# MAXIMUM POWER POINT TRACKING

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*Photovoltaic's (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the first step involves the photoelectric effect from which a second electrochemical process take place involving crystallized atoms being ionized in a series, generating an electric current. Photovoltaic's are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. The photovoltaic effect was first observed by Alexander-Edmond Becquerel in 1839. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transducer light energy.*

***Keywords:*** *Photovoltaic, photovoltaic effect, photochemistry, electrochemistry, solar power.*

## I. INTRODUCTION

Photovoltaic's (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the first step involves the photoelectric effect from which a second electrochemical process take place involving crystallized atoms being ionized in a series, generating an electric current. Power generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source – the sun. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. It is well proven, as photovoltaic systems have now been used for fifty years in specialized applications, and grid-connected PV systems have been in use for over twenty years. They were first mass-produced in the year 2000, when German environmentalists including Euro solar succeeded in obtaining government support for the 100,000 roofs program.

Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaic's has declined steadily since the first solar cells were manufactured, and the leveled cost of electricity from PV is competitive with conventional electricity sources in an expanding list of geographic regions Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity; have supported solar PV installations in many countries. With current technology, photovoltaic's recoups the energy needed to manufacture them in 1.5 to 2.5 years in Southern and Northern Europe, respectively.

Solar PV is now, after hydro and wind power, the third most important renewable energy source in terms of globally installed capacity. More than 100 countries use solar PV. Installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building (either building-integrated photovoltaic's or simply rooftop).

In 2014, worldwide installed PV capacity increased to at least 177 gigawatts (GW) , sufficient to supply 1 percent of global electricity demands. Due to the exponential growth of photovoltaic's, installations are rapidly approaching the 200 GW mark – about 40 times the installed capacity of 2006 China, followed by Japan and the United States, is the fastest growing market, while Germany remains the world's largest producer, with solar contributing about 7 percent to its annual domestic electricity consumption.

## II. BACKGROUND

The topic of solar energy utilization has been looked upon by many researchers all around the globe. It has been known that solar cell operates at very low efficiency and thus a better control mechanism is required to increase the efficiency of the solar cell. In this field researchers have developed what are now called the Maximum Power Point Tracking (MPPT) algorithms. MummadiVeerachary has given a detailed report on the use of a SEPIC converter in the field of photovoltaic power control. In his report he utilized a two-input converter for accomplishing the maximum power extraction from the solar cell [3]. M. G. Villalva in his both reports has presented a comprehensive method to model a solar cell using simulink or by writing a code. His results are quite similar to the nature of the solar cell output plots [1]-[2]. P. S. Revankar has even included the variation of sun's inclination to track down the maximum possible power from the incoming solar radiations. The control mechanism alters the position of the panel such that the incoming solar radiations are always perpendicular to the panels [9].M.Berrera has compared seven different algorithms for maximum power point tracking using two different solar irradiation functions to depict the variation of the output power in both cases using the MPPT algorithms and optimized MPPT algorithms [8]. Ramos Hernanz has successfully depicted the modeling of a solar cell and the variation of the current-voltage curve and the power-voltage curve due the solar irradiation changes and the change in ambient temperature [10].Studies show that a solar panel converts 30-40% of energy incident on it to electrical energy. A Maximum Power Point Tracking algorithm is necessary to increase the efficiency of the solar panel. There are different techniques for MPPT such as Perturb and Observe (hill climbing method), Incremental conductance, Fractional Short Circuit Current, Fractional Open Circuit Voltage, Fuzzy Control, Neural Network Control etc. Among all the methods Perturb and observe (P&O) and Incremental conductance are most commonly used because of their simple implementation, lesser time to track the MPP and several other economic reasons.Under abruptly changing weather conditions (irradiance level) as MPP changes continuously, P&O takes it as a change in MPP due to perturbation rather than that of irradiance and sometimes ends up in calculating wrong MPPT[11]. However this problem gets avoided in Incremental Conductance method as the algorithm takes two samples of voltage and current to calculate MPP. However, instead of higher efficiency the complexity of the algorithm is very high compared to the previous one and hence the cost of implementation increases. So we have to mitigate with a tradeoff between complexity and efficiency. It is seen that the efficiency of the system also depends upon the converter. Typically it is maximum for a buck topology, then for buck-boost topology and minimum for a boost topology. When multiple solar modules are connected in parallel, another analog technique TEODI is also very effective which operates on the principle of equalization of output operating points in correspondence to force displacement of input operating points of the identical operating system. It is very simple to implement and has high efficiency both under stationary and time varying atmospheric conditions [12].

## III. Testing of the MPLab ID card.

The MPLab ID Add on card which is installed on a PC is tested for its working bysimple sending and receiving data from the external circuit to the PC and back to the external circuit from the PC. This is accomplished by using Analog to Digital Converter (ADC). The analog signal is converter into digital form and fed to the PC. To send data from PC to the experimental module the digital signal is converted into analog signal by Digital to Analog Converter (DAC). Simulink models are used for receiving and sending signals to and from PC.

**Receiving data**

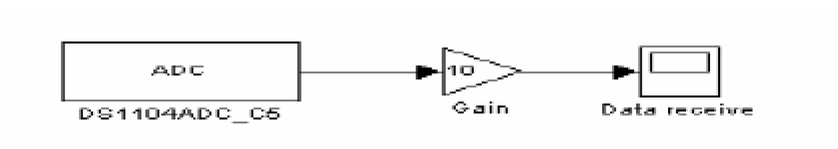


**Fig.1. Simulink model for receiving data**

Small models are developed such as receiving and sending the data. These models are useful for future applications requiring data acquisition systems. The Fig.1 shows the simulink model, which is used for the acquiring the data from the field and then displaying the data on the monitor. The data acquired is used for further processing. An ADC block is used for acquiring the data from the field an internal gain for amplifying the data and display is used to observe the signal on PC.

**Sending data**

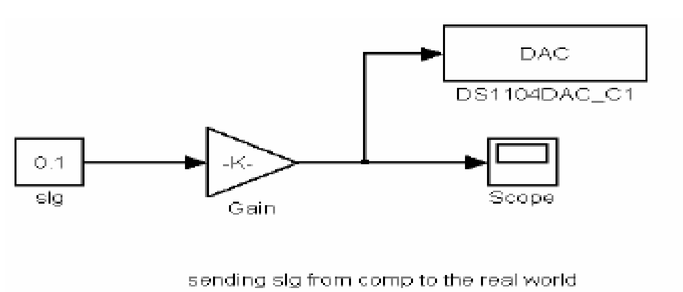

**Fig.2 Simulink model for sending data**

The next experiment shows how data is sent from the computer to the field. This signal can be a dc signal or a pulse or any low level ac signal. A signal is generated and amplified and then connected to a DAC through which the interfacing of the signal with the field device is done. As seen in the Simulinkmodel a signal is send to the display device through a DAC. The signal is observed externally on the multimeter or a voltmeter.

**1].Module power with and without MPPT system.**

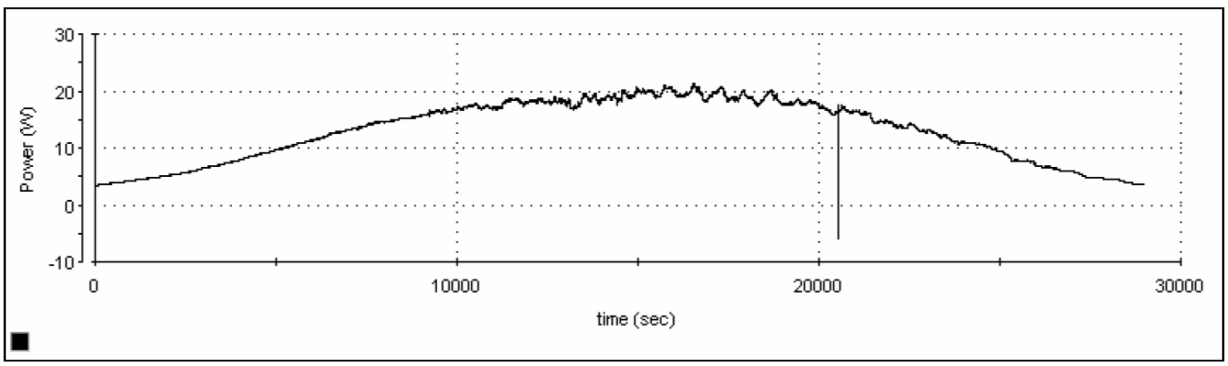


**Fig.3. Module power without MPPT system**

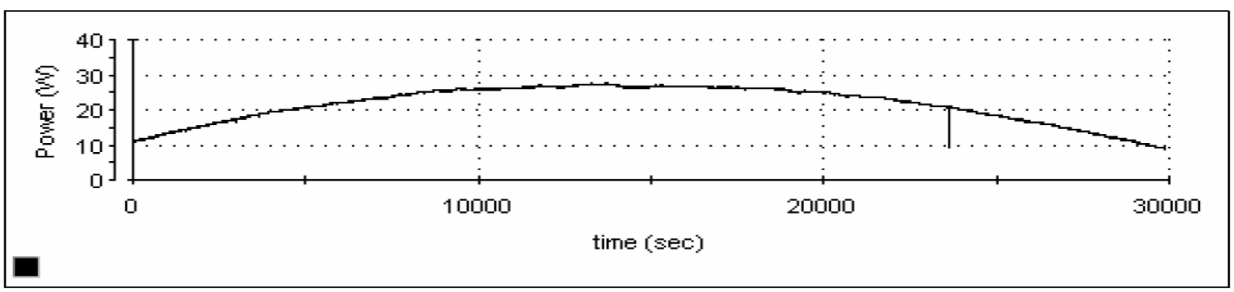


**Fig.4. Module power with MPPT system**

It shows the module power without and with MPPT system. It is observed that without the MPPT system the module power is about 20W. These readings were taken for the period of 8hrs (8:30am to 4:30pm). The module power increases with the increase in solar insolation from morning till (10000sec) noon time(12:00) noon. then the module power remains constant

(10000sec to 20000 sec) After noon the module power decreases till evening. But it never reaches the peak power.

When the MPPT system is connected we have increase in the module power. It isobserved that the module power is almost doubled for that particular insolation level.Again the same pattern is followed the module power increases till noon and thendecreases after noon. But with MPPT system the module power is increased by 50%. This proves the usefulness of the MPPT system.

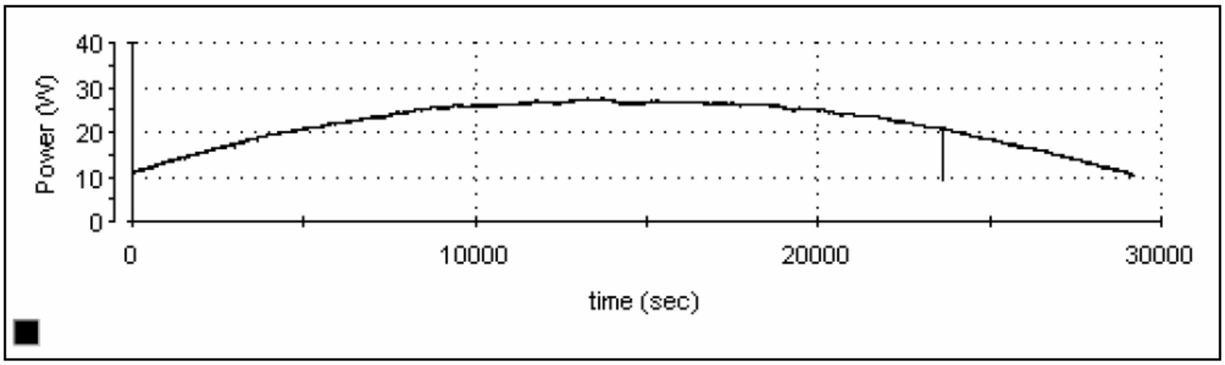


**Fig.5. .Module power With MPPT system**

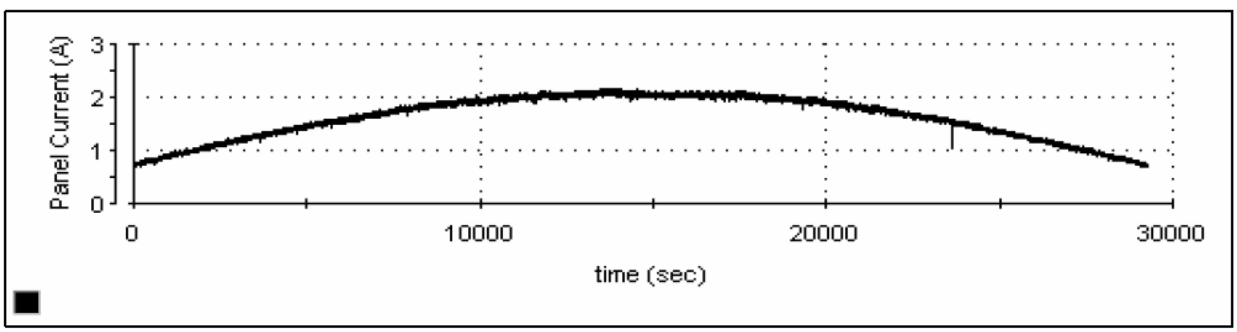


**Fig.6 Module Current with MPPT system**

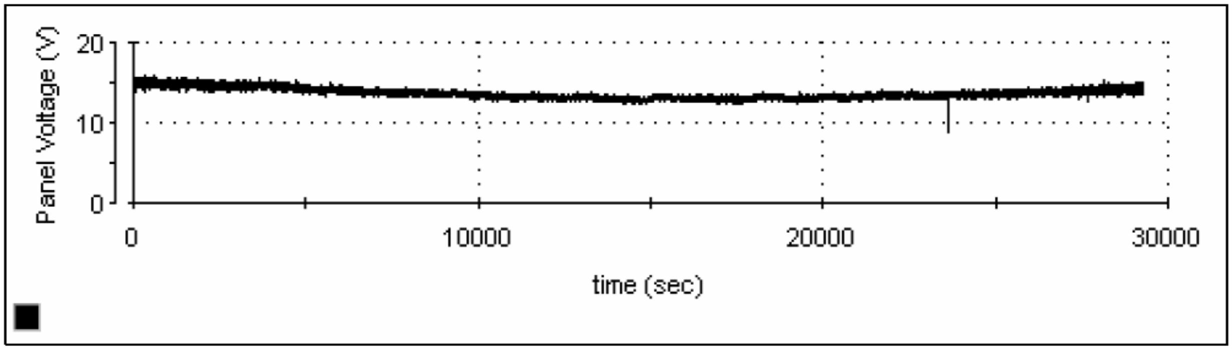


**Fig.7 Module Voltage with MPPT system**

The graph shows the Module Power, Current and Voltage when MPPT system is connected to the solar PV module. The results where plotted for the period of 8hrs(8:30am to 4:30pm). The maximum power (29W)that is obtained by the system is at noon time. As observed in the voltage and current profile of the module the voltage decreases as the power output increases but current increases. The variation in voltage is also due to the change in the input resistance due to the change in duty cycle as explained in the and the temperature of the module.

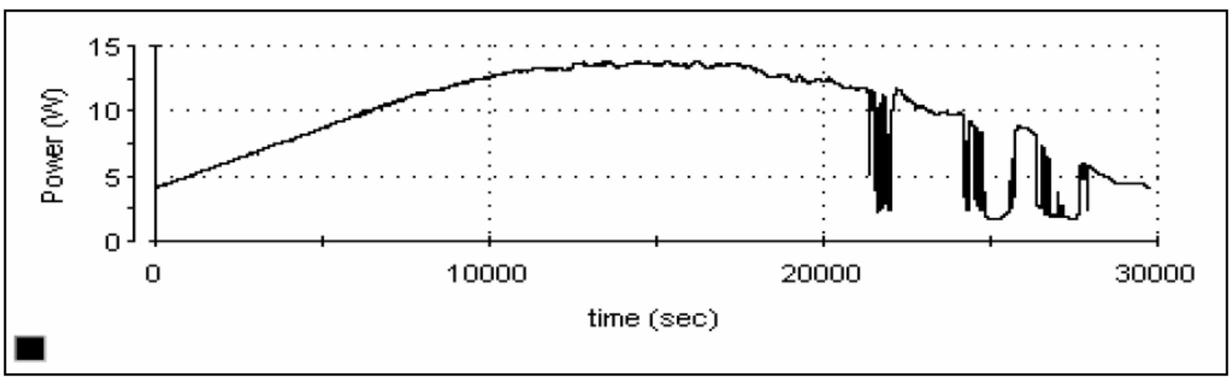


**Fig.8 Module power without MPPT system**

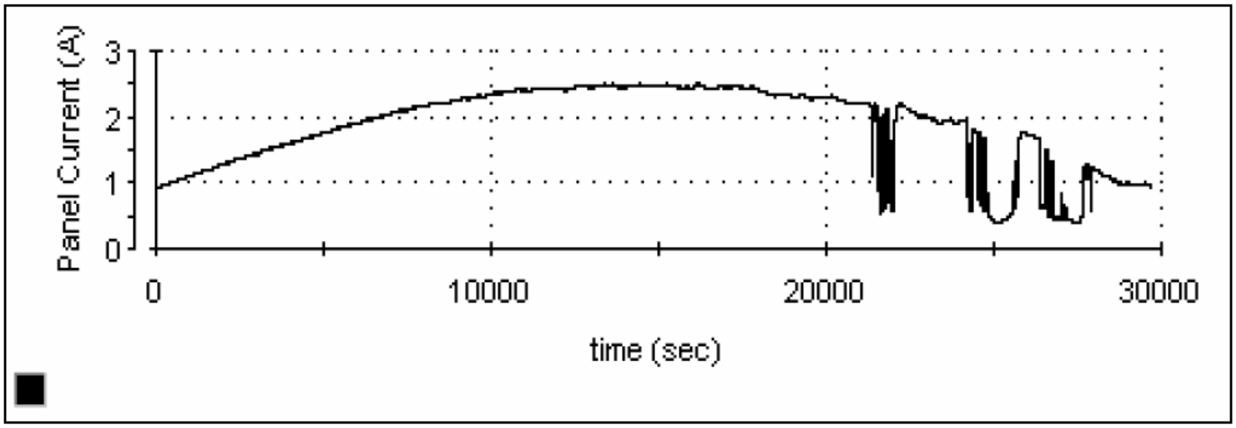


**Fig.9 Module power without MPPT systems.**

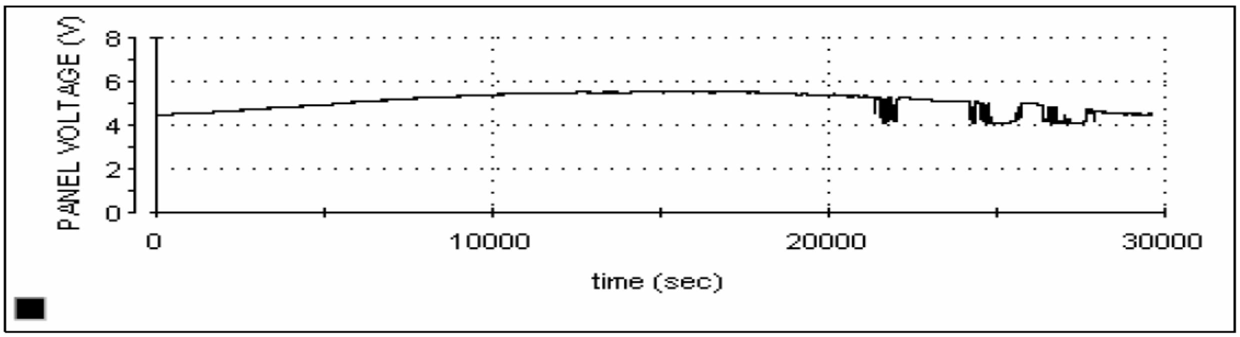


**Fig.10 Module Voltage without MPPT system**

The module is directly connected to the load without MPPT controller. The observations are the plot of module power, current and voltage are plotted. The module power obtained in this case is very low as compared to the module power in the case of MPPT system. The module voltage is also very low as the load is in direct in contact with the module. The module current is more in the noon time that it was observed in the case of MPPT system. The disturbance in the wave from time 20000 sec is due to the cloudy sky.

**With mppt and Without mppt**

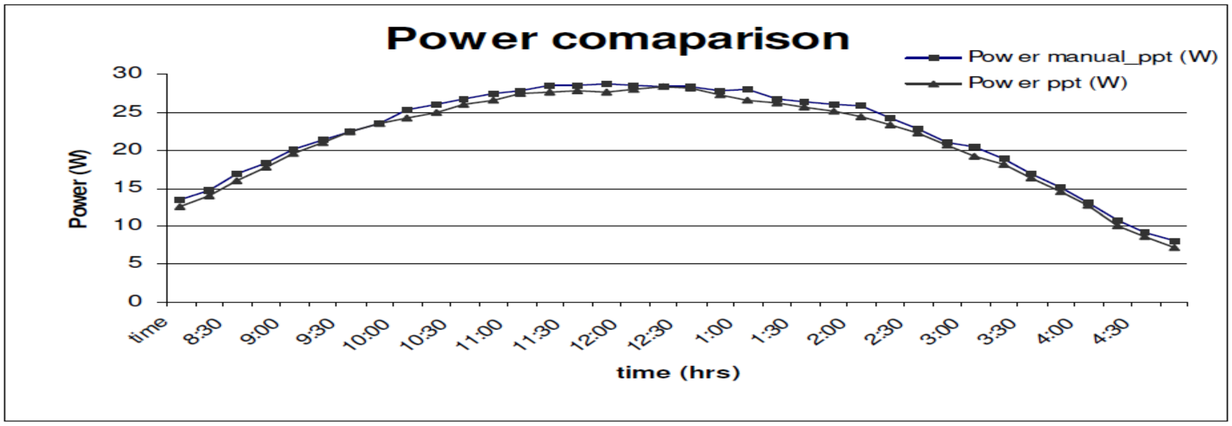


**Fig.11 .Module Peak power comparison between manual Peak Power tracking and Automatic Peak Power Tracking.**

The graph shows the comparison between the manual peak power tracking and the automatic peak power tracking. The manual tracking is performed by manually varying the duty cycle of the dc/dc converter to get the peak power point. The duty cycle of the converter is changed every 15 minutes and the peak power noted. The next day the automatic peak power tracker is implemented and the readings of the module power are noted after the period of 15 minutes. The efficiency of the algorithm can be calculated by dividing the manual power tracked readings from the automatic power tracked readings. The efficiency of the algorithm was found to be around 95%.

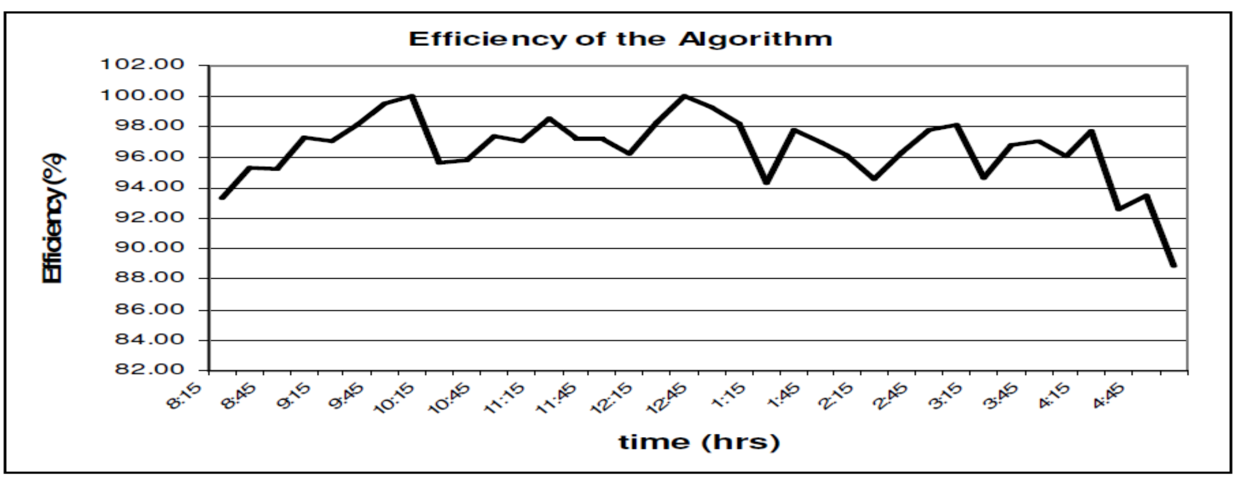

**Fig.12 Efficiency of the algorithm**

The efficiency curve of the algorithm shows that at the higher insolation level that is at the noon(12:00 noon to 1:45 pm) the efficiency is higher but as the insolation level decreases (2:15pm to 4:30pm) the efficiency also decreases. The decrease in efficiency occurs at the very low insolation level especially at in the evening time(4:00pm to 4:30pm). Overall the performance of the algorithm is satisfactory.

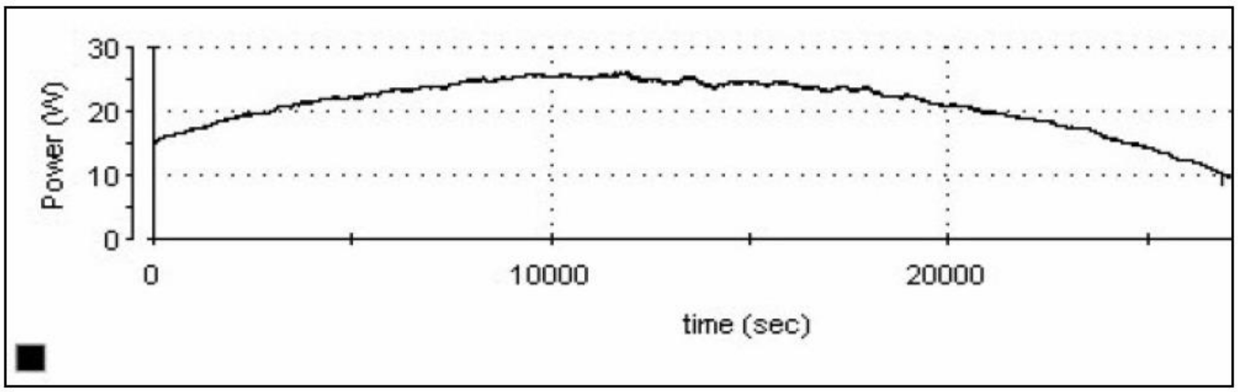


**Fig.13.Module Power with MPPT system for Step converter**

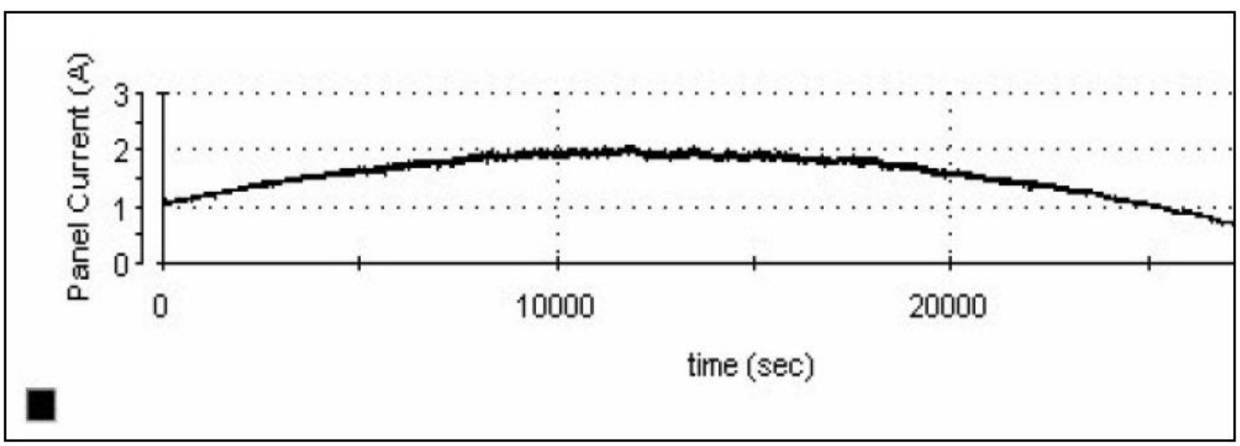


**Fig.14 Module current with MPPT system for step up converter**

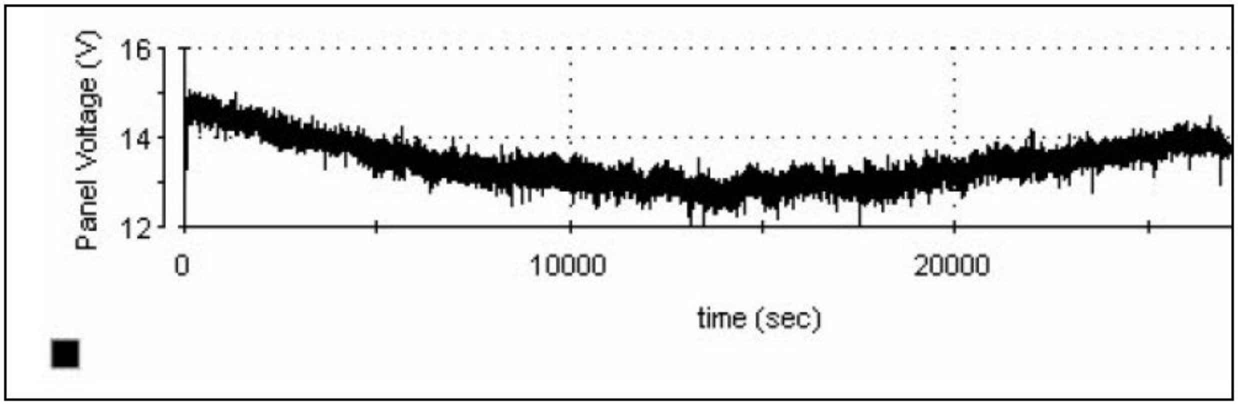


**Fig.15.Module Voltage with MPPT system for Step up converter**

The MPPT system was checked on the Step up converter. The peak power was obtained by the MPPT system using step up converter configuration. The results of the Module Power, Voltage and Current are obtained. The response matches with that of the step down converter .The response is similar but the only difference is obtained in the output voltage of the converter which is more than 15V as against the 3V. Obtained in the case of the step down converter.. This higher voltage is useful in most of the application related to the solar pv system

**1].**Development of Microcontroller based dedicated MPPT controller for solar PV module based on the present algorithm. This can be a low cost embedded controller.

**2].**Automatic recording and monitoring of the temperature and insolation level on the module to predict the peak power of the module.

**3].**Implementing the axial tracking with the electrical (MPPT) tracking on a solar pv module and checking its response on the module power output.

**4].**Implementing other algorithms as explained in chapter 3 on the MPLab ID and checking their response.

**5].** A whole stand alone system including the MPPT system and the inverter system can be developed using the MPLab ID.

## IV. FUTURE SCOPE

The model is simulated using SIMULINK and MATLAB. The plots obtained in the different scopes have been analyzed. The simulation was first run with the switch on no MPPT mode, bypassing the MPPT algorithm block in the circuit. It was seen that when we do not use an MPPT algorithm, the power obtained at the load side was around 95 watts for a solar irradiation value of 85 Watts per sq. cm. It must be noted that the PV panel generated around 250 Watts power for this level of solar irradiation. Therefore, the conversion efficiency came out to be very low. The simulation was then run with the switch on MPPT mode. This included the MPPT block in the circuit and the PI controller was fed the $V_{ref}$ as calculated by the P&O algorithm. Under the same irradiation conditions, the PV panel continued to generate around 250 Watts power. In this case, however, the power obtained at the load side was found to be around 215 Watt, thus increasing the conversion efficiency of the photovoltaic system as a whole. The loss of power from the available 250 Watts generated by the PV panel can be explained by switching losses in the high frequency PWM switching circuit and the inductive and capacitive losses in the Boost Converter circuit. Therefore, it was seen that using the Perturb & Observe MPPT technique increased the efficiency of the photovoltaic system by approximately 126% from an earlier output power of around 95 Watts to an obtained output power of around 215 Watts.

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