FACULTY OF ELECTRICAL ENGINEERING

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FINAL YEAR PROJECT REPORT

COMPARATIVE STUDY ON DIFFERENT CONFIGURATION OF INVERTER FOR PV SYSTEM

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“ I hereby declare that I have read through this report entitle “ Comparative Study On Different of Inverter Configuration for PV System” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Power Electronics and Drives)”

Signature : …….

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COMPARATIVE STUDY ON DIFFERENT OF INVERTER CONFIGURATION FOR PV SYSTEM

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A report submitted in partial fulfilment of the requirement for the degree of

Power Electronics and Drives

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2012

"I declare that this report entitle "Comparative Study on Different of Inverter Configuration for PV System" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….

Name : …….

Date : …….

ACKNOWLEDGEMENT

ASSALAMUALAIKUM,

Alhamdulillah prises to Allah s.w.t because with His permission, I have completed my final year project with report in successful between 2 semesters of period. During this period get new experiences that useable to me in future on handling task or project.

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ABSTRACT

The renewable energy nowadays, becomes more popular. It can be in types of solar energy, biomass energy, wind energy and so on. Renewable energy has been used in various applications but the main purpose is generic electricity. The solar energy is the main source of energy in our solar system. Solar energy has used for a system called photovoltaic system. In photovoltaic system there are varieties of element in generic the electricity such as inverter. The main purpose of this project is comparing three configurations of inverter which are string inverter, micro inverter and power optimizer that used for photovoltaic system. There are three configuration of inverter to be study on finding differentiate of each characteristic and behaviour. This project can be understanding by searching and find information from several of medium resource such as book, journal, article, and view from web or internet, interview and so on. The circuit has been simulated by PSCAD software. By PSCAD the observation of the characteristic had done. In this project, the target result of comparing three configuration of inverter is power optimizer.

ABSTRAK

Pada masa kini, penggunaan tenaga yang boleh diperbaharui semakin mendapat sambutan. Tenaga jenis ini berbentuk seperti tenaga solar, tenaga biomas, tenaga angin dan sebagainya. Tenaga yang boleh diperbahrui ini digunakan dalam pelbagai bentuk kegunaan tetapi kegunaan utama adalah untuk menjana elektrik. Tenaga solar merupakan sumber tenaga yang utama di dalam sistem solar kita. Tenaga ini telah mencetus satu sistem yang dipanggil "Photovoltaic System". Terdapat pelbagai elemen komponen dan bahagian yang digunakan dalam penjanaan melalui sistem ini. "Inverter" merukan salah satu element yang penting dalam sistem ini. Tujuan utama projek ini adalah membandingkan tiga jenis "inverter" berlainan konfigurasi iaitu "string inverter", "micro inverter" dan "power optimizer" yang digunakan dalam "photovoltaic system". Ketiga-tiga konfigurasi "inverter" ini mempunyai sifat, ciri-ciri dan fungsi yang berbeza. Projek ini dapat difahami dengan membuat kajian melalui pembacaan dan hasil carian maklumat yang pelbagai termasuklah dari buku, jurnal, artikel, laman-laman internet, hasil temuramah dan sebagainya. Projek ini juga melibatkan simulasi litar setiap konfigurasi "inverter" dengan menggunakan perisian PSCAD. Dengan perisian PSCAD ini, pemerhatian, analisis dan kesimpulan berkait dengan sifat dan ciri-ciri konfigurasi "inverter" dapat dilakukan. Di akhir projek perbandingan ketiga-tiga konfigurasi "inverter" ini dijangkakan "power optimizer" adalah konfigurasi "inverter" yang terbaik dari segi keberkesanan berfungsi dan ciri-ciri yang terdapat padanya.

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CHAPTER 1

INTRODUCTION

In chapter 1, there are discussing about the introduction of PV system in term of renewable energy and solar energy. The objective of the project can understand in flow of the system. It started from renewable energy, solar energy, PV system and inverter configuration. The PV system and inverter will explain and discuss in chapter 2. In this chapter also discuss about the problem statement, objective and scope of the project.

1.0 Renewable Energy

Recently, the needs of alternative energy source has being extremely increase as the world's energy demands rises. Early in 1950s, public have concern regarding on the negative environment impact of burning fossils fuels encouraged engineers and scientist to develop reliable alternative energy resources. Many countries began encouraged the development and testing of reliable renewable energy systems in invested into renewable energy through various programs [8].

Renewable energy is a phrase that is loosely used to describe any form of electric energy generated from resources other than fossil and nuclear fuels. This resources have include hydropower, wind, solar, wave and tide, geothermal and hydrogen. From all of that, the sun is the sources with the exception of geothermal and tidal energy. These resources have much less and no produced pollutions than burning fossils fuels and are constantly replenished [8].

Scientists and engineer have work since late 19th century on developing technologies in varies form of the renewable energy to generate electricity. Sir William George Armstrong invented a hydroelectric machine that produced frictional electricity in 1842. The first geothermal power plant in 1904 has invented by the Italian Prince, Piero Ginori Conti. The power plant has located at Larderello, Italy. Renewable energy field has developed during the past few years have led [8].

Regarding on 2008, renewable electricity has comprised electricity from hydro, wind, biomass, geothermal energy and solar energy. This has proven in figure 1.1 below. Renewable electricity has growing about 15.1%, in 2006, 15.8% in 2007 and 16.6% in 2008 with normalised hydro and wind electricity is mainly due to increasing installed capacity of wind turbines and solar energy installation [23].

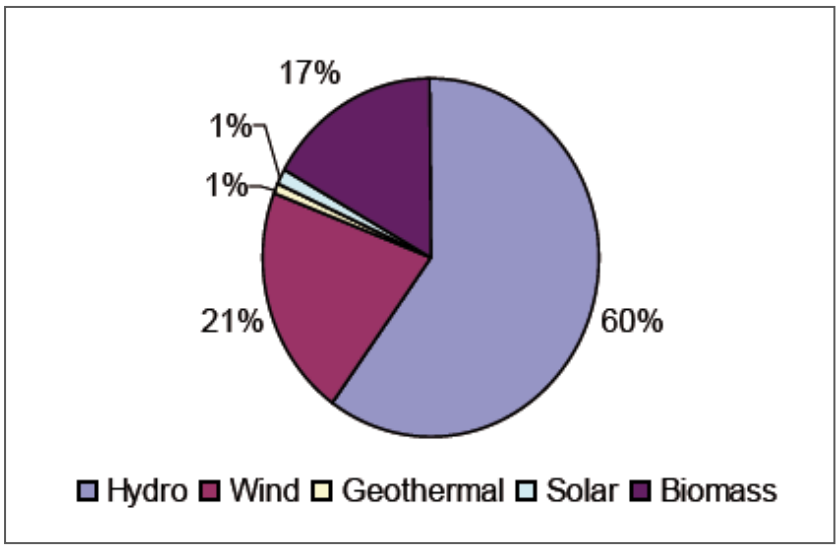

Figure 1.1: EU-27 renewable electricity by source in 2008 [23].

The primary source of energy in our solar system is the sun. Around 90% of the energy from sun was gain by the earth. The solar energy was named as Photovoltaic system. The photovoltaic system is from two words; photo means sunlight and voltaic means voltage [10]. It can be defined as conversion from sunlight to electricity energy. In this system, it have module of photovoltaic system, mechanical component and electrical and electronic component in providing the output desired [8].

Solar energy is typically harnessed by two methods. It is passive and active method. A passive solar energy system uses the sunrays directly to heat liquid or gas. The heated liquid or gas can then be used for air and water conditioning and industrial processes. An active system converts the sun's energy into electrical energy by using a photovoltaic (PV) semiconductor material called solar cell. The electricity generated can be used locally, exported to the power grid or both. The PV system have been categorizes into two types. There are grid-connection system means to operate in parallel with and interconnected with the electric utility grid. Second, is standalone system is independent of the electric utility to supply certain DC and/or AC electrical load [8].

Photovoltaic system has been introduced on the conventional photovoltaic cells in lately 1950s. In 1960's the application of the PV system on electrical power of earth in orbiting satellites were provided in principally. It has used on the Vanguard 1 orbitaring satellite. In space application eventually led to improved production efficiencies, higher conversion efficiencies, higher reliability and lower cost [9]. 1970's the system have improvement on manufacturing, performance and quality of the PV modules system. It had helped in reducing cost and opened up a number of opportunities for powering remote terrestrial application. For example battery charging for navigational aids, signals and low power needs. It becomes more popular on 1980s for customer electronic device such as calculator [4].

1.1Problem Statement

Photovoltaic system is a system which converts sunlight into electricity that absorb by solar panel. The system consists of basic element of panel array, maximum power point tracking (MPPT), battery, controller, inverter and load. Inverter is an electrical device that converts direct current to alternating current. The converted AC can be at any required voltage and frequency with the use of appropriate transformer, switching and control circuit. Nowadays, Malaysia has applied this technology in standalone system. However, conventional (string) inverter has used in their system. In conventional system, the producing output desired is not efficient. It cause from shading issues, compatibility, performances and more. However, the price is cheaper than other inverter. To overcome this problem, there are many of configurations for inverter that can use in photovoltaic system such micro inverter and power optimizer. This project is doing by comparing this inverter configuration on the performances, capabilities, reliabilities, reflection to shading and so on.

1.2 Objectives

The objectives of this project are;

i. To do study on performance on three inverter configuration that implemented in Malaysia.
ii. To determine the best performance inverter configuration and get one yield the most output for photovoltaic system in standalone system.
iii. To perform simplified simulations by using PSCAD on different configuration of inverter in PV systems.

1.3 Scopes

The scopes of this project are;

i. Three inverter configuration was studied namely string inverter, micro inverter and power optimizer.
ii. The simulation has done by using PSCAD in a simplified standalone configuration.
iii. The distance between the array and the inverter is 10 meters.
iv. The study describes the technology involves, characteristics of the configuration and the system.

CHAPTER 2

LITERATURE REVIEW

In chapter 2, on the literature review have discuss about the PV system and configuration of inverter. In the PV system, the background of system, types of PV system and PV system elements are explained.

2.0 Photovoltaic System

Becquerel in 1839 first person discovered the ability of certain material in converting the sunlight into electricity [8]. Then, German physicist Heinrich Hertz in 1887 has refined the finding. In generating low voltage is not useful for most power equipment and appliances designed for alternating current. Converter is needed to change the low voltage DC waveform of the PV arrays to an alternating current waveform at the frequency and voltage levels required by the load equipment. The solar arrays and the converter are the main component in the PV system. PV systems typically have two designs in storage and direct system [8]. PV system also has the two categories which are the grid-connected system and stand alone system [4].

This system is offer inherent of the advantages and the disadvantages. The advantage of this system is one of alternative natural source in supplying electricity to consumer. It can be designed in variety of application and operational requirement and for either centralized or distributed power generation. PV system also is modular easily expandable and transportable even in some case. Knowing that, PV system got source from natural source so the energy is independence and environment compatibility. It's also provided minimal maintenances and long service lifetimes. The most interesting is there is no bill to pay. However, PV system need high cost of PV modules and equipment. Otherwise, is limited surface area requirement in some case [4].

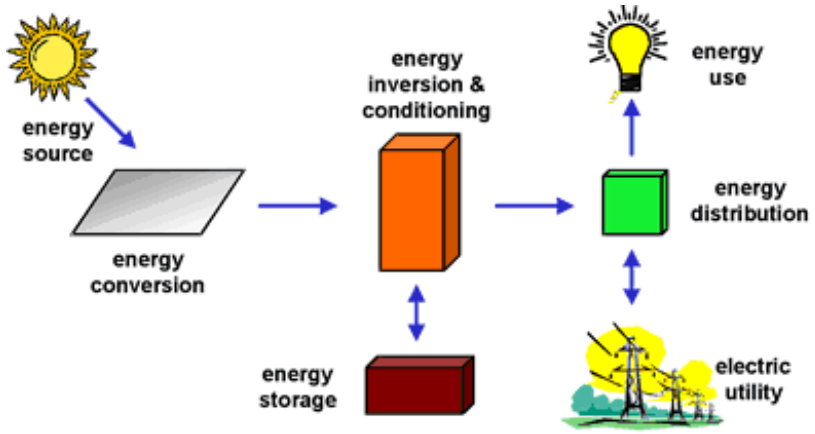

Figure 2.1: Basic figure of operation [4]

Figure 2.1 show the basic operation of the PV system. PV modules have absorbed the sunlight. The PV modules have arranged in arrays form. It can be connected in series or parallel form in order to get the highest energy form. Then, the source of sunlight will convert into electricity energy in direct current (DC) form. In division of energy inversion and conditioning, DC source will go through to maximum power point tracking (MPPT) to stabilize the voltage and send the surge current to inverter. The energy is transfer to inverter in functions to convert from the DC to AC source. The DC source energy also transferred to the battery to be store as storage element in providing supply to the electric load either at during night or cloudy weather. After converting the source to alternate current (AC), the energy will distributed to the utility or electrical load [4].

2.0.1 Types of the PV system.

a) Grid –Connected System

Grid-connection system means to operate in parallel with and interconnected with the electric utility grid. The primary of this system is the inverter also called as power conditioning unit. The inverter converts the DC power into AC power constantly with the voltage and power quality requirement of the utility grid and automatically stops supplying power to the grid when the utility grid is not energized. Between the PV system AC output circuit and the electric utility network, bi-directional interface is made up. This can allow the AC power produced to either supply to electrical load or to feed back to the grid utility when the PV system output is greater than the on-site load demand [4]. The system of this type has shown in figure 2.2.

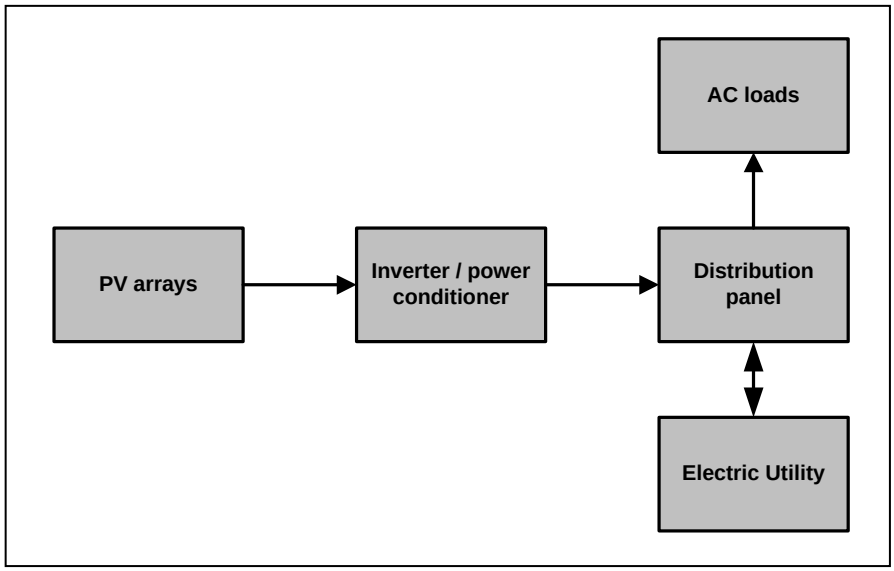

Figure 2.2: Diagram of grid-connected photovoltaic system [4].

b) Stand Alone System

Standalone system is independent of the electric utility to supply certain DC and/or AC electrical load. Stand alone system are divided into two types of design in storage design or direct design. In direct PV system is the simplest of the PV system because the module of the PV arrays is connected directly to the load of DC. Figure 2.3 below is describes in block diagram. Since there is no storage element the system only operates during daytime. This system can apply to the ventilation fans, water pump and small circulation pumps for solar thermal water heating. The maximum power output are critical and not in good performing. The maximum power point tracker (MPPT) is used between the array and load in order help better utilize the available output [4]. To achieve the desired performance without the MPPT, large of PV arrays are required for the system give the desired output [9].

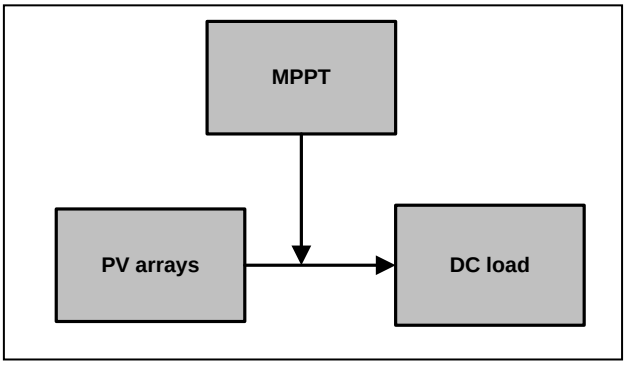

Figure 2.3: Direct coupled PV system [4].

In many stand alone system batteries are used for element that store the energy. Figure 2.4 is showed the flow of configuration [4]. This system is very applicable during cloudy days or after sundown. For this application, the deep discharge variety of lead acid battery is used. Design of a system with storage element need to consider the number of storage days required, determining system losses, determining the battery and array requirement. Selecting correct appropriate charge controller, inverter or other related equipment such fuses, wires and so on are required [9].

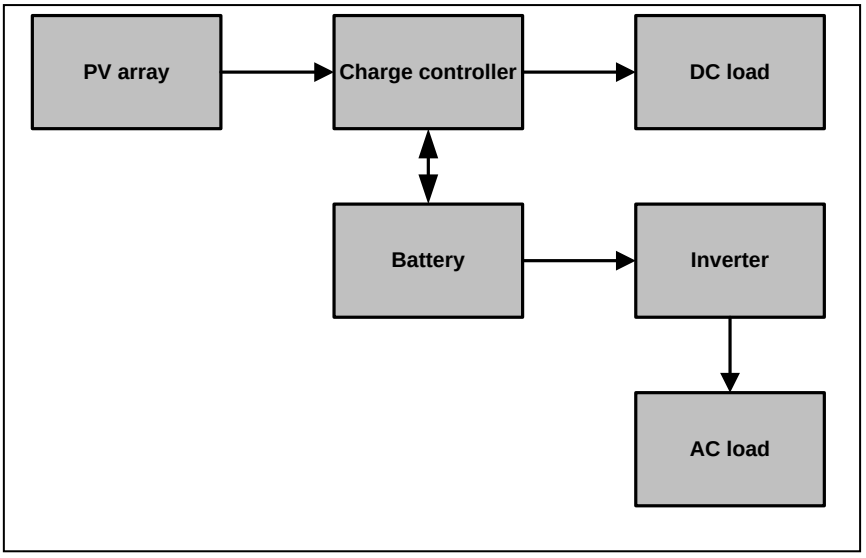

Figure 2.4: Diagram of standalone system with battery as storage [4].

2.0.2 Photovoltaic System Element

a) Solar panel

Solar panel is a form of active solar energy. It's converting sunlight into electricity to be used immediately or stored in a battery. Solar cells are made of semiconductor materials that included silicon. Several components are added in the construction of the solar cells such as a cover glass, antireflective coating and connecting grid. The cover glass is mounted on top of the cell to protect it from the harsh environment. Antireflective coating is used reduce the reflection losses of silicon because silicon is a very shinny material. A contact grid is used to collect the electron from the top of the n-type material [8].

There are two types of PV cell. It is concentrating in figure 2.5 and flat-plate as in figure 2.6. The cell consists of a lens mounted on the top of the n-type material. The p-types material is the base of the cell. When the cell is illuminated, the electrons move from the n-type to the p-type of the terminal. The energy has acquired by the electrons is discharged in the load resistance [8].

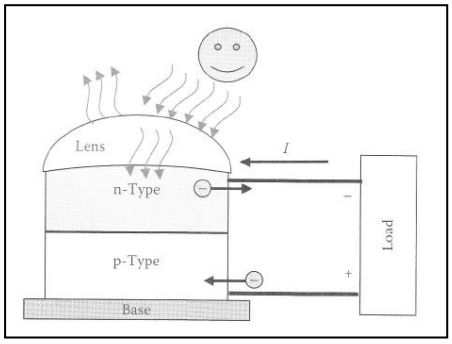

Figure 2.5: Concentrating PV cell [8]

The flat-plate PV cells are in rectangular and flat form. These common types of PV cell that used in commercial application. It often mounted at fixed of angles that maximize the exposure to the sun. The angle solar panel change into track of the optimal sun exposure during the day is more flexible system. When the sky is clear from clouds concentrating cell operate in best function. Flat-plate of the PV cell still produced electricity even in diffused light through the cloud while concentrating generates less power with it. Each cell of the flat-plate PV cell is connected in grid connection [8].

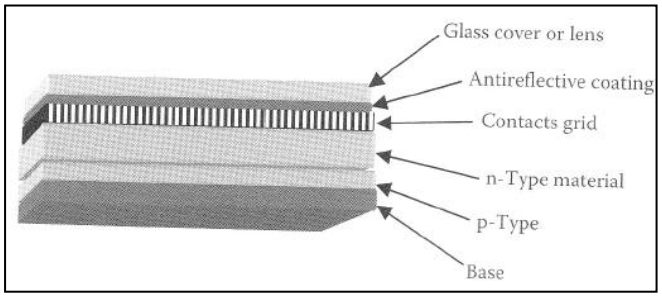

Figure 2.6: Main part of PV cell [8].

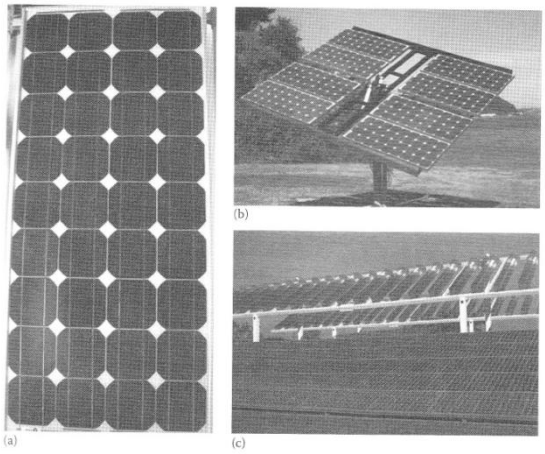

Figure 2.7: PV Module,arrays and system [8].

Then, by combined it the cell has became larger and called as module. Then, in system the module has connected with other module and has called as panel of the solar [8]. PV arrays are creates by connecting a number of panel and have arrange it in properly. The power available from one module is inadequate for the load. It does also can be connected in series, parallel or both to increase either output voltage or current. More sophisticated PV arrays are mounted on tracking devices that follow the sun throughout the days. To maximize the exposure of the cell to the sunrays thus increasing the output power of the system the tracking devices tilt the PV arrays [8].

The characteristic of the PV cell are as follow;

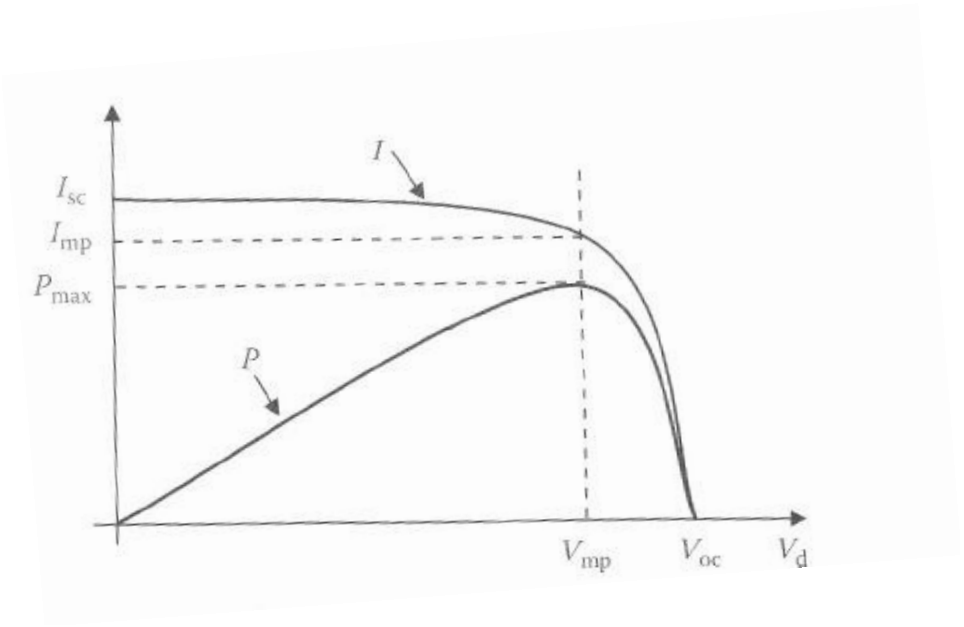

Figure 2.8 : Current-voltage and power-voltage characteristics of PV cell [8].

When the load current is zero, The PV voltage is at its maximum value known as open circuit voltage V_{oc}. If the load current increase, the voltage stay almost constant initially so substantially decrease until it reaches zero. At zero voltage, the output current of the PV is called short circuit current.