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International Design and Development of a 1x4 Microstrip Monopole Antenna Array at 5 GHz U-NII-2A Bands (5150 - 5350 MHz) For Wireless Fidelity Devices

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Abstract*— High-fidelity antennas are necessary due to the quick advancement of wireless communication technology, particularly for Wireless Fidelity (Wi-Fi) networks. Low antenna gain and a short signal range are two issues that frequently arise in Wi-Fi networks and can degrade the quality of data transmission. Consequently, an antenna design that can increase the overall system fidelity is required, particularly in the 5 GHz frequency band that is frequently utilized by Wi-Fi modem devices. This final project involves designing and developing a 1x4 microstrip monopole antenna array for Wireless Fidelity (Wi-Fi) devices that operate at the 5 GHz U-NII-1 and U-NII-2A bands (5150–5350 MHz). In order to facilitate Wi-Fi data transmission, this design aims to create an antenna with a higher gain, denser bandwidth, and appropriate radiation coverage. CST Studio Suite 2019 software was used to carry out the design on an FR4 substrate that was 1.6 mm thick and had a dielectric constant of 4.3. A Vector Network Analyzer (VNA) was then used to simulate, optimize, fabricate, and measure the design. With a simulated return loss of -51 dB, a VSWR of 1, and a bandwidth of 1 GHz with a bidirectional radiation pattern, the simulation and measurement results of the antenna demonstrate good performance. According to the measurement results, the bandwidth is 1.1 GHz, the VSWR is 1.2, and the return loss is -20 dB. The simulation and fabrication results demonstrate good suitability and conform to the requirements for creating Wi-Fi microstrip antennas.

***Keywords*— Microstrip antenna; monopole; array; Wi-Fi; gain; 5 GHz.**

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I. INTRODUCTION

In the current digital era, Wi-Fi is becoming a more common internet feature among the general public [1]. Wi-Fi has emerged as a crucial infrastructure in a variety of locations, including homes, schools, hotels, and more [2]. According to the latest data from PT. Telkom Indonesia (2025), the number of IndiHome customers increased by 10.4% over the course of a year, or roughly 9.8 million customers. This illustrates that Wi-Fi is not only an essential component but also a primary solution in the digital age, as evidenced by the growing number of users every year [3]. This trend highlights the increasing reliance on high-speed internet for various activities, from remote work and online education to streaming and gaming. As connectivity becomes more integral to daily life, service providers are likely to continue expanding their offerings to meet this rising demand. However, as the number of connected devices increases, new issues arise, such as slower upload and download speeds, higher packet loss and delay, lower throughput, and slower bandwidth [3], [4].

One solution to this problem is 5 GHz Wi-Fi technology, which operates effectively using the 5 GHz frequency [3]. To take advantage of this, an antenna that can function efficiently at the above-mentioned frequency is required. Microstrip antennas are one of the most widely used solutions. These antennas are known for their compact design, high production costs, and ease of integration with modern technology [5]. However, microstrip antennas also have several limitations, one of which is slow bandwidth [6].

Therefore, it is necessary to develop microstrip antennas that can be used with a wide frequency band, particularly using ultra-wideband (UWB) microstrip antennas [5]. UWB microstrip antennas are a type of antenna that can convert weak antennas into wideband antennas, thereby reducing the number of antennas required [7]. Based on research conducted by Ghouz et al. (2020), a UWB microstrip antenna with an FR4 frequency operating at 5 GHz for Wi-Fi transmission produced results of -58 dB return loss, Voltage Standing Wave Ratio (VSWR) 1, gain 2.2 dB, and bandwidth 1 GHz [8]. However, the gain obtained from the research conducted is still minimal. High gain means that the antenna can produce high-quality signals and high sensitivity [9].

As a result, this study proposes a solution to increase gain by scanning microstrip antennas using the array method [10]. The array configuration used, namely 1x4, was chosen because the horizontal orientation of the array can increase signal intensity in the horizontal plane. This is more suitable for the frequency characteristics of 5 GHz wireless Wi-Fi, which is generally used for inter-device communication in the horizontal plane. Conversely, the 4x1 configuration consistently produces a flat surface area, which is more suitable for applications involving inter-building communication or systems that require vertical distribution. Therefore, the 1x4 configuration was chosen to ensure better antenna performance when using Wi-Fi, which is typically done in the horizontal plane.

An antenna is a device that serves the purpose of efficiently detecting or receiving electromagnetic radiation [11]. The antenna's function is to make electromagnetic waves, electricity, or similar [12]. There are a few things that should be considered when analyzing an antenna, including the desired radiance shape and direction, the polarization, the working frequency, the bandwidth, and the input impedance [13]. There are several types of antennas, including yagi, grid, parabola, helix, sectoral, whip, and microstrip antennas [14].

There are two antenna systems: transmitter and receiver systems. Transmitter antennas are designed to transmit electromagnetic signals. On the other hand, receivers are ready to receive the intended signals. [15]

A microstrip antenna is a type of antenna made from PCB and can operate at very high frequencies [16]. This type of antenna has several advantages over other types, including light weight, ease of production, and compact dimensions [17]. Based on these characteristics, microstrip antennas are well suited for modern communication technologies, allowing their integration with various small-scale telecommunication devices [18]. Various applications, such as wireless communication systems, satellite communication systems, cellular communication systems, and other communication systems, use microstrip antennas [19].

Return loss can also be described as transmission impedance because it is not as strong as load impedance. The return loss specification is less than -10 dB. Therefore, return loss becomes less favourable. As a result of the increased amount of loss that occurs, devices such as antennas can function effectively and similarly [20].

II. METHODS

A. *Tools and Materials*

To design and calculate antenna parameters prior to fabrication and measurement, computers or laptops with CST STUDIO SUITE 2019 software are required. The fabrication process utilizes PCBs and a few additional solvent materials.

B. *Antenna Specifications*

The antenna used in this study is a 1x4 microstrip monopole array antenna that operates by receiving and transmitting electromagnetic signals at a frequency of 5 GHz. The microstrip antenna design must have a VSWR of approximately two so that a high VSWR can provide a good balance between the antenna and the transmission line, allowing data to be transferred efficiently from the transmitter to the antenna without much reflection. CST Studio Suite 2019 was used for design and simulation. The antenna specifications include an operating frequency of 5 GHz, return loss ≤ -10 dB, VSWR ≤ 2, gain > 2 dBi, and impedance of 50 Ohms. The substrate material used is FR-4 with a dielectric constant of 4.3 and a thickness of 1.6 mm.

c. *Antenna Design*

The first step is to measure the dimensions of the antenna, namely its width and length. Based on the test results using the same dimensions as the antenna, a substrate with a length of 70 mm and a width of 95 mm was used. Next, the ground plane is 21.95 mm long and 70 mm wide. The results of calculations using the antenna dimensions mentioned above produce various parameters that will be optimized through parametric studies. The results of the study using the initial antenna dimensions are shown in the table below.

TABLE 1
ANTENNA PARAMETER

Dimension	value
LG1	21.95
LSUB	70
LW	6
LW0	48.4
LW1	8
LW2	29
LW3	7.4
LW4	24.4
LW5	4.6
TS	1.6
Dimension	**value**
TT	0.035
W	2.89
W0	1
W1	3
W2	4.25
W3	1.2

W4	1
W5	1
WSUB	95

The length and width dimensions of the patch elements and the ground plane of the antenna elements to be simulated are determined based on the results of the equation calculations that have been performed. The 1x4 microstrip monopole array antenna then undergoes the process of designing the overall dimensions of the antenna. Determining the antenna frequency is the next step in designing a microstrip patch antenna after the antenna element dimensions have been obtained. The 1x4 microstrip monopole array antenna operates at a frequency of 5 GHz. The units used in the design are shown below. The following figure illustrates the use of gigahertz (GHz) frequency units, millimeter (mm) length units, and nanosecond (ns) time units in this design.

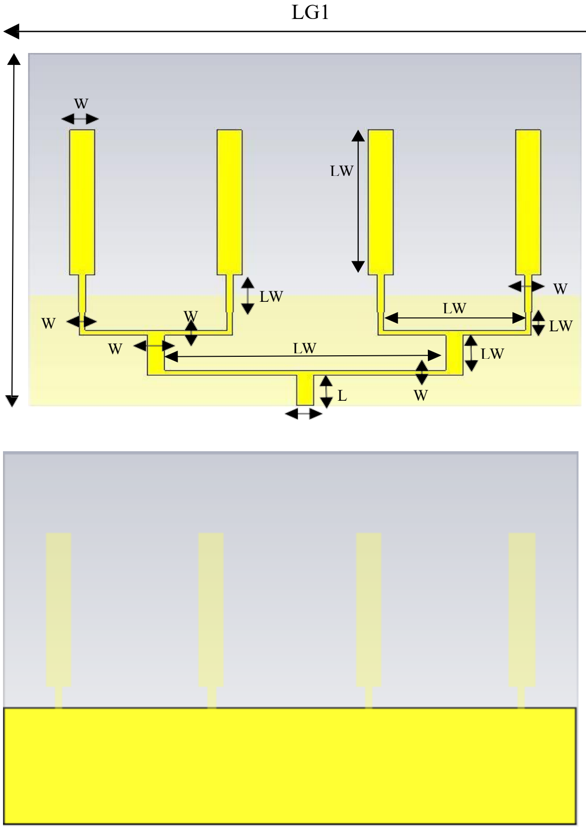
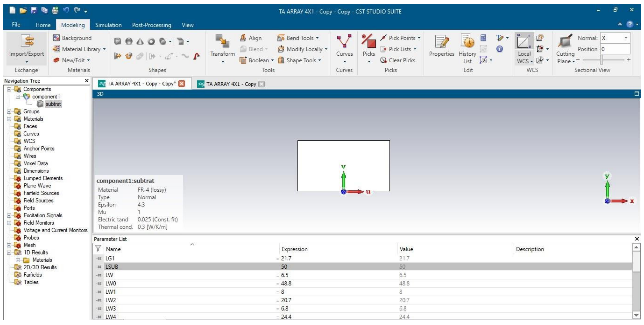


Fig. 1 Desain Antenna

III. RESULTS AND DISCUSSION

A. Design in CST

In the simulation process of a microstrip patch antenna at a frequency of 5 GHz, the antenna dimensions discussed earlier will be modeled and simulated using CST STUDIO SUITE 2019 software. Based on the simulation results, key parameters such as VSWR (Voltage Standing Wave Ratio), return loss, and radiation patterns will be analyzed and determined accurately, the design can be seen below.

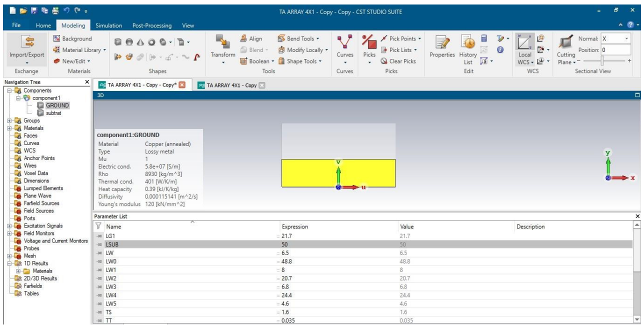


component1:subtrat

Material	FR-4 (lossy)
Type	Normal
Epsilon	4.3
Mu	1
Electric tand	0.025 (Const. fit)
Thermal cond.	0.3 [W/K/m]

Name	Expression	Value	Description
LG1	21.7	21.7	
LSUB	50	50	
LW	6.5	6.5	
LW0	48.8	48.8	
LW1	8	8	
LW2	20.7	20.7	
LW3	6.8	6.8	
LW4	24.4	24.4	

Fig. 2 Results of Substrate

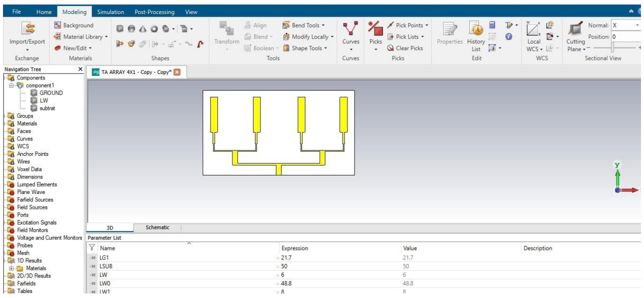


component1:GROUND

Material	Copper (annealed)
Type	Lossy metal
Mu	1
Electric cond.	5.8e+07 [S/m]
Rho	8930 [kg/m^3]
Thermal cond.	401 [W/K/m]
Heat capacity	0.39 [kJ/K/kg]
Diffusivity	0.000115141 [m^2/s]
Young's modulus	120 [kN/mm^2]

Name	Expression	Value	Description
LG1	21.7	21.7	
LSUB	50	50	
LW	6.5	6.5	
LW0	48.8	48.8	
LW1	8	8	
LW2	20.7	20.7	
LW3	6.8	6.8	
LW4	24.4	24.4	
LW5	4.6	4.6	
TS	1.6	1.6	
TT	0.035	0.035	

Fig. 3 Results of Ground Plane



Name	Expression	Value	Description
LG1	21.7	21.7	
LSUB	50	50	
LW	6	6	
LW0	48.8	48.8	
LW1	8	8	

Fig. 4 Results of Manufacturing a 1x4 Microstrip Monopole Antenna Array

B. Fabrication Results

The manufactured antenna is made of FR-4 Lossy substrate. The materials used in the manufacturing process are PCB and female SMA connectors. The manufacturing process of the metamaterial patch antenna can be seen in the illustration below.

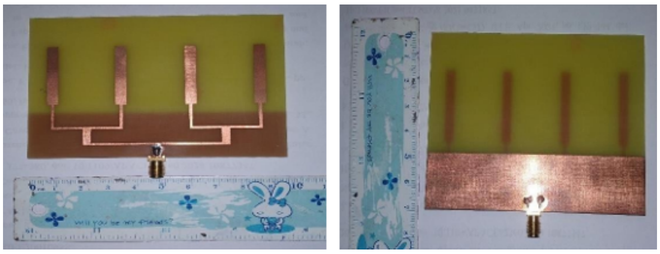


Fig. 5 Results Fabrication Antenna

C. Measurement of Return Loss

Fig. 6 Results of S-Parameter Simulation

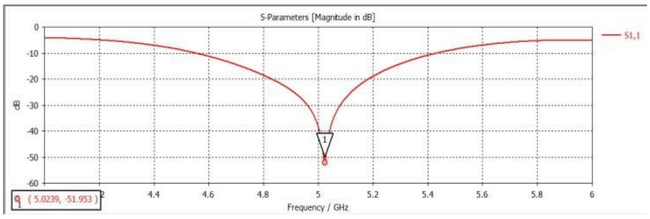


Fig. 7 Results of S-Parameter Measurement

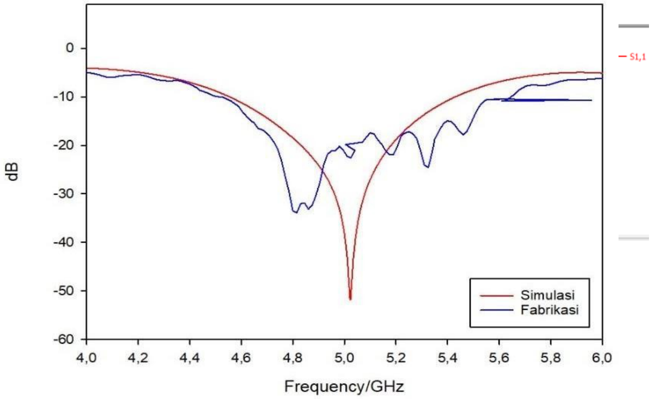


Fig. 8 Bandwidth from Simulation Results

The optimization results show a return loss value of -51.569 dB at a frequency of 5 GHz. This return loss value indicates excellent antenna performance in minimizing power reflection. The bandwidth obtained after optimization is 1 GHz or 1000 MHz, which is calculated from the difference between the highest frequency (5.4303 GHz) and the lowest frequency (4.5534 GHz) at a reception power of -10 dB. The bandwidth parameter is used to evaluate the operating frequency range of the antenna that can work well. Bandwidth measurements aim to determine the width of the antenna's working frequency coverage. A comparison of the bandwidth results from simulation and measurement shows the conformity between the theoretical design and practical implementation.

D. Measurement of VSWR

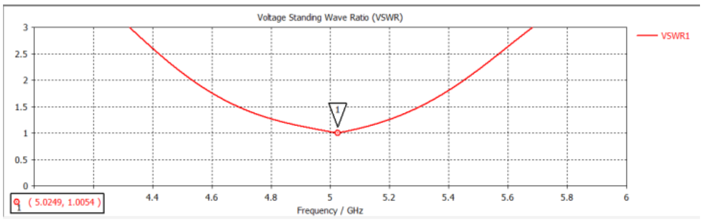
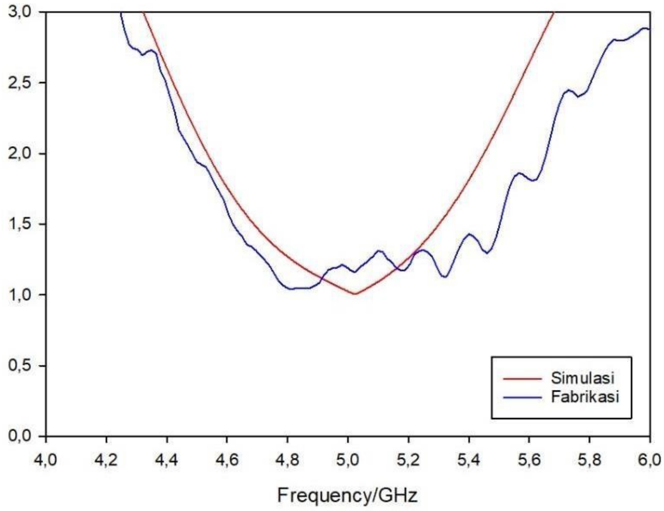


Fig. 9 Results of VSWR Simulation

Fig. 10 Results of VSWR Measurement

Based on the image above, the simulated VSWR value shows better performance than the fabricated antenna. At a frequency of 5 GHz, the simulated antenna produces a VSWR value of 1.0054, while the fabricated antenna has a VSWR value of 1.2. Although there is a difference between the two results, both meet the standard for good VSWR, which is ≤ 2. A VSWR value close to 1 indicates that the antenna has good impedance and minimizes wave reflection. Thus, the results of the microstrip antenna optimization in this study have met the desired parameters and show the compatibility between the simulation design and the fabrication implementation.

E. Measurement of Gain



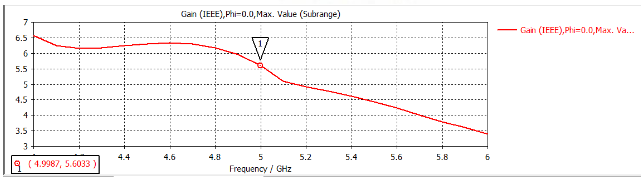


Fig. 11 Simulation Results of Gain

Gain can also be defined as an antenna characteristic that has the ability to measure the signal radiation produced by the antenna itself, or as a signal received from a direction. The simulation results shown in Figure 15 indicate that the maximum gain for a 1x4 microstrip array antenna at a frequency of 5 GHz is 4.181 dB.

F. Measurement of Radiation Patterns

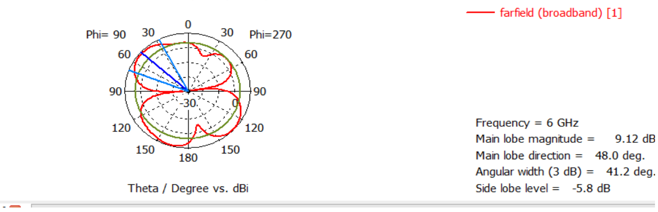


Fig. 12 Results of Radiation Pattern Simulation

The radiation pattern is a representation of the electromagnetic radiation emitted by a previously installed antenna. Based on the simulation results, the antenna radiation pattern is bidirectional, meaning that the antenna transmits signals in two directions at an operating frequency of 5 GHz, as shown in the illustration above. This bidirectional radiation pattern indicates that the antenna's radiation energy is distributed as evenly as possible in two main directions, in accordance with the characteristics of the microstrip patch type for length.

IV. CONCLUSION

The 1x4 monopole microstrip array antenna has been successfully designed and manufactured using the Lunak CST Studio Suite 2019 with fabrication results of 95 mm × 70 mm × 1.6 mm. This antenna uses the FR-4 (lossy) substrate with a dielectric constant of about 4.3.

Based on the simulation results, the antenna parameters determined are a return loss of -51 dB, a gain of 5.6 dB, a standing wave ratio (VSWR) of 1, and a frequency bandwidth of 1 GHz. In contrast, the test results on the manufactured antenna show a reflection loss of approximately -20 dB, a VSWR of approximately 1.2, and a bandwidth of approximately 1.1 GHz. Although there are numerical differences between the simulation and measurement results, both results are still within acceptable limits and meet the specified specifications.

Several factors can cause differences in values between simulation and measurement, including inconsistencies between two types of materials, low-quality connector soldering, and the influence of environmental conditions during the measurement process. Overall, the successfully installed 1x4 microstrip monopole array antenna performs well and meets the requirements for applications at 5 GHz.

REFERENCES

[1] R. Wijayanti, I. F. Addina, and E. Prawoto, “Pengaruh Kepuasan Konsumen, Switching Cost, Dan Kepercayaan Merek Terhadap Loyalitas Konsumen Pengguna Wifi Indihome Di Kecamatan Leksono,” *J. Akuntansi, Manaj. dan Perbank. Syariah*, vol. 4, no. 5, pp. 68–74, 2024, doi: 10.32699/jamasy.v4i5.8243.

[2] I. Nirkabel, W. Pt, and D. Teknologi, “22045-Article Text-83608-1-10- 20241001,” vol. 21, no. 2, pp. 274–279, 2024.

[3] F. Dan and S. Evaluasi, “ANALISIS PERFORMA JARINGAN WLAN PADA,” vol. 13, no. 3.

[4] Yusantono, “Analisis dan Perbandingan Jaringan WiFi dengan frekuensi 2.4 GHz dan 5 GHz dengan Metode QoS,” *J. Inf. Syst. Technol.*, vol. 05, no. 05, pp. 34–52, 2020.

[5] W. Azmi, N. Pratama, T. I. Suharto, and M. M. Sukma, “Rancang Bangun Antena Microstrip Ultra Wide-Band Menggunakan Metode Defected Ground Structure (Dgs) Pada Frekuensi 6 Ghz,” pp. 1–12, 2023.

[6] B. Bagus, M. A. Aditiyawarman, N. Pambudiyatno, and Y. Suprapto, “Desain Antena Mikrostrip Rectangular Array 2X1 Untuk Radar Kapal,” *J. Penelit.*, vol. 6, no. 3, pp. 159–172, 2021, doi: 10.46491/jp.v6i3.584.

[7] Harfan Hian Ryanu, Dhoni Putra Setiawan, and Edwar, “Desain Antena Mikrostrip UWB dengan Peningkatan Lebar pita dan Karakteristik Triple Notch Band,” *J. Nas. Tek. Elektro dan Teknol. Inf.*, vol. 10, no. 3, pp. 249– 256, 2021, doi: 10.22146/jnteti.v10i3.1878.

[8] H. H. M. Ghouz, M. F. Aboee, and M. Aly Ibrahim, “Novel wideband microstrip monopole antena designs for WiFi/LTE/WiMax devices,” *IEEE Access*, vol. 8, pp. 9532–9539, 2020, doi: 10.1109/ACCESS.2019.2963644.

[9] S. Munziah, I. Muhammadi, and M. P. K. Praja, “Analisis Pola Radiasi dan Gain pada Antena Cassegrain dengan Frekuensi C-Band,” *J. Telecommun. Electron. Control Eng.*, vol. 6, no. 2, pp. 152–162, 2024, doi: 10.20895/jtece.v6i2.1212.

[10] N. Aulia and Elisma, “Desain Antena Mikrostrip Array 2x4 dengan Teknik PencatuanProximity Coupled untuk Aplikasi 5G pada Frekuensi 2,6 GHz,” *Pros. 12th Ind. Res. Work. Natl. Semin.*, vol. 12, pp. 717–723, 2021.

[11] K. Jones A.S., L. Olivia N., and B. Syihabuddin, “Perancangan Antena MIMO 2×2 Array Rectangular Patch dengan U-Slot untuk Aplikasi 5G,” *J. Nas. Tek. Elektro dan Teknol. Inf.*, vol. 6, no. 1, 2017, doi: 10.22146/jnteti.v6i1.299.

[12] S. N. Posma, M. Yanuar Hariyawan, and A. Khabzli, “Rancang Bangun Antena Mikrostrip 900 MHz,” *Sntiki*, pp. 80–84, 2011.

[13] S. Rezkika, “Rancang Bangun Antena Mikrostrip Patch Segi Empat MultibandPada Frekuensi 2,1 , 2,6 , 2,8 dan 3,3 GHz,” *J. Inform. Dan Peranc. Sist.*, vol. 5, no. 1, pp. 29–36, 2023.

[14] S. Pramono, “Rancang Bangun Antena Microstrip Array 2x2 Frekuensi 2300 MHz,” *J. Tek. Elektro, Politek. Negeri Semarang*, vol. 3, no. 2, pp. 105–113, 2014.

[15] Y. Ikawati, “Sistem Antena Pemancar dan Penerima”.

[16] Y. Christyono, I. Santoso, and R. D. Cahyo, “Perancangan antena mikrostrip array pada frekuensi 850 MHz,” *Transmisi*, vol. 18, no. 2, pp. 87–95, 2016.

[17] Y. Rasiman, M. Muchaddats, D. M. Suryadarma, N. Air, S. Power, and O. Indonesia, “Antena microstrip,” vol. 4, no. 1, 2025.

[18] E. R. R. Briantoko, R. A. Firdaus, D. Dzulkiflih, M. Khoiro, and N. Winarno, “Desain Antena Mikrostrip Dengan T-Shape Bentuk Slot Pada Jaringan Selular 5G,” *Inov. Fis. Indones.*, vol. 13, no. 2, pp. 51–58, 2024, doi: 10.26740/ifi.v13n2.p51-58.

[19] Y. N. Kartikasari, A. Abdullah, M. E. N, D. Cahyono, and B. Bagus, “Analisis Faktor-Faktor yang Mempengaruhi Desain Antena Mikrostrip untuk Radar Altimeter dalam Ilmu Teknik Penerbangan : Bentuk Patch , Bahan Substrat dan Teknik Pembentukan Antena,” *J. Eng. Transp.*, vol. 1, no. 4, pp. 1–9, 2024.

[20] D. M. Handika, “Rancang Bangun Antena Mikrostrip Patch Circular Untuk Aplikasi 5G,” *Data Sci. Indones.*, vol. 2, no. 1, pp. 9–12, 2022, doi: 10.47709/dsi.v2i1.1518.