SVC SUPPLEMENTARY CONTROLLER FOR DAMPING OSCILLATIONS IN POWER SYSTEM

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To my beloved mother, father, brothers and friends

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ABSTRACT

Power system oscillations occur due to the lack of damping torque at the generators rotors. The oscillation of the generators rotors cause the oscillation of other power system variables such as bus voltage, bus frequency and transmission lines active and reactive power. Power system oscillations are usually in the range between 0.1 to 2 Hz depending on the number of generators involved in. They can be local or interarea oscillations. However, this project will focus on interarea oscillations only with the frequency range between 0.1 until 0.9 Hz. Flexible AC Transmission Systems (FACTS) got in the recent years a well-known term for higher controllability in power systems by means of power electronic devices. Several FACTS devices have been introduced for various applications worldwide. One of them is Static Var Compensator (SVC), which is a shunt device, provides dynamically variable shunt impedance to regulate the voltage at a bus where it is connected. Simulation of the case studies using SVC to show damping oscillations in the power system were done in Power System Analysis Toolbox. Moreover, location of SVC plays an important part to give effectively damped the oscillations. This project will discuss residue method to find the best placement of SVC for the case studies. Besides, the supplementary controller of SVC can be applied to improve the performance of damping oscillations in the power system. In this project, the supplementary controller for SVC is referred as proportional plus integral plus derivative controller. Lastly, a designing of SVC and supplementary controller to improve 10% of damping oscillations in the power systems is successfully designed.

ABSTRAK

Ayunan dalam sistem kuasa terjadi kerana kekurangan daya kilas redaman pada rotor di penjana. Ayunan pada rotor penjana boleh menyebabkan ayunan pada pembolehubah- pembolehubah sistem kuasa lain seperti voltan bas, frekuensi bas dan kuasa aktif dan reaktif talian penghantaran. Ayunan-ayunan dalam sistem kuasa kebiasaannya dalam julat antara 0.1 dan 2 Hz bergantung kepada jumlah penjana yang terlibat. Ayunan ini boleh terjadi samada ayunan tempatan ataupun ayunan antara dua kawasan. Walaubagaimanapun, projek ini akan memfokuskan kepada ayunan antara dua kawasan dengan julat frekuensi di antara 0.1 hingga 0.9 Hz. Sejak kebelakangan ini Sistem Penghantaran A.U Bolehlentur (SPAB) menjadi terkenal kerana kebolehkawalannya yang tinggi dalam sistem kuasa melalui peranti kuasa elektronik. Beberapa peranti SPAB telah diperkenalkan untuk pelbagai kegunaan di seluruh dunia. Salah satunya adalah Pemampas Var Statik (PVS) yang merupakan peranti selari di mana ianya menyediakan pembolehubah galangan selari untuk mengawal voltan pada bas yang disambungkannya. Simulasi kajian kes dengan menggunakan PVS bagi menunjukkan ayunan redaman dalam sistem kuasa telah dilakukan dalam *Power System Analysis Toolbox* . Tambahan pula, lokasi PVS memainkan peranan penting untuk memberikan ayunan redaman yang lebih berkesan. Projek ini akan membincangkan kaedah residue untuk mencari lokasi PVS yang terbaik dalam kajian kes. Selain itu, pengawal tambahan untuk PVS boleh digunakan bagi meningkatkan prestasi ayunan redaman dalam sistem kuasa. Pengawal tambahan untuk PVS dalam projek ini adalah merujuk kepada pengawal perkadaran dan pengkamiran dan pembezaan. Akhir sekali, kejayaan simulasi dengan menggunakan PVS dan pengawal tambahan untuk meningkatkan ayunan redaman sebanyak 10 peratus berjaya direka.

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ac	-	alternative current
dc	-	direct current
kV	-	kiloVolts
MVA	-	Mega Volt Ampere
p.u.	-	per unit
Qmax	-	maximum reactive power
Qmin	-	minimum reactive power
Sn	-	power rating
Vmax	-	maximum voltage
Vmin	-	minimum voltage
Vn	-	voltage rating
V_0	-	voltage magnitude
x_l	-	leakage reactance

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Modern power system consists of four main parts. These are known as generation, transmission, distribution and loads part. The generation, transmission and distribution parts works together in order to supply power to the loads or consumers.

Power system stability has been recognized as an important problem for secure system operation since 1920s. Many major blackouts caused by power system instability have illustrated the importance of this phenomenon. Historically, transient instability has been dominant stability problem on most systems, and has been the focus of much of industry's attention concerning system stability.

Damping electromechanical oscillations between interconnected synchronous generators is necessary for a secure system operation. This is because if this problem is not overcome, it will cause voltage instability that will be leading to voltage collapse.

Flexible AC Transmission Systems (FACTS) got in the recent years a well-known term for higher controllability in power system by means of power electronic devices. Several FACTS devices have been introduced for various applications worldwide.

Static Var Compensator (SVC) is one of FACTS device that is recognized to damp oscillations in the power system. Recently, many papers have been investigated on the application of SVC to damp oscillations in the power systems.

1.2 Problem Statement

A good power system should possess the ability to regain its normal operating condition after a disturbance. Since ability to supply uninterrupted electricity determines the quality of electric power supplied to the load, stability is regarded as one of the important topics in power system researches.

Power system stability can be defined by the ability of synchronous machines to remain in synchronism with each other. The capability of power system to remain in synchronism in the event of possible disturbances such as line faults, generator and line outages and load switching, is characterized by its stability.

Following unbalances in the system, a power system may experience sustained oscillations. These oscillations may be local or interarea depending on the numbers of generators involved in. Damping the oscillations is not only important in increasing the transmission capability but also for stabilization of power system conditions after critical faults. If the net damping of the system is negative, then the system may lose synchronism. Extra damping has to be provided to the system in order to avoid this.

The availability and successfully of FACTS devices such as SVC to damp these oscillations have been reported by many researchers. Therefore, this project will illustrate the effective ways of SVC to damp oscillations in the power system.

1.3 Objectives

The objectives of the project are:

i. To study on damping oscillations in power system.
ii. To determine the critical eigenvalue of case studies with SVC.
iii. To find the best location of SVC for damping oscillations.
iv. To design the SVC supplementary controller for damping oscillations.

1.4 Scope of the Project

This project focuses on damping oscillations in power system with Static Var Compensator (SVC). Below described the scope of the project:

i. Power system oscillations which are a part of power system stability. And SVC is one of device used to damp oscillations in the power system. The performance of SVC to damp oscillations in the power system will be illustrated by using MATLAB.

ii. This project will covered residue method to find best placement of SVC for two case studies; 9 bus test system and 11 bus test system. In order to get the result of eigenvalue analysis, the case studies will be run in Power System

Analysis Toolbox (PSAT), and then based on the result obtained, programming of residue method is run in M-file in MATLAB.

iii. In order to improve the damping of oscillations in the power system, supplementary control laws can be applied to SVC. In this project, these supplementary actions are referred to as proportional plus integral plus derivative (PID) controller.

1.5 Thesis Outline

This thesis is organized into six chapters. After this chapter, Chapter 2 will discuss on power system stability especially on power system oscillations and small signal stability. Besides that, a Flexible AC Transmission Systems (FACTS) device which is Static Var Compensator (SVC) also was discussed.

Chapter 3 concentrated on the placement of SVC device because the placement of this device plays an important rule to effectively damp oscillations in the power system. The method used to find the best placement of SVC also was discussed in this chapter. While Chapter 4 presents the design of SVC supplementary controller that can be applied to existing device to improve the damping oscillations in power system

Successful passing the previous chapter, we will analyze the result of SVC in order to dampen oscillation in case study in Chapter 5. Besides, the performance of SVC with supplementary also was discussed in this chapter. Finally, conclusions and recommendations of the report project to improve future work are documented in Chapter 6.