# DEVELOPMENT OF GENERATOR AGGREGATION TECHNIQUE FOR POWER SYSTEM

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A thesis submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical-Power)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

NOVEMBER 2009

To my beloved Mother and sisters

## ACKNOWLEDGEMENT

All praise be to Allah and may peace and blessings of Allah be upon our prophet, Muhammad and upon all his family and companions. Thanks to Allah who give me good health in my life and thanks to Allah for everything. Without help of Allah, I may not able to achieve anything in this research.

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my supervisor, Assoc. Prof. Dr. Azhar bin Khairuddin, for encouragement, guidance, critics, advices and supports to complete this research.

In addition, I am extremely grateful to my family for their prayers and encouragement for me to take the right step in life. My sincere appreciation also extends to all my colleagues for the support and incisive comments in making this study a success. Their views and tips are very useful indeed.

# ABSTRACT

Generator Aggregation is a technique for power system and this technique is important for analyzing because this method practically ignores the control system that exists in the generator system. Classical aggregation is still able to provide a good approximation on the stability of the system. .The theory of generator aggregation in transmission line systems based on faults and variation of voltage is presented. Voltage and frequency will very when a fault occurs in the power system. Fault study can be simplified by using the generators aggregation. Inertia aggregation techniques which are based on for assessment processing, to locate the location in transmission lines, are proposed in this thesis. The generator aggregation is extracted from the modal stability of voltages at the single and multi machines of the power system network. The technique identifies the fault by using the information contained in the system. 3 generators and 4 buses are modeled in the analyzing to the study. This technique is implemented in MATLAB and the performance is tested on the variation of simulation such as the model aggregated stability of voltage is faster than non aggregated.

# ABSTRAK

Aggregasi jana kuasa ialah satu teknik untuk sistem kuasa dan teknik ini adalah penting untuk analisa kerana cara ini mengabaikan sistem kawalan yang wujud dalam sistem jana kuasa secara praktikalnya. Aggregasi klasik masih memberi penghampiran yang baik pada kestabilan sistem. Teori aggregasi jana kuasa pada talian penghantaran yang berdasarkan kerosakan dan perubahan voltan telah dipersembahkan. Voltan dan frekuensi akan berubah apabila kerosakan berlaku pada sistem kuasa. Analisa kerosakan boleh dipermudahkan dengan menggunakan aggregasi jana kuasa. Teknik aggregasi lajakan berdasarkan proses penilaian untuk menentukan lokasi pada talian penghantaran telah dicadangkan dalam tesis ini. Aggregasi jana kuasa dirumuskan daripada modal kestabilan voltan pada satu dan pelbagai mesin dalam rangkaian sistem kuasa. Teknik ini mengenal pasti kerosakan dengan menggunakan informasi yang terkandung dalam sistem. Tiga jana kuasa dan empat bas telah dimodelkan dan dianalisa.Teknik ini telah dilaksanakan dalam MATLAB dan pencapaiannya diuji pada pelbagai simulasi, contohnya model kestabilan voltan yang telah diaggregasikan adalah lebih pantas daripada model yang tidak diaggregasikan.

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# CHAPTER 1

# INTRODUCTION

## 1 Introduction

Today, an efficient and reliable power system network is the main key to modernization. The size of the modern power system network is ever increasing, due to the high demands ranging from the heavy machineries in the industries to all the electrical appliances in both homes and offices. However, the power system network is constantly subjected to both internal and external disturbances. These disturbances are capable of causing instability which can be costly to both the supplier and user. Therefore a fast and accurate assessment of pre-fault and post-fault stability of the network is necessary. The process of determining the stability is known as Dynamic Security Assessment (DSA).

In dynamic security assessment, the critical clearing time is the measurement of the stability for a power system network. The critical clearing time is a complex function of many variables due to the complexity of the network. Therefore an accurate assessment of the system's stability is generally time-consuming and computationally intensive task.

MATLAB Power System Tools Box provides a timely assessment of a particular system network's stability by replacing the requirement of manual computation with pre-programmed software calculation. The software first retrieves the required information of all the buses, lines and machines in the network from the data provided. It then simulates the transient responses of the system network during the present of fault.

## 1.1 Fault in Power Systems Network

Some what about 80 % to as high as 90 % of faults on most overhead lines are transient. For such faults, by deenergizing the line long enough for the fault source to pass and the fault arc to deionize, the service can be restored by automatically reclosing the breaker. This can improve power system transient stability and reliability providing much higher service continuity to customers. However, reclosure onto a permanent fault may aggravate the potential damage to the system and equipment. Hence the dynamic security assessment can be very important factor for stability and reliability of power transmission system. The last stage of the programme is to simulate fault on the profile which has been created.

The 4 types of faults are:

a. Three phase fault
b. Line to ground fault
c. Line to line to ground fault
d. Line to line fault

## 1.2 Dynamic Reduction Process

As mentioned in the previous chapters, modern power system network has greatly increased in size and complexity due to the demand. With the increment of generators, buses and transmission lines, computation of the stability assessment becomes more complex and tedious. For the past decades, researches were carried out to explore means of attaining faster computation of the stability of the complex network system. The most prevalent method of all is to reduce the large complex power system to a single or equivalent system, whereby the dynamic characteristic of the power system were being kept within desired accuracy. This technique is very useful as dynamic study of a large power system network does not require the full system parameters. Only parts of the parameters are required to satisfy the computational constraints. The process of reducing a large power system network into a single or equivalent circuit, which retains the dynamic properties of the system, is called Dynamic Reduction Process. The dynamic reduction process can be divided into three stages: coherency identification, generator aggregation and network reduction.

### 1.2.1 Dynamic Security Assessment Connected to Software

In view of the competitive market and the importance of Dynamic Security Assessment, a software package with advantages of accuracy and timely computation is deemed alluring to the market. Therefore with the developments of new algorithm, it is essential for the software packages to keep up with the pace of research findings and developments so as to utilize the advantages and improvements of the new algorithm. The objective this thesis is to explore and design a software package based on initial aggregation algorithm. The software packages will be built on MATLAB platform due to the popularity of MATLAB software which being commonly use and the powerful mathematical function it possesses. The packages

are required to perform mathematical computation of the equivalent system's parameters with information of the complex network provided. With the successful implementation of the initial aggregation algorithm and computation of the aggregation parameters, transient response simulation can be conducted on the aggregated system. With the simulation result, a comparison of the accuracy between the original and aggregated system can be conducted.

## 1.3 Power System Security Assessment

Power system security assessment is performed to determine whether and to what extent a power system is able to operate in secure mode after a fault occurs during its operation.

It involves the evaluation of available data collected and estimate the security level of the system in its present state and estimation of the near future state.

Due to the nature of the disturbance and the set up of the power system network, there are two main elements to power system security assessment, static security assessment and dynamic security assessment. Static security assessment is usually performed prior to dynamic security assessment.

Static security assessment evaluates the post contingent steady state of the system. It neglects the transient behaviour and any other time dependent variations caused by changes in load conditions. Static security assessment also applies the assumption that the transition to new operating conditions has taken place. Its main objective is to ensure that the operating conditions are met in the new operation conditions. This assessment basically ignores the dynamics of the system and synchronization of the power system network during the process of transiting into post fault condition state remains unknown.

### 1.3.1 Generator Aggregation

The identifying the coherent set of generators, is to aggregate the generators in the set to a single or a few equivalent generators. This paper focuses on this part of the dynamic reduction process. The details of generator aggregation process will be explained in this project.

In general, the aggregation can be classified into 2 main categories, classical aggregation (CA) and detailed aggregation (DA) [1]. In classical aggregation, the equivalent inertia is the sum of the inertia of all the generators which is deemed coherent. The equivalent transient reactance is computed by basically paralleling the transient reactance of all the generators. This method practically ignores the control system that exists in the generator system. Although with the assumptions and loss of accuracy, classical aggregation is still able to provide a good approximation on the stability of the system.

## 1.4 Project Background

Joe h. chow et al [2] presented method for A Nonlinear Model Reduction Formulation for Power System Slow Coherency and Aggregation. This technique is described for the automatic formation of dynamic equivalents of generating units. It also has the capacity for handling the wide range of models used in practical studies.

### 1.4.1 Characteristic of Background

The setup of modern power system network is huge and complex, due to the complexity of the network, hence an accurate assessment of the system's stability is generally a time consuming and a computationally intensive task. In the past few years, various sophisticated programmers were developed to assist in the assessment of the network's stability replacing the requirement of manual computation.

Rui M.G. Castro et al [3] presented prediction method for an aggregated wind park model. In this paper, an aggregated reduced order wind park model is presented. This model has been established after the application of aggregation techniques to a detailed model and the use of singular perturbations theory.

## 1.5 Literature Review

Some interesting concepts were proposed in the past. Some of them were based on the analysis of DSA with correlation generator aggregation in power system that this project is considering.

Ricardo Galarza Pierre Accari William et al [4] presented prediction method for Inertial and Slow Coherency Aggregation Algorithms for Power System Dynamic Model Reduction. This method presented new aggregation algorithm for obtaining reduced order power networks when coherent generators are aggregated.

Erkan A.et al, [5] presented method for correlation based approach for power network reduction .this paper presented a power network reduction algorithm based on coherency. Since electrically close generators tend to swing together upon a disturbance, it determines coherent generator groups using their mutual electrical proximity.

## 1.6 Problem Statement

The research is method unite the following questions:

i. How to analyze dynamic security assessment with generator aggregation method?
ii. How to develop MATLAB based program to generator aggregation method?

## 1.7 Project Objective

The objectives in the research are:

i. To study and analyze Dynamic Security Assessment technique for power system.

ii. To develop of the generator aggregation algorithms from DSA assessment using MATLAB software.

iii. To compare the result for stability of both the aggregated and non-aggregated power systems.

## 1.8 Project Scopes

i. Illustration into the nature of power system security problems, and develop.

ii. Software package in accordance to the Inertial Aggregation Algorithm as it reduces the number of generators that are coherent in the network into a single or equivalent system.

iii. The main concern of this project is to survey and evaluate results between aggregated model's responses with original system's response.

## 1.9 Outline of the future

The thesis is dividing four chapters:

i Chapter 2, Literature Review
ii Chapter 3, Research Methodology
iii Chapter 4, Result and Discussion
iv Chapter 5, Conclusions and Future Work

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