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Studying the Features and Emulation of Solar PV Arrangement Using Simulink Model

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Abstract

Studding of PV systems in an active way needs accurate information of the P-V and I-V characteristic curves of solar PV order. So this paper shows emulation and an example of solar PV model utilize Matlab/Simulink. This example depends on math's equation and is explained during an equivalent circuit involving a photo current source, diode, shunt resistor representing leakage current and series resistor expressing the inside losses because of the current flow. The advanced model let the prognosis of PV array manner under various circuit model and ecological parameters (solar ray, temperature). A special model (240 Watt) solar collector using for this example, results was compared with manufactures curve with different points of the curve and show good conformity to the model.

Keywords: P-V and I-V characteristic, PV array, PV cell

I. INTRODUCTION:

PV panel has no pollution and it considered clean energy . Although the PV collector is presented to its rise invention cost [1]. The increase of oil praises makes solar power surely applicable energy supply for potentially long code. PV model performs the primary power transmutation part of a PV producer orders. The production type of collector depend from the solar ray, temperature of the cell, and the voltage of the PV model because PV model has not straight lines kind, it is important to replica it to the form and emulation of (MPPT) for the scheme implementation. Furthermore to math's modelling and simulation of the model can investigator to have a best understanding of its paper. This modelling mostly include the parataxis of the not straight lines I-V curve [1,2].

II. MATHEMATICAL EQUATIONS OF SOLAR PV CELL:

The single-diode commensuration circuit is depicted in Fig.1; which Consist of diode (D) in parallel with (I_{ph}). when light plops on the cell directly current will result. At night the solar cell work as a diode only. Shunt resistance (R_{sh}) and series resistance (R_s) are for leakage current and internal losses respectively.

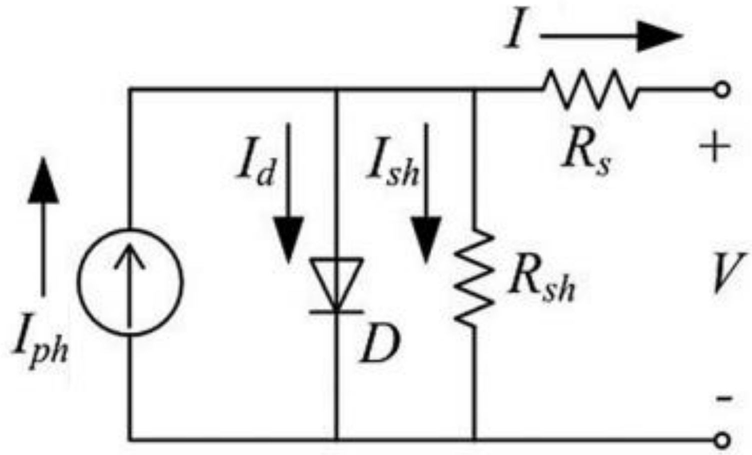


Fig. 1: Commensuration circuit of single-diode

then,

$$I = I_{ph} - I_d - I_{sh} \quad (1)$$

$$I = I_{ph} - I_s\left[e^{q(V+IR_s)/AKT} - 1\right] - (V + IR_s)/R_{sh} \quad (2)$$

Where,

I: output current of solar cell

$I_{d:}$ diode current

$I_{sh:}$ shunt-leakage current

$I_{s:}$ reverse saturation current

q: electron charge

A: ideal factor

K Boltzmann's constant

T: cell's actual temperature in Kelvin (ºK).

The ideal factor (A) in equation (2) determines the cell deviation from the ideal p-n junction (diode) characteristics; it ranges between (1and 5) 1 being the ideal value and is needed on PV expertise [6, 7] and is scheduled in Table (1). In our case, $A = 1.3$.

Table 1: Factor (A) Dependence on PV Technology [7]

Technology	Si-Mono	Si-Poly	a-Si:H	a-Si:H tandem	a-Si:H triple	CdTe	CTS	AsGa
A	**1.2**	**1.3**	**1.8**	**3.3**	**5**	**1.5**	**1.5**	**1.3**

The(I_{ph}) mostly depends on the solar radiation (H) and cell's actual high temperature (T), [5]:

$$I_{ph} = [I_{SC} + K_i(T - T_{ref})]\, H \qquad (3)$$

K_i : Temperature coefficient.

$$I_s = I_{rs}(T/T_{ref})^3 e^{\left[\frac{qE_G}{AK}\left(\frac{1}{T_{ref}} - \frac{1}{T}\right)\right]} \qquad (4)$$

Where:I_{rs} reverse saturation current

E_G: silicon bang -gap energy (E_G= 1.12eVfor silicon).

III. MODEL OF SOLAR PV ARRAY:

In order to make max power .the cells should be joined in parallel-series module organization .this PV collection is depicted in. 2 [5, 7].

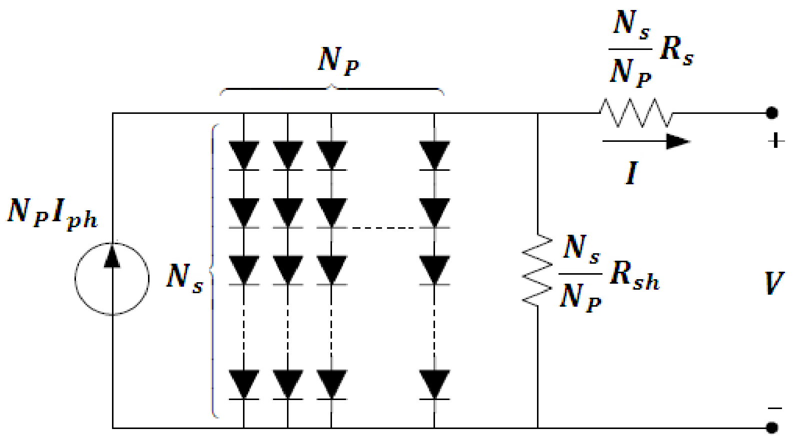


Fig. 2: Equivalent circuit of solar PV array

The output current and voltage of a above module becomes as:

$$I = N_P I_{ph} - N_P I_s\left[e^{(q(V/N_s + IR_s/N_P)\ /AKT)} - 1\right] - \left(\frac{N_P V}{N_s} + IR_s\right)/R_{sh} \ldots\ldots\ldots \quad (5)$$

The (R_s) and R_{sh} are considerably have an effect on PV production. The basic model with suitable difficulty is shown in Fig. 3 and can be facet [5]:

$$I = N_P I_{ph} - N_P I_s\left[e^{(q(V/N_s + IR_s/N_P)\ /AKT)} - 1\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

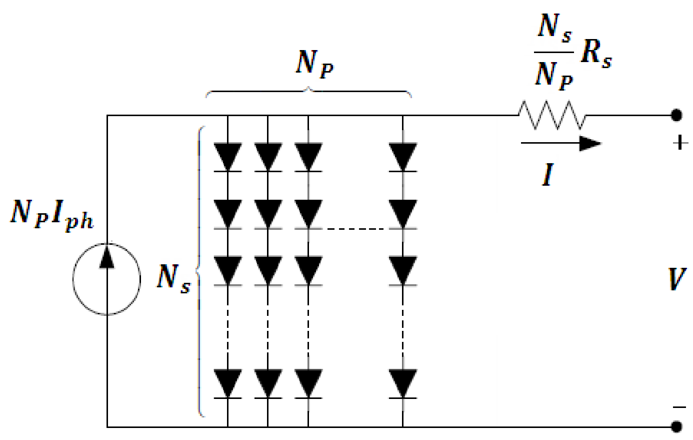


Fig. 3: Simplified model of solar PV array

The general (PV) module connection is illustrated in Fig. 4 [5, 7] and equation 7 describes this circut.

$$I = N_P I_{ph} - N_P I_s\left[e^{(q\,V/N_s AKT)} - 1\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

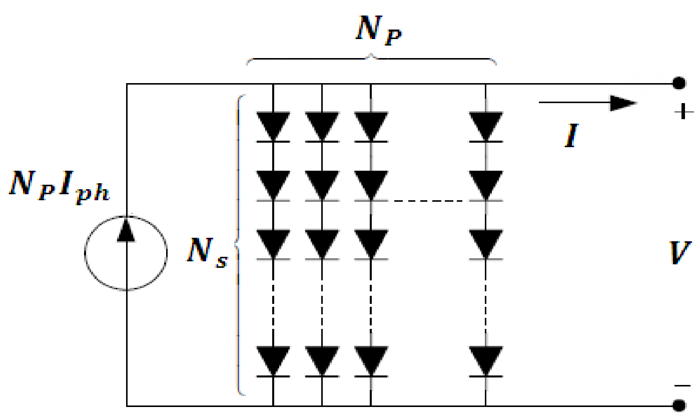


Fig. 4: Appropriate model of solar PV array

$$I_{rs} = I_{SC}/[e^{(qV_{OC}/N_s AKT)} - 1] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

Where,

$V_{OC}$is theopen-circuit voltage of a PV module.

IV. SIMULINK MODELLING FOR SOLAR PVARRAY:

The Solar PV model (SL6P60-240W) is send in modelling and the parameters is illustrated in Table (2) [8].

Table 2: Parameters Polycrystalline PV Module [8]

Electrical Characteristics

Characteristics	Unit	SL6P60-240W
Maximum Power (Pmax)	W	240
Power Tolerance	W	(0, +5)
Maximum Power Voltage (Vmp)	V	30.1
Maximum Power Current (Imp)	A	7.96
Open Circuit Voltage (Voc)	V	37.2
Short Circuit Current (Isc)	A	8.52
Module Efficiency (ηm)	%	14.76
Dimension of module	mm	
Pmax Temperature Coefficient	%/℃	
Voc Temperature Coefficient	%/℃	
Isc Temperature Coefficient	%/℃	
Maximum System Voltage	VDC	
Maximum Series Fuse Rating	A	
Operating Temperature	℃	
NOCT	℃	

STC:1000W/m2.AM1.5 and 25℃ cell temperature:

NOCT : Nominal Operating Cell Temperature

A block diagram of the stage by stage model based upon the equations (1 to 8) of PV array is characterized in Simulink environment as given in the following stages; as shown in Figures (5-11).

Stage 1:

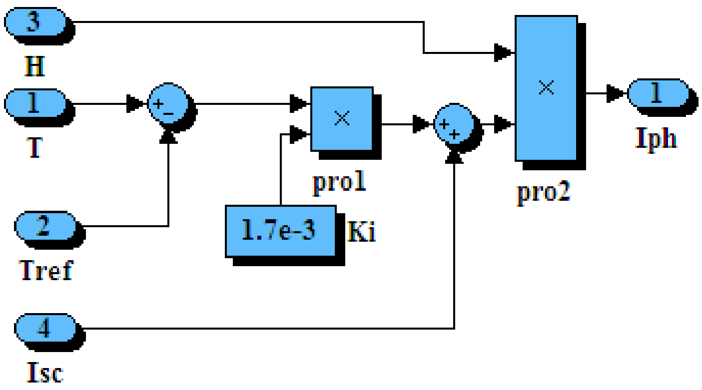


Fig. 5 : Subsystem for calculation of I_{ph}

Stage 2:

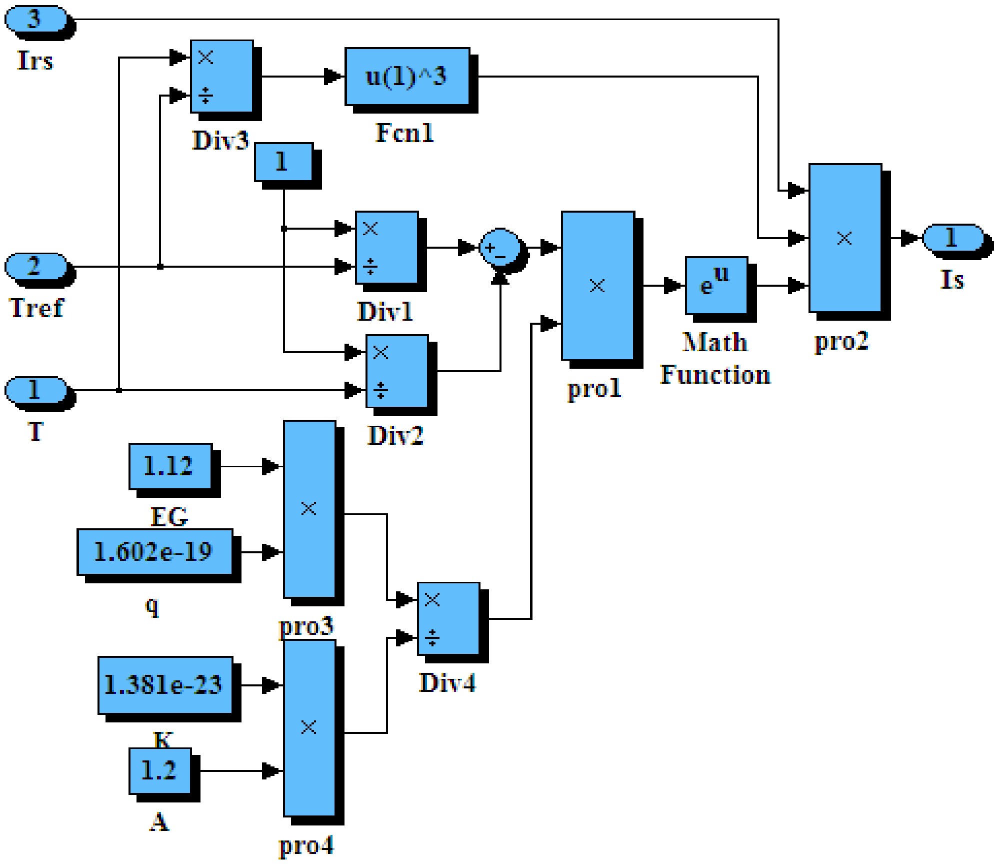


Fig. 6: Subsystem for calculation of I_s

Stage 3:

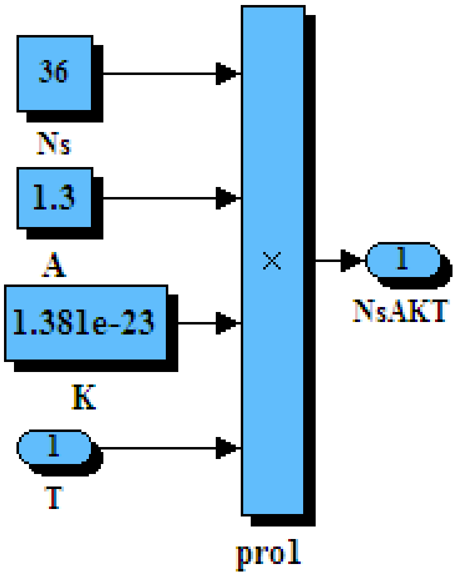


Fig. 7: Subsystem for calculation of N_sAKT

Stage 4:

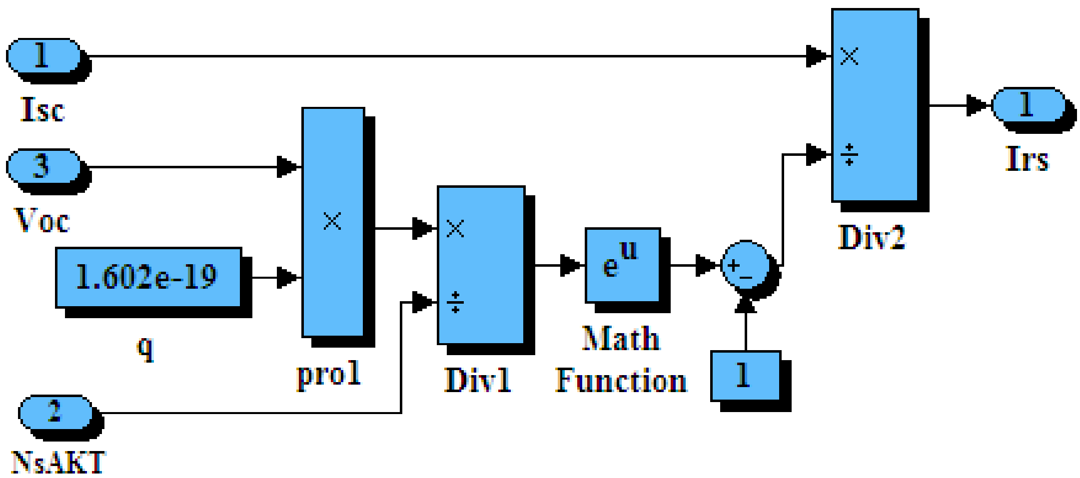


Fig. 8: Subsystem for calculation ofI_{rs}

Stage 5:

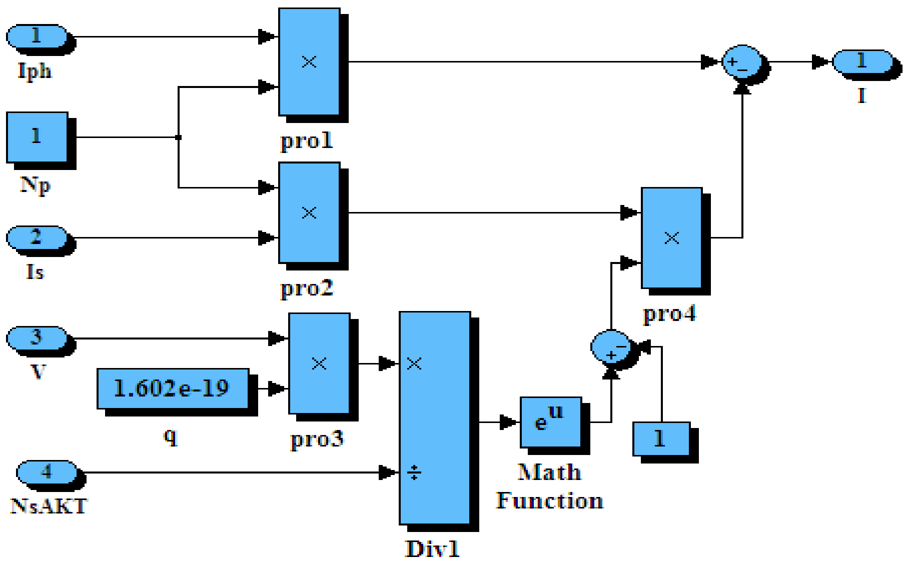


Fig. 9: Subsystem for calculation of the output current

Stage6: All above five subsystems are interconnected as given in Fig.10.

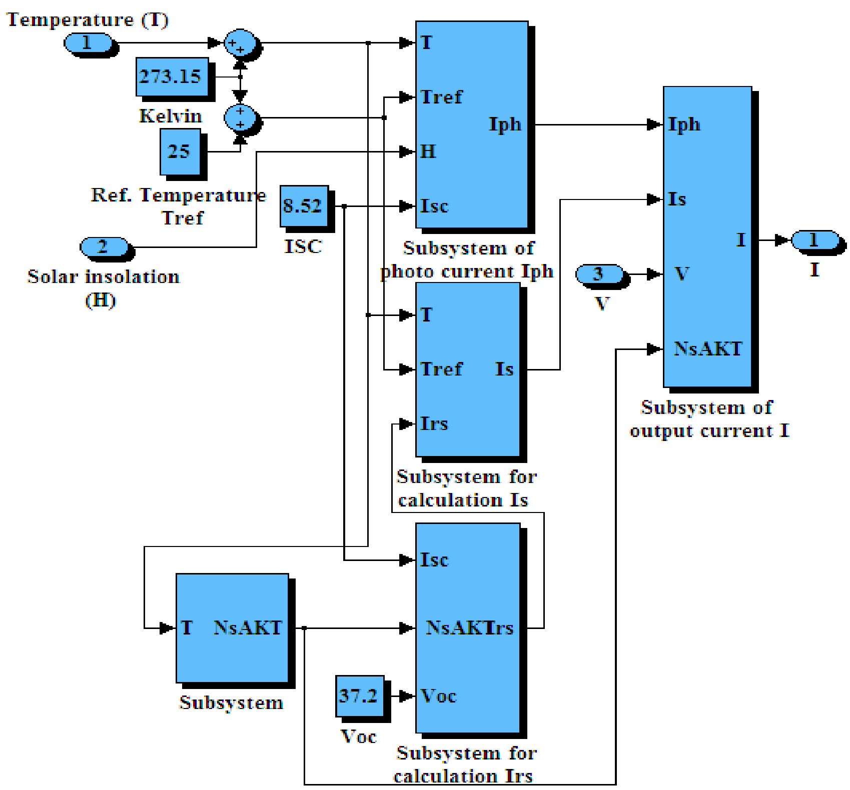


Fig. 10: Interconnection of five subsystems

The final model is shown in Fig. 11.

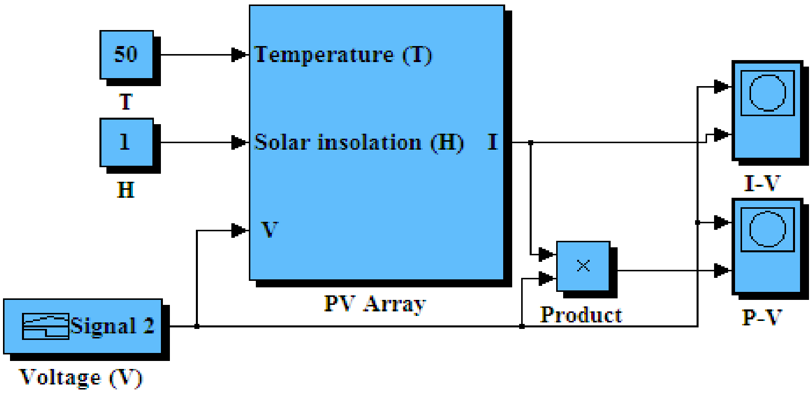


Fig. 11: Simulink circuit of PV model

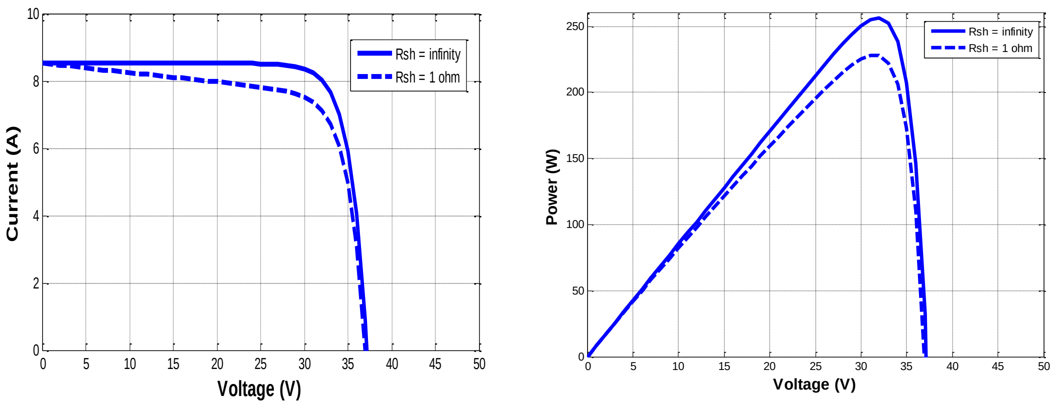
The last model takes radiation, working temperature in (ºC) and module voltage as input and gives the output voltage (V) and output current (I).

V. RESULTS AND DISCUSSION:

The Matlab/Simulink model in Fig. 11 readily offers an investigation in variation of model parameter (resistance R_s andR_{sh})and variation of environmental parameter (solar radiation & working temperature).

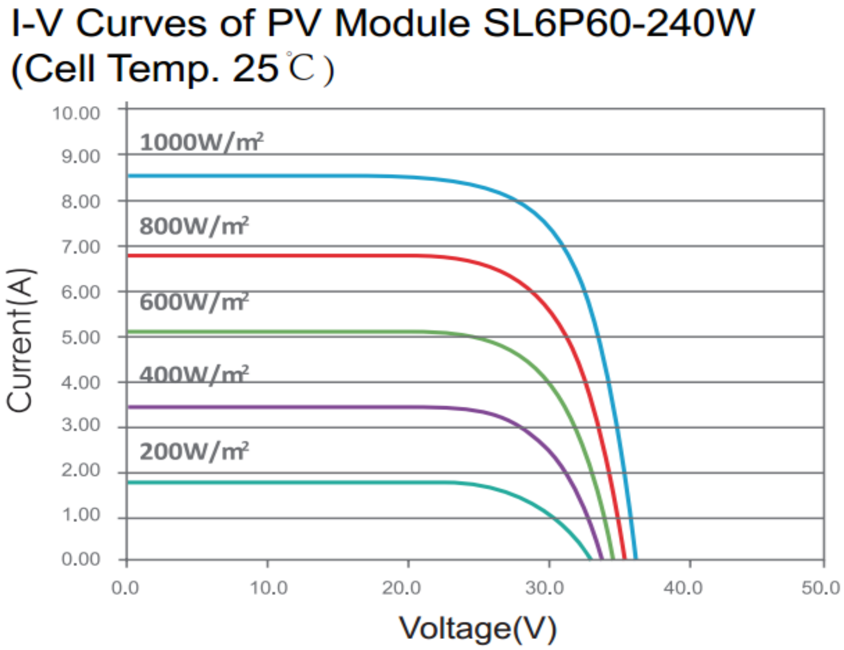
A. Model Parameters Variation:

In this section, effect of variation of series (R_s) and shunt resistance (R_{sh}) and their influence on I-V and P-V kind of PV form is studied. from fig.12 when the value of R_{sh} is increased the value of current and power will increase also.

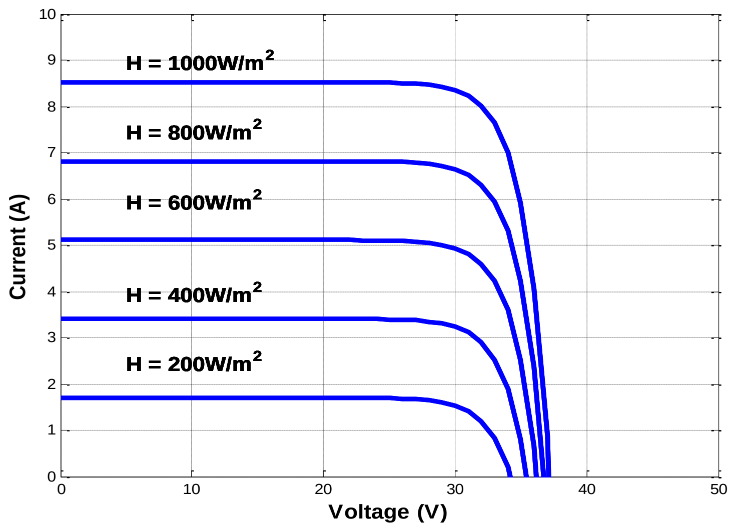


a **b**

Fig. 12: Effect of R_{sh} on the (a): I–V characteristics and (b): P–V characteristics at constant solar radiation (1kW/m^2) and constant temperature (25°C)



(a)



(b)

Fig. 13: I-V characteristic at constant temperature (25°C) with different solar radiation: (a) From data sheet, (b) From Matlab/Simulink[8]

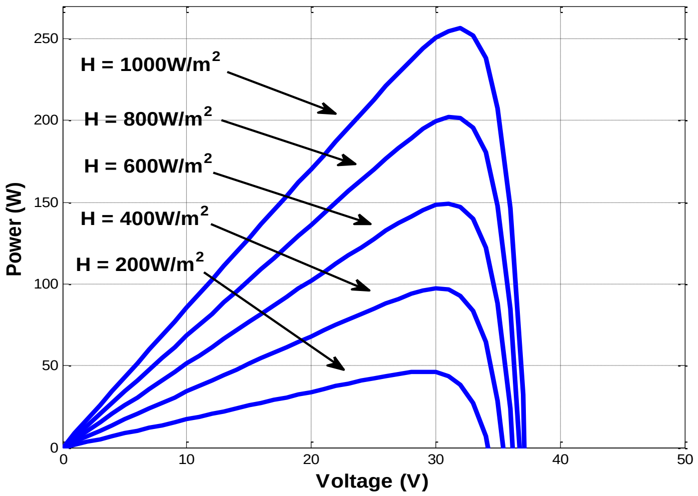
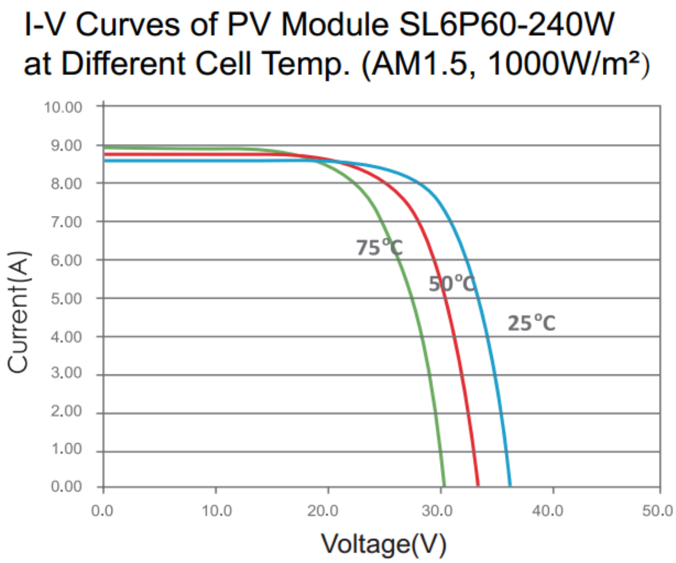


Fig. 14: Effect of solar radiation on P–V characteristics at constant temperature (25°C)

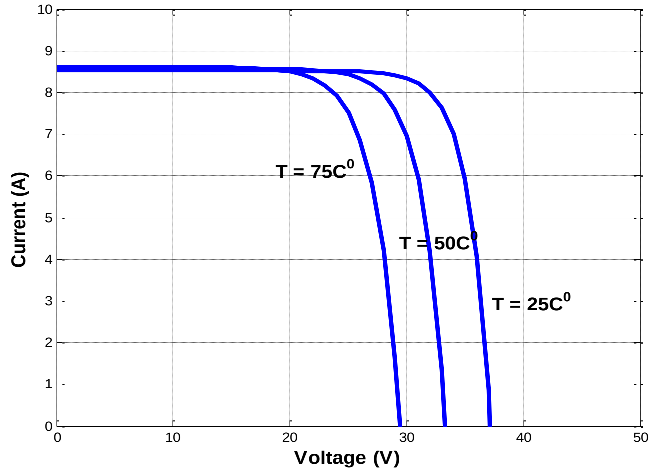
From fig.(13) and (14) we notice when irradiation is increased the current and power will increased also.

B. Effects of Temperature (T)

The aptitude of a pv is axing when the temperature is increased and the solar cell,(V,I,P_{max}) output are given in Figs. (15-16)



(a)



(b)

Fig. 15: I-V characteristic at constant solar radiation ($1kW/m^2$) with different temperature: (a) From data sheet, (b) From Matlab/Simulink[8]

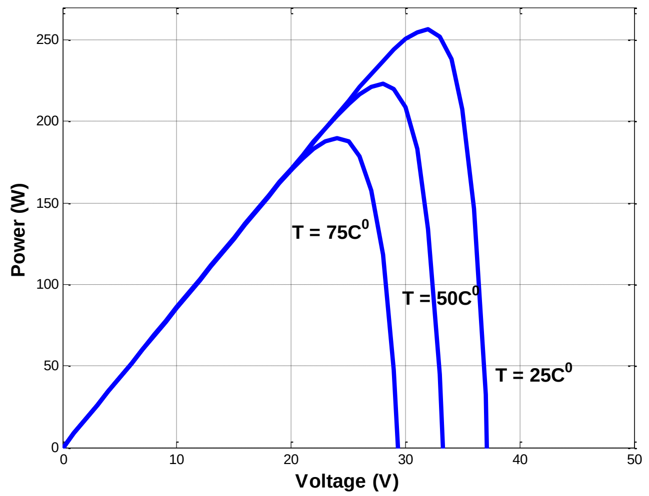


Fig. 16: Effect of temperature on P–V characteristics at constant solar radiation ($1kW/m^2$

From figs (15) and (16) we sea that the P_{max} well decrease as the working temperature increased.

CONCLUSIONS:

In this study, when temperature increased the power will decreased

when irradiation increased the power will increased.

when R_{sh} increased the PV current and power will increased also.

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