Underground Cable Fault Detection Device

Gilbert Steephan[1], N Sagar Sunil[2], Rahul M.M[3]
[1, 2, 3] Dept of Electrical and Electronics Engineering
[1, 2, 3] Sahrdaya College of Engineering and Technology

Abstract- *The project is intended to detect the location of fault in underground cable lines from the base station to exact location in kilometers using an Arduino micro controller kit. In the urban areas, the electrical cable runs in undergrounds instead of overhead lines. Whenever the fault occurs in underground cable it is difficult to detect the exact location of the fault for process of repairing that particular cable. The proposed system finds the exact location of the fault. This system uses an Arduino microcontroller kit and a rectified power supply. Here the current sensing circuits made with a combination of resistors are interfaced to Arduino micro controller kit to help of the internal ADC device for providing digital data to the microcontroller representing the cable length in kilometers. 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. In case of short circuit, the voltage across series resistors changes accordingly, which is then fed to an ADC to develop precise digital data to a programmed Arduino micro controller kit that further displays exact fault location from base station in kilometers. Whenever a fault occurs in a cable the buzzer produces the alarm to alert and to take an immediate action by field workers.*

Keywords- Matlab, Stabilization, Power quality, Voltage control, Invertor, Buck convertor, Boost convertor.

I. INTRODUCTION

A bundle of electrical conductors used for carrying electricity is called as a cable. An underground cable generally has one or more conductors covered with suitable insulation and a protective cover. Commonly used materials for insulation are varnished cambric or impregnated paper. Fault in a cable can be any defect or no homogeneity that diverts the path of current or affects the performance of the cable. So it is necessary to correct the fault. Power Transmission can be done in both overhead as well as in underground cables. But unlike underground cables the overhead cables have the drawback of being easily prone to the effects of rainfall,snow, thunder, lightning etc. This requires cables with reliability, increased safety, ruggedness and greater service. So underground cables are preferred in many areas specially in urban places. When it is easy to detect and correct the faults in overhead line by mere observation, it is not possible to do so in an underground cable. As they are buried deep in the soil it is not easy to detect the abnormalities in them. Even when a fault is found to be present it is very difficult to detect the exact location of the fault. This leads to digging of the entire area to detect and correct the fault which in turn causes wastage of money and man power. So it is necessary to know the exact location of faults in the underground cables. Whatever the fault is, the voltage of the cable has the tendency to change abruptly whenever fault occurs. We make use of this voltage change across the series resistor to detect the faults[2]This paper deals with the location of fault occurs in the cable by using the Arduino board that gives us the fault distance from the station. In common, urban region practices the digging method to find the underground cable fault which consume huge amount of time to find exact location of fault. The method used by underground lines fault detection is a technique for locating the fault. This paper shows us the way to find the fault location which helps in avoiding the digging method for the whole line. This will save time and reduce human efforts.[3]This project mainly focuses to detect location range of the underground wire fault. This is going to use the idea of Ohm's law. As per this principle, when small DC voltage is feed at one end of cable using network of resistors, there is change in current based on position of fault in the wire. If there occur any Short Circuit, then there is change in voltage in the wire, now this is given to the Analog to digital Converter of Arduino Mega development board that provide accurate digital data and will be displayed on LCD. In this way, we are able to get the specific range of defected wire(fault) from the base station. This System alarms when defect in wire occurs. It may also be used for the transmission of wire under the ground. Wires have their own resistance; Our prior concern is that, the resistance of cable may change in accordance with the wire length. The method used by underground lines fault detection is a technique for locating the fault. This paper shows us the way to find the fault location which helps in avoiding the digging method for the whole line. This will save time and reduce human efforts.[4]Now a days most of the power lines and cables in our city is becoming underground. This is due to the crowded lines present in the electric post and which is not good when there is a climatic change i.e., Rain, Wind etc. in order to resolve this we have gone for underground cables. So, most of the power lines and electric lines are present in the underground and thus providing a non-interrupted path of electric flow without any complaint. But we do know one thing, that is underground cables can also become faulty. So, when there is a fault in an underground cable. The whole area is affected due to the digging of the roads or place. This also makes power outage in many areas as to find the fault in order to fix it. So, to find the fault easily we came up with this idea of underground fault detection device in order to locate the fault real quick as it pinpoint the exact location of the fault and reduces time

II. LITERATURE REVIEW

2.1 TYPES OF FAULT

The faults mainly divided into three types.

- Open Circuit Fault
- Short Circuit Fault
- Earth Fault

2.2 Open Circuit Fault

- A break in the conductor of a cable is called open-circuit fault.
- This type of fault is checked with the help of a device called 'megger'.
- If the megger indicates 0 resistances in the circuit of the conductor, it means it is not broken.
- But if the megger measures infinite resistance, it means that the conductor is broken which needs to be replaced.

2.3 Short Circuit Fault

- When an insulator fails, it is due to the 2 conductors of a multi-core cable coming in contact with each other electrically, which indicates short-circuit failure.
- For this again, a megger is used. In this type, the 2 terminals of the megger are connected to any 2 conductors.
- Fault is indicated when the megger gives zero reading between the electricity conductors.

2.4 Earth Fault

If a cable's conductor comes in contact with the earth (ground), then it is called as earth fault. In order to identify this fault, the two terminals of the megger are connected to the conductor and to the earth, respectively. Earth fault can be studied if the megger indicates zero reading. The Same procedure is applied to the cable's other conductors.

2.5 Methods used to find UGC faults

An electrician or electrical engineer uses two methods to locate underground cable faults. They are as follows:

Sectionalizing: It involves physically cutting and splicing the cable, which can reduce the cable's reliability. In order to reduce the cable's reliability, the cable needs to be divided into small sections which enable us to find the fault. E.g. — On a 500-ft length cable, the cable is cut into 250-ft length sections each, and reading is measured in both ways with the help of Ohmmeter or high-voltage insulation resistance (IR) tester. If the reading on the IR tester shows low then it is defective. One has to repeat this procedure until reaching a short section which in turn will allow repairing the fault.

Thumping: This procedure requires noise to detect the fault. When a high voltage is supplied to a faulted cable, the high-current arc makes a loud noise enough to be heard. This method is relatively easier compared to Sectionalizing, but it has its own weaknesses. Thumping requires a high current amp at a voltage as high as 25kV to produce an underground noise, loud enough to be heard above ground. The high electricity current gets really hot, which ruins the cable insulation. Damage can be limited by reducing the power sent through the cable to a minimum required to conduct the test if you are skilled enough to carry out this test. On the other hand, moderate testing may not even produce sound loud enough to be heard. But frequent testing may cause the cable insulators to degrade to an unacceptable condition. Many electrical expert suppliers accept some level of damage to the insulators for 2 main reasons. Firstly, if thumping method is used for short period, so the cable insulation is damaged. Secondly, there is no existing technology which can replace this method.

However, there are new methods of locating cable faults that use a mixture of complex technologies

Time Domain Reflectometry (TDR): TDR uses low-energy signals through the cable to locate faults which cause no insulation degradation. When the signal is sent, a perfect cable returns the signal in a proper time and profile manner. While an imperfect cable will alter the time and profile, which can be seen on the TDR screen. The graph (called Trace) gives the user approximate distances to "landmarks" such as opens, cuts, Y-taps, transformers and water ingression. TDR method is not flawless. One weakness is that itdoes not pinpoint faults as this method is accurate only up to 1% of testing range and the information is also not sufficient enough. On other times, it allows more precise thumping which reduces time and cost.

Another drawback of this method is that reflectometers become blind to detect faults-to-ground if the resistance is greater than 200 ohms.

High Voltage Radar Method – There are three basic high-voltage radar methods.

Arc Reflection: This method requires the use of the current coupler and a storage oscilloscope with a thumper. The main advantage of this method is its ability to detect difficult and distant faults. Its disadvantage is its high output surge can damage the cables and reading the trace requires more skill compared to other methods.

Voltage Pulse Reflection Method: This method uses a voltage coupler and a proof tester. This method finds faults which occur above the maximum thumper voltage of 25kV.

III. METHODOLOGY

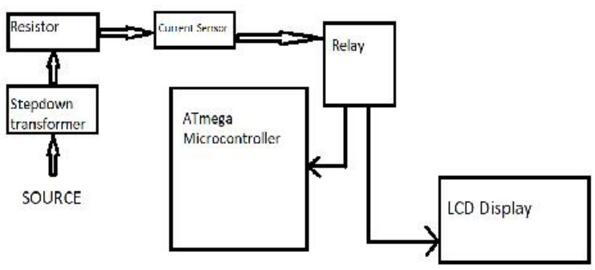

Fig 1: BLOCK DIAGRAM

Figure 1 shows the block diagram of the underground fault detection device. It consists of a source as input which is given to the stepdown transformer. Then it goes to resistor and then to the current sensor in which the current is measured passively without any interruption. Then we have a relay switch, which controls the flow of over voltage and when it occurs, it gives signal to the ATmega Microcontroller which is a part of Arduinouno. We also use an LCD display where the message signal is displayed. This is the sample block diagram of the device. We implemented this block diagram from studying the process of simulation in proteus 7. Simple steps are used for implementing the block diagram. By going deep into the working process we were able to study the working of the parts or the components.

COMPONENTS USED

ACS 714

The Allegro® ACS714 provides economical and precise solutions for AC or DC current sensing in automotive systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switch-mode power supplies, and over current fault protection. The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging. The output of the device has a positive slope (>VIOUT(Q)) when an increasing current flows through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sampling. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power loss. The thickness of the copper conductor allows survival of the device at up to 5× overcurrent conditions. The terminals of the conductive path are electrically isolated from the signal leads (pins 5 through 8). This allows the ACS714 to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques

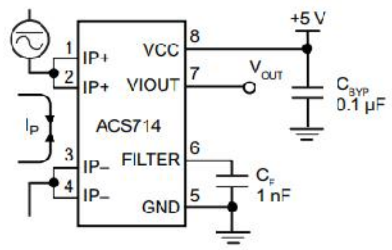

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Fig.2 ACS714

Terminal List Table

Number	Name	Description
1 and 2	IP+	Terminals for current being sampled; fused internally
3 and 4	IP–	Terminals for current being sampled; fused internally
5	GND	Signal ground terminal
6	FILTER	Terminal for external capacitor that sets bandwidth
7	VIOUT	Analog output signal
8	VCC	Device power supply terminal

Table.3.1 Terminal List Table

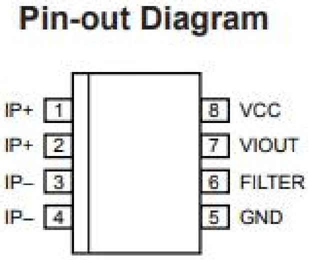

Fig.2.1 Pin-out Diagram

ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328. 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. 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.

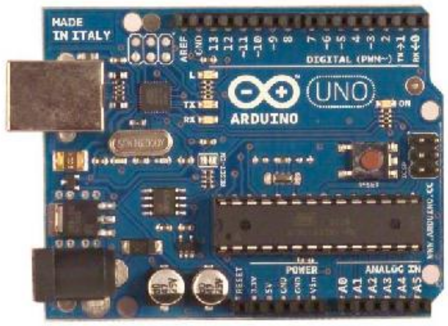

Fig.3 Arduino Uno

LCD DISPLAY

Liquid crystal display (**LCD**) is an electronically-modulated optical device shaped into a thin, flat panel made up of any number of color or monochrome pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power. Each pixel of an LCD typically consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axes of transmission of which are (in most of the cases) perpendicular to each other. With no actual liquid crystal between the polarizing filters, light passing through the first filter would beblocked by the second (crossed) polarizer. The main principle behind liquid crystal molecules is that when an electric current is applied to them, they tend to untwist. This causes a change in the light angle passing through them. This causes a change in the angle of the top polarizing filter with respect to it. So little light is allowed to pass through that particular area of LCD. Thus that area becomes darker comparing to others. For making an LCD screen, a reflective mirror has to be setup in the back. An electrode plane made of indium-tin oxide is kept on top and a glass with a polarizing film is also added on the bottom side. The entire area of the LCD has to be covered by a common electrode and above it should be the liquid crystal substance. Next comes another piece of glass with an electrode in the shape of the rectangle on the bottom and, on top, another polarizing film. It must be noted that both of them are kept at right angles. When there is no current, the light passes through the front of the LCD it will be reflected by the mirror and bounced back. As the electrode is connected to a temporary battery the current from it will cause the liquid crystals between the common-plane electrode and the electrode shaped like a rectangle to untwist. Thus the light is blocked from passing through. Thus that particular rectangular area appears blank. The surfaces of the electrodes that are in contact with the liquid crystal material are treated so as to align the liquid crystal molecules in a particular direction. This treatment typically consists of a thin polymer layer that is unidirectional rubbed using, for example, a cloth. The direction of the liquid crystal alignment is then defined by the direction of rubbing. Electrodes are made of a transparent conductor called Indium Tin Oxide (ITO).

Fig.4 LCD Display

RELAY

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts.

Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

Fig.5 Relay

RELAY DRIVER

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. The current needed to operate the relay coil is more than can be supplied by most chips (op. amps etc) a transistor is usually used to amplify the small IC current to the larger value required for the relay coil.

SIMULATION

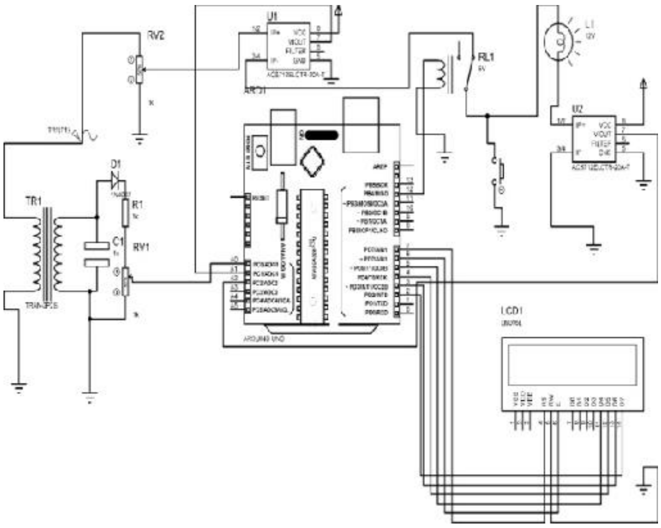

Fig.6 Simulation Circuit

We have done the simulation in the software called proteus 7. Which is an older version compared to the present generation. But we do the simulation part in this software for proper understanding and without less complication. The Proteus Design Suite is an Electronic Design Automation (EDA) tool including schematic capture, simulation and PCB Layout modules. It is developed in Yorkshire, England by Lab centre Electronics Ltd with offices in North America and several overseas sales channels. The software runs on the Windows operating system. The micro-controller simulation in Proteus works by applying either a hex file or a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables it's used in a broad spectrum of project prototyping in areas such as motor control, temperature control and user interface design.

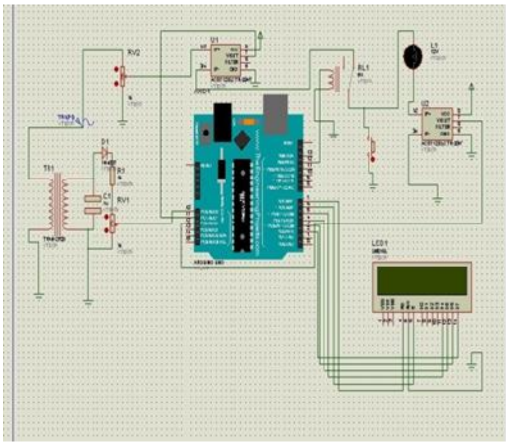

Fig.7 Proteus Simulation Circuit

EARTH FAULT CONDITION

The connection of noncurrent carrying part of an Electrical Equipment to Earth is called Earthing. During installation, most of the electrical equipment, machine's metallic body is connected to the earth to reduce the chances of electrical shock which is called body earthing. Electrical Earthing mainly done for safety purposes.Earthing system provides a very low resistance, when accidentally any live or phase wire touch to the body of the electrical equipment, fault current will be grounded or discharged through the earthing conductor and protect human from electrical shock.

Causes Of Earth Fault

Earthing is the connection of the metallic body of any electrical equipment, device or machine to the earth. So, if accidentally earth conductor damage, then that device not connected to the earth so there is no safety for electrical shock. Mainly the earning fault indicates the fault between line and earth. The main cause of earth fault in an overhead transmission or distribution line is the failure of the insulator. The insulator is used in an overhead transmission line to provide the insulation between the live conductor and the metallic tower which already connected to the earth. So, if insulation becomes fail, the fault current will flow through the live conductor and the metallic tower to the earth.

Line To Earth Fault

As the metallic body of any electrical equipment or device is connected to the earth. So, if the live or phase wire touch to the body of the electrical equipment then a huge current will flow through the phase and earth conductor which is known as Line to Earth Fault. When the line to earth fault occurs, a huge number of current flows so there will be a large voltage drop.

Effects Of Earth Fault

When Earth faults occur a huge amount of current flow through the phase and earthing conductor and a large voltage drop occurs. So, this will affect the other loads and it may cause the burning of phase or line conductor. Earth fault causes huge sparking, Heat, fire, etc.

Earth Fault Protection

Earth Leakage Circuit Breaker or ELCB is used to give protection against Earth Fault. It is a voltage-operated device. When earth fault occurs, a voltage appears across it and it tripped and disconnects the main power supply.

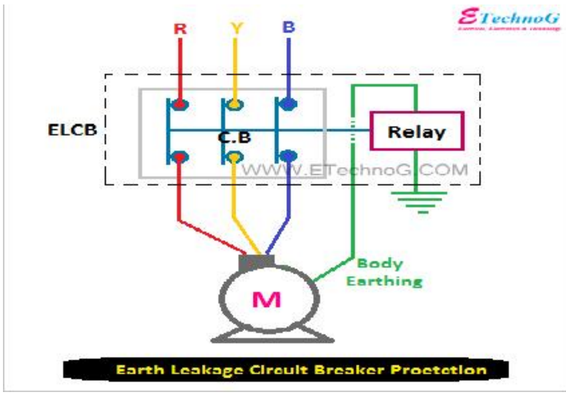

Fig. 8 Earth Fault Condition

Here, you can see the Relay of the ELCB is connected between the metallic body of the motor and the earth or ground. In the normal condition, the circuit breaker closed condition so the motor getting power supply. When earth fault occurs, the fault current will flow through the earthing wire and a voltage will appear across the relay coil and the relay will trip the circuit breaker. Thus, the motor will disconnect from the main power supply during the Earth fault.

OVERLOAD CONDITION

Every electric circuit in a wiring system must be protected against overloads. A circuit overload occurs when the amount of current flowing through the circuit exceeds the rating of the protective devices. The amount of current flowing in a circuit is determined by the load -- or the "demand" -- for current. For example, if a circuit is rated for 15 amps maximum, then a fuse or circuit breaker of that rating will be in that circuit. If the current exceeds 15 amps, the circuit breaker will open up, cutting off any more current flow.

Without overload protection wires can get hot, or even melt the insulation andstart a fire. There are two kinds of protection for electrical units that need to be considered. The first is concerned with the protection of the actual electrical wires supplying the circuits against an overload above their carrying capacity. The second type is concerned with protecting the individual appliances and electrical equipment connected to a supply circuit from an overload. Both types of protection involve either fuses or breakers, but are based on different ideas and objectives.

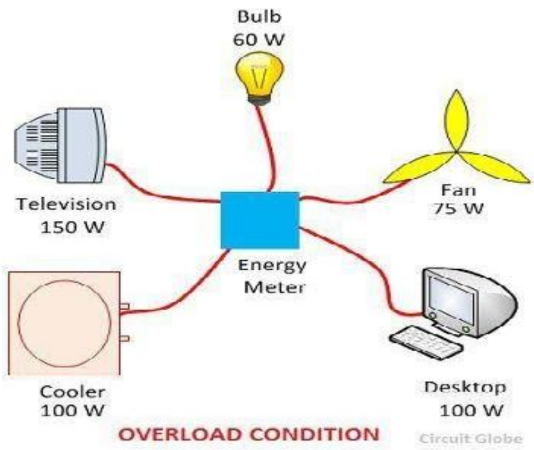

Fig. 9 Overload Condition

Circuit breakers could trip for a few reasons but if you've ever plugged in too many appliances all at once in one circuit then this might be due to an overload. Wires all have current ratings to signify how much amperage they can take. When an overload occurs, it means that the load draws current greater than the current (amperage) rating of that wire. This causes the wires to overeat and potentially cause a fire. The conditions we discussed here are mainly based on residential applications but the foundational concepts apply to commercial / industrial applications as well. For instance, motors have amperage ratings that are not meant to be exceeded. If they were to be exceeded, this causes a motor overload condition, which will cause the motor to overheat and burn out. Same concept and hazards apply. Both short circuits and overload conditions are dangerous and should be prevented. Prevent a fire hazard by using circuit breakers and similar electrical components. Remember to always be safe when installing and handling electrical parts. Always consult a professional electrician if you need help.

WORK COMPLETED

Initially we collected data about different types of faults and studied about it. After studying about the faults and its occurrence we moved into the simulation part. We did the simulation in proteus 7. We also developed a sample source code. In the simulation we implemented how earth fault condition and over load condition occur.

IV. COMPONENTS RATING

Table.4.1 Pin Description of LCD

Pin	Symbol	Level	Function
1	Vss	-	Power, GND
2	VDD	-	Power, 5V
3	Vo	-	Power, for LCD Drive
4	RS	H/L	Register Select Signal H: Data Input L: Instruction Input
5	R/W	H/L	H: Data Read (LCD->MPU) L: Data Write (MPU->LCD)
6	E	H,H->L	Enable
7-14	DB0-DB7	H/L	Data Bus; Software selectable 4- or 8-bit mode
15	NC	-	NOT CONNECTED
16	NC	-	NOT CONNECTED

Table.4.2 Common Operating Characteristics of ACS714

ELECTRICAL SPECIFICATIONS							
ITEM	SYMBOL	CONDITION		STANDARD VALUE			UNIT
				MIN.	TYP.	MAX.	
Input Voltage	VDD	VDD = + 5V		4.7	5.0	5.3	V
		VDD = + 3V		2.7	3.0	5.3	V
Supply Current	IDD	VDD = 5V		-	1.2	3.0	mA
Recommended LC Driving Voltage for Normal Temp. Version Module	VDD - V0	-20 °C		-	-	-	V
		0°C		4.2	4.8	5.1	
		25°C		3.8	4.2	4.6	
		50°C		3.6	4.0	4.4	
		70°C		-	-	-	
LED Forward Voltage	VF	25°C		-	4.2	4.6	V
LED Forward Current	IF	25°C	Array	-	130	260	mA
			Edge	-	20	40	
EL Power Supply Current	IEL	Vel = 110VAC:400Hz		-	-	5.0	mA

Table.4.3 Electrical Specification of LCD

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	V_{CC} = 5.0 V, output open	–	10	13	mA
Output Capacitance Load	C_{LOAD}	VIOUT to GND	–	–	10	nF
Output Resistive Load	R_{LOAD}	VIOUT to GND	4.7	–	–	kΩ
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	1.2	–	mΩ
Rise Time	t_r	$I_P = I_P(max)$, T_A = 25°C, C_{OUT} = open	–	5	–	μs
Frequency Bandwidth	f	–3 dB, T_A = 25°C; I_P is 10 A peak to peak	–	80	–	kHz
Nonlinearity	E_{LIN}	Over full range of I_P	–	1.5	–	%
Symmetry	E_{SYM}	Over full range of I_P	98	100	102	%
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A, T_A = 25°C	–	V_{CC} × 0.5	–	V
Power On Time	t_{PO}	Output reaches 90% of steady-state level, T_J = 25°C, 20 A present on leadframe	–	35	–	μs
Magnetic Coupling[2]			–	12	–	G/A
Internal Filter Resistance[3]	$R_{F(INT)}$			1.7		kΩ

V. CONCLUSION

Electrical Cables help in distribution of electrical energy. These cables face so many failures. Which is very complicate task to detect the faults in these cables. This system with the help of Arduino find the exact position of fault in cable from the base station in Km. Nowadays in many non-rural areas, the wires in underground are frequently used rather than atop lines. Whenever there is a fault in underground cable it become very tough to locate the correct position of the fault for the repairing of the cable. This system will work effectively for underground as well as atop cables. An Arduino Mega board used in this system. Here the Arduino is interfaced by the current sensing circuits which is made of combination of many resistors. The fault is generated by the set of switches. To increase the remote controlling capability of this industrial system we have proposed the low-cost solution. This project on detection of fault with working Arduino was made and fault distance in km from the ground station will be shown on the screen of LCD. Whenever there is the fault occurs then the switch which is analogous to the phase is recognized as the faulty phase to which fault switches are operated. In this way the sector having fault can be easily positioned. It is durable, safe and low consuming power device. This device can run on various channels to escape the interference with equipment or another wireless device. With the help of microcontroller, we can accurately detect the fault position. As faults occur in the cable, the fault location is displayed on the LCD display.

VI. FUTURE SCOPE OF THE PROJECT

We can further develop a better user interface by which detection of open circuit fault is possible in near future. To find the fault in ac circuits, fluctuation in impedance is measured with the help of capacitor. In this way we can find the fault distance.

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