LINE FAULT INDICATOR FOR SABAH RURAL DISTRIBUTION NETWORK

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A project report submitted in fulfilment of the
requirements for the award of the degree of
Master of Electrical Power

School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

FEBRUARY 2022

DEDICATION

This thesis is dedicated to my beloved family ~ my parents, my husband (*Arif Yulyanto*) and my daughters (*Farihah, Marissa & Aisyah*) for the endless love, sacrifices, prayers, supports and advices.

ACKNOWLEDGEMENT

I wish to express my special thanks of gratitude to my thesis supervisor, Dr. Zuraimy Bin Adzis, for his encouragement, guidance, critics and friendship. Without his continued support and interest, this proposal would not have been the same as presented here.

To all my fellow postgraduate students, thank you for supporting me both on and off the water. To my teammates ~ Nora, Linda & Tracy, thank you for helping me get through all the stress over these 2 years.

To my beloved family, thank you for the understanding, patience, encouragement and for pushing me farther than I thought I could go.

ABSTRACT

Due to Sabah's mountainous landscape, it is very challenging to provide electrification to rural area. Distribution systems are continuously exposed to fault occurrences due to various reasons, such as lightning strike, failure of power system components and etcetera. However, due to the long-distance distribution overhead lines often causing longer restoration time. Therefore, the concept of Line Fault Indicator would be beneficial for early ground fault detection which leads to fast fault clearance. The objective of this project is to inspect the ability of line fault indicator to react to overhead lines permanent faults. The analysis of the line's fault current will be conducted using CAPE software and it will be compared to the operational characteristics of the neon bulb of line fault indicator. Result from this simulation showed the relationship of neon bulb and fault's current characteristic for overhead permanent faults and provides assurance that the indicator is properly functioning in locating the faulted lines.

ABSTRAK

Mengambil kira bentuk geografikal Sabah yang bergunung ganang, adalah sangat mencabar untuk menyediakan bekalan elektrik ke kawasan luar bandar. Sistem pembahagian seringkali terdedah kepada pelantikan bekalan elektrik disebabkan oleh pelbagai punca seperti kilat, kegagalan komponen sistem kuasa, dan sebagainya. Namun yang demikian, talian pembahagian yang panjang sering menyebabkan masa pemulihan yang lebih lama diambil. Oleh yang demikian, konsep penunjuk kerosakan talian ini akan memberi manfaat untuk pengesanan awal kerosakan talian yang boleh membantu untuk pemulihan bekalan elektrik dengan cepat. Objektif projek ini adalah untuk memeriksa keupayaan penunjuk kerosakan talian bertindak balas terhadap kerosakan talian atas kekal. Analisis bacaan arus kerosakan akan dijalankan menggunakan perisian CAPE dan ia akan dibandingkan dengan ciri-ciri operasi bagi penunjuk kerosakan talian mentol neon. Hasil daripada simulasi ini menunjukkan hubungan mentol neon dan bacaan arus kerosakan bagi kerosakan kekal talian atas dan sekaligus memberi jaminan bahawa penunjuk berfungsi dengan betul dalam mengesan talian rosak.

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LIST OF ABBREVIATIONS

SESB	-	Sabah Electricity Sdn Bhd
SAIDI	-	System Average Interruption Duration Index
PE	-	Pencawang Elektrik
CAPE	-	Computer Aided Protection Engineering
SSU	-	Stesen Suian Utama
1P	-	Single Phase
3P	-	Three Phase
NOP	-	Normal Off Point
LFI	-	Line Fault Indicator

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CHAPTER 1

INTRODUCTION

1.1 Challenges of Electrification in Sabah

Sabah is known for its mountainous regions, beaches and tropical rainforests. Most of the population centres are along the West and East Coasts with a spine of mountains between them. There are also remote villages nestled among the highlands and rainforests. Due to these geographical challenges, there is insufficient infrastructure connecting major towns in Sabah. This has made the implementation of electrification to be very difficult and expensive because land access is far from the main grid connection.

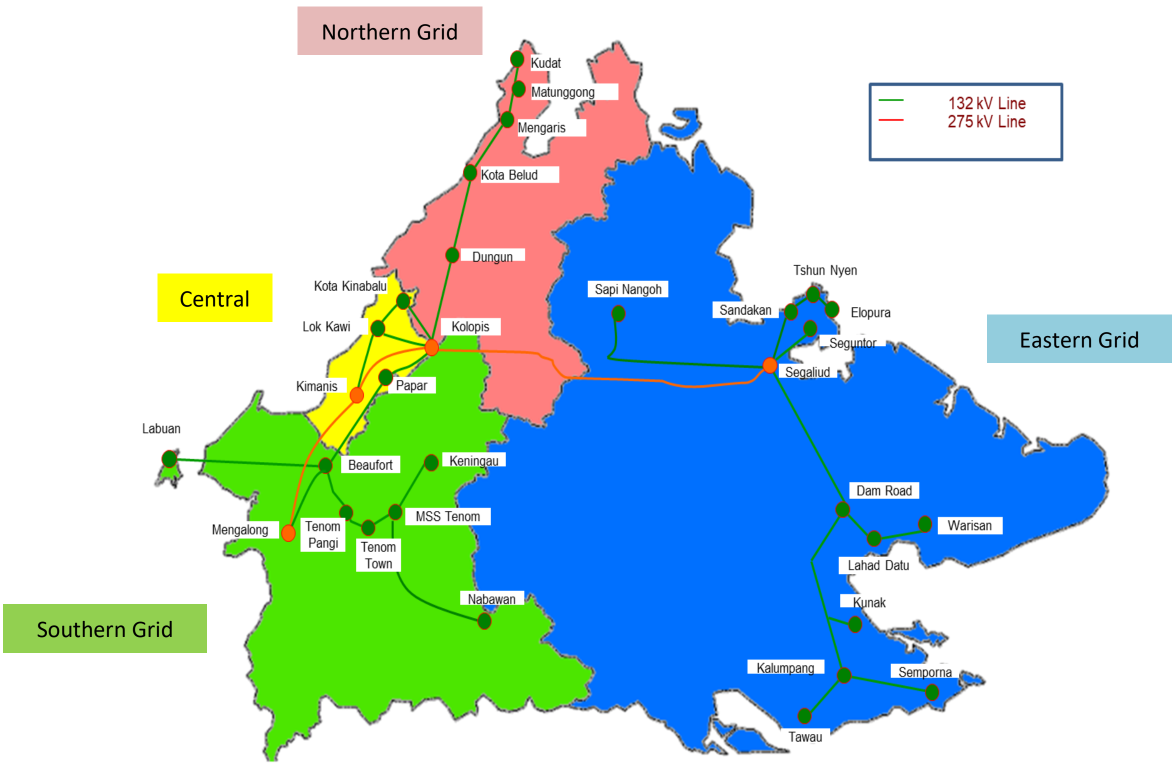

Figure 1.1: Sabah Main Grid 2022 [1]

Some of rural area in Sabah are rely on off-grid connections. These off-grid areas receiving their source of power from diesel generator, diesel-battery hybrid, solar-diesel-battery hybrid, and also from renewable energy sources such as solar, mini hydro and biomass generation.

The characteristics of power supply in rural areas are as follows [2];

a. Substation number is insufficient

   To balance the investment cost + operation cost with revenue from electricity sales, it is often resulting in substation and line construction difficulties. This led to insufficient number of substations in rural areas. The radius of distribution power lines is too long, often causing three-phase imbalance and other problems abound.

b. Load is small, scattered and uneven growth

   Rural areas are low in population density and dispersed communities with low level of consumption (low load factor) and low demand growth profile.

c. Not equipped with latest technology such as grid automation and information technology

   For off-grid network, the operation and maintenance activities are often underperformed due to limited/unavailability of substation automation system to assist the control and monitoring of rural network including substations and lines statuses.

1.2 Sabah Distribution Electricity Supply Profile

Sabah electric supply is similar to other states in Malaysia whereby the electric power begins at a generating station and delivered to the load centres via transmission network. Distribution network is the final stage in the delivery of electric power to end users. It receives the high voltage from the transmission line and then stepped down by a step-down transformer to the primary distribution level voltage.

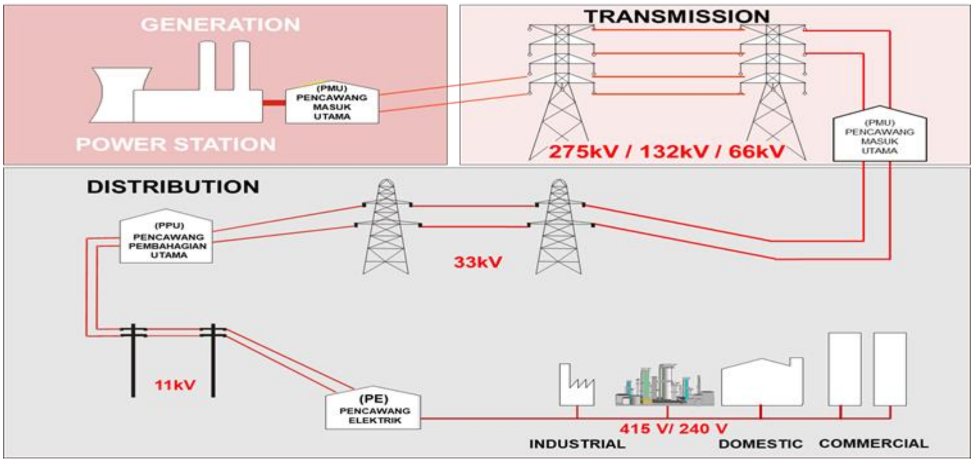

Figure 1.2: Sabah Electricity Supply Profile

In Sabah, distribution system starts when delivering 33kV and below. A typical power distribution system consists of distribution substation, feeders, distribution transformers, distributor conductors and service mains conductors. A distribution system must be able to meet the needs and requirements of all users from the smallest to the largest safely and economically.

Urban distribution mainly using underground cables for network power distribution, whereas for rural distribution network is mostly above ground with utility poles with radial power distribution. Current distribution line configuration in Sabah is consist of 86% overhead lines and 14% underground cables. [1]

System Average Interruption Duration Index (SAIDI) is a reliability indicator used by power utilities to measure the average outage duration experienced by each customer in a year [3]. The SAIDI formula is as written below;

$$\text{SAIDI} = \frac{\text{sum of all customer interruptions durations}}{\text{Total number of customers served}}$$

$$= \text{XXX minutes/customer/year}$$

For Sabah SAIDI performance, Distribution has always been the biggest contributor to high overall Sabah SAIDI since 2013;

	Generation	Transmission	Distribution	Overall 2016
Target 2016	20	30	200	250
SAIDI 2016	70.95	18.39	221.67	311.01

	2013	2014	2015	2016	2017 Annualised
Percentage of Distribution SAIDI from Total SAIDI	59%	30%	60%	71%	82%

Figure 1.3 Sabah distribution SAIDI as a major contributor to overall SAIDI, 2013 – 2017 [1]

It has been identified that there are four (4) main causes for why Distribution SAIDI remains high [4];

a. Installation configuration and infrastructure

Long spur line that far from main grid resulting in low power supply reliability rate

Constrained by geographical remoteness resulting in operation and maintenance difficulties

b. Maintenance culture – improper maintenance practices and operation

c. External factors – construction, open fire, vehicle, etc.

d. Natural factors – geologic hazard, flood, earthquake, etc.

However, in this project, focus will be made to the electrification installation and infrastructure for rural areas/off-grid areas only.

Detail analysis of the tripping records for distribution as shown in figure 1.3 is conducted and it reveals that overhead line faults due to trees and animals are the highest contributors to the overall tripping record, followed by equipment failures. Both root-causes are categorized as permanent fault that can only be cleared with human intervention.

Figure 1.4 SESB Distribution tripping root causes, 2013 – 2017 [1]

For permanent fault, since the fault is still on the line that need to be cleared manually, slow fault detection and isolation may cause an appalling reduction in system voltage, loss of synchronism, loss of revenue, permanent damage to the electrical equipment and worse case scenario it can cause loss of life. Since fault is unpredictable, a fast fault location and isolation is required to minimize the impact of fault in distribution systems and to lower the SAIDI contribution.

1.3 Problem Statement

The idea of this project came from the problem faced by maintenance team especially during the following conditions;

a) Off-grid network where the operation and maintenance activities are often underperformed due to limited/unavailability of substation automation system to assist the control and monitoring of rural network including substations and lines statuses.

b) Bad weather whereby the maintenance teams are having problems to locate the exact fault location.

c) Long spur lines that exposed to uncontrollable factors such as animals and trees that contribute to longer patrolling time. [4]

The purpose of the project is to be able to help SESB distribution maintenance team to improve the line performance and minimize the line interruptions specifically at rural off grid distribution electrification system by quickly identify and locate the exact fault location economically yet effectively, and then perform the corrective maintenance activities so that the line can be normalized as soon as possible.

1.3.1 Objectives of this Project

The objectives of the project are:

(a) To do literature search on neon lamp criteria

(b) To simulate permanent fault scenarios at 11kV networks using CAPE software

(c) To benchmark few actual tripping scenarios as per SESB tripping record

(d) To compare the simulation result and the actual tripping scenarios with fault indicator characteristics and to confirm whether the proposed fault indicator can detect the permanent fault for both simulated scenarios and actual scenarios.

1.4 Scope of the Project

In order to achieve the stated objectives, the scopes of this project will be focusing on off – grid network where there are no system automations available and all line patrolling need to be done manually by the maintenance team to detect the fault location and subsequently to clear the fault. The type of fault that will be considered is permanent faults since permanent faults are the highest contributors to the overall Distribution tripping record.

1.5 Report Organization

This thesis comprises of five chapters, and the summaries are as follows;

The first chapter is the introduction of the project. Chapter 1 is about Sabah supply outlook and the challenges faced especially for distribution network.

The second chapter is about the literature review of rural electrification, permanent faults and neon bulb as an indicator on distribution lines. A brief introduction of Ranau electricity supply outlook is presented to give overview on the challenges of electrification for rural area.

The third chapter is about the methodology that covers simulation using CAPE software. The fourth and fifth chapters are about findings, discussion as well as conclusion.

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