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Maximum Power Point Tracking Charge Controller for Photo-Voltaic System

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This article explains how to use the most common switching power supply topology to implement MPPT. Although there are many published books on the subject, only a few of them demonstrate how to actually implement the algorithms in hardware and list common issues and difficulties. We used Arduino uno in our effort to keep the design straightforward. It is fitted with different protections to shield the circuitry from abnormal conditions and contains features like an LCD display and LED indication. This setup can be used to charge a typical 12V lead acid battery with a 50W solar panel. An essential factor in the design of photovoltaic (PV) power generation systems is the maximum power point (MPP), which fluctuates with changing atmospheric conditions (such as solar radiation and temperature).

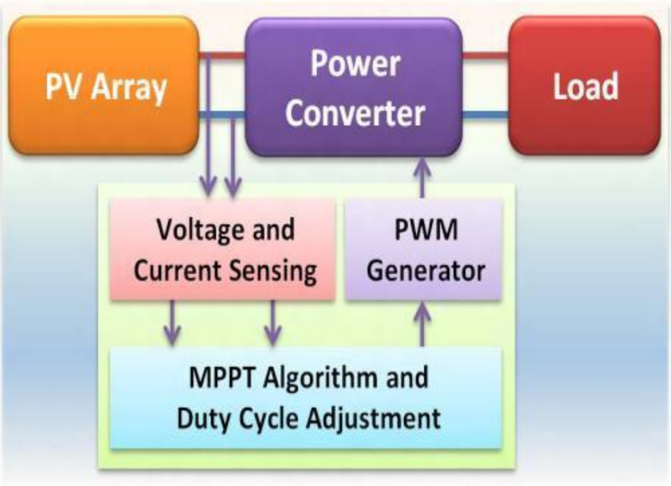
Keywords: - *Photovoltaic systems, MPPT techniques, Perturb and Observe, Buck converter, Arduino.*

1. INTRODUCTION

Using a solar panel or an array of panels without a regulator that can perform Maximum Power Point Tracking (MPPT) will frequently affect wasted power, which eventually results in the need to install further panels for the same power demand. For lower/cheaper bias that has the battery connected directly to the panel, this will also affect in unseasonable battery failure or capacity loss, due to the lack of a proper end of- charge procedure and advanced voltage. In the short term, not using an MPPT regulator will affect in an advanced installation cost, and, in time, the costs will escalate due to eventual outfit failure. Indeed, with a proper charge regulator, the prospect of having to pay 30- 50 further up front for fresh solar panels makes the MPPT regulator veritably seductive. The buck motor is used since it has a direct voltage transfer function when operating in nonstop Conduction Mode (CCM). This simplifies effects a lot, and the MPPT regulator can be enforced by operating directly on the motor duty cycle. The other typologies have a nonlinear voltage transfer function, and operating directly on the duty cycle will yield changeable results, especially at high-duty cycles. In this case, the algorithm modifies the solar panel operating voltage by using a commensurable integral (PI) control circle, which steers the voltage to the asked value (2- 9). In the posterior part of this paper, is the present basics of MPPT. The PO algorithm is explained in detail. The Buck motor is bandied. The total tackle design procedure is illustrated. The affair results are presented. Eventually concluding reflections are included.

2. SOLAR PANEL MPPT

The main problem answered by the MPPT algorithms is to automatically find the panel operating voltage that allows maximum power affair. In a larger system, connecting a single MPPT regulator to multiple panels will yield good results, but, in the case of partial shadowing, the combined power affair graph will have multiple peaks and denes (original maxes). This will confuse most MPPT algorithms and make them track inaptly. Some ways to break problems related to partial shading have been proposed, but they either need to use fresh outfits (like redundant monitoring cells, redundant switches, and current detectors for sweeping panel current), or complicated models grounded on the panel characteristics (panel array dependent). These ways only make sense in large solar panel installations and aren't within the compass of this operation note. immaculately, each panel or small cluster of panels should have its own MPPT regulator. This way the threat of partial shading is minimized, each panel is allowed to function at peak effectiveness, and the design problems related to transformers handling further than 20- 30A are excluded. A typical solar panel power graph (Figure 1) shows the open circuit voltage to the right of the maximum power point. The open circuit voltage (VOC) is obviously the maximum voltage that the panel labors, but no power is drawn. The short-circuit current of the panel (ISC) is another important parameter because it's the absolute maximum current you can get from the panel.



Block diagram of a MPPT controller

3. SOLAR PANEL CHARACTERISTICS

The literature on this subject generally agrees that the maximum quantum of power that can be uprooted from a panel depends on three important factors irradiance, temperature, and cargo. Matching panel and cargo impedances with a DC-DC motor makes sense, because for illustration if you have a 5V/ 2A cargo, and a 20W panel that has the MPP at 17.5 V/1.15 A, connecting the cargo directly won't work. Considering a simple resistive cargo, and the short-circuit current of1.25 A, the panel will only be suitable to give about 3V/1.2 A, or lower than 4W out of 20W. Temperature substantially changes the panel voltage operating point, while irradiance substantially changes the panel operating current. Figure 1 shows the effect of different irradiance situations on the panel voltage, current, and power. There are many MPPT algorithms that can be fluently enforced using an 8-bit microcontroller.

FRACTIONAL OPEN CIRCUIT VOLTAGE

The maximum power point voltage has a direct reliance on the open circuit voltage VOC under different irradiance and temperature conditions. Computing the MPP (Maximum PowerPoint) comes down to

EQUATION 1:

$$V_{MPP} = k_V V_{OC},$$

FRACTIONAL SHORT CIRCUIT CURRENT

The MPP can also be determined from the short-circuit current of the panel (ISC), because IMPP is linearly related to it under varying atmospheric conditions.

EQUATION 2:

$$I_{MPP} = k_I I_{SC}$$

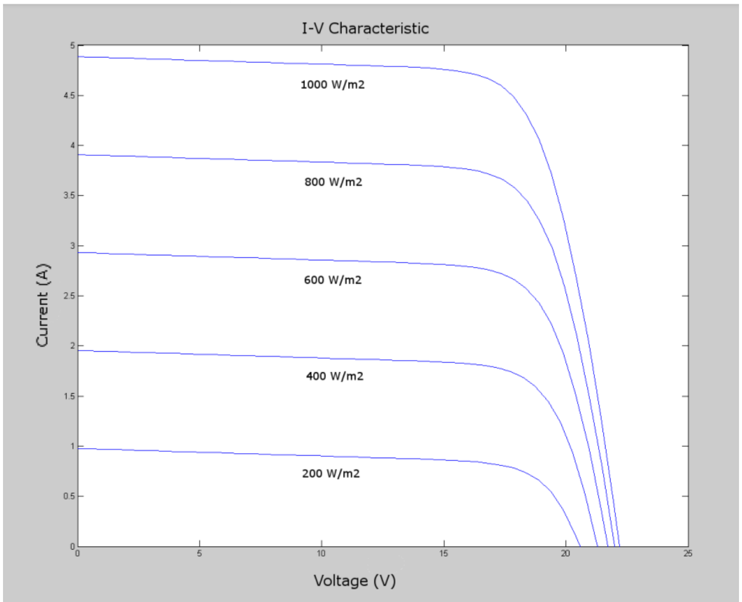


Fig3.1 PV characteristics curves of I-V

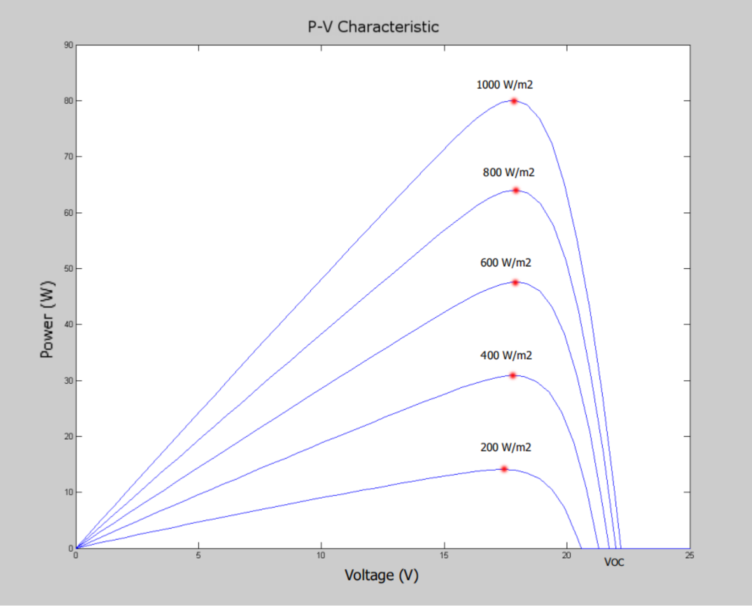


Fig3.2 PV characteristics curves of P-V

4. PERTURB AND OBSERVE (P&O)

P&O is one of the most bandied and used algorithms for MPPT. The algorithm involves introducing anxiety in the panel operating voltage. Modifying the panel voltage is done by modifying the motor duty cycle. The way this is done becomes important for some motor topologies. it is easy to understand that dwindling voltage on the right side of the MPP increases power. Also, adding voltage on the left side of the MPP increases power. This is the main idea behind P&O. Let's say that, after performing an increase in the panel operating voltage, the algorithm compares the current power reading with the former bone. If the power has increased, it keeps the same direction (increase voltage), else it changes direction (drop voltage). This process is repeated at each MPP shadowing step until the MPP is reached. After reaching the MPP, the algorithm naturally oscillates around the correct value. The introductory algorithm uses a fixed step to increase or drop voltage. The size of the step determines the size of the divagation while oscillating about the MPP. Having a lower step will help reduce the oscillation, but will decelerate down shadowing, while having a bigger step will help reach MPP briskly, but will increase power loss when it oscillates. To be suitable to apply P&O MPPT, the operation needs to measure the panel voltage and current. While executions that use only one detector live, they take advantage of certain tackle specifics, so a general purpose perpetration will still need two detectors.

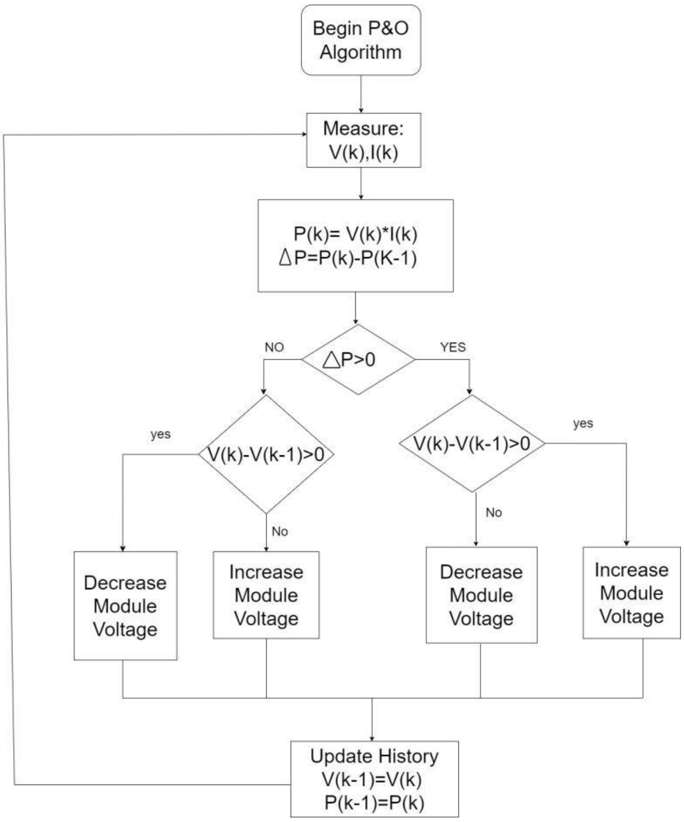


Fig4.1 P&O ALGORITHM

SWITCHED MODE DC-DC CONVERTERS

The heart of MPPT tackle is a switch- mode DC- DC motor. It's extensively used in DC power inventories and DC motor drives for the purpose of converting limited DC input into a controlled DC affair at a asked voltage position. MPPT uses the same motor for a different purpose regulating the input voltage at the PV MPP and furnishing cargo matching for the maximum power transfer. As stated over, in our design we've used the buck motor. The principle of the buck motor is presented below

The Buck Converter

A buck motor is a step-down DC to DC motor. it's a switched- mode power force that uses two switches(a transistor and a diode), an inductor and a capacitor.

Theory of operation

The operation of the buck motor is fairly simple, with an inductor and two switches (generally a transistor and a diode) that control the inductor. It alternates between connecting the inductor to source voltage to store energy in the inductor and discharging the inductor into the cargo.

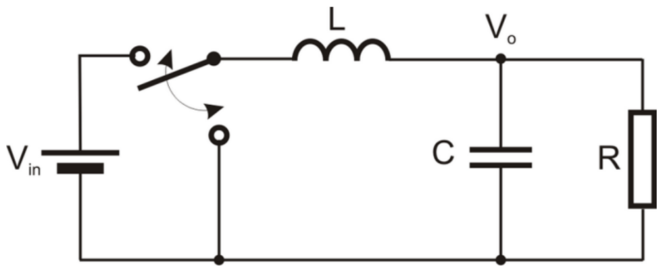


Fig4.2 Buck Converter

5.Table of Components and Specification

Component	Specification
Solar panel	The amount of power generated by a solar panel is measured in terms of its wattage under Standard Test Conditions, which include 25°C solar cell temperature, 1,000 watts of solar radiation per square metre, and 1.5 air masses.
Arduino uno	1. IC: Microchip ATmega328P. 2. Clock Speed: 16 MHz on Uno board, though IC is capable of 20MHz maximum at 5 Volts 3. Flash Memory: 32 KB, of which 0.5 KB used by the bootloader. 4. SRAM: 2 KB,EEPROM 1KB
Voltage Sensor	1. Input capacitance (40 max) 2.Voltage sensor accuracy, V_{in} range: 0 V to 1.1 V^{48} **((±3.5)** Max**))**
Current Sensor	Supply Voltage: 4.5V ~ 5.5V DC. Measure Current Range: -20A ~ 20A. Sensitivity: 100mV/A.
Buck Converter	Input voltage:4.75-35V. Output voltage:1.25-26V(Adjustable) Output current: Rated current is 2A,maximum 3A(Additional heat sink is required) Conversion Efficiency: Up to 92%.

MPPT Controller	Solar charge controllers are rated and sized by the solar module array current and system voltage. Most common are 12, 24, and 48-volt controllers. Amperage ratings normally run from 1 amp to 80 amps, voltages from 6-600 volts.

6.BLOCK DIAGRAM

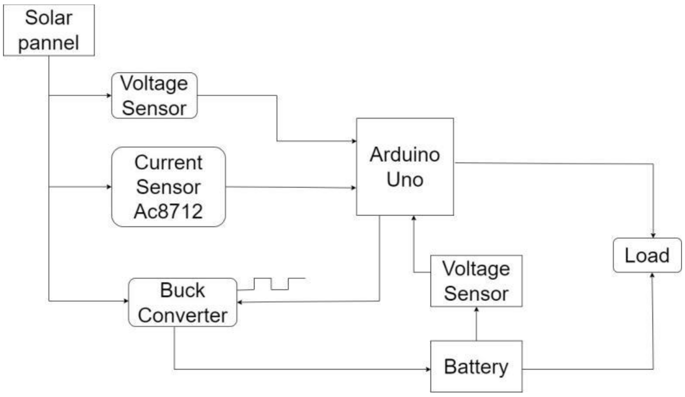


Fig6.1 Block Diagram of System

7. SIMULATION AND EXPERIMENTAL RESULTS

A. simulation Result

The circuit of the entire photovoltaic system is modelled using solar panel blocks for the PV system and microcontroller blocks for the MPPT algorithm in the PowerSim environment. The PV is depicted in Figure7.1 as being Without an MPPT system, when connected to a resistive load, the load imposes its own characteristics, which are typically different from the Maximum Power Point.

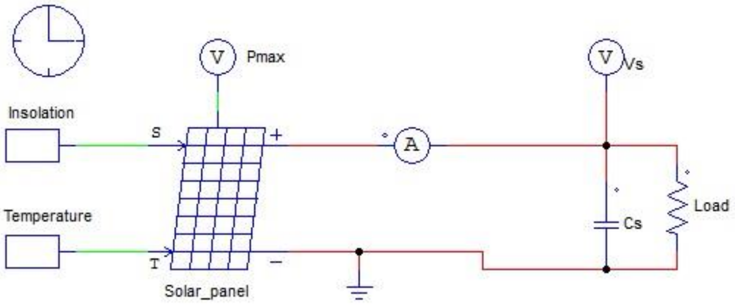


Fig7.1 PV panel without MPPT system

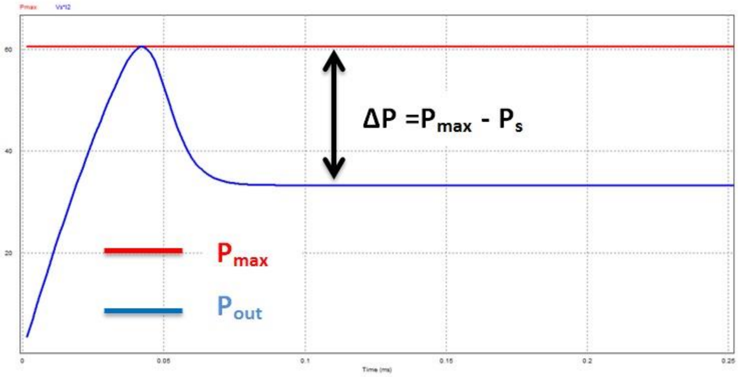


Fig7.2 PV-Output Power without MPPT system

The simulation result of the circuit in Figure7.1 demonstrates that the load is unable to extract the PV terminal's available power (Figure7.2). In order to solve this issue, we add a DC-DC boost converter with variable duty cycle. The goal of this addition is to alter the load characteristic so that it becomes dependent on the duty cycle D and enables us to move on the solar panel characteristic regardless of the load value. The boost converter is used to increase the input DC voltage to a greater output DC voltage. The DC-DC boost converter circuit is depicted in the schematic Figure8.a below. One MOSFET in this boost converter will be managed by a square wave control signal. Figure7.3 show the whole circuit diagram using a PV panel, DC-DC boost converter, load, voltage, and current sensors, as well as an MPPT controller.

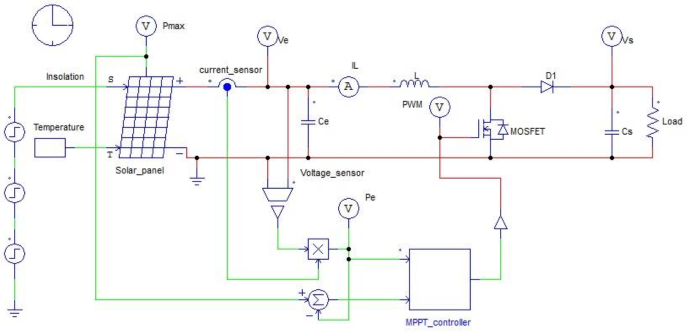


Fig7.3 PV panel with MPPT system

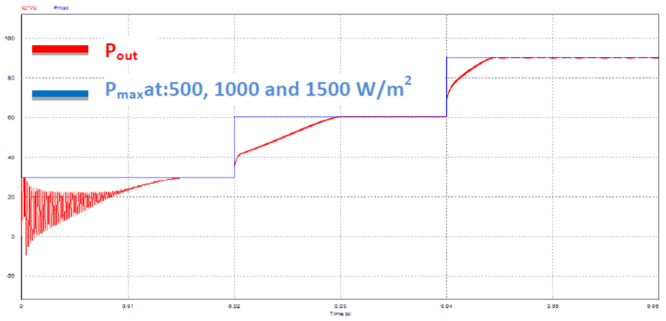


Fig7.4 PV-Output Power with MPPT system

The algorithm shown in Figure 4.1 is implemented in the MPPT controller bloc shown in Figure7.3This result shows how well the MPPT algorithm performs at irradiance steps of 500, 1000, and 1500 W/m2. The real values are displayed in red, and the MPP values are displayed in blue. We increased the simulation size of the MPPT system response to show the improvement in the performance of our improved P&O algorithm over the conventional P&O method. It is clear that the system using the traditional P&O algorithm shows a larger rate of instability than the system using the improved P&O method, which has better accuracy (see Figures 7.5 and 7.6).400mW for classical and 15mW for enhanced

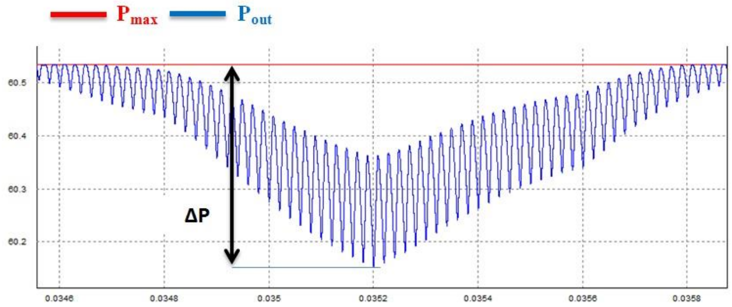


Fig7.5 Classical P&O accuracy

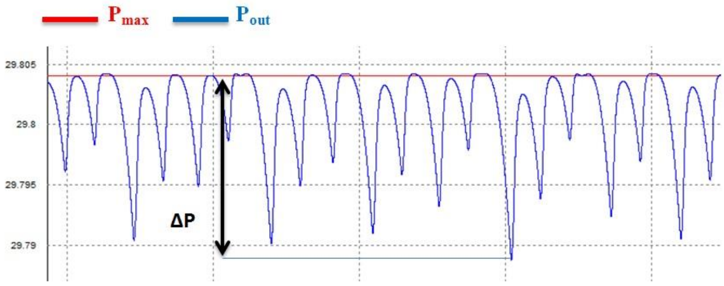


Fig7.6 Enhanced P&O accuracy

B. Hardware Implementation

The full implementation of the system, including the current and voltage sensors, DC-DC boost converter, and MPPT controller, is shown in Figure7.7.

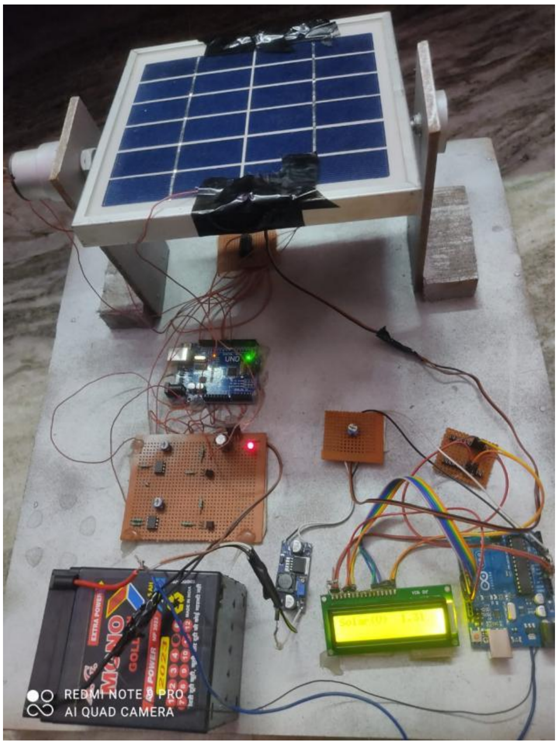


Fig7.7 MPPT hardware implementation

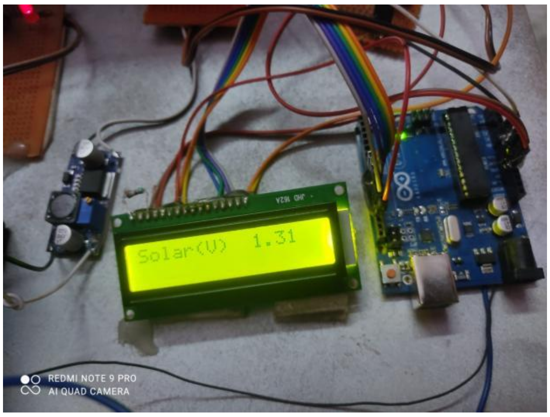


Fig7.8 Output on LCD When battery charge

8.CONCLUSION

The Maximum Power Tracker uses an iterative approach to chancing this constantly changing MPP. This iterative system is called hill climbing algorithm. To achieve MPPT, the regulator adjusts the voltage by a small quantum from the solar panel and measures power, if the power increases, farther adaptations in the direction are tried until power no longer increases. The voltage to the solar panel is increased originally, if the affair power increase, the voltage is continually increased until the affair power starts dwindling. Once the affair power starts dwindling, the voltage to the solar panel dropped until maximum power is reached. This process is continued until the MPPT is attained. This result is an oscillation of the affair power around the MPP.

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