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Modeling and simulation of an autonomous PV Generator dedicated to supply an agricultural pumping station

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Abstract

The objective of this work is the study, design and validation by simulation the model of an isolated photovoltaic chain composed of : PV Generator 4.2 KW, power conditioning system and a direct current load. This system is used to supply agricultural pumping station.
The effects of temperature and irradiation on the PV Generator are studied, in particular on the magnitudes of the short circuit current, the open circuit voltage and the power delivered by the system.
According to the characteristics of the load and the operating conditions (temperature, irradiation), we can find a big gap between maximum potential PV Generator power and that actually transferred to the pumping system.
In order to extract in every moment the maximum of power available at the terminals of the PV Generator and transfer it at the pumping system, we use a matching stage composed of a boost converter controlled by an algorithm of power maximization "P&O" and a pulse width modulation (PWM).

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Keywords: PV Generator, Boost converter, MPPT, P&O, modeling, Simulation

1. Introduction

The demand for electricity is increasing in recent years, leading research towards the development of renewable energy sources. In this context, a photovoltaic systems offers a very competitive solution.

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To overcome the performance issue PV Generators, it's necessary to optimize the design of all the parts that make up a PV system [1]. In addition, it's necessary to focus on the DC-DC converters used as an adaptation interface between the PV modules and the load to extract the maximum power, and operating the PV Generator at its maximum power point (MPP) with MPPT controller [2], consequently, obtain a maximum electric current at different variation of load and atmospheric conditions.

In this sense, this work try to design, simulate and validate the model of a photovoltaic Generator power 4.2 KW, dedicated to supply a pumping station.

2. Analysis and modelling

2.1. Description of the system

Generally, PV pumping systems consist of a PV Generator and a pumping subsystem [3]. These systems operate over sun without electrochemical storage. The water being pumped can be used directly or stored in a tank for future use. In order to extract the maximum power from the photovoltaic generator, the MPPT control is used (figure 1)

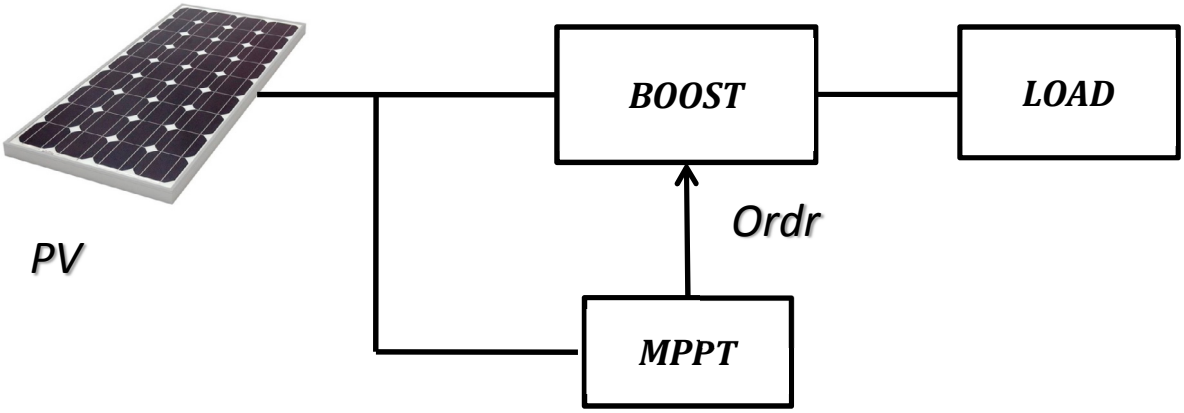

Fig. 1. Diagram of the system PV controlled by MPPT.

The first figure shows the general structure of an autonomous photovoltaic system. This structure consists of three blocks: (PV Generator, Boost with its control and a DC Load).

The PV Generator is responsible for the instant conversion of solar energy into electricity through the photovoltaic effect. This Generator consists of a plurality of photovoltaic modules connected in series and in parallel according to the required power.

The primary role of the power conditioning system (Boost converter & MPPT) is to optimize the transfer of power from the photovoltaic generator and the load. This system may be a DC-AC converter for an AC motor or a DC-DC converter to a DC motor.

In our case, the load is considered as a motor pump powered by direct current.

2.2. Mathematical Model Of Photovoltaic Generator

The power delivered by a cell is not sufficient to supply a load. we'll have to connect multiple cells in series and in parallel to form a PV module and achieve the desired power.

In turn, the interconnection of modules together in series and in parallel, to obtain a power even greater, defines the notion of the photovoltaic Generator.

For each module, the manufacturer gives the short circuit current (Icc) and open circuit voltage (Voc) under standard conditions (T=25 °C, G=1000 w/m²).

Assuming **ns** the number of modules connected in series in a branch and **np** the number of branches connected in parallel.