Maximum Power Point Tracking for Photovoltaic Systems

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Abstract: In this paper a new maximum power point tracking algorithm for photovoltaic arrays is proposed. The algorithm detects the maximum power point of the PV. The computed maximum power is used as a reference value (set point) of the control system. ON/OFF power controller with hysteresis band is used to control the operation of a Buck chopper such that the PV module always operates at its maximum power computed from the MPPT algorithm. The major difference between the proposed algorithm and other techniques is that the proposed algorithm is used to control directly the power drawn from the PV. The proposed MPPT has several advantages: simplicity, high convergence speed, and independent on PV array characteristics. The algorithm is tested under various operating conditions. The obtained results have proven that the MPP is tracked even under sudden change of irradiation level.

Keywords: Photovoltaic, maximum power point tracking, MPPT

I. INTRODUCTION

Renewable sources of energy acquire growing importance due to massive consumption and exhaustion of fossil fuel. Among several renewable energy sources, Photovoltaic arrays are used in many applications such as water pumping, battery charging, hybrid vehicles, and grid connected PV systems. As known from a (Power-Voltage) curve of a solar panel, there is an optimum operating point such that the PV delivers the maximum possible power to the load. The optimum operating point changes with the solar irradiation, and cell temperature. Therefore, on line tracking of the maximum power point of a PV array is an essential part of any successful PV system. A variety of maximum power point tracking (MPPT) methods are developed. The methods vary in implementation complexity, sensed parameters, required number of sensors, convergence speed, and cost [1]. This paper presents a simple MPPT scheme that does not require special measurements of open circuit voltage or short circuit current.

The proposed algorithm is divided into two major parts: maximum power computation, and direct power control of the power drawn from the PV. The maximum power is computed online using a modified perturb and observe algorithm. The computed maximum power is compared with instantaneous actual PV power, the error between reference (maximum) power and actual power activates ON/OFF controller with a hysteresis band to drive the buck chopper. Therefore, the instantaneous power extracted from the PV is maintained between the tolerance bands.

II. PV EQUIVALENT CIRCUIT

A solar cell basically is a p-n semiconductor junction. When exposed to light, a dc current is generated. The generated current varies linearly with the solar irradiance. The standard equivalent circuit of the PV cell is shown in Fig.1.
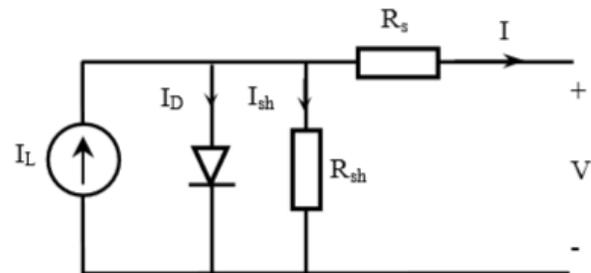
Figure 1: Equivalent circuit of PV solar cell

$$I = I_L - I_o \left(e^{\frac{q(V + IR_s)}{kT}} - 1 \right) - \frac{V + IR_s}{R_{sh}} \qquad (1)$$

Where:

I is the cell current (A).

IL is the light generated current (A).

Io is the diode saturation current.

Q is the charge of electron = 1.6x10-19 (coul).

K is theBoltzman constant (j/K).

T is the cell temperature (K).

Rs ,Rsh are cell series and shunt resistance (ohms).

V is the cell output voltage (V).

III. COMMONLY USED MPPT TECHNIQUES

The problem considered by MPPT methods is to automatically find the voltage VMPP or current IMPP at which aPV array delivers maximum power under a given temperature and irradiance. In this section, commonly used MPPT methods are introduced in an arbitrary order.

A.Fractional Open-Circuit Voltage: The method is based on the observation that, the ratio between array voltage at maximum power VMPP to its open circuit voltage VOC is nearly constant.

VMPP ≈ k1 VOC   (2)

This factor k1 has been reported to be between 0.71 and 0.78. Once the constant k1 is known, VMPP is computed by measuring VOC periodically. Although the implementation of this method is simple and cheap, its tracking efficiency is relatively low due to the utilization of inaccurate values of the constant k1 in the computation of VMMP.

B. Fractional Short-Circuit Current: The method results from the fact that, the current at maximum power point IMPP is approximately linearly related to the short circuit current ISC of the PV array.

IMPP ≈ k2 ISC   (3)

Like in the fractional voltage method, k2 is not constant. It is found to be between 0.78 and 0.92. The accuracy of the method and tracking efficiency depends on the accuracy of K2 and periodic measurement of short circuit current.

C.Perturb and Observe: In P&O method, the MPPT algorithm is based on the calculation of the PV output power and the power change by sampling both the PV current and voltage. The tracker operates by periodically incrementing or decrementing the solar array voltage. If a given perturbation leads to an increase (decrease) in the output power of the PV, then the subsequent perturbation is generated in the same (opposite) direction. So, the duty cycle of the dc chopper is changed and the process is repeated until the maximum power point has been reached. Actually, the system oscillates about the MPP. Reducing the perturbation step size can minimize the oscillation. However, small step size slows down the MPPT. To solve this problem, a variable perturbation size that gets smaller towards the MPP. However, the P&O method can fail under rapidly changing atmospheric conditions. Several research activities have been carried out to improve the traditional Hill-climbing and P&O

methods. Reference [4] proposes a three-point weight comparison P&O method that compares the actual power point to the two preceding points before a decision is made about the perturbation sign. Reference [5] proposes a twostage algorithm that offers faster tracking in the first stage and finer tracking in the second stage. To prevent divergence from MPP, modified adaptive algorithm is proposed in [6].

D. Incremental Conductance: The method is based on the principle that the slope of the PV array power curve is zero at the maximum power point.

$(dP/dV) = 0$.

Since $(P = VI)$, it yields: $\Delta I/\Delta V = \ -I/V$, at MPP   (4.a)

$\Delta I/\Delta V > \ -I/V$, left of MPP   (4.b)

$\Delta I/\Delta V < \ -I/V$, right of MPP   (4.c)

The MPP can be tracked by comparing the instantaneous conductance (I/V) to the incremental conductance (ΔI/ΔV). The algorithm increments or decrement the array reference voltage until the condition of equation (4.a) is satisfied. Once the Maximum power is reached, the operation of the PV array is maintained at this point. This method requires high sampling rates and fast calculations of the power slope.

IV. PROPOSED MPPT METHOD

Most MPPT techniques attempt to find (search) the PV voltage that results in the maximum power point VMPP , or to find the PV current IMPP corresponding to the maximum power point. The proposed algorithm tracks neither the VMPP nor the IMPP. However, it tracks directly the maximum possible power PMAX that can be extracted from the PV. The flowchart of the proposed MPPT method is shown in Fig. 2.
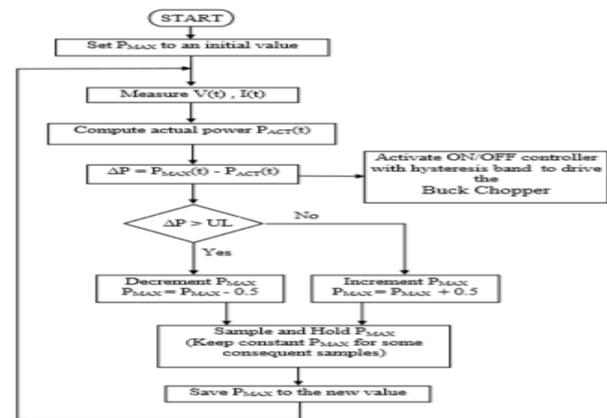
Figure 2: Proposed Tracking Algorithm

Increase gradually the computed value of PMAX and controls the power extracted from the PV to this value. If the actual power is well controlled within the tolerance band of the hysteresis controller, the partial tracking is succeeded and PMAX can be increased to greater value. But, if the power controller fails to track the PMAX, this means that the computedPMAX is greater than the maximum possible power of the PV. Therefore, a reduction (decreasing) in the computed PMAX must be done until the error between PMAX and PACT is limited between upper and lower limit. Actually, the algorithm starts by setting the computed maximum power PMAX to an initial value (zero or any other value). Actual PV voltage and current are measured. Then, the instantaneous value of PV power PACT is computed. The error between PMAX and PACT is input to ON/OFF controller with hysteresis band. The output of the controller is used to drive the power transistor of the Buck Chopper such that the PACT tracks PMAX. Till now, the real maximum power is not tracked. To track the maximum power, the error between PMAX and PACT is checked. If the error is lower than a certain upper limit (0.5 Watt), this means that the Power drawn from the PV is within allowable value, so we can increment PMAX by a certain step size. This new value of PMAX is stored and used to control the actual power of the PV to track this new value. Then the algorithm is repeated again. When the error between PMAX and PACT exceed the upper limit it means that the PV is no longer able to deliver this value of PMAX . Therefore, we have to decrement of PMAX by a certain step size (0.5 Watt).

V. SYSTEM MODELING:

The block diagram of the PV system under investigation is shown in Fig. 3. The PV power system is modeled using Power System Blockset under Matlab. The MPPT algorithm is modeled using simulink blocks.
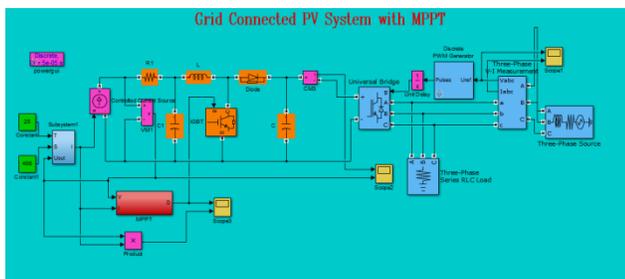
Figure 3: Simulink Model of the System

The PV system is attached with the MPPT system which tracks the maximum power of the PV system. The output of which is given to the converter circuit. The converter performs DC to AC conversion and gives the output to the universal bridge which boosts up the signal value and the enhanced signal is given to the PWM generator. The three phase output is then measured and analysed.

VI. SIMULATION RESULTS
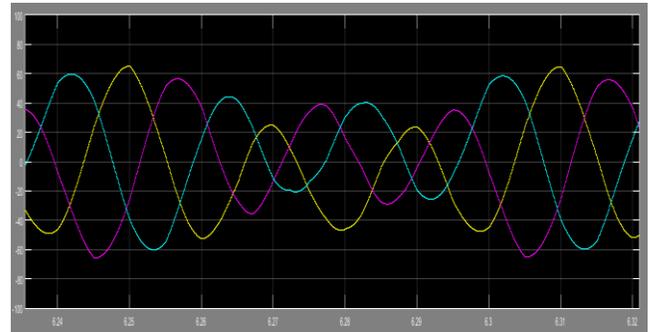
Figure 4: Three Phase Voltage Output
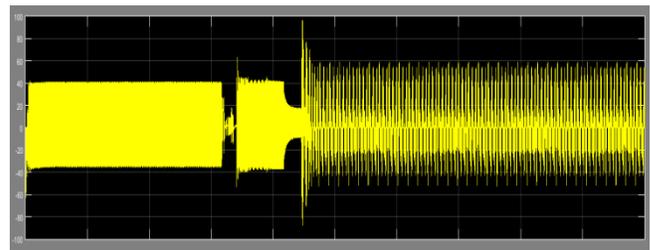
Figure 5: Boost Voltage
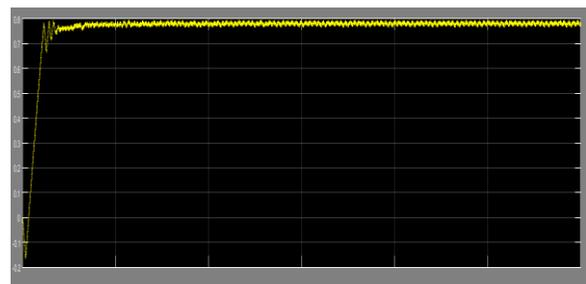
Figure 6: MPPT Output
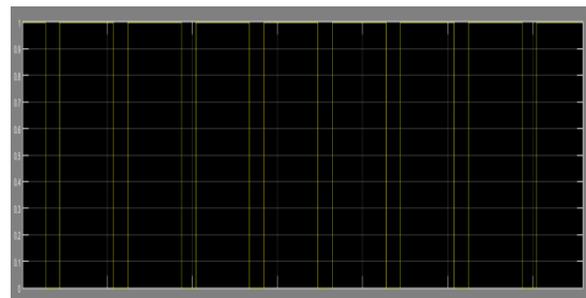
Figure7: MPPT Switching
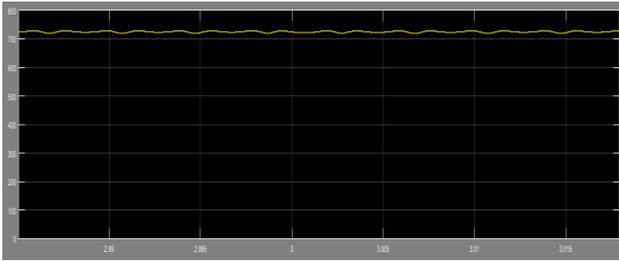
Figure8: Solar Power
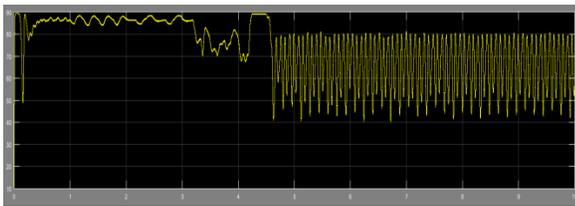
Figure 9: Solar Voltage
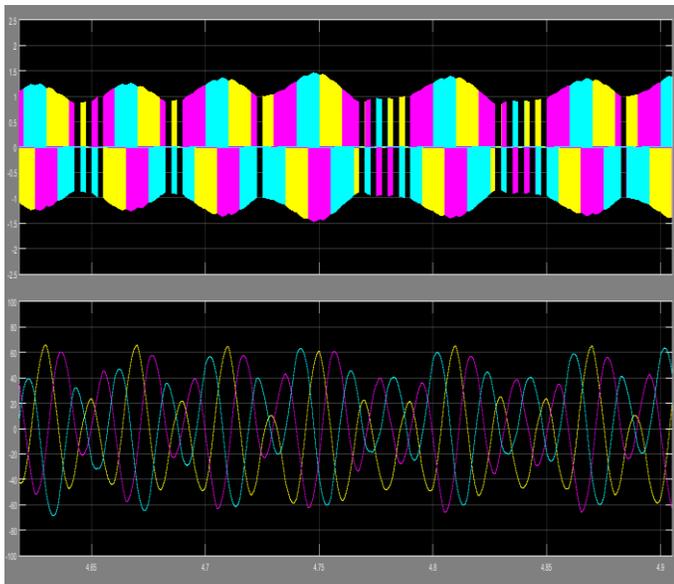
Figure 6.11: Current and Voltage of the System

VII. CONCLUSION

This method presented here control lead acid battery charging faster and efficiently. The control algorithm execute P&O method allow module to operate at maximum power point according to solar irradiation, and match load with the source impedance to provide maximum power. This MPPT model is more suitable because of less cost, easier circuit design. And efficiency of the circuit is increased by 20-25% in case of MPPT solar charge controller compare to a circuit without MPPT. And also saved the extra energy required in mechanical tracking. As Arduino based controlling is used, it

maintained constant 12V at the outputterminal i.e. at the batteryterminal.

VIII. FUTURE SCOPE

1. Hybrid of MPPT with mechanical tracking will give more efficiency, project can be extended in this direction.
2. Battery output is directly utilized to feed power in the dc grid which can be used for charging electronic devices like laptop, mobile directly.
3. By adding wifi module we can record our data in the system and optimize the data for better use.
4. Solar panel installed on urban and sub-urban areas with modified technology will lead in saving of our bill.

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