-28 February, Chennai India, 2018.

[13] Ajith Jerom B, R. Manimegalai, R. Manimegalai, "An IoT Based Smart Water Quality Monitoring System using Cloud", 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), no. 7, 24-25 February, Vellore India, 2020.

[14] S. Noorjannah Ibrahim, A.L. Asnawi, N.A. Malik, N.F.Mohd. Azmin, A.Z. Jusoh, F.N.Mohd Isa, " Filtration System: IoT Apllication in Water Management," IJECE, Vol.8, No.4, August 2018, pp 2503 -2511.

[15] C. Feng, J. Yuan, Y. Sun, J. You, "Design of Water Quality Monitoring System", 2020 International Conference on Artificial Intelligence and Computer Engineering (ICAICE), no. 4, 23-25 October, Beijing China, 2020.

[16] I.F. Almojela, S. M. Gonzales, K. Gutierrez, A.S. Santos, F.A. Malabanan, J.N.T. Tabing, C.B. Escarez, "WatAr: An Arduino-based Drinking Water Quality Monitoring System using Wireless Sensor Network and GSM Module", 2020 IEEE REGION 10 CONFERENCE (TENCON), no. 6, 16-19 November, Osaka Japan, 2020.

[17] M.J. Lakshmi, C.S. Sameen, D.Maneesha, G.Dharani, K.F. Mubeena, " Smart Home Using Blynk App Based On IOT, International Journal Of Creative Research Thoughts (IJCRT), Vol.10, Issue 5, May 2022, pp 341-345.

[18] S.N. Ibrahim, A.L. Asnawi, N.A. Malik, N.F.M. Asmin, A.Z. Jusoh, F.N.M. Isa," Web Based water Turbidity Monitoring And Automated Filtration System: IoT Application in Water Managemen," IJECE, Vol.8, No.4, August 2018, pp.2503-2511.

[19] I.M. Khalil, H.N. Abdulrazzak," Monitoring of water Purification Process Based on IoT," IOSR-JECE, Vol.14, Issue 2, Ser.1, Mar-Apr 2019, pp 56-62.

[20] Md.M. Rahman, C. Bapery, M.J. Hossain, Z. Hassan, G.M.J. Hossain, Md.M. Islam," Internet of Things Based Water Quality Monitoring System," IJMCER, Vol.2, Issue 4, 2020, pp 168-180.

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Comparative Analysis Of 4G LTE Network Quality At 900 Mhz And 2100 Mhz Frequencies

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***Abstract*— 4G networks were created to provide excellent service and fast data transmission. The goal is to promote better reception, maintain smooth data flow, and speed up information exchange. Indonesia has six mobile operators, each of which has the right to use the radio frequency spectrum to deploy mobile network services. The radio frequencies used are divided into 450 MHz, 850 MHz, 900 MHz, 1,800 MHz, 2,100 MHz, and 2,300 MHz. This research focuses on the comparison of 4G LTE network quality at 900 MHz and 2100 MHz frequencies.Data collection is done by conducting a drive test and using the dedicated mode method. The software that is utilized for data processing are TEMS Pocket and TEMS Discovery Device. The network quality of both frequencies is measured based on RSRP, SINR, and Throughput parameters. The results of network quality measurements were obtained for the 900 MHz frequency, namely, RSRP worth 79.54%, SINR worth 65.69%, and Throughput worth 37.65%. While the frequency of 2100 MHz, namely, RSRP is worth 82.1%, SINR is worth 76.84%, and Throughput is worth 72.18%. Of the two frequencies, the 2100 MHz frequency has a better value than the 900 MHz frequency.**

***Keywords*— 4G LTE, Radio Frequency, Comparison, RSRP, SINR**

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I. INTRODUCTION

4G networks are an extension of 3G technology, officially known as 3G. HSDPA (High Speed Downlink Packet Access) technology, also known as 3.5G technology, had previously been devel- oped based on WCDMA and has similarities to EVDO, which was developed based on CDMA in 2000. HSDPA is a cellular protocol that evolved from UMTS (Universal Mobile Telecommunica- tions System)[1].

Indonesia has six mobile operators registered with the Ministry of Communication and Infor- mation Technology (Kominfo). Each operator has the right to use the radio frequency spectrum to deploy cellular network services. The radio frequencies used are divided into 450 MHz, 850 MHz, 900 MHz, 1,800 MHz, 2,100 MHz, and 2,300 MHz. Of the six operators, Telkomsel has the longest frequency band. Telkomsel operator has a total frequency capacity of 105 Mhz[2]. Some of the frequency bands used by Telkomsel operators include; 850, 900, 1800, 2100 and 2300 Mhz. All Telkomsel 4G LTE networks have spread throughout Indonesia, including in the Korong Gadang Village area.

Korong Gadang Village is included in the administrative area of Kuranji Subdistrict, Padang City, West Sumatra. The population in 2021 was 20,125 people and has an area of 7.05 square kilometers[3]. The geographical location on the north is bordered by Gunung Sarik Village, the south is bordered by Pasar Ambacang Village, the west is bordered by Kalumbuk Village, the east is bordered by Kuranji Village.

Source from Telkomsel site data in 2022, there are 2 sites included in the Korong Gadang village area. The first site is SITEID PAD020 with the type of frequency band used is LTE1800, LTE900, LTE2300 and LTE2100. As for the second site with SITEID PAD145 with the type of frequency band LTE2300, LTE1800, LTE900 and LTE2100. Both sites have different antenna azimuths that allow coverage areas for the Korong Gadang area to be poorly met. In addition, each frequency band has different coverage limits and signal quality due to differences in antenna height at the site.

II. MATERIALS AND METHOD

In this research, checking the network quality of Telkomsel provider using the Drive Test method, which aims to see how the quality of the existing network in the area that has been taken real data and determine the influence and causes of problems in each 4G LTE parameter. The drive test measurement method used in this research is dedicated mode. Path planning is done to determine which areas will be taken network data later, as shown in Fig. 1.

Fig. 1. Drive Test Route

Drive test data collection is carried out using software TEMS Pocket that is already installed on a Samsung Galaxy S5 smartphone. The devices used when conducting the drive test are Smartphone and Global Positioning System (GPS). As for processing the data that has been taken using TEMS Discovery Device, the devices used for data processing are Laptop and Dongle.

A. *Fourth Generation Technology (4G)*

Fourth-generation technology stands for 4G, which describes the fourth generation standard of cell phone technology. 4G is a development of 3G and 2G technology. Worldwide, 4G has two standards, WiMAX and Long Term Evolution (LTE)[4]. Long Term Evolution (LTE) is a name given to a project of the Third Generation Partnership Project (3GPP) to improve the 3rd generation mobile phone standard or (3G), namely UMTS WCDMA. LTE is a development of the previous UMTS or (3G) and HSPA (3.5G) which LTE is referred to as the 4th generation or (4G)[5].

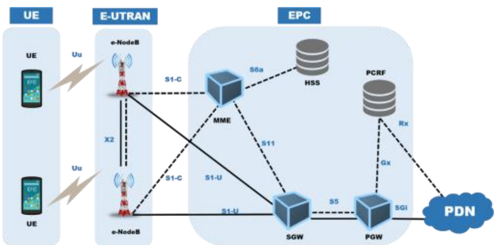

Fig. 2. 4G LTE Architecture[6]

B. *4G LTE Frequency Bands in Indonesia*

Indonesia has several types of 4G frequency bands available including Band 1 (2100 MHz), Band 3 (1800 MHz), Band 5 (850 MHz), Band 7 (2600 MHz), Band 8 (900 MHz), and Band 28 (700 MHz)[7]. In addition, the use of LTE frequencies is different in each city. Telkomsel has the largest 4G frequency band in Indonesia with a total frequency capacity of 105 Mhz. After the merger between Indosat Ooreedoo and Hutchison Tri, both have large frequency band allocations[8]. XL Axiata has a total frequency band allocation of 90 MHz, while Smartfren has a total of 62 MHz.

C. *Drive Test*

Drive Test is one part of the work in radio network optimization that aims to measure and collect real network information in the field. The information collected is the actual radio frequency (RF) conditions in an eNodeB[9]. The drive test measurement method is divided into two, with the following explanation[10]:

a. Idle Mode : It is a measurement of the quality of the signal received by the MS in download or connection activities. This mode aims to determine the network signal in areas that expe-rience low signal.

b. Dedicated Mode: This is a signal quality measurement followed by channel occupation dur-ing the download process to a specific server address. This mode aims to measure and iden- tify the data transfer speed.

C. Drive Test Data Collection

The way drive test data is collected is divided into four processes, including[11]:

a. Single Site Verification (SSV) : Single Site Verification is a method that is carried out for one site only. This method is performed on problematic sites or newly constructed sites to determine how far away the site is and whether it interferes with nearby sites. SSV is done to ensure the site is in an optimal and proportional state.

b. Cluster : Cluster is a drive test method that measures the network of each cluster or area consisting of several sites but only for one network operator.

c. Benchmark : The benchmark method is a drive test method to compare the network of an operator with the network of another operator in a cluster.

d. Optimization : Optimization is part of the analysis of interference or lack of service quality at the finished site.

D. *Drive Test Parameter*

Drive test is an activity to take data

(collecting) a network network using certain software and hardware. The following below are the majority of parameters used in drive tests on LTE technology[12]. To measure the quality of a 4G LTE network, there are several parameters that are most important, namely :,

a. Reference Signal Received Power (RSRP)

RSRP (Reference Signal Received Power) is LTE power signal received by the user in a certain frequency. The farther the distance between the site and user, the smaller the RSRP received by the user[13].

b. Reference Signal Received Quality (RSRQ)

RSRQ is the quality of the signal received by the UE. It is the ratio between RSRP and wideband power. RSRQ is also affected by the signal, noise and interference received by the UE. The unit of RSRQ is dB and the value is always negative[14].

c. Signal to Interference Noise Ratio (SINR)
SINR is the ratio of signal strength to background noise[15].

d. Throughput

Throughput is the effective data transfer rate, measured in bps. Headers in data packets re- duce this value. Throughput is related to the available bandwidth on the network. The band- width provided is not all used by applications on the network[16].

E. Test Mobile System (TEMS)

TEMS Investigation is short for test mobile system which is one of the software used to conduct drive tests[17]. While TEMS Pocket is one of the devices that can be used to observe cel- lular networks. TEMS is also useful for verification, maintenance, and troubleshooting of cellular networks as well as for basic cell planning tasks.

F. Google Earth

Google Earth, originally called Earth Viewer, is a virtual globe, map, and geographic infor- mation program developed by Keyhole.Inc, a company acquired by Google. Google Earth displays satellite images of the Earth's surface in a variety of resolutions, giving you visual access to a variety of information about cities, homes, roads, rivers, and more[18].

G. Key Performance Indicator (KPI)

Table 1. KPI Targets[19][20]

No	Parameter	KPI Targets
1	RSRP	90% ≥ -100 dBm
2	SINR	80% ≥ 0 dB
3	THROUGHPUT	≥ 7200kbps

Key performance indicators are tools for evaluating the quality and effectiveness of mobile net- work services. Some KPIs used to measure LTE network quality are:.

a. Reference Signal Received Power (RSRP)

Table 2. Range of RSRP Value[20]

RSRP	Color	Strength (dBm)
Excellent		-75 ≤ RSRP < 0
Very Good		-85 ≤ RSRP < -75
Good		-100 ≤ RSRP < -85
Fair		-110 ≤ RSRP < -100
Poor		RSRP < -110

b. Signal to Interference Noice Ratio (SINR)

Table 3. Range of SINR Value[20]

SINR	Color	Srength (dB)
Excellent		SINR ≥ 20
Good		13 ≤ SINR < 20
Fair		0 ≤ SINR < 13
Poor		SINR < 0

c. Throughput

Table 4. Range of Throughput Value[19]

Throughput	Color	Strength (Kbit/s)
Excellent		Throughput ≥ 12000
Very Good		7200 ≤ Throughput < 12000
Good		1500 ≤ Throughput < 7200
Fair		324 ≤ Throughput < 1500
Poor		0 ≤ Throughput < 324

III. RESULTS AND DISCUSSION

A. RSRP Parameter Result

RSRP is a power received by a user or MS (Mobile Station) from BTS (Base Transceiver Station). The closer the MS position is to the BTS, the better the signal will be received and the greater the RSRP value.

B. RSRP of 900 MHz Frequency

The following Fig.3. is a display of the results RSRP parameter drive test at a frequency of 900 MHz.

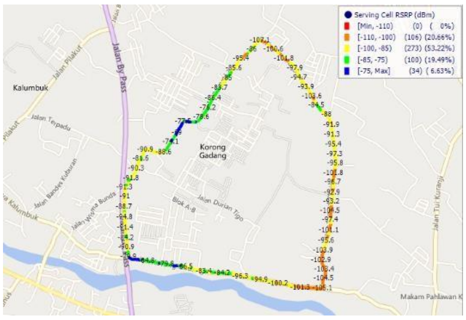

Fig. 3. Result display of RSRP at 900 MHz

Table 5. RSRP Value 900 MHz Frequency

Legend	Range (dBm)	Sample	Percentage (%)
Excellent	-75 ≤ RSRP < 0	34	6.63
Very Good	-85 ≤ RSRP < -75	100	19.49
Good	-100 ≤ RSRP < -85	273	53.22
Fair	-110 ≤ RSRP < -100	106	20.66
Poor	RSRP < -110	0	0.00
TOTAL		513	100,00

From the drive test data obtained for the results of the RSRP parameters of Telkomsel operators at a frequency of 900 Mhz, it can be seen in Fig.3. In this figure it can be seen that there are 513 samples obtained during the record process around the route. Signal reception in the very strong/ex- cellent category is marked with a blue indicator with a receiving power of >-75 dBm, which has 34 samples with a percentage value of 6.63%. As for the Very Good category in the -85 to -75 dBm value range, there are 100 samples with a percentage of 19.49% marked with a green indicator. Normal signal reception is marked with a yellow indicator, which has a receiving power of -100 dBm to -85 dBm from 273 samples with a percentage of 53.22%. Signal reception with a weak category is characterized by a red indicator, which has a receiving power of <-110 dBm from 0 samples at 0%. Signal reception with orange color with values at -100 to -110 has 106 samples with 20.66%.

C. RSRP of 2100 MHz Frequency

The following Fig.4. is a display of the results of the RSRP parameter drive test at a frequency of 2100 MHz.

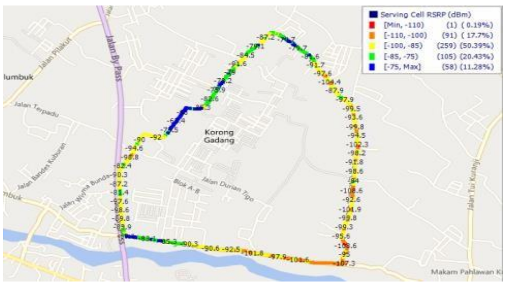

Fig. 4. Result display of RSRP at 2100 MHz

Table 6. RSRP Value 2100 MHz Frequency

Legend	Range (dBm)	Sample	Percentage (%)
Excellent	-75 ≤ RSRP < 0	58	11.28
Very Good	-85 ≤ RSRP < -75	105	20.43
Good	-100 ≤ RSRP < -85	259	50.39
Fair	-110 ≤ RSRP < -100	91	17.7
Poor	RSRP < -110	1	0.19
TOTAL		514	100

For the results of the Telkomsel operator drive test at a frequency of 2100 MHz can be seen in Fig.4. In table 6 it can be seen that there are 514 samples obtained during the data collection process. For the excellent signal reception category, there are 58 samples with a percentage of 11.28%, which are marked with blue indicators. In the Very Good/excellent category there are 105 samples with a percentage of 20.43%, marked with a green indicator. As for signal reception in the good category, there were 259 samples with a percentage of 50.39%, marked with a yellow indicator. For the mod- erate category, there are 91 samples and only 1 sample in the bad category, both have a percentage of 17.7% and 0.19% which are marked with orange indicators for the moderate category and red indicators for the bad category.

D. Comparison of RSRP Parameters at 900 MHz and 2100 MHz Frequencies

The following Fig.5. below is a graph of the percentage comparison of RSRP parameter values of Telkomsel providers at frequencies of 900 MHz and 2100 MHz.

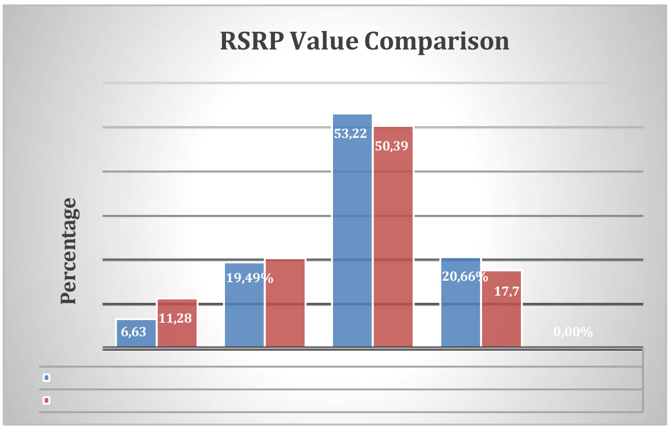

Fig. 5. Comparison of RSRP at 900 MHz and 2100 MHz

E. SINR Parameter Result

SINR which is the ratio of the signal strength between the main signal transmitted with in- terference compared to the background noise that arises (mixed with the main signal). In other words, the ratio between the average received power and the average interference and noise.

SINR of 900 MHz Frequency

The following Fig.6. is a display of the results of the SINR parameter drive test at a fre- quency of 900 MHz.

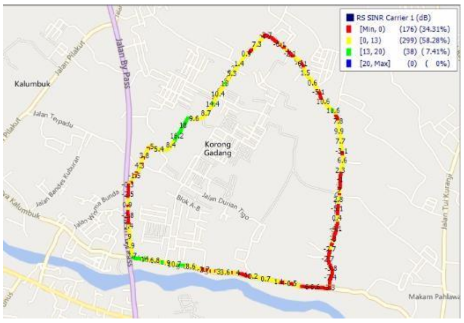

Fig. 6. Result display of SINR at 900 MHz

Table 7. SINR Value 900 MHz Frequency

Legend	Range (dBm)	Sample	Percentage (%)
Excellent	SINR ≥ 20	0	0.0
Good	13 ≤ SINR < 20	38	7.41
Fair	0 ≤ SINR < 13	299	58.28
Poor	SINR < 0	176	34.31
TOTAL		513	100

From the drive test data obtained for the results of the Telkomsel provider SINR parameters at a frequency of 900 Mhz can be seen in Fig.6. In table 7, it can be seen that during the record process, 513 samples were obtained. For the excellent SINR value category, not a single sample was obtained with a percentage of 0.0%. In the good/good category signal reception there are 38 samples with a percentage of 7.41% marked with a green indicator. For the moderate/fair category there are 299 samples with a percentage of 58.28%, having a receiving power of 0 dB to 13 dB marked with a yellow indicator. Signal reception with a weak category with a red indicator is 176 samples with a percentage of 34.31. It can be concluded that the SINR parameter of Telkomsel operator at a fre- quency of 900 MHz in the Korong Gadang area has very poor quality, because the largest number of samples is in the yellow and red indicators.

SINR of 2100 MHz Frequency

The following figure 7 is a display of the results of the SINR parameter drive test at a frequency of 2100 MHz.

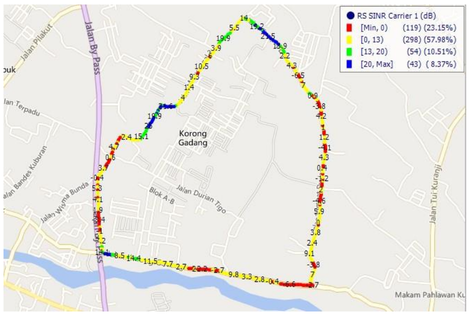

Fig. 7. Result display of SINR at 2100 MHz

Table 8. SINR Value 2100 MHz Frequency

Legend	Range (dBm)	Sample	Percentage (%)
Excellent	SINR ≥ 20	43	8.37
Good	13 ≤ SINR < 20	54	10.51
Fair	0 ≤ SINR < 13	298	57.98
Poor	SINR < 0	119	23.15
TOTAL		514	100

For Telkomsel provider drive test data at a frequency of 2100 MHz can be seen in Fig.7. During the record process there are 514 samples shown in table 4, where the signal reception in the excellent category is 43 samples with a percentage value of 8.37% which is marked with a blue indicator. For signal reception in the good category there are 54 samples marked with green indicators, having a percentage value of 10.51%. For the most samples there are moderate/fair category SINR values with 298 samples with a percentage value of 57.98%. As for the weak category, there are 119 sam- ples with a percentage value of 23.15% which is marked with a red indicator in Figure 4.5. The equation below shows the KPI value of the SINR parameter at a frequency of 2100 MHz.

Comparison of SINR Parameters at Frequencies of 900 MHz and 2100 MHz

The following figure 8 below is a percentage comparison graph of the SINR parameter value of Telkomsel operators at frequencies of 900 MHz and 2100 MHz.

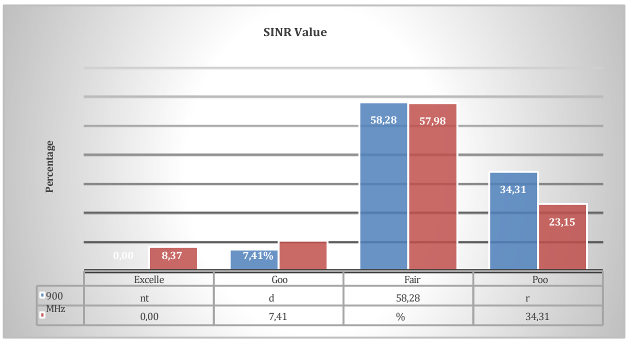

Fig. 8. Comparison of SINR at 900 MHz and 2100 MHz

F. Throughput Parameter Result

Throughput is a 4G parameter that shows the actual bandwidth measured at a certain size of time in a day using a specific internet when downloading a file or more commonly known as the download / upload speed. Throughput data only takes download data.

Throughput of 900 MHz Frequency

The following Fig.9. displays the results of the throughput parameter drive test at a fre- quency of 900 MHz.

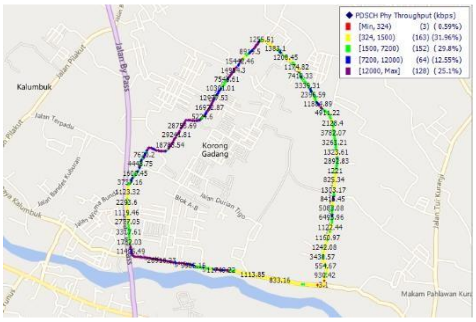

Fig. 9. Result display of Throughput at 900 MHz

Table 9. Throughput Value 900 MHz Frequency

Legend	Range (Kbit/s)	Sample	Percentage (%)
Excellent	Throughput ≥ 12000	128	25.1
Very Good	7200 ≤ Throughput < 12000	64	12.55
Good	1500 ≤ Throughput < 7200	152	29.8
Fair	324 ≤ Throughput < 1500	163	31.96
Poor	0 ≤ Throughput < 324	3	0.59
TOTAL		510	100,00

Figure 9 is the result of the drive test of throughput parameters of Telkomsel provider at a frequency of 900 MHz. From the data obtained for the throughput value of the very good category there are 128 samples with a percentage value of 25.1%. For the very good category there are 64 data samples with a percentage value of 12.55%. For the good category, the data obtained were 152 samples with a percentage value of 29.8%. As for the moderate category, the data obtained amounted to 163 samples with a percentage of 31.96%. Finally for the bad category there are only 3 samples with a percentage of 0.59%. In the measurement of throughput data that has been obtained, there are a total of 192 samples that exceed the value ≥ 7200 Kbps with a total percentage value of 37.65%.

Throughput of 2100 MHz Frequency

The following Fig.10. displays the results of the throughput parameter drive test at a fre- quency of 2100 MHz.

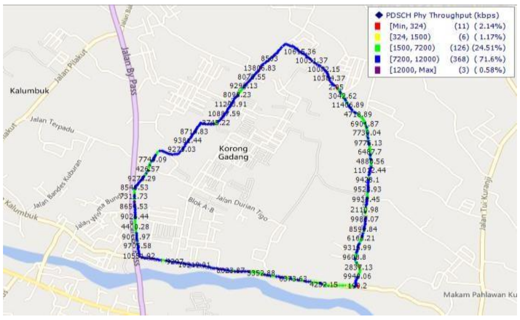

Fig. 10. Result display of Throughput at 900 MHz

Table 10. Throughput Value 2100 MHz Frequency

Legend	Range (Kbit/s)	Sample	Percentage (%)
Excellent	Throughput ≥ 12000	3	0.58
Very Good	7200 ≤ Throughput < 12000	368	71.6
Good	1500 ≤ Throughput < 7200	126	24.51
Fair	324 ≤ Throughput < 1500	6	1.17
Poor	0 ≤ Throughput < 324	11	2.14
TOTAL		514	100,00

Figure 10 is the result of the drive test of Telkomsel provider throughput parameters at a frequency of 2100 MHz. For the data that has been obtained, the most samples are obtained in the excellent/very good category with 368 samples with a percentage of 71.6%. In the excellent category there are only 3 samples with a percentage of 0.58%. For the good category there are 126 samples with a percentage of 24.51%, while for the medium and bad categories there are 6 and 11 samples with a percentage value of 1.17% and 2.14%.

Comparison of Throughput Parameters at Frequencies 900 MHz and 2100 MHz

The following Fig.11. below is a percentage comparison graph of Telkomsel provider throughput parameter values at frequencies of 900 MHz and 2100 MHz.

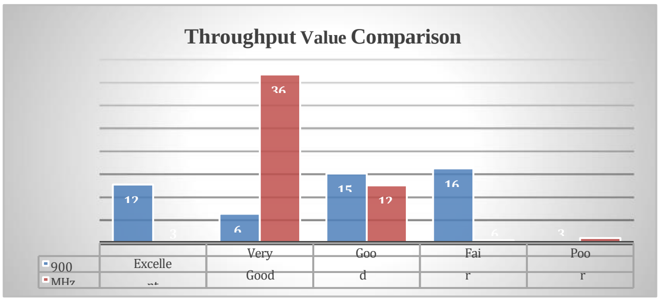

Fig. 11. Comparison of Throughput at 900 MHz and 2100 MHz

To see the comparison of the results of the throughput parameter drive test at frequencies of 900 MHz and 2100 Mhz can be seen in Figure 11. At a frequency of 900 MHz there are 192 data samples that reach the throughput parameter standard. For the 2100 MHz frequency, there are 371 data sam- ples that reach the throughput parameter standard. In the throughput parameter of Telkomsel opera- tor, 2100 MHz frequency has a good and stable value in the verygood category with a range of values ≥ 7200 Kbps to < 12000 Kbps. The advantage of 2100 MHz frequency lies in the speed of data transmission, therefore the throughput value of 2100 MHz frequency is much better and stable than 900 MHz frequency. In addition, the 2100 MHz frequency is a capacity band, which is a fre- quency that provides more bandwidth, which means it has a higher speed, but has a coverage area that is not so wide. While the 900 MHz frequency is a type of coverage band frequency, which is a frequency that has a very wide coverage area and propagates further, but has shortcomings in the speed of data transmission.

IV. CONCLUSION

Based on the results of the drive test that has been done and the results of data that has been processed through TEMS Discovery, the calculation of the percentage value of 4G LTE parameters are RSRP, SINR and Throughput. RSRP parameter has a target value ≥ 100 dBm is 90%, SINR parameter has a target value ≥ 0 dB is 80%, and throughput parameter has a target value ≥ 7200 Kbps. For the 900 MHz frequency results, the RSRP parameter obtained a value of 79.54%, the SINR parameter obtained a value of 65.69% and the throughput parameter obtained a value ≥ 7200 Kbps as many as 192 data samples. For the frequency of 2100 MHz, the SINR parameter obtained a value of 82.1%, the RSRP parameter obtained a value of 76.86% and the throughput parameter obtained a value ≥ 7200 as many as 371 data samples. Based on the drive test results, the quality of 2100 MHz frequency is better than 900 MHz frequency in Korong Gadang area.

REFERENCES

[1] F. H. Melvandino, W. Y. Bragaswara, H. Ramza, F. T. Industri, T. Elektro, and K. Rambutan, "ANALISIS TEST KELURAHAN KAMPUNG RAMBUTAN , JAKARTA," vol. 11, no. 3, 2023.

[2] Wahyunanda Kusuma Pertiwi, "Daftar Pita Frekuensi Operator Seluler di Indonesia dan Alokasinya,"*Kompas.com*,2021. https://tekno.kompas.com/read/2021/06/24/16 020067/daftar-pita-frekuensi-operator-

[3] seluler-di-indonesia-dan-alokasinya (accessed Aug. 10, 2023).

[4] Badan Pusat Statistik Kota Padang, "Kecamatan Kuranji Dalam Angka 2022," 2022.

[5] S. Kamila, "Apa Itu Jaringan 4G LTE? Ini Dia 5 Fakta yang Harus Kamu Ketahui," 2018. https://review.bukalapak.com/ (accessed Aug. 14, 2023).

[6] E. Dheni, K. Heru, and Y. Krisdianto, "Analisis Perencanaan Jaringan Long Term Evolution (LTE) di Pita Frekuensi 3500 MHz Dengan Mode TDD dan FDD Sebagai Frekuensi Alternatif," *J. Rekayasa Teknol. Nusa Putra*, vol. 8, no. 1, pp. 56–80, 2019.

[7] AuL, "Arsitektur LTE," 2019. https://ainuraulia.blogspot.com/2019/04/arsitektur-lte.html (accessed Aug. 21, 2023).

[8] Adinata, "Band 4G di Indonesia," 2022. https://midteknologi.com/blog/band-4g-di-indonesia/#:~:text=Dalam konteks Indonesia%2C beberapa jenis,Band 28 (700 MHz). (accessed Aug. 14, 2023).

[9] G. P. Riyanto, "Ini Rincian Pita Frekuensi Tri yang Dialihkan ke Indosat Setelah Merger," *Kompas.com*. https://tekno.kompas.com/read/2022/01/04/21040247/ini-rincian-pita- frekuensi-tri-yang-dialihkan-ke-indosat-setelah-merger#:~:text=Sebelum merger%2C Indosat sendiri sudah,total frekuensi hingga 145 MHz. (accessed Aug. 15, 2023).

[10] N. H. Herina, S. Dase, and Zaini, "Analisis Pengukuran Kinerja Jaringan 4G LTE Berdasarkan Hasil Drive Test," *Pros. Semin. Nas. Tek. Elektro dan Inform.*, pp. 97–102, 2022.

[11] Latifah Hidayati, "Analisa Kualitas Jaringan 4G LTE UntukProvider H3I Berdasarkan Parameter Drive TestMenggunakan Software Genex Probe 5.1 Di KotaPurwokerto," *Univ. Semarang*, 2020.

[12] S. Widodo *et al.*, "Instalasi Dan Pengujian Drive Tester Luring Disekitar Kampus Tembalang," *Orbith*, vol. 18, no. 3, pp. 271–278, 2022.

[13] I. G. M. Yogi Priyandana Adi Saputra, P. K. Sudiarta, and G. Sukadarmika, "Analisis Hasil Drive Test Menggunakan Software G-Net Dan Nemo Di Jaringan Lte Area Denpasar," *J. SPEKTRUM*, vol. 5, no. 2, p. 216, 2018, doi: 10.24843/spektrum.2018.v05.i02.p27.

[14] M. Yafiz, I. Suandi, and R. Rachmawati, "Analisis Perbandingan Kinerja Jaringan 4G LTE antara Provider Smartfren dan Indosat Ooredoo di Wilayah Kota Lhokseumawe," *J. Litek J. List. Telekomun. Elektron.*, vol. 17, no. 2, p. 29, 2021, doi: 10.30811/litek.v17i2.1961.

[15] W. E. Setyawan, J. Marpaung, and R. R. Yacoub, "Analisis Performansi Jaringan 4G

LTE Operator Hutchison 3 di Rumah Sakit Umum Universitas Tanjungpura Pontianak," *J. Univ. Tanjung Pura*, pp. 1–9, 2021.

[16] V. Kusumo, P. Sudiarta, and I. Ardana, "Analisis Performansi Dan Optimalisasi Coverage Layanan Lte Telkomsel Di Denpasar Bali," *J. Ilm. SPEKTRUM*, vol. 2, no. 3, pp. 12–18, 2015.

[17] L. D. M. A. W. K. M.Sarosa, "Rancang Bangun Dan Analisa Media Video Streaming Pada Jaringan 3G Dan 4G," *Jar. Telekomun. Digit.*, vol. 7, no. 2, pp. 14–22, 2018.

[18] R. Yanuari, P. Sudiarta, and N. Gunantara, "Analisa Kualitas Sinyal Jaringan Gsm Pada Menara Rooftop Dengan Membandingkan Aplikasi Metode Drive Test Antara Tems Investigation 8.0.3 Dengan G-Nettrack Pro," *J. Ilm. SPEKTRUM*, vol. 2, no. 4, pp. 39-45–45, 2015.

[19] N. E. Rozanda, I. Marzuki, and I. Permana, "Pemanfaatan Google Earth Imagery untuk Segmentasi Lahan Hijau," *Semin. Nas. Teknol. Inf. Komun. dan Ind.*, vol. (SNTIKI) 4, no. 2008, pp. 119–125, 2012.

[20] F. Aliansyah, "Usulan Perbaikan Layanan LTE Di Jalan Daan Mogot Dari Kota Tangerang Sampai Kota Jakarta Barat Proposed Improvement Of LTE Services On Daan Mogot Road From Tangerang City To West Jakarta City," vol. 8, no. 6, pp. 3972–3978, 2022.

[21] D. T. Scholarship, "Pertemuan ke 1 Monitoring Alarm Terkait Base Station_ terkait Cell Level dan Consistency Check.docx," p. 6, 2022.

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Rectifier Antenna (Rectenna) Microstrip Rectangular Patch Horizontal Slot on Television Signal Reception in the Ultra High Frequency (UHF) Band

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Abstract-This ***research* aims to design and test a rectangular miscrostrip rectifier antenna for television signal reception on the *Ultra High Frequency* (UHF) line.The research method includes designing an antenna design and designing a *Voltage Multiplier* rectifier circuit.The measured antenna parameters include working frequency, *return loss*, *bandwidth*, *VSWR*, antenna impedance, polarization, and *gain*.The results showed that the *return loss value in the* frequency range of 540-884 MHz has a value of ≤-10dB, with the lowest value of -26.After fabrication, the *Return Loss value* in the frequency range of 632-785 MHz has a value of ≤-10dB, with the lowest value of -42.375 dB at a frequency of 668 MHz.*VSWR* values in simulation and measurement results show values between 1 and 2, indicating that the antenna has good impedance tolerance with the system or transmission connected to it.The antenna impedance is 50.60Ω in simulation results and 51.107 Ω in measurement results.**

***Keywords*- Bandwidth; Design; Simulation; VSWR; Impedance**

I. INTRODUCTION

Rectenna is a type of antenna that can convert Radio Frequency (RF) waves into Direct Current (DC) voltage, so that we can use these DC waves as a voltage source for other devices without using batteries.Microstrip Antenna is a type of antenna that is popular in wireless technology because it has a low profile, is suitable for planar and non-planar surfaces, is simple, and is inexpensive, and can be produced using modern printed circuit technology [1].

A Vivaldi Coplanar antenna that has a size of 22x26.1 cm and a 5-stage double voltage rectifier circuit using a BAT17 diode that has been designed to work at a frequency of 900 MHz, this antenna also has a VSWR value of 1.3 and a gain of 3.86dBi. The maximum average output voltage produced by the rectenna depending on the input power level and antenna distance. For example, at a power level of 10dBm, the maximum average output voltage is 474.2mV at an antenna distance of 30 cm, 345.53 at a distance of 1m, and 208.27 mV at a distance of 1.5m.

In Arifin's research in 2016 on rectenna with other antenna users and different diodes, a microstrip rectangular patch array rectenna was designed for frequencies of 470-2400 MHz using two rectennas arranged in series and BAT17 diodes. The measurement results show a gain value of 7.126 dBm and the highest voltage reaches 1.358 Volts at a distance of 30 cm from the transmitting antenna [3].

In the final project, a Rectangular Microstrip Rectifier Antenna (Rectenna) is designed for the reception of television signals in the Ultra High Frequency (UHF) band. This antenna works in the frequency range of 470-800 MHz and uses a voltage multiplier rectifier circuit that is adjusted to produce an output voltage that can be utilized in the utilization of energy that has been converted by the rectifier.

II. THE MATERIALS AND METHOD

The rectifier antenna is done with the following steps

The first step is to determine the antenna specifications, including working frequency, resonant frequency, *VSWR*, *Return Loss, and Bandwidth*. These specifications will be a reference in antenna design. The second stage is to calculate the antenna path using Zeland IE3D Program Manager Version 12 software, the dimensions of the antenna patch are calculated for simulation. This *software* will assist in modeling and simulating antenna performance, so that the dimensions of the antenna patch can be adjusted to predetermined specifications. After obtaining the appropriate antenna patch dimensions, the next step is to design and simulate the Voltage Multiplier rectifier circuit using Multisim 13 software. This circuit corresponds to the microstrip antenna that has been designed to produce the desired voltage output. After designing an antenna rectifier that matches the specifications, the antenna rectifier fabrication is carried out. This fabrication process involves implementing the antenna design and filter circuit into physical form, so that the antenna rectifier can be tested and evaluated.

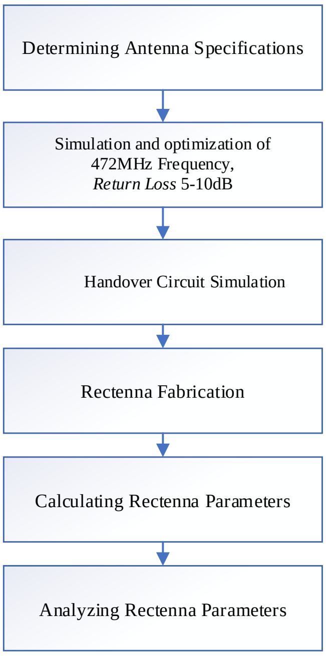

Figure 1.Antenna Design Syntax *Flowchart*

III. RESULTS AND DISCUSSION

After measuring and comparing the results of simulation and Antenna Fabrication, from the antenna parameters that are measured are working frequency, return loss, bandwidth, VSWR, antenna impedance, polarization and gain.

A. *Frequency and Return Loss*

Return Loss is a parameter that measures the extent to which signal power is reflected back to the antenna, *Return Loss* values *are* small values, usually lower than -10dB. A low *Return Loss* indicates little signal energy is reflected back to the antenna, If the *Return Loss* value is high, it indicates that there is a mismatch between the antenna and the connected source or load, which can damage the antenna and cause significant signal power losses.

The following Figure 1.1 is the Return Loss results obtained from simulation and measurement results.

Figure 1 Comparison of Simulated and Measured Working Frequency Graphs.

Figure 1 shows that the Return Loss value ≤- 10dB in the frequency range of 540-884 MHz, with the lowest value of -26.868 dB at a frequency of 598 MHz. Meanwhile, the measurement results after making the antenna show that the Return Loss value ≤-10dB occurs in the frequency range of 632-785 MHz, with the lowest value of -26.868 dB at a frequency of 598 MHz.

-42.375 dB at 668MHz, and there are also good return loss values in the frequency ranges 476-504MHz (-10.064dB) and 272-428MHz (-10.394dB to -10.447dB).

B. *Bandwidth*

Bandwidth is the range of frequencies over which a device or system can transfer or transmit data with the desired quality. In simple terms, bandwidth refers to the entire frequency spectrum used for transmitting signals or information. In the context of antennas, bandwidth refers to the range of frequencies over which an antenna can operate properly and maintain the desired performance. This range is usually measured in hertz (Hz) and can be expressed as a specific frequency range, e.g. 100 MHz to 1 GHz.

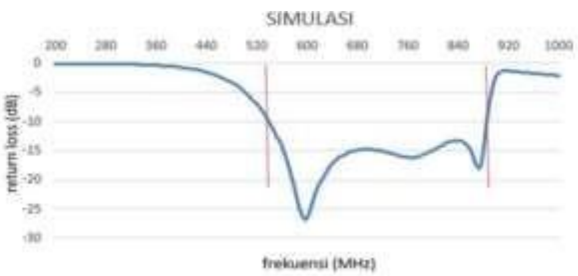

Figure 2 Simulated Antenna Bandwidth

Figure. 3 Bandwidth of Measured Antenna

C. Voltage standing wave Ratio

Comparison of VSWR values between simulation results and measurements can be seen in Figure 4. VSWR value is a measure to determine the extent to which the impedance of the antenna matches the impedance of the system or transmission connected to it. The ideal VSWR value is 1, which indicates that no power is reflected back and all the power radiated by the transmitting antenna is well received by the receiving antenna.

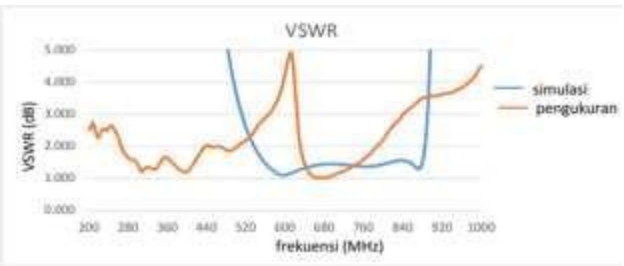

Figure 4 Comparison Graph of Simulated and Measured VSWR Values

In Figure 5 the *VSWR* value given can be seen from the simulation results and the measurement results in the frequency range of the antenna showing the *VSWR value* between 1 and 2. The simulation results at a frequency of 540-884MHz show that the *VSWR* value is between 1 and 2 so that the antenna in the simulation can be considered quite good in impedance with the system or transmission connected to it.Meanwhile, the frequency results on the 632-784MHz antenna also show *VSWR* values between 1 and 2.

D. Impedance

The impedance value of the antenna is 50.60Ω, the results of this simulation show the resonant frequency, but when measurements are made there is a shift in resonant frequency and value. This difference in value is still considered a value that matches the impedance of the Sma Connector used to connect the antenna to the network analyzer as a measuring instrument.

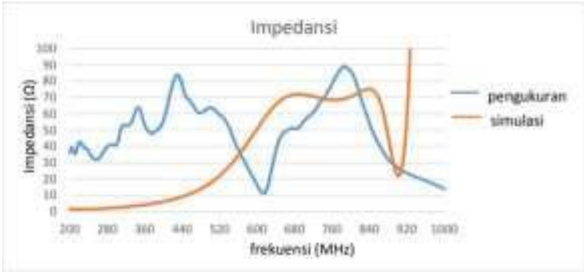

Figure. 5 Graphical comparison of simulated and measured Impedance values.

E. Polaradiation

Polaradiation shows that the level of receiving power on an antenna from the transmitting antenna. Figure 6 is the polaradiation shape of the antenna measurement results made. While in Figure 7 is the polaradiation shape of the simulation results. Which shows that the polaradiation of the antenna is omnirectional, namely the transmit pattern in all directions.

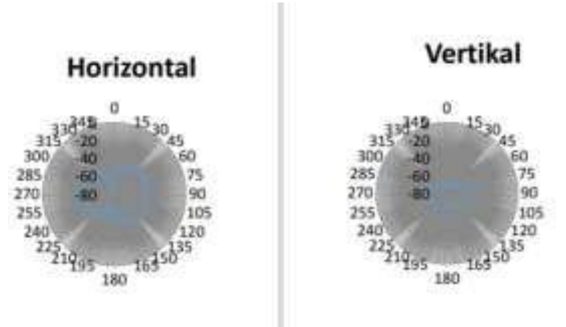

Figure. 6 Fabricated Polaradiation

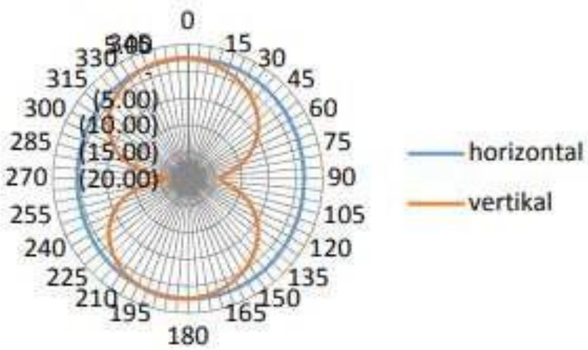

Figure. 7 Simulated Polaradiation Results

F. Antenna Gain

Gain measurements are made by comparing the transmitting power of the antenna to be tested with another antenna (as a reference antenna). Measurements using a 500 MHz dipole antenna by generating a frequency of 668 MHz, and a power of 10 dBm using a signal generator and antenna.

500 MHz monopole. The measurement results obtained values such as table 1.

Table.1 Comparison of Acceptability

No.	Antenna	Power (dBm)
1.	Dipole	-60
2.	Antenna Microstrip Rectangular Patch Horizontal Slot	-75

The gain value of the antenna can be found using equations. Microstrip antenna power in watts:

$$P = -75\, dBm$$

$$P(dBm) = 10 \log \frac{P(Watt)}{1mW}$$

$$-75 = 10 \log \frac{P}{1mW} \tag{1}$$

$$log^{-1} - 7.5 = \frac{P}{1mW}$$

$$3.162 \times 10^{-8} = \frac{P}{10^{-3}W}$$

$$P = 3.162 \times 10^{-11} W$$

The receiving power of a dipole antenna in Watts:

$$P = -60\, dBm$$

$$P(dBm) = 10 \log - \frac{P(Watt)}{1mW}$$

$$-60 = 10 \log \frac{P}{1mW} \tag{2}$$

$$log^{-1} - 6 = \frac{P}{1mW}$$

$$1 \times 10^{-6} = \frac{P}{10^{-3}W}$$

$$P = 1 \times 10^{-9} W$$

So the gain of the microstrip antenna is:

$$G = \frac{3.162 \times 10^{-11}}{1 \times 10^{-6}} = 3.162 \times 10^{-5}\, kali \tag{3}$$

Or in dB units the gain value is obtained:

$$G = 10 \log \frac{3.162 \times 10^{-11}}{1 \times 10^{-6}} = 10 \log 3.162 \times 10^{-5} = -45\, dB \tag{4}$$

The antenna gain obtained during the simulation is equal to 2.449 dBi for a frequency of 600 MHz. The greater the gain obtained, the better the transmitting power of the antenna.

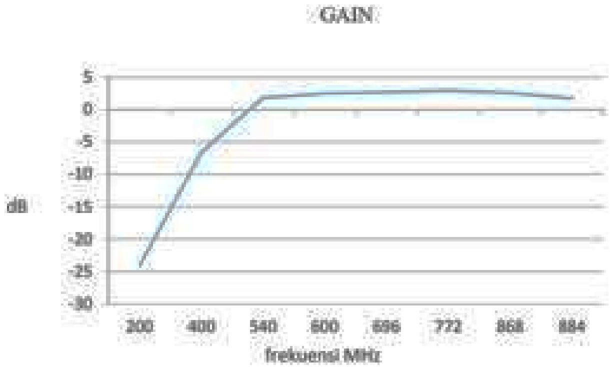

Figure. 8 Gain Graph of Simulation Results

IV. CONCLUSIONS

Based on the results of the discussion in this study, it can be concluded that the simulation and measurement results show that the antenna works in the desired frequency range of 540-884MHz (simulation) and 632-784 MHz (Measurement).*Return Loss* has a good value and is lower than -10dB. The *bandwidth* of the antenna is wide enough to allow reception of television signals in the desired frequency range. *VSWR* values between 1 and 2 in simulation and measurement results indicate that there is a good match between the impedance of the antenna and the transmission system to which it is connected.

LITERATURE

[1] Balanis, C. A. (2005). Antenna Theory: Analysis and Design (3rd ed.). John Wiley & Sons.

[2] Sheta, A. F., & Ghali, H. (2013). Design of a Compact Vivaldi Coplanar Rectenna for UHF RF Energy Harvesting. International Journal of Engineering Research & Technology (IJERT), 2(4), 981-986.

[3] Arifin, M. Z. (2016). Design of Rectenna for RF Energy Harvesting Application. Bachelor's thesis, Gadjah Mada University.

[4] Aviantoro Aditya Putra.(2016) et all. Design and Implementation of Rectifier Antenna Used Votlage Multiplier for UHF Frequency, e-. Proceding of Engineering, ISSN: 2355-9365, vol.3, No.3, page: 4391

[5] Rivaldo Ryan. (2018).Rectenna (Rectifier Antenna) 800MHz- 2500MHz, e-Proceding of Engineering, ISSN: 2355-9365, vol.5, No.2, page: 2281.

[6] Priutomo, Reza. 2015. Antenna Polarization. Types of Antennas, (online), (http://tkjsmkislam.blogspot.co.id/p/jenis-jenis-antena.html, accessed March 5, 2018)

[7] Mauludin, M. Subchan. 2014. Microstrip Television Antenna Design Using Fiberglass Epoxy, Thesis Faculty of Engineering, Wahid Hasyim University.

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Implementation Of Internet Of Things (Iot) Based Lecture Schedule In Building G Floor 3 Padang State Polytechnic

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Abstract. The internet of things-based lecture schedule aims to improve the efficiency and effectiveness of time management. Thus, students, lecturers, and staff can know the time change so that they can prevent delays. By using Arduino Uno as the main component microcontroller, RTC as a clock module that calculates the time that will be displayed on the LCD. Bell and Speaker will sound when the clock on the RTC is the same as the inputted schedule clock, then sent to IoT via the ESP01 wifi module. This tool can also be used as a medium for delivering information because it is equipped with a mic. The RTC in this tool successfully calculates the time according to real time where the Bell and Speaker can work on time according to the schedule. When the bell sounds the measured voltage is 225 volts while the speaker is 2 volts. This tool has also been connected to ThingSpeak using the ESP01 wifi module.

***Keywords*— Arduino Uno, Bell, RTC, Speaker, ThingSpeak**

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I. Introduction

Internet of things (IoT) is a concept that aims to expand the utilization of continuous internet connectivity that allows us to connect equipment, and other physical objects with networked sensors and actuators to obtain data and manage their own performance. Internet of things or often referred to as IoT is currently experiencing many developments. The development of IoT can be seen from the level of convergence of wireless, microelectromechanical (MEMS), internet, and QR (Quick Responses) Code technologies. IoT is also often identified with RFID (Radio Frequency Identification) as a communication method [7]. Internet of Things (IoT) with automatic bell refers to the use of IoT technology to control or manage the bell or alarm automatically through the internet network. At this time there are still many campuses that still do not have an IoT-based lecture schedule such as the 3rd floor of building g of Padang State Polytechnic has not implemented an IoT-based lecture schedule system.

Arduino Uno is a microcontroller board based on ATmega328 (datasheet). It has 14 input pins of digital output where 6 of them can be used as PWM output and 6 analog input pins, 16 MHz crystal oscillator, USB connection, power jack, ICSP header, and reset button. To support the microcontroller to be used, it is enough just to connect the Arduino Uno Board to a computer using a USB cable or electricity with an AC-to-DC adapter or battery to run it. The main function of the Arduino Uno is as a microcontroller development board that can be programmed easily using the C/C++-based Arduino programming language. By using Arduino Uno, users can quickly develop electronics and programming projects involving various sensors and actuators. has digital and analog I/O pins that allow interaction with various devices.Pin on Arduino is a place where to connect cables between Arduino pins with input / output devices (usually connecting to the project circuit on the breadboard). Arduino pins are usually in the form of female headers so that to get a connection from the Arduino pin it is only enough to plug the cable into the pin header hole. There are several pins on Arduino with different functions, each pin is labeled according to its name and function on the PCB.

The RTC (Real Time Clock) module is an electronic module that has a function to provide accurate time information in the form of digital data. The RTC module is equipped with an electronic circuit consisting of a crystal oscillator, a backup battery, and an electronic circuit that is responsible for storing the time and date. The RTC module used in this tool is the DS3231 RTC module. DS3231 is a device with six terminals, two of which are not mandatory for use, so basically we have 4 (four) main pins. Features of the DS3231 RTC Module are; RTC calculates seconds, minutes, hours and years, Accuracy: +2ppm to -2ppm for 0ºC to +40ºC, +3.5ppm to -3.5ppm for -40ºC to +85ºC, Digital Temperature sensor with ±3ºC accuracy, can sound an alarm twice a day, square wave output can be programmed, aging Trim Register, 400Khz I2C interface, low power consumption, the circuit can handle the switch automatically if there is a battery failure, backup CR2032 battery with a life span of two to three years, and portable size. The specifications of the DS3231 RTC Module are; DS3231 Module operating voltage: 2.3V - 5.5V, can operate at low voltages, consumes about 500nA when using batteries, maximum voltage on SDA, SCL: VCC + 0.3V, and operating temperature: -45ºC to +80ºC.

Speakers are output hardware that functions to output the results of processing by the CPU in the form of audio / sound. Speakers can also be called a tool for outputting sound produced by music devices such as MP3 Players, DVD Players and so on. In this research, the speakers used are midrange types. This mid range speaker is designed to be able to produce sound from a frequency range of 500 Hz - 5,000Hz. This type of speaker is also capable of creating sounds that sound clearer and more focused. The size of these speakers is in the range of 4 to 6 inches only. These speakers are widely used to produce vocal sounds. Mid range speakers are usually part of a 3 way type speaker. However, mid range speakers cannot produce high-pitched sounds. The work of the midrange type speaker is only to perfect the other two types of speakers in the 3 way type. The function of the midrange itself is to capture high frequency sounds that cannot be captured by the tweeter and midbass. By using a midrange, the resulting vocal sound is thicker and clearer.

Types of speakers based on type include; 1) 3 Way speakers are speakers consisting of a midrange that functions to capture high-frequency sounds that cannot be captured by tweeters or midbass. 3 Way speakers are a type of speaker with three types of frequencies. This type of speaker uses low, mid and high frequencies. 3 Way speakers are capable of producing frequencies ranging from 20 Hz to 20 KHz. 3 Way speakers include midrange, tweeter and full range speakers. 2) 2 Way speakers are a type of speaker that uses two frequency systems, namely high and low. 2 way speakers are speakers consisting of two tweeters which are audio components that play a role in spouting high-frequency sound. While two midbasses play a role in producing intermediate tones in an audio system, and consist of two x-overs whose job is to sort out the sound so that no 2 sounds overlap. The 2 Way Speaker includes a woofer and a tweeter.

Buzzer Electronics is an electronic component that can produce sound vibrations in the form of sound waves. In general, this electronic buzzer is often used as an alarm because its use is quite easy, namely by providing an input voltage, the electronic buzzer will produce sound vibrations in the form of sound waves that can be heard by humans.The working principle of the buzzer is very simple. When an electric current flows into the buzzer circuit, mechanical movement occurs in the buzzer. As a result, there is a change in energy from electrical energy to sound energy that can be heard by humans. Generally, the type of buzzer on the market is a piezoelectric buzzer that works at a voltage of 3 to 12 volts DC. The types of buzzers in the Arduino circuit based on the sound are divided into two, namely: active Buzzer, which is a buzzer that already has its own sound when given an electric voltage. This type of Arduino active *buzzer is* often also called a stand alone buzzer. Then passive buzzer, which is a buzzer that does not have its own sound. This type of *buzzer is* very suitable to be combined with Arduino because we can program the high and low tones. One example is a speaker. The specifications of the buzzer components are as follows: 1) Piezoelectric, which is in the form of a black tube which is the source of the sound. 2) Negative pin foot, which is a short buzzer foot to be connected to negative current or GND. 3) Positive pin foot, which is a long buzzer foot pin and its use is to be connected to positive current or VCC / 5V.

Furthermore, the power amplifier is an electronic circuit that serves to strengthen or enlarge the output signal on the sound. By using an amplifier, the sound coming from a microphone, speaker, megaphone will sound clearer and stronger.

LCD (Liquid Crystal Display) is a type of display media that uses liquid crystals as the main viewer. The features presented in this LCD are: consists of 16 characters and 2 lines, has 192 stored characters, there is a programmable character generator, can be addressed with 4-bit and 8-bit modes, equipped with a back light. The initialization process of arduino pins connected to LCD pins RS, Enable, D4, D5, D6, and D7, is carried out in the LiquidCrystal line (2, 3, 4, 5, 6, 127), where lcd is a variable that is called every time LCD-related instructions will be used.

The ESP01 Wifi Module is a wifi module that functions as an additional device for microcontrollers such as Arduino to connect directly to wifi and establish a TCP / IP connection. This module is also a complete chip which includes a processor, memory and also access to GPIO. ESP01 was developed by a developer from China called

"Espressif". ESP01 series products have many variants. One of the variants that we most often encounter is the ESP01 ESP-01 series. In 2014, AL-Thinker, a third-party manufacturer of this module, released the ESP-01 module which uses AT-Command as its configuration. The price is cheaper, has small module dimensions and low power usage. The ESP-01 module has a 2x4 DIL form factor with dimensions of 14.3 x 24.8 mm.

This module requires power around 3.3v and has three wifi modes, namely Station, Access Point and Both. This module is also equipped with a processor, memory and GPIO where the number of pins depends on the type 01 we use. So that this module can stand alone without using any microcontroller because it already has equipment like a microcontroller which we can see in Figure 1 below.

Figure 1. ESP01 Wifi Module

DFPlayer is an MP3 player module for Arduino that has a small size and its output can be directly paired to the speaker. This DFPlayer can function as a stand-alone module by adding batteries, speakers, and push buttons, or it can also use a combination of Arduino and other microcontrollers that have TX/RX capabilities. This DFPlayer supports several audio formats in general, such as MP3, WAV, and WMA and has supported micro SD with FAT16 and FAT32 file system types.

IDE is short for Integrated Development Environment, is a software used within the scope of Arduino because it is through this software that Arduino is programmed to perform the functions that are embedded through programming syntax to enter a command into the microcontroller so that Arduino can be used according to what is ordered.

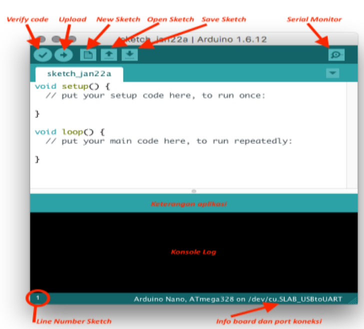

Figure 2. Arduino IDE Initial View.

In Figure 2 is a display of the Arduino IDE sketch, where this sketch serves to write a microcontroller device program that supports the Arduino IDE. The following is an explanation of the parts on the initial display of the Arduino IDE: Verify in previous versions was known as Compile. Before the application is uploaded to the Arduino board, make it a habit to verify the sketch first. If there are errors in the sketch, an error will appear. The Verify / Compile process converts the sketch to binary code to be uploaded to the microcontroller. Upload this button serves to upload the sketch to the Arduino board. Even if we don't click the verify button, the sketch will be compiled, then uploaded directly to the board. Unlike the verify button which only serves to verify the source code. New Sketch Opens the window and creates a new sketch. Open Sketch Opens a sketch that has already been created. Sketches created with the Arduino IDE will be saved with the .ino file extension Save Sketch saves the sketch, but does not compile it. Serial Monitor Opens the interface for serial communication, we will discuss further in the next section. Application Description messages that the application does will appear here, for example *Compiling* and *Done Uploading* when we compile and upload the sketch to the Arduino board Console log Messages that the application does and messages about the sketch will appear in this section. For example, when the application compiles or when there is an error in the sketch we made, the error information and line will be informed in this section. This section will show the position of the active cursor line in the sketch. Board and Port Information This section informs the port used by the Arduino board.

MIT App Inventor is an open-source web application originally developed by Google, and currently maintained by the Massachusetts Institute of Technology (MIT). App Inventor allows new users to program computers to build software applications for the Android operating system. App Inventor uses a graphical interface, similar to the user interfaces in Scratch and StarLogo TNG, that allows users to drag-and-drop visual objects to build applications that can run on Android devices.

ThingSpeak is an IoT platform that allows us to collect, store, analyze, visualize, and act on data from sensors or actuators, such as Arduino, Raspberry Pi, Black BeagleBone, and other hardware. ThingSpeak functions as a data collector that gathers data from node devices and also allows the data to be captured into a software environment for historical analysis of the data. The distinctive features of the ThingSpeak workflow are: create Channels and collect data, analyze and Visualize data, Act on data using one of several Apps

IoT-based lecture schedule can be used as a reminder or marker of entry, return, change of hours and break time and can be used to convey information or announcements. Therefore, the implementation of an IoT-based lecture schedule system can help improve efficiency in lecture schedule management and reduce the possibility of delays [4]. By looking at the urgency of IoT, the author is interested in conducting research by making a tool using Arduino Uno which can later be used as an IoT-based lecture schedule.

II. MATERIALS AND METHOD

The method used is to make a tool using Arduino Uno. The purpose of making this tool is 1) to provide automatic notifications and reminders to students and lecturers about scheduled lecture times, 2) the existence of an IoT-based lecture schedule system can make it easier for students, lecturers and staff to manage time, lecture schedules can be changed according to conditions such as regular schedules and Ramadan schedules using android applications and buttons on the *display*.

As a first step, it starts with the design stage. The design stage is a planning process before carrying out the tool manufacturing process. The process of making tools is carried out according to the design that has been done so that the tools made can function properly. Designing and making tools is the whole process of activities until this tool is complete. After the tool is finished, tool testing is carried out. Tool testing is one of the stages carried out to determine the success of the tool / system can work as expected. This tool testing was carried out in several trials.

III. RESULTS AND DISCUSSION

A. Design

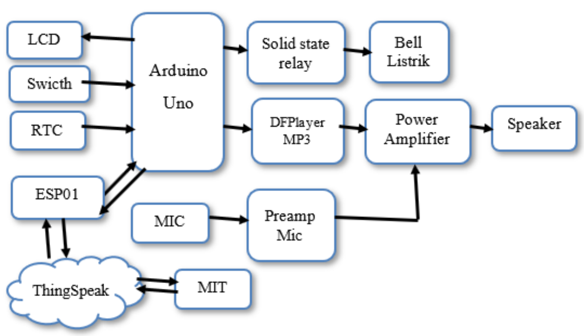

Figure 3. Block Diagram

The block diagram above shows the working system of the IoT-based lecture schedule system design tool using Arduino Uno as the controller of the RTC, Bell, Speaker and LCD and can change the schedule through a predetermined android application and ESP01 which functions to connect the device to android which in the block above explains the working system in outline which represents the main components that work according to their functions in the circuit. The design of the system block diagram can be seen that this tool uses internet media to access data on the ThingSpeak database. Arduino Uno in this tool is used as a microcontroller of an automatic lecture schedule tool that communicates with the ESP01 wifi module in order to access data on ThingSpeak. Real Time Clock is used to store real time displayed on the LCD and when the time on the RTC is right with the specified schedule, the Bell or Buzzer will sound and the Speaker will make a sound to notify the change of lecture hours. In this tool there is also a Mic and Speaker which is used for the delivery of information or announcements. MIT App Inventor on this tool is used as an application to set or change the lecture schedule where the data will be stored in ThingSpeak, the data on ThingSpeak will be sent to a device that has been connected to the internet. The design of this tool requires an electronic circuit that supports the work system. The following is a circuit used in hardware design.

B. Hardware Design.

LCD circuit with Arduino Uno

LCD is used for media displaying time from RTC. In this LCD the pins used are SCA, SCL, VCC and GND. The following LCD circuit image with Arduino Uno can be seen in Figure 4

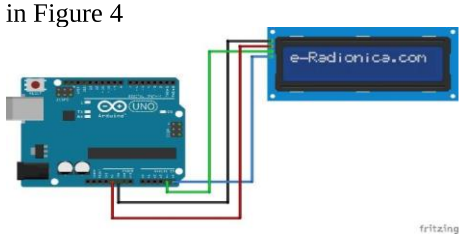

Figure 4. LCD circuit with Arduino Uno

Table 1. LCD Pin to Arduino Uno Pin Connection

No	LCD Pins	To Arduino Uno
1	VCC +5V	VCC +5V
2	GND (Ground)	GND (Ground)
3	SDA	A4
4	SCL	A5

RTC circuit with Arduino Uno

RTC is a module that can store time and date. Because it can store time, RTC is used as a clock for the lecture schedule system. The pins on the RTC are SCL, SDA, VCC and GND which are connected to the Pins on the Arduino Uno, namely A5, A4, 5V and GND. The following picture of the RTC circuit with Arduino Uno can be seen in Figure 5.

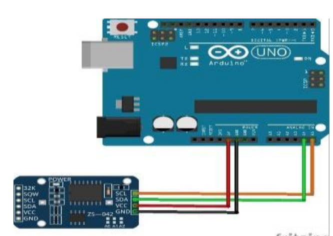

Figure 5. RTC circuit with Arduino Uno

Table 2 RTC Pin Connection to Arduino Uno.

No	RTC pins	To Arduino Uno
1	VCC +5V	VCC +5V
2	GND (Ground)	GND (Ground)
3	SDA	A4
4	SCL	A5

Buzzer circuit with Arduino Uno

The buzzer in this tool is used as a sound output for markers or reminders of time changes. The pins on the Buzzer, namely Positive (+) and Negative (-) are connected to the Arduino Uno Pin, namely Pin 12 and GND. Buzzer circuit image with Arduino can be seen in Figure 6

Figure 6. Buzzer circuit with Arduino Uno

Table 3 Pin Connection of Buzzer to Arduino Uno

No	Buzzer Pin	To Arduino Uno
1	Positive	Pin 13
2	Negative	GND

Mp3 DFPlayer and Speaker circuit with Arduino Uno

The circuit on this tool is used as a sound output where the music file or sound on the DFPlayer will be played by the Speaker according to the command that has been inputted on the Arduino Uno. A picture of the DFPlayer and Speaker circuit with Arduino can be seen in Figure 7.

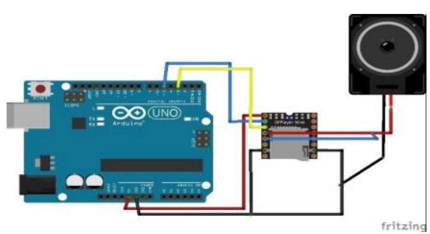

Figure 7. DFPlayer and Speaker circuit to Arduino Uno

Table 4. DFPlayer and Speaker Pin Connections to Arduino Uno

No	Speaker	DFPLayer	Arduino Uno
1	Positive	DAC_R DAC_L	
2		VCC	VCC +5V
3		RX	D5
4		TX	D3
5	Negative	GND	GND

ESP01 circuit with Arduino Uno

This circuit is used to connect the device to the internet using the ESP01 Wifi Module to Arduino Uno so that data can be sent to IoT and can be connected to a cellphone or laptop so that it can manage the device as desired. The ESP01 circuit image with Arduino can be seen in Figure 8.

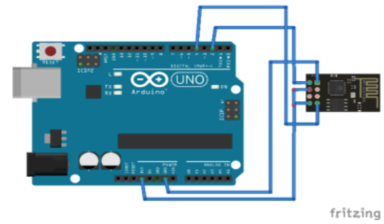

Figure 8. ESP01 circuit to Arduino Uno

Table 5 Pin Connection of ESP01 with Arduino Uno

NO	Pin ESP01	To Arduino Uno
1	RXD	D4
2	TXD	D2
3	VCC CH_DP	VCC +3V
4	GND	GND

Mic circuit with speaker

This circuit is a mic circuit that is connected to the mic preamp and continued to the power amplifier. This circuit serves to amplify the mic voltage.

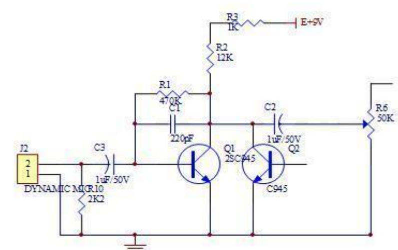

Figure 9. Mic circuit with preamp and power amplifier.

Button circuit with Arduino Uno

The button in this circuit functions to change the regular and Ramadhan schedule menus**.**

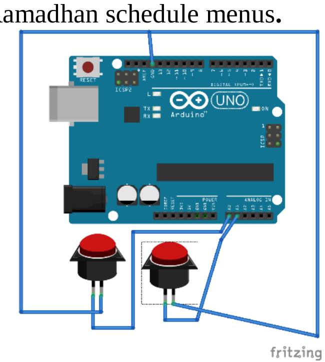

Figure 10 Button circuit with Arduino Uno.

Overall Tool Set

From the system design of each component that has been described, it can be seen how the overall system design is in the picture. Overall circuit image can be seen in Figure 10

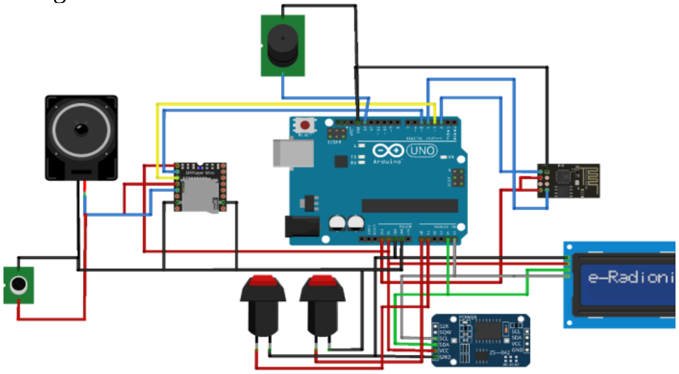

Figure 11. Overall circuitry of the tool.

Circuit Schematic and Layout

The following is a schematic view of the overall circuit made using proteus software as well as the layout of the device on the PCB. The schematic image can be seen in Figure 12 and the layout image can be seen in Figure 13.

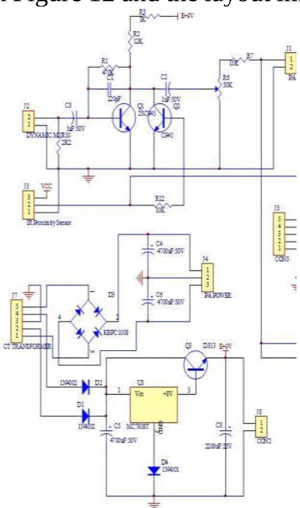

Figure 12. Schematic circuit

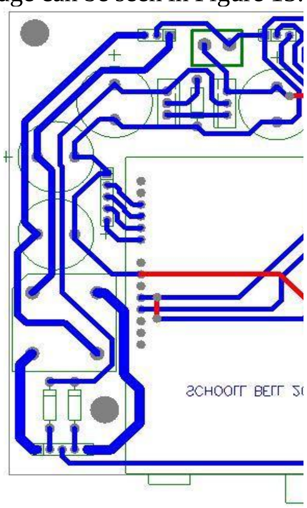

Figure 13. Layout

Software Design

After the manufacture of hardware devices, the next step is done
right is software design. Software is a control program for the overall performance of the device which aims to make the designed hardware work as desired where the microcontroller will be coded so that all modules can work and be controlled by this Arduino Uno microcontroller.

Flowchart and Algorithm

Flowchart is a diagram used to explain an algorithm. Flowchart consists of symbols connected by an arrow (directed). The goal is to facilitate writing and facilitate reading

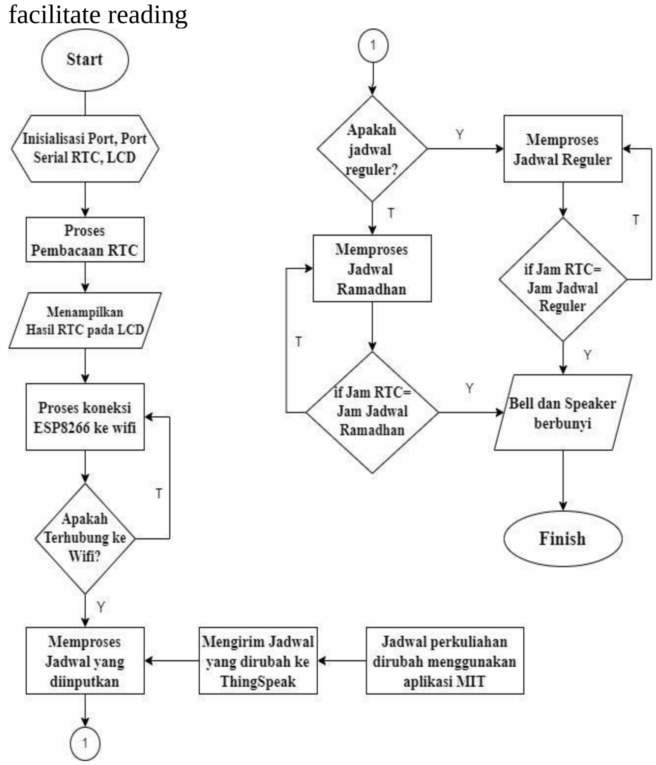

Figure 14. Flowchart of Tool Design

Thingspeak Creation

The Thingspeak creation step in this research starts by entering the *thinkspeak* web and then pressing *new channel* as shown in Figure 15 below.

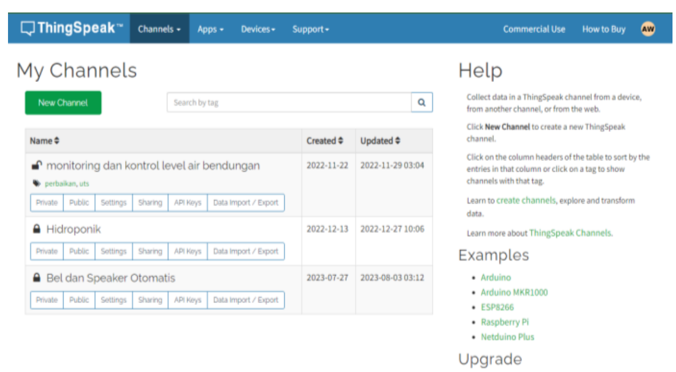

Figure 15. ThingSpeak channel creation view

Next, enter all the required parameters and press *save*. Then on the *sharing* menu change to *share channel view with everyone*, take the *API Keys* from the channel created, so that it can read and send data, as shown in Figure 16 below.

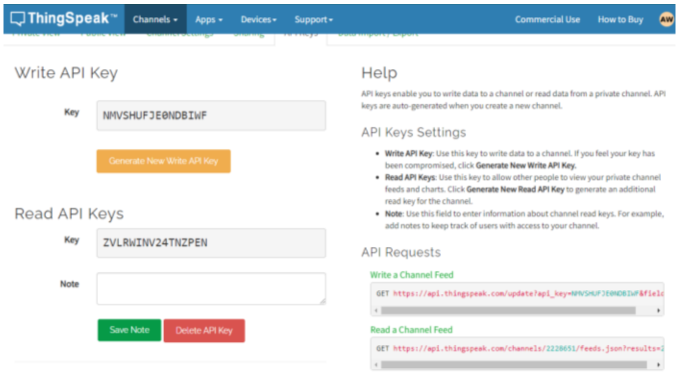

Figure 16 Channel Keys API View

In the next step, data transmission testing can be carried out. The results of the data transmission test can be seen in Figure 17 below.

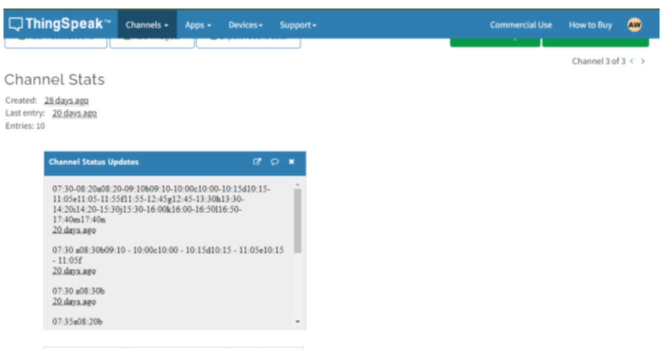

Figure 17 Display of Data Logged into ThingSpeak

Application Development

The application used to organize lecture schedules uses MIT App Inventor to create it. The steps for making this tool are; 1) make the application display as desired by entering the textbox, button, and others needed. Can be seen in Figure 18 and Figure 19

Figure 18 Initial view

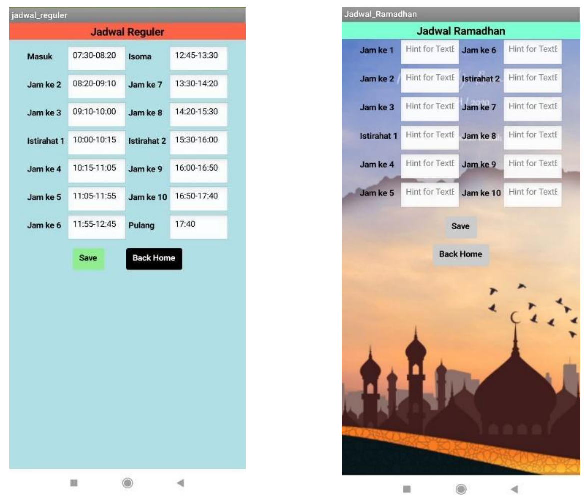

Figure 19 Regular and Ramadan Schedule Menu Display

Entering *API Keys is* useful for sending and receiving data which can be seen in Figures 20 and 21

Figure 20 Input Read API Keys

Figure 21 Input Write API Keys

Testing

Testing of this tool was carried out in several trials.

1. Bell/Buzzer Testing

Buzzer testing by measuring the voltage when the buzzer does not sound and when the buzzer sounds according to the schedule. When the buzzer does not sound the measured voltage is 0 volts, while when the buzzer sounds the measured voltage is 225 volts. This indicates that the buzzer can work according to the inputted program.

Table 6 Buzzer Voltage Measurement Results.

No	Hours	Voltage (V) Buzzer
1	07:30	225V
2	08:20	225V
3	09:10	225V
4	10:00	225V
5	10:15	225V
6	11:05	225V
7	11:55	225V
8	12:45	225V
9	13:30	225V
10	14:20	225V
11	15:30	225V
12	16:00	225V
13	16:50	225V
14	17:40	225V

2. Mic and Power Amplifier Testing

This test is carried out to find out how much the Mic voltage magnification is on the power amplifier.

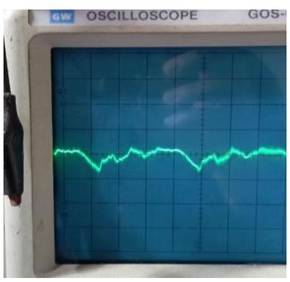

Figure 22 Oscilloscope Measurement Results on Mic

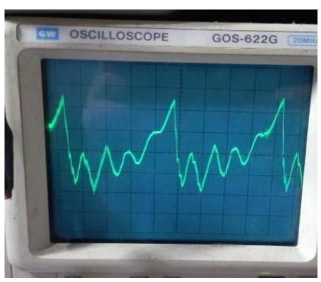

Figure 23 Oscilloscope Measurement Results on Power Amplifier

In the Oscilloscope, the Volts / Div is set at 20 mv / div, in Figure 22 it can be seen that the highest peak of the wave is as high as 0.4 div, so it can be calculated

$$\begin{aligned} Voltage1 &= Volts/div \times div \\ &= 20\ mv/div \times 0.4\ div \\ &= 8\ mv \end{aligned} \quad (1)$$

In Figure 23, it can be seen that the highest peak of the wave is 2.8 div, so it can be calculated

$$\begin{aligned} Voltage2 &= Volts/div \times div \\ &= 20\ mv/div \times 2.8\ div \\ &= 56\ mv \end{aligned} \quad (2)$$

Then it can be calculated that the voltage magnification on the power amplifier is as much as

$$\begin{aligned} Magnification &= Voltage\ 2/Voltage\ 1 \\ &= 56\ mv / 8\ mv \\ &= 7 \end{aligned} \quad (3)$$

So, the magnification of the mic voltage on the power amplifier is 7 times.

3.Speaker Testing

Speaker testing is done using an oscilloscope. In Figure 24 we can see the highest peak of the wave as high as 1 div with Volts/Div of 2V/div.

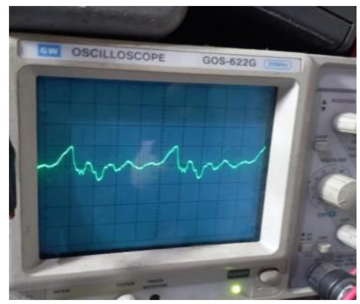

Figure 24 Oscilloscope Measurement Results on Speaker

Then the voltage on the speaker can be calculated as follows:

$$\begin{aligned} Voltage &= Volts/Div \times div \\ &= 2V/div \times 1\ div \\ &= 2V \end{aligned} \quad (4)$$

So, the voltage on the Speaker is 2 Volts when the Speaker is working.

4. Testing the RTC and LCD

This test is carried out to see if the RTC time is in accordance with real time and to see if the LCD and Buzzer work on time when changing hours.

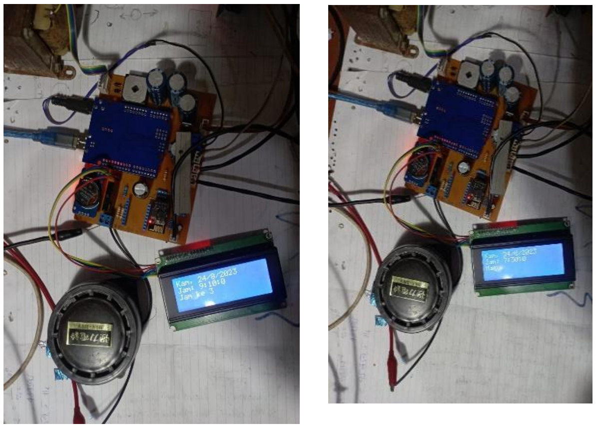
Figure 25 Results of RTC Display on LCD

5. ESP01 Testing

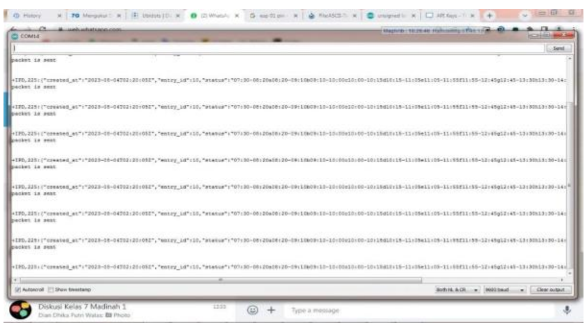
Figure 26 ESP01 Testing Results

Testing is done to find out whether the tool can connect to the internet using ESP01. Checking using the Serial Monitor on the Arduino IDE which can be seen in Figure 26. The Serial Monitor displays the data stored on ThingSpeak.

6. ThingSpeak and MIT App Inventor testing

The following are the results of ThingSpeak testing, when the lecture schedule is changed using the MIT application, the schedule data will be sent to the IoT platform, namely ThingSpeak. The picture of the test results of ThingSpeak and MIT App Inventor can be seen in Figure 27.

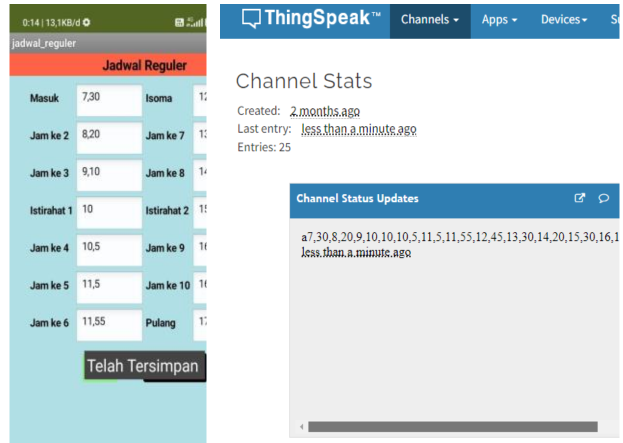

Figure 27 ThingSpeak and MIT App Inventor test results.

After testing and measuring this tool, some analysis is obtained, the Buzzer or Bell will sound according to the inputted schedule, it can be seen by measuring the Buzzer voltage when the Buzzer does not sound the measured voltage is 0 volts while when the Buzzer sounds the measured voltage is 225 volts. The second test is the voltage magnification of the Mic on the Power Amplifier. measurements were taken using an oscilloscope and then calculated using the formula Voltage = Volts / Div x Div which obtained a voltage on the mic of 8 mv and on the power amplifier the calculated voltage was 56 mv. To find out how many times the voltage magnification on the power amplifier, the result of the power amplifier voltage calculation is divided by the result of the mic voltage calculation, the result obtained is the magnification of the mic voltage by the power amplifier which is 7 times.

Speaker testing is done to find out if the speaker is functioning properly and see how much voltage is on the speaker when used. Measurements are made using an oscilloscope with Volts / Div of 2 volts / div where the peak wave height is 1 div. Then the calculation is done using the voltage formula = Volts / Div x Div which is the result of the calculation of 2 volts. RTC and LCD testing is done to see if the time on the RTC does not have an error or is not the same as real time. In this test the RTC works well. ESP01 testing can be seen in the Serial Monitor, the data taken is from ThingSpeak which imports data from the MIT App Inventor Application.

IV. CONCLUSION

After designing and making the "IoT-Based Lecture Schedule" tool, it can be concluded that;

By using Arduino Uno as the control of the RTC, ESP01, LCD, Buzzer and Speaker modules and Arduino IDE as a medium for making lecture schedule programming and programs to read data from ThingSpeak so that the tool can work properly,

The lecture schedule can be changed using a cellphone through an application made using MIT APP Inventor. Schedule data will be sent to ThingSpeak to be stored and will be sent to a device connected to the ESP 01 Wifi Module so that the device can connect to the internet. The device will process the data received and run the device according to the schedule sent earlier.

Managing the lecture schedule can be done using a mobile phone and a button on the display box. On the mobile phone, managing the schedule uses an application made with MIT App Inventor which has 3 screens, namely the first screen as the Home menu, the second screen as the Regular Lecture Schedule and the third screen as the Lecture Schedule in the month of Ramadan. While in the display box used 2 buttons for each schedule. Information delivery can be done directly using a mic connected to the speaker.

REFERENCES

[1] A.wRahim, "Design of E-Information Application for Funding Lecture Schedule Based on MobilewAndroid," *J. Process.*, vol. 12, no. 1, pp. 1000-1010, 2017

[Moh. Dwi Chaidier Rizaldi, Ahmad R. Pratama "Development of a Lecture Schedule Information System for the Faculty of Medicine, Islamic University of Indonesia Based on Android" vol. 2 No. 2, 2021

[3] Pauzan Muh, Yanti Indri, "Arduino-based Automatic School Bell Controlled Using *Mobile* Applications" vol. 10, No. 2, pp: 163-169, 2023

[4] R. Malhotra, D. Kumar, and D. P. Gupta, "An android application for campus information system," *Procedia Comput. Sci.*, vol. 172, pp. 863-868, 2020, doi: 10.1016/j.procs.2020.05.124.

[5] R. R. Putra, H. Hamdani, S. Aryza and N. A. Manik, "Automatic School Bell Scheduling System Based on RTC Using Microcontroller," Media Informatika Budidarma, vol. 4 No. 2, 2020.

[6] Sarmidi and A. Nurtado, "Arduino Uno-based Automatic School Bell Simulation," *J. Manaj. and Tech. Inform.*, Vol. 3, No. 1, pp. 121-130, 2019.

[7] Zein Afrizal, Farizy Salman, and Eriana Emi Sita, "Community Service to Socialize the Application of Internet Of Thing at Stmik Pranata Indonesia" vol. 1 No.1, 2023.

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Serial Rectifier Antenna (Rectenna) Microstrip Patch Circular 2.4 Ghz For RF Energy Harvester

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Abstract— **The source of Radio Frequency (RF) electromagnetic wave energy in the atmosphere is currently abundant and wasted due to the rapid development of today's RF technology. Utilizing a rectenna system to harvest energy, this RF energy source can be used as an environmentally friendly distribution method. To improve the rectenna's ability to convert electromagnetic waves into a direct voltage (DC) source, a recttenna system is designed using a serial rectenna system. using 3 antennas and 3 rectifier circuits, to design a serial rectenna system. A circular patch microstrip antenna with a frequency of 2.4 GHz is used in a serial receiver system to receive WiFi signals. Schottky diode 2860 and 1nF smd price are used in voltage doubling 6 stage rectifier circuit, which is used in rectifiers. The microstrip patch antenna found is capable of capturing and directing voltage to DC through testing and measuring the serial rectenna system. The system antenna has a return loss value of -26.29 dB, - 21.75 dB, and -28.57 dB, VSWR 1.11, 1.16, and 1.07, impedance of 51.1, 55.56, and 50.22, and bandwidth of 60 MHz. The resonant frequencies for 60 MHz and 50 MHz are 2.42 GHz, 2.36 GHz and 2.48 GHz. so that at a distance of 25 cm a single rectenna system produces a voltage of 51 points 3 mV. During this time, the serial receiver system can convert a direct voltage of 151.08.**

Keywords— **Rectenna; Serial Rectenna; Antenna; Rectifier; Voltage Doubler; Energy Harvesting;**

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I. INTRODUCTION

At the present time Almost all electronic devices today use direct current as a source of supply. Batteries are the most commonly used source of DC voltage. However, due to its chemical makeup and short life, Ananda battery (2018) becomes a product that contributes to environmental pollution. However, as cellular technology advances, radio frequency signals are becoming more widely used. As a result, radio transmitters such as base stations and access points have released excess RF energy into the atmosphere.

By energy harvesting, this abundant RF energy can be used as an energy source instead of distribution of low-power devices. (2015) (Ruhyat). Energy Harvesting according to Al-absi et al. and (2020) is a method to obtain electrical energy from environmental sources, such as RF signals, and convert it into a direct voltage (DC) source. Rectennas are very important for RF energy harvesting, according to (2013). Rectenna, according to Yuwono et al, (2016) combines a rectifier and antenna, with the role of an antenna to collect electromagnetic waves in the environment. Direct voltage (DC) will be generated by the rectifier by changing the connection and electrical signal sent by the antenna, Rectenna produces DC voltage, can be used as a wireless calculation for low-power devices without using batteries (Ruhyat, 2015).

A rectenna can work on RF Waves at a frequency of 2 GHz (access point frequency) can be operated by the rectenna. The RF waves of the access point are captured using a specific type of microstrip antenna, but to convert the RF waves into twice the DC output voltage, a rectifier circuit is needed that can correct and double the input voltage, Toudeshki et al recognized that, Crockroft-Walton voltage multiplier step-up transformers, charge pump circuits, capacitor-switch circuits, and boost or step-up converters are some examples of rectifier circuit techniques that can change voltage dc output becomes greater than the voltage received by the antenna, Rectenna has been implemented in previous studies using a single receiving antenna and rectifier voltage multiplier circuit with a number of stages of 5, and succeeded in producing a direct voltage of 5 mv at a distance of 25 cm from the transmitter (Dzakiyyah, 2016). In addition, a 3-stage rectifier circuit is used to implement the rectenna, and at a distance of 20 cm from the transmitter source produces an output voltage of 0 points092 mV (Hijriani et al., 2018). In addition, a direct voltage of 4.306 mV can be generated using a single rectifier system, consisting of a 2x2 microstrip patch array antenna and a dual diode rectifier circuit (Rifkiano et al., 2016). A weakness of previous studies was the generation of low output dc, which prevented it from serving as a replacement supply. And this is aimed at :

1) Creating a circular patch microstrip antenna with an operating frequency of 24 GHz.
2) Create a rectifier that can correct radio frequency waves. (RF) becomes direct current (DC).
3) Testing the working parameters of the serial receiver.
4) Use parameters to analyze the output of serial rectenna.

II. MATERIALS AND METHOD

A. Equation

Determine the radius of the irradiating element of the antennamicrostrip by using the following equation.

$$\alpha = \frac{F}{\left\{1 + \frac{2h}{\pi \varepsilon_r F}\left[ln\frac{\pi F}{2h} + 1,7726\right]\right\}^{1/2}} \quad (1)$$

First the calculation of the logarithmic function F is carried out. With fr = 2400 MHz; (εr) = 4.7, then the value of the logarithmic function F can be calculated by the equation

$$F = \frac{8,791 \times 10^9}{fr\sqrt{\epsilon r}} \quad (2)$$

Determine the size of the antenna transmission line, that is, by *the feed inset* model, which has a channel impedance of 50 Ω. The design of *the inset feed* slot length can be determined by equation.

$$yo = 0,3d$$

$$yo = 0,3 \times 16,42 \quad (3)$$

$$yo = 0,9852 \text{ cm} = 9,852 \text{ mm}$$

Specifies the width of *the feed inset* slot, using the equation

$$W_o = \frac{7,48 \times h}{e^{\left(Zo\frac{\sqrt{\varepsilon r+1,41}}{87}\right)}} - 1,25 \times t$$

$$W_o = \frac{7,48 \times 1,6}{e^{\left(50\frac{\sqrt{4,7+1,41}}{87}\right)}} - 1,25 \times 0.035 \quad (4)$$

$$W_o = \frac{12,544}{4,1395} - 0,0437$$

$$W_o = 2,9865 \text{ mm} \approx 2,99\ mm$$

Determining the length of the transmission line, it can be calculated using the equation.

$$L_0 = 0{,}25\lambda_d \text{ (m)} \tag{5}$$

Antenna

The most important part of wireless communication, which serves as a means of sending and receiving information, is the antenna. An antenna is a device that can send and receive radio waves, according to "The IEEE Standard Definitions of Terms for Antennas." There are many types of antennas, such as wired antennas, aperture antennas, microstrip antennas, array antennas, reflector antennas, and lens antennas. In accordance with the standards it adheres to, each antenna serves a unique purpose.

Antena Mikrostrip

Microstrip antenna is an antenna consisting of very thin radiation elements (conductors) placed in the ground plane, where between the plane and the radiation elements (conductors) are separated by a dielectric substrate with a certain dielectric constant value (εr). This antenna is lightweight and easy to fabricate because it has a small size so that it can be easily placed on all types of surfaces [5].

Microstrip antennas have three main elements: patch as a radiation element, dielectric substrate, and groundplane element. Each of these parts has a different function [6].

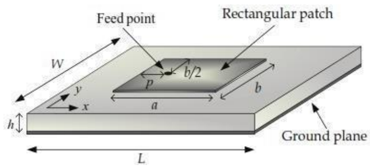

Figure 1. Microstrip Antennas [5]

Microstrip Patch Circular Antenna

A circular microstrip antenna is an antenna in the form of a circular patch. This shape antenna has the same performance as a rectangular patch microstrip antenna. In certain applications, such as arrays, circular patches have an advantage over other patches. The advantage of circular microstrip is the small substrate height h << λ [6].

Enumeration Insert Feed Technique

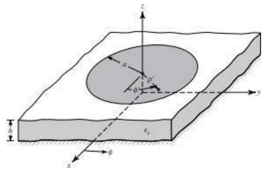

Figure 2. Antena Mikrostrip Patch Circular [6].

The patch antenna is connected to the transmission line using a technique called feeding.

The ability to apply this feeding method on the same substrate E and produce a planar structure is an advantage. To match the channel impedance with the patch without using additional adjustment elements, inserts are provided into the patch.

Figure 3. *Insert Feed* Antena Mikrostrip [10]

Rectifer

A rectifier (wave rectifier) is a part of the power supply that converts an AC voltage signal into DC voltage. The diode performs the function of a rectifier element using forward bias. Important parts of the voltage rectifier circuit are voltage reducers (transformers), wave rectifiers (diodes), and filters (capacitors). The two basic types of wave rectifiers are half-wave rectifiers and full-wave rectifiers [9]. Schotky HSMS 286 diode.

One type of diode that can function at low voltages is the Schottky diode. Schottky diodes, in contrast to ordinary diodes, can operate at an input voltage of 0.15-0.45 volts, in contrast to 0.7-1.7 volts for ordinary diodes. Schottky diodes can also operate between 0 and 5 GHz. To say that Schottky diodes are diodes that operate at high frequencies.

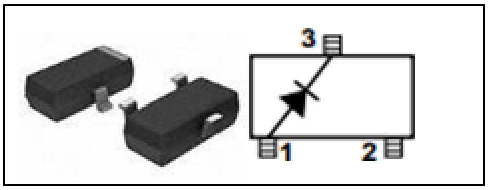

Figure 4. *Diode Schottky* [10]

Antenna Dimension Calculation Results

Tabel 2.1 Antenna Dimensions of the Calculation Results

No.	Dimension	Value (mm)	Information
1.	α	16,42	Radius antenna
2.	Yo	9,852	length slot inset feed
3.	Wo	2.99	Transmission Line Wide
4.	Lo	14,41	Transmission line length
5.	L	42,44	Ground plane length
6	W	42,44	Groundplane Wide

Research Flowchart

Flow of Design and Serial Creation of Rectenna In this final Project, Figure 5 illustrates the process of designing and manufacturing rectenna. Next, select antenna specifications, such as operating frequency, substrate type, and patch and groundplane size. Ansoft HFSS 13.0 software was then used to simulate the antenna. Next, create a rectifier using the n-stage voltage multiplier method, which requires a number of electronic components, including active components (diodes) and passive components (capacitors) The working frequency of the rectenna is used to determine which electronic components to use. A rectifier that converts the dc output of the antenna into a shape that can be measured by the AVO meter, serialized with the antenna to increase the output.

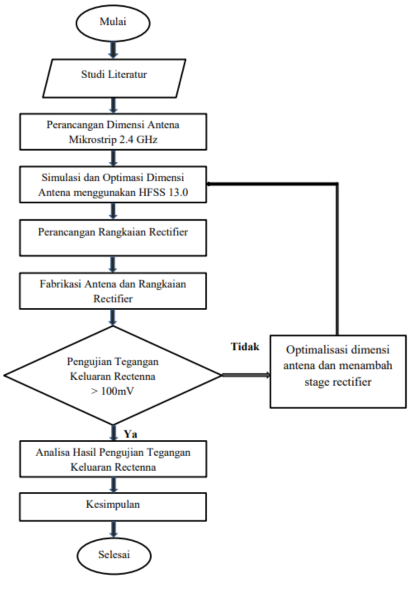

Figure 5. Flowchart Proposed schematic

Prepare the equipment needed in making this research such as Collecting all data from various reference sources such as books, journals, articles and other sources related to the design of this circular patch microstrip antenna . Before designing using software, it begins with doing antenna calculations to determine antenna dimensions.

The design of a circular patch microstrip antenna with HFSS software is carried out through several stages, starting with patch design by creating substrates and groundplanes, designing supply channels by combining patches with insert feed channels, designing ports by entering coordinate values and designing boundaries with the material becoming water (air) by entering its coordinate value.

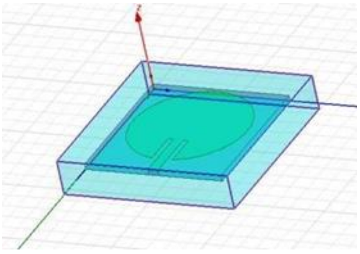

Figure 6. Antenna Design on HFSS Software Simulation

Antenna simulation

Simulates an antenna design with a frequency of 2.4 GHz, the highest number of phases needed, and the highest possible delta S value. Set the sweep type to fast and the frequency of the adjustment type to a linear step after that to edit the sweep window. In addition, its size is 0.01 GHz and its frequency is set between 2 and 3 GHz. If the design you want, select analyze all from the HFSS menu bar. It is necessary to do a lot of optimization if the simulation design is not as desired.

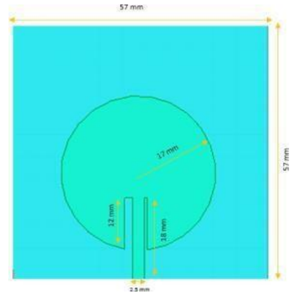

Figure 7. Optimized Antenna Design

Antenna Fabrication

Fabricate the results of antenna optimization that has been done by preparing tools and materials, cutting double layer PCB according to antenna size, attaching sticker paper that has been printed using corel draw, dissolving double layer PCB with solution (H3, HCL, H2O2), cleaning the solution with water and applying the sticker paper, connect the female SMA connector to the port Antennae by soldering on the *patch*. After that, take antenna measurements to get parameter values with measuring instruments that suit your needs.

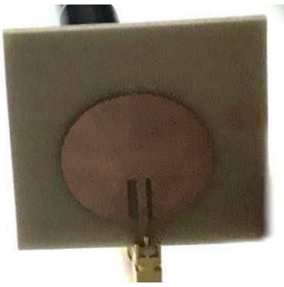

Figure 8. Antenna Fabrication Results that have been assigned port connectors

RF Harvester Design and Fabrication

After troubleshooting *the* design of the rectitifier circuit, the next step is to fabricate the RF Harvester by making an RF Harvester circuit using eagle software so that the layout can be arranged. After that, printing the layout onto the PCB is then dissolved and paired with components and soldering is done so that the RF Harvester circuit can be tested.

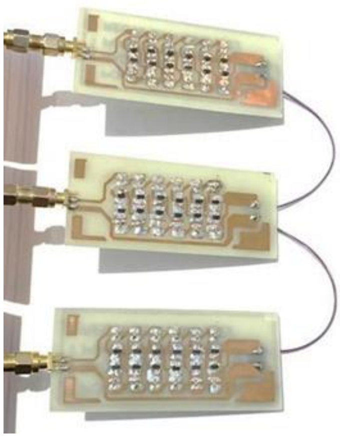

Figure 9. RF Harvester Seial Series

III. RESULT AND DISCUSSION

A. *Antenna Measurement Results*

To compare the antenna parameters obtained from the Ansoft HFSS 13.0 simulation with the actual measurements, antenna measurements were carried out. The desired antenna parameters, namely return loss, VSWR, and radiation patterns, are obtained through direct antenna measurements.

Return Loss Measurement

From Figure 10, it can be seen that the antenna return loss measurement uses Network Analyzer on antenna 1 with a blue line of -26.29 dB at a frequency of 2.425 GHz, antenna 2 with a red line of -21.75 dB at a frequency of 2.365 GHz, and antenna 3 with a green line of -28.57 dB at 2.485 GHz.

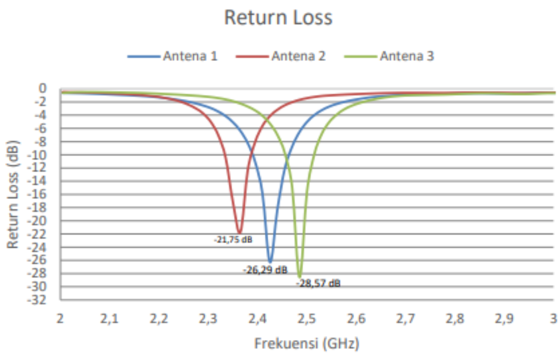

Figure 10. Antenna return loss measurement

VSWR Measurement

VSWR measurements are related to the reflection coefficient of an antenna. In general, the parameter values in a good VSWR are $1 \leq VSWR \leq 2$. The results of antenna VSWR measurements can be seen in figure 11.

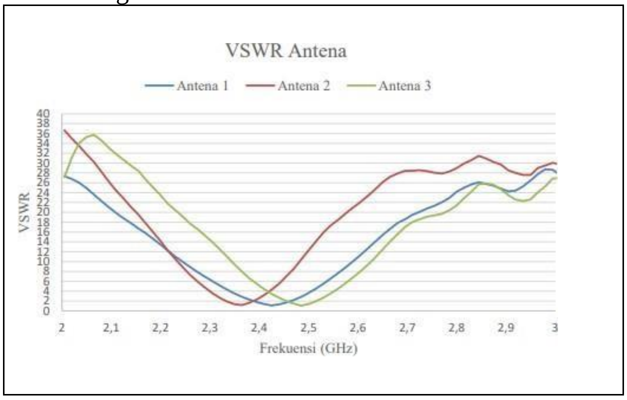

Figure 11. Antenna VSWR Measurement Results

Radiation Pattern Measurement

When the antenna is designed, measurements are taken to determine the direction of the wave beam. The antenna signal beam pattern is focused in only one direction according to the findings of polarization measurements made during antenna fabrication, namely unidirectional and bidirectional.

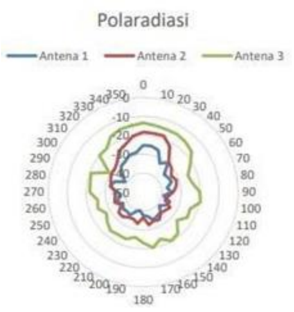

Figure 12. Fabricated Antenna Radiation Pattern

In measuring the radiation pattern for antenna 1, namely on the blue line, the radiation pattern is unidirectional, for antenna 2, which is on the red line, the antenna radiation pattern almost resembles the radiation pattern of antenna 1, which is *unidirectional*, while for antenna 3, which is on the green line, *the radiation pattern is* bidirectional .

B. *Antenna Simulation Results Using HFSS 13.0 Software*

This simulation is carried out to physically design an antenna with antenna parameters that match the desired specifications. The parameters seen during the simulation are *return loss*, VSWR, and radiation patterns.

Return Loss Simulation

To get the frequency that matches the patch, and the frequency that matches the specifications, several times optimization of the *patch* size is carried out by increasing its size. So that the *best return loss* during simulation is -24.66 dB at a frequency of 2.4 GHz as seen in figure 13.

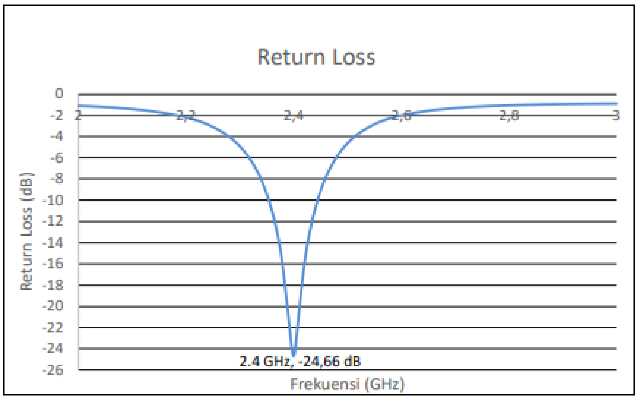

Figure 13. Antenna Return Loss Simulation Results

VSWR Simulation

In addition to affecting the return loss value, antenna dimension optimization also affects VSWR parameters. The VSWR value obtained during the simulation meets the criteria of a good antenna of 1.01 which works at a frequency of 2.4 GHz as shown in figure 14.

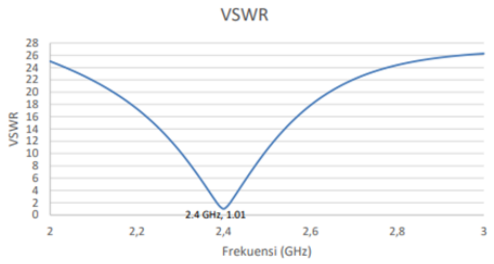

Figure 14. Antenna VSWR Simulation Results

Pattern Radiation Simulation

The antenna parameters determined during the next simulation are radiation patterns. The results of the simulation antenna radiation pattern that has been optimized form a *unidirectional radiation pattern* for a frequency of 2.4 GHz. This means that the simulated antenna has a transmit power that focuses in one direction can be seen in figure 15.

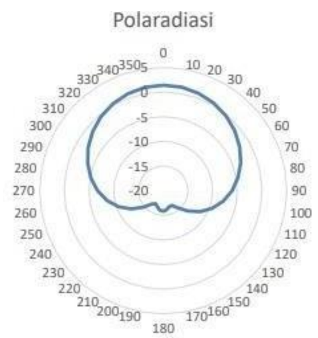

Figure 15. Simulated antenna radiation patterns

IV. CONCLUSION

From the design and testing of a circular antenna patch microstrip rectifier serial for RF energy harvesting in this final project it can be concluded that:

1. It has been designed circular microstrip patch antenna with a ground size of 57x57 mm and a frequency of 2.4 GHz.
2. To design the rectifier, a 6-stage voltage multiplier model was used. At a distance of 25 cm from the transmitter source, a single system produces a voltage of 50 points 1 mV, and a serial receiver produces a voltage of 151 points 8 mV.
3. Network analyzers, RF generators, and spectrum analyzers are used in the creation of the antenna measurement process, which produces results for circular patch antennas operating at a 2-point frequency of 42 GHz.
4. Bandwidth 60 MHz, 60 MHz, and 50 MHz, as well as directional polarization, are present at 2.36 GHz

and 2.48 GHz respectively. Return loss values are -26,29 dB, -21.75 dB, and -28.57 dB respectively..

REFERENCES

[1] Ansoft Corporation, (2005). User's guide High Frequency Structure Simulator. Pittsburgh USA. Tanansyah. Fraga, Ansini. Putri, & Ibnutoro. Santoso 24 Jam Mahir Ansoft HFSS. ISTN http://www.ansys.com/products/electronic s/ansys-hfss di download 9Februari 2017 http://www.etcs.ipfw.edu/~lin/IEEE-FortWayneSection/TechMeeting/ANSYS_HighPowerElectronicsDesign_ZTANG.pdf di download 10 Februari 2017

[2] Adi, M., & et.al. (2016). An Optimized Ink-Reducing Hollowed-Out Arm Meander Dipole Antenna Structure for Printed RFID Tags. International Journal of Microwave and Wireless Technology.

[3] Balanis, C. A. (2016). Antenna Theory: Analysis and Design 4th ed. John Wiley & Sons, INC

[4] Beenamole, K. S. (2009). Microstrip Antenna Designs for Radar Applications. DRDO Science Spectrum.

[5] Bullock, L., & et.al. (1971). An Analysis of Wideband Microwave Monopulse Direction Finding Techniques. IEEE Transactions on Aerospace and Electronic System Vol. 7, 188-203.

[6] Chongyi, Y., & et.al. (2017). Bandwidth-Enhanced Compact Meander Printed Dipole Antenna. ACES Journal, 310-317.

[7] Clarricoats, P., & Elliot, R. (1981). Multimode Corrugated Waveguide Feed for Monopulse Radar.

IEEE Proc. H, Microwave. Opt. Antennas, 102-110

[8] Cohn, S. (1968). A Class of Broadband Three-Port TEM-Mode Hybrids. IEEE Transactions Microwave Theory Technic, 110-116.

[9] Sun, H., Guo, Y. X., He, M., & Zhong, Z. (2013). A dual-band rectenna usingbroadband yagi antenna array for ambient rf power harvesting. IEEE Antennas and Wireless Propagation Letters, 12, 918–921. https://doi.org/10.1109/LAWP.2013.2272873

[10] Toudeshki, A., Mariun, N., Hizam, H., Izzri, N., & Wahab, A. (2014).Development of a New Cascade Voltage-Doubler for Voltage Multiplication. Chinese Journal of Engineering, February, 1–6. https://doi.org/dx.doi.org/10.1155/2014/948586

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