



## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

Nowadays, the electricity generation and supply business in Thailand and South East Asia region have rapid growth rate in last 10 years due to economics expansion of many other business sectors in Thailand and the profit from power generating business turn to be the huge income for government every year, the state enterprises need to improve utility services to support the growth especially in power generation and transmission business of Electricity Generating Authority of Thailand (EGAT) which has to increase the investment in power generation continuously to support rapid growth demand from providing adequate energy with reserved fuels and resources.

Power transmission system presents the vital roles of Thailand's electrical power network. The performance condition of the transmission system is not only used for indicating transmission efficiency, but also related to overall system reliability, which is usually made decrease by power outage. The frequently-happened outage which could decrease system stability and reliability can be considered into 3 categories :

1. Problems from voltage drops and system frequency changes.
2. Blackouts happened in distribution system of metropolitan area and provincial area from the generation and/or failure from cascading outage of transmission system , or the distribution system failure which can cause hazard results from lack of electricity in one or many large areas.
3. Temporary failure in system or transient system condition cause from voltage dips and voltage drops.

The better reliability of power system we need, the higher investment cost we have to invest for the system whenas most of the limited annual budgets of EGAT need to be invested in power generation.

So, one of the factors which can reduce investment cost in order to improve system reliability is to emphasise on design for criteria of the system and the main important equipment certainty and efficiency in the transmission system which can be effected to power system failures by many major causes of fault from both internal factors and external factors in power system environment

So, the improvement of system efficiency is needed to be aware of, especially considering on restoration time of the equipment or time to bring the system back to its ordinary state after fault occurred.

## **1.2 Statement of the Problems**

Power transformers are one of the major components, used for transforming electrical power between two or three different points of voltage, by increasing or reducing voltage levels to convenient for transmission, distribution and other various uses of electricity. Power transformers are the first priority equipment in the power system which are very expensive, enormous size, and being used continuously by feeding electricity for all of their whole operating time much more than other kinds of equipment.

So the maintenance and repairing operation can be done difficult, especially when failure happened from fault situation which might be alarmed either as an annunciator light or more complex lights.

So, it needs to have an expert determination whether that power transformer should be repaired or be able to be restored back to the system instantaneously for minimum restoration time after fault happened from protective relay signal or self protection signal to ensure that the system will not be disturbed harmfully and the consequences from happened fault will not damage the power transformer or other related equipment in the future after making system restoration.

Generally, the communication between monitoring operators at control centre and experts can be done easily in working hours but it becomes difficulty for after working hour period or when the experts sick, quit to work, retire or etc., especially the experts always need to be promoted to the higher position, be moved to more important position, or be invited to join working from external firms.

So, the developed expert system can play important roles in these situation by storing knowledge into computer system to eliminate weakness and also increase certainty and reliability of both daily works and power system. The failure, damages, defects, and abnormal operation of power transformers could affect vitally to the customers, and continuity of power generation.

EGAT's power transformers have various types and rates, each type of them has it own individual maintenance and operation procedures depended on it features, operating-controlled mechanisms, especially the main body used as insulator, and heat ventilator of their design types.

Maintenance and operation procedures can be referred from their manuals which normally have enough complete operating description, maintenance procedures, overhauling manuals, special tools needed to use when removing or inserting special parts, important constituent part description, instruction manual, and etc. All items in the manuals should be appreciated fluently by operators and related department due to having ability to diagnose most problems that will be occurred.

An example of recommendation for power transformer operation is as shown in Appendix E.

Thus, the development of expert system for power transformer diagnosis can help and support the maintenance and repairing operators in order to have capacity to solve more complicated problems correctly and instantly in the high level of expertise priority and reduce solution time for solving the power transformer problems which restoring time can be reduced as well.

All that mentioned provide fringe benefits directly to the operators, the respondent related department, especially for improving the performance of the transmission system.

### **1.3 Objectives**

To develop an expert system for power transformers in order to help diagnosing fault-alarms happened from the abnormal power transformer events by collecting knowledge and experiences from repairing experts and maintenance experts. the developed expert system will have capability to substitute expert determination for system restoration of power transformers after fault happening in a shorter diagnostic time and more accuracy, including reducing of unnecessary testing.

### **1.4 Scopes of Research**

Scopes of Research are as follows :

1.4.1 Consideration on 500kV., 230 kV., and 115 kV. rated power transformers for oil-immersed forced cooling type of the EGAT transmission system in the metropolitan area and central region of Thailand.

1.4.2 Personal computer will be used to develop the expert system under appropriate off-line expert system shell.

1.4.3 The research covers all types of major power transformer failures.

## **1.5 Expected Benefits of Research**

Expected benefits of research are as follows :

1.5.1 To help maintenance operators and repairing operators in order to solve complicated expertise problems correctly and instantly.

1.5.2 To minimise operating cost and maximise utilising time of power transformers from reducing restoration time.

1.5.3 To increase operating efficiency of employees, department, and transmission system.

1.5.4 To use knowledge, skills, and experiences collected from experts for solving problems and reducing risk from lack of experts at present and in the future, and to help the system developer and related human resources develop their own skills on both expert system skill and related knowledge from knowledge base or specialised skill.

1.5.5 To save human resources' training cost, development cost, and wages.

1.5.6 To reduce gap between man-machine interface.

1.5.7 To have capability to implement expert system and be able to design the other related types of expert system in the future.

## **1.6 Procedures and Methodology of Research**

Procedures and methodology of research are as follows :

1.6.1 Surveys of related environment and studies of development and detailed information of related equipment.

1.6.2 Literature and related theory surveys for system development tools and techniques, equipment and etc.

1.6.3 Selection of object-oriented tool or shell to be used between MS Visual Basic 4.0, Gensym's G2, Neuron Data's Smart Elements, and Borland Delphi 2.0, by determining feasibility of developer needs and environment related to objectives.

1.6.4 Collecting related data and effected factors, setting up schematic diagrams and principles of knowledge.

1.6.5 Summary solution methodology by using knowledge base put into expert system base by designing effective object class, input, output and process. Developing expert system from existing knowledge base by using selected tool and object class in both forward chaining and backward chaining, and then developing user interface.

1.6.6 Testing, modifying and checking the expert system.

1.6.7 Analysis and summarise research with suggestion.

1.6.8 Preparing final report.

## 1.7 Specific Words and Terminology

The terminology of specific words for basic understanding in power system and power transformer topics is as shown in Table 1.1 :

**Table 1.1 Specific Words and Terminology**

| <b>Word</b> | <b>Definition</b>   |
|-------------|---|
| Alarm       | : The warning signal of equipment, shown by annunciation at control room or power transformers to alert the danger event or abnormal event.   |
| Clear fault | : The correction of fault events or abnormal events in power system by human operators or protection system.  |
| DGA check   | : Dissolved Gas Analysis is the analysis of gas characteristics using gas chromatography technique which needs to be checked periodically and when fault happened to specify the abnormal event for monitoring power transformer condition and detecting incipient fault, including planning on fault handling, replacement, and maintenance. |

| <b>Word</b>                  | <b>Definition</b>  |
|------------------------------|--|
| Flash over                   | : The event that electrical current leaks from conventional conductor into the surface of insulator from overvoltage or contamination, and etc. the can enable the current flow from breaking down the insulator and conductivity of contamination.  |
| Ground relay                 | : A relay protection used for detecting abnormal ground current.   |
| Incipient fault              | : The slightly increasing of abnormal events of power transformer until detected by protective device.   |
| Load swing or MW, MVAR swing | : The event that the power stability of power system is disturbed from abnormal condition of equipment such as fault events, equipment failure, and etc. which can be affected to the other parts of the system.   |
| Maintenance                  | : The activities on work procedure from standard of work and instruction book of equipment for preventing and correcting malfunction of equipment, maintenance can be divided into corrective maintenance which consists of planned and unplanned corrective maintenance , and preventive maintenance which is overhauling, minor repairing, condition checking, and function checking, consists of fixed time maintenance and condition based maintenance.<br>Testing in maintenance procedures will be done occasionally for : <ul style="list-style-type: none"> <li>- periodic testing for checking equipment condition.</li> <li>- Commissioning testing of new equipment.</li> <li>- Testing after faults and abnormal events happened for equipment restoration.</li> <li>- Testing after equipment was repaired for evaluation and fine tuning.</li> </ul> Power transformer maintenance and standard of work will be described descriptively in Appendix F. |
| Malfunction                  | : The events that protective devices do not work properly when fault happened.   |
| Not - energize               | : Do not connect power transformers back to the power system.  |

| <b>Word</b>           | <b>Definition</b>  |
|-----------------------|--|
| Nuisance              | : The trip events or alarm events from malfunctioning of protective device.  |
| Outage, Planned       | : Bring any power system equipment out of the operation because of planned schedules.  |
| Outage, Forced        | : Bring any power system equipment out of the operation because of emergency events.   |
| Overhaul              | : The major maintenance of equipment.  |
| Power plant           | : The generation substation for installing generator. There are many types of power plants depended on sources of power for producing electric energy such as gas turbine plant, thermal plant, hydro power plant, Diesel plant, Solar plant.  |
| Protective relay      | : The protective equipment used to prevent damaging of power system.   |
| Re-energise           | : The restoration of power transformer back to the power system.   |
| Self protection relay | : The protective devices used to prevent internal damaging of power transformers.  |
| Substation            | : The place located for control room placement and substation equipment installation for metering, receiving transforming and transferring electric energy, and etc. EGAT's substations are called high voltage substation.  |
| Substation equipment  | : Equipment used in the power system for managing electric energy transmission and distribution.<br>Substation equipment can categorised by check items for maintenance and its installing location as follows :<br>Switchyard equipment : power transformer, circuit breaker, disconnecting switch, instrument transformer (CT,PT), capacitor bank, shunt reactor, static Var compensator, clamp connector, and other accessories such as junction box, metering structure, bus, conductor, tower, cable trench.<br>Control room equipment : control board, communication system of power line carrier signal and digital fault recorder and line fault locator, protective relay, teleprotection , telemetering, remote control, battery and battery charger, and air condition. |



| <b>Word</b>                      | <b>Definition</b>   |
|----------------------------------|---|
| Switchyard                       | : The specific area in substation for installing power system substation equipment.   |
| Tertiary Winding                 | : The third winding of transformer, used for additional load which must be kept isolated from secondary winding and used for supplying phase compensating device.   |
| Transmission system              | : The system used for transferring electrical energy between long-distance generating units and consuming units by using high potential levels for reducing energy losses. The system consists of transmission line, power transformers, interrupting devices, and etc.   |
| Trip                             | : The activating of circuit breakers controlled from operation of protective relay or self protection relay of power transformer, shows the type of protection by alarming on the annunciator.  |
| Units<br>(for electrical values) | : V. or Volts, the unit for measuring electrical potential.<br>: A. or Amperes, the unit for measuring electrical current.<br>: W. or Watts, the unit for measuring electrical power.<br>: VA. or Volt-Amperes, the unit for indicating electrical rated power of power transformers.<br>: Hz. or Hertz, the unit for measuring electrical frequency. |
| Under frequency                  | : The status of system frequency which is fallen down below standard 50 Hz.   |