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Battery Charging System from Cascaded DC/DC Converters

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ABSTRACT

This study considers an accumulator battery charging system from a photovoltaic panel with increased open circuit output voltage. The system consists of two series connected converters - step-down converter (buck) and step down/step up Single Ended Inductance Converter (SEPIC). The first converter limits the output voltage of the photovoltaic panel to the allowable range of input voltage variation of the second converter. The last converter implements the charging algorithm - constant current charge with voltage limit.
Keywords: photovoltaic, battery charger, buck converter, SEPIC converter.

INTRODUCTION

The available energy from renewable energy sources can not always be used in real time, so it needs to be stored in appropriate elements - most often rechargeable batteries, ultracapacitors, etc. An overview of the major systems for this is made in [1]. The comparative analysis in [2] shows that when using solar energy from a photovoltaic panel, mostly one-step converters for the charge of rechargeable batteries are used. There are solutions with series connection of two converters, as usually a direct current load is connected to the output of the first one [2]. In [3] is shown Cuk converter and buck converter cascade connection for providing the monitoring of the Maximum Power Point Tracking (MPPT) and constant current battery charge. The advantages are expressed in avoiding the risks of battery damage as a result of the changing voltage at the maximum power point [3]. Recently, the use of Single Ended Primary Inductance Converter (SEPIC) in photovoltaic power conversion systems [4,5] is used frequently. Its advantages are the possibility to work as a step-down/step-up converter without changing the polarity of the input voltage and the transistor control according to the common minus.

This study presents a battery charging system, which consists of two series connected converters - buck converter and SEPIC converter.

SYSTEM DESCRIPTION

Fig. 1 presents the block diagram of the system. The used photovoltaic panel has a broad output voltage range varying from 0 to 62 V, which initially led to the idea of using two converters.

To co-ordinate with the broad output voltage variation range of the photovoltaic panel, an

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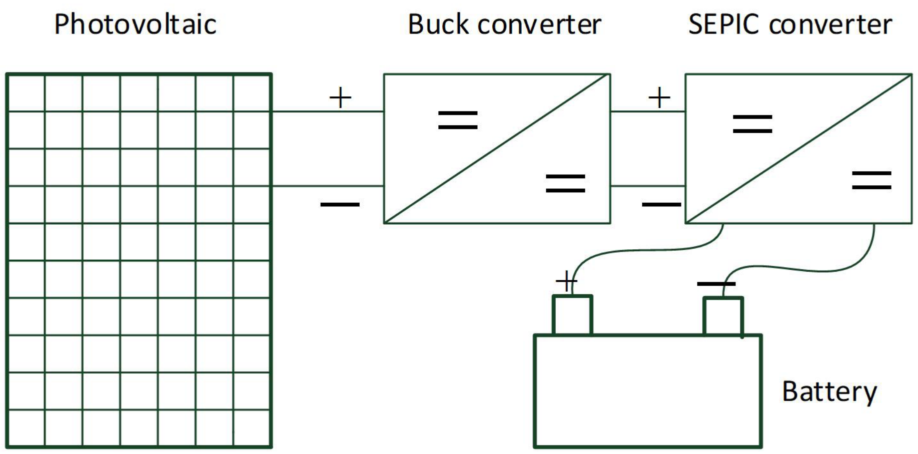

Fig. 1. Block diagram of the implemented system.

additional Buck converter whose output voltage is limited to 30 V is included. Simultaneously, it also implements the maximum power tracking algorithm - MPPT.

The developed step-down/step-up energy converter (SEPIC - Single Ended Primary Inductance Converter) implements battery charge algorithm - constant current with voltage limit and operates at an input voltage of 9 to 35 V.

The charge algorithm is illustrated in Fig. 2 [4]. At the start of charging - time t_o, the battery voltage has initial value U_{init}. After charging with constant current, the final charging voltage in time t_1 is reached. After this moment, the SEPIC converter switches to voltage stabilization mode, as its current consumption decreases with the time.

The system also provides the following protections in case of improper operation: electric overloading and short-circuit at the outlet of the battery; incorrect connection of the battery polarity; incorrect connection of the polarity of the photovoltaic panel.

EXPERIMENTAL

The panel used is type SP44 with the following data: open circuit voltage $U_{OC} = 62.5V$, short circuit current $I_{SC} = 1.26A$, maximum power $P_{MPP} = 44W$.

The rechargeable battery has nominal voltage of 12V and capacity of 50Ah - Monbat.

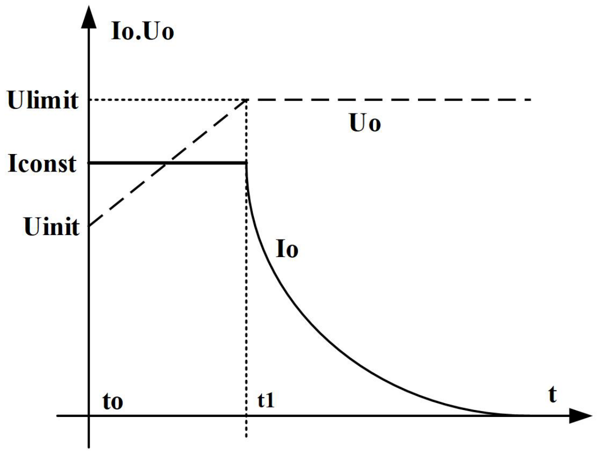

Fig. 2. Constant current I_{const} charge with voltage U_{limit} limit.

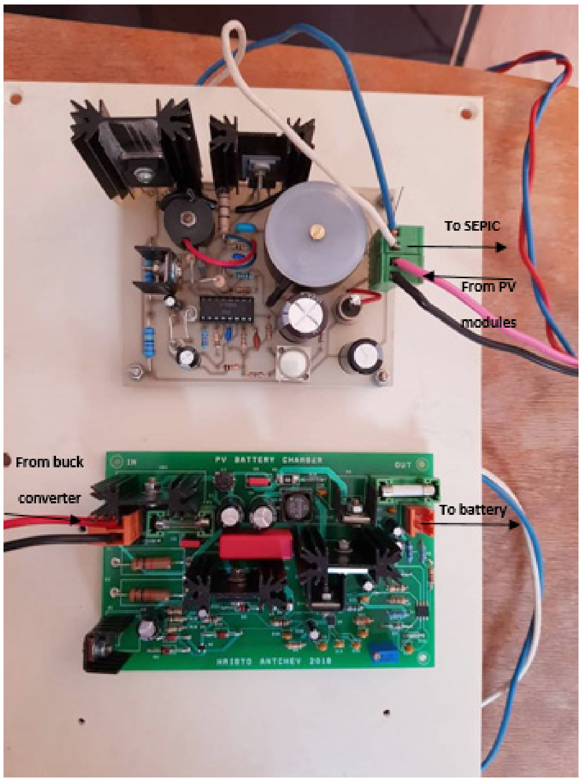

Fig. 3. Battery charging system.

Fig.3 shows the two converters. Basic elements of converters are shown.

The buck converter is implemented with a transistor IRFP450 and a diode BYV29-500. An integrated circuit TDA1060 is used to control it.

The complete schematic diagram of the SEPIC- converter is shown in [4]. The operation of the converter is described. An integrated circuit TPS40210 is used to control it.

CONCLUSIONS

The presented option for charging a rechargeable battery from a photovoltaic panel using two cascaded converters (buck converter and SEPIC) allows a broad variation of changes of the output voltage of the panel. At the same time, it provides tracking of the maximum power point - MPPT without the risk of applying inappropriate voltage to battery. The charge is always implemented according to the algorithm - constant current with voltage limit.

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