Underground Cable Fault Distance Locator

Mohd Tahir Wasim[1], Lokesh M Devadig[2], Siddappa V Ramadurga[3], Iqbal Ahammed A K[4]

[1,2,3]U.G Student Department of EEE, Anjuman Institute of Technology and Management (AITM), Bhatkal
[4]Associate professor, Department of EEE, AITM, Bhatkal, Karnataka, India

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Abstract - *This project proposes fault location model for underground power cable using microcontroller. The aim of this project is to determine the distance of underground cable fault from base station in kilometers. This project uses the simple concept of ohm's law. When any fault like short circuit occurs, voltage drop will vary depending on the length of fault in cable, since the current varies. A set of resistors are therefore used to represent the cable and a dc voltage is fed at one end and the fault is detected by detecting the change in voltage using a analog to voltage converter and a microcontroller is used to make the necessary calculations so that the fault distance is displayed on the LCD display.*

Key Words*: *Power supply unit, LCD, Bank of resistors, switches, Arduino UNO R3, Relays, GSM, ULN2003A.

1. INTRODUCTION

Most of the transmission lines are laid using the overhead line method, but now-a-days underground cable is widely used for safety and to develop the smart city. Underground cable installations are costly as compared to overhead cable, but are more reliable and also the life of underground cables is more as compared to overhead lines. Fault detection in underground cable is difficult as compared to overhead line cable. Underground cable is not affected by adverse conditions like a storm, rainfall, snowfall and varying in temperature. When the fault occurs in the underground cable its detection becomes difficult, so in this project we are going to find the location of the fault and which type of fault occurred.

1.1 Fault location methods

Fault location methods can be classified as

Online method**:** This method utilizes & process the sampled voltages& current to determine the fault points. Online methods for underground cable are less than overhead lines.

Offline method: In this method special instrument is used to test out service of cable in the field. There are two offline methods as following

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. Example:1) Tracing current method 2) Sheath coil method.

Terminal method**:** It is a technique used to detect fault location of cable from one or both ends without tracing. This method use to locate general area of fault, to expedite tracing on buried cable. Example:1) Murray loop method 2)Impulse current method.

1.2 Types of Faults

A fault in a cable can be classified into different types such as

Open Circuit Fault**:** This type of fault is better than short circuit fault, because when the open circuit fault occurs, then the flow of current through an underground cable becomes zero. This fault can be occurred by disruption in conducting path. Such faults occur when one or more phase conductors break.

Short Circuit Fault**:** when two or more conductor of the same cable in contact with each other ,then this is called a short circuit fault. It is impossible to detect visually without taking the cable apart. A short circuit fault occurs when the individual insulation of the cables is damaged.

Short circuit fault can be categorized in two types

Symmetrical fault**:** Three-phase fault is called symmetrical fault. In this all three phases are short circuited.

Unsymmetrical fault**:** In this fault magnitude of current is not equal & not displaced by 120 degree.

2. LITRETURE REVIEW

Abhay Sharma, Akash Mathur, Rajat Gupta, Ranjeet Singh, Er. Mansi Singh(2017), The proposed system finds the exact location of the open circuit fault. This system uses an 16F887 micro controller and a rectified dc supply. Here the project uses a capacitance method. When the current is flow through to the wire than the electromagnetic field is induced which is sense by a Darlington pair i.e. it removes an unwanted noise than it will be filtered and then pass through a voltage regulator gives a constantly 5v supply and then embedded IC is used to represent a fault. The project is assembled with capacitance method and representing fault in terms of yes or no. The fault occurring at a particular distance is displayed on a Liquid crystal display (LCD) interfaced to the microcontroller 16x2 LCD display connected to the microcontroller to display the information. The project will be implemented by using capacitor in an AC circuit to measure the impedance which can locate the open circuited cable. This project deals with microcontroller, buzzer and LCD.

Priyanka R, Priya B(2016), In this paper to detect a fault in an underground cable is still a challenging task in power system. In order to detect an underground cable fault, the standard concept of OHM'S LAW is used. This idea is used to determine resistive variation, short circuit fault, open circuit fault .This project provides accuracy in determining the exact location of fault, when a low DC voltage is applied at the feeder end through a series resistor (Cable lines), then current would vary depending upon the location of fault in the cable from the base station. This project provides detection of fault and also indication of cable's temperature at varying voltage using a developed prototype from a microcontroller family. In the hardware setup we use the ARM 11 MSP430 microcontroller launch pad and a low cost low power 2.4Ghz transceiver and a readable current sensor. We can use X-CTU and MATLAB coding for detecting.

Dhekale P.M., Bhise S.S(2015), This paper proposes an assistance tool to the pre-localization of the insulation defaults affecting electrical single-phase cables by using voltage and current measurements available in source substation. An equivalent network modeling defaults to the ground is analyzed by employing the distributed parameters approach. The per unit length values of these parameters are calculated according to the geometrical data of the cable. The specificity of this tool is the introduction of a resistance modeling sheath-ground insulation for the study of the various types of defaults to the ground (frank and resistive). Scenarios of default fault are applied to the underground cable 150 kV, connecting substations HTB of Tyna – Taparoura - Sidimansour in Sfax. A validation study is approved by the software SimulinkSimPowerSystems of MATLAB.

3. METHODOLOGY

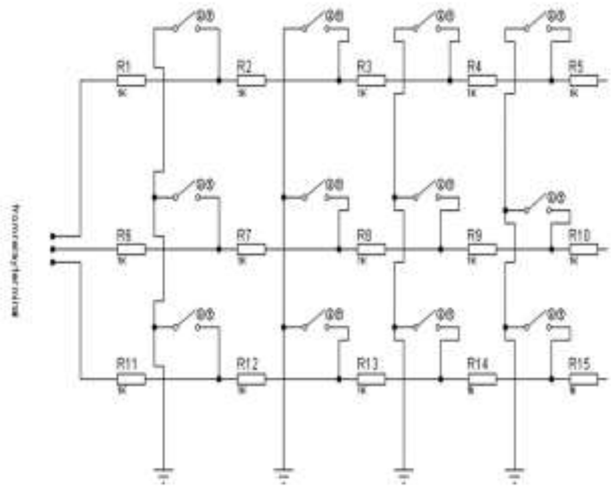

fig-1: Circuit diagram of R – Y – B Power cable connections

Here, 1K ohm set of resistors are used to represent the power cable (R – Y - B). DC voltage is fed at one end. When there is no fault in any phases, LCD will display as NF (No fault) because at that time, no voltage across any register of the cable. During NF – Fault switch will be open so no current will flow. Here, according to different voltages of R – Y – B phases, we have decided as 1 km, 2 km 3 km and 4 km. Particular ranges are clearly defined in the programming so once its detect that range, it will be display that particular range in kilometer by using Arduino. Finally same information sends to user by using GSM SIM .

Calculation:

- 5V DC is given to register R1.
- Register R6 – R10 – R14 is connected to R, Y and B phase Relay respectively.
- Voltage across any Power Cable Register = 0V because Fault switch = OFF.
- Now to find voltage across any register, when Fault switch = ON;
  For Example: 2 km Fault switch of Y phase = ON = Connected
  We have to apply Voltage Divider Rule;
  V11 = (R11/ (R1+ R2+ R3+ R10+ R11))xVs
  V11 = (1K/ (1K + 1K + 1K + 1K + 1K))x5
  V11 = 1 Volt
  Where Supply Voltage = Vs = 5
  Similarly we can find the voltage across any register. Voltage will keep on decreases when the kilometer increases.

3.1 Circuit diagram

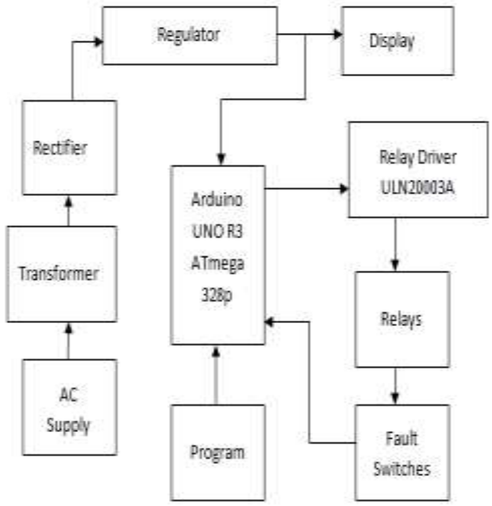

fig-2: Circuit diagram of system

In this project we are designing to achieve monitoring of underground cable and to provide information about detected fault. Ex:- Over voltage, under voltage, short circuit and open circuit conditions will be monitored by respective sensors. Fig.3.8 shows the block diagram of fault detection in underground cable.The 230V supply is first stepped down to 12V AC using a step-down transformer. This is then converted to DC using full wave rectifier. The AC ripples is filtered out by using a capacitor and given to the input pin of this regulator. At output pin of this regulator we get a constant 5v DC which is used for Arduino and other ICs in this project. If any fault occurs that will be detected by the Arduino and convert the analog to digital value and interfacing stage i.e. buffer, driver and relay unit. Buffer is used for temporary storage, driver is used to drive the relay and relay for switching. Controller analyses the received signal and activates the GSM modules to send information to concern person. Controller as well activates the alerting system via interfacing stage. In the transmitting section, the corresponding voltage drop is fed into the controller which is inbuilt in Arduino. This is consists of a 16bit and 32bit Analog to Digital converter. The 16bit Analog to digital converter converts the voltage into digital signal which is received from the fault switches and bank of resistors. The controller makes necessary calculations regarding the fault location.This data is then transmitted to the receiving section. The transceiver is interfaced with the display, the display shows the status of the cable at each phase. Also the distance of the cable at particular phase is displayed. The corresponding changes in the voltage and current help us to determine the type of fault in the cable. The data's are displayed using Arduino coding. The resistive variation, current reading can be obtained.

3.2 Algorithm

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 "R:" at the starting of first line in LCD.

Step4**:** Call ADC Function, depending upon ADC output, displays the fault position.

Step5**:** Call delay.

Step6**:** Repeat steps 3 to 5 for other two phase.

3.3 Flow chart

The Flow chart of underground fault detection Initialize the input and output ports, declare timer, ADC, LCD. When the fault occurs in the underground cable, the system starts to find out fault in each phase. If the fault present in R-phase corresponding relay will activate and display the phase name on the LCD. This data will convert into analog to digital with the help of ADC which is inbuilt in Arduino, and the Arduino calculates data in km equivalent to the digital data to LCD, and LCD display the location of fault. If there is no fault in R-phase, the system will search the fault in other phases in a similar manner.

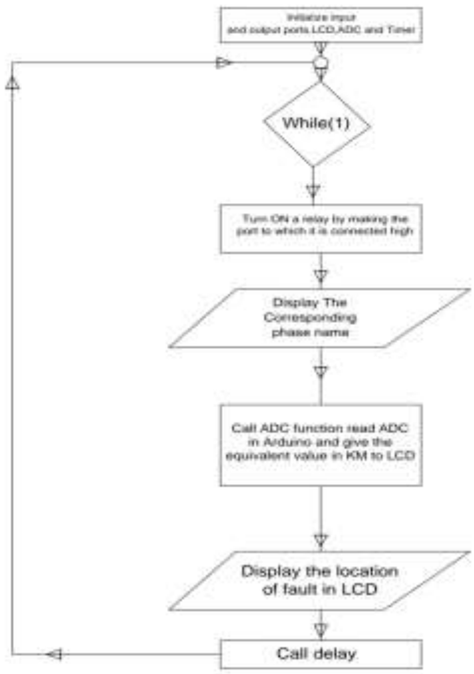

fig-2: block diagram of flow chart

3.3 Programming

```
// include the library code:
#include <LiquidCrystal.h>

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

// define phase control pins
int phase[3] = {7, 8, 9};

int distance(int inputVoltage)
{
 if (inputVoltage >= 890 && inputVoltage < 920) {
  return 8;
 }
 else if (inputVoltage >= 850 && inputVoltage < 890) {
  return 6;
 }
 else if (inputVoltage >= 750 && inputVoltage < 850) {
  return 4;
 }
 else if (inputVoltage >= 600 && inputVoltage < 750) {
  return 2;
 }

 else return 0 ;

}

void setup() {
 // set up the LCD's number of columns and rows:
 lcd.begin(16, 2);

 // set pin mode for phase relays
 for (int j = 0; j < 3; j++) {
  pinMode(phase[j], OUTPUT);
 }

}

void loop() {
 digitalWrite(phase[0], HIGH);
 delay(500);
 int dist1 = distance(analogRead(A0));
 if (dist1 == 0) {
  lcd.setCursor(0, 0);
  lcd.write("R: ");
  lcd.setCursor(3, 0);
  lcd.write("NF   ");
 }
 else {
  lcd.setCursor(0, 0);
  lcd.write("R: ");
  lcd.setCursor(3, 0);
  lcd.print(dist1);
  lcd.setCursor(4, 0);
  lcd.write(" KM");
 }
 digitalWrite(phase[0], LOW);
 digitalWrite(phase[1], HIGH);
 delay(500);
 int dist2 = distance(analogRead(A0));
 if (dist2 == 0) {
  lcd.setCursor(8, 0);
  lcd.write("Y: ");
  lcd.setCursor(11, 0);
  lcd.write("NF   ");
 }
 else {
  lcd.setCursor(8, 0);
  lcd.write("Y: ");
  lcd.setCursor(11, 0);
  lcd.print(dist2);
  lcd.setCursor(12, 0);
  lcd.write(" KM");
 }
 digitalWrite(phase[1], LOW);
 digitalWrite(phase[2], HIGH);
 delay(500);
 int dist3 = distance(analogRead(A0));
 if (dist3 == 0) {
  lcd.setCursor(0, 1);
  lcd.write("G: ");
  lcd.setCursor(3, 1);
  lcd.write("NF   ");
 }
 else {
  lcd.setCursor(0, 1);
  lcd.write("G: ");
  lcd.setCursor(3, 1);
  lcd.print(dist3);
  lcd.setCursor(4, 1);
  lcd.write(" KM");
 }
 digitalWrite(phase[2], LOW);
}
```

4. CONCLUSIONS

The hardware model of Underground Cable Fault Locator is implemented and favorable results were brought forward. This hardware model can locate the exact fault location in an underground cable.

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

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