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Jember – East Java, Indonesia • 27 October 2021

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Preface: The 3rd International Conference on Physical Instrumentation and Advanced Materials (ICPIAM) 2021

Physics Department – University of Jember, Indonesia, 27 October 2021

The 3rd International Conference on Physical Instrumentation and Advanced Materials (ICPIAM) 2021 is a serial international seminar held as a form of collaboration bi-annual event between the Faculty of Mathematics and Natural Sciences, University of Jember and the Faculty of Science and Technology (FST) Universitas Airlangga (UNAIR).

This conference (ICPIAM 2021) was held as a means for academics, scientists and researchers to discuss, share and exchange information, experiences, methods and research findings as well as the latest innovations at the international level. Through this conference, links will also be formed between researchers and academics to establish cooperation and collaboration both in the fields of education and research internationally.

This conference was attended by 60 presenters who have submitted paper from their studies and researches. They come from Japan, Malaysia, and mostly from Indonesia such as (BPPT, LAPAN, UNAIR, UNEJ, ITB, UNAND, UNCEN, and many more). All the presenters will convey their speech in the 6 different parallel rooms as given in the book of abstract. All presented and reviewed paper will be considered to be published at the AIP Conference Proceedings (Scopus indexed proceedings). We deeply thank the authors for their enthusiastic and high-grade contribution.

The 3rd ICPIAM 2021 would not be possible running without the dedicated efforts of many people especially all organizing committee members who have made planning and organizing the programs. We are grateful to IsDB and Jember University for the funding support, also Physics Student Association (HIMAFI) and volunteers who contributed to the various processes that make up the conference and it would not be possible for me to name them all in this short message.

Bowo Eko Cahyono, Ph.D.
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S-shaped microstrip antenna design for 5 GHz WiFi

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Mutmainnah, Khusnah Makhwiyatul, Bowo Eko Cahyono, et al.

S-Shaped Microstrip Antenna Design for 5 GHz Wifi

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Abstract. Microstrip antenna is an antenna made of a thin metal strip capable of working at high frequencies. The microstrip antenna has been widely used in wireless technology, one of for WiFi (Wireless Fidelity) networks. In the study S-shaped microstrip antenna was designed and manufactured for the frequency of 5 GHz. Characteristics of the S-shaped microstrip antenna were determined both by using simulation and measurement based on the microstrip antenna parameters. The microstrip antenna was designed in an S-shaped patch configuration with a small dimension of 3.5 x 3.5 cm using copper (annealed) and the substrate was rectangular using lossy FR-4 material with a thickness of 1.6 mm. This research found that the S-shaped microstrip antenna works at a frequency of 5 GHz with a return loss of -19.076 dB, VSWR is 1.25, bandwidth is 227 MHz (4.54%), and again of 4.28 dBi. The radiation pattern of the E and H fields leads to a bidirectional pattern that emits and receives signals in two specific focal directions. Measurement results then showed that S-Shaped microstrip antenna works at a frequency of 5 GHz with a return loss of -15.33 dB, VSWR is 1.41, a bandwidth of 190 MHz (3.58%). The microstrip antenna can be applied to WIFi of the frequency of 5 GHz.

INTRODUCTION

Today's wireless communication systems use a lot of microstrip antennas because of their light weight and simple structure. Another advantage of microstrip antennas is that they are easy to manufacture and low in cost but have good performance [1]. Microstrip antennas are not only used in the health sector [2], [3] and communication radar [4], [5] but they are also applied to wireless technology.

Microstrip antennas are widely used in wireless technology, one of which is for WiFi (Wireless Fidelity) networks. Wireless Fidelity (WiFi) is one of the developments of wireless networks that work on networks and WLAN (wireless Local Area Network) devices. The WLAN communication standard has been set by the Institute of Electronical and Electronic Engineers (IEEE), namely IEEE 802.11 a/b/g which works at 2.4 GHz and 5 GHz frequencies [6].

Recently researches on the design and manufacture of microstrip antennas have been carried out in order to obtain efficient characteristics of microstrip antennas. Various variations of microstrips have been developed, including the CPS structure. The open loop dipole CPS microstrip design has been carried out with a U-shaped insert at a frequency of 2.4 GHz for WiFi applications [7]. Microstrip antennas can be designed in various shapes by changing or modifying the shape of the patch into various shapes including E-shaped, C-shaped, and S-shaped. The

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S-shaped microstrip in previous researchers was designed horizontally in the 5-6 GHz frequency range [8], the S-shaped with the addition of a ground plane works at a frequency of 2.5 GHz.[9]. Inverted S-shaped microstrip antenna design was applied to X-Band, which works at frequencies of 9.08 GHz, 11.0 GHz, and 11.86 GHz [10]. The triple-S-shaped microstrip antenna can be used for dual band applications that work at frequencies of 5.4 GHz and 5.9 GHz [11].

In this reseach, the design and fabrication of an S-shaped microstrip antenna was performed for the application of 5 GHz WiFi frequency. The S-shaped microstrip antenna was designed with an S-shaped patch configuration using copper (annealed) copper material and a rectangular substrate using lossy FR-4 material with a thickness of 1.6 mm. The properties of the S-shaped microstrip antenna was studied based on the parameters of the microstrip antenna including return loss, bandwidth, VSWR, gain, and radiation pattern.

METHOD

As shown in Figure 1, the microstrip antenna was designed in the shape of the letter S using copper (annealed) copper material and a rectangular substrate using lossy FR-4 material has a dielectric constant of 4.6 with a thickness of 1.6 mm

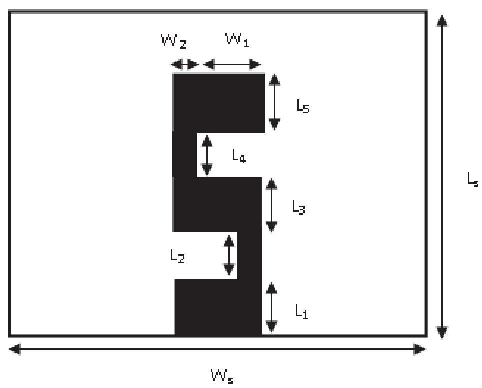

FIGURE 1. S-shaped microstrip antenna design

PSO (Particle Swarm Optimization) method is used in optimizing the patch length (L1, L2, L3, L4, L5) and patch width (W1 and W2) for a working frequency of 5 GHz. Specifications expected from the S-shaped microstrip antenna include either return loss smaller than -10 dB, VSWR smaller than 2, and the highest gain for the frequency of 5 GHz. The dimensions of the optimized S-shaped microstrip antenna at a frequency of 5 GHz are described in Table 1.

TABLE 1. Dimensions of the S-Shaped Microstrip Antenna

Dimensions	Description	Size (mm)
L_1	Patch length L1	5.47
L_2	Patch length L2	5.26
L_3	Patch length L3	6.55
L_4	Patch length L4	6.00
L_5	Patch length L5	6.50
W_1	Patch width W1	4.07
W_2	Patch width W2	1.35
hp	Patch thickness	0.035
Ls	Substrate length	35
Ws	Substrate width	35
hs	Substrate thickness	1.62

The S-shaped Microstrip design is then fabricated based on the specifications as shown in Table 1 and shown in Figue 2. The properties of the S-shaped Microstrip were then measured. The parameters of the S-shaped microstrip antenna were analyzed and compared with the results of the previous simulation. Microstrip antenna parameters analyzed in this research are VSWR, return loss, bandwidth, gain, and radiation pattern.

RESULTS AND DISCUSSION

Figure 2 is an S-shaped microstrip antenna fabricated with the dimensions of the antenna in accordance with Table 1. The characteristics of the parameters of the S-shaped microstrip antenna simulation results and measurement results are shown in table 2.

FIGURE 2. S-shaped microstrip antenna fabrication

TABLE 2. Parameters of S-Shaped Microstrip Antenna

Parameters	Simulation	Measurement
Frequency	5 GHz	5.3 GHz
Return loss	-19.076 dB	-15.33 dB
Bandwidth	227 MHz (4.54%)	190 MHz (3.58%)
VSWR	1.25	1.41

Measurement results showed that parameters of the S-shaped microstrip antenna were slightly different from the simulation results shown in table 2. Based on this comparison, it is known that the working frequency of the measured S-shaped microstrip antenna has shifted, with a difference of 0.3 GHz. In the application, it is difficult to find the same results between simulation and fabrication as also found in two previous studies. In those two studies, the frequency shift were found to be 0.10 GHz [12] and 0.5 GHz [13].

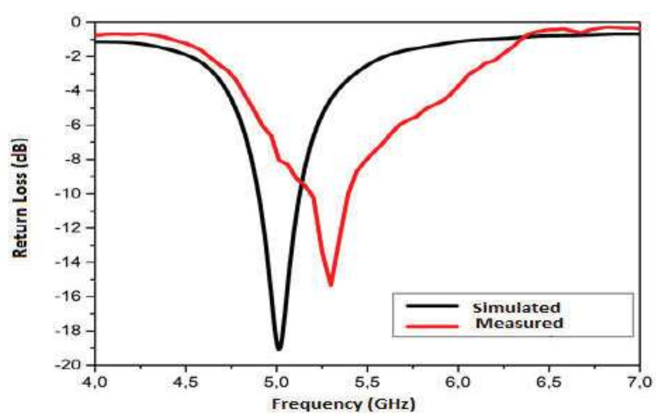

FIGURE 3. Return loss simulation and measurement results

The return loss value from the simulation result was -19,076 dB being smaller than that from the measurement result, which is -15.33 dB. Return loss from the simulation showed that the reflected power was 1.23% and the transmitted power was 98.77%. While the return loss from measurement results showed the reflected power is 2.93% and the transmitted power is 97.07%.

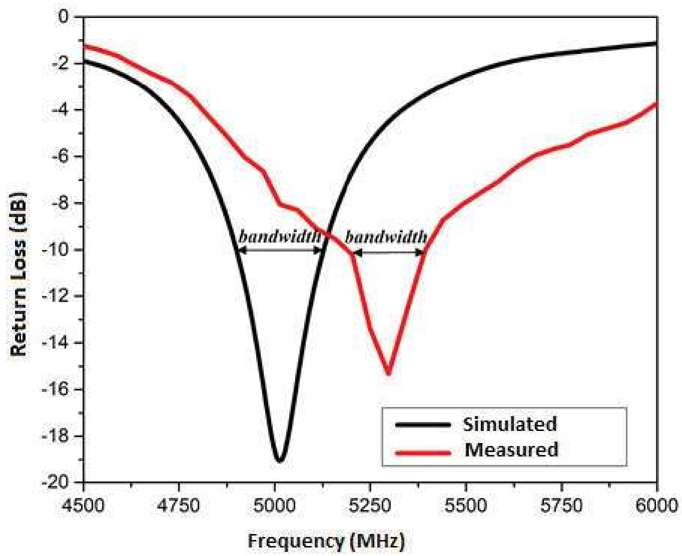

FIGURE 4. Bandwidth simulation and measurement results

Figure 4 shows the bandwidth obtained from the simulation and measurement results. The bandwidth of the simulation results is 227 MHz (4.54%), while the measurement results are 190 MHz (3.58%). The large bandwidth affects the transmission speed, the larger or wider the bandwidth, the faster the power is transmitted. The S-shaped microstrip antenna that has been designed by Zulkifli *et. al* , using a substrate with a dielectric constant of 2.2 and a total thickness of 3.2 mm resulted in a bandwidth of 951.3 MHz at a working frequency of 5.75 GHz. A thick substrate with a low dielectric constant provides a wide bandwidth, but causes a large microstrip antenna volume and increases the possibility of standing wave formation. A thin substrate with a high dielectric constant can reduce the size of the microstrip antenna but produce a smaller bandwidth. The bandwidth value can be increased by adding a ground plane using the PBG structure carried out by Niboriya *et. al* [14]. but the working frequency is 6.14 GHz, it is not for the wifi frequency

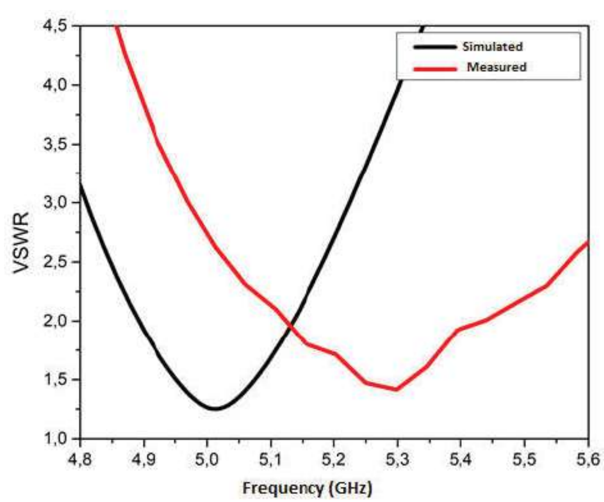

FIGURE 5. VSWR simulated and measured results

The VSWR simulated and measured results are shown in Figure 5. The VSWR value in this research microstrip has a measurement VSWR of 1.41 while the simulation results are 1.25. The smaller VSWR value indicates that the inference wave is getting smaller so that the simulated VSWR value is better than the measurement results. VSWR is a function of the reflection coefficient, which is the ratio between the incident wave and the reflected wave. The reflected wave interferes with the incident wave so that the phase of the incident wave is disturbed by the reflected wave which causes the incident wave to be damaged.

The simulated radiation pattern at a frequency of 5 GHz of E field and H field are shown in Figures 6 and 7 respectively. The radiation pattern shows a bidirectional pattern, namely the antenna transmits and receives signals in two specific focus directions. The area where the largest power radiated from the E field and H field pattern was directed at an angle of 46^o with a power of 15.7 dB and 19.76 dB, respectively. The HPBW (Half Power Beam Width) is around 56^0.

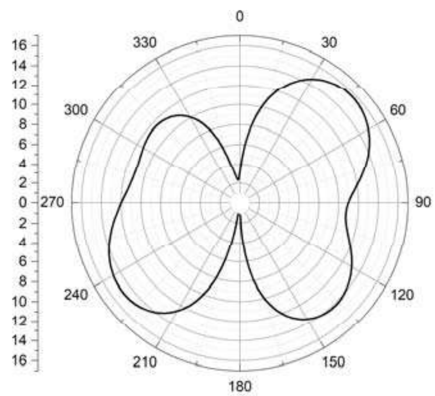

FIGURE 6. Simulation results of the E field radiation pattern at a frequency of 5 GHz

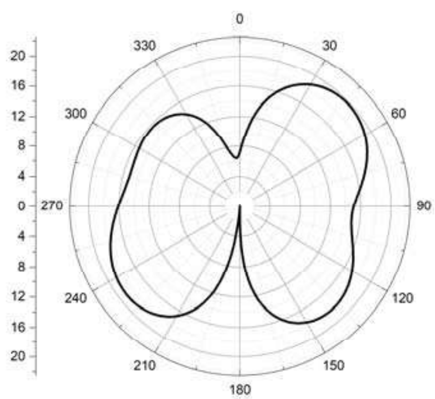

FIGURE 7. Simulation results of the H field radiation pattern at a frequency of 5 GHz

The radiation patterns of E field and H field of the measurement at the frequency of 5 GHz are shown in Figure 8 and Figure 9 respectively. The radiation pattern of the E field and H field measurements has a pattern that is in accordance with the simulation results although it is not smooth, namely the bidirectional pattern. The value of the largest power pattern of the E field leads to an angle of 50^o, which is 14.87 dB with an HPBW value of 65^o. In the H field, the maximum main lobe value leads to an angle of 55^o with a power of 17.84 dB and an HPBW of 65^o. Based on the radiation pattern we can determine the direction of the antenna to get the best signal intensity. HPBW can be described as an area where the antenna can still work well.

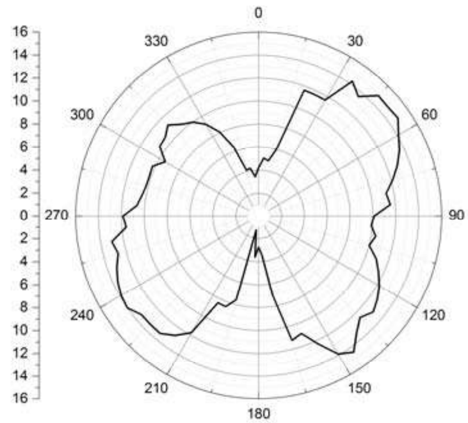

FIGURE 8. Measurement results of the E field radiation pattern at a frequency of 5 GHz

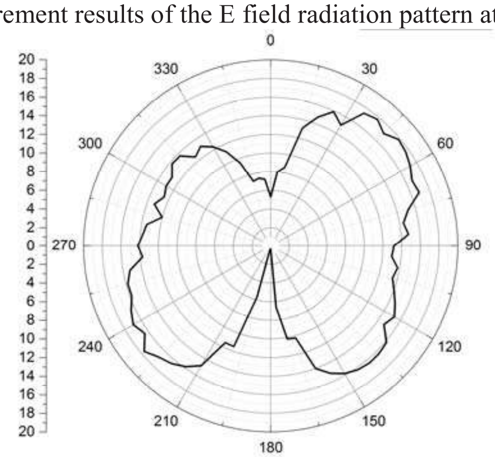

FIGURE 9. Measurement results of the H field radiation pattern at a frequency of 5 GHz

In beside of the propose antenna measured and simulated gain which are shown in Figure 10. The gain valu are shown from 4.5 dB to 5.5 dB at 5 GHz frequency.

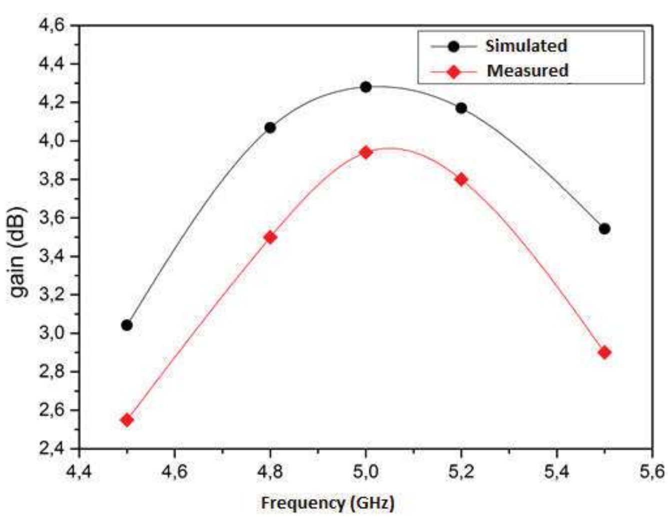

FIGURE 10. Simulation and measurement gain variation graph

Based on the graph in Figure 10. it is known that the gain value at 5 GHz frequency has the highest gain value both simulation and measurement results. The gain of an antenna is affected by the power transmitted. The measured gain is 3.94 dBi, while the simulated gain is 4.28 dBi. This microstrip antenna can be applied to Wifi frequency 5 GHz even though it has a small gain value because the antenna has a return loss of - 15 dB.

CONCLUSION

The S-shaped microstrip antenna was designed and fabricated. The parameters of the S-shaped microstrip antenna obtained from the simulation were frequency of 5 GHz, return loss value of -19.076 dB, VSWR of 1.25, bandwidth of 227 MHz (4.54%), and gain of 4.28 dBi. Meanwhile, the parameters obtained from measurement were frequency of 5.3 GHz, return loss of -15.33 dB, VSWR of 1.41, bandwidth of 190 MHz (3.58%) and gain of 3.94 dBi. This fabricated microstrip antenna can be applied to WiFi.

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REFERENCES

[1] H. Elsadek, "Microstrip Antennas for Mobile Wireless Communication Systems". *Egypt: Electronic Research Institute*, pp 163-187 (2010).

[2] S. Subramanian, B. Sundarambal, and D. Nirma, "Investigation on Simulation-Based Specific Absorption Rate in Ultra-Wideband Antenna for Breast Cancer Detection", *IEEE Sensors Journal*, vol. 18, no.24 (15 December 2018).

[3] L. Wang, "Microwave Sensors for Breast Cancer Detection", *Sensors,* vol 18, no 655, pp 2-17 (2018).

[4] S. R Galaba and V Kumar, Designing Multiband Matematerial Load Microstrip Patch Antenna for SAR Application, *IEEE: International Conference on Microwave and Photonics (ICMAP)*, 11-13 Dec. 2015.

[5] W. Wang, M. Guo, J.Wang and Z. Li, "Miniaturized Antenna with High Gain and Low Side-Lobe for Automotive Anti-Collision Radar", *IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting*, pp 1507-1508 (8-13 July 2018).

[6] K. Vavelidis, I. Vassiliou, T. Georgantas, A. Yamanaka, S. Kavadias, , G. Kamoulakos, C. Kapnistis, Y. Kokolakis, A. Kyranas, P. Merakos, I. Bouras, S. Bouras, S. Plevridis, , and N. Haralabidis, "A Dual-Band 5.15–5.35-GHz, 2.4–2.5-GHz 0.18 μm CMOS Transceiver for 802.11a/b/g Wireless LAN", *IEEE Journal of Solid-State Circuits*, vol. 39, no.7, July 2004.

[7] Mutmainnah, dan Y.H Pramono. "Open-loop Dipole Microstrip Antenna with U-shape Insertion for 2.45 GHz Wireless Applications". *International Journal of Microwave and optical Technology*. 12 (5): 399-405 (2017)

[8] F.Y. Zulkifli, F. Narpati., and E. T. Rahardjo. "S-shaped Patch Antenna Fed by Dual Offset Electromagnetically Coupled for 5-6 GHz High Speed Network". *PIERS ONLINE*. 3 (2): 163-166 (2007).

[9] H. H. Lin, C.Y. Wu, dan S.H. Yeh. Metamaterial Enhanced High Gain Antenna for WiMAX Application. *IEEE Region 10 Conference*, 30 Oct.-2 Nov 2007.

[10] M. Samsuzzaman, and M. T. Islam. "Inverted S-Shaped Compact Antenna for X-Band Applications". *The Scientific World Journal*: 11 (2014)

[11] S. V. Sudhakar, K. K. Kiran, G. B. Rao, K. S. Raju, M. U. Rao, dan K. N. L. V. Priya, "Design of Triple-S shaped Microstrip patch Antenna for Dual band Applications", *Recent and Innovation Trends in Computing and Communication*. 3 (3) (2015).

[12] G. Du, X. Tang, and F. Xiao , Tri-Band Metamaterial-Inspired Monopole Antenna With Modified S-Shaped Resonator, *Progress In Electromagnetics Research Letters,* vol. 23, pp 39-48 (2011).

[13] R. V. Khrisna, S. R., dan R. Kumar, "Design of Ultra Wideband Trapezoidal Shape Slot Antenna with Circular Polarization. *International of electronics and Communications*", vol 67, no 12. 2013

[14] S. B, Niboriya C. Choudhary, and G. Prabhakar,"S-Shaped Wideband Microstrip Patch Antenna with Enhanced Gain and Bandwith for Wireless Communication*", International Journal of Computer Applications*. vol 73, no 7, pp 17-20 (2013).