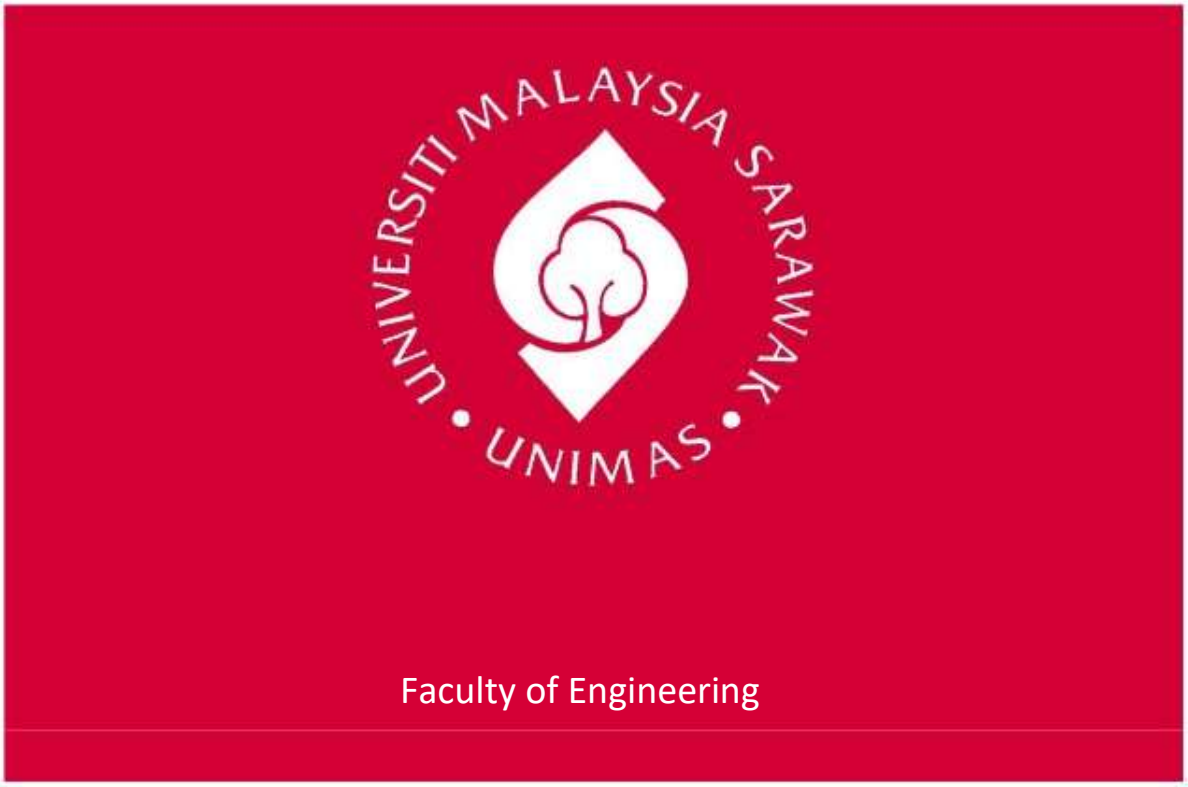

CLASSIFICATION OF PERCEPTRON ELECTRIC DISCHARGE SIGNAL ON PATTERN RECOGNITION APPROACH

Amealy Liony anak Tom

Bachelor of Engineering (Hons) in
Electronics (Telecommunications)
2019

UNIVERSITI MALAYSIA SARAWAK

Grade: A-

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Final Year Project Report ☑

Masters ☐

PhD ☐

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This declaration is made on the 13 day of June 2019.

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I Amealy Liony anak Tom, 50376, Faculty of Engineering

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CLASSIFICATION OF PERCEPTRON ELECTRIC DISCHARGE SIGNAL ON PATTERN RECOGNITION APPROACH

AMEALY LIONY ANAK TOM

A final year project report submitted in partial fulfilment of
the requirement for the degree of
Bachelor of Engineering (Hons) in Electronics (Telecommunications)

Faculty of Engineering
Universiti Malaysia Sarawak
2019

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report ☐

Masters ☐

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First and foremost, in successful accomplishment of this study, I would like to convey my deepest gratitude and appreciation to my supervisor, Dr Kho Lee Chin for her excellent supervision, attention, and professional guidance throughout my time in this university and in completing this work, which I consider all that as something that are beyond repayment. She provided me with useful advice and guidance and wisdom without hesitation.

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ABSTRACT

Partial discharge (PD) analysis is a mutual method for condition monitoring and diagnostics in high insulation system in the power substation. This method can be applied as a tool for assessing the lifespan of the insulation system like transformers and detect insulation malfunctions before they lead to failure. This report describes the performance of the analytics tool used for PD activities that occur of the insulation system in the substation. In most cases, PD will occur in the insulation system due to ageing process, operational over stressing or defects introduced. Different PD sources have different effects on the condition and performance of power equipment's in the insulation system. Therefore, for further analysis, the ability to accurately differentiate the PD signals generated is seen as a critical function for future diagnostic systems. In the realistic field conditions, multiple types of PD sources may be activated or occur simultaneously within the insulation system. Wavelet Transform based feature extraction was proposed to extract the reliable features in this study. These input features were used to train the classifiers in order to classify each of the PD defects type. Classifications were performed using different types of classifiers, namely the artificial intelligence classifiers, which include Multi-layer Perceptron (MLP) and Support Vector Machine (SVM). The other classifiers used in this study were Random Forest (RF), K-Nearest Neighbours (KNN) and Naïve Bayes. It was found that MLP and SVM performed well followed by RF and KNN classifiers while Naïve Bayes was the weakest among them all.

ABSTRAK

Pelepasan separa (PD) analisis adalah kaedah biasa untuk memantau keadaan dan diagnostik dalam sistem penebatan yang tinggi di pencawang kuasa. Kaedah ini boleh digunakan sebagai alat untuk menilai jangka hayat sistem penebat seperti alat untuk menukar voltan litar dan boleh mengesan kerosakan penebat sebelum mereka membawa kepada kegagalan. Laporan ini menerangkan perkembangan alat analisis untuk aktiviti PD yang berlaku pada sistem penebat di pencawang kuasa. Dalam kebanyakan kes, PD akan berlaku dalam sistem penebat disebabkan oleh proses penuaan, operasi yang lebih menekankan atau kecacatan diperkenalkan. Sumber PD yang berbeza menghasilkan kesan yang berbeza pada keadaan dan prestasi peralatan kuasa dalam sistem penebat. Oleh hal yang demikian, untuk analisa selanjutnya, keupayaan untuk membezakan dengan tepat isyarat PD yang dihasilkan dilihat sebagai fungsi kritikal untuk sistem diagnostic pada masa hadapan. Dalam keadaan yang realistik, pelbagai jenis sumber PD boleh diaktifkan atau berlaku secara serentak dalam sistem penebat. Teknik pengekstrakan ciri yang berdasarkan *Wavelet Transform* telah dicadangkan untuk mengekstrak ciri-ciri yang boleh dipercayai dalam kajian ini. Ciri-ciri ini telah digunakan sebagai input untuk melatih pengelas untuk mengelaskan setiap jenis kerosakan PD. Klasifikasi telah dijalankan dengan menggunakan pelbagai jenis pengelas seperti Pengelasan Rangkaian Tiruan (ANN) yang termasuk Pelbagai Lapisan Perceptron (MLP) dan Mesin Vektor Sokongan (SVM). Pengelas yang lain digunakan dalam kajian ini adalah *Random Forest (RF), K-Nearest Neighbour (KNN)* dan *Naive Bayes*. Hal ini telah mendapati bahawa MLP dan SVM menghasilkan prestasi yang baik dan diikuti oleh pengelas RF dan KNN manakala Naive Bayes adalah pengelas yang paling lemah antara mereka semua.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
BPNN	-	Backpropagation Neural Network
CWT	-	Continuous Wavelet Transform
DWT	-	Discrete Wavelet Transform
ENN	-	Ensemble Neural Network
FCM	-	Fuzzy-C Mean
KNN	-	K-Nearest Neighbour
MLP	-	Multi-Layer Perceptron
MNN	-	Modular Neural Network
NN	-	Neural Network
PD	-	Partial Discharge
PNN	-	Probabilistic Neural Network
PRPD	-	Phase Resolved Partial Discharge
RBFN	-	Radial Basis Function Network
RF	-	Random Forest
SNN	-	Singular Neural Network
SVM	-	Support Vector Machine
WT	-	Wavelet Transform

CHAPTER 1

INTRODUCTION

1.1 Background

Partial discharge (PD) causes deterioration in the insulating system of high voltage apparatus. PD that happens in the high voltage equipment can disseminate and eventually causes fiasco in the system. Partial discharge (PD) is a type of breakdown that does not fully connect the electrodes. PD takes place if the local electric field is greater than the threshold value, causing a partial breakdown of the surrounding medium. PD has a transient nature and is characterized by pulsating currents with a duration of several nanoseconds to few microseconds. This can lead to severe insulation damage and considerably cut down the life span of high voltage equipment. Therefore, it is very important to identify the electric discharge defects in the insulation system before it causes even more failure on the high voltage equipment. PD can be categorized into few categories such as Corona discharges, Surface Discharges, Internal Discharges and discharges in electrical trees. The signal of electric discharge can be detected by using antenna, from electromagnetic waves, for very high or ultra-high frequency.

Classifications of PD patterns play a crucial part in manufacturing, quality certainty and service life valuation of the high voltage equipment. It is of interest due to the relation of the PD activities and the dielectric materials ageing process. Classification of PD is a process in determining whether an input pattern belongs to a particular class. Pattern classification is one type of the pattern recognition which has wide implementations including handwritten character recognition, speech recognition and PD

pattern and PD pattern recognition. Classification of PD patterns is a highly-skill task needed to be performed by an expertise. To perform the pattern recognition task, four main approaches have been identified namely, template matching, structural techniques, statistical techniques and neural network based techniques:

i. In template matching, the pattern to be recognized is matched and correlated with the stored templates. However, this techniques does not work efficiently in the existence of distorted patterns [1].
ii. Structural techniques is used to recognize complex patterns. It is preferred to adopt a hierarchical system, where a pattern is considered to be made up of simple sub-patterns which are further composed of simpler sub patterns [1].
iii. In statistical techniques, each pattern is characterized by some measured features. The features are chosen in such a way that different patterns occupy non-overlapping feature space [1].
iv. Neural networks are structures that are made up of neuron-like structures. This technique provides an efficient result in the field of classification. Different types of neural networks are used depending on the requirement of the application [1].

Pattern recognition of PD is significant in determining consequential risks of an insulation breakdown where servicing or replacing is required for the current component. Many works on PD classification have been performed in numerous equipment of the power system. For instance gas insulated switchgears and substations, power cables and transformers. Various types of classifiers are commonly used which includes Support Vector Machines, Fuzzy Logic and Neural Networks.

To identify different types of PD, a group of distinctive discriminatory features acts as a recognition markers in PD [2]. This unique identification allowing them to be recognized accordingly. It is essential to select which discriminatory attributes to be extracted in order to perform PD classification and also choosing a suitable technique to be used for the feature extraction. Feature extraction is fundamental to extract the unique features that equate each discharge. During the training process, the features that has been

extracted are used as the input features of the classifier. Feature extraction activity allows quicker and simpler handling as the size of the raw PD data has been reduced.

1.2 Problem Statement

An outage at the power substation would cause notable and crucial consequences to either huge number of the suburban users or effects to industrial plants. The interpretation of electric discharge patterns is capable to reveal the source of electric discharge and evaluate the effects of the electric discharge on high voltage equipment in the power substation. Therefore, it is compulsory to initiate methodologies in detecting the prior signs of evolving faults. These methodologies can provide the network operators involved with the useful information. Monitoring the electric discharges, as a symptom of insulation failure, can be used to improve the reliability of the high-voltage insulation. This eventually can prevent costly failures on the electrical equipment.

Electric discharge often encounter with disruption causes by radio transmissions, power electronic components, random noise from switching, lightning, arcing, harmonics and interferences from ground connections [3]. A lot of investigation works have been carried-out on denoising the electric discharge signals and these have been enhanced over the years. Artificial noise is initiated by adding evenly distributed random number to phase and charge can be seen in most of previous research works. However, a better, ideal and comprehensive denoising standard with the classifier providing higher rate of accuracy has yet to be achieved.

1.3 Objectives

The objectives for this study are:

i. To study the performance of the pattern recognition model in terms of the recognition rate on different sources of partial discharge signal.
ii. To identify the pattern recognition model with the most reliable accuracy in classification of partial discharge sources.

1.4 Scope of Work

Several types of classifiers have been introduced and utilized to identify and classify the PD signal patterns such as Multi-Layer Perceptron (MLP), Support Vector Machine (SVM), Random Forest (RF), Naïve Bayes and K-Nearest Neighbours (KNN) model. In this study, the mentioned classifiers are investigated for their effectiveness and accuracy in classifying the PD signals pattern.

Discrete Wavelet Transform (DWT) is employed as the feature extraction technique in this study, combined along with each of the pattern classifiers. This is to optimize the performance and to achieve effective classification of partial discharges by the classifiers.

1.5 Overview of the Study

This thesis is divided into five chapters. In Chapter 1, named Introduction, introduces the background, problem statement, objectives of the research and the scope of this work.

Chapter 2 deals with the Literature Review, which means this chapter overviewing the previous related researches on this study. Brief descriptions on different models of pattern classifiers are reviewed in this chapter.

Chapter 3, named Methodology, presents the steps carried out to achieve the objectives of this study. This chapter overviews the feature extraction method and the PD classifiers used in this work. Brief description on Wavelet Transform analysis method is also reviewed in this chapter.

In Chapter 4, deals with the results and discussions of the study. All of the measurements and classification results that have been performed in this study are detailed in a systematic manner.

Chapter 5 presents the conclusions and the future work recommended for this work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the information about partial discharges along with their model to generate those artificial partial discharges and their typical frequency spectrum. The system to scan and monitor the PD and different types of pattern recognition model also reviewed briefly in this chapter. Detailed review of previous works related to PD classification was presented.

2.2 Partial Discharges

Partial discharge phenomenon can be divided into two types of discharges. Those two types of PD are external partial discharge and Internal Discharge. External partial discharge is named for PD that occurs outside of the power equipment. Such types of discharge occurs on overhead line like on armature and etc. Corona discharge and Surface Discharge are the examples of external PD. Internal partial discharge is a type of PD that occurs inside of a system. Void for instance is categorized under Internal Discharge. The information about the properties of insulating materials used in high power equipment is given by the PD measurement system [4].

2.2.1 External Partial Discharges

In the free space, PD around a conductor is called as Corona discharge. This discharge usually occurs as there is non-uniform field on sharp edges of the conductor subjected to high voltage. The insulation provided is either air, gas or liquid. This PD sometimes appear as a bluish glow on the HV wires and sizzling sound can be heard along HV power lines. Corona discharge is usually created at sharp transitions on the electrodes, such as sharp corners, projecting points, edges of metal surfaces, or on small diameter wires [5]. The Corona discharge can be generated artificially in the laboratory as illustrated in Figure 2.1 and the typical frequency spectrum of Corona discharge is illustrated in Figure 2.2.

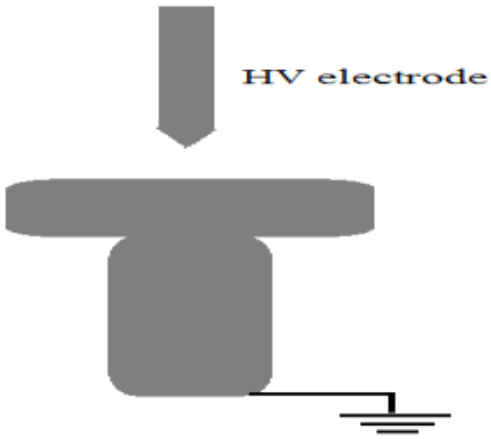

Figure 2.1: Artificial Corona Discharge Model [5]

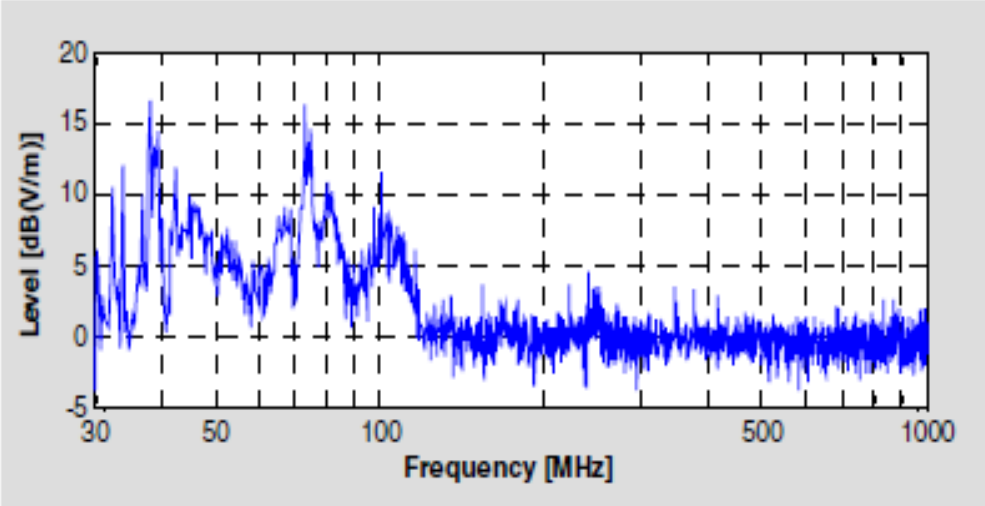

Figure 2.2: Typical Frequency Spectrum Signal for Corona Discharge [5]

Surface Discharge belongs to external discharge that takes place on interfaces of dielectric material such as gas or solid interface. They are developed as the applied voltage increases. Surface Discharges in the air become effective in the areas with high electric force that value is greater than 3E6 V/m. Generally, they are also called as 'Corona discharges' but for the purpose of the paper the term 'Surface Discharges' is more specific. Surface Discharge are capable to damage the solid insulation [6]. Figure 2.3 and Figure 2.4 illustrate the model to generate the artificial Surface Discharge and typical frequency spectrum of Surface Discharge respectively.

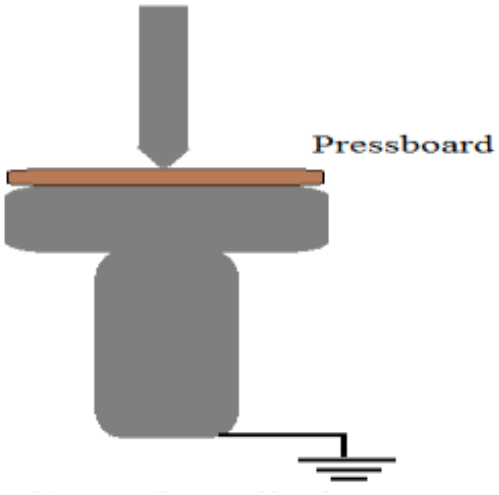

Figure 2.3: Artificial Surface Discharge Model [5]

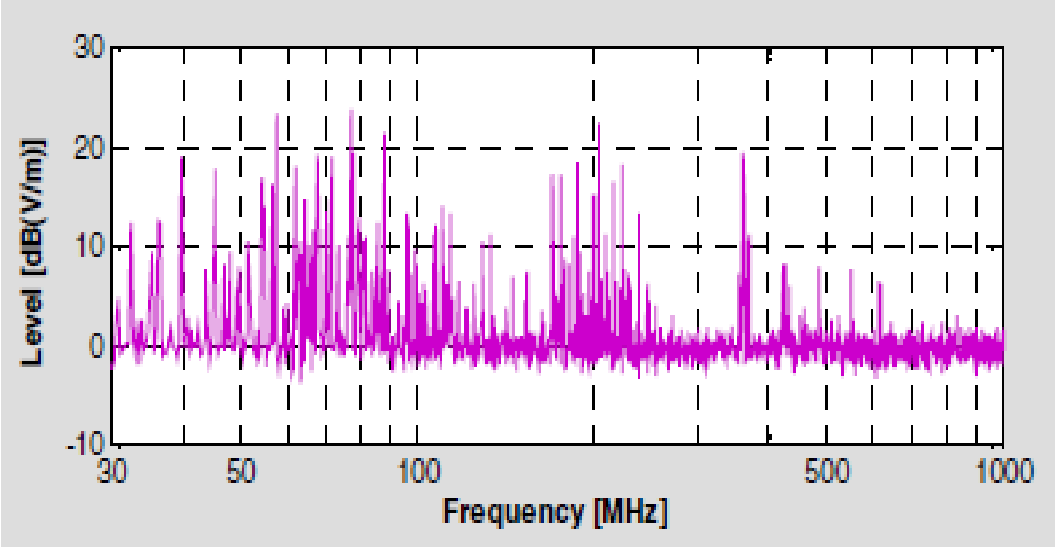

Figure 2.4: Typical Frequency Spectrum Signal for Surface Discharge [5]