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An Improved Strategy for High-Efficiency Multistage PV Module Using MPPT Technique

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Abstract: Renewable energy supplies are renewable energy sources that are of great benefit to the world today. Among the most commonly used renewable energy resources, solar energy is used to produce electricity, clean water supplies, respectively in every area of our lives. Photovoltaic cell transforms solar energy into electricity type, which includes solar cells. Some MPPT systems have been suggested to obtain optimum efficiency out of this system under different weather conditions. For an efficient operation and power extracted from a PV module, an MPPT is necessary. To improve the accuracy of the Solar Panel, a variety of approaches are used, the most common of which is MPPT or P&O. The basic goal of full power point tracking is to interpret the voltage and current from the solar panel, measure the power, and then display the power to its limit. Multi-stage DC-DC converter manages MPPT, and PWM controls grid current from Inverter. The inverter circuit provides all the activities in a single phase that involve MPPT and grid current power. In this proposed work, the DC / AC converter will be intended to ensure the system's safe interconnection and procedure and to retain the utility grid's power quality, so both MPPT techniques will be analyzed, established and contrasted via a converter to convert the highest energy from PV to the grid.
Keywords: Maximum power point tracking (MPPT); power quality; inverter; multistage converter; perturb and observe (P&O); incremental conductance method (ICM); photovoltaic (PV); pulse width modulation (PWM);

I. INTRODUCTION

The electric power grid is historically not built to support the production and consumption of renewable energy at the distribution level. The electric utility companies use various types of electrical production systems focusing on various equipment designs and choices. There are significant challenges and barriers to an equitable solution to grid-based utilize of RES[1]. One of the main crucial elements for the long-term economic viability of distributed RES is the optimization of average electrical device efficiency. Accuracy, as well as efficiency, are two major aspects of any power supply device. Power reliability means the existence of a 24 x 7 base power supply which signifies the adequacy of the electrical system from generation to distribution at all levels. Power quality, on the other hand, is related to both the degree of variation or distortion in the waveform of pure supply and the supply's continuity[1]. Any major variation in line voltages magnitude, frequency, waveform or symmetry is a possible issue with power quality. In the current surplus-power scenario, load features and electrical system specifications have significantly changed. The instruments and equipment currently used in manufacturing, commercial and household structures are more susceptible to fluctuations in demand than those used in the past. It is due to the higher need for power electronics and microprocessor-based innovations in equipment and appliances.

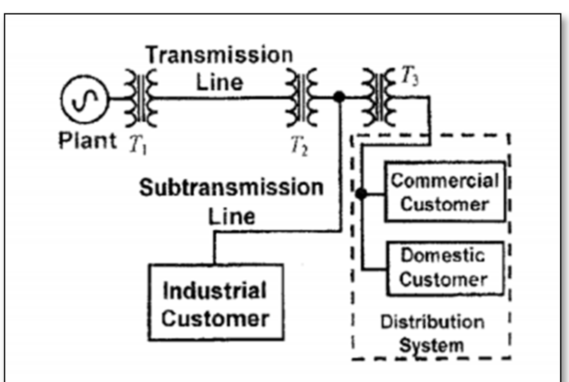

Fig. 1. Shows the Typical power system

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The performance of PV systems is affected by the shape of its I-V (current-voltage) curve as well as the P-V (power voltage) curve. Solar cells have properties of the nonlinear (inverse exponential) I-V and P-V characteristics. For varying temperature and irradiance this composition varies separately [2]. The point which provides the maximum energy output accessible for a described array is recognized as MPP. This value occurs under STC to produce optimum panel output at 25 ° C temperature and 1000 W / m2 irradiance. Using continuous MPP, the MPPT method is utilized to achieve the highest conversion efficiency for the PV panel [2].
The equivalent model can be used as a guide for working as a simulator of solar cells. Simulations of PV panels is defined for Solarex MS-60W panels which use 36 solar cells to generate 60W power output. But this energy is distributed basically in areas having plenty of sunshine, and at STC (Standard Testing Condition) too [2]. More efficient systems require to be installed for remote areas that track panel for STC and produce power grid production.
To optimize power productivity and increase device efficiency for distributed environment conditions, a continuously fixed point (desired output) needs to be obtained. This point is achieved when the PV panel operates at its optimum point of operation i.e., Max Power Point. Unfortunately, due to changes in environmental circumstances as well as load parameters, it's hard to maintain constant MPP [3]. Thus, it becomes important to pressure the device to monitor at its optimum power point in all circumstances to ensure desired output from the system. The reason for such an issue is an MPPT device [3].
MPPT includes a solar panel, a dc-dc transformer, an MPPT controller as well as a corresponding output load. In this paper, the proposed MPPT discusses acquiring the highest power outcome with improved energy quality [3].

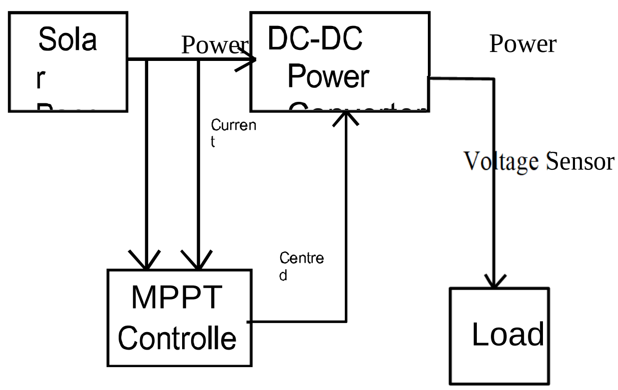
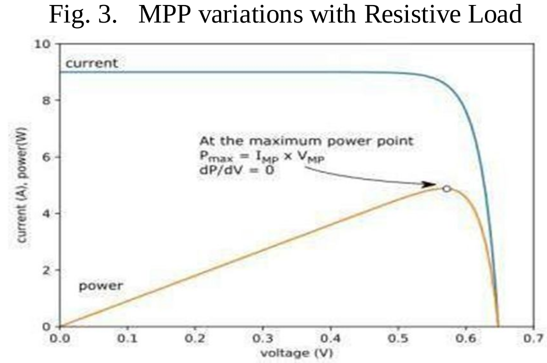


Fig. 2. Block figure of MPPT

The device is selected to match voltage regulation, frequency regulation, energy control, as well as harmonics regulate with fast RT, decreased error, as well as enhanced gain, even under modifying circumstances. The energy generated at the PV output is also calculated by the properties of the devices utilize to generate the voltage as well as the current required [4].
In the MPPT device, the solar panel functions as a simulator that collects sunlight as well as gives power output. The perceived changes in the production of the panel with varying environmental circumstances based on a variety of factors. This comprised a panel size, the connection among panel and load (i.e., converter), the expected value or setpoint monitoring system (i.e., controller). The power consumption of the panel is caused by changes in temperature and irradiance variables that move freely during the day [6].

Fig. 3. MPP variations with Resistive Load



II. LITERATURE REVIEW

A. Maximum Power Point Tracking (MPPT)

Solar cells have very low efficiency. Workouts should be carried out to match the source and load appropriately, with the explicit purpose of increasing efficiency. Maximum Power Point Tracking is one of these methods (MPPT). This method is used to get a steady output from a variable source. The I-V curve of a solar system is non-linear, making it difficult to use for powering a specific heap. This is accomplished by using a converter with a different duty cycle thanks to an MPPT algorithm [5].

B. Methods of MPPT

To achieve maximum power point tracking, here are two ways below:

1) *Perturb and observe method (POM):* The process begins by setting an initial value for the estimated maximum power Pm (usually zero). The real PV voltage and current are then measured at regular intervals, and the momentary PV power, then P and Pm is calculated and compared. P is assigned as the new value of Pm if it is higher than Pm. The P is calculated in real-time, and the comparison is conducted constantly [3]. As a result, the final value of Pm will be the maximum power that can be given to the load. The input impedance should be the same as the load impedance for optimal power transfer across the load. In actual systems, the duty cycle of the converter is modified based on the load matching mechanism, so that the output power is nearly equal to the input [3].
2) *Incremental Conductance method (ICM):* In this strategy the PV exhibit's incremental conductance dI/dV to figure the indication of dP/dV. At the point when dI/dV is equivalent and inverse to the estimation of dP/dV (where dP/dV =0) the calculation demonstrates that the maximum power point is come to and it is ended and gives back the comparing benefit of working voltage for MPP[7]. This strategy tracks quickly changing illumination conditions more precisely than P&O.

C. Boost Converter

Since the PV panel's output is so low, its voltage must be boosted in order to supply to the grid. The solar panel produces very low DC voltage as its output. Therefore, a boost chopper is required to increase the voltage level. An inductor, a diode, and a high repetition switch are the main components of a boost converter. These provide energy to the stack in a controlled manner at a voltage higher than the required voltage range. To keep the output voltage steady, one capacitor is connected to the sending end. [1].

1) *Operation Modes:* There are two modes of operation here, charging mode and discharging mode. When the switch is closed energy- elements got charged from the source, so it is called charging mode. At the instant when the switch is opened, energy-elements got discharged which is known as discharging mode. [1].
2) *Charging Mode:* The switch is closed in charging mode, which means current flows through the inductor, which stores energy as a magnetic field. The diode helps the capacitor enhance the voltage level at the output by limiting the flow of current in the opposite direction. [7].
3) *Discharging Mode:* Because the impedance is higher when the switch is opened, the current will be reduced. To keep the current flowing toward the load, the magnetic field that was previously formed will be destroyed. As a result, the polarity will be flipped (means the left side of the inductor will be negative now). As a result, two sources will be connected in series, resulting in a greater voltage being applied to the capacitor via the diode. [6].

D. PV Inverter

Different inverter topologies and controllers are typically utilised to interface the PV and the utility grid in a grid-connected PV system. The Vmax from the dc-dc boost converter is then fed into a full-bridge switching converter dc–ac inverter. At the point of common coupling (PCC) with the grid, a filter (L filter) permits only the fundamental and some minor voltage harmonics to appear. Its control system is designed to generate an output current Ice that is: 1) almost sinusoidal, 2) in phase with the grid voltage Vgrid at the PCC, and 3) has an rms value (i.e., the converter transfers the dc power to the ac grid) [2].

$$Pgr = Vgrid(rms) * Ic(rms) \quad (1)$$

$$(rms) = Pc / Vc \quad (2)$$

The converter senses the instantaneous Vgrid and calculates its rms value. Equation two is used to calculate the rms value of the reference output current (rms) A phase-locked loop (PLL) system passes the instantaneous grid voltage Vgrid across it. The PLL is utilised to offer a unit power factor operation that synchronises the inverter output current with the grid voltage and provides a clean sinusoidal current reference. The sinusoid Vsyn produced by the PLL mechanism has a unity amplitude and is in phase [2].

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The inverter is made up of two arms, each containing two semiconductor switches and antiparallel freewheeling diodes for discharging the reverse current. The reverse load current flows via these diodes in the case of a resistive-inductive load. These diodes allow an alternate way for inductive current to flow even when the switch is turned off. [4].

The approach is used to switch the inverter to sinusoidal PWM. Multiple output pulses are generated per half cycle in this modulation approach, with pulse widths varying. Each pulse's breadth varies in proportion to the amplitude of a sine wave measured at its centre. By comparing a sinusoidal reference with a high-frequency triangle signal, the gating signals are created [4].

III. PROPOSED METHODOLOGY

To achieve maximum power from the solar panel we can follow the following approach. Here a solar panel is connected to an MPPT device which sends the signal to the IGBT (insulated gate bipolar transistor) switch such that it can maintain the voltage level to match the characteristics impedance of the solar panel with the load. After that, an H-bridge inverter is connected to the DC-DC converter and finally, power is transmitted to the grid.

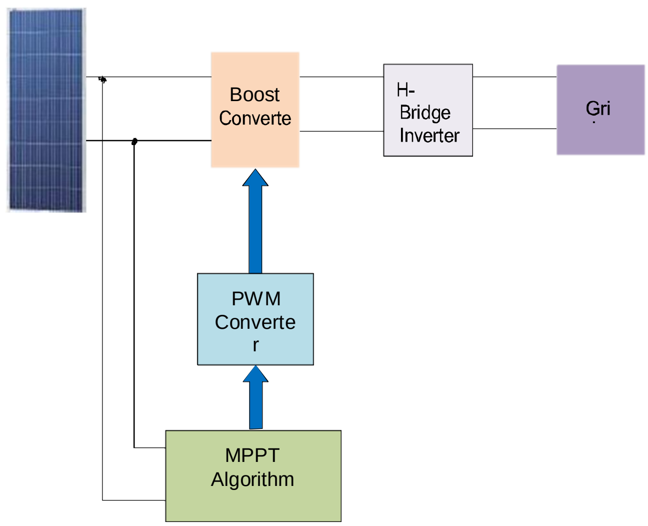

Fig. 4. Shows the proposed approach

$$P + \Delta P = (I + \Delta I).(V + \Delta V)$$

$$P + \Delta P = I.V + \Delta V.I + \Delta I.V + \Delta I.\Delta V \quad (3)$$

Clarify formula through ignoring the continual values of P as well as product I.V together with low points of product ΔI.ΔV Which is almost negligible, an expression for dynamic impedance reduces to the equation.

$$\Delta P = \Delta V.I + \Delta I.V \quad (4)$$

ΔP should be 0 at the peak value. Therefore, at peak value the above equation in the restriction becomes:

$$dV$$
$$-V/I \quad (5)$$

This equation represents that the source dynamic impedance determines the static impedance negative. Using a suitable inverter as well as the controller may boost the oscillating condition or improvement in DI[11].

The characteristics of OP differ with the rise in temperature overload. As a direct panel, as well as a load link, is expensive and impractical, Converters are utilized as an interface to transform the parameter output from solar panels to CV. Converters are power devices that transform one voltage kind to another.

The converters are mostly of two AC and DC kinds. AC converters transform sinusoidal input voltage AC to varying magnitude AC voltage at the output, while DC converters convert DC voltage at the output.

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To implement the MPPT algorithm we can follow the following flow chart [13].

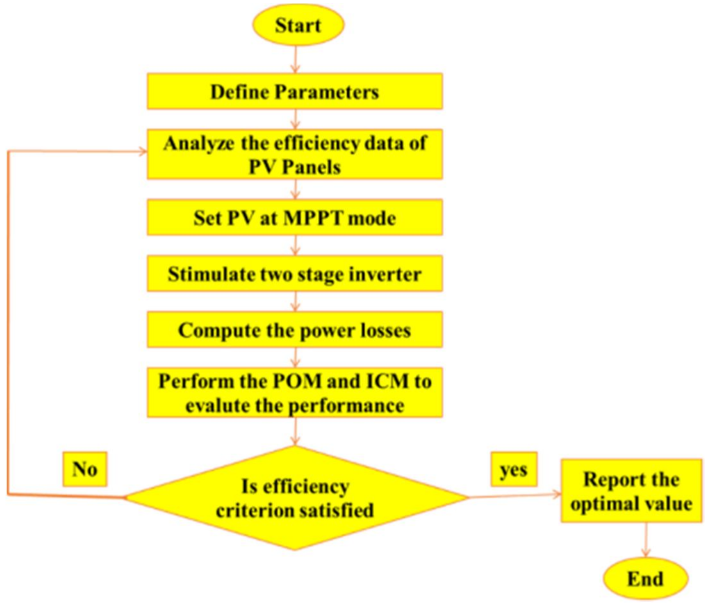

Fig. 5. An approach to performing MPPT algorithm

A. Simulation

To simulate the above algorithm, we have to follow the following steps:

- First, connect a solar panel to constant irradiation of 1000 W/m^2 and temperature of 25^o C.
- Then there is a boost converter to enhance voltage level.
- A signal from the MPPT device will be sent to the switch of the boost converter such that it will adjust the voltage level.
- An H-bridge inverter is connected to the output of the converter to convert DC to AC.
- This AC power is transmitted to the grid via a transmission line.

B. Simulink design of Grid linked PV device

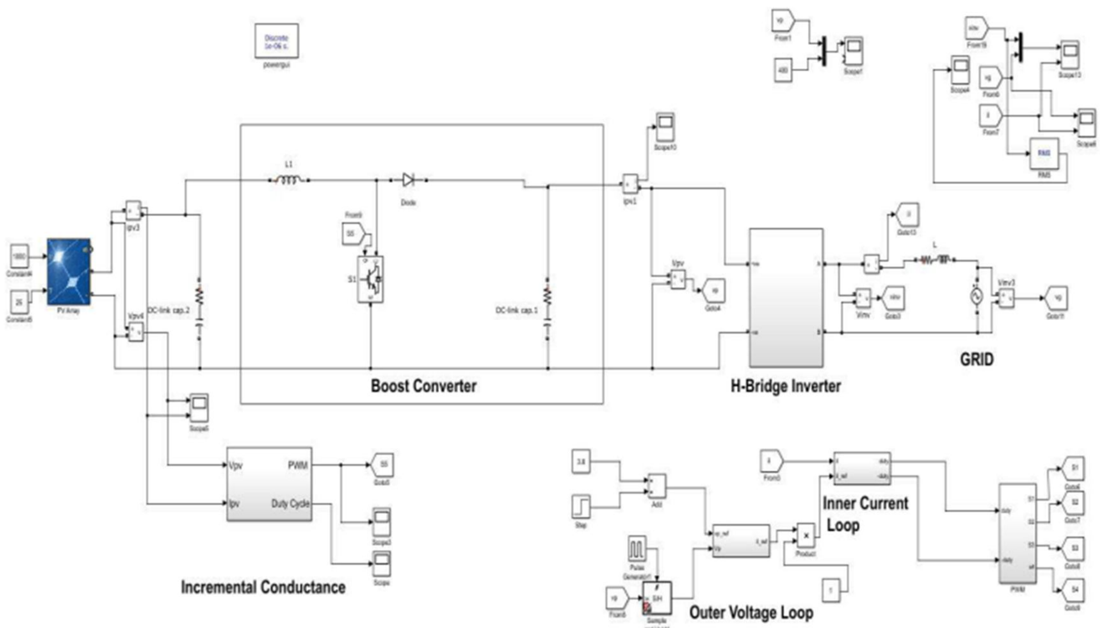

Fig. 6. Grid-connected PV system Simulink model utilising Incremental Conductance

IV.RESULTS AND DISCUSSION

From the above simulation we can conclude the following:

A. When the load changes, there will be a small dip in the voltage but then it will again rise in the next cycle.
B. The response time of the P&O method is high compare to the incremental conductance method.
C. Also, the efficiency of ICM is better than POM.

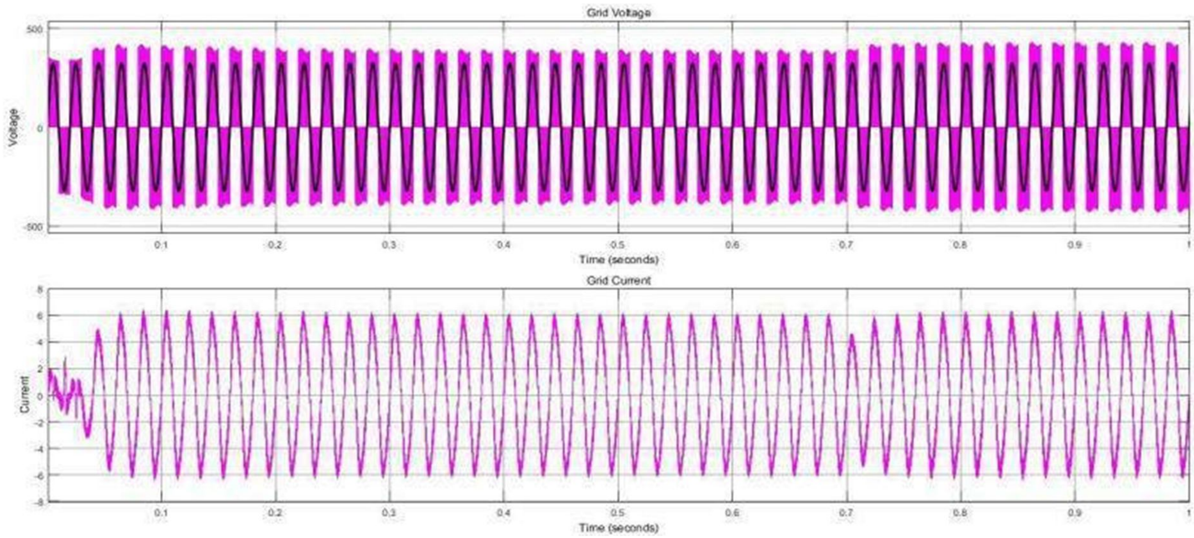

Fig. 7. Grid voltage and current for Perturb and Observe Algorithm

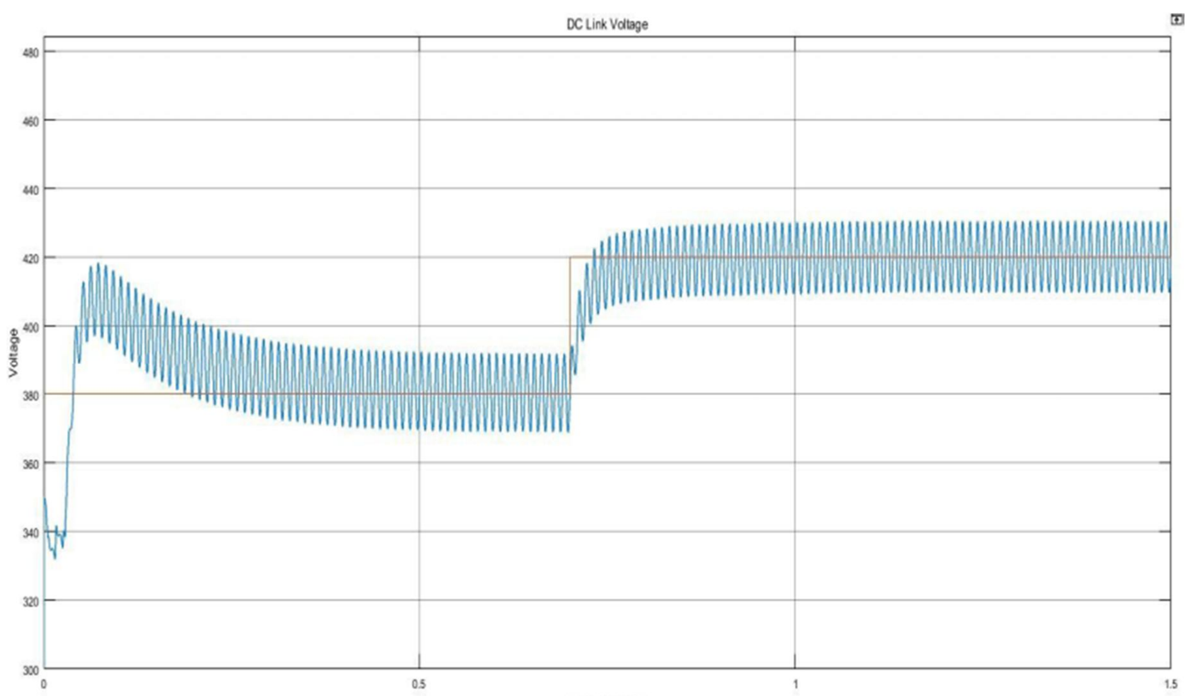

Fig. 8. Dc link voltage for Perturb and Observe

From the above diagram, it is clear that in perturb and observe method there is a small transient in starting which decreases rapidly over time.

V. CONCLUSION

We looked at how to use the maximum power point tracking method to send power from a solar panel to the grid. To get the best performance out of the solar cell, high power point monitoring techniques are used. Precise power point monitoring can come from a variety of sources, including perturbation and observation, incremental conductance, parasite capacitance, constant voltage and constant current, and so on. For a single-phase grid-connected PV system, the perturb and observe and incremental conductance techniques are investigated.

For bringing the DC link voltage to the reference voltage, perturb and observe takes longer than incremental conductance. For making grid current in phase with grid voltage, P&O takes 0.04s and incremental conductance takes 0.02s.

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