Journal of Advances in Science and Technology

Vol. VI, Issue No. XII, February-2014, ISSN 2230-9659

AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

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Journal of Advances in Science and Technology
Vol. VI, Issue No. XII, February-2014, ISSN 2230-9659

Comparability Research of Highest Power Point Tracker Approaches for Photovoltaic Programs

Lokesh Kumar

Assistant Professor, Sityog Institute of Technology Aurangabad Bihar

Abstract – Photovoltaic (PV) systems have been used for many decades. Today, with the focus on greener sources of power, PV has become an important source of power for a wide range of applications. Improvements in converting light energy into electrical energy as well as the cost reductions have helped create this growth. Even with higher efficiency and lower cost, the goal remains to maximize the power from the PV system under various lighting conditions.

The proposed MPPT has several advantages: simplicity, high convergence speed, and independent on PV array characteristics. The algorithm is tested under various operating conditions. The obtained results have proven that the MPP is tracked even under sudden change of irradiation level.

These techniques vary in many aspects as simplicity, digital or analogical implementation, sensor required, convergence speed, range of effectiveness, implementation hardware, popularity, cost and in other aspects. This paper presents in details comparative study between two most popular algorithms technique which is incremental conductance algorithm and perturb and observe algorithm. Three different converter buck, boost and cuk converter use for comparative in this study. Few comparison such as efficiency, voltage, current and power output for each different combination has been recorded. Multi changes in irradiance, temperature by keeping voltage and current as main sensed parameter been done in the simulation. Matlab Simulink tools have been used for performance evaluation on energy point. Simulation will consider different solar irradiance and temperature variations.

The interest in distributed maximum power point tracking increases along with increasing deployment of photovoltaic generators and the constant pressure to reduce the cost of photovoltaic generated energy. Distributed maximum point tracking facilitates a significant boost of captured photovoltaic power. In this paper, a maximum power point tracker method using sliding mode control for a photovoltaic system is presented. The system includes a photovoltaic array, a DC/DC converter and a DC/AC inverter connected to a load. The designed control regulates the converter output voltage and it maximizes the power generated by the photovoltaic array. To obtain it, the sliding surface used to control the DC/DC converter is adjusted according to PV array output power. The control law designed and the results in a simulation platform will be presented.

This paper presents a reliable maximum power point tracker (MPPT) for photovoltaic (PV) systems. This MPPT tracks the maximum power point of a PV module by calculating the optimum resistance of the PV module at certain solar radiation level, ambient temperature value and load impedance. The calculated resistance is used to calculate the optimum duty cycle of the DC-DC converter triggering signal using a developed relation. Based on results, the proposed MPPT has better efficiency (95%) than perturbation and observation (P&O) method (92 %). Moreover, the proposed method is faster than P&O method because there is no perturbation around the MPP during the tracking process.

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INTRODUCTION

Recently, the maximum power point tracking technology becomes very important for photovoltaic systems. Consequently, many developments have been done in this area until it reached the saturation phase. As a result, the interest of the authors when implementing this work has been focused on achieving a certain added value in the proposed system, which can be found in the accurateness, speed and low cost. Thus, the developed algorithm presents the advantage of its simplicity and its high speed which also helps to improve photovoltaic system efficiency.

Source in many cases. Most commonly applied PV systems can be found in remote and rural areas where no public grid is available. A typical small photovoltaic power system (off-grid) can contain the following components: solar PV array, with a number of series/parallel interconnected solar modules and protection elements, a DC/DC converter, a DC/AC inverter and a control system.

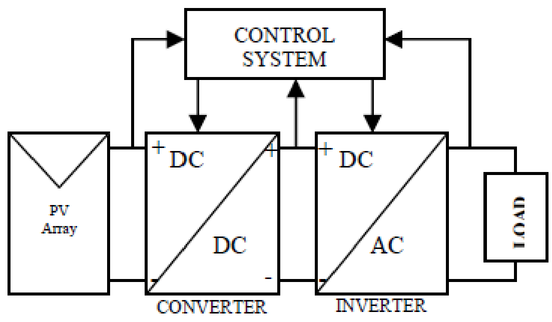

Figure: Basic structure photovoltaic system

Typically, in photovoltaic (PV) systems a high voltage is obtained by connecting multiple modules in series to form a string of modules. Since modules in a string are connected in series, a mismatch of currents among the individual modules reduces the output current of the whole string, inserting losses which are disproportional to the shading. In attempting to address this problem, module level maximum power point tracking (MPPT) methods, otherwise known as distributed maximum power point tracking (DMPPT), are increasingly reported.

A MPPT is used for extracting the maximum power from the solar PV module and transferring that power to the load. A dc/dc converter (step up/ step down) serves the purpose of transferring maximum power from the solar PV module to the load. A dc/dc converter acts as an interface between the load and the module. By changing the duty cycle the load impedance as seen by the source is varied and matched at the point of the peak power with the source so as to transfer the maximum power.

Therefore MPPT techniques are needed to maintain the PV array's operating at its MPP. Many MPPT techniques have been proposed in the literature; example are the Perturb and Observe (P&O) methods, Incremental Conductance (IC) methods, Fuzzy Logic Method etc.

PHOTOVOLTAIC FUNCTION

Figure shows a simple model of a PV cell. RS is the series resistance associated with connecting to the active portion of a cell or module consisting of a series of equivalent cells.

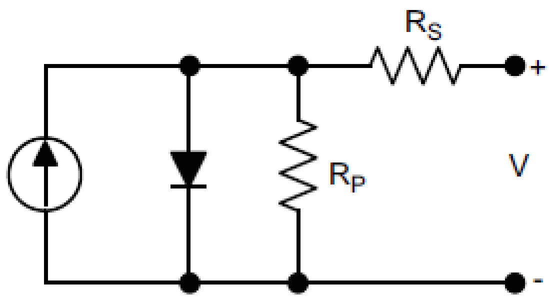

Figure: Simple PV Model

A solar cell basically is a p-n semiconductor junction. When exposed to light, a dc current is generated. The generated current varies linearly with the solar irradiance. The standard equivalent circuit of the PV cell.

It is assumed that a maximum power point of a particular solar PV module lies at about 0.75 times the open circuit voltage of the module. So by measuring the open circuit voltage a reference voltage can be generated and feed forward voltage control scheme can be implemented to bring the solar PV module voltage to the point of maximum power. One problem of this technique is the open circuit voltage of the module varies with the temperature.

DISTRIBUTED HIGHEST POWER POINT TRACKING ARCHITECTURES

With the increasing deployment of PV generation and the constant need to reduce the cost of PV generated electricity, mismatch losses can no longer be tolerated. This gave rise to a new group of PV architectures, called Distributed Maximum Power Point Tracking (DMPPT). DMPPT facilitates the extraction of maximum power from each individual module, thus eliminating the mismatch losses.

The second class DMPPT employs Front-end DC optimizers, also known as Module Integrated Converters (MICs). The MICs are connected in front of the PV modules and their outputs are connected in series to form a string. In this architecture, the MPPT is performed on a per-module basis, thereby allowing PV modules to operate at different currents – each module at its MPP current. Thus, underperforming modules do not limit the whole string, nor are they bypassed. Each module contributes its entire potential power.

TECHNIQUE EXPLANATION

A real PV array has been modeled. It consists of 30 PV modules with 36x2 monocrystalline silicon solar cells each one, connected in series and parallel. Each module can produce 106 W of DC electrical power with an area of 126.5 square centimeters. The array is configured as follows: fifteen modules are connected in series, resulting a nominal operating voltage of 325 V. Then, 2 of these series strings are connected in parallel, resulting in a current of 6A. The rated power of the PV array is 2.6 kW (DC).

In order to allow the interaction between a DC/DC converter and the PV array, a simulation model for a PV array has been developed, including the dependence of the PV array output with the irradiance and temperature. The model was implemented in Simulink, helped by the Sim Power System block set.

Most MPPT techniques attempt to find (search) the PV voltage that results in the maximum power point VMPP , or to find the PV current IMPP corresponding to the maximum power point. The proposed algorithm tracks neither the VMPP nor the IMPP. However, it tracks directly the maximum possible power PMAX that can be extracted from the PV.

In the current-control simulation, each algorithm tracks the MPPT of the low-pass-filtered irradiance data. The current control dynamics are not easily controllable and fail for the rapid irradiance changes found in the unfiltered data. However, on the low-pass-filtered data, current control with PO and ES admits almost perfect MPPT. ES has efficiency η_{ES} = 0.9963 with rise time of 0.02 s, and PO has efficiency 0.9898 with rise time of 6.9 s. The step size for PO is ΔI = 0.5 A.

RESULTS AND SIMULATION

All simulation and result for every converter have been recorded to make sure the comparison of the circuit can be determined accurately. The input, output, voltage, current and power is the main comparison to take into consideration. The complexity and simplicity of the circuit have been determined based on the literature. Convergence speed, hardware required and range of effectiveness.

To ensure the effectiveness of the proposed algorithm, a MATALB code for the proposed system in figure 4 has been developed. The modeled system consists of one PV module (200 Wp, 26.3 V, 7.61 A), (60 Ah/24 V) storage battery and load. Figure 6 shows the simulated load profile. The total consumption is 930 Wh where the peak of the load is 120 Watt. The peak solar radiation is 800 W/m2 while the solar day long is about 12 hours.

CONCLUSION

A novel ES algorithm that utilizes the natural inverter ripple was tested on a simulated array inverter system. Thismethod was benchmarked against the popular PO method using 25 min of rapidly varying irradiance data taken on June 2007 at Princeton University. The irradiance data represent a worst case scenario for MPPT due to the presence of fast moving, scattered cloud cover. It was shown that ES slightly outperforms PO in total power efficiency, and drastically outperforms in transient rise time to the maximum power point, with two orders of magnitude speed-up. Moreover, ES has guaranteed convergence and stability properties, which are ideal for variable weather conditions and unmodeled dynamics.

In this paper, a sliding mode integral control of the boost converter has been analyzed. The reported controller uses the output power of the PV array, output voltage of the converter and an input signal, which in this case is the switching signal. The control law provides voltage regulation at the converter output, and guarantees the maximum power point of the PV array.

A practical case developed in a Matlab/Simulink simulation platform has been presented, and the results confirm the adequate performance of designed control. So, the dynamical response of the control is around one period of the voltage supply.

This work presents high-level architectural aspects of photovoltaic DMPPT systems and their performance in terms of efficiency, control and stability. PV string operation under inhomogeneous insolation is clarified. In addition, a distinction between feedback based regulation and MPPT is emphasized. MPPT units' location is discussed and possible instabilities are demonstrated. The architectures are classified in two categories: the full power processing category, of which mainly the front end DC optimizers architecture is analyzed, and the minimal power processing category, consisting of the shuffling, the RECC, and the Energy Feed Forward architectures.

This paper has presented a comparison of two most popular MPPT controller, Perturb and Observe Controller with Incremental Conductance Controller. This paper focus on comparison of three different converter which will connected with the controller. One simple solar panel that has standard value of insolation and temperature has been included in the simulation circuit. From all the cases, the best controller for MPPT is incremental conductance controller. This controller gives a better output value for buck, boost and cuk converter. Hence this controller will give different kind of curves for the entire converter. In simulation Buck converter show the best performance the controller work at the best condition using buck controller.

The proposed method offers different advantages which are: good tracking efficiency, relatively high convergence speed and well control for the extracted power thanks to the direct power control unit based on the ON/OFF hysteresis controller.

In general, for whatever method that is chosen, it is better to be accurate than fast. Fast methods tend to bounce around the maximum power point due to noise present in the power conversion system. Of course, an accurate and fast method would be preferred but the cost of implementation needs to be considered.

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