“ I hereby declare that I have read through this report entitle “Time and Current Grading for Inverse Definite Minimum Time (IDMT) Coordination Relay Setting” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

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TIME AND CURRENT GRADING FOR INVERSE DEFINITE MINIMUM TIME (IDMT) COORDINATION RELAY SETTING

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This Report is Submitted in Partial Fulfilment of Requirements for the Degree of Bachelor in Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

I declare that this report entitle "*Time and Current Grading for Inverse Definite Minimum Time (IDMT) Coordination Relay Setting*" 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 candidature of any other degree.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

The primary function of a protection system in electrical power network is to ensure the continuity of the electrical supply. To achieve this, the protection system must be able to detect the abnormal condition in electrical circuit or piece of equipment, to identify the location of fault and to isolate the fault section of circuit or the faulty equipment without disrupting the electricity supply to the rest of network. The simple protective system device is a fuse or CB. Upon sensing the abnormal current passing through a circuit, the fuse or CB will disconnect the electrical supply to the circuit by self-destructive. The protective equipment used in a protection system includes current transformer (CT), relays, timers and trip coils.

An overcurrent relay provides turn out to be one the majority of essential protective devices. It has recently been applied as the main and backup protection in power system for its functions of high reliability, selectivity and cost effective. Additionally, a unique function that the IDMT overcurrent relay is getting quick fault clearing times. The magnitude of the current is inversely proportional due to the operating time of the relay. This means that for higher fault current, shorter operating time is required to clear the fault.

Usually, much more complex network system, the protective relay coordination problem occurs because of the bad relay coordination. A careful concern in selecting the overcurrent setting, usually time multiple setting and plug setting are usually essential to obtain the greatest protection in making sure the reliabilities throughout the incident of any faulty circumstances. For interconnected networks, it is needed to take a look at the performance of a complete relay setting scheme. For example review is practically difficult by hand for a complex interconnected system, and additionally digital computers should be used [1].

The conventional and traditional technique that includes of lots of tiresome and hard task and in determining the plug and time multiple setting for every own relay is adoptive and is still significant for a basic network. This technique is almost difficult for a complex and interconnected network. Therefore, the review in determining the functionality of the IDMT protection can be achieved by the execution of the Computer Aided Protection Engineering software, CAPE [2]. Cape consists of an involved set of ten data management and evaluation programs developed to help protection engineers with their day-to-day actions of selecting, setting, and coordinating protective relays [3]. The functionality of the relays in a radial system is anticipated and is decided by the real relay settings. This project provides the study of the time and current grading for inverse definite minimum time coordination relays setting of a simple radial distribution system network.

1.2 Problem Statement

A few disruptions in power supply were due to the inappropriate setting or wrong selection of the power protection devices. Therefore, it had caused inherent tripping, inadequate over current protection and inactivated earth fault. This information of design power system protection play very crucial rules to make sure that is no disruption of power supply. It is include the load flow analysis, fault analysis, proper setting and technique of relay setting.

1.3 Objective Project

The main objectives for this project are:

- To analyze load flow, fault analysis and coordination of the relay power at system network by using simulation software Cape.
- To analyze the performance of time and current grading method designed for power system network based on IDMT relay.
- To develop proper setting technique for over current and earth fault using the IDMT MK 2000 relay.

1.4 Project Scope

The scopes of this project are:

- To analyze the load flows, fault analysis and coordination of the relays at power system network using simulation software Cape.
- To focus on overcurrent and earth fault relay operation, the relay setting current and time and the relay characteristic.
- To study the fault analysis for the over current, short circuit and earth fault.
- To determine the components and parameters that used in the network system such as calculate the fault, fault MVA, time multiple setting (TMS), and time operating of the relays.

1.5 Expected Project Outcome

Project should be:

- Successful analyze the load flow, fault analysis and coordination of the relay power at system network by using simulation software Cape.
- Successful in setting the IDMT MK 2000 relays for over current protection in the system.
- Successful in coordination and implementing the IDMT MK 2000 relays in the selected power network system.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory and Basic Principles

Protection system for power system has been developed to minimize the damage and to make sure supply in safe condition, continuously and economically. Relay is one of the most important components in protections system. There is several kind of relay that each kind has own characteristic. A relay is device that makes a measurement or receives a signal that causes it to operate and to effect the operation of other equipment. It responds abnormal conditions in faulty section of the system with the minimum interruption of supply. The advantages of isolating a system faults as quickly as possible include for personnel a public, minimizing damage to plant and minimizing effects on system stability.

Protection towards extra present is usually the primary protection system to build. Through this simple theory, the graded overcurrent system and discriminative fault protection has been created. This should not be confused with „overload‟ protection, that generally can make apply of relays that work in a time connected in some degree to the thermal capability of the plant to be guarded. Overcurrent protection is targeted totally to the clearance of faults, although with the settings usually obtained several determine of overload protection may be obtained [4].

2.1.1 Discrimination

A protection system must be able to discriminate between healthy and faulty equipment and circuits. It can be achieved by current (magnitude), time and comparison. The simple radial distributions network system as shown in Figure 2.1.

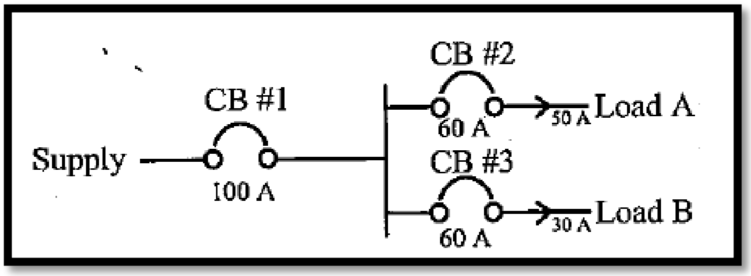

Figure 2.1: Simple radial distributions.

The CB 1 is set to trip at 100A and CB 2 and CB 3 is set to trip at 60A. After that, current drawn by a load A is 65 A and load B is 30A. CB 2 will trip since current drawn exceed 60A. CB 1 will not trip since total current drawn is 95 A and less than 100A. For this case, discrimination between CB 1 and CB 2 is archived by current grading.

Now let"s consider the condition of CB 1 is set to trip at 100A CB 2 and CB 3 is set to trip at 60A. The current drawn by load A is 90A and load B is 30A Then, CB 2 will trip since current drawn exceed 60A. CB 1 will trip since total current drawn is 120 A and more than 100A. There will be no supply for both load A and B even though load B draws current less than tripping value. Thus in order to prevent this, time delay device is necessary for each breaker. Figure 2.2 show the time delay for each CB.

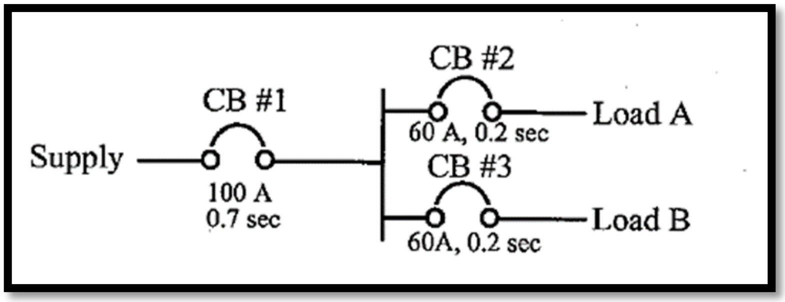

Figure 2.2: Time delay for each CB.

The minimum time interval is usually between 0.3 and 0.5s. It is required to prevent simultaneous tripping. CB 1 is set to trip at 100A at 0.7s. CB 2 and CB 3 is set to trip at 60A at 0.2s. Then, current drawn by load A is 90A and load B is 30A. After that, CB 2 will trip first since current drawn by exceed 60A and shorter time delay. CB 1 will not trip since longer time delay. There will be no supply for load A and load B is still operating. This discrimination between CB 1 and CB 2 is achieved by time grading.

A differential (or comparison) protection system compares the current flowing into equipment (i.e. cable, transformer) with the current flowing out. If there a difference, the protection will operate. The differential protection system is used for protection „a piece" of equipment such as a cable or a transformer. It is calling a „unit"of protection system.

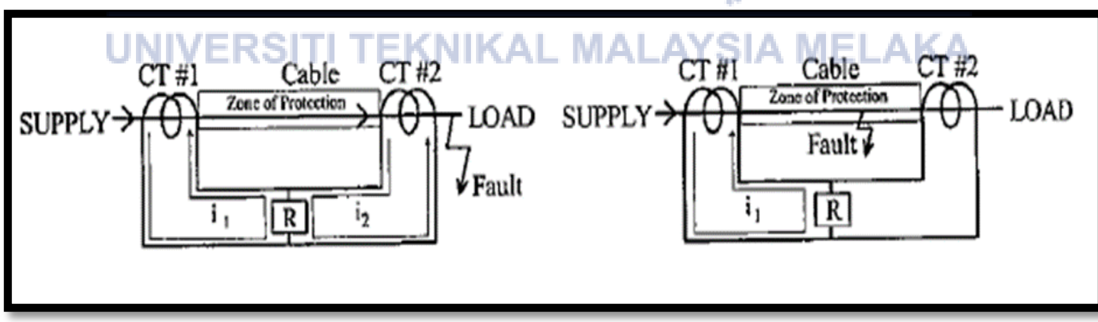

Figure 2.3: Balanced current.

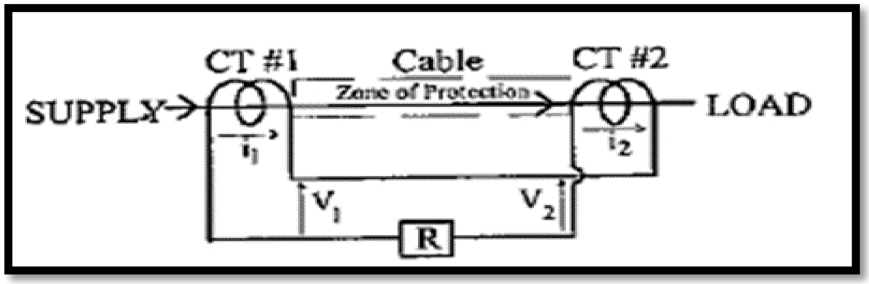

Figure 2.4: Balanced voltages.

2.1.2 Earth Fault Protection

Faults studies form essential things of power system. The issue consists of determining bus voltage and line currents throughout various sorts of faults. Faults on power are separated into two which is balanced and unbalanced faults. Types of unbalanced faults are single line to ground faults, line to line faults and double line to ground faults [5].

A fault in a circuit is any breakdown which will disturbs with the normal flow of current. The faults are associated with abnormal change in current, voltage and frequency of the power system. Faults occurs in a power system due to insulation breakdown of equipment, flashover of lines initiated by lightning stroke and because of permanent damage to conductors [6].

Other than, much more responsive protection towards earth faults can be achieved by using a relay which reacts only to the residual current of the system. The earth-fault relay is totally same by load currents, no matter if balanced or not. It can be provided a setting which is restricted only by the style of the equipment and the occurrence of unbalanced leakage or capacitance currents to earth. This is an essential concern if settings only a few percent of system rating are regarded, since leakage currents may make a residual quantity of this order.

The lower configurations allowable for earth-fault relays are really helpful. Earth faults are not only by far the many of all faults, but may be restricted in magnitude by the neutral earthing impedance. The basic connection shown in Figure 2.5 can be prolonged by connecting overcurrent elements in the individual phase leads, as shown in Figure 2.6, and applying the earth-fault relay between the star points of the relay group and the current transformer.

Phase fault overcurrent relays are frequently supplied on only two phases since these will identify any interphase fault; the connections to the earth-fault relay are not affected by this concern. The setup is shown in Figure 2.7.The typical settings for earth-fault relays are 30%-40% of the full-load current or minimum earth-fault current on the part of the system being guarded.

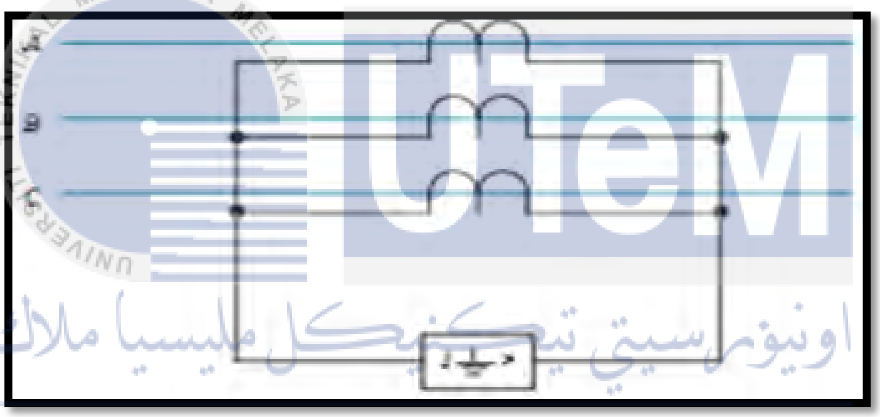

Figure 2.5: Residual connection of fault transformer to earth fault relays.

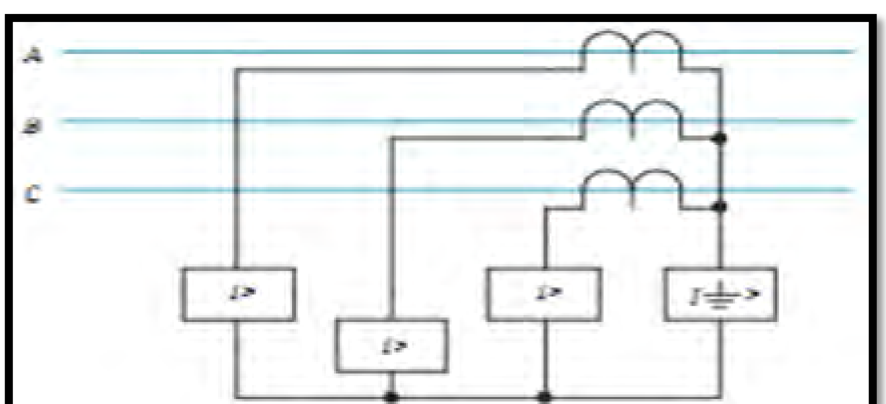

Figure 2.6: Residual connection of fault transformer to earth fault relays.

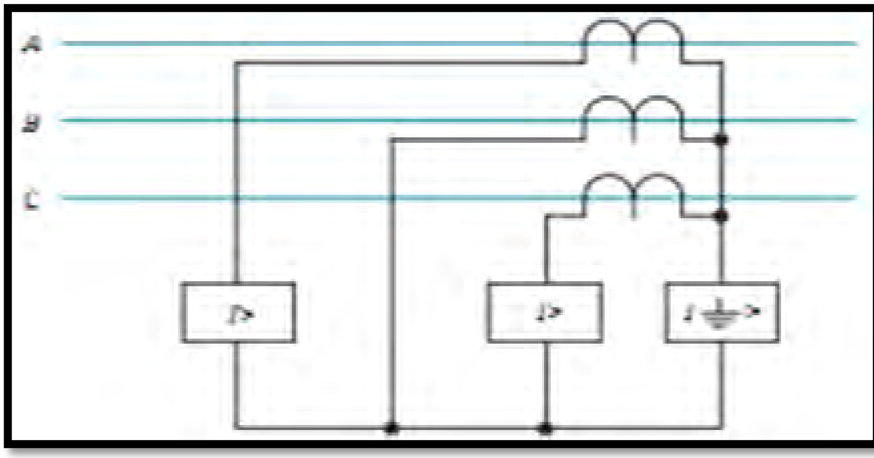

Figure 2.7: Residual connection of fault transformer to earth fault relays.

2.1.3 Relay Coordination Concept

2.1.3.1 Radial System

The specific protective relay as primary or backup is important in distribution system. When the relay applied to protect its own system element it is thought of primary relay, when to backup other relays for fault at remote location, it is serving as backup relay. Providing both functions simultaneously; serving primary relay for its own zone protection and backup relay for remote zone of protection. Besides, the protective relay must be time-coordinated, so that the primary relay will always operate faster than the backup relay. So, the setting and coordination of the relay is the very important part to make sure which relay stands for primary and the other one for backup.

2.1.4 Relay Current Setting

An overcurrent relay has a minimum operating current, known as the current setting of the relay. The current setting must be chosen so that the relay does not operate for the maximum load current in the circuit being protected, but does operate for a current equal or greater to the minimum expected fault current. Although by using a current setting that is only just above the maximum load current in the circuit a certain degree of protection against overloads as well as faults may be provided, the main function of overcurrent protection is to isolate primary system faults and not to provide overload protection.

In general, the current setting will be selected to be above the maximum short time rated current of the circuit involved. Since all relays have hysteresis in their current settings, the setting must be sufficiently high to allow the relay to reset when the rated current of the circuit is being carried. The amount of hysteresis in the current setting is denoted by the pick-up/drop-off ratio of a relay – the value for a modern relay is typically 0.95. Thus, a relay minimum current setting of at least 1.05 times the short-time rated current of the circuit is likely to be required.

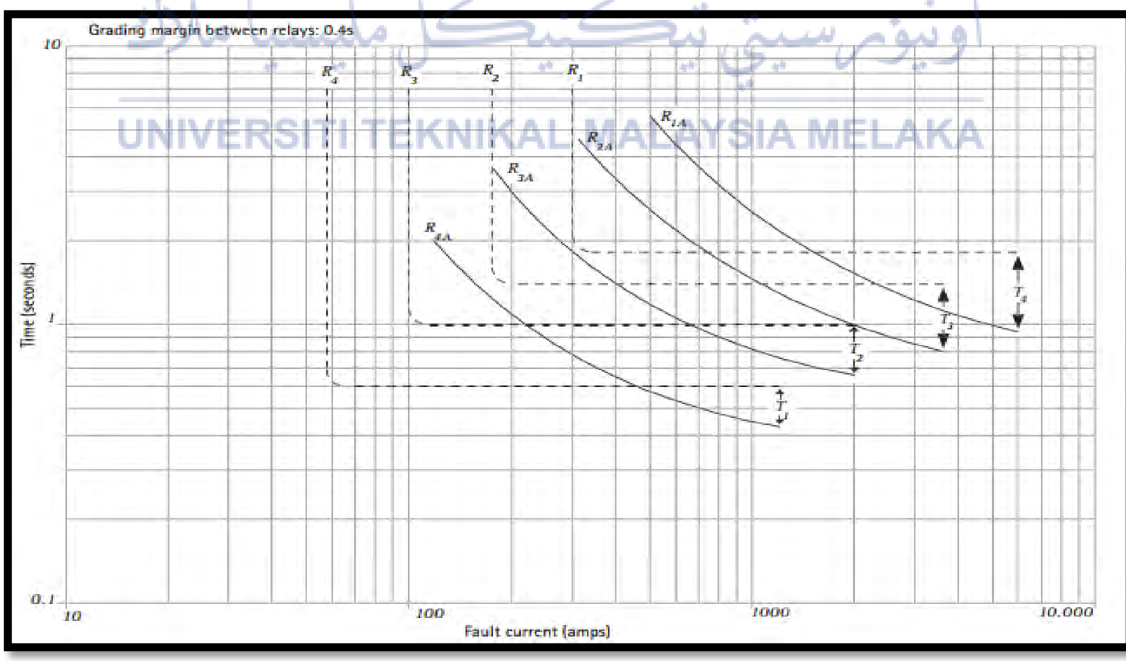

Figure 2.8: Definite Time Characteristic for Overcurrent Relay

Table 2.1: Setting of Independent (definite) time relay

Relay	Current Set (A)	Operating time (s)
R_{1A}	300	1.8
R_{2A}	175	1.4
R_{3A}	100	1
R_{4A}	57.5	0.6

2.1.5 Component of Protection

2.1.5.1 Current Transformer (CT)

A current transformer (CT) is used for measurement of alternating electric currents. For small current at low voltage, trip coils and ammeters can be connected directly to the circuit such as in series with the load. However, larger current and HV system, there is not practical to measure in series as example 100 A and above. The function of current transformer (CT) are to isolate the primary voltage of the system from the protection and measuring equipment and transform the high primary current in the circuit to a small secondary current of 1A or 5A. CT are divided into two main types which is for protection CTs and measurement CTs. Current transformers are commonly used in metering and protective relays in the electrical power industry [7].

A current transformer transform a value of primary current to a standardizing small value of secondary current easy to handle for measurement instrument or protective relay. The standard secondary values are 5 Amp, 2 Amp and 1 Amp the preferred value is 5 Amp.

1) PVC taped ring CT.

The black PVC tape are applied on the enameled copper wire winding on the toroidal core, these are suitable for indoor use, commonly used in L.T. Switchboard and starter panel.

2) Epoxy encapsulated CT.

The toroidal core and enameled copper wire winding are placed into a suitable size of plastic moulded shell, epoxy resin then completely cover the transformer and cured to the solid state. These CT are higher in cost but are robust and the winding are totally covered by epoxy resin protection.

3) Moulded Case CT.

The toroidal core and the enameled copper wire winding are moulded in between 2 plastic moulded shell, thus providing a tough and robust finished.

4) Products range: IEC 44-1/96.

- PVC ring CT
- Saturation CT
- Wound Primary CT
- Moulded Case CT
- Interposing CT
- Epoxy encapsulated CT
- Summation CT

Figure 2.9: Current Transformer

<u>Current Transformer (CT)</u>

1. Standard IEC 44-1/96
2. Ratio 100/5A
3. S/NO 362754
4. TYPE PR-34
5. Rated frequency 50/60Hz
6. 0.72/3.0Kv
7. Insulation class INSUL CL: B
8. CLASS 1 – non revenue measurement including power and energy
9. VA 15

Table 2.2: Limit of current error and phase displacement for measuring current transformer.

Table - limit of current error and phase displacement for measuring current transformer (class 0.1 to 1)

Accuracy Class	± Percentage current (ratio) error at percentage of rated current shown below				± Phase displacement at percentage of rated current shown below							
					Minutes				Centiradians			
	5	20	100	120	5	20	100	120	5	20	100	120
0.1	0.4	0.2	0.1	0.1	15	8	5	5	0.45	0.24	0.15	0.15
0.2	0.75	0.35	0.2	0.2	30	15	10	10	0.9	0.45	0.3	0.3
0.5	1.5	0.75	0.5	0.5	90	45	30	30	2.7	1.35	0.9	0.9
1.0	3.0	1.5	1.0	1.0	180	90	60	60	5.4	2.7	1.8	1.8

2.1.5.2 Protection Relay

A relay is a device that can measure electrical quantities which is voltage and current, then sends the signal to activate a sudden pre-determined change or change in one or more circuit for example to trip the circuit. A protection relay is a relay that responds to abnormal condition in an electrical installation and controls a CB so as to isolate the faulty section of the system. There are three types of protection relays which are electromagnetic relays, electro-thermal relay and electronic relay [8].

The electromagnetic and electronic relay has an inverse time-current characteristic as example the operating. This relay is named as an Inverse Definite Minimum Time (IDMT). For this project, the relay MK2000 was used.

Figure 2.10: Inverse Definite Minimum Time relay.

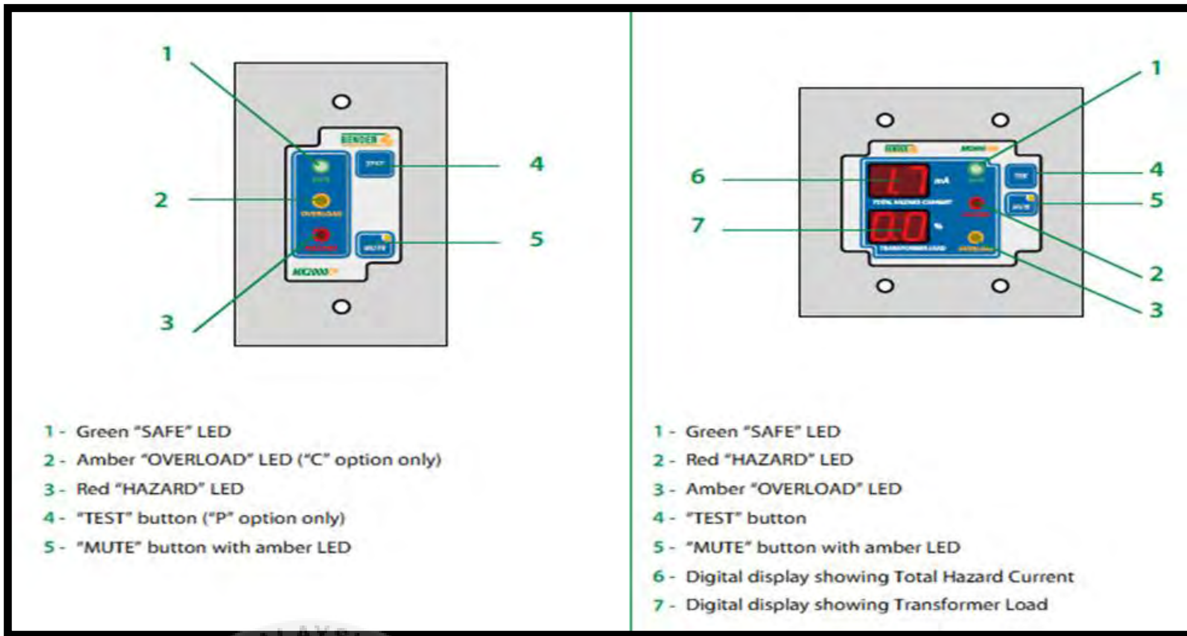

Figure 2.11: Digital Display

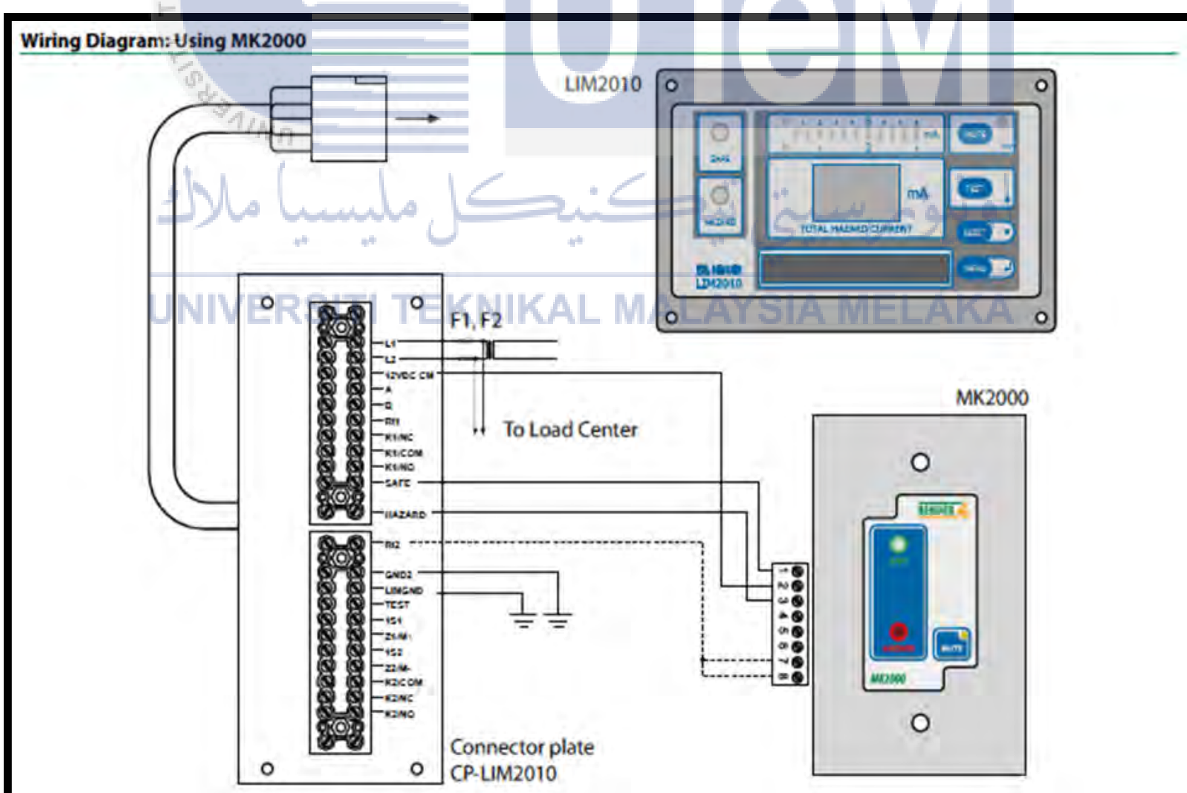

Figure 2.12: Wiring Diagram using MK2000

2.1.5.3 Time-current characteristics of the IDMT relay

The plug setting (PS) relays are universal equipment, which can be used for both high and low voltage systems. The same relay can be used for small and large current, for example, 60A and 1000A. In this condition, the items that have to be changed are the CTs and re-setting the PS of the relay.

PS=Actual current in primary circuit / rated primary current of CT (2.1)

Besides, time multiplier setting (TMS) is the time current characteristics of IDMT relays complies with BS 142 and IEC 255 with the following formula:

$$\text{Time}\ ,\ t = \frac{K}{(M^{\beta}-1))} \times TMS \qquad (2.2)$$

$$\text{Where M} = \text{plug setting multiple} = \frac{\textbf{Fault current}}{\textbf{Current setting of relay}} \qquad (2.3)$$

K and **β** are constant

Table 2.3: Value of **K** and **β**

Type of curve	**K**	**B**
Standard (Normal)	0.14	0.02
Very inverse	13.5	1.0
Extremely inverse	80	2.0

Manufacturer can use other value of K and β or supply graph of operating characteristic.

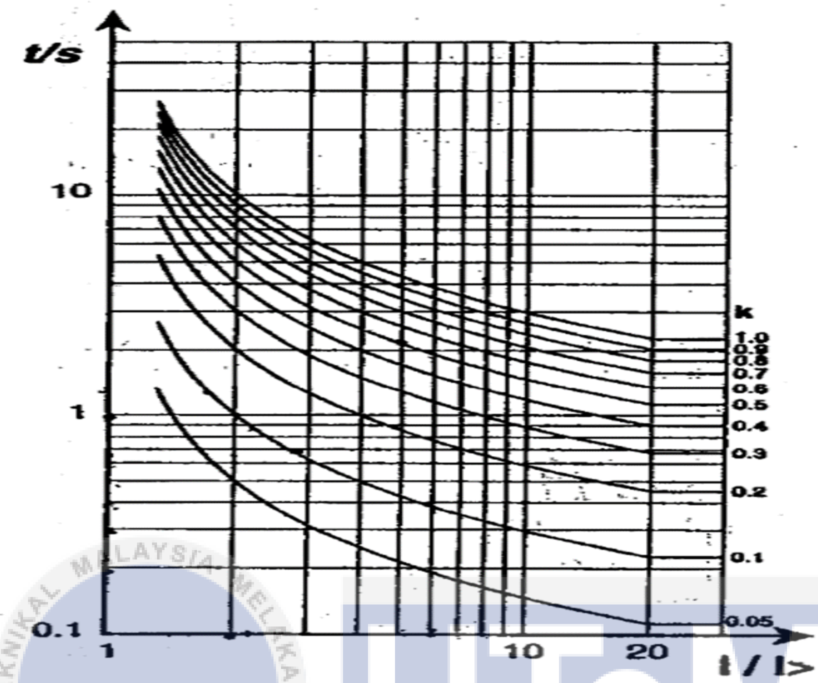

Figure 2.13: IDMT Normal Inverse.

Typical Connection of relay and CT

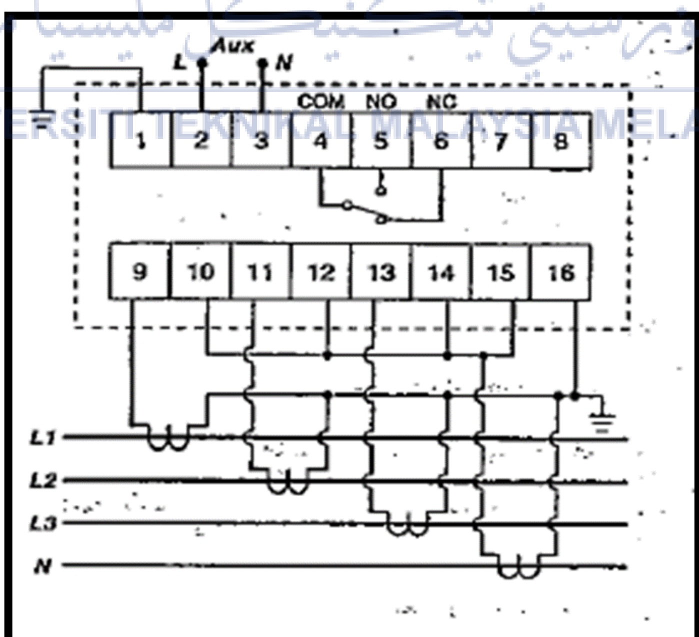

Figure 2.14: Connection of relay and CT.

Over current and earth fault relay connections

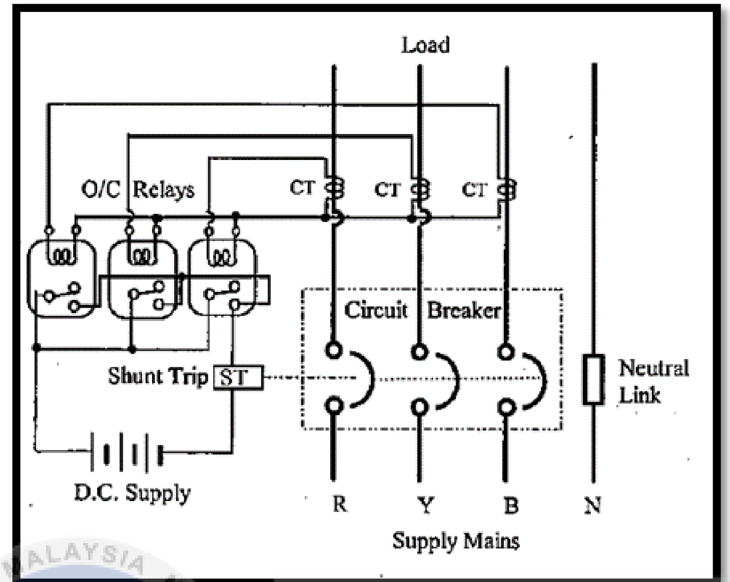

Figure 2.15: Over Current connections.

The output of the CT is connected to the coils of the respective O/C relays. If there fault in any phase, the relay in that phase will operate and trip the CB.

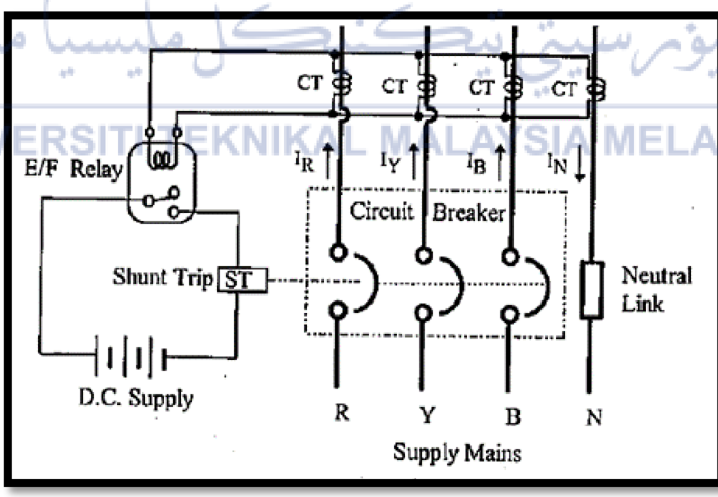

Figure 2.16: Fault relay connections.

Healthy circuit- sum of the phase current is equal to current flowing in the neutral even in short circuit event. If there fault in any phase to neutral or earth, part of the current will not return to the supply by the neutral wire. If the current exceed the setting of the earth fault relay setting, the relay will operate and trip the CB.

2.2 Review of Previous Related Work

In this part, it will explain more elaborate for this project about the references that related to the case study of this project. In an era of rapidly expanding technology, various methods and assets and facilities improved in terms of quality and performance. It"s also the same thing towards to the time and grading for grading of inverse definite minimum time coordination relays setting. Even though it is had been conducted in many times, it is still have the weakness. There are many ways in developing of time and current grading of inverse definite minimum time coordination relays setting.

According to this paper, problem that arises is to guard against the possible failure of main protection devices in power system protection, overcurrent usually employed as backup protection [9]. So the solution for overcurrent protection coordination is a highly constrained combinatorial optimization and is subject to the user preference on time grading and current grading. The operation of overcurrent relays is based on the current magnitude. Distinguish by magnitude only be used where there is a great change in fault current as is the case between primary and secondary windings of transformer is called relays. Several simple protections devices are discriminate by time basis. The time delay is being generally inversely proportional to the current level. There schemes are supplied to the medium voltage systems as an integral part of the circuit breaker where it would be inefficient to offer protections relays.

Besides, by referring to this journal the inverse definite minimum time (IDMT) overcurrent relay coordination need to be operated by capable engineers with a lot of time, cost and result may not easy to be validated [10]. Protective relays are extensively practical for industrial plant power system as main protective devices as they are reliable, cost effective and selective. For all power plant, electrical structure they need to take serious about the safety which means take care the protections because it can give an effect to our project and others. The most important for industrial plant, poor coordination may spread fault zones wider caused unnecessary power blackout or damage to our equipment is good overcurrent relay coordination which are avoidable or even more affect backup utility substations. So, for the further usage it"s prefer to use inverse definite minimum time for a properly ways. IDMT is the relay with an inverse current or time characteristic. The time delays are decreased for higher currents and time are long for low currents flow.

The next paper is clearly point out the study of the relay coordination is limited to IDMT time overcurrent relays that provide protection for the small ration of the test network by applying three phase fault. The three phase fault which is least compared to single line to ground, line to line, double line to ground fault. It produced the most severe fault current [11]. Computer aided protection engineering is a software had been choose to conduct or to measure the value of each fault occurs. In this software, it can measure the load flow analysis besides measure the fault current. The graphical interface of CAPE is practical as it allows protection engineer to do any essential editing, revision or even upgrading of the existing setting to ensure proper coordination to the network system. Other feeder structure, such as ring network and other types of faults can also be applied by using CAPE.

According to this paper, overcurrent relays have been commonly used as a cost-effective alternative for the protection of substations and distribution system or as a secondary protection of transmission system [12]. An over current relay, there would be a current coil. When normal current flows through this coil, the magnetic effect generated by the coil is not sufficient to move the moving element of the relay. But when the current through the coil increased, the magnetic effect increases, and after certain level of current, the deflecting force generated by the magnetic effect of the coil, crosses the restraining force [13]. The intention is the highest possible reduction of tripping times for a selective fault clearing in distribution networks protected by overcurrent relays without communication links.

The optimization is solved by the method of Lagrange generalized with the Karush-Kuhn-Tucker conditions and is focused at selective fault tripping with shorter tripping times as standard characteristics and conventional coordination methods. Overcurrent relay coordination becomes a mathematical optimization task.

A notable advancement regarding their average and maximum tripping times which can be achieved using standard characteristics and conventional coordination methods [14]. The proper coordination constraints are included by using linear approximations for the relay dynamics. In [15], risk analysis is used to enhance the location of circuit breakers on the distribution feeders. A breaker is designed to protect an electrical circuit from damage caused by overload or short circuit. Circuit breakers are made in variable sizes, from small to big devices which protect an individual household machine up to large switchgear designed to protect high voltage circuits feeding an entire city.

The operating time can be constant irrespective of the magnitude of the fault current. Next, this research paper presents an optimal coordination of direction overcurrent relays in power systems. The coordination problem formulated as a non-linear constrained mono-objective optimization problem. This problem is overcome by a variant of evolutionary optimization technique name differential evolution is used [16].

Protection relay plays a vital role with the operation of any power system. Overcurrent protection is one of the basic protective relaying principles and inverse time overcurrent relays is considered as the backbone of the protection strategies in distribution networks where the overcurrent relay settings are chosen to achieve coordination, guaranteeing fast, selective and reliable relay operation to isolate the power system faulted section [17]. Generally, integration of distribution generation has various impacts on distribution systems and one major challenge is its effect on the protection system including the increase of short circuit levels, changing the distribution system nature into dynamic, bidirectional power flow nature in addition to the relay coordination failure [18].

Different optimization methods, including conventional and heuristic techniques, have been applied to determine the optimum time dial and pickup current settings of the relays that guarantee coordination and minimum total relay operating times [19,20]. Other proposed protection coordination techniques used different or modified groups of relay settings and characteristics [21].

From the research provides a full understanding of principle and the knowledge about the time and current grading for inverse definite minimum time coordination relay setting. Many papers focused on the overcurrent relays, the coordination, the CAPE software and others. All the research will be used to develop their weakness or to prevent the probability from project failure.

2.3 Summary and Discussion of the Reviews.

On the chapter above, all the knowledge and the information about this project will be improved by do the research study on the journal, paper and others. From the research, it can detect and study the problem that had been arises during doing the research.

Generally, there are much knowledge on relays which knows the types of relays, the operation of relays and how to protect the relays. For this research, it more focused on inverse definite minimum time relays. For typical relays, each of these two constants has four definite values and choosing between them indicates the selected relay operating curve either standard inverse, very inverse, extremely inverse or long time standby earth fault time and current relay characteristics. The protective relay is a device that constantly monitors the condition of a particular section of the circuit of network to determine whether there is a need to open a circuit breaker to isolate any abnormality in the system. The main purpose of protective relays is to establish on most power system as a performance of protective scheme.

Next is the research paper about overcurrent relay. Overcurrent relaying, which is simple and economic used for providing primary protection in transmission, distribution and sub transmission systems. The backup relays should be avoided to reduce the power outages, mal-operation. Therefore, overcurrent relay coordination in power distribution network is a major concern of protection engineer. The back-up protection should initiate tripping, if the primary protection does not clear the fault. Each protection relay in the power system needs to be coordinated with the relays protecting the adjacent equipment, the overall protection coordination is thus very complicated.

For the knowledge, the overcurrent protection is a protective relay which responds to a rise in current flowing through the protected over a pre-determined value. Overcurrent relays are classified under code 5x (for example are 50, 51) in ANSI relay code. The main purpose of overcurrent relay are exactly is the name suggested to operate based on the overcurrent flowing into a system and prevent much scenario from taking place.

Besides, the fault had been conduct in this research is earth fault protection. An external fault in the star side will result in current flowing in the line current transformer of the affected phase and at the same time a balancing current flows in the neutral current transformer, hence the resultant current in the relay is therefore zero. Then, when a feeder fault causes the supply-side relay to trip, not only are the customers on the faulted feeder troubled with an outage, but all the customers that are being served by the other feeders from the same supply-side relay and breaker also experience an outage. Therefore discrimination must be enabled during fault conditions can be done in the following ways.

1. By monitoring only current level – current grading.
2. By monitoring time delayed operation – time grading.

2.3.1 Current Graded Protection

A simple way of acquiring selective protection is to use time grading. This is to grade the operating times of the relays in such a way that the relay nearest to the fault spot operates first. An overcurrent relays were using to apply the time-graded with either definite time characteristic or inverse time characteristic. The operating time of definite time relays does not depends on the magnitude of the fault current, while the operating time of inverse time relays is shorter, the fault current magnitude become higher.

The time-graded protection is suitable for radial networks. The principle of inverse time protection is particularly suitable for radial networks where the variations of short-circuit power due to changes in network configuration are small or where short-circuit current magnitude at the beginning and end of the feeder ranges considerably. In these cases, the operating time of the protection at high fault current magnitudes can usually speed up the use of inverse time relays in favor of definite time relays. Time grading with fuses is also easier to attain with inverse time relays.

2.3.2 Time and Current Graded Protection

Time and current-graded protection can be applied in cases where the fault current magnitudes in faults happening in front of and behind the relaying point are different. Due to the different fault current levels using inverse time relays but also multi-stage definite time relays, different operating times can be attained in either direction. In this way the asked for time grading can be provided and the operating time specifications can be achieved.

The study of the time grading toward one particular generator feeder is simple if the operating characteristic of the protection of the other generator feeders are mixed in a single operating characteristic of a so-called equivalent generator feeder. In ring and mesh networks, the selectivity of the protection can be based on directional overcurrent relays. Directional relays are required as different operating times are needed based on the location of the fault. If the fault spot is in front of the relaying point on the feeder or behind the relaying point, for example, on the incoming feeder or on the bus bar system.

The directional overcurrent relay works once the fault current exceeds the set start current and the direction of the fault current complies with the setting. Thus the selectivity of the protection is based on both time and current direction. The directional overcurrent protection can operate either according to definite time or inverse time characteristics and the above mentioned central principles of time-grading are also applicable to directional protection.

Short circuits occur in power system when equipment insulation fails due to system over voltages caused by lighting or switching surges, to insulation contamination (salt spray or pollution), or to other mechanical causes. The resulting short circuit or fault current is determined by the internal voltages of the synchronous machine and by the system impedances between the machine voltages and the fault.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Principles of the Methods Used

One of the important parts in developing and construct a project is the research methodology will end up with a good project result. Based on previous journal, for the IDMT phase and earth fault programs, the protection methods is split into three stages, failure of circuit breaker, nearest to the fault and failure of the circuit breaker at the remote end of the faulty feeder. For the first fault position, adjacent to the circuit breaker of the selected feeder, the operating times of the IDMT overcurrent relays need to calculate. For measure time and current grading for IDMT relays, its more focused on relay MK2000 which is have 2, if one is failure then the other one function as a backup.

Besides, the operation of overcurrent is based on the current magnitude of the primary and the relay operation time is inversely proportional to the current magnitude. The examples as Figure 3.1 fault I and II below.

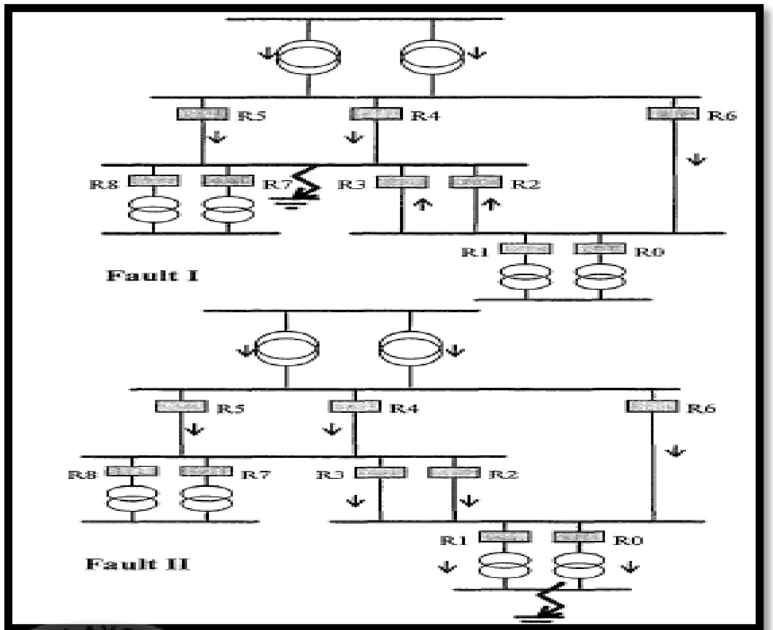

Figure 3.1: Fault I and II [9]

Considering the fault I case shown Figure 3.1, only the relays R2, R3, and R6 are need to be coordinated within each other. The time setting of R6 relays in the upstream requires to grade with time settings of the R2 and R3 in the downstream by a grading margin of 0.4s. The current in branch R6 is approximately equal to the branch (R2 or R3) left behind. For Fault II case, the relay upstream/downstream relationship are changed as in Table 3.1 must be satisfied in order to prevent unwanted operation.

Table 3.1: The relay upstream/downstream relationship

Upstream relays	Downstream relay need to be graded
R6	R0, R1
R2	R0, R1
R3	R0, R1
R4	R0, R1, R2, R3
R5	R0, R1, R2, R3

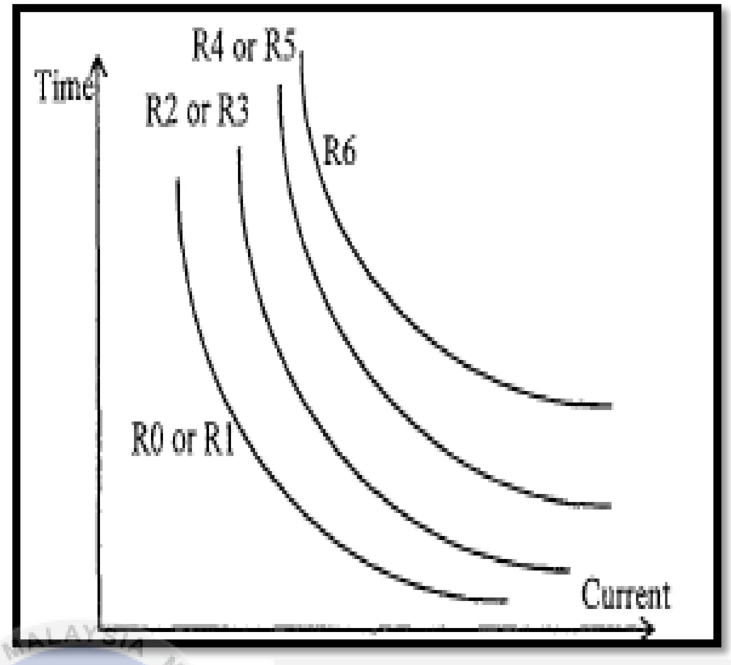

Figure 3.2: Grading graph for fault II

Refer to Table 3.1: The conventional grading graph is drawn with various relay coordination characteristics as shown in Figure 3.2. As relay setting cannot be changed automatically to cope with the system running conditions, the relay settings must be so set to cater for all possible fault cases within the coordination limit. A well-coordinated overcurrent relay system should give the shortest relay operation times with discrimination for all fault cases.

Besides, my projects are using CAPE software to complete all the value to measure. To use the CAPE software, the line diagrams need to model which state how much the substation and what type of network are used. CAPE software used to measure the value of fault current which is divided into two categories. First, asymmetrical fault is containing the single line to ground fault, line to line fault and double line to ground fault. Second, the symmetrical fault is containing only one which is three phase fault.

1) Single line to ground fault

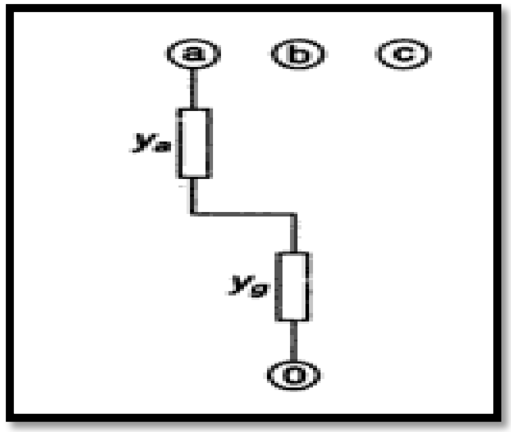

Figure 3.3 : Single- Line to ground [22]

2) Double line to ground fault

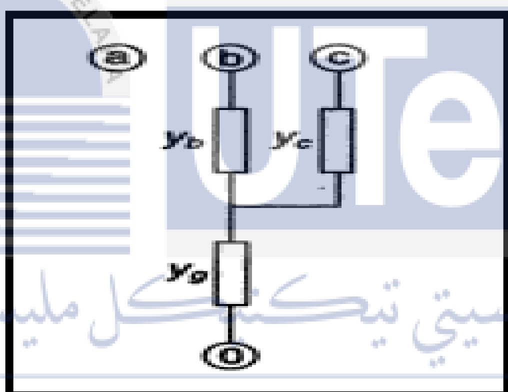

Figure 3.4 : Double line to ground fault [22]

3) Line to line fault

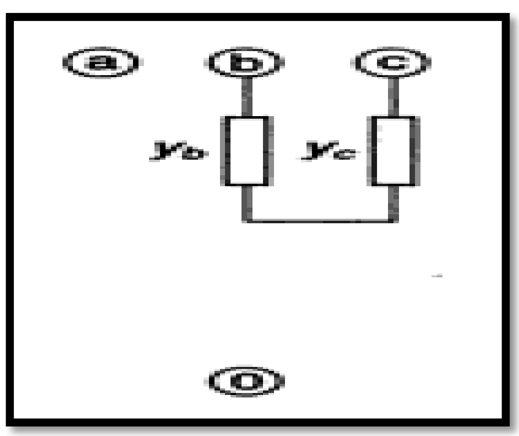

Figure 3.5: Line to line fault [22]

4) Three phase fault.

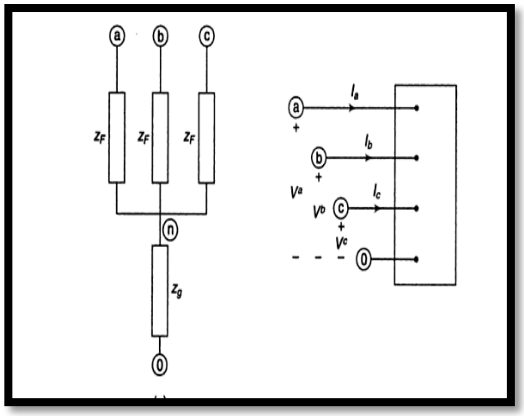

Figure 3.6 : Three phase fault [22]

To apply this entire fault into network model, the data is needed such as the value of apparent power and the power factor at each substation. The impedances for generator and transmission line is need to insert too. Besides that, by doing the simulation CAPE software it also can measure the value of power flow which is containing voltage, reactive power at each substation for branch flow and losses from substation to substation.

3.2 Discussion on the selected technique and approach used.

This part will briefly review the development of the project from beginning until the completion of the project. Based on my case study, this project conducted to develop the time and current grading for IDMT coordination relay setting. By using CAPE software, the fault current as mention already can be determined by the simulation of the software but before to run the software the parameter such as the value or reactive power, power factor, distance between substation to substation, the value of impedance for generator and transmission line, and the lastly the value of limitation.

The time grading principle requires the relay of any pair which is nearer to the power source to operate more slowly. With a definite time system, the grading increments accumulate to make the tripping time at the supply point long if several sections of grading are involved. When there is little variation if fault current throughout the feeder system, little improvement is obtained by using inverse time relays. The system is long enough to cause appreciable fault current variation throughout in length.

The alternative technique consists of adding supplementary instantaneous overcurrent elements with high settings. Such relays can, however, be added to a normal graded system and set so as to operate with close up faults but to not operate with a maximum current which may flow to a fault at the remote end of the respective section. A portion of the section will therefore be protected with high speed, while the inverse time graded system will cover the remainder of the line.

3.2.1 Secondary Current injection testing for relay tripping time characteristic.

During the trip time data collection stage, the trip testing was divided by regard to the TMS into 5 types. The minimum setting current had been chosen in the relay due to the thermal behavior of the secondary test set. The higher the setting in the relay will delay the testing progress. It is because high current generates will lead to the longer cold-time of the test set.

Then, need to limit secondary current injection to the lowest as possible with regards to the maximum „on‟ time for a continuous current and also for higher intermittent currents. Internal start contact mode is selected to obtain the appropriate trip time based on contact make after a certain amount of current trigger the relay coil.

3.2.2 Testing Procedure for Overcurrent Protection Relay

3.2.2.1 General

1. Record all particulars of relay to be tested and its working settings,
2. Change the setting to test settings where appropriate,
3. Check that auxiliary supply voltage connected to the relay corresponds to rated auxiliary voltage stated on its nameplate.

3.2.2.2 Starting Current

1. Connect output of test to R (red) phase of relay. Turn on auxiliary supply to the relay,
2. Increase the output of test set gradually until overcurrent element of R (red) phase pucks up. Record the current in the test form. Switch off the test set,
3. The appropriate connection of relay testing,
4. Ensure that control know on test set has returned to zero position. Then switch on the test set.

3.2.2.3 Timing Test

1. Connect a trip contact to timer stop terminals of the test set. A pair of voltage free contacts is preferred.
2. Switch on the test set, increase current to 1.3 times of setting current. Switch off the test set with control know remaining in the same position.
3. Switch on the test set to inject the current and start time at time same time. After trip contact has operated record the relay operating time in test form. Switch off the test set.

3.3 Description of the Work

The flow charts below shown in Figure 3.7 illustrate all the tasks to be done at each stages of the project. It important to make sure the project complete at the on time.

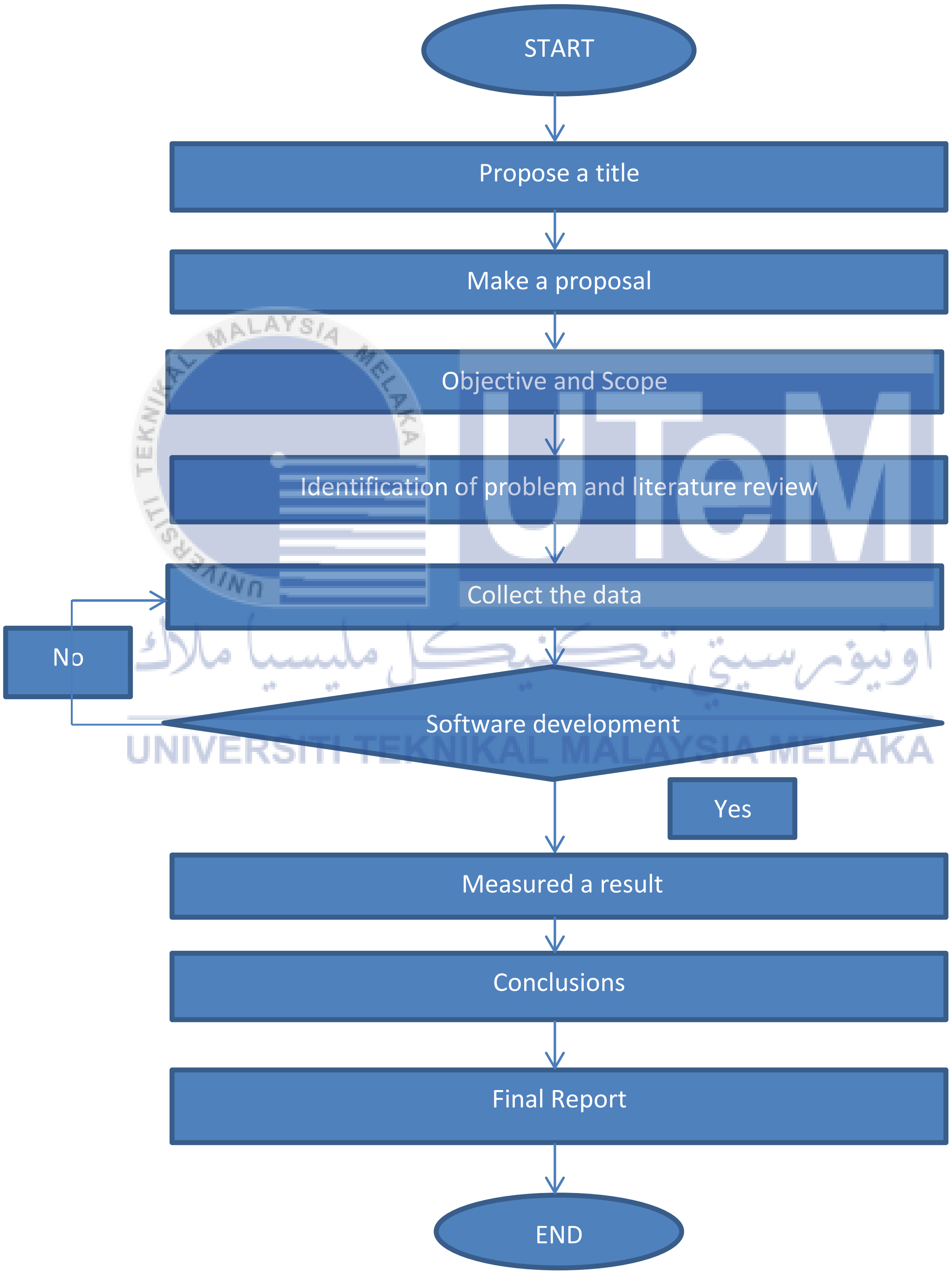

Figure 3.7: Flow Chart of methodology

3.4 Methodology Gantt chart and Key Milestones

3.4.1 Gantt Chart

Table 3.2: Table Gantt chart

Project Activities	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14
Find a project title and supervisor														
Register project title														
Research of Journal/literature														
Study of literature														
Progress report														
Submission of project														
Seminar/Presentation														
Modify of returning report														
Submission of correct report to supervisor														

3.4.2 Key Milestone

Table 3.3: Key Milestone

Project Progress	Duration
Collect all of Journal and Literature Review	September 2014
Study related calculation involved	October 2014
Study on the initial set up of Cape software	October 2014
Write Progress Report draft	October 2014
Submit report	November 2014
First seminar	November 2014
Develop the software	December 2014 – March 2015
Write a report	April 2015
Submit report	May 2015
Final seminar	May 2015

3.5 Methodology of the projects

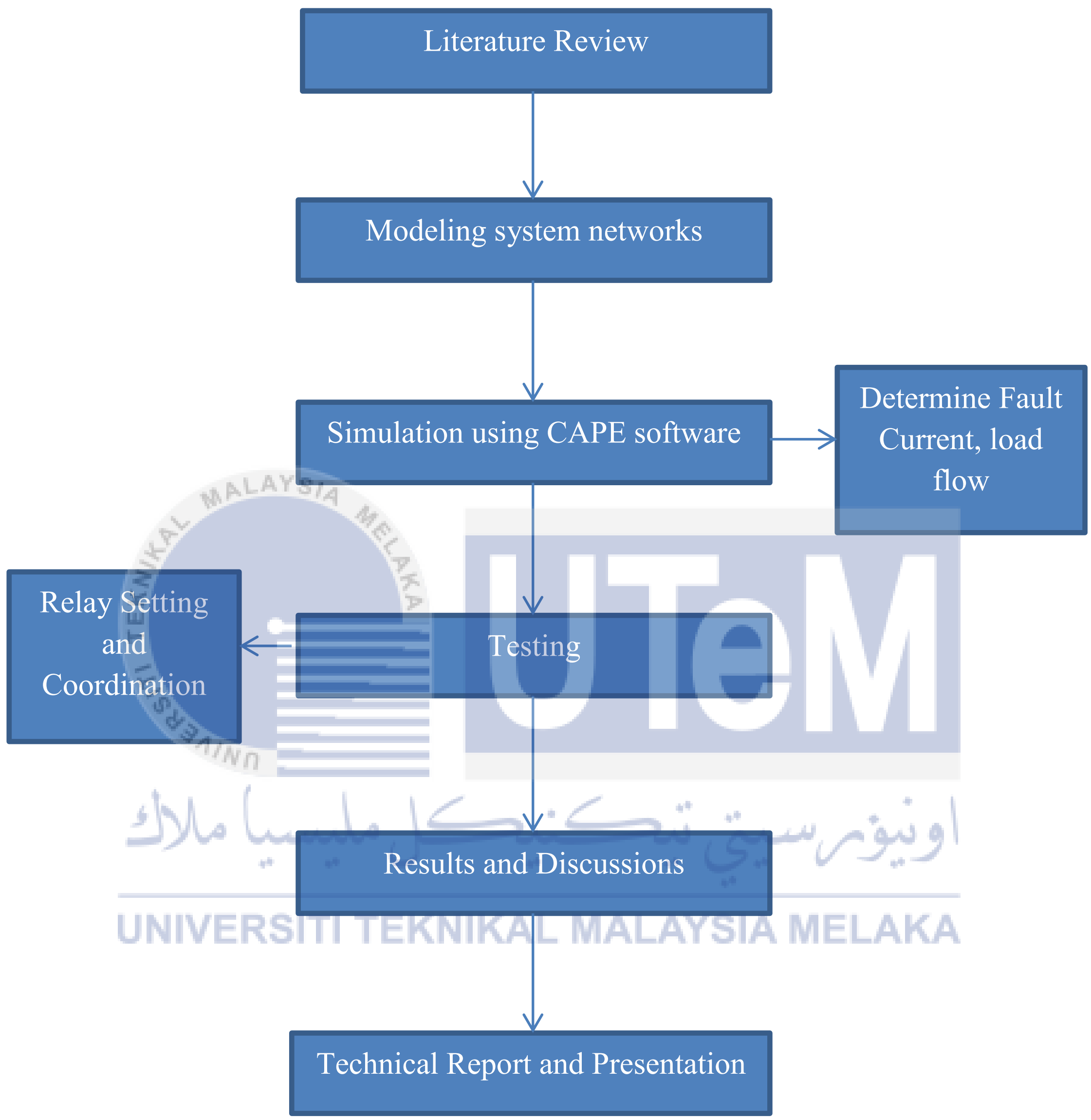

Figure 3.8: Methodology of the Projects

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, all results will be analyzed and discuss which is include faults analysis, power flow study, and relay coordination study by using the simulation method of the CAPE software. This is the standard method for design the protection system.

Results for load flow study, fault current have been done which is having two types of faults. First, balanced fault which is containing the three phase to ground fault. Second, unbalanced fault which are single line to ground fault, line to line fault and double line to single fault. To run the CAPE software, the data at each buses system is needed. By using the data, the Cape software can simulate to measure the fault current and the power flow analysis. This project is focus on 14 buses system.

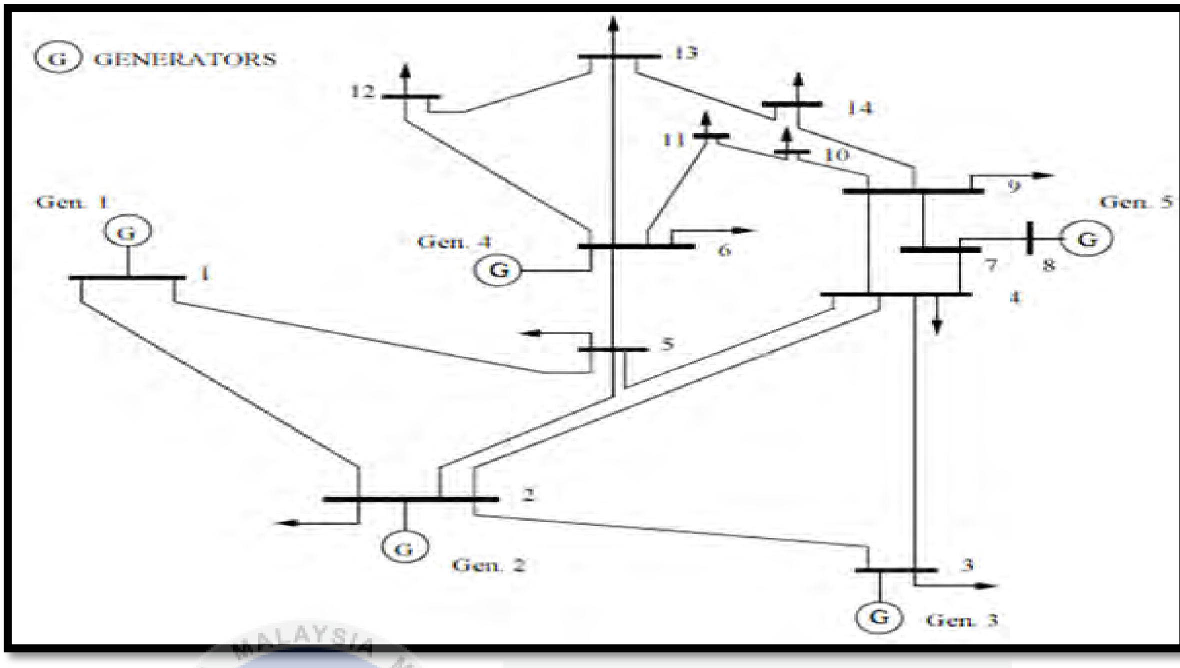

Figure 4.1: IEEE 14 bus systems.

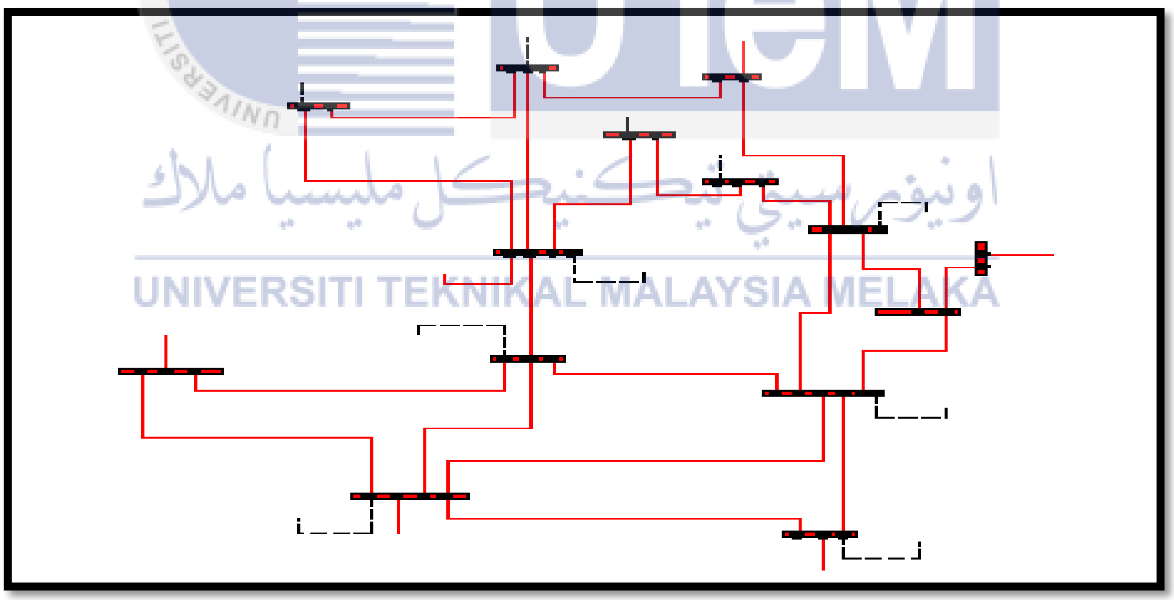

Figure 4.2: One line diagram using CAPE software

To draw this system network, all the values is needed such as value of reactive power, power factor, distance between substation, impedance for generators, and data of transmission lines. All the values are the IEEE data. The values are shown in Appendix A, B and C.

4.2 Load Flow Study

Load flow analysis is to determine the value of the real power, reactive power, power flow, voltages and currents at each bus for the system. For this project, there are load connected to the system network. The values of voltage, real power, and reactive power at each bus were measured as shown in Appendix F. This CAPE program prepares the line output data. It is designed to display the active and reactive power entering the line terminals and line losses as well as the net power at each bus. Also included are the total real and reactive losses in the system.

Load flow form an important part of power system analysis. The problem consists of determining the magnitudes and phase angle of voltages at each bus, active and reactive power flow in each line. To solve the problem, the system is assumed operating under balanced condition and single phase model. The system buses are generally classified into three types which is slack bus, load buses and regulated buses. All the result values of branch flows, line losses and the value of voltage real power, reactive power at each bus include generator and load are shown in Appendix D, E and F.

4.3 Fault Analysis

Based on the results, the value of faults are be measured by using Cape software. The types of power in system network such as balanced fault and unbalanced fault. Balanced fault impacts every of the three phases consistently. Unbalanced fault really does not impact every of the three phases consistently. Typical kinds of unbalanced faults and their own reasons:

- Single line to ground fault – a short circuit in among one line and touch to ground, frequently triggered by physical contact, as an example because of lightning.
- Line to line fault – a short circuit in between lines triggered by ionization contact, such as damaged insulator.

- Double line to ground fault – two lines contact with the ground, frequently because of storm damage.

4.3.1 Unbalanced Faults

In the unbalanced faults, all the simulation had been taken and recorded which are single line to ground faults, line to line fault and double line to ground faults. Fault analysis studies had been carried out to determine the value of the fault during abnormal condition. Table below shows all the unbalanced fault results.

4.3.1.1 Single Line to Ground Faults

Table 4.1: Results single line to ground fault.

No. of bus	Single line to ground fault(Phase A)					
	Phase A		Phase B		Phase C	
	Current(Amps)	Angle(°)	Current(Amps)	Angle(°)	Current(Amps)	Angle(°)
1	2331.71	-53.8	0	0	0	0
2	2301.49	-56.4	0	0	0	0
3	2201.32	-65.0	0	0	0	0
4	1798.16	-62.8	0	0	0	0
5	1651.89	-63.4	0	0	0	0
6	2257.30	-75.9	0	0	0	0
7	1554.40	-78.0	0	0	0	0
8	1962.73	-83.7	0	0	0	0

9	1427.29	-76.2	0	0	0	0
10	1163.67	-78.7	0	0	0	0
11	1047.99	-79.9	0	0	0	0
12	864.654	-77.9	0	0	0	0
13	1128.30	-77.4	0	0	0	0
14	859.225	-79.4	0	0	0	0

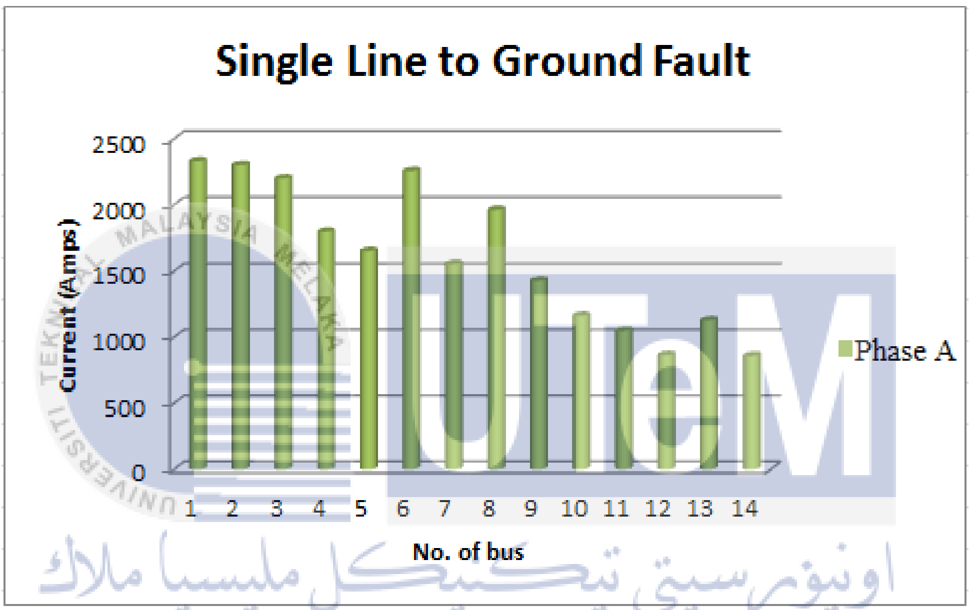

Figure 4.3: Single Line to Ground Fault.

The single to ground can occur in any of three phases whether in phase A, B or C to ground. Based on Figure 4.3, the Phase currents at Bus 1, Bus 2, Bus 3, Bus 6 and Bus 8 have higher current than others busses because at this bus only have the generator was connected. Then, the differences between buses are caused by their own load respectively.

4.3.1.2 Line to Line Fault

Table 4.2 : Result line to line fault.

No. of bus	Line to line fault(Phase B & C)					
	Phase A		Phase B		Phase C	
	Current(Amps)	Angle(°)	Current(Amps)	Angle(°)	Current(Amps)	Angle(°)
1	0	0	2221.68	-135.7	2221.68	44.3
2	0	0	2114.13	-140.0	2114.13	40.0
3	0	0	2076.31	-149.7	2076.31	30.3
4	0	0	1816.63	-144.2	1816.63	35.8
5	0	0	1930.27	-144.0	1930.27	36.0
6	0	0	2110.50	-159.0	2110.50	21.0
7	0	0	1519.49	-158.5	1519.49	21.5
8	0	0	1976.36	-168.6	1976.36	11.4
9	0	0	1452.20	-158.5	1452.20	21.5
10	0	0	1236.61	-160.7	1236.61	19.3
11	0	0	1117.85	-161.4	1117.85	18.6
12	0	0	918.530	-160.4	918.530	19.6
13	0	0	1149.19	-160.3	1149.19	19.7
14	0	0	950.164	-162.1	950.164	17.9

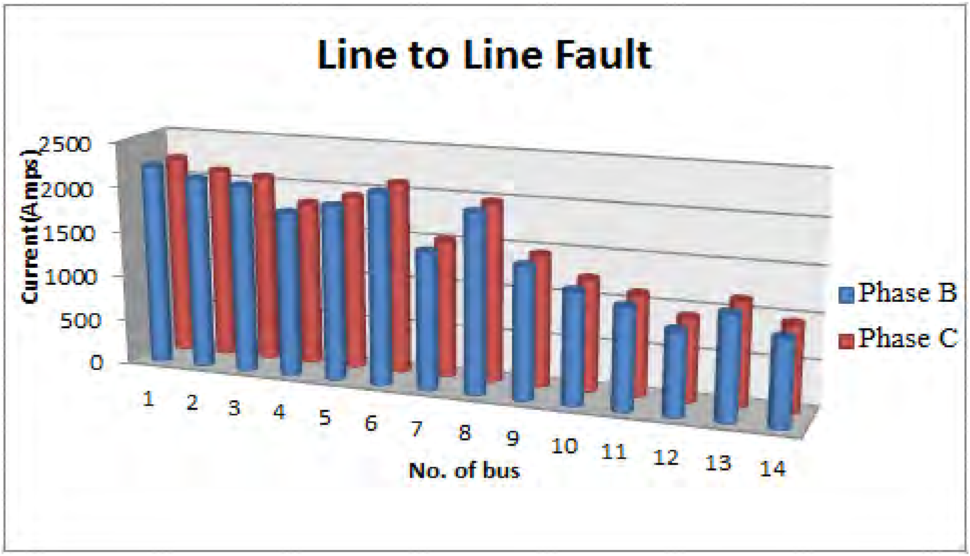

Figure 4.4 : Line to Line Faults.

Based on the result in Figure 4.4, Phase B and C are have the same current in each busses. This is because; Phase B and C connect in parallel. On the others hand, the direction between phase B and C are different because they are in different sequence. In each bus, there have no magnitude and direction in phase A. This is because, only connected between two phase.

4.3.1.3 Double Line to Ground Fault

Table 4.3 : Result double line to ground fault.

No. of bus	Double line to ground fault(Phase B & C)					
	Phase A		Phase B		Phase C	
	Current(Amps)	Angle(°)	Current(Amps)	Angle(°)	Current(Amps)	Angle(°)
1	0	0	2390.48	-169.4	2348.89	70.0
2	0	0	2442.92	-177.9	2482.24	69.4
3	0	0	2356.53	-174.8	2334.61	59.4
4	0	0	1967.05	-177.8	1957.98	61.0
5	0	0	1891.35	-176.8	1850.03	60.2
6	0	0	2108.29	-171.6	2120.62	45.1
7	0	0	1474.86	-175.1	1538.32	42.4
8	0	0	1822.02	-162.9	1983.36	36.0
9	0	0	1438.76	-177.0	1503.40	42.1
10	0	0	1218.10	-176.5	1330.36	38.6
11	0	0	1095.55	-175.9	1115.54	37.6
12	0	0	990.821	-176.8	1057.79	39.1
13	0	0	1147.48	-175.3	1140.38	40.5
14	0	0	942.589	-176.6	978.09	36.4

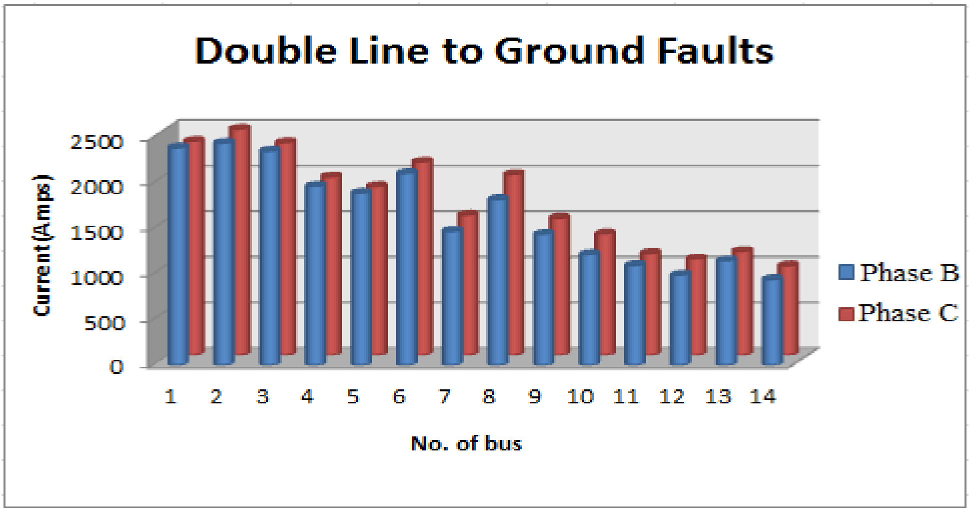

Figure 4.5 : Double Line to Ground Faults.

Based on the result in Figure 4.5, Phase B and C currents at Bus 1,2,3,6 and 8 are the highest current compared to other busses because Bus 1,2,3,6 and 8 have the generator. Then, phase currents B and C at the rest bus show a little different fault current due to their own loads. Besides that, the angle is respectively different. Other than that at phase A there is no phase current because the fault occurs at phase B and C through faults impedance to ground.

4.3.2 Balanced Faults

Table 4.4 : Result three phase to ground fault.

No. of bus	Three phase to ground fault(Phase A & B & C)					
	Phase A		Phase B		Phase C	
	Current(Amps)	Angle(°)	Current(Amps)	Angle(°)	Current(Amps)	Angle(°)
1	3110.19	-45.7	3110.19	-165.7	3110.19	74.3
2	2825.71	-50.0	2825.71	-170.0	2825.71	70.0
3	2797.30	-59.7	2797.30	-179.7	2797.30	60.3
4	2282.41	-54.2	2282.41	-174.2	2282.41	65.8
5	2228.88	-54.0	2228.88	-174.0	2228.88	66.0
6	2502.61	-69.0	2502.61	171.0	2502.61	51.0
7	1754.55	-68.5	1754.55	171.5	1754.55	51.5
8	2342.87	-78.6	2342.87	161.4	2342.87	41.4
9	1676.86	-68.5	1676.86	171.5	1676.86	51.5
10	1427.91	-70.7	1427.91	169.3	1427.91	49.3
11	1290.78	-71.4	1290.78	168.6	1290.78	48.6
12	1060.63	-70.4	1060.63	169.6	1060.63	49.6
13	1326.97	-70.3	1326.97	169.7	1326.97	49.7
14	1097.15	-72.1	1097.15	167.9	1097.15	47.9

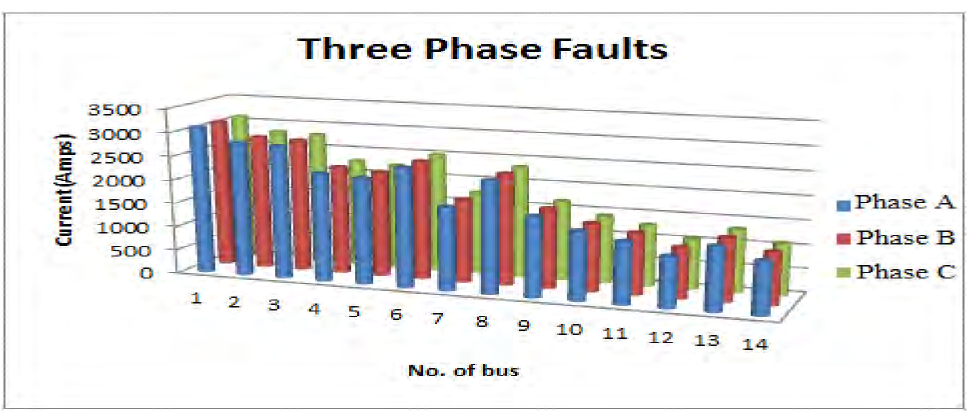

Figure 4.6 : Three Phase to Ground Faults.

Balanced fault consist only one fault which is three phase fault. The symmetrical fault or balance fault is defined as the simultaneous short circuit across all three phases. It occurs infrequently but it is the most severe type of fault encountered. This is clearly shown in the results on Bus 1 to Bus 14 have a same magnitude at phase A, B and C. According to Figure 4.6, the phase current at Bus 1,2,3,6 and 8 has the highest current compare to others buses because generator that eventually has low impedance during fault. If the value of the impedance is lower, the fault current will be higher.

4.4 Relay Setting for Overcurrent (O/C)

This relay performs overcurrent protection of the substation on the selected bus and substation via Bus 1 to Bus 5, Bus 2 to Bus 1 and Bus 5 to Bus 2. Then the selected faults which is the phase faults had been applying on the each bus at the different time. If the faults occur at bus 1, relay 1 will be operating as a primary protection, while relay 5 will operate as a backup protection. Besides, if faults occur at bus 2, relay 4 will be operating as a primary protection, while relay 6 will operate as a backup protection. Thus, the operating time for the relay to trip had been taken from the simulation of CAPE software. The formulation is shown below.

$$Plug\ Setting\ Multiple(PSM) = \frac{Fault\ Current}{CT\ ratio\ of\ primary} \tag{4.1}$$

Normal Inverse Characteristic time, (tc):

$$tc = \frac{k\beta}{PSM^{a}-1}(s) \tag{4.2}$$

$$Time\ Multiple\ Setting(TMS) = \frac{t_{operating}}{t_{characteristic}} \tag{4.3}$$

$$Time\ Delay(T_D) = t_{operating} + 0.4 \tag{4.4}$$

If fault is occurring at bus, relay 1 will works as a primary protection, so;

i. Relay 1, the operating time for the relay to trip $t_o = 0.6s$

By using the equation 4.1, the plug setting multiple for relay 1 is;

$$Plug\ Setting\ Multiple(PSM) = \frac{Fault\ Current}{CT\ ratio\ of\ primary}$$

$$= \frac{670.95A}{0.3x500}$$

$$= 4.473$$

Calculate the time characteristic by using the equation 4.2;

$$tc = \frac{0.14}{4.473^{0.02}-1}(s)$$

$$= 4.60s$$

Thus, the value of TMS can be determined by using equation 4.3, when the operating time is 0.6s;

$$Time\ Multiple\ Setting(TMS) = \frac{t_{operating}}{t_{characteristic}}$$

$$= \frac{0.6}{4.60}$$

$$= 0.13$$

For relay 1; Choose PS = 30%, TMS 0.13

Relay 5 will works as backup protection, by using the equation 4.1, the plug setting multiple for relay 5 can be calculated as shown below;

$$Plug\ Setting\ Multiple(PSM) = \frac{Fault\ Current}{CT\ ratio\ of\ primary}$$

$$= \frac{670.95}{200}$$

$$= 3.35$$

After calculate the time characteristic by using equation 4.2 above;

$$tc = \frac{0.14}{3.35^{0.02}-1}(s)$$

$$= 5.72s$$

Thus, the value of TMS can be determined by using equation 4.3, when the time delay between relay is $T_D = 0.6s + 0.4s$;

$$TMS = \frac{T_D}{t}$$

$$= \frac{0.6+0.4}{5.72}$$

$$= 0.17$$

For Relay 5; Choose PS= 100%, TMS= 0.17

ii. Relay 2, the operating time for the relay to trip $t_o = 0.9s$

By using the equation 4.1, the plug setting multiple for relay 1 is;

$$Plug\ Setting\ Multiple(PSM) = \frac{Fault\ Current}{CT\ ratio\ of\ primary}$$

$$= \frac{455.74A}{0.2x500}$$

$$= 4.6$$

Calculate the time characteristic by using the equation 4.2;

$$tc = \frac{0.14}{4.6^{0.02}-1}(s)$$

$$= 4.5s$$

Thus, the value of TMS can be determined by using equation 4.3, when the operating time is 0.9s;

$$Time\ Multiple\ Setting(TMS) = \frac{t_{operating}}{t_{characteristic}}$$

$$= \frac{0.9}{4.5}$$

$$= 0.2$$

For relay 2; Choose PS = 20%, TMS 0.2

Relay 3 will works as backup protection, by using the equation 4.1, the plug setting multiple for relay 3 can be calculated as shown below;

$$Plug\ Setting\ Multiple(PSM) = \frac{Fault\ Current}{CT\ ratio\ of\ primary}$$

$$= \frac{455.74}{200}$$

$$= 2.28$$

After calculate the time characteristic by using equation 4.2 above;

$$tc = \frac{0.14}{2.28^{0.02}-1}(s)$$

$$= 8.42s$$

Thus, the value of TMS can be determined by using equation 4.3, when the time delay between relay is $T_D = 0.9s + 0.4s;$

$$TMS = \frac{T_D}{t}$$

$$= \frac{0.9+0.4}{8.42}$$

$$= 0.15$$

For Relay 3; Choose PS= 100%, TMS= 0.15

iii. Relay 6, the operating time for the relay to trip $t_o = 1.03s$

By using the equation 4.1, the plug setting multiple for relay 1 is;

$$Plug\ Setting\ Multiple(PSM) = \frac{Fault\ Current}{CT\ ratio\ of\ primary}$$

$$= \frac{430.93A}{0.3x200}$$

$$= 7.18$$

Calculate the time characteristic by using the equation 4.2;

$$tc = \frac{0.14}{7.18^{0.02}-1}(s)$$

$$= 3.48s$$

Thus, the value of TMS can be determined by using equation 4.3, when the operating time is 1.03s;

$$Time\ Multiple\ Setting(TMS) = \frac{t_{operating}}{t_{characteristic}}$$

$$= \frac{1.03}{3.48}$$

$$= 0.3$$

For relay 6; Choose PS = 30%, TMS= 0.3

Relay 4 will works as backup protection, by using the equation 4.1, the plug setting multiple for relay 4 can be calculated as shown below;

$$Plug\ Setting\ Multiple(PSM) = \frac{Fault\ Current}{CT\ ratio\ of\ primary}$$

$$= \frac{430.93}{200}$$

$$= 2.15$$

After calculate the time characteristic by using equation 4.2 above;

$$tc = \frac{0.14}{2.15^{0.02} - 1}(s)$$

$$= 9.07s$$

Thus, the value of TMS can be determined by using equation 4.3, when the time delay between relay is $T_D = 1.03s + 0.4s$;

$$TMS = \frac{T_D}{t}$$

$$= \frac{1.03 + 0.4}{9.07}$$

$$= 0.15$$

For Relay 6; Choose PS= 100%, TMS= 0.15

Relay setting is making to analysis the curve characteristic of the selective relay. Relay will be tested for study the operating time and pick up current of the relay. For setting the Plug Setting (PS), the current flow to the primary current can be set as the designed current. While the Time Multiple Setting (TMS) of the relay it can determine the operating time of the relay when the relay will be operated.

4.5 Relay Coordination

For the relay coordination, the area had been choosing shown in figure below. The simulation result on the CAPE software has been taken when faults occur at bus 1, bus 2 and bus 5.

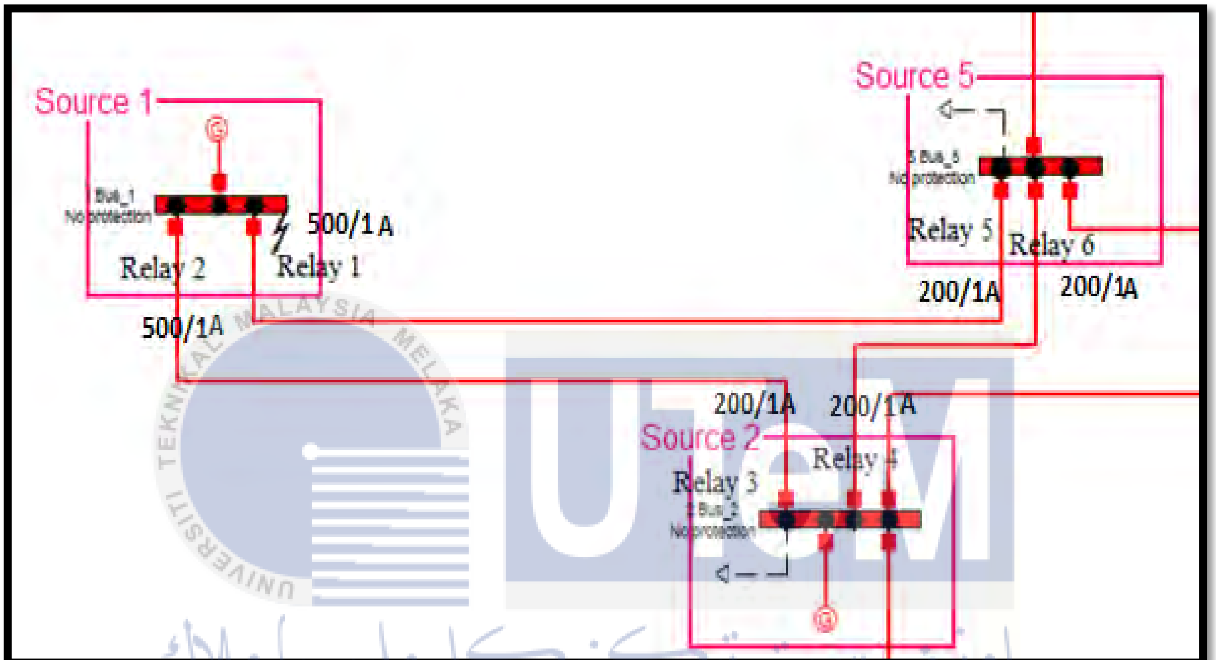

Figure 4.7 : Selected areas for relay coordination.

<u>Applying three phase to ground fault at substation 1 (Relay 1 to Relay 5)</u>

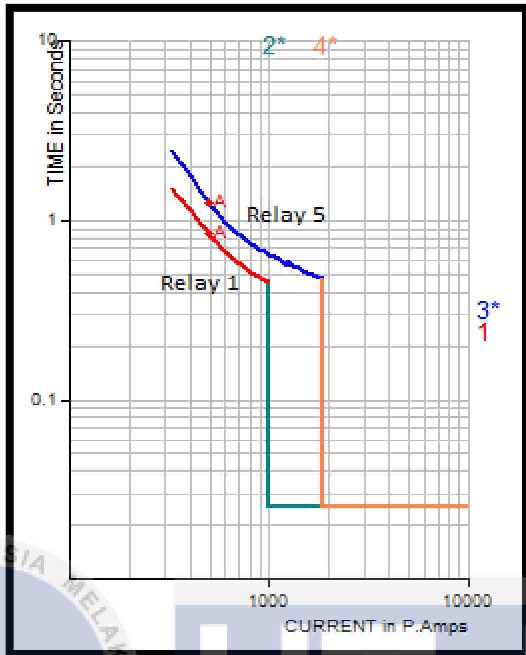

Figure 4.8: Coordination Relay by using the simulation.

Table 4.5: Coordination Relay.

Relay	Operation for relay when three phase fault occur			
	Fault current (Amps)	Toperating (s)	Plug Setting (%)	TMS
1	670.95	0.6	30	0.13
5	670.95	1.002	100	0.17

Refer to figure 4.8 above, which is the coordination between two relay simulation results. This simulation is simulating with two relay at Substation_1 and Substation_5 which is relay 1 and relay 5. The faulty occur at Substation_1. Then, the relay 1 is set at 0.13 as a time multiple setting (TMS) and 0.3 of plug setting. While for relay 5 the time multiple setting (TMS) is 0.2 and the plug setting (PS) is at 1 percent. The operating time for relay 1 is 0.6s, while for relay 5 are 1.002s. The time delay (T_D) between two relay is based on the IEC standard which is 0.4s.

Applying three phase to ground fault at substation 2 (Relay 2 to Relay 3)

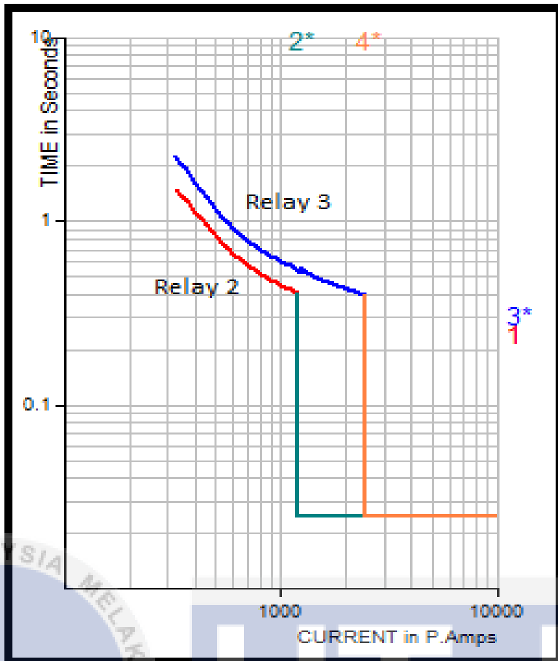

Figure 4.9: Coordination Relay by using the simulation.

Table 4.6: Coordination Relay.

Relay	Operation for relay when three phase fault occur			
	Fault current (Amps)	Toperating (s)	Plug Setting (%)	TMS
2	455.74	0.948	20	0.2
3	455.74	1.350	100	0.15

Refer to figure 4.9 above, which is the coordination between two relay simulation results. This simulation is simulating with two relay at Substation_1 and Substation_2 which is relay 2 and relay 3. The faulty occur at Substation_2. Then, the relay 2 is set at 0.2 as a time multiple setting (TMS) and 0.2 of plug setting. While for relay 3 the time multiple setting (TMS) is 0.2 and the plug setting (PS) is at 1 percent. The operating time for relay 2 is 0.95s, while for relay 5 are 1.350s. The time delay (T_D) between two relay is based on the IEC standard which is 0.4s.

<u>Applying three phase to ground fault at substation 5 (Relay 6 to Relay 4)</u>

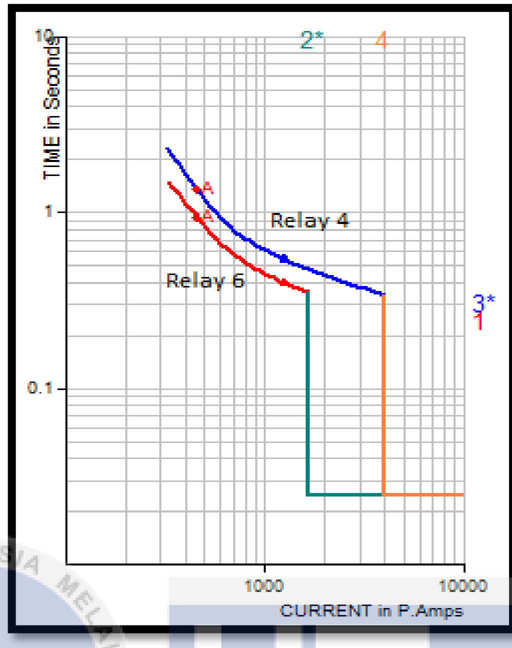

Figure 4.10: Coordination Relay by using the simulation.

Table 4.7: Coordination Relay.

Relay	Operation for relay when three phase fault occur			
	Fault current (Amps)	Toperating (s)	Plug Setting (%)	TMS
6	430.93	1.027	30	0.3
4	430.93	1.463	100	0.15

Refer to figure 4.10 above, which is the coordination between two relay simulation results. This simulation is simulating with two relay at Substation_5 and Substation_2 which is relay 6 and relay 4. The faulty occur at Substation_5. Then, the relay 6 is set at 0.3 as a time multiple setting (TMS) and 0.3 of plug setting. While for relay 6 the time multiple setting (TMS) is 0.15 and the plug setting (PS) is at 1 percent. The operating time for relay 6 is 1.027s, while for relay 4 are 1.463s. The time delay (T_D) between two relay is based on the IEC standard which is 0.4s.

All figure above shown the coordination relays by using the CAPE simulation software. Only normal inverse characteristics are used for all relay in this study. Among the various possible methods used to achieve correct relay coordination are those using either time or overcurrent, or a combination of both. The common aim of all three methods is given to correct discrimination. Each one must isolate only the faulty section of the power system network, leaving the rest of the system undisturbed.

CHAPTER 5

CONCLUSION

5.1 Conclusion

As the conclusion, this project "Time and Current Grading for IDMT Coordination Relay Setting" has been achieved in analyzed the fault analysis, load flow and relay coordination at power system network by simulation using CAPE software. In analyzing the load flow system, it can determine the value of voltage, real power, reactive power at each bus, value of the branch flow and value of line losses. For fault analysis, the value of balanced and unbalanced fault can be determined during the simulation of CAPE software. Besides, is it also successfully in developing the proper technique for over current and earth fault by using the IDMT relay. In setting the proper relay, the calculation method has been done in find out the operating time, time multiple setting (TMS), plug setting (PS) for the relay.

5.2 Limitation of the Project

For each project, there had the own limitation on making of the projects. One if the limitations of this project were to grade the time and current setting for IDMT MK 2000 relay. This relay only protects for over current and earth fault current that is occur at any location of the system network. It is used to isolate the fault and minimizing the damage cause by the fault.

Other than that, another limitation of this project is the relay characteristic curve. For this project, only use the standard inverse or normal inverse characteristic for IDMT relay.

5.3 Recommendation

In the recommendation, one of the suggestion is to analyze a single line diagram on the others types of systems network. This is because, for this project it is only covered for radial system network. So, it will bring a different method to setting and coordination the relay on the others network situation.

Besides, the relay could be test with the other characteristic curve such as extreme inverse, long inverse and very inverse. By using a different characteristic of relay, it can be investigate the operating time and relay performance. This project can be proceeding to a different scheme protection such as current differential protection or distance protection.

ACKNOWLEDGEMENT

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Besides, I would like take this responsibility to say thanks to my family for supporting me and also my friends for giving me the idea.

Thank you.

ABSTRACT

Protections are viral due to the safety. It is the main aspects due to safety matters in the network systems. In fact, the maximum percentage fault occurs in the reality life is more due to unbalanced fault compare to balanced fault. In transmission line faults, roughly 5% are balanced fault. This is in contrast to an unbalanced fault, where the three phases are not affected equally. Lack of coordination in the relay setting might lead to inherent tripping in the system. The impact will reduce the system efficiency and might be cause danger to the consumers. This problem can be solved by proposing the proper relay setting technique by coordination the value of current and time in particular system. Relay that used in this project is inverse definite minimum time relay (IDMT) and it is have a widely application in distribution system. On the other hand, this study will use Computer Aided Protection Engineering (CAPE) software to analyze the selected area to determine the performance of the network system. As a result, the values of the simulation which is the fault and the relay coordination will be recorded. The result from the CAPE software is more accurate in term of power flow, fault analysis and relay coordination. As a conclusion, the CAPE can be used to analyze the values of power, fault analysis and relay coordination. Then, the impact of the relay setting will be avoided miscommunication, tripping happen to the network.

ABSTRAK

Perlindungan adalah perkaitan kepada keselamatan. Ia adalah aspek utama kepada hal-hal keselamatan dalam sistem rangkaian. Malah, peratusan kerosakan maksimum berlaku dalam kehidupan realitinya adalah lebih disebabkan oleh kesalahan yang tidak seimbang berbanding dengan kesalahan yang seimbang. Dalam kerosakan talian penghantaran, kira-kira 5% adalah salah seimbang. Ini berbeza dengan suatu kesalahan yang tidak seimbang, di mana ketiga-tiga fasa tidak terjejas sama. Kekurangan penyelarasan dalam suasana geganti mungkin menyebabkan tersandung wujud dalam sistem. Kesan ini akan mengurangkan kecekapan sistem dan mungkin menyebabkan bahaya kepada pengguna. Masalah ini boleh diselesaikan dengan mencadangkan teknik penetapan geganti yang betul dengan penyelarasan nilai dan waktu semasa dalam sistem tertentu. Relay yang digunakan dalam projek ini adalah songsang yang pasti masa geganti minimum (IDMT) dan ia mempunyai aplikasi secara meluas dalam sistem pengagihan. Sebaliknya, kajian ini akan menggunakan Berbantukan Komputer Kejuruteraan Perlindungan (CAPE) perisian untuk menganalisis kawasan yang dipilih untuk menentukan prestasi sistem rangkaian. Akibatnya, nilai-nilai simulasi yang bersalah dan penyelarasan geganti akan direkodkan. Hasil daripada perisian CAPE adalah lebih tepat dari segi aliran kuasa, analisis kesalahan dan penyelarasan geganti. Kesimpulannya, yang CAPE boleh digunakan untuk menganalisis nilai-nilai kuasa, analisis kesalahan dan penyelarasan geganti. Kemudian itu, kesan penetapan geganti akan dielakkan, tersandung berlaku kepada rangkaian.