PARTICLE SWARM OPTIMIZATION FOR MPPT : SIMULATION AND ANALYSIS

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Dedicated to my beloved parents

Daud bin Jusoh & Wan Zaharah binti Wan Mahmood

Siblings

Ahmad Dzulhazril bin Daud

Noor Dzuliana binti Daud

Ahmad Dzulhairi bin Daud

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and

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ABSTRACT

Energy conversion efficiency of solar photovoltaic (PV) is low. Maximum Power Point Tracking (MPPT) is one of the most economical ways to increase the efficiency of solar photovoltaic . The main function of this MPPT is to ensure the maximum power output extracted from the PV array. This project is to design Particle Swarm Optimization (PSO) algorithm as MPPT controller to extract maximum power from the PV module under normal shading conditions. The proposed technique for this project is based on the intelligence algorithm to control power output from the PV module and dc-dc power converter should be switched to obtain the maximum power output. The results show that the power oscillation at steady state is significantly diminished which can improve the PV conversion efficiency. The parameters of the PSO algorithm will be changed in order to see its tracking performance. Simulation of the PV module, PSO algorithm and dc-dc boost converter are done, using MATLAB-Simulink software. It is found that the change of PSO algorithm parameters gives the better result on the convergence speed and ability to find the optimum point.

ABSTRAK

Kecekapan penukaran tenaga solar photovoltaic (PV) adalah rendah. Penjejakan Titik Kuasa Maksimum (MPPT) adalah salah satu cara yang paling ekonomi untuk meningkatkan kecekapan suria fotovoltan. Fungsi utama MPPT ini adalah untuk memastikan maksimum output kuasa diekstrak daripada PV. Projek ini adalah untuk membina Pengoptimum Kerumunan Zarah (PSO) algoritma sebagai pengawal MPPT untuk mengeluarkan kuasa maksimum daripada modul PV di dalam keadaan teduhan normal. Teknik yang dicadangkan untuk projek ini adalah berdasarkan kepada kecerdasan algoritma untuk mengawal kuasa output dari modul PV dan penukar kuasa dc-dc. Keputusan menunjukkan bahawa ayunan kuasa pada keadaan stabil adalah berkurangan secara ketara di mana boleh meningkatkan kecekapan penukaran PV. Parameter algoritma PSO ini diganti untuk melihat prestasi penjejakan. Simulasi modul PV, algoritma PSO dan penukar kuasa dc-dc selesai dengan menggunakan perisian MATLAB-Simulink. Daripada simulasi ini, didapati bahawa perubahan parameter algoritma PSO memberikan hasil yang lebih baik dalam halaju penumpuan dan kebolehan untuk mencari titik optimum.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

RE	-	Renewable Energy
MPPT	-	Maximum Power Point Tracking
PV	-	Photovoltaic
MPP	-	Maximum Power Point
P&O	-	Perturb and Observe
HC	-	Hill Climbing
IC	-	Incremental conductance
FLC	-	Fuzzy Logic Controller
ANN	-	Artificial Neural Network
EA	-	Evolutionary Algorithm
PS	-	Partial Shading
GA	-	Genetic Algorithm
PSO	-	Particle Swarm Optimization
DE	-	Differential Evolution
DC	-	Direct Current
CCM	-	Continous conduction mode
DCM	-	Discontinuous conduction mode
PI	-	hysteresis controller
PWM	-	Pulse Width Modulation
I	-	Current
V	-	Voltage
P	-	Power

LIST OF SYMBOLS

NP	-	Number of population
w	-	Inertia weight
c1	-	learning factor, cognitive parameter
c2	-	learning factor, social parameter
P_{best}	-	particle best position
G_{best}	-	generation best position
D	-	duty ratio
L	-	inductance
C	-	capacitance

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, usage of renewable energy (RE) sources could decrease the green house emissions and gives positive impact to the world. Among all of renewable energy sources, solar photovoltaic becomes one of the most important renewable energy sources because of the long term benefits, environmental friendliness and almost free maintenance.

However, high initial cost of solar system and low energy conversion efficiency of the PV module has been recognised as the major hindrance in its widespread acceptance [1]. Enormous amount of works have been done in order to improve the performance of the solar energy. With improving the maximum power point tracking (MPPT) capability, the solar system efficiencies can be developed. It is one of the most economical ways that can be done.

The main challenge in the MPPT is the highly nonlinear characteristic curves of PV source which varies accordingly to the environmental effects like solar

irradiation and temperature. Since the voltage–current characteristics change continuously, the MPP on power-voltage characteristics curve is not consistent, cause problems in the tracking performance. During partial shading conditions, where non-uniform solar irradiation received by PV array, the MPP tracking process become more complicated. The effect of the partial shading is the complexity of PV curve which gives multiple peaks and it is difficult to track the true and real MPP.

The MPPT techniques can be categorised into two types which are conventional and soft computing methods. For the first type, the conventional methods which includes perturb and observe (P&O), hill climbing (HC), incremental conductance (IncCond), fractional open circuit voltage and short circuit current. While for the second type is based on soft computing method which consists of fuzzy logic controller (FLC), artificial neural network (ANN) and evolutionary algorithm (EA) [2].

The conventional method is most widely used due to their simplicity in implementation and benefits. Most of the conventional methods can give good steady-state and dynamic performance under normal conditions. However, they typically exhibit high oscillation around the operating point and unable to track properly the MPP under rapid fluctuation of solar irradiance [3]. Furthermore, none of the conventional techniques are capable of dealing with partial shading (PS) conditions [4]. This is because of the incapability of the conventional methods to differentiate between local and global peaks.

Researches expressed their innovative by suggesting soft computing techniques based global search algorithm to find global maxima during partially shaded conditions [5]. Among all soft computing techniques, FLC and ANN proven to be displayed better steady state and dynamic performance than conventional method [2]. Meanwhile, both techniques are difficult to achieve optimised design. FLC requires an expert knowledge while ANN needs large amounts of training data. To overcome these limitations, EA is the best technique to deal with the MPPT

problem since it work based on set of points instead of single points used in conventional search and optimisation techniques.

Recently, several EA methods have been suggested such as the most popular ones are genetic algorithm (GA), particle swarm optimisation (PSO), and differential evolution (DE). Among the EA techniques, PSO is highly potential due to its simple structure, easy implementation and fast computation capability [6].

1.2 Problem statements

Currently, photovoltaic system most widely used as renewable energy sources since the source (sun) is abundance and environmental friendly. Although the installation price is expensive, the solar systems almost free maintenance.

Despite of these advantages, high initial cost and low energy conversion efficiency of solar system have been justified as the major hindrance in its widespread acceptance. The PV communities have been carried out enormous amount of works in order to improve the solar system's efficiency.

Among of all the works done to increase the photovoltaic system efficiency, MPPT based on soft computing methods are low cost and powerful techniques. Otherwise, the methods can solve the changes due to environmental conditions compare to conventional methods which is more popular.

1.3 Objectives of Project

The objective of this paper is to study about MPPT for photovoltaic system that has been used in order to solve the non-linear curves of P-V and I-V. Both curves are changed under environmental conditions.

However, PSO Algorithm as MPPT technique will be used in order to cater the problems occurred during changes of solar irradiation, temperature and partial shading. The viability of PSO will be studied too. Then, for the tracking performance, the effect of changes PSO parameters will be investigated.

1.4 Scope of Project

In this report, limitation works are based on conventional method of MPPT. The application of PSO algorithm as the MPPT technique will be justified. The capabilities and the viability of PSO to solve the problems need to be studied too. The changes parameters of PSO should be identified to observe their effects and analysis will be done after that.

This report presents the modification of PSO Algorithm for optimisation purposed in order to deal with MPPT problems. The proposed technique of PSO can be applied properly to track the MPP of PV source.

1.5 Methodology

For the methodology process, firstly need to do literature review on the MPPT and PSO as one of the MPPT techniques. In the literature review, the PV system which consists of PV array, converter and MPPT controller will be discussed further. The problems in solar PV efficiency and how to overcome the problem will be justified with using PSO Algorithm. PSO will solved the problems occurs in any condition in order to achieve the main purpose to extract maximum power from solar system.

Then, design the complete solar PV system with using the MATLAB Simulation Software. The designation should justify the parameters of PSO algorithm that is suitable with MPPT application. The justifications of the parameters need to be justified by the user.

After that, do the changes of the PSO parameters which are number of particle (NP),inertia weight (w) and learning factors (c1,c2). The effects of the control parameters will be analysed to observe the performance of PSO.

Next, proceed with the thesis writing or prepare report. The report should be complete with the elements starting from introduction until conclusion, and then submit the report at the end.

1.6 Structure of Thesis

This report consists of six chapters, which are from this chapter until appendices. There are summary of each chapter of this report.

Chapter 1 described about an introduction. In this chapter, an overview of this project had been discussed which includes background, problem statements, objectives, scopes of work and methodology.

Chapter 2 explained about the literature review. It presented an overview of PV model. Besides that, a study of boost converter also had been included in this chapter.

Chapter 3 discussed on the MPPT controller which involves conventional method and soft computing method.

Chapter 4 clarified about the simulation of PV system and implementation of MPPT controller in the system designed. Boost converter involves in this project also been discussed in this chapter. The system models are designed using MATLAB-Simulink software.

Chapter 5 explained about results and discussion. In this chapter, the simulation results about the effect of PSO parameters change had been analyzed and discussed.

Chapter 6 described the conclusion of the project. The recommendation for future works also suggested in this chapter.

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