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DESIGN AND IMPLEMENTATION OF OF AN ARDUINO BASED UNDERGROUND CABLE FAULT DETECTION

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Arduino, Cable, microcontroller, resistance

ABSTRACT

The research is to determine and locate the position of underground cable fault from a remote station in KM using a microcontroller. The practice of underground cabling is a common system employed in many modern cities. When fault occur in an underground cable for some reasons, the repairing process related to that particular cable is difficult because it is not easy to find the exact location of the cable fault. The proposed system is to find the specific area of the fault. The research will utilized the concept of Ohms law i.e., when a small DC voltage is injected at the feeder end of a cable line through a series resistor, the current flow varies depending on the location of fault in the cable. If t short circuit fault occur (Line to Ground), the voltage across resistors in series changes accordingly, which is then fed to an Analog-to-Digital Cable to develop precise digital data which a programmed microcontroller of 8051 family would display in kilometers. The fault occurring at a particular distance and the respective phase is displayed on a Light Crystal Display interfaced to the microcontroller.

INTRODUCTION

Till the last decade the cables where made to lay overhead and currently the scenario is to lay underground cable, which is superior to the earlier method. This is because the underground cables are not affected by the adverse weather conditions. Neither does the hot sunny day or rain influence it. But when the cable breaks due to some reasons it's very difficult to locate where the fault is. Right now what is done is that, they locate the approximate area and uncover the cables from the location and check it physically to locate the specific point of discontinuity.

Currently an Arduino, a microcontroller, is being developed which can be used to locate the break from an external point. When an underground cable is broken or Short-circuited then an Arduino will be connected to the circuit and locate the exact position of discontinuity. Hence it is an advantage for repairing the fault. The other instruments that can be included are odometer, video cam, remote navigation etc.

For most of the worldwide operated low voltage, medium voltage and high voltage distribution lines underground cables have been used for many decades. To reduce the sensitivity of distribution networks to environmental influences underground high voltage cables are used more and more. They are not influenced by weather conditions, heavy rain, storm, snow and ice as well as pollution. The rising demand for electrical energy increases the importance and priorities of uninterrupted service to customer. Thus, faults in power distribution networks have to be quickly detected, located and repaired.

A cable fault can be defined as any defect, inconsistency, weakness or non-homogeneity that affects the performance of a cable. All faults in underground cables are different and the success of a cable fault location system depends to a great extent on practical aspects and the experience of the operator. To accomplish this, it is necessary to have personnel trained to test the cables successfully and to reduce their malfunctions. An efficient cable fault location service must include, taking full control of electrical safety, pinpointing the position of the fault, excavation, repair of the cable, testing of the repaired cable and return to service reinstatement of the ground service.

Fault Finding

Underground cables are used in 33kV, 11kV and 415V distribution networks. Faults are major disturbance to the power system. Hence the need to locate the faulty point in an underground cable in order to facilitate quicker repair, improve the system reliability and reduced outage period. Power cable fault location techniques are used in power system for accurate pinpointing of the fault positions. The benefits of accurate location of fault are:

1. Fast repair to restore back the power system.
2. Improve the system availability and performance.
3. Reduce operating cost and save the time required by the crew searching in bad weather, noisy area and tough terrains.

Various fault classification and location methods have been proposed and they can be categorized as analytical methods, artificial intelligence (AI) based methods, travelling wave methods and software based methods.

Methods of Fault Classification

Fault classification identifies the type of fault on the fault lines in the system. There are different methods proposed for the fault classification. This section reviews arduino based method which is useful in detecting the type of fault.

Goal and Objectives

a. To review the approach of fault classification and location of underground cable.
b. To simulate the network using AN ARDUINO MICROCONTROLLER software.
c. To classify the type of fault in underground cable.
d. To estimate fault location of underground cable

Block Presentation of a SCADA Control for Remote Industrial Plant

The block diagram of an Arduino based underground cable fault detection is shown below

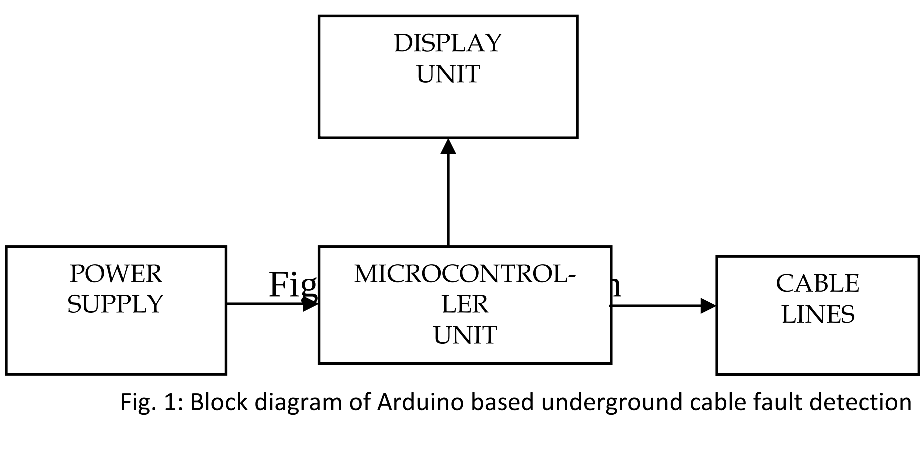

Fig. 1: Block diagram of Arduino based underground cable fault detection

THE POWER SUPPLY UNIT: The power supply section basically performs the following function;

- step down the input voltage supply
- convert the ac supply to dc
- filter the pulsating dc to a pure dc
- regulate the unregulated dc signal at the output

MICROCONTROLLER UNIT: this consists of Arduino uno board. It receives data from the analog to digital converter through it input port, process the data and gives the output through the display unit. In this project we use a microcontroller from 8051 family which is of 8-bit. The program is burned into ROM of microcontroller written in either Embedded C, assembly language or Arduino programming language.

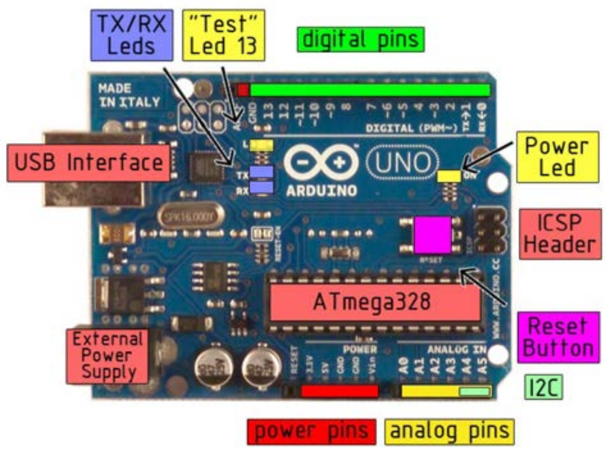

Fig.2.9.Arduino Uno Board

TECHNICAL SPECIFICATION OF ARDUINO UNO:

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

DISPLAY UNIT: The fault occurring at what distance and which phase is displayed on a 16 character, 2-line alphanumeric LCD display interfaced with the microcontroller.

Fig. 2.8: LCD Display

Table 1: Pin Description of LCD

PIN No	FUNCTION	NAME
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

CABLE LINES SECTION: This section consist of resistors and switches properly modelled to represent the characteristics of the cable to be tested

DESIGN ANALYSIS

This project is micro-controller based; therefore, it has both the hardware and software components. As a result, the design is a combination of the three main units namely; the software, the hardware and the power supply unit. It means, at some point, the design will combine both the hardware and software (i.e. programming)

1. *The Power Supply*

The circuit uses standard power supply comprising of a step-down transformer from 230Vto 12V and 4 diodes forming a bridge rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 470µF to 1000µF. The filtered dc being unregulated, IC LM7805 is used to get 5V DC constant at its pin no 3 irrespective of input DC varying from 7V to 15V. The block diagram of a regulated power supply is shown below

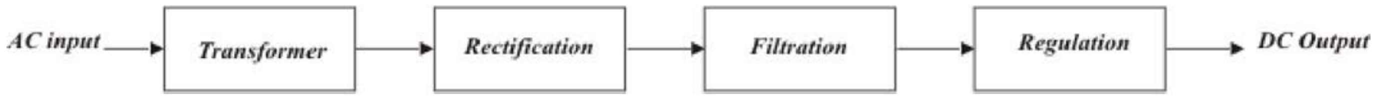

Fig 2 Regulated Power Supply

2. The Display using LCD 16x2 (Lm016l)

The project requires a display system in order to enable its user to see whether an open circuit or short circuit fault has been introduced by the switch. LM016L is a 16 x2 crystal liquid display (LCD), hence, it has two rows and each can accommodate 16 characters. To control the backlight of the LCD, a fixed 2200 ohm resistor was used to set the backlight to a brightness level rather than using variable resistor to allow user to set it. This help to avoid damage to the LCD and avoid setting it to the level where characters cannot seen. RS,EN,D4,D5,D6, and D7 were connected to pin 11,10,9,8,7, and 6 as shown in the circuit diagram.

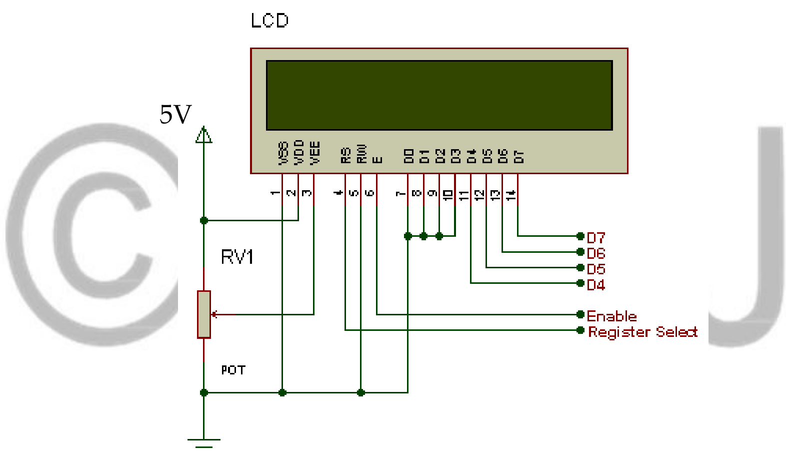

Fig. 3: LCD display circuit

With the limitation on the number of characters the LCD can display at a time, some of the character were abbreviated otherwise they cannot be all displayed simultaneously. To achieve that a function called ***DisplayLcd*** whose job is to accept values of the voltage drop in the resistors as arguments passed to it and displays them on the LCD was created.

DESIGN OF THE HARDWARE PART

The project uses four resistors in series representing and a normally closed button between each resistors and three resistors connected In parallel with a normally open button in between them to form the cable which is to be tested.

Selection of Resistors

The resistor used was based on the calculation be

By voltage divider rule,

$$V_{drop} = \left(\frac{R_4}{R_4 + R_5}\right) Vin$$

$$2.5 = \frac{R_4}{R_4 + R_5} 5$$

$$0.5 = \frac{R_4}{R_4 + R_5}$$

Cross multiplying

$R_5 = (R_4 + R_5)(0.5)$

$R_5 = 0.5R_4 + 0.5R_5$

$R_5 (1 - 0.5) = 0.5R_4$

$R_5 (0.5) = 0.5R_4$

$$R_5 = \frac{0.5R_4}{0.5}$$

$R_5 = 1R_4$

Taking $R_4 = 10k\Omega$

Calculation Of Short Circuit Voltages

At 2km,

Voltage drop is given as;

$$V_{drop} = \left(\frac{R5}{R5+R4}\right) Vin$$

$$\left(\frac{2200}{2200+10000}\right) 5$$

$$= \frac{11000}{12200} = 0.90V$$

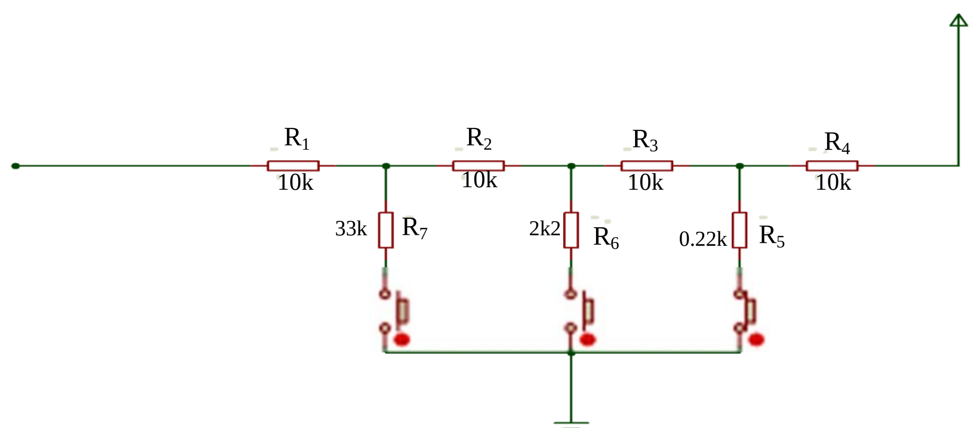

Fig. 4: Short circuit at 2km with SW3 closed

At 4km, Voltage drop is given as;

$$\frac{R6}{R6+(R3+R4)} \times Vin = \frac{22,000}{22000+20,000} \times 5 = \frac{110,000}{42,000} = 2.61v$$

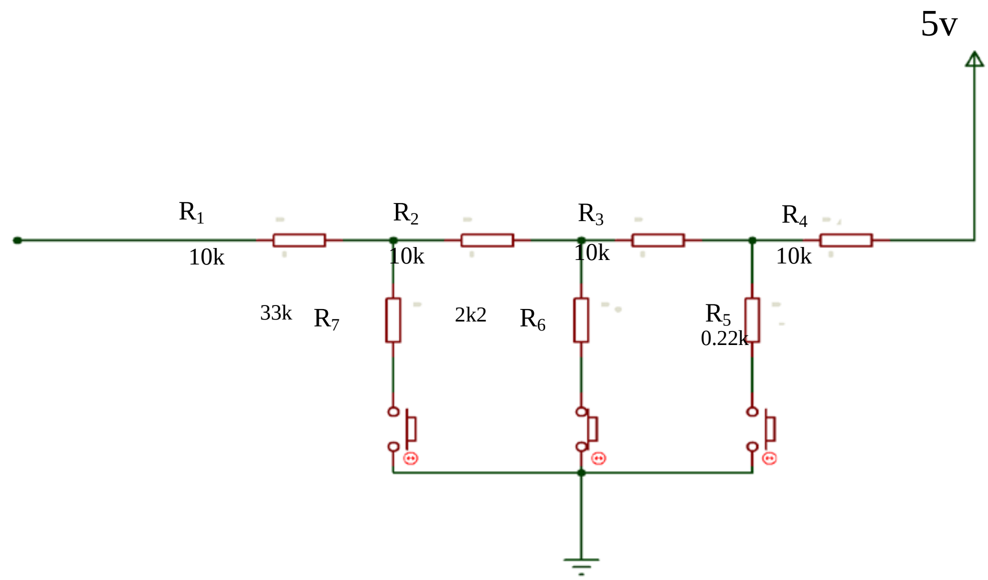

Fig. 5 short circuit at 4km with SW4 closed

At 6km, Voltage drop is given as;

$$\frac{R7}{R7+R2+R3+R4} \times Vin = \frac{47,000}{47,000+30,000}$$

$$\frac{235,000}{77,000} = 3.05v$$

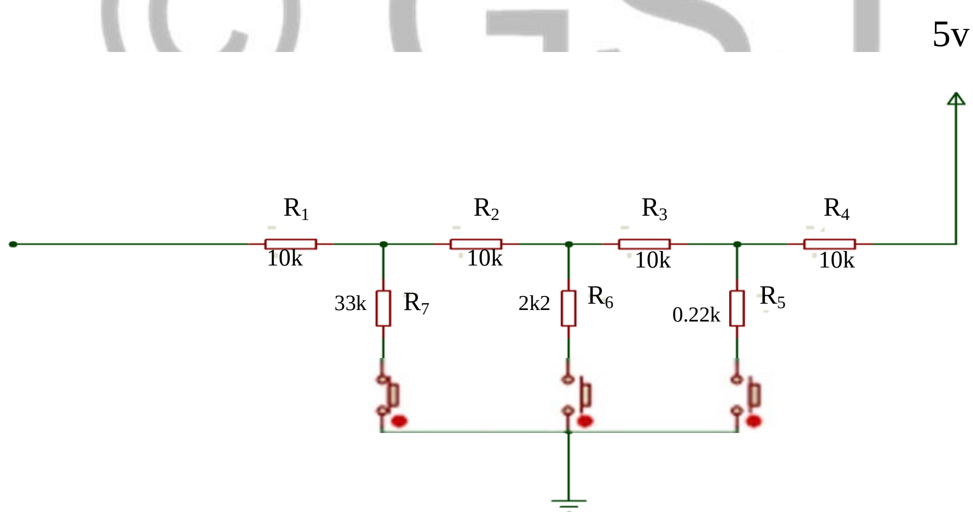

Fig. 6: short circuit at 6km with SW5 closed

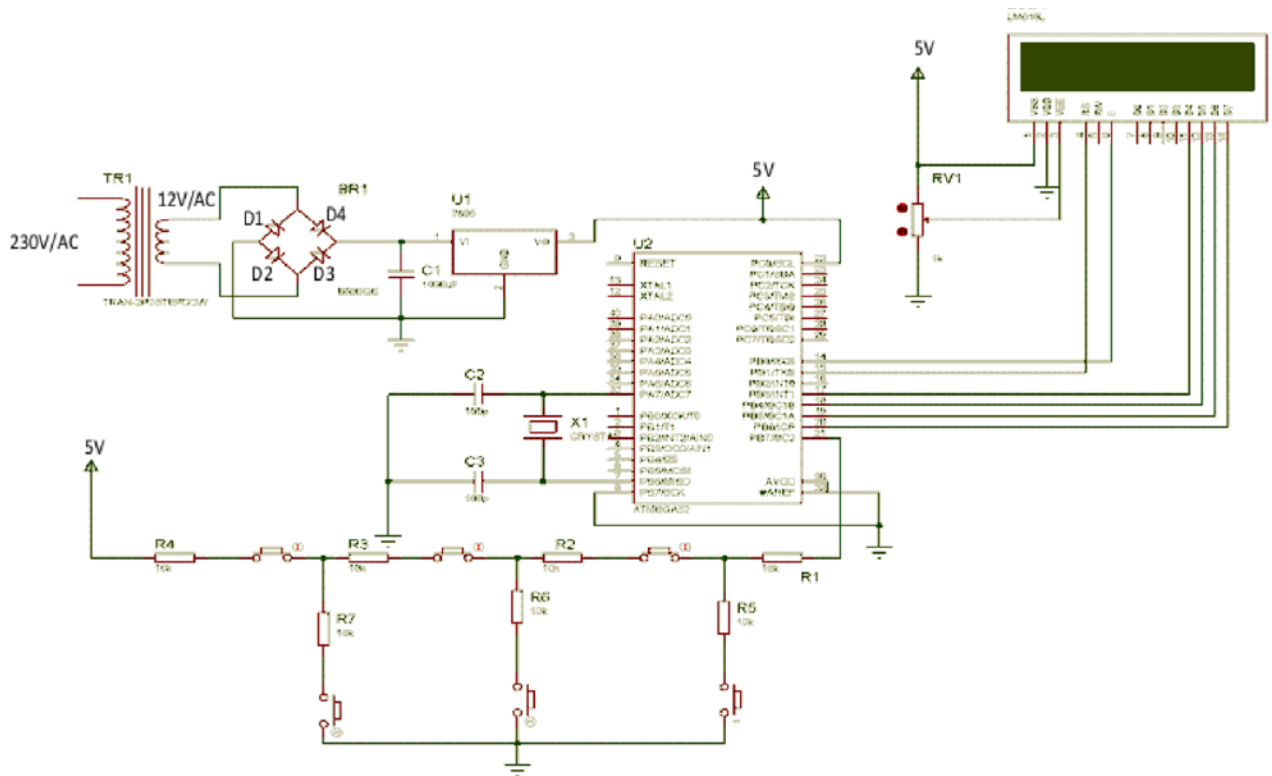

Fig. 7: Circuit diagram of Arduino based underground cable fault detection

ALGORITHM AND FLOWCHART

Algorithm:

Step1: Initialize the ports, declare timer, ADC, LCD functions.

Step2: Begin an infinite loop; turn on relay 1 by making pin 0.0 high.

Step3: Display "R:" at the starting of first line in LCD.

Step4: Call ADC Function, depending upon ADC output, displays the fault position.

Step5: Call delay.

Step6: Repeat steps 3 to 5 for other two phases.

FLOW CHART

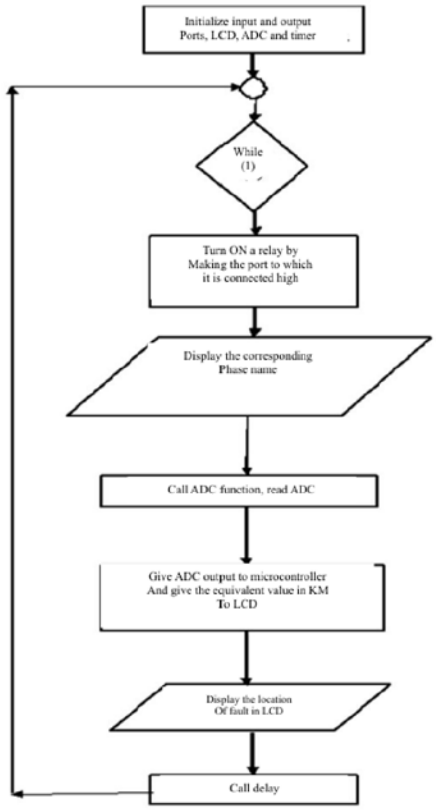

Fig. 8 flow chart

Testing and Result

The aim of testing is to ascertain that after the design and construction of the entire circuit, it will perform the required function optimally as desired. Three basic tests were carried out and they include:

1. Visual inspection test
2. Continuity test
3. Operation test

The four resistances in series representing cables i.e. R1, R2, R3, R4 and the six switches representing faults are simulated using Protus software. Switch SW4 is closed. This results in a voltage drop across R4. The voltage across R4 when various switches are closed is tabulated as follows:

Table 2: Table of value of open circuit fault

S/NO	SWITCH OPEN	VOLTAGE DROP CROSS RESISTOR	DISTANT AT WHICH FAULT OCCURS
1	SW4	2.49-2.60	2KM
2	SW5	1.67-1.80	4KM
3	SW6	1.99-2.02	6KM

Table 3: Table of value of short circuit fault

S/NO	SWITCH OPEN	VOLTAGE DROP CROSS RESISTOR	DISTANT AT WHICH FAULT OCCURS
1	SW4	0.45-0.99	2KM
2	SW5	2.05-2.60	4KM
3	SW6	3.27-3.50	6KM

Conclusion

Nowadays, electrical energy is being increasingly demanded and in order to maintain reliability and security to an acceptable level, new technologies for protection and control of power schemes are needed. For distribution system, underground system is very important these days. In this project, a method that employs simple ohms law for fault classification and location in medium voltage underground system is designed.To begin, this approach is based on voltage divider rule. For this reason, Arduino uno and protus software are used for simulation. Different types of faults with different fault locations are simulated by arduino software to prepared input data. On the other hand, in protus software, two arduino based method of fault classifier and fault location estimation were designed. Models were trained and then tested with different set of data. From the results, different types of faults could be classified and located on the cable with high accuracy. The percentage error between arduino output and real output is less than three percent. This shows that the proposed technique is able to offer acceptable accuracy in both of the fault classification and fault location estimation. Moreover, Arduino uno could be used as a part of a new generation of high speed advanced fault locators.

Acknowledgment

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