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SIMULINK based Modeling and Simulation of Standalone 170 watt PV system using Newton Raphson method

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Abstract—

This paper introduces an approach to Model a photovoltaic system based on Newton Raphson method, the simulation result of this simulation is studied and The results are simulated for a typical daily variation of solar radiations. The effect of temperature on this simulation results is also shown. A commonly used solar array model is linear and combination of a simple current source and resistances..

Keywords— - MPPT, photo voltaic system, system modeling, PV cells, Temperature effect

NOMENCLATURE.

I_{ds}	Diode saturation current.
I_{ph}	Photon current.
T_{actual}	Actual Temperature in K.
T	Nominal Temperature in K.
G_0	Solar radiation on the solar cell in W/m^2.
G	Nominal solar radiation in W/m^2.
K_c	Current/temperature coefficient.
I_{dst}	Temperature dependent diode saturation current.

I. INTRODUCTION

E XTRACTING useable electricity from the sun was made possible by the discovery of the photoelectric mechanism via a semiconductor device which converts photon energy into electrical energy. The amount of installed megawatts of solar arrays rapidly grows; while the panel price decreases Solar energy is the least polluting and the most inexhaustible of all known energy sources. Due to the high cost of solar cells, it is necessary that PV module operate at its maximum power point, but solar cell produces the solar power changes according to change in solar radiation and temperature [1].As irradiation and temperature level changes rapidly, the voltage produced fluctuates and become inconstant. There are three ways to increase the efficiency of a solar photovoltaic system [2].The first is to increase the efficiency of the solar cell. The second is to increase the efficiency of a PV system is to employ a solar panel tracking system. The third method is to maximize the energy conversion from the solar panel by using MPPT controller.
Solar array characterization is necessary, since manufacturers usually provides only standard test conditions (STC) data, i.e panel performance at nominal sun irradiations

II. PHOTOVOLTAIC CELL MODEL

This section starts with the modeling concepts of single diode PV cell without emphasis given on physics of how to pv cell transforms the solar photon into electrical power. The standard PV cell equivalent circuit diagram shown in Fig.1, diode is connected in parallel to current source, the photon energy incident on the PV cell generate current. This current is directly proportional to the amount of photon energy incident on PV cell. A more accurate model can be represented by inclusion of the following.

- Internal losses represented by series resistance R_s.
- Considering leakage current represented by R_{sh}.
- Effect of temperature on diode saturation current I_{ds}.
- Temperature dependence of the photon current, I_{ph}.
- Diode quality factor β.

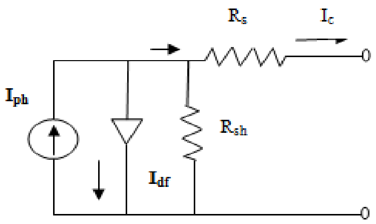

Figure 1: Equivalent circuit of a PV cell.

Applying KCL to the model circuit:

$$I_{ph} - I_{ds} - \frac{V_d}{R_s} - I_c = 0 \qquad (1)$$

$$I_c = I_{ph} - I_{df} \qquad (2)$$

Diode forward biased current.

$$I_{df} = I_{ds}[\exp\left(\frac{qV}{\beta kT}\right) - 1] \qquad (3).$$

Now considering effect of R_s and R_{sh} of each PV cell thus the above equation is expressed as:

$$I_c = I_{ph}N_p - I_{ds}N_p[\exp\left(\frac{qV + I_cR_s}{\beta V_t}\right) - 1] - \frac{V + I_cR_s}{R_{sh}} \quad \ldots(4)$$

Where $V_t = kT$, N_p= Number of PV cells connected in parallel.
I_{ph} photon current also depends on temperature, now considering the effect of temperature.

$$I_{ph}(T) = \left[I_{ph}(T_0) + K_I \Delta T\right]\frac{G_0}{G} \qquad (5)$$

$$\Delta T = T_0 - T.$$

The temperature dependence of diode saturation current I_{dst} can be expressed as:

$$I_{dst} = I_{ds}\left(\frac{T}{T_0}\right)^3 \exp\left[\frac{qE_g}{\beta k}\left(\frac{1}{T} - \frac{1}{T_0}\right)\right] \qquad (6)$$

III. PV ARRAY DESCRIPTION

To estimate the performance of PV cell, under all weather conditions. We cannot ignore the effect of solar radiation cell temperature. The photo current is directly proportional to solar radiations [5] also shown in results. The variation of the saturation current as a function of temperature is described by [6]. The PV array must operate electrically at a certain voltage that corresponds to the maximum power point under the influence of given operating conditions like temperature and solar radiation. To achieve this, a maximum power point tracker (MPPT) is used based on the perturbation & observation technique [7]. For a PV array with operating
Voltage as V and current as I, the power is P= VI. At the maximum power point, dP/ dV should be zero with its sign defined by:

$$\frac{1}{V}\frac{dP}{dV} = \frac{1}{V}\frac{d(VI)}{dV}$$
$$= \frac{1}{V} + \frac{dI}{dV}$$

In many literature It has been discussed how maximum power point tracking can be obtained with the variation of duty cycle using DC/DC convert. So they are not discussed further.

IV. SPECIFICATION

Table 1: Specifications of Solar Photovoltaic Modules

Configuration	Single Glass Laminated Type With 72 Cells (12 × 6) In Series
Overall Size	1595 (± 3) × 790 (± 2) × 50 (± 1) MM
Weight	15 Kg. (Typical)
Module Frame	Anodized Aluminum
Typical Electrical Characteristics of L24150 type module (170Wp)	
Open Circuit Voltage (V_{oc})	42.0 V
Short Circuit Current (I_{sc})	4.86 A
Operating Voltage	35 V
Max Power Output	170.0 W± 3%

V. PV ARRAY DESCRIPTION

The photo current is directly proportional to solar radiations [8] while the influence of solar radiation, cell temperature, dust, shadow and wind is important to estimate the performance under all weather conditions. The variation of the saturation current as a function of temperature is described by [9].

VI. SIMULATION RESULTS AND DISCUSSION

In the PV array simulation all modules are considered to be identical and to work under identical temperature and solar radiation conditions. Figure:2 current vs voltage characteristics for four temperature level and Figure:3 shows the power-voltage characteristics for pv cell.

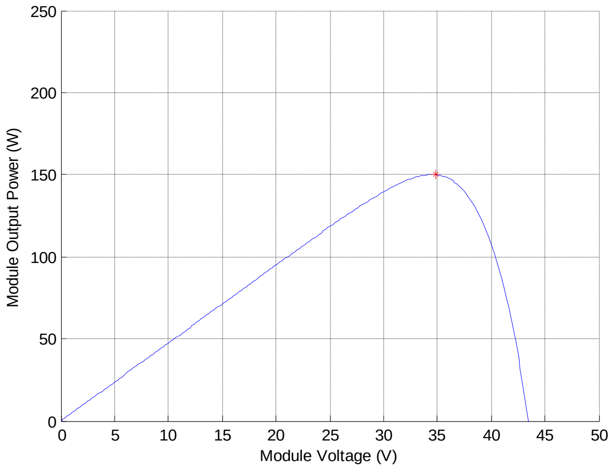

Figure 2: P– V characteristics for a PV cell.

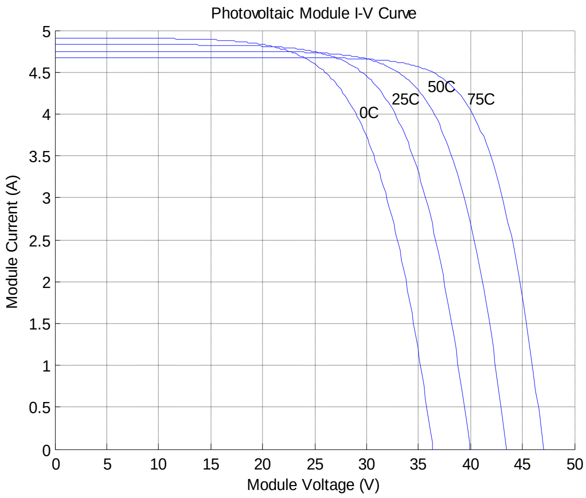

Figure 3: I– V characteristics for four temperatures level.

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