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Simplified Particle Swarm Optimization Cuddleded MPPT Scheme For Partial Shaded Standalone PV System

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Abstract:
In Renewable Energy (RE) system, the Solar Photovoltaic (SPV) energy system is a fast developing and eco friendly energy conversion system, the improvement of renewable energy system owed to diminish fossil fuel and environmental pollution. The power capacity of SPV energy system is low and the high cost associated to installation, the result for cost effectiveness SPV modulator and its controller design continuously developed for high power harvesting with efficiency. This paper illustrates an overview of Simplified Particle Swarm Optimization (SPSO) technique and illustrates problem of tracking peak power from partially shaded PV panels. In partially shaded system, there are many peaks points indentified in the P-I characteristics curves of the PV panels. This work suggest a method for identify the exact peak among the many power peaks by the use of SPSO algorithm. To validate proposed system simulate by using Simplified Particle Swarm Optimization (SPSO) which contain solar PV-array model, dc-dc buck/boost converter and R load. Proposed Simplified Particle Swarm Optimization (SPSO) system eliminates the random numbers in the velocity factor to calculate velocity function. The maximum velocity factor changes are limited to a particular value.

The proposed system validated by simulation using SIMULINK package in Matlab. The results proved that SPSO algorithm proposed for MPPT provide good performance to converge the correct Global Peak (GP) power with partially shaded MPPT PV solar system.
Keywords*: Solar PV system, MPPT, Particle swarm optimization algorithms.*

Introduction:

The efficiency of solar PV energy system affected by three factors, one is PV panel efficiency (between 8-15%), second is the efficiency of the inverter (95-98%) and the algorithm used for maximum power point tracking (MPPT) efficiency (above 98%). PV arrays exhibit non linear V-I characteristic with single point, where at the point power available is peak and the result MPPT algorithms introduce in the controllers [1]. In PV system to harvest the maxim power and hence MPP algorithm need to added in power converting devices. The climatic changes causes variation in irradiance and temperature, the *P-I* characteristics reveal multiple power peaks points ie., whole module of the P-V array exposed to part of irradiances. During cloudy seasons PV panels subjected to shadowing effects may fully or partially, in partial shading condition n-numbers of peaks and many local and a Global Peak (GP) exhibit in PV curves. The unnecessary power losses occur, when MPPT algorithm identify one of the local peak instead of true Global Peak power point during cloudy and partial shaded.

Fuzzy-Logic-Control approach is effective, it need fuzzification, rule base, defuzzification process, and provide fast precise convene to the peak operating power point throughout steady state[1]. If a sudden disturbance occurs, the MPPT algorithm indentifies the all available local peak power point. From local power peaks the algorithms evaluate one as the actual Global Peak power. Hence results, response of the MPPT system make slow [2].The proposed approach eliminates drawbacks of the conventional MPPT like Perturb and Observe(PO) method. The global mode will initiated during partial shading, to searching of GP, and also tries to find the GP[3]. When GP is obtained in SPSO after stop constraint reached, this will activate P&O with new GP. This method is proved to be effective; it increases the level of computation MPPT system significantly ie., very complex.

II. P-V CELL MATHEMATICAL MODEL

Basically the PV cell is a p-n junction made up of semiconductors. It converts solar energy into direct current. The Fig.1 depicts the equivalent model of a single P-V cell, it contain a diode parallel with current source [4].

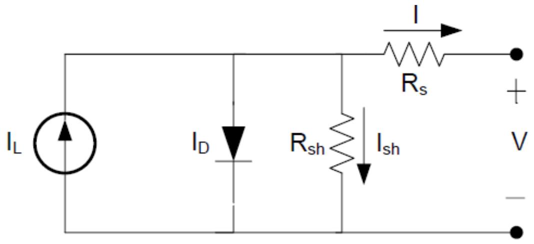

Fig.1 Simple equivalent circuit of PV cell

The R_s -series resistance equivalent to internal losses, the R_{sh} -shunt resistance provide path to the leakage current(I_{sh}). The above equivalent circuit is given by equn. (1)

$$I = I_L - I_{sc}\left(exp^{\left(\frac{V+R_S I}{v_t}\right)} - 1\right) \quad (1)$$

If the shunt resistance R_{sh} is neglected, then assume I_L is qual to I_{sc} and also $\exp((V+R_sI)/v_t) >> 1$. Then, the resulting characteristic equation is (2) with boundary conditions I =0 and I=I_{sc}.

$$I = I_{sc}\left[1 - \exp\left(\frac{V+R_S I - V_{oc}}{v_T}\right)\right] \quad (2)$$

The desired output voltage and current obtained by connecting PV cells in series and parallel.

Over all mathematical model PV module is given by [6],

$$I_{pv} = I_{scg}\left[1 - \exp\left(\frac{V_{pv}+R_{sg}I_{pv}-V_{ocg}}{v_T N_{sm} N_{sc}}\right)\right] \quad (3)$$

Where suffixes, *scg* –represent short circuit parameters, *ocg* - represent open circuit parameters and *sg* -represent series circuit parameters and also

V_{pv} -is PV array output voltage

I_{pv} -is PV array current

N_{sc} -is the number of cells connected series in PV module and

N_{sm} -is the number of PV array modules in series

By using the above equation (3), simulated PV array characteristics are depicted in Fig.2. The parameters used for Simulation are given in Table 1.

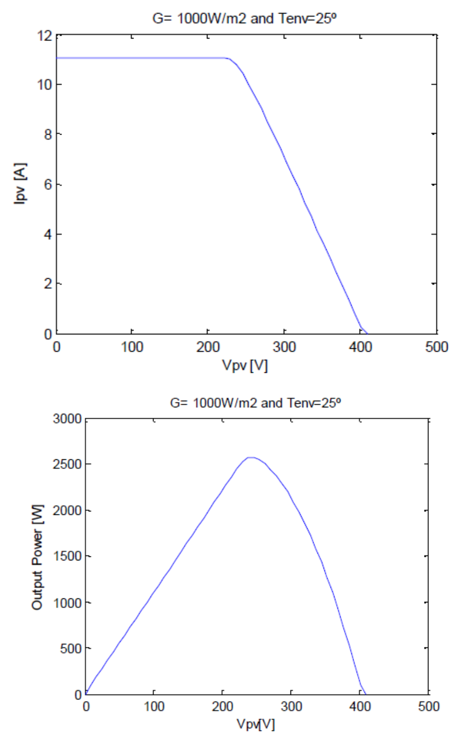

Fig 2(a). I-V characteristics Fig 2.(b) Power(P)- voltage(V) characteristics

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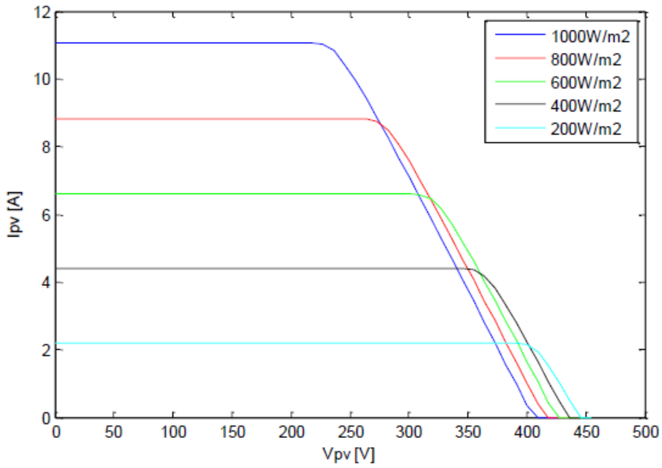

Fig 3. I-V curves of PV array for different Irradiations

III. SIMULATION OF SOLAR PV MODEL WITH SPSO MPPT

The objective of this work paper is model to track the peak maximum power from PV panel by using PSO based MPPT algorithms independently of the converter used. The proposed model simulated in Matlab®/Simulink® with modeling of the PV modules, MPPT control block and power converter. Proposed MPPT Controller generates the gate signal by using the SPSO MPPT algorithm is depicted in Fig 4.

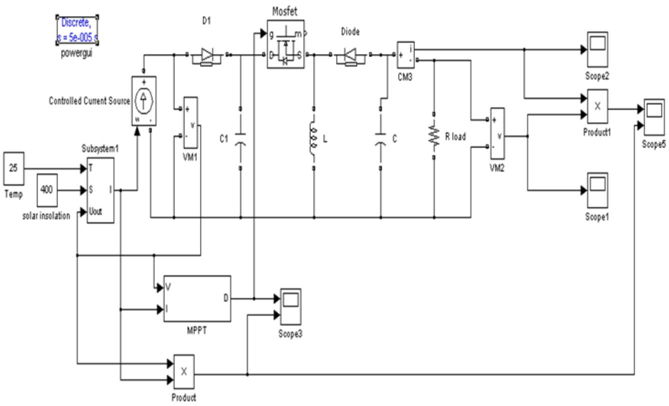

Figure 4. Solar PV system converter with the MPPT

TABLE 2

Circuit Parameters

Converter Parameters	**Value**
Inductance(L)	1mH
Capacitance(C)	2e-3F
Switching	50kHz
Frequency(Fs)	
Voltage(Vo) output	12.0 V
Duty ratio(D)	61%
Load Resistance(R)	500 ohm
Sampling Interval	0.05s

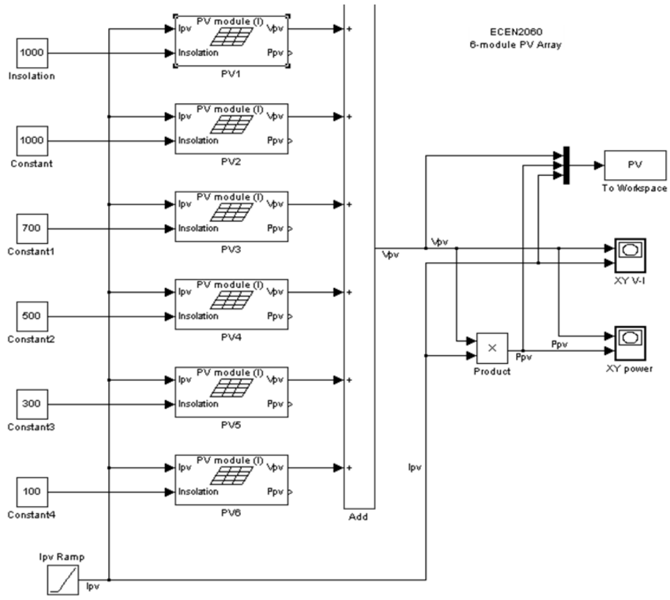

Figure 5. Solar PV system array simulation model

For maximum insolation is consider to be at 1000 W/m^2, if the PV module is non-shaded. During the shaded condition for example at 40% insolation the PV module receives about 400 W/ m^2. The parameters used in all the simulations are as follows,

Table 1

PV SOLAR ARRAY PARAMETERS AT S.T.C 25^{o}C

Parameters	**Symbol**	**Module Value**	**Array value**
No. PV Modules	N_{pv}	-	6
open circuit voltage	V_{oc}	22V	133.2V
short circuit current	I_{sc}	5 A	5.45A
Voltage with MPPT	V_{MPPT}	17V	103.2V
Current with MPPT	I_{MPPT}	5A	4.95A

Maximum Power	P_{max}	85.14W	510.84W

IV. PARTICLE SWARM OPTIMIZATION (PSO) METHOD

PSO is modelled from the behaviour of bird flock and evolutionary algorithm search method in a population. The PSO algorithm depicts a swarm is called particles, and the every particle stand for a candidate solution. The behaviour Particles imitates the success of neighbouring particles. From the succeeded best particle P_{best} in a region, also the best feasible solution found by the G_{best} particle. The position of the Particle x_i is altered by using

$$x_i^{k+1} = x_i^k + V_i^k + 1 \quad (4)$$

where, v_i – is velocity component.

The V_i^{k+1} is calculated by,

$$V_i^{k+1} = w\,V_i^k + C_1 r_1\{P_{besti} - x_i^k\} + C_2 r_2\{G_{besti} - x_i^k\} \quad (5)$$

Where,

w -inertia weight

c_1 and c_2 – acceleration coefficients

Note : random numbers r_1 and r_2.

Fig. 6 depicts swarms movement in the optimization calcualtion.

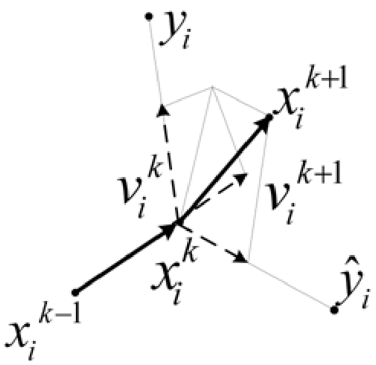

Fig. 6 PSO swarm movement

V. MPPT USING PSO

The Peak value power in a PV system obtained from P-I curve by PSO algorithm. The optimization problem with (N_p) number of particle can be defined as:

$$x_i^k = I_g = [I_{g1}, I_{g2}, I_{g3}, I_{g4} \ldots . I_{gj}]$$

$$j = 1,2,3,4,5 \ldots N_p$$

The main objective function is given as:

$$f(x_i^k) > f(y_i)$$

Where, f = power of PV array.

Due to irregular shading, the Power obtained from PV array alters. In this situation, by reinitialise the particles to investigate the new GP(MPP). The condition to be satisfied for initilise particles,

$$\left|\frac{P(x_{i+1}) - P(x_i)}{P(x_i)}\right| > \Delta P$$

VI. SIMPLIFIED PARTICLE SWARM OPTIMIZATION

For the MPPT system, conventional particle swarm optimization used traces GP. The last two parts in equation (5) is dependent r_1 and r_2. The changes of velocity cause the particle changes their position towards searching the GP. Hence between two successive iteration variations in duty cycle is very low and respective voltage changes also low. Hence more iteration needed to attain final result. From the best position a huge modification in the velocity equation is required to pursue the best location. Result reduces probability to converging a narrow peak to in its place of the GP. The problem addressed by monitor the PV curve changes in during partial shaded condition. The key element problem solved by eliminating random numbers in equation.5. The equation of velocity can be written as

$$V_i^{k+1} = wV_i^k + \{P_{besti} - x_i^k\} + \{G_{besti} - x_i^k\} \quad \text{for } 0 < V < V\text{Max} \quad (6)$$

(or)

$$v_i^{k+1} = wv_i^k + \{G_{besti} + P_{besti} - 2x_i^k\} \quad \textbf{(7)}$$

The transformed above equation is called as SPSO. The modification given advancement: 1) particle behaviour is deterministic because of elimination of random number and obtain the consistent in final solution.

By the control of V_{max}, for accurate tracking values of duty cycles increased or decreased slowly. The GP tracking is guaranteed, even searching capability tends fast.

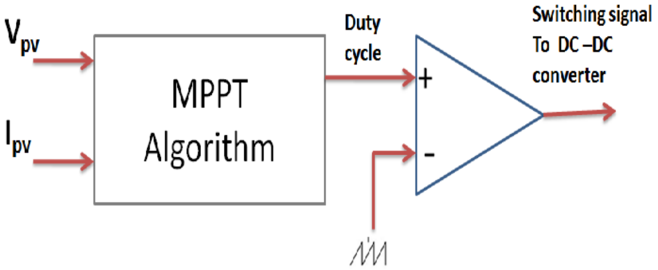

Figure 7. Direct Control structure

To define the SPSO to track the MPP, the duty cycles with N_p particles is given by,

$$x_i^k = d_g = [d_{g1}, d_{g2}, d_{g3}, d_{g4} \dots \dots , d_{gNp}]$$

(4.5)

The objective function given as

$$\boldsymbol{f}(\boldsymbol{x}_i^k) > \boldsymbol{f}(\boldsymbol{P}_{\text{besti}})$$

(4.6)

The two modes MPPT algorithm operates in good weather condition, the environmental variation changes slowly, the algorithm uphold the active GP of PV system is called local mode. During partial shading occurs, the algorithm immediately the implement SPSO subprogramms to compute GP, i.e, global mode activated. Under good weather condition the algorithm moves to local mode, if GP is successfully located. Local mode means, HC with variable step-size changes is employed.

VII. Simulation parameters and results

The following parameters which is given in table II is used simulate PSO algorithm . The PSO particles are initialised by random manner. Table III consist predetermined initialization is and Fig.8 depicts solar PV array model implemented in simulation for validation, the simulation carried out with PV system that contain boost DC to DC converter with PSO MPPT controller.

Table II

N_p	W	c_1	c_2	OP
3	0.3	1.3	1.5	0.16

Table III

No: particles(N_p)	1	2	3
Initial Isc values	0.78Isc	0.43Isc	0.6Isc

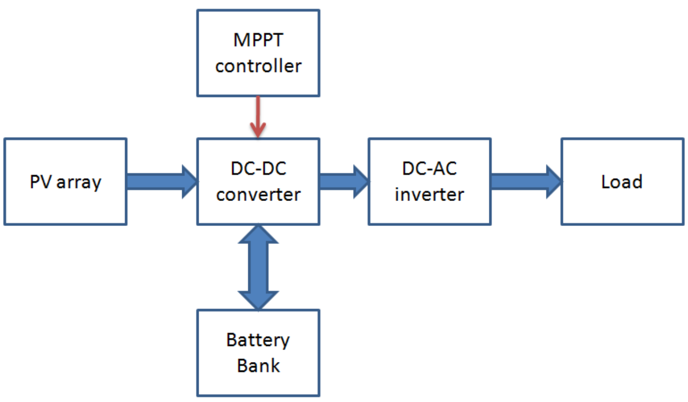

Figure 8. Solar PV with MPPT controller

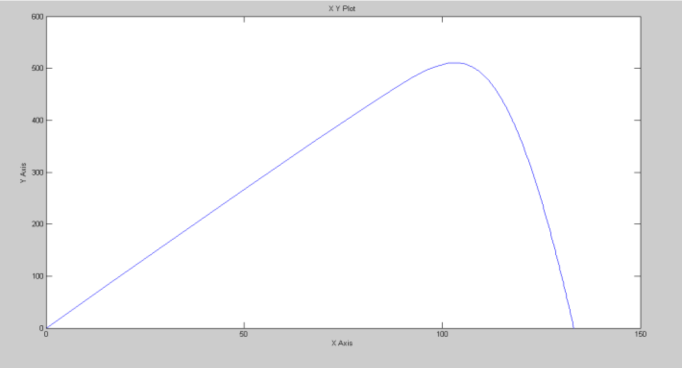

Figure 9. Solar P-I characteristics

Fig. 9 depicts Power(P) –current(I) characteristics curve for the given configuration.

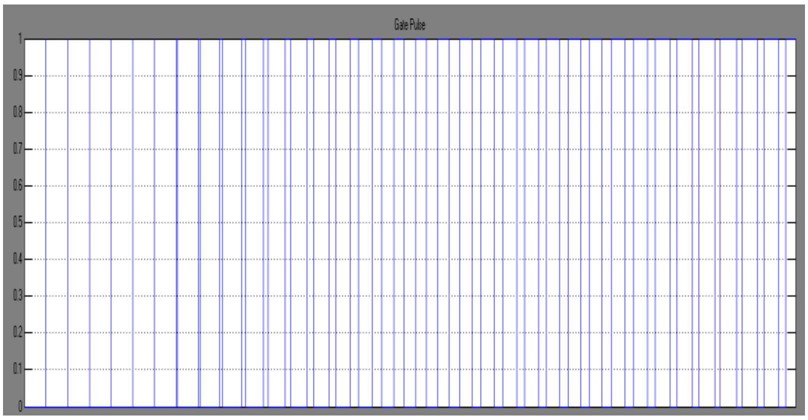

Fig.10. Gate pulse from MPPT controller

Fig. 10 depicts the gate pulse generation based PSO algorithm implemented for above simulation model.

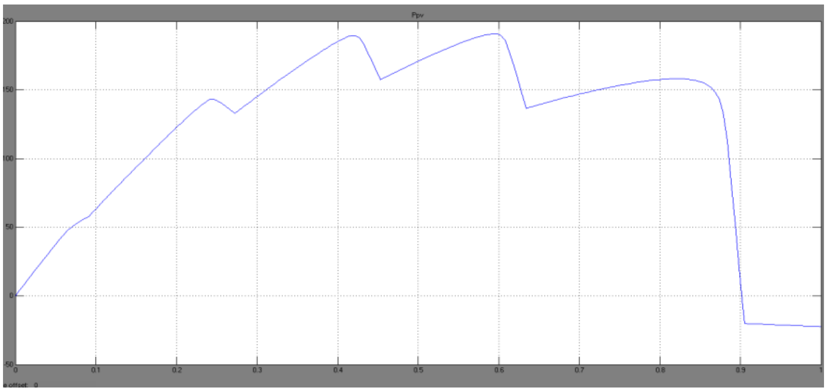

Fig.11. The PV Array Power during Partial shading

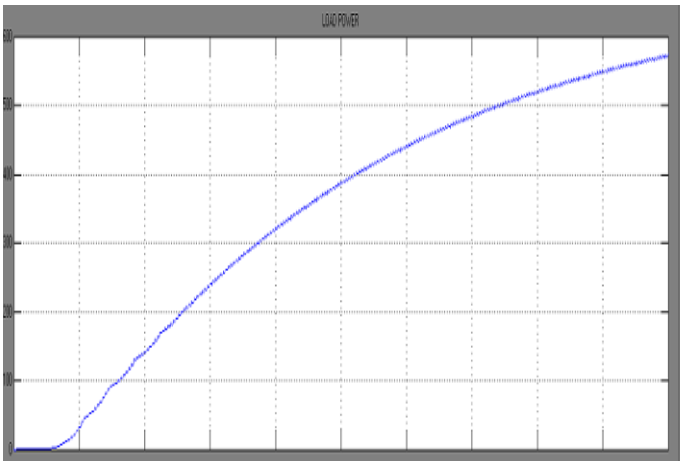

Fig 12. Output Power with MPPT

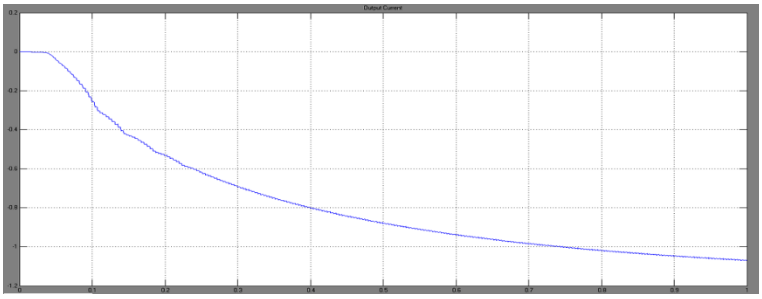

Figure 13. Output Current with MPPT

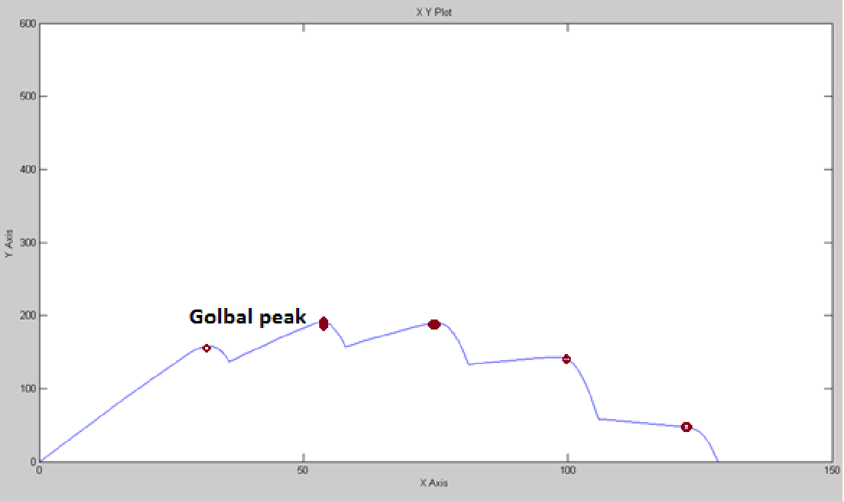

Figure 14. PV Characteristics of Array during Partial Shading

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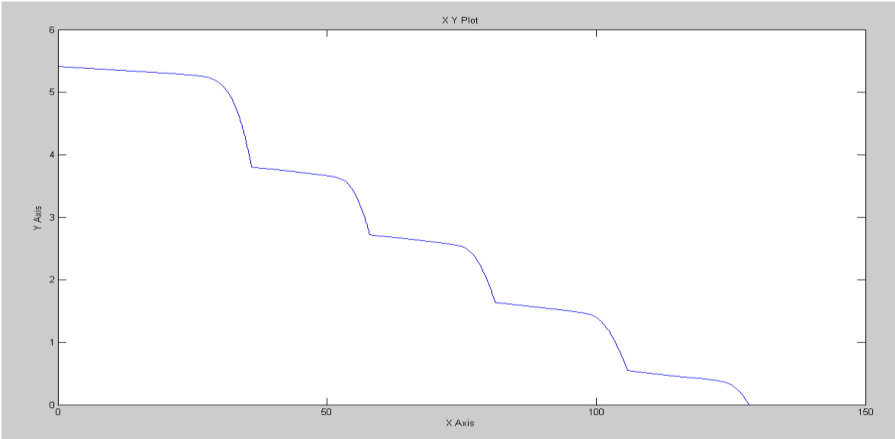

Figure 15. V-I Characteristics under Partial shading condition

CONCLUSION

This work presents a simple and well-organized photovoltaic maximum power tracking system. The PV array model and controllers of PSO based MPPT system simulated by using MATLAB. The PV modelled equivalent circuit simulation result is reasonable, provides exact matching with the real time PV module. Simulations carried out for validate the SPSO MPPT algorithms with actual irradiance from the two different weather conditions. The results shows increase in the efficiency of energy from PV and also SPSO method is implemented to identify MPP in a solar PV standalone system.

A Simplified PSO reduces control structure implemented without random number initialization. Even though the simpler in control structure, the proposed SPSO provide significant exactness and converging speed appraise with HC method. Due the straightforwardness of SPSO algorithm it is easy to configure in microcontrollers.

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