CURRENT TRANSFORMER PERFORMANCE IN HIGH VOLTAGE AND LOW VOLTAGE SYSTEMS

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For my dearest wife Fazlinda,

My beloved sons Muhammad Khairul Afif

&

My family for their encouragement and blessing

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ABSTRACT

Current Transformers (CT's) are instrument transformers that are used to supply a reduced value of current to meters, protective relays, and other instruments. Current transformer provide isolation from the high voltage primary, permit grounding of the secondary for safety, and step-down the magnitude of the measured current to a value that can be safely handled by the instruments. It is one of the critical protective devices in a high voltage substation and low voltage switch board. It is used as a sensor to detect faults that will generate signal to trip the protective relay. The performance of current transformer is very important in preventive and predictive maintenance. It can reduce number of injury and minimize system and equipment failure as well as help to reduce the cost. In this work, the method of measuring and testing the electrical characteristics of CT's are first investigated and the experience gained in the measurement and testing are then used to check and verify the characteristics of CT's found the low voltage switchboard of the Electrical Installation lab. The procedures and steps involved in the measurement and testing are reported and discussed in this work. The method of measurement in the low voltage switchboard are also reported and discussed in this work.

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ABSTRAK

Pengubah arus adalah pengubah peralatan di mana ia di gunakan untuk membekalkan nilai arus yang berkurangan kepada meter, geganti perlindungan dan peralatan – peralatan lain. Pengubah arus menyediakan pemencilan daripada voltan tinggi di bahagian utama yang membenarkan pembumian di bahagian sekunder untuk tujuan keselamatan dan magnitud arus yang di ukur di kurangkan kepada satu nilai yang lebih selamat di kawal oleh peralatan tersebut. Ia adalah salah satu peralatan perlindungan yang kritikal di pencawang voltan tinggi dan voltan rendah di papan suis. Ia di gunakan sebagai penderia untuk mengesan kerosakan di mana ia boleh menghasilkan isyarat untuk menghidupkan geganti perlindungan. Prestasi pengubah arus adalah sangat penting dalam penyelenggaraan pencegahan dan jangkaan.Ia boleh mengurangkan bilangan kemalangan, meminimumkan sistem dan kegagalan peralatan di samping mengurangkan kos.Dalam kerja ini, kaedah mengukur dan menguji ciri ciri elektrik bagi pengubah arus di siasat dan dari pengalaman yang di perolehi dalam mengukur dan menguji tersebut di gunakan untuk menyemak dan mengenalpasti ciri-ciri pengubah arus dalam voltan rendah di papan suis di dalam makmal pemasangan elektrik. Langkah langkah yang terlibat di dalam pengukuran dan pengujian di laporkan dan di bincangkan di dalam kerja ini.Kaedah pengukuran di dalam voltan rendah di papan suis juga di laporkan dan di bincangkan.

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LIST OF SYMBOLS/ ABBREVIATIONS

Symbols:

i_1	-	Primary current
i_2	-	Secondary current
n_1	-	Primary turns
n_2	-	Secondary turns
H	-	Magnetic field
i_e	-	Excitation current
n	-	Winding ratio
R_1	-	Resistance of the primary winding
R_2	-	Resistance of the secondary winding leakage inductances
l_1	-	Primary leakage inductances
l_2	-	Secondary leakage inductances
ϕ	-	Flux
e_1	-	Primary emf
e_2	-	Secondary emf,
v_1	-	Primary potential
v_2	-	Secondary potential
μ_r	-	Relative permeability
L	-	Inductor
Vs	-	Secondary voltage
f	-	Frequency
B	-	Magnetic flux density
A	-	Net core area
k_1	-	A unitary constant corresponding to the unit chosen for B and A

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k_2	-	A constant depending on unit H and l
Ww	-	Watt per weight

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Abbreviations:

CT	-	Current Transformer
DC	-	Direct Current
HV	-	High Voltage
LV	-	Low Voltage
VT	-	Voltage Transformer
PT	-	Potential Transformer
IDMT	-	Inverse Definite Minimum Time
ACB	-	Air Circuit Breaker
MCCB	-	Moulded Case circuit breaker
MCB	-	Miniature Circuit Breaker
IEC	-	International Electrotechnical Comission
IEEE	-	Electrical and Electronic Engineer
ANSI	-	American National Standards Institute
TC	-	Test Certificate
MK	-	Marshalling Kiosk
BBP	-	Bus Bar Protection

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CHAPTER I

INTRODUCTION

1.1 Objective

i To measure the characteristics of different type of current transformer

ii To familiarize with the measuring equipment used to test current transformers.

iii To assess the different techniques of measuring the characteristic of current transformer.

iv To test current transformers in high voltage substations and low voltage switch boards.

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1.2 Statement of Problem

i Insulation is the major component, which plays an important role in the life expectancy of the current transformer. To determine the performance and aging of the asset, insulation behavior is a main indicator. In the absence of insulation monitoring and assessment, good number of current transformer due to insulations problems, before reaching to their designed technical life. Insulation failure can cause electrical shocks, creating a real hazard to personal and equipment.

ii If the value of knee point voltage that is gain doesn't match with the name plate value, it will show that it has been cheated by the manufacture, low quality of the current transformer and the current transformer is damage.

iii The ratio of Current Transformer that does not follow the manufacturer's data will give a problem to the protection system. When there is a difference ratio value in the secondary current, it may give wrong information to the relay. Therefore the relay can't recognize the signal or sometimes the signal detected can't deliver right information. As the conclusion, the protection system does not work as expected

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1.3 Project Scope

The project focuses on testing the high voltage substation and low voltage switch board.

These are the scope of the testing:-

1. DC Resistance of CT and Loop Resistance of Secondary Windings Test
2. Magnetization Test of CT Cores
3. Polarity Tests
4. Ratio Check (Primary Injection)
5. Insulation Test

This project will be done in the Makmal Pendawaian Domestik, Jabatan Kejuruteraan Elektrik Kuasa, Fakulti Kejuruteraan Elektrik dan Elektronik at Universiti Tun Hussein Onn Malaysia. Project will be focused on method for testing the current injection by using a secondary current injection test set (SCITS100).

These are the scope of the testing:-

1. Current transformer excitation characteristics test
2. Current transformer ratio tests
3. Polarity checks

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1.4 Significance of the study

The purpose of this project is to:

1. Familiarize the performance and the characteristics of the current transformer.
2. To study the types of current transformer.
3. To gain a testing procedure of the current transformer
4. To explore a high voltage (HV) and low voltage (LV) system that is related closely with the industrial sector.

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CHAPTER II

CURRENT TRANSFORMER

2.1 Introduction to Current Transformers

This chapter shows the purpose of current transformer. A current transformer is kind of electrical instrument that is produced particularly to provide a flow of current in the secondary circuit that is properly perpendicular to the amount of current flowing in its primary circuit. It actually measures alternating current flowing by way of a conductor. As it is used to measure current, a current transformer is normally classified as a kind of instrument transformer. It could also measure the voltage drop across any known resistor. This could be applied for a low current application but is often impractical for high current applications. The resistor consumes more power (decreasing efficiency) unless the resistor is extremely low in value, in such case there might be very little voltage the measure. The resistor can also be very large. The resistor's heat might affect the resistor value, so reducing accuracy of its measurement.

A current transformer could accurately calculate the alternating current and put out a reasonable voltage that is proportional to the current, but it is without as much heat and size that an appropriate resistor may require. The current transformer could perform its function with extremely little insertion loss into the conductor current is been

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calculated. A current transformer as well offers voltage isolation among the conductor and the measuring circuitry. Proper function of a current transformer wants use of a load resistor. And load resistor is normally referred as to a "burden resistor".

The most excellent core structure for a current transformer in way of electrical performance is a toroidal coil. Many toroidal current transformers normally have only one winding. This winding is generally a "high turns" winding that functions as the secondary winding. In application, the toroidal current transformer is fallen over an end of a high current wire or buss bar that further conducts the primary current.

Split core current transformers are especially planned so that they could be gathered around a buss bar without cutting off the buss bar. "C" cores and "U" core structures are normally used for split-core current transformers as they are comparatively simple to take apart and put back together across the buss bar. Traditionally, this has not been realistic for toroidal coils, but there are presently some supple toroids that allow the "split-core" feature of installing it around a buss bar. They have restricted application. Some printed circuit board applications would use bobbin wound current transformers with two or more windings.

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2.2 Theoretical of Current Transformer

Current transformers consist of a magnetic circuit in toroid form. The primary is made up of n1 turns or simply a single conductor crossing the toroid ($n_1 = 1$). The secondary is wound in n_2 regular turns around this toroid. Ampere's theorem states that the sum of the ampere-turns is equal to the circulation of the magnetic field vector.

$$n_1 i_1 + n_2 i_2 = \int \vec{H}.\vec{n}.dl \tag{2.1}$$

where

$\vec{H}$ = magnetic field

$\vec{n}$ = tangent unit vector

A transformer is said to be perfect when

$$\int \vec{H}.\vec{n}.dl = 0 \tag{2.2}$$

In the real transformer, this term refers to the error introduced by the magnetic circuit and defines the exciting current i_e formed at the secondary by:

$$n_1 i_1 + n_2 i_2 = n_2 i_e \tag{2.3}$$

If $n = \frac{n_2}{n_1}$ is the winding ratio, the relationship is written as:

$$\frac{i_1}{n} + i_2 = i_e \tag{2.4}$$

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