TRAVELLING WAVE METHOD FOR TRANSMISSION SYSTEM FAULT LOCATION

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To my beloved mother and father and sisters and brothers

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ABSTRACT

Extra high voltage transmission lines are designed to transfer large amount of power from one location to another. The length exposed to the environment is a major reason for occurrence of faults on the lines. A fault on a high voltage transmission line affects the stability of the overall power system, which sometimes leads to permanent damage of the equipment. Travelling wave theory on transmission line systems based on faults and others parameter is presented. Voltage and current travelling waves are generated when a fault occurs on the transmission line. The velocity of propagation of travelling waves is finite and the level of the waves decreases with increase in the distance traveled. Information about the fault can be obtained by analyzing the travelling waves. A few travelling wave techniques, which are based on analog signal processing, to locate the location in transmission lines, are proposed in this thesis. The travelling waves are extracted from the modal voltages and currents at the single and multi terminals of the transmission line. The techniques identify and locate the fault by using the information contained in the waves. A power system has been modeled in the results of single phase to ground fault. From the wave, arrival and reflection times are obtained and then used in different formulas for both single and multi end to determine the fault locations. The techniques have been simulated using PSCAD/EMTDC and their performance has been tested on 2 Busbars and IEEE 15 Busbars test systems. The results reveal that the technique is able to locate the fault. Multi end approach result is found to be more accurate than single end technique.

ABSTRAK

Talian penghantaran voltan tingi tambahan (EHV) direka untuk menghantar jumlah kuasa yang besar dari satu tempat ke tempat yang lain. Talian yang terdedah kepada persekitaran adalah penyebab utama berlakunya kerosakan talian. Kerosakan talian penghantar voltan tinggi mempengaruhi kestabilan keseluruhan sistem kuasa, dimana kadangkala ia menyebabkan kerosakan kekal kepada peralatan. Teori pergerakan gelombang pada sistem talian penghantaran berdasarkan kerosakan-kerosakan dan parameter lain diterangkan, pergerakan voltan dan arus terhasil apabila berlakunya kerosakan pada talian penghantaran. Halaju pergerakan gelombang-gelombang ini adalah terhad dan tahap gelombang-gelombang ini berkurang dengan petambahan jarak pergerakan. Maklumat kerosakan talian boleh diperolehi dengan menganalisis pergerakan gelombang-gelombang ini. Beberapa teknik pergerakan gelombang untuk mengenalpasti lokasi kerosakan talian penghantaran berdasarkan pemprosesan signal analog telah diperkenalkan dalam tesis ini. Pergerakan gelombang-gelombang ini diekstrak dari modal voltan dan arus pada talian penghantaran yang mempunyai satu terminal dan juga pelbagai terminal. Teknik-teknik ini mengenalpasti dan menentukan lokasi kerosakan dengan menggunakan maklumat yang terdapat pada gelombang-gelombang tersebut. Model sistem kuasa diperolehi dari keputusan-keputusan kerosakan satu fasa ke bumi. Masa tiba dan pemantulan didapati dari gelombang yang kemudiannya digunakan dalam formula-formula yang berbeza untuk kedua-dua hujung tunggal dan berbilang dalam menentukan tempat kerosakan. Teknik tersebut telah disimulasi menggunakan PSCAD/EMTDC dan perlakuannya telah diuji ke atas sistem ujian 2 bus dan 15 bus IEEE. Keputusan yang diperolehi menunjukkan bahawa teknik tersebut berkebolehan menentukan tempat kerosakan. Pendekatan hujung berbilang telah didapati memberikan keputusan yang lebih tepat berbanding dengan teknik hujung tunggal.

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LIST OF SYMBOLS

α	-	Attenuation constant [Nepers/m]
Y	-	Admittance [℧]
C	-	Capacitance [F]
Z_0	-	Characteristic impedance [Ω]
G	-	Conductance [℧]
L	-	Inductance [H]
Ψ	-	Mother Wavelet
v	-	Propagation speed [km/s]
γ	-	Propagation constant
R	-	Resistance [Ω]
t	-	Time [s]
i_0	-	
D	-	Distance [km]

LIST OF ABBREVIATIONS

EHV	-	Extra High Voltage
EMTDC	-	Electromagnetic Transient Direct Current Analysis
PSCAD	-	Power Systems Computer Aided Design
GPS	-	Global Positioning System
ATP	-	Alternative Transients Program
ATPDraw	-	A preprocessor for ATP
CCA	-	Cross Correlation Analysis
CWT	-	Continuous Wavelet Transform
DFT	-	Discrete Fourier Transform
DWT	-	Discrete Wavelet Transform
EMTP	-	Electromagnetic Transient Program
FFT	-	Fast Fourier Transform
STFT	-	Short Time Fourier Transform
TW	-	Travelling Wave
TWR	-	Travelling Wave Recorder
TDR	-	Time Domain Reflectometery
t_s		Sampling Time [sec]
t_i	-	Current transformation matrix
WTC	-	Wavelet Transform Coefficients
WCF	-	Wavelet Correlation Function

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Fault studies form an important part of power system analysis .There are different types of faults. Faults on power transmission lines are divided into three phase balanced faults and unbalanced faults. Different types of unbalanced faults are the single line to ground fault, line-to-line fault, and double line to ground fault.

In Electric power system, when transmission line fault occurring, plenty of transient components of different frequency will be generated. Lots of fault information is included in the transient components. So it can be used to predict the fault or abnormity of equipments or power system, deal with the fault and analyze the reason of fault or abnormity, the reliability of the power system will be considerably improved. Today, to accurately obtain large amounts of various fault transient information in time has become the reality. However, the key problem is how to use those transient signals to detect fault or to classify fault. Therefore, the new information mergence methods and the effective technology used in detection and classification of electric power system faults transient is need to studied.

A power system, when affected by faults, will results in the disruption of power flow. It is essential to find the fault location to repair and restore this flow. The location of faults must be determined quickly and accurately to improve the economy, safety and reliability of such a power system.

Many schemes have been devised to locate faults, most are which based on the travelling wave propagation on the transmission line. However, diagnosing a fault in a system poses many difficulties, especially for conventional logical techniques or linear algorithms. This is especially true because most faults locators rely only on local measurements, which do not take into account all the information from both terminals of lines.

1.2 LITERATURE REVIEW

In 1981 T. Takagi,et.al. [1] The subject of fault location has been of considerable interest to electric power utility engineers for a long time. Fault detection and location methods that have been proposed and implemented so far can be broadly classified as those using the power frequency phasors in the post-fault duration

In another study in 2004, Zeng Xiangjun, et.al. [2] Fault location using travelling wave has been applied in extra-high voltage power grids successfully, a new travelling wave fault location system is developed simply in a cost-effective way for power networks (especially for distribution system) in this paper. Two travelling wave sensors are developed to capture the current travelling wave flowing from the capacitive equipment to earth and the voltage travelling waves in all three phases. The outputs of the sensors are then applied to the trigger and time tagging by using Global Position System (GPS) receiver. The fault position is calculated by the travelling wave arrival times in every power station where only one fault locator is installed.

In 1998, Qin Jian Chen, et.al. [3] Presents a new fault location principle based on the double terminal methods of travelling wave using continuous wavelet transform (CWT). Due to the attenuation and distortion of travelling wave propagation in a transmission line, travelling wave correctly. Since CWT has much better resolution for locating a transient event in time-domain, the arrival time can be defined by characteristic point of travelling wave extracted by suitable continuous wavelet with the optimal dilation parameters, and the propagation velocity depends on the physical configuration of a transmission line and the optimal dilation parameters

Also S. Ekici and S. Yildirim in June, 2006[4] have presents a wavelet transform (WT) and artificial neural network (ANN) based algorithm for estimating fault location on transmission lines , This paper presents a wavelet transform (WT) and artificial neural network (ANN) based algorithm for estimating fault location on transmission lines. The algorithm is developed as a one-end frequency based technique and used both voltage and current effect resulting from remote end of the power system. Fault simulation is carry out in Alternative Transient Program (ATP). One cycle of waveform, covering pre-fault and post-fault information is abstracted for analysis. The discrete wavelet transform (DWT) is used for a reprocessing and this data are used for training and testing ANN. Five types of mother wavelet are used for signal processing to identify a suitable wavelet family that is more appropriate for use in estimating fault location. It is found that the proposed method gives satisfactory results and it was useful for estimating fault location.

It is in the May 2004 both of A., Elhaffar, M., Lehtonen,[5] have done a new method as fault locator that is based on the characteristics of the travelling waves investigates the problem of fault localization using travelling wave current signals obtained at a single-end of a transmission line and/or at multi-ends of a transmission network. A review of various signal-processing techniques is presented. The wavelet transform is found to be more accurate than conventional signal processing techniques for extracting the travelling wave signals from field measurements. In this thesis, an optimization method has been developed to select the best wavelet candidate from several mother wavelets. The optimum mother wavelet was selected and used to analyze the fault signal at different details' levels. The best details' level, which carries the fault features, was selected according to its energy content. From the line and network data, the travelling wave speed is calculated for each line using the optimum mother wavelet at different detail levels. Accurate determination fault location depends on the proper details wavelet level as well as the propagation speed.

Various other developments can be seen in the work of other researchers for instance, a backup protection scheme for a transmission network, which uses an action factor based expert decision system to provide optimal fault clearance for faults located anywhere in the protected network, can be seen in the work of Tan, 2000. On the other hand, Chen, Zheng , luo Chengmu) ; su Jinxi and wu Xinrong in 2001,[6] uses a fault location algorithm which is based on the distributed parameter technique using synchronized samples with a Global Positioning System (GPS). It can eliminate the effect of line-shunt capacitance automatically. By considering untransposed and unbalanced transmission lines, phase components are transformed to model components in the fault location algorithm. Computer simulations show a high accuracy and a location error of about 0.4%. It is also not influenced by fault resistance, type, location, and incident.

In 1983 P.A. Crossly and P.G. McLaren, [7] in order to achieve the different of the signal processing techniques have been employed, including cross correlation between the forward and backward travelling waves along the line. In the single-ended method, the fault transients which is reflected from the fault point and arrive at the relay terminals, produces a highly correlated signal for a delay time equal to twice the travelling time of the transients to the fault location. This time can be then used to find the distance from the relay to the fault location. However, there are also some bottlenecks.

1.3 Problem statement

Conventional fault detection algorithms are designed based on current or voltage magnitude measurements. Increase of current magnitude or decrease of voltage/impedance magnitude could be considered as a measure to detect a system fault. These algorithms are dependent on various factors such as fault resistance and power system short circuit capacity.

Current based starters get confused when load current is significant compared to fault current. Conventional over current based starters may not be able to detect faults with high amount of fault resistance.

Current and voltage magnitudes should be estimated correctly using appropriate filtering algorithms. When a fault happens on a transmission line, the power system goes through a transient period. It might not be easy to determine current/voltage signal magnitude fast and precisely during the transient period after the occurrence of the fault.

As power systems grow in both size and complexity, it becomes necessary to identify different system faults faster and more accurately using more algorithms that are powerful. It would be desirable to design a reliable and fast algorithm to classify different power system faults for various system parameters and fault states.

In this project report , a hardware implementation of fault detection and location based on travelling wave is proposed; a prototype system will developed on travelling wave prove capable of real-time fault detection

1.4 Objective

This project aims to achieve the following:-

i. To review various methods Fault Location Signal Processing Techniques.
ii. To develop travelling wave fault location method via PSCAD package program.
iii. To analysis the techniques and simulate on 2 Bus and IEEE15 Busbars

1.5 Scope

The scope of this project will be is in five stages.

i. Review various methods in Fault Location Signal Processing Techniques
ii. Analysis fault location using travelling wave signals extract at single –end of transmission line and multi-end.
iii. Apply the wavelet transform as the signal processing technique.
iv. Perform fault locating by using the PSCAD software package program.
v. Analyze and verify results were tested on2 Bus and IEEE 15 busbar system.

1.6 Project Report Organization

This project report organized into six chapters, which completely cover the whole work. The work has been conducted for fault location via travelling wave.

Chapter two that discusses on literature review and related work on fault location methods and theory on travelling wave.

In third chapter various methods related to fault location signal processing techniques, and summary are discussed.

In fourth chapter, discussion on the methodology process is presented by showing the detailed diagram of the project methodology for single, multi end and highlights briefly the steps that have been taken to meet the objective of this project.

In fifth chapter, the sixth chapter, in tandem, the results and discussion, the conclusion as well as some suggestions for the future work are presented.

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