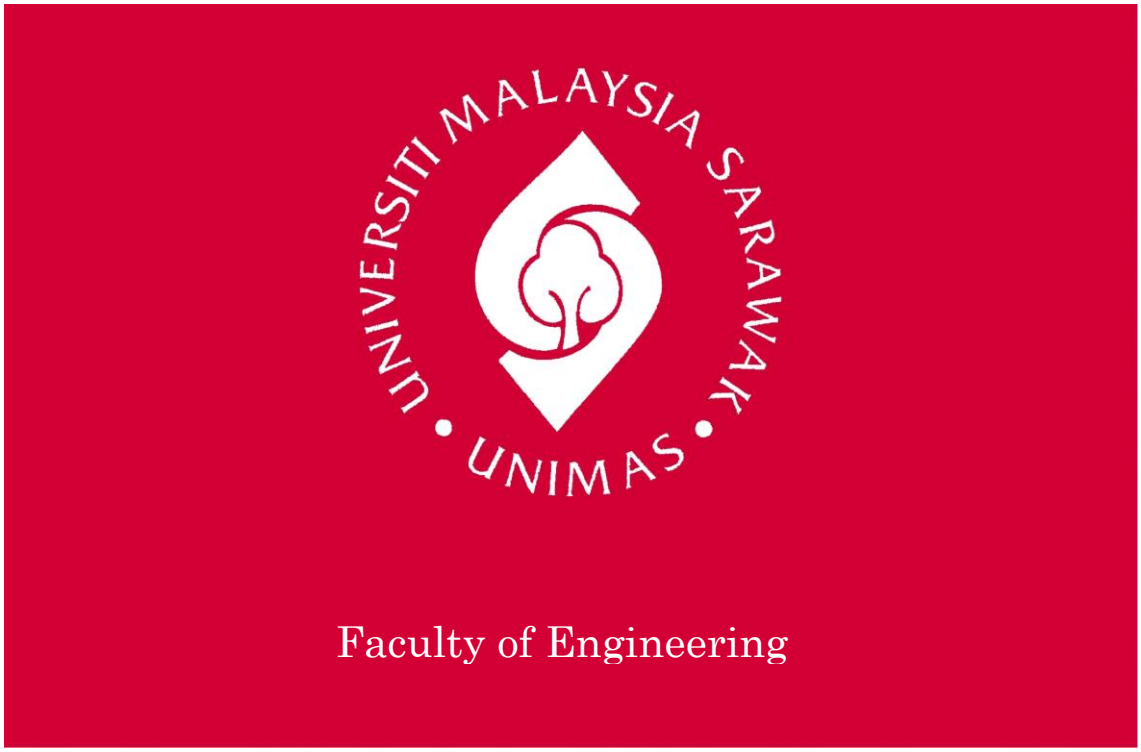


# DEVELOPMENT OF A SYSTEM TO IMPROVE SAFETY IN SWITCHING OF HIGH VOLTAGE CIRCUIT BREAKERS

MUHAMAD ATIF BIN NORZAN SHAH

**Bachelor of Engineering (Hons) in Electronics**

**(Telecommunication) Engineering**

**2017**

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

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Final Year Project Report ☑

Masters ☐

PhD ☐

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# DEVELOPMENT OF A SYSTEM TO IMPROVE SAFETY IN SWITCHING OF HIGH VOLTAGE CIRCUIT BREAKER

MUHAMMAD ATIF BIN NORZAN SHAH

This project is submitted in partial fulfilment of

The requirement for the degree of

Bachelor of Engineering (Hons) in Electronic

(Telecommunication)

Faculty of Engineering

UNIVERSITI MALAYSIA SARAWAK

2017

# ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful

Alhamdulillah praises to Allah for the strengths and His blessing in completing in project and thesis writing. This project has been made possible as a result of the cooperation and support rendered by several individuals. While it is impossible to list down all of them, I am grateful for their assistance.

First and foremost, great appreciation was cast to Ir. Dr. Prashobh Kuranakaran and Mr. Asfar Satari bin Abdullah of Universiti Malaysia Sarawak for his excellent guidance, encouragements, and advice throughout the entire duration of this project. Without both of them cooperation and dedicated work in keeping the project on track, I would not be able to complete the project on time.

Besides that, I would like to thank you for the lecturers that may have helped, contributed ideas, giving advises in making this project to be successful. Thankfulness would like to give to all my friends for their help, advice, and encouragement throughout this project. They had helped me in sailing through the many hard days in lives and studies all these while.

Last but not least, I would like to thank my beloved family members especially to my father who had always been there to support and given their utmost encouragement to me during the process of completing this report. I hope that I can make my mother proud of me even though she not here anymore. May Allah bless you.

# ABSTRACT

The aim of this project is to create a safety system that develops a Pneumatic system to break High voltage switchgear (11KV to 33kV). This project has the grant scheme by OSAKA Gas Foundation in Cultural Exchanged Research (OGFIGE). It focuses on designing and constructing a switchgear breaker system that can do the switching process in substations without using any manpower and most of all, switching is done remotely by indisputable distances. By allowing service personnel to stand outside the arc-flash boundary at substations while assigned to do the switching, the remote switch operators reduce the need for a full-body arc flash hazard suit**.** The architecture and design of the remote switch system consist of 2.5 Horsepower Air Compressor, Electrical contacts, Contactor with ON and OFF contact, Circuit Breaker, Electro-pneumatic valve, Electro-pneumatic cylinder, Connecting wires, Ratchet Strap, and Pneumatic tubing and others**.** An optimum design of the remote switch is determined by its ability to break the actual Sarawak Energy selected Switchgears. Therefore, the size of the pneumatic cylinder is taken into consideration whether it is the optimum size to be installed onto the switchgear.

# ABSTRAK

Tujuan projek ini adalah untuk mewujudkan satu sistem yang menggunakan sistem pneumatik untuk memecahkan suis voltan tinggi (11KV sehingga 33kV). Projek ini mempunyai skim geran dari OSAKA Yayasan Gas Dalam Kebudayaan Ditukar Penyelidikan (OGFIGE). Ianya memberi tumpuan kepada mereka bentuk dan reka pemutus suis gear yang boleh melakukan proses peralihan di pencawang tanpa menggunakan keupayaan tenaga kerja manusia dan yang paling penting, pensuisan dilakukan dari jarak yang telah ditetapkan. Dengan membolehkan pihak yang bertanggungjawab berada di luar kawasan yang berbahaya di pencawang semasa melakukan penukaran suis, operasi pengendali suis dari jarak jauh juga memudahkan dengan tidak memerlukan memakai pakaian kalis kemalangan. Seni bina dan reka bentuk suis jauh terdiri daripada 2.5 Horse-kuasa pemampat udara, contactor elektrik, Contactor dengan ON dan OFF kenalan, injap Electro-pneumatik, silinder Electro-pneumatik, Menyambung wayar, tali ratchet, dan pneumatik tiub untuk udara mengalir . Sesuatu reka bentuk optimum suis jauh ditentukan oleh keupayaan untuk memecahkan sebenar Sarawak Energy Switch-gear itu. Oleh itu, saiz silinder pneumatik diambil kira sama ada ia merupakan saiz yang optimum untuk dipasang ke suis.

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# LIST OF ABBREVIATION

| | | |
|---|---|---|
| HV | - | High Voltage |
| LV | - | Low Voltage |
| MV | - | Medium Voltage |
| UHV | - | Ultrahigh Voltages |
| EHV | - | Extra High Voltages |
| SEB | - | Sarawak Energy Berhad |
| TNB | - | Tenaga Nasional Berhad |
| CB | - | Circuit Breaker |
| ACB | - | Air Circuit Breaker |
| MCCB | - | Molded Case Circuit Breaker |
| H | - | Hydrogen |
| $SF_6$ | - | Sulphur Hexafluoride |
| HP | - | Horse Power |
| DC | - | Direct Current |
| AC | - | Alternating Current |
| V | - | Voltages |
| A | - | Amperes |
| SP | - | Set Point |
| PV | - | Process Variables |

# CHAPTER 1

# INTRODUCTION

## 1.1 Project Overview

The aim of the project is to create a portable safety switching system which can be easily carried by electrical technicians to break or close high voltage circuit breaker. By focusing on safety as the precedence, breaking high voltage switchgear could be very hazardous to humans when contacts occur. When dealing with electrical equipment, opening the circuit breaker is more dangerous than closing it out by two times. Flashovers, a high-voltage electric short circuit made through the air between exposed conductors are likely to happen as a human is a conductor to the electricity current. This safety switching is the solutions to keep technicians outside the arc-flash boundary during dangerous operations. The project will show on how to implement a portable hardware safety system that can control the switching of the high voltage circuit breaker. This project not focusing only on safety of personnel that dealing with high voltage circuit breaker but also the electrical substation system because all the equipment are expensive.

In this project, the terms switchgear and circuit breaker usual used in this report. The switchgear is the combination of electrical disconnect switches, fuses or circuit breaker to control, protect and isolate electrical equipment. Switchgear used to de-energize equipment to allow work to be done and to clear faults downstream. Meanwhile, the circuit breaker is automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Actually, anything used in the controlling of electricity from a small switching in the home to the largest circuit breaker in power companies is all termed switchgear.

## 1.2 Project Background

Since back year there are so many cases of accident and evidence on switchgear failed on the operated. In Malaysia, the unwanted accident happened on February 2015 where three Tenaga Nasional Berhad (TNB) technicians who were critically injured in an electrical substation explosion. Sadly, one of the three TNB technicians died and the others were badly injured with second degree burning while conducting switch exchange work. (Malay mail online, Feb 2015). This kind of accident and failure happened all around the world including Malaysia.

Thus, the portable safety switching system breaker comes in the first place to solve the failed switchgear in an electrical substation. The development of a system to improve safety in the switching of high voltage research was done with a grant scheme by OSAKA Gas Foundation in Cultural Exchanged Research (OGFIGE).

There are many classification and typical application to be considered on the functionary of switchgear. This particular design project development is focusing on the most common switchgear which used levers for switching method. The switchgear that had been chosen to be tested for this project are metal clad switchgear. It a type of medium-voltage switchgear construction. Metal-clad switchgear is a draw-out type of switchgear in which the breaker is removable or can be racket out to a disconnected from the bus position, for testing or maintenance of the breaker. [1]

## 1.3 Problem Statements

The main problem of this project is how to implement an additional mechanical hardware onto high-voltage circuit breaker in order to create a circuit connection and disconnection. Statistics had shown that many people have died or are badly injured up to second-degree burns on their bodies by performing on high voltage switching. There is a need to find a way to perform these switching remotely or away from the arc boundary.

## 1.4 Objectives

The main objectives of this thesis is to:

1. To design and create a control system to improve safety in switching o high voltage circuit breaker.
2. To install the safety switching system on actual high voltage circuit breaker.
3. To investigate and study the concept of the high voltage circuit breaker system and its program plan development using electro-pneumatic

## 1.5 Scopes of Project

This project aim is to improve the switching system for high voltage circuit breaker by developing a portable system using the electro-pneumatic system.

The project studied onto inventing a system that could assist human to break and start up high voltage circuit breaker safely without making any risks. The analysis consists of:

- The understanding the characteristics of switchgear which include its functionality and causes that could cause them to fail.
- To create and analyze a method that can reduce the amount of possibility of risk when the task of breaking the circuit breaker is carried out.
- This project will also show the method of on how the circuit of the instrument is made.

## 1.6 Project Outline

Project outline is summarized about all the chapters in this report and whole project planning. This thesis is organized into five chapters which include Introduction,

Literature Review, Methodology, Result, Discussion and also Conclusion. Each chapter presented materials that will lead to the completion of the projects. The brief information of each chapter is described as below:

Chapter 1 covers the introduction to the project including researchers on the project overview, background, problem of statement, objectives, scope of the project, and project development.

Chapter 2 provides a project overview including the operation of switchgear, circuit design, and information on equipment and components used in the project including the characteristics.

Chapter 3 includes the method used and the flow chart of the project. The circuit connection, the installation of the system to the switchgear and other related information will be included in this chapter.

Chapter 4 includes all the result obtained and outcome for the hardware of switching high voltage circuit breaker and their installation. The detailed analysis and discussion will also be included in this chapter based on the results.

Chapter 5 is the conclusion of this project. Some recommendations for future works and improvement of this project will also be included in this chapter.

# CHAPTER 2

# LITERATURE REVIEW

## 2.0 Introduction

This chapter analyses the development of a system to improve safety in the switching of high voltage circuit breakers. It including the theoretical background case, conceptual components, and design study in the components used which including the safety conditions and functionality.

## 2.1 Switchgear

Switchgear is the key equipment in the distributed network. It operated to connect and disconnect electric power supplies and systems. Switchgear is a general term which covers the switching device and its combination with related control, measuring, defensive and controlling gear, together with embellishments, fenced in areas and supporting structures.

Switchgear is connected in electrical circuits and systems operated from low voltage, such low as 220-240V in housing applications, straight up to 1100 kV and above that were been used in transmission networks or power company. Switchgear can be categories into four group which categories by their power and functionality. The low voltage switchgear, medium voltage distribution switchgear, high voltage transmission

switchgear and dc switchgear are the classification group of the switchgear. All type of the switchgear will be explained in detail.

The main basic classes of equipment in the switchgear are isolator, switches, fuse-switch combinations, circuit breaker, earthing switches, and others. For the literature review on the equipment that been regularly used in the switchgear, this thesis focusing on the listed part. [2]

Switchgear permits to switch on or off the generator, transmission line, distributors, and other electrical equipment during normal operation condition. Meanwhile, when a failure happens on any part of the power system such as short circuit, a heavy current will flow through the equipment and interruption occurred. However, the switchgear detects the fault and disconnected the unnatural section from the system. [4]

### 2.1.1 Disconnector

A disconnector or an isolator is a mechanical switching device which in the vacant position gives a sheltered working hole in the electrical system which withstands typical working system voltage and any overvoltages which may happen. It can open or close a circuit if an irrelevant current is exchanged, or if no huge change happens in the voltage between the terminals of the shafts. Current can be conveyed for indicated times within ordinary operation and under unusual conditions. [2]

**Figure 2.1:** The double side disconnector

### 2.1.2 Switches

Everyone know and had the experience to see or deal with the switch, wherein homes, school or university. The switch is a very common mechanical device that able to make, carry and interrupt current occurring under typical conditions in a system. It used to close and open a circuit safely, even if a fault is present. It must, thus, be able to close acceptably carrying a peak current corresponding to the short-circuit fault level, and it must have the capacity to carry this fault current for a specified period, usually one or three seconds. [2]

### 2.1.3 Fuse-switch combinations

A fuse and a switch can be utilized as a part of a blend with evaluations picked so that the circuit works at streams in an overabundance of the appraised hindering or breaking limit of the switch. Such a gadget is known as a 'wire switch' if the circuit holder is additionally utilized as a feature of the principle moving contact gathering, or a 'switch meld' if the breaker is a different and static part of a get together which incorporates the switch associated with the arrangement. Figure 2.2 shows schematically the different mixes of the circuit, switch, and disconnector that are accessible. [2]

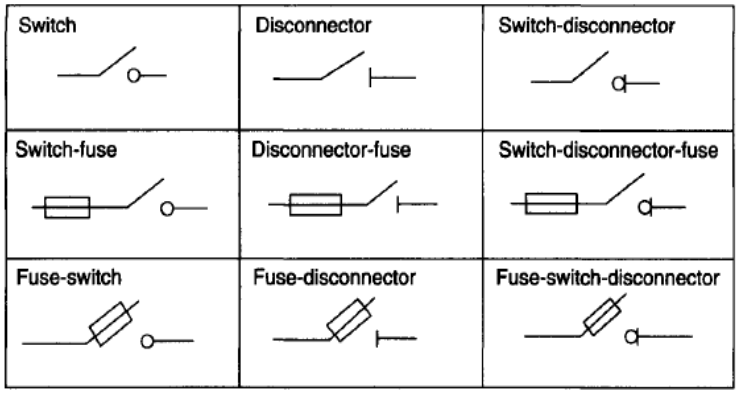


**Figure 2.2:** The summary of equipment definitions

### 2.1.4 Circuit breaker

A circuit breaker is a mechanical switching device that able to make, carry and interrupt currents occurring in the system under normal conditions. The circuit breaker able to carry for a specified time and to make and interrupt currents arising in the system under defined abnormal conditions, such as short circuits. The circuit breaker is a key device in many switching and protection systems where it's the first electrical component that faced electrical current. [2]

### 2.1.5 Earthing switches

An earthing switch function for the earthing and short-circuiting of circuits after finished the operation of the circuit breaker and it discharges the excessive charges that are trapped in line after the opening of line by circuit breaker to earth through it. It is able to withstand currents for a specified time under strange conditions. Unfortunately, it is not required to carry normal service currently. [2]

## 2.2 Types of switchgear

Switchgear can be classified or divided into four main sections which are low voltage switchgear, medium voltage distribution switchgear, high voltage transmission switchgear and dc switchgear. The design consideration for this project are focusing on metal-clad switchgear were the most common switchgear in Sarawak Energy Berhad (SEB) which still uses levers to switching services. There are a bit similarities between low voltage switchgear, medium voltage switchgear, and high voltage switchgear on the aspect of transmission but the functionality and practices are different were basically it based on the voltages level.

### 2.2.1 Low voltage (LV) switchgear

Low voltage switchgear easily can by categorized as any type of circuit breaker that operated at the voltage under 600V. Air circuit breaker (ACB) and molded case circuit breaker (MCCB) are the examples of low voltage switchgear. The modem air circuit breaker is generally used as an incoming device on the supply side of a low voltage switchboard, and it represents the first line of protection on the load side of the transformer while the moulded case circuit breaker may be used as an incoming device, but it is more generally used as an outward device on the load side of a switchboard. [2]

### 2.2.2 Medium voltage (MV) switchgear

Medium-voltage switchgear or distribution switchgear for the most recognized to cover currently in the range 1 kV to 36kV, but specifically, by referring on DOE Electrical Safety Guidelines, medium voltage run from 600V up to 69 kV. A 72.5kV or even 132kV, for example, can be considered as distribution voltages rather than transmission voltages, and the equipment overlaps with high-voltage or transmission switchgear in this range. [2]

### 2.2.3 High voltage (HV) switchgear

The transmission of high powers over long separations requires the utilization of high voltage (HV), extra high voltage (EHV) or ultrahigh voltage (UHV). Their range of classification class of high voltage can be differentiated as for high voltage between 69 kV up to 230 kV, the extra high voltage between 230 kV up to 1100 kV and ultrahigh voltage approximately at 1100 kV. As we know, the lower voltages were introduced first, and as the technologies have developed these have increased so that now the highest transmission voltages being used are 1100 kV. [2]

## 2.3 Type of Circuit Breaker

As mention in previous, the circuit breaker is one of the components in the switchgear and switchgear are a group of electrical equipment and a component that combined under one metal cover body. Break normal load current and to interrupt fault current caused by the short circuit are the purpose of the circuit breaker.

### 2.3.1 Oil Circuit Breaker

The insulating oil circuit breaker is very famous design in the early production of circuit breakers. During the early year $19^{th}$, there is the various design of arc control circuit breaker are introduced. The aim of the designing absolutely to improving the performance and reducing the hazardous from the switchgear or circuit breaker.

The working principle oil circuit breaker operation starting with the oil circuit breaker contacts are opened under the insulating oil and then an arc is struck between it. The evaporation of the surrounding oil occurs from the heat released by the arc and the evaporated gaseous separates it into a substantial volume of hydrogen gaseous under high pressure. The hydrogen gas is then overcome a volume which is about one thousand times that of the oil decomposed.

The process continued as the insulating oil be pushed away from the arc and an expanding hydrogen gas bubble surrounds the arc region and adjacent portions of the contacts.

The arc destruction is expedited commonly by two processes method. Firstly, the arc being cooled by hydrogen (H) gas that has high heat conductivity. As a result, it aiding the de-ionisation medium between the contacts. The second process is when the gas sets up turbulence in the oil and the process forces it to move into the compact space between the contacts, hence the arcing or the spark produces from the arc path eliminated. The arc finally extinguished and the circuit current interrupted. [4]