GENERATION AND HVAC TEST ON INSULATOR (VULCANIZED RUBBER)

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MAY 2008

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

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Date : 7 MAY 2008

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

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ABSTRACT

The High Voltage Construction is a system of components for applications in high voltage technology. 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 300kV.This project will discuss on the high voltage construction which allow the generation of AC voltages up to 300KV. This system built with install each component to form single arrangement can generate till 300 kV which built according to stages. The equipment which is available in the high voltage lab will be used to study and develop a high voltage testing procedure. At the end of the project phase a testing procedure will be develop to be use by the future student. IEEE standard 4-1995 will be use as reference. The application range for the high voltage construction 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.

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 I

INTRODUCTION

1.1 Introduction to AC voltage

The voltage of an alternating current can be changed by a transformer. This simple, inexpensive, static device permits generation of electric power at moderate voltage, efficient transmission for many miles at high voltage, and distribution and consumption at a conveniently low voltage. With direct (unidirectional) current it is not possible to use a transformer to change voltage. On a few power lines, electric energy is transmitted for great distances as direct current, but the electric energy is generated as alternating current, transformed to a high voltage, then rectified to direct current and transmitted, then changed back to alternating current by an inverter, to be transformed down to a lower voltage for distribution and use.

In addition to permitting efficient transmission of energy, alternating current provides advantages in the design of generators and motors, and for some purposes gives better operating characteristics. Certain devices involving chokes and transformers could be operated only with difficulty, if at all, on direct current. Also, the operation of large switches (called circuit breakers) is facilitated because the instantaneous value of alternating current automatically becomes zero twice in each cycle and an opening circuit breaker need not interrupt the current but only prevent current from starting again after its instant of zero value.

1.2 Problem statement

This system builds according to stages. This system built with install each component to form a single arrangement which can generate till 300kV. The major problem of this project is difficult to build up the 2nd and 3rd stages configuration because the laboratory floor is not design due to the high impact conditions. For this project, I only can do the configuration for a single stage up to 100kV which is related to my project.

Besides that, the testing device is still new and shall apply in learning process. I must do more research on characteristic of heafely kit construction to make sure that is no damage on testing object when the experiment is done. For simulation, there is no specific software which is related to the heafely equipment. It is quite difficult to simulate the high voltage circuit for this project.

The testing procedures and safety precaution should also 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.

1.3 Objectives

Through this project, test configurations are available which allow the generation of AC voltages up to 100kV. The objectives of this project are:

i. To study and generate alternating current voltage using new high voltage construction kit.
ii. To build and apply high voltage construction as test equipment which are used in high voltage system.
iii. To Practice person in do simulation to confirm experiment products.
iv. To conduct the lab session for high voltage testing.
v. To analyses the experimental result.
vi. To develop the high voltage testing procedures and safety precaution for high voltage AC test on insulator (vulcanized rubber).

The main objective of this project is to develop the high voltage testing procedures manual and safety precaution for high voltage AC test on insulator (vulcanized rubber). This project started with the first objective which is to study and analyze the characteristics of high voltage AC generating process. It is important to understand the process to generate high voltage AC with testing object and without testing object.

Then, this project continued with second objective which is simulating the generation AC circuit using LTspice simulation. It is contains the simulation of the project without the testing object. Basically in consists 1st stage, 2nd stage and 3rd stage simulation process. Then, it followed by the objective which is conduct the high voltage lab testing on rubber and then, the analysis on the experimental result will be carried out. Finally, the testing procedures manual and safety precaution for AC high voltage test on insulator (vulcanized rubber) will be carried out.

1.4 Scope

For this project, high alternating voltages AC are required for experiment. Scopes of this project is learning the generation of AC high voltage up to 100kV. Beside that, the characteristic of AC voltage, how to develop and do the testing using the new construction kit must be analyzed. Standard AC testing procedures manual and safety precaution for AC high voltage test on insulator (vulcanized rubber) will be carried out.

Chapter 1 describes about the introduction for AC voltage, problem statement due to the project development process, objective and the scope of this project.

Chapter 2 will discuss based on the literature review. It is contains about the explanation for generation on high voltage and cascade transformer theory. Based on this chapter, the component project software listed and the basic theory with the specification which is required due to the experiment listed.

In chapter 3, methodology for the project, simulation and experiment are explained. This is shown the flows of the project from the beginning until the end of the project.

Chapter 4 describe about the experimental setup. Project theory and all the equipment will be clearly stated in this chapter. It is also provide how to develop the arrangement before the experiment carried out.

Chapter 5 focused on testing procedure. It is contains the safety precaution due to the experiment and specification related to the experiment process. All the safety and specification must be followed exactly to prevent any damage of the equipment and prevent injury to any person during experiment.

Chapter 6 will focused on result and discussion. All result for the simulation and the experiment will be explained clearly. Comparison between the results by the theory and manufacture will be more clearly describes in this chapter. The analysis due to the experiment also has been discussed clearly.

Chapter 7 will conclude based from the overall project from beginning until the final step of the project development. This chapter also contains suggestion due to the experiment session in the high voltage testing lab.

CHAPTER II

LITERTURE RIVIEW

2.1 Generation high alternating voltages

For generation of high alternating voltage for less than 300kV, 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 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.

2.2 Cascade transformer

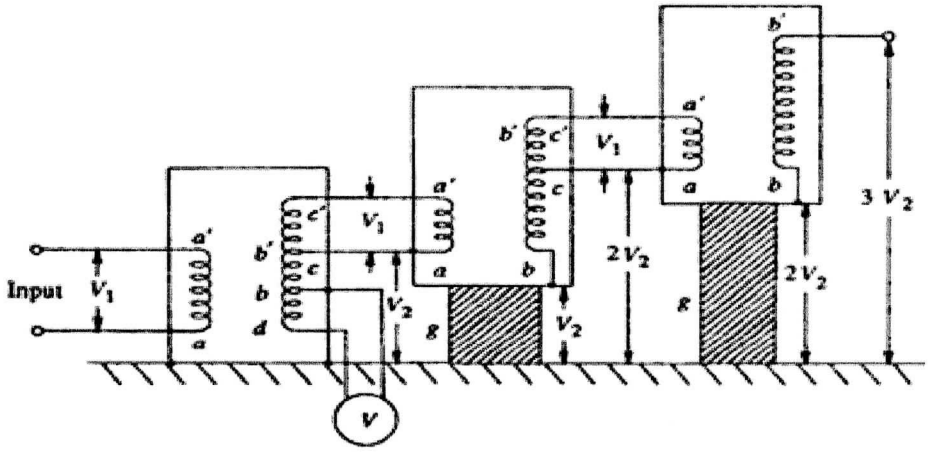

Fig. 6.10 Cascade transformer connection (schematic)

V_1 — Input voltage
V_2 — Output voltage
aa' — L.V. primary winding
bb' — H.V. secondary winding
cc' — Excitation winding
bd — Meter winding (200 to 500 V)

Figure 2.1: Cascade transformer connection (schematic)

The diagram shows the cascade transformer units in which the first transformer is at the ground potential along its tank. The second transformer is kept on insulators and maintained at a potential of V_2, the output voltage of the first unit above the ground. The high voltage winding of the first transformer is connected to the tank of the second unit. The low voltage winding of this unit is supplied from the excitation winding of the first transformer, which is in series with the high voltage winding of the first transformer at its high voltage end. The rating of the excitation winding is almost identical to that of the primary or the low voltage winding. The high voltage connection from the first transformer winding and the excitation winding terminal are taken through a bushing to the second transformer.

Supply to the units can be obtained from a motor generator set or through an induction regulator for variation of the output voltage. The rating of the primary or the low voltage winding is usually 230V or 400V for small units up to 100kVA. For the larger outputs, the rating of the low voltage winding maybe 3.3kV, 6.6kV or 11kV.

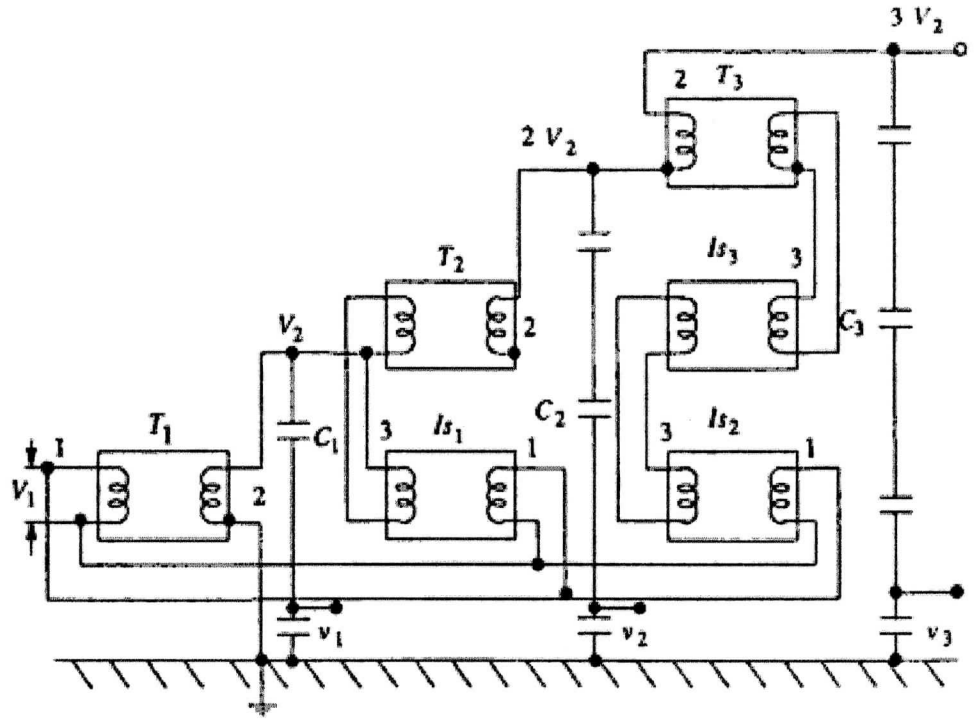

Fig. 6.11 Cascade transformer unit with isolating transformers for excitation

T_1, T_2, T_3 — Cascade transformer units
I_{s1}, I_{s2}, I_{s3} — Isolation transformer units
C_1, C_2, C_3 — Capacitance voltage dividers for h.v. measurement after 1st, 2nd and 3rd stages
V_1, V_2, V_3 — For metering after 1st, 2nd and 3rd stages
1. Primary (l.v. winding), 2.h.v. winding, 3. Excitation winding.

Figure 2.2: Cascade transformer unit with isolating transformer

This figure is providing the excitation to the second and the third stages. The isolating transformer is 1:1 ratio transformers insulated to their respective tank potentials and are meant for supplying the excitation for the second and third stages at their tank potentials. The power supply to the isolating transformers is also fed for the same ac input.

The advantages of this scheme is natural cooling, the design of the transformer is light and compact. Besides that, the transportation and assembly is also easy. Testing of HV apparatus / insulation involves supplying of the capacitive loads. The nominal power rating is related in kVA, $P=K.V2\omega C$, where K(> 1MV).Typical capacitance value for high capacitance test object is selected base on table 2.1 below[1].

Table 2.1: Test object and suitable capacitance value

Test object	**Capacitance value**
power transformer (<1MVA)	1000pF
power transformer (>1MVA)	1000-10000 pF
HV power cable (solid insulation)	250-300 pF/m
HV power cable (gas insulation)	50-80 pF/m
Metal Clad sub-station (G.I.S)	100-10000 pF

2.3 Rubber

Rubber is a natural or synthetic vulcanizable 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.

Silicone rubber is widely used for cable insulation. High temperature vulcanized(HTV) silicone rubber is being used in the manufacture of outdoor high voltage insulators and also in the form of extended sheds on ceramic insulators to improve their performance under severally polluted condition.For applications in outdoor high voltage insulators, another type of silicone rubber called the room temperature vulcanized (RTV) rubber is also used. Silicone rubber is immune to ultraviolet radiation. As on today, all the electrical utilities are attempting to use silicone rubber for the sheds of all types of overhead line insulators[1].

2.4 Vulcanized rubber

Rubber in its natural form is highly insulating but it absorbs moisture readily and gets oxidized into a resinous material; thereby it loses insulating properties. When it is mixed with sulphur along with other carefully chosen ingredients and is subjected to a particular temperature it changes into vulcanized rubber which does not absorb moisture and has better insulating properties than even the pure rubber. It is elastic and resilient. For high voltage testing purpose the material chosen is the vulcanized rubber that has a dimension as shown in figure 2.3 below.

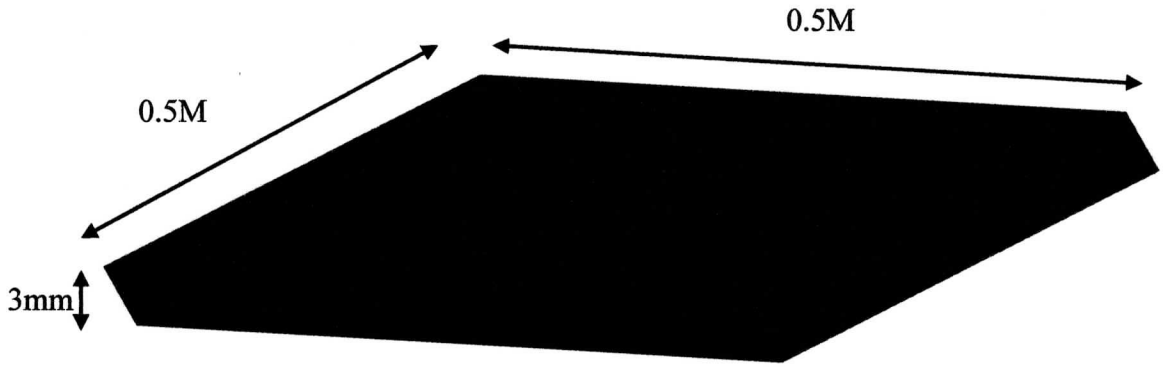

Fig 2.3: Test Object (Vulcanized Rubber)

The electrical properties expected of rubber insulation are high breakdown strength and high insulation resistance. In fact the insulation strength of the vulcanized rubber is so good that for lower voltages the radial thickness is limited due to mechanical consideration.

The physical properties expected of rubber insulation are that the cable should withstand normal hazards of installation and it should give trouble-free service. Vulcanized rubber insulated cables are used for wiring of houses, buildings and factories for low-power work[3].