Structure Improvement of P&O MPPT Algorithm of PV System based on Least Mean Square Algorithm

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ABSTRACT

A photovoltaic system, also Solar PV power system is a power system designed to supply usable solar power by means of Photovoltaics as a renewable energy sources. Nowadays, PV system has gained high popularity and widely used. Many renewable sources are available, among these; solar energy seems to be the most promising for widespread utilization. Here, to overcome the difficulties of fast changing environment and suddenly changing power of PV array, least mean Square (LMS) methods is proposed together with P & O MPPT algorithms. This proposed MPPT can track the MPP not only accurately but also its dynamic response is very fast in response to the change of environmental parameters in comparison with the conventional P & O MPPT algorithms. This MPPT is simpler, just using the stepping duty size in reference to the error calculated by the LMS methods.

KEYWORDS

Photovoltaic power, MPPT, LMS, duty cycle, PV control

1 INTRODUCTION

The excessive use of fossil fuels brings about two serious problems: the exhaustion of conventional fossil fuels and grave environmental degradation. Both problems threaten the sustainability of future development. In order to sustain rapid social and economic growth, governments worldwide are promoting renewable energy exploitation to cut down on the emission of greenhouse gases, which causes global warming. According to the United Nations Framework Convention on Climate Change (UNFCC), twelve countries have submitted their pledges to reduce the rate of greenhouse gas emission by 2020. The world's biggest greenhouse gas emitter, the US, claims that its greenhouse gas emissions will fall 17% by 2020, while China, the second-biggest emitter, assures that it will reduce carbon dioxide emissions per unit of GDP in 2020 by 40% to 45% compared to 2005. In the past few decades, developed nations worldwide have widely adopted large-scale photovoltaic systems for power generation.

Solar energy obtained from a solar PV cell is fluctuating in nature affected by external environment conditions like solar irradiance and cell temperature. The amount of power extracted from PV system is a function of the PV module voltage and current. The operating point of the PV generator is located at the intersection of its current (I) and voltage (V) curve with the load line. The PV generator, with I-V and power (P)-V characteristics, specifies a unique operating point at where the possible maximum power point (MPP) is delivered. At the MPP, the PV generator operates at maximum power efficiency. The I-V characteristics of the PV system are nonlinear and will change with external environment like irradiance and temperature of a PV cell, so the power output is also changing. MPPT algorithms regulate output power of PV array automatically by to obtain the maximum power output under given temperature and Irradiance. [1]

Presently, numerous techniques have been proposed so far for realize the MPP. These MPPT methods are different in complexity, sensors requirement, convergence speed, cost implementation, effectiveness and popularity. Among them Perturb and Observe (P &O) method, constant voltage method and the incremental conductance are most common and widely used. The constant voltage is the simplest of them and the P &O MPPT algorithms is mostly used, due to its ease of implementation. A drawback of P&O MPPT technique is that. At steady state, the operating point oscillates around the MPP giving rise to the waste of some amount of available energy and the system accuracy is low. These conventional MPPT methods face a difficulty to track the MPP in fast changing environment.

To overcome the difficulties of common used MPPT methods of P & O algorithms we previously proposed, perturb and observe (P&O) algorithm with adding the duty ratio perturbation was used to obtain the MPP. It means that the duty ratio was used directly as the control parameters for MPPT controller in P&O algorithm. In our algorithm, the operating point was initialized to 50% duty ratio. If the power increases, the algorithms continue to perturb the system in the same direction otherwise in the opposite direction with a chosen duty step size. Applying duty cycle in conventional P&O MPPT algorithm, we can obtain the performance improvements in terms of MPP tracking accuracy and deviation reduction. [2]

Here, to overcome the difficulties of fast changing environment and suddenly changing power of PV array, least mean Square (LMS) methods is proposed together with P & O MPPT algorithms. This proposed MPPT can track the MPP not only accurately but also its dynamic response is very fast in response to the change of environmental parameters in comparison with the conventional P & O MPPT algorithms. This MPPT is simpler, just using the stepping duty size in reference to the error calculated by the LMS methods.

2 Maximum Power Point Tracker (MPPT)

Solar energy obtained from a solar PV cell is fluctuating in nature affected by external environment conditions like solar irradiance and cell temperature. The amount of power extracted from PV system is a function of the PV module voltage and current. In this regard, many different studies have been conducted in the literature to obtain PV characteristics for the PV model. Since PV power is fluctuating, the peak power point is also fluctuating. Therefore, the tracking for maximum peak power point is very necessary for maximum efficiency of PV power generations. [3]

The operating point of the PV generator is located at the intersection of its current (I) and voltage(V) curve with the load line. The PV generator, with I-V and power (P)-V characteristics, specify a unique operating point at where the possible maximum power point (MPP) is delivered. At the MPP, the PV generator operates at maximum power efficiency. In this regard, many different methods have been conducted and developed in the literature to obtain the maximum power point tracking (MPPT). [4]

A MPPT is an algorithm is often integrated with the DC-AC inverter (or DC-DC converter) to harvest the maximum output power of PV arrays. The most commonly used MPPT algorithm is the Perturb and Observe (P&O) method. P&O method is one of the most commonly used MPPT algorithms for tracking the maximum power due to its simplicity. This algorithm works repeatedly perturbs on the input by a fixed step. Then, PV power output is compared with that of the previous perturbation cycle. If the power increased, the perturbation goes in the same direction in the next perturbation cycle; otherwise, the perturbation direction should be in reserved. The principle diagram of the P&O method and flowchart are shown in figure 1 and 2 respectively.

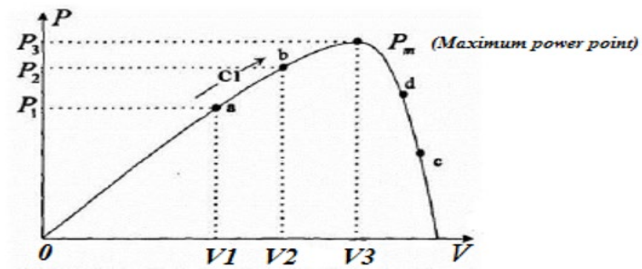

Figure 1: Principle diagram of P&O MPPT algorithm

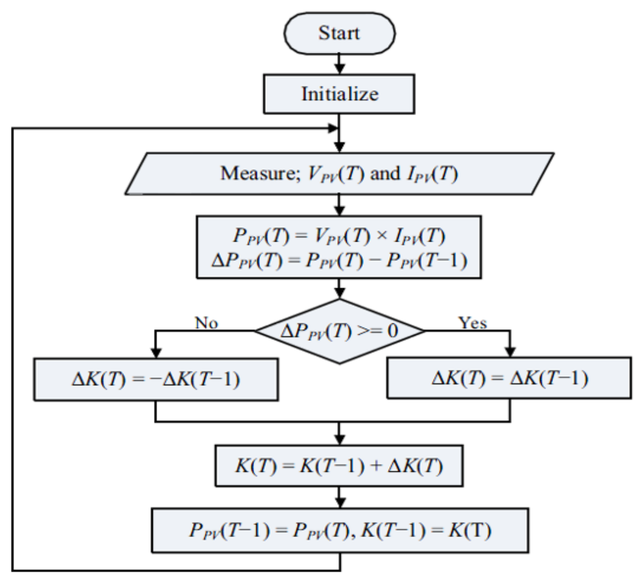

Figure 2: Flowchart of P&O MPPT algorithm

3 Electrical Parameters of PV systems

Photovoltaic cells, modules and arrays produce dc power when exposed to sunlight. Their electrical performance is represented by their current-voltage (I-V) characteristic. An I-V curve represents an infinite number of current and voltage operating point pairs for a PV generating device, at a given solar irradiance and temperature operating condition. See figure 3 PV modules produce voltage and current output that varies with solar irradiance and temperature. Key operating points along the I-V curve are rated by the manufacturer at specified test conditions and affixed on product labels. These rated I-V parameters are the basis for sizing and designing the photovoltaic source and output circuits, and for comparing with field measurements on PV arrays. [5]

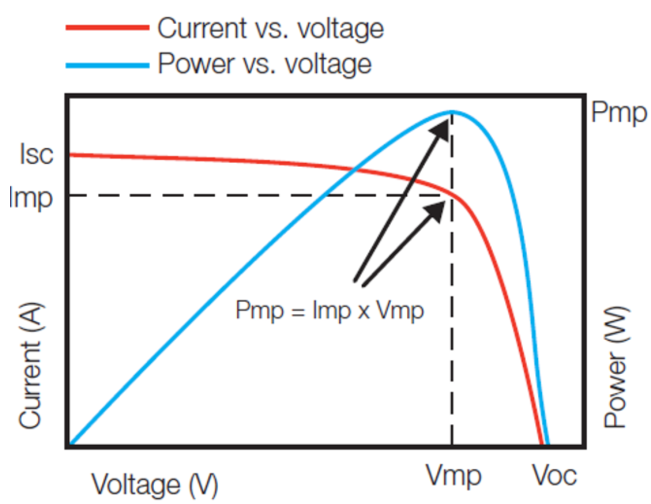

Figure 3: I-V corves for module and array

4 LMS Algorithm

The algorithm using LMS Methods in the conventional P&O algorithm was shown at the following Fig. 2. Here, the proposed method including LMS methods preforms an additional measurement of power differences by calculating the error. As it can be seen on the figure below, the changes in power, difference between the measured and estimated gave the error and based on LMS error, power value is continuously mapped by small amount step sizes to track the certain fluctuation in PV outputs. Here, if the error is high then the duty value i.e. stepping value also increased with big values from the initially defined value. Therefore, in this proposed LMS based MPPT, we stepping the duty cycle size according to the error updated by original LMS algorithms. First, we check the error is either positive of negative, then checking the error range with high difference or low we define the stepping duty cycle size that will help to recover the MPP value in rapidly change environment condition.

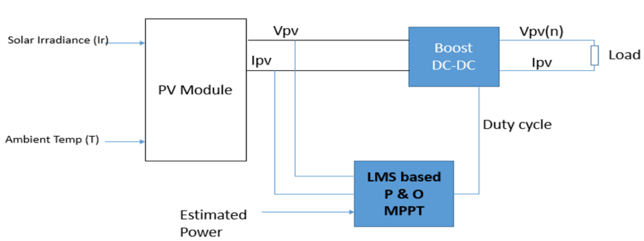

Figure 4: LMS model with DC-DC Converter

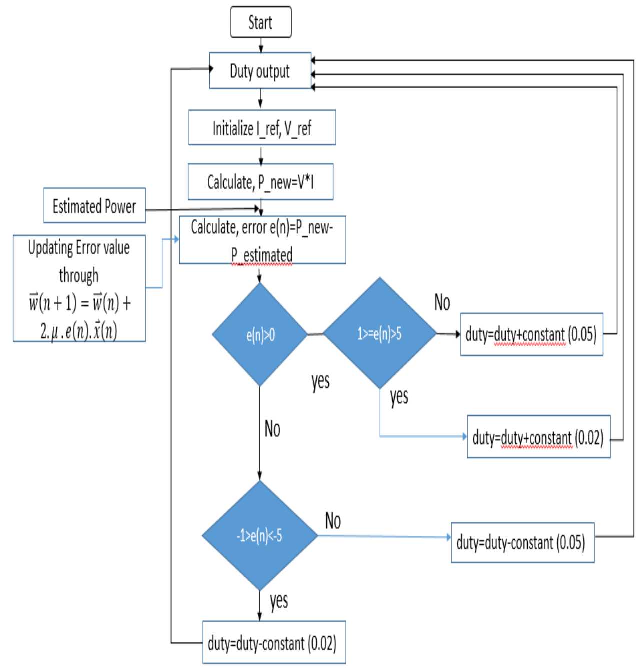

Figure 5: Flowchart of LMS based MPPT algorithm

- The proposed method including LMS methods preforms an additional measurement of power differences by calculating the error.
- Initialize the I-V from the PV array. And calculate the power
- Estimate the error by using the calculate power and estimated power i.e. $e(n) = y(n) - d(n)$ where, y (n) and d (n) are calculated and estimated power respectively.
- Set the training factor μ, we have to choose very carefully so that weighting vector can converged
- Using the LMS algorithms; to update the error by updating the weighting coefficient $\vec{w}(n+1) = \vec{w}(n) + 2.\mu.e(n).\vec{x}(n)$
- Mapped the error value every time and set the duty step size according to the error.
- Initially duty cycle value is 0.5 taking a mean value between 0 and 1. Then, First check the $e(n) > 0$ i.e. measured power is greater than the estimated power, so the perturbation in the positive direction, then mapped the error with limit, if error is small, that shows there is small fluctuation in the power so increased the duty value with small step size, $1 =< e(n) > 5$, Then increased the duty value with 0.002 i.e. $D(n) = D(n) + 0.02$ Otherwise increased with big duty size $D(n) = D(n) + 0.05$, So that it can track the

MPP with less deviation in highly fluctuating environment.

- Vice versa decreased the duty size in same way in negative perturbation. Which is clearly showing in flow chart figure 2.
- In addition, this generated duty cycle control the DC-DC converter constant voltage output to track the MPP effectively.

The PV module of 100wp capacity, monocrystalline power output has been chosen for the modelling and analysis. The figure shows the comparison of PV power output between the newly proposed LMS based MPPT algorithms with P&O algorithm with duty cycle stepping and with voltage value i.e. conventional method. It clearly shows that the differences in power outputs. The black lines (the case using LMS based) in the figure shows generating higher output powers with less deviation. It means that less fluctuating is happened for tracking MPP if we use LMS based stepping duty cycle as the control parameter in P&O algorithm. Thus this experimental result shows that, with implementing the LMS based perturbation technique in the P&O MPPT algorithms, it has better time response and more performance that is accurate.

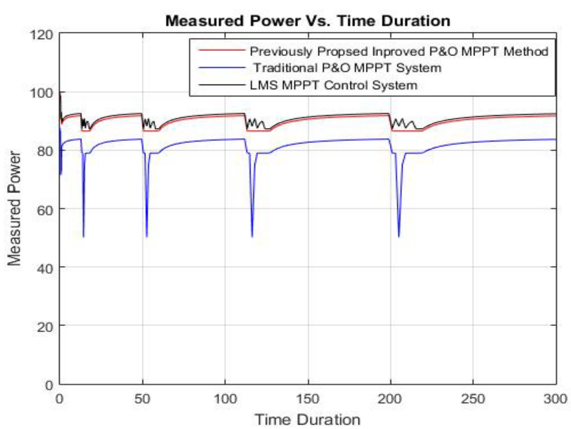

Figure 6: Comparison of LMS and conventional method

5 CONCLUSIONS

This study has focused on the mainly Solar PV data analysis and modelling with application of best model for fault detection in PV system. This thesis provides the details of solar PV data analysis, and solar PV power modelling as a function of solar irradiance by using simple modelling algorithms such as LMS, linear regression and multiple linear regression. Modelling accuracy are evaluated using real solar PV data to find out which model is best.

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