# INSTANTANEOUS PROTECTION SCHEME FOR BACKUP PROTECTION AT HIGH VOLTAGE TRANSMISSION LINE

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# INSTANTANEOUS PROTECTION SCHEME FOR BACKUP PROTECTION AT HIGH VOLTAGE TRANSMISSION LINE

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This research specially dedicated to both my beloved mother, father,
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## ABSTRACT

The protection scheme in this research is the typical protection system at high voltage system; such as 132kV, 275kV and 500kV. This research will analyse the existing protection scheme for transmission line that the power utility has implemented, and will propose a new protection scheme to improve the performance of existing scheme. Currently, existing protection scheme that implemented by power utility for backup protection operation has a higher fault clearing time, no restoration time and did not utilize support relays. This research will focus on backup protection operation of high voltage overhead transmission line, which has taken up the communication as the main protection failed to communicate or the relay fail due to loss of DC supply or the relay function itself has blocked. Other than that, all support relays will be utilized in order to improve the protection system. The improvement will consider three elements, which are fault clearing time, fast restoration time and relay utilization. Each improvement will have its own philosophy and concrete reason, which will give advantages or disadvantages to the transmission line of protection system. The effect of improvement schemes will also consider the outcome on other schemes to ensure time coordination did not overlap. Every possibility of fault will be analysed in order to have a clear understanding on the effect of the three elements. CAPE software will be used as a tool for simulation and to analyse its compatibility with real application. CAPE software is able to model the practical transmission line as well as relay logic. It is also able to perform fault in the tested area. The result from simulation has shown that the backup protection operation for fault clearing time and restoration time has been improved. It also intensifies the network system stability particularly during the occurrence of the maximum fault current.

# ABSTRAK

Projek ini digunakan secara tipikal bagi skim perlindungan pada sistem voltan tinggi seperti 132kV, 275kV and 500kV. Projek ini akan menganalisa skim perlindungan sandaran asal yang digunakan pada talian penghantaran yang juga diamalkan oleh pembekal kuasa dan mencadangkan skim perlindungan yang baru di tambah baik dari skim perlindungan yang asal. Pada ketika ini, skim perlindungan sandaran yang diamalkan oleh pembekal kuasa mempunyai masa yang tinggi untuk mengasingkan arus kerosakan, tidak pantas mengembalikan sistem dan tidak memaksimakan penggunaan geganti. Projek ini akan tertumpu kepada operasi perlindungan sandaran bagi talian penghantaran voltan tinggi dengan beranggapan komunikasi bagi perlindungan utama telah gagal berkomunikasi atau geganti tidak beroperasi kerana kehilangan bekalan arus terus atau fungsi geganti itu sendiri telah dihalang. Selain itu, geganti-geganti sokongan akan dimanafaatkan sepenuhnya bagi menambah baik sistem perlindungan. Penambahbaikan akan mengambil kira tiga elemen iaitu kepantasan mengasingkan arus kerosakan, kepantasan mengembalikan sistem dan memaksimakan penggunaan geganti sokongan. Setiap penambahbaikan akan mempunyai falsafah tersendiri dan alasan yang teguh dimana mempunyai kebaikan dan kekurangan pada system perlindungan talian penghantaran. Kesan dari skim penambahbaikan akan juga mempertimbangkan kesan kepada skim lain agar tidak bertindih dengan koordinasi masa. Setiap kemungkinan berlaku arus kerosakan akan dianalisa untuk mendapatkan gambaran jelas kesan kepada ketiga-tiga elemen. Perisian CAPE akan digunakan sebagai medium untuk menjalankan simulasi dan menganalisa. Perisian CAPE juga berkebolehan untuk mereka talian penghantaran secara praktikal termasuk logic pada geganti. Ia juga berkebolehan untuk membina arus kerosakan pada kawasan pengujian. Hasil keputusan simulasi menunjukkan penambahbaikan kepada kepantasan mengasingkan arus kerosakan, kepantasan mengembalikan sistem dan memaksimakan penggunaan geganti sokongan. Selain itu, skim yang dicadangkan juga menjadikan sistem lebih stabil terutama ketika berlaku arus kerosakan maksimum.

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| | | |
|---|---|---|
| TNB | - | Tenaga Nasional Berhad |
| CAPE | - | Computer-Aided Protection Engineering |
| CT | - | Current Transformer |
| VT | - | Voltage Transformer |
| CB | - | Circuit Breaker |
| TE | - | Telecommunication Equipment |
| 87CD | - | Current Differential Relay |
| 21Z | - | Distance Relay |
| 79AR | - | Auto-reclose Relay |
| 50BF | - | Breaker Fail Relay |
| DBLL | - | Dead Bus Live Line |
| LBLL | - | Live Bus Live Line |
| LBDL | - | Live Bus Dead Line |
| LZOP | - | Local Zone Of Protection |

# LIST OF SYMBOLS

| | | |
|---|---|---|
| $V$ | - | Voltage |
| $AC$ | - | Alternating Current |
| $DC$ | - | Direct Current |
| $Hz$ | - | Hertz |
| $A$ | - | Ampere |
| $\mu A$ | - | Micro-Ampere |
| $3^{rd}$ | - | Third |
| kV | - | kilo-Volt |
| t | - | Neural output |
| % | - | Percentage |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Protection Scheme Background

Protection scheme is a vital part that could give mass impact to the system operation. The effect of the scheme malfunction may cause wrong tripping sequence and will ruin the system, affecting the customers. In fact, small setting discrepancies may cause an increase in fault clearing time and cause system feeding to the fault being longer than the system design [1].

Typically, unit protection being used as the main protection; such as pilot wire and current differential relays due to its capability to detect faults at certain area. Besides that, non-unit protection being used as backup protection; such as distance and overcurrent relay which have the capability to detect faults in-zone and out-zone that differentiated by time coordination.

Current differential relay at the transmission line rely on communication between substations to detect faults, which will disable the protection for both substation during the loss of communication [2]. However, distance relay has its own benefits, unlike the existing differential relay; failure of a distance relay on one side does not result in failure of the protection on the other side [3]. The value of distance relay provides engineers the tools and flexibility to design a more secure and dependable protection schemes [4].

Currently, protection schemes for transmission line are equipped with backup protection, although the design scheme does not have a similar impact as the main protection. The best scheme design should be able to give approximately an equal impact as the main protection, even during backup protection operation.

This study will suggest the best theoretical solution to enhance backup protection scheme for transmission line that will have exactly the same capability identical to the main protection. The enrichment process will be based on fault clearing time, fast restoration time, relay utilization and practicality of the enhanced schemes to be applied in real application. In this research, Tenaga Nasional Berhad (TNB) standard scheme will be used since it offers a very practical scheme that has been adopted for a long period. The existing scheme for this research will be based on the TNB Transmission System Protection and Control, Code of Practice booklet.

## 1.2 Project Background

Transmission lines being used as a typical medium to transmit power from generation part to distribution part. In Malaysia, transmission lines have been designed to occupy high voltage levels such as 132kV, 275kV and 500kV, depending on the study of the system in needs. The main reason behind the principle is to reduce losses during transmission of bulk power. [5]

A study regarding power utility in Malaysia has been done to define the capability of the system to feed the faults, in order to protect the high voltage apparatus and system. Protection scheme design must be in line with the competency of the apparatus and the system. The aptitude consists of the minimum requirements needed in designing protection schemes, for example; fault clearing time for 132kV system must be below or equal to 150ms. Other than that, fault clearing time for 275kV and 500kV must be below or equal 100ms [5]. It is used as a limit for the main protection.

By using fault clearing time as a reference, it will help the designer to coordinate the time for the breaker to be opened during fault as required. Rather than only affecting the coordination time, it will also cause an increase in specification for breaker time opening, relay detection and much more in order to achieve fault clearing time requirement. The voltage level on the transmission line, length, distance to sources, load flows and also stability study's parameters are the example of effects to the protection scheme for typical transmission lines [6].

Other than that, the transmission lines normally equipped with auto-reclose function that is designed to minimize the restoration time during transient fault, such as lightning. Auto-reclose scheme able to be released for multiple times, depending on the stability of the system to adapt the fault current. Normally, in high voltage application, the utility will only tolerate single reclose due to the outcome of fault current, that can cause major voltage dip and will reduce lifecycle of sensitive high voltage apparatus such as circuit breaker [7]. However, auto-reclose scheme is only available during the main protection operation, and will be idled during backup protection operation [5]. This had caused a long restoration time for transmission lines, even in facing transient fault that supposedly can be reduced, if auto-reclose function is embedded in backup protection operation. Besides that, the existing backup scheme does not fully utilize the existing relay during backup protection operation.

## 1.3 Problem Statements

The protection schemes that have been implemented by power utility did not emphasize on backup protection, which could lead to the inefficient backup protection and require long restoration time. Existing protection scheme design for transmission lines contain main and backup protection relays that are supported with auto-reclose and synchronous relays. The auto-reclose and synchronous relays only run to support main protection relay for fast normalizing. This had caused the capability of the relay is under-utilized during backup protection operation, which will bring improper fault isolation.

## 1.4 Objectives of Study

The main objectives of this project are:-

a) To propose a new scheme that will improve fault clearing time during backup protection operation
b) To fully utilize all available relays during backup protection operation
c) To analyse new proposed scheme in real application using software.

## 1.5 Scope of Study

For this project, the scope will cover the backup protection operation, assuming that the main protection is in block condition. Practically, block condition is referring to the relay fail, communication fails and relay DC supply fail. Other than that, any improvement achieved will only consider the three elements, which are fault clearing time, restoration time and relay utilization.

## 1.6 Limitation

This project is carried out using software, which will act exactly similar to the real application. However, this project will not be comparing the simulation result with the industrial practice since it only offers a theoretical solution.

## 1.7 Thesis Outline

**Chapter 1** explains the general protection scheme for main and backup protection and its behaviour. Other than that, project objectives and project scopes also being emphasized in this chapter.

**Chapter 2** focuses on the literature review related to the protection schemes for the transmission lines. It will cover the overall concept of general protection schemes together with the benefits and drawbacks. Other than that, the existing protection schemes will be highlighted in detail and being compared with other studies.

**Chapter 3** discusses the methodology of the project, the common concept of existing relays and proposes some improvements to the backup protection scheme. This chapter will also concentrate on the benefits and drawbacks of improvements being proposed; and presents a complete improved backup protection schemes.

**Chapter 4** highlights on the simulation by using CAPE software for the existing schemes and improved schemes. The simulation will focus on the three elements, which are fault clearing time, restoration time and relay utilization.

**Chapter 5** reviews the conclusion of improved schemes for instantaneous backup protection. This chapter will also discuss the recommendation for future works.

## 1.8 Summary of work

Generally, this project will undergo six processes begins with data collection and literature review. The first touch off will give an idea for the project title. The project flow chart is as per shown in Figure 1.1.

In the literature review, all existing research, which studied on the transmission lines had been collected and reviewed. This would give a chance for researcher to choose a topic in need to be discussed further, particularly for the topics which have a higher impact towards industrial application. The first step will contribute to the specific topic of choice, which highlights more on backup protection scheme for the transmission line. Hence, the title being chosen is the instantaneous protection scheme for backup protection at high voltage transmission line.

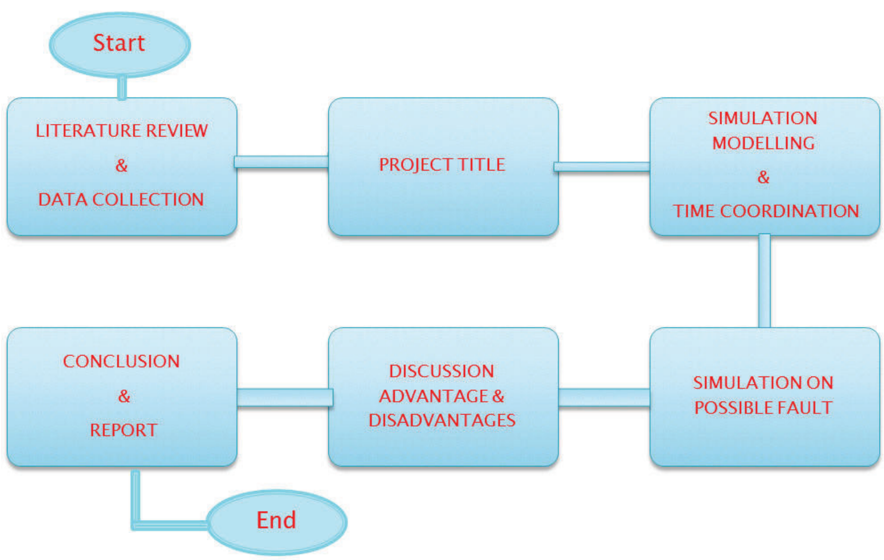


**Figure 1.1: Flow Chart of the Project**

The next part is the simulation, which required modelling of the practical system using CAPE software. Other than that, the relays logic and time coordination which being implemented in practice will be simulated to represent the existing scheme. The setup of the existing scheme will identify the benefits and drawbacks of the proposed protection scheme. The proposed scheme will also be modelled, which will only pinpoint on relays logic and new time coordination.

The simulation result will be discussed in detail to analyse the advantages and disadvantages of the new proposed scheme itself.

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