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Photovoltaic (*pv*) Module Design Matlab/Simulink for Battery Power Charging

K. Bhaskar[a] K. Siddappa Naidu[a] and N.G. Ranganathan[b]

[a]Department of Electrical & Electronics Engineering, Veltech Dr. RR & Dr. SR University, Avadi, Chennai- 600 062

E-mail: bhaskark@veltechuniv.edu.in, ksiddappanaidu@veltechuniv.edu.in

[b]Department of Chemistry, Veltech Dr. RR & Dr. SR University, Avadi, Chennai- 600 062

E-mail: ngranganathan@gmail.com

Abstract: The objective of the present communication is to consider the PV Module or Cluster as one gadget in a complex environment.

Method/Analysis: This paper has taken to in account certain parameters (*i*) assigned by Constructor (*ii*) constants and certain obscure parameters. An attempt has been made to consider the parameters like the photograph current I_{ph} the immersion current (I_0) of the Ideality factor (A) in the Matlab/Simulink simulation and the results are arrived.

***Findings**:* The proposed R_p model is most precise. It is the most proper to recreate PWX500PV module (49W). For PWX500PV module (49W) every one of the parameters are accessible to the register iteratively R_s & R_p. the proposed R_p model is currently used to recreate the pv module at various estimations of irradiance and temperature. The I(*v*) attributes for different irradiances from 200W/m^2 to 1000W/m^2 and taking the STC temperature have been obtained. The temperature profile has been varied from 0^{0}C to 60^{0}C at STC irradiance .The irradiance has been varied from 200W/m^2 to 1000W/m^2.

The irradiance fluctuates from 200W/m^2 to 1000W/m^2 under STC temperature and from our earlier work this has been fixed to get 1250 Watts at 25^{0}C for charging the lead acid battery effectively and efficiently. The voltage may be fixed as 65 of the irradiance as 1000W/m^2 with a series resistance as R_s = 10 ohms.

Novelty/implement: Using MATLAB/ Simulink model it is able to fix into variables the photograph current (I_{ph}) the immersion current (I_0) and the ideality fig(A) apart from the parameters (*i*) arranged by construction (*ii*) constants. With the parameters obtained from this work the PV module will be placed under the Lab view control module to have an effective control circuit for charging the battery at ambient temperature to get maximum efficiency of this will be our future work.

Keywords: *Irradiance, Temperature, I(V)/P(V) trademark, MATLAB/Simulink.*

1. INTRODUCTION

An attempt has been made in the present communication to charge a battery module using a controller assisted by Matlab/Simulink simulation software. The vast majority of the makers' information sheets don't give enough data about the parameters which depend upon climate conditions (irradiance and temperature). The quantity of obscure parameters also poses problems when the proportional circuit of the picked model turns out to be more helpful. In view of these, a few suppositions regarding the physical way of the cell conduct is important to build up a scientific model of the PV cell and the PV module, the aim of the present communication is to consider the PV module or cluster as one gadget in a complex environment.

The current I(V) is a non-direct condition with numerous parameters in this simulation. The parameters are (*i*) assigned by constructors, (*ii*) constants (*iii*) the ones which must be figured. In addition to these, searchers create improved strategies where some obscure parameters can't be ascertained. They are hence accepted constants. For instance, in1 the series resistance, R_S has been incorporated. In this model the parallel resistance is not considered. The same supposition is considered in[1-6] Different creators disregard both parallel and arrangement resistances. However, these two attributes of the PV module are vital. These are resolved all the more precisely in[7-11]In addition to these a few different parameters are to be considered like the photograph current (I_{ph}), the immersion current (I_0) and the ideality factor (A).

The present attempt is to consider all these possibilities in the simulation and the results arrived at presented and discussed in this paper.

2. PRESENTATION AND MODELING OF PV MODULE

2.1. Ideal Single Diode Model

The model considered as per in the Figure 1*a*. A diode is associated in hostile to parallel with the light created current source. The yield current I is obtained by Kirchhoff law:

$$I = I_{ph} - I_d \tag{1}$$

Where I_{ph} is the photocurrent, I_d is the diode current which is corresponding to the immersion current and is given by the condition (13):

$$I_d = I_o[\exp(V/A.N_s.V_T) - 1] \tag{2}$$

V is the voltage forced on the diode. $$V_T = K.T_C / q \tag{3}$$

I_o is the spillage current of the diode(A), V_{TC} = 26 mV at 300 K for silisium cell, T_C is the real cell temperature (K), *k* Boltzmann steady 1.381 X 10^{-23} Joules/K, *q* is electron charge (1.602. 10^{-19}).

V_T is known as the warm voltage in view of its selective reliance of temperature, as considered[12] Ns: is the quantity of PV cells associated in arrangement. A_n is the ideality variable. It relies upon PV cell innovation and can be taken from Table 1. It is to be noted that A will be a constant which relies on PV cell innovation.

Every one of the terms by which, V is separated in condition (2) under exponential capacity are conversely relative to cell.

Table 1
Ideality factor(A_n)

Technology	*Ideality factor*	*Technology*	*Ideality factor*
Si-mono	1.2	a-Si-H triple	5
Si-poly	1.3	cdTe	1.5
a-Si-H	1.8	CTs	1.5
a-Si-H tandem	3.3	AsGa	1.3

Temperature thus fluctuates with changing conditions. In this work, this term is called the warm voltage (V). The ideality element is viewed as constant and is got from Table 1. The warm voltage '*a*' is displayed by condition (4).

$$a = N_S. A.k.T_C/q = N_S. A.V_T \quad (4)$$

In[11], "*a*" is called "the altered ideality calculate" and is considered as a parameter to decide, while An is the diode ideality, as indicated in Table 2.

2.2. Practical Model with Rs

The model is presented in the Figure 1*b* the circuit is modified with parallel resistance in the simulation. In actuality, it is difficult to disregard the arrangement resistance R_S and the parallel resistance R_P as a result of their effect on the proficiency of the PV cell and the PV module. When R_S is takeninto thought, condition (2) ought to take the following structure:

$$I_d = I_o[\exp(V + I.R_S/a) - 1] \quad (5)$$

Obviously, Figure 1(*b*) is a rearranged structure, simple to execute in test systems. Figure 1(*c*) is the most illustrative of the PV cell.

2.3. Practical Model with R_S and R_P

The Model is presented in the Figure 1*c* By applying Kirchhoff law, current will be obtained by the equation:

$$I = I_{ph} - I_d - I_p \quad (6)$$

I_P, is the present hole in parallel resistor. As indicated by the condition (7), the yield current of a module containing Ns cells in arrangement will be:

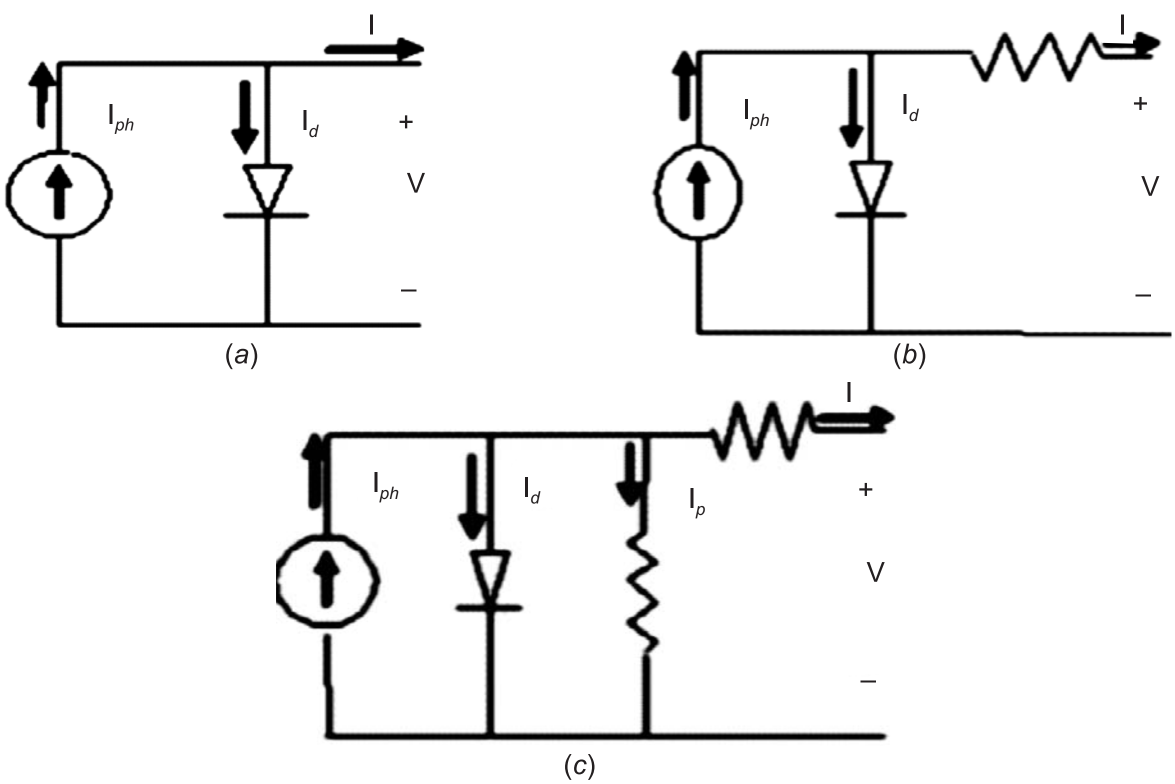


Figure 1: (*a*) Ideal single Diode Model (*b*) Practical model with R_s (*c*) Practical model with R_s and R_p

Table 2
PWX 500 PV Module (49 W) Characteristics

Parameters	*Values*	*Parameters*	*Values*
P_{mp}(W)	49	$R_s(\Omega)$	0.55
I_{mp}(A)	2.88	Noct °C	45
V_{mp}(v)	17	μ_{sc}(K°)	$1.3*10^{-3}$
I_{sc}(A)	3.11	K_d(K°)	$-72.5*10^{-3}$
V_{oc}(V)	21.8	Ns	36

$$I = I_{ph} - I_o[\exp(V + I.R_S/a) - 1] - V + I.R_S \quad (7)$$

It is difficult to decide the parameters of this supernatural condition. However, this model offers the best match with test values.

3. DETERMINATION OF THE PARAMETERS

The quantity of parameters differs relying upon the picked model and on the presumptions embraced by the searchers. For instance, in[5-8], it is viewed as that I_{ph}, I_0, R_S, R_P and the variable ideality are five parameters that rely on the occurrence sunlight based radiation and the cell temperature. While, the obscure parameters are I_{ph}, I_0, R_S and γ.Where $\gamma = A.N_S$. In this work the four parameters that must be assessed are likewise I_{ph}, I_0, R_S, R_P.

3.1. Determination of I_{ph}

According to Figure 1*a*, the output current at the (STC) condition is:

$$I - I_{ph\,ref} - I_0[\exp(V/a_{ref}) - 1] \quad (8)$$

This condition permits measuring $I_{ph,\,ref}$ which can't be resolved something else. At the point when the PV cell is short circuited.

$$I_{sc\,ref} = I_{sc\,ref} - I_{0\,ref}[\exp(0/a_{ref}) - 1]$$
$$= I_{ph\,ref} \quad (9)$$

In any case, this condition is legitimate just in perfect case. In this way, the equity is not right. And afterward, condition (10) must be composed as

$$I_{ph\,ref} \sim I_{sc\,ref} \quad (10)$$

The photocurrent depends on both irradiance and temperature:

$$I_{ph} = G/G_{ref}(I_{ph\,ref} + \mu_{SC}.\,\Delta T) \quad (11)$$

G : Irradiance (W/m2),

G_{ref} : Irradiance at STC = 1000W/m2,

ΔT = Tc _ Tc_{ref} (Kelvin),

$Tc,_{ref}$: Cell temperature at STC = 25 + 273 = 298 K,

μ_{sc}: Coefficient temperature of short circuit current (A/K), provided by the manufacturer, $I_{ph,\,ref}$: Photocurrent (A) at STC. Block diagram for battery chagrining using solar PV module, which is monitored using MPPT algorithm is formed as shown in the figure 2.

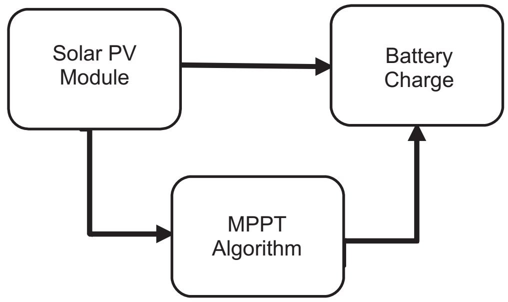


Figure 2: Block Diagram

3.1. Determination of I_0

The shunt resistance R_p is for the most part viewed as incredible, so the last term of the relationship (8) ought to be dispensed with for the following estimation[9-11]. By applying condition (8) at the three most astounding focuses at standard test condition: the voltage at open circuit (I = 0, V = Voc, ref), the current at short out (V = 0, $I = I_{sc, ref}$), and the voltage (V_{mpref}) and current (Imp, ref) at greatest force, the accompanying conditions can be composed:

$$I_{SC\ ref} = I_{ph\ ref} - I_{0\ ref}[\exp(I_{SC\ ref}*R_s) - 1] \tag{12}$$

$$0 = I_{ph\ ref} - I_{0\ ref}[\exp(V_{oc}/a_{ref}) - 1] \tag{13}$$

$$Imp\ ref = I_{ph\ ref} - I_{0\ ref}[\exp(V_{pm\ ref} + I_{ph\ ref}R_s/a_{ref}) - 1] \tag{14}$$

The (–1) term has to be neglected because it is very smaller than the exponential term. According to equation (11), and by substituting (Iph,ref) in equation (14):

$$0 \sim I_{SC\ ref} - I_{0\ ref}\exp(V_{oc}/a_{ref}) \tag{15}$$

So :

$$I_{0\ ref} = I_{SC\ ref}\exp(-V_{oc\ ref}/a) \tag{16}$$

The reverse saturation current is defined by:

$$I_0 = DT_C^3\exp(-q€G/A.K) \tag{17}$$

€G: Material band gap energy (eV),(1.12 eV for Si)

D = Diode diffusion factor

For the simulation of I_{ph} the Matlab figure is shown in Figure 3. This is a different version of the existing $I_{SC\ ref}$ – model to adopt to get the required parameters for our purpose.

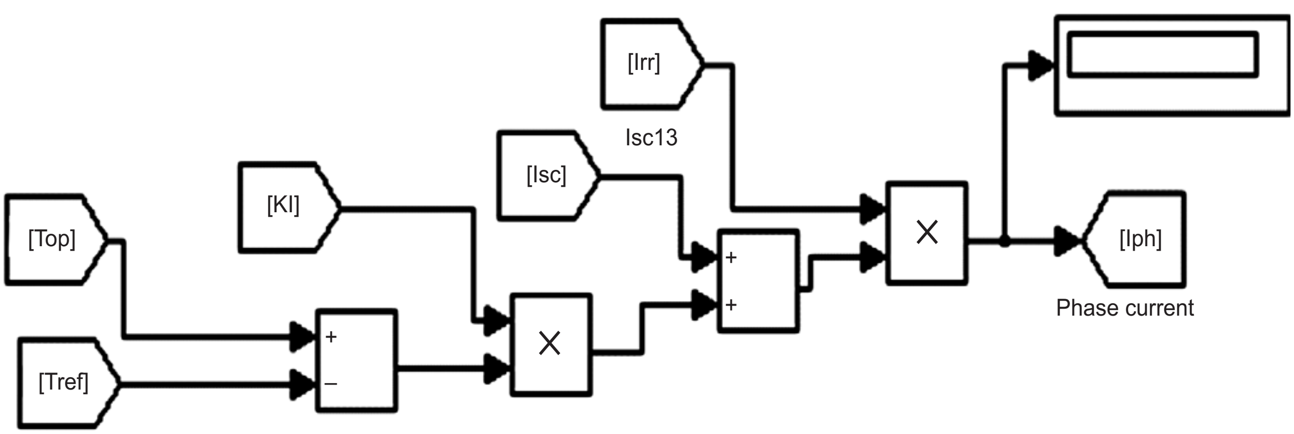


Figure 3: I_{ph} model implementation

For implementation Figure 4 is employed in Matlab/Simulink to get the parameters required.

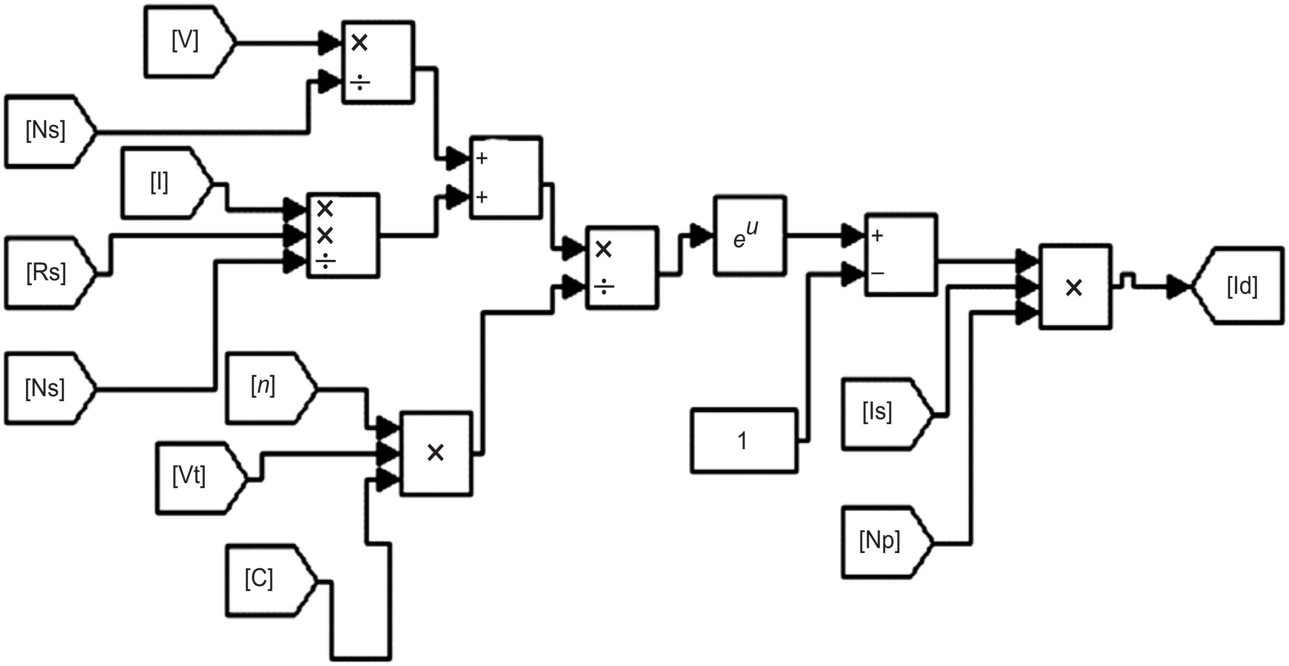


Figure 4: $I_{o\ ref}$ implementation

For implementation Figure 5 is employed in Matlab to get the parameters I_O

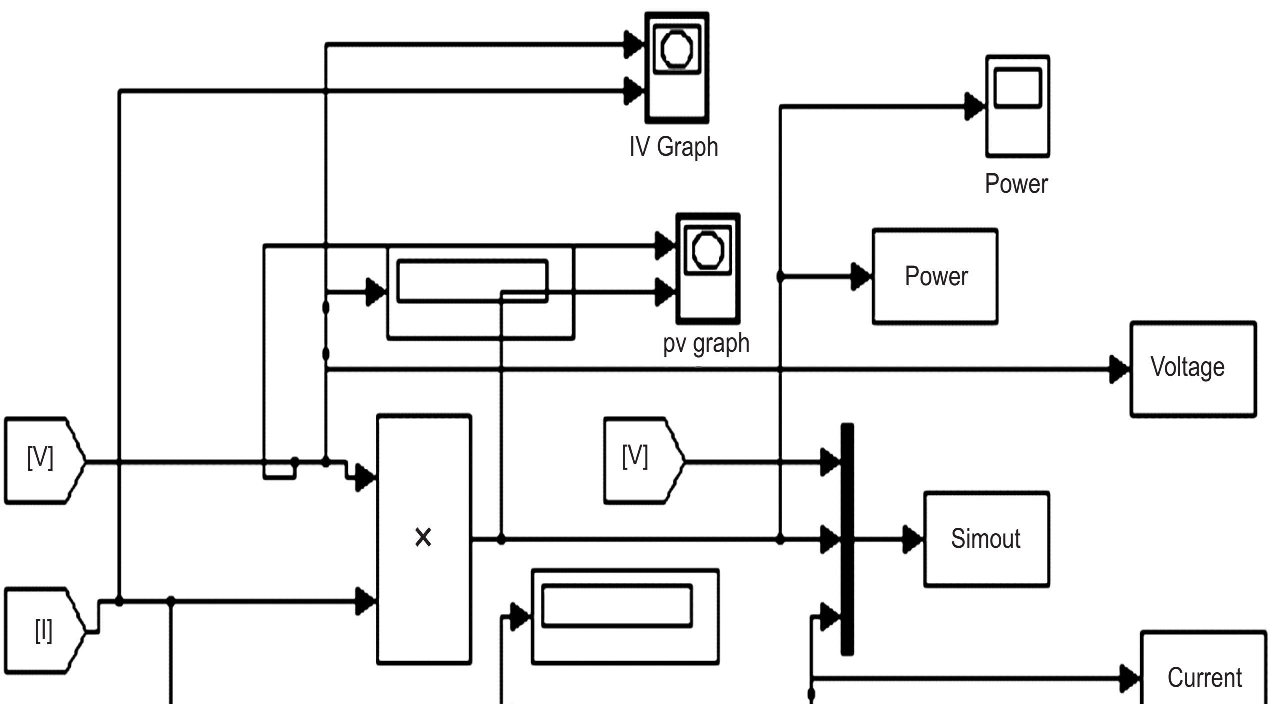


Figure 5: I_o implementation

Figure 6 is employed to get the parameters with R_p term included in the circuit.

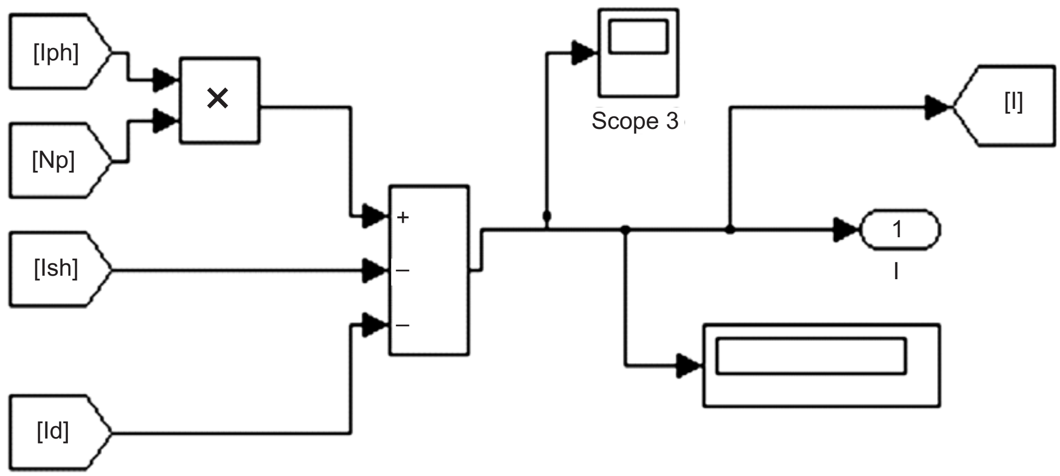


Figure 6: Detailed model with R_p Term

Figure 7 is employed to get block diagram of PV module using Matlab.

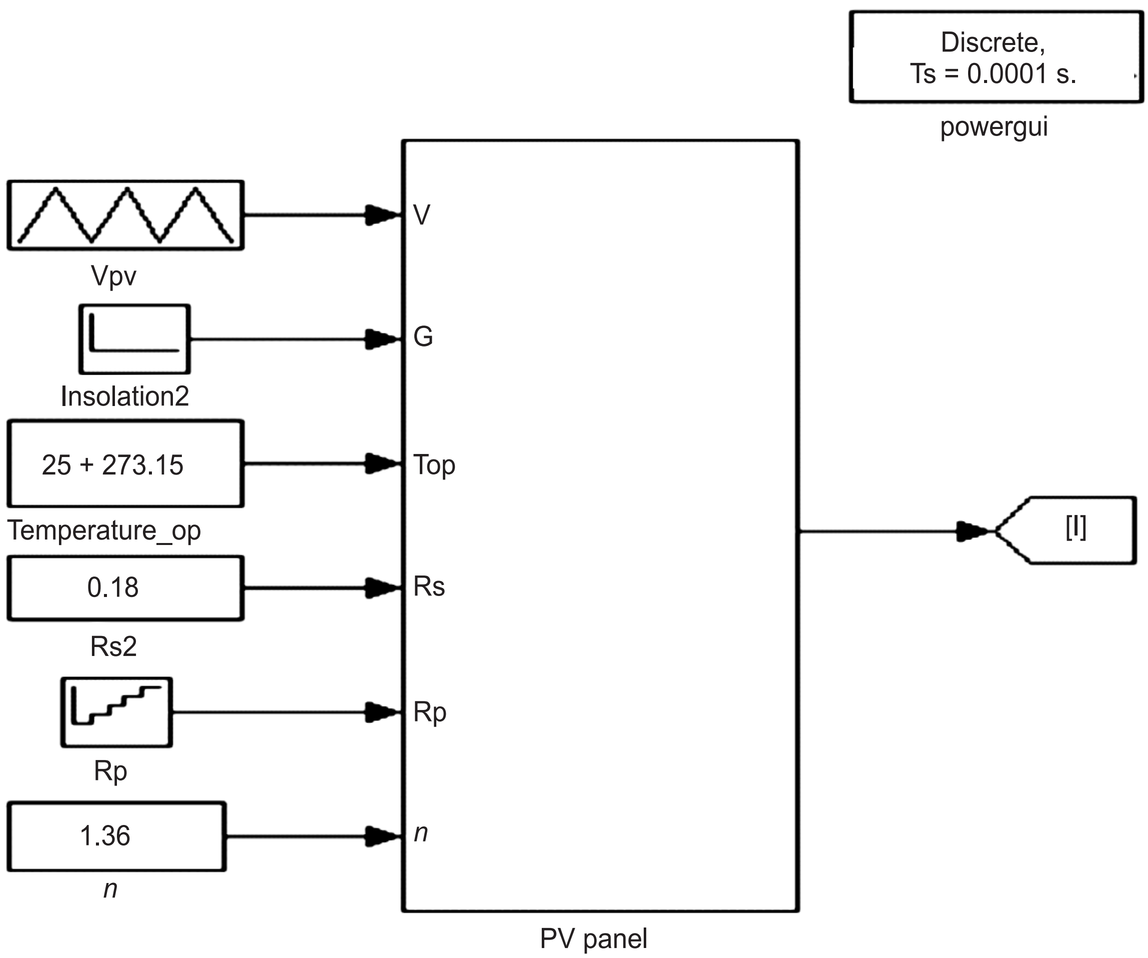


Figure 7: Presentation of the hole pv module

Figure 8 is employed to get grouped sub systems of the module using Matlab.

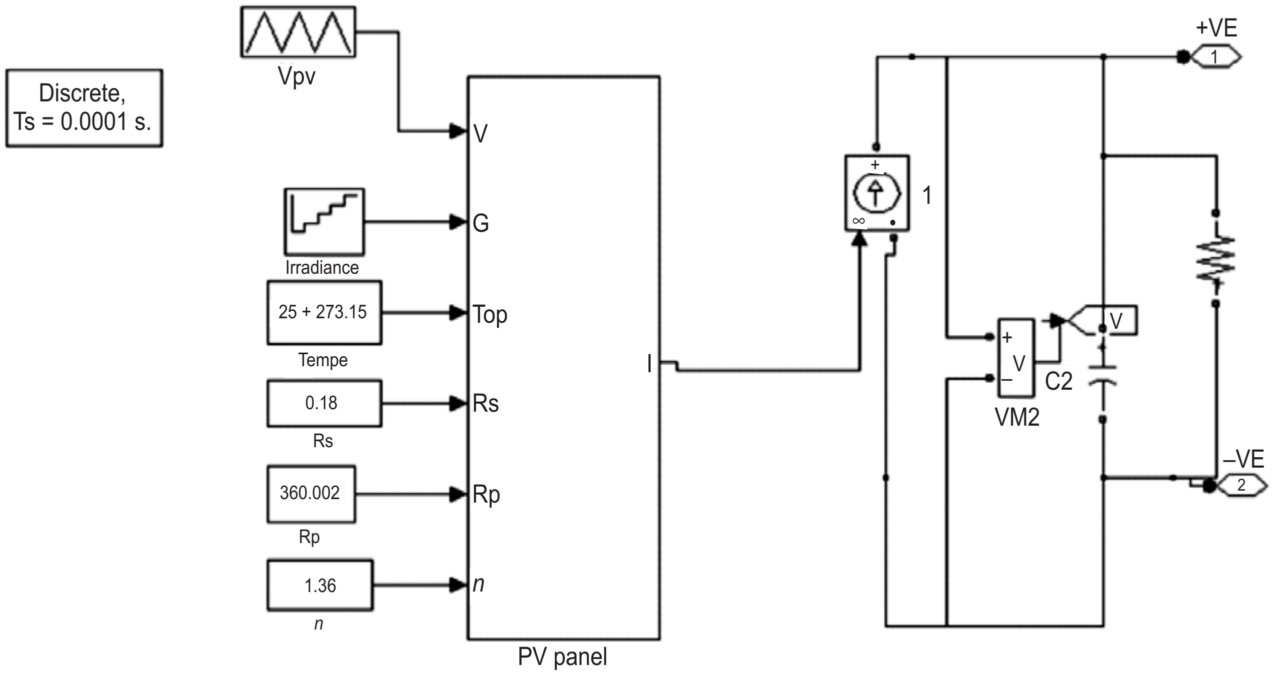


Figure 8: Grouped sub systems of the module

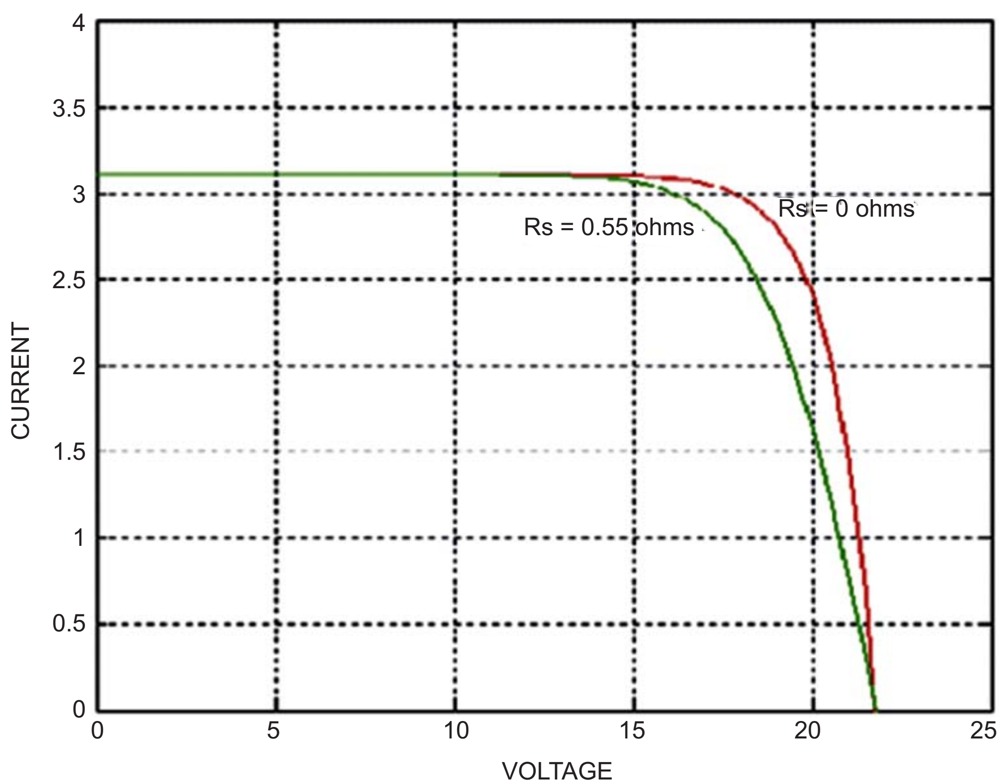


Figure 9: I(V) Characteristic in R_S Model

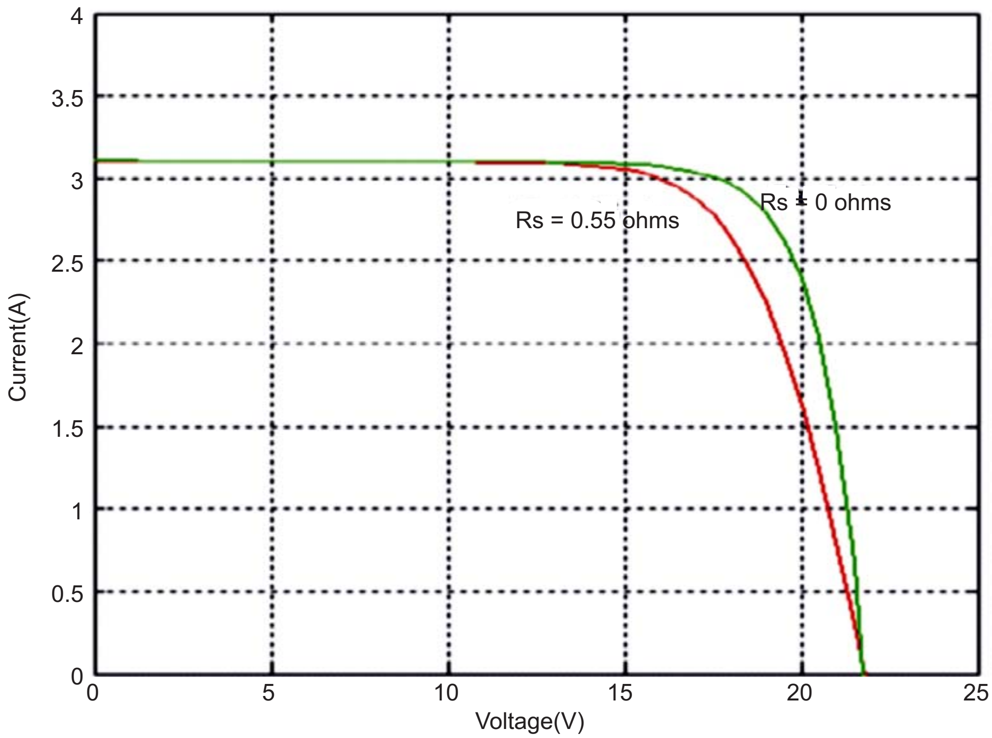


Figure 10: P(V) Characteristic in R_S Model

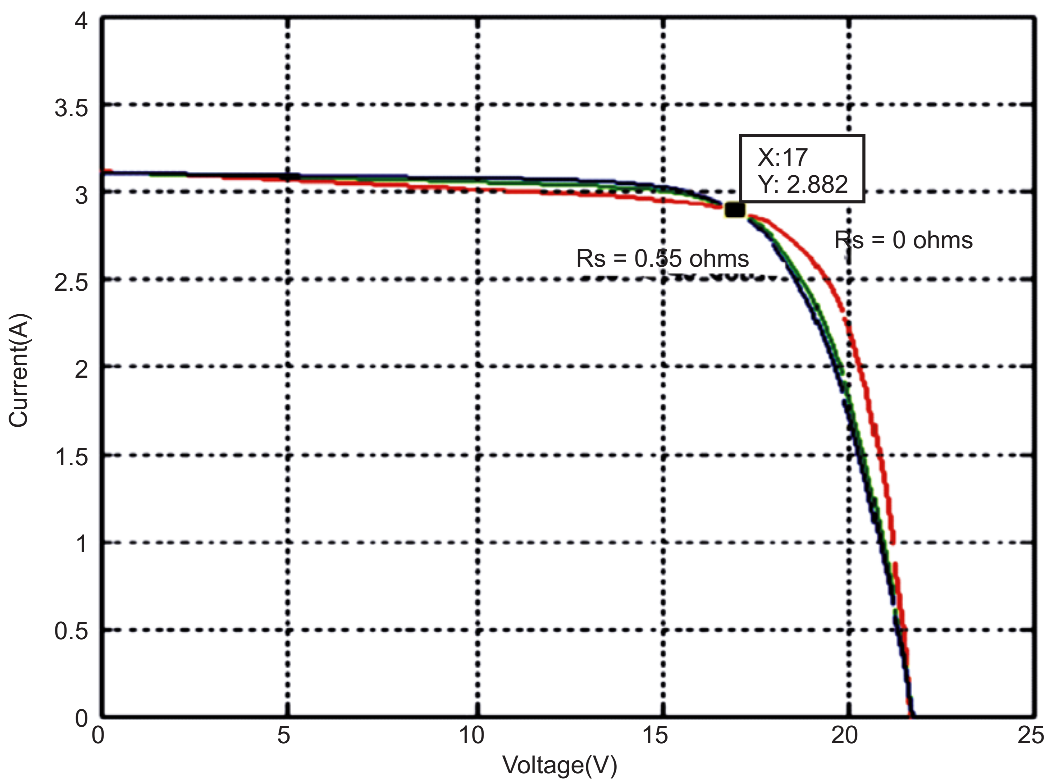


Figure 11: I(V) Characteristic in R_S Model

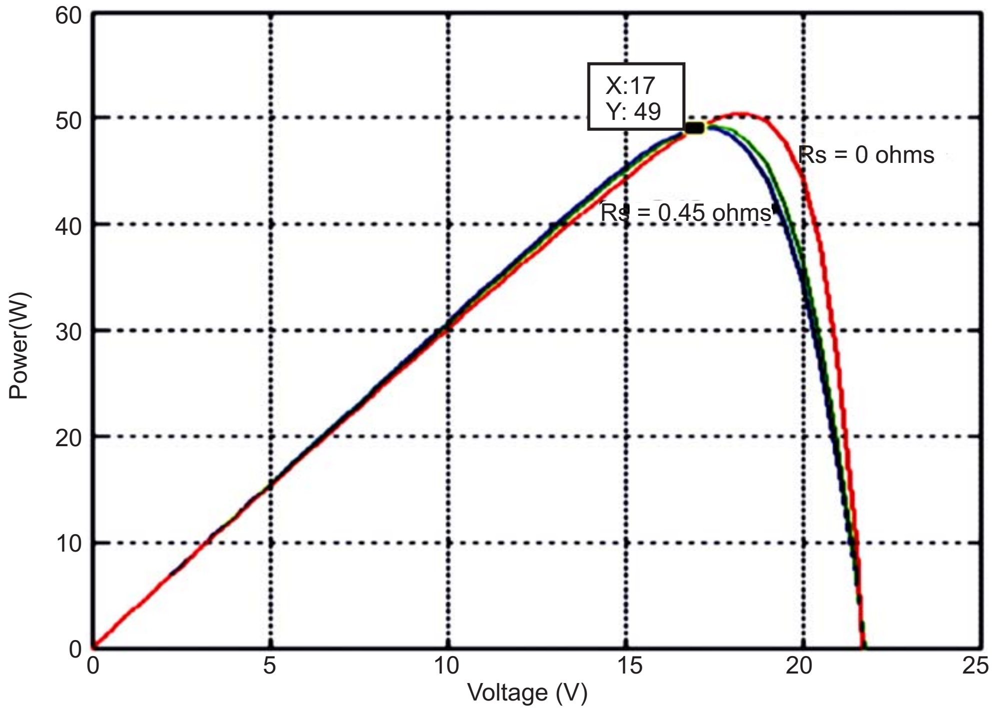


Figure 12: I(V) Characteristic by varying temperature

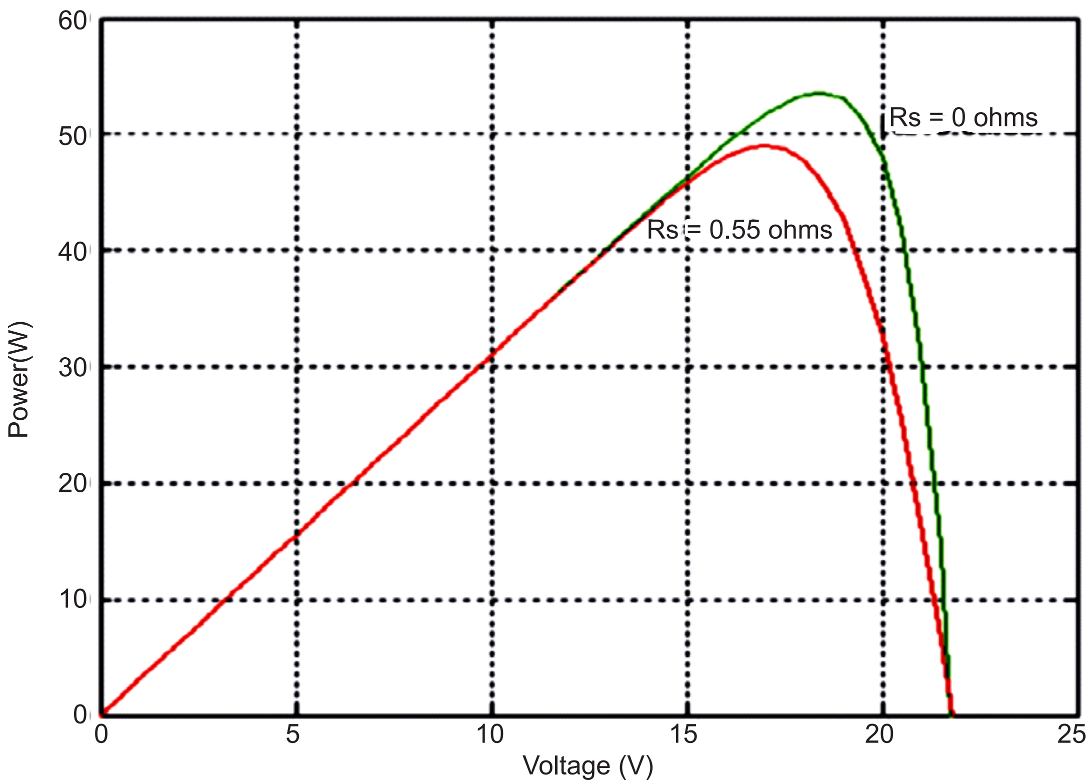


Figure 13: I(V) Characteristic IN R_p model

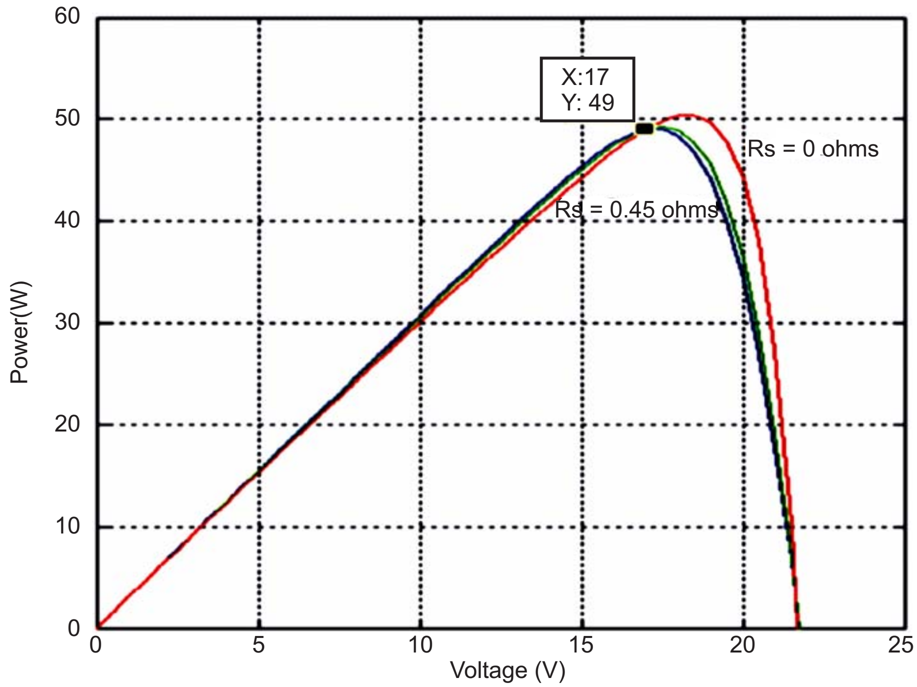


Figure 14: P(V) Characteristic FOR R_S model

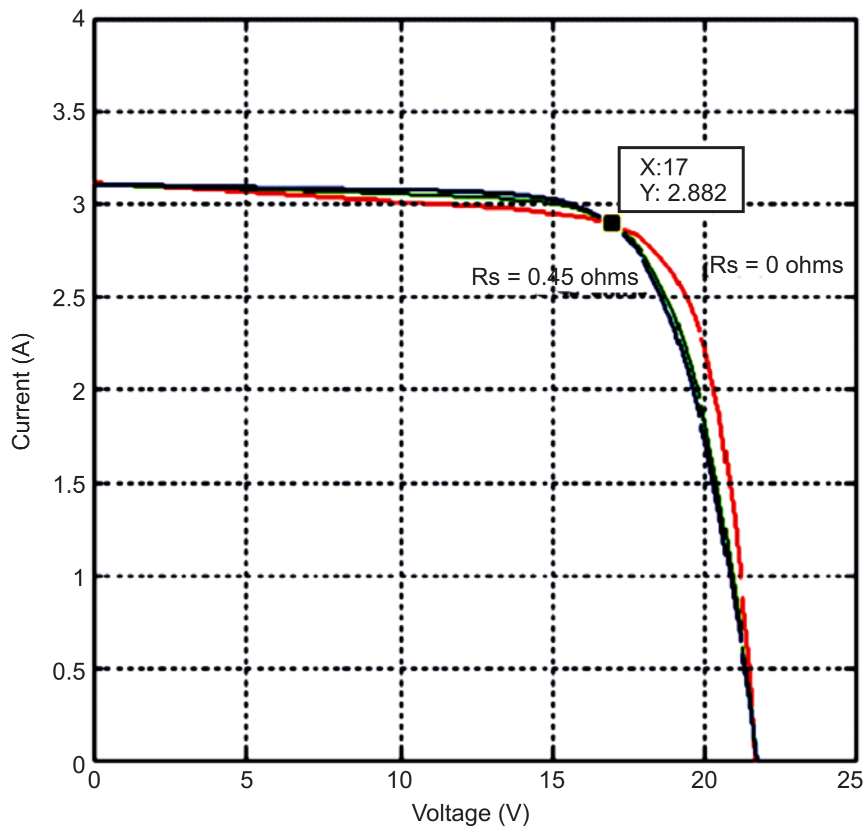
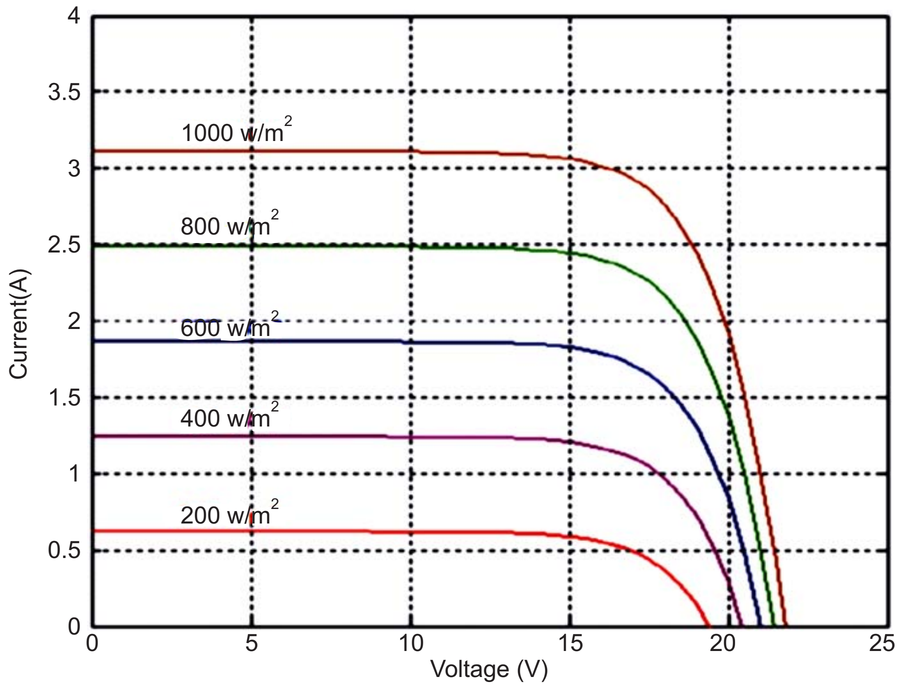


Figure 15: I(V) Characteristic FOR R_S model



Figuare 16: I(V) Characteristic for different irradiance

3.2. Simulation using MatLab/Simulink

With a specific end goal to dispose[13-16] of the diode dispersion variable, condition (18) is figured twice; at Tc and at $T_{c,ref.}$ At that point, the proportion of the two conditions is composed in the following expression:

$$I_0 = I_{oref}\,(T_c/T_{c\,ref})^3 \exp\,[(-q€G/A.K)(1/T_{c\,ref} - 1/T_c)] \quad (18)$$

$$I_0 = I_{SC\,ref} \exp\,[(-V_{OC\,ref}/a)\,(T_c/T_{c\,ref})^3 \exp\,[(-q€G/A.K)(1/T_{c\,ref} - 1/T_c) \quad (19)$$

Condition (20) presents I_0 with a few parameters gave by the makers as (Voc, ref, Tc, ref), others, identified with the innovation of the PV cell, as (An, eG) and a few constants. Be that as it may, "an" and Tc are wards of real temperature. That is the reason; I_0 must be resolved at constant

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3.3. Determination of RP and RS

The parameters are (*i*) assigned by constructors, (*ii*) constants (*iii*) the ones which must be figured. In addition to these, searchers create improved strategies where some obscure parameters can't be ascertained. They are hence accepted constants[17-18].

Keeping in mind the end goal to make the proposed display more sound, R_P and R_S are picked so that the processed max power P_{mp} is equivalent to the trial one P_{mp}, ex at STC conditions. So it is conceivable to compose the following condition:

$$I_{mp\,ref} = P_{mp\,ref} / V_{mp\,ref}$$

$$= I_{Pref} - I_{0ref}\,[\exp(V_{mpref} + I_{mpref}{*}Rs/a) - 1] - (V_{mpref} + I_{mpref}{*}Rs)/R_p \quad (20)$$

$$R_P = V_{mpref} + I_{mpref}{*}Rs)/I_{SCref} - I_{SCref}\,[\exp(V_{mpref} + I_{mpref}{*}Rs - V_{OCref}/a)$$

$$+ I_{SC\,ref} \exp\{(-V_{oc\,ref}/a)\} - (P_{maxex}/V_{mp\,ref})] \quad (21)$$

The cycle begins at $R_S = 0$ which must increment keeping in mind the end goal to move the displayed MPPT until it matches with the trial Maximum Power Point. The comparing R_P is then figured. There is stand out pair (R_p, R_S) that fulfills this condition.Figure 3 is the simulation diagram uses to simulate 1ph (phase current) similarly figure 4 is used for simulating I_D(ideal current) Figure 5 is uses to get Rp, The usage exhibited in Figure 6 was utilized to recreate the proposed model by augmenting R_S until coordinating P_{mp} with $P_{mp, ex}$ and Figure 8 is the overall figure used for the PV Module in the present work. Figure 9 represents grouped subsystems of the module.

Three bends for three unique estimations of Rs are introduced in Figure13. The test estimation of most extreme force at STC, gave by the maker of PWX 500 PV module (49 W) was utilized as a part of condition (22). The iterative strategy to register the pair (R_S, R_P) gave R_S= 0.45 Ω, R_P= 310.0248 Ω. These two qualities make the projected model the most illustrative of the picked PV module.

Keeping in mind the end goal to reproduce another PV module, its particular exploratory greatest force is presented in the condition (22) afterward, the iterative strategy is utilized again to decide the proper pair (R_S, R_P) which makes this same model the most illustrative. Presently, the R_P model can be utilized to reenact the given module at various temperatures and irradiances.

4. SIMULATION OF THE PV MODEL

First, condition (11) is substituted in condition (12) which gives the photocurrent and after that, condition (12) is executed in MATLAB/Simulink environment. The outcome is discussed in Figure3.

The converse immersion current at STC I0, ref is executed as well, as indicated by condition (17). It is displayed in Figure 4. - This permits the reproduction of I_0 which is sown in Figure 5. It is a schematic type of condition (20).

Equation (8) can be thought of in two unique structures; with and without the third term containing the parallel resistance R_P. The both types of conditions (8) are recreated and displayed separately in Figure 6 and 7.

The complete model is displayed in Figure 8. Irradiance and temperature are the inputs while the yields are present and voltage.

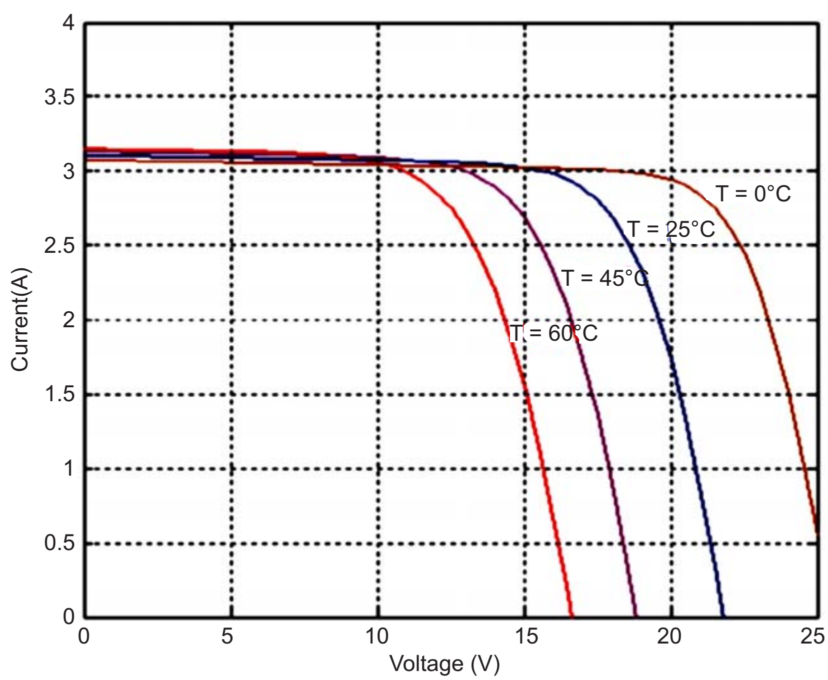

Figure 17: I(V) Characteristic for different Temp

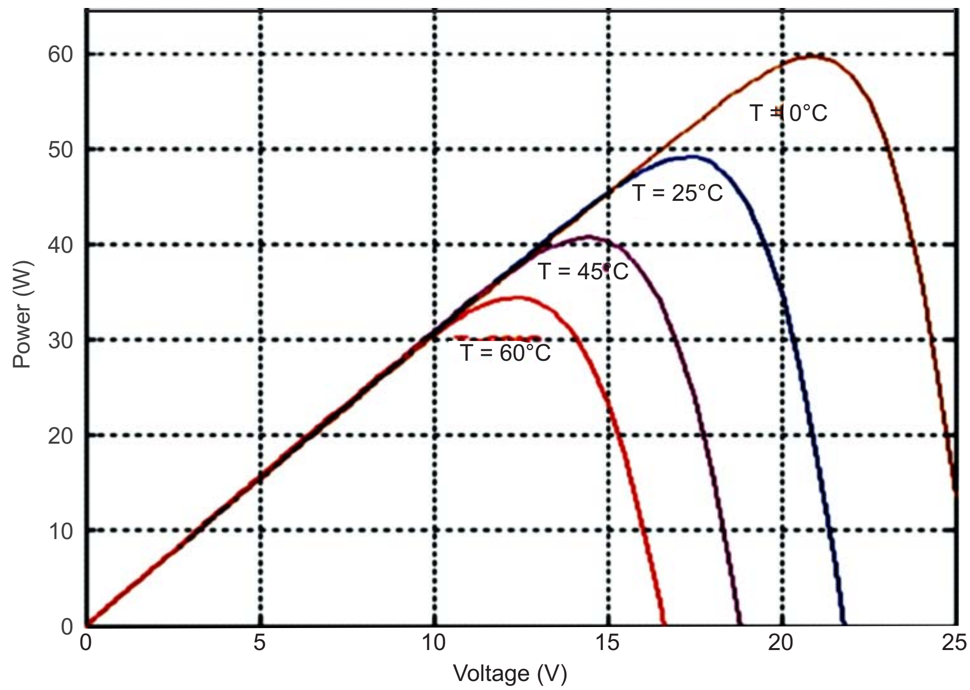

Figure 18: P(V) Characteristic for different Temp

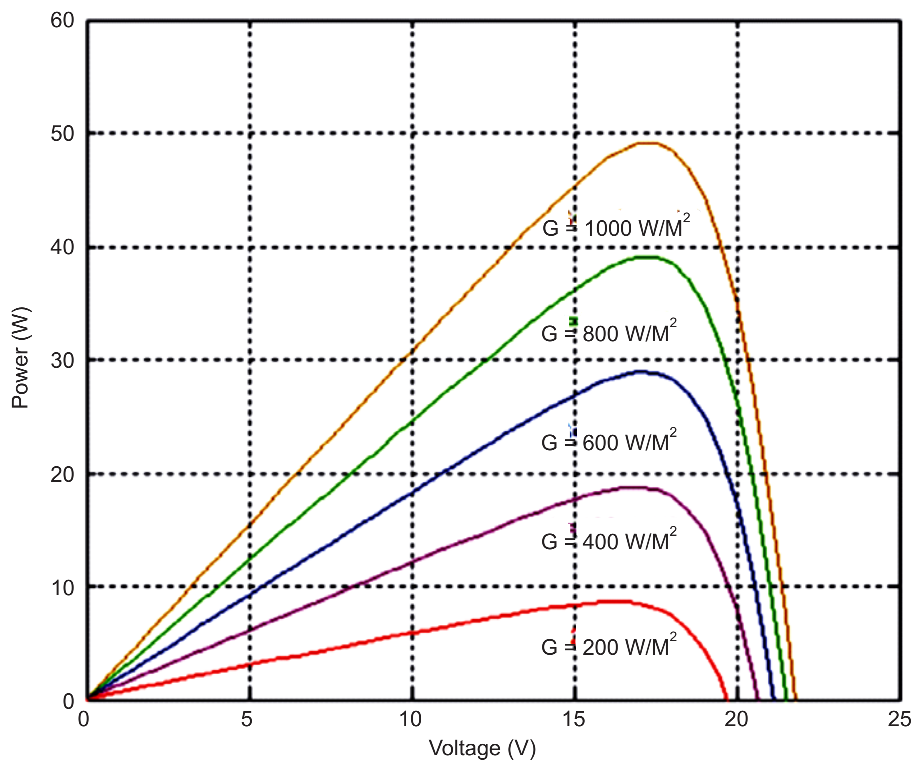

Figure 19: P(V) Characteristic for different Temp

To make reenactment very much sorted out, subsystems are gathered and exhibited in Figure 9

5. DISCUSSION

To start with, I(V) is plotted for Rs equivalent to zero and Rs = 0.55.Similar behavior is observed in Figure 10 where maximum power is obtained at Rs = 0.55 and the figure 11where maximum power obtained at Rs = 0.45. The last estimation of the arrangement resistance is given by maker. From this figure9 is seems that $I_{SC}$is not influenced It is conceivable to call attention to a few remarks in Figures. 9 and 10; as the way that neither Isc nor Voc are influenced by the change of the arrangement resistance. Notwithstanding this, the shape moves to the rectangular structure when Rs diminishes. The Maximum Power Point moves to one side, in this way, Pmp is backward extent to the arrangement resistance. This is as per the fill variable connection (Anne and Michel, 2006; Bernard, 2004):

$$FF = P_{mp}/V_{oc}*I_{sc} \tag{22}$$

On the off chance that Isc and Voc are consistent, the fill variable FF changes just as per Pmp. which is with deference of both Rs and Rp in condition (21).

As appeared in Figure 12, it is affirmed that the producer did not contemplate the parallel resistance, in light of the fact that the crest force of the Rs model in this work matches with the exploratory crest power given in the information sheet for Rs =0.55 O. Yet, for the Rp model, the crest force is legitimately not exactly the trial one (See Figure12).

The proposed Rp model is more precise and the most proper to recreate PWX 500 PV module (49 W) and some other PV module. For PWX 500 PV module (49 W), every one of the parameters are accessible to register iteratively Rs and Rp . The qualities were connected in the definite Rp model displayed in Figure 6. The outcomes are exhibited in Figures13 and 14.

The proposed Rp model is currently used to recreate the PV module at various estimations of irradiance and temperature. TheP (V), I (V) attributes are introduced in Figure 14 and Figure15 by differing irradiance from 200 W/m^2 to 1000 W/m^2 and taking The STC temperature. In Figure16, the temperature shifts from 0^0 C to 60 ^{0}C at STC irradiance.

P(V) qualities are then introduced in Figure17 by fluctuating temperature from 0^0 C to 60^0 C at STC under STC irradiance. In Figure18 the irradiance fluctuates from 200 W/m^2 to 1000 W/m^2 under STC temperature.0^0C to 60^0 C at STC irradiance. P(V) qualities are then introduced in Figure17 by fluctuating temperature from 0 ^{0}C to 60 ^{0}C at STC under STC irradiance. In Figure19 the irradiance fluctuates from 200 W/m^2 to 1000 W/m^2 under STC temperature.from the earlier work system for charging the battery needs 1250 watts from at 25^{0c} and the voltage may be fixed at 65 at irradiance 1000w/m^{2}with series resistance R_S =10 ohms.

6. CONCLUSIONS

The following conclusions may be arrived at through the MatLab/Simulation it is possible to fix maximum irradiance at 1000w/m^2 this is needed to charge the battery at ambient temperature 25^{oC} to 30^{oC} where the charging efficiency is maximum(Bhaskar et.al)

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