Maximum power point tracking techniques for photovoltaic array system

[1]Mohit Sharma, [2]Sonam Gupta,
[1]Student, [2]Assitant Professor,
Electrical department,
sawmi devi dayal institute of engineering and technology, Panchkula, India

***Abstract* - This paper explores five maximum power point tracking (MPPT) techniques, i.e. the Perturb and Observe (P&O). Incremental Conductance (IC), Fuzzy Logic Control [FLC], Neural Network. And ANFIS[An adaptive Neuro-fuzzy inference system]**

***Index Terms* - MPPT, P&O, IC, FLC, NN, ANFIS**

I. INTRODUCTION

From the currently available forms of renewable energy, solar energy is the most favorable, freely available and plausible technology for generating electricity. However, solar energy has low efficiency due to the photovoltaic (PV) panel's non-linear I-V and P-V output characteristic [1].The efficiency of photovoltaic panels can however be improved by forcing the panel to operate at its maximum power point (MPP). This is achieved using various Maximum power point tracking (MPPT) techniques that control a DC-DC converter. When a solar cell is operating without a MPPT technique, the power drawn from the PV cell is determined by the load. When MPPT is implemented, the MPPT technique will regulate the amount of power drawn from the PV cell by regulating the duty cycle of the DC-DC converter [1]. The MPPT technique will also ensure that the PV cell does not operate close to open circuit voltage or short circuit current.

The basic structural unit of a solar system is the PV module, which itself is composed of solar cells. A solar cell converts energy from the photons of sunlight into electricity by means of the photoelectric phenomenon found in certain types of semiconductor materials [2]. An individual solar cell can only produce a small amount of power. To increase the electrical output power of a required system, solar cells are generally connected in series or parallel to form PV modules. Operating point of solar cells depends on various factors such as temperature, insulation and so on. Changes in insulation on panels due to fast climatic changes such as murky weather and temperature can change the photovoltaic array output power. Another characteristic is that output power of photovoltaic systems is non-linear and depends on above mentioned factors thus they do not perform with desirable efficiency. To overcome this problem, maximum power point trackers are used to make full utilization of PV modules and reduce the power failure due to environmental conditions [2].

II. MPPT TECHNIQUES

Perturb and Observe Technique

The Perturb and observe technique is an example of a hill climbing method. The classic P&O techniques measures the PV panel's output voltage and current and evaluates the corresponding power .The Perturb and observe technique is an example of a hill climbing method. The classic P&O technique measures the PV panel's output voltage and current and evaluates the corresponding power [1]. A voltage perturbation is introduced and the power is measured again. The technique will evaluate the change in power measured. If the resulting change in power is positive, the P&O technique perturbs the voltage again in the same direction until the change in power is negative. At this instance, the algorithm will change the direction of the perturbation in the opposite direction. When the Maximum power point is reached the P&O technique will oscillate around that point, the MPP. The perturbation value to the duty cycle is constant throughout the operation of the algorithm [1].

The output current and voltage of the PV system are measured at instant time k, so as to calculate the generated power. The derived power and voltage are compared with the measured values, determining the direction towards the MPP at the P-V curve of the PV system. Then, the respective fixed dV is added or subtracted to the previous reference V, in order to operate the PV array at the MPP. The reference voltage V is then compared with the measured voltage, and the result from a PI controller regulates the duty cycle of the Pulse Width Modulated (PWM) fly back converter [3].

Incremental Conductance Based On MPPT

The INC technique utilizes the voltage derivative and current to have a track of the MPP. Unlike the P&O technique, IC technique does not use the change in power to track the MPP. For each sampling instant, the instantaneous conductance is compared with its negative conductance [3]. If the instantaneous conductance presents higher value, Voltage is increased as the PV operates, otherwise voltage is decreased. That means that there is an increase in the irradiance, so Voltage has to be increased. As in P&O methodology the proposed INC-based MPPT algorithm is a closed-loop control technique, implementing a PI controller for the regulation of the duty cycle of the PWM dc-dc converter [3].

The operating point for a PV panel which corresponds with its maximum power output can be stated as the ratio of PV panel's terminal current and voltage. In other words, the MPP for a PV panel corresponds to an operating condition where the large signal conductance is identical to the negative of the incremental conductance. To attain maximum power output from a photovoltaic panel by the incremental conductance method exploits the requirement by utilizing a controller to achieve the relation that large signal conductance is identical to the negative of the incremental conductance[4].

The Fuzzy Logic Control MPPT Algorithm Of Photovoltaic System

The process of FLC can be classified into three parts, first is fuzzification, second is rule evaluation and third is defuzzification. The fuzzification step involves taking a crisp input, such as the change in the voltage reading, and amalgamating it with stored membership function to produce fuzzy inputs. To transform the crisp inputs into fuzzy inputs, membership function must be first allotted for each input. Once the membership functions are allotted, fuzzification take a real time inputs and analogize it with the stored membership function information to produce fuzzy input values [5].The second part of fuzzy logic processing is the rule evaluation in which the fuzzy processor uses linguistic rules to determine what control exertion should occur in response to a give set of input values. The result of rule evaluation is a fuzzy output for each type of resultant action. The last step in fuzzy logic processing in which the expected value of an output variable is derived by segregate a crisp value in the universe of discourse of the output fuzzy sets . In this procedure, all of the fuzzy output values effectively modify their respective output membership function. One of the most frequently used defuzzification techniques is called Center of Gravity (COG) or centroid method [5].

PV system is a nonlinear system, the work state of solar cells are also difficult in using accurate mathematical model, so for it is suitable of amalgamate the fuzzy control with the neural network for attain the MPPT of photovoltaic system[6].

Fuzzy systems are knowledge based also referred rule based systems. The main part of the Fuzzy systems is the IF-THEN rules in the sense that all the other three components are used to interpret these rules and make them usable for specific problems [7].The first step involves formulation of the rules from human experts or domain knowledge. The next step is to combine these rules into a single system. Fuzzy logic can be applied to systems that are nonlinear and difficult to model using mathematical tools, especially those that are too vague or too complicated to be described by simple mathematical equations .A fuzzy inference system (FIS) essentially defines a nonlinear mapping of the input data vector into a scalar output, using fuzzy rules. The Fuzzifier maps input numbers into corresponding fuzzy membership functions. This is required in order to activate rules written using linguistic variables. The defuzzifier then maps output fuzzy sets into a crisp number. Given a fuzzy set that enclose a range of output values, the defuzzifier returns one number, thereby moving from a fuzzy set to a crisp number[7].

Neural Networks MPPT

Artificial neural networks are more commonly accepted as a technology offering an alternative way to solve complex problems. An artificial neural network is a n mathematical model that endeavor to simulate the structure and functionalities of biological neural networks [8]. A neural network is an information processing system. It consists of a number of simple highly interconnected processors (units) known as neurons similar to biological cells of the brain. These neurons are interconnected by a large number of links, over which signals can pass. Each neuron receives many signals over its incoming connections, and produces a single outgoing response. Such networks have exceptional pattern recognition and learning capabilities [8].

A formal neuron can be considered as an operator that receives a number of inputs variables, of external environment or from other neurons. Each of these inputs is weighted by a weight, said synaptic weight. It provides an output only when the sum exceeds a certain threshold internal [9].

Anfis Based MPPT

Solar irradiance and temperature are taken as the input training data set for the ANFIS. The ANFIS controller outputs the crisp value of maximum available power from the Solar PV module corresponding to specific temperature and solar irradiance conditions. [10]. The output power from the PV module is evaluated by using multiplication algorithm of sensed operating voltage and currents. The error in the power is processed using a proportional- integral (PI) controller. The control signal output from the PI controller is given to the PWM block. The PWM signal is generated using high frequency carrier signal comparison with the control or modulating signal [10].

III. CONCLUSION

Photovoltaic energy suffers from high implementation cost and low efficiency. For PV energy to become a primary alternative option for energy generation, the efficiency has to be improved. Maximum Power Point Trackers Contribute significantly in improving the efficiency of the solar panel system.Making an iPhone application on Mppt, thanks to Ankit sharma,Amit garg,Gurmeet Badwal And Vishal lohia . This study explored the comparison of five different Maximum Power Point Tracking (MPPT) techniques Perturb and Observe (P&O), Incremental conductance (IC).The fuzzy control MPPT algorithm. Neural network and ANFIS.

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