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Hybrid MPPT Method for Grid Interconnected Photovoltaic Cells

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Abstract: *A great deal of research is being carried out the performance of photovoltaic (PV) grid-connected systems. Solar PV energy is one of the most promising renewable resources that use the abundant and free energy from the sun having clean, inexhaustible and environment friendly cyclic operations. This paper represents a simulation model of photovoltaic cells with grid interconnected. In this paper a hybrid MPPT technique is used to extract more and more power from the photovoltaic cells arrangement. In this paper perturb and observe technique for MPPT is combined with the optimization technique. And finally with this application a significant enhancement of pv power has been obtained.*

Index terms MPPT: *Maximum power point tracking, photovoltaic, PV*

1. INTRODUCTION

Solar energy has the great opportunities and many advantages of all the sources of renewable energy sources. Grid-connected photovoltaic (PV) system does not require bulk and heavy weight batteries. The transportation cost also decreases by the grid connected photovoltaic systems. It also reduces transmission losses. As Conventional sources of energy are rapidly depleting and the cost of energy is rising day by day, photovoltaic energy becomes a promising alternative source.

Some of the advantages listed below:

1) Abundant
2) Pollution free
3) Solar energy is distributed throughout the earth
4) Solar energy is clean and noise-free source of electricity and
5) Solar energy is endless and it is unlimited.

The main drawbacks of solar energy are listed below:
(1) The initial installation and equipment cost is considerably high whereas the energy conversion efficiency is relatively low.
(2) Their output do not match with the output of conventional power stations
(3) For these types of plants a large area of land is required.

To overcome these problems, the following two ways can be used:
1) Efficiency of conversion of solar energy into electrical energy is increased and
2) Maximum power is extracted from the photovoltaic cells.

In recent years, Photovoltaic system has become one of the main way to use solar energy. To understand and analyze the performance of a grid connected PV system, simulation model of a grid connected PV system is required.

Block diagram of grid –connected photovoltaic system is shown in Fig.1

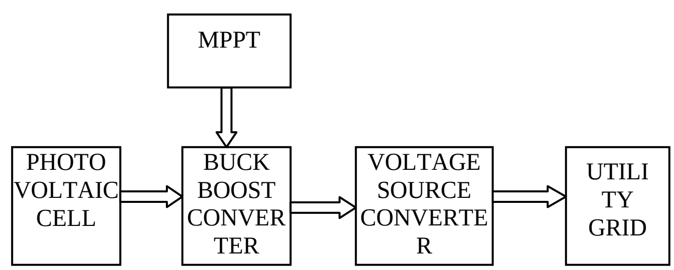


Fig. 1: Block Diagram of Grid Interconnected Photovoltaic System

This block diagram includes array photovoltaic cells, a buck boost converter, voltage source inverter (VSI), a control system by which the duty cycle of the buck boost converter is controlled, a utility grid. The PV array consists of a number of individual photovoltaic cells that are connected in series and parallel to convert sunlight to electricity by the use of the photovoltaic effect. The PV array produces the unregulated dc power, and hence power electronics and control equipment points are required to convert dc to ac power. A voltage source converter (VSI) is used to convert dc power produced by photovoltaic cells into ac power and this ac power is fed into the utility grid. The control system of voltage source converter consists of current control regulator and voltage control regulator. Current control regulator and voltage control regulator is used to achieve the dc voltage regulation at dc link and unity power factor at grid and the voltage control regulator is applied to achieve maximum power point tracking. Maximum power point tracking (MPPT) can effectively improve the solar energy conversion efficiency of PV systems. In this paper, Perturb-and-observe (P&O) technique and the bacterial foraging optimization technique are together applied, the efficiency and duty cycle is improved. And finally with this application a significant enhancement of pv power has been obtained.

2. MODEL DESIGN

In the model design of a Photovoltaic system short-circuit current (I_{sc}) from a cell is nearly proportional to the illumination, while the open-circuit voltage (V_{oc}) may drop only 10% with an 80% drop in illumination. The important result of these two effects is that the power of a PV cell decreases when light intensity decreases and/or temperature increases. The amount of power generated by a PV cell depends on the operating voltage of the PV cell array. The point at which the PV operates at highest efficiency and maximum power is called the maximum power point (MPP).

And the methods or techniques used to track the maximum power point for photovoltaic arrays are called Maximum Power Point Tracking (MPPT) technique. The light generated current (I_{pv}.) is the function of solar irradiance and surrounding temperature. In this model the effect of wind speed are not taken into consideration and wind speed is neglected

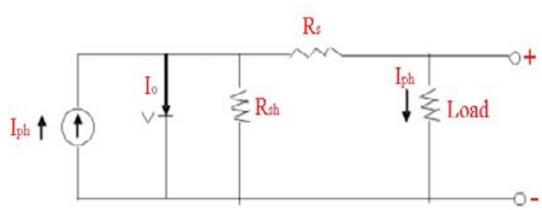


Fig. 2: Equivalent circuit of a practical Solar cell

A solar cell uses a *p-n* junction and the physical configuration are shown in Fig 2. Current and voltage relationship is given by the diode characteristics equation

Diode characteristic

$$I_d = I_{sat} * [\exp(V_d/V_T) - 1]$$

where:
I_d=diode cuurent (A)
V_d=diode voltage (V)
I_{sat}=diode saturation current (A)
V_T=temperature voltage
And the temperature voltage is obtained by the following equation

$$Vt = \frac{kT}{q * Qd * Ncell * Nser}$$

where
T=cell temperature (K),
k=Boltzman constant
q=electron charge
Q_d=diode quality factor
N_{cell}= number of series-connected cells per module
N_{ser}=number of series-connected modules per string
The value of the diode quality factor 'Q_d' may be arbitrarily chosen usually $1<=Q_d<=1.5$. In this model value of diode quality factor is taken is 1.3.

3. PROPOSED MPPT

Perturb and Observe involves a perturbation in the operating voltage of the PV array. In this method, if we are operating on the left side from the Maximum Power Point (MPP) then increases the voltage then the power also increases. On the left side of the MPP the power is directly proportional to the voltage. After reaching the Maximum Power Point, if we continue to increases the voltage then it will decreases the power . On the right side of the Maximum Power Point the power is inversely proportional to voltage.

In this model the Perturb and Observe MPPT technique is combined with the Bacterial Foraging Optimization (BFO). The Bacteria Foraging Optimization is inspired by the social foraging behaviour of Escherichia coli. BFO shows good efficiency in solving real-world optimization problems. Due to good results obtained from the application of BFO, scientists of different fields apply this optimization technique in different areas.

In this proposed MPPT technique the Perturb and Observe combines with the Bacterial Foraging Optimization technique. To apply the Bacterial Foraging Optimization some of the steps which are used are given below

1) *Chemotaxis* : This process describes the movement of a bacteria *Escherichia coli* (*E.coli)* cell through swimming and tumbling via flagella. Biologically an *E.coli* bacteria can move in two different ways either in clockwise direction or in anti clockwise direction. It can swim for a period of time in the same direction or it may tumble, and alternate between these two modes of operation for the lifetime. This step in the BFO represents the movement of bacteria.
2) *Swarming*: By the study of this interesting it has been observed that for several motile species of bacteria including *E.coli*. A group of *E.coli* bacteria arrange themselves in a ring by moving up to the nutrient gradient when placed in a semisolid matrix with a single nutrient chemo effecter. The E.coli cells when stimulated by a high level of *succinate*, cells of E.coli release an attractant *aspertate*, which helps them to aggregate into groups and

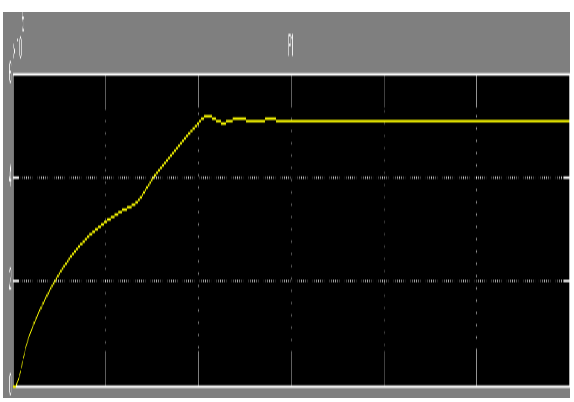
thus move as concentric patterns of swarms. These bacteria cellsare with high bacterial density.*succinate*, cells of E.coli release an attractant *aspertate*, which helps them to aggregate into groups and thus move as concentric patterns of swarms. These acteria cells are with high bacterial density.

3) *Reproduction*: At last unhealthy bacteria die whereas from each of the healthier bacteria asexually split into two bacteria, which are then placed in the same location. In this way swarm size keep constant.
4) *Elimination and Dispersal:* Sudden changes in the local environment where a bacterium population lives, and these sudden changes may occur due to various reasons e.g. a significant local rise of temperature may kill a group of bacteria that are currently in a region with a high concentration of nutrient gradients. Events can take place in such a fashion that all the bacteria in a region are killed or a group is replaced into a new location. For the simulation of this phenomenon in BFOA some bacteria are liquidated at random with a very small probability while the new replacements are randomly initialized over the search space.

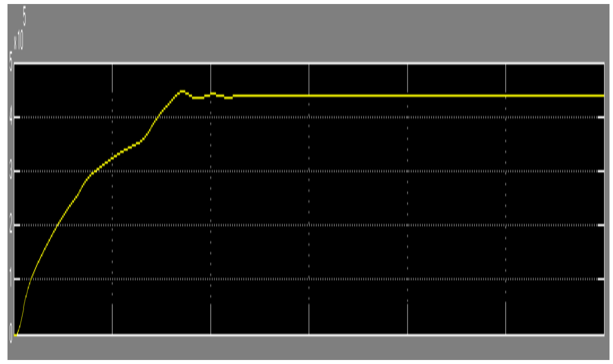
In this MPPT technique optimization is done and for this a function is required to be created, and this function is optimized to solve the real time problems. In this a function is created with the help of MATLAB programming. And in this proposed MPPT the perturb and observe technique reach the Maximum Power Point by controlling the duty cycle. And the BFO optimize the duty cycle for maximization of power and in this way the power output is improved.

4. SIMULATION RESULTS

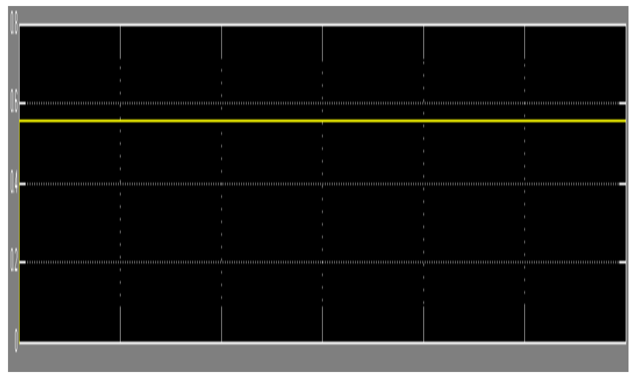
Output power of Grid interconnected PV system with Hybrid MPPT method



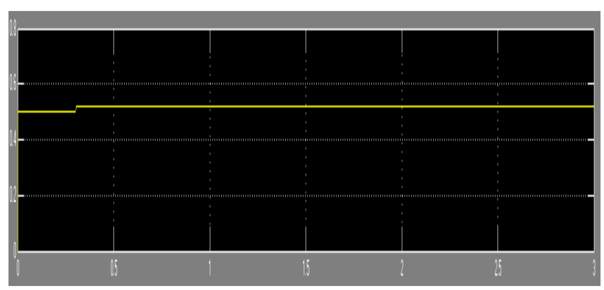
Output power of Grid interconnected PV system with Perturb and observe MPPT method



Duty cycle of Grid interconnected PV system with Hybrid MPPT method



Duty cycle of Grid interconnected PV system with Perturb and observe MPPT method



5. CONCLUSION

Grid-connected PV systems can provide a number of benefits to electric utilities, such as power loss reduction, improvement in the voltage profile, and reduction in the maintenance and operational costs of the electric network. In a grid connected PV system, if the power generated by the PV cells is less than the user demand then the user demand is fulfilled by the grid. And if the PV generates more power from the user demand then the power will be sent to utility grid for further use of this power. The duty cycle obtained from the Perturb and Observe MPPT technique is 0.52 whereas with the hybrid MPPT technique duty cycle is 0.556. In this way the power loss is minimized. Bacterial Foraging Optimization (BFO) technique has successfully employed in the Grid connected PV systems and by the application of BFO the power output will be increased and the duty cycle is also improved.

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