GENERATION AND HIGH VOLTAGE AC TECS ON INSULATOR (PLYWOOD)

MOHD ASHMAWI BIN BAHARUDDIN

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This Report Is Submitted In Partial Fulfillment Of Requirements For The Bachelor Of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

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"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)"

Signature : .....

Supervisor's Name : Pn. Junfa bt Mat Lazi

Date : 7/5/08

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

Signature : .....

Name : Mohd Ashmawi Bin Baharuddin

Date : 7/5/2008

Specially dedicated to my beloved family,

Baharuddin bin Omar

Khanzanah binti Yaacob

Ahmad Junaidi bin Baharuddin

Mohd Ridhuan bin Baharuddin

Mohd Shukri bin Baharuddin

Nur Ilani binti Baharuddin

Puan Jurifa Mat Lazi, Dr Musse Muhammud Ahmed, Mr Hidayat Zainuddin, Mr Alias Khamis, and all my friends,

Thanks for guidance and support...

Mohd Ashmawi bin Baharuddin
Faculty of Electrical Engineering, UTEM
June 2004 – May 2008

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ABSTRACT

The purpose of this project is to develop the Haefely type AC generator high voltage testing. The new equipments which are available in the high voltage lab will be used in order to study and analyze the characteristics of high voltage. This project focuses on AC generator where the voltage is expected up to 100kV.This project is to generate the AC high voltage and do the testing on object related to the high voltage. The configuration is built up by inserting high voltage construction KIT elements such as compensating reactor, top electrode, control unit, regulating transformer, measuring capacitor and others to form a self supporting arrangement. Computer simulation will be done in order to compare the simulation result with the experimental result. At the end of this project, we should be able to prepare the manual or testing procedures and be able to do high voltage testing up to 300Kv

ABSTRAK

Sistem pembinaan voltan tinggi adalah merupakan satu sistem komponen yang diaplikasikan dalam teknologi voltan tinggi. Sistem ini digabungkan untuk membentuk satu konfigurasi yang sangat menarik. Sistem ini membenarkan keluaran voltan AC sehingga mencapai 300kV. Projek ini akan membincangkan tentang pembinaan sistem voltan tinggi tersebut. Sistem ini dibina mengikut peringkat dengan memasang setiap komponen untuk membentuk satu susunan dan mampu menghasilkan keluaran maksimum sehingga 300 kV pada peringkat yang terakhir. Peralatan ini terdapat di makmal voltan tinggi dan akan digunakan untuk menjalankan eksperimen terhadap bahan yang digunakan sebagai penebat. Pada fasa terakhir projek ini, satu langkah untuk tujuan meguji bahan penebat akan dikeluarkan untuk tujuan rujukan kepada pelajar berdasarkan Piawaian IEEE 4-1995. Sistem ini bukan saja digunakan dalam makmal-makmal voltan tinggi universiti-universiti teknikal malah ia juga merupakan satu sistem ujian rutin bagi tujuan industri untuk menguji peralatan elektrik.

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CHAPTER 1

INTRODUCTION

1.1 Project Overview

HAEFELY High Voltage Construction equipment can be used in multiple applications in high voltage technology. This equipment can be used in generation of high DC, AC or Impulse voltage for high voltage testing. This HAEFELY High Voltage Construction equipment is new equipment which is available in the High Voltage Lab in Faculty of Electrical Engineering. This equipment will be used for studies by all electrical engineering students for the High Voltage Engineering subject. Since this equipment generates extremely high voltages, proper steps and safety precaution need to be taken when handling the equipment. Hence, standard manual procedure that describes all the steps and safety precautions needs to be provided as a guidelines when use the HAEFELY High Voltage Construction equipment. Focusing on this point, this project was introduced.

This project focuses on AC generator where the voltage is expected up to 100kV. This project is to generate the AC high voltage and do the testing on plywood (3mm). The configuration is built up by inserting high voltage construction KIT elements such as compensating reactor, top electrode, control unit, regulating transformer, measuring capacitor and others to form a self supporting arrangement. Computer simulation on PSpice software will be done in order to compare the simulation result with the

experimental result. At the end of this project, standard operating manual will be the output for this project as a guideline in the High Voltage Lab.

1.1.1 Keywords

1. AC Generator
2. Standard Operanting Procedures (Manual)
3. High Voltage Testing
4. Pspice Simulation

1.2 Project Objective

There are five objectives that need to be achieved to complete this project which are:

i. To develop the high voltage standard operating procedure and safety precaution for high voltage lab purpose.
ii. To study and analyze the breakdown characteristic of high voltage AC configuration.
iii. Carry out testing on plywood.
iv. Carry out simulation using PSpice software.
v. To compare the result between the experimental andsimulation.

The main objective of this project is to develop the high voltage testing procedures manual and safety precaution for high voltage AC test on plywood

To achieve this main objective, this project started with the first objective which is to study and analyze the characteristics of high voltage AC generator. It is important to understand the process to generate high voltage AC.

Then, this project continued with second objective which is simulating the generation AC circuit using Pspice simulation. Then, it followed by third objective which is conduct the high voltage lab testing on plywod and then, the analysis on the experimental result will be carried out.

Finally, the main objective of this project which is to develop the testing procedures manual and safety precaution for AC high voltage test on plywood will be carried out.

1.3 Project Scope

Scope of this project is to generate the high alternating voltage using High Voltage Construction KIT. This scope is focusing on high voltage testing which will generate the voltage up to 100kV. 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, the manual for high voltage testing on plywood and safety precaution manual will be produce for high voltage lab purpose.

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 this equipment is new equipment that available in the university, the complete user manual and complete documented manual that describes the steps on handling the equipments needs to be provided. The manual and lab procedures will be discussed in this project considering to the safety precaution.

Even though the basic testing procedure manual has been provided by the manufacturer, the steps on handling the equipment is not elaborated in details. So, it is necessary to analyze the characteristic and specification in order to apply in the

laboratory for learning process. High voltage test on plywood also will be conducted to get its breakdown voltage. This test is to get its breakdown voltage as a benchmark for future study.

The testing procedures and safety precaution should be prepared because it involved the high voltage up to 100kV. In order to produce the testing procedures manual, details investigation on the equipments, its characteristics, purposes and testing procedures need to be done. Since this is high voltage equipments, necessary safety precaution needs to be taken when implementing the equipments. It also necessary to ensure that all the equipments are follows the specification which has been given by supplier.

CHAPTER 2

LITERATURE REVIEW

2.1 Generation of High Voltage Alternating Current

When test voltage requirements less than 300kV, a single transformer can be used for test purpose. The impedance of the transformer should be generally less than 5% and must be capable of giving the short circuit current for 1 minute or more depending on the design.

To generate high voltage, single unit construction transformer becomes difficult and costly due to insulation problems. So, the large transformer is very expensive. So, the other alternative to generate high voltage is by series several cascade transformers.

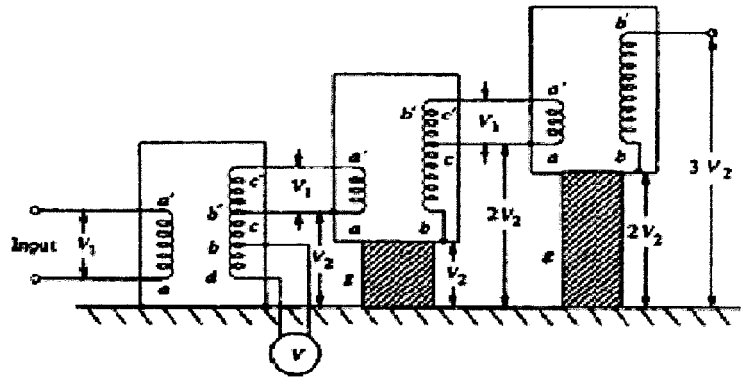

Figure 2.1 Schematic diagram of the cascade transformer units

V1 – Input Voltage

V2 – Output Voltage

aa' – L.V. primary winding

bb' – H.V. secondary winding

cc' – Excitation winding

bd – meter winding

2.2.1 Cascade Transformer

Figure 2.1 shows a typical cascade arrangement of transformers used to obtain up to 300 kV from three units each rated insulation at 100 kV. The low voltage winding is connected to the primary of the first transformer, and this is connected to the transformer tank which is earthed. One end of the high voltage winding is also earthed through the tank. The high voltage end and a tapping near this end are taken out at the top of the transformer through a bushing, and form the primary of the second transformer. One end of this winding is connected to the tank of the second transformer to maintain the tank at high voltage. The secondary of this transformer too has one end connected to the tank and at the other end the next cascaded transformer is fed. This cascade arrangement can be continued further if a still higher voltage is required [1].

In the cascade arrangement shown, each transformer needs only to be insulated for 100 kV, and hence the transformer can be relatively small. If a 300 kV transformer had to be used instead, the size would be massive. High voltage transformers for testing purposes are designed purposely to have a poor regulation. This is to ensure that when the secondary of the transformer is short circuited (as will commonly happen in flash-over tests of insulation), the current would not increase to too high a value and to reduce the cost. In practice, an additional series resistance (commonly a water resistance) is also used in such cases to limit the current and prevent possible damage to the transformer. The cascade transformer arrangement shown is the basic principle involved. The actual arrangement could be different for practical reasons [1].

2.2 AC configuration overview

High alternating voltage AC are required for experiments and AC tests as well as a supply for most of the circuits to generate high direct (DC) or impulse voltage. Test transformers generally used for this purpose have considerably lower power rating and frequently much larger transformation ratios than power transformers. The primary winding is usually supplied by regulating transformers fed from the main supply. Most tests and experiments with high AC voltage require precise knowledge of the value of the voltage. This demand can normally only be fulfilled by measurement of the voltage on the high voltage side of the transformer. The circuit for the AC configuration consists of a high voltage transformer with a maximum output voltage of 100kV and a capacitive voltage divider for the measurement of the voltage on the high voltage side.

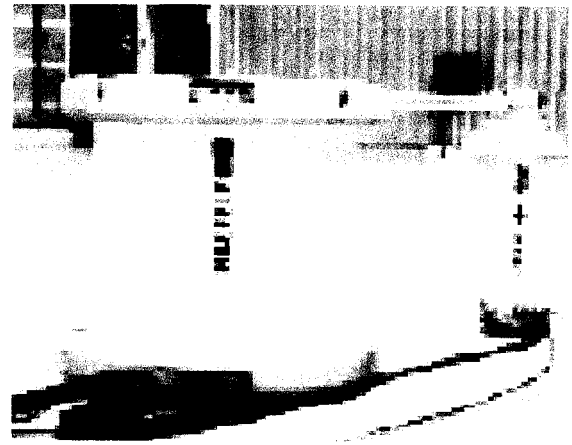

Figure 2.2: Hardware configuration of high voltage AC

For the 2 stages configuration, two transformers are put together in a cascade configuration to reach a maximum output voltage of 200kV. For this reason, each transformer is equipped with a tertiary winding. The tertiary winding is used for coupling two transformer modules. For this the tertiary winding of one module is connected to the primary winding of the succeeding module. Also two measuring capacitors are connected in series for the measuring of an AC voltage of 200kV. For configurations with more than one stage, compensating reactors type KDL

(compensating reactor) is recommended to extend the load range of the cascade configuration.

2.2.1 Application

The High Voltage Construction KIT is a system of components for applications in high voltage technology. All components have the same length and mechanical interconnections. They can be combined to form a test configuration and are extremely versatile. Test configurations are available which allow the generation of AC voltages up to 300 kV. This project is focusing on generating high voltage AC up to 100kV. 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 tests on electrical equipment up to 300 kV.

A complete test system requires a volume of 30 m^3 and a floor surface of three by four meters. The configuration is built up, as it name suggests, by simply inserting the various elements to form a self-supporting structure. In spite of its striking simplicity, the kit 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 kit elements. The high voltage kit has very compact dimensions and a wide range of application. It is portable and truly represents a complete high voltage test system.

2.3 General remark for setup

The assembly of high voltage circuits using the high voltage construction KIT is quick and easy. An example is the structure of an AC circuit 100 kV (without matching

transformer or control unit). The configuration is built up by inserting elements to form a self-supporting arrangement. No additional tools are required.

This sophisticated design can make user to change their circuit. That's especially an advantage, for combined systems. Every connection cup has six possible combinations. Two vertical and four horizontal.Every floor pedestal has two threads on opposite sides for ground connection. This way the grounding can be made at the end of the assembly simply by screwing the copper foil to the floor pedestals without need to rearrange them.

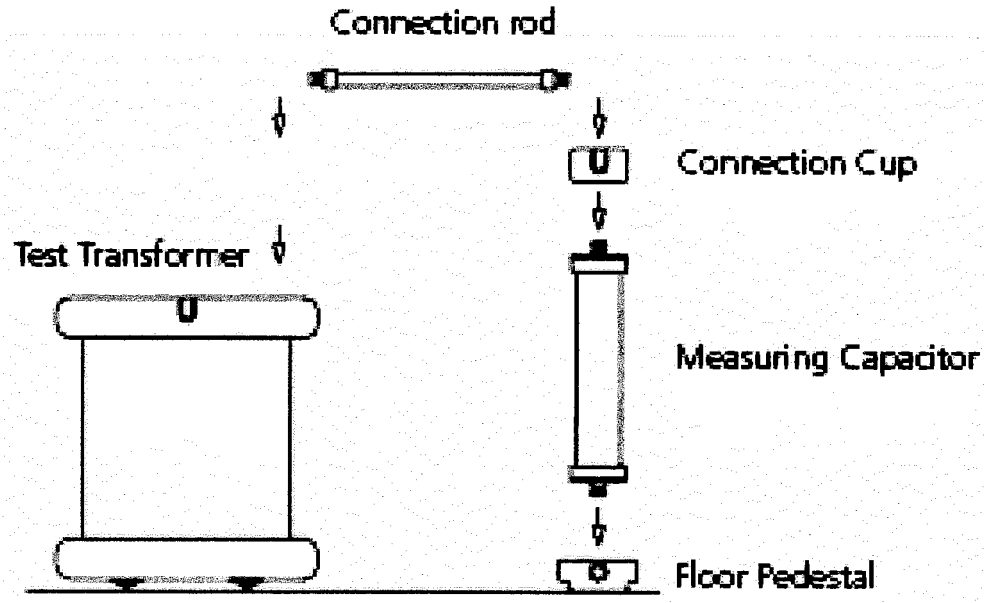

Figure 2.3 Configurations with more than just one stage

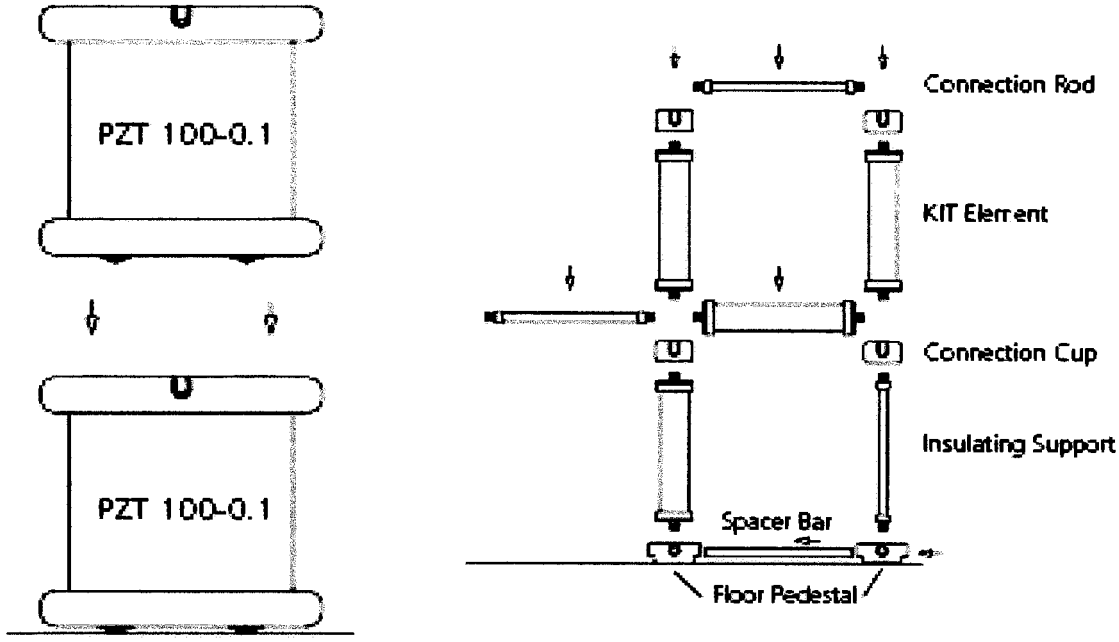

Figure2.4 multiple circuit