

**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.

## 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.

## TABLE OF CONTENTS

CHAPTER	CONTENTS	PAGE
	THESIS STATUS CONFIRMATION	
	SUPERVISOR'S CONFIRMATION	
	TITLE	i
	TESTIMONY	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF FIGURES	xii
	LIST OF TABLES	xv
	LIST OF SYMBOLS / ABBREVIATIONS	xvii
<b>CHAPTER 1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Objectives	1
	1.2 Statement of problem	2
	1.3 Project scope	3
	1.4 Significance of study	4
<b>CHAPTER II</b>	<b>CURRENT TRANSFORMER</b>	<b>5</b>
	2.1 Introduction to Current Transformer	5
	2.2 Theoretical of Current Transformer	7

2.2.1	Hysteresis – Saturation	10
2.2.2	Perfect transformer	12
2.2.3	Linear transformer	12
2.2.4	Saturable transformer without hysteresis	12
2.2.5	Saturable transformer with hysteresis	12
2.3	Type of current transformer testing	13
2.3.1	Insulation Test	13
2.3.2	Magnetization Test of CT Cores	13
2.3.3	Polarity Tests	13
2.3.4	DC Resistance of CT Cores and Loop Resistance	13
2.3.5	Ratio Tests	13

**CHAPTER III      HIGH VOLTAGE AND LOW VOLTAGE  
PROTECTION SYSTEM      14**

3.1	Substation protection	14
3.2	Factors Influencing Location	15
3.3	Typical Features of a Substation	15
3.4	Substation Equipment	16
3.4.1	The Power Transformer	16
3.4.2	Bus Bars	17
3.4.3	Circuit Breakers	18
3.4.4	A protective Relays	19
3.4.5	High Voltage Disconnect Switches (Isolator)	20
3.4.6	Voltage and Current Transformers	21
3.4.7	Circuit Switchers	21

3.5	Low Voltage Switch Board Protection	23
3.5.1	Introduction	23
3.5.2	Flow chart of Low Voltage Main Switch Board	24
3.5.3	Protective devices in Low Voltage Switch Board	25
3.5.3.1	Current transformer	25
3.5.3.2	Protective relay	25
3.5.3.3	Circuit Breaker	26

## CHAPTER IV

### CURRENT TRANSFORMER

	MAGNETISATION CURVE	27
--	---------------------	----

4.1	Introduction	27
4.2	The purpose of a magnetisation curve.	28
4.3	3 zone in magnetisation curve	28
4.4	Knee Point Voltage from the magnetisation curve	30
4.5	Method in finding the knee Point or Effective Point of Saturation	31
4.5.1	Method 1: ANSI/IEEE 30 <sup>0</sup>	31
4.5.2	Method 2: ANSI/IEEE 45 <sup>0</sup>	32
4.5.3	Method 3: IEC/BS 10%-50%	33
4.6	Excitation Curve from Core Material Characteristic	35
4.7	Calculating current transformer secondary voltage Vs based on current Characteristics	39

<b>CHAPTER V</b>	<b>METHODOLOGY</b>	<b>40</b>
5.1	Introduction	40
5.2	Flow Chart	41
5.2.1	Project Flow Chart	41
5.2.2	Flow chart of current transformer in High Voltage Substation	42
5.2.3	Flow chart of current transformer in Low Voltage Switch Board	43
5.3	Experiment Instrument and Equipment	44
5.4	Preparation Prior to Perform the Testing	45
5.5	Testing Procedure in High Voltage Substation	46
5.5.1	Experiment 1: DC Resistance of CT and Loop Resistance of Secondary Windings	46
5.5.2	Experiment 2 : Magnetization Test of CT Cores	49
5.5.3	Experiment 3 : Polarity Tests	51
5.5.4	Experiment 4 : Ratio Check (Primary Injection)	52
5.5.5	Experiment 5 : Insulation Test	54
5.5.6	Experiment 6 : Magnetising curve testing	57
<b>CHAPTER VI</b>	<b>RESULT AND DISCUSSION</b>	<b>58</b>
6.1	Introduction	58
6.2	General Data	59
6.2.1	Serial reference number	59

6.2.2	Current transformer rating	60
6.2.3	Visual Check	61
6.3	Experiment Result	62
6.3.1	Experiment 1: DC Resistance of CT and Loop Resistance of Secondary Windings	62
6.3.2	Experiment 2: Magnetization Test of CT Cores	65
6.3.3	Experiment 3: Polarity Tests	70
6.3.4	Experiment 4: Ratio Check (Primary Injection)	71
6.3.5	Experiment 5 : Insulation Test	73
6.3.6	Experiment 6: Current Transformer Excitation Characteristics Test	75
6.3.7	Experiment 7: Polarity Check	78
6.3.8	Experiment 8: Ratio check	80

<b>CHAPTER VII</b>	<b>CONCLUSION</b>	82
--------------------	-------------------	----

<b>REFERENCES</b>		84
-------------------	--	----

## LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	Current Transformer equivalent circuit	8
2.2	Current transformer phasor diagram	9
2.3	Magnetising curve and their incidence on $i_c$	11
3.1	Function of substation	15
3.2	500/275/132 KV substation	16
3.3	Power Transformer	17
3.4	Busbar	18
3.5	Circuit Breaker	19
3.6	Over current Relay	20
3.7	Isolator	20
3.8 (a)	Current Transformer	21
3.8 (b)	Voltage Transformer	21
3.9	Single line diagram for 132KV system substation	22
3.10	Flow chart of Low Voltage Main Switch Board	24
4.1	Figure of Equivalent circuit	28
4.2	Current transformer magnetisation curve	29
4.3	Knee Point ANSI/IEEE 30° Tangent to the curve	31
4.4	Knee point ANSI/IEEE 45° tangent to the curve	32
4.5	Knee point ANSI/IEEE 45° from two linear sections of the current transformer curve	33
4.6	IEC/BS Knee Point as the intersection of straight lines extended from non saturated and saturated parts of the excitation curve.	34
4.7	IEC/BS 10%-50% as the secondary voltage at which an increase of 10 % produces an increase	

	in magnetizing current Of 50 %	34
4.8	Figure of core material in current transformer	35
4.9	Equivalent circuit of current transformer	37
4.10	Figure of equivalent circuit of current transformer	39
5.1	Project flow chart	41
5.2	Flow chart of current transformer in High Voltage Substation	42
5.3	Flow chart of current transformer in Low Voltage Switch Board	43
5.4	Voltage regulator.	44
5.5	The set up current transformer equipment	44
5.6	The polarity test set	45
5.7	Circuit Connection for DC Resistance of current transformer core test.	47
5.8	Circuit Connection for Loop resistance of current transformer test.	48
5.9	Circuit Connection for Magnetization test of current transformer core	50
5.10	Circuit Connection for polarity test	52
5.11	Circuit Connection for ratio check	53
5.12	Circuit Connection for Secondary to earth insulation resistance test	55
5.13	Circuit Connection for Primary to earth insulation resistance test	55
5.14	Circuit Connection for Primary to secondary insulation resistance test	56
6.1	The knee point of current transformer core class 2P20	68
6.2	The knee point of current transformer core class 05	69
6.3	Current Excitation Curve at 150/5 A CL 1 15VA	75
6.4	Current Excitation Curve at 150/5 A CL 10P10	

	15VA	77
6.5	Diagram of current transformer excitation characteristics test	77
6.6	Diagram of a polarity check	78
6.7	Diagram of a ratio check	81



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## LIST OF TABLES

TABLE	TITLE	PAGE
4.1	Table of unit and constant	36
4.2	Table of current transformer connection	40
6.1	Data of the serial reference number	59
6.2	Data of the current transformer rating	60
6.3	Result of the Visual Checking	61
6.4	Result of the Current Transformer Resistance	63
6.5	Result of the Loop Resistance of Current Circuits	63
6.6	Result of the Load/Burden Resistance of Current Circuits	64
6.7	Result of the Magnetisation Curve for current transformer	65
6.8	Result of the difference between IEEE-45 knee point and IEC/BS 10/50	67
6.9	Result of the Polarity Check	70
6.10	Result of the Primary Injection Test	72
6.11	Result of the Insulation Resistance Test	73
6.12	Result of the Magnetisation Curve for current transformer (150/5 A CL 1 15VA ) in low voltage switch board	75
6.13	Result of the Magnetisation Curve for current	

	transformer (150/5 A CL 10P10 15VA ) in low voltage switch board	76
6.14	Result before changing the polarity in secondary part	79
6.15	Result after changing the polarity in secondary part	79
6.16	Result of ratio test	80



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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
$\phi$	-	Flux
$e_1$	-	Primary emf
$e_2$	-	Secondary emf,
$v_1$	-	Primary potential
$v_2$	-	Secondary potential
$\mu_r$	-	Relative permeability
$L$	-	Inductor
$V_s$	-	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

- $k_2$  - A constant depending on unit H and /
- $W_w$  - 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 Commission
IEEE	-	Electrical and Electronic Engineer
ANSI	-	American National Standards Institute
TC	-	Test Certificate
MK	-	Marshalling Kiosk
BBP	-	Bus Bar Protection

## 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.

## 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

### 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

#### 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

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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