

**PROPOSED ALGORITHMS FOR INCIPIENT  
FAULTS DIAGNOSIS OF OIL-FILLED  
TRANSFORMERS**

By

**Mostafa Mahmoud Ibrahim Abdo**

A thesis submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfillment of the

Requirements for the Degree of

**MASTER OF SCIENCE**

In

**Electrical Power and Machines Engineering**

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY**

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**Prof. Dr. Essam El-Din Abo-ElZahab**

**Dr. Mahmoud Mohamed Sayed**

Electrical Power and Machines department

Faculty of Engineering - Cairo University

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**Approved by the**

**Examining Committee**

---

**Prof. Dr. Sobhy Serry Dessouky**  
**Port Said University**

**External Examiner**

---

**Prof. Dr. Adel Dia El-Din Shaltout**  
**Cairo University**

**Internal Examiner**

---

**Prof. Dr. Essam El-Din Abo-ElZahab**  
**Cairo University**

**Main Supervisor**

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY**

**GIZA, EGYPT**

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## **LIST OF PUBLICATIONS**

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- 2) Mostafa.M.Ibrahim, M.M.Sayed, and E.E.Abu El-Zahab, “Artificial intelligence solution for incipient faults diagnosis of oil-filled power transformers”, Accepted for publication in the journal of electric engineering, will be available online by March 2016.

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## LIST OF SYMBOLS AND ABBREVIATIONS

- **Chemical symbols**

H <sub>2</sub>	: Hydrogen
CH <sub>4</sub>	: Methane
C <sub>2</sub> H <sub>6</sub>	: Ethane
C <sub>2</sub> H <sub>4</sub>	: Ethylene
C <sub>2</sub> H <sub>2</sub>	: Acetylene
CO	: Carbon monoxide
CO <sub>2</sub>	: Carbon dioxide
O <sub>2</sub>	: Oxygen
N <sub>2</sub>	: Nitrogen

## • Abbreviations

DGA	:Dissolved gas analysis
FIS	:Fuzzy inference system
FLA	:Fuzzy logic approach
ANN	:Artificial neural network
AFC	:Actual fault condition
AI	:Artificial intelligence
GA	:Genetic algorithm
PD	:Partial discharge
D1	:Discharge of low energy
D2	:Discharge of high energy
T1	:Thermal fault ( $T < 300^{\circ}\text{C}$ )
T2	:Thermal fault ( $300 < T < 700^{\circ}\text{C}$ )
T3	:Thermal fault ( $T > 700^{\circ}\text{C}$ )

## **ABSTRACT**

Power transformers are one of the most expensive and important equipment in power systems. Fault occurrence within a power transformer may lead to the interruption of the electrical energy to consumers.

A power transformer during operation is subjected to different stresses such as electrical stress and thermal stress which lead to liberation of gases from the hydrocarbon mineral oil. Dissolved gas analysis (DGA) is one of the most useful methods to detect power transformers incipient faults. There are different conventional DGA methods developed for analyzing these gases such as key Gas, Rogers Ratio, Dornenburg, International Electrotechnical Commission (IEC) Ratio, and Duval triangle. Artificial Intelligence (AI) can also be used to detect power transformers incipient faults.

In this thesis, two different proposed algorithms based on artificial intelligence techniques (fuzzy logic approach and neural network approach) are used to get the correct diagnosis of the incipient faults in order to avoid the drawbacks of the conventional DGA methods. In order to examine the accuracy of the proposed artificial intelligence fault diagnosis techniques, various power transformers DGA results are tested. The accuracy of each approach is then calculated and compared with the accuracy of the conventional DGA methods.

# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 General**

Power transformers have an essential impact in both the transmission and distribution of electrical energy. It is one of the very important oil-insulated components in power systems and its operational state determines the safety of the whole power system. Failure within a power transformer may lead to long interruption in electrical energy supply and need expensive repairs. Any incipient fault within a transformer must be detected as early as possible in order to prevent the transformer from more deterioration. Several diagnosis methods are developed in order to determine the various fault types occurring during transformers operation like arcing, partial discharge and hot spots.

Dissolved Gas Analysis (DGA) is considered an effective tool to diagnose the incipient fault within a power transformer. There are many conventional methods developed to determine transformer fault which are Key Gas method, Rogers Ratio Method, Dornenburg Ratio Method, IEC Ratio method and Duval Triangle method. However, these conventional methods have many disadvantages. One disadvantage is that conventional DGA techniques sometimes fail to determine the correct diagnosis of a power transformer due to the no matching codes for diagnosis due to the coding boundary and the sharp codes change. Another disadvantage is that conventional DGA techniques sometimes do not take into consideration some possible transformer conditions. Recently, many artificial intelligence (AI) methods have been developed in order to overcome the disadvantages of the conventional DGA methods.

### **1.2 Thesis objectives**

The main objectives of the thesis can be summarized in the following points:

1. Studying the stresses that affect oil-filled power transformers and their effect on the insulating oil.
2. Studying the main conventional DGA techniques and their drawbacks.