MODELING AND ANALYSIS PV MODULE IN VARIOUS TEMPERATURE AND IRRADIANCE INPUTS USING MATLAB/SIMULINK ALGORITHM

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DEDICATION

Thanks and dedication to my wife, Rosmiza Binti Yasok, my son Mohammad Nur Akif Haikal Bin Norhaisam, my daughters Nurdhia Safiya Binti Norhaisam, Nuraisyah Zahra Binti Norhaisam and Nursalsabila Binti Norhaisam, who have been physically and mentally supporting me during my Master's degree. I appreciate your all support and help with my siblings and relatives.

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Thank you all, and only Allah SWT will give all of you the right reward.

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ABSTRACT

Photovoltaic (PV) systems offer a potential solution to the global energy crisis. Modeling study and analysis involving solar PV module is an important task in PV system to be more user friendly, improve reliability and performance. However, the output characteristics of PV module are nonlinear, since they are dependent on environmental conditions such as solar irradiance and temperature, as well as local climate conditions such as humidity and wind. The various methods used have some common gaps as the absence of step by step procedure which cause difficulties to understand. Indeed, accurate modeling of PV module is important to provide a better understanding of their operation and output characteristics, since simulations can be used to understand the behavior of PV module under various operating conditions. The objective of the project is first, to build and model a solar photovoltaic (PV) module algorithm using Matlab/Simulink. Second, to simulate and analyze behavior of the model in various temperature and irradiance input conditions. Third, to validate the results obtained from the simulations by comparing the output characteristics with the manufacturer's data sheet. The methodology used by presenting the principles of detailed modeling of PV module using Matlab/Simulink software. The constructed model is taken from the equations obtained from the equivalent circuit of a single diode model. The PV Module block is a five-parameter model using a light-generated current source (IL), diode, series resistance (Rs), and shunt resistance (Rsh) to represent the irradiance and temperature dependent I-V and P-V characteristics of the module. This method provides a simple, reliable and highly flexible method to adapt PV module to different environmental conditions such as irradiance, temperature and physical parameters of solar module such as resistance, current, voltage, ideality factors and others. The results show that the simulation blocks created are almost identical to real PV module module, compatible with various types of PV module and user friendly.

ABSTRAK

Sistem fotovoltaik (PV) menawarkan penyelesaian berpotensi untuk krisis tenaga global. Kajian dan analisis pemodelan yang melibatkan solar PV module adalah tugas penting dalam sistem PV untuk lebih mesra pengguna, meningkatkan kebolehpercayaan dan prestasi. Walau bagaimanapun, ciri output PV module tidak linear, kerana bergantung pada keadaan persekitaran seperti penyinaran matahari dan suhu, serta keadaan iklim tempatan seperti kelembapan dan angin. Pelbagai kaedah yang digunakan mempunyai beberapa jurang yang sama seperti ketiadaan prosedur langkah demi langkah yang menyebabkan kesukaran untuk difahami. Sesungguhnya, pemodelan PV module yang tepat adalah penting untuk memberikan pemahaman yang lebih baik mengenai ciri operasi dan outputnya, kerana simulasi dapat digunakan untuk memahami tingkah laku PV module dalam pelbagai keadaan operasi. Objektif projek ini adalah pertama, untuk membina dan memodelkan solar fotovoltaik module menggunakan algoritma Matlab/Simulink. Kedua, untuk mensimulasi dan menganalisis tingkah laku model dalam pelbagai keadaan input sinaran dan suhu. Ketiga, untuk mengesahkan hasil yang diperolehi dari simulasi dengan membandingkan ciri output dengan helaian data pengeluar. Metodologi yang digunakan dengan mempersembahkan prinsip pemodelan terperinci PV module menggunakan perisian Matlab/Simulink. Model yang dibina ini diambil dari persamaan yang diperoleh dari litar setara model diod tunggal. Blok PV module adalah model lima parameter yang menggunakan sumber arus yang dihasilkan cahaya (IL), diod, rintangan siri (Rs), dan rintangan selari (Rsh) untuk mewakili sinaran dan suhu yang bergantung pada ciri-ciri I-V dan P-V modul. Kaedah ini menyediakan kaedah yang mudah, boleh dipercayai dan sangat fleksibel untuk menyesuaikan PV module pada keadaan persekitaran yang berbeza seperti sinaran, suhu dan parameter fizikal modul suria seperti rintangan, arus, voltan, faktor idealiti dan lain-lain. Hasilnya, data simulasi yang diperoleh pada model Matlab / Simulink hampir sama dengan modul module PV sebenar dan serasi dengan pelbagai input parameter dan mesra pengguna.

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LIST OF ABBREVIATIONS

IEA	-	International Energy Agency
NEC	-	National Electrical Code
RE	-	Renewable Energy
PV	-	Photovoltaic
I-V	-	Current (A) – Voltage (V)
P-V	-	Power (W) – Voltage (V)
AC	-	Alternating Current
DC	-	Direct Current
MPPT	-	Maximum Power Point Tracker
KCL	-	Kirchhoff's Current Law
MPP	-	Maximum Power Point
STC	-	Standard Test Condition
SEDA	-	Sustainable Environment Development Agency
NREL	-	National Renewable Energy Labs
GC	-	Grid Connected
Vmp	-	Maximum Power Voltage (V)
Imp	-	Maximum Power Current (A)
Pm	-	Maximum Power (W)

LIST OF SYMBOLS

IL	-	Light generated current (A)
ID	-	Diode current (A)
Ish	-	Shunt resistance current (A)
IS	-	Saturation current of the diode (A)
Rs	-	Series resistance (ohm)
Rsh	-	Shunt resistance (ohm)
k	-	Boltzmann's constant = 1.38×10-23 J/K
q	-	Electron charge = 1.6×10-19 C
n	-	The factor of ideal diode [$1 \leq n \leq 2$]
T	-	Ambient temperature (K)
o_C	-	Celsius
G	-	Solar irradiance (W/m2)
G_0	-	Reference solar irradiance (W/m2)
IL_0	-	Reference light generated current (Amp)
T_0	-	Reference temperature (K)
Ns	-	The number of solar cells
Ipv	-	PV module current (Amp)
Vpv	-	PV module voltage (Amp)
CT	-	Temp. coefficient of the light generated current (A/K)

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The solar industry has expanded rapidly over the last few years, and photovoltaic (PV) systems in particular have increased significantly. The rapid growth is mainly due to the need for alternatives to the fossil-electric fuel generation industry, concerns about the global climate, lower photovoltaic costs and investment in distributed energy resources to improve energy grid efficiency. Solar Road Map IEA estimates that solar PV energy will contribute as well as supply around 11% of global electricity demand by 2050 and will reduce CO2 emissions by 2.3 gigaton (Gt) per year [1-2].

In Malaysia today, solar PV generates 194GWh or less than 1.7% of the total amount. However some years will come, the interest of solar PV in the energy mixture is expected to increase. Expectations in 2040-2050 it would be roughly 13,540GWh from 29,358GWh or 46% of the power generated from renewable energy (RE). With this not impossible Malaysia will be a major player in the solar power industry, especially in the manufacture of solar photovoltaic cells (PV) and module for the implementation framework of 20 years will come with more competitiveness. Figure 1.1 shows the Average Rate Solar Irradiance by Towns in Malaysia (Yearly Average Value) 2018-2020.

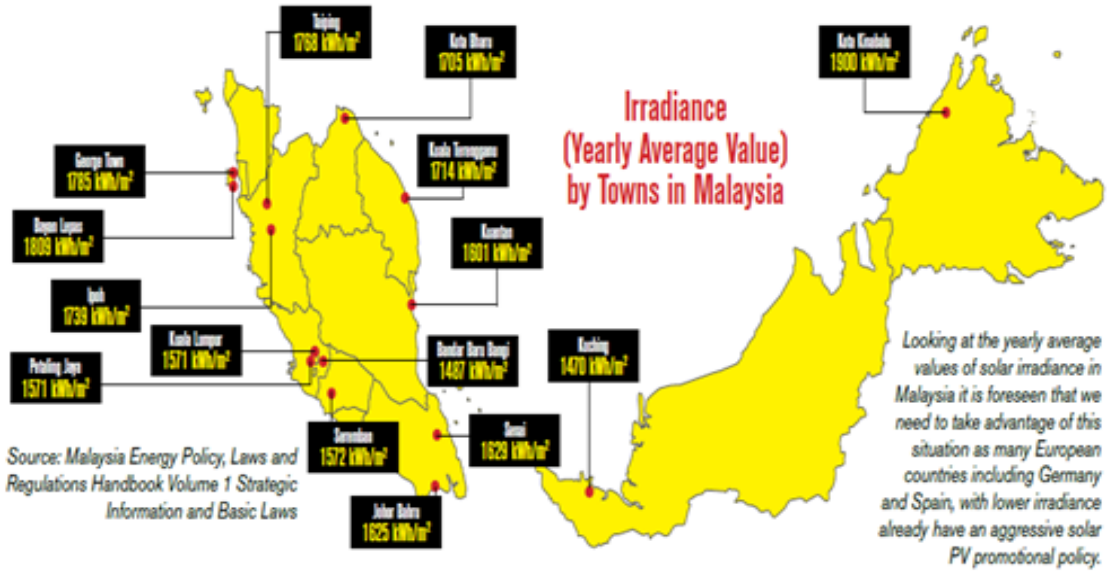

Figure 1.1: Average Rate Solar Irradiance by Towns in Malaysia (Yearly Average Value)

The study of faults in solar photovoltaic (PV) module is an important task in PV systems to improve reliability, performance and protection. Despite the fact that PV systems do not have moving parts and typically need low maintenance, different fault conditions are still subject to them. Photovoltaic (PV) systems offer a potential solution to the global energy crisis. The solar energy industry is currently on the increase in popularity as technology matures and, as a result, the material costs are reduced due to better technologies. Figure 1.2 shows the Fundamentals of Solar (PV) Systems.

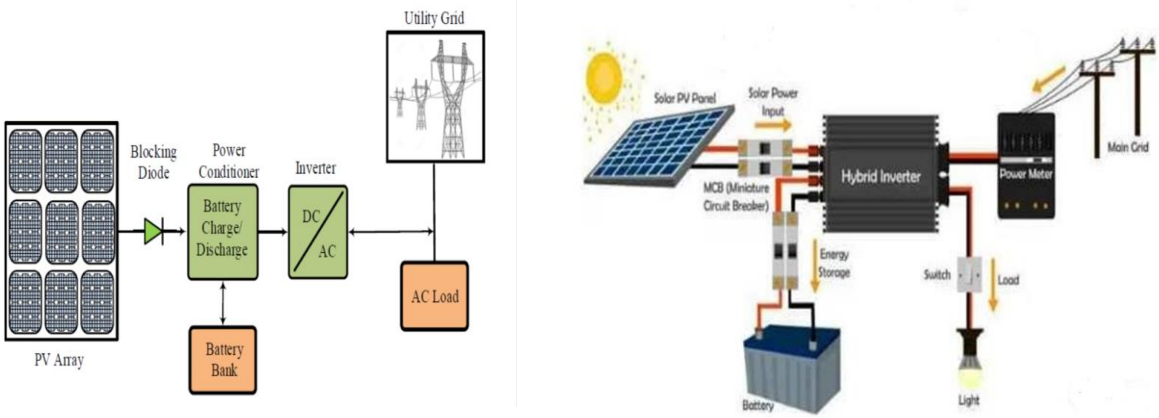

Figure 1.2: The Fundamentals of Solar (PV) Systems

However, capital costs and maintenance costs of modul PV module are still high as they are mostly installed outdoors, where they experience mechanical and electrical stress, resulting in additional power loss, hot spot formation and various complications on PV module. If the initial steps are not well planned and controlled, the efficiency of the PV module module system will be affected and cause the system to be unable to operate fully.

With PV module modeling and analysis project in various temperature and irradiance inputs using matlab / simulink algorithm it can analyze the behavior of the system visually, simulation and even record the data obtained clearly.

This PV module modeling and analysis project is done according to the steps and sequence so that it is more accurate and promises more efficient and effective monitoring and diagnosis of PV module module system with various temperature and irradiance inputs taken. Figure 1.3 shows the fundamentals of PV module structure.

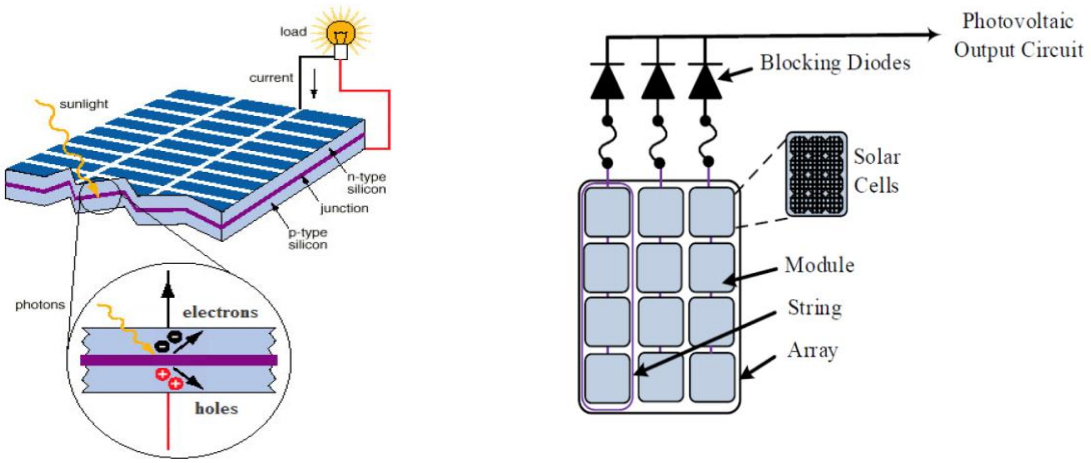

Figure 1.3: The Fundamentals of PV Module Structure.

In general, this project is related to modeling as well as simulation. For the initial design of a simulation project, modeling and control algorithms using Matlab / Simulink programming need to be studied and refined.

During this project, electrical components such as PV Module, String, Module, Solar Cells and Blocking Diodes which are the main components in solar photovoltaic system were studied. Then, the problems introduced by the system and each fixable part are determined. In this section also, some weaknesses of the existing study can be identified and some ideas related to better systems can be suggested.

In the literature review section, it is mostly about the study of modeling and analysis in solar photovoltaic module that are to gain knowledge and achieve the main objectives of this study. This process is the initial step of the study to determine the problems and solutions available for the selection of the appropriate scope and modeling. The knowledge and ideas gathered ensure that an understanding of the study of modeling and analysis in solar photovoltaic module systems is achieved.

This solution method also helps to get additional ideas related to the existing project so that it can be modified. This can indirectly find the added value of modeling and simulating solar photovoltaic module. Methods of solar photovoltaic module systems from existing studies have been identified and presented in the next topic.

1.2 Problem Statement

The problem statements for this project are: -

1. PV module output characteristics are nonlinear because they are influenced by environmental factors such as solar irradiation and temperature, as well as local climate factors like humidity and wind.

2. There are some common gaps in the various ways, such as the lack of a step-by-step procedure, which makes it difficult to understand. As a result, a model is proposed that can analyse the effect of all parameter variations on PV module features in a Matlab/Simulink environment.

3. Because simulations can be used to study the behaviour of PV modules under various operating conditions, accurate modelling of PV modules is vital to provide a better understanding of their operation and output characteristics.

1.3 Objectives of Project

The objectives of the project are:

a) To build and model a solar photovoltaic (PV) module algorithm using Matlab/Simulink.

b) To simulate and analyze behavior of the model in various temperature and irradiance input conditions.

c) To validate the results obtained from the simulations by comparing the output characteristics with the manufacturer's data sheet.

1.4 Scope of Project

This project focuses on the modeling and analysis of pv module in various temperature and irradiation inputs using matlab / simulink algorithms. The scope of this project is: -

1. The purpose of this project is to present the concepts of thorough photovoltaic (PV) module modelling using Matlab / Simulink software.
2. The equations obtained from the equivalent circuit of a single diode model are used to build the model.
3. Modeling and simulations based on I-V and P-V output characteristics using models built under varied temperature and solar irradiance input circumstances.
4. As a result, the simulation data obtained on the Matlab / Simulink model are almost identical to real PV module module and compatible with various parameter inputs and are user-friendly.

1.5 Project Report Outline

This report is written to generate innovative and important ideas in PV module systems to improve reliability, performance and efficiency. Through this report also, can increase the knowledge related to modeling and analysis of solar PV module system which is one of the most important parts or pulse in the solar power generation sector. In fact it is one of the renewable resources that is in high demand in the industrial market today. Five main chapters are separated in this report which include Introduction, Literature review, Project methodology, Results and analysis, Discussion, conclusion and future works.

Chapter 1 generally describes on the Photovoltaic (PV) module system. This chapter also provides information on the introduction for this project is written to give a clear view about the ways and direction of this study. This chapter includes introduction, study background, problem statement, objectives, scopes and last thesis outline.

Chapter 2, this section describes an overview of the available literature. Through literature review, several important theories and principles related to this project have been studied. Literature that has been identified to assist in this project was selected. It has also been read and studied thoroughly to get some knowledge and information that can be applied throughout this project. Literature review sources mainly from journals, articles and other internet sources related to the focus of this project study. The introduction, analysis of current research, review of the proposed methodology, research discrepancy, and chapter overview are also included in all chapters.

Chapter 3, a project methodology covering the steps and techniques to complete this project has been determined. This chapter discusses the overall procedure for achieving the objectives of this project. Several new innovations are also proposed in this chapter. The PV module system modeling method using Matlab/Simulink simulation was made and shown the sequence of steps as well as the results obtained compared with the manufacturer data sheet. This simulation model has an almost accurate and reliable output by using temperature and solar irradiance as inputs. The analysis and simulations of this modeling are performed in detail and the effects on the I-V and P-V curves are discussed.

Chapter 4, is a chapter for the display of all the results as well as the analysis of the results obtained from the modeling and simulation. The results of the analysis and data will be collected and discussed in detail in this chapter. In addition, some of the projects contained in the methods and objectives will also be evaluated and shown here. Finally the data and results obtained need to be verified to determine validity.

Chapter 5, is a section that summarizes the results of the project that has been done. Conclusions were drawn to emphasize how the methodology would meet the objectives of this project. The results obtained from this project should be significant for our thinking on the improvement of existing studies. In other words, provide convenience and benefits to users as well as technology and future work.

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