# BATTERY CHARGING CIRCUIT USING BOOST CONVERTER WITH MPPT


## ABSTRACT:

The usage of Carbon Fossil Fuels increased to the greater extent i.e., the world has to look for another alternative due to the residue of the fossil fuels. In such aspect the most available renewable energy source would be the solar energy source. The people started adapting to solar but the the major problem with the solar is efficiency. So, this is all about to obtain the maximum efficiency from the solar panel using MAXIMUM POWER POINT TRACKING(MPPT) for charging a battery.


**MPPT,**maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries.

## PV characteristics :

The electrical characteristics of a photovoltaic array are summarized in the relationship between the output current and voltage. The amount and intensity of solar insolation (solar irradiance) controls the amount of output current ( I ), and the operating temperature of the solar cells affects the output voltage ( V ) of the PV array. Solar cell I-V characteristic curves that summarize the relationship between the current and voltage are generally provided by the panels manufacturer and are given as:

## Solar Array Parameters :

- **VOC = open-circuit voltage** – This is the maximum voltage that the array provides when the terminals are not connected to any load (an open circuit condition). This value is much higher than Vmp which relates to the operation of the PV array which is fixed by the load. This value depends upon the number of PV panels connected together in series.
- **ISC** = short-circuit current – The maximum current provided by the PV array when the output connectors are shorted together (a short circuit condition). This value is much higher than Imp which relates to the normal operating circuit current.
- **MPP** = maximum power point – This relates to the point where the power supplied by the array that is connected to the load (batteries, inverters) is at its maximum value, where MPP = Imp x Vmp. The maximum power point of a photovoltaic array is measured in Watts (W) or peak Watts (Wp).
- **FF** = fill factor – The fill factor is the relationship between the maximum power that the array can actually provide under normal operating conditions and the product of the open-circuit voltage multiplied by the short-circuit current, ( VOC x ISC ) This fill factor value gives an idea of the quality of the array and the closer the fill factor is to 1 (unity), the more power the array can provide. Typical values are between 0.7 and 0.8.
- **%eff** = percent efficiency – The efficiency of a photovoltaic array is the ratio between the maximum electrical power that the array can produce compared to the amount of solar irradiance hitting the array. The efficiency of a typical solar array is normally low at around 10-12%, depending on the type of cells (mono crystalline, poly crystalline, amorphous or thin film) being used.

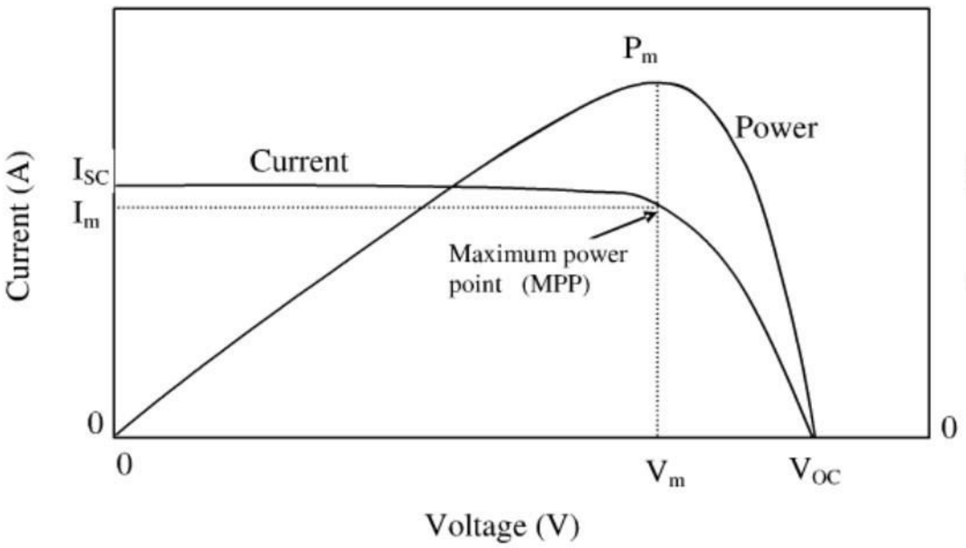


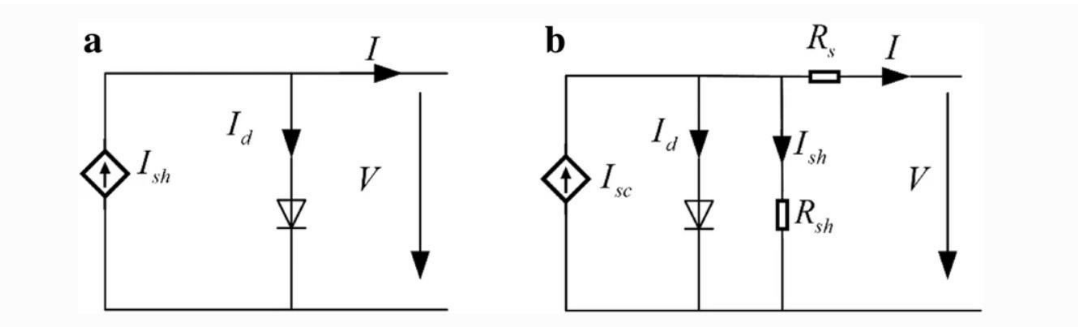

Fig:1 PV characteristics of Solar Cell

**PV cell equivalent circuit:**

An ideal PV cell can be presented by a current source with a diode connected in parallel. In the ideal case, the series and shunt resistances are considered to be zero and infinite, respectively. However, in real system, both the series and shunt resistances have finite values and must be considered. In Fig. 1, both the ideal and practical equivalent circuits of a solar cell are shown. From Fig. 1b the generated current (I) by the PV cell is given by

$$I = I_{sc} - I_d - I_{sh}$$

$$I = I_{sc} - \left(\frac{V + IR_s}{R_{sh}}\right) - I_o\left(e^{\frac{v+IR_s}{nV_T}} - 1\right)$$




PV cell Equivalent circuit

Where VT is the thermal voltage, Rs and Rsh represent the internal series and parallel resistances, respectively. Isc is the short-circuit current, Io is the reverse saturation current, VD is the voltage across the diode, I is the current output and n is the ideality factor of the diode (1~ 2).

A simplified model after neglecting the shunt resistance is shown in Fig. 1a, and accordingly the following equation can be derived.

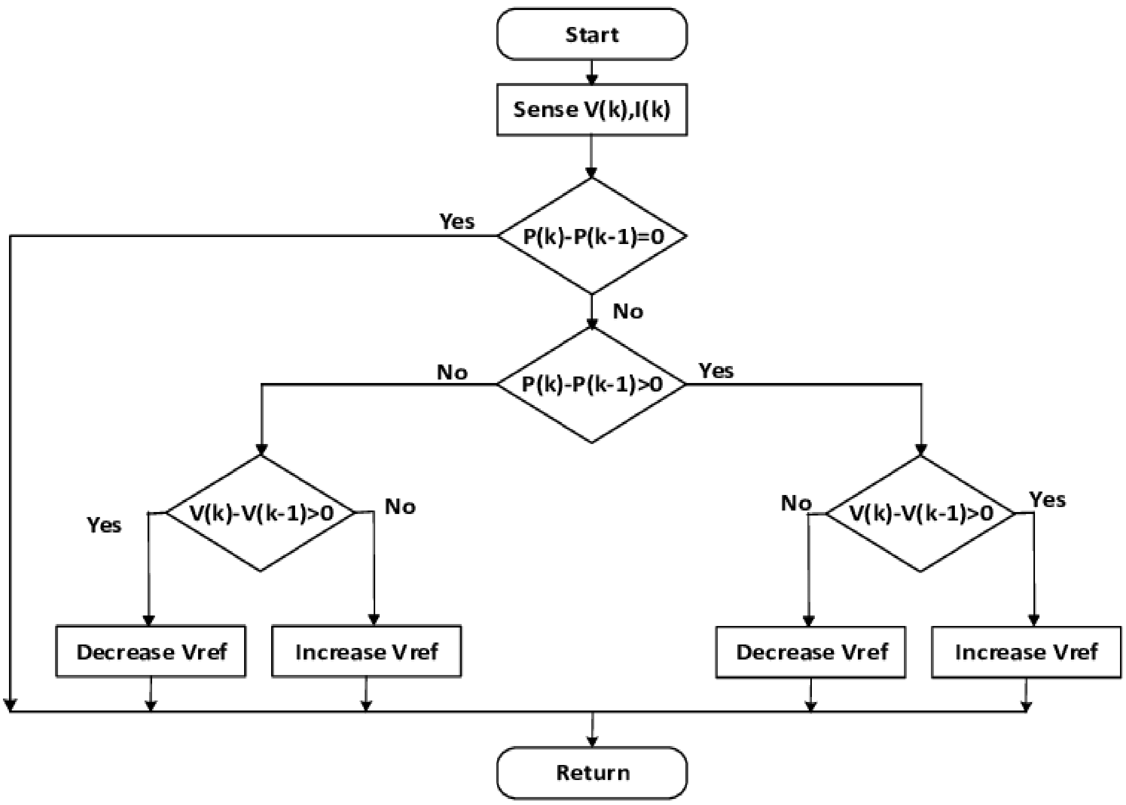
$$I = I_{sc} - I_o\left(e^{\frac{v+IR_s}{nV_T}} - 1\right) \quad (3)$$

PV cell output voltage can be found by considering T = KT/q in (3) as

$$V = -IR_s + \frac{AKT}{q}\ln\frac{(I_{sc} + I_o - I)}{I_o}$$

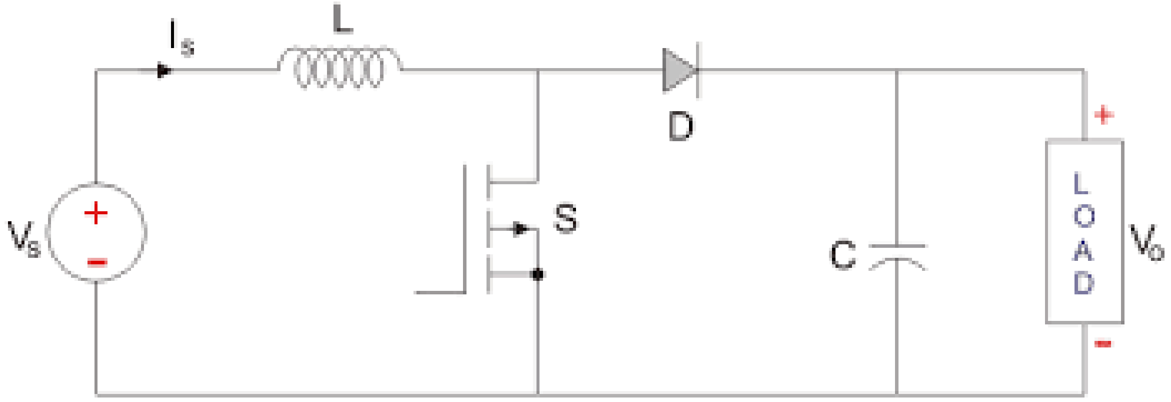
## **Perturb and Observe Method**:

P&O method is used for tracking the MPP. In this technique, a minor perturbation is introduced to, cause the power variation of the PV module. The PV output power is periodically measured and compared with the previous power. If the output power increases, the same process is continued otherwise perturbation is reversed. In this algorithm perturbation is provided to the PV module or the array voltage. The PV module voltage is increased or decreased to check whether the power is increased or decreased. When an increase in voltage leads to an increase in power, this means the operating point of the PV module is on the left of the MPP . Hence further perturbation is required towards the right to reach MPP. Conversely, if an increase in voltage leads to a decrease in power, this means the operating point of the PV module is on the right of the MPP and hence further perturbation towards the left is required to reach MPP.

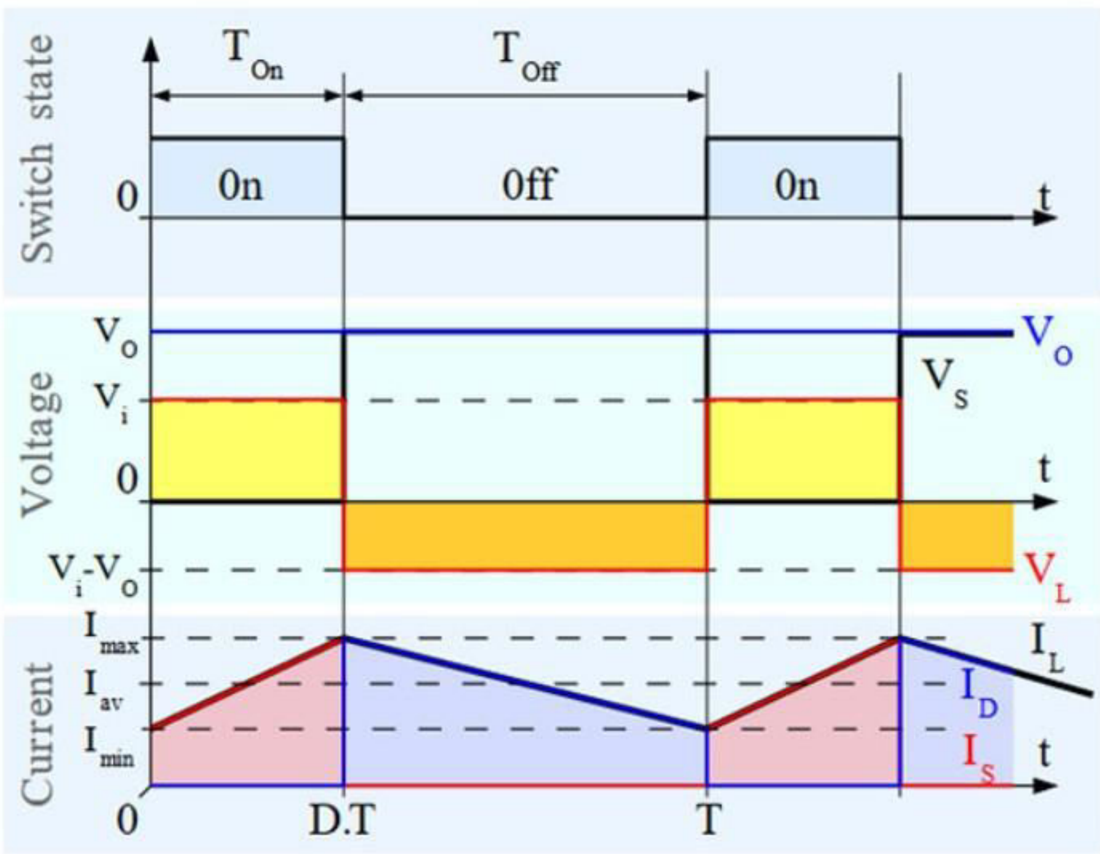


**BOOST CONVERTER:**

A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter).




$$\frac{V_o}{V_i} = \frac{1}{1-D}$$



**Design Parameters:**

Ratings:

Input Voltage = 30 V

Output Voltage = 40 V

Rated Power = 200 W

Current Ripple ($\Delta I_L$) = 20%

Voltage Ripple ($\Delta V_0$) = 10%

Frequency = 5KHZ

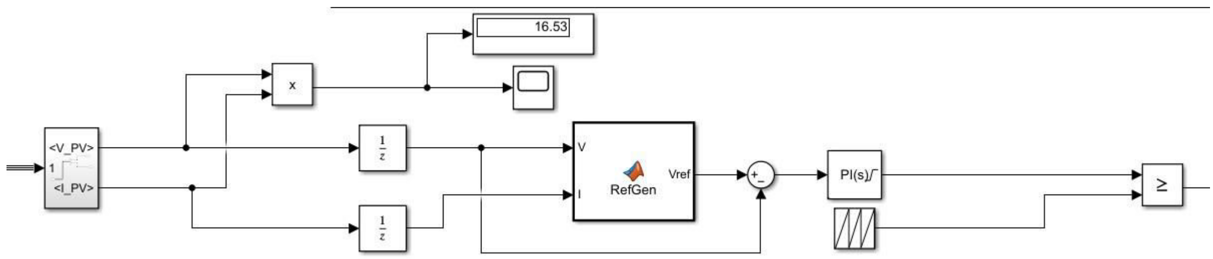
The obtained parameters using the boost converter analysis are

Duty Cycle(D) = 0.25

Inductance(L) = 1.5mH

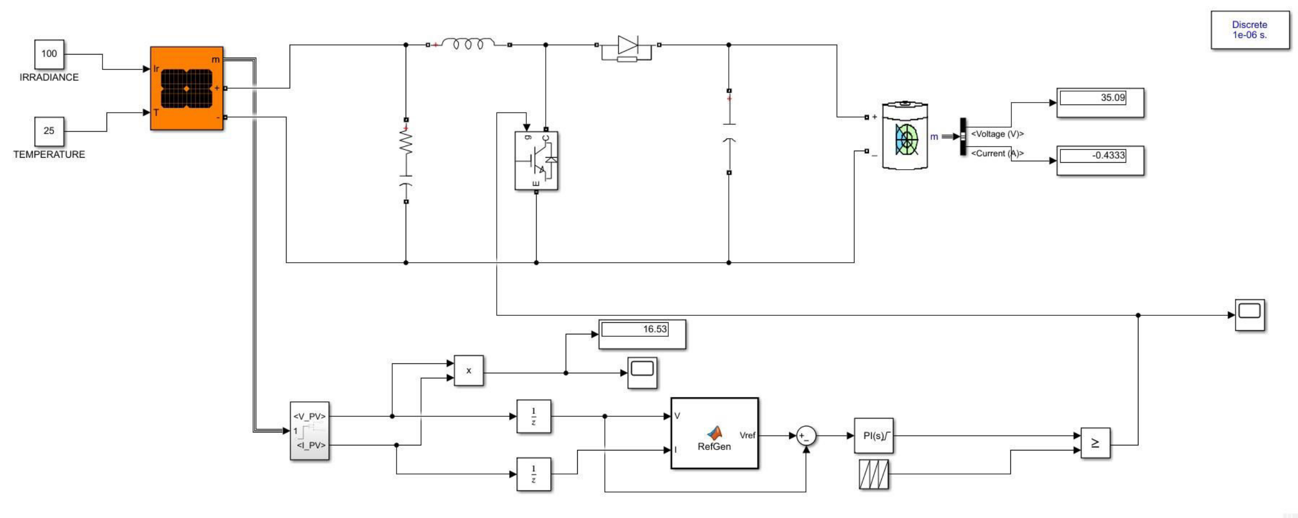
Capacitance(C) = 0.0625mF

**Controller Design** :




G

**Circuit Diagram**:

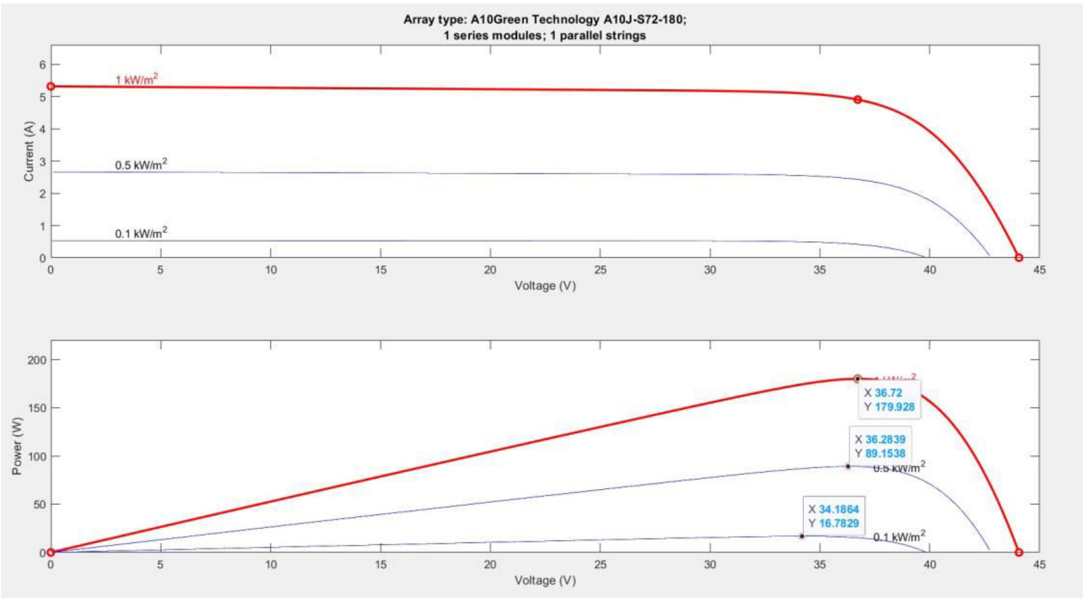



**Battery Charging circuit of Boost Converter using MPPT**

**Procedure:**

I. Make the circuit according to the circuit diagram
II. Select the required PV array module and note down the plot of PV characteristics for maximum power point
III. Design the boost converter circuit and give proper readings according to the calculations
IV. Design the controller circuit according to given circuit diagram of controller
V. Select the proper Battery for charging
VI. Run the simulation for different irradiance and note down the readings obtained
VII. Different plots has to be noted down and observations has to be tabulated

**PV plot for maximum power points**:

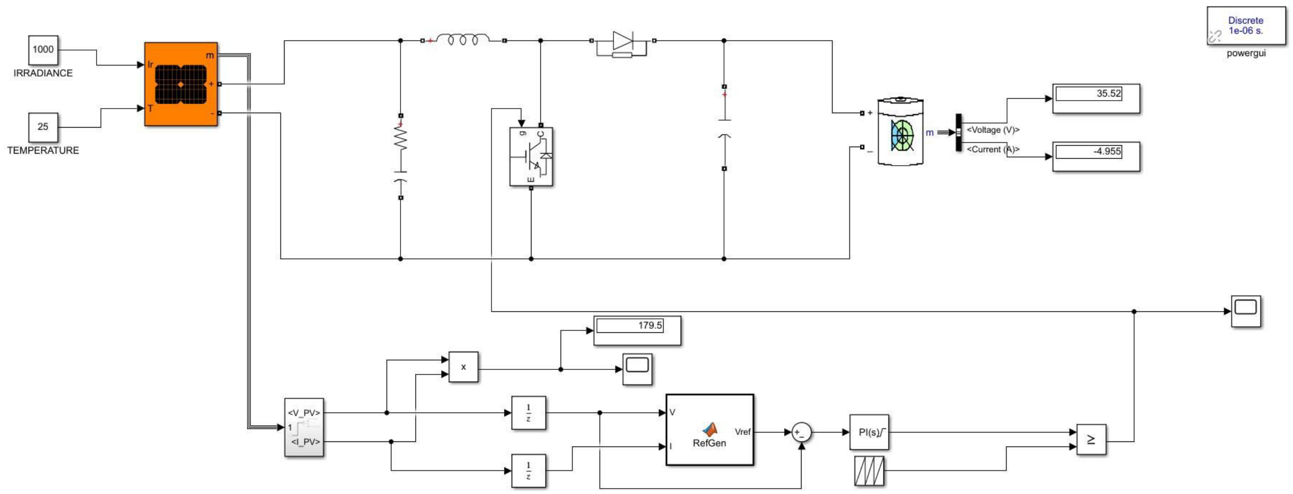


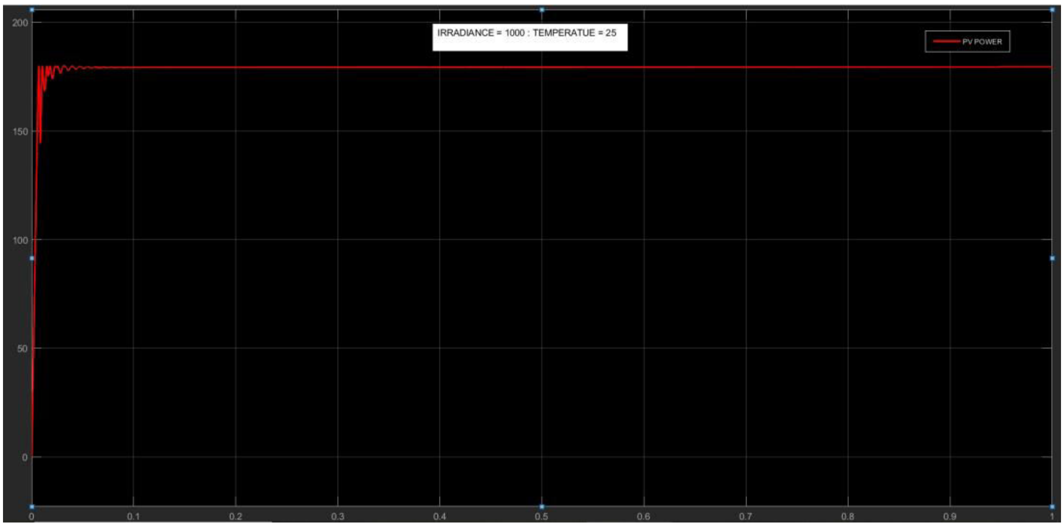

**Observations**:

| Sl.No | IRRADIANCE | MAXIMUM POWER POINT TRACKING | | BATTERY VOLTAGE(V) |
|---|---|---|---|---|
| | | GRAPH | SIMULATION | |
| 1. | 1000 | 179.92 | 179.5 | 35.52 |
| 2. | 500 | 89.158 | 89.04 | 35.28 |
| 3. | 100 | 16.78 | 16.53 | 35.09 |

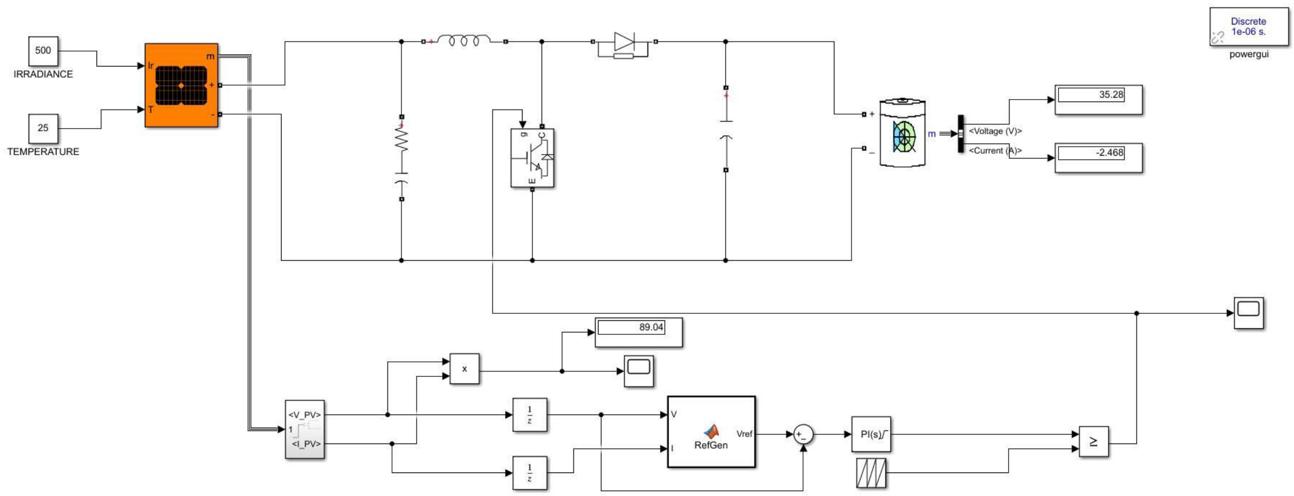
## Figures:

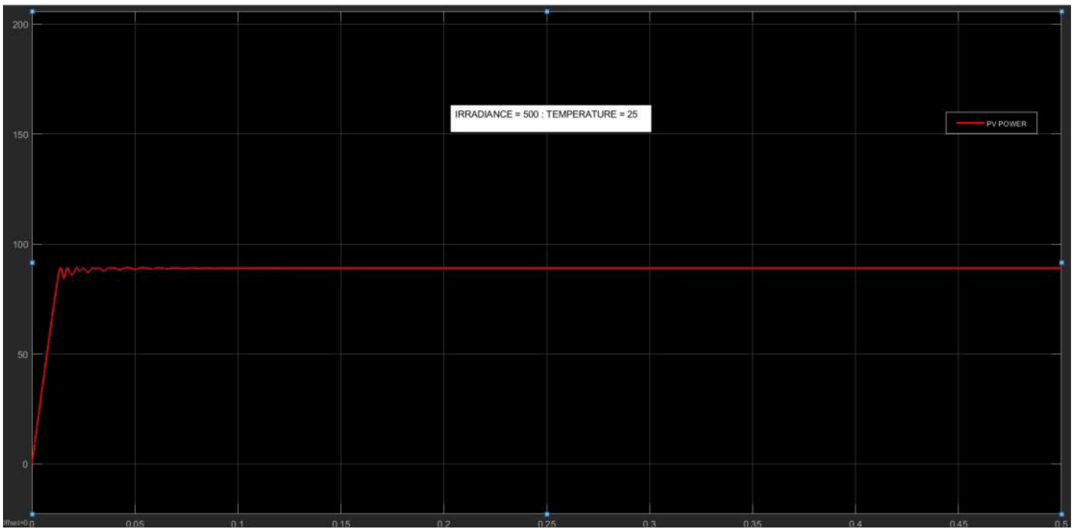
**1.** IRRADIANCE = 1000 , TEMPERATURE = $25^{0}C$



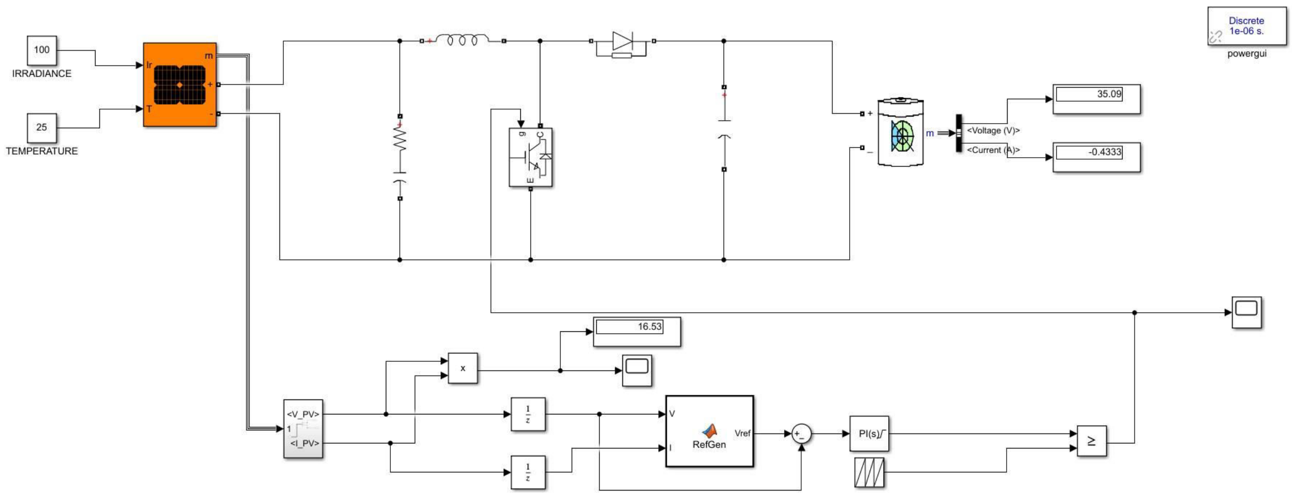



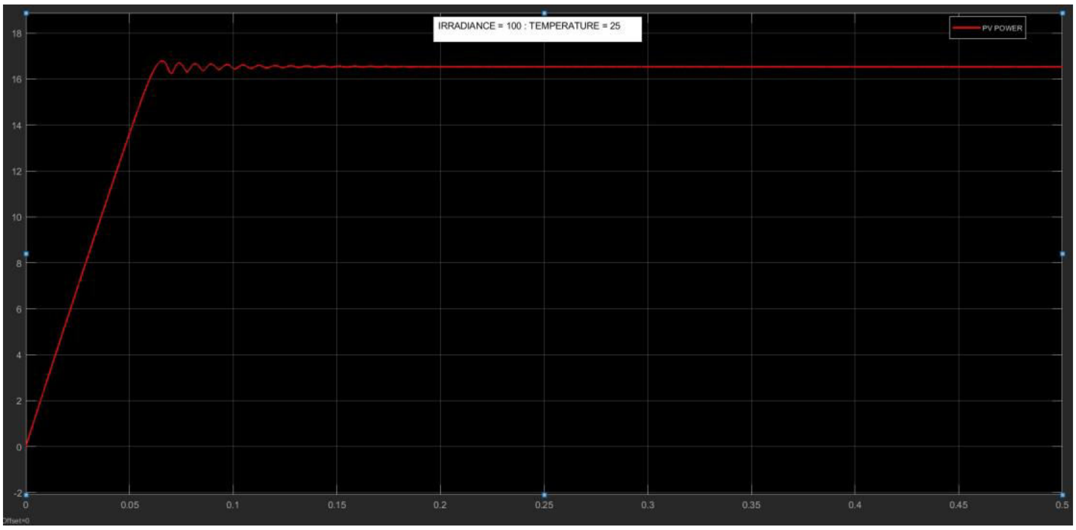

2. IRRADIANCE = 500 , TEMPERATURE = $25^{0}C$



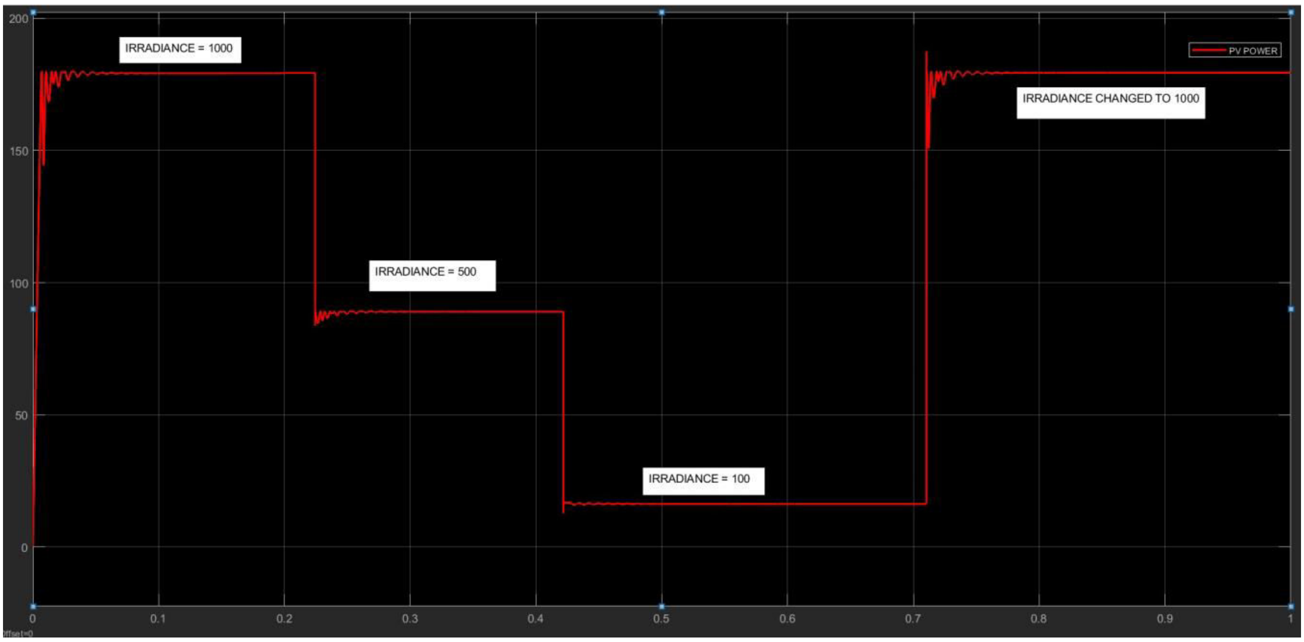



3. IRRADIANCE = 100 , TEMPERATURE = $25^{0}$C



**Change in IRRADIANCE:**




**CONCLUSION:**

Hence the Battery has been charged to its rated voltage from boost converter using the MPPT of PV module. The MPPT point has been tracked for every variation in IRRADIANCE. Maximum power has been maintained throughout the steady state(I.e., proper utilization of PV stack) has been obtained.