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Design and Development of Microcontroller Battery Filling Control System Arm Cortex M0-Nuc 120 on Axial Axis Wind Turbine Type

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Abstract. Indonesia is an archipelago and one country located on the equator with abundant wind energy potential. Various studies of wind turbine models are used to study electric power systems. This development is based on various research focuses such as turbine propellers, wind speed, and electrical charging coefficients. So that in this study there is a need to design a charger controller to charge a 6 Volt battery load, 4.5 Ah on the axial axis mini wind turbine type plant. In this charger contoller circuit is composed of 2 circuits namely the boost converter circuit using a 3.2 mH inductor and power IRFP460 MOSFET and pulse signal generator range PWM (Pulse With Modulation) and 4N35 Optocoupler IC and ARM CORTEX M0-NUC 120 Microcontroller. The method used is through preliminary observation, problem identification, literature study and field studies, determining parameters and data collection. From the results of the charger controller trial results obtained an average output voltage of this controller is ± 6 volts, which has adjusted the voltage specifications to charge the 6 volt battery and the resulting current is an average of 0.02 amperes. With a frequency of 1.25 KHz and a duty cycle of 70%. The highest charger controller efficiency occurs at 7 m/s wind speed with an efficiency value of 3%. The design of the charge controller that has been made for the output voltage of the DC 1-4V generator which will be increased by the boost converter with the input voltage value of 6-7 volts to meet the charge voltage for the battery battery 6V, 4.5Ah, the output variable of the generator DC is controlled by the charge controller using the switching method. The battery charging control system using this auto cut off circuit works when the Depth of Discharge voltage of the 6 V battery is 50% at a measured voltage of 6.12 V and the charging process stops when the voltage reaches 6.05 V.

Keywords: design, development, battery filling, axial axis, wind turbine

1. Introduction

The necessity for electric power in Indonesia in particular and in the world in general is increasing. This is due to the increase in population, economic growth and increasing consumption of energy consumption patterns. Electric energy is a vital energy for human civilization in everyday activities and in industrial activities. The electrical energy is used for a variety of needs, such as lighting as well as process processes involving electronic items and industrial machinery. With large electrical energy demand, it is necessary to supply enough energy sources to meet these needs. Of course, keeping the fossil energy available is known to decrease. Given that it requires a renewable resource whose existence is unlimited, in order to obtain this condition it is necessary strategic steps that can support the provision of electric energy optimally and affordable.

One of the efforts to tackle the energy crisis is reducing dependence on fossil energy sources by utilizing alternative energy sources. One of the alternative energy that can be used is the energy found in nature like wind. One of the benefits of renewable energy that currently has great potential to be developed is wind energy. This energy is a clean energy and the production process does not pollute the environment (Nakajima and Ikeda, 2008).

Wind energy is a natural resource that can be obtained free of charge that is abundant and available continuously throughout the year. Indonesia is an archipelago country with approximately 17,500 islands with a coastline length of more than 81,290 km. Indonesia has a very large wind energy potential of around 9.3 GW and a total capacity of about 500 MW (Daryanto, 2007). Wind energy can be utilized in wind power generation which is a method to generate electric energy by rotating the wind turbine connected to the generator then the results are stored in the battery and to keep the current and voltage generated from the generator needed a controlling system so that electrical energy is entered into the optimal battery. For that, it will be done to know the performance of Vertical Axis Wind Turbine.

This Vertical System Axis Wind turbine can be used as a source of electrical energy in everyday life especially in operating equipment that requires electrical energy. Electric energy generated by wind turbine cannot be used directly to the load; the electric energy is charged and stored in the battery or ACCU. Charging process is a process of electrical system in a vehicle that works to recharge the battery so that it is always in good condition and meets the needs of electrical energy for other electrical systems. In the Vertical Axis Wind turbine battery charging system there are several obstacles, one of which is the constraints on the battery charging system (charge controller system). In the process of charging the power source into the battery, the current and voltage generated by the generator is unstable and does not correspond to the allowable set point input so it is needed a system that can control current and voltage automatically for charging process. This battery charging control system uses the ARM Cortex M0 NUC 120 microcontroller as its controller.

2. Result and discussion

On design research a built-in controller on this axial axis turbine plant based on the ARM CORTEX M0-NUC 120 microcontroller by performing testing and data retrieval process with the following steps.

2.1. Testing on the wind turbine miniplant

Testing of the wind turbine mini plant was carried out on the coast of Kenjeran, Surabaya, East Java at 17.54 WIB. The results obtained from the wind turbine testing process is that the tool is able to work properly and all supporting components such as electrical systems, mechanics and monitoring are able to work as expected

2.2. Chargers of the controller system in the mini turbine Axial axis plant

There is a panel box that is used to integrate all components of monitoring and control equipment and also as protection from unwanted things. The system of the charger controller is assembled in a panel box using a PCB. The position of this sequence is after the system of monitoring the voltage and current and the output of the DC generator.

2.3. Testing PWM Signal Power Switch Ignition Circuit

The ignition circuit of the IC 4N35 power switch and PWM is one of the methods used for safety and switching of power components of the IRFP460 MOSFET which is used by the charge controller circuit on the mini plant wind turbine. The ignition of signal power switch uses a 4N35 IC opt coupler on this charge controller circuit to observe the following figure.

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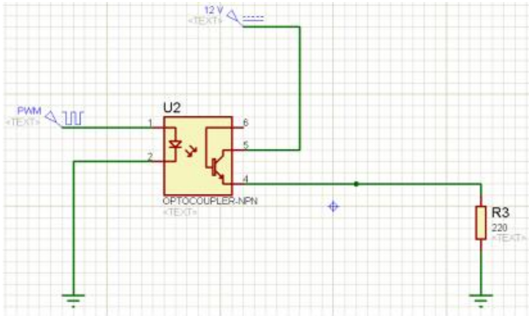

Figure 1. The ignition of signal power switch PWM

2.4. Charge Controller Circuit Testing

The next step is the process of testing the charge controller circuit by looking at the comparison between the input generator value and the output value of the controller. The testing process can be seen in the picture as follows

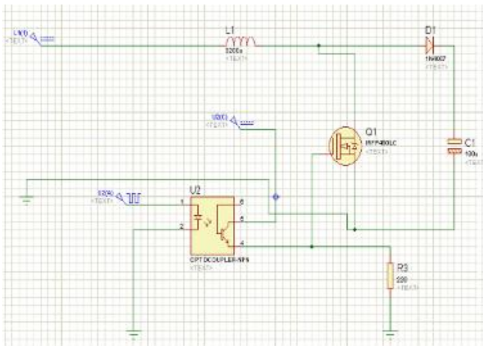

Figure 2. Controller circuit of Boost Converter

Based on the schematic in Figure 2, testing is done according to the measurement configuration. At the time of testing that has been carried out on the Kenjeran beach is using the voltage generated by a 36 volt DC generator with measurement parameters and input voltage ratio of 1-4 volts, wind speeds of 3-8 m/s, switching power MOSFET frequency and 70% duty cycle. The load used is a dry battery with a specification of 6 volts, 4.5 Ah with a capacity of 70%. The MOSFET power type used is IRFP460N.

The greater the wind speed the input voltage generated will be greater and automatically the output voltage generated is also greater. The graph of the comparison of the amount of wind speed to the input voltage generated by the DC generator and the output voltage generated by the boost converter can be observed in the following figure.

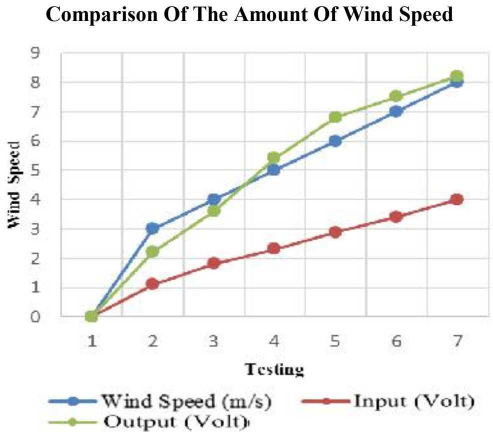

Figure 3. The graph of the comparison of the amount of wind speed

The output voltage generated from this boost converter system can be directly applied to the battery charging process but the voltage is less fulfilling the criteria. The voltage is stable and safe if you are charging the 6 volt battery. So it is necessary to design a series of automatic battery charging (auto cut off). This auto cut off circuit serves as a safety sequence and battery charging control. The output voltage of this boost converter will be coupled with the battery charger circuit (auto cut off). The auto cut off circuit is used as a circuit breaker that enters the battery or a 6 VDC battery when full. During charging conditions, the red LED lights will light up.

When the battery or battery capacity is full the transistor TIP41 will OFF. When the zener diode breakdown of 6.1 volts is reached, the zener diode will open and drain the current to the base of the base. In principle, this auto cut off system does not experience a 100% cut-off completely, when the zener breakdown voltage is reached, the zener diode will open and trigger the transistor BC548 to ON, the current will flow to the Emitter's feet to the ground and the white LED lights will dim and will the brighter if the zener diode breakdown is reached. Because the current is flowed to the ground, the current to the battery will be very small and keep the voltage at the specified limit.

The 6 volt battery charging process with a battery capacity of 70% or 4.2 volts using an auto cut off circuit and a regulator with 6 volt input.

After the battery has a capacity of 100%, the voltage will be adjusted to the maximum input voltage of the battery that is equal to 6.08 volts so that the current will not enter the battery and the battery charging process will stop. This is indicated by the white LED indicator light that lights up more brightly.

2.5. Testing the Charge Controller Series With a 6 Volt Battery Load

The charge controller system testing is integrated with the specifications of the current and voltage measuring devices in the monitoring system in the mini wind turbine plant. The specifications of this measuring instrument are used as a reference if there is a correction in the testing of the data testing of the mini wind turbine plant. The battery capacity used is 4.7 - 4.9 volts or ± 80%. With a current and voltage monitoring system, then the controller output response to the input given is then tested. This data testing and retrieval was carried out as much as 30 data sets. A graph of current and time readings can be observed in the figure as follows.

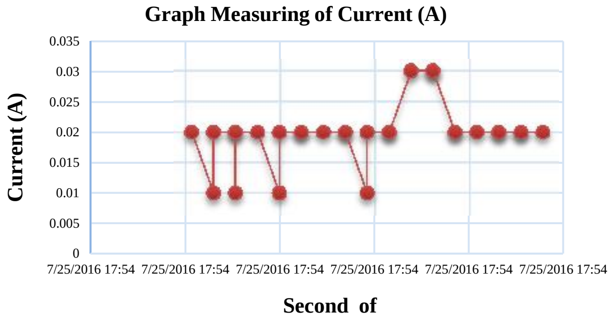

Figure 4. Current graph against the function of time

From the picture is a current graph against the function of time with an average current measurement of 0.02 amperes with an average wind speed of 5 m / s. This data retrieval process also includes the output voltage generated by the charger controller system. This voltage data retrieval is also carried out in conjunction with 30 data flow measurements. The results of the measurement data and data retrieval of the output voltage from the charge controller system with a 6 volt battery.

From the Output Controller System Voltage Measurement Data, with a switching frequency value of 1.25 KHz, a duty cycle of 70% and using a 6 volt battery load of 80% capacity. Obtain graphs of current and time readings that can be observed in the figure

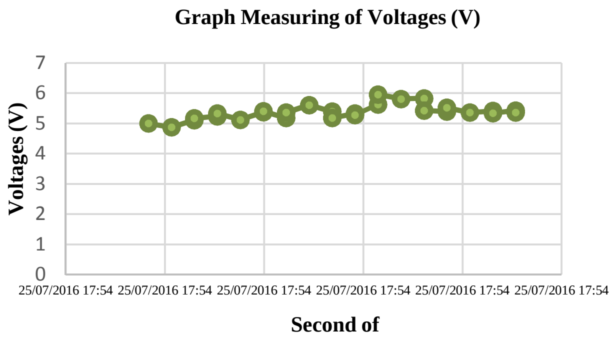

Figure 5. *Voltage graph against the time function*

From the image is a voltage graph against the time function with an average measurement of battery charging voltage of 5.36 volts with an average wind speed of 5 m / s. This data retrieval process also includes the output voltage generated by the charger controller system. Based results of the data from the current and voltage testing that has been done is the output charge controller using a battery load of 6 V battery, 4.5 Ah capacity of 80%, obtained the efficiency value of the charger controller. Based on the output value the average current and tension of the boost converter is 0.002 amperes and 5.36 volts can be calculated the charger controller efficiency value.

The average value of the charge controller system efficiency is 3%. This result is obtained from the distribution of Pin and Pout values with an additional load of 3 watts of light, 6 volts. From the results of the data presented in table 4.5, it is obtained a graph of the value of the charger controller efficiency that can be observed in the figure as follows.

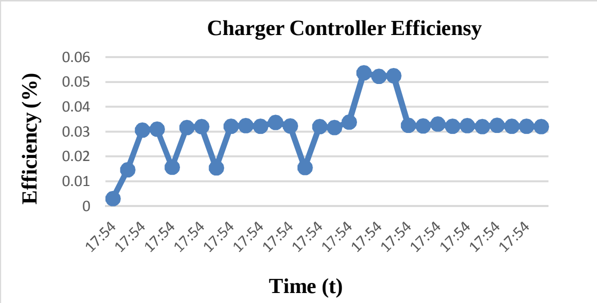

Figure 6. Efficiency graph of Charge Controller

From Figure 6 is a system efficiency graph of the time function with an average measurement of the efficiency of the battery charging system by 3% with an average wind speed of 5 m/s. The greatest efficiency value is obtained at a wind speed of 5% with a wind speed of 8 m /s.

3. System Analysis

Of all the tests that have been carried out namely testing PWM pulse generator signal, testing the output voltage at the foot of the Gate MOSFET, testing the charge controller circuit using one MOSFET and charge controller testing on the mini turbine hoizontal axis plant plant is analyzed. Starting from the discussion for the first test of the PWM generator pulse signal using a power switch ignition circuit. PWM signals are generated through a power switch igniter with 4N35 IC and the STM32F303 Discovery microcontroller with duty cycle is set in the program with a frequency of 1.25 kHz. Testing PWM pulse signal output with a duty cycle of 70% after the output voltage is checked, there is a change in the output voltage value in accordance with changes in the value of the duty cycle given as data in table 4.1 and table 4.2, it can be ascertained that the generation of PWM pulse signals through the STM32F303 Discovery can work properly . With a maximum value on the duty cycle 70% is 0.9 volts. In the measurement process and the second test discusses the reading of the output voltage at the foot of the gate mosfet. Based on the data in figure 4.4 and figure 4.6 shows the duty cycle value of 70% has a maximum error with a ratio of 80% duty cycle value of 0.12 volts. This can happen because the generation of a PWM pulse signal with a 70% duty cycle has the greatest value when compared with an 80% duty cycle value. In the comparison value of 70% duty cycle and 80% shows an error value of 0.12 volts. With the input voltage on the Collector optocoupler foot of 12 volts from the output of 4.6 volts from the adapter and the duty cycle value of 70%, the voltage output at the 4.3-4.6 volt MOSFET (Vgate) foot gate is obtained. From this measurement can be ascertained the system works well.

Testing the charge controller circuit the results of current and voltage testing with the test data and measurement of the current generated by the charge controller system with a switching frequency value of 1.25 KHz, 70% duty cycle and using a 6 V battery load, 4.5 Ah capacity of 80%. With an average voltage value generated by the boost converter system against the time function with an average measurement of battery charging voltage of 5.36 volts with an average wind speed of 5 m / s. Measurement of the current value with an average current value generated by the charger controller system to the function of time with an average measurement of battery charging current of 0.02 amperes with an average wind speed of 5 m / s.

From the average measurement of the current value and voltage generated by the charger controller obtained the efficiency value of the charger controller system. When analyzing the battery charging system, the charger controller system will charge if the battery is in use or the Depth of Discharge (DoD) is 10% with a measured voltage of 5.4 volts. The discharge process will be exceeded if the battery capacity is 100% with a rated voltage of 6.05 - 6.08 volts. Data efficiency analysis of the charge controller system uses a 6 V, 4.5 Ah battery load and 3 watt lamp. From the calculation of Pin and Pout calculations, the average value of the charger controller system efficiency is 3% with an average wind speed of 5 m / s. The greatest efficiency value is obtained at wind speeds of 5% with a wind speed of 8 m / s. This is because the wind speed is very fast at 17.54.29 so the DC generator also rotates very fast and produces a greater current and voltage value. So it can be concluded if the winds that rotate the wind turbine blade the greater the voltage, current and efficiency of the charger controller system.

4. Conclusion

Based on the design of the tools and the results of the research, the design of the charge controller in the horizontal axis mini plant wind turbine can be concluded, namely:

1. The design of the charge controller that has been made for the output voltage of the DC generator 1-4V which will be increased by the boost converter with the input voltage value of 6-7 volts to meet the charge voltage for the 6V, 4.5Ah battery.
2. The output variable of the DC generator is controlled by the charge controller using the switching method. By determining the frequency and value of the duty cycle to generate the PWM signal through the ARM CORTEX M0-NUC 120. The generated PWM signal will be the input of the 4N35 optocoupler IC to perform the switching process. The charge controller circuit works with a frequency value of 1.25 KHz and a duty cycle of 70%.
3. The battery charging control system uses the auto cut off circuit.

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