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An interactive learning on power system control
(ILPOSCO) / Mohd Hafiz Fahmi Md Fadzah.

**AN INTERACTIVE LEARNING ON
POWER SYSTEM CONTROL (ILPOSCO)**

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MAY 2008

“I hereby certify that I have read and understood the following project thesis. To my opinion, this thesis is sufficient in term of scope and quality in term of scope and quality to achieve partial fulfillment for the Degree of Bachelor in Electrical Engineering (Industrial Power).”

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Date : **7th MAY 2008**

AN INTERACTIVE LEARNING ON POWER SYSTEM CONTROL

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**This Report Is Submitted In Partial Fulfillment Of Requirements For The
Bachelor Degree Of Electrical Engineering (Industrial Power)**

**Faculty of Electrical Engineering (FKE)
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MAY 2008

“I hereby declared that this report is a result of my own work except for the works that have been cited clearly in the references.”

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Specially dedicated to my beloved family,

Md Fadzah Bin Chat

Naziah Binti Mortazah

Faridzahanum Binti Md Fadzah

Fairul Nizam Bin Md Fadzah

Farizul Amri Bin Md Fadzah

Farah Wahidah Binti Md Fadzah

Noor Fariah Binti Md Fadzah

Fashahah Binti Md Fadzah

Pn Jurifa Binti Mat Lazi and all my friends,

Thanks for your guidance and support...

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ABSTRACT

Due to the popularity of the internet, e-learning has become a new method of learning in recent years. Through the internet, learners can freely absorb new knowledge without the restriction of time and place. With this method, users do not need to use books as reference to certain subject because all the notes and practices are being downloaded in this e-learning. This project is focus on Power System Control. The objective of this project is to produce an interactive and effective learning module using Flash MX Macromedia. At the same time, this project will produce analysis and simulation of power system control. It will use Flash MX Macromedia software for the learning module and MATLAB software for analysis and simulation. This project also will use other software that related to this e-learning project. This topic concentrated on the problems on establishing a normal operating state and optimum scheduling of generation for a power system. It deals with the control of active and reactive power in order to keep the system in steady-state. The objective of the control strategy is to generate and deliver power in interconnected system as economically and reliably as possible while maintaining the voltage and frequency within permissible limits. The real and reactive powers are controlled separately. The load frequency control (LFC) loop control real power and frequency and the automatic voltage regulator (AVR) loop regulates the reactive power and voltage magnitude. Load frequency control (LFC) has gained in importance with the growth of interconnected systems and has made the operation of interconnected system possible. Today, it is still the basis of many advanced concepts for the control of large systems.

ABSTRAK

Sejajar dengan populariti internet, e-pembelajaran telah menjadi satu kaedah pembelajaran yang baru dalam tahun-tahun kebelakangan ini. Melalui internet, pelajar-pelajar boleh menyerap ilmu baru secara bebas tanpa sekatan masa dan tempat. Dengan cara ini, pengguna-pengguna tidak perlu menggunakan buku-buku sebagai rujukan untuk subjek tertentu kerana keseluruhan nota-nota dan latihan-latihan telah dimuatturun dalam e-pembelajaran ini. Projek ini memfokuskan tentang Kawalan Sistem Kuasa. Objektif projek ini adalah bagi melahirkan satu modul pembelajaran interaktif dan berkesan menggunakan Flash Macromedia MX. Pada masa yang sama, projek ini akan menghasilkan analisis dan simulasi kawalan sistem kuasa. Ia akan menggunakan perisian Macromedia Flash MX untuk modul pembelajaran dan perisian MATLAB untuk analisis dan simulasi. Projek ini juga akan menggunakan perisian lain yang berkaitan dengan e-pembelajaran ini. Tajuk ini menumpukan perhatian pada masalah-masalah dalam menghasilkan satu keadaan pengendalian yang normal dan penjadualan optimum bagi menghasilkan satu sistem kuasa. Ia berkaitan dengan kawalan kuasa aktif dan reaktif supaya sistem itu dalam berada dalam keadaan mantap. Tujuan strategi kawalan ini adalah untuk menjana dan menyampaikan kuasa bagi system yang berhubung dari segi ekonomi dengan sebaik mungkin disamping mengekalkan voltan dan frekuensi dalam had-had yang telah ditetapkan. Kuasa aktif dan reaktif dikawal secara berasingan. Gelung kawalan frekuensi beban (LFC) mengawal kuasa aktif dan frekuensi manakala gelung pengatur voltan automatik (AVR) mengatur kuasa reaktif dan magnitud voltan. Kepentingan kawalan frekuensi beban (LFC) telah bertambah dengan pertumbuhan sistem-sistem yang berhubung dan telah memungkinkan operasi sistem yang berhubung. Hari ini, ia adalah masih dasar bagi konsep-konsep maju yang banyak untuk kawalan sistem-sistem besar.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

E-learning has become one of most concerned paths for people to acquire their expected knowledge. Many universities have been invested a huge amount of resources to implement their e-learning platform. Most of developed countries have reserve a big rate of education funding to support their e-learning strategies to enhance the education exports. Under these circumstances, many industrial developers and researchers are much interested in e- learning research and development.

1.2 Problem Statement

E-learning has become one of most popular methods for the people to acquire their expected knowledge. Due to high demand and effectiveness of this method commonly in educations, e-learning has become a useful tool for students to acquire and develop certain skill.

Most of old methods are difficult to understand and non effective for student. Student can't understand what they learned when only read a book. The usage of books as reference might be boring and could not attract certain students to study for long period of time. Most of student cannot see what they have learned without simulation

and analysis. Due to this problem, e-learning might be an option or sufficient method to overcome the problem arises.

This project is been developed based on the problem arise related to the Power System Control. An Interactive Learning on Power System Control (ILPOSCO) is one of the examples to solve the students' problems. The common problems are usually the understanding of Power System Control applications, how to control power system, why the power system must be control, and power system operation. In ILPOSCO, these problem are discussed and solved using interactive presentation and easy to understand. To develop interactive and user friendly ILPOSCO, the understanding of Macromedia Flash MX is a must. This is to ensure that the outcome of the project is reaching its goal and suits the target audiences.

1.3 Project Objectives

Nowadays, the rapid advancements in technology and telecommunications, especially in Internet, have led to an explosive growth of web-based courses. Many universities have used Internet to deliver distance learning and with continuous improvement of technology of information and communication, the World Wide Web is emerging as the most popular medium for delivering instruction.

Many companies and universities have adopted e-learning to train their employees and students. The e-learning student can make and enterprise and education more competitive by increasing the knowledge of its employees and students.

There are three objectives of this project to make it successful. It is:

- i. To produce an effective and interactive learning on Power System Control (ILPOSCO) using Macromedia Flash MX.
- ii. To produce an analysis and simulation of Power System Control with MATLAB.

- iii. To help lecturer do their teaching job and help student easily understand what they learned.

1.4 Scope of Work

Power System Control title is a big scope and need to be specified so that the project goes on track and run smoothly. For ILPOSCO, a few scopes have been specified as guidance in developing this project.

The scopes of work are describes as follow:

- i. Development of learning module for Power System Control using Macromedia Flash MX that will focus on Load Frequency Control and Automatic Voltage Regulator.
- ii. Analysis on Power System Control using Matlab programming.

With these scopes as guidelines, the project will achieve its objectives successfully.

1.5 Report Structure

There are eight chapters in this report, which are Introduction, Literature Review, Power System Control Theory, Project Methodology, Software Development, Project Results, Analysis of Power System Control and Conclusion.

- i. Introduction explained about the importance of e-learning nowadays and to targeted audiences. It also explained about the project scope that have guide throughout this project development.

- ii. Literature Review described about e-learning journals. These journals helped as guidelines and gave a brief idea about what e-learning should have and how to implement it in education and engineering world.
- iii. Power System Control Theory chapter consists of the theories and formulas that are being used related to the Power System Control such as Load Frequency Control (LFC) and Automatic Voltage Regulator (AVR).
- iv. Project Methodology defined the method that being used for developing the e-learning project. This method helps to organize time and work so that the project runs as planned.
- v. Software Development describes the process of how the software is being developed from phase to phase. It also showed the advantages of using Macromedia Flash MX in developing the project interactively.
- vi. Project Results showed the result that has been achieved throughout the project development. It also state target audiences for this project and benefits to them as this project helps them in various ways.
- vii. Conclusion discussed about future development, suggestions and improvement that can be added to the project in future.

CHAPTER 2

LITERATURE REVIEWS

This chapter deals with the projects that have been created before to get one idea about project design, conception, specification and any information relating to improve the project. This literature review includes research studies and software development concerning power system control application, behavior and design as they relate to e-learning development.

2.1 Introduction

As we know, there are many things that can gain our knowledge and the most important medium are books. Books play an important role to deliver and generate knowledge. Scientists, intellectual and other scholar in the world use books as a medium to write their work and to be published for other people as guidelines. But today, books are not attracting readers anymore and mission to produce reading culture among Malaysians cannot be accomplished. Therefore, e-learning is designed to be the best solution to solve this problem.

What is e-learning? E-learning is a general term used to refer to computer-enhanced learning. It is used interchangeably in so many contexts that it is critical to be clear what one means when one speaks of e-learning'. In many respects, it is commonly associated with the field of advanced learning technology (ALT), which deals with both

the technologies and associated methodologies in learning using networked and multimedia technologies.

2.2 Previous E-learning

A few literature reviews have been made regarding this project on intention to improve understanding on Power System Control and other topics. Here a few e-learning topics have been chosen such as An Educational Simulation Tool for Power System Control and Stability by Costas Vournas, Emmanuel Potamianakis, Cedric Moors and Thierry Van Cutsem from University of Liege, Belgium and Interactive Learning Modules for Electrical Engineering Education by Don Lewis Millard from Rensselaer Polytechnic Institute as a guideline to help in developing this project. [6]

Costas Vournas, Emmanuel Potamianakis, Cedric Moors and Thierry Van Cutsem have produced an e-learning title An Educational Simulation Tool for Power System Control and Stability. This paper presents a Simulink-based educational tool development for the purpose of illustrating power system control and stability notions as well as introducing students to realistic, though tractable in size and design problems. The tool is also used for research purposes. Relevant courses are taught to last-year undergraduate as well as graduate students at the University of Liege, Belgium and the National Technical University of Athens, Greece. After a brief description of the corresponding curricula, the paper describes the simulation tool and gives examples of problems and assignments given to the students. [7]

Another e-learning produced by Don Lewis Millard is Interactive Learning Modules for Electrical Engineering Education. These multimedia materials are created with the Director authoring environment and can be accessed via a standard Web browser. Instructors can use Interactive Learning Modules (ILMs) for their lecture and demonstrations so that, students can use them for structured exercises and learners can

use them anytime, anywhere via the Internet. The ILMs allow the students to explore concepts in more detail and gain practical experience in design and application

2.3 Journals Related to E-learning

Journals search on the internet indicates various types of comments and topics regarding the usage of e-learning as a new method of learning. Basically the journals discussed e-learning as an alternative to gain knowledge and information besides using books.

Giuseppe Ali, Eleonora Bilotta, Lorella Gabrielle, Pietro Pantano IAC, Consiglio Nazionale delle Ricerche and INFN-Gruppo c. Cosenza have produce a journal title An E-learning Platform for Academy and Industry Networks. They discussed about the difference between virtual classroom and traditional teaching classroom. This is an environment specially design for allowing the users to interact in synchronous mode (videoconference, audio conference, chatting), asynchronous mode (web pages, web forum, e-mail, document repository), or mixed mod, where both modes are available on internet (steaming video, streaming audio).

In another journal title Building an E-learning Platform by Access Grid and Data Grid Technologies, Hsin-Chuan Ho, Chao-Tung Yang and Chi-Chung Chang discussed that distance education is very effective method of learning. The advantage of distance education is that it can overcome the obstacle of geographical location, making students on remote sides feel that they are at incidence like being in the environment of attending classes in a classroom. Moreover, it can save cost and time of the students for their commutation to, and from the classroom.

2.4 Conclusion of Reviews

From the studies, researches and software development above, it is obvious that e-learning system can provide a better strategy and understanding for teaching, learning, administration and system development. E-learning will become one of most important means of the education and as a medium delivering knowledge and information, especially for the universities and the outside world in the future.

CHAPTER 3

POWER SYSTEM CONTROL THEORY

3.1 Introduction

This topic concentrated on the problems on establishing a normal operating state and optimum scheduling of generation for a power system. It deals with the control of active and reactive power in order to keep the system in steady-state. The objective of the control strategy is to generate and deliver power in interconnected system as economically and reliably as possible while maintaining the voltage and frequency within permissible limits. The real and reactive powers are controlled separately. The load frequency control (LFC) loop control real power and frequency and the automatic voltage regulator (AVR) loop regulates the reactive power and voltage magnitude. Load frequency control (LFC) has gained in importance with the growth of interconnected systems and has made the operation of interconnected system possible. Today, it is still the basis of many advanced concepts for the control of large systems.

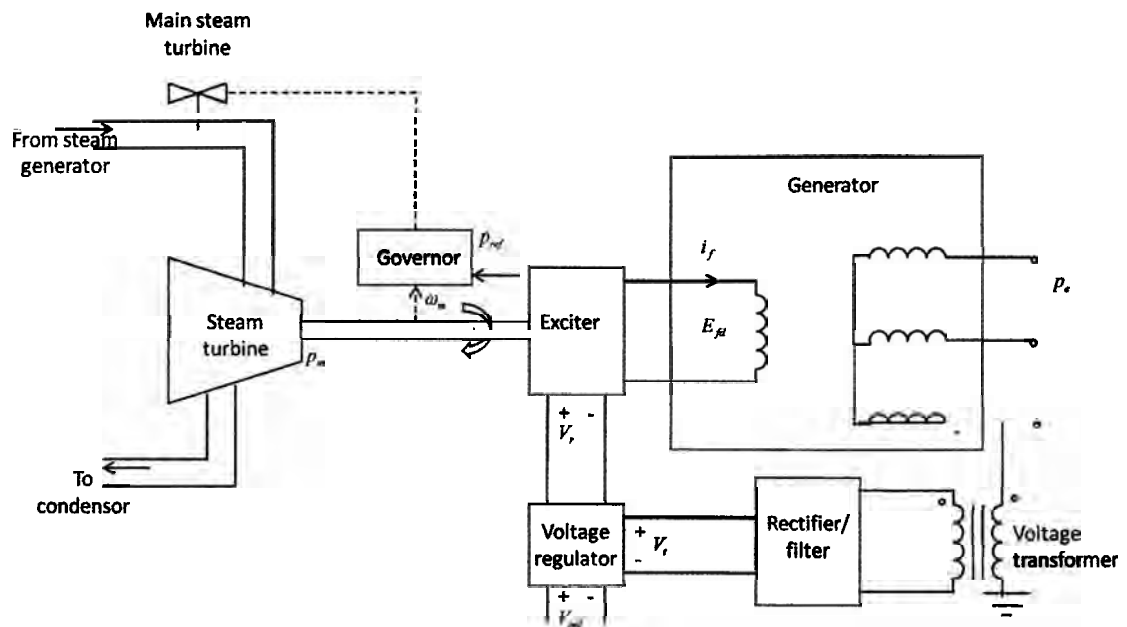


Figure 3.1: Voltage regulator and turbine-governor controls for a steam turbine generator

Figure above shows two basic controls of a steam-turbine generator; voltage regulator and turbine-governor. The voltage regulator adjusts the power output of generator exciter in order to control the magnitude of generator terminal voltage V_t . When the reference voltage V_{ref} is raised (or lowered), the output voltage V_r of the regulator increases (or decreases) the exciter voltage E_{fd} applied to the generator field winding, which in turn act to increase (or decrease) V_t , which is use as a feedback signal in the voltage regulator. If V_t decreases, the voltage regulator increases V_r to increase E_{fd} , which in turn acts to increase V_t .

The turbine governor adjusts the steam valve position to control the mechanical power output P_m of the turbine. When reference power level P_{ref} is raised (or lowered), the governor moves the steam valve in the open (or close) direction to increase (or decrease) P_m . The governor also monitors the rotor speed ω_m , which is use as a feedback signal to control the balance between P_m and electrical power output P_e of the generator. Neglecting losses, if P_m greater than P_e , ω_m increase and the governor moves the steam valve in the close direction to reduce P_m . Similarly, if P_m is less than P_e , ω_m decreases, and the governor moves the valve in the open direction.

3.2 Load Frequency Control (LFC)

The operation objective of the LFC is to maintain reasonably uniform frequency, to divide the load between generators and to control the tie-line interchange schedules. The change in frequency and tie-line real power are sensed, which is a measure of the change in rotor angle δ , i.e., the error $\Delta\delta$ to be corrected. The error signal, Δf & ΔP_{tie} are amplified, mixed and transformed into real power command signal ΔP_v , which is sent to the prime mover to call for an increment in the torque. The prime mover therefore brings change in the generator output by an amount ΔP_g which will change the value of Δf and ΔP_{tie} within the specified tolerance.

First step in analysis and design of the control system is mathematical modeling of the system. The two most common methods are the transfer function method and the state variable approach. The state variable approach can be applied to portray linear as well as nonlinear systems. In order to use the transfer function and linear state equations, the system must be linearized. Proper assumption and approximations are made to linearize the mathematical equations describing the system, and the transfer function model is obtained for the following components.

3.2.1 Generator Model

Applying the swing equation of a synchronous machine to small perturbation, we have

$$\frac{2H}{\omega_s} \frac{d^2 \Delta\delta}{dt^2} = \Delta P_m - P_e \quad (3.1)$$

or in terms of small deviation in speed

$$\frac{d\Delta \frac{\omega}{\omega_s}}{dt} = \frac{1}{2H} (\Delta P_m - \Delta P_e) \quad (3.2)$$

With speed express in per unit, without explicit per unit notation, we have

$$\frac{d\Delta\omega}{dt} = \frac{1}{2H} (\Delta P_m - \Delta P_e) \quad (3.3)$$