

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. Antenna 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.

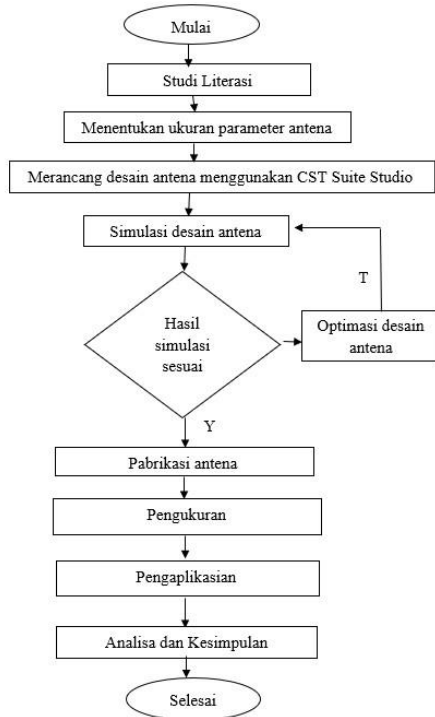


Figure 1 Flowchart antenna planning

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.

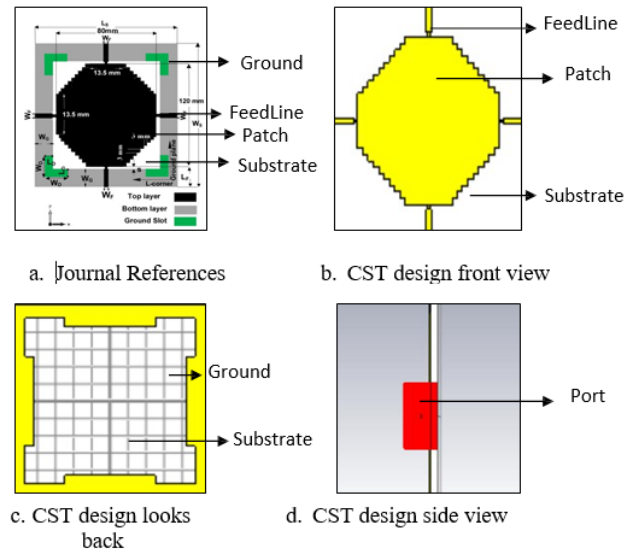


Figure 2 Antenna Design

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.

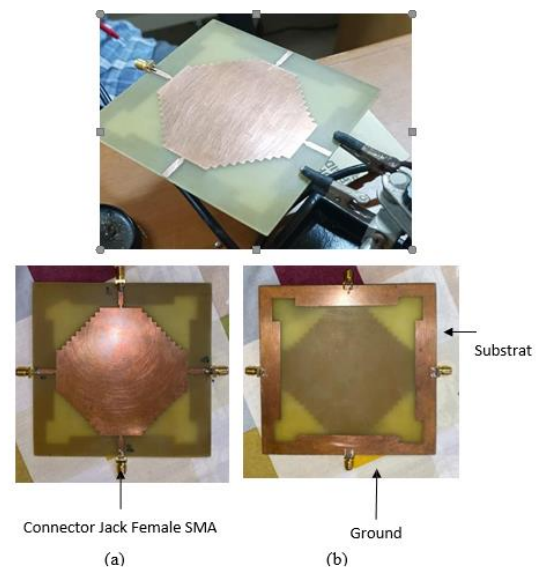


Figure 3 Antenna design offered (a) front view (b) rear view

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	Slot Size	
	Substrate/Ground	Referensi (Paper)	Modification
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.

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.

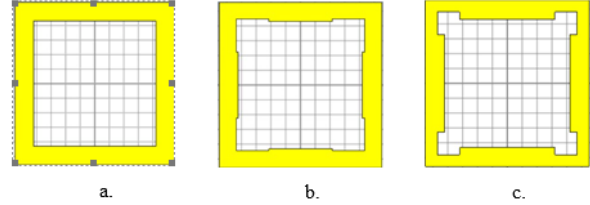


Figure 4 (a). Antenna Without Slot (b). Antenna Reference Slot LD=1.5 WD=20 (c). Slot antenna LD=5 WD=15

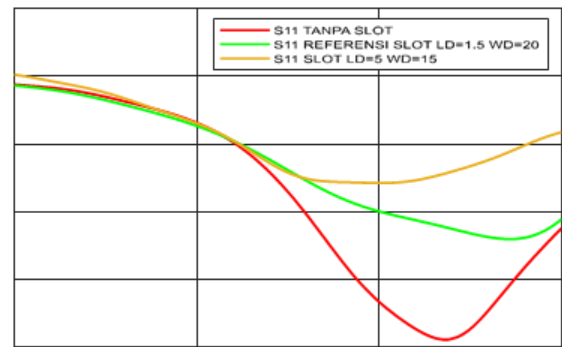


Figure 5 S11 Simulation Results

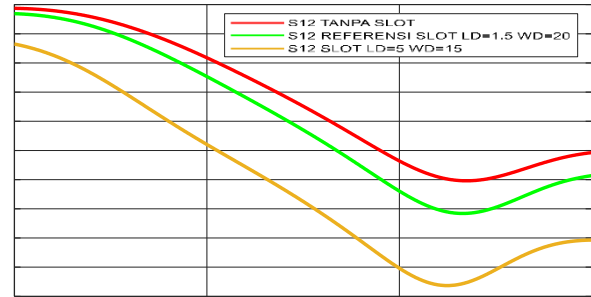


Figure 6 S12 Simulation Results

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.

III. RESULTS AND DISCUSSION

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.

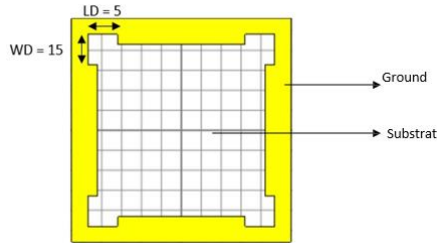


Figure 7 Antenna Optimization Results Design

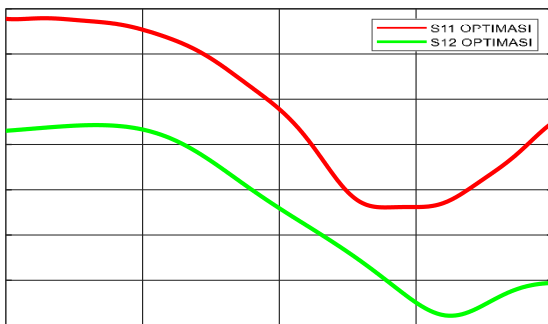


Figure 8 Antenna Simulation Results After Optimization

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.

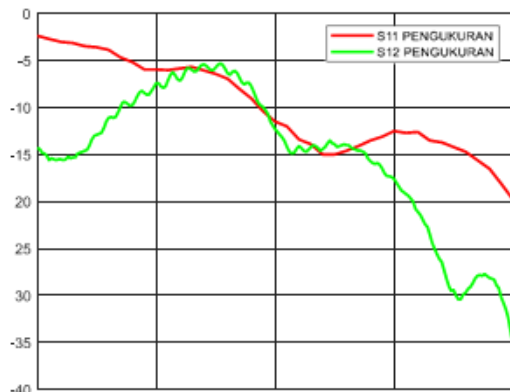


Figure 9 Measurement Results

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 permittivity of the antenna material that is fabricated which causes inequality in parameter values from measurement and simulation results.

E. Return Loss Comparison

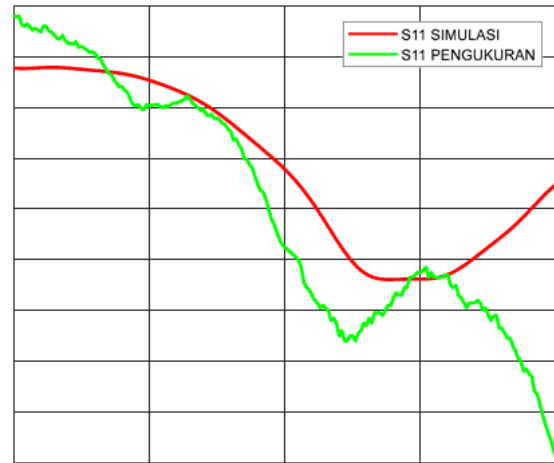


Figure 10 Return Loss Comparison

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

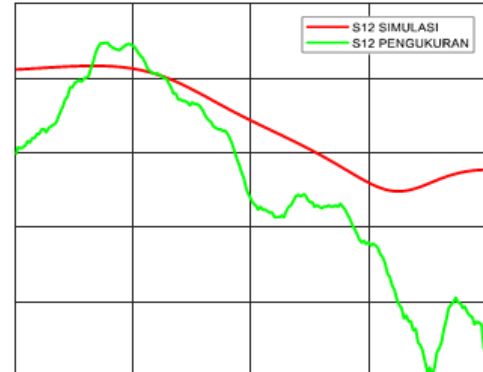


Figure 11 Voltage Standing Wave Ratio (VSWR) Results

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.

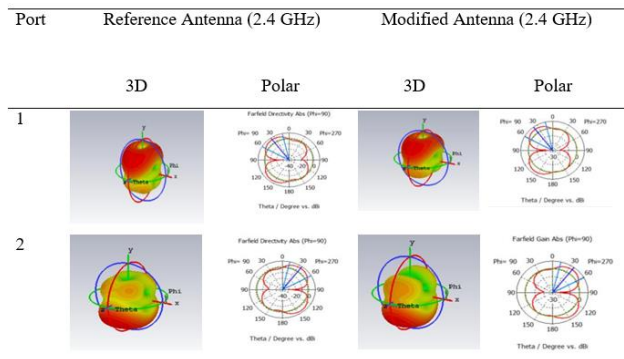


Figure 12 Comparison of radiation patterns

H. Insulation Comparison

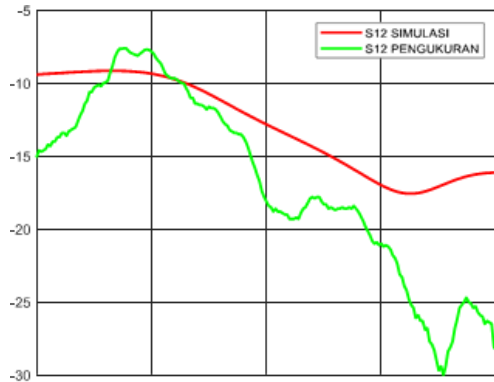


Figure 13 Insulation Comparison

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

	Angle distance			
10	30° 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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