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Health Monitoring and Fault Detection in Power Distribution Transformer Using Scada

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ABSTRACT

A wireless LoRa-based data transmission system for micro grids. The suggested system provides data gathering from numerous units within a micro grid and permits connecting of several sensors to the LoRa transceivers. The suggested system aims to focus on the communication between the local controllers of each distributed generation (DG) unit and the central controller of the microgrid due to the potential usage of low-bandwidth communication methods. The data from the sensors is gathered and transmitted to the LoRa gateway, acting as a central monitoring system in a proof of concept test bed arrangement. Through their local controllers, control signals are delivered to different microgrid components such as DG units, storage systems, and load. In this study, instead of using cloud servers typically utilized in Internet- of-Things (IoT) monitoring systems, a private server is constructed using Node-Red to enhance communication security. To evaluate the data transmission pace, the proposed system undergoes a range test. It has achieved data transmission of over 90% at a distance of 4 kilometers. Finally, a test bed experiment is conducted to establish one- directional data flow in a grid monitoring system, validating critical aspects of the suggested system.

***Keywords*: LoRa Module, DG unit, Underground Cable, Micro grids, IOT.**

1. INTRODUCTION

Transformer is one of the vital electrical power systems which are majorly encountered in our day-to-day life. Power line transmission may be carried out by either overhead methods or underground transmission methods. Power transformers are resilient by their construction and give more efficient output by stepping down the voltage. In general, power transformers step down the voltage from 500kv to 120kv at the distribution end. The occurrence of fault in the transformer may be various reasons which may include increase in load supply (current), insulation break down which results in blackout. The transformer loss is considered to be very high compared to other such power systems. This may happen due to natural calamities causes malfunction of the transformer. It may also obstruct the constant supply of the transformer.

In the recent studies, almost all electric power transmission companies have employed relays with circuit indicators for detection of fault occurring zones in power transmission lines. Although it consists of sensors, breakers and other communication system is used to which looks giant in construction and consumes more time and cost for locating fault. Despite the limitations, there are also challenges in accurately identifying the precise location of faults. Currently, fault indicator technology has provided a dependable approach for locating permanent faults. But implementation of this technology is a tedious process and requires a more human effort in identifying the fault zone and clear the fault which consumes several hours to rectify. Supervision of transmission line fault detection using SCADA technology contributes the solution for these several concerns which may include faster fault localization. Acquiring fault diagnosis reduction in installation and maintenance cost. The implementation of these technology tends the improvement of delivery of data to corresponding supervisory in faster rate. So that’s why there should be proper identification of faults in the transmission lines is needed.

2. THEORY OF OPERATION

In this method, health monitoring of power distribution transformer and fault detection in underground power distribution cables or lines. Initially, supervision of health parameter of the distribution transformer is carried over. The health parameters of the distribution transformer which is considered here are temperature, oil level, voltage drop and overload current. Power supply of 230v from the source is split up into four sections. Initially, one of the power supplies is utilized to power the step- down transformer, which reduces the voltage from 230V to 5V to supply power to all the devices in the kit. Secondly, the same power supply is given to voltage sensor to detect the voltagedrop in transmission line.

Another power supply, the phase line is wound up with current sensor and it is connected with indicator and neutral line is directly connected to the indicator for detecting the overload in the transmission line.

And the rest one of the supplies is given to the relay for zone indication. The temperature sensor employed here is LM35. This sensor will power up by 5V power supply. The range of the LM35 sensor is preset in the program by user. Along with this, the cooling fan relates to temperature sensor. This sensor will pass the analog signals to ADC in which those signals where later converted into digital output. Whenever the temperature crosses or reaches the threshold level, the coolant fan will automatically turn ON for reduction of temperature level up to the preset value. In addition, with these, oil level sensor (P43) is connected with circuit board. The change in oil level in the transformer is identified using the sensor. This sensor will pass the analog signals to ADC in which those signals where later converted into digital output.

This sensor will pass the analog signals to ADC in which those signals where later converted into digital output. The above all parameters data are stored and retrieved in AT89s52 microcontroller. Along with these, LCD is connected with the microcontroller to display all the data or parameters. The change in oil level in the transformer is identified using the sensor. This sensor will pass the analog signals to ADC in which those signals where later converted into digital output. The above all parameters data are stored and retrieved in AT89s52 microcontroller. Along with these, LCD is connected with the microcontroller to display all the data or parameters. In other hand, fault detection in the power transmission line in various zones will be processed. Two 2-Channel Relays are employed to enable low electrical current to control high current loads. These relays are connected to the circuit board to control the system's operations and zone identification. Along with that, these relays are connected with the indicator which locates the fault zone. LoRa plays a major role in this proposed system. LoRa is used for communicating the data over a long range. The power supply for LoRa is 5V. The LoRa module is connected with the circuit board in order to transmit and receive data because the LoRa can acts as both receiver and transmitter as well as. Here we employed two LoRa. One is connected with the circuit board and another one is connected with personal computer (PC). SCADA software is used to monitor all the health parameters as well as the fault in transmission line. This software is also used to control the relays both automatically and manually. Along with this, distance of the fault occurring zone from the transformer and in addition with this impedance of the transmission line can be located.

3. PROPOSED SYSTEM

The primary aim of the proposed system is to safeguard the power distribution transformer from reverse current in case the under- cable line is damaged, while also providing alert indicators to the appropriate supervisory personnel.

a. Hardware Components

1) AT89s52 Microcontroller

Fig 1. ATMEL AT89S52 Microcontroller

The AT89S52 is a powerful 8-bit microcontroller that boasts both exceptional performance and low power consumption. Its internal programmable flash memory is 8K bytes in size and is made using high-density non-volatile memory technology from Atmel. The device's pinout and instruction set are in compliance with industry standards. The microcontroller's program memory can be updated either in-system or through traditional non-volatile memory programmes, thanks to the on-chip Flash. With its adaptable 8-bit CPU and in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is an affordable and highly flexible solution for a wide range of embedded control applications. The device comes equipped with 32 I/O lines, 8K bytes of Flash, 256 bytes of RAM, three 16-bit timer/counters, a Watchdog timer, two data pointers, a six-vector two-level interrupt architecture, an on-chip oscillator, and clock circuits. Additionally, the AT89S52 includes two software-configurable power saving modes and static logic, allowing it to operate down to zero frequency. When idle mode is activated, the CPU is turned off, but the Memory, timers and counters, serial port, and interrupt system remain operational. In the Power-down mode, the oscillator is frozen and all other chip operations are disabled until the next interrupt or hardware reset. Nonetheless, the RAM contents are saved.

2) Temperature Sensor

Fig 2. LM35

Measuring temperature is a fundamental requirement for implementing environmental control, as well as certain chemical, electrical, and mechanical controls. Cost, space restrictions, temperature sensor durability, and accuracy are all typical factors that need to be taken into account. The LM35 is an IC temperature sensor that offers high precision, with its output being directly proportional to the temperature (in degrees Celsius). Unlike thermistors, the sensor circuitry is sealed and therefore not susceptible to oxidation or other such processes. This allows for more accurate temperature measurement with the LM35. Additionally, the device has low self-heating and generates less than a 0.1-degree Celsius temperature rise in still air. It has an operating temperature range from -55°C to 150°C, and its output voltage changes by 10mV for every degree Celsius rise/fall in ambient temperature, giving it a scale factor of 0.01V/ oC.

3) Float Switch

Fig 3. Float level switch sensor

A float switch is an instrument that is employed to measure the liquid level in a tank. The switch can activate a pump, indicator, alarm, or other devices based on the liquid level. By simply flipping the float, it is simpleto change from normally open to normally shut. The level sensor can handle a maximum load of 50W. The level will require a minimum voltage of 250V DC. A float switch operates by either opening or closing a circuit, depending on whether the liquid level is rising or falling. Typically, float switches are designed as "normally closed," which means that the circuit is completed by the two wires coming from the top of the switch when the float is at its lowest point and resting on its bottom clip or stop. With float switches, the circuit is often opened or closed by a magnetic reed switch. Epoxy is used to adhere a glass tube housing the reed to a stainless steel or plastic stem. In a float switch, as the magnet moves closer to the contacts, they are attracted and make contact, allowing electricity to flow through. When the magnet moves away, the contacts lose their magnetization and separate, breaking the circuit.

The magnetic reed switch in a float switch is typically enclosed within a hermetically sealed stem made of plastic or stainless steel. As a fluid level changes, the float's sealed magnet slides up and down the length of the stem. As the magnet moves past the enclosed contacts of the reed switch in the float switch, they are pulled together, thereby completing a circuit between the two lead wires. The switch's bottom clip may often be removed, the float inverted, and the clip put back on to reverse the procedure illustrated. After making this modification, the switch circuit will be open when the float is resting on the bottom clip and closed when the float rises. Float switches may offer millions of on/off cycles for years of dependable performance when utilized appropriately. Failures are usually brought on by overloading, which is frequently brought on by voltage spikes.

4) Voltage Sensor

Fig 4. Isolation Transformer

For measuring value of voltage, we can use the isolation transformer. Voltage Sensor is an accurate, reasonably priced voltage sensor. The resistive voltage divider principle was used in its design. It may five times lower the input voltage to the red terminal connection. The Arduino can accept analogue input voltages up to 5V, while the voltage detection module can accept input voltages of up to 25V (for 5V systems) or 16.5V (for 3.3V systems). Since the AVR chips used in the Arduino have a 10-bit analogue-to-digital converter, this module can achieve a resolution of 0.00489V (5V/1023). This means that the minimum detectable voltage for the input voltage detection module is 0.02445V (0.00489V x 5). The input voltage range for this module is 0-25V DC supply, and the voltage detection range is 0.02445V to 25V DC supply, with an analogue resolution of 0.00489V. Furthermore, the positive terminal of the DC input connector should be connected to the VCC terminal, while the negative terminal should be connected to the GND terminal.

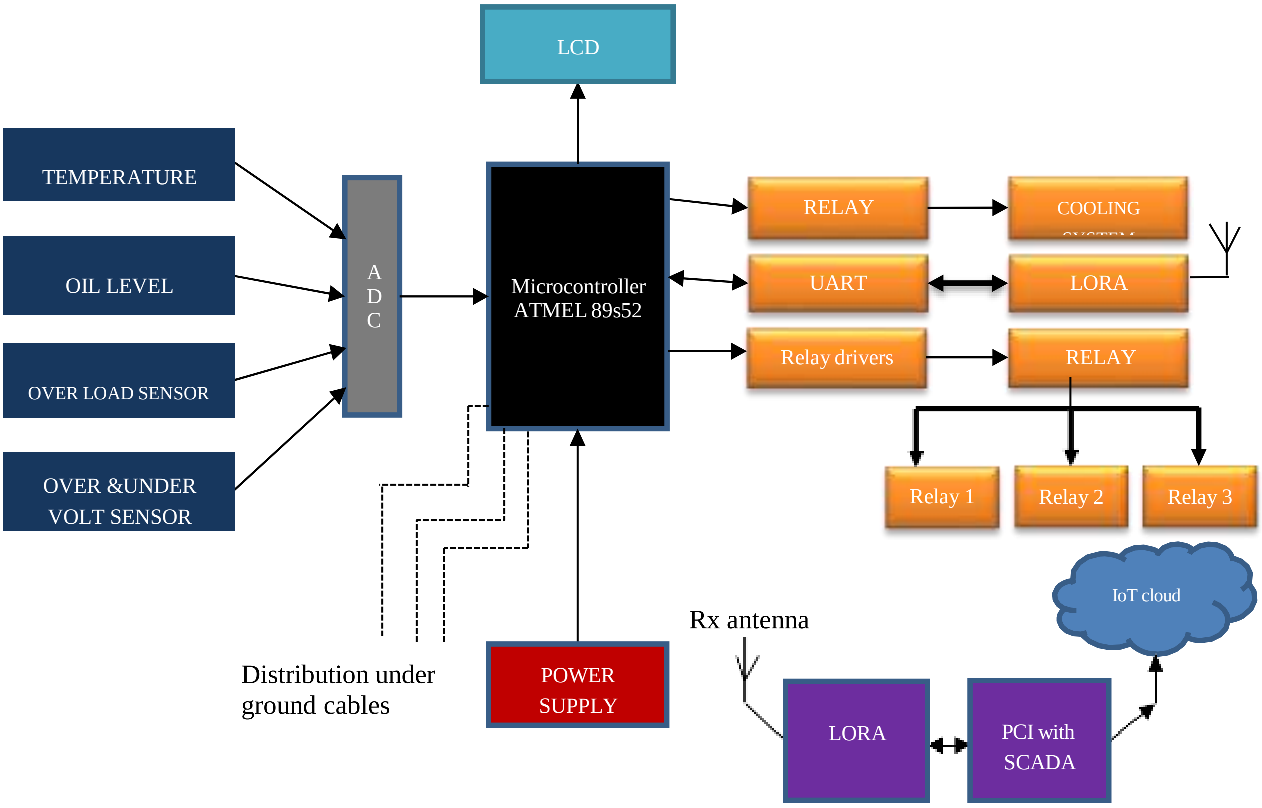

Fig 5. Block diagram of the project

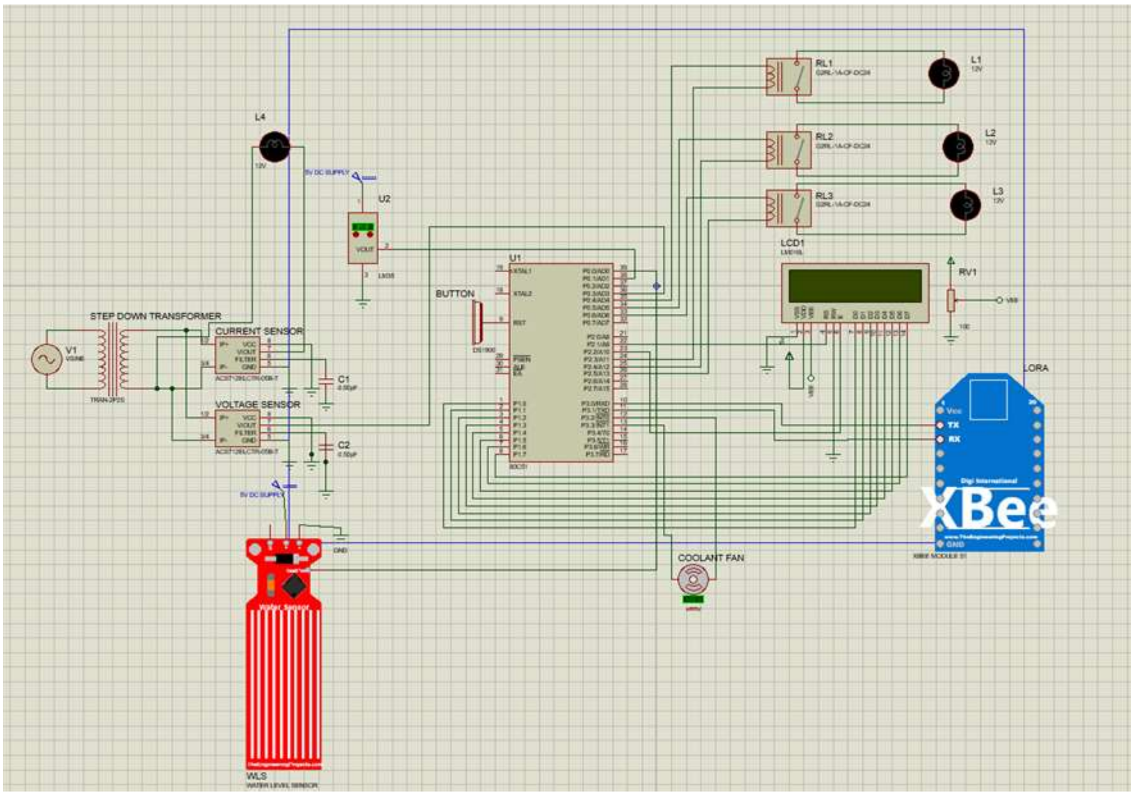

Fig 6. Circuit Diagram

5) Relay

Fig 7. 2 Relay Card

An electrical switch of this kind is a relay. When electricity passes through the relay coil, a magnetic field is produced that attracts a lever and modifies the switch contacts. Relays are double throw (changeover) switches with two switch positions since the coil current can be either on or off.

Relays are electrical switches that allow a low-power signal to control a high-power circuit. They consist of an electromechanical mechanism that opens and closes a switch when an electrical signal is applied. This allows a circuit to control another circuit that is electrically isolated and can handle a different voltage, current, or type of load. Relays are commonly used in automation systems, control panels, motor control circuits, and many other applications where a low- power signal needs to control a high-power circuit. This is a 2- channel, 5-volt, 10-ampere interface board for relays. Many appliances and other high-current machinery can be controlled by it. Direct control from 3.3V or 5V logic signals from a microcontroller is possible. Relays are commonly used to switch high power and high voltage circuits using low power control signals from microcontrollers or other electronic devices. For example, a relay may be used to switch a 230V AC mains circuit using a low voltage battery circuit. The relay's coil is connected mechanically and magnetically to the second circuit, with no direct electrical connection. To activate the relay coil, a current of typically 30mA for a 12V relay, but up to 100mA for relays designed for lower voltages, is required. As most integrated circuits (ICs) are unable to provide this level of current, a transistor is usually used to amplify the small IC current to the higher current needed to energize the relay coil. However, some devices such as the

555 timer IC can directly power relay coils without amplification, since they have a maximum output current of up to 200mA. Relays can have many more sets of switch connections than the standard SPDT or DPDT configuration; for instance, relays with four sets of changeover contacts are frequently used. The majority of relays are made to be mounted on a PCB, but if you take care not to melt the plastic casing, you may connect wires straight to the pins.

6) Current Sensor

Fig 8. Current Sensor

The single-phase ac current sensor modules in the 5A range have an analogue output of 5A/5mA and can measure alternating current currents less than 5A. It can execute a variety of tasks, including precise signal sampling and suitable compensation, thanks to an integrated sampling resistor and a precision micro current transformer. The module has a 5A current measurement range and allows for adjustment of the output analogue amount. When current flows through a conductor, a magnetic field is produced around it, in accordance with Ampere's law. The strength of the magnetic field is directly proportional to the current flowing through the conductor. Similarly, when a magnetic field changes around a conductor, a voltage is induced in the conductor, according to Faraday's law of electromagnetic induction. These phenomena are the basis for many electrical devices and principles, including transformers, motors, generators, and electromagnetic interference (EMI). Current sensors are developed to take use of both of these phenomena. An appropriate form for a measuring and/or control system is then created by using the generated magnetic field to produce proportionate voltage or current.

7) LCD

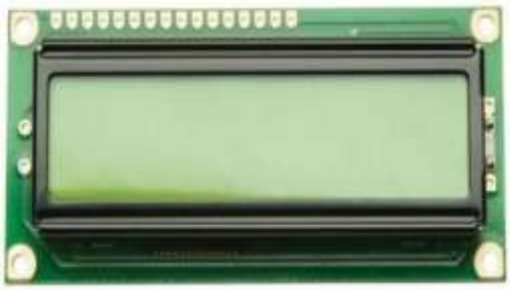

Fig 9. LCD

This straightforward alphanumeric display features two lines and 16 characters, all written in black on a green background. The commonly used HD44780 parallel interface chipset is utilized. Access to the interface code is unrestricted. This LCD screen has to be interfaced with using at least 6 universal I/O pins. There is an integrated LED backlight. Both the 4bit and 8bit variants work.

There are many applications for electronic display modules, sometimes known as LCD (Liquid Crystal Display) screens. A 16x2 LCD display module is a liquid crystal display with a grid of 16 horizontal and 2 vertical rows of characters. Each character is made up of a 5x8 pixel matrix, and can display alphanumeric characters, symbols, and custom characters. The display is controlled by a microcontroller through a parallel interface, and typically requires only a few pins to communicate with.

These displays are commonly used in a variety of devices, including digital clocks, calculators, thermometers, and other measurement devices. They offer several advantages over multi-segment LEDs, including better readability, higher resolution, and lower power consumption. The following are the causes for this: LCDs are accessible, simple to program, and unrestricted in their ability to display distinctive and even custom characters, animations, and other components (unlike with seven segments). Two lines with a total of 16 characters each make up a 16x2 LCD. The command register and data register in a 16x2 LCD display are responsible for controlling the display's behavior and showing information on the screen. The command register stores the instructions that control the behavior of the LCD, such as clearing the screen or setting the cursor location. The data register stores the actual data that will be displayed on the screen, including characters, symbols, and other graphical elements. Each character on the LCD is represented by a 5x7 pixel matrix, which can be individually controlled and manipulated by sending commands and data to the LCD module.

8) LoRa

Fig 10. LoRa

Long-range radio communication, or LoRa, is a type of physical radio communication. It is based on chirp spread spectrum (CSS) and spread spectrum modulation (SSM) technologies. Lora WAN specifies both the system architecture and the communication protocol. ITU-T Y.4480, often known as Lora WAN, is a standard for the organization (ITU). LoRaWAN is a wireless WAN (Wide Area Network) protocol that enables long-range, low-power communication between IoT devices. It is designed to operate in the sub-gigahertz frequency bands and allows for long-range communication with low power consumption. The LoRa Alliance is an open, non-profit association of members who are committed to developing and promoting the LoRaWAN protocol as a global standard for IoT networks. Semtech is one of the founding members of the LoRa Alliance and is a key supplier of LoRa technology. A channel's Lora WAN data rate might be anything from 0.3 and 50 kbit/s. We are employing the NRL24L01 insteadof LoRa for our suggested system since model experiments might differ from real-time experiments. Zigbee NRL24L01 is therefore used for this suggested one. The NRL24L01 data modem has automated receive/transmit mode switching, LED indication, and half-duplex operation at 2.4 GHz. It seems like you are describing a wireless communication module that can be used to send and receive data through a serial port or similar device. The module operates at a variable baud rate of 9600/4800/38400/19200 bps and uses the RS232 level for serial communication. It can be used with other 2.4 Ghz Sensor embedded models (TTL, 30 metre range) or with the NRL24L01 modem for two-way wireless data transmission with a higher data rate and greater transmission distance. The communication protocol is self- contained and transparent to the user interface, making it easy to integrate into existing designs.

A. Software Components

KEIL C**:** The Keil C51 C Compiler for the 8051 microcontroller is the most widely used 8051 C compiler worldwide" may not be entirely accurate, as there are several other popular C compilers available for the 8051 microcontroller, including SDCC (Small Device C Compiler) and IAR Embedded Workbench. However, the Keil C51 compiler is a well-established and widely used compiler in the industry. Compared to other 8051 C compilers currently on the market, it has more functionality. The Keil C51 C Compiler allows developers to write programs for 8051 microcontrollers in C language, which can be compiled to generate machine code with performance comparable to that of assembly language. The compiler also provides language extensions that enable developers to access all the resources of the 8051 microcontroller. This makes it easier and faster to develop embedded applications for the 8051 microcontroller. The C51 Compiler creates relocatable object modules that contain symbolic information which can be used for debugging. The symbolic information includes function names, variable names, and other information that can help with the debugging process. The Vision Debugger or an in-circuit emulator can be used to debug the code by setting breakpoints, examining variables, and stepping through the code. The compiler also creates a listing file, which, if requested, can contain symbol table and cross references data, in addition to the object file.

EMBEDDED C: Embedded C programming is used for programming microcontrollers and other embedded systems that have specific hardware constraints and requirements.

It is a variant of the C programming language that has been extended to include features that are useful for embedded systems programming, such as support for fixed-point arithmetic and direct access to hardware peripherals. The C Standards Committee created the Embedded C standard to provide a uniform set of language extensions for embedded systems programming. This standard includes features like named address spaces, support for fixed-point arithmetic, and direct hardware access through pointers. Embedded C programming includes all the standard features of the C language, such as the main() function, variable declarations, conditional expressions, loops, functions, arrays, strings, structures, and bit operations. However, it also includes additional features that are specific to embedded systems programming. Embedded C programming is often used for programming microcontrollers, which are small, specialized computers used in a variety of devices, including automotive systems, medical devices, and industrial control systems. It is also used for programming other embedded systems, such as digital signal processors and FPGA-based systems.

PROTEUS: The procedural programming language Proteus (Processor for Text Easy to Use) is fully working. Proteus is one of the richest languages for text manipulation since it combines many functions from other languages, such as C, BASIC, Assembly, and Clipper/dBase. It is very versatile when dealing with strings and has hundreds of methods only for that purpose.

Initially, Proteus was a DOS, Windows, and Unix system tool for modifying text and binary files and writing CGI scripts. Eventually, hundreds of specialized functions for network and serial connection, database querying, system service development, console programmes, keyboard emulation, and ISAPI scripting were added to the language to make it more Windows-oriented (for IIS

SCADA: SCADA (Supervisory Control and Data Acquisition) systems are used in various industries to monitor and control remote operations. They typically consist of hardware components such as sensors, controllers, and communication devices, as well as software components such as the SCADA server, human-machine interface (HMI), and data storage and analysis systems. SCADA systems collect data from sensors and other devices in real time and send it to the SCADA server for analysis and display on the HMI. Operators can then use the HMI to control and monitor the industrial process remotely. SCADA systems also provide logging and reporting features to help operators analyze performance and troubleshoot issues.

B. Flow Chart

A flow chart is a graphical representation of a process that shows the various steps involved in that process. It typically uses different shapes and symbols to represent different types of actions or decisions, with arrows indicating the flow of information or materials between them. Flow charts can be used to describe the working of a system, such as a software program, a manufacturing process, or a business workflow, in a clear and visual manner. The below flow chart represents the transformer health monitoring system.

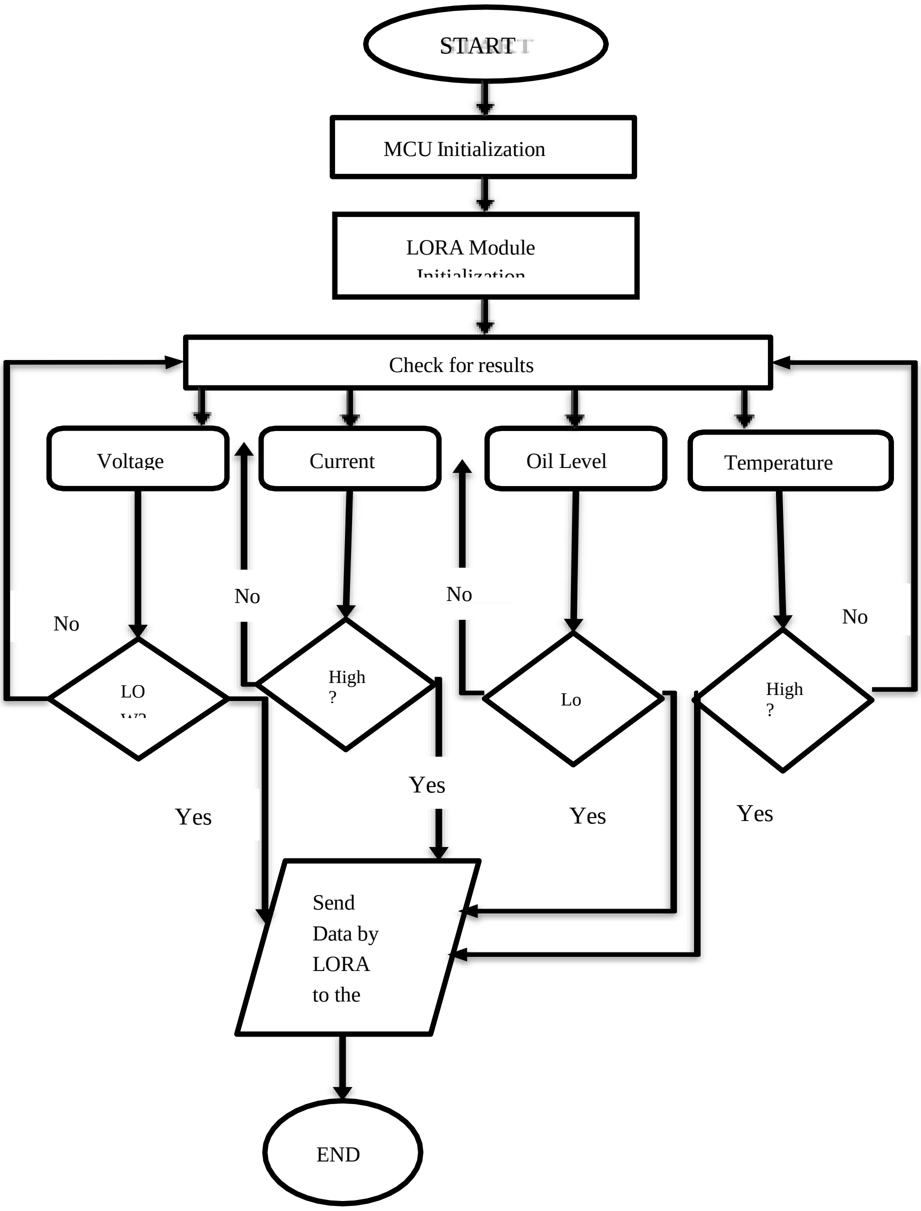

Fig 11. Flow Chart for transformer health monitoring

The below flow chart represents the fault identification in underground power transmission line.

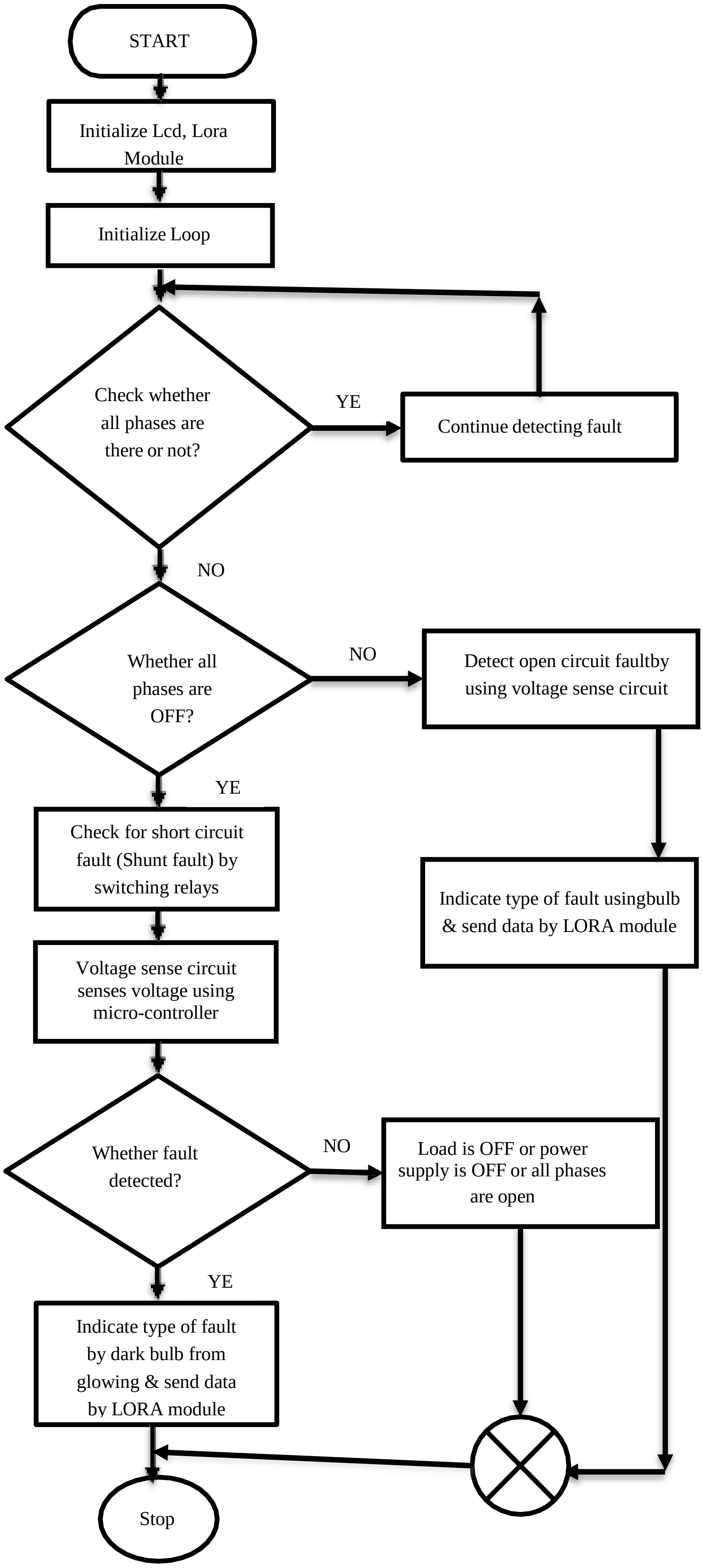

Fig 12. Flow Chart for fault detection

4. RESULT AND ANALYSIS

The proposed system monitors the parameters and displays the data on the LCD screen and parallelly detection of fault in the underground cable also occurred and sends the data within fraction of seconds through LoRa technology and it can be visualized by SCADA. This helps the operators to locate the fault precisely and send the service man to exact location of failure or damaged cable to clear the fault and restore the power system back into service. This system is mainly applicable for identify the exact location of fault instead of dig the whole line sand or any obstacles. The data for every phase can also be recorded for every several period of time and can be used for monitoring. Behaviors of the transmission network for various zones can be supervised with greater extension is achieved.

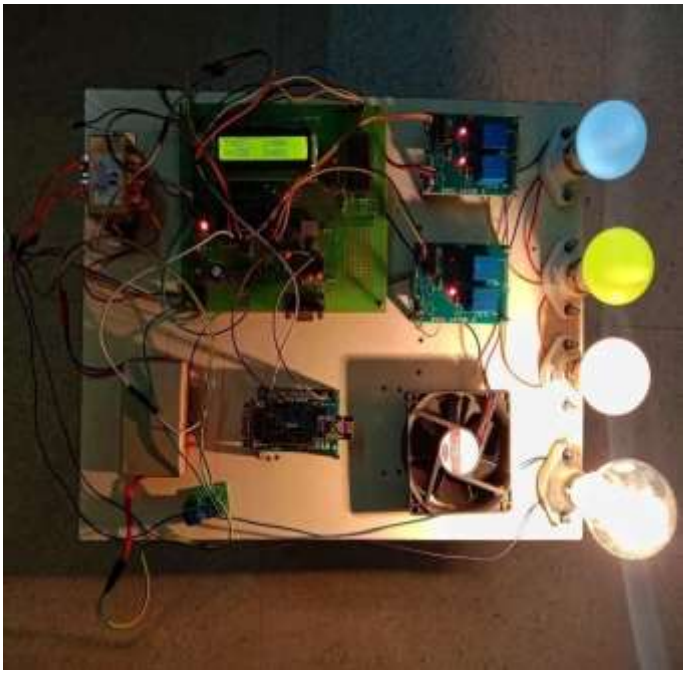

Fig 13. Project Setup

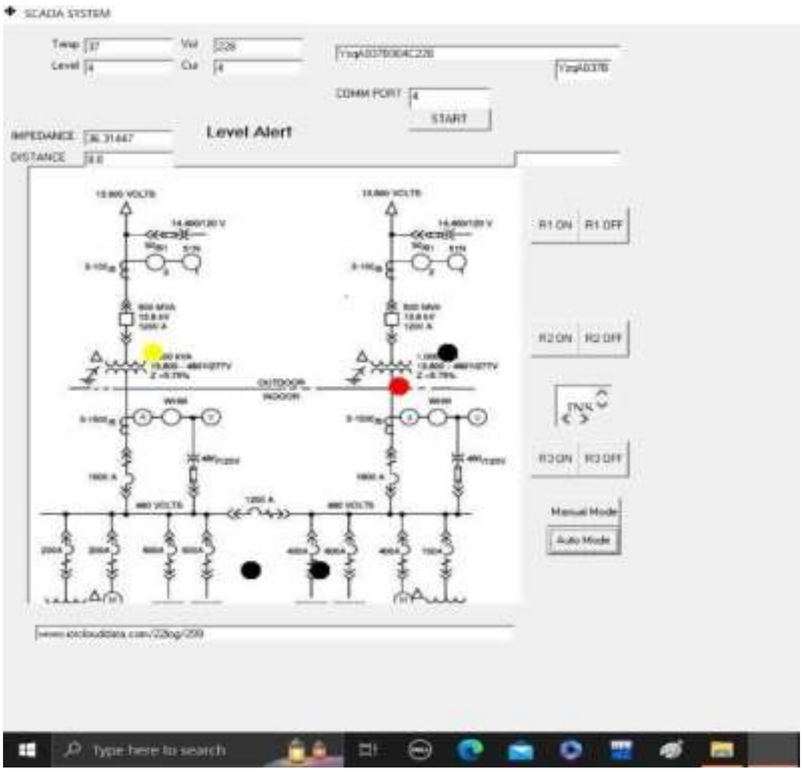

Fig 14. SCADA Output

Fig 15. Mobile IOT Webpage

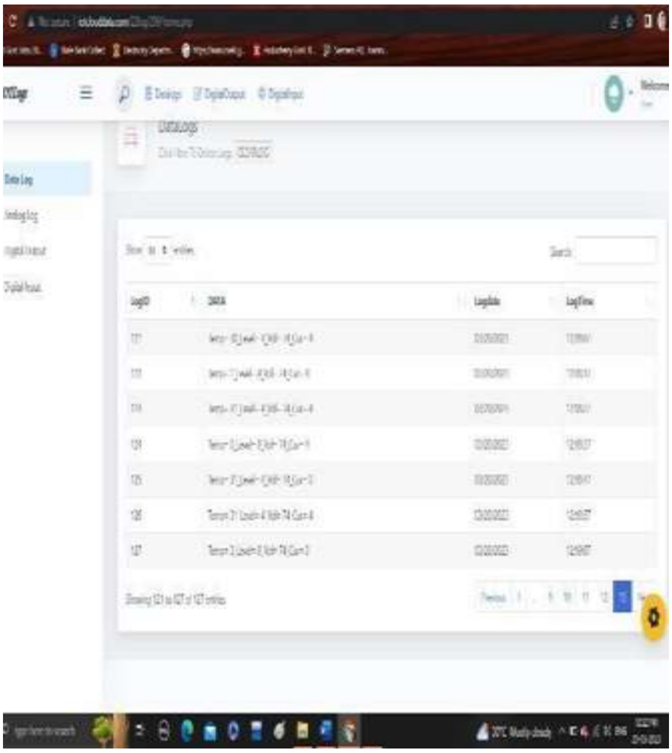

Fig 16. PC IOT Webpage

5. CONCLUSION

This work suggests the monitoring the health parameters and spot the location of fault in the transmission cables over the distances. The implementation of LoRa system will enhance the speed of locating the zone of fault occurring. Utilization of this system provides greater efficiency, conveys the detection of fault occurring areas within few seconds. This reduces the time consumption so that occurring of fault can be rectified as soon as possible. The proposed system outperforms the existing schemes in terms of accuracy, predicting the fault in zone. The fault detection and monitoring the health parameters in the transformer can be done far better than the existing system. This work will provides the control Centre for identifying the fault zones and monitoring the health parameters using the LoRa technology.

6. FUTURE SCOPE

In future scope the technologies would get more upgraded with IoT and LoRa in a effective and efficient way to emerge the technologies in a power distribution transformer for detection of fault in transmission line which leads to enrich the faster identification of occurrence of zone. We hope that the implementation of this project tends to more advancement of the future and provide more easier way to convey the zone of fault occurrence in the transmission lines at the same time monitoring the health parameters.

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