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Simulation of a Solar Cell considering Single-Diode Equivalent Circuit Model

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Abstract. This paper focuses on single-diode photovoltaic cell models. Comprehensive simulation studies are carried out in order to adequately assess temperature dependence, solar radiation change, diode ideality factor and series resistance influence. A comparison between an ideal model single-diode solar cell and a model of single-diode solar cell with a series resistance is also presented. Finally, conclusions are duly drawn.

Key words

Photovoltaic energy, solar cells, modelling, simulation.

1. Introduction

In recent years, significant photovoltaic (PV) deployment has occurred, particularly in Germany, Spain and Japan [1]. Also, PV energy is expected to become an important player in the coming years in Portugal, since it is one of the European countries with the highest levels of solar radiation. Sunshine in mainland Portugal varies between 1800 and 3100 hours per year, so the country has a huge potential for solar energy exploitation.

At the present the tenth largest PV power plant in the world is in Moura, Portugal, with an installed capacity of 46 MW. The aim is to reach 1500 MW of installed capacity by 2020, according to the Portuguese National Strategy ENE 2020, multiplying tenfold the existing capacity [2].

A PV system directly converts sunlight into electricity. The main device of a PV system is a solar cell. Cells may be grouped to form panels or arrays. Power-electronic converters are usually required to process the electricity from the PV device. These converters may be used to regulate the voltage and current at the load, to control the power flow in grid-connected systems, and for the maximum power point tracking (MPPT) of the device [3].

The solar cell is basically a semiconductor diode exposed to light. Solar cells are made of several types of semiconductors using different manufacturing processes [4].

The electrical energy produced by a solar cell at any time instant depends on its intrinsic properties and the incoming solar radiation [5].

The solar radiation is composed of photons of different energies, and some are absorbed at the *p-n* junction. Photons with energies lower than the bandgap of the solar cell are useless and generate no voltage or electric current. Photons with energy superior to the bandgap generate electricity, but only the energy corresponding to the bandgap is used. The remainder of energy is dissipated as heat in the body of the solar cell [6].

A single-diode PV cell model is considered in this paper, including the effect of the series resistance. The paper uses the equivalent circuit of a solar cell with its parameters as a tool to simulate in order to consider the irradiance and temperature change, the I-V characteristics of PV cell.

2. Modelling

A. Ideal Solar Cell

As mentioned previously, the solar cells are semiconductor with a *p-n* junction fabricated in a thin wafer or layer of semiconductors. When exposed to light a photo current proportional to the solar radiation is generated, if the photon energy is greater than the band gap. In the dark, the I-V characteristics of a solar cell have an exponential characteristic similar to that of a diode [7].

In order to maximize the extracted output power from a PV power plant with the help of MPPT control, the understanding and modelling of PV cell is necessary [8].