‘’I hereby declare that I have read through this report entitled “Modeling and Analysis of an Overcurrent Protection and Coordination in Power System Network using PSCAD Software” and found that it has complied the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

Signature : . . . . . .

Supervisor’s Name : . . . . . .

Date : . . . . . .

MODELING AND ANALYSIS OF AN OVERCURRENT PROTECTION AND COORDINATION IN POWER SYSTEM NETWORK USING PSCAD SOFTWARE

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A report submitted in partial fulfillment of the requirements for the degree of Electrical Engineering (Industrial Power)

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2016

I declare that this report entitled “Modeling and Analysis of an Overcurrent Protection and Coordination in Power System Network using PSCAD Software” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in the candidate of any other degree.

Signature : . . . . . .

Name : . . . . . .

Date : . . . . . .

DEDICATION

To my beloved father
MUSLIM BIN NGADI

To my lovely mother
RAFEAH BINTI JAJURI

Relatives and Siblings

Classmates and Friends

ACKNOWLEDGEMENT

In the name of Allah S.W.T, the most gracious and merciful, praise to Allah the lord of universe and may blessing and peace of Allah be upon his messenger Muhammad S.A.W. First of all I would like to thank Allah for granting me the courage and health for the completion of this project report.

I would like to thank my supervisor Dr. Mohd Hendra Bin Hairi who taught me how to become a researcher. His professional behavior and excellent guidance in this project makes all the difficulties an easy one.

I have spent 3 months of my final year project in Power System Computer Aided Design Software (PSCAD) to complete my simulation. Mostly, thank Dr. Mohd Hendra Bin Hairi for very helpful to introduce and supervise me about PSCAD software.

During these 22 years of being a student, I have had many teachers who worked hard to educate me. I am aware of the great influence they have had on my life. I say thanks to all my teachers.

Being far from my family for nearly 4 years, I can understand better how precious they are. I believed my parents did a magnificent job on educating their kids even though they had very little resources available. Thanks to my father and my mother for their parental advice.

ABSTRACT

The case study in this project to analysis of an overcurrent protection and coordination in power system which is represent by using software of Power System Computer Aided Design (PSCAD). Protection against overcurrent by using coordination system benefits to protect the power system against any fault in order to limit the amount of duration during any interruption between breakers. To maintain high integrity of power system, this system could be minimizing damage in the system and components. Actually, faults may occur due to several reasons and they cannot be avoided such as lightning or other mechanical and natural causes.

Since the commencement of modern electrical system, coordination assignments were performed to guarantee that protection system would work with the necessary reliability and security. The tools to perform such task have developed from the utilization of a glass table with light and log-log curve sheets into computer base projects with GUI. Meanwhile, protective devices have likewise experienced progressions from the electromechanical gadgets to the multifunctional, numerical devices. All through the changes in coordination tools and protective devices setups, a great number of protection coordination standards will stay. In expansion, new systems are created to help us with the utilization of protection systems to reduce fault in basic to protection system functions. The advancements in the coordination projects and present day multifunctional numerical devices utilized as a part of distribution and industrial systems.

ABSTRAK

Kajian dalam projek ini adalah untuk menganalisis sistem perlindungan lebihan arus dan koordinasi dalam sistem kuasa dengan menggunakan perisian Reka Bentuk Berbantukan Sistem Kuasa Komputer (perisian PSCAD). Perlindungan terhadap arus lebih manfaat dengan menggunakan sistem koordinasi untuk melindungi sistem kuasa terhadap apa-apa gangguan dan menghadkan jumlah tempoh masa gangguan antara pemutus. Untuk mengekalkan integriti yang tinggi sistem kuasa, sistem ini boleh mengurangkan kerosakan dalam sistem dan komponen. Sebenarnya, kesilapan boleh berlaku kerana beberapa sebab dan tidak boleh dielakkan seperti kilat atau sebab-sebab mekanikal dan semula jadi lain.

Sejak bermulanya sistem elektrik moden, tugasan penyelarasan telah dilakukan untuk menjamin bahawa sistem perlindungan akan bekerjasama dengan keboleh percayaan dan keselamatan yang diperlukan. Alat untuk melaksanakan tugas itu telah dibangunkan daripada penggunaan meja kaca dengan cahaya dan log-log graf lengkung ke dalam projek-projek asas komputer dengan GUI. Sementara itu, peranti perlindungan telah juga mengalami janjang dari alat elektromekanik untuk pelbagai fungsi, peranti berangka. Semua melalui perubahan dalam alat penyelarasan dan peranti perlindungan, sejumlah besar standard penyelarasan perlindungan akan kekal. Dalam pengembangan, sistem baru yang dicipta untuk membantu kami dengan penggunaan sistem perlindungan untuk mengurangkan masalah dalam asas kepada fungsi sistem perlindungan. Kemajuan dalam projek-projek penyelarasan dan masa kini peranti berangka pelbagai fungsi digunakan sebagai sebahagian daripada pengedaran sistem dan sistem perindustrian.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Major electrical power systems are generation, transmission, and distribution. From the generation of electricity, power supply will distribute through the transmission line. The transmission line will reach the distribution system to separate the power supply. In distribution system, there are including primary and secondary distribution system. This system runs the power supply from the substations going to the customer.

Power systems are concerned about the generation, transmission, distribution and utilization. Actually, power system utility is probably the largest and most fully used in the world in each country. Interruption or fault could be happen in anytime and anyplace in the power system. Fault can happen either in external interruption or internal interruption caused by lightning or switch surges, to insulation disturbance, or other mechanical and natural causes. System protection and coordination was design to conserve minimum damage when interruption occurs. The limitation of time during interruption controlled to make sure the interruption not damaging the equipment of electrical devices. Information of protection and coordination to protect any generation or, transmission line or, distribution power system to get course of system operation.

Protective relay is one of the components that very important in protection and coordination. These components give an advantage to reduce harmful damage to both electrical equipment and public when there have any interruption fault occur. The characteristics of relay design to get action as fast as possible when the fault current happens.

1.2 Project Background

The simple design of power system network should describe the real situation of power system flow. The value of power, voltage and current is given to fulfill the relation. The design also include fault to operate the function of circuit breaker. Three phase fault was applied because it was the worst fault and high current. The function of protection and coordination is to limit the duration during interruption or fault. This is because when fault happen, the transient of fault will cause damage of electrical equipment. To overcome this problem, time dial of relay must be small and probably fast action to trip.

In electrical power system, fault happen when there have an abnormal current condition. For example, short circuits happen when the accidentals low resistance connection or current bypass through the normal load. There some interruption or failures that can cause the open-circuit fault happen. In three phase systems, fault can happen during phase or ground fault. There is only happen either phase fault or ground fault or both phase and ground fault. In power system, protective device was design to stop the faults when occur and protect the device from damage(Chen et al., 2012).

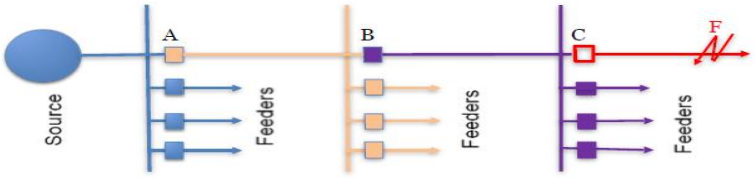


Figure 1.2.1 Coordination for Radial System

1.3 Problem Statement

Power system is the flow of power to supply electricity to customer. To give full of power supply to customer, there might be not have any disturbance or interruption in power transportation. Protection system is one of the most necessary ways to protect the transportation of power supply. During the transportation of power supply, there has much electrical equipment that influence in the system. The electrical components that influence in the system are transformer, buss bar, transmission line and etc. When an interruption occurs, the overcurrent will interrupt the electrical component. Each of the components has the limitation to support the overcurrent fault. Time is the most factors that can attach damage to the electrical element. The exposing of equipment to the interruption longer than usual time will take the equipment to damage.

In Overcurrent Protection and Coordination, there have many circuit breaker that will take action in one circuit which is 'protective' circuit breaker and 'protecting' circuit breaker. Protecting circuit breaker will take action first when fault happen. If protecting circuit breaker fail to isolate the fault, so it will affected the second circuit breaker. Now the damage taken during fault increasing to two damage circuit breaker. During this interruption, the disadvantage will effect to the customer. Customer will don't have any power supply until the maintenance complete by worker. Therefore, the maintenance cost will increase compare the damage of one circuit breaker than two circuit breaker that get damage.

1.4 Project Objectives

The objectives of this project are stated below:

1. Modeling a simulation of overcurrent protection and coordination power system network.
2. Reduce exposure and isolate problem.
3. Put the limitation of duration during an interruption.
4. Minimizing the damage during interruption.

1.5 Scope

In this project, there are some limitations are made:

- Using Power System Computer Aided Protection (PSCAD) to design the power network.
- Only use current transformer and Inverse Time Over Current (itoc51) as relay.
- Overcurrent protection and coordination in distribution system.
- Faults apply in three phase, double phase and single phase. Three phase fault is used as the worst fault.
- The distribution system will discover in 132kV-33kV distribution system in Behrang.

There are some limitations during this project. First is to find the true information about generation, transmission line, distribution and circuit breaker. To get the trusted information, journal and IEEE standard is taken from the library and revision book. Next, this project will do only in a design by using PSCAD. There is no outside observation has been done. To analyze the correction of data inserted, calculation has been done to confirm the data input.

1.6 Expected Project Outcome

The expectation to this project is the duration time between two operating relay might be ±0.4s. The overcurrent fault was applied to certain zone to see the action of relay during the interruption. There have two characteristics in overcurrent protection and coordination which is main protection circuit breaker and backup protection circuit breaker. The situation when the faults occur, the main circuit breaker will isolate the fault first and if it is not, so the backup circuit breaker will take action and isolate fault. The duration to second circuit breaker will take action is ±0.4 sec which is normally use in TNB Sdn. Bhd. Protection system.

1.7 Significant of project

The research of signal in relay operation of overcurrent protection and coordination, there has a time margin between two signals of operation relay. The relay will operate when fault occur. To improving the protection coordination, the main system of tripping needs a backup system to flow the power supply through the customer.

1.8 Report outline

The main focus of this report was to discuss about the overcurrent protection and coordination system in distribution system. Modeling the simulation of protection coordination by using Power System Computer Aided Design (PSCAD) was used as a simulator in this report. This report will divide into five parts which are introduction, literature review, research methodology, results and conclusion.

The first part is introduction which discuss about overall of the research. The part of this chapter such as project background, problem statement, objectives, scope of the project, expected project outcome, significant of the project and report outline will be discussed in this project. In chapter 2, this section was fully discussed about the literature review. The basic components that have been used in this project was discussed and explained. The main theory of the project was taken as a reference to do this project. All the rated got from the journal was used to make the simulation. The main sources of this section actually come from the journals, reference books, articles and internet sources. Next section is methodology of the running project. In this section was discussed the way to complete this project. The procedure to complete the simulation until getting the result was discussed. The result and discussion was clearly discussed in chapter 4. The result outcome from the simulation was clearly explained and discussed. Chapter 5 is the final chapter for this report where the chapter will discuss on the conclusion of the project. Conclusion is the project final statement whether all the process and result is achieved the objectives stated or not.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature review overview

This part discuss about the reviews and information data about protection and coordination. The information data must be understood to complete the project. Every data and standard was collect from revision book, journals and world web.

2.2 What is Power System Protection?

Protection can be define as "the science, skill, and art of applying and settings relays or fuses to provide maximum sensitivity to faults and undesirable conditions, but to avoid their operation on all permissible or tolerable condition"-*Blackburn*(Durand, 2010). [1]

Power systems are subjected to various types of fault. Generally fault currents are high since fault impedances are normally low. Breaking of conductors creates numerous faults, while failure of insulation creates a shunt type of fault. In power system, faults may occur due to several reasons and they cannot be avoided. This will result in an increase of current and reduction of voltage. Hence, system stability and reliability are also affected. Therefore, to protect the various parts of power system and the system as a whole, power system protection is necessary.

Power system protection is used to protect power system against any fault in order to:

i. Prevent danger and accident to public.
ii. Minimize damage to equipment.
iii. Minimize supply disruption.
iv. Maintain high integrity of power system quality.

Power system protection works through detection of fault and subsequent isolation of the fault using relay combination with circuit breaker or fuse. With correct setting of relay and selection of fuse rating, proper fault isolation can be achieved.

Main function of protection system in electrical power system is to ensure the continuity of the electrical power supply. To fulfill this condition, protection device must be able to detect the abnormal current condition in electrical equipment or circuit. It does also can detect the location where the faults occur. To execute the isolate zone, protective device must have true decision to take action. Protection also can protect the other equipment from taking damage and can flow current depend on rating(Homburg, Power, Engineer, & Services, 2011). [2]

2.3 What is Protection and Coordination?

Protection and coordination is a protective device that can manage the best timing of tripping when interruption occurs. The main advantage is to minimize the total damage of electrical component(IEEE, 1997)[4]. Besides, it can increase the lifespan of the electrical component.

Actually, protection coordination is a design of protective devices that can divide the power system into a protective zone. When a fault is happen in certain zone, the protective actions will take actions to isolate the zone from the entire system. Overlapped regions are created by two sets of instrument transformer and relays for each circuit breaker. This system designed to eliminate unprotected areas of redundancy(Fecime, 2008). [3]

The goal of protection and coordination is to minimize the outage of a greatest extent possible. Historically, protective device coordination was design on a log-log paper. But in a modern methods, protection devices normally design in a detailed computer based analysis and reporting.

There are some objectives from protection and coordination. The objective of this protection coordination must be achieved. The condition of overcurrent protection and coordination will be following the characteristics as listed below.

- Minimize the damage and time of fault and reduce the number of customer that will affect during interruption.
- Minimize the service for any interruptions occur that cause the damage to equipment.
- To identify the fault location easily in a way to reduce of time service outage.

There are four type of coordination:

1. **Fuse to Fuse Coordination**

One fuse is called protected fuse and the other fuse is called protecting fuse. In other when fault happen, protecting fuse must be melt first to interrupt the abnormal current. This will protect the protected fuse from take damage(Zamani, Sidhu, & Yazdani, 2010).[5]

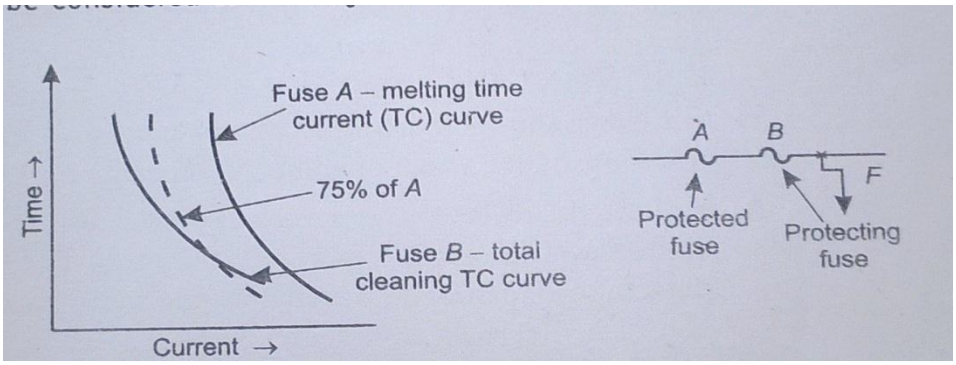


Figure 2.3.1 Time Versus Current Fuse To Fuse Coordination

2. Auto Recloser to Fuse

When the fault is occur in a network, autorecloser will interrupt first. If auto recloser not trip, the fuse will take damage. So, to reduce the damage of electrical equipment, the autorecloser will take action first. (Hor, Kangvansaiehol, Crossley, & Shafiu, 2003)[6]

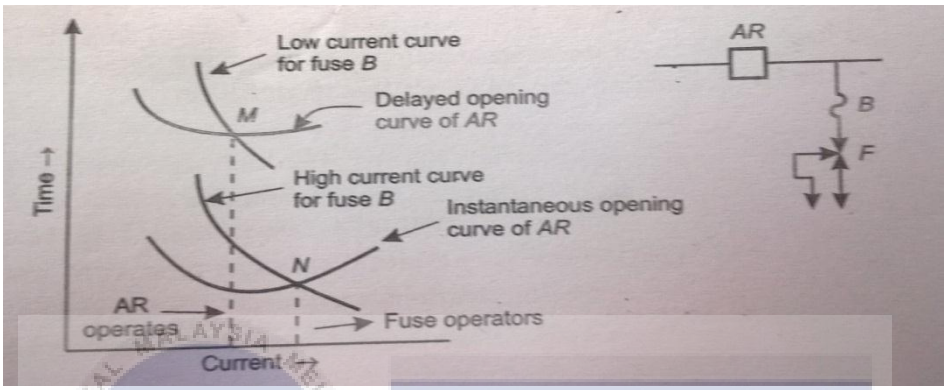


Figure 2.3.2 Time Versus Current Auto-Recloser To Fuse Coordination

3. Circuit Breaker to Fuse

In this operation, circuit breaker will back up the fuse if any failure happens to the fuse. The fuse will trip first. If fuse fail to trip during fault, the circuit breaker will interrupt.(Hor et al., 2003) [7]

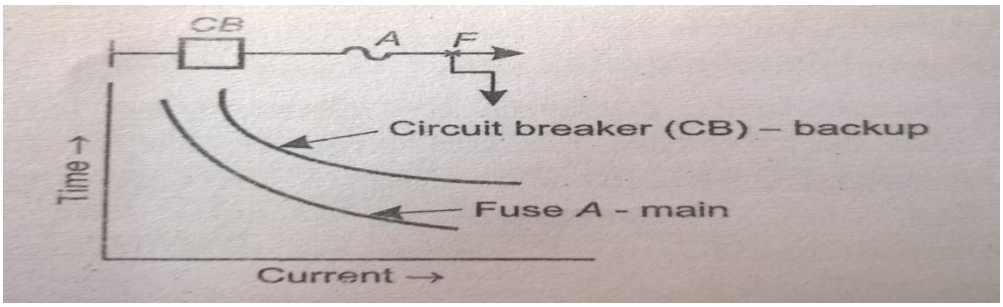


Figure 2.3.3 Time Versus Current Circuit Breaker To Fuse Coordination

The other operating system is fuse as backup to the circuit breaker operation. The main protection is come from circuit breaker to interrupt the fault. The relay from the circuit breaker should operate instantaneously so that the faults will interrupt. This will protect the fuse from blowing. The operating relay at fuse must at rating about 135% more

than total fault occur. So the total fault will clear at circuit breaker relay for combination phase to phase fault. (Lin, Member, Zhao, & Bo, n.d.)[9]

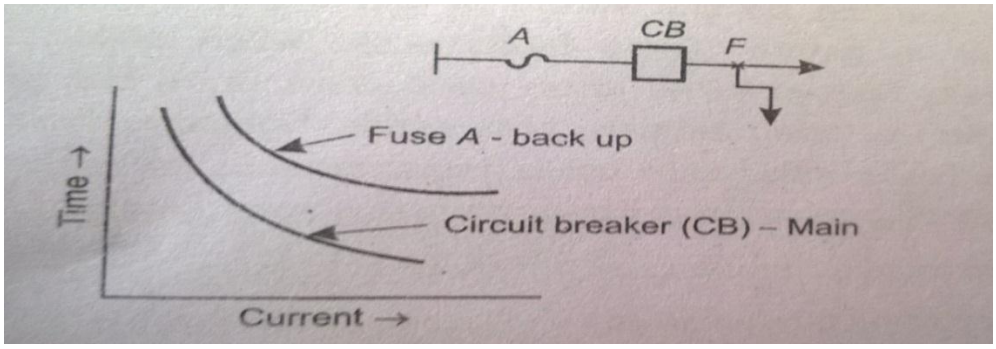


Figure 2.3.4 Time versus current circuit breaker to fuse coordination

4. Circuit Breaker to Auto-Reclosers.

In this operating system, auto recloser will provides main protection of the network. Circuit breaker will operate after auto recloser fail to operate the interruption. Circuit breaker will provide backup protection to the zone after auto recloser. (Zamani et al., 2010)[8]

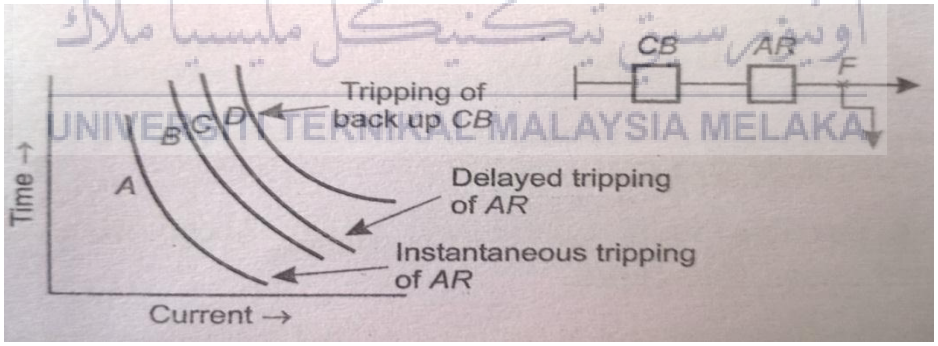


Figure 2.3.5 Time versus current circuit breaker to auto recloser coordination

2.4 PSCAD software

Power System Computer Aided Design is used to construct simulates and model system easily. It deals with more simple and easy with the power system network design. It is including a comprehensive library of system models ranging from simple passive elements and control functions to electric machines and other complex devices.

2.4.1 What is PSCAD software

Power System Computer Aided Design is used to construct, simulates, and model system easily. It also can provide a limitless probability in power system simulation. By using PSCAD, it deals with more simple and easy with the power system network design. It is including a comprehensive library of system models ranging from simple passive elements and control functions to electric machines and other complex devices. (Manitoba-HVDC Research Center, 2010)[10]

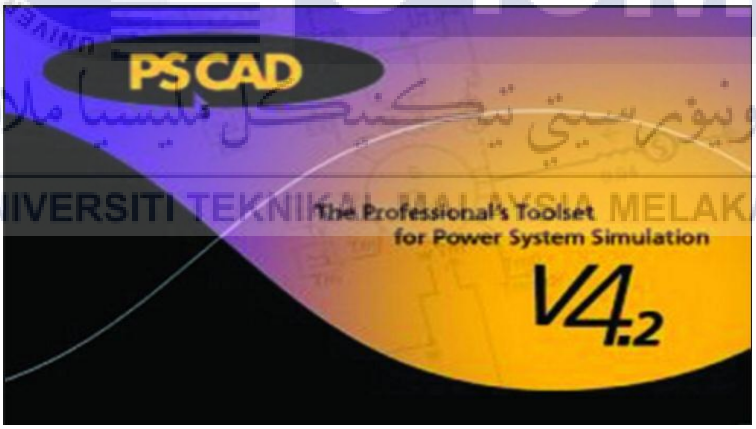


Figure 2.4.1 Power System Computer Aided Design

2.4.2 Application of PSCAD Software

There are the applications for the PSCAD Software:

i. Design a simulation of single line diagram or three line diagram.
ii. The design might be in HVDC or LVDC power system network.
iii. Applying overvoltage due to fault in power system network.

iv. Operation of circuit breaker in the system when fault happen

v. Function of fuse to send a data to a circuit breaker.

vi. Parametric studies are commonly used to run hundreds of simulations to find the worst case when the phase shift of a fault, the fault type, or its location varies.

vii. Applications in distribution network. (Converters, n.d.)[11]

2.4.3 PSCAD Master Library

Components or any equipment of circuit can be copied from the master library. There is much type of components that have in the master library which is:

i. Network Components

RLC components, Transformer with saturation, Frequency dependent transmission lines cables, synchronous machines, induction motors with exciter governor and turbine models, faults, breakers, surge arresters, current voltage sources, and multiple harmonic injectors.

ii. **Power Electronic Components**

Thyristors, diodes, GTOs, HVDC valve group, SVS, and FACTS devices.

iii. **Control Blocks**

Derivative, delay, differential lag, integrator, limit, complex pole, lead lag, filter, amplifier, switch, and Boolean functions.

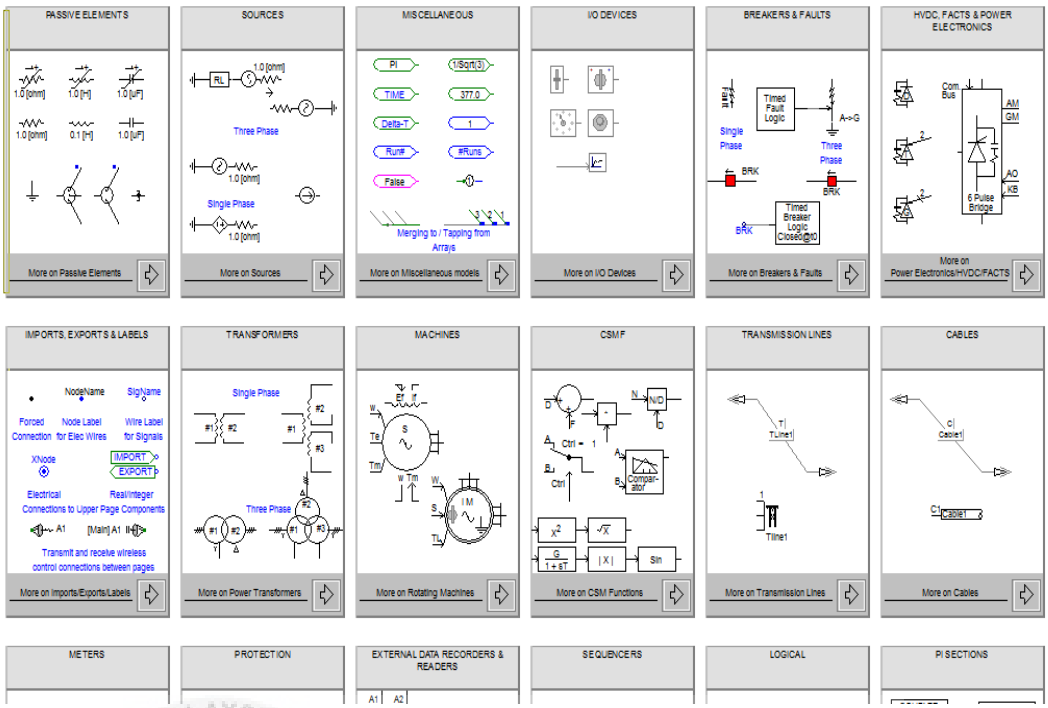


Figure 2.4.2 Master Library in PSCAD

2.5 Faults Analysis Studies

Common phenomenon when the faults are happens in insulation equipment. The overvoltage's commonly caused by lightning, switching surges and etc. Sometimes even mechanical causes may create short circuits. There are various faults contain in electrical networks. (Muljadi et al., 2013)[12]

There are the effects of short circuits:

i. When sort-circuits happen, it will cause a thermal damage to the equipment.

ii. A mechanical damage will occur at transformer, generator or buss bar due to high magnetic forces or overcurrent during faults.

There are two main types of faults in power system network:

i. Symmetric faults

This fault also called as balance fault. This fault will affect all the three phases equally and all the system remains balance. This fault is most fully easiest way to analyze and it is relatively rare.

Fault is an abnormal current which are several times larger than a normal current. it will caused a magnetic forces and torques produces that may damage the system of generator. In a motor, an electro dynamics forces on the stator end windings may results in displacement coils against one another. This may cause the damage to the insulation windings and loosening of support. Following a short circuit, it is always recommended that the mechanical bracing of end windings to checked for any possible to loosing. As the faults are cleared with in three cycles generally the heating efforts are not considerable. (Instructions, 2000)[14]

Other well thon that line to line or line to ground faults will results to interruption in a few cycles by the circuit breakers. It is necessary to select a circuit breaker that capable to operate successfully during faults. It also able to prevent a high voltage that prevails the power system network. Consider in a circuit which have R-L connected to a voltages source, the circuit being switched on through a switch.

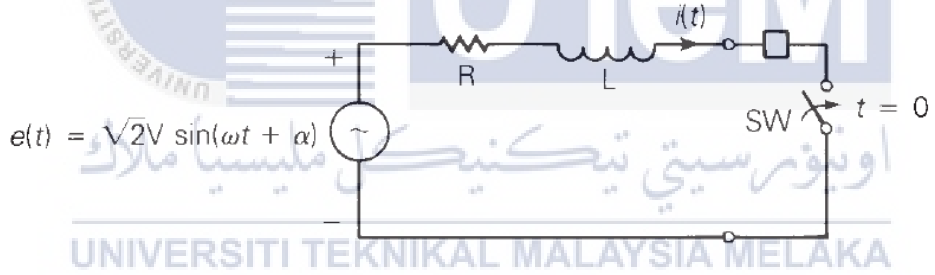


Figure 2.5.1 Example of Short Circuit

ii. Unsymmetrical faults

Any unsymmetrical fault causes unbalanced currents to flow in the system. This fault not like as a symmetrical fault, the system cannot directly reduced to single phase system. Most of the faults that occur in power system are unsymmetrical faults. Unsymmetrical faults occur in single line to ground faults, line to line faults, or double line to ground faults. Since unsymmetrical fault will flow an abnormal or unbalanced current to through the power system. The symmetrical components are methods to determine the overcurrent and voltages in part of occurrence in the fault.

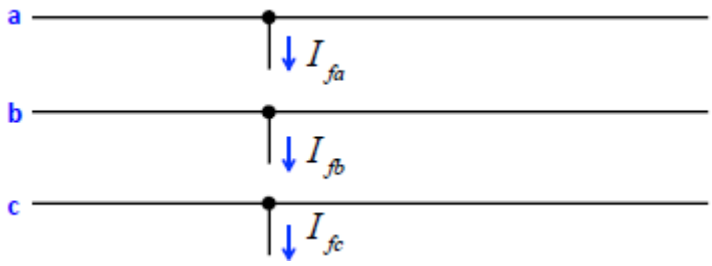


Figure 2.5.2 Unbalanced Fault

The figure 2-14 shows the three lines a, b and c of three phase system in the network when fault happen. The flow of current from each line into the fault is indicated by arrows shown besides hypothetical stubs connected to each line at the fault location.

2.6 Relay

Relay is devices that detect an abnormal current and initiate it into a corrective condition as fast as possible to return in normal condition. The quickness response times are a few milliseconds often required. Consequently, human intervention in the system is unavailable because the response must be fast and automatic and cause minimum amount of disruption to the power system. ("Protection Scheme For Low Voltage Distribution," 2011)[13]

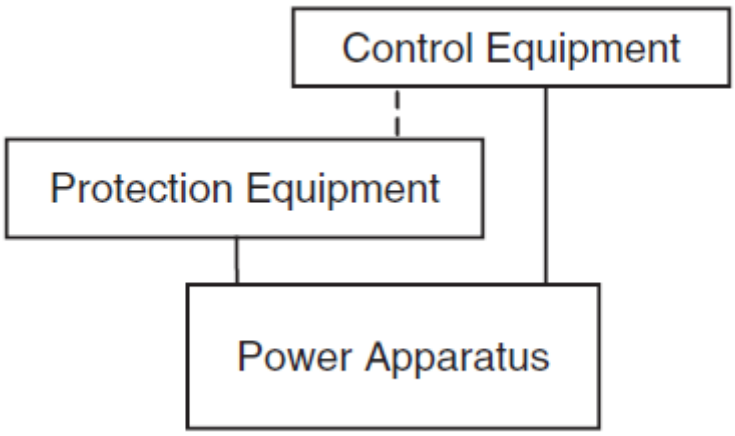


Figure 2.6.1 Three-Layer Structure of Power System

2.6.1 Characteristics of relay

There are many characteristics of relay must be consider to ensure the system is fully protected and no unwanted condition(Hor et al., 2003) [15].

1. Reliability, dependability and security
2. Selectivity of relays and zones of protection
3. Relay speed
4. Primary and backup protection

Reliability, dependability and security

Reliability is generally understood to measure the degree of certainty that equipment will perform as usual. There have two alternatives that might be the relay can be unreliable which are, when relay operate as not at expected condition and the relays can operate as expected condition. This leads to a system relay that reliable relay must be dependable and secure (Shah, Patel, Patel, & Wani, 2015)[16]. Dependability defined as operating relay that can function when the fault happen which there are design to operate. If the operation of relay is fail, there might be secure characteristics of relay. Security is a measuring certainty that when relay operate incorrectly in any fault happen.

Complete protection must be designed as high dependability. So, the fault can be cleared in any condition without failure. It will become the security of relay increase. Consequently, mis-operation of relay will result unwanted trip that caused by insecure relay operation (Soman, 2009)[19].

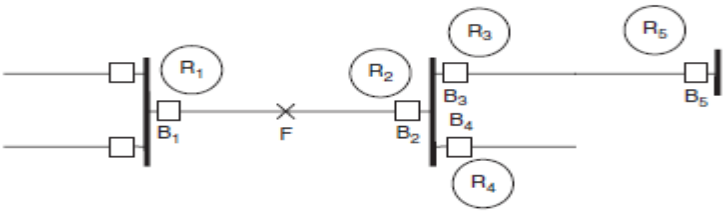


Figure 2.6.2 Reliability of Protection System

The Figure 2.8.2 shows the normal circuit when the fault happens in between circuit breaker B1 and B2. When the fault occur, if B2 not trip which relay R2 not operate for this fault, it has become unreliability through a loss dependability. If relay R5 will operate and circuit breaker B5 trip, this become unreliable because loss of security. So, relay was designed as protective equipment at each location. This condition will become the relay unreliable and insecure.

Selectivity of Relays and Zones of Protection

The property of relay is not designed in power system protection when the relay not operate when the fault happen. The relay must be response as protective equipment in every zone locate. Relays usually get the input from the current transformer CT's. Current transformer will bond with the circuit to the relay. The CT does will provide the ability of detection of fault and circuit breaker have ability isolate the fault and disconnecting power supply in that zone (Lin et al., n.d.)[17].

To cover all equipment in a protection power system, the zones protection must following the requirement.

- All power system must be covered by at least one zone and good relaying is important when there is include at least in two zones.
- Zone protection must be overlap from being unprotected. A no overlapping will result the zones to be unprotected. The zone of overlap must be small so that the fault happen in that zone will be minimized. This will remove larger segment of power system from service (Sadeh, 2005)[21].

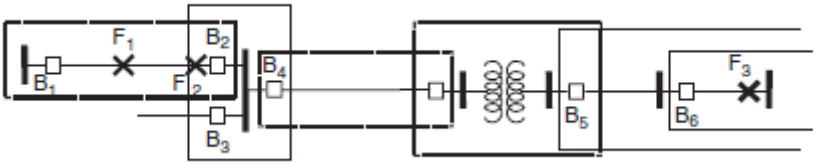


Figure 2.6.3 Closed and Open Zones Protection

The figure 2.8.4 shows that the condition when the closed and open zone in the circuit. Consider as fault happen in F1, the circuit breaker that will include in this tripping is B1 and B2. In other, when the fault is happen at F2, inside the overlap between zones of protection of transmission line and buss. This will cause the B2, B3 and B4 to trip. The opening of B3 and B4 is unnecessary because interrupted of power supply to other consumer during interruption. Next, consider the fault happen at F3, the circuit breaker B6 will take action to trip. The breaker B5 will back up the protection if the B6 not trip to clear the fault.

2.6.2 Relay Speed

Relay was designed to remove fault as fast as possible. In a fault, must be considered the voltage and current waveform that have transient phenomena. The relay must be separate the meaningful and significant through this condition base on decision on secure relaying. The comparison of relay response time and degree of certainty is inverse one. This is the most basic properties in all protection systems (Tan, McLaren, Jayasinghe, & Wilson, 2002)[18].

Relays are classified as their speed by following the operation below:

1. **Instantaneous:** This relay will take action as soon as secure decision is made. No time delay is considered to slow down the relay operation.
2. **Time Delay:** Time delay inserted between relay to make decision to trip take action.
3. **High Speed:** A relay that can operate in less than specified time. Relay generally can operate in a 50 milliseconds (3 cycles on a 60 Hz system).
4. **Ultra High Speed:** this operation of relay in 4 milliseconds and this relay not be considered in standard relay system.

Inverse Definite Minimum Time (IDMT) Relay Characteristics

The time-current characteristic of relay according to IEC 60255 can be classified into:

i. Definite Time (DT)

ii. Inverse Definite Minimum Time (IDMT)

- Normal/Standard inverse (SI)
- Normal inverse (NS)
- Very inverse (VI)
- Extremely inverse (EI)

The time-current characteristics of Definite Time (DT) and Inverse Definite Minimum Time (IDMT) relay is as shown in figure below:

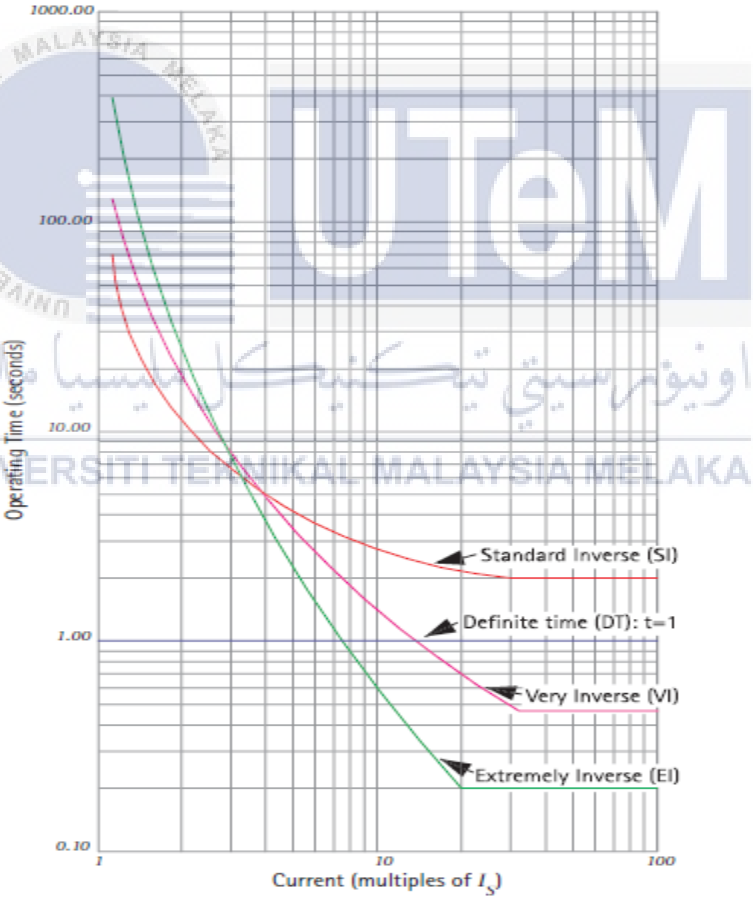


Figure 2.6.4 Time-Current Characteristics Of Definite Time (DT) And Inverse Definite Minimum Time (IDMT) Relay

Table 2.6.1 Relay Characteristics to IEC 60255

Relay characteristics	Equation (IEC 60255)
Normal/Standard inverse (SI)	$t = \frac{0.14}{PSM^{0.02} - 1} \times TMS$
Very inverse (VI)	$t = \frac{13.5}{PSM^{0.02} - 1} \times TMS$
Extremely inverse (EI)	$t = \frac{80}{PSM^{0.02} - 1} \times TMS$
Long time standard earth fault	$t = \frac{120}{PSM^{0.02} - 1} \times TMS$

The characteristics of Inverse Definite Minimum Time (IDMT) relay inverse in the initial part and tends to definite minimum operating as the current increases due to core saturation in electromechanical relay. The most commonly used relay characteristics in TNB is Inverse Definite Minimum Time (IDMT) with Standard inverse (SI) characteristics. (Ansi et al., n.d.)[20]

To achieve desired relay operating time, two parameters needed to be correctly set, namely:

i. Plug Setting (PS)
ii. Time Multiplier Setting (TMS)

Plug Setting (PS) signifies the minimum value of the operating current that will cause the relay to reach its completely operated state when started from the reset condition.

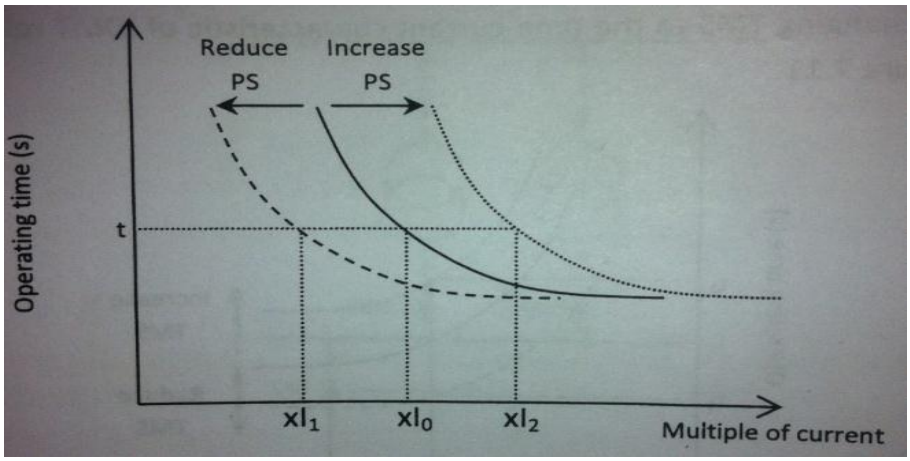


Figure 2.6.5 Effect of Changing Plug Setting (PS)

Plug Multiplier Setting (PSM):

Plug setting multiplier (PSM) is the ratio of the fault current to the relay current setting, Iset and defined as follows:

$$PSM = \frac{If}{CT\ Ratio \times PS \times I_{Relay\ Rating}} = \frac{If}{Iset} \qquad (2.0)$$

Where,

- CT Ratio – Current Transformer ratio
- PS – Plug setting/ Pickup current = Iset
- If – current of fault

Plug setting multiplier signifies the severity of the current seen by the relay. Plug multiplier setting value of less than 1 shows that a normal current is flowing. The relay should be able to pick up a current when the plug multiplier setting is greater than 1.

Time Multiplier Setting (TSM):

The time multiplier setting is a factor that affects the operating time of a relay. Time multiplier setting ranges from 0 to 1.0. If time multiplier setting set to 0, then the two contacts in example fixed and moving contacts are permanently closed. If time multiplier setting is set to 1.0, the distance between two contacts is as far back as it can go in example 180 degree, and the disk has to move through its maximum travel in order to operate the contacts. The effect in figure :

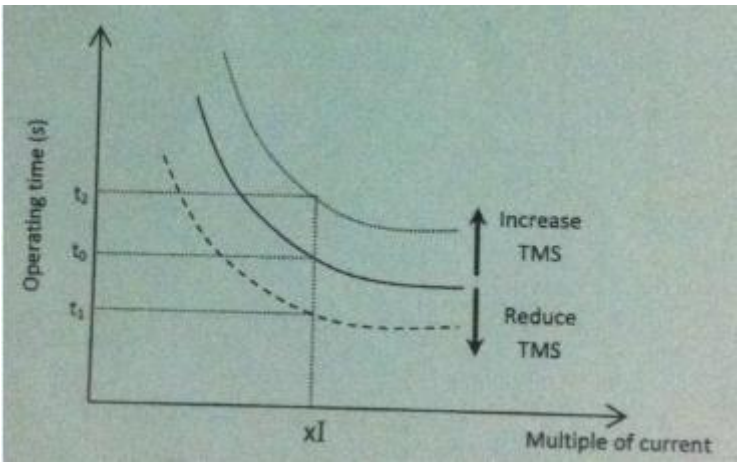


Figure 2.6.6 Effects of Changing Time Multiplier Setting (TMS)

In summary, the relationship between plug setting and time multiplier setting used to determine the relay operating time, t in standard inverse IDMT relay is expressed as follows:

$$t = \frac{0.14}{PSM^{0.02}-1} \times TMS \qquad (2.1)$$

CHAPTER 3

METHODOLOGY

3.1 Literature review

Find the information about overcurrent protection and coordination in power system from book, journal and internet. The information needed to be discussed for further understanding and able to the design of power system operation.

3.2 Collecting data

In this season, all standard of circuit breaker, fuse and power system were collected from library.

- Time-current characteristics of DT and IDMT relay.
- Using standards IEC 60255-3

3.3 Design the simulation

The simulation was design in a single line diagram and three line diagrams. Power System Computer Aided Design used to design the simulation. This design containing six case of protective devices. Each case contain of three phase fault, double phase fault and single phase fault.

3.3.1 Construct single line diagram

Simple single line diagram was constructed which have generator, transformer, meter and load. Fault is attached at the constructed design to analysis the overcurrent protection and coordination.

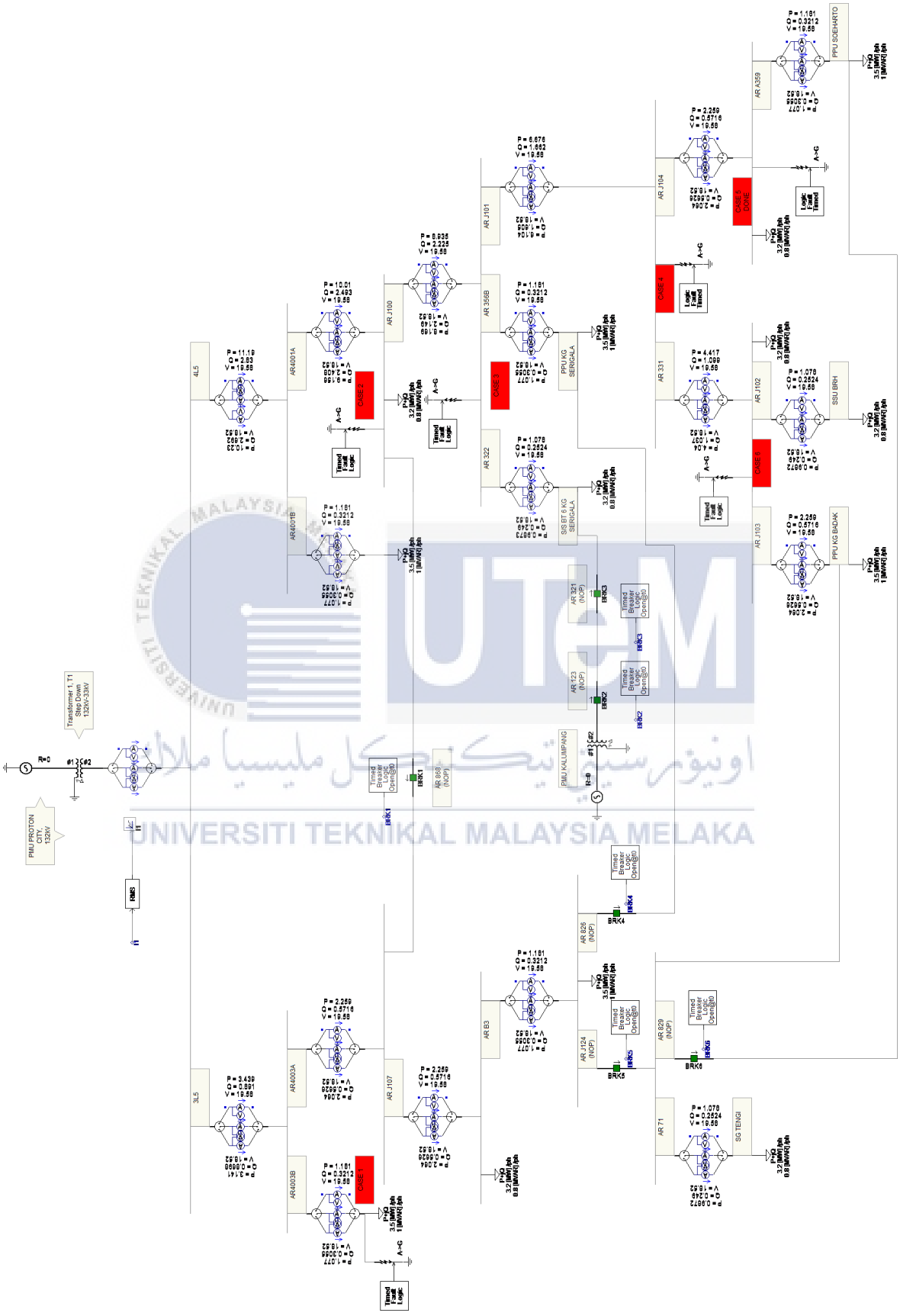


Figure 3.3.1 Single Line Diagram of Distribution System

3.3.2 Transformer

Figure 3.3.1 show that single line diagram was constructing to apply the overcurrent protection and coordination. The circuit contain of one power source that will supply for 132kV. There are three transformer stated to step down the power supply to contribute the load. For the first transformer, T1 will step down the power supply from 132kV to 33kV. The 33kV supply will separate through the buss bar and consume to other load.

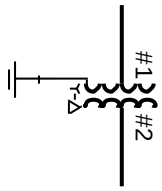


Figure 3.3.2 Three Phase Two Winding Transformer

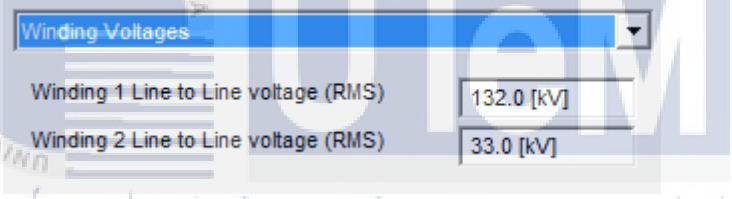


Figure 3.3.3 Transformer 1, T1

3.3.2.1 Multi-meter

The Multi-meter performs virtually all possible system quantity measurements, all contained within a single, compact component. The Multi-meter is inserted in series within the circuit (3-phase, single-line or 1-phase), so bulky Node Loops are not required. The component measures the following quantities:

- Instantaneous Voltage
- Instantaneous Current
- Active Power Flow
- Reactive Power Flow
- RMS Voltage
- Phase Angle

In this project, multi-meter was put in every zone. The multi-meter shown in figure 3.3.6 represented as a circuit breaker which name as CB. The multi-meter will measure the current so it can use in relay setting.

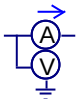


Figure 3.3.4 Multi-meter

3.3.3 RMS Meter

The Single Phase RMS Meter calculates the RMS value of any real input variable, as a function of time. The component may be set to output one of two different algorithms, depending on the users preference:

- **Analog**: This function calculates the RMS value of a time domain input signal. The integration is performed by using a non-ideal integrator, with a time constant given by the input parameter called **RMS Smoothing Time Constant**.
- **Digital**: This calculation method using a 'moving data window approach', where the RMS value for a buffered set of data is calculated each time step. The size of the buffer is determined by the input parameter **of** Samples in a Cycle**.**

The choice of which function is best suited for a particular study depends on its use. The Digital method will provide a very smooth output signal, which works well for control. The Analog method will produce ripple in the output signal, depending on the input signal frequency and the **RMS Smoothing Time Constant** parameter, but can respond much faster to changes.

3.3.4 Relay setting

In this simulation, inverse time overcurrent relay element as shown in figure 3.3.7 and figure 3.3.8 was use to analyze the data. Actually inverse time overcurrent relay element is defined as a current operated relay produces an inverse time-current characteristic by integrating a function of current F(I) with respect to time. F(I) is positive above and negative below a pre-determined input current called 'Pickup Current'. Pickup current is therefore the current at which integration starts positively and the relay produces an output 1 when the integral reaches the pre-determined positive set value. The input to this component is a measured current signal (can be in per-unit or kA). The function F(I) is defined as a trip when the input current is higher than the Pickup Current and reset when the current is less than the Pickup Current.

1st case:

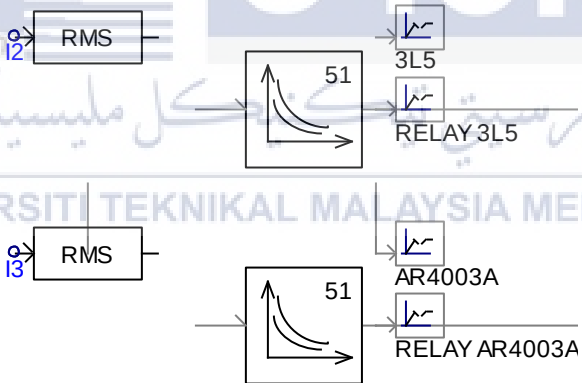


Figure 3.3.5 Inverse Time of Overcurrent Relay for 3L5 and AR4003A

2ND case:

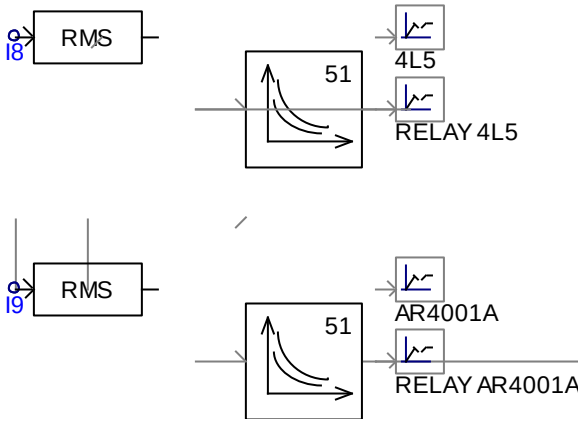


Figure 3.3.6 Inverse Time of Overcurrent Relay for 4L5 and AR4001A

3rd case:

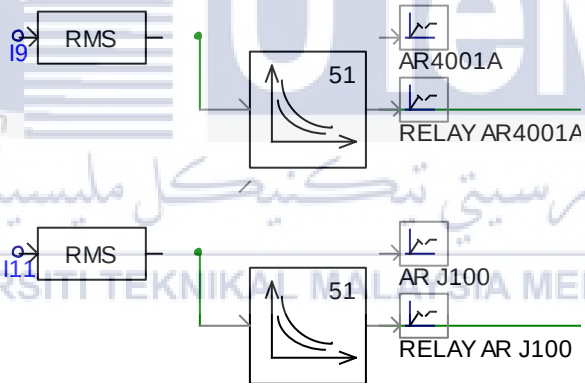


Figure 3.3.7 Inverse Time of Overcurrent Relay for AR4001A and ARJ100

4th case:

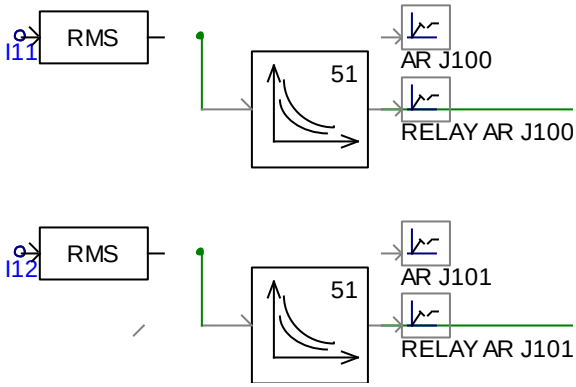


Figure 3.3.8 Inverse Time of Overcurrent Relay for ARJ100 and ARJ1001

5th case:

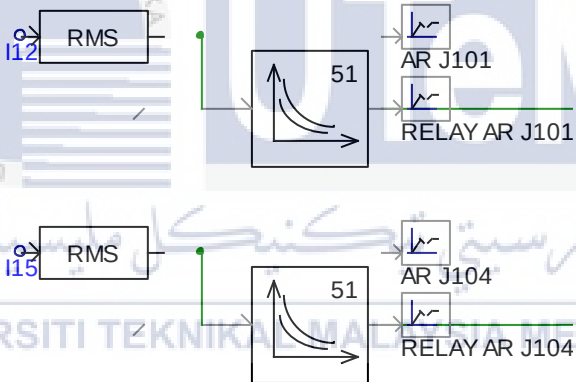


Figure 3.3.9 Inverse Time of Overcurrent Relay for ARJ101 and ARJ104

6th case:

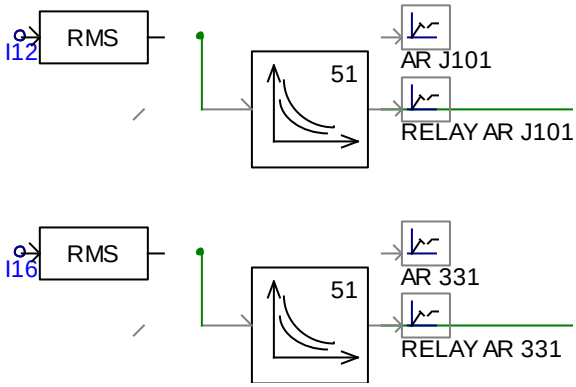


Figure 3.3.10 Inverse Time of Overcurrent Relay for AR J101 and AR 331

3.3.5 Fault Finding

In this season, fault was applied in many type of fault which is three phase, double phase and single phase fault. The fault was applied in the beginning of time duration the project running. The duration of fault is 2.8 seconds, while the simulation running at 3 seconds. The overcurrent was observed to get appropriate setting for relay.

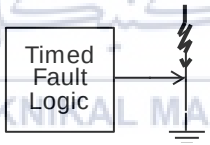


Figure 3.3.11 Three Phase Fault

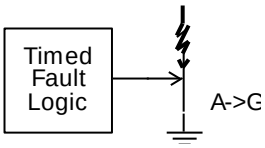


Figure 3.3.12 Line-to-Ground

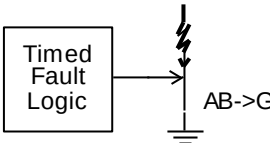


Figure 3.3.13 Double Line-to-Ground

The entire component will generate three type of fault in maximum 10,000 A. An external connection is supplied to the component so that the user may connect any type of external fault circuit directly to the fault common point.

The entire Fault is controlled through an input signal, where the fault logic is:

- 0 = Cleared
- 1 = Faulted

The time fault logic shows in figure 3.3 will operate the output of this fault is used specifically for controlling the fault state and duration of fault.in this project, the fault was applied at duration of 0 seconds from the running circuit which is fault applied in starting of running simulation. The fault will continue in 2.8 seconds that is the duration of fault happening to interrupt the circuit as shown in figure 3.3.14.

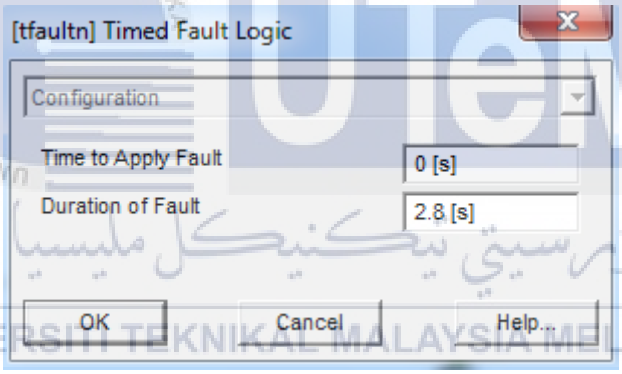


Figure 3.3.14 Timed Fault Logic

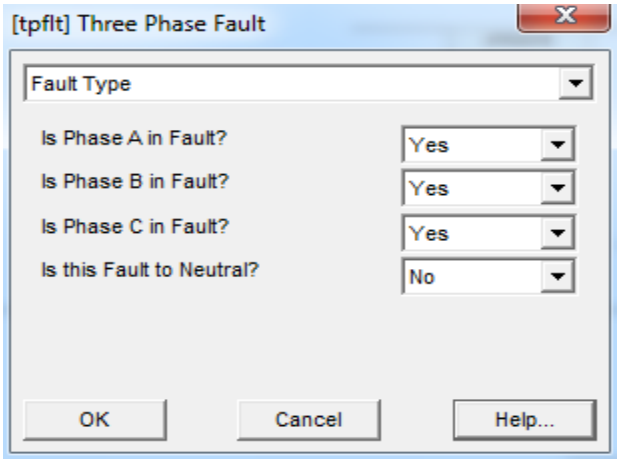


Figure 3.3.15 Type of Fault

Figure 3.3.15 shows the setting for fault that want to apply in the circuit. In this project, three phase fault was applied which use phase A, phase B, phase C and fault. Normally three phase fault was applied to setup the operation of relay. This is because three phase fault is the worst faults that happen in the interruption. Whether another fault happens, the relay also can operate and isolate the fault.

3.4 Troubleshoot the simulation

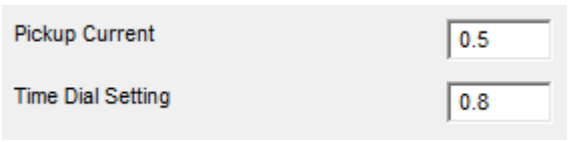
After the simulation constructed was completed, there have much problem to collect data. The data shown are not possible with true condition in power system equipment. The problem was listed as listed below:

3.4.1 Relay settings problem

Firstly, the relay settings not follow the actual value cause problem to the circuit breaker tripping. When fault is attached, the breaker did not operate at correct time. The circuit breaker will operate either late or too fast during interruption. During the troubleshoot, many value pickup current and time dial setting has been change to get the correct timing for breaker to operate. Try and error was possible in this troubleshoot.

1st Case:

Relay 3L5:



Relay AR 4003B:

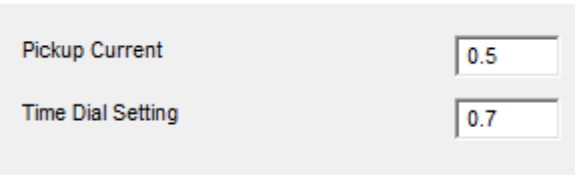
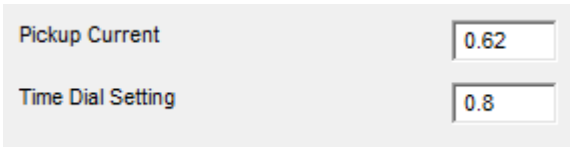


Figure 3.4.1 Relay setting for 3L5 and AR4003B

2ND Case:

Relay 4L5:



Relay AR 4001A:

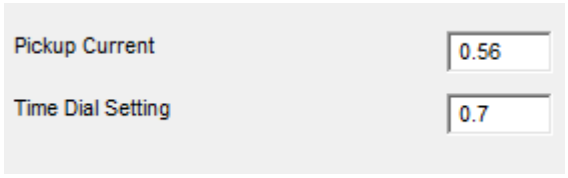


Figure 3.4.2 Relay setting for 4L5 and AR4001A

3RD Case:

Relay AR J100:

Relay AR4001A:

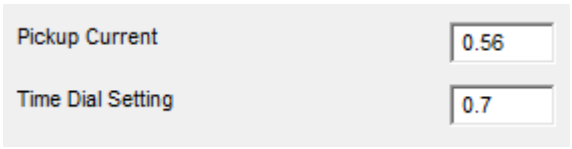
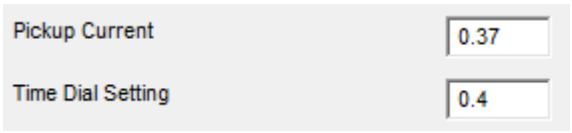


Figure 3.4.3 Relay setting for AR J100 and AR4001A

4TH Case:

Relay AR J101:



Relay AR J101:

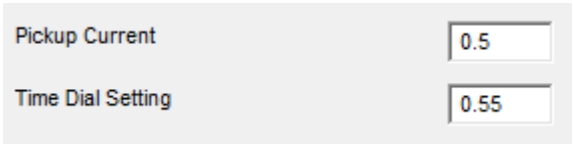


Figure 3.4.4 Relay setting for AR J101 AND AR J100

5TH Case:

Relay AR J104:

Relay AR J101:

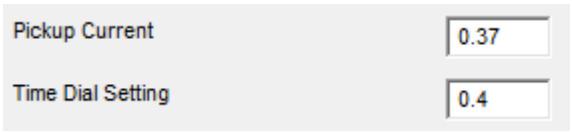
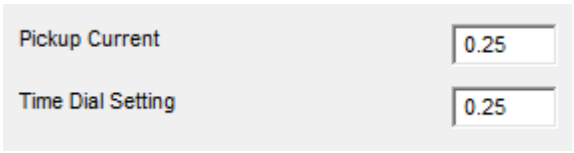


Figure 3.4.5 Relay setting for AR J104 and AR J101

6TH Case:

Relay AR 331:



Relay AR J101:

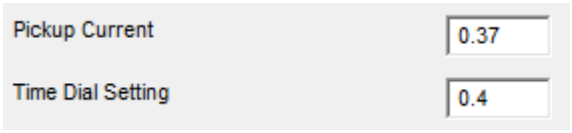


Figure 3.4.6 Relay setting for AR 331 AND AR J101

Pickup current is the current at which integration starts positively. The relay produces an output '1' when the integral reaches 1.0. The value of pickup current as shown in figure above was set in try and error method. The fault will occur in 0 seconds, so the relay setting must be providing in a safety time.

Actually the duration between two circuit breaker or relay setting will be set to delay ±0.4 seconds. It was used by the Tenaga Nasianal Berhad to make safety backup refer to IES 6025-3. The relay setting must be setup from the downstream to upstream. Normally the main buss bar or relay near to the power supply will early setup. This is because distribution will come later than power supply plant or transmission line. For relay setting in distribution will follow the early relay setting as soon as it can function and can do tripping.

Time dial setting is to determines the value of the integral, at which the trip output is actuated, and hence controls the time scale of the time-current characteristics

The relay setting can be approved by the calculation as the setting is true. The formula comes from the Inverse Definite Minimum Time, IDMT standard.

Equation 1 Formula Relay Operating Time

$$PS = \frac{I_{load\,max}}{CT\ Ratio \times I_{Relay\ Rating}} \quad (3.0)$$

$$PSM = \frac{If}{CT\ Ratio \times PS \times I_{Relay\ Rating}} = \frac{If}{Iset} \quad (3.1)$$

$$t = \frac{0.14}{PSM^{0.02} - 1} \times TMS \quad (3.2)$$

- PSM – Current (multiples of plug setting)
- CT Ratio – Current Transformer ratio
- PS – Plug setting/ Pickup current = Iset
- If – current of fault
- TMS – Time Delay

Time dial setting is to determine the value of the integral, at which the trip output is actuated, and hence controls the time scale of the time-current characteristics.

3.5 Methodology Flowchart

There is only relay is used to present the coordination protection. The designed simulation of power system network is just want to show the basic concept for overcurrent protection and coordination relay signal. The operation of relay against abnormal current was analyzed between two relay to protect the zone of protection. Moreover, troubleshoot method is most important step in this project because without this method the simulation can't be completely done. The analysis of relay setting and calculation was proved.

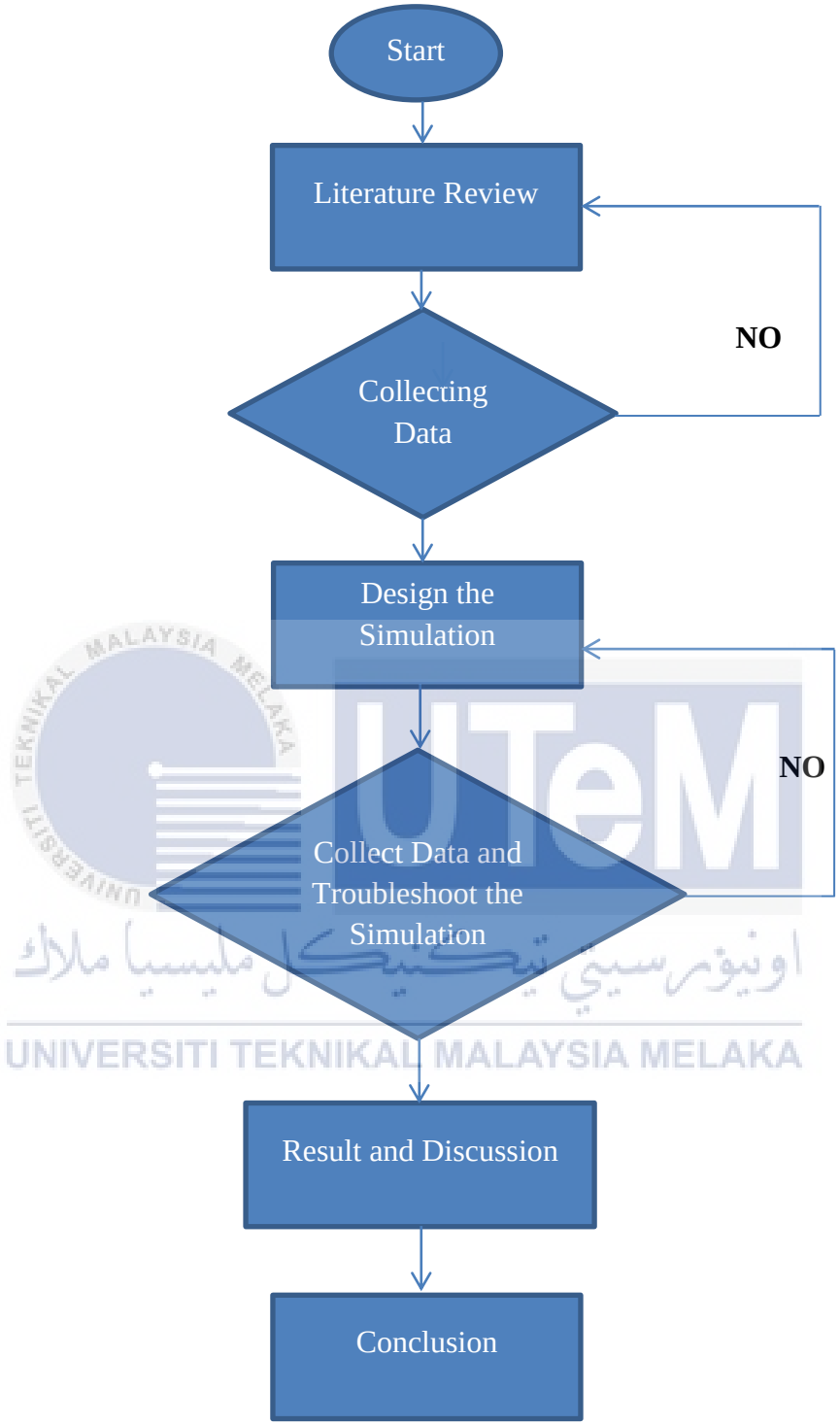


Figure 3.5.1 Methodology Flowchart

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

To achieve the objective, there are many analyses that will many type of case was handle in this project. To fulfill the characteristics of overcurrent protection and coordination, the simulation was obtain six case studies. Every case study have their own relay setting. Each relay was tested with three type of fault.

4.2 Result and Discussion

In this season will be discussed about the coordination protection get from simulation. There are for relay use in this simulation to operate during fault. There are six case handle in this project, every case will concurred the relay setting in three phase fault. Follow the other fault and the effect of tripping time of the relay by using the relay setting at three phase fault.

4.3 1st Cases

In this phase discussed about time margin for protection coordination, the way to overcome supply interruption and relay signal study in different type of fault. Every part of the case showing the same overcurrent interruption but there is a different in place of the interruption.

4.3.1 Time Margin for Protection Coordination

In this part of operation as shown in figure 4.3.1, the average power running was 2MWatts. The fault was applied at downstream at load near to the AR4003B. Actually, relay at buss bar 3L5 is called protective device and the other AR4003B is called protecting device. In other when fault happen, protecting device must be clear fault first to interrupt the abnormal current. This will protect the protected device from take damage.

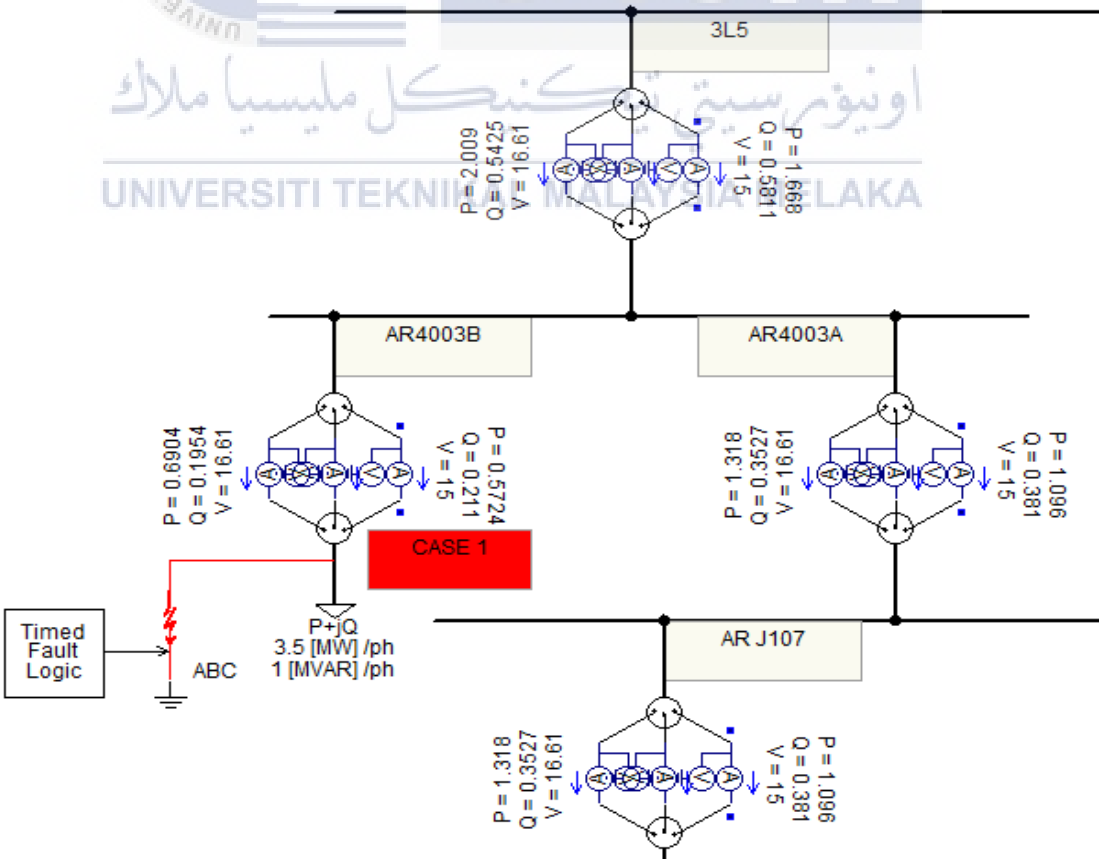
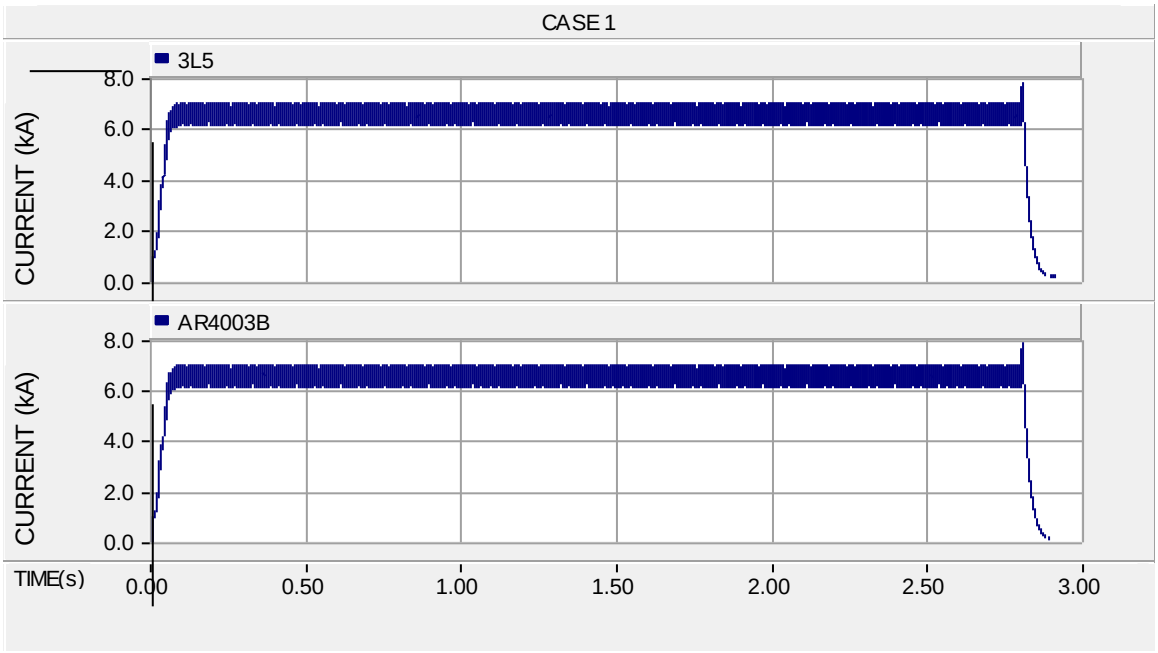
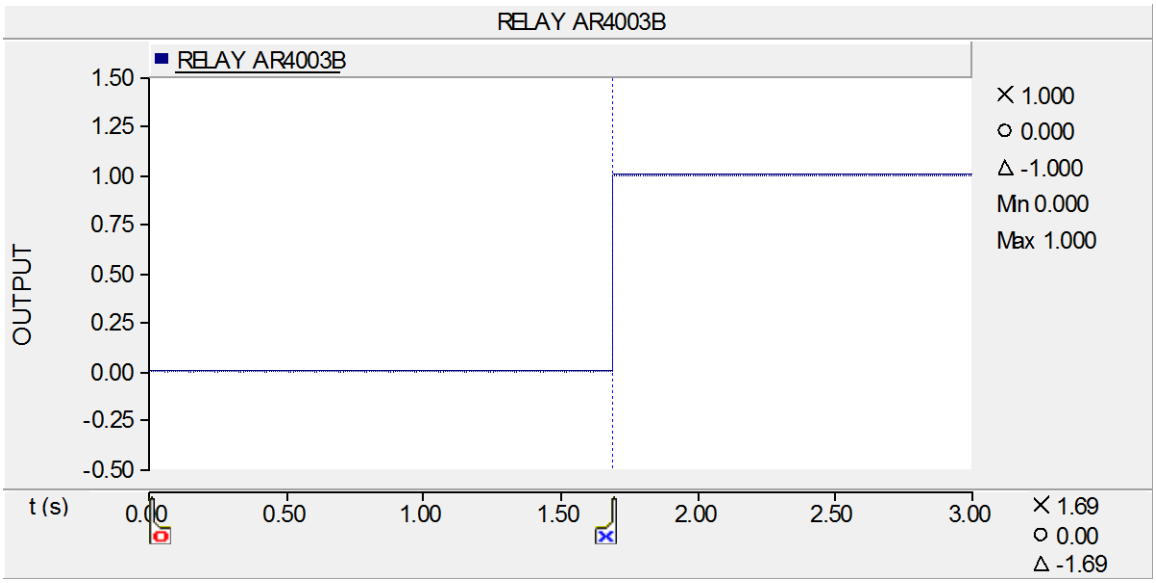


Figure 4.3.1 Operation of Relay at AR4003B and 3L5



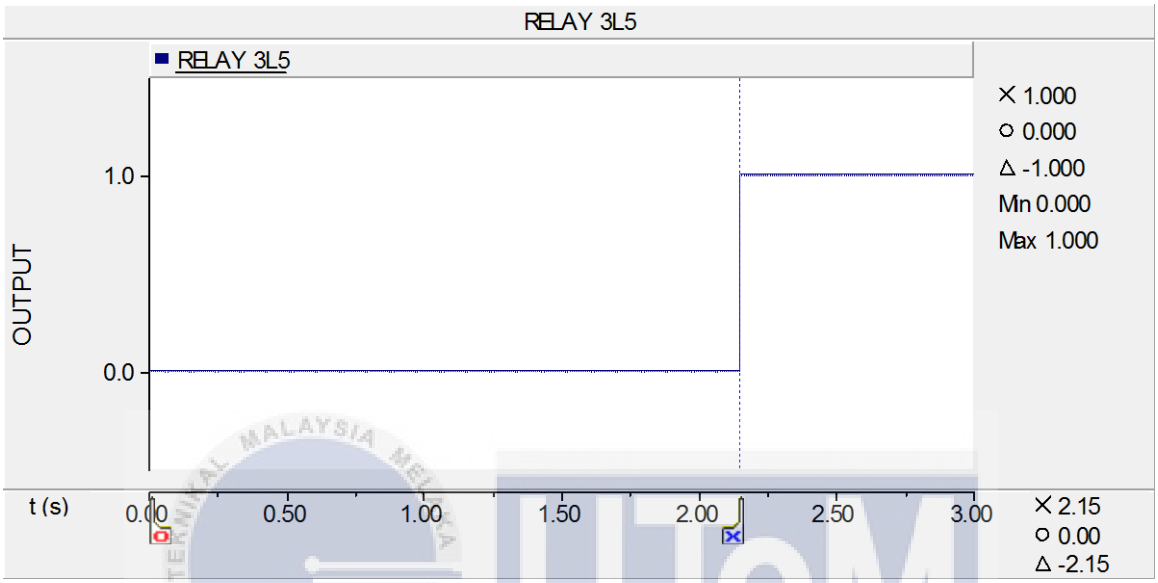
Graph 4.3.1 Fault current AR4003B and 3L5

As the graph shown above, the fault current is 7000 A at transient waveform. The normal current at for AR4003B and 3L5 was 70 A and 20 A. The value of current was used as pickup current at relay setting. Actually, the pickup current is the current at which integration start positively. When the value of current more than the pickup current setting. So the integration will produce output '1'. In correlation, time dial setting also has function to make the integration to produce '1'. Actually, the more time dial setting, the more delay the relay will take action.



Graph 4.3.2 Relay Operation Time Tripping for AR4003B

The graph shown above was the time to relay to take action when fault happen. The relay setting was setup at ±1.7 seconds as the relay will take action. This relay will firstly to take action because the nearly to the fault. Even when this relay is malfunction, the relay at 3L5 will take action and isolate the fault as backup relay.



Graph 4.3.3 Relay Operation Time Tripping for 3L5

The graph above shows the output versus time the circuit running in 3.0 seconds. The output will propagate to 1 which the fault happens in starting circuit running. Refer to the graph 4.3.2, the 3L5 relay will take action in ±2.1 seconds. Actually, the relay must be operating in time of fault happen and depend on the relay setting. The relay will delay in 0.05s due to the characteristics of relay discussed at 2.8.3 (relay speed characteristics). The rating speed for relay is in high speed which is 50miliseconds. Refer to the relay setting shown in figure 3.4.1 (*pickup current AR4003B=0.5, time dial AR4003B=0.7 and pickup current 3L5=0.5, time dial 3L5=0.8*) the relay will operate between two operating relay is 0.4s.

The nearest breaker with fault is relay AR 40003B, so relay AR 40003B will operate first to clear the fault. If relay at AR 40003B not operate due to the unreliability, the relay at 3L5 will operate as protective device. The duration to relay 3L5 to operate is 0.4s after relay AR 40003B cannot operate.

The current fault can contain from graph 4.3.1 is used in calculation of plug multiplier setting. The simulation can be proving by the calculation of plug multiplier setting and time delay. So the time of relay will operate and calculated as shown below:

Equation 2 Relay Operating Time at AR 40003B

$I_{Fault_{AR4003B}} = 9.3\ kA;$

$$PSM_{AR4003B} = \frac{If}{Iset} = \frac{9.3}{0.5} = 18.6$$

$$t_{AR4003B} = \frac{0.14}{18.6^{0.02} - 1} \times 0.7$$

$$t_{AR4003B} = 1.62\ seconds$$

The time relay operate get from the calculation is 1.62 seconds. The graph show the time to relay operate is 1.69 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

Equation 3 Relay Operating Time at 3L5

$I_{Fault_{AR4003B}} = 9.3\ kA;$

$$PSM_{3L5} = \frac{If}{Iset} = \frac{9.3}{0.5} = 18.6$$

$$t_{3L5} = \frac{0.14}{18.6^{0.02} - 1} \times 0.8$$

$$t_{3L5} = 1.9\ seconds$$

The value of fault apply in this calculation was using the main relay that attach with the fault.so the value of fault used is 9300 A.

The time relay operate get from the calculation is 1.9 seconds. The graph show the time to relay operate is 2.15 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

4.3.2 Overcome supply interruption

This part discussed about the second objective of this project which is reduce exposure and reducing the problem. As shown in figure 4.3.2, the fault occurs at load near to the substation AR4003B. The main relay is AR4003B and the backup relay is at 3L5.

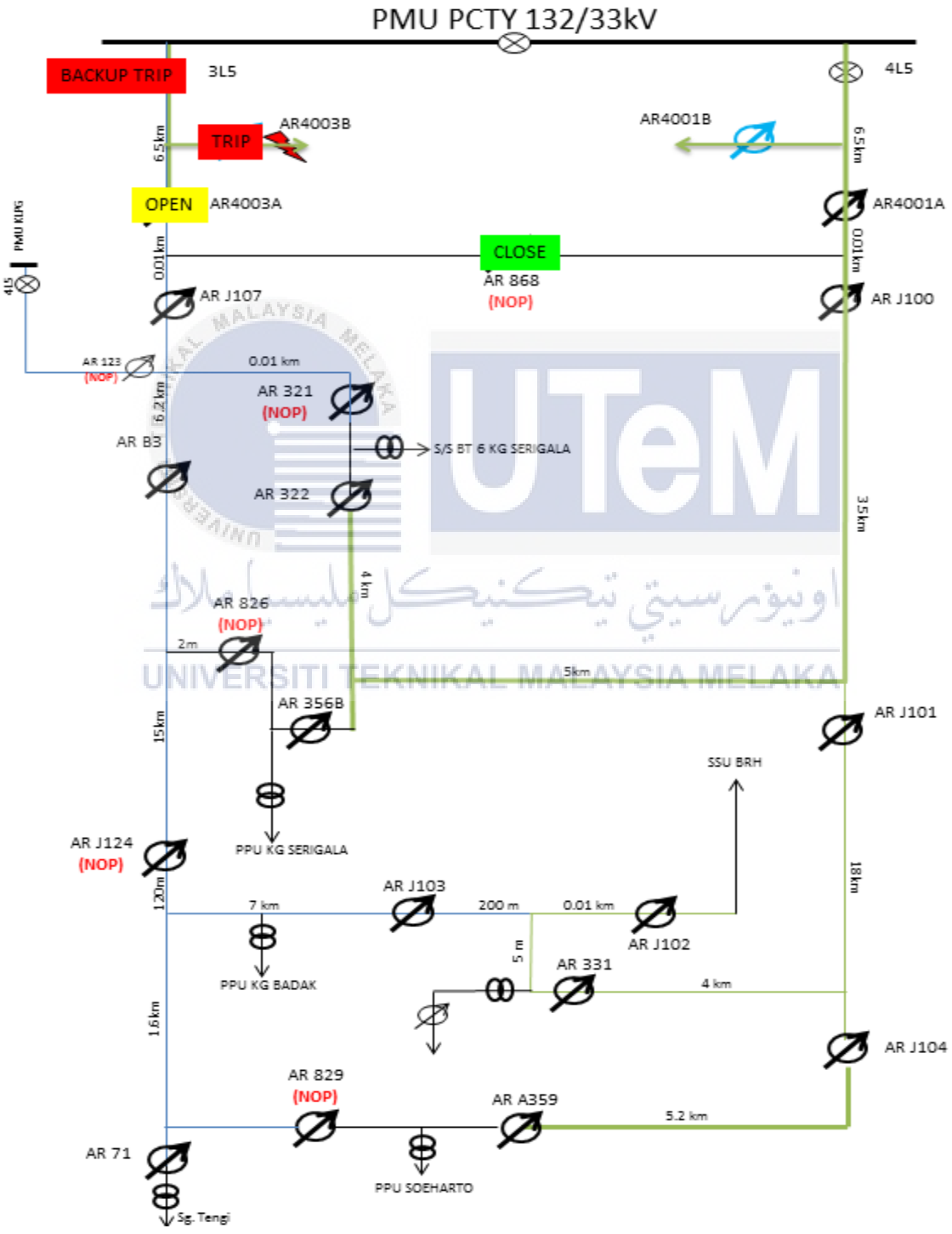


Figure 4.3.2 Case 1 Backup Supply Interruption

When the fault occurs, relay AR4003B will operate first to isolate the problem. If relay AR4003B is not operating caused by the relay error, relay at 3L5 will take operate and isolate the fault. In this case, AR4003A will be switching open to cut off the supply and enable the maintenance to be done by worker. The normal of point at AR868 will close to give supply at the downstream of AR4003A.

4.3.3 Relay signal in different type of fault

In this part discussed about the effect when there have another fault that happen in the distribution system. The relay setting was actually was used in three phase fault case. Whether the value of fault is become less than three phase fault. The relays still operate but the operation time is not same. Actually, the less amount of current fault, more the duration of relay to operate. The result will provide in the simulation as shown below:

Table 4.3.1 Time Operation of Relay at AR4003B and 3L5

Fault (A) / Time (s)	AR4003B	3L5
Line-to-Line	1.69	2.15
Double Line-to-Ground	1.70	2.20
Line-to-Ground	More than 3.0	More than 3.0

The data collected in the simulation by using different type of fault. The table show that the lower of current fault occur in the distribution, the time to relay operate will take longer. The relay still can operate to isolate the fault. Low current of fault will not take hard damage to the electrical component in distribution system if the time take to relay operate is longer.

4.4 2nd Cases

In this phase discussed about time margin for protection coordination, the way to overcome supply interruption and relay signal study in different type of fault. Every part of the case showing the same overcurrent interruption but there is a different in place of the interruption.

4.4.1 Time Margin for Protection Coordination

In this part of operation as shown in figure 4.4.1, the average power running was 10MWatts. The fault was applied at downstream at load near to the AR4001A. Actually, relay at buss bar 4L5 is called protective device and the other AR4001A is called protecting device. In other when fault happen, protecting device must be clear fault first to interrupt the abnormal current. This will protect the protected device from take damage.

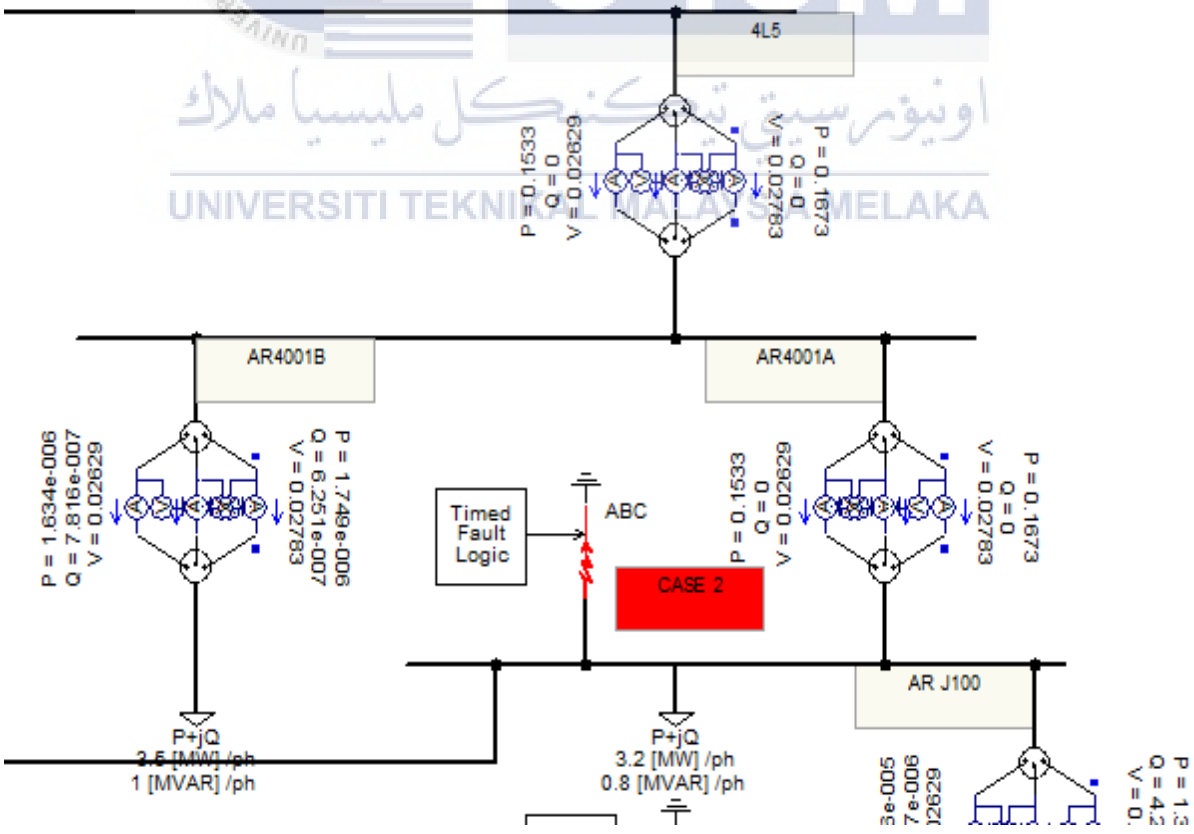
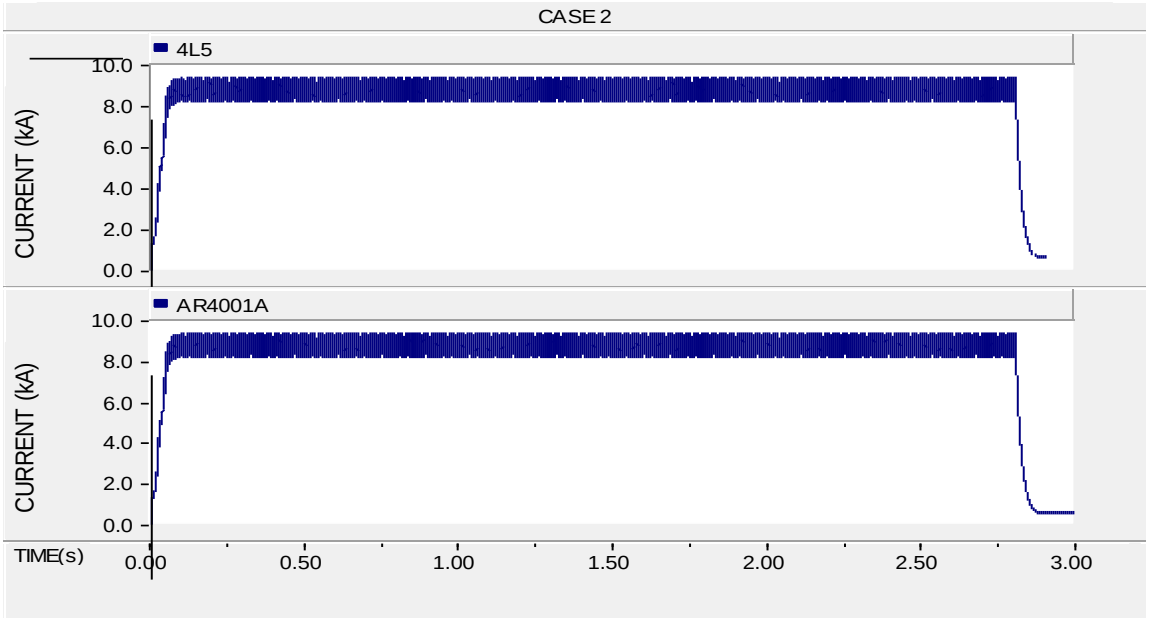
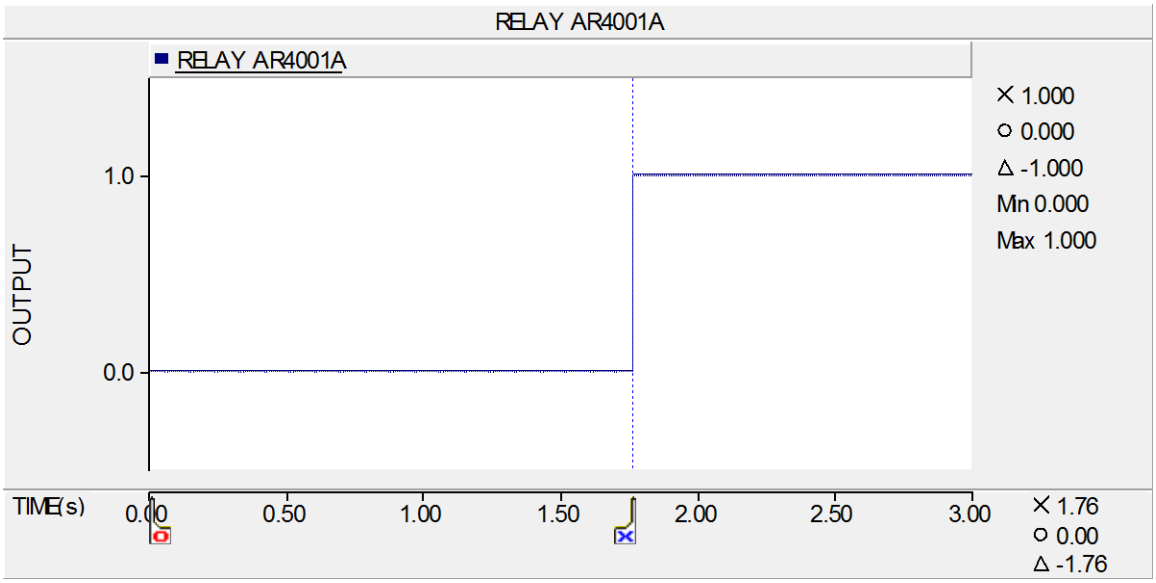


Figure 4.4.1 Operation of Relay at AR4001A and 4L5



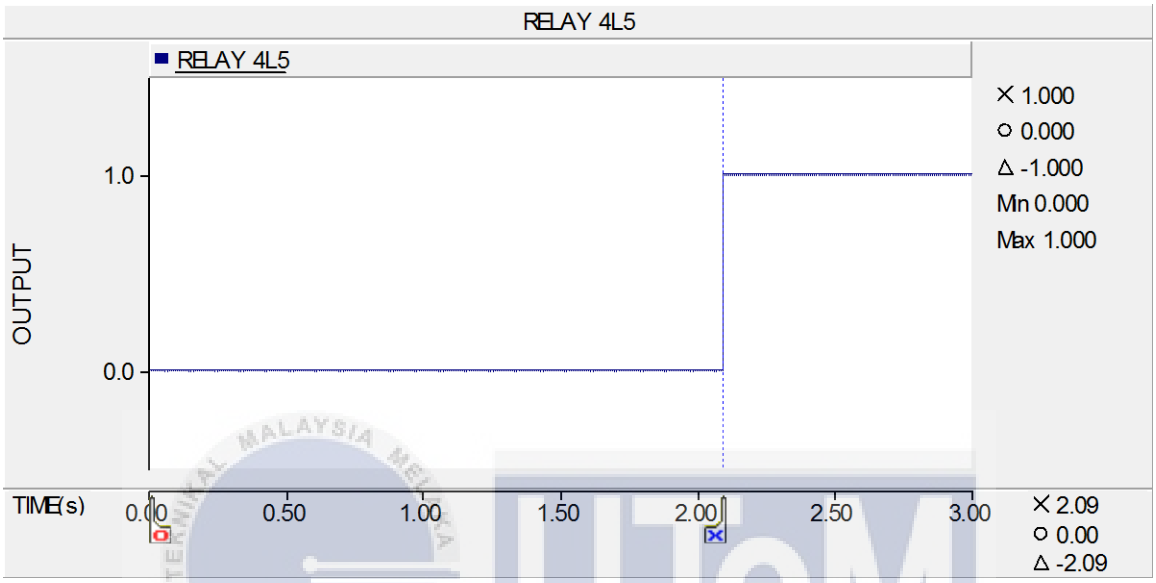
Graph 4.4.1 Fault current for AR4001A and 4L5

As the graph shown above, the fault current is around 9000 A at transient waveform. The normal current at for AR4001A and 4L5 was 560 A and 620 A. The value of current was used as pickup current at relay setting. Actually, the pickup current is the current at which integration start positively. When the value of current more than the pickup current setting. So the integration will produce output '1'. In correlation, time dial setting also has function to make the integration to produce '1'. Actually, the more time dial setting, the more delay the relay will take action.



Graph 4.4.2 Relay Operation Time Tripping for AR4001A

The graph shown above was the time to relay to take action when fault happen. The relay setting was setup at ±1.7 seconds as the relay will take action. This relay will firstly to take action because the nearly to the fault. Even when this relay is malfunction, the relay at 4L5 will take action and isolate the fault as backup relay.



Graph 4.4.3 Relay Operation Time Tripping for 4L5

The graph above shows the output versus time the circuit running in 3.0 seconds. The output will propagate to 1 which the fault happens in starting circuit running. Refer to the graph 4.4.3; the 4L5 relay will take action in ±2.1 seconds. Actually, the relay must be operating in time of fault happen and depend on the relay setting. Refer to the relay setting shown in figure 3.4.2 (*pickup current AR4001A=0.56, time dial AR4001A=0.7 and pickup current 4L5=0.62, time dial 4L5=0.8*) the relay will operate between two operating relay is 0.4s.

The nearest breaker with fault is relay AR4001A, so relay AR4001A will operate first to clear the fault. If relay at AR4001A not operate due to the unreliability, the relay at 4L5 will operate as protective device. The duration to relay 4L5 to operate is 0.4s after relay AR4001A cannot operate.

The current fault can contain from graph 4.4.1 is used in calculation of plug multiplier setting. The simulation can be proving by the calculation of plug multiplier setting and time delay. So the time of relay will operate and calculated as shown below:

Equation 4 Relay Operating Time at AR 40001A

$I_{Fault_{AR4001A}} = 9.4\ kA$;

$$PSM_{AR4001A} = \frac{If}{Iset} = \frac{9.4}{0.56} = 16.79$$

$$t_{AR4001A} = \frac{0.14}{16.79^{0.02} - 1} \times 0.7$$

$$t_{AR4001A} = 1.69\ seconds$$

The time relay operate get from the calculation is 1.69 seconds. The graph show the time to relay operate is 1.76 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

Equation 5 Relay Operating Time at 4L5

$I_{Fault_{AR4001A}} = 9.4\ kA$;

$$PSM_{3L5} = \frac{If}{Iset} = \frac{9.4}{0.62} = 15.16$$

$$t_{3L5} = \frac{0.14}{15.16^{0.02} - 1} \times 0.8$$

$$t_{3L5} = 2.0\ seconds$$

The value of fault apply in this calculation was using the main relay that attach with the fault.so the value of fault used is 9400 A.

The time relay operate get from the calculation is 2.0 seconds. The graph show the time to relay operate is 2.09 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

4.4.2 Overcome supply interruption

This part discussed about the second objective of this project which is reduce exposure and reducing the problem. As shown in figure 4.4.2, the fault occurs at load near to the substation AR4001A. The main relay is AR4001A and the backup relay is at 4L5.

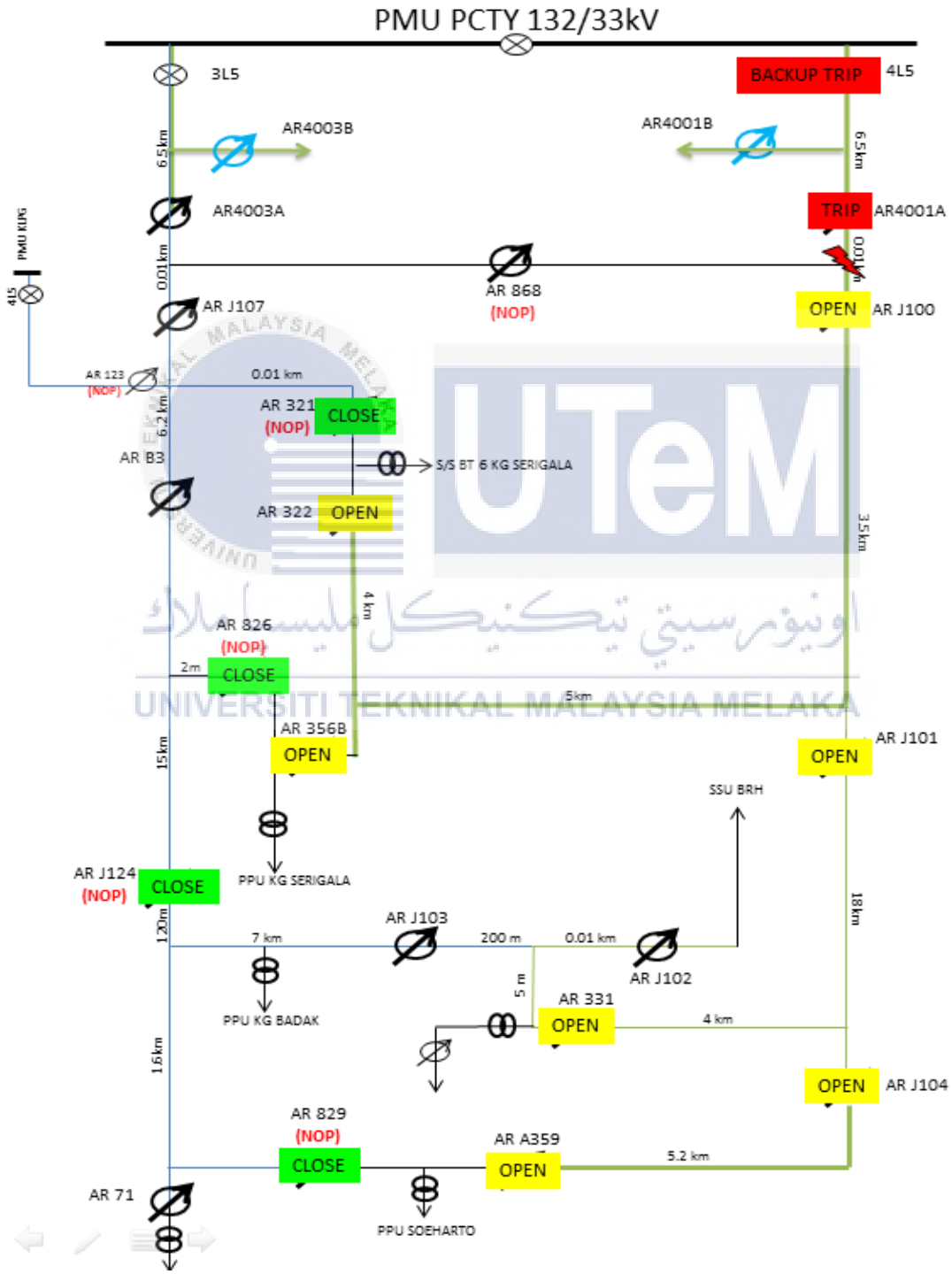


Figure 4.4.2 Case 2 Backup Supply Interruptions

When the fault occurs at downstream AR4001A, the relay will operate first to isolate the problem. If relay AR4001A is not operating caused by the relay error, relay at 4L5 will take operate and isolate the fault. In this case, ARJ100, AR322, AR356B, AR331, AR359, ARJ104, ARJ101 will be switching open to cut off the supply and enable the maintenance to be done by worker. The normal of point at AR321, AR826, ARJ124, and AR829 will close to give supply at the downstream of buss bar.

4.4.3 Relay signal in different type of fault

In this part discussed about the effect when there have another fault that happen in the distribution system. The relay setting was actually was used in three phase fault case. Whether the value of fault is become less than three phase fault. The relays still operate but the operation time is not same. Actually, the less amount of current fault, more the duration of relay to operate. The result will provide in the simulation as shown below:

Table 4.4.1 Time Operation of Relay at AR4001A and 4L5

Fault (A) / Time (s)	AR4001A	4L5
Line-to-Line	1.76	2.09
Double Line-to-Ground	1.81	2.15
Line-to-Ground	More than 3.0	More than 3.0

The data collected in the simulation by using different type of fault. The table show that the lower of current fault occur in the distribution, the time to relay operate will take longer. The relay still can operate to isolate the fault. Low current of fault will not take hard damage to the electrical component in distribution system if the time take to relay operate is longer.

4.5 3rd Cases

In this phase discussed about time margin for protection coordination, the way to overcome supply interruption and relay signal study in different type of fault. Every part of the case showing the same overcurrent interruption but there is a different in place of the interruption.

4.5.1 Time Margin for Protection Coordination

In this part of operation as shown in figure 4.5.1, the average power running was 10MWatts. The fault was applied at downstream at load near to the ARJ100. Actually, relay at buss bar AR4001A is called protective device and the other ARJ100 is called protecting device. In other when fault happen, protecting device must be clear fault first to interrupt the abnormal current. This will protect the protected device from take damage.

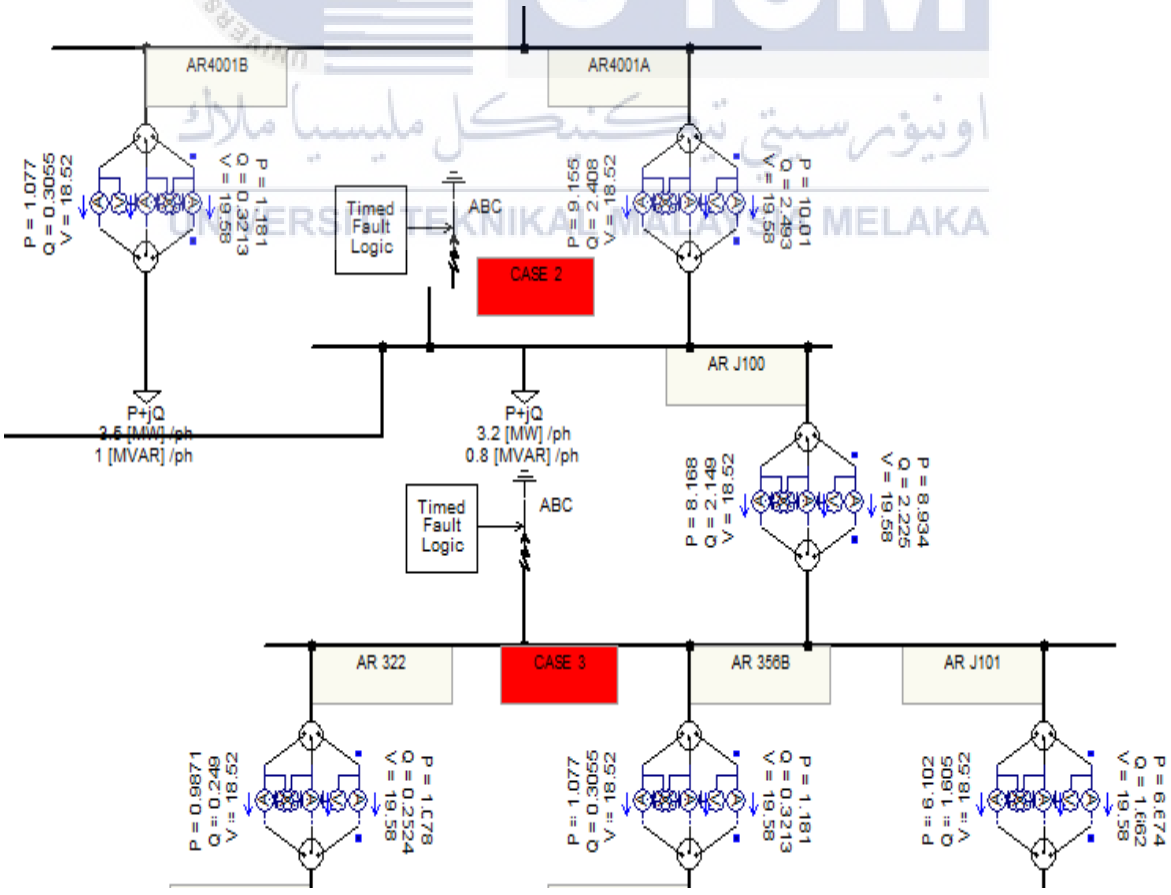
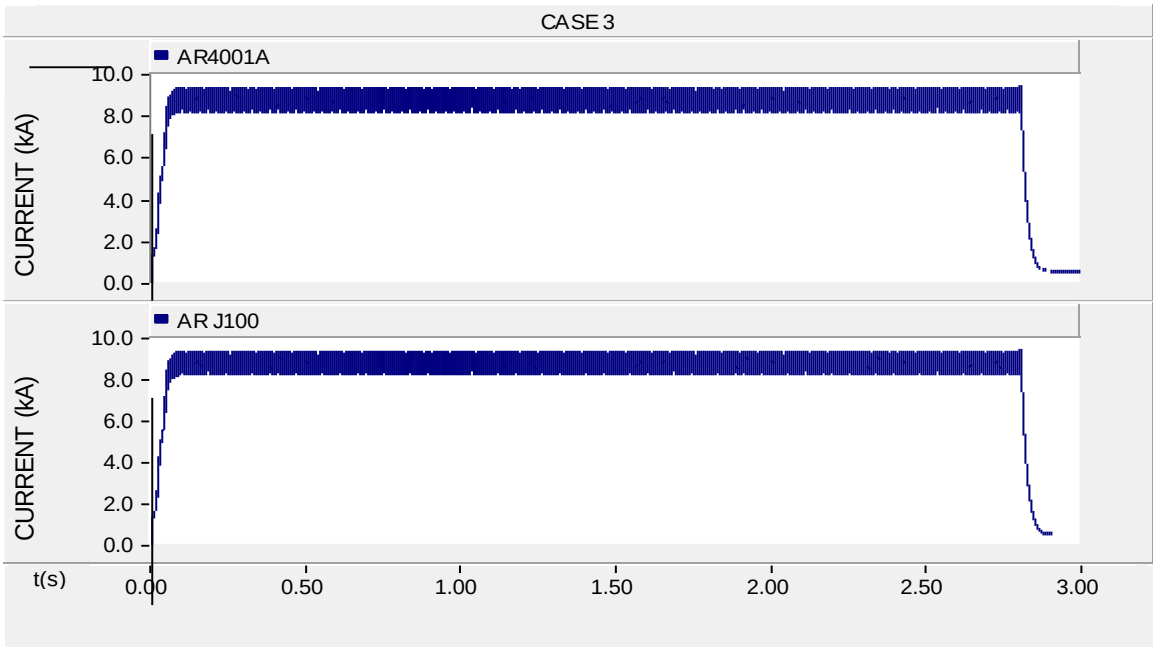
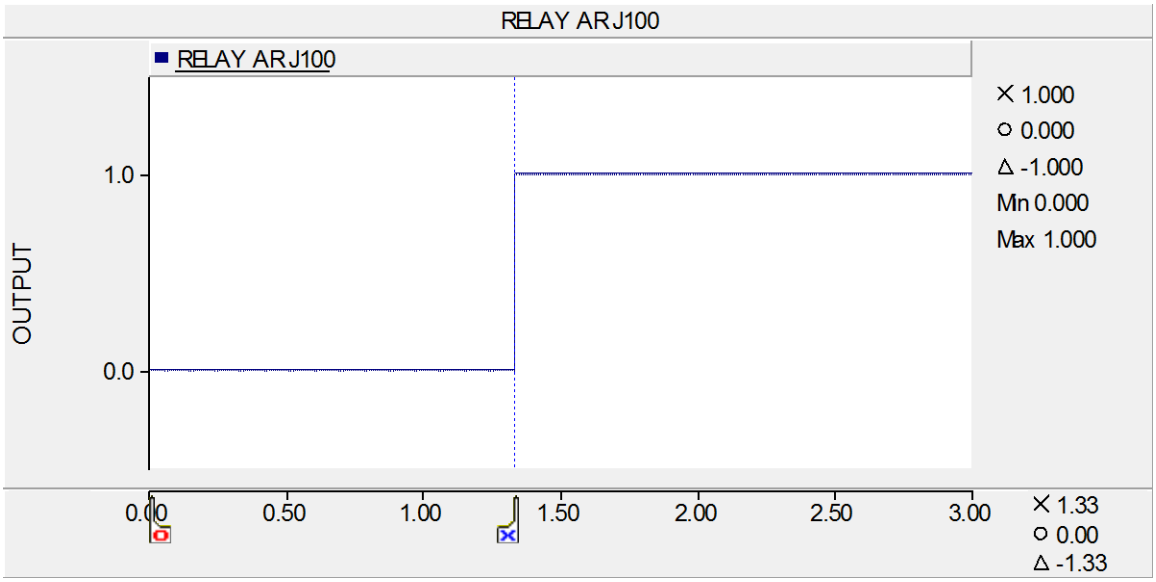


Figure 4.5.1 Operation of Relay at ARJ100 and AR4001A



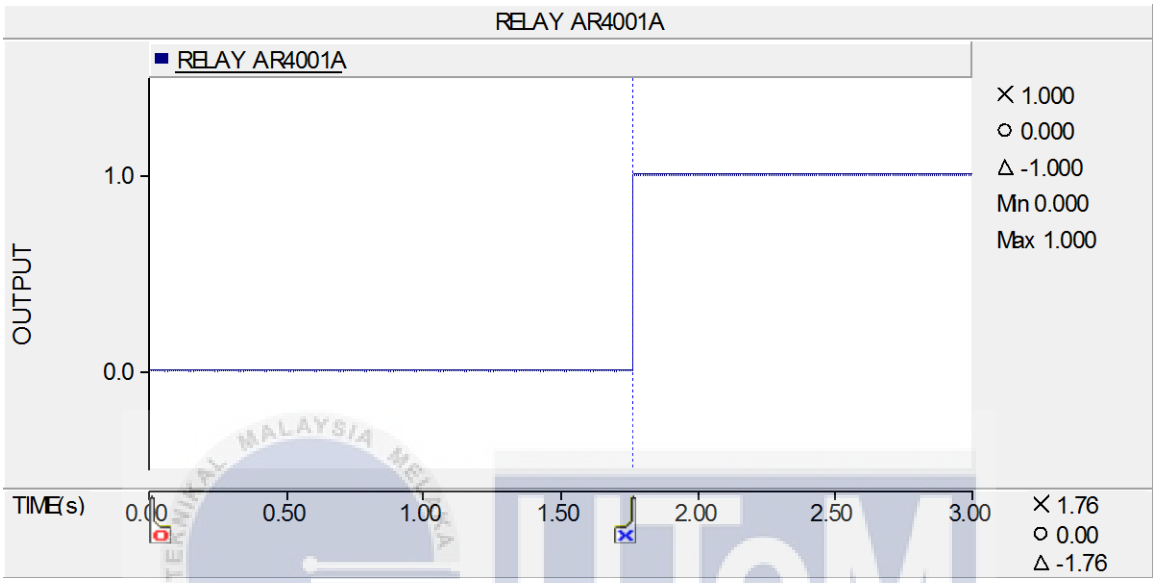
Graph 4.5.1 Fault current for ARJ100 and AR4001A

As the graph shown above, the fault current is 9000 A at transient waveform. The normal current at for ARJ100 and AR4001A was 500 A and 550 A. The value of current was used as pickup current at relay setting. Actually, the pickup current is the current at which integration start positively. When the value of current more than the pickup current setting. So the integration will produce output '1'. In correlation, time dial setting also has function to make the integration to produce '1'. Actually, the more time dial setting, the more delay the relay will take action.



Graph 4.5.2 Relay Operation Time Tripping for ARJ100

The graph shown above was the time to relay to take action when fault happen. The relay setting was setup at ±1.3 seconds as the relay will take action. This relay will firstly to take action because the nearly to the fault. Even when this relay is malfunction, the relay at AR4001A will take action and isolate the fault as backup relay.



Graph 4.5.3 Relay Operation Time Tripping for AR4001A

The graph above shows the output versus time the circuit running in 3.0 seconds. The output will propagate to 1 which the fault happens in starting circuit running. Refer to the graph 4.5.3; the AR4001A relay will take action in ±1.7 seconds. Actually, the relay must be operating in time of fault happen and depend on the relay setting. Refer to the relay setting shown in figure 3.4.3 (*pickup current ARJ100=0.5, time dial ARJ100=0.55 and pickup current AR4001A=0.56, time dial AR4001A =0.7*) the relay will operate between two operating relay is 0.4s.

The nearest breaker with fault is relay AR J100, so relay AR J100will operate first to clear the fault. If relay at AR J100 not operate due to the unreliability, the relay at AR4001A will operate as protective device. The duration to relay AR4001A to operate is 0.4s after relay AR J100 cannot operate.

The current fault can contain from graph 4.5.1 is used in calculation of plug multiplier setting. The simulation can be proving by the calculation of plug multiplier setting and time delay. So the time of relay will operate and calculated as shown below:

Equation 6 Relay Operating Time at AR J100

$I_{Fault_{\text{AR J100}}} = 9.4\ kA$;

$$PSM_{\text{AR J100}} = \frac{If}{Iset} = \frac{9.4}{0.5} = 18.8$$

$$t_{\text{AR J100}} = \frac{0.14}{18.8^{0.02} - 1} \times 0.55$$

$$t_{\text{AR J100}} = 1.27\ seconds$$

The time relay operate get from the calculation is 1.27 seconds. The graph show the time to relay operate is 1.33 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

Equation 7 Relay Operating Time at AR4001A

$I_{Fault_{\text{AR J100}}} = 9.4\ kA$;

$$PSM_{AR4001A} = \frac{If}{Iset} = \frac{9.4}{0.56} = 16.79$$

$$t_{AR4001A} = \frac{0.14}{16.79^{0.02} - 1} \times 0.7$$

$$t_{AR4001A} = 1.69\ seconds$$

The value of fault apply in this calculation was using the main relay that attach with the fault.so the value of fault used is 9400 A.

The time relay operate get from the calculation is 1.69 seconds. The graph show the time to relay operate is 1.76 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

4.5.2 Overcome supply interruption

This part discussed about the second objective of this project which is reduce exposure and reducing the problem. As shown in figure 4.5.2, the fault occurs at load near to the substation AR J100. The main relay is AR J100 and the backup relay is at AR4001A.

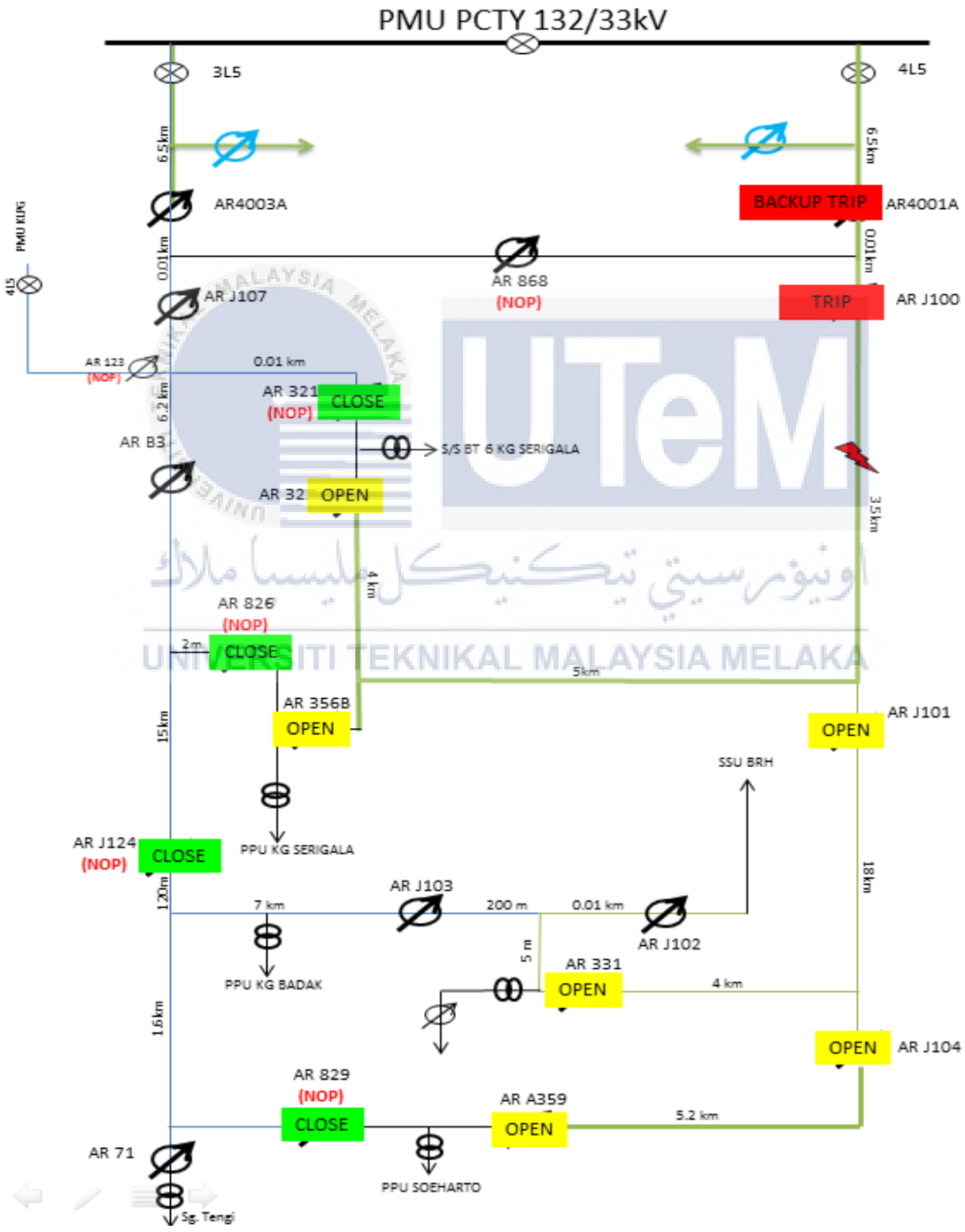


Figure 4.5.2 Case 3 Backup Supply Interruptions

Then the fault occurs at downstream ARJ100, the relay will operate first to isolate the problem. If relay ARJ100 is not operating caused by the relay error, relay at AR4001A will take operate and isolate the fault. In this case, AR322, AR356B, AR331, AR359, ARJ104, ARJ101 will be switching open to cut off the supply and enable the maintenance to be done by worker. The normal of point at AR321, AR826, ARJ124, and AR829 will close to give supply at the downstream of buss bar.

4.5.3 Relay signal in different type of fault

In this part discussed about the effect when there have another fault that happen in the distribution system. The relay setting was actually was used in three phase fault case. Whether the value of fault is become less than three phase fault. The relays still operate but the operation time is not same. Actually, the less amount of current fault, more the duration of relay to operate. The result will provide in the simulation as shown below:

Table 4.5.1 Time Operation of Relay at ARJ100 and AR4001A

Fault (A) / Time (s)	ARJ100	AR4001A
Line-to-Line	1.33	1.76
Double Line-to-Ground	1.37	1.81
Line-to-Ground	2.65	More than 3.0

The data collected in the simulation by using different type of fault. The table show that the lower of current fault occur in the distribution, the time to relay operate will take longer. The relay still can operate to isolate the fault. Low current of fault will not take hard damage to the electrical component in distribution system if the time take to relay operate is longer.

4.6 4th Cases

In this phase discussed about time margin for protection coordination, the way to overcome supply interruption and relay signal study in different type of fault. Every part of the case showing the same overcurrent interruption but there is a different in place of the interruption.

4.6.1 Time Margin for Protection Coordination

In this part of operation as shown in figure 4.6.1, the average power running was 7MWatts. The fault was applied at downstream at load near to the ARJ101. Actually, relay at buss bar ARJ100 is called protective device and the other ARJ10 is called protecting device. In other when fault happen, protecting device must be clear fault first to interrupt the abnormal current. This will protect the protected device from take damage.

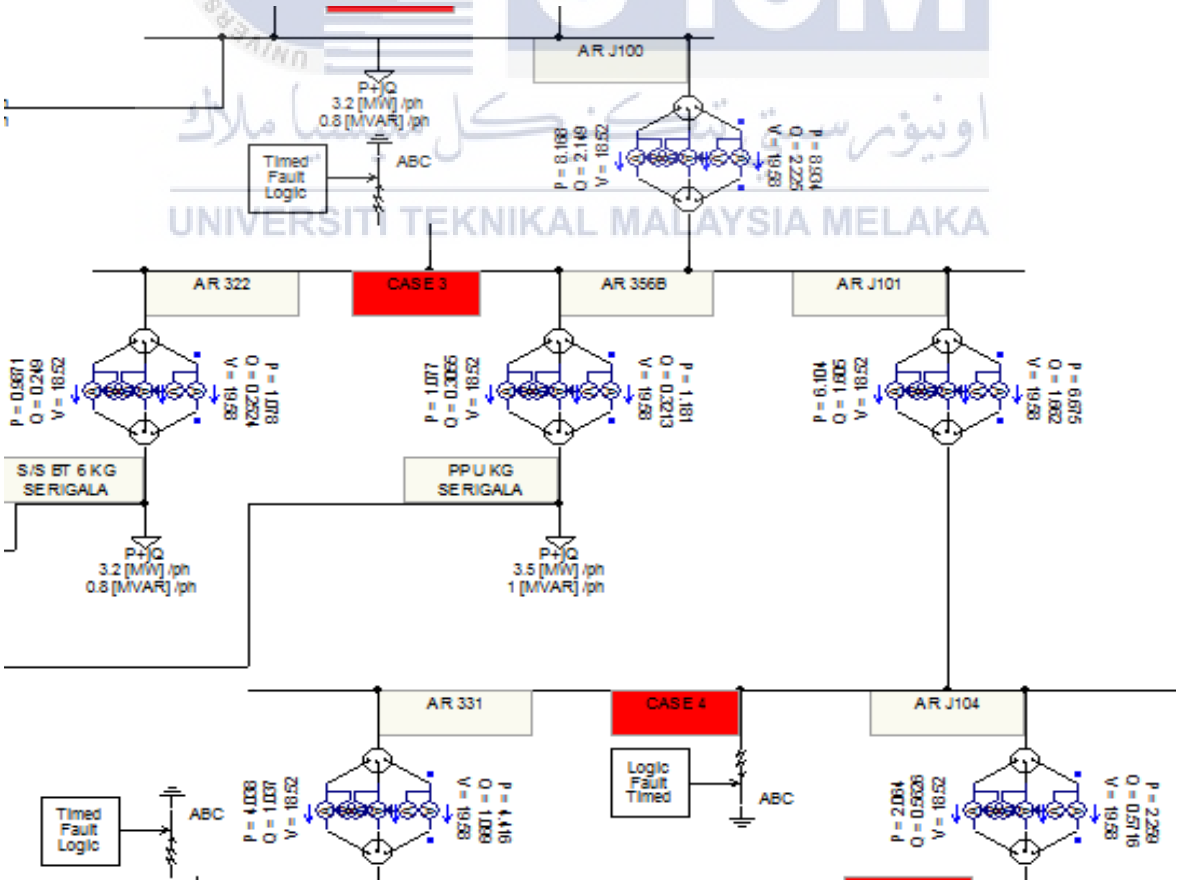
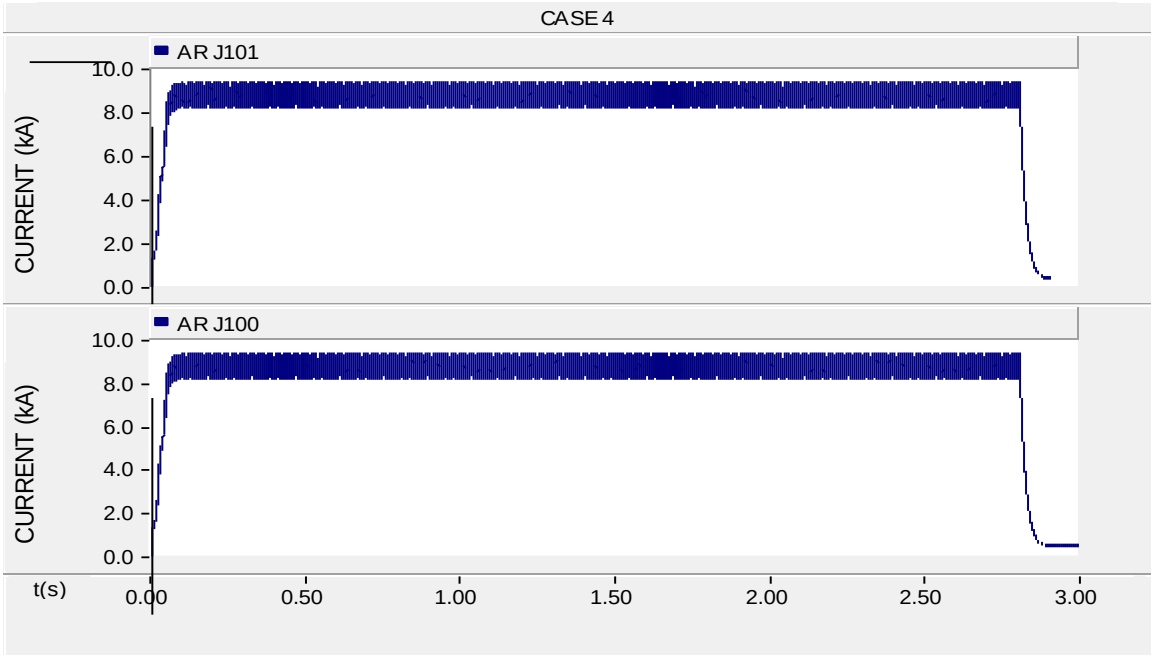
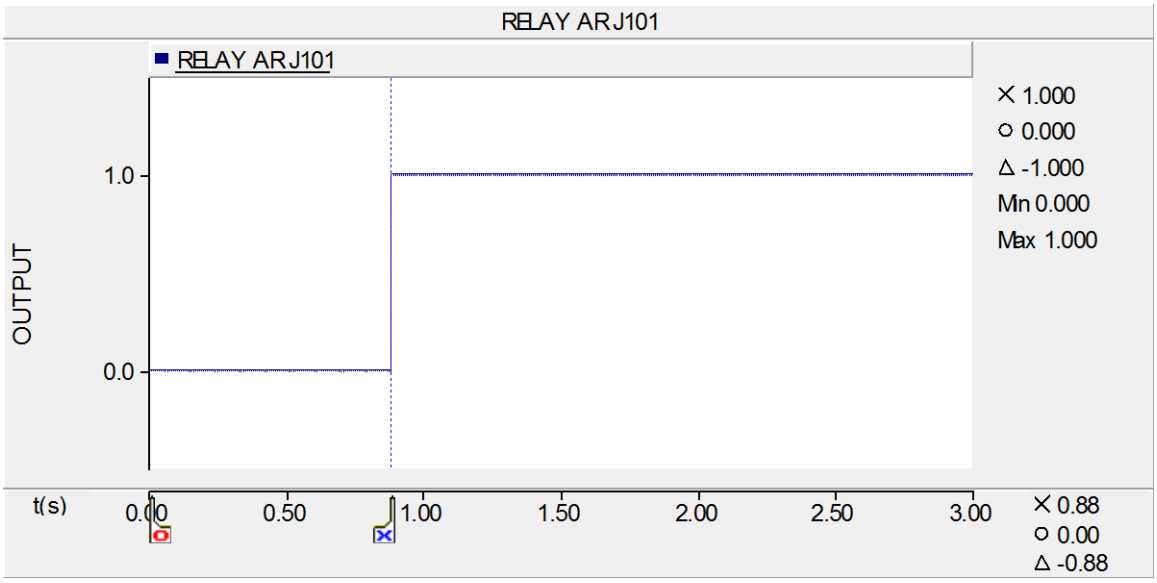


Figure 4.6.1 Operation of Relay at ARJ101and ARJ100



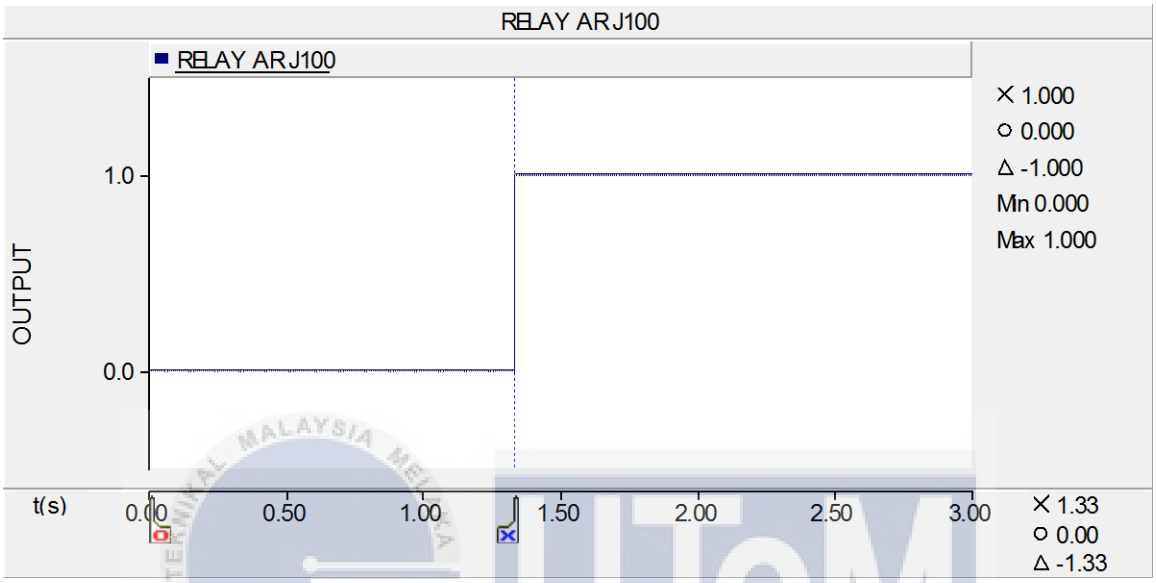
Graph 4.6.1 Fault current for ARJ101 and ARJ100

As the graph shown above, the fault current is 10,000 A at transient waveform. The normal current at for ARJ101 and ARJ100 was 500 A and 370 A. The value of current was used as pickup current at relay setting. Actually, the pickup current is the current at which integration start positively. When the value of current more than the pickup current setting. So the integration will produce output '1'. In correlation, time dial setting also has function to make the integration to produce '1'. Actually, the more time dial setting, the more delay the relay will take action.



Graph 4.6.2 Relay Operation Time Tripping for ARJ101

The graph shown above was the time to relay to take action when fault happen. The relay setting was setup at ±0.9 seconds as the relay will take action. This relay will firstly to take action because the nearly to the fault. Even when this relay is malfunction, the relay at ARJ100 will take action and isolate the fault as backup relay.



Graph 4.6.3 Relay Operation Time Tripping for ARJ100

The graph above shows the output versus time the circuit running in 3.0 seconds. The output will propagate to 1 which the fault happens in starting circuit running. Refer to the graph 4.6.3; the ARJ100 relay will take action in ±1.3 seconds. Actually, the relay must be operating in time of fault happen and depend on the relay setting. Refer to the relay setting shown in figure 3.4.4 (*pickup current ARJ101=0.37, time dial ARJ101=0.4 and pickup current ARJ100=0.5, time dial ARJ100=0.55*) the relay will operate between two operating relay is 0.4s.

The nearest breaker with fault is relay ARJ101, so relay ARJ101 will operate first to clear the fault. If relay at ARJ101 not operate due to the unreliability, the relay at ARJ100 will operate as protective device. The duration to relay ARJ100 to operate is 0.4s after relay ARJ101 cannot operate.

The current fault can contain from graph 4.6.1 is used in calculation of plug multiplier setting. The simulation can be proving by the calculation of plug multiplier setting and time delay. So the time of relay will operate and calculated as shown below:

Equation 8 Relay Operating Time at AR J101

$I_{Fault_{\mathrm{ARJ101}}} = 9.4\ kA$;

$$PSM_{\mathrm{ARJ101}} = \frac{If}{Iset} = \frac{9.4}{0.37} = 25.41$$

Note that the value of plug multiplier setting is more than 20, the maximum value of 20 will be used in the calculation.

$$t_{\mathrm{ARJ101}} = \frac{0.14}{20^{0.02} - 1} \times 0.4$$

$$t_{\mathrm{ARJ101}} = 0.9\ seconds$$

The time relay operate get from the calculation is 0.90 seconds. The graph show the time to relay operate is 0.80 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

Equation 9 Relay Operating Time at ARJ100

$I_{Fault_{\mathrm{AR\ J101}}} = 9.4\ kA$;

$$PSM_{\mathrm{AR\ J100}} = \frac{If}{Iset} = \frac{9.4}{0.5} = 18.8$$

$$t_{\mathrm{AR\ J100}} = \frac{0.14}{18.8^{0.02} - 1} \times 0.55$$

$$t_{\mathrm{AR\ J100}} = 1.27\ seconds$$

The value of fault apply in this calculation was using the main relay that attach with the fault.so the value of fault used is 9400 A.

The time relay operate get from the calculation is 1.27 seconds. The graph show the time to relay operate is 1.33 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

4.6.2 Overcome supply interruption

This part discussed about the second objective of this project which is reduce exposure and reducing the problem. As shown in figure 4.6.2, the fault occurs at load near to the substation AR J101. The main relay is AR J101 and the backup relay is at ARJ100.

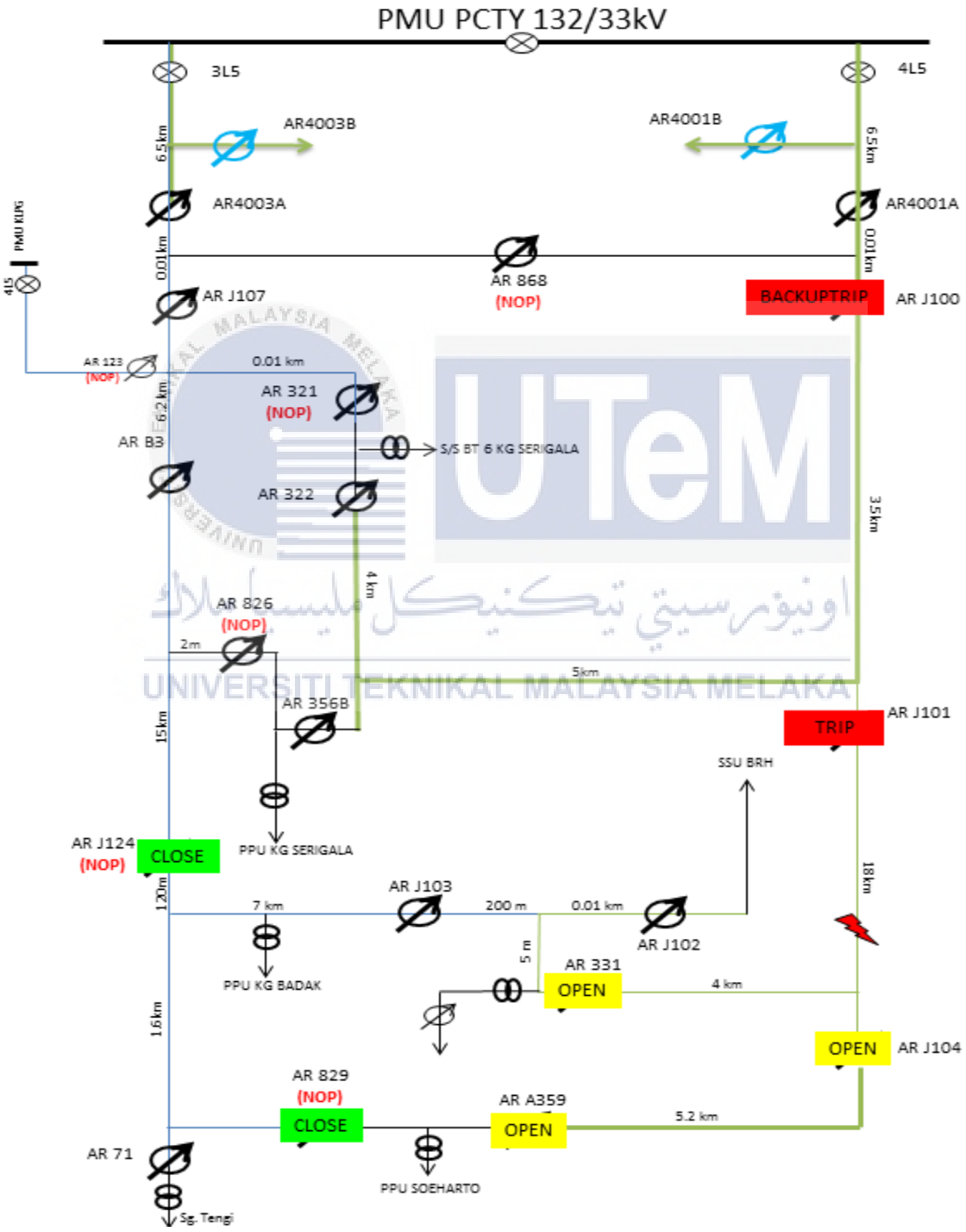


Figure 4.6.2 Case 4 Backup Supply Interruptions

Then the fault occurs at downstream ARJ101, the relay will operate first to isolate the problem. If relay ARJ101 is not operating caused by the relay error, relay at ARJ100 will take operate and isolate the fault. In this case, AR331, AR359 and ARJ104 are switching open to cut off the supply and enable the maintenance to be done by worker. The normal of point at ARJ124, and AR829 will close to give supply at the downstream of buss bar.

4.6.3 Relay signal in different type of fault

In this part discussed about the effect when there have another fault that happen in the distribution system. The relay setting was actually was used in three phase fault case. Whether the value of fault is become less than three phase fault. The relays still operate but the operation time is not same. Actually, the less amount of current fault, more the duration of relay to operate. The result will provide in the simulation as shown below:

Table 4.6.1 Time Operation of Relay at ARJ101and ARJ100

Fault (A) / Time (s)	ARJ101	ARJ100
Line-to-Line	0.88	1.33
Double Line-to-Ground	0.90	1.37
Line-to-Ground	1.60	2.65

The data collected in the simulation by using different type of fault. The table show that the lower of current fault occur in the distribution, the time to relay operate will take longer. The relay still can operate to isolate the fault. Low current of fault will not take hard damage to the electrical component in distribution system if the time take to relay operate is longer.

4.7 5th Cases

In this phase discussed about time margin for protection coordination, the way to overcome supply interruption and relay signal study in different type of fault. Every part of the case showing the same overcurrent interruption but there is a different in place of the interruption.

4.7.1 Time Margin for Protection Coordination

In this part of operation as shown in figure 4.7.1, the average power running was 3MWatts. The fault was applied at downstream at load near to the ARJ104. Actually, relay at buss bar ARJ104 is called protective device and the other ARJ101 is called protecting device. In other when fault happen, protecting device must be clear fault first to interrupt the abnormal current. This will protect the protected device from take damage.

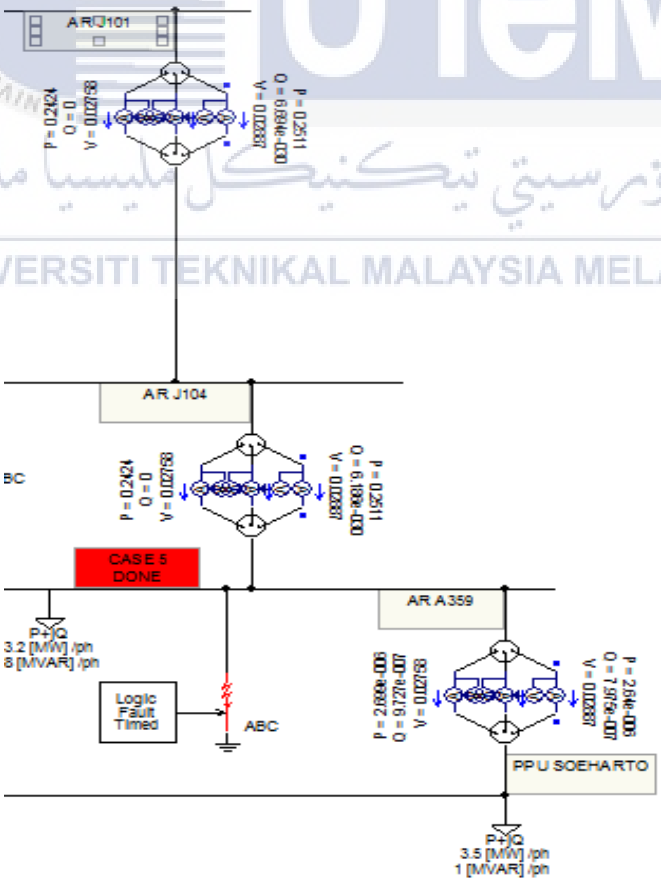
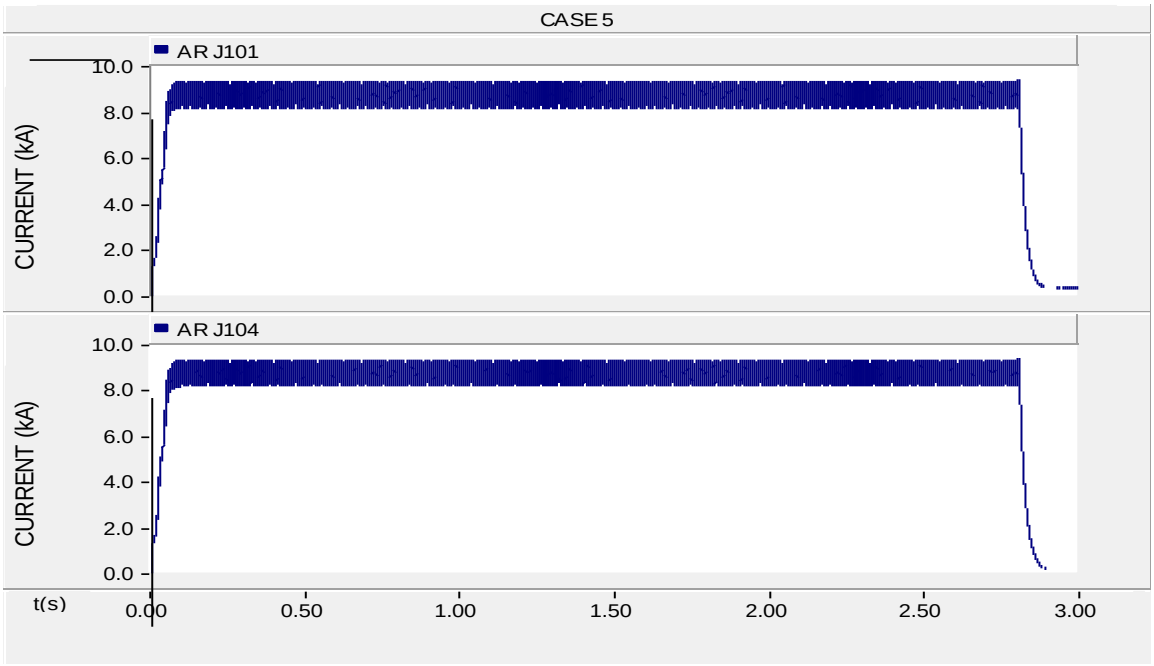
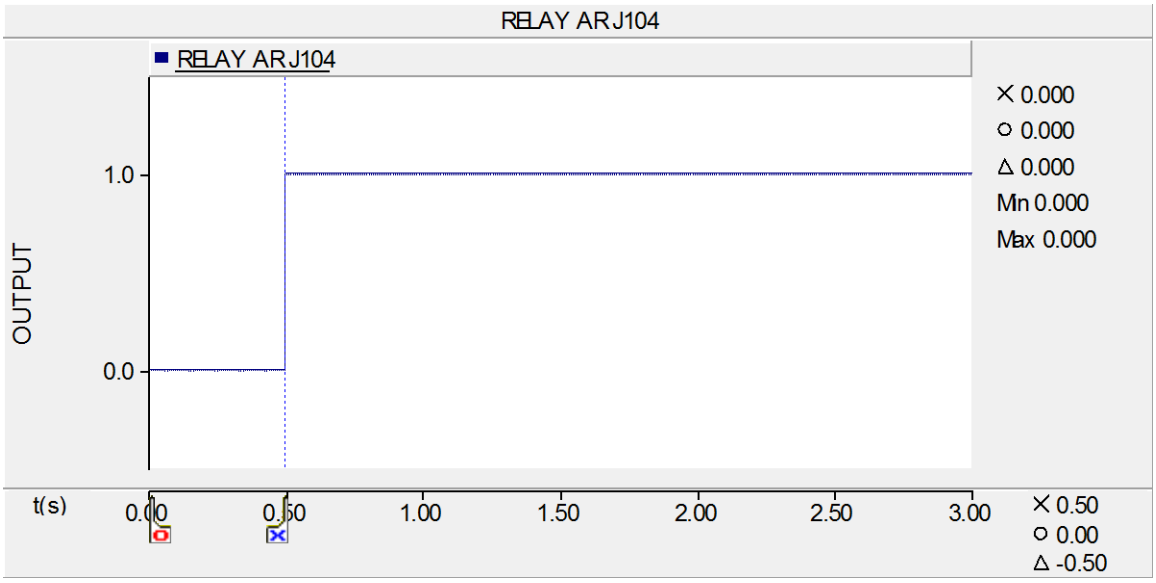


Figure 4.7.1 Operation of Relay at ARJ104 and ARJ101



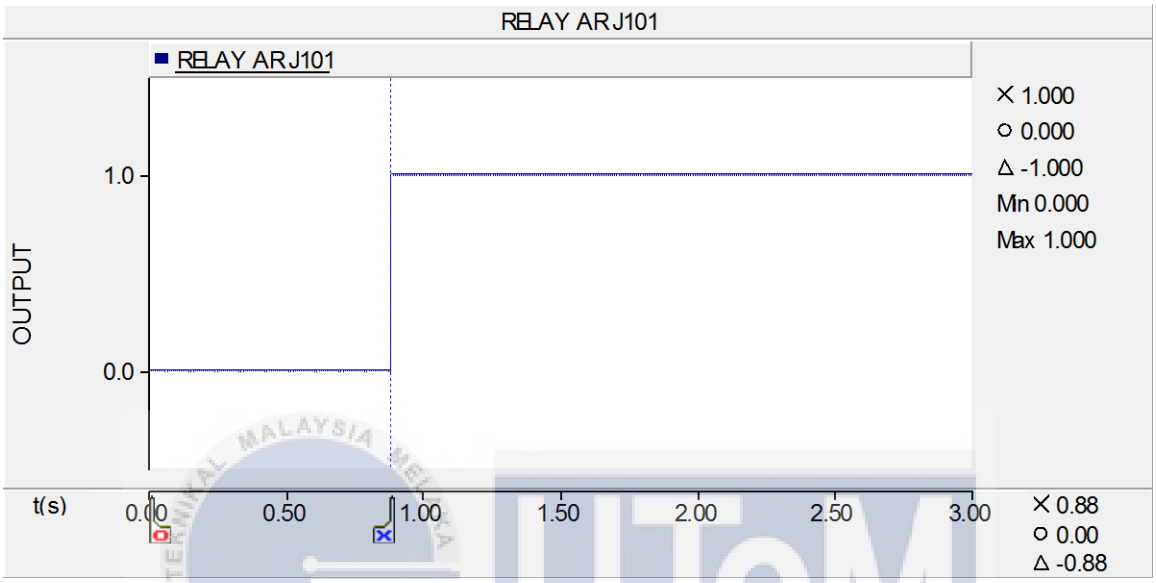
Graph 4.7.1 Fault current for ARJ104 and ARJ101

As the graph shown above, the fault current is 9400 A at transient waveform. The normal current at for ARJ104 and ARJ101 was 130 A and 370 A. The value of current was used as pickup current at relay setting. Actually, the pickup current is the current at which integration start positively. When the value of current more than the pickup current setting. So the integration will produce output '1'. In correlation, time dial setting also has function to make the integration to produce '1'. Actually, the more time dial setting, the more delay the relay will take action.



Graph 4.7.2 Relay Operation Time Tripping for ARJ104

The graph shown above was the time to relay to take action when fault happen. The relay setting was setup at ±0.5seconds as the relay will take action. This relay will firstly to take action because the nearly to the fault. Even when this relay is malfunction, the relay at ARJ101 will take action and isolate the fault as backup relay.



Graph 4.7.3 Relay Operation Time Tripping for ARJ101

The graph above shows the output versus time the circuit running in 3.0 seconds. The output will propagate to 1 which the fault happens in starting circuit running. Refer to the graph 4.7.3; the ARJ101 relay will take action in ±0.9 seconds. Actually, the relay must be operating in time of fault happen and depend on the relay setting. Refer to the relay setting shown in figure 3.4.5 (*pickup current ARJ104=0.13, time dial ARJ104=0.3 and pickup currentARJ101=0.37, time dial ARJ101=0.4*) the relay will operate between two operating relay is 0.4s.

The nearest breaker with fault is relay AR J104, so relay AR J104 will operate first to clear the fault. If relay at AR J10 not operate due to the unreliability, the relay at AR J101 will operate as protective device. The duration to relay AR J101 to operate is 0.4s after relay AR J104 fail to operate.

The current fault can contain from graph 4.7.1 is used in calculation of plug multiplier setting. The simulation can be proving by the calculation of plug multiplier setting and time delay. So the time of relay will operate and calculated as shown below:

Equation 10 Relay Operating Time at AR J104

$I_{Fault_{ARJ104}} = 9.4\ kA$;

$$PSM_{ARJ104} = \frac{If}{Iset} = \frac{9.4}{0.13} = 72.3$$

Note that the value of plug multiplier setting is more than 20; the maximum value of 20 will be used in the calculation.

$$t_{ARJ104} = \frac{0.14}{20^{0.02} - 1} \times 0.3$$

$$t_{ARJ104} = 0.60\ seconds$$

The time relay operate get from the calculation is 0.60 seconds. The graph show the time to relay operate is 0.50 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

Equation 11 Relay Operating Time at ARJ101

$I_{Fault_{\mathrm{ARJ101}}} = 9.4\ kA$;

$$PSM_{\mathrm{ARJ101}} = \frac{If}{Iset} = \frac{9.4}{0.37} = 25.41$$

Note that the value of plug multiplier setting is more than 20, the maximum value of 20 will be used in the calculation.

$$t_{\mathrm{ARJ101}} = \frac{0.14}{20^{0.02} - 1} \times 0.4$$

$$t_{\mathrm{ARJ101}} = 0.90\ seconds$$

The value of fault apply in this calculation was using the main relay that attach with the fault.so the value of fault used is 9400 A.

The time relay operate get from the calculation is 0.9 seconds. The graph show the time to relay operate is 0.88 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

4.7.2 Overcome supply interruption

This part discussed about the second objective of this project which is reduce exposure and reducing the problem. As shown in figure 4.7.2, the fault occurs at load near to the substation AR J104. The main relay is AR J104 and the backup relay is at ARJ101.

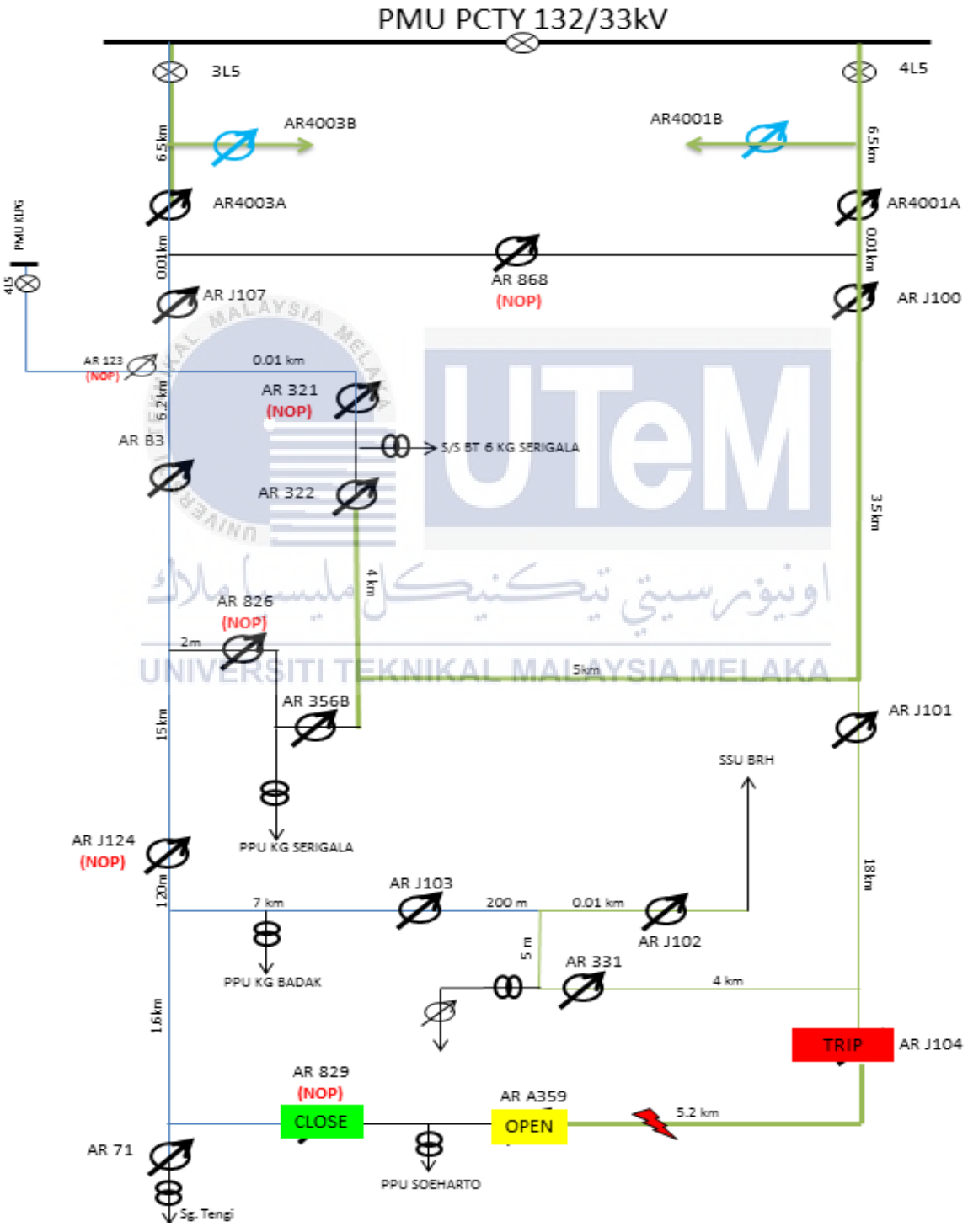


Figure 4.7.2 Case 5 Backup Supply Interruptions

Then the fault occurs at downstream ARJ104, the relay will operate first to isolate the problem. If relay ARJ104 is not operating caused by the relay error, relay at ARJ101 will take operate and isolate the fault. In this case, AR359 is switching open to cut off the supply and enable the maintenance to be done by worker. The normal of point at AR829 will close to give supply at PPU Soeharto.

4.7.3 Relay signal in different type of fault

In this part discussed about the effect when there have another fault that happen in the distribution system. The relay setting was actually was used in three phase fault case. Whether the value of fault is become less than three phase fault. The relays still operate but the operation time is not same. Actually, the less amount of current fault, more the duration of relay to operate. The result will provide in the simulation as shown below:

Table 4.7.1 Time Operation of Relay ARJ104 and ARJ101

Fault (A) / Time (s)	ARJ104	ARJ101
Line-to-Line	0.50	0.88
Double Line-to-Ground	0.51	0.90
Line-to-Ground	0.75	1.60

The data collected in the simulation by using different type of fault. The table show that the lower of current fault occur in the distribution, the time to relay operate will take longer. The relay still can operate to isolate the fault. Low current of fault will not take hard damage to the electrical component in distribution system if the time take to relay operate is longer.

4.8 6th Cases

In this phase discussed about time margin for protection coordination, the way to overcome supply interruption and relay signal study in different type of fault. Every part of the case showing the same overcurrent interruption but there is a different in place of the interruption.

4.8.1 Time Margin for Protection Coordination

In this part of operation as shown in figure 4.8.1, the average power running was 2MWatts. The fault was applied at downstream at load near to the AR331. Actually, relay at buss bar ARJ101 is called protective device and the other AR331 is called protecting device. In other when fault happen, protecting device must be clear fault first to interrupt the abnormal current. This will protect the protected device from take damage.

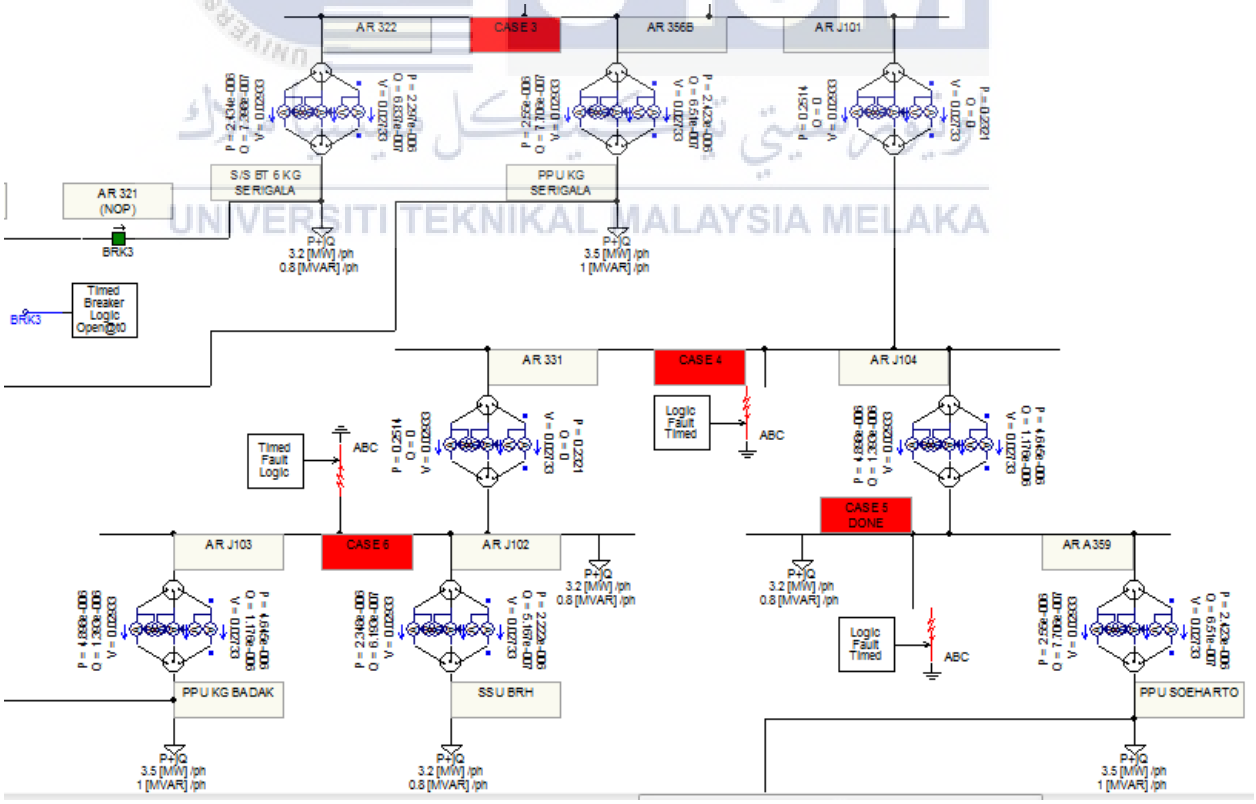
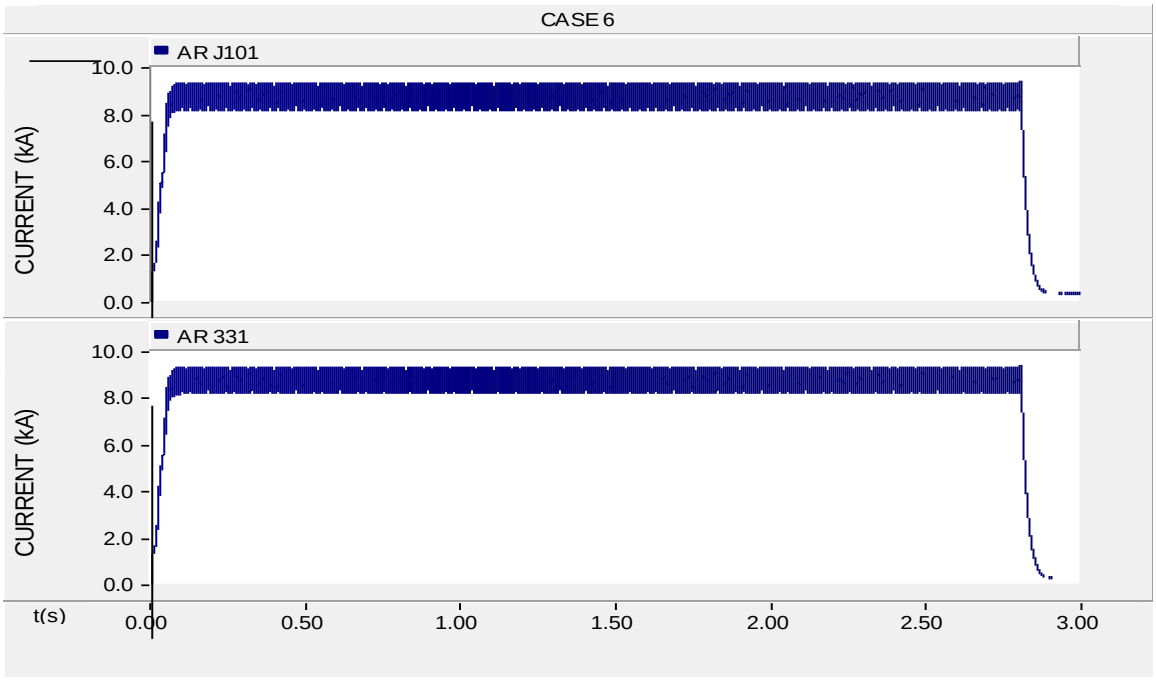
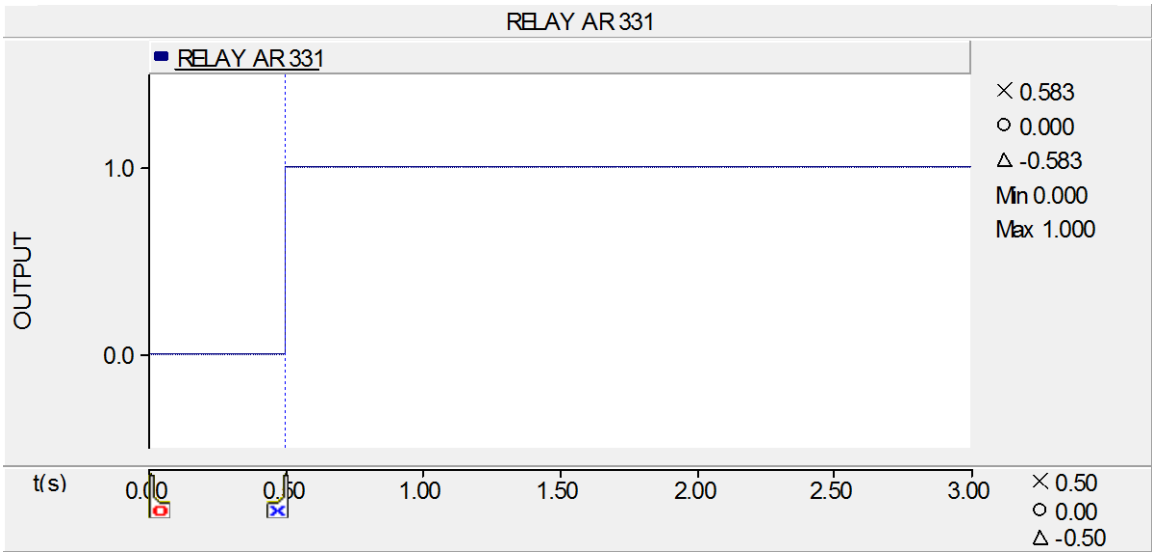


Figure 4.8.1 Operation of Relay at AR331 and ARJ101



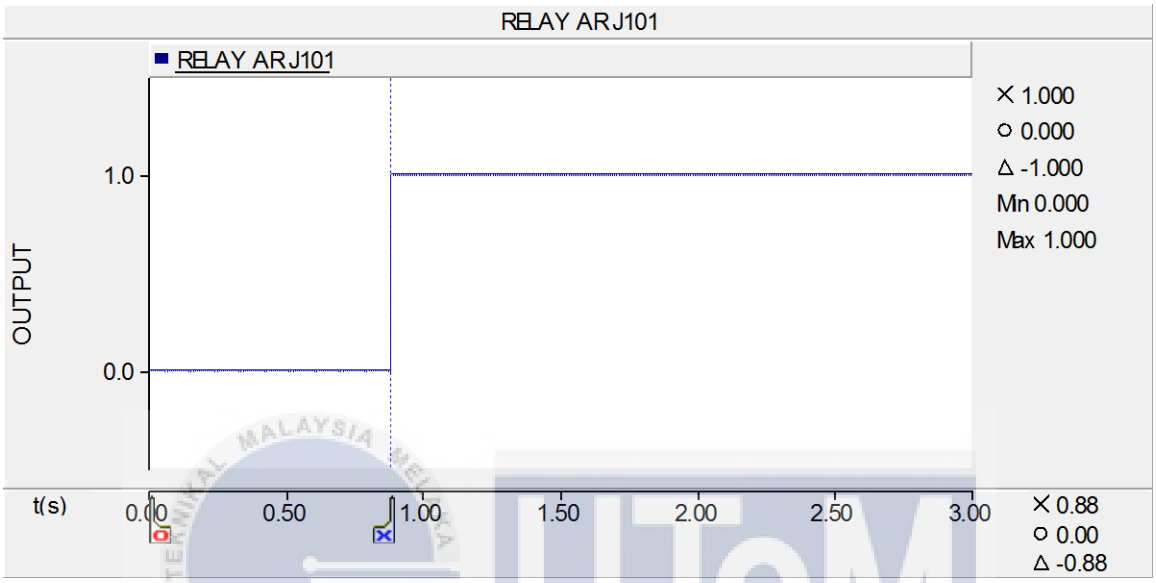
Graph 4.8.1 Fault current for AR331 and ARJ101

As the graph shown above, the fault current is 9400 A at transient waveform. The normal current at for AR331 and ARJ101 was 250 A and 370 A. The value of current was used as pickup current at relay setting. Actually, the pickup current is the current at which integration start positively. When the value of current more than the pickup current setting. So the integration will produce output '1'. In correlation, time dial setting also has function to make the integration to produce '1'. Actually, the more time dial setting, the more delay the relay will take action.



Graph 4.8.2 Relay Operation Time Tripping for AR331

The graph shown above was the time to relay to take action when fault happen. The relay setting was setup at ±0.5 seconds as the relay will take action. This relay will firstly to take action because the nearly to the fault. Even when this relay is malfunction, the relay at ARJ101 will take action and isolate the fault as backup relay.



Graph 4.8.3 Relay Operation Time Tripping for ARJ101

The graph above shows the output versus time the circuit running in 3.0 seconds. The output will propagate to 1 which the fault happens in starting circuit running. Refer to the graph 4.8.3; the ARJ101 relay will take action in ±0.9 seconds. Actually, the relay must be operating in time of fault happen and depend on the relay setting. Refer to the relay setting shown in figure 3.4.6 (*pickup current AR331=0.25, time dial AR331=0.25 and pickup current ARJ101=0.37, time dial ARJ101=0.4*) the relay will operate between two operating relay is 0.4s.

The nearest breaker with fault is relay AR 331, so relay AR 331 will operate first to clear the fault. If relay at AR 331 not operate due to the unreliability, the relay at ARJ101 will operate as protective device. The duration to relay ARJ101 to operate is 0.4s after relay AR 331 cannot operate.

The current fault can contain from graph 4.8.1 is used in calculation of plug multiplier setting. The simulation can be proving by the calculation of plug multiplier setting and time delay. So the time of relay will operate and calculated as shown below:

Equation 12 Relay Operating Time at AR 331

$I_{Fault_{AR331}} = 9.4\ kA;$

$$PSM_{AR331} = \frac{If}{Iset} = \frac{9.4}{0.25} = 37.6$$

Note that the value of plug multiplier setting is more than 20; the maximum value of 20 will be used in the calculation.

$$t_{AR331} = \frac{0.14}{20^{0.02} - 1} \times 0.25$$

$$t_{AR331} = 0.57\ seconds$$

The time relay operate get from the calculation is 0.57 seconds. The graph show the time to relay operate is 0.50 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

Equation 13 Relay Operating Time at ARJ101

$I_{Fault_{\mathrm{ARJ101}}} = 9.4\ kA;$

$$PSM_{\mathrm{ARJ101}} = \frac{If}{Iset} = \frac{9.4}{0.37} = 25.41$$

Note that the value of plug multiplier setting is more than 20, the maximum value of 20 will be used in the calculation.

$$t_{\mathrm{ARJ101}} = \frac{0.14}{20^{0.02} - 1} \times 0.4$$

$$t_{\mathrm{ARJ101}} = 0.90\ seconds$$

The value of fault apply in this calculation was using the main relay that attach with the fault.so the value of fault used is 9400 A.

The time relay operate get from the calculation is 0.9 seconds. The graph show the time to relay operate is 0.88 seconds. The value is near because there some error in calculation. This might be the decimal point that use in calculation is not enough as real running simulation.

4.8.2 Overcome supply interruption

This part discussed about the second objective of this project which is reduce exposure and reducing the problem. As shown in figure 4.8.2, the fault occurs at load near to the substation AR 331. The main relay is AR 331 and the backup relay is at ARJ101.

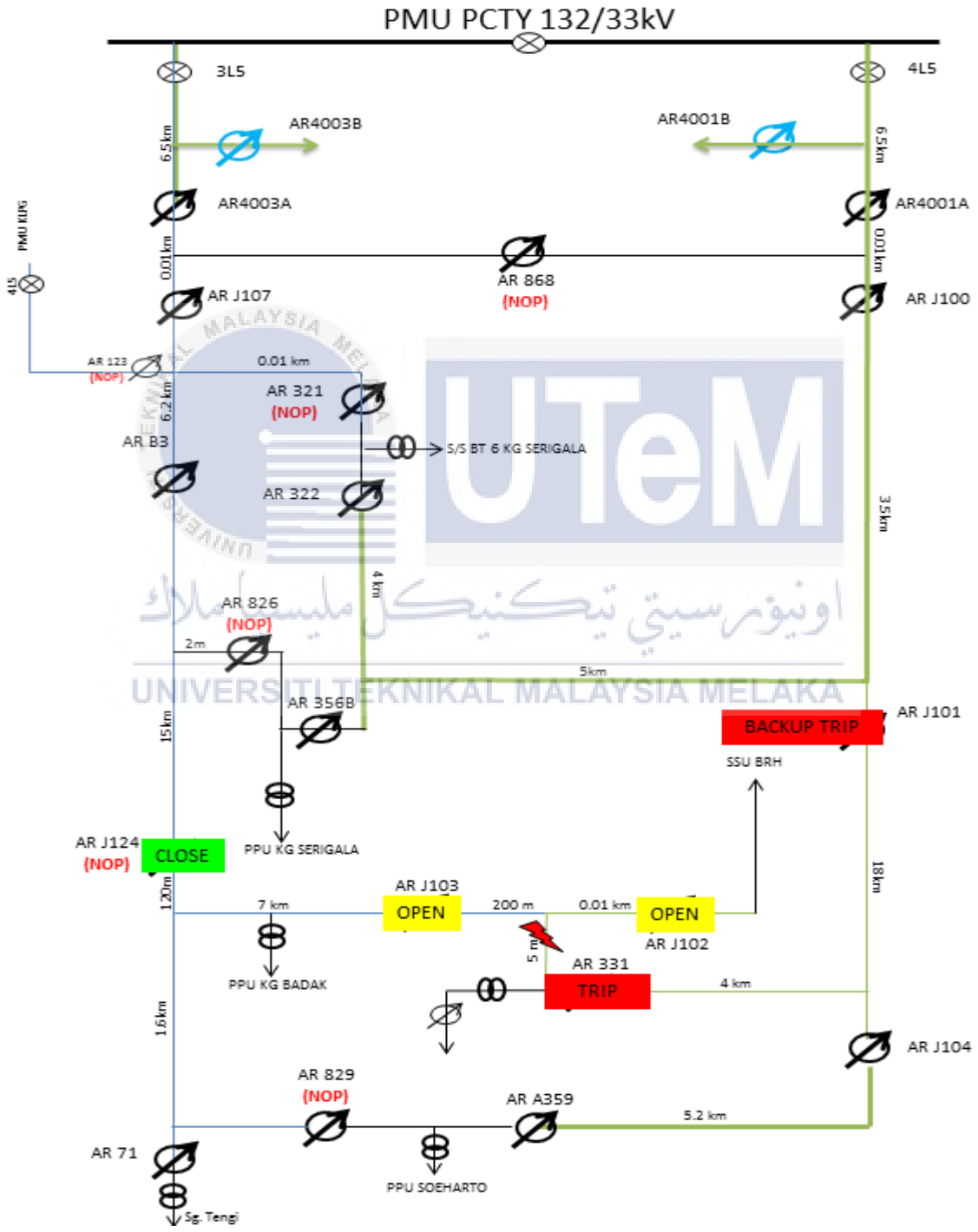


Figure 4.8.2 Case 6 Backup Supply Interruptions

Then the fault occurs at downstream AR331, the relay will operate first to isolate the problem. If relay AR331 is not operating caused by the relay error, relay at ARJ101 will take operate and isolate the fault. In this case, ARJ102 and ARJ103 is switching open to cut off the supply and enable the maintenance to be done by worker. The normal of point at ARJ124 will close to give supply at PPU Kg. Badak.

4.8.3 Relay signal in different type of fault

In this part discussed about the effect when there have another fault that happen in the distribution system. The relay setting was actually was used in three phase fault case. Whether the value of fault is become less than three phase fault. The relays still operate but the operation time is not same. Actually, the less amount of current fault, more the duration of relay to operate. The result will provide in the simulation as shown below:

Table 4.8.1 Time Operation of Relay at AR331 and ARJ101

Fault (A) / Time (s)	AR331	ARJ101
Line-to-Line	0.50	0.88
Double Line-to-Ground	0.51	0.9
Line-to-Ground	0.83	1.6

The data collected in the simulation by using different type of fault. The table show that the lower of current fault occur in the distribution, the time to relay operate will take longer. The relay still can operate to isolate the fault. Low current of fault will not take hard damage to the electrical component in distribution system if the time take to relay operate is longer.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This section examines the conclusion and recommendations about simulation design in overcurrent protection and coordination. The design of manufacturing is depending to the 'Tenaga Nasional Berhad, TNB' power system network. In each case was study about the condition of relay signal and time duration of operation. In additionally, every case was testing by interrupt with many type of fault and the effect of operation relay.

5.2 Conclusion

In general, the over current relay setting coordination is much more difficult to achieve by using the simulation. Since, the magnitude of fault current is very much higher typically in few thousands of amperes. Each relay will have own setting to commit that the relay will operate during any type of fault. In additionally, the time operation must be fixing and need maintenance to ensure the operation of relay in good condition. On other hand, addition of load will affect the total power in the power system distribution. So, the maintenance of relay is important to still update and can operate in time.

Moreover, over current and coordination actually a systematic application of current actuated protective devices in the electrical power system. This will remove only a minimum amount of equipment from service in a fault condition. The purpose of coordination protection is not about to minimize damage and process outage cost, but it is also can provide protection to the public that expose to the power system network. These failures might be caused injuries or death to worker or consumer. The coordination study of an electric power system consists of an organized time-current study of all devices in series from the utilization devices to the source. These study the comparisons between two protective devices when certain levels of abnormal current pass through it.

Furthermore, the coordination study provides data useful for the protective relay setting in this project. The understanding gain about protection relay and it characteristics to protect each zone in power system network. In a completion of protection coordination, the accessibility of supply to the customer is much more important. Failure to give supply at customer will be a big problem in protection coordination. In that case, there are no protection coordination attach in that distribution system or power system network. So, the employee must alert in fault condition to make sure the customer do not exposure to the problem.

In addition, in protection coordination the time margin can vary between 0.30 seconds to 0.50 seconds. During the current practice for this simulation, the time margin will be 0.4 seconds. The margin is set to be a safety in a protection coordination system. The increasing of time margin will affect the damage during interruption. The more electrical component expose to the high current, less the protection will be get in the system. So, minimizing the damage during the interruption is much more important in overcurrent protection and coordination.

5.3 Future Recommendations

Actually, this research is tiny about the relay signal and operation in protection coordination. This will result less in real protection coordination. For some improvement from this research, some recommendations have made to overcome the weakness or overcurrent protection and coordination. The implementers have been proposed as follows:

In this simulation should have design the real component of relay. It will add more information about the relay setting and the weakness of protection relay. In addition, real life coordination protection should have circuit breaker to completing the tripping and isolate fault. The research about circuit breaker in their function of protection system is important to take seriously. The simulation must be providing the circuit breaker to complete the overcurrent protection and coordination system.

Moreover, research for fault in any condition and place where the fault occur is very important. It is an important prediction that the protection coordination system will be ready in every condition of fault. Addition of fault study such as earth fault should have to discuss and get knowledge the effect to the coordination protection system. Internal fault in the relay should take into a count. Error in the relay is the worst problem that will cause the relay is malfunction.

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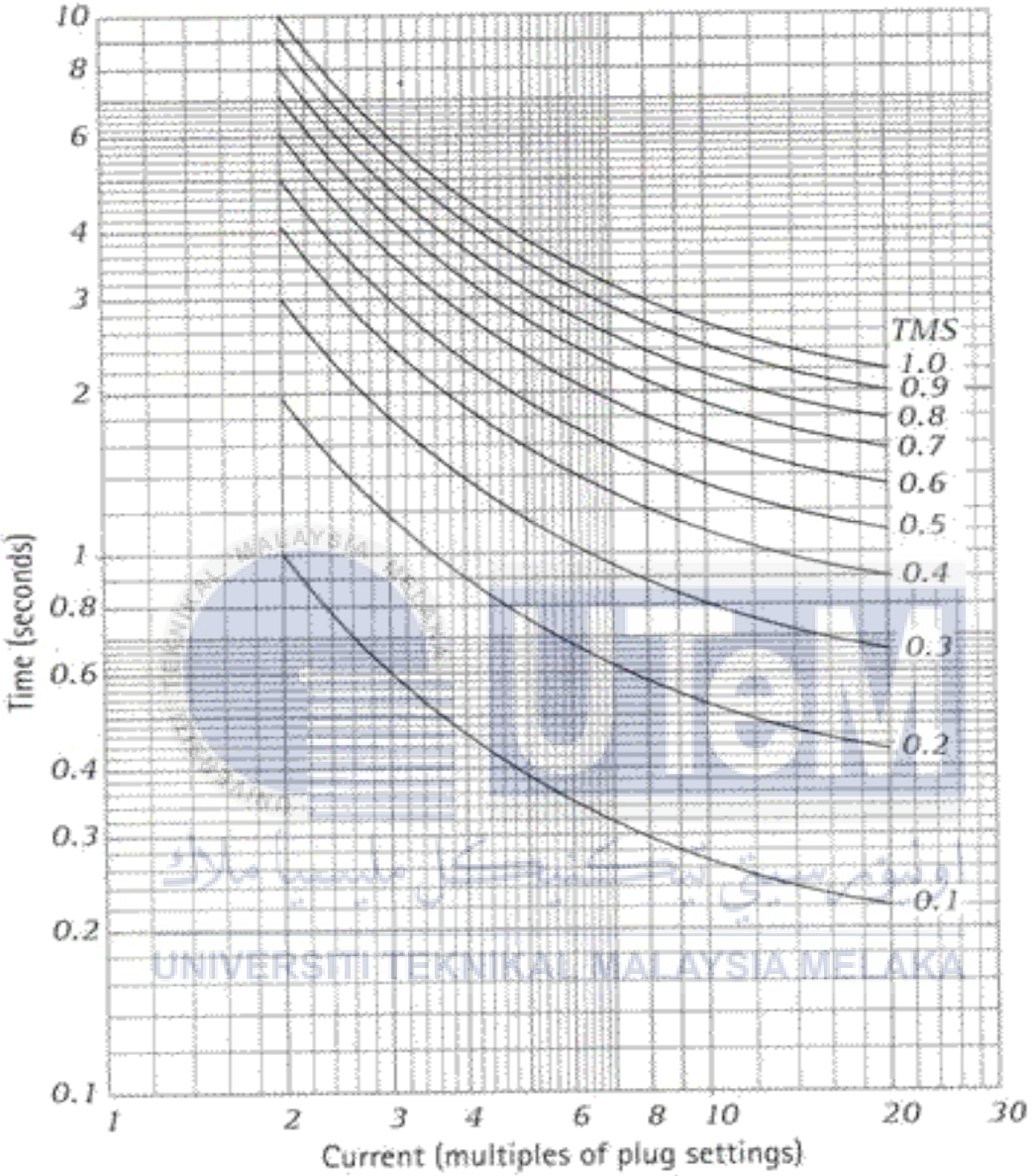
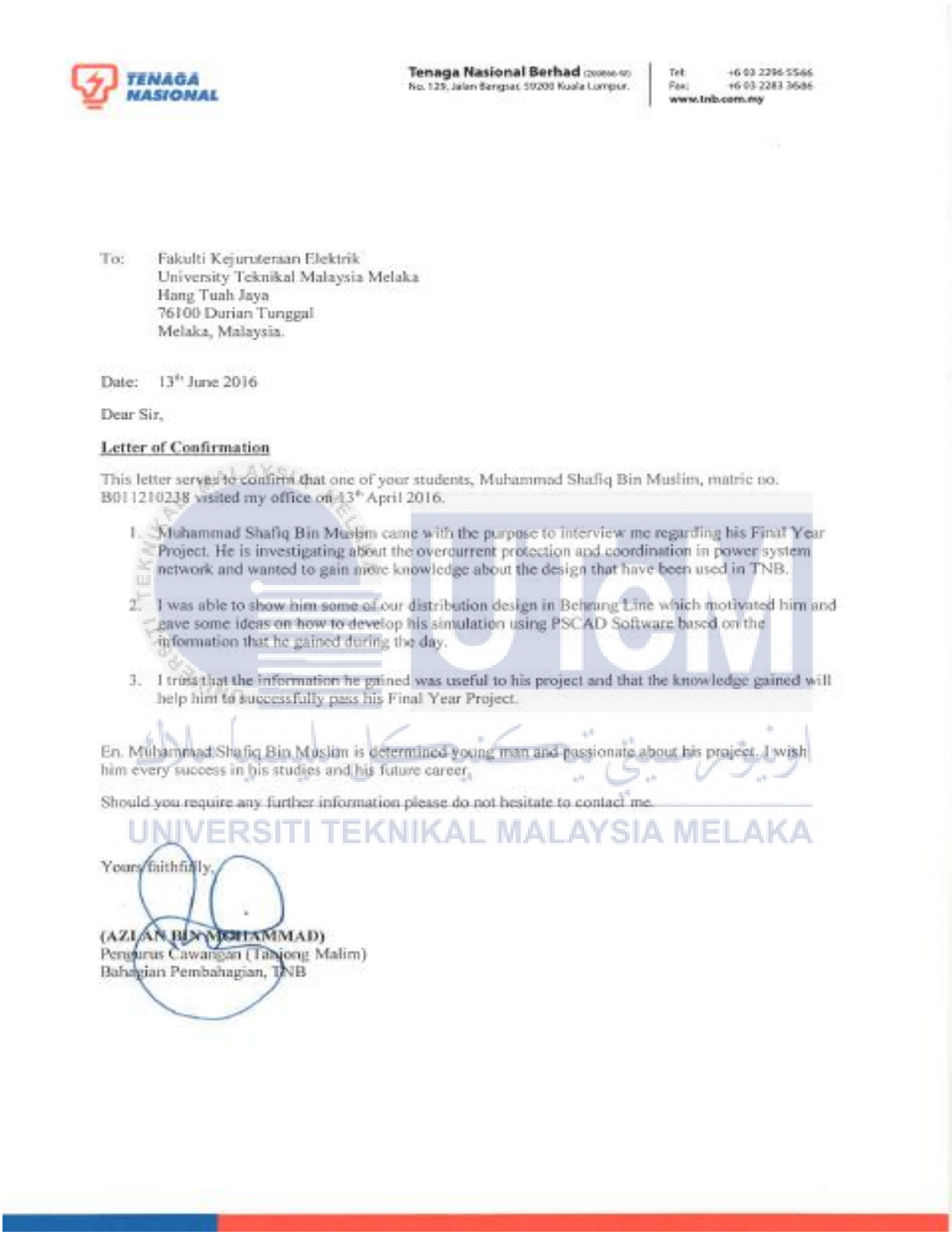
APPENDIX

Appendix A: Inverse Definite Minimum Time (IDMT)



APPENDIX

Appendix B: Letter of Confirmation from Tenaga Nasional Berhad



TENAGA NASIONAL

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To: Fakulti Kejuruteraan Elektrik
University Teknikal Malaysia Melaka
Hang Tuah Jaya
76100 Durian Tunggal
Melaka, Malaysia.

Date: 13th June 2016

Dear Sir,

Letter of Confirmation

This letter serves to confirm that one of your students, Muhammad Shafiq Bin Muslim, matric no. B011210238 visited my office on 13th April 2016.

1. Muhammad Shafiq Bin Muslim came with the purpose to interview me regarding his Final Year Project. He is investigating about the overcurrent protection and coordination in power system network and wanted to gain more knowledge about the design that have been used in TNB.

2. I was able to show him some of our distribution design in Behrang Line which motivated him and gave some ideas on how to develop his simulation using PSCAD Software based on the information that he gained during the day.

3. I trust that the information he gained was useful to his project and that the knowledge gained will help him to successfully pass his Final Year Project.

En. Muhammad Shafiq Bin Muslim is determined young man and passionate about his project. I wish him every success in his studies and his future career.

Should you require any further information please do not hesitate to contact me.

Yours faithfully,

(AZLAN BIN MOHAMMAD)
Pengurus Cawangan (Tanjong Malim)
Bahagian Pembahagian, TNB