Implementation of Buck-Boost Converter for Remote Area Lighting System

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Abstract

In this Paper the design and implementation of a stand-alone solar power LED lighting system are the study objectives. The system includes solar cells, high power light-emitting-diode (HP-LED), bi-directional buck-boost DC converters, lead-acid battery and microcontroller (PIC). In recent years, due to the development in industry, environmental pollution and energy shortage, therefore it is imperative to develop renewable energy. In a variety of renewable energies,one of the most attractive selections solar energy.LED lighting equipment for future development is the trend, which has several merits namely low power consumption, long life. The system's main circuit is a bi-directional buck-boost converter, combining a single-chip microcontroller to manage, control both of charging and discharging functions. The function of maximum power point tracking control and high power light-emitting-diode driving control functions in the system. Finally through computer simulation this design has been verified.

Keywords-Stand-alone solar power LED lighting system, Buck-Boost converter, MPPT

1.Introduction

The main focus of this project is to determine the options that are available to replace grid-powered street lamps with a stand-alone system that has the reliability to work under the worst conditions. The renewable energy source selected for this project is a solar photovoltaic panel. The study was undertaken to determine the capabilities of a stand-alone systems and to determine if the long-term saving of electricity The development of renewable energy has been an increasingly critical topic with the growing problem of global warming andWith greater research for other environmental issues., alternative renewable sources namely wind, water, geothermal and solar energy have become increasingly important for electric power generation. Although photovoltaic cells are nothing new, their use has become more common and people worldwide is using it.

The most important aspect of a solar cell is that it generates solar energy directly to electrical energy through thesilicon cells which is used in solar photovoltaic module,Although each cell outputs a relatively low voltage (approx. 0.7V under open circuit condition), if many are connected in series, a solar photovoltaic module is formed. Although the price for such cells is low, making use of a solar cell is still requiring substantial financial investment.

Stand-alone systems can be built to power small loads namely water pumps and street lights, to the entire loads of a house. The design required to build a stand-alone system includes a solar panel, a voltage controller, and batteries. The requirement of AC power for loads, the design is made with an inverter. To control the output voltage of a panel, an MPPT is employed to increase the efficiency of the power to the batteries and load. Dependability of the load must be considered to determine the amount of reserve energy the system must have to provide continuous operation. The advantages of a stand-alone system are independent from the power grid, replacement of petroleum-fueled generators, and cost effective compared to running the power lines to remote areas.

2. System configuration and modelling

Fig 1.Shows the block diagram of PV panel, bidirectional buck-boost converter and battery for remote area lighting application.

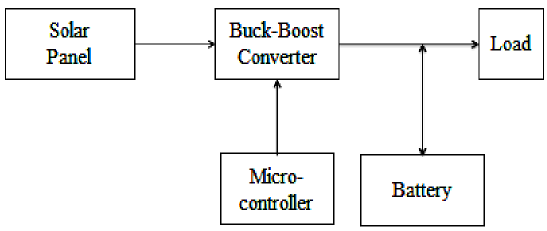

Figure 1.Proposed method Block Diagram

2.1Bidirectional Buck-Boost Converter

Galvanic isolation between multi-source systems is a requirement mandated by many standards. Personnel

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safety, noise reduction and correct operation of protection systems are the main reasons behind galvanic isolation.Voltage matching is also needed in many applications as it helps in designing and optimizing the voltage rating of different stages in the system. Both galvanic isolation and voltage matching are usually performed by a magnetic transformer in power electronic systems,which calls for an ac link for proper energy transfer. Although this approach is similar to unidirectional dc-dc converters, the need to bidirectional power flow significantly adds to the system complexity. Furthermore, when high efficiency soft-switching techniques are to be applied, this complexity tends to be more.This structure consists of two high-frequency switching dc-ac converters and a high-frequency transformer which is primarily used to maintain galvanic isolation between two sources. This transformer is also essential for voltage matching in case of large voltage ratio between two sources. The transformer calls for ac quantities at its terminals and thus a dc-ac converter is employed on each side.

As energy transfer in either direction is required for the system, each dc-ac converter must also have bidirectional energy transfer capability. With the same token, the dc buses in this structure must also be able to either generate or absorb energy.The dc buses shown are assumed to have stiff-voltage characteristics, i.e. their Thevenin impedance is negligible. In practice they are connected to a dc source or an active load likeultra-capacitor or dc-link capacitor, battery which resemble an ideal voltage source with stiff voltage characteristics. If the current-fed type converter is assumed that the required elements to realize stiff current are incorporated inside the converters.

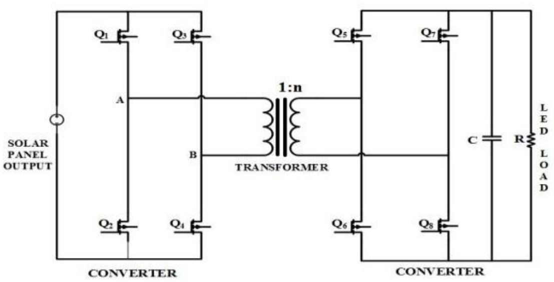

Figure 2.Circuit diagram of Bidirectional Buck-boost converter

2.2 Photovoltaic cell

In the Photovoltaic cell modelling there are two types of modelling namely silicon crystalline technology and thin film technology. Silicon crystalline is used in this proposed method. The solar Pv model is made by means of considering that each solar cell is of 0.6V rating, so that 40 Cells are connected in series and hence the desired output of 24V is obtained.The PV output is fed to the battery for charging and discharging with the help of the bidirectional buck-boost converter.

2.3 MPPT (PERTURB AND OBSERVE)

The P&O algorithm is also called“hill-climbing”,.The duty cycle of the power converter involvesHill-climbing perturbation and P&O a perturbation in the operating voltage of the DC link between the PV array and the power converter. In the case of the Hill-climbing, perturbing the power converter duty cycle implies modifying the voltage of the DC link between the PV array and the power converter, so the name refer to the same technique, the sign of the last perturbation and the sign of the last increment in the powerIn this method are used to decide what the next perturbation should be.

2.4 Battery

Lead acid battery is used in this method.the charging is made by buck mode and discharging of the battery is done by means of the boost mode of the converter conduction in the daytime and in the night hours corresponding to the microcontroller operation combined with the converter.

3. Matlab/Simulink model of a PV cell

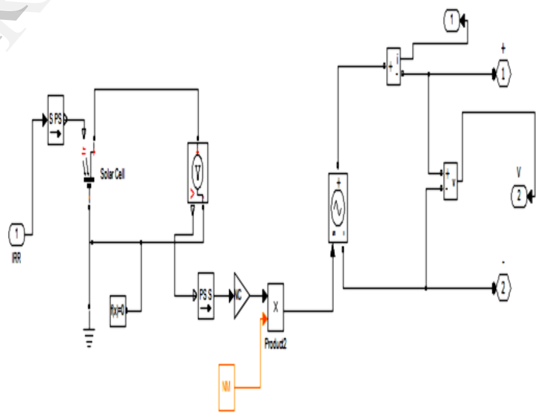

Figure 3.Simulink model of a PV cell

The PV cell model is made by means of combining each solar cell which is connected in series and produce the voltage of 24V

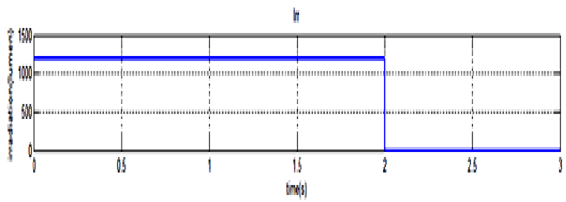

Figure 4.Irradiation waveform of a PV

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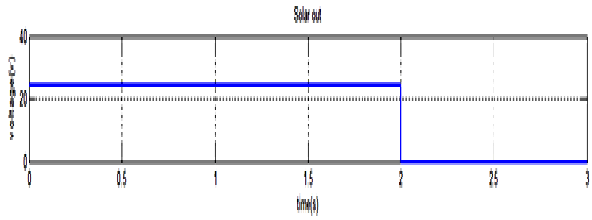

Figure 5.Output Voltage waveform of a PV

3.1 Matlab/Simulink model of a converter subsystem

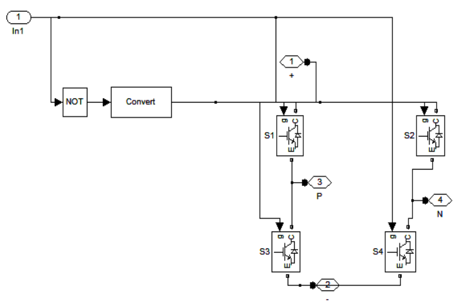

Figure 6.Simulink model of Converter Subsystem

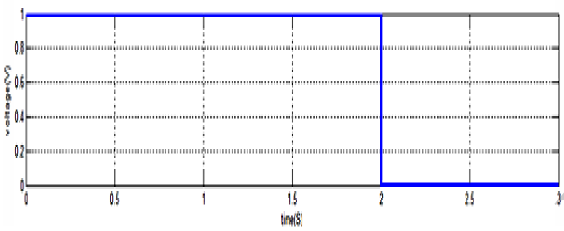

Figure 7.Buck mode waveform of converter

In the buck mode the battery is charged output voltage is bucked by means of converter and hence fed to the battery during daytime.

3.2 Matlab/Simulink model of MPPT subsystem

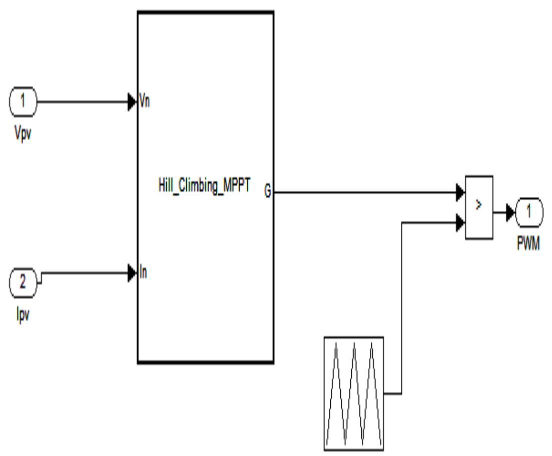

Figure 8.Simulation diagram of MPPT Subsyatem

The MPPT model is made as such that P&O algorithm is used by means of comparing the actual reference signal with the solar PV output signal and hence the maximum power point tracking is done

3.3 Load parameter

In this proposed method HP LED loads used for lighting application, the load gets supply during night hours by means of the discharging of voltage from the battery with the help of converter in boost converter.

In the boost mode battery output voltage is boosted by means of converter and hence fed to the lighting load during night hours

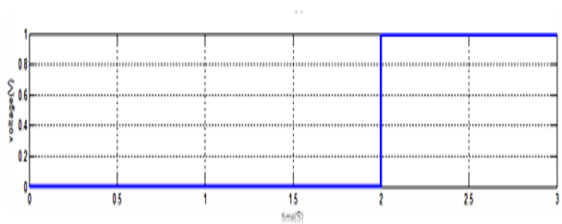

Figure 9. Boost mode waveform of converter

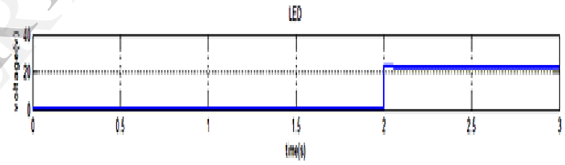

Figure 10. Load voltage waveform

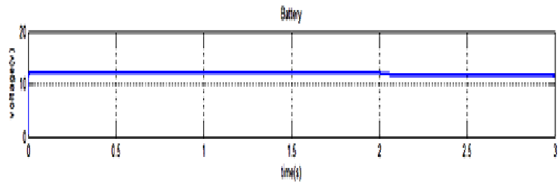

Figure 11. Battery voltage waveform

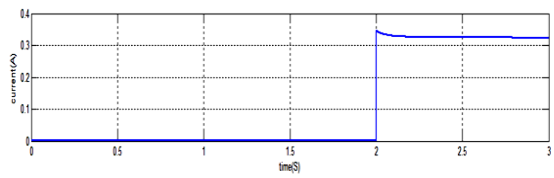

Figure 12. Load current waveform

4. Conclusion

In this proposed method Renewable energy system is implemented here is suitable for residential applications such a system would typically provide a regulated DC output voltage that may also track the input mains utility voltage in phase and amplitude at watts. Thus a system such as this can be deployed easily with little concern about adapting a home electrical wiring to take advantage of solar energy. In addition, the designed converter control system is highly stable for the all possible operating points. The proposed converter has the merits of making use of low-voltage batteries, operated in stable margin operating points in addition to the advantages of bidirectional power flow at the converter to the load and low-power consumptions. Thus the power interruption problem is completely eliminated.

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