ASYMMETRIC CLOVER PATCH ARRAY MICROSTRIP ANTENNA AT 2.4 GHZ FREQUENCY

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ABSTRACT

Microstrip antenna is one type of antenna that has been widely used in laboratories in universities because it is practical and easy to produce. The author uses different amount of clover-shaped patch on two different microstrip antennas with 3x3 and 5x5 asymetrical format to analyze the parameters on 2.4 GHz operation frequency. The results of the simulation of VSWR values were consecutively 1.5 and 1.204. The results of simulation for bandwidth were consecutively 368 MHz and 435 MHz. The results of simulation for gain value were consecutively 8.071 dB, and 8.873 dB.

Keywords: microstripantenna, array antenna, asymmetrical.

INTRODUCTION

The development of wireless data communication technology continues to increase along with the use of internet access. One of the standards of Wireless LAN technology is the IEEE 802.11b standard (2.4 GHz-2.5 GHz). Wireless Fidelity (Wi-Fi) is a WLAN technology with IEEE 802.11b standard with an operation frequency of 2.4 GHz.

Microstrip technology is a medium (substrate) that has dielectric characteristics that can be used for propagation of electromagnetic waves with MIC (Microstrip Integrated Circuit) technology for microwave frequencies. The structure of the microstrip antenna in the form of a conductor on the surface of the substrate is called as *patch*. The part of the conductor under the substrate that functions as an unwanted signal reflector is called as *ground*.

The microstrip antenna is designed to be an antenna array in order to get better antenna performance parameters, accordingly, it is expected that the performance parameters obtained are better than a single antenna.

To design and simulate microstrip antennas to fit the intended purpose, the microstrip antenna components are resized using the CST Studio Suite application so that the simulation results match the expected results in the form of VSWR values between 1 and 2. Other parameters to be discussed include return loss, bandwidth, radiation pattern, and gain.

ANTENNA ANALYSIS

Antenna analysis includes antenna performance parameter analysis and antenna dimension analysis.

A. Voltage Standing Wave Ratio (VSWR)

Voltage Standing Wave Ratio (VSWR) is the ratio between the maximum and minimum voltage on a standing wave due to the reflection of a wave caused by the mismatch of impedance of the antenna input with the feeder line. In practice, the value of VSWR which becomes the threshold of an antenna that works well is 1 <VSWR<2. The value of VSWR can be calculated through equation (1):

$$VSWR = \frac{Vmax}{Vmin} = \frac{Vo^{+} + Vo^{-}}{Vo^{+} - Vo^{-}} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$
(1)

B. Return Loss

Return loss is one of the parameters used to find out how much power is lost in the load and returned as a reflection. Return loss occurs due to a mixture of information wave (source) and reflection wave. The return loss value defines the reduction in the amplitude of the reflected power compared to the transmit power. The return loss value can be determined by the following equation:

$$RL = 20 \log \Gamma = 20 \log \frac{VSWR - 1}{VSWR + 1}$$
(2)

Where RL = return loss (dB)

C. Bandwidth

An antenna's bandwidth is defined as the frequency range at which the antenna can work optimally according to the characteristics (such as input impedance, radiation pattern, beamwidth, polarization, gain, efficiency, VSWR, return loss, and axial ratio) that are determined. In a microstrip antenna, the bandwidth is the size of the bandwidth when the VSWR response of antenna is ≤ 2 .

D. Radiation Pattern

The radiation pattern of an antenna is a graphical statement that describes the radiation properties of an antenna in a remote field as a function of direction. In the radiation pattern, you can see the main lobe and minor lobe. Main lobe is the maximum radiation direction of the antenna. While the minor lobe consists of back lobe and side lobe which is radiation in other directions which is actually not desired.





E. Gain

Gain (directive gain) is the antenna character associated with the ability of the antenna to direct its signal radiation, or receive signals from a particular direction. Gain is not a quantity that can be measured in physical units in general such as watt, ohm, or other units, but rather a form of comparison. Therefore, the unit used for gain is decibel. The gain can be determined by equation (2) below:

$$G(\theta, \phi) = 4\pi \left(\frac{U(\theta, \phi)}{P_{m}}\right)$$
(3)

Where G is Gain.

F. Antenna dimension analysis

Before determining the dimensions of the radiating element, the wavelength of the transmission line is determined at 2.4 GHz resonance frequency with the following equation:

$$\lambda_g = \frac{c}{f_r \sqrt{\varepsilon_r}} \tag{4}$$

Then the dimension of the circle irradiation element is determined with the equation [1], [2], [4], [5], [7], [11]:

$$Rp = \frac{F}{\{1 + \frac{2h}{\pi\epsilon_{\Gamma}F} \left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726 \right] \}^{1/2}}$$
(5)

By calculating logarithmic functions F through the equation:

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\varepsilon_r}} \tag{6}$$

The dimensions of the transmission line with different impedances namely 100 ohms, 70.7 ohms, and 50 ohms are known by the equation [1], [2], [5], [6], [7]:

$$Wt = \frac{2h}{\pi} \left(B - 1 - \ln(2B - 1) + \frac{\varepsilon_r - 1}{2\varepsilon_r} \left[\ln(B - 1) + 0.39 - \frac{0.61}{\varepsilon_r} \right] \right)$$
(7)

B is obtained by the equation:

$$B = \frac{60\pi^2}{Z_0 \sqrt{\varepsilon_r}}; Z_0 = 50\Omega, 70.7\Omega, 100\Omega$$
(8)

The length of the transmission line is obtained by the equation:

$$Lt = \frac{\lambda g}{4} \tag{9}$$

The dimensions of the clover antenna can be seen in Table-1 below.



Figure-1. Clover Single Patch Microstrip Antenna.

Table-1. Antenna dimensions.

Dimension parameter	Value
Rp	10.6 mm
Wt	3.11 mm
Lt	15 mm

G. Antenna Design

Microstrip antennas are not only designed and produced with a single element, but are also designed as arrays in general [3], [8], [9], [10]. Array antennas are designed by combining several radiating elements with a transmission line connecting each element [12]. The size of the transmission line is adjusted using the transformation method $^{1}\!/4\lambda$, for impedance adjustments, with line impedances of 50 ohms, 70.7 ohms and 100 ohms.

In this study, the authors made two antennas with 3x3 and 5x5 asymetrical format, with a focus on achieving the target value of VSWR of ≤ 2 and Return Loss of ≤ -10 dB. The asymmetrical array antenna design that will be simulated in the CST Studio Suite application can be seen in Figure-2 and Figure-3 below.



Figure-2.3x3 asymmetrical clover array microstripantenna.



Figure-3.5x5 asymmetrical clover array microstripantenna.

H. Simulation Results

Simulation results in the form of VSWR, Return Loss, Bandwidth, Radiation Pattern, and Gain will be discussed in this section. Simulations were carried out using CST Studio Suite 2014 with a frequency range of 1.4 GHz - 3.4 GHz with a middle frequency of 2.4 GHz. Microstrip antenna substrate used FR-4 material with a thickness of 1.6 mm and patch used cooper (annealed) material.

Figure-4 shows the VSWR simulation results of the two antennas. The 3x3 and 5x5 antennas, respectively, showed VSWR results of 1.5 and 1.204 at 2.4 GHz frequency.



Figure-4. VSWR simulation of the antennas.

Return value allowed on antenna production was \leq -10 dB. Figure-5 shows the simulation results of the return loss of the two antennas. At the 2.4 GHz frequency, the 3x3 and 5x5 antennas got a return loss value of - 13,974 dB and -20,669 dB, respectively.



Figure-5. Simulation of return loss of the antennas

Bandwidth is one of the parameters determining the antenna performance, where the antenna specifications are expected to be achieved when operated at frequencies included in the antenna's bandwidth. Respectively, the 3x3 and 5x5 antennas had a bandwidth range of 386.5 MHz and 429.65 MHz and it can be seen in Figure-6 below.



Figure-6. Bandwidth simulation of theantennas.

The radiation pattern of the two antennas can be seen in Figure-7. The 3x3 antenna had a directional radiation pattern and the 5x5 antenna had a bidirectional radiation pattern.



Radiation Pattern



Figure-7. Radiation pattern simulation of the antennas.

e important parameter in the antenna is gain. Gain describes the ratio of antenna radiation intensity in a particular direction to antenna radiation intensity when working with isotropic radiation patterns. A good gain value is \geq 3 dB. The gain pattern can be seen in Figure-8. In the simulation, the 3x3 and 5x5 antennas respectively achieved a gain value of 8.071 dB and 8.873 dB.

Gain Pattern



Figure-8. Gain simulation of the antennas.

CONCLUSIONS AND SUGGESTION

Based on the simulation results and analysis of the 3x3 and 5x5 asymmetrical array antennas, several conclusions can be drawn, namely:

- a) The arrangement of antenna arrays with more radiating elements can improve antenna performance on performance parameters, with a smaller value of VSWR and Return loss.
- b) The arrangement of antenna arrays with more radiating elements makes the bandwidth value of the antenna even greater.
- c) The arrangement of antenna arrays with more radiation elements can increase antenna gain.

ACKNOWLEDGEMENT

The author wishes sincere thanks to Ministry Education and Culture Republic of Indonesia and University of Brawijaya.

REFERENCES

- [1] Balanis Constantine A. 2005. Antenna Theory Analysis and Design. Kanada: John Wiley & Son.
- [2] Adel Bedair, Abdel-Mooty, Abdel-Rahman. 2005. Design and Development of High Gain Wideband Microstrip Antenna and DGS Filters Using Numerical Experimentation Approach. Disertasi: University of Magdeburg.
- [3] Garg R., Bhartia P., Bahl I., dan Ittipiboon A. 2001. Microstrip Design Handbook. Norwood: Artech House Inc.
- [4] Girish Kumar, K.P. Ray. 2003. Broadband Microstrip Antennas. London: Artech House.
- [5] Liang J., C.C. Chiau, X. Chen, dan C. G. Parini. 2004. Printed circular disc monopole antenna for Ultrawideband applications. Electronics Letters, 40(20), 30 September, IEEE Journal.
- [6] Nakar Punit S. 2004. Design of a Compact Microstrip Antenna for use in Wireless/Cellular Devices. Tesis. Florida State University.
- [7] P. K. Singhal, Bhawana Dhaniram, dan Simta Banerjee. 2003. A Stacked Square Patch Slotterd Broadband Microstrip Antenna. Journal of Microwaves and Optoelectronics. pp. 60-66.
- [8] Vullers Ruud J.M., Visser. Huib J. 2008. RF Harvesting using Antenna Structures on Foil. Proceeding of Power MEMS. Jepang.
- [9] Yuwono Rudy., Mujahidin I., Mustofa A., Aisah. 2015. Rectifier using UFO Microstrip Antenna as Electromagnetic Energy Harvester. Advanced Science Letters, 21(11), ISSN: 1936-6612, pp. 3439-3443, November.
- [10] Dan, Stefan Tudose. 2013. Rectifier Antenna Design fo Wireless Sensor Networks. Rumania: Polytechnic University of Bucharest.
- [11] Yuwono R., dan R. Syakura. 2014. Star-L-shaped Circularly Polarized Ultra-Wideband Microstrip Antenna for Wireles Applications. Applied Mechanics and Materials. 548-549: 776-779.



- [12] Yuwono R., dan Adrian Rifqi Anshari. 2015. Design Microstrip Antenna 400MHz-800MHz for Difital Television with Customized Clover Patch. AASCIT Communications, 2(5). ISSN: 2375-3803. 10 Agustus.
- [13] Yuwono R., dan Oky Prana Wijaya. 2019. IEEEXPLORE. Symmetrical and Asymmetrical Microstrip Array Antenna.2019 2nd International Conference on Computer Applications & Information Security (ICCAIS), 1-3 May, Riyadh, Saudi Arabia DOI: 10.1109/CAIS.2019.8769502