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Underground Fault Cable Detection Using Wireless Technology

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***Abstract*-Detecting fault cable system proposes fault location model for underground power cable using microcontroller. Fault location models are to determine the distance of underground cable fault from base station in kilometers. This project uses the simple concept of ohm's law. When any fault like short circuit occurs, voltage drop will vary depending on the length of fault in cable, since the current varies. A set of resistors are therefore used to represent the cable and a dc voltage is fed at one end and the fault is detected by detecting the change in voltage using a analog to voltage converter and a microcontroller is used to make the necessary calculations so that the fault distance is displayed on the LCD display.**

***Keywords*- Underground cable, fault location, fault detection, location methods, Microcontroller.**

I.INTRODUCTION

Detection of Fault cable is to determine the distance of underground cable fault from base station in kilometers using an Arduino board. Many time faults occur due to construction works and other reasons. Cables have some resistance.

We are mainly focusing that 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 resistance value, we will call that is fault point and fining that place through Arduino technology. That fault point represents the standard of distance (kilometer) from the base station. This value displayed by display unit. Before attempting to locate underground cable faults on cable, it is necessary to know where the cable is located and what route it takes. If the fault is on secondary cable, knowing the exact route is even more critical. Since it is extremely difficult to find a cable fault without knowing where the cable is, it makes sense to master cable locating and tracing and to do a cable trace before beginning the fault locating process. Success in locating or tracing the route of electrical cable and metal pipe depends upon knowledge, skill, and perhaps, most of all, experience.

Although locating can be a complex job, it will very likely become even more complex as more and more underground plant is installed. It is just as important to understand how the equipment works as it is to be thoroughly familiar with the exact equipment being used.

Internet of things is a network of physical objects or people called "things" that are embedded with software electronics, network, and sensors that allows these objects to collect and exchange data. The goal of IoT is to extend to internet connectivity from standard devices like computer, mobile, tablet to relatively dumb devices like toaster.

IoT makes virtually everything "smart" by improving aspects of our Life with the power of data collection, AI algorithm, and networks. The thing in IoT can also be a person with a diabetes monitor implant, animal with tracking devices, etc. The entire IoT process starts with the devices themselves like smartphones, smart watches, electronic appliances like TV, washing machine which helps you to communicate with the IoT platform.

1. Challenges of IoT:

- Inefficient testing and updating
- Concern regarding data security and privacy
- Software complexity
- Data volumes and interpretation
- Integration with AI and Automation
- Devices Require a constant power supply which is difficult
- Interaction and Short-range communication

II. IoT

The expression "Internet of Things" (IoT), coined back in 1999 by Kevin Ashton, the British technology pioneer who cofounded the Auto-ID Center at the Massachusetts Institute of Technology, is becoming more and more mainstream. In opening the IoT Week 2013 with a pre-recorded video message. A short insisted on the realization that IoT is here now it is not the future but the present. While Gartner identifies IoT as one of the top ten strategic technology trends, Cisco forecasts 50 billion devices connected by 2020, a potential market in excess of $14 trillion, and also claims that IoT is actually already here.

Similarly, it is not only companies with a technological focus, such as Ericsson, Bosch or Siemens that use IoT to advertise their cutting-edge technologies–media companies such as the BBC are conducting research activities and have plans for IoT deployment.

In short, we are currently on the verge of witnessing the emergence of a “mega-market”, where markets such as home and building automation, electricity generation and distribution, logistics, automotive, as well as telecommunications and information technology will steadily converge. As yet, we do not know the consequences of connecting all of these smart objects (smart meter, e-vehicle, cargo container, fridge etc.) to the Internet. At the same time, the Internet of Things (IoT) is not something you will experience as such it. What you will see is that more and more objects become connected. If you are selling products, you will be negotiating with providers of connectivity.

If you are building, selling or inventing models or tools for providing services or applications, you will notice that the convergence of IoT, big data and energy efficiency, combined with cheap hardware, software, data storage and analytics, favors open standards, innovation and interoperability. Daily activities that were distinct become interwoven in new formats and business models. Thus, in effect, the Internet of Things is a combination of a technological push and a human pull for more and ever-increasing connectivity with anything happening in the immediate and wider environment – a logical extension of the computing power in a single machine to the environment: the environment as an interface. This push-pull combination makes it very strong, unstoppable, fast and extremely disruptive.

1. IoT Application Example 1: Transport/Logistics-
In transport logistics, IoT improves not only material flow systems but also the global positioning and automatic identification of freight. It also increases energy efficiency and thus decreases energy consumption. In conclusion, IoT is expected to bring profound changes to the global supply chain via intelligent cargo movement. This will be achieved by means of continuous synchronization of supply chain information and seamless real-time tracking and tracing of objects. It will make the supply chain transparent, visible, and controllable, enabling intelligent communication between people and cargo/goods.

2. IoT Application Example 2: The Smart Home-
Future smart homes will be conscious about what happens inside a building, mainly impacting three aspects: resource usage (water conservation and energy consumption), security and comfort. The goal is to achieve better levels of comfort while cutting overall expenditure. Moreover, smart homes also address security issues by means of complex security systems for detecting theft, fire or unauthorized entry. The stakeholders involved in this scenario constitute a very heterogeneous group. Different actors will cooperate in the user’s home, such as Internet companies, device manufacturers, telecommunications operators, media ser-vice providers, security companies, electricity utility companies, etc.

3. IoT Application Example 3: Smart Cities-
While the term smart city is still a fuzzy concept, there is general agreement that it is an urban area which creates sustainable development and high quality of life. Giffinger et al.’s model elucidates the characteristics of a smart city, encompassing economy, people, governance, mobility, environment and living.9 Outperforming in these key areas can be achieved through strong human or social capital and/or ICT infrastructure. For the latter, an initial business analysis concludes that several sectors/industries will benefit from more digitalized and intelligent cities (examples for a city of one million people)

III. ARDUINO UNO

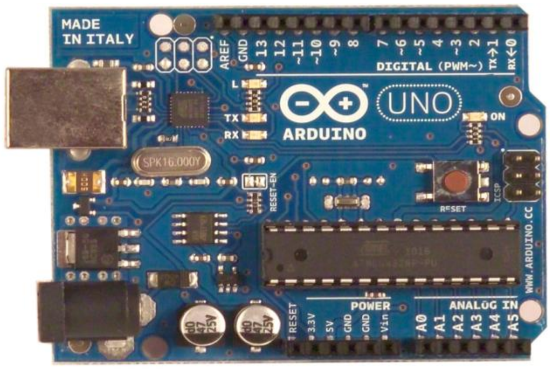

Fig 1. Aurdino microcontroller board

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 crystal oscillator, 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 Atmega8U2 programmed as a USB-to-serial converter.

"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.

IV. POWER

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN:** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V:** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator or be supplied by USB or another regulated 5V supply.
- **3V3:** A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND:** Ground pins.

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V. MEMORY

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

VI. INPUT AND OUTPUT

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The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode(), digital Write(), and digital Read() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms.

In addition, some pins have specialized functions:

1. Serial: 0 (RX) and 1 (TX).
Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

2. External Interrupts: 2 and 3.
These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

3. PWM: 3, 5, 6, 9, 10, and 11.
Provide 8-bit PWM output with the analog Write () function.

4. SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).
These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

5. LED: 13.
There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. The Uno has 6 analog inputs, each of which provides 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference () function.

Additionally, some pins have specialized functionality:

- **I2C: 4 (SDA) and 5 (SCL).** Support I2C (TWI) communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analog Reference ().
- **Reset.** Bring this line LOW to reset the microcontroller.

Typically used to add a reset button to shields which block the one on the boardgenerator is used to create an arc across the shunt fault which creates a momentary short circuit that the TDR can display as a downward-going reflection.

The filter protects the TDR from the high voltage pulse generated by the surge generator and routes the low-voltage pulses down the cable. Arc reflection is the most accurate and easiest pre location method. The fault is displayed in relation to other cable landmarks such as splices, taps and transformers and no interpretation is required. Arc reflection makes it possible for the TDR to display “before” and “after” traces or cable signatures. The “before” trace is the low-voltage radar signature that shows all cable landmarks but does not show the downward reflection of a high resistance shunt fault. The “after” trace is the high-voltage signature that includes the fault location even though its resistance may be higher than 200 Ω. This trace is digitized, stored and displayed on the screen and the cursors are positioned in order to read the distance to the high resistance fault.

VII. GPS NAVIGATION DEVICE

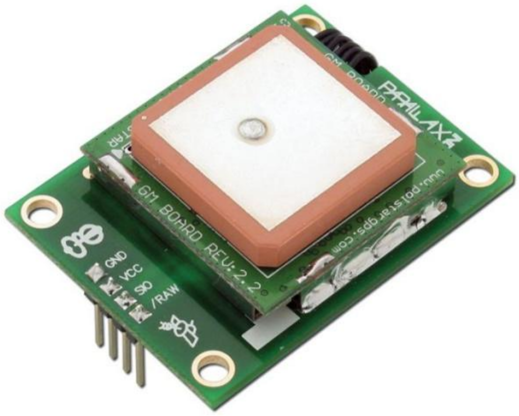

Fig 2. GPS navigation device.

A GPS navigation device is any device that receives Global Positioning System (GPS) signals for the purpose of determining the device's current location on Earth. GPS devices provide latitude and longitudeinformation, and some may also calculatealtitude, although this is not considered sufficiently accurate or continuously available enough (due to the possibility of signal blockage and other factors) to rely on exclusively to pilot aircraft. GPS devices are used in military, aviation, marine and consumer product applications.

GPS devices may also have additional capabilities such as:

- Containing maps, which may be displayed in human readable format via text or in a graphical format?
- Providing suggested directions to a human in charge of a vehicle or vessel via text or speech.
- Providing directions directly to anautonomous vehiclesuch as a robotic probe
- Providing information on traffic conditions (either via historical or real time data) and suggesting alternative directions.
- Providing information on nearby amenities such as restaurants, fueling stations, etc.

In other words, all GPS devices can answer the question "Where am I?", and may also be able to answer:

- Which roads or paths are available to me now?
- Which roads or paths should I take in order to get my desired destination?
- If some roads are usually busy at this time or are busy right now, what would be a better route to take?
- Where can I get something to eat nearby or where can I get fuel for my vehicle?

Consumer GPS navigation devices include:

- Dedicated GPS navigation devices.
- GPS modules that need to be connected to a computer to be used.
- GPS loggers that record trip information for download. Such GPS trackingis useful for trailblazing, mapping by hikers and cyclists, and the production of geocoded photographs.

Converged devices, including GPS Phones and GPS cameras, in which GPS is a feature rather than the main purpose of the device. Those devices may be assisted GPS or standalone (not network dependent) or both.

VIII. OVERVIEW OF GSM

1. GSM Modem:

Fig 3. GSM modem

2. Applications:

- SMS based Remote Control & Alerts.
- Security Applications.
- Sensor Monitoring.
- GPRS Mode Remote Data Logging.

3. Features:

- Status of Modem Indicated by LED.
- Simple to Use & Low Cost.
- On board switching type power supply regulator.
- RS232 output.

IX. FAULTS IN UNDERGROUND CABLES

1. Faults in Underground Cables:

1.1 **Open circuit fault -** When there is a break in the conductor of a cable, it is called open-circuit fault. The open-circuit fault can check by a merger. For this purpose, the three conductors of the 3-core cable at far end are shorted and earthed. Then resistance between each conductors and earth is measured by a merger.

1.2 **Short-circuit fault** -When two conductors of a multi core cable come in electrical contact with each other due to insulation failure, it is so called as short-circuit fault. Merger can also be used to check this fault. For this the two terminals of a merger are connected to any two conductors. If the merger gives a zero reading it indicates short-circuit fault between these conductors. The same is repeated for other conductors taking two at a time.

1.3 **Earth fault -** When the conductor of a cable comes in contact with earth, it is called earth fault or ground fault. To identify this fault, one terminal of the merger is connected to the conductor and the other terminal connected to the earth. If the merger indicates zero reading, it means the conductor is earthed.

2. Time domain reflectometry (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.One weakness of TDR is that it does not pinpoint faults. TDR is accurate to within about1% of testing range.

3. Spark-induced Electromagnetic Signals:

- During a voltage break-down in a conductor of length l, a spark-induced electromagnetic signal is generated exactly where the break-down takes place.
- Two waves will propagate in both directions with a constant signal propagation velocity, denoted v, towards the direction of the extremities of the conductor (denoted A and B).
- The time difference Δt measured between the two signals arriving at the extremities of the conductor allow calculating the distance if the fault from the extremity A by the simple relation.

4. Terminal Methods:

4.1 Blavier Test (For a Single Cable Faults): When a ground fault occurs in a single cable and there is no other cables (withoutfaulty one), then blavier test can be performed to locate the fault in a single cable.

Suppose-
Fault to ground resistance = r
Resistance from the Far end to the cable fault = r2
Resistance from the testing end of the cable to the fault =r1

First, we will insulate the far end of the cable to determine the resistance between lines to ground, which is;
$R1 = r1 + r$ Now, we will ground or earth the far end of the cable to find the resistance between line to ground again.
$R2 = r1 + r \times r2$
$r + r2$
But the total resistance (before occurring the fault) was
$R = r1 + r2$

Solving the above equations for r2 (fault location or distance), we get
$x = R2 - (R1 - R2)\ (R - R2)$

4.2 Murray Loop Test:
Wheatstone bridge's principle is used in Murray loop test to find the cable faults.The Wheatstone bridge is kept in balance by adjusting resistance of the ratioarms Ra and Rb until the galvanometer deflection is zero.

5. Tracer Method:
In this method fault of the cable can be detected by walking on the cable lines. Fault location is denoted from electromagnetic signal or audible signal. This method is used to find the fault location very accurately.Transmitter create electromagnetic signals on metallic conductors by producing output current.This electromagnetic field radiates from the line is sense by receiver and we can find exact location of fault as well as depth of the cable.
Cable locating test sets, often referred to as cable tracers, may be grouped as follows:

- **Low frequency:**usually less than 20 kHz sometimes referred to as audio frequency (AF).
- **High frequency:**usually higher than 20 kHz and in the radiofrequency (RF) range to about 80 kHz.
- **60 Hz:**most tracers provide this mode to allow tracing of energized cables.

Low frequency (AF) is considered the general-purpose selection because it is more effective in tracing the route of cables located in congested areas due to less capacitive coupling to everything else in the ground.

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