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# Experimental Setup of Maximum Peak Power Tracking for SSLS

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## Abstract

Renewable energy plays an important role in the generation of electricity. The Maximization of power from a solar photovoltaic module (SPV) is of special interest as the efficiency of the SPV module is very low. The conversion efficiency drops by about 0.38 % / ◦C increase in panel temperature. Energy produced by PV module is dependent on the environmental condition such as temperature and solar insolation. The given solar insolation and temperature there is only one maximum peak point (MPP) at which PV module delivers the maximum power. Hence, in order to extract maximum power and to increase the utilization efficiency of the module, it is necessary to operate it at MPP. To achieve this, maximum peak power tracking systems have developed such as perturb and observe (P&O) and InCd. The present work describes the maximum peak power tracker (MPPT) for the SPV module connected to a resistive load like a solar street light. The maximum peak power tracker is successfully developed and tested in the laboratory. The simulation part is developed and studied in MATLAB/ SIMULINK. The measured parameters are voltage, current & power. The system has been tested on solar PV module.

**Keywords:** Solar Photovoltaic (SPV), PWM, Boost converter, IGBT, MPP, P&O, InCd

## INTRODUCTION

The growing demand for electricity and the recent environmental threats such as global warming has led to need for new source of energy that is cheaper and clean with no emission. The increasing prices of oil and decreasing level of oil have made solar energy most suitable as an energy source. The solar energy is directly converted into electrical energy by a solar photovoltaic module.

The photovoltaic modules are made up of Polycrystalline shells are melting various silicon crystals together, making them cheaper than monocrystalline setups.. Once the silicon (both monocrystalline and polycrystalline) has been properly prepared, it is treated, or 'doped', with phosphorous and boron to form a semiconductor i.e. silicon cells.

The silicon solar cells which give the output voltage of around 0.6 to 0.7V under open circuit condition. When many such cells are connected in series we get a solar PV array. Normally in a module there are 36 cells which amount to an open circuit voltage of about 20V to 25V. The ratings will be depending on the area of the individual module cell. The output of the cell produces higher current when the area of the cell will be more. To get higher power output the modules are connected in series and parallel combinations forming solar PV arrays. A typical characteristic curve of the called current (I) and voltage (V) curve and power (W) and voltage (V) curve of the module shown in figure.1

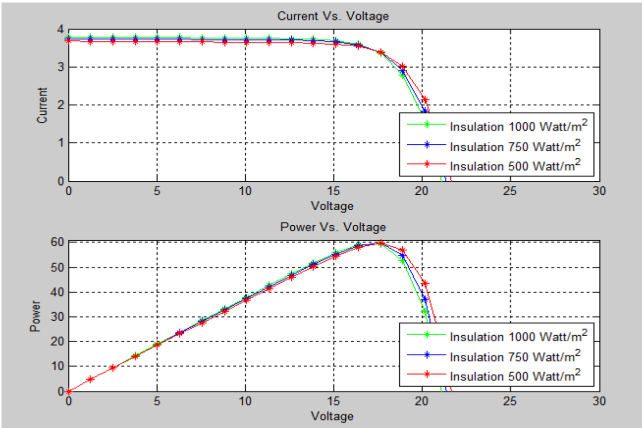


**Figure 1.** Changes in Insolation Level the characteristics of the solar PV module

The tracker (MPPT) is used for extracting the maximum power from the solar PV module and transferring that power to the load. A dc/dc converter (Boost Converter) serves the purpose of transferring maximum power from the solar PV module to the load. The power output of a Solar PV module changes with the change in direction of sun, changes in solar insolation level and with varying temperature as shown in the figure. 1 & 2.

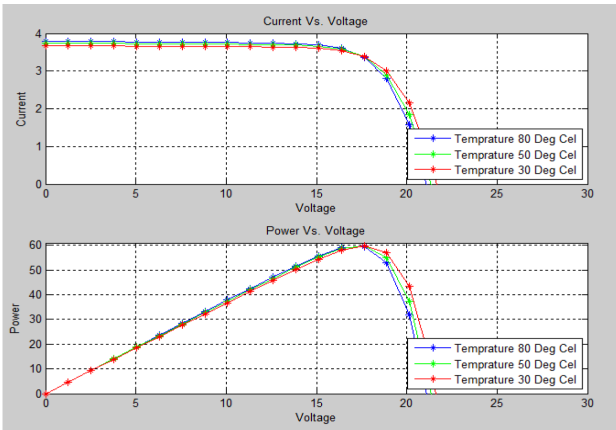


**Figure.2** Changes in module characteristic due to change in temperature

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## PROPOSED SYSTEM

The new system designed and developed a prototype for a two axis solar tracker that will maintain the solar panel orthogonal to the sun, no matter what the sun's position is in the sky. The model consists of two parts;
The upper part operates in horizontal axis while the lower part operates in the vertical axis. Since both parts operate independently, therefore included two DC motors for controlling axis. The first motor is used to control the horizontal axis & second motors are used to control Vertical axis. For controlling the motion and direction of the motor, the design includes sensors and microcontroller and hence the direction of the panel towards the sun. The difference in voltage output from the sensors are fed into the microcontroller, which then drives the DC motor in the direction required & when it reached to the final position limit switches are used to control the panel.

The single axis solar trackers have only one axis of rotation either horizontal or a vertical. In the tropical region the horizontal type is used where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes, where the sun does not get very high, but summer days can be very long. These have an automatically adjustable tilt angle of 0 - 45 °and automatic tracking of the sun from East to West. The PV module itself is used as a light sensor to avoid unnecessary tracking movement. At night the trackers goes to initial position

Disadvantages of single axis tracking (Dual Axis is Beneficial):

- Tracking is only one direction.
- The output is low as compared to dual axis trackers.
- The lower degree of accuracy in directional pointing.

Dual axis trackers is advantage over the single axis tracker, it tracks the sun in horizontal as well as vertical direction to get the added power output (approx. 40% gain) and convenience.

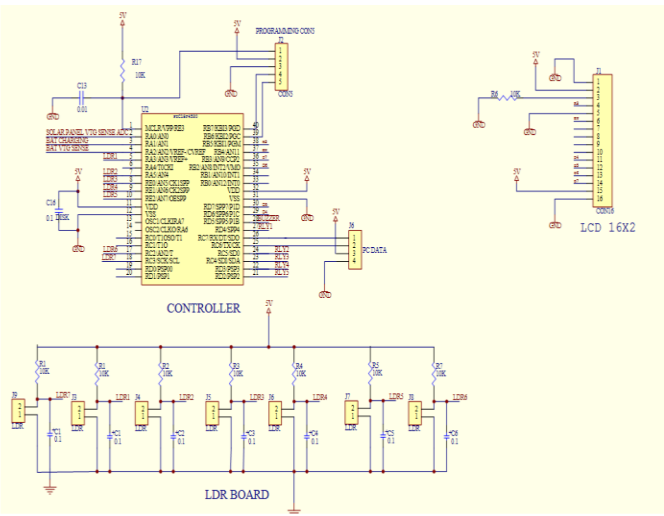


**Figure.3** Circuit diagram of two axial solar tracking

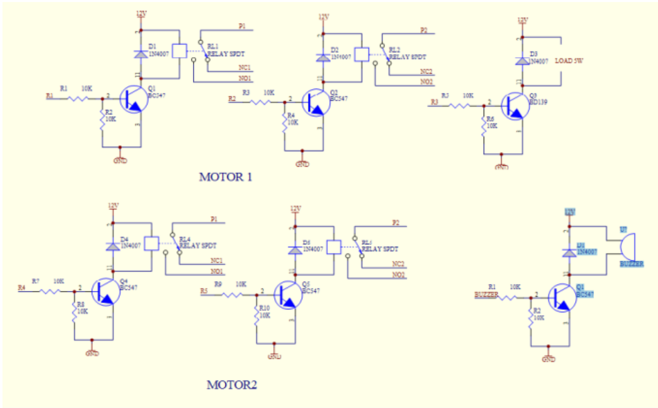


**Figure.4** Driver circuit for two axial solar tracking

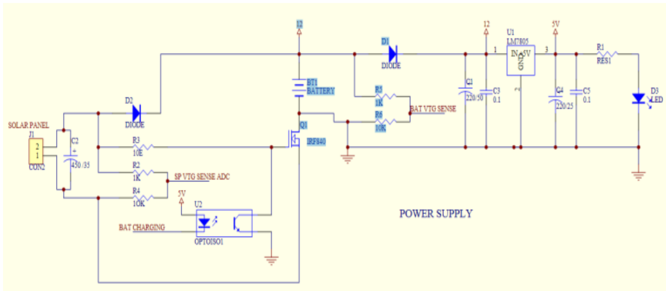


**Figure.5** Converter & Battery charging circuit

It system consist of a PV panel, DC-DC boost converter and the load. The implementation of proposed mathematical standalone PV module implementation takes into account of each component as well as actual component specification. The DC-DC converter module is connected between the PV array and the load.

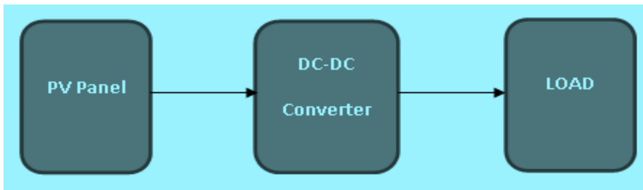


**Figure.6** Proposed system

The PV array which is used & it is made up of monocrystalline. The monocrystalline solar panels are made from a large crystal of silicon. The monocrystalline solar panels are the most efficient to convert sunlight into electricity to generate more power; however, they are the most expensive. They will give the better performance in lower light conditions than the other types of solar panels. It has two layers one is very thick and another is very thin. The array used here contains thick n layer. An array contains 36 cells and each cell can produce a maximum of 0.5 volts thus the maximum of 18 volts can be extracted from a PV panel. The output varies from 12 to 18 volts for different values of load.

The DC-DC boost converters circuit used to convert the unregulated dc input to a controlled dc output at the desired voltage level by varying the frequency. To apply a dc voltage across an inductor or transformer for a period of time (usually in the 20 kHz to 5 MHz range) which causes current to flow through it and store energy magnetically, then switching this voltage off and causing the stored energy is to be dissipated to the output in a controlled manner. By varying the duty cycle the output voltage will be regulated. This is achieved using a *chopper*, circuits whose elements dissipate negligible power. *Pulse-width modulation* (PWM) allows controlling and regulation of the total output voltage. It is considered the heart of the system, thus it will affect the overall performance of the power system. The ideal converter exhibits 100% efficiency; but practically it exhibits, efficiencies 70% to 95% are typically obtained.

## SIMULNK MODELS OF PV ARRAY

A solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. The electromagnetic radiation of solar energy can be directly converted to electricity through the photovoltaic effect. Typically a low voltage generated in PV cells of about 0.5V. So PV cells are connected in series (for high voltage) and in parallel (for high current) combination to form a PV module for desired output. Performance evaluation shows a solar panel can generate output power above 60% of its rated value for only six hours of a day from 9.00 am to 3.00 pm [3].

An ideal cell is modeled by a current source in parallel with a diode. However, no solar cells is ideal and thereby shunt and series resistances are added to the model as shown in the PV cell figure 7 & figure 8. The value of intrinsic series resistance '$R_S$' is very small and equivalent shunt resistance '$R_P$' has a very high value. Energy available from the solar cells is not in a uniform manner, it randomly varies according to environmental conditions like temperature, the intensity of radiation and partial shading effects [5].

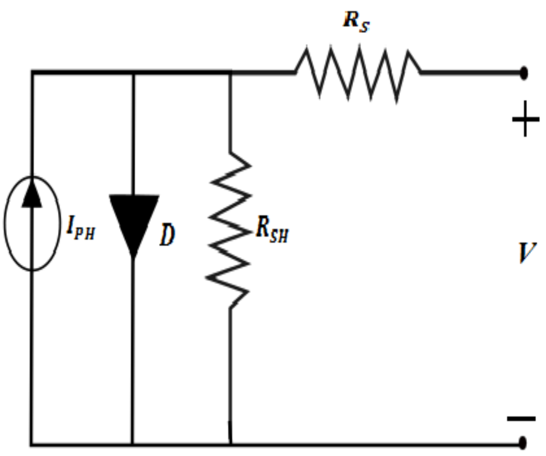


**Figure.7** Equivalent model of solar cell

Applying Kirchoff's law to the node where $I_{ph}$, diode, $R_p$ and $R_s$ meet, we get

$$(I_{PH} - I_d - I)R_{SH} = V + IR_S \tag{1}$$

But

$$I_d = I_0\left(e^{\frac{V+IR_S}{\frac{nkT}{q}}} - 1\right) \tag{2}$$

$$I = I_{PH} - I_0\left(e^{\frac{V+IR_S}{\frac{nkT}{q}}} - 1\right) - \frac{V + IR_S}{R_{SH}} \tag{3}$$

Where,

$I_{PH}$-Light-generated current or photocurrent,

$I_0$-cell saturation of dark current,

Electron charge q = 1.6 ×10-19C

Boltzmann's constant k= 1.38 ×10−23J/K,

T-cell's working temperature,

A -is an ideal factor,

$R_{SH}$- is a shunt resistance, and

$R_S$-is a series resistance.

A PV array is a group of several PV modules which are electrically connected in series and parallel circuits to generate the required current and voltage.

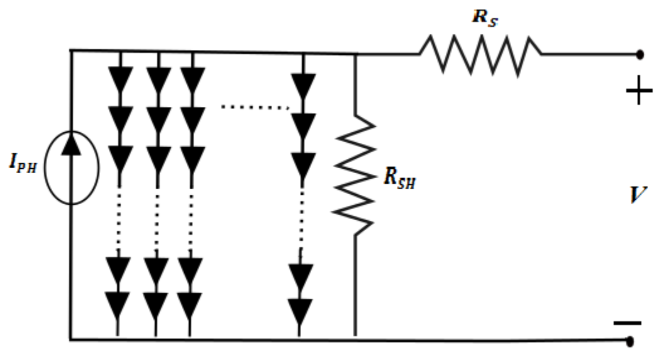


**Figure. 8** Equivalent circuit for the solar module.

$$I = I_{PH} - I_0\left(e^{\frac{V+IR_S}{\frac{nkT}{q}}} - 1\right) - \frac{V + IR_S}{R_{SH}} \tag{4}$$

$$I = N_P I_{PH} - N_P I_S\left[e^{\frac{\frac{q\left(\frac{V}{N_S}+IR_S\right)}{N_P}}{KT_C A}} - 1\right] - \frac{\frac{N_P V}{N_S} + IR_S}{R_{SH}} \tag{5}$$

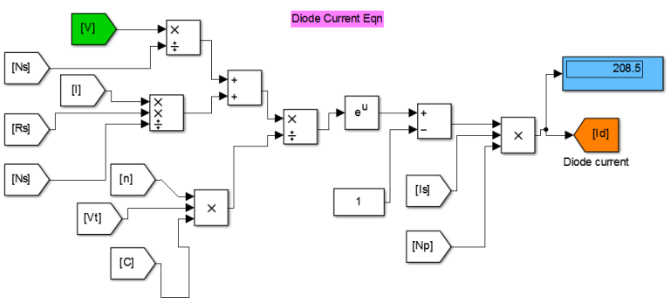


**Figure 9.** Simulink model of Diode current equation

## SIMULATION RESULTS OF PV ARRAY

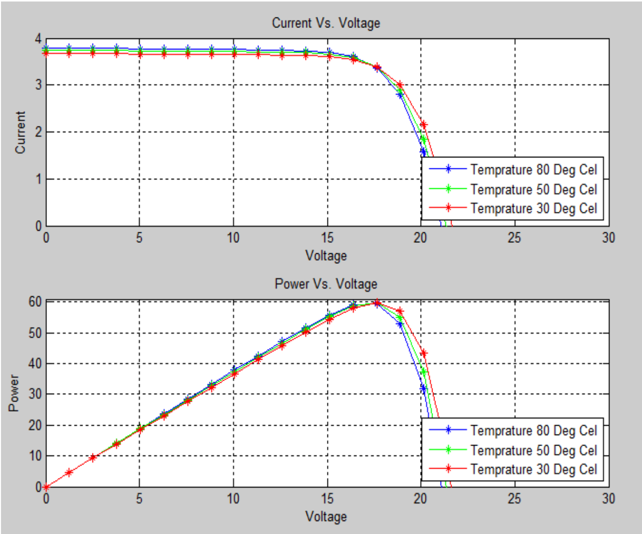


**Figure 10.** PV Array Characteristics due to change in insolation

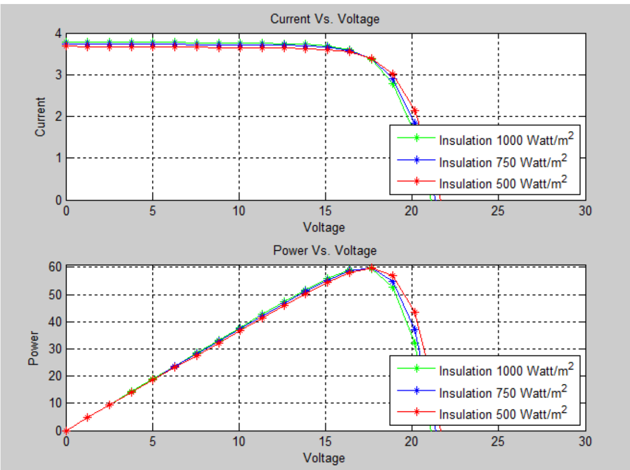


**Figure 11.** PV Array Characteristics due to change in temperature

The characteristics of Solar cells are based on the phenomenon of photovoltaic effect i.e. the ability of semiconductors to convert electromagnetic radiation directly into electrical current [7].

The output characteristics of PV array are nonlinear and greatly affected by solar radiation, temperature and load condition [8]. The power changes non-linearly with respect to the voltage and current. Hence there is only one voltage and current at which Maximum Power Point (MPP) exists for certain climate conditions. [2]

Since the increase in temperature increases reverse saturation, the total output current and hence, the output power decreases. The conversion efficiency drops by about 0.38 % per ◦C increase in panel temperature [3].

The increase of irradiance output current and the power increases. This is due to the fact that the increase in irradiance increases the light-generated photocurrent. However, the increase in irradiance also increases the open-circuit voltage, Voc; but this increase is less than that of Iph due to the logarithmic dependence of $V_{oc}$ on G.

## P&O ALGORITHM

In this paper, I propose a PWM-based controller to track the maximum power point in a non-uniform P-V curve. Within this paper and taking into consideration the effects of changes in insolation and temperature on the PV system, MPPT control methods that build on the P&O algorithms is implemented, evaluated, and compared in a Matlab/Simulink environment [2]. This implementation signifies the use of electronics components and sampling frequencies, so its performance is relatively simple, as is its implementation, which can be done with microcontrollers and digital programming [9]. The simulation is carried out to justify the effectiveness and robustness of the proposed method.

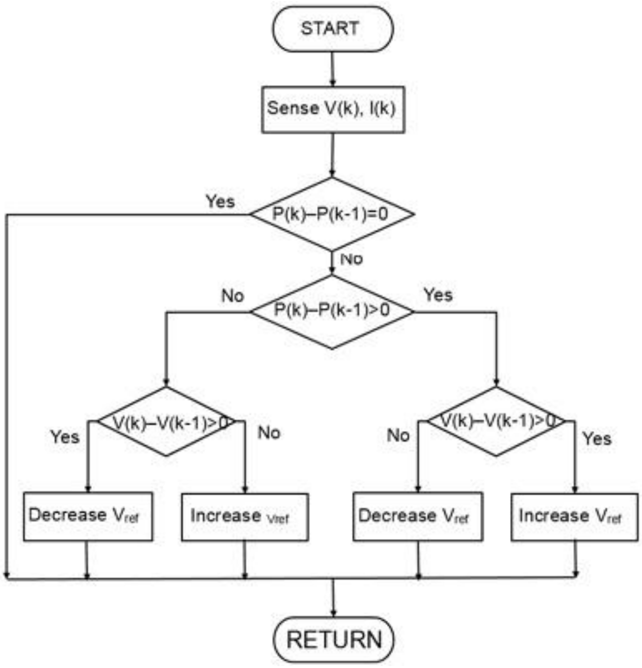


**Figure.12** Flow chart of P&O Algorithm

In this algorithm, the operating voltage of the PV module is perturbed and the resulting change in power is observed. If the change is positive, then it is supposed that it has moved the operating point closer to the MPP. Thus, the operating point of the voltage perturbation is in the same direction toward the MPP. If the change is negative, the operating point has moved away from the MPP, and the direction of perturbation should be reversed to move back toward the MPP [7].

## EXPERIMENATL SETUP OF P&O MPPT ALGORITHM

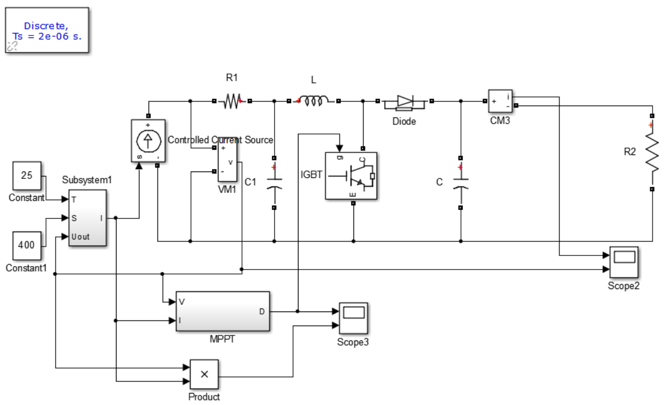


**Figure 13.** Simulation model of P&O MPPT Algorithm

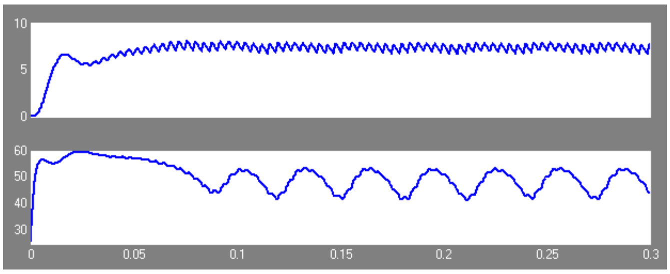


**Figure.14** Simulation result of P&O Algorithm

## POWER VARIATION AT DIFFERENT TEMPRATURE LEVELS

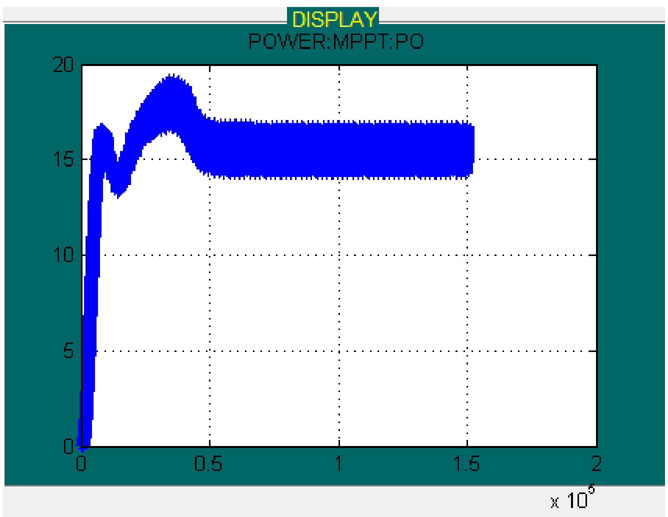


**Figure.15** Power Variation at 300°C temp. with insolation 1000 Watt/m$^2$

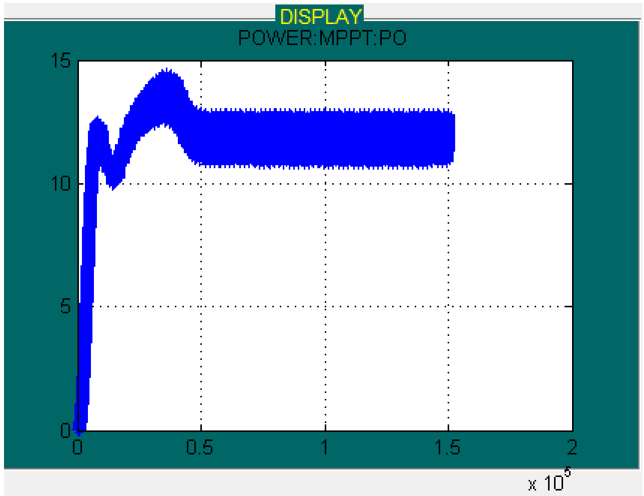


**Figure.16** Power Variation at 325°C temp with insolation 1000Watt/m$^2$

## CONCLUSION

The power output of module improves by about (doubles) with the MPPT system than it was without the MPPT system. It is observed that the module gives the output peak power at noon time. In early morning it gives power of about 34% less and same power is obtained in the evening. The temperature has effect on the peak power and it was observed that as the temperature increases the peak power decreases.

Insolation of the module is an important parameter for PV system. The power output of the module decreases as the insolation level decreases. So a 3W module gives only a power below of about 15W at 1000 Watt/m$^2$ insolation. Due to decreases in insolation level the power output decreases very sharply.

## REFERENCES

[1] Yiqun Wang and Yongpan Liu, “Storage-less and Converter-less Photovoltaic Energy Harvesting with Maximum Power Point Tracking for Internet of Things,” 2015 IEEE.

[2] Manoj Patil, “Design and Simulation of Perturb and Observe Maximum Power Point Tracking Using MATLAB/Simulink,” 2015 International Conference on Industrial Instrumentation and Control, May 28-30, 2015 IEEE.

[3] Wim J.C. Melis, “Increasing Solar Panel Efficiency in a Sustainable Manner,”IEEE ENERGYCON 2014, May 2014 , Dubrovnik, Croatia.

[4] Pavel Domorad, “Partial shading problem solution for solar arrays fed by MPPT via permanent monitoring of individual panels,” 2014 IEEE 28-th Convention of Electrical and Electronics Engineers.

[5] Al Jumlat Ahmed, “Performance Evaluation of Solar Panel and Proposed New Algorithm of Solar Tracking

System,"2nd International Conference on Green Energy and Technology, September 2014 IEEE.

[6] Rokeya Jahan Mukti, "Designing an Efficient Photovoltaic System with Maximum Power Point Tracking Technique by Comparing Different Converter Topologies," 17th International Conference on Computer and Information Technology, 2014 IEEE.

[7] Alex Joseph and Kamala J, "PV Array Characteristics Analysis Under Partial Shading & Modeling of P&O MPPT Applied Boost Convertor Using Matlab/Simulink," 2013 IEEE. 2013 IEEE

[8] P.Badari Narayana, "Design & Simulation of Solar DC Pump in Simulink," 2013 IEEE.

[9] Jaypalsinh Chauhan, "Comparison of MPPT Algorithms for DC-DC Converters Based Photovoltaic Systems," 2013 IEEE.

[10] Dogga. Raveendhra, "Design of FPGA based Open Circuit Voltage MPPT Charge Controller for Solar PV System," 2013 International Conference on Circuits, Power and Computing Technologies, 2013 IEEE.

[11] Li Sze Chow, "Optimization of Solar Panel with Solar Tracking and Data Logging," Student Conference on Research and Development (SCOReD), 16 -17 December 2013, 2013 IEEE.

[12] Azadeh Safari and Saad Mekhilef, "Simulation and Hardware Implementation of Incremental Conductance MPPT With Direct Control Method Using Cuk Converter," IEEE Transactions on industrial electronics, VOL. 58, NO. 4, APRIL 2011 IEEE

[13] B. M Hasaneen, "Design and Simulation of dc/dc boost converter," 2008 IEEE.

[14] Application of non-conventional & renewable energy sources, Bureau of Energy Efficiency.

[15] Ahmad Taghinia, "Comparison of single junction GaAs and In0.2Ga0.8N based solar cells at various temperatures," International Conference on Advances in Energy Engineering (ICAEE 2011), 2011.

[16] Martin A. Green1, "Solar cell efficiency tables," PROGRESS IN PHOTOVOLTAICS: RESEARCH AND APPLICATIONS, Wiley Online Library, 2011.