Critical factors affecting the photovoltaic characteristic and comparative study between two maximum power point tracking algorithms

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ABSTRACT

This paper presents the characterization and the modeling of the electric characteristics of current–voltage and power–voltage of the photovoltaic (PV) panels. The philosophy behind digital simulation of solar energy systems is that experiments which normally should be done on real systems under high assembling costs can be done numerically in a short time on a computer, thus saving time and investments. The electric parameters of PV cells and the optimal electric quantities of PV panels have been analyzed (voltage and power) according to the meteorological variations (Temperature, solar irradiation ...). The obtained results show that the diode parameters of the PV cells depend on solar irradiation: the current saturation increases with solar irradiation. This induces a decrease of the optimal voltage with solar irradiation; when the solar irradiation varies from 600 W/m² to 1000 W/m². By taking into consideration all the modeling results, the electric behavior of the cells association in parallels or in series, as well as the aging of a PV panel have been analyzed. Moreover, a comparative study between two types of MPPT techniques that are used in photovoltaic systems to extract the maximum power have been introduced which are Perturb and Observe (P &O) and Incremental Conductance (INC).

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Energy resources, the energy through the photovoltaic (PV) effect can be considered the most essential and prerequisite sustainable resource because of the ubiquity, abundance, and sustainability of solar radiant energy. In fact, the demand for solar energy has increased by 20%—25% over the past 20 years [1]. The Systems applications of photovoltaic's production may be independent (water pumping, electric vehicles, public lighting ...) or connected to the grid (power plants) [2]. PV module modeling primarily involves the estimation of the nonlinear I–V curves. Previous researchers have utilized...
circuit topologies to model the characteristics of the module when subjected to environmental variations such as changed in irradiance and temperature. By far, the simplest approach is the one-diode model.

However, the photovoltaic industry is not able to solve all our current problems and to substitute traditional energy sectors. Indeed, the recovered energy is too low and the cost is still higher than other sectors. Under the normal weather conditions, the photovoltaic generator can operate over a wide range of voltage and current. But it cannot provide a maximum of power for the particular values of current and voltage. Indeed the characteristic I(V) of the generator depends on climatic parameters as temperature and illumination. These natural variations cause a significant change in the maximum power point. For this reason, PV generators are connected to loads by dc–dc converters called MPPT. The MPPT changes the operation point of the PV system to find the maximum possible power in any case [3]. Generally boost converters are used for transferring the maximum output power of the panel. The advantages of the boost converters in some applications are the low input current ripple, and the easy control [4,5]. Furthermore, in the continuous current mode, the boost converter has better characteristics than the buck converter [6–9].

According to the above mentioned studies, this paper deals with the modeling of PV cell, module and array according to manufacturer supplied data for a specific module, and then the model is used to study characteristics of PV under different atmospheric conditions. And also a comparative study of the two models of solar cell: one and two-diode.

A comparative study between two types of MPPT techniques is shown as well. Finally, brief conclusions are mentioned.

**Photovoltaic modules for electricity generation**

One important way to convert solar radiation into electricity occurs by the photovoltaic effect which was first observed by E. Becquerel in 1839. It is quite generally defined as the emergence of an electric voltage between two electrodes attached to a solid or liquid system upon shining light onto this system.

Practically all photovoltaic devices incorporate a PN-junction in a semiconductor across which the 36 photovoltage is developed. These devices are also known as solar Cells. The semiconductor material has to be able to absorb a large part of the solar spectrum. Dependent on the absorption properties of the material the light is absorbed in a region more or less close to the surface. When light quanta are absorbed, electron–hole pairs are generated and if their recombination is prevented they can reach the junction where they are separated by an electric field [10]. Fig. 1 shows the typical structure of a photovoltaic cell.

To understand the operation of a PV cell, it needs to consider both the nature of the material and the nature of sunlight.

**PV cell modeling (comparative study)**

The literature proposes two famous model [10]: single-diode and two-diode model. In this section, a comparative study was conducted as to select the appropriate model.

Mathematical equations describing quantitatively the system characteristics are formulated from this analysis and translated into computer to be used in the simulation process.

**Single-diode modeling**

The equivalent circuit of a PV cell includes a current source, a diode, a series resistance and a shunt resistance. A solar cell is modeled by the following electrical diagram shown in Fig. 2.

Where the Diode models the behavior of the cell in the dark, the current generator models the current $I_{ph}$ generated by the illumination, finally, the two resistors model the internal losses: The serial resistance $R_s$ models the ohmic losses of the material and takes into account the specific contacts between the various constituent parts of the cell resistivity, namely emitter, base and metal contacts. This resistance should be as low as possible, the shunt resistance $R_{sh}$ models the noise currents through the cell and it is known as the
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