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Sliding Mode Controller for Solar System

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Abstract: The battery charger for photovoltaic (PV) systems is very important for the solar cell guarantee in the absence of sunlight. This type of charger must be used immediately with the MPP, and cut off the subordinate part of the battery charging current to extend its service life, the battery charging structure is composed of DC-DC converters, which control the battery current and PV panel voltage. The SMC (sliding mode controller) generates a voltage reference (control signal) for controlling action, or its control action is a reference for battery charging current. This type of current reference value recently reached the lower limiter after a certain period of time, and the current limiter is executed by the sliding mode controller (SMC). This study incorporates SMC horizontality and reachability tests to expand the SMC controller design. Under fast variations of irradiance and temperature, the proposed device is modeled and simulated in MATLAB Simulink. The results obtained with the proposed MPPT are then compared to those obtained with the incremental conductance (IC) process. The findings show that the sliding mode MPPT can generate more electrical energy than the IC MPPT, with more benefits percent's for both the sunny daily profile and the gloomy daily profile.
Keywords: Sliding mode controller MPPT, IC MPPT, AC, DC.

1. Introduction

One of life's most basic requirements is electrical energy. Some people may notice it, and some may not think electricity is the backbone of society. To meet today's electricity demand, a variety of methods or technologies have been created to ensure that electricity is always present and produced in large amounts every day. Generating energy through renewable energy technologies today is considered ideal and reliable for both economic and environmental purposes. The most promising sources in this period are photovoltaic (PV) energy because it is free from pollution and can be exploited all over the world in large quantities. Solar energy is particularly useful in remote areas such as deserts or rural areas where the impractical use of existing resources due to transportation fuel difficulties and lack of energy lines. The load includes a battery pack. Sliding mode control (SMC) using to be controlled duty cycle DC-DC inverter. The maximum power point MPP estimated by the given SMC is used as a reference to track MP to make the PV system work at this point. The aim is to analyze the control of an independent PV system. The accomplishment of solar applications will depend on the efficiency of power electronics equipment to operate solar energy (PVG) effectively even in changing climatic conditions.

2. Sliding Mode Control in Mppt

Beginning in 1960, Sliding-mode-controller (SMC) was suggested and extended by several researchers from former Russia. Only in Russia was the sense confined until a book by Itkis and Utkin was written in English. SMC was eventually developed into a general method of control and has been used for numerous forms of systems, including non-linear systems, time-variant systems, MIMO systems and large scale systems. In recent years, because of its appealing characteristics, SMC has been commonly used for the regulation of complex unpredictable processes. SMC is a special category of Variable Structure Control Systems (VSCS), characterized by a discontinuous control structure that changes to cause the system state to enter as the system crosses such multiples in the state space and then to stay inside the state space called the sliding surface on a given surface. When confined to the sliding surface, the system dynamics are referred to as an ideal sliding motion and represent the regulated system actions, resulting in decreased order dynamics with respect to the original plant. This reduced order dynamics offers desirable benefits, such as parameter variance insensitivity and matching uncertainties and disruptions, making SMC takes the significant priority as a robust scheme for control. Although the control law is not a continuous function, in finite time, the sliding mode can be achieved. It showed the usefulness of SMC with multiple inputs containing non-linarites and uncertainties to stabilize uncertain non-linear processes. In uncertain structures, the controller guarantees the sliding mode's hitting state. Robust and solid is the controller.

Utkin et al showed the potency of SMC by adding it to electric drives. For complex, uncertain systems, the SMC scheme is a well-known robust control system. SMC, however, suffers from the hazardous chattering Effect that prevents them from being used widely in use. SMC efficiency is also highly based on the sliding board. It may lead to harmful effects if the sliding surface is not correctly built. Based on both back-stepping and sliding mode approaches, a fast and efficient MPPT control for a PV system has been developed.

A DC converter with a resistive load is used to supply the PV module in this device. There are two loops to the control scheme in this system. The first loop calculates the maximum power voltage (MPV) used as a reference value for back stepping sliding mode controller (BSMC) regulation in the second loop. By changing the DC-DC boost converter's service cycle, the BSMC-based controller powers the PV mechanism to run very similar to the MPP.

3. Design and Development

Figure 3.1 views a simplified circuit diagram of the photovoltaic unit. This diagram can be considered as a boost converter DC / DC, because it is mostly used in photovoltaic systems. In any case, it can be verified by this assumption DC / DC design. In order to illustrate the DC relation of a two-stage configuration in a conventional PV inverter, the system architecture contains battery as a voltage source for system load, where the DC/DC stage was controls to the DC converter by using a new technique to control the PWM, called sliding mode controller SMC instead of the traditional controller proportional integration (PI), as shown in figure 3.3.

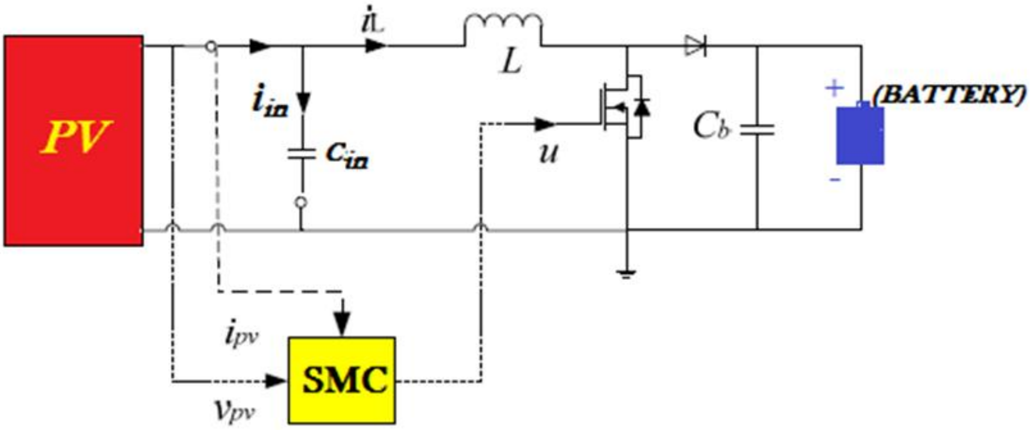


Figure 3.1 The Equivalent Circuit Diagram of the SMC.

All algorithms will be implemented using MATLAB environment. The findings from these implantations are used to plot I-V curve which is used later to investigate the effectiveness of the MPP. Inside the MATLAB environment, the SIMULINK application is used to achieve this controller according the graphical block mentioned in Figure 3.2.

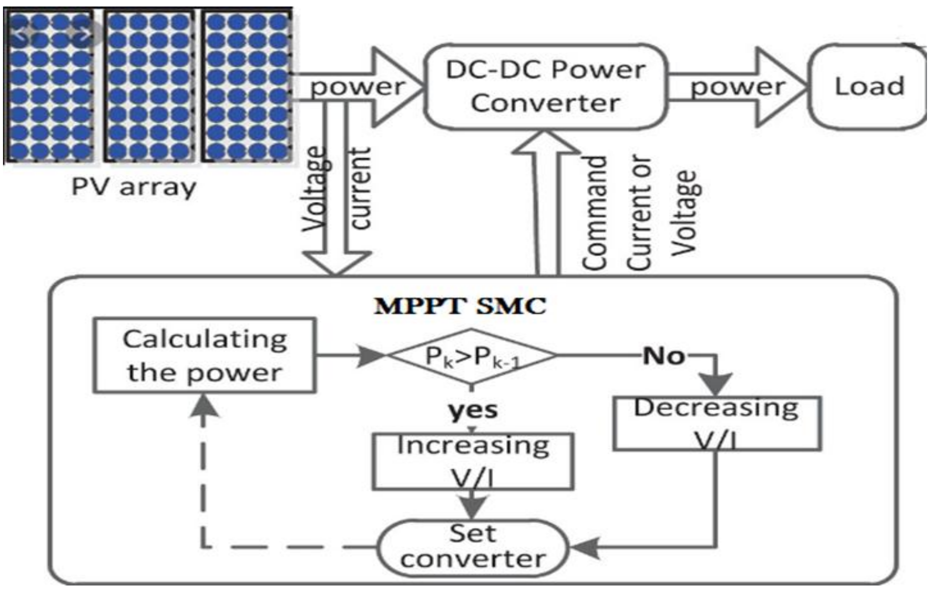


Figure 3.2 PV Panel Modelling with SMC.

A novel technique of MPPT is considered for the new controller. This technique utilizes a smart algorithm and is optimized using the SMC algorithm. In addition, the proposed controller utilizes a smart multi stages charging algorithm in order to minimizing the charging time. The components of the photovoltaic power generation system are introduced and mathematical model is performed, including control and optimization methods. Subsequently, the charge controller was discussed, including design aspects, functions and charge control methods. Consequently, the new controller is modelled based on complete mathematical models. In order to determine the performance parameters and evaluate the validity and efficiency of the new controller, a PV system is fully design and analysis using the SIMULINK application in MATLAB environment.

4. Evaluate and Analysis

The proposed system is appeared in Figure 4.1 It is made out of the PV show, DC-DC boots converter, the controller, the battery bank, these parts will be portrayed in detail in the following stage. It will be executed dependent on MPPT strategy using a SMC. The responsibility prototype of the boost converter is constrained by the width adjustment signal created by the SM controller. The widths of these heartbeats are dictated by the estimations of system boundaries, which are the board surrounding temperature (Tpv), Irradiance (Irr), board current (Ip) and voltage (VP), charging current (Ibat :), battery voltage (Vbat) and battery temperature (Tbat). The system programming program contains the rationale of the MPPT algorithm, in figure 3.4 shows the block diagram with SMC, and the consistent current steady voltage battery-charging.

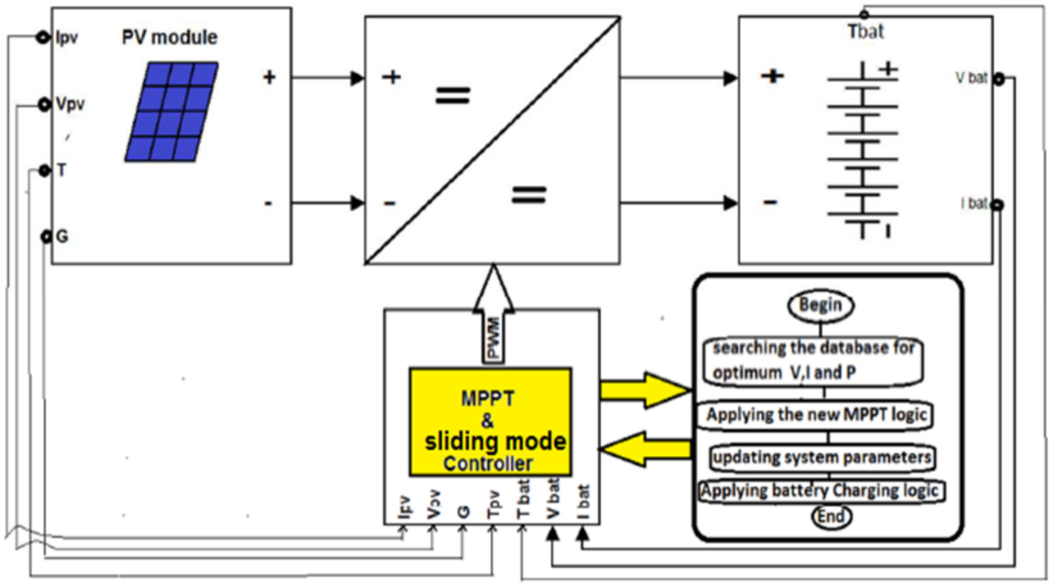


Figure 4.1 the charger controller block diagram.

Proposed SMC_MPPT

The SMC-MPPT algorithm is separated into two stages. The first is to test the actual reference voltage (VMPP) esteem at which the system will arrive at its greatest power. The second is the SMC PV voltage guideline at the VMPP voltage esteem. The rule capacity of this controller is to make a request using a voltage reference (Vref) to control the structure to work at the most outrageous power point (MPP). The essential peculiarity in this method is to describe the commitment of the controller as: VP _ VMPP. This data can be easily decided and reliant on the objectivity standard among VMPP and PMPP. So if the structure will work at the VMPP, the constraint of power will be gained (PMPP).

In this work, the calculation was adjusted so as to incorporate SMC. The SMC limits the mistake where the yield will be equivalent to obligation cycle amendment.

Parameters for solar model: open circuit voltage-21V, short circuit current-5A, Power -100 W, reference temp-25 and sun illumination S=1 (1 sun=1000 w/m^2) Simulation model of the complete system consisting of Solar PV model, boost converter, MPPT model and SMC controller model is as shown Fig.4.2. Model of PV cell is designed by using current controlled voltage source. PV cell characteristic equations are written as a function. Solar insulation, ambient temperature and number of series connected modules are the input to this function. This function block also takes measured PV cell voltage as input and gives control current signal to controller current source.

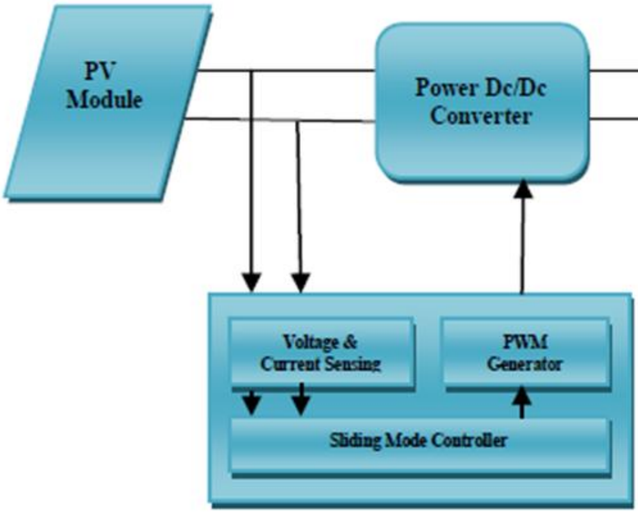


Figure 4.2 Block diagram with SMC model for PV

Algorithm for incremental conductance MPPT method is implemented in SIMULINK. This algorithm block takes PV voltage and PV current as input and generates reference voltage command. Error signal between reference voltage signal generated by MPPT algorithm block and actual voltage is fed to SMC controller. Output control signal is compared with triangular career to generate pulse width modulated signal (PWM).

The system is simulated using the SIMULINK environment to study the two states of PI and SMC. In this case, separating a parallel panel uses 230W solar panels without extreme natural changes (normal mode) and shadow effects, environment temperature and irradiance change normally resulting in a slight deviation from the reference. When use of SMC it can be seen in Figure 4.3 that, the photoelectric output voltage (Vpv) returns to average reference 12 volte after 0.08 seconds, while the voltage response when use the PI controller is slower than that of the SMC (which hits normal at 0.2 seconds.

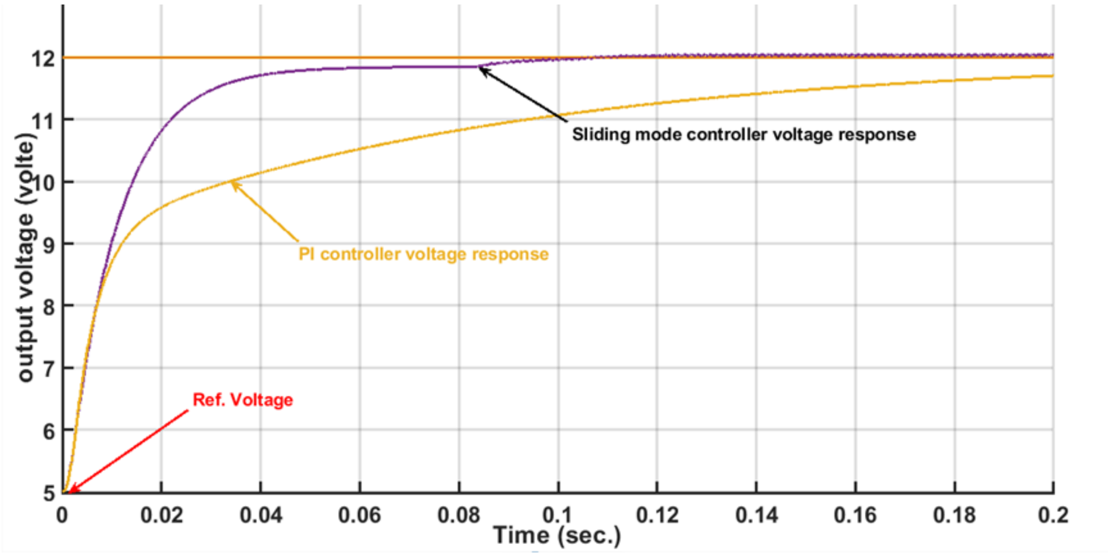


Figure 4.3 shows the normal mode for solar cell using PI and SMC.

When solar irradiance changes (at constant temperature), the behavior of PV is shown in Figure Obviously, the power is greatly affected by solar radiation, but has little effect on the open circuit voltage.

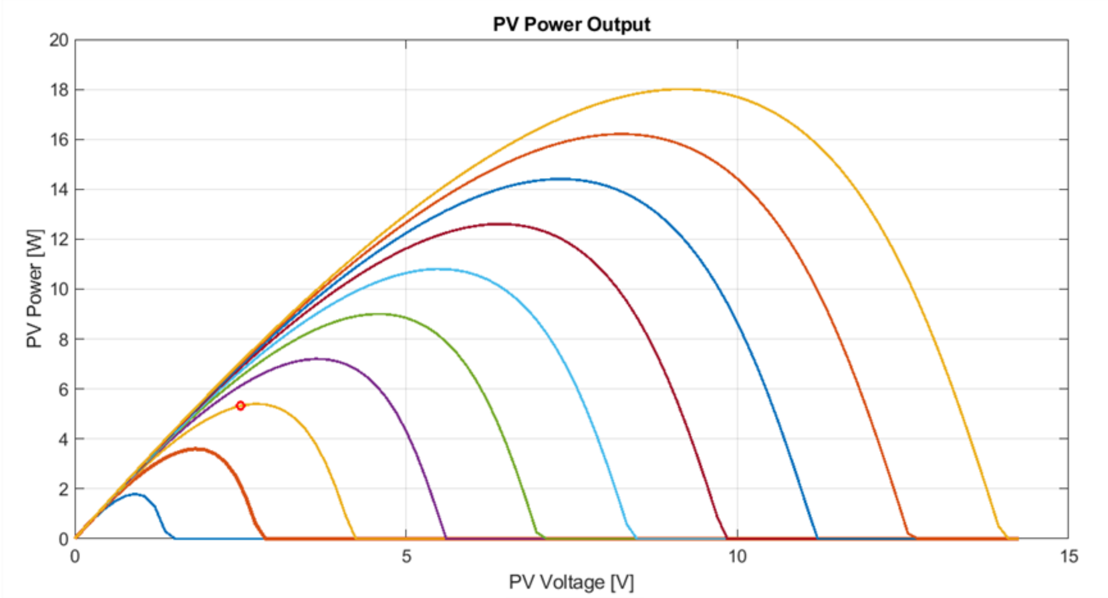
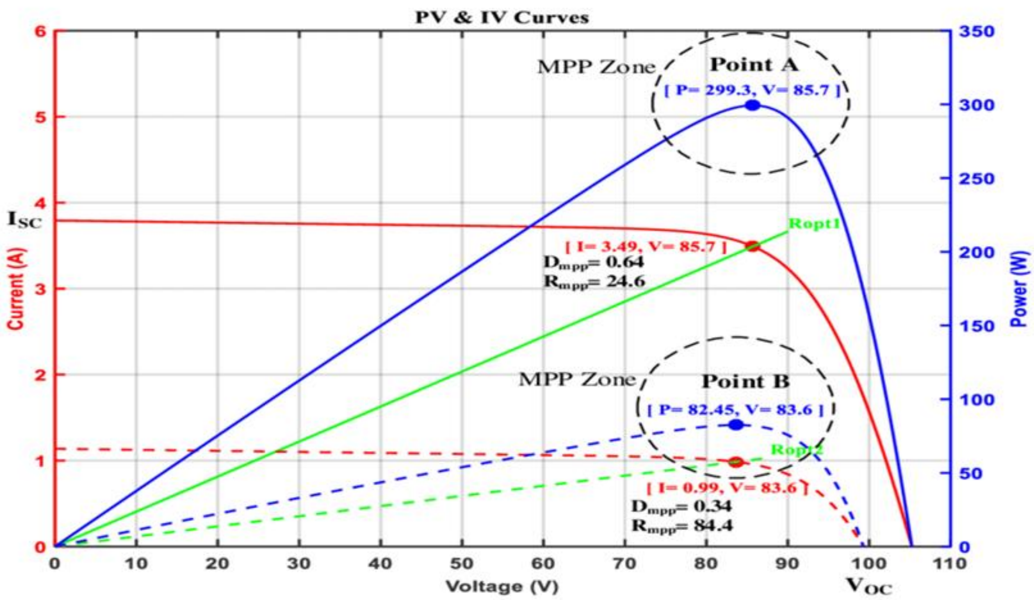


Figure 4.4 (a) shows the power types of photovoltaic modules under the influence
Of the irradiance.

The MPP with SMC can often be seen casually following changes in solar radiation, with the IC method moving but the SMC process not moving. Similarly, when compared to the IC method, the SMC requires a system-consistent state within milliseconds. Figure 4.5 (b, c) shows the duty cycle behavior of the step-up converter under the influence of solar radiation, which is selected as the regulator law. It can be clearly seen that the SMC algorithm for the increase and decrease of the solar radiation level compensates for and determines the change in the duty cycle to follow the MPP without movement, which contradicts the usual IC method. It can be concluded from entertainment activities that the load pattern of the boost converter α adapts appropriately to its ideal value with fluctuating solar radiation, whereby the PV module voltage is controlled in such a way that it follows its ideal value...



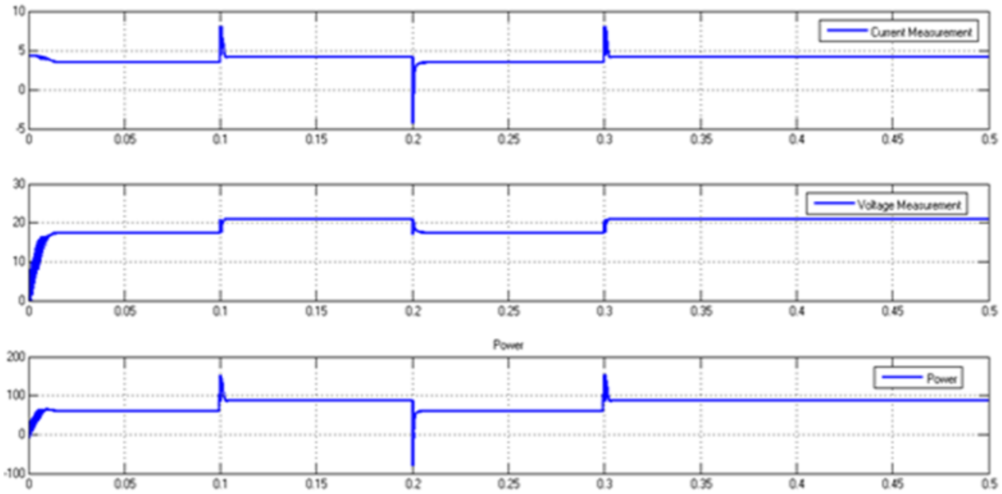


Figure 4.5 b, c: Output current, voltage, power of PV panel v/s time MPPT using SMC.

5. CONCLUSION

From the previous figures, the constant voltage (CV) MPPT algorithm can be fixed to the maximum power point (MPP) within 16 Ms. There is no uncertainty that the power obtained is around 85 Watt, which is close to the theoretical MPP for this solar radiation and temperature. To be accurate, the estimated value of MPP for solar radiation of 1000 Watt per m² and a temperature of 25 ° C is 86.6 Watt. It is still possible that the PV system cannot compensate for the MPP. Even though everything is still there, there is still some power sticking out. Table 4.1 shows some correlations of the number of sensors that are important for the working MPPT algorithm. The constant voltage method (CV method) is cheaper in the introduced MPPT strategy because it specifically requires a voltage sensor. Indeed, voltage sensors are indeed cheaper than current tests. Due to the variable self-esteem, PI and SMC are the fastest MPPT. Since various MPPT algorithms were tried with a coefficient K of around 0.01, the improvement in the variable disturbance estimate of PI and SMC can be clearly seen.

The results in Table 5.1 show some of the shortcomings of MPPT. In any case, only P&O has enough capability to maintain MPP, regardless of whether the two PV modules have been associated with different insulation, which triggers MPP and global MPP. Various tried and tested MPPT algorithms ignore the method of determining the global MPP, but all methods can choose to achieve a local one.

Table 5.1: Drawbacks of the different MPPT techniques

MPPT Technique	Drawbacks
Constant Voltage (CV)	- Supplied Power non-constant in charge mode - MPP Lost when a temperature change
Temperature Method	- Supplied Power non-constant in charge mode.
Incremental Conductance (IC)	- For sudden temperature variation, then IC takes down and then it back up =>long response time =>more loses.
Perturb and Observe Fixed (P&Oa)	- Same as IC issue under temperature change. - If two panels are connected in series with different solar irradiance, then P&Oa takes down.
Perturb and Observe Variable (P&Ob)	- Supplied Power non constant in rated mode. - If two panels are connected in series with different solar irradiance, then P&Ob takes down.
Three-Point Weighted (P&Oc)	- Same as IC issue under temperature change. - If two panels are connected in series with different solar irradiance, then MPP is obtained.
Short-Current Pulse (SC)	- Difficult choice between a frequent estimation of the short-circuit current and loses induced by solar irradiance and temperature fluctuations.
PWM Method	- If two panels are connected in series with different solar irradiance, then P&Ob takes down.

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