GENERATION OF HV IMPULSE AND TESTING ON INSULATOR

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7 MAY 2008

"I hereby declare 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 Requirement For The Degree of Bachelor In Electrical Engineering (Industrial Power)

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May 2008

" I hereby declare that this report is a result of my own work except for the experts that have been cited clearly in the reference."

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ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to all my friends who have helped us at various stages in the refinement of this project proposal. I grateful to Mr. Alias bin Khamis my supervisor for giving me the knowledge and guidance in this project. Also not forget to Mr. Hidayat and Mrs. Jurifa for giving me guidance in the laboratory.

In the end, I thank to my mother and father for their unconditional support and absolute understanding during studying here.

ABSTRACT

The high voltage test configuration for impulse voltage up to 400 kv with different output power. The major factor of constructing the impulse high voltage kits is to simulate the stresses due to external and internal over voltage and also for fundamental investigation of breakdown mechanism. This project is using insulator (Rubber) as a test object to find the breakdown voltage and do analysis of their breakdown characteristic. This application range for high voltage kit covers not only in high voltage laboratories, but also as an industrial test system for routine and type test on Electrical equipment or insulator (Rubber).

ABSTRAK

Konfigurasi dalam ujian voltan tinggi untuk voltan dedenyut (Impulse) menghasilkan voltan sehingga 400 kv dengan kuasa keluaran berbeza. Faktor yang utama dalam membina voltan tinggi adalah dengan menjalankan simulasi desakan disebabkan oleh kegagalan luaran dan dalaman, ia juga untuk megkaji asas mekanisme kegagalan. Projek ini dikaji dengan menggunakan penebat (Getah) sebagai satu ujian bagi mencari voltan runtuh dan untuk menganalisis ciri-ciri kegagalan itu sendiri. Julat aplikasi ini merangkumi peralatan voltan tinggi bukan sahaja dalam makmal-makmal voltan tinggi, malah juga untuk satu sistem ujian industri rutin dan jenis ujian yang dijalankan untuk peralatan elektrik dan juga penebat (Getah).

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LIST OF ABBREVIATION

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

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 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 35,000 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 1000 V 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 [3]. 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 (article 490.2). 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 standards generally are more restrictive where the chance of contact with such high voltage circuits exists.

1.2 Problem Statement

Each of the projects has their own problem to be discussing before starting the project. By stating the problem statement it easy to know the purpose of doing this project and what are the problem to be solved. Below are the problem statements for this project.

- To analyze the breakdown voltage of insulator (Rubber).
- Procedure of testing must follow standard.
- New lab still low of safety.

1.3 Experiment Objective

Before conducting or doing the project, the objectives of the project are the main focus in this project. At the last of this report from the conclusion the objective are stated where it succeed or not. Below are the objectives of this project.

- To understand the characteristic of lighting impulse voltage (LI).
- To generate a high voltage impulse using high voltage construction kit.
- Do comparison between practical, experiment and simulation.
- Do procedure and safety of using equipment in the lab.
- Do a testing on insulator (Rubber) to analyze their breakdown voltage.

1.4 Scope of Project

This project report consists of five chapters, chapter one is introduction, chapter two literature review, chapter three methodology, chapter four result and discussion and chapter five is the conclusion. Chapter one will be explain about the high voltage definition, history and standard. This chapter also states the problem for the project, objective and scope of the project report.

Chapter two will discuss about the theory of impulse voltage, there are five parts in this chapter to be discuss. First part about the theory of impulse voltage, second part types of impulse testing, third part impulse voltage circuit, fourth and five are about equipment and component that are use in this project.

Chapter three is the methodologies for the whole processes of project from PSM I until PSM II. In project methodology will explain the whole project procedure from starting finding and research the topic until choose the best circuit. For simulation method will explain the step of simulation project circuit. Lastly experiment methods are explaining the step in the experiment project.

In chapter four is discussing about the project result, this chapter consist of simulation and experimental result. In simulation part will discuss the result of output waveform and experiment part will discuss the output waveform from the oscilloscope. Finally the last chapter five is the conclusion of the whole project report and suggestions.

CHAPTER 2

LITERATURE REVIEW

2.1 Impulse Voltage

Impulse voltages are frequently caused by two kinds of transient voltage whose amplitudes may greatly exceed the peak values of the normal ac operating voltage. The first kinds are lighting over voltages, an average bolt of negative lightning carries a current of 30-to-50 kilo amperes, transfers a charge of 5 coulombs, and dissipates 500 megajoules of energy (enough to light a 100 watt light bulb for 2 months). However, an average bolt of positive lightning (from the top of a thunderstorm) may carry a current of 300-to-500 kilo amperes, transfer a charge of up to 300 coulombs, have a potential difference up to 1 Giga volt (a billion volts), and may dissipate enough energy to light a 100 watt light bulb for up to 95 years. A negative lightning stroke typically lasts for only tens of microseconds, but multiple strikes are common. A positive lightning stroke is typically a single event. However, the larger peak current may flow for hundreds of milliseconds, making it considerably hotter and more dangerous than negative lightning [2].

The second kind is caused by switching phenomena. Their amplitudes are always related to the operating voltage and the shape is influenced by the impedance of the system as well as by the switching conditions. The rate of voltage rise is usually slower, but it is well known that the wave shape can also be very dangerous to different insulation system, especially to atmospheric air insulation in transmission system with voltage level higher than 245kV. Although the actual shape of both kinds of over voltages varies strongly, it became necessary to simulate these transient voltages by relatively simple means for testing purposes.

2.2 Types Of Impulse Testing

The IEEE-4 and IEC-60 Standard Techniques for HV Testing define various wave shapes to be used in HV testing. Various ANSI, IEC, AEIC, and other standards for T&D apparatus and other components define specific test requirements and test voltage levels for particular products. Per the appropriate standard, impulse testing is done as a design test, a production test, or both.

2.2.1 Lighting Impulse

Lighting impulse wave shape is defined with a front time of 1.2μs and a tail time of 50μs, within tolerances. The front time Ts of a lighting impulse is a virtual parameter defined as the 1.67 times the interval between the instants when the impulse is 30% and 90% of the peak value (Figure 2.1).

The virtual origin *O* of a lighting impulse is the instants preceding that corresponding to 30% by a time 0.3Ts. The time to half-value Tr (or tail time) of a lighting impulse is a virtual parameter defined as the time interval between the virtual origin *O* and the instant when the voltage has decreased to the half peak value [1].

The curves of lighting impulse often have high-frequency oscillations superimposed, due to the pararistic inductances of the impulse circuit, the amplitude should not exceed 5% of the test voltage.
Standard Lightning Impulse:

- Front time Ts: 1.2μs (tolerance: ±30%)
- Time to half-value Tr: 50μs (tolerance: ±20%)

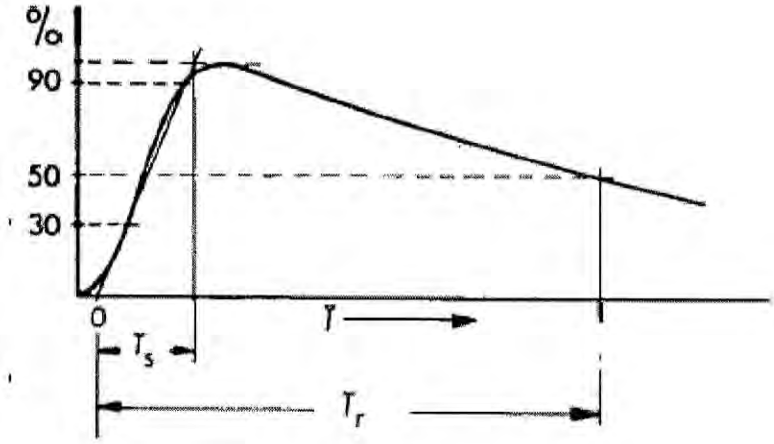

Figure 2.1: Lightning impulse

2.2.2 Switching Impulse

Switching impulse wave shapes is defined with a front time of 250μs and a tail time of 2500μs, within tolerances. The time to peak C1 of a switching impulse is the time interval between the actual origin and the instant when the voltage has reached its peak value (Figure 2.2).

The time to half-value Th for switching impulse is the time interval between the actual and the instant when the voltage has first decreased to half peak value. The time above 90% is the time interval during which the impulse voltage exceeds 90% of its peak value [1].

Standard Switching Impulse:

- Time to peak C1: 250μs (tolerance: ±20%)
- Time to half-value Th: 2500μs (tolerance: ±60%)

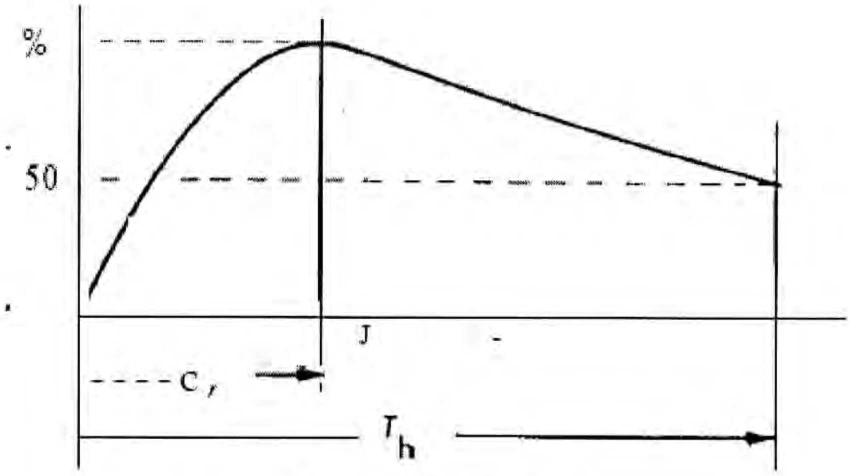

Figure 2.2: Switching impulse

2.3 Impulse Withstand Testing Characteristic

Figure 2.3 below are show the characteristic of impulse testing on insulator to see whether there is any damage.

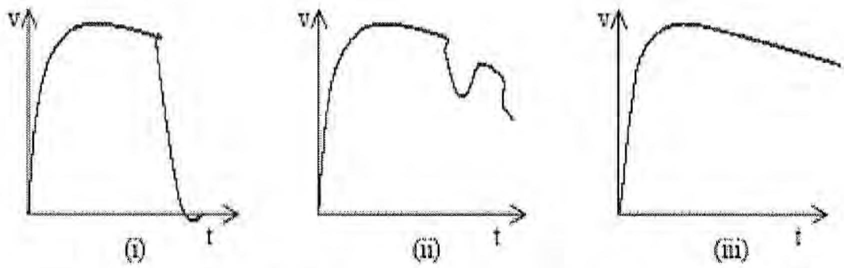

Figure 2.3: Observe Impulse Waveforms

In the event of complete damage, breakdown of the insulator due to the application of the impulse voltage will be indicated as in (i). If the insulator has suffered only a minor damage the waveform would show no distortion, but would show as in (ii). If there is no damage caused due to the impulse, the waveform will be complete and undistorted as in (iii). In testing high voltage insulator whose actual breakdown is in air (i.e flashover take place before breakdown of insulator) figure 2.4 show the flashover impulse waveform.

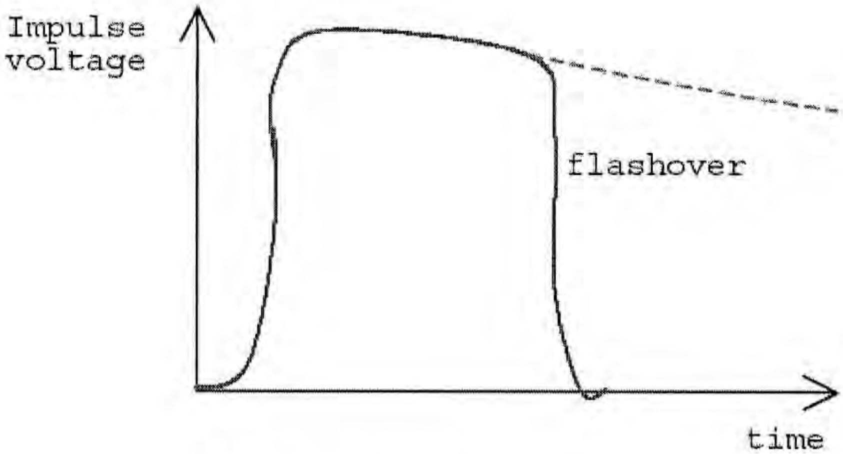

Figure 2.4: Chopped Impulse Waveform

2.4 Impulse Voltage Generator Circuit

Impulse generators for high voltage testing have been built up to now almost exclusively in the well-known Marx circuit. The basic principle of this circuit is the rapid series connection of charged capacitors whereby spark gaps are used to make the series switching.

2.4.1 Single-Stages Generator Circuits

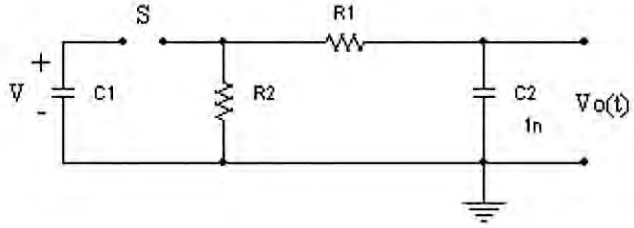

Figure 2.5: Impulse stage 1 circuit

Refer to figure 2.5 the capacitor C_1 is slowly charge from a dc source until the spark gap S break down. This spark gap acts as a voltage-limiting and voltage-sensitive switch, whose ignition time (time to voltage break down) is very short in comparison to T_s. As such single-stage generator may be used for charging voltages from some kV up to about 1MV, the sphere gap will offer proper operating conditions. The resistor R_1 and R_2 and the capacitance C_2 from wave shaping network R_1 will primarily damp the circuit and control the front time T_s. R_2 will discharge the capacitor and therefore essentially control the wave tail. The capacitance C_2 represents the full load, example the object test as well as all other capacitive elements, which are in parallel to the test object. From this circuit front time and tail time can be calculated by using the equation below.

$$\text{Front time, } t_1 = 3(R_1)\left(\frac{C_1 C_2}{C_1 + C_2}\right) \quad (2.1)$$

$$\text{Tail time, } t_2 = 0.7(R_1 + R_2)(C_1 + C_2) \quad (2.2)$$

2.5 Insulator (Rubber)

Rubber is a natural or synthetic vulcanized high polymer having high elastic properties. Electrical properties of rubber depend on the degree of compounding and vulcanizing. General impurities, chemical changes due to ageing, moisture content and variations in temperature and frequency have substantial effects on the electrical properties of rubber. Some important electrical properties and application of different types of rubber are given in figure 2.6.