BACKUP DISTANCE PROTECTION COORDINATION FOR THREE TERMINAL HV TRANSMISSION LINE CONSIDERING MAIN PROTECTION FAILURE

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

School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

JULY 2021

ACKNOWLEDGEMENT

Thanks be to God for giving me the strength to complete this project in the allotted time. First of all, many thanks to lecturer Ir Dr Syed Norazizul b Syed Nasir for helping me a lot in preparing this final year project.

Thanks also to my mother, wife and children because always to give me strength, motivation and support during the process of completing this project. This is also an opportunity for me to thank my friends for helping me a lot and giving me words of encouragement. They are very supportive and meaningful to me

Finally, once again I would like to thank all those involved in making this final project a success.

Thank you.

ABSTRACT

The protection system scheme in transmission line is very important to maintain security and reliability of power system. This research will focus on the protection scheme at the three terminal transmission line such as 132kV and 275kV that implement in Malaysia utility and propose a new distance protection system scheme. The backup protection schemes in Malaysia utility has a higher fault clearing time. This research will focus on backup protection operation of three terminal overhead transmission line for all condition with considering main protection fail, DC supply fail or communication fail. Therefore, this study will propose and improve the backup protection scheme, two components will consider which are fault clearing time and distance relay zone configuration. Each improvement has own philosophy and concreate reason to determine advantages for backup protection scheme in three terminal transmission line. The effect for improvement need to ensure time coordination did not overlap with others scheme. To analyse existing and new protection scheme in this study, ETAP software will be use. All decision of fault clearing time and zone coverage can generate by ETAP simulation. The propose method able to help utility to have better fault clearing time and zone of coverage.

ABSTRAK

Skema sistem perlindungan di saluran penghantaran sangat penting untuk menjaga keselamatan dan kebolehpercayaan sistem kuasa. Penyelidikan ini akan menumpukan pada skema perlindungan di saluran penghantaran tiga terminal seperti 132kV dan 275kV yang dilaksanakan utility di Malaysia dan akan mencadangkan skema sistem perlindungan jarak jauh yang baru. Skema perlindungan sandaran utiliti di Malaysia mempunyai masa penyelesaian kesalahan yang lebih tinggi. Penyelidikan ini akan menumpukan pada operasi perlindungan sandaran tiga saluran penghantaran overhead terminal untuk semua keadaan dengan mempertimbangkan perlindungan utama gagal, bekalan DC gagal atau komunikasi gagal. Oleh itu, kajian ini akan mencadangkan dan memperbaiki skema perlindungan sandaran, dua komponen akan dipertimbangkan iaitu konfigurasi zon relay masa dan jarak pelepasan kesalahan. Setiap peningkatan mempunyai falsafah dan alasan yang tepat untuk menentukan kelebihan skema perlindungan sandaran dalam tiga saluran penghantaran terminal. Kesan penambahbaikan perlu memastikan koordinasi masa tidak bertindih dengan skema yang lain. Untuk menganalisis skema perlindungan yang ada dan baru dalam kajian ini, perisian ETAP akan digunakan. Semua keputusan masa penghapusan kesalahan dan liputan zon dapat dihasilkan dengan simulasi ETAP. Kaedah cadangan dapat membantu utiliti untuk mempunyai masa penyelesaian kesalahan dan zon liputan yang lebih baik.

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LIST OF ABBREVIATIONS

TNB	Tenaga Nasional Berhad
ETAP	Electrical Transient Analyzer Program
CT	Current Transformer
CCVT	Coupling capacitor voltage transformer
VT	Voltage Transformer
CB	Circuit Breaker
87CD	Current Differential Relay
21Z	Distance Relay
GPS	Global Positioning System
VLSI	Very Large Scale Integration
PMU	Phasor Unit Measurements

LIST OF SYMBOLS

v	Voltage
AC	Alternating Current
DC	Direct Current
Hz	Hertz
A	Ampere
kV	Kilo-Volt
%	Percentage
ms	millisecond
s	second

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The transmission line has relatively large physical dimensions and is exposed to the elements of electrical power systems. Therefore, this transmission line requires a protection system to ensure the stability, efficiency, security and reliability [1]. Main and backup protection are requiring in each power system. In the event of a main protection is a fail or in the event of a malfunction, backup protection should able to clear the fault so that the entire transmission lines are safe and healthy [1].

In 1969, Rockefeller presented the implementation of digital relaying for the first time in the world [2]. The advances in VLSI (Very Large Scale Integration) technology and software approaches led to the creation of microprocessor-based relays, which were initially available commercially in 1979 [3]. The reliability of modern highly complex power system depends on the selective, high-speed clearing of faults on high-voltage transmission lines. A lot of effort has been done in this area to enhance the performance of digital protective relays and the application of intelligent approaches for fault diagnosis and protective relay operations [4].

The principle of distance relaying method for the protection of high and extra high voltage (EHV) transmission and sub-transmission lines due to their high speed fault clearance compared to over current relays. [5]. A distance relay determines the protective zone by estimating the electrical distance to the fault and comparing the result threshold. Distance relays have evolved from electromechanical from static to microprocessor-based (digital) relays [5]. The distance relays detect the defective line and kind of fault when a problem occurs in an electrical transmission line, however they may under or over reach depending on pre-fault loads, fault resistance, and remote end in-feeds. With the increase in speed at which the estimate is obtained, the impedance calculated by a digital distance relay increases. As a result, an impedance relay with a specific reach setting can't run at any speed [6].

The first digital computer for relaying was installed in the 1960s, allowing the relay engineer to store information and modify the reach characteristics of a distance relay to fit the application and create fault location algorithms [7,8]. These digital fault locators estimate the reactance of a defective line based on the computation of voltage and current phasors at the line terminals, however these fault locators require a simplifying hypothesis to compute the fault distance, lowering the accuracy of the results. Although one-end algorithms, which process signals from both terminals of the line are better than the two-end algorithms [9,10], which process signals from both terminals of the line, are simpler and easier to implement.

Typically, backup protection is given by distance (e.g. zone 2 and 3), overcurrent and earth fault protection with IDMT (Inverse Definite Minimum Time) characteristics. According to history, normally backup protection failures are in zone 3. Such changes in fault levels may pose additional challenges to distance and overcurrent protection backup areas, either making them vulnerable to unwanted or non-operation or requiring complicated assessment and likely adaptation of settings depending on prevailing system conditions [11].

This study proposes the best technical approach for improving transmission line backup protection scheme that would have almost the same functionality and is equivalent to the main protection. The method of enrichment would be based on fault clearance time, zone of coverage like a practicality of the enhanced schemes to be implemented in actual use. In this research, Tenaga National Berhad (TNB) standard scheme and transmission system practise will use [12].

1.2 Problem Statement

The available differential protection scheme is also considered to be suited to protect three-terminal lines and is free from problems associated with the power swing but backup protection performance may be affected if an infeed and outfeed at T-point condition occurs during a fault [13]. The addition problem of a three terminal will exacerbate the distance protection scheme's challenges by causing under-reach and overreach issues due current flow outwards at one terminal [14]. This causes the backup protection relay operation not to operate efficiently and may be result in incorrect fault isolation when high current fed from nearest terminals [15]. In terms of solutions there is no answer so far that can cover all conditions, so where the least impactful coordination can be applied

1.3 Objective

The objectives of this study as follow: -

i. To evaluate existing protection scheme in the transmission line.

ii. To analyse fault clearing time and distance relay zone coverage during backup protection operation using ETAP simulation.

iii. To propose a new scheme to improve fault clearing time and zone coverage during backup protection operation using ETAP simulation.

1.4 Scope

The Scope of this study are:

i. This project will cover the backup protection operation for three terminal transmission line, considering the all main protection failure like relay, communication and DC supply.

ii. Beside the project, for improve this protection scheme, this project only considering the two elements, which are fault clearing time and distance protection zone coverage.

iii. All the result will be show using ETAP simulation.

iv. This study only focus on bolted fault and will ignored high resistance fault

1.5 Thesis Organization

Chapter 1 the existing main and backup protection scheme was actions clarified. The project objectives and project scopes are also highlighted in this chapter.

Chapter 2 the emphasis is on a literature review relating to transmission line protection schemes. The overall definition of general protection systems, along with the benefits and disadvantages, will be protected. Other than that, the new propose protection schemes will be detail and contrast with other studies.

Chapter 3 this chapter discuss the project methodology, the common objectives of existing protection scheme and proposes some changes to the framework for backup protection. This chapter also proposed modifications and provides a total change in the distance protection.

Chapter 4 highlight on simulation of distance relay scheme using ETAP simulation. This chapter will concentrate on the two item, which are fault clearing time and distance relay zone coverage

Chapter 5 reviews the conclusion of improved new protection schemes for backup protection on three terminal transmission line. This chapter will also discuss the recommendation for future works.

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