



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA
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FINAL YEAR PROJECT II REPORT

**ANALYSIS OF SOLAR CONVERTER A SINGLE STAGE
POWER CONVERSION PV-BATTERY SYSTEM**

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**ANALYSIS OF SOLAR CONVERTER A SINGLE-STAGE POWER
CONVERSIONPV-BATTERY SYSTEM**

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**A report submitted in partial fulfilment of the requirements for the degree
of Power Electronic and Drive**

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APPROVAL

I hereby declare that I have read through this report entitle “ Analysis of Solar Converter a Single-Stage Power Conversion PV-Battery System” and in my opinion this report is sufficient in terms of scope and quality as a partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drives).

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Date : 1st June 2015

DECLARATION

I declare that this report entitle “Analysis of Solar Converter a Single-Stage Power Conversion PV-Battery System” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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Date : 1st June 2015

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ABSTRACT

Photovoltaic (PV) system is now recognised to be most widely accepted method of harnessing renewable energy sources. In general, due to the weather condition the solar energy is changed because solar PV electricity outputs are highly sensitive to effects of irradiation and temperature changes. Energy storage such as batteries and fuel cells are able to make solar PV system becomes more stable energy source and it can be dispatched at the request which result in improving performance and value of the output solar PV system. The proposed research objective are to evaluate the output current and power characteristic of PV module and observe the system response to varies whether the condition in terms of change in cell temperature and solar irradiance. Besides, aimed of modelling and simulate a single stage power conversion. So, in this project a new converter called reconfigurable solar converter (RSC) in SIMULINK/MATLAB for photovoltaic (PV)-battery application since it uses single-stage conversion instead of multistage conversion to perform DC-DC and DC-AC operations. This converter solution is appealing for PV-battery application because it minimizes the number of conversion stages, thereby improving efficiency, simple in construction and reducing cost.

ABSTRAK

Photovoltaic (PV) sistem kini diiktiraf sebagai kaedah yang paling sesuai untuk meluas manfaat sumber tenaga yang boleh diperbaharui. Secara umum, penghasilan tenaga elektrik daripada sistem solar berubah-ubah mengikut keadaan cuaca kerana sistem ini sangat sensitif kepada kadar sinaran matahari dan perubahan suhu. Alat penyimpanan tenaga seperti bateri dan sel-sel bahan api boleh menjadikan system solar PV sebagai sumber tenaga yang lebih stabil dan dapat memenuhi permintaan dunia bagi meningkatkan prestasi dan penghasilan tenaga elektrik sistem solar. Objektif kajian yang dijalankan adalah untuk menilai arus keluaran dan ciri-ciri kuasa modul PV serta memerhatikan tindak balas sistem ketika menerima perubahan suhu sel dan sinaran matahari yang berbeza. Selain itu, tujuan penyelidikan ini adalah untuk pemodelan dan simulasi penukaran kuasa satu peringkat. Oleh itu, dalam projek ini penukar kuasa baru yang dipanggil pembentukan semula penukar kuasa solar (RSC) dalam SIMULINK / MATLAB untuk photovoltaic (PV) bateri system. Penukaran kuasa satu peringkat dan bukannya penukaran berbilang bagi melaksanakan operasi DC-DC dan DC-AC dapat mengurangkan bilangan peringkat penukaran, sekali gus meningkatkan kecekapan, mudah dalam struktur pembinaan dan mengurangkan kos.

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LIST OF SYMBOLS

PV	– Photovoltaic
RSC	– Reconfigurable Solar Converter
DC	– Direct Current
AC	– Alternating Current
MPPT	– Maximum Power Point Tracking
MPP	–Maximum Power Point
BOS	– Balance of System
VOC	– Open circuit voltage
I_{sc}	– Short Circuit Current
FF	– Fill Factor
PCU	– Power Conditioning Units
CCM	– Continuous Current Mode
SOC	– State Of Charge
P&O	– Perturb and Observe
INC	– Incremental Conductance

CHAPTER 1

INTRODUCTION

1.1 Motivation

Nowadays, in order to meet the requirements of the power demands of local and global appliances, renewable and non-renewable energy resources are commercially used. However, enhancement on awareness of the earth safety, renewable energy sources are fast gaining importance over non-renewable due to global interrelated problems face the world. Winds, hydro, solar and also bio-mass are several examples of renewable energy sources.

Solar power is sustainable and totally inexhaustible either created from sunlight or heat from the sun to form a clean green source of electricity. This source of electricity does not pollute the air otherwise gives positive environment impact and also improve energy security by reducing the need for foreign oil import. Solar photovoltaic (PV) systems in which have become increasingly popular and are ideally suited for distributed system among all renewable energy strategies in this country due to Malaysia is situated at the equatorial region with an average solar radiation of 400–600 MJ/m² per month. This is because the solar powers that produce are highly dependence on the radiation. On the other hand, photovoltaic system has its own several fundamental merits such movement free, identified as a static and alternative energy which can result to a long term and low maintenance-cost renewable system.

When it comes to connection strategies, PV application system can be distributed into two types which are stand-alone system and grid connected system. Basically, a stand-alone PV plant is a system based on electrochemical batteries as energy storage. Additional generation system is attach together such as those powered by fuel engines, is on the basic of regularization of PV generation and of full satisfaction of load consumptions [1]. Otherwise, grid linked type of PV power plants does not essential any energy storage due to the existence of the distribution grid act as a convenient container for the electrical energy. Theoretically, grid connected system can perform both as an ideal generator and also as an ideal load) [2]. But lately, major principle attention has been focuses on make use of batteries and fuel cell as an energy storage in grid-linked PV system in order to improve the power quality problems of real distribution system and provide attractive, convenient and useful solar PV power system.

This project presents analysis of solar converter a single-stage power conversion PV-battery system, which is introducing Reconfigurable Solar Converter (RSC). In recent years, accretion consumption of solar PV application has been increase with the demand in competency and together along less in cost. Based on the research, RSC perform single stage power converter that is simpler in structure compared to the traditional approach by using multi level converter. Therefore, single stage converter technique would use less in component counts thus assist in reducing the converter cost. The electricity produced by solar energy sometimes offer instantaneous response to the load demand, as the source of solar PV system does not deliver a regular supply straightaway compatible with the consumption need. The key notion of the RSC is to use a single stage of power conversion for battery system to achieve various operation methods which is mainly integration between DC to DC conversion (PV to battery), and DC to AC conversion (PV to grid, battery to grid and also PV or battery to grid)[4].

The RSC ideas result from the reality that the system of energy storage integration of unity scale solar PV system success if there is minimal overlap or enough gap between the release time and the PV energy storage. Figure 1.1 shows the different integration of operation between the PV generated power with the time of use. For case (a), the energy from PV constantly delivered to grid system without any uses of storage system.. However, for the other case (b) and (c), the energy gained firstly stored in the storage system which is battery and later the battery or both battery and PV system supply to the load. The integration methods of case (b) and (c) has the maximum value and the RSC methods

provide benefits compared to the other integration methods due to the presence of time delay or gap between the generation power and consumption power [13]. The presence of the storage element makes the solar electricity system more compatible and more efficient.

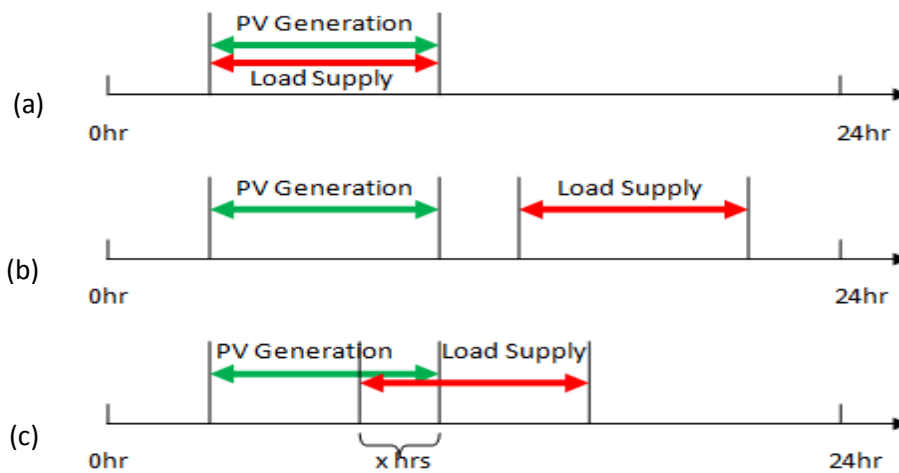


Figure 1.1: Different scenario between PV generation power and load supply sequence with time gap.

1.2 Problem Statement

Currently, the utilization of non-renewable energy resources is known to have negative impact on the environment. Moreover, the disadvantages of using finite resources are endangers the earth, limited of supply and also expensive. Due to rapid depletion of the fossil fuel, human being create other strategies by move on to demand the renewable energy sources that available in Malaysia such as biomass, wind, hydro and also solar energy. Solar PV system is one of the most popular renewable energy because its availability and sustainability has increased with the time. However, deficiency would happen when there is major drawback of PV which could limit efficiency and affect the system performance. The problem encounter when the output power of PV cannot attain 100% due to inconsistency of irradiance and the environmental effect. To get the optimum power generated by the solar panel, the system required to match between its internal resistance and the load applied. This is because a slight increase in percentage of the output power for solar power plant is significant. On the other hand, there will be a major problem of energy consumption without energy storage which be used to retain the desired output power during the low radiance or night time.

1.3 Objectives of Project

The objectives of this project are:

- i) To analyze i-v and p-v characteristic curves of PV module.
- ii) To simulate and model a single stage power conversion by using MATLAB or Simulink.
- iii) To observe the system response to varies whether the condition in terms of change in cell temperature and solar irradiance within the storage system.

1.4 Scope of Project

The scope of work of this project considers modelling of PV system during the normal and sunny day only. So, there is no consideration will be taken under the rain and cloudy day. The energy storage used which is battery is applied at the night where the absence of the sun. In addition, this modelling system focuses on simulation and analysis by using MATLAB/Simulink software.

1.4 Expected Outcomes

The expected simulation result should be modelling of the solar PV converter in order performing DC-DC and DC-AC operation. For DC-DC (Boost) power converter, the output voltage or current gained must be straight line as the conversion in the form of direct current (DC). While, three phase sinusoidal output wave are developed for DC-AC (inverter) power conversion. In addition, the characteristic of the solar PV module in Simulink should be satisfied as the theoretical approaches.

1.6 Report Outline

Chapter 1

The thesis report begins with the introduction of a single stage solar converter for PV battery system in chapter 1. A brief research background explained on the importance and advantages of renewable energy research. Besides, other element such problem statement, objectives, scope of the project, and expected outcomes are also identified in this chapter.

Chapter 2

This followed chapter discusses about literature review for system and component used in this project. Books, internet, journals and also paper works which is related to the project research are used as a reference guide and to assist in completing this research project. Each of the system and component corresponds to the research are also explained briefly based on the findings from various sources either from.

Chapter 3

This chapter discussed and explained the methodology used in order to complete this project. The major part in the chapter focuses on designing and modelling of the PV system and power converter system using MATLAB/ SIMULINK software. The proposed technique will be explained more detail by using equations, control algorithm and modified structure model used to support. The circuit topology that uses of power electronic converter approaches for photovoltaic battery system is described. In addition, the project Gantt Chart and key milestones also covered in this chapter.

Chapter 4

Subsequently, Chapter 4 will discuss about the result and discussion. All graph, chart, table, and also figure regarding to the result obtain are included in this chapter. Progress of the project highlighting the result achieved from the conversational/ basic method. It is expected that the project going smoothly and be able to provide the basis model of power converter result.

Chapter 5

Finally, chapter 5 will address briefly summarize of the proposed technique of a single stage solar converter for PV battery system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the contents are deeply clarified on the literature review regarding the research of solar PV system, power converter and also battery charging. Theoretically, the entire basic fundamental throughout the research is compiling as well as review some of the methods being model of a single stage converters for PV battery system. In addition, related works regarding to this research project will also be conferred in depth. Besides all the merits and demerits of the proposed design is analyzed for preferable understanding. In order to complete the research, further explanation on the most suitable method is distinguish to complete this project.

2.2 Theory and Basic Principles

As mentioned in chapter 1, numerous methods have been proposed to construct the modelling of PV system and the power conversion used for PV battery system. Therefore, this chapter will review some of the methods being used to model the PV system as well as DC-DC and also DC-AC power converter. Besides that, basic concepts regarding PV will be viewed as well as the system also shall be discussed.

2.2.1 Photovoltaic Systems

The “photovoltaic” terminology is a combination between of two terms which is “photo” means light and “voltaic” means voltage. Photovoltaic system in this discussion uses the principle of photovoltaic cells which directly convert the incoming light radiation into electricity by using solar panel. Basically, the basic building block of the PV cell consist at least two main semiconductor layers. Both of layer are bound together with a positively charge and the other layer has negatively charge. The mechanism starts when the incoming light from the sun strikes the solar cell; the semiconductor material in the cell absorbs the photons from the light with a chemical reaction [4].

Meanwhile, PV system normally consist of various parts to be operated which are DC or AC power converter, storage system, mounting components and interconnections of an electrical racking that grasp the solar panels together. To make the system more effective, it has been built along with maximum power point tracking (MPPT), solar concentrator, energy management software, solar tracker and also battery system with charger for backup system [5]. On the other hand, the request of solar power has increased consistent due to demand of global world. So, the PV system must be more convenient such as electricity gained by the sunlight through the panel capable to be used directly, converted, or being fed into the larger electricity powered by central generation plants [7]. Refer figure 2.1 for the sequence diagram from a solar cell to a PV system.

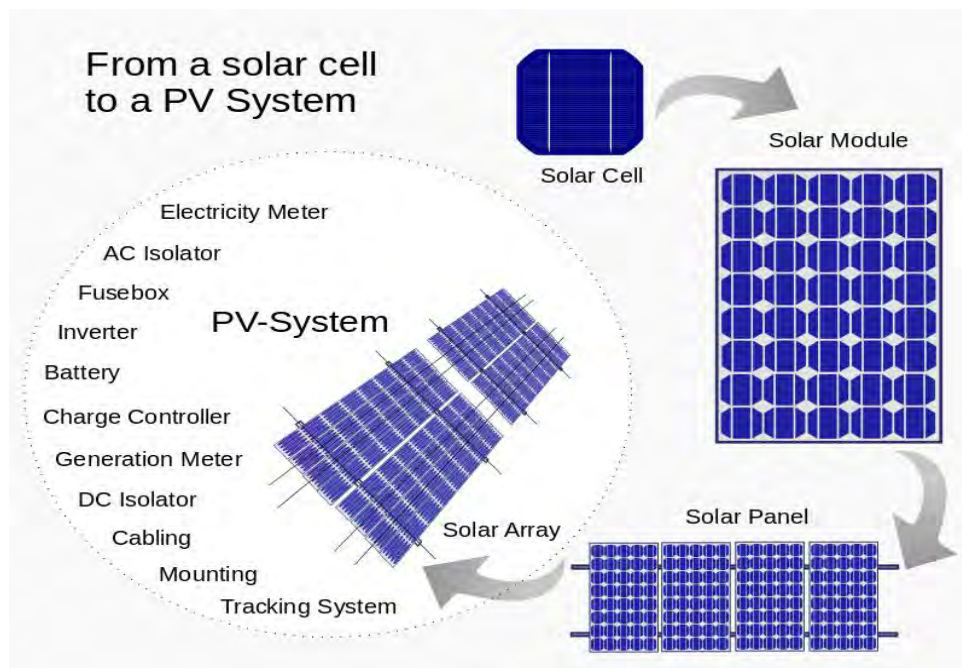


Figure 2.1: Solar Cell, Modules, Array and PV system [14].

The Solar cell is the basic fundamental of a PV system which is change the incoming light intensity directly into electric power throughout the process of Photovoltaic effect. A single solar cell cannot give rise to high output power, an example of silicon type indicates that a single solar cell produce an output voltage around 0.6V. To increase solar power generated, the solar cell are joining together either in series or shunt to produce larger PV module. On the other hand, PV module usually called as solar panels that could produce an output power between ranges of 10 Watts to 300 Watts [3].

However, there is ways to generate high power by integrating the PV modules together to form a PV array. This PV array can be made up of any number structure of PV modules. This modularity results in a flexible system of an electricity based on solar source that meets the required amount of power needed whether small or large power. Balance of system (BOS) contains an integration of components in solar system which enables the solar power to be applied properly to the load [14]. Table 2.1 discusses the function of the BOS components.