FACULTY OF ELECTRICAL ENGINEERING

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FINAL YEAR PROJECT REPORT

DEVELOPMENT OF HUMAN MACHINE INTERFACE (HMI) AND INTERFACING FOR LOW VOLTAGE DISTRIBUTION AUTOMATION SYSTEM (DAS)

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"I hereby declare that I have read through this report entitle "**Development of Human Machine Interface (HMI) And Interfacing for Low Voltage Distribution Automation System (DAS)"** and found that it has complied the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation & Automation) with honours"

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DEVELOPMENT OF HUMAN MACHINE INTERFACE (HMI) AND INTERFACING FOR LOW VOLTAGE DISTRIBUTION AUTOMATION SYSTEM (DAS)

Submitted By:

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A progress report submitted in partial fulfilment of the requirement for the degree of

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I declare that this report entitle “**Development of Human Machine Interface (HMI) And Interfacing for Low Voltage Distribution Automation System (DAS)”** 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 candidate of any other degree.

Signature : ....

Name : MOHAMMAD HARIZ BIN ZARIR

Date : ....

Dedicated, in thankful appreciation for support, encouragement and understandings

To:

My supervisor, Prof Madya Mohd Ariff bin Mat Hanafiah

My beloved father and mother, Zarir Bin Ahmad and Nasiah Binti Nasro

My family members and all friends

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ABSTRACT

In this technology era, the need of electricity is beyond the demand. Such this requirement is to be fulfilled every time. This is because the power distribution system is one of the most important parts of a power system in the delivering electricity to consumers. Therefore, in this study, the Distribution Automation System (DAS) technique was used to solve the problems experienced by the 415/240V low voltage distribution system due to the line under repair or fault. The development of the Human Machine Interface (HMI) and the Interfacing in this project will help to detect and identify fault and restore the system back. Thus, all the equipment can be controlled and monitored remotely.

ABSTRAK

Dalam era teknologi ini, keperluan tenaga elektrik adalah di luar permintaan. Seperti keperluan ini adalah yang perlu dipenuhi setiap masa. Ini adalah kerana sistem pengagihan kuasa adalah salah satu bahagian yang paling penting dalam sistem kuasa dalam penghantaran elektrik kepada pengguna. Oleh itu, dalam kajian ini, teknik Sistem Pengagihan Automasi (DAS) telah digunakan untuk menyelesaikan masalah-masalah yang dialami oleh 415/240V sistem pengagihan voltan rendah seperti wayar sedang diperbaiki atau bersalah. Pembangunan Antara Muka Manusia Mesin (HMI) dan perhubungan dalam kehendak projek ini membantu untuk mengesan dan mengenal pasti kerosakan dan memulihkan sistem semula. Oleh itu, semua peralatan boleh dikawal dan dipantau dari jauh.

MOTIVATION

This project is expected to contribute some improvements to the distribution network management field and also deal with fault occurrence efficiency on the distribution side. By conducting this project, it enables the student to learn about power system management. Besides, it provides a clearer understanding on how to develop the Human Machine Interface (HMI) based on student creativity. The developments of prototype for LV substation panel also give extra knowledge how the substation operates and how to control it. Other than that, this work can be a guideline for the student if want to involve in power system management in future.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

An electrical power system is a network of electrical components that consist of generation, transmission and distribution. These three major part also known as the grid. Each grid may have minor differences between countries due to geographical factors, demand variances, region and etc. These power grids typically transmits electricity in three levels of voltage which are High Voltage (100,000 Volts upwards), Medium Voltage (1000 Volts to 100,000 Volts) and Low Voltage (1 to 1000 Volts). The generation gains its electricity from the power plant system. For the transmission system, it carries the power from the generating centres to the load and the distribution system feeds the power to the consumer [1].

The Distribution Automation System or known as DAS is a complete automation of all controllable equipment and functions in this distribution power system. It enables to remotely monitor, control and regulate the distribution assets and network using connectivity from the substation of the consumer and the distributed resources. This system also optimizes the flow of electricity from the utility to the consumers, and to ensure the system operates efficiently and reliably.

1.2 Problem Statement

A major requirement of the electricity supply systems is high supply reliability for the consumer which is mainly determined by the distribution network. But the disruption on the low voltage downstream 415/240V system such as overloading, line under repair or other fault will cause the interruptions of electricity supply to the customers. Thus, the technicians has to manually locate the faulty point before restore it back and this tedious work may last for extended periods of time.

Considering the extensive size of the network, all problems can be effectively solved. This system of monitoring and controlling of electric distribution networks is known as Distribution Automation System (DAS). Thus, by creating the Human Machine Interface (HMI) and Interfacing between the control room and distribution substation, fault identification, fault clearing task and system restoration of low voltage downstream 415/240V can be done easily using DAS solution technique. Therefore, all faults that occur on the distribution line can be controlled and monitored in order to enhance supply reliability and quicker response to satisfy the customers.

1.3 Objectives

The main objectives of this project are:

1) To develop a Human Machine Interface (HMI) for Low Voltage Distribution Automation System (DAS) by using InduSoft Web Studio (IWS).
2) To implement I-7188EG controller which acts as Interfacing for the Low Voltage Distribution Automation System (DAS).
3) To develop a prototype of a real Low Voltage Distribution Automation System (DAS).

1.4 Scope of Research

The research architecture of Distribution Automation System (DAS) consists of three major parts. The first part involves the study of Human Machine Interface (HMI) which run under the Microsoft Window (XP or above version) platform using InduSoft software. This part provides monitoring for the substation remotely. The second part consists of I-7188EG controller embedded Ethernet. This controller acts as the Interfacing for the DAS. The logic programming will be downloaded into the controller by using IsaGRAF software. This controller is used to handle all the control function between the HMI and substation. Last part is the study of the control circuit in the substation panel that will be used as the I/O modules for the controller.

1.5 Contribution of Project

This project is expected to contribute some improvement to the distribution network management field and also deals with fault occurrence efficiency on the distribution side. By utilizing this system, the effect of fault occurs of 415/240V can be minimized. Besides, it will provide a clearer understanding to the power utility company about the process and the advantages of the Distribution Automation System (DAS). Other than that, this work can be a guideline for other researcher who wants to make improvements of this project in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this chapter, it will explain more on the theory and basic concept that have been used to achieve the project objectives. To achieve all the goal, several numbers of studies has been conducted which covered the software and hardware part. Besides, the information about previous work also had been mentioned in this chapter. Thus, this chapter is very important in order to provide a clearer understanding about the system.

2.2 Project Background

2.2.1 Low Voltage Distribution System

In general, Low Voltage (LV) Distribution System refers to an electricity supply with a rating from 1 to 1000 Volts. It serves at the last stage of electric power system as a sources of energy supply for the consumer side. The LV receives power supply after passing through the substations that step-down the Medium Voltage (MV) from 11 kV to 415 Volts. From that, three-phase system (415 Volts) and single-phase system (120/240 Volts) is produced for the uses of consumer. Figure 2.1 below is shown the overall process of electrical power system from the first stage to the last stage.

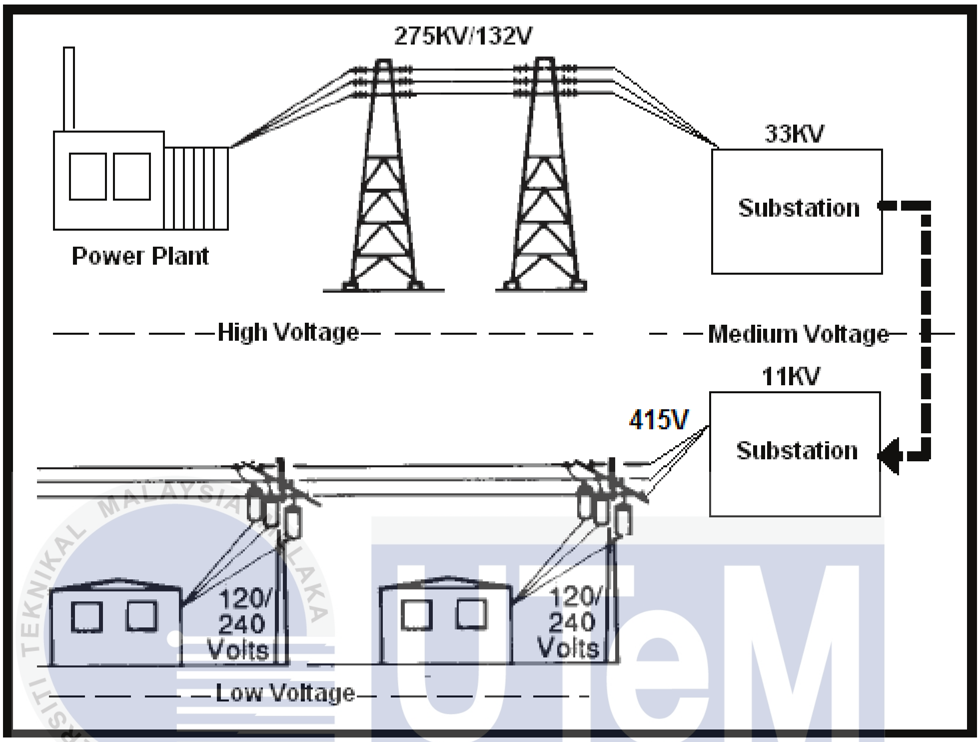

Figure 2.1: Typical Power Production and Distribution Process.

2.2.2 Distribution Automation System (DAS)

2.2.2.1 Introduction of DAS

Distribution Automation System (DAS) is the complete automation of all controllable equipment and functions in the distribution power system. It is basically a system that allows for automatically monitor, computerized control of a utility's distribution facility with little or no human intervention [1]. The main purpose of the distribution automation system is to improve the efficiency of the supply restoration time under unplanned outage condition.

In this system, the electrical parameters and other various quantities are recorded and then have been feed using a data acquisition device called RTU. These quantities are transmitted to a central computer control through a communication medium. The acquired data is processed and displayed using a Graphic User Interface (GUI). In the event of a system quantity crossing a pre-defined threshold, an alarm is generated. The necessary action will then be determined by the computer and the command will then be sent to the RTU to be executed[1]. Based on Figure 2.2 below, the interconnection of distribution, control and communication system for Distribution Automation System (DAS) is shown.

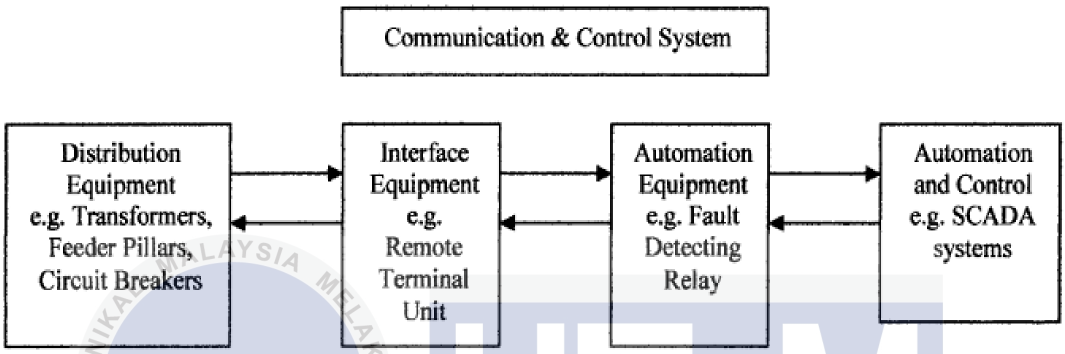

Figure 2.2: Interconnection of Distribution, Control and Communication System[1].

2.2.2.2 The Advantage of DAS

In this millennium age, distribution automation system (DAS) seems to be the best choice to be added to every distribution network. Especially when the system needs for controlling and monitoring from far placed. DAS also gives a big advantage to the utility company in managing the distribution system. There are as follows:

- Increase the distribution reliability by improving the operations and maintenance work.
- Give faster disturbance analysis and fault location.
- Provide asset monitoring for aging infrastructure and avoid asset from overloading.

2.2.3 Human Machine Interface (HMI)

Human Machine Interface (HMI) is a medium that acts as a user interface which allow the user to interact with the machine in a graphical way. It provides a monitoring, controlling and managing a system process. Thus, the user can view all the status and data just from the monitor of the computer instead going directly to the system.

There have several types of HMI software that is currently used in the market. The Table 2.1 describes the details for all the types of HMI that commonly used.

Table 2.1: Type of HMI.

Type	Details
InduSoft Web Studio (IWS)	- Enable to build full-featured Supervisory Control and Data Acquisition (SCADA) or HMI applications for industrial automation. - Using build-in language which easier to use.
Visual Basic (VB)	- A program that creates an application using the components provided but required higher understanding in programming language.
LabVIEW	- System-design platform and development environment for a visual programming language.

2.2.4 Communication Network

Communication network is divided into two groups. There are wired and wireless network. For wired network, it uses cable as a connection medium. Fiber-optic cable, power line carrier (PLC) and coaxial metallic cable are several types of wired network. While wireless network is generally implemented and administered using radio communication. Wireless network also has several types which are a Wireless Personal Area Network (WPAN), Wireless Local Area Network (WLAN), Wireless Metropolitan Area Network (WMAN) and Wireless Wide Area Network (WWAN). Table 2.2 below will describe the advantages and disadvantages of Wired and Wireless network.

Table 2.2: Advantages and disadvantages of Wired and Wireless network.

Type	Advantage	Disadvantage
Wired Network	- Ethernet cables, hubs and switches are very inexpensive. - Some connection sharing software packages are free. - Extremely reliable. - Wired LANs offer superior performance.	- Need to run cables in difficult environments through walls, floors and ceilings. - Network cables can disconnect or become faulty consequently causing the connection to fail.
Wireless Network	- Mobile computers do not need to be tied to an Ethernet cable and can roam freely within the WLAN range. - It is relatively easy to set up a WAP and configure a WNIC using a wireless connection utility.	- The potential for radio interference due to weather, other wireless devices, or obstructions like walls. - If one major section breaks down, for example the Router, the whole network will be affected.

2.2.5 Field Device Interface

Field device is acting as the data acquisition, which designed to send and receive data. This field device comes with variety choice such as microcontroller, microprocessor and etc. The table below will describe the advantage and disadvantage of PIC Microcontroller and I-7188EG Controller. The advantages and disadvantages of PIC Microcontroller and I-7188EG Controller is described in Table 2.3 below.

Table 2.3: Advantages and disadvantages of PIC and I-7188EG Controller.

Type	Advantage	Disadvantage
PIC Microcontroller	- Can have varieties of function depends on the requirement.	- Required the knowledge of programming language.
I-7188EG Controller	- Easy to program. - Can have varieties of I/O module.	- The price is very expensive. - Required the knowledge of logic control.

2.2.6 Low Voltage Substation Panel

2.2.6.1 Protective Relay

A protective relay is the unit for supervising the electric circuits based on certain ranging. Its main objectives are fault detection and reading measurements supplied from connected devices, such as current transformers, voltage transformers, position indicators etc. Therefore, when a measurement is out of set up specification, the relay then gives trip commands to a circuit breaker to cut-off the whole system. The following table will describe about the type of protective relay. Table 2.4 describes the type of protective relay in the market.

Table 2.4: Type of Protective Relay.

Type	Details
MK2200	Protection and measuring unit for the power system. Able to detect low current, over current and earth fault.
ABB Relion	A feeder protection and management relays. Also provide versatile communication as well as sophisticated functionality.

2.2.6.2 Universal Measuring Device

Universal measuring instruments are applied for measuring, recording and monitoring of electrical values in low and middle voltage networks. The measurement is rated for 1 and 3 phase systems with or without neutral. These devices feature high accuracy, compact design, and measuring of harmonic currents / voltages for all phases. Universal measuring instruments replace up to 15 other devices, such as ammeters, voltmeters, voltmeter-switches, power meters (kW, kVA, kvar und cos phi), active / reactive power counters, harmonic analysers, measuring converters, hour counters, etc. Besides, the device will provide data of the real value that will display on the Human Machine Interface (HMI).

2.2.6.3 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. 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. Figure 2.3 shows the overview of the relay structure.

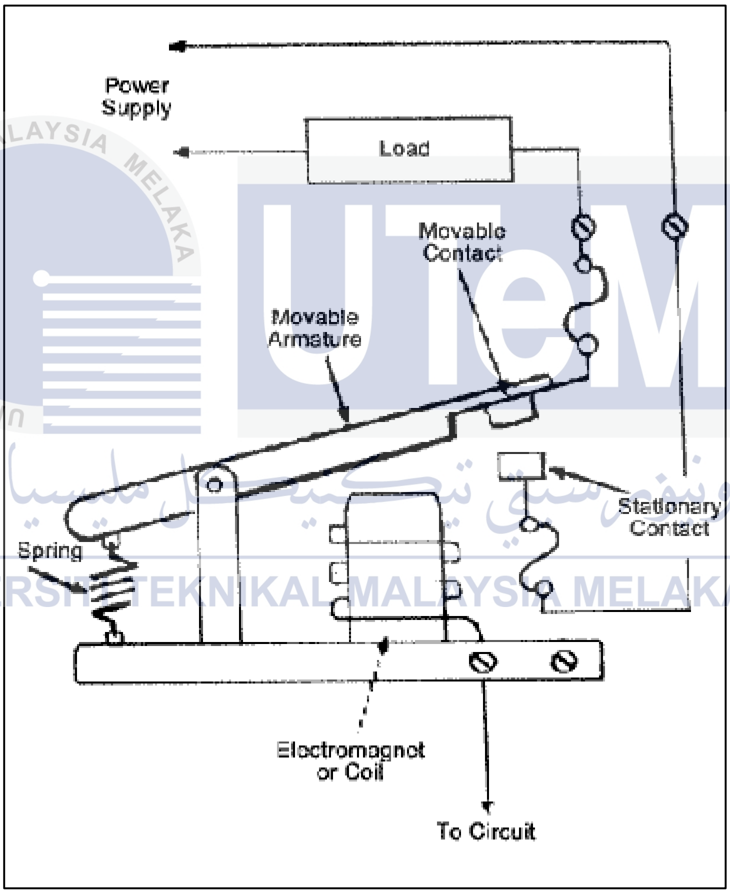

Figure 2.3: Overview of Relay Structure.

2.3 Related Previous Work

2.3.1 Customized Fault Management System for Low Distribution Automation System

This paper was made by a researcher in Universiti Teknikal Malaysia Melaka (UTeM). In this paper, fault management system is referred as the fault detection, fault location, fault isolation, supply restoration and manual control. The system used is equipped with automated equipment to detect earth fault and overcurrent conditions. The RTU is act as the converter for Human Machine Interface (HMI) and interact with I/O modules. Besides, the system mention in this paper was attached at the consumer side. Which means the fault error is not coming from the distribution line, but from the overloading used by consumers. This paper also describes the comparison between laboratory results and simulation results.

2.3.2 Development of Customized Distribution Automation system (DAS) for Secure Fault Isolation in Low Voltage Distribution System

From this paper that was made by researcher at Universiti Teknikal Malaysia Melaka (UTeM), Distribution Automation System (DAS) is divided into three parts. There are investigation of Human Machine Interface (HMI), logic programming for the controller and I/O Module. In this paper, the result was obtained by conducting a real experiment using prototype distribution system. This paper also only focuses on monitoring and controlling the fault that occur at consumer side. Besides, the results were shown on the HMI screen.

CHAPTER 3

METHODOLOGY

3.1 Project Architecture

Figure 3.1 shows the overall project architecture for Final Year Project (FYP). This project is divided into 3 major parts that need to be completed during the FYP. For part 1, it is only involving the designed of Human Machine Interface (HMI) for Distribution Automation System (DAS).

In part 2, it uses integrate software and hardware where the I-7188EG controller is programmed based on certain condition and then implement it at the Low Voltage Substation Panel. The last part, part 3 is the identification of input and output module. In this part, it only involves hardware where the component inside the panel is identified in order to enable controlling it using the HMI.

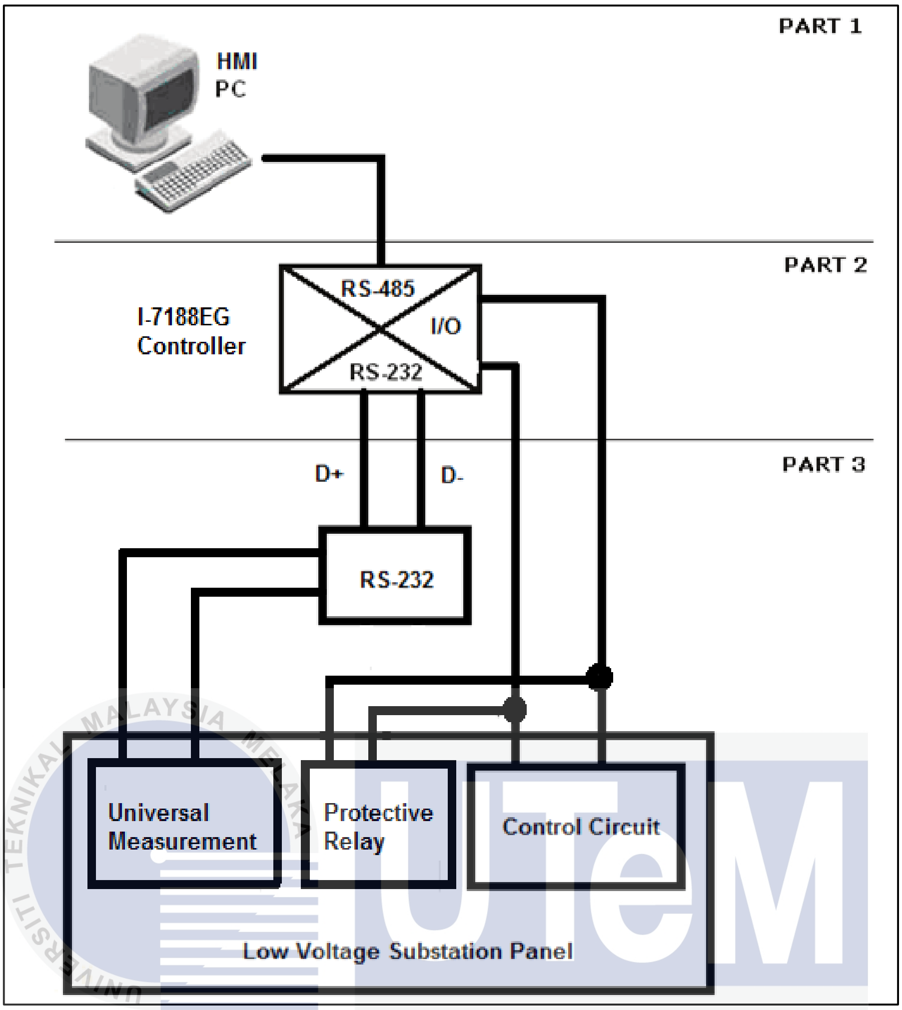

Figure 3.1: Overall Project Architecture

3.2 Software

3.2.1 InduSoft Web Studio (IWS)

The software application that had been used to develop a Human Machine Interface (HMI) is using InduSoft Web Studio (IWS). IWS is a powerful, integrated tool that exploits a key feature of the Microsoft operation system and enable to build full feature SCADA.

IWS also able to fix the problem fast as it receives an alarm, visually on the screen or via web browsers.

Figure 3.2 below shows the flow chart for HMI process development. The process begins by creating the project file in the IWS application. Then the screen group is developed based on the designer creativity. After that, creating the tag for all the functions such as button, slider, meter and etc. so that it able to complete the command given. Lastly, all the command is build and simulates it.

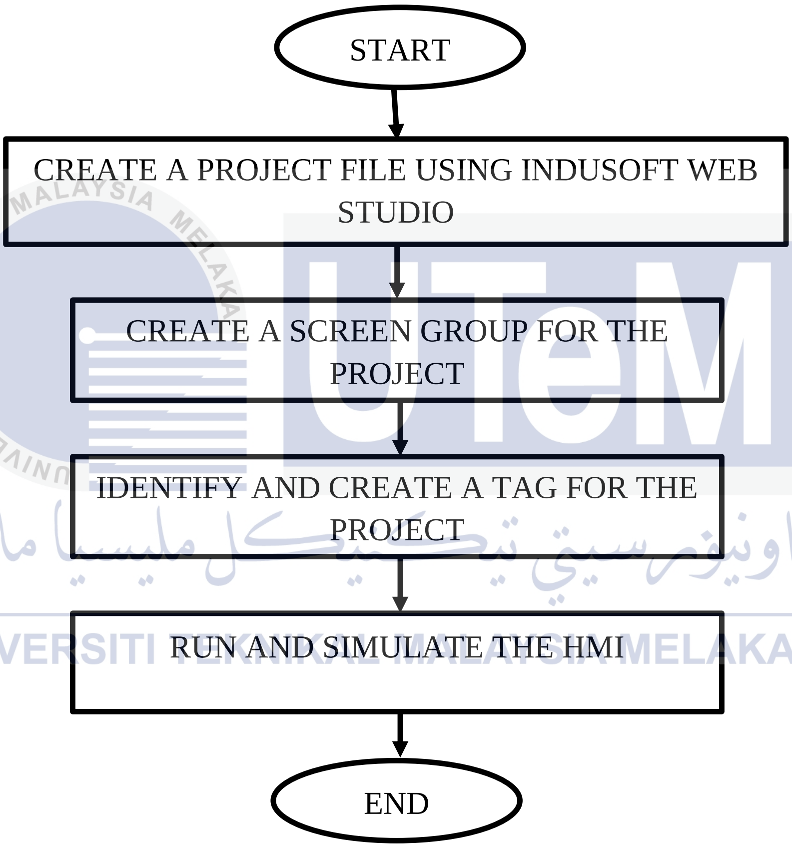

Figure 3.2: Flow Chart for Human Machine Interface Process Development

3.2.2 ISaGRAF

In this project, I-7188EG Controller was configured using an ISaGRAF software. ISaGRAF is a control software environment that enables to create local or distributed control systems. It provides a combination of a highly portable, robust control engine (Virtual Machine) and an intuitive application development environment (Workbench).

ISaGRAF also a real-time soft-logic programming system that supports all programming languages, which is ideal for industrial applications such as data acquisition system, distributed control system, factory and building automation, motion control, remote I/O system and wireless control systems. Figure 3.3 shown the flow chart for I-7188EG configures process.

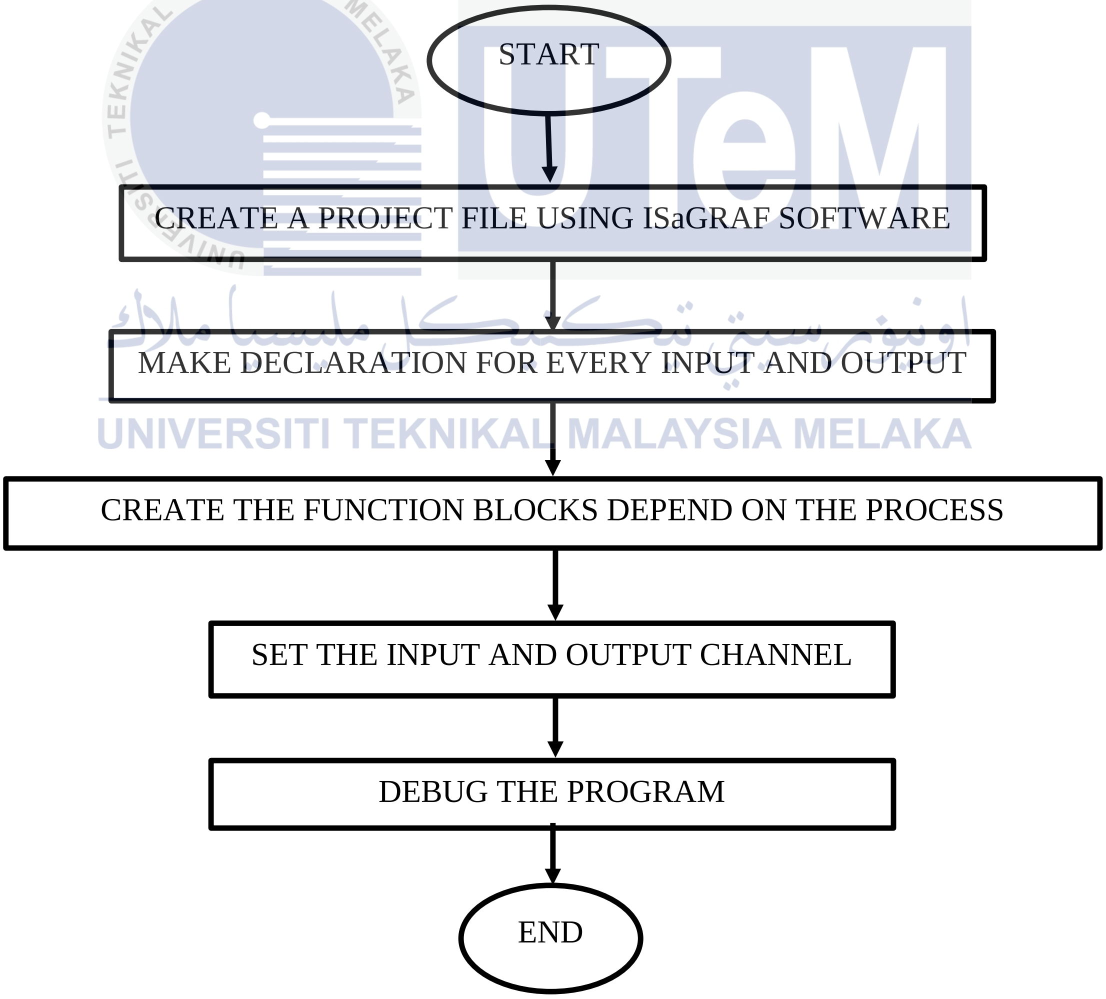

Figure 3.3: Flow Chart for I-7188EG Configure Process

3.3 Hardware

3.3.1 Low Voltage Substation Panel

Figure 3.4 shows the prototype of the LV substation panel. The substation is a custom made by FKE students. The panel has the same function as the substation at the distribution side which act as a feeder for Low Voltage downstream 415/240V before supplied it to the consumer. The panel able to detect faults that occurs such as Overcurrent and Earth Fault. Besides, the panel also able to operate in both conditions whether in Remote or Local condition.

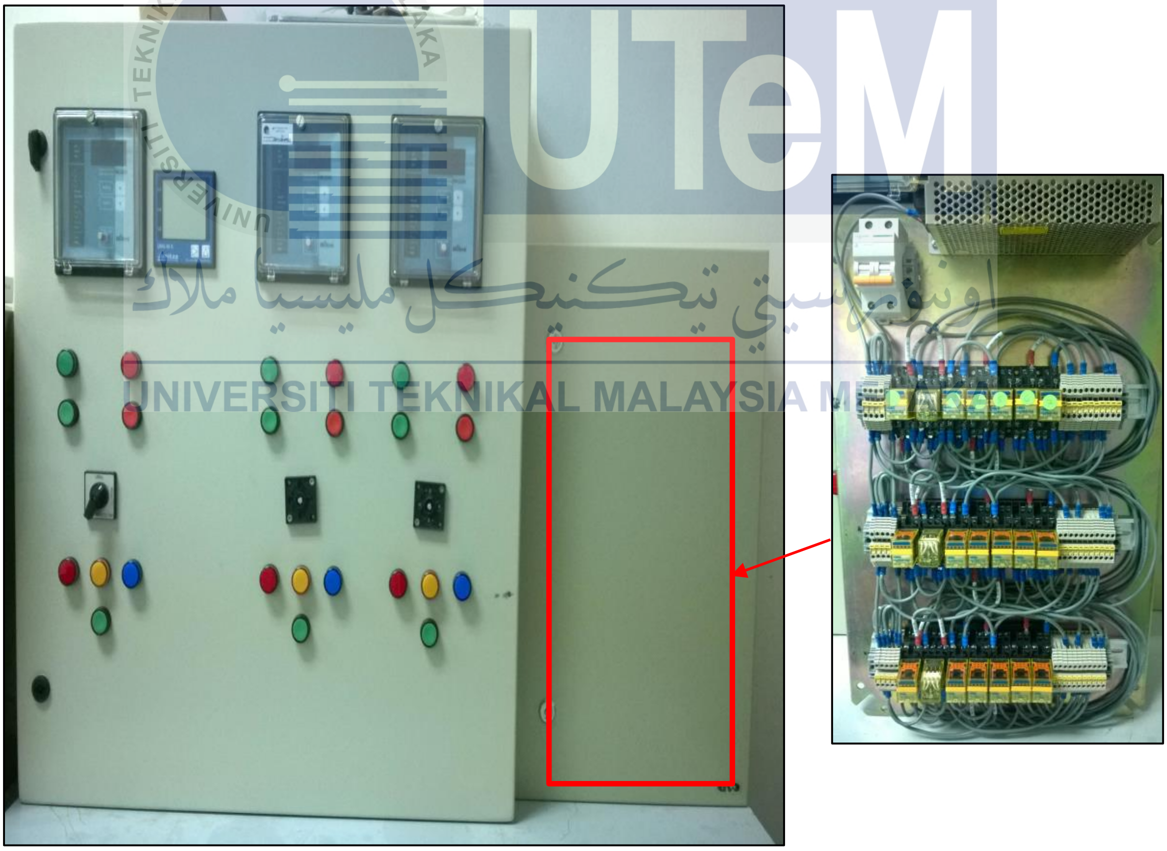

Figure 3.4: The prototype of Low Voltage Substation Panel.

3.3.1.1 Control Circuit

From the schematic diagram of the panel, the single-line diagram of the control circuit was drawn. Thus, full view on how the panel is operated can be obtained. Besides, it provides a clear understanding about the panel and the identification of I/O can be made easily. From this drawing also, it gives more understanding on what the HMI will looks like. This is because it provides clear paths what the HMI need to control and monitor. Figure 3.5 shows the single-line diagram of a control circuit for the LV Substation Panel.

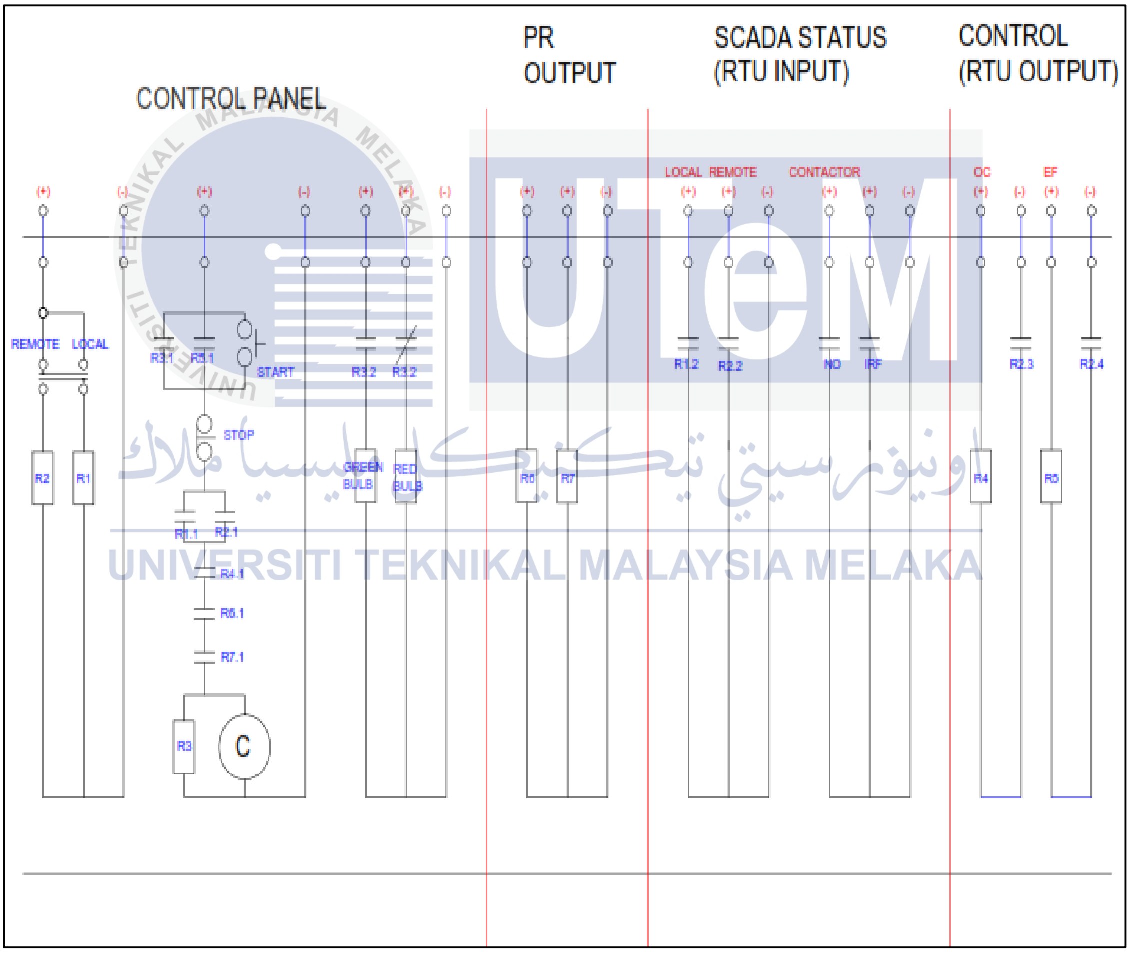

Figure 3.5: Single-Line Diagram of Control Circuit.

3.3.1.2 Protective Relay

In order to detect overcurrent and earth fault, MK2200 had been selected. It acts as the current sensor in this project. It is a digital microprocessor that provides a very user-friendly access to all the relay settings, meter and fault data. Besides, a fully digital user interfaces with bright seven-segment display. MK2200 also can be converted to a network system through RS485 Modbus-RTU communication channel.

3.3.1.3 Universal Measurement

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 measuring inputs, either../5A or../1A current transformers can be connected. The connection diagram for UMG 96 is shown in Figure 3.6.

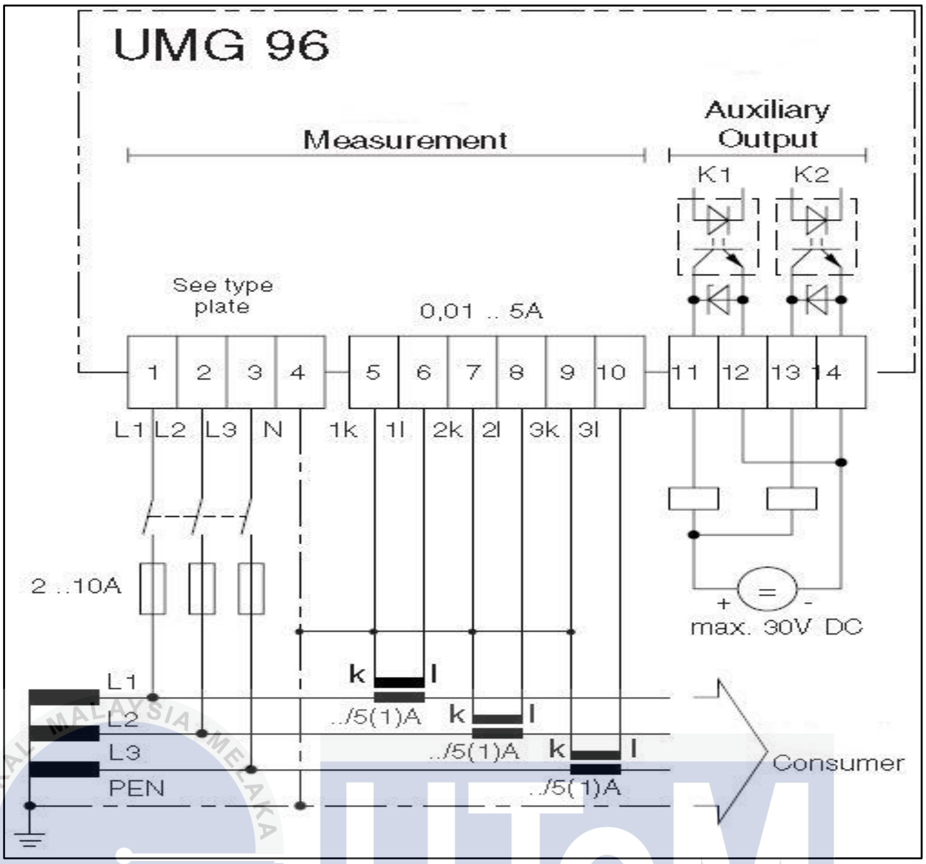

Figure 3.6: Connection Diagram of UMG 96

3.3.2 Interfacing

In this project, I-7188EG controller is selected as the Interfacing. The controller used logic programming that can configure using IsaGRAF software manufactured by ICPDAS. I-7188EG is responsible for communicating with the SCADA equipment using RS485 protocol. This controller also acts as a converter to link the SCADA equipment to X508 module. The controller also receives data from universal measurement by using RS232 protocol. Table 3.1 below will shows the hardware and software feature for I-7188EG controller while Figure 3.7 shown the physical shape of I-7188EG Controller.

Table 3.1: Software and Hardware feature for I-7188EG Controller.

Software Feature	- MiniOS7 Embedded Operating System (DOS-like) - ISaGRAF Ver.3 SoftLogic Inside - Support IEC 61131-3 Standard - Accepts max. 64 KB ISaGRAF code size
Hardware Feature	- 80188 CPU (16-bit & 40 MHz) - Built-in watchdog timer (WDT) to improve the system stability - SRAM (512 KB), Flash (512 KB) - 10M Ethernet Ports - 2 Serial Ports (RS-232/485) - I/O Expansion Bus Interface (support one X-board I/O expansion board)

Figure 3.7: I-7188EG Controller

3.3.3 Communication Network

The communication protocol that had been used in this project is RS-232 and RS-485 protocol which means wired communication had been selected. In Figure 3.8, it described the characteristic of RS-232 and RS-485. Generally, the RS-232 is best for short-distance low-speed requirements. It is a simple and low cost, and plenty of components are available to build the interface. The RS-485 is for higher speeds over longer ranges or if duplex networking capability is required. Again, many standard parts are available to create the interface.

KEY CHARACTERISTICS OF THE RS-232 AND RS-485 SERIAL INTERFACES

Parameter	RS-232	RS-485
Line configuration	Single-ended	Differential
Mode of operation	Simplex or full duplex	Simplex or half duplex
Maximum cable length	50 feet	4000 feet
Maximum data rate*	20 kbits/s	10 Mbits/s
Typical logic levels	±5 to ±15 V	±1.5 to ±6 V
Minimum receiver input impedance	3 to 7 kΩ	12 kΩ
Receiver sensitivity	±3 V	±200 mV

* Maximum rate at maximum cable length

Figure 3.8: Characteristic of RS-232 and RS-485

CHAPTER 4

RESULT AND DISCUSSION

4.1 Overview

In this chapter, it will describe the results and discussion of the projects that had been conducted based on the objectives which had been set earlier. The results will be arranged based on the project architecture that had mentioned in the previous chapter.

4.2 Human Machine Interface (HMI)

The HMI created in this project is based from the substation that will be controlled and monitor. In this report, the priority that the HMI need to control and monitor is the Contractor Relay condition, Overcurrent Fault condition, Earth Fault condition and Protective Relay condition. Thus, the HMI created is based those specifications.

4.2.1 Login Interface

Login is a main requirement in this HMI. It functions as a security for the interface. In this project, there have 3 groups of user. There are engineers, operator and guest. The difference between all this groups is the capability to access the parameter inside the HMI. Figure 4.1 shows the login interface for the HMI develop.

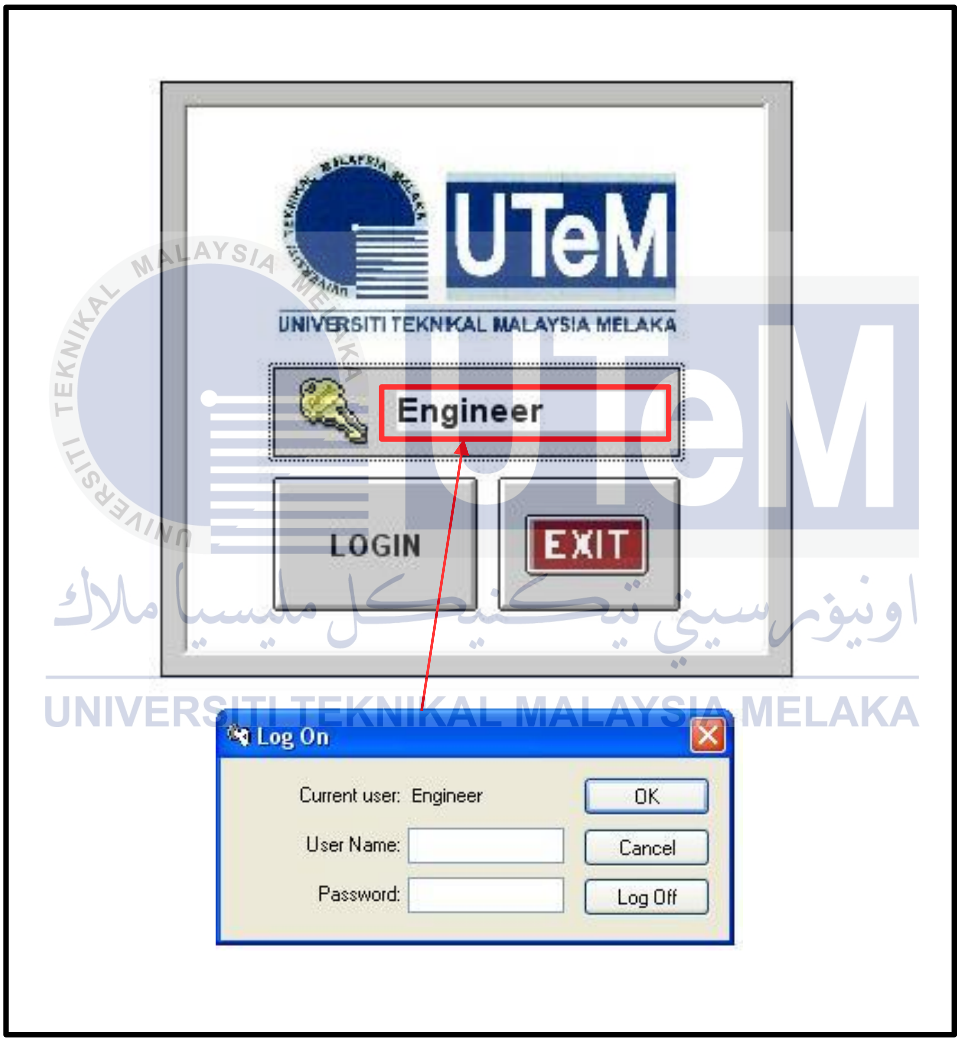

Figure 4.1: Login Interface.

4.2.2 Overall Interface

Overall interface stand for the overall view of the HMI. In this tab, there have Header Section, Navigation Section and Main Section. For Navigation Section, there has another 4 section that will navigate to a different section. There are System Info, Contactor, Trend and Alarm History. Figure 4.2 will explain all the parameters at the overall interface.

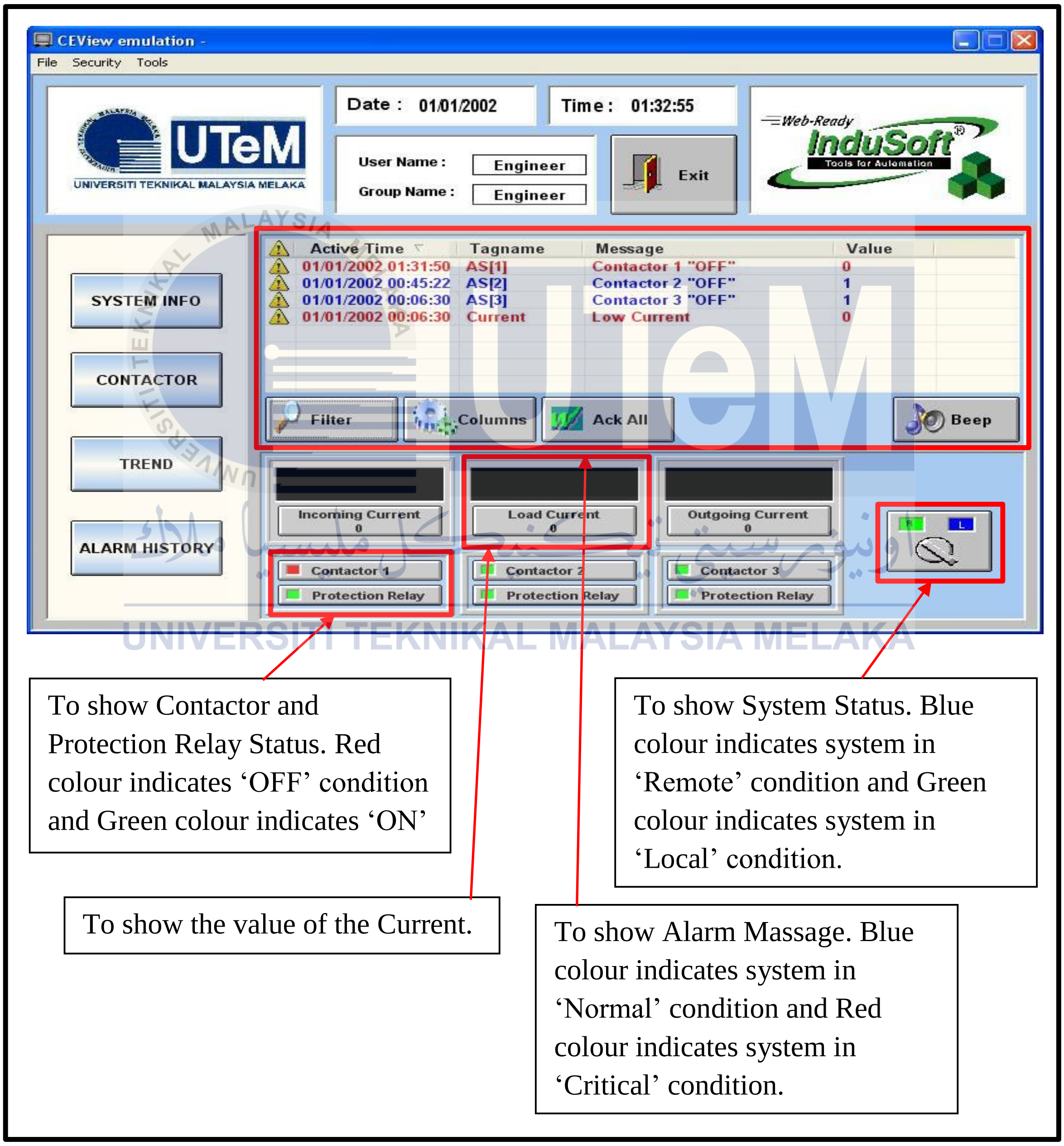

Figure 4.2: Overall Interface.

4.2.3 System Info Interface

This section shows the details about the computer such as Computer Network, Application and Product Version and Computer Info. The section was added just to make extra information for the user about the current computer status. Thus, it will provide a clear view about the system to the user. Figure 4.3 shows the view of the system info interface.

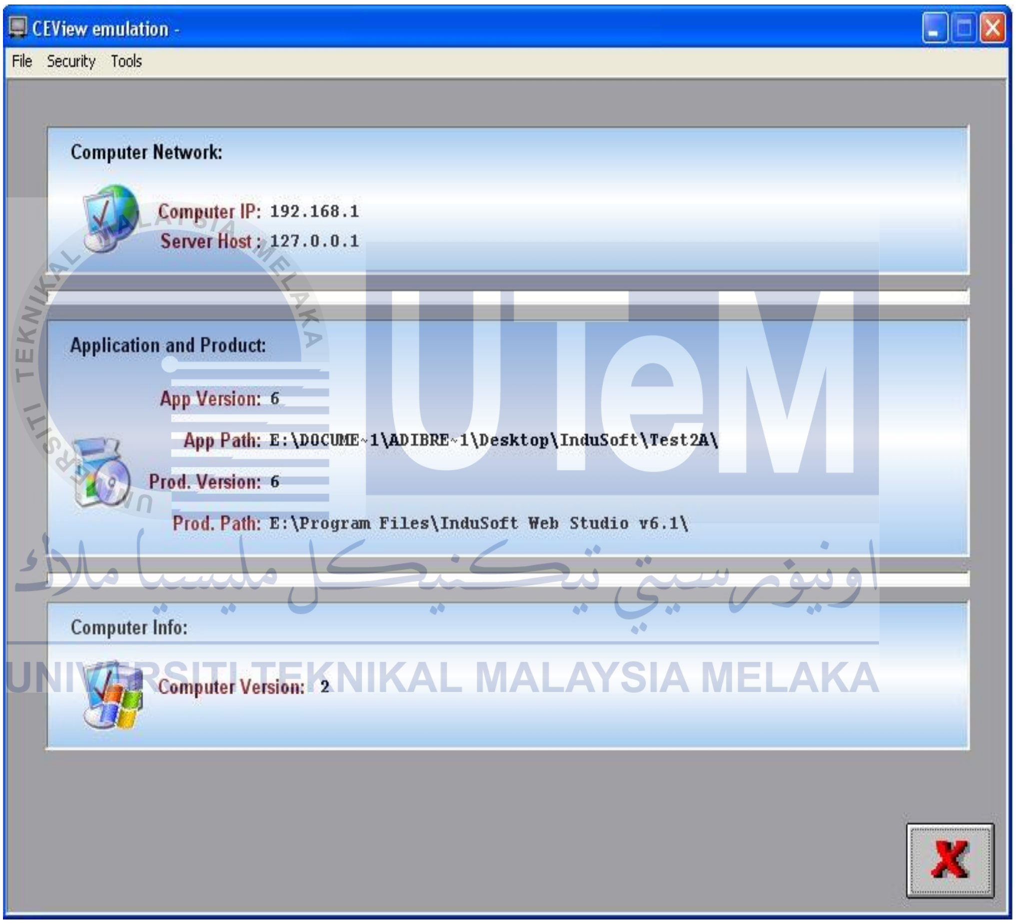

Figure 4.3: System Info Interface.

4.2.4 Contactor Interface

Contactor interface is one of the major requirements in this HMI. This is because, in this tab, it allowed the monitoring and controlling of the contactor relay. The contactor divided into 3 parts that need to be controlled and monitored. There are Incoming Contactor, Load Contactor and Outgoing Contactor. All contactor have same functionality. When the contactor in 'OFF' condition, the distribution line will not have a power supply and when the contactor is in 'ON' condition, it will allow the power supply to flow through distribution line. Figure 4.4 shows the contactor interfaces for the HMI develop.

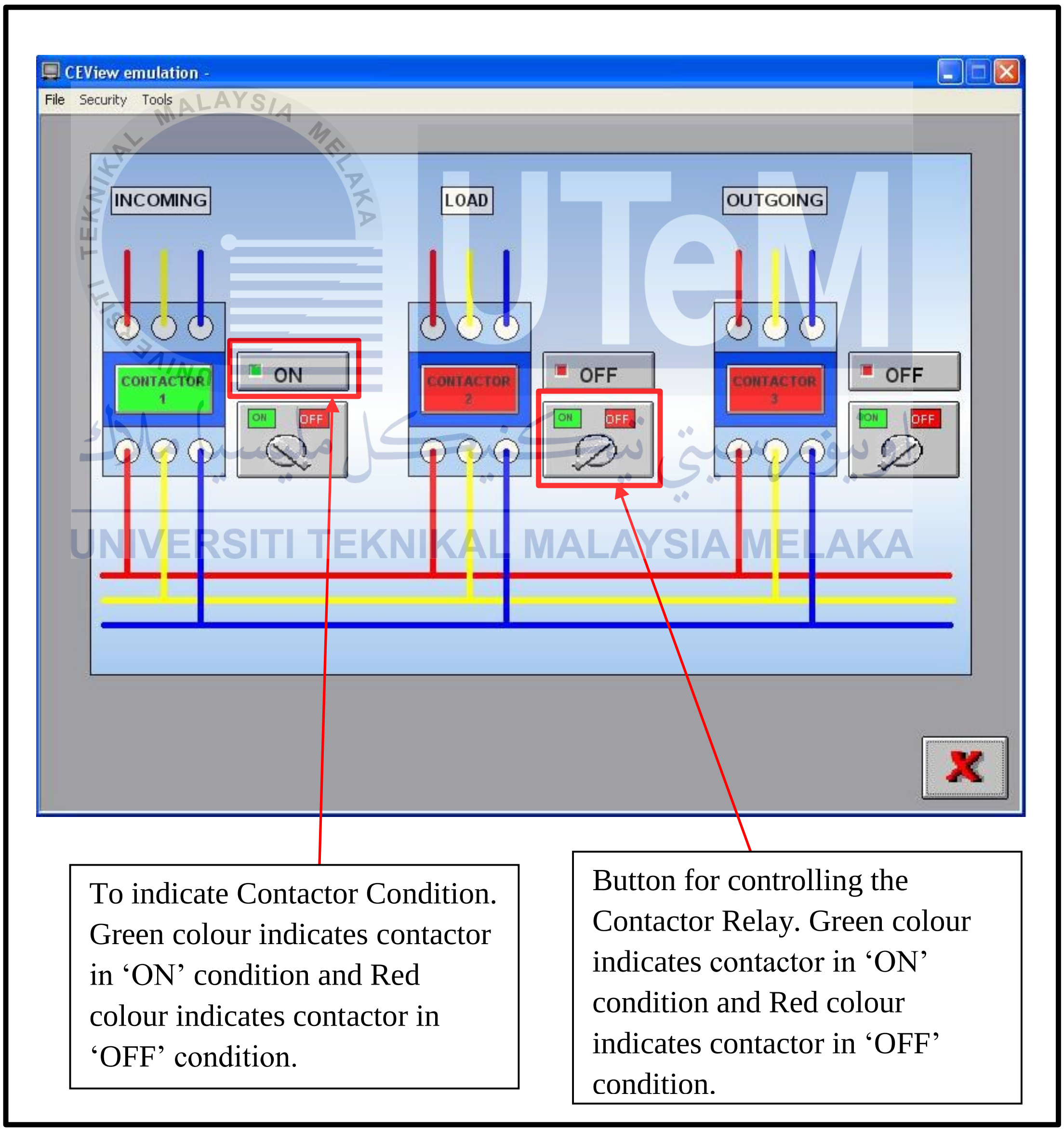

Figure 4.4: Contactor Interface.

4.2.5 Trend Interface

Trend interface is used to show the value of current and voltage in graph interface. Figure 4.5 shows the trend interface in the HMI system. The benefit of the interface is it provides the data in graph interface which will ease the user to make an analysis. Besides, the graph displays in real-time value and require real input to generate the graph.

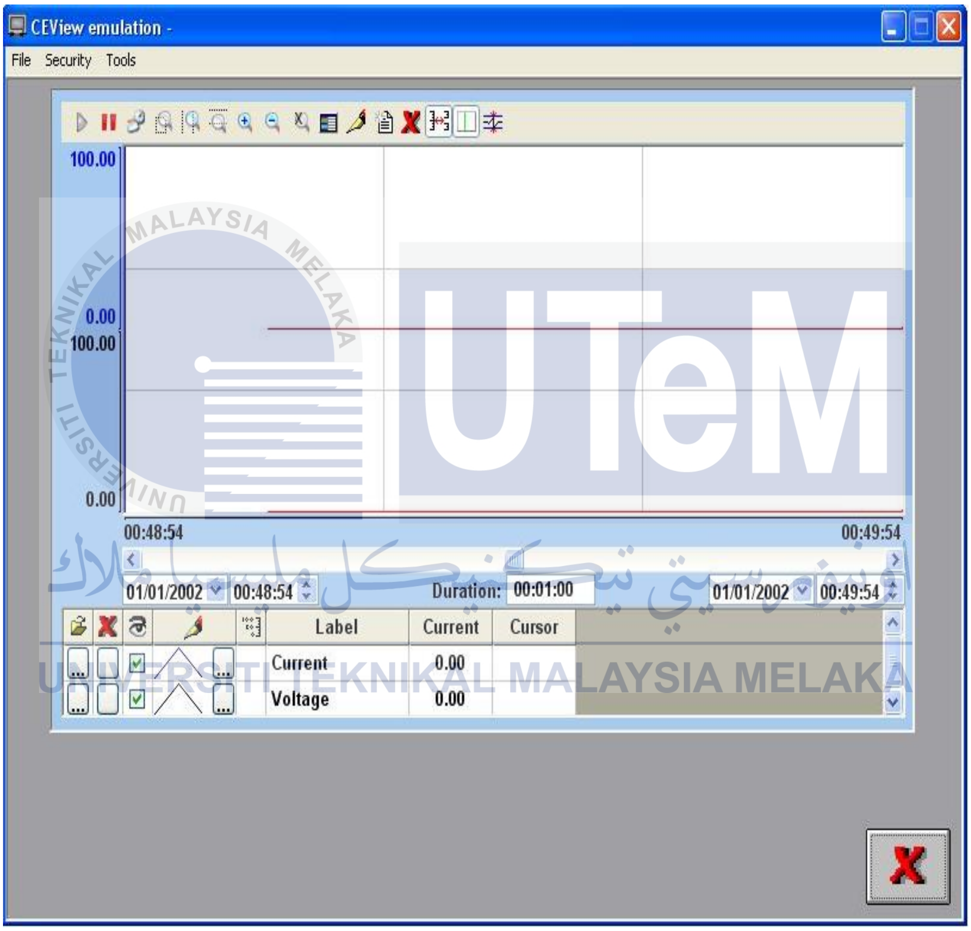

Figure 4.5: Trend Interface.

4.2.6 Alarm History Interface

Alarm History Interface helps the user to record all the action that had been taken. Thus, other user can know what action and problem that had been faced by previous users. This interface also one of the important things that should include in this HMI. This because the alarm history interface provides the record data that later will used as documentation. Figure 4.6 shows the interface for alarm history.

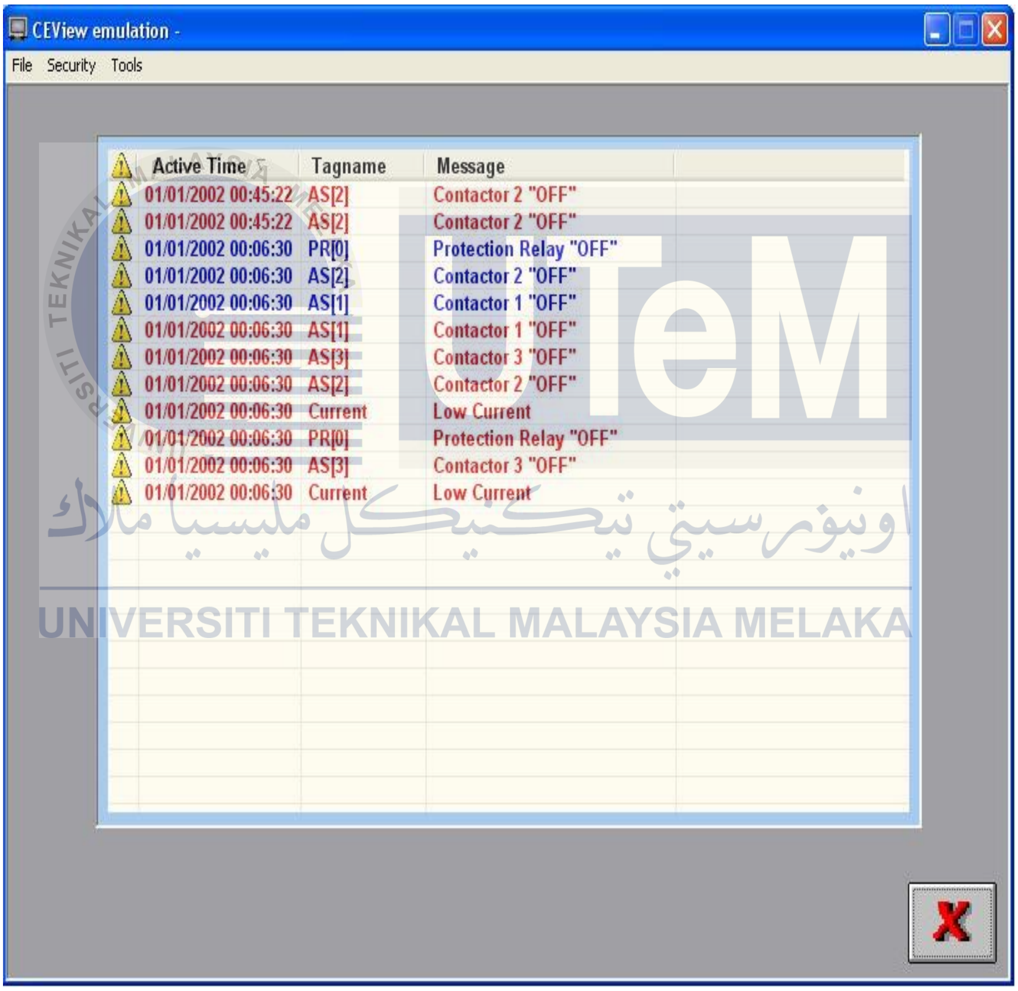

Figure 4.6: Alarm History Interface.

4.2.7 HMI Communication Driver Interface

After completing all the interface, next the HMI needs to setup its communication driver so that it able to communicate with the I-7188EG Controller. In this project, the HMI used MODBUS as its communication protocol. Thus, all the button and real data declare it address in this communication driver. Figure 4.7 shows the button and real data declaration address.

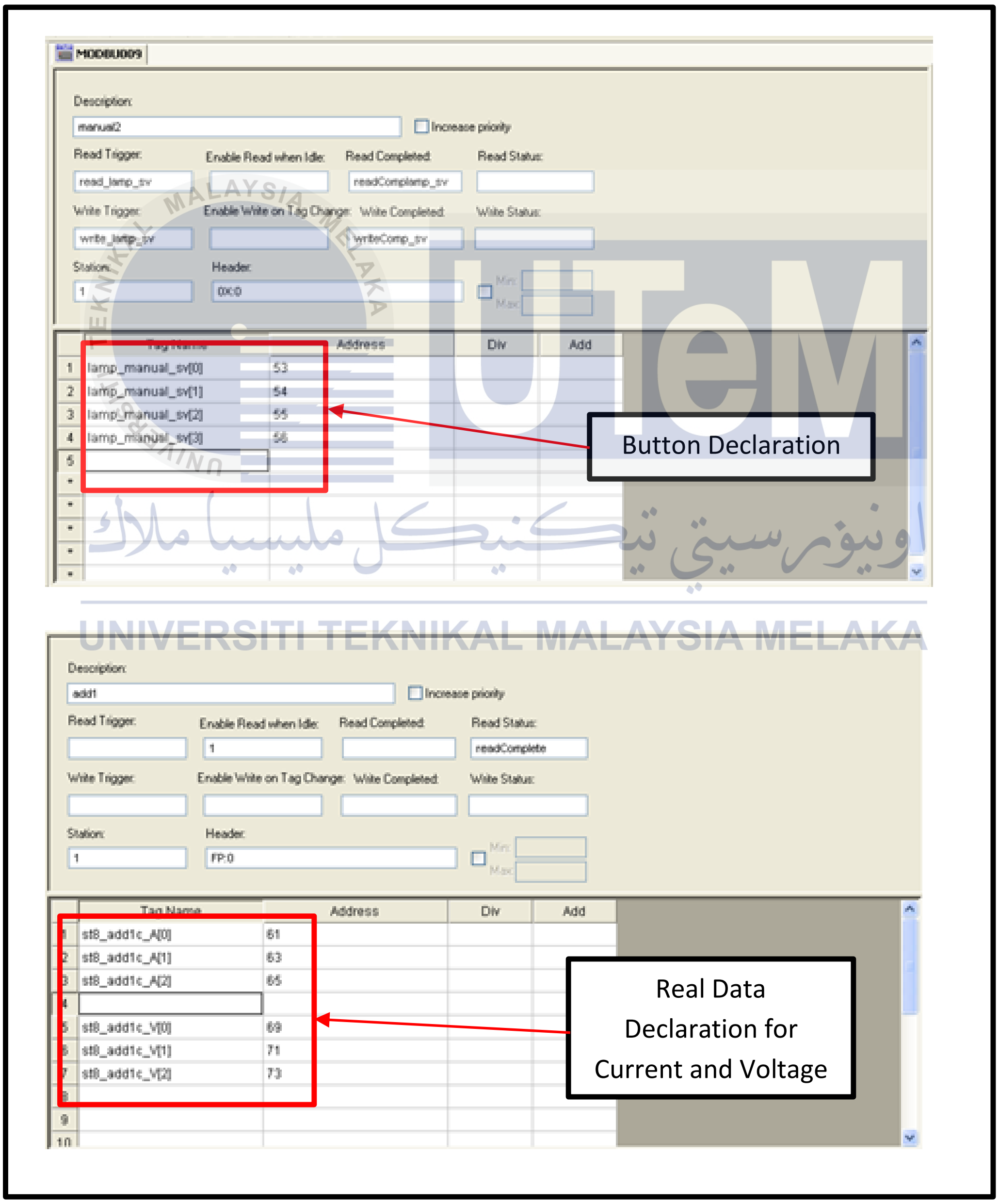

Figure 4.7: The Button and Real Data Declaration Address.

4.3 I-7188EG Controller

As mentioned earlier, the controller acts as the interfacing between the HMI and the substation. Thus, I/O module needs to be defined in order to make the system operate. From the drawing that had been drawn before, the data that will go into I/O module was presented in Table 4.1 below. Figure 4.8 and Figure 4.9 shows the configuration process of I/O module for I-7188EG Controller using ISaGRAF software.

Table 4.1: I/O Module

Detail	I/O Module
Internal Relay Fault, IRF (MK2200)	Digital Input 0
Relay, R1	Digital Input 1
Relay, R2	Digital Input 2
Contactor, C	Digital Input 3
Relay, R4	Digital Output 0
Relay, R5	Digital Output 1

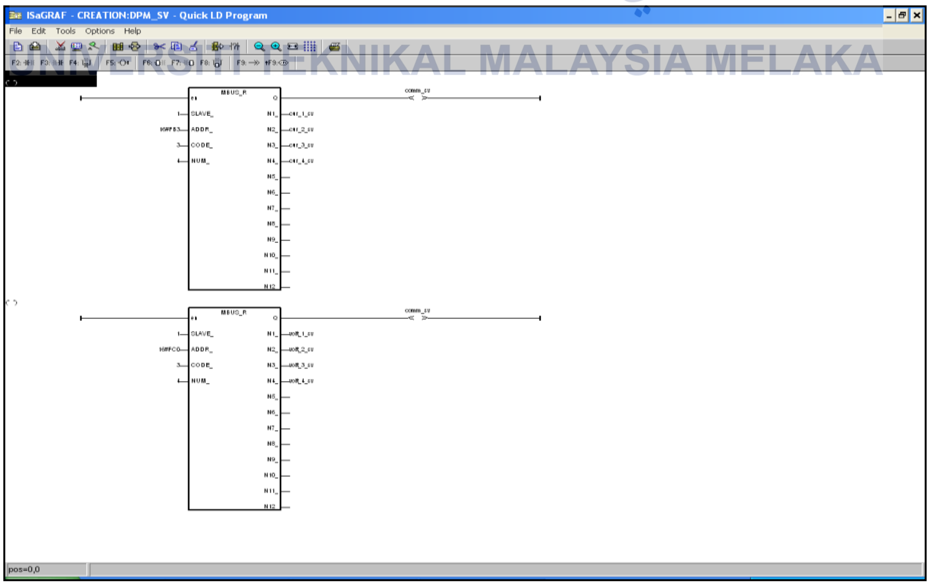

Figure 4.8: The Current and Voltage Configure using ISaGRAF Software.

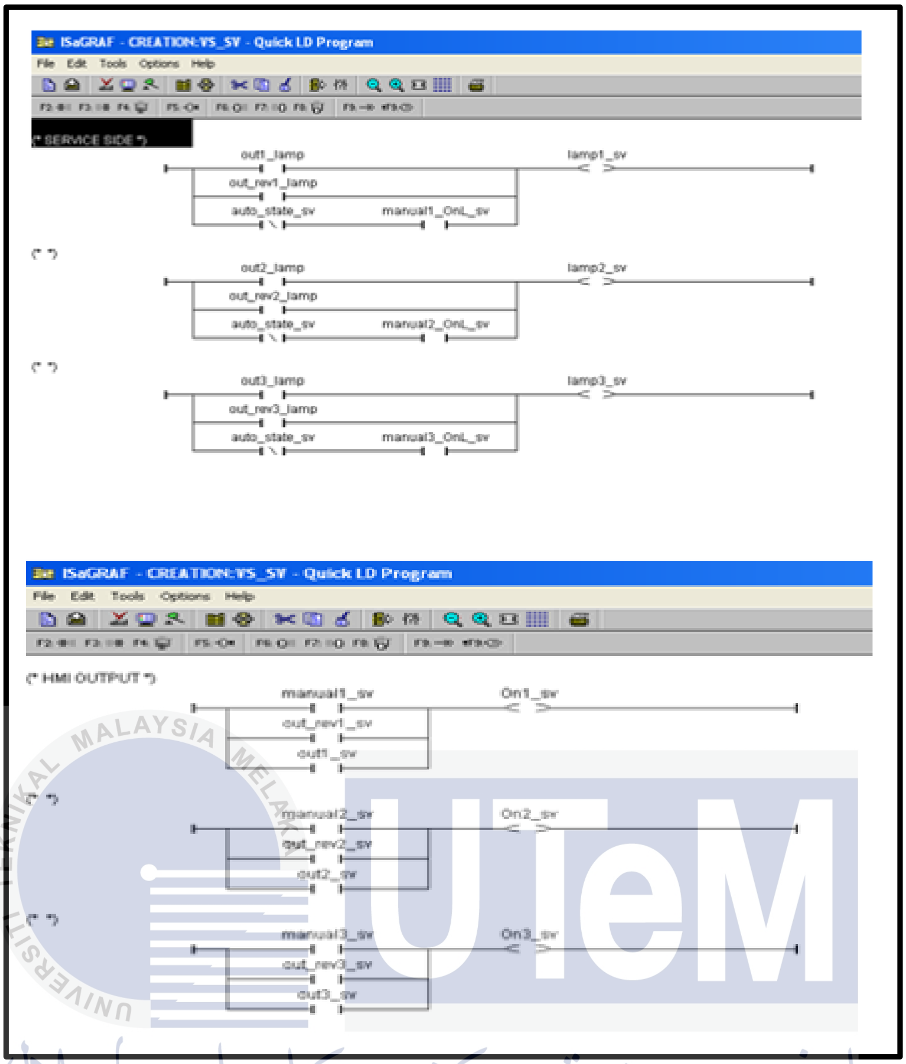

Figure 4.9: Button Configure using ISaGRAF Software.

4.4 Low Voltage Substation Panel Operation and Testing

4.4.1 Overall Operation

When the START button is switched 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 415/240V to flow into the system. The STOP button can trip all the operation. Either in local or the remote access.

4.4.2 Local Operation

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

4.4.3 Remote Operation

Remote process is where all the control and monitoring of the substation is made using the HMI. Therefore, the worker do not require to go to the substation when a fault occurs. This is because it can be done using the HMI.

4.4.4 Testing the Substation

The testing was conducted in order to see whether the HMI can control the control circuit of the substation or not. For the overcurrent and earth fault, the test was conducted by tripping the protective relay, MK2200. This to make sure the protective relay functioned well in this project.

4.4.4.1 Local Operation

During the local operation, the remote access was isolated. When isolated, the relay R1 will be switched 'ON', thus it will give a signal to the I-7188EG Controller at the D1 terminal about the status of the current selection. In this condition also, the operator needs to press 'START' or 'STOP' button manually to start and stop the process. Table 4.2 shows the relay status when on local mode condition. Figure 4.10 shows the HMI displayed for the substation panel during Local Condition.

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

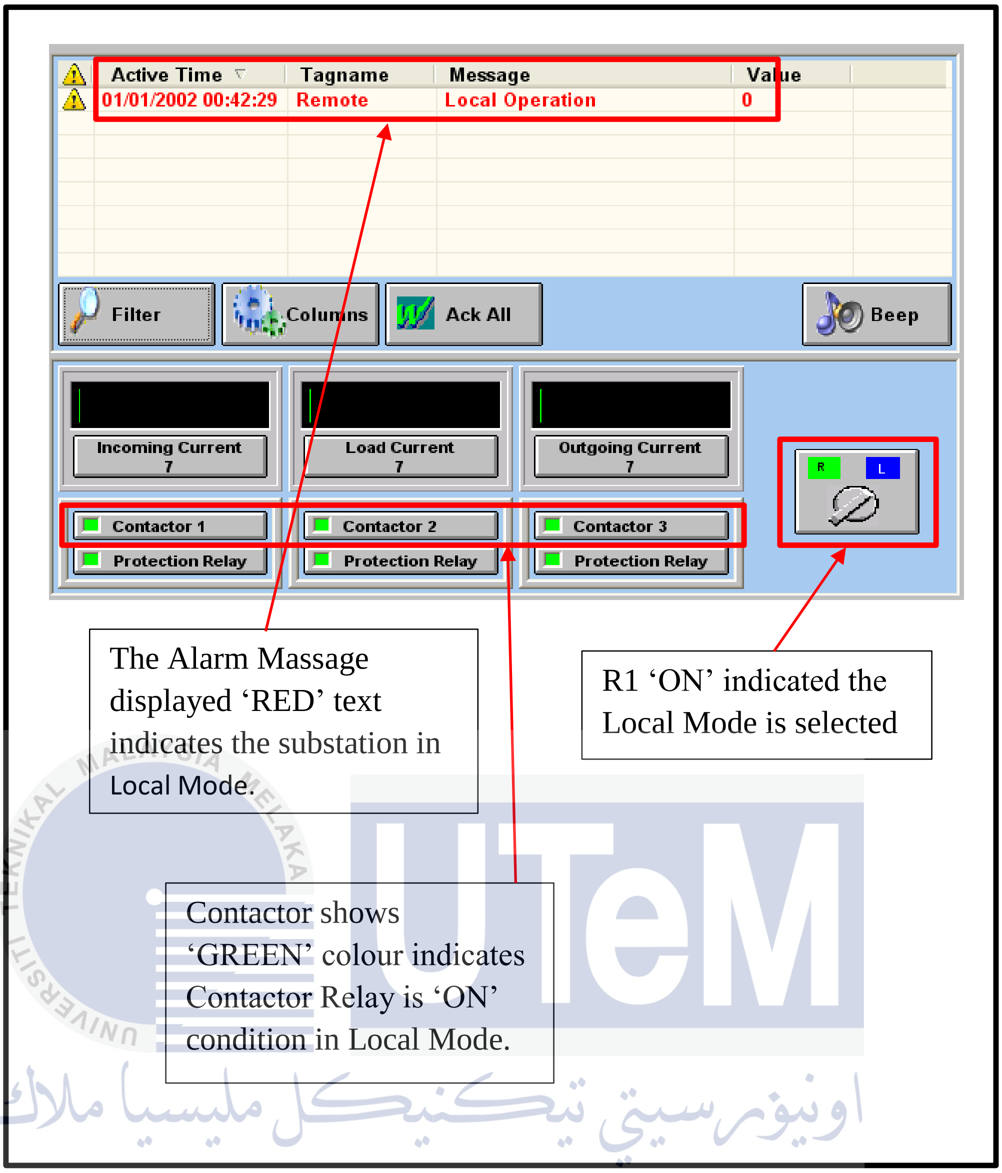

Figure 4.10: HMI Status during Local Condition.

4.4.4.2 Remote Operation

For remote operation, the relay R2 was turn 'ON' while relay R1 turn 'OFF'. During this condition, the HMI has full authorized on the substation. Thus, the process can started or stopped remotely. Table 4.3 shows the relay status when in remote mode condition. Figure 4.11 shows the status of the substation panel by using HMI.

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

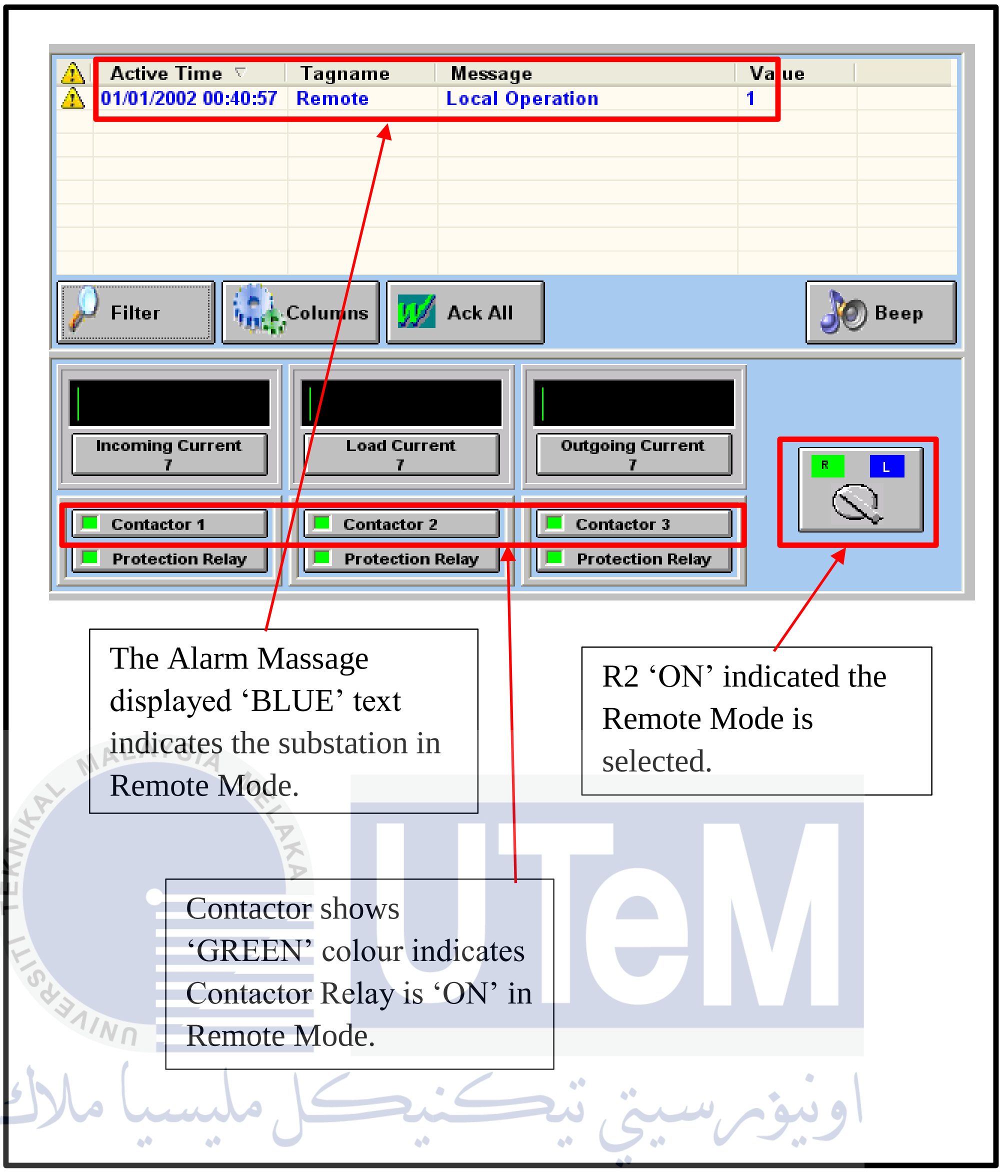

Figure 4.11: HMI Status during Remote Condition.

4.4.4.3 Cut-off Operation

The cut-off operation refer to the contactor had been switch 'OFF' by using HMI. At this time, 415/240 Volts cannot flow through the distribution line as its supply had been cut-off. Table 4.4 shows the relay condition when in cut-off condition. Figure 4.12 shows the HMI status during Cut-Off Condition.

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

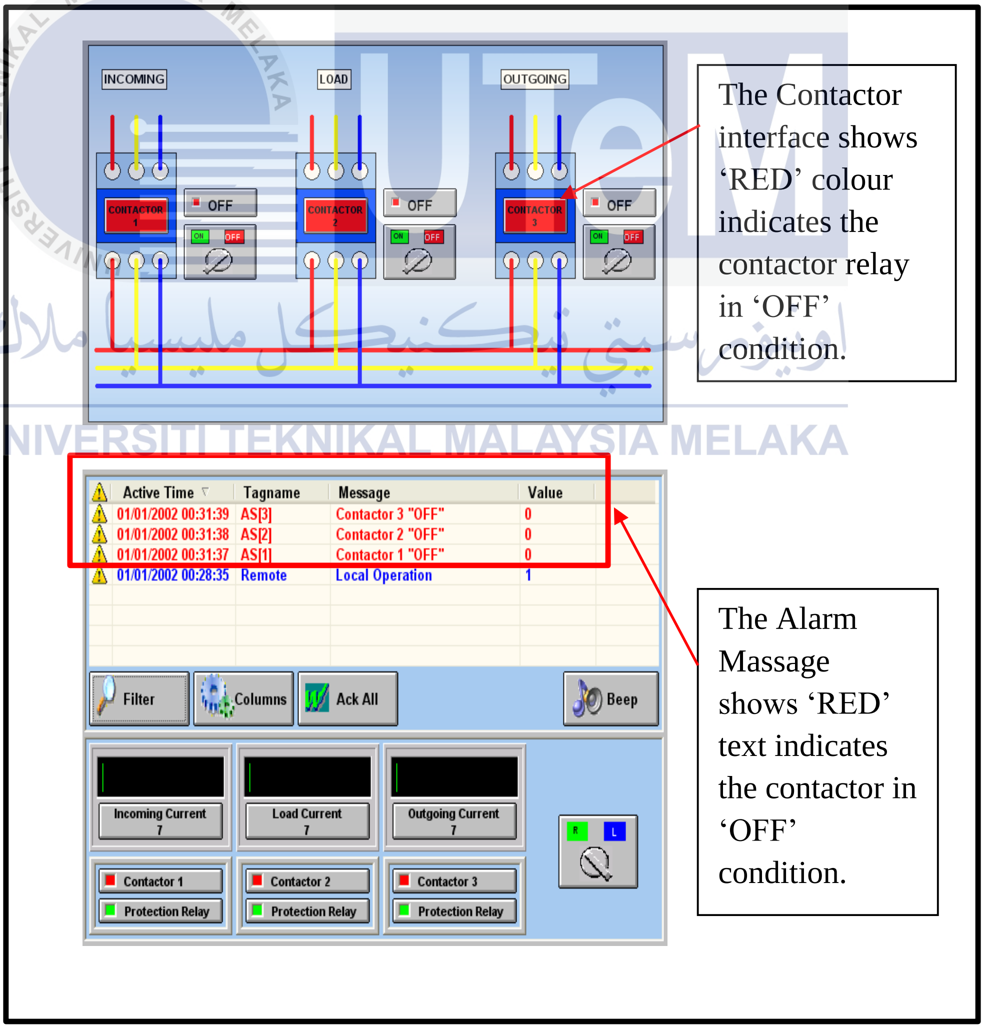

Figure 4.12: HMI Status during Cut-Off Condition.

4.4.4.4 Restoration Operation

Restoration operation occurs when the Contactor was energized back after had been cut-off manually or by fault. The restoration relay was triggered remotely by using HMI. Table 4.5 shows the relay when in restoration condition.

Table 4.5: Relay Restoration Condition

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

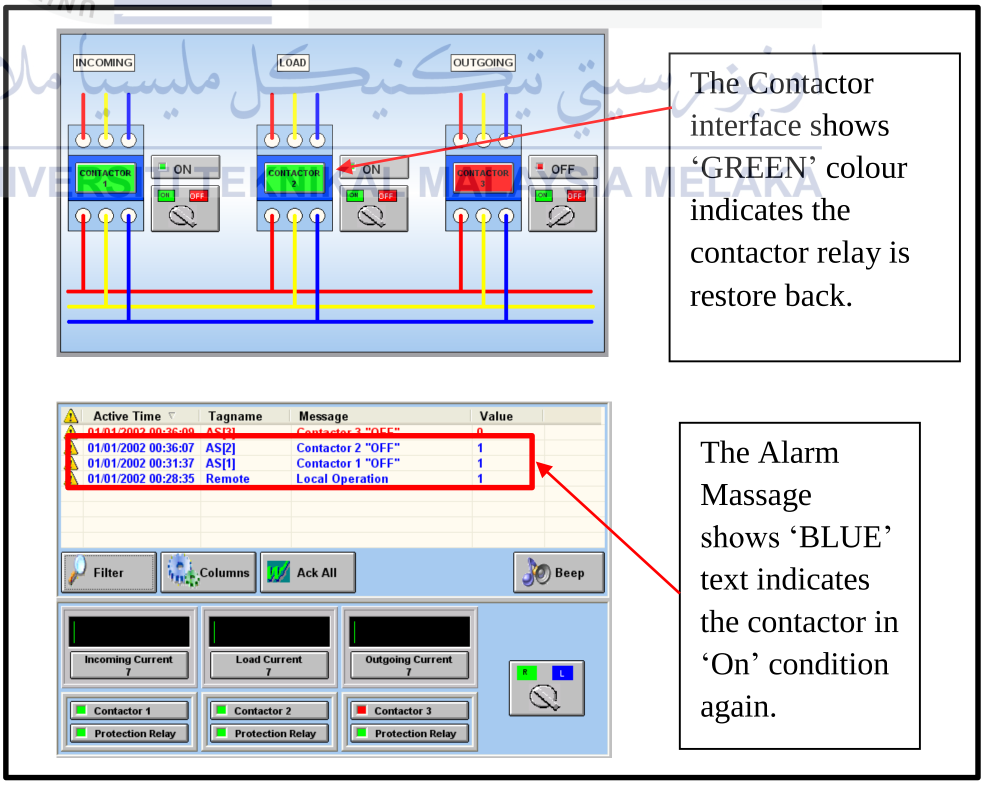

Figure 4.13: HMI Status during Restoration Condition.

4.4.4.5 Overcurrent Condition

Overcurrent condition only occurs when the current sensor detects the overflow of current. The fault was detected by using protection relay, MK2200 which function as current sensor in this project. In this testing, the overcurrent fault was created by tripping the protection relay, MK2200 in this substation. The restoration process can be made either using remote or local operation. Table 4.6 shows the relay condition when in overcurrent fault occur. Figure 4.14 shows HMI status during Overcurrent Condition.

Table 4.6: The Overcurrent Relay Status

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

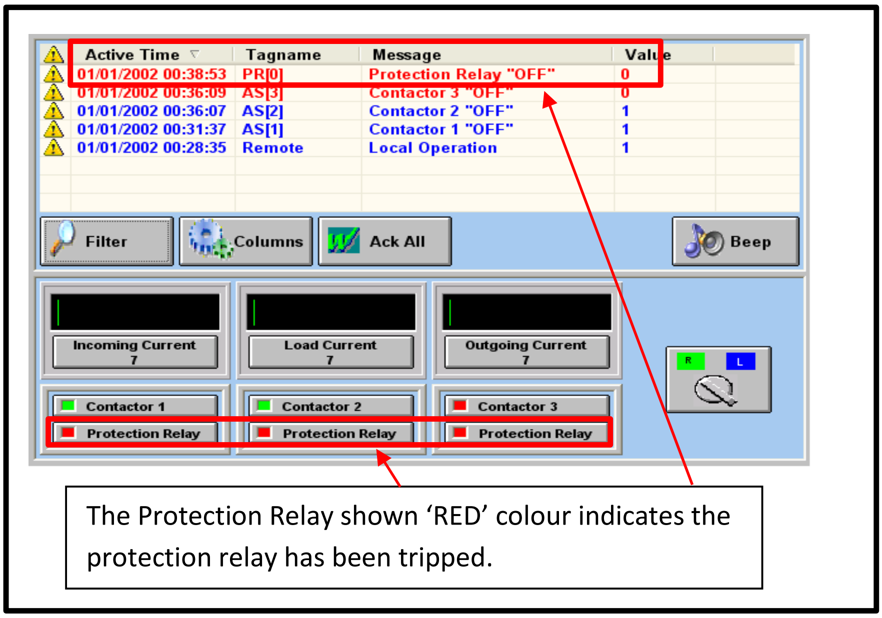

Figure 4.14: HMI Status during Overcurrent Condition.

4.4.4.6 Earth Fault Condition

Earth fault occurs when one of the distribution lines either red, yellow or blue line contact with the ground. This caused by the distribution line to short circuit condition. Same with overcurrent testing, the fault was created by tripping the protection relay. Besides, the restoration of contactor can be made by using remote or local operation. Figure 4.6 shows the relay condition when the earth fault occurs.

Table 4.7: The Earth Fault Relay Status

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

4.5 Summary

The results obtained helps to understand more about the whole process. From the result, HMI helps the operator to reduce restoration time because the restoration operation can be done remotely. Besides, the monitoring process that also provided in the HMI helps to reduce fault identification time as the screen shown the alarm information to the operator remotely. Other than that, the operator can get extra data from the HMI such as the trend of the input voltage and current and system current condition.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this project, all objectives for the development of Human Machine Interface (HMI) and Interfacing for Low Voltage Distribution Automation System (DAS) had been achieved successfully. Currently, the SCADA system in the low distribution system implemented by TNB only focuses on alarm monitoring. SSO has to operate the control functions at the HMI side. The operator needs to analyse the situation and to make appropriate actions. In this research, a DAS solution technique was implemented in order to provide an automatic fault cut-off and restoration for low distribution system.

The HMI created capable to detect the fault and restored the substation back to it into normal condition. Besides, whenever the system detects a fault, an alarm message will be displayed at the HMI side to acknowledge the operator. The HMI also capable to communicate with the I/O devices by using an embedded Ethernet controller. The extra features that shown by HMI such as data logging, trend and history report will provide extra information for the operator.

5.2 Recommendation

This project is a step towards developing DAS for LV distribution system and much more work lies ahead in evaluating new DAS technology. However, the outcome of this project may valuable for other researcher to make improvement on 11/0.415kV LV downstream distribution system. Besides, this project only focused on a radial distribution system which mean when fault occur, there will be a power loss to the consumer unless the distribution system is powered up back. Therefore, some of the improvement can be made for other researcher are:

1) Implement at loop distribution system. This allowing the HMI to control at least two feeders to reduce the impact of faults by quickly isolated them.

2) Using wireless communication medium instead of wired network. This allowing the HMI to control and monitor the substation from far places.

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