Cuckoo Optimization Algorithm for MPPT of Photovoltaic Systems

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Abstract. *The article presents a review about Maximum Power Point Tracking (MPPT) of PV system based cuckoo search algorithm. Cuckoo search (CS) provides several advantages such as the process of tuning parameters is few with high efficiency beside fast convergence. Cuckoo search uses a random walk according to le'vy flight in searching process. MPPT by using cuckoo search is compared to other two methods, neural network method which needs training for data and the incremental conductance method. DC-DC converter is utilized with direct duty cycle control of PWM based PID controller. The PID controller parameters are tuned using particle swarm optimization (PSO) and compared with classical methods. The results show that CS can track MPP under different operating conditions with lower power losses compared to the other two methods. Recently many researches start on a new topology called cuckoo search optimization (CS), This method has a several advantages over conventional methods and over others methods. CS for MPPT of PV system is applied and compared with two methods, namely artificial neural network (ANN) and incremental conductance methods (IC). To ensure the capability of the proposed search method, CS, different operating conditions are considered and tested. PID controller tuned by PSO to control the duty cycle of the DC-DC converter to guarantee MPP is applied.*

Keywords: *Maximum Power Point Tracking (MPPT), le'vy flight, Cuckoo Search Algorithm.*

1. INTRODUCTION

Electric energy is essential to our day today life. Traditionally, the generation of electric energy involved in the combustion of fossil fuels which led to major problems to human beings and environment. Accordingly, efforts have recently been focused on finding alternative ways to generate electricity from clean and sustainable energy resources such as sunlight. Using photovoltaic (PV) systems, sunlight can be converted into electrical energy that can be instantly used, stored or connected to the grid. Unfortunately, the initial implementation costs of PV systems are relatively high. In addition, the efficiency of the energy conversion process in PV systems is relatively low. Recently, solar energy or photovoltaic energy applications are getting increased especially in stand-alone configuration. It is one of the most promising sources of renewable energy. The limitations of PV energy system such as the low efficiency and the non-linearity of the output characteristics, make it necessary to obtain a Maximum Power Point (MPP) operation. Variations on solar irradiance levels, ambient temperatures and CUCKOO OPTIMIZATION ALGORITHM FOR MPPT OF PHOTOVOLTAIC SYSTEMS M. Mohamed Mahdhoom Riya, Asst.Prof.L.Muniaselvan Department of EEE, V V College of Engineering, Toothukudi District, Tamil Nadu, India. dust accumulation on the surface of the PV panel affect the output of the PV System. The aim of (Maximum Power Point Tracking) MPPT technique is to automatically obtain an optimal MPP operation under variable atmospheric conditions. Several MPPT techniques have been developed for PV system. The algorithms are Incremental condition (IC), perturbation and observation (P&O), Hill Climbing, Current sweeping, constant voltage algorithm, One Cycle Control and sliding mode Control. Most widely used in MPPT controller algorithms were Incremental condition and Perturbation and Observation (P&O). The idea of those algorithms is quite similar. In P&O, the perturbation is made in the operating point till maximum power achieved. Where in IC, the P-V curve slope of the PV system is checked till it reaches zero at which MPP operation is achieved. One other MPPT technique used for PV system is the constant voltage algorithm, in which the MPP operation achieved by keeping the 2 ratio between the PV voltage at the maximum power and the open circuit voltage constant. Although, the above discussed MPPT methods are widely used because of the ease of implementation and the independent of the atmospheric measurements, they still have some disadvantages. One of them is the power oscillation and around MPP which is caused by fixed perturbation step size. Another disadvantage is the confusion in the direction of

tracking which is caused by rapidly changing in atmospheric conditions provides a solution of the fixed iteration size by introducing a variable iteration size varies according to the operating point. 2. Block diagram of the Proposed method The block diagram of the proposed method is shown in fig.1. The system consists of PV module, DC/DC power converter, a multilevel DC/AC inverter and load. The PV module arrangement is considered with multi-string technology. As the irradiance level is inconsistent through the day, the amount of power generated by the PV module is always changing with weather conditions. The sliding mode control is used to extract maximum power from PV array. The DC power from the PV array is boosted using the DC-DC buckboost converters with DC bus converter.
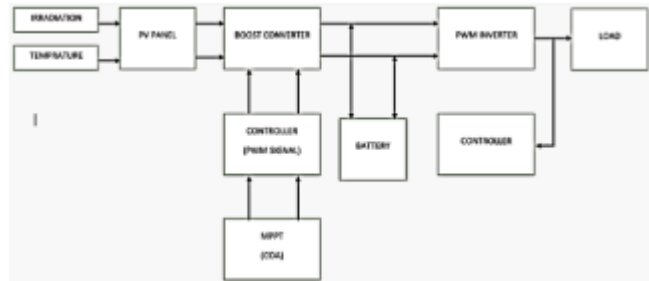

FIGURE 1. Block Diagram of the Proposed Method

The output of these converters is the DC power supply of the multilevel DC/AC power converter. The output of PWM inverter is AC voltage and SPWM with the closed loop PI control has been simulated using MATLAB software.

2. Cuckoo Search Algorithm

Cuckoos are fascinating birds, due to their beautiful sounds, and their aggressive reproduction strategy. There are some types of cuckoo birds like ani and guira. These types lay their eggs in communal nests and these may remove others' eggs to increase the hatching probability of their own eggs. Brood parasitism is the behaviour of some cuckoo birds, Tapera are intelligent birds that imitates the host birds in shape and colour, that may led to increase reproduction probability. It is surprising and magnificence to look at the timing of the process of laying eggs for Tapera. Firstly, cuckoos female select a group of host species with similar nest sites and egg characteristics to their own, then choosing the best from these nests. Host birds could be fooled and accept foreign eggs but if these eggs discovered, they are dumped outside the nest or the nest completely destroyed and go to new area to build a new nest. Usually there are three kinds of brood parasitism namely intraspecific, cooperative and nest takeover.

3. Le'vy Flight

The Cuckoo birds start in looking for the best nest, but this step has an important role in cuckoo's reproduction method. The process of searching the nest is the same as the process of searching food, the walks and directions are chosen and modelled on certain mathematical functions, le'vy flight is one of the most common models. A recent study by Reynolds and Frey shows that the fruit flies or Drosophila melanogaster, explore their landscape using a series of straight flight paths punctuated by sudden 900 turn leading to a le'vy flight style. This behavior is used in making optimization for different problems. le'vy flight is a random walk in which the step lengths have a probability distribution and steps are defined in terms of the step lengths.
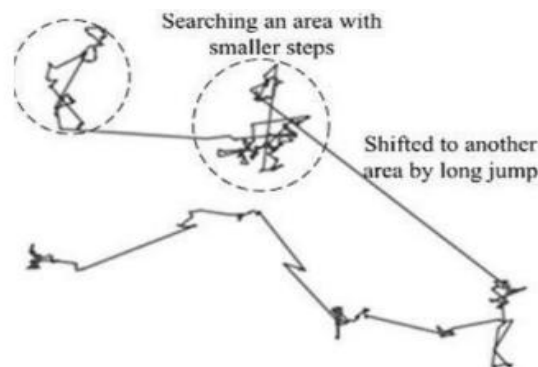

Fig 2. Le'vy Flight

Cuckoo Search Algorithm There are three idealized rules used for CS have been used by Yang and Deb. These rules are: 1. Each cuckoo lays one egg at a time and places it in a randomly chosen nest. 2. The best nest with high quality of eggs will carry over to the next generation. 3. The number of available nests is fixed and the egg laid by a cuckoo is discovered by the host bird with a probability of Pa, Where $Pa \in [0, 1]$. If the host birds are discovered the cuckoo's eggs, the host bird can abandon its nest or destroy cuckoos' eggs or in this case a new nest will be generated with probability Pa. In simple form, the last assumption can be approximated by the fraction Pa and the n nests are replaced by new nests (with new random solutions). In a simple form the following simple representation is used, each egg represents a solution and a cuckoo egg represents a new solution. In this this work, a simple approach is used where each nest has only a single egg. When generating a new solutions $Xi(t+1)$ for a cuckoo i a levy flight is performed 1. CS depends on the population as in both Particles Swarm Optimization (PSO)and Genetic Algorithm (GA), but it uses some sort of elitism and/or selection similar to that used in harmony search. 2. The possibility for any large step in addition to the step length has weighty tail that led to the process of randomization is more efficient. 3. CS has less tuned parameters compared to GA or PSO, so that CS can thus be extended to the type of Meta population Algorithm.

5. MPPT ALGORITHM

In this work, MPPT using cuckoo search is proposed there is a random initial solution of the operating voltage of PV panel, Va , is equal to [0, 25, 0]. Va according to the CS procedure represents the nest. The fitness value of power is calculated as in (3)

$$Pa = Va \times Ia \text{-------(3)}$$

Then find the best current, choose a random nest and generate a new solution by random walk as $Vi\,(t+1) = Vi\,(t) + \alpha \oplus \text{L'evy}\,(\lambda), \text{----------(4)}$

A simplified scheme of a random walk is used which is less efficient than levy flights. In addition to the step size should be a vector for problems with different scales, with step size=0.05, After new solutions are generated, values of the fitness are tested again and best current is selected. Iterations are performed until all nests reach at the maximum power point. A MATALB code is developed to search MPP using CS of for PV 60W module. The PV voltages and currents are measured using voltage and current sensors, respectively. The reference voltage calculated from MPPT algorithms tracked by CS is generated at each temperature and irradiation level, $Vref$. The difference between $Vref$ and the measured output voltage from PV, Vpv, is calculated to produce the error voltage, $Verror$. This error is used as an input signal to the PID controller, the output of the PID controller is compared to saw tooth waveform to produce the duty cycle for DCDC converter. The PID controller is preferable over the P or PI controller. Trial and error method is used for tuning the parameters of PID controller. This method is not guaranteed to calculate the controller coefficients so that artificial intelligent are used for tuning PID control parameters.

Structure of MPPT using Cuckoo Search Algorithm Simulation and Results: The proposed system has been simulated in MATLAB Simulink environment.
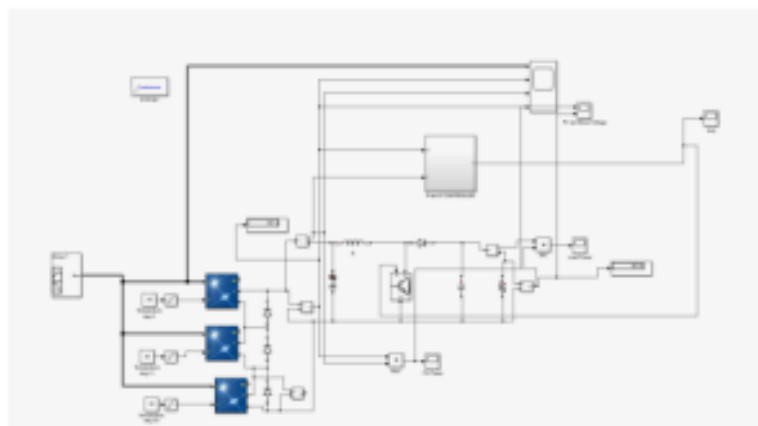

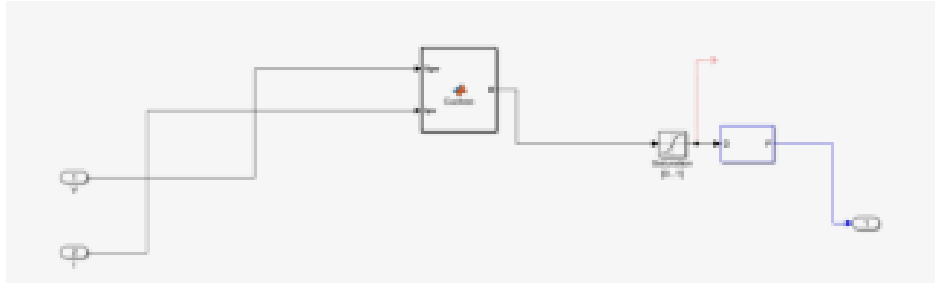Fig.3. Structure of MPPT Cuckoo Search Algorithm

Fig.4. Structure of P & O Controller Using Cuckoo Search Optimization
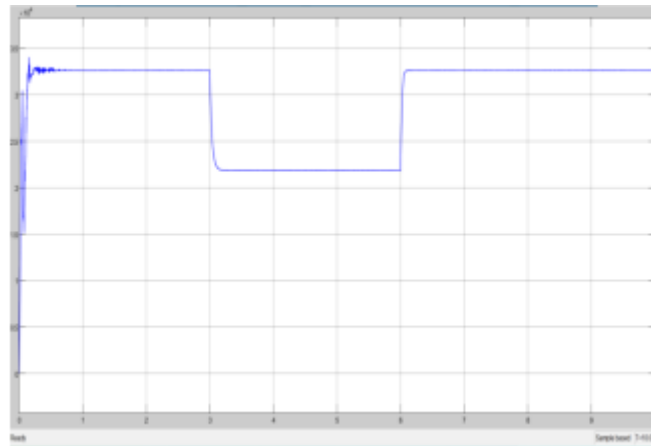

Fig.5. Output power of PV panel

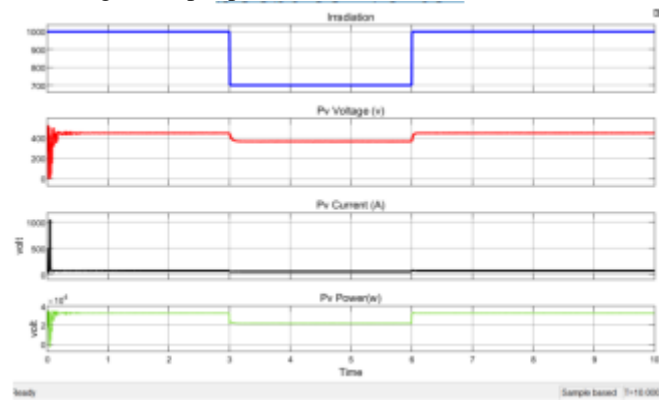Fig.6. Output power of the dc to dc boost converter

Fig.7. Solar PV output parameters

CONCLUSION

As per the geographical location of the country, India stands to its benefit and has tremendous scope of generating solar energy. Solar Power Generation alone can cater more than 60-65% of our entire need of power. Thus, we have to focus on following future plans of installing large projects. Apart from above, we also have to focus on Roof Top Solar Energy Generation that may cut down our need to more than 50% need of every house hold. MPPT algorithm employing Cuckoo search algorithm, depending on the cuckoo natural behaviour and simplified form of levy flight distribution. Results show that cuckoo is capable of tracking the MPP efficiently. It is confirmed by comparing results with other methods such namely, Incremental Conductance and Hill Climb Algorithm. Cuckoo search gave maximum power greater than Incremental Conductance and Hill Climb Algorithm. Moreover, in cuckoo search method, no further fluctuations.

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