COORDINATION OF VOLTAGE REGULATING DEVICES FOR ACTIVE DISTRIBUTION NETWORK MANAGEMENT

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Special dedication goes to:

My beloved husband and son,

Mother, father and all family,

All my friends and colleagues.

For their encouragement, support and motivation.

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ABSTRACT

Coordination of voltage regulating devices for active network management can be described as a process of controlling the network equipment and voltage regulating devices that serve in normal condition to enhance the utilization of network assets and minimize the requirement of their reinforcement to enable development of the system. It is important for voltage regulation implementation where the voltage supplied to the end user has to be maintained inside the regional acceptable limit. Voltage fluctuation in distribution system not only interrupted the electrical machinery functioning but it could cause damages and malfunction to the electrical equipment. The operations of voltage regulating devices at selected points in current distribution systems are controlled by the system operator based on their experiences. Poor decision in coordinating the devices may lead to poor quality of the output voltage profile and frequent action of the devices which results in high cost of operation and maintenance in terms of wear and tear. Considering having an optimum output voltage with the most minimum cost and dependency on system operator, a method to coordinate the voltage regulating devices is being enhanced. By identifying the LTC transformer and mechanically switched capacitor as the voltage regulating devices, this project research strives to illustrate the impact that a distribution system could have with different setting of the devices. A modified IEEE 13 node test feeder has been used as a system modeling while the simulation has been carried out using an OpenDSS source code interfacing with Visual Basic of C++. The results show that proper coordination of the voltage regulating devices result in better output voltage profile and less frequent action of the regulating devices.

ABSTRAK

Coordination of voltage regulating devices for active network management boleh dijelaskan sebagai sistem mengkoordinasi peranti pengawal voltan di dalam rangkaian agihan bekalan elektrik untuk meningkatkan penggunaan aset rangkaian dan meminimumkan keperluan operasi peranti bagi membolehkan pembangunan sistem. Ia penting bagi pelaksanaan *ubahsuaian voltan* di mana voltan yang dibekalkan kepada pengguna perlu dikekalkan di dalam had yang boleh diterima serantau. Turun naik voltan dalam sistem agihan tidak hanya menganggu fungsi jentera elektrik malah ianya boleh menyebabkan kerosakan kepada peralatan elektrik. Operasi peranti pengawal voltan pada lokasi yang dipilih di dalam rangkaian agihan sediaada, dikawal oleh pengendali sistem berdasarkan pengalaman mereka. Keputusan yang kurang tepat dalam menyelaras peranti mengakibatkan penghasilan voltan yang tidak optimum dan operasi peranti yang berlebihan seterusnya meningkatkan kos operasi untuk penyelenggaraan. Memandangkan kepentingan menghasilkan voltan dengan kos yang paling minimum dan kurang kebergantungan kepada pengendali sistem, kaedah untuk menyelaras peranti pengawal voltan sedang dipertingkatkan. Dengan mengenal pasti *LTC Transformer* dan *Mechanically Switched Capacitor* sebagai peranti pengawal voltan, projek penyelidikan ini berusaha untuk menggambarkan impak yang berlaku kepada sistem agihan dengan aturan peranti yang berbeza. *IEEE 13 Node Test Feeder* yang telah diubahsuai digunakan sebagai model sistem manakala simulasi telah dijalankan menggunakan OpenDSS dan Visual Basic C++. Keputusan menunjukkan bahawa penyelarasan yang betul kepada peranti pengawal voltan dapat menghasilkan voltan yang lebih baik sekaligus mengurangkan operasi peranti pengawal voltan.

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LIST OF ABBREVIATIONS

AC	-	Alternating current
COM	-	Component Object Model
DSS	-	Distribution System Simulation
EPRI	-	Electric Power Research Institute
IEEE	-	Institute of Electrical and Electronics Engineer
LTC	-	Load Tap Changing
MSC	-	Mechanically Switched Capacitor
MS Office	-	Microsoft Office
VBA	-	Visual Basic Application

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CHAPTER 1

INTRODUCTION

1.1 General Background

Nowadays, electricity is considered as a necessity to all people. It is no more prosperity that only being provided to certain range of people. Emergence of technology create challenging and competitive environment to the utility provider in fulfilling the customers order which, days by days are demanding a better quality of electricity. Interruption in power supply is not an option to them as they pay for the service. Furthermore, the giant company who runs the operation 24 hours a day, seven days a week, could not have tolerance to the disturbance in power supply.

1.2 Problem Statement

Amongst the greatest challenges in power system is to ensure the supplied voltage in distribution networks remains within the prescribed voltage bounds while considering the minimum action for regulating that voltage in order to sustain the

reasonable commercial value. Furthermore, the fluctuation in voltage supplied may cause the system to malfunction and damage to the electrical equipment.

One of the main reasons that causing the voltage in distribution network to deviate from the prescribe voltage limits is due to the continuous changes in load demand by the customers. Normally, the load demand is high during day time and low at night and early in the morning. However, it is also depending on the area connected to the distribution sub-station where industrial, residential and commercial buildings should have different characteristics of load profile.

Other reasons contributing to the uneven and variation of voltage profile in the distribution networks are:

a) Growing proportion of renewable energy resources as part of distribution generation. The variable output of the renewable energy such as solar and wind turbine depend on meteorological conditions.
b) Bidirectional power flows in the network system, since supplied power of the distribution generations (DGs) are connected at the load side of the grid at medium and low voltage.

These scenarios of uneven voltage profile in distribution networks create a challenge to the system operator where the voltage regulating devices such as Load Tap Changing (LTC) Transformer and Mechanically Switched Capacitor (MSC) need to be operated manually depending on its individual voltage set-point. Generally, the voltage set-point of each device will be decided by the operator based on their experience. Also the system operator is responsible to change the voltage set-point at selected locations once or twice per day depending on their operation practices.

1.3 Project Objective

This research project aims for the followings:

1. To coordinate the voltage regulating devices in order to maintain the prescribe voltage profile in distribution network system.
2. To minimize the tap changing and switching action of voltage regulating devices.
3. To observe an output voltage profile when different setting of voltage regulation controller apply to the system.
4. To analyze and control the system voltage profile over a 24 hours period.

1.4 Scope of Project

The scopes of this project are categorized as follows:

1. Identifying and selecting the common voltage regulating devices that has been used in most of the distribution network system such as LTC transformer and MSC.
2. Modifying a selected distribution network system (IEEE 13 Node Test Feeder) and introducing a 24 hours load shape for daily simulation.
3. Modeling and simulation of the modified IEEE 13 node test feeder network using OpenDSS source code with Visual Basic of C++ interfacing.
4. Comparison of the output voltage profile and tap action of the voltage regulating devices for:

a. Default setting.

b. Different setting of voltage regulating devices.

1.5 Methodology

This project research will be modeled based on modified IEEE 13 Node Test Feeder network which encompasses standard components for distribution network system such as transmission line, transformer, capacitor, load and etceteras. The complete distribution circuit then will be simulated using OpenDSS source code and later on to be interfaced with Microsoft Visual Studio of Visual C++. Tap changer movement and voltage at selected points will be observed and discussed as part of the results.

1.6 Report Outline

This thesis report consists of four chapters. Chapter one consists of an introduction to the overall project title where the objectives and scope of works has been discussed. In chapter two, the modeling and simulation for the distribution network system has been introduced and discussed. Result will be studied and discussed in chapter three. While in the last chapter, which is chapter four, the conclusion and suggestion for future work will be recommended.

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