"I hereby declare that I have read through this report entitle *"Transformer Faults Classification From Polarization Current Measurement Results by Using Statistical Technique"* and in my opinion this thesis is sufficient in terms of scope and quality for awarding the degree of *Bachelor of Electrical Engineering (Industrial Power)*"

Signature	:	…….....
Supervisor's Name	:	MOHD SHAHRIL B AHMAD KHIAR
Date	:	16 JUNE 2014

TRANSFORMERS FAULTS CLASSIFICATION FROM POLARIZATION CURRENTS MEASUREMENT RESULTS BY USING STATISTICAL TECHNIQUE

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

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June 2014

I declare that this report entitle "*Transformer Faults Classification From Polarization Current Measurement Results by Using Statistical Technique*" is the result of my own research and work, 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 : MOHAMMAD SYAHIR BIN MANSOR

Date : 16 JUNE 2014

Specially dedicated, in thankful appreciation for the support, encouragement and understandings for my beloved mother, father, brother and my supervisor.

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ABSTRACT

In general, the presence of moisture and others impurities inside the insulator or oil can cause the breakdown of the power transformer. Polarization and Depolarization Current (PDC) is one of the technique to assess the condition of insulation oil in power transformer and can be applied in many electrical apparatus such as power cables and on load tap changer as well as to estimate conductive and moisture contents of the insulations. Basically, it is a technique that is based on time domain measurement and has been use since 1990's. This analysis work seeks to classify the pattern of faults by find the ranges in PDC data obtain from Tenaga Nasional Berhad Research (TNBR) by using Statistical Technique and Graphical Method. Actually, there will be some challenge to classify the faults into a proper range. These faults consists of partial discharge, arcing and overheating that will be focus on this analysis work. In analysis work result obtained, the range of partial discharge fault is $(5.0 - 8.0) \times 10^{-8}$ Ampere. Whereas, the range of arcing fault is $(8.0 - 11.0) \times 10^{-8}$ Ampere. Lastly, the overheating fault range is greater than 11.0×10^{-8} Ampere. At the end of the analysis work, the results obtained in analysis work will verify from the previous research by referring the ranking of the transformer faults. Furthermore, the results obtained in analysis work can be apply as a references to Tenaga Nasional Berhad Distribution (TNBD) when doing a maintenance process at the real power transformer using PDC measurement to find the transformer faults.

ABSTRAK

Secara umum, kehadiran kelembapan dan lain-lain kekotoran di dalam penebat atau minyak boleh menyebabkan kerosakan pada pengubah kuasa. *Polarization and Depolarization Current (PDC)* adalah salah satu teknik untuk menilai keadaan minyak penebat dalam kuasa pengubah dan boleh digunakan dalam pelbagai peralatan elektrik seperti kabel kuasa dan *on-load tap changer (OLTC)* untuk mengenalpasti konduktif dan kelembapan kandungan penebatan . Pada asasnya, ia adalah satu teknik yang berasaskan ukuran masa domain dan telah digunakan sejak tahun 1990-an. Analisis ini bertujuan untuk menentukan jenis kerosakan corak dengan mencari julat data PDC yang diperolehi daripada Tenaga Nasional Berhad Penyelidikan(TNBR) dengan menggunakan kaedah grafik dan teknik statistik. Sebenarnya, akan ada beberapa cabaran untuk mengklasifikasikan kerosakan semasa menentukan keputusan. Kerosakan ini terdiri daripada *partial discharge, arcing and overheating* yang akan memberi tumpuan dalam kerja-kerja penyelidikan ini. Dalam analisis hasil kerja yang diperolehi, julat *partial discharge fault* adalah $5.0 - 8.0) \times 10^{-8}$ Arus. Manakala, julat *arcing fault* ialah $(8.0 - 11.0) \times 10^{-8}$ Arus. Akhir sekli, *overheating fault* ialah lebih besar 11.0×10^{-8} Arus. Pada akhir kerja analisis, keputusan yang diperolehi dalam kerja-kerja analis akan disahkn melalui kajian sebelumnya dengan merujuk susunan pengubah rosak. Tambahan pula, keputusan dalam kerja analisis ini boleh digunakan sebagai rujukam kepada Tenaga Nasional Berhad Pengagihan (TNBD) apabila melakukan proses penyelenggaraan di pengubah kuasa sebenar menggunakan pengukuran PDC untuk mendapatkan pengubah yang rosak.

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LIST OF ABBREVIATION

RVM	-	Return Voltage Method (RVM)
FDS	-	Frequency Domain Spectroscopy
PDC	-	Polarization and Depolarisation Current
DC	-	Direct Current
TNB	-	Tenaga Nasional Berhad
TNBR	-	Tenaga Nasional Berhad Research
TNBD	-	Tenaga Nasional Berhad Distribution
OLTC	-	On-load tap changer
SOM	-	Self-Organizing Map

LIST OF SYMBOL

Co	-	The geometrical capacitance of the test object
σ_o	-	DC conductivity of the dielectric material
ε_o	-	The vacuum permittivity
δ(t)	-	The delta function
f (t)	-	Fundamental memory property of the dielectric system
I_{pol}	-	Polarization current
I_{dpol}	-	Depolarization current
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
μ	-	Mean of a sample
X_n	-	Sample values
n	-	The total number of samples
σ^2	-	Variance
σ	-	Standard Deviation
r_{xy}	-	Sample correlation
s_{xy}	-	Sample covariance.
$s_x\ s_y$	-	Sample standard deviations
p_{xy}	-	Population correlation coefficient
σ_{xy}	-	Population covariance
$\sigma_x\ \sigma_y$	-	Population standard deviations
A	-	Current

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 General Background

Power transformers play a vital role in the whole electrical power system. The main insulation system or power transformer consists of insulation oil which degrades under a combined a action of thermal, electrical, mechanical and other impurities during transformer routine operation [1,2]. The degradation of the main insulation system in transformer is recognized to be one of the major causes of transformer breakdown [3,4]. Therefore, accurately assessing the status of the transformer insulation is important. In recent years, exploring the new characteristic quantities and new technologies those reflected the state of transformer insulation has been taken seriously.

Return Voltage Method (RVM), Frequency Domain Spectroscopy (FDS) and Polarization and Depolarisation Current (PDC) are new non-destructive diagnostic techniques for determining the moisture content and faults of a power transformer [5]. However, this research work will be focused on PDC as one of the non-destructive method for determining the faults of a power transformer. The advantages of PDC is they are easy to handle due to its ability to assess the condition of oil and paper separately without opening the transformer tank [6]. There are many research about the influence of moisture, ageing and temperature on the PDC characteristics of mineral oil paper insulation [7,8]. Basically, PDC gives information about about the oil conductivity within seconds after a DC voltage step application and about the barrier conductivity over a long period of time. PDC measurement is done by application of a direct current (DC) voltage across the test object for a long duration (up to 10,000 seconds) [9].

In general, this analysis work will be focussed on PDC data collected from TNBR. Basically, PDC data consists of normal condition samples and faults condition samples of transformer. For the transformer faults condition, it can be divided by three faults which is partial discharge fault, arcing fault and overheating fault. In addition, PDC data collected from different sites location of transformer at Pencawang Pembahagian Utama (PPU). Each PDC data consists of three samples. From each samples PDC data, consists of five repetitions of polarization and depolarization current data. All the samples consists of thousonds PDC data in ampere. Therefore, PDC data will be analyse using graphical method and statistical technique to classify the transformer faults into a proper range.

1.2 Motivation

Previously, this analysis work is linked from TNBR where the real PDC data collected from the real transformers due to a transformer faults problem. Basically, there is no reference about the PDC analysis ranges due to faults transformer problem. Therefore, the project gives motivation to produce a new method to analyse PDC data by using statistical technique and graphical method to pattern classification transformer fault. Futhermore, the results obtain in analysis work will be validate with the previous research that will be explain in Chapter 2. At the end of analysis work, new reference will be coming out which can assist Tenaga Nasional Berhad Distribution (TNBD) and TNBR to determine the transformer faults based on the proper range results.

1.2 Problem Statement

PDC is one of the non-destructive method that being widely used to assess the moisture contents, ageing condition and faults of electrical equipments. In this analysis work, the PDC data collect from TNBR. Previously, PDC measurement was used to access the condition of oil transformer, whether in normal condition or faults condition. These faults consist of arcing, overheating and partial discharge. The problem with this research is to analyse the PDC data collected from TNBR and classify the faults into a proper range. Basically, there is no reference about the PDC analysis range due to transformer faults problem. Therefore, the statistical technique and graphical method will introduce in analysis work to analyse PDC data to produce a proper range results. At the end of the analysis work,

the results obtains in statistical technique and graphical technique will be validate with the previous research.

1.3 Objective of Study

In order to achieve this study, the following points are highlighted:

(i) To collect the PDC data from different conditions of transformer which consists of normal, arcing, overheating and partial discharge from TNBR.

(ii) To analyse and classify the transformer faults into a proper range by using graphical method and statistical technique.

(iii) To verify the result obtain by referring the previous research.

1.3 Scope of Study

(i) From PDC data collected from TNBR, only polarization current data will be used to analyse the transformer faults.

(ii) Transformer faults consists of overheating, arcing and partial discharge as a data set.

(iii) Using standard deviation method to obtain the transformer faults result into a proper range.

(iv) Verify the results with previous research which is related faults in mineral transformer oil.

1.5 Report Outline

This report basically is divided into five chapters. In Chapter 1, provides readers a first glimpse at the basic aspects of the research undertaken, such as general background, motivation, problem statement, objectives of study and scopes.

In Chapter 2, discuss about the reviews of past studies which is related in analysis work. The literature review is conducted to understand the concept and also to get some ideas about the PDC and types of Statistical Technique that had been trying to give some explanation.

In Chapter 3, presents the flow of the study and methodology being used in this study. This is shown the steps that to clear a view of the flow of this project and try to manage the project according time given. The flow is to analysed the PDC data and apply the standard deviation method in statistical technique to produce the results.

In Chapter 4, shows project achievement by highlighting the results achieved by using standard deviation method. In this analysis work, power transformers at different places consists of three sample data collected during testing will be analysed. The results then will be compared from the previous research which is related in this analysis.

In Chapter 5, consists of conclusions based on the overall works and results. This is followed by project contribution and recommendations for future study work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Literature Review

In this chapter, a review of past studies that is related to this research work will be discussed. The literature review is conducted to understand the concept and also to get some ideas about the Polarization and Depolarization Current (PDC) and types of statistical technique. For previous years, many of the studies that have been done to diagnose of the power transformer by different methods in order to find defects of the transformer. In recent years, exploring the new characteristic quantities and new technologies those reflected the state of transformer insulation has been taken seriously. In [5], Return Voltage Method (RVM), Frequency Domain Spectroscopy (FDS) and PDC are new non-destructive diagnostic techniques for determining the moisture content and faults of a power transformer. The reason is, they are easy to handle and portable information which have been widely studied. However, in this research only PDC techniques will be discussed in this chapter.

This chapter, will review previous research related in PDC technique and statistical techniques to get some ideas to analyse PDC data collected from TNBR and classify the transformer faults into a proper range. Section 2.2, will be discussed about the theoretical of PDC. This section is important because it will be explained clearly the basic concept about PDC principle and theory. In Section 2.3, will be discussed the details about the application of PDC for electrical equipments. These electrical equipments applied in PDC consist of solid insulation, cable insulation and oil insulation will be explained in Section 2.3.1 to Section 2.3.3. Furthermore, Section 2.4 will be discussed the application PDC analysis on Power Transformer. In Section 2.4.1, discuss about the moisture and surface humidity in two identical transformers. While, Section 2.4.2 will be discussed about PDC analysis applied in free water in a refurbished transformer. For the Section 2.4.3, will be discussed PDC analysis applied in water and contaminants in a new On-Load Tap Changer (OLTC). In addition,

Section 2.5 will be discussed in details about PDC applied in mineral transformer oil. Basically, this research results will be used as a reference in this analysis work. Whereas, in Section 2.6 will review about the types of the statistical techniques. Mean, variance, standard deviation, and correlation coefficients function (CCF) will be explained in Section 2.6.1 to Section 2.6.4.

2.2 Theoretical of Polarization and Depolarization Current

According to [10-15], researcher had been investigate the principles of PDC measurement technique. PDC measurement is a useful technique for assessing the condition of the insulation materials in power transformers. The PDC measurement procedure consists in applying a DC high voltage across a test sample for a long time (up to 10,000 seconds). Figure 2.1 shows the schematic diagram of the PDC measuring technique.

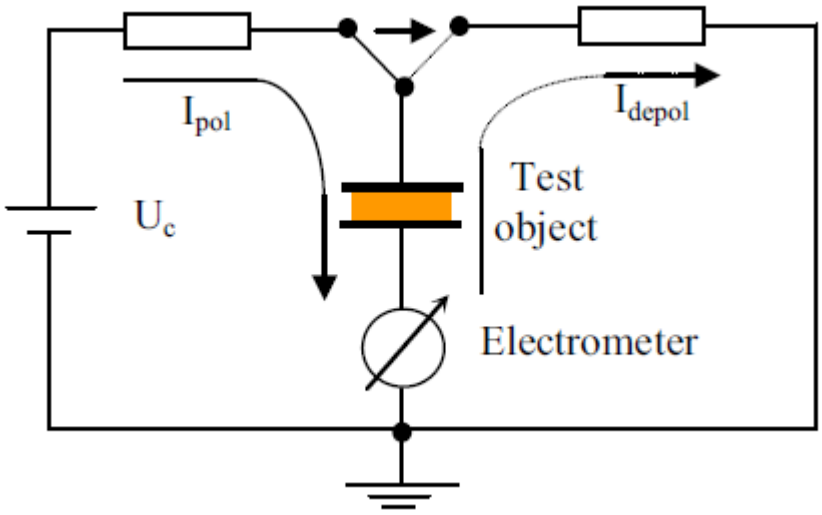

Figure 2.1: Principle of test arrangement for the PDC measuring technique [15]