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Approaches to Transmission Line Fault Detection Utilizing GPS: An Overview

Chinnu U.S.[1], Sujatha S. [1], Adhil Muhammad N.[2], Jisa K. Sabu[2*], Mithul Santhosh[2], Sanath Solaman[2]

Abstract

Transmission line protection is essential since 80–86% of power system issues are related to transmission lines. This study suggests a way to classify and identify different types of short circuit faults on transmission lines. There are several operating and fault conditions on high-voltage line transmission, such as L-L fault, single phase to earth fault, and double line fault. Proteus Professional 8 software simulates three fault scenarios: triple line fault, triple line to ground fault, and triple line. The connected devices to the electricity grid are harmed by these defects. This work's primary goal is to identify the type of transmission line problem and analyse different sorts of defects. For modelling and assessing the different faults, a transmission line model spanning 100 km was developed. There was a fault block in a basic power system block library, and the harmonic content of the different faults was examined along with the effects of the faults. Based on the research, a hardware model is created that uses an ESP32 processor and actuating relays to detect transmission line defects and display the type of fault and its distance from the source.

Keywords: Transmission line, ESP 32 microcontroller, Double line fault, Actuating relays, Powergrid

INTRODUCTION

Transmission lines are crucial components of electrical power systems, responsible for delivering electricity from power plants to various distribution points. Ensuring the reliability and safety of these transmission lines is paramount for uninterrupted power supply and the prevention of potential hazards. One of the critical challenges in maintaining the reliability of transmission lines is the timely detection and localization of faults that can disrupt the flow of electricity. Different faults and anomalies commonly occur in transmission lines. Any malfunction that prevents the appropriate passage of electric current in any power system network or circuit is referred to as a fault. This could result in an unanticipated conducting route formation, or a short circuit fault, or it could stop the flow of electricity, or an open circuit fault. [12].

***Author for Correspondence**
Jisa K. Sabu
E-mail: eeejisaksabu@gmail.com

1-Assistant Professor, Department of Electrical and Electronics Engineering, Baselios Mathews II, College of Engineering, Sasthamcottah, Kerala, India
2-Student, Department of Electrical and Electronics Engineering, Baselios Mathews II, College of Engineering, Sasthamcottah, Kerala, India
3-Student, Department of Electrical and Electronics Engineering, Baselios Mathews II, College of Engineering, Sasthamcottah, Kerala, India
4-Assistant Professor, Department of Electrical and Electronics Engineering, Baselios Mathews II, College of Engineering, Sasthamcottah, Kerala, India
5-Assistant Professor, Department of Electrical and Electronics Engineering, Baselios Mathews II, College of Engineering, Sasthamcottah, Kerala, India
6-Assistant Professor, Department of Electrical and Electronics Engineering, Baselios Mathews II, College of Engineering, Sasthamcottah, Kerala, India

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The short circuit electric current in a power system circuit will normally increase to a level six to ten times higher than the proper or standard full load electric current when fault current flows in the power system network [23]. When conductors or any pair of transmission lines encounter one another or the earth, a typical fault in an electric power system circuit occurs. Common electric power system circuit faults include single line, single line to ground, double line, double line to ground, triple line, and triple line to ground faults. These faults are said to occur when conductors or any two

transmission lines meet one another or the earth [48]. These problems, which are typical of transmission lines, are also known as short circuit faults.

Heavy short-circuit currents must be prevented from flowing via the power transmission system, which by cutting off the malfunctioning part of the system, could compromise employee safety and damage large pieces of equipment permanently [910]. Traditional methods of fault detection rely on manual inspection, which is time-consuming, costly, and often prone to errors. However, with advancements in technology, particularly the integration of Global Positioning System technology, new opportunities have emerged for more efficient and accurate fault detection on transmission lines.

GPS technology provides precise positioning information, allowing for real- time monitoring of transmission line assets over vast geographical areas [1114]. By equipping transmission line infrastructure with GPS-enabled sensors, utilities can continuously monitor the status and performance of their assets remotely. This enables rapid identification and localization of faults, such as line breaks, insulator failures, or vegetation encroachment, before they escalate into more significant issues. Machine learning techniques can be employed to improve the accuracy of fault detection algorithms by continuously learning from historical data and adapting to evolving fault patterns.

In this project work we are implementing how to determine the fault, its live location by using GPS technology. Moreover, GPS-based fault detection systems offer benefits beyond fault identification. They facilitate predictive maintenance by providing insights into the condition of transmission line assets, enabling utilities to schedule maintenance activities proactively and minimize downtime.[15] The examination of transmission line faults may be done easily utilizing Proteus software on a computer. The goal of this research project is to analyse and identify power system transmission line faults to suggest the appropriate choice of protective measures and allow utility companies to offer their customers services while maintaining the necessary equipment and people safety at a reasonable cost.[16]

Block Diagram

Figure 1 explains the block diagram of transmission line fault detection using actuating relays and ESP 32 microcontroller. The main components are ESP 32 microcontroller, switching circuit, relays and LCD screen. The 3 phases R, Y, B are represented by connecting 3 single phase transformers (230/12 V) and the supply is rectified using bridge rectifier, voltage regulators (LM7805) and filter circuits for a constant 5 V supply to microcontroller and 4 channel relays. The switch circuit outputs are connected to Vcc and A0 pins of microcontroller and relay. The digital pins 2 to 5 and pins 11, 12 of microcontroller are connected to LCD display which displays the type and distance of fault.

An electrical transformer that lowers electricity from a higher level of 230 volts to a lower level of 12 volts is called a 230/12 V inverter[17-20]. The transformer is designed to handle an input voltage of 230 volts and provide an output voltage of 12 volts. The principal winding and its supplementary winding are its two independent windings. While the secondary winding is linked to the load (12 volts), the primary winding is connected to the input voltage source (230 volts). The transformer's main job is to reduce the voltage from 230 volts to 12 volts. The transformer's main and secondary windings' turns ratio allows for this step-down transformation.

An electrical circuit that changes alternating current to direct current is called a bridge rectifier. In power supply circuits, it is frequently used to deliver a constant DC output from an AC input source. Four diodes stacked in a bridge shape make up the bridge rectifier circuit. The bridge's two diagonally opposed corners get the AC input voltage, while the other two corners receive the DC output voltage. The four diodes in the bridge rectifier are typically semiconductor devices that allow current to flow in one direction only. An electronic circuit or device that maintains a steady output voltage in the face of changes in temperature, load current, or input voltage is known as a voltage regulator. It is frequently utilised in a variety of electrical and electronic systems to give delicate components steady, dependable

power. A voltage regulator's main job is to maintain a steady output voltage under various conditions by controlling it within a predetermined range. This is achieved by adjusting the resistance or switching characteristics of the regulator circuit in response to changes in the input voltage or load.

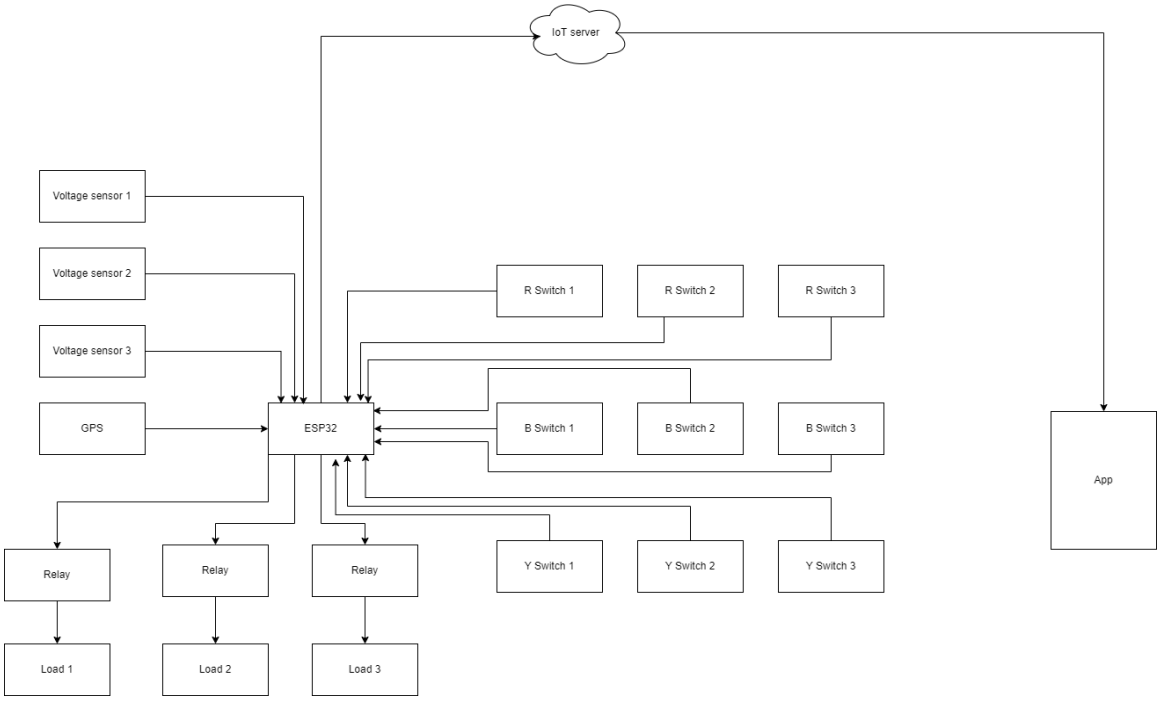

FIG 1. Block diagram of transmission line fault detection using GPS

The ESP32 microcontroller is a highly versatile and powerful chip developed by Espressif Systems, widely used in various Internet of Things and embedded systems projects. Equipped with a dual-core Xtensa LX6 processor with a maximum clock speed of 240 MHz, the ESP32 provides powerful computing power for Internet of Things applications. It has a Harvard design that allows for simultaneous instruction fetches and data access to boost performance. The instruction and data buses are kept distinct.

The dual-core design enables multitasking and real-time operation, making the ESP32 suitable for applications requiring simultaneous processing tasks. The ESP32 integrates Wi-Fi and Bluetooth connectivity, supporting both classic Bluetooth and Bluetooth Low Energy protocols. Wi-Fi connectivity is provided by a built-in 2.4 GHz Wi-Fi transceiver, supporting 802.11 b/g/n standards for wireless communication. Bluetooth support allows for seamless connectivity with other devices, enabling applications such as wireless audio streaming, device control, and data exchange.

The Global Positioning System (GPS) is a satellite-based navigation system that can deliver location and time data anywhere on or near the planet as long as four or more GPS satellites can see each other clearly. Each GPS satellite continuously transmits radio signals containing time and position information. GPS devices on the ground, in cars, aeroplanes, and smartphones pick up these signals. GPS has become an indispensable technology with widespread applications in navigation, surveying, timing, agriculture, search and rescue, and many other fields, contributing to increased efficiency, safety, and convenience in modern society.

MIT App developer helps in developing an app called “Line Break”. In this app it analyze whether the fault is detected or not. This also allows us to determine the exact place in real time where the defect is found.

Circuit Diagram Implementation

Load actuating relays are connected to microcontrollers and bulbs for indication of voltage drop in the line as shown in figure 2. Switch circuit consists of analog switches separated with 1 Kohm resistance as representation of 2 km distance in transmission line. The project works as follows:

- The single-phase supply is given to the circuit for the operation of loads.
- As no fault is created from switch circuit the LCD display shows no fault (NF) in every phase.
- The creation of the fault is done by using switch circuit which resembles the three phases of transmission lines.
- When a fault is created from switch circuit by pressing the analog switch. The nominal value of resistance of respective line gets reduced. An analog signal is generated which is sensed by actuating relay.

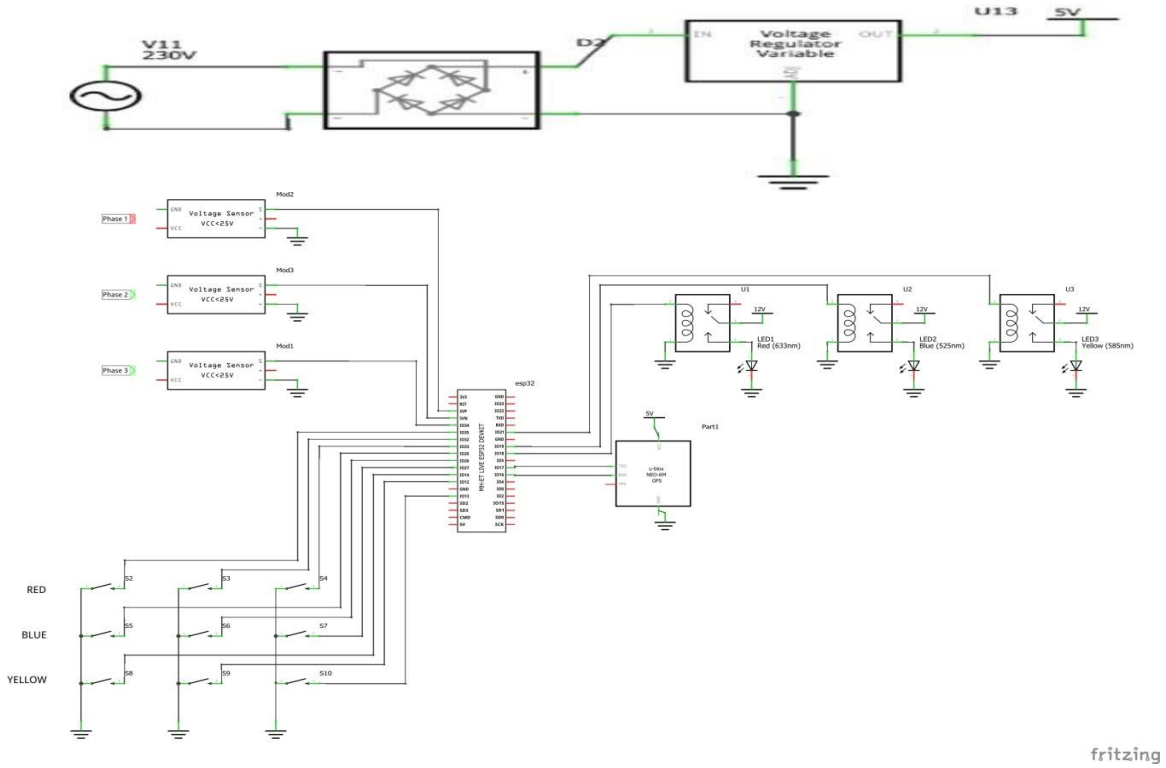

FIG 2 Circuit diagram of transmission line fault detection using GPS

- The microcontroller A0, which is coupled to the switch circuit, transforms the analogue input into a digital output.
- The generated digital signal is processed, and the fault created in respective phase is displayed in the LCD. The hardware model of transmission line fault analysis and detection using actuating relays and ESP 32 controller.
- When the fault is created it resembles a short circuit fault hence there will be a reduction in voltage.
- The reduced voltage is observed from the load representation bulbs RYB.
- When the fault is sensed by actuating relays, the microcontroller receives the signals and gives to the GPS.
- GPS receives those signals and shows the location in which the fault had occurred.

Design Concept

Relay selection

Maximum load = 230V, 10A Microcontroller pin voltage = 3.3V So, the relay selected is 5V DC model with switching limit of 230V AC at 10A

$$Vout = Vin \times \frac{R2}{R1+R2}$$

3.3 = 5 * R2
10k Ω + R2R2 = 20 K Ω

Transformer Selection

Vin is the input voltage of 230V
Vout is the output voltage of 12V
Isecondary is the output current of 1A

Consider the Equation

Vin = N primary = I secondary
Vout N secondary I primary

We can find the turns ratio using the voltage ratio
230 = N primary
12 N secondary
primary = 19.167
N secondary

We can Find the Primary Current

I primary = I secondary
N primary / N secondary
I primary = 1
19.167
= 0.0522A

Simulation

Software called Proteus was used for the simulation as shown in figure 3. The Proteus software suite is a widely used tool in the field of electrical and electronics engineering, primarily for designing, simulating, and testing electronic circuits. Developed by Lab centre Electronics Ltd., Proteus offers a comprehensive set of features tailored for electronic design automation. Here are some key details about Proteus software in the context of electrical engineering: Proteus provides a user- friendly interface for designing electronic circuits using a schematic capture module. Users can drag and drop components from an extensive library of electronic components, including resistors, capacitors, integrated circuits (ICs), microcontrollers, sensors, and more, onto the schematic canvas.

Proteus's ability to simulate things is one of its most potent characteristics. The software includes a built-in mixed-mode SPICE (Simulation Program with Integrated Circuit Emphasis) simulator, allowing users to simulate analog and digital circuits. It supports various simulation types, including transient analysis, AC analysis, DC sweep, and more. Users can examine performance metrics and model how their circuits will behave in various scenarios. With Proteus, users can create virtual prototypes of their electronic circuits, allowing them to validate designs before prototyping or manufacturing physical hardware.

By locating and resolving problems early in the design process, this virtual prototype capabilities helps lower development time and costs. Microcontroller-based system simulation is supported by Proteus. Users can design and simulate embedded systems using popular microcontroller models, such

as those from the PIC, AVR, ARM, and Arduino families. The software provides tools for programming and debugging microcontroller firmware within the simulation environment. In addition to schematic capture and simulation, Proteus offers tools for printed circuit board (PCB) design.

Users can seamlessly transfer their schematics to the PCB layout module, where they can place components, define trace routing, and generate manufacturing files such as Gerber files for PCB fabrication. Proteus is a popular tool in educational contexts for teaching simulation and gadgets design. Its intuitive interface and comprehensive features make it an ideal platform for students and educators to learn and experiment with electronic circuits without the need for expensive hardware. Proteus integrates various modules seamlessly, allowing for a smooth workflow from schematic design to simulation and PCB layout. Users can iterate on their designs efficiently, making adjustments as needed based on simulation results or design requirements. Overall, Proteus software plays a vital role in the electrical engineering domain, enabling engineers, hobbyists, and students to design, simulate, and test electronic circuits effectively and efficiently.

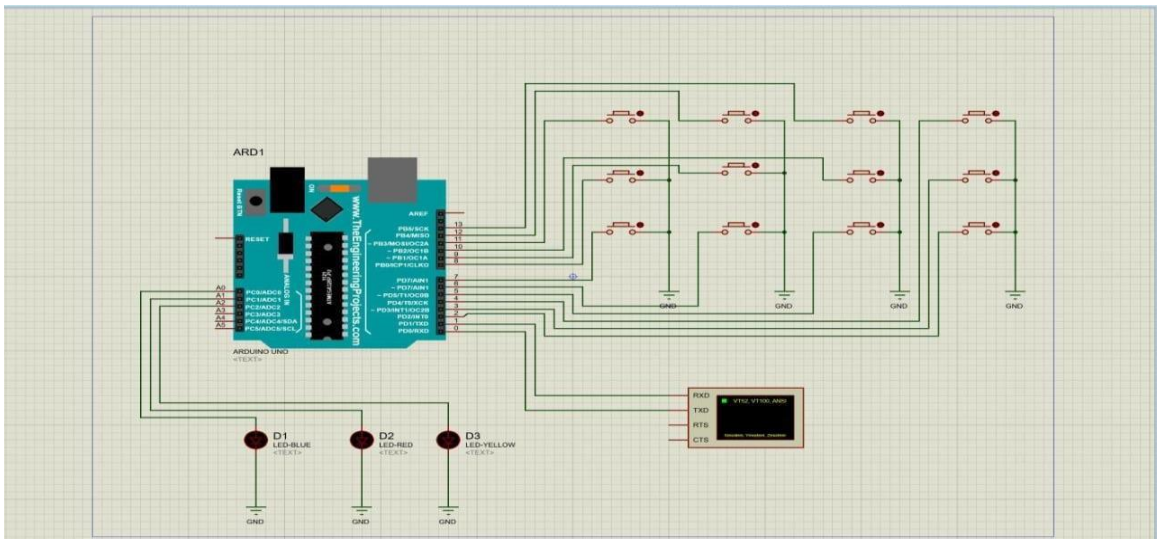

FIG 3. Simulation diagram

Hardware Implementation

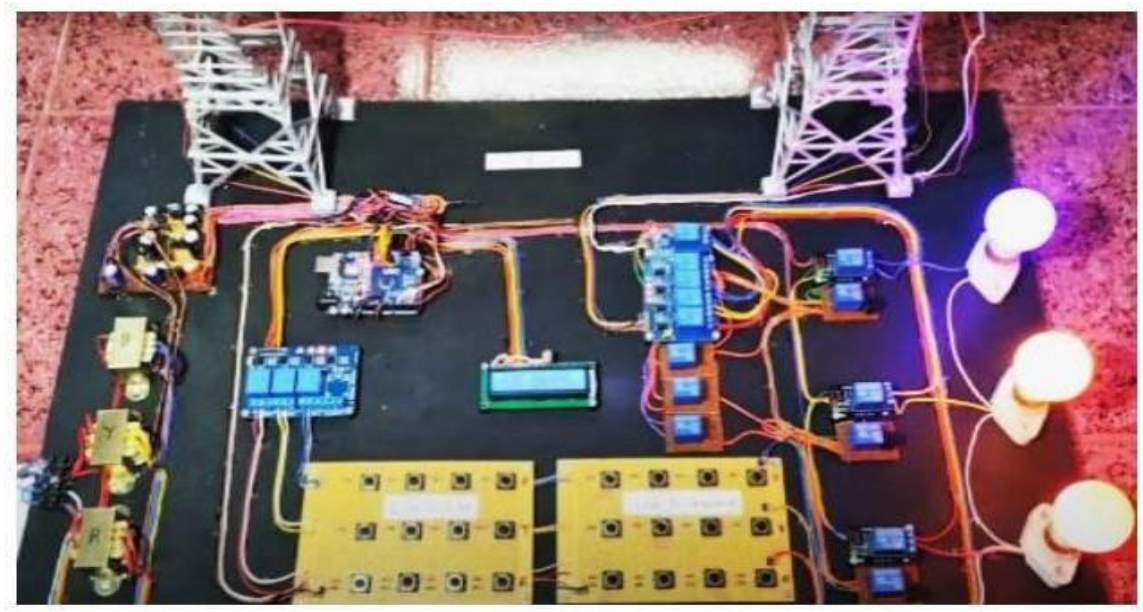

Fig 4 Prototype Testing

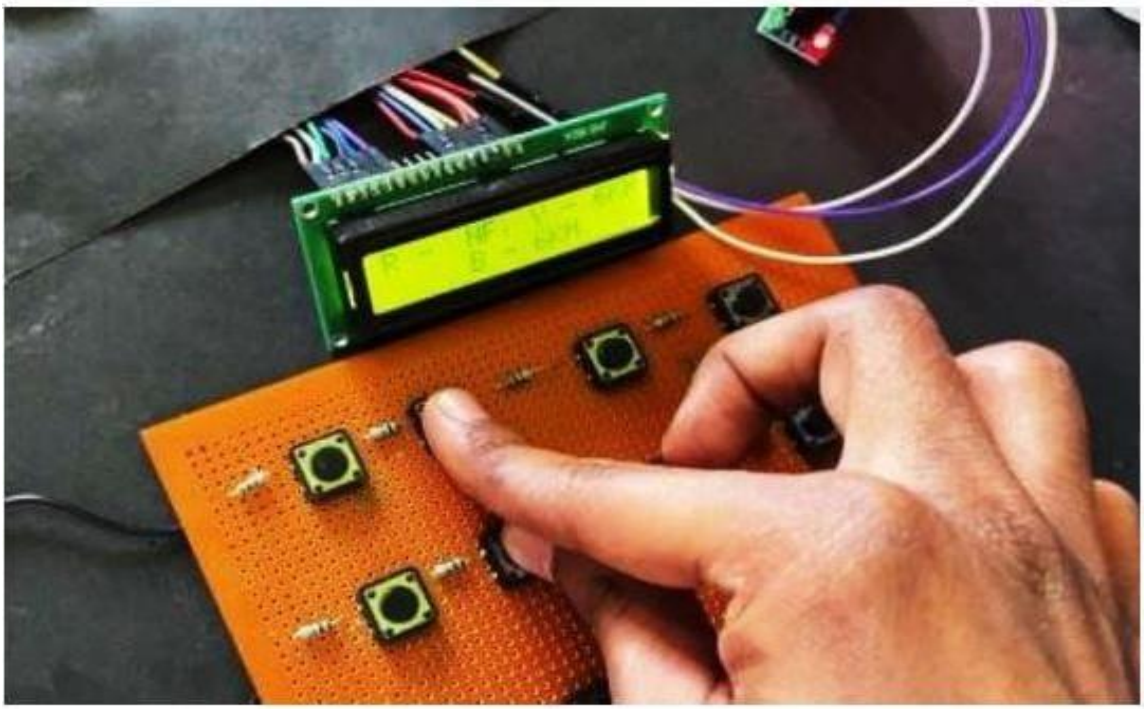

Fig 5. Hardware model

The above figure 4 and figure 5 represent the prototype testing and hardware model of transmission line fault detection using GPS respectively.

Results And Discussion

When fault is created in respective phase by switch circuit the set impedance is reduced and voltage will be dropped. Thus, the fault is sensed by actuating relay and sends signal to microcontroller to display the type of fault and distance where it occurred as shown in figure 6 and figure 7.

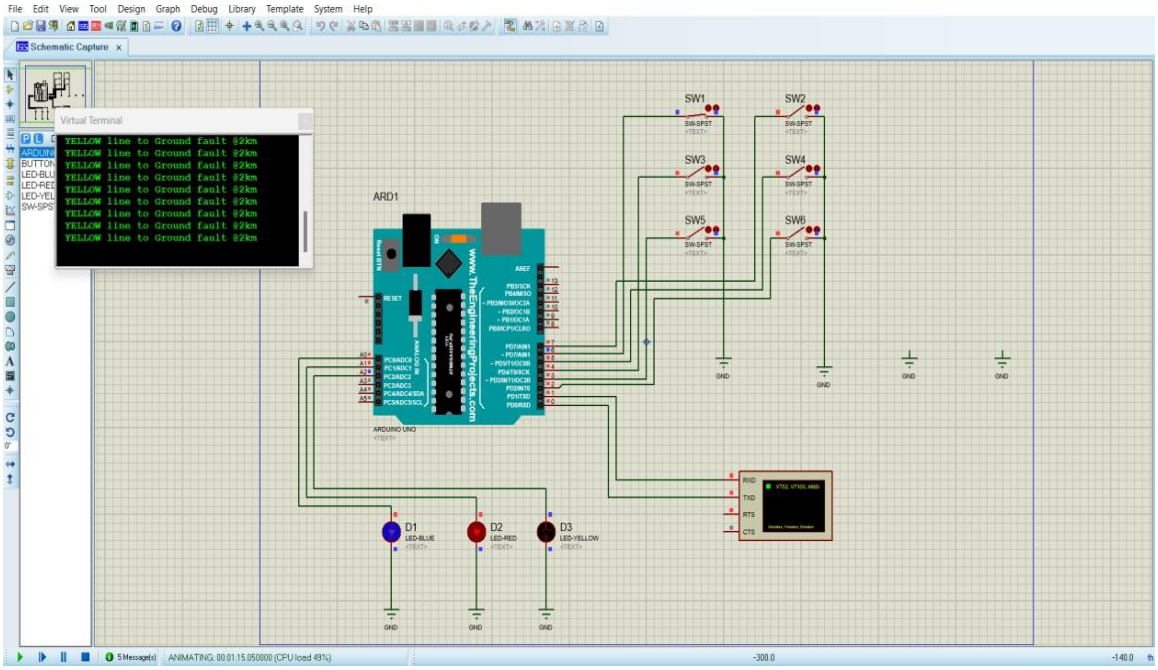

FIG 6 LG Fault

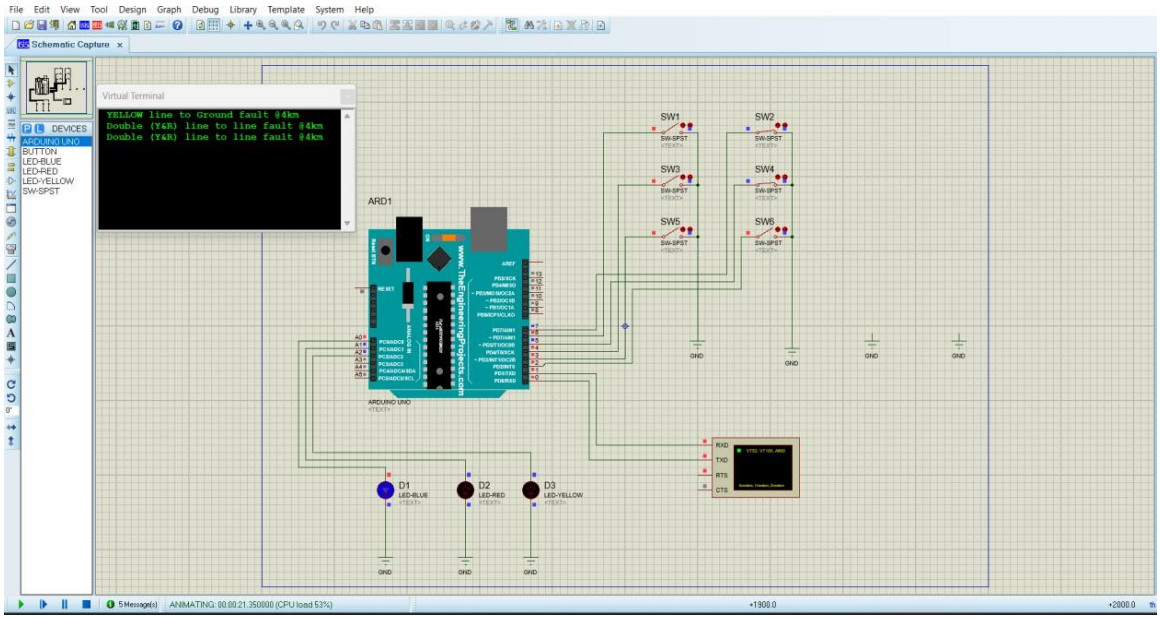

FIG 7 LLG Fault

CONCLUSION

Transmission lines transmit huge power from the generating station to consumers through distribution lines, it does this at high voltage to reduce losses along transmission line. But, when transmission line breakdowns happen, the delivery of power is interrupted. In this study, a system for finding transmission line defects is presented. The transmission line fault locator has undergone successful testing. This hardware variant is capable of pinpointing the precise site of a transmission line fault. The utilisation of GPS technology for transmission line fault detection presents a viable strategy to improve the dependability and effectiveness of power transmission networks. By integrating GPS technology into fault detection systems, it becomes possible to accurately locate faults along transmission lines, thereby minimizing downtime, improving grid reliability, and reducing maintenance costs. GPS enables precise location tracking, allowing utilities to pinpoint the exact location of faults along transmission lines. This accuracy expedites repair efforts, reduces outage duration, and minimizes service interruptions for consumers. GPS-based fault detection systems provide real-time monitoring of transmission lines, enabling utilities to promptly detect and respond to faults as they occur. This proactive strategy guarantees the stability of the electricity system and helps prevent cascading failures. By swiftly identifying and isolating faults, GPS-based systems contribute to enhancing grid reliability and resilience.

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