The current and voltage curves simulation solar module using IV tracer networks

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Abstract. Simulation is done to see that the output parameter value of a solar module. Output produced a solar module as measured manually does not provide information that solar modules working at optimal power. Information on the performance of a solar module can be done with a piece of equipment called IV Tracer. IV Tracer work to collect data by varying the value of the working voltage of solar modules ranging from short circuit to open relations. IV Tracer circuits using MOSFETs IRF540 with snubber circuits produce 52 samples of data for 506 mS. The shape of the characteristic curve of current and voltage (IV) produced in accordance with the datasheet PSIM with the fill factor of 0.71. IV Tracer circuit can generate output parameters according to the theory of power changes to variations in temperature values of 0.05% and variations in light intensity of 0.14%. IV Tracer circuit with MOSFET switching system and may dampen stepping snubber circuit voltage of -0.2 V in accordance with the solar module to be tested.

Keywords: Solar Module, Current and Voltage Characteristic Curve (IV), Tracer IV, PSIM

1. Introduction

The potential of solar energy is strongly influenced by climate change that occurred. Knowing the characteristics of a solar module needs to be tested. Parameters that can affect the results of the above output is the light factor, the temperature of the solar module, the angle of incidence of light and solar radiation [1][2].

Testing solar modules with a variety of conditions in a given environment is performed to determine the nature of the solar modules produce electrical energy. Measurement of the value of the output of a solar module that is done manually will not give information about the families, the solar module if the parameter is a maximum performance value. Energy produced by a solar module illustrated in a characteristic curve shape current and voltage (IV) [3,4]. The curve contains information about important parameters that are owned by a solar module, the parameters contained in the current and voltage characteristic curve (IV), among others; The maximum power (Pmax), maximum voltage (Vmax), the maximum current (Imax), the open-circuit voltage (Voc), short circuit current (Isc) and a fill factor (fill factor / FF) [1].Current and voltage characteristic curve (IV) a solar
module is obtained by tracking the value of output using a piece of equipment called IV Tracer [5,6,7,8]. IV Tracer works by varying the working voltage of solar modules ranging short circuit to open circuit relationships [4]. The circuit loading on the previous study using two (2) pieces of the MOSFET to produce forms of current and voltage characteristic curve (IV) a solar module [4,5,9,10]. In this study, the simplification of the circuit using a single MOSFET as a switching system with a snubber circuit as a load for varying the voltage. IV Tracer circuit is simulated in the PSIM software to show the form of current and voltage characteristic curve (IV) on the module according to the solar module datasheet.

Simulations carried out with a view to obtaining the conditions according to standard tests (STC) is the light intensity of 1000 W / m² and a temperature of 25 °C [1,6,8]. Some environmental conditions are tested in simulations carried out to demonstrate the influence of the characteristic curves of current and voltage (IV) on the solar module. Circuit simulation performed by using a polycrystalline solar module types with a small capacity is expected to provide comprehensive information about the shape of the characteristic curve of current and voltage (IV) according to the datasheet.

2. Literature Review

2.1. Characteristics of Solar Modules

There are some important points of the characteristic curve of current and voltage (IV) which shows the performance of solar modules on certain conditions (Figure 1), namely [9,11,12]:
1. Rated maximum power point (MPP)
2. Short-circuit current (Isc)
3. Open circuit voltage (Voc)

![Figure 1. The characteristic curves I - V on solar modules [11,13]](image)

2.2. Switching systems

Snubber circuit (Figure 2) needed to reduce interference when switching occurs. In the DC-DC switching circuit is needed once a snubber circuit to cut the VDS voltage having a voltage ripple (spike) is high on the MOSFET [3,14,15,18,19]. Supplied switching circuit after the voltage on the input side, the voltage spike caused by leakage inductance (inductance leak) is high enough so that the required snubber circuit which serves to reduce the voltage spike. In the snubber circuit greater the value of the capacitors used, the greater the voltage is cut [3,16,17,19]. But the value of the capacitors used must conform with the series resistor with a capacitor and diode are mounted parallel fast.
The value of Rs and Cs values can be calculated with the following equation [3].

\[ R_s = \frac{t_{on}}{5C} \]  \hspace{1cm} (2)

\[ C_s = \frac{I_L t_f}{2V_f} \] \hspace{1cm} (3)

Rs = custody snubber (Ω) \hspace{1cm} Cs = snubber capacitor (F)
Vf = Voltage MOSFET (V) \hspace{1cm} IL = Current MOSFET Expenses (A)
ton = The lifetime of the MOSFET (S) \hspace{1cm} tf = Time Fall MOSFET (S)

3. Method
In this research, the circuit simulation using Power Simulation software (PSIM). PSIM is a software that is used to determine the condition of the circuit in detail the parameters that can be adjusted. The results of the current and voltage characteristic curve (IV) produced is expected to show the value of the parameter characteristics of solar modules according to the datasheet.

The solar modules (Figure 3) in this experiment is a type of polycrystalline solar modules with little power is 5VDC. The Prototype solar modules under test can be shown on the specification as follows [20]:

| Type          | GH65x65         |
|---------------|-----------------|
| The maximum voltage | 5.5 V          |
| The maximum current    | 110 mA         |
| maximum output       | 0.4 W          |
| dimension            | 65 mm x 65 mm x 3 mm. |

3.1. Module Test

Modules such as the above parameters will be included in the conditioning based on simulation software PSIM input. Further by simplifying the design using MOSFETs and snubber circuits. The IV Tracer schematic drawing of the solar module with a series of short circuits is shown in figure 4.
Design series solar modules using n-type MOSFET IRF540N the snubber circuit. The circuit is applied is a system of short circuit of solar modules. The process of switching voltage spikes that cause snubber designed to minimize disturbance to the combination of a high-frequency diode with the type of FR-207. A snubber circuit is designed based on the value of the component datasheet IRF540 MOSFET ie \( IL = 16A \), \( ton = 11 \) ms, \( tf = 35 \) ms \( Vt = 6V \) so that it can be determined as a matter of the following: [3]. Based on the calculations above, the selected value component approach these results with 47uF capacitor and resistor values 5Ω.

4. Results and Discussion

4.1. The circuit simulation Tracer IV

Circuit simulation applied to the program PSIM to see the shape of the current and voltage curves of solar modules produced by the circuit in accordance with the parameters contained in the datasheet. IV Tracer circuit testing is done with a few variations of the environmental conditions that the light intensity and temperature.

In testing simulated by testing solar module parameters to variations in the environment that affect. Results obtained through simulation to temperature variation showed a decrease in the voltage parameter value is quite large. Increasing the value of testing temperature between 25°C, 45°C and 65°C with a fixed light intensity conditions.

The power parameters showed an average decline of 0.05% to the value of the voltage drop of 0.59%. The overall value can be shown in Table 1.

| No. | Parameter     | Condition 1 | Condition 2 | Condition 3 | The average change |
|-----|---------------|-------------|-------------|-------------|--------------------|
| 1   | Temperature (°C) | 25          | 45          | 65          | 20                 |
| 2   | Irradiant (W / m²) | 1000        | 1000        | 1000        | 0                  |
| 3   | Pmax (W)       | 0.430       | 0.380       | 0.330       | 0.050              |
| 4   | Vmax (V)       | 4.500       | 3.930       | 3.330       | 0.590              |
| 5   | Imax (A)       | 0.095       | 0.097       | 0.100       | 0.002              |
| 6   | Voc (V)        | 5.500       | 4.910       | 4.320       | 0.590              |
| 7   | Isc (A)        | 0.110       | 0.113       | 0.116       | 0.003              |

In the form of current and voltage characteristic curve (IV) showed a large enough voltage drop, in this case, is different from the current which shows very little improvement. This occurs in accordance with that contained in the theoretical study with results in line with the solar module to be tested.

In testing the variations in light intensity showed a decrease in current parameter values is quite large. Impairment testing of light intensity between 1000 W / m², 700 W / m² and 400 W / m² with fixed temperature conditions. Power parameters showed an average decline of 0.14% to the value of
the current decline of 0.03%. The decrease is not too large due to the current capacity of solar modules tested specifications. The overall value can be shown in table 2.

| No. | Parameter | Condition 1 | Condition 2 | Condition 3 | The average change |
|-----|-----------|-------------|-------------|-------------|-------------------|
| 1   | Temperature (0C) | 25          | 25          | 25          | 0                 |
| 2   | Irradiant (W / m2) | 1000        | 700         | 400         | 300               |
| 3   | Pmax (W)      | 0.430       | 0.280       | 0.150       | 0.140             |
| 4   | Vmax (V)      | 4.500       | 4.360       | 4.090       | 0.210             |
| 5   | Imax (A)      | 0.095       | 0.065       | 0.035       | 0.030             |
| 6   | Voc (V)       | 5.500       | 5.350       | 5.100       | 0.200             |
| 7   | Isc (A)       | 0.110       | 0.077       | 0.045       | 0.032             |

The current scale of impairment in accordance with the capacity of solar modules listed on the dataset. In the voltage values also occur down outside generated so that the parameter changes in light intensity changes substantially to the power generated.

4.2. Switching circuit perform

The capacitor current at the time of switching showing the conditions of charge and discharge of the load coming from the solar module. Rated current and voltage that occur in solar modules, capacitors, and resistors show the same value. MOSFET in that it has an important role when performing switching current shows rapid reduction in the figure below. The parameter performs output current in the circuit can be shown in the following figure.

Based on the current output parameters of the solar module and circuit IV Tracer shows the same value in the short-circuit current is 0.110 A with switching times for 506 mS. Based on the results of the comparison between the circuit and the IV Tracer happens to solar modules provide the same value. Factors charging the capacitor showed a very fast along with the MOSFET switching process is done.

The snubber circuit and MOSFET show the condition of the properties as inverting the value that these disorders can be mitigated by a combination of a series resistor, a diode with a capacitor. Inverting the value given by the circuit at 5.48 V. Figure 5 shown a graphical form output voltage snubber circuit.
Snubber circuit to provide voltage inverting so that interference can be reduced. A voltage spike on a graph form a solar module provides a voltage drop when the switching process of -0.2 V as a voltage inverter, which causes an interference voltage value.

5. Conclusion
Simulations using a series conducted IV Tracer shows the curve shape of solar modules in accordance with the solar module datasheet with the fill factor was 0.71. IV Tracer circuit can generate output parameters according to the theory of power changes to variations in temperature values of 0.05% and variations in light intensity of 0.14%. System circuit used to mitigate disruptions such as that shown in the graph of -0.2 volts corresponding to the solar modules are tested. Based on the results, researchers can provide advice on further research to be carried out analyzing the factor loadings combined with other types of snubber circuits.

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