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Performance Analysis of Stand-alone PV system using PSO and Cuckoo MPPT Techniques

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KEYWORDS

ABSTRACT

The (PV) photovoltaic panel's characteristic is non-linear and highly depended on solar irradiation and temperature cell variations. For that reason, a Maximum Power Point Tracking (MPPT) algorithm is essential so that it is possible to draw peak power from the photovoltaic panel to obtain the maximized produced energy. The main purpose of MPPT technique is to make sure that the solar panel is producing the maximum power. This extracts the maximum amount of power at any given time. This paper proposes a concept of a different MPPT techniques for BOOST converter for improving the performance of PV system in terms of efficiency and power from the PV system. Basically, BOOST converter is proposed as interface between load and PV module array as DC-DC converter for voltage improvements. Also, a Partical Swarm Optimization and Cuckoo concept is proposed in this paper for further improvement of PV power. The MATLAB/SIMULINK power system tool box will be used to stimulate the proposed system.

INTRODUCTION

Solar energy is the one of the best renewable energies for future applications. So, the use of photo voltaic (PV) systems increased with reduced costs and increased efficiency. But the generation of electricity from photo voltaic (PV) system is more expensive than the other non- renewable energy sources. We know that non-conventional sources which are also known as renewable energy resources are becoming more popular now a days as they are available nature free. Renewable energy sources are defined as the sources which can be reproduced from nature again and again once even, they used.

There are many advantages with renewable energy resources comparing to non-renewable energy source. Some of the advantages are renewable energy sources are cost free and also pollution free compared to non-renewable resources. Some of the main examples for

these renewable resources are solar, wind, tidal etc. Here in this project work we are considering solar as the source and obtaining maximum power from the sun by using maximum power point tracking algorithms (MPPT's). There are many algorithms are used for extracting maximum power such as perturb and observe, incremental conductance, fuzzy control etc. In our daily life, power electronic converters have been widely used, not only for industry applications but also in many electronic products, such as portable devices and consumer electronics. Actually, most electronic devices are not using energy directly from the power system or a battery set. To provide the required voltage or current level to a load, in general, a power electronic converter is interposed between the power source and the load to perform the conversion of the voltage or current level and in addition to regulate the power requirement.

A conventional power electronic converter is supplied from a single input source, but may provide multiple outputs. In the case that two or more voltage or current levels are required by the loads, a transformer with multiple output windings is employed [1], [2]. On the other hand, however, for some applications, the loads may not be powered from a single source but from two or more input sources specified by different voltage, current, and power ratings [3-13]. For example, a solar power-based street lamp is mainly supplied from solar cells, but needs a subordinate battery power.

Photovoltaic System:

Photovoltaic system is one of the energy sources in renewable family, as compared to all DG systems it plays a key role in the present power generation systems because of it freely available in environment and its durability. The PV system converts sun irradiance into electrical current with photon effect. This current is converted into electrical voltage with the help of solar electrical equivalent circuit [5]. And a DC-DC MPPT converter is used to extract maximum output from the solar system. The structure of solar system is shown in figure 1.

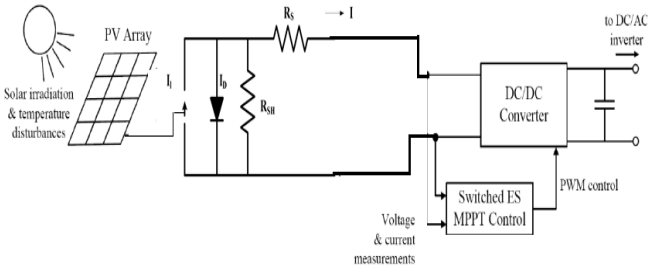

Figure 1: Structure of Solar Energy System

The expression for Photovoltaic system current is shown in equation (1),

$$I = I_{ph} - I_D - I_{sh}$$

$$I = I_{ph} - I_o[e^{(\frac{qV_D}{nKT})}] - (\frac{V_D}{R_s}) \quad (1)$$

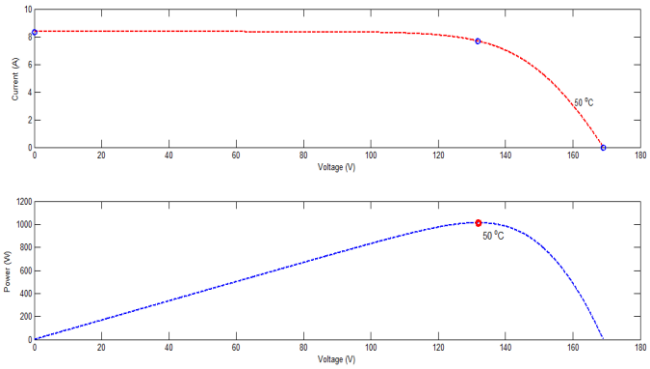

Figure 2: V-I Characterestics of PV system

Figure 2, shows the characterestics of P-V and I-V of photovoltaic system. From this the maximum power point of system in identified. The structure of closed loop control diagram from dc-dc converter using MPPT technique is shown in figure 3 [6]. Here, the reference signal obtained from MPPT is compared with PV system voltage and applied to PWM converter to generate duty cycle required for dc-dc converter.

DC-DC Converter:

The solar converter, is nothing but a DC-DC boost converter which is used to regulate solar power with MPPT control diagram. In this paper a cuckoo based MPPT technique is proposed. The control diagram for DC-DC boost converter is shown in Figure 3. As the solar panel voltage /current increases, the PWM generator increases its repetition rate thus resulting in increased output current. At the same time, additional voltage is applied to the inductor thus increasing its charge current. Where the initialization is based on voltage and power calculations that are based on current and voltage values acquired from sensors [9]. Once the

actual power is calculated, then the next cycle of the measurement is compared to previous value to change the reference voltage Vref.

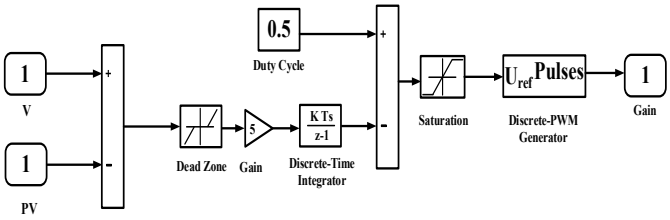

Figure 3: MPPT based PWM controller for DC-DC converter

MPPT techniques:

The purpose of MPPT technique is to design a suitable reference signal required for PWM of DC - DC converter this MPPT technique increases the efficiency of DG system and battery charging controllers.

ALGORITHM OF PERTURB OBSERVE METHOD

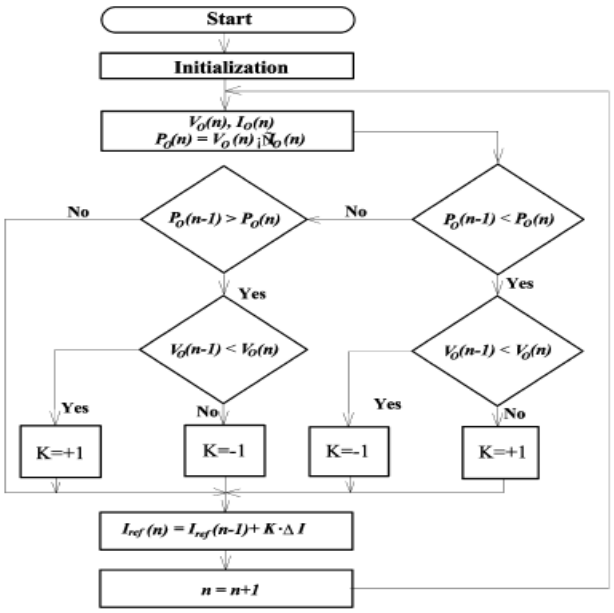

Figure 4: Flow chart of the MPPT algorithm with P&O method.

By comparing the recent values of power and voltage with previous ones, the P&O method shown in the flow chart can determine the value of reference current to adjust the output power toward the maximum point [4].

ANFIS CONTROLLER

Fuzzy Logic Controller:

The major complexity in conventional PID controller is mathematical analysis with multiple variables and constant interfacing. The major three issues with conventional PID controller is (a) time delay, (b) step function response and (c) ramp or soak function response.

In order to overcome these issues, this paper is implemented with soft computing controller called as Fuzzy logic Controller. Fuzzy Logic is one type in artificial intelligence and it is based on the information which is either true or false. FLC is a function or group of flexible set of if-then rules.

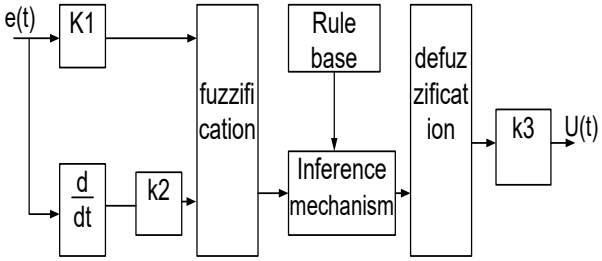

Figure 5: Architecture of FLC system

Figure 5, shows the basic structure of fuzzy logic controller with two inputs namely error of dc link voltage and change in error. Each input of FLC is a set of 5 memberships (i.e MS, S, Z, H, VH). The minimum of the two inputs of Medium small, small, zero, high and medium high are chosen which ultimately try to fire the set of IF-THEN rules. If error input is Z AND change in error input is H then the output is MH.

Table 1 Rule-Base formation for 5*5 input FLC

e/ce	MS	S	Z	H	MH
MS	MS	S	Z	H	MH
S	MH	H	Z	S	MS
Z	S	Z	H	MH	MS
H	S	S	MS	H	H
MH	S	Z	H	H	MH

ANN Controller:

Figure 6 shows the basic architecture of artificial neural network, in which a hidden layer is indicated by circle, an adaptive node is represented by square. In this structure hidden layers are presented in between input and output layer, these nodes are functioning as membership functions and the rules obtained based on the if-then statements is eliminated. For simplicity, we considering the examined ANN have two inputs and one output. In this network, each neuron and each element of the input vector p are connected with weight matrix W.

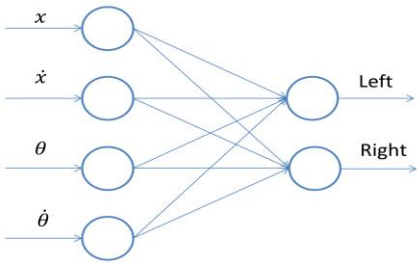

Figure 6: ANN architecture for a two-input multi-layer network

SIMULATION ANALYSIS:

Simulation results of output PV power of the five different MPPT algorithms mentioned earlier, Under standard conditions (1000 W/m^2 and 25°C). Perturb and observe need 0.41 sec to track the maximum power point and it is shown in Fig 7.

The Incremental conductance method need 1.75 sec to track the maximum power point and it is shown in Fig 7.

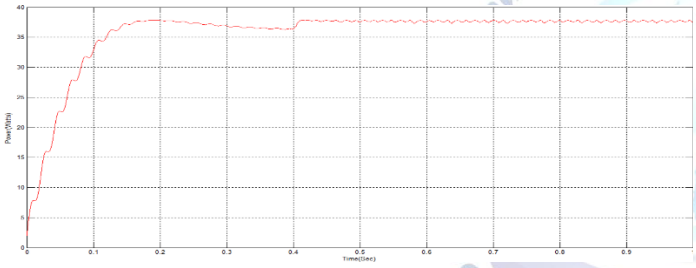

Figure 7: Perturb and Observe Simulation Result of PV Output Power

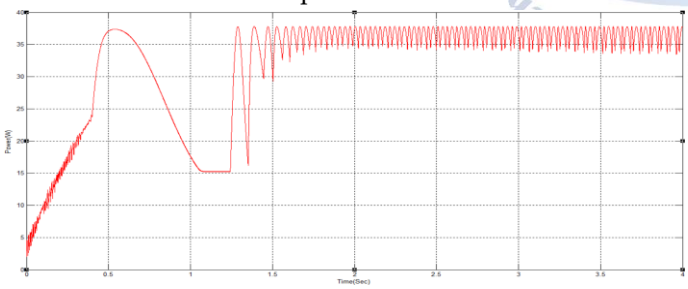

Figure 8: Incremental Conductance Simulation Result of PV Output Power

SIMULATION DIAGRAM USING PSO AND CUCKOO

PSO is a stochastic optimization technique based on the movement and intelligence of swarms. In PSO, the concept of social interaction is used for solving a problem. It uses a number of particles (agents) that constitute a swarm moving around in the search of space, looking for the best solution.

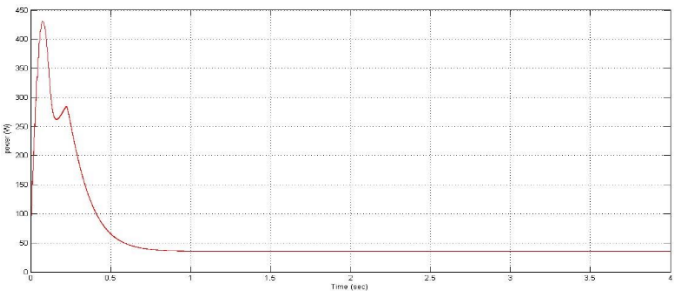

Figure 9: Particle Swarm Optimization Simulation Result of PV Output Power

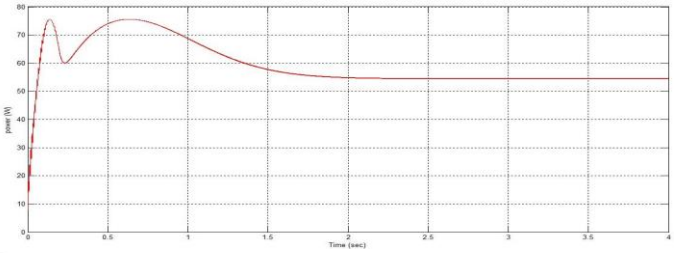

Figure 10: Cuckoo Search Simulation Result of PV Output Power

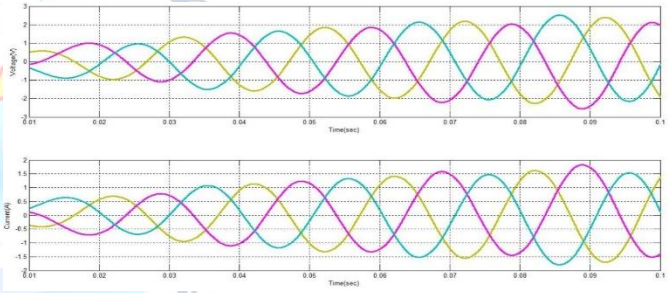

Figure 11: Simulation waveform for Inverter Voltage and current using ANFIS

Table 1: Comparison of MPPT's

S.NO	MPPT Methods	Settling Time for various techniques (Sec)	Maximum OutputPower (W)
1	P&O	0.41	37.5
2	SMC	0.55	38
3	FSCC	0.6	37.8
4	FOCV	1.2	35.5
5	IC	1.75	38
6	**PSO**	**0.7**	**48**
7	**CSA**	**2.0**	**55**

In the above table 1, although the settling time of PSO is higher than P&O, SMC, FSCC and CSA is higher than P&O, SMC, FSCC, FOCV, IC but we can observe

that maximum output power is improved by using PSO and CSA MMPT techniques.

CONCLUSION

In this project, presented the photovoltaic system which contains a PV array, DC-DC converter related to a resistive load and an MPPT algorithm. The MPPT algorithm is needed so that the operating point of the PV curve is at the MPP. Different MPPT techniques like PO, INC, FOC, SMC, PSO and Cuckoo are described and compared. Based on the simulation results, it can be seen that with all of the different techniques, the PV panel is able to operate at the maximum power. However, the performance of PSO and Cuckoo are better than the other techniques.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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