A NEW SUPERVISORY CONTROL SYSTEM FOR DOMESTIC PROTECTION SYSTEM

By

JAYVARMAA A/L RAJARAM

FINAL PROJECT REPORT

Submitted to the Department of Electrical & Electronic Engineering

in Partial Fulfilment of the Requirements

for the Degree

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(Electrical & Electronic Engineering)

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved:

_____

Ir Dr Nursyarizal Bin Mohd Nor

Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

SEPTEMBER 2013

UNIVERSITI TEKNOLOGI PETRONAS

CERTIFICATION OF ORIGINALITY

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

_____

JAYVARMAA A/L RAJARAM

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First of all, I would like to express my gratitude to God for giving me the strength and good health to complete this project. Deepest appreciation to my mother who has been giving me a lot of moral support and encouragement to successfully complete this project and also supported me financially a lot

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ABSTRACT

Power failure is a common problem when there are electrical faults occurred, which would lead to discontinuity of electrical supply to domestic building. For domestic consumers, power continuity is very important since some of the appliances such as refrigerator, aquarium and alarm system require a continuous electrical supply. However, fault occurred in the system will trip the earth leakage circuit breaker (ELCB) and disrupt the supply to all the appliances. Fault may occur due to short circuit, ground fault or overloading. Thus a New Supervisory control system is being developed to supervise the faults which occur in domestic building using zigbee wireless technology and to automatically control the system via wireless to ensure power continuity and avoid any property loses.

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CHAPTER 1

PROJECT BACKGROUND

1.1 Background of Study

Power failure is a common problem when there are electrical faults occurred, which would lead to discontinuity of electrical supply to domestic building. For domestic consumers, power continuity is very important since some of the appliances such as refrigerator, aquarium and alarm system require a continuous electrical supply. However, fault occurred in the system will trip the earth leakage circuit breaker (ELCB) and disrupt the supply to all the appliances. Fault may occur due to short circuit, ground fault or overloading. Thus, the aim of this project is to develop an automatic system, for single-phase power system to overcome the problems. The automatic system is able to detect and isolate the fault in order to ensure the power continuity in the building via a Supervisory Control system. To develop a Supervisory Control system a projects based on Zigbee wireless technology is being executed which is very cost effective and could easily monitor on the status of power continuity to domestic building. Upon developing this project using Zigbee wireless technology, it will basically merged with an existing project which has already been developed in the university which is the automatic ELCB and automatic fault location detector fabricated in a single system for more better and effective usage of the Supervisory Control system to control the existing prototype to sustain power continuity to domestic building.

1.2 Problem Statement

1) ELCB is in trip condition until it is manually switch ON when house if left unoccupied for a period of time.
2) Current auto reset ELCB system is unable to operate if the faulted MCB is still in ON position
3) Power discontinuity for a long time will contribute to property loss such as food damage, malfunction of alarm system and dying of exotic fish.

1.3 Project Objectives

The objectives of this project are:

- To detect and isolate the fault location in single phase system via Auto-Epros system
- To provide control and monitoring system on a single phase system via Auto-Epros system

1.4 Scope of study

In order to develop this project it requires a deep understanding in domestic electrical wiring mainly on single phase type and the configuration of zigbee wireless technology which will be combined with automatic fault detection system .The main focus on this project will be on detecting the fault location in domestic building and the ability for user to control it via a Supervisory Control system.

Major Scopes of work for this project are:

- To design a control box which is integrated with zigbee wireless device and PIC 16F887 in a single circuit and control the output using relays.
- To design a Graphical User Interface(GUI) for pc to allow user to monitor the system using Microsoft Visual Basic 2010
- Develop a system which is applicable and stimulate real time applications

CHAPTER 2

LITERATURE REVIEW

2.1 Wireless technology for control and monitoring

Wireless technology has rapidly grown for various purposes and especially for controlling and monitoring system, it has replaced the system which uses complex wiring system which would eventually deteriorate as its aging and might cause a lot of defects which could cause short circuit and damages to a system. So through wireless system it would be easier to transmit and receive data in a very fast rate without complexity, and this could lead to more reliable and efficient way to control and monitor a particular system. Besides that it is also very cost effective in term of installation and maintenance compared to wired system. In the current market there is various kind of wireless technology which is available as for example infrared (IR), Bluetooth, Radio frequency, Z-wave, Insteon and etc. From all the available wireless technology zigbee wireless technology has been an very effective solution to develop a controlling and monitoring system, as it's a very low cost, low power and low rate wireless network standard which could be implemented for supervisory and control system in houses, factories and offices according to (Jun, Guangming et al. 2011). Zigbee is used mostly for a short distance wireless monitoring and control purpose [2]. Zigbee has been developed based on Open system Interconnection (OSI) layer model [3]. (Sarijari, Rashid et al. 2008) stated that zigbee standard is build on the IEEE 802.15.4 low rate wireless personal area networks(WPAN) standard based which consist with the physical layer(PHY) and Medium Access Control (MAC) layers shown on figure 1 and it combines with zigbee alliance which includes network layer and application layer[2]. The physical layer has been designed to operate at two frequency range in Europe 866MHz, 915MHz and in global frequency of 2.4GHz[3].

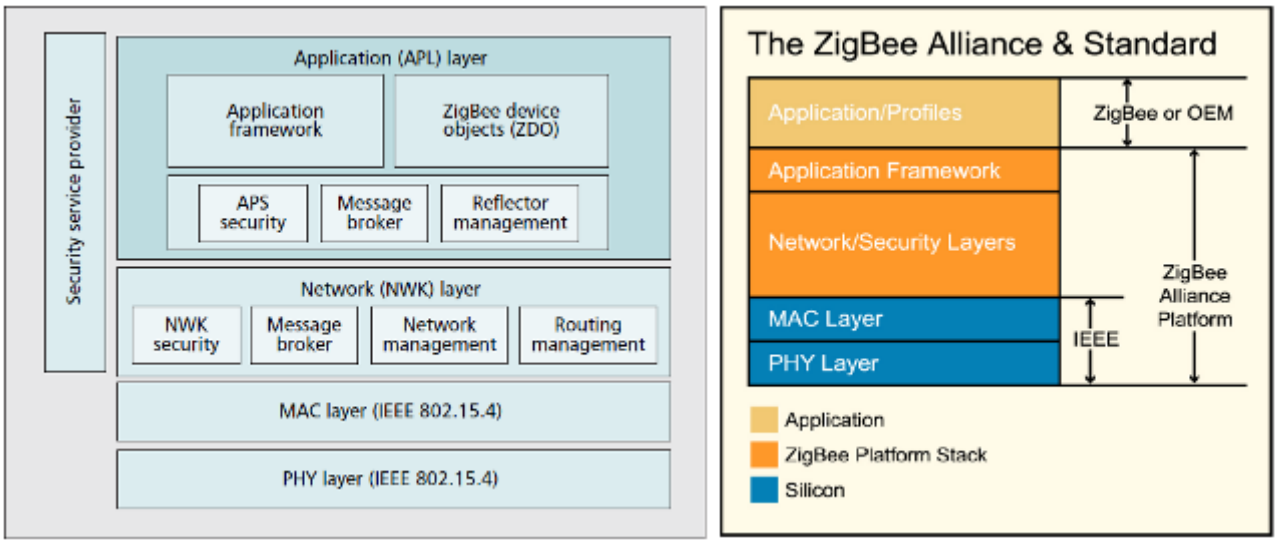


Figure 1:ZigBee Stack Architecture[4]

2.1.1 Application Layer

According to (Ondrej, Zdenek et al. 2006) application layer could be programmed according to user preference. In zigbee the program is written in zigbee device and has been specified, this is the part makes the device to be either FFD or RFD, network security functions and the counter and actions to system log [6].

2.1.2 Network layer

The communication of zigbee standard is being carried out by network layer. It manages routing, security functions and the network configuration and zigbee has a dynamical network and the task of the network layer is to sustain the information regarding the nodes within the network stated by (Ondrej, Zdenek et al. 2006).

2.13 IEEE 802.15.4

PHY and MAC layers is a standard of IEEEE 802.15.4 which defines to low rate wireless personal area network which is being utilize in zigbee technology .IEEE 802.15.4 standard combined with zigbee standard creates an easy address, low cost implementation of power and flexible towards unlimited number of wireless low data rate monitoring and control application[6].

2.1.4 Physical Layer (PHY)

The physical layer defined in IEEE 802.15.4 is the lowest layer in the stack. Its main function is to encode and decode bits which is sent and received and it communicates with the MAC layer as an example link quality indication, receiving sensitivity and signal strength indication according to (Ondrej, Zdenek et al. 2006).(Khanh Tuan Le , 2004) stated that the IEEE 802.15.4 standard PHY has been a choice of various wireless industries due to its globally frequency operation which is 2.4Ghz which contributes flexibility and application design.

2.1.5 Medium access control layer (MAC)

MAC controls the access to the shared frequency channels [6] . It generates and verifies addresses to connect with a network [6]. It could be configures with two type of devices Full function Devices (FFD) with could work with any of the topologies (mesh, star and cluster tree), as it could communicate to any other devices in the network stated by (Larry Leob.2004).Reduced Function Device (RFD) is a limited to communicate to other networks and could be a network coordinator as it could be used for point to point communication purpose [9].

2.2 Zigbee Wireless Network

Zigbee is a very simple technology as it could communicate in 2 way direction, one as the data transmitting part and another one as data receiver part. This technology is being utilize globally for the purpose of building control, data acquisition, monitoring system and automation for manufacturing according to (Ondrej, Zdenek et al. 2006) .The main idea beyond this technology is a system which could compromise with low data rate wireless network technology and low power consumption[1].Below is the advantages of zigbee technology which has been stated by (Palanisamy, Kumar et al. 2011).

- Low complexity because it's very simple to be configured
- Low data baud rate:10kbs-250kbs(2.6Ghz)
- Low power consumption because of its low duty cycle which provides more battery life
- Support multiple topologies
- High network capability up till 65000 nodes on a network
- Data transmission range up till 100m-1500km
- Provides secure connection between devices and indicates
- Low cost because the modules are more cheaper compared to other available technology

2.3 Comparison between wireless communication technologies

It is vital to understand the main differences between a zigbee, Bluetooth as well as wifi which both three of this technology uses wireless protocols to communicate. Basically all this devices has the same design characteristic as defined in IEEE 802.15.4 whereby it only has similarities on the physical layers (PHY) as well as the media access control (MAC) layer according to and on the network layer and application layer it basically differs because separate alliance companies work to develop a certain specification which could lead them to commercialize their very own technology according to (Zucatto, Biscassi et al. 2007. Even though it has very common similarities it totally differs in term of simplicity of design and network configuration as well as data flow rate. Table 1 below illustrates the vast difference between zigbee, wifi and Bluetooth technology

Table 1: Difference between wireless technologies

Feature	**Wifi**	**Bluetooth**	**Zigbee**
Battery life time	Several hours	Several days	Several years
Complexity	High complexity	Complex	Simple
Nodes Number	32	7	65000
Coverage	100m	10m	100m-1.5km
Extension	Roaming enable	no	yes
Data rate	100	10m	100m-1.5km
Security	SSID64bit	128bit	128bit AES
Time for Network Communication	3 second	10 second	30 millisecond
Data Range	11&54 Mbits/Sec	1 Mbits/Sec	20,40 ,250 kBits/Sec
Networking Topology	Point to hub	Ad-hov very small network	Cluster tree,mesh,star
Operating Frequency	2.4Ghz & 5Ghz	2.4 Ghz	868(Europe).2.4Ghz globally

2.4 Topologies inside Zigbee Network

A zigbee network could work with three networking topologies which are the star, cluster tree and mesh. Basically all this three network is preferred because of four main reasons. According to (Wenqi, Healy et al. 2010) the first reason is because of its flexibility as the device could be placed anywhere in a place which compromises the data transmission range and the network is self forming and self healing [10].Secondly is the network scalability as zigbee technology has the capability to deploy around 65000 nodes through a building[10] .Thirdly is the network availability which has a optimum performance and could easily transmit and receive data without any interference which would make users to have a user friendly system to control and monitor a system[10] .Lastly it's because simple maintenance compared to other wirelesses network as it could be configured and perform diagnostic using a pc/laptop this eventually means if compared to a wired system to detect and rectify a problem its requires more cost and time[10].

2.4.1 Star topology

The network in star topology is managed by one coordinator and communicates with the end user device which exchange information with the coordinator [3]. To be more simple in star topology master will be the Full Functional Device (FFD) and Reduced Function Device (RFD) functions as slave according to (Borade and Laeeq 2012). Star topology could reduce network failure as all the end device is connected to a particular coordinator. The main advantage of a star topology is additional Reduced Function Device could be added into the network. The main disadvantage is if the coordinator fails the network will be down.

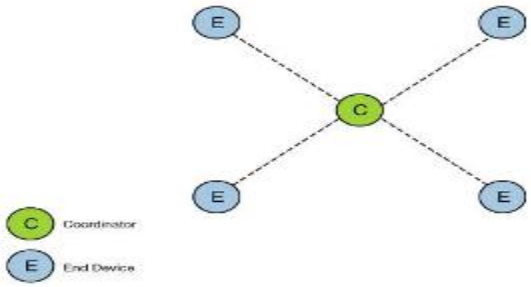


Figure 2: Star Topology

2.4.2 Mesh Topology

According to (Borade and Laeeq 2012) mesh topology is a network which has point to point link which enables any coordinator to communicate with any other coordinator in the network .If there is new device is being installed in mesh network it has the capability of self organizing automatically according to network and could optimize data traffic[3]. This network suits well in commercial application and for industrial control and monitoring process which requires a large network because it could reconfigure data transmission if it fail by choosing different node to transmit data[11].

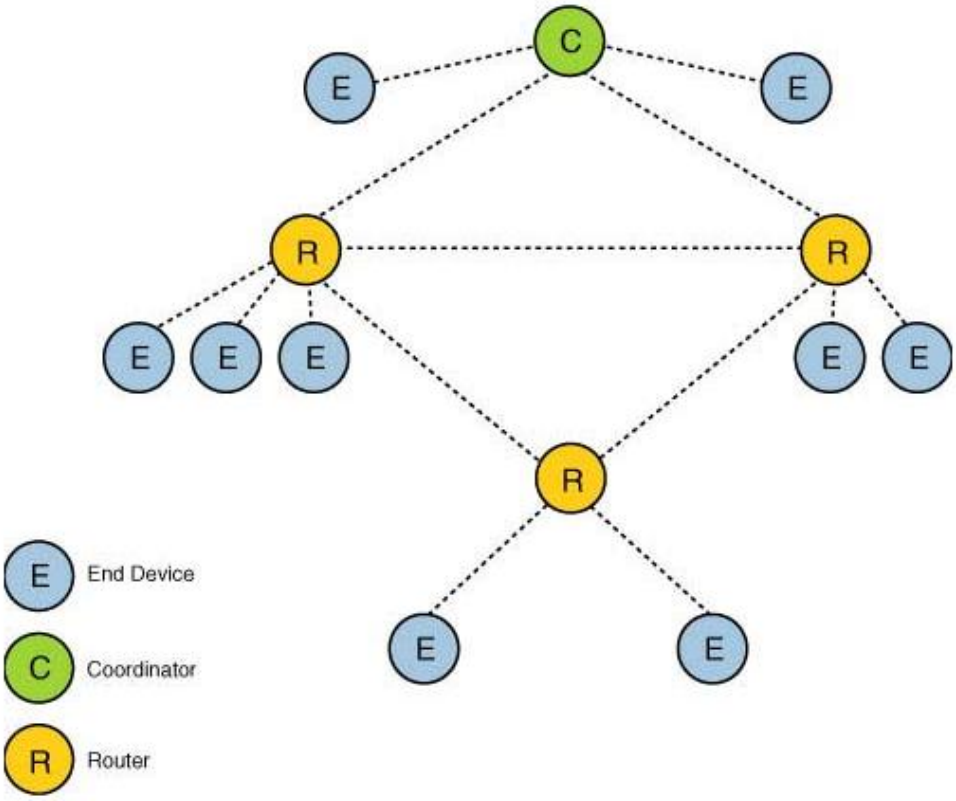


Figure 3: Mesh Topology

2.4.3 Tree Topology

According to (Li-Hsing and Wei-Ting 2008) in a tree topology it consist of three main things which is the root called coordinator, internal nodes as routers or FFD and leaf nodes which is the end device or could be defined as RFD. This topology is often used in building for devices in different floors to control end devices through a coordinator connected to router to send signals [3].The advantage of this topology is its scalable as the secondary nodes allow more devices to be connected to the centralized one. The disadvantage will be if the back bone of the hub fails it may cause the whole network system to be down.

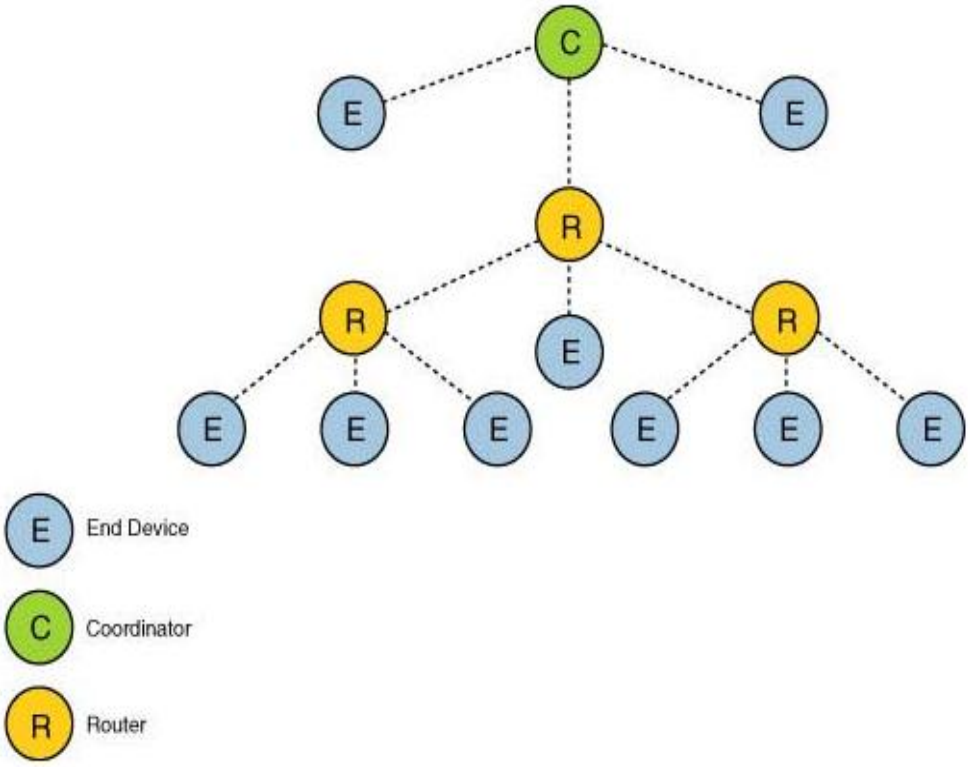


Figure 4: Tree Topology

2.5 Graphical User Interface (GUI) and Protection components

To work on my project which involves in monitoring and controlling a single phase protection system which has been developed in the university, it is important to understand the main components which involves in the single phase protection system and the interface required from pc/laptop to send data to control the system through zigbee wireless technology. The interface which will be used to communicate with transmitter and receiver which uses zigbee standard will be Graphical User Interface (GUI) which is to be developed using Microsoft visual studio 2010.

2.5.1 Graphical User Interface (GUI)

In order to transmit a date from a centralized position to the end device to perform a process there should be an interface which could communicate with the transmitting device and in current world to transmit a data, particular user had to be trained well to be able to operate the system which requires the skills decoding various information and outputs from the user interface. So in order to make this process system in a simple manner human machine interface should be designed in a way as it will be user friendly to transmit required information to the hardware setup stated by (Lavergne 2000). So by using a Graphical User Interface system it will be easier for users to control and transmit a data without any complexity. It's the best solution to interface computer and human. The system is so simple which only requires an input either from a keyboard or to work on the graphical view of the task required to be carried out For example in Scada system the power system network is interpreted in graphical view and operators could just isolate a switchgear by an input from the mouse transmitting command via fibre optics or wireless system. So by mean it is user friendly interface which could control any hardware operation.GUI could be developed in various kind of platforms such as Microsoft Visual Studio, Labview or Matlab

2.5.2 Components of protection system

Generally for domestic electrical protection the main protection purpose will be focused on over current and earth faults for a single phase system. For over current protection usually Miniature Circuit Breakers will be used as protection device and Earth Leakage Circuit Breaker (ELCB) or Residual Current Circuit Breaker (RCCB) will be used for earth faults as a protection device.

2.5.3 MCB (Miniature Circuit Breaker)

The main purpose of a Miniature circuit breakers are to protect electrical equipments against overload (thermal) and short circuit (electromagnetic) hence it derive the meaning of protecting electrical equipments from excessive temperature rises according to (Edvard .2012).These Miniature circuit breakers are mainly used in distribution system and basically miniature circuit breaker is designed without the use of fusible element isolating a circuit during an over current incident [15]

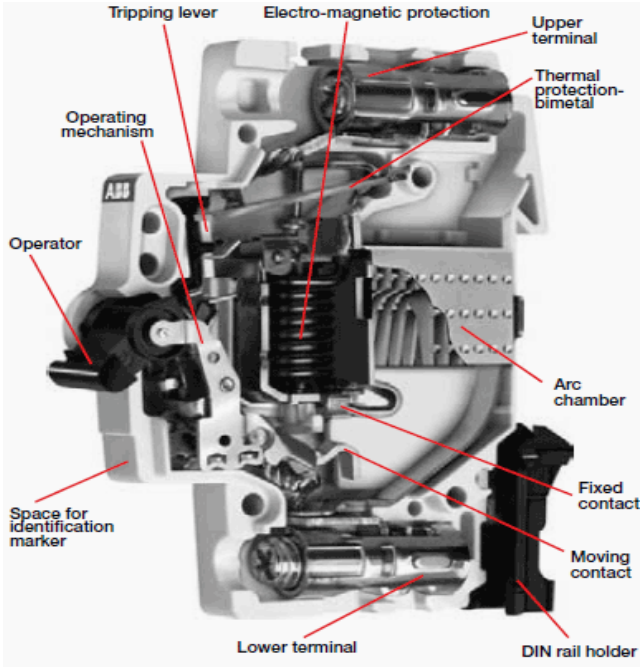


Figure 5: (MCB) Miniature circuit breaker construction detail

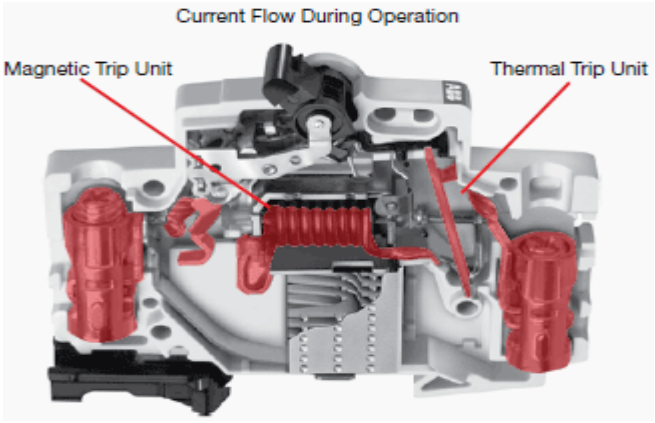


Figure 6: (MCB) Current flow during operation

2.5.4 RCCB

RCCB (residual current circuit breaker) is a residual current device which is used in domestic buildings as a protection device against electrocution. RCCB is device which could monitor on the unbalanced current which flows through life conductors and will trip if there is any faults as its designed to be very sensitive on the ground fault and touch current [15]. According to (Jiguparmar2011) RCCB is not designed to protect against over current and short circuit so it is usually build with MCB as protection device against over current and short circuit[16] .

2.5.5 Earth Leakage Circuit Breaker (ELCB)

Earth Leakage Circuit Breaker (ELCB) operated when there is an earth leakage current to ground from a wiring system and disconnects the power supply.

There are two types of ELCB;

1) Voltage earth leakage circuit breaker
2) Current earth leakage circuit breaker

2.5.5.1 Voltage earth leakage circuit breaker

A voltage ELCB basically has sensing coil and when it detects sufficient voltage across the coil it will disconnect the power and will remain in off condition if it is not manually on back by consumer.

2.5.5.2 Current earth leakage circuit breaker

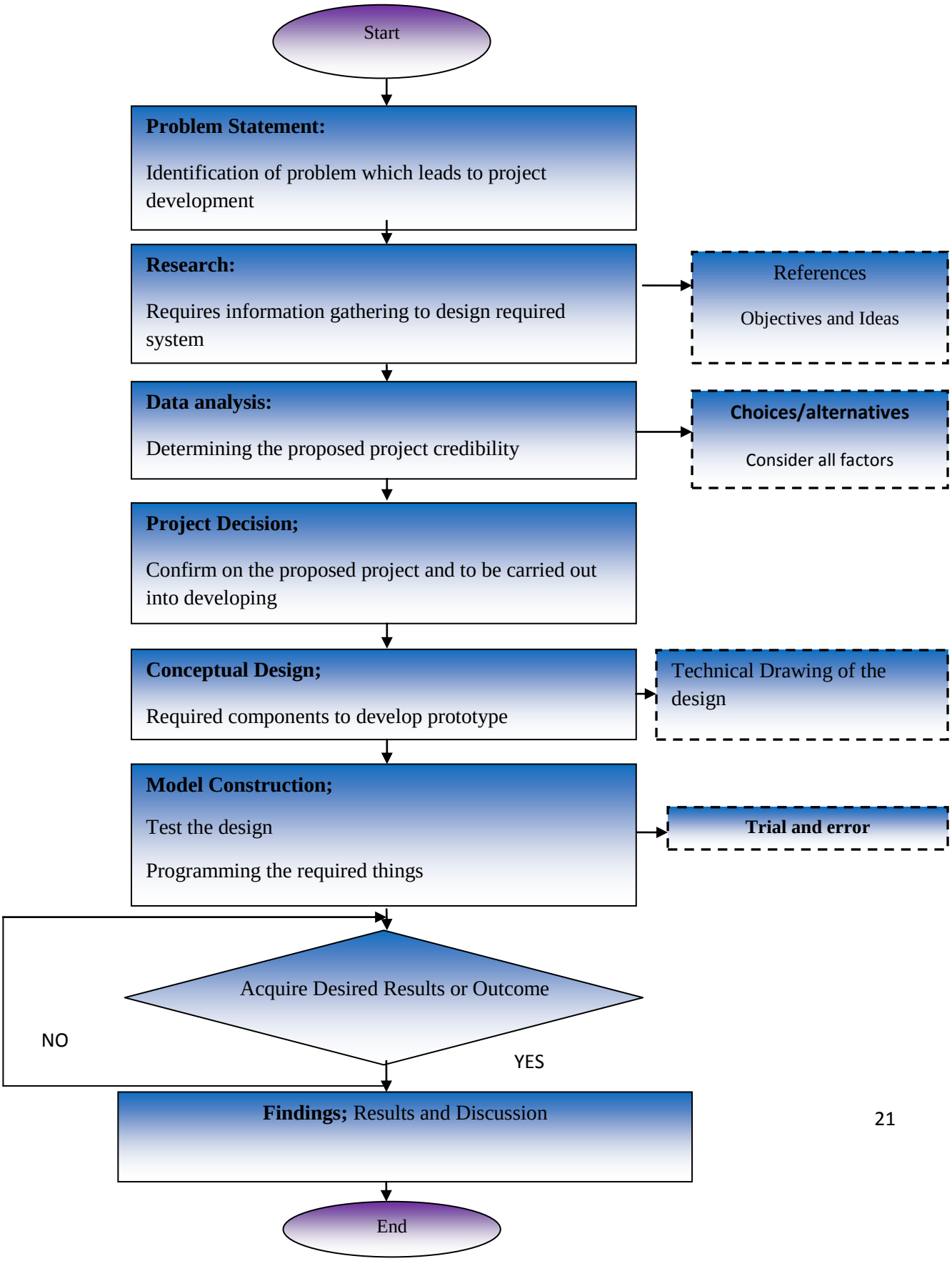
This is breaker know as RCD as mentioned in the RCCB deception part, and it operates as the current passes through a sensing coil and if there is any imbalance in current then this device will detect it and trip the contact.

CHAPTER 3

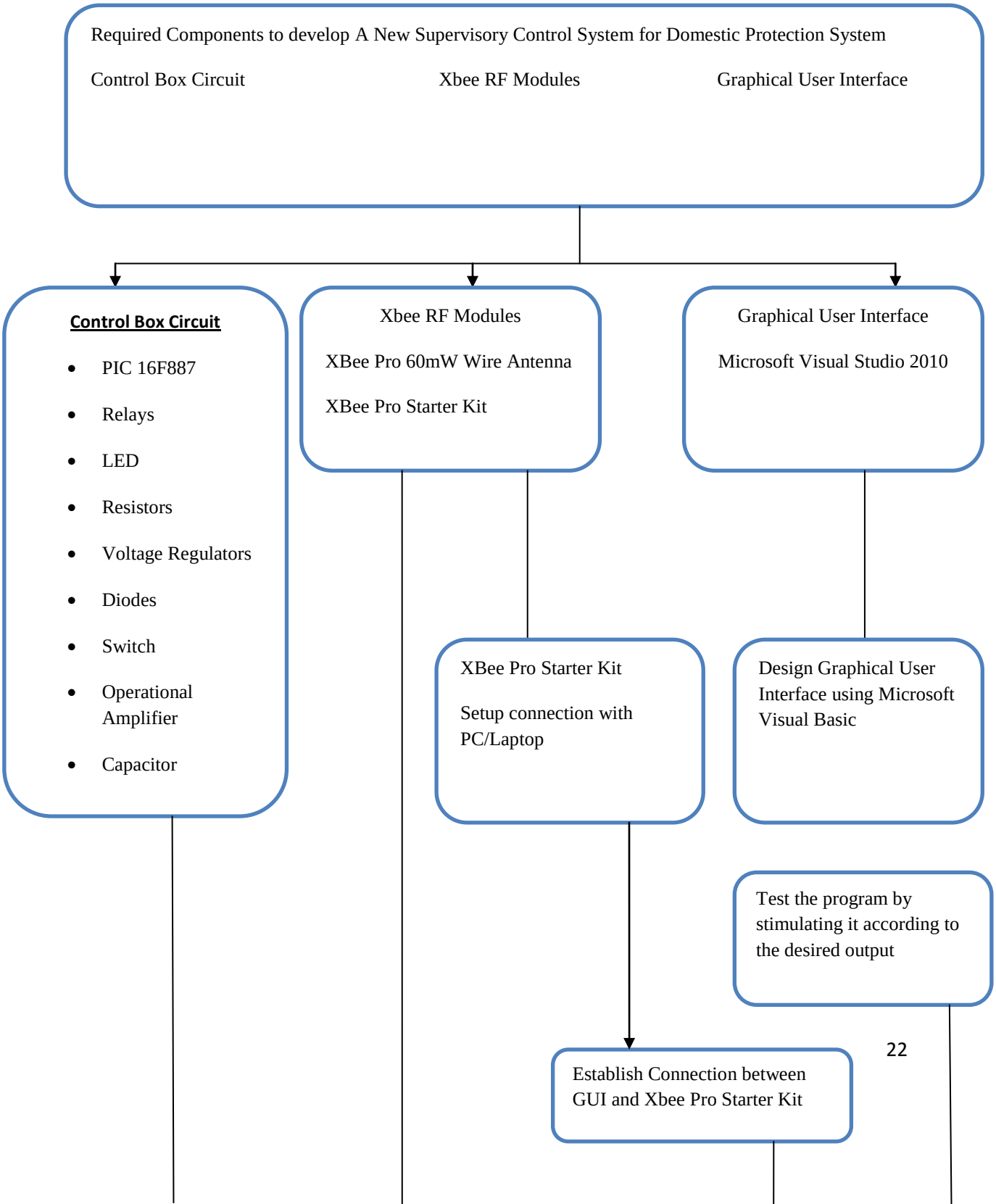
METHODOLOGY

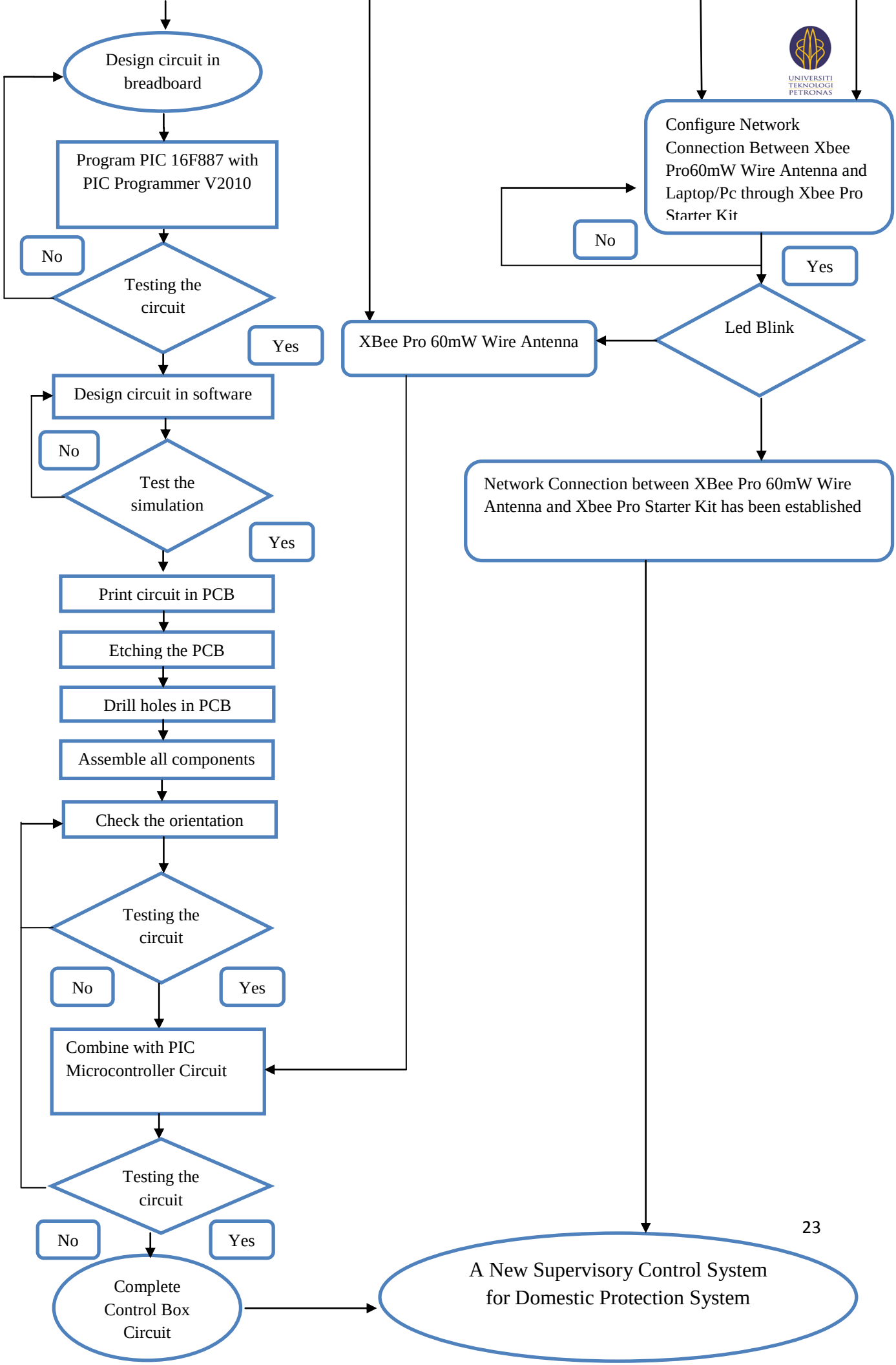
To begin this project a proper research methodology has to be carried out on each criteria which is required by the project. To develop a Supervisory and Control system which is to be combined with a single phase protection system there should be a good flow of understanding on each part of the design in the system, from the interface created to transmit data to the hardware until the receiving part which will act to send output signals to the protection system. In order to develop this prototype it is vital to understand required components to build the system and programs which will be used to control it, as FYP 1 requires deep understanding of the all the design criteria which will make an easier way to carry out task and finish the prototype successfully in FYP2.It requires much time on the programming part as two different type of program has to be develop which is for the Graphical User Interface Part and for the control box circuit which has PIC 16F887.On the data transmitting and receiving part which uses zigbee standard its vital to understand the required hardware because there is a lot of hardware's available in the market which serves its own purpose of usage, for example as for my project a RF module is required but there is 2 more modules which could also serve the same purpose such as the wifi module and Bluetooth module with different configuration of network system and interface. So before purchasing any of the readily available hardware's in the market its better to do much research on the required things because the allocated time frame to finish the whole project is around 8 months for FYP1 and FYP2.It will also help on better cost management without wasting any money on purchasing the wrong items which couldn't be utilize on the development of this project.

3.1 General Procedure of Project



3.2 Specific Procedure of Prototype Development



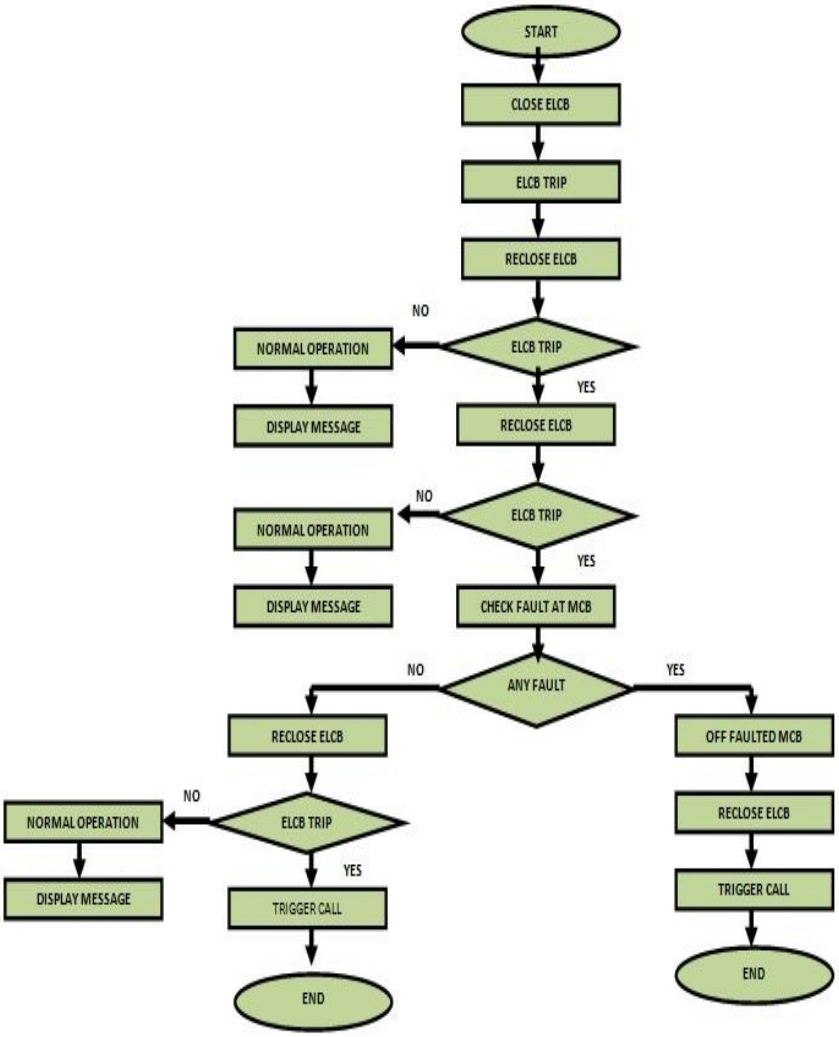

Design circuit in breadboard
Program PIC 16F887 with PIC Programmer V2010
No
Testing the circuit
Yes
Design circuit in software
No
Test the simulation
Yes
Print circuit in PCB
Etching the PCB
Drill holes in PCB
Assemble all components
Check the orientation
Testing the circuit
No
Yes
Combine with PIC Microcontroller Circuit
Testing the circuit
No
Yes
Complete Control Box Circuit
XBee Pro 60mW Wire Antenna
Configure Network Connection Between Xbee Pro60mW Wire Antenna and Laptop/Pc through Xbee Pro Starter Kit
No
Yes
Led Blink
Network Connection between XBee Pro 60mW Wire Antenna and Xbee Pro Starter Kit has been established
A New Supervisory Control System for Domestic Protection System

3.2.1 Power Recovery via Auto-Pros System

Power recovery is important to ensure continuous power supplied to specified electrical appliances such as refrigerator or aquarium. Previously, power recovery is manually done. Auto-Epros system has been developed to overcome this matter, with two main processes involved in:

- Detect MCB fault location and isolate it
- Reset ELCB once fault isolated

Flowchart below illustrated the power recovery process in auto-pros system

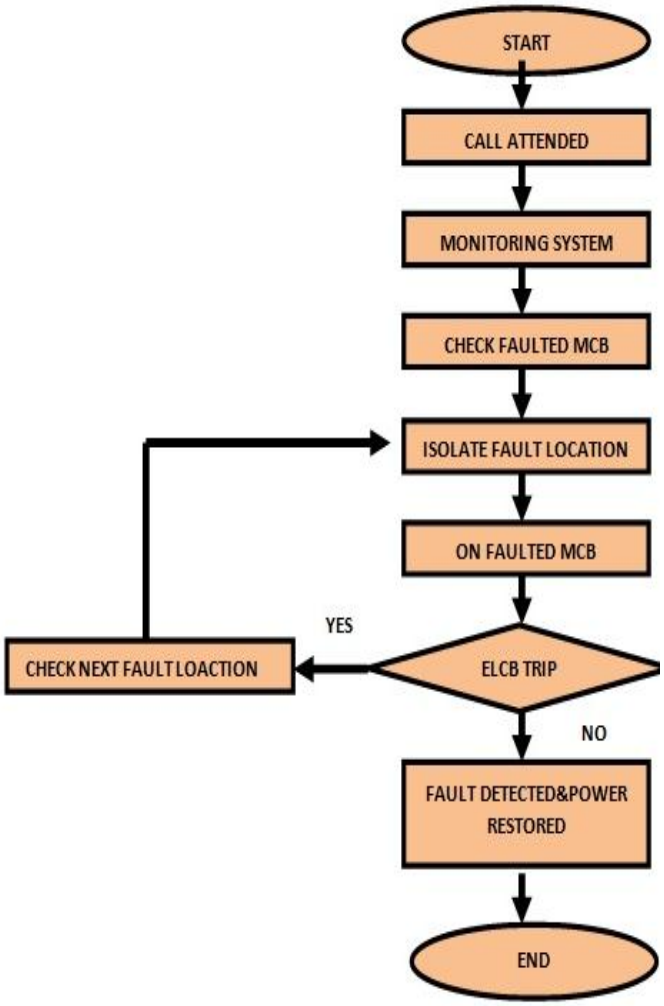


3.2.2 Power Recovery via supervisory and control system to isolate the fault location

A New Supervisory an control system is developed to isolate the fault location in the MCB and on back the isolated MCB for power recovery process .Basically there is two main steps involved as below:

- Detect faulted MCB via Monitoring System
- Isolate fault location and on back the isolated MCB via control system

Flow Chart bellow illustrated the power recovery process:



3.3 Brief Idea on the overall Prototype

Figure 7 shows a brief idea on how the supervisory and control system works in controlling auto-pros system.

- On/Off of the MCB or isolate/connect the load command is send through the GUI via serial com port which is connected to Xbee Pro starter Kit
- The signal is then transmitted to the Xbee module connected with the control box and is processes in the microprocessor and signals are sent to the relays to control the auto-epros system
- This system al acts vice versa, when a fault occurs at the auto-epros system ,the signal is send to the control box and is interpreted by the microprocessor and the command is send through its Rx/Tx to the Xbee module and is transmitted via wireless the Xbee Pro starter kit and the tripping signal will be able to be detected in the GUI design

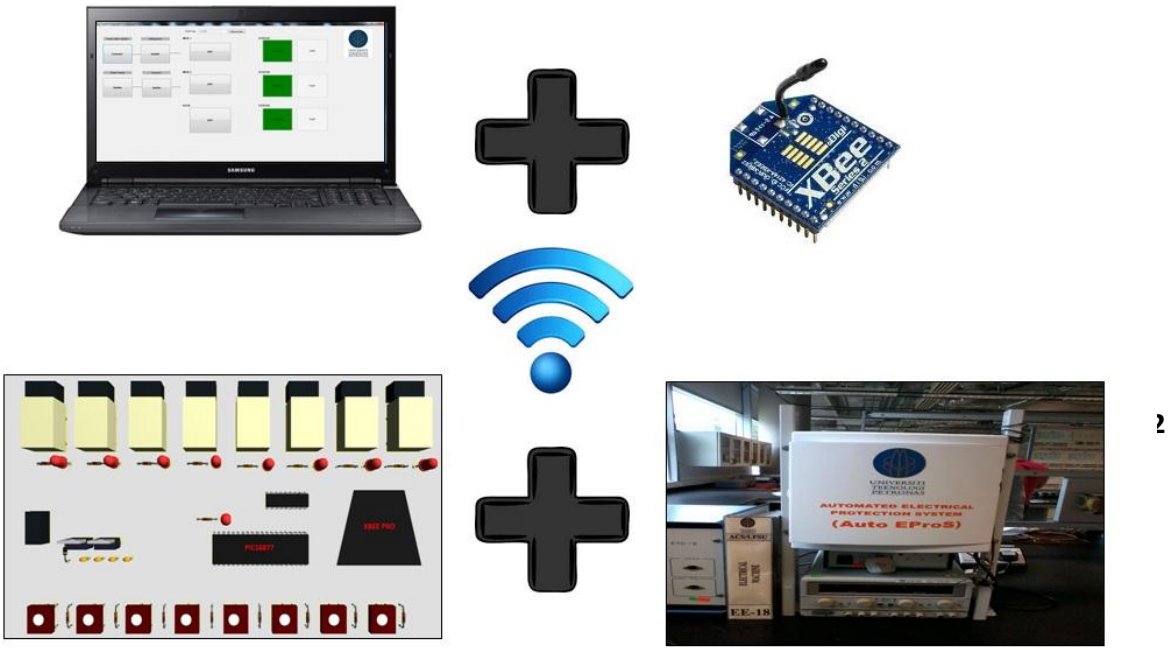


Figure 7: Illustration of the Prototype

3.4 Tools and Equipments Required

- Required Hardware for prototype:-

Table 2: Hardware and function

Components/Hardware	Functions
Xbee Pro Starter Kit	As a signal transmitter from laptop to control box circuit
Xbee Pro 60mW Wire Antenna Clamp	To receive signal from transmitter and send over to microcontroller
PIC 16F887	Integrated in the control box to interpret signal receive from receiver and send signals to relays
Control Box	Consist of electronic components such as Relay ,Led Resistor, Capacitor, Voltage regulator,Darlington Transistor array, Oscillator and etc to perform supervisory and monitoring
Laptop/Pc	To monitor and control the protection system
PIC Programmer(USB ICSP)	To program the PIC microcontroller

- Required software for the prototype:-

Table 3: Software and Function

Functionality	Software Used
Documentation	Microsoft Word
Programming	Microsoft Visual Basic 2010, Hi-Tech Compiler,MPLAB,UC00A
Simulation and Design	Proteus and Altium Designer

3.5 Description of main Hardware's Involve for prototype

3.5.1 Xbee Pro Starter Kit

Description

This Xbee Pro Starter Kit basically comes with the Xbee Pro module as it is integrated on the Xbee starter kit .There is also starter kit which is available without the Xbee Pro module but it would be tough for user to connect it as it requires good soldering skills. There is two type of starter kit which is Xbee Starter Kit and Xbee Pro Starter Kit it mainly differs in the communication range. Refer appendix 1 for the features

3.5.2 XBee Pro 60mW Wire Antenna

Description

Xbee Pro 60mW Antenna is a very simple and reliable wireless communication module which could communicate with microcontroller and could be used as a transmitter and receiver depends on the desired configuration .There is two types of modules which is Xbee and Xbee Pro as it differs in range of communication. Refer appendix 1 for the features

3.5.3 IC PIC 16F887

Description

This Integrated Circuit is a product of Microchip and it is easy to program as there is only 35 single word instructions. Its a 8 bit microcontroller .This is a EEEPROM data memory type 256 bytes. Has 2 comparators 14 channels of 10 bit Analogue to Digital converter. Most application in automotive, industrial and consumer appliance. Refer appendix 1 for the feature

3.6 Gant Char for FYP II

No	Detail/Week – FYP II	1	2	3	4	5	6	Mid-Semester Break	7	8	9	10	11	12	13	14
1	Software & Hardware Development															
2	System Functionality Test															
3	System Troubleshooting															
4	System Implementation & Prototype Fabrication															
5	Draft Report															
6	Submission & Completion of Project															

3.7 Key Milestone for FYP 2

1st Week

- Work on schematic design and refining process

2nd Week

- Learn on schematic to PCB implementation using a new software Protel DXP

3rd Week

- Work on PCB development in protel DXP

4th Week

- Work on PCB resizing to be fabricated

5th Week

- Work on PIC programming to be programmed into PCB after development

6th Week

- Troubleshooting PIC programming which has bugs

7th Week

- Fabricating PCB and solder all the required components and program the PIC

8th Week

- Troubleshoot PIC program to the preferred input output

9th Week

- Work on visual basic interface between control box and GUI design

10th Week

- Work on control box combination with auto-epros

11th Week

- Work on control box combination with auto-epros and rectifying all the possible problems

12th Week

- Prepare final report and try to finish the project perfectly

13th Week

- Final report submission and prepare for viva

14th Week

- Viva on completed project

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Results

Based on the methodology a simple design has been made to illustrate the whole prototype design on how actually its works to supervise and control the single phase protection system .Figure 8 shows the idea of design which will be implemented as the GUI (Graphical Interface) and Figure 9 illustrates the whole system which will be fabricated as a prototype in future

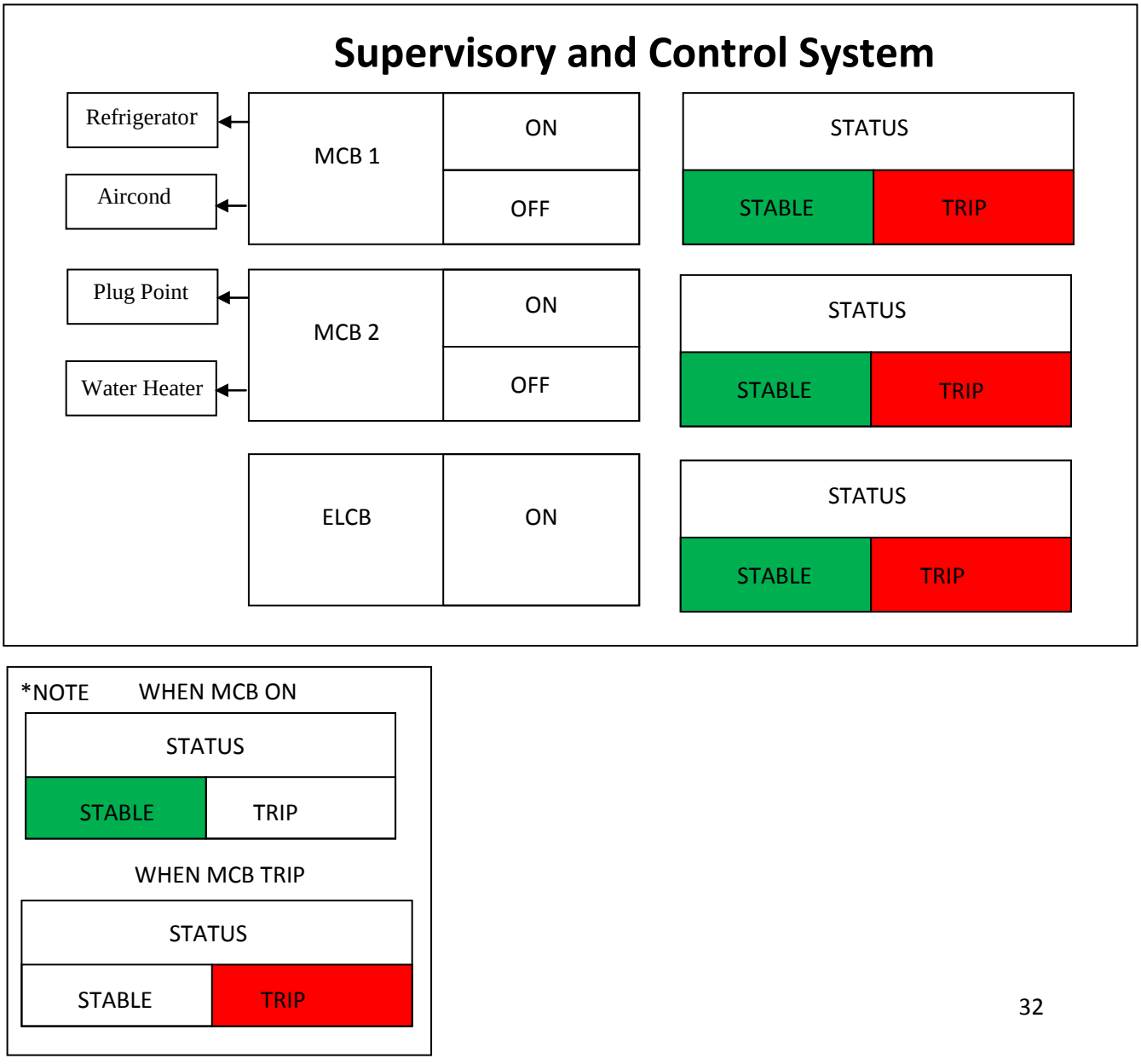


Figure 8: Design illustration of GUI

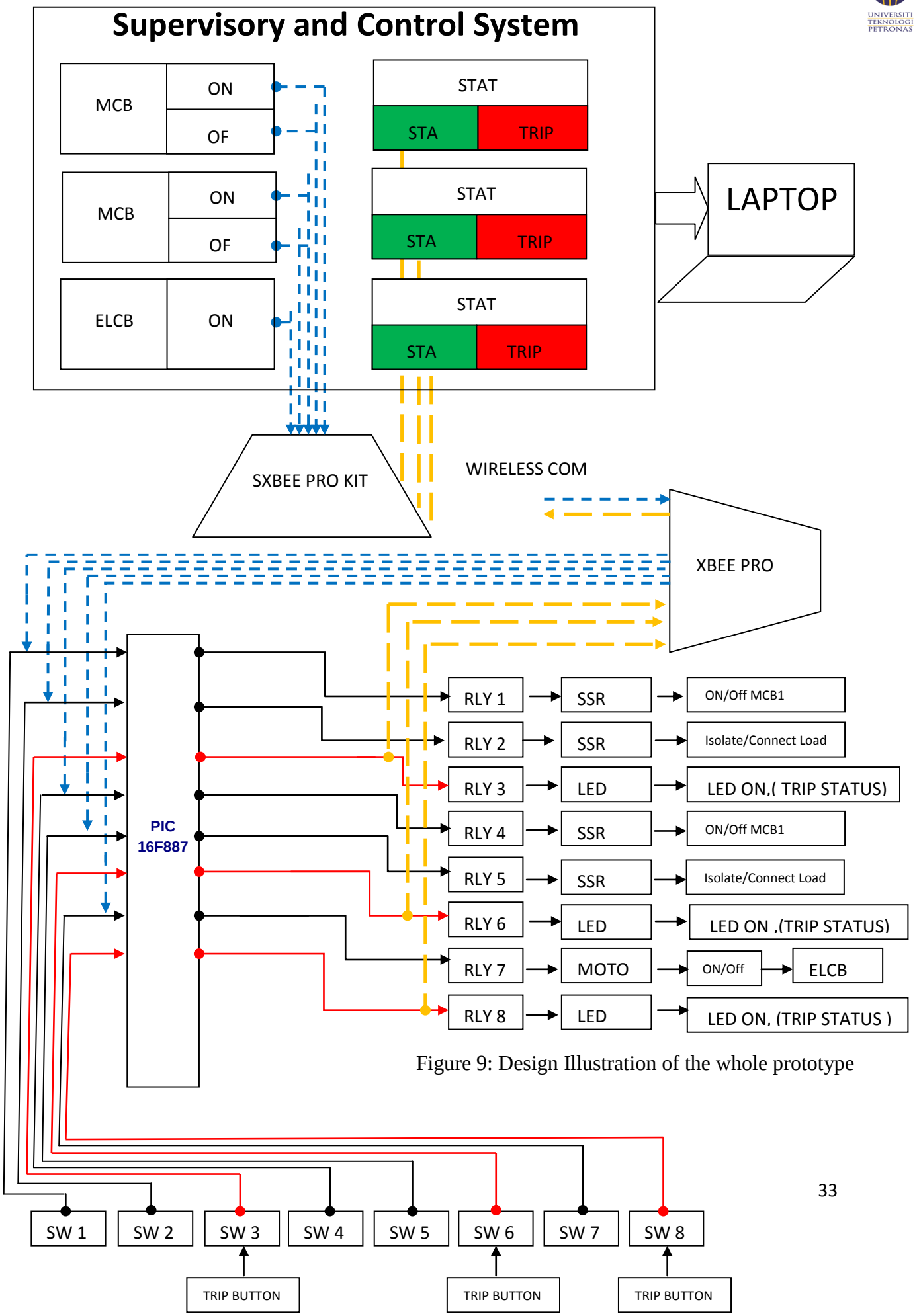


Figure 9: Design Illustration of the whole prototype

4.1Design of the control box

The basic control box design will be as figure 10 and 11. It uses a supply of 5V for the PIC microcontroller as well as the ULN2083 to control the output which is to the relays from the 8 switches. Ex: Switch 1 gives an analog input which will trigger the microcontroller to send the signal to the Darlington transistor array which then triggers the relay to switch on. And as for the Xbee Pro Module it uses 3.3 Volts using a LM317 voltage regulator and as for example if a continuous analog input is given to switch 3,6,8 it will transmit data to the Xbee Pro connected to user pc to indicate that there is power failure in system by showing 'trip' indication.

Based on the 2D circuit design in figure 10 and schematic design in figure 11;

PIC16877 is used as a cpu to process the input data from the switches and Xbee Pro transceiver to perform iterations and sending signal's to the Darlington transistor

Led's functions as an indicator to the input signal either manually through the switches or from the user pc using GUI

Resistors acts to restrict the amount of current flow to avoid damages to the components and to pull up current

Oscillator functions to provide clock signal as in this design it is 20MHz for the PIC to process the data.

Darling Transistor Arrays(ULN2803) acts as an interface between low logic level digital circuitry from PIC Microcontroller to the higher current/voltage components as in this case the relays

Capacitor are used to ensure the amount of voltage being provided as its function is to charge and discharge

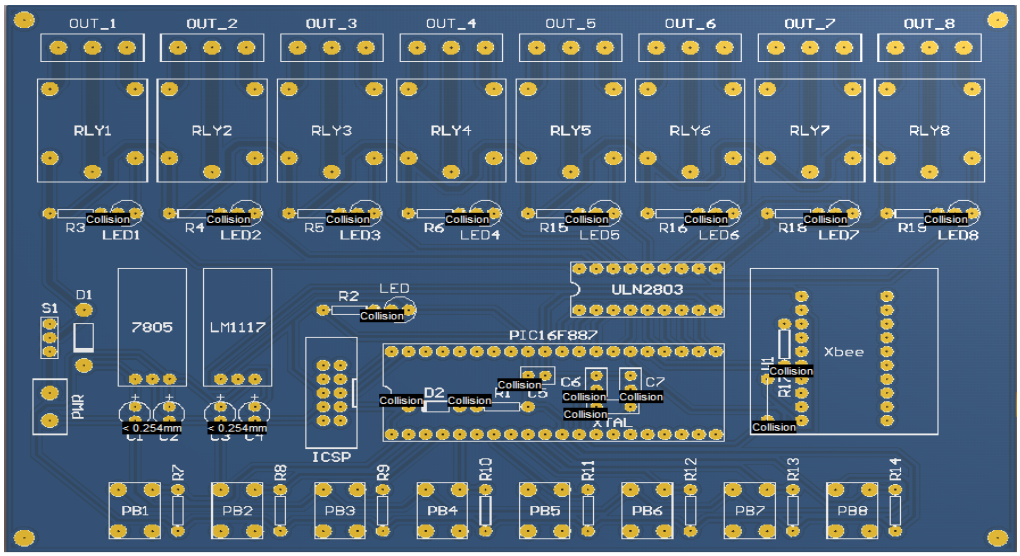


Figure 10:2D circuit Design

4.1.1 Schematic Design of Control Box

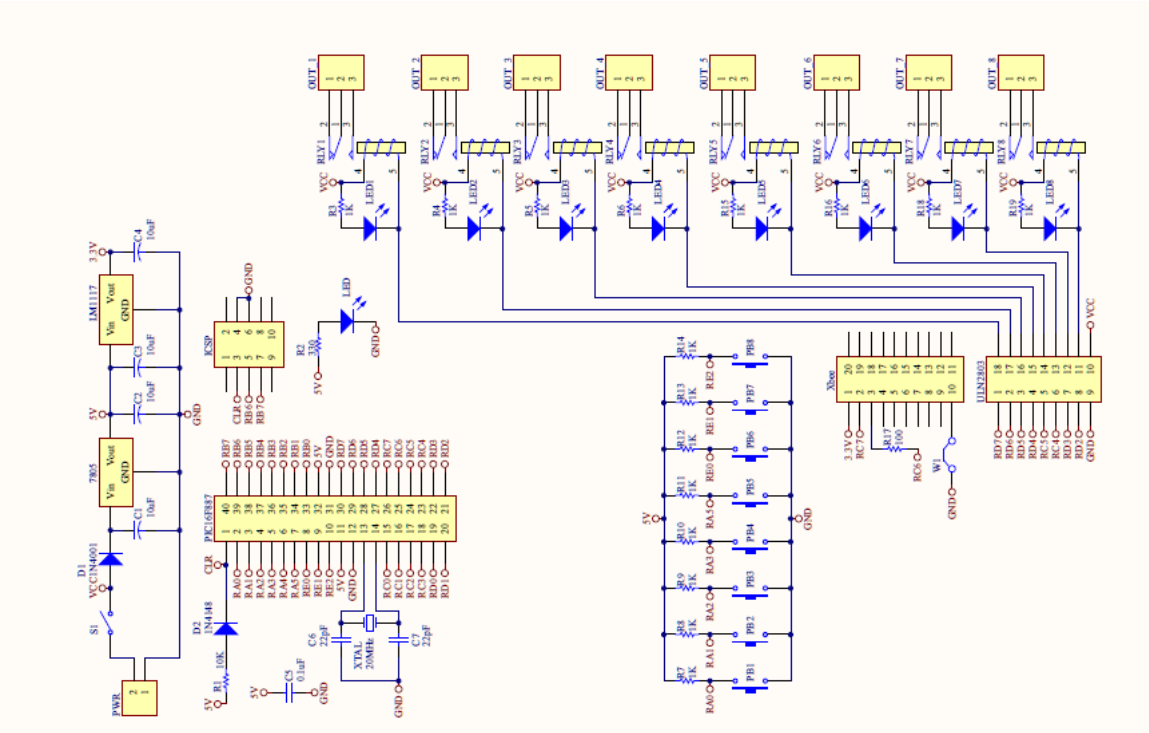


Figure 11: Schematic Design of Control Box with Protel DXP

4.1.2 PCB Design of Control Box

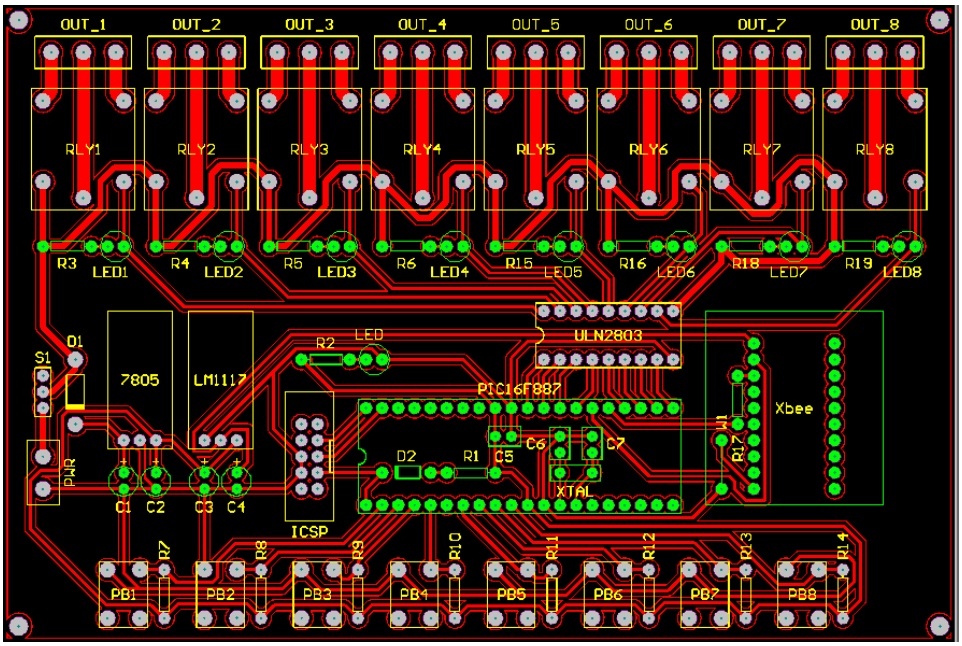


Figure 12:PCB Design of Control Box with Protel DXP

4.2 Merging Control Box and Auto-Epros Design

Figure 12 illustrates on the merging of the control box and the auto-epros system controlled by arduino.

When a permanent earth fault occurs the ELCB basically will reclose for three times and all this reclose process is controlled by ardunino via a motor

When the faulted MCB has been detected by the arduino system the power flow for that particular MCB will be disconnected via solid state relays and power flow been recovered

The control box basically could monitor all the events via wireless and could detect the tripped condition of the faulted MCB when arduino output to solid state relay are 0V through a relay and it is able to isolate the faulted appliance specifically through try and error process and connect back the tripped MCB to recover power flow.

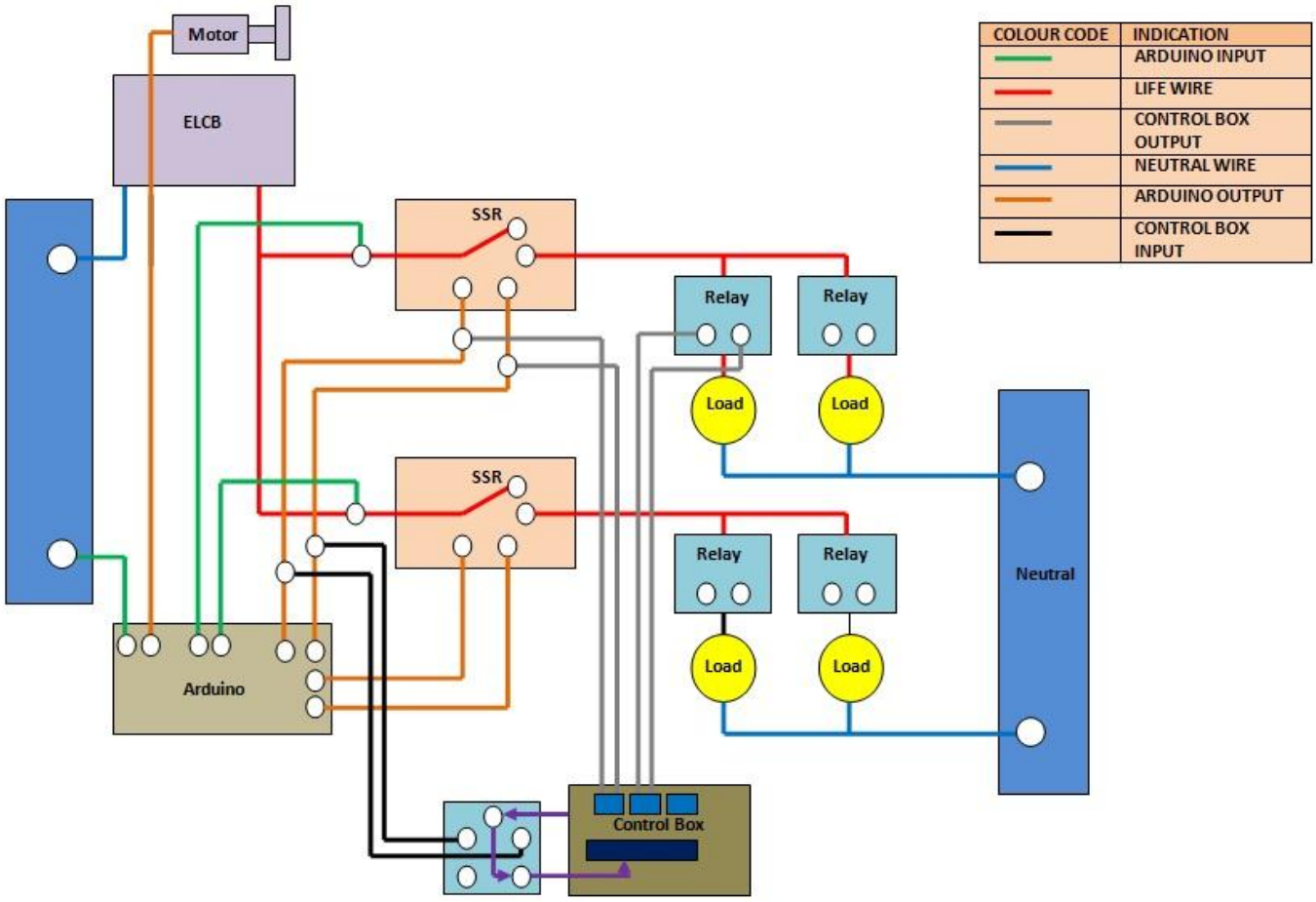


Figure 13: Merging Control Box and Auto-Epros Design

4.3 GUI Design

Figure 14 shows design 1 and figure 15 Shows design 2 which has been carried out using Microsoft Visual Studio which could be connected with SKXBEE pro kit using serial com port.

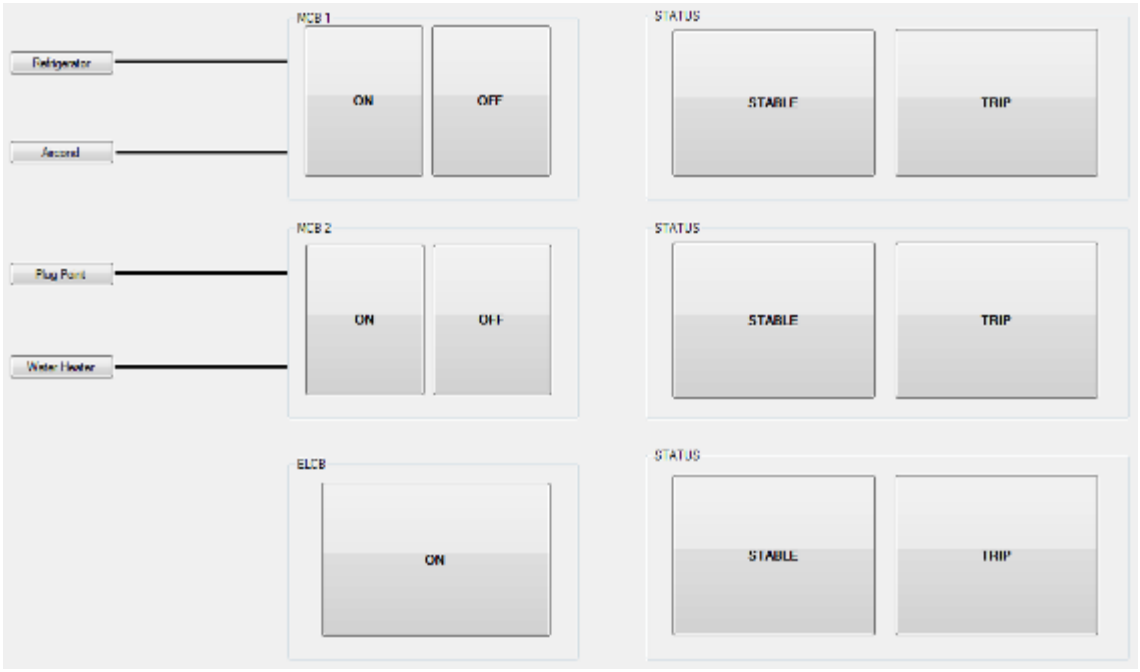


Figure 14: GUI Design 1 in Microsoft Visual Studio

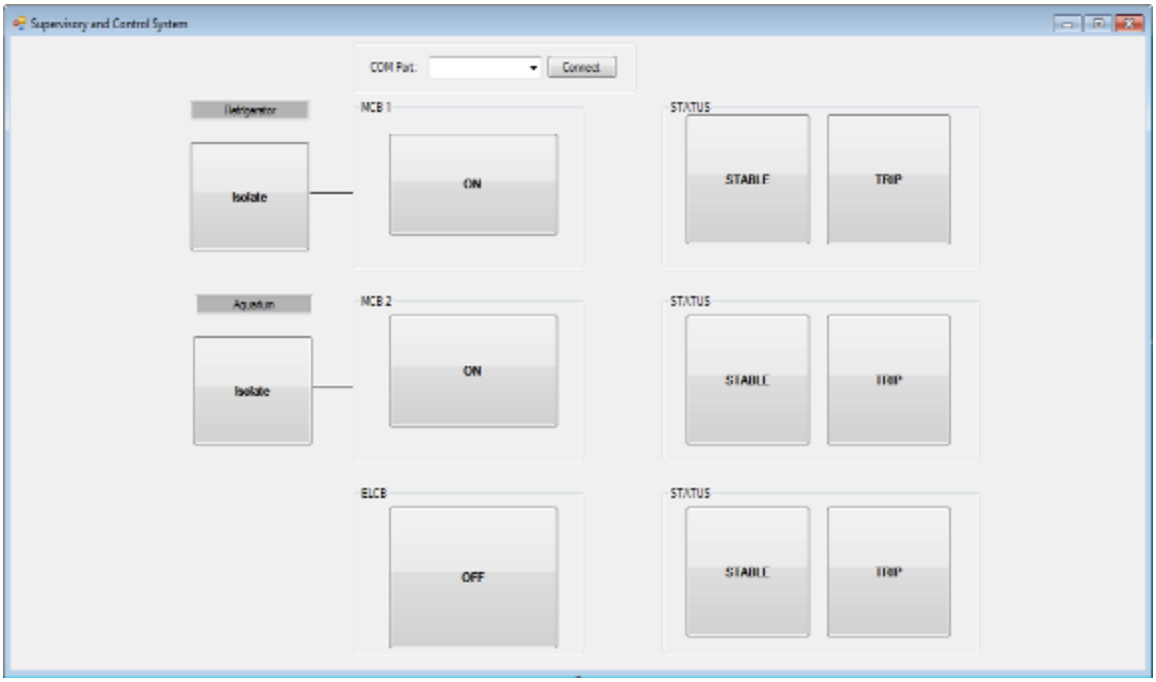


Figure 15: GUI Design 2 in Microsoft Visual Studio

Based on the on the design in figure 16 a serial comport has been initialized for the GUI to be connected with the SKXBEE Pro .Figure 16 and 17 shows before com port selection and after selection and figure 18 and 19 shows the led indication before connection and after connection which has been initialized

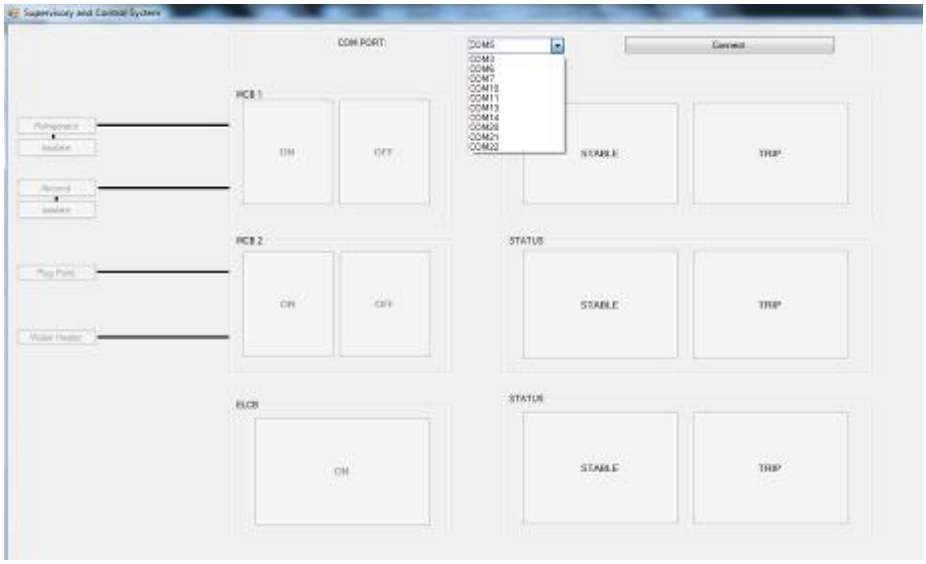


Figure16: Before connection with SKXbee Pro

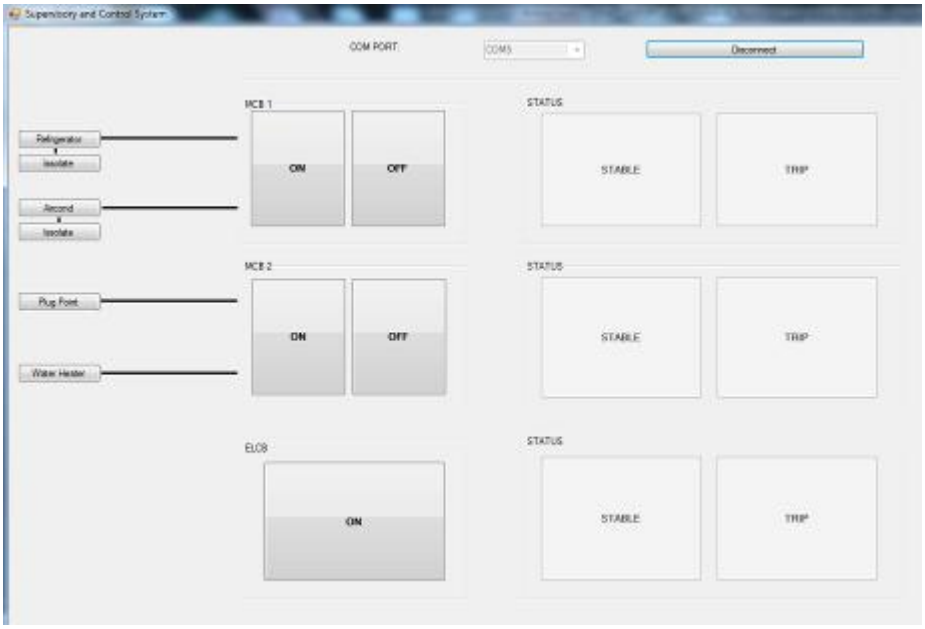


Figure 17: After Connection with SKXbee Pro

4.4 GUI Connection with SKXbee Pro

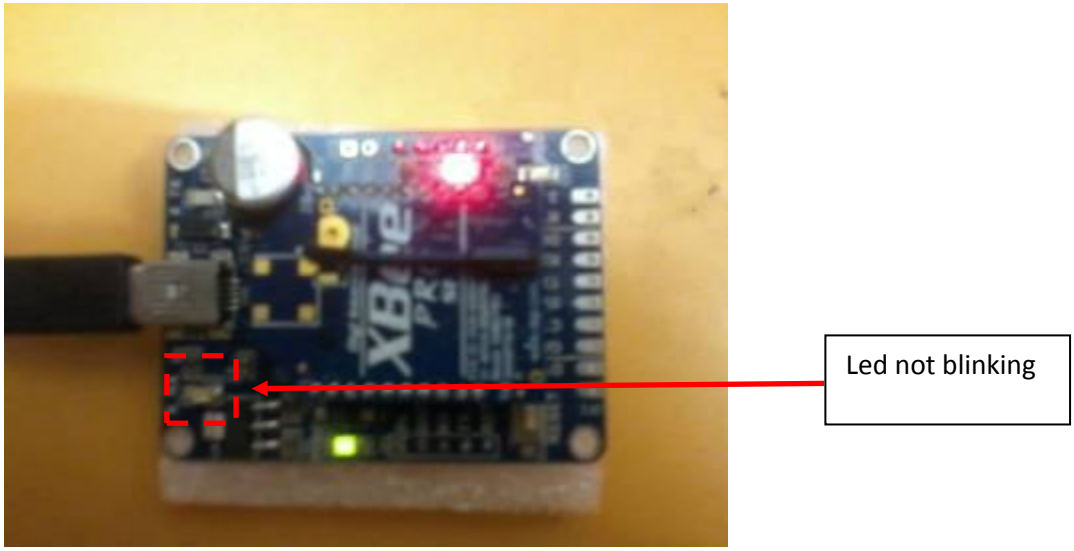


Figure 18: Before connection establishment with GUI

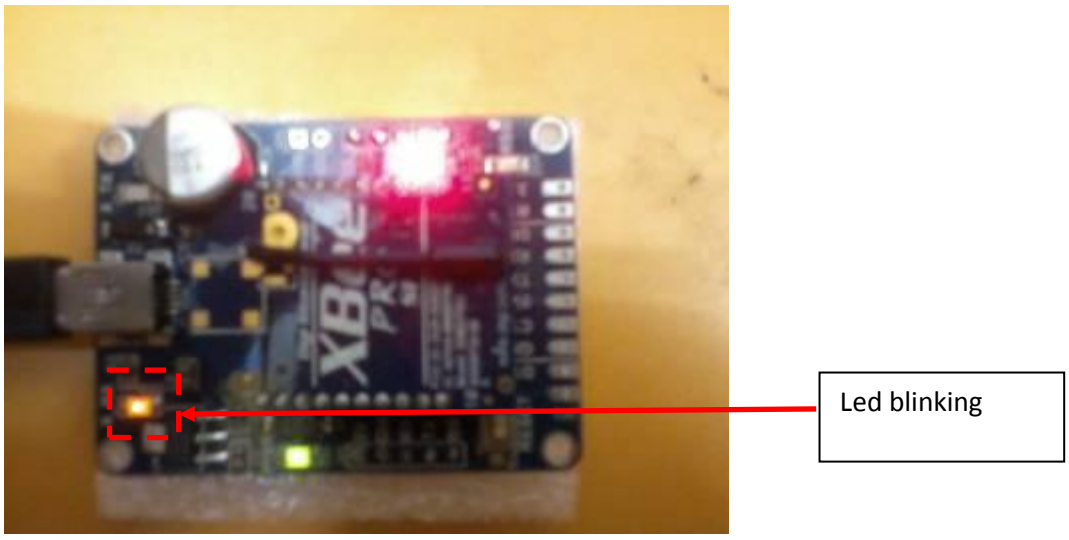
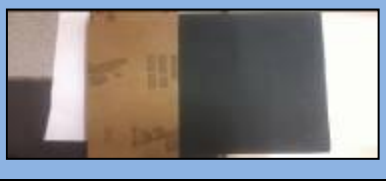


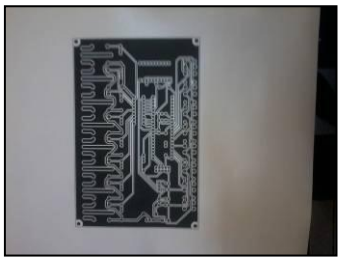
Figure 19: After connection establishment with GUI

4.5 Development of PCB Design into PCB board

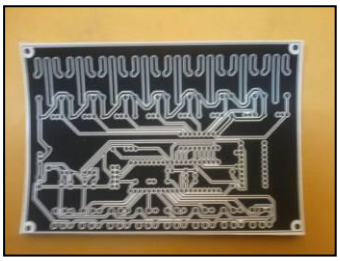
Required Materials and Equipment for PCB development

Equipment Materials	Image
Sticker Paper This Material is used to print out the pcb design to be transferred to pcb copper.	
Iron This equipment is used to provide heat on the sticker paper so that the printed circuit from the sticker paper will be transferred to the copper	
Etching Acid This liquid is used to remove unwanted circuit path in the pcb design	
Mini Drill This Equipment is used to drill holes in the PCB	
Solder Iron This equipment is used to solder all the pin through hole components in the circuit	
Sand paper This Material is used to remove the oxide from the pcb .	

4.5.1 PCB development procedure

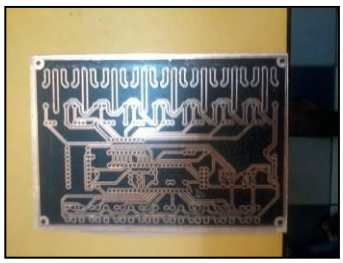


PCB design is printed out in a sticker paper



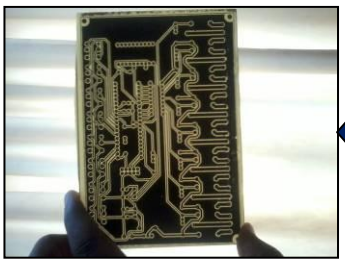
PCB design is cut to the exact size of the design

Sticker paper is attached to the pcb as above

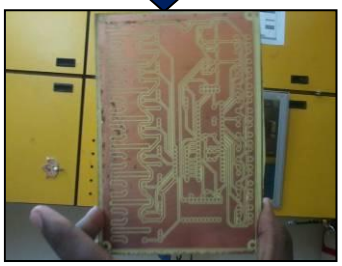


Upon applying heat the design from the sticker paper is transferred to pcb copper

The PCB is etched using ferric chloride acid by moving the container gently



The unwanted pcb copper has been removed and the carbon is removed using kerosene or petrol



PCB design with removed carbon

PCB is drilled using mini drill

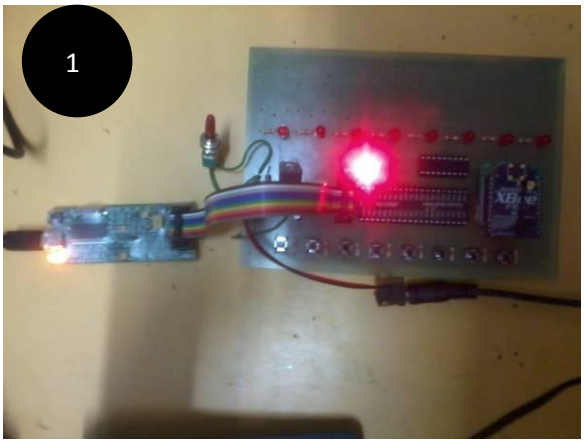
PCB is soldered with the respective components

FINAL PRODUCT

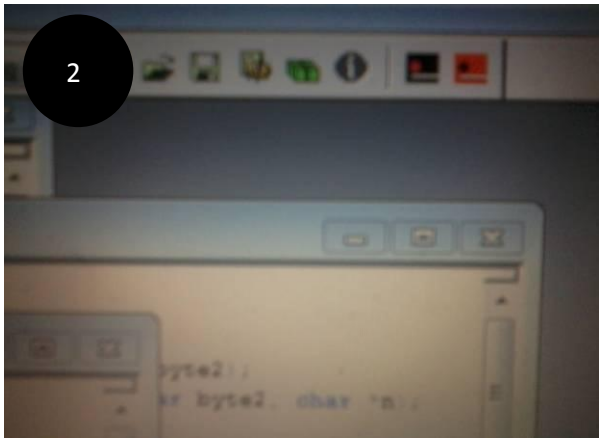
Figure 20: PCB development

4.6 Programming Control Box Circuit

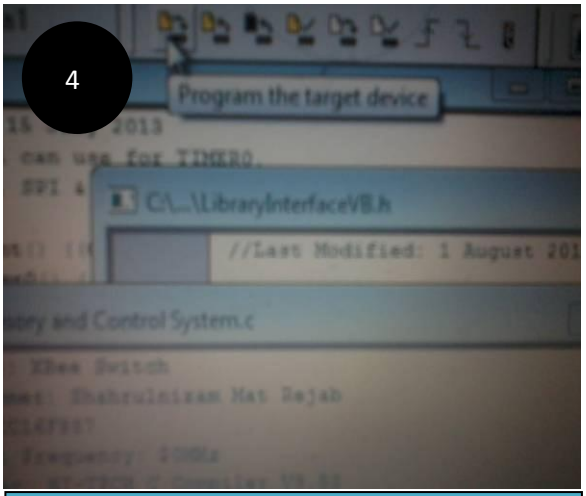
After completing the circuit design it has to programmed using pic programmer as show in figure 21.



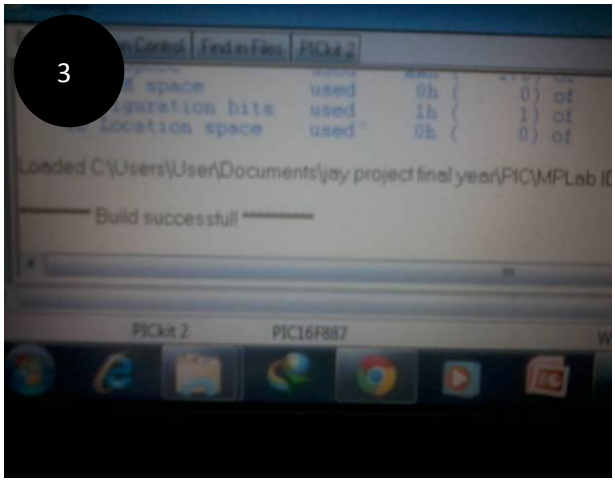
PIC Programmer is connected as above to the circuit



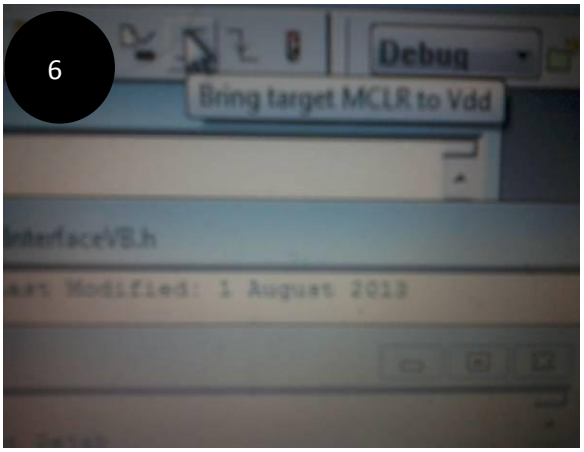
The black box top right is clicked to build the program



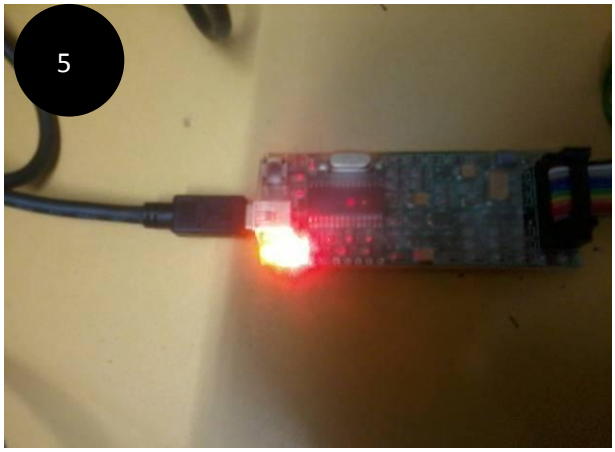
Click the program the target device button



Indication of successful build



Finally set the MCLR to VDD



Red Led in the programmer indicates program successful

4.7 Testing control box circuit

Upon completing the programming procedure the circuit has been tested as per programmed and the results are as in figure 22.

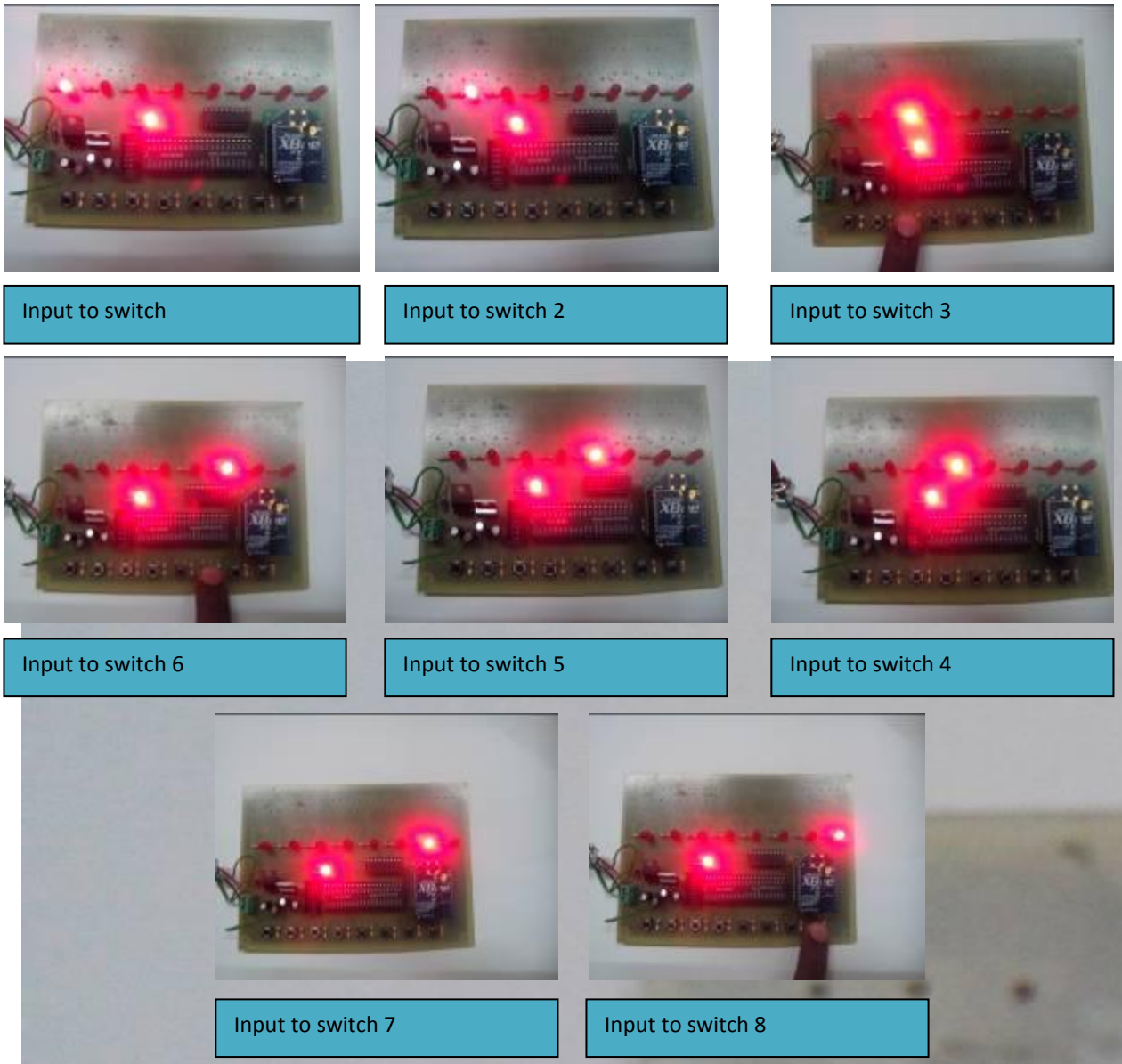


Figure 22: PCB development

4.8 Prototype development

After completing the testing procedure and assured the circuit design has been successful working. The prototype has been developed into a more fine design and been fabricated show in PCB development process above. Figure 23 shows the prototype

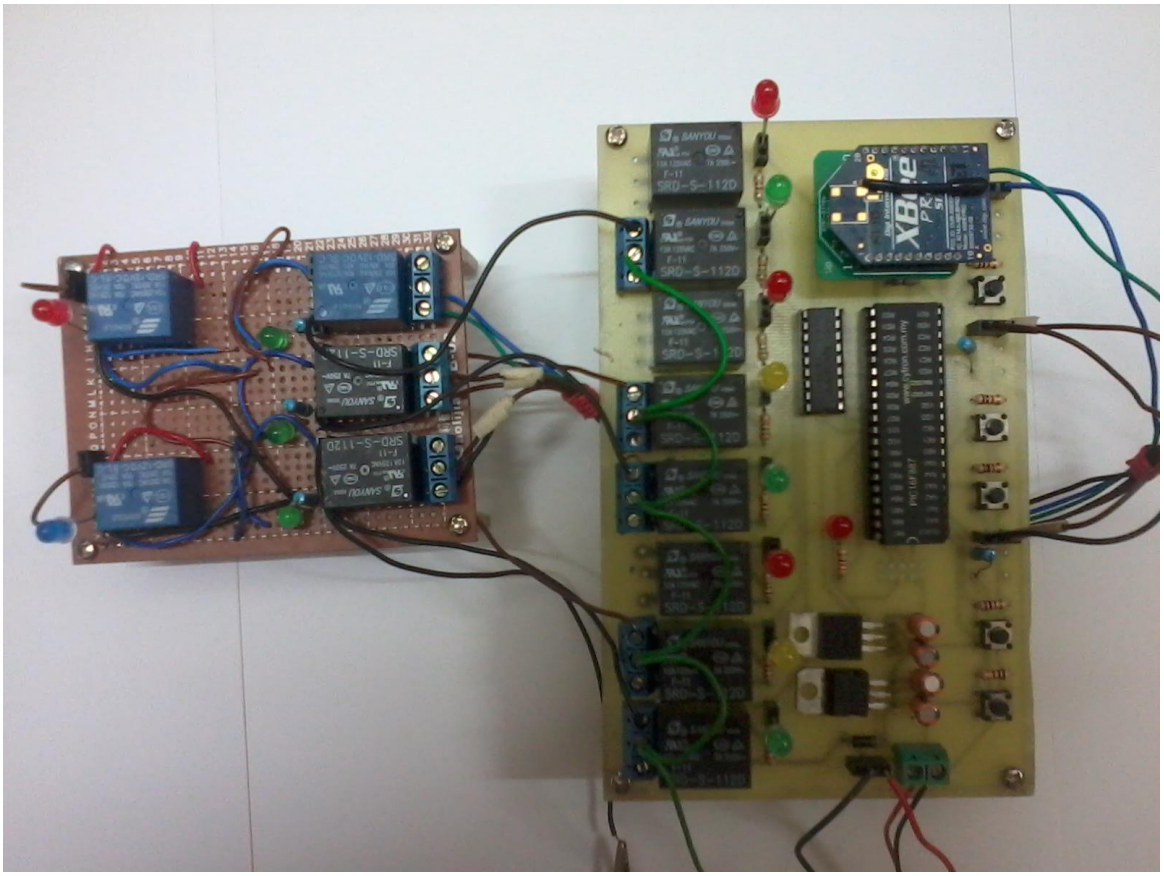


Figure 23: Control Box prototype

4.9 Prototype test results via GUI Controlling and Monitoring

A. ElCB and MCB'S stable condition

Figure 24 shows the results when the power flow is stable without any fault

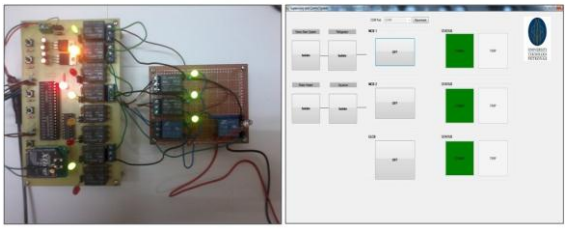


Figure 24: ELCB&MCB's Stable Condition

B .MCB 1 tripped condition

Figure 25 shows the results when MCB1 is tripped using GUI via wireless to control box

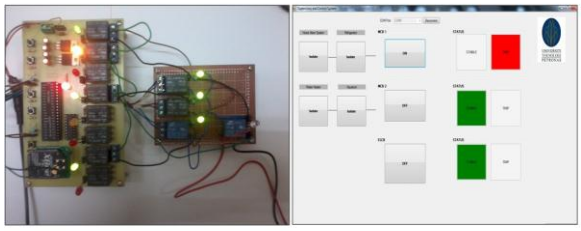


Figure 25: MCB1 Tripped Condition

C.MCB 2 tripped condition

Figure 26 shows the results when MCB2 is tripped using GUI via wireless to control box

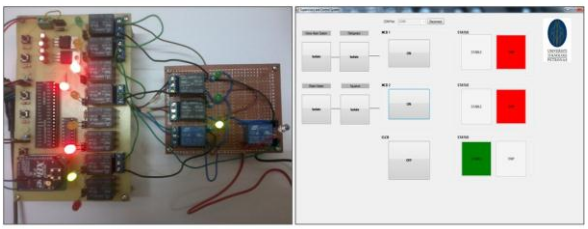


Figure 26: MCB2 Tripped Condition

D.ELCB&MCB's tripped condition

Figure 27 shows the results when ELCB and both MCB'S are tripped using GUI via wireless to control box

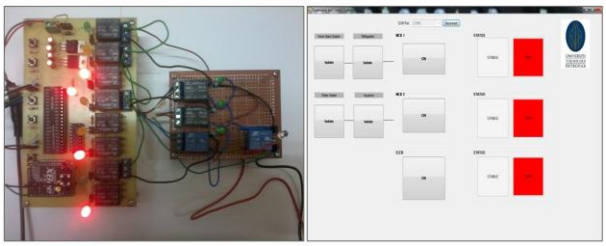


Figure 27: ELCB&MCB'S Tripped Condition

4.10 Prototype test results via GUI to isolate fault location

The Control box which has been designed has been tested out for its required operation mainly in for condition ELCB and MCB'S in stable condition, MCB 1 has tripped, MCB 2 Tripped and ELCB and MCB'S in tripped condition

Figure 28 shows the results when the ELCB and the MCB are in stable condition as the power flow is stable without any fault

A. Power Flow in stable condition

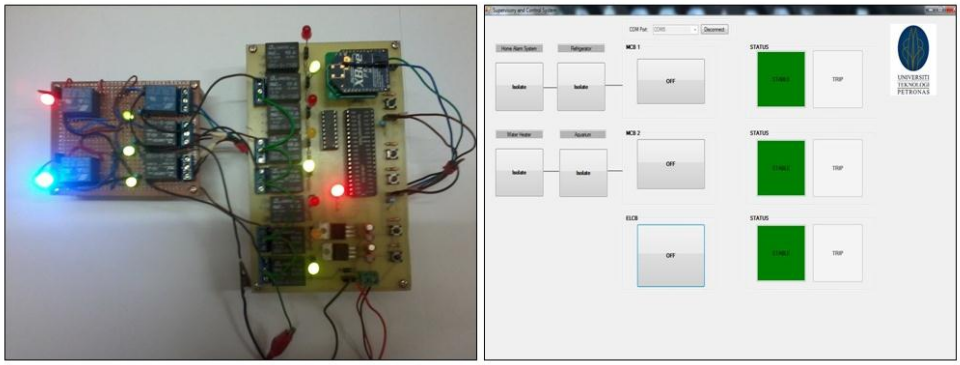


Figure 28: ELCB&MCB'S Stable

B. Fault Condition at MCB 1

Figure 29 shows the results when fault occurs in MCB and is shown clearly by the LED indication that here is no any power flow during the fault at MCB1 and the load's connected to it

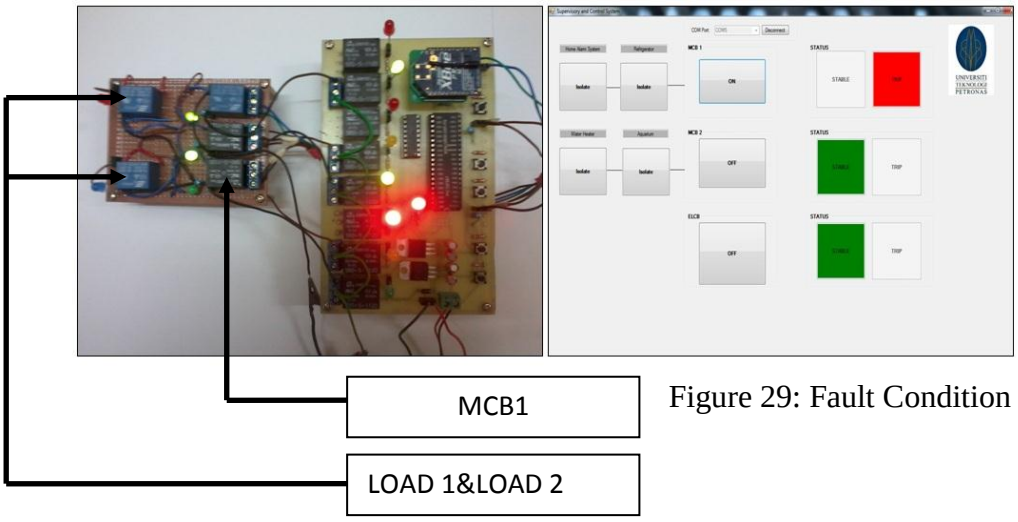


Figure 29: Fault Condition at MCB

C. Isolating faulted load

Figure 30 shows the results when faulted load is being isolated by using try and error procedure

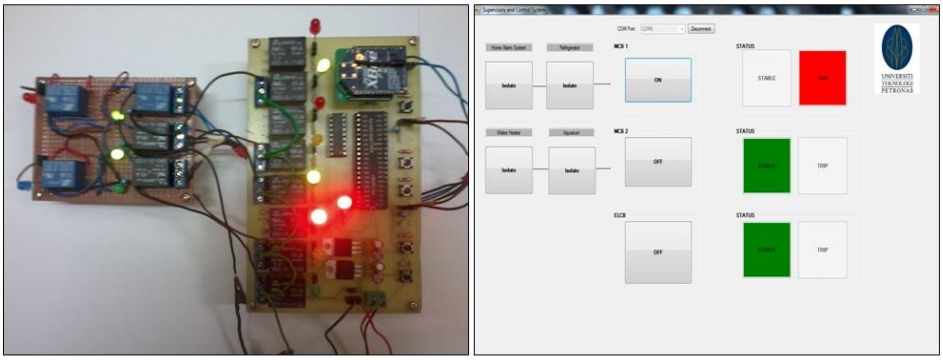


Figure 30: Isolating faulted load

D. Power flow at MCB 1 Recovered

Figure 31 shows the results when faulted load has been isolated which is connected with MCB1 and the power flow has been recovered in MCB1

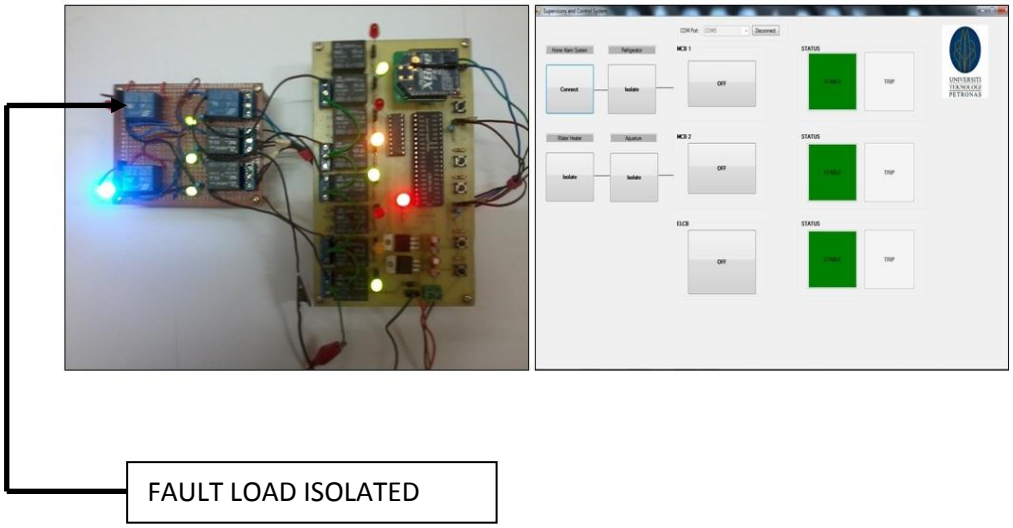
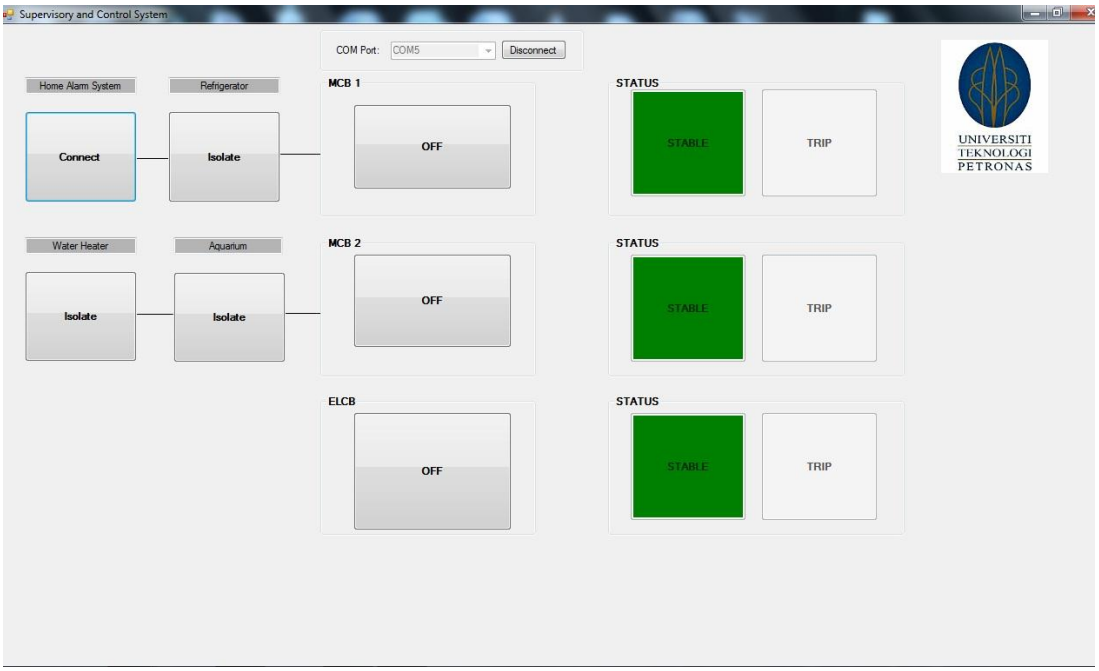


Figure 31: Power Flow at MCB1 Recovered

4.11 The Complete Prototype of the control Box and GUI

Figure 32 shows the complete design of the control box and GUI which has been successfully developed and the idea of A New Supervisory and Control system for Domestic Protection system has been realized



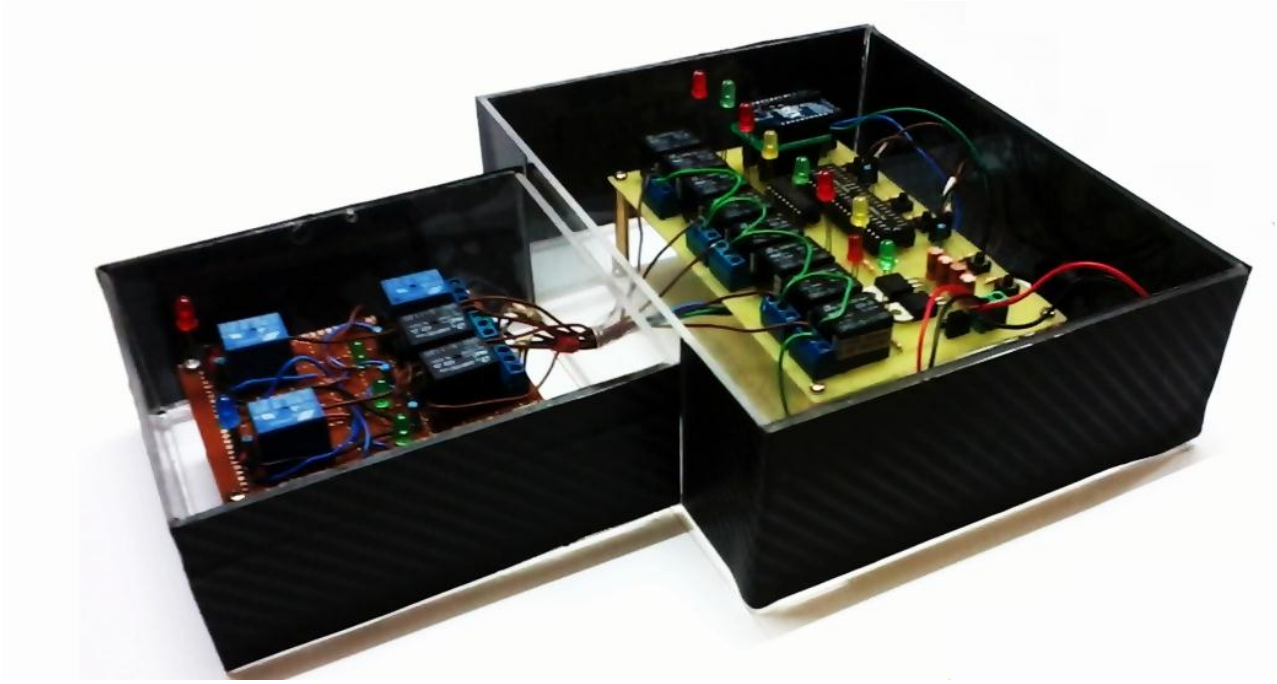


Figure 32: Complete Design of Prototype

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This project, Automated Electrical Protection System or Auto-Epros with A New Supervisory and Control System can be considered as a new invention in electrical protection field. Since the progress can be said is on schedule and the tests are done successfully, the project seems going to be a successful project. With the additional features of the supervisory and control system it has made possible for the system to able to locate fault location at MCB, isolate it via wireless and reset the ELCB automatically This project requires high understanding in power system as well as vast knowledge in electronic to accurately measure the parameters and make it able to communicate with electronic components. Towards the end of this project, it is expected that this project will be significant in terms of technical and economical besides commercially valued.

5.2 Recommendations

Towards the end of this project, a few recommendations are to be made as followings in order to improve the efficiency and effectiveness of the system developed:

- Use Solid State Relays to realize the control box to be combined with the Auto-Epos system
- Replace the Xbee wireless module with wifly module which uses same protocols which is zigbee wireless technology
- Develop an android application GUI which will be able to operate the control box via wireless
- Develop a network cloud which would able to connect the android application with the control box wifly module

The system may be developed for three phase system as well, for industrial purposes

Appendix 1

XBEE PRO STARTER KIT

Features:

- Communication range up to 1500 meters
- Soldered with XBee-Pro module and tested before being shipped
- USB Plug and Play UART function
- 5V powered
- 5V UART interface, ready for microcontroller interface
- Default baud rate of 9600bps
- Long Range Data Integrity
- Low power consumption
- Compact yet easy and reliable platform
- As serial port replacement (wireless)
- Point-to-point, point-to-multipoint and peer-to-peer topologies

XBee Pro 60mW Wire Antenna

Features:

- ISM 2.4 GHz operating frequency
- 60 mW (+18 dBm) power output (up to 1500m)
- Industrial temperature rating (-40° C to 85° C)
- Indoor/Urban range: up to 300 ft (100 m)
- Outdoor/RF line-of-sight range: up to 1 mile (1500m)
- Interface data rate: Up to 115.2 Kbps
- Operating frequency: 2.4 GHz
- Supply voltage: 2.8 - 3.4 V
- Transmit current: 270 mA (@ 3.3 V)
- Receive current: 55 mA (@ 3.3 V)
- Power-down sleep current: <10 µA
- 2mm pitch to pitch DIP pin
- Wire Antenna

IC PIC 16F887

Features:

- Pin Count: 40
- Program Memory: 14KB Flash
- CPU Speed (MIPS): 5
- RAM Bytes: 368
- Data EEPROM (bytes): 256
- Digital Communication Peripherals: 1-A/E/USART, 1-MSSP(SPI/I2C)
- Capture/Compare/PWM Peripherals: 1 CCP, 1 ECCP
- Timers: 2 x 8-bit, 1 x 16-bit
- ADC: 14 channel, 10-bit
- Comparators: 2
- Operating Voltage Range (V): 2 to 5.5

Appendix 11

Coding for PIC

```
//Project: A New Supervisory Control System
//Programmer: Jayvarmaa Rajaram
//PIC: PIC16F887
//Crystal Frequency: 20MHz
//Compiler: HI-TECH C Compiler V9.83
//Last Modified: 3 November 2013

#define    TIMER0
#define    UART
#define    jayvarmaa
#define    UART_BUFFER     90
#define SW1           RA0
#define SW2           RA1
#define SW3           RA2
#define SW4           RA3
#define SW5           RA5
#define SW6           RE0
#define SW7           RE1
#define SW8           RE2
#define RELAY1        RD7
#define RELAY2        RD6
#define RELAY3        RD5
#define RELAY4        RD4
#define RELAY5        RC5
#define RELAY6        RC4
#define RELAY7        RD3
#define RELAY8        RD2
#define COUNT         100
```

```
#include "LibraryHardware.h"
#include "LibraryPeripheral.h"
#include "LibraryInterfaceVB.h"

unsigned char data[UART_BUFFER];
char z;
unsigned int counter;

void pic_init(void);
char read_sw(void);
char read_relay(void);

static void interrupt isr(void)
{
if(RCIF==1){
     data[z]=uart1_read();
     if(z<UART_BUFFER-1) z++;
     counter=0;}
if(TMR0IF==1){
     TMR0IF=0;
     if(counter<COUNT) counter++;
     else z=0;}
}

main()
{int temp=0;
pic_init();                              //initialize PIC
uart1_init(9600);                  //initialize UART
data[0]=0;
for(;;){
     if(SW1==0){
      RELAY1=!RELAY1;
      delay(500);
```

```
 while(SW1==0) continue;}
if(SW2==0){
 RELAY2=!RELAY2;
 delay(500);
 while(SW2==0) continue;}
RELAY3=!SW3;
if(SW4==0){
 RELAY4=!RELAY4;
 delay(500);
 while(SW4==0) continue;}
if(SW5==0){
 RELAY5=!RELAY5;
 delay(500);
 while(SW5==0) continue;}
RELAY6=!SW6;
if(SW7==0){
 RELAY7=!RELAY7;
 delay(500);
 while(SW7==0) continue;}
RELAY8=!SW8;

if((data[0]!=0)&(counter==COUNT)){
 temp=serial_from_to(data,'S','.');
 uart1_string("S");
 uart1_number(read_relay(),BIN,8);

if(temp == 1)
{ RELAY1=1; }
else if (temp == 2)
{ RELAY1=0; }
else if (temp == 3)
{ RELAY2=1; }
else if (temp == 4)
{ RELAY2=0; }
```

```
    else if (temp == 5)
    { RELAY4=1; }
    else if (temp == 6)
    { RELAY4=0; }
    else if (temp == 7)
    { RELAY5=1; }
    else if (temp == 8)
    { RELAY5=0; }
    else if (temp == 9)
    { RELAY7=1; }
    else if (temp == 10)
    { RELAY7=0; }

data[0]=0;}
}
}

void pic_init(void)
{
TRISA=0b00101111;
TRISB=0b00000000;
TRISC=0b10000000;
TRISD=0b00000000;
TRISE=0b00000111;
setup();
timer0(0);
enable_tmr0();
enable_rc1();
}

char read_sw(void)
{int i=0;
if(SW1==0) i=i+1;
if(SW2==0) i=i+2;
```

```
if(SW3==0) i=i+4;
if(SW4==0) i=i+8;
if(SW5==0) i=i+16;
if(SW6==0) i=i+32;
if(SW7==0) i=i+64;
if(SW8==0) i=i+128;
return i;
}

char read_relay(void)
{int i=0;
if(RELAY1==1) i=i+1;
if(RELAY2==1) i=i+2;
if(RELAY3==1) i=i+4;
if(RELAY4==1) i=i+8;
if(RELAY5==1) i=i+16;
if(RELAY6==1) i=i+32;
if(RELAY7==1) i=i+64;
if(RELAY8==1) i=i+128;
return i;
}
```

Coding for Visual Basic

```
Public Class Form1
    Dim Data As String
    Dim Temp As Integer = 0
    Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        BtnConnect.Text = "Connect"
        BtnMCB1ON.Enabled = False
        BtnRefrigerator.Enabled = False
        BtnMCB1Stable.Enabled = False
        BtnMCB1Trip.Enabled = False
        BtnMCB2ON.Enabled = False
        BtnAircond.Enabled = False
        BtnMCB2Stable.Enabled = False
        BtnMCB2Trip.Enabled = False
        BtnELCB.Enabled = False
        BtnELCBStable.Enabled = False
        BtnELCBTrip.Enabled = False
        Button1.Enabled = False
        Button2.Enabled = False
        CbbComport.Enabled = True
        Timer1.Interval = 200
    End Sub

    Private Sub CbbComport_DropDown(ByVal sender As Object, ByVal e As
System.EventArgs) Handles CbbComport.DropDown
        CbbComport.Items.Clear()
        For i As Integer = 0 To My.Computer.Ports.SerialPortNames.Count - 1
            CbbComport.Items.Add(My.Computer.Ports.SerialPortNames(i))
        Next
    End Sub

    Private Sub BtnConnect_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles BtnConnect.Click
        If BtnConnect.Text = "Connect" Then
            If CbbComport.Text = "" Then
                MsgBox("Please Select COM Port")
            Else
                BtnConnect.Text = "Disconnect"
                BtnMCB1ON.Enabled = True
                Button1.Enabled = True
                Button2.Enabled = True
                BtnRefrigerator.Enabled = True
                'BtnMCB1Stable.Enabled = True
                'BtnMCB1Trip.Enabled = True
                BtnMCB2ON.Enabled = True
                BtnAircond.Enabled = True
                'BtnMCB2Stable.Enabled = True
                'BtnMCB2Trip.Enabled = True
                BtnELCB.Enabled = True
                'BtnELCBStable.Enabled = True
                'BtnELCBTrip.Enabled = True
                CbbComport.Enabled = False

                If SerialPort1.IsOpen Then
```

```
                SerialPort1.Close()
            End If

            SerialPort1.PortName = CbbComport.SelectedItem
            SerialPort1.BaudRate = 9600
            SerialPort1.Parity = IO.Ports.Parity.None
            SerialPort1.StopBits = IO.Ports.StopBits.One
            SerialPort1.DataBits = 8
            SerialPort1.Open()
            Timer1.Start()
        End If
    Else
        BtnConnect.Text = "Connect"
        BtnMCB1ON.Enabled = False
        BtnRefrigerator.Enabled = False
        Button1.Enabled = False
        Button2.Enabled = False
        'BtnMCB1Stable.Enabled = False
        'BtnMCB1Trip.Enabled = False
        BtnMCB2ON.Enabled = False
        BtnAircond.Enabled = False
        'BtnMCB2Stable.Enabled = False
        'BtnMCB2Trip.Enabled = False
        BtnELCB.Enabled = False
        'BtnELCBStable.Enabled = False
        'BtnELCBTrip.Enabled = False
        CbbComport.Enabled = True
        BtnMCB1Stable.BackColor = Color.Transparent
        BtnMCB1Trip.BackColor = Color.Transparent
        BtnMCB2Stable.BackColor = Color.Transparent
        BtnMCB2Trip.BackColor = Color.Transparent
        BtnELCBStable.BackColor = Color.Transparent
        BtnELCBTrip.BackColor = Color.Transparent
        Timer1.Stop()
        SerialPort1.Close()
    End If
End Sub

Private Sub BtnMCB1ON_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles BtnMCB1ON.Click
    If BtnMCB1ON.Text = "ON" Then
        Temp = 1
        'BtnMCB1ON.Text = "OFF"
    Else
        Temp = 2
        'BtnMCBON.Text = "ON"
    End If
End Sub

Private Sub BtnRefrigerator_Click(ByVal sender As System.Object, ByVal
e As System.EventArgs) Handles BtnRefrigerator.Click
    If BtnRefrigerator.Text = "Isolate" Then
        Temp = 3
        'BtnRefrigerator.Text = "Isolate"
    Else
        Temp = 4
        'BtnRefgrirator.Text = "Connect"
    End If
```

```
    End Sub

    Private Sub BtnMCB2ON_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles BtnMCB2ON.Click
        If BtnMCB2ON.Text = "ON" Then
            Temp = 5
            'BtnMCB2ON.Text = "OFF"
        Else
            Temp = 6
            'BtnMCBON.Text = "ON"
        End If
    End Sub

    Private Sub BtnAircond_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles BtnAircond.Click
        If BtnAircond.Text = "Isolate" Then
            Temp = 7
            'BtnAircond.Text = "Isolate"
        Else
            Temp = 8
            'BtnAircond.Text = "Connect"
        End If
    End Sub

    Private Sub BtnELCB_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles BtnELCB.Click
        If BtnELCB.Text = "ON" Then
            Temp = 9
            'BtnELCB.Text = "OFF"
        Else
            Temp = 10
            'BtnELCB.Text = "ON"
        End If
    End Sub

    Private Sub Timer1_Tick(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Timer1.Tick
        SerialPort1.Write("S" & Temp & ".")
        Temp = 0
        Data = SerialPort1.ReadExisting
        If Data <> "" Then
            If Data.Substring(8, 1) = "1" Then
                BtnMCB1ON.Text = "OFF"
            Else
                BtnMCB1ON.Text = "ON"
            End If

            If Data.Substring(8, 1) = "1" Then
                BtnMCB1Stable.BackColor = Color.Transparent
                BtnMCB1Trip.BackColor = Color.Red

                BtnMCB1Stable.BackColor = Color.Green
                BtnMCB1Trip.BackColor = Color.Transparent
            End If
            If Data.Substring(7, 1) = "1" Then
                BtnRefrigerator.Text = "Connect"
            Else
                BtnRefrigerator.Text = "Isolate"
```

```
            End If

            If Data.Substring(6, 1) = "1" Then
                BtnMCB1Stable.BackColor = Color.Transparent
                BtnMCB1Trip.BackColor = Color.Red
            Else
                BtnMCB1Stable.BackColor = Color.Green
                BtnMCB1Trip.BackColor = Color.Transparent
            End If
            If Data.Substring(5, 1) = "1" Then
                BtnMCB2ON.Text = "OFF"
            Else
                BtnMCB2ON.Text = "ON"
            End If

            If Data.Substring(5, 1) = "1" Then
                BtnMCB2Stable.BackColor = Color.Transparent
                BtnMCB2Trip.BackColor = Color.Red

                BtnMCB2Stable.BackColor = Color.Green
                BtnMCB2Trip.BackColor = Color.Transparent
            End If
            If Data.Substring(4, 1) = "1" Then
                BtnAircond.Text = "Connect"
            Else
                BtnAircond.Text = "Isolate"
            End If

            If Data.Substring(3, 1) = "1" Then
                BtnMCB2Stable.BackColor = Color.Transparent
                BtnMCB2Trip.BackColor = Color.Red
            Else
                BtnMCB2Stable.BackColor = Color.Green
                BtnMCB2Trip.BackColor = Color.Transparent
            End If

            If Data.Substring(2, 1) = "1" Then
                BtnELCB.Text = "OFF"
            Else
                BtnELCB.Text = "ON"
            End If

            If Data.Substring(1, 1) = "1" Then
                BtnELCBStable.BackColor = Color.Transparent
                BtnELCBTrip.BackColor = Color.Red
            Else
                BtnELCBStable.BackColor = Color.Green
                BtnELCBTrip.BackColor = Color.Transparent
            End If

        End If

    End Sub
```

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