Modeling of Power Response of Photovoltaic Model Using Perturbation-Observation and Incremental Conductance Methods

by

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بسم الله الرحمن الرحيم

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LIST OF ABBREVIATIONS

PV	Photo voltage
D	Duty cycle
$v_{control}$	Voltage in control diode
$\hat{V}_{st}$	Saw tooth voltage
v_d	Regulated dc supplies
MPPT	Maximum power point tracking
K_{MV}	Voltage factor in
V_o	Opine circuit voltage
I_{sc}	Short citrcu t curent
K_{MI}	Current factor
Rsh	Shunt resistance
G	The irradiation w/m^2 (the light intensity)
Iph	The measured solar current –generated
Is	The saturation current of diode
Vt	The thermal voltage, kT/q
K	The Boltzmann constant
T_c	The temperature of Device parameter value
Q	The electron charge
N	The quality factor (diode emission coefficient)

Pemodelan Power Response Photovoltaic Model Menggunakan Perturbation Dan Pemerhatian dan Kaedah Conductance Incremental

ABSTRAK

Pencarian sumber tenaga masih merupakan satu masalah utama dalam era ini dan ia masih merupakan salah satu focus penting untuk banyak negara. Tenaga yang boleh diperbahurui menjadi salah satu trend yang cepat berkembang di industry sebab ia boleh digunakan untuk menyelesaikan masalah kekurangan sumber tenaga. Dalam masa yang sama, matahari bertanggjungjawab kepada kebanyakan tenaga yang terdapat di dunia ini. Sistem photovoltaic yang mendapat tenaga daripada matahari and menukarnya kepada tenaga elektrik, merupakan salah satu penyelesaian yang terbaik untuk menyelesaikan masalah kekurangan tenanga. Dalam sistem ini, terdapat satu titik yang dipanggil Maximum Power Point (MPP) yang mewakili tenaga keluaran maksimum yang dijanakan oleh sistem. Tetapi system ini boleh diganggu oleh faktor-faktor persekitaran seperti sinaran dan suhu. Oleh sebab itu, perubahan dalam faktor-faktor persekitaran akan menjejaskan nilai MPP dan penggunaan cara pengesanan boleh mengembalikan sistem kepada nilai maksimum. Cara ini dipanggil kaedah Maximum Power Point Tracking (MPPT). Terdapat banyak kaedah dalam bidang ini dengan prestasi berbeza. Variasi ini menyebabkan kekeliruan dalam pemilihan kaedah Maximum PowerPoint Tracking. Dalam penyelidikan ini, banyak jenis kaedah pengesanan telah dikaji dan diklasifikasikan berdasarkan ketepatan, kelajuan pengesanan dan kerumitan dengan mempertimbangkan kaedah Perturbation and Observation (PO) dan Incremental Conductance (IC) kerana kaedah-kaedah ini merupakan kaedah yang paling biasa untuk memilih cara pengesanan maksimum yang sesuai digunakan di Malaysia. Teknik pemodelan telah digunakan dan diuji untuk membuat perbandingan antara dua kaedah tersebut. Model ini menggunakan sinaran dan suhu sebagai parameter input untuk memberi satu petunjuk prestasi antara variasi tenaga output dengan masa. MATLAB telah digunakan dalam penyelidikan ini. Keputusan menunjukkan masa tindak balas yang lebih baik dan prestasi yang lebih lancar apabila menggunakan kaedah Incremental Conductance (IC) berbanding dengan kaedah Perturbation and Observation (PO) untuk Malaysia.

Modeling of Power Response of Photo-Voltaic Model Using Perturbation & Observation and Incremental Conductance Methods

ABSTRACT

Since the search of the energy source considered as one of the main problems in this era, then it will be still one of the most important concerns of the countries. The renewable energy became one of the faster-growing trends in industrial societies since it becomes used for solving shortfall problem in the energy source. In the meantime, the sun is responsible for almost all the energy available on the earth. Photovoltaic systems, which gets the energy from the sun and convert it to electrical energy is one of the best solutions to solve the shortage problems. In this system, there is one point called Maximum Power Point (MPP) representing the maximum output power that can be generated from the system, but the system will be disturbed by changing the environment factors like irradiance and temperature. Therefore, the changing of environment factors will effect on the value of MPP, and make the system back to a maximum value by using the tracking methods. It is called Maximum Power Point Tracking Method (MPPT). There are many methods in this field with a different performance because this variation leads to confusion in the selection of the suitable Maximum Power Point Tracking Methods. This research has reviewed many types of tracking methods and classified them according to the accuracy, tracking speed, and complexity, by considering the Perturbation and Observation (PO) and Incremental Conductance (IC) methods being as the most commonly methods in order to choose the most suitable maximum tracking method to be applied in Malaysia. The modeling technique has been made and tested to compare between these two methods. This model uses the irradiation and temperature as inputs parameters to give a performance indication between the variations of output power with respect to time. MATLAB have been used in this research. The result shows better time response and smooths performance while applying Incremental Conductance (IC) method than Perturbation and Observation (PO) for Malaysia. Towards completion of this project, the project aimed to create a comparative model, for the two selected methods. The project other aims included adding the time response and stability factors while testing the two methods using the models based on the inputs from different states in Malaysia. When using the model for Malaysian data and taking the average irradiance and temperature for the two proposed methods, it is recommended to use the INC method, which shows faster response and better stability.

CHAPTER 1

INTRODUCTION

1.1 Background

The energy source is one of the main problems in this era and the search for it was and is still one of the most important concerns of countries. With the passage of the time, the search for the renewable energy becomes more important and to solve shortfall problem in energy source it became one of the faster-growing trends in industrial societies. To find new solutions, the project requires a large range of fields and research. In the meantime, the sun is responsible for almost all the energy available on the earth, except for tides, radioactive material, and the earth's residual internal heat. All others are converted form of the sun's energy (Hussein A K, 2011).

The Solar cells' operation depends on the semiconductor technology. The principle refers when the two semiconductors are put into contact the electricity flowing between them and uncovered to light (photons). This phenomenon is called the photovoltaic effect; Edmund Becquerel first time discovered it in 1839. In 1950, the real Actual development of photovoltaic (PV) technology began. The research continues today at industry and national laboratories around the world, focusing on the efficiencies of increasing conversion and the mass produce strategies to decrease the cost of producing PV modules (Awaya, H., et al.1999).

The solar energy and photovoltaic (PV) is one of the best solutions to these problems, especially when to consider the cost and it may give great design in a high ratio of energy. In addition, it can be applied in huge areas around the world where the resource for it is the solar radiation, which is always available as an input shown in.

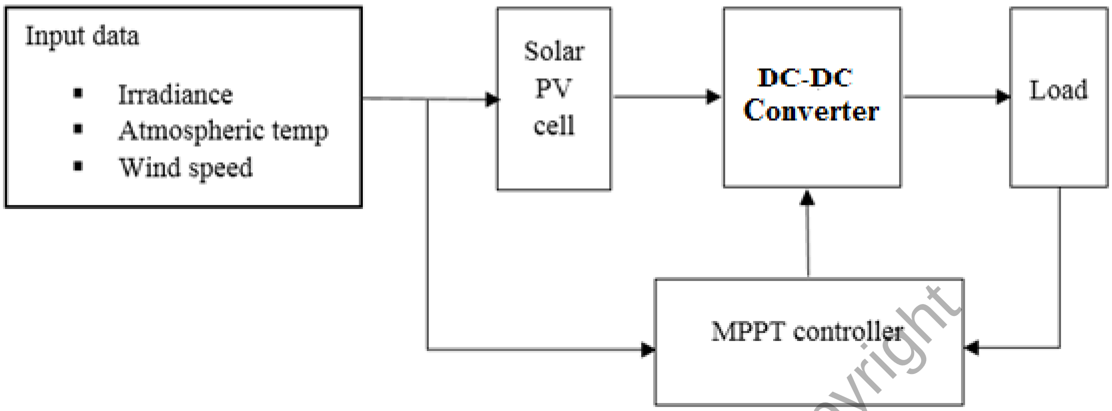

Figure 1.1: Photovoltaic model (Aliesfahani, S., & Shahbazian, M, 2015).

The possibility of solar radiation to reach the Earth's surface is great. For instance, the irradiation power for a unit area is reached up to 1000 W/m^2. It must be accentuating that its potential is renewable and inexhaustible. (Sergey Karabanov, 2010).

Using the solar radiation is a thermal application for getting thermal power and PV conversion electrical power. Furthermore, the PV systems function based on direct conversion of solar power by semiconductor materials as shown in Fig. 1.1. Nowadays, the PV systems with a range of applications are increasing rapidly. PV systems can install power between several Watts (even less) up to several Megawatts. Due to this, PV generation has significant advantages (Brown K.E., Mitchell R.L. PV 2005).

PV is used to get electrical power from the solar radiation. It is made up of one or more PV panels and the output power is not enough to meet the requirement of buildings to allow the modules to be connected to gather as arrays. The capital cost of PV modules is the main drawback, which depends on solar radiation and area temperature (Hussein A. Kazem, Tamer K, 2013).

The maximum power point tracking is a technique used to get the maximum possible power from PV systems. The best output is not constant due to the complex factors that are effective in the system, namely solar radiation, the temperature and total resistance. The maximum power point is an optimum point to get it from a device located between PV modules and the load. To track the MPP for PV systems, there are many methods proposed to get the accurate output. (Bhatnaogar, P. & Nema, R. K., 2013).

1.2 Problem Statement

Since the PV, systems would be prone to the disturbance by the changing in the environment factors like irradiance and temperature, which affect the value of the maximum power produced by the system as shown in figure 1.2. In addition, there are many methods to return the model to work in maximum called Maximum Power Point Tracking methods

Different researchers have environmentally highlighted this problem in the latest years. Maximum Power Point Tracking is defined as one point on the photovoltaic (power- voltage) curve and (current-voltage) curve which representing the maximum generated power as shown in Fig 1.2. As this point is affected by the changes of the climate factors or load, it needs to track the maximum power point (MPP) of PV systems. Moreover, the energy conversion efficiency of PV module is getting low and will cause a mismatch between supply and load (Blackstone, B, Y., & Premrudee preechacharn, S., 2012).

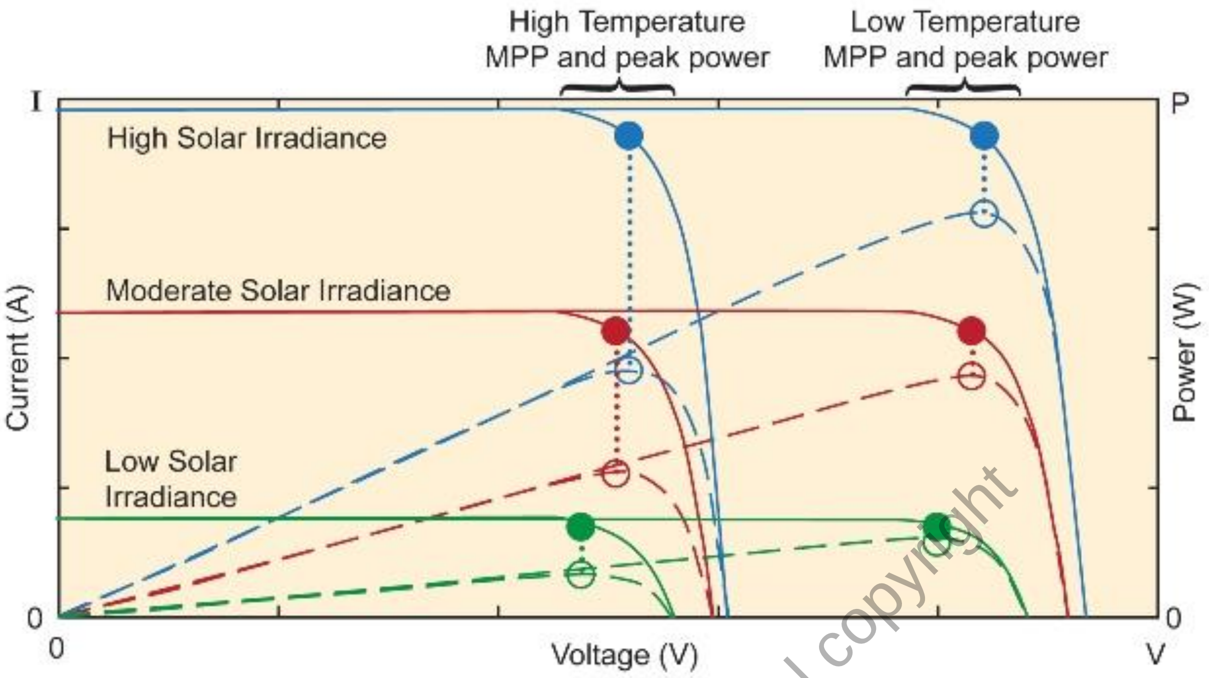

Figure 1.2: Environmental factors effect to MPP (Houssamo, I., Locment, F., & Sechilariu, M, 2010).

There are many methods for tracking the maximum power point in PV systems, either direct or indirect methods, online or offline methods. There is a variation among them in the conditions of some critical parameters like complexity, accuracy, number of variables used, speed, hardware implementation, cost, tracking efficiency and so on.

Among these too many methods, there are two main popular methods; Perturbation and Observation (P&O) and Incremental conductance (INC), and have been used widely in this field, but unfortunately, no one of them hasn't been yet standardized to be applied. All the application for these two methods in Malaysia was applied generally without any indication with certainty for any of these to be dominant. The problem cab summarized:

No selection for the optimized method to calculate the MPP, since there are many methods each one has its own advantage over the others, In addition, the comparison between the most two popular methods (P&O and INC) has been applied in Malaysia, and the selection between these two methods is not easy because of their similarity output response results.

1.3 Research Objectives

The development of this research looks at studying the PV system and tracking methods with compare in the characteristics of tracking speed and accuracy. The main objectives of this study are to investigate the following issues:

i. Investigate photovoltaic system and tracking methods characteristics.

ii. Analysis and compare between the main two common maximum power point tracking methods Perturbation and Observation (P&O) and Incremental Conductance (INC)

iii. Build a model allows the two selected methods to work in same conditions.

iv. Change the climatic factors (irradiation & temperature) &check the result, in order to propose one method as the most suitable for Malaysia

The model includes the programming of two methods by using MATLAB 9 software to get the output as a curve. In addition, this study allows to any researcher in future to use his data and study the response.

1.4 Scope of Research Works

Photovoltaic systems have been studied by considering the variation in methods of power point tracking characteristics, this variation is based on based on clarifying these methods and comparing between the most common methods in this field namely perturbation and observation (P&O) and Incremental conductance (INC) as shown in Fig. 1.3. Moreover, create a model to compare between them and allow to others to compare or check any of them by using his data. (Khanaki.M, 2014).

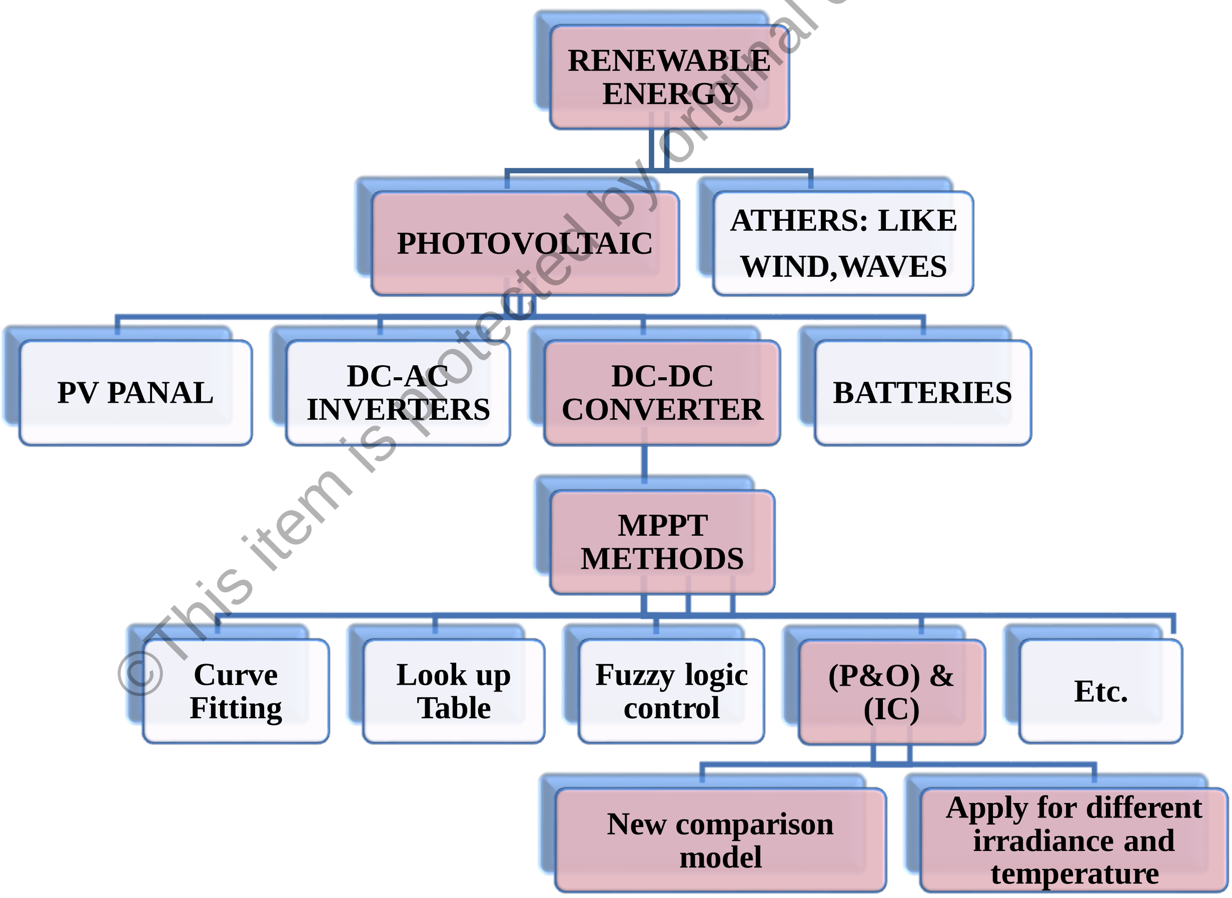

Figure 1.3: Scope of work.

1.5 Thesis Outline

In this thesis, five chapters were formed, which is, Chapter1 Introduction. Chapter 2 theory and literature survey. Chapter 3 comparative between P&O method and INC method, building a model, which allows the two selected methods to work in the same conditions. Chapter 4 Examining the response with changing climatic factors followed by checking the response, in order to propose one of these MPPT methods that are the most suitable for the whole Malaysia. Finally, chapter 5 contains the Conclusion and Suggestion for Future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

When the photons of sunlight reach the solar panel and absorbed by a semiconducting material like silicon. It charges the source to take out the energy from the array of solar panels and converts the solar energy to DC electricity. Moreover, the system is usually connected in the next step directly to the load or to feed the grid (Abdulmajeed, Q. M., Kazem, H, 2013; Roopa, P., S. E., & Vengatesh, R. P., 2011).

Since the PV systems can be affected by changing of the climatic conditions, the output power will not counties in the same value, the system need method to tracking for the maximum point (Banos, R., Manzano-Agugliaro, 2011) , MPPT defined as a technique used to get the maximum possible power from photovoltaic systems. (Chowdhury, S. R., & Saha, H., 2010; Li, S., Haskew, T. A, 2011). Apart from that, the maximum power point is the optimum point that can be obtained from a device located between PV modules and the load. There are many methods proposed to get the accurate output to track the MPP for PV systems. This study reviews different MPP methods and highlights the research challenges (Balamurugan, T., & Manoharan, S, 2012).

2.2 Solar Radiation

Solar radiation reaching the ground earth and the machinery of the global solar radiation (G_T) on horizontal of the surface are shown in Figure 2.1. Solar radiation is classified as two parts: Direct solar radiation (bean radiation) (G_B) the radiation that falls directly from the sun, and diffused solar radiations (G_D) other radiation which have been scattered because of the clouds and other particles in the sky.

$$GT = GB + GD \tag{2.1}$$

The bean radiation that makes the fall in angle with the ground is known as the altitude angle (α), the angle ξ represented the incidence from zenith. When the surface is horizontal, the incidence angle is equal to the zenith angle (θ) (Grossmann, W. D., G, & Steininger, K. W, 2013).

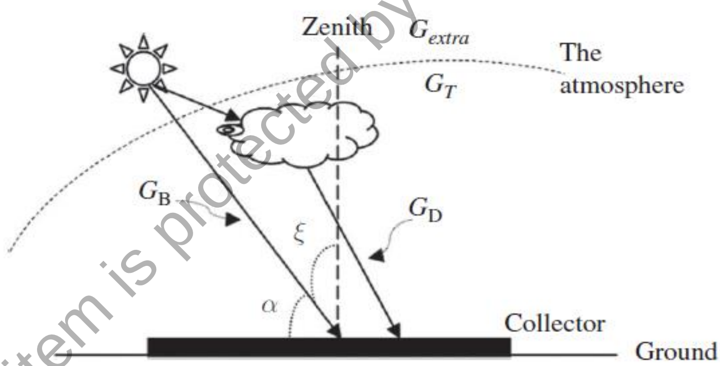

Figure 2.1: The Solar Radiation (Hocaoglu, F. O, 2013).

2.3 Photovoltaic System Description

The typical photovoltaic system consists of PV modules, photovoltaic cell, batteries, inverter (DC-AC), and controller (DC-DC). A brief description is given in this section.

2.3.1 Photovoltaic Cell

The single Photovoltaic cell comprises a thin wafer semiconductor that includes twain layers, normally made of pure silicon (there are many differed semiconductors to make the PV cell, but crystalline silicon is the most common one).

One side of the layers is doped with boron material and another is doped with phosphorous, this activity takes place to make the extra of the electrons on one side and the shortage of the electrons in another side. Once the sunlight bombards photocell, the photons in sunlight will bang some of the excess electrons. This situation leads to the difference in the voltage between the two sides try moving from the excess side to the shortfall side. This voltage in silicon is 0.5 V as both sides of metallic contacts are made of a semiconductor. Moreover, while the outside circuit is attached the contacts, the electrons back to another side as well as current will flow through the circuit. The PV cell does not have storage space capacity; it just acts like a pump of the electron. Therefore, the determined of the value of current is by the electrons number knocking the solar photons. The more cells are produced; the more electrons will be delivered by more intense sunlight. (Sanchis, P., López, J., Ursúa, A., & Marroyo, L., 2005).

2.3.2 PV Module

The design of the PV model, in the beginning, depends on the size of needs, in which the PV array for the given application relies on the energy production and expected power on an hourly, monthly or annual basis. In the PV layer, the solar cells are gathered to collect the light of the sun. This is due to the connection of the cells in series or parallel to get the required voltage and current (Yetayew, T. T., & Jyothsna, T. R., 2013).