FAULT LOCATION USING LINE IMPEDANCE WITH THE PRESENCE OF ARC RESISTANCE

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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

JANUARY 2014

Dedicated to my lovely Mother

To the soul of my Father

To my Brothers and Sisters

To my Wife

And to all those that believed in me

ACKNOWLEDGEMENT

First and foremost, my unlimited appreciation goes to my Lord Allah (swt) for the endless mercies, blessings and guidance through from birth till now and forever. Then I shall forever be grateful to my parents, my siblings and my wife for their belief in me and for their unending support.

My sincere appreciation goes to my supervisor **Dr. Ahmad Safawi bin Mokhtar** for his guidance and support. My earnest appreciation also goes to all my friends and colleagues that helped me to successfully complete the Master program and this project. To you all I say thank you.

Besides, I would like to thank the authority of Universiti Teknologi Malaysia (UTM) for providing us with excellent environment and useful facilities such as the rich online database that is needed to complete this project.

ABSTRACT

Many methods were developed to identify the estimated location of faults in distribution systems. They are either dealing with the travelling waves generated by faults at high frequencies or using the fundamental frequency components. Among them “Fault Impedance Methods” are the most popular, but their accuracy is affected by the presence of fault resistances and the presence of arcs. In this project, PSCAD is used for simulating several types of faults, focusing in three lines to ground faults with different cases, including faults with and without fault resistance in addition to faults with arc. The fault impedance method code that improved to consider the presence of arcs and its resistance and implemented using MATLAB programming environment is used to estimate the fault location for the previous cases. As expected, the method is sensitive to the presence of fault resistance and fault arcs. However, the improved method achieved good results for faults with arcs at distances higher than 15 km and slightly improved results for shorter distances.

ABSTRAK

Pelbagai kaedah telah dibangunkan untuk mengenal pasti lokasi kerosakan dalam sistem penghantaran bekalan elektrik. Kerosakan pada system penghantaran bekalan elektrik bergantung kepada gelombang penghantaran dihantar pada frekuensi tinggi atau komponen frekuensi asas."Kaedah kerosakan galangan " merupakan kaedah yang paling popular, tetapi ketepatan mereka banyak dipengaruhi oleh kehadiran rintangan dan arka. Perisian PSCAD digunakan untuk menganalisis jenis kerosakan terutama sekali pada kerosakan "3 line to ground" termasuk kerosakan yang melibatkan rintangan dan juga yang tidak melibatkan rintangan. Aturacara MATLAB yang dibangunkan dalam projek ini akan digunakan untuk mengenalpasti lokasi kerosakan pada sistem penghantaran bagi kes-kes sebelumnya dengan mengambil kira rintangan dan arka. Seperti yang telah dijangkakan, kaedah yang dibangunkan dalam projek adalah sangat berkesan dan sensitif pada kehadiran rintangan dan arka. Kaedah yang dibangunkan dalam projek ini telah berjaya mengenalpasti lokasi kerosakan pada sistem penghantaran pada jarak 15km ke bawah dengan mengambil kira kehadiran rintangan dan arka

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

1.1 Introduction

In electrical power systems, permanent faults manifest in some sort of damage that must be repaired before restoration of supply. The process of restoration can become faster if the exact fault location is known or can be estimated with good accuracy. The estimation of fault location can be achieved by fault locators that can provide estimate for both sustained and transient faults. Despite their transient nature, as the supply can be restored normally, transient faults may cause minor damage in power system element or they may be a result of power system element aging and act as early warning for permanent fault, but evidences are not easily found during inspection. Fault locators help in those locations identification for deeper inspection, early repair and corrective actions to avoid fault recurrence and prevent the consequent major damages. [1]

In transmission systems, and due to the high impact on system stability and the wider effect of faults within them, a lot of researches were performed and sophisticated instruments and methods were developed to help in identification of the faulty section and fault location and very fast and highly selective protection systems are usually installed, among these protection systems PMUs or phase measuring units achieved high accuracy faults location using either synchronised sequence measurement or synchronised phasor measurement. [2, 3]

On the other hand, fault location process in distribution systems, traditionally, did not involve any type of instruments dedicated for the fault location purpose, where visual inspection in the form of line patrolling was usually performed and sometimes line sectioning was used to reduce the inspection area if the fault sustained but no evidence found. The traditional fault location technique is not recommended as it involves switching on fault that may lead to dangerous consequences in addition to the long downtime needed to locate the fault.

Generally, fault location methods in distribution systems use a wide range of techniques that can be divided into the following four main categories [1, 4,5]

- **Traveling wave-based methods**, which are based on the traveling waves analysis, usually use time domain information for determining the location of fault by applying signal processing techniques, the high frequency components of fault generated transients are extracted and used for fault locating and it involves some sort of transformation of the measured signal such as

    1. Wavelet transform
    2. Frequency domain analysis
    3. Cross-correlation technique
    4. Clark transformation

- **Fundamental frequency voltages and currents methods,** un-like the previous category, these methods utilize the fundamental frequency voltage and current measurements to formulate equations that help in identifying the fault location.

- **Impedance-based methods**, which can be considered as part of the previous category. However, it is classified as different category as its ease of implementation made it the most popular among utilities

- **Knowledge-Based Methods**, which can be further divided into:

    1. Artificial Neural Networks.

    2. Matching Approach.

    3. Hybrid methods.

Many challenges face fault location in distribution systems summarized as follows [4]

- Fault generated signals are recorded solely at the feeding substation

- Existence of several laterals

- Non-symmetrical lines

- Highly unbalanced operation

- Time-varying loads

1.2 Problem Statement

Due to the higher dependence on electrical supply in modern life and the increasing costs of power interruption and down time caused by faults, the fault location techniques such as line patrolling and line sectioning, which were traditionally used in distribution networks became not acceptable. Many fault type and fault location methods were developed; among them, impedance-based methods are the most common, which are calculating the distance-to-fault from impedance-to-fault and the system parameters. However, in presence of fault impedance, iterations are to be made to find the most plausible solution. The presence of arcs in distribution networks is usually accompanied with permanent faults, where the accurate identification of location is essential for fast isolation and faulty element corrective action implementation.

1.3 Objectives of The Research

The research is aimed at developing a new fault location method using line impedance technique and considering the presence of arc and its resistance, which will be achieved by:

- Developing an algorithm for the detection of the presence of faults arcs from the voltage and current measurement utilising the established and tested methods.

- Developing an algorithm for estimating the arc resistance when detected utilising the established and tested methods

- Utilising the established and tested method for fault location and combine it with arc detection and arc resistance estimation methods to develop the new method.

1.4 Scope of The Research

The scope of the research is as follows:

- Building several models for radial distribution system in order to apply the method on them, starting from simple radial system with one section, adding sections effect by introducing sections with different parameters at the end of the line and finally a model for distribution systems with lateral.

- Developing the fault location method.

- Simulating several types of faults such as

    - Single phase, three phase

    - With and with-out fault resistance

    - With and with-out arcs

- Applying the measurement taken from the simulation software for each case to the developed method to estimate the fault location and the method accuracy and make comparison with other method.

1.5 Expected Contributions

The expected contributions of the successful development of the method are

- Helping in differentiating between the permanent and transient faults.

- Providing good estimate for the location of the fault, whether it has arcs or not.

1.6 Thesis Outline

The thesis will be divided into five chapters.

Chapter One covers a brief introduction and background about faults and fault location methods, the objectives, the scope and the expected contributions of the research.

Chapter Two contains the literature review on fault location methods, arc detection methods and arc resistance estimation methods.

Chapter Three discusses the methodology employed in the method development and method evaluation including the software models used and their configuration in addition to the method development and its steps.

Chapter Four covers the results presentation in tabular and charts forms added to the analysis and discussion of these result.

Chapter Five summarizes the results, state conclusion and highlight recommendations and future work suggestions.

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