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# Real-time Photovoltaic Simulator using Current Feedback Control

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**Abstract**

In this proposal article, mathematical model of Photovoltaic model is investigated the relationship of the Photo Voltaic's irradiance, temperature and parameters comparing to its output power. It leads in to an analyzing and developing of the Photovoltaic Simulator. By which, Photovoltaic simulator is utilized by the DC converter circuit with a current feedback control. This may be useful if is possible to implementing into a real world Photovoltaic simulator. In this paper, Photovoltaic simulator is modeled using MATLAB/Simulink program, which is composed of DC converter and a proper control scheme. It can be observed from the simulation results that I-V relationship of the Photovoltaic simulator is quite the same as of such Photovoltaic mathematical model. This means that, it is possible to build a real Photovoltaic simulator in commercial in a further work.


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*Keywords:* Photovoltaic model; Photovoltaic simulator; DC Converter; Feedback control

## 1. Introduction

Generally, Photovoltaic cell converts photons into electric potential from its PN junction [1]. Nowadays, it is worldwide renewable energy source because of their energy-friendly environment [2]. However, its high costs may cause the difficulties in development and experiments for laboratory. Mean by that, practical Photovoltaic simulator

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which emulates output characteristics of Photovoltaic module through a real converter circuit can be used in replacement of an actual Photovoltaic module in laboratory scale.

## 2. Photovoltaic Model

### *2.1. Mathematical model*

The equivalent circuit of Photovoltaic is shown in Figure 1. When Photovoltaic cell is exposed to sunlight, an electrical current will flows proportional to the solar irradiance [3].

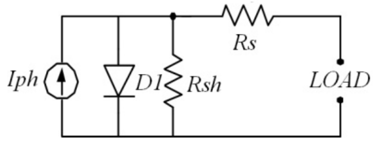


Fig. 1. Photovoltaic Single Diode model

In Figure 1, the circuit of Photovoltaic model is described using equations of schottky diode incorporated with quality factor in account of the recombination effects in space-charge region [3], which are given by equations (1) to (3).

$$I = I_{ph} - I_S \left\{ e^{q.\left(\frac{V+IR_S}{NKT}\right)} - 1 \right\} - \frac{(V - IR_S)}{R_{sh}} \tag{1}$$

$$I_{ph} = \left( I_{SC} + K_I.\left(T - T_{ref}\right)\right)\lambda \tag{2}$$

$$I_S(t) = I_S.\left(\frac{T}{T_{ref}}\right)3.e^{\left\{\left(\frac{T}{T_{ref}}-1\right).\frac{E_g}{NV_t}\right\}} \tag{3}$$

Where $I_{ph}$ is photon current, $R_s$ , $R_{sh}$ are series and shunt resistance, $N$ is ideal diode factor, $K$ is Boltzman constant, $q$ is electron charge and $I_s$ is saturation current of diode, $K_I$ is short-circuit current temperature coefficient of Photovoltaic cell, $I_{sc}$ is short circuit (SC) current of cell , $\lambda$ is solar irradiance, $E_g$ is energy in band gap of semiconductor and $V_t$ is ambient temperature voltage. By consideration, The behavior of Photovoltaic cell is the relation of $N$, $I_{ph}$, $I_s$, $R_s$ and $R_{sh}$,. In which , these parameter depend on solar irradiance ($\lambda$) and temperature ($T$) [1].

However, Photovoltaic module is a congregation of Photovoltaic cells. So, V-I relationship of Photovoltaic module ( neglecting $R_s$, $R_{sh}$) is given in (4) [1], where $n_s$ and $n_p$ are number of series and shunt cells in Photovoltaic module.

$$I = n_p.I_{ph} - n_p.I_S \left( e^{\left(\frac{qV}{N.K.T.n_s}\right)} - 1 \right) \tag{4}$$