A STUDY TO AVOID TOTAL BLACKOUT IN UTP WHENEVER GDC SUPPLY IS PARALLEL WITH TNB

by

NUR SYAZWANI BT ABDUL SAMAT

DISSERTATION

Submitted to the Electrical & Electronics Engineering Programme

in Partial Fulfilment of the Requirements

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Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

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BACHELOR OF ENGINEERING (Hons)

(ELECTRICAL & ELECTRONICS ENGINEERING)

Approved by,

____

(**IR MOHD FARIS BIN ABDULLAH)**

Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JUNE 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Nur Syazwani Bt Abdul Samat

ABSTRACT

This report summarizes the documentation of information on the research of my final year project entitle “A study to avoid total blackout whenever GDC is parallel with TNB”. The purpose of the project is to study and recommend solution to avoid the case of total blackout in UTP whenever fault occurs at TNB side. UTP maximum demand (MD) is 5.9MW and supplied via 2x4.2MW generators from GDC. Whenever one generator is on outage due to tripping or maintenance, TNB supply is connected in parallel with the in-service generator to meet UTP load demand. If any fault occurs at TNB side at the time, it will result the tripping of TNB-GDC interconnected feeder hence causing total blackout in UTP. In order to come out with the solution, the author will need to study about the protection system with good understanding of the network system. This project will need the author to used critical thinking to analyze simulation that had been done using DigSILENT Power Factory 13.2 software to show the result of the research. This report is includes technical explainations on the system, project activities along with simulation result and analysis towards the completion of this project. Hopefully, all those information is useful towards better network reliability in future.

ACKNOWLEDGEMENTS

Final Year Project has been such a challenging yet satisfying experience for me as the author of the project. Firstly, I am grateful for ALLAH S.W.T as giving me the strength and opportunity to complete my final year project. I would like to show my appreciation to the project supervisor, Ir. Mohd Faris Abdullah for helping me throughout this one year by giving guidance, ideas and motivation. His helpful guidance with tenacious supervision, also patience to make me understand deserve a special mention. Without his expertise as professional engineer, I can never complete the project. I also would like to express gratitude to my colleagues who had helped me giving ideas and support me in completing this project. Special thanks to the FYP committee that help to give guideline in order to complete the project. Not to forget, all the lab technicians that had assist in technical practical expertise. Since this project involves GDC, I would like to mention my deep appreciation towards all the staff from the organization that helps me to collect relevant data in my project. Not to forget, Ir. Fatimie Irzaq and UTP Maintenance Department that give support to me by providing data to complete the network setting for simulation. Last but not least, prayer from my dearest parent helps me a lot to keep focus and can cope with the challenge in completing this project.

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ABBREVIATIONS

UTP	Universiti Teknologi PETRONAS
GDC	Gas District Cooling
TNB	Tenaga Nasional Berhad
SIKD	Seri Iskandar
MIS/PMU	Main Intake Substation
UFLS	Under frequency load shedding
UVLS	Under voltage load shedding
MD	Maximum Demand
GTG	Gas Turbine Generator
PLC	Programmable Logic Controller
IDMT	Inverse Definite Minimum Time
OCEF	Over Current Earth Fault
PS	Plug Setting

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Electricity supplied to Universiti Teknologi PETRONAS (UTP) comes from the Gas District Cooling (GDC) power plant, located beside the university itself. UTP's electricity maximum demand (MD) is currently 5.9MW and is supplied from 2 x 4.2MW generators from GDC. In order to ensure high security and reliability of the supply, UTP's distribution network is connected to Tenaga Nasional Berhad (TNB) source from Seri Iskandar Main Intake Substation (SIKD) at 11kV with 'hot standby' mode of operation. Figure 1 below is an overview of the entire system.

Figure 1: System Overview

TNB supply will normally be connected in parallel with GDC when the following occurs:

1. UTP load demands exceed the GDC generation at any particular time

2. UTP hosts important function. Figure 2 shows an example of an important event recently hosted by UTP.

Figure 2: Important function at UTP attend by Chancellor

1.2 Problem Statement

Whenever one of the gas turbine generators (GTG) is on outage due to tripping or maintenance, TNB supply is needed to support the UTP load.

TNB supply is needed to support the UTP load whenever any one of the GDC’s gas turbine generators suffers outage due to tripping or is under maintenance. However, the drawback of this procedure is that, if there is any fault occurring on the TNB side in PMU Sri Iskandar, TNB-GDC interconnected feeder will be tripped and causes blackout to the affected area.

The project focuses on the study of ways to avoid total blackout when the situation as above occurs and come out with recommendations to improve the system in order to avoid repetitive cases in the future.

1.3 Objectives

The objective of this project is to study and recommend solutions to avoid the case of total blackout in UTP whenever faults occur at TNB side. It is hoped that appropriate solutions can be provided to overcome the blackout issue if the main reason for the blackout to occur is known.

1.4 Scope of study

The scopes of study for this project covers:-

- The development of the understanding GDC network system. This includes the parallel and island mode of operation process and distribution of electricity to its client as well as its protection system.

- Distribution protection guideline study and exposure

- Analyzing the data of GDC such as the fault, relay and time taken before the system (breaker) react to the problem.

- Familiarize with DigSILENT 13.2 Power Factory software to do the simulation of the network system

- Studying the concept of load shedding scheme to be implemented in the project

- Understanding and learning basic Programmable Logic Controller in order to show the complete ladder diagram for the load shedding scheme.

1.5 Relevancy of the project

The project holds an importance to both the author and those involved in the project. It is hoped that through this project, UTP-GDC and any other power distributor who uses the same network topology would take into consideration the few recommendations that has been developed to further enhance their plant's capabilities as well as find the appropriate methods to solve the blackout issue and other similar problem such as power shortage. The author hoped that the system developed using the DigSILENT software could be useful for the analysis of the network system.

In order to complete the project, the author had gained knowledge to develop a complete power distribution network simulation system especially to simulate on possible ways for blackout to occur using DigSILENT. The knowledge gained throughout the project would be useful and applicable in real working environment.

1.6 Feasibility of project

The project aims to be completed within the specific timeframe (approximately 1 year) and is designed towards the improvement of UTP-GDC and TNB's power distribution network. Starting the project from zero, the author manages to get along with the project development steps by steps to the end. Sometimes it seems not enough time to complete the project but somehow the objective of the project is achieved.

CHAPTER 2

LITERATURE REVIEW

2.1 Network System Study

In an electrical distribution network, the element of the network consists of generator, busbar, transformer, switchgear and others. Each of these element have it owns function to ensure that the network is working and can supply electricity to consumer. In this project, the author had study the behavior of GDC- MIS UTP and MIS UTP-TNB network that lead to the total blackout.

2.2.1 Sequence of Event Leading To Total Blackout At UTP

Under normal island mode of operation, both UTP Generators is supplying UTP load. In this situation, the breaker K06 and K09 are in open position. This can be observed at Figure 3.

STAGE I

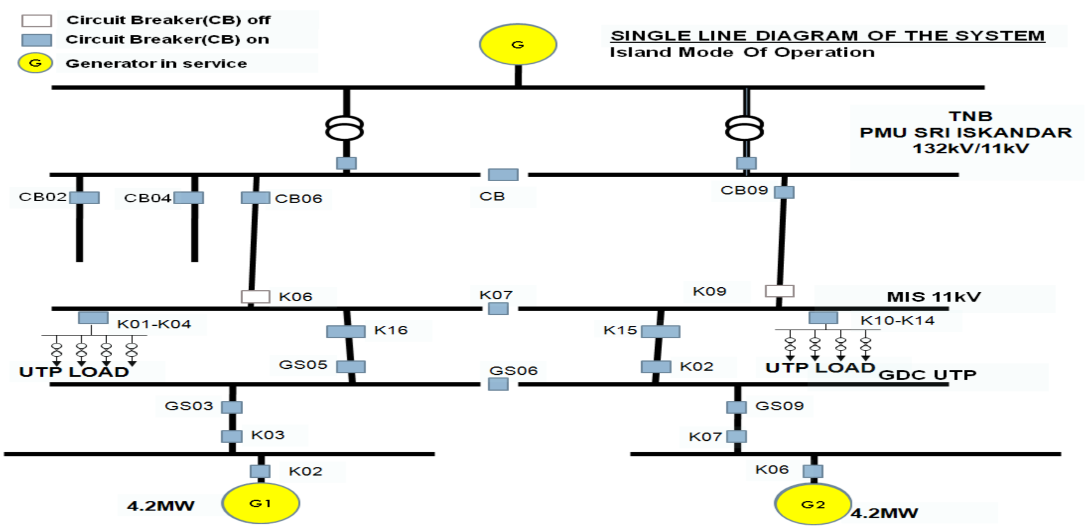


Figure 3: Island Mode of Operation

In Figure 4, under parallel mode of operation, both generators are in service. The breaker K06 will normally close while K09 has to be open. If feeder CB06-K06 is not available due to faulty cable or others then K09 will be used to parallel with TNB network.

STAGE 2

Part a

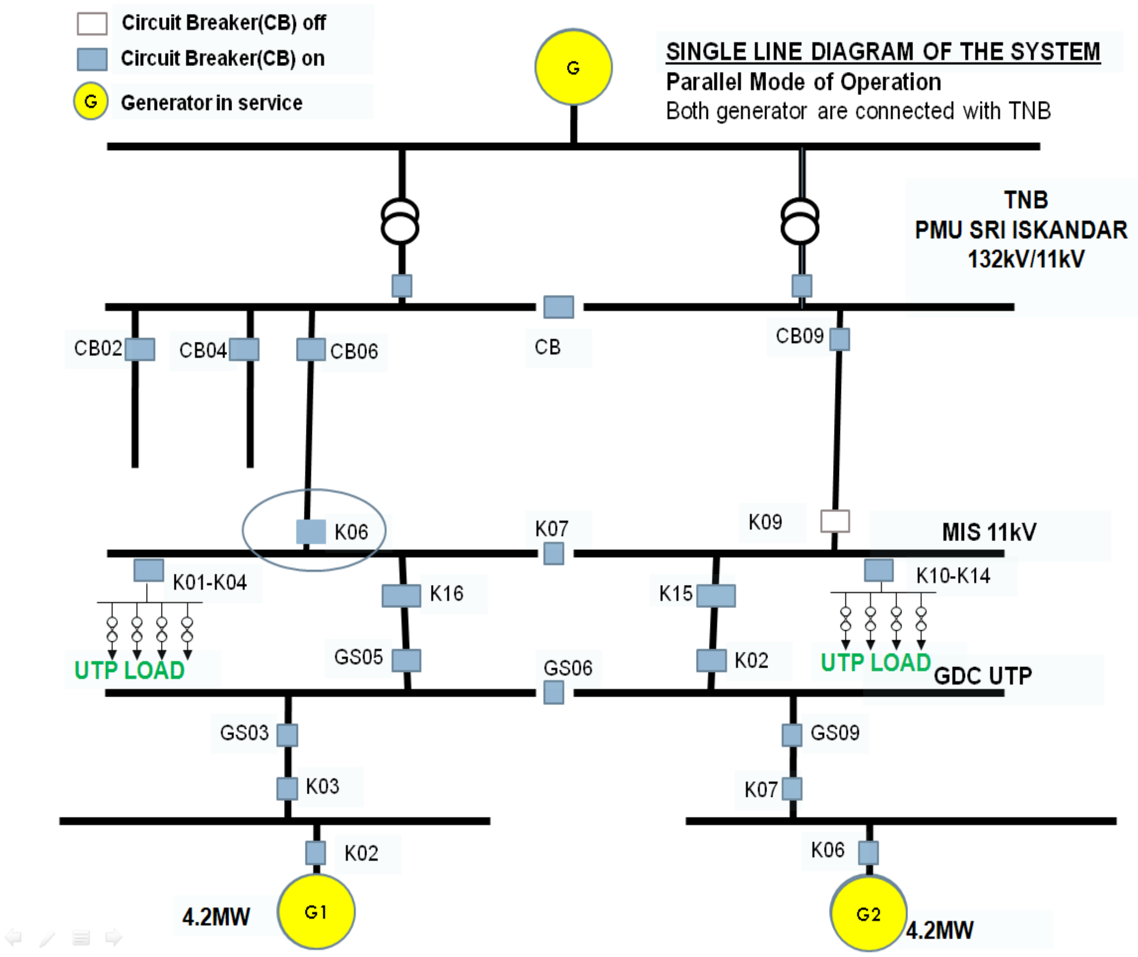


Figure 4: Parallel Mode of Operation

Figure 5 shows the single line diagram shows that the system is still in the parallel mode of operation where only one generator available with K06 connected in parallel with TNB.

STAGE 2

Part b

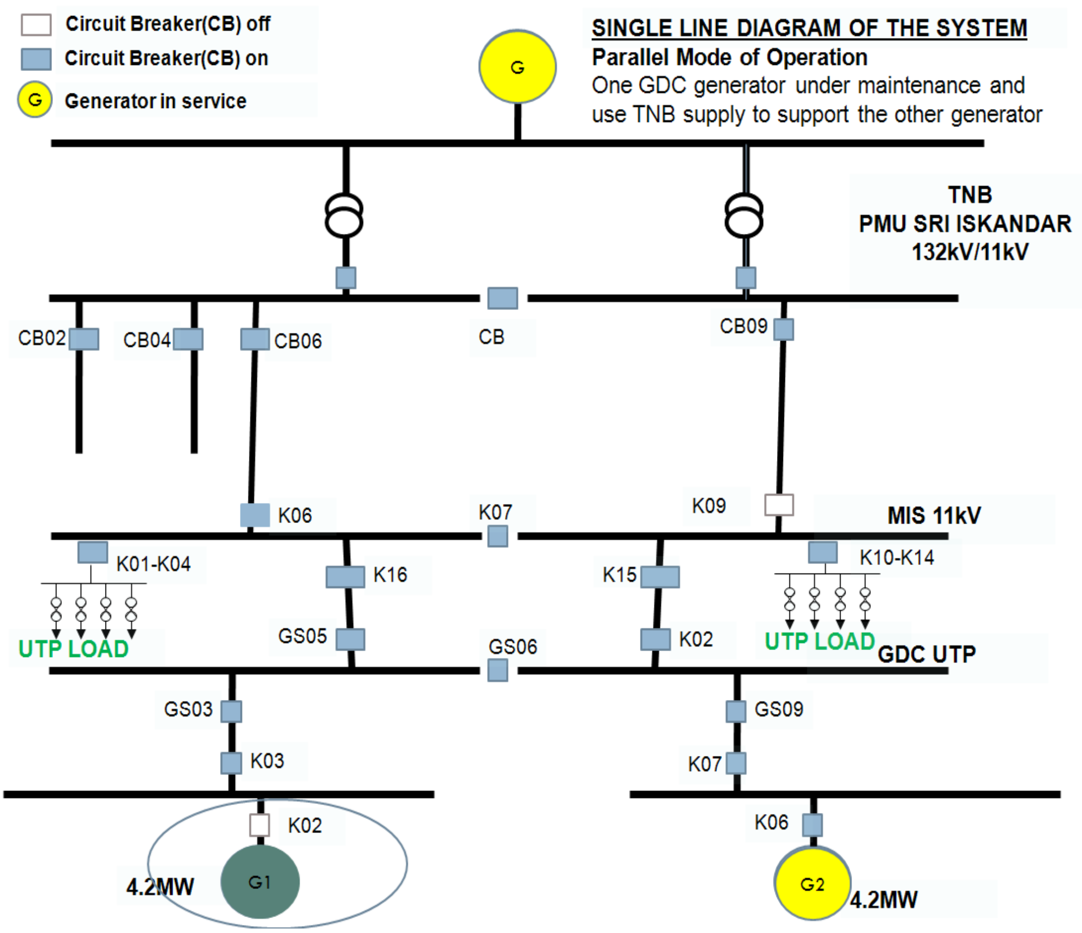


Figure 5: Parallel Mode- one generator in service

At Figure 6, the single line diagram shows that the network is in parallel mode of operation. Fault has occurred at the CB02 of the TNB feeder.

STAGE 3

Part a

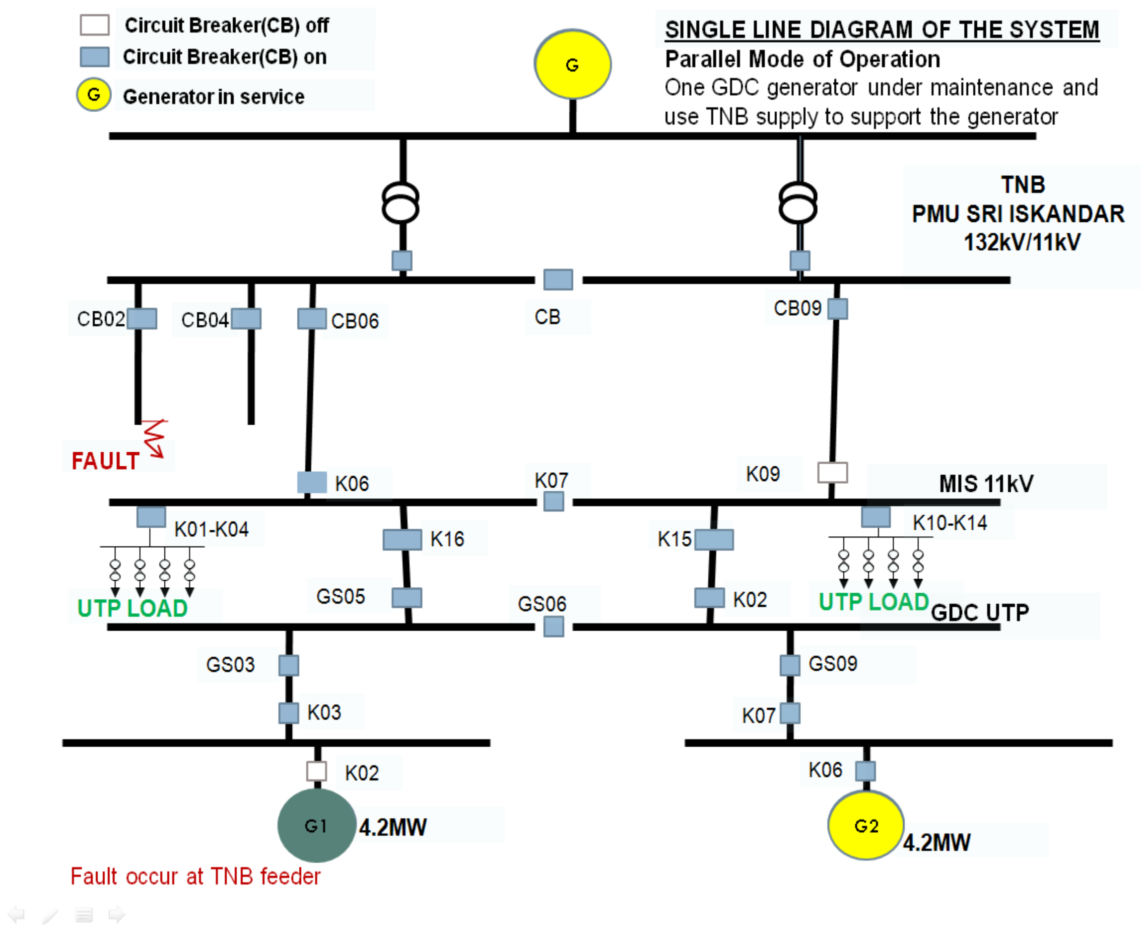


Figure 6: Fault occur at TNB feeder

PMU SIKD also gives supply to other customer around that area. Whenever fault occurs at TNB feeder, in this case we decide it CB02, the GTG of generator 2 will also feed the fault as being shown at Figure 7

STAGE 3

Part b

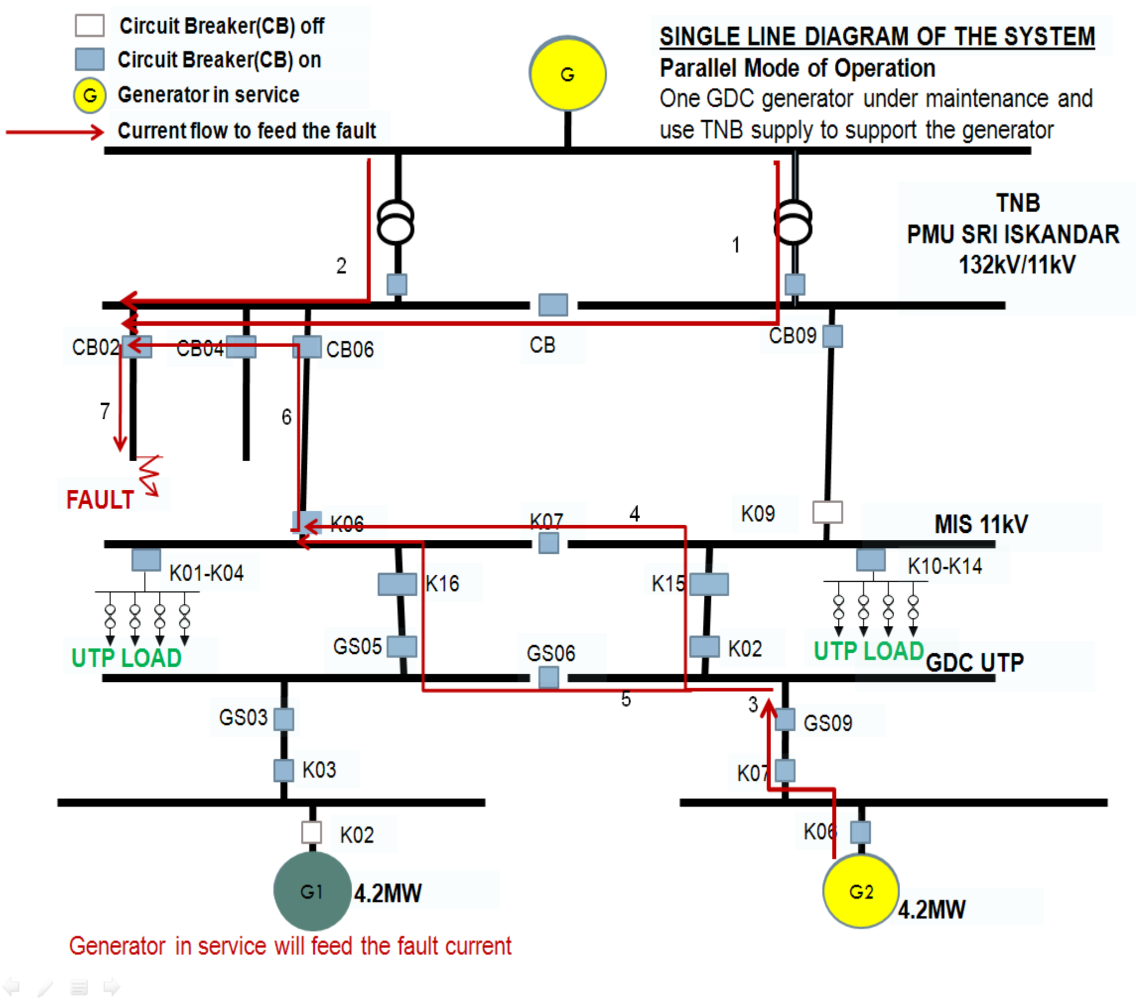


Figure 7: Generator Feed the Fault

Figure 8 shows breaker K06 will open because its directional relay has a lower setting to protect the generator from feeding the fault. Later, the Generator G2 will trip because it could not support the whole UTP load hence TOTAL BLACKOUT occurs.

STAGE 4

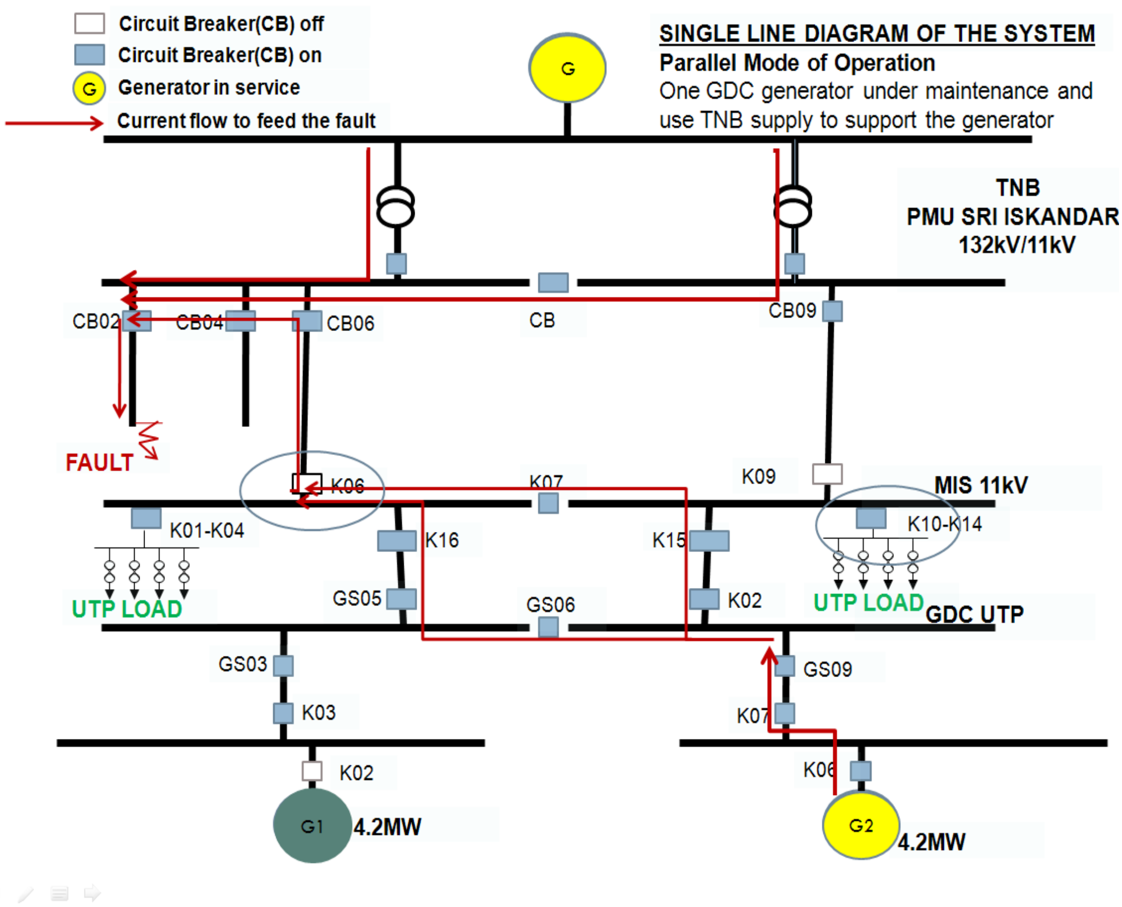


Figure 8: Event of Total Blackout

Therefore, the network always need good protection scheme to ensure the reliability of the system. There are important elements that are useful as basic protection scheme and will be explain later. These elements are needed to avoid system breakdown and outage to the specific areas.

2.2 Relay

The standard protective system consists of the basic component such as sensing device, relay and circuit breaker. The connection is as shown in figure 9 below.

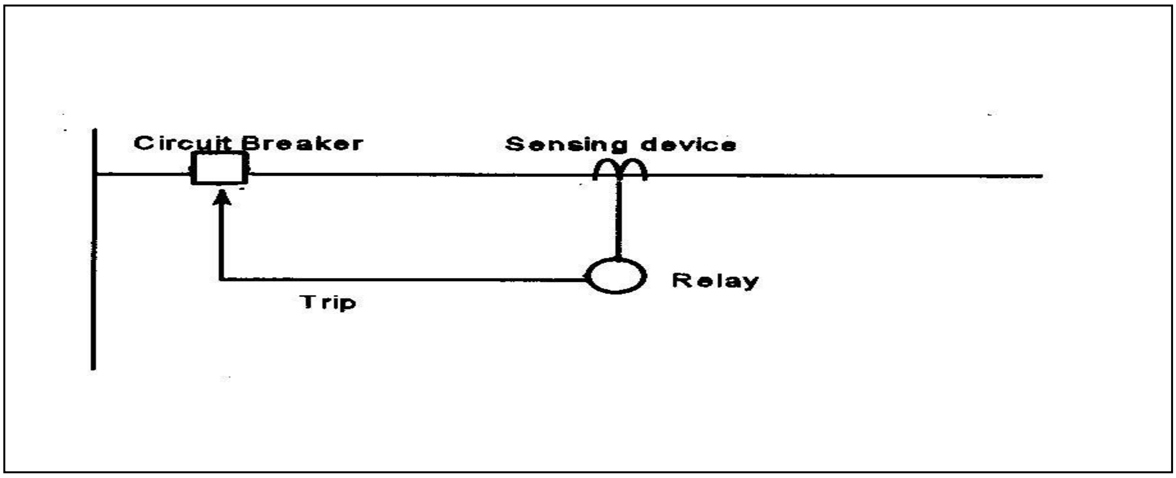


Figure 9: Protection requirement

There are five protection criteria to be fulfilled to ensure good protection. This includes selectivity, sensitivity, stability, fast reaction, and reliability [4]. All these criteria will be included when doing analysis to the system later.

The supply security of a distribution system network defines the availability of power supply to consumer according to the restoration time. There are 4 level of supply security which are level 1-4 [3].

For Level 1, restoration time is less than 5 seconds, the distributor must use at least two feeders that operate in parallel [4]. Since GDC-TNB has a parallel connection, this would be one possible concept that can be used to avoid blackout

2.2.1 Operation of relay

Relay is one of the basic components of the distribution protection. It acts as the decision maker of the network system as it 'instructs' the system to trip or not in the event of system failure. Relay will help the network to be separated from the fault.

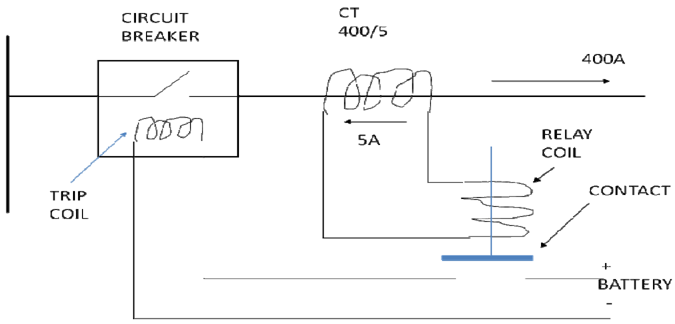


Figure 10: Basic component of protection system

Relay will operate depending on the setting. Whenever fault occurs, relay should operate and disconnect the circuit in time before the system exceeds the short circuit rating. Relay operation is normally classified into time/current characteristic that includes:-

- Instantaneous
- Definite time
- Inverse Definite Minimum Time(IDMT)

The feeder protection normally uses the IDMT characteristic for its choice of relay.

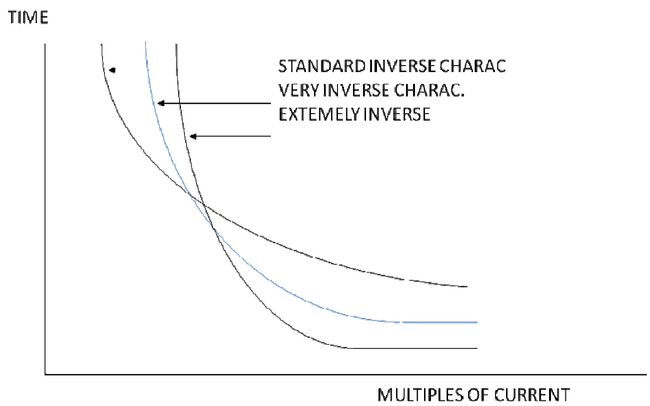


Figure 11: IDMT characteristic

The relay setting of IDMT characteristic for standard inverse characteristic can be calculated using the equation below:-

$$t = \frac{0.14 \times \mathrm{TMS}}{\left(\frac{\mathrm{FAULT\ \ CURRENT}}{\mathrm{SETTING\ \ CURRENT}}\right)^{0.02} - 1}$$

Where TMS: time multiplier setting

Apart from relay, other components of protection system such as circuit breaker and sensing device are also important. The function of a circuit breaker is to isolate the circuit, while the sensing device is to measure the fault quantity and send to the relay.

2.2.2 Grading Margin

It is required to check the grading margin in order to get better relay setting in protection system. Grading margin between adjacent relays is determined by several factors which are:-

- Circuit breaker time
- Relay overshoot
- Instrument errors

There are two methods to determine the grading margin which are fixed and variable. For fixed margin, time margin is estimated is according to:-

1	CB time	0.10s
2	Relay overshoot	0.04s
3	Relay error	0.10s
4	Instrument error	0.10s
5	Safety margin	0.10s
	TOTAL MARGIN	***0.44s***

Usually, the range will be in between 0.3-0.5s. In this project, the choice for grading margin is 0.4s

2.3 Over Current And Earth Fault Protection

Overcurrent and earthfault (OCEF) protection is widely used in distribution protection. OCEF is used to protect feeder, transformer, motors, capacitor and other equipment. OCEF relay should:-

- operate when the circuit carry more than maximum load continuously
- be set not to operate at the overloaded current level in time slightly shorter than the maximum overload time
- operate and disconnect the circuit under fault condition

The combine OCEF relay is shown in the diagram below. This protection scheme is good whenever the system is solidly grounded or using grounded through resistance NER (neutral earthing resistance) [4]. If the system is grounded through high impedance, the earth fault relay may not be sensitive enough to detect the earth fault current.

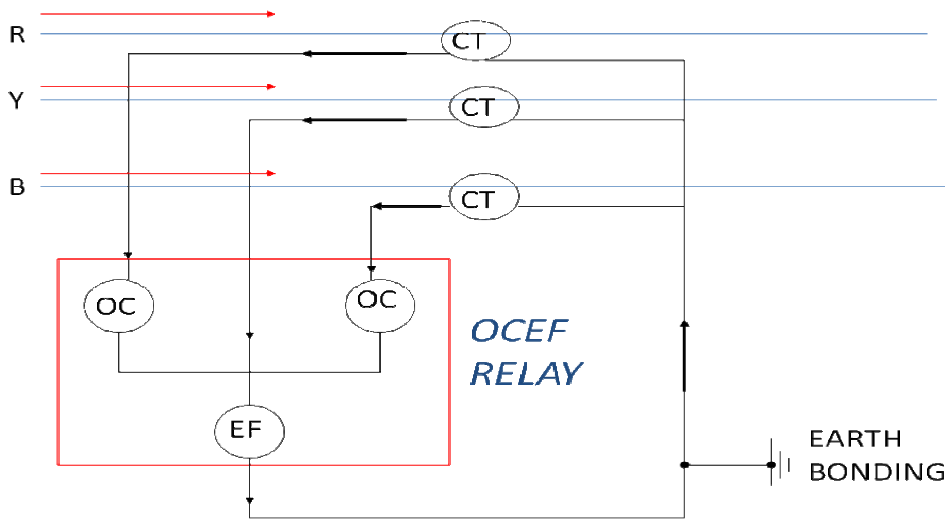


Figure 12: OCEF relay

The OCEF relay operates according to Lenz Law principle. When current is supply to a conductor, it will create the induce voltage. This will induce the other current that is opposite direction from the original. For different type of fault, the relay will trigger in different way for example over current and earth fault case.

2.4 Autoreclose Relay

Automatic reclose equipment is defined as the equipment which automatically recloses the relevant line's circuit breakers following their opening as a result of the detection of a temporary or transient fault in the network system. In applying autoreclose, three items must be considered. They are

- Choice of dead time
- Choice of reclaim time
- Choice of the number of shots

This concept is used on overhead line. The system is used to reclose lines that are tripped by self-clearing faults.

Whenever the fault is being isolated from the system, the breaker can turn on back automatically and it minimizes the interruption time. If the fault does not disappear within the dead time, the relay closes the trip circuit and in a single shot reclose, then the breaker contact is finally separated [5].

In order to make sure that the autoreclose is functioning well, the calculation of the setting relay must be done accurately.

2.5 Directional Protection

In a parallel feeder, directional protection can be used to operate as unit protection by means of distinguishing faulty current direction [6]. Based on that special feature, it enables better discrimination of the faulty part of the network than with overcurrent and earthfault protection. It is necessary to use it in the following conditions:

- in a system with several sources
- in closed loop or parallel-cabled systems
- in isolated neutral systems for the feedback of capacitive currents and
- to detect an abnormal direction of flow of active or reactive power (generators).

The figure of the Directional overcurrent and earthfault protection scheme is as bellow:-

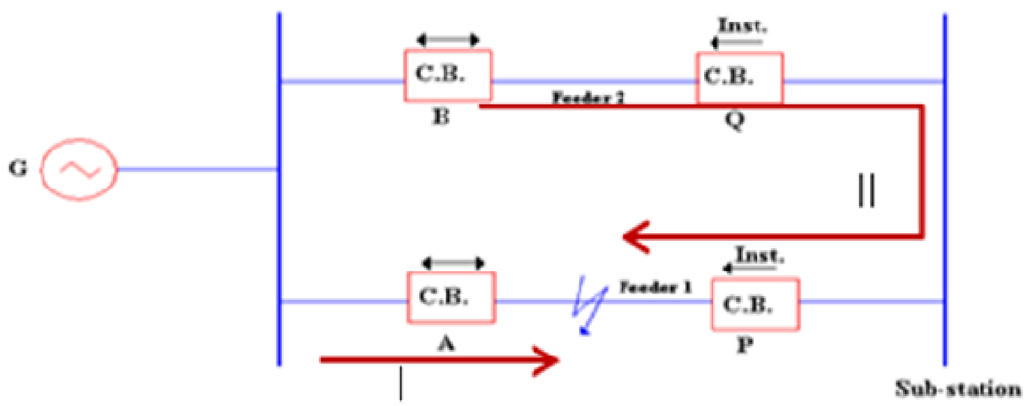


Figure 13: Directional Relay on parallel Feeder

If a fault occurs on one feeder, it can be isolated from the system and the continuity of supply can be maintained from the other feeder. The parallel feeder cannot be protected by non directional relay over current and earthfault (OCEF) relays only. It is necessary to use directional relay and to grade the time setting of relays for selective tripping [7].

The protection system requires that:-

- Each feeder has a non directional OCEF relay at the generator end. These relays should have inverse -time characteristic (IDMT).

- Each feeder has a reverse power or directional relay at the substation end. These relays should be instantaneous type and operate only when power flows in the reverse direction i.e. in the direction of arrow at P and Q.

Suppose an earthfault occurs on feeder 1 as shown in Fig 6. It is desired that only circuit breakers at A and P should open to clear the fault whereas feeder 2 should remain intact to maintain the continuity of supply. The fault is fed through two routes

(a) directly from feeder l via the relay A

(b) from feeder 2 via B, Q, and P

Therefore, power flow in relay will be in normal direction in relay Q but is reversed in relay P. This causes the opening of circuit breaker at P. Also the relay in A will operate while relay B remains inoperative. It is because these relays have inverse-time characteristics and current flowing in relay A is in excess of that flowing in relay B. In this way the faulty feeder is isolated.

2.6 Load Shedding

Load shedding is the condition where some of the supply will be cut down at specific load that is to be determined to avoid the whole network facing an outage because of the interruption such as the frequency drop from its normal.

Load shedding schemes can increase system reliability by preventing total system collapse during emergency operating situations when load exceeds generation [8]. Large decreases in frequency can only occur when an area is separated from the interconnected system and is left with a generation-load imbalance.

This may result from a major system disturbance that creates large power swings, causing protective equipment operation and system islanding. If the generation does not match the load in the isolated area, an automatic load shedding scheme based on system frequency can be used to maintain system stability and provide additional protection for remaining loads and other equipment.

There are some steps or level of load shedding that is usually used. The more level it has, the better is the service. It is because if there is only drop in frequency is very little but we cut off the supply more than enough, the system is not reliable enough. So, in order to produce better system performance in the load shedding, we must have at least 3 steps/levels.

In this project, there are some other criteria apart from number of steps that need to be consider in producing good load shedding scheme that includes:-

- Maximum loads demands
- Size of load shed at each step
- How the frequency setting at each step
- Delay time before the load being shed
- Location of relay to operate in performing load shedding

2.6.1 Under Frequency Load Shedding

In the process of determining the best under frequency load shedding scheme, three guidelines were considered. The goal of load-shedding is, firstly, to prevent the frequency falling below the limit of 47.5 Hz, which would subsequently cause the activation of the under frequency turbine protection.

Secondly, following a transient state of the system, the frequency should level off at a satisfactory level. This condition is already met with the first demand, mentioned before.

Finally, load-shedding should affect as few power consumers as possible. Another very important aspect of load-shedding design is the danger of shedding too much load, which can result in an over frequency. There are three different load-shedding schemes that can be implement through the research which includes:-

1. An invariable maximal amount of load-shedding with a fixed amount of load shedding per step.

2. An invariable maximal amount of load-shedding, with the amount of load-shedding per step variable in accordance with the rate of frequency decline.

3. A variable maximal amount of load-shedding, with the amount of load-shedding per step variable in accordance with the rate of frequency decline.

With the three different implementation of load shedding, there will be some advantages and disadvantages using those schemes. In the first scheme, the frequency gradient threshold was not taken into account, while the load-shedding thresholds and the total load shed in each step, respectively, were set.

The second and the third scheme take the frequency gradient threshold into account. In order to set the appropriate value of the frequency gradient, we first checked the maximum frequency decline following the system splitting.

The main differences between the second and third load shedding scheme is the total load to be shed. In the second scheme the amount is fixed, while in the third scheme it varies according to the frequency gradient. When using the frequency gradient one has to assure proper coordination with the neighbouring systems.

Under the situations of significant generation/load mismatch causing a decline in frequency, the utility generally dropped load at the distribution substation level. Normally this was accomplished using under frequency relays monitoring the substation bus, set to trip the distribution feeder circuit breakers.

2.6.2 Under Voltage Load Shedding

Voltage collapse or uncontrolled loss of load or cascading may occur, for example, when sending sources are far enough removed from an area that the voltage at its loads experience a significant drop, especially during outage contingencies. System studies are needed to determine which systems are the potential candidates for a suitable UVLS scheme [19].

It is most useful in a slow-decaying voltage system with the under-voltage relay time delay settings typically between 3 to 10 seconds. When overloads occur on long transmission lines in conjunction with a significant local voltage dip, then the effect of UVLS action would also be to alleviate such overloads. Features that must taken into consideration in implementing UVLS includes:-

1. Long term voltage collapse
2. Classical voltage collapse
3. Transient instability.

2.6.3 System Condition Load Shedding

Whenever fault occurs at any feeder at Sri Iskandar Main Intake Substation, the other network will feed the fault current as shown in the diagram. The generator must be protected from damage during the fault. Generator will feed the fault current that is interconnected with it. To avoid that, the circuit breaker will trip whenever it reaches the setting current to avoid the damage. Usually the setting is low to make sure the generator is not overloaded.

With only generators at GDC to supply load to UTP, it is not enough to cover the load demand and overload problem surface again. The total blackout will happen because the generator is overloaded and cannot support the demand of load.

Throughout the research, there are some possible solutions that can avoid the outage. By applying load rejection method, total blackout can be avoided especially to important places like Chancellor Complex and academic building. The GDC generator can supply the load without any interruption although fault occurs in the TNB network system.

Whenever the fault at the TNB feeder is being isolated from the network system, the system can be normalized back to normal. To minimize the interruption time, the concept of autoreclose could be applied in the network system. Before complying to the action, the voltage must be checked to make sure there is no fault at the interconnection of the network between UTP and TNB source. Autoreclose can minimize the interruption time because whenever the fault is cleared from the system, the system is restored back to normal state

2.7 Parallel Operation of Generators to an Infinite Bus

In this project, the generators at GDC are isolated from the grid system or in other word, island mode of operations. It shows that UTP does not depend on the power supplied from the power from grid. However, the generators are still connected in parallel in hot standby mode to ensure reliability**.**

In order to parallel the generators to the grid, there are conditions to be met which include:-

1. The root means square (rms) line voltage of the generators must be equal.
2. Have the same phase sequence
3. The phase angle must equal
4. The frequency must be higher from normal frequency that is running

However, when those generators (2x4.2MW GDC generators) are connected to a large power system in this case the TNB grid, the power system is simply too large that it will not affect the operation of the generator and does have as much effect on the power system. So, in this case, the grid is an infinite bus

Infinite bus is a power system so large that its voltage and frequency do not vary regardless of how much real and reactive power is drawn from or supplied to it [18]. So, when GDC generator connected to large system (TNB SIKD), no changes in frequency and terminal voltage are expected in the system.

Therefore, under frequency load shedding cannot be implemented in this situation. It is because of the generator connected parallel to infinite bus will not be affected the change in frequency.

2.8 Protection Logic Diagram Using PLC And Ladder Diagram

At the end of analysis, the protection scheme will be produced. Usually, the protection scheme is in the logic sequence that always being implement in some sort of ladder diagram.

Programmable Logic Controller (PLC) is a computer, having connections to external inputs and outputs. The PLC program has the task to set the outputs depending on the inputs outputs and the program itself.

Below are some of the important symbol that will be used in the ladder diagram by referring to the component of the network diagram such as busbars, transformer, generator and others [16].

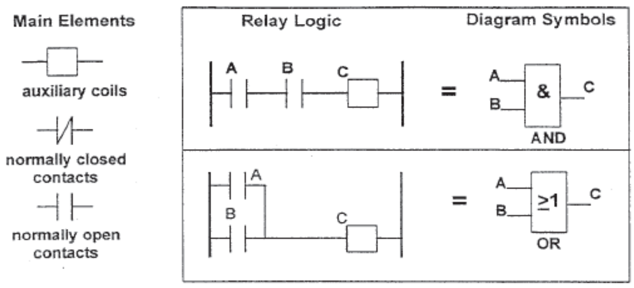


Figure 14: Basic element of ladder logic diagram

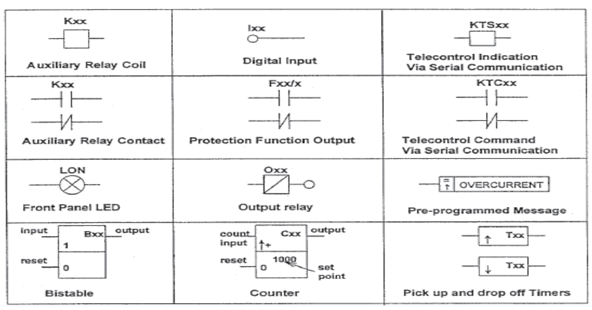


Figure 15: Resource available in ladder logic programming

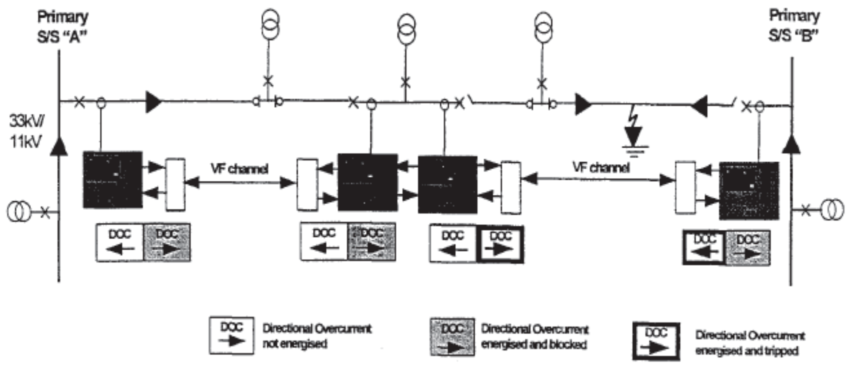


Figure 16: Example principle operation of cable unit protection base on directional blocking scheme.

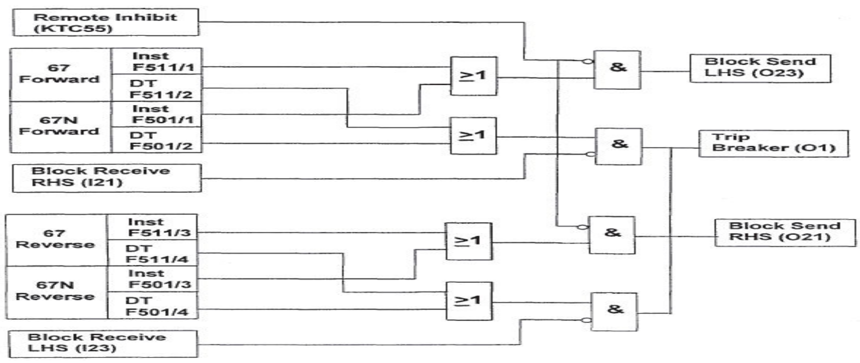


Figure 17:

Block diagram of basic logic of directional blocking scheme as example above.

Below is the equipment that will be used.

Figure 18: PLC1-Guard PLC-QM2 Digital Input & Output

The program will be executed once the system's program has been developed. The figure shows a snapshot of the ladder diagram designed in the lab.

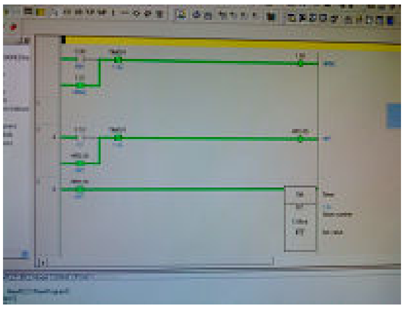


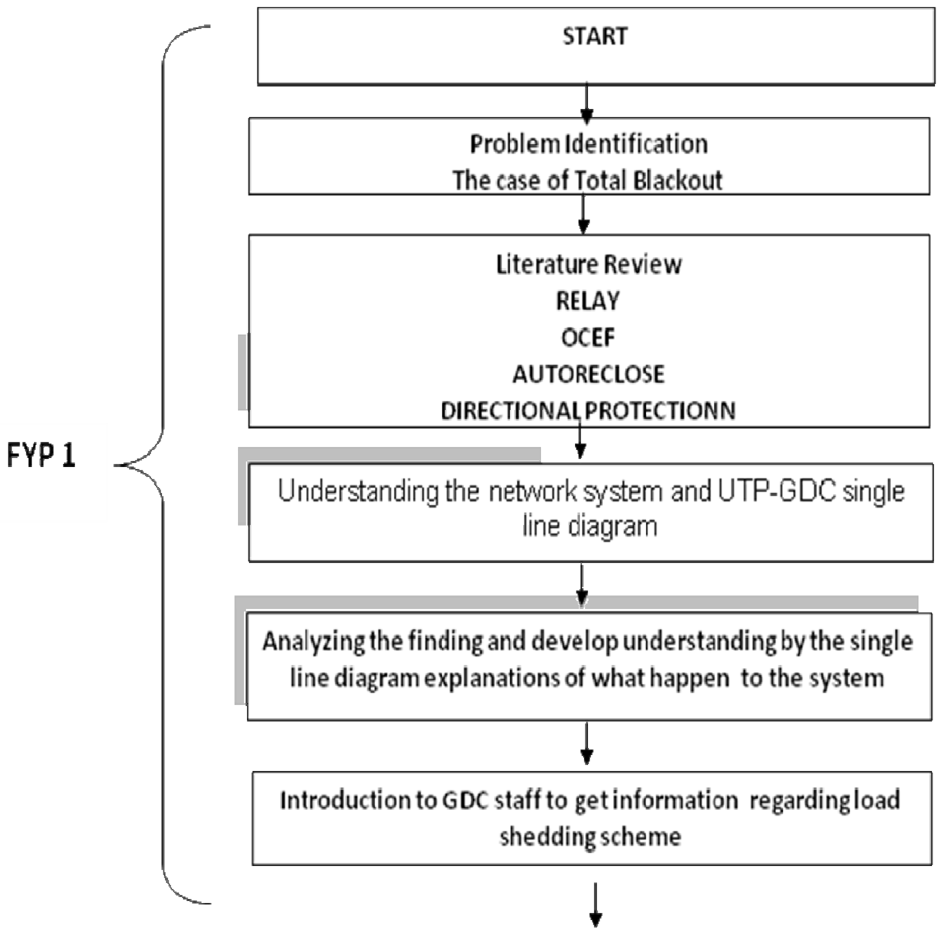
Figure 19: Ladder Diagram Execution

With all these basic knowledge on PLC, the author then will create a simple ladder diagram to show that load shedding is possible using PLC programming

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification



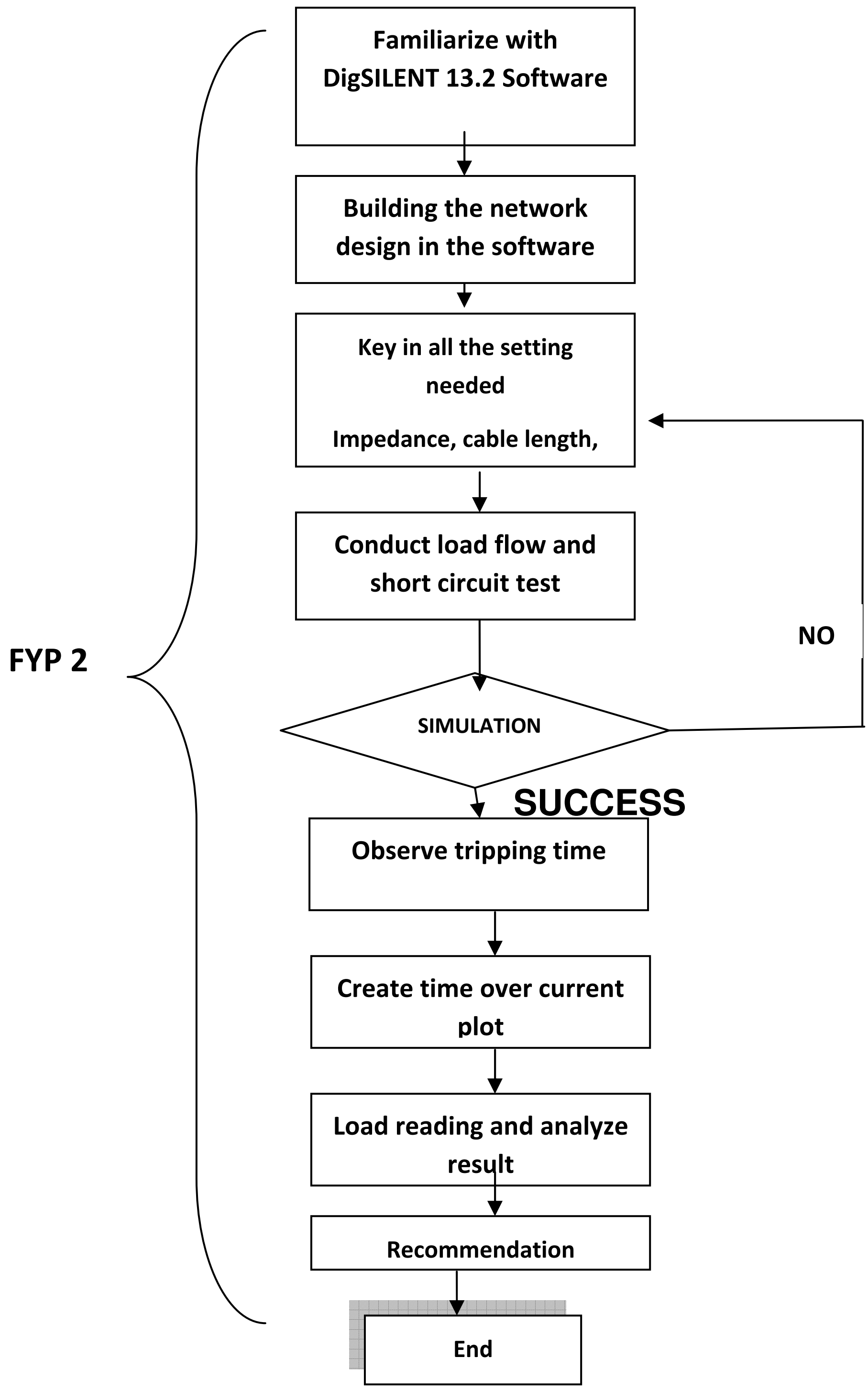


Figure 20: Flow chart of Procedure

3.2 Research methodology

In order to complete the project, the research must be done to get useful information. Apart from research through internet and journal, the author had weekly discussion on the conceptual study with the supervisor for understanding. The author also had read books regarding the protection system and other reading material that is useful to the project.

3.3 Tools and Equipment

- DIgSILENT power factory software
- GDC data for analysis

All the results and the proposed solution will be simulated using DigSilent software. We can determine whether we have done the correct settings by analyzing the simulation results later.

In using DigSILENT Power Factory, there are six steps involve before we can actually start doing the analysis in the network that we are supposed to do. Each step must be completed first before proceeding to the next step to avoid errors in the simulations:-

- STEP 1 : Creating power system element
- STEP 2 : Data manager
- STEP 3 : Creation of subsystem
- STEP 4 : Connecting the subsystem

3.4 Project activities

A thorough research on the objective and concept of protection philosophy in distribution system will be done throughout the project to ensure that all information and data presented are correct. The author needs to have good understanding regarding the theory and concept before start proposing solution. The project milestone includes the study and manipulation of DIgSILENT software for the purpose of simulation. All obtained data would be compared to get the best solution to overcome the case of total blackout.

To summarize all the relevant activities, a Gantt chart as below is created.

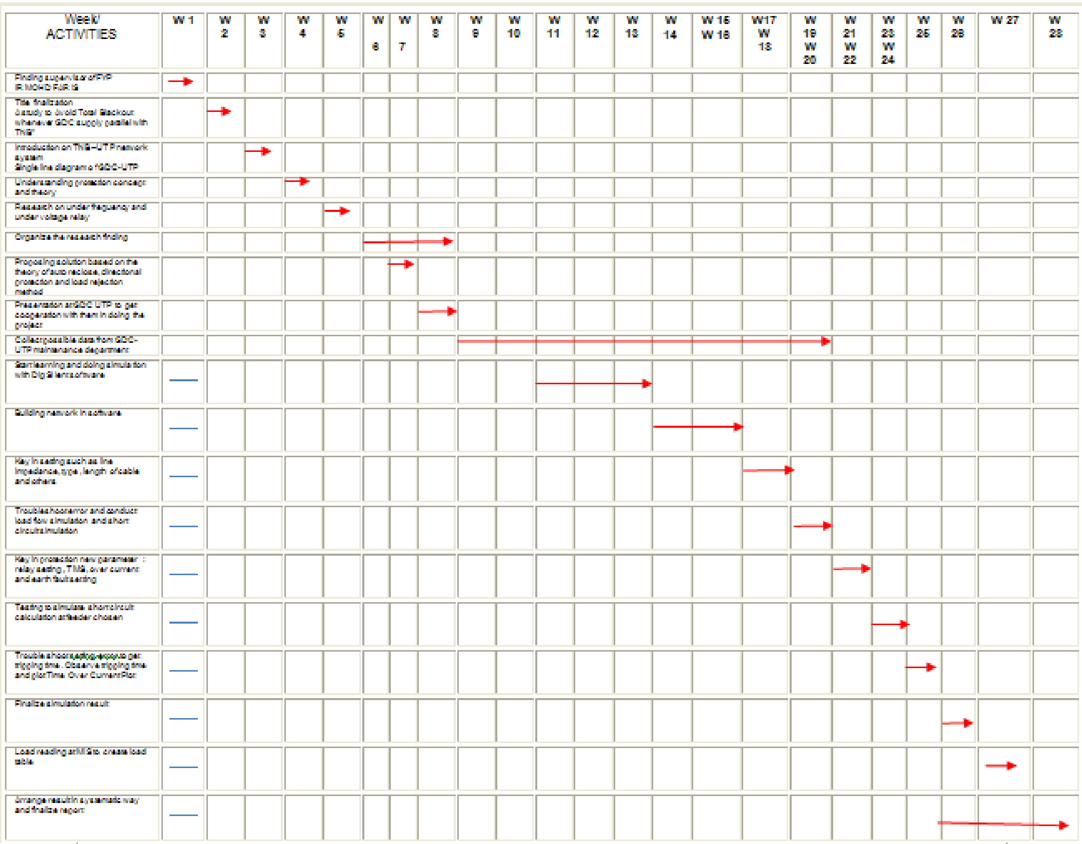


Figure 21: Gantt Chart

3.5 Project progress

The good network system must undergo some processes that include:-

- Modeling
- Simulation
- Analysis of the simulation result

3.5.1 Modeling

Based on the network, the modeling job in the DigSILENT Power Factory is done. It is important to be familiarized with the software in order to make the work done efficiently.

Then, network model is sketched using DigSILENT Power Factory. An appropriate element should be selected to be put into the designed grid. The UTP GDC network consists of:-

1. 32 lines
2. 10 substations
3. synchronous machine(generator)

    a. 2 is used normally
        - 1 standby that used as black start at GDC
        - 1 TNB source input

Figure show the network that has been modeled in DigSILENT power factory

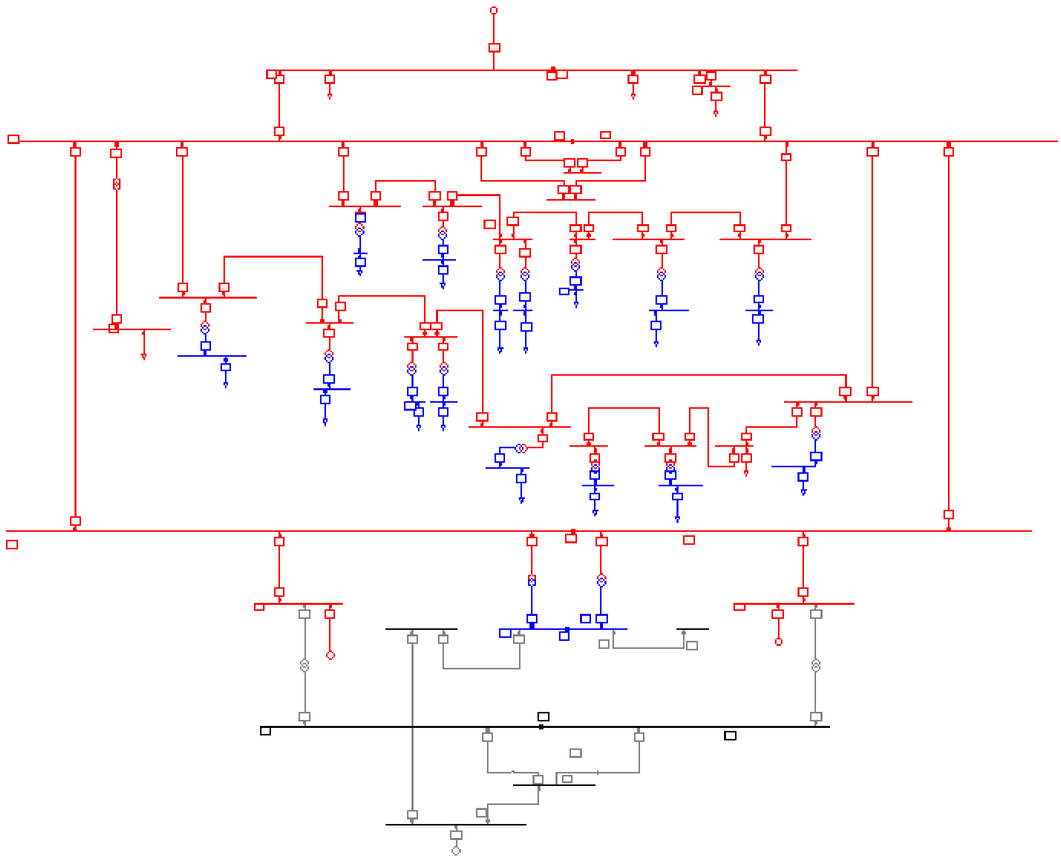


Figure 22: Modeling Using DigSILENT network

3.5.2 Simulation

Before doing the simulation, all the parameter needed should be set up. These parameters include the generator setting, the breaker setting, impedance of the network and others parameter that is important to get the accurate simulation result.

In order to make sure the simulation can be as accurate as possible, GDC data setting is very important. Possible assumption is made to get the simulation to run. After a while, the setting with the exact and latest setting data is used to get nearly perfect as actual network. The purpose of doing it is to avoid any error.

This is because, even small error in the network may cause the system designed to be unreliable for modeling and study purpose. In order to ensure that the settings are close to perfect state, the settings used are cross-checked with the data from GDC and is also confirmed with the charge man in charge of the plant.

3.5.2.1 Load Flow Simulation

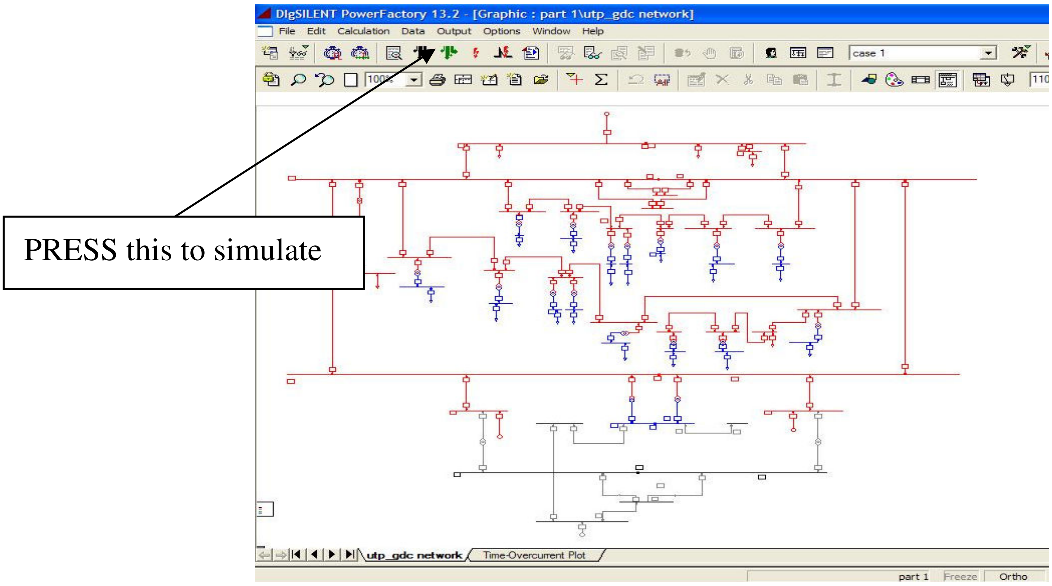


Figure 23: Simulating load flow using DigSILENT

3.5.2.2 Short Circuit Simulation

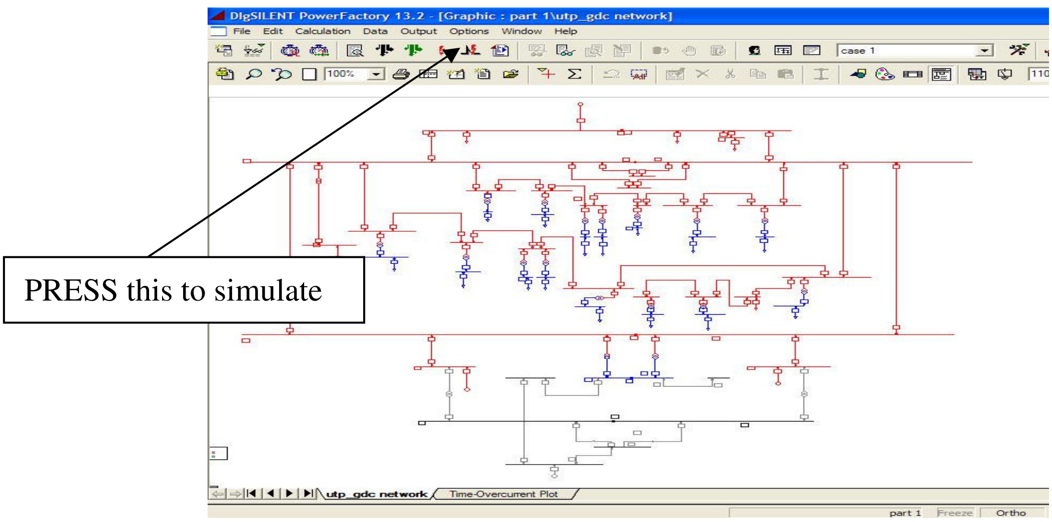


Figure 24: Simulating short circuit using DigSILENT

3.5.3 Analysis of the Simulation Result

As planned earlier, analyses that have been planned can be proceed after successfully doing the simulation.

These analyses were planned according to this project objective after analyzing the software manual on which analysis is suitable to be conduct at the network. Then the load shedding scheme can be proposed to be implemented in the network to avoid the event of total blackout repeated.

Summary of analysis steps taken are:-

1. Fault simulation type
    - Over current
    - Earth fault
2. Observe relay tripping time
3. Arrange according the fastest tripping time to the slowest
4. Observe the grading margin between relay at K06 and all upstream relay
    - Minimum margin 0.4s to avoid breaker trip at the same time.
5. Analyze total blackout situation
6. Propose new setting if needed
7. Load shedding methodology
    - Event of total blackout can be avoided

3.5.4 Protection Scheme

After all the analysis is completed, it is hoped that the protection scheme of the network can be produce. The entire protection schemes will be shown in the logic sequence and also ladder diagram.

In order to produce the protection scheme diagram, the author will refer to what had been explained in literature review earlier [16].

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Simulation of Total Blackout at UTP during Fault at TNB Feeder

Simulation is being carried out to prove total blackout condition when fault occurs at TNB feeder.

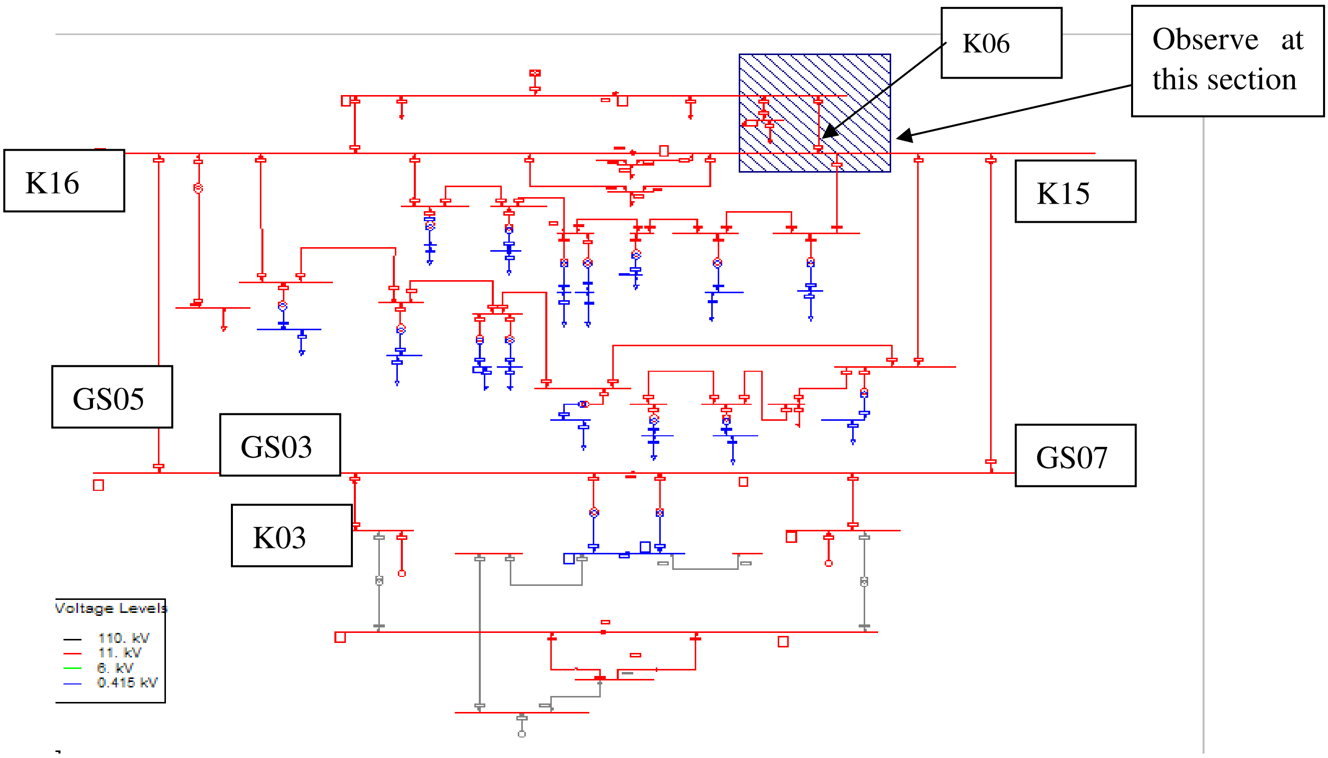


Figure 25: Network Simulation

Fault at busbar Terminal 37 with zero feeder length to simulate fault condition at PMU SIKD busbar will be use as reference for analysis since it gives the highest fault current and shortest tripping time. In simulation result, this ***Terminal 37*** represented ***CB02*** that had been discuss in the Network System Study in literature review earlier.

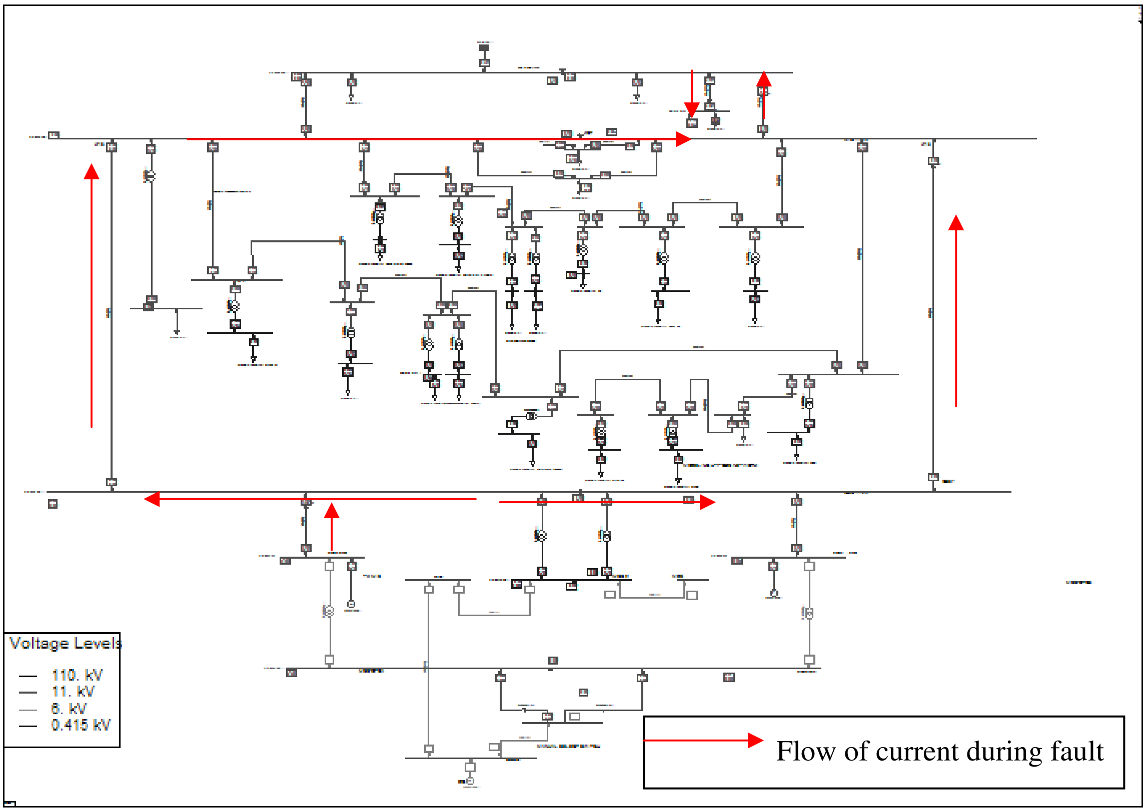


Figure 26: GDC Generator in Service Feeding the Fault Current

Since K06 is the interconnected breaker between UTP-TNB system, both over current and earth fault conditions have been simulated to show the event that lead to tripping of K06. The maximum demand is 5.9MW.

Analysis of relay triggering time is done for GS07 and K15 because the same relay operating should be observed at GS05 and K16 respectively.

4.2 Over Current Fault Simulation

4.2.1 Fault Current Flow Rate

Figure 28 shows that the flows of fault current from generator during TNB feeder fault.

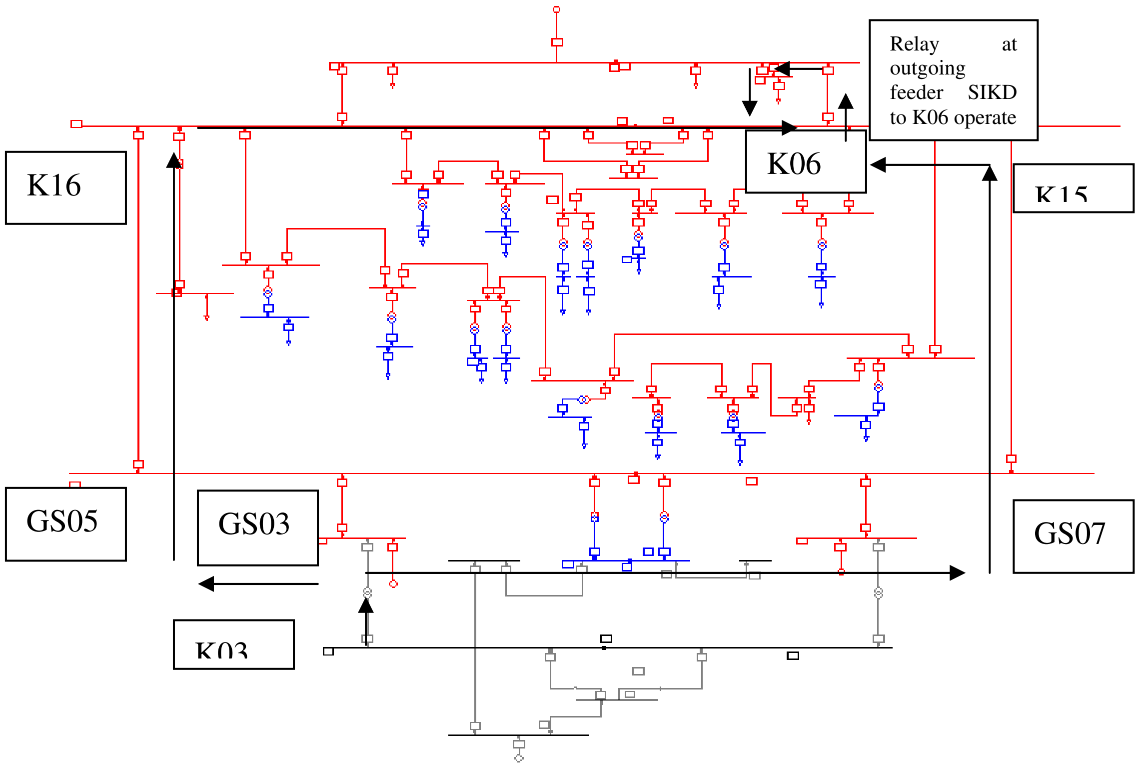


Figure 28: Generator Feed the Fault during Three Phase Fault

4.2.2 Observation of relay tripping time simulation

Three phase over current fault at Terminal 37 simulation give the following relay tripping time

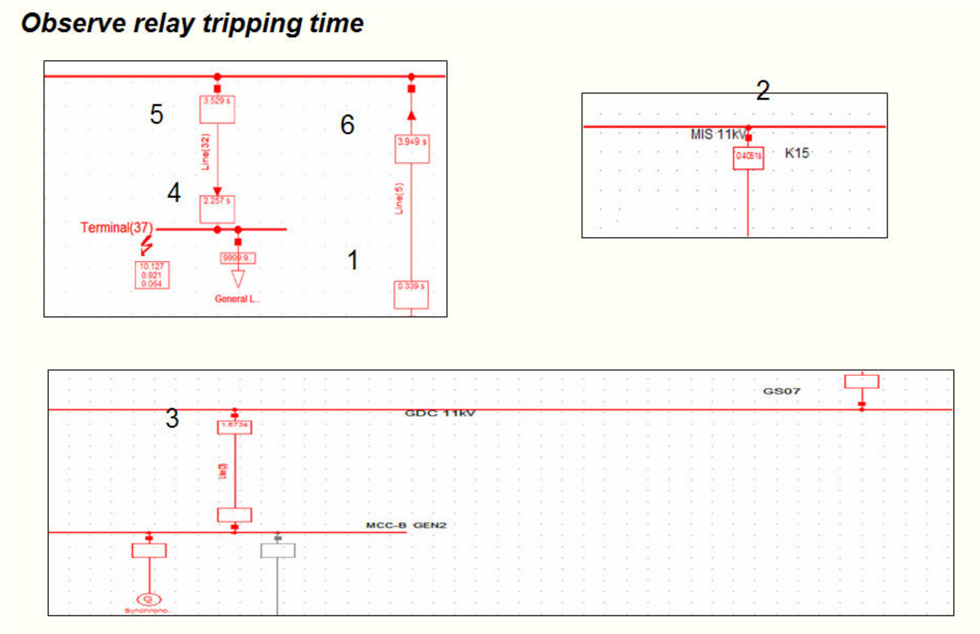


Figure 27: Three Phase Fault

4.2.3 *Arranging tripping time in ascending order*

Sequence of relay tripping time for the case is

1	Relay at K06	0.339s
2	Relay at K15	0.4061s
3	Relay at GS03	1.673s
4	Relay at incoming feeder at Terminal(37)	2.257s
5	Relay at outgoing feeder SIKD to Terminal 37	3.529s
6	Relay at outgoing feeder SIKD to K06	3.949s

4.2.4 Analysis of relay the tripping time

- A minimum margin of 0.4s between adjacent relays is required to avoid breaker trip at the same time.

From the sequence of tripping time, it can be observed that relay K06 will operate at 0.339 while relay K15 at 0.4061s. There is sufficient margin between relay K06 and the other upstream relays. So, when there is fault, K06 will trip together with K15 because there is ***not enough margin time.***

4.2.5 Analysis of immediate total blackout event

Since K15 and K16 feeders are having the same parameter setting and cable length, those breakers will trip together with K06. So the ***event of immediate total blackout*** will occur. This is because MIS is disconnected from the electricity source. So MIS cannot supply the UTP load at all.

4.2.6 Remedial Relay Setting To Avoid Immediate Total Blackout

- New relay setting to ensure sufficient grading margin for relay K06 and K15

Over current setting before adjustment as below:-

- TMS=0.2
- PS =0.4pu

Where TMS: time multiplier setting

PS : plug setting

In this situation, the setting K15 need to be adjusted to have the sufficient grading margin. Since K06 trip at 0.339s so K15 setting should trip at least 0.739s (0.339s + 0.4s = 0.739s).

Calculating the fault current:-

TMS=0.2, PS=0.4pu

$$t = \frac{0.14 \times \text{TMS}}{\left(\frac{\text{FAULT CURRENT}}{\text{SETTING CURRENT}}\right)^{0.02} - 1}$$

0.4061s = 0.14(0.2)/ ((I_f/400A)$^{0.02}$ - 1)

I_f = **11.217kA**

To get the margin of 0.4s, K15 must trip after 0.739s. So the new setting that is possible to get the margin as below :-

0.739s = 0.14(TMS)/ ((11.217kA/400A)$^{0.02}$ - 1)

TMS = **0.36** $\simeq$ 0.375

From the calculation the minimum TMS should be 0.36. So the nearest possible setting that can be chosen in the case is when **TMS=0.375.**

TMS = 0.375

t = 0.140(0.375)/ ((11.217kA/400A)$^{0.02}$ - 1)

= **0.761s**

With TMS = 0.375 , the tripping time of K15 will be at 0.761s.With the new setting the event of immediate total blackout can be avoided. However, after K06 trip, the generator will be overload if load shedding is not being implemented. Load shedding details will be discussed in the load shedding methodology later.

Over current setting after adjustment to make sure total blackout not happen when there is fault at outside feeder and to be able to do the load shedding as below.

K15 new setting:-

- TMS=0.375, corresponding tripping time should be: t = 0.761s
- PS =0.4pu

4.3 Earth Fault Simulation

4.3.1 Fault Current Flow Path

Figure 30 shows the flow of fault current from generator during TNB feeder fault.

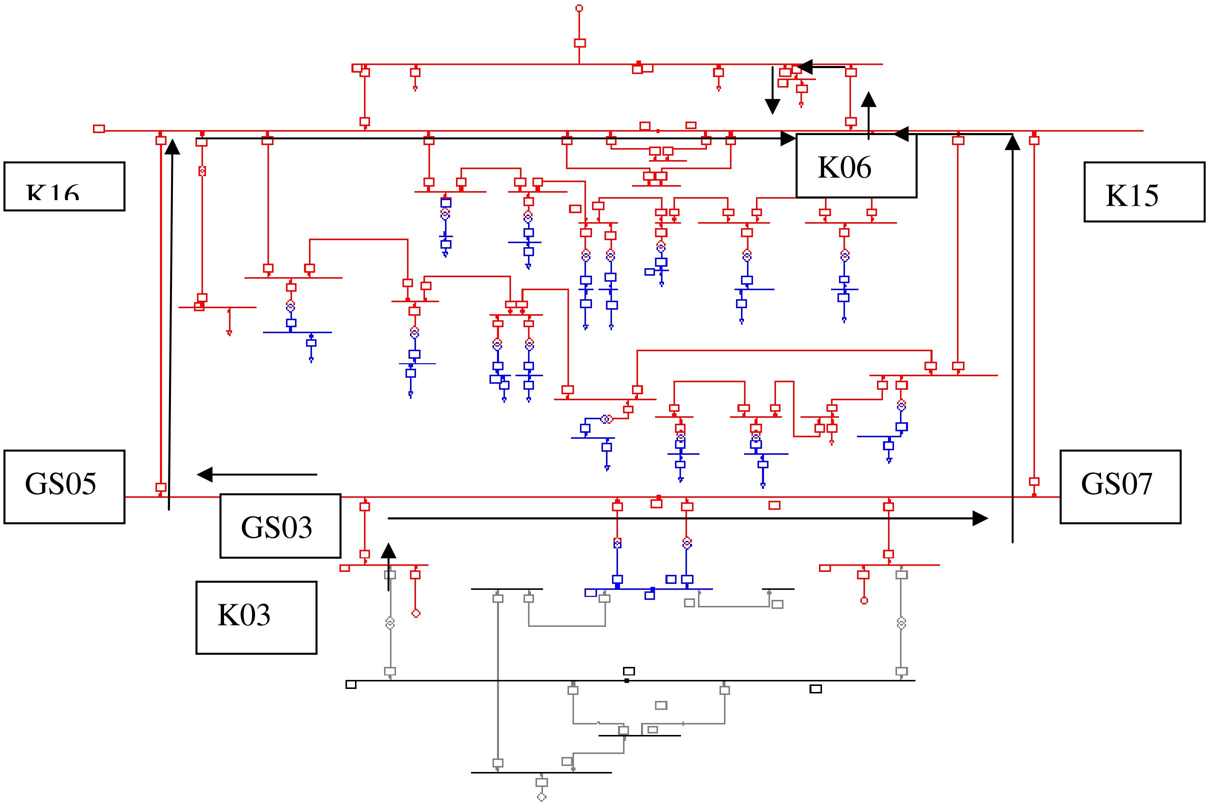


Figure 30: Generator Feed the Fault during Earth Fault

4.3.2 Observation of relay tripping time

Single line to ground fault at Terminal 37 simulation give the following relay tripping time.

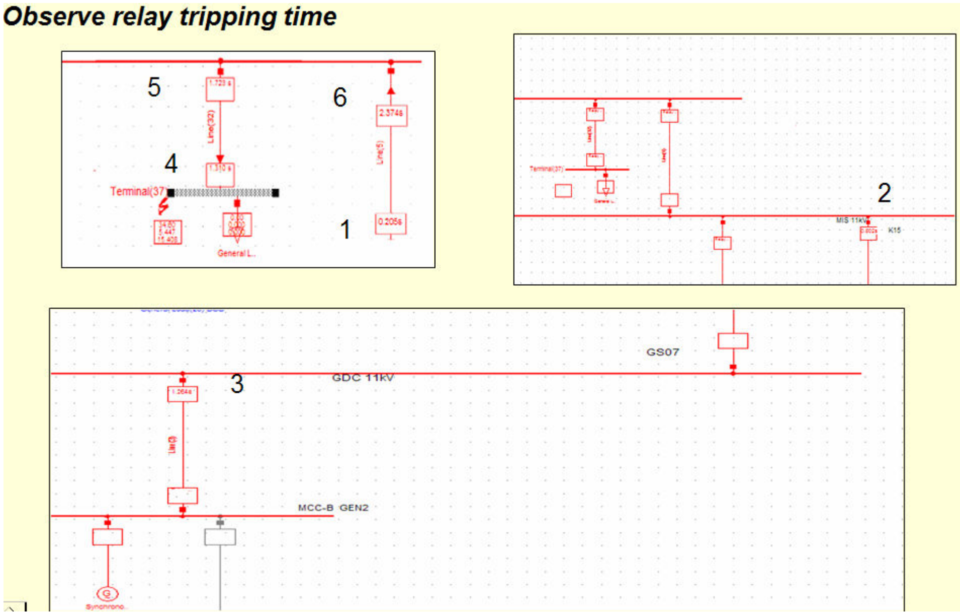


Figure 29: Single Line to Ground Fault

4.3.3 Arranging tripping time in ascending order

Sequence of relay tripping time:-

1	Relay at K06	0.205s
2	Relay at K15	0.802s
3	Relay at GS03	1.264s
4	Relay at incoming feeder at Terminal(37)	1.310s
5	Relay at outgoing feeder SIKD to Terminal 37	1.723s
6	Relay at outgoing feeder SIKD to K06	2.374s

4.3.4 Analysis of relay tripping time

- A minimum margin of 0.4s different tripping time between adjacent relays is required to avoid breaker trip at the same time.

From the sequence of tripping time, it can be observed that there is not enough margins between K06 and K15.There is sufficient margin for relay K06 with all other upstream relay. So, when there is fault, K06 will not trip together with K15 because there is ***enough margin time.***

For K15 and GS03, the margin is more than 0.4s (1.264s -0.802s = 0.462s). So, GS03 will not trip at the same time K15 trip.

4.3.5 Analysis of immediate total blackout eevent.

When K06 trip, the fault is isolated around the UTP load. This could not only one of the GDC generator will supply to the UTP load. It will cause the generator overloaded because one generator could not supply the entire UTP load.

The ***event of immediate total blackout*** will occur when any of the upstream relay trip on over current protection.

4.3.6 Remedial Relay Setting To Avoid Immediate Total Blackout

Since immediate total blackout does not occur relay setting can be maintained. We can proceed to load shedding methodology to overcome generator overloading.

4.4 Load Shedding Methodology

To avoid the event of total blackout, load shedding need to be implemented to ensure generator can survive to feed the remaining load after K06 trip. Tripping of after K06 tripped as being observed earlier, UTP will face the event of total blackout because of generator overloaded problem.

As being discusses earlier, the two types of fault namely over current & earth fault that being analyze swill be studied for load shedding implementation.

4.4.1 *Over Current Fault*

In order to selected CB for load shedding, auxiliary relay to send tripping signal selected CB for load shedding operating time.

K06 trip time = 0.339s

Auxiliary relay operating time = 20ms

CB at MIS opening time = 100ms

Grading margin = 0.4s

So 0.339s + 20ms + 100ms + 0.4s =0.859s

- The operating time before upstream breaker tripping must be at least **<u>0.859s</u>**

K15: 0.761s

GS03: 1.673s

From above data, K15 tripping time is not sufficient to meet upstream breaker operating time of 0.859s since K15 will trip at 0.761s.

So, K15 will need at least 0.859s for load shedding to be implemented, and the new TMS setting as calculated below.

$$t = \frac{0.14 \times \text{TMS}}{\left(\frac{\text{FAULT CURRENT}}{\text{SETTING CURRENT}}\right)^{0.02} - 1}$$

0.859s = 0.14(TMS)/ ((11217A/400A)$^{0.02}$ - 1)

TMS = 0.423 ≃ **0.45**

4.4.2 Earth Fault

K06 trip time = 0.205s

Auxiliary relay operating time = 20ms

CB at MIS opening time = 100ms

Grading margin = 0.4s

So 0.205s + 20ms + 100ms + 0.4s =0.725s

- The operating time until upstream breaker tripping must be at least **0.725s**

Upstream relay operating time:-

K15: 0.802s

GS03: 1.264s

Comparing K15 tripping time of 0.802s with the minimum time of 0.725s for generator to sustain overloading, no adjustment to the relay setting is required.

Hence, only over current TMS setting need to be changed to avoid immediate total blackout and successfully implement load shedding scheme.

Finally, the objective to prevent UTP total blackout due to TNB feeder fault can be avoided by adjusting K15 over current setting.

The summary of over current setting for K15as below:-

SETTING	**PS**	**TMS**
OLD	**0.4**	**0.2**
NEW	**0.4**	**0.45**

4.5 Priority Load Demand

In UTP, Chancellor Complex has the highest priority to get electricity supply. Table below show the load consume by Chancellor Complex.

Table 1: Priority supply Demand

Load Description	Power Consumption (kW)
SSBMH	1524
SSBRC	1829
SSBERC	914
Chill water Pump	609
Undercroft	1524

By looking at the given data, all parts of chancellor complex have been separate to a five sections. They are, SSBRC, SSBMH, SSBERC, Chill Water Pump and Undercroft.

- SSBRC : Information Resource Centre
- SSBMH : Chancellor Hall
- SSBERC : Exterior in Chancellor Complex
- Chilled Water Pump : To cool and dehumidify air
- Undercroft : Below compartment of Chancellor Complex

In order to make sure the propose solution relevant, the author also had done load reading with the help of GDC staff to get the load use at a time. Load reading had been done at Main Intake Substation UTP. From that, the load demand from every feeder can be observed.

Figure 34: Load Reading at MIS to Get Load Demand

Based on the result stated earlier, all other feeder can be disconnected from source during load shedding exercise except feeder K03 and K10 that give supply to the Chancellor Complex.

From the total priority load, the total demand from the following:-

- SSBRC : Information Resource Centre
- SSBMH : Chancellor Hall
- Chilled Water Pump : To cool and dehumidify air

Total power needed to supply from those places above:-

1524kW (SSBMH) +1829kW (SSBRC) + 609kW (Chilled Water Pump) = 3962kW@ 3.962MW

The demand not exceeds the capacity of one GDC generator which is **4.2MW**. So the load shedding is possible to be implemented in this case to ensure reliability in the priority area.

4.6 Automatic Load Restoration

4.3.1 Restoration Supply Protection Scheme

STAGE 1

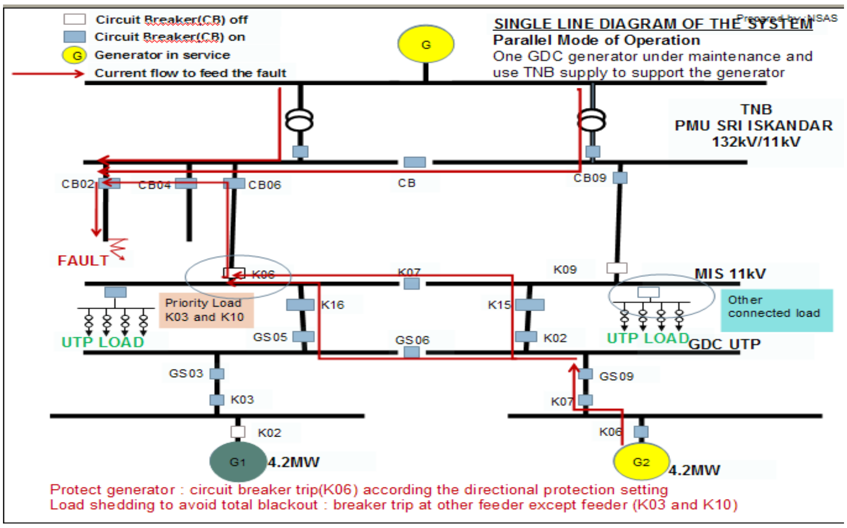


Figure 31: Implementation of Load Shedding

In order to avoid total blackout, load shedding scheme will be used to trip other than breaker K03 and K10. In this case, G2 is continuously supplying the essential load to UTP as can be seen at Figure 31.

STAGE 2

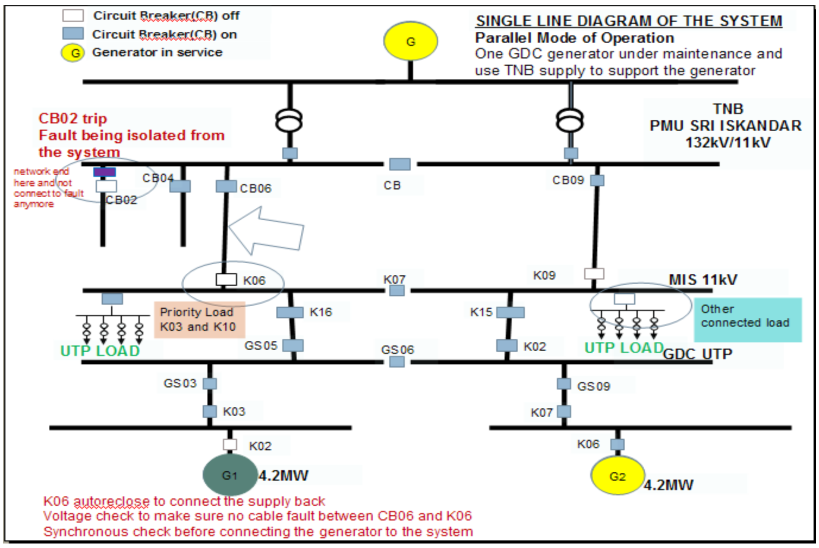


Figure 32: Isolating the Fault from the Network

Figure 32 shows when the breaker CB02 (Terminal 37) at the faulty feeder trips, the fault would be isolated from the network. The breaker K06 will close back by auto reclose function provided that no fault feeder CB06-K06. This is to ensure that the voltage on feeder CB06-K06 and closing of breaker K06 is done in synchronization with G2 generator. After successfully closing the breaker K06, other breaker that had been load shed before will be closed to restore the whole supply to UTP.

STAGE 3

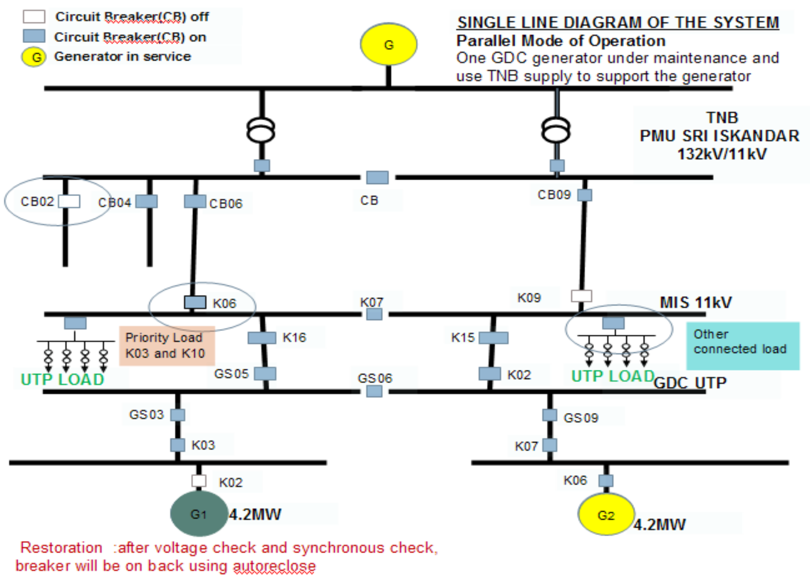


Figure 33: Restoration of Supply

After doing the synchronization check at breaker K06, we can close the breaker K06 and then other breaker that had been load shed will be closed to restore the whole supply to UTP as can be observe in Figure 33.

4.7 Load Shedding Logic Diagram

PLC (programmable logic controller) is used in this project to come out with the ladder diagram to get the logic sequence of load shedding. Figure shows that equipment used Digital Input /Output to relate the external input/output of the ladder diagram.

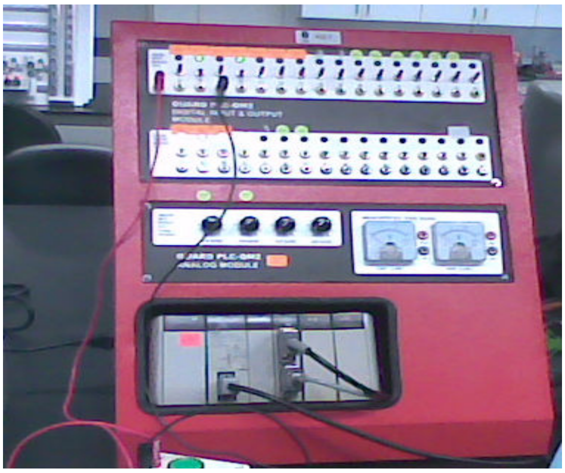


Figure 35: PLC1-Guard PLC-QM2 Digital Input & Output

Load shedding scheme can be implement using PLC. There are a lot of advantages if PLC is being used in designing load shedding scheme logic diagram. The programmed can be modifying according to our requirement. It is the substitute for hardwired relay panels.

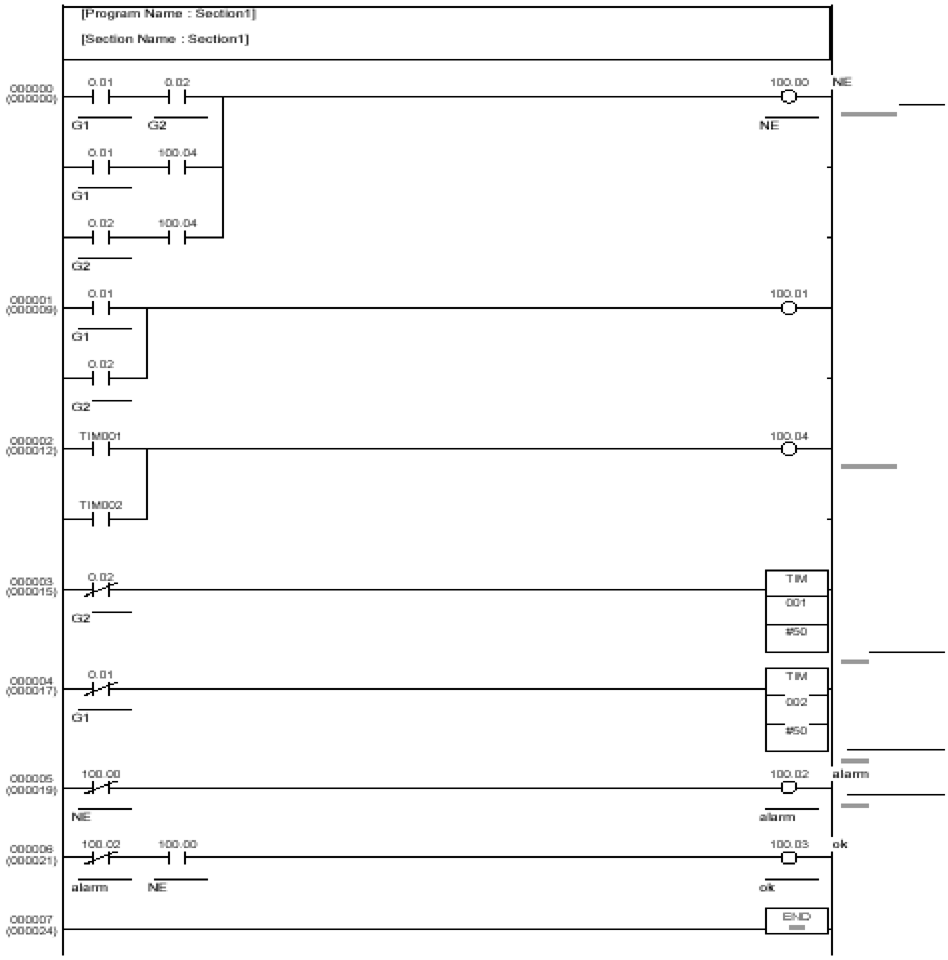


Figure 36: PLC Programming

The PLC programmed run rung by rung. It follows the logic sequence that had been studied based on the problem. So the logic sequence will depends on the problem definition. With that, the possibilities of the PLC programmed facing error once it can be executed.

The programmed summary consist of 3 input which is Generator 1 GDC , Generator 2 GDC and TNB supply .The program have 4 output that include supply to non-essential, supply to essential , system OK and alarm ON.

When one input turn ON, it will only supply to essential and alarm ON. When both load being supply which is essential and non essential, the system OK or in normal condition.

CHAPTER 5

CONCLUSION AND RECCOMMENDATION

5.1 Conclusion

Throughout the project research, there are ways to overcome the case of total blackout in UTP. From the network system, the study could lead to the result such that increase the reliability of the system and minimize the outage time. Modification to the setting of available network. The good network system is where the reliability of the system is high. By understanding the protection system, we can find out the solution of tripping problem to achieve the objective of the project. Finally, total blackout in UTP can be avoided.

5.2 Recommendation

5.2.2 Recommendation towards Improvement of the System

In any project paper, analysis is very important. After completing the modeling and simulation part, analysis can be done. Because of time constraint, the analysis done is not enough to prove the objective perfectly. So author recommend that people will use the network model that the author had build to continue doing result analysis. More analysis can be done but the author cannot really do the analysis perfectly because time is used more on learning the software, building the network and key in the data.

This network model can be used to analyze future problem that occur in GDC-UTP and TNB interconnected system. By doing the simulation, we can avoid the possible problem that affects the reliability of electricity supply.

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APPENDICES

APPENDIX A
GANTT CHART

Week/ 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	W 15 W 16	W1 7 W 18	W 19 W 20	W 21 W 22	W 2 3 W 2 4	W 2 5	W 2 6	W 27	W 28
Finding supervisor of FYP IR MOHD FARIS	→																						
Title finalization A study to Avoid Total Blackout whenever GDC supply parallel with TNB		→																					
Introduction on TNB –UTP network system Single line diagram of GDC-UTP			→																				
Understanding protection concept and theory				→																			
Research on under frequency and under voltage relay					→																		
Organize the research finding						→	→	→															
Proposing solution based on the theory of auto reclose, directional protection and load rejection method							→																
Presentation at GDC UTP to get cooperation with them in doing the project								→															
Collect possible data from GDC-UTP maintenance department									→	→	→	→	→	→	→	→	→	→					
Start learning and doing simulation with Dig Silent software											→	→	→										
Building network in software														→	→								
Key in setting such as line impedance, type , length of cable and others																→							
Troubleshoot error and conduct load flow simulation and short circuit simulation																	→						
Key in protection new parameter : relay setting , TMS, over current and earth fault setting																		→					
Testing to simulate short circuit calculation at feeder chosen																			→				
Trouble shoot setting error to get tripping time. Observe tripping time and plot Time Over Current Plot																				→			
Finalize simulation result																					→		
Load reading at MIS to create load table																						→	
Arrange result in systematic way and finalize report																					→	→	→