FAULT CLASSIFICATION OF A TRANSMISSION LINE USING WAVELET TRANSFORM AND ARTIFICIAL NEURAL NETWORKS

HARNETTA HASHLEYNNA ANAK MAKERLY

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical Power)

School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

JANUARY 2019

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers and academicians. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my supervisor, Dr. Mohd Hafiz Bin Habibuddin, for encouragement, guidance, critics and friendship. Without his continued support and interest, this thesis would not have been the same as presented here.

My fellow postgraduate classmates should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am also thankful and grateful to all my family member.

ABSTRACT

Power reliability and quality plays an important role in transmission power system. Faults occurrence will damage the equipment along the transmission line. Hence, it is crucial to accurately detect the location of the fault to shorten the fault clearing process and improve the reliability of the system. This study will be focusing on identifying the fault in overhead transmission line using wavelet transform and classify it using artificial neural network. The power system of the transmission line will be modelled in MATLAB2013a/SIMULINK to obtain and pre-process the fault data and analyzed them by using discrete wavelet transform. The mother wavelet daubechies4 (db4) is employed to decompose high frequency component from the fault signals. The data sets obtained from DWT are used to train and test the ANN architecture by using neural network toolbox of MATLAB. Several types of fault with different location of fault and fault resistances have been simulated and an attempt has been applied to identify and classify the fault appropriately. By using the proposed method, high accuracy of fault classification was be achieved and gives more reliable results.

ABSTRAK

Kebolehpercayaan dan kualiti kuasa memainkan peranan penting dalam sistem kuasa penghantaran. Kejadian kerosakan akan memusnahkan peralatan di sepanjang talian penghantaran. Oleh itu, adalah penting untuk mengesan lokasi kerosakan secara tepat untuk memendekkan proses pembersihan kerosakan dan meningkatkan system kebolehpercayaan. Kajian ini akan menumpukan perhatian untuk mengenalpasti kerosakan dalam talian penghantaran ‘overhead’ menggunakan transformasi wavelet dan mengklasifikasikannya menggunakan rangkaian neural buatan. Sistem kuasa talian penghantaran akan dimodelkan dalam MATLAB2013a / SIMULINK untuk mendapatkan dan pra-proses data kerosakan dan dianalisis dengan menggunakan transformasi wavelet diskret. Ibu wavelet daubechies4 (db4) digunakan untuk mengurai komponen frekuensi tinggi dari isyarat kerosakan. Set data yang diperoleh daripada DWT digunakan untuk melatih dan menguji seni bina ANN dengan menggunakan kotak alat rangkaian neural MATLAB. Beberapa jenis kerosakan dengan lokasi yang berbeza dari kerosakan dan rintangan kerosakan telah disimulasikan dan pelbagai percubaan telah dijalankan untuk mengenal pasti dan mengklasifikasikan kesalahan itu dengan sewajarnya. Dengan menggunakan kaedah yang dicadangkan, ketepatan tinggi klasifikasi kesalahan tercapai dan memberikan hasil yang lebih dipercayai.

TABLE OF CONTENTS

	TITLE	PAGE
	DECLARATION	**ii**
	DEDICATION	**iii**
	ACKNOWLEDGEMENT	**iv**
	ABSTRACT	**v**
	ABSTRAK	**vi**
	TABLE OF CONTENTS	**vii**
	LIST OF TABLES	**ix**
	LIST OF FIGURES	**x**
	LIST OF ABBREVIATIONS	**xi**
	LIST OF SYMBOLS	**xii**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Background of Study	1
1.2	Problem Statement	2
1.3	Research Objectives	2
1.4	Scope of Work	2
1.5	Thesis Outline	3
CHAPTER 2	**LITERATURE REVIEW**	**5**
2.1	Introduction	5
2.2	Fault Analysis	5
	2.2.1 Symmetrical Faults	6
	2.2.2 Unsymmetrical Faults	7
2.3	Discrete Wavelet Transform	8
	2.3.1 Calculation of Wavelet Energy Distribution	10
	2.3.2 Clarke’s Transformation Matrix	11
2.4	Fault Classifier Using Artifician Neural Network	12

CHAPTER 3	**RESEARCH METHODOLOGY**	**15**
3.1	Introduction	15
3.2	Input Data	15
3.3	Fault Simulation	16
3.4	Wavelet Transform	17
3.5	ANN for Fault Classification	18
3.6	Summary	20
CHAPTER 4	**PROPOSED WORK**	**21**
4.1	Simulation Result and Analysis	21
4.2	Wavelet Transform for Fault Detection	21
4.3	ANN for Fault Classification	36
CHAPTER 5	**CONCLUSION AND RECOMMENDATIONS**	**39**
5.1	Research Outcomes	39
5.2	Recommendations	39
REFERENCES		**40**

LIST OF TABLES

TABLE NO.	TITLE	PAGE
Table 2.1	Types of Fault	6
Table 3.1	Overhead transmission line parameter	16
Table 3.2	Input data for ANN training	18
Table 3.3	Binary coding for ANN training	19
Table 4.1	ANN Output when fault resistance is 0.01Ω	37
Table 4.2	ANN Output when fault resistance is 0.5Ω	37
Table 4.3	ANN Output when fault resistance is 2Ω	38

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
Figure 2.1	Symmetrical Fault	7
Figure 2.2	Unsymmetrical Fault	8
Figure 2.3	Discrete Wavelet Transform	9
Figure 2.4	Wavelet Decomposition Tree by the DWT analysis to 4-level decomposition	9
Figure 2.5	Multilayer Perceptron Neural Network	14
Figure 3.1	Methodology to identify and classify the faults	15
Figure 3.2	Power system model	16
Figure 3.3	MATLAB Simulink diagram of the power system	17
Figure 3.4	Architecture of ANN	18
Figure 3.5	Overall Program Flowchart	20
Figure 4.1	Current waveform when fault location is 15km and fault resistance is 0.01Ω at (a) LL fault, (b) LG fault, (c) LLG fault, (d) LLL fault and (e) LLLG fault.	23
Figure 4.2	Voltage and current waveform when fault location is 15km and fault resistance is 0.5Ω at (a) LL fault, (b) LG fault, (c) LLG fault, (d) LLL fault and (e) LLLG fault.	25
Figure 4.3	Voltage and current waveform when fault location is 15km and fault resistance is 2Ω at (a) LL fault, (b) LG fault, (c) LLG fault, (d) LLL fault and (e) LLLG fault.	27
Figure 4.4	Decomposition at level 5 when fault location is 15km and fault resistance is 0.01Ω at (a) LL fault, (b) LG fault, (c) LLG fault, (d) LLL fault and (e) LLLG fault.	30
Figure 4.5	Decomposition at level 5 when fault location is 15km and fault resistance is 0.5Ω at (a) LL fault, (b) LG fault, (c) LLG fault, (d) LLL fault and (e) LLLG fault.	32
Figure 4.6	Decomposition at level 5 when fault location is 15km and fault resistance is 2Ω at (a) LL fault, (b) LG fault, (c) LLG fault, (d) LLL fault and (e) LLLG fault.	35
Figure 4.7	Performance curve for fault classification	36

LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
DWT	-	Genetic Algorithm
LIF	-	Low Impedance Fault
HIF	-	High Impedance Fault
FFT	-	Fast Fourier Transform

LIST OF SYMBOLS

Z	-	Impedance
A	-	Approximate wavelet level
D	-	Detailed wavelet level
s	-	Signal
ψ	-	Mother Wavelet
E	-	Energy
R	-	Resistance
L	-	Inductance
C	-	Capacitance

CHAPTER 1

INTRODUCTION

1.1 Background of Study

A transmission line is the electrical conductors that carrying an electrical signal from generating station to the end users. The wave of voltage and current are transmitted from one end to another. To ensure the improvement of the system reliability, faster in the maintenance and restoration of power supply and quick detection of faults, accurate fault location is needed as mentioned by [1, 2]. Faults occurs when high excessive currents are flowing in which causes the damage to the equipment and devices. Hence, fault diagnosis is necessary to design suitable protection devices.

The faults are categorized into two which are unsymmetrical and symmetrical faults. Unsymmetrical faults are commonly occurs in the transmission line and is less severe than the symmetrical fault. The faults are namely line-to-ground (L-G), line-to-line (L-L) and double-line to ground (L-L-G) faults. These faults causes unbalanced in the system whereby the impedance value in each phase are different and are difficult to analyzed. The symmetrical faults are also known as balanced faults and are namely line-to-lint-to-ground (L-L-G) and line-to-line-to-line (L-L-L). These types of faults are very severe, however it are rarely occur in the power system. The system will remains balanced when faults occurs but the equipment and devices will damage severely. [3,4] When faults occurs on the overhead line, it is due to weather conditions such as lightning strike, heavy rains, fog, salt spray on contaminated insulators. These environmental conditions will disturb the power supply and also damage the electrical installation. [5]

The short circuit occurs between phase to neutral or ground or phase conductors cause low impedance faults (LIF) while high impedance fault (HIF) normally occurs due to conductors touching the ground surface or a tree branch. [6] It is important to discriminate between LIF and HIF especially for locating faults schemes, precisely. [7]

1.2 Problem Statement

Fault which occurs on transmission lines not only effects the equipment but also the power quality. So, it is necessary to determine the fault type and location on the line and clear the fault as soon as possible in order not to cause such damages. Hence, pre-processing must be applied to improve the reliability of the power system.

1.3 Research Objectives

The objectives of the research are :

(a) To analyse the transmission line fault with Discrete Wavelet Transform.

(b) To classify the fault type using Artificial Neural Network (ANN)

1.4 Scope of Work

The analysis of the fault identification and classification is categorized into two stages. Firstly, the pre-processing stage is carried out in which the simulation of signals with different types of faults are simulated using MATLAB Simulink 2013a. Three types of faults are single line to ground, double lines to ground, line to line and three phase fault. The waveform and signal produced will be computed using Wavelet Transform (WT) algorithm.

Secondly, the data from the pre-processing stage were analyzed and train using Artificial Neural Network (ANN) by simulation using MATLAB Simulink 2013a.

1.5 Thesis Outline

Chapter 1 generally describe on the fault occurs at the transmission line. This chapter also provides information on the objectives of the study, problem statement and the scope of the study.

Chapter 2 focused on the previous work done to improving the reliability of combined transmission line and methods and classifiers available to analyze the fault in the transmission line.

Chapter 3 discuss on the modelling of the overhead transmission line using SimPowerSystem toolbox of MATLAB to simulate the fault signals.

Chapter 4 analysed the result obtained from MATLAB software. The analysis of different types of faults signals will be discussed in this chapter.

Chapter 5 explain the conclusion of the overhead transmission line system and recommendation.

REFERENCES

[1] Bhuvnesh Rathore and Abdul Gafoor Shaik. “Wavelet-Alienation Based Transmission Line Protection Scheme.” IET Generation, Transmission & Distribution.

[2] Mahdi R., Ahmadreza M., Alireza A. (2015). "Fault Location in Transmission Lines Using Neural Network and Wavelet Transform." International Congress on Electric Industry Automation (ICEIA), IEEE.

[3] S. Seyedtabaii (2012). "Improvement in the performance of neural network-based power transmission line fault classifier." IET Generation, Transmission & Distribution, Vol. 6, Iss. 8, pp. 731–737

[4] Mousam Choudhury and Dr. Amrita G. (2015). "Transmission Line Fault Classification Using Discrete Wavelet Transform" 2015. IEEE.

[5] Geng N., Tianying X. Wei P., et al. (2017). "Fault Analysis of Power Transmission Line in a Generalized State-space Model Perspective." 2017. IEEE.

[6] Amin G., Herbert. L. G., Hossein A. M. (2016). "High Impedance Fault Detection: A Review." Electric Power Systems Research. Science Direct

[7] Ahmed R. A, Ragad A.E.S, Almaoataz Y.A, Nabil M,A. (2015). “Critical aspects on wavelet transforms ased fault identificatin procedures in HV transmission line.” IET Generation, Transmission & Distribution, pp. 1–10.

[8] Hanif Livani and C. Yaman Evrenosoglu, (2014) “A Machine Learning and Wavelet-Based Fault Location Method for Hybrid Transmission Lines." IEEE Transactions On Smart Grid, Vol.5

[9] Abdullah A., et. al (2015). “New Algorithm for Detection and Fault Classification on Parallel Transmission Line using DWT and BPNN based on Clarke's Transformation.” Neurocomputing, http://dx.doi.org/10.1016/j.neucom.2015.05.026

[10] A. Ngaopitakkul, et al. (2012). "An application of discretr wavelet transform and support vector machine algorithm for classification of fault types on underground cable." International Conference on Innovations in Bio-Inspired Computing and Application. IEEE.

[11] Zhiqing C., et. Al. (2006). “Energy Distribution Analysis of Impact Signals Based on Wavelet Decompositions.” Mechanical and Aerospace Engineering Department University of Virginia.

[12] N. Fischer, et. al (2012). “Protective relay traveling wave fault location.” International Conference on Developments in Power System Protection.

[13] Shimaa B., et al. (2014). “Fault location in underground cables unsing ANFIS nets and discrete wavelet transform.” Journal of Electrical Systems and Infirmation Technology 1 (2014) 198-211. Science Direct.

[14] Mamta P. and R. N. Patel. (2012). “Fault Detection and Classification on a Transmission Line using Wavelet Multi Resolution Analysis and Neural Network.” (2013). International Journal of Computer Applications (0975 – 8887) Volume 47– No.22.

[15] Nilesh S. ans R.P. Singh. (2016). “Transmission line faults detection – A review.” International Jurnal of Electrical Engineering & Technology, Volume 7, Issue 2, pp 50-58.

[16] P. Rajaraman et. al. (2016). “Fault classification in transmission lines using wavelet multi-resolution analysis.” IEEE.

[17] Rafael S.P. et. al. (2016). “A novel fault classification method using wavelet transform and artificial neural network.”. IEEE.

[18] Eisa B., and Orner A. (2012). “Transmission Line Faults Detection, Classification and Location using Artificial Neural Network.” IEEE.

[19] K. M. Silva et. al. (2006). “Fault detection and classification in transmission lines based on Wavelet Transform and ANN.” IEEE Transactions on Power Delivery, Vol. 21, No. 4. IEEE.

[20] Majid Jamil et. al (2015). “Fault detection and classification in electrical power transmission system using artificial neural network.” SpringerPlus.

[21] Sanjay Kumar et. al (2014). “Artificial Neural Network Based Method for Location and Classification of Faults on a Transmission Lines.” International Journal of Scientific and Research Publications, Volume 4, Issue 6.