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Optimum MPPT Scheme For Solar System Under Partial Shading Condition

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***Abstract*-In recent times a huge attention has been given on development of proper planning at the global, national and regional level to handle the energy consumption on one hand and consequent emissions on the other. Energy models help in integrated assessment considering availability, potential, economics, emission, technology, social acceptance etc. In this work a detailed analysis has been done of research advancements in the field of power sector using the solar energy by utilizing the fuzzy logic-based control and estimation methodology. The collected information comprises of various solar system-based application which are recently proposed and how the fuzzy inference system is applied in this application. We have focused on MPPT based solar system performance enhancement by use of fuzzy logic controller's designs optimized by particle swarm optimization (PSO). We have described about different latest A.I. techniques that has been hybrid with fuzzy logic for improving PV array based solar plants performance in recent time. The artificial intelligence technique applied in this work is the Particle Swarm Optimization (PSO) algorithm and is used to optimize the fitness functions for maximum power point tracking rule set. By using PSO algorithm, the optimized controller is able to maximize energy to the system loads while also maintaining a higher stability and speed as compared to P& O based MPPT algorithm.**

***Keywords*-Photovoltaic systems, maximum power point tracking (MPPT), particle swarm optimization (PSO), perturb and observe (P&O).**

I-INTRODUCTION

In spite of the course impacts of the money related emergency that have influenced each part, in differing degree and geography, the interest in renewable energy keeps developing with a maintainable pattern. By new report of the UNEP (United Nation Environment Program), the interest in renewable energy rose 5% in 2008 demonstrating certainly the foundation of new strategies for electric power generation and affirms that this area speaks to now a standard energy investment. The atmosphere of the great soundness of renewable energy is the product of the cooperation of the legislative and societal engagement towards substantial activities to moderate environmental change by lessening Green House Gasses (GHG), decreasing their reliance on fossil fuel supply and making energy security a key need. Surely, the current monetary and sparing emergency might have backed off the interest on the fossil fuel energy and driven down costs.

PV is an appealing wellspring of renewable energy for conveyed urban power generation because of their generally small size and quiet operation. Their applications are required to fundamentally expand everywhere throughout the world. Sun based photovoltaic power is a non-specific term utilized for electrical power that is produced from daylight. A sun based photovoltaic system changes over sunlight into electricity. Fundamental building block of solar photovoltaic power is the solar cell or photovoltaic cell. A solar cell is a self-contained electricity-producing device constructed of semi-conducting materials. Light strikes on the semi-conducting material in the solar cell, creating direct current (DC). Fig. 1.1 shows the voltage and current characteristic curves of a photovoltaic (PV) cell. It is very easy to find the maximum power point with the help of a power curve in Fig.1.

When the PV works at the maximum power point, the energy transfer efficiency from sunlight to electrical power is at its maximum. The equivalent circuit of a PV module used is shown in Fig. 2. In the calculation of the power output of a PV module, we assume that a maximum power point tracker will be used. Manufacturers of PV modules supply information on the voltage and current of the maximum power point at a reference temperature and a reference irradiance. The output current I can be expressed as a function of the output voltage V from the equivalent circuit of the PV module. Normally, the power output curve at every hour is used for power system optimization. In this work, the forecasting data of the PV power output based on the maximum power point tracker issued for implementation of PV modules. In the PV system, the maximum power output is presented by (1) [1].

$$p_s = \eta SI(1 - 0.005(t_o - 25))$$

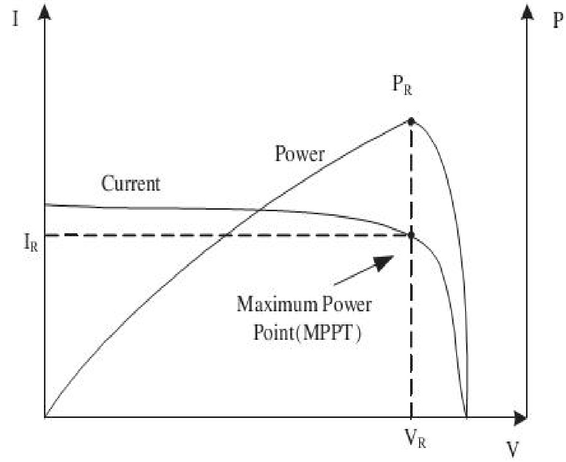


Fig. 1: V-I characteristic curve and maximum power point of PV

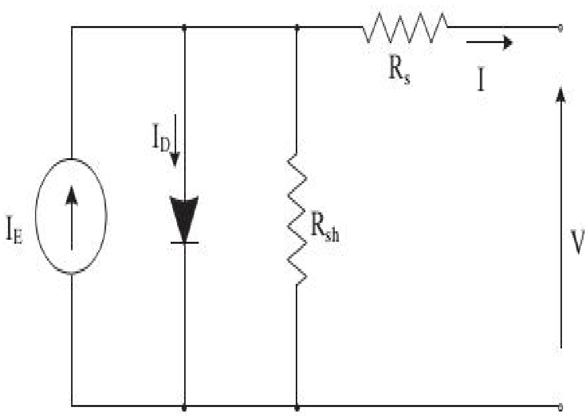


Fig. 2: Equivalent circuit of a PV module.

Generally, MPPT is adopted to track the maximum power point in the PV system. The efficiency of MPPT depends on both the MPPT control algorithm and the MPPT circuit. The MPPT control algorithm is usually applied in the DC-DC converter, which is normally used as the MPPT circuit. Typical diagram of the connection of MPPT in a PV system is shown in Fig. 3. [2]

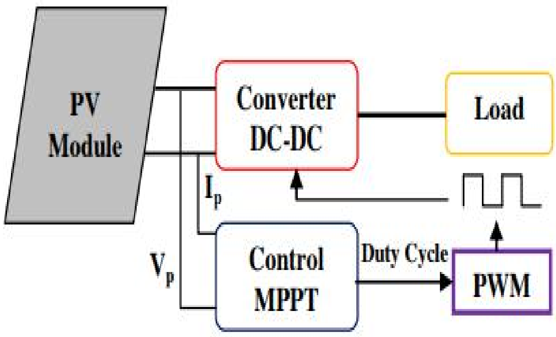


Fig. 3: PV System with MPPT diagram.

The complete photovoltaic system model is poised of the PV array, maximum power point tracker, battery charge controller, energy dispatch controller, batteries, critical loads, inverter and non-critical loads. In command to simplify the simulation and focus on the controller aspect of this system, all of the biased system components (for example maximum power point tracker, the inverter, wiring, batteries, and so on.), are assumed to operate at 100% efficiency; in the actual world though, these components are non-trivial, through several maximum power point tracking algorithms being recently proposed. Usually, PV panels vary in efficiency from 6% to 30%; though the high efficiency panels are generally reserved for spacecraft usage because of their high radiation tolerances and higher power-to-weight ratio. An irregular equivalent to the PV arrays being simulated. The main focus of this study is to study, compare and improve the Maximum Power Point Tracker (MPPT) by use of PSO based algorithm.

II-MAXIMUM POWER POINT TRACKING

The characteristic curves of a solar cell are nonlinear and depend on the irradiance level and ambient temperature, resulting in a unique current–voltage (I–V) curve. Consequently, the operating point (OP) of a PGS must be adjusted to the extent in which the maximum efficiency of the solar cells can be achieved, and this technique is called maximum power point tracking (MPPT) [3]. The Perturb and Observe (P&O) method is the most common MPPT approach applied in commercial PGSs [4]. This method determines the system control commands according to the difference in the power output between the current system state and previous system state. Consequently, determining the perturbation step applied to a system is an essential topic. At the point when a considerable annoyance step is used by a framework, the time required for the framework to track the maximum power point (MPP) and accomplish an unfaltering state is short, yet the measure of force misfortune brought about by the bother is high. PSO based controller techniques can be applied to nonlinear systems. Moreover, such techniques do not require accurate system parameters or complex mathematics models to achieve superior control performance. Therefore, PSO-based MPPT methods have become a worthy research topic.

Regarding the input variable selection, most MPPT techniques take the error (e(t)), usually defined as

Ppv(t) − Ppv(t− t), dPpv(t)/dVpv(t) or dPpv(t)/dIpv(t),

where Ppv(t) represents the panel output power and the change in error (de(t)/dt) as inputs [5].

To increase the effectiveness of the PSO-based MPPT method under partial shading condition, efficient methods that can be used to determine the duty cycle setting values are proposed. These methods rapidly determine the fitness function setting values according to the P–V curve of solar cells under standard test conditions (STC, i.e. 1000 W/m2, 25 °C) with partial shading. This technique can enhance the adequacy of PSO-based MPPT strategies and embraces a basic strategy outline. The strategy applies the particle swarm optimization (PSO) system to get the improved information for duty cycle setting. Because of the way that the PSO approach must focus on a cost capacity to improve, the technique of planning the cost capacity which meets the execution prerequisites of PGS is likewise proposed. Finally, after obtaining the optimized duty cycle values, an inexpensive controller is adopted to implement the proposed PSO-based MPPT method. To validate the correctness and effectiveness of the proposed system, the simulations and experiments are then conducted.

III-PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization (PSO) is an evolutionary computation technique, which is inspired by flocks of birds and shoals of fish. In PSO, a number of simple entities (the particles) are placed in the space of some problem and each evaluates its fitness as its current location. Each particle determines its movement through the space by considering the particle which had the best fitness and the history of its own, then it moves with a velocity. At last, the swarm is liable to move near the best area. The speed and position of every molecule is balanced by the accompanying formulas:

Vid =WXVid + c1Xrand()X(Pid-Xid)+C2XRand()X(Pad-Xid) Xid =Xid + Vid

here c1 and c2 are termed the cognitive and social learning rates. These two parameters control the relative importance of the memory of the particle itself to the memory of the neighbourhood. The variable rand() and Rand() are two random functions that is uniformly distributed in the range [0,1].

Xi = (Xi1, Xi2, … ,XiD) represents the ith particle. Pi = (Pi1, Pi2, …,PiD) represents the best previous position of the ith particle.

The symbol g represents the index of the best particle among all the particles. Vi = (Vi1, Vi2, … ,ViD) represents the velocity of the ith particle. Variable is the inertia weight.

In this section, we propose two improved algorithms called Dynamic and Adjustable Particle Swarm Optimization 1 (DAPSO1) and DAPSO2. In DAPSOs, in order to adjust the velocity of each particle, all particles are calculated the distance from itself to the global best position by the following function.

Δxdi=|(xdi-xgbest)|

FDd = Max(Δxdi)

Where Xid is updated by the velocity which is adjusted by the distance from particle to the global best and is the adjustment coefficient. DAPSO1 and DAPSO2 differ from the adjusting method. In DAPSO2, the velocity and position of each particle is adjusted by the following formulas:

$$V_{id} = WXV_{id} + c_1Xrand()X(P_{id}\text{-}X_{id}) + C_2XRand()X(P_{ad}\text{-}X_{id})$$

$$V_{id} = \begin{cases} V_{id} * \left(1 + \frac{rand()}{4} * \frac{Gene-Iter}{Gene}\right) & \frac{\Delta x_{di}}{FD_d} > 0.5 + ac_d \\ V_{id} * \left(1 - \frac{rand()}{4} * \frac{Gene-Iter}{Gene}\right) & \frac{\Delta x_{di}}{FD_d} < 0.5 - ac_d \\ V_{id} & 0.5 - ac <= \frac{\Delta x_{di}}{FD_d} <= 0.5 + ac \end{cases}$$

$$X_{id} = X_{id} + V_{id}$$

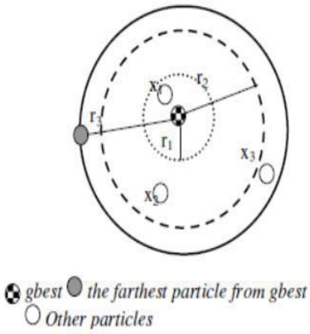


Fig. 4: Three radius of (0.5- ac)* FDd, (0.5+ ac)* FDd, and FDd .

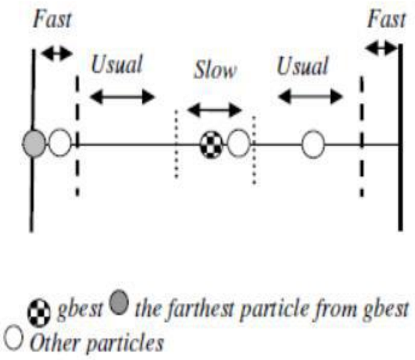


Fig. 5: Adjust the velocity according to the distance from the particle to gbest.

The general flow of DAPSOs and the flowchart of DAPSO are shown as follows.

Step 1. Initialization of a population of particles with random positions and velocities.

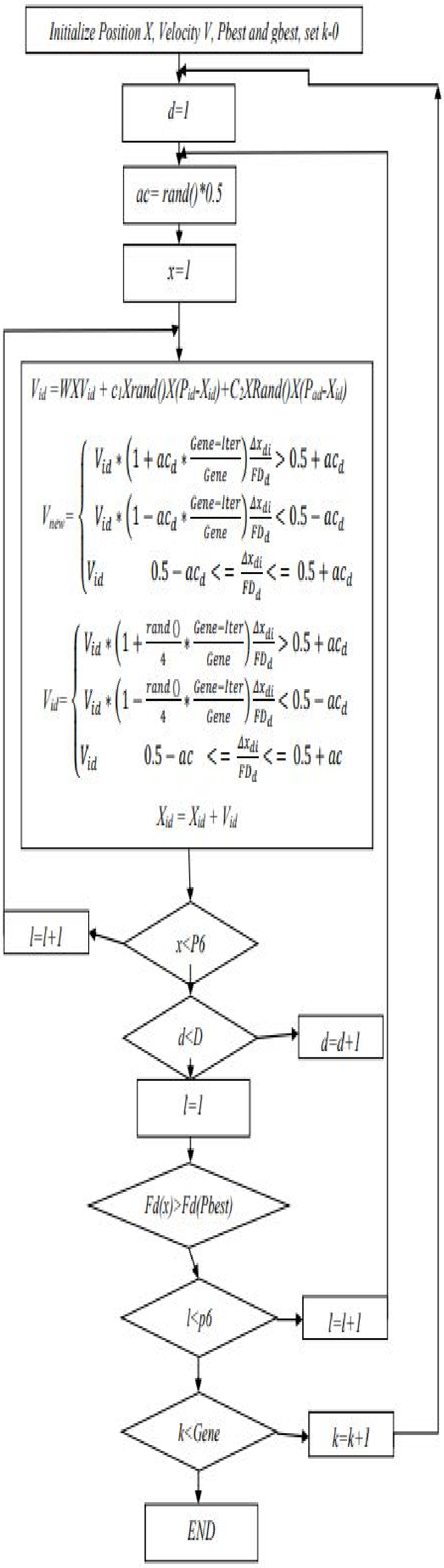
Step 2. Evaluation of particles.

Step 3. Calculate the distance from each particle to the global best position and save the farthest distance in the memory.

Step 4. Adjust particle's velocity according to its distance from itself to the global best position.

Step 5. Update particle's position by the adjusted velocity.

Step 6. Repeat Step.2~Step.5 until termination criteria are met.



IV- FLOWCHART OF DAPSO

V-MODEL AND SIMULATION RESULT

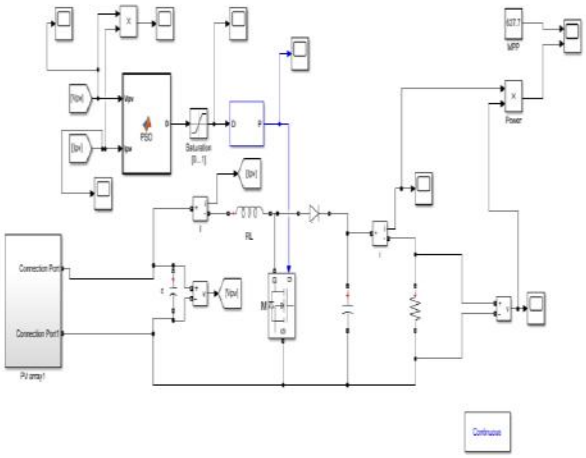


Fig 6: PV array with PSO MPPT controller

Figure shows the complete model design after assembling the PV array MPPT controller to the boost converter. The current model is operated at partial irradiance 500,800,1000,1000 W/m2 at temperature 25 C. The power, current and voltage output of PV array is shown in scope 4 and output of converter is shown at scope 5.

Similarly, Iin and Vin are the PV array current and voltage output given to the input of DC-DC converter. The MPPT controller varies the duty cycle of gate pulse as per the value of voltage and current change i.e Vin and Pin such that after iterative perturbation in voltage the converter input condition achieves the state of maximum power point. Due to this we can observe fluctuation in Vin ,Iin and Pin in starting moments of plot of figure 7.

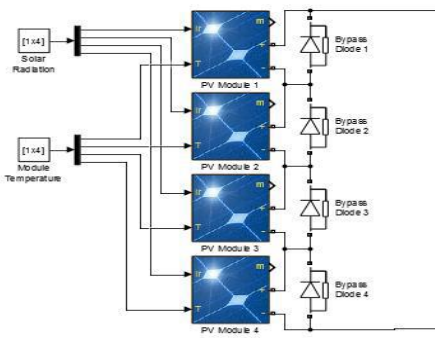


Fig 7: Simulink Model For PV array.

In the figure 7 partial shading solar irradiance signal is given to get Vout for irradiance in W/m^2 is given as S and temp (temperature) is given at input T.

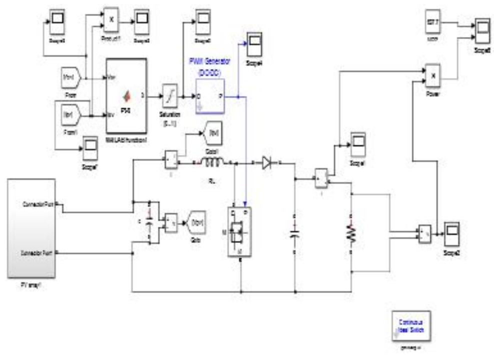


Fig 8: PV array with PSO MPPT controller and Buck converter.

Figure 8 shows the complete model design after assembling the PV array MPPT controller to the boost converter. The current model is operated at partial irradiance 500,800,1000,1000 W/m^2 at temperature 25 C. The power , current and voltage output of PV array is shown in scope 4 and output of converter is shown at scope 5 Similarly Iin and vin are the PV array current and voltage output given to the input of DC-DC converter. The MPPT controller varies the duty cycle of gate pulse as per the value of voltage and current change i.e Vin and Pin such that after iterative perturbation in voltage the converter input condition achieves the state of maximum power point.

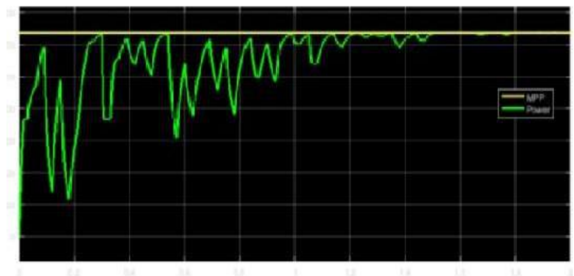


Fig 9: PV array with MPPT controller and boost converter input power, current and voltage.

Due to this we can observe fluctuation in Vin ,Iin and Pin in starting moments of plot of figure 9 .After some time as the max. power point is achieved the perturbation becomes very small just to maintain the duty cycle at a voltage desired Vin. We can see that at steady state Vin is at 30V and Pin is 637W (approx.).

VI-CONCLUSION

In latest time renewable energy sources are gradually becoming very important source of energy. In comparison to all the renewable sources of energy the solar power is most suitable due to its property of least carbon emissions. The output power of a solar photo voltaic cells depends on the sunlight exposure, irradiation intensity and the environmental temperature. This work considers the case of obtaining maximum power from photovoltaic cells-based array for power system usage. The objective is consideration of a design of power system that fulfils the requirement of stable and fast maximum power point tracking (MPPT) controller. The PSO optimized controller-based results are compared with the conventional techniques such as P&O and normal controlling methods which shows that the power output by the PSO optimized scheme gives higher power than both methods. The design consists of electronically gate controlled MOSFET based boost converter interfaced with photovoltaic arrays for DC-DC converter development operating at MPPT conditions. By applying the gate pulse width switching are controlled with appropriate duty cycle evaluation by MPPT algorithm related rules. The proposed scheme based PSO optimized controller results also have an advantage that the Pout has ripple free performance and it is faster than other and P&O controlling scheme. In future the obtained investigation and simulation results of the proposed PSO optimized can be validated on real time experimental setup-based practical’s to shows that the simulation results closely agree with the experimentally obtained results for validating the experimental power circuit and control circuits of the dc- dc converter.

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