MATLAB SIMULINK MODEL OF A PHOTOVOLTAIC CELL

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The purpose of the research is to make Simulink model of a photovoltaic cell (PV-cell) allowing to calculate both voltage and current generated by the PV-cell.

A PV-cell is a specialized semiconductor diode that converts the sun light into direct current (DC). Large sets of PV-cells can be connected together to form solar modules, arrays, or panels.

PV-cells convert the sun's energy into electricity. Whether they are used in our calculator or orbiting our planet on satellites or airplanes, ships and know a day's everywhere in the world, they rely on the photoelectric effect: the ability of matter to emit electrons when a light is shone on it.

Silicon is what is known as a semi-conductor, meaning that it shares some of the properties of metals and some of those of an electrical insulator, making it a key ingredient in solar cells.

Sunlight has particles called photons, which radiate from the sun. When these photons hit the silicon atoms of the solar cell, they transfer their energy to loose electrons, knocking them clean off the atoms. Freeing up electrons is however only half the work of a solar cell: it then needs to herd these stray electrons into an electric current. This involves creating an electrical imbalance within the cell, which acts a bit like a slope down which the electrons will flow in the same direction. This imbalance is made possible by the internal organization of silicon. Silicon atoms are arranged together in a tightly bound structure. By squeezing small quantities of other elements into this structure, two different types of silicon are created: n-type, which has spare electrons, and p-type, which is missing electrons, leaving «holes» in their place.

MATLAB Simulink – is very famous soft allowing to present researches both in mathematical style and electrical style. It contains a lot of program libraries, as a SimPowerSystems for power engineering purposes. Unfortunately this library hasn't got any embedded standard blocks for solar stations calculating. It is not useful and it needs to be improved.

There are a lot of MATLAB Simulink models of PV systems in science literature. For example [1]–[3].

In [3] is considered model of PV module made using SimPowerSystems library (Fig. 1). This model contains these blocks: Anode, Cathode, Controlled Current Source, Voltage measuring meter, Bypass Diode, S-Function Builder and two input parameters – $S1$ for solar irradiation and T for temperature. The S-Function Builder block contains a program realizing calculation algorithm allowing to use standard formula for volt-ampere characteristic of PV-cell:

$$I_d = I_0 \left(e^{\frac{qV}{K_B \cdot T}} - 1 \right) - I_{ph}, \qquad (1)$$

where I_d – is the current through p-n junction; I_0 – is the saturation current of p-n junction; q – is the charge of one electron; V – is the voltage generated by PV-cell; K_B – is Boltzmann constant; T – is the temperature of p-n junction and I_{ph} – is the photovoltaic current.
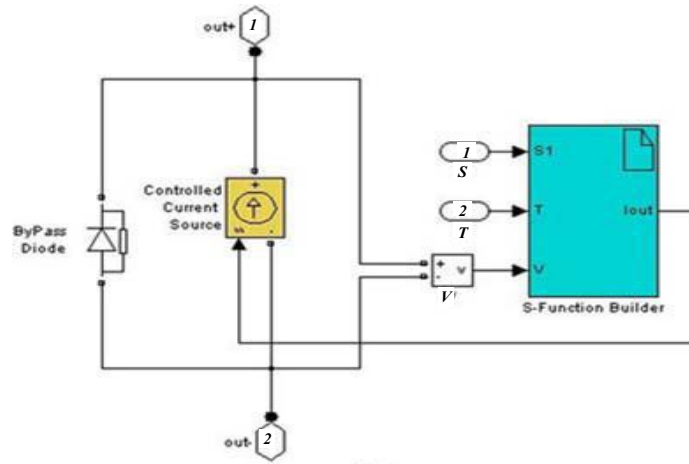

Fig. 1. Existing MATLAB Simulink model of a photovoltaic cell

The photovoltaic current I_{ph} is generated by PV-cell while the solar irradiation is not zero. Approximately this current may be calculated with formula:

$$I_{ph} = K \cdot S, \tag{2}$$

where K – photovoltaic coefficient; S – solar irradiation.

To present formulas (1)–(2) in electrical style globally is used equivalent scheme allowing modulate volt-amperage characteristics of a single PV-cell (Fig. 2).
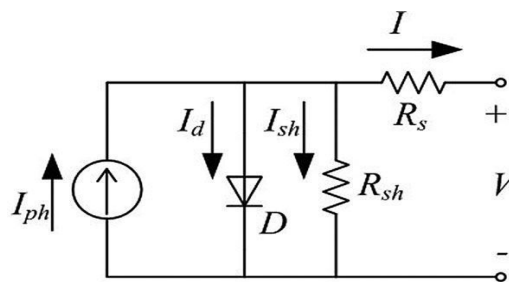

Fig. 2. Equivalent scheme of a single solar cell

This scheme contains: current source for photovoltaic current; diode for the current through p-n junction; R_{sh} – the shunt resistance in real conditions; R_s – is the series resister in real conditions; V – the output voltage and I – is the output current.

The disadvantage of the existing model presented in Fig. 1 is it contains only two input parameters that are Temperature and Solar Irradiation. This model did not allow to correct parameters of PV-cell usefully. Also this model did not allow to change values of R_{sh} and R_s in electrical style.

After our research we have made our own model of PV-cell using MATLAB Simulink (Fig. 3).
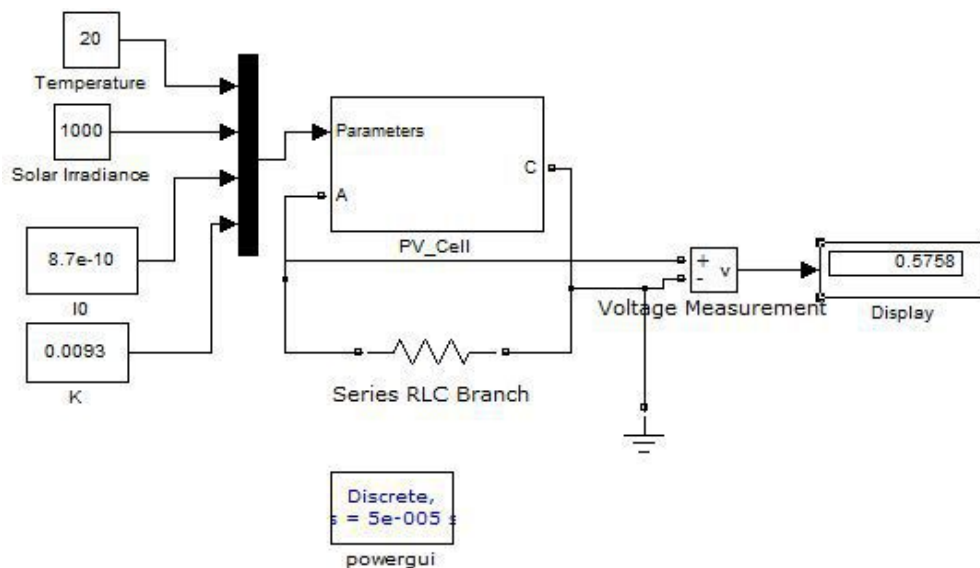

Fig. 3. MATLAB Simulink Model of a PV-cell developed by us

For our model we use four input parameters. Two of them are variable (temperature and solar irradiation) and two are constant (I_0 and K). The values of I_0 and K depend on type of PV-cell.

Block "PV_Cell" is a subsystem what contains both mathematical and electrical blocks calculating volt-amperage characteristic of PV-cell by using formulas (1)–(2).

To calculate I_0 and K parameters we have made experimental measuring with solar module "OSP XTP 250". These parameters we should use as a constant parameters for concrete type of PV-cell.

Our model allows to assemble many of PV-cells (60 cells for "OSP XTP 250" for example). Using the developed model we can make the model of the solar power station and calculate its generated voltage current and efficiency by the time.

Also our model allows to imitate damages into the solar cells to analysis results for solar modules and solar power stations.

To check developed model it needs to get some experimental volt-amperage characteristics.

L i t e r a t u r e   r e f e r e n c e s

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