VOLTAGE STABILITY CONTROL FOR MICRO GRID WITH ARTIFICIAL INTELLIGENCE TECHNIQUE

LIANG CAI HONG

BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

VOLTAGE STABILITY CONTROL FOR MICRO GRID WITH ARTIFICIAL INTELLIGENCE TECHNIQUE

LIANG CAI HONG

A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering with Honours

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this thesis entitled "VOLTAGE STABILITY CONTROL FOR MICRO GRID WITH ARTIFICIAL INTELLIGENCE TECHNIQUE 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	:	
Name	:	Liang Cai Hong
Date	:	24/5/2019

APPROVAL

I hereby declare that I have checked this report entitled "VOLTAGE STABILITY CONTROL FOR MICRO GRID WITH ARTIFICIAL INTELLIGENCE TECHNIQUE" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

To my beloved mother and father

ACKNOWLEDGEMENTS

During this semester, I successfully complete Final Year Project 2 (FYP 2). In this 14 weeks, I have received generous help, guidance and caring from many wonderful people.

First and foremost, I would like to extend my sincere thanks to all those who supported me the possibility to complete this project. The deepest appreciation I give to my FYP supervisor, Dr Norhafiz bin Salim, whose always provide stimulating suggestions and encouragement. He is very patiently, kindly and enthusiasm to give me the guidance, motivation, and knowledge of this project. Without his guidance in step by step, this report might have never been complete. Thanks very much again for my supervisor, Dr Norhafiz has given many suggestion and support in my FYP.

Furthermore, a special thanks to my beloved family for their supportive and understanding. Although I don't have many times to back home, they still understand me and give me support to continue the project.

Most specially thanks to all of my friends whose give me encouragement and support when I feel very stress. I really need express my gratitude to them for giving me a warm hug when I feel want to give up. Lastly, I have to appreciate the comment and advices given by panels especially in presentation that has improved my project.

ABSTRACT

Voltage stability has become an important issue because there are some blackout incidents have been happened that caused by voltage instability. The main problem of voltage instability is the failure working of reactive power demand as the load demand increases. In this project, the main objective is to investigate the voltage stability control in a power system. A designed micro grid system is modelled without controller to analyze the voltage stability. To maintain the voltage stability of system, Artificial Intelligence (AI) technique as a proposed method is developed with Fuzzy Logic (FL) technique. As a comparison, a micro grid system with Proportional Integral (PI) controller is modelled and compared the analysis results with Fuzzy Logic Controller (FLC). As result obtained, the voltage stability in a power system is investigated with artificial intelligence technique. According the results obtained, a PI controller is performed a better result in high load power while a fuzzy logic controller has a better performance in low load power. Thus, both controller can be used to control the voltage stability of the micro grid system.

ABSTRAK

Kestabilan voltan telah menjadi isu penting kerana terdapat beberapa insiden pemadaman telah berlaku yang disebabkan oleh ketidakstabilan voltan. Masalah utama ketidakstabilan voltan adalah kegagalan kerja permintaan kuasa reaktif apabila permintaan beban meningkat. Dalam projek ini, objektif utama adalah untuk mengkaji kawalan kestabilan voltan dalam sistem kuasa. Sistem grid mikro yang dirancang dimodelkan tanpa pengawal untuk menganalisis kestabilan voltan. Untuk mengekalkan kestabilan voltan sistem, teknik Kecerdasan Buatan (AI) sebagai kaedah yang dicadangkan dibangunkan dengan teknik Fuzzy Logic (FL). Sebagai perbandingan, sistem grid mikro dengan pengawal Integral Proportional (PI) dimodelkan dan membandingkan hasil analisis dengan Pengawal Logik Fuzzy (FLC). Hasilnya, kestabilan voltan dalam sistem kuasa disiasat dengan teknik kecerdasan buatan. Menurut hasil yang diperoleh, pengawal PI dilakukan dengan hasil yang lebih baik dalam daya beban tinggi manakala pengawal logika fuzzy mempunyai prestasi yang lebih baik dalam daya beban rendah. Oleh itu, kedua-dua pengawal boleh digunakan untuk mengawal kestabilan voltan sistem grid mikro.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

FLC	-	Fuzzy Logic Controller
PV	-	Photovoltaic
AI	-	Artificial Intelligence
PI	-	Proportional Integral
FL	-	Fuzzy Logic
ANN	-	Artificial Neural Network
NL	-	Negative Large
NS	-	Negative Small
ZE	-	Zero
PS	-	Positive Small
PL	-	Positive Large

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Overview

Chapter 1 defines the research background, motivation, problem statement, objective and scope of the project. The research background of voltage stability in a power system, a microgrid and the method used in this project are described. The motivation, problem statement, objective and scope of the project are clearly explained.

1.2 Research Background

Recently, power system networks that especially the sections of transmission have been conducted under extremely stressful conditions. There are some factors that are affecting the voltage stability of a power system. The factors are unbalancing reactive power, load variation, changing the speed of prime mover, heavy loads and long transmission lines, large different changes in power angle and power transfer, and failure gain in synchronism and short circuit. Under these factors, a power system can display a new type of unstable behavior characterized by slow (or sudden) voltage drops, sometimes escalating into a collapse. Due to history of voltage stability, The problem of voltage stability is first distinguished by Soviet Union scholar Malkovich in the 1940s [1]. Several voltage instability incidents have taken place worldwide. As a consequence, voltage stability has become an important concern in the planning and operation of the power system.

To determine the maximum load power in power system and analyze the voltage stability, P-V curve as shown in Figure 1.1 [2] is popularly used as a tool. After the load power overshoot the limitation power, P-V curve can analyze the load power that a bus may withstand before the breakdown of voltage. The bus voltage begins to

fall down until it reaches the critical point or a voltage collapse point (knee of the PV curve) when the load power over a bus's power limit.

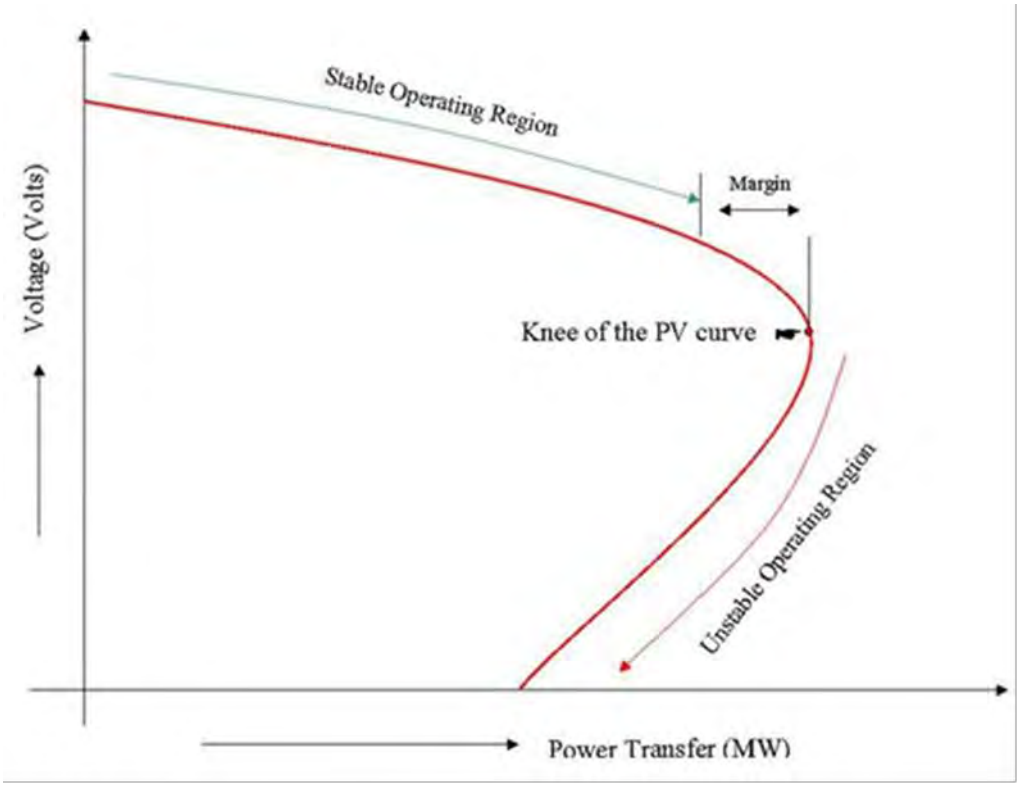

Figure 1-1: P-V curve.

A micro grid is a combination of domestic distributed loads and low voltage energy sources, including micro turbines, wind turbines, photovoltaics (PV) and storage devices [3]. Micro grids comprise various types of power generation resources, storage systems, and effective programs that optimize the use of renewable energy and ease energy management, response of demand and reduction of load. Due to the rapid growth of renewable energy, micro grids also use solar photovoltaic (PV) or wind farm as energy resources. There are many reasons for the importance of micro grid used. They are improving efficiency of the larger power grid, good for the environment with renewable resources, secure from attacks in cyber and physical. It shows that a micro grid play a main role in power system.

In this paper, the main focus is to investigate the voltage stability control in a power system. It also needs to study on voltage stability in a micro grid. To improve the problem of voltage stability in a micro grid, the method that artificial intelligence technique is used.

1.3 Motivation

This section will focus on two main aspects that are voltage stability in a micro grid and artificial intelligence technique. During a small disturbance, increase in load demand, or change in system condition occurs in power system, the voltage of the system will drop and uncontrollable because of the network failure to meet the growing demand of reactive power. This phenomena will lead to voltage instability which make the system collapse. For an example, one of the problems that occurred in Malaysia is the major blackout event on 13 January 2005, which make the local councils to trim some loads for the balancing of the generations and distribution demands [4]. It is very important to maintain voltage in steady state value and make sure that the stable condition in power system.

To implement the artificial intelligence technique in a micro grid is another aspect that focused on this section. Due to new era technology, the Fourth Industrial Revolution (IR 4.0) is a transformation in economies, jobs and also society. Under IR 4.0, artificial intelligence (AI) as one of physical and digital technologies is perfectly met the challenges to make digital companies that can communicate, analyze, and use data to drive smart physical action. With the smart technology, AI technique is used to improve the problem of voltage stability in micro grid.

1.4 Problem Statement

The major issue and equipment loading without modifying the capacity of transmission line is to preserve the voltage stability in power system. The voltage will become unstable when the load demand increases and the capacity of transmission insufficiency. This situation will lead to failure meet the reactive power demand. Due to the limitation of reactive power / voltage control of the generator, the system will lead to voltage instability. As the voltage instability, the power system's inability in keeping with the demand of reactive power. Furthermore, the instable voltage will also occur in a micro grid system and it makes the most disruption in power system. Hence, this paper will propose an artificial intelligence technique as a method to improve the voltage stability.

1.5 Objective

The main objective of this project is to investigate the voltage stability control in a power system.

The following objectives of this project are:

i. To develop reactive power control using artificial intelligence (AI) technique.

ii. To verify the impact of voltage stability control for micro grid network.

1.6 Scope

This project is focusing on power system voltage stability analysis. To analyze the results of the project, a designed system is modelled and tested as a micro grid system. In this system, it will be developed using DC voltage as energy sources. A Fuzzy Logic technique will also be used to improve the voltage stability control of micro grid system. The simulation results will be obtained by using MATLAB Simulink.

1.7 Project Outline

The main focus of this project is to investigate the voltage stability control in a power system. This report is divided into five chapters. The chapters are:

Chapter 1: Introduction about the voltage stability control for micro grid with artificial intelligence technique. Explanation about the motivation, problem statement, objective, scope and project outline.

Chapter 2: Literature Review about the voltage stability, micro grid and Fuzzy Logic (FL).

Chapter 3: Methodology discusses about the flowchart of the project, the model micro grid without controller, micro grid with Proportional Integral (PI) controller and micro grid with Fuzzy Logic Controller (FLC).

Chapter 4: Results and discussion which are the results of the test system and the performance of the voltage in the system.

Chapter 5: Conclusion about the summaries of results and the recommendation of future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Investigation will be discussed on voltage stability, micro grid and artificial intelligence technique. Section 2.2 describes a concept of voltage stability. Section 2.2.1 describes the different method on voltage stability. Section 2.3 discusses the concept of micro grid. Micro grid structure is presented in section 2.3.1 and the impact of micro grid on voltage stability is discussed in section 2.3.2. Artificial intelligence (AI) technique is discussed in section 2.4. Fuzzy Logic (FL) is presented in section 2.4.1. Finally, a comparison on other controller is presented in 2.4.2.

2.2 Concept of Voltage Stability

Voltage stability is described as a power system's capability to conserve the voltages in stable condition at all buses after having a disturbance from a balanced point. An overview on voltage stability is presently one of the most important research fields in power systems. In some literature papers, numerous problems of voltage stability have been investigated from many multiple perspectives. According to [5], the problems of voltage instability that caused voltage fall down have been reported in many countries , such as Canada, France, Japan, USA, and otherwise. In paper [6]–[8], the main factor that make voltage collapse is increase in load demands which will lead to failure of the reactive power demand. As it impacts the performance and capacity by the delivery of real power to end users, the role of reactive power will not be overstated. It can lead to a voltage collapse phenomenon that has caused several blackout incidents worldwide [9], [10] since the problems of reactive power are rejected.

Voltage stability has divided to some categories as shown in Figure 2.1. Voltage stability is divided to small-disturbance voltage stability and large-disturbance voltage stability. Small disturbance voltage stability is defined as the ability of the system that voltage stability can be preserved after have a small disturbance or load

system increases. The load will be affected when the effect of given time. Large disturbance voltage stability states that the voltage stability for all buses system can be preserved after system faces large disturbance, i.e. the failure of system, fault, and the cutting machine. It is determined by the interaction between the system and the characteristic load and between continuous and discontinuous control and protection.

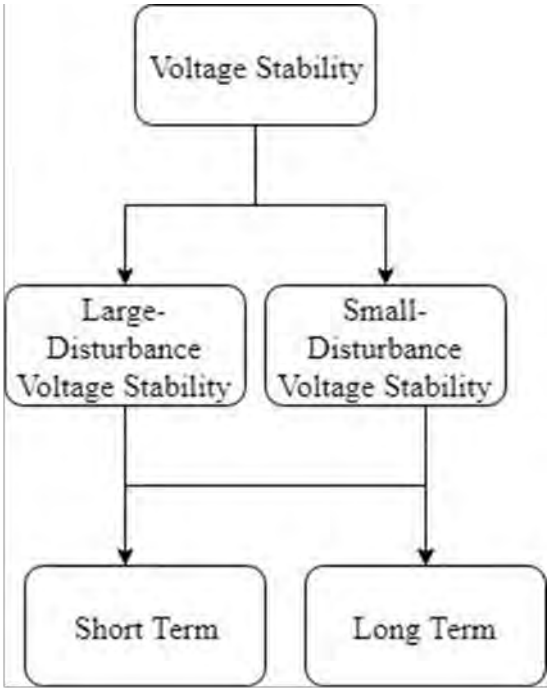

Figure 2-1: Categories of voltage stability

2.2.1 Different Method on Voltage Stability

In paper [11], a problem of voltage instability in power system is well described. The paper analyse the voltage instability of power system using real power-voltage (PV) modal analysis, voltage stability margin (VSM), reactive power-voltage (QV), load real power (P) margin, and reactive power (Q) margin. The result is reliable with the method.

Many methods are discussed as many journal papers. One of journal paper [12] stated that the analysis of the short-term voltage stability method using the stability limit in the P-V plane. The authors advance an analysis method using the stability

boundary and transient P-V curves. The result show that the induction motor's acceleration or declaration status by comparing the load's operating point to the limit line. It is also a useful method in determine the short-term voltage stability.

To improve the voltage stability, previous studies in [13] was discussed the method is using Artificial Neural Network (ANN). In this paper, several types of line voltage stability indices (LVSI) are differentiated to determine the weakest line of power system. IEEE 9-bus and IEEE 14-Bus system are used to analyse the results. By implement of feed forward back propagation neural network (FFBPNN) which is type of artificial neural network (ANN), the results were analyse. It can concluded that ANN is sufficient and suitable method to prevent the voltage instability.

2.3 Concept of Micro Grid

In recent years, voltage stability in the context of micro grids has caught the eye of researchers because renewable energy sources have penetrated the world's power networks [14].

A large-scale power system usually contains of generating, transmitting and distributing systems in which the power plants are somehow far from the power system. As both in terms of operation and in order to secure the power systems, even though this is not always the case in all systems, the operators tend to bring the units of power generation nearer to the distribution systems. There are some cases that called micro grid power systems.

Many descriptions for micro grid have been created. One of the definition in [15], micro grids are electrical distribution networks of low voltage, heterogeneously composed of distributed generation, storage, load and organized autonomously from the bigger early grid.

However, there are three modes of a micro grid that are island mode, grid connected mode and transition to grid connected mode [16].

Many approaches to analyzing the voltage stability of the micro grid were presented in the literature. In [5], PV and QV curves have been used. The voltage stability in low voltage micro grids also described in [8] but it is in aspects of active and reactive power. The frequency and voltage control method for islanded micro grid based on multienergy storages also discussed in [17].

Most of the previous studies have been carried out either on IEEE test systems or on some real systems with changes and assumptions tailored to the study objectives. The study is carried out on a real micro grid system.

2.3.1 Micro Grid Structure

A micro grid is defined as a system consisting of generating sources, focusing on the use of renewable energy, the equipment of storage and the connected loads to meet the energy demand. The general structure of a micro grid as shown in Figure 2.2 [18] includes by energy storage system, different generation systems and units of power management which for examples are pure converter, regulator, grid-tied inverter and converter.

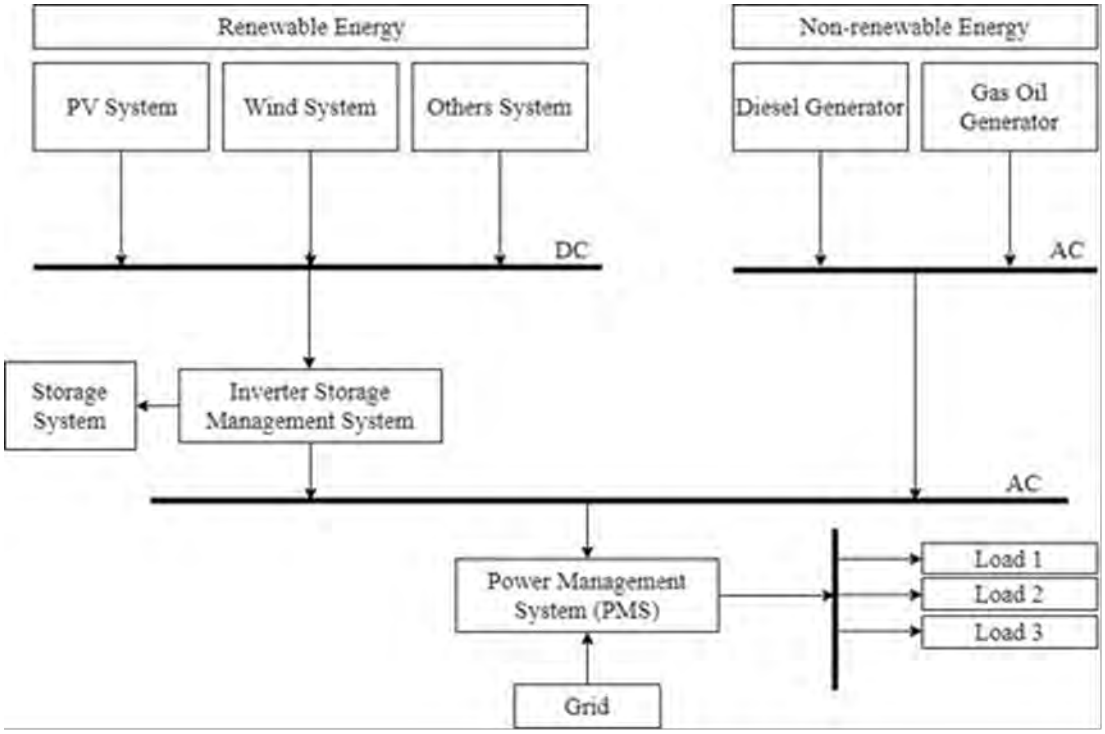

Figure 2-2: General structure of a micro grid

2.3.2 Impact of Micro Grid on Voltage Stability

According to [19], the effects of a micro grid on the voltage stability of power system is proposed. A micro grid is allowed into the IEEE 14 bus system and the impacts of voltage stability is presented. A fault is also added into the system and carried the results. The power system's dynamic reaction time with micro grid is quicker than the basic state system. In a shorter time than the basic system, this system also has a steady state. The voltage of the micro grid power system has better values than the basic state after the steady state has been achieved. The positive impacts have also seen that the changes of reactive power when the power system is with micro grid.

2.4 Artificial Intelligence Technique

Artificial intelligence (AI) is a term which in its broadest sense indicates a machine or artifact 's ability to conduct the identical type of functions that define human thinking. According to [20], AI is the computer science part of the design of smart computer systems, i.e. Systems that display the personality in action of humanity which are language, knowledge, ability to learn, logic, problem solving, etc.

Artificial intelligence (AI) techniques found in the power system are fuzzy logic (FL), expert systems (ESs), artificial neural networks (ANNs or NNWs) and more techniques. The uses of AI techniques are in control, design, estimation, simulation, fault diagnostics, and fault-tolerant control in micro gird and renewable energy system. As paper , some example of application that using artificial intelligence (AI) techniques in smart grid and renewable energy systems are discussed.

2.4.1 Fuzzy Logic

Fuzzy Logic (FL) is one of artificial intelligence (AI) techniques to solve the problems with more accurate results. The Fuzzy Logic (FL) is a principle-based control system where a guideline is a control decision mechanism for correcting the impact of some factors that cause of the power system.[21] Although they are mostly easier to understand and apply, one of major strengths over other AI techniques is the capacity of fuzzy systems to handle such information. Fuzzy systems handle applications with incomplete or imprecise data including approximation of function, categorization