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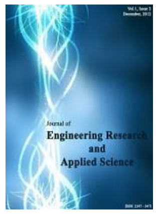

Control for a solar photovoltaic water pumping system

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Abstract
Photovoltaic solar energy is being widely used to supply several terrestrial applications including water pumping. As a matter of fact, in developing countries, water demand is quite high with a parallel availability of solar radiation. We introduce a method for modeling and controlling a photovoltaic pump system based on a controlled centrifugal pump in order to improve the cost and performance of the pumping system. The work in this paper concerns the investigation on a solar PV pumping chain. Obtained results point out the efficiency given by the proposed system.

Keywords: Photovoltaic, Control, Converter, Centrifugal Pump, Strategy, water pumping

1. Introduction

In recent years, the use of photovoltaic energy has been paying more attention and it is one of the most rapidly growing and the cleanest energy sources [1-2]. The electrical energy produced by photovoltaic energy can be exploited in different ways as it is inexhaustible nature, pollution free, distributed over the earth, maintenance free and continuous cost reduction, the most important advantage is the reduction of carbon dioxide emissions [3]. Besides, drinking water supply is of vital importance for life and the human need for water is continuously growing. This need becomes crucial in rural areas and islanded sites, where it is difficult or even impossible to use classical energies. Water pumping using different form of energies has been proposed as solution for water supply. Solar thermal, wind energy and hybrid system are the most investigated forms of energy for this purpose [4-5]. Also, solar energy has recently received considerable attention in dry and sunny areas. Nowadays, it is considered as the most attractive source due to the continuously development of solar cell material [6].

Water and solar energy are essential elements of our daily life. They are particularly important in remote and desert regions such as South Algeria [7]. Therefore, increasing the demand for water in these areas is a matter of sustainable development. Algeria has done its utmost to ensure water supply to all regions in the north through the construction of new dams and in the south. Algeria's vast groundwater resources and undeveloped land require the use of electricity, and electricity itself is almost unavailable throughout the Sahara [8].
In remote areas, pumping water using photovoltaic solar energy is a solution that is well suited to these regions [9]. Indeed, the majority of these regions are very sunny and this energy has the advantage of being unlimited and clean unlike conventional energy which has the constraints of distance from the electrical grid and the constraints of transporting the fuel and periodic maintenance [10]. Several researches deal with this subject, such as pumping irrigation water by solar photovoltaic energy, especially for technical and economical optimization [11].

2. Operating Solar Water Pump

The solar powered water pump can provide water where power lines cannot reach. They are commonly found in aeration, pond filtration, aquarium filtration and well pumps. These types of pumps are mainly used in areas that have electricity problems. Otherwise, you will not have a stable power supply. It is an ideal water withdrawal system for green energy that combines the advantages of reliability, economy and environmental protection (see Fig. 1).

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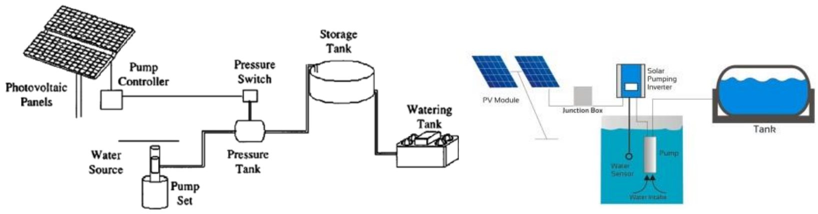

Figure 1 Schematic overview of solar water pumping.

3. Operating Diagram Of The Solar Water Pump

3.1. Introduction

The block diagram of the solar water pump consists mainly of a controller, an electric motor or battery, a water pump and solar panels (PV). It is essentially an electric pump that runs on electrical energy obtained from solar panels. These panels receive energy from sunlight. The connected battery or motor controls the direct or alternating current. The motor of a pump unit converts electrical energy into mechanical energy. It can be DC or AC.

3.2. DC Solar Pump

This pump has an electric motor that uses direct current. Therefore, no inverter is needed for this pump. In recent years, the use of permanent magnet DC motors as drive motors for photovoltaic pump systems has increased rapidly. In fact, this type of motor has good performance and is maintenance-free. In addition, compared to other types of pumps, the centrifugal system has many advantages: it is small in size, relatively quiet in operation, and all types of motors on the market are easy to implement. The pumping unit studied in our system consists of a centrifugal pump driven by a permanent magnet DC motor (see Fig. 2).

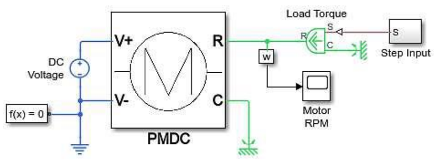

Figure 2. Permanent magnet DC motor (PMDC)

3.3. Centrifugal Pump

Water pumps can be classified according to their operating principle: either volumetric or centrifugal. In addition to these two classifications, which will be described later, there are two other types of pumps that can be distinguished according to the physical location of the pump in relation to the water being pumped: the suction pump and the delivery pump. A centrifugal pump is the most common type of pump used in boreholes. It works with a high-speed rotating impeller in a casing that is called a stage. The impeller throws the water radially out of the casing by centrifugal force. If more pressure is needed than a single stage can produce, additional stages are added. A centrifugal pump must run at a certain speed before it can overcome the static lift required to pump water into the storage tank (see Fig. 3).

Figure 3. Centrifugal pump driven by electric motor or direct solar electric.

4. Results and Discussion

In the simulation model, it used a BP SX150s solar panel with a power of 200 W consisting of 80 cells in series, whose experimental electrical characteristics are those collected in Table 1 under the standard conditions.

Table 1. BP SX150s solar PV module (at E = 1000 W/m^2; T = 298 K).

Electricity characteristics	Values
Maximum power of the module	200 W
Short circuit current	4.75 A
Open circuit voltage	44.5
Maximum current	4.5
Maximum voltage	35
Number of cells in series	80

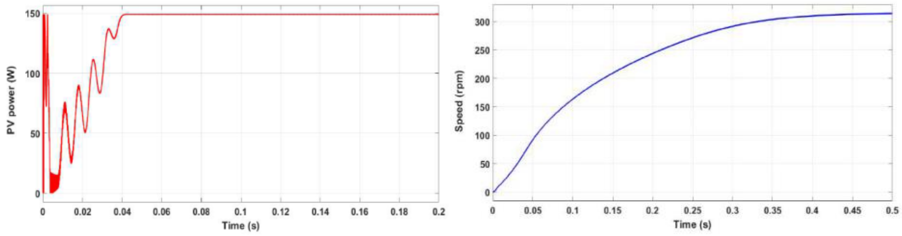

Figure 4. Variation of solar PV power (W) with time and variation pump speed (rpm) with time.

The figures above (Fig. 4) show the PV power and the PMDC motor speed respectively. It can be seen that the power has a maximum value of almost 200 W. It is also observed that the motor speed increases with increasing inverter output voltage.

5. Conclusion

The photovoltaic pumping system is used to supply drinking water to remote sites where no energy source is available. The chosen panel model was simulated in a MATLAB/Simulink environment. The simulation results obtained from the complete photovoltaic pumping system were carried out. The Boost converter was used with PMDC control by the optimization algorithm in order to extract the maximum possible power supplied by the GPV generator.

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