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DESIGN AND IMPLEMENTATION OF ARDUINO BASED EMBEDDED SYSTEM FOR UNDERGROUND CABLE FAULT DETECTION

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ABSTRACT

The extensive use of underground cables is because of the several advantages such as more secure than overhead lines, less susceptible to damage in adverse weather conditions, less expensive for shorter distance, environment friendly and low maintenance. However, it is difficult to locate the fault in underground cable.

We have designed such embedded system which determines the distance of underground cable fault from the base station in kilometer. This system uses the standard concept of Ohm's law at the feeder end trough cable lines. When the fault occurs then the voltage changes accordingly, which is given to the embedded system through ADC. The firmware of the systems processes the input signal and displays the faulty phase on LCD screen with the range in kilometer on computer screen

Keywords: *Underground cables, fault, embedded system.*

I. INTRODUCTION

Underground cables are extensively applied in power distribution networks due to the benefits of underground connection, involving more secure than overhead lines in bad weather, less liable to damage by storms or lightning, no susceptible to trees, cost effective for shorter distance, environment-friendly and low maintenance. These underground cables are 8 to 15 times more expensive than equivalent overhead lines, less power transfer capability, more liable to permanent damage following a flash-over, and difficult to locate fault. Faults in underground cables can be normally classified as two categories: incipient faults and permanent faults. The reason for incipient faults in power cables is the aging process, where the localized deterioration in insulations exists. Electrical overstress in conjunction with mechanical efficiency, unfavorable environmental condition and chemical pollution may result into the permanent in insulations. Eventually, incipient faults would fail into permanent faults sooner or later.

The primary stage detection of incipient faults provides early alarm system for the breakdown of the defective cable, even trip the suspected feeder to limit the repetitive voltage transients. The exact location of permanent faults in cables is necessary for electric power distribution networks to improve network reliability, ensure customer power quality, speed up restoration process, minimize outage time, reduce repairing cost and maintain network reliability. The state estimation (SE) is an auxiliary tool to provide the necessary information for the proposed location algorithms. The related methods published in journals and proceedings are reviewed, summarized and compared in the next subsections. [1]

The objective of this system is to determine the distance of underground cable fault from base station in kilometer. The underground cable system is common practice followed in many urban areas. After the birth of a fault due to any reason at that time the restoring of specific cable is huge task because we unable to find the exact location of the cable fault. This system uses the standard concept of ohm's law is applied at the feeder end through a series resistor (cable lines). When there is generation of short circuit (line to ground), the voltage across series resistors changes, which is then given to an ADC to develop precise digital data which the program microcontroller Arduino board would display in which phase fault occur on LCD display and in how much range display on computer screen in km.

II. BLOCK DIAGRAM

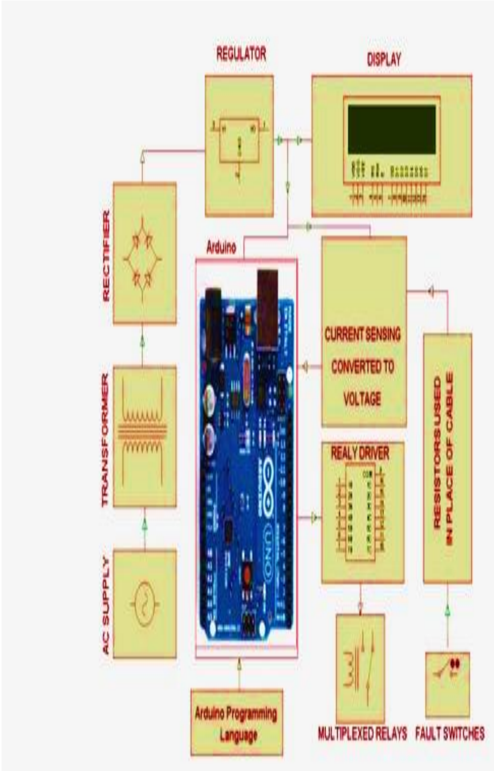

Figure 2.1 Block Diagram

The 230V ac supply is given to the step-down transformer. The 230V supply is step down to 9V. Then it is given to the rectifier circuit which convert it into 5v dc, its then fed to the cable through a series resistor. if the fault occurs microcontroller sense this fault as a change in voltage drop across series resistor and given to Arduino board. Arduino analyzing this fault and give an appropriate command to LCD and computer to show on which line and in which range fault occurs. Simultaneously relay receives command from Arduino to trip from faulty line to healthy line.

III. FAULTS

A fault in an electrical system is defined as abrupt electric current. In case of a short circuit faultcurrent bypasses the normal load. An open-circuit fault occurs due to breakdown of circuit [2]. In three-phase systems, a fault may involve one or more phases and ground, or may occur only between phases. In a "ground fault" or "earth fault" current flows into the earth. Thetransient short circuit current of a fault can be determined. In power systems, shield equipment's not only sense the fault condition but also operate the required circuit breakers and other devices to protect the loss of service due to a failure. "Symmetrical Fault" occurs in poly-phase system which affects each phase equally. In other condition if only few phases are affected, then such fault is known as "asymmetrical fault". It becomes more complicated to analyze this faults because all the pre assumptions are no longer applicable. In order to study asymmetrical fault method of components is applied.The sole objective of any power system protection is to locate the fault and solve it as early as possible.

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III.I Open circuit fault

When there is a break in the conductor of cable. It's called open circuit fault. Due to high resistance Megger is used to detect such fault. For this purpose, the 3 conductor of the 3 core cable at the far end are shorted and earthed. Then resistance between each conductor and earth is measured by megger. The megger will indicate zero resistance in the circuit of the conduct or that is not broken. However, if conductor is not broken, the megger will indicate infinite resistance in its circuit.

III.II Short circuit fault

When two conductors are multi core cable come in electrical contact with each other due to insulation failure, it's called short circuit fault. again, we can seek the help of megger to check this fault. For this purpose, the two terminal of the cable are connected to any two conductors, if the megger gives zero reading.it indicate short circuit fault between these conductors.

III.IV. Earth fault

When conductor of a cable come in contact with earth, it's called earth fault or ground fault.to identify this fault, one terminal of the megger is connected to the conductor and other terminal connected to earth. If the megger indicates zero reading. Its mean the conductor is earthed; the same procedure is repeated for other conductor of the cable.

III.V Fault Analysis

Under normal operation conditions, a power system operates under balanced conditions with all equipment carrying normal load currents and the bus voltages within the prescribed limits. This condition can be disrupted due to a fault in the power system. A fault in power system is nothing but a failure that hampersthe normal flow of current. A short circuit fault occurs when the insulation of the system fails resulting in low impedance path either between phases or phase to ground. This causes excessively high current flow in the circuit, requiring the operation of protective equipment to prevent damage to equipment.

III.VI Symmetrical faults

The reason for three phase symmetrical fault is due to application of three equal fault impedances Z_f to the three phases, as shown in fig. If Z_f=0 the fault is called a solid or bolted fault. These faults can be of two types: (a) line to line to ground fault (LLLG fault) or (b) line to line to line fault (LLL fault). Since the three phases are equally affected, the system remains balanced. That is why it is called as symmetrical fault or a balanced fault and its analysis is done in per phase basis. This is very severe fault that can occur in the system. Fortunately, such faults occur infrequently and about 5% of the system faults are three phase faults.

III.VII Unsymmetrical faults

The faults in which the balanced state is disturbed are called as unsymmetrical or unbalanced faults. The usual type of unsymmetrical fault in a system is a single line to ground fault (LG fault). Almost 60 to 70% of faults are LG faults. The other types of unbalanced faults are line to line fault (LL faults) and double line to ground faults (LLG faults).About 15 to 25% faults are LLG faults and 5 to 15% are LL faults. They are as follows:

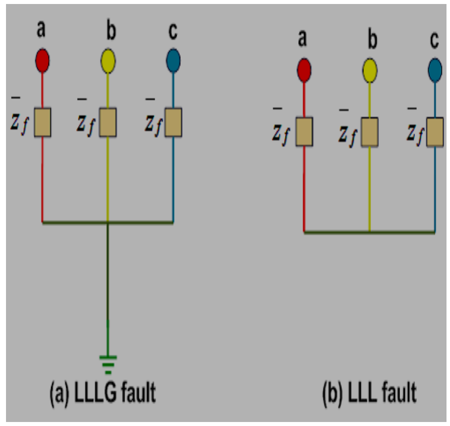

Figure.3.1: Symmetrical Fault

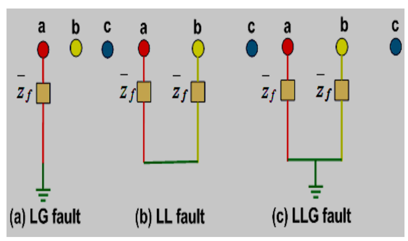

Figure 3.2 Unsymmetrical faults

Majority of the faults occur in the transmission line as they are exposed to external elements. The mechanical failure of line or insulator and tree branches may cause short circuit. Fault analysis is necessary for selecting proper circuit breaker rating and for relay setting and co-ordination. The symmetrical faults are analyzed on per phase basis while the unsymmetrical faults are analyzed using symmetrical components. Further Z_{bus} matrix is very useful for circuit studies.

IV. SYSTEM SOFTWARE

```
#include <LiquidCrystal.h> [4]
Liquid Crystal LCD (5, 4, 3, 2, 1, 0);
constintnumRows = 2;
constintnumCols = 16;

intval = 0;        // variable to store the read value
intA_zero = 9;
intA_one = 10;
intA_two = 11;
intA_three = 12;

int z = 13;

void setup()
{

pinMode(z, INPUT);
lcd.begin(numCols,numRows);
```

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```
lcd.print("Line    --> R YB");
lcd.setCursor(0, 1);
lcd.print("Fault   -->");

      // sets the digital pin "z" as input
pinMode(6, OUTPUT);     // sets the digital pin "A_zero" as output
pinMode(7, OUTPUT);      // sets the digital pin "A_one" as output
pinMode(8, OUTPUT);      // sets the digital pin "A_two" as output

pinMode(A_zero, OUTPUT);      // sets the digital pin "A_zero" as output
pinMode(A_one, OUTPUT);       // sets the digital pin "A_one" as output
pinMode(A_two, OUTPUT);       // sets the digital pin "A_two" as output
pinMode(A_three, OUTPUT);     // sets the digital pin "A_three" as output

Serial.begin(9600);

}

void loop()
{
  // Select address 0000
digitalWrite(A_zero, LOW);
digitalWrite(A_one, LOW);
digitalWrite(A_two, LOW);
digitalWrite(A_three, LOW);
  if(digitalRead(z)==1)
  {
digitalWrite(6, HIGH);
lcd.setCursor(0,5);
lcd.print("{");
{
Serial.println("Fault in line Red at 16Km");
delay(500);
}
  }

  // Select address 0001
digitalWrite(A_zero, HIGH);
digitalWrite(A_one, LOW);
digitalWrite(A_two, LOW);
digitalWrite(A_three, LOW);
  if(digitalRead(z)==1)
  {
digitalWrite(6, HIGH);
lcd.setCursor(0,5);
lcd.print("{");
Serial.println("Fault in line Red at 8Km");
delay(500);

  }
```

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```
 // Select address 0010
digitalWrite(A_zero, LOW);
digitalWrite(A_one, HIGH);
digitalWrite(A_two, LOW);
digitalWrite(A_three, LOW);
 if(digitalRead(z)==1)
 {
digitalWrite(6, HIGH);
lcd.setCursor(0, 5);
lcd.print("{");
Serial.println("Fault in line Red at 4Km");
delay(500);
 }

 // Select address 0011
digitalWrite(A_zero, HIGH);
digitalWrite(A_one, HIGH);
digitalWrite(A_two, LOW);
digitalWrite(A_three, LOW);
 if(digitalRead(z)==1)
 {
digitalWrite(6, HIGH);
lcd.setCursor(0, 5);
lcd.print("{");
Serial.println("Fault in line Red at 2Km");
delay(500);
 }

 // Select address 0100
digitalWrite(A_zero, LOW);
digitalWrite(A_one, LOW);
digitalWrite(A_two, HIGH);
digitalWrite(A_three, LOW);
 if(digitalRead(z)==1)
 {
digitalWrite(7, HIGH);
lcd.setCursor(2,16);
lcd.print("{");
Serial.println("Fault in line Yellow at 16Km");
delay(500);
 }

 // Select address 0101
digitalWrite(A_zero, HIGH);
digitalWrite(A_one, LOW);
digitalWrite(A_two, HIGH);
digitalWrite(A_three, LOW);
 if(digitalRead(z)==1)
 {
digitalWrite(7, HIGH);
lcd.setCursor(2,16);
lcd.print("{");
```

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```
Serial.println("Fault in line Yellow at 8Km");
delay(500);
  }

  // Select address 0110
digitalWrite(A_zero, LOW);
digitalWrite(A_one, HIGH);
digitalWrite(A_two, HIGH);
digitalWrite(A_three, LOW);
  if(digitalRead(z)==1)
  {
digitalWrite(7, HIGH);
lcd.setCursor(2,16);
lcd.print("{");
Serial.println("Fault in line Yellow at 4Km");
delay(500);
  }

  // Select address 0111
digitalWrite(A_zero, HIGH);
digitalWrite(A_one, HIGH);
digitalWrite(A_two, HIGH);
digitalWrite(A_three, LOW);
  if(digitalRead(z)==1)
  {
digitalWrite(7, HIGH);
lcd.setCursor(2,16);
lcd.print("{");
Serial.println("Fault in line Yellow at 2Km");
delay(500);
  }

  // Select address 1000
digitalWrite(A_zero, LOW);
digitalWrite(A_one, LOW);
digitalWrite(A_two, LOW);
digitalWrite(A_three, HIGH);
  if(digitalRead(z)==1)
  {
digitalWrite(8, HIGH);
lcd.setCursor(3,2);
lcd.print("{");
Serial.println("Fault in line Blue at 16Km");
delay(500);
  }

  // Select address 1001
digitalWrite(A_zero, HIGH);
digitalWrite(A_one, LOW);
digitalWrite(A_two, LOW);
digitalWrite(A_three, HIGH);
  if(digitalRead(z)==1)
```

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```
  {
digitalWrite(8, HIGH);
lcd.setCursor(3,2);
lcd.print("{");
Serial.println("Fault in line Blue at 8Km");
delay(500);
  }

  // Select address 1010
digitalWrite(A_zero, LOW);
digitalWrite(A_one, HIGH);
digitalWrite(A_two, LOW);
digitalWrite(A_three, HIGH);
  if(digitalRead(z)==1)
  {
digitalWrite(8, HIGH);
lcd.setCursor(3,2);
lcd.print("{");
Serial.println("Fault in line Blue at 4Km");
delay(500);
  }

  // Select address 1011
digitalWrite(A_zero, HIGH);
digitalWrite(A_one, HIGH);
digitalWrite(A_two, LOW);
digitalWrite(A_three, HIGH);
  if(digitalRead(z)==1)
  {
digitalWrite(8, HIGH);
lcd.setCursor(3,2);
lcd.print("{");
Serial.println("Fault in line Blue at 2Km");
delay(500);
  }

}
```

V. RESULT

V.I CASE 1: No Fault condition

In the result analysis in ideal condition that means when there is no fault the LCD show there is no fault on 3 phases (i.e. in R, Y, and B).

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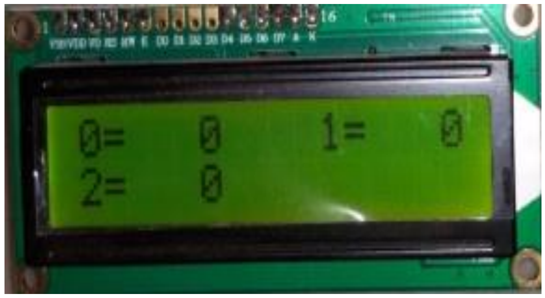

FIGURE 5.1 No Fault condition

V.IICASE 2: When L-G fault occurs

V.II.I When fault occurs in R phase

When the fault occurs in the R phase with respect to ground i.e. line to ground the LCD shows there is fault on R phase and range(i.e. distance in km) shown in serial monitor.at the same time relay trip from faulty cable to healthy cable.

FIGURE 5.2 Fault In R-Phase

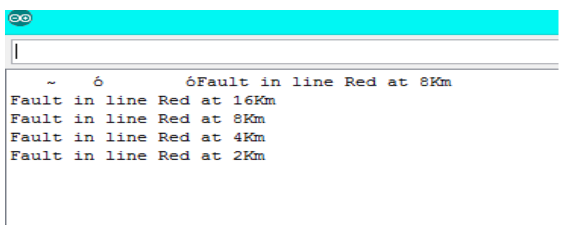

FIGURE 5.3 Range in km on computer screen

Similarly, we have obtained same results for Y and B phases

CASE V.II: When double line to ground fault occurs

V.II.I. When fault occurs in R and Y phase

When fault occurs in any of the two the LCD shows there is fault in R and Y phases and range (i.e. distance in km) shown in serial monitor.at the same time relay trip from faulty cable to healthy cable

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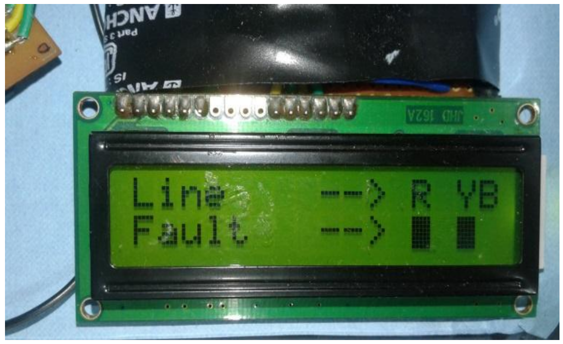

Figure 5.3 Fault I R-Y Phases

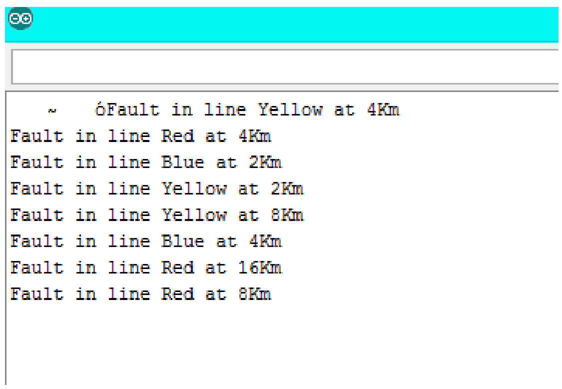

FIGURE 5.4Range in km on computer screen

Similarly, we have obtained same results for phases R-B and Y-B

VI. COMPARISON

Table 6 Comparison table for Loop test and Ardunio

Loop Test	Ardunio
It is based on Wheatstone Bridge method[3]	It is based on simple Ohm's Law
It is use to find earth or short circuit fault	It is use to find L-G , DL-G, Short circuit fault
For finding fault variable resistor is used	For finding fault fixed resistor used
Exact location of fault is not available	Exact location of fault is available

VII. CONCLUSION

In this concept we have detected exact location of fault, whether its l-l fault or l-g fault in the underground cable from feeder end in km by using ARDUINO BOARD. For this we used simple concept of OHM'S LAW so fault can be easily detected and repaired. This will help the operator to detect the fault in very short time. It is very cost effective.

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