 ISSN 2614-4859

Design of Electrolysis Current Control in Water Ionizer with Voltage Source from Solar Energy

Dhaifullah Allam [a,1,*], Ekki Kurniawan [a,2], Irham Mulkan Rodiana [a,3]

[a] Telkom University, Jl. Telekomunikasi No. 1, Terusan Buah Batu, Bandung and 40257, Indonesia
[1] dhaifullahallam63@gmail.com *; [2] ekkikurniawan@telkomuniversity.ac.id; [3] irhammulkan@telkomuniversity.ac.id
* corresponding author

Keywords
Alkaline water
Acid water
Electrolysis current
pH
Solar Cell Module
Water ionizer

ABSTRACT

Water is one of the human needs. Many types of water are needed and good for humans, including alkaline water and acidic water. Alkaline water has benefits, one of which improves the immune system. While acidic water has advantages, one of which is an antiseptic or disinfectant. There are obstacles to this water-producing device. It is still costly for water-producing equipment, and it is still infrequent to use solar energy as a source of electricity. The author will make a device that produces alkaline water and acid water with solar energy as a power source using a Solar Cell Module (MSS). A water ionizer is an instrument to ionize water and its mineral content by using the water electrolysis method so that the water ionizer can produce alkaline water and acid water. The tool in this study used a 20 WP solar cell module that stores electrical energy in a 12V 7AH battery. Other components used are the container water ionizer, PH4502C pH sensor, INA219 current sensor, and DS18B20 temperature sensor connected to a microcontroller. The value of the current produced depends on the TDS of the water used. If the TDS of the water is high, the current generated is also high. Changes in pH were obtained in this study with a maximum pH increase of 2.60 and a maximum decrease of 9,30 pH.

1. Introduction

Water is one of the essential needs for humans because about 60% of human body weight is liquid. It's no wonder the human body needs water to carry out its functions. Good water for daily use and mineral drinking water is alkaline and acidic water. The first device to produce alkaline water and acid water for consumption came from Japan, by electrolysis of mineral water, which can produce hydrogen and oxygen gas and alkaline water and acid water, which has benefits for society. Alkaline water meets the requirements for drinking, which are stipulated based on the Regulation of the Minister of Health of the Republic of Indonesia No. 492/Menkes/Per/IV/20210[1]. It can even be said that there are many benefits. In contrast, acid water can be used for people's daily needs.

Equipment to produce continuous alkaline and acid water has been sold. However, the tool still has weaknesses, including the relatively high price and not yet affordable by the wider community. Therefore, a water ionizer will produce alkaline water and acid water to produce alkaline water and acid water.

Indonesia is a tropical country that has abundant solar energy resources. In normal weather conditions, the sun illuminates each hemisphere of Indonesia for 10-12 hours, the total energy intensity of the radiation (Ir) average is 4.8 kWh /m^2 [2].

Solar Cell Module (MSS) can generate voltage and direct electric current (DC) for the electrolysis of water, and by using the Solar Cell Module (MSS), it can also store electrical energy in batteries that can generate direct current (DC) voltage and current. Also. Because one of the tools that use voltage and direct current (DC) is a water electrolysis system that can produce alkaline water and acid water.

For the design of electrolysis current control, which will be carried out using a control on the output voltage, sourced from the Solar Cell Module (MSS), which stores electrical energy in the

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battery/battery, with the method pulse width modulation (PWM), so that the voltage can be controlled, and the current generated from the electrolysis process can also be controlled by this method.

2. The Proposed Method/Algorithm

2.1. Block Diagram System

Following is a block diagram that will be made, namely the design of electrolysis current control on a water ionizer with a voltage source from solar energy.

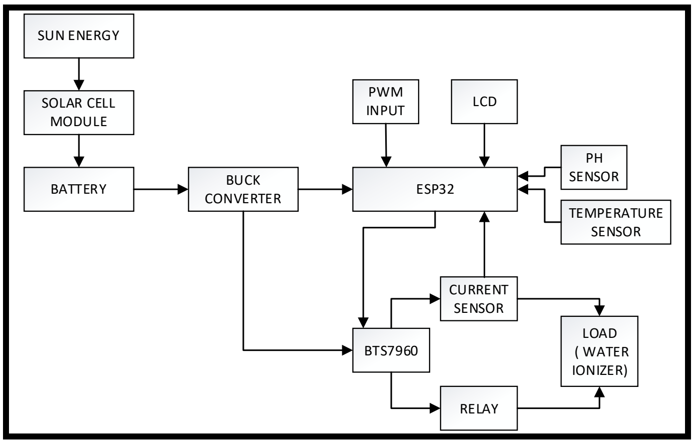

Fig. 1. Block Diagram System

2.2. Design Hardware

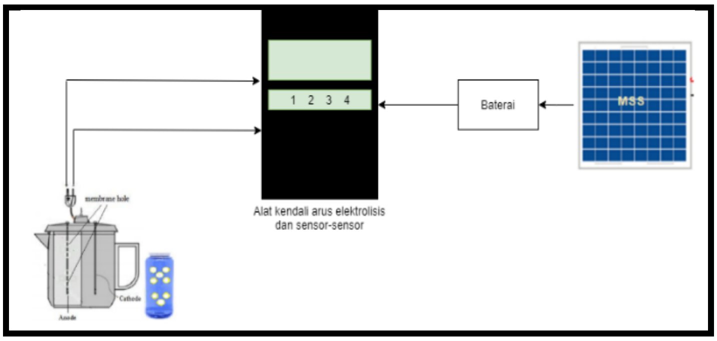

Fig. 2. Design Hardware

To realize the tool, the design is hardware designed to connect each component. Some of the devices used are Solar Cell Modules (MSS), batteries, electrolysis containers, electrodes, Stainless-steel and carbon, current sensors, pH sensors, temperature sensors, relays, ESP32 microcontrollers and LCDs.

3. Method

3.1. Mineral Water Ionizer (MWI)

Define Mineral Water Ionizer (MWI) is used to ionize water and its mineral content by using the mineral water electrolysis method. This Mineral Water Ionizer (MWI) can produce alkaline and acid water.

3.2. Electrolysis

Electrolysis is the decomposition of electrolytes in an electrolytic cell by an electric current [3]. Electrolysis is carried out using a direct current (DC) source and cannot be carried out with an alternating current source[3].

In the electrolysis process, the electrode is energized by an electric current (DC) so that the compounds in the electrolyte decompose to form ions, and an oxidation-reduction process occurs to produce gas. The electrolysis process states that the oxygen atom forms a negatively charged ion (OH-

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), and the hydrogen atom forms a positively charged ion (H+). At the positive pole, the ions are H+ attracted to the cathode, which is negatively charged so that the ions are H+ attached to the cathode. The hydrogen atoms will form hydrogen gas in gas bubbles on the cathode that float up. The same thing happened to the OH ions, which fused at the anode and then formed oxygen gas in the form of gas bubbles[4].

Electrolysis of water is the event to decompose water (H2O) into oxygen (O2) and hydrogen gas (H2) by using an electric current through the water. At the cathode, two water molecules react by capturing two electrons, reducing H2 and hydroxide ions (OH-). Meanwhile, two other water molecules break down into oxygen gas(O2) at the anode, releasing 4ions H+, and electrons flow to the cathode. The ions H+ and OH- undergo neutralization to form some water molecules. The overall balanced reaction of water electrolysis can be written as follows.

$$2H2O(\ell) \rightarrow 2H2(g) + O2(g)$$

Chemical reactions that occur at the cathode and anode. The cathode gets a negative voltage, while the anode receives a positive voltage. The flow of electrons occurs from the voltage source to the cathode. In the cathode electrolyte, electrons are sent to the anode. The anode sends electrons back to the voltage source. At the cathode, two reduction reactions occur, namely two moles of electrons (2e-) two moles of hydrogen ions (H+) to form one mole of hydrogen gas (H2) under standard conditions with a magnitude of Eo = 0.00 volts. The second reaction is two moles of electrons (2e-) two moles of water (H2O(l)) to form one mole of Hgas2 and one mole of hydroxide ions OH-, with a voltage of Eo = -0.83 volts[5].

$$2\ H+\ (aq)\ +\ 2e-\ \rightarrow H2\ (g) \qquad Eo = 0.00\ V$$

$$2\ H2O\ (l) + 2e\ -\!\!\rightarrow H2\ (g)\ of\!+\ OH-\ (aq)\ E° = -0,\ 83V$$

At the anode, two reactions occur, namely, with a voltage of E° = + 0.40 volts, OH- ions from oxygen gas (O2), and Hmolecules2O (I), meanwhile with a voltage of E° it becomes + 1.23 volts of water molecules decomposes into oxygen gas, releasing 4 H+ ions and flowing electrons to the source through an electric current with a voltage of E° = + 1.24.

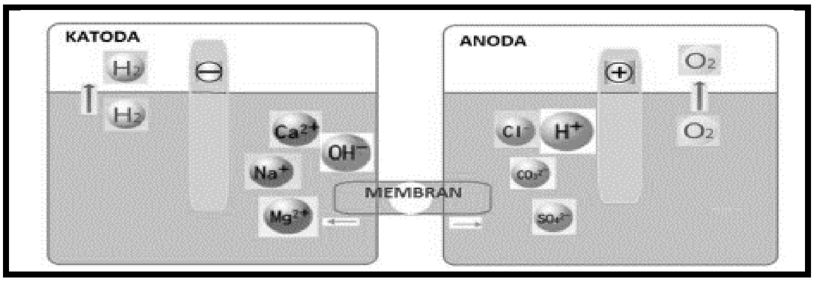

Fig. 3. Electrolysis Process

$$4OH\text{-}(aq) \rightarrow O2\ (g) + 2\ H2O\ (l) + 4e- \qquad Eo = 0.401V$$

$$2H2O(l) \rightarrow\ O2\ (g) + 4H+\ (aq) + 4e- \qquad Eo = 1.23$$

3.3. Solar Cells

Solar energy is the source of energy that is infinite and inexhaustible availability and energy can also be used as alternative energy is converted into electrical energy using solar cells. A solar cell is a device that converts sunlight energy into electrical energy by the photovoltaic effect; therefore, it is also called a photovoltaic cell (Photovoltaic cell - abbreviated PV).

The power supply for the solar cells used comes from renewable energy sources, namely by using energy from sunlight. One of the renewable energies that can be utilized is energy from the sun. Indonesia is a tropical country with a reasonably high potential for solar energy[6][7].

Renewable energy has a significant role in meeting energy needs considering that the source is very abundant. This is because the use of fuel for conventional power plants in the long term will deplete the dwindling resources of oil, gas and coal and cause environmental pollution[8][9]. One of

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ISSN 2614-4859

the efforts that have been developed is the Solar Power Plant (PLTS)[10]. To find out the solar cell can work well, then the efficiency equation of the solar cell is obtained.

$$\eta = \frac{P_{(solar\ cells)}}{I\ x\ A} \quad (1)$$

Description: η : Efficiency of solar cells
P : Cell Power (solarcells)
I : Solar Intensity (W/m²)

4. Results and Discussion

Following are the results of testing the electrolysis current control system on a water ionizer with a voltage source from solar energy.

Table 1. First Test with TDS Value of Bottled Drinking Water 81 ppm

Hour	Result				Temp (°C)	pH	
	V solar cell (V)	Vout (V)	Current (mA)	Power (mW)		Acidic (in acidic bottle)	Alkaline (in alkaline bottle)
11.00	18,80	12,70	7,10	90,170	27,56	8,20	8,20
11.30	19,80	12,80	7,60	97,280	27,59	7,40	8,80
12.00	20,00	13,30	8,36	111,188	27,64	7,20	9,00
12.30	19,80	13,50	8,35	112,725	27,64	7,10	9,10
13.00	19,60	13,00	8,38	108,940	27,86	7,00	9,20
13.30	19,50	12,70	8,28	105,156	27,86	6,90	9,40
14.00	19,20	12,30	7,95	97,785	27,94	6,80	9,50
Average power				103,321			
Average temperature					27,72		
Changes in acid pH						1,40	
The average change in acid pH						0,23	
Changes in alkaline pH							1,30
The average change in alkaline pH							0,21

Table 2. Second Test with PDAM Water TDS Value 290 ppm

Hour	Result				Temp (°C)	pH	
	V solar cell (V)	Vout (V)	Current (mA)	Power (mW)		Acidic (in acidic bottle)	Alkaline (in alkaline bottle)
11.00	19,20	12,40	20,30	251,720	27,56	7,90	7,90
11.30	19,80	12,40	20,50	254,200	27,62	6,90	8,70
12.00	20,00	13,40	21,50	288,100	27,75	6,60	9,00
12.30	19,90	13,00	21,70	282,100	27,81	6,40	9,20
13.00	19,80	12,50	21,70	271,250	27,87	6,20	9,30
13.30	19,70	12,40	20,40	252,960	27,96	6,00	9,30
14.00	19,10	12,40	20,40	252,960	28,00	5,90	9,40
Average power				264,756			
Average temperature					27,79		
Changes in acid pH						2,00	
The average change in acid pH						0,33	
Changes in alkaline pH							1,50
The average change in alkaline pH							0,25

Table 3. Third Test with PDAM Water TDS Value 690 ppm

Hour	Result				Temp (°C)	pH	
	V solar cell (V)	Vout (V)	Current (mA)	Power (mW)		Acidic (in acidic bottle)	Alkaline (in alkaline bottle)
11.00	19,00	12,40	60,40	748,960	27,50	7,70	7,70
11.30	19.50	12,80	60,40	773,120	27,62	6,80	9,10
12.00	20,00	13,50	61,20	826,200	27,69	6,50	9,30
12.30	19,80	13,00	61,30	796,900	27,75	5,80	9,70

Hour	Result				Temp (°C)	pH	
	V solar cell (V)	Vout (V)	Current (mA)	Power (mW)		Acidic (in acidic bottle)	Alkaline (in alkaline bottle)
13.00	19,70	12,80	61,50	787,200	27,87	4,50	9,80
13.30	19,40	12,50	60,80	760,000	27,94	4,20	10,00
14.00	19,00	12,40	59,40	736,560	28,00	3,80	10,20
Average power				775,563			
Average temperature					27,76		
Changes in acid pH						3,90	
The average change in acid pH						0,65	
Changes in alkaline pH							2,50
The average change in alkaline pH							0,41

Table 4. Fourth Test with PDAM Water TDS Value of 950 ppm

Hour	Result				Temp (°C)	pH	
	V solar cell (V)	Vout (V)	Current (mA)	Power (mW)		Acidic (in acidic bottle)	Alkaline (in alkaline bottle)
11.00	19,00	12,30	81,15	998,145	27,50	7,80	7,80
11.30	19.50	12,50	85,30	1066,250	27,56	6,80	9,10
12.00	19,90	13,20	86,32	1139,424	27,62	6,30	9,50
12.30	19,70	12,80	86,30	1104,640	27,62	6,20	9,80
13.00	19,40	12,60	88,30	1112,580	27,94	5,80	10,10
13.30	19,00	12,50	86,35	1079,375	28,06	5,30	10,30
14.00	19,00	12,40	85,10	1055,240	28,06	4,90	10,40
Average power				1079,379			
Average temperature					27,76		
Changes in acid pH						2,90	
The average change in acid pH						0,48	
Changes in alkaline pH							2,60
The average change in alkaline pH							0,43

Table 1-4 is a test control device electrolysis current in the water ionizer with a voltage source from solar energy. The tests were carried out for 3 hours each, from 11.00 to 14.00, because the sun was above the solar cells at that hour. Different results were obtained from each experiment, and it can be seen from the value of the current, power and changes in pH, for the present matter, the greater the TDS value of the water, the greater the value of the electrolysis current, if the current increases, the power will also increase, because the applied voltage is relatively constant.

The highest pH value was obtained when the water had a TDS value of 950 ppm, which was electrolyzed for 3 hours, the pH of the water became 10.40. The smallest pH value was obtained when the water had a TDS value of 690 ppm, which was electrolyzed for 3 hours, the pH of the water became 3.80. The most significant current value is obtained from water with a TDS value of 950 ppm at 13.00. The electrolysis process lasts for 2 hours which is 88.30mA, while the smallest current value is obtained from water with a TDS value of 81 ppm at 11.00. The new electrolysis process will start immediately, which is 7,10mA.

5. Conclusion

Based on the results of the design, testing and data collection on the control of the electrolysis current on the water ionizer with a voltage source from solar energy, it is as follows.

1. The electrolysis current control system on the water ionizer with a voltage source from solar cells uses Pulse Width Modulation (PWM) to adjust the voltage that enters the water ionizer. The electrolysis current can also be controlled because the current is directly proportional to the voltage. This control system uses a voltage source from solar cells absorbed by the Solar Cell Module (MSS) and stores electrical energy in the battery.
2. The current influence on the electrolysis process dramatically affects the electrolysis process because the more significant the current, the faster the pH changes from the electrolysis process. The TDS value of water also greatly affects the value of the current because the higher the TDS value of the water, the higher the value of the resulting current.

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ISSN 2614-4859

3. By using a 20 WP solar cell whose output is stabilized by a 12V 7AH battery, it can produce alkaline water, and acid water, which is carried out by an electrolysis process with various water TDS values, namely 81 ppm, 290 ppm, 690 ppm and 950 ppm, the average pH increase is obtained. It is 1.975, the average pH drop is 2.55, the average current is 43.79mA, the average power is 555.754mW, and the maximum battery output or PWM value is 255. Electrolysis current is also very influential from the voltage value and the current flowing in each electrode

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