MPPT for Standalone PV System under Partially Shaded Condition using Genetic Algorithm

K. Murali Krishna, S. Ashok Reddy, K. Siva Shankar

***Abstract:** sun oriented vitality is spotless, renewable and its decentralized character is suitable well at the scattered State of the zones with low thickness of populace. The expense of Electricity from the sun oriented cluster framework is more costly than the power from the utility network. In this way, it is important to work the PV framework at most extreme proficiency by following greatest force point at any natural condition. In this work, the Genetic algorithm is utilized to control the operation of the PV exhibit keeping in mind the end goal to separate the most extreme force. The outcomes acquired are looked at and talked about.*

***Keywords:** PV System, Maximum Power Point Tracking (MPPT), Genetic algorithm, P&O algorithm.*

I. INTRODUCTION

Renewable imperativeness transforms into an essential hotspot for a few applications in the most recent four decades. It is hard to supply electrical hugeness to little applications in remote districts from the utility cross area or from little generators. Stay single photovoltaic (PV) frameworks are the best blueprints in different negligible electrical centrality request applications, for instance, correspondence structures, water pumping and low power mechanical assemblies in provincial zone[1]. This paper presents comparing the ability of solar power tracking from the partially shaded panels using Genetic algorithm and P&O algorithm. The rest of the paper is organized as follows. Section II presents the PV Cell modeling; section III presents PV Array characteristics; section IV presents conventional P&O algorithm; section V presents proposed technique Genetic Algorithm; section VI presents comparison results.

II. PHOTOVOLTAIC CELLS

Operating Principle: Photovoltaic cells are the major portions of greater sun based shows. Essentialness is made when photons of light from the sun strike a sun controlled cell and are a sorted inside the semiconductor material. This stimulates the semiconductor's electrons, conveying on the electrons to stream, and making a usable electric current[2]. The present streams in one heading and subsequently the force made is named direct present (DC) as will be elucidated in a word underneath. PN convergence (diode) is a farthest point between two differently doped semiconductor layers. One is a P-type layer (excess openings), and the second one is a N-type (plenitude electrons).

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Mr. K. Murali Krishna, M.Tech-Student in Power Electronics and Electrical Drives, Pragati Engineering College, Surampalem (A.P). India.

Mr. S. Ashok Reddy, Asst. Professor of Department of Electronics and Electrical Engineering, Pragati Engineering College, Surampalem (A.P). India.

Mr. K. Siva Shankar, M.Tech- Student in Power Electronics and Electrical Drives, Pragati Engineering College, Surampalem (A.P). India.

At the breaking point between the P and the N district, there is an unconstrained electric field, which impacts the delivered electrons and openings and chooses the heading of the current.

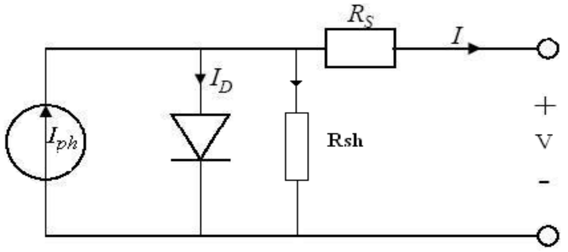

Fig. 2.1 Equivalent circuit model of PV cell

Voltage output of a PV cell:

$$V_{pv} = \frac{ATK}{q} \ln\left[\frac{I_{ph} - I_{pv} - I_0}{I_0}\right] - I_{pv} R_s \quad (1)$$

Current output of a PV cell:

$$I_{pv} = N_p * I_{ph} - N_p * I_0 \left[\exp\left\{q * \frac{\left(V_{pv}\right) + \left(I_{pv} R_s\right)}{N_s AKT}\right\} - 1\right] \quad (2)$$

$$I_0 = I_{or}\left[\frac{T}{T_r}\right]^3 \exp\left[\frac{q * E_{go}}{AK}\left\{\frac{1}{T_r} - \frac{1}{T}\right\}\right] \quad (3)$$

PV array power can be calculated the following equation:

$$P_{pv} = V_{pv} * I_{ph} - V_{pv} * N_p * I_0 \left[\exp\left\{q * \frac{V_{pv} + I_{pv} R_s}{N_s AKT}\right\} - 1\right]$$

(4)

V_{pv}= output voltage of the pv cell(V)
I_{pv}= output current of a pv cell(A)
N_s = number of modules connected in series
N_p = number of modules connected in parallel
I_o = PV cell saturation current (A)
*R*s=the series resistance of a PV cell
A = B is an ideality factor=1.6
K = Boltzmann constant=1.3805e-23Nm/K
T is the cell temperature in Kelvin =298K
Q is electron charge=1.6e-19Coulombs

Specifications:

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TABLE I. Solar Panel Specifications:

Parameter	Values
Maximum power(Pmax)	60W
Voltage at Pmax(Vmax)	17.1V
Current at P_{max} (I_{mpp})	3.5 A
Open circuit voltage (V_{oc})	21.1 V
Short circuit current (I_{sc})	3.8 A
Operating Temperature	25 ^{0}C

TABLE II. Boost Converter Specifications:

Parameters	Values
Switching frequency (f_s)	25 kHz
Load Resistor (R)	15 Ω
Inductor (L)	1 mH
Capacitor (C_1 & C_2)	220 μF

III. PV ARRAY CHARACTERISTICS

As it is pivotal to work the PV vitality change framework at or close to the most extreme force point to build the PV framework proficiency, the investigation of PV qualities was the fate of awesome significance. Likewise the greatest force working point is changes with Irradiation and temperature [2-3]. In this manner the following control of greatest force point is an entangled issue. Hence the use of Conventional MPPT techniques such as **P&O algorithm,** MPPT methods based on soft computing techniques such as **Genetic algorithm** have gained great popularity to solve this problem

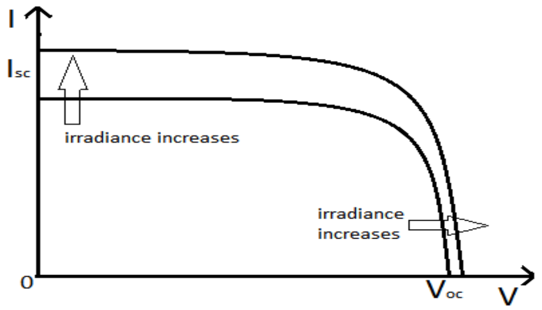

Fig.3.1. I-V curves with variable irradiation

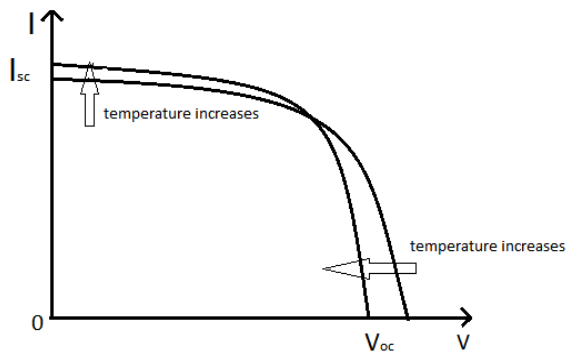

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Fig.3.2. I-V curves with variable temperature

Boost converter:

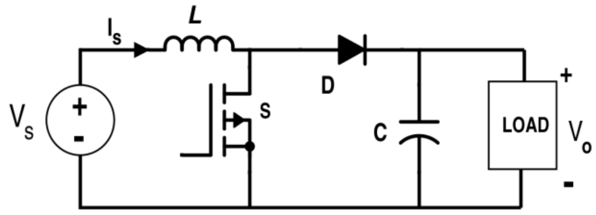

Fig.3.3. Boost converter

Boost converter is only a DC/DC converter which has boosting the voltage to keep up the most extreme yield power steady for every one of the states of temperature and sunlight based irradiance varieties. at the point when the switch S is on, the present develops in the inductor L because of the positive inductor voltage is equivalent to the information voltage. The switch is then opened after some little timeframe. At the point when S is off, the voltage crosswise over L turns around and adds to the information voltage, along these lines makes the yield voltage more prominent than the info voltage. For enduring state operation, the normal voltage over the inductor over a full period is zero[7-9]. The most extreme force point tracker utilizes the DC/DC converter to modify the PV voltage at the greatest force point. A help converter is chosen to actualize MPPT on account of their straightforwardness and its regular use in down to earth applications.

The steady state equations of a Boost Converter are given below:

$$Vin * Ton - (Vo - Vin)Toff = 0 \quad (5)$$

$$Vin * D * T = (Vo - Vin)(1 - D)T \quad (6)$$

$$Vo/Vin = 1/(1 - D) \quad (7)$$

The expressions for the inductor and capacitor is,

$$L = D(1 - D)R/2f \quad (8)$$

$$C = k/2fR \quad (9)$$

Assuming loss less circuit:

$$Vin\ Iin = Vo\ Io = (Vin\ Io)/((1 - D)) \quad (10)$$

$$Iin = Io/((1 - D)) \quad (11)$$

The input resistance of the boost converter is:

$$Rin = Vin/Iin \quad (12)$$

$$Rin = (Vo\ (1 - D))/(Io/((1 - D))) \quad (13)$$

$$Rin = Ro\ (1 - D)^2 \quad (14)$$

By observing the above equation (14), by changing duty ratio between 0 to 1, the input resistance is varies from R_0 to 0. At one instant the input resistance is equal to the output

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resistance, so as per greatest force exchange hypothesis when source resistance is equivalent to the heap resistance most extreme force exchange to the load [7]. In this way, all things considered, circumstances we require a framework that consequently changes D worth to Dmax to such an extent that most extreme force can be exchanged to the heap.
Here we are using Conventional MPPT techniques such as P&O algorithm; MPPT methods based on soft computing techniques such as Genetic algorithm are used to extract the maximum power.

IV. MPPT BY USING P&O ALGORITHM

The block diagram of perturb and observe maximum power point tracking technique is shown in fig 4.1. Here PV array converts solar irradiation in to electrical energy. The output power of PV array depends upon the solar irradiance and temperature. The output power of PV array is given to the load through the dc-dc boost converter. The output voltage and current are given to P&O MPPT controller.

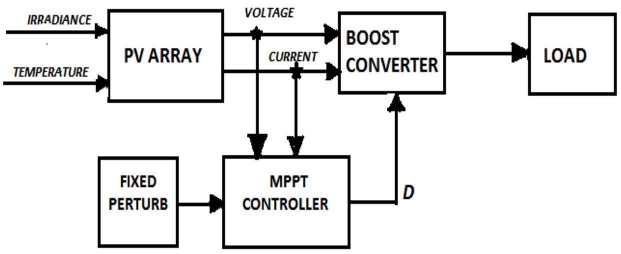

Fig.4.1 Block diagram of P&O MPPT method

A. PV Module under uniform shading:

A number of series-parallel connected PV modules are used to form a PV array for a desired voltage and current level. In this paper, the tested PV array consists of five modules in a single series string as shown in Fig 4.2.

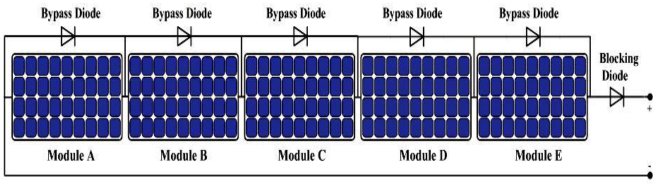

Fig.4.2. 5 PV Modules Connected in Series under uniform shading

The following PV curve represents the maximum power tracking from the panel under uniform irradiation condition using perturbation and observation algorithm. Here the curve drawn between the PV array voltage (V) and PV array power(W)

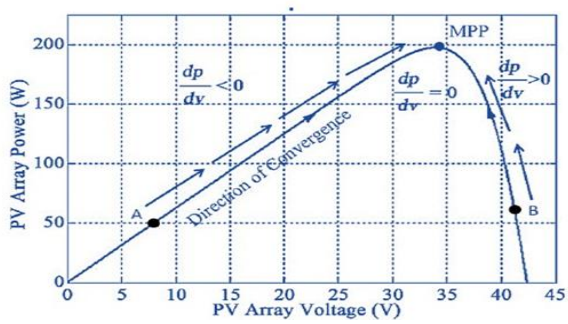

Fig.4.3. PV curve Under uniform Radiation

B. PV Module under non uniform shading:

The power generated by PV panels depends on irradiance, temperature and shading conditions. It is difficult to maintain uniform irradiance on all the modules at all times so the performance of the module is affected. Such a problem may arise due to the clouds, neighboring buildings, dirt, etc. Under partial shading conditions, the power from the PV module can be dramatically reduced. Modules under shade absorb a large amount of electrical power, generated by the other modules under high irradiation, and convert it into heat.

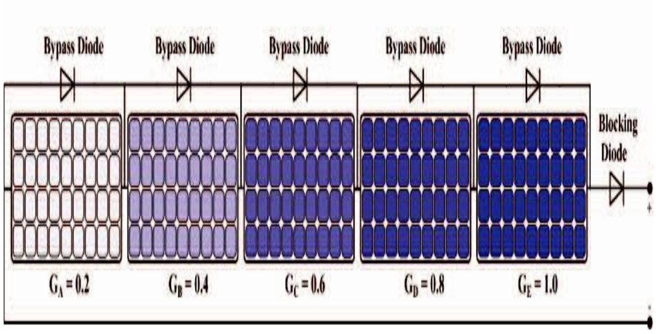

Fig.4.4. 5 PV Modules Connected in Series under uniform shading

This heat may harm the low lit up modules under specific conditions. To assuage the weight on shaded modules, sidestep diodes and blocking diodes are included crosswise over and between the modules individually

Flowchart of P&O algorithm:

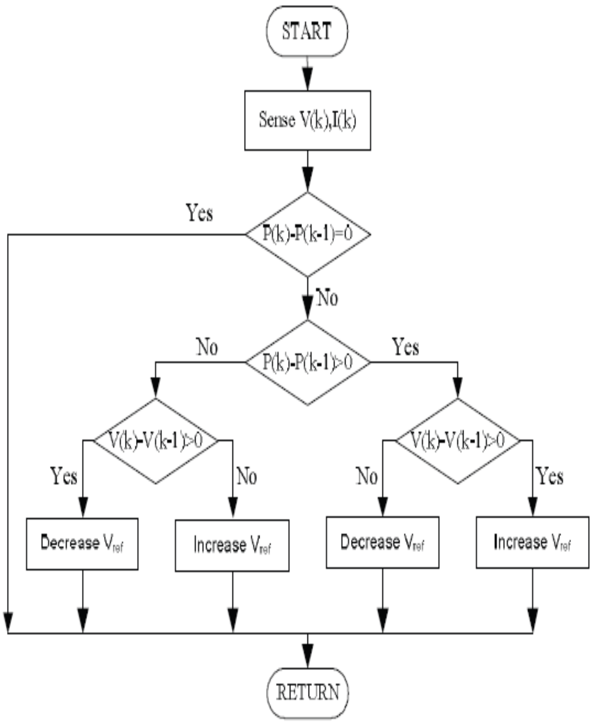

Fig 4.5. Flowchart of P&O algorithm:

The following PV curve and IV curve represents the maximum power tracking from the panel under non uniform irradiation condition using perturbation and observation algorithm. Here the curve drawn between the PV array voltage (V) and PV array power (W)

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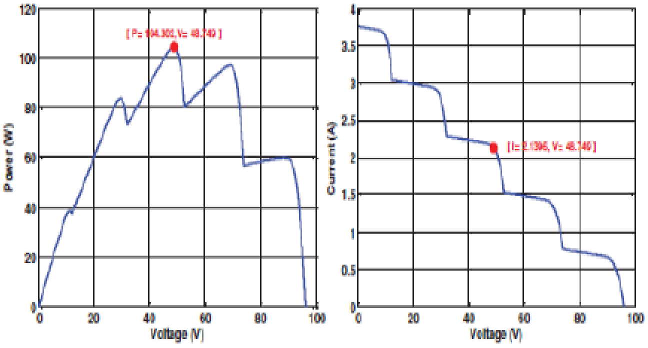

Fig 4.6 P-V &I-V characteristics under partially shaded conditions

Hence Conventional MPPT methods fail to track the maximum power point during partially shaded conditions because of number of local points on the curve. So to overcome these problems we are going for MPPT methods based on soft computing techniques i.e Genetic algorithm.

V.GENETIC ALGORITHM BASED MPPT OF A PV SYSTEM

Genetic Algorithms are are pursuit calculations in light of regular determination and common hereditary qualities. Hereditary Algorithms (GA) give a general way to deal with hunting down worldwide minima or maxima inside a limited, quantized pursuit space[10]. Since GA only requires an Approach to assess the execution of its answer surmises with no priori data; they can be connected for the most part to about any streamlining issue. The "customary" GA is made out of a wellness capacity, a choice procedure, and hybrid and transformation administrators which are represented by altered probabilities [11-12].

Fitness:

The fitness function provides a a path for the GA to examine the execution of every chromosome in the populace. Since the wellness capacity is the main connection between the GA and the application itself, the capacity must be picked with care [12]

Selection:

The selection operator chooses chromosomes from the present era to be guardians for the following generation [10]. The likelihood of every chromosomes determination is given by:

$$Ps(i)=f(i)/ \sum^{N}_{J=1} f(j) \qquad (15)$$

Once one chromosome is selected, the probabilities are renormalized without the selected chromosome, so that the parent is selected from the remaining chromosomes..

Crossover:

The crossover/reproduction operator registers two posterity for every guardian pair given from the choice administrator. This posterity, after transformation, make up the new generation [11].

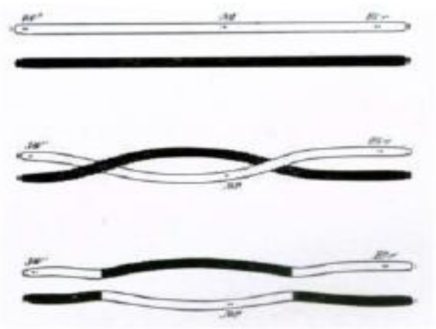

Fig.5.1 Crossover of Two Strands of Chromosome

Mutation:

Mutations are global searches as shown in fig 5.2. A probability of change is again foreordained before the calculation is begun which is connected to every individual piece of every posterity chromosome to figure out whether it is to be altered.

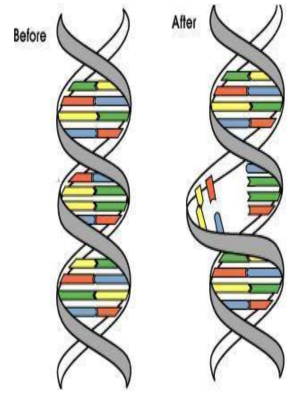

Fig.5.2 Mutation of Two Strands of Chromosome

Flow chart of Genetic Algorithm:

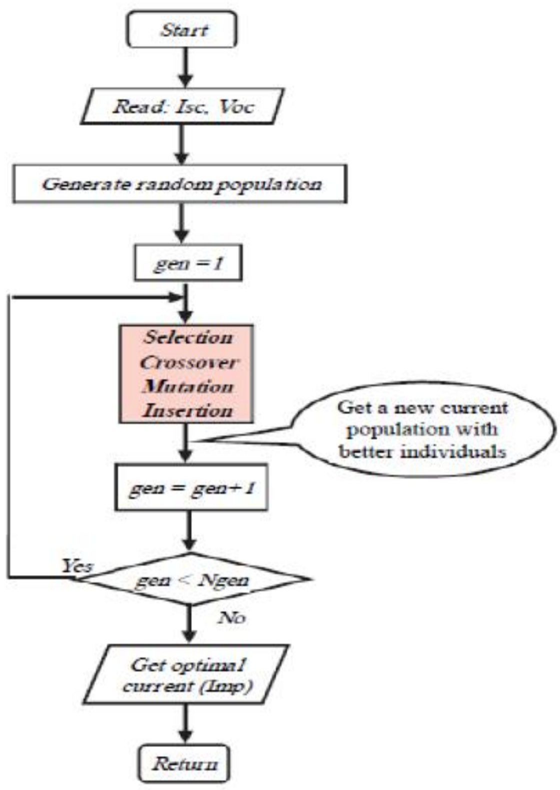

Fig 5.3. Flowchart for genetic algorithm

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Objective function for MPPT using Genetic Algorithm:

The goal is to solve some optimization problems where we search for an optimal solution in terms of the variables of the problem (current and voltage) by imposing the constraints on the current and the voltage which should be both bigger than zero.

$$fitness = \begin{cases} P(V,I)/P_{max}; & if \quad P_{max} < P \\ 0; & otherwise \end{cases}$$

The power equation shown above is a non-linear function of current and voltages which are a function of control variables. The maximization problem is subjected to the following equality and inequality constraints:

$$V < V_{max} \text{ and } P < P_{max} \qquad (16)$$

Our objective is to maximize the output power of the PV array. This can be achieved by generating the population for two variables one parameter as input independent and other as the dependent parameter[12].

$$P=V*I \qquad (17)$$

out of these V and I are the variable parameters and these values of the variable must always lie within the permissible limits.

$$F(X) = V(x)* I (X) \qquad (18)$$

VI. RESULTS AND DISCUSSION

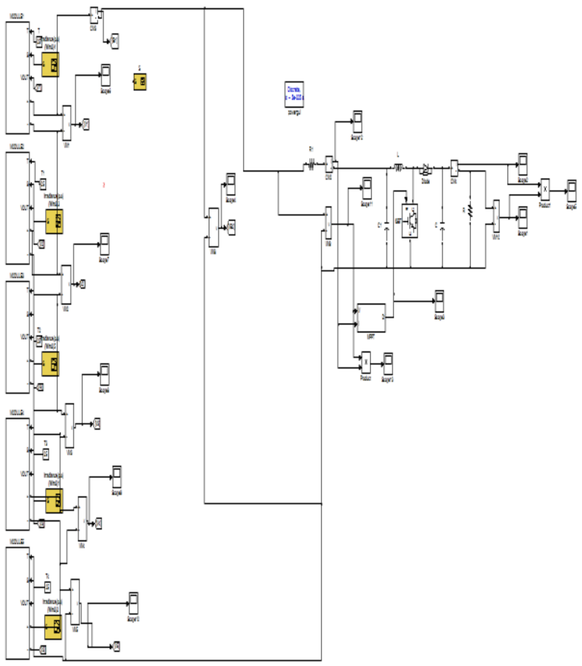

Fig. 6.1. Simulink model of complete PV system with MPPT connected to resistive load.

The following results are represents, under uniform, non uniform shaded condition with and without P&O algorithm.

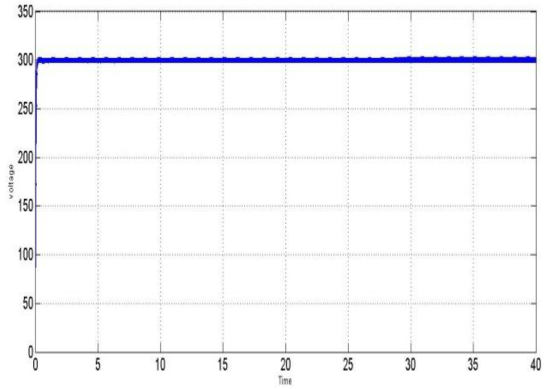

Fig 6.2 under uniform shading,V output without P&O.

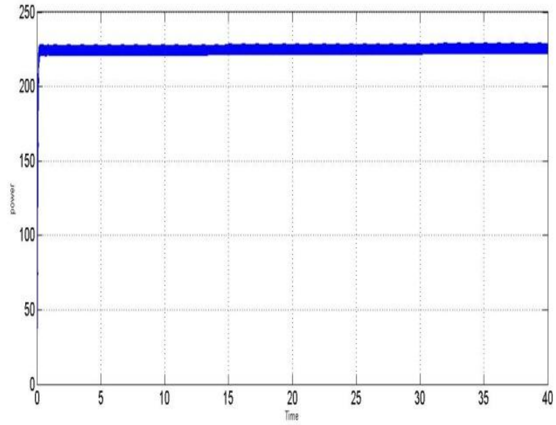

Fig 6.3 under uniform shading, P out without P&O.

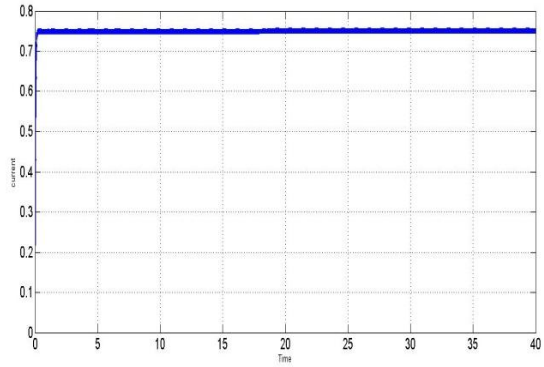

Fig. 6.4 under uniform shading, I output Without P&O

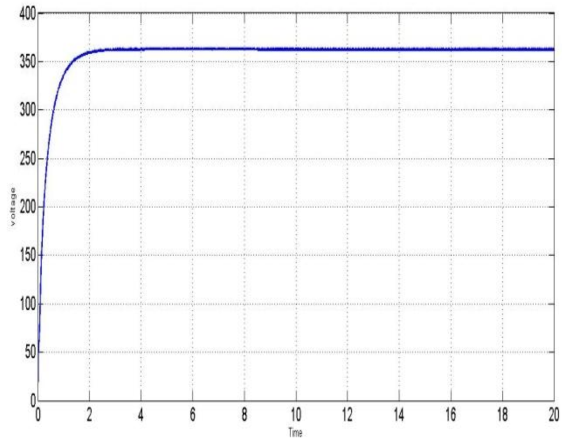

Fig.6.5 under uniform shading output With P&O

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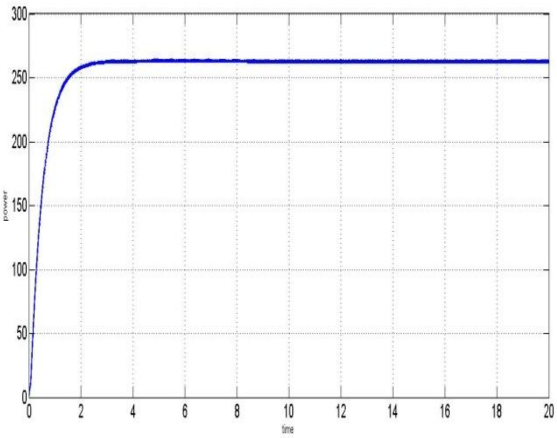

Fig.6.6 under uniform shading, P output With P&O

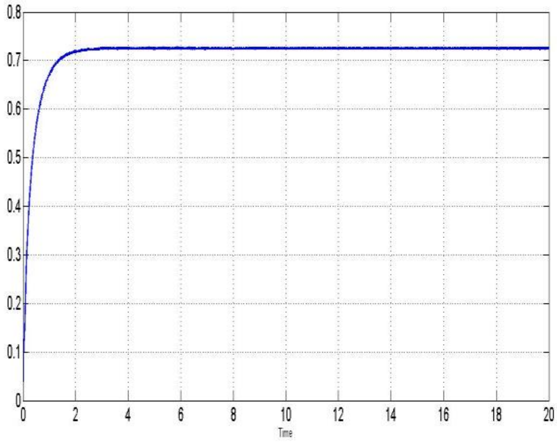

Fig.6.7 under uniform shading, I output With P&O

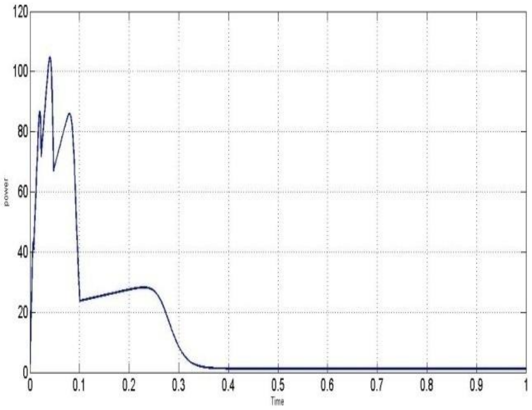

Fig.6.8 Under partiallyshading, P output without P&O

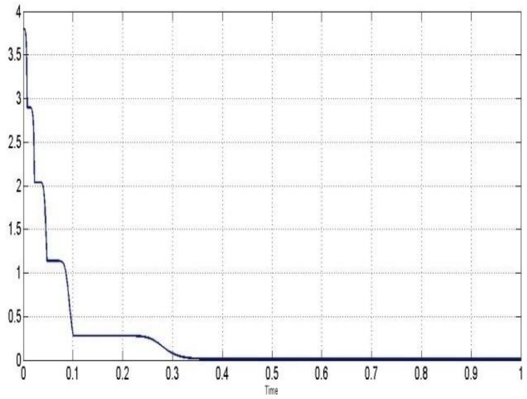

Fig.6.9 Under partially shading, I output without P&O

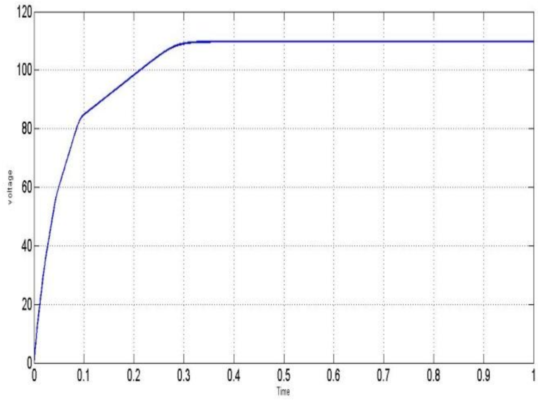

Fig.6.10 Under partially shading output without P&O

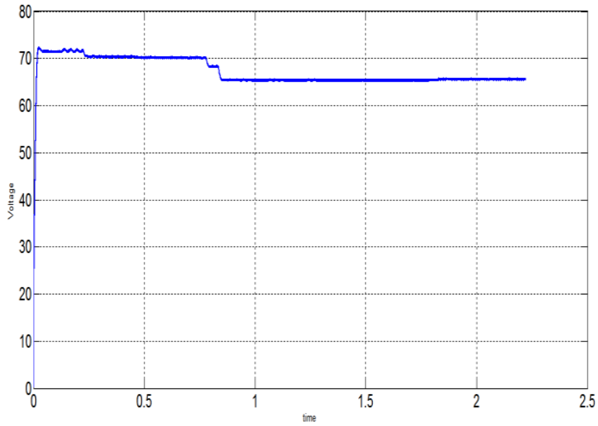

Fig 6.11 output Voltage under partially shaded condition with P&O.

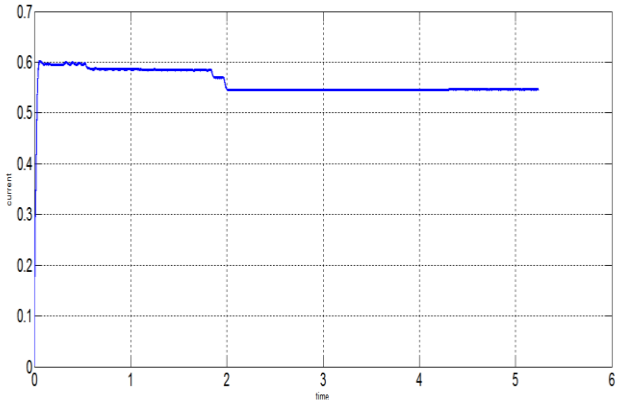

Fig 6.12 output current under partially shaded condition with P&O.

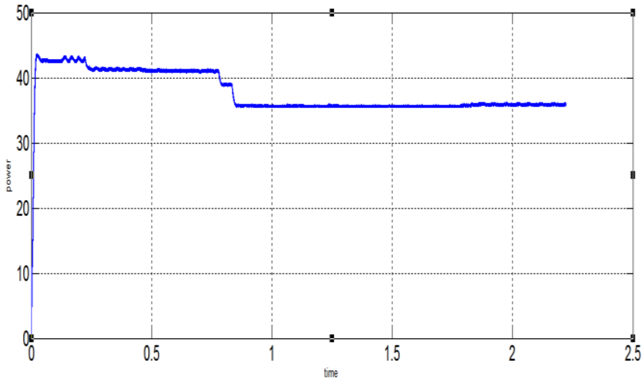

Fig 6.13 output power under partially shaded condition with P&O

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Praposed Technique under Partially Shaded Condition Using- **Genetic ALGORITHM:**

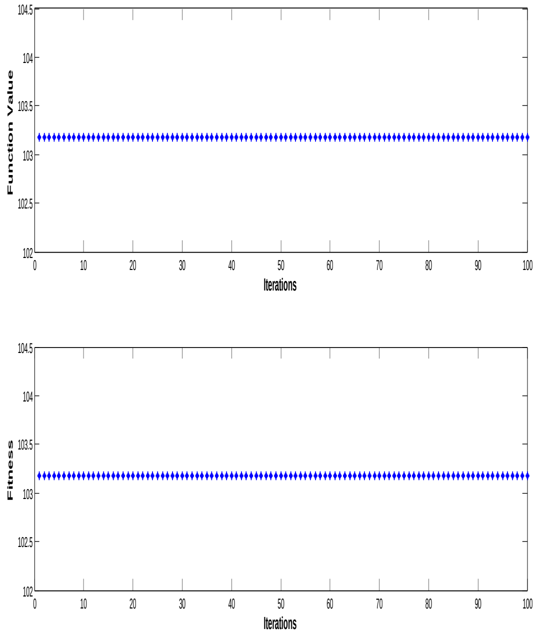

Fig 6.14 .Function value VS number of iterations using genetic algorithm for 100 iterations.

TABLE III. Comparison of MPPT results Using P&O and GENETIC Algorithm Method

S.No	parameter	Under uniform shaded condition		Under partially shaded condition		Under partially shaded condition with GA
		With out P&O	With P&O	With out P&O	With P&O	
1	voltage	300.4	360	109.7	66	48.71
2	current	0.714	0.750	0.019	0.54	2.1
3	power	225	255.6	2-104	36	103.3

VII. CONCLUSION

In order to accurately track the maximum power point of PV system an efficient MPPT technique require. A genetic algorithm based maximum power point tracking technique was proposed in this work. Basic theory of genetic algorithm and its process flow along with objective function for Maximum Power Point problem is defined. After observing the results we can concluded that, a Genetic algorithm based maximum power point tracking technique has high tracking accuracy compared to P&O MPPT technique. This method can detect the global maximum points under partially shaded conditions.

REFERENCES

1. Bidyadhar Subudhi and Raseswari Pradhan, "A Comparative Study on Maximum Power Point Tracking Techniques for Photovoltaic Power Systems" IEEE Transactions on Sustainable Energy, 2013, Vol. 4, No. 1
2. Moacyr Aureliano Gomes de Brito, Luigi Galotto, Jr., Leonardo Poltronieri Sampaio, Guilherme de Azevedo e Melo, and Carlos Alberto Canesin, Senior Member, "Evaluation of the Main MPPT Techniques for Photovoltaic Applications" IEEE Transactions on Industrial Electronics, 2013, Vol. 60, No. 3.
3. M. A. S. Masoum, H. Dehbonei, and E. F. Fuchs, "Theoretical and experimental analyses of photovoltaic systems with voltage and current based maximum power point tracking," IEEE Trans. Energy Conv., 2002, Vol. 17, No. 4, pp. 514–522
4. Subudhi and R. Pradhan, "Characteristics evaluation and parameter extraction of a solar array based on experimental analysis," in Proc. 9th IEEE Power Electron. Drives Syst., Singapore, 2011
5. T. Esram, J. W. Kimball, P. T. Krein, P. L. Chapman, and P. Midya, "Dynamic maximum power point tracking of photovoltaic arrays using ripple correlation control," IEEE Trans. Power Electron.,2006, Vol. 21, No.5, pp. 1282–1291
6. K. Ishaque, Z. Salam, and H. Taheri, "Simple, fast and accurate two diode model for photovoltaic modules," Solar Energy Mater. Solar Cells, 2011, Vol. 95, pp. 586–594.
7. LI Chun, ZHU Xin, SUI Sheng and HU Wan, "Maximum Power Point Tracking of a Photovoltaic Energy System Using Neural Fuzzy Techniques", J Shanghai Univ (Engl Ed), 2009, 13(1), pp.29-36.
8. Abdulaziz M, S. Aldobhani and Robert John, " Maximum Power Point Tracking of PV System Using ANFIS Prediction and Fuzzy Tracking", Procs. Of the Inter. Multi Conf. of engineers and Computer cientists 2008, vol. II, IMECS 2008, 19-21 March,Hong Kong.
9. K. Abdelsalam, A. M. Massoud, S. Ahmed and P. N. Enjeti, "Highperformance adaptive perturb and observe MPPT technique for photovoltaic-based microgrids," IEEE Trans. Power Electron., vol. 26, no. 4, pp. 1010–1021, Apr. 2011
10. D.G. Lorente, S. Pedrazzi, G. Zini, A. Dalla Rosa, P. Tartarini, Mismatch losses inPV power plants, Sol. Energy 100 (2014) 42–49.
11. Y.Shaiek, M.Ben Smida, A.Sakly, M.F.Mimouni"Partial Shading Impact on MPPT Methods of Solar PV Generator' ,Solar Energy ,2013
12. S. Silvestre, A. Boronat, A. Chouder, Study of bypass diodes configuration on PVmodules, Appl. Energy 86 (2009) 1632–1640.
13. S.Daraban, D. Petreus, C. Morel"A novel MPPT (maximum power point tracking) algorithm based on a modified genetic algorithm specialized on tracking the global maximum power point in photovoltaic systems affected by partial shading",Energy,2014

K. Murali Krishna, was born in 1992 at peddapuram, He completed his Graduation in Electrical and Electronics Engineering from the Pragati Engineering College affiliated to jntu Kakinada, Surampalem in 2014. currently studying PG in Power Electronics and Electrical Drives in Pragati Engineering college, surampalem, affiliated to JNTU kakinada .His research area interested in Renewble energy, power electronics, electrical drives

Ashok Reddy sathi, was born in 1986 at anaparthi, he completed his graduation in EEE department , regency institute of technology, in 2010. m.tech (power systems with emphasis on h.v.e) from kakinada institute of technological sciences affiliated to jntu kakinada in NOV-2014.Renewble energy, power systems

K. Siva Shankar, He completed his Graduation in Electrical and Electronics Engineering from the Pragati Engineering College affiliated to jntu Kakinada, Power Electronics and Electrical Drives in Pragati Engineering college, affiliated to JNTU kakinada surampalem. His Research interest in Renewable energy, power electronics, electrical drives

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