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Energy storage based on maximum power point tracking in photovoltaic systems: A comparison between GAs and PSO approaches

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ABSTRACT

In this paper, a comparison between GAs and PSO Approaches is considered to select and generate an optimal duty cycle which varies with photovoltaic parameter in order to extract the maximum Power from Photovoltaic System using real values of temperature and insolation. The energy storage has very important role in renewable energy. To illustrate the energy storage, we have used a battery type lead-acid simulated in Matlab/Simulink. The obtained simulations results show the effectiveness and the robustness of the proposed approaches.

Introduction

Photovoltaic source are widely used today in many applications such as battery charging, water heating system, satellite power system, and others applications. Recently, researchers have strongly promoted the use of solar energy as a viable source of energy. Solar energy possesses characteristics that make it highly attractive as a primary energy source that can be integrated into local and regional power supplies since it represents a sustainable environmentally friendly source of energy that can reduce the occupants' energy bills [1].

The manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years due to the increased demand for renewable energy sources.

The promising incentives to develop alternative energy resources with high efficiency and low emission are of great importance to reduce the emission of greenhouse gases and decrease the dependence on fossil fuels [2]. Solar energy is one of the most essential and prerequisite resource of sustainable

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energy because of its ubiquity, abundance, and sustainability. Regardless of the intermittency of sunlight, solar energy is widely available and completely free of cost [3].

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 [4].

Optimization in photovoltaic systems attracts a lot of researchers in the last decade due to their importance with grow day to day [5–9].

The particle swarm optimization "PSO" technique is applied in photovoltaic system by Refs. [7,8] and the genetic algorithms have been proposed for the optimization of the same system in Ref. [9]. The optimization of solar energy using Perturb and Observe "P&O" or fuzzy logic combined to optimization technique have been studied by Refs. [10,11].

PSO is a technique that evolutionary uses a "swarm" of solutions candidate to develop an optimal solution of the problem. The degree of optimality is measured by a fitness function defined by user. The PSO is different from other methods of evolutionary computation in order that members of the swarm called "particles" are scattered in space of the problem [12].

The Genetic Algorithms "GAs" is a technique based on natural selection, the process that drives biological evolution. The GAs uses a "population" of solutions candidate to develop an optimal solution of the problem. The degree of optimality is measured by a fitness function like PSO. The GAs is different from other methods of evolutionary computation in order that members of the public called "individual" are scattered in space of the problem and create the next generation from the current population [13].

At present, lead-acid batteries are widely used because of their mature technology and low price, but cycle life is very limited. Sodium sulphur batteries with their high energy density, high efficiency of charge/discharge and long cycle life, are primarily suitable for large-scale non-mobile applications such as grid energy storage [14–16]. However, it requires a high operation temperature and has the highly corrosive nature of sodium polysulfide.

In this paper, a comparison between GAs and PSO Approaches is considered to select and generate an optimal duty cycle which varies with photovoltaic parameters in order to extract the maximum Power from Photovoltaic System using real values of temperature and insolation collected from "URAER", Unit of Applied Renewable Energy, Ghardaïa, Algeria on November 05, 2012 where the insolation and the temperature are measured respectively by K&Z CHP1 Pyrheliometer and Campbell CS215 for maximum power point tracking in photovoltaic systems taking into account storage system. The obtained simulations results show the effectiveness and the robustness of the proposed approaches using Matlab/Simulink.

The introduction is presented in section 1. The photovoltaic equivalent circuit model is given in section 2. Section 3 is dedicated to the simulation and validation of the photovoltaic model. The real values of temperature and insolation, collected from "URAER", Unit of Applied Renewable Energy Ghardaïa, Algeria are presented in section 4. Boost converter and pulse with modulation is presented in section5. The considered algorithms with their learning algorithms are proposed in section 6 and section 7 respectively. The simulation results and discussion are shown in section 8. The storage system applied to the considered photovoltaic system is presented in section 9. Finally, the present paper is achieved by a conclusion.

Photovoltaic equivalent circuit model

A photovoltaic model presented by general mathematical model equations using the output and the inputs, there is a current source contains the illumination value depends [17] in parallel with a diode and in parallel with a resistor in series with a further resistor, the numbers of the resistors in parallel or in series gives the position of the cell is in series or in parallel [18], that is to say the objective that we are interested in current or voltage. The typical equivalent circuit of PV cell is shown in Fig. 1.

The basic equations describing the I–V characteristic of the PV cell solar model are given in the following equations [17]:

$$0 = I_{ph} - I_D - I_{pv} - \frac{V_{pv} + R_s \cdot I_{pv}}{R_p} \quad (1)$$

$$I_D = I_0 \cdot \left(e^{V_D/V_T} - 1\right) \quad (2)$$

where:

$$V_D = V_{pv} + I_{pv} \cdot R_s \quad (3)$$

$$V_T = \frac{n \cdot K \cdot T}{q} \quad (4)$$

and:

I_{PV}: The cell current (A)
I_{ph}: The light generated current (A)
I_D: The Shockley diode equation (A)
I_0: The diode saturation current (A)
R_S: The cell series resistance (Ohms)
R_P: The cell shunt resistance (Ohms)
V_D: The diode voltage (V).
V_T: The temperature voltage (V)
V_{PV}: The cell voltage (V)
n: Dimensionless junction material factor
K: The Boltzmann constant 1.38*10–23 J/K

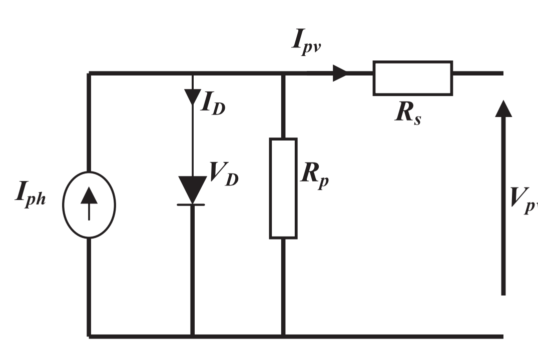

Fig. 1 – Typical circuit of PV solar cell.