

Perturb & Observe MPPT Technique used for PV System Under different Environmental Conditions

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ABSTRACT - Solar photovoltaic (PV) cells are used for the conversion of solar energy into electrical energy by using power electronics converter. These solar PV cells exhibit nonlinear characteristics and very small efficiency. The characteristic of photovoltaic cells become more difficult under changed environmental condition such as partial shading.

Due to these problems, it becomes necessary to researchers to extract maximum power from solar PV cells under inconsistent atmospheric conditions. Maximum power point tracking (MPPT) scheme is used to extract maximum power from solar PV cells. Various types of MPPT schemes are proposed, namely open circuit, short circuit, perturb and observe (P&O)/hill climbing, incremental conductance, and so forth.

Key Words: Solar cell, MPPT, P&O, Photovoltaic

1. INTRODUCTION

Global energy demand is growing exponentially. This rise in demand causes concern pertaining to the global energy crisis and associated environmental threats. The solution of these issues is seen in non-conventional energy sources. Solar energy is considered one of the main sources of renewable energy, available in plenty and also free of cost. Solar photovoltaic (PV) cells are used to convert solar energy into unregulated electrical energy. These solar PV cells exhibit nonlinear characteristics and give very low efficiency. Therefore, it becomes essential to extract maximum power from solar PV cells using maximum power point tracking (MPPT). Perturb and observe (P&O) is one of such MPPT schemes. The behavior of MPPT schemes under continually changing atmospheric conditions is critical. It leads to two conditions, i.e., rapid change in solar irradiation and partial shading due to clouds, etc. Also, the behavior of MPPT schemes under changed load condition becomes significant to analyze. This article aims to address the issue of the conventional P&O MPPT scheme under increase solar irradiation condition and its behavior under changed load condition. The modified MPPT scheme is implemented in the control circuit of a DC-DC converter. The simulation study is done using PSIM simulation software. A prototype unit is tested with artificial light setup on a solar PV panel to simulate the changed solar irradiation condition. The results of the modified MPPT scheme are compared with existing schemes. The modified MPPT scheme works fast and gives improved results under change of solar irradiation. Furthermore, the steady state oscillations are also reduced.

1.1 MAXIMUM POWER POINT TRACKING FOR PV CELL

The power delivered by a PV system of one or more photovoltaic cells is dependent on the irradiance, temperature, and the current drawn from the cells. Maximum Power Point Tracking (MPPT) is used to obtain the maximum power from these systems. Such applications as putting power on the grid, charging batteries, or powering an electric motor benefit from MPPT. In these applications, the load can demand more power than the PV system can deliver. In this case, a power conversion system is used to maximize the power from the PV system. There are many different approaches to maximizing the power from a PV system, these ranges from using simple voltage relationships to more complex multiple sample based analysis. Depending on the end application and the dynamics of the irradiance, the power conversion engineer needs to evaluate the various options.

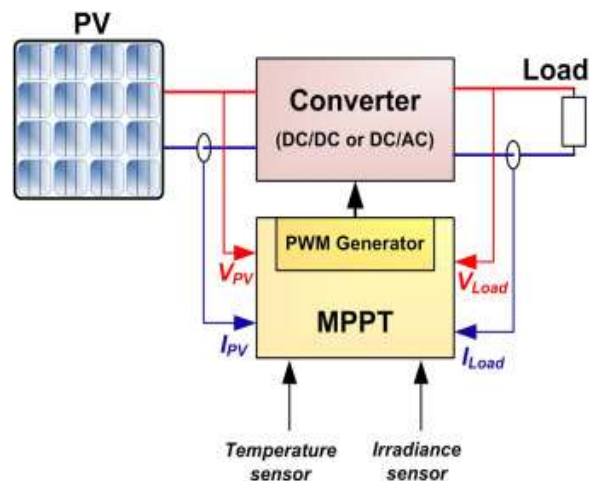


Fig 1. Block diagram of Typical MPPT system

2. RESEARCH METHODOLOGY

2.1. Comparison of different MPPT techniques from literature survey:

Reference	MPPT technique	Control variable	Converter type	Observations
Proposed	Confined search spaced P&O	Duty cycle	Boost converter	This paper presents a modified P&O algorithm integrated with dual axis solar tracker that confines the search space of the algorithm within the maximum power point containing area. Confinement of the algorithm's search space lessened the response time to the changing weather conditions that in return decreases the Steady-state oscillations at the MPP.
(Killi and Samanta, 2015)	Drift-free P&O algorithm	Duty ratio, dynamic perturbation	SEPIC converter	The authors state that in high solar insolation, conventional P&O algorithm suffers from drift because of the wrong decision taken by the algorithm. The paper Presents a modified P&O algorithm that avoids the drift in suddenly changing irradiance and accurately tracks the MPP.
(Tang et al., 2017)	Model predictive control	MPC duty cycle	Boost converter	The paper proposes an MPC based MPPT algorithm for the large-scale marine PV system. The system maximizes the solar energy utilization by overcoming the dynamic partial shadings.
(Chaieb and Sakly, 2018)	Simplified Accelerated Particle Swarm Optimization	Duty cycle	Buck converter	The paper presents a modified version of the particle swarm optimization. The results reveal that the proposed algorithm is able to track the global maximum, especially under the partial shading conditions.
(Al-Dhaifallah et al., 2018)	Fractional order control based incremental conductance	Duty cycle	Boost converter	The paper presents a fractional order control based incremental conductance MPPT algorithm. The results show high tracking accuracy for remarkable climate changes. The integration of the fractional order control with the conventional INC algorithm increases the

				tracking speed by 41. 67%.
(El Khazane and Tissir, 2018)	Finite Time Sliding Mode Control (FTSMC)	Duty cycle	DC-DC converter	The proposed FTSMC MPPT technique ensures the fast error tracking capability for the PV pumping system.
(Alik and Jusoh, 2018)	Variable step size P&O	Duty cycle	Boost converter	The paper presents a modified P&O algorithm that increases the efficiency of the system by 16% in partial shading conditions.

The desired power output is obtained by joining several PV cells together. The block diagram of the proposed model is given in Fig 1. A photovoltaic generator is supplying a DC load, (e.g. a battery) through an adaptation stage constituted by a boost converter driven by an MPPT charge controller assuming the maximum efficiency for the energy transfer.

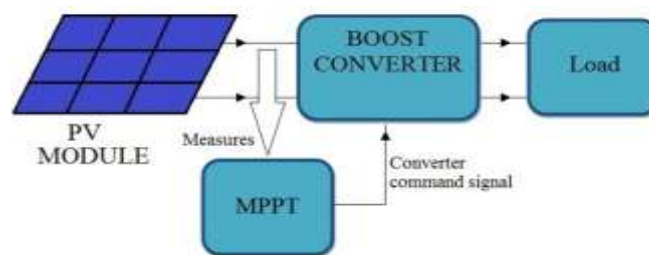


Fig.2. Block diagram of the MPPT system

Various MPPT control algorithms proposed for tracking of maximum power. In this paper there are three MPPT algorithms are proposed for comparison view, and these are:

- a) Modified perturb and observe (MP&O)
- b) Artificial Neural Network (ANN)
- c) Fuzzy logic controller

The PV output power is supplied to the load through the DC-DC converter. The MPPT technique generates the desired pulses for the switching of DC-DC converter. With the aid of these switching pulses for the duty cycle of DC-DC converter, the solar PV module is forced to work in a maximum power mode. Figure describes control techniques with DC-DC converter.

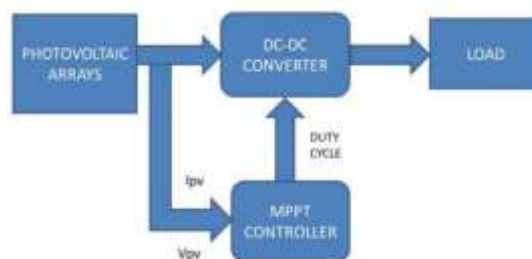


Fig.3. Block diagram of PV system

MPPT placement:

Traditional solar inverters perform MPPT for the entire PV array (module association) as a whole. In such systems the same current, dictated by the inverter, flows through all modules in the string (series). Because different modules have different I-V curves and different MPPs (due to manufacturing tolerance, partial shading, etc.) this architecture means some modules will be performing below their MPP, resulting in lower efficiency.

Some companies (see power optimizer) are now placing maximum power point tracker into individual modules, allowing each to operate at peak efficiency despite uneven shading, soiling or electrical mismatch.

Data suggests having one inverter with one MPPT for a project that has east and west-facing modules presents no disadvantages when compared to having two inverters or one inverter with more than one MPPT.

Perturb and observe:

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 above that point. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

Modified Perturb and Observe method:

This method is an improved method of perturb and observe (P&O) method. P&O is unable to track the power during load changes and rapid variation of environmental condition. MP&O method can meet the desired shape which is ineffective in case of P&O method. Although response time is improved, but power oscillation still pertains in case of MP&O algorithm.

That presents the idea to focus on ANN and fuzzy logic controller.

Advantages:

1. Simplicity: This algorithm solves one linear equation. Therefore, it does not consume much computational power.
2. It can be implemented as analog or digital circuits.
3. Since temperature varies slowly with time, there are no steady-state oscillation and instability.
4. Low cost: temperature sensors are usually very cheap.
5. Robust against noise.

Disadvantages:

1. Estimation error might not be negligible for low irradiance levels (e.g. below 200 W/m²).

MODEL FORMULATION OF MPPT SYSTEM IN SIMULINK ENVIRONMENT:

Fig. 3 shows a complete model of the Solar Photovoltaic system incorporating a boost converter that boosts the voltage from the Maximum Power Point Tracking algorithm (MPPT). The simulation of this model has been done by taking different values of Irradiance and Temperature.

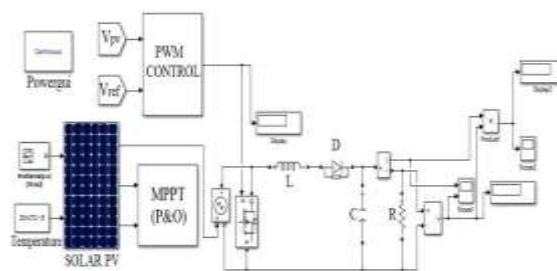


Fig.3. Simulink model of the proposed PV system

P&O MPPT algorithm:

This method structures a simple regulation in closed loop incorporating only a few controlled parameters. The P&O algorithm compares the previously delivered power with the one after disturbance by periodically varying the voltage of the panel with a minuscule incremental step to reduce the oscillation around the MPP or the desired step. This algorithm has a wide application in commercial systems due to its simplicity and involvement of few measured parameters. The principle of this method is described by flowchart is given in Fig 4.

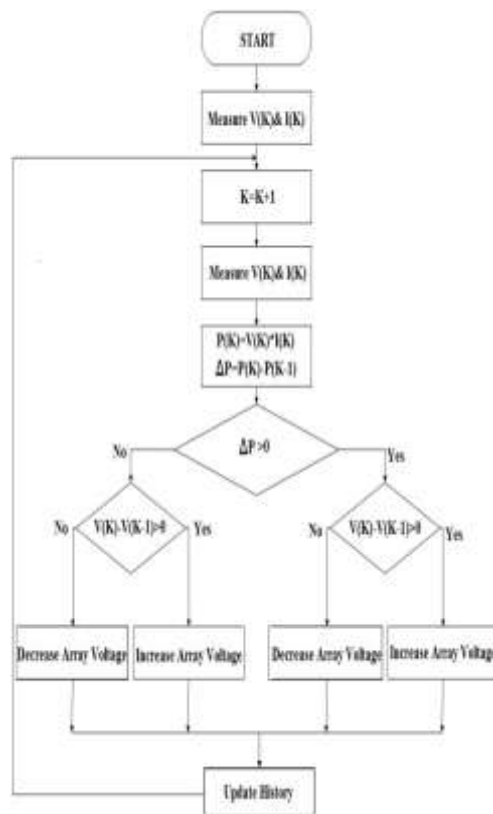


Fig.4. P&O flowchart

Modeling of P&O:

The detailed Matlab/Simulink model is shown in Fig. 5. The photovoltaic voltage (V_{pv}) and current (I_{pv}) are taken as the perturbation inputs from solar photovoltaic array module to MPPT unit. The duty cycle D is obtained as output.

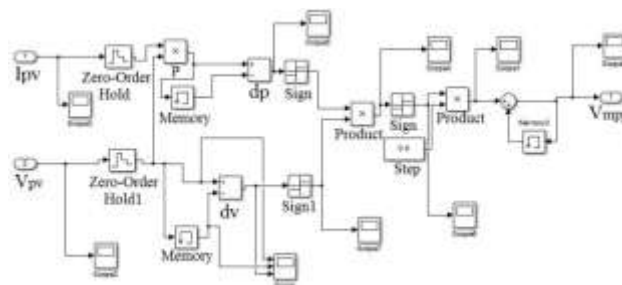


Fig.5. Modeling of MPPT technique

3. RESULTS AND DISCUSSIONS:

The variations of voltage and power with time are shown in the various graphs. The temperature and irradiance are varied and the characteristics curves of voltage and power are plotted with respect to time. From the graphs, it can be seen that as the irradiance is increased, the voltage increases and so there is a change in the output waveform. Thus, a direct effect on the output voltage with respect to the irradiance and temperature can be observed. The temperature when increased the PVG gives a higher output power.

It is observed from the graph that the variations are non-linear and are rather exponential.

The outputs as obtained are shown in Fig.6.

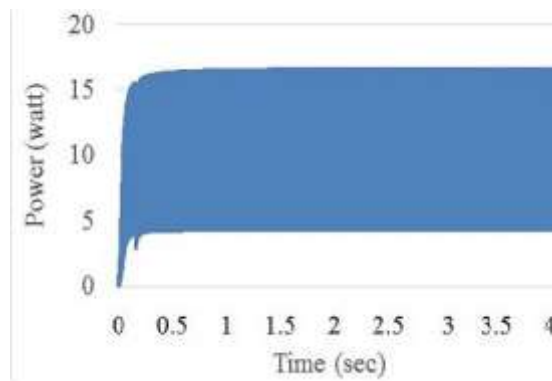


Fig.6. Output Power at $T=25^{\circ}\text{C}$ & $I_{rr}=500 \text{ watt/m}^2$

Fig.6 shows the plot of output power with respect to time at temperature 25°C and irradiance 500 watt/m^2 . Whereas Fig.6 shows the output power for the same system for the same temperature but at a higher irradiance 1000 watt/m^2 .

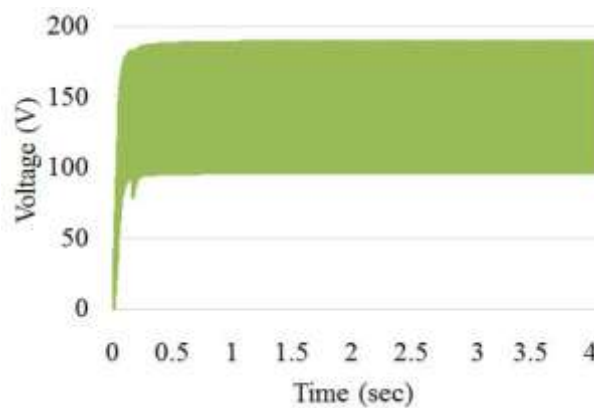


Fig.7. Output voltage at $T=25^{\circ}\text{C}$ & $I_{rr}=500 \text{ watt/m}^2$

The graph shown in Fig.7 depicts the variation of the output voltage with respect to time when temperature is taken to be 25°C and irradiance of 500 watt/m^2 .

4. CONCLUSIONS:

This research primarily serves to establish a proposed simulation model for the solar photovoltaic system performed along with P&O technique for Maximum Peak Power Tracking. The motive of the paper i.e. to develop an efficient and optimized system has been achieved. The maximum power point tracker has to match its load to that of the maximum available power from a PV generator (PVG) with the highest electrical efficiency. This was obtained by integrating P&O algorithms into the MPPT controller. The duty of the boost converter is controlled by the aforesaid algorithm.

The common method is implemented under Matlab/Simulink environment. There are many countries in the world located in the tropical and temperate belt, where the intensity of sunlight may reach up to 1000 W/m^2 . Effect of environmental parameters viz. temperature and irradiance variations could also be observed from simulated characteristics. The boost converter is used to step up the PV array output with the Perturb and Observe technique for controlling the duty ratio of boost converter switch.

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