ANALYSIS OF STATIC VAR COMPENSATOR (SVC) FOR POWER TRANSMISSION SYSTEM

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18 NOVEMBER 2005

" I hereby declare that I have read this project report and in my opinion this project report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering (Industry Power)."

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This report is submitted in partial fulfillment of requirements for the degrees of Bachelor of Electrical Engineering (Industry Power)

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NOVEMBER 2005

" I hereby declare that this project report is the result of my own work and all sources of references have been clearly acknowledged."

Signature : ....

Name : Rosfariedzah binti Rusli

Date : 18th November 2005

To my beloved parents,

En. Rusli bin Hashim and Puan Adziah binti Ibrahim.

ACKNOWLEDGEMENT

First of all, I am greatly indebted to Allah s.w.t on His blessing to make this project successful.

I would like to express my gratitude to Puan Aida Fazliana binti Abdul Kadir, my supervisor of Bachelor's project. During the research, he helped me a lot especially in guiding to use Power System Computer Aided Design (PSCAD). Then, during the discussion session, she tried to give me encouragement and assistance, which finally leads me to the completion of this project.

Finally, I would like to dedicate my gratitude to my parents, lecturers and staff of Electrical Engineering Faculty, Kolej Universiti Teknikal Kebangsaan Malaysia, my classmates and who helped me directly or indirectly in the completion of this project. Their encouragement and guidance mean a lot to me. Their sharing and experience foster my belief in overcoming every obstacle encountered in this project.

Guidance, co-operation and encouragement from all people above are appreciated by me in sincere. Although I cannot repay the kindness from them, I would like to wish them to be well and happy always.

ABSTRACT

FACTS – an acronym for flexible alternating current transmission systems is a new solution to the operational problems that is will rely on the upgrading of existing transmission level by using the latest power electronic equipment and methods. Among these is the shunt-connected SVC (static VAR compensator) for voltage control which is was first demonstrated in Nebraska and commercialized by GE in1974 and by Westinghouse in Minnesota in 1975 [2]. SVC is a static var generator or absorber whose output is adjusted to exchange capacitive or inductive current to maintain or control specific parameters of the electrical power system (typically bus voltage). Its also can be used to control the VAR compensation, damping oscillations, transient and dynamic stability and voltage stability. The main objective of this project is to improve the voltage level of the system using an SVC. In this thesis, 2 bus and 11 bus system will be designed and simulate in steady-state and transient condition using the Power System Computer Aided Design (PSCAD). Both of the system in each condition again will be simulated, this time the system was installed with SVC. The simulation of the performance comparisons between without and with SVC shows that the system is more efficient when it was installed with SVC. The voltage waveform shows that the voltage level of the system with SVC is close to 1 pu.

ABSTRAK

FACTS – adalah akronim untuk *flexible alternating current transmission systems* adalah satu penyelesaian baru kepada masalah-masalah operasi yang mana bergantung kepada peningkatan tahap penghantaran sedia ada dengan menggunakan peralatan dan kaedah elektronik kuasa yang terbaru. Di antaranya ialah SVC (*static VAR compensator*) sambungan pirau untuk mengawal voltan yang pertama kali dididemonstrasikan di Nebraska dan dikomersialkan oleh GE pada tahun 1974 dan Westinghouse di Minnesota pada tahun 1975. SVC adalah penjana atau penyerap statik var yang mana hasil keluarannya akan dilaras untuk menukar arus aruhan atau kemuatan untuk mengawal atau mengekalkan parameter-parameter tertentu sesuatu sistem kuasa elektrik (selalunya voltan bas). Ia juga boleh digunakan untuk mengawal lebihan var, mengurangkan ayunan, kestabilan dinamik dan ketidaktetapan serta kestabilan voltan. Objektif utama projek ini adalah untuk memperbaiki tahap voltan di dalam sistem dengan menggunakan SVC. Di dalam tesis ini, sistem 2 bas dan 11 bas akan dilukis dan disimulasikan dalam dua keadaan iaitu keadaan mantap dan fana dengan menggunakan *Power System Computer Aided Design* (PSCAD). Kedua-dua sistem dalam setiap keadaan akan disimulasikan sekali lagi, kali ini sistem dipasangkan dengan SVC. Simulasi bagi perbandingan prestasi di antara dengan SVC dan tanpa SVC menunjukkan sistem adalah lebih cekap bila dipasang dengan SVC. Gelombang keluaran voltan menunjukkan tahap voltan bagi sistem yang dipasangkan dengan SVC adalah menghampiri 1 pu.

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CHAPTER 1

INTRODUCTION

Voltage problem or voltage stability is always being a limiting factor in power system stability control. The problem can be solve by using the flexible AC transmission system (FACTS) such static var compensator (SVC), controllable series compensator (CSC), phase shifter (PS), thyristor-controlled series compensator (TCSC) and others. The main function of FACTS is to increase existing transmission network capacity while maintaining or improving the operating margins necessary for grid stability. This project result hopefully will show the SVC can improve the voltage level of the transmission line.

1.1 Background of the Static Var Compensator (SVC)

A static var compensator (SVC), has been used since the mid-1970's. It addresses the problem of keeping steady-state and dynamic voltages within bounds, and has some ability to control stability, but none to control active power flow. The SVC uses thyristor valves to rapidly add or remove shunt-connected reactors and/or capacitors, often in coordination with mechanically reactors and/or capacitors.

The first application of an SVC to voltage control was demonstrated on the Tri-State G & T System in 1977 by General Electric Co. (GE), which is headquartered in Fairfield, Conn. Another SVC with stability and voltage control, developed with EPRI funding by Westinghouse Electric Corp. of Pittsburgh began operation in 1978 on the Minnesota Power & Light System [1].

1.2 Analysis of Static Var Compensator (SVC)

Transmission lines both generate and absorb reactive power. A large quantity of reactive power in the system leads to a lot of wasted power, therefore an effort is made to minimize it. Since the transmitted load varies continually with demand, this causes the reactive power balance of the line to vary as well. In order to continuously control dynamic power swings under various loading conditions a Static VAr Compensator (SVC) is used, at a smaller scale (domestic and small industry) it also known as power factor correction.

In practice a static var compensator consists of a bank of binary (Xc = 1,2,4,8,16..) configured capacitors which are switched in and out as necessary to give a range of values. The more capacitors that are switched in the more reactive VAr's produced.

Dynamic VAr compensation is more complex and uses complex logic, binary switched capacitors and a smoothly variable inductance, to continuously adjust to the network requirements. VAR is short for Volt-Ampere-Reactive.

The main reasons for incorporating SVC in transmission and distribution systems are:

- Stabilizing voltage in weak systems
- Reducing transmission losses
- Increasing the transmission capacity, thus delaying the need for new lines
- Increasing stability for transient disturbances
- Increasing damping of small disturbances
- Improving voltage control and stability
- Damping power oscillations [3].

1.2 Thesis Objectives and Scope of Work

The objectives of this thesis are listed as follows:

i. To study on SVC in order to improve the voltage level in power transmission system.
ii. To analyze in steady state and transient state when SVC is installed in the system.
iii. To evaluate how SVC affects the system voltage.

In this thesis project, the scope of work will be undertaken in the following stages:

i. Study of the 2 bus and 11 bus system and the operation of SVC.
ii. Design the 2 bus and 11 bus system using PSCAD.
iii. Perform simulation of both systems. Its include four condition for each system:
    a) steady-state without SVC
    b) steady-state with SVC
    c) transient without SVC

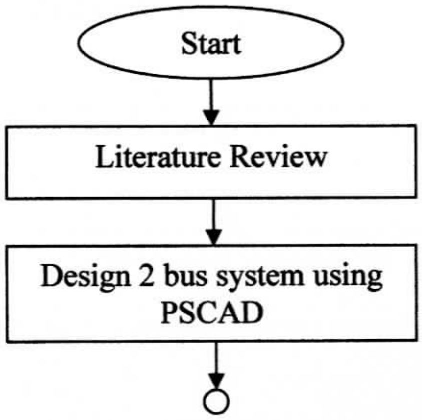
a) transient with SVC

ii. The comparisons among each condition for each system were investigated.

1.2 Methodologies

In order to finish this project, some methodologies have been used. It can be divided into two part includes the literature review of 2 bus and 11 bus system, FACTS devices especially SVC and also the power system transmission stability. The other method is using the PSCAD software. It used to design and simulate the model of transmission line.

Figure 1.1 show the flowchart of this project from it was started until its finish and how this project was done.



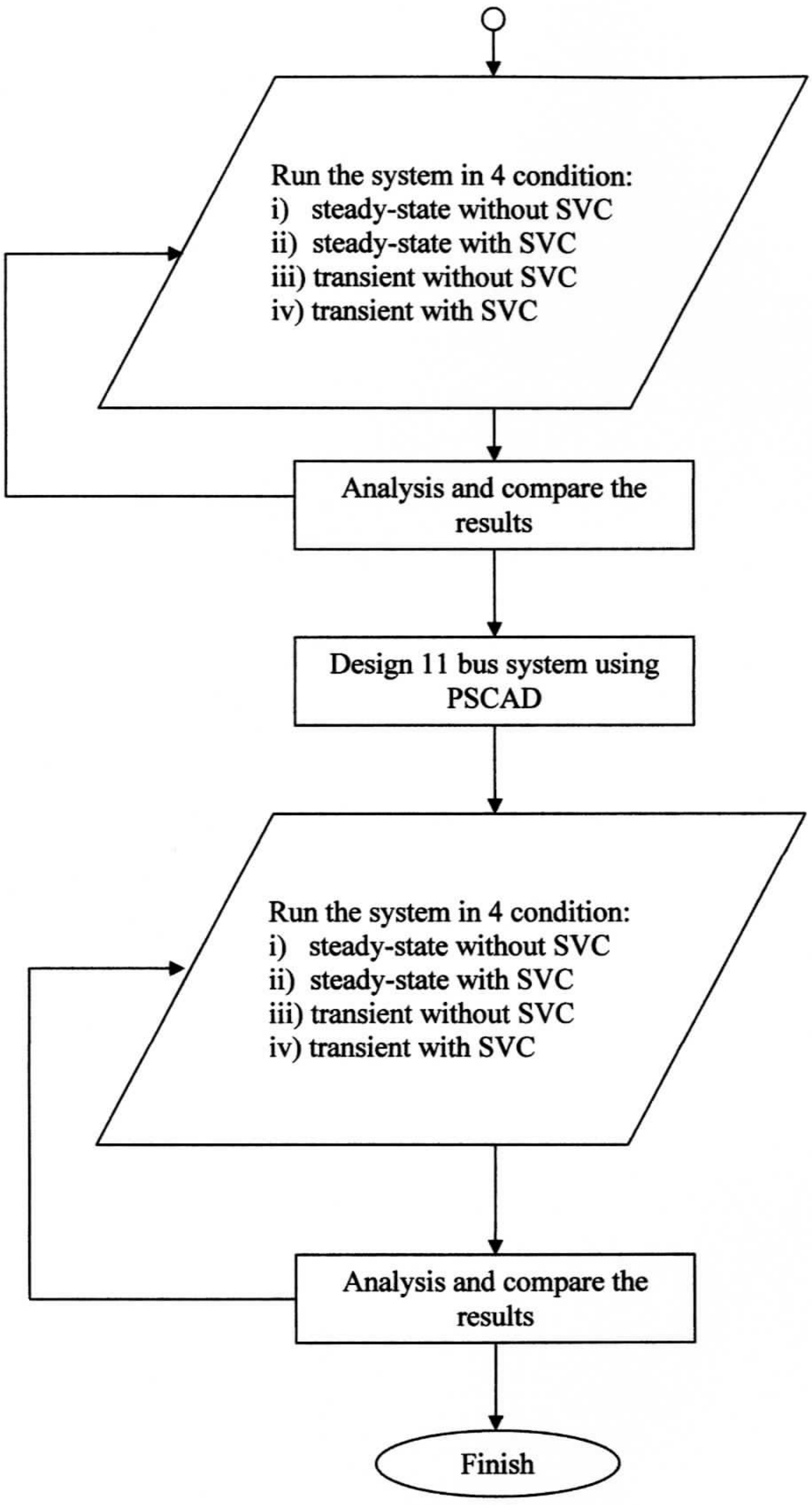


Figure 1.1 : Project's flowchart

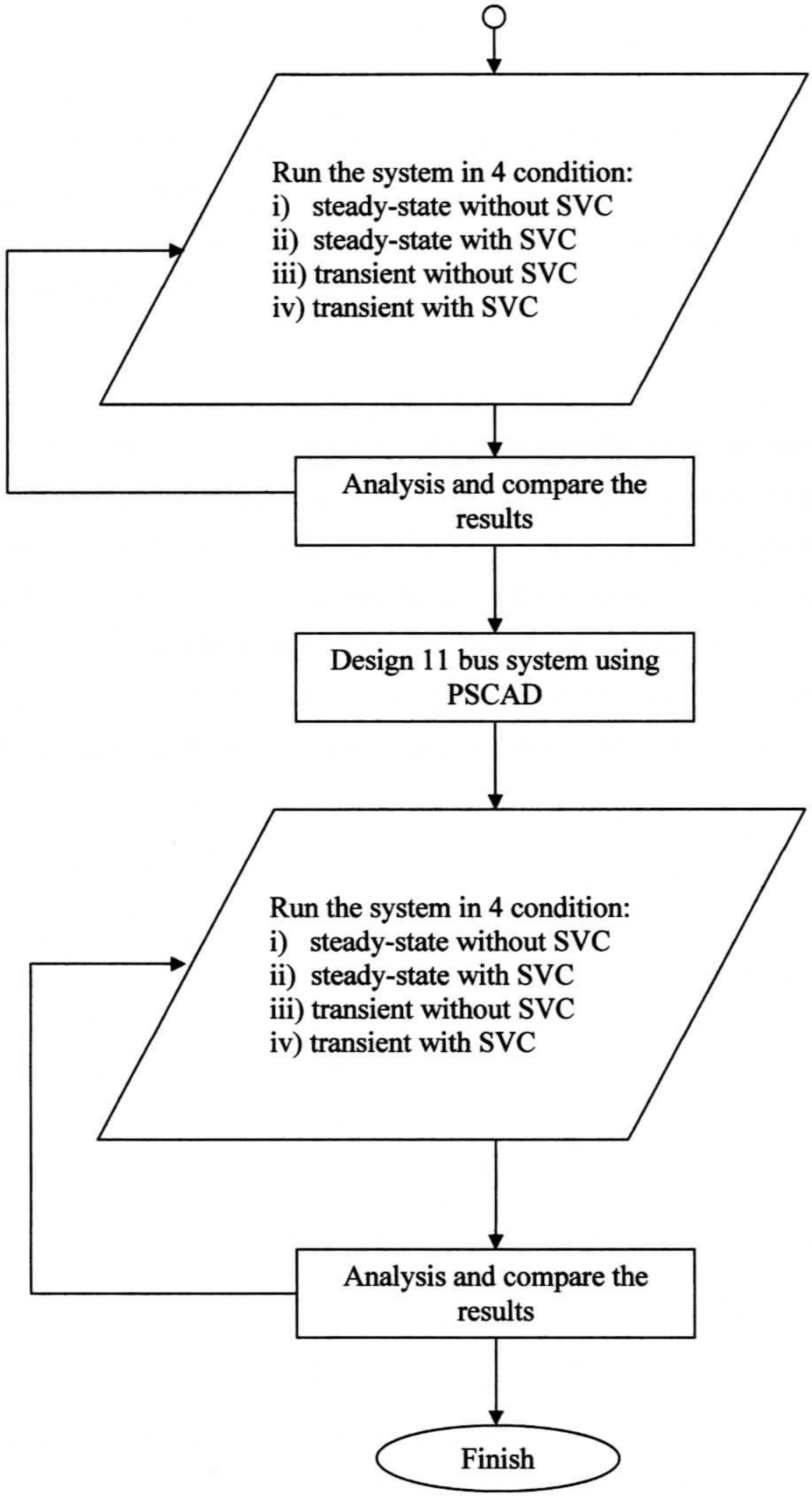


Figure 1.1 : Project's flowchart

1.6 Thesis Organization

The rest of the project report is organized as chapter by chapter. Chapter 2 describes the literature review which have been done before and during the project. The chapter also briefly discussed about the principle operation of SVC and its mathematical equations.

Chapter 3 discusses the approach used in order to design and simulate the system. (PSCAD). Chapter 4 presents the simulation performances in each condition for both system. The chapter also shows the waveform of the system. Chapter 5 describes the analysis of each condition and comparison of four condition for each system. In this chapter also shows the waveform for 2 condition in each graph frame to see the difference. Chapter 6 gives the conclusions to the thesis and recommendations to improve and further research in this work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the model of 2 bus and 11 bus system are described and presented. The purpose of this chapter is to review the principle operations and the related equations of the static var compensator which is use to improve the voltage level in power transmission system.

2.2 Static Var Compensator

By using combinations of the static VAR system (SVS) elements, a static **VAR** compensation scheme with any desired control range can be formed. A typical static **VAR** system scheme may consist of a TCR, a three-unit TSC, and filters for laminating TCR-generated harmonics. Filters produce about 10 to 30 % of reactive power of TCR MVAr rating at power frequency. The TCR current rating should be slightly larger than that of one TSC unit to ensure a smooth control characteristic.

Control power and thyristor gating energy may be lost and shutdown of SVS might be required, if the voltage drops a certain level (typically *0.3* pu) for long periods [6]. Figure 2.1 show the real SVC which is installed in Namibia.

Figure 2.1 : 1 Auas static var compensator

2.1.1 SVC Structure

SVC installations consist of a number of building blocks. The most important is thyristor valve, i.e. stack assemblies of series connected antiparallel thyristors to provide controllability. Air core reactors and high voltage AC capacitors are the reactive power elements used together with the thyristor valves. The equipment's step-up connection to the transmission voltage is achieved through an SVC power transformer. The thyristor valves, together with auxiliary systems, are located inside an SVC building, while the air core reactors and capacitors, together with a power transformer, are located outdoors.