THE IMPROVEMENT AND OPTIMIZATION OF THE POWER MANAGEMENT INTERFACING FOR PV SYSTEM

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A report submitted in partial fulfillment of the requirements for the degree of Electrical Engineering (Control, Instrumentation and Automation).

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2012

" I hereby declare that I have read through this report entitle "The improvement and optimization of power management interfacing for PV system" and

found that it has comply the partial fulfillment for awarding the degree of Bachelor of

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Supervisor's Name	:	PUAN NURUL AIN BIN MOHD SAID
Date	:	....

I declare that this report entitle "*The improvement and optimization of power management interfacing 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.

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Special dedicated to my beloved parents and siblings who fully supported me throughout my study life

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest thankfulness and appreciation to everyone who has lent me their hand in completing this Final Year Project report. Without contributions from different individuals or groups, this report may not able to accomplish on time.

Next, I would like to convey my utmost gratitude to my beloved supervisor, Madam Nurul Ain bin Mohd Said for her encouragement, valuable advice and guidance throughout this project. In addition, I would also like to take this opportunity to express my gratitude towards my course-mates and friends for their supports, advice and knowledge sharing in completion of this report. Apart from that, I would like to express my appreciation to my beloved family members for their understanding and mental support in producing this progress report.

Last but not least, I would like to express my gratefulness to any other individual or group whom are not mention but has also play an important role in this report. I hope that this report can contribute some information and knowledge to everyone. Thank you.

ABSTRACT

Stand alone photovoltaic system is an off grid electric system mainly used in remote areas to convert the sunlight into electricity for the supply of the load. The purpose of this project is to improve and optimize the power management interfacing for the standalone photovoltaic system. It will focus primarily on the design and development of the system which consists of photovoltaic arrays, lead acid battery, inverter, controller and load. In order to ensure the performance of the photovoltaic system, a simulation will first be done using Proteus software. At the end of the project, the photovoltaic system is expected to be able to work under three states of energy transition that will be controlled by the PIC microcontroller. The three states of energy transition are PV panel to load, PV panel to battery, and battery to load.

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CHAPTER 1

INTRODUCTION

1.1 Problem statement

Nowadays, the depletion of the traditional energy sources and its drawback towards the environment had become one of the major concerns among the countries. Therefore, renewable energy with its advantages of inexhaustible use and pollution free is required. Solar energy is one of the most vital parts of the renewable energy system. However, the inconsistent of the solar irradiation during daytime and the absence of the sunlight at night limit the usage of the renewable energy. This is due to the major prerequisite of a stand-alone PV system is the presence the sunlight. The unpredictable climatic condition without sunlight such as windy or overcast day had become the major obstacle for stand-alone PV system to supply the sufficient energy to the load. Thus, it is indispensable to have a solar energy system that can convert the sunlight into electricity and store the excessive energy for the future use.

1.2 Objective

The purposes of this project are:

1. To develop a standalone photovoltaic system with the storage device.
2. To control the standalone photovoltaic system for the purpose of the energy transition using PIC microcontroller.

1.3 Project scope

This project will focus primarily on the design and development of the standalone photovoltaic system with the existence of the energy storage device. In addition, this project will also cover the energy transition parts that are controlled by using PIC microcontroller. However, this project does not cover the measurement of the total number of charges that can be delivered from the solar panel to the battery in order to charge the battery.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the recent years, renewable energy such as wind energy, water energy and solar energy had been given more widespread attention among the countries. Solar energy which is also known as photovoltaic energy is the most promising alternative energy due to its advantages of pollution free, maintenance-free, cost-effective and inexhaustible use [1]. Nevertheless, its high installation cost, low conversion efficiency of the PV modules and very much weather dependant characteristic had restricted the usage of solar energy on a large scale [2]. Solar energy is widely used in various applications such as household appliances, solar cars, and even electric aircrafts [3]. Photovoltaic energy is converted to electrical energy by the use of photovoltaic power generation system which consists of several PV cells. Photovoltaic system can be divided into two categories which are stand-alone PV system and grid-connected PV system.

2.2 Types of PV system

2.2.1 Stand-alone PV system

Stand-alone PV system is an off-grid electrical system. It involves in the energy conversion without the utility grid [4]. It is typically used in remote areas such as islands and vehicles that are hard to reach by the power grid as shown in Figure 2.1. Since output power from the PV panel fluctuates according to the solar irradiation and ambient temperature, an energy storage device is required to provide power at night and during overcast days [5] [6]. Apart from that, it is also necessitate to place a charge controller in the PV system in order to prevent the battery from overcharge.

Figure 2.1: Stand-alone photovoltaic system in remote areas [7].

2.2.2 Grid-connected PV system

Unlike stand-alone PV system, grid-connected PV system is connected with the utility grid in its basic construction as shown in Figure 2.2. It is also known as utility interactive PV system or grid tied PV system. The power grid acts as the battery storage backup of the system. When the output power generated from the PV array is more than load demand, the surplus energy will be fed to the power grid. The energy from the utility grid will then be used during the insufficient PV generation in order to regulate the deficiencies that are occurred [8] [9].

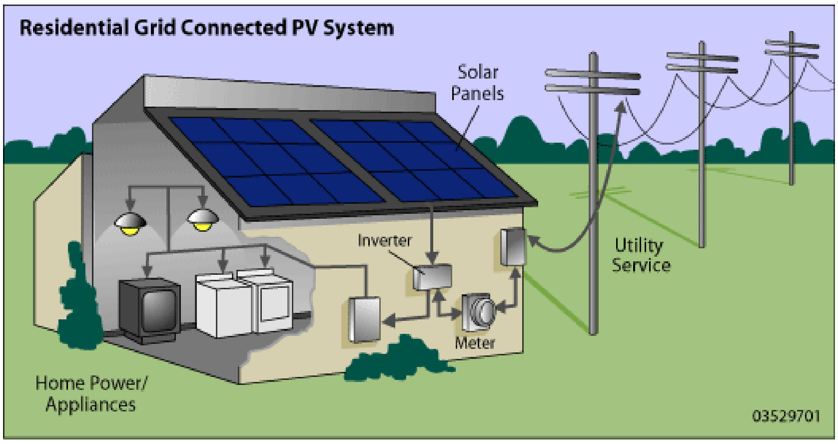

Figure 2.2: Grid connected PV System for the residential area [10].

2.3 Components of stand-alone PV system

Stand-alone PV system consists of PV generator (PV cells, modules, panels, array), controller, battery, inverter and AC load as shown in Figure 2.3.

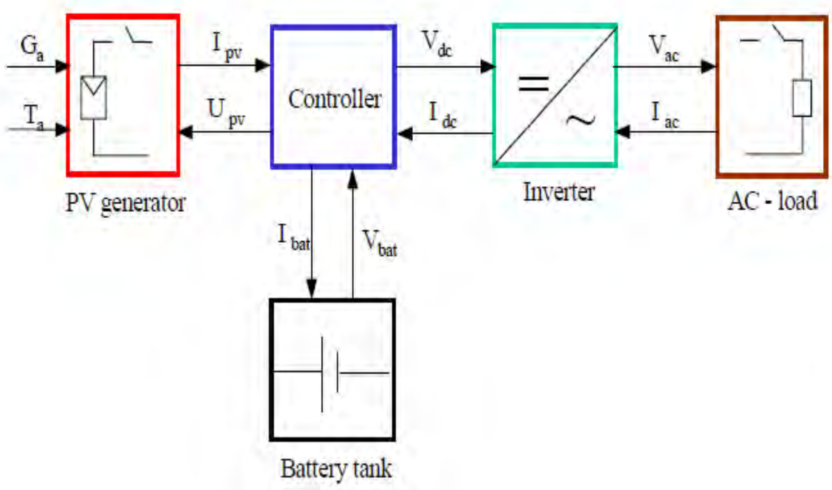

Figure 2.3: Block diagram of the stand-alone PV system [11].

2.3.1 PV cell

PV cell is the part of the stand-alone PV system that responsible in the sunlight-to-electricity conversion. The number of PV cell that employed depends on the current, voltage and power requirement of the system. A large number of PV cell is needed for the large output power needed. A PV array consists of many PV panels, while PV panel contains many PV modules, and a PV module comprise of many PV cells that are connected in series or parallel as shown in Figure 2.4. The performance of the PV cell will also vary according to the solar irradiation and ambient temperature [11].

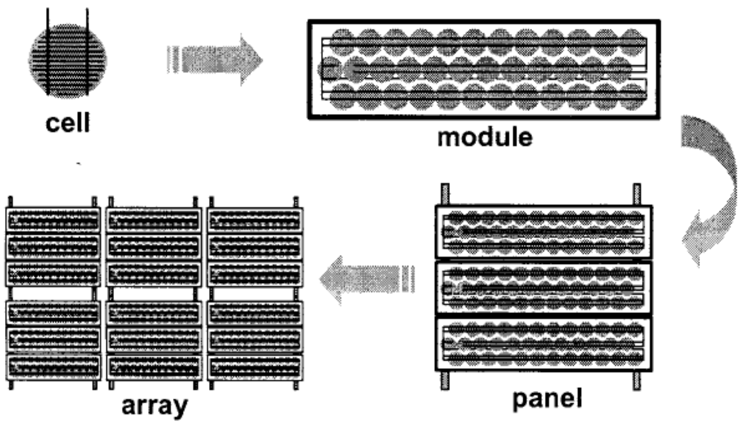

Figure 2.4: PV cells, modules, panels, and array [11].

2.3.2 Controller

Controller is the most vital part in a stand-alone PV system. It is essential to have a controller in a PV system that with storage energy device. This is because it involves in the protection scheme for the battery in controlling charging and discharging of the battery in order to prevent overcharge and prolong battery life. It is responsible in managing the load flow of the system. It manages the three states of charge which are power flow from the PV panel directly to the load, power flow from PV panel to the battery and power flow from the battery to inverter and the load. The switching of the three states of charge is managed by the controller based on the weather conditions and load demands [11]. There are a wide variety of control algorithms that are used by the controller such as maximum power point tracking control (MPPT), PLC control, on/off charge controller, PWM charge controller, PIC microcontroller and so on.

2.3.3 Battery

Since the output power from the PV panel is intermittent and uncertainty due to the atmospheric conditions, therefore battery is needed in a stand-alone PV system. Battery that acts as the backup source of energy ensures the continuous flow of power in the system. It is used to store the excessive energy when output power from PV panel exceeds the load demand. However, the energy stored in the battery bank is required to supply to the load when the output power from PV panel insufficient to apply to the load. In addition, battery protection is needed in PV system in order to prolong battery life since battery is a weak yet expensive element in PV system [12]. In order to enable a battery to be used for long term storage, the certain characteristic of battery is required such as long life, very low self-discharge, long duty cycle, long charge storage efficiency, low cost and low maintenance [13]. Apart from that, the battery capacity in stand-alone PV system can be calculated by

$$Battery\ capacity\ (Ah) = \frac{total\ Watt-hour\ (Wh)\ per\ day\ used\ by\ appliances\ \ X\ day\ of\ autonomy}{battery\ \ loss\ \ X\ \ depth\ of\ discharge\ \ X\ \ nominal\ \ battery} \text{--------------------(2.1)}$$

Where; battery capacity calculated in unit Ampere hour (Ah),

battery loss which is usually considered as 0.85,

depth of discharge that normally considered as 0.6.

2.3.3.1 Types of battery

(i) lead-acid battery

Lead-acid battery is the most common battery that is used in current stand-alone PV system. It is the most economical energy storage device within the storage of large quantities of electrical energy [14].

(ii) Nickel-cadmium battery

Nickel-cadmium battery is suitable to be used in the stand-alone PV system especially in cold climates as it is more robust than lead-acid battery. Compared to lead-acid battery, nickel-cadmium battery has a number of benefits such as long life, low maintenance and survivability from excessive discharges. Nevertheless, the major drawback of this type of battery is its expensive price and also limited availability [15].

2.3.4 Inverter

The output of the inverter is connected to the AC load. It converts the DC power from PV panel into AC power in order to supply to the load. The selection of the inverter is depends on the power required by the load. The rating of inverter has to be 20-30% much higher than the power that required by the load [16].

2.4 Journal Comparison for the method used in controller

From the four journal papers that are compared in the Table 2.1, it can be concluded that PIC microcontroller is the best control algorithm to be used in the stand-alone PV system in controlling the states of energy transition. PIC microcontroller which is basically software based is easy to alter according to the different climatic conditions that might vary in diverse of time. This is because only C code that is implemented inside the PIC microcontroller need to be changed when different demand is required. This is more convenient and easy for maintenance compared to the MPPT technique which is more focus on the hardware implementation. For MPPT technique, specified connection of the circuit is needed to be constructed in order to get the MPP and it may results trouble to the user due to the complexity of the circuit. Besides that, characteristic of MPPT that only operate well under the existence of sunlight condition had made it less favourable in this project. Unlike MPPT, PIC microcontroller can set to consider all the possible different atmospheric condition by only modifying the C code written. In addition, this is also because the PIC microcontroller that uses C code can perform variety of complex control.

The model of the PIC microcontroller that is chosen in this project is PIC 16F877A as it is the most common type in the PIC family. Apart from that, MikroC software is also use in order to program the PIC microcontroller. In addition, 50W PV panel is used in this project and 12V lead acid battery is also selected to store the surplus energy of the PV system. Lead acid battery is the most common type of battery that is used in the stand-alone PV system.

Table 2.1: Comparison of the journals [17] [18] [19] [20].

Author	Title	Method	Result
Nowshad Amin, Lam Zi Yi, Kamaruzzaman Sopian	Microcontroller based smart charge controller for stand-alone solar photovoltaic power systems	PIC microcontroller and PWM charging method	**Advantages:** -C code in PIC controller is more user friendly -cheaper and more affordable -able to provide more intelligent control with the same device simply by changing the program parameters -able to perform complex task -can be used with or without battery by switching toggle switch
Mei Shan Ngan, Chee Wei Tan.	A Study of Maximum Power Point Tracking Algorithms for Stand-alone Photovoltaic Systems.	Maximum Power Point Tracking (MPPT) control technique Direct method -Pertub and Observe (P & O) method -Incremental conductance (INC) Method -Feedback voltage or current -Fuzzy logic method -Neural network method Indirect method	Pertub and observe (P & O) method **Advantages:** -simple -only few parameters are required **Disadvantages:** -energy loss due to oscillation around MPP Incremental conductance (INC) method **Advantages:** -able to generate good results under rapidly changing environment

		-look-up table -open circuit PV voltage -short circuit PV current	-attain lower oscillation around MPP compared to P & O method **Disadvantages:** -more expensive and complicated Open-Circuit Voltage method **Advantages:** -cheap - easy implementation **Disadvantages:** -constant value that depends on characteristic of PV array is not valid in the presence of partial shading of PV array Short-circuit current method **Disadvantages:** -output power produced will not be maximum and MPP never reached since linear relationship between PV array output current at MPP and PV array short-circuit current is an approximation Fuzzy logic controller (FLC)

			Advantages: -deals with imprecise inputs -cope with nonlinearity well -display a better behavior than P & O method -quick tracking of MPP -less fluctuation in steady-state and produce smooth signal **Disadvantages:** -depends on user's experience and knowledge rather than technical understanding of the system
S.Mekhilef, N.A.Rahim, R.A.Rahman, T.W.Jau	PIC based Photovoltaic Maximum Power Point Tracking Control System	MPPT and PIC microcontroller	MPPT **Disadvantages:** -default position of solar panel always cannot get most power from the sun -MPPT only easy during clear day and controversy arises during overcast day PIC **Advantages:** -assists to get better MPPT
L.Sanidad, R.Parsons,	Effect of On/Off Charge	On/Off Charge Controller	**Disadvantages:** -lower performance since