# ESTIMATION OF FAULT DISTANCE LOCATION USING ARTIFICIAL NEURAL NETWORK

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*To my lovely wife and sons, beloved parents, siblings,*

*mighty lecturers and friends*

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# ABSTRACT

Electricity demand in Malaysia is significantly increasing. Expanding the grid system to cater the new demand leads to several additional problems on the fault detection and protection coordination system. Single line to ground fault is commonly happen in grid system with possibility of 65% to 70% occurrence in distribution system. Fault detection is currently identified using costly special software. Typically, detection on single line to ground fault is analyzed by the pattern, placement, with and without bus monitoring approaches. Hence, this study is focused to improve the current fault detection approach on a single line to ground fault. The objective of this study is to develop a system that could estimate the faults location using artificial neural network (ANN) by Levenberg Marquardt Backpropagation (LMB) training approach. This ANN approach will be adapted in Matlab Software. A-10 bus will be developed, and faults will be simulated using Power World Software. During the implementation of the ANN, several buses will be added to enhance the capability of the neural network to detect fault distance in the system. To verify the effectiveness of the proposed ANN on the estimation fault distance determination, 21-bus distribution system has been compared for the validation purpose, with consideration of different location of the generation sources. Capability of the proposed approach has been assessed using a curving fitting tool in Matlab in terms of means square error (MSE) and regression plot (R). From the findings, it shows that LMB method can be implemented for location-based fault detection estimation once it was trained with 150 ANN hidden layer. Under the best condition, the deviation between regression of transmission line for 10-Bus single line and 21-Bus quad generation system has been achieved at 0.057%.

# ABSTRAK

Permintaan elektrik di Malaysia semakin meningkat. Perluasan sistem grid untuk menampung permintaan baru membawa kepada beberapa masalah tambahan pada sistem pengesanan kesalahan dan penyelarasan perlindungan. Garisan tunggal ke kesalahan tanah lazimnya berlaku dalam sistem grid dengan kebarangkalian 65% hingga 70% ia terjadi dalam sistem pengagihan. Pengesanan kesilapan lazimnya dikenalpasti menggunakan perisian khas di mana harganya sangat mahal. Biasanya, pengesanan pada garis tunggal untuk kesalahan tanah dianalisis melalui corak, penempatan, dengan dan tanpa pendekatan pemantauan bas. Oleh itu, kajian ini difokuskan untuk memperbaiki pendekatan pengesanan kesalahan semasa pada satu baris ke kesalahan tanah. Objektif kajian ini adalah untuk membangunkan sistem yang boleh menganggar lokasi kesalahan menggunakan rangkaian saraf buatan (ANN) oleh pendekatan latihan Levenberg Marquardt Backpropagation (LMB). Rangkaian neural buatan (ANN) ini akan disesuaikan dengan Perisian Matlab. Sebuah-10 bus akan dibangunkan, dan kesalahan akan disimulasikan menggunakan Perisian Power World. Semasa pelaksanaan ANN, beberapa bas akan ditambah untuk meningkatkan keupayaan rangkaian saraf untuk mengesan jarak kerosakan di dalam sistem. Untuk mengesahkan keberkesanan ANN yang dicadangkan pada penentuan jarak kesalahan anggaran, sistem pengagihan 21-bas telah dibanding untuk tujuan pengesahan, dengan pertimbangan lokasi yang berbeza dari sumber penjanaan. Keupayaan pendekatan yang dicadangkan telah dinilai menggunakan alat pemasangan lengkung di Matlab dari segi kesilapan segi empat (PKS) dan plot regresi (R). Keputusannya, kaedah LMB boleh digunakai bagi menganggar lokasi kesalahan setelah dilatih dengan 150 ANN hidden layer. Dalam situasi terbaik, perbezaan regrasi talian penghantaran antara 10-bus dan 21-bas tercapai pada 0.057%

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| | | |
|---|---|---|
| AI | - | Artificial Intelligence |
| ANN | - | Artificial Neural Network |
| kV | - | Kilo Volt |
| LG | - | Single Line to Ground |
| LL | - | Line to Line |
| LLG | - | Double Line to Ground |
| LMB | - | Levenberg Marquardt Backpropagation |
| MW | - | Mega Watt |
| MVA | - | Mega Volt Ampere |
| MVAr | - | Mega Volt Ampere Relative |
| MSE | - | Mean Square Error |
| p.u. | - | Per Unit |
| R | - | Regression |
| Ybus | - | Admittance Bus |
| Zbus | - | Impedance Bus |

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# CHAPTER 1

# INTRODUCTION

## 1.1. Introduction

Malaysia is a Southeast Asian country occupying parts of the Malaysia Peninsular and part of the Borneo island. It is known for its beautiful beaches, rainforests and demographic mixture of its major racial component such as Malay, Chinese and Indian with European cultural influences. The capital, Kuala Lumpur, is home to colonial buildings, busy shopping districts such as Bukit Bintang and skyscrapers such as the iconic, 451m-tall Petronas Twin Towers. The Gross Domestic Product (GDP) in Malaysia was worth 296.36 billion US dollars in 2016 [1].

The GDP value of Malaysia represents 0.48 percent of the world economy. GDP in Malaysia averaged 83.47 USD billion from 1960 until 2016, reaching an all-time high of 338.10 USD billion in 2014 and a record low of 2.42 USD billion in 1961 [1]. The GDP growth can be translated into the energy demand increase as one of the correlative factor, specifically the electricity as the main energy source used in Malaysia. Demand on electrical capacity increased rapidly over the year in commercial, industrial and residential sector starting from 1978 to 2015. This is shown by the line graph as featured in Figure 1.1 on the statistics of our domestic electricity consumption significant increase [2].

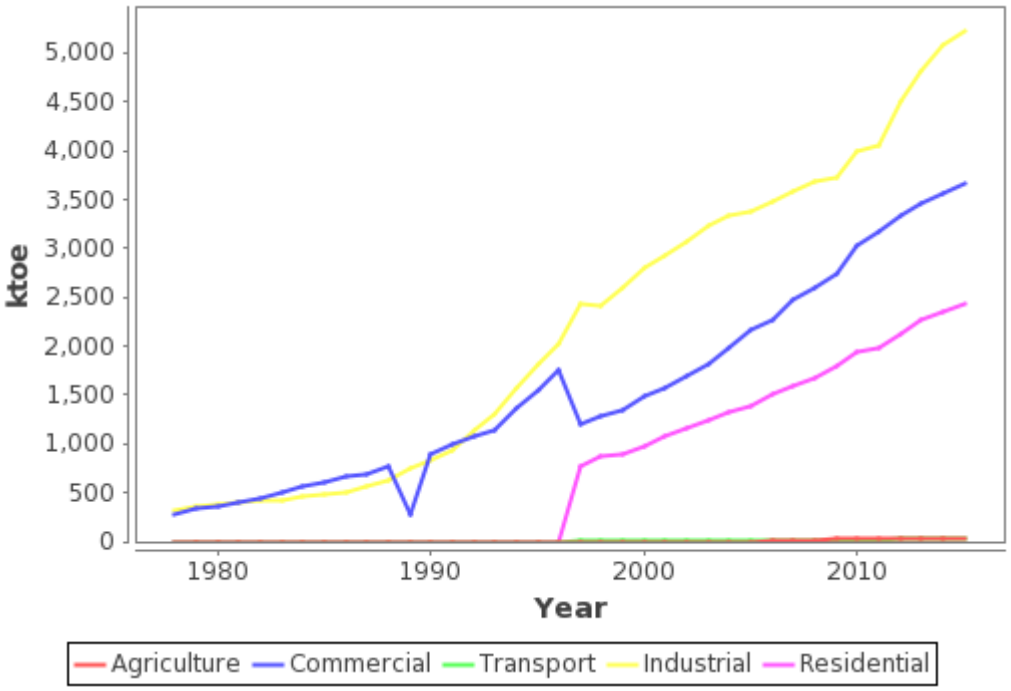


**Figure 1.1** Malaysia in Electrical Demand from 1978 to 2015

Hence, simultaneously the transmission and distribution system also need to be upgraded to increase the capacity to fulfil the increasing demand. Similarly, the protection scheme also needs to be upgraded to cover the existing and new demand capacity without any interruption. Protection scheme must have a capability to locate, to isolate and detect the probability fault happen in distribution system. Impedance based method and travelling wave is some of the example of fault detection done by the previous studies [3][4][5].

In this study, artificial neural network by Levenberg Marquardt Backpropagation (LMB) will be applied to estimate fault distance detection. Current fault detection method will be improvised based on the travelling wave and impedance methods. The computerized tool has made the fault distance detection becomes simpler

with higher efficiency. Both symmetrical and asymmetrical fault category can occur in the power system. Single line to ground (SLG) is the most common asymmetrical fault happened in the grid system with over than 70% from the overall fault type, followed by double line to ground fault (LLG) and line to line fault (LL) [6]. This study will focus on the SLG fault type.

## 1.2. Problem Statement

As electricity demand keeps increasing, and the number of distributed generator (DG)s in the system rapidly increased, fault detection by location such as installation of monitoring tool becomes more complicated and expensive. During fault occurrence, the fault current may flow either from single source or multiple sources if the power system is connected to the grid with multiple distributed generator (DG). The multiple DG system will contribute additional current source to the fault location [7] and the magnitude of fault current is slightly higher compared to distribution system with single generation. Therefore, the fault location scheme in distribution network needs to be improvised to provide better system reliability. Moreover, it has been recorded that more than 70% faults happened is single line to ground fault (SLG) [6].

## 1.3. Objectives

The main purpose of this project is to develop a system to estimate the distance of fault location. The specific objectives of this study include: -

1) To estimate the fault distance location using LMB-based on ANN approach for a 10-bus with a single generation in radial system network.

2) To validate the performance of the proposed system with 21-bus of quad generation system.

## 1.4. Scope of Study

The scopes of the project outlined to fulfil the objectives are as follows:

1) Focus only on Single Line to Ground (SLG) at ten 10-bus with single generation and 21-bus with quad generation in radial system network.

2) Simulate line-to-line (SLG) fault using Power World software with in line fault in one (1) km fault distance at all transmission line.

3) Develop proposed ANN with Levenberg Marquardt Backpropagation (LMB) and train the system.

## 1.5. Report Outline

In Chapter 1, the research background of this project is given. In this section, the problem statements of the executed project, objectives and its scope are also stated. In Chapter 2, the literature on the previous works has been listed and summarized. Only relevant issues have been included in this section. Meanwhile, in Chapter 3, the detail of the step-by-step project methodology is explained thoroughly. The preliminary results based on the current progress are given in Chapter 4. Lastly, the final outcomes are listed in Chapter 5.

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