Design of Switch Operation Mode Rectenna and Analysis Effect of Power Absorbed Rectenna toward Power Received on FM 88-108 MHz Radio

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Abstract—Energy harvesting process can be done in many ways. One of them is by using rectenna. Rectenna is a combination of rectifier and antenna that can convert electromagnetic power into DC output voltage. The use of rectenna will disturb radio device because rectenna will absorb electromagnetic waves around the radio so a switch to adjust the time rectenna will work is necessary. As there is already an exclusive automatic switching method for rectenna and its neighboring device, which is Switch Operation Mode Rectenna, this research will discuss about the design of Switch Operation Mode Rectenna on radio by using 5V relay circuit, which functions as a regulator of radio and rectenna. This research also discusses how the effect of rectenna on the power received by FM 88-108 MHz radio.

Index Terms—Rectenna, switch, energy harvesting, DC voltage.

I. INTRODUCTION

Rectifier antenna (rectenna) can be used for energy harvesting with its antenna serves as the receiver of electromagnetic waves and the rectifier works to convert the electromagnetic wave into DC voltage [1].

The use of rectenna will affect the power received by radio device because rectenna will absorb electromagnetic waves around the radio [2]. Therefore, it is necessary to regulate the time rectenna will work and Switch Operation Mode Rectenna (SOMR) is an exclusive automatic switching method for rectenna and its neighboring device, which, in this case, is a radio (SOMRR) [3]. This switch will activate the rectenna if the radio connected to the switch is off or not working and will deactivate the rectenna if the connected radio is active [4].

II. RESEARCH METHODOLOGY

This study used a 5V relay circuit to set the switch on the radio and rectenna, two rectennas, a FM 88-108 MHz radio, and a field strength analyzer tool to measure the power received by radio's antenna and rectenna as objects of analysis [5].

There are five measurements for SOMRR. The first measurement is to measure rectenna's output voltage when it is not connected to SOMRR. The second is to measure

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rectenna's output voltage when it is connected to SOMRR and the radio is off [6]. The third is similar to the second but the radio is on. The fourth is to measure rectenna's output voltage and the power received by radio's antenna when the radio is on [7]. The fifth is similar to the fourth measurement but the radio is on [8].

The first three measurements used one rectenna and a SOMRR. Each of the first three measurements is done three times and the average value is used to compare the three measurements [9].



Fig. 1. Arrangement of rectenna's output voltage and SOMRR's received output power measurements when the radio is on.



Fig. 2. Arrangement of rectenna's output voltage and SOMRR's received output power measurements when the radio is off.

The fourth and fifth measurement used two rectennas, one on the left of the radio while the other on the right [9]. The two measurements have 1-31 cm distance variation, and the value is recorded every 3 cm. The arrangement for the fourth measurement can be seen in Fig. 1 while the fifth can be seen in Fig. 2.

III. RESULT AND ANALYSIS

A. Rectenna's Output Voltage without SOMRR

The measurement on rectenna's output voltage when it is not connected to SOMR has an average of 2.201 V. The details can be seen in Table I.

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TABLE I: RECTENNA'S OUTPUT VOLTAGE RESULT WHEN IT IS NOT CONNECTED TO SOMRR

	Rectenna's output voltage (V)				
1 st test	2 nd test	3 rd test	Average		
2.197	2.202	2.205	2.201		

B. Rectenna's Output Voltage with SOMRR and Radio is Off

Rectenna's voltage output measurement result when the rectenna is connected to SOMRR and the radio is off has an average of 2.110 V. The details can be seen in Table II.

 TABLE II: RECTENNA'S OUTPUT VOLTAGE RESULT WHEN IT IS

 CONNECTED TO SOMRR AND THE RADIO IS OFF

Rectenna's output voltage (V)				
1 st test	2 nd test	3 rd test	Average	
2.10	2.110	2.110	2.110	

C. Rectenna's Output Voltage with SOMR and Radio is On

Rectenna's output voltage measurement result when the rectenna is connected to SOMR on radio and the radio is on has an average of 0.0337 V. The details can be seen in Table III.

TABLE III: RECTENNA'S OUTPUT VOLTAGE RESULT WHEN IT IS CONNECTED TO SOMR ON RADIO AND THE RADIO IS ON

Rectenna's output voltage (V)					
1 st test	2 nd test	3 rd test	Average		
0.0300	0.0340	0.0370	0.0337		

As seen in Fig. 3, rectenna's output voltage when it is not connected to SOMR does not differ much from when it is connected to SOMR on radio with the radio being off. However, rectenna's output voltage when it is connected to SOMR on radio and the radio is on is very different from the other two measurement results with the value being very close to zero.



Fig. 3. Comparison of rectenna's output voltage during the first three measurements.

D. Rectenna's Output Voltage and SOMRR's Received Output Power When the Radio is on with Distance Variation

Fig. 4 shows rectenna's output voltage when the radio is on according to the distance from the radio, which do not have significant difference in value despite the distance. The right rectenna has 2.253 voltage as its highest output, which is obtained at 4 cm distance, while the left rectanna has 2.224 voltage as its highest output, which is obtained at 4 cm distance [10].



Fig. 4. Rectenna's output voltage when the radio is on.



Fig. 5. Rectenna's power calculation result.



Fig. 6. SOMRR's received power when the radio is on.

For the power calculation, the rectenna is connected to a resistor with 1 k Ω resistance, and the calculation result can be seen in Fig. 5. The highest power on right rectenna is

0.00508 watts, which is from right rectenna's output voltage value at 4cm distance, while the highest power on left rectenna is 0.00495 watts, which is from left rectenna's output voltage value at 4cm distance.

Unlike rectenna's output voltage, the power received by SOMRR's antenna when the radio is on is fluctuating according to the distance, as seen in Fig. 6. The lowest power is -65.61 dBm, which is obtained at the closest distance between rectenna and SOMRR, which is 1cm, and the highest power is -60.08 dBm, which is obtained at 28cm distance.

E. Rectenna's Output Voltage and SOMRR's Received Output Power when the Radio is Off with Distance Variation

Fig. 7 shows rectenna's output voltage when the radio is off according to the distance between rectenna and the radio. The output voltage results do not have significant difference despite the difference in distance.



Fig. 7. Rectenna's output voltage when the radio is off.



Fig. 8. SOMRR's received power when the radio is off.

Unlike rectenna's output, SOMRR's received power fluctuates along with the increase of the distance between rectenna and the radio. The lowest received power is -71.85 dBm at 25cm distance while the highest is -69.19 dBm at 1cm distance.

IV. CONCLUSION

From the results, it can be seen that rectenna's output voltage when it is not connected to SOMRR is close to its output voltage when it is connected to SOMRR and the radio is off with the value of 2.201 V and 2.110 V respectively while its output voltage is close to zero when it is connected to SOMRR and the radio is on. Therefore, the design of SOMRR using 5V relay circuit is proved to be working well.

Rectenna's output voltage value tends to not differ significantly despite the difference in the distance between rectenna and radio no matter when the radio is off or on while SOMRR's received power tends to fluctuate.

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