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A simulation model for sizing PV installations

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Abstract

Electric energy consumption in the arid Saharan regions is continuingly increasing due to increasing urbanization. Photovoltaic solar energy may be a suitable form of alternative electric energy production due to the abundance of solar energy in this region. In this paper we are presenting the general outline of a simulation model used to size and assess the performance a PV installation using DELPH5 programming language. This program allows the user to determine at any moment the performance of the PV installation by comparing the PV electric energy produced and the required consumption load and. It also permits the optimization of the system relative to the factor of time.

Keywords: Photovoltaic system; Simulation; Modelling; Performances; Optimization

1. Introduction

Photovoltaic electric energy has become a major emphasis in Algeria since 4/5 of the country is the Saharan desert, receiving approximately around 6 KWh/m^2/day. More than all fossil types of energy combined. But the development of photovoltaic industry as in any other type of industry has economic criteria and constraints that must be met for it to be economically feasible. Some of the economic factors influencing the cost feasibility of a PV installation are the cost of basic materials [1,2] and the flexibility of the installation to meet various domestic needs of the user.

Conversion from solar to photovoltaic electric energy is one of the mostly direct usages of solar energy. In isolated regions such as those of the Saharan desert, and because of the scarcity of means it is necessary to optimize PV installation to utmost possible in order to have the least costly system possible.

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Computer simulation techniques can be used to test the performance of various components of the PV system before they are put in place hence reducing materials and installation costs [2].

2. Modeling of photovoltaic system

Photovoltaic conversion is the direct transformation of solar energy into immediately usable direct electric current. From a technical standpoint, PV power systems have the potential to meet a large portion of energy demand worldwide [1]. A photovoltaic system contains the following components:

- photovoltaic array (generator)
- controller
- voltage transformer
- inverter to convert DC produced to AC current
- storage battery

2.1. Modeling of PV array

A PV generator consists of modules connected in series to increase the voltage and in parallel to increase electrical output (Fig. 1). The relationship between current and voltage is expressed by the following relationship

$$\frac{I}{M_p} = I_{cc} - I_o\left[e^{\left(\frac{c_2}{n}\left(\frac{V}{Ms}+\frac{Rs.I}{Mp}\right)\right)} - 1\right] \qquad (1)$$

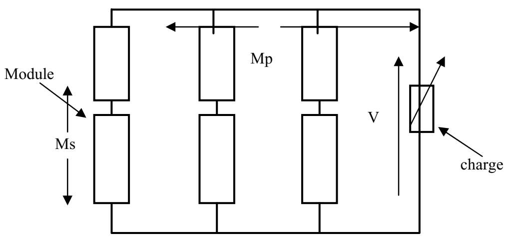

Fig. 1. A photovoltaic array.

where I = output current; I_{cc} = light generated current per module; I_o = reverse saturation current per module; R_s = diode series resistance per module (ohms); N = number of modules in each series string; M_s = number of module strings in strings in series; M_p = number of module strings in parallel.

This relationship holds true only if the array cells are identical and having the same characteristic $I = F(V)$.

2.2. Temperature modeling

Cell temperature (T_c) varies according to global solar irradiance and ambient temperature according to the following equation:

$$T_c = T_a + \left(\frac{N_{oct} - 20}{800}\right)\cdot G_b$$

N_{oct}, normal cell operating temperature provided by manufacturer data; T_a, Ambient temperature; G_B, Global solar irradiance

2.3. Modeling the battery

Experimental testing of solar batteries leads to the following model for load and off-load [3]

$$V = V_0 \pm I\cdot R$$

$$V = \left\{V_o + k.\frac{Q}{\frac{C_T}{1+a\cdot I}(1+\alpha c\cdot\Delta T+\beta c\cdot\Delta T^2)}\right\} \mp \left\{\left(\frac{P_1}{1+I} + \frac{P_3}{\left[1-\frac{Q}{C_T}\right]P_4} + P_5\right)(1-\alpha\cdot c\cdot\Delta T)\right\} \qquad (2)$$

where the + sign is for the charge and – sign for the discharge:

V_0 = initial voltage

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