ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 6, Issue 10, October 2017

Underground Cable Fault Distance Detector using ATmega328 Microcontroller

Tanmay Kedia[1], Vinita Sahare[2], Kanchan Kumar Bauri[3], Rajendra Kumar Sahu[4], Sanjeev Kumar[5], Abhijeet Lal[6]

UG Student, Department of EEE, BIT Durg, Chhattisgarh. India[1, 2,3,4,5]

Assistant Professor, Department of EEE, BIT Durg, Chhattisgarh. India[6]

ABSTRACT: The underground cable system is a common practice followed in many areas and various industrial units. Whenever a fault occurs in this system for some reason, the repairing process relating to that faulty cable becomes difficult owing to untraceable of the exact faulty location of the cable.Therefore, the objective of this paper is to determine the location of fault in underground cable lines from the source station to exact location of fault in any units here in kilometres.For this paper, the basic concept of Ohm's law is used according to which, 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. That is in case if there is a short circuit in the form of line to ground, the voltage across series resistors changes accordingly which is then fed to an ADC inbuilt in already programmed microcontroller to create the exact data which would display the exact location of fault in kilometres from the source station in the connected LCD and also indicate the corresponding R, Y, B phase where fault occurred with the exact distance.For this paper, the ATmega 328P micro controller and a rectified power supply are 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 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 of phase and location of fault in kilometre.

KEYWORDS: Underground Cable, Ohm's Law, Time domain Reflectometer, ATmega 328P micro controller, LCD.

I.INTRODUCTION

Electrical energy is generated in the generating station and then it is distributed to the different loads at different areas for consumption through step up and step down transformers. Distribution of the electrical energy is done via electric cables.Study of cable failures and development of accurate fault detection and location methods has been interesting research topics in the past and present. Fault detection 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.There are many ways to find the cable fault location. This paper deals with the method to Locate Faults in a Damaged Cable. Before fixing any fault in cables, the fault has to be identified first.
Types of common underground Cable Faults:

- 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

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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.

Here the case of ground faults locationis chosen for this paper.

II.LITERATURE SURVEY

Frequent fault in underground cables due to the breakdown of paper plastic insulation due to chemical reaction or poor workmanship 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 carried out. In case where visual inspection is not helpful then the entire length of cable is replaced. This manual method is not only expensive but also results in heavy loss of revenue to the power distribution company. This research is aimed at designing an underground cable fault location distance detection to solve this problem.The research work will help in identification and location of underground cable fault without unearthing the entire length of the cable before repair or replacing entire cable due to difficulty in locating the fault.

III.WORKING OPERATION

Principle

- “Underground Cable Fault Distance Detector using ATmega328 Microcontroller” works mainly on the principle of Ohm's Law where a low DC voltage is applied at the feeder end through set of series resistors (which is the equivalent model of underground cable).
- Time Domain Reflectometer (TDR) The TDR sends a low-energy signal through the cable, causing no insulation degradation. A theoretically perfect cable returns that signal in a known time and in a known profile. Impedance variations in a "real-world" cable alter both the time and profile, which the TDR screen or printout graphically represents. This graph (called a "trace") gives the user approximate distances to "landmarks" such as opens, splices, Y-taps, transformers, and water ingression. One weakness of TDR is that it does not pinpoint faults. TDR is accurate to within about 1% of testing range. Sometimes, this information alone is sufficient. Other times, it only serves to allow more precise thumping. Nevertheless, this increased precision can produce substantial savings in cost and time. Another weakness of TDR is that Reflectometer cannot identify faults-to-ground with resistances much greater than 200 ohms.
- In addition to this, it also incorporates the concept of the Millman's Theorem.
- Besides this, the project is a slight modification of Blavier's Test Method.

Explanation

The main operation lies on the fact that when the current flows through the set of series resistors in each of the three set of line 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. The voltage drops across the series resistors changes accordingly and then the fault signal goes to internal ADC of the microcontroller to develop precise digital data. Then microcontroller will process the digital data and the output is being displayed in the LCD connected to the microcontroller in kilometres as per the programming conditions.

The power supply given to the circuit is 230V ac supply, which is fed to step down transformer (9 V-0 V) which steps down the voltage from 230 V to 9V which is then fed to a full wave bridge rectifier to rectify the ac voltage into pulsating dc voltage. The ripple in rectified output is then removed with the help of a 1000 microfarad electrolytic capacitor. Since a constant 5 V voltage source is desired in our circuit, because the Microcontroller (ATmega328), 16x2 LCD (Liquid Crystal Display), Relay Drivers and Relays,etc. and the other components work at 5V supply; therefore, we are using two voltage regulators (7805). These voltage regulators convert the filtered output to 5V constant supply voltage. The first voltage regulator U2 feeds the voltage to microcontroller, LCD, and the set of series resistors. While the second voltage regulator U3 feeds the relay and relay driver IC ULN2003A.

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Vol. 6, Issue 10, October 2017

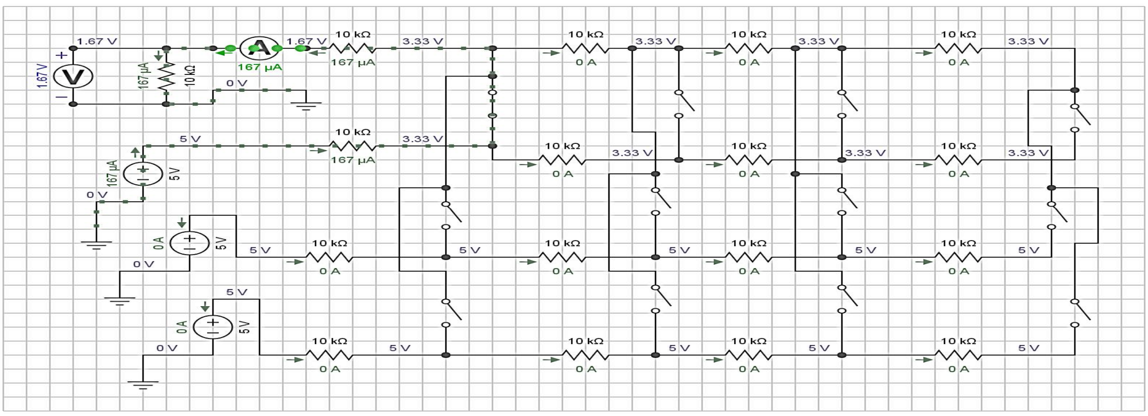
Also this model consists of three relays which are driven by a relay driver IC ULN2003A. The relay used here drives the bulb load to indicate the fault being occurred in corresponding phases and can be used to trip the power supply to the set of series resistors.

The fault creation environment is made by a set of switches at every known equivalent kilometre as indicated by the set of series resistors to cross check accuracy of the same. When a fault is occurred at the distance in a phase (or two phases or three phases) current flows through the shorted line and developing drops across the corresponding phase resistors. This drop is sensed by the ADC (built inside the microcontroller) through Port and converts it into equivalent digital data. The microcontroller then process these data according to fault conditions pre-programmed into the microcontroller and then sends out display signals about the location of fault to LCD which finally displays the location of the fault in kilometres and simultaneously send the signals to the relay driver IC which further drives the bulb load connected to the relay.

The model 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.

IV. SIMULATION OF MODELLED SET OF RESISTORS CIRCUIT FORMING PART OF THE CIRCUIT DIAGRAM DEVELOPED IN EVERYCIRCUIT APP

A. After research on TDR, this circuit simulation is developed on Basis of Ohm's Law in EveryCircuit App



But here we are detecting only the location of fault without any identification of proper phase.

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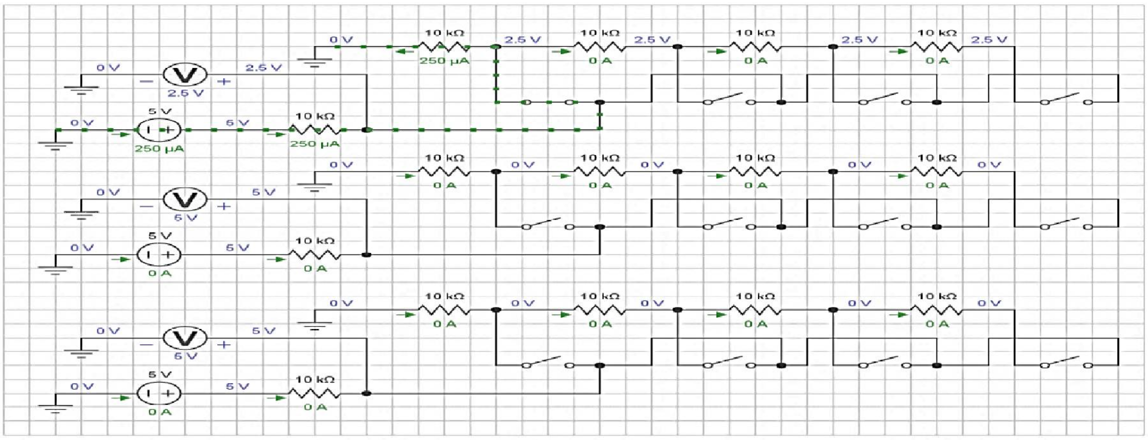
B. After review of Blavier's Test, the circuit is modified and the simulation is again performed.



This resistors set model stands correct for further proceedment of design of fault distance detection circuitry which is shown in Proteus simulation. And here fault detection results are found along with phase identification as shown in below mentioned table.The results are valid for all the phase (R, Y, and B) separately in this resistor set model.

V. EXPERIMENTAL RESULTS IN TABULATION FORM for 10 KΩ Resistance

Location of Fault	Pre-fault Voltage, V_{ref} (in Volts)	Voltage drop Measured ,V_d (in Volts)	Current flowing through fault location, I_f (in µA)	Calculated Digital ADC Data for Microcontroller : $(V_d \times 1024)/V_{ref}$
At 1 Km	5	2.50	250	512
At 2 kms	5	3.33	167	682
At 3 kms	5	3.75	125	768
At 4 kms	5	4.00	100	819

DOI:10.15662/IJAREEIE.2017.0610019

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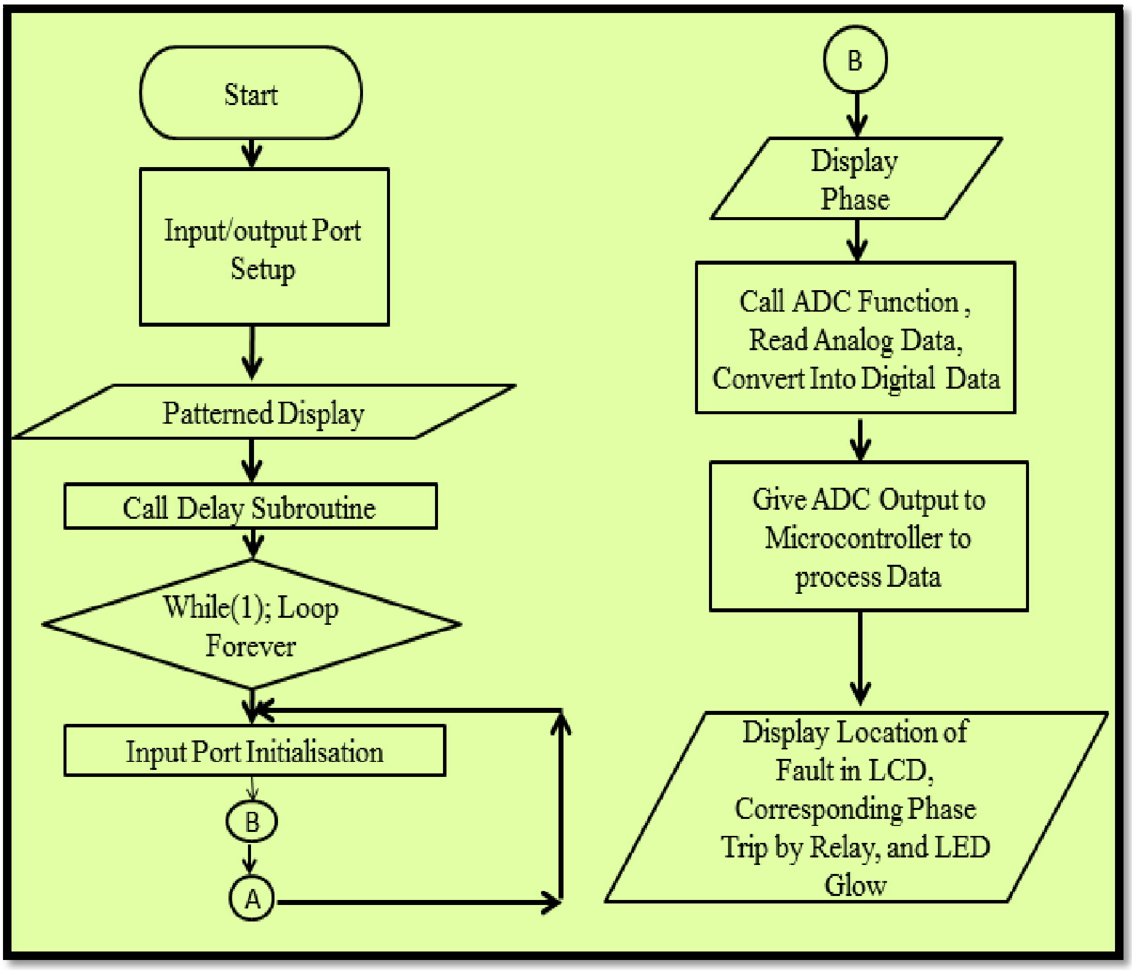
VI. FLOWCHART



VII. RESULT AND DISCUSSION

Simulation of fault distance detection is also conducted in Proteus 8 Software as shown below and different results are obtained as per case chosen. In this model set of series resistors in each phase of the line is 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 kept on 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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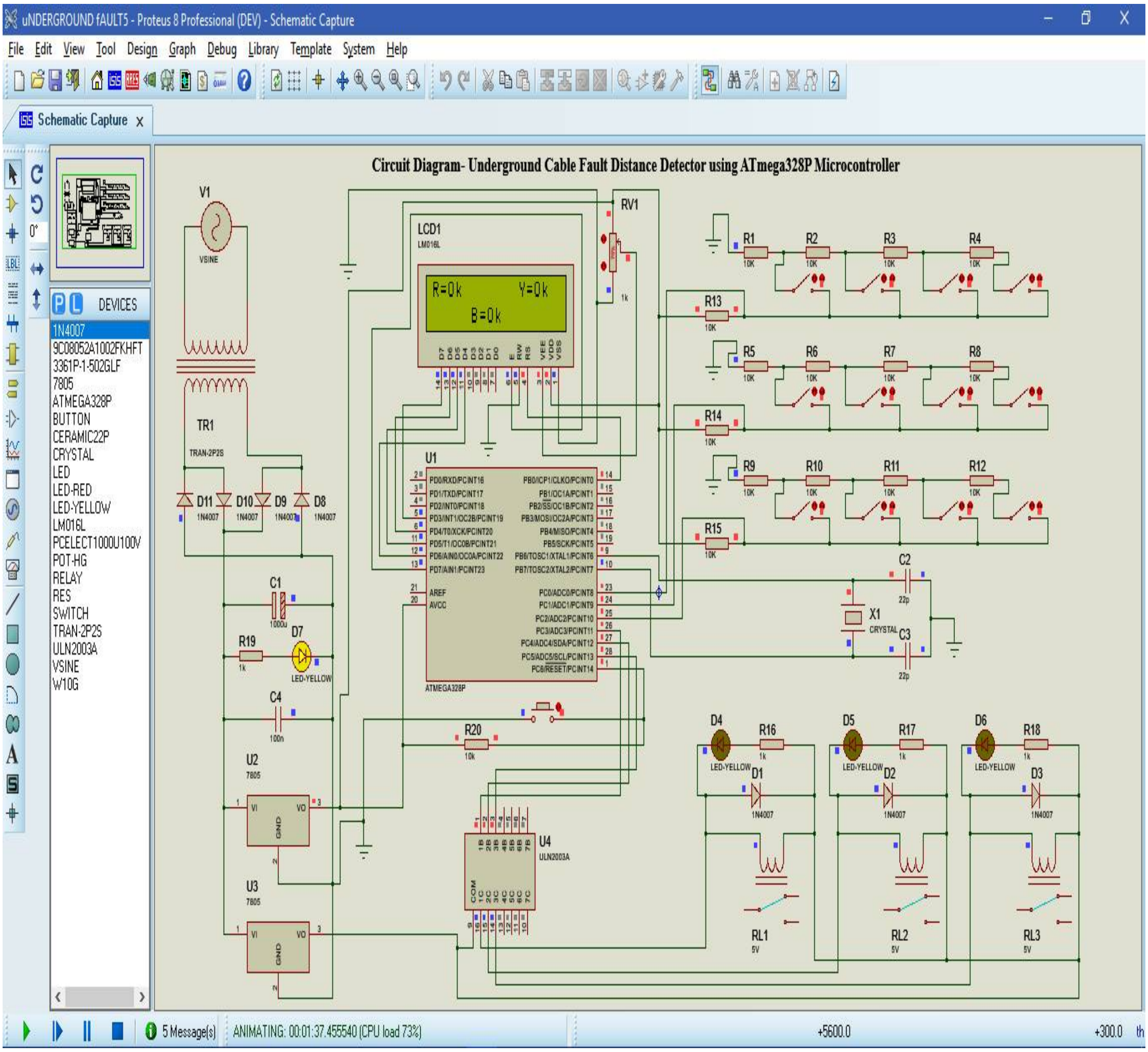
Case 1: No fault Occurred when simulation started.



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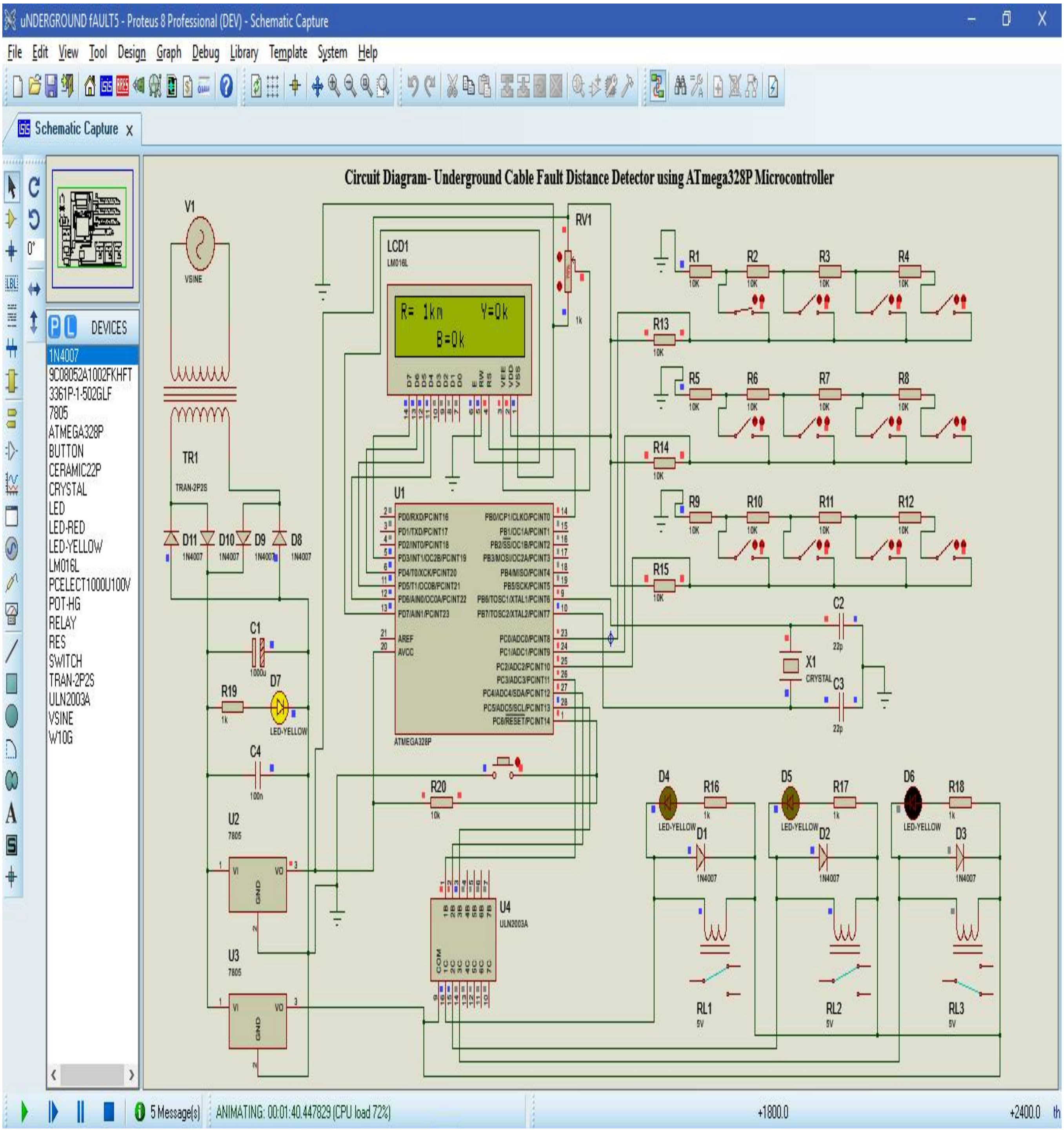
Case 2: fault occurred when Switch 1 across Resistance R1 of phase R is closed.



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.

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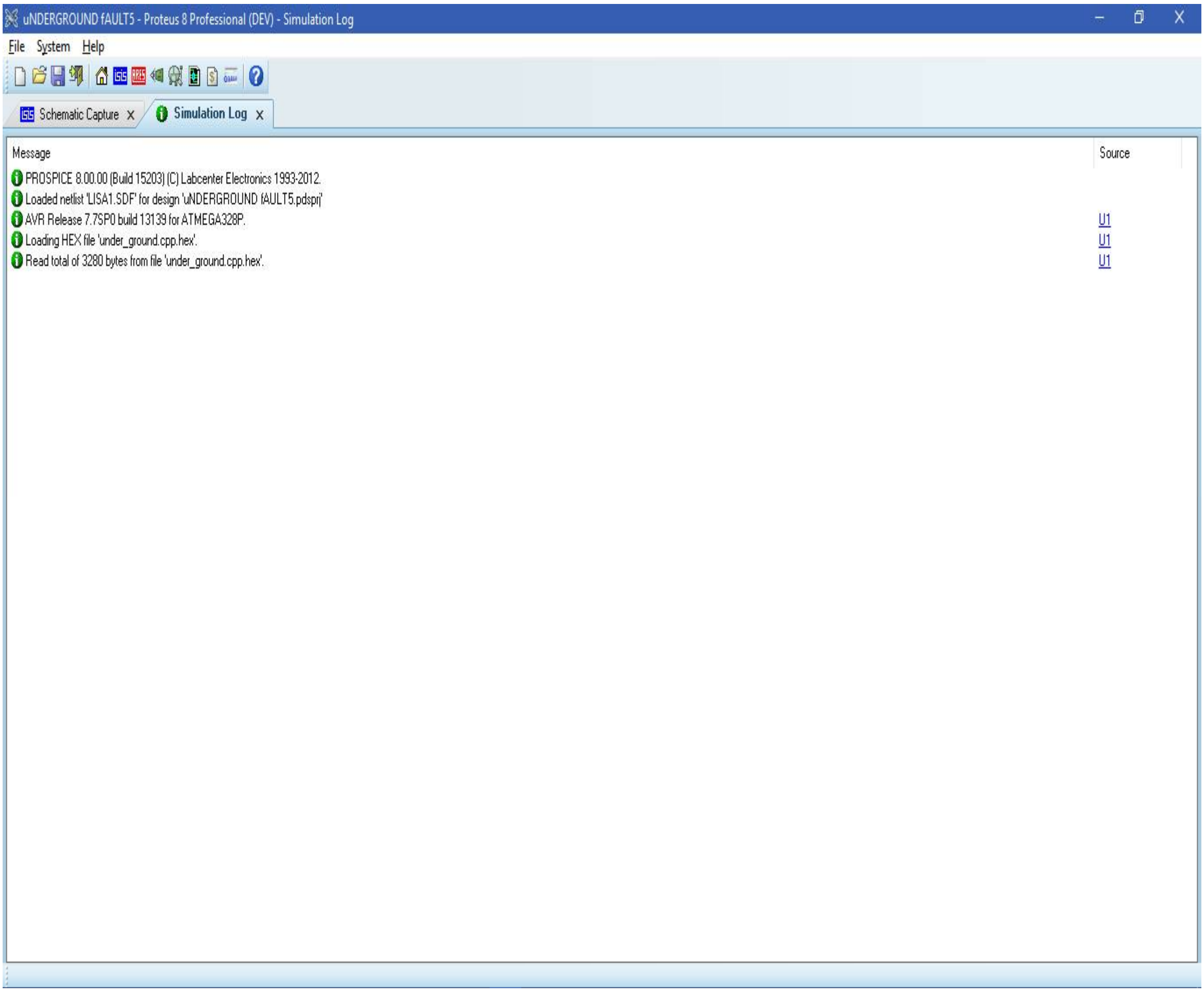
Simulation Log of Circuit Diagram developed in Proteus 8 Software



VIII.CONCLUSION

This paper described the Underground Cable Fault Distance Detector Using ATmega328 Microcontroller in 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 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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