ARCING FAULT RECOGNITION USING SPECTRAL ANALYSIS METHOD

MAJID GHOLAMI

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

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

MAY 2009

ABSTRACT

In transmission lines while one fault happens it's crucial to recognize the kind and the type it belongs to. This means it must be indentified whether it is transient or permanent. The methods for recognizing these faults can be categorized into two varieties. First, in the dead time of recloser and second during faults. This project studies the second method which has the capability to recognize the type of fault during the fault, means before the breaker's opening, which is called spectral analysis method. In this project programming of arcing faults recognition base on spectral analysis method was presented in ATP and MATLAB software. Then, the most frequent single-phase to ground fault on transmission line was considered and results were evaluated with and without the fault resistance into fault model. Ultimately, it is concluded that spectral analysis method operates sooner than previous methods for arcing fault recognition that can improve the power system transient stability and reliability. Furthermore, it provides much higher service continuity to the costumers.

ABSTRAK

Dalam satu talian penghantaran apabila berlaku kerosakan, maka proses mengenalpasti jenis kerosakan adalah kritikal. Ini bermaksud kerosakan itu mesti dikenalpasti samada ianya sementara atau kekal. Kaedah untuk mengenalpasti kerosakan ini boleh dikategorikan kepada 2 jenis iaitu masa alchir penutupan dan semasa kerosakan. Kajian ini menumpu kepada kaedah yang ke dua dimana jenis kerosakan dikenalpasti sewaktu kerosakan itu berlaku iaitu sebelum pemutus litar dibuka yang dipanggil kaedah analisis spectral. Dalam kajian ini, pengaturcaraan mengenalpasti kerosakan lengkung berasaskan kaedah analisis spectral telah dilakukan dengan menggunakan perisian ATP dan MATLAB. Kemudian, kekerapan kerosakan fasa-tunggal dalam lini penghantaran dipertimbangkan dan keputusannya dinilai dengan penangkis kerosakan dalam model kerosakan. Akhirnya, dapat dibuat kesimpulan bahawa kaedah analisis spectral beroperasi lebih cepat daripada kedah sebelumnya dalam mengenalpasti lengkung kerosakan dan ini boleh meningkatkan kestabilan dan kebolehpercayaan sistem kuasa sementara. Tambahan pula, ianya menyediakan perkhidmatan yang lebih baik kepada pelanggan secara berterusan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Autorecloser is a circuit breaker equipped with the mechanism that can automatically close the breaker after it has been opened due to a fault. Autoreclosers are used in coordinated protection schemes for overhead line power distribution circuits. These circuits are prone to transitory faults such as nearby lightning strikes, wind-borne debris, squirrels climbing insulators, and the like.

With a conventional circuit breaker or fuse, a transient fault would open the breaker or blow the fuse, disabling the line until a technician could manually close the circuit breaker or replace the blown fuse. But an Autorecloser will make several pre-programmed attempts to re-energize the line. If the transient fault has cleared, the

Autorecloser's circuit breaker will remain closed and normal operation of the power line will resume. If the fault is some sort of a permanent fault (downed wires, tree branches lying on the wires, etc.) the Autorecloser will exhaust its pre-programmed attempts to re-energize the line and remain tripped off until manually commanded to try again. Many of faults on overhead power lines are transient and can be cured by Autoreclosing [1].

The result is increased availability of supply. Worldwide experience has shown AR to be a very valuable feature, especially during multiple faults when power networks are heavily stressed. However, AR is not without its risks, which have to be balanced against the benefits. Some of the inherent risks have been overcome with improvement in circuit and logic design of the AR relay, but the principle outstanding risks are those associated with reclosing onto permanent faults [2–4].

1.1.1 Fault Recognition

Somewhat about 80 % to as high as 90 % of faults on most overhead lines are transient. For such faults, by deenergizing the line long enough for the fault source to pass and the fault arc to deionize, the service can be restored by automatically reclosing the breaker. This can improve power system transient stability and reliability providing much higher service continuity to customers. However, reclosure onto a permanent fault may aggravate the potential damage to the system and equipment. Hence the fault recognition can be very important factor for stability and reliability of power transmission system [5].

1.1.2 Arcing Fault

An arc fault is a high power discharge of electricity between two or more conductors. In power engineering, a transient fault (arcing fault) is a fault that is no longer present if power is disconnected for a short time. Many faults in overhead power lines are transient in nature. At the occurrence of a fault, power system protection shall operate isolating the area of the fault. A transient fault will then clear and the power line can be returned to service.

Typical examples of transient faults include [2]:

- Momentary tree contact
- Bird or other animal contact
- Lightning strike
- Conductor clash

In electricity transmission and distribution systems an automatic reclose function is commonly used on overhead lines to attempt to restore power in the event of a transient fault. This functionality is not as common on underground systems as faults there are typically of a persistent nature. Transient faults may still cause damage both at the site of the original fault or elsewhere in the network as fault current is generated [2].

1.1.3 Spectral Analysis Method

Performance and power analysis in modern processors requires managing a large amount of complex information across many time-scales. Fourier analysis allows one to transform a waveform into a sum of component (usually sinusoidal) waveforms in the frequency domain; in this way, the waveform fundamental frequencies (periodicities of repetition) can be clearly identified [6].

The voltages and currents at the line terminals contain harmonics. The distortions of signal waveforms depend on the fault distance and the arc voltage amplitude. The line terminal voltage and the current contain the harmonics induced by arc voltage, particularly the odd components. These amplitudes are not comparable to the fundamental harmonic amplitude, but in spite of that are mathematically recognizable and measurable. So the spectral analysis method can be used for arcing fault recognition during the fault [7].

1.2 Project Background

V.V. Terzija et al [8] presented main numerically definition of the arc voltage waveform. As a basis of the result of this research, some researchers used these properties to recognise the type of fault during faults. But also some researchers worked on recognise the type of fault based on the deadtime of recloser.

1.2.1 Characteristic of Long Arc in Free Air

V.V. Terzija et al [8] presented Parametrische Modelle des Lichtbogens und Parameterschatzung auf Grund der simulierten und echten Daten. In his work the arc voltage waveform is defined numerically on the basis of a great number of arc voltage records obtained in the high voltage laboratory using a transient recorder with the sampling frequency of 10.417 kHz .

V.V. Terzija et al [9] presented long arc in still air: modeling simulation and model parameter estimation. the long arc in still air is initiated under laboratory conditions in the high power test laboratory FGH-Mannheim (Germany).

V.V. Terzija et al [10] presented long arc in free air: modeling, simulation and model- parameters estimation. It is shown that the long arc in free air possesses nonlinear and nonstationary features. Features are investigated by analysis data records obtained in the FGH-Mannheim high power test laboratory (Germany).

1.2.2 Arcing Fault Recognition

G e. Y. et al [11] presented prediction method for preventing single phase reclosing on permanent fault. The principle of method is distinguishing between temporary and permanent faults based on measuring the voltages on the opened phase conductor and investigates these voltages at temporary and permanent fault conditions separately.

Aggarwal et al [12] presented neural network based adaptive single pole autoreclosure technique for EHV transmission systems. Adaptive Single Pole AutoReclosure (SPAR) offers many advantages over conventional techniques. In the case of transient faults, the secondary arc extinction time can be accurately determined and in the case of a permanent fault.

Ahn . S. et al [13] presented an alternative approach to adaptive single pole autoreclosing in high voltage transmission system based on variable deadtime control. This paper presents a new concept, based on variable dead time control; in adaptive single pole auto-reclosing (SPAR).

D juric et al [14] presented digital signal processing algorithm for arcing fault detection in transmission systems where derived by processing line terminal voltage and current during the fault, i.e. before the breaker opening that can be applied only for three phase symmetrical and double phase faults.

RADOJEVIC et al [5] presented spectral domain arcing fault recognition and fault distance calculation in transmission systems for unsymmetrical faults. The method is based on simultaneous processing of the first and third voltage and current harmonics. They are used not only for arc voltage detection, but also for fault distance calculation. Thus, the method can be used for fault location, too.

RADOJEVIC [7] presented a novel approach to the distance protection, fault location and arcing fault recognition for single-phase to ground faults. This method is based on simultaneous processing of the first and third voltage and current harmonics too, but the fault model of this method is containing of the fault resistance of the fault.

C.J.Lee et al [15] presented two-terminal numerical algorithm for fault location estimation and arcing fault recognition. It based on the synchronized phasors measured from PMUs that are installed at both sides of the transmission lines. The fundamental and third harmonic phasors are used to estimate fault location and arc voltage amplitude.

This project presents programming of arcing faults recognition base on spectral analysis method in ATP and MATLAB software and considers most frequent single-phase to ground fault on transmission line and verify results with and without the fault resistance into fault model.

1.3 Research Questions

The research will basically focus in answering the following questions:

i. How to analyze arcing faults recognition with spectral analysis method?

ii. How to develop an ATP and MATLAB based program to trace arcing faults recognition base on spectral analysis method?

iii. How to verify the results of spectral analysis method with and without the fault resistance into fault model?

1.4 Objectives

i. To study and analyze arcing faults recognition with spectral analysis method

ii. To develop an ATP and MATLAB based program to trace arcing faults recognition base on spectral analysis method

iii. To verify the results of spectral analysis method with and without the fault resistance into fault model

Remark: for single phase to ground faults

1.5 Scope

Since somewhat about 90% of faults on most lines are transient. The make distinction between permanent and transient fault are important for better performance of (AR) in the transmission lines. . Because Recloser onto permanent fault may aggravate the potential damage to the system and equipment. We propose this project base on spectral analysis method for arcing fault recognition which will derived by processing line terminal voltage and current during the fault. The main concern of this project is to survey and evaluate results with and without the fault resistance into fault model for single-phase to ground fault.

1.6 Report Organization

This project has been categorized into 5 chapters which are introduction, literature review, research methodology, results & discussion and conclusion & recommendation.

In the first chapter, introduction, the basic elements of the project such as objectives, scope and problem statement have been explained.

Afterwards, in the literature review, all the previous studies which have been done in this realm have been mentioned in order to prepare a roadmap for further studying.

In the forth chapter, results and discussion, after programming of arcing fault recognition base on spectral analysis method in ATP and MATLAB software , single phase to ground fault on transmission line is considered and it is verified with and without the fault resistance into fault model.

In the last chapter a conclusion has been made based on the previous analysis which had been carried out in the forth chapter. Then a recommendation was proposed in order to find the best choice between various arcing fault recognition.

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