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Modeling Combined Effect of Temperature, Irradiance, Series Resistance (R_s) and Shunt Resistor (R_{sh}) on Solar Cell by MATLAB/ Simulink

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Abstract: **In this project a single solar cell performance is analysis with change in the various electrical and mechanical parameters. The open circuit voltage and short circuit current (I-V) and P-V of solar cell is varies with the influence electrical and mechanical parameters. In this project we analysis the solar cell with the following parameter such as temperature, irradiance and series resistance (R_s) and shunt resistor (R_{sh}). The analysis is done separate and combined effect of temperature and irradiance with series and shunt resistor. The single solar cell model is done by MATLAB-Simulink tool and the output under change in various parameters is verified.**

Index terms **— temperature, irradiance and series resistance (R_s) and shunt resistor (R_{sh}), solar cell, isolation**

I. INTRODUCTION

India is the first country in the world to set up a minister called Minister of New and Renewable energy for non-conventional energy resources. As India is a tropical country having high solar insolation, the best alternative measure of renewable green energy is solar energy.

India is the fifth largest producer and end user of electricity in the world and demand is expected to increase from 900 billion kilowatt-hours (kWh) to 1,400 billion kWh by March 2017. India is in a state of recurrent energy lack with a demand-supply gap of almost 12% of the total energy demand. To meet this demand, Solar is the only entirely renewable alternative energy source with the fundamental capability to satisfy the energy needs of India.

In January 2010, India's Ministry of New and Renewable Energy (MNRE) under the Jawaharlal Nehru National Solar Mission (JNNSM) declared the aim of installing 20 Gigawatts (GW) of grid-connected solar power and 2 GW of off-grid solar by 2022. In terms of overall installed PV capacity, India comes fourth After Japan, Germany and U.S. In the area of Photovoltaic India today is the second largest manufacturer in the world of PV panels based on crystalline solar cells. (Industrial production in this area has grasped a level of 11 MWper year About 10% of the world's overall PV production PV panels based on crystalline solar cells).A major drive has also been initiated by the Government to trade Indian PV products, systems, technologies and services

Due to the day by day increasing energy demand, shortage and environmental impacts of conventional energy sources, more attention has been given to utilize the renewable energy. In a tropical Asian country like India, the most promising alternative of renewable green energy resource of the future is the sun. Since this energy source is free, abundant, feasible and environmental friendly, it become more popular. Although there are several benefits in solar energy, there are some challenges that obstruct its growth. The two main challenges are low conversion efficiency and its erratic nature of power output.

To improve the conversion efficiency of the PV System, a technique is adopted which is known as Maximum power point tracking. MPPT make the PV system to operate at its maximum power. As such, many MPPT techniques have been introduced and implemented. By conventional popular MPPT methods, it's easier to find the maximum power in nonlinear P-V curve under uniform insolation, as there will be single maxima. However, under partially shaded conditions, these MPPTs can fail to track the real MPP because of the multiple local maxima which can be appeared on P-V characteristic curve. On the impact of partial shading on PV panels and the failure of the conventional

The solar panel is affected with the various environment conditions and its internal parameters. Its output open circuit voltage (Voc) and short circuit current (Isc) will be affected due to this. In order utilize the solar power fully we need to have proper PV modeling and its Parameter based on that. So that only we have able to utilize the solar power properly and we have some alteration to get a maximum power for PV system.

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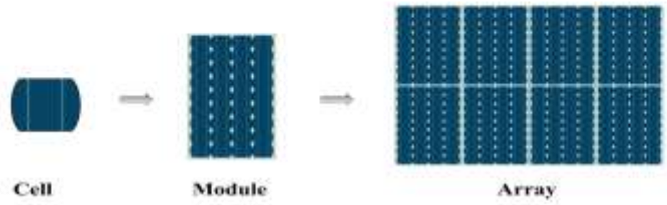
II. FAMILIARIZATION OF PV SYSTEM

This section described the mathematical model of the basic element solar cell. The mathematical model of solar cell can be further implemented for the PV module and PV array modeling. Photovoltaic cells are the basic building blocks on construction of PV power Systems. The amount of power delivered by a PV cell is, typically, restricted to few Watts, due to the surface area limitation. For raising the generated power, in order to reach hundreds of Watts, PV cells may be grouped in a PV module. Similarly, it is possible to connect a group of PV modules (series, parallel or both) in order to obtain a PV array, whose power range is established from kilo-Watts to mega-Watts.



Relationship among PV cell, module and array

A. PHOTOVOLTAIC CELL:

Solar cells are the building blocks of a PV array. These are made up of semiconductor materials like silicon etc. A thin semiconductor layer is specially treated to form an electric field, positive on a side and negative on the other. Electrons are knocked loose from the atoms of the semiconductor material when light strikes upon them. If an electrical circuit is made attaching a conductor to the both sides of the semiconductor, electrons flow will start causing an electric current. It can be circular or square in construction.

B. PHOTOVOLTAIC MODULE:

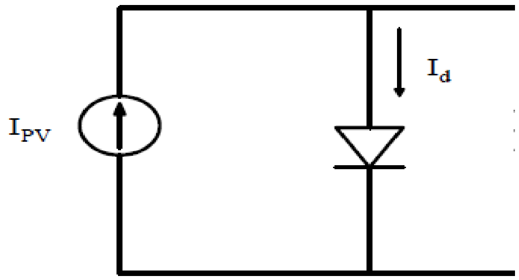
The voltage generated by a single solar cell is very low, around 0.5V. So, a number of solar cells are connected in both series and parallel connections to achieve the desired output. In case of partial shading, diodes may be needed to avoid reverse current in the array. Good ventilation behind the solar panels are provided to avoid the possibility of less efficiency at high temperatures.

C. PHOTOVOLTAIC ARRAY:

To fulfill the requirement of the power, the power produced by a single module is not enough. PV arrays can use inverters to convert the dc output into ac and use it for motors, lighting and other loads. By connecting in series, the modules get more voltage rating and by connecting in parallel, the modules reach the current specifications.

III. EQUIVALENT CIRCUIT MODELS

Equivalent circuit models define the entire I-V curve of a cell, module, or array as a continuous function for a given set of operating conditions. One basic equivalent circuit model in common use is the single diode model, which is derived from physical principles and represented by the following circuit for a single solar cell:



Equivalent circuit models

By using Kirchhoff's current law, we can formulate the governing equation for this equivalent circuit for current I:

I=I -I - Ish *L d*

Here,

I_L: The light-generated current in the cell

I_d: The voltage-dependent current lost to recombination

I_{SH}: The current lost due to shunt resistances.

In this single diode model, Id is modelled using the Shockley equation for an ideal diode:

$$I_D = I_0\left[\exp\left(\frac{V+IR_s}{nV_T}\right)-1\right]$$

Where the diode ideality factor (unitless, usually between 1 and 2 for a single junction cell), is the saturation current, and is the thermal voltage given by:

$$I_D = I_0\left[\exp\left(\frac{V+IR_s}{nV_T}\right)-1\right]$$

where is the diode ideality factor (unitless, usually between 1 and 2 for a single junction cell), I_o is the saturation current, and V_T is the thermal voltage given by:

$$V_T = \frac{kT_c}{q}$$

Where k is Boltzmann's constant k = 1.380650 x 10-23 JK-1 and q is the elementary charge 1.6021766208(98) $\times 10^{-19}$ coulombs.

Writing the shunt current as **$Ish=(V+IR_{Se})/R_{sh}$** and combining this and the above equations results in the complete governing equation for the single diode model.

For a photovoltaic module or array comprising N_S cells in series, and assuming all cells are identical and under uniform and equal irradiance and temperature (i.e., generate equal current and voltage),

$$\mathbf{I_{module} = I_{cell}}$$

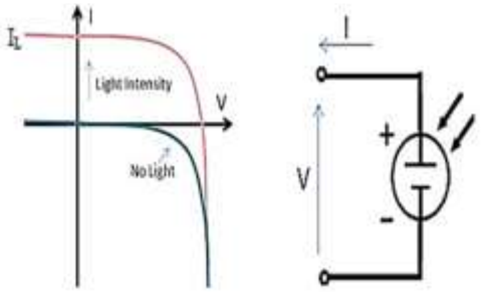
$$\mathbf{V_{module}=N_S*V_{cell}}$$

In some implementations the thermal voltage V_T, diode ideality factor A, and numbers of cells in series are combined into a single variable termed the modified ideality factor:

$$a = \frac{N_s n k T_c}{q}$$

IV. THEORY OF I-V CHARACTERIZATION

PV cells can be modeled as a current source in parallel with a diode. When there is no light present to generate any current, the PV cell behaves like a diode. As the intensity of incident light increases, current is generated by the PV cell, as illustrated in Figure



I-V Curve of PV Cell and Associated Electrical Diagram

In an ideal cell, the total current I is equal to the current Iℓ generated by the photoelectric effect minus the diode current ID, according to the equation:

$$I = I_L - I_D = I_L - I_o\left(e^{\frac{qV}{kT}} - 1\right)$$

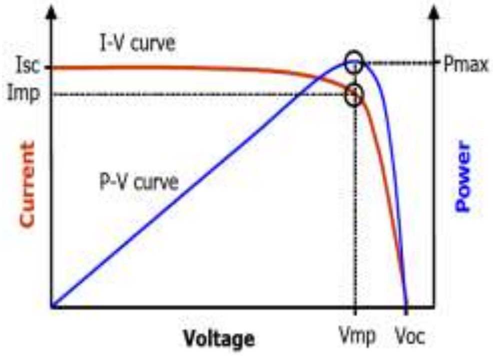
where I0 is the saturation current of the diode, q is the elementary charge 1.6x10-19 Coulombs, k is a constant of value 1.38x10-23J/K, T is the cell temperature in Kelvin, and V is the measured cell voltage that is either produced (power quadrant) or applied (voltage bias). A more accurate model will include two diode terms; however, we will concentrate on a single diode model in this document. Expanding the equation gives the simplified circuit model shown below and the following associated equation, where n is the diode ideality factor (typically between 1 and 2), and RS and RSH represents the series and shunt resistances that are described in further detail later in this document:

$$I = I_l - I_0\left(exp^{\frac{q(V+I\cdot R_S)}{n\cdot k\cdot T}} - 1\right) - \frac{V + I\cdot R_S}{R_{SH}}$$

We conclude some above equations

- Diode saturation current (IO), PV current ( ) and thermal voltage ( ) are temperature dependent.
- PV current (I_{PV}) directly proportional to the irradiance
- Gives accurate shape between mpp and open circuit voltage
- '**a**' expresses the degree of ideality of the diode and it is totally empirical, any initial value of a can be chosen in order to adjust the model

The characteristics I-V curve of an irradiated PV cell has the shown in the voltage across the measuring load is swept from zero to VOC, and many performance parameters for the cell can be determined from this data, as described in the sections below.



Illuminated I-V Sweep Curve

V. PV MODULE PERFORMANCE PARAMETERS

PV module performance is given by the following parameters:

- Short Circuit Current (ISC)
- Open Circuit Voltage (VOC)
- Maximum Power (PMAX)
- Current at PMAX (IMP)
- Voltage at PMAX (VMP)
- Fill Factor (FF)
- Efficiency (η)

D. Short Circuit Current (ISC)

When the impedance is low, the short circuit current ISC corresponds to the short circuit condition and is calculated when the voltage equals 0. At V=0, I = ISC

ISC occurs at the beginning of the forward-bias sweep and is the maximum current value in the power quadrant. For an ideal cell, this maximum current value is the total current produced in the solar cell by photon excitation. For forward-bias power quadrant, ISC = IMAX = Iℓ

E. Open Circuit Voltage (VOC)

When there is no current passing through the cell, the open circuit voltage (V_{OC}) is occurred.

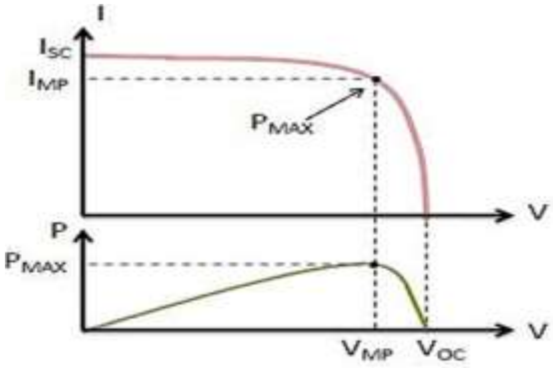
At I=0, Voltage = V_{OC}

V_{OC} is also the maximum voltage difference across the cell for a forward-bias sweep in the power quadrant.

For forward-bias power quadrant, VOC= VMAX

F. Maximum Power (PMAX), Current at PMAX (IMP), Voltage at PMAX (VMP)

The power generated by the cell in Watts can be easily calculated along the I-V curve by the equation P=IV. At the ISC and VOC points, the power will be zero and the maximum value for power will occur between the two. At this maximum power point the voltage and current are represented as VMP and IMP respectively.

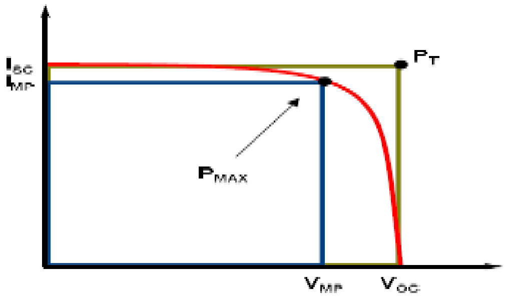


Maximum Power from an I-V Curve

G. Fill Factor (FF)

The Fill Factor (FF) is essentially a measure of quality of the solar cell. It is calculated by comparing the maximum power to the theoretical power (PT) that would be output at both the open circuit voltage and short circuit current together. FF can also be interpreted graphically as the ratio of the rectangular areas depicted

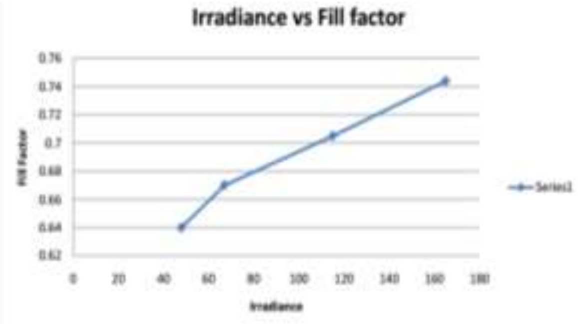
$$FF = \frac{P_{MAX}}{P_T} = \frac{I_{MP}.V_{MP}}{I_{SC}.V_{SC}}$$



Getting the FF from the I-V Characteristics Curve

More fill factor is required, and relates to an I-V Characteristics curve that is more square-like. The range typical fill factor is from 0.5 to 0.82. Fill factor is also often represented as a percentage.

SL NO	IRRADIANCE (Watt/m^2)	INTENSITY (lux)	FILL FACTOR
1	48	590	0.64
2	67	910	0.67
3	115	2000	0.705
4	165	3230	0.744



H. Efficiency (η):

The ratio of the output power Pout, compared to the solar input power, Pin is called efficiency of Solar Cell. Pout can be taken to be PMAX since the solar cell can be operated up to its maximum power output to get the maximum efficiency.

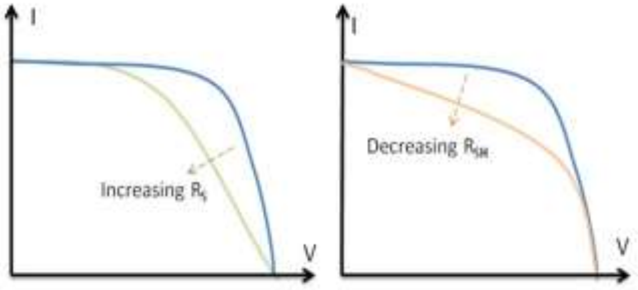
$$\eta = \frac{P_{out}}{P_{in}} \Rightarrow \eta_{MAX} = \frac{P_{out}}{P_{in}}$$

Pin is taken as the product of the irradiance of the incident light, measured in W/m2 or in suns (1000 W/m2), with the surface area of the solar cell [m2]. The maximum efficiency (ηMAX) found from a light test is not only an indication of the performance of the device under test, but, like all of the I-V parameters, can also be affected by ambient conditions such as temperature and the intensity and spectrum of the incident light. For this reason, it is recommended to test and compare PV cells using similar lighting and temperature conditions.

I. Shunt Resistance (RSH) and Series Resistance (RS)

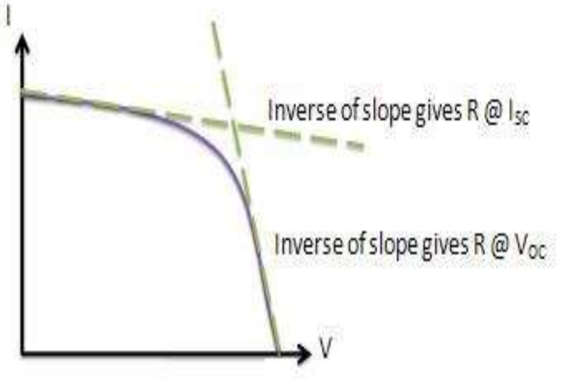
During operation, the efficiency of solar cells is reduced by the dissipation of poweracross internal resistances. These parasitic resistances can be modelled as a parallel shunt resistance (R_{SH}) and series resistance (R_{Se}), as depicted

For an ideal cell, RSH would be infinite and would not give an alternate path for current to flow, while RS would be zero, resulting in no further voltage drop before the load. Decreasing RSH and increasing Rs will decrease the fill factor (FF) and PMAX as shown. If RSH is decreased too much, VOC will drop, while increasing RS excessively can cause ISC to drop instead.



Effect of Rs & RSH

It is possible to approximate the series and shunt resistances, RS and RSH, from the slopes of the I-V curve at VOC and ISC, respectively. The resistance at Voc, however, is at best proportional to the series resistance but it is larger than the series resistance. RSH is represented by the slope at ISC. Typically, the resistances at ISC and at VOC will be measured and noted



Obtaining Resistances from the I-V Curve

If incident light is prevented from exciting the solar cell, the I-V curve shown and it can be obtained. This I-V curve is simply a reflection of the "No Light" curve about the V-axis. The slope of the linear region of the curve in the third quadrant (reverse-bias) is a continuation of the linear region in the first quadrant, which is the same linear region used to calculate R_{SH}. It follows that R_{SH} can be derived from the I-V plot obtained with or without providing light excitation, even when power is sourced to the cell. It is important to note, however, that for real cells, these resistances are often a function of the light level, and can differ in value between the light and dark tests.

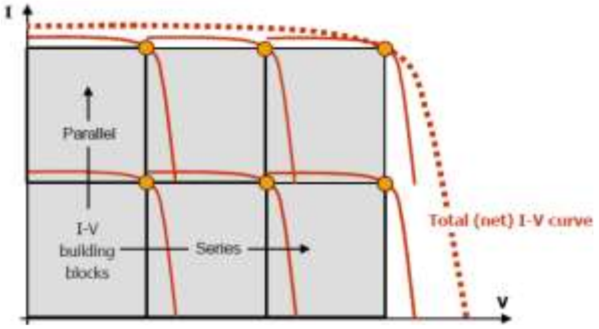
J. Temperature Measurement Considerations

The crystals used to make PV cells, like all semiconductors, are sensitive to temperature. When a PV cell is exposed to higher temperatures, ISC increases slightly, while VOC decreases more significantly.

For a specified set of ambient conditions, higher temperatures result in a decrease in the maximum power output PMAX. Since the I-V curve will vary according to temperature, it is beneficial to record the conditions under which the I-V sweep was conducted. Temperature can be measured using sensors such as RTDs, thermistors or thermocouples.

K. I-V Curves for Modules

For a module or array of PV cells, the shape of the I-V curve does not change. However, it is scaled based on the number of cells connected in series and in parallel. When n is the number of cells connected in series and m is the number of cells connected in parallel and ISC and VOC are values for individual cells, the I-V curve is produced.



I-V Curve for Modules and Arrays

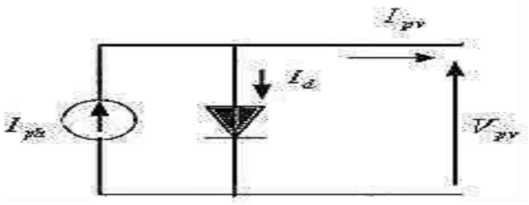
L. Response of Irradiance

Changes in irradiance significantly affect the current and power output of a PV system, but have a much smaller effect on the voltage. The fact that the voltage differs little with changing the sunlight levels makes PV systems compatible for battery charging application.

VI. METHODOLOGY

M. Ideal Solar Cell (1M4P):

The I-V characteristics of a solar cell have an exponential characteristic similar to that of a diode [3]. The ideal equivalent circuit of solar cell is a current source in parallel with a single-diode. This model involves the following four unknown parameters: m, Iph, and Is, this model is also called 1M3P (Single Mechanism, Three Parameters). The configuration of the simulated ideal solar cell with single-diode



Equivalent model of single diode ideal solar cell

The characteristic equation is deduced directly from the Kirchhoff law:

$$I_{pv} = I_{ph} - I_d$$

The diode current is

$$I_d = I_s\left(e^{\frac{qV_{pv}}{mkT}} - 1\right)$$

so the output current is presented by the following non linear I-V equation:

$$I_{pv} = I_{ph} - I_s\left(e^{\frac{qV_{pv}}{mkT}} - 1\right)$$

For the same irradiation and PN junction temperature conditions, the short circuit current Isc is the greatest value of the current generated by the cell and the open circuit voltage Voc is the greatest value of the voltage at the cell terminals.

They are given by:

$$I_{sc} = I_{pv} = I_{ph}$$

for Vpv=0

$$V_{pv} = V_{oc} = \frac{mkT}{q}\ln\left(1 + \frac{I_{sc}}{I_s}\right)$$

for Ipv=0

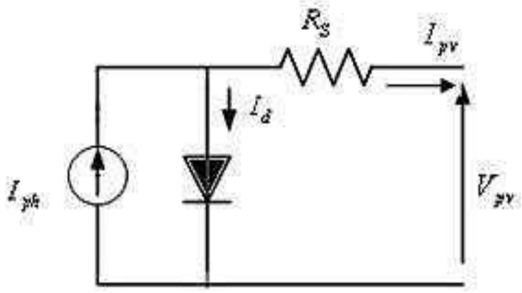
The output power is:

$$P - V_{pv}\left[I_{sc} \quad I_s\left(e^{\frac{qV_{pv}}{mkT}} \quad 1\right)\right]$$

N. Solar Cell with Series Resistance:

More accuracy can be introduced to the model by adding a series résistance. The electric scheme equivalent to this model.

This model involves the following four unknown parameters: m, Iph, Rs and Is model which is also called 1M4P (Single Mechanism, Four Parameters)



Equivalent model of single diode solar cell with series resistance (1M4P).

The diode current is:

$$I_d = I_s\left(e^{\frac{q(V_{pv}+R_S I_{pv})}{mkT}} - 1\right)$$

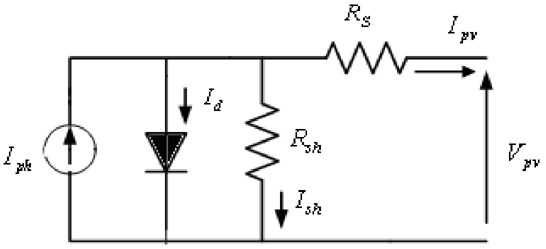
Therefore, the I-V characteristics of the solar cell with single-diode and series resistance are given by:

$$I_{pv} = I_{ph} - I_s\left(e^{\frac{q(V_{pv}+R_S I_{pv})}{mkT}} - 1\right)$$

For the same irradiation and PN junction temperature conditions, the inclusion of a series resistance in the model implies the use of a recurrent equation to determine the output current in function of the terminal voltage. A simple iterative technique initially tried only converged for positive currents

O. Solar Cell with Series and Shunt Resistances (1M5P):

The photovoltaic cell in this case is represented by the circuit of Fig which consists of a current source modeling the light flux, the losses are modeled by two resistances: shunt resistance, and series resistance. The model thus involves the following five unknown parameters: m, Iph, Rs, Rsh and Is. This model is also called 1M5P (Single Mechanism, Five parameters)



Equivalent model of single diode solar cell with series and shunt resistances

The characteristic equation can be deduced directly by using the Kirchhoff law:

$$I_{pv} = I_{ph} - I_d - I_{sh}$$

And the shunt current is:

$$I_{sh} = \frac{V + R_S I_{pv}}{R_{sh}}$$

Where the diode current is:

$$I_d - I_s\left(e^{\frac{q(V_{pv}+R_S I_{pv})}{mkT}} - 1\right)$$

The relationship between the PV cell output current and terminal voltage according to the single-diode model is governed by equation:

$$I_{pv} = I_{ph} - I_s\left(e^{\frac{q(V_{pv}+R_S I_{pv})}{mkT}} - 1\right) - \frac{V_{pv}+R_S I_{pv}}{R_{sh}}$$

For the same irradiation and PN junction temperature conditions, the inclusion of a series resistance in the model implies the use of a recurrent equation to determine the output current in function of the terminal voltage. A simple iterative technique initially tried only converged for positive currents.

The modeling of the PV cell in the three cases was done applying the previous equations. Many types of simulation are carried out depending on the chosen model and the selected parameters.

P. TEMPERATURE EFFECT

In this section, change of open circuit voltage (VOC) and short circuit current (ISC) with temperature is theoretically explored keeping irradiance level constant.

1. Change of VOC

Temperature has a dominant effect on VOC which can be escribed by the following equation:

$$V_{OC2} = V_{OC1}\left(\frac{T_2}{T_1}\right) + \frac{E_G}{e}\left(1 - \frac{T_2}{T_1}\right)$$

where, Voc1 is the open circuit voltage at temperature T_1 and Voc2 at T_2. If we take the differential form of equation then we get:

$$\frac{dV_{OC}}{dT} = \frac{1}{q}\frac{dE_G}{dT} - \frac{1}{T}\left(\frac{E_G}{q} - V_{OC}\right)$$

After analyzing these equations we can conclude that for silicon solar cell, for every 10C increase in temperature Voc drops by about $0.002/0.55 \approx 0.4\%$ from its room temperature value.

2. Change of ISC

Change of short circuit current with temperature is negligible. Actually, there is a very small increase of short circuit current with temperature.

Q. IRRADIANCE EFFECT

In this section, change of open circuit voltage (VOC) and short circuit current (ISC) with irradiance is theoretically studied keeping temperature constant.

1. Change of VOC

Open circuit voltage changes logarithmically with irradiance (indicated by I_1 and I_2) as follows:

$$V_{OC2} = V_{OC1} + \frac{nk_B T}{e}\ln\left(\frac{I_2}{I_1}\right)$$

2. Change of ISC

Short circuit current is linearly dependent on irradiance which is given by the following equation:

$$I_{SC2} - I_{SC1}\left(\frac{I_2}{I_1}\right)$$

R. Temperature and Irradiance effect separately:

The rise of temperature there is a small increase in short circuit current and a remarkable decrease in open circuit voltage as expected theoretically from equation. One additional thing is the fall of power output with the rise of temperature as expected. It can be noticed that, with the rise of irradiance the short circuit current rises remarkably as a result of linear relation as shown in equation but the rise open circuit voltage is not so remarkable because of having a logarithmic relation as discussed by equation can be explained as a manifestation of the rise of power with irradiance level.

VII. INFLUENCES OF MECHANICAL AND ELECTRICAL PARAMETERS

The rise of irradiance the cell temperature also rises; both the open circuit voltage and short circuit current changes simultaneously by their dominant issues called temperature and irradiance respectively. Short circuit current rises with irradiance and open circuit voltage falls with temperature remarkably. As a result we get a rarely cited but practically obvious scenario. That is the fall of open circuit voltage with the rise of irradiance due to temperature effect. This is because temperature has a dominant influence on open circuit voltage as the temperature level increases the open circuit voltage drops steeply. Though the open circuit voltage increases logarithmically with irradiance the decrease due to increase of temperature has more far reaching effect on open circuit voltage which not only overcomes this increased amount but also decreases open circuit voltage to some extent. So, we observe an overall decrease in open circuit voltage. Also demonstrates the same concept as in the case of. This fall of open circuit voltage with irradiance can be verified experimentally by using sun simulator. As a result of unavailability of this equipment, an experimental data in almost same scenario taken from reference. In this experiment, a polycrystalline silicon solar cell is attached to a metal plate and its temperature is stabilized at different levels like 500, 400, 300 and 200 C for various irradiance levels regulated by sun simulator. As it is obvious that, open circuit voltage at high irradiance value (for example 100 mw/cm2) may fall below of its lower irradiance value (for example 20 mw/cm2 at 200C) at an elevated temperature (500C) Measured (circles) and calculated (lines) *I-V* curves of a polycrystalline Si solar cell. *I-V* curves measured at irradiance 0 mw/cm2 and 100 mw/cm2 and T=200C and 500Cwere used for reference *I-V* curves.

In the three models, the temperature is maintained constant Mat 25°C and by varying the irradiation (250W/m2, 500W/m2, 750W/m2, 1000W/m2). It shows the Matlab program results under these conditions on I-V and P-V characteristics respectively. It is clear that current generated by the incident light depends on irradiation, the higher the irradiation, the greater the current. On the other hand, voltage is staying almost constant and it is not going to. The influence of irradiation on maximum power point is clear, the higher the irradiation, the major of the maximum power point will be explained.

Second, the irradiation is maintained constant at 1000W/m2 and varying temperature (25°C, 50°C, 75°C, 100°C) will generate the characteristic curves.

It show the simulation results of I-V and P-V characteristics respectively under the same conditions. The current generated by the incident light is going to stay

constant although it increases slightly while the voltage decreases.

The effect of the temperature increase decreases voltage and power. It shows the influence of both the irradiation and the temperature, we can remark that the I-V and P-V curves are similar to these of the irradiation influence with slightly higher values of power; the effect of the temperature in this case is almost ignored

A. Influence of Series Resistance and Temperature:

The influence of the serial resistance on the characteristic I-V and P-V of 1M4P and 1M5P photovoltaic cells. The series resistance is the slope of the characteristic in the area where the PV cell behaves as a voltage generator it does not change the open circuit voltage, and when it is high, it decreases the value of the short circuit current. The increase of the series resistance results in a decrease in the slope of the power curve. The influence of both the series resistance and the temperature on the same previous models is presented where the short circuit current took the same value while the open circuit voltage is increased.

B. Influence of Series Resistance and Irradiation:

The importance of the series resistance, which indicates the difference between the different models. The performance of a 1M4P PV cell is much degraded when Rs and the irradiation are high, on the other side the model 1M5P is not so influenced by the series resistance as the 1M4P model

C. Influence of Shunt Resistance and Temperature:

The shunt resistance is a resistance which takes into account the unavoidable leakage of current that occurs between the terminals of a solar cell. In general, when the shunt resistance is very high, its effect is felt especially in the generation of power. The influence of the shunt resistance on the current-voltage characteristics results in a slight decrease in open circuit voltage and an increase of the slope of the I-V curve of the cell in the area corresponding to operation as a source of current.

D. Influence of Shunt and Series Resistances:

The effect of the two resistors series and parallel at the same time, where it can be concluded that the effect of the series resistance is negligible, relative to the shunt resistance. A minimization of the value of the shunt resistance induces an estrangement from the real operation of the cell.

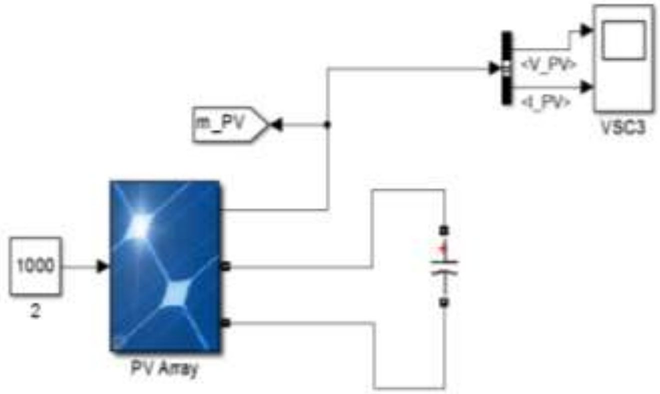
E. Influence of Shunt Resistance and Irradiation:

The simultaneous influence of shunt resistance and the irradiation on a 1M5P model, from which we can collude that the I-V and P-V characteristics are similar to these of the shunt resistance influence shown, with the same values of short circuit current and open circuit voltage, so the shunt resistance influence in this case was been ignored relative to the irradiation influence.

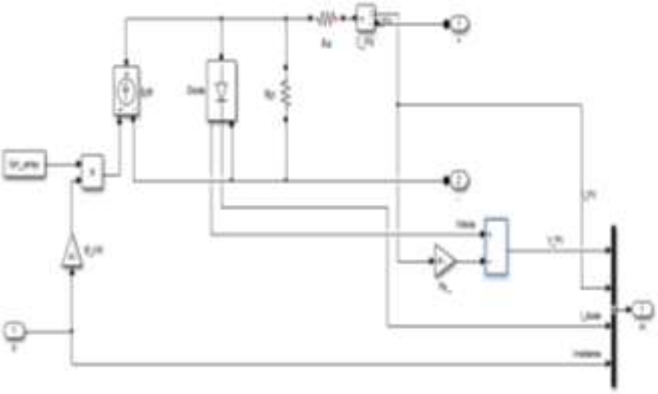
VIII. MODELING OF PV PANEL

The PV module was implemented in Matlab-Simulink using the equations had been presented previous section. The block diagram of the PV module model is shown. A Function Builder is used to built a PV module with the parameter and it is called PV module model. There are three inputs and one output ports in this model, where S1 is insolation, T is temperature of PV module, V is output voltage of PV module, Iout is output current of PV module. Iout is connected to a controlled current source to simulate output current of PV module. A resistance (Rse) connected in series with the positive output of the controlled current source, and a resistance (Rsh) is connected in parallel with both of them. A bypass diode is also included.

It can be created as a subsystem that is a basic PV module model in this paper. The operating temperature of this test system is -40°C to 90°C. In the test system model containing the following parameters number of cells in series, Maximum power (W), Irradiance W/m2 ,Temperature C, Open circuit voltage (V),Short circuit current (A), Series resistance of PV model (ohms), Parallel resistance of PV model (ohms) , Diode quality factor of PV model, Open circuit voltage temp. Coefficient (V/deg.C), Short circuit current temp. Coefficient (A/deg.C), Electron charge Coulombs (q), Boltzmann's Constant (k) and Joules/Kelvin.

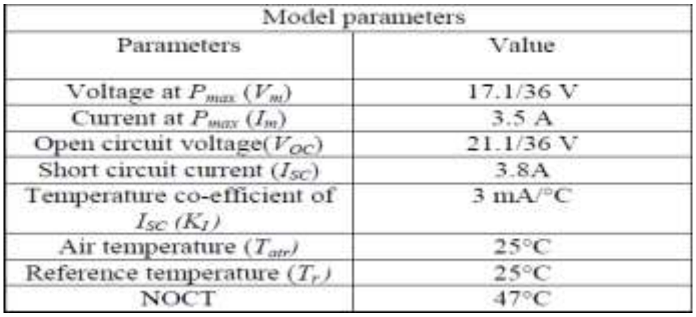


PV panel model



PV array subsystem

S. PV module Parameters:

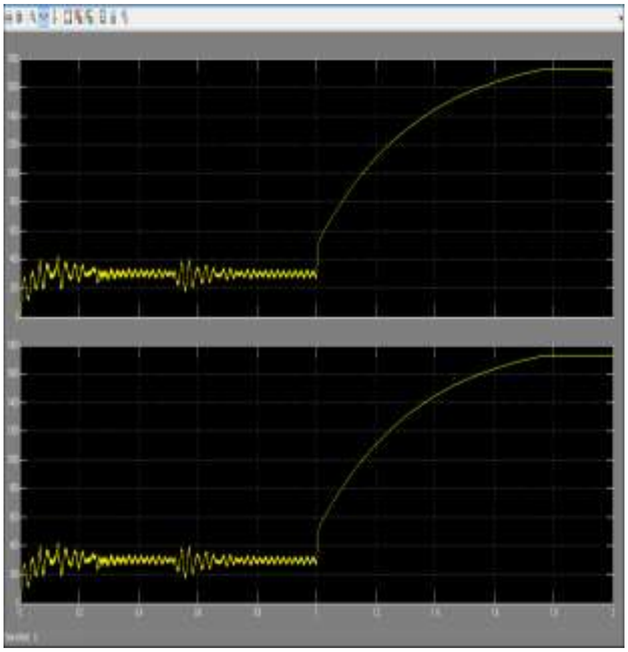


Model parameters	
Parameters	Value
Voltage at P_{max} (V_m)	17.1/36 V
Current at P_{max} (I_m)	3.5 A
Open circuit voltage(V_{OC})	21.1/36 V
Short circuit current (I_{SC})	3.8A
Temperature co-efficient of I_{SC} (K_I)	3 mA/°C
Air temperature (T_{air})	25°C
Reference temperature (T_r)	25°C
NOCT	47°C

IX. SIMULATION RESULTS

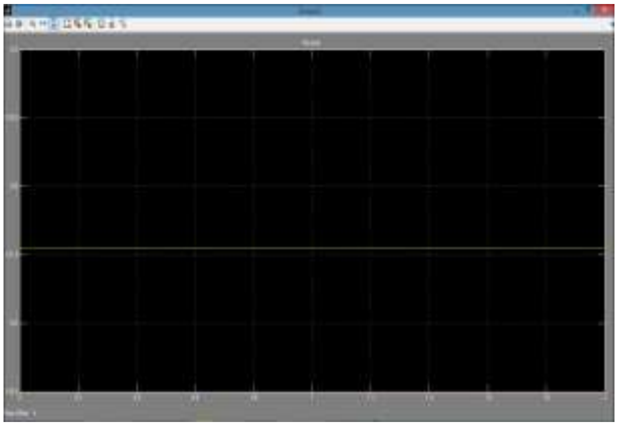
The simulation results for the desired system are done in MATlab Simulink and its output given in the following figures.

The fig shows the output voltage and current of boost converter. Upton 0.8 sec it will works on non MPPT mode after 0.8 sec I just enable the mppt of my system so it will improve the output voltage and current after 0.8sec



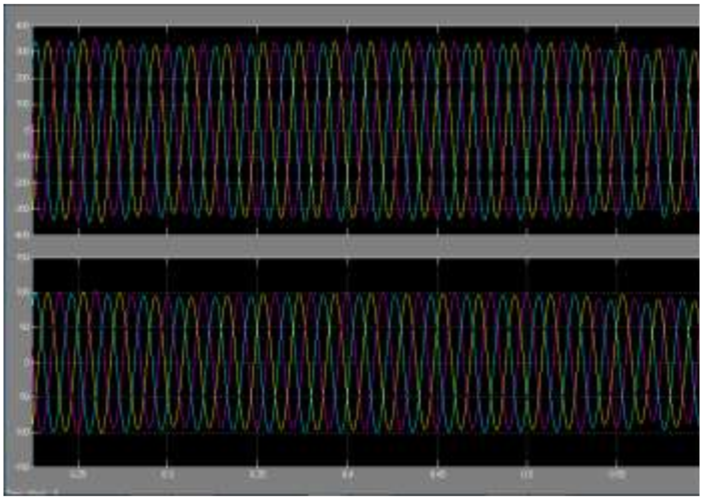
Boost converter output voltage and current

In this fig it shows the voltage of PV module at 230 as an irradiance input and 15 k as a temperature input to PV module. In that if we increase the irradiance value output of PV module also improved. And if the temperature value increases the output of PV module decreases. And similarly my Shunt resistance increases output increases and its series resistance increase output decreases.



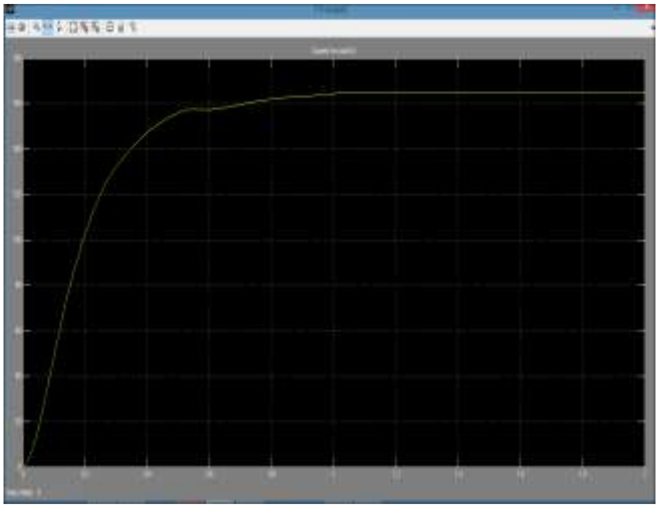
PV output voltage

The fig shows the output of my inverter after filtered with LC filter. And we are using switching frequency as 1KHZ to the inverter and the output of inverter is connected with load.



Inverter output voltage and current

And we are using one more load for DC output from the boost converter. We just added a DC motor to the output of boost converter and the performance of DC motor with respect to PV output is given in fig. And the fig shows the speed of DC in rad/sec



Load Performance (DC motor speed)

X. CONCLUSIONS

In the exciting literature they are consider only one parameter such as irradiance, temperature, series resistance (Rse) and shunt resistance (Rsh)and their effect separately. But in this paper we are analyses the separate and combined analysis of this electrical and mechanical parameter. When the increase in irradiance to very higher value it will leads to increase in temperature to higher value corresponded to it. And when temperature is not controlled properly it will affect the open circuit voltage lower than to its low irradiance value. And a comparison between these models demonstrated that the solar cell with series resistance model offers a more realistic behavior for the photovoltaic systems while it combines between the simplicity and the precision. The single diode model was analyzed in function of physical phenomena such as the resistance series and the resistance shunt, and the environmental parameters as the irradiation and the temperature.

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