GENERATE AND TESTING
HIGH VOLTAGE AC, DC AND IMPULSE ON
THE MATERIAL OF INSULATOR ON OIL
TRANSFORMER

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BEKP

2009

"I hereby declared that I have read through this report entitles "Generate and Testing High Voltage AC, DC And Impulse On The Material Of Insulator On Oil Transformer and found out that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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GENERATE AND TESTING HIGH VOLTAGE AC, DC AND IMPULSE ON THE MATERIAL OF INSULATOR ON OIL TRANSFORMER

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

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MAY 2009

I declare that this report entitle "Generate And Testing High Voltage AC, DC And Impulse On The Material Of Insulator On Oil Transformer" 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 candidature of any other degree.

Signature : .....

Name : SABARUDDIN BIN MOHAMMAD

Date : 07 MAY 2009

To my beloved mother and father, sister and brothers,

Mohammad Manap, Munah Binti Majid, Mariam Mohammad and Zamri Mahat

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ABSTRACT

This project is about to generate and testing high voltage AC, DC and Impulse on the material of insulator and oil transformer. HV test objects are limited to measuring the inception voltage (inkV) and the largest discharge magnitude (in pC) and comparing these to the test specifications. Impulse voltage test demonstrates the strength of an insulation system and its components against impulse voltage. The problems of Ordinary transformer insulating oil is that arise are most frequently due to contaminant by dirt, air and water. The condition of the oil as initially installed must be good. If an accidental over-voltage results in a flashover, the oil will have a small amount of carbon in it, weakening the oil. Filtering is a wise thing to do if any spark-over occur. If the oil should inadvertently become so carbonized that it becomes perceptibly darkened, then the oil is weakened point where corona established on the solid on which the transform are wound. Once corona is established, which happen at less than once oil is badly weaken tracks will grow until breakdown occurs. The pre-breakdown characteristics of transformer oil in the presence of different levels of contamination.

ABSTRAK

Projek ini adalah berkaitan penjanaan dan pengujian voltan tinggi AC, DC dan Impulse pada penebat dan minyak transformer. Pengujian objek Voltan Tinggi (HV) ialah terhad kepada pengukuran voltan (inkV) dan magnitud cas (pC) dan perbandingan antara spesifikasi ini. Ujian voltan impulse digambarkan sebagai kekuatan sistem penebatan dan komponen itu berlawanan dengan voltan impulse. Masalahnya, bagi alatubah biasa dalam minyak penebatan ialah kenaikan berdasarkan pencemaran bendasing oleh habuk, udara dan air yang mengganggu kualiti minyak tersebut. Keadaan minyak yang digunakan mesti dalam keadaan baik. Apabila berlakunya voltan lebih minyak tersebut akan mengandungi karbon menyebabkan berlakunya kejatuhan fungsi minyak. Penapisan adalah cara untuk mengelakkan kelemahan pada minyak tersebut daripada berlakunya kehilangan penebatan. Apabila korona hadir ia akan menyebabkan minyak hentitugas sehingga mencapai tahap kritikal minyak berfungsi. Sifat Pra-hentitugas minyak alatubah akan hadir pada peringkat pencemaran bendaing yang berbeza keadaan.

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LIST OF ABBREVIATIONS

AC, ac	-	Alternating current
PD	-	Partial discharge
DC, dc	-	Direct current
C	-	Capacitor
PCB	-	Polychlorinated biphenyl
BS	-	British Standard
IEC	-	International Electrotechnical commission
TNB	-	Tenaga Nasional Berhad
IEEE	-	Institute of Electrical and Electronic Engineers
ASTM	-	The American Society for Testing and Materials Standard
DMI 551	-	Digital Measuring Instrument
OT276	-	Operating Terminal
HV	-	High Voltage
KF	-	Impulse Sphere gap

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CHAPTER 1

INTRODUCTION

1.1 Introduction to High Voltage AC Voltage

In order to properly size an AC Test Set, it is necessary have the maximum test voltage required. The maximum test voltage is determined by the relevant standard that equipment is being built to plus any additional user-defined over sizing to take into account changes to test standards, or special end-user requirements.

PD (Partial discharge) requirements testing is usually performed at lower levels than AC withstand levels. If PD testing is required it is necessary to know the PD sensitivity level for the test and the test voltage. Specifying too high a PD test voltage or unnecessarily low PD free rating for the system inflates the cost of a test system.

1.2 Introduction to DC Voltage

High voltage direct current (HVDC) is used to transmit large amounts of power over long distances or for interconnections between asynchronous grids. When electrical energy is required to be transmitted over very long distances, it can be more economical to transmit using direct current instead of alternating current. For a long transmission line, the value of the smaller losses and reduced construction cost of a DC line, can offset the additional cost of converter stations at each end of the line. Also, at high AC voltages significant (although economically acceptable) amounts of energy are lost due to corona discharge, the capacitance between phases or, in the case of buried cables, between phases and the soil or water in which the cable is buried [1].

HVDC (High Voltage Direct Current) provides necessary features to avoid technical problems in the power systems, and it increases the transmission capacity and system stability very efficient and it assists in prevention of cascading disturbances.

HVDC links are sometimes used to stabilize against control problems with the AC electricity flow. In other words, to transmit AC power as AC when needed in either direction between two places transmitting would require the (highly challenging) continuous real-time adjustment of the relative phase of the two electrical grids.

DC power at low voltage could not be transmitted over long distances, thus giving rise to high voltage alternating current (AC) electrical systems. Nevertheless, with the development of high voltage valves, it was possible to once again transmit DC power at high voltages and over long distances, giving rise to HVDC transmission systems.

1.3 Introduction to Impulse Voltage

Switching Impulses can be generated on larger loads than lightning impulses since routine values of inductance do not influence the long front and tail times. The wave shaping resistor sets for switching impulse.

In order to maintain a lightning impulse wave within the standards, the overshoot on the front time must be less than 5%. In the special case of testing large capacitance samples, such as power cable, the front time requirement is relaxed for front time (<5μs), making overshoot less of an issue.

1.4 Problem statement

This project test is builds according by stage. For this project, I just do the configuration for single stage up to 100kV which is related to my project for comparison between high voltages AC, DC and Impulse sources.

Beside that, I done the research on characteristic on high voltage kit construction to make sure that is no damage on testing object to see the characteristic of the oil transformer. For simulation, there still is no specific software which is related to test this high voltage testing equipment. The software used is LTspice as a high voltage simulation circuit to see the result just can simulate for the generation side without test object.

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 equipment, its characteristic, purposes and testing procedures need to be done. Since this is high voltage equipment, 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.

1.5 Objective

Through this project, test configurations are available which allow the generation of AC, DC and Impulse up to 100kV in single stages. The aim of this project is to research about generating and testing high voltage AC, DC and Impulse on the material of insulator and oil transformer of:

i. To analyze the oil transformer output breakdown voltage with high voltage testing between AC, DC and Impulse source of generation voltage.
ii. To generate and testing high voltage to shows characteristic of oil transformer.
iii. To find problem related with oil transformer especially oil aging and other infected.
iv. To test the level of oil transformer insulation and the time breakdown of the oil.
v. To develop the high voltage testing procedures and safety precaution for high voltage AC, DC and Impulse test on the insulator (oil transformer).

1.6 Scope

The scope of this project is involve with different source high voltage testing like alternating current(AC), direct current(DC) and impulse voltage. Then, scope of generation voltage will be up to 100kV for single stage only. Beside that, the characteristic of AC, DC and Impulse voltage, to develop and do testing using new generation set must be analyzed. The test also includes the different sphere gap distance to see the characteristic. Standard testing procedures manual and safety precaution for AC, DC and Impulse high voltage on insulator will be carried out.

To calculate the gap between two ball electrode to see the time of oil breakdown. Actually the standard gap between two balls is 2.5mm, follow the TNB standard and other standard.

Then, made comparison actual result with simulation result about their breakdown voltage and related analysis. The comparison will do between new and old oil transformer with different source of generation AC and DC for only single stage.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

British Standard BS 7671:2008 defines high voltage as any voltage difference between conductors that is higher than 1000 V AC or 1500 V ripple-free DC, or any voltage difference between a conductor and Earth that is higher than 600 V AC or 900 V ripple-free DC.

2.1 Generating high voltage alternating current (HVAC)

We have resources for system voltages up to 400kV (274 kV to earth) for generation and for measurement alternating current. We can generate and measure alternating current up to 10 kA.

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

In addition to the normal windings, namely, the low and high voltage windings, a third winding known as meter winding is provided to measure the output voltage. For higher voltage requirements, 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.

2.1.1 Cascade Transformer

Refer the Figure 2.1, the cascade transformer units in which the first transformer is at ground potential along with 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 unit is supplied from the tank of the second unit. The low voltage winding of these units 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 ends [2].

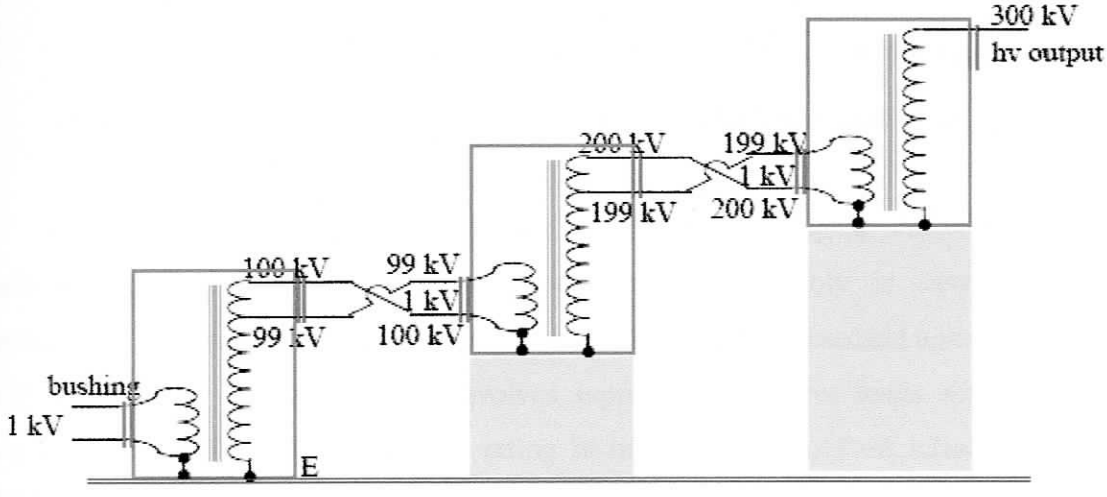
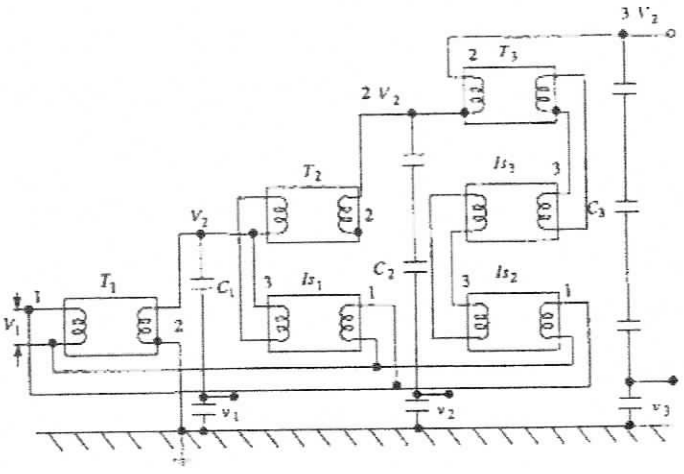


Figure 2.1: Cascade Transformer Connections

Supply to the units can be obtained from motor-generator set through an induction regulator for variation of the output voltage. The rating of the primary or the low voltage winding is usually 230 0r 400V for small units up to 100kA. For larger outputs, the rating of the low voltage winding may be 3.3kV, 6.6kV or 11kV.

In Figure 2.2, providing the excitation to the second and the third stages is shown. Insolating transformer is 1:1 ratio transformers insulated to their respective tank potentials and are meant for supplying the excitation for the second and the third stages at third tank potentials. Power supply to the insolating transformer also fed from the same a.c. input.



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 Units with Isolating Transformers for Excitation

The advantage of this scheme is that the natural cooling is sufficient and the transformer is light and compact. Transportation and assembly is easy. Also the construction is identical for isolating transformer and high voltage cascade units. Testing of an HV apparatus or isolation always involves supplying capacitive loads with very low power dissipation. 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.

Table 2.1: Test object and suitable capacitance value

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