Simulation Of Underground Cable Fault Detection and Location

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Abstract - The main objective of this project is to detect the faults and abnormalities occurring in underground cables using an arduino .The basic idea behind the working of this project is ohms'slaw .At the feeder end ,when a DC voltage is applied, based on the location of fault in the cable ,the value of current also changes .So in case of a short circuit fault like L-G or L-L fault the change in voltage value measured across the resistor is then fed to the in-built ADC of the Arduino .This value is processed by the Arduino and the fault is calculated in terms of distance from the base station. This value is sent to the LCD interfaced to the Arduino board and it displays exact location of the fault from the base station in kilometers for all the three phases. This project is arranged with a set of resistors which represent the length of the cable. At every known kilometer fault switches are placed to induce faults manually. Finally, the fault distance can be determined.

1. INTRODUCTION

1.1 Introduction

An bundle of electrical conductors used for carrying electricity is called as a cable. An underground cable generally has one or more conductors covered with suitable insulation and a protective cover. Commonly used materials for insulation are varnished cambric or impregnated paper. Fault in a cable can be any defect or non-homogeneity that diverts the path of current or affects the performance of the cable. So it is necessary to correct the fault. Power Transmission can be done in both overhead as well as in underground cables. But unlike underground cables the overhead cables have the drawback of being easily prone to the effects of rainfall, snow, thunder, lightning etc. This requires cables with reliability, increased safety, ruggedness and greater service. So underground cables are preferred in many areas specially in urban places, when it is easy to detect and correct the faults in overhead line by mere observation, it is not possible to do so in an underground cable. As they are buried deep in the soil it is not easy to detect the abnormalities in them. Even when a fault is found to be present it is very difficult to detect the exact location of the fault. This leads to digging of the entire area to detect and correct the fault which in turn causes wastage of money and manpower. So, it is necessary to know the exact location of faults in the underground cables.

1.2 Motivation

Till the last decades, a million miles of cables are threaded in the air across the country. But currently, it is laid in the underground, which is larger than an earlier method. Because, underground cables are not affected by any adverse weather conditions like pollution, heavy rainfall, snow, and storm, etc. But, when any problem occurs in cable, it is very difficult to find the exact location of the fault due to not knowing the exact location of the cable. Day by day, the world is becoming digitized so the project is proposed to find the location of the fault in a digital way. When the fault occurs, the process of repairing related to that particular cable is very difficult.

To overcome this problem, here is a project namely an underground cable fault distance locator, used to find the location of the fault for underground cable.

1.3Objective:

- To detect the exact location of short circuit cable fault in the underground cables from the feeder end in km by using resistors and dc supply.
- To detect the exact location of open circuit cable fault in an underground cable from feeder end at any distance with respect to cable by using capacitors and ac supply.

2. Literature Survey

The problems faced by most electrical companies are detection of faults in underground cables. In underground electricity distribution systems, the cables used are placed in the ground or in some form of ducts. This makes the cables strong and the chances of faults in them are very little. Whenever there is a fault in these cables, it becomes difficult to locate and repair the fault as conductors are not visible. Needless to say, detecting these faults is a lot like finding a needle in a haystack. There are many methods to locate the faults along with new detection technology and electrical items, which makes the task easier and less time-consuming. However, do note that there is no single or a combination of methods to be considered as the "Best". There are different types of methods for different faults which make it safe and efficient to locate the faults without damaging the cable. The aim of this project is to determine the distance of underground cable fault from base station in Km.

2.1 FAULTS IN UNDERGROUND CABLES:

Generally, there are different types of faults. Frequently occurring faults are given below

1) Open Circuit Fault

2) Short Circuit Fault

3) Earth Fault

2.1.1 OPEN CIRCUIT FAULTS:

These faults occur due to the failure of one or more conductors. The most common causes of these faults include joint failures of cables and overhead lines, and failure of one or more phases of circuit breaker and also due to melting of a fuse or conductor in one or more phases. Open circuit faults are also called as series faults. These are unsymmetrical or unbalanced type of faults except three phase open fault.

2.1.2 SHORT CIRCUIT FAULTS:

A short circuit can be defined as an abnormal connection of very low impedance between two points of different potential, whether made intentionally or accidentally. These are the most common and severe kind of faults, resulting in the flow of abnormal high currents through the equipment or transmission lines. If these faults are allowed to persist even for a short period, it leads to the extensive damage to the equipment. Short circuit faults are also called as shunt faults. These faults are caused due to the insulation failure between phase conductors or between earth and phase conductors or both.

The various possible short circuit fault conditions include three phases to earth, phase to phase, single phase to earth, two phase to earth and phase to phase.

In single line to ground fault (L-G):

fault occurs between anyone of the three lines and the ground.

In double line to ground fault (LL-G):

fault occurs between any two of the three line and the ground.

In line-to-line fault (L-L):

fault occurs between any two lines.

2.1.3 EARTH FAULT:

An earth fault is an inadvertent contact between an energized conductor and earth or equipment frame. The return path of the fault current is through the grounding system and any personnel or equipment that becomes part of that system.

2.2 FAULT DETECTION METHODS

2.2.1 OFFLINE METHODs:

In this method special instrument is used to test out service of cable in the field. This offline method can be divided into two methods .They are tracer method and terminal method.

2.2.1.1 TRACER METHOD:

In this method fault point is detected by walking on the cable lines. Fault point is indicated from audible signal or electromagnetic signal. It is used to pinpoint fault location very accurately**.**

2.2.1.2 TERMINAL METHOD:

It is a technique used to detect fault location of cable from one or both ends without tracing. This method is used to locate general area of fault, to expedite tracing on buried cable.

2.2.2 ONLINE METHOD:

This method utilizes and processes the sampled voltages and current to determine the fault points. Online method for underground cable are less common than overhead lines.

3. DESIGN METHODOLOGY

3.1 INTRODUCTION

• The project is assembled with a set of resistors representing cable length in KM's and fault creation is made by a set of switches at every known KM to cross check the accuracy of the same. The fault occurring at a particular distance and the respective phase is displayed on a LCD interfaced to the Arduino board. The project uses the standard concept of Ohms law i.e whenever there is a short circuit (Line to Ground) fault , the voltage across series resistors changes accordingly, which is then fed to inbuilt ADC of Arduino board to develop precise digital data for display in kilometers.

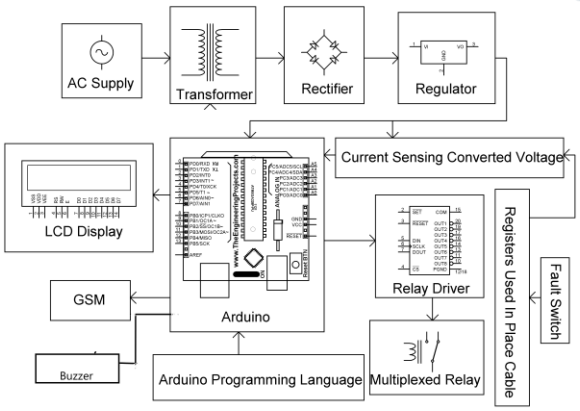

FIG 3.1 BLOCK DIAGRAM

3.1.1 OVERVIEW OF BLOCK DIAGRAM

• The circuit consists of a power supply,4-line display, Arduino and resistance measurement circuit. To induce faults manually in the kit, fault switches are used. About 12 fault switches are used which are arranged in three rows with each row having 4 switches. The 3 rows represent the 3phases namely R, Y and B. The fault switches have 2positions-Nofault position (NF) and fault position(F). Main component of the underground cable fault detection circuit is low value resistance measurement. It is constructed using a constant current source of 100mAmps. It can measure very low value resistance as the cables have around 0.01Ohm/meter resistance. For 10meter cable resistance becomes 0.1 Ohm. This circuit can measure resistance up 50Ohm, Maximum cable length it can check up to 4 kilometers. So starting from the reference point 4 sets of resistances are placed in series. These 4 sets of resistances represent the three phases and the neutral. Short circuit faults, Symmetrical and unsymmetrical faults can be determined by this method. This project uses three set of resistance in series ie for example (R10-R11-R12-R12, R17-R16-R14R21,R20-R19-R18-R25) one for each phase. Each series resistor represents the resistance of the underground cable for a particular distance and so here four resistances in series represent 1-4kms. Value of each resistance is 1kΩ **.**

One relay for each phase R,Y and B, a three relays are used and the common points of the relays are grounded and the NO points are connected to the inputs of R17, R21 and R2 and being the three phase cable input. As supply needed for the relays is higher than that of the Arduino, Relay driver is used to boost the supply and provide it to the relays. A 230VAC supply is applied to the transformer from where it is stepped down to 12V AC. From the transformer the alternating current gets converted into direct current when it passes through a Bridge wave rectifier. The 12V DC then goes to the voltage regulator where it gets converted from12V DC to 5V DC. Voltage regulator is used also converts the variable Dc supply into constant DC supply. This 5V DC is used to supply power to the arduino and the LCD. Power supply to the LCD is given from the voltage regulator. When fault is induced by operating any of the 12 switches (to F position), they impose conditions like LG, LL, LLG fault as per the switch operation. As a result of the fault, there is a change in voltage value. This voltage value measured across the resistance is fed to the ADC of the Arduino. Using this value, the Arduino computes the distance.

Finally, the distance of the fault from the base station is displayed in kilometers.

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3.2 Proposed System

We show that utilizing data consolidation and erasure system settings, a business may save costs and survive interruptions. Second, we present an inner-chunk erasure coding method with on-demand piece reconstructing to reduce overheads in the event of a failure. Third, we create and implement a container-based share control strategies to combine tiny data portions into a bigger unit for dynamic provisioning.

3.1.2 ADVANTAGES:

Any type of cable fault detection possible.
Potentially-Reduced Maintenance and Operating Costs
Human resource is required less
Less damage during severe weather
Far fewer momentary interruptions
Improved Public Safety
Particular operation will do with zero error

3.1.3 DISADVANTAGES:

Underground cables have higher initial cost

Insulation problems at high voltages.

Best suited for short distances only.

4. OPERATION AND WORKING

OPERATION:

The main operation lies on the fact that when the current flows through the set of series resistors in each of the three set of lines the current would vary depending upon the length of the cable from the place of fault that occurred if there is any short circuit fault. The voltage drops across the series resistors changes accordingly and then the fault signal goes to internal ADC of the microcontroller to develop precise digital data.
Then microcontroller will process the digital data and the output is being displayed in the LCD connected to the microcontroller in kilometres as per the programming conditions.

4.1 WORKING:

- The power supply given to the circuit is 230V ac supply, which is fed to step down transformer (12 V-0-12 V) which steps down the voltage from 230 V to 9V which is then fed to a full wave bridge rectifier to rectify the ac voltage into pulsating dc voltage.
- The ripple in rectified output is then removed with the help of a 1000 microfarad electrolytic capacitor. And it is given to voltage regulator (7805).
- These voltage regulators convert the filtered output to 5V constant supply voltage. The first voltage regulator U2 feeds the voltage to microcontroller, LCD, and the set of series resistors. While the second voltage regulator U3 feeds the relay and relay driver IC ULN2003A.
- Also this model consists of three relays which are driven by a relay driver IC ULN2003A. The relay used here drives the bulb load to indicate the fault being occurred in corresponding phases and can be used to trip the power supply to the set of series resistors.
- The fault creation environment is made by a set of switches at every known equivalent kilometre as indicated by the set of series resistors to cross check accuracy of the same.

- When a fault is occurred at the distance in a phase (or two phases or three phases) current flows through the shorted line and developing drops across the corresponding phase resistors.
- This drop is sensed by the ADC (built inside the microcontroller) through Port and converts it into equivalent digital data.
- The microcontroller then process these data according to fault conditions preprogrammed into the microcontroller.
- It sends out display signals about the location of fault to LCD which finally displays the location of the fault in kilometres and simultaneously send the signals to the relay driver IC which further drives the bulb load connected to the relay.
- The model uses four sets of resistors in series for each phase of the cable line i.e.
- R1,R2,R3,R4 for phase R,
- R5,R6,R7,R8 for phase Y

- R9,R10,R11,R12 for phase B and
- R13, R14 and R15 are used in series with supply line of each phase as shown in the circuit diagram.
- Each set of four series resistors represents the resistance of the underground cable for a specific distance of 4kms equally divided into 1km for each resistor.
- The resistors R13, R14 and R15 develop respective voltage drops corresponding to the occurrence of ground fault in one phase or two phases or three phases. The other end of resistors R1, R3 and R5 are connected to ground.

4.2 ALGORITHM FOR SHORT CIRCUIT FAULT DETECTION:

- Step1: Initialize the ports, declare timer, ADC, LCD functions.
- Step2: Begin an infinite loop; turn on relay 1 by making pin 0.0 high.
- Step3: Display phase name at the starting of first line in LCD.
- Step4: Call ADC function . Depending upon ADC output, LCD displays the fault position.
- Step5: call Delay
- Step6: Repeat steps 3 to 5 for other two phases

5 Flow chart

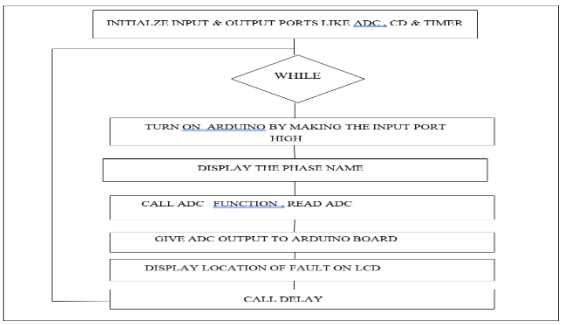
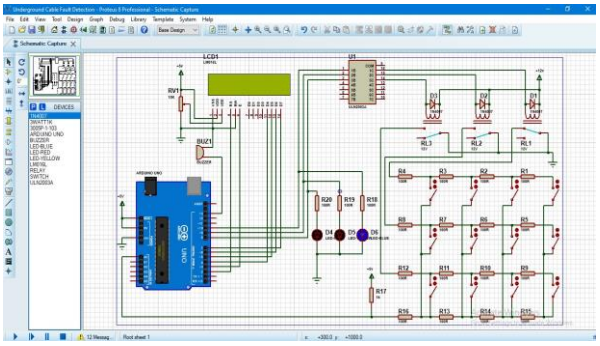


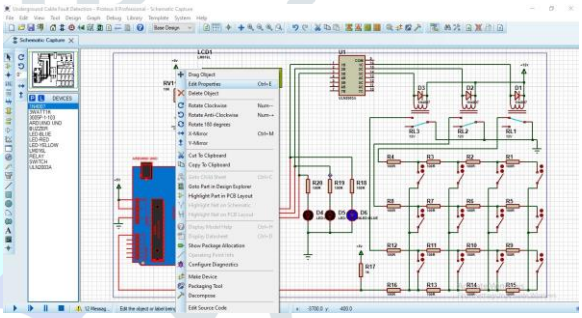
Fig 1: Frame work Flow Chart

6 RESULTS SCREEN SHOTS

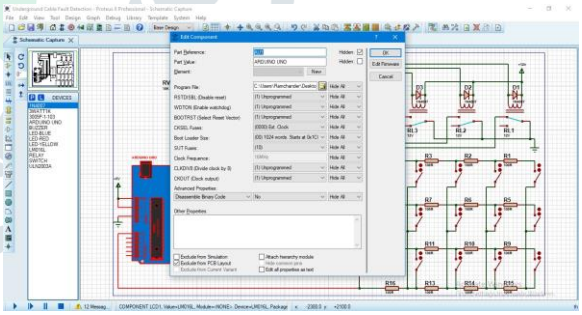
STEP 1: Install proteus and draw the schematic diagram.



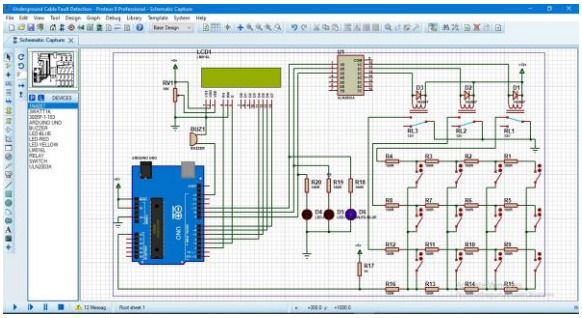
STEP 2: Select edit properties by right clicking on the arduino Uno.:



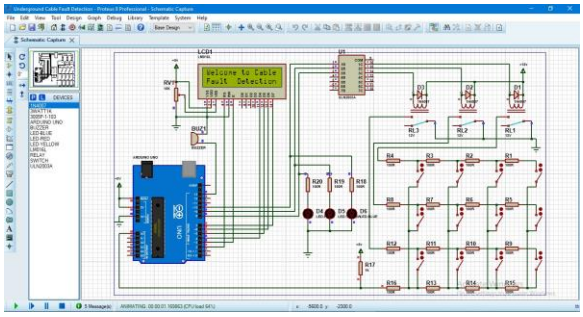
STEP 3: Dump arduino code in the arduino Uno by inserting the hex file in program file:



STEP 4: Run the simulation:



STEP 5: Initiation of the simulation after the compilation is done:



7. CONCLUSION

Underground cables are prone to a wide variety of faults due to underground conditions, wear and tear, rodents etc. Also detecting fault source is difficult and entire line is to be dug in order to check entire line and fix faults.

So, we propose this project to detect the exact location of short circuit fault in the underground cables from the feeder end in km by using an Arduino microcontroller. Relay helps to separate the faulty line from healthy line.

This saves a lot of time, money and efforts and also allows to service underground cables faster.

Future Enhancement

✓ Further this project can be enhanced by using capacitor in an AC circuit to measure the impedance which can even locate the open circuited cable, unlike the short-circuited fault only using resistors in DC circuit as followed in the above proposed project.

✓ Further this project can be used to find the insulation of the cable, EMF generation in the cable, check the power quality at instantly.

✓ .

8. References

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