AUTOMATED ELECTRICAL PROTECTION SYSYEMS – APPLIED FOR THREE-PHASE SYSTEM

By

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CERTIFICATION OF APPROVAL

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CERTIFICATION OF ORIGINALITY

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

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Haris Bin Rozani

ABSTRACT

Continuous supply of electricity to domestic building is a major concern for the consumers. The consumers need a continuous electricity supply to their appliances such as refrigerator, aquarium and their alarm system. Tripping of Earth Leakage Circuit Breaker (ELCB) will break the supply to all the appliances. An automatic three-phase system is required to restore the supply to the appliances by turn on back the ELCB. But when there is a permanent fault in the system, the ELCB cannot be turned on back to normal because it will trip again due to the fault. So the objective of the project is to develop a system to detect the location of permanent fault. The location of the fault is important to be determined in a first place in order to isolate the fault from the system. So the fault MCB will turn off and ELCB can be reclosed back to normal position to let the appliances have the electricity supply. The idea is when the location of fault is determined, an automatic system to isolate the MCB that has fault can be developed. So when the MCB that has fault has been isolated, the ELCB can be turned on without tripping again. The system that has been developed using the microcontroller will compare the value of current at live wire and the value of current at neutral wire. If the difference is more than preset value, the system will show the detection in so the location of fault is determined. Thus, the prototype have been made. Finally, based on the capability of this project and the reasonable cost, it is possible to commercialize it to the market.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 Project Background

Continuous supply of electricity is really important for the customers thus power reliability is critical to a domestic building. Some electrical equipments and appliances need to be turned on even when the occupants leave the building such as alarm system, refrigerator and aquarium ventilation system. But electrical fault may occur in a system that can break the electricity supply. Thus, the automatic systems that can detect the location of electrical permanent fault need to design to isolate the permanent fault from the system. The breaker can be designed to automatically turn on the Earth Leakage Circuit Breaker (ELCB) in order to restore the supply.

1.2 Problem Statement

Tripping of ELCB when there is no occupant inside may lead to undesired circumstances. The critical appliances such as aquarium, refrigerator and alarm system need a continuous supply of electricity to operate. The problem comes when the ELCB trips when no occupants in the house due to internal or external disturbance. When electricity supply is not available, operation of critical equipment such as alarm system will be stopped. Loss of electricity supply may also contribute to property lost due to equipment failure such as dying of exotic fish and food damage.

Besides that, problems arise when the short circuit happens to the earth leakage circuit breaker. Especially for three-phase system, most of the user failed to search the main problems that happen to the circuit breaker and which phase tripped. The user also needs to push up the button on manually. Most people do not know how to determine the cause of the problems occurs on that system. Thus, this system is designed and constructed to overcome the problems related to the short circuit problems.

1.3 Project Objectives

The main objective of this project is to develop an automatic system which can detect the location of fault. This project is focusing on determining the location of fault in a wiring system where it is important in designing an automatic circuit breaker which it can handle the permanent fault.

The objectives of this project are:

i) Develop an automatic system to detect the location of fault in three-phase systems.
ii) Develop the system that can cut down the fault location so the other MCB can operate normally.
iii) To add-on the features of ELCB and MCB

1.4 Scope of Project

The *Automated Electrical Protection System – Applied for Three-Phase System* project is actually a design and construction of a system which push up the plunger of the circuit breaker by using the motor when the leakage current to the earth happen. It also detects the location that fault occurs and MCB that has faulted then been isolated so the other phase and other MCB will run normally. The circuit breaker will operate when it has the permanent damage or temporary damage.

Usually, user needs to turn on the ELCB and MCB manually, so the user always expose to the hazard which it is very dangerous to human if the user affected to the electric shock. To avoid such bad things happen, ELCB automatically created so that the buttons can be switched on and off automatically depending on the damage done in applying the system without requiring the user to view and search for the cause of the damage. With this system, users themselves will find out whether it is damage to the temporary or permanent damage that requires replacement of a new component in the distribution board.

CHAPTER 2
LITERATURE REVIEW

Until now, there is no automatic electrical protection system in domestic building for three-phase systems. This project is newly developed. This chapter will review about the three-phase system, function and principal operation of circuit breaker and also will discuss about application of ELCB. Then it will review about components of hardware and software that will be use in order to modify the ELCB.

2.1 Three-phase Systems

Three-phase electric power refers to the distribution system that commonly used by the national grid to transfer power. It is also used by the domestic building and household that has heavy loads. Generally, a three-phase system is more economical compared single-phase or two-phase systems because it uses less conductor material at the same voltage to transmit electric power.

The three-phase systems consist of neutral wire as it allows the system to use a higher voltage while still supporting lower-voltage single-phase appliances. For high-voltage distribution, the loads can be connected between phases (phase-phase connection) so commonly it does not to have a neutral wire [1].

Three-phase has properties that make it very desirable in electric power systems:

- The phase currents are possible to reduce the size of the neutral conductor because in case of a linear balance, it tends to cancel out one another and summing them to zero.
- All the phase conductors carry the same current for a balanced and so can be the same size.
- Generator and motor vibrations can be reduces when the power transfer into a linear balanced load is constant.

- Three-phase systems can produce a magnetic field that rotates in a specified direction, which simplifies the design of electric motors.

Although three-phase has many advantages but this system cannot perfectly protect the electrical circuit, electrical equipment and also human life from the high voltage. So, the circuit breaker is needed to make more protection.

2.2 Circuit Breaker

A circuit breaker is an electrical switch that can automatically operate to protect an electrical circuit from electrical damage caused by overload or short circuit [2]. The electric power circuit of the device can be open or closes either during normal or abnormal condition of power system. Different from fuse, a circuit breaker can be reset to its normal condition once it opens while the fuse can operates only once hence it has to be replaced.

The normal system for circuit breaker operation is to energize or disenergize loads. During abnormal conditions due to excess current, circuit breaker will open to protect the equipment and surroundings from possible damage. These excess current are usually because of the sustained overload, lightning, deterioration of equipment, or accidents.

There are many different technologies used in circuit breaker such as:

i. Miniature Circuit Breaker (MCB)

- Rated current not more than 100A.
- Trip current normally not adjustable.

ii. Moulded Case Circuit Breaker (MCCB)

- Rated current up to 1000A.
- Consist of thermal or thermal magnetic operation.
- Trip current may be adjustable.

iii. Residual Current Device (RCD)

- Also known as a Residual Current Circuit Breaker (RCCB).
- Able to detect current imbalance.

iv. Earth Leakage Circuit Breaker (ELCB)

- Only detects earth current directly rather than detecting imbalance.

v. Residual Current Breaker with Overcurrent Protection (RCBO)

- Combination of the function of RCD and an MCB.

2.2.1 Operation of Circuit Breaker

Basically, circuit breaker consists of solenoid which is electromagnet that pulling force increases with the current. The circuit breaker's contacts are held closed by a latch. When the current in the solenoid exceed the rating of the circuit breaker, the latch then is released the solenoid's pull and allows the contacts to open by spring action.

The core can provide sufficient force to release the latch. It was restrained by a spring until overload current occur. When the current exceed the breaker rating, the magnetic circuit will close as the solenoid pulls the core through the fluid. Besides that, the solenoid force to release the latch is also provided by short circuit current regardless of core position thus it can bypassing the delay feature. Ambient temperature affects the time delay but does not affect the current rating of a circuit breaker [3].

2.3 Earth Leakage Circuit Breaker (ELCB)

ELCB is a device that used in electrical protection systems with high earth impedance to prevent shock. The main purpose of earth leakage protectors is to prevent injury to humans and animals due to electric shock [4].

An ELCB is a specialized type of latching relay which can disconnects the power in unsafe condition when the incoming mains power is connected through its switching contact. The fault current detected from live to ground (earth) wire of the installation. The grounding wire is connected to the ELCB. The current through the wire is measure. If the current is too high, then the ELCB cut the power feed. Furthermore, if sufficient voltage appears across the ELCB's sense coil, the power will switch off and need manually reset. An ELCB however, does not sense fault currents from live to any other earthed body [4].

There are two types of ELCB which are voltage operated ELCB and current operated ELCB. Voltage operated ELCB is currently not been used in domestic wiring since the current operated ELCB is more reliable to be installed in household. Current operated ELCB is also known as RCD which protect the circuit against earth leakage. The details and method of operation between current and voltage operated are different but the function is same.

Today, ELCB have been almost totally replaced by RCD (except in very old installations) due to a number of problems. One advantage of ELCB over RCD is the ELCB have fewer nuisance trips because they are less sensitive to fault conditions (Depends on installation details and the discrimination enhancing filtering in the ELCB.). Therefore by electrically separating cable armour from cable CPC, an ELCB can be arranged to protect against cable damage only, and not trip on faults in downline installations [4]. The example of ELCB for single phase system is shows in Figure 1.

Figure 1: Earth Leakage Circuit Breaker (ELCB)

2.4 Residual Current Device (RCD)

A Residual Current Device (RCD) or Residual Current Circuit Breaker (RCCB) is an electrical wiring device that can detect the flow of current. Whenever the current is not balanced between the neutral conductor and the phase conductor, RCD will disconnect a circuit. The presumption is that such an imbalance may represent current leakage through the safety ground wiring or through the body of a person who is grounded and accidentally touching the energized part of the circuit [5]. Figure 2 shows the example of RCCB.

Figure 2: Residual Current Circuit Breaker

RCD is designed to prevent electrocution by detecting the leakage current (typically within 5 to 30 milliamperes), which can be far smaller than the currents needed to operate the conventional circuit breakers or fuses (several amperes). RCD is intended to operate within 25 to 40 milliseconds before the electric shock occur.

RCD is operated by measuring the difference between the current flowing out through the live conductor and current flowing in through the neutral conductor. The current between the two conductors are measures using a differential current transformer. If there is current imbalance between the conductor (do not sum to zero), there is a leakage of current occur to somewhere else and the device will open its contacts.

For three-phase systems, all live and the neutral conductors must pass through the current transformer. RCD is complementary to over-current detection. RCD cannot provide protection for overload current or short-circuit currents, except for the special case of a short circuit from live to ground (not live to neutral).

The RCCB acts to switch off the electricity much faster than a fuse or MCB [5]. For this project, RCCB is chosen because of several characteristic as shown in Table 1.

Table 1: Characteristic of RCCB

Rated Voltage	230VAC (2 poles), 400VAC (4 poles)
Rated Current	25A, 40A, 63A
Rated Residual Operating Current	30mA, 100 mA, 300mA, 500mA
Residual Current off-time	0.1s
Minimum Value of Rated Making and Breaking Capacity	1 kA
Rated Condition Short Circuit Current	In = 25A or 40A, Inc = 1500A In = 63A, Inc = 3000A

2.5 Miniature Circuit Breaker (MCB)

Miniature circuit breakers (MCB) are commonly used in the electrical consumer units of domestic buildings and small industrial premises as a protection to the electrical supply to respective electrical circuits of the building [7]. Usually single pole breakers of MCB are often used in domestic building and a plurality of such MCB are configured and installed in a cabinet.

MCB is typically consists of an electrical contact mounted on a movable contact carrier in order to interrupt the current path. This movable contact will interrupt the current by rotating away from a stationary contact. Besides that, MCB also include a movable handle as operating mechanism which has three stable positions: on, off and tripped. These three positions tell the operator what condition the contacts are in when the handle is viewed [7].

The trip mechanism of MCB is automatically releasable to effect the tripping operations and need to manually reset by following tripping operations. The mechanism will respond to instantaneous high current to open the contact and interrupting the current flow.

2.6 DC Motor

DC Motor is operated by converting electric power into mechanical work. The working principle is by current flowing through a coil producing a magnetic field that spins the motor.

Motor will be use in this project for push back ELCB's spring trap that is actually very hard to push, so selection of motor is important to make sure that the ELCB's spring trap can be ON back automatically. The important characteristic that must be highlight is the working voltage and motor torque.

For this project, the author prefers to use Servo Motor. Servo Motor is one kind of DC Motor which is quite expensive if compared with DC motor. It was because the motor need enough strength to pull up the breaker. The rotation of servo motor is slower compared to DC motor but it has sufficient enough power to turn ON the ELCB.

Figure 3 shown are the examples of Servo motor.

Figure 3: Micro Servo Motor

2.7 Relay/Contactor

A relay is one kind of an electrical switch which opens and closes under the control of another electrical circuit. The switch is typically included an electromagnet to open or close the contacts. Relay can be considered as form of an electrical amplifier because its ability to control higher power of output circuit than the input circuit When the current flowing through the coil of the relay, it will creates a magnetic field which attracts a switch and changes the switch contacts [3].

The relays are changeover switched and have two switch positions which the coil current can be turn on and off. Most of the relay can operate quickly. Relay is able to reduce noise in a low voltage application and can reduce arcing in a high voltage or high current application. The symbol circuit of relay and the relay are shown in figure 4 below:

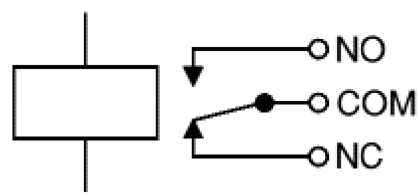

Figure 4: Symbol Circuit of Relay

Another type of relay is a contactor. Contactor function is similar to a relay which used for switching a power circuit but applicable for higher current ratings. A contactor is controlled by another electrical circuit which has a much lower power level than the switched circuit.

The difference between the contactors and the relays are the contactor is designed to be directly connected to high-current load devices while relay for the lower load. Relay are usually designed with normally closed (NC) and normally open (NO) applications as shown in Figure 4. Devices switching more than 15 amperes or in circuits rated more than a few kilowatts are usually called contactors [9]. Table 2 below shows the differences between relay and conductor:

Table 2: Differences between Contactor and Relay

Contactor	Relay
Switches load of higher wattage	Switches load for lower wattage
Generally switch currents above 10-15 Amperes	Generally switch currents less than 10-15 Amperes
Generally switch voltage 120 VAC or greater	Generally switch voltage less than 240 VAC

2.8 Current Detector

There are several types of current detector such as current transducer, transtronics current detector and current transformer (CT) which are use for detected current by sensing the AC current. Basically it gives us positive feedback whether the ELCB has current or not flow through it when it is in OFF condition. Figure 5 below is an example of current transducer:

Figure 5: Current Transducer

2.9 Microcontroller

Microcontroller is the most important part for the project. It controls most of the systems for this prototype. The author use Arduino as a preferred microcontroller. Arduino is a flexible and easy-to-use open-source electronics prototyping platform. It contains almost everything needed to support the programs of microcontroller. Arduino have its own software that can communicate with the computer or projects can be stand-alone.

For the project, the program is designed manually according to the specification of the needs by following its format. The microcontroller on the board is programmed using the Arduino Programming Language and the Arduino Development Environment [10]. There are many model of Arduino, for this project the author use model Arduino Uno as shown in Figure 6.

Figure 6: Arduino UNO microcontroller board

Arduino Uno is one of the microcontroller that will be use for the project which contains a total of 14 digital input/output pins (6 of the output can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a reset button, an ICSP header and a power jack. It also can connect to the computer via USB cable. Table 3 shows some of the specifications of Arduino Uno [10].

Table 3: Specifications of Arduino Uno

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7 to 12V

Input Voltage (limits)	6 to 20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB
SRAM8 KB EEPROM	2 KB
Clock Speed	16 MHz

2.10 Software part

Software can be used for designing and simulating circuit of the project and this part is the very important part where it decisive how to start the project. After the designing and simulating the project circuit success, then the real circuit would be made based on it. Actually, there are three softwares that can assist to make this project:

i) LabVIEW 6i (designing simulating circuit)
ii) ISIS Professional (designing simulating circuit)
iii) Arduino Development Environment (Software for Arduino UNO)

2.11 Summary

The review that has been made this project is aimed to be easily understood and more knowledge about the ELCB and all equipment used before it is modified. Most of the review in this chapter are from studies conducted over the Internet and related books.

CHAPTER 3
METHODOLOGY

3.1 Procedure of project

The project is started by collecting of related data on the domestic electrical wiring procedures and practices. Some procedures are identified for the project to accomplished starting from gathering the required information until the system testing and implementation.

From Figure 7, the project started with topic selection which done by the concern of electrical protection. Under this concern, the project is aim to handle the permanent fault. From the topic selection, studies and understandings of the topic is made so that the planning of the project flow can be done.

After that, simulations are done to the circuit to get the output and results so that it can be analyzed and monitored. Then, the circuit and the prototype design done to be tested later. The design is made by the help of ARDUINO software, the microcontroller circuit is designed and the inputs and outputs of the design acknowledged. The circuit designed is then fabricated into prototype. The prototype fabricated will be tested later to verify whether it does meet the simulation criteria and the project objectives or not. The prototype also evaluated again to make sure if any improvement needed. When completed, the prototype will be presented to the panel of jury involved. The Figure 7 is shown.

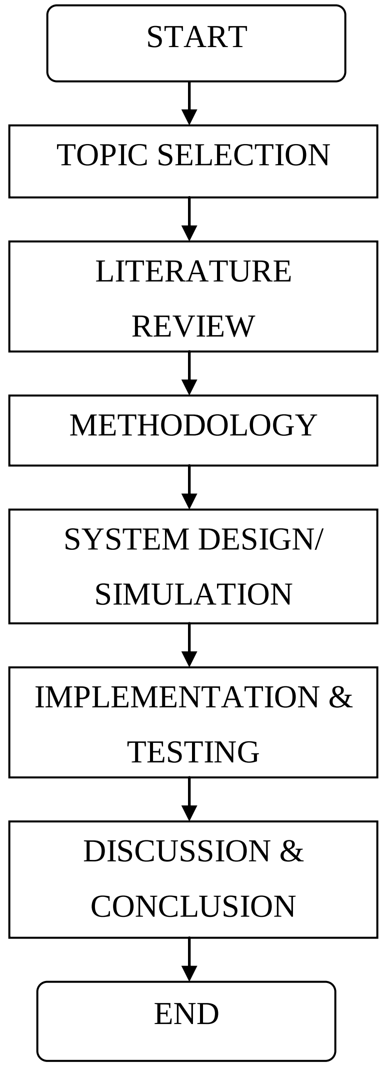

Figure 7: Project Methodology

The information of domestic electrical wiring procedures and practices is collected in the first phase. Data of domestic electrical wiring equipments such as Earth Leakage Circuit Breakers (ELCB), Miniature Circuit Breaker (MCB) and fault behavior are being discussed. The programming for microcontroller is studied in order to design the program to detect the fault location.

See Appendix for Gantt Chart and Key Milestone.

3.2 Flow of operation

In this system design, a system to auto reset when ELCB and trigger the user if fault has been determined. The system will automatically reclose the breaker after is tripped. But if it is tripped again, the possibility of permanent fault occur is high. So, it is dangerous if we try to reclose the ELCB again. Thus the system will detect which phase and MCB causes the fault and isolate the faulted MCB while reclose other MCB. The flow of operation is represented in the Figure 8.

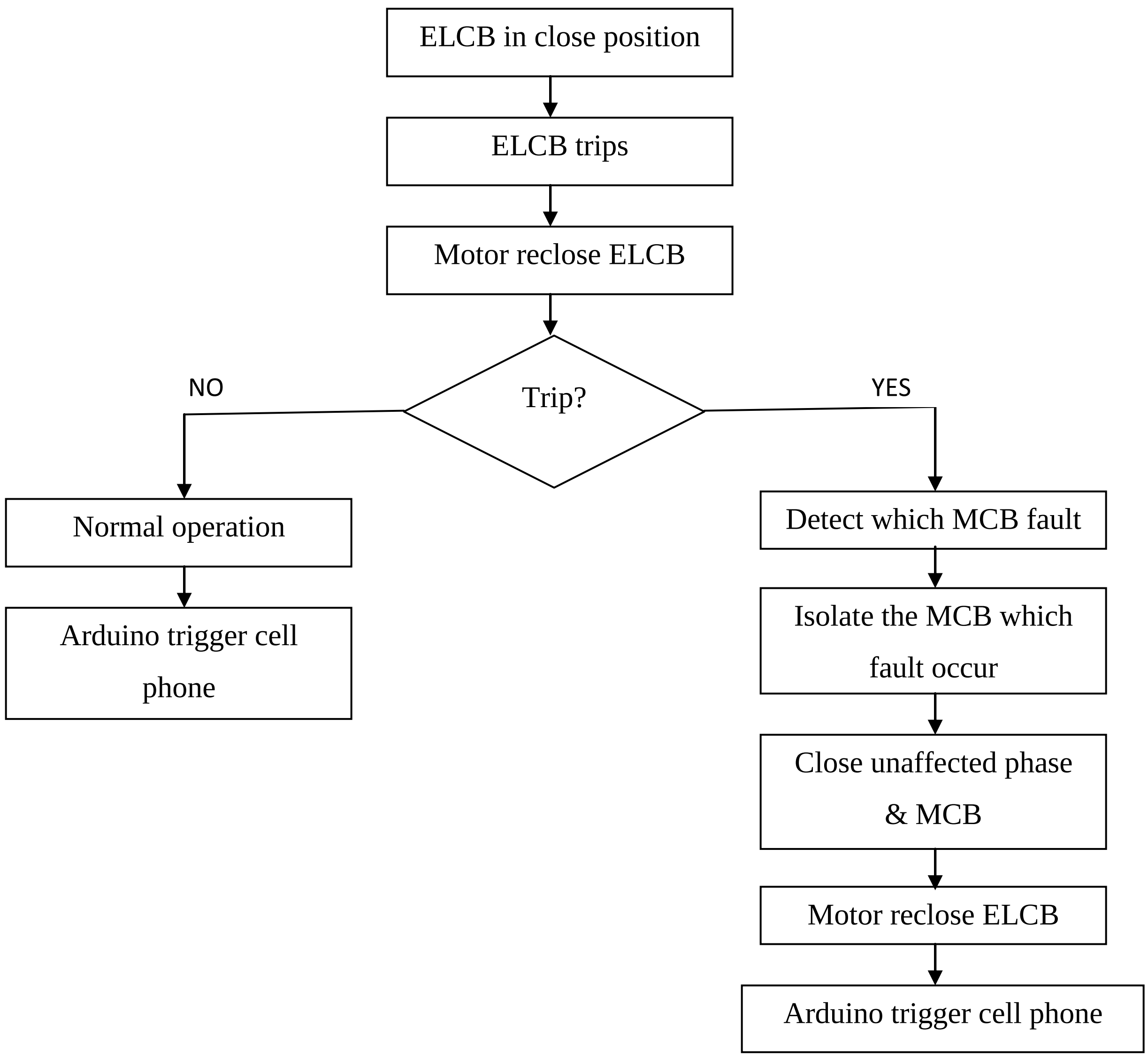

Figure 8: Flow of Desired Operation

3.3 Tools and Equipment Required

❖ Software

Software part that will be used for designing and simulating circuit of the project is shown in Table 4.

Table 4: Software Part of the Project

Part	**Software**
Electrical Circuit	i) ISIS Profesional ii) LabVIEW 6i iii) Arduino Development Environment
Documentation	Microsoft Word
Presentation Slide	Microsoft Power Point

❖ Hardware

The components that list in Table 5 are the components that will be use for making the hardware of this project.

Table 5: Material and Description of Hardware

Material	**Description**
ELCB	Main Component of the project
MCB	Small Breaker that connected to the load from ELCB
DC Motor 12V	To pull the ELCB's spring trap
Relay/ Contactor	To operate a switching mechanism mechanically
Arduino Uno	To control the output
Voltage Regulator	To step down the voltage as an input to Arduino
Cell phone	To call the user when permanent fault occur
Casing	Material to cover the part

3.4 Expected Result

In this project, the expected outcomes are basically related with 3 main circuits. First circuit is to switch ON automatically the ELCB's spring trap using a motor. Second's circuit is to detect current flow through the ELCB and which phase and which MCB fault and the last circuit is the circuit that isolate the fault MCB so the other equipment run normally. The circuits must simulate and testing first so that the operation of this project operates with directive and fluently with a given time.

3.5 Constraint Faces

There are several constraints faces throughout the project:

i) The component and equipment for three-phase system is more expensive than single phase.

ii) The circuit breaker for three-phase is more complicated than for the single phase so further study has to be made.

3.6 Summary

The methodology is an important part to making a project becomes more efficient and extremely proper. The methods used are intended to provide an extremely good impact to the project. With this working method, the system is a way to make the project better than no method. With the flow chart, we will better understand the project and facilitate us in this project. The methods often can help us in arranging the project became better and more proper.

CHAPTER 4
RESULT AND DISCUSSIONS

4.1 Prototype

In this project, the prototype will be designed for demo purpose. The entire prototype of the project is shown in Figure 9.

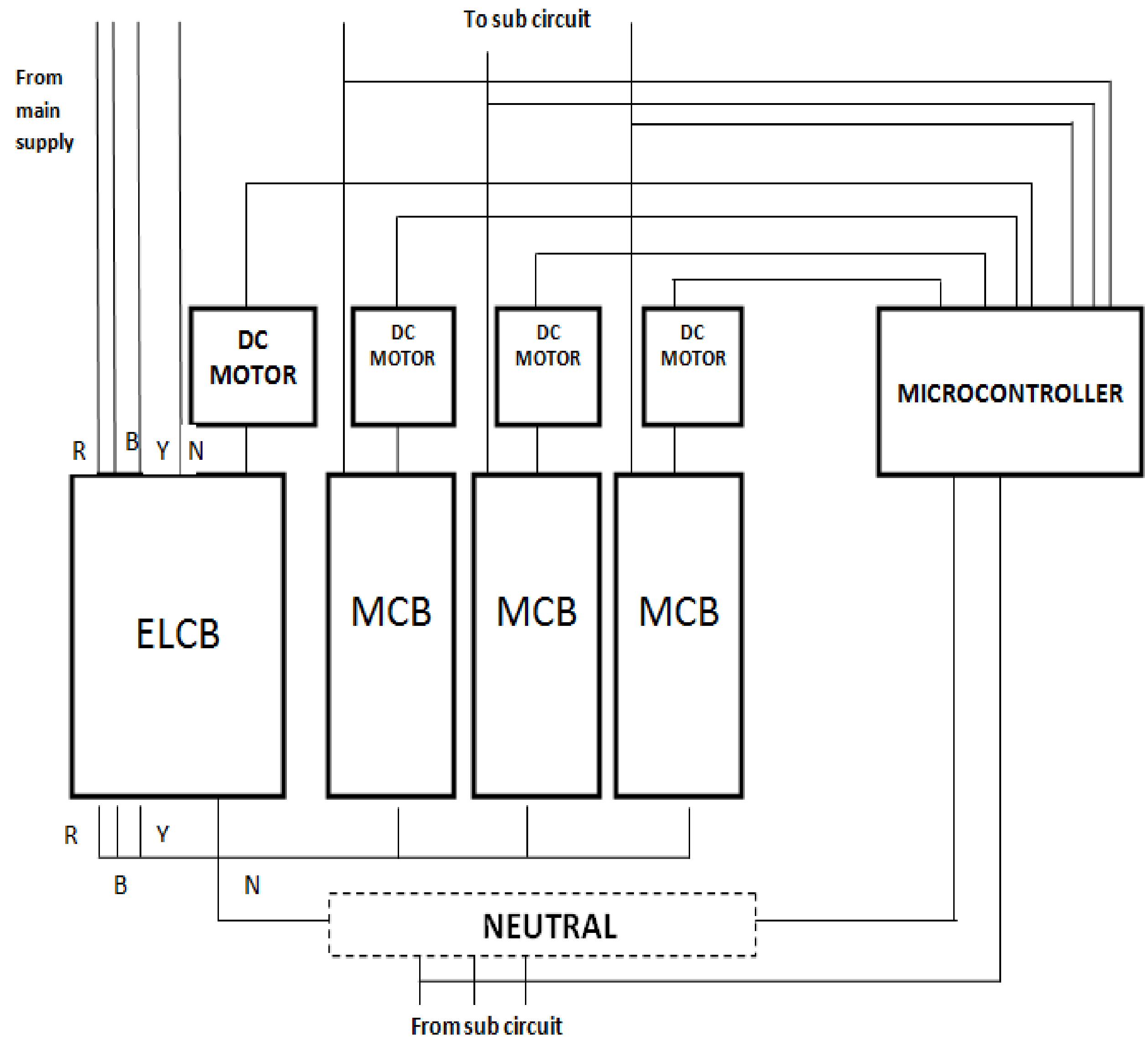

Figure 9: Proposed Prototype

When the fault current occurs, the ELCB and MCB will trip and gives input to microcontroller. After a few seconds, the motor will pull up the ELCB's spring trap to

ON back the electricity. However, when it trip again, Arduino will detect which location that cause the fault and then isolate the fault location from the running electricity and the systems will turn ON back automatically.

Motor is powered by the battery. A tiny hole at ELCB and MCB spring trap has been made to insert the cable to pull up the spring trap. When the breaker trips, relay will trigger the motor to pull up the ELCB's spring trap. The spring trap is actually very hard to push although by hand. So the selection of motor is important to make sure the spring trap can be on back automatically and servo motor is chosen.

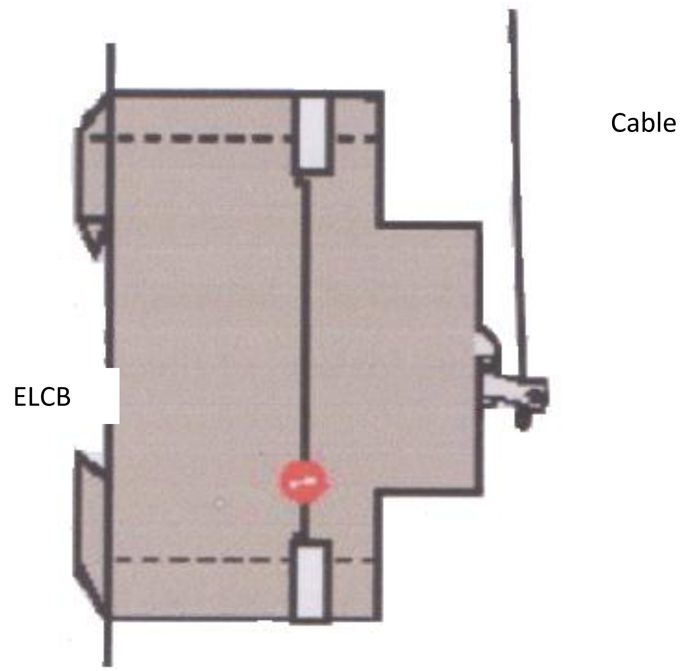

Figure 10: Pull up Mechanism Design

4.2 LCD Display

The author has decided to use LCD Display as part of the prototype. LCD which stands for Liquid Crystal Display (LCD) is a flat visual display that uses the light of liquid crystals. LCD Display can be use to display such a words, digits and 7-segment display.

They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. LCDs are used in a wide range of applications including computer monitors, television, instrument panels, aircraft cockpit displays, and signage.

The type of LCD used in this prototype is 2x16 LCD as shown in Figure 11.

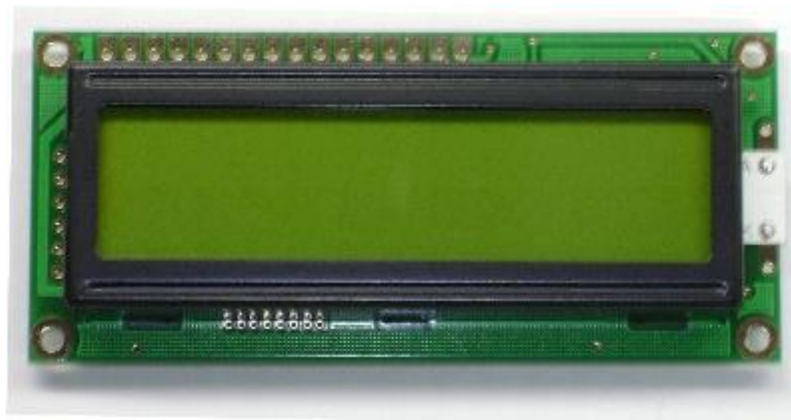

Figure 11: 16x2 LCD Display

Arduino is used to put the instructions in the instruction register. The display of the LCD is controlled by putting the data into the Arduino Development Environment software that form the image of what you want to display into the data registers.

To wire the LCD screen to Arduino, Potentiometer is required to control the contrast of the display. 10K potentiometer is connected to +5V and GND the wiper (output) is connected to LCD screen VO pin (pin3) of Arduino. Figure 12 shows the connection of LCD to the Arduino.

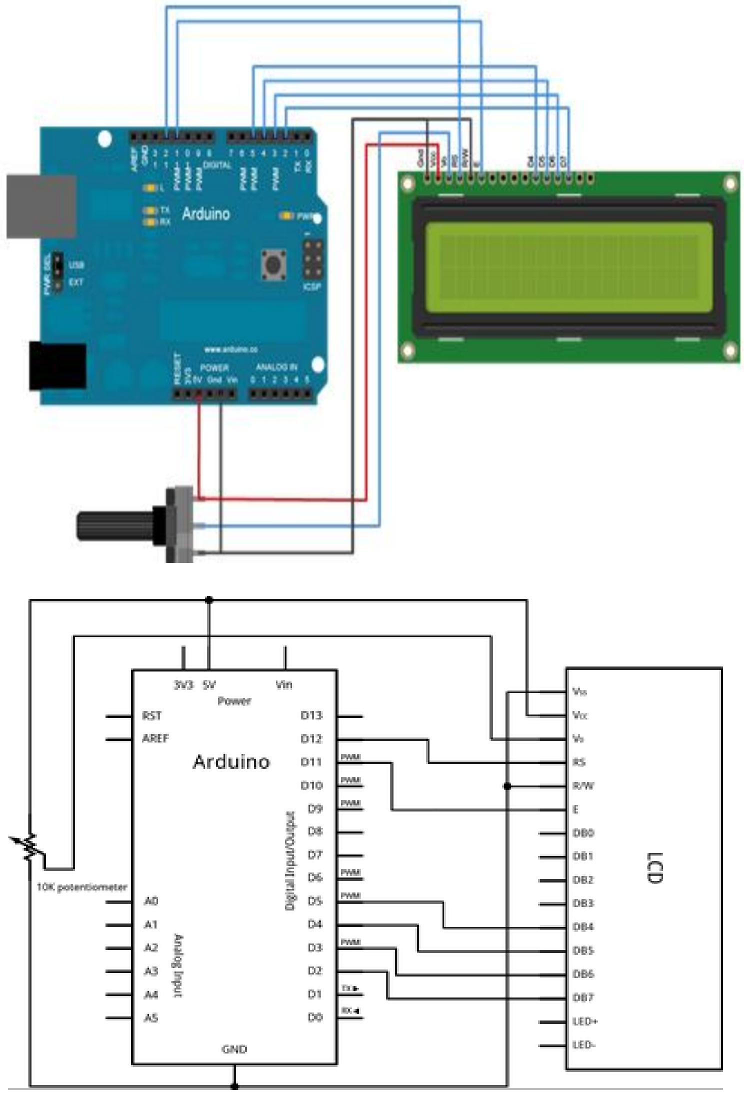

Figure 12: Arduino and LCD Connection

4.3 Result of Operation

The result operation is summarizing as shown in Table 6:

Table 6: Summary of the Result

Case 1	ELCB trip first time → Motor auto-reset ELCB → LED is ON
Case 2	MCB trip first time → Motor auto-reset MCB → MCB trip second time → Motor auto-reset ELCB → LED is ON
Case 3	MCB trip first time → Motor auto-reset MCB → MCB trip second time → Motor auto-reset MCB → MCB trip third time → Circuit detect fault → Motor auto-reset faulted MCB → LED is ON

Case 1 and 2 are simple operations that involve the servo motor to pull up the ELCB's spring trap if it's trip. Each of the LED represented the breaker (ELCB and MCB). While Case 3 need the uses of current transducer to operate. The result from above can be illustrated in figure 13 below:

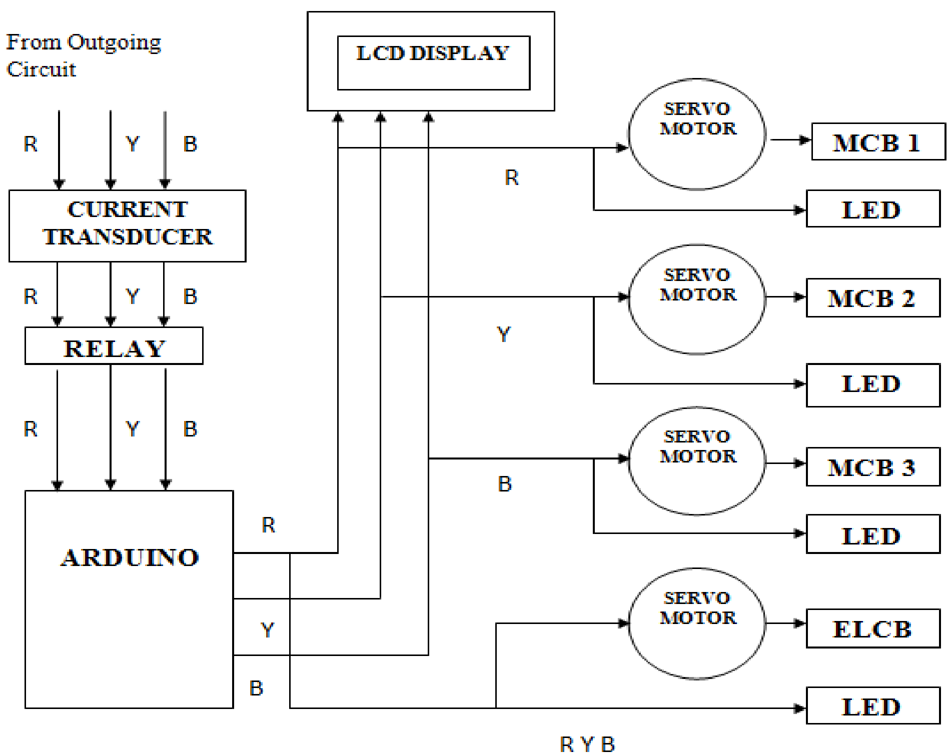

Figure 13: Circuit Design

The current is coming from each of the conductor line (Red, Yellow, Blue), When the trip occur, the relay will turn ON and give the output to Arduino. Each conductor line is in the different input for the Arduino to process. If one of the breakers is tripping, as example the red line trip. The Arduino will turn ON the servo motor to pull up the MCB 1. At the same time, the LED that represents the red line will turn ON and the LCD will display to indicate that which MCB is trip. The same concept goes for the yellow and blue line.

When the ELCB is tripping, all the MCB also will trip so all the ELCB and MCB will turn ON back. But if one of the MCB trip, it can be either the entire breaker will trip or that MCB will trip alone.

For the Case 3, after the circuit breaker trip for the third time, the current transducer will take action. Current transducer will compare the value from the incoming supply to ELCB with the outgoing supply to Arduino. If there is current imbalance between the two lines, the Arduino will not turn ON back the motor while the others will turn ON back and can operate normally.

4.4 Design Layout

Figure 14 and Figure 15 shows the design layout of this project, the design consists of ELCB, MCB, motor, and casing. The casing contains electrical part such as battery, electrical circuit, and cell phone and microcontroller.

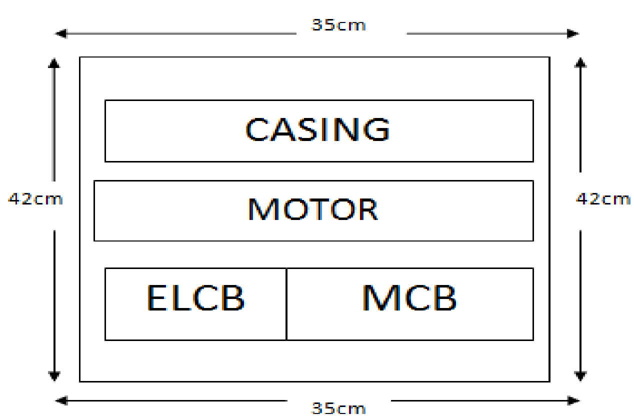

Figure 14: Design Layout

Figure 15: Design of Prototype

One of the main features of this project is to auto-reset ELCB when short disturbance occur. Thus, a servo motor had been put above the circuit breaker as shown in Figure 14 and Figure 15. The size of layout is considered based on the size of the ELCB and MCB.

4.5 Market Potential

People in real world need continuously electric supply. Some of them may loss thousands ringgit when there is no electric supply at their homes. This situation also can harm the user who's not aware about permanent fault. Based on the capability of this project, it is possible to commercialize it to the market. Besides that, the cost of the project is reasonable. Table 7 tabulated the summary of total cost of this project to be implementing.

Table 7: Total Cost

Part	Cost (included the quantity)
RCCB	RM 62
MCB	RM 20
Servo Motor	RM 150
Arduino UNO	RM 100
LCD Display 16x2	RM 20
Relay	RM 20
Casing and fabrication	RM 20
Cell phone	RM 30
Total Cost	**RM 422**

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As a conclusion, the objective and the scope of this project is achieved successfully. The objectives of this project are to improve the features of current ELCB and to develop a prototype of automatic electrical protection systems for three-phase. The system was built with an Arduino board as microcontroller circuit to control the operation. The systems will active the servo motors to do the resetting task if there is tripping case occur. The systems also can detect current flow through the ELCB and can isolate the fault so the other equipment can run normally. The system will also alert the user if permanent fault occur. Finally, this project has provides the author the chance to deal with the concept and the operation of ELCB and the microcontroller. The author also has learned to program the microcontroller with the C programming language. Furthermore, the author has trained himself to be positive in tackling the entire problem faced from early stage until the current progress.

5.2 Recommendation

This project still needs some improvement before it becomes commercialized. The pull up mechanism should be improved in a proper way so that the user didn't need to make a hole at the ELCB's spring trap. Besides that, the space for prototype can be much smaller if the entire component compress together in one box. The cost also can be reduced if this project uses PIC18F452 instead of Arduino board since both of them are microcontroller.

The function of the call alert and programming part for the communication between the modem with the microcontroller should be study further if the system needs to design for two ways communication since this project just design for one way communication system.

For the servo motor, the systems that can switch off relay should be included to stop the motor from continuously running instead of just switch on the relay. It is because the servo motor can become damage if there was continuously running.

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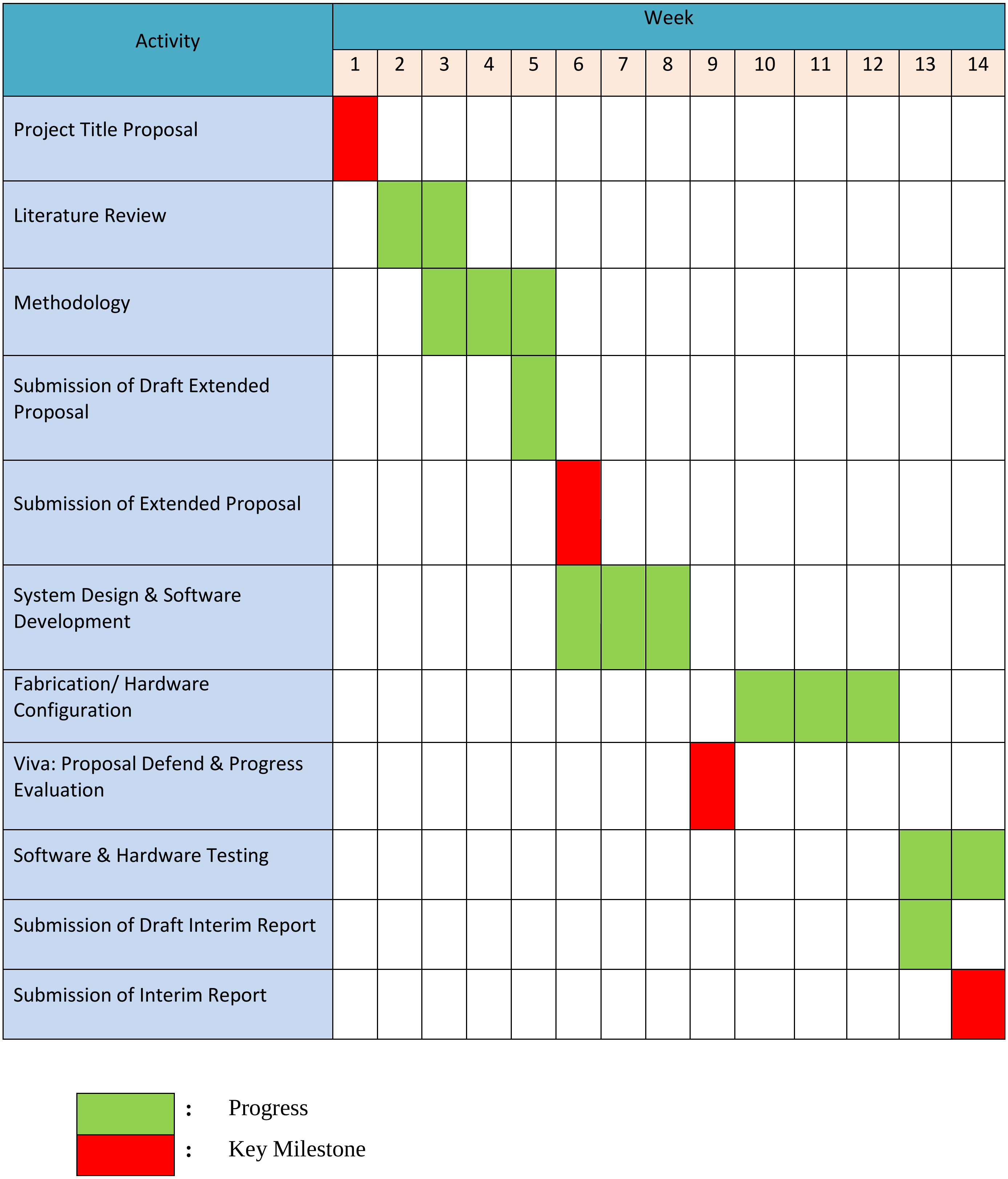
APPENDIX

APPENDIX A

GANTT CHART AND KEY MILESTONE

Progress Monitoring (Gantt Chart) for Final Year Project 1



Progress Monitoring (Gantt Chart) for Final Year Project 2

Activity	Week														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Project Work Continue															
Submission of Draft Progress Report															
Submission of Progress Report															
Discussion & Conclusion															
Pre-EDX															
Preparation for Final Report															
Submission of Draft Final Report															
Submission of Final Report															
Viva															

: Progress

: Key Milestone

APPENDIX B

ARDUINO CODING

```
// include the library code:
#include <EEPROM.h>
#include <LiquidCrystal.h>

//Initialize
//int countF=0; //fault counter
int countr=0;int countb=0;int county=0;int counte;
int countS=0; //state counter
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup(){

  Serial.begin(9600); // initialize serial communication
  pinMode(0, INPUT); //mcb1
  pinMode(1, INPUT); //mcb2
  pinMode(6, INPUT); //mcb3
  pinMode(7, INPUT); //elcb

  pinMode(8, OUTPUT); //LED 1/mcb1
  pinMode(9, OUTPUT); //LED 2/mcb2
  pinMode(10, OUTPUT); //LED 3/mcb3
  pinMode(13, OUTPUT); //LED 4/elcb

  // set up the LCD's number of columns and rows:
  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("haris's Breaker!");
}

void loop(){

    //First Trip

    if(digitalRead(0)==HIGH && countr==0){
    delay(2000);
    digitalWrite(8, HIGH); //motor 1 is ON
    delay(4000); // on time motor = 4 sec
    digitalWrite(8, LOW); // motor 1 is OFF

    // Turn off the blinking cursor:
    lcd.noBlink();
    delay(3000);
    // Turn on the blinking cursor:
    lcd.blink();
    delay(3000);

    // set the cursor to column 0, line 1
```

```
// (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print("  MCB 1 trip");

countr=1;
}

if(digitalRead(1)==HIGH && county==0){
delay(2000);
digitalWrite(9, HIGH); //motor 2 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(9, LOW); // motor 2 is OFF

// Turn off the blinking cursor:
lcd.noBlink();
delay(3000);
// Turn on the blinking cursor:
lcd.blink();
delay(3000);

// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print("  MCB 2 trip");

county=1;
}

if(digitalRead(6)==HIGH && countb==0){
delay(2000);
digitalWrite(10, HIGH); //motor 3 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(10, LOW); // motor 3 is OFF

// Turn off the blinking cursor:
lcd.noBlink();
delay(3000);
// Turn on the blinking cursor:
lcd.blink();
delay(3000);

// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
// print the number of seconds since reset:
```

```
lcd.print("  MCB 3 trip");

countb=1;
}

if(digitalRead(7)==HIGH && counte==0){
delay(2000);
digitalWrite(8, HIGH); //motor 1 is ON
digitalWrite(9, HIGH); //motor 2 is ON
digitalWrite(10, HIGH); //motor 3 is ON
digitalWrite(13, HIGH); //motor 4 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(8, LOW); // motor 1 is OFF
digitalWrite(9, LOW); // motor 2 is OFF
digitalWrite(10, LOW); // motor 3 is OFF
digitalWrite(13, LOW); // motor 4 is OFF

// Turn off the blinking cursor:
lcd.noBlink();
delay(3000);
// Turn on the blinking cursor:
lcd.blink();
delay(3000);

// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print("  ELCB trip");

counte=1;
}

//Second Trip

if(digitalRead(0)==HIGH && countr==1){
delay(2000);
digitalWrite(8, HIGH); //motor 1 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(8, LOW); // motor 1 is OFF

// Turn off the blinking cursor:
lcd.noBlink();
delay(3000);
// Turn on the blinking cursor:
lcd.blink();
delay(3000);
```

```
// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print("  MCB 1 trip");

countr=2;
}

if(digitalRead(1)==HIGH && county==1){
delay(2000);
digitalWrite(9, HIGH); //motor 2 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(9, LOW); // motor 2 is OFF

// Turn off the blinking cursor:
lcd.noBlink();
delay(3000);
// Turn on the blinking cursor:
lcd.blink();
delay(3000);

// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print("  MCB 2 trip");

county=2;
}

if(digitalRead(6)==HIGH && countb==1){
delay(2000);
digitalWrite(10, HIGH); //motor 3 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(10, LOW); // motor 3 is OFF

// Turn off the blinking cursor:
lcd.noBlink();
delay(3000);
// Turn on the blinking cursor:
lcd.blink();
delay(3000);

// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
```

```
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print("  MCB 3 trip");

countb=2;
}

if(digitalRead(7)==HIGH && counte==1){
delay(2000);
digitalWrite(8, HIGH); //motor 1 is ON
digitalWrite(9, HIGH); //motor 2 is ON
digitalWrite(10, HIGH); //motor 3 is ON
digitalWrite(13, HIGH); //motor 4 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(8, LOW); // motor 1 is OFF
digitalWrite(9, LOW); // motor 2 is OFF
digitalWrite(10, LOW); // motor 3 is OFF
digitalWrite(13, LOW); // motor 4 is OFF

// Turn off the blinking cursor:
lcd.noBlink();
delay(3000);
// Turn on the blinking cursor:
lcd.blink();
delay(3000);

// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print("  ELCB trip");

counte=2;
}

//Third Trip


if(digitalRead(7)==HIGH && counte==2){
delay(2000);
}
if(digitalRead(7)==HIGH && digitalRead(0)==HIGH){
delay(2000);
digitalWrite(9, HIGH); //motor 2 is ON
digitalWrite(10, HIGH); //motor 3 is ON
digitalWrite(13, HIGH); //motor 4 is ON
delay(4000); // on time motor = 4 sec
```

```
digitalWrite(9, LOW); // motor 2 is OFF
digitalWrite(10, LOW); // motor 3 is OFF
digitalWrite(13, LOW); // motor 4 is OFF
}

else if(digitalRead(7)==HIGH && digitalRead(1)==HIGH){
delay(2000);
digitalWrite(8, HIGH); //motor 2 is ON
digitalWrite(10, HIGH); //motor 3 is ON
digitalWrite(13, HIGH); //motor 4 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(8, LOW); // motor 2 is OFF
digitalWrite(10, LOW); // motor 3 is OFF
digitalWrite(13, LOW); // motor 4 is OFF
}

else if(digitalRead(7)==HIGH && digitalRead(6)==HIGH){
delay(2000);
digitalWrite(8, HIGH); //motor 2 is ON
digitalWrite(9, HIGH); //motor 3 is ON
digitalWrite(13, HIGH); //motor 4 is ON
delay(4000); // on time motor = 4 sec
digitalWrite(8, LOW); // motor 2 is OFF
digitalWrite(9, LOW); // motor 3 is OFF
digitalWrite(13, LOW); // motor 4 is OFF
}
counte=3;
}

/*
if((analogRead(A0) != analogRead(A1)) countr == 2 ){   //red line and red line

delay(2000);
digitalWrite(8, HIGH); //motor 1 is ON
digitalWrite(9, LOW); // motor 2 is OFF
digitalWrite(10,HIGH); // motor 3 is ON
digitalWrite(13,HIGH); // motor 4 is ON
}


else if((analogRead(A2) != analogRead(A3)) county == 2 ){      //yellow and
yellow line

delay(2000);
digitalWrite(8, HIGH); //motor 1 is ON
digitalWrite(9,HIGH); // motor 2 is ON
digitalWrite(10,LOW); // motor 3 is OFF
```

```
  digitalWrite(13,HIGH); // motor 4 is ON
 }


 else if((analogRead(A4) != analogRead(A5)) && countb == 2 ){      //blue and
blue line

  delay(2000);
  digitalWrite(8, HIGH); //motor 1 is ON
  digitalWrite(9,HIGH); // motor 2 is ON
  digitalWrite(10,HIGH); // motor 3 is ON
  digitalWrite(13,LOW); // motor 4 is OFF
 }
*/
```

APPENDIX C

CURRENT TRANSDUCER LTS 6-NP DATASHEET

APPENDIX D

MICRO SERVO MOTOR HD-1900A DATASHEET