A

PROJECT REPORT

ON

PHOTOVOLTAIC SOLAR POWER GENERATION WITH MAXIMUM POWER POINT TRACKER

Submitted in partial fulfillment of the requirements for the award of degree of

BACHELOR OF TECHNOLOGY
in
EE

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SCHOOL OF AUTOMATION

CERTIFICATE

I hereby submit the project entitled **PHOTOVOLTAIC SOLAR POWER GENERATION WITH MAXIMUM POWER POINT TRACKER in** the **School of Automation** of the Banasthali Vidyapith, under the supervision of **MR. PAWAN KUMAR PATHAK** , School of Automation, Banasthali Vidyapith, Rajasthan, India.

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ABSTRACT

Global energy demand is increasing exponentially. This increase in demand causes concern pertaining to the global energy crisis and allied environmental threats. The solution of these issues is seen in renewable energy sources. Solar energy is considered one of the major sources of renewable energy, available in abundance and also free of cost. Solar photovoltaic (PV) cells are used to convert solar energy into unregulated electrical energy. These solar PV cells exhibit nonlinear characteristics and give very low efficiency. Therefore, it becomes essential to extract maximum power from solar PV cells using maximum power point tracking (MPPT). Perturb and observe (P&O) is one of such MPPT schemes. The behavior of MPPT schemes under continually changing atmospheric conditions is critical. It leads to two conditions, i.e., rapid change in solar irradiation and partial shading due to clouds, etc. The proposed MPPT has several advantages: simplicity, high convergence speed, and independent on PV array characteristics. The algorithm is tested under various operating conditions. The obtained results have proven that the MPP is tracked even under sudden change of irradiation level.

ACKNOWLEDGEMENTS

Firstly, we would like to convey our sincere regards to our head of department Ms. Shailly Sharma, School of Automation and our coordinator Mr. Ashish Mathur and Mr. Sumit Nema who gave the chance to work on this project.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

One of the major concerns in the power sector is the day-to-day increasing demand but unavailability of enough resources to meet the power demand using the conventional energy resources. Demand has increased for renewable sources of energy to be utilized along with conventional systems to meet the energy demand. Renewable sources like wind energy and solar energy are the prime energy sources which are being utilized in this regard. In the recent past years, due to energy crisis and environment pollution, the electrical generation system using photovoltaic cells become more significant. Photovoltaic (PV) power generation systems can substantially reduce environmental issues such as green house effect and air pollution. In a photovoltaic system solar energy can be converted directly into electrical energy. Photovoltaic cells are the basic component of a photovoltaic system. Cells may be grouped in series and parallel to form a solar module. Again, modules may be grouped in series and parallel to form photovoltaic arrays. Cells are connected in parallel to increase the output current and connected in series to increase the output voltage.

The major problem in PV power generation system is the amount of electric power generated by PV module is always changing with weather conditions, i.e., irradiation. Therefore, Maximum Power Point Technique (MPPT) algorithms is implemented which has led to the increase in the efficiency of operation of the solar modules.

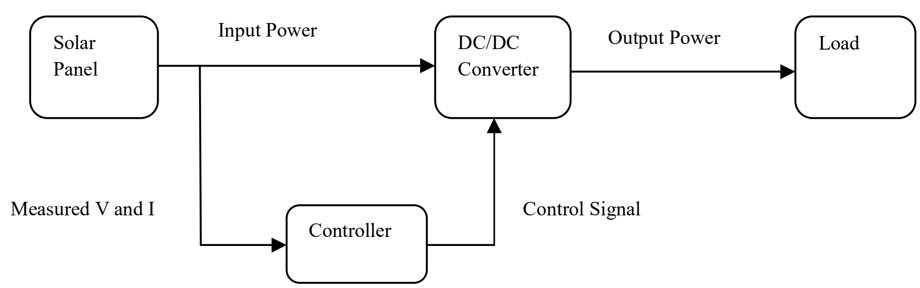


Fig1: MPPT Block Scheme

1.2 Background

In theory solar energy was used by humans as early as 7^{th} century B.C when history tells humans used sunlight to light fires with magnifying glass materials. Later in 3^{rd} century B.C., the Greeks and Romans were known to introduce solar power with mirrors to light torches for religious ceremonies. These mirrors became a normalized tool reformed as "burning mirrors". Another early use for solar energy that is still popular today was the concept of FGD in buildings.

In late 1700s and 1800s, researchers and scientists had success using sunlight to power boats for long voyages. They also harvested the power of the sun to produce solar power steamed boats. Ultimately, it's clear that even thousands of years before the era of solar power plant, the concept of manipulating the power of sun was a common practice.

1.2.1 SOLAR PANELS

In 1883, Charles Fritts actually produced water; however solar cells as we know them today are made with silicon, not selenium. The first solar cell (silicon) could convert sunlight at 4% efficiency, less than quarter of what modern cells are capable of. Between 1957 and 1960 Hoffman electronics made a number of breakthroughs with photovoltaic efficiency, improving record from 8% to 14%.

The next major achievement was in 1985 when the University of South Wales achieved 20% efficiency for silicon cells. In 1999, a solar cell with 33.3% efficiency, the University of South Wales broke that record again in 2016 when the researchers reached 34.5% efficiency.

1.2.2 MPPT

Now since we know about the efficiency of the solar panels , which is so low , so we try to extract maximum available power from PV models using maximum power point tracker i.e. MPPT. The MPPT is algorithm that include in charge controllers used for extracting maximum power, by making them operate at most efficient voltage. MPPT solar charge controller is the charge controller embedded with MPPT algorithm to maximize the amount of current going into the battery from PV module.

Here in our Project we are going to study about Perturb-and-Observe algorithm for MPPT

1.2.3 SOLAR SYSTEM

There are three types of Solar systems present in the market and we can choose them according to the needs.

1) Grid Connected Solar PV System:- Grid Connected Solar PV Systems are the most commonly installed systems. These systems are connected to the grid and do not require a battery system.

2) Off-Grid Solar system:-An "Off Grid" Solar System, is also called a 'stand-alone' system. This system is not connected to the grid and requires a battery system. Off Grid Solar PV Systems are rare and usually only found in rural areas that have difficulties connecting to the grid.

3) Hybrid:-A Grid Connected Solar PV System with battery is sometimes referred to as a Hybrid System. This system stores the excess energy generated by a Solar PV System for the home to use when the solar panels are no longer generating electricity from the sun.

   Now since we know about different types of Solar systems we must also know that for these doff solar systems we have different types of Inverter but the MPPT algorithm remains the same throughout.

1.3 Motivation

What Motivated us?

Since this topic is really a great combination of science (physics) and welfare of ecosystem, we found it really interesting and useful. The rays coming from sun and how can we extract maximum from it just by an algorithm isn't it interesting? This will play a pivotal role in near future since sun is inexhaustible and extracting maximum from it is great for environment as well.

1.4 Organization of Report

This report has been broadly divided into 5 chapters. The first one being the introduction chapter, 2 is on modeling of a solar cell. Chapter 3 deals with the operation of boost converter to be used in the project. Chapter 4 is on maximum power point tracking and study of the Perturb and Observe algorithm. Conclusion and future work are listed in chapter 5. All the simulation models that are used for various simulations are given in the respective chapters.

CHAPTER – 2

PV MODULES

2.1 MODELLING OF SOLAR CELL

A solar cell is the building block of a solar panel. A photovoltaic module is formed by connecting many solar cells in series and parallel. Considering only a single solar cell; it can be modeled by utilizing a current source, a diode and two resistors. This model is known as a single diode model of solar cell. Two diode models are also available but only single diode model is considered here.

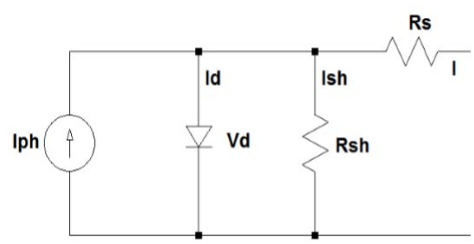


Fig 2.1: Single diode model of a solar cell

2.2 EFFECT OF VARIATION OF SOLAR IRRADIATION

The P-V and I-V curves of a solar cell are highly dependent on the solar irradiation values. The solar irradiation as a result of the environmental changes keeps on fluctuating, but control mechanisms are available that can track this change and can alter the working of the solar cell to meet the required load demands. Higher is the solar irradiation, higher would be the solar input to the solar cell and hence power magnitude would increase for the same voltage value. With increase in the solar irradiation the open circuit voltage increases. This is due to the fact that, when more sunlight incidents on to the solar cell, the electrons are supplied with higher excitation energy, thereby increasing the electron mobility and thus more power is generated.

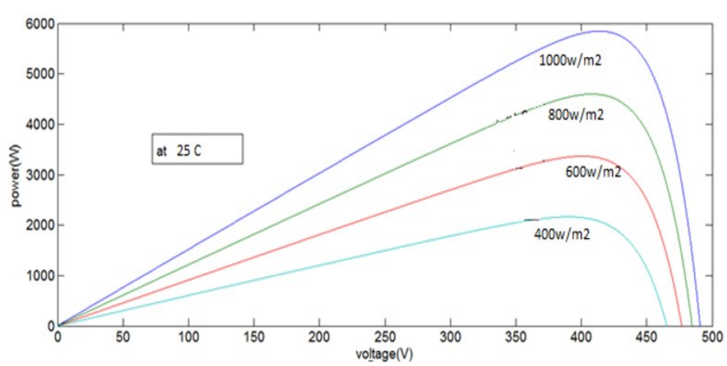


Fig 2.2: Variation of P-V curve with solar irradiation

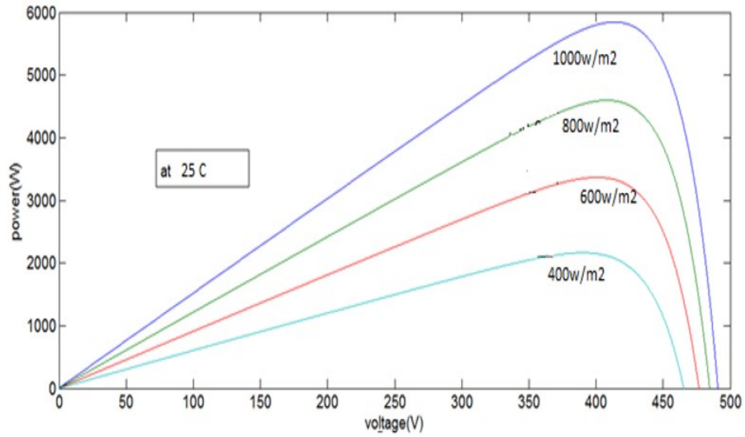


Fig 2.3: Variation of I-V curve with solar irradiation

2.3 EFFECT OF VARIATION OF TEMPERATURE

On the contrary the temperature increase around the solar cell has a negative impact on the power generation capability. Increase in temperature is accompanied by a decrease in the open circuit voltage value. Increase in temperature causes increase in the band gap of the material and thus more energy is required to cross this barrier. Thus the efficiency of the solar cell is reduced.

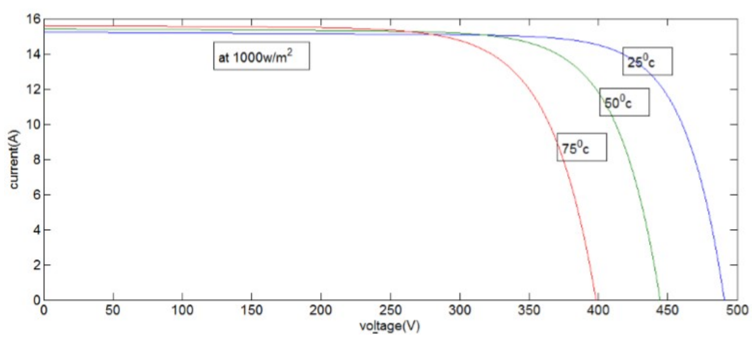


Fig 2.2: Variation of P-V curve with temperature

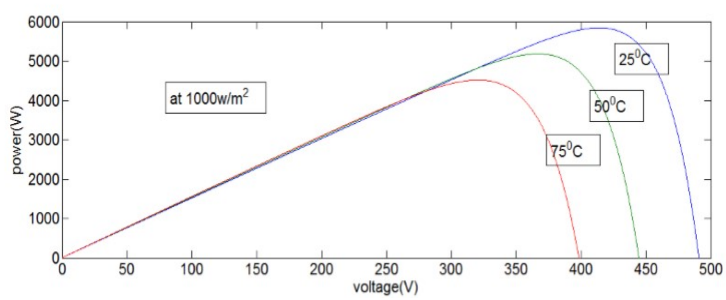


Fig 2.5: Variation of I-V curve with temperature

2.4 P-V Module

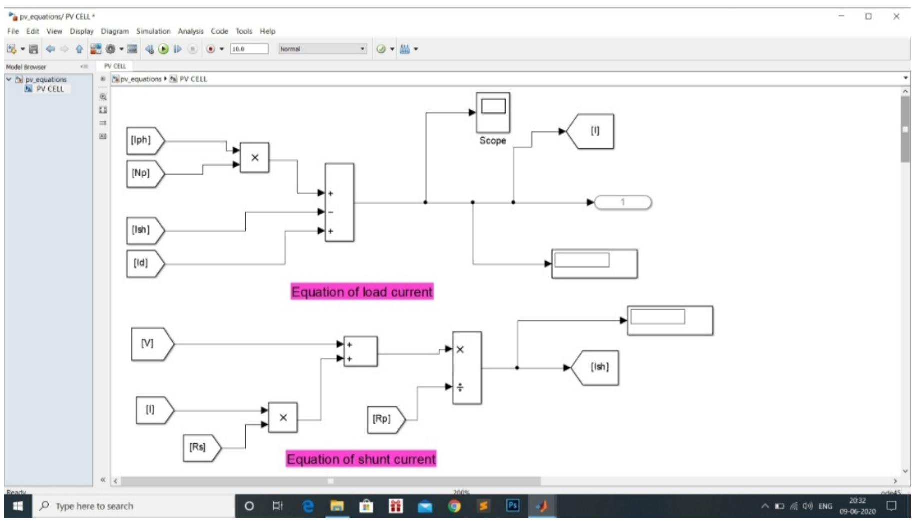
The term solar panel is used colloquially for a photo-voltaic module. A PV module is an assembly of photo-voltaic cells mounted in a framework for installation. Photo-voltaic cells use sunlight as a source of energy and generate direct current electricity.

There are several methods in modeling PV cell characteristics. The methods are numerical methods, analytical techniques, artificial intelligence techniques and linearization and Thevenin's equivalents.

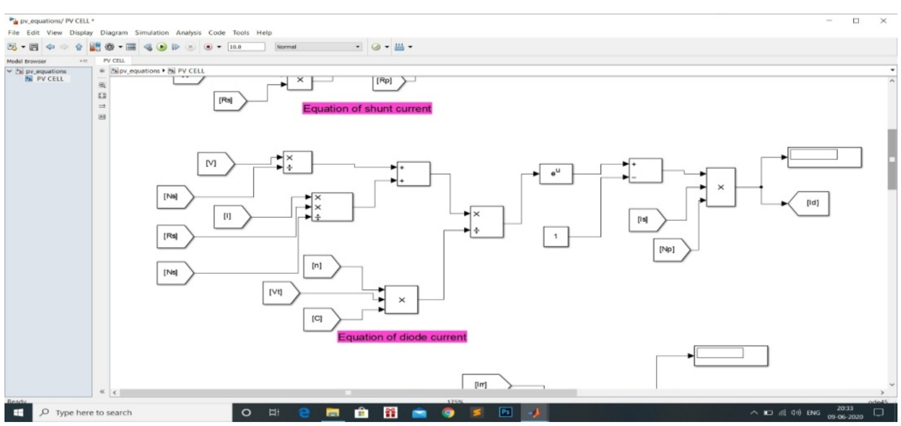
We will use analytical techniques.

Mathematical equations for the solar P-V modules are

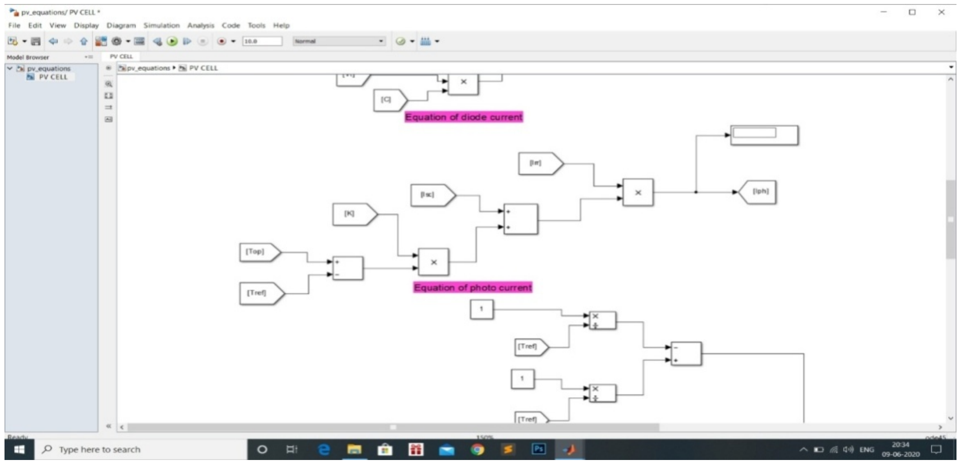
1) $I_{(load)} = I_{(photo)} * N_p - I_{(shunt)} - I_{(diode)}$
2) $I_{(shunt)} = \{v + I_{(load)} * R_s\} / R_p$



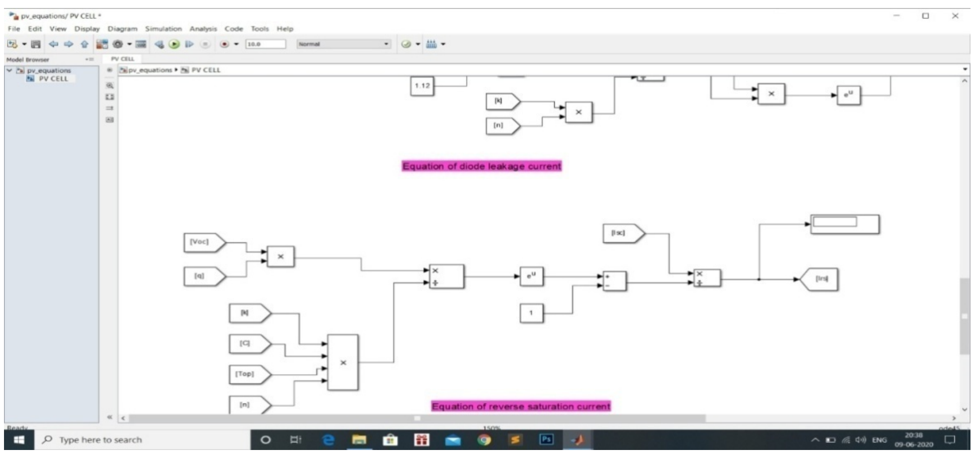
3) $I_{(diode)} = I_s * N_p * \exp[(V + I * R_s) / N_s]$



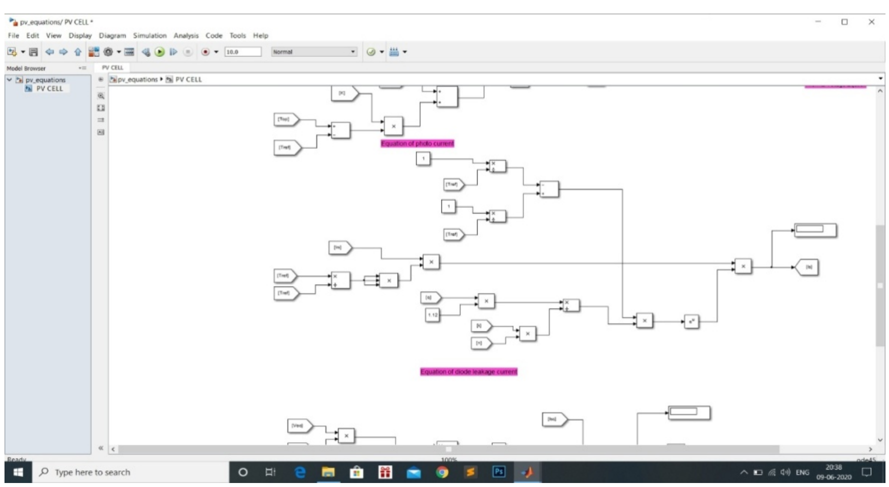
4) $I_{(photo)} = [(T_{op}-T_{ref}) *K+I_{sc}] *I_{rr}$



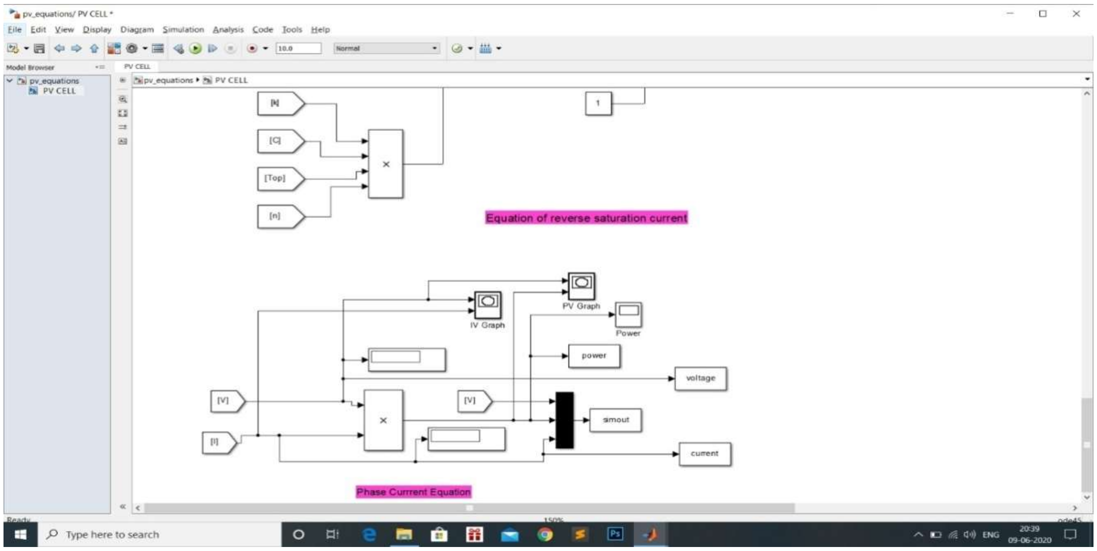
5) $I_{(rev\_sat)} = I_{sc}/[\exp\{(q*V_{oc}) /(N_s*K*C*T_{op})\} - 1]$



6) $I_{(dl)} = I(_{rev\_sat})*[\{T_{op}/T_{ref}\}\text{^}3]*\exp[\{(q*1.12)/(k*n)\}*(1/T_{ref} - 1/T_{op})]$



7) Phase Current Equation



2.5 Simulation model of P-V Module

The simulation model for P-V module is given in fig 2.5 below.

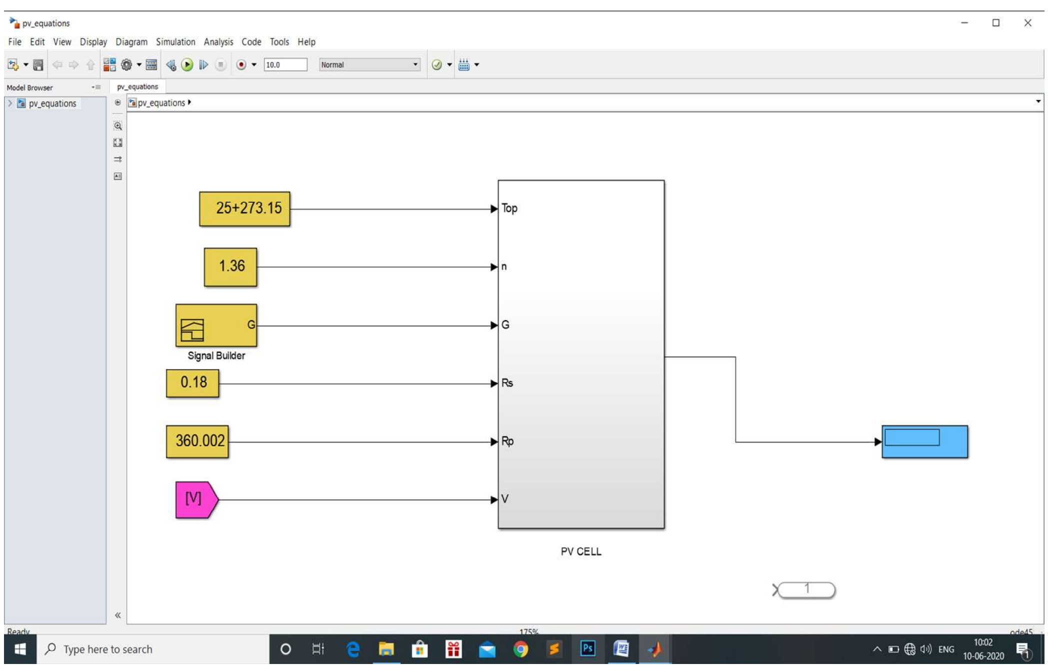


Fig 2.6: Simulation model of P-V Module

CHAPTER 3

BOOST CONVERTER

3.1 DC-DC Converter for Solar PV System

The DC-DC converter is used to supply a regulated DC output with the given DC input. These are widely used as an interface between the photovoltaic panel and the load in photovoltaic generating systems. The load must be adjusted to match the current and voltage of the solar panel so as to deliver the maximum power. DC/DC converters are described as power electronic switching circuits since they convert one 0form of voltage to another. These may be applicable for conversion of different voltage levels.

Generally three basic types of converters are accountable as per their use. They either step up by boosting voltage at output known as Boost Converter or by stepping down by reducing the voltage known as Buck converters. There is another class of converters used for both stepping up or down the voltage output described as Buck-Boost converters. Buck-Boost converters reverse polarity of output voltage, as such they are sometimes known as inverters.

3.2 Boost Converter

Boost converter steps up the input voltage magnitude to a required output voltage magnitude without the use of a transformer. The main components of a boost converter are an inductor, a diode, a capacitor and a high frequency switch. These in a coordinated manner supply power to the load at a voltage greater than the input voltage magnitude. The control strategy lies in the manipulation of the duty cycle of the switch which causes the voltage change. Figure 2.1 represents the circuit diagram of DC-DC boost converter.

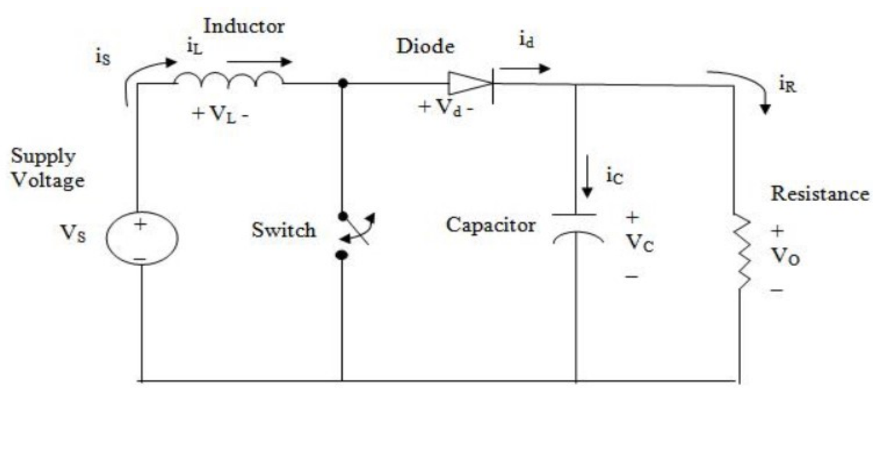


Fig 3.1: Circuit diagram of boost converter

3.3 Modes of Operation

There are two modes of operation of a boost converter. Those are based on the closing and opening of the switch. The first mode is when the switch is closed; this is known as the charging mode of operation. The second mode is when the switch is open; this is known as the discharging mode of operation

Mode I: Switch is ON, Diode is OFF

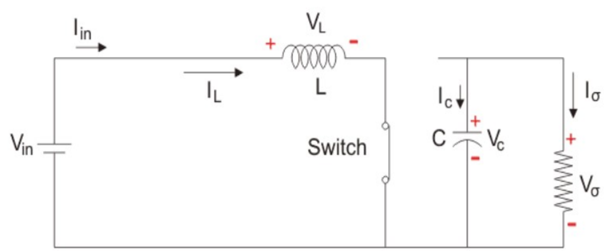


Fig 3.2: Switch ON, Diode OFF

The Switch is ON and therefore represents a short circuit ideally offering zero resistance to the flow of current so when the switch is ON all the current will flow through the switch and back to the DC input source. Let us say the switch is on for a time T_{ON} and is off for a time T_{OFF}. We define the time period, T, as $T=T_{ON}+T_{OFF}$ and the switching frequency,

$$f_{switching} = \frac{1}{T}$$

Let us now define another term, the duty cycle,

$$D = \frac{T_{ON}}{T}$$

Let us analyze the Boost converter in steady state operation for this mode using KVL.

$\therefore V_{in} = V_L$

$\therefore V_{in} = L\frac{di_L}{dt} = V_{in}$

$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{DT} = \frac{V_{in}}{L}$

Since the switch is closed for a time $T_{ON} = D_T$ we can say that $\Delta t = DT$.

$$(\Delta i_L)_{closed} = \left(\frac{V_{in}}{L}\right) DT$$

Mode II: Switch is OFF, Diode is ON

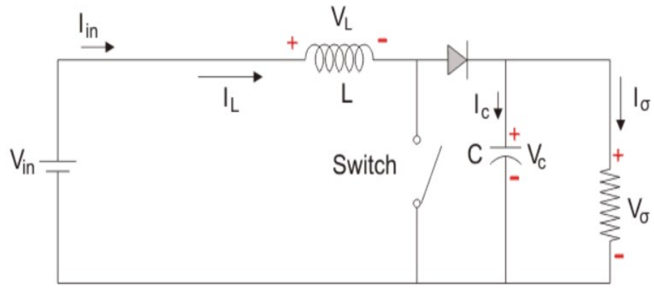


Fig 3.2: Switch OFF, Diode ON

In this mode, the polarity of the inductor is reversed. The energy stored in the inductor is released and is ultimately dissipated in the load resistance, and this helps to maintain the flow of current in the same direction through the load and also step-up the output voltage as the inductor is now also acting as a source in conjunction with the input source. But for analysis, we keep the original conventions to analyze the circuit using KVL.

Let us now analyze the **Boost converter** in steady state operation for Mode II using KVL.

$$\therefore V_{in} = V_L + V_o$$

$$\therefore V_{in} = L\frac{di_L}{dt} = V_{in} - V_o$$

$$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{(1-D)T} = \frac{V_{in-}V_o}{L}$$

Since the switch is open for a time $T_{OFF} = T - T_{ON} = T - DT = (1-D)T$ we can say that $\Delta t = (1-D)T$

It is already established that the net change of the inductor current over any one complete cycle is zero.

$$(\Delta i_L)_{closed} + (\Delta i_L)_{open} = 0$$

$$\left(\frac{V_{in}-V_o}{L}\right)(1-D)T + \left(\frac{-V_o}{L}\right)DT = 0$$

$$\left(\frac{V_o}{V_{in}}\right) = \frac{1}{1-D}$$

Where V_o is the output voltage, D is the duty cycle and V_{in} is the input voltage which in this case will be the solar panel voltage

3.4 Waveforms

Figure 2.4 shows the different characteristics of boost converters. It shows the source voltage, source current, inductor current and capacitor current with respect to time for a complete duty cycle.

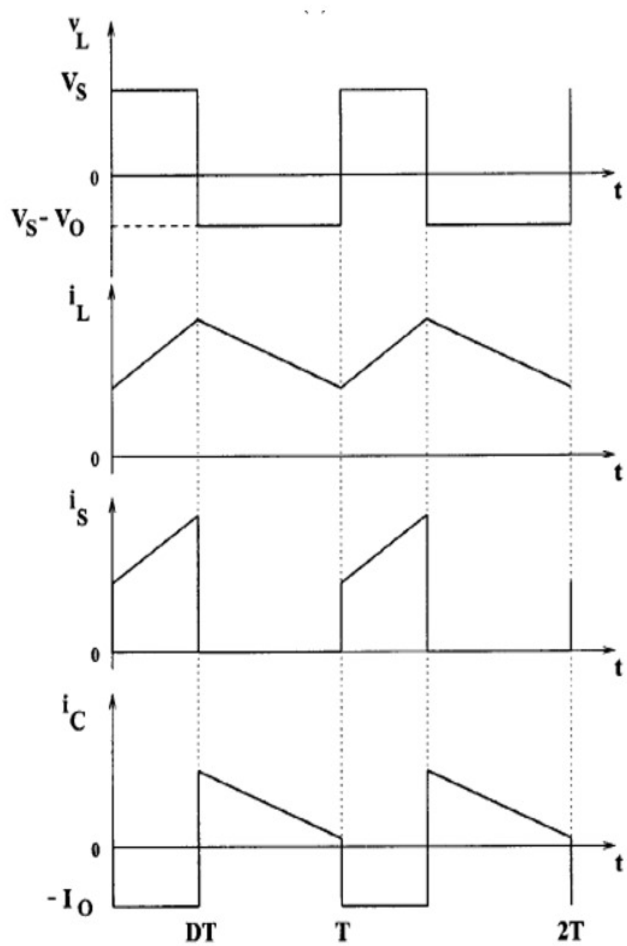


Figure 3.4: Waveforms of boost converter

It is assumed that the switch is made ON and OFF at a fixed frequency and let the period corresponding to the switching frequency is T. Given that the duty cycle is D, the switch is ON for a period equal to DT and the switch is OFF for a time interval equal to (1-D) T. The inductor is continuous and is greater than zero.

3.5 Modeling of Boost Converter

The DC-DC boost converter circuit consists of Inductor (L), Diode (D), Capacitor (C), load resistor (R_L), the control switch (S). The components are connected in such a way with the input voltage source (V_{in}) so as to step up the voltage. The duty cycle of the control switch controls the output voltage of the boost converter. Hence by varying the ON time of the switch, the output voltage can be varied. Thus, for the duty cycle "D" the average output voltage can be calculated using

$$\left(\frac{V_o}{V_{in}}\right) = \frac{1}{1-D}$$

Where, V_{in} and V_o are the input and output voltage of the converter respectively and D is the duty cycle of the control switch. In an ideal circuit, the output power of the converter is equal to input power which yields

$$P_o = P_{in}$$

$$i.e.\ V_o I_o = V_{in} I_{in}$$

A. Selection of Inductor

The inductor value of the boost converter are calculated using

$$L = \frac{V_{in}}{f_s \Delta I_L}$$

Where, f_s is the switching frequency and ΔI_L is the input current ripple. Current ripple factor (CRF) is the ratio between input current ripple and output current. For good estimation of inductor value CRF should bound within 30%.

The current rating of inductor should be always higher than that of the maximum output current.

$$\Delta I_L / I_o = 0.3$$

The current rating of the inductor should be always higher than that of the maximum output current.

B. Selection of Capacitor

The capacitor value can be obtained from

$$C = I_o / (f_s \Delta V_O)\ D$$

where ΔV_O is the output voltage ripple which is usually considered as 5% of the output voltage which yields ,

$$\Delta V_O / V_O = 5\%$$

3.6 Block diagram of Boost Converter

The DC-DC boost converter is designed for $V_{in} = 12\ V$, V_O=20.99 V, $I_o = 1.05$ amp.

Using these values the components values are calculated as follows L=200µH, C=50µF and R_L=20Ω. The block diagram is shown in the figure below.

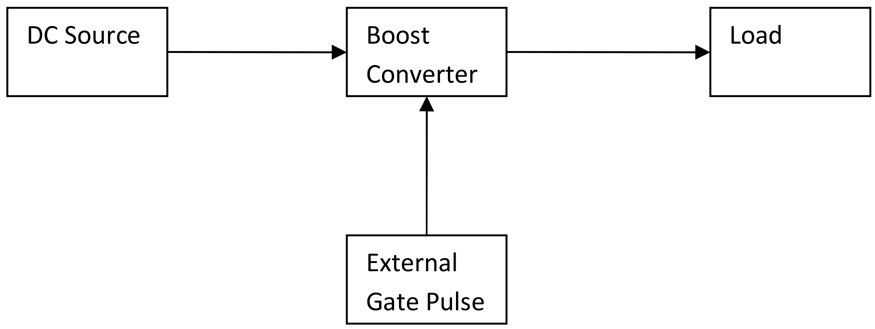


Fig 3.5: Block diagram model of boost converter

3.7 Simulation Model

The MATLAB simulation model for the above block diagram is given in fig below. It consist of one switch input voltage source, inductor, DC load and scopes to observe the output.

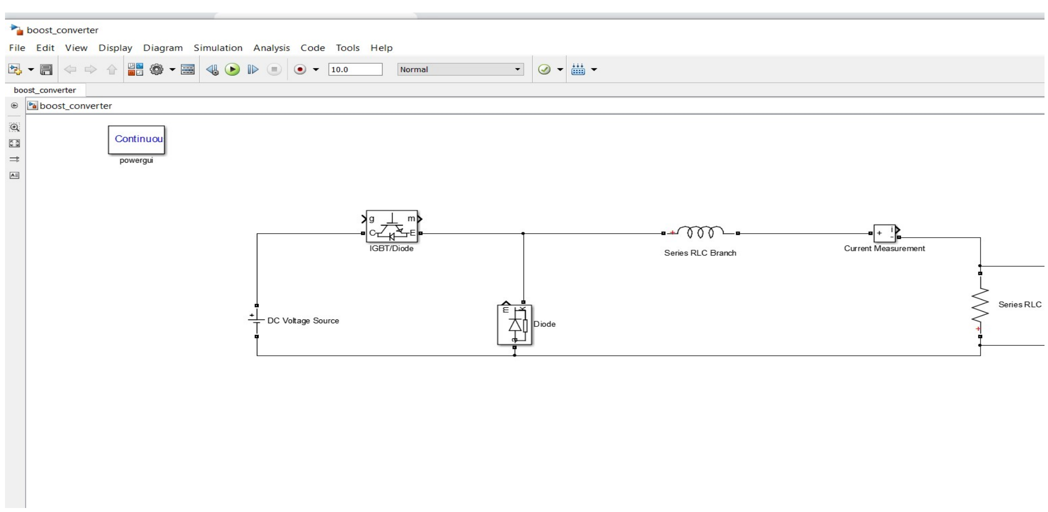


Fig 3.6: Simulation model of Boost

CHAPTER 4

MAXIMUM POWER POINT TRACKING

4.1 Modeling of PV Array and Performance Enhancement by MPPT Algorithm

This section proposes modeling and simulation of photovoltaic model. Taking into account the temperature and sun's irradiance, the PV array is modeled and its voltage current characteristics and the power and voltage characteristics are simulated. This enables the dynamics of PV system to be easily simulated and optimized. It is noticed that the output characteristics of a PV array are influenced by the environmental factors and the conversion efficiency is low. Therefore a maximum power tracking (MPPT) technique is needed to track the peak to maximize the produced energy. The maximum power point in the power- voltage graph is identified by an algorithm called perturbation & observation (P&O) method or Hill climbing. This algorithm will identify the suitable duty ratio in which the DC/DC converter should be operated to maximize the power output.

4.2 MPPT Technique Used in Solar PV System

The principal drawback of the PV Systems is their low efficiency. The typical efficiency of a solar cell is around 8-15%. In case of the solar panels, it becomes hardly 30-40%. That means the panels are capable to convert only 30-40% of the incoming solar irradiations into electrical power. So the fundamental aim of this part of the thesis is to increase the efficiency. There are several methods available, by which we can Improve the efficiency by matching the source and load properly. The maximum Power Point Tracking (MPPT) is on such method, which has a huge importance in the era of Photovoltaic Technology. Now-a-days this technique is vastly used to develop maximum possible power from a varying source under a variable temperature and irradiance conditions. We know the Maximum Power Transfer Theorem tells that the output power of a circuit is maximum, when the Thevenin impedance of a circuit i.e. the source impedance matches with the load impedance and complex conjugate to it. So, MPPT problem is one kind of impedance matching problem.

Solar cells have a very complex relationship between solar irradiation, temperature and the total resistance that develops a non-linear output efficiency which can be analyzed based on the I-V curve. So the main function of MPPT is to sample the output of the cells and apply the proper load to obtain the maximum power for any given location, time, season and environment conditions. The MPPT not only enables an increase in the power delivered from the PV module to the load, but also enhances the operating lifetime of the PV system. Various types of MPPT methods can be differentiated based on various features including the type of sensors required, convergence, speed, cost, range of effectiveness, implementation of hardware requirements, popularity etc.

The operating characteristics of a solar cell consist of two regions i.e. the current source region and the voltage source region.

In the current region, the internal impedance of the solar cell is high and this region is located on the left side of the current-voltage curve. The voltage source region, where the internal impedance is low, is located on the right side of the current-voltage curve.

As per Maximum Power Transfer Theorem, Maximum Power is delivered to load when source internal impedance matches load impedance. For determining MPP appropriate Tracker is introduced between PV system and load. It is to be designed that gives good performance, fast response, and less fluctuations. Since the efficiency of the PV is affected by the panel's irradiance and temperature which are stochastic and unpredictable.

For this reason, it is not possible to connect the load directly to the PV to obtain the maximum power, so it is necessary to include a balance of system (BOS). Typically this BOS is a DC-DC converted to adjust the properties of the load. This converter has the advantage of managing the power delivered to the load.

A DC/DC convertor (step up/ step down) serves the purpose of transferring maximum power from the solar PV module to the load. A DC/DC convertor acts as an interface between the load and the module. By changing the duty cycle the load impedance as seen by the source is varied and matched at the point of the peak power with the source so as to transfer the maximum power. This acts as adjustment to match impedance of source & load. MPPT is normally opened with the use of a DC-DC convertor (step up or step down). The location of the MPP is not known, but can be located, either through calculation models or by search algorithms.

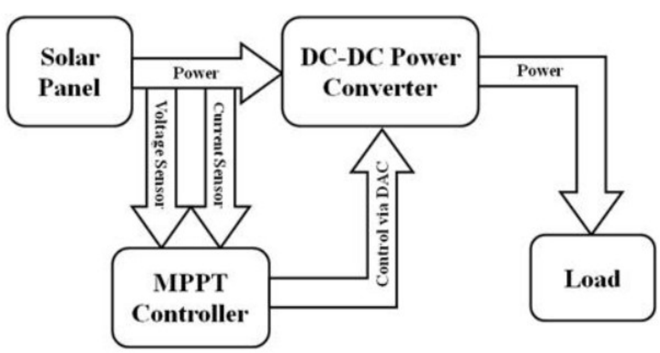


Fig 4.1: Block diagram of MPPT system

The typical block diagram of MPPT system considered for simulation study which is derived from the concept of basic block diagram are given in fig 4.1 and 4.2 respectively.

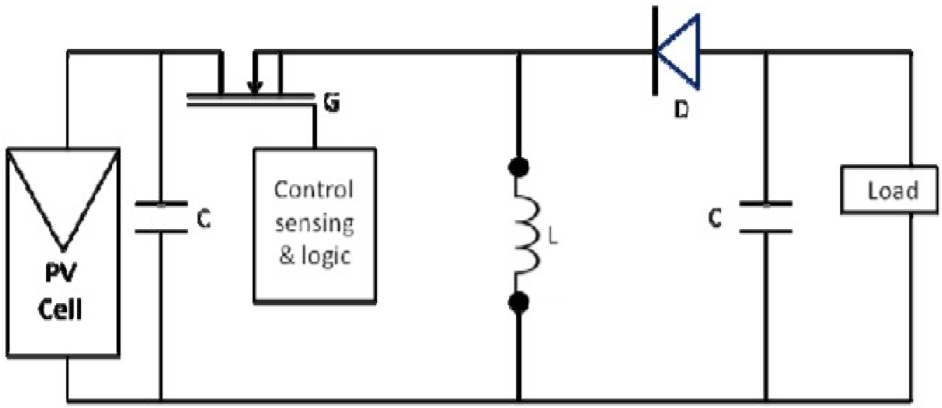


Fig 4.2: Block diagram of Typical MPPT System

There are several MPPT method exists in order to maximizing the output power. The existing methods are

a) Perturb and observation method.
b) Incremental conductance method.
c) Parasitic capacitance method.
d) Voltage based peak power tracking method.
e) Current based power tracking method.

Among all the MPPT methods, Perturb & Observer (P&O) and Incremental Conductance (IC) are most commonly used because of their simple implementation and lesser time to track the maximum point and also economic reasons.

MPPT technique	Convergence Speed	Implementation Complexity	Periodic Turning	Sensed parameters
P & O	Varies	Low	No	Voltage
INC	Varies	Medium	No	Voltage current
Fractional V_{OC}	Medium	Low	Yes	Voltage
Fractional V_{IC}	Medium	Medium	Yes	Current
Fuzzy Logic	Fast	High	Yes	Varies

Table 4.1: Characteristics of different MPPT Techniques

4.3 Perturb and Observer MPPT Method

The P&O algorithms operate by periodically perturbing (i.e. incrementing or decrementing) the array terminal voltage or current and comparing the PV output power with that of the previous perturbation cycle. If the PV array output changes and power increases (dP/dV > 0), the control system moves the PV array operating point in that direction; otherwise the operating point is moved in the opposite direction. In the next perturbation cycle the algorithm continues in the same way.

A common problem in P&O algorithms is that the array terminal voltage is perturbed every MPPT cycle; therefore when the MPP is reached the output power oscillates around the maximum, resulting in power loss in the PV system. Perturb & Observe (P&O) is the simplest method and is widely used. In the technique we generally use only one sensor, that is the voltage sensor, to sense the PV module voltage and hence the cost of implementation is less and hence easy to implement without any complexity.

The time complexity of this algorithm is very less for calculating the maximum power but on reaching very close to the Maximum Power Point (MPP) it doesn't stop at the MPP and keeps on perturbing on both the directions so for that reason it have multiple local maximum at the very same point. First of all the algorithm which reads the value of the current and voltage from the photovoltaic module from that power is calculated the value of voltage and power at that instant is stored. Hence slight perturbation is added in the increasing direction. The next values at the next instant are measured and power is again calculated. Hence, by adjusting the maximum power duty cycle can be obtained based on it.

In certain situation like changing atmospheric conditions and change in irradiance the maximum power point shifts from its normal operating point on the PV curve. In the next iteration it changes its direction and goes away from the maximum power point and results in multiple local maxima at the same point as shown in fig 4.2. So the maximum power point deviates from its original position.

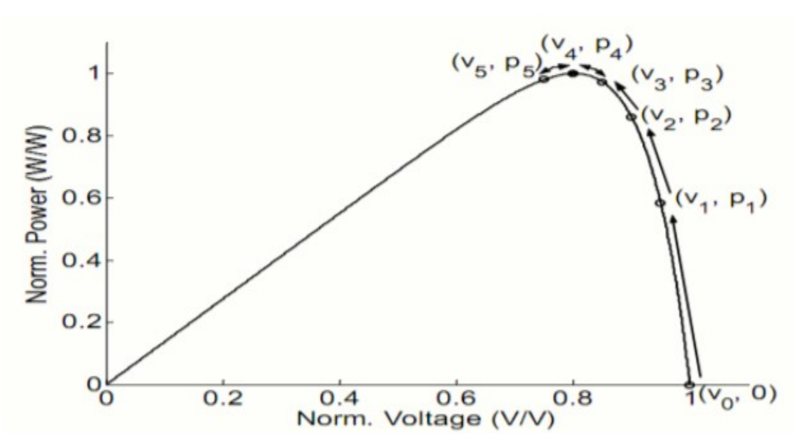


Fig 4.3: P-V Curve

4.4 Algorithm for Perturb and Observe Technique

a) Read the value of current and voltage from the solar PV module.
b) Power is calculated from the measured voltage and current.
c) The value of power and voltage at k^{th} instant are stored.
d) The next values at $(k+1)^{th}$ instant are measured again and power is calculated from the measured values.
e) The power and voltage at $(k+1)^{th}$ instant are subtracted with the values from k^{th} instant.
f) In the power voltage curve of the solar PV module, it is inferred that in the right hand side curve where the voltage is almost constant and the slope of power voltage is negative (dP/dV<0) where as in the left hand side, the slope is positive (dP/dV<0). Therefore the right side of the curve is for the lower duty cycle (nearer to zero) where as the left side curve is for the higher duty cycle (nearer to unity).
g) Depending on the sign of the dP i.e. (P(k+1) - P(k)) and dV i.e. (V(k+1) – V(k)) after subtraction the algorithm decides whether to increase the duty cycle or to reduce the duty cycle.

4.5 Flow Chart of Perturb and Observe MPPT Algorithm

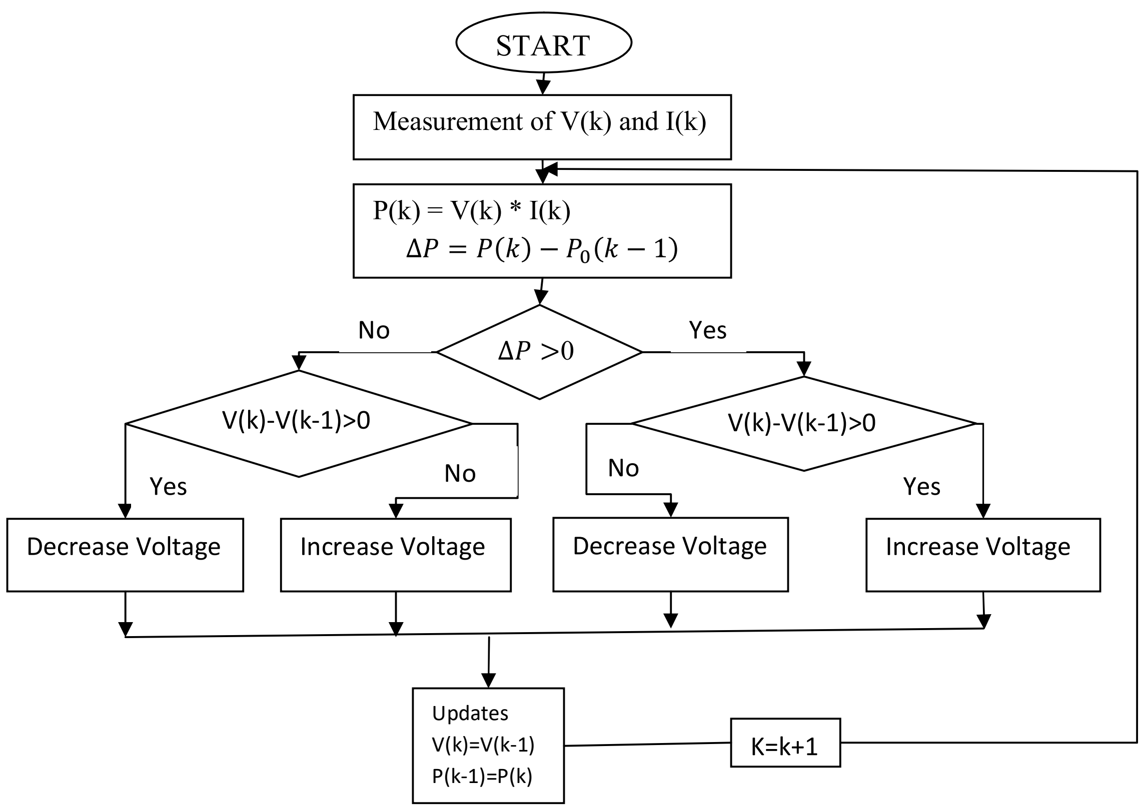


Fig 4.4: Flow Chart of Perturb and Observe MPPT algorithm

4.6 Limitations of Perturb and Observe Algorithm

In a situation where the irradiance changes rapidly, the MPP also moves on the right hand side of the curve. The algorithm takes it as a change due to perturbation and in the next iteration it changes the direction of perturbation and hence goes away from the MPP as shown in the fig 4.5. However, in this algorithm one sensor is used as voltage sensor, to sense the PV array voltage and so the cost of implementation is less and hence easy to implement. The time complexity of this algorithm is very less but on reaching very close to the MPP it doesn't stop at the MPP and keeps on perturbing in both the directions. When this happens the algorithm has reached very close to the MPP and an appropriate error limit is set or a wait function can be used which ends up increasing the time complexity of the algorithm.

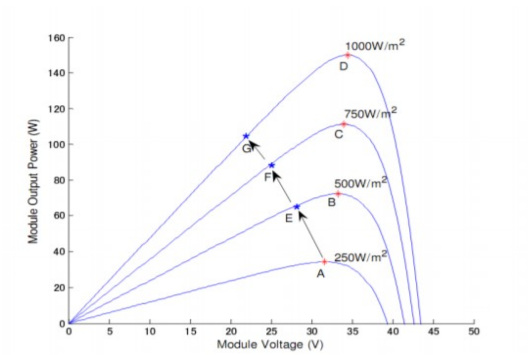


Fig 4.5: Curve showing wrong tracking of MPP by P&O algorithm under rapidly

4.7 Simulation Model of P&O

The figure below shows the simulation model of Perturb and Observe done on MATLAB.

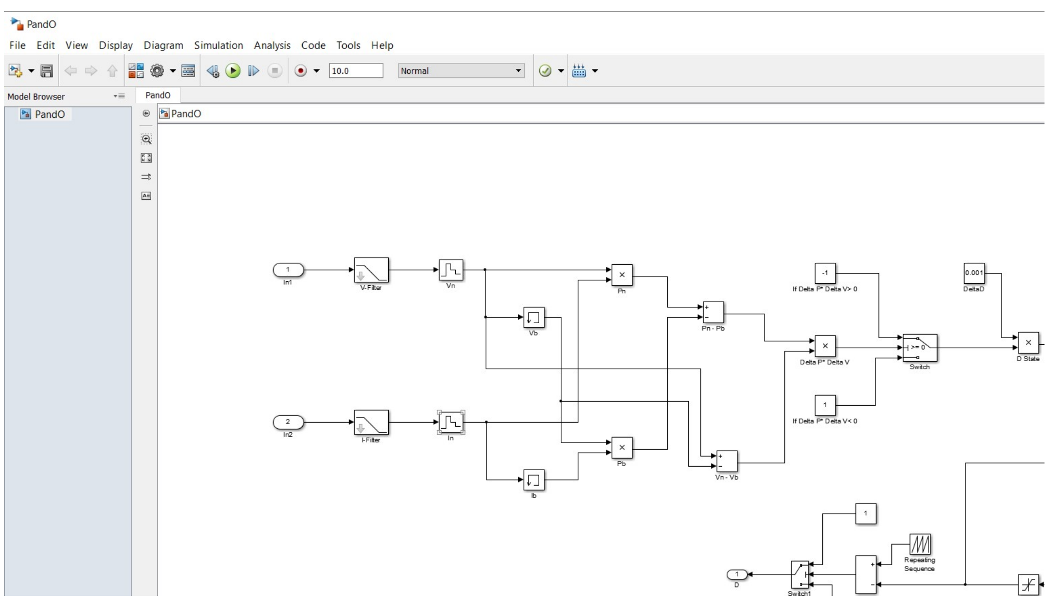


Fig 4.6: Simulation model of P&O

CHAPTER 5

Conclusion and Future Work

5.1 Conclusion

In this chapter, the photovoltaic system with DC-DC boost converter and maximum power point controller has been designed and constant voltage of 21.5V is maintained at the output side of the converter. For the specified input variation, a regulated dc output voltage of 21.5V has been obtained resulting in an efficiency of 95%. It is concluded that Perturb & Observe method has better efficiency compared to Incremental Conductance method at low power. In this case, Perturb & Observe method gave an increase of 2.6% in voltage, 5.3% increase in current and 7% increase in power at low power output, but is inefficient in case of sudden change in irradiance level. From the modeling of boost converter, it was also observed that the output voltage of the boost converter increases along with the increase in duty cycle.

5.2 Future Work

Improvement to this project can be made by tracking the maximum power point in changing environmental conditions. Environmental change can be change in solar irradiation or change in ambient temperature or even both. This can be done by using Simulink models to carry out MPPT instead of writing it code in Embedded MATLAB functions. In the Simulink models the solar irradiation and the temperature can be given as variable inputs instead of constant values as done here.

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