A Review on Implementation of MPPT for PV System with using Buck-Boost Converters

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***Abstract*--The Maximum Power Point Tracking (MPPT) is a technique used in power electronic circuits to extract maximum energy from the Photovoltaic (PV) model Systems. In the recent decades, photovoltaic power generation has become more important due its many benefits such as needs a free maintenance and environmental.**

Advantages of solar cell are fuel free. However, there are two major barriers for the use of PV systems, low energy conversion efficiency and high initial cost. To improve the energy efficiency, it is important to work PV model system.

System always at its maximum power point. So far, many researches are conducted and many papers were published and suggested different methods for extracting maximum power point. This report presents in details implementation of Perturb and Observe MPPT using buck and buck-boost Converters. Some results such as current, voltage and output power for each various combination had been recoded. The simulation has been accomplished in software of MATLAB.

***Keywords:*Maximum power point tracking, photovoltaic model system, Perturb and Observe, DC-DC Converters.**

I. INTRODUCTION

The usage of modern efficient photovoltaic solar cells (PVSCs) has featured as a masterminding alternative of energy conservation, renewable power and demand-side management. Due to their initial high expensive, PVSCs have not yet been an exactly a tempting alternative for electrical usage who are able to purchase less expensive electrical energy from the utility grid. However, they have been used widely for air conditioning in remote, water pumping a disolated or remote areas where utility power is not available or is high costly to transport. Although PVSC prices have decreased considerably during the last years due to new developments in the film technology and manufacturing process. The harnessing of solar energy using PV modules comes with its own problems that arise from the change in insulation conditions. Those changes in insulation conditions strongly influence the efficiency and output power of the PV modules.

A great deal of research has been accomplished to improve the efficiency of the photovoltaic system. Several methods to track the maximum power point of a PV module have been suggested to solve the problem of efficiency and products using these methods have been made and now commercially available for consumers.

A maximum power point tracker is used for obtaining the maximum power from the solar PV module and conversion to the load. A non-isolated DC-DC converter (step up/ step down) offers the purpose of conversion maximum power to the load. A DC-DC converter acts as an interface between the load and the PV module.

1.1 Pv Cell

The solar cell is the basic unit of a PV system. An individual solar cell produces direct current and power typically between 1 and 2 W, hardly enough to power most applications. Solar Cell or Photovoltaic (PV) cell is a device that is made up of semiconductor materials such as silicon, gallium arsenide and cadmium telluride, etc. that converts sunlight directly into electricity. The voltage of a solar cell does not depend strongly on the solar irradiance but depends primarily on the cell temperature. PV modules can be designed to operate at different voltages by connecting solar cells in series.

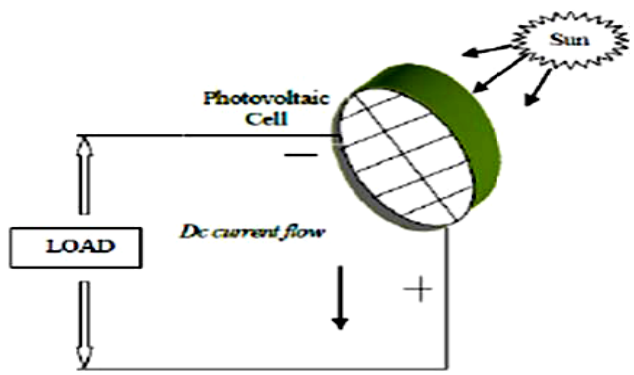

Figure 1.1 PV Cell

1.2 PV- Module

Usually a number of PV modules are arranged in series and parallel to meet the energy requirements. PV modules of different sizes are commercially available (generally sized from 60W to 170W). For example, a typical small scale desalination plant requires a few thousand watts of power. PV energy is of increasing interest in electrical power applications. Photovoltaic (PV) energy is clean, pollution free, and inexhaustible.

A PV cell is connected in series and parallel. Series connection is responsible for increasing the voltage of module whereas the parallel connection is responsible for increasing the current. Solar cell can be modeled by a current source and an inverted diode connected in parallel to it. It has its own series and parallel resistance. Series resistance is due to hindrance in the path of flow of electrons from n to p junction and parallel resistance is due to the leakage current. Photovoltaic (PV) energy is clean, pollution free, and inexhaustible. It is important to operate PV energy conversion systems near the maximum power point to increase the output efficiency of PV arrays. The output power of PV arrays is always changing with solar irradiation and atmospheric temperature

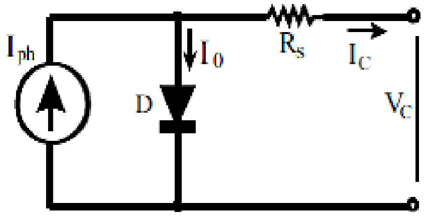

Figure 1.2Single diode model of solar cell I_c

A simple electrical equivalent one-diode model, as illustrated in Fig. 2, expresses a solar cell, which is modelled as a photocurrent source *I*ph, one diode, and a series resistance *R*S, representing the PV cell resistance. Thus, equations to describe the relationship between the current and voltage of a PV cell,

$$I_{pv=Iph}\text{-}I_{sat}\ [\frac{q(Vpv+IpvRs)]}{(AKT-1)}$$

Where,
I_c = cell output current
V_c = cell output voltage
I_{ph} = light generated current
I_o = reverse saturation current
R_s = series resistance of the cell
I = IPh− ISeexp q (V + Irs) / k TCA −1 − (V + Irs) / Rsh

1.3 Maximam power point tracking

Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is not a mechanical tracking system that “physically moves” the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. Additional power harvested from the modules is then made available as increased battery charge current. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different

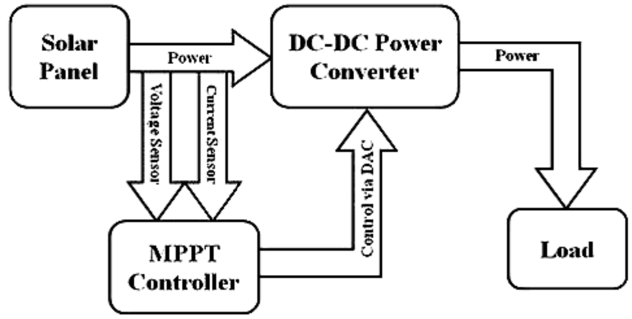

Figure 1.3Block diagram of typical MPPT system

Solar panel is used as energy source. DC-DC Converter is used for transferring maximum power from the solar PV module to the load. MPPT Controller track maximum power

II. LITERATURE SURVEY

The Maximum Power Point Tracking (MPPT) is a technique used in power electronic circuits to extractmaximum energy from the Photovoltaic (PV) Systems. In the recent decades, photovoltaic power generationhas become more important due its many benefits such as needs a few maintenance and environmental.

Advantage arefuel free. However, there are two major barriers for the use of PV systems, low energyconversion efficiency and high initial cost. To improve the energy efficiency, it is important to work PVsystem always at its maximum power point. So far, many researches are conducted and many papers werepublished and suggested different methods for extracting maximum power point. This paper presents indetails implementation of Perturb and Observe MPPT using buck and buck-boost Converters. Some results such as current, voltage and output power for each various combination have been recorded. Thesimulation has been accomplished in software of MATLAB Mathworks.**[1]**
The amount of power generated from aphotovoltaic (PV) system mainly depends on the followingfactors, such as temperatures and solar irradiances. Accordingto the high cost and low efficiency of a PV system, it shouldbe operated at the maximum power point (MPP) which changeswith solar irradiances or load variations. This paper presents animproved maximum power point tracking (MPPT) algorithm ofa PV system under real climatic conditions. The proposed MPPTis based on the perturbation and observation (P&O) strategyand the variable step method that control the load voltage toensure optimal operating points of a PV system. The proposedMPPT algorithm has been implemented by a dSPACEDSPcontroller. The experimental results show that the PV powersystem, using the proposed MPPT algorithm, is able to accuratelytrack maximum power points (with minimum steady-state poweroscillations) under rapid irradiance variations.[2]
Energy , especially alternative source of energy is vital for the development of a country. In future, theworld anticipates to develop more of its solar resource potential as an alternative energy source to overcome thepersistent shortages and unreliability of power supply. In order to maximize the

power output the system components ofthe photovoltaic system should be optimized. For the optimization maximum power point tracking (MPPT) is apromising technique that grid tie inverters , solar battery chargers and similar devices use to get the maximum possiblepower from one or more solar panels. Among the different methods used to track the maximum power point, Perturband Observe method is a type of strategy to optimize the power output of an array. In this method, the controller adjuststhe voltage by a small amount from the array and measures power, if the power increases, further adjustments in thatdirection are tried until power no longer increases. In this research paper the system performance is optimized byperturb and observe method using buck boost converter.[3]

Photovoltaic (PV) energy is the most important energy resource since it is clean, pollution free, and inexhaustible. Due to rapid growth in the semiconductor and power electronics techniques, PV energy is of increasing interest in electrical power applications. It is important to operate PV energy conversion systems near the maximum power point to increase the output efficiency of PV arrays. A MPPT plays a very vital role for extracting the maximum power from the solar PV module and transferring that power to the load. In this paper a survey of recent Maximum Power Point Tracking (MPPT) Technique for Photovoltaic (PV) System is presented.[4]

Photovoltaic (PV) offers an environmentally friendlysource of electricity, which is however still relativelycostly today. The maximum power point tracking(MPPT) of the PV output for all sunshine conditionsis a key to keep the output power per unit cost lowfor successful PV applications. This paper proposes anew method for the MPPT control of PV systems, which uses one estimate process for every twoperturb processes in search for the maximum PVoutput. In this estimate-perturb-perturb (EPP)method, the perturb process conducts the search overthe highly nonlinear PV characteristic, and theestimate process compensates the perturb process forirradiance-changing conditions.[5]

In this paper utilization of a boost converter for control of photovoltaic power using Maximum Power Point Tracking (MPPT) control mechanism is presented. First the photovoltaic module is analyzed using SIMULINK software. For the main aim of the project the boost converter is to be used along with a Maximum Power Point Tracking control mechanism. The MPPT is responsible for extracting the maximum possible power from the photovoltaic and feed it to the load via the boost converter which steps up the voltage to required magnitude. The main aim will be to track the maximum power point of the photovoltaic module so that the maximum possible power can be extracted from the photovoltaic. The algorithms utilized for MPPT are generalized algorithms and are easy to model or use as a code. The algorithms are written in m files of MATLAB and utilized in simulation. Both the boost converter and the solar cell are modelled using SimPower Systems blocks[6]

Although solar energy is available throughout the day its insolation varies from morning to evening and with changing climatic conditions. As the efficiency of solar PV panel is low it becomes mandatory to extract maximum power from the PV panel at any given period of time. Several maximum power point tracking (MPPT) techniques are proposed for the purpose. Incremental conductance MPPT technique has higher steady-state accuracy and environmental adaptability. This paper investigates implementation issues of Incremental conductance MPPT algorithm. High frequency DC-DC Buck converter is used to interface PV panel with load. The Matlab Simulink model of the system is developed and results are validated with experimental results obtained using laboratory prototype of the system.[7]

III. PROPOSE WORK

3.1 Buck-Boost Converter

The last and most important type of switching regulator is the buck-boost converter. In this converter, the buck and boost topologies covered earlier are combined into one. A buck-boost converter is also built using the same components used in the converters covered before. The inductor in this case is placed in parallel with the input voltage and the load capacitor. The switch or transistor is placed between the input and the inductor, while the diode is placed between the inductor and the load capacitor in a reverse direction, shown in Figure 3.1. The buck-Boost converter provides an output voltage that may be less than or greater than the input voltage

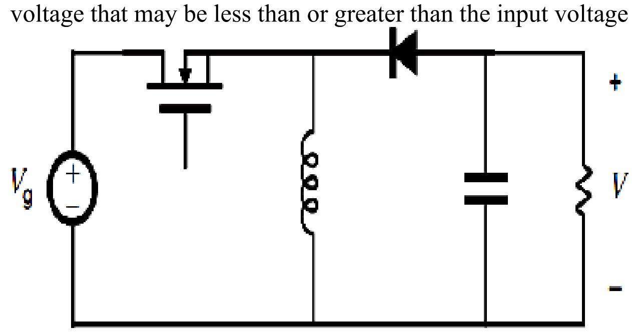

Figure 3.1 Basic buck-boost converter and its dc conversion ratio

3.2 *Simulation of MPPT Control Algorithm*

The weather and load changes cause the operation of a PV system to vary almost all the times. A dynamic tracking technique is important to ensure maximum power is obtained from the photovoltaic arrays. The following algorithms are the most fundamental MPPT algorithms, and they can be developed using micro controllers.

The MPPT algorithm operates based on the truth that the derivative of the output power (P) with respect to the panel voltage (V) is equal to zero at the maximum power point. In the literature, various MPP algorithms are available in order to improve the performance of photovoltaic system by effectively tracking the MPP. However, most widely used MPPT algorithms are considered here, they are:

1. Perturb and Observe (P&O)
2. Incremental Conductance (In Cond)
3. Constant Voltage Method

3.3 Perturb and Observe (P&O)

In this method a slight perturbation is introduce system. This perturbation causes the power of the solar module changes. If the power increases due to the perturbation then the perturbation is continued in that direction. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses. When the steady state is reached the method oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small. The method is developed in such a manner that it sets a reference voltage of the module corresponding to the peak voltage of the module. A PI controller then acts moving the operating point of the module to that particular voltage level. It is observed that there some power loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions.

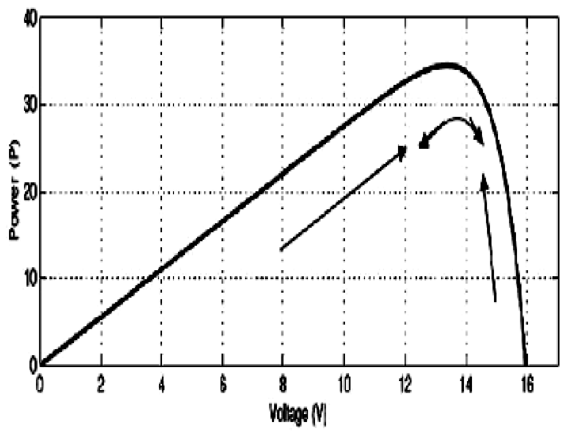

Figure 3.2 Voltage Vs Power Curve

The most commonly used MPPT algorithm is P&O method. This algorithm uses simple feedback arrangement and little measured parameters. In this approach, the module voltage is periodically given a perturbation and the corresponding output power is compared with that at the previous perturbing cycle. In this algorithm a slight perturbation is introduce to the system. This perturbation causes the power of the solar module various. If the power increases due to the perturbation then the perturbation is continued in the same direction. After the peak power is reached the power at the MPP is zero and next instant decreases and hence after that the perturbation reverses as shown in Figure 3.3. When the stable condition is arrived the algorithm oscillates around the peak power point. In order to maintain the power variation small the perturbation size is remain very small. The technique is advanced in such a style that it sets a reference voltage of the module corresponding to the peak voltage of the module. A PI controller then acts to transfer the operating point of the module to that particular voltage level. It is observed some power loss due to this perturbation also the fails to track the maximum power under fast changing atmospheric conditions. But remain this technique is very popular and simple.By varying the duty cycle of the buck boost converter, the source impedance can be matched to adjust the load impedance which improves the efficiency of the system. The performance has been studied by the MATLAB/ Simulink.

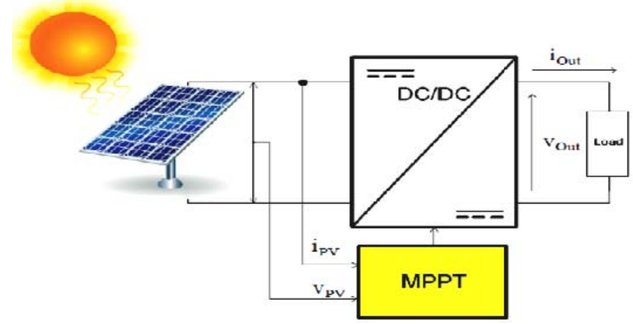

Figure 3.3. PV module and dc/ dc converter with MPPT

3.4 MPPT Techniques

There are many MPPT Techniques are available which are as follows.

- Perturb and observe
- Incremental conductance
- Fuzzy Logic Control
- Current Sweep Method
- Fractional Open-Circuit Voltage

The maximum power point tracking is successfully carried out by this research using perturb and observe method. The PV module working on photovoltaic effect actually improves the system efficiency. Compared to other methods of maximum power point tracking, the perturb and observe method seems to be easy for the optimization of the photovoltaic system using buck boost converter. By varying the duty cycle of the buck boost converter, the source impedance can be matched to adjust the load impedance which improves the efficiency of the system. The performance has been studied by the MATLAB. In future, the maximum power point tracking could be carried out without the use of controllers in order to reduce the cost and complications of hardware can be removed.

3.5 Selection of Converter

It operates as the main part of the MPPT. A dc/dc converter (step up/ step down) serves the purpose of transferring maximum power from the solar PV module to the load. A dc/dc converter acts as an interface between the load, when proposing an MPP tracker, the major job is to choose and design a highly efficient converter, which is supposed to operate as the main part of the MPPT. The efficiency of switch-mode dc–dc converters is widely used. Most switching-mode power supplies are well designed to function with high efficiency. Among all the topologies available, both buck and buck–boost converters provide the opportunity to have either higher or lower output voltage compared with the input voltage. The buck converter can be found in the literature as the step down converter . This gives a hint of its typical application of converting its input voltage into a lower output voltage, where the conversion ratio M = Vo/Vi varies with the duty ratio D of the switch.

The boost converter is also known as the step-up converter. The name implies its typically application of converting a low input-voltage to a high out-put voltage, essentially functioning like a reversed buck converter.

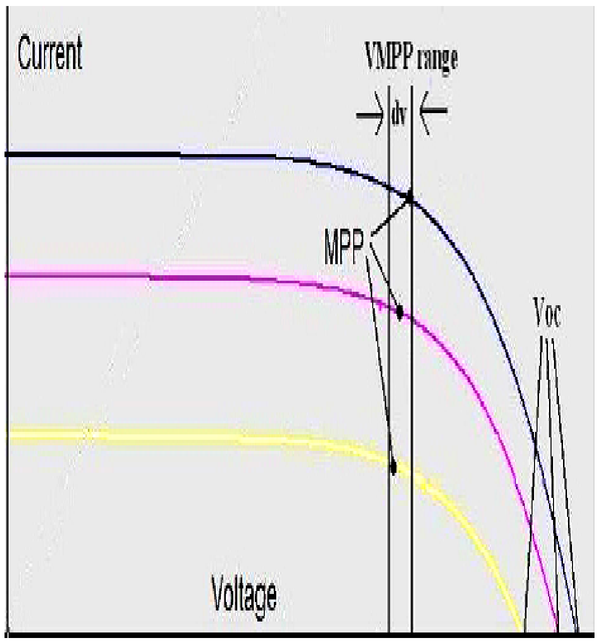

Figure3.4 Constant Voltage Method in V-I curve

Where,

V_{OC}-Open circuit voltage

V_{OC} represented the open circuit voltage of the PV panel. VOC depends on the property of the solar cells.

A commonly used V_{OC}/VMPP value is 76%. This relationship can be described by equation

$VMPP = k * V_{OC}$

Where, k ≈0.76 in this case.

IV. MATLAB-SIMULINK ENVIRONMENT

The model shown in Figure 4 represents a block diagram of a PV array connected to a resistive load through a dc/dc (buck or buck boost) converter with MPPT controller. Block diagram of a PV array connected to the load In Figure 8 the model of PV panel as a constant dc source created using the subsystem block from Simulink library browser, which included all functions of PV panel. The model has three inputs irradiance, temperature and voltage input that is coming as a feedback from the system and the output of the block gives the current. This model generates current and receives voltage back from the circuit tracking Algorithm.

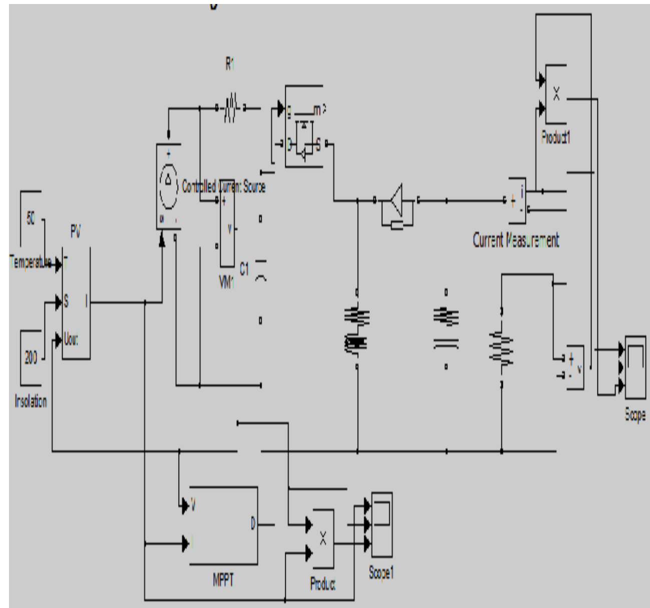

Figure 4.SIMULINK circuitdagram of buck-boostconverter and P&O MPPT

V. RESULTS AND SIMULATION

In this report, the simulation model is developed with MATLAB/SIMULINK. The simulation model of the proposed method and the waveforms are shown in fig.5. The proposed circuit needs independent dc source which is supplied from photovoltaic cell. The inputs are fed by voltage and current of the PV terminals, while the output provides duty cycle for the buck boost converter. The input voltage is 24V and the output voltage after being buck boosted up is 48.2V and shown in fig.5. Buck Boost converter controls the output voltage by varying the duty cycle *k,* of the switch and the value of k is 0.67 which is calculated using the formulae $\mathbf{V_o = V_s*k / 1-k}$. If we vary the pulse width of the pulse generator various voltage ranges at the output can be obtained. Once the buck boost converter injected the power from the pv panel and the PID controller starts function, it varies the value of duty cycle which will change the input value that is sensed by the PID controller. By using the PID controller the error has been minimized in the system and the efficiency is improved.table.1 below shows the output values for PV panel.

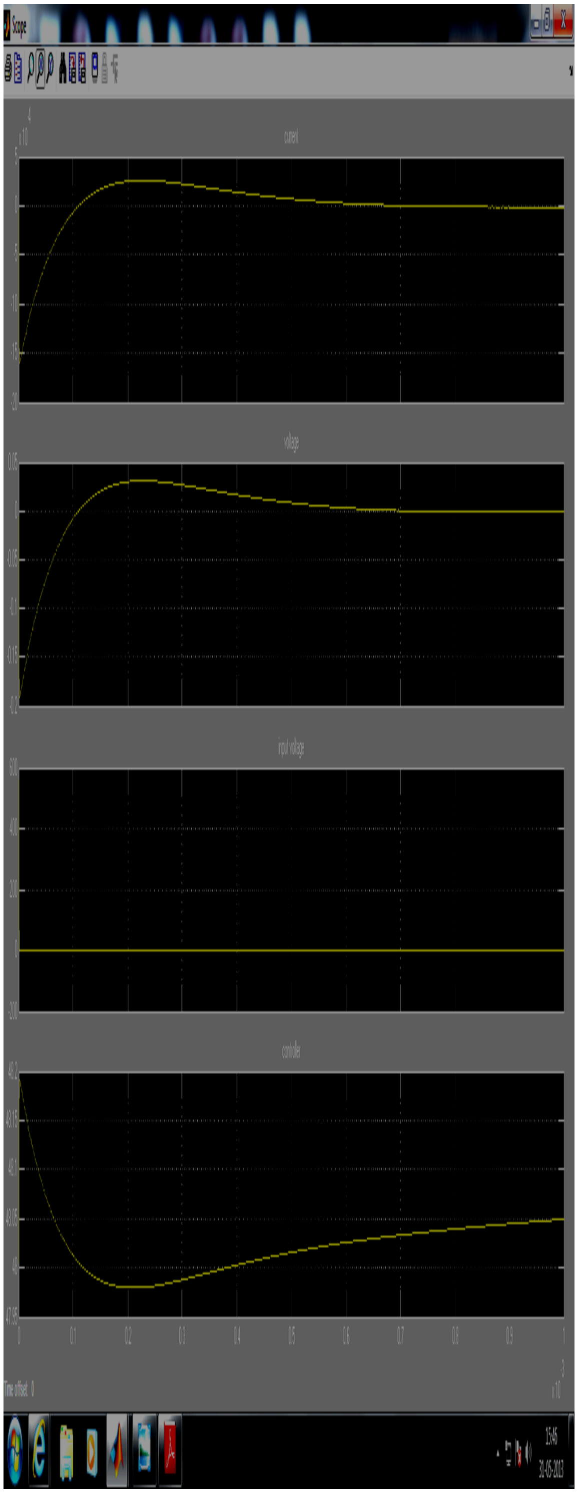

Figure 5 Waveforms

The simulation result at constant temperature (T=50 degree) with changes in the isolation
(S=400 to 200 w/m²)

From the Figure5, the results below including current, voltage and power:

At T=50 degree and S=400 w/ m²

I= -4.7 Ampere, V=-47 volt and P=470 watt

At T=50 degree and S=200 w/ m²

I=-3.8 Ampere, V=-38 volt and P= 350 watt

1- Perturb and Observe add oscillations to the output value, this is the main drawback of using this technique.

2- Buck converter suppresses the oscillations more efficiently than buck-boost converter.

Table.1 Output value for PV panel

MPPT METHOD	Output Voltage (V)	Output Current(A)	Output Power(W)	Efficiency (%)
Perturand Observe	48.2	4.82	232.32	90

VI.CONCLUSION

P&O MPPT method is implemented with MATLAB-SIMULINK for simulation. The MPPT method simulated in this paper is able to improve the dynamic and steady state performance of the PV system simultaneously. Through simulation it is observed that the PV system completes the maximum power point tracking successfully despite of fluctuations. When the external environment changes suddenly the system can track the maximum power point quickly. Both buck and buck-boost converters have succeeded to track the MPP but, buck converter is much more effective specially in suppressing the oscillations produced due the use of P & O technique.

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