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# Maximum Power Point Tracking in PV System with Industry Applications

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**ABSTRACT**

The paper work is the new maximum power point tracking method using in voltage controller in photo-voltaic system for Stand-Alone industry Applications with battery energy storage. The output of the PV array is unregulated DC supply due to change in weather conditions. The maximum power is tracked with respect to temperature and irradiance levels by using DC-DC converter. The perturbation and observes algorithm is applied for maximum power point tracking (MPPT) purpose. This algorithm is selected due to its ability to withstand against any parameter variation and having high efficiency. The solar cell array powers the steady state energy and the battery compensates the dynamic energy in the system. The aim of the control strategy is to control the SEPIC converter and bi-direction DC-DC converter to operate in suitable modes according to the condition of solar cell and battery



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## 1. INTRODUCTION (10 PT)

Solar energy has become a promising alternative source because it has many advantages such as abundance, pollution free and renewability. The solar photovoltaic (PV) power will play an important role in alleviating the energy crisis and reducing the environmental pollution and has a bright prospect of applications. Due to the nonlinear relationship between the current and the voltage of the photovoltaic cell, it can be observed that there is a unique maximum power point (MPP) at a particular environment, and this peak power point keeps changing with solar illumination and ambient temperature. In recent years, a large number of techniques have been proposed for maximum power point tracking (MPPT), such as the constant voltage tracking (CVT), the incremental conductance (INC) method, the perturb-and-observe (P&O or hill-climbing) method [1], [2]. Perturbation and Observation (P&O) method has a simple feedback structure and fewer measured parameters. It operates by periodically perturbing (i.e. incrementing or decreasing) the array terminal voltage and comparing the PV output power with that of the previous perturbation cycle. In this manner, the peak power tracker continuously seeks the peak power condition. MPP is tracked by using DC-DC converters [3]. Much attention has been given to the single ended primary inductor converter (SEPIC) topology recently because output voltage may be either higher or lower than input voltage .The output is also not invertedas is the case in a fly back or Cuk topology. The input and output voltages are DC isolated by a coupling capacitor and the converter works with constant frequency PWM.

Inverters are static power converters that produce an ac output waveform from a dc power supply. The dc power from SEPIC is fed to inverter to get ac output power [4], [5]. A Bi-Directional DC-DC Converter (BDC) is connected between the Sepic Converter and Inverter. BDC is used to store the dynamic energy in battery and supply to load when there is overcast sky or at night [6], [7], [8], [9]. For sinusoidal ac outputs, the magnitude and frequency should be controllable. This is done by comparing a sinusoidal wave of the same frequency as inverter output against triangular carrier frequency wave. This technique called sinusoidal pulse width modulation (SPWM) mainly used because of its simplicity and ease of implementation. The output voltage magnitude is controlled by closed loop control system using PI controller [10].

A micro PV system structure in which two PV modules connected in series is considered and it provides an output power of nearly 160 Watts. To address the micro PV system structure, this paper proposes a novel MPPT algorithm, which is based on the improved research on the characteristics of the PV array to track the global MPP even under non-uniform insulation. Battery charging and discharging is done using BDC (Bidirectional converter). BDC is operated in three modes namely; Buck, Boost and Bidirectional. The algorithm was verified with MATLAB-SIMULINK that it can track the real MPP very fast when the temperature changes. The closed loop operation of proposed system is verified with MATLAB simulations including Load and source disturbancesLiterature review that has been done author used in the chapter "Introduction" to explain the difference of the manuscript with other papers, that it is innovative, it are used in the chapter "Research Method" to describe the step of research and used in the chapter "Results and Discussion" to support the analysis of the results [2]. If the manuscript was written really have high originality, which proposed a new method or algorithm, the additional chapter after the "Introduction" chapter and before the "Research Method" chapter can be added to explain briefly the theory and/or the proposed method/algorithm [4].

## 2. PROPOSED SYSTEM CONFIGURATION

The block diagram schematic of the proposed solar energy conversion scheme is shown in Figure 1. It consists of a solar cell array, a battery, SEPIC Converter, bi-directional DC-DC converter (BDC) and single phase Inverter. The solar cell array and battery are connected to the same DC Bus through the Sepic Converter and bi-directional DC-DC converter respectively. The system has several advantages:

(1) The charging and discharging currents of the battery are only controlled by the BDC and the system structure is simpler.
(2) The over-load power is supplied by the battery
(3). The energy management can be realized through the control of the UDC and BDC, ensuring the system to work with high efficiency.

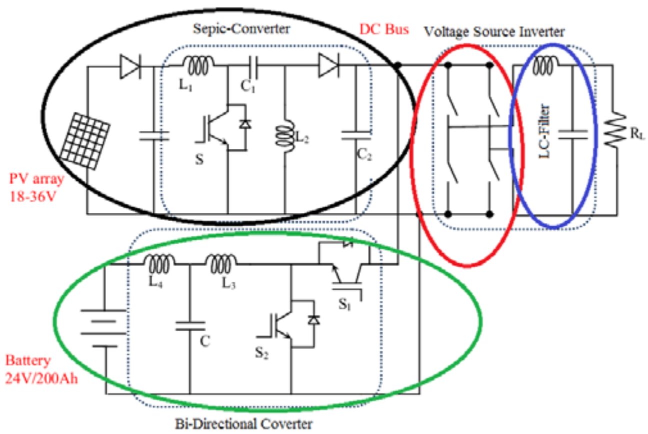


Figure 1. Block diagram of proposed system configuration

The output Power of the SEPIC converter is varied due to temperature and irradiations. Hence, the Maximum power is tracked and extracted from the PV array and transferred to the stand-alone load through single phase Inverter. The controller generates the gating pulses for the SEPIC converter, BDC and Inverter to extract maximum power, Energy management and to maintain desired ac output voltage and frequency across load terminals.

### 2.1 Sepic Converter

The buck–boost feature of the SEPIC widens the applicable PV voltage and thus increases the adopted PV module flexibility. Among all the available converters, SEPIC has the merits of non-inverting polarity, easy-to drive switch, and low input-current pulsating for high-precise MPPT that makes its integral characteristics suitable for the low-power PV charger system. SEPIC Converter can raise the output voltage to a suitable range, and can supply an isolation route to isolate the input and output terminal after terminate charging. But this circuit has two disadvantages; one is low efficiency and the other needs two inductors. The efficiency is not the major factor when charger is designed and use of coupling inductor solves the other disadvantage. Therefore the SEPIC is a good choice for constant current converter design. The operation principle of SEPIC is: when S turns ON, the input source stores energy in the inductor $L_1$. The inductor current $I_{L1}$ increases linearly. The energy stores in capacitor$C_1$ will transfer into inductor $L_2$.The energy for the load is supplied by capacitor $C_2$. When S turns OFF, the energy stored in inductor $L_1$ transfer to $C_1$. The energy stored in $L_2$ will transfer to $C_2$ through Diode and supplying the energy to loading.

### 2.2 MPPT maximum power point tracking Algorithm

The ‘‘P&O’’ method is that which is most commonly used in practice by the majority of authors. It is an iterative method of obtaining MPP. It measures the PV array characteristics, and then perturbs the operating point of PV generator to encounter the change direction. The maximum point is reached when (dPpv/dVpv) =0. An example algorithm flow chart of the most basic form is shown in Figure 2. The operating voltage of the PV generator is perturbed, by a small increment ΔVpv, and the resulting change, $\Delta P_{pv}$, in power, is measured. If $\Delta P_{pv}$ is positive, the perturbation of the operating voltage should be in the same direction of the increment. However, if it is negative, the system operating point obtained moves away from the MPPT and the operating voltage should be in the opposite direction of the increment.

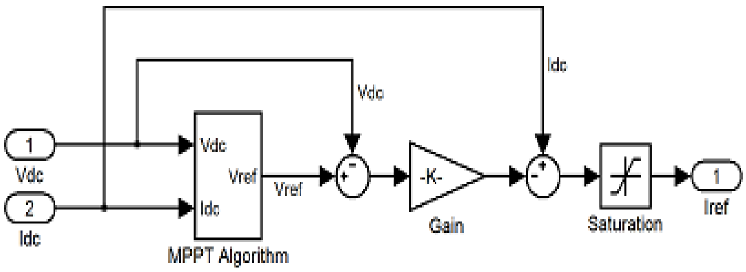


Figure 2. MPPT and the operating voltage with P&O algorithm

The P&O algorithm is also called “hill-climbing”, but both names refer to the same algorithm depending on how it is implemented. Hill-climbing involves a perturbation on the duty cycle of the power converter and P&O a perturbation in the operating voltage of the DC link between the PV array and the power converter [8]. In the case of the Hill-climbing, perturbing the duty cycle of the power converter implies modifying the voltage of the DC link between the PV array and the power converter, so both names refer to the same technique. In this method, the sign of the last perturbation and the sign of the last increment in the power are used to decide what the next perturbation should be. As can be seen in Figure 3 on the left of the MPP incrementing the voltage increases the power whereas on the right decrementing the voltage increases the power.

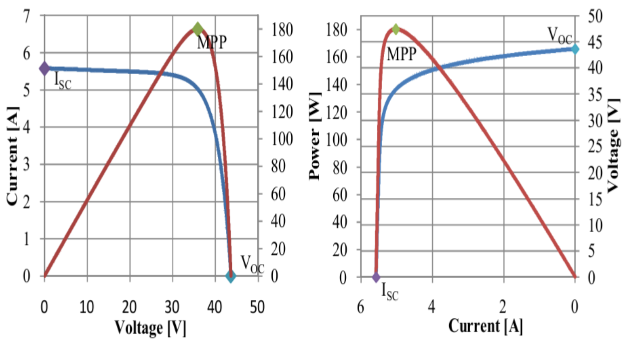


Figure 3. P&O algorithm PV panel characteristic curves

If there is an increment in the power, the perturbation should be kept in the same direction and if the power decreases, then the next perturbation should be in the opposite direction. Based on these facts, the algorithm is implemented [8]. The process is repeated until the MPP is reached. Then the operating point oscillates around the MPP. This problem is common also to the In Cond method, as was mention earlier. A scheme of the algorithm is shown in Figure 4.

### 2.3 Bidirectional DC-DC Converter

A bidirectional DC-DC converter which allows transfer power between two DC sources becomes an important topic of power electronics. When power flows to one direction the converter works in buck mode, on the other hand, when the power flows to the other direction the converter works in boost mode. When there is excess energy in PV array, BDC works in buck mode and the Battery will be in charging mode but when there is cloudy or at nights, BDC works in boost mode and then battery supplies power to load. This can be achieved by controlling the duty cycle. LCL configuration is used to effectively damp out the ripples in the Battery current. Possible modes of operation of BDC are; Buck mode, Boost mode, Bidirectional mode. Bidirectional mode Circuit shownin Figure 5 for our project work, take output voltage [11].

### 2.4 PWM Converter (Inverter)

The block diagram of closed loop operation of single phase inverter is shown in Figure 6. Output voltage of inverter is controlled by using PI controller. Sine wave pulse width modulation (SPWM) or PWM modulation is used to control the four switches of inverter [11].

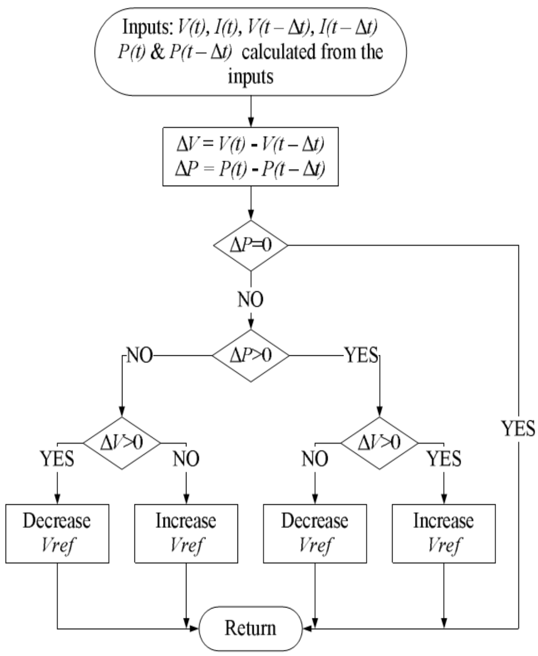


Figure 4. The flowchart of the P&O Algorithm

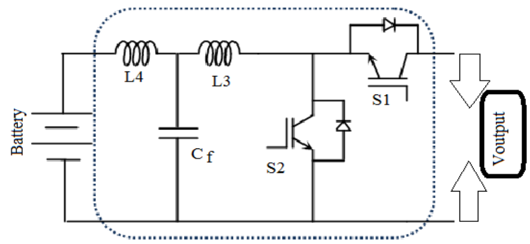


Figure 5. Bidirectional mode Circuit

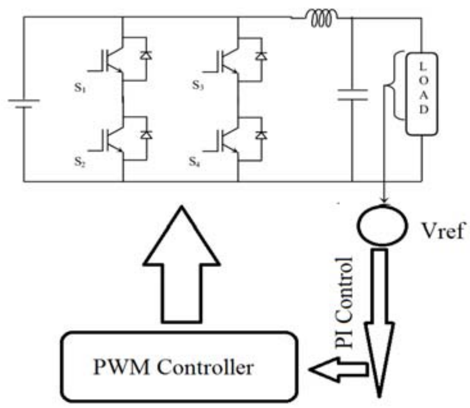


Figure 6. Closed loop operation of PWM inverter

## 3. RESULTS AND DISSCUSIONS

All The simulation results of the proposed scheme such as active power fed to load, load voltage and load current, DC link voltage and current are shown in Figures 7-11. Three similar solar panel with open circuit voltage Voc= 21.2V and Isc 5.17A are connected in series which triples the Voltage keeping current same. Now resistor 10 ohm load connected, output voltage 20volts, 2amp current. The change in climatic conditions effects the inverter voltage and current. The maximum power rating of each panel is 75W, as the panels are connected in series maximum power will be 140W. The main objective is to extract the maximum power. SEPIC converter specifications are given below; Input voltage = 10V to 36V DC; Maximum Duty cycle = 0.755; Minimum Duty cycle = 0.5; Switching Frequency = 15Khz.For above specifications the inductor and capacitor values are calculated by using standard design equations.L1=2.57e-6H, L2=2.57e-6H, C1=4.7e-6F, Co= 100e-6F Due to change in the temperature and irradiance there sportive maximum power changes. The maximum power is tracked at 70% duty cycle. Shown in Figure 7 is the modal of project schema and Figures 8 to 11 are the results of input or output voltage and current waveforms.

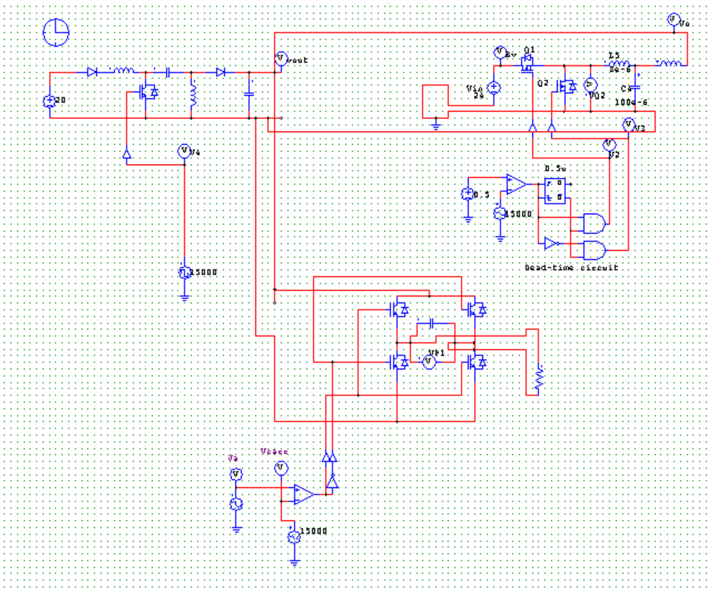

Figure 7. Psim Circuit Diagram

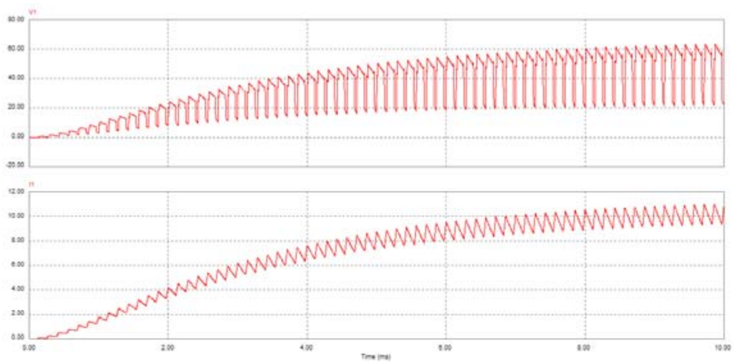

Figure 8. Voltage and Current Waveform for Sepice Converter

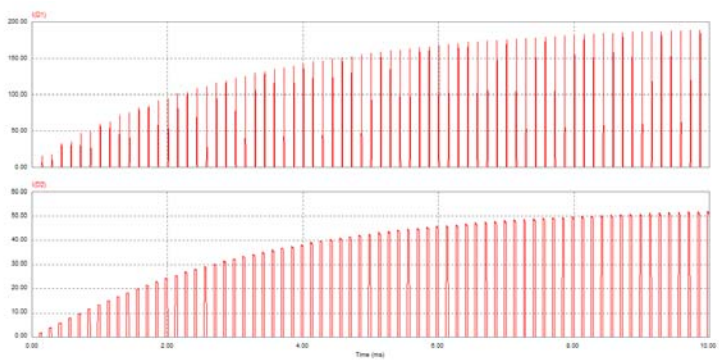

Figure 9. $D_1$, $D_2$ Current Waveform

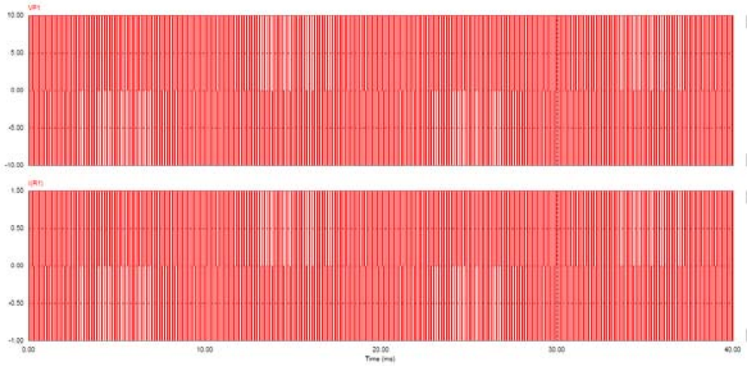

Figure 10. Output DC Voltage

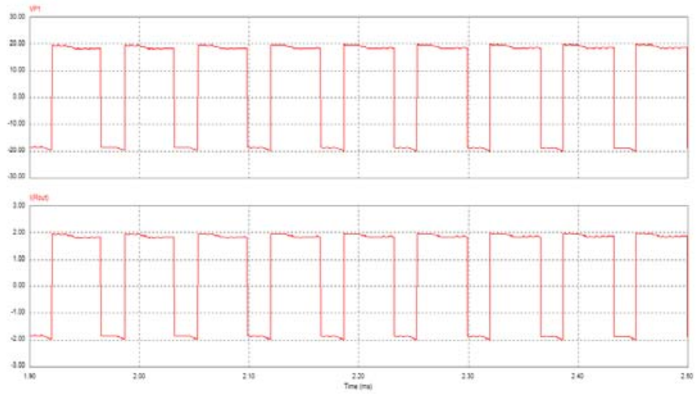

Figure 11. Output System AC voltage & AC Current

## 4. CONCLUSION

When the PV array is used as a source of power supply to stand alone loads, it is necessary to use the MPPT to get the maximum power point from the PVarray and implemented with Psim Simulation for simulation. The MPPT is implemented by using a SEPIC-Converter, which is designed to operate under continuous conduction mode, the PV panel and battery. The BDC can operate in three modes: buck, boost and shutdown illustrated using simulation results. At the same time, output results of inverter with SPWM control strategy have better voltage control and simulation results of system demonstrate that system demonstrate that the PV system has the fast and effective response under changing irradiance levels. So the PV generation system based P&O MPPT method, BDC and SPWM control for single-phase voltage source PWM inverter is feasible and effective. Perturbation and observe Algorithm is used as the control algorithm for the MPPT. From results of simulation, it can be seen that the P&O MPPT algorithm which is able to improve the dynamic and steady state performance of the PV system. BDC is operated in suitable modes according to the conditions the PV system has the fast and effective response under changing irradiance levels. So the PV generation system based P&O MPPT method, BDC and SPWM control for single-phase voltage source PWM inverter is feasible and effective.perturbation and observe Algorithm is used as the control algorithm for the MPPT. From results of simulation, it can be seen that the P&O MPPT algorithm which is able to improve the dynamic and steady state performance of the PV system. BDC is operated in suitable modes according to the conditions

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