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IoT based Underground Cable Fault Detection System

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Abstract: ***Any distribution network is probably going to urge faults, on and off the supplier likewise as user. During the event of any fault, the event goes unreported for long length of your time. Manual reporting can result in long interruption; it may take lot of time. To beat the issue, a model is built that finds the variations in voltage values, with the utilization of a circuit based on micro controller. The faults are often classified supported comparison between the values received from rated guidelines of the distribution side power lines. Whenever the present line is failed, the micro controller instantly initiates a message to the concerned person accordingly the control node expressing the specific road area where deficiency is occurring. A significant motivation behind identifying issue in real time is to protect the transformer at the soonest. The framework is planned to identify the place of issue in underground transmission network from the source place in terms of kms, to locate the failure spot, the link should be tried and tested for flaws. At whatever point the defect happens in underground cable network, it's very complex to identify the specific area of where the issue occurred and procedure of fixing that specific cable, so this framework provides an easiest way to identify the fault with the utilization of the facilities and factors provided in the field of IoT. The fault is calculated based on the voltage drop through the cables and Arduino microcontroller catches this information, then the distance is found and displayed on the LCD and the same information as an alert message is sent to the control station using GSM module. Some basic rules of electronics such as voltage divider rule and resistance rule are playing major role in this paper.***
Keyword: Underground cable, IoT, GSM, and Fault Location.

I. INTRODUCTION

Indian National grid is the electricity transmission network for high voltage. The present Indian grid has power transmission and distribution lines, to transmit electricity through an overhead cable (transmission line) by towers/poles. Electricity transmission networks are developing persistently and their unwavering quality getting more significant than any other time in recent days. The underground cables are used for longer duration of time for supplying lesser and medium voltage. High voltage lines in the underground transmission lines are utilized increasingly more as they usually are not impacted for the cause of climate conditions, over rain, strong wind that is storm, snowfall or pollution in the environment. Despite the fact that the Cable assembling innovation is improving consistently, there are still impacts which may make link come up short during test and activity. Anyway cables can be effortlessly harmed by erroneous establishment or poor jointing, while resulting outsider harm by common works, for example, digging or control edging.

The overhead cables are replaced with underground cables for the transmission of electricity by the undergrounding method. Overhead cables are generally used as maximum of the insulation is provided by air and this reduces the amount of power transmission for huge quantities of electrical energy. The installation cost of overhead cables can be less but the operational cost is too large. But in case of undergrounding of electrical transmission lines, even though the initial cost is more the operational cost of the cables will reduce over the lifetime.

The linemen are to be ready during the days when failure occurs, to figure on the lines as fault may occur at any point of your time for any cause. The most of the reason for the fault is either the low quality of conductors/cables used for transmission/distribution or electrical theft.

We might have been observed the negligence of power lines handled by the electricity department or by some linemen. When the fault is occurred due to the civil works on the road causes breakage, then the fault is cleared just by twisting lines rather than providing a joint.

In some situations, the conductors are required to get replaced with the new ones during fault, at that point the inferiority conductors are placed, this might cause fault in future.

Techniques to spot the precise location of fault on the road are possible as they can be seen to the bare eyes and we can find the specific distance where the flaw has occurred and so it can then easily repair it within less time.

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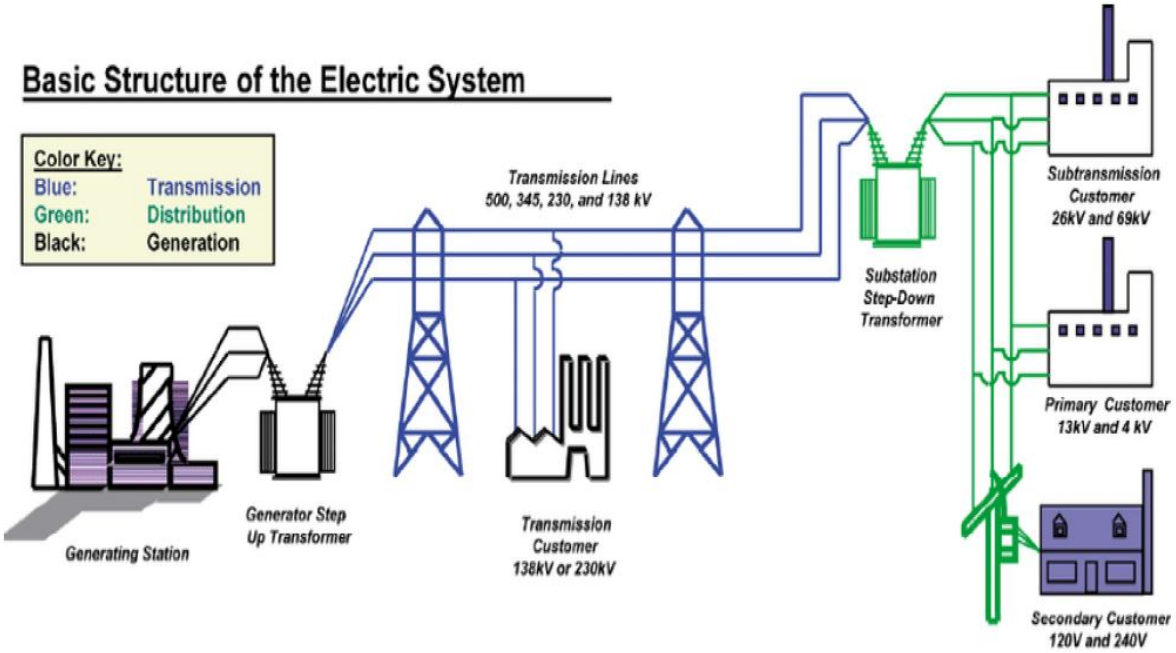

Fig 1: Basic Structure of the Electric system

The system needs to be investigated for the electrical theft in the supply lines and so at the distribution lines and at feeders. This can be really not an easily handled straightforward work. It will be a good choice of an undergrounding, if we want a replacement of the system. The electrical accident may happen either while performing a work on the lines or unidentified broken lines laid on the bottom. The death rate of electrical accidents may be reduced by proper installation of undergrounding of cables.

Fig 2: Underground cable laying

However, the undergrounding of cables can be constructed, during that time each and every materials used for construction and for all the requirements including the manhole utmost care needs to be taken. If the entire system is constructed with high quality materials and with all positive intension, then this system will work for a longer duration of time and it lives healthy for an extended period of your time.

The long term India with underground electric power lines will avoids electrical theft, reduces the interruption of power supply to the patron, reduced cost requirement of maintenance, enlarges the sweetness of the state, reduces the death rate of electrical accidents, it also acts as a step to be a developed nation.

Process of finding the flaws periodically will be defined as fault identification. The damage to the line or conductor of power transmission is called by name line faults and this is due to its effect on its resistance. If permitted for tolerance it will results in breakdown of voltage.

The various kinds of cable faults can occur and it depends on the reason of the fault. So first they should be categorized before it is cleared. For this the important action is of the insulation of the conductor. Whereas some kind of cables are at high risk because of effect of thermal effects from external sources and also of the chemical reaction, and such effects can be seen generally in high-voltage cables, in those affected part is the conductor's insulation. Finding the underground cable are often a posh job, it is even tougher task because the underground plant is static and it is fixed.

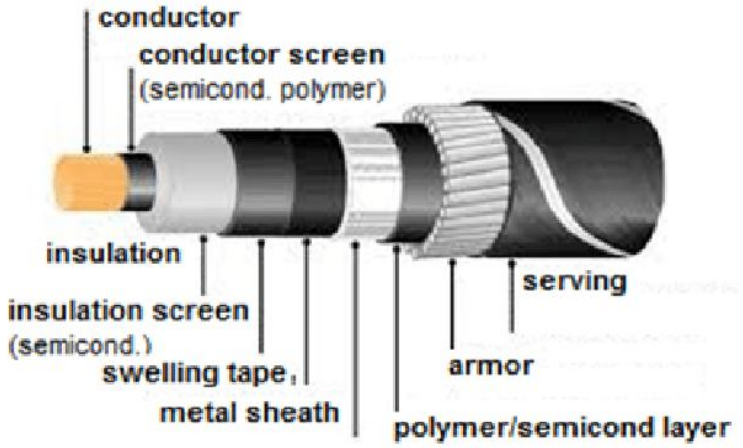

Fig 3: Arrangement of a multi core power cable

A. Existing System

In general, fault location techniques for underground cable network can be categorized in two groups:

1) *Tracer Technique:* In this strategy the fault can be found by walking on the network of cable connection installed i.e. path of the cable lines. Damage or failure location is represented by an audible sound or electromagnetic signal. Using this method the flaw location can be exactly found.
2) *Terminal Technique:* In this strategy flaw is found at the ends of the cable lines either at the one end or at the both ends without checking all along its path like in tracer strategy. This sort of technique is very much useful to seek out common fields of the flaw to speed up the trace on buried lines.

Tracer Technique

Terminal Technique

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Underground links are prone to different issues due to the environment under the ground, tare, rodents and so many such conditions. Diagnosing the base reason of the failure is difficult and then, to check and repair, the entire whole cable has to take out starting from the feeder end.

Wherever the failure occurs the task of identifying and correcting it in the underground links is quite difficult and the expense needed to achieve this task is also more.

So there is a need of framework, to discover a way which makes simpler to locate the underground cable faults and empower to fix them at the earliest opportunity.

The framework is planned to identify the place of issue in underground transmission network from the source place in terms of kms, to locate the failure spot the link should be tried and tested for flaws. At whatever point the defect happens in underground cable network, it's very complex to identify the specific area of where the issue occurred and procedure of fixing that specific cable as we need more labour effort and time in tracer technique and it is quite impossible to know the exact location in case of terminal technique.

B. Disadvantages of Existing System

1) The main problem in the current system is the implementation of the underground lines for power transmission is expensive and if failure happens it will be difficult to identify it and repair it as it is invisible to the bare eyes due to the reason that they are installed under the ground.
2) The time and cost of finding the fault is more.
3) The approached framework is an IOT empowered system of underground line failure location identifier. The fundamental rule based this framework is Ohm's law. At the event when failure happens in the conductor, the voltage which is utilized to locate the flaw distance drops. The framework contains Microcontroller, GSM, relays & resistor-switch arrangement.

C. Proposed system

The fundamental target of this approach is, any transmission network is likely to urge failures. If any failure occurs at some point, the situation may not be reported for longer duration of time. Detecting it manually may take lot of time. To beat the issue, a model is built that finds the variations in voltage values, with the utilization of a circuit based on microcontroller. At whatever point the preset cable is crossed, the microcontroller in a span of seconds starts a message to the concerned person and accordingly the control node expressing the specific road area where deficiency is occurring. A significant motivation behind identifying issue continuously is to protect the transformer at the soonest.

D. Advantage of Proposed System

These are explicit preferences of the proposed framework contrasted with the current strategies once being used:

1) Fault identification and location will be an on-line process since it will be conceivable to find faults on empowered lines.
2) Result understanding is simple and straight forward not at all like TDR whose screen shows are uncomfortable to be deciphered by laypeople.
3) The general expense of buying and introducing the framework will be lower than the case with the current strategies.
4) Easily find the underground link flaw where it has happened.

E. Applications

1) The identification of the flaw in the underground line connection is too hard to even think about detecting since it is absurd to expect to work out issues like line to line and other such flaws which are possible in the instance of overhead line.
2) This display of underground cable fault distance may well be employed in underground power transmission for tracing the precise fault location and distance.
3) The underground links are utilized for power applications where it's troublesome, unreasonable, and in any case risky to use the overhead lines.
4) They're widely utilized in highly involved urban territories, in power plants, and to deliver power to the buyers.

II. LITERATURE SURVEY

In this paper [1] it is proposed that, after the detection of instance of deficiency inside the underground cable, the microcontroller cautions the client remotely through the IOT. The event of fault occurrence up to a predefined distance is regularly explored through this proposed framework. The flaw finder in this methodology gauges the current and voltage of underground cable and if there is any high contrast among voltages and current happens at the two terminals of issue identifier then locator will alerts the client remotely without going close [1].

Nowadays a significant number of the nations are settling on underground links rather than overhead links for transmission because of the lots and lots of its advantages over overhead links. The most difficult issue with the underground cables is finding the distance of the flaw in the lines during the event of failure as they are laid under the ground. This task assists with recognizing the sort of flaw just as its area. By utilizing GSM, we can able to get the fault distance by sending the information as a text message format to the respective person using GSM [2].

This venture utilizes the basic theory behind the ohm's law. At any point the flaw like short out happens, voltage drops depending upon the length of flaw in link. A set of series arrangement of resistors are implemented as a link and some power supply in the form of DC voltage will be provided at one end and the flaw distance is found by recognizing the voltage change utilizing a ADC and a microcontroller is utilized to make the fundamental counts hence the flaw separation is shown on the LCD. Thereby the fault distance is found and it is printed on the LCD. The flaws and the reason for the flaws in the underground cable network for transmission is complicate thing as it can be seen barely and so we need to dig the ground and need to check the entire network to find the place of failure. That's why there is a need of an approach to overcome from this issue thus this paper presents the idea towards this issue [3].

In this manner, the essential idea of Ohm's law is discovered appropriate on a fundamental level to build up a flaw area following framework. In view of the Ohm's Law, it is discovered that the link's resistivity is relative to its length under consistent states of temperature and the area of its cross section and in this manner if a small power is given at the supply point by using the resistor connected in series, the current would differs w.r.t. the area of deficiency in the link. Here a framework is created which comprises of a microcontroller, LCD, Fault Circuit, Wi-Fi Module and regulated power supply with balanced power yield. The proposed framework gives the actual place of the failure in the underground lines [4].

This proposed system finds the exact location of the fault. The prototype is modeled with a set of resistors representing cable length in km and fault creation is made by a set of switches at every known distance to cross check the accuracy of the same. In case of fault, the voltage across series resistors change accordingly, which is then fed to an ADC to develop precise digital data to a programmed PIC IC that further displaysfault location in distance. The fault occuring distance, phase, and time is displayed on a 16x2 LCD interfaced with the microcontroller. IOT is used to display the information over internet using Wi-Fi module ESP8266. A webpage is created using HTML coding and the information about occurrence of fault is displayed in a webpage [5].

III. METHODOLOGY

The Module descriptions of the methodology is as follows:

A. Supply Part

It is an electronic unit which is employed to relinquish regulated power supply to any electronic system. The parts/blocks which form the provision part are:

1) Transformer
2) Bridge rectifier
3) Voltage regulator

Bridge rectifier

7805 voltage regulator

B. Controller Part

Arduino is open source and single board architecture microcontrollers. Arduino Uno is used to produce display according to fault by executing program loaded into it.

Arduino UNO board

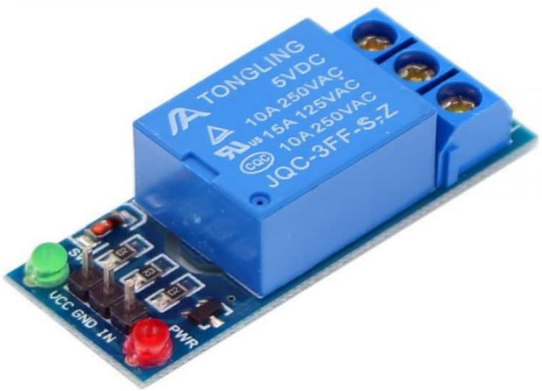
C. Fault Switches

1) *Cable Line:* The circuit is ready employing a set of resistors arranged in an exceedingly row in serial manner. A row of 4 resistors represent the cable line. That row is scanned through a relay for any fault occurrence.

Push button or switch

Resistor

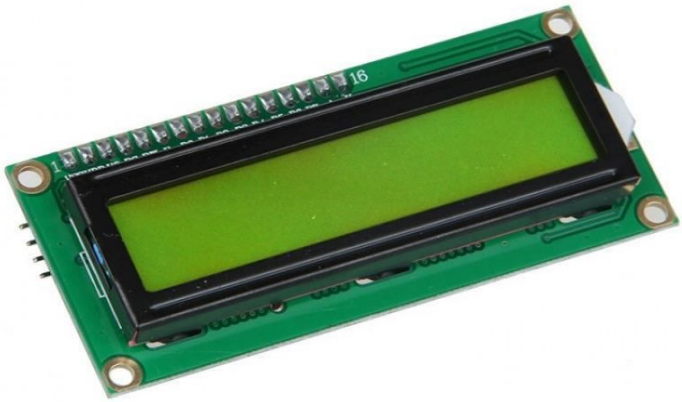
2) *Relay:* A relay can operated electrically and it can be utilized like a switch and it can also utilized in a circuit. Relays were broadly utilized in phone ex-changes and early PCs. To shield electrical circuits from over-burden, relays with adjusted working attributes are utilized. They're called as protective relays.



Relay board

D. Display Part

1) *LCD Display:* This block consists of double line and sixteen character LCD display. LCD stands for liquid Display. It consists of 16 pins within which there are 8 data lines. Four data lines are used for displaying a line. It will display the message comparable to the fault occurrence. The controller gives output characters to print the message on the screen of the display. The contrast LED+ will be given +5V to glow brightly. If the LED+ is grounded, then the message or text is displayed with low brightness which is enough visible.



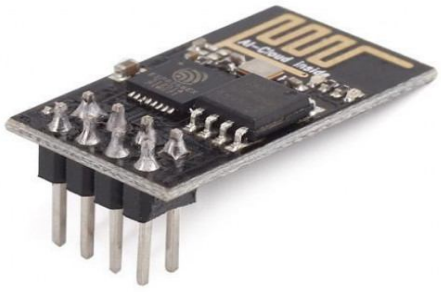
16*2 LCD display

2) *GSM:* A GSM module is utilized to build a communication between a cell phone/PC and a GSM framework. Commands like instructions are used to make GSM to cooperate with microcontroller. The microcontroller send these commands.

GSM module

E. Internet Part

1) *Esp8266 Wi-Fi Module:* This is the module which is used to connect to the internet and using this we can able to send the data collected from the thing to the dedicated server or webpage. In this approach the collected data is sent to the Thingspeak, in this we can able to get the data stored and we can also monitor in real time.

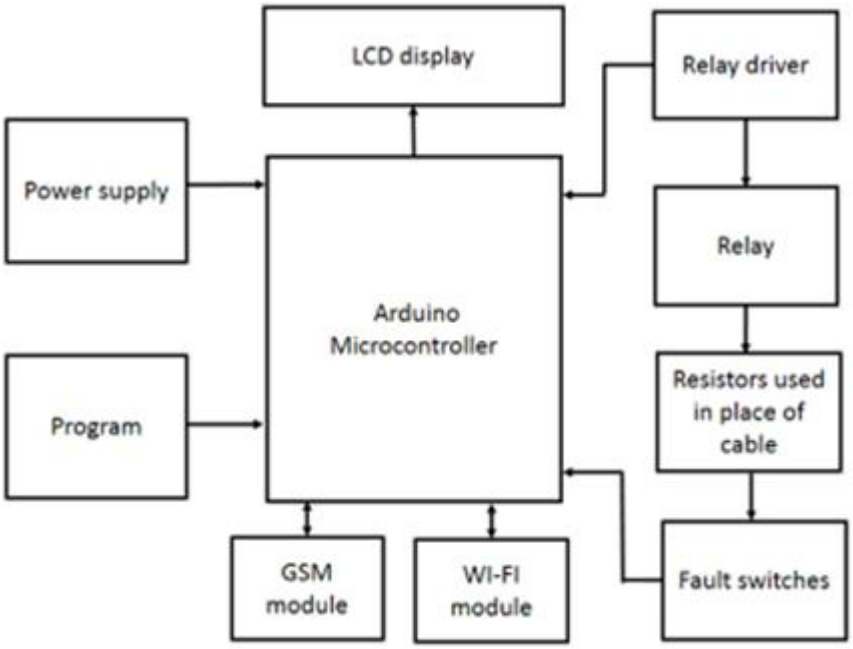


ESP8266 Wi-Fi module

2) *Thingspeak:* ThingSpeak is an open-source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates.

ThingSpeak: IoT Platform

The system Architecture is shown below:



System Architecture

The above figure depicts the block diagram of the approach. In this approach the work is about designing to realize observation of underground lines and to supply details about recognized fault. The first thing to describe is about the power supply. Here first 230 voltage supply will be stepped down to 12 volts that to AC utilizing a transformer. This can be then changed over to DC utilizing bridge rectifier. Then it is send to the voltage regulator and this will filter the noise or variations or ripples in the AC. the resulting voltage from this regulator is 5V which is given to the Arduino controller and to the other chips used in the project. If any fault occurs that will be detected by the microcontroller i.e., Arduino board and convert the analog to the digital value. Controller receives this signal and analyze it and initiates the GSM module to make it to send the data to concerned individual in the event of any fault occurs. Coming to the transmitting segment, the voltage drop is given to the controller which is inbuilt in arduino. This can be consists of a 16-bit Analog to Digital converter. The 16-bit ADC transforms the voltage which is received from the switch-resistor arrangement to digital valued signal. The controller then makes required calculations to find the fault location.

At that point this information is transmitted to the receiving segment. The receiver is the display it prints the distance of the link and link status at each phase. The corresponding voltage changes used to find the flaw area and the same message will be informed to the respective department using GSM. The block diagram consists of following units.

a) *Power Supply*: The power supply block of this approach contains transformer, rectifier and the regulator components. All these in implementation are built inside an adapter and we all just need to plug the pin of the adapter to the controller. Transformer here works as a step down transformer, and converts the supply of 230V AC stepping it down to 12V AC. Then the output is given to the rectifier here in this the 12V of AC power supply is converted to the Direct Current Voltage supply that is DC and then the resulted voltage is given to the regulator to remove the variations and to produce constant DC voltage.

b) *Arduino*: Arduino microcontroller and arduino IDE (which is used to write the instructions, compile and then upload it to the board) are used in the process of developing this project. We just need to USB cable to connect the board to the IDE which is running on our computer to load our code.

c) *Relay*: These are like switches that can open the circuits and can close the circuits in in electromechanical or electronically manner.

d) One electrical circuit is controlled by another circuit by open or close the links by the use of relays. Relays has two states normally open and normally close. These can control higher voltages & amplifying the voltage by giving smaller voltage as input. By identifying the electrical abnormalities including over current, undercurrent whatever the damage can happen to the equipment, it can be prevented by the use of protective relays. In addition to these, the relays have more and more number of applications in electrical field.

e) *LCD*: Liquid crystal display is used to display the message which is sent from the microcontroller in short it can be said like it is used to interface with the microcontroller. The generally used LCDs are 16*2 displays. In this, the quantities 16 means 16 columns and 2 means a pair of rows. LCDs are utilized to display words and digits also.

f) *Resistor*: The set of resistors are connected sequentially to represent cable of particular length. Each resistor represents the cable of length of 2km line. In total 3 set of 4 resistors are used in this project. So the length of 8km cable is under monitoring here.

g) *Fault switches:* The switches are used here to induce the fault to the cable within some distance. Each switch is placed at every 2km distance of the cable and it means the pressing of switch creates a fault at any point within that distance. 4 switches are used per cable or per phase in total 3 set of 4 switches are used in the approach.

h) *GSM*: This is a module which is communicate with the controller and here it is used to send the message to the predefined phone number as and when the flaw in the underground cable occurs in any of the 3 phases, the alert message will be sent to the particular mobile number.

i) *Wi-Fi Module-ThingSpeak:* this module is used send the data from the system to the ThingSpeak which is an IoT tool used to store and analyze the data. ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. You can send data to ThingSpeak from your devices, create instant visualization of live data, and send alerts when fault occurs.

III. ALGORITHM

A. *Fault Location*

The circuit needs 12V of voltage to operate.

The circuit will work, and it has been administered with the assumption of a 3 lines which are represented by red, yellow and blue phases. In general the resistance of a conductor without fault and with fault are different. Keeping this thought and characteristic of a cable in mind resistors were utilised as a cable and push buttons i.e., switches were used as to induce the faults. When a fault (induced from the switches) occurs the flow of voltage through the cable changes and with the support of Resistance Rule principle, the distance is found as the failure in the conductor changes the resistivity of it. So 4 resistors are used for representing each phase and each resistor serve as a cable length of 2 kilometres and so the highest length under consideration is 8km

With the use of the voltage divider principle during the event of fault occurrence, the voltage supplied to the cable is divided by the switch at the separate location and transform this information to the Arduino. The Code for detecting this different voltage is written in Arduino IDE and this voltage value is detected as an analog signal from the built in ADC in Arduino. And this ADC changes the analog to digital value and this will be printed on the 16*2 LCD display module.

The relay drivers is used here to connect the conductors which are series of resistors here to the Arduino through its assistance. These drivers are connected to the 3 relays those are blue yellow and red. Each relays are scanned sequentially and each of them in turn scans the specific colored conductors. When there is no flaw in any conductor then the display shows as NF which means No Fault along with respective phase name, and when fault occurs it displays phase name with fault occurred distance in kms.

After that as soon as fault occurs the information displayed using LCD and the alert message is sent to the person who is responsible for the action using GSM as a text message. The Voltage divider rule says "The voltage is split between two resistors which are connected nonparallel in direct proportion to their resistance".
Then finally the data which is collected from the microcontroller is sent to the ThingSpeak and the using 3 different channel thus happens the monitoring of all three phases.

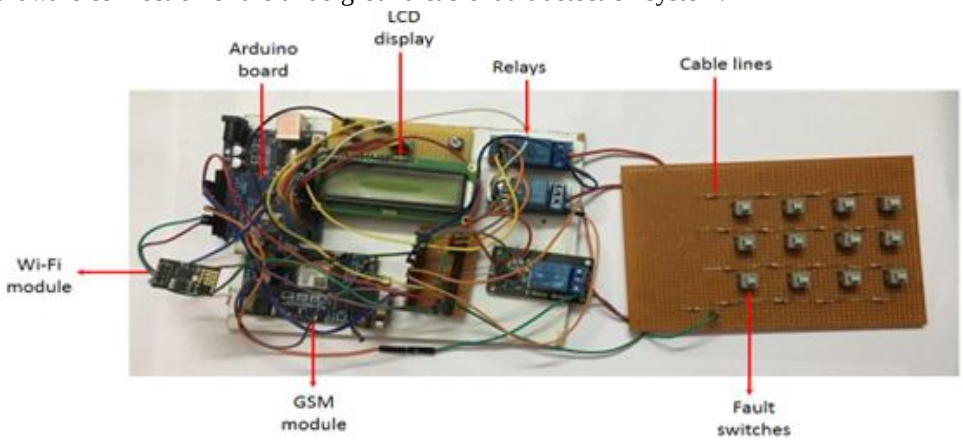
B. Algorithm for Finding Fault Location

1) *Step 1:* Include the mandatory header files.
2) *Step 2:* Configuring the microcontroller for reading the values.
3) *Step 3:* Configuring the system to convey data to the sender.
4) *Step 4:* ADC conversion is done and thereby find the situation of the fault.
5) *Step 5:* Find out the gap supported this voltage value.
6) *Step 6:* Return the result. Display it on LCD and send the fault location to mobile.
7) *Step 7:* Collected data is sent to the ThingSpeak using Wi-Fi module.

IV. EXPERIMENTAL RESULTS

The results of the system are shown below.

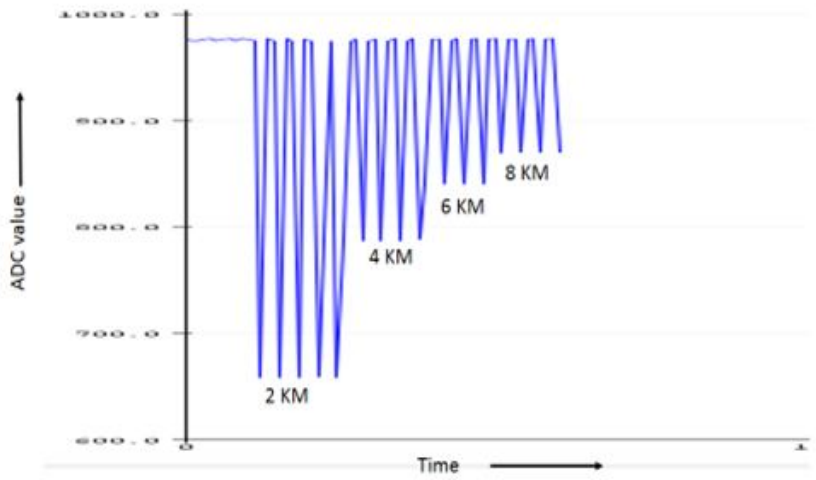
1) The complete hardware connection of the underground cable fault detection system.



2) LCD displaying NF when there is no fault at all the phases.

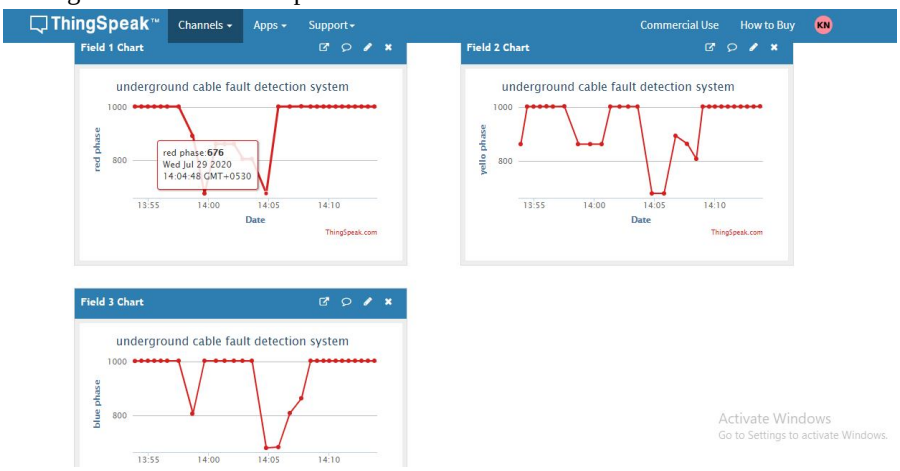
3) LCD displaying when fault occurs at particular distance at particular phase

4) Serial Plotter showing voltage drop values across the cable when fault occur in single line.

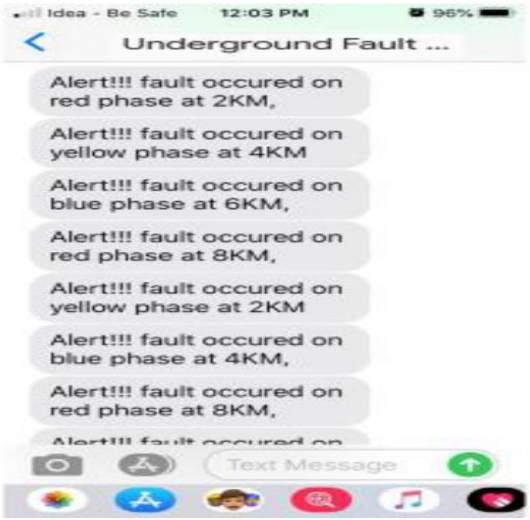


Voltage drop variations during fault occurrence

5) ThingSpeak showing the voltage variations in each phases.



6) The message sent to the concerned person's mobile as a text message.



7) Table showing voltage variations during fault occurrence.

Distance in KM	ADC value from Arduino	Voltage drop in Volts	Differential Voltage in Volts
2 KM	676	3.30	1.69
4 KM	806	3.93	1.06
6 KM	862	4.21	0.78
8 KM	893	4.36	0.63

V. CONCLUSION

In this task we can identify the area of deficiency inside the underground link from feeder end in km by utilizing Arduino utilizing idea of OHM's law, so issue might be effectively recognized and fixed. This task utilizes Ohms Law idea, when a power is applied to the feeder point through relays, at that point the supply would differ which upheld the situation of issue happened inside the line, just in the event that is there any short happened from line to ground, at that point the voltage across arrangement resistor changes as needs be, at that point it's taken care of ADC to create accurate information, which the pre-customized in the microcontroller will show in kilometres. The proposed framework is made with a series of resistor arrangement that represents the length of a conductor in kilometres, and furthermore the flaw creation is planned with an arrangement of switches placed each at known distance (kilometre) to cross check the precision of the distance. The flaw happened at the specific line is appeared on a display associated with a microcontroller.

VI. FUTURE ENHANCEMENT

The future enhancement will be, we can collect these data and store it in a database in a server and use this data for further analysis. And also we can include things like accessing this system from remote place with additional security. We can include security by creating user interface with login for the admin and other authorised people only. By using this technique, the user or supply company can easily get the fault location and distance at their work place through the dedicated website.

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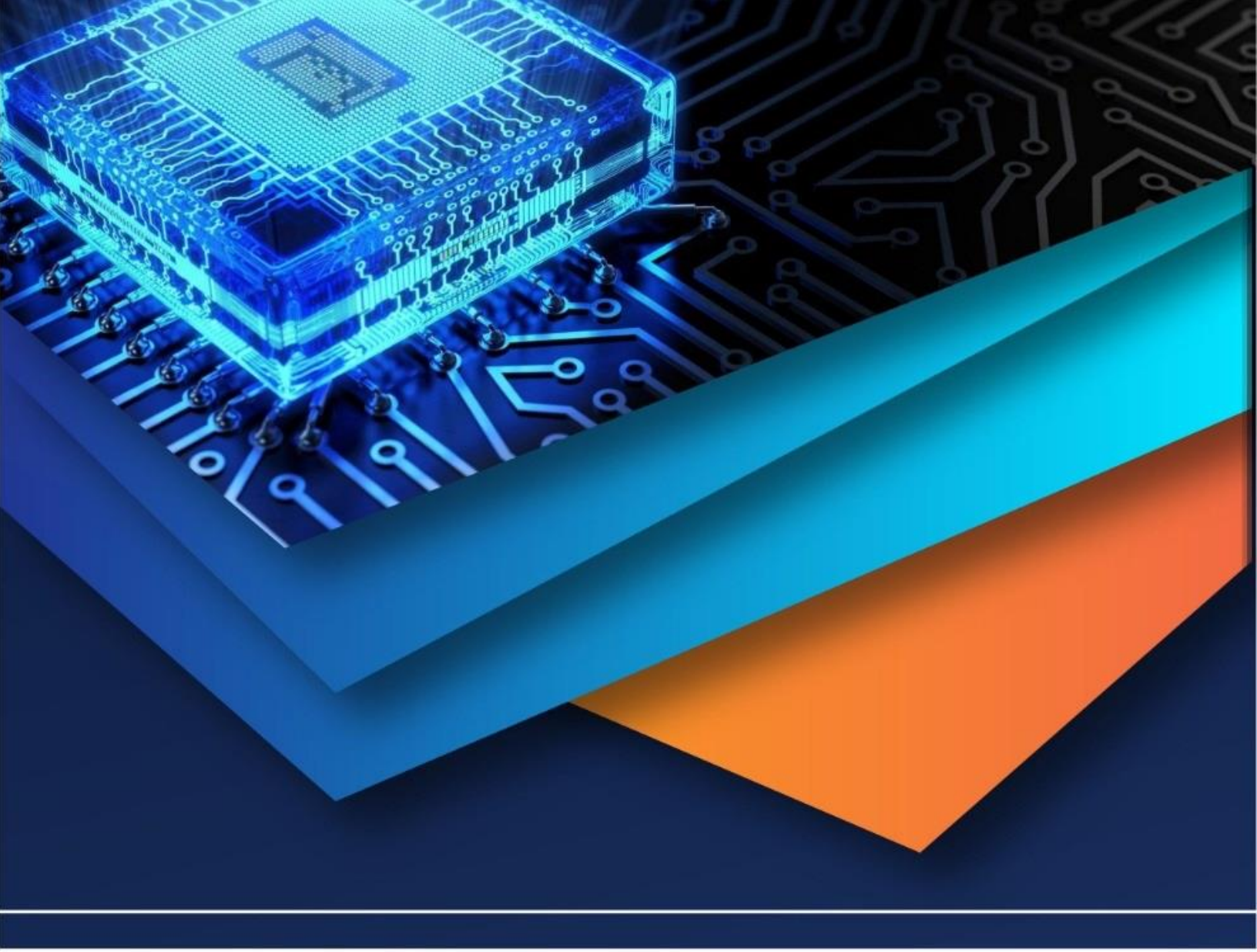

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