DEVELOPING A STOCHASTIC MODEL FOR PARTIAL DISCHARGE DETECTION IN VOIDS OF POLYMERIC CABLE INSULATION

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ABSTRACT

The detection of Partial Discharge (PD) is a useful tool in the maintenance and operation of electrical high voltage power cables. It has attracted many research and development efforts within the past one and a half decade. However, questions regarding the analysis and interpretation of PD data are still unanswered. In this research, an attempt is made to develop a simulation programme that can be used for developing a better understanding of the nature of PD phenomena based on its stochastic nature. It is done in consideration to the statistical properties of measured PD data from previous research, as well as the use of trial and error to obtain some parameters. Simulation was done in an effort to reconstruct the electrical field model of voids in polymeric cables using MATLAB M-files and statistical data from Phase Resolve Partial Discharge (PRPD) patterns. Such modeling can work for both electrical and acoustic data and may be used as a basis for comparison of future PD detection outcomes. The results indicates that the model worked well in the reconstruction of the field patterns of voids from given time and statistical data using the computer programme developed. Though the time was limited, the result seems to present new insight regarding the field patterns in the void. Phase and time data were combined in an effort to realize the objectives.

ABSTRAK

Pengesanan Separuh Nyahcas (PD) adalah amat berguna dalam penyelengaraan dan operasi bagi kabel kuasa voltan tinggi. Para penyelidik tertarik kepadanya sejak satu atau setengah dekat dahulu. Akan tetapi, persoalan tentang analisis dan penukaran maklumat PD masih tidak dapat ditentukan dengan sepenuhnya. Dalam penyelidikan ini, perisian simulasi telah dibentukkan untuk memahami fenomena semulajadi PD berdasarkan stochastik semulajadinya. Ia telah dilakukan berdasarkan ukuran statistik daripada penyelidik sebelum ini dan pelbagai cara percubaan untuk tujuan mendapatkan data telah dilakukan. Simulasi terhadap kesan elektrik di kabel polymetric telah dijalankan berdasarkan perisian MATLAB M-files dan data statistik yang diperolehi dari corak "Phase Resolve Partial Discharge (PRPD)". Pemerhatian terhadap data elektrik dan akustik boleh dijadikan asas kepada perbandingan pengesanan PD pada masa depan. Keputusan menunjukkan model itu dijalankan dengan lancar dalam corak kosong yang dibuat dengan menggunakan perisian komputer. Walaubagaimanapun, kesuntukan masa tidak mendatangkan sebarang masalah untuk mendapatkan keputusan yang baik. Demi mencapai objektif, gabungan data bagi fasa dan masa telah dilakukan.

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LIST OF SYMBOLS AND ABBREVIATIONS

E_0	-	Eternally applied electrical field stress(v/mm)
E_{inc}	-	Inception electrical field (voltage at which discharge takes place)
E_i	-	Internal field
E_{res}	-	Residual field given as a percentage of E_{inc}
f	-	Power frequency
T	-	Period of the applied ac sine wave
τ	-	Function used for time lags
N_p	-	number of binary phase windows
1/c	-	Waiting time for discharge to occur after $E_0 > E_{inc}$
q	-	Charge/discharge in pC
φ_i	-	i^{th} phase channel where i = {1,2,3,…,256}
PD	-	Partial Discharge
PRPD	-	Phase resolved partial discharge
X	-	Stochastic variable
σ	-	Standard deviation
Pd	-	Probability Density
μ	-	Mean

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CHAPTER 1

INTRODUCTION

1.1 Background

High voltage power cable failure can cause a long interruption, costly repairs and loss of revenue. Insulation failure due to Partial Discharge, has been a major cause of cable problems during the past two decades. Early detection and accurate diagnosing of insulation faults can prevent such problems and contribute to greater system reliability.

Partial Discharge (PD) activities in XLPE and other polymeric, high voltage cables are caused by various defects, such as voids, shield protrusions, contaminants and advanced stage of water treeing. PDs will gradually degrade and erode the dielectric materials, eventually leading to total breakdown. Hence it is of great importance to be able to effectively detect the existence and location of such faults if proper maintenance procedures are to be carried out.

Several methods of detection of partial discharge have been used in the past, each having its own merit and demerit. The standard and most traditional method has been by Electrical means. This requires bulky, expensive equipment, which in many cases are not affordable. However, within the past two decade other methods of detection have been researched and developed to capture the PD waveform based on its non electrical properties in the form of sound, light and capacitive effects.

Nevertheless, continued development of the PD detection process requires models and Computer simulations to aid in the classification and extraction of data about physical models. This, implies the need for research that can reduce time and costly equipment and improve accuracy of analysis of the available data.

In this research, an effort is made towards contributing to the development of PD analysis technique, and in creating a greater awareness of the underlying stochastic processes. The concept is dealt with throughout the five chapters included in this thesis. Chapter 2 provides a comprehensive review of the PD process and modeling techniques, as well as the methods used in analyzing and interpreting the data. Here an emphasis is also placed on stochastic modeling.

Chapter 3 explains the methodology used in terms of MATLAB and the discrete signal processing techniques employed in the current stochastic model. While Chapters 4 and 5 focus on the results and interpretation of data. Conclusions and recommendations are given based on these results.

1.2 Statement of the Problem

Major drawbacks to PD detection, especially, in acoustic measuring systems, are believed to be cause, not only by stochastic interferences, but also to the lack of proper analysis procedures and interpretation of the PD data. So far, attempts to establish a proper Model for PD have not been realized by previous researchers. This is due mainly to the lack of understanding regarding the stochastic nature of PD as well as the absence of PD simulation programmes.

1.3 Objectives:

The main objectives of this research project are:

1. to develop a Matlab simulation programme that will aid in the analysis and interpretation of PD signals through the use of modeling procedures and outcomes.

2. to develop a model which can aid in the analysis and interpretation of PD data obtained from voids though a combination of the phase/time resolved approach.

3. to serve as a basis for further research work in the detection of partial discharge in cable system .

1.4 Scope of Study

The research was carried out in the Universiti Teknologi Malaysia (UTM) to

1. Study text, magazines, articles and other prior research materials on various PD detection systems and models.

2. Develop and use Matlab simulation Programme to modeling and analyze PD signals with regards to electrical charge and time separation.

1.5 Contributions of the Research Project

Major contributions of the project are:

1 It can aid in the development of PD detection systems through the use of the simulation programme developed in MATLAB M-files.

2 It will provide a method for establishing a relationship between a reference stochastic Electrical PD model and acoustic counterpart as obtained from phase resolved method. This can ultimately help in assessing the efficiency of both electrical and acoustic PD detection systems in extracting both quantitative and qualitative information about internal cavities.

3 It will also act as a reference in carrying out further research work in the study of the PD signal. Both electrical and acoustic counterpart can be compared with

simulation results from the programme which allows adjustment of control parameters for time lag.

Such a model can ultimately help in the prediction of breakdown with regards to the stochastic properties

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