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DEVELOPMENT OF A NEURO-FUZZY SYSTEM FOR CONDITION MONITORING OF POWER TRANSFORMERS

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A dissertation submitted to the

Department of Electrical Engineering, University of Moratuwa

in partial fulfilment of the requirements for the

Degree of Master of Science

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DECLARATION

The work submitted in this dissertation is the result of my own investigation, except where otherwise stated.

It has not already been accepted for any degree, and is also not being concurrently submitted for any other degree.

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Abstract

Well-being of Power Transformers is crucial to the reliable operation of a Power System. They represent a high capital investment in a Transmission Substation while being a key element determining the loading capability of the station within the network. With appropriate maintenance, including insulation reconditioning at the appropriate time, the technical life of a transformer can be extended. Assessment of Power Transformer condition is very important to maintenance engineers on the way to diagnose incipient faults and implementation of necessary maintenance plans to prolong their life span. Therefore different testing methods and diagnosis techniques are used for condition assessment of transformers; namely Dissolved Gas Analysis (DGA), moisture content measuring tests in oil/paper, Insulation Resistance (IR) measurement, acidity in oil etc. Accuracy of the final conclusion depends on the experience and knowledge of the maintenance engineer and the data which he referred to. Therefore, it is appropriate to have an Expert System, as a guide to maintenance engineers in the Ceylon Electricity Board (CEB), so as to address the above problems.

This thesis describes the degradation of insulation, ageing process, faults and testing methods of transformers. Much attention was paid to DGA as a diagnosis tool. This thesis introduces two computer based expert systems to analyze the results from various diagnosis techniques and tests which are used in CEB at present. First program was written on Visual Basic environment and included essential tests including DGA which are carried out by CEB for its transformers. Knowledge base for this program was developed by using various standards, text books, transformer manufacturers' recommendations and the opinions of my supervisors and experienced engineers. Twenty Five (25) numbers of DGA test results of transformers were analyzed by using this program and such transformers were grouped according to the IEEE standards. Limitations of conventional DGA methods with frequent non-decisions can be addressed by fuzzy-logic based diagnosis for power transformer incipient faults. Therefore, the second program was developed to meet the above demand by using Adaptive Neuro-Fuzzy Inference System (ANFIS) in MATLAB Environment. The developed ANFIS–based diagnosis system provides further improvement to fuzzy-logic based techniques by providing auto-learning capabilities. This program was tested for faults with 30 DGA test results and the outcome is within the satisfactory level.

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Acronyms and Abbreviations

^0C	Centigrade
ANFIS	Adaptive Neuro-Fuzzy Inference System
ANN	Artificial Neural Networks
ASTM	American Society for Testing and Materials
C_2H_2	Acetylene
C_2H_4	Ethylene
C_2H_6	Ethane
C_3H_6	Propylene
CBM	Condition-Based Maintenance
CEB	Ceylon Electricity Board
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
DGA	Dissolved Gas Analysis
DP	Degree of Polymerization
EPM	Electrical Preventive Maintenance
FIS	Fuzzy Inference System
FL	Fuzzy Logic
H_2	Hydrogen
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IR	Insulation Resistance
KOH	Potassium hydroxide
kV	Kilovolts
kVA	Kilovoltampere
MTBF	Mean Time Between Failures
MVA	Mega-volt-amps
PD	Partial Discharge
PM	Preventive Maintenance
ppm	Parts per million
RCM	Reliability-Centered Maintenance
RTF	Run-to-Failure
TBM	Time-Based Maintenance
TCGA	Total Combustible Gas Analysis
TF	Transformer

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