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by Alex Taufiq

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Design of Wind and Solar Power Plant Applies the Concept of Hybrid Technology Based on the Internet of Things

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Abstract. In this study, a prototype wind and solar power plant were designed to implement the concept of an IoT- based redundant system using Arduino Mega 2560 Built-in Wifi as a programmatic controller. From the results of the analysis obtained voltage produced by solar cell panels when in sunny weather conditions get a result of 11.00-14.50 Vdc. While from Permanent Magnet Generator (PMG) can produce from a rotation value radius of 37.5-150 rpm of 3.6–7.71 Vdc before being given a step-up. The redundancy system uses 2 relays from each plant in charge of maintaining the lower limit voltage value of 8 Vdc. While in the Charging system is used 1 relay is tasked to maintain the voltage value at the battery capacity of 13.45 Vdc. The performance result has an average output produced by Photovoltaic and PMG of 14.50 Vdc and 9.534 Vdc. While for the initial voltage value on the battery at 8.39 Vdc. So that the overall performance value of plts and pltb in the charging process is 80.16 watts / h and the charging process stops at a value of 13.45 Volts.

INTRODUCTION

Today, electricity needs in various regions of the world, especially developing countries, are still predominantly sourced from fossil fuels such as coal and petroleum (Marlistya Citraningrum, 2019).Indonesia as an island nation has abundant natural resources, which can be used as an energy source for the survival of life. But over time, the availability of nature is now increasingly thinning, and in anticipation of renewable energy (EBT) is the best alternative (Kementerian ESDM, 2016). Renewable energy sources are environmentally friendly sources of energy that do not pollute the environment and do not contribute to climate change and global warming, because the energy obtained comes from sustainable natural processes, such as sunlight, wind, water, biofuels, and geothermal (Kementerian ESDM, 2016).

The area that will be a priority in the development of renewable energy is in the district of Karangbinangun in Lamongan district with 71 hamlets in the sub-district. While the energy that can be developed is utilizing the presence of solar radiation and the potential for wind congestion in the region. While the potential of solar energy in east Java

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averages 4.3 kW / m2 with the total potential of solar energy per year in the Lamongan region reaches 177,750 MW. Then the average wind energy potential in Lamongan region of 6,058 m/s with a total per year can produce 4.65 mW (Vian Vebrianto, 2015). Furthermore, the problem faced by the region is the existence of a clean water crisis during the dry season, resulting in the dew of water contained in the sub-district dries up. While the water dew is used by the surrounding community for daily needs and for irrigation of agricultural areas around the sub-district. The source of water obtained by embung water comes from the Bengawan solo river. To obtain the water source, the surrounding residents still use a water pump that can move the water of Bengawan solo river to the water dew but the pump still utilizes the electricity supply from PLN so that it is also one of the factors that cause the burden of spending on the surrounding residents is increasing (FIDHI, 2020).

Because of the problem, it is necessary to use renewable energy that can be a solution for watering water. Therefore, the design of Wind and Solar Power Plants with a hybrid technology concept using IoT systems can provide electricity supply in pump houses so as not to provide a greater cost burden when using electricity supply from PLN and also support the development of renewable energy (EBT). Renewable Energy Innovation (EBT) applied is Control and Monitoring System of Wind and Solar Power Plant. With Hybrid Technology Concept using IoT system. Starting from using a closed-loop control system to set the output system produced by Solar and Wind Power so that when the process of transferring energy on the charging battery does not exceed the input limit that has been set. There is also a current and voltage monitoring system on the battery to measure how much electricity is acceptable. Therefore, the idea of designing Wind and Solar Power Plants with a Hybrid Technology Concept using an IoT system can provide opportunities to improve the agricultural economic sector in the environment and in the local community.

METHODOLOGY

This research started from the first literature study to look for references to control, monitoring, and safety systems of wind and solar power plant technology based on the Internet of Things. Second, decide on the formulation of problems from PLTB and PLTS technology. Third, the preparation of design and design of the manufacture containing the design, materials, and process variables measured. Fourth, the manufacture of power generation tools that will be made in detail ranging from hardware, software, and mechanics. Fifth, the process of assembling components. Sixth, the testing process measured using voltage and current sensors so that it can determine the resulting power performance (Raafiu & Darwito, 2018). We can use the on/Off control system on the leverage system to keep the resulting performance stable. Furthermore, data retrieval and analysis of physics variables are performed. The final step is the creation of a results report.

This hybrid system was designed using two energy sources, namely Solar Power Plant (PLTS) with photovoltaic 200 Wp and Bayu Power Plant (PLTB) as an alternative energy source used to meet the needs of electricity in the homes of residents in Karangbinangun Lamongan. The prototype model can be seen in Figure 1.

Design of Power Plant Wind and Solar Power

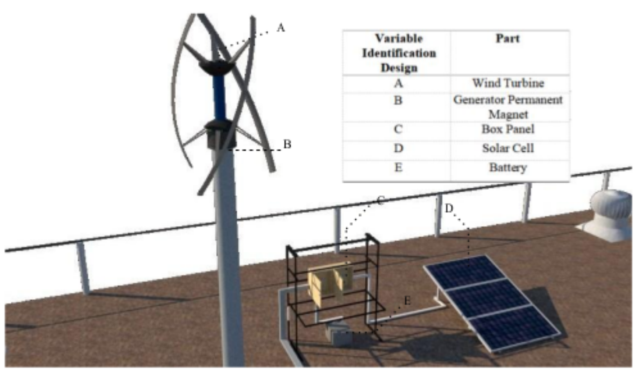

FIGURE 1. Design of wind turbine and solar power

Design of Systems Control and Monitoring

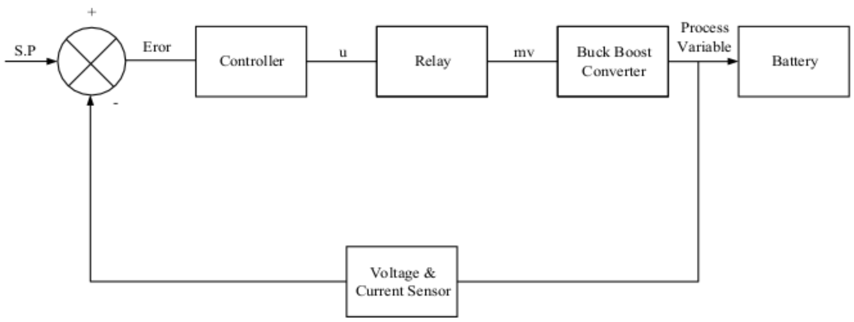

FIGURE 2. Closed Loop System

In Figure 2 the control loop diagram above explains that the system power plants wind and solar using closed- loop control system with 1 actuator and 2 sensors that can maintain the stability of the desired output process or following the setpoint. Then the variables measured are Voltage and Current. Input or set point that must be maintained is the voltage of the result of wind and solar power (Kurniawan, 2016). This system can run by keeping the value fixed at voltage even during the day which has a light intensity received by solar power about 60-100% greater than in wind power while in night conditions wind speed received by wind power about 80-100% than the light intensity received by solar power. Therefore, in the application of wind and solar power design using a closed-loop control system can provide a stable performance value as desired.

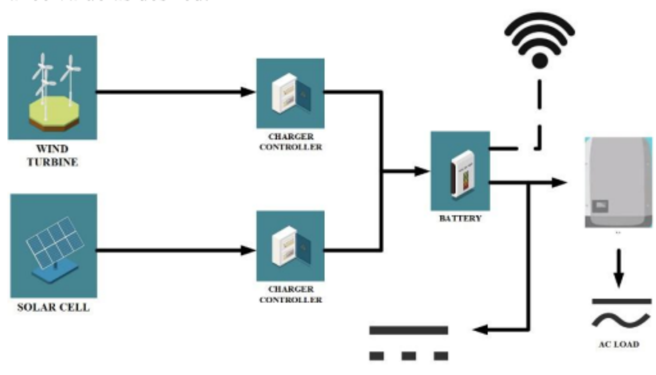

FIGURE 3. Control Automation System Process Design

From the Figure 3, the design of the existing system process explains how the hybrid system power plant works in general and sequentially, the first process of all energy produced by all existing generating sources namely solar cell system and wind energy system is channeled into the control unit. This energy control unit includes the controller unit that uses the mega Arduino which then gives input signal to the actuator, namely from the relay contained in the PLTB and the relay on the PLTS while the buck-boost converter is used to maintain the desired voltage output value. The relay installed on the two system units is intended to be the executor of the task to drain the electrical voltage after the command by the controller. Then those two sensors serve to measure the variable process and send a feedback signal to the controller so that it can know the error value of the process. The sensors used are voltage and current using a 25V voltage sensor and an ACS712 current sensor. This system runs a dual system of two energy produced by adjusting the conditions in the field that is starting from the morning- an afternoon with the intensity of light from the sun is more optimal compared to wind speed and then after that afternoon - night wind speed is more reliable than from solar power. The proposed system design and development structure explain the working description of the developed system. Therefore, implementing this control system can provide balance in performing a process so that it can be in accordance with our wishes (Winasis et al., 2017). After the process goes the next stage is charging the battery on the 12V battery so that the results of the two processes, namely PLTB and PLTS can be stored properly. In other conditions on the Safety Instrument System is in the controller unit that can be controlled if there is a condition of lightning or excessive voltage control unit will give a command signal on all relays to OFF so as not to damage the equipment or components (Hidayanti & Dewangga, 2020).

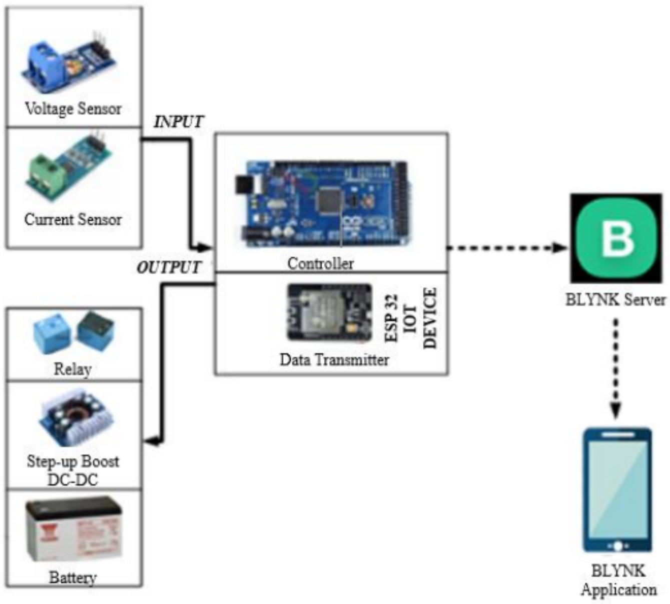

FIGURE 4. Control system design scheme

This detailed hardware scheme can be seen in Figure 4 where the input section contains volatge and current. The output section is relay, step-up boost DC-DC, and battery. This hardware has the following workings the system turns on and off controlled through gadgets that have been installed BLYNK application after the system turns on the relay starts to activate and appears the results of monitoring current and voltage generated by the sensor.

RESULT AND DISCUSSION

Savonius wind turbines are a type of turbine drag-type wind, where the turbine is generate power by utilizing the drag produced from each of his spoons.Drag is a force that works the opposite with the direction of the wind that pounded. Turbine Power, *P*w defined as multiplication between mass flow rate, ρAV with kinetic energy per unit mass of $1/2\ V_{Wind}$. Mathematically able to written as follows $P_W = 1/2\ \rho_{AV}^2$. The design result is that savonius wind turbines can be seen in Figure 5.

FIGURE 5. Design Implementation of Wind Turbine

In the design of this hybrid generation system, one of the variables that are handled and monitored is the voltage generated from power energy wind and solar so that it can be set the voltage value according to the desired set point and monitored through blynk. Before the sensor is assembled, it must undergo testing and calibration first can be seen in Figure 6. The tests performed are variation testing. For voltage sensor variation testing tested with large flow rates of 2V, 4V, 6V, 8V, 10V with generator signal calibrator.

FIGURE 6. Validation and testing voltage sensor

TABLE 1. Test result of variation value with sensor voltage.

Measuring Range (V)	Standard Reading (V)	Reading Sensor (Voltage Sensor 0-25V)			Average Reading (V)	Correction (V)
		1	2	3		
2 - 10	2	02.12	02.37	02.15	21.860	-0.2133
	4	04.01	04.19	04.22	42.220	-0.1700
	6	06.21	06.56	06.34	63.360	-0.3700
	8	08.28	08.38	08.36	8.445	-0.3400
	10	10.34	10.21	10.12	10.275	-0.2233

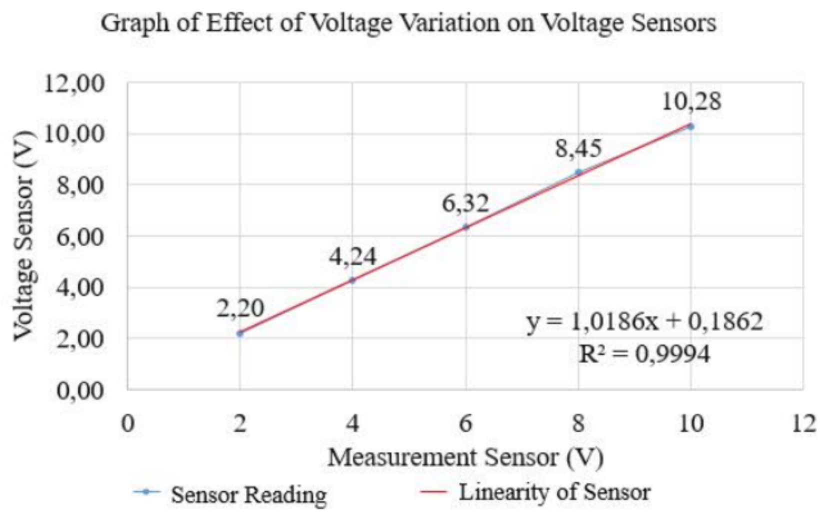

FIGURE 7. Static characteristic graph of voltage measurement voltage sensor and measuring instrument with a fixed value

From these results, it can be concluded that the characteristics of the sensor are obtained by the result of measurement uncertainty of 0.04, with a standard deviation of 0.12 and a degree of freedom of 0.027. The sensor has an error percentage value of -0.000940299%. Next tests performed are fixed value testing and variation testing. For variation testing current sensors are tested with large flow rates of 4mA, 8mA, 12mA, 16mA, 20mA with a generator signal calibrator.

FIGURE 8. Current sensor testing with Generator signal

TABLE 2. Testing the ACS712 sensor using variation values.

Measuring Range (mA)	Standard Reading (mA)	Reading Sensor (Sensor ACS712 30 A)			Average Reading (mA)	Correction (mA)
		1	2	3		
4 - 20	4.1	4.21	4.37	4.15	4.2260	-0.2100
	8.1	8.10	8.09	8.21	8.3210	-0.1000
	12.1	12.21	12.56	12.28	12.3380	-0.3167
	16.0	16.28	16.38	16.26	16.313	-0.2733
	20.1	20.22	20.28	20.19	20.25	-0.1967

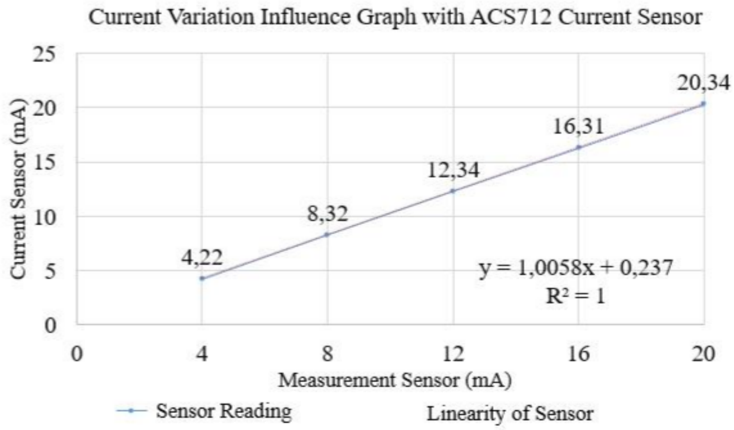

FIGURE 9. Current variation influence graph with ACS712 Current Sensor

From these results, it can be concluded that the characteristics of the sensor are obtained by the result of measurement uncertainty of 0.03, with a standard deviation of 0.11 and a degree of freedom of 0.021. The sensor has an error percentage value of -0.000538653%. Next, voltage Testing PMG Generator Using Dc Motor without Load. In testing PMG generators using a dc motor without load is done to find out the output voltage produced by the generator rotation with different RPM (Rotation per Minute) rotation in the hope that after using hybrid control can produce a constant output voltage of 12 VDC and DC, 13.5 VDC as charging the battery using a charge controller.

TABLE 3. Voltage Testing PMG Generator Using Dc Motor

No	Rotation Speed (RPM)	Output Generator before Step-up (Vdc)	After Step-up Output Voltage Generator (Vdc)
1	100	2.15	4.62
2	200	4.87	7.09
3	300	5.32	8.29
4	400	7.11	11.89
5	500	8.56	13.74

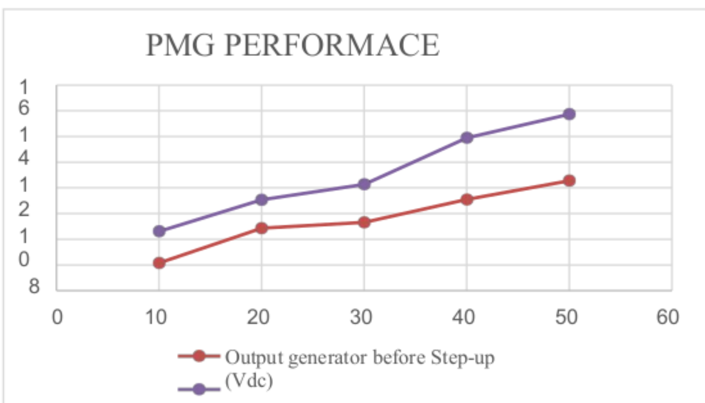

FIGURE 10. PMG Generator Performance Testing

Last, safety charging testing on batteries using relay drivers is to find out if the relay driver can work properly in accordance with the orders of the controller with the condition of the voltage source received by the battery is less than 11V (voltage specified in the Arduino Mega 2560 program) then the relay must be active to drain electricity from the hybrid power source to the battery.

TABLE 4. Testing Safety Charging using Relay

Program Description	Pin Logic		Voltage Pin		Status Relay	Description
	22	24	22	24		
Battery Voltage < 11.00 V	0	0	0	0	*off*	Relays connect power source hybrid to battery (charging).
Battery Voltage > 11.00 V	1	1	4.88	4.88	*on*	Relay disconnects source hybrid generator to battery (discharging)

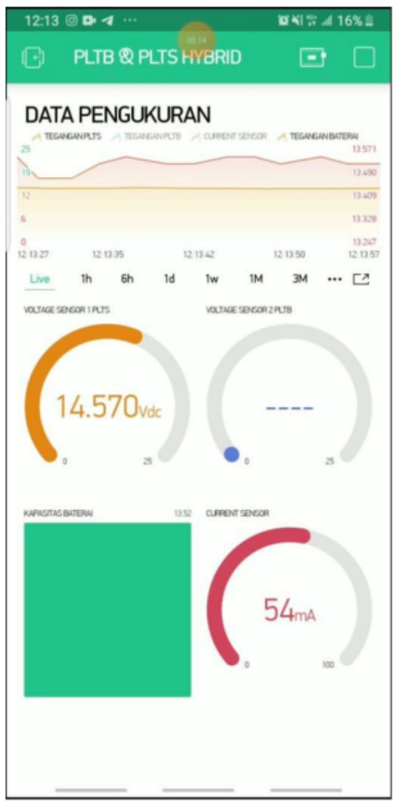

FIGURE 11. Monitoring blynk

The result of software design for the monitoring system with the interface used is Blynk which is an Internet of Things (IoT) designed to monitor the voltage values generated by PLTB and PLTS, the voltage capacity on the battery, the current value generated on charging to the battery and finally the measurement graph of those values. After that, if the monitoring system can run for sensor sensing results through blynk can be done by entering the super chart option on the blynk. Then there is the action option to send measurement data in the form of CSV or want to delete all data in the database. If the user wants to know the results of the measurement obtained then can choose in the export to CSV section. Users can confirm whether the data has been entered into the Gmail that has been registered. After the data goes to Gmail, it can be known the results of monitoring using excel so that can be recorded the resulting performance value.

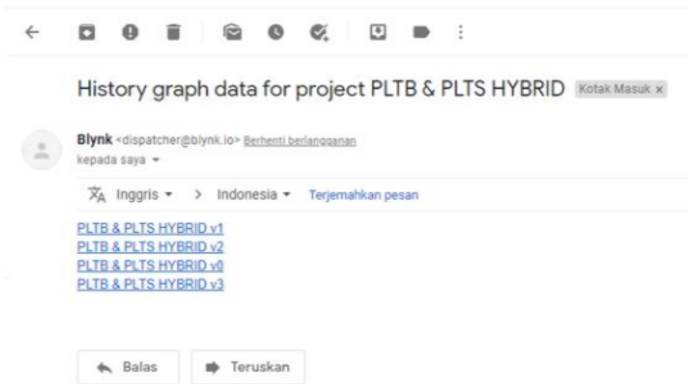

FIGURE 12. Measurement data results from monitoring

TABLE 5. Safety charging test results on batteries

Time (s)	Battery Voltage (V)	Upper Limit (V)	Relay	Time (s)	Battery Voltage (V)	Upper Limit (V)	Relay	Time (s)	Battery Voltage (V)	Upper Limit (V)	Relay
0	8.39	13.45	1	55	10.52	13.45	1	110	12.6	13.45	1
5	8.68	13.45	1	60	10.71	13.45	1	115	12.79	13.45	1
10	8.89	13.45	1	65	10.89	13.45	1	120	12.98	13.45	1
15	8.95	13.45	1	70	11.09	13.45	1	125	13.16	13.45	1
20	9.21	13.45	1	75	11.27	13.45	1	130	13.35	13.45	1
25	9.38	13.45	1	80	11.46	13.45	1	135	13.54	13.45	0
30	9.57	13.45	1	85	11.65	13.45	1	140	13.73	13.45	0
35	9.71	13.45	1	90	11.84	13.45	1	145	13.54	13.45	0
40	9.95	13.45	1	95	12.03	13.45	1	150	13.73	13.45	0
45	10.14	13.45	1	100	12.22	13.45	1	155	13.54	13.45	0
50	10.33	13.45	1	105	12.41	13.45	1	160	13.55	13.45	0

In the table above, relay control system testing is carried out against voltage setpoints. The voltage value test is measured every 5 seconds so that the response can be known on the relay after exceeding the setpoint. If the voltage value is more than 13.45Vdc then the relay condition is off, but if the voltage value is less than 13.45Vdc then the relay will turn on. The following image below is a graph image of the Hybrid response of PLTB and PLTS is as follows:

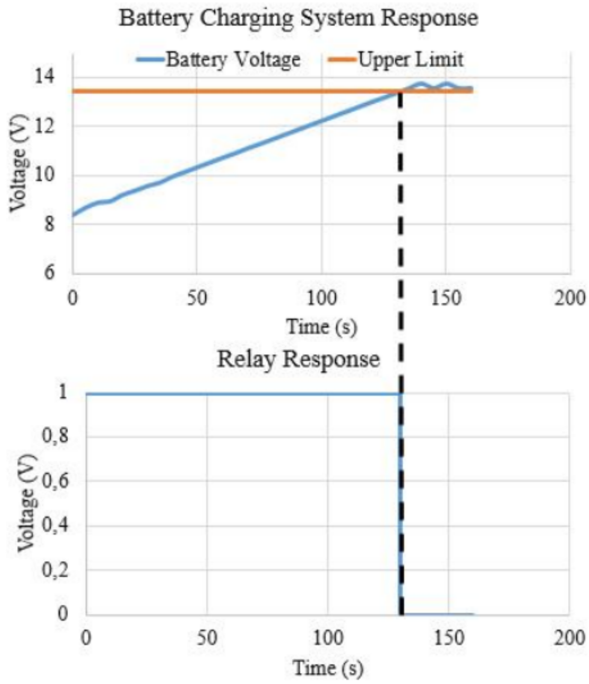

FIGURE 13. Relay system response graph as safety

From the image above, it is known the response of the relay to the voltage rate on the battery charging. In the beginning, the voltage value produced is still below the limit value of 13.45Vdc so that the relay is still in a state of light. At the time of the 140th second the resulting voltage value is above the predetermined limit value so that the relay can perform its action to break the voltage flow on the battery charging.

CONCLUSION

Wind and solar power generation technology can be used as a generator to create electricity supplies for pumps in the water dew. All components can work well with error values of less than 1* standard deviation and the performance rate produced by the plant can reach 395 Watts stored by batteries. The voltage generated by solar cell panels with sunny weather conditions around 13-19 Vdc before being given a step-up. While from PMG can produce from the radius of 300-400 rpm rotation value of 11-10 Vdc. So at the voltage value need to use step-up as a stabilizer of the voltage value for the charging system on the battery that is as complete as 12 Vdc. As for the safety charging experiment is done using automatic integration between the controller and the relay module where the controller will give a set-point voltage value of 12.50 Vdc so that if from the measurement results using a voltage sensor 0-25 Vdc exceeds the maximum limit then the relay will perform actions to disconnect the voltage.

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