GENERATION HIGH VOLTAGE AC, DC AND IMPULSE

ON XLPE CABLE

Nur Khairul Bariyah binti Mahyudin

4 BEKP 2

MAY 2009

"I hereby declare that I have read through this report entitle "Generation High Voltage AC, DC and Impulse on XLPE cable" 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 ALIAS BIN KHAMIS

Date : 11MAY 2009

GENERATION HIGH VOLTAGE AC, DC AND IMPULSE ON XLPE CABLE

NUR KHAIRUL BARIYAH BINTI MAHYUDIN

This Report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MAY 2009

I declare that this report entitled "Generation High Voltage AC, DC and Impulse on XLPE cable" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidate at any other degree.

Signature : .....

Name : NUR KHAIRUL BARIYAH BINTI MAHYUDIN

Date : 11 MAY 2009

To my beloved mother and father

JAMALIYA BINTI MD YUSOF
MAHYUDIN BIN HJ HASHIM

And

To my beloved family

Thank You

ACKNOWLEDGEMENT

First and foremost, I would like to thank to Allah the Almighty for giving me the ability to complete my overall Project Sarjana Muda 1 and 2. I would like to enlarge my appreciation to my supervisor, Mr. Alias bin Khamis because of the kindness heart to accept me as one of the students under his supervision. Special thanks also dedicated to him for all advices, critics, insight and willingness dealing with me to help me completing this project. The technical assistance of all technicians from the Faculty of Electrical and also other faculty are gratefully acknowledged. Special thanks to my parents and friends that had supported me since the beginning till the end of this project. Without their support and help, this project will not be successful as it was. Finally, I would like to thank the place that I begin for all the experiences and knowledge that I gained throughout my learning sessions in Universiti Teknikal Malaysia Melaka (UTeM). All this valuable experiences will be useful for me in the future.

ABSTRACT

The purpose of this project is to develop High Voltage Alternating Current (HVAC), High Voltage Direct Current (HVDC) and Impulse testing procedure manual for Teaching and Learning (T&L) of High Voltage subject for final year students at Universiti Teknikal Malaysia Melaka (UTeM). The testing procedure focuses on HVAC, HVDC and impulse. Prior to that, the new equipment which are available in the High Voltage laboratory, UTeM is used to study and analyze their performances 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 High Voltage generation set at UTeM and factors that may affect the testing results. The HVAC, HVDC and impulse tests are also conducted on test object (XLPE cable) to study and analyze its characteristics and performance as an insulator. In order to achieve the objectives of this project, proper High Voltage 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 HVAC, HVDC and Impulse 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-ulangalik (HVAC), Voltan Tinggi Arus Terus (HVDC) dan Voltan dedenyut untuk Pengajaran dan Pembelajaran (P&P) bagi subjek Voltan Tinggi kepada pelajar tahun akhir di Universiti Teknikal Malaysia Melaka (UTeM). Prosedur pengujian ini melibatkan konfigurasi pengujian Voltan Tinggi Arus-ulangalik (HVAC), Voltan Tinggi Arus Terus (HVDC) dan Voltan dedenyut. 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 dan 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-Ulangalik, Arus Terus dan dedenyut juga dijalankan ke atas bahan penebat (kabel XLPE) 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 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 perisian 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-ulangalik, Arus Terus dan dedenyut dengan menggunakan bahan penebat beserta dengan langkah-langkah keselamatan disediakan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

AC	-	Alternating current
ANSI	-	American National Standard Institute
AEIC	-	The Association o Edison Illminating Companies
DC	-	Direct current
DMI	-	Digital Measuring Instrument
HV	-	High Voltage
IEC	-	International Electrotechnical Commision
IEEE	-	Institute of Electrical and Electronics Engineers
Hz	-	Hertz
Kg	-	kilogram
kV	-	Kilo Volt
LED	-	Light Emitting Diode
LCD	-	Liquid Crystal Display
LV	-	Low Voltage
ma	-	mili Ampere
Mm	-	mili meter
M	-	Mega
nF	-	nano Farad
OT	-	Operating Terminal
pF	-	piko Farad
PSM	-	Project Sarjana Muda
V	-	Volt
W	-	Watt
Ω	-	Ohm

LIST OF APPENDICES

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. Such applications have become essential to sustain modern civilization.

One of high voltage laboratory equipments is High Voltage Generation Set. This High Voltage 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 HVAC, HVDC and Impulse. Test configuration are available which allow the generation of AC voltages up to 300 kV, DC voltages up to 400kV and Impulse voltages up to 400kV with different output power ratings. Such test configurations are

extremely compact and their flexibility allows the test system to be matched to the prevailing conditions in the test room (dimension, height etc). The application range for the high voltage KIT covers not only use in high voltage laboratories of technical universities, but also as an industrial test system for routine and type test on electrical equipment up to 30kV.

A complete test system requires a volume of $30m^3$ and a floor surface of three by four meters. The configuration is built up, as it name suggest, by simply inserting the various elements to form a self-supporting structure. No tools are required. In spite of its striking simplicity, the generation set is equipped with all the components of comparable large industrial test systems. The accuracy of the measuring instruments is such that they compare favorably with larger test systems and are used by calibration laboratories. Numerous accessories are available for the basic generation set elements. The high voltage generation set has very compact dimensions and a wide range of application. It is portable and truly represents a complete high voltage test systems [1]. 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 project. XLPE cable is used as the test object in this project.

1.2 Problem Statement

Each project has its own problems to discuss before starting it. By starting the problem statement, it easy to know the purpose of doing this project and what are the problems to be solved. Below are the problem statements for this project:

1) To know how to generate and testing high voltage.
2) To analyze the output of XLPE cable with different source of generating voltage.
3) To know other problem related with XLPE cable.
4) To analyze the breakdown voltage of insulator (material of XLPE cable).

1.3 Project Objectives

Before conducting or doing the project, the objectives of the project are the main focus in this project. Below are the objectives of this project:

1) To generate a high voltage using generation test product.
2) To know how to generate high different source for XLPE cable.
3) Do procedure and safety of using equipment in the lab.
4) Do a testing on insulator (XLPE cable) to analyze their breakdown voltage.

1.4 Project Scope

This project involves computer simulation development of HVAC, HVDC and impulse generation circuits without test object using LT Spice and PSPICE software. The laboratory sessions of HVAC, HVDC and Impulse testing object (insulator-XLPE cable) are conducted before the results data being analyzed. The testing product manual that described the details steps on handling the high voltage equipment with and without test object as well as the safety precaution is developed.

1.5 Thesis Outline

Chapter 1 briefly summarizes the project background and problems statements as well as elaborates the objectives and scope of the project.

Chapter 2 discusses literature review of the project and the source achieved by gathering information through internet and reference book to further study on theory related to this project. This chapter also includes explanation on the generation of high voltage AC, DC, Impulse, LT Spice software and test object which is XLPE cable. The standard techniques for high voltage testing also discussed in this chapter.

Chapter 3 is the project methodology. The project methodology which is the most important part that describes the flow of the project is also discussed in detail in this chapter. Also discusses the overview of this generation set test equipment and ways setup this test equipment, application and safety precaution when conducting the experimental works and also discusses the test XLPE cable. Also explains the manual testing that will be developed including the steps the test and measuring equipment by considering the safety precaution when doing the testing.

Chapter 4 discusses the details results of this project. All the data and waveforms obtained are presented in this chapter

Chapter 5 discusses about analysis made from result is consist comparison about HVAC, HVDC and Impulse.

Chapter 6 discusses the conclusion and recommendation of these project activities. The recommendation given may be postulated as a contribution to the future time to university and industry.

CHAPTER 2

LITERATURE REVIEW

2.1 High Voltage Definition

The definition of high voltage depends on the context of the discussion. Two factors considered in the classification of a "high voltage" are the possibility of causing a spark in air, and the danger of electric shock by contact or proximity.

In electric power transmission engineering, high voltage is usually considered any voltage over approximately 35000 volts. This is a classification based on the design of apparatus and insulation.

The International Electro technical Commission and its national counterparts (IET, IEEE, VDE, etc.) define high voltage circuits as those with more than 1000V for alternating current and at least 1500 V for direct current, and distinguish it from low voltage (50 – 1000 V AC or 120- 1500 V DC) and extra low voltage (<50 V AC or < 120 V DC) circuits [2]. This is in the context of the safety of electrical apparatus.

In the United States 2005 National Electrical Code (NEC), high voltage is any voltage over 600 V. Laypersons may consider household mains circuits (100-250 V AC), which carry the highest and most dangerous voltages they normally encounter, to be high voltage. For example, an installer of heating, ventilation and air conditioning equipment may be licensed to install 24 Volt control circuits, but may not be permitted to connect the 240volt power circuits of the equipment.

Voltages over approximately 50 volts can usually cause dangerous amounts of current to flow through a human being touching two points of a circuit, so safety standard generally are more restrictive where the chance of contact with such high voltage circuits exists.

2.2 Generation of High Alternating Current Voltages (HVAC)

For generation of high alternating voltage are less than about 300 kV, a single transformer can be used for test proposes. The impedance of the transformer should be generally less than 5% and must be capable of giving the short circuit current for one minute or more depending on the design. In addition to the normal windings namely, the low and high voltage windings, a third windings known as meter winding is provided to measure the output voltage. For higher voltage requirements, a single unit construction becomes difficult and costly due to insulation problems. Moreover, transportation and erection of large transformer become difficult. These drawbacks are overcome by series connection or cascading of the several identical units of transformer, where in the high voltage windings of all the units effectively come in series [1].

2.3 Generation of High Direct Current Voltages (HVDC)

Generation of high direct current (DC) voltages is mainly used in research work in the areas of pure and applied physics. Besides, the high voltages are sometimes needed in insulation tests on cable and capacitors. Normally, for generation of DC voltages of up to 100kV, electronic valve rectifiers are used and the output currents are about 100mA. The rectifier valves require special construction for cathode and filaments since a high electrostatic field of several kV/ cm exists between the anode and the cathode in the non-conduction period. The rectifier circuits for producing high DC voltages from AC sources maybe:

a) Half wave rectifier
b) Full wave rectifier
c) Voltage double type rectifiers

2.3.1 Half Wave Rectifier Circuit

A half wave rectifier is a special case of a clipper. In half wave rectifier, either the positive or negative half of the AC wave is passed easily, while the other half is blocked, depending on the polarity of the rectifier. Because only one half of the input waveform reaches the output, it is very inefficient if used for power transfer. Half-way rectification can be achieved with a single diode in a one phase supply.

A half wave rectifier is a special case of clipper. In half wave rectification, either the positive or negative half of the AC wave is passed easily, while the order half is blocked, depending on the polarity of the rectifier. Because only one half of the input waveform reaches the output, it is very inefficient if used for power transfer. Half-wave rectification can be achieved with a single diode in a one phase supply [3].

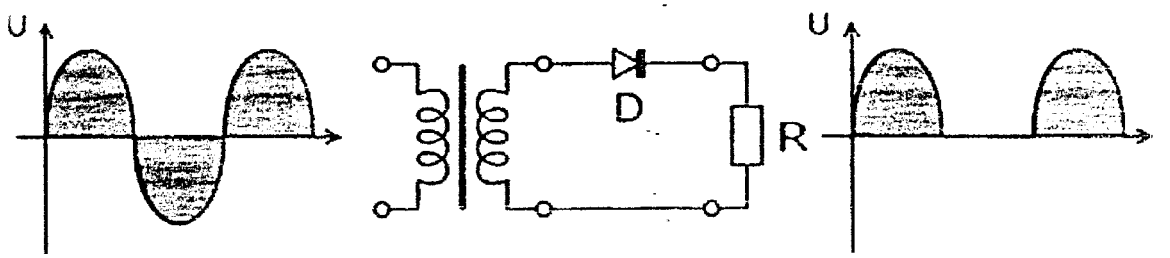

Figure 2.1: Half wave rectifier