GENERATION OF HIGH VOLTAGE IMPULSE AND TEST ON INSULATOR (PLYWOOD)

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MAY 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)"

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

Faculty of Electrical Engineering
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May 2008

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

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Name : RAHMAN BIN HASSAN
Date : 7 MAY 2008

Dedicated to my beloved parents...

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ABSTRACT

The purpose of this project is to design and develop multistage impulse voltage generator and test on insulator plywood by using Hafely construction KIT. The main objective of this project is to develop the high voltage impulse testing procedures and safety precaution for high voltage lab purpose. This project include 3-stages impulse generator where the voltage is expected up to 400kV which is for 1-stage it can generate impulse until 140KV, 2-stage 280KV and 3-stages up to 400KV. For test on insulator (plywood), only 1-stage and 2-stages impulse generator was needed to test dielectric strength on plywood. The experimental result will be analyzed to calculate the dielectric strength of plywood in order to know whether a plywood is good for insulation material or not. At the end of this project, the testing procedures manual will be provided considering the safety precaution when conduct the experimental work using high voltage equipment.

ABSTRAK

Tujuan projek ini adalah mereka bentuk dan membangunkan beberapa peringkat penjana gelombang dedenyut voltan dan ujian ke atas papan lapis dengan menggunakan pembinaan Hafely KIT. Objektif utama projek ini adalah untuk menyediakan prosedur dan peraturan keselamatan untuk tujuan makmal voltan tinggi bagi tujuan pengujian ke atas penebat dengan gelombang dedenyut voltan tinggi. Projek ini melibatkan 3 peringkat penjana desakan beza upaya (dedenyut) di mana voltan adalah dijangka sehingga 400kV yang mana untuk 1 peringkat ia boleh menjana desakan sehingga 140KV, 2 peringkat 280KV dan 3 peringkat sehingga 400KV. Untuk ujian ke atas penebat (papan lapis), hanya 1 peringkat dan 2 peringkat penjana dedenyut diperlukan untuk menguji kekuatan dielektrik ke atas papan lapis. Hasil ujian yang dibuat akan dianalisis bagi menentukan samada kekuatan dielektrik papan lapis sesuai digunakan untuk dijadikan bahan penebat yang baik. Di akhir projek ini, manual prosedur pengujian akan disediakan dengan lengkap mengikut peraturan keselamatan bekerja pada peralatan voltan tinggi.

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LIST OF ABBREVIATIONS

KV	-	Kilovolt
HV	-	High Voltage
DC	-	Direct Current
AC	-	Alternating Current
IMP	-	Impulse
IEEE	-	Institute of Electrical and Electronics Engineers
IEC	-	International Electrotechnical Commission

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CHAPTER I

INTRODUCTION

1.1 Background Project

This project describes developing the Haefely type of high voltage impulse generator by using High Voltage Construction KIT. This is a system of components for applications in high voltage technology. The impulse voltage is requiring in high voltage to simulate the stresses due to external and internal overvoltage and as fundamental investigations of breakdown mechanism. An impulse voltage generator consists of capacitors, resistors, and spark gaps. The capacitors are first charged in parallel through charging resistors by a high-voltage, direct-current source and then connected in series and discharged through a test object by a simultaneous spark-over of the spark gaps.

The purpose of this project is to develop the high voltage testing procedures for breakdown insulator (plywood) and safety precaution for high voltage lab. This project include 3-stages impulse generator where the voltage is expected up to 400kV which is for 1-stage it can generate impulse until 140KV, 2-stage 280KV and 3-stages up to 400KV. This project try to create multistage impulse generator and find suitable stages according to test object withstand. For test on insulator (plywood), only 1-stage and 2-stages impulse generator was needed to test dielectric strength on plywood. The capacitors are first charged in parallel through charging resistors by a high-voltage, direct-current source and then connected in series and discharged through a test object by a simultaneous spark-over of the spark gaps.

1.2 Project Objective

The main objective of this project is to develop the high voltage testing procedures test on insulator (plywood) and safety precaution for high voltage lab purpose. Second objective is to analyze and generate the standard lightning impulse using Multistage Impulse Generators. This project creates two stage impulse voltages using high voltage construction KIT up to 280KV and finally to compare the result data between impulse generator without test object and with test object.

1.3 Project Scope

Scope of this project is building up the impulse voltage using High Voltage Construction KIT and developed manual testing procedures for impulse voltage test without test object and with test object. This scope is focusing on 1-stage and 2-stages configuration for high voltage testing which will generate the voltage up to 280KV. At the same time comparison between theory and testing will be conducted in order to get the right outcome. At the end of this project is to develop the high voltage testing and the safety precaution should be prepared.

1.4 Problem Statement

HAEFELY High Voltage Test Set is the new equipment that available in the High Voltage Lab at Faculty of Electrical Engineering. Since the equipments are not use yet, it is necessary to analysis the characteristic and specification in order to apply in the laboratory for learning process. The testing procedures and safety precaution should be prepared because it involved the high voltage up to 400kV. It also necessary to ensure that all the equipments are follows the specification which has been given by supplier. Even though the basic testing procedure manual has been provided by the manufacturer, the steps on handling the equipment is not elaborated in details.

1.5 Methodology

The general flow of the project can be illustrated in the flowchart in figure 1.1. Before proceed on the report, study on the previous research should be carried out and necessary project planning should be arranged. For this report, there are several steps should be taken in order to achieve the project's scope and objectives. Basically, Project Methodology defines the planning process flow and principles that are essentials guide to produce a well planning project..

Besides, selected approach or methodology will be described the activities that may do in every stage. The requirements that are requisite in this system will be explained in high level project requirements and followed with project schedule and milestones.

1.5.1 Literature Review

Find the information related with the project from internet, journal, reference book etc and try to understand s about the basics project.

1.5.2 Design and Software Simulation

Design the impulse generator high voltage circuit and simulate by using the Pspice software then, find the data result suitable with lab testing result.

1.5.3 Lab Testing (impulse generation without test object)

After the software simulation for the circuits were succeeded, the hardware for DC configurations for High Voltage 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.

1.5.4 Analysis 1

Do the analysis for characteristics and specification of high voltage equipment which available at high voltage lab and try to understand about their application and make comparison between experimental and simulation. The flow chart that describes the methodology for this project is shown in the flow chart 1.1.

1.5.5 Lab Testing (impulse generation with test object)

The lab testing session will also be conducted with the test object has been chosen which is plywood. By doing this test, the breakdown voltage for that test objects can be determined.

1.5.6 Analysis 2

In this part, the analysis on the lab testing results with the test object will be carried our. 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.

1.5.7 Testing Procedures Manual

Finally, the testing procedures manual for DC High Voltage testing will be developed as per planning.

1.6 Methodology Flowchart

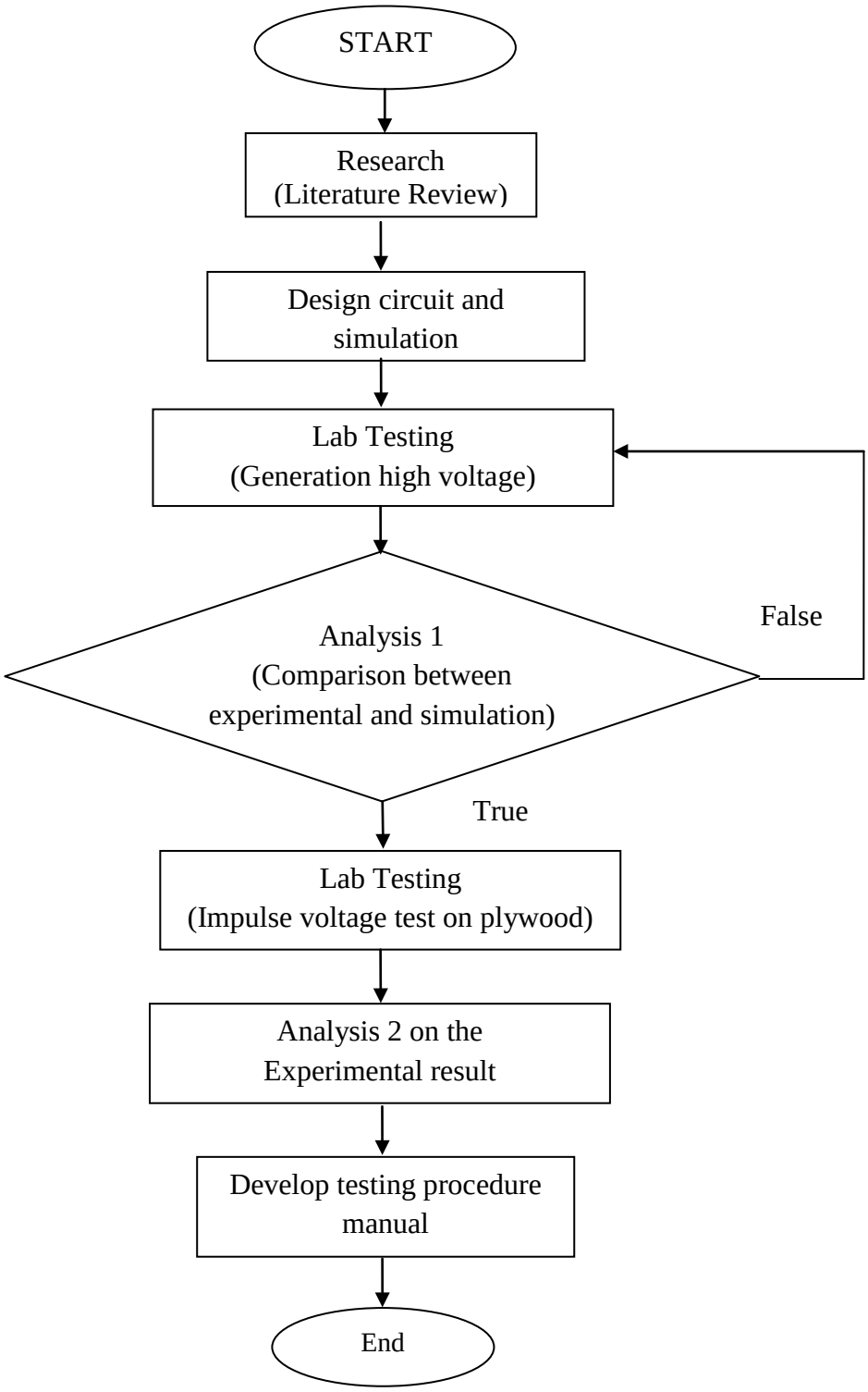

Figure 1.1: Methodology Flowchart

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The information's are based on books, internet information, review thesis and discussion with supervisor. The focuses of finding information about High voltage testing procedure, including generation impulse voltage, standard waveform for lightning impulse, type of insulator, type test on insulator, and study of characteristic for breakdown voltage on insulator.

Basically to measure high-voltage and basic testing techniques should be referred standard IEEE or IEC, so far as they are generally applicable, to all types of apparatus for alternating voltages, direct voltages, lightning impulse voltages, switching impulse voltages, and impulse currents [1]. This revision implements many new procedures to improve accuracy, provide greater flexibility, and address practical problems associated with high-voltage measurements. In order to generate lightning impulse voltage, the standard wave form of lightning impulse voltage must be understand and clear it is because the present of knowledge on standard of lightning characteristics is important before to test on insulator.

In the high voltage testing, the amplitudes and types of the test voltages always higher than the normal or rated voltages of the apparatus under test. The selection of high voltage testing equipment had been prescribed by the national or international standards.

2.2 Generation of Impulse Voltage

Based on reference [1], Impulse voltage is an electrical apparatus which produces very short high-voltage or high-current surges. Such devices can be classified into two types impulse voltage generators and impulse current generators. High impulse voltages are used to test the strength of electric power equipment against lightning and switching surges. Also, steep-front impulse voltages are sometimes used in nuclear physics experiments. Impulse voltage usually generated by discharging high-voltage capacitors through switching onto a network of resistors and capacitors. It also was called a unidirectional voltage that rapidly rises to a peak value and then drops to zero more or less rapidly an also known as pulse voltage. In high voltage technology a single, unipolar voltage pulse is term an impulse voltage.

An impulse voltage generator consists of capacitors, resistors, and spark gaps. The capacitors are first charged in parallel through charging resistors by a high-voltage, direct-current source and then connected in series and discharged through a test object by a simultaneous spark-over of the spark gaps [7]. The impulse current generator comprises many capacitors that are also charged in parallel by a high-voltage, low-current, direct-current source, but it is discharged in parallel through resistances, inductances, and a test object by a spark gap. The impulse waves are generally represented by

$$V = V_o [\exp(-\alpha t)-\exp(-\beta t)] \quad (1)$$

The above equation represents a unidirectional wave which usually has a rapid rise to the peak value and slowly falls to zero value. The general wave shapes (for 1000kV). Front time = 1.2μs, Fall time = 50μs, $\alpha = -0.0146$, $\beta = -2.467$

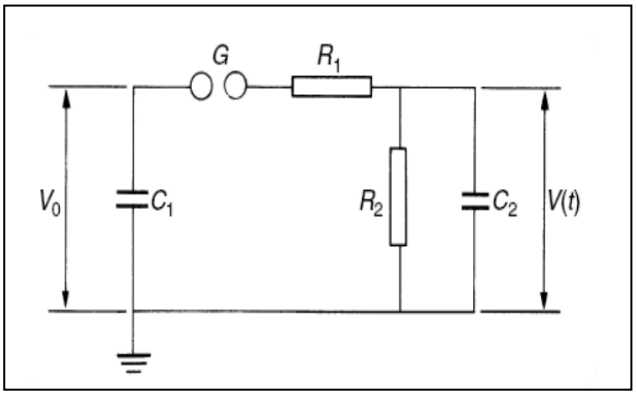

Figure 2.1: Equivalent Circuit Impulse Voltage [2]

Figure 2.1 shows equivalent circuit for impulse voltage generation. This circuit was proven by review thesis from Wong Ing Siong [3]. Based on the thesis, when the capacitor (C_1) has been fully charged, the circuit is ready for the triggering pulse to cause voltage breakdown at the sphere gap. After the breakdown of sphere gap, voltage will pass through the waveshaping circuit and resistors R_1 and R_2 will determine the front time and tail time of the lightning impulse. The output voltage is appearing at load capacitor (C_2) [10]

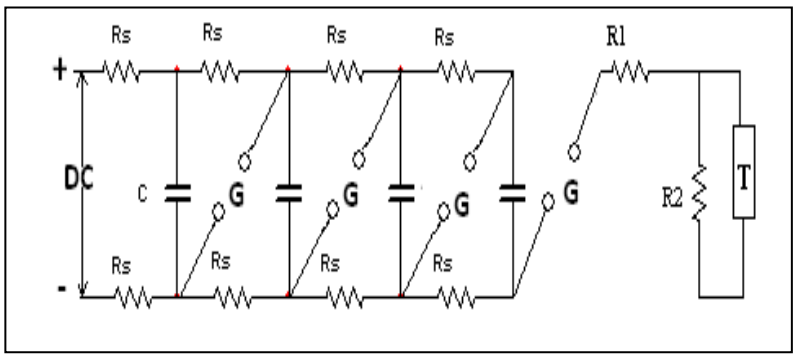

Figure 2.2: Multiplier Impulse Circuit

Figure 2.2 shows multistage impulse generator circuits which can produce high impulse voltage. The arrangement for charging the capacitors in parallel and then connecting them in series for discharging was originally propose by Marx [1].