# Transmission Line Fault Detection




## Sonargaon University

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# DECLARATION

We, the undersigned students of the Department of Electrical and Electronic Engineering, Sonargaon University, hereby declare that the project report entitled **"Transmission Line Fault Detection"** is the outcome of our own work, carried out under the supervision of Jim Mortaej Chowdhury, Lecturer, Department of EEE, Sonargaon University.

We affirm that the work presented in this report is based on our original effort, investigations, and practical implementation. It has not been submitted, either in whole or in part, to any other institution or authority for the award of any academic degree or professional qualification.

Through this project, we aimed to design and develop a reliable, low-cost transmission fault detection, electrical, and software systems. The knowledge, analysis, and results presented here reflect our dedication to applying engineering skills in solving real-world problems.

We take full responsibility for the accuracy and authenticity of the content of this report.

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# CERTIFICATEION

This is to certify that the project report entitled **"Transmission Line Fault Detection"** is a Bonafide record of the work carried out by –

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in partial fulfilment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering (EEE) at Sonargaon University.

The project has been completed under my supervision and guidance, and it is a genuine record of the successful work done by them. I wish the students every success in their future activities.

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# ABSTRACT

At present, transmission line protection is a major concern in power transmission systems, as nearly (85–87) percent of power system disturbances occur in transmission lines. Identifying the source of faults is a complex task; however, fast fault detection can help protect equipment from severe damage. Accurate fault location enables service personnel to quickly remove permanent faults and identify the areas where faults occur frequently, thereby reducing fault occurrence and minimizing the duration of power outages.

In this research paper, an Arduino board has been used to detect the fault location in transmission lines, and the information is transmitted to the control center through an Arduino Nano device. The signal is further sent to a protective circuit to safeguard against overcurrent conditions, and then processed by the Arduino Nano (microcontroller).

A current sensor is connected to the Arduino, so that in case of a short circuit, the current through the series resistors changes. This variation is related to the resistance, which in turn depends on distance and load. When the resistance drops below a defined threshold value, the relay connected to the Arduino turns OFF the load, thereby preventing major damage.

An LCD display will show the status of the transmission line, including the voltage and current values. Additionally, a buzzer will sound when a fault is detected. Furthermore, SMS alerts will be sent to a specified number via a GSM modem.



Keywords: Arduino Nano, Microcontroller, LCD, SMS

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# CHAPTER 1
# INTRODUCTION

## 1.1 Project Goal

The main goal of this project is to design and develop a low-cost, an efficient system for detecting and locating fault losses, reduce downtime, and improve the reliability of the electrical power system.

## 1.2 Motivation

Frequent power interruptions and equipment damage caused by undetected faults lead to high maintenance costs and customer dissatisfaction. Conventional protection schemes are often expensive, complex, and slower to respond in real-time scenarios. This work is motivated by the need for an affordable and energy-efficient solution that can be deployed widely, including in developing regions where cost constraints are significant.

## 1.3 Objectives

Develop an Arduino-based prototype capable of detecting transmission line faults in real time. Continuously monitor voltage and current to identify abnormal conditions quickly. Automatically isolate the faulty section to prevent equipment damage and reduce power-outage duration. Design a compact and low-power hardware platform suitable for large-scale installation. Provide a system architecture that supports optional IoT/GSM integration for remote alerts and cloud-based data logging. Enhance the overall reliability and safety of the power distribution network while reducing maintenance costs.

## 1.4 System Features

Real-Time Monitoring: Voltage and current sensors provide continuous measurement of line conditions. Automatic Protection: Relay circuitry instantly disconnects the load when a fault is detected. Compact & Energy-Efficient: Small physical footprint and low power consumption allow easy installation and scalability. Scalable Communication: Supports expansion with GSM or IoT modules for remote monitoring. User Interface: LCD display shows live voltage/current readings and system status.

## 1.5 Social Impact

The proposed system can significantly reduce the duration and frequency of power outages, improving the quality of life for consumers and enhancing productivity in commercial and industrial sectors. By protecting equipment and lowering maintenance costs, utilities can allocate resources more efficiently, contributing to a more sustainable and resilient electrical infrastructure.

## 1.6 Problem Statement

Despite advances in protective relaying, cost-effective, fast-acting fault-detection systems remain a challenge particularly for developing regions and remote grids. Existing solutions may require complex communication networks or high installation costs. Therefore, there is a need for a low-cost, reliable, and easily deployable system that can promptly detect transmission line faults, isolate faulty sections, and communicate status to operators.

# CHAPTER 2
# HARDWARE DESCRIPTION

## 2.1 Block Diagram

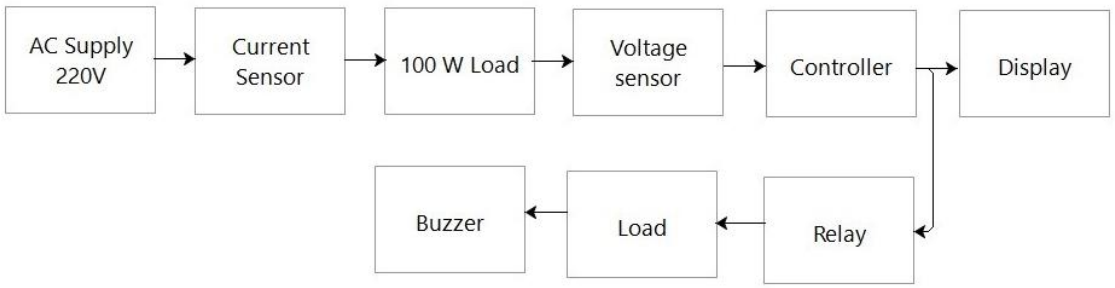



*Figure 1: Block Diagram*

## 2.2 Block Diagram Analysis

AC Supply 220V: This is the primary power source for the system, typically coming from a standard wall socket. It provides alternating current (AC) power.
Current Sensor: This sensor measures the amount of current (electrical flow) passing through the circuit. It detects any abnormal increase in current, which is a sign of a short circuit.
100W Load: This is a load (like a bulb or a heating element) connected to the circuit. It serves as an example of the normal current flow in the system.
Voltage Sensor: This sensor measures the voltage after the load. It can detect any unusual changes in voltage, such as a voltage drop or a surge.
Controller: This is the "brain" of the system, usually a microcontroller (like an Arduino). It receives data from the current and voltage sensors and compares it to a predefined value.
Display: When the controller detects an error, it sends a signal to a display (like an LCD screen) to show the error status.
Relay: When the controller detects an error, it sends a signal to the relay. The relay acts as an electrical switch that automatically disconnects the power supply to prevent damage.
Buzzer: When the controller detects an error, it activates the buzzer as an audible warning.
Load: This load is shown twice in the diagram, but it's actually the same one. It's the main circuit load controlled by the relay.

## 2.2 Hardware Components

The list of hardware components that are required are:

- Arduino Nano (Micro controller)
- SMPS
- LCD
- Current Sensor
- Voltage Sensor
- Relay Module
- Buzzer
- Indicator
- Regulator
- AC Bulb 5W
- AC Bulb 100W

## 2.2 Flowchart Explanation

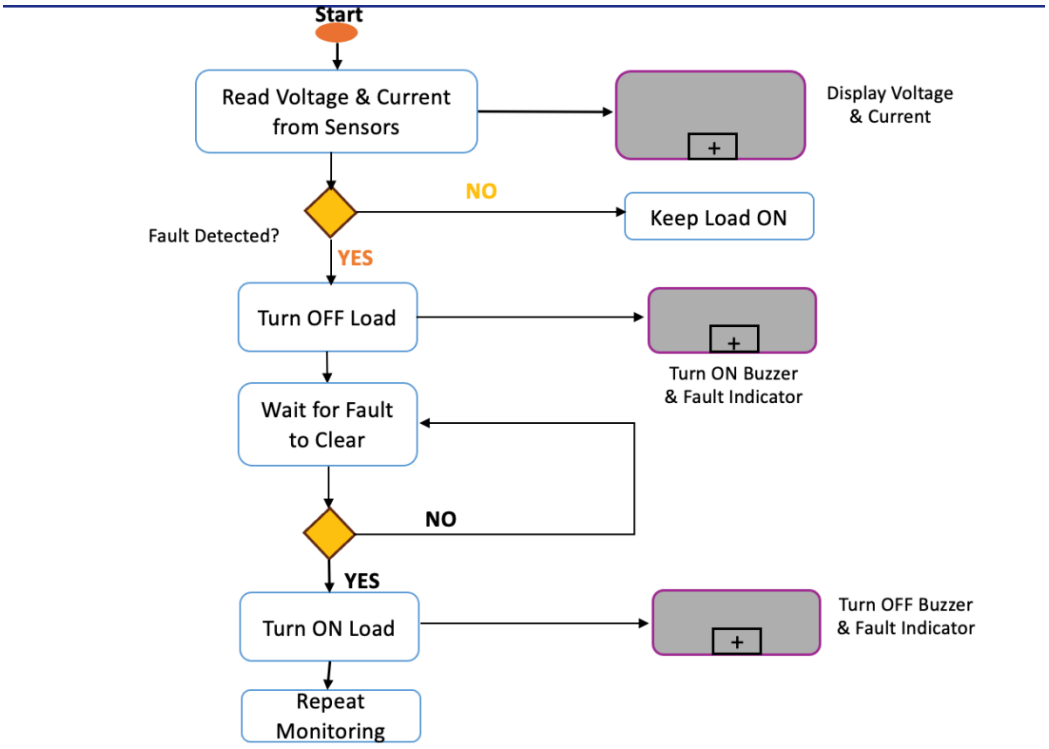



*Figure 2: Flow Chart*

**Start** The process begins here.

**Read Voltage & Current from Sensors** In the first step, the system collects data from the voltage and current sensors. Simultaneously, this data is shown on a display so the user can see the current status (Display Voltage & Current).

**Fault Detected?** The system analyzes the collected data to check if any fault (e.g., short circuit, over-voltage, or over-current) has been detected.

**If no (No):** If no fault is detected, the system continues to operate normally, and the load remains ON (Keep Load

ON). It then returns to the first step to start collecting data again (Repeat Monitoring).

**If yes (Yes):** If a fault is detected, the system moves to the next step.

**Turn OFF Load:** As soon as a fault is detected, the system immediately turns OFF the load (Turn OFF Load) as a safety measure. At the same time, a buzzer and a fault indicator are activated to alert the user.

**Wait for Fault to Clear** After the load is turned off, the system waits and repeatedly checks if the fault has been cleared.

**If no (No):** If the fault is still present, the system continues to wait and remains stuck in this step (Wait for Fault to Clear).
**If yes (Yes):** If the fault has been successfully cleared (e.g., the short circuit has been fixed), the system moves to the next step.

**Turn ON Load:** Once the fault is cleared, the system automatically turns the load back ON (Turn ON Load). Simultaneously, the buzzer and fault indicator are turned OFF (Turn OFF Buzzer & Fault Indicator) to stop the alert.

**Repeat Monitoring** After the load is turned back on, the system begins monitoring the voltage and current again from the first step, ready to detect any new faults that may occur.

This flowchart illustrates how an automatic circuit protects itself and the connected load from any fault.

## 2.3 Equipment Details:

### 2.3.1 Aeduino Nano

**T**he Arduino Nano, as the name recommends it will be smaller, closed and bread-board cordial micro-controller module. The module weight could be 7grams includes measurements of 4.5CMS to 1.8CMS This section has the details about the specialized specifications in particular about pins also elements of each and each pin in the Nano

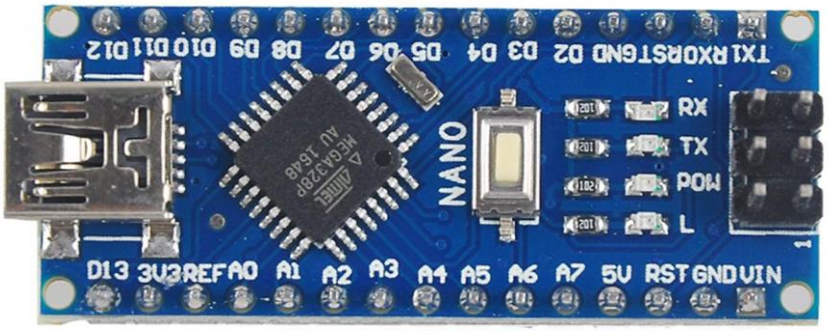



*Figure 3: Arduino Nano*

board, while UNO has 6 ADC ports yet Nano has 8 ADC ports. The USB port is utilized for programming and sequential checking. The highlight in Nano is that it will pick the most grounded power supply with the possible distinction, and also force supply choosing jumper is not suitable.

### 2.3.2 Arduino Pin Description

#### I. Power

The Arduino Nano will able to controlled through the Mini-B USB association, 6-20V and also not required regulated outer force source, or also 5V directed outside power supply. The force supply highest voltage.

## II. Memory

The ATmega328P has 32 KB, (also with 2 KB used for the bootloader.
The ATmega328P.

## III. Input and Output

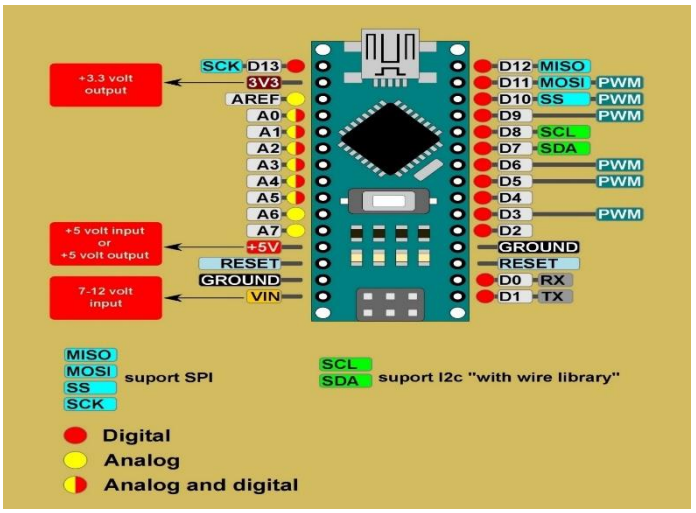



*Figure 4: Pin Description*

### 2.3.3 Pin Names and Their Functions

Arduino Nano Pinout contains 14 advanced pins, 8 simple Pins, 2 Reset Pins and 6 Power Pins.
Each of these Digital and Analog Pins are allocated with various capacities yet their fundamental capacity is to be designed as information or yield.
The general pins accomplish a complete goal of 10 bits while measuring the worth between 0-5V.
Arduino consists a gem oscillator of 16 MHz This is required to deliver a clock of recurrence using consistent volts.
There is one constraint using this board for example it doesn't accompany power jack, resembles we could not stockpile outside power supply besides a battery.
These boards don't use USB for associations with a computer, all things being equal, it accompany Mini USB support.
The board is similar to Arduino boards accessible on the lookout, however the small shape made these boards stand apart with other boards.
It is customized utilizing Arduino IDE means an Integrated Development Environment which will run on disconnected and over the web.
Not in previous courses of action needed to run the chip. All we need is a circuit, small in size than general USB and Arduino IDE program introduction on the computer. USB cable is required to move the code from desktop to the chip.
Each nail to the Nano board accompanies a particular capacity related to that.
We could look the simple pin that can be utilized as a simple to computerized converting where A4 and A5 pin can likewise be utilized for I2C correspondence.
Vin. Input power source voltage to the board when utilizing an outside voltage wellspring between 7V-12V. It is a managed power supply voltage of the board that is utilized to control the regulator and different segments put on the board.

3.3V. Is a base voltage created by the voltage controller on the chip.

I2C correspondence is created utilizing pins A4 and A5 where A4 addresses the sequential information line that
conveys the information and A5 addresses the sequential clock line that is a clock, produced through the expert gadget, utilized for information synchronizing the gadgets on the I2C transport.

## 2.3.4 Arduino Pin Description Table

| Pin Name | Function | Working Description |
|---|---|---|
| VIN | Power Input | Provides input voltage (7–12V) to power the board. |
| 5V | Power Output | Gives regulated 5V output to power sensors and modules. |
| 3.3V | Power Output | Provides 3.3V output (max ~50mA) for low-voltage devices. |
| GND | Ground | Ground pins for completing electrical circuit connections. |
| RESET | Reset | Resets the microcontroller when pulled LOW. |
| D0 (RX) | Digital I/O, UART | Used for digital input/output or UART data receive. |
| D1 (TX) | Digital I/O, UART | Used for digital input/output or UART data transmit. |
| D2 – D13 | Digital I/O | General purpose digital input/output pins. |
| D3, D5, D6, D9, D10, D11 | PWM Output | Provide Pulse Width Modulation output for analog control. |
| D2, D3 | Interrupts | Can be used as external hardware interrupt pins. |
| D10 (SS), D11 (MOSI), D12 (MISO), D13 (SCK) | SPI | Used for SPI communication with devices. |

| | | |
|---|---|---|
| A0 – A7 | Analog Input | Measure analog voltages (0–5V) with 10-bit resolution (0–1023). |
| A6, A7 | Analog Only | Can only be used as analog input (not digital output). |
| A4 (SDA), A5 (SCL) | I²C | Used for I²C communication (data and clock lines). |
| AREF | ADC Reference | Provides external reference voltage for ADC measurements. |
| ICSP Header | Programming | Used to upload bootloader/firmware and for SPI communication. |

## 2.4 SMPS

A Switched-Mode Power Supply (SMPS) is an electronic circuit that converts power with much higher efficiency compared to a conventional linear power supply. It regulates voltage by using high-frequency on-off switching.

How Does an SMPS Work?

An SMPS operates on a simple but effective principle. Here's a step-by-step analysis of its working process:

**AC-to-DC**: Conversion (Rectification): First, the alternating current (AC) from the input is converted into direct current (DC) using a rectifier circuit. This DC voltage is raw and contains many ripples, so a capacitor is used to smooth it out.

**Switching:** In this step, the smoothed DC voltage is rapidly switched on and off using a semiconductor switch (usually a MOSFET or BJT). This switching frequency is typically very high (e.g., 50 kHz to 1 MHz). Due to this high-speed switching, the circuit can use a very small transformer.

**Step Up/Down (Transformation):** The high-frequency, pulsed voltage goes through a small transformer. This transformer steps the voltage up or down as required.

**Final DC Conversion (Final Rectification):** The pulsing voltage coming out of the transformer is again converted into a smooth and stable DC output using a rectifier and filter circuit.

**Control (Feedback and Control):** A control circuit continuously monitors the output voltage. If the output voltage drops or rises beyond a set value, the control circuit changes the duration of the switching (Duty Cycle) to bring the voltage back to a stable state.

### 2.4.1 Advantages of an SMPS

An SMPS has several key advantages that set it apart from linear power supplies:

**High Efficiency:** It typically provides an efficiency of over 70% to 90%, which results in much less power

loss and reduced heat generation.

**Small Size and Light Weight:** Due to the high switching frequency, it uses a smaller transformer, which helps reduce the overall size and weight of the device.

**Cost-Effective:** Its manufacturing cost is lower than that of a linear power supply.

**Voltage Regulation:** It can operate within a wide range of input voltages and keep the output voltage stable.

### 2.4.2 Disadvantages of an SMPS

Despite its advantages, an SMPS also has some limitations:

**Electromagnetic Interference (EMI):** The high-frequency switching can create electromagnetic interference, which can affect the performance of sensitive circuits.

**Complex Circuit Design:** Its design and construction are more complex than those of a linear power supply.

An SMPS is widely used in computers, mobile chargers, televisions, and other electronic devices. It is an indispensable part of modern electronics technology.



*Figure 5: SMPS*

## 2.5 LCD Explanation

A 2x16 alphanumeric LCD display is a small screen commonly used in electronic projects to show messages and information. The "2x16" designation means it has two rows (or lines), with each row capable of displaying 16 characters or alphanumeric symbols.

These displays typically come with backlighting to ensure readability in low-light or dark conditions. You can display letters, numbers, and some special characters on this screen.




*Figure 6: LCD Display Explain*

**How It Works**

These LCDs are connected to a microcontroller (like an Arduino) to function. Data and instructions are sent from the microcontroller to the LCD via specific pins. The LCD has a built-in controller (such as the Hitachi HD447780) that interprets the received data and instructions and displays the characters on the screen.

**The main pins of the LCD are:**

**Data Pins (D0-D7)**: These pins are used to send the data (character codes) to be displayed on the screen.

**Control Pins:**

**RS (Register Select)**: This pin determines whether you are sending data or instructions.

**R/W (Read/Write)**: This pin determines if data will be written to the LCD or read from it. Typically, we only write data, so it is connected to ground (GND).

**EN (Enable)**: This pin prepares the LCD to receive data or instructions.
Due to its ease of use and low cost, the LCD display is widely used in everything from hobbyist electronics projects to industrial machinery.



*Figure 7: LCD Display*

## 2.6 Specific Uses of the 2x16 LCD Display

The LCD display, especially the 2x16 alphanumeric display, is very popular for its versatile uses. It is used to display important information in various projects. Here are some of its specific applications:

### i. General Electronics Projects

Temperature and Humidity Meter: Data collected using a temperature and humidity sensor (e.g., DHT11) can be displayed directly on the LCD screen.
Voltage and Current Monitor: Voltage and current sensors can be used to measure the electrical flow in a circuit and display it on this screen. It can also be used to show the battery's charge level.
Timers and Counters: It can function as a stopwatch, countdown timer, or an event counter for a project.

### ii. Smart Home and Automation

Smart Doorbell: When someone presses the doorbell, a message like "Someone is at the door" can be displayed on the LCD.
Automated Light Control: The LCD display can show the status of room lights ("Light ON" or "Light OFF").
Project Status: In robotics or other automated projects, it is used to display the current status (e.g., "Task in progress" or "Ready").

### iii. Security and Alarm Systems

Security System: When a motion sensor is activated, a message like "Intruder Detected" can be displayed on the LCD. It can also be used as a small screen for entering passwords.
Fire Alarm: If smoke or gas is detected, it can display alert messages like "Fire Detected!" or "Gas Leak."

### iv. Other Uses

Robots: Robots use an LCD display to provide information about their current task or status (e.g., "Moving forward").
Gaming Devices: This display can be used to show scores, levels, or other game information on small handheld gaming devices.
These displays are easy to program, and their low cost and clear display make them an ideal choice for all kinds of electronics projects. Using it can make your project more interactive.

### v. Circuit Description

Above is a very straightforward program. Control Port is an open source / open channel producer. While many of the same ports have internal pull-out pins, not much is missing. So, by mixing two 10K external pull-outs, the circuit is more integrated with a wider range of PCs, some of which may not.

## 2.7 Current Sensor

This is a component used to measure the electric current flowing through a circuit. It is typically used to detect overcurrent, short circuits, or other faults. This module primarily consists of three main parts:

**Terminal Block**: This is the green connecting part where wires are attached. The circuit whose current needs to be measured is connected through this terminal block.

**Sensor Chip**: The black chip in the middle of the module is the main sensor. This chip measures the current flowing through the wire and generates a corresponding voltage signal. This signal can be read by a microcontroller (like an Arduino or Raspberry Pi).

**Header Pins**: The three pins on one side of the module are the connecting pins. These pins are typically:
**VCC**: Power supply (+).
**GND**: Ground (-).
**OUT**: This is the output voltage signal from the sensor, which is proportional to the amount of current.

**How It Works**

This type of sensor typically operates on the principle of the **Hall Effect**. When electricity flows through a conductor, it creates a magnetic field around it. The Hall Effect sensor measures this magnetic field and provides a voltage output based on its intensity. Since the magnetic field's intensity is proportional to the current, it's possible to determine the amount of current by measuring the output voltage. These modules are used in various electronic projects, such as:

- Electrical protection systems
- Battery monitoring systems
- Solar power systems
- Motor current control in robotics

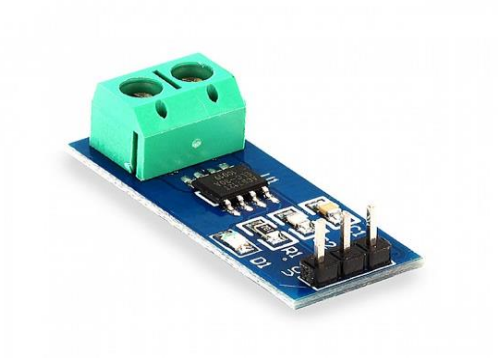


*Figure 8: Current Sensor*

## 2.8 Voltage Sensor

Explanation of the AC Voltage Sensor Module
This module is mainly composed of a transformer and a small circuit board. Its primary function is to step down a high AC voltage into a manageable voltage signal that can be read by a microcontroller (like an Arduino).

### 2.8.1 Pin Connections

Right-side Pins: These are used for the DC power supply and output.

**Vcc:** This is used to provide power to the module. It typically operates on +5V or +3.3V DC voltage.
**Output:** This is the module's output pin. It provides an analog voltage signal that is proportional to the measured **AC voltage.** This signal is connected to an analog pin on a microcontroller (e.g., A0 on an Arduino).
**GND**: This is the ground pin of the module, which is connected to the negative terminal of the DC power supply.
**GND**: This is also a ground pin, often used to improve circuit stability.

**Left-side Terminals**: These terminals are for connecting the AC input.
**AC** : Neutral: This connects to the neutral wire of the AC power line.
**AC** : Phase: This connects to the phase wire of the AC power line.

### 2.8.2 Main Components of the Module

**ZMPT101B**: This is the core transformer chip of the module. Its job is to safely step down the input AC voltage to a lower value.

**Circuit Board**: The board contains various resistors, capacitors, and an amplifier circuit to process the voltage from the transformer and convert it into a suitable analog signal for the microcontroller.
Using this module, a microcontroller can easily monitor the real-time voltage of an AC circuit, which is highly useful in projects like power protection systems, energy meters, or smart home applications



*Figure 9: Voltage Sensor*

## 2.9 Relay Module (5V 4Channel)

### 2.9.1 4-Channel Relay Module Explained

A relay is an electrical switch that uses a low-voltage signal (typically 5V DC) to control a high-voltage circuit (like 220V AC). A 4-channel relay module contains four such relays, allowing you to control four separate devices or circuits.

### 2.9.2 Main Components

**Relays**: The four main blue, rectangular blocks on the module are the relays. Each relay has three terminals for connecting the load:
**NO (Normally Open)**: This terminal is disconnected in its normal state. It connects when the relay is

activated.
**NC (Normally Closed)**: This terminal is connected in its normal state. It disconnects when the relay is activated.
**COM (Common)**: This connects to the input wire of the load.
**Input Pins**: The pins on the right side of the module are for connecting to a microcontroller.
**VCC**: This is the power supply pin for the module, typically supplied with +5V DC.
**GND**: This is the ground pin.
**IN1, IN2, IN3, IN4**: These four pins are the inputs. When a 'high' or 'low' signal (according to the microcontroller's program) is sent to one of these pins, the corresponding relay is activated.
**LED Indicators**: Each relay has a small LED light. When a relay is activated, its corresponding LED lights up, making it easy to see which relay is currently on.

### 2.9.3 Functionality

This module primarily acts as an **isolator**. It completely separates your microcontroller's sensitive low-voltage circuit from the high-voltage circuit. When you send a signal to a relay using an input pin (like IN1), a circuit inside the module activates that relay. Through this relay, you can digitally turn on/off high-voltage devices such as electric fans, lights, pumps, or any other high-voltage load. In simple terms, it's a safe and effective way to give our small electronic projects the ability to control large electrical loads

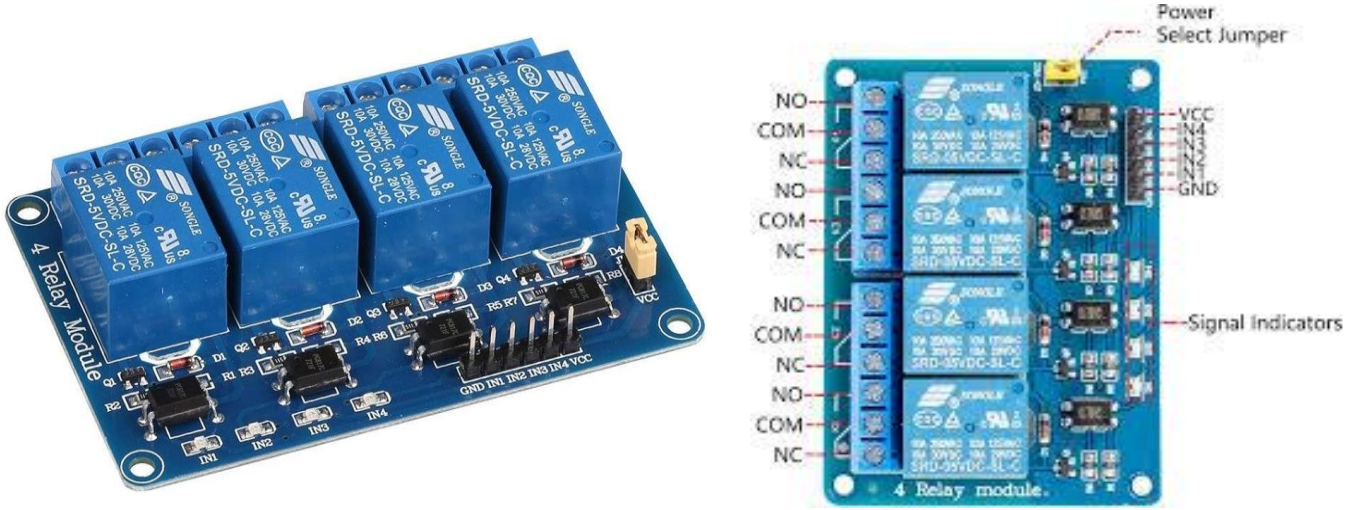



*Figure 10: Relay Module*

## 2.10 Buzzer

An AC buzzer, which looks like a small cylinder, has the primary function of creating an audible signal to indicate a fault (such as a short circuit, over-temperature, or over-voltage) or an emergency situation.

- **Key Features**

  **Audio Alert**: This device produces a sound at a specific frequency to warn people about a

problem. The sound wave or Wi-Fi signal-like symbols on the top of the buzzer in the image indicate its audio function.

**Voltage**: It works directly with AC voltage (e.g., 220V AC). Its voltage rating is often written in small text on its body, which confirms its functionality. It can be connected directly to a 220V AC line.

**LED Indicator**: Some models have a built-in LED light that provides a visual alert in addition to the sound. This is a red buzzer that emits light from within, serving as a visual alarm.

**Installation**: These buzzers are typically mounted in holes on a control panel and fastened with nuts. It has two terminals at the bottom where the two AC power wires are connected.



*Figure 11: Buzzer*

## 2.11 Indicator

### Explanation of AC Indicator Light

These devices are mainly used to provide **visual signals**. Their primary function is to quickly and easily inform the user about the status of a specific electrical circuit (such as ON, OFF, or FAULT).

- **Key Features**
  **Colors:** In the picture, you can see three different colored indicators: red, yellow, and green. These colors are generally used to indicate specific states:
  **Green:** Usually represents a "normal" or "active" state. For example, when a machine is running or the power supply is stable, the green light glows.
  **Yellow (Amber):** Indicates a warning or "caution" state. For instance, when a fault is imminent, a short circuit occurs, or a part of the system malfunctions, the yellow light glows.
  **Red:** Represents the power state. When the system is ON, the red-light glows.
  **Voltage:** These indicator lights work directly on AC voltage (e.g., 220V AC). Their voltage rating is usually written on the body of the indicator.

- **Functionality**
  AC indicator lights work as part of the **"**Fault Indicator**"** step in a flowchart such as "Turn ON Buzzer & Fault Indicator." When the system detects a fault according to the flowchart, the indicator light is activated through a relay or control circuit. As a result, the user not only hears an audible alert (buzzer) but also sees a visual signal (color indication), making it easier to quickly understand the type of fault. his feature is especially important in industrial environments, where operators need to assess situations rapidly and take timely action.



*Figure 12: Indicator*

## 2.12 Regulator

### Fan Regulator

A fan regulator is an electrical device used to control the speed of electric ceiling fans and table fans, and to regulate voltage.

**Key Features**

**Rotary Knob**: The round knob in the center of the image is used to either increase or decrease the voltage.
**Symbol**: A fan blade symbol is shown on the knob, which makes it easy to understand that it is used for a fan. However, in this case, it is being used for voltage regulation.

**Functionality**

A fan regulator primarily controls speed by increasing or decreasing the voltage supplied to the fan. But here I have used it to increase and decrease the voltage.



*Figure 13: Regulator*

# CHAPTER 3
# SOFTWARE DESCRIPTION

## 3.1 Arduino C Compiler

The Arduino Integrated Development Environment (IDE) is used for writing, compiling, and uploading code to the Arduino Nano microcontroller. It supports the C/C++ programming language and provides a user-friendly interface for project development.
Key features of Arduino IDE:
Code Editor: Allows writing programs (“sketches”) in simplified C/C++.
Compiler: Converts the human-readable sketch into machine code that the Arduino can execute.
Uploader: Transfers the compiled code to the Arduino board through a USB connection.
Serial Monitor: Displays real-time data (such as voltage, current, or fault messages) sent from the Arduino.

## 3.2 Working Sketch

The software continuously monitors voltage and current readings from the sensors and decides whether a fault has occurred.
Steps of the software process:
Initialization:
Serial communication begins.
LCD, GSM, and sensor modules are initialized.
Data Acquisition:
Voltage and current values are read from sensors.
These values are displayed on the LCD.
Fault Detection:
The measured values are compared with predefined thresholds.
If the values exceed limits (over-voltage, over-current, or short circuit), the controller identifies a fault.
Protective Action:
The relay turns OFF the load immediately.
The buzzer and indicator are activated.
An SMS alert is sent via the GSM module.
Fault Clearance:
The system continuously checks whether the fault is cleared.
If normal conditions return, the relay turns ON the load, and alarms stop.

## 3.3 Libraries

Services provide extra functionality for use in drawings, such as interacting with equipment or managing information. Select a collection from the Shape, Integrate Library submenu to use it in a design. It’ll also place zero or more include statements there at top of something like the file and collect the library with your image. Libraries boast the number of available storages on the board because they will be transported with your sketch. If a doodle does not require such library however at time, just erase it include statements from your code.
In the history section, there is a list of institutions. With Uno programming, a few packages are included. Some may be not.

## 3.4 Third Party Hardware

Outsider gadget backing may be added to your book catalog's firmware directory. Board defines (which appear in the board menu), center libraries, bootloaders, and computer engineer definitions is one of the stages that may be presented there. To begin, create the gear directory, then learn to tie the outer level and place it in that sub-index. (If you use" usb" as the sub-index name, you'll overwrite existing built-in Atmel stage.) To remove, you delete the book.
See the outsider Equipment description for the further information on how to construct packages for enemy machinery.

## 3.5 The Compilation Process

In actuality, the aver code is plain old c sans the headers (he incorporates what not). The IDE stores the current record as aduino.dc in the 'tory' index when you push the 'bulk' button, then runs it around in its 'lib' index. This motor reproduction or direct reinforcement copies Arduino's as prog.c into 'repub,' starting with'wiringlite.inc.' These activity converts the nodemcu code to a collin file (called prog.c). Regarding that, it copies all of the records in the 'central' index to 'dems'. Adding to these records adds instructions to the vernacular. These files represent the fulfillment of the various micro - controller directives. Pascal Tang's Procyon avr-lib, which is found in the 'coalition' registry, protects the main documents. The code at lib/tmp is now ready to be processed with the script found in 'procedures.' If the make activity goes well, you'll have a function called program. Hex that can then be fed into graphics Card.

# CHAPTER 4
# PROJECT DESCRIPTION

## 4.1 Project Model

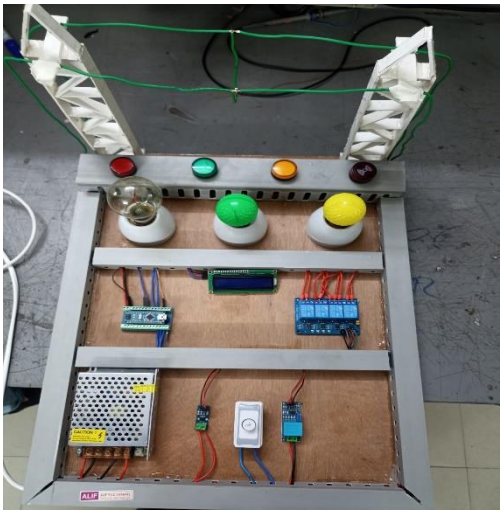
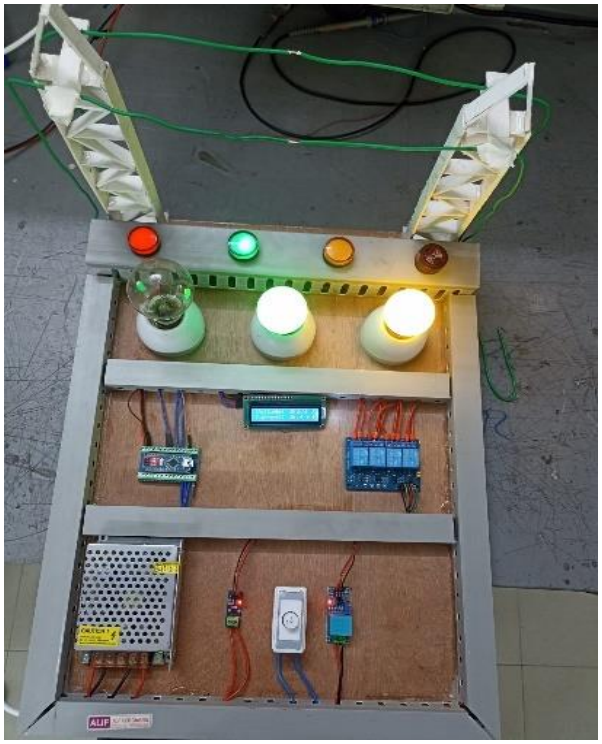


*Figure 14: Project Model*

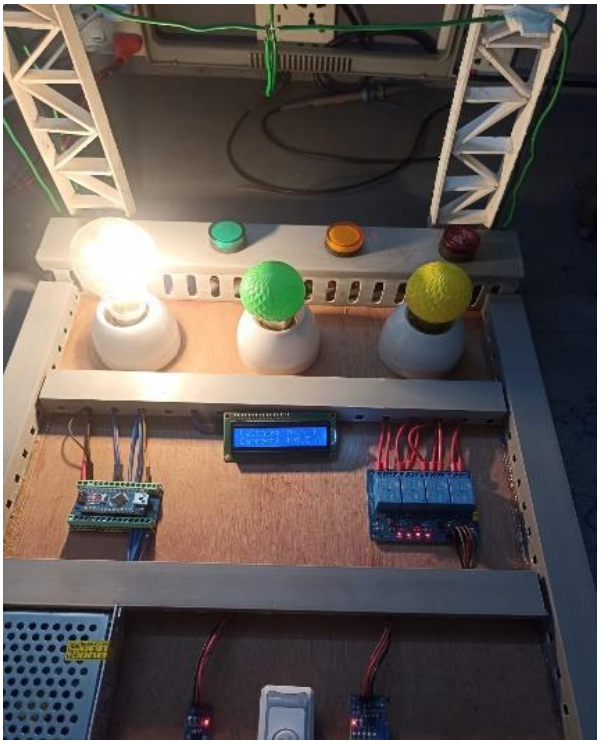
## 4.2 Working Principle

The set up or field device consists of 2 major components, and microcontroller. The over voltage sensor and short circuit sensors are attached to both microcontroller and transmissions lines maintaining the connection between them, meanwhile the Arduino is connected to and the LCD, buzzer, are connected to Arduino completing the circuit. When supply is given to the circuit, if there is any fault in the circuit like high voltage or over voltage the voltage sensor comes in to work and indicates the Arduino which sends signal to lcd to display that there is a short circuit at a specific area and also the buzzer will be alerted. if there are any short circuit respective sensors come in to work. In this process we can detect four types of signals.

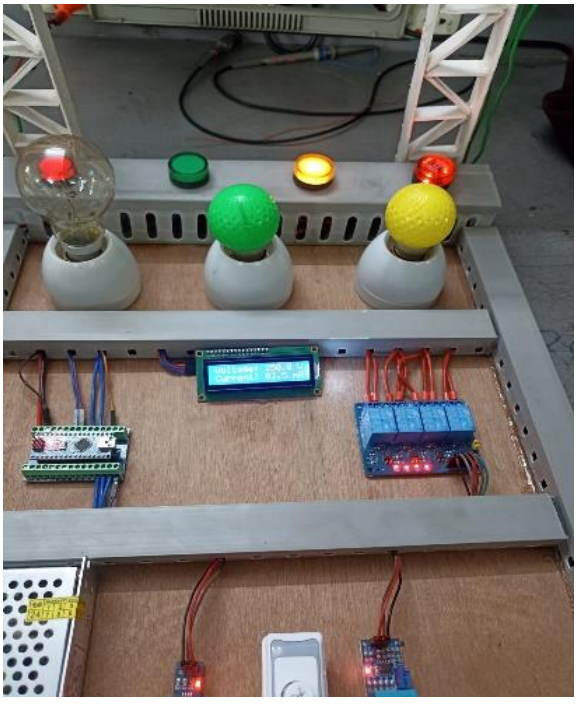
- Low voltage signal.
- High voltage signal.
- Short circuit signal.



*Normal Mode*



*Short Circuit Mode*



*Over Voltage Mode*

*Figure 15: Project Output*

# CHAPTER 5
# RESULT & DISCUSSION

## 5.1 Summary

The primary objective of this project was to develop an automatic, reliable, and cost-effective Transmission Line Fault Detection System capable of quickly identifying faults and accurately transmitting the information to the concerned operator or control center. Built with an Arduino-based microcontroller, current and voltage sensors, a relay module, a GSM modem, and an LCD display, the system can continuously monitor line voltage and current under real operating conditions. Whenever the voltage or current exceeds the defined limits, the system immediately disconnects the load, activates audible/visual alarms (buzzer and indicator), and sends an SMS alert to a registered mobile number.
Practical testing demonstrated that this prototype responded rapidly to over-voltage, short-circuit, open-circuit, and fire faults.

Real-time monitoring and automatic isolation effectively minimized equipment damage.
The system operates efficiently with low power consumption and its compact size makes installation easy. As a result, the proposed solution can significantly improve the reliability and safety of the power distribution network while reducing the need for human intervention and lowering maintenance costs.

## 5.2 Result

- We tested the project and it worked perfectly, as shown figure 4.3 on the LCD of the Physically Look Project Picture. Normal voltage signal.
- We have identified signals separately. Short circuit signal.
- The values of the voltage sensors are correctly sent to the chip. At the same time, all text is shown correctly on the display.

The Arduino Nano has to be properly calibrated from the sensor

## 5.3 Advantages

- **Real-Time Response**
  Continuously monitors voltage and current and takes immediate action whenever any abnormal condition is detected.
- **Wide Coverage**
  Can be easily implemented across larger transmission networks compared to many existing fault-detection methods.
- **Cost-Effective**
  Uses affordable components such as the Arduino Nano, current/voltage sensors, and a relay module, which keeps the overall cost very low.

- **High Reliability**
  Ensures consistent operation and accurate fault detection, thereby improving the overall reliability of the power distribution network.
- **Compact Design**
  The system’s small size and lightweight hardware make installation and maintenance simple and convenient.

# CHAPTER 6
# CONCLUSION

## 6.1 Conclusion

Through this research work, a low-cost, Arduino-based Transmission Line Fault Detection System has been designed and implemented, which can make a significant contribution to improving the safety and reliability of the power distribution network.
The proposed system continuously measures line voltage and current and compares them with predefined limits.
Whenever an abnormal condition occurs, it immediately detects the fault and disconnects the load to protect the equipment.
In real-world tests, the system demonstrated high accuracy and fast response for various types of faults such as short circuit, over-voltage, and open circuit.

## 6.2 Major Achievements

Automatic Protection: The relay module disconnected the load as soon as a fault was detected and automatically reconnected it after the fault was cleared.
Reliability in Harsh Weather: The system maintained stable operation even under adverse conditions such as storms, lightning, and strong winds.
Compact and Energy-Efficient Design: Because of its small size and low power consumption, the system is easy to transport, install, and use for long-term operation.

## 6.3 Significance of the Research

This project provides an effective solution for ensuring continuity and safety in power distribution networks. It reduces maintenance costs and protects long-life equipment, which is valuable for both industrial and residential applications.
Overall, this research proves that even a low-cost, microcontroller-based solution can provide high reliability and safety for electrical systems. The outcomes serve as a practical guideline for developing advanced protection technologies in modern power distribution networks.

## 6.4 Limitation

Transmission line fault detection has some limitations.

- False Alarm
- Limited Coverage
- Detection Delay
- Environmental Interference
- Complex Fault Types
- Data Overload
- Maintenance Challenges
- Integration Issues
- Cost Considerations
- Cybersecurity Risks

## 6.5 Future Work

In the future, if GSM support is integrated into the system, it will become more effective for remote fault detection and monitoring. Whenever a fault occurs, an SMS alert can automatically be sent to a registered mobile number. As a result, operators will be able to receive fault information quickly and take necessary actions even without being physically present at the site.

Future Work

The current design of this project serves as an effective prototype, but there are several areas where it can be further enhanced in the future:

- **IoT and Cloud Integration**
  Connecting the system to an Internet of Things (IoT) platform would enable real-time data storage and analysis in the cloud.
  Operators could monitor faults remotely through a web or mobile dashboard from any location.
- **Artificial Intelligence and Machine Learning**
  Machine learning algorithms can be incorporated to analyze sensor data and predict potential faults (predictive maintenance).
  This would allow necessary preventive actions to be taken before a fault actually occurs.
- **Expanded Network Coverage**
  The system has so far been tested on small-scale transmission lines. For use in high-voltage and long-distance power grids, both hardware and communication protocols need to be strengthened.
- **Solar and Backup Power Support**
  Adding solar power or battery backup would keep the system operational even during power outages.
- **Enhanced Cybersecurity**
  As internet-based connectivity grows, implementing data encryption, secure login, and controlled remote access will be essential to protect system integrity.
- **Additional Sensors and Features**
  Integrating sensors for temperature, humidity, or wind speed could help predict faults caused by environmental conditions.
  A GPS module could be added to provide faster and more precise geographic fault location.

# REFERENCES


[1] P. Zhang, F. Li and N. Bhatt, “Next-generation monitoring, analysis, and control for the future smart control center,” *IEEE Transactions on Smart Grid*, vol. 1, no. 2, pp. 186–192, 2010.

[2] V. C. Gungor and F. C. Lambert, “A survey on communication networks for electric system automation,” *Computer Networks*, vol. 50, no. 7, pp. 877–897, May 2006.

[3] F. C. F. Guerra and W. S. Mota, “Current transformer model,” *IEEE Transactions on Power Delivery*, vol. 22, no. 1, pp. 187–194, Jan. 2006.

[4] M. Rahnema, “Overview of the GSM system and protocol architecture,” *IEEE Communications Magazine*, vol. 31, no. 4, pp. 92–100, Apr. 1993.

[5] P. Ramachandran, V. Vittal and G. T. Heydt, “Mechanical state estimation for overhead transmission lines with level spans,” *IEEE Transactions on Power Systems*, vol. 23, no. 3, pp. 908–915, Aug. 2008.

[6] E. Tsykunov, L. Labazanova, A. Tleugazy and D. Tsetserukou, “SwarmTouch: Tactile interaction of human with impedance-controlled swarm of nano-quadrotors,” in *Proc. IEEE/RSJ Int. Conf. Intelligent Robots and Systems (IROS)*, pp. 4204–4209, 2018.

[7] N. Jain, A. Dongariya and A. Verma, “Critical evaluation of several kinds of task scheduling systems for partnership amongst data transmission,” in *Proc. 2017 Int. Conf. Information, Communication, Instrumentation and Control (ICICIC)*, pp. 1–4, 2017.

[8] N. R. Nagarajan, S. Sathishkumar, K. Balasubramani, C. Boobalan, S. Naveen and N. Sridhar, “Chopper-fed speed control of DC motor using PI controller,” *IOSR Journal of Electrical and Electronics Engineering*, vol. 11, no. 3, pp. 65–69, 2016.

[9] P. J. Patel et al., “A regulated power supply for accelerator driven system,” in *Proc. IAEA*, pp. 1–8, 2009.

# APPENDIX

```
#include "ACS712.h"
#include <ZMPT101B.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define ZMPT_PIN A2        // Sensor connected to A2
#define FREQ 50.0          // Your AC frequency (50Hz or 60Hz)
#define Load1 9          // D11 pin for Buzzer
#define Load2 10          // D11 pin for Buzzer
#define Status 11          // D11 pin for Buzzer
#define Buzzer 12          // D11 pin for Buzzer


// Create sensor objects
ZMPT101B voltageSensor(ZMPT_PIN);
ACS712 sensor(ACS712_05B, A1);
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Current measurement variables
float upper, lower, old;

// 1s Timer
unsigned long startMillis;
unsigned long currentMillis;
const unsigned long period = 1000;

void setup() {
  Serial.begin(9600);
  Serial.setTimeout(10);

  // Initialize LCD
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.clear();

  // Output pin setup
  pinMode(Load1, OUTPUT);
  pinMode(Load2, OUTPUT);
  pinMode(Status, OUTPUT);
  pinMode(Buzzer, OUTPUT);
  digitalWrite(Load1, HIGH);
  digitalWrite(Load2, HIGH);
  digitalWrite(Status, HIGH);
  digitalWrite(Buzzer, HIGH);

  // Voltage sensor calibration
  voltageSensor.setSensitivity(220);

  // ACS712 calibration
  sensor.calibrate();
}

void loop() {

  ACS712();   // measure current
  ZMPT101B(); // measure voltage
}

// ----------------------------
// Current measurement function
// ----------------------------
void ACS712(void) {
  currentMillis = millis();

  if (currentMillis - startMillis >= period) {
```

```
    float H = sensor.getCurrentAC();
    float I = H * 1000;
    // Noise filtering
    if (I < 0.10) I = 0;

    upper = I + 0.5;
    lower = I - 0.5;

    // Only update if significant change
    if (I != old) {
      if ((old <= lower) || (old >= upper)) {
        Serial.print("Current: ");
        Serial.print(I, 2);
        Serial.println(" mA");

        // Update LCD line 1 without clearing whole display
        lcd.setCursor(0, 1);
        lcd.print("Current:"); // overwrite previous value
        lcd.setCursor(9, 1);
        lcd.print(I, 1);
        lcd.print(" mA  ");

        // Fault detection condition
        if (I > 50) {
          digitalWrite(Load1, LOW);
          digitalWrite(Load2, LOW);
          digitalWrite(Status, LOW);
          digitalWrite(Buzzer, LOW);
        } else {
         digitalWrite(Load1, HIGH);
        digitalWrite(Load2, HIGH);
        digitalWrite(Status, HIGH);
        digitalWrite(Buzzer, HIGH);
        }

        old = I;
      }
    }

    startMillis = currentMillis;
  }
}

// ----------------------------
// Voltage measurement function
// ----------------------------
void ZMPT101B(void) {
  float voltage = voltageSensor.getRmsVoltage(FREQ);

  // Print on Serial Monitor
  Serial.print("AC RMS Voltage: ");
  Serial.print(voltage, 2);
  Serial.println(" V");

  // Print on LCD (line 0)
  lcd.setCursor(0, 0);
  lcd.print("Voltage:       "); // overwrite previous value
  lcd.setCursor(9, 0);
  lcd.print(voltage, 1);
  lcd.print(" V");

  if (voltage > 225 || voltage < 215) {
          digitalWrite(Load1, LOW);
          digitalWrite(Load2, LOW);
          digitalWrite(Status, LOW);
          digitalWrite(Buzzer, LOW);
        }
```