DETECTION OF INSULATION FAULTS IN TRANSFORMER USING WAVELET ANALYSIS

ALI ASGHAR

UNIVERSITI TEKNOLOGI MALAYSIA

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To my beloved niece,

For being a beacon of light that shines in my life...

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ABSTRACT

Recognition of key insulation faults in power transformers through impulse testing was certainly not seen as a big problem as it had emerged today but talking of minor faults which are often neglected after the impulse testing by the naked eye had been a challenging task for a very long time in power transformers. Hence there is seen a need of such a tool which should be capable of verifying the signals/waves after these di-electric tests, as the recognition of such faults is immensely essential to overcome any disastrous situation in the longer run. This work proposes an influential approach which is proficient in detecting such minor faults. The methodology uses wavelet analysis technique, the dyadic-orthonormal wavelet transform (DOWT) in particular. The principle idea behind the working is to detect the fault (noise) at the particular time instance after decomposition of recorded faulty current responses into detailed and smoothed description of the usual signal. The results showed that for three different frequency scales i.e. 10-5MHz for scale 1, 5-2.5MHz for scale 2 and 2.5-1.25MHz for scale 3, higher localized filter coefficient i.e. L=45 is seen to be much more efficient in detecting the fault at a particular instant than the L= 8 filter coefficients under the dyadic-orthogonal wavelet transform function. Therefore the projected technique proved to be robust and way far efficient as compared to the other methods to resolve such group of faults.

ABSTRAK

Pengenalpastian kesilapan penebat utama dalam transformer kuasa melalui ujian dorongan semestinya dilihat sebagai masalah besar dimasa ia timbul masakini tetapi bercakap tentang kerosakan kecil yang sering diabaikan selepas ujian dorongan oleh mata kasar telah menjadi satu tugas yang mencabar bagi masa yang sangat lama dalam transformer kuasa. Oleh itu dapat dilihat bahawa ada keperluan terhadap alatan yang mampu mengenalpasti isyarat gelombang selepas ujian di-elektrik, sebagai pengenalpastian kesilapan itu adalah amat penting untuk mengatasi keadaan-keadaan yang buruk untuk tempoh jangkamasa panjang. Kerja ini mencadangkan satu pendekatan berpengaruh yang mahir dalam mengesan kesilapan-kesilapan kecil ini. Kaedahnya menggunakan teknik analisis wavelet, khususnya pengubahan wavelet dyadic-orthonormal (DOWT). Idea asas di sebalik tugasan ini adalah untuk mengesan kesilapan (bunyi) pada masa yang tertentu selepas penguraian kesilapan tindakbalas semasa yang direkodkan kepada penerangan terperinci dan lancar isyarat yang biasa. Keputusan menunjukkan bahawa untuk tiga skala frekuensi yang berbeza, i.e. 10-5MHz pada skala 1, 5-2.5MHz pada Skala 2 and 2.5-1.25MHz pada skala 3, pekali penapis setempat tinggi iaitu L = 45 adalah lebih berkesan dalam mengesan kesilapan pada ketika tertentu berbanding pekali penapis L = 8 dalam fungsi pengubahan wavelet dyadic-orthonormal. Oleh itu, teknik yang diunjurkan telah terbukti mantap dan cara yang jauh lebih berkesan berbanding dengan kaedah lain untuk menyelesaikan kesilapan-kesilapan ini.

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LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
FT	-	Fourier Transform
TF	-	Transfer Function
PSD	-	Partial Spectral Discharge
FFT	-	Fast Fourier Transformation
STFT	-	Short Time Fourier Transformation
BIL	-	Bus Impedance Loading
FFA	-	Fast Fourier Analysis
DWT	-	Discrete wavelet transform
CWT	-	Continuous Wavelet Transform
FWT	-	Fast Wavelet Transform
X[n]	-	Original signal
H[n]	-	High pass filter
G[n]	-	Low pass filter
FRA	-	Frequency Response Analysis
WT	-	Wavelet Transform
DOWT	-	Dyadic-Orthonormal Wavelet
Vin	-	Input Voltage
Vout	-	Output Voltage

LIST OF SYMBOLS

kv	-	Kilo Volts
µ	-	micro
↓	-	Down sampling

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CHAPTER 1

INTRODUCTION

This chapter focuses on the importance of impulse testing for the assessment of the integrity of its winding insulation along with the necessity of implying the Wavelet analysis as the most effective diagnose technique. It contains a brief Background of impulse testing along with the evolution of various diagnose techniques, Problem statement, Purpose of the Study, Objectives of the Study, Significance of Study, and Scope of Study.

1.1 Background

Insulation failure today is regarded as one of the most important causes of the failure of power transformers. Transformer's Impulse testing after assembling is a standardized and recognized procedure for the evaluation of the over voltages due lightening or transient changes. They cover voltage sequences produced in a laboratory and then applied to the transformers for analysis and further testing per IEC Standards. Normally the hindrance in the manufacturing or insulation breakdowns leads to the failure contrary to impulse voltage stresses. The foremost and the fundamental objective are to detect the fault or noise in the signal along with the exact localization in multi-domain i.e. time and frequency for a better understanding of the problem.

For quite a long period the applied voltage signals and the corresponding current signals had been examined manually by reviewing the oscilloscope records, the interpretation of whose was intensively based on the knowledge and understanding of the researchers/experts carrying out the analysis still it ends up with great in-accuracies as it has to be observed by the naked eye which used to hamper the transformer's service life in the longer run. With the invention of digital recorders and analyzers, the room and trend for the frequency domain analysis opened for the researchers with special reference to the transfer function approach. It was a milestone in the field of signal analysis. In the current few years the use of computers and other equipped soft wares helped researchers in the application of impulse fault categorization. They have managed to come up with the number of analysis technique starting from ANN, FT, PSD and ultimately to WT.

Wavelets have been extensively used in numerous areas of which the most common ones are noise eradication, data compression, image feature's detection, harmonic elimination and singularity detection in the waveforms. The main advantage of Wavelet Analysis over the Fast Fourier technique lays in the detection and localization of fault in multi-purpose domain i.e. both frequency and time domain analysis. Currently after finding its superiority over other conventional methods it has been introduced and successfully applied in power transformer's analysis. It is an increasingly developing tool with growing applications in science and engineering. It specifies the degree of similarity between the signal and a basis junction, called mother wavelet and is achieved by dilating the mother wavelet and translating it over the signal. Thus, WT maps one dimensional time domain signal to a two dimensional functions of time and frequency. It yields a possibly more accurate representation of the fault in the required responses and is best at analysing and detecting the localize occurrence of minor faults in the neutral current records. Therefore, this project presents the classification of different impulse faults arousing after the impulse testing occurring in several situations and diagnosing it with the use of Wavelet analysis.

1.2 Problem Statement

Although the researchers have come a long way in deducing several multi-purpose techniques pertaining to the detection and diagnoses of the faults occurring in the power transformer impulse testing but there are still some queries which are needed to be dealt with. Generally, the results obtained after the impulse testing of power transformers are free of any noise or distortion as observed by naked eye. But we observed somewhat otherwise; as in numerous situations the same faults were seen to be damaging the transformer's service life later. This is where the problem lies. The central fact which is needed to be taken into account is to figure out any techniques which can both detect and diagnose such minutest faults, like turn to turn, which are hard to detect by a naked eye or by FT, PSD, ANN due to their respective limitations in frequency or time domain localization, at the impulse testing to avoid troubles in the later run. This project primarily focuses on the detection and diagnoses of such miniature faults at its initial stage of impulse testing by effectively employing Wavelet analysis and then comparing the result with the original results to see any sign of deviation.

1.3 Purpose of Study

The most important goal is to have a better understanding of the problem and its respective solutions too. Though thorough research has been conducted concerning the deduction of such technique which should be skillful in detecting the exact location and time of the faults but still there was a lot more yet to be explored. Thus through this work, one should be able to well understand the problem at first place pertaining to different faults in the transformer and selection of an efficient technique to detect such faults. However the proposed wavelet analysis with dyadic-orthogonal transform function technique used offers a justified solution to the discussed problem as well. Therefore in the end one will be having a firm understanding and knowledge related to the field.

1.4 Objectives of the study

a) To study in detail the impulse testing of a transformer along with the different types of insulation faults associated with it.

b) To propose Wavelet analysis with Dyadic-Orthogonal transforms (DWT) technique as an alternative method for the accurate and precise detection of faults during transformer impulse testing.

1.5 Scope of the Study

Fault analysis and diagnose of transformer is necessary and vital, since power quality remains the top most priorities of utilities in today’s world. Insulation breakdowns due to the high amplitude impulse voltages, produced by the lightening or switching transients and failure due to the fault currents is taken to be the greatest source of the power transformer’s failure. Contrast of the reduced and full voltages determines the presence of fault in a power transformer during impulse tests. There have been multi techniques to analyse and predict such faults but if the fault is minutest, they may not reveal the failure accurately. For such minutest variations, Wavelet analysis has been proposed due to its excellent simultaneous localisation of time and frequency decomposition characteristics unlike the other methods.

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