PARAMETER IDENTIFICATION FOR FAULT DETECTION OF POWER TRANSFORMER USING ARTIFICIAL NEURAL NETWORK

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Dedicated to my beloved parents

Rosli bin Abdul Hamid & Wan Mazlina binti Wan Mahmood

Siblings

Rashidah binti Rosli

Muhammad Afiq bin Rosli

and

All my friends in MEP programme

for their support and encouragement

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Thank You.
Wassalam

ABSTRACT

Fault diagnosis is a challenging problem because there are numerous fault situations that can possibly occur to an electrical transformer. There are a lot of previous works done by researchers on fault diagnosis in power transformer but all of them used data from Dissolved Gas Analysis (DGA) as input for detection. This study will focus on parameter identification that is electrical measurement, which is voltage and current for fault detection due to several limitations of data from DGA that can lead to wrong diagnosis of fault in power transformer. The transformer that been used in this power system model is 132/20 kV with 250 MVA rating. The simulation of nine types of possible fault has been done by MATLAB R2013a Simulink software. To recognize the pattern of fault data, ANN was chosen because of it was easy to apply in power system network and it will work as pattern classifier with the ability to identify fault types accurately. The ANN programming has been done by ANN Pattern Recognition Tool that also in MATLAB R2013a software. It is found that the fault of power transformer can be detected by measuring electrical parameter such as voltage and current and with ANN, detection and classification of fault can be done to diagnose fault in power transformer. After the fault data had been trained for a few times, ANN will learn how to classify it accurately and then it is able to properly resolve new situations which are different from those fault data presented in the learning process.

ABSTRAK

Diagnosis kerosakan adalah masalah yang mencabar kerana terdapat banyak situasi kesalahan yang mungkin boleh berlaku kepada pengubah kuasa elektrik. Terdapat banyak kerja-kerja sebelum ini dilakukan oleh penyelidik di diagnosis kerosakan dalam pengubah kuasa tetapi semua daripada mereka menggunakan data daripada Analisis Gas terlarut (DGA) sebagai input untuk pengesanan. Kajian ini akan memberi tumpuan kepada mengenal pasti parameter pengukuran elektrik, iaitu voltan dan arus untuk mengesan kerosakan kerana beberapa batasan data dari DGA yang boleh membawa kepada kesilapan dalam diagnosis kerosakan pengubah kuasa. Pengubah kuasa yang digunakan dalam sistem model ini ialah pengubah kuasa 132/20 kV dengan 250 MVA. Simulasi sembilan jenis kerosakan yang mungkin berlaku telah dibuat dengan menggunakan perisian MATLAB Simulink R2013a. Untuk mengenali corak data kerosakan, ANN telah dipilih kerana ia adalah mudah untuk memohon dalam rangkaian sistem kuasa dan ia akan bekerja sebagai corak pengelas dengan keupayaan untuk mengenal pasti jenis kerosakan dengan tepat. Pengaturcaraan ANN telah dilakukan oleh Alat Pengiktirafan Corak yang juga dalam MATLAB perisian R2013a. Didapati bahawa kerosakan pada pengubah kuasa boleh dikesan dengan mengukur parameter elektrik seperti voltan dan arus dan dengan ANN, pengesanan dan pengkelasan kerosakan boleh dilakukan untuk diagnosis kerosakan dalam pengubah kuasa. Selepas data kerosakan telah dilatih untuk beberapa kali, ANN akan belajar untuk mengelaskannya dengan tepat dan kemudian ia mampu untuk menyelesaikan situasi baru yang berbeza daripada data kerosakan dalam proses pembelajaran.

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LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
SVM	-	Support Machine Vector
IEC	-	International Electrotechnical Commision
GA	-	Genetic Algorithm
FTA	-	Fault Tree Analysis
HMM	-	Hidden Markov Model
DGA	-	Dissolved Gas Analysis
OLTC	-	On Load Tap Changing
ELM	-	Extreme Learning Machine
DFTA	-	Dynamic Fault Tree Analysis
CHMM	-	Coupled Hidden Markov Model
DHMM	-	Discrete Hidden Markov Model
LMS	-	Least Mean Square
MSE	-	Mean Square Error
ROC	-	Receiver Operating Characteristic
V	-	Voltage
I	-	Current

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CHAPTER 1

INTRODUCTION

1.1 Background

Power transformer is one of the most important equipment in electrical power system and it has a great effect on electrical equipment's security, operating cost and national economic advance. Once failures for the large-scale power transformer occur, it can result in tremendous economic losses and serious society impact [1]. Therefore, it is very important to detect the fault in power transformer as early as possible so that the reliability of power system will be improved.

Power system stability depends on the reliable operation of various individual components within the network. Power transformer is one of the necessary and significant units in the transmission and distribution levels of a power system. However, it is subjected to many different types of faults which may cause interruptions in power supply; consequently result in serious economic losses as well as social impacts. Several fault diagnosis methods only could able to detect all the faults. Figure 1.1 shows type of fault in power transformer. As a result, effective fault diagnosis approaches are warrant to detect and analyze the power transformer internal faults, and eliminate the associated impacts to the lowest possible level.

Faults in a transformer can be categorized as internal and external faults. External faults include asymmetric fault, line-to-ground fault, line-to-line fault, and so on while the internal faults include winding defects and winding insulation failures resulting in turn-to- turn fault or ground fault. The insulation degradation may happen because of several reasons including magnetizing inrush current, lightning strikes, prolonged overload, and failure of cooling mechanism [2].

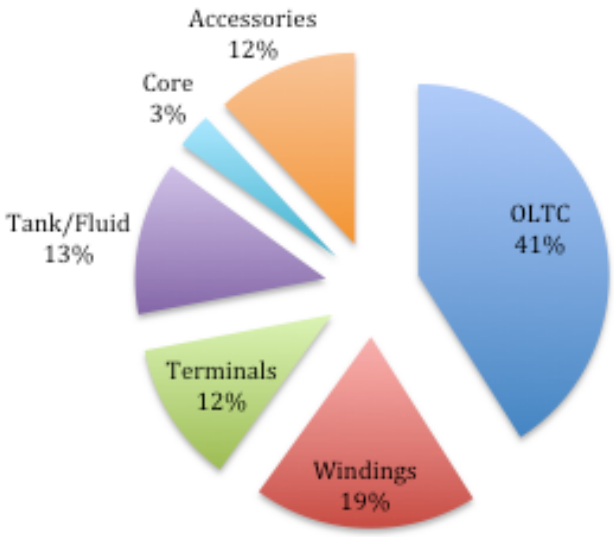

Figure 1.1 Types of fault in power transformer [2]

There are two main parts to address the problem when fault occur in power transformer happen. First is detection of the fault along with its classification and second is detecting the location of the fault. For detecting and classifying faults, different faults patterns are required.

Nowadays, there are many expert systems for power transformer fault diagnosis such as Artificial Neural Network (ANN), Support Vector Machine (SVM), Genetic Algorithm (GA), Fault Tree Analysis (FTA), Hidden Markov Model (HMM), Fuzzy and so on. Among of all expert study ANN is highly potential due to it learns from examples presented during the training process and also the neural

network operates as a pattern classifier and its ability to identify fault types and fault location accurately.

1.2 Problem Statements

Power transformers require a proper maintenance with an approach of efficient condition monitoring techniques and diagnostic tools. Fault diagnosis is a challenging problem because there are numerous fault situations that can possibly happen to an electrical transformer.

Nowadays there are so many methods that can be used for power transformer fault diagnosis, but many researchers used data from Dissolved Gas Analysis (DGA) as input for detection. DGA is a common practice in the incipient fault diagnosis of power transformers but it has several limitations which is it cannot precisely localize a fault and if the transformer has been refilled with fresh oil, results are not indicative of faults. Sometimes, in DGA due to lack attention during management of oil sampling and storage, gas-in-oil concentrations can present significant deviations that may lead to misinterpretation of DGA and next, wrong diagnosis of fault in power transformer.

Therefore, this project will focus on electrical measurement such as voltage (V) and current (I). The research for this project will be done and simulations will be carried out in order to do the fault diagnosis for the power transformer.

The method for power transformer fault diagnosis that will be used in this study is Artificial Neural Network (ANN). The Neural Network is suitable for use because of it significant advantages in important factors such as cost, speed of

operation, reliability, ease of maintenance and ease of initial development. By using ANN, the decision-making criteria are done by learning it from examples presented during the training process and it can operate as a pattern classifier with ability to identify fault location accurately.

1.3 Objectives

The objectives of this project are:

i. To model and simulate the power system network by using MATLAB R2013a Simulink.

ii. To identify the fault in power transformer by using electrical parameter such as voltage (V) and current (I).

iii. To diagnose the fault in power transformer by using Artificial Neural Network (ANN).

1.4 Scope of Study

In this project, limitation works are based on power transformer external fault, which are line-to-line, line-to-ground, and line-to-line-to-ground faults. The first part is to study and simulate the fault in power transformer by using computer software that is MATLAB R2013a Simulink. Star-star 132/20 kV transformer is used for this simulation.

The second part is to develop a system that can locate the fault in power transformer by using ANN method. Simulation of ANN is done by using MATLAB R2013a software. Parameters to be considered are the simulation input of the network, which are the voltage and current values at primary and secondary of the transformer, and also its output of fault location. The efficiency of the neural network is to be tested and verified.

1.5 Methodology

For the methodology process, firstly need to do literature review to find a suitable method to do fault diagnosis in power transformer. ANN was chosen because of it was easy to apply for power system operators and also ANN learns by examples, which is it can be trained with known example of a problem to acquire knowledge and experiences.

The first stage is modeling a power system model with 132/20 kV transformer by using MATLAB R2013a Simulink. Second stage is simulating and analyzing the fault in the power transformer by electrical parameters that are voltage and current at both side of transformer. The third stage is training an ANN using the simulation data in MATLAB R2013a, and the last stage is evaluating the trained ANN.

Next, proceed with the thesis writing or prepare the report. The report should be complete with the elements starting from introduction until conclusion, and then submit the report at the end.

1.6 Structure of Thesis

This report consists of six chapters, which are from this chapter until appendices. There are summary of each chapter of this report.

Chapter 1 described about an introduction. In this chapter, an overview of this project had been discussed which includes background, problem statements, objectives, scopes of work and methodology.

Chapter 2 explained about the literature review. It presented an overview of power transformer fault diagnosis methods.

Chapter 3 discussed on literature review on Artificial Neural Network method that had been used to perform this project.

Chapter 4 explained about the methodology in this project. In this chapter the possible faults had been simulated, and then the inputs and targets data arrangement for ANN programming had been shown.

Chapter 5 explained about results and discussion. In this chapter, the result of ANN Programming had been analyzed and discussed.

Chapter 6 described the conclusion of the project. The recommendation for future works also suggested in this chapter.

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