STUDY OF MPPT TECHNIQUES FOR PERFORMANCE EVALUATION OF SOLAR ARRAY

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Abstract

The need for renewable energy sources is increasing because of the intense energy crisis in the world today. Solar energy is an essential untapped resource in a tropical country like India. The most important issue for the utilization and reach of solar PV systems is their low efficiency and high capital cost. In this paper, we extract maximum obtainable solar power from a PV module and use the energy for a DC application. This paper investigates in detail the concept of Maximum Power Point Tracking (MPPT) which remarkably increases the efficiency of the solar photovoltaic system. MPPT is used in PV systems to maximize the PV array output power.

Keywords: Maximum Power Point Tracking (MPPT), PV Systems, VMPP, IMPP, duty cycle, Irradiance.

I.INTRODUCTION

Using a solar panel or an array of panels without a controller that can perform Maximum Power Point Tracking (MPPT) will often result in wasted power, which ultimately results in the need to install more panels for the same power requirement. For smaller/cheaper devices that have the battery connected directly to the panel, this will also result in premature battery failure or capacity loss, due to the lack of a proper end-of-charge procedure and higher voltage. In the short term, not using an MPPT controller will result in a higher installation cost and, in time, the costs will escalate due to eventual equipment failure. Even with a proper charge controller, the prospect of having to pay 30-50% more up front for additional solar panels makes the MPPT controller very attractive. Maximum power point tracking control technique is used mainly to extract maximum capable power of the PV modules with respective solar irradiance and temperature at particular instant of time by Maximum Power Point Tracking Controller. A number of algorithms are developed to track the maximum power point efficiently .Several algorithms have been proposed in the literature on the maximum power point tracking (MPPT) problem, which have inspired numerous strategies to maximize photovoltaic systems efficiency under various irradiance conditions.

II. Maximum Power Point Tracking Algorithms

MPPT algorithms are mandatory in PV implementation because the MPP of a solar panel varies with the irradiation and temperature, so the use of MPPT algorithms are needed in order to achieve the maximum power from a solar array.

These techniques differ in many characteristics such as necessary sensors, their cost, and range of effectiveness, complexity, convergence speed, temperature change, correct tracking when irradiation and hardware needed for the performance among others. The Perturb and Observe and the incremental conductance algorithms are the most typical these techniques,.

Most of these methods produce a local maximum and some, like the fractional short circuit current or open circuit voltage, give an approximated MPP, not the exact one. However, if the PV array is partly shaded, there are multiple maxima in these curves. In order to reduce this problem, some algorithms have been implemented as in [14]. In the next section the most popular MPPT techniques are discussed.

There are multiple techniques used to track the maximum power point. Some of the most famous

1) Perturb and observe (hill climbing method)
2) Incremental Conductance method
3) Fractional short circuit current
4) Fractional open circuit voltage
5) Neural networks
6) Fuzzy logic

A. PERTURB & OBSERVE

The Perturb &Observe algorithm is also termed “hill-climbing”, but both names indicate same algorithm depending on how it is executed. Perturb & Observe (P&O) is the simplest method. This algorithm use only one sensor, voltage sensor which sense the PV array voltage. The cost of implementation is less therefore it is simple to implement. The time required for this algorithm is very less. It reaches very close to the MPP but it doesn’t stop at the MPP and keeps on perturbing on both the directions. When this happens the algorithm has reached very close to the MPP and we can set an appropriate error limit or can use a wait function which ends up increasing the time complexity of the algorithm. It includes a perturbation on the duty cycle of the power converter and P&O a perturbation in the operating voltage of the DC link between the PV array and the power converter. On the other hand, the method does not take account of the swift change of irradiation level and considers it as a change in MPP due to perturbation and ends up calculating the wrong MPP. To evade this problem we can use incremental conductance method.

B. INCREMENTAL CONDUCTANCE

To detect the output voltage and current of the PV array, incremental conductance method uses two voltage and current sensors. At MPP the slope of the PV curve is 0.

$$(dP/dV)MPP=d(VI)/dV$$

$$0=I+VdI/dVMPP$$

$$dI/dV_{MPP} = - I/V$$

The left hand side is the rapid conductance of the solar panel. When this rapid conductance equals the conductance of the solar then MPP is reached. By sensing the voltage and current together, the error due to change in irradiance is eliminated. The complexity and the cost of implementation increases.

C. FRACTIONAL OPEN CIRCUIT VOLTAGE

The near linear relationship between VMPP and VOC of the PV array, under varying irradiance and temperature levels produce the fractional VOC method.

$$V_{MPP} = k1\ V_{oc}$$

Where k1 is a constant of proportionality. Since k1 is dependent on the characteristics of the PV array being used, it usually has to be computed in advance by empirically decide VMPP and VOC for the specific PV array at different irradiance and temperature levels. The factor k1 has been reported to be between 0.71 and 0.78. Once k1 is known, VMPP can be computed with VOC measured periodically by momentarily shutting down the power converter. However, this incurs some disadvantages, including temporary loss of power.

D. FRACTIONAL SHORT CIRCUIT CURRENT

Fractional ISC results from the fact that, under varying atmospheric conditions, IMPP is approximately linearly related to the ISC of the PV array.

$$I_{MPP} = k2\ I_{sc}$$

Where k2 is a proportionality constant. Just like in the fractional VOC technique, k2 has to be determined according to the PV array in use. The constant k2 is generally found to be between 0.78 and 0.92. Measuring ISC during operation is problematic. An additional switch usually has to be added to the power converter to periodically short the PV array so that ISC can be measured using a current sensor.

E. FUZZY LOGIC CONTROL

The fuzzy logic control can deal with indefinite inputs. It does not need a precise mathematical model and can handle nonlinearity. Microcontrollers have made in the popularization of fuzzy logic control. The fuzzy logic made up of three stages: inference system, fuzzification and defuzzification.

4. NEURAL NETWORK

These techniques of implementing MPPT are converted for microcontrollers are neural networks. Neural networks commonly have three layers: input, hidden, and output layers. The number nodes in each layer vary and are user-dependent. The input variables are PV array parameters like ISC and VOC, atmospheric parameters like temperature and irradiance, or mixture of these. The output is normally one or various reference signals like a duty cycle signal used to drive the power converter to operate at or close to the MPP.

III. CONCLUSION

This paper proposed the various techniques for maximum power point tracking .These methods include Perturb and observe (hill climbing method) , Incremental Conductance method , Fractional short circuit current , Fractional open circuit voltage , Neural networks and Fuzzy logic. These techniques are using some of the advanced algorithms called as P&O and IncCon .The application of these algorithms along with microcontroller PIC18F452 enable the tracking of the maximum power generation from PV system. Also the microcontrollers used are very efficient as well as cost effective which makes these techniques realizable in real world. MPPT optimization can further be carried by using some software and simulation techniques which are high performance and advanced. This has provided a wide research options in field of MPPT to study dynamic MPPT efficiencies and performance. The efficiency performances of the modified P&O and InCond algorithms are being widely accepted among others .But it can be said that the modified hill-climbing algorithms seems to perform better than the fuzzy logic. Also fuzzy logic technique is difficult to tackle. Thus according to the results found in the literature suggest that the modified P&O algorithm is simpler for obtaining the dynamic MPPT efficiencies.

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