DEVELOPMENT OF LOW VOLTAGE DISTRIBUTION AUTOMATION SYSTEM BASED ON REMOTE TERMINAL UNIT, ABB RTU211

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)

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2014

I declare that this report entitle “The Development Of Low Voltage Distribution Automation System Based On Remote Terminal Unit, ABB RTU 211” 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 condition of any other degree.

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Dedicated , in thankful appreciation for support, encouragement and understandings

To:

My supervisor Prof Madya Mohd. Ariff Bin Mat Hanafiah ;

My beloved mother and father , Zaiton Binti Haji Satimin and Abdul Razak Bin Mat Jamil;

My family members and all friends

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Apart from that, I also would like to thanks to Mr. Ahmad Ismail Bin Man and Mr Mohd Adam Bin Sepee who are the experts at ACIS Technology Sdn. Bhd. in advanced system in contol and intelligent system development in guiding me from the beginning of this project, provide me a place, tools and equipment to complete this project.

Last but not least, I would like to express my deepest love and gratitude to my beloved parents for giving me unlimited encouragement during my studies in University Technical Malaysia Malacca (UTeM).

ABSTRACT

During these days, distribution automation system is developing. The technology of remotely monitors the distribution system, facilitates supervisory control of devices and provides decision support tools to improve the system performance is very demanding. Based on the research, the protection system of the distribution on 415/240 V has not been implemented yet. Therefore, this project is one of the three parts in developing the fast response distribution automation system. This report content the brief description on the distribution automation advantages, functionality and reliability. The substation development are based on the Remote Terminal Unit, ABB RTU211 input and output. In this project, the designing of the 415/240 V substation has been done as well as the controller. As for this substation, the incoming, outgoing and the load controller and the whole documentation of this project completion have also been included. The approach of this system is the identification faults that might occurs, how to detect and what action to be taken for these situations. The overall picture of this system will be discussed more inside this report by considering the scope and limitations.

ABSTRAK

Pada masa sekarang, sistem automasi pengagihan sedang giat membangun. Teknologi mengawal sistem agihan dengan jarak jauh memudahkan kawalan penyeliaan alat dan membekalkan alat-alat sokongan untuk memperbaiki data dengan prestasi sistem yang sangat berkembang. Berdasarkan penyelidikan, sistem perlindungan pengagihan di 415 / 240 V belum dilaksanakan lagi. Oleh sebab itu, projek ini ialah salah satu daripada tiga bahagian dalam memajukan sistem automasi pengagihan reaksi pantas. Laporan ini mengisi perihal ringkas di kelebihan-kelebihan automasi pengagihan, fungsi dan kegunaannya. Pembangunan pencawang ini berdasarkan Remote Terminal Unit, ABB RTU211 data masukkan dan data keluarannya. Dalam projek ini, rekaan 415 / 240 pencawang V telah dibuat serta pengawal. Bagi pencawang ini, masukan, dan juga keluaran dan pengawal beban telah didokumentasi keseluruhan penyiapan projek ini. Pendekatan sistem ini ialah mengenal pasti kesalahan-kesalahan yang mungkin berlaku , bagaimana untuk mengesan dan apa tindakan menyangka situasi-situasi ini. Keseluruhan gambaran sistem ini akan dibincang lebih bahagian dalam laporan ini dengan mempertimbangkan skop dan had yang telah ditetapkan.

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LIST OF ABBREVIATION

DAS – Distribution Automation System

RTU – Remote Terminal Unit

Modbus – Serial Communication Protocol

ASCII - American Standard Code for Information Interchange

TCP/IP - Transmission Control Protocol/Internet Protocol

FLISR - Fault Location, Isolation and Service Restoration

HMI – Human Machine Interface

CT – Current Transformer

CHAPTER 1

INTRODUCTION

1.1 Project Title

The Development of Low Voltage Distribution Automation System Based on Remote Terminal Unit, ABB RTU 211.

1.2 Project Overview

In every distribution system, there are substations controlling the power supply to the consumers. The requirements of every distribution system is the proper voltage, availability of power on demand and the reliability. A good distribution system should ensure the voltage variations at consumers terminal are within permissible limits.

The distribution substation contain the incoming, outgoing and the load. The low voltage switching system and back-up system needed to meet the efficient distribution system network.

This project are focus on developing one substation with the controller circuit based on input output of ABB RTU211.

1.3 Problem Statement

Electrical interruption always occur in industrial environment and it makes the electrical quality of the distribution system performance not at its best. The interruption of operations in industrial such as blackout, electrical frequency and voltage causes huge effects on the big scale industry with high growth of economy. Nowadays, the demand on the intelligent power distribution system will overcome the blackouts and maintaining the high quality of electricity.

In Distribution Automation System, DAS, there are three major parts. Firstly, the fault detection system, which is the input and the output to be controlled by the controller. Secondly is the Remote Terminal Unit, RTU configuration system. This RTU will act device that send and receive the data from the feeder to the Human Machine Interface, HMI. Which this also known as Supervisory Control and Data Acquisition, SCADA system. The third Part is the HMI development. This is the interface for the user to control the DAS in a control room.

The identification of response to the system will be develop during the first stage which is the control circuit of the feeder. This includes how the data sent and how the data receive from and to the Remote Terminal Unit, ABB RTU211.

1.4 Project Objectives

1. To study the process of faults identification by Remote Terminal Unit in Distribution Automation System.

2. Design the substation and its control circuit for Low Voltage Distribution Network System based on the ABB RTU211's input and output.

3. To verify the operation of the Distribution Automation system control circuit.

1.5 Project Scope

Major objective of this project is to develop the Ring Bus System which will be explained in the next point. By narrowing down a little bit, the scope of the project has been decided into one of three substations needed. In any substation the feeder, RTU, and the HMI are needed.

Based on the major parts mentioned in the Problem Statement earlier, this project are focussing on the first part which is the development of the input and output of the fault detection system which is also called as the feeder.

This system is applicable on the 415/240 kV distribution system. This project will develop one the substations which covers the incoming, outgoing and the load of electrical distribution system. It also covering the control circuit to be controlled by the RTU.

1.6 Contribution of Project

The design of the first substation of these three substation will be the master of all the consumer below it. The main idea of this project is to develop the fast response fault management system for the distribution automation system of 415kV / 240kV.

Based on the Figure 1.1, it shows the ring system that connected with two main supply and three substations. It shows the normal condition of the network distribution system. The main supply can supply all three substations if there is faults occurs between substation 1 and 2 or substation 2 and 3.

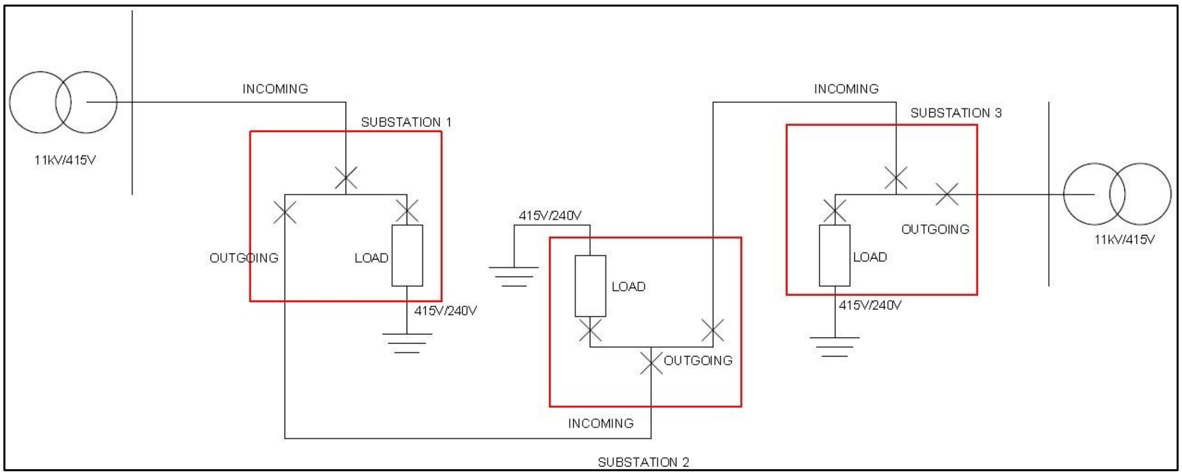

Figure 1.1: The main idea of distribution system.

CHAPTER 2

LITERATURE REVIEW

2.1 Distribution Automation System (DAS)

The purpose of Distribution Automation System (DAS) is to controlling, monitor, intelligence and connectivity from the substation to the customer and distributed resources [1]. DAS is able to monitor, coordinate and operate customers components in real time mode [2].

Distribution system is able to identify various electrical faults in the system feeder as well as delivering the high quality and reliable electrical supply. This system is able to accommodate various power plants with versatile resources. This is an important responsibility of the distribution company [15].

The DAS built with improved technology that enables to mobile monitoring and control breakers and switches on distribution network in real-time including the distribution substations [7].

2.1.1 Fault Location, Isolation and Service Restoration, FLISR

The acronym for FLISR is stand for Fault Location, Isolation and Service Restoration. After occurrence of any fault, the key challenge to any power distribution utility is to locate/ detect the faulty section, Isolate the faulty section and restore un-faulted areas, as quickly as possible. Faster the restorations after fault- better its impact on Reliability Indices (tangible benefit) and grater is customer satisfaction (intangible benefit) [4].

2.1.2 Advantages of Distribution Automation System (DAS) [5]

Operational & Maintenance benefits:

- Outage duration is reduced by using the auto restoration scheme makes the improvement of reliability.
- Means of automatic VAR control can improve voltage control.
- Man hours and man power will be reduced.
- Operational data information is accurate and useful planning constructed.
- Fault detection and behaviour analysis are improvised.
- System process schedule and component loading are improvised.

Financial benefits:

- The increment of revenue due to quick regeneration.
- System capacity employed will be improvised.
- Quality of provider will be improvised for customer retention.

Customers related benefits:

- Operation reliability is better.
- Industrial/Commercial customers will minimize interruption cost.
- Quality of provider is improvised.

2.2 Remote Terminal Unit, RTU

RTU hardware which are configured as the data acquisition device to acquire electrical parameters data from line, process information and the transmission of commands and instructions to component in DAS [3]. Besides that, RTU is built with an open ended distributed processing configuration consisting of main processor, peripheral I/O modules, termination panels, power supplies & communication equipment/interface [6].

The basic functionality of ABB RTU 211 has been tabulated in Table 2.1. It includes the hardware's features of power quality monitor, fault detection and the protection function, communication type, temperature monitoring and the firmware upgrade of the RTU.

2.2.1 Basic Functionality of RTU

Table 2.1: The Ability of ABB RTU 211

Hardware	Functionality
Power Quality Monitor	• Power drop • Power rise Power Interruption Total Harmonic Distortion-Voltage • Total Harmonic Distortion-Current • Current TDD • Current Unbalance Ratio • Over and Under Voltage
Fault detection and the protection function	• Handle new algorithm of fault indicator and restraint of inrush current • Sectionalize function

	• Detection the direction of fault current flowing • Fault detection in non-grounding feeder • Save and transmit the current wave and voltage wave in fault
Communication type	• DNP3.0 • Modbus, Bluetooth • RS-232, Rs-485, Ethernet
Temperature monitoring	Give the temperature and humidity data of inside and outside control box
Firmware upgrade	Remote firmware upgrade by file transfer function

Table 2.1 shows the ability of the remote terminal unit model ABB RTU 211.

2.2.2 Advantages of RTU

- One engineering tool for the complete RTU family
- Reduced operating and maintenance costs through advanced diagnostic tools
- Integrated Human Machine Interface (HMI) functionality, PLC functions and network components in one RTU system
- Reduced engineering hours through efficient engineering tools
- Small number of configurable hardware components for all applications reduces spare part costs
- One solution, from pole top RTUs to large complex trans- mission RTUs, with consistent system functionality.[6]

2.3 Overcurrent

It basically means that an over current exists when the current (A) exceeds the rating of the equipment or the ampere capacity of the cable conductor [9]. The cause of an overcurrent is the overload on the circuit, a short circuit or even the ground fault. IEC 60255 defines a number of standard characteristics as follows:

- Standard Inverse (SI)
- Very Inverse (VI)
- Extremely Inverse (EI)
- Definite Time (DT)

2.4 Earth Fault

Earth fault current is a current that flows directly from phase conductors to earth. It may also refer to a current that flows from protective conductors from the point of an insulation breakdown [10].

To avoid earth fault current, a protection is implemented by professionals. Protection requires interruption to the supply of a current to a circuit or system. Interruption is only set to occur when current leakage to the Earth is detected. The current leakage must be higher than the pre-determined threshold, if it exceeds it, than interruption occur.

2.5 Switchboard

A switchboard is a distribution board (DB) that receives a large amount of power and dispatches it in small packets to various electrical equipment [11]. It has power-controlling devices such as breakers, switches along with protection devices such as fuses, etc. Switchboards in general are divided into the following four classes [11]:

- Direct-control panel-type
  - With the direct-control panel-type, switches, rheostats, bus bars, meters, and other apparatus are mounted on the board or near the board and the switches and rheostats are operated directly by operating handles if they are mounted on the back of the board
- Remote mechanical-control panel-type
  - Remote mechanical-control panel-type boards are the AC switchboards with the bus bars and connections removed from the panels and mounted separately away from the load. This type of board is designed for a heavier duty than the direct-control type switchboards and is used up to 25 000 kVA.
- Direct-control truck-type
  - Direct-control truck-type switchboards are used for 15 000 V or lower and consist of equipment enclosed in steel compartments completely assembled. The high-voltage parts are enclosed and the equipment is interlocked to prevent any operational mistakes. This type of a switchboard is designed for low- and medium-capacity plants and for auxiliary power in large generating stations.
- Electrical-operated.
  - Electrically operated switchboards employ solenoid or motor-operated circuit breakers. Electrically operated switchboards make it possible to locate high-voltage and other equipment independent of the location of the switchboard. Switchboard frames and structures should be grounded. For low-potential equipment, the conductors on the rear of the switchboard are usually made of a flat copper strip known as a copper bus bar. Aluminium bus bars are also used due to its low cost. Switchboards must be individually adapted for each specific electrical equipment/system.

2.6 Circuit Breaker

A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow [11]. There are several types of circuit breaker as shown in Table 2.2.

Table 2.2: Types of circuit breaker

Classification	Types
Arc Quenching Media	• Oil Circuit Breaker • Air Circuit Breaker • SF_6 Circuit Breaker • Vacuum Circuit Breaker
Services	• Outdoor Circuit Breaker • Indoor Circuit Breaker
Operating Mechanism	• Spring Operated Circuit Breaker • Pneumatic Circuit Breaker • Hydraulic Circuit Breaker
Voltage Level	• High Voltage • Medium Voltage • Low Voltage

2.7 Electrical Conductor and Insulator

Conductivity is the ability or power to conduct or transmit heat, electricity, or sound. Metals such as copper typify conductors, while most non-metallic solids are said to be good insulators, having extremely high resistance to the flow of charge through them. "Conductor" implies that the outer electrons of the atoms are loosely bound and free to move through the material. Most atoms hold on to their electrons tightly and are insulators. In copper, the valence electrons are essentially free and strongly repel each other.

Insulators are materials that resist the flow of electricity, so electricity does not easily pass through. Examples are plastic, wood, rubber, cloth, air, glass. Some materials are better electricity insulators than others.

2.8 Relay

Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit. As relay diagrams show, when a relay contact is normally open (NO), there is an open contact when the relay is not energized. When a relay contact is Normally Closed (NC), there is a closed contact when the relay is not energized. In either case, applying electrical current to the contacts will change their state [12].

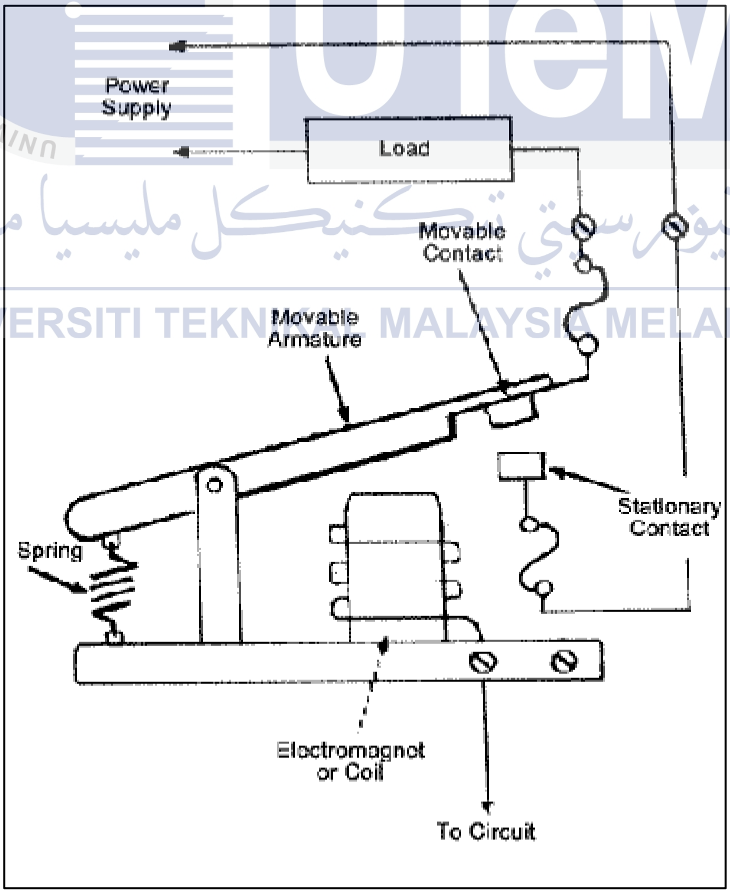

Figure 2.1: The internal parts of power relay system

Relays are generally used to switch smaller currents in a control circuit and do not usually control power consuming devices except for small motors and Solenoids that draw low amps. Nonetheless, relays can "control" larger voltages and amperes by having an amplifying effect because a small voltage applied to a relays coil can result in a large voltage being switched by the contacts.

Protective relays can prevent equipment damage by detecting electrical abnormalities, including overcurrent, undercurrent, overloads and reverse currents. In addition, relays are also widely used to switch starting coils, heating elements, pilot lights and audible alarms.

Based on Figure 2.1, relays involve two circuits: the energizing circuit and the contact circuit. The coil is on the energizing side; and the relays contacts are on the contact side. When a relays coil is energized, current flow through the coil creates a magnetic field. Whether in a DC unit where the polarity is fixed, or in an AC unit where the polarity changes 120 times per second, the basic function remains the same: the magnetic coil attracts a ferrous plate, which is part of the armature. One end of the armature is attached to the metal frame, which is formed so that the armature can pivot, while the other end opens and closes the contacts. Contacts come in a number of different configurations, depending on the number of Breaks, poles and Throws that make up the relay.

For instance, relays might be described as Single-Pole, Single-Throw (SPST), or Double-Pole, Single-Throw (DPST) [13].

Important terms in relays operation:

1. Frame
   - Heavy-duty frame that contains and supports the parts of the relay.
2. Coil
   - Wire is wound around a metal core. The coil of wire causes an electromagnetic field.
3. Armature
   - A relays moving part. The armature opens and closes the contacts. An attached spring returns the armature to its original position.
4. Contacts
   - The conducting part of the switch that makes (closes) or breaks (opens) a circuit.

2.9 Current Transformer

Current Transformers (CT) are used for current metering and protection in high voltage network systems. They transform the high current on the high voltage side into low current (1 or 5 A) adequate to be processed in measuring and protection instruments (secondary equipment, such as relays and recorders).

A current transformer also isolates the measuring instruments from the high voltage of the monitored circuit. Current transformers are commonly used for metering and protection in the electrical power industry [14].

There are several types of current transformer invented in this world, the type and the description of three common current transformer has been tabulated in table 2.3.

Table 2.3: Types of current transformer

Type	Description
Ring Core	available for measuring currents from 50 to 5000 amps, with windows (power conductor opening size) from 1" to 8" diameter.
Split Core	available for measuring currents from 100 to 5000 amps, with windows in varying sizes from 1" by 2" to 13" by 30". Split core CT's have one end removable so that the load conductor or bus bar does not have to be disconnected to install the CT.
Wound Core	designed to measure currents from 1 amp to 100 amps. Since the load current passes through primary windings in the CT, screw terminals are provided for the load and secondary conductors. Wound primary CT's are available in ratios from 2.5:5 to 100:5 (Models 189 and 190 are examples of wound primary CT's).

CHAPTER 3

DESIGN METHODOLOGY

3.1 Overview of Project Flow

The operation switchboard has been designed, this has been designed by using the schematic circuit. Next is the identification of the components needed. For example, contactor, power relay, current transformer etc. Thirdly, is purchasing item, this process takes two weeks of this project time frame. At the same time, the panel design and component placement has been overlaid by using AutoCAD 2010. The other simulations test also has been done to make the verification of this system operation such as Multisim and CX-One PLC Programmer. After all these components has been fabricated into the substation, the test was conducted as to test the relay operation for this system.

This project was carried out at ACIS Technology where they are experts in advance in control and intelligent system development.

3.2 Progress of the project

Table 3.1: Gantt Chart Final Year Project 1

No	Task	Weeks														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Collecting and study previous researches															
2	Implement data in the research															
3	Designing and modeling substation system and operation															
4	Testing simulation and improvise															
5	Collecting Result & Analysis															
6	Report Progress															
7	Presentation															

Table 3.1 shows the Gantt Chart of the Final Year Project 1 project planning. This project planning has achieved the first objective where to study and identify the functionality and process occurred in the distribution automation system.

Table 3.2: Gantt Chart Final Year Project 2

No	Task	Weeks														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Research on hardware implementation	■	■	■	■											
2	Purchasing components			■	■	■	■									
3	Overlay and fabricate hardware components				■	■	■	■	■	■	■	■				
4	Testing hardware and improvise							■	■	■	■	■	■			
5	Collecting Result/Analysis Result											■	■			
6	Report Progress											■	■	■		
7	Presentation													■	■	■

Table 3.2 shows the Gantt Chart of the Final Year Project 2 project implementation process. In this outline process, the remaining two objectives have been achieved where the designing and the verification of the substation built for the distribution automation system.

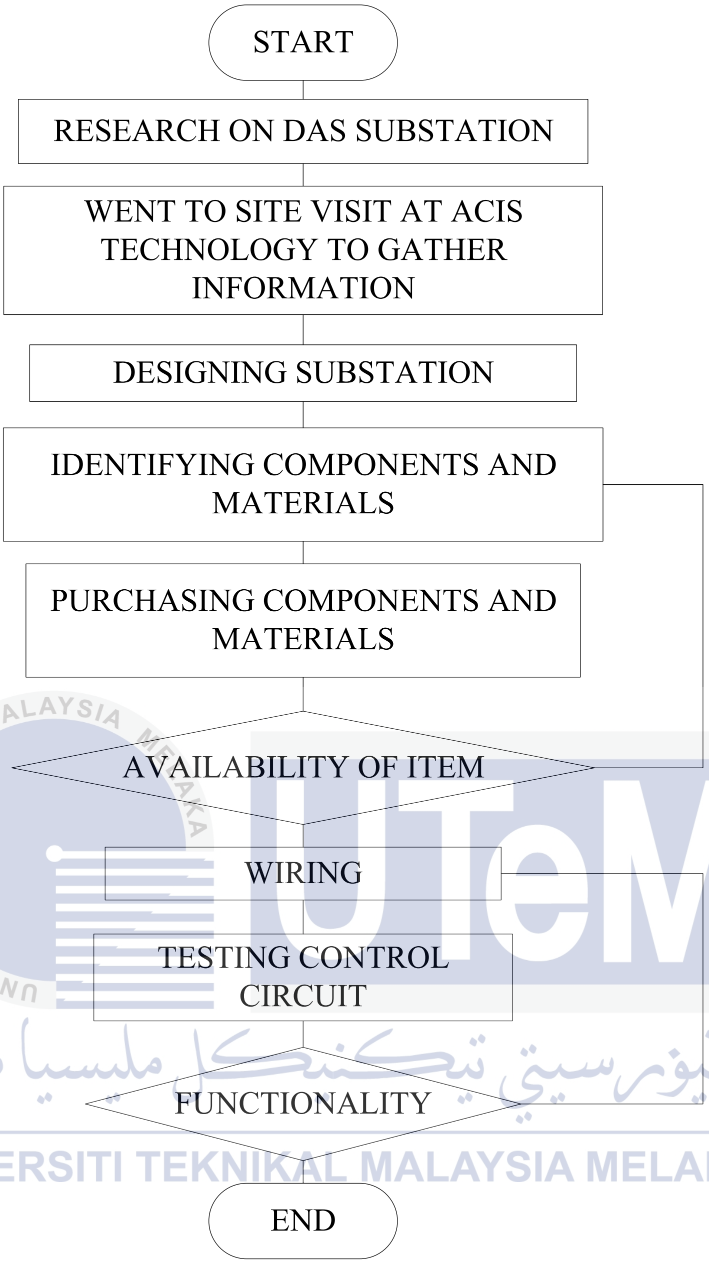

Figure 3.1: Flow chart planning for FYP

Figure 3.1 shows the overall process of developing this project. Every stage planned will justify the objectives highlighted earlier in this report.

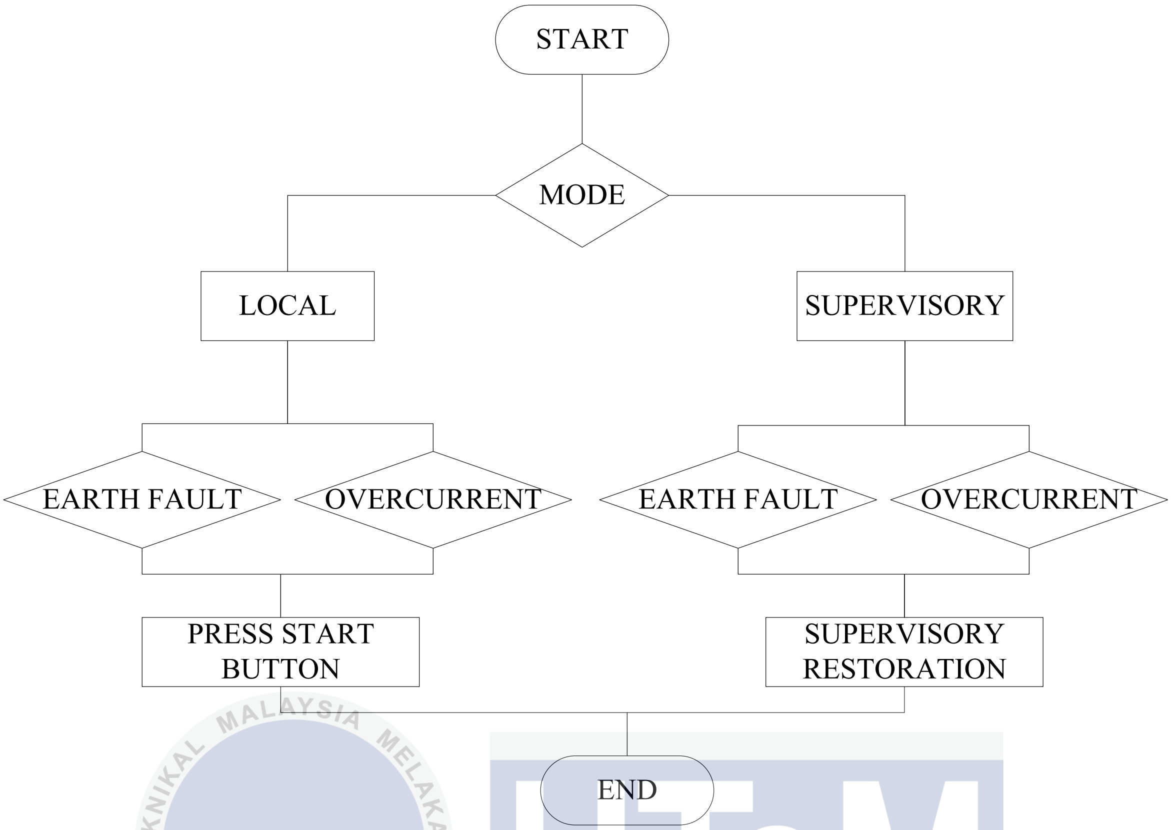

Figure3..2: Flow chart of substation control circuit

Table 3.2 shows the process of the substation. There are two selectable modes in this substation, the LOCAL and SUPERVISORY mode. The local mode is controllable only at the place where the substation is located while the supervisory mode can be controllable by using a SCADA system.

3.3 Implementation Project

3.3.1 Literature Review

The literature review section shows the study on the distribution automation system. Apart from that, the idea of overall system and the protection in low voltage distribution system also have been studied. There are several journals cited from the IEEE Explore, websites, books and product manuals.

3.3.2 Drafting

Drafting is a technical drawing made for this project. As for this project, Figure 3.3 shows the AutoCAD 2010 software which has been used in order to build the technical drawing for the substation. This drafting process, all the measurements can be shown. Such as depth, height and width of the design. The complete technical drawing has been attached in Chapter 4.

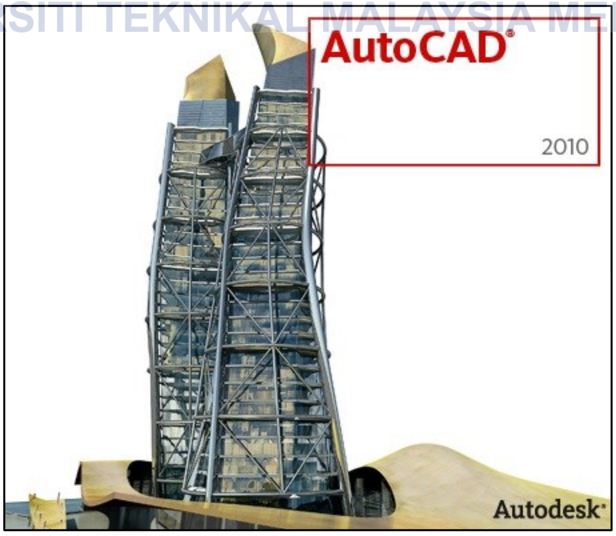

Figure 3.3: AutoCAD 2010

3.3.3 Component Selection

I. Remote Terminal Unit, ABB RTU211

By referring to the Figure 3.4, the Master Control Module here represents the RTU itself. While the Measurement and Fault Detection Module represent the IED used as the feeder. The communication media used in this block configuration is the serial communication RS 232 to RS 485. The status display module is the HMI of the system.

Besides that, the Optical MODEM is the communication media from the RTU to the control room server. Power supply module is the power block and the regulator for the RTU to operate and the Digital I/O is the signal processed from the feeder to the RTU.

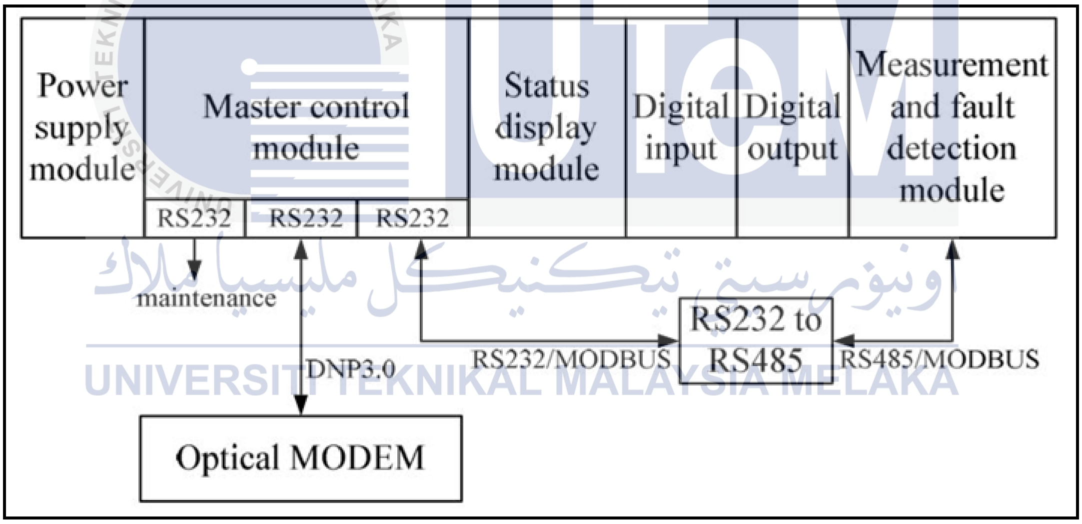

Figure 3.4: Remote terminal unit block configuration [7].

Table 3.3: RTU hardware

Hardware Serial and Name	Functionality
560 CM01 CPU Unit	Control process events and communications. Two microprocessors: • MPU 32 bit main processing unit • SLC 8 bit serial line controller
560 PSU10 Power Supply Unit	Input voltage: 24V DC Output Power: 38W
23BI61 Binary Input Unit	16 Binary input channel and supports: • Single Indicator • Double Indication • Pulse counter value input • 8 bit digital measured • 16 bit digital measured
23AI61 Analog Input Unit	6 analogue input channel and measures: • ± 2.5mA • ± 5mA • ±10mA • ±20mA • 4-20mA • ±1Vdc • ±10Vdc
23BO62 Binary Output Unit	8 potentially isolated output and the type of signals: • Object Command • Set point message • General output message

23AO60 Analog Output Unit	Current output type: • ± 2.5mA • ± 5mA • ±10 mA • ±20 mA • 4- 20 mA	Voltage output type: • ± 1.25 Vdc • ± 2.5 Vdc • ± 5 Vdc • ±10 Vdc

Table 3.3 shows the list of hardware inside the ABB RTU 211, the CPU Unit [6]. CMU01 is the device which managing and controlling the I/O boards via interface to the RTU 211 serial I/O bus. Apart from that, it writes commands to output and the reading process from the input. The communication with control centres and local MMI system via integrated serial line interfaces.

The Binary Input/output processor reads the input register and process each input according to the loaded process signal type and parameters. While the Analog Input/output processor control A/D converter and read digitized analog measured value.

II. Overcurrent and Earth Fault Detection Relay, MK2200

This relay employs extensive advanced numerical techniques which are implemented in real time for the computation of measured input quantity [9].

This protection relay has been chosen because it can measure the overcurrent and earth fault based on our desired setting. In this project, the output response used for this device is the two output contactors which are the R2 as the earth fault response contactor and the R3 the output response for the overcurrent fault.

The low-set start signal, high set-set start signal, low-set trip signal and high-set trip signal has been configured in the relay as tabulated in Table 3.4 and 3.5. The default setting should be changed to 1 for activating the features and change the overall binary combination to the hexadecimal value to be configured into the protection relay.

Based on Table 1:

S2.0: Overcurrent Low-set signal

S2.1: Overcurrent Low-trip signal

S2.2: Over current High-start signal

S2.3: Overcurrent High-trip signal

S2.4: Earth Fault Low-start signal

S2.5: Earth Fault Low-trip Signal

S2.6: Earth Fault High-start signal

S2.7: Earth Fault High-trip signal

1 = Connected

0 = Disconnected

	S2.7	S2.6	S2.5	S2.4	S2.3	S2.2	S2.1	S2.0
Default Setting	0	0	0	0	0	0	0	0
Default setting (Hexa)	0				0			
User setting								
User setting (hexa)								

Table 3.4: The configuration of R2 contactor in MK2200

Based on Table 2:

S3.0: Overcurrent Low-set signal

S3.1: Overcurrent Low-trip signal

S3.2: Over current High-start signal

S3.3: Overcurrent High-trip signal

S3.4: Earth Fault Low-start signal

S3.5: Earth Fault Low-trip Signal

S3.6: Earth Fault High-start signal

S3.7: Earth Fault High-trip signal

1 = Connected

0 = Disconnected

	S3.7	S3.6	S3.5	S3.4	S3.3	S3.2	S3.1	S3.0
Default Setting	0	0	0	0	1	0	1	0
Default setting (Hexa)	0				A			
User setting								
User setting (hexa)								

Table 3.5: The configuration of R3 contactor in MK2200

III. Universal Measuring Device

The UMG96S is suited for fixed mounting and the measurement of voltage, current, power etc. in low voltage distribution system. The measurement is designed for 3 phase systems with neutral conductor. The measurement and supply voltages must be connected to the UMG 96 via a separation (switch or power switch) and an overcurrent protection fuse (2-10A) in the building installation.

The auxiliary voltage needed for operation of UMG 96 is taken from the measurement voltages L1-N, L2-N and L3-N. To the current measurement inputs, either ../5A or ../1A current transformers can be connected.

For each random test one period is scanned. From those sampled values the microprocessor calculates the electric magnitudes. These measured values are indicated within the programmable display. The programming data and the minimum and maximum values are saved all 15 minutes in a non-volatile storage (EEPROM). The transistor outputs K1 and K2 can be used as switching or pulse outputs. The scanning frequency is calculated for all measuring inputs from the net frequency of phase one.

Current Measurement

Current transformers with a secondary current of 1A or 5A can be connected to the UMG 96 by choice. The pre-setting is a current transformer ratio of 5A/5A. As the secondary current, only 1A or 5A can be set. In programming mode the current transformer setting is marked with the symbol “CT”.

Figure 3.5 shows the example of the current setting and display from the UMG96S. There are Primary and secondary of the value displayed as same as the current transformer basic operation principle.

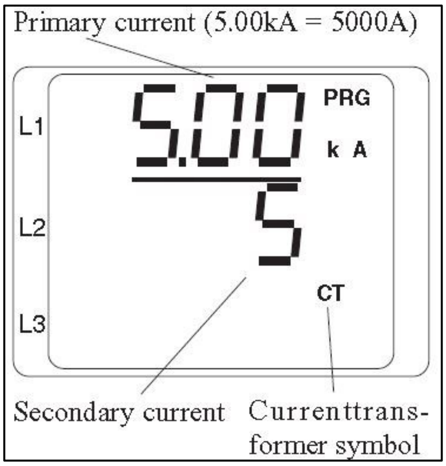

Figure 3.5: The Current Setting on UMG96S

Voltage Measurement

The UMG96S takes the measurement voltage as operating voltage. The measurement is designed for three phase systems with neutral conductor. The measurement and operating voltage must be connected to the UMG96S via separation and a fuse within the installation.

There are several selectable displays for the voltages in this measuring device; the secondary voltage and the phase voltage as shown in Figure3.6.

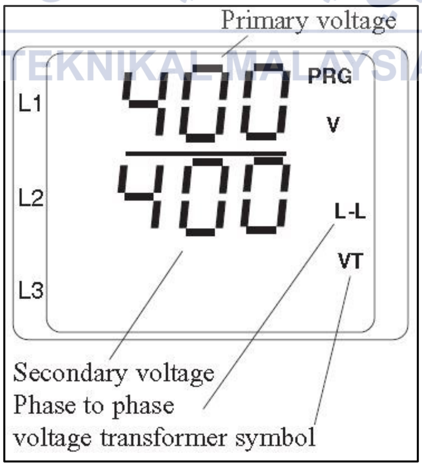

Figure 3.6: The Voltage setting on UMG96S

Serial Interfaces

Serial ports are used to transmit information in or out in one bit in a time. Different types of interfaces got different type of applications. Depending on the version of the UMG96S, there are three serial interfaces. The serial interfaces are:

Profibus DP

- The UMG96S has a 9-pole SubD sleeve on the back side. On this sleeve, a RS485 interface is wired, which is operated by the Profibus DP protocol. Via this RS485 interface, up to 32 participants can be connected. A repeater must be used if more participants needed.

RS232/MODBUS RTU

- The possible distance between two RS232 devices on the used cable and baud rate for a distance 15m the baud rate is 9600. The RS232 and RS 485 cannot be operated at the same time.

RS485/MODBUS RTU

  - All units shall be connected in a single line bus structure. Up to 32 units can be located within one segment. The termination resistor was used at each segments end.

Connection Diagram & Terminal Connection

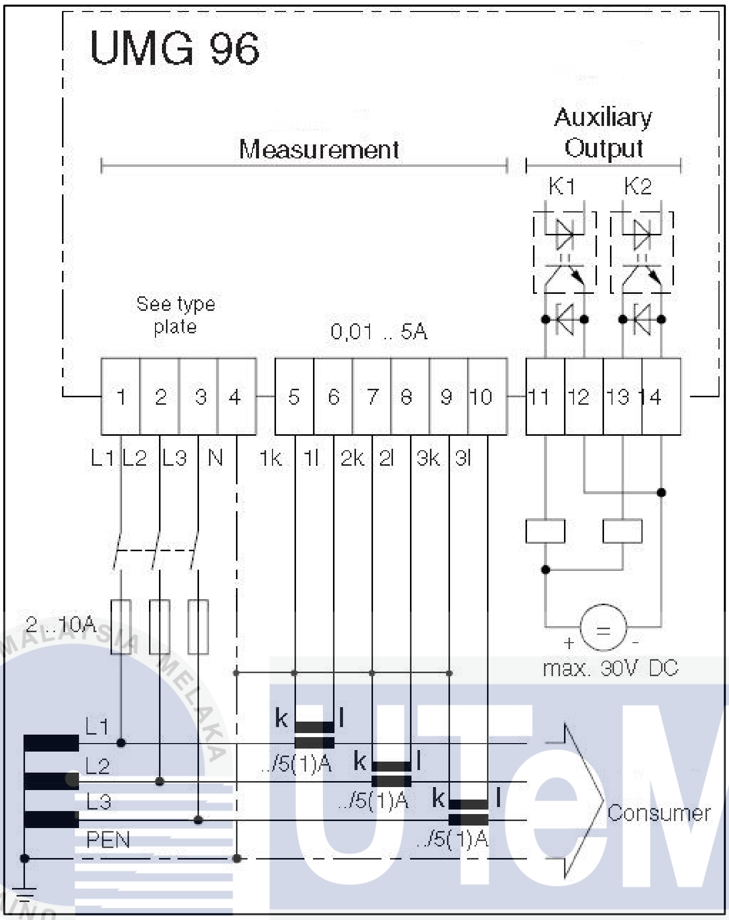

Figure 3.7: Connection Diagram UMG96S

The current measurement is carried out via current transformers of either ../5A or ../1A. The connection were showed in the Figure 3.7.

IV. Contactor SIEMENS Model 3TS34 11-0BB4

Figure 3.8 shows the contactor is a kind of relay, especially for switching electrical power circuits. There is a control coil that moves the spring loaded armature by magnetic attraction. The moving contacts are attached to the armature, and either make or break contact with fixed contacts. These contacts switch the electrical supply. There are a lot of configurations of contactors, such as coil voltage, AC, DC, the current rating of the contacts [11]. Some are fitted with auxiliary functions like overload sensors, other contacts to send lamp supervisory signals, test buttons.

Figure 3.8: Contactor DC 24 V

V. 3.6.5 Busbar

A bus bar is usually a thick strip of copper or aluminium that normally conducts electricity within a distribution board, switchboard, substation or any other electrical apparatus. Bus bars are usually used to carry or dispense very large currents, to a several devices that are inside the switchgear.

As for this project, the busbar with 600mm x 30mm x 3mm has been used. There are four bars representing L1, L2 L3 and Neutral. These busbar feeds currents to the incoming, load and the outgoing of the substation. Figure 3.9 is the sample of the busbar used.

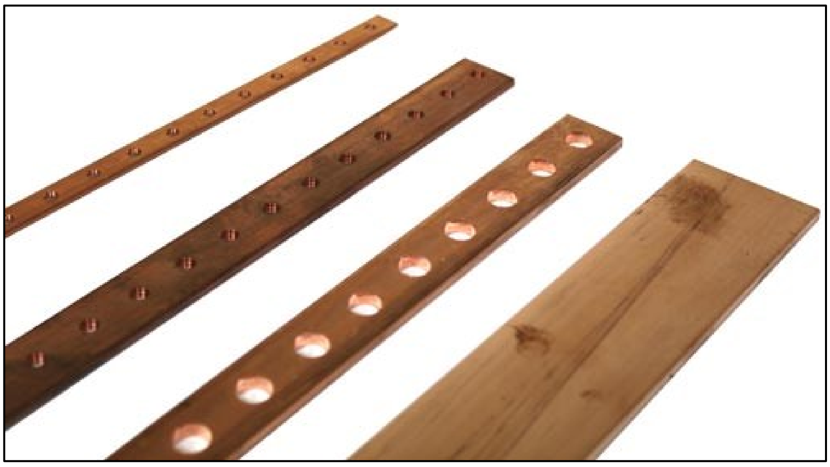

Figure 3.9: Various sizes of busbar

VI. Current Transformer

There are several steps that need to be taken before identifying what current transformer should be used [14].

1. Determining the current transformer ratio

   For the primary current, select the standard value immediately higher than the current to be measured.

   For the secondary current, choose 1 A or 5 A depending on the instrument or relay, and on the distance between the transformer and the instrument it is feeding:

   - 5A secondary is used when instruments or relays are close to the transformer, less than 10m.
   - 1A secondary is preferably selected when the distance between the current transformer and the instrument transformer or the relay is above 10m.

32

2. Determining the current transformer output
    - It is recommended to select the output rating as close as possible to, but higher than the calculated burden, since the characteristics regarding accuracy and safety factor might otherwise be modified.
3. Defining the accuracy class as per the application
    - The class of the current transformer:

      Standards = Class 0.1 or 0.2

      Tariff metering= Class 0.5 - 0.5S - 0.2 - 0.2S

      Industrial division metering = Class 1

      Measure display = Class 1 or 3

      Protection = Class 5P or 10P
4. Defining the transformer type with focus on fitting
    - When the primary current is very low, a few amps to a few tens of amps, a wound primary transformer is preferably used. Their performances are reduced when the primary current is quite low.

VII. Power Relay

Based on the literature reviews, the power relay that suits this application is the one DC 24V. For this project, the IDEC RU2S-C-D24 model has been chosen. Despite with the relevant rating and performance, this model is currently available in the market and quiet easy to find any retail. This is the double pole double throw power relay. Table 3.6 shows the characteristic of the power relay chosen.

Table 3.6: The DPDT power relay characteristics and performance.

Coil Rating	24 VDC
Contact Rating	250 VAC / 30 VDC
Contact Resistance	50mΩ max
Minimum Applicable Load	24 VDC
Operating Time	20ms max
Release Time	20ms max

Apart from that, there are also the 4-throw power relay used in this hardware implementation. The model of this relay is IDEC RY4S-UL. Table 3.7 shows the characteristic and performance of the double pole four throw relay.

Table 3.7: The DP4T power relay characteristic and performance.

Coil Rating	24 VDC
Contact Rating	660VA AC / 90W DC
Contact Resistance	50mΩ max
Minimum Applicable Load	110V AC / 220 V AC / 30V DC
Operating Time	20ms max
Release Time	20ms max

3.3.4 Simulation

The simulation stage has been done by using PLC CX-One Programmer and also Multisim 11.0 softwares. The aim for this simulation testing is to validate the functionality of the control circuit as well as obtaining the wiring connection for the actual hardware wiring. Apart from that, the current and the voltages has been measured to ensure the condition of the components were not exceeding its limit. All the circuit designed has been analysed in Chapter 4.

3.3.5 Fabrication

The fabrication process is the further stage after complete purchasing all the components needed. The fabrication is included cutting the steels, drill the screw holes, attaching the bakelite into the panel etc.

3.3.6 Hardware Testing

After the complete circuit has been done, the testing must be done in order to justify the process planned earlier. All the result has been attached in Chapter 4.

3.3.7 Troubleshooting

It is important to have the control circuit drawings, details of devices, their interconnection and interlocking while troubleshooting the control circuits. ‘Block Interlocking Diagram’ and ‘Control Sequences’ of the equipment/machine operations should be available during troubleshooting. Drawings and details of the power circuit of the equipment or the machine, control devices, contactors, timers, counters, safety, and protection devices, etc. are needed for troubleshooting the root cause.

Appropriate test and measurement instruments required for testing the control and power circuit of the equipment, or the machine must be available.

To troubleshoot the problem, perform the following steps:

(i) Check the control supply, check control voltage between DC positive, and negative terminal.

(ii) Check whether each relay has tripped. Check this with the help of a multimeter. Check voltage between the neutral terminal and the outgoing terminal of the relay contact, connected to the stop pushbutton. If the overload relay has not tripped and the multimeter shows that the control voltage between the two points is OK, then go to next point.

(iii) Check the control voltage at the stop pushbutton outgoing terminal to the start pushbutton. If the voltage is OK, then go to next point.

(iv) If two NO contacts are connected in parallel to each other, and the motor runs only when the start pushbutton is pressed, it indicates that, the NO contact of the main contactor must close as soon as the main contactor is switched on. It also indicates that the contactor that holds the control circuit on is not closing. The wires connected in parallel from the NO contact to the start pushbutton NO contact may be closed, or the NO contact of the main contactor is not closed, due to a faulty contact. To confirm this, take a loop of insulated wire, and short the contact. This change the NO contact block of the main contactor.

CHAPTER 4

RESULTS

4.1 Schematic Diagram

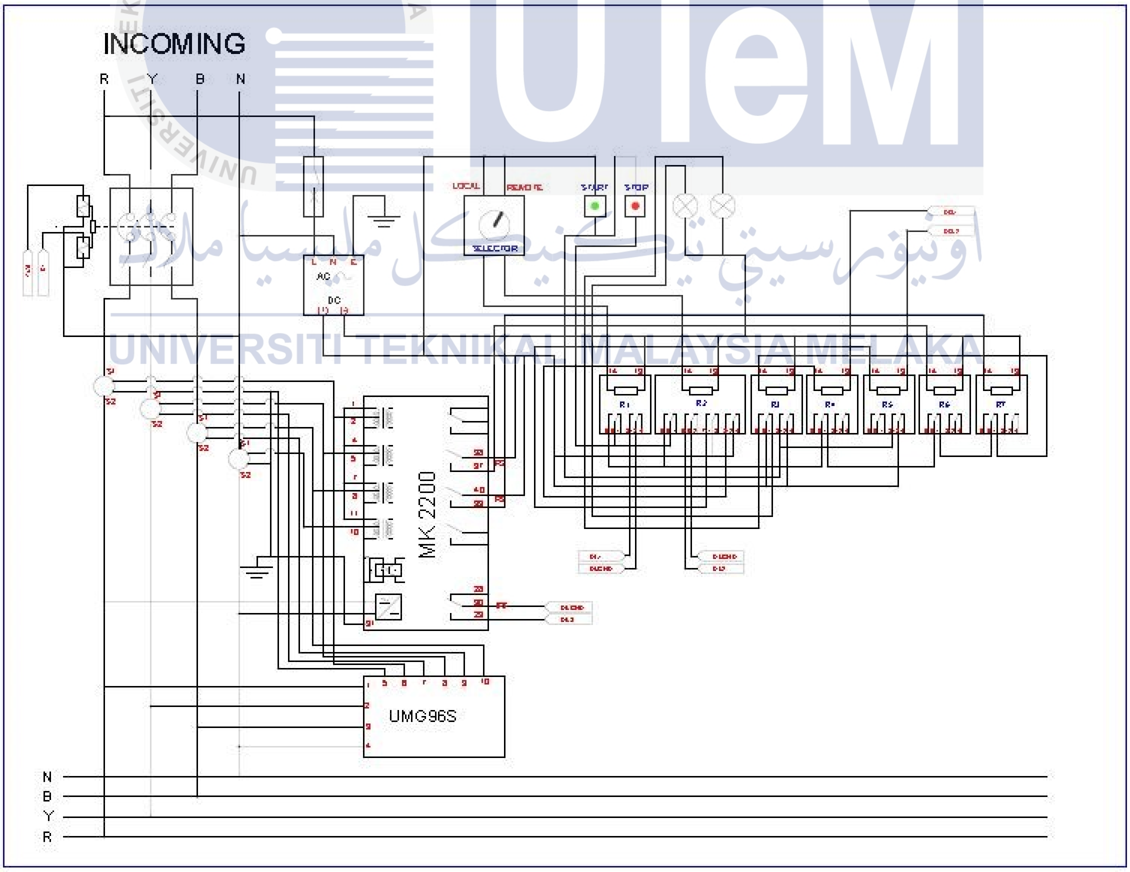

Figure 4.1: The overall substation system schematic circuit

The overall substation system schematic diagram circuit is shown in Figure 4.1 and the schematic diagram of the control circuit is shown in Figure 4.2.

By referring to the Figure 4.1, the MK2200 is the protection relay which gives input response to the control circuit if there is any earth fault or overcurrent happened. The input of the MK2200 is the amount of the current flow from the current transformer to it. The response is based on the setting configured in MK2200. Apart from that, the UMG96S was placed as to monitor the value of the voltage and current.

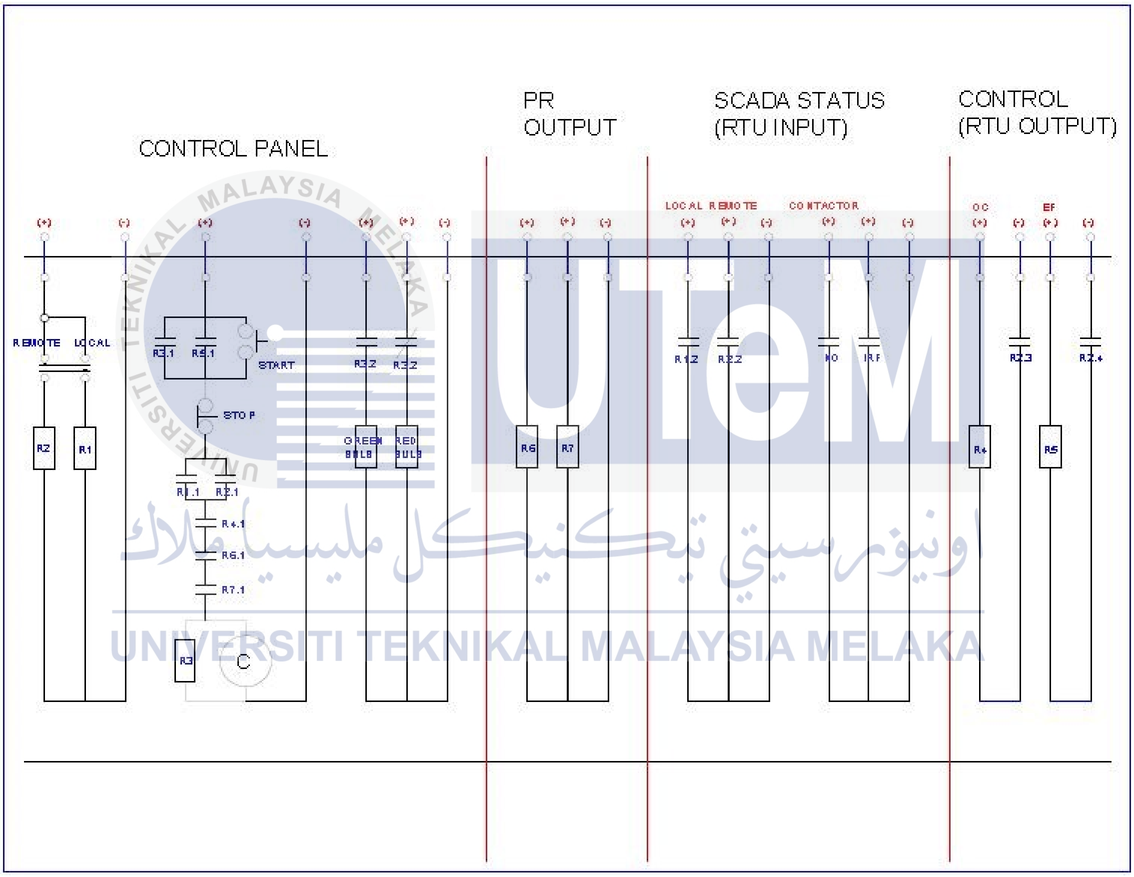

Figure 4.2: The schematic diagram for the control circuit.

The schematic circuit was made at the designing system stage. By referring to the Figure 4.2, there are 4 sections divided from the control circuit. The main control panel, which is to cut off the contactor, the output response received from the protection relay, the SCADA input as the system status and controllable output made from the RTU.

4.2 Switchboard Panel

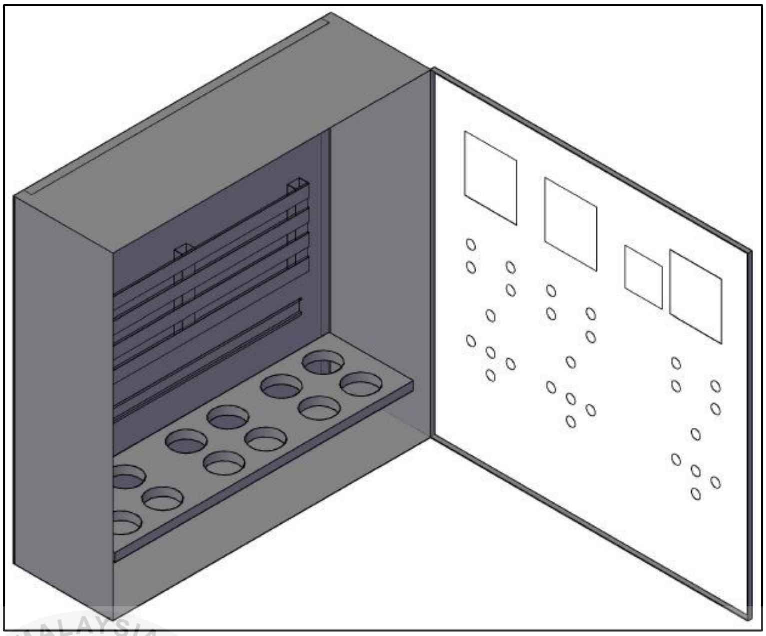

Figure 4.3: Switchboard 3D view

Based on Figure 4.3, the switch board consists of three parts; incoming, outgoing and the load. This figure shows the arrangement of the components that will be placed inside the substation. There are three slots for protection relay, the busbar as for the power supply, controller switch and the bracket for the current transformer.

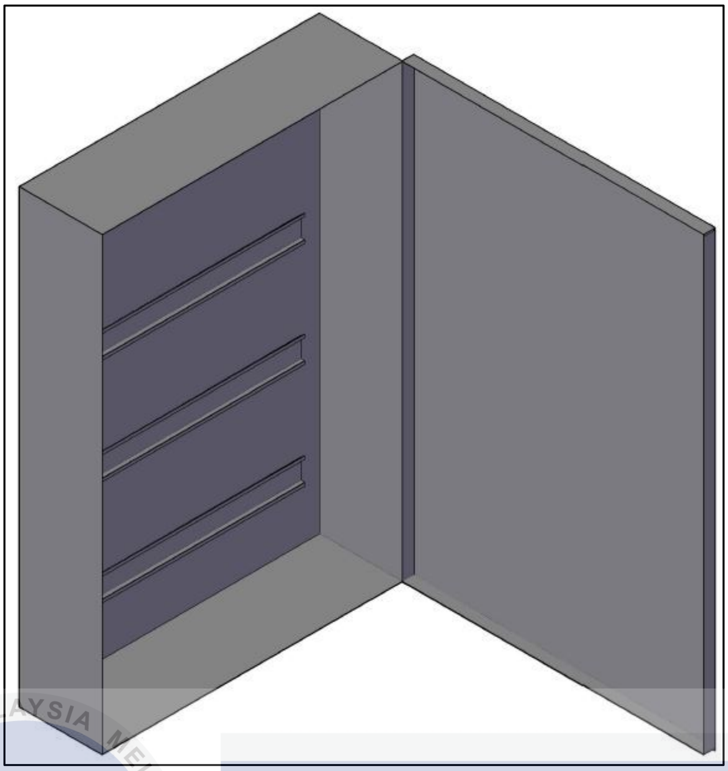

Figure 4.4: Switchboard controller panel casing

Figure 4.4 shows the din rail made for the power relay and the terminal block for the incoming, outgoing and the load respectively. The actual arrangement of this control circuit has been attached into the attachment section.

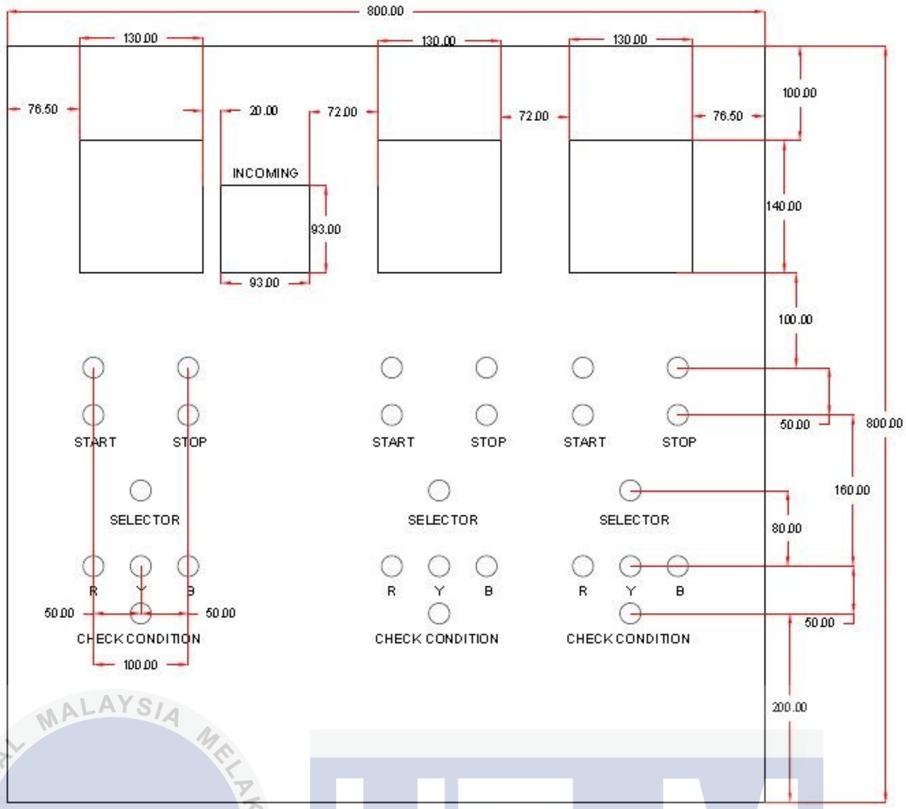

Figure 4.5: Switchboard panel front dimension

Figure 4.5 shows the dimension of the panel box for the substation. Each protection relay indicates the incoming, outgoing and load respectively. This figure shows the arrangement made for placing the current transformer, busbar, switches and the protection relay.

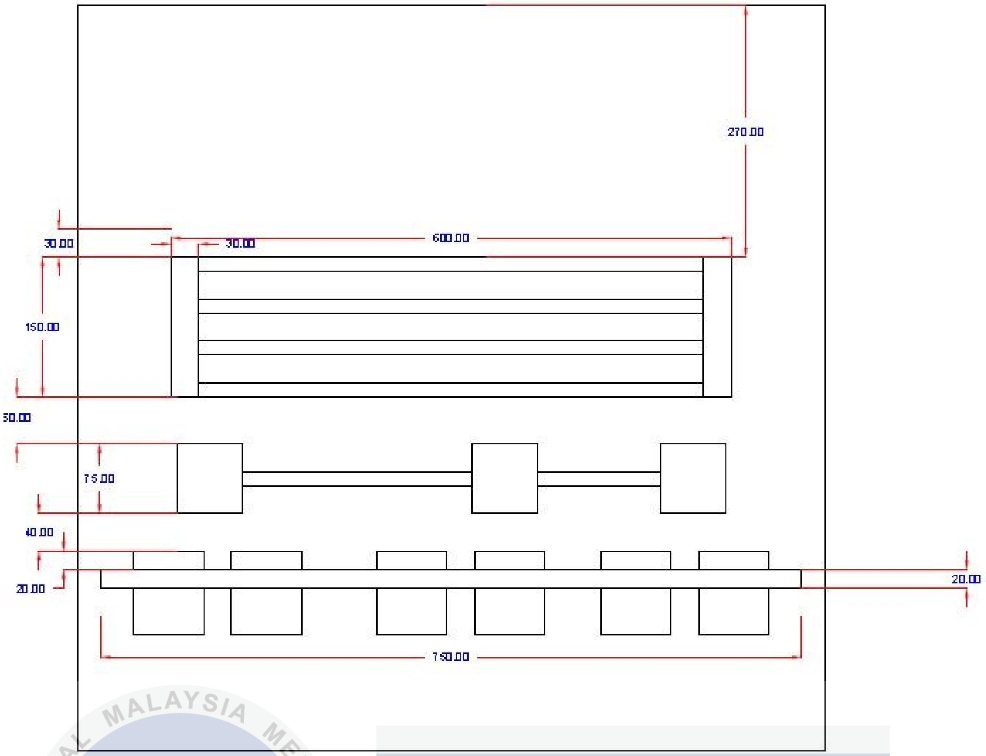

Figure 4.6: The internal arrangement of the substation

Theoretically, the three phase system consists of L1 (RED), L2 (YELLOW), L3 (BLUE) and Neutral (BLACK). There are four busbars which represent each phase required in power system shown in Figure 4.6. The wires are attached from the busbar to each contactor. Then the wiring goes inside the current transformer core to be analysed and the output is connected to the protective relay.

4.3 Hardware

4.3.1 Checklist items

Table 4.1 shows the total amount of components used for developing this system. It cover the incoming, outgoing and the load section of the distribution system.

Table 4.1: Checklist of component used for this project

Item	Amount	Description
Main Panel Switchboard	1	800mm x 800mm
Controller Panel	1	400mm x 600mm
AC Contactor 64A	3	
Busbar	4	600mm x 20mm
Bakelite	2	190mm x 20mm x 30mm
	1	750mm x 210mm x 20mm
Current Transformer	12	500/5A
Overcurrent and Earth Fault Relay	3	Mikro, MK2200
Universal Measurement Device	1	UMG96S, Janitza
AC Lamp Indicator	3	AC Red
	3	AC Blue
	3	AC Yellow
	3	DC Green
	3	DC Red
Electrical Selector	3	Kraus & Naimer
AC to DC Power Supply Adapter	1	240 V AC / 24 V DC
Switch	6	Green
	3	Red
Din Rail	3 meter	Material of Aluminium

4.3.2 Testing the control circuit

(i) Overall

When the START button is switches on, the relay, R3 started to energize and its contactor will latch the power supply for the controller circuit. Apart from that, the Main Contactor will also magnetize and allowing the 415V to flow into the system.

The STOP button can trip all the operation. Either in local or the remote access. The system can be resumed when the restoration is triggered in remote condition or the start button pushed in the local mode.

(ii) Local

Local process is where the maintenance occurs at the substation and the system is manually reset by the worker. During this operation the remote access was isolated. Therefore, any response from the control station could not be reached at this time.

When isolated, the selector will switch on the relay R1, thus it energized and the contactor will turn to NC and gives the signal to the RTU at the D1 terminal about the status of the current selection, the other contactor will complete the power source circuit to be run when the START button is pushed.

Based on Table 4.2, the selector switched on R1 to activate the R3 to be latched the control system circuit. The contactor will respond based on the status of R3. R3 isolated the control circuit and the contactor.

Table 4.2: Relay status on local mode

Relay	Status
R1	ON
R2	OFF
R3	ON
R4	OFF
R5	OFF
R6	OFF
R7	OFF
Contactor	ON

(iii) Remote

When the system is switched into the Remote access, the system is controllable from the control room by SCADA. At this stage, the system can also disconnect manually and remotely. Apart from that, this remote access can be used to obtain data, as well as reconfigure the protection relay, MK2200 remotely.

Based on Table 4.3, the selector switched on R2 which allow the control from the SCADA system. The contactor of R2 will complete the power supply circuit as well as activating R3.

Table 4.3: Relay status on remote mode

Relay	Status
R1	OFF
R2	ON
R3	ON
R4	OFF
R5	OFF
R6	OFF
R7	OFF
Contactor	ON

Cut off system can only be made in remote access mode. This is where the control room disconnects the whole system by sending a step signal from the control room. Based on Table 4.4, the R4 was placed to bypass all the signals sent to the R3 to be disconnected.

Table 4.4: Relay Cut Off condition

Relay	**Status**
R1	OFF
R2	ON
R3	OFF
R4	ON
R5	OFF
R6	OFF
R7	OFF
Contactor	OFF

The restoration process can only be made in remote condition where the SCADA system sends a pulse signal to the system and activating R5 as shown in Table 4.5. R5 will complete the main control circuit as well as continue latching the circuit. The pulse signal was sent to the External Digital Input of the MK2200. Based on its specification, it will trigger with 24V DC or 220 VAC. In this system, the 24 V DC was chosen.

Table 4.5: Relay status on Restoration Process

Relay	**Status**
R1	OFF
R2	ON
R3	ON
R4	OFF
R5	ON
R7	OFF
Contactor	ON

(iv) Fault detected from protection relay, MK2200

When there is an overcurrent happens, R6 disconnect the main control circuit as shown in Table 4.6. While the earth fault situation will trigger the R7 to disconnect the system as shown in Table 4.7. The contactor from the MK2200 is connected makes the step signal were sent to those relays and makes the system stays OFF until the system was reset. The MK2200 can to be restored by using the Restoration Process mentioned earlier, manually go to the substation and press reset button or it will restore by itself automatically based on the setting mode. In this project, the automatically restored are not included.

Table 4.6: The Overcurrent Relay status

Relay	Status
R1	ON if in Local Mode
R2	ON id in Remote Mode
R3	OFF
R4	OFF
R5	OFF
R6	ON
R7	OFF
Contactor	OFF

Table 4.7: The Earth Fault Relay status

Relay	Status
R1	ON if in Local Mode
R2	ON id in Remote Mode
R3	OFF
R4	OFF
R5	OFF
R6	OFF
R7	ON
Contactor	OFF

CHAPTER 6

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The project title low voltage distribution network system based on the ABB RTU211's input and output representing the construction of the substation to be controlled by using the remote terminal unit, ABB RTU211. However, the configuration of the remote terminal unit has not been included in this project. The key aspect discussed on the process and manufacturing of the substation in the distribution automation system was precisely explained and illustrated with technical drawings in order to obtain justification regarding the necessary action and precaution in developing the substation. Subsequently, this substation is one of the three similar substation that need to be made to achieve the project contribution of the development of distribution automation system.

The first objective has been met during the first semester of the Final Year Project progress. The process in fault identification by remote terminal unit in distribution automation system information has been gathered and analysed briefly. Usually, the source of the information was based on the previous research and implementation. The second objective has started on the first semester and were achieved on the second semester. The substation development was carried out at ACIS Technology Sdn Bhd. They provide advanced control and intelligent system development. The next objective can be done when the previous two objectives have been met. The verification of the process has been done and the results obtained were successfully as planned.

The designing stage is the brainstorming ideas to come out with the process of the system. Then, two conditions have been decided which were Local Mode and Remote Mode. Those are the two different ways to handle this substation. The item identification stage were depending on the availability of the product. Apart from that, the wiring stage was completely done based on the schematic circuit done in the brainstorming stage. The testing stage was done successfully done.

Finally, all the progress planned for this project was successfully followed accordingly.

5.2 Recommendation

Conventionally, the substation is almost the same, the difference is how the control circuit does the controlling process. As for the recommendation, this project should be implemented various kinds of process from the system such as, the collection of data and the monitoring of the system.

Apart from that, the controllable substation can be done by using GSM or any other communication media related. The RTU can be varied and the functionality can be added more.

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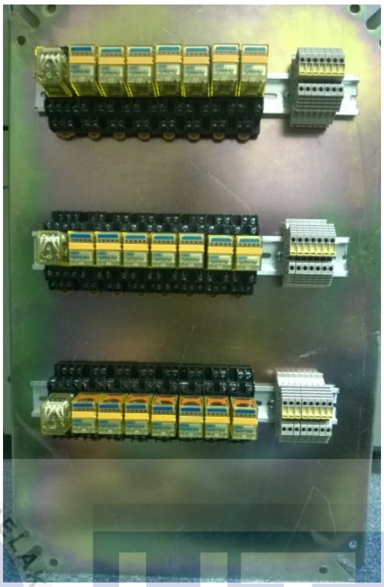
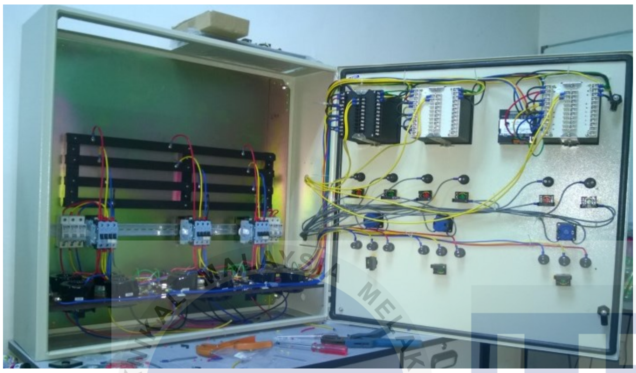
APPENDICES

		
Bakelite cutting process as the CT holder.	The Power Relay arrangement for control circuit	The contactor used for this project. Model SIEMENS 3TS34 11-0B

	The current Transformer used for this project Ratio: 100/5A Class 1 VA: 15

	The Final outside view of the substation. The most left is the incoming, followed by outgoing and load.
	Wiring progress for the substation.
	The component placement before wiring process.