

Maximum Power Point Tracking With Sliding Mode Control

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Abstract

In this paper utilization of a boost converter for control of photovoltaic power using Maximum Power Point Tracking (MPPT) control mechanism is presented. First the photovoltaic module is analyzed using SIMULINK software. For the main aim of this work the buck converter is to be used along with a Maximum Power Point Tracking control mechanism. The MPPT is responsible for extracting the maximum possible power from the photovoltaic and feed it to the load via the boost converter. The main aim will be to track the maximum power point of the photovoltaic module so that the maximum possible power can be extracted from the photovoltaic.

Keywords—Maximum power point tracking, MPPT, photovoltaic generator, sliding mode control

I. INTRODUCTION

One of the major concerns in the power sector is the day-to-day increasing power demand but the unavailability of enough resources to meet the power demand using the conventional energy sources. Demand has increased for renewable sources of energy to be utilized along with conventional systems to meet the energy demand. Renewable sources like wind energy and solar energy are the prime energy sources which are being utilized in this regard. The continuous use of fossil fuels has caused the fossil fuel deposit to be reduced and has drastically affected the environment depleting the biosphere and cumulatively adding to global warming.

Solar energy is abundantly available that has made it possible to harvest it and utilize it properly. Solar energy can be a standalone generating unit or can be a grid connected generating unit depending on the availability of a grid nearby. Thus it can be used to power rural areas where the availability of grids is very low. Another advantage of using solar energy is the portable operation whenever wherever necessary.

In order to tackle the present energy crisis one has to develop an efficient manner in which power has to be extracted from the incoming solar radiation. The power conversion mechanisms have been greatly reduced in size in the past few years. The development in power electronics and material science has helped engineers to come up very small but powerful systems to withstand the high power demand. But the disadvantage of these systems is the increased power density. Trend has set in for the use

of multi-input converter units that can effectively handle the voltage fluctuations. But due to high production cost and the low efficiency of these systems they can hardly compete in the competitive markets as a prime power generation source.

The use of the newest power control mechanisms called the Maximum Power Point Tracking (MPPT) algorithms has led to the increase in the efficiency of operation of the solar modules and thus is effective in the field of utilization of renewable sources of energy.

II. MAXIMUM POWER POINT TRACKING

A typical solar panel converts only 30 to 40 percent of the incident solar irradiation in to electrical energy. Maximum power point tracking technique is used to improve the efficiency of the solar panel. The efficiency of a solar cell is very low. In order to increase the efficiency, methods are to be undertaken to match the source and load properly. One such method is the Maximum Power Point Tracking (MPPT). This is a technique used to obtain the maximum possible power from a varying source. In photovoltaic systems the I-V curve is non-linear, thereby making it difficult to be used to power a certain load. This is done by utilizing buck converter whose duty cycle is varied by using a mppt algorithm. A boost converter is used on the load side and a solar panel is used to power this converter.

III. METHODS FOR MPPT

3.1 PREVIOUS WORK: PERTURB AND OBSERVE METHOD

In this algorithm a slight perturbation is introduced in the system. Due to this perturbation the power of the module changes. If the power increases due to the perturbation then the perturbation is continued in that direction. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses. When the steady state is reached the algorithm oscillates around the maximum point. In order to keep the power variation small the perturbation size is kept very small. The algorithm is developed in such a manner that it sets a reference voltage of the module corresponding to the maximum voltage of the module. A Microcontroller then acts moving the operating point of the module to that particular voltage level. It is observed that there some power

loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions.

3.2 PROPOSED WORK MPPT EMPLOYING SLIDINGMODE CONTROLLER

In contrast to PWM based MPPT, we propose a sliding-mode controlled MPPT. Such a controller presents two major advantages: first, by a proper choice of the switching surface, the response to variations in radiation is accelerated by an order of magnitude. In addition, the sliding-mode control

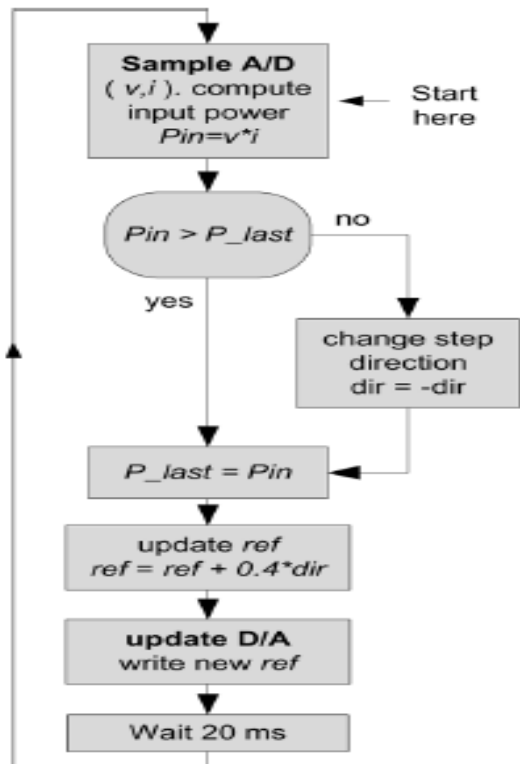


FIG1: MPPT algorithm used with the sliding-mode controller. This being the ordinary “perturb & observe” (P&O) algorithm, outputting *ref* to the comparator.

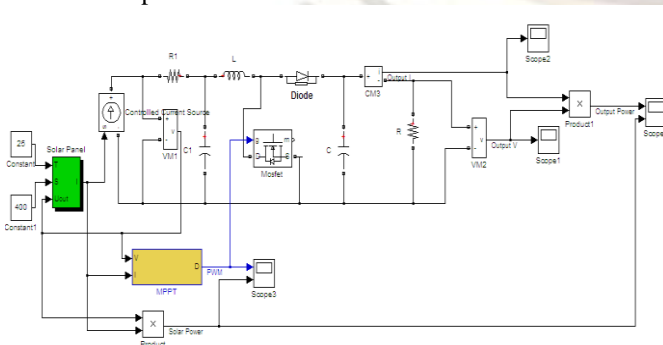


FIG 2: Model of solar cell with boost converter and MPPT system(p&o algorithm)

facilitates operation as either a voltage-source or a current source, thus, it guarantees stability all across the photovoltaic curve—from short-circuit to open-circuit. The implementation of the control is simple and requires inexpensive hardware. This work validates these results by theory, simulations, and experimentation. This group suggested an MPPT controller based on an inner sliding-mode loop, which uses the input capacitor current as the main state variable. By comparison, in this work the inductor’s current is taken as the main state variable. This approach is generally more robust and stable, as the energy stored in the converter is a direct outcome of the inductor’s current. Consequently, the converter is inherently over-current protected, even during start-up or transient conditions, and is stable over a very wide range of voltages and currents.

3.2.1 DESIGN AND IMPLEMENTATION

In typical *dc-dc* converter applications, it is desirable to regulate the output voltage to a constant value. In other cases, such as sliding-mode controlled inverters, the output voltage needs to follow a sinusoidal shape resulting in a time varying switching surface. Similarly, in the case of gyrators an adaptive surface is required. For MPP tracking, we define the switching surface by a linear combination of the PVG voltage and current. Assuming a large output capacitor (or battery load) the converter output voltage may be assumed to be semi-constant. Thus, the PVG voltage and current constitute all the converter’s state variables, resulting in the switching surface given by (1)

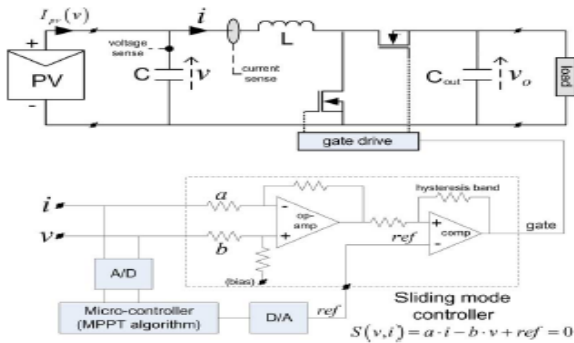
$$S(v, i) = a \cdot i - b \cdot v + ref = 0 \quad (a, b > 0)$$

$S < 0$: ON state;

$S > 0$: OFF state;

Where *i* and *v* are the inductor’s current and input voltage, and *a*, *b* and *ref* define the switching surface. *a* and *b* set the slope in the PVG *i-v* plane, and are chosen as non-negative, and *ref* sets the offset. When $S < 0$ (on state), the low transistor is on, and the inductor charges. The current *i* increases, $s(v, i)$ and increases. When $S > 0$ (off state), the low transistor is off, and the stored energy flows to the load. The current *i* decreases, and $s(v, i)$ decreases. As a result, is kept in a “switching band” around $S = 0$. This controller constricts the system’s operation to the sliding switching surface. The sliding mode circuitry consists of an op-amp and a comparator, which directly toggles the transistor gates as shown in Fig. 3. To extract maximum power, the switching surface is adjusted by the MPPT algorithm, to intersect with the exact MPP at any given time. This algorithm is implemented in the micro-controller. It samples the input power, and adjusts the switching surface by updating the constant *ref*, which is fed to the comparator. The proposed approach is indifferent

to the MPPT algorithm selected; we chose P&O due to its simplicity.



(FIG3: Sliding mode based MPPT implementation)

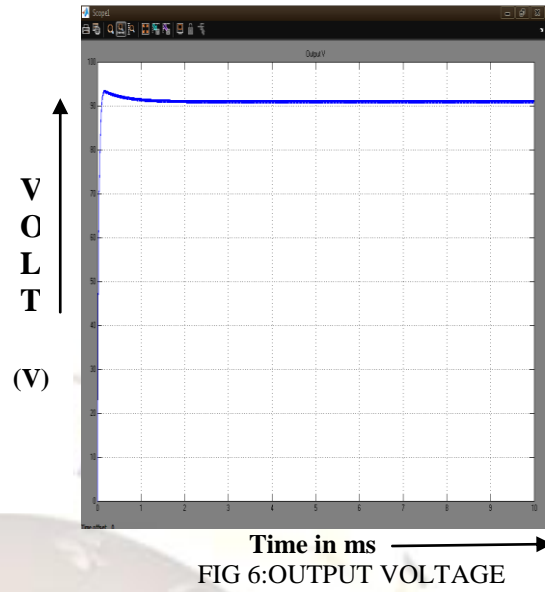


FIG 6: OUTPUT VOLTAGE

Solar System With MPPT And Sliding Mode Control

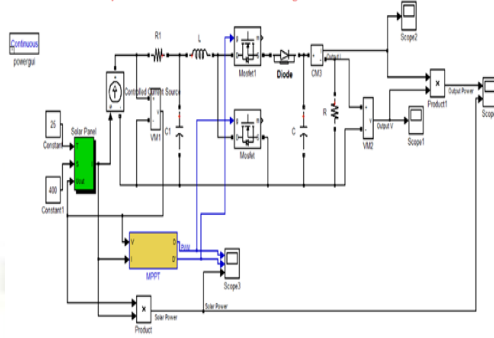


FIG 4: Model of solar cell with boost converter and MPPT system (sliding mode algorithm)

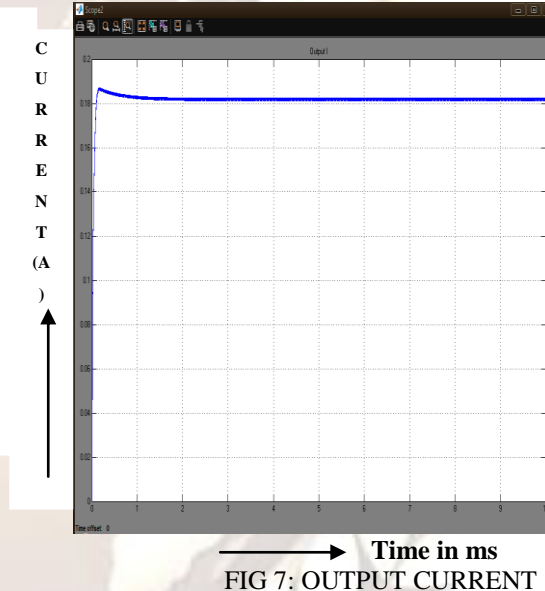


FIG 7: OUTPUT CURRENT

IV. EXPERIMENTAL RESULTS

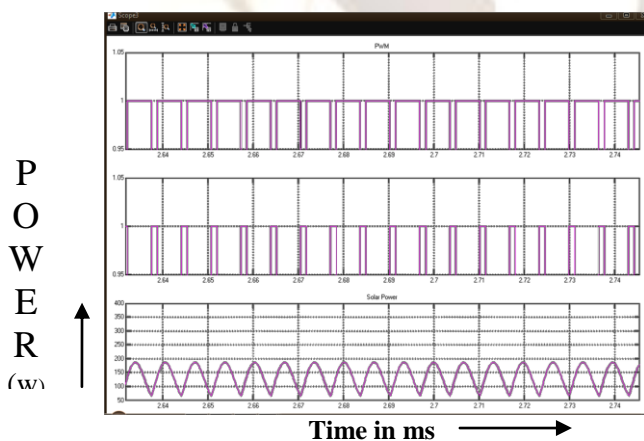


FIG 5: PWM & SOLAR POWER

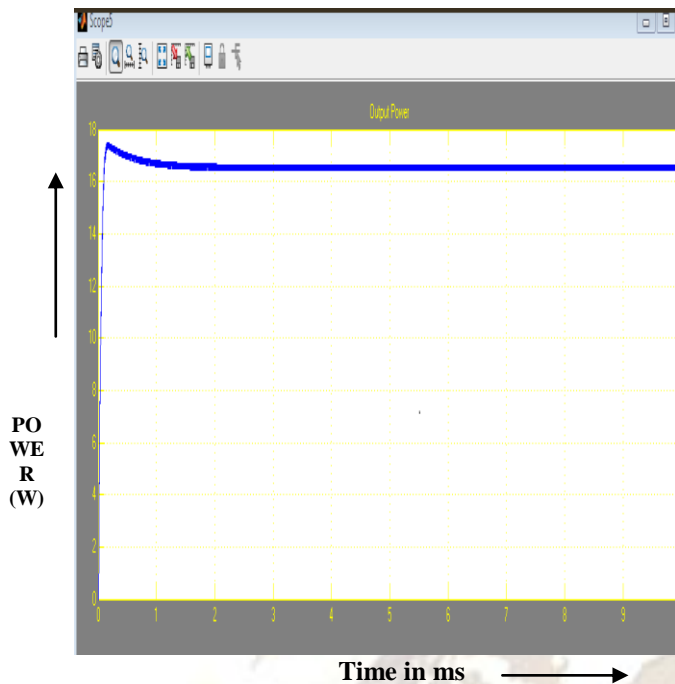


FIG 8:OUTPUT POWER

V. CONCLUSION

This work introduces a sliding-mode based MPPT method. In comparison to PWM based MPPTs, convergence to maximum power is accelerated by an order of magnitude. This is accomplished by an optimal selection of the switching surface. In addition, the controller can operate either as a voltage source or a current source, maintaining stability all across the photo-voltaic curve.

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