INVESTIGATION ON AUTO-RECLOSER DEADTIME FOR 275kV KOLOPIS – SEGALIUD SABAH GRID USING PSCAD SOFTWARE

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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)

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FEBRUARY 2022

DEDICATION

This thesis is dedicated to my friends, who constantly motivated and helped me to persevere in completing this course.

ACKNOWLEDGEMENT

In preparing this thesis, I was encountered several hurdles and challenges in completing the selected project. Fortunately, I was in contact with experienced fellow engineers and outstanding academicians. Their contributions have allowed me to expand my understanding on the subject matter, thus completed this thesis.

Particularly, I would like to express my sincere appreciation to my supervisor, Dr. Noorazlinda Binti Ahmad, for guidance and encouragement. I am also thankful for my fellow engineer, Ag Shahrin Afwan Ag Tahir, for his abundance assistance in completing the project. Furthermore, I am grateful for my dearest friends, Winches M. Samuel, Joy J. Majaham and Albert Marcus for their constant motivation and support from the beginning until the end of this course. Without them all, I could not have completed this thesis as presented here.

My fellow postgraduate students should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family member.

ABSTRACT

The purpose of this study is to investigate the optimum deadtime for 275kV auto-recloser that improves the performance of 275kV Kolopis-Segaliud Sabah Grid Transmission Line. The outcome from this study has confirmed the optimum deadtime for 275kV auto-recloser through simulation using PSCAD Software. The 275kV Segaliud-Kolopis Sabah Grid Transmission Line was modelled in PSCAD Software in order to mimic the actual system, thus analysis of deadtime for 275kV auto-recloser was able to be performed. Several conditions were considered which was grouped into three cases. The conditions considered were intended to allow analysis on operation of auto-recloser with regards to absence and presence of fault, and various value of deadtime. Simulation results indicated the success of the auto-reclose to perform reclosing mechanism when fault detected and then cleared from the system in accordance with stipulated performance criteria. Thus, the optimum deadtime is confirmed through, firstly calculation, and then simulation, that is 365ms. Although, the outcome from this study can be implemented directly, provided approval from relevant authority, it has been suggested that further study to be conducted in order to ensure the success of the implementation.

ABSTRAK

Kajian ini dilakukan bertujuan mengkaji nilai *deadtime* yang optimum untuk aplikasi *275kV auto-recloser* yang mana mampu memperbaiki prestasi Talian Penghantaran 275kV Kolopis-Segaliud Sabah Grid. Hasil kajian ini telah mengesahkan nilai optimum *deadtime* untuk aplikasi *275kV auto-recloser* menerusi simulasi menggunakan *PSCAD Software*. Talian Penghantaran 275kV Kolopis-Segaliud Sabah Grid telah dimodelkan dalam *PSCAD Software* bagi menghasilkan model yang menyerupai system sebenar, dan seterusnya membolehkan analisa *deadtime* untuk aplikasi *275kV auto-recloser* dijalankan. Beberapa situasi telah dipertimbangkan yang mana telah dikategorikan kepada tiga kes. Situasi-situasi tersebut adalah bagi membolehkan analisa ke atas operasi *auto-recloser* dijalankan, dengan pertimbangan tanpa dan dengan *fault*, dan juga pelbagai nilai *deadtime*. Hasil simulasi menyatakan keberjayaan mekanisma *reclosing* apabila *fault* dikesan dan dihilangkan dari sistem mematuhi kriteria prestasi yang telah ditetapkan. Oleh itu, nilai optimum *deadtime* telah disahkan menerusi, bermula dengan pengiraan, dan kemudian simulasi, iaitu 365ms. Walaupun hasil kajian ini boleh dilaksanakan secara terus, tertakluk kepada kelulusan pihak berkuasa yang berkaitan, namun, kajian selanjutnya perlu dijalankan bagi memastikan perlaksanaan tersebut adalah berjaya.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

SESB	-	Sabah Electricity Sdn. Bhd.
TNB	-	Tenaga Nasional Berhad
PMU	-	Pencawang Masuk Utama (Main Intake Substation)
ms	-	millisecond
kV	-	kilovolt
km	-	kilometre

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Sabah Electricity Sdn. Bhd. (SESB) is the sole electricity supplier for Sabah state and Labuan Federal Territory (F.T.). SESB is a subsidiary company to Tenaga Nasional Berhad (TNB). The transmission systems installed in Sabah are interconnected thus commonly known as Sabah Grid. The highest voltage level installed in Sabah Grid is 275 kV which comprises of Kolopis-Segaliud Line and Kolopis-Kimanis Line. There are few ongoing projects to expand the 275 kV lines in order to provide better electricity supply throughout Sabah state and Labuan F.T.

The transmission line of 275 kV Kolopis-Segaliud is a 325km length connecting PMU Kolopis, which is located in the west coast of Sabah state, and PMU Segaliud, which is located in the east coast of Sabah state. Currently, the power plants are densely located in the west coast. Hence, the electricity supply has to be transferred to the east coast in order to ensure continuous supply for customers there. The 275 kV Kolopis-Segaliud Transmission Line is the only facility to transfer electricity supply from the west coast to the east coast. According to information obtained from SESB, the average power transferred from the west coast to the east coast is 216MW. Thus, this transmission line is the backbone in ensuring adequate electricity supply throughout Sabah state. Subsequently, any interruption to the line will affect significantly to electricity supply for Sabah state. Illustration of Sabah grid is as shown in Figure 1.1 below:

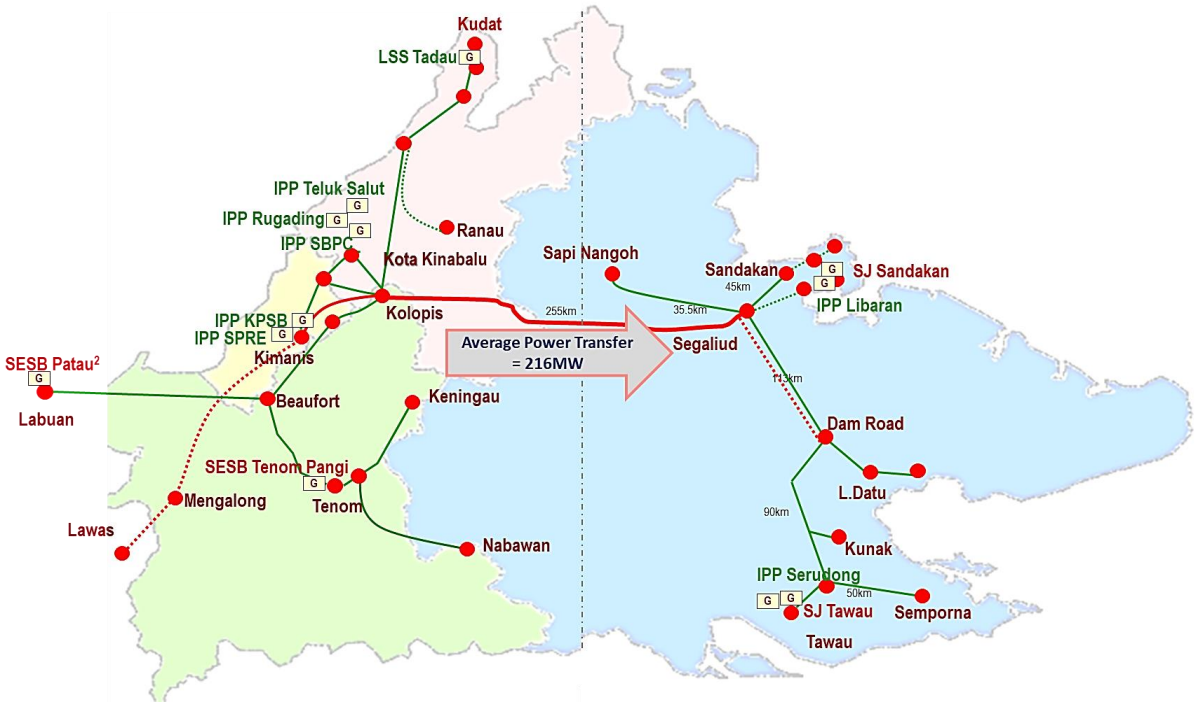

Figure 1.1: Average Power Transfer from The West Coast to The East Coast of Sabah (SESB)

The construction of 275 kV Kolopis – Segaliud is a double circuit bison conductor with current carrying capacity is 667 A per circuit. The 667 A is equals to 317.8 MVA and 353 MW (at 0.9 power factor). Double circuit serves as N-1 system for the line should any of the line is tripped without completely losing supply of electricity. The line is equipped with protection system complying with SESB's requirement. One of the protection devices in the system is auto-recloser.

Auto-recloser is commonly used protection device for medium voltage and high voltage overhead lines in Sabah Grid due to its function of self-restoring electricity supply. It is able to clear transient fault, i.e. caused by lightning or contact of grounded object, up to three attempts thus to restore the electricity supply to the line. This function eases the operation team as it minimises the need for human intervention to restore the electricity supply and reduce the duration of supply interruption.

Nonetheless, there are several factors that influencing the performance of auto-recloser. One of the factors is dead time setting. Dead time is the idle time that is set for after a fault is detected and thus breaker is positioned to OPEN, until the breaker is positioned to CLOSE. The activity to position the breaker to CLOSE after dead time lapsed is also known as reclosing. Setting of dead time is crucial in order to ensure the success of reclosing. If the dead time setting is too short, then the reclosing may fail. If otherwise, the fault may become severe thus affecting the electrical equipment. For SESB's system, the equipment short circuit current withstand duration is 3 seconds for 31.5 kA. Therefore, the deadtime setting should not exceed 3 seconds considering the fault detected is 31.5 kA or larger.

The dead time setting is differed according to single-pole breaker or three-pole breaker. Single-pole breaker is for fault detected is single phase fault thus require single-pole breaker reclosing. Similarly, three-pole breaker is for fault detected is three phase fault thus require three-pole breaker reclosing. For 275 kV Kolopis-Segaliud transmission line, the dead time setting for single-pole breaker is 750 ms, while for three-pole breaker is 3000 ms. Unfortunately, based on performance assessment conducted by SESB internally, the fail rate for reclosing is 60 percent. This figure is considerably high. This figure can be translated as out of 100 times of reclosing attempts, 60 times of those reclosing has failed. For those 60 times, the maintenance team has to come down to site and attempt reclosing manually. This has contributed to duration of supply interruption.

Auto-recloser can be set for reclosing by single-shot and up to three-shot. Shot can be translated as number of attempts for reclosing. Should the setting be single shot, thus, after fault is detected, the auto-recloser will attempt for reclosing for only one attempt. Should the reclosing fail, the breaker will remain positioned as OPEN until it is manually CLOSE. Similarly, for three-shot, where the auto-recloser will attempt for reclosing up to three attempts. Should the reclosing fail after the third attempts, thus, the breaker will remain positioned as OPEN until it is manually CLOSE. For 275 kV Kolopis-Segaliud transmission line, the setting is single-shot.

The purpose of this study is to obtain the optimum value of dead time setting which should able to reclose the system successfully. The dead time setting is firstly obtained through calculation using established formula. After that, varies of dead time settings are selected and tested through simulation of PSCAD Software. Nonetheless, the single-shot setting is maintained throughout the study. In addition, performance criteria is set in accordance to SESB's standard practise as part of the requirement for successful reclosing.

1.2 PROBLEM STATEMENT

Currently, the SESB's protection setting for 275 kV auto-recloser is as tabulated in Table 1.1 below:

Table 1.1: SESB's Protection Setting for 275 kV Auto-Recloser

No.	Auto-Reclosing Scheme	Minimum Dead Time (ms)	Fail Rate (%)	Maximum Shot Number
1	275 kV Single Pole Auto Reclose	750	60	1
2	275 kV Three Pole Auto Reclose	3000		

However, as shown in Table 1.1, the fail rate for reclosing attempt in order to restore the supply is significantly high i.e. 60 percent. The fail rate herein is referring to the number of failures of the installed 275 kV auto-recloser to reclose and normalise the system after fault is detected and auto-recloser is triggered to OPEN the breaker. The figure is based on the annual report produced by Protection Department, SESB. Nonetheless, there is no proper study being conducted to analyse and evaluate the suitable auto-reclosing dead time for 275 kV Transmission Line.

Meanwhile, other countries have different value for dead time. For instance, Indonesia (i.e PT PLN) set their protection setting for deadtime of single-pole auto reclose and three-pole auto reclose is 3 seconds. Whereas for South Africa (i.e. ESCOM), their protection setting for dead time is 1 second. Notably, the protection setting for dead time of auto-recloser varies depending on the installation, company policies, geographical value and etc. Unfortunately, the fail rate for respective dead time is unable to be obtained for purpose of this report.

Due to the significantly high figure of fail rate for reclosing attempt in order to restore the supply for 275 kV auto-recloser and variation of dead time set by other countries, there is indeed a need for a study to determine the most optimum dead time that potentially could reduce the fail rate, hence lower than impact, on Sabah Grid as overall, should the 275 kV Kolopis – Segaliud Line is triggered to trip due to presence of fault in the system.

1.3 OBJECTIVES

The objectives of this project are as in the following:

a. To model and simulate 275 kV Kolopis – Segaliud Transmission Line with auto-recloser using PSCAD software
b. To analyse the operation of auto-recloser in accordance with SESB Protection Standard Practise during normal condition and line fault condition
c. To evaluate the performance of the auto-recloser by varying the dead time value

1.4 SCOPE OF PROJECT

The scope of project is defined to guide the project to be carried out within limited capability and to ensure the objectives of this project are met accordingly. The scope of project is to ensure a more focused finding to be obtained and analysed.

Therefore, the scope of this project is limited to the following:

a. 275 kV Transmission Line from PMU Kolopis to PMU Segaliud of SESB.
b. Single shot of the auto-reclosing for single pole and three pole transmission line.
c. Performance criteria is set as per according to SESB's standard practise as in the following:
    i. Voltage difference between sending end and receiving end of less than 20 %
    ii. Phase angle difference between sending end and receiving end of less than 20 %
    iii. Frequency difference between sending end and receiving end of less than 0.12 Hz

1.5 RESEARCH DESIGN SPECIFICATION

1.5.1 Definition of Variables

The variables for the research are as follows:

- *Independent variable*: dead time setting
- *Dependent variable*:
  - *i.* performance criteria according to SESB's standard practise i.e. voltage difference of less than 20 %, phase angle difference of less than 20 % and frequency difference of less than 0.12 Hz.
  - *ii.* position of breaker switch i.e. OPEN (or trip) and CLOSE (no trip)

1.5.2 Research Approach

The research approach for this research is quantitative approach.

1.5.3 Research Type

The type of research is applied research since the outcome from this research can be used directly to be applied in protection setting for SESB system in order to improve the performance of the 275 kV Transmission Line from PMU Kolopis to PMU Segaliud, provided approval from the SESB Management.

1.5.4 Data Type

There are two types of data that will be collected and used for this research, which as follows:

- *Primary data*: simulation outputs of PSCAD software, SESB's Protection Setting
- *Secondary data*: published articles, textbooks, SESB's Protection Performance Report

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