"Saya akui bahawa saya telah membaca karya ini pada pandangan saya karya ini adalah memadai dari skop dan kualiti untuk tujuan penganugerahan ijazah Sarjana Muda Kejuruteraan Elektrik (Kuasa Industri)."

Tandatangan : .....

Nama Penyelia : EN. HIDAYAT BIN ZAINUDDIN

Tarikh : 7/5/2008

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : .....

Supervisor's Name : EN. HIDAYAT BIN ZAINUDDIN

Date : 7/5/2008

HIGH VOLTAGE DC GENERATION AND TESTING ON INSULATOR (ACRYLIC PLASTIC)

NUR ZAWANI BINTI SAHARUDDIN

This Report is submitted in Partial Fulfillment of Requirements for The Degree of Bachelor in Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

May 2008

"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya jelaskan sumbernya."

Tandatangan : .....

Nama : NUR ZAWANI BINTI SAHARUDDIN

Tarikh : 07/05/08

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

Signature : .....

Name : NUR ZAWANI BINTI SAHARUDDIN

Date : 07/05/08

Dedicated to my beloved parents …

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ABSTRACT

The purpose of this project is to develop the High Voltage Direct Current (HVDC) testing procedure manual for Teaching and Learning (T&L) of High Voltage subject for final year student at Universiti Teknikal Malaysia Melaka (UTeM). The testing procedure focuses on all 3 stages of HVDC configuration in which the voltage can be generated up to 420kV. Prior to that, the new equipment that available in the HV lab, UTeM is used to study and analyze its performance to be compared with the data manual provided by the manufacturer. As for Research and Development (R&D), this analysis determines the suitability of the test room of HV lab at UTeM and factors that may affect the testing results. The HVDC test is also conducted on test object (acrylic plastic) to study and analyze its characteristic and performance as insulator. In order to achieve the objectives of this project, proper HV testing with and without test object based on IEEE std 4-1995 Standard Techniques for High Voltage Testing are conducted. In addition, computer simulation using LT Spice software is also conducted for comparison purposes between simulation and experimental results. Hence, at the end of this project, the required testing procedure manual for HVDC testing with and without test object including the safety precaution has been developed.

ABSTRAK

Tujuan projek ini dijalankan adalah untuk menyediakan satu manual prosedur pengujian Voltan Tinggi Arus Terus *(HVDC)* untuk Pengajaran dan Pembelajaran (P&P) bagi subjek Voltan Tinggi kepada pelajar tahun akhir di Univeristi Teknikal Malaysia Melaka (UTeM). Prosedur pengujian ini melibatkan kesemua tiga peringkat konfigurasi pengujian Voltan Tinggi Arus Terus di mana voltan maksimum yang boleh dijana ialah 420kV. Untuk tujuan tersebut, perkakasan voltan tinggi yang terdapat di makmal voltan tinggi, UTeM digunakan bagi mengkaji dan menganalisis keupayaan alat tersebut untuk dibandingkan dengan data manual daripada pihak pembuat. Untuk tujuan Penyelidikan and Pembangunan *(R&D)*, analisis ini menentukan kesesuaian bilik pengujian di makmal voltan tinggi dan faktor-faktor yang dapat memberi kesan terhadap keputusan pengujian. Pengujian Voltan Tinggi Arus Terus juga dijalankan ke atas bahan penebat (plastik acrylic) untuk mengkaji dan menganalisis ciri-ciri dan keupayaan bahan tersebut sebagai penebat. Bagi mencapai objektif projek ini, sesi ujian voltan tinggi menggunakan bahan penebat dan tanpa bahan penebat dijalankan merujuk kepada piawaian yang ditetapkan oleh *IEEE std 4-1995 Standard Techniques for High Voltage Testing*. Di samping itu, simulasi komputer ke atas litar projek juga dilakukan dengan menggunakan perisiaan LT Spice untuk membuat perbandingan di antara keputusan simulasi dan ujian makmal. Pada akhir projek ini dijalankan, satu manual lengkap berkenaan dengan cara-cara pengujian Voltan Tinggi Arus Terus dengan menggunakan bahan penebat dan tanpa menggunakan bahan penebat beserta dengan langkah-langkah keselamatan telah disediakan.

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LIST OF ABBREVIATIONS

AC	–	Alternating Current
DC	–	Direct Current
HV	–	High Voltage
HVAC	–	High Voltage Alternating Current
HVDC	–	High Voltage Direct Current
IEC	–	International Electrotechnical
IEEE	–	Institute of Electrical and Electronics Engineers
PC	–	Polycarbonate
PMMA	–	Polymethyl Methacrylate
R&D	–	Research and Development
T&L	–	Teaching and Learning
UTeM	–	University Teknikal Malaysia Melaka

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CHAPTER 1

INTRODUCTION

1.1 Project Background

In modern times, high voltages are used for a wide variety of applications covering the power systems, industry, and research laboratories [1]. Such applications have become essential to sustain modern civilization.

One of high voltage lab equipments is HAEFLEY High Voltage equipment. This HV equipment can be used in multiple applications in high voltage technology and used in generation of High Voltage Direct Current (HVDC), High Voltage Alternating Current (HVAC) and Impulse voltage.

The High Voltage Laboratory at Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka (UTeM) is a new laboratory facilitated with this High Voltage equipment. This equipment will be used in Teaching and Learning (T&L) of high voltage subject in which this will involve all electrical engineering students. Besides, this equipment is also essential in Research and Development (R&D). Since this equipment generates high voltages, necessary handling steps and safety precaution need to be taken when handling the equipment. Hence, proper testing procedure manual describing all the steps and safety precautions as a guidelines is very important when use the High Voltage equipment.

This project focuses on HVDC testing that may be reached up to 400kV. Basically, the HVDC generator system available at the laboratory consists of 3 stages of HVDC generation configurations. For 1 stage of the HVDC configuration, voltage

up to 140kV can be generated, while for the 2 stages of the HVDC configuration, the expected voltage is up to 280kV and finally for the 3 stages of the HVDC configuration, the voltage can be reached up to 400kV. The main objective of this project is to develop the testing procedure manual that describes the detail steps on handling the high voltage equipment and the safety precaution when performing high voltage test with and without test object. acrylic plastic is used as the test object in this project.

1.2 Problem Statement

It is well known that procedures are very important when dealing with experimental works. The High Voltage lab at FKE, UTeM is equipped with 3 stages of HVDC generation system that can generate up to 400kV. The HVDC generator is new equipment for T&L of High Voltage subject as well as for R&D at the university. The basic procedure manual (user manual) has been provided by the manufacturer for user reference to operate the equipment. However, the steps on handling the equipment are not elaborated in experimental format. Thus, it is vital to produce a complete testing procedure for future reference in T&L and R&D process.

Consequently, detail investigation on the equipment, its characteristic, purposes and testing procedures need to be done in order to produce the testing procedures manual. Besides, a necessary software simulation needs to be done to verify the lab results. Since this is high voltage equipments, necessary safety precaution needs to be taken when implementing the equipments. A HVDC circuit may be especially dangerous because it will cause muscles to lock around the wire [4]. Accidental contact with high voltage will usually result in severe injury or death. This can occur as a person's body provides a path for current flow causing tissue damage and heart failure. Hence, the safety requirements when handling the high voltage equipments need to be studied and highlighted in the procedure manual as well.

1.3 Project Objectives

There are four objectives that need to be accomplished in order to make this project successful which are:

(a) To conduct software simulation of HVDC generator circuits (without test object)
(b) To conduct the lab experimental works of high voltage testing with and without test object (insulator- acrylic plastic)
(c) To analyse the software simulation with the lab testing results for without test object
(d) To develop the testing procedures manual for HVDC testing with and without test object test object (acrylic)

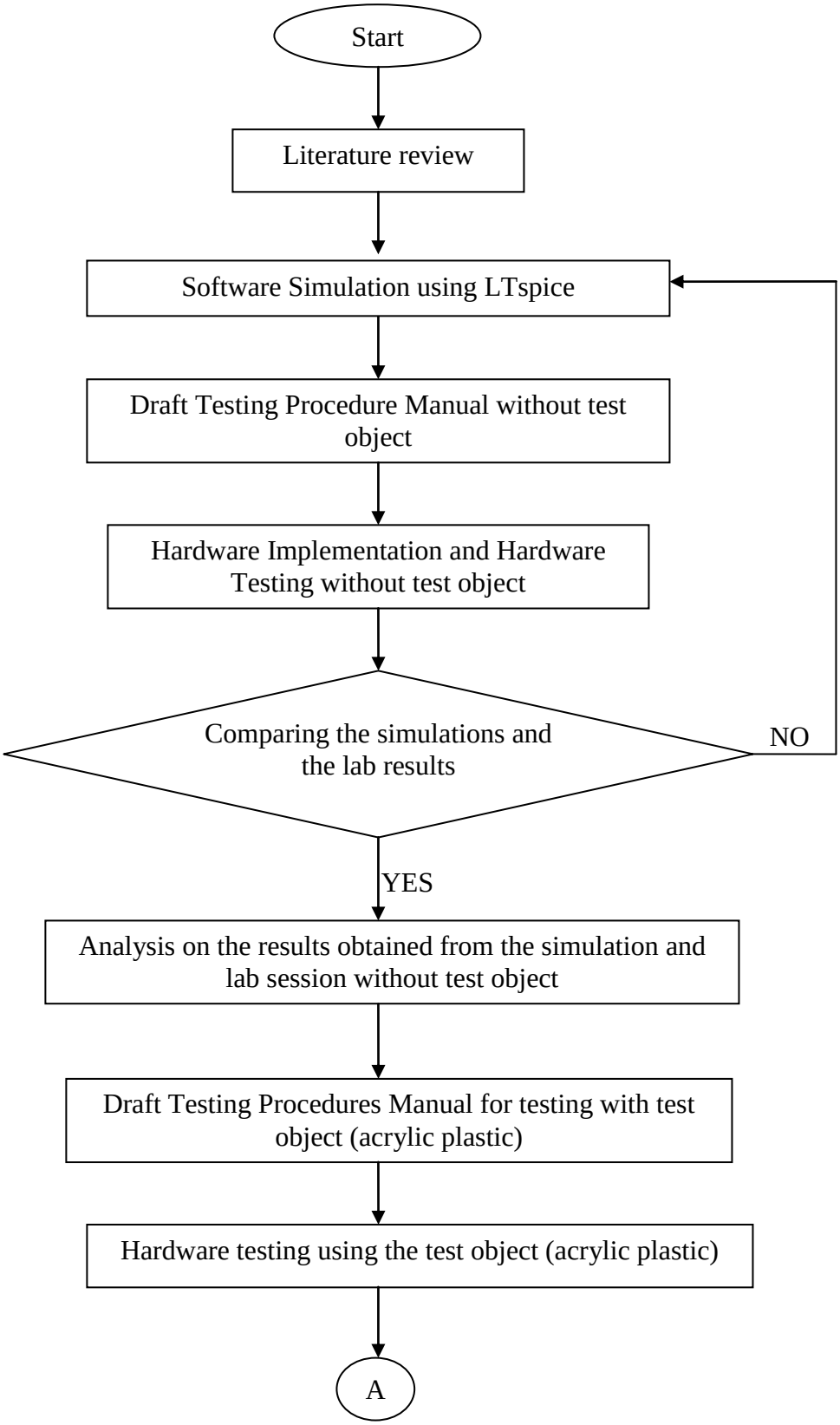
1.4 Project Scope

This project involves computer simulation development of HVDC generation circuits without test object using the LT Spice software. The laboratory sessions of HVDC testing with and without test object (insulator- acrylic) are conducted before the results data being analysed. The testing procedure manual that describes the details steps on handling the high voltage equipment with and without test object as well as the safety precaution is developed.

1.5 Project Methodology

In order to complete this project, a necessary project planning should be arranged. For this project, there are several steps should be taken in order to achieve the project objectives scope. Basically, Project Methodology defines the planning process flow and principles that is essential guide to produce a well planning project. Besides, selected approach or methodology will describe the activities that might be done in every stage.

The flow chart that describes the methodology for this project is shown in the flow chart below.



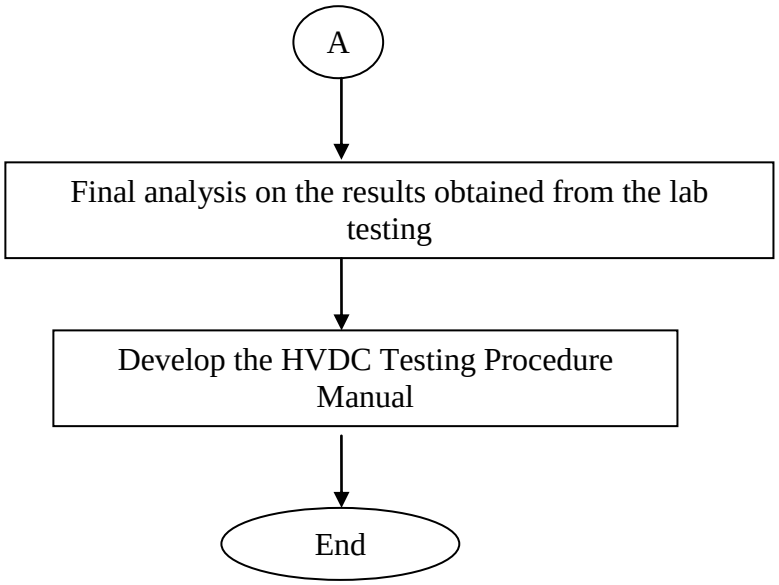


Figure 1.1: Flow chart of the project methodology

(a) Literature Review

The literature review is conducted by doing some research and finds information that related to the project through out resources such as internet, books, IEEE articles, journals and etc. this early stage of doing project is vital so that the high understanding of the project can be achieved.

(b) Software Simulation (without test object)

The next step is constructing the software simulation to the project circuit. Basically, there are three stages for the HVDC test which are 1 stage, 2 stages and finally 3 stages. All these three circuits are created and simulated using the LT Spice software. The software simulation result will be compared with the lab testing results without testing object.

(c) Testing Procedure Manual (without test object)

The basic testing procedures manual will be drafted first. In this manual, the basic steps that need to be taken when conducting the high voltage testing without test object will be high lighted. All the safety precautions that need to be taken also will be included in this procedure. This manual will be rewritten upon necessary when there are any points or procedures that need to be included.

(d) Hardware Implementation and Lab Testing (without test object)

After the software simulation for the circuits were succeeded, the hardware for HVDC configurations for HVDC testing without test object will be implemented in the High Voltage Lab. This lab testing will carry out the High Voltage testing for this stage to get the desired testing procedures.

(e) Analysis and Comparison (without test object)

In this part, the analysis on the simulation result and lab testing results will be done. Then, the comparison between the simulation results and the lab testing results will be carried out to achieve the objectives and scopes of this project.

(f) Testing Procedure Manual (with test object)

This manual will describe the basic and important steps that need to be taken when conducting the high voltage testing with the test object. All the safety precautions that need to be taken also will be included in this procedure. This manual will be rewritten upon necessary when there are any points or procedures that need to be included.

(g) Lab Testing with Test Object

The HVDC testing session will be conducted with the test object that has been chosen which is acrylic plastic. By doing this test, the breakdown voltage for that test objects will be determined. All the testing results will be recorded for further analysis.

(h) Analysis and Comparison

In this part, the analysis on the lab testing results with the test object will be carried out. All the data and results obtained from the lab testing will be recorded and will be plotted in the graph. Finally, necessary analysis will be carried out on the results obtained such as compare the breakdown voltage obtained from two different stage of HVDC configuration, compare the results between different thickness of test object and etc.

(i) Testing Procedure Manual

Finally, the testing procedures manual for HVDC testing will be developed as per planning.

1.6 Thesis Outline

Chapter 1 briefly summarizes the project background and problem statements as well as elaborates the objectives and scope of the project. The project methodology which is the most important part that describes the flow of the project is also discussed in detail in this chapter.

In Chapter 2, the literature review includes few methods can be used to generate the HVDC voltage. Some of the methods that used to generate the high voltage are half wave rectifier circuit, full wave rectifier circuit, and voltage doubler circuit. Besides, the basic introduction to the HAEFLEY High Voltage Kits and LT Spice software are discussed in this chapter. The brief elaboration on the test object (acrylic plastic) and IEEE std 4-1995 Standard Techniques for High Voltage Testing are elaborated.

Chapter 3 introduces the HVDC generation for all 3 stages and its entire hardware configuration. Besides, it also discusses the safety when performing the HVDC testing. The development of the Testing Procedure Manual without test object is included in this chapter.

The Chapter 4 elaborates the HVDC testing on the insulator by referring the IEEE std 4-1995 Standard Techniques for High Voltage Testing. The Testing Procedure Manual with test object is carry out in this chapter.

Chapter 5 details the results of the project. All the data and waveforms obtained are presented in this chapter. Necessary comparison and analysis is carried out in this chapter.