UGC JOURNAL NUMBER 44557

International Journal of Allied Practice, Research and Review

Website: www.ijaprr.com (ISSN 2350-1294)

Performance Analysis of Solar Photovoltaic System for Electric Vehicles

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Abstract - ***To take care of the energy demand of the utility, solar based photovoltaic has just developed as persuading sustainable power source innovation. Solar based Photovoltaic (PV) modules are a standout amongst the best, practical, and eco-accommodating frameworks in late world. Automobiles which are energized by the conventional fuels emits harmful gases to the environment at the same time these energy resources are depleting at alarming level which is speculated to end soon. As alternative energy source, solar is considered the best option for the future Electric Vehicles (EV) while maintaining clean environment. This work outlines the variety of productivity and factors of photovoltaic array module under genuine working condition for integration with battery and Ultracapacitor to form hybrid energy storage system. MATLAB SIMULINK is utilized to examine PV attributes to assess the MPP (Maximum Power Point) for solar based photovoltaic cells array thinking about the impact of different irradiation and different temperature levels.***

Keywords - ***Renewable Energy, Electric Vehicle, Solar irradiation, Solar cell, PV array, Ultra-capacitor***

1. Introduction

Presently energy requirement of a day is overall an issue of concern. So as to beat the difficulty of energy emergency, the resources of sustainable power source have turned into a noteworthy issue in the current years lately [1]. Sustainable power source is utilized to create electric power by solar based energy utilizing the idea of Photovoltaic (PV). This has come into see for its awesome points of interest and lesser upkeep [2]. Although, amongst solar powered innovation, the photovoltaic cells array (PV) have been making an optimistic consideration because of its ability of energy transformation without intermediate heating process [3-5]. On the off chance that the solar based energy is utilized as a part of right track, it can address the issue of having adequate energy of the world [6-8]. Photovoltaic (PV) solar oriented cell frameworks dependably demonstrate non-linear voltage-current relationship which changes with various sorts of natural and electrical parameters [1]. Most generally utilized materials for Photovoltaic (PV) change are mono-crystalline, poly-crystalline silicon, shapeless silicon and thin Film innovations. Silicon crystalline have distinctive kinds of structure's, for example, single crystalline type silicon, silicon type with multi-crystalline and type of ribbon casted

multi-crystalline silicon [7]. Panels of Photovoltaic are the principal conversion unit of power. For known ecological condition, at hand is MPP (Maximum Power Point), a working fact on I-V qualities, in which most extreme power yield is accomplished. In this manner, at the MPP the effectiveness will be streamlined. The capacity to ensure yield attributes of a photovoltaic array module is vital for the outline of maximum power point following and regulation technique. Various techniques were put forward for displaying PV board and removing parameters of panel [8].

Increment in the prerequisite of oil based commodities and developing worry about an Earth-wide temperature boost has cleared a route for investigation of elective energy assets for electric vehicles. EVs are a contrasting option for regular fuel controlled autos, productive, further solid, essentially lesser intricate, financially savvy, and biodegradable. To defeat the constraints of the Electric Vehicles, another idea is put forward as innovation in EV called as Hybrid Electric Vehicle. Diverse efficient clean energy sources, for example, solar based - PV, wind, fuel cell (FC), battery, Ultracapacitor (UC) and so forth, are profoundly used as an essential energy sources in the cutting edge HEV [9-11]. The examination of various electric vehicle advances uncovers the benefits of hybrid vehicles above the ordinary ICE vehicle, battery controlled electric vehicle, and fuel cell (FC) vehicle [10]. The electrical source energy, electronic (PE) controlled converter and motor have in height impact on the execution of electric vehicle.

The paper is sorted out as takes after: Segment 2 gives the itemized portrayal about solar based, battery and Ultracapacitor frameworks associated in hybrid system. Area 3 points of interest the recreation of the working model. In segment 4, results were examined and analysed down. At last the conclusion is briefed in segment 5.

II. System Components a Physics of Solar Pv

Photovoltaic cells change over daylight based radiation particularly into energy of DC electricity. The basic material for the entire photovoltaic (PV) cell available commercially, which is highly pure type silicon, which is gotten from sand materials or quartz materials. Basically, there are three sorts of developments which are utilized as a part of the creation of PV cells; polycrystalline; monocrystalline and silicon of amorphous type [12]. The crystalline Silicon advancement is routinely used as sort of point of view, or benchmark of solar powered oriented power age innovation. When in doubt, the PV cell advancement status depends upon the capability of cell, and cost of assembly. The point of convergence of Innovative work wherever all through the world is on improving its capability and cost, where the perfect game plan relies upon an exchange off between them. The proficiency of a PV cell is controlled by the material's capacity to retain energy of photon for a high range while maintaining the material band gap. The electrons of semiconductor which are weakly bonded forming the valence band are the cells which forms photovoltaic cell [13,14]. Suitable amount of energy striking the valance band frees those fortified electrons to take them to different level of energy known as conduction band. Upon reaching conduction band, electrons can lead power through the system; electrical load system. A PV cell makes use of the energy generated by photons from sunshine to soften their band energy up along these lines making DC electric current. Conventionally, power created by PV cells are low (around 2-3 W) [15]; henceforth, for achieving high power for high power appliance, PV cells are associated together for building a PV module.

A solar based cell is block building piece of sunlight based PV panel. Photovoltaic array module is framed interfacing various solar based cells in parallel & series or its combinations.

Seeing just a solitary solar based cell, it also demonstrated using a current source, two resistors and one diode. Thus the model is recognized as a solitary diode configured solar cell model [16, 21-22].

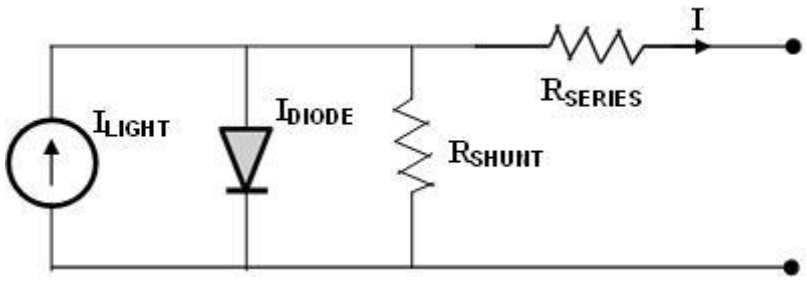


Figure 1: Solar Cell Model

The comparable single diode circuit of the solar powered cell appears in Figure 1. The V-I curve condition of solar based cell [17] is demonstrated as takes after:

$$I = I_{light} - I_{saturation-diode}\left(Exp^{\left[\frac{q(V+I_{R-series})}{AkT_c}\right]} - 1\right) - \frac{(V + I_{R-series})}{R_{shunt}}$$

Where, V is output voltage at terminals, A is ideality factor diode, Boltzmann's constant (= 1.38×10^{-23} / ^{2}), charge of electron (= 1.6×10^{-19}) and T_C, temperature of solar cell.

Photocurrent or light created current; primarily relies upon solar based in solution & cell operational temperature is portrayed below:

$$I_{light} = G\left[I_{SC} + K_{SC}\left(T_c - T_{reference}\right)\right]$$

Where, G: solar isolation (KW/m^2), I_{SC}: short circuited current maintained at 25 ℃ & 1KW/m^2, K_{SC}: temperature coefficient at I_{SC}.

The diode saturated current change with temperature of the cell which is portrayed with E_{gap} is semiconductor energy band gap as:

$$I_{cell} = I_{reverse-saturation-diode}\left(\frac{T_c}{T_{reference}}\right)^3 Exp\left[\frac{qE_{gap}\left(\frac{1}{T_{referecnce}} - \frac{1}{T_c}\right)}{kA}\right]$$

B. Battery and Ultracapcitor System

Different studies have revealed that the Lithium Ion battery is best suited for EVs at present with the advancement of battery technology. Battery can be used for supplying energy to the EVs which can store energy which can be charged using solar PV during day time. The battery model is given in figure 2. Battery system is demonstrated using an equivalent circuit connecting a voltage source in series with constant internal [18]. DC-DC converter (bidirectional buck-boost) is intermediate connection between battery bank and DC-link. Figure 3 demonstrates a modelled equivalent diagram circuit of Ultracapacitor (UC). UC basically comprises with series equivalent resistor (ESR) that takes care of discharging and charging, capacitance (C) and capacitor in parallel (EPR) that demonstrates discharge [19]. Ultracapacitor capacitance and resistance is represented as [20],

$$\text{Resistance}_{UC} = \text{Number}_{\text{series cell}} \times \frac{\text{ESR}}{\text{Number}_{\text{parallel cell}}}$$

$$\text{Capacitance}_{UC} = \text{Number}_{\text{parallel cell}} \times \frac{\text{ESR}}{\text{Number}_{\text{series cell}}}$$

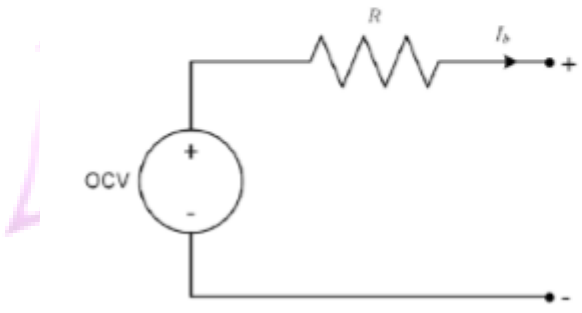


Figure 2: Battery Model

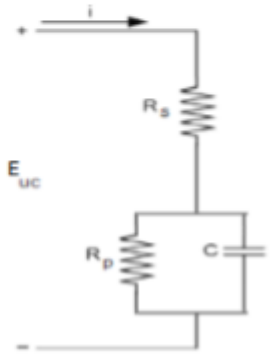


Figure 3: Ultra capacitor Model

III. Simulation of Solar PV using MATLAB/SIMULINK

Computer Simulation using MATLAB/SIMULINK is performed for the solar module developed considering diode PV cell model. Particular estimations of the information and climatic parameters are considered keeping in mind the temperature condition of Rajasthan where the heat goes easily up to 50 °C in summer season. Simulation test on solar PV module at two conditions:

a. Keeping temperature constant while varying intensity of solar radiation

b. Keeping solar radiation constant while varying module temperature

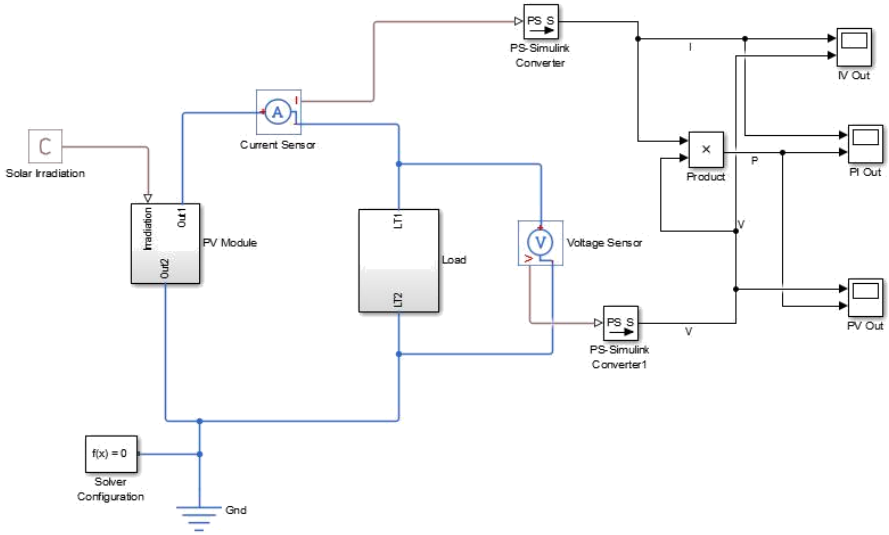


Figure 4: Simulink Model of Solar PV

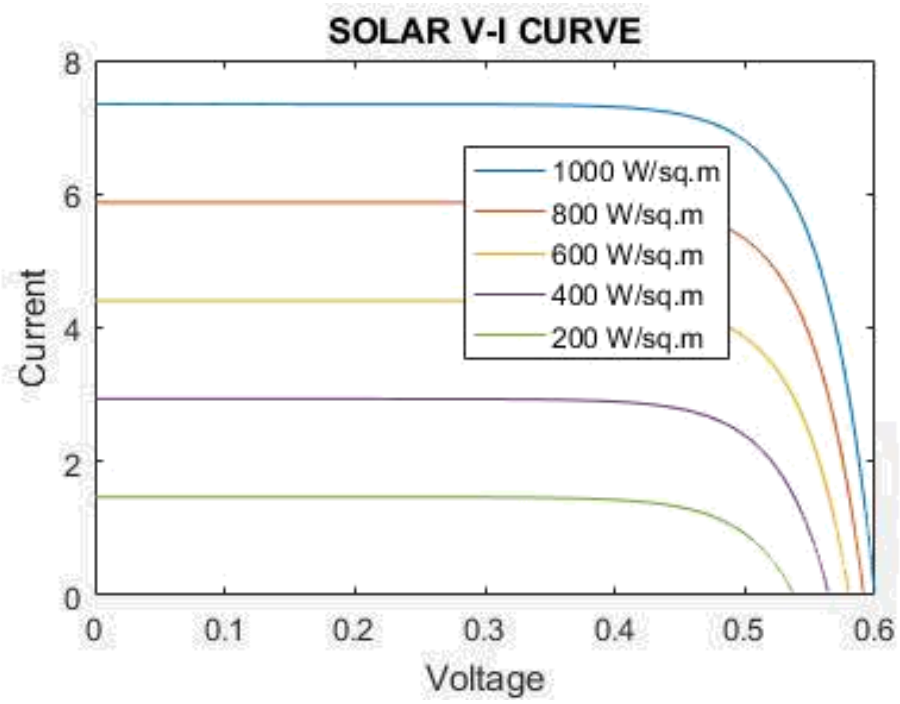
The proposed computer simulation for analysis of solar PV module is shown in figure 4. The output characteristics of various relations of power, voltage and current are plotted and analyzed for varying irradiations and temperatures.

IV. Result and Discussion

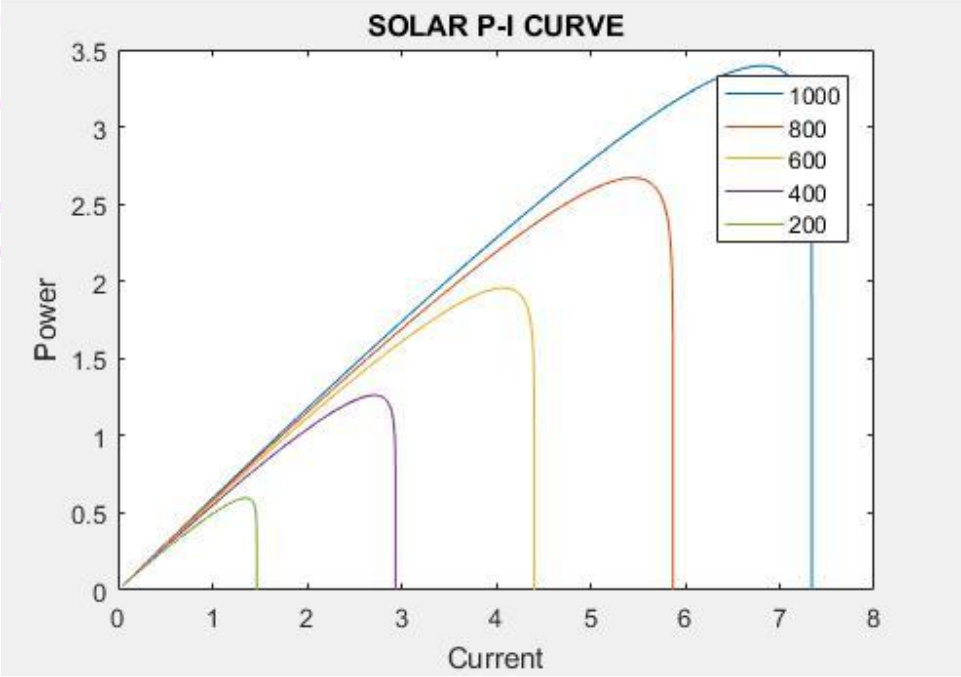
The simulation analysis performed on solar PV module keeping in mind about the light electric vehicles which reveals the details of the modules which would be connected the system that will help in giving continuous energy to the electric vehicular system energised by battery along with Ultracapacitor forming hybrid energy storage system where battery and UC is further charged using solar PV modules. This analysis is done as proposed. Figure 5 show the V-I relation curve, P-I relation curve and P-V relation curve whose temperature is kept constant at 25 °C while varying the radiation on the solar panel.

It is evident from the figure 5 that with increasing irradiance, the generation of current and power is increases so thus the maximum power.

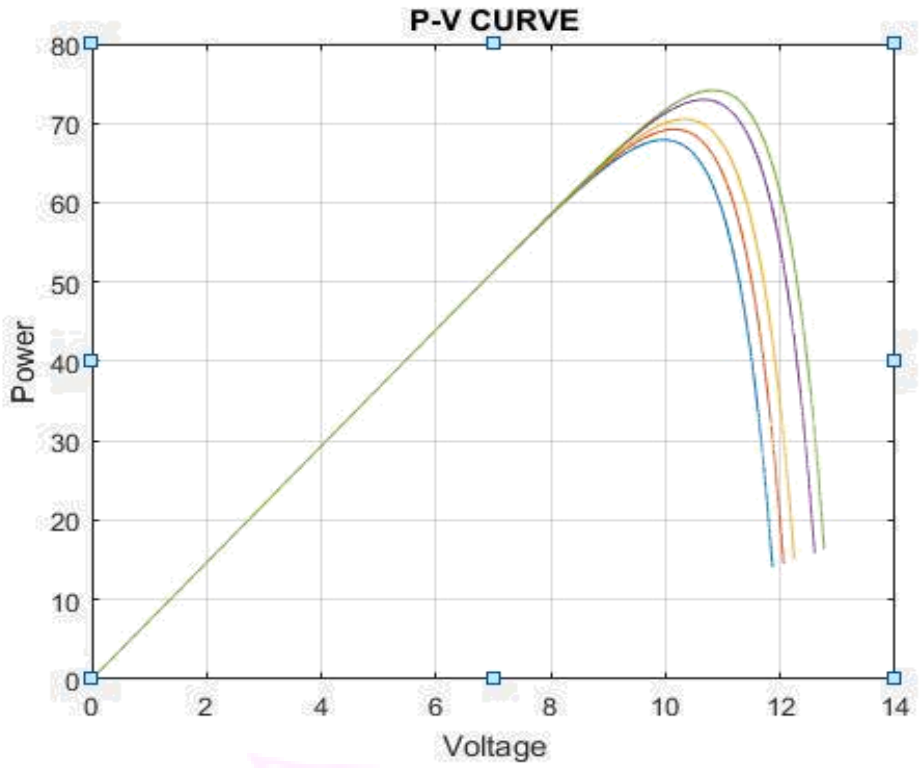
Figure 6 show the V-I relation curve, P-I relation curve and P-V relation curve whose irradiance is kept constant while varying the temperature of the solar panel. This is performed with maintaining a voltage of 12 V for simple analysis which can be used for charging of batteries with terminal voltage as generated by solar PV panel. The characteristics indicate that although power increases but maintaining a constant terminal voltage is a challenging situation while constant current maintenance is not a problem.



(i) I-V relation Curve with Varying Irradiation

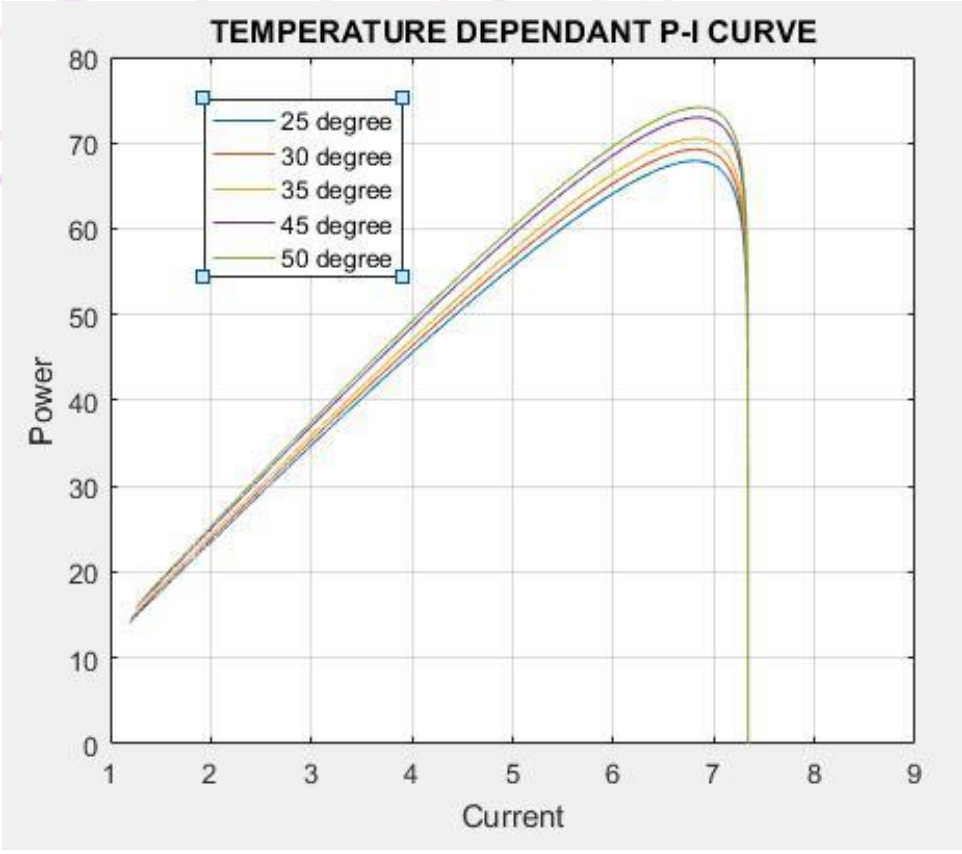


(ii) P-I relation Curve with Varying Irradiation

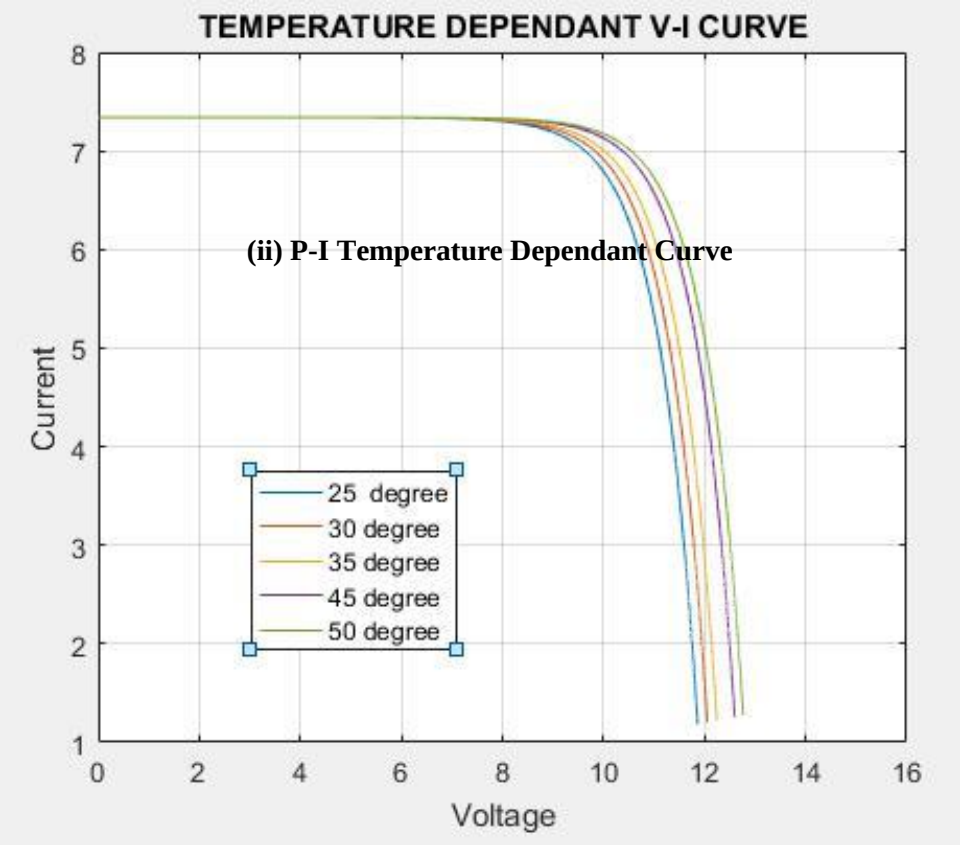


(iii) P-V relation Curve with Varying Irradiation

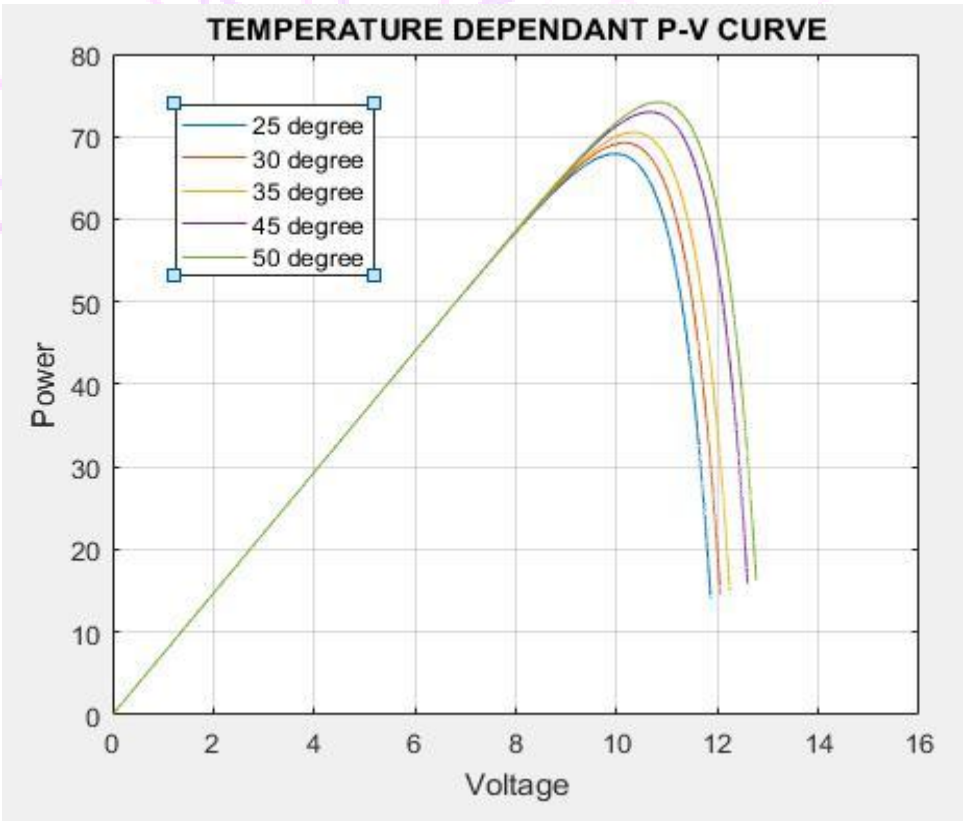
Figure 5: Solar PV with Varying Irradiation



(i) I-V Temperature Dependant Curve



(ii) P-I Temperature Dependant Curve



(iii) P-V Temperature Dependant Curve

Figure 6: Solar PV with Varying Temperature

VI. Conclusion

The solar PV model was analyzed for integration with battery and Ultracapacitor for uses of HESS to provide energy source for electric vehicles. A careful investigation detail that the increment of irradiance increases the generation of current and power thus higher maximum power but increasing the temperature of the sola PV module causes a challenge in maintain a constant terminal voltage across the PV panel while maintaining constant current. This challenge in stable voltage maintenance can further be research where a temperature efficient solar PV module can be developed by considering different types of material used in developing solar cells.

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