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# IoT Technology Based Underground Cable Fault Distance Detection System Using ATmega328P Microcontroller

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ABSTRACT: The objective of this paper is to determine the location of fault in underground cable lines<sup>[1]</sup> from the source station to exact location of fault in any units, here in kilometres. Whenever a fault occurs in the underground cable line for some reason, the repairing process relating to that faulted cable becomes difficult owing to lack of proper system for tracking the exact fault location and the type of fault occurred in the cable. For this, a system has to be developed to find the exact location of the fault in the distribution line system for all the three phases R, Y & B for different type of situations of faults. Here in this paper single line to ground, double line to ground & three phase faults have been considered. Therefore, the basic concept of Ohm's law<sup>[2]</sup> is found suitable in principle to develop a fault location tracking system. Based on the Ohm's Law, it is found that the resistance of the cable is proportional to its length under constant conditions of temperature and the cross section area and therefore if a low DC voltage is applied at the feeder end through a series of resistor in cable lines, the current would vary depending upon the location of fault in the cable. Here a system is developed which consists of a microcontroller, LCD display, Fault Sensing Circuit Module, IoT Wi-Fi Module and proper power supply arrangement with regulated power output. Hence, if there is a short circuit in the form of line to ground<sup>[3]</sup> in any phase/phases, the voltage across series resistors changes accordingly and an analog signal in the form of voltage drop is generated by the fault sensing circuit of the introduced system, which is then fed to an ADC inbuilt in already programmed microcontroller to create the exact digital dataand after processing the data the output will be displayed in the connected LCD with the exact location of fault occurred in kilometres from the source station and simultaneously also indicate the corresponding R, Y, B phase where fault occurred with the exact distance. The same processed information output will appear in the webpage through connected IoT Wi-Fi Module. In this system, ATmega 328P micro controller<sup>[4]</sup> is used. Here the current sensing of circuits made with a combination of resistors is interfaced to ATmega328 micro controller with the help of internally inbuilt ADC for providing the digital data to microcontroller. The fault sensing circuit is made with the combination of set of series resistors &the set of switches alongside each resistor. The relays are controlled by the relay driver. A 16x2 LCD display is connected to the microcontroller to display the information of phase/phases and location of fault in kilometres.

#### KEYWORDS: Underground Cable System, Ohm's Law, ATmega 328P micro controller, Fault Sensing Circuit, IoT Wi-Fi Module, LCD Display.

#### I. INTRODUCTION

Use of underground power cable is expanding due to safetyconsiderations and enhanced reliability in the distribution systems in recent times<sup>[5]</sup>. Due to safety reasons and high power requirements in densely populated areas, use of underground cable has seen a sharp hike. The underground cable systems have the advantages of not getting affected by any adverse weather condition such as storm, snow, heavy rainfall as well as pollution. But it has its own drawback for immediate tracking of fault in the underground cable lines.



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Study of cable failures and development of accurate fault detection and location methods has been interesting research topics in the past and present. Fault tracking entails determination of the presence of a fault, while fault location detection includes the determination of the physical location of the fault. However, this fault detection and fault location detection technology for underground power distribution systems is still in developing stages.<sup>[6]</sup>

Before fixing any fault in cables, the fault has to be identified first. There are many ways to find the cable fault location. This paper deals with the method to locate faults and identify the phase line in damaged cables. A basic idea of fault location and phase identification in the pictorial view is undernoted.



Fig.1: Schematic Diagram of Basic Idea

#### **II. LITERATURE SURVEY**

Frequent fault in underground cables due to the breakdown of paper plastic insulation <sup>[7]</sup>due to chemical reaction or poorworkmanship during installation and the difficulties in locating the approximate fault area have been a serious problem. Most Underground Faults are located by unearthing the entire length of cable to enable visual inspection to be carriedout. In case where visual inspection is not helpful then the entire length of cable is replaced. This manual method is notonly expensive but also results in heavy loss of revenue to the power distribution company. This research is aimed atdesigning an underground cable fault location distancedetection to solve this problem. The research work will help inidentification and location of underground cable fault without unearthing the entire length of the cable before repair orreplacing entire cable due to difficulty in locating the fault.

#### **III.WORKING PRINCIPLE & OPERATION**

#### Principle

• The system works mainly on the principle of Ohm's Law where a low DC voltage is applied at the feeder end through fault sensing circuit.



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#### Operation

- The operation of the system states that when the current flows through the fault sensing circuit module the current would vary depending upon the length of the cable from the place of fault that occurred if there is any short circuit fault with the Single Line to ground fault, or double line to ground fault, or three phase to ground fault.<sup>[8]</sup> The voltage drops across the series resistors changes accordingly and then the fault signal goes to internal ADC of the microcontroller to develop digital data. Then microcontroller will process the digital data and the output is being displayed in the LCD connected to the microcontroller in kilometres and phase as per the fault conditions. This Output is also displayed in the webpage through the IoT Wi-Fi Module ESP8266 connected to the system.
- The power supply given to the system is 230V ac supply. This 230 V supply is fed to the two Adapter Modules (12 V, 2 Amps. each). The adaptor module 1 and 2 converts the AC voltage to DC. The ripple in output of adaptor module 1 is then removed with the help of a 1000 microfarad electrolytic capacitor. Since a constant 5 V voltage source is desired for our system, because the Microcontroller (ATmega328), 16x2 LCD (Liquid Crystal Display), Relay Drivers and Relays, Fault Sensing Circuit Module <sup>[9]</sup>, IoT Wi-Fi Module<sup>[10]</sup>, etc. and the other components work at 5V supply, hence we are using three voltage regulators (7805). These voltage regulators convert the filtered output to 5V constant supply voltage. The first voltage regulator (VR<sub>1</sub>) feeds the 5 Volts supply to the microcontroller, LCD display, and the set of series resistors while the second voltage regulator VR<sub>2</sub> feeds the relay driver IC ULN2003A and 3 three relays. The third Voltage regulator is connected to the IoT ESP8266 Wi-Fi Development Board Module which gives 5 Volts DC supply to it.
- The project consists of three relays which are driven by a relay driver IC ULN2003A. The relays used here switches off/on the bulb loads R, Y and B to indicate the fault being occurred in corresponding phases.

#### IV.DEVELOPMENT OF CIRCUIT DIAGRAM

#### A. Simulation of Fault Sensing Circuit Diagram in Proteus 8 Software

A system of set of series resistors in each phase resembling 3 phase underground cable lines along with slider switches for fault creation has been developed as shown in Fig. 2.



Fig.2: Simulation of Fault Sensing Circuit in Proteus 8 Software



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The Table 1 shows the observation of resistances and currents while simulating the ault sensing circuit.

Location of Fault	Cable Resistance During Fault Conditions, R <sub>DC</sub> (in kΩ)	Total Resistance of Cable During Fault Condition, $R_T$ (in $k\Omega$ )	Current flowing through Fault Sensing Circuit, I <sub>F</sub> (in µA)
At 1 Km	10	20	250
At 2 kms	20	30	167
At 3 kms	30	40	125
At 4 kms	40	50	100

#### Table 1: Observation Sheet for Fault Sensing Circuit

Fig.3 shows the simulation log report of fault sensing circuit developed in Proteus 8 Software.



Fig.3: Simulation Log Report of Fault Sensing Circuit in Proteus 8 Software



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#### **B.** Simulation of Basic Circuit Diagram in Proteus 8 Software

A fault detecting system is developed in Proteus 8 using microcontroller ATmega328P IC, LCD display, Relays, fault sensing circuit, etc. as shown in Fig.4.



Fig.4: Simulation of Basic Circuit Diagram (with fault) in Proteus 8 Software

The Table 2 shows the observation of voltage drops and calculated digital ADC data for each kilometre and upto four kilometres with pre-fault voltage source of 5 Volts. while simulating the Basic circuit diagram.

Location of Fault	Pre-fault Voltage, V <sub>Ref</sub> (in Volts)	$\label{eq:calculated} \begin{array}{l} Calculated \ Voltage \ Drop \ during \\ Fault \ Conditions, \ V_d \ (in \ Volts): \\ V_d = V_{Ref} \text{-} \ \{I_F \ x \ (R_T \text{-} R_{DC}\} \end{array}$	Calculated Digital ADC Data for Microcontroller : (V <sub>d</sub> x 1024)/V <sub>Ref</sub>
At 1 Km	5	2.50	512
At 2 kms	5	3.33	682
At 3 kms	5	3.75	768
At 4 kms	5	4.00	819

Table 2: Observation Sheet for Dasic Circuit Diagram	Table 2:	Observation	Sheet for Basic	<b>Circuit Diagram</b>
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Fig.5 shows the simulation log report of basic circuit diagram of fault detection system developed in Proteus 8 Software.



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Fig.5: Simulation Log Report of Basic Circuit Diagram in Proteus 8 Software

#### C. Circuit Diagram with IoT Wi-Fi Module

A fault detecting system is developed using above statedbasic circuit diagram in Fig. 4 with the help of IoT Wi-Fi Module as shown in Fig.6.



Fig.6: Circuit Diagram with IoT Wi-Fi Module



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#### V. MAJOR COMPONENTS USED

#### **1. AC/DC ADAPTER**

An AC/DC adapter<sup>[11]</sup> or AC/DC converteris a type of external power supply, often enclosed in a case similar to an AC plug. Other common names include plug pack, plug-in adapter, adapter block, domestic mains adapter, line power adapter, wall wart, power brick, and power adapter. This module is 230 V AC - 12 V, 2A DC Adapter Module.



Fig.7: 230 V AC- 12 V, 2 A DC Adapter

#### 2. IoT Wi-Fi ESP8266 Module

The **Internet of things** (**IoT**) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, & connectivity which enable these objects to connect and exchange data. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.Lolin NodeMCU V3 is an open-source firmware and development kit that helps you to prototype your IOT product. The V3 is a "version" invented by producer LoLin to signify minor improvements to the AMICA V2 boards.



Fig.8: IoT ESP8266 Lolin NodeMCU V3 WI-Fi Module



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#### 3. Microcontroller

The ATmega328/P is a low-power CMOS 8-bit microcontroller based on the AVR® enhanced RISC architecture. This empowers system designer to optimize the device for power consumption versus processing speed. It has 32KBytes of In-System Self-Programmable Flash program Memory, 1KBytes EEPROM, 2KBytes Internal SRAM and Write/Erase Cycles of 10,000 Flash/100,000 capable EEPROM. It can be programmed using Arduino IDE.





#### 4. Fault Sensing CircuitModule

The fault sensing circuit module is made by making use of a set of switches at every known equivalent kilometre as indicated by the set of series resistors to cross check accuracy of the same. The circuit uses four sets of resistors in series for each phase of the cable line i.e. R1, R2, R3, R4 for phase R, R5, R6, R7, R8 for phase Y and R9, R10, R11, R12 for phase B. Also resistors R13, R14 and R15 are used in series with supply line of each phase as shown in the circuit diagram. Each set of four series resistors represents the resistance of the underground cable for a specific distance of 4kms equally divided into 1km for each resistor. The resistors R13, R14 and R15 develop respective voltage drops corresponding to the occurrence of ground fault in one phase or two phases or three phases. This drop is then sensed by the ADC built in microcontroller. The other end of resistors R1, R3 and R5 are connected to ground.



Fig.10: Fault Sensing Circuit Module



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#### VI.FLOWCHART



Fig.11: Programming Flowchart

#### VII. EXPERIMENTAL RESULTS

The fault distance detection system is being run and tested which shows the different outcomes of faults in LCD display of the system and followed by mobile webpage through IoT Wi-Fi Module as per case chosen. This system consists of fault sensing circuit having set of four series resistors in each phase of the line equally divided into 4 parts at a distance of 1 Kilometre each where a slider switch is connected to the supply. When the switch is closed the current flows through the resistor and voltage drop occurs which indicates that a fault to ground has occurred. There are various case studies conducted with all the three phases (R, Y, and B) of cable line individually in each phase. There are 4 nos. of slider switches in each phase totalling to 12 nos. of such switches in all the three phases.



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Case 1:When No fault has occurred. Outcome is R, Y and B all "OK".

6	242 🛪 🖬	al 61% 💼 2	1:03
	192.168.43.86	1	E
	UNDERGROUND FAULT DETECTIO	N	
	R phase OK		
	Y phase OK		
	B phase OK		
		* **	

Fig.12 (a): System View

Fig. 12(b): Mobile Webpage View

Case 2:Fault occurred when SW2 of phase Y and phase B are closed. Outcome is Fault has occurred in phase Y and phase B at 2 Km.

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RAAR A		192.168.43.86		Ξ
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		R phase CR		
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		B phone fault on 240m		
Eig 12 (a): System View		Eig 12 (d) Mahila Wah	nona Viam	

Fig.12 (c): System View

Fig. 12 (d): Mobile Webpage View

Likewise there might be various cases of fault occurred in all these three cable line i.e. fault may occur in single phase, in two phases and also three phases at a time.

#### VIII. CONCLUSION

This paper described the IoT Technology Based Underground Cable Fault Distance Detection System Using ATmega328P Microcontroller in softwareand hardware simulation form and results were successful. A full-fledged prototype model had been implemented as a proof of concept to realize and understand the real time scenarios in underground cable system. Through this prototype simulation model the proposed architecture had been demonstrated



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that can effectively satisfy the requirement of exact fault location detection in the underground cable system and it is believed that this model can be a promising technology to solve future fault location detection problem.

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