

FPGA를 이용한 소형 태양광 발전 니켈 수소 전지 충전 시스템의 POS MPPT 제어

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FPGA based POS MPPT control for a small scale charging system of PV-nickel metal hydride battery

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Abstract - Recently, the small scale photovoltaic (PV) electronic devices are drawing attention as the upcoming PV generation system. The PV system is commonly used in small scale PV applications such as LED lighting and cell phone. This paper proposes photovoltaic output sensorless (POS) maximum power point tracking (MPPT) control for a small scale charging system of PV-nickel metal hydride battery using field-programmable gate array (FPGA) controller. A converter is connected to a small scale PV cell and battery, and performs the POS MPPT at the battery terminal current instead of being at the PV cell output voltage and current. The FPGA controller and converter operate based on POS MPPT method. The experimental results show that the nickel metal hydride battery is charged by the maximum PV output power.

power of PV array increases as well by the POS MPPT control method, based on the output power of PV cell, tracks the MPP by comparison of duty ratio and battery current.

The FPGA controller is operated for the battery charging current. The battery charging current is calculated by the POS MPPT control method. The MOSFET is switched by FPGA PWM signal. The maximum power is generated by PV cell. The maximum power is charged into the nickel metal hydride battery.

1. Introduction

The concern for environmental issue has been rising in the world such as global warming by increasing carbon dioxide. Moreover, the global energy shortage and the need for sustainable energy system enforce the development of power supply structures that are based mainly on renewable resources. The photovoltaic (PV) system is gaining importance as a renewable source due to advantages such as the absence of fuel cost, little maintenance and no noise [1]. The PV system is commonly employed in a small scale PV applications such as LED lighting and cell phone.

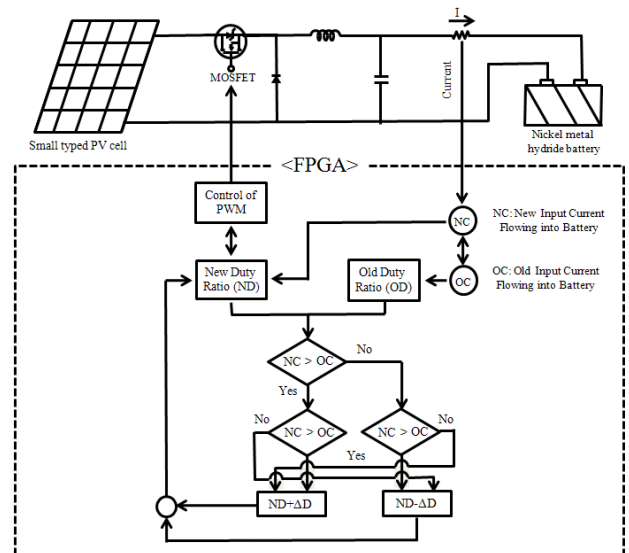
In a PV generation system, there are various methods of controlling the maximum output power of PV cell. The conventional power comparison Maximum Power Point Tracking (MPPT) control method has to feed back the information of both voltage and current coming out from PV array. So, the structure of control circuit becomes complex [2-5].

Few solutions have been proposed by considering the MPPT at the load terminals. In this case, if the controller system can be modelled by means of a POS (Photovoltaic Output Sensorless), the MPPT controller can be simplified by monitoring only the DC-DC converter output current [4-8].

This paper deals with a small solar cell based nickel metal hydride battery charging system using POS MPPT control method. The proposed POS MPPT control system uses only one sensor for the converter output current feedback. Thus, the battery charging system is much simpler than any other conventional charging system. The system consists of field-programmable gate array (FPGA) controller, DC-DC buck converter and nickel metal hydride battery. The experimental results show the maximum power tracking of PV cell output and the detailed charging characteristics of the nickel metal hydride battery.

2. PV POS control scheme

Fig. 1 shows the block diagram of the POS MPPT control scheme. In the proposed POS MPPT control, the battery input current 'I' of PV system is the only significant component of the MPPT control scheme. The power conversion system is controlled by PWM control. The duty ratio causes an increase in the output current of the power converter which flows into the load. The system is controlled by POS MPPT control algorithm. The input current as well as the input power of a battery goes toward their maximum values. The output



<Fig. 1> Block diagram of MPPT control method

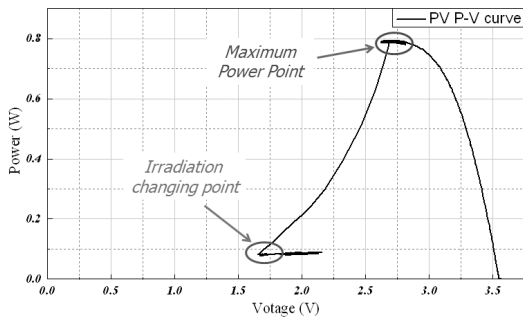
3. Experiment and results

The battery charging system is composed by a small scale PV cell, a buck converter controlled by FPGA controller and nickel metal hydride battery. The parameters of battery charging system are described in Table 1. The maximum power of PV cell is 1.5 W. The voltage at MPP of PV cell is 3 V. The current at MPP of PV cell is 500 mA. The battery voltage is 1.2 V. The battery capacitance is 2000 mAh.

<Table 1> Parameters of battery charging system

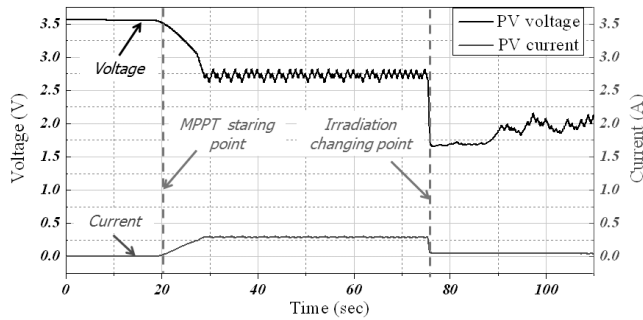
System	Parameter	Data
PV cell	Maximum power point	1.5 W
	Maximum voltage point	3 V
	Maximum current point	500 mA
FPGA	Model	EPIC6Q230
	ADC scale	8bit ADC
Battery	Voltage	1.2 V
	Capacitance	2000 mAh

Fig. 2 illustrates the relationship between power and voltage of PV cell under variable weather conditions. The FPGA controller is operated by POS MPPT control. The PV cell output power is tracked to the maximum power point. The manufactured PV system is operated by POS control method, and POS control is tracking the maximum power point.



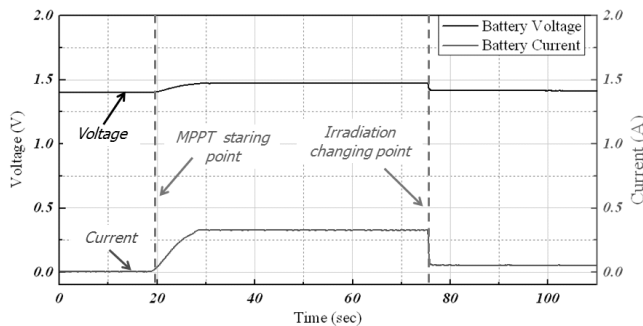
<Fig. 2> Experimental results of POS MPPT P-V curve

Fig. 3 illustrates the experimental results for the voltage and current of PV cell under variable weather condition. The FPGA controller is operated by POS MPPT method after 20 second. The irradiation is dropped by shadow after 75 second. The PV output voltage and current tracked well the optimal value when the irradiation was changed.



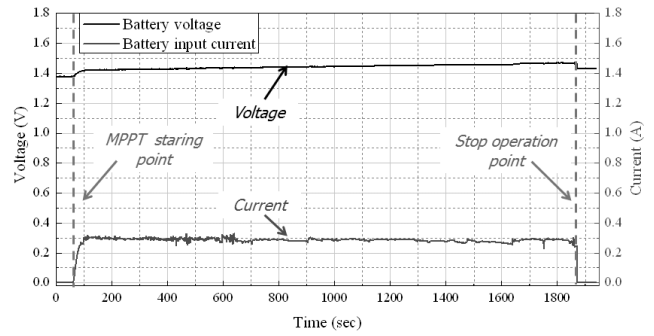
<Fig. 3> Output voltage and current of PV cell

Fig. 4 shows the experimental results for the voltage and input current of battery under variable weather condition. The battery is charged by maximum input current. The battery voltage is influenced by battery charging current.



<Fig. 4> Terminal voltage and input current of battery

Fig. 5 displays the experimental results for the voltage and input current of battery under variable weather condition for long time. The battery terminal voltage increased as in the Fig. 5. The battery voltage increased in proportional to the charging current. The starting battery voltage is 1.38 V. The charged battery voltage is 1.43 V after 1800 second. The increase of battery terminal voltage is 0.05 V during about 1800 second. Fig. 5 illustrates the variation of battery voltage according to the difference of the charging current of battery.



<Fig. 5> During long term, experimental results of terminal voltage and input current of battery

4. Conclusions

This paper demonstrates the FPGA based POS MPPT control for a small scale charging system of PV-nickel metal hydride battery. The main advantage of the system is that only the battery input current is used for MPPT control, resulting in simplification of the control circuit and algorithm. Due to the current is only feedback for proposed system, the control circuit and algorithm can be simplified, and the cost of overall system can be reduced as result.

The system uses the maximum power from small solar cell to charge nickel metal hydride battery. The DC-DC buck converter and FPGA controller are employed to control the maximum power of PV cell.

Acknowledgements

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