ARDUINO-POWERED FAULT IDENTIFICATION SYSTEM FOR UNDERGROUND ELECTRICAL NETWORKS

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ABSTRACT:
Underground electrical cables play a vital role in modern power distribution systems due to their enhanced safety, aesthetics, and reduced exposure to environmental damage. However, locating faults in these cables can be time-consuming and expensive without precise diagnostic tools. This study presents a low-cost, Arduino-powered system for detecting and locating faults in underground electrical cables based on the resistance-based fault location principle. The proposed system identifies open, short, and earth faults by injecting test signals into the cable and measuring voltage drops across known resistances. It calculates the approximate distance to the fault using basic electrical formulas and displays the results on an LCD screen. The system also includes real-time alert capabilities for rapid maintenance response. The Arduino microcontroller ensures simple automation, fast fault localization, and scalability. Experimental results show that this prototype provides accurate fault detection over short to medium distances, offering a cost-effective solution for utilities and maintenance teams.

I.INTRODUCTION

With the increasing demand for reliable and uninterrupted power supply, underground electrical cabling has become a preferred method for distribution, especially in urban and sensitive environments. Unlike overhead lines, underground cables are less susceptible to weather-related damages and vandalism. However, one major challenge with underground cabling is the difficulty in fault detection and location, which often requires expensive equipment and trained personnel.

Faults in underground cables can be caused by insulation breakdown, moisture ingress, rodent activity, or mechanical damage during excavation. Timely identification of these faults is essential to avoid prolonged outages and minimize repair costs. Traditional fault detection methods, such as time-domain reflectometry or bridge techniques, though effective, are often complex and costly for small-scale applications.

To address this, the present work proposes a cost-efficient, Arduino-based underground cable fault detection system that can identify and approximate the location of faults in low-voltage distribution cables. The system operates by applying a low-voltage DC signal and measuring resistance or voltage variations to infer fault presence and distance. The Arduino microcontroller acts as the processing unit, interpreting sensor inputs, calculating fault parameters, and displaying output on an LCD. This compact, standalone system is ideal for deployment in local grids, academic institutions, and small industries, where budget and space constraints limit the use of advanced diagnostic tools.

II. LITERATURE SURVEY

A broad deficiency area model for underground force cable in conveyance framework utilizing voltage and current estimations at the sending-end has just been proposed by Yang, Xia, in a paper distributed in November 2008. The paper presents an investigation of a proportional circuit that models a blamed underground cable framework utilizing circulated parameter approach. Investigation of succession organizes in three-stage arrange by applying the limit conditions is additionally introduced. Utilizing the examination, System consist of laser transmitter and receiver. And the laser transmit a burst of electromagnetic radiation and when this radiation reflect by the barrier then this reflect light transmitted by Zig Bee communication module to the controller In this case the driver able to take decission to avoid the accidence as much as possible.

Westrom distributed in February 1997, clarifies how infusing a progression of tweeted beat streams into the blamed cable, soon after the event of the cable flaw utilizing a heartbeat

generator unit can be utilized for an exact count of the area of the cable deficiency. It has been named as 'shortcoming separation locator'.

Zhao, W in August 2000, proposed a superior way to deal with cable flaw area framework, basically comprising of synchronized testing method, wavelet investigation and voyaging wave standard. Alongside the prologue to three significant methods and a blueprint of the new plan, this paper presents a definite wavelet examination of broken transient waveforms and consequently decides the best wavelet levels for this specific application.

Gilany et.al distributed in January 2007, introduced a wavelet-based issue area conspire for matured cable frameworks when synchronized advanced deficiency recorded information are accessible at the two terminals of the cable. The wavelet peculiarity identification hypothesis is utilized as an amazing sign handling device to appraise the area of the issue in multiend-matured cable frameworks.

Schulze, Member, IEEE et.al Peter Schegner, "Two Terminal Fault Location on Unsymmetrical Transmission Lines",IEEE,2010 , introduced the blackout of a line because of an issue can be costly, subsequently the issue must be cleared as quick as could be expected under the circumstances. Computerized security transfers comprise of shortcoming locators dependent on a few strategies

Xu Sun, Wing Kin Lee1, Yunhe Hou1, et al, Philip W. T. Pong1" Underground Power Cable Detection and Inspection Technology Based on Magnetic Field Sensing at Ground Surface Level ",IEEE ,2014 introduced that IOT based underground cable line shortcoming discovery framework being useful to discover flaws and its area in simple way .Underground cables have been broadly utilized with the advancement of intensity framework lattice.

III.DESIGN OF HARDWARE

This chapter briefly explains about the Hardware. It discuss the circuit diagram of each module in detail.

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 ceramic resonator, 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 Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode. Arduino board has the following new features:

- 1.0 pin out: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"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, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

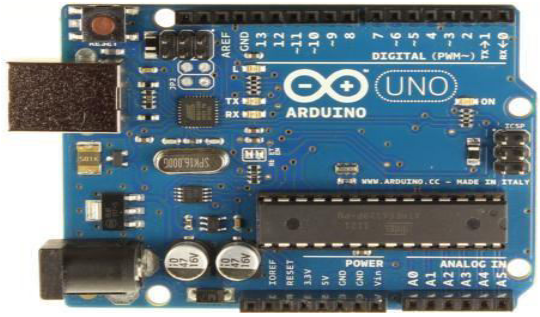


Fig: ARDUINO UNO

POWER SUPPLY:

The power supplies are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. A d.c power supply which maintains the output voltage constant irrespective of a.c mains fluctuations or load variations is known as "Regulated D.C Power Supply".

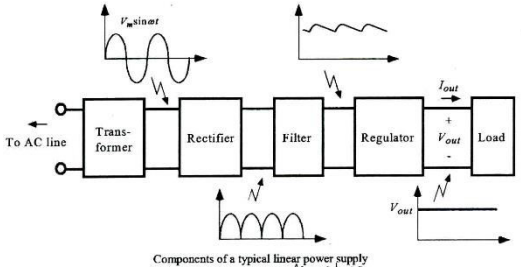


Fig: Block Diagram of Power Supply

LCD DISPLAY

A model described here is for its low price and great possibilities most frequently used in practice. It is based on the HD44780 microcontroller (Hitachi) and can display messages in two lines with 16 characters each. It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols that user makes up on its own. Automatic shifting message on display (shift left and right), appearance of the pointer, backlight etc. are considered as useful characteristics.

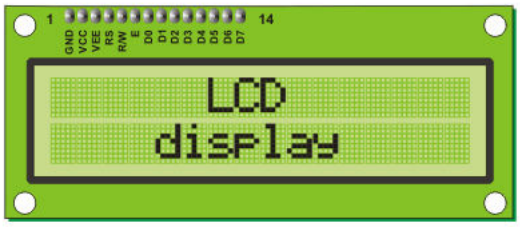
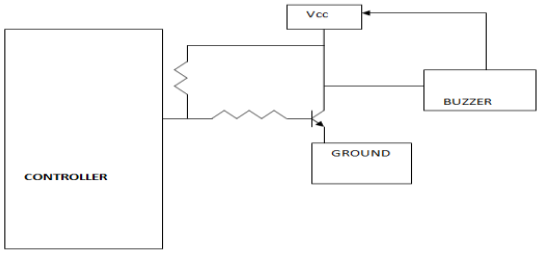


Fig: LCD

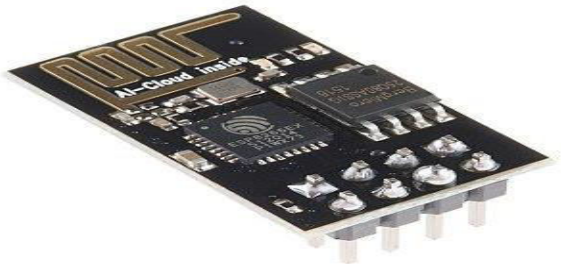
BUZZER

Digital systems and microcontroller pins lack sufficient current to drive the circuits like relays, buzzer circuits etc. While these circuits require around 10milli amps to be operated, the microcontroller's pin can provide a maximum of 1-2milli amps current. For this reason, a driver such as a power transistor is placed in between the microcontroller and the buzzer circuit.



WIFI MODULE:

The **ESP8266** is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espressif Systems.[1]The chip first came to the attention of western makers in August 2014 with the **ESP-01** module, made by a third-party manufacturer, Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted.[2] The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation.[3]The **ESP8285** is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.[4]The successor to these microcontroller chips is the ESP32.



LED:

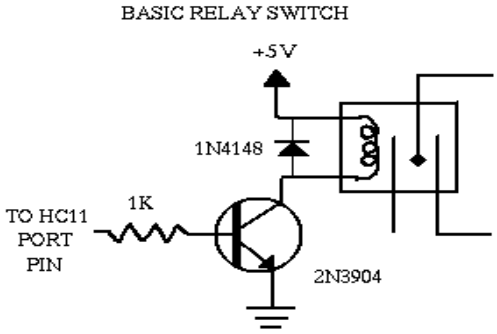
A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated.[5] When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons.

This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. LEDs are typically small (less than 1 mm^2) and integrated optical components may be used to shape the radiation pattern.

Early LEDs were often used as indicator lamps for electronic devices, replacing small incandescent bulbs. They were soon packaged into numeric readouts in the form of seven-segment displays and were commonly seen in digital clocks. Recent developments have produced LEDs suitable for environmental and task lighting. LEDs have led to new displays and sensors, while their high switching rates are useful in advanced communications technology.

LEDs have many advantages over incandescent light sources, including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. Light-emitting diodes are used in applications as diverse as aviation lighting, automotive headlamps, advertising, general lighting, traffic signals, camera flashes, and lighted wallpaper. They are also significantly more energy efficient and, arguably, have fewer environmental concerns linked to their disposal.

RELAY



The following schematic shows the basic circuit.

A relay is an electrically operated switch. When you turn it on, it switches on way. When it is off, it switches the other way. You can use a relay to switch on and off a high current device. A relay has an electromagnet, called a coil, and a lightweight switch inside it. When you energize the coil, a piece of the switch is attracted by the coil's magnetic field, which switches the switch on or off.

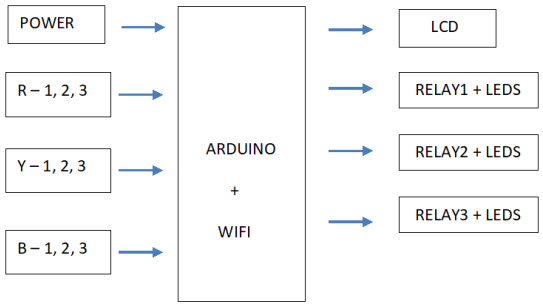
Mechanical relay:

Typical Mechanical Relay connection pin

This is a very important section. The introduction to this electrical control switch, call a Relay. It is basically a device to activate a mechanical switch, by electrical means. This is unlike a switch which is activated manually. In another words it is a device that convert electrical signal to a mechanical energy back to electrical signal again. Similar to mechanical switch, they can be described as 2P2T, single pole double throw, etc... How it works? A electrical voltage will be applied to activate a coil in the relay. The coil being powered up, will generate a magnetic force that will attract the lever. This lever will be pulled towards the

magnetized coil, causing an action that will switch the mechanical contact.

IV. BLOCK DIAGRAM:



Working: Commonly people have been using business voltage (230V).This voltage is adventure down through development down transformer. Transformer is an electrical device that trades electrical imperativeness between in any event two circuits through electromag neticinduction.. Generally, transformers are usedto addition or decreasing the voltages of trading stream in electric power applications.These adventure down voltage goes to rectifier unit Rectifier is just an electronic contraption which used to change over an AC supply into DC supply. This endeavor we were using length rectifier.12V AC supply is changes over into 12V DC supply. These voltage moves to the controller unit. Controller is an electrical contraption which is used to keep up a reliable voltage. Here we were using two voltage controller. Explicitly voltage controller 7812 and voltage controller 7805.7812 voltage controller keeps up the 12V DC supply. These voltage is adequate to work hand-off unit and 7805 voltage controller keeps up the 5V DC supply. These voltage is used to manage the Arduino unit. We moved the program in the unit. Program was created if any fault occur in the connection, immediately will open the exchange terminal and isolate that messed up line in a manner of speaking. Rest of various lines works normally. By and by a days embedded system changed metorically. Arduino is the pushed variation of embedded structure. These Arduino has adequate sorts yet we picked Arduino UNO. These Arduino UNO serves to develope many impelled variation of Arduino UNO makes straightforward condition .it successfully to get various contraptions using consecutive port. Next we move the hand-off. Move is just an electrical contraption here which went about as a switchif any fault occur in the line, will isolate the line using hand-off. The connector of the exchange moves from commonly close direct to the routinely open conducet .we viably find the fault and to isolate the accuse line. Show unit is partner the Arduino pack which is used to where the fault occurs and to demonstrate to itself. Underground cable fault detector deals with finding of exact fault location from the base station itself. The proposed system finds the exact location of the fault. This paper uses the standard concept of Ohm's law i.e. As soon as a low DC voltage is applied at the feeder end through a series resister, the current would vary depending upon the location of fault in the cable. Cables have some resistance. We are mainly focusing on the resistance. Resistance can vary with respect to the length of the cable. If the length of the cable is increase, the value of the resistance will also increase. If any deviation occurs in the value of resistance, we will call that is fault point and finding that place through Arduino technology. The standard of distance (kilometre) from the base station is represented by the fault point. This value displayed by display unit LCD. Whenever a fault occurs in a cable the buzzer produces the alarm to alert and to take an immediate action by field workers.

V.CONCLUSION

This study successfully demonstrates a microcontroller-based underground cable fault identification system that offers a practical, affordable alternative to traditional fault detection technologies. Using a simple resistance-based measurement technique, the system detects and locates faults with satisfactory accuracy for low-voltage distribution networks. The integration of Arduino provides an efficient way to automate data collection, calculation, and display, while reducing system complexity and cost.

The experimental prototype confirmed the system's effectiveness in identifying open, short, and earth faults in different types of underground cable setups. Moreover, the solution's compact design, user-friendly interface, and low power consumption make it

suitable for field deployment and educational applications.

In conclusion, the Arduino-powered fault detection system offers a scalable platform that can be enhanced further with IoT features, GSM alerts, and integration with smart grid systems. Future developments may involve incorporating wireless data transmission, AI-based fault prediction, and adaptation for high-voltage networks to broaden its utility and impact.

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