DESIGN AND IMPLEMENTATION OF AUTOMATIC THREE PHASE CABLE FAULT DETECTION FOR UNDERGROUND CABLE

by

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A project
submitted as partial fulfilment of the requirement for the degree of

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CERTIFICATE OF APPROVAL

The project entitled as "**Design and Implementation of Automatic Three Phase Cable Fault Detection for Underground Cable**" submitted by **Amit Biswas**, bearing Matric ID. **ET 141070** and **Kazi Md Jobayer**, bearing Matric ID. **ET 141060** of session **Spring 2018**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on **12 May, 2018**.

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DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this project has been submitted elsewhere for the award of any degree or diploma.

Amit Biswas

Kazi Md Jobayer

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All praises and thanks to Almighty, the Lord of the world, the most Beneficent, the most Merciful for helping us to accomplish this work.

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Authors

ABSTRACT

This project is to determine the distance of underground cable fault from the base station in kilometers and displayed on the LCD screen. Underground cable system is a common followed in major areas in Metro cities in developed countries. While a fault occurs for some reason, at that time the fixing process related to that particular cable is difficult due to exact unknown location of the fault in the cable. This technology is used to find out the exact location of the fault and to calculate data in onboard system of this proposed hardware module at the same time it display on the LCD screen. This system uses the standard theory of Ohms law, i.e., when a low DC voltage is applied at the feeder end through a series resistor i.e. cable lines, then the current would vary depending upon the location of the fault in the cable as the resistance is proportional to the distance. In case, there is a short circuit (Line to Ground), the voltage across series resistors changes according to the resistance that changes with distance. This is then fed to an ADC to develop precise digital data, which the programmed microcontroller of the ATmega328 family displays in kilometers.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Introduction

As Bangladesh emerging as a developing country, civilized area is also increasing day by day. As underground cables are best under such conditions its utilization is also growing because of its obvious advantages like lower transmission losses, lower maintenance cost and they are less susceptible to the impacts of severe weather and so many. However, it is having few disadvantages too like expensive installation and detection of fault location. As it is not visible, it becomes difficult to find exact location of the fault.

It is very crucial to maintain reliability of power system. That is why it is required to minimize the fault occurrence in power system and fasten the clearance of fault. It needs accurate and fast method to identify the faults and its clearance so that power disturbance can be resolved in short period. In overhead system, it is quite easy to fine the faulty area than underground system because of few obvious reasons. There are so many techniques in overhead system like Phasor Measurement Unit [1], which is capable of identifying the accurate location of fault and its types. However, in case of underground systems such systems cannot be used.

Fault location in underground cable systems has existed since people first started installing power transfer equipment in the ground in the late 1800's [2]. Since this early beginning, the use of cable has increased substantially and with it, the techniques for locating cable faults have been expanded and supplemented. As additional fault location methods became available and existing methods were modified throughout the world, knowledge of all the methods was never maintained. Dissemination of new approaches and available equipment was infrequent among utilities.

The benefits of underground cables over overhead lines have led to wider application of cables to electrical distribution systems. They are reliable than overhead lines in bad weather not susceptible to trees, cheaper for short distances and requires lower maintenance. However, underground cables have few disadvantages also including the fact that they are more prone to permanent faults after a flashover and difficult for fault location. Majority of the faults in underground cable systems are permanent in nature and are usually one among the following: core to sheath to ground fault, core to ground fault and core to sheath fault. The accurate identification of the faulted location of permanent faults in cables is very important for power distribution networks for better reliability, to ensure power quality, quicker restoration process, lesser outage time, reduced repairing cost etc.

1.2 Project Overview

The main operation of this project lies on the fact that when the current flows through the set of series resistors in each of the three set of line the current would vary depending upon the length of the cable from the place of fault that occurred if there is any short circuit fault with the Single Line to ground fault, or double line to ground fault, or three phase to ground fault. The voltage drops across the series resistors changes accordingly and then the fault signal goes to internal ADC of the microcontroller to develop precise digital data. Then microcontroller will process the digital data and the output is being displayed in the LCD connected to the microcontroller as per the programming conditions. The power supply given to the circuit is 220V ac supply, which is fed to step down transformer which steps down the voltage from 220 V to 12V which is then fed to a full wave bridge rectifier to rectify the ac voltage into pulsating dc voltage. The ripple in rectified output is then removed with the help of a 1000-microfarad electrolytic capacitor. Since a constant 5 V voltage source is desired in our circuit, because the Microcontroller 16x2 LCD, Relay Drivers etc. and the other components work at 5V supply; therefore, we are using voltage regulators (7805). These voltage regulators convert the filtered output to 5V constant supply voltage. The voltage regulator feeds the voltage to microcontroller, LCD, the set of series resistors and relay drivers.

1.3 Motivation

Fault in a cable is defined as a physical condition that causes a device, a component, or an element to fail to perform in a required manner. It will occur because of any defect, weakness or no homogeneity or by breaking of conductor and failure of insulation. Power cable fault location techniques are used in power system for accurate pin pointing of the fault positions. However, in case of underground cable, determining cable fault detection is not an easy task. Because the cables located under the ground and it is not possible to check all the point individually. In this project, we have proposed an easy method for detection underground cable fault using Ohm’s Law method.

We hope that this project work will help in detection of underground cable fault with an affordable cost estimation.

1.4 Project Objective:

The main objective of our project given below:

i. To Detect Line to Line and Earth Fault for Underground Cable.

ii. To Determine Fault Location and Calculate the Fault in Kilometer and Show it on LCD.

iii. To Perform a Real-time Fault Detection Performance.

1.5 Report Outline

Six chapters has covered in the course of design and development of this project. The chapters and their contents are as follows:

- Chapter 1 is the introductory chapter that gives the overview, motivation and objective of the project.
- Chapter 2 is literature review. Previous work related of this project has discussed in this chapter.
- Chapter 3 is hardware description. In this chapter, all the components used in this project has described elaborately.
- Chapter 4 deals with the system design of the project. In this chapter Block diagram, Circuit diagram, Flow chart and Programming of the project has discussed.
- Chapter5 deals with the system implementation and results, Objective verification and system specification.
- Finally, the summary of this project has discussed in detail in chapter 6. The limitation of the project, advantage and future development has discussed on this topic

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Electrical energy is generated in the generating station and then it is distributed to the different loads at different areas for consumption through step up and step down transformers. Distribution of the electrical energy is done via electric cables. Study of cable failures and development of accurate fault detection and location methods has been interesting research topics in the past and present. Fault detection entails determination of the presence of a fault, while fault location detection includes the determination of the physical location of the fault. However, this fault detection and fault location detection technology for underground power distribution systems is still in developing stages. There are many ways to find the cable fault location. This paper deals with the method to Locate Faults in a Damaged Cable. Before fixing any fault in cables, the fault has to be identified first. For most of the worldwide-operated low voltage and medium voltage distribution lines underground cables have been used from many decades [11]. To reduce the sensitivity of distribution networks to environmental influences underground high voltage cables are used more and more. Underground cables have been widely used in power distribution networks due to the advantages of underground connection, involving more security than overhead lines in bad weather, less liable to damage by storms or lightning. It is less expensive for shorter distance, eco- friendly and low maintenance. If any fault occur in cable, then it is difficult to locate fault. So this project has used to detect the location of fault in digital way. The requirement of locating the faulty point in an underground cable in order is to facilitate quicker repair, improve the system reliability and reduced outage period [3]. The underground cable system is very useful for distribution mainly in metropolitan cities, airport and defense services. Underground distribution cables are usually characterized with different technical difficulties regarding detecting and locating their faults. Different factors participate into these difficulties including their remarkable charging currents, cable construction and variations of their equivalency resulted from the variety of bonding and grounding methodologies.

Frequent fault in underground cables due to the breakdown of paper plastic insulation due to chemical reaction or poor workmanship during installation and the difficulties in locating the approximate fault area have been a serious problem. Most Underground Faults are located by unearthing the entire length of cable to enable visual inspection to be carried out. In case where visual inspection is not helpful then the entire length of cable is replaced. This manual method is not only expensive but also results in heavy loss of revenue to the power distribution company. This research is aimed at designing an underground cable fault location distance detection to solve this problem. The research work will help in identification and location of underground cable fault without unearthing the entire length of the cable before repair or replacing entire cable due to difficulty in locating the fault.

2.2 Review of Previous Works

Some previous works based on underground cable fault detection has given below.

2.2.1 Identification of Underground Cable Fault Location & Development

Mr. M. R. Hans, Ms. Snehal C. Kor, Ms. A. S. Patil

Identification of underground cable fault has detected by using Murray Loop Test Method [10] in this paper [4]. This test has used to find the fault location in an underground cable by making one Wheatstone bridge in it and by comparing the resistance, the fault location has detected. However,

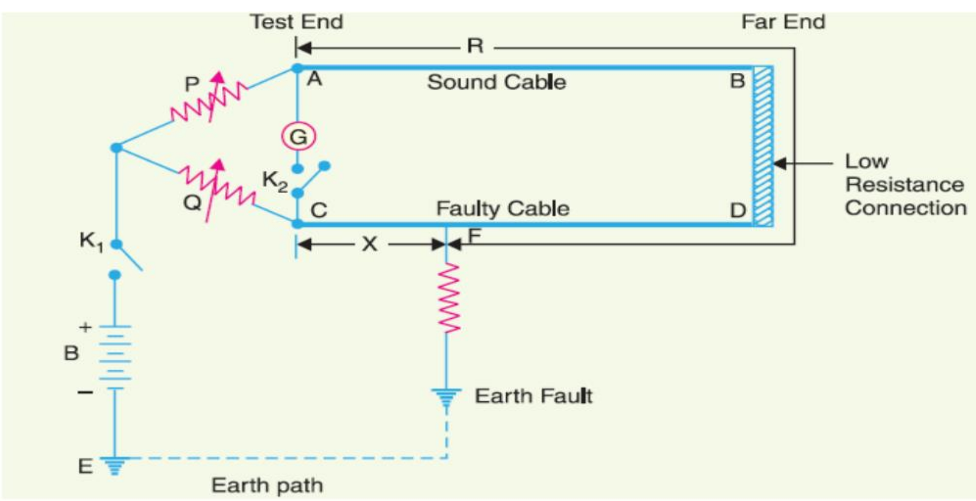

Fig. 2.1 Murray Loop Test Method for Underground Cable Fault Detection [4]

precise cable length is required to perform this test. The necessary connection of the Murray loop test has shown in **Fig. 2.1**. In this method, simple OHM's law has used to locate the short circuit fault. A DC voltage has applied at the feeder end through a series resistor, depending upon the length of fault of the cable current varies. The voltage drop across the series resistor changes accordingly, this voltage drop has used in determination of fault location. This method has assembled with a set of resistors representing cable length in KMs and fault creation has made by a set of switches at every known KM to cross check the accuracy of the same. The voltage drop across the feeder resistor is given to an ADC which develops a precise digital data which the

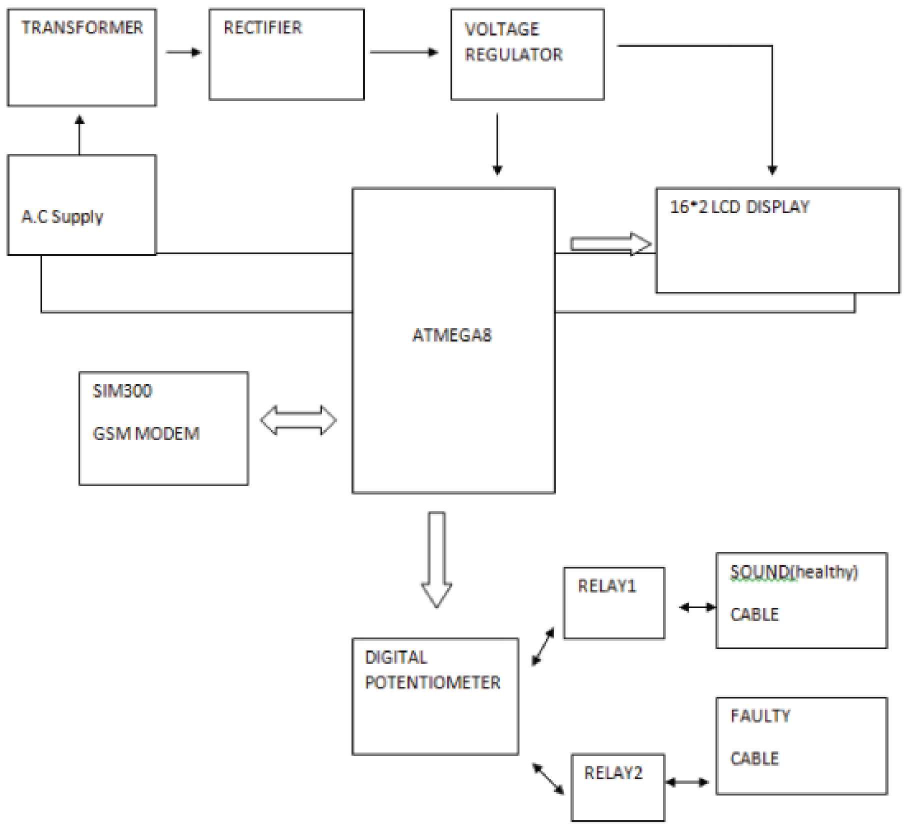

Fig. 2.2 Block Diagram of Murray Loop Method [4]

programmed microcontroller would display the same in Kilometers. As shown in **Fig 2.2**, the fault occurring at what distance and which phase has displayed on a 16X2 LCD interfaced with the microcontroller. In this method, ATMega8 microcontroller has used, which is of 8-bit and assembly language has used to program the microcontroller. The power supply has used here, consists of a step down transformer 230/12V, which steps down the voltage to 12V AC. This has converted to DC using a Bridge rectifier. The ripples are removed using a capacitive filter and it is then regulated to +5V using a voltage regulator 7805 which is required for the operation of the microcontroller and other components The power supply circuit which is used to run the set up consists of step down transformer which is 230 V step-down to 12 V. In this circuit, DB107 has used to form bridge rectifier, which delivers pulsating DC voltage & then fed to capacitor filter the output voltage from rectifier has fed to filter to eliminate any a. c. components present even after rectification. The filtered DC voltage has given to regulator to produce 12 V constant DC voltages.

2.2.2 Underground Cable Fault Detection using Arduino

T.Nandhini, J.Shalini, T. Sai Sangeeetha, D.Gnanaprakasam

In this system, the Underground fault detection deals with finding the exact fault location from the base station. The authors were mainly focused on resistance of wire. Resistance can vary with respect to the length of the cable. If the length of the cable increases, the value of the resistance will also increase [7]. If any deviation occurs in the resistance value, we call that as fault point and

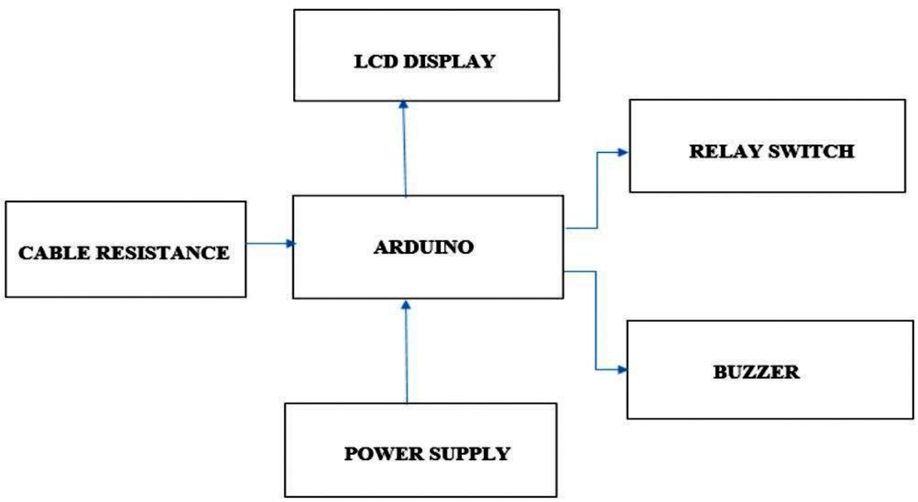

Fig. 2.3 Block Diagram of Underground Cable Fault Detection Using Arduino [7]

that point can be identified with the help of Arduino technology. Relays and other peripherals like LCD display, buzzer has interfaced with an Arduino Uno as shown in **Fig 2.3**. That fault point represents the standard of distance (kilometer) from the base station and the display unit displays the value. They uploaded the program in the kit. Program has written and if any fault occurs in the cable, immediately it will open the relay terminal and disconnect that faulty line only. Rest of the other lines operates normally. The connector of the relay moves from normally closed conduct to normally open conduct. We can easily find the fault and disconnect the faulty line. Display unit has connected to the Arduino kit, which is used to display where the fault occurs. Once faults occur in the cable, the display unit displays the exact fault location and displays which phase is affected in the cable and how long it is affected and buzzer system is used to create an alerting signal. Buzzer systems create an alerting sound signal, once the fault occurs in the underground cable. Proteus Virtual System Modelling combines mixed mode SPICE circuit Simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. The version used for this project design is Proteus Professional 7.0. Proteus Professional Software for automated design of electronic circuits. The package is a system of circuit simulation, based on the models of electronic components in PSpice. A distinctive feature of the package Proteus Professional is the possibility of modelling of the programmable devices: Microcontrollers, Microprocessor, DSP and others. Additionally, the package of Proteus Professional is a system design of printed circuit boards. Proteus Professional can simulate the following microcontrollers: 8051, ARM7, AVR, Motorola, PIC, Basic Stamp. The library contains the components of data Simulation of microprocessor software within a mixed mode SPICE simulator.

2.2.3 Underground Cable Fault Distance Detector using ATmega328 Microcontroller

Tanmay Kedia, Vinita Sahare, Kanchan Kumar Baur, Rajendra Kumar Sahu

In this system the main operation lies on the fact that when the current flows through the set of series resistors in each of the three set of line the current would vary depending upon the length of the cable from the place of fault that occurred if there is any short circuit fault with the Single Line to ground fault, or double line to ground fault, or three phase to ground fault [8]. The voltage drops across the series resistors changes accordingly and then the fault signal goes to internal ADC of the microcontroller to develop precise digital data [9]. Then microcontroller will process the digital data and the output is being displayed in the LCD connected to the microcontroller in kilometers as per the programming conditions. The power supply given to the circuit is 230V ac supply, which is fed to step down transformer (9 V-0 V) which steps down the voltage from 230 V to 9V which is then fed to a full wave bridge rectifier to rectify the ac voltage into pulsating dc voltage. The ripple in rectified output is then removed with the help of a 1000-microfarad electrolytic capacitor. Since a constant 5 V voltage source is desired in our circuit, because the Microcontroller (ATmega328), 16x2 LCD (Liquid Crystal Display), Relay Drivers and Relays etc. and the other components work at 5V supply; therefore, we are using two voltage regulators (7805). These voltage regulators convert the filtered output to 5V constant supply voltage. The first voltage regulator U2 feeds the voltage to microcontroller, LCD, and the set of series resistors. While the second voltage regulator U3 feeds the relay and relay driver IC ULN2003A. The block diagram that has shown in **Fig 2.4** describe the step by step procedure of the system. In addition, this model consists of three relays, which are driven by a relay driver IC ULN2003A. The relay used here drives the bulb load to indicate the fault being occurred in corresponding phases and can be used to trip the power supply to the set of series resistors. The fault creation environment is made by a

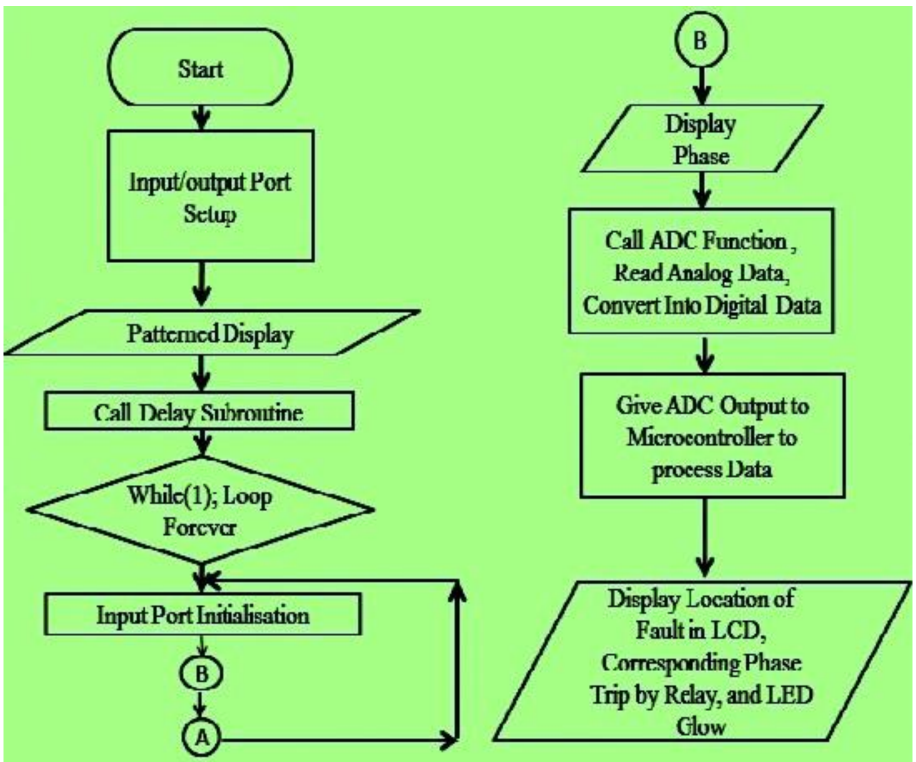

Fig. 2.4 Flow Chart of Underground Cable Fault Distance Detector using ATmega328 Microcontroller [8]

set of switches at every known equivalent kilometer as indicated by the set of series resistors to cross check accuracy of the same. When a fault is occurred at the distance in a phase (or two phases or three phases) current flows through the shorted line and developing drops across the corresponding phase resistors. This drop is sensed by the ADC (built inside the microcontroller) through Port and converts it into equivalent digital data. The microcontroller then process these data according to fault conditions pre-programmed into the microcontroller and then sends out display signals about the location of fault to LCD which finally displays the location of the fault in kilometers and simultaneously send the signals to the relay driver IC which further drives the bulb load connected to the relay. The model uses four sets of resistors in series for each phase of the cable line. In addition, resistors has used in series with supply line of each phase as shown in the circuit diagram. Each set of four series resistors represents the resistance of the underground cable for a specific distance of 4kms equally divided into 1km for each resistor. The resistors develops respective voltage drops corresponding to the occurrence of ground fault in one phase or two phases or three phases. The ADC built in microcontroller then senses this drop. The other end of resistors are connected to ground. Simulation of fault distance detection is also conducted in Proteus 8 Software as shown below and different results are obtained as per case chosen. In this model, set of series resistors in each phase of the line is equally divided into 4 parts at a distance of 1 Kilometer each where a slider switch is connected to the supply. When the switch is kept on current flows through the resistor and voltage drop occurs which indicates that a fault to ground has occurred. There are various case studies conducted with all the three phases (R, Y, and B) of cable line individually in each phase. There are four nos. of slider switches in each phase totaling to 12 nos. of such switches in all the three phases. This paper described the Underground Cable Fault Distance Detector Using ATmega328 Microcontroller in simulation form and results were successful. A full-fledged prototype model had been implemented as a proof of concept to realize and understand the real time scenarios in underground cable system. Through this prototype, simulation model the proposed architecture had been demonstrated that could effectively satisfy the requirement of exact fault location detection in the underground cable system and it is believed that this model can be a promising technology to solve future fault location detection problem.

CHAPTER 3

HARDWARE DESCRIPTION

3.1 Introduction

Hardware is the most important fact for a project. Choosing the necessary hardware is also very difficult. In this chapter, we are going to describe the hardware used for this project. We will also discuss the function of the chosen parts. By the end of this chapter, one will understand the reason behind choosing the used components and their function to this project.

3.2 List of Components

- Arduino Pro Mini
- ACS712 Current Sensor
- LCD
- I2C Adapter
- Relay
- Step Down Transformer
- Diode
- Capacitor
- Voltage Regulator

3.3 ATmega328 Microcontroller

ATmega328 microcontroller is a 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes [12]. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

Table 3.1 represents the summary of ATmega328 Microcontroller.

Table 3.1 Summary of ATmega328 Microcontroller

Parameter Name	Value
Program Memory Type	Flash
Program Memory (KB)	32
CPU Speed (MIPS)	20
SRAM Bytes	2048
Data EEPROM (bytes)	1024
Digital Communication Peripherals	1-UART, 2-SPI, 1-12C
Capture/Compare/PWM Peripherals	1 Input Capture, 1 CC
Timers	2 x 8 bit, 1 x 16 bit
Comparators	1
Temperature Range (C)	-40 to 85
Operating Voltage Range (V)	1.8 to 5.5
Pin Count	32

3.3.1 Arduino Pro Mini

The Arduino Pro Mini is a microcontroller board based on the ATmega328 has shown in **Fig 3.1**. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, an on-board resonator, a reset button, and holes for mounting pin headers [1].

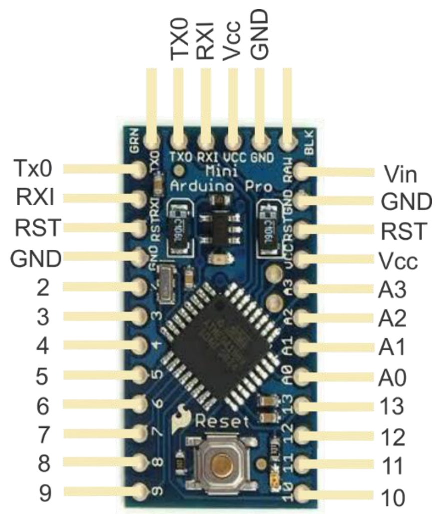

Fig 3.1 Pinout of Arduino Pro Mini [12]

Table 3.2 represents the summary of Arduino Pro Mini.

Table 3.2 Summary of Arduino Pro Mini

Parameter Name	Value
Microcontroller	ATmega328
Operating Voltage	5V
Digital I/O Pins	14
PWM Pins	6
UART	1
SPI	1
I2C	1
Analog Input Pins	6
External Interrupts	2
DC Current Per I/O Pin	40mA
Flash Memory	32KB (2KB Used by Bootloader)
SRAM	2KB
EEPROM	1KB
Clock Speed	16 MHZ

3.4 ACS712 Current Sensor

The ACS712 is a bi-directional, Hall Effect current sensing IC as shown in **Fig 3.2**. The current is passed through the IC; with little to no effect on the voltage, and the IC measure the magnetic field generated by the current. This is a breakout board for the fully integrated Hall Effect based linear ACS712 current sensor. The sensor gives precise current measurement for both AC and DC signals [13]. Thick copper conductor and signal traces allows for survival of the device up to 5 times overcurrent conditions. The ACS712 outputs an analog voltage output signal that varies linearly with sensed current. The device requires 5VDC for VCC and a couple of filter capacitors.

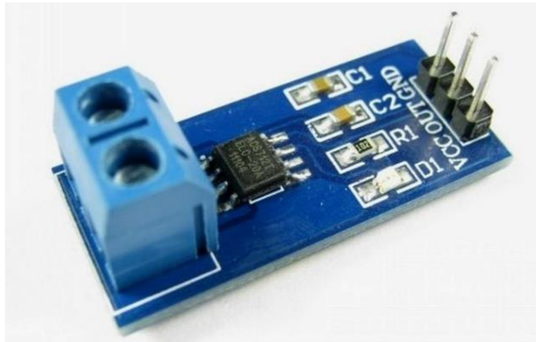

Fig 3.2 ACS712 Current Sensor Module [13]

Table 3.3 represents the summary of ACS712 Current Sensor.

Table 3.3 Summary of ACS712 Current Sensor

Parameter Name	**Value**
Supply Voltage	4.5-5.5V
Supply Current	10mA
Current Measurement Range	30A
Output	Bi-directional Analog Voltage
Sensitivity	66 mV/A

3.5 Step Down Transformer

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. A varying current in one coil of the transformer produces a varying magnetic field, which in turn induces a varying electromotive force or "voltage" in a second coil. Power can be transferred between the two coils through the magnetic field, without a metallic connection between the two circuits. Faraday's law of induction discovered in 1831 described this effect. Transformers are used to increase or decrease the alternating voltages in electric power applications. In this project a step down transformer has used where primary coil take 220-volt as input and secondary coil output is 12volt. This step down transformer has use to energize motors, solenoid valve, hot gun that has used in this project.

3.6 LCD Display

LCD displays has seen everywhere. Computers, calculators, television sets, mobile phones, digital watches use some kind of display to display the time. An LCD is an electronic display module, which uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates a display 16 characters per line in two such lines. In this LCD [14], each character has displayed in a 5×7pixel matrix.

Table 3.4 represents the summary of 16x2 LCD Display.

Table 3.4 Summary of 16x2 LCD Display

Pin No.	Description	Name
1	Ground (0V)	Ground
2	Supply voltage (5V)	Vcc
3	Contrast adjustment	V_0/ V_{ee}
4	Low for command register, high for data register	RS (Register select)
5	Low to write; High to read.	RE (Read/Write)
6	When low use as output device, when high use as input device. Generally grounded it.	E (Enable)
7	8-bit Data Pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Back light Vcc (5V)	Led+
16	Backlight Ground (0V)	Led-

Fig 3.3 shows the pinout of a LCD Display.

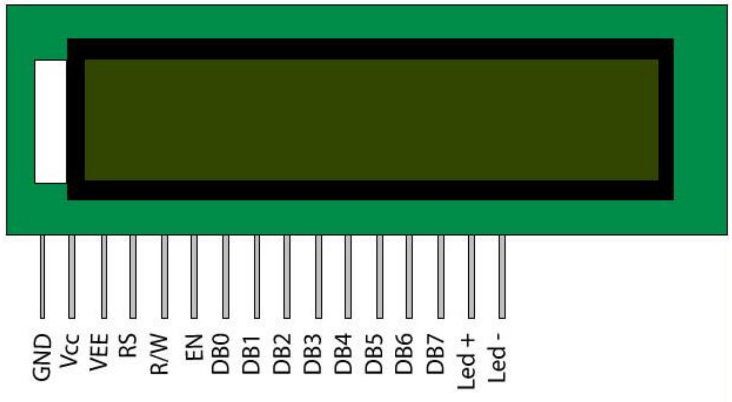

Fig 3.3 16x2 LCD Display [14]

3.7 I2C LCD Adapter

Serial I2C LCD display adapter as shown in **Fig 3.4** converts parallel based 16 x 2 character LCD display into a serial i2C LCD that can be controlled through just 2 wires. Adapter uses PCF8574 chip that serves as I/O expander that communicates with Arduino by using I2C protocol.

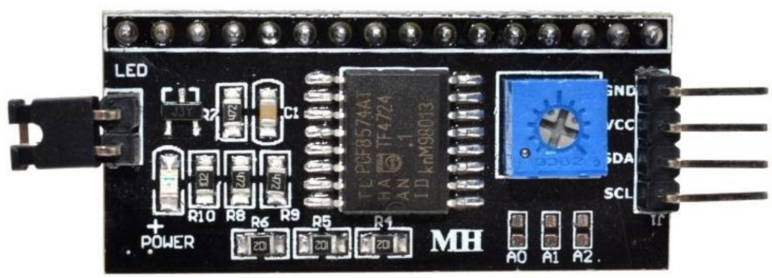

Fig 3.4 I2C LCD Adapter Module [15]

A total of 8 LCD displays can be connected to the same two wire I2C bus with each board having a different address. The default i2C address is 0X27 and may be changed to any of the following 0X20~0X27 via soldering A0 A1 A2 pins [15].

3.7.1 Features of I2C LCD Adapter

- 16 x 2 Character LCD display is controlled via just two wires
- Up to 8 LCD displays with adapters can be connected and controlled by the same two wire I2C bus

- Easy to control using Arduino board
- Compatible with 16 x 2 character LCD displays
- Adapter includes 16-PIN male header connector for soldering to LCD display
- Contrast is adjusted via onboard potentiometer
- Backlight may be turned on/off via jumper
- Standard 5V voltage supply

3.8 Relay

A relay is an electrically operated switch. Relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit [16]. As relay diagrams has shown in **Fig 3.5**, when a relay contact is normally open (NO), there is an open contact when the relay is not energized. When a relay contact is Normally Closed (NC), there is a closed contact

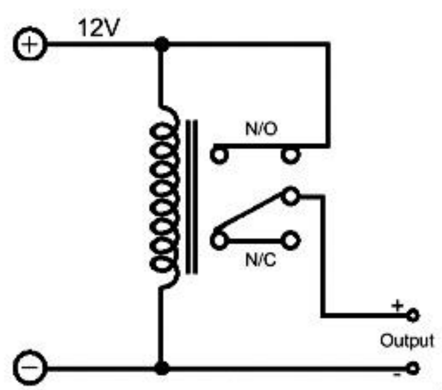

Fig 3.5 Internal Structure of a Relay [16]

when the relay is not energized. In either case, applying electrical current to the contacts will change their state. Magnetic latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in applications where interrupted power should not be able to transition the contacts.

3.9 Diode

A diode is a device has shown in **Fig 3.6** which only allows unidirectional flow of current if operated within a rated specified voltage level. Diode only blocks current in the reverse direction while the reverse voltage is within a limited range and the voltage at which this breakdown occurs is called reverse breakdown voltage. The diode acts as a valve in the electronic and electrical circuit. A P-N junction is the simplest form of the diode, which behaves as ideally short circuit when it is in forward biased and behaves as ideally open circuit when it is in the reverse biased [17]. Beside simple PN junction diodes, there are different types of diodes although the fundamental principles are more or less same. Therefore, a particular arrangement of diodes can convert AC to pulsating DC, and hence, it is sometimes called as a rectifier. The symbol of a diode is shown below, the arrowhead points in the direction of conventional current flow.

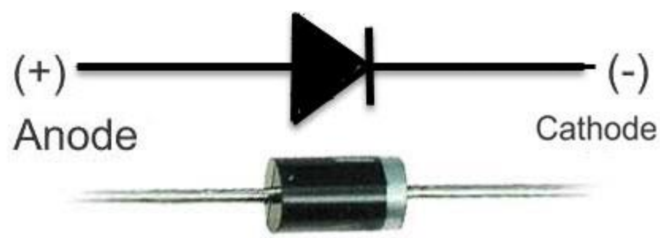

Fig 3.6 Diode Symbol and Polarity [17]

In a PN junction diode when the forward voltage is applied i.e. positive terminal of a source is connected to the p-type side, and the negative terminal of the source is connected to the n-type side, the diode is said to be in forward biased condition. There is a barrier potential across the junction. This barrier potential is directed in the opposite of the forward applied voltage. So a diode can only allow current to flow in the forward direction when forward applied voltage is more than barrier potential of the junction. This voltage is called forward biased voltage. For silicon diode, it is 0.7 volts. For germanium diode, it is 0.3 volts. When forward applied voltage is more than this forward biased voltage, there will be forward current in the diode, and the diode will become short-circuited. Hence, there will be no more voltage drop across the diode beyond this forward biased voltage, and the external resistance connected in series with the diode only limits forward current. Thus, if forward applied voltage increases from zero, the diode will start conducting only after this voltage reaches just above the barrier potential or forward biased voltage of the junction. The time, taken by this input voltage to reach that value or in other words, the time, taken by this input voltage to overcome the forward biased voltage is called recovery time.

3.10 Capacitor

Capacitor is an electronic component that stores electric charge has shown in **Fig 3.7**. The capacitor is made of 2 close conductors (usually plates) that are separated by a dielectric material. The plates accumulate electric charge when connected to power source. One plate accumulates positive charge and the other plate accumulates negative charge. The capacitance is the amount of electric charge that is stored in the capacitor at voltage of 1 Volt. The capacitance is measured in units of Farad (F). The capacitor disconnects current in direct current (DC) circuits and short circuit in alternating current (AC) circuits. As a capacitor is a passive component, it does not generate any energy but it can store energy from an energy source like a battery or another charged capacitor. When we connect a battery (DC Source) across a capacitor, one plate is attached to the positive end of the battery, and other plate is attached to the negative end of the battery. Now, potential of that battery is applied across that capacitor.

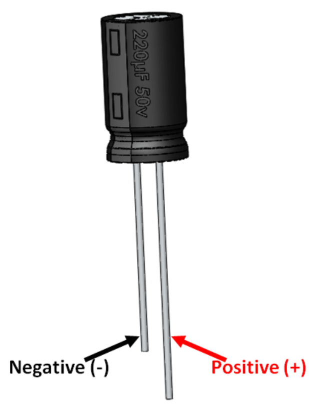

Fig 3.7 Polarity of a Capacitor [18]

At that situation, plate-I is in positive potency with respect to the plate 2. At steady state condition, the current from the battery tries to flow through this capacitor from its positive plate to negative plate but cannot flow due to the separation of these plates with an insulating material. An electric field appears across the capacitor. As time goes on, positive plate will accumulate positive charge from the battery, and negative plate will accumulate negative charge from the battery. After a certain time, the capacitor holds maximum amount of charge as per its capacitance with respect to this voltage. This time span is called charging time of this capacitor.

3.11 Voltage Regulator

A voltage regulator is an integrated circuit (IC) that provides a constant fixed output voltage regardless of a change in the load or input voltage. It can do this many ways depending on the topology of the circuit within, but for the purpose of keeping this project basic, we will mainly focus on the linear regulator. A linear voltage regulator works by automatically adjusting the resistance via a feedback loop, accounting for changes in both load and input, all while keeping the output voltage constant. In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels. The L78xx series of three terminal positive regulators is available.

CHAPTER 4

SYSTEM DESIGN

4.1 Introduction

This chapter includes system design and simulation of this project. Block diagram, Circuit diagram and Flowchart of the system has discussed below.

4.2 Block Diagram

Block diagram of this project has shown in **Fig 4.1**. An Arduino Pro Mini has used in this project Which is the main driver of this whole system. For fault mode selection, two push button has used. These button has used for demonstrating the line fault detection and earth fault detection. Four relay has used in this project for fault detection.

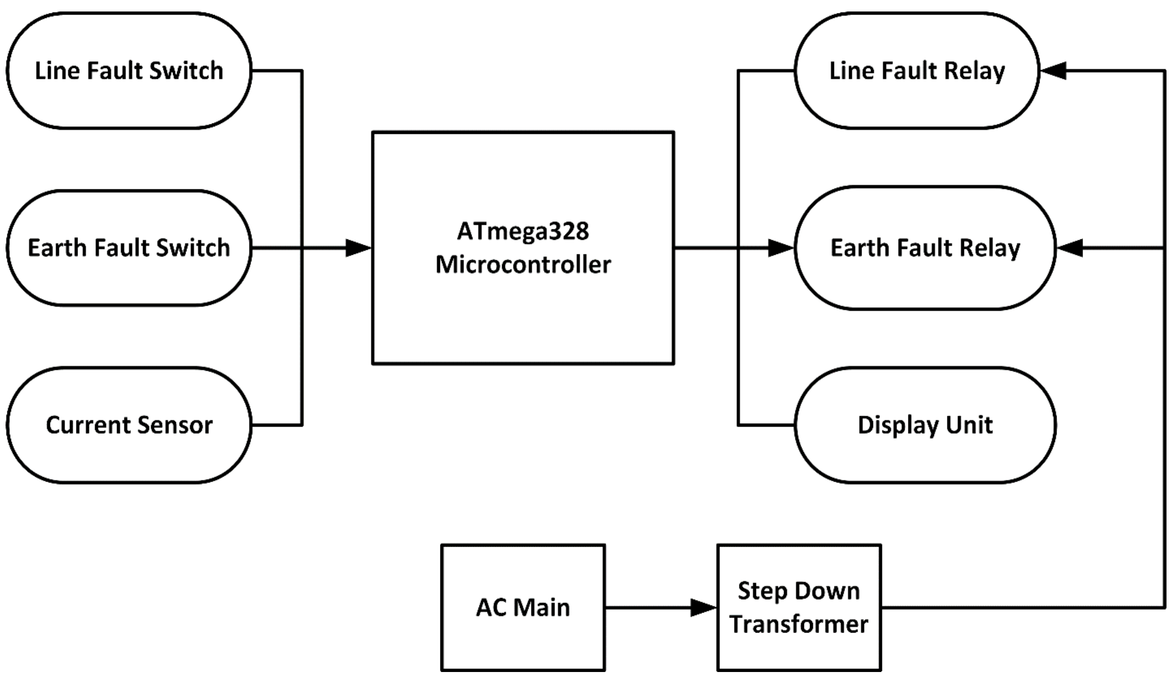

Fig 4.1 Block Diagram of the System

For line fault three relay has used for RYB line fault detection and another relay has used with earth cable for detecting earth fault. A current sensor has used to calculate the current. The fluctuation of current has used to determine the fault in real time. The fault has calculated in Kilometer for practical observation. A LCD display has used to visualize every certain step of this project.

4.3 Circuit Diagram

The circuit of this system has shown in **Fig 4.2**. All the peripherals of this project has controlled by using an ATmega328. The LCD display has connected to the 34 and 35 number pin via an I2C connector. Two pushbuttons are connected to the pin number 2 and 3Relay driver has used to control the associate relays preciously.

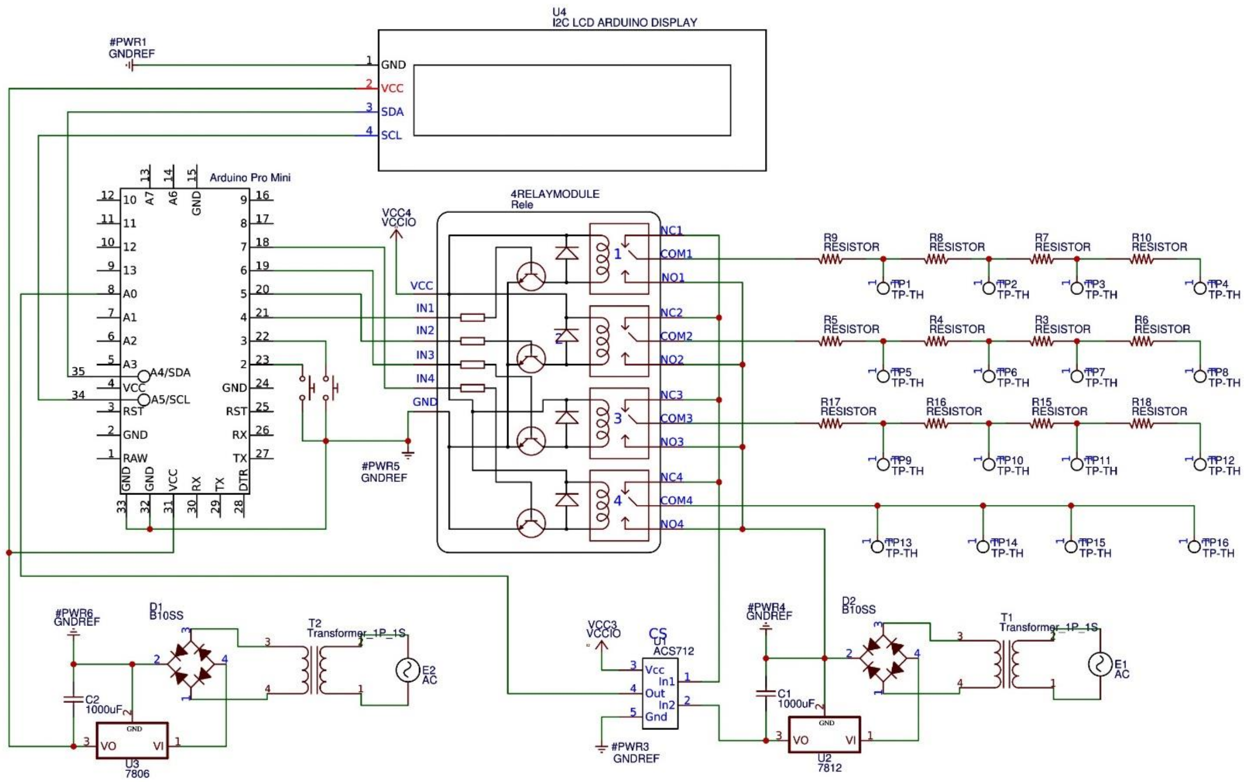

Fig 4.2 Circuit Diagram of the System

The relay board has eight relay available. Four relay has used from the relay board. Theses relays are interfaced with pin number 4, 5, 6 and 7 of ATmega328. The current sensor has interfaced with A0 pin of microcontroller. The reason of connecting the current sensor is, current sensor provides floating value of measured current in Ampere. To calculate the value correctly, it has to be connected with analogue port. Normally closed points of relays are shorted and has connected with current sensor for measuring current values. In this circuit, we have used additional esistance with RYB wires. Because without external resistance, the resistance from this amount of wire will not be enough for measurement of faulty lines. The relay driver has powered by a step down transformer energized from AC source.

4.4 Programming

The programming of this whole has system has described in brief below.

4.4.1 Library Functions

- Wire.h: This library allows communicating with I2C devices. Arduino communicate with I2C devices through the SDA (data line) and SCL (clock line) pin.
- LiquidCrystal_I2C.h: This library allows an Arduino board to control Liquid Crystal Displays (LCDs) based on the Hitachi HD44780 chipset. The library works with in either 4- or 8-bit mode.

4.4.2 User Defined Functions

- Void setup(): The void keyword is used only in function declaration. It returns no information to the function from it was called. The setup function initializes variables, pin modes, start using library etc. The setup function will only run once, after each power up.
- Void loop(): This function is used for running main program over and over again. This helps continuous execution of certain program simultaneously.
- Serial.begin(9600): Serial.begin(9600) doesn't actually print anything. Rather it initializes the serial connection at 9600 bits per second. Both sides of the serial connection (i.e. the Arduino and computer) need to be set to use the same speed serial connection in order to get any sort of intelligible data.
- void modeOne(): This used defined function has used for detecting line faults i.e. YR fault, YB fault and RB fault. At the very beginning of this function it will show LL/LP Short

Test on the LCD display. Then it will measure the current using ACS712 Current Sensor. By determine the current values it will further calculate the actual fault location.

- void modeTwo(): This used defined function has used for detecting ground faults i.e. YN fault, RN fault and BN fault. At the very beginning of this function, it will show Earth Fault Test on the LCD display. Then it will measure the current using ACS712 Current Sensor. By determine the current values it will further calculate the actual fault location.
- float ctReading(): Float means that the return type of the function will be floating point value. This user defined function has used for measuring current sensor value. This function takes 150 values and average them for accurate measurement.
- void allRealoff(): This user defined function has used for resetting relays after the end of the procedure.

4.5 Flow Chart

The flowchart of the whole system has shown in **Fig 4.3**. This flowchart has subdivided into two parts. The Mode One sub-division which represents line fault has shown in **Fig 4.4** flow chart, Mode Two which presents earth fault has shown in **Fig 4.5** flow chart.

The system will start with LCD output showing Cable Fault Detection. Then it will for switch press. In this project, we have used two switch. One switch has used for simulating Line Fault and another switch has used for Earth Fault. When first switch will be pressed, the system will understand that we are simulating a line fault. Then the algorithm will continue to mode one section. Here we have described the whole procedure for line fault detection. At first, it will check the fault between Yellow and Red wire. As instruction, the system will turn off the relay that has connected with Yellow wire and turn on the relay that has connected with Red wire. Here the offset current value has calibrated as 2.5 Amp. If the current value is greater than offset value, the system confirms that Yellow and Red wire are shorted and it shows the fault location in LCD with distance. However, if Yellow and Red wire are not shorted i.e. no fault occurred, it will then check Yellow and Black wire. The system will turn off the relay that has connected with Yellow wire and turn on the relay that has connected with Black wire. The offset current value has calibrated as 2.5 Amp. If the current value is greater than offset value, the system confirms that Yellow and Black wire are shorted and it shows the fault location in LCD with distance. If Yellow and Black

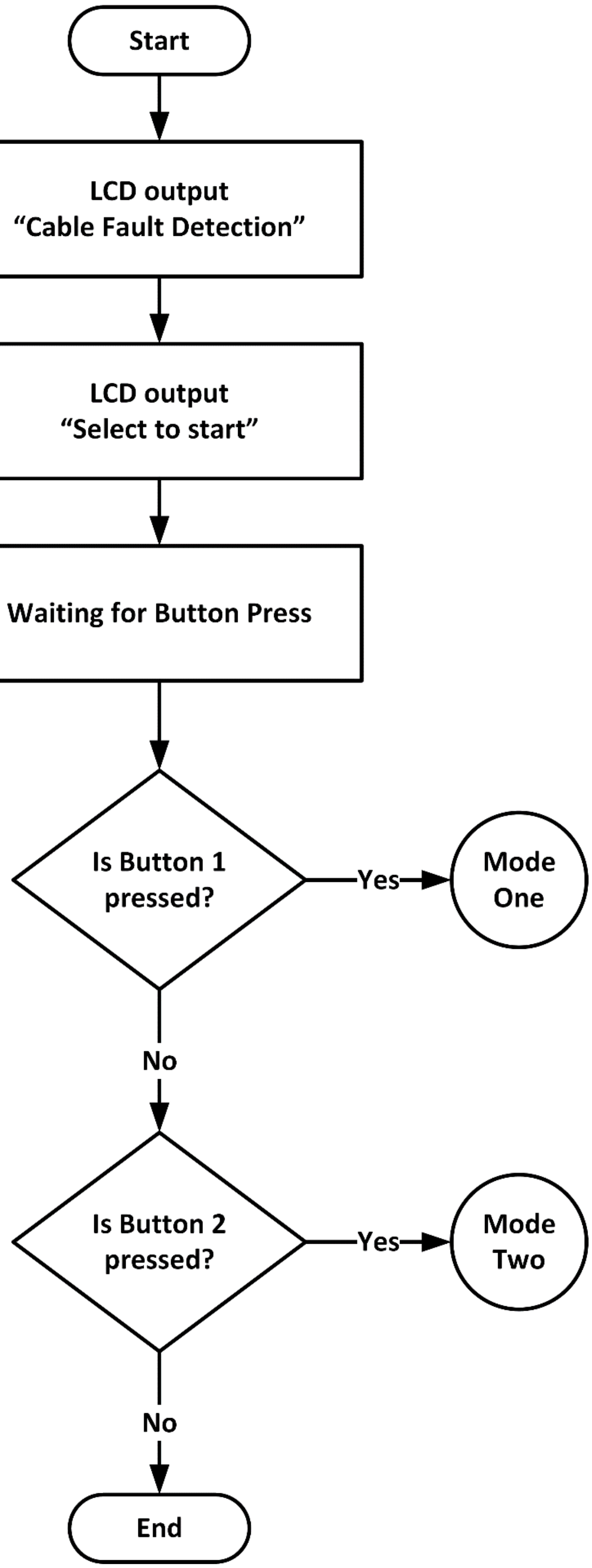

Fig 4.3 Overall Flow Chart of the System

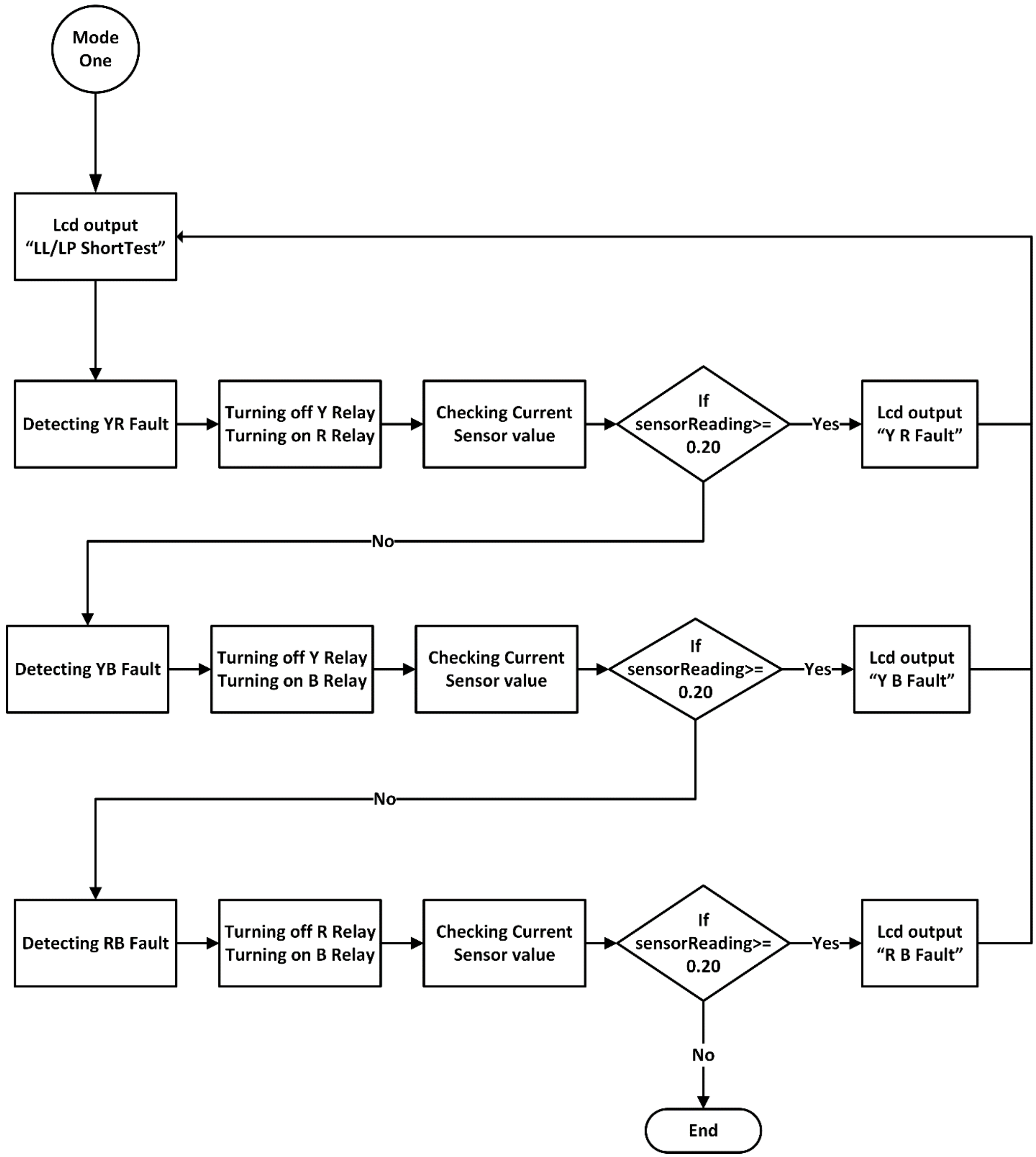

Fig 4.4 Mode One Sub process of Main Flow Chart

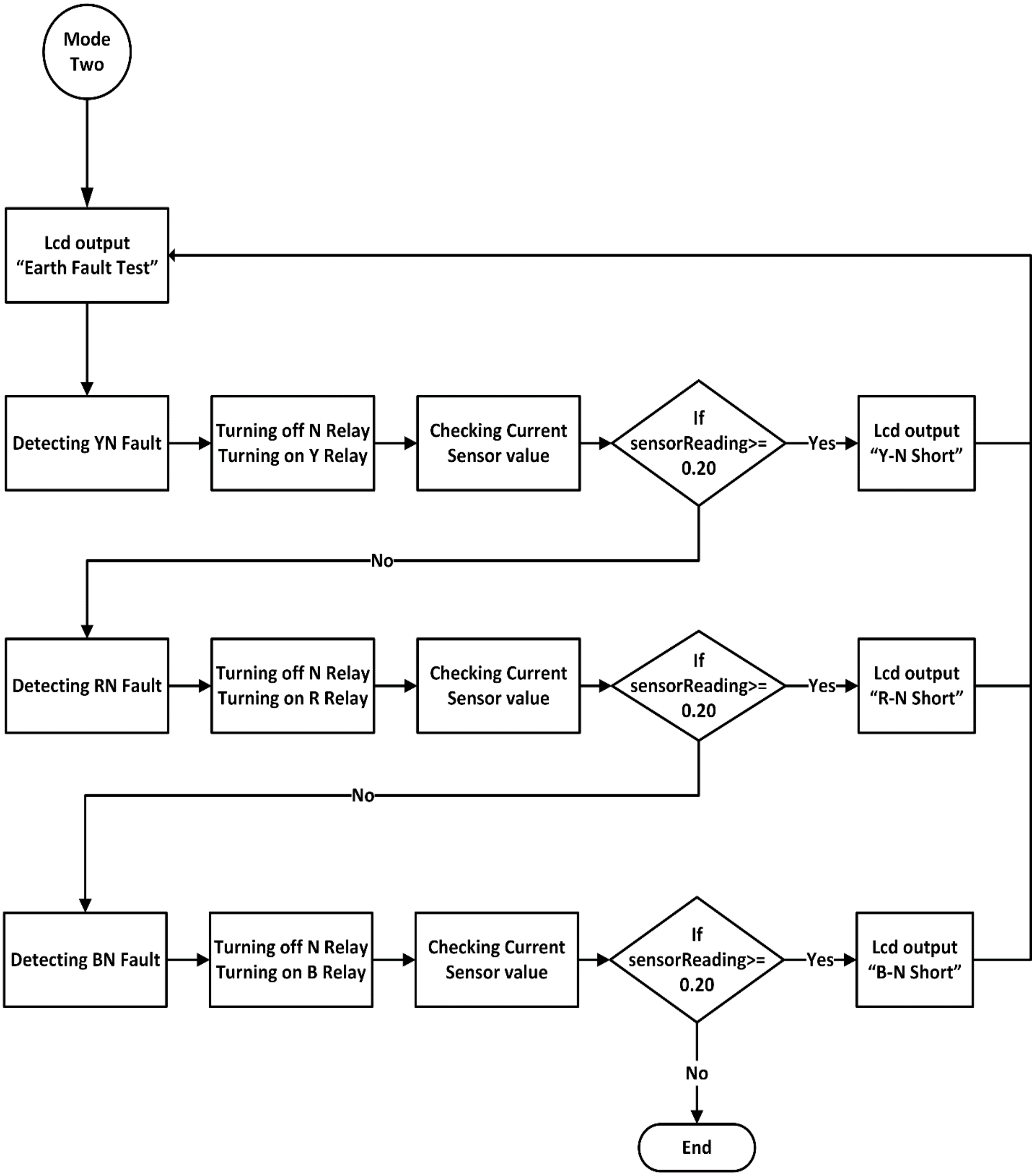

Fig 4.5 Mode Two Sub process of Main Flow Chart

wire are not shorted i.e. no fault occurred, it will then check Red and Black wire. The system will turn off the relay that has connected with Red wire and turn on the relay that has connected with Black wire. If the current value is greater than offset value, the system confirms that Red and Black wire are shorted and it shows the fault location in LCD with distance.

When second switch will be pressed, the system will understand that we are simulating earth fault. Then the algorithm will continue to mode two section.

Here we have described the whole procedure for earth fault detection. At first, it will check the fault between Yellow and Neutral wire. As instruction, the system will turn off the relay that has connected with Yellow wire and turn on the relay that has connected with Neutral wire. Here the offset current value has calibrated as 2.5 Amp. If the current value is greater than offset value, the system confirms that Yellow and Neutral wire are shorted and it shows the fault location in LCD with distance. However, if Yellow and Neutral wire are not shorted i.e. no fault occurred, it will then check Red and Neural wire. The system will turn off the relay that has connected with Red wire and turn on the relay that has connected with Neutral wire. The offset current value has calibrated as 2.5 Amp. If the current value is greater than offset value, the system confirms that Red and Neutral wire are shorted and it shows the fault location in LCD with distance. If Red and Neutral wire are not shorted i.e. no fault occurred, it will then check Black and Neutral wire. The system will turn off the relay that has connected with Black wire and turn on the relay that has connected with Neutral wire. If the current value is greater than offset value, the system confirms that Black and Neutral wire are shorted and it shows the fault location in LCD with distance.

CHAPTER 5

SYSTEM IMPLEMENTATION AND RESULT

5.1 Introduction

In this chapter, the complete implementation and objective justification have discussed with proper demonstration.

5.2 Project Overview

The complete project overview has shown in **Fig 5.1**. The project has mounted on a wood board that holds all the necessary hardware. Three color-coated wire i.e. Red, Yellow and Black wire has

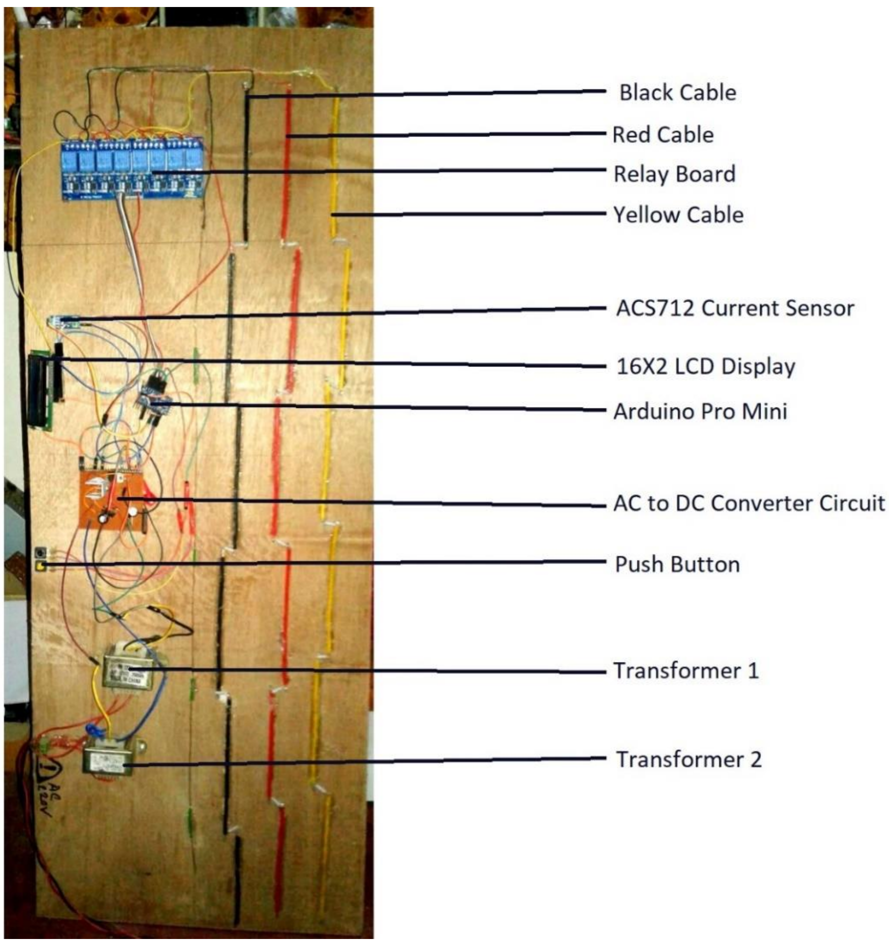

Fig 5.1 Overview of the Project

used for simulating line fault and earth fault. Two Step down transformers has used for necessary power supply. Relays, LCD Display, Current sensors has interfaced with Arduino Pro Mini.

5.3 Objective Justification

In this segment, we have showed all result that we have got from our project.

5.3.1 Line Fault Result

We have shorted Red and Black wire using crocodile clip as in **Fig 5.2**.

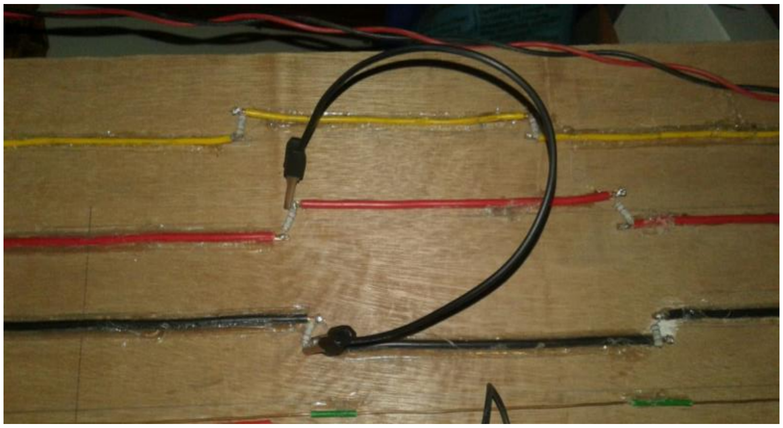

Fig 5.2 Red and Black Wire Shorted

After shorting the cable, system process data for calculation and tell user to wait.

Fig 5.3 System Wait for the Measurement of RB Short Location

The system has detected that Red and Black wire has shorted and fault location is 5.64 Kilometer as shown in **Fig 5.4**.

Fig 5.4 RB Short Fault Distance in Kilometer

Now, we have shorted Yellow and Black wire using crocodile clip as in **Fig 5.5**.

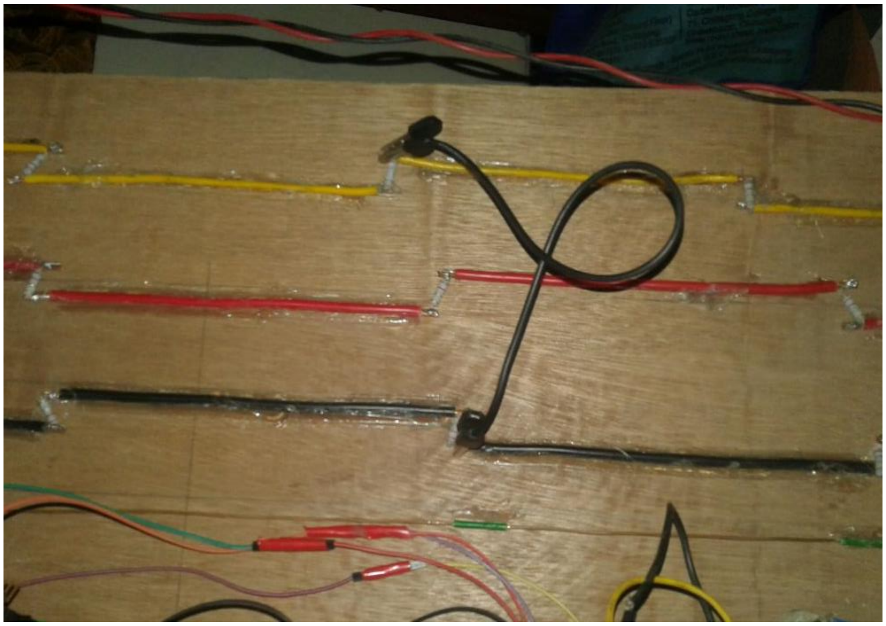

Fig 5.5 Yellow and Black Wire Shorted

After shorting the cable, system process data for calculation and tell user to wait.

Fig 5.6 System Wait for the Measurement of YB Short Location

The system has detected that Yellow and Black wire has shorted and fault location is 5.48 Kilometer as shown in **Fig 5.7**.

Fig 5.7 YB Short Fault Distance in Kilometer

Now, we have shorted Yellow and Red wire using crocodile clip as in **Fig 5.8**.

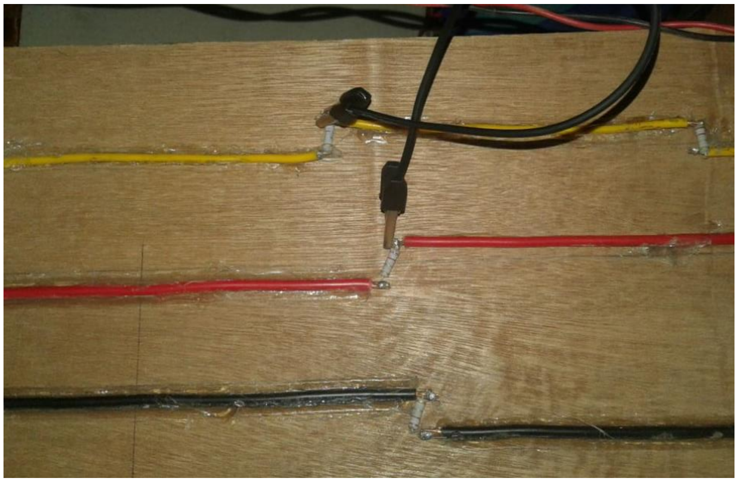

Fig 5.8 Yellow and Red Wire Shorted

After shorting the cable, system process data for calculation and tell user to wait.

Fig 5.9 System Wait for the Measurement of YR Short Location

The system has detected that Yellow and Red wire has shorted and fault location is 5.60 Kilometer as shown in **Fig 5.10**.

Fig 5.10 YR Short Fault Distance in Kilometer

5.3.2 Earth Fault Result

To detect earth fault, we have shorted Black and Earth wire using crocodile clip as in **Fig 5.11**.

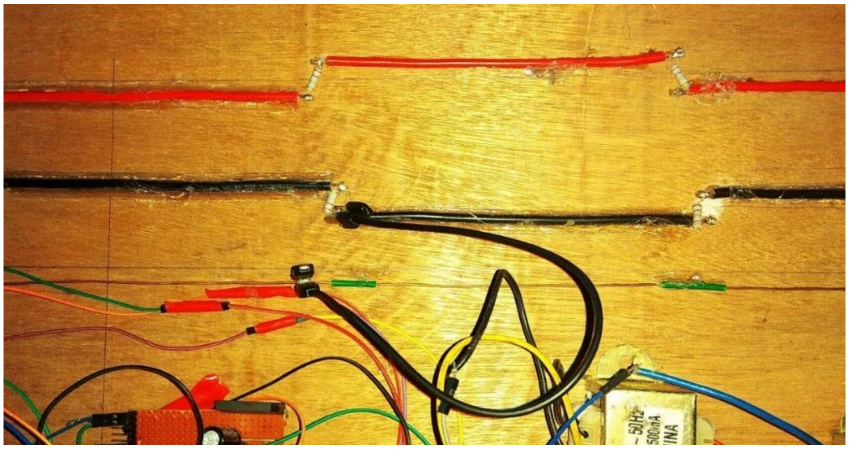

Fig 5.11 Black and Earth Wire Shorted

After shorting the cable, system process data for calculation and tell user to wait.

Fig 5.12 System Wait for the Measurement of BN Short Location

The system has detected that Black and Neutral wire has shorted and fault location is 6.05 Kilometer as shown in **Fig 5.13**.

Fig 5.13 BN Earth Fault Distance in Kilometer

Then we have shorted Yellow and Neutral wire using crocodile clip as in **Fig 5.14**.

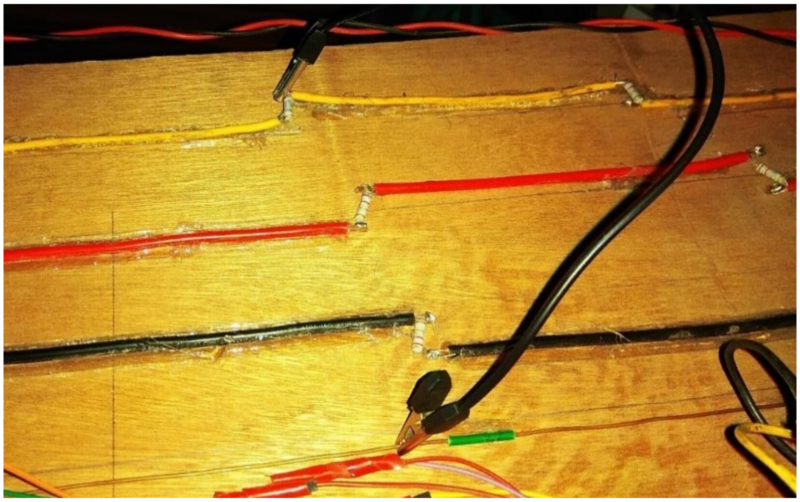

Fig 5.14 Yellow and Neutral Wire Shorted

After shorting the cable, system process data for calculation and tell user to wait.

Fig 5.15 System Wait for the Measurement of YN Short Location

The system has detected that Yellow and Neutral wire has shorted and fault location is 5.85 Kilometer as shown in **Fig 5.16**.

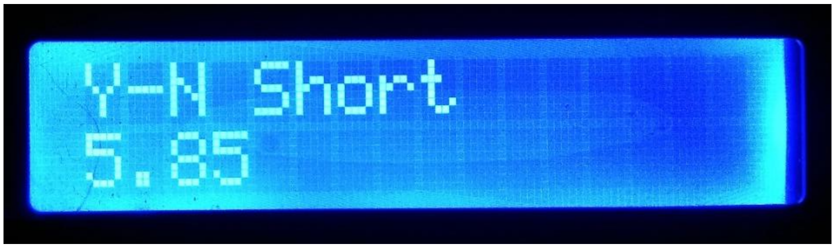

Fig 5.16 YN Earth Fault Distance in Kilometer

Then we have shorted Red and Neutral wire using crocodile clip as in **Fig 5.17**.

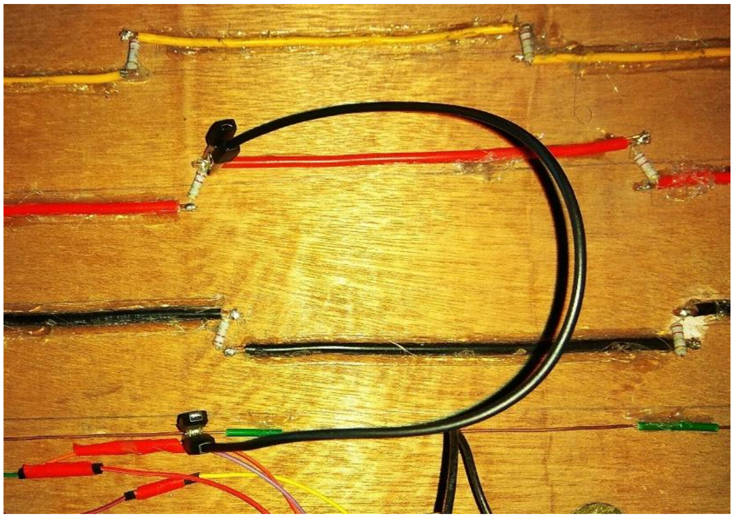

Fig 5.17 Red and Earth Wire Shorted

After shorting the cable, system process data for calculation and tell user to wait.

Fig 5.18 System Wait for the Measurement of RN Short Location

The system has detected that Red and Neutral wire has shorted and fault location is 5.85 Kilometer as shown in **Fig 5.19**.

Fig 5.19 RN Earth Fault Distance in Kilometer

When all fault has resolved, in LCD screen the system will show that, No More Fault.

Fig 5.20 LCD Output after Resolving Earth Fault

CHAPTER 6

CONCLUSION

6.1 Conclusion

The main purpose of building underground cable fault detection is to provide an affordable solution for finding cable fault that occurs in underground cable. However, underground cable system is not still as much as popular as western countries, but still in some areas of Bangladesh, the system is stared to captivate. The development of this system will help in implementing a fault detection device that is easy to use, accurate and can be implanted at an affordable price.

6.2 Limitation of Our Project

The limitation of this project has discussed below.

- In our project, due to lack of space, we have used short amount of wire. We have added resistance manually to simulate line fault and earth fault.
- As we have used resistance and short amount of wire, the value of fault is not fully accurate due to the temperature variance.
- The offset value of current sensor need to calibrate manually and the value varies sometimes due to change of main AC voltage.

6.3 Future Improvement

Some future work can be implemented later by further research has proposed below.

- This project will be able to show distance accurately for the faulty cables in case of line fault and earth fault.
- The complexity of the program can be reduced. Hence, the detection of fault will be instantaneous and much accurate.

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APPENDIX A

SOURCE CODE

```
#include < Wire.h >

#include < LiquidCrystal_I2C.h >

LiquidCrystal_I2C lcd(0x27, 20, 4);

#define yRelay 7

#define rRelay 6

#define bRelay 5

#define nRelay 4

#define cSensor A0

float appliedV = 12;

void setup() {

Serial.begin(9600);

pinMode(2, INPUT_PULLUP);

pinMode(3, INPUT_PULLUP);

pinMode(4, OUTPUT);

pinMode(5, OUTPUT);

pinMode(6, OUTPUT);

pinMode(7, OUTPUT);

allRelayOff();

lcd.init();

lcd.backlight();

lcd.print("CableFaultDetection");

lcd.setCursor(0, 1);

lcd.print("Select To Start");

delay(5000);
```

```
  lcd.clear();
  lcd.print("Select To Start");
  lcd.setCursor(0, 1);
  lcd.print("B.Ln/Ph Y.Earth");
  delay(5000);
  lcd.clear();
  lcd.print("B.Ln/Ph Y.Earth");
  lcd.setCursor(0, 1);
  lcd.print("CS Raw:         ");
  delay(5000);
}
void loop() {
  // put your main code here, to run repeatedly:
  Serial.println("Select Mode");
  int buttonstate = digitalRead(2);
  if (buttonstate == 0) {
    modeOne();
  }
  int Buttonstate = digitalRead(3);
  if (Buttonstate == 0) {
    modeTwo();
  }
  float sensorReading = ctReading();
  Serial.println(sensorReading);
  lcd.setCursor(8, 1);
  lcd.print(sensorReading);
  delay(100);
}
```

```
void modeOne() {
  //yr yb rb
  float sensorReading = 0;
  float resistance = 0;
  float distance = 0;
  lcd.clear();
  lcd.print("LL/LP ShortTest");
  lcd.setCursor(0, 1);
  lcd.print("Please Wait...");

  //YR
  digitalWrite(yRelay, LOW);
  digitalWrite(rRelay, HIGH);
  delay(1000);
  sensorReading = ctReading();
  Serial.println(sensorReading);
  if (sensorReading > 0.20) {
    lcd.clear();
    lcd.print("Y-R Short");
    allRelayOff();
    resistance = (appliedV / sensorReading);
    distance = ((resistance / 2) / 2);
    lcd.setCursor(0, 1);
    lcd.print(distance);
    delay(5000);
    sensorReading = 0;
  }
```

```
allRelayOff();
delay(500);

//YB
digitalWrite(yRelay, LOW);
digitalWrite(bRelay, HIGH);
delay(1000);
sensorReading = ctReading();
Serial.println(sensorReading);
if (sensorReading > 0.20) {
  lcd.clear();
  lcd.print("Y-B Short");
  allRelayOff();
  resistance = (appliedV / sensorReading);
  distance = ((resistance / 2) / 2);
  lcd.setCursor(0, 1);
  lcd.print(distance);
  delay(5000);
  sensorReading = 0;
}
allRelayOff();
delay(500);

//RB
digitalWrite(rRelay, HIGH);
digitalWrite(bRelay, LOW);
delay(1000);
sensorReading = ctReading();
```

```
  Serial.println(sensorReading);
  if (sensorReading > 0.20) {
    lcd.clear();
    lcd.print("R-B Short");
    allRelayOff();
    resistance = (appliedV / sensorReading);
    distance = ((resistance / 2) / 2);
    lcd.setCursor(0, 1);
    lcd.print(distance);
    delay(5000);
    sensorReading = 0;
  }
  allRelayOff();
  delay(500);

  if (sensorReading <= 0.19) {
    lcd.clear();
    lcd.print("LL/LP ShortTest");
    lcd.setCursor(0, 1);
    lcd.print("No LL/PP Fault");
    allRelayOff();
  }
  delay(3000);
  lcd.clear();
  lcd.print("B.Ln/Ph Y.Earth");
  lcd.setCursor(0, 1);
  lcd.print("CS Raw:           ");
}
```

```
void modeTwo() {
  float sensorReading = 0;
  float resistance = 0;
  float distance = 0;
  lcd.clear();
  lcd.print("EarthFault Test");
  lcd.setCursor(0, 1);
  lcd.print("Please Wait...");

  //YN
  digitalWrite(nRelay, HIGH);
  digitalWrite(yRelay, LOW);
  delay(1000);
  sensorReading = ctReading();
  Serial.println(sensorReading);
  if (sensorReading > 0.20) {
    lcd.clear();
    lcd.print("Y-N Short");
    allRelayOff();
    resistance = (appliedV / sensorReading);
    distance = (resistance / 2);
    lcd.setCursor(0, 1);
    lcd.print(distance);
    delay(5000);
    sensorReading = 0;
  }
  allRelayOff();
```

```
delay(500);
//RN
digitalWrite(nRelay, HIGH);
digitalWrite(rRelay, LOW);
delay(1000);
sensorReading = ctReading();
Serial.println(sensorReading);
if (sensorReading > 0.20) {
  lcd.clear();
  lcd.print("R-N Short");
  allRelayOff();
  resistance = (appliedV / sensorReading);
  distance = (resistance / 2);
  lcd.setCursor(0, 1);
  lcd.print(distance);
  delay(5000);
  sensorReading = 0;
}
allRelayOff();
delay(500);

//BN
digitalWrite(nRelay, HIGH);
digitalWrite(bRelay, LOW);
delay(1000);
sensorReading = ctReading();
Serial.println(sensorReading);
if (sensorReading > 0.20) {
```

```
    lcd.clear();
    lcd.print("B-N Short");
    allRelayOff();
    resistance = (appliedV / sensorReading);
    distance = (resistance / 2);
    lcd.setCursor(0, 1);
    lcd.print(distance);
    delay(5000);
    sensorReading = 0;
  }
  allRelayOff();
  delay(500);

  if (sensorReading <= 0.19) {
    lcd.clear();
    lcd.print("EarthFault Test");
    lcd.setCursor(0, 1);
    lcd.print("No More Fault");
    allRelayOff();
  }
  delay(3000);
  lcd.clear();
  lcd.print("B.Ln/Ph Y.Earth");
  lcd.setCursor(0, 1);
  lcd.print("CS Raw:             ");
}
float ctReading() {
  unsigned int x = 0;
```

```
  float AcsValue = 0.0, Samples = 0.0, AvgAcs = 0.0, AcsValueF = 0.0;
  for (int x = 0; x < 150; x++) { //Get 150 samples
    AcsValue = analogRead(A0); //Read current sensor values
    Samples = Samples + AcsValue; //Add samples together
    delay(3); // let ADC settle before next sample 3ms
  }
  AvgAcs = Samples / 150.0; //Taking Average of Samples
  //((AvgAcs * (5.0 / 1024.0)) is converitng the read voltage in 0-5 volts
  //2.5 is offset(I assumed that arduino is working on 5v so the viout at no current comes
  //out to be 2.5 which is out offset. If your arduino is working on different voltage than
  //you must change the offset according to the input voltage)
  //0.066v(66mV) is rise in output voltage when 1A current flows at input
  AcsValueF = (2.5 - (AvgAcs * (5.0 / 1024.0))) / 0.066;
  Serial.println(AcsValueF); //Print the read current on Serial monitor
  return AcsValueF;
}
void allRelayOff() {
  digitalWrite(yRelay, HIGH);
  digitalWrite(rRelay, HIGH);
  digitalWrite(bRelay, HIGH);
  digitalWrite(nRelay, HIGH);
}
```