A Step-by-Step Guideline for Modeling of Photovoltaic Panel by Using ISIS-Proteus Software

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ABSTRACT

We designed and implemented the electric scheme of the solar panels in PROUTEUS ISIS-Capture in accordance with their architecture in this work, which concentrates on how to create a specific library of any commercially available solar panels in that environment.
Currently, the existing photovoltaic panel models are mostly based on MATLAB or PSPICE software, barely based on ISIS-PROTEUS software. This paper focuses on the model of photovoltaic cells or panels based on PROTEUS software. This enables the operation of each panel supplying a resistive load or other charges to be modelled. Additionally, simulation is utilized to accurately establish the electric properties of the panels and those of the single or multiple maximum power points in response to changes in temperature and sun irradiation. We applied the modeling method using ISIS Proteus software to Isofoton-75 solar panels, and to confirm the validity of the results obtained, we compared them with the experimental results.

I. Introduction

The world today, including countries and governments, is forced to develop and exploit renewable energy sources (sun, wind, water,...) due to the current energy crisis and the pollution resulting from current energy sources (oil, gas, etc.)[1–8]. Among these renewable energies, we find in the first place, in terms of spread and ease of exploitation, the production of electrical energy using photovoltaic panels[9–14]. One of the steps of studying and developing renewable energy sources is the creation of virtual environments on the computer for simulation[15–17].
Models are mathematical or conceptual representations of real systems. They are generated for the purpose of understanding and predicting behavior that can be measured or observed. In the context of PV systems, models are used to understand and predict energy or power output from PV systems under a wide range of environmental, design, and site conditions. Modeling makes it possible to present the I-V characteristics of a module according to a set of parameters (such as the temperature and the irradiance of the PV cells) and to estimate the optimal performance of the PV module[18].
In this work, the need to characterize and evaluate the performance of photovoltaic modules in order to ensure optimal performance and technical quality in photovoltaic power systems was highlighted. Modeling a photovoltaic (PV) module is an essential step for evaluating the efficiency of photovoltaic energy production systems. Currently, the existing photovoltaic panel models are mostly based on MATLAB or PSPICE software, barely based on ISIS-PROTEUS software[19]. In this work we designed and implemented the electrical scheme

for solar panels in a PROUTEUS-ISIS environment, which focuses on how to create a specific library of any commercially available solar panels in that environment. This enables the operation of each panel supplying a resistive load or other charges to be modelled. Additionally, simulation is utilized to accurately establish the electric properties of the panels and those of the single or multiple maximum power points in response to changes in temperature and sun irradiation.
We applied the modeling method using ISIS Proteus software to Isofoton-75 solar panels, and to confirm the validity of the results obtained, we compared them with the experimental results.

II. PV cell and panel model

A solar cell or panel is a device that converts sun irradiation into electrical energy. The relationship between its electrical elements, radiation intensity and temperature can be expressed mathematically and represented in an electrical circuit[13,20–22] , as shown in Figure 1.

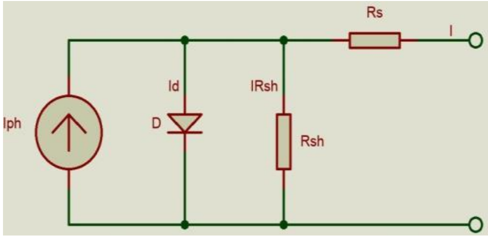


Figure 1. Equivalent circuit for PV cell

The equivalent electrical circuit of the photovoltaic cell or panel in Figure 1 can be expressed mathematically as follows:

$$I = I_{ph} - I_D - I_{sh} \quad (1)$$

$$I_{ph} \approx I_{cc} = f(G, T_c) \quad (2)$$

$$I_{ph} = \frac{G}{G_{ref}}\left(I_{ph.ref} + \alpha \cdot \Delta T\right) \quad (3)$$

$$I_D = I_s(exp^{\frac{qV_D}{AKT_c}} - 1) = I_s(exp^{\frac{qV_C+R_S I}{AKT_c}} - 1) \quad (4)$$

$$I_{sh} = \frac{V_D}{R_{sh}} = \frac{V+R_S I}{R_{sh}} \quad (5)$$

$$I_s = I_{s.ref}\left(\frac{T_c}{T_{c.ref}}\right)^3 exp\left[\left(\frac{E_g}{AK}\left(\frac{1}{T_{c.ref}} - \frac{1}{T_c}\right)\right)\right] \quad (6)$$

The photovoltaic module consists of cells connected in series (n_s)

$$I_D = I_s\left[exp\left(\frac{q(V_{pv}+R_S I_{pv})}{An_{cs}KT_c}\right) - 1\right] \quad (7)$$

$$I_{sh} = \frac{\frac{V_{pv}}{n_{cs}}+R_{sc}I_{pv}}{R_{shc}} = \frac{V_{pv}+n_{cs}R_{sc}I_{pv}}{n_{cs}R_{shc}} = \frac{V_{pv}+R_S I_{pv}}{R_{sh}} \quad (8)$$

Where I_{ph} is Photon current, I_D,V_D are diode current and diode voltage, I_{sh} is leakage current flowing through the shunt resistance, R_{sh} is Shunt resistance, R_s is Series resistance, I_{pv} is Output current of the PV cell (A), V_{pv} is Output voltage of the PV cell (V), I_{sc} is short circuit current (A), V_{op} is open circuit voltage (V), G is Solar irradiation (W/m²), T is Operating cell temperature (K), I_s is Diode saturation current(A), q is Electron charge (1,6e-19 Coulomb), k is Boltzman constant (1,38e-23 J/K), E_g is Band gap energy of the semiconductor (1.1eV) and A is The ideality factor of the diode.

III. A simulation platform the PROTEUS for the study and modeling of PV

modules

Proteus is a design software developed by Labcenter Electronics for electronic circuit simulation, schematic capture and PCB design. Its simplicity and user friendly design made it popular among electronics hobbyists. Proteus is commonly used for digital simulations such as microcontrollers and microprocessors. It can simulate LED, LDR, USB Communication, etc. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

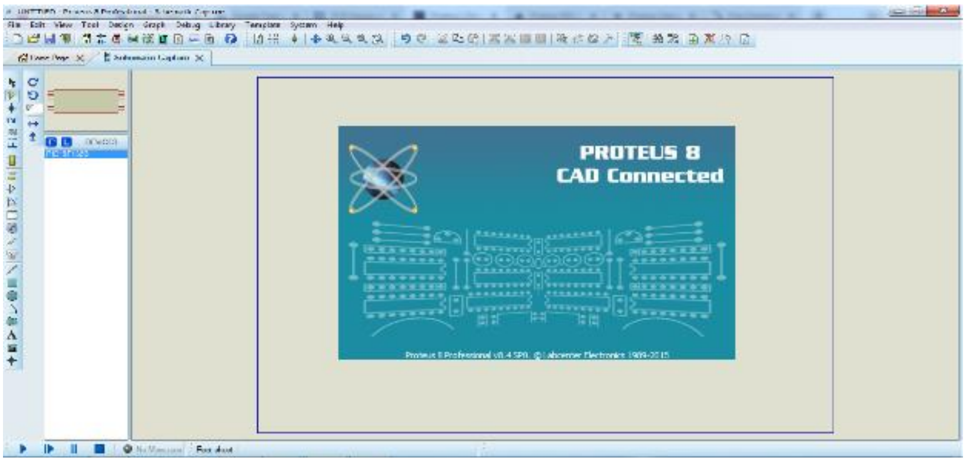
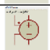


Figure 2. work space of ISIS-Proteus software

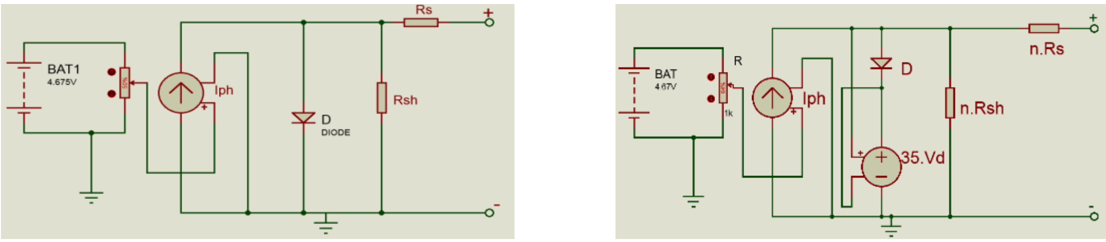
The program is characterized by its ease of use in terms of finding electrical components and linking them to each other. The program also contains a huge library consisting of various electrical components and measuring devices. And also, through this program, we can see the results in the form of graphics. The table 1 presents the various electrical components that we need in order to model the photovoltaic panel on the ISIS-Proteus software.

Table 1. The different symbols we need for our PV system simulation in ISIS-Proteus

Symbol	Noun	Description
	VCCS	Linear voltage controlled current source
	VCVS	Linear voltage controlled voltage source
	POT	Variable resistor / potentiometer with lin or log law
	BATTERY	Battery (Multi-cell) DC voltage source
	DIODE	Diode
	RES	Resistor

As shown in Fig. 3, in order to model a PV panel in Proteus tool, the below steps are followed:

1. A "Voltage Controlled Current Source" block controlled by "DC Voltage Source" block is used to model the I_{ph} Source. In order to change the values of I_{ph} related to the change in radiation intensity, we add a variable resistor (potentiometer) in series with the continuous source DC.
2. A "Linear voltage controlled voltage source" block controlled by VD diode characteristic. This block integrated to presented the number of cells by multiplication the diode characteristic in n. For example to simulate our model *Isofotón*-75 we give the number 35 to the block in order to represent 36 cells connected in series.
3. Two resistors are used to model the shunt resistor and the series resistor with the values mentioned in table I.



(a) (b)

Figure 3. PV cell and panel model implemented under ISIS-Proteus software, (a) PV cell model, (b) PV panel model

As already mentioned, the photovoltaic panel that we simulate as an example in this study is module *Isofotón*-75, which bears the parameters mentioned in Table 2.

Table 2. Parameters of the PV module *Isofotón*-75 at STC

Type	*Isofotón*-75
Maximum power (P_{max})	75W
Open Circuit Voltage (V_{oc})	21.6V
Short Circuit Current (I_{sc})	4.67A
Voltage at Pmax (V_{mp})	17.3V
Current at Pmax (I_{mp})	4.34A
The number of cells	36
Shunt Resistance Rsh	199.48 Ω
Series Resistance Rs	0.2402Ω
Light-generated current Iph	4.6756A

In order to plot both the I-V and P-V characteristics of the photovoltaic panel using the model shown in Figure 4, we adjust the solar radiation intensity by means of a variable resistance R. In order to take all the points on the I-V characteristic, we use a variable resistance (CH) representing the load where we change it from zero (I_{cc} measurement) to its maximum value (V_{oc} scale). In order to take measurements, we use both voltmeters and amperemeters. As a working example to simulate an Isofotone-75W photovoltaic panel on a ISIS-Proteus, we need the parameters of the photovoltaic panel (see table 1), such as resistance R_{sc}=199.48 Ω, resistance R_s=0.2402 Ω, The number of cells 36 and current I_{ph}=4.6756A. Figure 4 presents the circuit.

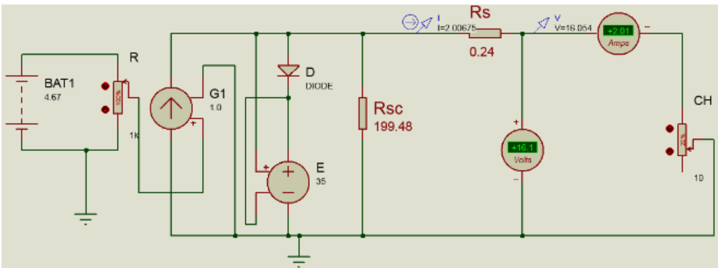


Figure 4. Equivalent circuit of a photovoltaic panel for measuring the I-V characteristic.

For three radiance values 1050W/m², 700W/m² and 300W/m², we plot the I-V and P-V (see figure 5) properties by changing the load values with the CH variable resistance.

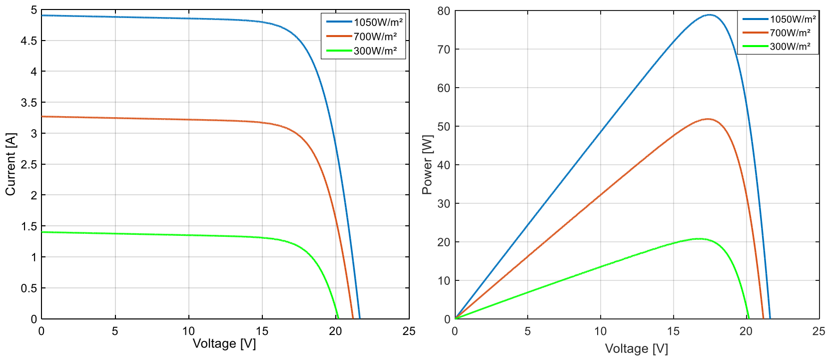


Figure 5. The I-V and P-V simulation results of the isfetone 75W module; according to the solar irradiation for a fixed temperature of 25°C

IV. Validation of the Proteus PV panel model by experimental results.

In order to improve and examine the validity of the model, the curves simulated by ISIS Proteus were compared with the experimental curves, which are practically obtained for a range of variation in the power of the illumination received by the photovoltaic panel (between 200 to 1000W/m²). These experimental data are provided by an EKO Instruments MP-160 I-V curve plotter to characterize the panels and plot the I(V) characteristic of the photovoltaic module.

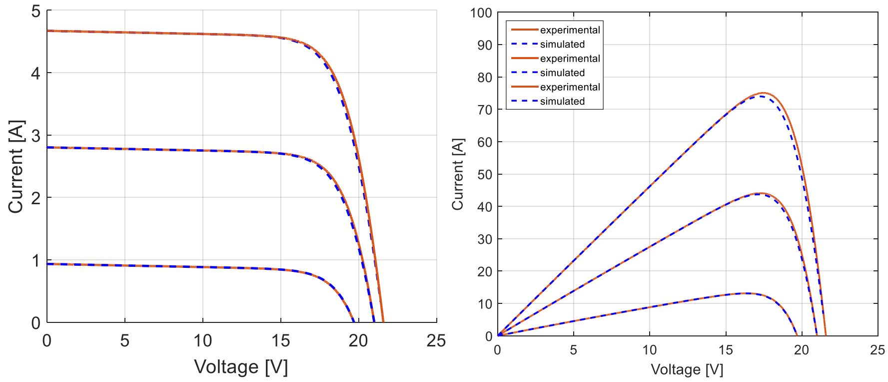


Figure 6. and P-V characteristics obtained by our model and experimental data at three different irradiations (200W/m², 600W/m² and 1000W/m²).

Figure 6 shows the I–V and P-V characteristics obtained by our model and experimental data at three different irradiations (200W/m², 600W/m² and 1000W/m²). And as shown in figure 6, the model accurately is in accordance with the experimental data both in the power and the current I-V characteristics.

V. Conclusion

In this work, we presented a clear and simple method for simulating both the cell and the photovoltaic panel using the ISIS-Proteus program. Modeling a photovoltaic system using ISIS-Proteus has proven to be a cost-effective software solution. It has the ability to research a variety of independent PV system characteristics, and the simulation findings are generally consistent with the experemenls data. Compared to previous modeling methodologies, this approach, combined with the accuracy of its results, makes translating the I-V curves of a PV module to desired conditions and power prediction much simpler.

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