INTELLIGENT FAULT DETECTION AND CLASSIFICATION FOR A POWER TRANSMISSION LINE USING POWER SYSTEM STABILIZER SIGNALS

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To my late beloved father, late sister Ramziah, my mother, my brothers and sisters

For their
Sacrifices, Encouragements and Supports

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ABSTRACT

The analysis of how power system stabilizer (PSS) able to stabilize the power system efficiently during the transmission line is an important area of research in power operation and planning. One of the essential works of power system security is to operate and handle information on fault detection effectively. In the proposed thesis, the oscillation for tow machine in “one phase fault”, “Fault with and without PSS”, “Fault with and without SVC”, are recorded at various fault locations. Multi Resolution Analysis (MRA) Wave Transform is used for fault detection. The MRA analyses the signal, where the statistical features for different locations and condition of the fault are extracted efficiently. The features are fed to Probabilistic Neural Network (PNN) to act as a fault classifier. The features are set as input vectors and the locations are set as the target. Graphic User Interface is used to monitor the whole system. When the fault is classified using PNN, its location can be used to generate control signals for PSS, which will be used to improve the stability in the power system. Therefore, this work shows the new techniques in detecting, classifying, and locating faults in a transmission line based on PSS signals as compared to traditional methods.

ABSTRAK

Projek ini mencadangkan kajian tentang bagaimana *Power System Stabilizer* (PSS) boleh menstabilkan sistem kuasa secara efisien pada saluran transmisi. Bidang kajian ini penting dalam operasi kuasa dan perancangan. Satu langkah yang pinting dalam keselamatan sistem kuasa dalam jalan pengendalian dan pengurusan maklumat kuasaberkaitan pengesanan kesalahan secara berkesan. Dalam projek ini, osilasi untuk enjin tow pada "satu fasa kesalahan", "*Fault* dengan dan tanpa PSS", "*Fault* dengan dan tanpa SVC " direkod di pelbagai lokasi kesalahan digunakan untuk pengesanan kesalahan Analisis Multi-Resolusi (MRA) gelombang Transformasi. MRA analisis menganalisis isyarat di mana ciri statistik untuk pelbagai lokasi dan keadaan kesalahan diperoleh secara berkesan. Ciri-ciri yang diberikan untuk kebarangkalian *Neural Network* (PNN) untuk bertindak sebagai suatu penggolong kesalahan; masukan vektor dan lokasi diberi sebagai sasaran. Pengatara muka yang digunakan untuk memantau keseluruhan sistem. Ketika kesalahan dikelaskan menggunakan PNN, lokasinya boleh digunakan untuk menghasilkan isyarat kawalan untuk PSS untuk meningkatkan kestabilan sistem kuasa. Oleh kerana itu, kajian ini akan menunjukkan teknik baru dalam mengesan, mengklasifikasi, dan menentukan kesalahan-kesalahan dalam saluran penghantaran berdasarkan isyarat PSS berbanding dengan kaedah konvensional.

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LIST OF SYMBOLS

a	-	Activation Function
$a_{[n]}$	-	Approximations
b^n	-	n Bias
D	-	Dimension
$d_{[n]}$	-	Details
dw	-	Speed Deviation
G	-	Generator
G_0	-	Low Pass Filter
h	-	Thresholded wavelet coefficient
H_0	-	High Pass Filter
$\boldsymbol{IW}$	-	Weight Matrix
LW	-	Layer Weight
$M1$	-	Machine one
$M2$	-	Machine two
nb,i	-	Number of bins
$nprod$	-	Neuron Product Box
$\boldsymbol{p}$	-	Input Victor
Pa	-	Acceleration Power
Peo	-	Output Electrical Power
Pm	-	Mechanical Difference Power
pu	-	Per Unit
Q	-	No of Neurons
R	-	No of Element
s	-	Scale parameter
S^n	-	Number of Neurons in n Layer

t	-	Time
$\boldsymbol{T}$	-	Target
v	-	Voltage at local node
v_b	-	Voltage base
v_m	-	Voltage at SVC node
$\boldsymbol{w}$	-	Weight
$X(j)$	-	Number of date with equal spaced within bin
$x(t)$	-	Signal
$X[n]$	-	Sequence Signal
Xb	-	Date with equal spaced
Yb	-	decomposition signal
Y_L	-	Local Load
Z	-	Transmission Line
τ	-	Translation parameter
ψ	-	Mother wavelet

LIST OF ABBREVIATIONS

AI	-	Artificial Intelligent
ANFIS	-	Adaptive Network Fuzzy Interface System
ANN	-	Artificial Neural Network
CWT	-	Continuous Wavelet Transform
db	-	Daubechies
DWT	-	Discrete Wavelet Transform
EMTDC	-	Electromagnetic Transients Including Direct Current
FACTS	-	Flexible Alternative Current Transmission Systems
FMB	-	Free-Model based
FMBOC	-	Free-Model based Optimal Controller
FWT	-	Fast Wavelet Transforms
GRNN	-	Generalized Regression Neural Network
GUI	-	Graphical User Interface
HTG	-	Hydraulic Turbine and Governor
HVDC	-	High Voltage Direct Current
IEEE	-	Institute of Electrical & Electronic Engineering
JPEG	-	Joint Photographic Expert Group
LQR	-	Linear Quadratic Regulator
MATLAB	-	Matrix Laboratory
MB PSS	-	Multiband Power System Stabilizer
MRA	-	Multi Resolution Analysis
NN	-	Neural Network
PNN	-	Probabilistic Neural Network
POD	-	Power Oscillation Damping

PSS	-	Power System Stabilizer
RBN	-	Radial Bases Network
RCGA	-	Real-Coded genetic algorithm
SIL	-	Surge Impedance Loading
STFT	-	Short Time Fourier Transform
SVC	-	Static Var Compensator
SWT	-	Stationary Wavelet Transforms
TCR	-	Thyristor Controlled Reactor
TSC	-	Thyristor Switched Capacitor
TSR	-	Thyristor Switched Reactor
TV	-	Television
VAR	-	Volt-Ampere Reactive
WPD	-	Wavelet Packet Decomposition
WT	-	Wavelet Transform

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CHAPTER 1

INTRODUCTION

1.1 Overview

Power system consists of complex electric power transmission line that delivers electricity from the main generator to various places. The power transmission network consists of power plants connected to multiple substations that supply electricity to desired area. The length of the transmission line depends on how far the desired area is from the power plants; it might be hundreds to thousands kilometres along the way, as illustrated in Figure 1.1.

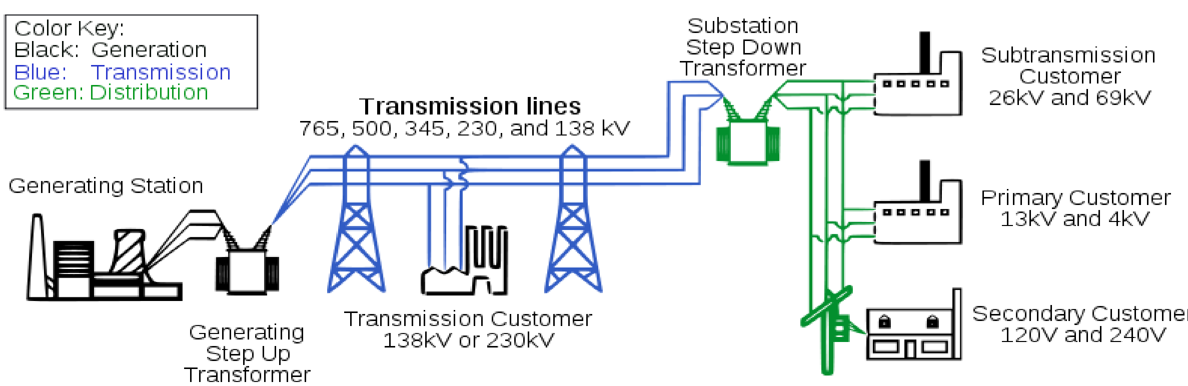

Figure 1.1 Electric Power System.

Usually power transmission lines use three phase ac current or single phase ac current, while high-voltage direct current systems are used for long distance transmission, or undersea cables. However the electricity is transmitted at 110 kv or above in order to reduce the energy lost in transmission, and the power is usually transmitted as alternating current through overhead power lines. The material for overhead transmission line is always aluminum alloy, made into several strands with steel strands, and sometime copper. The amount of power transmitted along the transmission lines is limited due to the length of the line. For a short line, heating might occur due to line losses and if too much current is drawn, it may damage the system. For intermediate-length lines on the order of 100 km around 60 miles, the limit is set by the voltage drop in the line, and for longer lines, system stability sets the limit to the power that can be transferred.

1.2 Problem Statement

The essential purpose of establishing power system security is to control power operation and transmission line by clearing faults and overcoming the disturbances that occur. Electric power systems are among the largest and complex structure, where are subjected to a wide range of small and large disturbance and faults conditions that can be defined in term of locations, resistance, type, and inception time. The power system is a highly nonlinear system that operates in a constantly changing environment since loads, generator outputs and parameter change continuously. When it is subjected to disturbance and fault condition, the stability depends on the initial operation condition and the nature of disturbance. However, the system must be able to adjust to the changing condition and clear faults condition to continue in a satisfaction operation.

The electric power must be transferred from generators in the plant system in a way that reduces the speed deviation and oscillations. It is consists of different complex integrated elements where faults cab occur somewhere along the generating station and highly interconnected power system. These faults on need to be detected, located rapidly, classified correctly and cleared as fast as possible in order to stabilise the power system operations. Fault detection provides additional level of security.

Power system oscillations system cannot operate without control technique and compensating strategy. The operator has to control the power that the generator supplies under normal operating conditions that will improve the transient stability and power oscillation that can damp of the power system. In most generators, the speed system is adjusted by the prime mover to keep the generator speed constant, and regulate voltage systems. The automatic control in power systems must ensure transient stability and avoid oscillation being occurred by the generators or faults during the transmission.

1.3 Objectives of The Project

The main aim of this study is to propose a new method in supervised neural network fault classifier from transmission line signals extracted from power systems during the transmissions; Power Systems Stabilizer (PSS) and Static Var Compensator (SVC) play rules in improving stability and damping oscillation. As already known, Power systems stabilizers have been used to add damping to electromechanical oscillations to improve the transient stability and power oscillation. Initially, they act through the generators excitation system in such a way that a component of the electrical torque proportional to speed change is generated.

The detection and classification of fault technique in the transmission line is therefore a very critical area in power system to ensure stability of power system during transmission. Moreover, knowing the location and feature of the faults which occur in transmission line gives the ability for Power System Stabilizer to improve the stability by clearing these faults. Power systems stabilizer (PSS) uses lead network compensator to regulate the input signal and give the correct phase, and also adopted in order to improve the stability of inter-area mode.

The output signals of the speed deviations of the generator machine_1are taken as the input for wavelet analysis. The basic concept in wavelet analysis is to select a proper wavelet transformation, and then perform an analysis using its translated and dilated versions. In this study the Daubechies wavelet transform (db) is used to analyze the speed deviation measured in the test system and extract features of faults in the transmission line.

1.4 Scope of The Project

Power system stability is similar to the stability of any dynamic system, and has fundamental mathematics, as power system develop through the growth in interconnection of new technologies and controls and increasing of operation and demand different form of instability factors involved. Furthermore, there are many different kinds of instability that exist for example; voltage stability, frequency stability, and interarea oscillation and so forth. Therefore, clear understanding of different kinds of instability and faults need to be reviewed in order to develop the system control of designing a satisfactory power system stability that will meet our requirement in stabilising the power system operations.

Many application and useful techniques has been applied in the recognition of faults. Many of them could distinguish which phase of the three power system is faulty, with their some algorithm and proposed techniques that show good performance in defining different combination of faulty detections, e.g. fault type, fault resistance, fault inception angle, fault location, pre-fault power flow direction, and short circuit level. When faults occur on the transmission line, the power system goes through a transient period, and then the power system will be ruling to step up the power system to be in the dynamic area as shown in Figure 1.2.

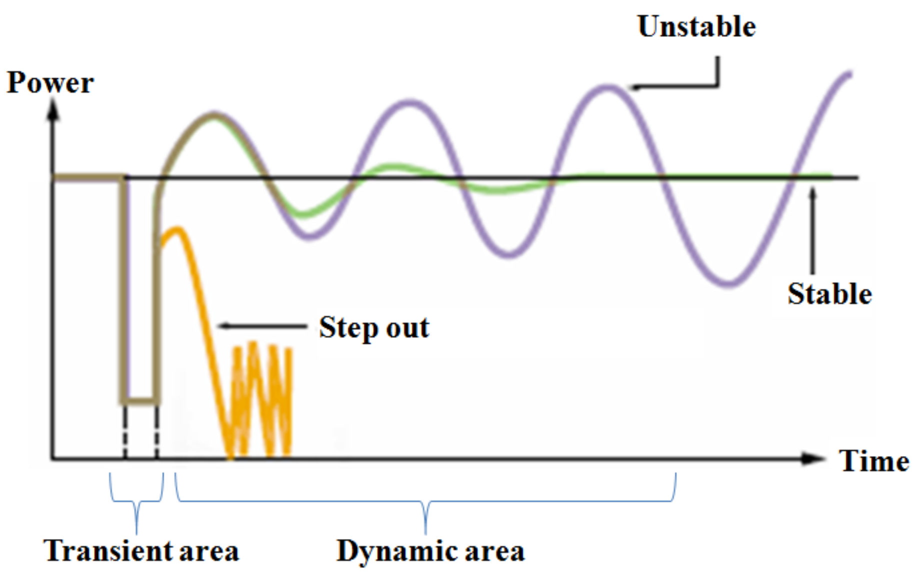

Figure 1.2 Power System Stabilizer effect in transmission line.

During transmission, fault signature will be detected and classified in terms of type, location, resistance, inception angle. This is important in order to understand the behavior of faults to overcome and clear then by the use of power system stabilizer.

For fault detection using a Multi Resolution Analysis (MRA) Wavelet Transform, the nature of oscillations signals is to decay rather than grow. This leads to mathematical analysis techniques necessary to predict system performance, and control methods to ensure that oscillations decay with time. For fault classification, the supervised neural network is considered as one of the best classifier. However, in order to use them as a classifier technique, it needs special algorithms and training data which could be implemented and used as output control signals by the power system stabiliser (PSS).

1.5 Thesis Out Line

This thesis is organized into six chapters:

Chapter 1 introduces a comprehensive overview, scope and objectives of the project.

Chapter 2 provides an extensive review of fault detection on transmission lines, performance of modern Power System Stabilizer, and fault classification which is are proposed by researchers.

Chapter 3 discusses the background of the project and the Basic concepts of power system stability, applying PSS in power system, Wavelet Transforms, and Artificial Neural Networks.

Chapter 4 describes of the methodology process and highlights the steps that have been taken to achieve the objective of this project.

Chapter 5 presents the results of fault detection and classification on transmission line using power system stabilizer signals, which applied in one phase fault in different locations, then the signals are fed to Wavelet Transform to get best features and use them it as input to Probabilistic Neural Networks (PNN).

Chapter 6 consists of the conclusion and some suggestions for future work.