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# Microcontroller-Based MPPT Control for Standalone PV System with Sepic Converter

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**Abstract:** The photovoltaic (PV) stand-alone system requires a battery charger for energy storage. This paper presents the modelingand controller design of the PV charger system implemented with the single-ended primary inductance converter (SEPIC). The designed SEPIC employs the peak-current-mode control with the current command generated from the input PV voltage regulatingloop, where the voltage command is determined by both the PVmodule maximum power point tracking (MPPT) control loop and the battery charging loop. This paper gives a detailed modelingof the SEPIC with the PV module input and peak-current-modecontrol first. This paper describes the operational principles of the proposed converter and it performance in photovoltaic application together with the MPPT algorithm. The simulation results showed that the proposed converter has performed successfully as a high gain boost converter for standalone PV application.

**Key words:** Maximum power point tracking (MPPT) · Power balance control · Single-ended primary inductance converter · (SEPIC) · Stand-alone

## INTRODUCTION

Several environmental protection regulation and the presolar power is more and more attractive due to thedictable shortage of conventional energy sources. As aresult, many research works have addressed the development of solar power system in recent years. Many types of photovoltaic(PV) power conversion systems have been developed includingthe grid-connected system for reducing the power from the utility and the stand-alone system for providing the load power without the utility. The stand-alone systemrequires battery for energy storage to supply the load power during the period without or shortage of solar power. Because the Another important issue of the PV charger system is the power balance control that was faced commonly for multiple-source system, such as fuel-cell hybrid vehicle, hybrid PV and fuel-cell power system, hybrid wind, solar and distributed-generation power system and so on. For the PV charger system, MPPT and battery charging must be co operative and the load demand must be considered simultaneously such that the PV power can be utilized effectively and the battery is suitably charged [1]. It classies the system into various states based on the operating conditions of the PV module, the battery and the load. By judging the state and setting the related control goal, the power will be balanced to satisfy the MPPT control and battery charging requirement. However, the multi objective control algorithm requires sense of many states and sophisticated state judgment and thus, needs software programming. This paper will present a power balance control method that achieves the same functions as that in but with only a simple control circuit. In addition, the proposed power balance control can also be extended to the system with more sources like those shown in. Furthermore, all power sources can be utilized with the preset priority based on their importance to the system Total number of MPPT papers per year, since 1968.system. As such, many MPP tracking (MPPT) methods have been developed and implemented. The methods vary in complexity, sensors required, convergence speed, cost, range of effectiveness, implementation hardware, popularity and in other respects [2]. They range from the almost obvious (but not necessarily ineffective) to the most creative (not necessarily most effec-tive). In fact, so many methods have been developed that it has become dif cult to adequately determine which method, newlyproposed or existing, is most appropriate for a given PV system.we have elected not to reference patents. Papers

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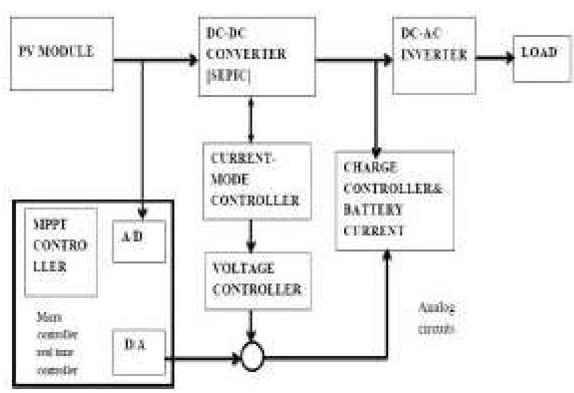
referencingMPPT methods from previous papers without any modification or improvement have also been omitted. It is possible that oneor more papers were unintentionally omitted. We apologize ifan important method or improvement was left out.This manuscript steps through a wide variety of methods with a brief discussion and categorization of each. We have avoided discussing slight modications of existing methods as distinctmethods. For example, a method may have been representedin context of a boost converter, but later on shown with a boost-buck converter, otherwise with minimal change. The manuscript concludes with a discussion on the different methods based otheir implementation, the sensors required, their ability to detect multiple local maxima, their costs and applications they suit. Atable that summarizes the major characteristics of the methods is also provided.Given the large number of methods for MPPT, a survey ofthe methods would be very benecial to researchers and practi-tioners in PV systems.However,recent papers have generally had shorter, more cursory literaturereviews that largely summarize or repeat the literature reviewsof previous work. This approach tends to repeat what seems tobe conventional wisdom that there are only a handful of MPPTtechniques, when in fact there are many.

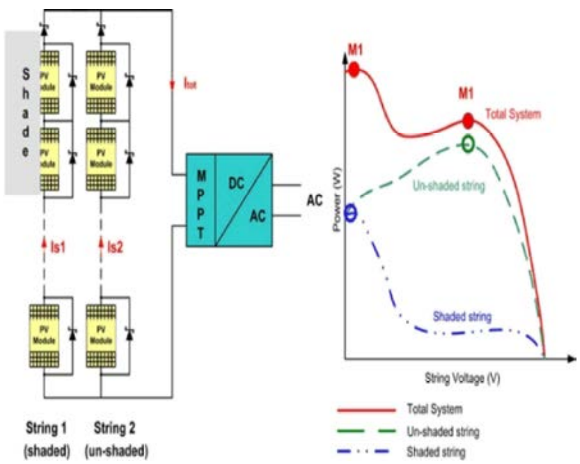
**Existing System:** The existing system represents modeling and controller design of the PV charger system implemented with the buck boost dc-dc converter. It is also the step up and step down converter.but efficient is somewhat less compare to the SEPIC converter.The designed Buck Boost converter employs the peak-current-mode control with the current command generated from the input PV voltage regulating loop, where the voltage command is determined by both the PV module maximum power point tracking (MPPT) control loop and the battery charging loop. When the battery voltage drops to a given value, the Flyback DC/DC converter is shut down to prevent the battery from over-discharging [3]. The SEPIC PFC circuit draws energy from the AC-line utility to drive the HID lamp via the low-frequency square-wave DC/AC inverter.

**Proposed System:** The proposed MPPT controller tracks the peak power of the.PV module based on the power–voltage (P -Vp ) characteristics and the incremental conductance algorithm. In the positive-slope region (dP/dVp > 0), the operation voltage is increased. On the other hand, in the negative-slope region (dP/dVp < 0), the operation voltage is decreased.The peak power point starting from any operating point willbe nally reached through a few steps of voltage adjustment.In this paper, for increasing the tracking speed as well as theprecision, the voltage adjusting speed is slope dependent. In thepositive-slope region, the adjusting speed will be slower thanthe negative-slope region because the positive slope is smallerthan the negative slope in amplitude. The adjusting speed willbe slowed down near the peak power point. This is effectiveto prevent the tracking oscillation near the peak power pointto increase the MPPT precision. The direction value isaccumulated with a memory and then scaled with Gain 2 to the required voltage range. To make the MPPT start from the open-circuit voltage, the Init voltage nearing the open-circuit voltage is adopted to set the initial voltage command before the start of the converter. The voltage command is nally limited by Limiter 2 to limit the attainable PV voltage. Rf -Cf is added to reduce the leading-edge spike caused by the discharge of the internal capacitor of the switch and the diode recovery current. The slope compensation signal is addedto the sensed current to prevent the subharmonic oscillation, as the duty cycle is larger than 0.5. The slope compensation signal is provided by the ramp signal coupled with a capacitor Cd. A single lithium ion battery typically discharges from 4.2 volts to 3 volts; if other components require 3.3 volts, then the SEPIC would be effective.

**Block Diagram**



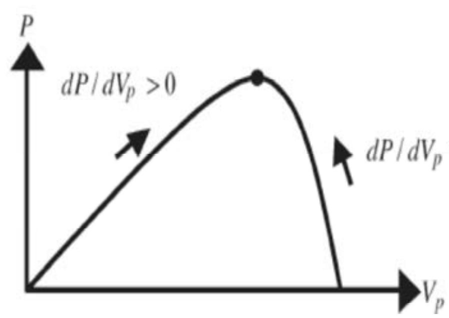

**Explanation:** The control objective is to balance the power flow from the PV module to the battery and the load such that the PV power is utilized effectively and the battery is charged with three charging stages. several environmental protection regulation and the presolar power is more and more attractive due to thedictable shortage of conventional energy sources. As aresult, many research works have addressed the development of solar power system in recent years. Many types of photovoltaic (PV) power conversion systems have been developed includingthe grid-connected system for reducing the power from the utility and the stand-alone system for providing the load power without the utility. The stand-alone systemrequires battery for energy storage to supply the load power during the period without or shortage of solar power. Because the Another important issue of the PV charger system is the power balance control that was faced commonly for multiple-source system, such as fuel-cell hybrid vehicle, hybrid PV and fuel-cell power system, hybrid wind, solar and distributed-generation power system and so on. For the PV charger system, MPPT and battery charging must be co operative and the load demand must be considered simultaneously such that the PV power can be utilized effectively and the battery is suitably charged.



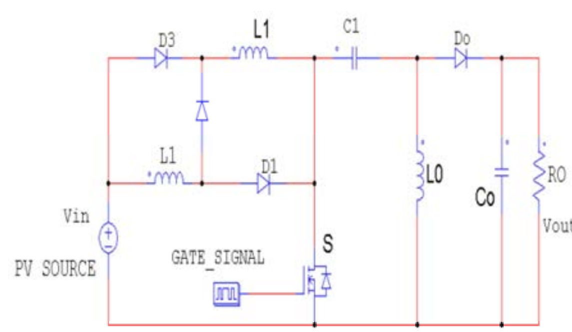

The photovoltaic (PV) stand-alone system requires a battery charger for energy storage.The stand-alone power system is used primarily in remote areas where utility lines are uneconomical to install due to geographical difficulties. They do not have any connection to the electrical mains. If the load is to be supplied continuously, the generated power needs to be stored using a battery. Examples: In small devices (e.g. calculators, parking meters) only DC is consumed.In larger systems (e.g. buildings, remote water pumps) AC is usually required. To convert the DC from the modules or batteries into AC, an inverter is used. This project gives a detailed modeling of the SEPIC with the PV module input and peak-current-mode control first. Accordingly, the PV voltage controller, as well as the adaptive MPPT controller, is designed and a prototype system is built. The effectiveness of the proposed method is proved with some simulation and experimental results. It is a new high-efficiency topology for transformer less systems.

Circuit configuration of the proposed PV charger.built. The effectiveness of the proposed system is proved withsome PSIM simulation and experimental results.available maximum PV power is less than the load power. Theinsuf cient power will be automatically supplied by the dis-charge of the battery.The partial charging modewherein the available maximum PV power is larger than theload power and the excessive power will charge the battery, but the charging current is still less than the preset charge current.

**MPPT Controller Design:** The proposed MPPT controller tracks the peak power of the PV module based on the power–voltage (P-Vp) characteristic shown in Fig. and the incremental conductance algorithm. In the positive-slope region (dP/dVp > 0), the operation voltage is increased. On the other hand, in the negative slope region (dP/dVp < 0), the operation voltage is decreased.




**Circuit Configuration and Power Balance Control of the Charger**




**Proposed Modeling of Hybrid DC-DC Sepic Converter:** The SEPIC converter employs the peak-current-mode control with an outer PV voltage regulating loop,where the voltage command (V *(I*b ), the signal generated by the battery current controller thatis a proportional and integral (PI) controller will go positiveand be limited to be zero. It results that the voltage commandp ) is generated by combiningthe MPPT control loop and the battery charging loop. The com-bination of MPPT and charging control is for instantaneously balancing the system power to charge the battery with threestages, namely, constant-current, constant-voltage and oating-charge stages. (V *p ) is determined completely by the MPPT controller and thus, the PV module is operated in the MPPT point, as shownin Fig. 2(a) and (b). As the available peak power of the PVmodule is larger than the battery charging and load requirement,the battery current it will reach its command (I*Based on the PV power generation, the battery SOC andb ),and the signal generated by the battery current controller willgo negative and will now add voltage to increase the voltage command generated by the MPPT controller.

The control-to-output transfer function of the SEPIC in CCM with output-voltage regulation can be derived for the following form:

$$\left.\frac{\tilde{V}_B}{\tilde{D}}\right|_{\tilde{V}_P=\tilde{V}_{C_2}=0} = \frac{V_P - V_B}{D'^2} \frac{\left(1 - s\frac{DL}{D'R_L}\right)}{\left(1 + s\frac{L}{D'^2R_L} + s^2\frac{LC_o}{D'^2}\right)}$$

Where D is the duty ratio of the switch, with D'= 1- D. Here, for deriving above equation, the battery is changed to be an output-filter capacitor Co, the input voltage Vp is changed to be a constant-voltage source and the inductors are set to be L1 = L2 = L for simplification, opposite to output voltages regulation as the conventional converter the proposed PV charger regulates the input voltage.

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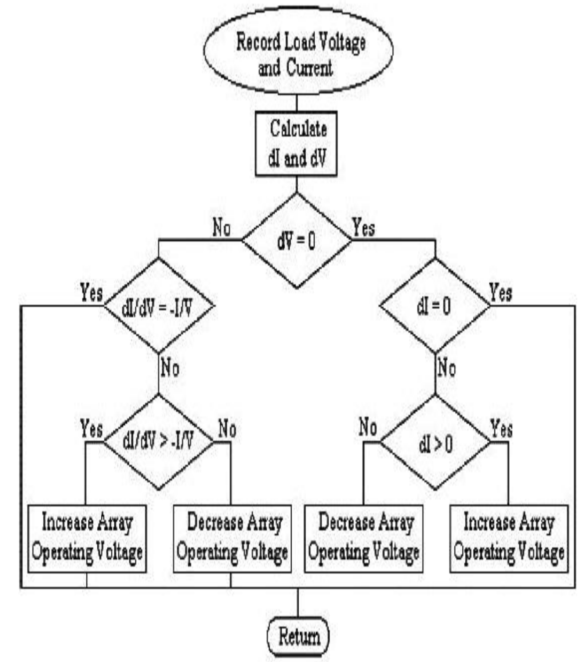
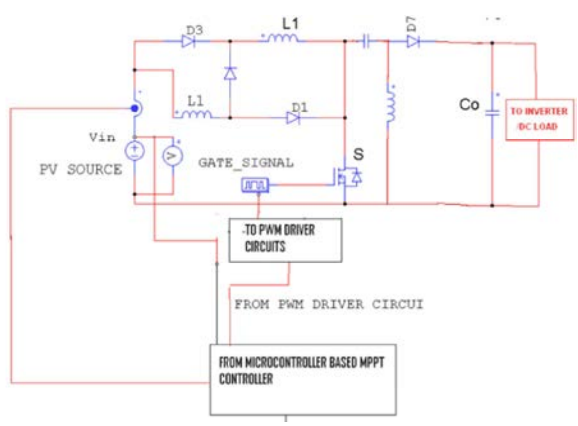
When the battery voltage drops to a given value, the Flyback DC/DC converter is shut down to prevent the battery from over-discharging. The SEPIC PFC circuit draws energy from the AC-line utility to drive the HID lamp via the low-frequency square-wave DC/AC inverter: thus, the HID street lighting system will not be extinguished even if the battery is fully discharged. With a coupled inductor, high inputpower factor can be achieved at the AC-line utility side using a simple transition-mode (TM) PFC control.




**Flowchart of MPPT Controller**

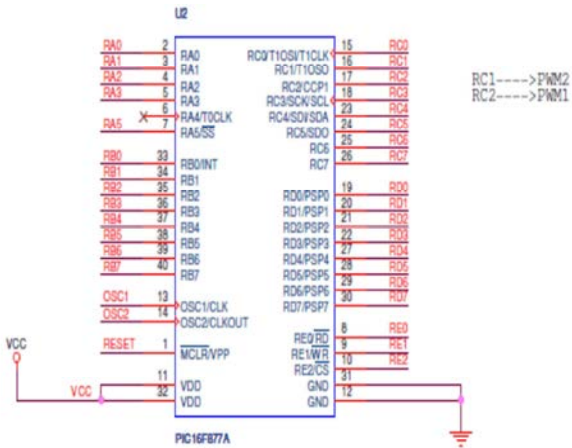



**Modified Sepic Converter:** The proposed topology utilizes a hybrid switching structure by only adding one additional diode, inductor and a small capacitor, like similar in operation to their PWM converter technique but they have several significant performance over conventional PWM converter.The hybrid Sepic converter in the step-up mode is obtained by using above figure, the input inductor of a classical Sepic becoming unnecessary.

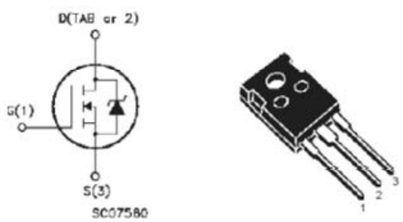
$$V_o = \frac{D(1+D)}{D_1} V_{in}$$

The output voltage that obtained becomes i.e. in a (1+D) times more dc gain than that provided by a classical Sepic converter.

**Microcontroller PIC16f877A**



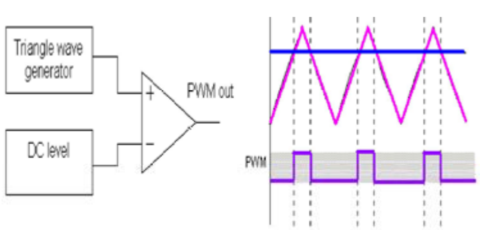

**IR2110 MOSFET/IGBT Driver Circuit:**




| TYPE | $V_{DSS}$ | $R_{DS(on)}$ | $I_D$ |
|---|---|---|---|
| IRFP450 | 500 V | < 0.4 Ω | 14 A |

The IR2110/IR2113 is high voltage, high-speed power MOSFET and IGBT drivers with independent high and low side referenced output channels. The output driver's feature a high pulse current buffer stage designedfor minimum driver cross-conduction. Propagation delays are matched to simplify use in high frequency applications. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high side configuration, which operates up to 500 or 600 volts.

**PWM Control:**




The peak amplitude of triangular waveform is given by

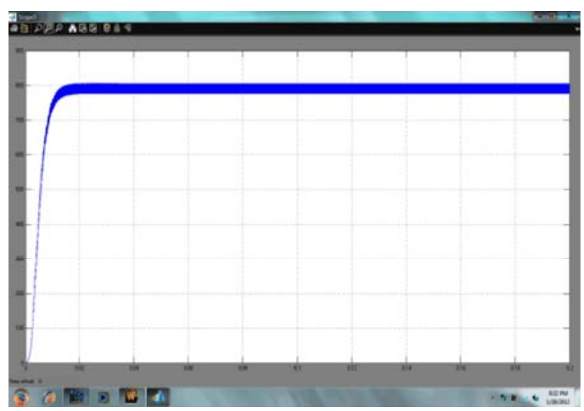
Vo (pp) = 2.R2/R3.Vcc

The output frequency of oscillation is given by

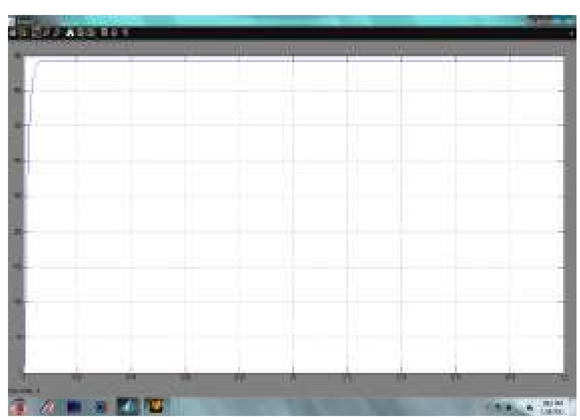
FO = R3/4R1C1R2

For varying the values of resistance R1 with fixed values of R3 and R2 the output frequency FO can be varied.

**Stimulation Results:** To confirm the performances, the proposed MPPT method is compared with the conventional MPPT method by using MATLAB 7.9. Fig a) shows the change in the operating point position when the surrounding conditions are slowly changing and get somewhat low power compare using SEPIC converter. Fig. b) shows the operation of the proposed MPPT method under a slowly attained maximum power for this condition.



- With using hybridmodel SEPIC converter



- Without using SEPIC converter

**Advantages:**

- Higher efficiency
- Reduced size and weight
- Simpler structure and control
- Provide a high voltage gain without extreme switch duty cycle
- Lower switching stress on the semiconductor devices so as to reduce cost switch conduction and turn-on losses
- Ripple free continuous output and input current.

**Applications:**

- A battery voltage can be above and below that of the regulator's intended output.
- Grid supply system.
- Stand alone PV system
- Industrial UPS

## CONCLUSION

The proper presented a PV charger implemented with the SEPIC converter. The system has been proved to be effective inthe MPPT and power balance control. The proposed modeling method of the converter with the PV module input and peak-current-mode control, the adaptive MPPT control method, aswell as the power balance control method can also be applied to the charger with other types of converter. The MPPT controller was implemented with the Matlab real-time control in thispaper and it will be changed to be implemented with the microprocessor or DSP and integrated with the voltage controller.

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