



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOP FUZZY LOGIC TO MONITOR THE HEALTH OF
TRANSFORMER BY USING DGA**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electrical Engineering Technology ((Power Industry) with Honours

By

**MUHAMMAD ZULHILMI BIN MOHD HANAFI
B071110185
900129035153**

FACULTY OF ENGINEERING TECHNOLOGY

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory committee is as follow:

:

.....
(Project Supervisor)

ABSTRAK

Gas yang dihasilkan dalam minyak yang penuh penebat pengubah boleh digunakan untuk mengesan keadaan bersalah yang baru terhasil. Analisis gas terlarut(DGA) adalah satu kaedah pendekatan yang terkenal untuk mengesan keadaan bersalah yang baru terhasil dalam transformer larut di dalam minyak. Kehadiran gas utama diawasi dan diperiksa secara berkala. DGA adalah teknik yang paling dipercayai dan berkesan untuk memantau keadaan tersebut. Tujuan projek ini adalah untuk mendapatkan kaedah terbaik untuk mengesan kesalahan yang baru jadi di dalam pengubah sebenar. Terdapat beberapa kaedah untuk mengesan kesalahan yang baru jadi seperti: Gas Utama, Nisbah Roger, Doernenburg , Nisbah IEC dan Duval Triangle. Hasilnya pelbagai teknik kaedah tidak memberikan hasil yang sama bagi sample minyak yang sama. Kaedah ini lebih berdasarkan pengalaman peribadi daripada formulasi matematik. Untuk keadaan bersalah berganda disebabkan oleh kombinasi yang berbeza daripada gas yang dihasilkan, kaedah DGA tidak dapat menyesuaikan diri untuk memeriksa masalah. Untuk mengatasi masalah ini, pendekatan logic kabur diperkenalkan untuk mendapatkan anggaran untuk menganggarkan kekaburan yang terlibat dalam masalah. Pendekatan logic kabur membantu mengatasi had DGA dalam keadaan bersalah berganda disebabkan pencampuran gas yang terhasil. Program MATLAB dibangunkan untuk mensimulasikan automatic penggunaan kaedah, dengan itu dengan membandingkan kedua-dua bersalah simulasi dan kesalahan sebenar pengubah ini kaedah terbaik DGA dapat dipilih.

ABSTRACT

The gases produced in oil filled insulation transformer can be used for detecting incipient faults. Dissolve gas analysis (DGA) is a famous approach method for the detection of incipient fault condition within the oil immersed transformers. The presence of key gasses is supervised and checked regularly. DGA is the most reliable and effective technique for condition monitoring. The aim of this project is to get the best method for detecting incipient fault of the actual transformer. There are number of method to detect the incipient fault such as: Key Gas, Roger Ratio, Doernenburg, IEC Ratio and Duval Triangle. As a result, various method techniques do not give the same result for the same oil sample. The method based more on personnel experience than mathematical formulation. For multiple fault condition due to different combination of produced gas, DGA method could not adapt to diagnose the problem. To overcome this problem, fuzzy logic approach is introduced to get an approximate to estimate ambiguity involved in a problem. Fuzzy logic approach help overcome the DGA limitation of multiple fault condition due to the mixing up of the produce gases. MATLAB program is developed to automatic simulate the method use, thus by comparing both the simulation fault and actual fault of the present transformer the best method of DGA is selected.

DEDICATION

To my beloved parents and to my family

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

H_2	-	Hydrogen
CH_4	-	Methane
C_2H_6	-	Ethane
C_2H_4	-	Ethylene
C_2H_2	-	Acetylene
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
>	-	More than
<	-	Less than
\geq	-	More than and equal to
\leq	-	Less than and equal to
RDC	-	Winding Resistance
IR	-	Insulation Resistance
DIRANA	-	Dielectric Response Analysis

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will describe about the introduction of this project which includes the project background of the whole project, the problem statement that occur before this entire project will be complete. The objectives and scope that are needed to be fulfilled for this project are completely described in this chapter.

1.1 Background

Power transformer is a major component of power system which has no successor for its major role [1]. The transformer, being key element in the transmission and distribution of electrical energy need early attention for its importance. To improve the reliability of the equipment and to avoid any breakdown failure and damage, effective testing and diagnostic techniques must be used [2]. Early detection can reduce damage to the equipment and consequently prevent premature breakdown or failure subsequently lead to huge savings in the operation and maintenance costs and improve the overall system reliability [3]. On the transformers, consequence of electrical and thermal stresses that is detected on the oil

insulator of the transformer will lead to fault [2-3]. The type of faults that often occur in power transformers are arcing, partial discharge, overheating, sparking, corona and thermal fault at low temperature [1-5].

Transformer oils are combination of many different hydrocarbon molecules. They are composed essentially of saturated hydrocarbon called alkane which general molecular formula is C_nH_{2n+2} [4, 6]. The key fault gases produce from electrical and thermal stresses are hydrogen (H_2), methane (CH_4), ethane (C_2H_6), ethylene (C_2H_4), acetylene (C_2H_2), carbon monoxide (CO) and carbon dioxide (CO_2) [1-12]. To detect the type of fault inside the transformer it is by measuring the amount of gases inside the transformer and the gases are produced in transformer oil. Fault is determined by the presence of the gases and severity of the fault indicates on the amount of the gases produced.

There is several type method of test to use to determine the fault gases for transformer oil such as Winding Resistance (Rdc) Test, Insulation Resistance (IR) Test, Tan Delta Test, Transformer Turn Ratio Test, Dissolved Gas Analysis (DGA) test and Dielectric Response Analysis (Dirana) Test [10]. DGA has been known as one of effective and reliable test for the detection of incipient fault condition inside the oil immersed transformer [4]. DGA consist of five techniques which is Key Gas, Rogers Ratio, Doernenburg, IEC Ratio and Duval Triangle [1-12]. Although DGA has been become increasingly effective and reliable, at some point DGA fail to diagnose in some cases because of multiple type fault occurs inside a transformer [3]. This problem happen due to complication of different gases collected and may cause hard to be diagnosed base on the fault type. Fuzzy logic can be introduced to diagnose the problem [3].

Fuzzy logic give alternative way an approximate but effective means of solving the diagnose problem that are too complex or too hard to solved. Fuzzy logic is different from mathematic that can only be chosen 0 or 1, fuzzy logic can calculated on any range value between 0 and 1 and can be set on the range of any value between the number of 0 to 1 [3]. Fuzzy logic an approximate effective way of handling a ambiguity problem. Fuzzy logic can give a final result of diagnosis

problem and membership function can be adjusted to make a conclusion. In this paper, DGA method is investigate to monitor the health of transformer and fuzzy logic controller was developed to simulate the data obtained.

1.2 Problem Statement

Now, a lot of simulation software for monitor and design especially for power transformer is active at market like SCICOSLAB, PSPICE, Power World, Maxwell and ANSYS. However, this software is not suitable for monitor the health of transformer and develop fuzzy logic program. MATLAB software can be used to determine the incipient fault and at the same time develop fuzzy logic program. Power transformer are the most valuable and important equipment in the operation of modern power system. In this report, by developing fuzzy logic program to compare simulation fault and actual fault present in the transformer it can detect the incipient fault in transformer. Detection of incipient faults can be done using DGA techniques by selecting one of the method that Key gases, Roger Ratio, IEC Ratio, Duval Triangle, and Doernenburg, To get the best method, comparison between the method is taken for the accurate fault condition between simulation fault and the actual fault of the present transformer. Finally, from the simulation fault of the transformer using suggestion method for maintenance and protection the transformer can be proposed in the future.

1.3 Project Objective

The objective of this project is:

1. To compare the result of simulation fault and actual fault present in the transformer.
2. Choose the best method for determining incipient fault of transformer based on DGA.

3. Creates some basic construction fuzzy controller block diagrams using Simulink.

1.4 Scope Of Research

In order to achieve the objectives mentioned above, scope of the project should be highlighted. This project will follow the scope of study as below:

1. Select the best method for determining incipient fault of the transformer based on DGA analysis test. They are: Key Gas, Roger Ratio and IEC Ratio.
2. Develop a fuzzy logic controller using MATLAB to implement the DGA analysis test.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

DGA have become increasingly important in recent year to determine the fault of the transformer. In this section, the literatures give the general view of all of the aspect of this project based on previous method and experiment knowledge to be implemented inside the project.

2.1 Transformer testing

Dadan Nurafiat and Agus Puwardi, (2011) stated that the condition of the transformer can exceed the approximate life using several type of test to diagnose the life of the transformer [8]. Agus Puwardi, (2011) mentioned on this paper that diagnostics basically on the main power transformer and auxiliary power transformer for transformer testing [8]. Below figure 2.1 and figure 2.1, from PT.Indonesia Power Kamojang Geothermal Power Plan the main power transformer and auxiliary power transformer unit 1 [8].



Figure 2.1: Main Transformer under Test [8]



Figure 2.2: Auxiliary Transformer under Test [8]

2.2 Type Test

There is several type of test that can be conduct for power transformer such as:

2.2.1 Transformer Turn Ratio Test [8]

2.2.2 Winding Resistance (RDC) Test [8]

2.2.3 Insulation Resistance (IR) Test [8]

2.2.4 Tan Delta Test [8]

2.2.5 Dissolved Gas Analysis (DGA) Test [8]

2.2.6 Dielectric Response Analysis (Dirana) Test [8]

2.3 DGA Gas Analysis

Transformer fault is based on different type of gases produced and which lead to different type of fault in transformer, DGA analysis is used to monitor and identify the chemical analysis of these gases [1-4]. In this research project, to obtain dissolve gas in transformer oil DGA gas test is applied [9]. In 2011 Dadan Nurafiat studied due to the mixture and increase of gas concentration in oil-immersed power transformer the breakdown and failure of the transformer happen.

2.4 Mechanism Of Gas Generation

In a recent study (Er. Lee WaiMeng, 2009) stated from the hydrocarbon molecules of the mineral oil the essential of gas generation is the decomposition between the chemical bonds interaction. The transformer produced hydrogen (H_2), methane (CH_4), ethane (C_2H_6), ethylene (C_2H_4), acetylene (C_2H_2), carbon monoxide (CO) and carbon dioxide (CO_2) [1-3]. The gases will dissolve in the transformer oil and transformer produced this type of fault gas when generated. Thus the quantity of gases become saturated with the transformer oil and then the production generated gases depends on the fault, next the gas is released from the transformer to atmosphere [12]. The chemical structure of these gases is shown in Figure 1. From