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Designing and Modelling of Real-Time Identification of Optimal Operating Points in Photovoltaic Power Systems

Sukhwinder Singh[1], Er. Ravinder Kumar[2], Er. Krishan Kumar[3]
[1]M.Tech Student, AIET, Faridkot, INDIA
[2]Assistant Professor, EE, AIET Faridkot, INDIA
[3]Lecturer, EE, JCD Polytechnic, Sirsa, INDIA

ABSTRACT

In this paper we show that, PV cell is a non-linear device made of semiconductor materials. It is rated by its DC output power (watt) and described by coupled non-linear equations. The output from a single PV cell is as low as 12-17 volts, hence to increase that we connect them in different configurations like series, parallel or combination of series and parallel. Its output is affected by various factors like solar radiation(S), cell temperature (T), wind speed (W_s), energy gap (E_g), number of cells in parallel (N_p) and series (N_s). After observing the I-V and P-V characteristics we can conclude that by increasing the cell temperature(T) at constant irradiance voltage, current and power output decreases whereas they increases after increasing the solar radiation(S) at constant temperature(T).

***Keywords*--** PV cell, Energy, DC

I. INTRODUCTION

In this concern, Photovoltaic (PV) cell produce clean, renewable and reliable energy with long life of service. A Photovoltaic cell converts sunlight to electrical energy. Due to change in global warming, high rate of crude oil and production is too costly for thermal power energy because of coal is at end position. Photovoltaic (PV) systems researches mainly divided into two areas i.e., array physics, design and optimization. In the design, manufacturing and evaluation of PV systems, choosing a suitable model is an important issue for PV cells and modules in predicting their behavior. Most of the researchers single diode adopted model which describes basic characteristics of I-V and P-V of solar models. Whereas few researcher adopted the two diode model and one of them emphasized triple diode model to simulate the space charge recombination effect by exponential voltage dependence separate current component. Irrespective of any type of modeling. It is observed that the output energy depends on solar radiation, the temperature of the cell and the voltage produced in the photovoltaic module. The voltage and current available at the terminals of a PV device may directly feed small loads.

In addition there are many other internal factors of device itself, such as type of material, path of the semi conductor current, reverse saturation current of semiconductor, ideality factor etc., which may affect its performance. In this paper an attempt is made to discuss such effects that may interrupt the PV cell performance.

1.1 PHOTOVOLTAIC SYSTEM

The PV systems are designed to supply power to electrical loads. The load may be AC or DC type and depending upon the application, the load may require power during the daytime or during the night-time or even for 24 hr. a day. Since a PV panel generates power only during sunshine hours, some energy storage arrangements is required to power the load during non sunshine hours. This energy storage is usually accomplished through batteries. During the non-sunshine hours, the load may also be power by auxiliary power sources such as diesel generator, wind generator or by connecting the PV system to the grid or some combination of these auxiliary sources. PV system can be broadly divided into the following these categories as shown in Figure 1.1 [3].

1. Stand-alone PV system
2. Grid-connected PV system
3. Hybrid PV system

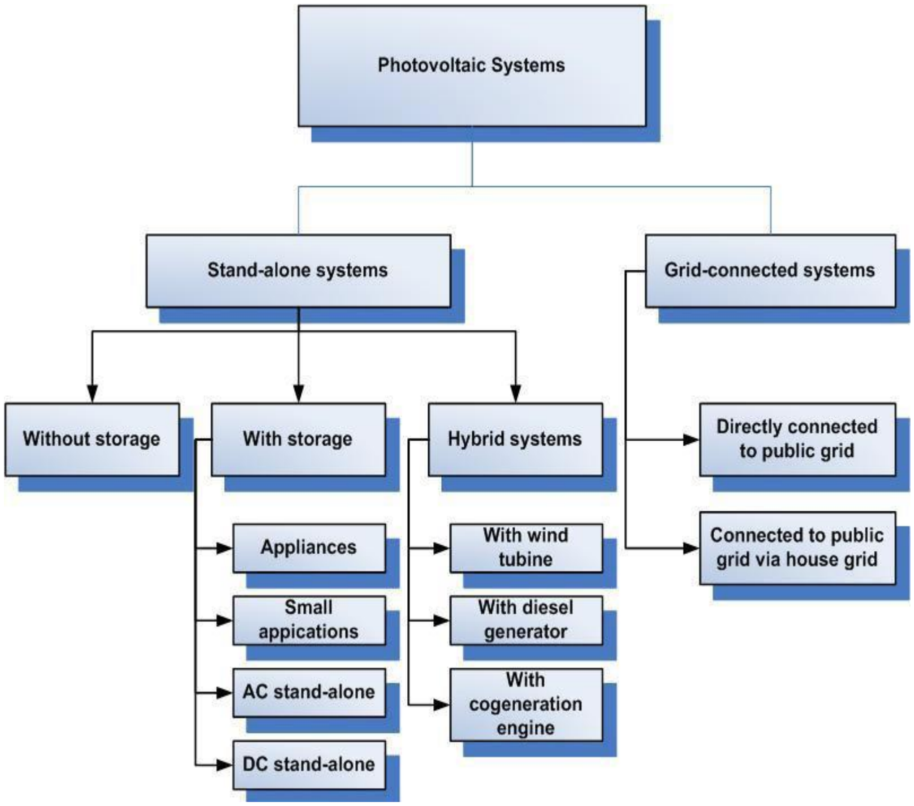

Fig 1.1 Classification of PV system

1.2 STAND ALONE PV SYSTEM

A stand-alone system is the one which is not connected to the power grid, shown in fig.1.2.in stand alone system the solar energy output is matched with the load demand. In the stand alone photovoltaic system the energy storage is main feature. It is also called off grid PV system. It require large amount of battery for fulfillment of electricity for day and night.

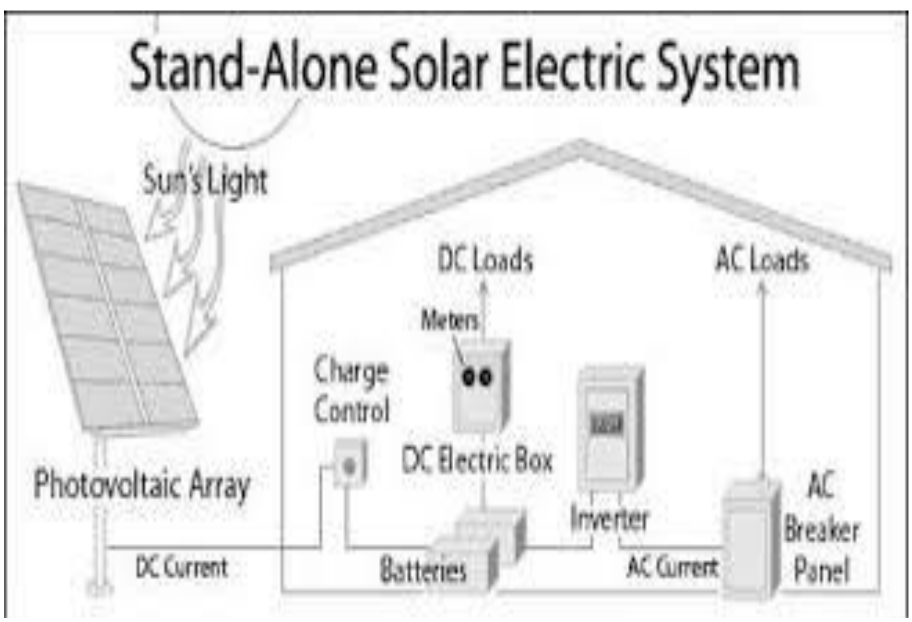

Fig 1.2 –Stand alone PV System

1.3 NEED OF MULTI PULSE INVERTER FOR PV CELL SYSTEM

Day by day the demand of electricity is increasing and that demand cannot be meet up by the conventional power plants. So if we go for the renewable energy it will be better for our next generation. Multi pulse (12 pulse inverter) inverter system is more reliable than other PV system. Maximum power output reduces its capital cost so we go for the different techniques or topology ted with multi pulse inverter If generated solar energy is integrated to the pulse inverter, dc voltage comes with maximum output which mean we can achieve the maximum production of power by which we can further produce the max electricity .Which is needful to satisfy demand of electricity.

II. LITERATURE REVIEW

Jain et al. (2006) in this paper it proposed Lambert-W function based SDM which enables the solutions to be exact, explicit, and straight forward and is not necessary to ignore resistance effects. However, that model does not intrinsically reduce the complexity because the root of the Lambert W-function can only be calculated by using iterative approximations.

K. Nishioka et al. (2007) in this paper discussed about the electrical characteristics of the multi crystalline solar cells are analyzed by a three-diode model (TDM), which further takes into account the influence of grain boundaries and leakage current through the peripheries. Although the DDM and TDM have certain advantages, the extra diodes increase the computational complexity. Accordingly, the SDM is considered to feature a good compromise between simplicity and accuracy.

Huan-Liang Tsai et al. (2008) in this paper it shows that the main contribution and implementation of a generalized PV model in the form of masked block, which has a user-friendly icon and dialog in the same way of MATLAB/SIMULINK block libraries or other component-based electronics simulation software packages, such as Caspoc. A unique procedure for the simulation of photovoltaic modules with MATLAB/SIMULINK. One diode equivalent circuit is employed in order to investigat I-V and P-V characteristics of typical 36 W solar modules are given.

Abir Chatterjee et al. (2011) in this paper it presented that a PV model estimation method from the PV module data based on a single diode model of a PV cell. in this paper the different parameters like temperature, irradiance and current-voltage are observed, and also in single diode model of PV cell is to es timate the parameters of arrays with change in temperature and irradiance.

Kon Chuen Kong(2012) in this paper it discussed that cur rent- Voltage characteristic that involves only one variable. A formula that describes the I-V characteristics is found based on the information gathered, and the values of I and P (Power) are determined according to different values of V. Afterwards, the natural cubic spleen interpolation method is used to build a mathematical model that can approximate those values. Finally, the bisection method is used as an optimization method in determining the value of V that can produce the maximum power. As a result, mathematical models that approximate the I-V and P-V characteristics are built. Through those models, the optimum values of V are determined. The major finding is the estimated values of V, I and P that generate the most energy under a fix condition.

Y. Mahmoud et al. (2012) this paper tells us that Ignoring the effect of the resistance is a typical approach to reduce the complexity of PV models and also proposes the simplified single-diode model (SSDM) which removes the Rp from the general SDM. The further simplified single-diode model (FSSDM), also known as the ideal single-diode model (ISDM), neglects the Rs and Rp as well.

Jieming Ma et al. (2013) this paper proposes an approximate single-diode PV model that enables high-speed predictions for the electrical characteristics of commercial PV module. that operate in various atmospheric condition. Continuous least squares approach is applied to fit the PV behaviors in a simple manner. The proposed mathematical modeling approach is easy and straightforward and does not depend on iterative procedures to obtain solutions. The accuracy of the proposed model is evaluated through simulations. The results showed that the obtained current values are in good agreement with the experimental data. Future work integrating the real-time optimization of PV energy will highlight the value of this approximate modeling method.

III. PROBLEM FORMULATION

Since the last decade the energy related problem is so vast and other factor energy related like economical problem, due to continue pollution and reckless cutting of trees effects the environmental condition or results bad weathering conditions. Other sources of electricity like thermal power plant, hydro power plant, nuclear power plant .these sources of energy have some disadvantages like thermal power plant need a coal but there are not enough availability of coal for a long time and a large man power for thermal and same in the hydro a definite season is require for generation of electricity and in nuclear there is a high risk of radiation and lot of precaution need for their generation and much costly.

Conventional energy sources are unable to meet the increasing demand for energy worldwide. So, alternative energy sources like sunlight, wind and biomass come into existence. On the other hand, the photovoltaic is non-polluted, it is renewable energy source and everlasting photovoltaic power grown rapidly in the last decade owing to the deterioration of the environmental quality and the escalation of fossil fuel cost. Although, it has a high cost and low efficiency, its energy contribution is low yet it is very essential to have effective and flexible models of energy and have many advantages and application in today life due this it is more comfort and reliable model of energy than other.

Photovoltaic (PV) systems researches mainly divided into two areas i.e., array physics, design and optimization. In the design, manufacturing and evaluation of PV systems, choosing a suitable model is an important issue for PV cells and modules in predicting their behavior. Most research is done by researcher in single diode based PV cell and some few going to double diode. We are configure the PV cell in multi-diode configuration and write a MATLAB program for simulating a PV module consisting of 40 PV cells connected in series and 2 cells connected in parallel, and observe the system response to various weather conditions (change in ambient temperature and solar irradiance). Also comparisons I-V and P-V characteristics for all three configuration PV cell single diode, double diode and triple diode with various weather conditions.

3.1 OBJECTIVES

The objectives of this assignment are learning to use MATLAB for simulating I-V and P-V characteristics of a PV module, implementing the Newton-Rap son method for solving the nonlinear equation to obtain the I-V characteristic curve, and writing the MATLAB program so that it can later be used for developing a complete system model including a DC-DC converter.

3.2 PROPOSAL OF PROJECT

Other researcher have research on single and double diode and find their result with their suitable method but i used triple diode model with different irradiation, and weather condition, the proposed intelligent methods may be used for hardware applications in order to obtain practical results. However it is computational more but my proposal is to find a better result than the single and double diode.

3.3 METHODOLOGY

- To study the behaviour of solar cell, module and array.
- To plot the study of solar panel in different weather condition like Temp.and irradiance.
- To achieve the stated objectives following methodology will be adopted:
- Study of single diode, double diode and triple diode module and its working principle.
- Mat lab for simulating I-V and P-V Characteristics of a PV module.
- Implementing the Newton Rap son method for solving the non linear equation to obtain the I-V characteristics curve and writing the Mat lab Program.

IV. PRESENT WORKS

Photovoltaic (PV) systems researches mainly divided into two areas i.e., array physics, design and optimization. In the design, manufacturing and evaluation of PV systems, choosing a suitable model is an important issue for PV cells and modules in predicting their behavior. Most research is done by researcher in single diode based PV cell and some few going to double diode. We are configure the PV cell in multi-diode configuration and write a MATLAB program for simulating a PV module consisting of 40 PV cells connected in series and 2 cells connected in parallel, and observe the system response to various weather conditions (change in ambient temperature and solar irradiance). Also comparisons I-V and P-V characteristics for all three configuration PV cell single diode, double diode and triple diode with various weather conditions.

The objectives of this assignment are learning to use MATLAB for simulating I-V and P-V characteristics of a PV module, implementing the Newton-Raphson method for solving the nonlinear equation to obtain the I-V characteristic curve, and writing the MATLAB program

4.1 PV CELL DESCRIPTION AND ITS OPERATING PRINCIPLE

A PV cell is a semiconductor p-n device that produces current when irradiated. This is due to electron-hole pair forming in the semiconductor material that absorbs photons with energy exceeding the band-gap energy of the semiconductor material. The PV cell consists of front and back contacts attached to the semiconductor material, the contacts can collect the charge carriers (negatively charged electrons and positively charged holes) from the semiconductor p and n layers and supply the load with the generated current (DC).

4.2 EQUIVALENT CIRCUIT MODEL

A PV cell can be represented by a current source connected in parallel with a single diode, since it generates current when it is illuminated and acts as a diode when it is not. The equivalent circuit model also includes a shunt and series internal resistance that can be represented by resistors Rs and Rsh (Figure 4.1). Rsh and Rs can be replaced with an equivalent junction resistor Rj for a simplified model (Figure 4.2)

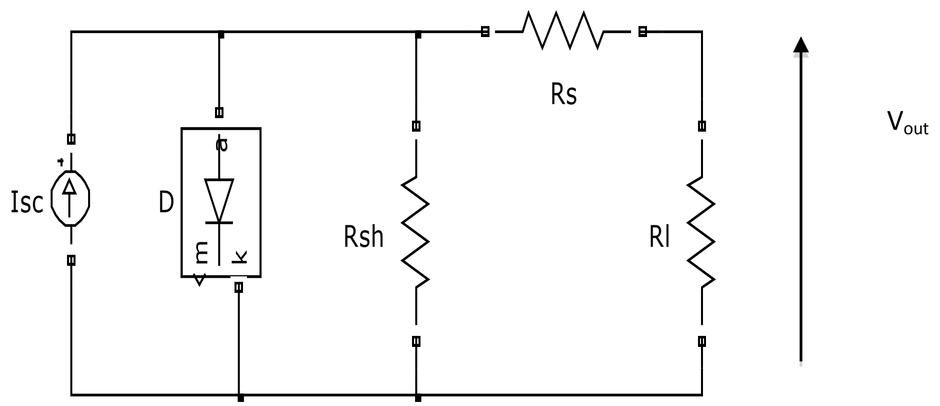

Figure 4.1: Equivalent Circuit

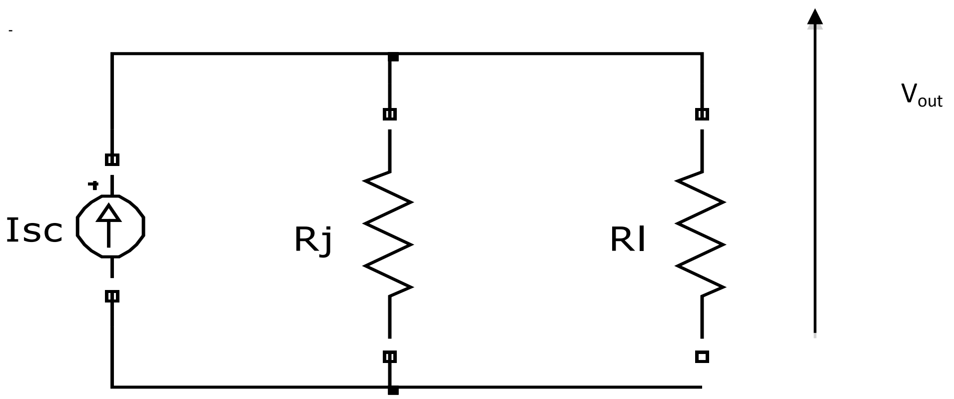

Figure 4.2: Simplified equivalent circuit

Connecting PV cells in parallel, as shown in Figure 4.3, increases the total current generated by the module ($I_{out}=I_1+I_2+I_3+\ldots$). The total current is equal to the sum of current produced by each cell. To increase the total voltage of the module, cells have to be connected in series as in Figure 4.4 ($V_{out}=V_1+V_2.+V_3+\ldots$)

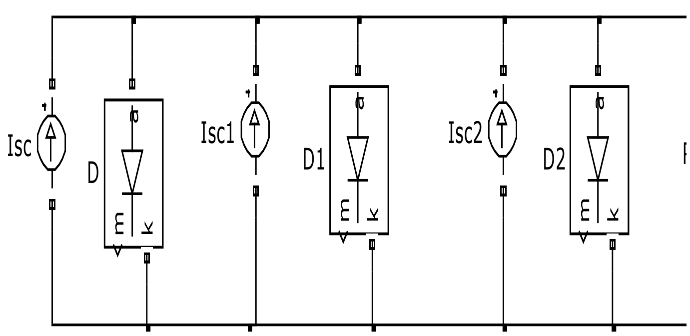

Figure 4.3 PV cell in parallel

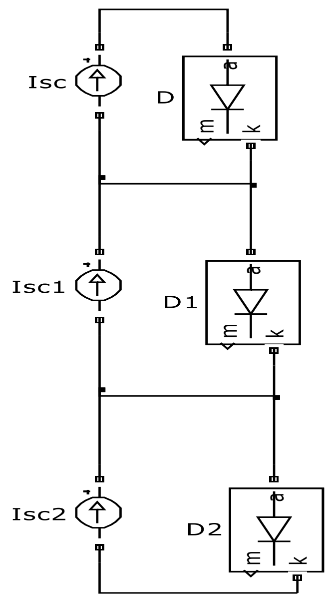

Figure 4.4 PV cell in series

V. RESULT AND DISCUSSION

Figure 5.1 (a) shows how the I-V characteristic of single diode PV cell changes depending on irradiation G (in kW/m^2) when Ta=25°C. I_{SC}=3.8A, given that n_p=2, I_{max} of the PV module is 7.6A, V_{max}=9.25V. Since I_{SC} is directly proportional to G, the characteristic curves in Figure 5.1 show the predicted response to the change of irradiation. There is a change in V_{OC} as G reduces from 1 to 0.2, but this is not as considerable as the change in I_{OC} from 7.6 to 1.5A.

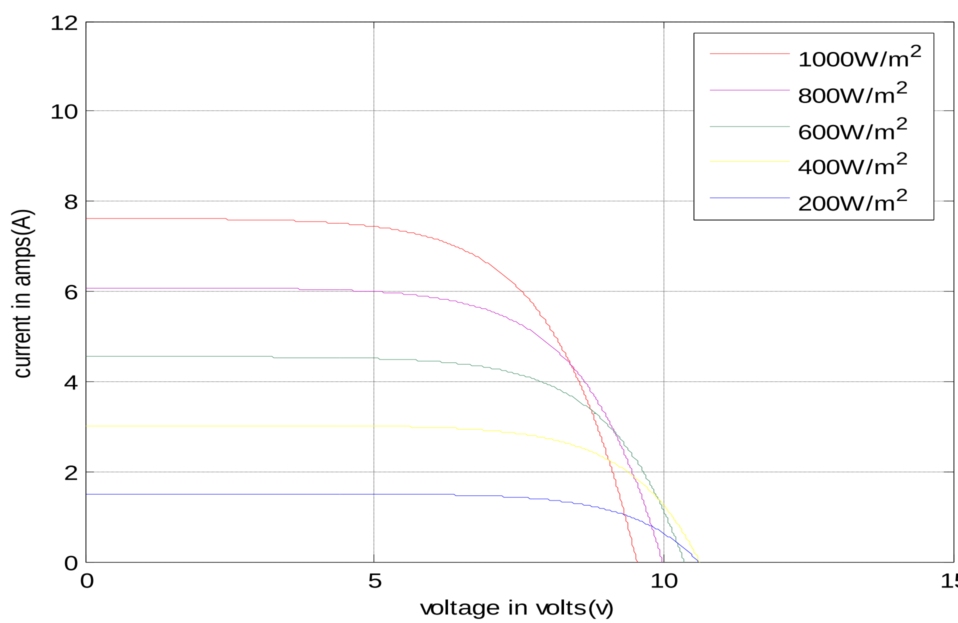

Fig.5.1(a) I-V characteristic of single diode PV cell with different irradiation G (W/m^2)

In Figure 5.1(b) shows how the I-V curve changes when ambient temperature Ta increases and when G is constant (W/m^2). Ta has an effect on V_{OC} ; V_{OC} of each cell reduces by approximately 0.23mV for every 1°C increase of Ta. I_{SC} increases slightly as Ta increases, but not enough to compensate the power loss due to decreasing $V_{OC.}$

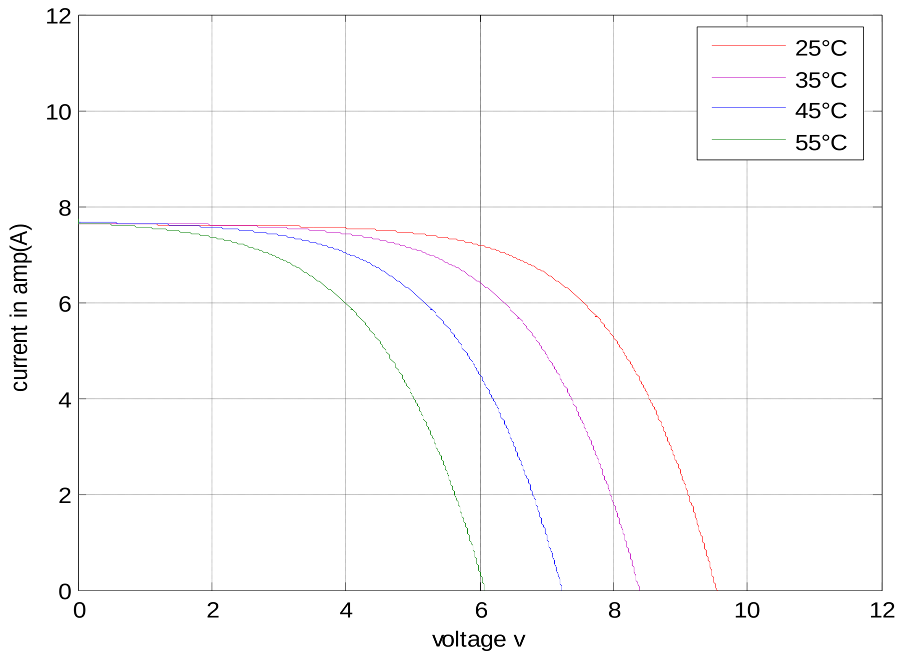

Fig. 5.1 (b) I-V characteristic of single diode PV cell with different temperature Ta (°C)

The graphs in Figures 5.1 (c) and (d) show the P-V characteristic curves for the single diode PV cell, and their dependence on irradiation G (in W/m^2) and Ta (°C). Both set of curves show the expected results, which correspond to the I-V characteristics. With reduction of G, power decreases due to decrease in current (47W to 11W) and increase of Ta reduces power due to decrease in voltage (47W to 24W).

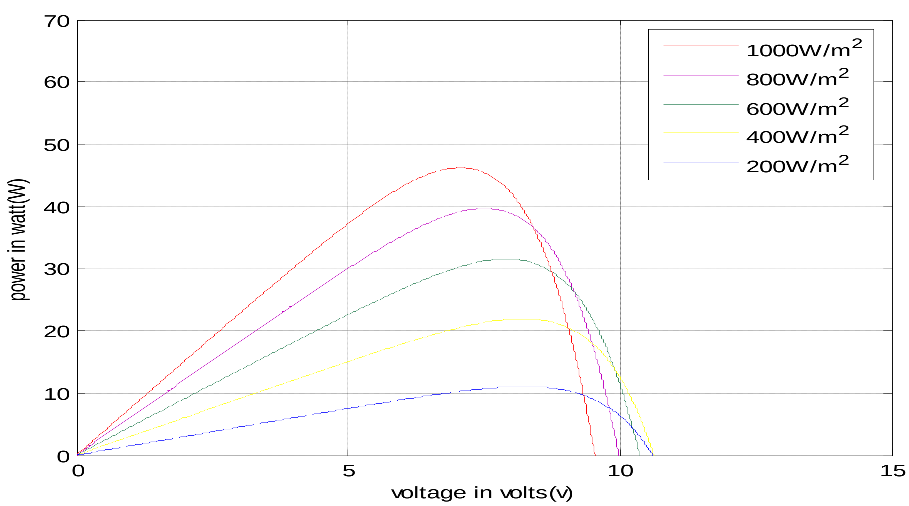

Figure 5.1 (c) P-V characteristic curves for the single diode PV cell with different irradiation G (W/m^2)

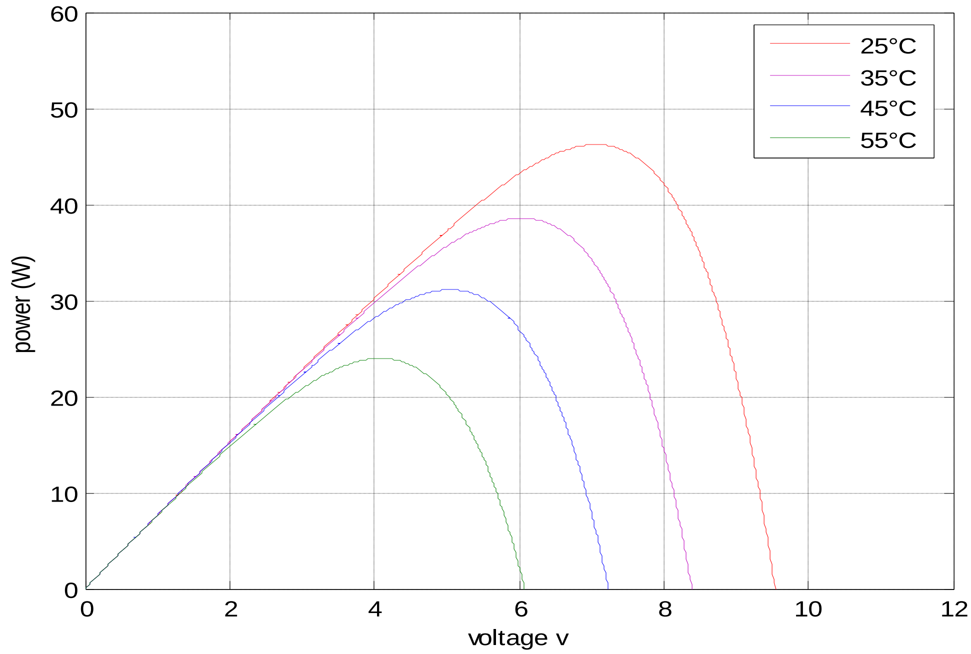

Fig 5.1 (d) P-V characteristic curves for the single diode PV cell with different temperatures Ta (°C)

Table 5.1 Power of single diode PV cell in different irradiation G(W/m^2) and temperature Ta(°C)

	G(W/m^2)				
	1000	800	600	400	200
P_{MPP}, W	47	40	32	22	11
	Ta(°C)				
	25	35	45	55	
P_{MPP}, W	47	39	31	24	

VI. FUTURE SCOPE AND CONCLUSION

FUTURE SCOPE

In this dissertation, to analysis of PV cell module using mathematical model based upon single, double and triple diodes configuration and obtained the I-V and P-V characteristics is estimated for all the three cases using MATLAB programming. The effect of irradiation, temperature and ideality factor in each case has been analyzed and comparison of all cases topologies (single diode, double diode and triple diode) in I V and PV characteristic with different different irradiatio n G (W/m^2) and temperature Ta (°C). As a future work, the proposed intelligent methods may be used for hardware applications in order to obtain practical results. In order to develop an optimal green generation option, another topic that should be taken into account is the combination and coordination with other controllers involved in PV systems, like the DC-dc converter and dc-ac inverter control in grid – connected mode applications.

CONCLUSION

In this dissertation, to analysis of PV cell module using mathematical model based upon single, double and triple diodes configuration and obtained the I-V and P-V characteristics is estimated for all the three cases using MATLAB programming. The effect of irradiation, temperature and ideality factor in each case has been analyzed and comparison of all cases topologies (single diode, double diode and triple diode) in I-V and P-V characteristic with different different irradiation G (W/m^2) and temperature Ta (°C). It is analyzed that, the number of diode increase than increase power level of the model for different irradiation G (W/m^2) and temperature Ta (°C). The Newton- Raphson method are used for solving non-linear equations such as *f(I)*, is the fact that it uses approximation, therefore the accuracy of the method is determined by the pre-set relative error tolerance. The smaller the error tolerance, the more accurate the result, but this also increases the processing time during a simulation. In systems where quick response and small processing time is of importance, there will be a trade-off between time and accuracy.

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