HIERARCHICAL VOLTAGE CONTROL STRATEGY IN INTERCONNECTED POWER SYSTEMS

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To my beloved father and mother

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ABSTRACT

In interconnected power systems, voltage variation is controlled in a centralized way which can only be done at the control centre to monitor and restore the voltage profile in the system within the permissible value. A large power system can have a complicated network which makes coordination a difficult task to come up with an efficient way to maintain system voltage profile. A decentralized area control will be developed based on the electrical distance concept with reference to the pilot bus using the sensitivity of the reactive power and voltage in the network. A voltage control scheme will be produced to maintain voltage profile in the decentralized control area by using a local element; which is the transformer by optimizing the tap setting to improve voltage profile in the system. This voltage control system will enable a better use of existing reactive power resources. A network of 118 bus system is used as a test case. The comparison with different implementation of the voltage control with generators only will be analyzed. A Matlab program will simulate the voltage profile by using Newton Raphson load flow. The impact of LTCs transformer appears by manipulating the admittance matrix and results on improving the system voltage profile to overcome bus voltage fluctuations.

ABSTRAK

Di dalam sistem kuasa elektrik, perubahan voltan di kawal dan diawasi melalui satu pusat kawalan sahaja. Satu pusat kawalan itu digunakan untuk memastikan nilai perubahan voltan dapat di kembalikan kepada jumlah asal. Apabila semakin bertambah bilangan beban di dalam sistem, penstrukturan kawalan voltan sukar mengenal pasti kaedah terbaik untuk mengawal sistem voltan. Dengan mengunakan konsep pengagihan pusat kawalan, iaitu berdasarkan sensitif di antara voltan dan kuasa tidak aktif. Kawalan voltan akan mengunakan pengubahalih dengan mengubah kedudukan tempat lilitan bertemu. Penggunaan pungubahalih dapat memaksimakan penggunaan bekalan kuasa tidak aktif yang mana kedudukannya hamper dengan beban. Projek ini menggunakan IEEE 118 kes data untuk melihat impak pengubahalih terhadap kawalan voltan didalam rangka kawasan yang luas dan kompleks.

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LIST OF ABBREVIATIONS

SVC	-	Secondary Voltage Control
PVR	-	Primary Voltage Regulator
LTCs	-	Load Tap Changers
TVC	-	Tertiary Voltage Control
STATCOM	-	Static Syncronous Compensator
DC	-	Direct Current
TCR	-	Thyristor Control Reactor
TSC	-	Thyristor Switch Capacitor
CSVC	-	Coordinated Secondary Voltage Control
DSVC	-	Decentralized Secondary Voltage Control
AVR	-	Automatic Voltage Regulator
TSO	-	Transmission System Operator
SVR	-	Secondary Voltage Regulator

CHAPTER 1

INTRODUCTION

1.1 Introduction

In interconnected power system, the large system give the coordinator in the control system, difficulty to implement voltage control in the system because of the complexity of the system [1]. All equipment used in power systems are rated for a certain voltage with a permissible band of voltage variations. Voltage at various buses must be controlled within specified regulation figure [2]. The real power demanded by the load must be equal to the real power produced. Practical loads are consume reactive power and the reactive power demand may exceed the fixed value which will causes the receiving end voltage to varied to meet the reactive power demand. Thus a reactive power was related to the receiving end voltage. To maintain the receiving end voltage within its tolerance value, a fixed amount of reactive power must be produced from the line.

Voltage control is intended to compensate for voltage and reactive power demand disturbances in order to maintain a proper voltage profile along the network. A decentralized area will be developed based on the electrical distance with reference of pilot bus using the sensitivity of the reactive power and voltage in the network [3]. Currently, there are three level model of voltage control in interconnected power system, first the primary voltage control in which the controller will get the voltage profile of the network and will provide an automatic control with the closed loop design. Normally, the generating will become the primary source of controlling voltage by adjustment excitation of the generator. Then, secondary voltage control which gets the voltage profiles of the network in the small scale of area by finding the voltage in the pilot bus. The controlling method will be developed by the sources of reactive inside the control area or local area.

The network is divided into control areas that are semi-independent or at least have no effect on the adjoining areas and the voltage plan of each of them is fixed and controlled by acting in a coordinated way on control equipment available and on the set point voltage of the generators in operation. This action is performed on a "pilot" point of the area which should be representative of the change in voltages throughout the area [4]. Lastly is tertiary optimization in which the operator of the system tries to optimize the voltage profile and provides for the reference value of secondary voltage control [5-7]. This project will focus on the secondary voltage control; whereby the controlling will be at the local area. Secondary voltage control practices in many power utilities aims to maintained voltage magnitude within the required band [8]. The monitoring and optimizing of the voltage stability margin has not commonly been associated with the routine secondary voltage controls [9]. The secondary voltage control applications rely on the automatic/manual control of individual secondary voltage control devices.

The automatic operation of LTCs, an important secondary voltage control device, has been known as a potential source of deterioration of the voltage stability margin [10]. The conventional manual control operations of reactive sources are performed based on the operator’s past experience or rigid operation manual. When a system encounters disturbances under stressful conditions, fast and regionally coordinated control decisions need to be made within limited time frame. The design of a hierarchical voltage control system strategy is important to mitigate the impact of disturbances on power system stability.

1.2 Problem Statement

To control the voltage variation in interconnected power system, there were three stages of monitoring and control which is primary voltage control whereby the voltage control is set by the generation in the system but the problem was when there was a remote bus that far from the generating resource, there will be reactive power losses during transmission of energy. By conducting the hierarchical voltage control strategy to include the secondary voltage control which is to coordinate the reactive power sources within the area in interconnected power system.

A number of load tap changers (LTCs) are available to regulate distribution network voltages. LTCs operations cause transients and wear on the LTCs themselves. Therefore, it is desirable to minimize the number of tap operations. Traditionally, LTCs control is based entirely on local measurements with no coordination between different voltage levels or branches of the network. Since there are many cascaded tap changers, this gives rise to unwanted effects. For example, tap operations in different levels or branches of the networks might counteract one another and the short spikes will occur due to counteracting tap operations.

1.3 Objectives

The objectives of this project have been classified as follows:

i. To identify the impact of LTCs Transformer on voltage variation and control in the transmission line.
ii. Comparison of LTCs Transformer and Generator in term of efficiency of controlling voltage in interconnected power system.

iii. Simulate the voltage control during overload by adding load and increasing the load

1.4 Scope of Projects

Before doing any analysis and simulation setup, literature review is needed to provide a good theory and understanding. The input knowledge can be obtained from various resources such as books, journals, internet, and papers. This project is primarily focused on developed decentralize voltage control by partition it into several area in interconnected power system.

After the mathematical model of voltage control has been developed, the system will be tested on the IEEE 118 bus interconnected power system, the simulation will be conducted by using MATLAB and the data will be collected. The data approximately will show the bus that will be affected for the voltage variation and the reactive compensation coordination strategy will be implementing to the voltage control system.

1.5 Structure of project report

Chapter 1: This chapter described the introduction of voltage control in interconnected power systems and importance of voltage control. In addition to that, it provides introductory explanations about problem statement, project objectives and scope of project.

Chapter 2: A review of the literature in the previous research is presented in this chapter, which includes the reactive power resources and the implementation technique in voltage control from several utilities.

Chapter 3: This chapter describes the methodology of this project. The steps and procedure to develop the voltage control scheme and its characteristics will be discussed.

Chapter 4: This chapter discusses and analyzes the result of voltage control scheme implementation on the test system.

Chapter 5: The project is concluded in this chapter. Recommendations for future works were also discussed in this chapter.

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