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# Implementation of P and O MPPT Algorithm in Solar Explorer Kit

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**Abstract**: To get the most energy utilization out of the PV system installation, it must operate at the maximum power point of the curve. In order to operate at the maximum power point of the curve, the C2000 Piccolo Microcontroller (TMDSSOLARPEXPKIT) uses an MPPT. Maximum Power Point Tracking (MPPT) is used to get the maximum power possible when using photovoltaic devices, such as a solar panel. The MPPT is used to control power at any type of environmental condition. They are typically used in electrical power converter systems. MPPT controllers convert the module operating voltage obtained from the solar panel into a battery voltage and also raise the output current in the process.

**Keywords**: TMDSSOLARPEXPKIT, MPPT.

## I. INTRODUCTION

Solar energy is one of the most important renewable energy sources. The main applications of photovoltaic (PV) systems are in either stand-alone (water pumping, domestic and street lighting, electric vehicles, and military and space applications) or grid-connected configurations (hybrid systems, power plants) but PV systems have two problems: the first problem is that the conversion efficiency in electric power generation is low. The second is that the amount of the electric power generated by solar arrays changes continuously with weather conditions [1].The PV cell has non–linear current–voltage qualities. The power delivered by an array increases to a point, as the current draw rises. The maximum power point is usually at the knee of the curve. The aim of the MPPT subsystem is to determine just where that point is, and to regulate current accordingly. The factors that make the location and tracking the maximum power point a bit more challenging are temperatures and the partial shading of an array. The rapid changes in irradiance or temperature may introduce multiple local maxima. It is possible to track the MPPT that is one of the key functions that every PV should have to optimize the energy captured. The MPPT has been reported in different works. A comparison among many different MPPT techniques has been presented in [2], [3], and [4]. The Perturb and Observe (P&O) and Incremental Conductance (IC) methods receive the best rankings [2]. The P&O method is able to improve the dynamic and steady state performance of the PV system simultaneously [3]. From [4], it is found that IC method has less oscillation in comparison to P&O method which results in higher efficiency. The IC method offers different advantages which are: good tracking efficiency, response is high and well control for the extracted power [4].

## II. SOLAR EXPLORER KIT

Solar explorer kit is a low voltage platform to evaluate C2000 microcontroller family of devices for renewable energy applications such as PV inverter. The input to the solar explorer kit is a 20V DC power supply which powers the controller and the supporting circuitry. A 50W solar panel can be connected to the board (Typical values Vmpp 17V, Pmax 50W). However for quick demonstration of the power processing, a PV emulator power stage is integrated on the board along with other stages that are needed to process power. The control of the PV panel is kept separate from the control of the other stages. PV is light dependent source; the PV panel emulator can be used to test PV inverter under changing lighting conditions. This simplifies the debug and demonstration. The Solar Explorer kit can be used to implement a PV inverter system by connecting the power stages.

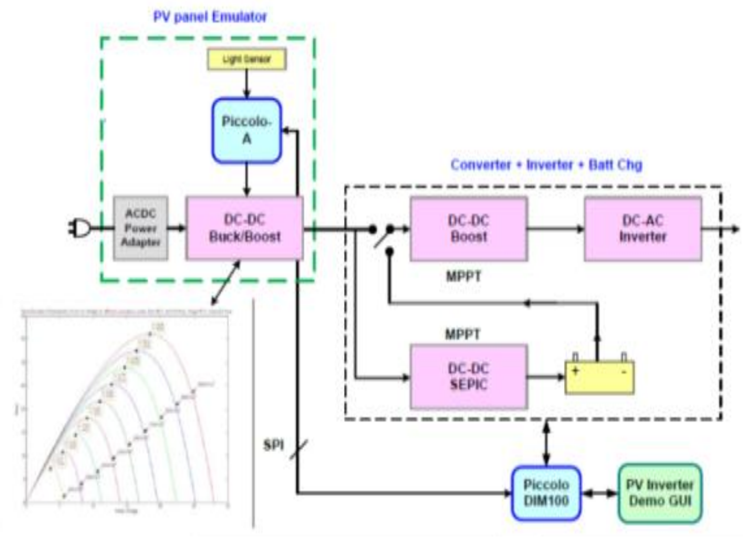


Fig. 1 Block diagram of the solar explorer kit [4]

## III. SEPIC CONVERTER

The SEPIC (Single Ended Primary Inductor Converter) is used as an interface between the PV array and the load to provide load impedance matching with the PV source. SEPIC is essentially a boost converter followed by buck-boost converter. Therefore SEPIC is similar to buck-boost converter but it has the advantage of having non- inverted output. Also the coupling capacitor offers isolation between output side and input side which is unique to SEPIC converter only. In SEPIC converter, MPP tracking can be done with ease because of low input ripple current. In addition to that, SEPIC converter is more efficient than buck-boost converter. Figure shows the SPEIC converter in the solar explorer kit. $V_{pnl}$ is the input of the SEPIC converter. $V_{batt}$ is the output of the SEPIC converter. PWM4A is the gate signal for the SEPIC converter generated from the MPPT.

POWER STAGE PARAMETERS

Input voltage ($V_{pnl}$): 0 - 30 V (panel input)

Input current ($I_{pnl}$): 0 - 3.5 A (panel input)

Output voltage ($V_{batt}$): 10 – 16 V dc max

Output current ($I_{batt}$): 0 -3.5 A

Power rating: 50W max

$F_{sw}$ = 200 kHz

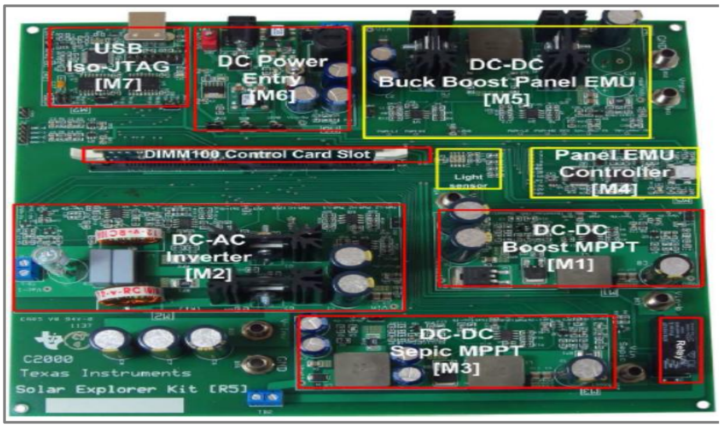


Fig. 2 Overview of the solar

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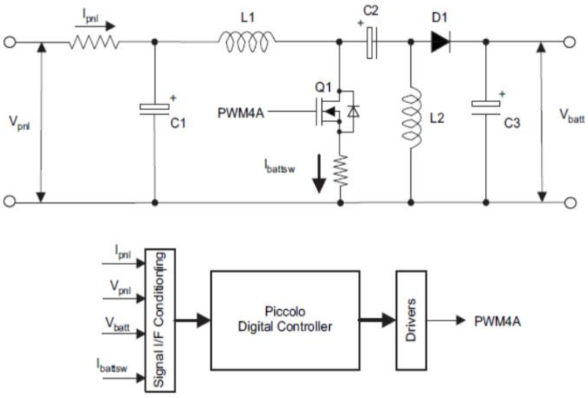


Fig. 3 Circuit diagram of the SEPIC converter [4]

## IV. SYSTEM BLOCK DIAGRAM

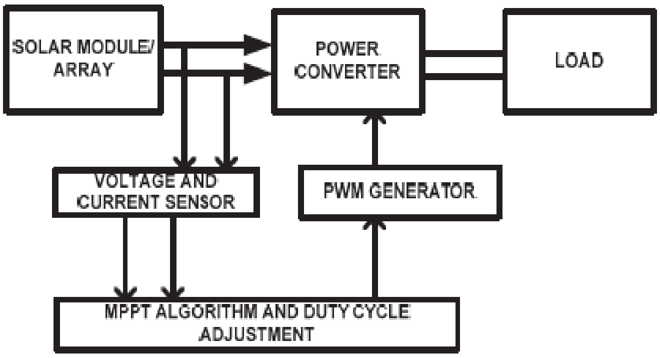


Fig. 4 Overall system block diagram

The Figure 4 shows the PV system block diagram with MPPT Technique. It consists of PV array, SEPIC converter, MPPT block, and finally load. Combination of Series and parallel solar cells constitute PV array. Series connection of solar cells boost up the array voltage and parallel connection increases the current. In order to change the input resistance of the panel to match the load resistance (by varying the duty cycle), a DC to DC converter is required. SEPIC converter is used to obtain more practical uses from solar panel. The input of SEPIC converter is connected to PV array and output is connected to load. MPPT block receives and signals from PV array. The output of MPPT block is series of pulses. These pulses are given to the SEPIC converter. Converter works based on these pulses to make the PV system operate at Maximum power point (MPP).

## V. MPPT

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 a SEPIC converter whose duty cycle is varied by using a MPPT algorithm

**Method for MPPT**

There are various MPPT algorithms. Some of them are describe here.

1. P and O
2. Incremental conductance
3. Fractional open circuit voltage
4. Fractional short circuit current

Perturb and Observe (P and O)

In this method the controller adjusts the voltage by a small amount from the array and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called the Perturb and Observe method and is most common, although this method can result in oscillations of power output. It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall of power against the voltage above the maximum power point.

Flow Chart of P And O MPPT Algorithm

The most commonly used method for maximum power point racking is studied here. The method is P and O. The perturb and observe (P&O) algorithm for finding the MPP is widely used in commercial applications. This method uses current and voltage sensors to measure the output of a solar array. The P&O algorithm can be the cheapest to implement. Generally, P&O is also the simplest to implement due to its reliance on passive element circuits to measure the current and voltage. These measurements are the only outside data sources the MPPT algorithm needs to determine whether to increase or decrease the duty cycle. By comparing the input power to the previously measured input power, we can determine whether to lower or raise the duty cycle to continue tracking the MPP. By changing the duty cycle after a set amount of time, the P&O algorithm checks the previously measured input power. If the newly measured input power is greater than the previously measured input power and the new input voltage is greater than the old input voltage, it decreases D to move closer to the peak power. If the input voltage was less than previously measured and it had greater input power, the algorithm increases D. If the new power measured is less than previously measured and the new voltage is greater than the old voltage, D decreases to converge to an MPP. Finally, if the power and voltage are less than previously measured, the algorithm decreases D. This algorithmic flow chart can be seen in Figure 5.

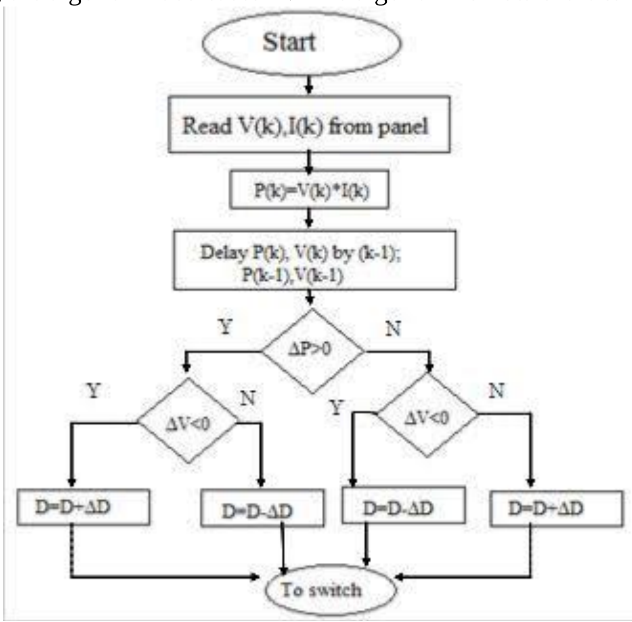


Fig. 5 Flow chart of the P and O algorithm

## VI. ALGORITHM INTERFACING

P and O algorithm is interfacing with the solar explorer kit by using the MATLAB. B2 and B3 are the ADC pin of the TMSF28035 processor.B2 is the input voltage pin of the SEPIC converter and B3 is the input current pin of the SEPIC converter. From these pins the voltage and the current is measured. There is a voltage reference in the ADC pin which is 3.3 V. For measuring the voltage there is a factor of safety 1/10 and for current the factor is 1. The rate transition block is used to convert a data from one block to another block at the different sampling rate. MPPT algorithm is coded in the MATLAB function block. There is a limit set for the duty ratio by using the saturation block. For getting the percentage value the duty will be multiplied by 100. That will be given to the PWM4A pin of the processor.

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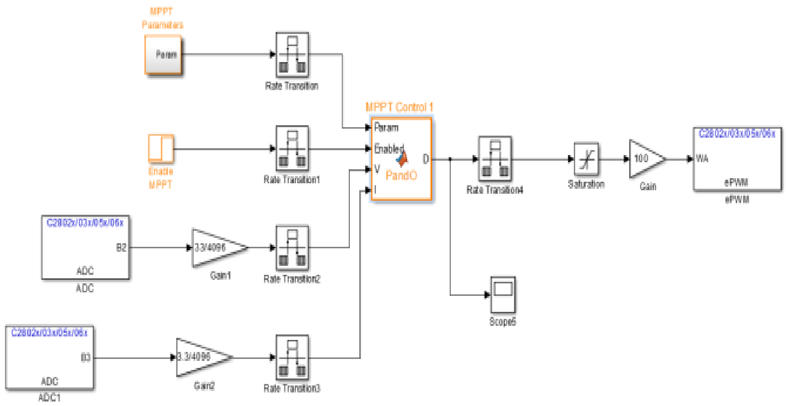


Fig. 6 Simulink model of P and O algorithm

## VII. EXPERIMENTAL SETUP

Fig. 7 Experimental Setup

The figure shows the experimental setup of the P and O MPPT algorithm implemented in the SEPIC converter. In the source side we are using a sepic convertor connected to a solar panel in order to enhance the output voltage so that it can be used for different applications like light, motor load etc. By algorithm interfacing the MPPT algorithm is fed and varying of the duty ratio can be observed. A maximum power will be obtained by a suitable duty ratio. The PWM generated is then fed to the sepic converter so that the halogen bulb connected to the kit will glow. By changing the duty cycle of the sepic converter appropriately we can match the source impedance with that of the load impedance, thus maximum power can be obtained.

## VIII. RESULT

The model was implemented using the P and O MPPT algorithm and the bulb was glow. A PWM pulse was generated using the sepic converter in the solar explorer kit. The duty ratio observed was 28% to 30% and the frequency was observed to be 203 kHz. The generated PWM is shown in figure 8.

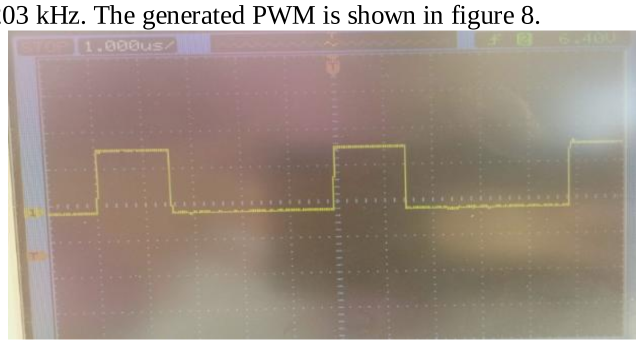

Fig. 8 Generated PWM for the SEPIC converter

Voltage waveforms were also observed. Partial shading is one of the major factor on tracking the maximum power. The voltage waveforms thus obtained is also affected by shading. On providing shade there is a dip in voltage waveforms which can be observed in Fig.9. Initially the panel voltage was 13V but it was varying to 16V due to shading.

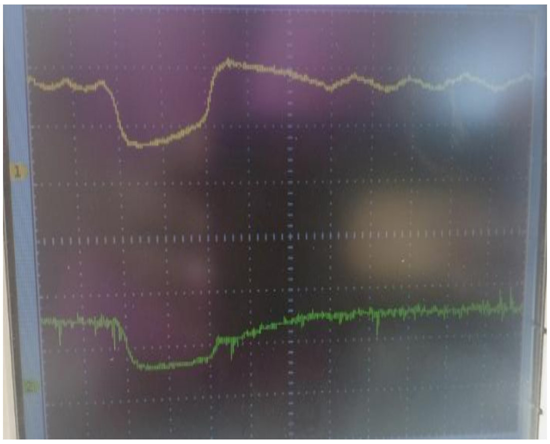

Fig. 9 Input voltage (yellow) and Output voltage (green) of the SEPIC converter

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OBSERVATIONS

| | |
|---|---|
| Panel output voltage | 13 V to 16 V |
| SEPIC input voltage (multiplied by a factor 1/10) | 1.3 V to 1.6 V |
| SEPIC input current (multiplied by a factor 1) | 0.32 A to 0.36 A |
| Voltage across the lamp | 5 V to 7 V |
| Duty ratio | 28% – 30 % |
| Frequency | 203 kHz |

COMPARISON OF DIFFERENT MPPT ALGORITHMS

Certain observations while implementing the MPPT algorithms are listed below

| **PARAMETER** | **Incremental conductance Algorithm** | **P & O Algorithm** | **Constant voltage Algorithm** |
|---|---|---|---|
| Solar input | 14.83V | 13-16 V | 12.13V |
| Vlamp | 5.6 V | 5.2-5.4 V | 4.25 V |
| Duty ratio | 30% | 28-30% | 34% |

## IX. CONCLUSION

When MPPT is used there is no need to input the duty cycle, the algorithm iterates and decides the duty cycle by itself. But if MPPT had not been used, then the user would have had to input the duty cycle to the system. When there is change in the solar irradiation the maximum power point changes and thus the required duty cycle for the operation of the model also changes. But if constant duty cycle is used then maximum power point cannot be tracked and thus the system is less efficient. From the individual analysis of each technique, it can be stated that CV uses only one voltage sensor associated with easy implementation, but efficiency is poor. P and O presents the advantage of operating close to the MPP, independent of temperature and irradiance variations, although it uses a two sensors. IC uses variable step to achieve high speed and low steady state error. Finally, the performance of the MPPT algorithm has been analyzed by using a SEPIC converter supplying a load.

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