IOT Based Underground Cable Fault Detection System

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Abstract - In the urban areas, the electrical cables run in underground instead of overhead lines .Repairing overhead wire breaks can be accomplished in hours, whereas underground repairs can take days or weeks. Diagnosing fault source is difficult and entire cable should be taken out from the ground to check and fix faults. The project work is intended to detect the location of fault in underground cable lines and inform the base station in prior. This prototype uses voltage sensing circuit which checks continuously for the fault in the cable. In case of fault, the voltage across the cable changes accordingly, which is then fed to an ADC to develop precise digital data to a programmed PIC IC , through Wi-Fi module ESP8266, the fault location is updated to the base station . The fault occurring location is also displayed on a 16X2 LCD interfaced with the PIC16F877A microcontroller.

Key Words: Underground Cable, fault location, IOT, PIC micro controller, cables used, voltage sensed, webpage.

1. INTRODUCTION

Undergrounding is the replacement of overhead cables providing electrical power or telecommunications, with underground cables. This is typically performed for aesthetic purposes, but also serves the additional significant purpose of making the power lines less susceptible to outages during high wind thunderstorms or heavy snow or ice storms. Undergrounding can increase the initial costs of electric power transmission and distribution but may decrease operational costs over the lifetime of the cables[1].Due to which digging of entire area has to do, for detecting and correcting the fault which in turn causes wastage of money and manpower. While the fault occurs for some reason at that time the repair process related to that particular cable is difficult due to not knowing the exact location of fault [1].

Hence this paper is very helpful for determining exact location and send this message to the base station, then the system works and alerts the field workers.

II.MECHANISM OF BREAKDOWN OF CABLE

There are two ways in which breakdown of cables usually occurs. One way is by a progressive coring and tracking, which always starts from the core or sheath, and ultimately bridges the electrodes. Another way is by thermal instability which occurs due to rapid Increase in power factor in rise in temperature [1, 2].

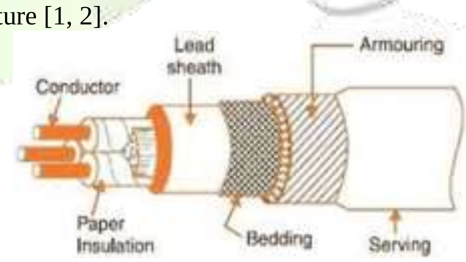

Fig1.Cross sectional view of underground cable

A marked difference between the methods of breakdown is that coring, once it occurs, will continue until the cable breaks down, another the time duration may be considerable for complete action. In thermal instability, however, no damage occurs until just before breakdown [3, 4], so that if the load is reduced before breakdown the cables will not have suffered any permanent change. A very common occurrence is for coring to start and then introduce thermal instability at the center of coring.

III.CAUSES OF FAILURE OF UNDERGROUND CABLES

1. Another most common cause is the mechanical puncturing of the lead sheathing of a cable, such as by a crowbar, especially in industrial installations where excavation and building operations are carried on in areas having several underground cables.

2. The cable may also get damaged due to vibration fatigue or overheating [4]

IV. VARIOUS FAULTS AND HOW TO DETECT THEM

OPEN CIRCUIT FAULT

When one or more cable conductors (cores) break, it leads to discontinuity. This discontinuity also occurs when the cable comes out of its joint due to mechanical stress.

Fault Detection

An open circuit is characterized by infinite resistance. This is utilized in fault detection. The conductors at the far end are bunched together (shorted) and earthed. Then the resistance between each conductor and the earth is measured using a megger.

Observations

1. If there's no fault, megger will read nearly zero.
2. If there's an open circuit in a conductor, the will read infinite when connected between that conductor and the earth.

SHORT CIRCUIT FAULT

It occurs only in multi-cored cables. When two or more conductors of the same cable come 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. It can also be detected using a megger [5, 6].

Fault Detection

A short-circuit is characterized by zero resistance. This is utilized in fault detection. The resistance between any two conductors is measured using a megger. This is done for all the conductors, two at a time.

Observations

If the megger reads zero, it indicates that a short-circuit fault has occurred between those two conductors.

EARTH FAULT

When any of the conductors of the cable comes in contact with the earth, it is called an earth fault. This usually occurs when the outer sheath is damaged due to chemical reactions with soil or due to vibrations and mechanical crystallization. It is somewhat similar to a short circuit fault as the current again takes the least resistive path and flows through the earth. This too can be detected using a megger.

Fault Detection

The megger is connected between the conductor and the ground and megger reading is noted. This is repeated for all the conductors of the cable.

Observations

If an earth fault is present, the megger will show nearly zero reading.

V. TEST METHODS

Time Domain Reflectometer (TDR)

Fig2.Megger Time Domain Reflectometer

A **Time Domain Reflectometer (TDR)** sends a short-duration low energy signal (of about 50 V) at a high repetition rate into the cable. This signal reflects back from the point of change in impedance in the cable (such as a fault). TDR works on the similar principle as that of a RADAR. A TDR measures the time taken by the signal to reflect back from the point of change in impedance (or the point of fault). The reflections are traced on a graphical display with amplitude on y-axis and the elapsed time on x-axis. The elapsed time is directly related to the distance to the fault location. If the injected signal encounters an open circuit (high impedance), it results in high amplitude upward deflection on the trace. While in case of a short-circuit fault, the trace will show a high amplitude negative deflection.

Arc Reflection Method

The arc reflection method uses a TDR with a filter and thumper. The thumper (or surge generator) is used to create an arc across the shunt fault which creates a momentary short-circuit so that the TDR can show a downward deflection effectively. The arc reflection filter protects the TDR from high voltage surge generated by the thumper and routes the low-voltage signal down the cable.

VI. PROPOSED SYSTEM

The proposed system is an IOT enabled underground cable fault detection system. The basic principle behind the system is Ohms law. When fault occurs in the cable, the voltage varies which is used to calculate the fault distance. The system consists of Wi-Fi module, Microcontroller. The block diagram of the fault detection system is shown in the Figure .The power supply is provided using step-down transformer, rectifier, and regulator. The voltage sensing circuit of the cable provides the magnitude of voltage drop across the cable to the microcontroller and based on the voltage the fault distance is located [1,2].

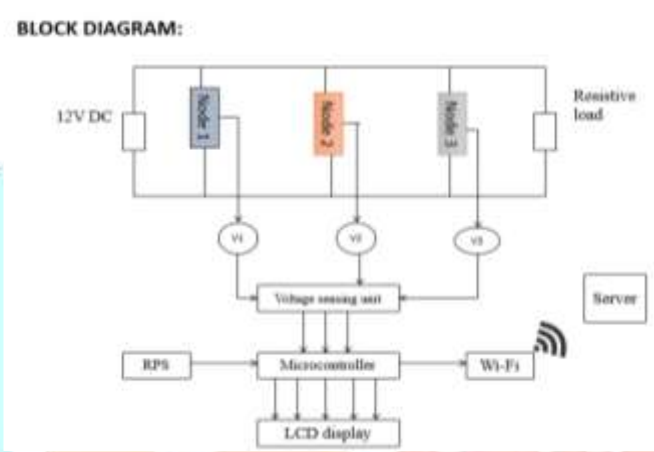

Fig 3: Schematic representation of the prototype

VII. FLOW CHART

The flow chart of the logic behind the fault detecting system is given in Figure 4. The input and output ports of Microcontroller, LCD display and Wi-Fi module of the system are configured and initialized. When fault occurs (switch is pressed), the fault distance, time and phase are displayed corresponding to that fault. The above fault information will be displayed in the webpage using Wi-Fi module.

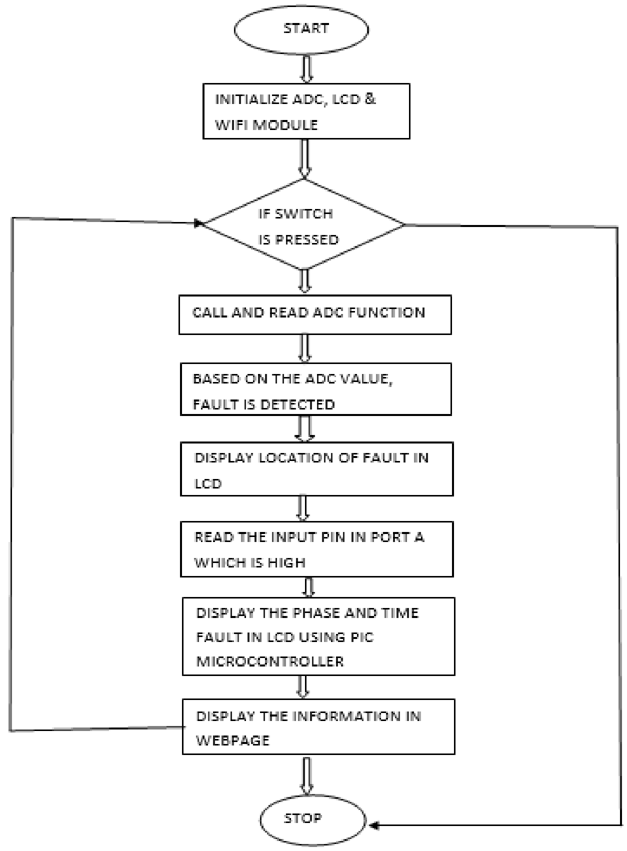

Fig 4. Flow Chart of Fault Detection System

VIII. HARDWARE USED

Pic Microcontroller

PIC microcontrollers consists of 3 timers, out of which the Timer 0 and Timer 2 are 8-bit timers and the Time-1 is a 16-bit timer, which can also be used as a counter. The PIC Microcontroller consists of 8-channels, 10-bit Analog to Digital Converter. The operation of the A/D converter is controlled by these special function registers: ADCON0 and ADCON1. Oscillators are used for timing generation. PIC microcontrollers consist of external oscillators like crystals or RC oscillators. In case of crystal oscillators, the crystal is connected between two oscillator pins, and the value of the capacitor connected to each pin determines the mode of operation of the oscillator.

PWM Mode: It provides pulse width modulated output with a 10-bit resolution and programmable duty cycle.

PIC16 series consists of five ports, such as Port A, Port B, Port C, Port D and Port E.

EEPROM: It consists of 256 bytes of memory space. It is a permanent memory like ROM, but its contents can be erased and changed during the operation of the microcontroller. The contents into EEPROM can be read from or written to, using special function registers like EECON1, EECON2, EEDATA, etc.

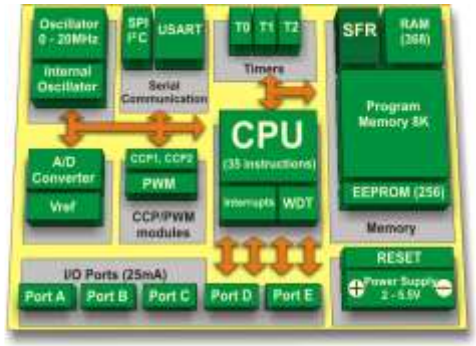

Fig 5. PIC Microcontroller

Rps (regulated power supply)

Regulated power supply is an electronic circuit that is designed to provide a constant dc voltage of predetermined value across load terminals irrespective of ac mains fluctuations or load variations. The output voltage remains constant irrespective of variations in the ac input voltage or variations in output (or load) current. The power supply circuit consists of step down transformer which is 230v step down to 12v.In this circuit 4diodes are used to form bridge rectifier which delivers pulsating dc voltage and then fed to capacitor filter the output voltage from rectifier is fed to filter to eliminate any AC components present even after rectification. The filtered DC voltage will be given to regulator to produce 12v constant DC voltage.

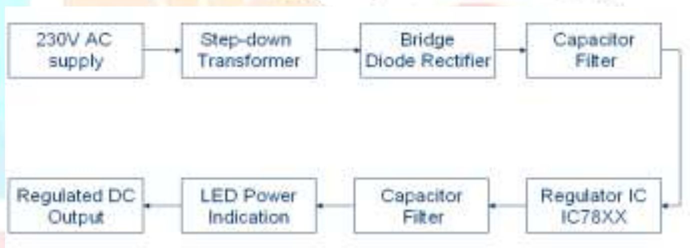

Fig 6. block diagram of RPS

Wi-Fi

Wi-Fi is a technology that allows electronic devices to connect to a wireless LAN (WLAN) network.
Using the 2.4 gigahertz (12 cm) UHF and 5 gigahertz (6 cm) SHF ISM radio bands.
Wi-Fi compatible devices can connect to the Internet via a WLAN network and a wireless access point.
Wi-Fi nodes operating in ad hoc mode refers to devices talking directly to each other without the need to first talk to an access point (also known as base station).

The success was recorded in Mobile Computing magazine and later published formally in IEEE Transactions on Wireless Communications.

Fig 7.Wi-Fi module

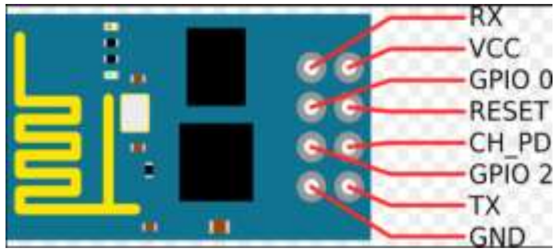

Fig 8. ESP8266 pinout

LCD Display

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc.

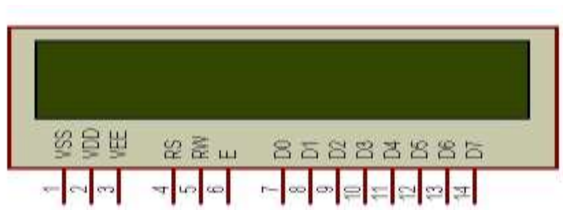

Fig 9. Liquid Crystal Display

Pin No.	Name	Description
Pin no. 1	VSS	Power supply (GND)
Pin no. 2	VCC	Power supply (+5V)
Pin no. 3	VEE	Contrast adjust
Pin no. 4	RS	0 = Instruction input 1 = Data input
Pin no. 5	R/W	0 = Write to LCD module 1 = Read from LCD module
Pin no. 6	EN	Enable signal
Pin no. 7	D0	Data bus line 0 (LSB)
Pin no. 8	D1	Data bus line 1
Pin no. 9	D2	Data bus line 2
Pin no. 10	D3	Data bus line 3
Pin no. 11	D4	Data bus line 4
Pin no. 12	D5	Data bus line 5
Pin no. 13	D6	Data bus line 6
Pin no. 14	D7	Data bus line 7 (MSB)

Table 1.LCD Pin Discription

IX. OBSERVATION AND RESULT

The fault detection system is simulated using Proteus 8.5 professional software and the fault information is displayed in the LCD. The simulation and hardware setup of the fault detection system are shown in the Figure 9 and Figure 10 respectively. The Fault display message is shown in the table 2. The work "IoT Based Underground Cable Fault Detecting system" is an efficient system as it reduces the time to detect the exact location of fault.

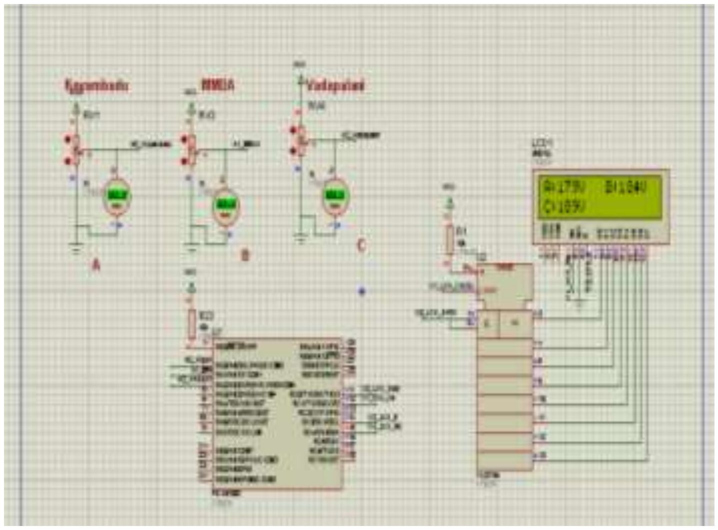

Fig 10. Simulation of the System using Proteus

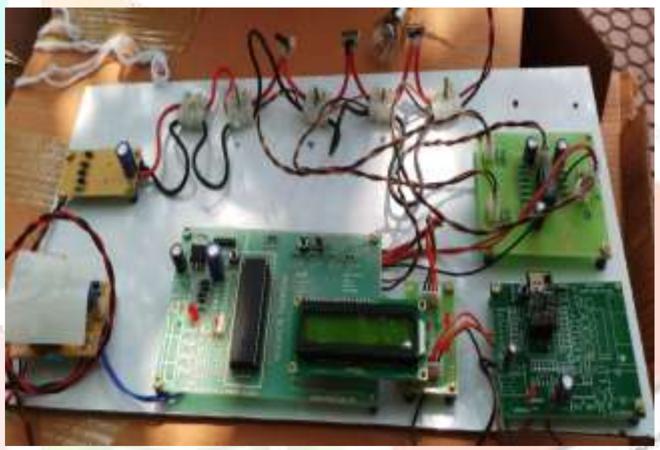

Fig 11. Hardware Setup of the System

Table 2 Fault Display Message in the Webpage

X. CONCLUSION

The short circuit fault at a particular distance in the underground cable is located to rectify the fault efficiently using simple concepts of Ohms law. The work automatically displays the phase, distance and time of occurrence of fault with the help of PIC 16F877A and ESP8266 Wi - Fi module in a webpage. The benefits of accurate location of fault are fast repair to revive back the power system, it improves the system performance, it reduce the operating expense and the time to locate the faults in the field.

XI. FUTURE SCOPE

The work can be extended for open circuit fault, short circuit Line to Line Fault (LL) and double Line to Ground Fault (LLG). The open circuit fault can be detected using a capacitor in ac circuit which measures the change in impedance and calculate the distance of fault.

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