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Fuzzy logic-based voltage controlling mini solar electric power plant as an electrical energy reserve for notebook

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Abstract

This project aims to develop and to test a prototype of mini Solar Electric Power Plant (mini SEPP) for a notebook battery charging with constant output voltage from a fluctuated input voltage. The mini SEPP consist of solar cells, boost converter, and ATmega128 microcontroller. Fuzzy logic as control method is used to control output voltage of mini SEPP. In this research, error tolerance of mini SEPP output voltage is 5% of set voltage. Testing of mini SEPP has done in three conditions: cloudy weather, sunny with cloud weather, and sunny weather. Result of the test had shown that mini SEPP worked in sunny weather properly but it didn't work properly in cloudy weather and sunny weather with cloud because output power of solar cells was not at maximum point but the mini SEPP still charged notebook battery.

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Keywords: microcontroller; boost converter; fuzzy logic; battery charging; notebook; mini solar electric power plant.

1. Introduction

Notebook is an electronic device which is used by many people for helping their work. Notebook can be operated by a Li-ion battery or ac power source. Notebook's battery can be used to operate notebook for 2-3 hours. Problem now, notebook user can not charge the notebook's battery in area not electrified. Need to create a converter which can convert available energy in nature into electrical energy used for notebook battery charging. Sun energy is an

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available energy in nature that can be converted into electrical energy using solar cell. Since the electrical energy produced by solar cell is fluctuated, the converter also must have ability to stabilize the electrical energy produced by solar cell. With this, the problem above can be resolved by creating mini solar electric power plant (mini SEPP) as an electrical energy reserve for notebook.

Last research had showed that photovoltaic system could be controlled through the boost converter with voltage-feedback technique [1]. The output voltage of boost converter is recorded continuously and then compared with microcontroller's set voltage. Then, the voltage difference is used as a parameter for the microcontroller producing a PWM signal for controlling boost converter switching. Propose system of mini SEPP in this project is also using voltage-feedback control technique while fuzzy logic is used as control method and embedded in microcontroller. The difference between output of the converter and the microcontroller's set voltage will be an input for fuzzy logic in order to produce control signal. Limitation problems of this project are the notebook's battery charging using constant voltage method. The notebook used in this project have a specification of 11,1 V 4000mAh battery, and error tolerance of controlling voltage is 5% of set voltage.

2. Research methodology

Basic concept of mini SEPP is stabilizing the output voltage of PV module from fluctuated input voltage. Mini SEPP contain of PV module, boost converter, microcontroller, and fuzzy logic control system. Fuzzy logic is written in programming language and downloads to the microcontroller.

2.1. Characteristic of solar cell

Solar cell is a semiconductor device which able to convert energy of sunlight into electrical energy. Equivalent circuit of solar cell is shown in Fig. 1. Equation for solar cell characteristic can be written [2].

$$I = I_{LG} - I_{OS}\left\{eks\left[\frac{q}{AkT}\left(V + IR_S\right)\right] - 1\right\} - \frac{V + IR_S}{Rsh} \tag{1}$$

where I is cell output current, I_{LG} is light generated current, I_{OS} is cell reverse saturation current, q is electronic charge, A is dimensionless factor, k is Boltzmann's constant, T is temperature, V is cell output voltage, R_S is series resistance, and R_{SH} is shunt resistance. I-V characteristic curve of solar cell is shown in Fig. 2.

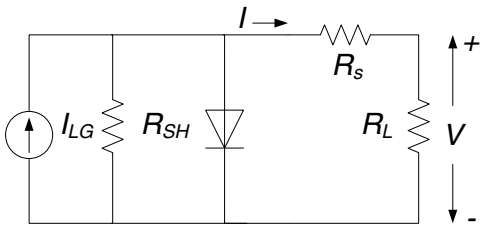

Fig. 1. Equivalent circuit of solar cell