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Fireworks Algorithm for MPPT

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***Abstract*—In today's electricity generation sector, solar system has created its own important place in generating a clean energy by means of using solar PV panels. Solar energy is an extraordinary renewable source of energy which has ability to generated power through the sun light for most of the equipments used for domestic purposes. The problem with the PV panels is partial shading. For this problem it is necessary to implement the MPPT techniques. MPPT is a maximum power point tracking which gives efficient amount of power by adjusting the voltage and current using algorithms. This paper implements a new MPPT technique used for generating electricity and duty cycle control is done in the proposed MPPT technique using ARM 7 (LPC2148) processor.**

***Keywords*— Solar PV Panels, MPPT Techniques, ARM7(LPC2148) Processor**

I. INTRODUCTION

The solar energy system is the most reliable technology used for the generation of electricity. As the storage of coal is reducing rapidly and is creating pollution in day to day life, it is necessary to build up a new kind of clean energy source that can fulfil all requirements for the electricity generation. In recent years, Renewable energies like solar and wind played a key role in generation of power because they are environment friendly, a sustainable source of energy, and can be built on the consumer side. Photovoltaic (PV) systems are considered to be one of the most efficient and well-accepted renewable energy sources because of their reliability in distribution system, vehicle applications, transportation, and satellite.

PV systems have a major drawback which is the nonlinearity between the output voltage and current particularly under partial shading. During partial shading, the overall P–V characteristic curve has multiple peaks. Therefore, a conventional maximum power point (MPP) tracker (MPPT) such as hill climbing, incremental conductance, and ripple correlation could miss the global maximum point.

Maximum power point tracking or MPPT is invented to reduce the fluctuations in the output voltage and current by adjusting the parameters such that the point of maximum power is obtained.

As under partial shading, the pv panel gives nonlinear output because of nonlinear relation between voltage, current and power. The output observed is shown in I-V characteristic of the PV cell. There are lots of constant fluctuations in I-V curve as the irradiance, temperature and power are fluctuating. The change temperature has inverse effect on change in output voltage and change in irradiance affects output current proportionally.

A study of partial shading implies that by using a conventional MPPT during partial shading could result in less losses of PV output power. So, there are many ways to generate the power using different techniques of MPPT.

As shown in below graphs, temperature and output voltage are inverse to each other i.e. by increase in temperature, the output voltage will decrease and vice versa. The decrease in irradiance will decrease output current. So, for getting the MPP it is necessary to take care of the output voltage with the change in temperature

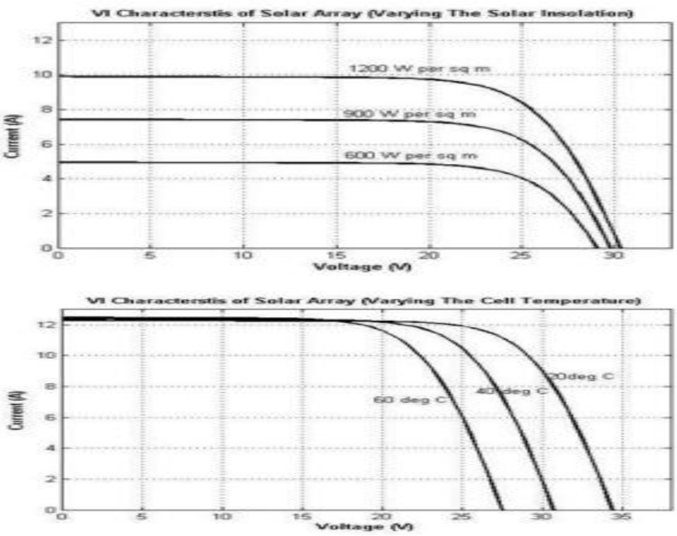

Fig. 1. I-V Characteristics

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For a given I-V characteristic, for the ideal condition the temperature and irradiance are consider to be constant. With constant temperature and irradiance, there is a single knee point of the curve with a current-voltage that produces point at maximum power. The Resistance, R=V/I, is the resistance connected across the terminals of the PV cell to

get this maximum power point (MPP). The main aim behind applying the MPPT system is to examine the power output of the PV panel and vary the resistance to achieve maximum power as the irradiance and temperature changes accordingly.

A. Hill Climbing/P&O

Hill climbing and P&O method is the best conventional method for implementing MPPT. Hill climbing is done by means of perturbation of the duty ratio of the power converter. The PV array is connected to the converter by perturbing the duty ratio, the PV output current will get perturb and accordingly perturb the PV output voltage. Hill climbing and P&O methods are different in types but there way of getting the output power is same. As it is seen in the graph, the voltage increases when MPP is at the left of the curve and the power also increases as well. The voltage decreases when MPP is at the right of the curve and hence the power decreases accordingly. Hence if the power increases, the perturbation should kept as it is but if the power is decreasing it should be reversed. This algorithm works when there is a change in instantaneous PV output voltage and current for one switching cycle.The process is continuous until the MPP is obtained. As there is change in output voltage accordingly the perturbation will also change. So, for minimizing this problem, the step size of perturb must be small. However, a small sized perturb can slow down the MPPT. The solution for that is to apply variable perturbation for each switching cycle.

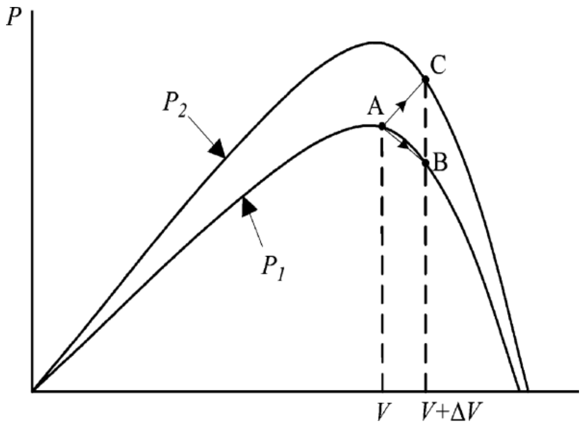

Fig. 2. P-V Curve

Under rapid atmosphere changing condition, the hill climbing and P&O methods have lots of problems in implementing MPPT. Operating point A shows that when the PV voltage is kept constant, the perturbation will bring the point to B and the perturbation will get reversed because of decrease in power. However, if the irradiance increases, the MPP will get shifted to the left of the curve and hence the operating point will shift from A to C. This gives an idea about constant perturbation and ensures that the MPP is constant. For that purpose, a three-point weight comparison

P&O method is used which the two values of power such that the precision is obtained. The best suited controller for hill climbing and P&O are DSP or microcomputer control.

B. Incremental Conductance

The incremental conductance method is oriented by considering the slope as zero. There are some conditions for this INC are given by

dP/dV = 0, at MPP

dP/dV > 0, left of MPP

dP/dV < 0, right of MPP.

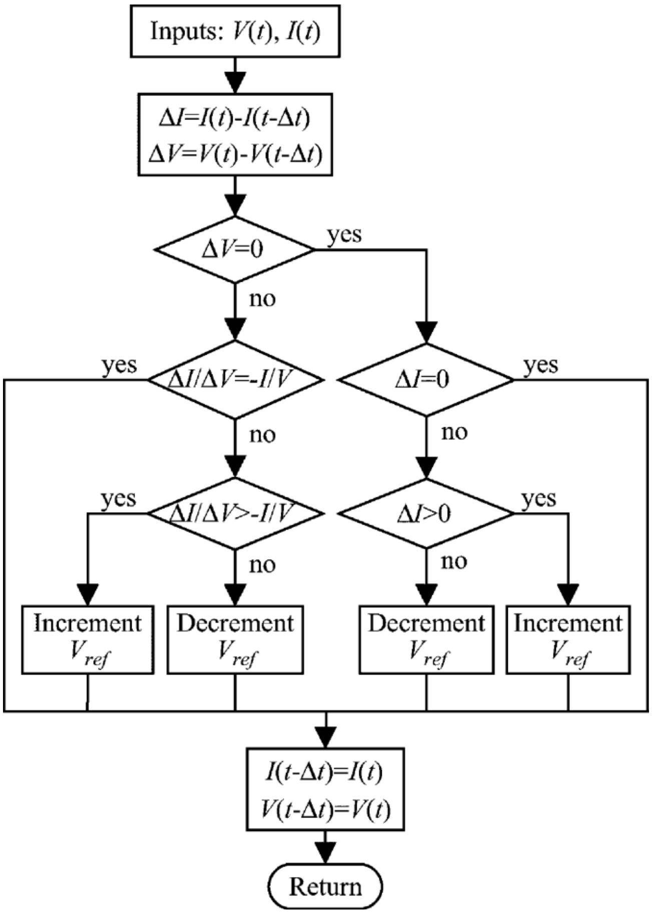

Fig. 3. Incremental conductance algorithm

Since

$$\frac{dP}{dV} = \frac{d(IV)}{dV} = I + V\frac{dI}{dV} \cong I + V\frac{\Delta I}{\Delta V}$$

(1) can be rewritten as

$$\begin{cases} \Delta I/\Delta V = -I/V, & \text{at MPP} \\ \Delta I/\Delta V > -I/V, & \text{left of MPP} \\ \Delta I/\Delta V < -I/V, & \text{right of MPP.} \end{cases}$$

In this algorithm, the comparison has been done between instantaneous and the incremental conductance to track MPP. V_{ref} is the reference voltage. At the MPP, V_{ref} is equal to Vmpp. As the MPP is obtained, change in current is noted with the change in atmospheric condition. The algorithm decrements or increments Vref to track the new MPP. MPP is tracked by determining the speed of incrementation. Fast

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tracking is observed by the size of increment. The bigger the size of increment the fast the tracking can be done. By controlling the power converter the ratio of the short circuit current to the open circuit voltage can be made proportional to the load resistance.

II. FIREWORK ALGORITHM

The proposed firework algorithm is based on the explosion process of fireworks which is considered as a swarm intelligence algorithm. Firework algorithm is designed to maintain the diversity of sparks obtained by the fireworks. It is a search algorithm which represents the potential solutions in searching the MPP by considering the newly generated sparks. This algorithm briefs about the optimizations technique require obtaining a good quality solution.

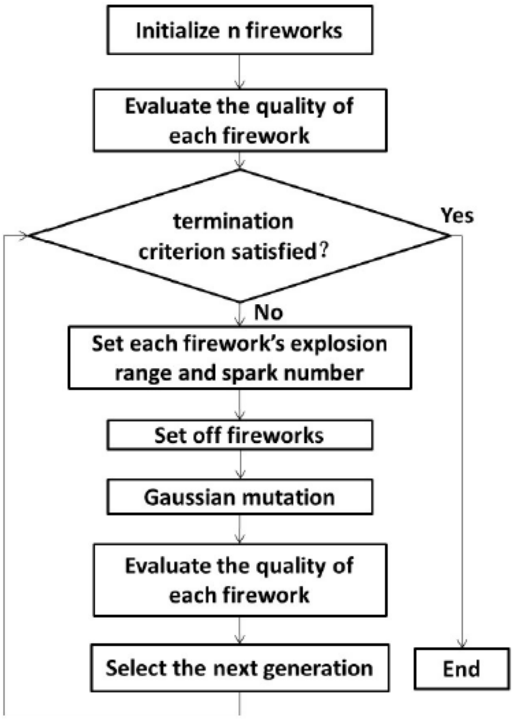

Fig. 4. Firework Algorithm

As the firework explosion takes place, the FA uses the procedure to explore the potential search space. For each firework, an explosion process is initiated and a shower of sparks occupies the area around it. As the explosion takes place, the firework showers the sparks close to its area. Thus, firework explosion process can be expressed such that the exploded firework can take care of the point which is close to the maximum power.

$$S_i = m.\frac{y_{\max} - f(x_i) + \xi}{\sum_{i=1}^{n}(y_{\max} - f(x_i)) + \xi}$$

Where m is used to control the number of sparks, n is the number of fireworks, Ymax is the maximum value of objective function among the number of fireworks.

Following are the analogies to determine the parameters of FA as

S. No.	Real Firework	Firework Algorithm
1.	Firework	One solution
2.	Sparks	Neighbor solutions
3.	Firework location	Solution space
4.	Quality of firework explosion	Solution quality

III. SYSTEM CONFIGURATIONS

A Grid connected inverter system is one of the most attractive systems used now-a-days. It consists of PV array, DC-DC converter and a DC link.

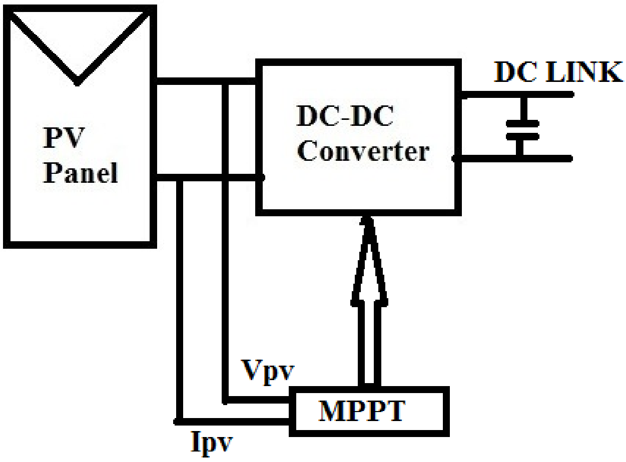

Fig. 5. Block Diagram of PV System

The conventional method for achieving less harmonics and improvement in power factor is to sense the output voltage and output current of the PV panel. In this system, there are two major disadvantages which are high cost and low utilization of the existing hardware circuits.

A DC/DC boost converter is built and the output of this converter is given to the inverter. It forwards the input voltage to the inverter and generates the power of the PV module to the given system.

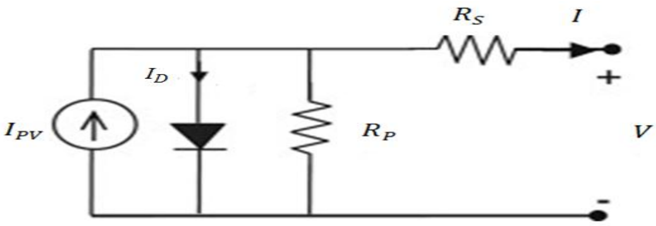

Fig. 6. Single diode model

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By applying KCL, the output of the PV array is given by

$$I = I_{pv} - I_D - \frac{V_D}{R_p} \qquad (1)$$

Where,

I_D - Diode current

V_D - Diode voltage.

The ideal diode equation is given by ideal diode law is

$$I_D = I_o\,(e^{V_D/\alpha V_t} - 1) \qquad (2)$$

Where,

a - Ideality constant of diode

V_t - Thermal voltage.

Considering any temperature, the thermal voltage is as follows

$$V_t = N_s kT/q \qquad (3)$$

Where, k -the Boltzmann constant

T - Cell temperature in Kelvin

q - Electron charge

N_s - Number of cells in series.

The solar PV output voltage is given by:

$$V = V_D - IR_s \qquad (4)$$

The change in irradiance changes the output voltage. This is occurred due to partial shading. Hence, MPPT techniques are applied in Solar PV system to get the MPP even if there is change is irradiance or atmospheric conditions. This can be done by changing the duty cycle of the power converter connected.

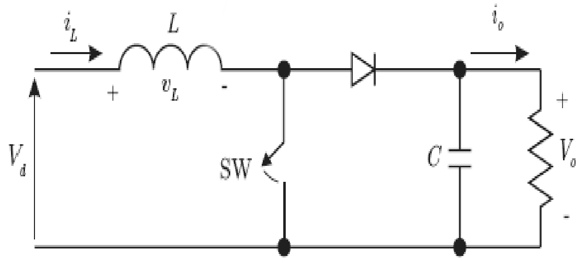

Fig. 7. DC-DC Boost Converter

Where L is an inductor, C is a capacitor, SW is a switch and Vd is an input voltage.

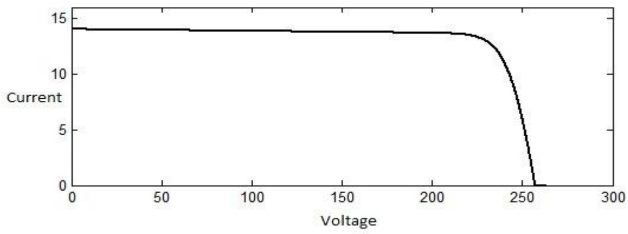

Fig. 8. I-V CURVE of ideal PV

IV. RESULT

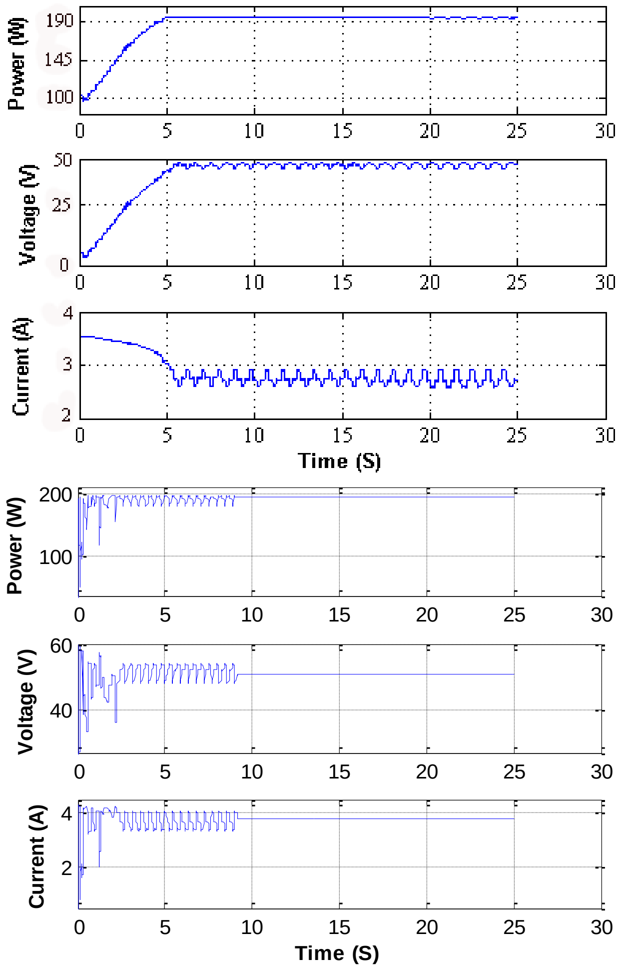

Fig. 9. Hill Climbing and PSO under full irradiance

Partial shading condition should be assimilate by effect of 3S-2P configuration, the lowest value of irradiance is considered to be 700 W/m^2 and 300 W/m^2 and other PV panels are kept at 1000W/m^2. Simulation results are taken for HC, PSO and firework methods considering partial shading conditions. HC method reaches local MPP having power value slightly lower than 65W failing to locate the global peak with a lower convergence time of nearly 4 sec due to the initialization being closer to the local peak. Even though PSO method manages to track the global peak whose power value is 106 W and takes a convergence time of 9 sec.

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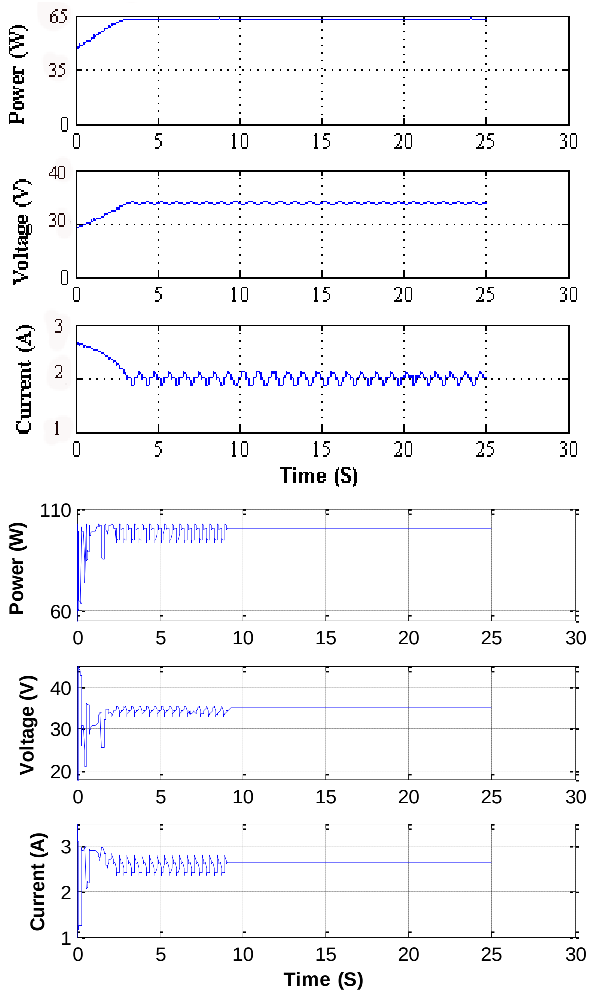

Fig. 10. Hill Climbing and PSO under partial shading

V. CONCLUSIONS

The Firework algorithm is implemented on the proposed model and it is observed that the model is giving output efficiently. A three phase grid connected inverter fed from the solar PV array is developed. The pulses have been successfully generated by using PWM generator and the expected output has been observed at the load as well as at the inverter side. Analysis further suggests that a controller is required to feed constant power to the grid.

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