

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

Nasrul^{a*}, Afrizal Yuhane^b, Latifah Hanum^c

^a Department of Electrical Engineering, Politeknik Negeri Padang, West Sumatra, Indonesia

*Corresponding author: nasrulnawi.065@gmail.com

Abstract- This research aims to design and test a rectangular microstrip 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 ≤ -10 dB, with the lowest value of -26 . After fabrication, the Return Loss value in the frequency range of 632-785 MHz has a value of ≤ -10 dB, 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 51.107Ω 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 22×26.1 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 3.86 dBi. 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 10 dBm, the maximum average output voltage is 474.2 mV 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.

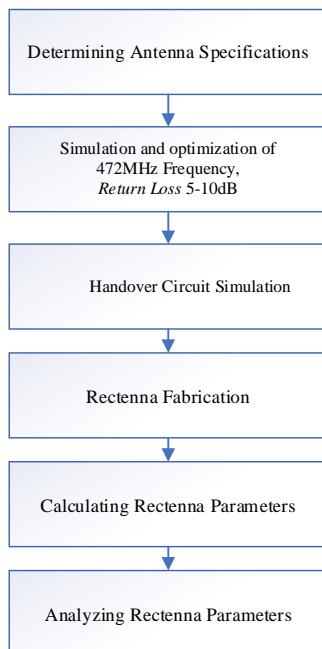


Figure 1. Antenna Design Syntax *Flowchart*

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.

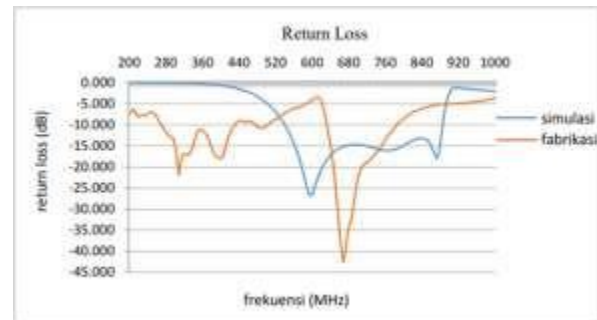


Figure 1 Comparison of Simulated and Measured Working Frequency Graphs.

Figure 1 shows that the *Return Loss* value ≤ -10 dB 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 ≤ -10 dB 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.

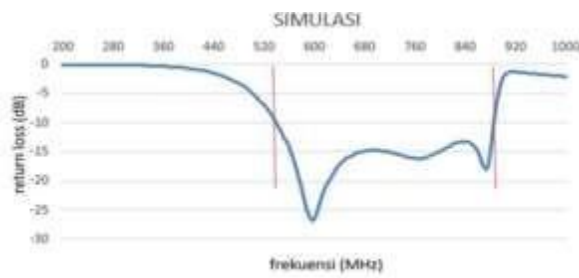


Figure 2 Simulated Antenna Bandwidth



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.

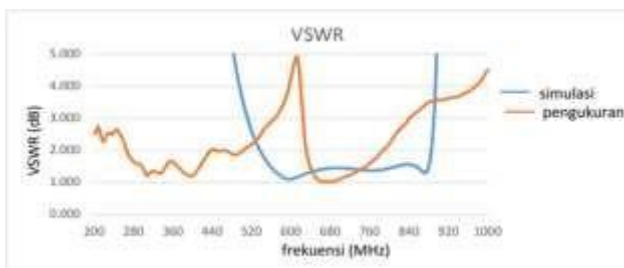


Figure 4 Comparison Graph of Simulated and Measured VSWR Values

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.

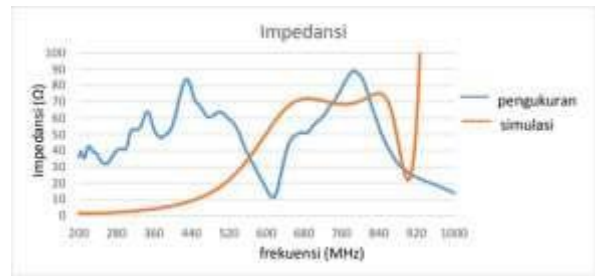


Figure 5 Graphical comparison of simulated and measured Impedance values.

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 omnidirectional, namely the transmit pattern in all directions.

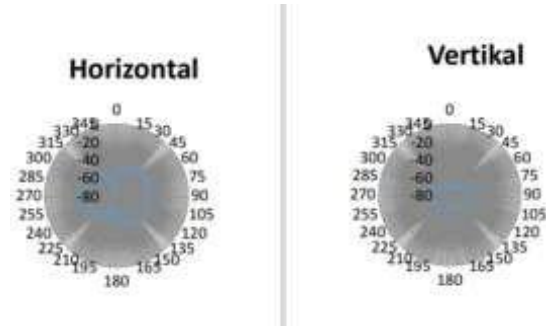


Figure 6 Fabricated Polaradiation

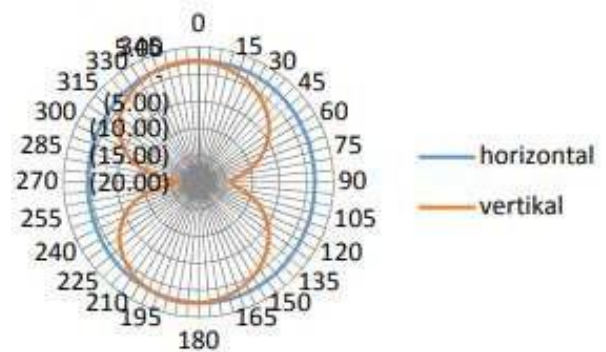


Figure 7 Simulated Polaradiation Results

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:

$$\begin{aligned}
 P &= -75 \text{ dBm} \\
 P(\text{dBm}) &= 10 \log \frac{P(\text{Watt})}{1\text{mW}} \\
 -75 &= 10 \log \frac{P}{1\text{mW}} \quad (1) \\
 \log^{-1} - 7.5 &= \frac{P}{1\text{mW}} \\
 3.162 \times 10^{-8} &= \frac{P}{10^{-3}\text{W}} \\
 P &= 3.162 \times 10^{-11}\text{W}
 \end{aligned}$$

The receiving power of a dipole antenna in Watts:

$$\begin{aligned}
 P &= -60 \text{ dBm} \\
 P(\text{dBm}) &= 10 \log \frac{P(\text{Watt})}{1\text{mW}} \\
 -60 &= 10 \log \frac{P}{1\text{mW}} \quad (2) \\
 \log^{-1} - 6 &= \frac{P}{1\text{mW}} \\
 1 \times 10^{-6} &= \frac{P}{10^{-3}\text{W}} \\
 P &= 1 \times 10^{-9}\text{W}
 \end{aligned}$$

So the gain of the microstrip antenna is:

$$G = \frac{3.162 \times 10^{-11}}{1 \times 10^{-6}} = 3.162 \times 10^{-5} \text{ kali} \quad (3)$$

Or in dB units the gain value is obtained:

$$G = 10 \log \frac{3.162 \times 10^{-11}}{1 \times 10^{-6}} = 10 \log 3.162 \times 10^{-5} = -45 \text{ dB} \quad (4)$$

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.

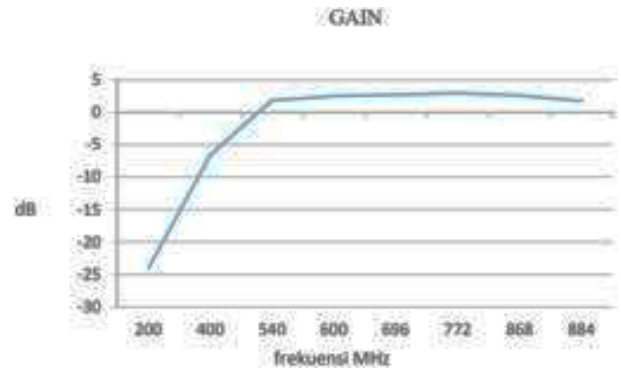


Figure. 8 Gain Graph of Simulation Results

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.

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