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Fly Back Converter Based Energy Storage System Using FPGA

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Abstract: At present scenario the popular research due to the effect of over usage of non-renewable energy has shown serious effect in the human life and also on the environment. This work implements a FPGA based battery energy system using solar cells under various illumination and temperature. It performs Maximum Power Point Tracking (MPPT) based on perturbation and observation method, where it gets the desired maximum power by changing the duty cycle of the switch in the converter. The control algorithm is simple and easy to implement. The algorithm is implemented with the help of FPGA controller which controls the duty cycle by outputting PWM pulse based on the voltage and current from the solar panel. The generated power from the solar cells using the converter is stored in the lead-acid battery to supply the load. The solar power can be utilized for the purpose of various applications the main conversion is based on the photovoltaic effect and has Maximum Power Point Tracking (MPPT) to be carried out on I-V characteristics of any given instance. The solar cell provides electricity to the remote area.

Keywords: Photovoltaic, Maximum Power Point Tracking (MPPT), Xilinx FPGA

I. Introduction

In the last few years, the effect of over usage of nonrenewable energy has shown serious effect on the human life and also on the environment. With nuclear power plant, despite of the inexpensive power generation, it also results in global warming and greenhouse effect. The nuclear waste also became one of the threats. Thus the world is forced to adopt and use green energy power generation technologies.

The green energy power generation technologies include wind energy, solar energy, tide energy, fuel cells, hydraulic power etc. Among these wind and solar power form the most promising technologies in our country Generating power from wind energy requires low dense area and also the installation cost is more. Also it yields low economic output. Thus the next promising energy resources is solar power as it has the advantages of less maintenance, large scale installation is possible, no noise, no waste and abundant supply.

The solar power can be utilized for the purpose of various applications the main conversion is based on the photovoltaic effect and has Maximum Power Point Tracking (MPPT) to be carried out on I-V characteristics of any given instance. The solar cell provides electricity to the remote area. A Photovoltaic (PV) array has only one maximum power point on I-V characteristic at any given instance. As the PV array I-V characteristic shifts with changing include illumination and cell temperature the maximum power point moves. Therefore, to operate a PV array at or near its maximum power output, several methods of maximum power point tracking MPPT have been suggested. Here Perturbation and observation method is used.

II. PHOTOVOLTAIC CELL

Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect. When semiconductor materials are exposed to light, the some of the photons of light ray are absorbed by the semiconductor crystal which causes a significant number of free electrons in the crystal. This is the basic reason for producing electricity due to photovoltaic effect. Photovoltaic cell is the basic unit of the system where the photovoltaic effect is utilized to produce electricity from light energy.

A typical photovoltaic system consists of two major parts: the solar panels that generate DC power from sunlight and the power electronics that convert DC into standard AC voltages. Most solar cells on the market can achieve 13 ~ 15% of energy conversion and over 20% in lab environments. While research goes on to improve the PV cell efficiency, it is fundamentally the power electronics that provide controllability over this renewable energy source. In particular, good control to track the maximum power that the PV cells can provide is critically important because the photovoltaic energy is subject to weather changes and the amount of electricity produced by solar panels is highly unpredictable throughout the day.

There are many issues concerning the development of a practical PV system, e.g., energy conversion, grid connection, etc. This research carried only focus on one particular power control technique, that is, maximum power point tracking (MPPT). Due to the mismatch between load line and operating characteristic of the solar cells, the power available from the solar cells is not always fully extracted. Maximum power point tracking (MPPT) is a control technique to adjust the terminal voltage of PV panels so that maximum power can be extracted.

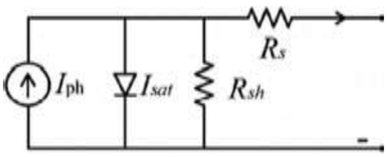

Figure 1. Equivalent circuit of the PV array

The equivalent circuit of a PV array is shown in Fig. 1. Is at is the diode saturation current. There is some leakage current through shunt resistor R_{sh}. Normally, the value of shunt resistor R_{sh} is so big and the value of cascade resistor R_s is so small that both of them can be omitted. V and I represent the PV array output voltage and current, respectively.

III. FLY BACK CONVERTER

Fly back converter is used to control the charging process as it provides isolation and suitable for low power applications. Figure 2. Shows the schematic diagram of the fly back converter.

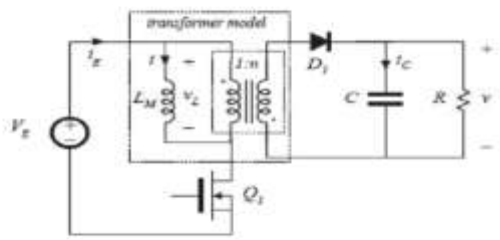

Figure 2. FLY BACK CONVERTER

The behavior of most transformer-isolated converters can be adequately understood by modeling the physical transformer with a simple equivalent circuit consisting of an ideal transformer in parallel with the magnetizing inductance. The magnetizing inductance must then follow all of the usual rules for inductors; in particular, volt-second balance must hold when the circuit operates in steady-state. This implies that the average voltage applied across every winding of the transformer must be zero.

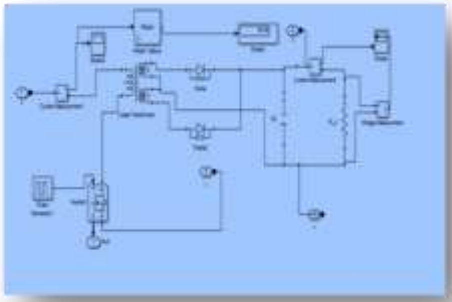

Figure 3. Schematic view of Fly back converter

Figure 3. Shows the schematic view of fly back converter of, 1 and 2 terminals are the supply voltage from the super capacitor and it is connected to the primary side of inductor and MOSFET'S negative terminal as well. The scope4 arrangement will clear to get output voltage of super capacitor.

The output voltage from the super capacitor is sampled by 1/5th ratio and displayed using mean value for the clear view. After that the MOSFET arrangement will trigger the inductor terminals with the help of the PWM signal generator. The PWM signal generator generates the signal by means of the proposed controlled technique by sampling the PV panel voltage.

The output of the inductor arrangement was given to the diode and capacitor arragnement for the rectification purpose. The capacitor C0 will stores the output voltage of the flyback converter and its displayed by the scope.

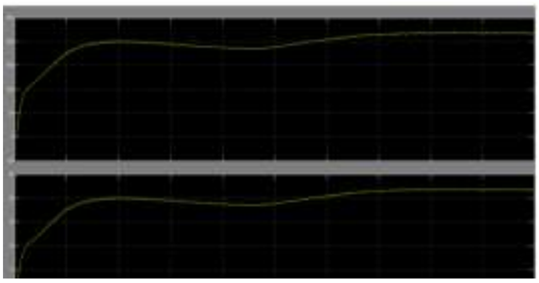

Figure 4. Fly back converter waveforms

The parallel connected RL arrangement is acts as load of converter to measeure the current and voltage across the load by means of voltage and current measurement block.

The Figure 4. shows output of the flyback converter waveforms were followed by and finally the output of the flyback converter fed to the battery arrangement by the connector terminals named as 2 and 4.

IV. XILINX FPGA

The output of the solar panel is sensed and given to the dividing circuit to reduce it to the range of FPGA kit (Spartan 3E). The reduced current and voltage is given as the input to the FPGA kit these values are taken as the input for the ADC conversion and the converted digital output is then implemented in MPPT algorithm where the duty cycle of the switch is changed according to the calculated power. Thus the constant output is achieved from the converter.

About FPGA: Xilinx Field Programmable Gate Arrays (FPGAs) are highly flexible, reprogrammable logic devices that leverage advanced CMOS manufacturing technologies, similar to other Industry- leading processors and processor peripherals. Like processors and peripherals, Xilinx FPGAs are fully user programmable. For FPGAs, the program is called a configuration bit stream, which defines the FPGA's functionality. The bit stream loads into the FPGA at system power-up or upon demand by the system. The process whereby the defining data is loaded or programmed into the FPGA is called configuration.

Configuration is designed to be flexible to accommodate different application needs and, wherever possible, to leverage existing system resources to minimize system costs. Similar to microprocessors, Xilinx FPGAs optionally load or boot themselves automatically from an external nonvolatile memory device. Alternatively, similar to microprocessor peripherals, Spartan-3 generation FPGAs can be downloaded or programmed by an external “smart agent”, such as a microprocessor, DSP processor microcontroller, PC, or board tester. In either case, the configuration data path is either serial to minimize pin requirements or byte-wide for maximum performance or for easier interfaces to processors or to byte-wide Flash memory. Similar to both processors and processor peripherals, Xilinx FPGAs can be reprogrammed, in system, on demand, an unlimited number of times. After configuration, the FPGA configuration bit stream is stored in highly robust CMOS configuration latches (CCLs). Although CCLs are reprogrammable like SRAM memory, CCLs are designed primarily for data integrity, not for performance. The data stored in CCLs is written only during configuration and remains static unless changed by another configuration event. the frequently used perturbation and observation method with a simple mathematic formula in maximum power point tracking, despite the power losses incurred by perturbation around the maximum power point. However, a microchip with a less expensive and moderately difficult calculation capability can be selected to lower the costs of overall circuit, making it highly promising for industrial use.

V. RESULTS

The parameter of solar cells of 20 W powers is listed below

Total Power	- 20W
Short Circuit Current	- 1.19 A
Open Circuit Voltage	- 21.0V
Voltage at Maximum Power	- 17.0V
Current at Maximum Power	- 1.18A

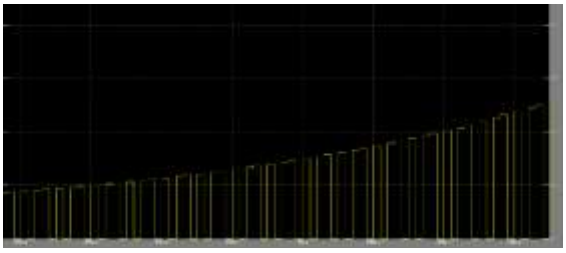

Figure 5. Output voltage of super capacitor Waveforms

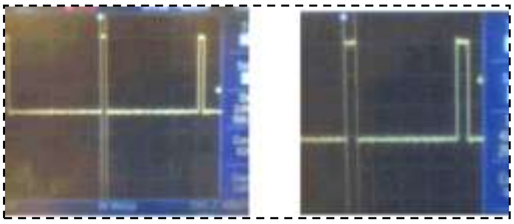

Figure 6. Shows the Varying PWM Pulses

Figure 5. Shows the output voltage of the super capacitor and the wave form and Figure 6. Shows the Varying PWM Pulses produced by FPGA.

VI. CONCLUSION

The outcome of this work in which solar energy can be converted and stored in battery with maximum power tracking capacity in which a FPGA is used to retrieve the voltage and current in the fly back circuit for increasing or decreasing the duty of the MOSFET switch to achieve maximum power output. Additionally, this work adopts the frequently observation in Maximum Power Point Tracking, despite the power losses incurred by perturbation around the maximum power point. However, a microchip with a less expensive and moderately difficult calculation capability can be selected to lower the costs of overall circuit, making it highly promising for industrial.

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