JOURNAL ON COMMUNICATIONS

ISSN:1000-436X

REGISTERED

Scopus

www.jocs.review

Optimal Control of Optimization-Based Solar Photovoltaic Systems

[1] Vivek Kumar Yadav, [2] E Vijay Kumar
[1,2] Department of Electrical Engineering
[1,2] SRK University, Bhopal

ABSTRACT

The demand for energy has been rising quickly in recent years. Innovative approaches to energy conservation are being put forth. To reduce electricity costs and increase the return on investment for solar module purchases, an environmentally friendly system should be developed. When compared to other conventional sources, the photovoltaic industry can be more competitive since its systems are more cost-effective and efficient. Irradiation and panel temperature present greater difficulties for PV modules due to their instability. As a result, PV panel electricity generation is inherently unstable. To harvest the most power from PV modules, the Maximum Power Point Tracking (MPPT) technology is employed. To maximize power extraction from PV modules or strings of PV modules, a DC-to-DC converter has been utilized to match the impedance between PV modules or arrays of modules. Grey Wolf Optimization (GWO), Particle Swarm Optimization (PSO), and Perturb and Observe (P&O) techniques have all been used in this work. These algorithms' MPPT performance has been confirmed in the MATLAB/Simulink environment.

Keywords— MPPT, P&O, PSO, GWO, Buck converter.

I. INTRODUCTION

In 21 century the utilization of renewable sources of energy has been increased rapidly. Solar energy is one of the important renewable sources of energy since it is clean, pollution free and in exhaustible. Non-conventional energy sources act vital contribution in the field of electric power system. There are various types of Non-conventional resources, i.e solar energy, wind energy, Bio – gas, tidal etc. Non-conventional energy sources are used for generations of electric power. Solar system is one of the Non-conventional energy sources. it is used for electric power generation. The solar energy is converted heat energy into electrical energy by solar photovoltaic modules. Solar Energy is made up of silicon cells. Solar cells are connected in series and parallel. When solar cells connected in series in this condition Increases the rating of current in this modules, the cell area increased individual. Number of Solar PV modules is connected in the series and parallel combinations that is known as solar PV array i.e. is applicable for obtaining maximum output power.

Now days many researchers are working to improve the materials and methods for high output power. Solar Photo Voltaic panels generate electricity is called the "Photovoltaic Effect". The simplest form the Photovoltaic Effect can be described as follows: when a solar cell is illuminated, electron-hole pairs are generated and the electric current is obtained. The electric current is the difference between the solar light generated current and diode current.

There are several accesses to obtain maximizing power extraction in solar systems. In is methods, we track the sun intensity to obtain the, maximum power point (MPPT) tracking or both. In this research, MPPT tracking techniques are apply and comparison has been done between with different optimization methods as like Perturb & Observe Particle Swarm Optimization and Grey Wolf Optimization for finding maximum power point.

II. RELATED WORKS

[1] Optimization methods are applied to obtain the track maximum power. A DC- DC power converter is applied to step–up voltage of solar photovoltaic system. It containing at least semiconductor device as like a diode and a transistor. The boost converter also contains battery for storage the energy. Inductance, a capacitor. The capacitor reduces ripple voltage and filters.

Buck-Boost converter is applied to obtain the Z (impedance) matching between the Solar PV array and the load. There are many approaches to propose in this paper. The perturb and observe is based on technique are the most widely applicable in commercial products. The perturb and observe methods can be implemented.

Simulation result is verified by power sim simulator and experimental. Three MPPT methods, classical P&O and a new enhanced PSO algorithm and GWO. [2] Maximum power tracking (MPPT) that is mainly concerned on Incremental conductance method with direct control.
In this methods microcontroller (dsPIC30F2010) has been used for controlling for maximum power tracking. There are many methods to obtain the optimize power by different techniques i.e Perturb and 0bserve, Incremental Conductance (Inc), fuzzy logic. [4]

In this paper expound the +ve impact effect of the maximum power point tracking methods on the solar PV system. In this paper expound the theory of operation of different methods. Electronics converters are applied for tracking the maximum power.
This paper is implemented different algorithm for obtain optimize power and comparison the result.

III. METHODOLOGY

Methodology of proposed method is described in the flowchart which is mentioned in the figure1.

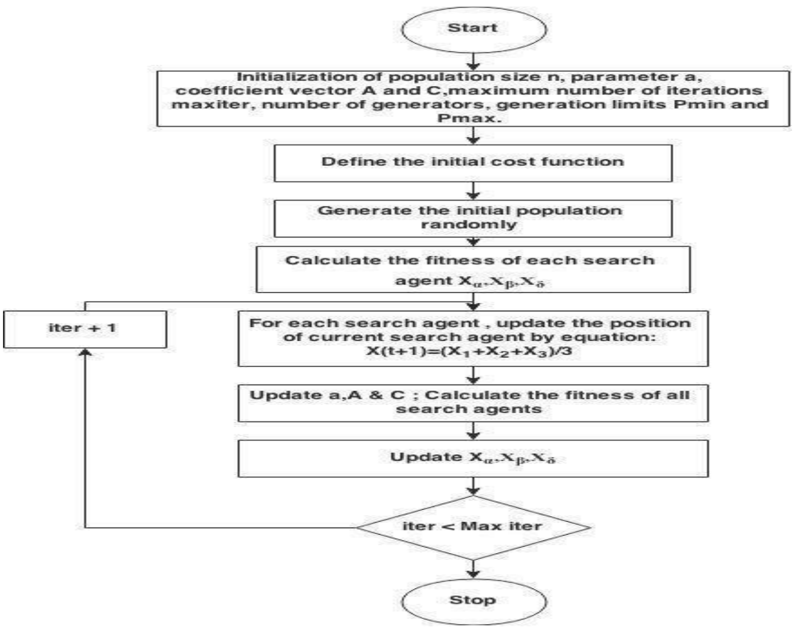

Figure 1: Flowchart of Grey Wolf Optimization Algorithm

IV. MATHEMATICAL MODELLING OF SOLARPV SYSTEMS

A mathematical expression involved in current source type PV model which is represented by continually circuit shown in fig. 2.

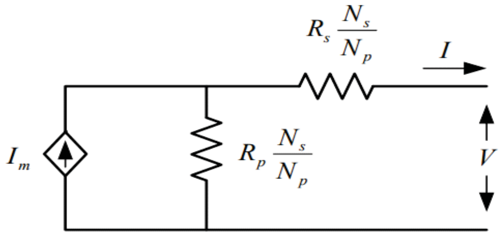

Figure 2: Equivalent Circuit PV Module

The generalized equation of PV model is given by equation which is given below.

$$I_{pv}N_p\_I_oN_p\left[\exp\left(\frac{V+R_s\left(\frac{N_s}{N_p}\right)I}{V_t a N_s}\right)-1\right]$$

Where,
R_s = Series resistance of array
R_p = Parallel resistance of array
I_m is the module current
Ns & Np Ns are the number of series and parallel

The thermal voltage of PV array is given in the equation given below.

$$V_t = \frac{N_{cs}KT}{q}$$

Where,
Ncs = N_0 of series connected cell,
K = Boltzmann's constant
T = Temp. in P-N junction
Ipv = Photo-voltaic current

Ipv can be expressed in equation given below.

$$I_{pv} = \left(I_{pvn} + K_i \Delta T\right)\frac{G}{G_n}$$

Here, Io = reverse leakage current and explained in equation,

$$I_o = \frac{I_{scn} + K_i \Delta T}{\exp\left(\frac{V_{ocn} + K_v \Delta T}{aV_t}\right) - 1}$$

Where,
Ipvn = Generated,
G = Irradiance at normal condition.
Iscn = Short Circuit Current
Voc = Open Circuit Voltage

V. SIMULATION RESULTS

PV module, MPPT Controller and DC to DC converter are cascaded together shown in figure3. PV is shown in left side and yellow box MPPT controller which is part of Matlab Subsystem. Resistive load (green block) where power is extracted from PV module and measured by Scope (Blue block). Duty of IGBT switch is controlled by MPPT controller which can change based upon the load or any change in environmental condition.

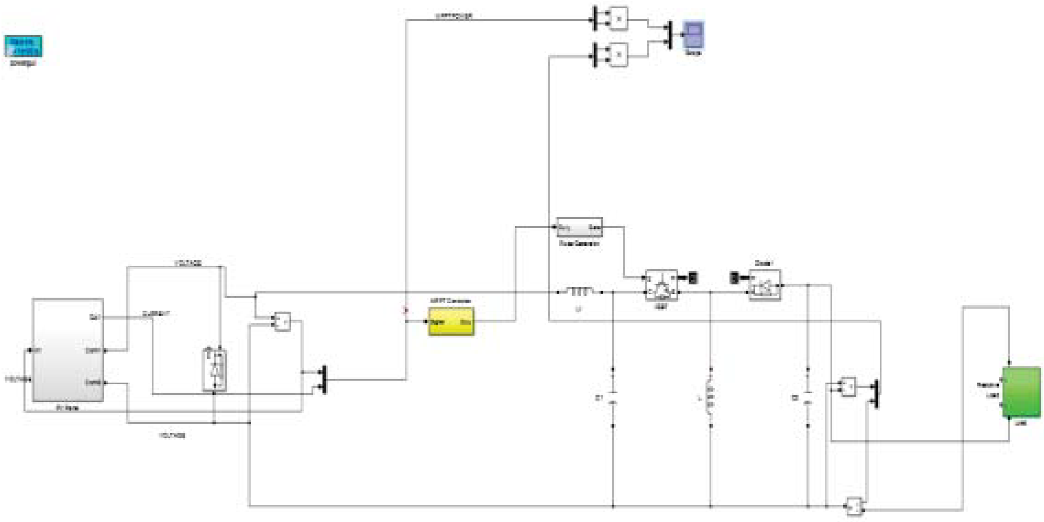

Figure 3: Simulink Model

Maximum power which can be extracted by PV module shown in yellow line and pink line shows power dissipated in resistive load. Simulation time was chosen to be 0.2
second. Step size is 1e-6. After 0.14s simulation runs in steady state. In Fig we obtain the maximum power from solar panel is 322.2W show in yellow line using optimum operation of solar photovoltaic system using grey wolf optimization method and pink line is resistive load and its value is 281.9W.

Table 1: Comparison Result Obtained by P&O, PSO & GWO

Temperature	P&O		PSO		GWO	
($T^{o}C$)	Max Power (watts)	Power across Load in (W)	Max Power (watts)	Power across Load in (W)	Max Power (watts)	Power across Load (Watts)
10	270.1	234	270.3	226.8	270.6	227
20	280	242	280.5	237.5	280.7	237.6
30	289	251	291.2	248.5	291.6	248.7
40	297.5	258	297.7	259.5	301.6	259.8
50	305	266	310	270	312.4	271
60	313	272.8	322	280	322.2	281.9

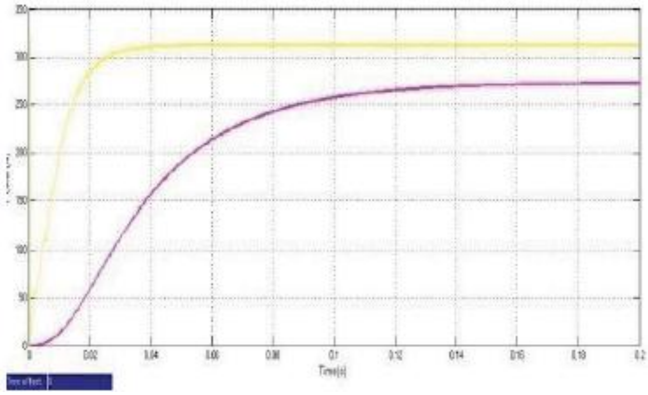

Figure 4: Maximum Power and Power Dissipated in Load by using P&O

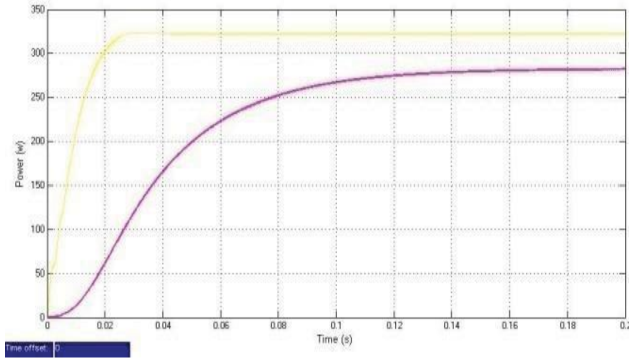

Figure 5: Maximum Power and Power Dissipated in Load by using PSO

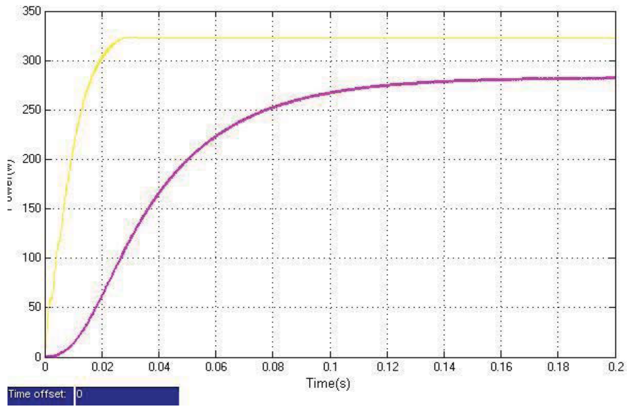

Figure 6: Maximum Power and Power Dissipated in Load by using GWO

The results of P&O, PSO and GWO have been displayed with respect to the temperature in increasing fashion which is given in the table1.

VI. CONCLUSION

In this paper, the simulation of MPPT of PV panel using Perturb & Observe (P&O), Particle Swarm Optimization (PSO) and Grey Wolf Optimization (GWO) methods has been presented. A comparison of PV panel output corresponding to all three algorithms and its power dependence on temperature has been shown. The results obtained after using GWO technique is best compare to the other two technique. It has been seen that with increase the temperature, power also increases. So, it may be said that maximum power is depend on irradiation temperature. It may be concluded that Grey Wolf Optimization (GWO) technique shows better results and may be used MPPT of PV panel.

REFERENCES

[1] C. Jaen, C. Moyano, X. Santacruz, J. Pou, Antoni Arias, “Overview of maximum power point tracking control techniques *Electronics Circuits and Systems Conf., vol.1*, pp. l099-1102, 2008.

[2] E. Koutroulis, K. Kalaitzakis, “Development of microcontroller-based photovoltaic maximum power tracking control system, “*IEEE Trans. Power Electronics.,* vol.1, pp. 10-14, 2001.

[3] E. Malarvizhi, J. Kamala, A. Sivasubramanian, “Evaluation of particle swarm optimization algorithm in photovoltaic applications,"*in proc 10th International. Intelligent Systems and Control (ISCO) Conf., vol.*2, pp. 1-6, 2016.

[4] N. Femia, G. petrone, G. Spagnuolo and Vitelli, “Optimization of Perturb and Observe maximum power point tracking method,’’*IEEE Trans. Power Electronics.,* vol-20, pp.26-30,2005.

[5] XU. Honghua, “The study on development of PV technology in China,” *IEEE Trans. Power System Technology.,* vol. 31, no. 20, pp. 77-81, 2007.

[6] P. Bhatnager, R. K. Nema, “Maximum power point tracking control techniques: State of the art in photovoltaic application,”*IEEE Trans. Renewable and Sustainable Energy Reviews.,* vol. 23, pp. 224-241, 2013.

[7] Udhayavinodhini, P. Anbarasu, G. Suresh, “MPPT desion using perturb & obserb method combined with fire algorith, “*IEEE Trans. Instrument and Control.*, vol. 3, pp. 68-71, 2015.

[8] D. T. Reddy Challa, I. Raghavendra, “Implementation of incremental conductance MPPT with direct control method using cuk converter, “*International Journal of Modern Engineering Research (IJMER).,* vol.2, no.6, pp. 4491-4496, 2012.

[9] Al-Nema. M. A, Mr. Shamil and Al-Layla, “Analysis, Design and implementation of modified single-phase inverter, “*IEEE Trans. Power Electronics.,* vol.19, pp. 1184-1194, 2007.

[10] C. Kashif Ishaque, Zainal, Md Amjad, S. Mekhilef, “An improved particle swarm optimization (PSO)-Based mppt for pv with reduced steady-state oscillation, “*IEEE Trans. Power Electronics,* vol.27, no.8, pp. 68-76 2012.

[11] V. Salas, E. olias, A. Barrado, A. Lazaro, “Review of the maximum power point tracking algorithms for standalone photovoltaic system, “*IEEE Trans. Power Electronics*, vol. 90, no.11, pp.1555- 1578, 2006.

[12] G. Eason, B. Noble, I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of bessel functions,” *Phil. Trans. Roy. Soc.*, vol. A247, pp. 529-551, 1955.

[13] Esram T, Chapman P. L, “Comparison of photovoltaic array maximum power point tracking techniques,” *IEEE Trans. Energy Conversion.,* vol.22, no2, pp 439-449. 2007.

[14] Bo-Ruei Peng, Kun-Che Ho, Yi-Hua Liu, “A novel and fast MPPT method suitable for both fast changing and partially shaded conditions, “*IEEE Trans. Industrial Electronics.,* vol. 65, pp. 3240-3251, 2018.

[15] Hong Li, Wenzhe Su, Fang Ren, Changlin Ji, Jinhu Lü, “Three-point bidirectional perturbation MPPT method in PV system,” *in proc 43rd Annu. IEEE Industrial Electronics Society Conf.,* vol.3, pp. 7986-7991, *2017.*

[16] M. H. A. Majid, A M. R. Arshad, “Cooperative underwater acoustic source searching based on adaptive PSO algorithm,” *Underwater system technology: in proc 7th Annu. IEEE Theory and Applications (USYS) International Conf.,* pp. 1-6, 2017.

[17] Moh. Zaenal Efendi, Farid Dwi Murdianto, Rangga Eka Setiawan, “Modeling and simulation of MPPT sepie converter using modified PSO to overcome partial shading impact on DC microgrid system,”*IEEE Trans. Engineering Technology and Applications (IESETA) International Electronics Symposium .,* pp. 27-32, 2017.

[18] E. Malarvizhi, J. Kamala, A. Sivasubramanian, "Evaluation of particle swarm optimization algorithm in photovoltaic applications," *in proc 7th Annu. Intelligent Systems and Control (ISCO) International Conf.,* vol.7, pp. 1-6, 2016.
[19] N. Kumar, I. Hussain, B. Singh, B. K. Panigrahi, "Rapid MPPT for uniformly and partial shaded PV System by using jayade algorithm in highly fluctuating atmospheric conditions," *IEEE Trans. Industrial Informatics.,* vol.13, pp. 2406-2416,2017.
[20] Hong Li, Wenzhe Su, Fang Ren, Changlin Ji, Jinhu Lü, "Three-point bidirectional perturbation MPPT method in PV system," in proc *7th Annu 43rd IEEE Applies Industrial Electronics Society IECON.,* pp. 7986-7991, *2017.*
[21] S. Paul and W. Jewell, "Optimal capactor placement and sizes for power loss reduction using combined power loss index-loss sensitivity factor and genetic algorithm, "*IEEE Trans. Power and Energy Society General Meeting.,* vol.2, pp.1-8, 2012.
[22] C. Hari Prasad, K. Subbaramaiah, P. Sujatha, "Grey wolf optimization algorithm for maximum annual savings in radial distribution system, "In *Proc of the Second International Conference Methodologies and Communication on Computing (ICCMC). IEEE Conf.*,vol.2,pp68-72, 2018.
[23] S. Mirjalili, S. Md. Mirjalili. A. Lewis, "Grey wolf optimizer, "*Advances in Engineering Software,* vol. 69, pp. 46-61, 2014.