UNDERGROUND CABLE FAULT DETECTION WITH GSM ALERT

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ABSTRACT

This paper is on 'underground cable fault detection system using GSM module'. The main motto of this project is to implement a system which is able to detect a fault in underground as well as on surface transmission line. This system is able to detect two types of fault, short circuit fault and leakage fault. It will be also detect the exact location where the fault has been occurred. It uses current sensing technique across all three phase lines and monitors current variations with the help of differential operational amplifier and AVR Atmega 8 microcontroller. Once the fault is detected it will indicates fault and its type on LED panel, and gives beep indication using Buzzer and with the help of GSM module it will send notification alerts via SMS which consist of fault type and its location to authorized person. In this way the system minimize the time as well as money.

Keyword : - *Underground cable, AVR Atmega 8 microcontroller, Operational amplifier, GSM module, voltage regulator, transformer, electrolytic & ceramic capacitors, LEDs, buzzer, resistors.*

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1. INTRODUCTION: -

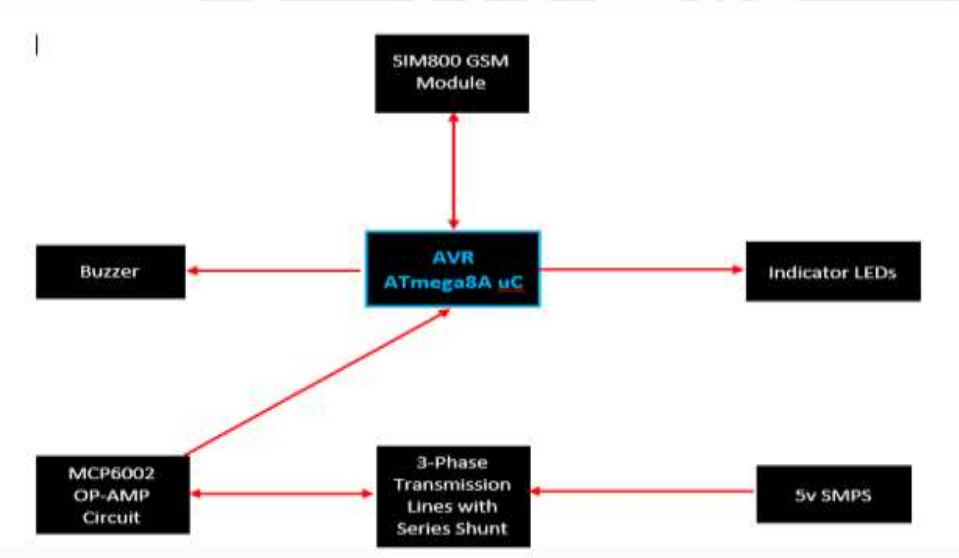
The underground cable fault detection and identification system is a power electronics and embedded system-based project which is used to detect two types of faults occurs in underground or on-surface power transmission lines. As the maintenance of such underground power transmission lines/cables takes lots of manpower and time to identify the exact location and type of fault. To overcome such problem this system is designed. It is able to detect and identify faults such as short-circuit fault and leakage fault. It can identify faults as well as their location. It uses current sensing technique across all three phase lines and monitors current variations with the help of differential op-amp and microcontroller. For current sensing it uses four shunt resistors and dual differential op-amps attached in series with R & B phase lines. Once the fault is detected the system indicates fault and its type on LED panel, gives beep indication using buzzer and also sends SMS message alert consists of fault type and its location to authorized person. With the help of differential op-amps and shunts this system is also able to sense current across phase lines with some calculation done by the microcontroller internally.

This current is then continuously monitored by the microcontroller in order to identify fault and their types. The LED panel consists of four LEDs out of them one is used to indicate type of fault (open-ckt, or leakage) rest of them are used to indicate the location of fault within 3-phase lines as a binary pattern. A buzzer is also used to give beep indication in case of fault identification. The op-amp used in this system is a low-power, and low-noise op-amp which makes it better suit for such application to detect small voltage drops across shunt resistors attached in series to power lines. All the input and output devices are controlled and driven through an 8-bit AVR microcontroller. This microcontroller is programmed to perform various tasks such as generating time events and interrupts, detecting input signals, generating output signals, reading analog signals from op-amps and converting them to analog with the help of internal 10-bit ADC (Analog to Digital Converter), sending and receiving data on UART (Universal Asynchronous Transmitter & Receiver) serial lines connected to GSM module.

These various devices such as GSM module, op-amps, buzzer, LEDs, are attached to dedicated and specific GPIOs of microcontroller as per their usage. The overall system is completely controlled with a single microcontroller which makes it suitable solution for such application. The complete system is powered through a step-down transformer and regulator-based DC regulated power supply which gives a constant source of 5v DC which is sufficient to drive devices such as op-amp, microcontroller, buzzer, LEDs, etc. The GSM module is powered through 12v DC. The system consists of easily available and low-cost hardware devices and components which makes it more suitable for such applications

The embedded system firmware of this system is written and debugged in embedded C++ programming language for Atmel AVR microcontrollers in Atmel Studio 7.0 software. For hardware designing of this project, proteus professional software is used which is a lightweight and optimized software for circuit and PCB designing and simulation. The complete system is designed and implemented in such a way that it will be more reliable and also a cost-efficient solution for such problems in power and signal transmission and distribution lines/cables/links. With the help of such system we can save money as well as time needed for maintenance of underground faulty power transmission cables/lines.

2. BLOCK DIAGRAM:-



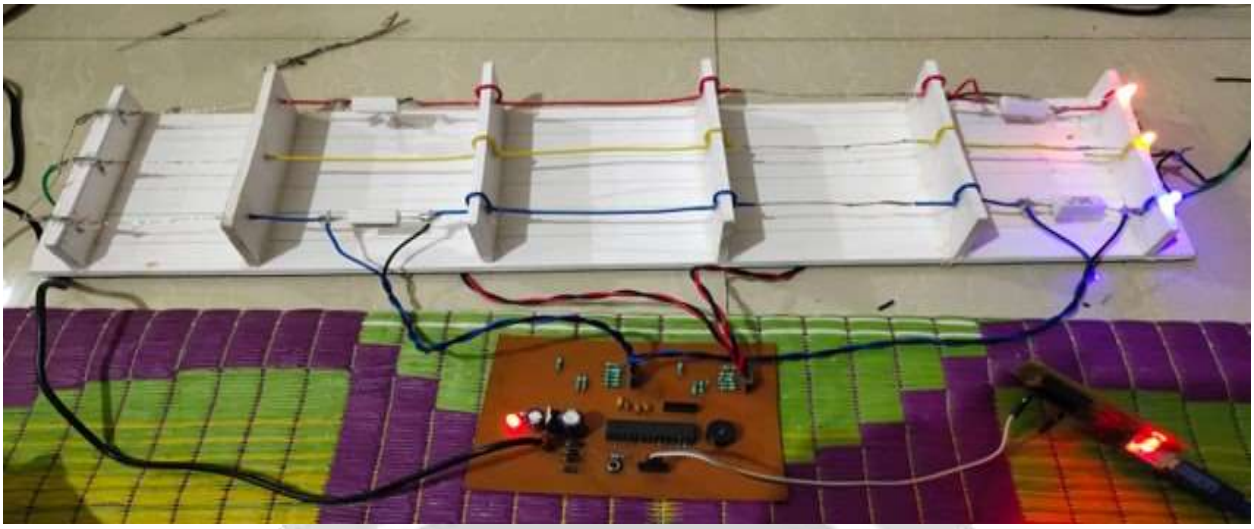


Fig -1: hardware model

3.WORKING:-

The Underground Cable Fault Detection & Identification circuit consists of various electronic & electrical components and devices as shown in circuit diagram. The circuit is mainly divided into three units which are made up of various passive and active electronics components and devices such as microcontroller, operational amplifier IC, GSM module, buzzer, regulator IC, transformer, LEDs, resistors, capacitors, etc. The complete circuit is powered through a power supply unit mainly consisting a step-down transformer, a full bridge rectifier, filter capacitors, and a 5v voltage regulator. The step-down transformer is used to convert high-voltage AC of 220v into low-voltage AC of 12v. This secondary low voltage AC from transformer is feed into full-wave bridge rectifier made up of four PN-Junction silicon diodes (D1, D2, D3, and D4) which converts 12v AC into 12v pulsating DC.

This 12v pulsating DC is then filtered into 12v pure DC (with minimum pulsations) with the help of electrolytic capacitor of 1000uF (C1). This 12v DC is not suitable to drive 5v low-voltage devices such as microcontroller, op-amp, buzzer, LEDs, etc. In order to convert this 12v DC into low-voltage 5v DC a regulator IC (U2-7805) is used. The output of this 5v regulator IC is coupled with one electrolytic capacitor of 100uF (C2) which acts as a coupling capacitor. For power indication a LED (D5) along with resistor (R2) is connected to 5v VCC through GND. For fault indication four LEDs and a buzzer are used. Out of this four LEDs one LED is used to indicate the type of fault and rest of them are used to indicate location where the fault is occurred.

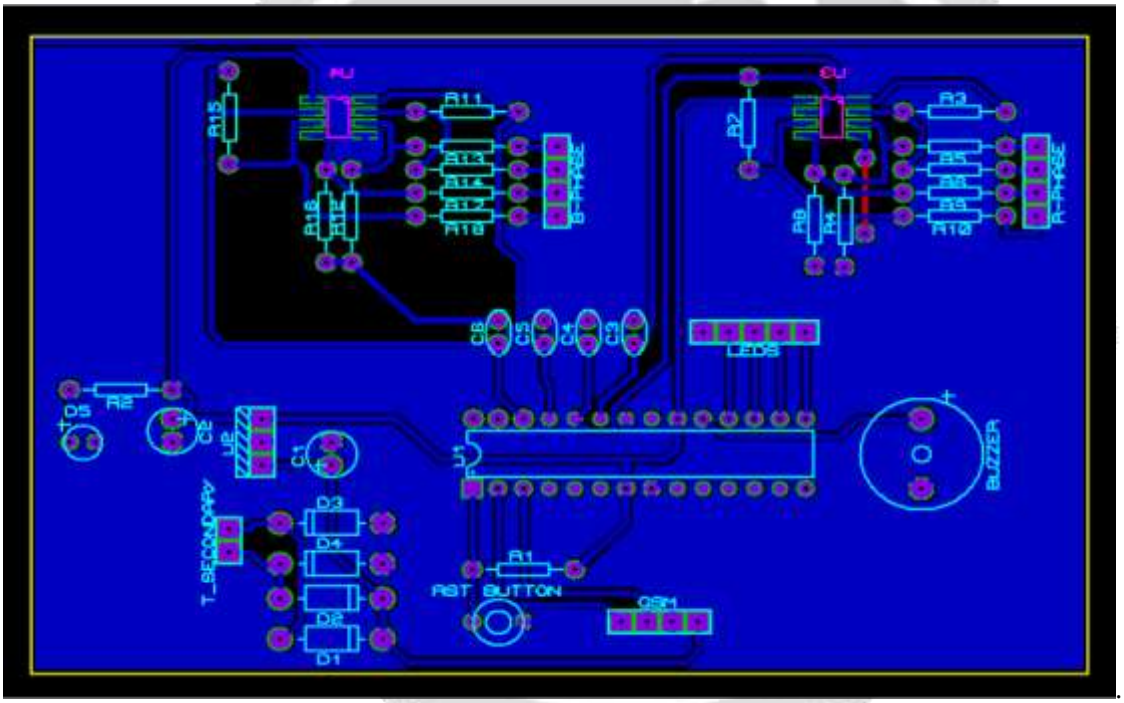
The type indication LED glows in case of phase lines short-circuit fault and it remains OFF in case if the leakage fault occurs. The rest of the LEDs are used to identify the location of fault with 3-bit binary pattern as shown in table below. The buzzer is used to give alert for all type of faults and for all locations within three phase lines. These LEDs and buzzer are connected to GPIOs (General Purpose Inputs & Outputs) of microcontroller which is programmed to drive these output devices when the fault is detected. In order to sense current through R & B phase lines four shunt resistors of around 1 Ohms are added in series with R as well as B phase lines. The voltage across these resistors are measured with the help of low-noise, low-power operational amplifiers (U3: A, B U4: A, B) which are configured in differential op-amp configuration. With the help of few fix value resistors (R3 to R18) these op-amp based differential amplifiers are configured to amplify input signal with a gain of around x10. This amplified signals from all four differential amplifiers are then filtered with the help of ceramic capacitor of 0.1uF/100nF (C3, C4, C5, and C6) which acts as a simple LPF (Low Pass Filter) to minimize high frequency ripples/components from the analog signal.

The filtered signal from op-amp and filter caps are then feed into dedicated ADC (Analog to Digital Converter) pins of microcontroller. The microcontroller processes this analog to digital converted signal and calculates voltage across all four resistors. With the help of classic Ohm's Law formula, the current across fix value

resistor is calculated. These calculated currents are then monitored using program inside a microcontroller in order to identify faults across lines. When two of the phase lines are short-circuited or leak then currents across them varies. This variation in currents causes different current drops in measurement. For wireless notification alerts a SIM800 GSM module is used which sends SMS messages with proper fault location and type. This GSM module is controlled via UART (Universal Asynchronous Receiver & Transmitter) port of microcontroller which is programmed to communicate at fix baud rate of 9600 b/s.

The microcontroller sends and receives AT commands to and from the GSM module in order to initialize the module and send SMS messages. To control all input and output devices an 8-bit ATmega8A AVR microcontroller (U1) is used which is programmed to process and handle various input and output signals from various devices. This microcontroller is programmed in embedded C++ programming language with higher optimization as it is having limited memory size of few KB (RAM: 1KB, ROM: 8KB).

4. PCB DESIGN:-



5. COMPONENTS USED: -

(1) MICROCONTROLLER: -

Microcontrollers are used in automatically controlled devices, such as automobile engine control systems, medical devices which are implantable, remote controls, machines in offices, power tools, appliances, toys and other embedded systems.

(2) VOLTAGE REGULATOR IC: -

A voltage regulator is an integrated circuit (IC) that provides a constant output voltage regardless of a change in the load or input voltage. It can do this many ways depending on the topology of the circuit, but in our project, we will mainly focus on the linear regulator.

(3) OPERATIONAL-AMPLIFIER:- An operational amplifier is **an integrated circuit that can amplify weak electric signals**. An operational amplifier has two input pins and one output pin. Its basic role is to amplify and output the voltage difference between the two input pins.

(4) BUZZER:-

Buzzer 5V (Wire type) is a loud continues type Buzzer. It has two wires for connection and can work on 3 to 7V DC. Just connect it to power supply and will give loud sound. Most buzzers produce sound in the range of 2 to 4 kHz. The buzzer produces sound based on reverse of the piezoelectric effect.

(5) TRANSFORMER:-

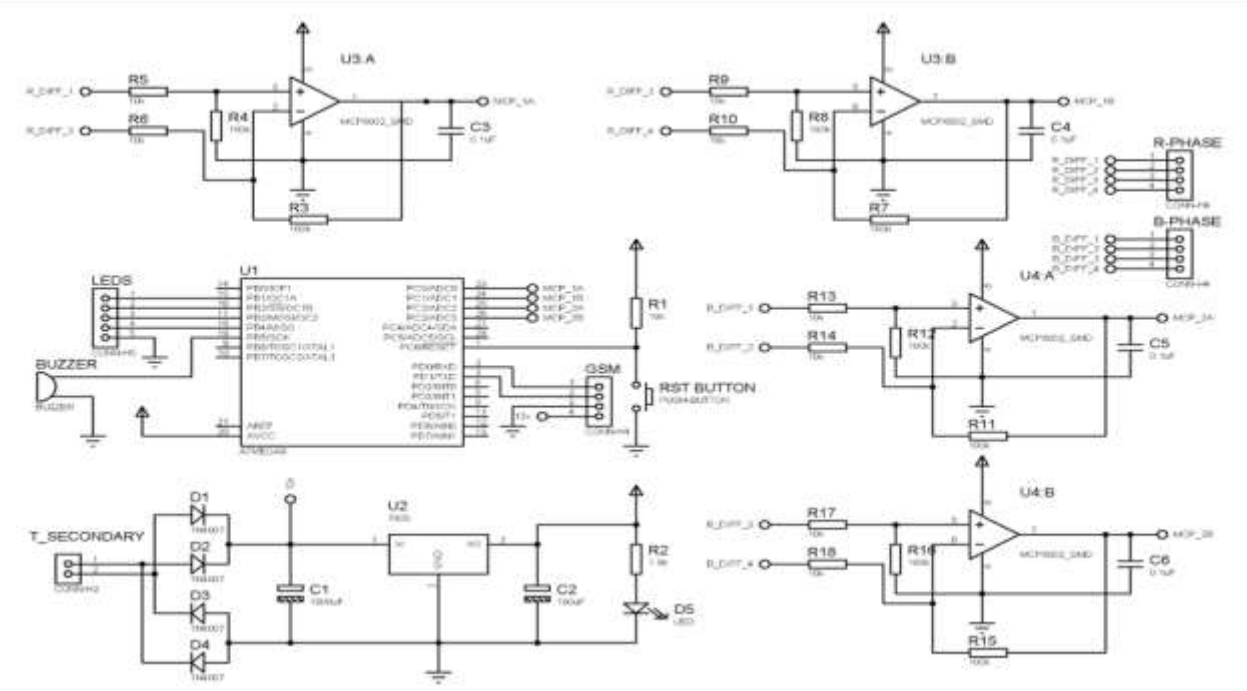
A transformer is a device that transfers electric energy from one alternating-current circuit to one or more other circuits, either increasing (stepping up) or reducing (stepping down).

6. LIST OF COMPONENTS:-

Sr. No.	Part	Quantity
1.	Microcontroller ATmega8	1
2.	28-Pin IC Base	1
3.	LM7805 5v voltage regulator IC	1
4.	SIM800 GSM Module 2g/3g	1
5.	MCP6002 OP –Amp IC SMD	4
6.	5V 1A SMPS	1
7.	Small Buzzer	1
8.	2 Leg Tactile Switch (Push-To-ON)	1
9.	12-0-12 2A Transformer	1
10.	Medium Size Copper Clad PCB	1
11.	Male & Female Bug Strip	1
12.	IN4007 Silicon Diode	1
13.	Flexible wire bundle	1, 1
14.	Any Colour LED	5
15.	Electrolytic Capacitors: a) 1000 uF b) 100 uF	1
16.	Ceramic Capacitors : a) 0.1 uF	4
17.	Resistors :	

	a) 1 ohm shunt b) 100 ohm c) 1.8 ohm d) 10kohm e) 100kohm	4 3 1 9 8

7. CIRCUIT DIAGRAM:-



8. ADVANTAGES:-

1) This underground cable fault identification system is able to detect and identify type of faults such as short-circuit, open-circuit, leakage current, etc. occurs in power transmission lines.
2) It is able to send notification alerts through SMS with proper fault type and parameters to authorized person(s).
3) Apart from wireless GSM SMS alert system it also consists of fault indicator LEDs, and a buzzer to give beep indication in case of fault.
4) It uses low-power, low-noise operational amplifier as a differential amplifier which is able to sense current across lines with higher accuracy.
5) The complete system is designed on a single low-power, low-cost advance 8-Bit AVR microcontroller which makes it more reliable and cost efficient.

9. DISADVANTAGES:-

Sensor are also connected through underground lines/wires which also faces problems such as fluctuating signals, improper signals, or no signals from sensors.

Due to improper network strength, system may be unable to send SMS/Message alerts in real time

10. FUTURE SCOPE:-

In this project we identify two types of faults short circuit fault and leakage fault. Here we are detecting the fault location where it has been occurred. In future this project will detect even minute faults and we can extended to detect faults over large area.

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