PV MAXIMUM POWER POINT TRACKING BASED ON SINGLE-INPUT FUZZY LOGIC CONTROLLER

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I dedicate this to all my beloved family members. Esspecially to my beloved mother, Siti Hasnah Bahari and my father, Abd Karim Sudir.

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Thank You.
Wassalam

ABSTRACT

In this project, a new algorithm of maximum power point tracking (MPPT) for photovoltaic is proposed. The algorithm is based on simpilified fuzzy logic controller (FLC). The simplified FLC has one input, which is derived from the signed distance method. Due to the single-input FLC, the number of rules and tuning parameters are significantly reduced. Thus, simpler design and faster computation are expected using the simplified FLC. The simplified FLC MPPT is compared with conventional FLC MPPT. Both algorithms are implemented in stand-alone PV system that uses boost-converter. The stand-alone PV system with the algorithms are designed in MATLAB software and simulated. Result shows that the simplified FLC has similiar performance with conventional FLC. Both MPPT algorithms tracked maximum power point vary fast. Eventhough their performance are same, simplified FLC present some advantages such as simplicity of tuning of membership function, the control rule is built in one-dimensional space, the computational complexity is reduced and faster ans so on.

ABSTRAK

Di dalam projek ini, satu kaedah mengesan titik kuasa tertinggi (MPPT) untuk sistem fotovoltadicadangkan. Kaedah ini adalah berdasarkan pada kawalan logik kabur (FLC) yang dimudahkan. FLC yang dimudahkan mempunyai satu input yang dihasilkan daripada kaedah ‘signed distance’. Hasilnya, rekaan yang lebih mudah dan pengiraan yang cepat boleh didapati dengan menggunakan FLC yang dimudahkan. MPPT FLC yang dimudahkan dibandingkan dengan FLC MPPT yang biasa. Kedua-dua kaedah ini digunakan dalam sistem sistem berdiri sendiri fotovolta yang menggunakan penukar galak. Sistem berdiri sendiri fotovolta dan kaedah-kaedah tersebut direka menggunakan aplikasi MATLAB dan disimulasikan.. Keputusan menunjukkan kaedah FLC yang dimudahkan mempunyai pencapaian yang sama dengan FLC yang biasa. Kedua-dua kaedah MPPT ini dapat mengesan titik kuasa maksimum dengan cepat sekali. Walaupun pencapaian mereka sama, MPPT FLC yang dimudahkan mempunyai beberapa kelebihan seperti mudah untuk menala fungsi keahlian, jadual peraturan kawalan dibina dalam satu ruang dimensi sahaja dan pengiraan yang kompleks dimudahkan dan cepat dan sebagainya.

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PV	-	Photovoltaic
MPPT	-	Maximum power point tracking
P & O	-	Perturb and observe
IC	-	Incremental conductance
HC	-	Hill climbing
FLC	-	Fuzzy logic controller
ANN	-	Artificial neural network
EA	-	Evolutionary algorithm
MPP	-	Maximum power point
SFLC	-	Simplified fuzzy logic controller
DC	-	Direct current
STC	-	Standard test conditions
PWM	-	Pulse width modulation
CFLC	-	Conventional fuzzy logic controller

CHAPTER 1

INTRODUCTION

1.1 Background

Energy demand is increasing every year due to increase in population and some other reasons. However, amount of fossil energy is decreasing. This means human cannot depend only on fossil energy to meet the increasing energy demand. Renewable energy such as solar power, wind power, geothermal power and fuel cell energy are being considered to meet the increasing energy demand. Renewable energy is not only unlimited in source but also produce zero or very low of pollution to the environment. Solar energy is one of popular renewable energy being used today. The source of solar energy is unlimited and produces zero pollution to the environment. Photovoltaic is used to convert the solar energy to electrical energy. Improvement of the performance of photovoltaic is going on until today to make the efficiency of the photovoltaic as high as possible.

Generally, there are two areas to improve the performance of solar photovoltaic system which are photovoltaic manufacturing process and power management strategy. An inappropriate power management strategy will result in low efficiency in solar photovoltaic system. One of the power management strategies being developed is the maximum power point tracking (MPPT). MPPT is a method to find voltage and current of a photovoltaic module at which it will operate at maximum power output under certain temperature and irradiance. MPPT methods are categorized in two types which are conventional methods and intelligent methods. Examples of conventional MPPT are perturb and observe method (P & O), incremental conductance method (IC) and hill climbing method (HC). Examples of intelligent MPPT are fuzzy logic control method (FLC), artificial neural network method (ANN) and evolutionary algorithm method (EA). P & O method and IC method are usual because there are easy and simple to be implemented [5]. However, P & O method has two disadvantages which are power oscillation at maximum power point (MPP) and divergence of MPP under rapid atmospheric change [2]. IC method also has a problem of power oscillation when fast tracking of the maximum power is desired [5]. Fast convergence to MPP and minimal oscillation about MPP can be achieved using fuzzy logic control method [2]. However, conventional fuzzy logic control method yields complex control rules. The conventional FLC presents difficulty of modification and tuning of control rules. Due to this problem, author in [6] simplified the inputs of FLC to one input which is known as simplified fuzzy logic controller (S-FLC). The control rules are reduced, hence it is easier to modify and tune the control rules.

1.2 Objective of the project

There are few objectives to be achieved in this project:

1. To propose a new algorithm for maximum power point tracking (MPPT) based on simplified fuzzy logic (S-FLC).
2. To compare the performance between the proposed simplified fuzzy logic controller (S-FLC) MPPT with conventional fuzzy logic controller MPPT. The types of performance that will be compared are MPPT response time to the steady state and MPPT response time to the changing of atmospheric condition.

1.3 Scope of the project

A stand-alone typed of photovoltaic system will be used in this project. Figure 1.1 shows a simple concept of a stand-alone photovoltaic system with MPPT.

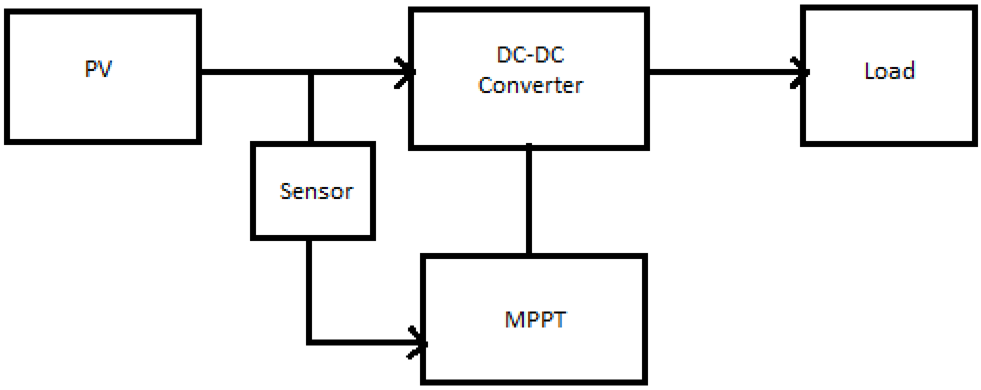

Figure 1.1 A stand-alone PV system with MPPT

This project only involves simulation using software. MATLAB software will be used for the simulation. All components in the stand-alone MPPT system as shown in Figure 1.1 will be modeled using MATLAB.

One-diode model of photovoltaic will be used in the stand-alone system. This model will be constructed in MATLAB. Figure 1.2 shows the one-diode model of photovoltaic.

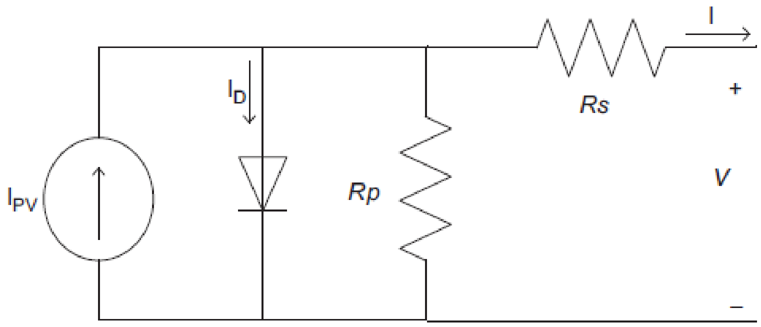

Figure 1.2 One diode model of PV [12]

The type of dc-dc converter that will be used in this project is boost DC-DC converter. Figure 1.3 shows the circuit of DC-DC boost converter.

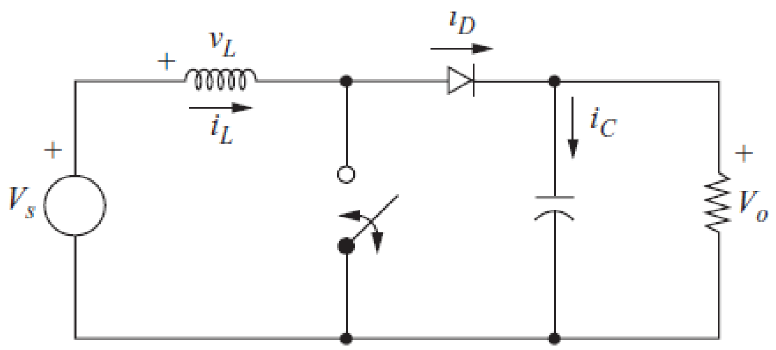

Figure 1.3 DC-DC boost converter [11]

The performance of the proposed simplified fuzzy logic controller MPPT will be compared only with conventional fuzzy logic controller MPPT. The types of performance that will be compared are MPPT response time to the steady state and MPPT response time to the changing of atmospheric condition.

1.4 Problem Statement

The P & O method of maximum power point tracking (MPPT) and IC method are simple and easy to be implemented [5]. However, P & O method yields two weaknesses namely power oscillation at maximum power point (MPP) and divergence of MPP under rapid atmospheric change [2]. IC method also yields the same problem as P & O MPPT method [5]. Fuzzy logic controller method yields some advantages such as fast convergence to MPP and minimal oscillation around MPP [2]. However, there are complex control rules in conventional fuzzy logic controller. Due to complex control rules, difficulty of modification and tuning of control rules happen in conventional fuzzy logic controller. Due to this problem, simplified fuzzy controller is introduced by author in [6] by simplifying the inputs of conventional fuzzy logic controller to one input using signed distance method. In the simplified fuzzy logic controller, the control rules are reduced, hence it is easier to modify and tune the control rules.

1.5 Thesis Outline

This report consists of five chapters, which are from this chapter to conclusion. Chapter 1 introduces the background of the research, objective of this project, scope of project, problem statement and the overall thesis outline.

Chapter 2 focuses on literature reviews of this project based on journals and other references. The literature reviews are about photovoltaic module characteristic, conventional fuzzy logic controller, simplified fuzzy logic controller and dc-dc boost converter.

Chapter 3 mainly discusses on the methodology of the project. Procedures of designing PV model, dc-dc boost converter, conventional FLC MPPT, simplified FLC MPPT and stand-alone PV system in MATLAB are elaborated in this chapter.

Chapter 4 presents the results and discussions of the project. The discussion focused on the result of maximum power point tracking time of the conventional FLC MPPT and simplified FLC MPPT. Comparison of the result of both MPPTs is also discussed.

Chapter 5 concludes overall about the project based on the result. Some recommendations for future works are stated.

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