Development of Maximum Power Point Tracking Solar Charge Controller for 120 Volt Battery System at Pandansimo Hybrid Power Plant

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Abstract. Pandansimo Hybrid Power Plant (HPW) is located at Pandansimo Beach, Bantul, Yogyakarta. It has a maximum capacity of 57.5 kW, combining solar and wind energy technologies. Currently a part of it (4 kWp solar panel system) is used for ice maker machine with an efficiency merely of 60% in average. To increase efficiency of system and safety of battery charging, a special Maximum Power Point Tracking (MPPT) Solar Charge Controller is developed. This system is developed to optimize power transfer from solar panel array to battery, which is shown as solar panel characteristic in a I-V curve. The purpose of this research is to develop the MPPT Solar Charge Controller with PID algorithm for 120 volt battery system and 4 kWp solar panel. The Solar Charge Controller (SCC) design uses microcontroller system that is easy to repair and improve. The SCC component can be found easily in local electronic components stores around Yogyakarta. The SCC design involves several main parameter: PWM switching frequency 50 kHz, mosfet IRFP260 power switching device, 120 Volt battery, rated current charge of 40 ampere, and three state battery charge sequential. The result of this research are the MPPT SCC with average efficiency of more than 90%, real charge current of 30 Ampere, and PV voltage optimum of 165 Volt.

1. Introduction

Pandansimo Hybrid Power Plant is the one largest station in Central Java and Special District of Yogyakarta Province, which has renewable energy power generation from solar and wind [1]. This HPW consists of 40 wind turbines. Each turbine produces 1kW of electricity. Otherwise, to convert the sun energy, this plant also uses solar panels which have production capacity up to 15kW.

The HPW builded in the fish village of the Pandansimo Coast used to fulfill the daily needs of the society. That is, to produce a thousand of ice blocks per day and also pumps the well water to irrigate the agricultural lands on coastal line, especially on summer. In otherwise, the electricity also used to streetlighting and supply for some food shops near the beach.

The HPW has three main components, solar panel, generator, wind turbine, battery charging controller, and also inverter. Deals with battery charging process, there is a gassing. The gassing forms hydrogen and oxygen. That condition will be profitable at specific concentration. But if it is over, it
will cause an explosion. In other side the discharging process will cause a potentially deep discharging. The deep discharging causes the decremination of battery’s life cycle.

To avoid these cause, the battery charge controller used to protect the battery from overcharging or over discharging [2], [3]. The battery charge controller also used to give information to the user about the condition of the battery array, so the user will be able to control the electricity consumption.

The purpose of this research is to develop the MPPT Solar Charge Controller with PID algorithm for 120 volt battery system and 4 kWp solar panel. The SCC component can be found easily in local electronic components stores around Yogyakarta. The SCC design involves several main parameter: PWM switching frequency 50 kHz, mosfet IRFP260 power switching device, 120 Volt battery, rated current charge of 40 ampere, and three state battery charge sequential.

2. Literature

Research conducted by Beng Tito entitled New MPPT method for photovoltaic cells based on PI controller, discusses a new method for MPPT solar cells based on PI controller. Analysis of simulation work done by MPPT design based on boost converter. In the study that produced the tracking of both algorithm, from the simulation obtained that the ICM algorithm generated 2016.8 watts rated power. while the PI algorithm generated 2017.3 watts of power. This study concluded that the PI algorithm has advantages in terms of speed and tracking process than the ICM algorithm.

Research conducted by Dianggoro entitled Design Maximum Power Point Tracker (MPPT) Solar Panels For Cuk Converter Using Hill Climbing Methods, discusses the design of the MPPT system using Continuous Conduction Mode (CCM). Research that conducted by Dianggoro (2011) use simulation to determine the reliability of the system. The algorithm used in this MPPT is Hill Climb Search (HCS). The result is the system which has implemented MPPT could increase the output power ranging from 4.70 to 36.49 % compared to the system without MPPT. This test done with some variations of load 5 ohms, 10 ohms, and 15 ohms as well as varying levels of irradiation.

3. Basic theory

Maximum Power Point Tracking is a technique to track the voltage which could generate the maximum power from solar array. Energy from solar panels has the characteristics described in the V-I curve. Therefore, this technique is applied to find the maximum power point on the V-I curve. This MPPT device integrated in a electronic device for voltage conversion. MPPT here is a DC / DC converter with a controller. Existing work processes within the MPPT controller can be classified into several algorithms such as Constant Voltage.

In this algorithm refers to the open circuit voltage (Voc) were measured when the DC connection is opened. The voltage at the maximum power point can be calculated by the equation below.

\[ V_{ref} = k \times V_{oc} \]  (3.1)

Then the Vref will become the set point to control the output voltage. PID algorithm used to control the output voltage. It is ziegler-nichols method.

4. Implementation of Research

This research conducted with implementing steps are as follows:

A. socialization activities

Conducting active communication with the user and operator of Pandansimo HPW to create a good cooperation, so the research and its implementation could running on good way. The most competence part of this socialization is the administrator and the operators. The meeting material in this activities delivered in order to create an active cooperation between the HPW’s administrator and the researchers. Then will make the good understanding of the W-SCC system.

B. Designing the Engineering Detail

The Detail Engineering Design (DED) conducted to create the best design of the device with microcontroller [4], [5]. This research are conducted based on its previous. This research conducted
with more complex, such as the higher charging current capacity. The design of the W-SCC shown in figure 1.

![Block Diagram of the W-SCC](image)

**Figure 1.** Block Diagram of the W-SCC

The design of the W-SCC used microcontroller [2], [3], [12]–[17], [4]–[11] system. The adjustment logics based on easy programming. The W-SCC system implemented with the specification showed in Table 1.

| Parameter                  | Value            |
|----------------------------|------------------|
| Voltage                    | 48 VDC           |
| Max. Voltage               | 100VDC           |
| Avg. charging current      | 60 Ampere DC     |
| Max. charging current      | 80 Ampere DC     |
| Consumption                | 30 mA            |
| Mode Charging              | PWM              |
| Protector                  | Heater Resistor  |
| Microcontroller            | AT Mega 32       |
| Display                    | LCD 16x2         |
| Control input              | Key-Pad 3x4      |
| Power Switching Comp.      | IGBT             |
| Casing                     | Aluminium / sealed |
| Cooler                     | Pasiv Heat Sink  |
| Data Logger                | SD Card 2 Gb     |
C. The Devising of hardware
Devise the whole components into a Printed Circuit Board (PCB). After the circuit board finished, then mounted it into a box as a component protector from sea water corrosivity aspect. The schematic with microcontroller of the device shown on Figure 2.

![Figure 2. W-SCC control device schematic](image)

D. Programming
This step conducted after the hardware is done. The programming used to control the performance of the system. The W-SCC device uses a PID control [18] to determine the output voltage. After this embedded system is done, the device tested in workshop field then. The test conducted with 400Wp and 60V solar panels and a 100Ah battery bank.

![Figure 3. Workshop testing](image)

E. Implementation
The implementation of W-SCC device is installed at Pandansimo HPW. This step involve the administrator ans operators of the Pandansimo HPW. Then the evaluation is conducted to know the performance of the W-SCC system or the HPW it self.
The contribution of the operators really needed to operates the device correctly. The operators also follow the accompaniment process.

5. Conclusion
The test conducted in workshop used 400Wp and 60V solar panel, and also 100Ah battery. The test showed that the device worked well. The charging indicator shows 54.4V of the charging voltage and 2.5A of its current. The test also conducted in the HPW system in the field. On this field test, the W-SCC device shows the good performance. And the W-SCC system is applicable to be implemented directly to the HPW system.

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Figure 4. Field testing
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