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Underground Cable Fault Detection using Robot

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ABSTRACT

Present trend of laying cables for various purposes is to lay underground. Companies prefer laying the cables underground because the climatic adversities don't affect this. With advantages come challenges. There are many difficulties in laying the cables and once laid in case of any complaints, it is difficult and costly to fix it. This paper is about the robot that is designed by us which is capable of finding where the complaint lies, so the engineer can directly get the hole dug at that point and fix the issue. The basic principle of Electromagnetic Theory is employed to detect the discontinuity in the cable. Using a signal injector, a low frequency signal is passed through the wire and the induced magnetic field is used to detect the fault.

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1. 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 the hot sunny day nor the rain is to influence it. But when the cable breaks due to some reasons it's very difficult to locate that. Currently what is done is they find the approximate location and dig the cables out from the location and check it manually to find the exact point of discontinuity.

Currently a robot is developed which can be used to locate the break from an external point. When an underground cable is broken or Short-circuited then our robot will move over it and locate the exact position of discontinuity. Hence it is an advantage for repairing the same. 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.

2. WORKING PRINCIPLE

The fault detection robot consists of a signal generator part and robotic part. Short circuit cable is checked for its continuity by passing a 3 KHz low frequency signal. A signal generator can be used to generate this signal. The AC signal passing through wire produces a magnetic field around it. This magnetic field is sensed by the robot using a inductor circuit. The AC signal sensed by robot is then amplified using a LM386 circuit. This amplified signal is then rectified and converted to DC. DC level is provided to the analog input of microcontroller. Microcontroller converts this analog input to digital signal. Based on the program programmed in the microcontroller the robots movement is controlled.

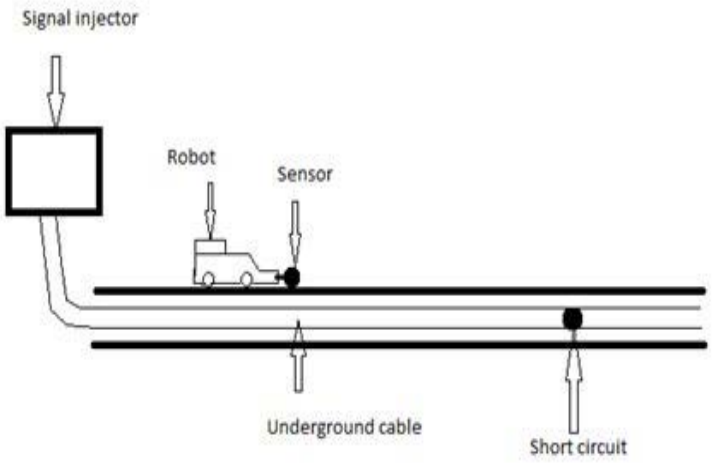

Figure 1. Schematic representation.

When the robot reaches the point where the discontinuity lies, the magnetic field will be zero. In such case the input signal at the analog input port will be substantially low. When the input signal strength is less than 10 (binary reading), the PIC is programmed to display, short circuit Detected and is displayed in LCD.

3. PROBLEM ANALYSIS

The actual implementation of the robot is fields where the cables are laid. In such scenario the robot is bulky in size. Hence, for the presentation sake, a model of actual robot is developed and the fault detection is done on a wire that is laid on the floor.

As more priority is for accuracy, it is advised to use simple low speed DC motor drive. For higher speed movement, a stepper motor can be used. But the cost of motor and motor drive is costly.

Also, testing of Open loop circuit can be conducted. But due to time constraint and the requirement of a high amplifier circuit, it is decided to avoid this for the time being.

4. PROPOSED SYSTEM

The basic principle behind the proposed system is Faraday's law. If a current is flowing inside the wire there will be a EMF generated around it. An inductor circuit is used to generate a voltage using the EMF.

In cases of short circuit, the EMF generated will be zero and there will be negligible voltage generated. Hence, a condition is provided where voltage is less than say 20 (binary value), the robot will stop and that will be the point of discontinuity.

This voltage is amplified using a LM386 circuit and compared with the reference voltage in PIC and based on the values, the robot is driven forward or to the right or to the left.

There is a LCD which will display the field strength.

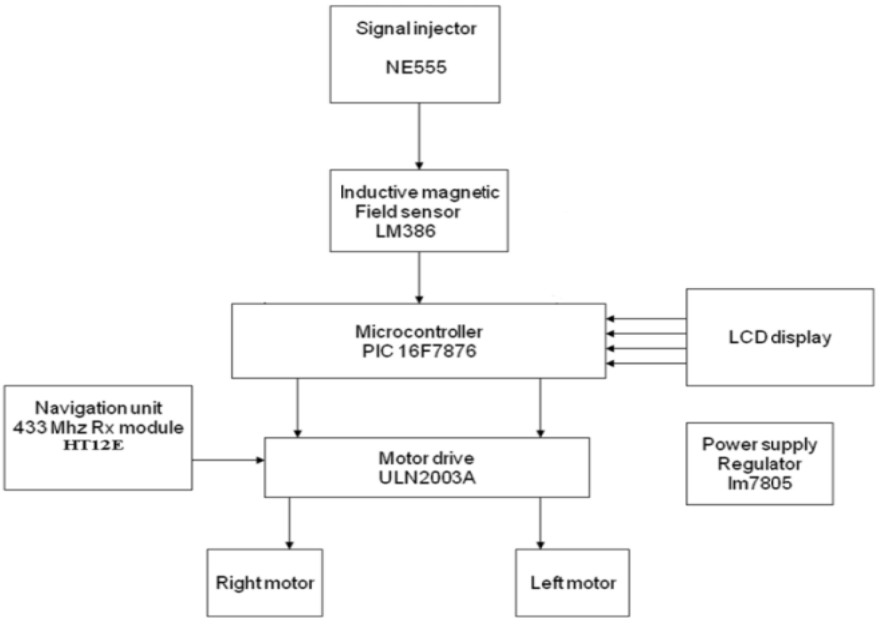

Figure 2. Block Diagram

5. COMPONENTS

The signal generated by the signal generator can be detected using a field sensing coil. A LM 386 amplifier amplifies the signal produced by signal generator. It can be rectified and input to the analog pin RA1 of microcontroller. After the processing the input for controlling the direction of motor is taken from RC0 and RC1 respectively and LCD connected to port RB. The current through the motor is amplified by ULN 2003. The microcontroller is worked sufficiently by a 5V regulated supply. In microcontroller a 20 Mhz. crystal oscillator is used for providing frequency. Figure 2 shows the overall circuit diagram.

1. Signal Injector

Signal injector is used to generate low frequency voltage (around 3 KHz) using a 555 multi vibrator circuit. How the signal is generated is explained in detail below.

Two capacitors are added in series to the power supply. Hence at the center of the capacitor, the voltage will be Vcc/2. Also a capacitor circuit is preferred over a resistor circuit to get the voltage as it blocks DC and transmits only AC.

The cable is connected between the Pin 3 and the capacitor mid-point. The 555 circuit oscillates and toggles the voltage at Pin 3 between V_{cc} and Ground. When Pin 3 is grounded, the voltage at center of capacitor is higher than the Pin 3 and hence the current will flow inside the IC. When the Pin 3 has Vcc, then the voltage at the center point is less than the Pin 3 and the current flows outside. Hence the current flow will be bi-directional and hence this will generate an alternate current.

Such an alternating current through the wire will produce an electromagnetic field. This magnetic field will produce a voltage inside the inductive sensor.

2. Cable Sensor

The low frequency AC voltage signal from a signal generator is amplified using a LM386 circuit. In normal case the input voltage is 20mV to 100mV. The amplifier circuit amplifies this around 50 to 200 times.

This amplified signal is passed through a diode and is used to charge a capacitor. This voltage is passed to RA0 pin of PIC microcontroller.

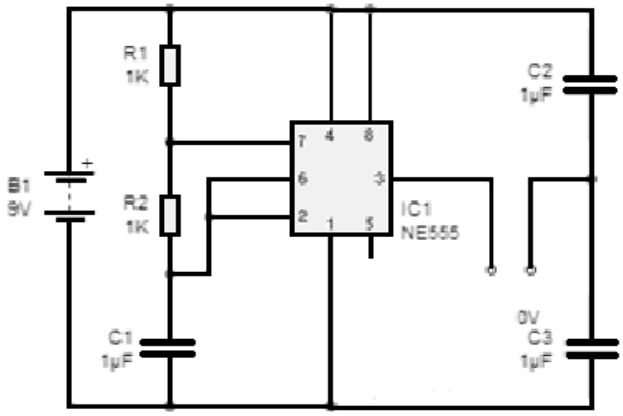

Figure 3. Signal injector.

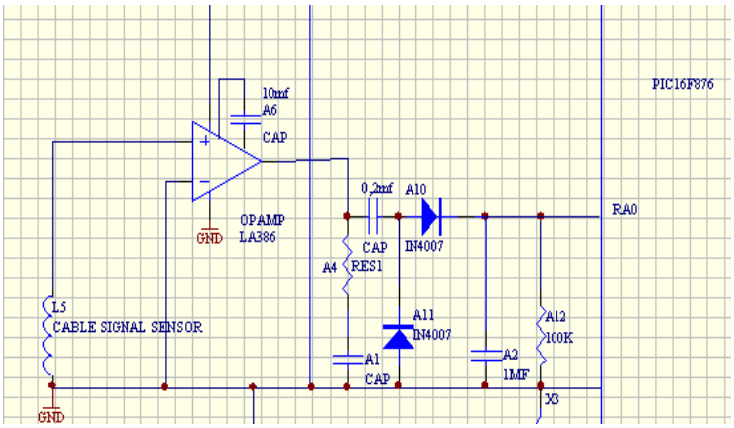

Figure 4. Signal sensor circuit diagram

When the inductor circuit moves away from the wire, the field strength decreases and when it moves near the wire field strength increases. The change in field strength is passed on to PIC, which controls the direction of movement of robot.

3. Microcontroller Circuit

Microcontroller is the core unit of the circuit. The program written on it controls the movement of motors and the message display based on the cable signal strength which is provided as input.

When cable fault is detected, this will trigger the alarm. We use an audio announcement as an alarm.

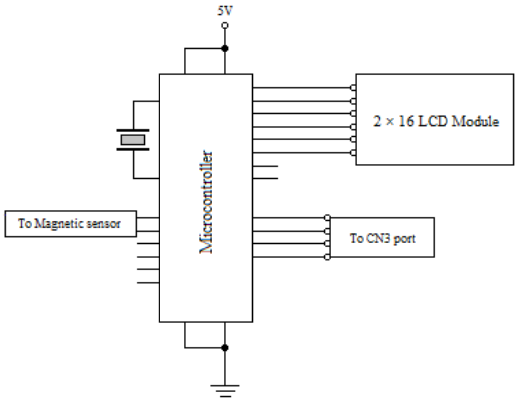

Figure 5. Microcontroller circuit

4. Navigation Circuit

Relays are used for triggering the motor circuit. H-bridge can also be used for navigation circuit but the limitation it has is that temperature rises at a steep rate thereby damaging the motor and hence cannot be used for long duration.

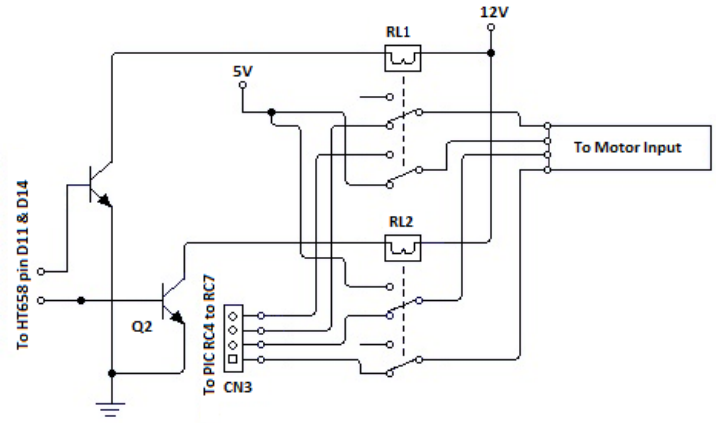

Figure 6. Navigation and switching circuit

5. Transmitter and Receiver

Transmitter and Receiver Circuit can be used for manual operation of the robot. This can be used for applications such as path finding in addition to cable fault detection. HT12D/E can be used as transmitter and receiver module whose circuit diagram and pin-out details is same as those shown in Figure 7.

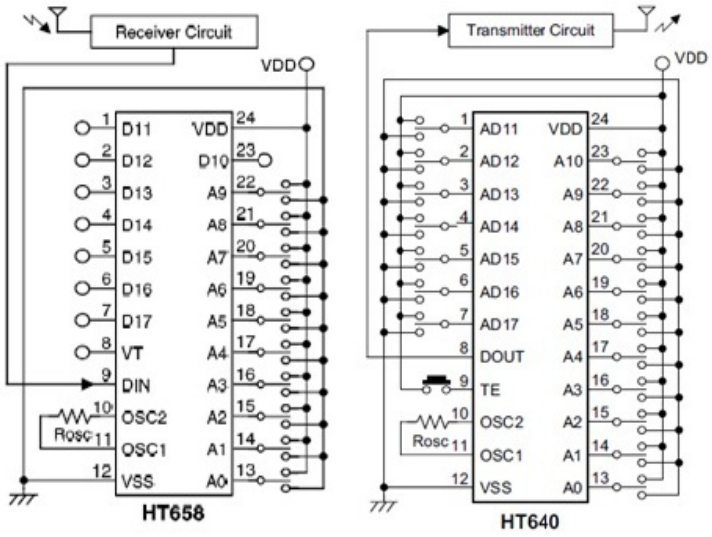

Figure 7. Transmitter Receiver Circuit

6. Motor Control Circuit

The output from the micro controller is passed through the ULN relay driver circuit which is connected to left and right motor. The signal strength which is provided at the RA0 pin of microcontroller is programmed to control the movement of the motor.

Also there is an external input navigator using which can be used to control the robot from an external point so as to place the robot at a specified point. By using this external navigation, the relay disconnects from the microcontroller unit and connects to remote system.

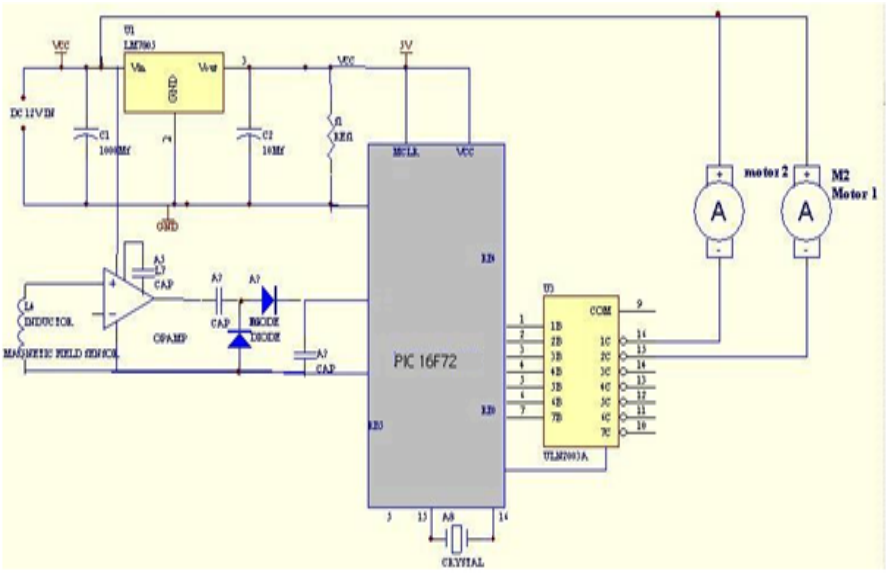

Figure 8. Overall Circuit

6. WORKING

The core aim of the robot is designed for short circuit detection which is very useful to detect the underground cables breaks. As the cables are laid for a larger area, the continuity can be checked using the multimeter first. Once the stretch of wire where the discontinuity exists is detected, the robot can be used for detecting the exact location.

A wire is connected to the signal generator unit and then the robot is placed on to the cable using the external remote navigator circuit. The robot is placed in such a way that the discontinuity lies in the forward direction. Then the 3 KHz signal is passed through the wire and also provides the power to the robotic unit. Once the current starts moving, as per the Faradays law there will be an Electro Magnetic Field will be generated which will generate a voltage which is provided to Micro controller RA0 pin and there by controls the movement of the robot.

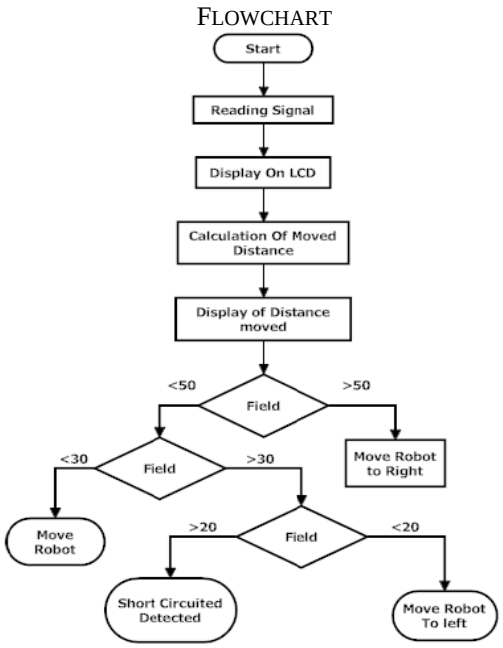

Figure 9. Flowchart of fault location

When the robot reaches the point of discontinuity, there will no EMF and hence this will trigger the alarm circuit (here use an Audio Announcer). The HALL sensor unit can be provided to measure the exact distance the robot has moved which will be displayed in the LCD module.

As one get to know the exact location, he/she can get dig at that point and get the issue fixed easily.

7. MERITS AND DEMERITS

Merits

1. Used for short circuit detection in underground cables from an external point.
2. Reduce manual labour.
3. Cost effective.
4. Can be used for applications other than cable fault detection.

Demerits

1. Not Self reliable
2. Difficult to replace a component in the robot if it fails.

8. CONCLUSION

Current scenario of digging along the cable laid and then pulling the cable out and checking whether the fault exists in the cables is a tedious work. This is not only is wastage of manpower and money for the companies, but this also causes a lot of inconvenience to the normal public. We believe that our cable fault detection robot will solve this issue to a great extent and will be really helpful for such application. The robot that we have designed is very much user-friendly and can be easily controlled. Also, the robot is cost effective.

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