PROJECT REPORT ON

AUTOMATIC FAULT DETECTION IN DISTRIBUTION LINES USING ARDUINO MICROCONTROLLER

Project report submitted in partial fulfillment of requirements for the degree of "Bachelor of Technology in Electrical Engineering" of Assam Science and Technology University, Guwahati

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Acknowledgment

We would like to extend our gratitude to our respected and esteemed guide, Dr. Barnali Goswami Ma'am, for her invaluable guidance and steadfast support throughout our project. Her expertise, understanding, and insightful suggestions were instrumental in helping us to fully grasp and develop the subject matter at hand.

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Declaration By the Candidates

We hereby declare that the project work with the title "AUTOMATIC FAULT DETECTION IN DISTRIBUTION LINES USING ARDUINO MICROCONTROLLER" is an authentic record of our work submitted in partial fulfillment of requirements for the award of the degree of "Bachelor of Technology in Electrical Engineering", carried out during the academic even semester from January to June of the session 2023-2024, under the supervision of Dr. Barnali Goswami Ma'am, Professor, Department of Electrical Engineering, Assam Engineering College, Jalukbari-781013, Assam. This project work has not been submitted to any other institute for the award of any degree or diploma. We have followed the guidelines provided by the Department of Electrical Engineering, Assam Engineering College, Jalukbari-781013, Assam, as per Assam Science and Technology University regulation, in preparing the project report. We have also conformed to the norms and guidelines given in the ethical code of conduct of Assam Engineering College. Whenever we have used materials (e.g. data, theoretical analysis, figures, tables, and text) from other sources, we have given due acknowledgment to them by citing them in the text of this project report and giving their details in the bibliography.

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Abstract

This project describes a method for fault detection in distribution lines using an Arduino microcontroller. The method involves connecting current sensors to the Arduino, which then analyses the data to detect anomalies that may indicate a fault. The advantages of using this method include its low cost, flexibility, and ease of use. The open-source nature of the Arduino platform allows for customization and modification of the code to suit specific needs. This approach can be an effective solution for small-scale systems and can be used as a cost-effective alternative to more complex fault detection systems. The goal of an Arduino challenge is to solve a specific problem or create a unique project using Arduino boards and components. However, challenges such as the limited processing power of the Arduino, potential issues with sensor calibration, and susceptibility to environmental noise need to be addressed to ensure reliable operation. Despite these challenges, the proposed system is highly effective in detecting faults, with improved accuracy and efficiency compared to traditional methods. Therefore, it could be a promising solution for fault detection.

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Chapter 1

Introduction

Fault detection in distribution lines is a crucial task for ensuring the stability and reliability of the electrical power system. The aim is to detect faults such as short circuits, open circuits, and ground faults as soon as possible to prevent damage to equipment and avoid power outages.

The transmission network is a crucial component of the power system, with a high level of energy loss during transmission and distribution. Power transmission companies typically rely on circuit indicators to detect faults in their transmission lines. However, this approach is limited in its accuracy and response time. To address these challenges, wireless sensor-based monitoring of transmission lines offers several benefits such as real-time structural awareness, quicker fault localization, accurate fault diagnosis, cost-effectiveness through condition-based maintenance, and more.

One common method for fault detection in distributed generation systems is the use of protective relays. These devices are connected to the distribution network and monitor the voltage and current levels. When a fault is detected, the protective relay sends a signal to trip a circuit breaker, which isolates the faulted section of the network. This helps to prevent damage to equipment and minimize the impact of power outages.

Another important aspect of fault detection in distributed generation systems is the ability to quickly and accurately locate the source of the fault. This is important for minimizing the time and cost associated with repairing the fault. Various techniques such as Distance protection, Impedance protection, Current Differential protection, and Distance protection using advanced communications can be used to locate faults in the distribution network.

The primary function of a protection system in power systems is to quickly identify and isolate faults to ensure safety, reduce equipment damage, and maintain stability. Understanding system faults, their detection, and the safe isolation of the faulty device is crucial for power system protection. By conducting an evaluation of essential electrical loads and evaluating the power required for the system, a clear understanding of the necessary power production is obtained. Additionally, monitoring power fluctuations, such as minimum and maximum voltage from the

AC supply mains, helps in ensuring consistent power quality. This project utilizes the concepts of microcontrollers and current sensors to achieve this.

This is a cost-optimized solution for real-time monitoring of the power system through the use of sensors placed in various components of the power network. The success of this approach depends on the design of a cost-effective and reliable network architecture that can deliver a large amount of highly reliable data in real-time. This network must also be able to transport sensitive data, such as the current state of the transmission line and control information, to and from the transmission grid. The proposed framework offers a solution for the design of a real-time data transmission network that meets the stringent requirements of these applications. In conclusion, fault detection is an essential aspect of the operation. It is necessary to ensure the safe and reliable operation of these systems, minimize the impact of power outages, and maintain the stability of the overall power system.

Arduino boards offer several advantages, including low cost, flexibility, and ease of use. Their affordability makes them accessible for various applications, while their open-source nature allows for extensive customization to meet specific needs. The user-friendly Arduino programming environment is accessible even to those without an electrical engineering background. However, Arduino boards have notable disadvantages. They possess limited processing power and memory, making it challenging to handle large amounts of data or perform complex calculations in real time. Additionally, their compatibility is restricted to a specific set of components and sensors, complicating the integration of new or different parts. Despite these limitations, Arduino boards remain a popular choice for many due to their cost-effectiveness and adaptability.

Chapter 2

Theoretical Background

Power systems are vulnerable to faults caused by factors like natural events, equipment failure, or human error. Faults disrupt normal operations, altering characteristic values such as impedance. These issues include short circuits and open circuits, leading to over current, under voltage, unbalanced phases, reversed power, and high voltage surges. Consequently, faults can cause equipment failures, electrical fires, and network interruptions.

2.1 Types of Faults

Faults in a three-phase power system are mainly categorized into two types: open circuit faults and short circuit faults. Additionally, these faults can be classified as symmetrical or unsymmetrical. These different types of faults will be discussed in more detail.

2.1.1 Open Circuit Fault

An open circuit fault typically results from the failure of one or two conductors in the power system. This type of fault occurs in series with the line and is also known as a series fault. This type of fault can have a significant impact on the reliability of the power system, by reducing the voltage level in the affected phase or phases, tripping protection devices, and causing damage to equipment and power outages if not cleared quickly. The figure below illustrates the open circuit faults for single--, two, and three-phase (or conductors) open conditions.

The most common causes of these faults include joint failures of cables and overhead lines, failure of one or more phases of circuit breaker, and to melting of a fuse or conductor in one or more phases.

Open circuit faults are also called series faults. Open circuit faults can further be categorized as:

- Single-Phase Open Circuit Fault,
- Two-Phase Open Circuit Fault
- Three-Phase Open Circuit Fault.

These are unsymmetrical or unbalanced types of faults except for the three-phase open fault.

Consider that a transmission line is working with a balanced load before the occurrence of an open circuit fault. If one of the phases gets melted, the actual loading of the alternator is reduced and this causes the acceleration of the alternator to rise, thereby it runs at a speed slightly greater than synchronous speed. This overspeed causes overvoltage in other transmission lines.

Thus, single- and two-phase open conditions can produce an unbalance of the power system voltages and currents that cause great damage to the equipment.

Causes of Open Circuit Fault

- Broken wire
- Loose connection
- Faulty components such as switch or relay
- Corrosion
- Damage to the electrical insulation

Effects of Open Circuit Fault

- Abnormal operation of the system
- Danger to the personnel as well as animals
- Exceeding the voltages beyond normal values in certain parts of the network, which further leads to insulation failures and the development of short circuit faults.

Removing open circuit faults as soon as possible is important to minimize damage, even though they may be able to be tolerated for longer periods than short circuit faults.

2.1.2 Short Circuit Fault

A short circuit is a low-impedance connection between two points of different potential that can be created intentionally or unintentionally. It results in high abnormal currents flowing through equipment or transmission lines which can cause extensive damage if left unresolved. These faults are commonly referred to as shunt faults and are caused by insulation failure between phase conductors between earth and phase conductors, or both. In this type of fault, the conductors of the different phases come into contact with each other with a power line, power transformer, or any other circuit element due to which the large current flows in one or two phases of the system. Short circuit faults can further be categorized as:

- Symmetrical Fault
- Unsymmetrical Fault

Symmetrical Fault:

A Symmetrical fault is a type of short circuit fault that affects all three phases of a system. This type of fault maintains balance in the system, even after the fault has occurred. Symmetrical faults are typically found at the terminals of generators and can be caused by a variety of factors such as resistance in the arc between conductors or a low-resistance connection to the ground. These types of faults are often cleared quickly and efficiently by protective devices such as circuit breakers. The symmetrical fault is sub-categorized into:

- Line-to-Line-to-Line Fault (LLL Fault).
- Three-phase Line-to-Ground-Fault (LLLG Fault).

Such types of faults are balanced, i.e., the system remains symmetrical even after the fault. The L – L – L fault occurs rarely, but it is the most severe type of fault which involves the largest current. This large current is used for determining the rating of the circuit breaker.

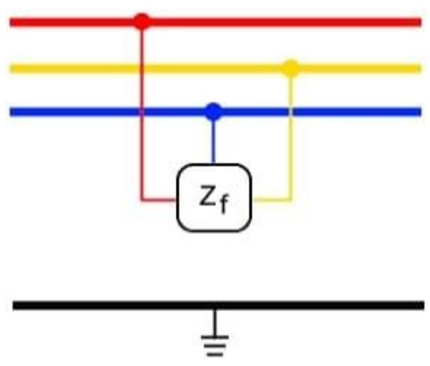

Fig 2.1: L-L-L fault

Three-phase line to the Ground Fault

The three-phase line to ground fault includes all three phases of the system as shown in figure 2.2. The L-L-L-G fault occurs between the three phases and the ground of the system. The probability of occurrence of such type of fault is nearly 2 to 3 percent.

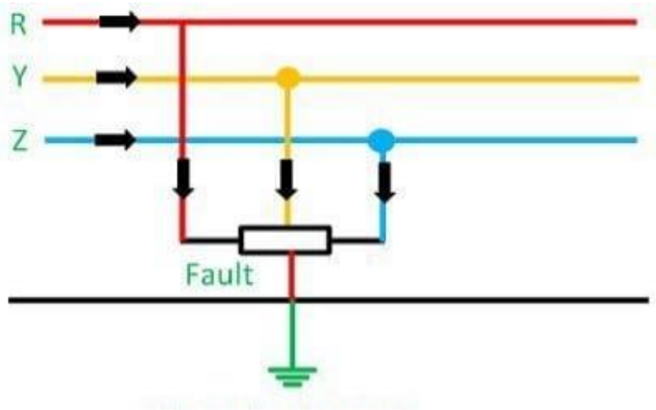

Fig 2.2: L-L-L-G fault

Unsymmetrical Fault

Unsymmetrical faults, also known as unbalanced faults, occur when there is a difference in magnitude and phase between the three phases of a power system. These types of faults involve one or two phases, such as L-G, L-L, or L-L-G faults, and they cause the system to become unbalanced. Unsymmetrical faults can be caused by a variety of factors, such as equipment failure or human error, and they can have a significant impact on the stability and reliability of the power system. It is often more difficult to diagnose and repair than balanced faults, and they may require specialized equipment or techniques to resolve. The unsymmetrical fault is sub-categorized into:

- Single Line-to-ground (L – G) Fault
- Line-to-Line Fault (L – L)
- Double Line-to-ground (L – L – G) Fault

Unsymmetrical faults are the most common types of faults that occur in the power system.

Single-Line-to-Ground Fault

A single line-to-ground fault is a type of electrical fault in a power system where one phase of the power system is connected to the ground through a fault system as shown in figure 2.3. This can occur due to various reasons such as insulation failure, equipment failure, or damage to power lines. The fault creates a low impedance path to the ground, which can cause large current flows and potentially damage equipment. In a power system, protection devices such as circuit breakers are used to detect and isolate faults to prevent damage and ensure the stability of the system.

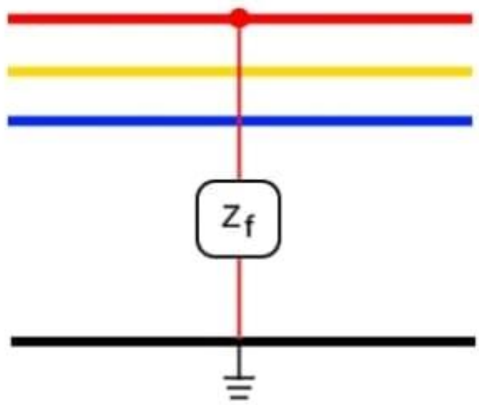

Fig 2.3 L-G fault

Line-to-Line Fault

A line-to-line fault is a type of electrical fault in a power system where two phases of the power system are directly connected, bypassing the intended insulation system as shown in figure 2.4. This can occur due to various reasons such as insulation failure, equipment failure, or damage to power lines. The fault creates a direct path for current flow between the two phases, which can cause large current flows and potentially damage equipment. In a power system, protection devices such as circuit breakers are used to detect and isolate faults to prevent damage and ensure the stability of the system

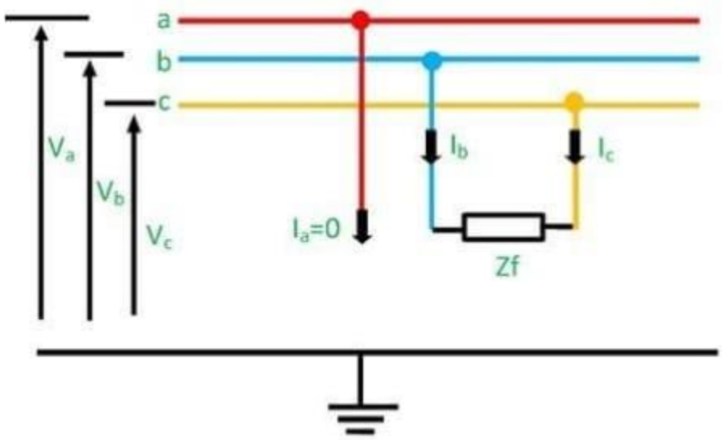

Fig 2.4: L-L fault

Double-Line -to Ground Fault

A double line-to-ground fault is a type of electrical fault in a power system where two phases of the power system are connected to the ground through a fault system as shown in figure 2.5. This can occur due to various reasons such as insulation failure, equipment failure, or damage to power lines. The fault creates two low impedance paths to the ground, which can cause large current flows and potentially damage equipment. In a power system, protection devices such as circuit breakers are used to detect and isolate faults to prevent damage and ensure the stability of the system.

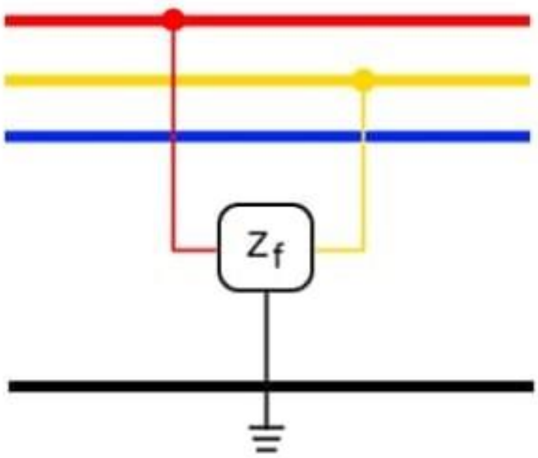

Fig 2.5: L-L-G fault

Causes of Short Circuit Faults

Short circuit faults are caused by a low resistance connection between two points in an electrical circuit where there should be a high resistance. The most common causes of short circuit faults include:

• Insulation failure: Insulation around wires and equipment can degrade over time, leading to a short circuit when the bare wire comes into contact with other parts of the circuit.

• Overheating: Overheating of equipment or wiring can cause a short circuit as the insulation melts or burns away.

• Human error: short circuits can be caused by human error, such as improper wiring or installation, or by accidental damage to equipment or wiring.

• Lightning strikes: A lightning strike can cause a short circuit in power lines and equipment.

• Equipment failure: short circuits can also be caused by a failure of equipment, such as a switch or circuit breaker.

• Moisture: A short circuit can occur when moisture gets into electrical equipment, causing a conductive path between two points in the circuit.

Short circuit faults are dangerous, as they can generate large currents that can cause damage to equipment and be a potential safety hazard.

Effects of Short Circuit Faults

• Arcing faults can lead to fire and explosion in equipment such as transformers and circuit breakers.

• Abnormal currents cause the equipment to get overheated, which further leads to a reduction of the life span of their insulation.

• The operating voltages of the system can go below or above their acceptance values which creates a harmful effect on the service rendered by the power system.

• The power flow is severely restricted or even completely blocked as long as the short circuit fault persists.

2.2 Lower Voltage

Low voltage is a relative term, the definition varying by context. Different definitions are used in transmission and distribution lines, and the electronics industry. Electrical safety codes define "low voltage" circuits that are exempt from the protection required at higher voltages. These definitions vary by country and specific code. Lower voltage is defined as incoming line voltage at the point of use which is smaller than the Public Service Commission’s mandated legal limits; and/or smaller than the voltage ratings of the connected equipment. The lower voltage is considered a safety hazard by all industry standards and can cause premature failure of connected equipment. Devices could be damaged by lower line voltage.

2.3 Over Voltage

Over voltage is defined as incoming line voltage at the point of use which is greater than the Public Service Commission’s mandated legal limits; and/or greater than the voltage ratings of the connected equipment. Overvoltage is considered a safety hazard by all industry standards and can cause premature failure of connected equipment. Overvoltage has been a widely known industry problem for many years, but it is not generally understood by many who have to deal with it. Power companies have been unable to control it adequately. Overvoltage occurs most often during severe cold winter weather for the following reasons:

- Inadequate size of power distribution systems;
- Slow reaction time for power company’s distribution systems to regulate voltage during extreme load variations; and
- Abrupt reductions of loads.

Chapter 3

Methodology

The approach to detect faults in transmission lines involves using an Arduino microcontroller, starting with a detailed simulation phase using Proteus software. Current and voltage sensors are strategically placed along the transmission line and are operated using relays. In the simulation phase, the system's functionality is thoroughly tested and verified. These sensors measure the current and voltage levels and send the data to the Arduino. The Arduino analyzes this data and detects any abnormalities that may indicate a fault. By first simulating the entire setup in Proteus, potential issues can be identified and resolved, ensuring a smooth transition to the hardware phase where the actual sensors and Arduino are deployed to monitor the transmission lines in real time. This comprehensive approach ensures reliable fault detection and system integrity.

3.1 Components used

1. Arduino Uno Microcontroller.
2. ACS712 current sensor.
3. 16x2 LCD.
4. Relay.
5. Transformer.
6. LED
7. Buzzer
8. Resistor

3.1.1 Arduino Micro-controller

Arduino Uno is a microcontroller board based on the ATmega328P. It is an open-source electronics platform that allows for easy programming of interactive projects and applications. The Arduino Uno features 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal oscillator, and a USB connection for programming and power. It can be programmed using the Arduino Integrated Development Environment (IDE) using C or C++. The Arduino Uno is widely used in the DIY electronics community and is popular for its simplicity and ease of use.

Fig 3.1.1 Arduino UNO

3.1.2 ACS712 Current Sensor

The ACS712 is a current sensor that measures AC or DC currents. It uses the Hall effect to measure current flowing through a conductor placed in a magnetic field. The sensor outputs an analog voltage proportional to the current flowing through the conductor. The ACS712 has a range of current measurement options, including 5A, 20A, and 30A. It is commonly used in power supplies, battery chargers, and motor control circuits for measuring the current consumption of loads. The ACS712 is a low-cost and compact solution for current sensing and is easily integrated into a microcontroller-based system, such as an Arduino board.

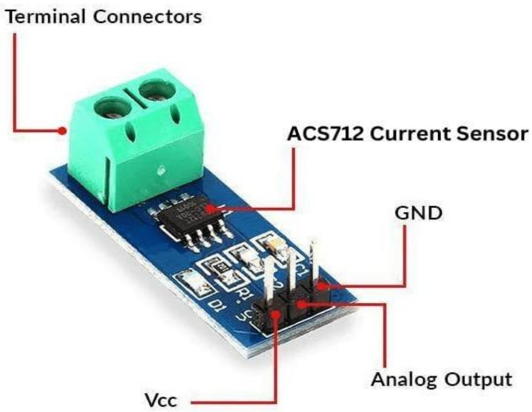

Fig 3.1.2 ACS712 current sensor

3.1.3 16x2 LCD Display

A 16x2 LCD is a liquid crystal display (LCD) that can display two lines of 16 characters each. It is commonly used as an output display in various electronics projects. The display has a built-in controller that manages the display of characters and symbols. It is connected to a microcontroller, such as an Arduino, through a set of data pins and control pins. The 16x2 LCD is an economical and practical solution for displaying information and can be easily programmed to display custom messages and data.

Fig 3.1.3 16x2 LCD Display

3.1.4 Relay

A relay is an electrically operated switch that opens or closes a circuit in response to an electrical signal. It is used to control high-power circuits with a low-power signal and to isolate different circuits to prevent electrical interference. Relays are commonly found in a variety of applications including automotive, industrial control and consumer electronic.

Fig 3.1.4 Relay module

3.1.5 Transformers

A transformer is an electrical device used to step up and down the AC voltages. There are two types of transformers: Step-up and step-down transformers. A step-up transformer increases the magnitude of voltage while step down transformer decreases the magnitude of voltage. Depending on the ratio of the number of turns in the primary & secondary winding a transformer is characterized as step up or step down. For this project purpose, considering 1Φ voltage to be around 220 V, 3 step down power transformer of rating 220/12 has been used to represent a realistic representation of the 3Φ system.

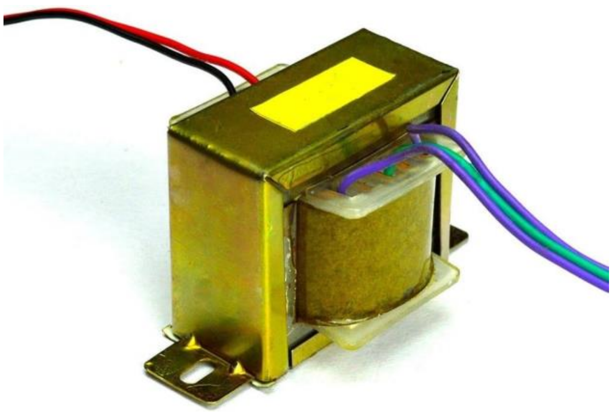

Fig 3.1.5 Transformer

3.1.6 Buzzer

A buzzer is an audio signalling device commonly used in electronics. It typically operates at 5V, emits a continuous or pulsed sound, and has a frequency range of 2kHz to 5kHz. Buzzer specifications may vary, but they usually include voltage rating, sound output level in decibels (dB), and mounting options.

Fig 3.1.6 Buzzer

3.1.7 Resistor

A 10-watt resistor (that is 10WATTIK) is a power resistor designed to handle up to 10 watts of electrical power without overheating. It typically has a resistance value specified in ohms and is built to dissipate the heat generated during operation effectively. These resistors are commonly used in various electronic circuits, including power applications.

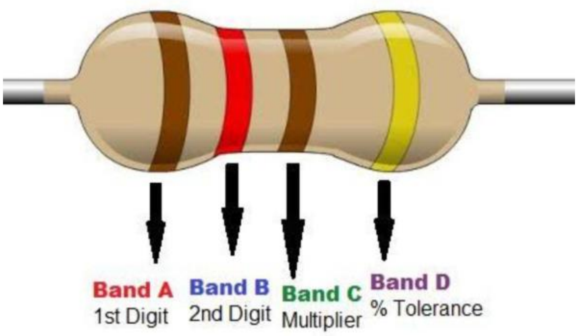

Fig 3.1.7 Resistor

3.1.8 LED

LED lights, or Light light-emitting diodes, have revolutionized the lighting industry. They are energy-efficient, using up to 80% less electricity than traditional incandescent bulbs, making them cost-effective and environmentally friendly. LEDs are long-lasting, with a lifespan of up to 25,000 hours or more, reducing the need for frequent replacements. They emit minimal heat, making them safer and ideal for various applications. LED lights come in various colors and can be dimmed, providing versatility in lighting design. Their rapid on/off capability and durability make them suitable for a wide range of uses, from residential to industrial and commercial settings.

Fig 3.1.8 LED

3.2 Implementation

To implement this method, the following steps should be taken:

1. Connect the current sensors to the Arduino: The sensors are placed at strategic points along the transmission line and are connected to the Arduino.

2. Write code to read the data: The Arduino code should be written to read the data from the sensors and store it in variables.

3. Implement algorithms to compare the current levels: The algorithms compare the current levels with normal operating values and detect any anomalies.

4. Trigger an alarm or send a notification: If a fault is detected, the Arduino can trigger an alarm and trip the circuit.

5. Store the data: The data collected by the sensors should be stored for later analysis and troubleshooting.

3.3 Flowchart

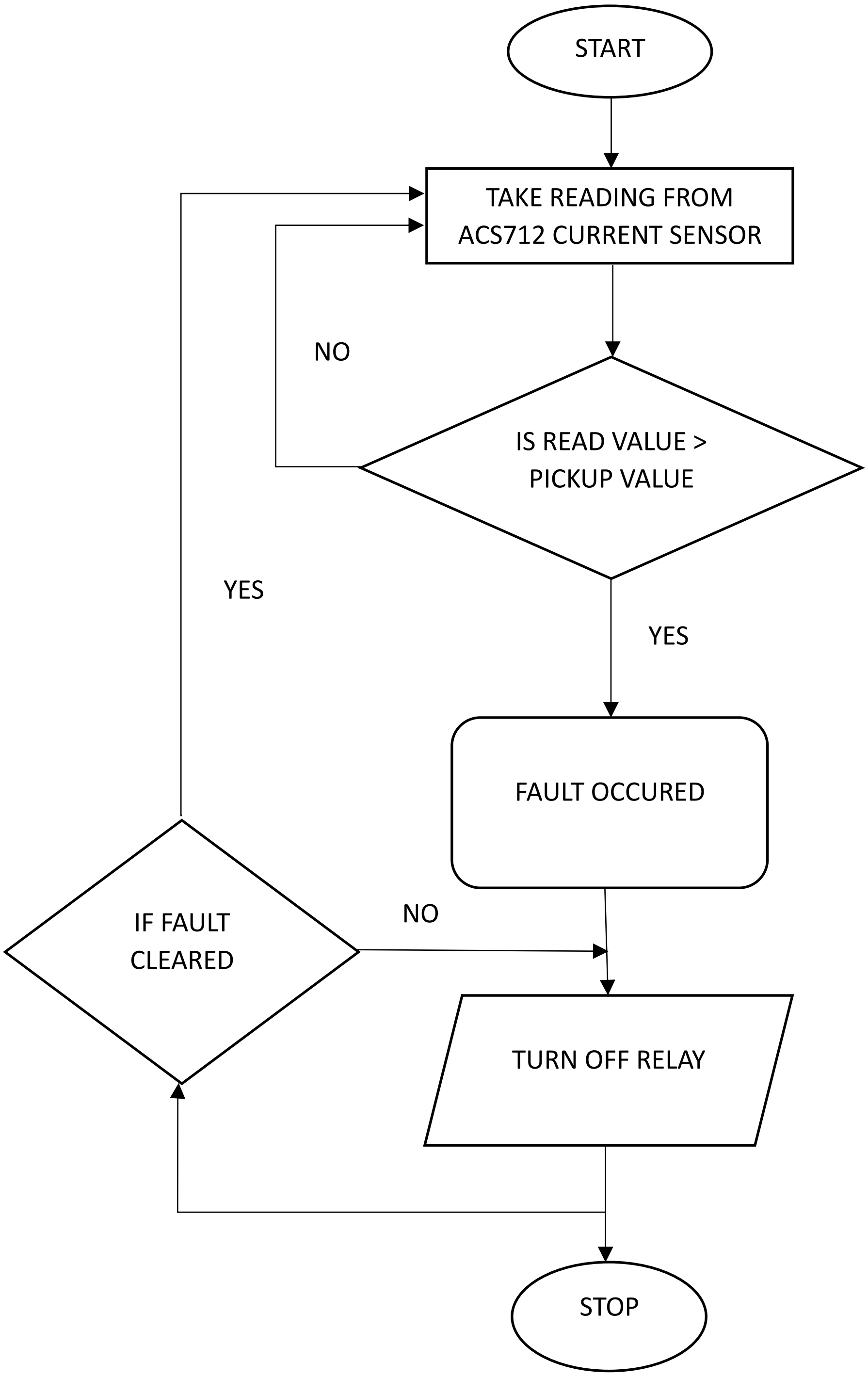

Fig 3.3 Flowchart

3.4 Circuit Diagram

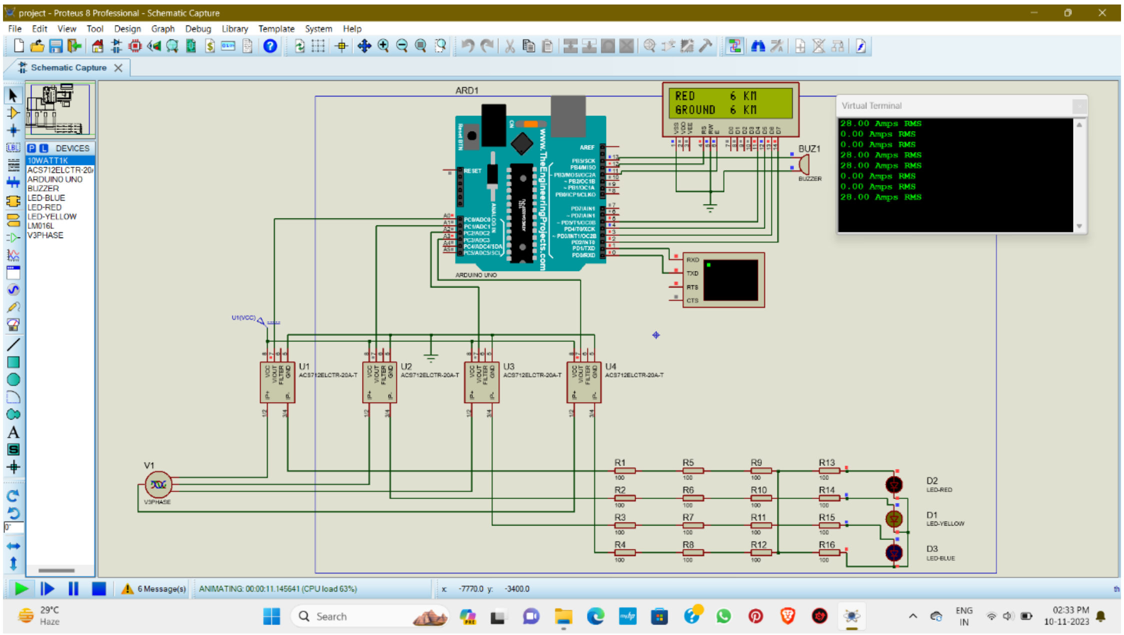

Fig 3.4 Circuit diagram

3.5 Working

The output from the transformers is fed to the ACS712 current sensor. A relay is connected in series with the current sensor and the line through the NO ports of the relay. Arduino is used to control the relays and take readings from the current sensor.

Initially, when the supply is ON, Arduino sends a signal to relays and as a result, NO pins are closed. Current flows to the load from the transformer via the current sensor. Arduino also collects the data from the current sensor.

Under any abnormal condition, Arduino compares the collected current reading from the sensor with a pre-determined value. If the current read from the sensor is greater than the pickup current, the Arduino sends a signal to turn off the relay thus preventing severe damage and ensuring the safety of the equipment.

Chapter 4

Results

We simulated various fault conditions and observed the system's response. For the Line-to-Line (LL) Fault, a short circuit between two lines was created, with sensors detecting deviations and the Arduino displaying the fault condition along with the fault distance as shown in fig 4.2. The Three-Line (LLL) Fault involved shorting all three phases, which the sensors captured and the Arduino displayed accurately as shown in fig 4.3, including the fault distance. For the Three-Line-to-Ground (LLLG) Fault, connecting all three phases to the ground caused extreme changes that were detected and displayed by the Arduino, with the fault distance indicated as shown in fig 4.1. The Line-to-Ground (LG) Fault was simulated by grounding one phase, with the Arduino promptly detecting and displaying the fault along with the distance to the fault. In the hardware tests, the Arduino reliably detected and displayed all fault conditions in real time, including the fault distances. Below are images of the simulation and hardware detection for each fault condition, including the fault distance.

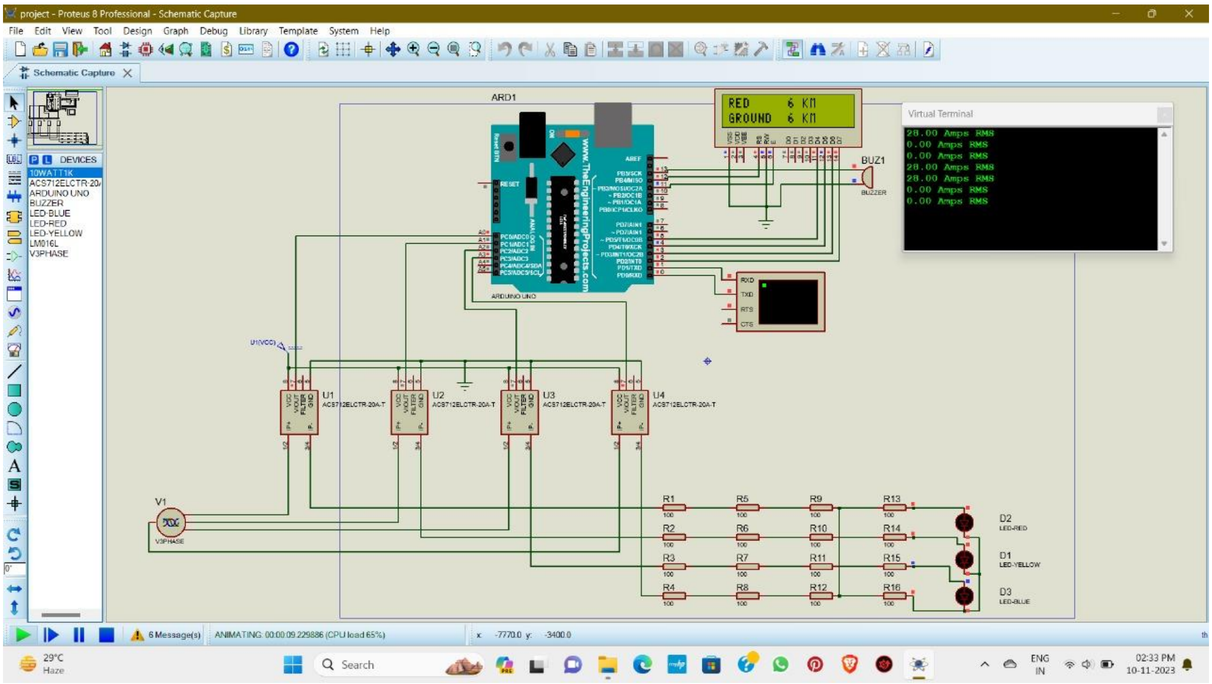

Fig 4.1: LLL-G fault at a distance 6 KM

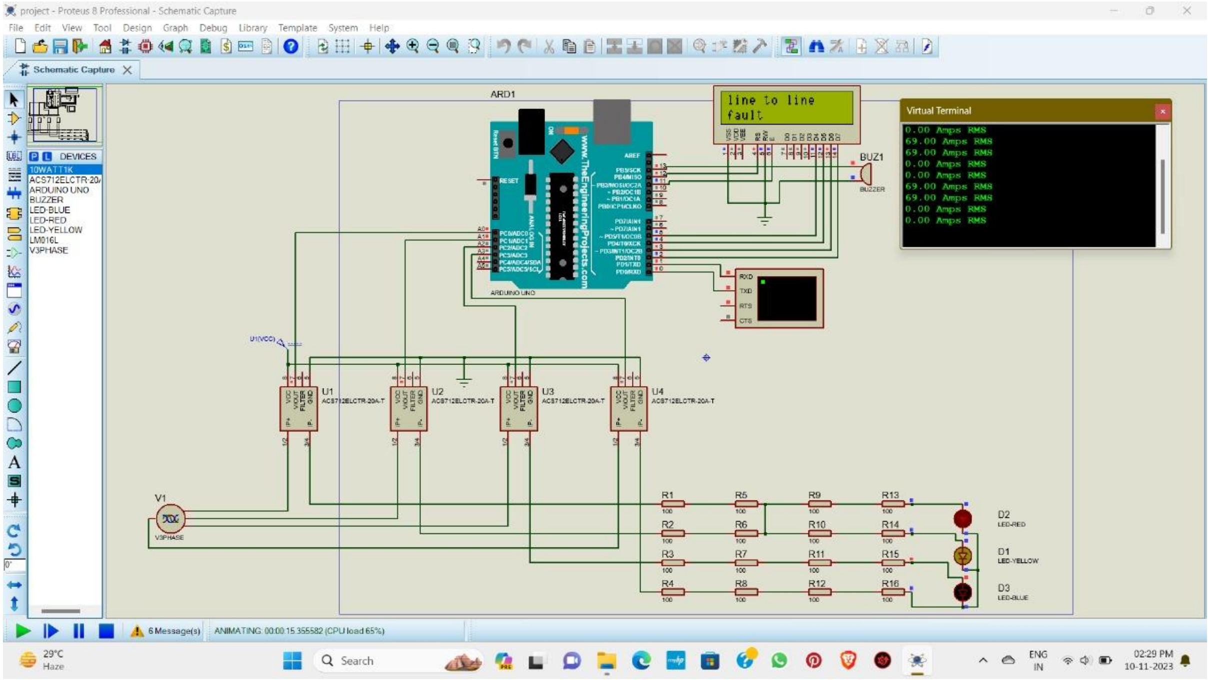

Fig 4.2 Simulation of L-L fault

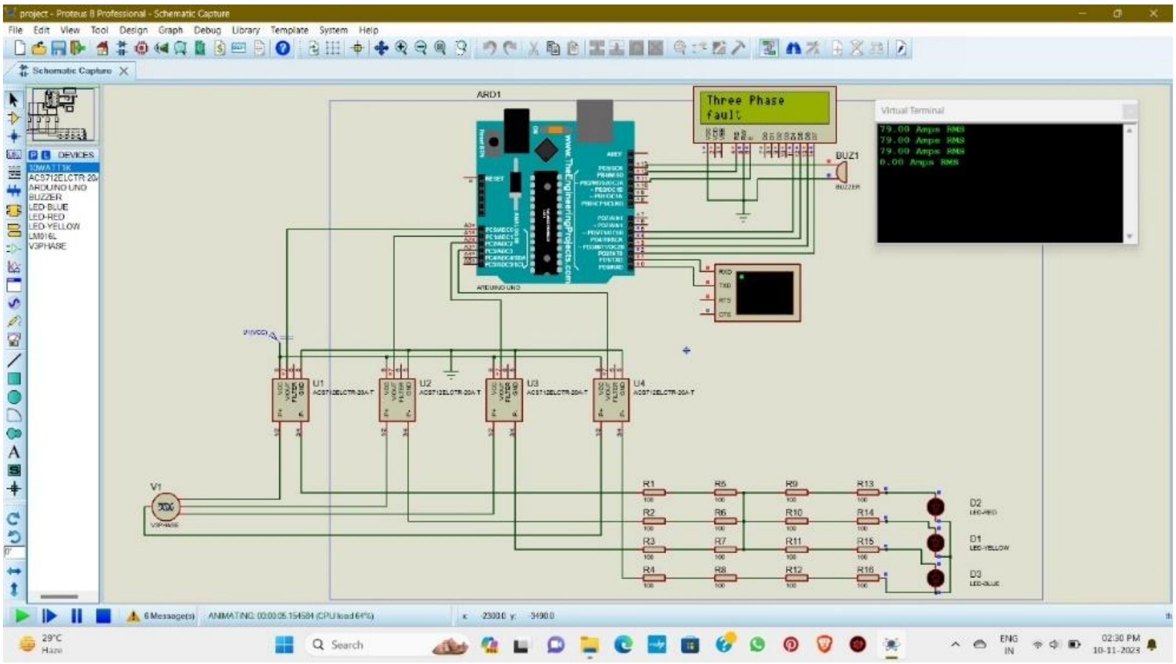

Fig 4.3 Simulation of LLL fault

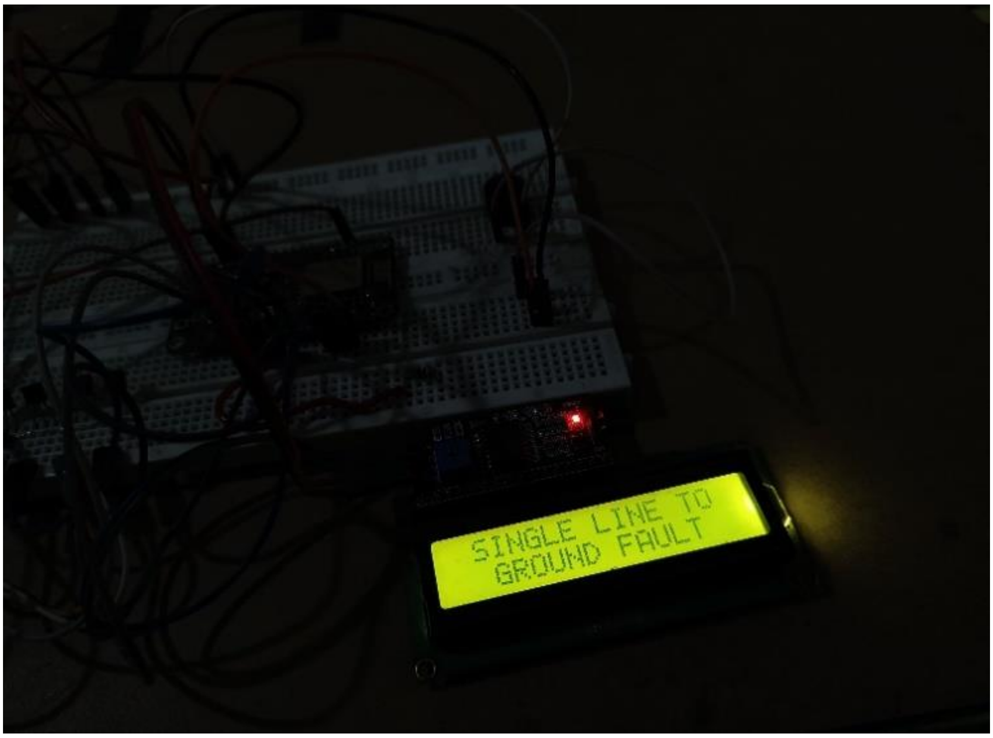

Fig 4.4 Single line to Ground fault detection

Fig 4.5 Three Phase fault

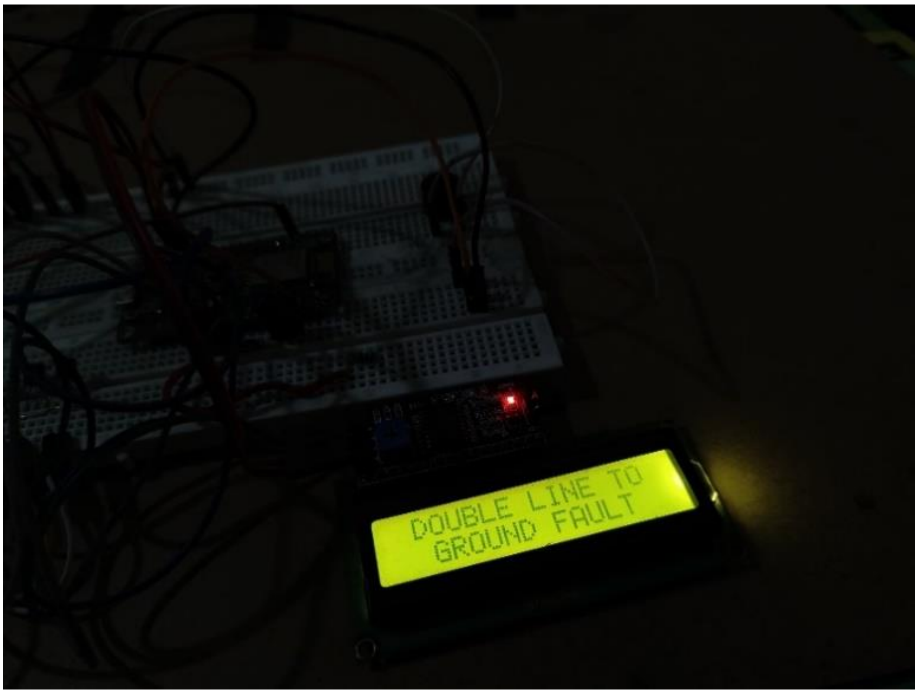

Fig 4.6 Double line to ground fault

Chapter 5

Conclusion and Future Scope

Using Arduino for fault detection in three-phase distribution lines is a powerful and cost-effective solution for detecting and addressing faults in these systems. This project demonstrated the feasibility of using an Arduino board, a transformer, relay modules, current sensors, and a 5V battery supply to build a reliable and accurate fault detection system. The Arduino board processes the data, while the relay modules isolate faults to protect the system from damage. While there are some limitations such as limited processing power and memory, these can be overcome by careful design and component selection.

The future scope of using Arduino for fault detection is very promising. As technology continues to evolve, the capabilities of Arduino-based systems will expand with advancements in micro-controller technology, leading to improved processing power and memory. Enhanced security features will reduce the risk of hacking and other security threats. Increased compatibility with a wider range of components will facilitate the creation of customized fault detection systems. The incorporation of more advanced algorithms will improve data analysis and fault detection accuracy. Integration with artificial intelligence and machine learning will enable the systems to learn and adapt over time, enhancing their effectiveness. Additionally, future Arduino systems are expected to feature more user-friendly interfaces, simplifying setup, configuration, and usage.

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7. Programming and Interfacing with Arduino by Yogesh Misra eBook ISBN9781003201700

8. Building Arduino Projects for the Internet of Things by Adeel Javed

Appendix

```
#include <Arduino.h>
#if defined(ESP32)
#include <WiFi.h>
#elif defined(ESP8266)
#include <ESP8266WiFi.h>
#endif
#include <Firebase_ESP_Client.h>
#include "addons/TokenHelper.h"
#include "addons/RTDBHelper.h"
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <TinyGPS++.h>
#include <SoftwareSerial.h>
#define WIFI_SSID "RCX"
#define WIFI_PASSWORD "rahul1234"
String Secret_Key = "itsproject1";
float Send_Latitude = 26.139757;
float Send_Longitude = 91.665537;
#define API_KEY "AIzaSyCdKk77vnzMQ4L6sf7KNvqCkh_s4-jvFNY"
#define DATABASE_URL "https://fault-detection-ace93-default-rtdb.firebaseio.com/"
FirebaseData fbdo;
FirebaseAuth auth;
FirebaseConfig config;
```

```
String C1, C2, C3, dist, fault, lat, lon;
bool signupOK = false;
LiquidCrystal_I2C lcd(0x27, 16, 2);
double pickup = 500;
const int R_N = D5, R_G = D6, R_B = D7, R_R = D8;
static const int RX = D1, TX = 1;
static const uint32_t GPSBaud = 9600;
TinyGPSPlus gps;
SoftwareSerial ss(RX, TX);
int sensor, curr;
const int curr_pin = A0, Reset = D4, buzzer = D0;
int N_curr, G_curr, B_curr, R_curr;
bool N_Line = false, G_Line = false, B_Line = false, R_Line = false, init = false, trip = false,
print_curr = false;
String distance = " ", fault_type = "nof";
int button_state = 0, fault_curr = 0, send_dist = 0;

void setup() {
Serial.begin(9600);
lcd.begin();
lcd.backlight();
WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
while (WiFi.status() != WL_CONNECTED) { delay(300); }
config.api_key = API_KEY;
config.database_url = DATABASE_URL;
```

```
if (Firebase.signUp(&config, &auth, "", "")) { signupOK = true; }
config.token_status_callback = tokenStatusCallback;
Firebase.begin(&config, &auth);
Firebase.reconnectWiFi(true);
C1 = "fault_data/" + Secret_Key + " current1";
C2 = "fault_data/" + Secret_Key + " current2";
C3 = "fault_data/" + Secret_Key + " current3";
dist = "fault_data/" + Secret_Key + " distance";
fault = "fault_data/" + Secret_Key + " faulttype";
lat = "fault_data/" + Secret_Key + " latitude";
lon = "fault_data/" + Secret_Key + " longitude";
pinMode(Reset, INPUT);
pinMode(R_N, OUTPUT);
pinMode(R_G, OUTPUT);
pinMode(R_B, OUTPUT);
pinMode(R_R, OUTPUT);
digitalWrite(R_R, HIGH);
delay(500);
sensor = analogRead(curr_pin);
pickup = (sensor / 2) + 5;
digitalWrite(R_R, LOW);

void loop() {
gps_location();
```

```
button_state = digitalRead(Reset);
trip = false;
read_curr();
faults();
if (((N_Line) && (G_Line)) || ((N_Line) && (B_Line)) || ((N_Line) && (R_Line)) ||
((G_Line) && (B_Line)) || ((G_Line) && (R_Line)) || ((B_Line) && (R_Line))) {
trip = true;
read_curr();
while (button_state == HIGH) {
if ((R_Line) && (B_Line) && (G_Line)) {
fault_type = "tpf";
curr_print = false;
}
else if (((R_Line) && (B_Line)) || ((B_Line) && (G_Line)) || ((G_Line) && (R_Line)))
{
curr_print = false;
if (N_Line) { fault_type = "dltg"; }
else { fault_type = "ltl"; }
}
else if (((G_Line) && (N_Line)) || ((R_Line) && (N_Line)) || ((B_Line) && (N_Line)))
{
fault_type = "sltg";
curr_print = false;
}
upload_data();
```

```
button_state = digitalRead(Reset);
}
}
else {
if (!print_curr) {
trip = false;
print_loading();
send_dist = 0;
fault_type = "nof";
}
print_curr = true;
print_live_curr();
upload_data();
}
reset_faults();
}
void reset_faults() {
N_Line = false;
G_Line = false;
B_Line = false;
R_Line = false;
init = false;
fault_curr = 0;
}
```

```
void read_curr() {
if (trip) {
digitalWrite(R_N, LOW);
digitalWrite(R_G, LOW);
digitalWrite(R_B, LOW);
digitalWrite(R_R, LOW);
}
else {
digitalWrite(R_N, HIGH);
digitalWrite(R_G, LOW);
digitalWrite(R_B, LOW);
digitalWrite(R_R, LOW);
N_curr = read_sensor();
digitalWrite(R_N, LOW);
digitalWrite(R_G, HIGH);
digitalWrite(R_B, LOW);
digitalWrite(R_R, LOW);
G_curr = read_sensor();
digitalWrite(R_N, LOW);
digitalWrite(R_G, LOW);
digitalWrite(R_B, HIGH);
digitalWrite(R_R, LOW);
B_curr = read_sensor();
digitalWrite(R_N, LOW);
```

```
digitalWrite(R_G, LOW);
digitalWrite(R_B, LOW);
digitalWrite(R_R, HIGH);
R_curr = read_sensor();
}
}
int read_sensor() {
delay(50);
sensor = analogRead(curr_pin);
curr = (sensor / 2);
return curr;
}
void faults() {
if (N_curr > pickup) { N_Line = true; }
if (G_curr > pickup) { G_Line = true; if (!init) { fault_curr = G_curr; init = true; } }
if (B_curr > pickup) { B_Line = true; if (!init) { fault_curr = B_curr; init = true; } }
if (R_curr > pickup) { R_Line = true; if (!init) { fault_curr = R_curr; init = true; } }
}
void upload_data() {
if (Firebase.ready() && signupOK) {
if ((Firebase.RTDB.setInt(&fbdo, C1, abs(R_curr))) && (Firebase.RTDB.setInt(&fbdo,
C2, abs(B_curr))) && (Firebase.RTDB.setInt(&fbdo, C3, abs(G_curr))) &&
(Firebase.RTDB.setInt(&fbdo, dist, send_dist)) &&
```