Symbolization of the electric diagram of the marketed solar panels in the Orcad- Pspice environment.

A. Aziz, K. Kassmi
Université Mohamed Premier, Faculté des Sciences, dépt de Physique, LEAA , Oujda, Maroc.

F. Olivié, A. Martinez
Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS/CNRS), 7 avenue du Colonel Roche, 31 077, Toulouse, France.

In this paper, focuses on how to create a special library of some marketed solar panels in the Orcad-Pspice environment using the design features provided by the founder, we established and implanted in Orcad-Pspice the electric scheme of the solar panels according to their architecture. This makes it possible to model the operation of each panel when it is closed on a resistive load. Also, simulation is used to determine the electric characteristics of these panels according to temperature and solar irradiation.

I INTRODUCTION

Design and optimization of photovoltaic (PV) systems [1-4] (implantation of solar panel (s), energy converters and special control) require a powerful circuit simulators. Within our framework, the Orcad-Pscipe simulator [5-7] is used, because it is simple and effective in establishing and simulating the complex electric circuits.

Generally, the implantation of marketed PV panels (or panels arrays), in the circuit simulators, poses problems of PV generator models. In [6,7], several techniques are described to create new components (PV generators), in the Orcada-Pspice simulator library which will be directly called by their equivalent circuits (symbols). The method adopted at the time of system implantation is known as symbolization.

In this paper, based on the which returns in the framework of the 'Action Intégrée (Franco-Marocaine) N° MA/03/78' and 'the Scientific Research Support Work (PROTARS III) D43/06', some currently marketed solar panels are symbolized by electric diagrams (blocks) in the Orcad-Pscice simulator library. These symbols are used as sources of energy in the analysis, the design and the optimization of the photovoltaic systems. Particularly, we present the symbolization results of the SP75 panel [8] which will be the subject of PV generator in our PV system under development.

II. ELECTRIC DIAGRAM OF PV GENERATORS

II.1. Symbolization of the electric diagram of photovoltaic cells

In all solar panels, a basic solar cell is represented according to the model of Fig. 1 [1]. In this diagram:

- the current generator (Iccc) provides a short-circuit current which is a function of the solar irradiation (Pvar) according to an equation determined by the characteristics I(V) provided by the manufacturer:

$$Iccc = a \bullet Pvar + b \qquad -1-$$

where, a and b are constants which depend on PV cells

- D is a diode whose parameters (IS: saturation current, η: idealist factor) are given by simulations at the time of the modelling of PV generators. In this diode, the general equation of the current as follows:

$$I = I_S\left(\exp\left(\frac{q \bullet V}{\eta \bullet KT}\right) - 1\right) \qquad -2-$$

where, V: voltage applied at the diode boundaries, q: electron charge, K: Boltzmann constant, T: temperature.

Thus, on this Orcad-Pspice environnement, one can integrate a PV cell according to the model of Fig.1 [6,7].

- Rs and Rp are resistances, standing for the voltage drops per ohmic contact and leakage current.

The parameters (Iccc, Rsss, , Rppp) are preceded by '@'. Meaning that their value will be given later on the final diagram of the solar panel. But if we want to model the PV cell, it suffices as shown in Fig.2 to indicate their value.

The Rs resistance is determined by simulations and Rp resistance is set at 1 MΩ [2].

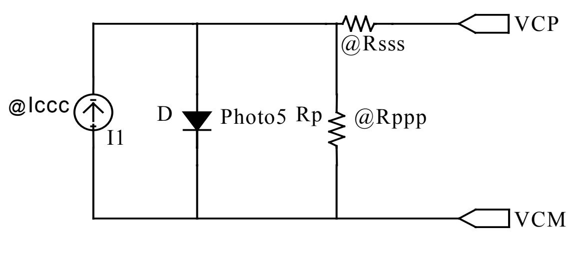

FIGURE 1: Electric scheme of one photovoltaic cell [1]

The PV cell of Fig.1 is depicted using block shown in Fig.2 [7]. This block is thus regarded as a circuit of the Orcad-Pspice simulator library.

It should be noted that at the time of the simulations parameterised by the illumination power, we indicate that Iccc depends on illumination following Eq.1. Also, we remember that the test standard conditions (TSC) are defined by irradiance power of 1000W/m^2, a temperature of 25°C and a spectrum AM1.5 [1].

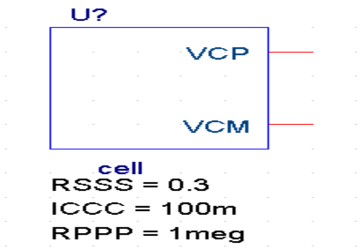

FIGURE 2: Symbol of one PV cell in the Orcad-Pspice environment [7].

II.2. Symbolization of the electric diagram of pv panels

As shown previously, in the Orcad-Pscipe environment, it is possible to symbolize a column of PV cells (Fig. 3) and a panel [7] (Fig. 4). Therefore, for a given panel, we can simulate its electric characteristics (voltage, power-voltage) by calling directly the panel of the Orcad-Pscipe library. The PV panel final diagram is characterized by parameters (Icc, Rs, Rp) obtained by simulation using the technical sheet. We can also carry out these simulations according to the intensity of illumination and temperature.

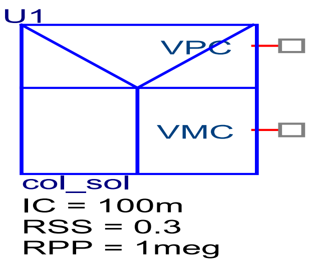

FIGURE 3: Symbolization of a PV cell column made of 36 cells in the Orcad-Pscipe environment [7].

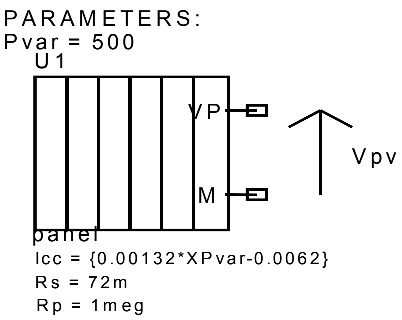

FIGURE 4: Symbolization of PV panel made of 6 columns in the Orcad-Pscipe environment [7].

III SYMBOLIZATION OF THE MARKETED SOLAR PANELS

In the sequel, based on technical sheet provided by the manufacturer (Schell solar), we determine the electric diagram of the marketed solar panel SP75. Then, is integrated into this diagram the Orcad-Pspice environment and the simulation results of current-voltage and power-voltage characteristics are presented according to illumination level and temperature. This panel will be used to design and fabricate our PV system.

III.1. Panel SP75 structure

The SP75 module is a solar panel made of mono crystalline silicon. It consists of 36 solar cells connected in series (Fig. 5). The surface of each solar cell is about 125mm X 125mm. Module SP75 can deliver 75 Watts under 17 volts (standards test conditions (TSC)). The module surface is 120 cm X 52.7 cm.

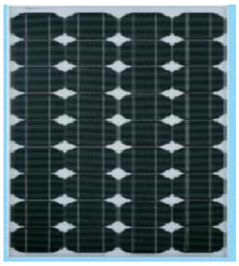

FIGURE 5: Solar panel SP75 [8].

III.2. Electric characteristics of panel SP75

Figure 6 shows typical characteristics I(V) of the solar module at various levels of cell illumination and temperatures. From these characteristics, the electric characteristics of this panel under TCS can be obtained (See table 1). Thus, it appears that panel SP75 can deliver, in the TCS, it 75 W, 4.41A under an optimal voltage of 17V.

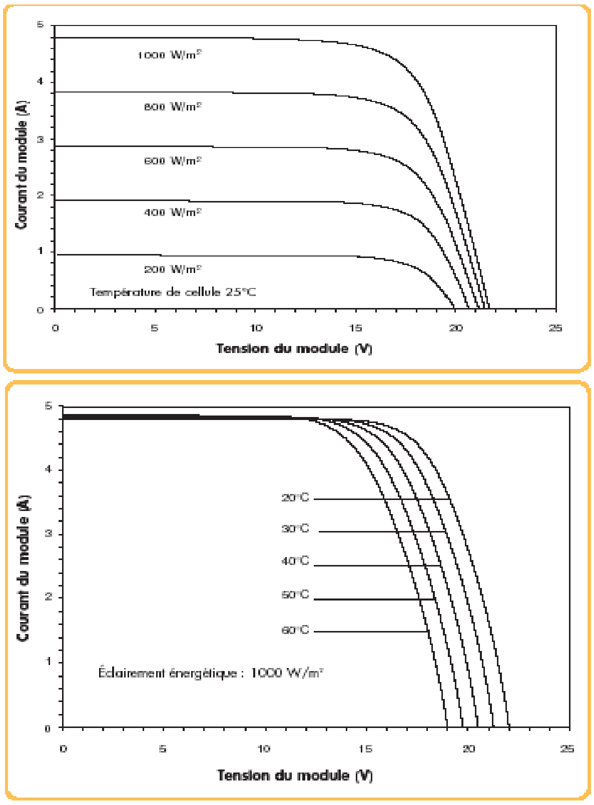

FIGURE 6: Characteristics I(V) according to illumination and temperature for an illumination of 1 000 W/m² [8].

Table 1: Electric characteristics of the SP75 panel in TSC [8].

Maximal power	75 W
Optimal voltage	17 V
Optimal current	4.4 1A
Open circuit voltage	21.7 V
Short circuit current	4.8 A

III.3. Electric symbolization of the sp75 panel in orcad-pspice environment

From the characteristics given in Fig 6, it can be derived that the current crossing a cell could be described according to illumination (Pvar (W/m^2)):

$$I_{cc}(A)=0.00481*Pvar-0.0125 \qquad \text{-3-}$$

To model the SP75 PV panel, we have:

- symbolized the photovoltaic cell by fixing the following simulation parameters:
  - The short circuit current Icc is given by Eq. 3,
  - Rs = 12.5 mΩ,
  - Rp = 1MegΩ.
  - Pspice Model of the diode D (Is=100pA, Rs=3m, Ikf=.3227, N=1, Xti=0, Eg=1.11, Cjo=302.5p, M=.7206, Vj=.50, Fc=.5, Isr=1.2u, Nr=1.426).
- symbolized a panel by associating 36 elementary cells in series,

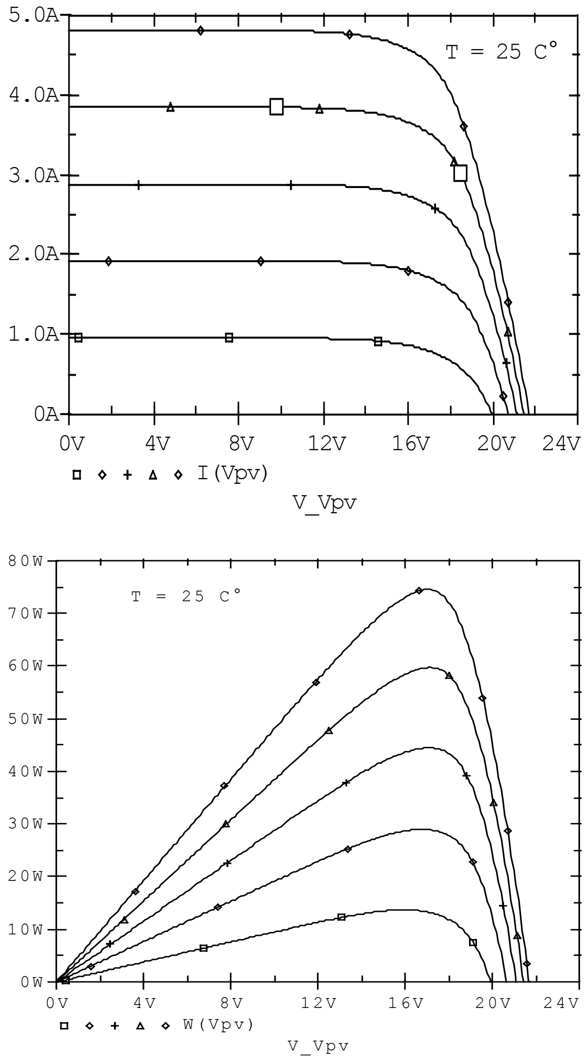

FIGURE 7: Simulated I(Vpv) and P(Vpv) characteristics, in the Orcad-Pspice environment, according to the solar irradiation for a fixed temperature of 25 °C. Solar irradiation in W/m^2 (□ : 200, ◊ : 400, + : 600, Δ : 800, o :1000).

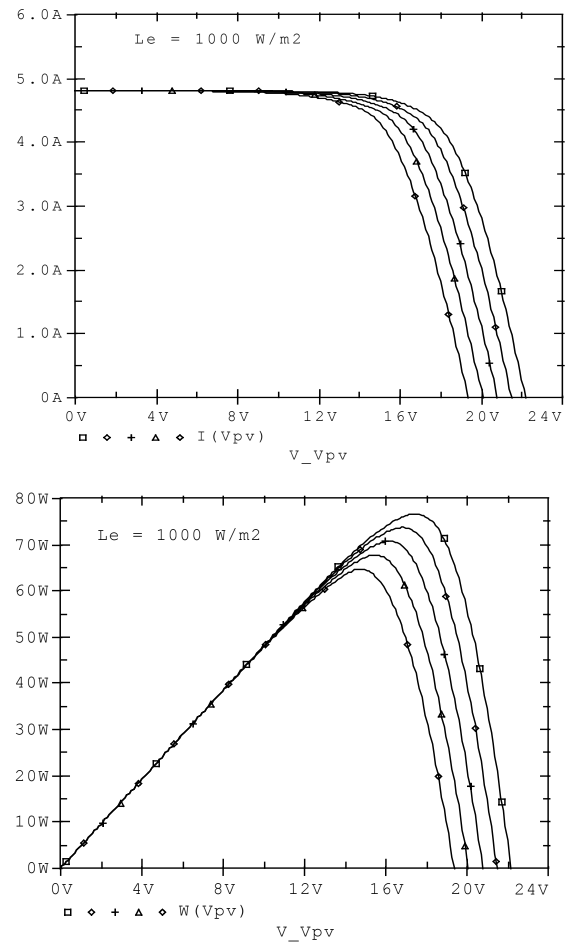

FIGURE 8: simulated characteristics I(Vpv) and P(Vpv), in the Orcad-Pspice environment, according to the temperature with irradiation set at 1 000 W/m^2. Temperature T in °C *(□: 20, ◊ : 30, + : 40, Δ : 50, o :60)*

In Fig. 7, the characteristics I(Vpv) and P(Vpv) have been simulated according to the irradiance level for a temperature of 25 °C. Compared with the manufacturer characteristics (Fig.6), we deduce a very good agreement between the real characteristics (experimental) and those deduced by simulation for the panel symbolized in the Orcad-Pscipe environment.

In Fig. 8 the I(Vpv) and P(Vpv) characteristics have been simulated according to temperature for an solar irradiation of 1000 W/m^2. As previously, we get a very good greement between these simulated characteristics and those given by the manufacturer. The results obtained show that marketed solar panels can be symbolized using the equivalent electric model and then integrated into a special library of the Orcad-Pspice simulator. This makes it possible to analyse the design and optimization of PV systems for a well exploitation of the solar energy.

IV Conclusion

In this paper, we briefly described the various stages of symbolization in the Orcad- Pspice environment of the electric scheme of marketed solar panels. More particularly, symbolization results and SP75 panel modelling have been presented. By exploiting the data provided by the manufacturer, all the electric characteristics of this panel were found:

- resistance connected in series and parallel of the elementary cell,
- short circuit current (ICC) according to solar irradiation.
- the Pspice model of diode D, in the elementary cell, is built by simulation (saturation current, ideality factor ect....),

With the help of symbolization used to integrate the solar panels into the library of the Orcad-pspice software, we can further investigates the design and optimization of a photovoltaic system for an optimal use of solar energy.

Acknowledgment

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