

# Comparison of Modelling of Solar Cell in SimElectronics and SimPowerSystem Using MATLAB/Simulink

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**Abstract-** Solar energy conversion to electrical energy is one of the prospective energy sources due to its continuous incoming to Earth. Solar energy can be harvested in many ways; most popular nowadays is the use of photovoltaic cells. Use of small-power-rate solar-cells is very popular for small portable applications, but development of technology is making it possible to construct solar power plants of hundreds of kilowatts and this kind of energy sources are becoming more popular. The advantages of this kind of energy source are that it is renewable and it produces zero emissions to the atmosphere. One of the most significant disadvantages of photovoltaic panels is the need for special energy converters or maximum power point tracking (MPPT) converters that are able to provide maximum energy yield, because of the non-linear V-I curve of the photovoltaic cell. Correct and detailed mathematical modelling of photovoltaic panels is able to help to develop control techniques for maximum power point tracking converters. In order to overcome the disadvantages of Simscape solar cell block, a model of photovoltaic cell has been developed during the research on photovoltaic energy sources. This paper works different PV models of SimElectronics and SimPowersystems using MATLAB.

**Index Terms-** PV cells, Mathematical model of solar cell, MATLAB Simulink and SimPowerSystem model.

## 1. INTRODUCTION

Solar energy is clean and inexhaustible source of energy, which is essential in the globally prevailing circumstances: energy demand is increasing as population is increasing, the fossil fuel resources are being rapidly depleted and environmental problems becoming ever more serious. With the help of photovoltaic devices, we can convert this huge light energy into electrical energy. The PV module represents the fundamental power conversion unit of PV generator system. The output characteristics of PV module depends on the solar radiation of the cell

temperature and output voltage of PV module Matlab is one of the most popular modeling and computational software packages in the world and this paper is related to the development of SimPowerSystems-based models of photovoltaic panels that is in comparison to SimElectronics PV Model. Matlab has Simscape block library that contains a model of the photovoltaic cell that in combination with other blocks of this kind can be interconnected according to the photovoltaic panel's circuit structure.

## 2. PV CELL

Typically, any PV cell gives output voltage in the range of 0.5 to 0.85 depending upon its constraints materials. Therefore, to obtain high voltage large number of PV cells are connected in series to form photovoltaic module.

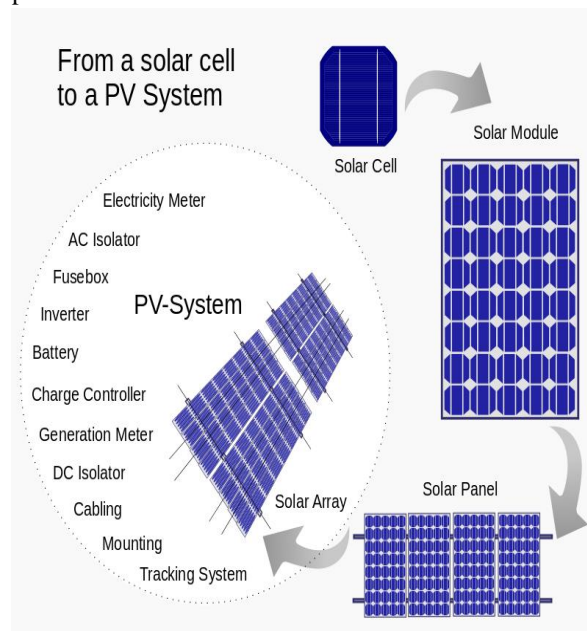


Fig 1. PV System.

And combination of such modules is called panel and such panels are connected to make PV Arrays.

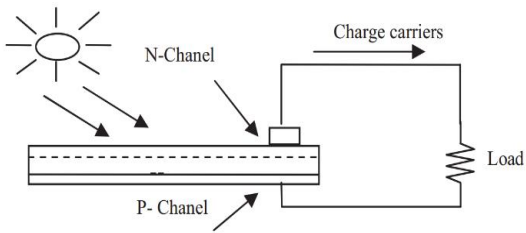


Fig. 2. Energy conversion

We know how the solar energy is converted into electrical energy. In the above Fig. 2, a demonstration is shown on energy conversion. We take output from this system. With the help of proper MPPT algorithm we get maximum power. For that, we need accurate parametric values which can be found via mathematical model. In MATLAB, there is SimPowerSystem based model, SimScape based model and SimElectronics used Models are available.

### 3. MODELLING OF PV CELL

The major parameters required in modelling are short circuit current ( $I_{sc}$ ), series resistance ( $R_s$ ), shunt resistances ( $R_{sh}$ ), saturation current ( $I_s$ ) and the diode ideality factor ( $a$ ). The conventional PV cell can be represented by using single diode model as shown in Fig. 3. This model is known as a single diode model of solar cell.

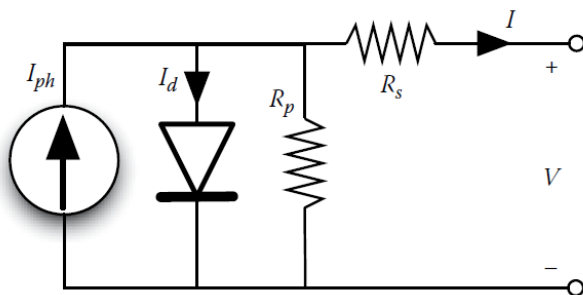


Fig 3. Equivalent Circuit Model of PV Model

The current source  $I_{ph}$  represents the photoelectric effect due to light. An ideal diode ( $I_d$ ) connected parallel to  $I_{ph}$ , describes the PV junction inside the solar cell. Shunt resistor ( $R_p$ ) describes the shunt losses inside the PV cell and series resistor ( $R_s$ ) represents the series losses within the solar cell. current ( $I$ ) is the total current that is generated by the cell, minus losses and  $V$  represents the total voltage across the load.

As circuit theory dictates, equivalent circuit output current ( $I$ ) will increase if the series resistance is very

low to nil and the parallel resistance is very high to infinity. Hence, the characteristic equation for the single diode model, including shunt and series losses, is given by:

$$I = I_{ph} - I_s \left[ \exp \left( \frac{V + I \cdot R_s}{a \cdot V_t} \right) - 1 \right] - \frac{V + I \cdot R_s}{R_p}$$

With the use of these equations we have various approaches for parameter calculations. Based on the approach and the software used we have different techniques of calculation.

### 4. MATLAB SIMULATION AND RESULTS

Mathematical block system of MATLAB simulation software is used to analyse the performance characteristics of tandem cell. Above stated mathematical expression modelled by using mathematical blocks in Simulink environment. The model considers the change of V-I curve in respect to the temperature (Simscape model has only current change ratio in respect to the temperature). Both proposed and Simscape models are composed of 32 photovoltaic cell models connected in series and divided to two sub-strings reflecting the circuit diagram of a real PV-panel SPR-90-WHT-I produced by SunPower Corporation.

The estimation of correct parameters is very important for proper modeling of the photovoltaic cell as there is a large number of factors that have strong influence on the performance. The experimental data for model verification was estimated using SPR-90WHT-I solar panel. The 90W photovoltaic panel has the following parameters available on datasheet and listed in Table 1.

Table 1. Parameters for SPR-90WHT-I solar panel

Parameter Description	Abbreviation	Value
Maximum Power at 1000W/m <sup>2</sup> and 25°C, AM1.5 (W)	$P_{MPP}$	90
Open Circuit Voltage (V)	$V_{OC}$	21.2
Short Circuit Current (A)	$I_{SC}$	5.5
Maximum Power Voltage (V)	$V_{MPP}$	17.7
Maximum Power Current (A)	$I_{MPP}$	5.1
Voltage change by temperature increase (mV/°C)		-60.8
Current change by temperature increase (mV/°C)		2.2

#### 4.1 Calculation of parameters using SIMULINK Model using SimPowerElectronics Blocks

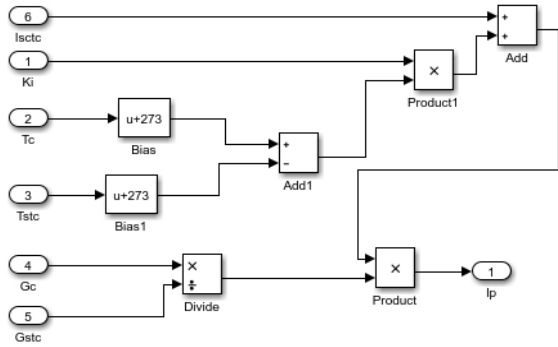


Fig 4. Ip calculation.

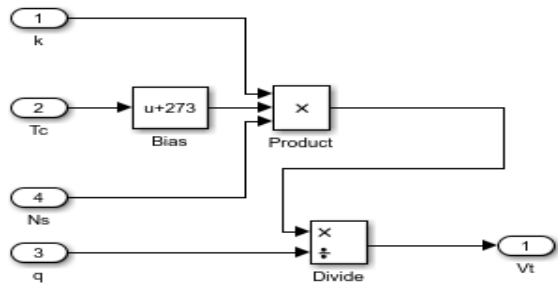


Fig 5. Vt calculation.

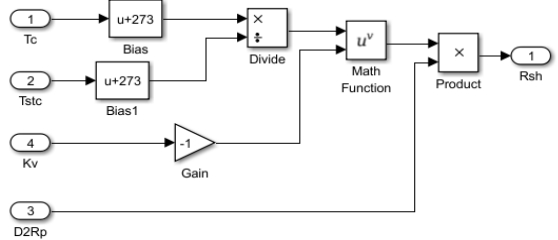


Fig 6. Rsh calculation.

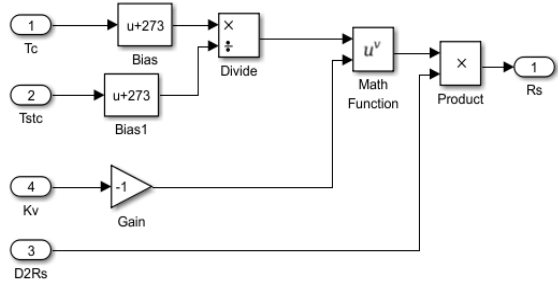


Fig 7. Rs calculation.

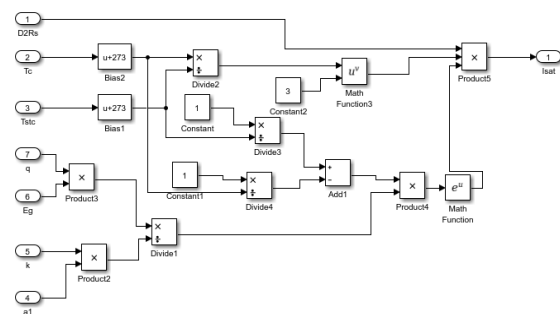


Fig 8. diode saturation current calculation.

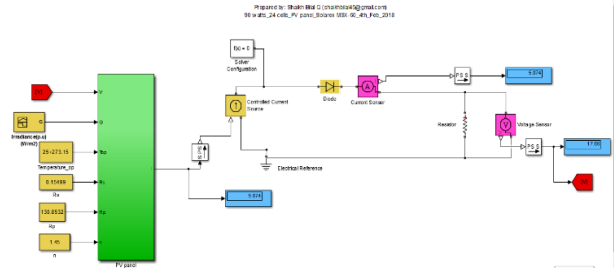


Fig 9. MATLAB/Simulink model using SimElectronics Blocks

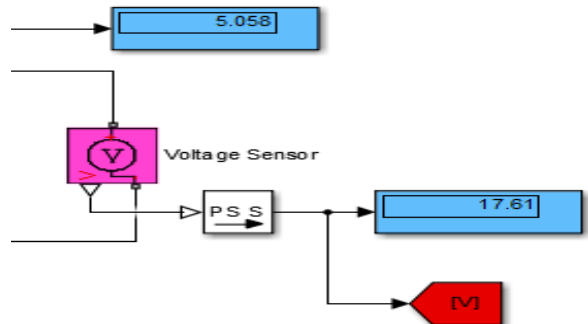


Fig 10. IL and VL

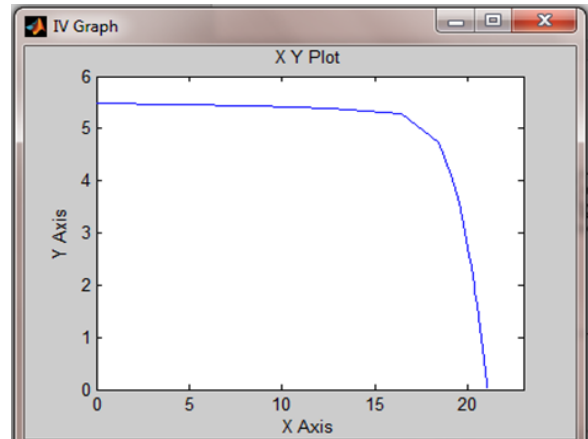


Figure 11. I-V Curve

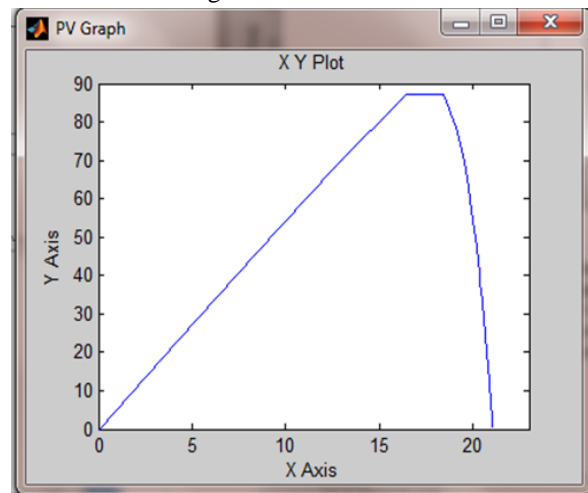


Fig 12 P-V Curve

4.2 PV model using SimPowerSystem Blocks

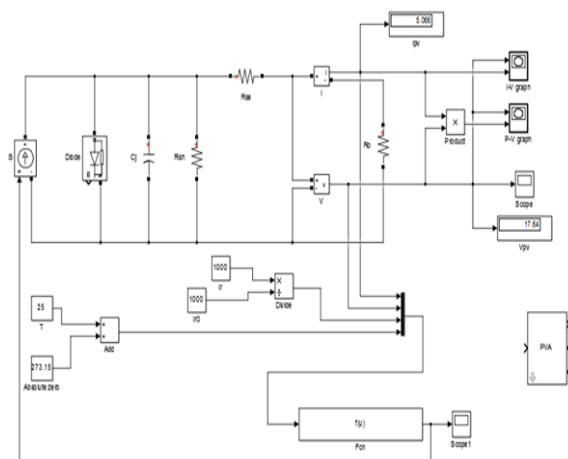


Fig 13 SimPowerSystem Model

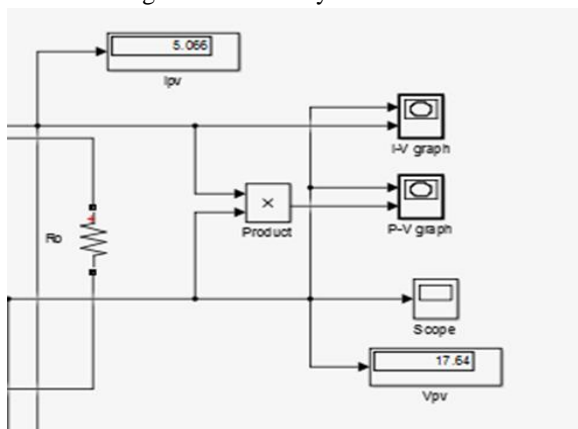


Fig 14. Output Values VL and IL

5. RESULT DISCUSSION

MODELS	$V_L(V)$	$I_L(A)$
SIMELECTRONICS	17.61	5.058
SIMPOWERSYSTEM	17.64	5.066
MEASURED	17.7	5.1

6. CONCLUSION

By analysis, we can say the mathematical model using SimPowerSystem Blocks has more accuracy. Also, the model composed for this project has a reference of voltage and current in order to control output characteristics of the model. Both models are using parameters that can be found in producer's datasheets except the series and shunt resistances that must be estimated experimentally and/or analytically. I-V curve of the proposed model is closer to the experimental data than the solar-cell block that can

be found in the library. A test of models during dynamic processes showed difference in voltage and current pulsation levels. Simulations with models in combination with switching converters shows that the speed performance of the Simscape based model is much better using only one of the solvers available in Matlab2009, while both of the models are slow if other solvers are used.

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