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"Design and Development of Underground Cable Fault Detection and Localization using IoT"

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Abstract - *In today's world, underground cable systems are very commonly implemented. As the cables are below the ground level, it is very difficult to find faults. Here, in this paper we are implementing a system to locate the occurred fault in the underground cable system and display it on the web page as well as on the LCD. This method can detect open as well as short circuited underground cables. For open circuit fault detection, capacitance measurement circuit is used and for short circuit fault detection, inductance measurement circuit is used.*

In this paper, the fault in the cable is detected by the microcontroller. The microcontroller processes the data and the output is displayed on the LCD and the webpage through internet.

Key words **— underground, microcontroller, open circuit, short circuit, inductance, capacitance, webpage.**

1. INTRODUCTION

Power transmission can be possible in both overhead as well as underground cables as the latter are more prone to several effects of rainfall, snow, thunder lightning etc. Underground cables are mostly used for power applications where it impractical, difficult or dangerous to use overhead lines. Though underground cables have a high installation cost, they have smaller voltage drops, low chances of developing faults and low maintenance costs, the band of land required for installing underground cables is less and those cables are less affected to the impacts of weather. There are several advantages of underground cables over overhead lines as it poses no danger to wildlife or low flying aircrafts, not easy to steal, make illegal connections or sabotage. Considering the safety and the increase in reliability the use of cables underground is increasing. But there is a problem when a fault occurs in the cable. It becomes extremely difficult to find the faults and determine their exact location, and furthermore repairing process for the cable becomes more difficult. In this paper, a fault detector has been developed which is user friendly, cheaper, no complicated components are used and not bulky.

In this paper we are detecting two types of faults in cable. They are:

- **Open circuit:** Due to mechanical stress in the cable, the conductors (cores) inside the cable breaks which leads to discontinuity. This is called open circuit fault. In open circuit, capacitance of cable varies linearly with the length of cable. Hence by measuring the capacitance we can detect the length of open circuit fault. Capacitance is measured by using internal RC Circuit. Capacitance of cable used in this method is in the range of few picofarad.

- **Short circuit:** When conductors of the same cable come in contact with each other, then a short circuit fault occurs. In short circuit, inductance of cable varies linearly with length of short circuit length. Inductance is measured by using LC Circuit. Inductance of cable used in this method is in the range of 80uH – 30,000uH.

In this method, we are using ATMega328 as controlling and processing unit. Also NodeMCU module is used for sending data over the internet. The capacitance and inductance of the cable is sensed and the output is given to the ATMega328 microcontroller. The microcontroller processes the received input and detects whether the fault has occurred and displays the corresponding output on the web page in graphical format and on the LCD.

2. LITERATURE SURVEY

In 2001, S. Navaneethan [1] has proposed technique for automatic fault location for underground low voltage distribution networks. It uses signals from existing Time Domain Reflectometry instrument. TDR signals are processed for eliminating reflections occurred by single phase tee off and for locating open and short circuit faults in 3 phase cable. In TDR method, first the signal is send into cable from starting point. If any impedance mismatch occurs then signal is partially or completely reflected and impedance mismatch shows open circuit or short circuit fault. Reflected signals are checked for both faulty and healthy phases and these reflected signals are used for locating faults. New TDR fault location method uses an existing TDR signals along

with advanced signal processing techniques. Adaptive filtering method is used for comparing TDR signal to locate a fault.

In 2009, You Chung Chung [2] has described a capacitance and inductance sensor circuit for detecting lengths of open and short circuited cables. Length of open or short circuited cable varies linearly with capacitance or inductance. There are several methods available for detecting length. But it is found that implementing 555 timer circuit is very efficient circuit for detecting length of open and short circuit cable. Reflectometry method for detecting fault is cost effective hence for cost sensitive applications capacitance and inductance sensor circuits are most effective.

In 2010, Tarlochan S. Sidhu[3] has presented two algorithms for detecting incipient faults in underground cable. Wavelet based algorithm detects the physical conditions like signals containing discontinuities, spikes, and then it classifies different frequency components in different frequency bands. Wavelet analysis separates the measured signal into high frequency coefficient to describe the transient state and low frequency coefficient to express fundamental frequency components. Superimposed component based algorithm is designed for detecting SLG incipient faults. It includes three steps detection of transient inception, selecting faulty phase and classification.

In 2012, Md. Fakhrul Islam, Amanullah M T Oo, Salahuddin. A. Azad [4] has proposed techniques which are currently used in practice for locating cable fault and new efficient techniques suggested by researcher. It also provides guidelines for designing small and lightweight high voltage fault locating machine. A-frame, Thumper, Time Domain Reflectometer, Bridge method are used for detecting faults. In A-frame method for locating ground fault, direct current is injected into cable. Thumper method requires an operator to walk along the path of cable and listen the sound. In Bridge method, Wheatstone bridge circuit is used to measure resistance for calculating distance of fault.

In 2015, Pooja P.S, Lekshmi M. [5] has developed algorithm for incipient fault location in time domain. This algorithm measures distance to fault by considering the arc voltage with respect to line impedance. It uses data collected from PQ, monitors to detect the fault location in terms of impedance by considering arc voltage. It can also be applied to single line to ground cable for detecting fault.

In 2016, Nikhil Kumar Sain, Rajesh Kajla, Mr.Vikas Kumar [6] has proposed a model for detecting fault location in underground power cable by using microcontroller. It uses concept of Ohm's law for determining distance of fault location from base station. Resistor set represents the cable and dc voltage is applied at one end. When fault occurs, there is a change in voltage drop that gets detected by ADC and microcontroller makes some calculations so that fault location gets displayed on LCD and send over a GSM.

3. PROPOSED DESIGN

A. *Block Diagram*

The power supply consists of step down transformer 230/12V, which steps down the voltage to 12V AC. This is converted to DC using bridge rectifier. The ripples are removed using capacitive filter and it is then regulated to +5V using voltage regulator 7805. ATMega328 microcontroller requires 5V power supply for its operation. Hence this is provided by the designed 5V power supply which is provided by the designed power supply. The open circuit fault in cable is detected by the RC circuit which is in-built in the microcontroller. The short circuit fault in cable is detected by the LC circuit which consists of a cable whose inductance is in the range of 80uH – 30,000uH and 2 capacitors of 470uF and (200uF-220uF) connected in parallel. The values from the RC and LC circuit are given to the ADC of the microcontroller. The ATMega328 processes the input received and sends the output whether the fault has occurred or not, type of fault whether open or short circuit fault to the NodeMCU module and also to the LCD. The NodeMCU module further sends the data to the ThingSpeak Cloud and it displays the data in graphical representation on webpage. The graphical representation shows the type of fault occurred and the distance of the fault from the base station. The same is also displayed on the LCD present in the unit.

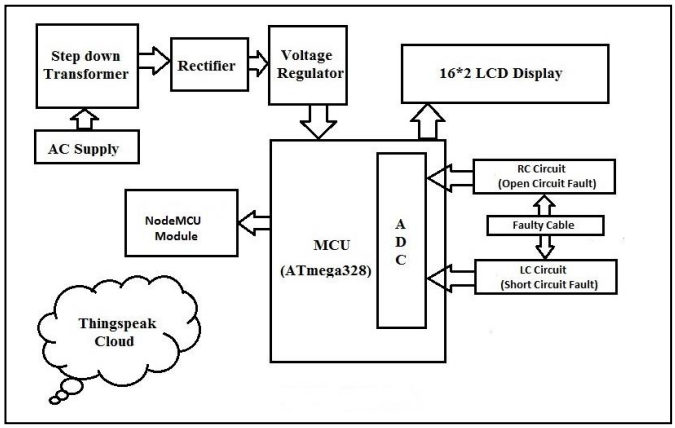

Fig1. Proposed Block Diagram

B. *Operation*

Arduino microcontroller can measure the capacitance based on the principle of time constant of the capacitor. Time taken for voltage across the capacitor to reach 63.2% of its voltage when fully charged is called time

constant of capacitor. It measures the capacitance of cable by considering the following equation

TC=R*C

where TC is time constant of the capacitor

R is resistor

C is capacitance of the capacitor (in this case a cable)

Cable whose open circuit fault is to be detected is connected to ADC pins of microcontroller. ADC will measure voltage across the cable. Internal timer of microcontroller then starts counting the time till the voltage reaches 63.2% of full charge voltage. The timer will be stopped at this point and the capacitance of the cable will be calculated. Capacitance of the cable varies linearly with the distance of open circuit fault.

For calculating the distance in a cable with short circuit fault, the cable is connected at ADC pins of microcontroller parallel to capacitors and will form a LC circuit. We are applying 5V pulse from microcontroller to charge the capacitors in the circuit. Then we changed voltage from 5V to 0V. This pulse will make circuit to resonate by creating a sinusoidal signal oscillating at resonating frequency. Sinusoidal pulse is applied to LM339 comparator. It will convert it into the square wave with 50% duty cycle and a pulsein() will measure the time of square wave and the measured time is doubled which will give time period and inverse of time period which will be frequency. A pulsein() will measure the time in microseconds, the time taken from rising edge to falling edge. In this way, the frequency will be measured and by using following equation $F=1/(2*\pi(LC)^{0.5})$

the unknown inductance value will be calculated. Inductance of cable is directly proportional to length of short circuit fault in the cable.

4. RESULT

The proposed design instantly detects the type of fault and distance of fault from base station will be displayed on LCD and through NodeMCU module to the ThingSpeak cloud which will display the cable information on the webpage graphically.

5. CONCLUSION

In this paper, two detection techniques are proposed and tested for the detection of faults underground. It is a low cost solution, less bulky, robust, less power consuming and can be used for all types of cables. A simple concept of RC circuit and LC circuit is used for the fault to be easily detected and repaired. It detect the exact fault i.e. short circuit and open circuit fault from the feeder end in kilometers by using the microcontroller.

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