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ARDUINO BASED UNDERGROUND TRANSMISSION CABLE FAULT LOCATION SYSTEM

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ABSTRACT

The transmission line fault location requires intense human effort and resources. Typically this process is time consuming and while digging the cable there is a risk of damaging the insulation .This paper provides a simple and safe alternative by automating the process of fault detection and location. The project uses the simple concept of OHMs law where a low DC voltage is applied at the feeder end through a series resistor. The current would vary depending upon the length of fault of the cable in case there is a short circuit of LL or 3L or LG etc. The series resistor voltage droop changes accordingly which detects the exact location of the fault for process of repairing that particular cable. The proposed system finds the exact location of the fault. This system uses an Arduino micro controller kit and a rectified power supply. Here the current sensing circuits made with a combination of resistors are interfaced to Arduino micro controller kit to help of the internal ADC device for providing digital data to the microcontroller representing the cable length in kilometers. The fault creation is made by the set of switches. The relays are controlled by the relay driver. A 16x2 LCD display connected to the microcontroller to display the information. In case of short circuit, the voltage across series resistors changes accordingly, which is then fed to an ADC to develop precise digital data to a programmed Arduino micro controller kit that further displays exact fault location from base station in kilometers. The project in future can be implemented by using capacitor in an AC circuit to measure the impedance which can even locate the open circuited cable.

Keywords: ***Transmission cable fault location, LL or 3L or LG , Arduino micro controller kit, ADC, LCD***

1. INTRODUCTION

Transmission lines are needed to carry the electrical power. Underground transmission lines have lower visibility and less affected by weather, therefore, they are more popular in urban area. However, the lower visibility of underground transmission lines cause difficulty to maintain. Therefore, fault location for underground transmission lines is a notable research topic [1]. Power quality monitors serve as the voltage and current sensors in an automatic fault location system. Fault measurements captured by the meters are downloaded automatically, integrated into a relational database, and processed for impedance calculations. The system can detect and locate both single-phase faults and multi-phase faults [2]. Fault location in protective relays has been available for over 20 years. These relays use impedance-based fault location algorithms, typically from one terminal of the transmission line [2]. The field case shows that the fault location estimation is off by 475 feet in a 25Km composite line application [3]. Impedance-based FL algorithms are dependent on the system loading during the fault period, because one of the required inputs is the load in each node of the system. Thus, due to the stochastic behaviours of load variations it may be very difficult to estimate the correct load data to be used in the FL algorithm [4].

The data gathered in the specialised literature, the software PROTEUS was used to simulate a single phase circuit model subject to phase to earth failures. The estimated fault distance is based on the measurements of voltage and current at the sending and receiving ends, which are calculated by the software [5].The simulations are performed by adopting the fault resistance value of Rf = 0.1ohm. This parameter, Rf, in principle, cannot be measured, and therefore should not be regarded as an input parameter of the network, although it influences the employment of techniques for fault location in the underground system [6]. Short Circuit Fault is when two conductors of a multi core cable come in critical contact with each other due to insulation failure, it is so called as short circuitt fault. Megger can also be used to check this fa ult. The two terminals of a megger are connect ed to any two conductors. If the megger gives a zero reading it indicates short-circuit fault between these conductors. The concept of OHM's law is used so fault can be easily detected and repaired [7].

It's a difficult task to identify the faults in underground cables. By using Arduino controller, we can find out exact the fault location. Once faults occur in the cable, the display unit displays the exact fault location that displays which phase is affected in the cable [8]. Regular conducting wire along with resistors is used to represent t he power cable. Four switches and the resistors have been inserted at regular intervals on the wire. These switches are used to create faults. Power sup ply of +5V is provided from one end of the cable and an LED [9].7805 voltage regulator maintains the 5V DC supply. This voltage is used to hand le the Arduino kit. [10]

2. EMBEDDED SYSTEMS

An Embedded System is a combination of computer hardware and software , and perhaps additional mechanical or other part s, designed to perform a specific function. An embedded system is a microcontroller-based, software driven, reliable, real-time control system, autonomous, or human or network interactive, operating on diverse physical variables and in diverse environment s and sold into a competitive and cost conscious market.

2.1. Embedded System Design Cycle

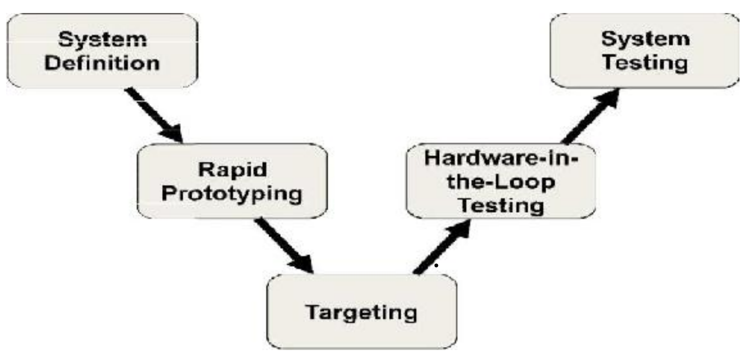

Fig 1. "V Diagram"

An embedded system is not a computer system that is used primarily for processi ng, not a software system on PC or UNIX, n ot a traditional business or scientific application. Hig h-end embedded & lower end embedded systems. High-end embedded system - Generally 32, 64 Bit Controllers used with OS. Examples: Personal Digital Assistant and Mobile phones etc. Lower end embedded systems - Generally 8,16 Bit Controllers used with a minimal operating syste ms and hardware layout designed for the specific purpose.

Applications

1) Military and aerospace embedded software applications

2) Communication Applications

3) Industrial automation and process control software

4) Mastering the complexity of applications.

5) Reduction of product design time.

6) Real time processing of ever increasing amounts of data.

7) Intelligent, autonomous sensors.

2.2 CLASSIFICATIONS

- ✓ Real Time Systems.
- ✓ RTS is one which has to respond to events within a specified deadline.
- ✓ A right answer after the dead line is a wrong answer.

2.2.1 RTS Classification

- ✓ Hard Real Time Systems
- ✓ Soft Real Time System

2.2.2 Hard Real Time System

- ✓ "Hard" real-time systems have very narrow response time.
- ✓ Example: Nuclear power system, Cardiac pacemaker.

2.2.3 Soft Real Time System

- ✓ "Soft" real-time systems have reduced constrains on "lateness" but still must operate very quickly and repeatable.
- ✓ Example: Railway reservation system – takes a few extra seconds the data remains valid.

3. TYPES OF CABLE FAULTS:

Following are the types of Cable Faults Commonly Found in the underground Cables.

- ✓ **Open-Circuit Faults**: Open circuit fault is a kind of fault that occurs as a result of the conductor breaking or the conductor being pulled out of its joint. In such instances, there will be no flow of current at all as the conductor is broken (conveyor of electric current).
- ✓ **Short-circuit or cross fault**: This kind of fault occurs when the insulation between two cables or between two multi-core cables gets damaged. In such instances, the current will not flow through the main core which is connected to load but will flow directly from one cable to another or from one core or multi-core cable to the other instead. The load will be short circuited.
- ✓ **Ground or earth faults**: This kind of faults occurs when the insulation of the cable gets damaged. The current flowing through the faulty cable starts flowing from the core of the cable to earth or the sheath (cable protector) of the cable. Current will not flow through the load then.

3.1 Causes Of Cable Faults:

Faults in cables are mostly caused by dampness in the paper insulation of cables. As a result, it may damage the lead sheath which is protecting the cable. Lead sheath can be damaged in many ways. Most of them are the chemical action of soil on the lead when buried, mechanical damage and crystallization of the lead through vibration. In an electric power system, a **fault** or **fault current** is any abnormal electric current. For example, a short circuit is a fault in which current bypasses the normal load. An open-circuit fault occurs if a circuit is interrupted by some failure. 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. The prospective short circuit current of a predictable fault can be calculated for most situations. In power systems, protective devices can detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure.In a polyphaser system, a fault may affect all phases equally which is a "symmetrical fault". If only some phases are affected, the resulting "asymmetrical fault" becomes more complicated to analyse. The analysis of these types of faults is often simplified by using methods such as symmetrical components.

3.2. Fault Detector And Locator:

The following is the block diagram of the project implemented by us. It describes every aspect of the project in a glance.

Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino.

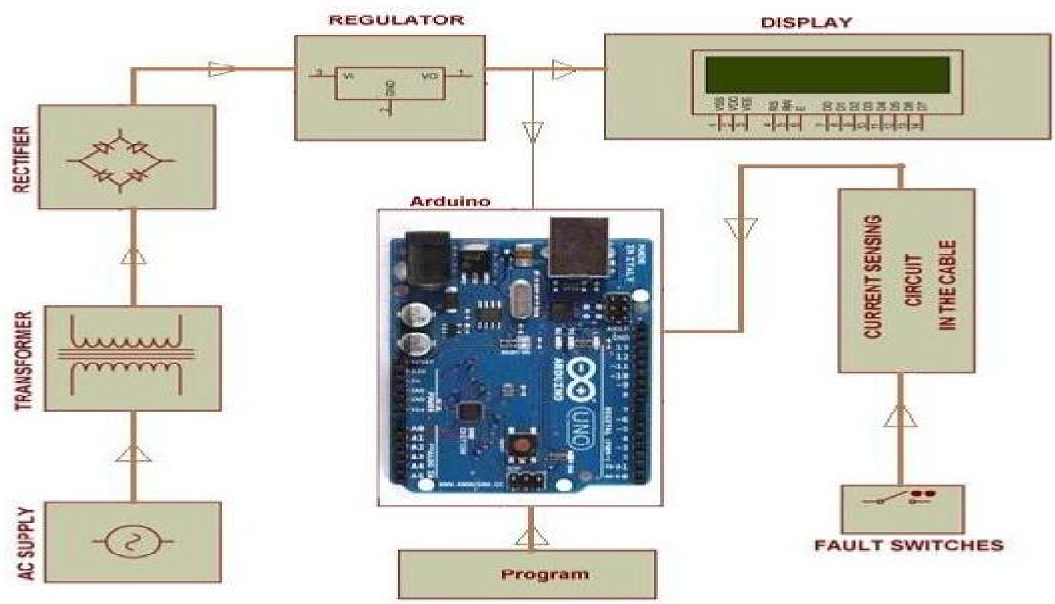

Fig 2. Block Diagram of Fault Location System

3.2.1 USB Overcurrent Protection:

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

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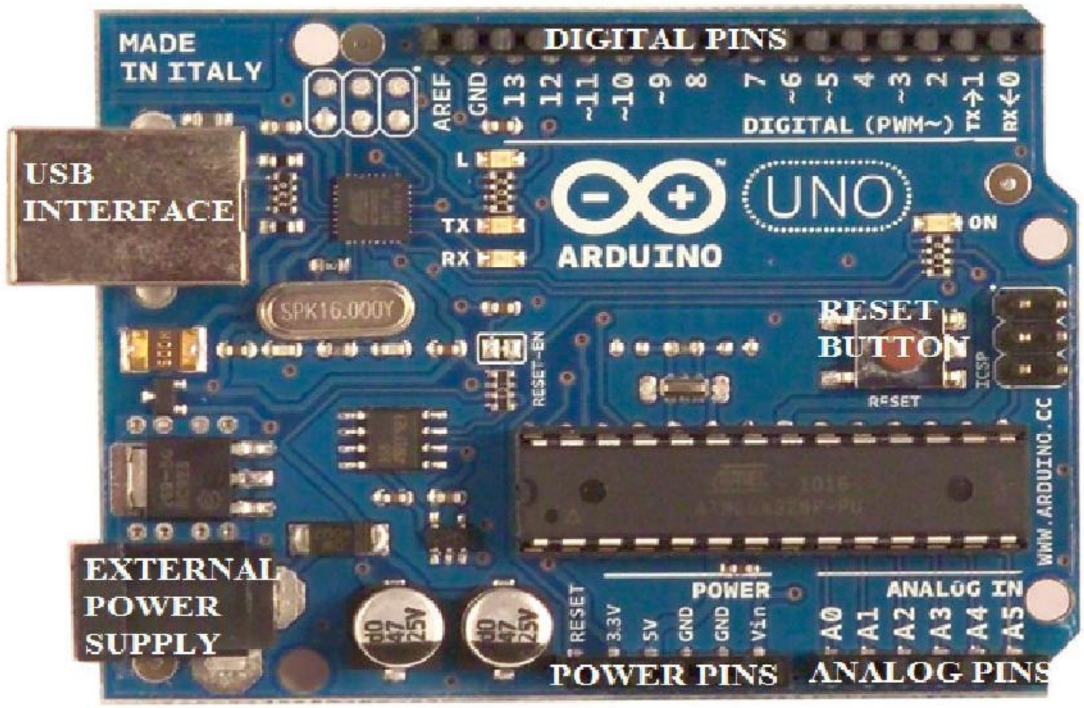

Fig 3.Arduino Board

4. SIMULATION:

For simulation purpose we have used “PROTEUS 8.1 SP1 BUILD 17358 WITH ADVANCED SIMULATION” software. And we have used a library which consists of ARDUINO UNO.The above figure represents the simulation diagram in “PROTEUS” of the underground fault location. Here the input is taken from a 5v dc source. The simulation uses arduino uno in place of a microcontroller as it has integrated clock circuit and is a device ready to use.

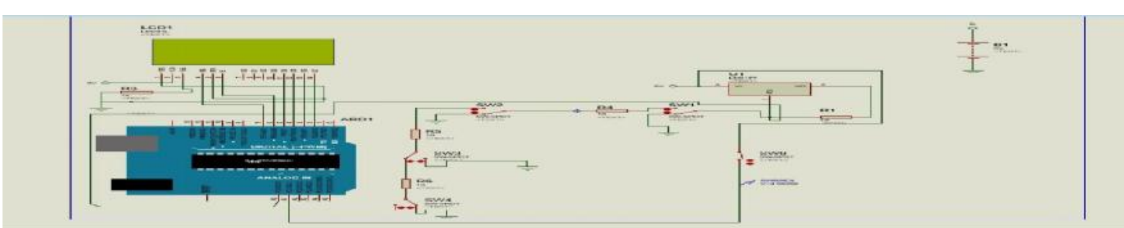

Fig 4. Simulation diagram in proteus

A series of resistors are used in place of a transmission wire. In this fault location system we mainly deal with resistance as we are calculating only that parameter by measuring voltage and current of the system. Hence the simulation would be able to demonstrate the operation of the project and by using switches we are able to show the distance of the occurrence of the fault. This can be achieved as we already know that resistance is proportional to length. The simulation also uses liquid crystal display, spdt switches , LM317T voltage regulator for this project. In proteus the operation of the components is similar to the operation of components in real life. Hence proteus was preferred for simulation.

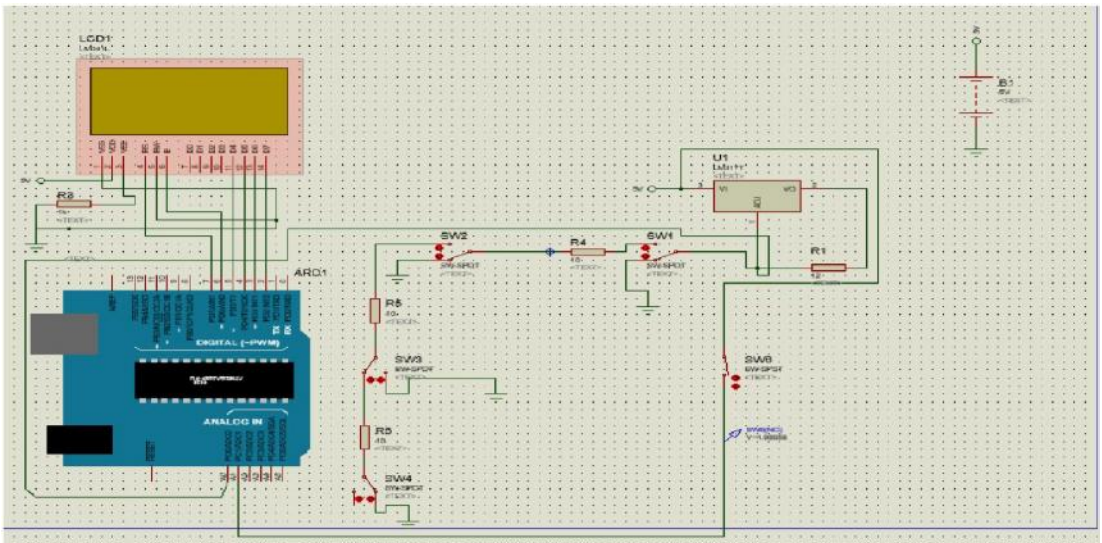

Fig 5.Connection Diagram In Proteus

5. HARDWARE RESULTS:

The following hardware components are used to design the hardware

Table 1 List of Hardware Components

S.No	List of Hardware Components		
1	Transformer (230 – 12 V Ac)	6	Liquid Crystal Display
2	Voltage Regulator (Lm 7805)	7	1n4007
3	Rectifier	8	Resistor
4	Filter	9	Capacitor
5	Arduino (Atmega328)	10	Voltage Regulator (Lm 317t)

i. No Load:

Under this condition , there is no fault so there is no readings to be taken.

ii. Switch 1 is closed:

When the switch 1 is made to close then the resistor R1 comes into the circuit i.e., now the resistance of the transmission wire has become 1ohm. So depending upon the code, the location of the fault is calculated and displayed.

iii. Switch 2 is closed:

When the switch 2 is closed then the resistor R2 comes into series with resistor R1 thus demonstrating the increase in the resistance of the transmission line. So we have now created a short circuited fault.

iv. Switch 6 is closed:

When the switch 6 is closed, which is connected in between the supply 5v and the sensor measuring voltage i.e arduino here. It demonstrates of a line to line fault.

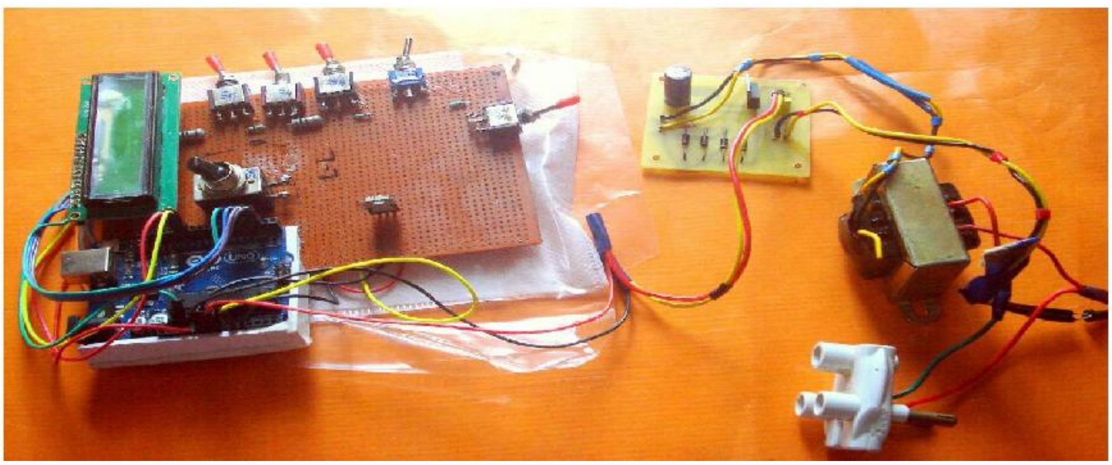

Fig 6. Hardware kit

5.1 Results:

Here, we can observe the results for different faults according to the change in the resistance which can be effected by the operating the switches.

Table *2: Results of Hardware Implementation*

Switch Position	**Line Resistance (switch is closed)**	**Fault location**	**LCD Display**
No Load	---	---	NO FAULT
Switch 1 Closed	1ohm	1.02 Km	Open Circuit Fault

Switch 2 Closed	2 ohm	2.28 Km	Short Circuit Fault
Switch 6 Closed	2.01ohm	2.52 Km	Line to Line Fault

From the above results we can see that the project is capable of working as demonstrated. It's a difficult task to identify the faults in underground transmission lines. By using Arduino controller we can find out exact fault location. Once faults occur in the cable, the display unit displays the exact fault location that displays which phase is affected in the cable.

6. CONCLUSION:

The project "ARDUINO BASED UNDERGROUND CABLE FAULT DETECTION SYSTEM" has been successfully designed and tested. Integrating features of all the hardware components used have developed it. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit. Secondly, using highly advanced IC's and with the help of growing technology the project has been successfully implemented. The main advantage of using this project is, it is less costly and unlike distance relays it does not require any other extra equipment or communication with other devices.

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