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LOW TENSION AND HIGH TENSION UNDERGROUND CABLE FAULT LOCATOR FOR MAINTENANCE SCHEDULING – A CASE STUDY

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Abstract - Our aim with this project is to learn how the complicated fault can be easily find with such equipment and operation. The cable is at 1.5m depth and 45cm width. If the fault occurred then it is not possible to find it easily with naked eyes as the fault that occurred is not on the surface of the ground.

Keywords:

I. INTRODUCTION

The project uses the standard concept of Ohms law i.e., when a low DC voltage is applied at the feeder end through a series resistor (Cable lines), then current would vary depending upon the location of fault in the cable. In case there is a short circuit (Line to Ground), the voltage across series resistors changes accordingly, which is then fed to an ADC to develop precise digital data which the programmed microcontroller of 8051 family would display in kilometers. The project is assembled with a set of resistors representing cable length in KM's and fault creation is made by a set of switches at every known KM to cross check the accuracy of the same. The fault occurring at a particular distance and the respective phase is displayed on a LCD interfaced to the microcontroller. There are hundreds of trains which run daily on Indian Railways and the various systems which are involved in the operation of trains are Track, Rolling stock, Loco, Electrical Traction, Signalling and Telecom and traffic control systems. Railway Signalling and Telecom circuits run on hundreds of kilometers of underground cables. Although adequate precautions are taken in lying of cables beneath the ground and underground cables are not affected by any adverse weather condition like pollution, heavy rainfall, snow and storm etc. there are other factors which may cause faults in the cables.

Type of Cables carrying S&T circuits

i) Signalling cables PVC insulated PVC sheathed and armoured signalling cables. Generally, used copper conductor core sizes are 1.5 sq.mm. and 2.5sq.mm. Most commonly used cores are 2C, 4C, 6C, 8C, 9C, 12C, 19C, 20C, 24C & 30C.

(ii) Telecom cables

• Polyethylene Insulated Jelly Filled (PIJF) cables

• 4 or 6 Quad cables (Core size 0.9 mm)

• Co-Axial Cables

Major causes of cable fault Some of the causes of cable faults are as given below:

• Ageing.

• Corrosion of sheath.

• Moisture in the insulation.

• Heating of cable.

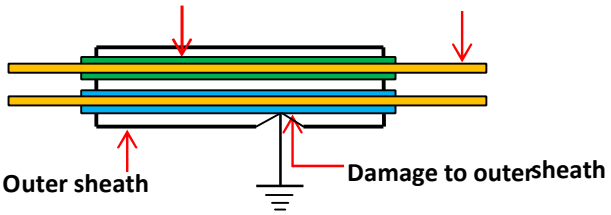
• Fire and lightning surges. Electrical puncture

• Damage during laying.

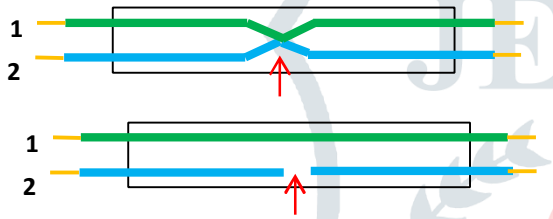
Types of cable faults : The common faults which develop in the conductors of multi-core cables are:

Earth fault When any of the conductors of the cable comes in contact with the earth, it is called an earth fault. This type of fault allows the current, carried by the conductor to leak to the earth directly or indirectly instead of going to the apparatus to which the conductor is connected. This usually occurs when the outer sheath is damaged due to chemical

reactions with soil or due to vibrations and mechanical crystallization.



Short circuit fault When two or more conductors of a multi-core cable come in contact with each other, then this is called a short circuit fault. A short-circuit fault occurs when the individual insulation of the conductor core is damaged.



Open circuit fault

As the name suggests, this fault involves an open circuit in the conductors. When one or more cable conductors (cores) break, it leads to discontinuity. This discontinuity also occurs when the cable comes out of its joint due to mechanical stress. This is known as Open circuit fault.

Low insulation fault

Sometimes when the cable core insulation material is deteriorated by ageing, moisture, excessive heating or dirt the insulation resistance is dropped to very low value (several hundred to several kilo ohms) it is called as low insulation fault. But if the insulation resistance is of the order of mega ohms and less than 2 Mega Ohms it is termed as high resistance fault or bad insulation. In both the cases, the quality of communication or flow of current through the cable is badly affected and the cable needs replacement.

II Need for cable fault localization

Whenever a fault occurs in one or more conductors of underground cable, be it an earth fault, open/short circuit fault or low insulation fault, the circuit completing through the conductor or conductors is interrupted which in turn affects the functioning of connected equipments. In a railway signalling system the operation of signals or its associated equipments is badly affected due to cable fault. Similarly if a cable fault occurs in a telecom cable, the circuits associated with Block working, Control or other communication systems may not work. Unless the fault is identified and rectified, the train movement is badly disrupted.

(i) Detection of type of fault

The type of cable faults mentioned in section 1.4 cannot be detected visually as these are buried underground. However all the above type of faults can be detected with the help of a Megger.

Usually 500 V megger is used for testing insulation resistance of Signalling cables whereas 100 V megger is used for Telecom cables

An open circuit fault is characterized by infinite resistance. Hence when the resistance between conductor which is break at some point and the earth is measured using a megger it will read infinite resistance.

A short-circuit is characterized by zero resistance. If the resistance between any two conductors which are shorting each other at some point is measured using a megger it will read zero resistance.

If the resistance between any two conductors is low, the megger may show reading between several hundred ohms to less than 2 Mega Ohms.

An earth fault is somewhat similar to a short circuit fault as the current again takes the least resistive path and flows through the earth. The megger is connected between the faulty conductor and the ground. If an earth fault is present, the megger will show nearly zero reading.

Detection of location of fault

Finding the type of a fault in underground cables using a megger may not be a difficult task. But it is very difficult to locate and repair the fault. For detecting the exact location of cable fault special techniques are required.

Advantages of cable fault localization

Detecting the cable faults and pinpointing the fault location makes task faster and easier for the site engineers through modern Cable Fault Localization techniques. Fast and precise fault location plays a significant role in speeding up system renovation, diminishing great financial loss and operating cost thereby minimizing down time and most importantly ensuring system availability and performance.

Techniques used for cable fault localization

There are different technique for locating faults in underground cables namely:

(i) Murray loop test
(ii) Varley loop test
(iii) Cable Thumping
(iv) Time Domain Reflectometer (TDR)
(v) High Voltage Radar method
(vi) Intelligent Bridge Testing

. Sectionalizing: This procedure risks reducing cable reliability, because it depends on physically cutting and splicing the cable. Dividing the cable into successively smaller sections and measuring both ways with an ohmmeter or high-voltage insulation resistance (IR) tester enable to narrow down search for a fault. This laborious procedure normally involves repeated cable excavation.

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 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.

3. Murray loop test: It is a bridge circuit used for locating faults in underground or underwater cables. It uses the principle used in potentiometer experiment. One end of the faulted cable is connected through a pair of resistors to the voltage source. Also a null detector is connected. The other end of the cable is shorted. The bridge is brought to balance by changing the value of RB.

In above figure, RC is proportional to (l+ (l-x)) and RD is proportional to l. Therefore, $\boldsymbol{RA/RB=r=RC/RD = (2l-x)/x}$

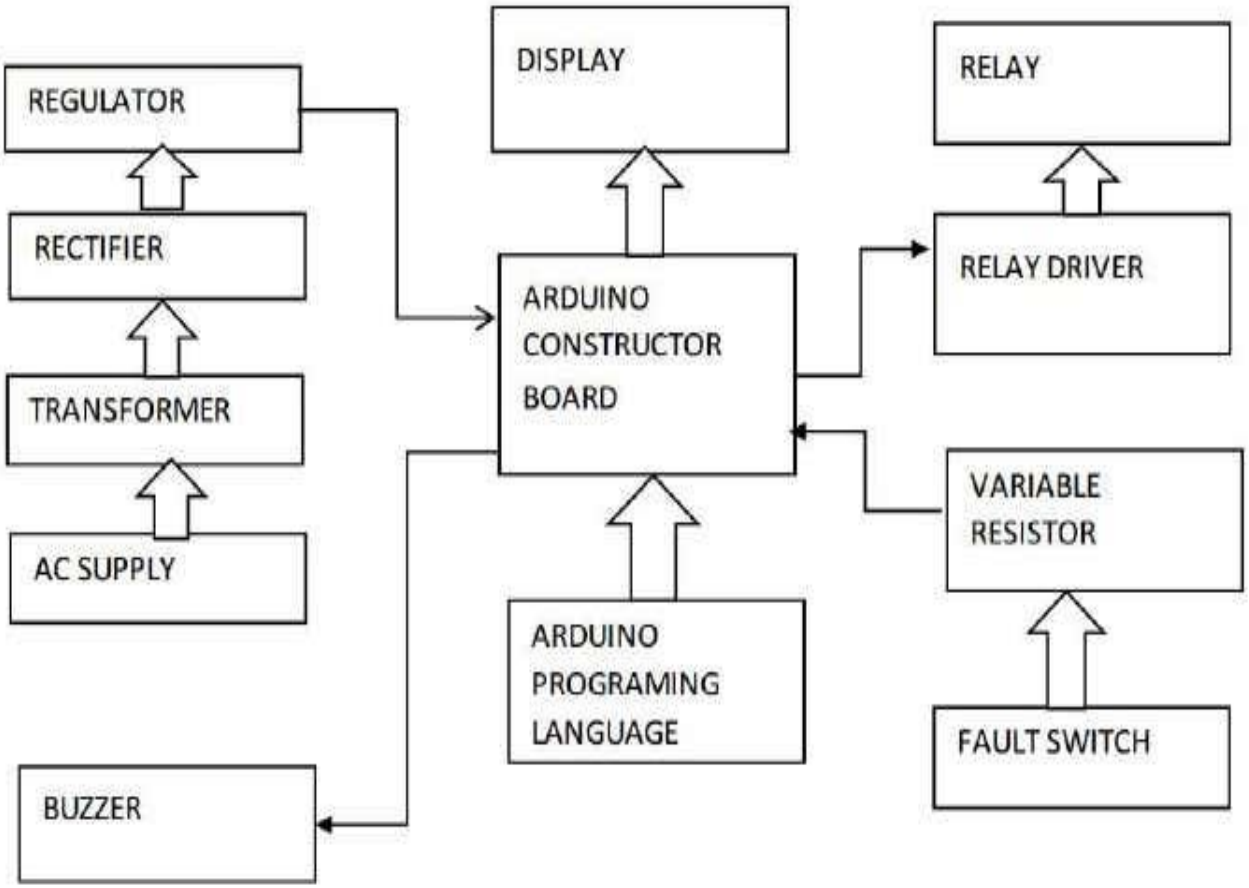
1. And hence $\boldsymbol{x= 2l/(r-1)}$

2. Where l is the length on each segment of wire, r is the ratio RA/RB and x is the length of faulty segment. The main disadvantage of this method assumes that only a single fault exists, a low resistance when compared with cable resistance and cable conductors have uniform resistance per unit length.

3. Varley loop test: If the fault resistance is high, the sensitivity in Murray bridge is reduced and Varley loop may be more suitable but only a single fault exists. Except that here the ratio arms are fixed and a variable resistance is connected to the test end of the faulty cable.

III.BLOCK DIAGRAM

In this project simple Ohm's law is used to locate the short circuit fault, where a DC voltage is applied at the feeder end through a series resistor, depending upon the length of fault of the cable current varies. The voltage drop across the series resistor changes accordingly and this voltage drop is used in detection of fault location in the cables. The below figure is a block diagram of cable fault distance surveyor. In this project power supply consists of a step down transformer (230/12V), which step down the voltage to 12V AC and it is converted into DC by using a by ridge rectifier. It is assembled with a group of resistors representing cable lengths in kilometers. The voltage drop across the feeder resistor is given to an ADC which supplies digital information which the programmed microcontroller would show an equivalent on LCD in kilometres.



Digital Cable fault Locator:

ANDIG Model 5289M Digital Cable Fault Locator is manufactured and supplied by of M/s Andig Systems, Bangalore. It is basically a combination of Pulse Echo Meter (TDR) and High Resistance Fault locator. It can locate break, short (loop) and low insulation faults in underground copper cable. The distance to fault is displayed directly in metres and there are no calculations involved.

Technical specifications

Physical Dimension

Width : 265 mm Height : 195 mm
Depth : 140 mm Weight : 3 Kgs (Approx.)

Power

Battery : Internal Rechargable Li-Ion Battery
Charging source : External 16 V DC, 1A Adapter
Operating time : 8 hours continuous without Back light

Environment

Operating temperature : 0 to 50° C

Display

240 X 128 dot-matrix Graphic, Liquid Crystal Display (LCD) with Back light

Pulse Echo mode

Max range : 10 Kms (0.9 to 1.5 mm)
Accuracy : Better than 1% of reading
V.O.P.: Fixed for Standard cable or User Programmable
Waveform Storage : Upto 20 Waveform

Low Insulation Faults Mode

Max. range : For open & Short Circuit faults - 5 Kms.
For Low insulation faults - 15 Kms
Accuracy : +/- 0.5% of reading
Output Connectors : 4 Front Panel Banana sockets
Serial I/O Ports : RS-232
Testable Low insulation Resistance : 2 Mega Ohms

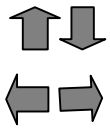
Front Panel Description

The front panel of Digital Cable Fault Locator is given below:

Function of different keys

SELECT : When Pressed selects highlighted menu on display screen

MENU : When Pressed Main Menu is displayed



: Moves Up & Down the highlighted Menu

: Moves Left or Right the selected cursor or increments/ decrements function selected in multifunction box.

RANGE : Display range status (RANGE 1 upto 1km, RANGE 2 upto 2km, RANGE 3 upto 3.5km, & RANGE 4 upto 5km) Select range using Left & Right arrow keys.

ZOOM : It displays current zoom status from zoom1zoom5. At zoom 6 it displays maximum expanded waveform. (Select Zoom level Using Left & Right arrow keys)

CUR : Selects Cursor 1 or Cursor 2

BACK : Not Used

GAIN : Selects Gain level (Default sets to Gain 1) & displays status in multifunction box.

START : When pressed starts testing the Cable Pair under test (Display Scanning)

PRINT : Not Used

B/L : Switches ON Back Light

LINE 1 : Socket pair for connecting faulty pair under test

LINE 2 : Socket pair for connecting good reference pair

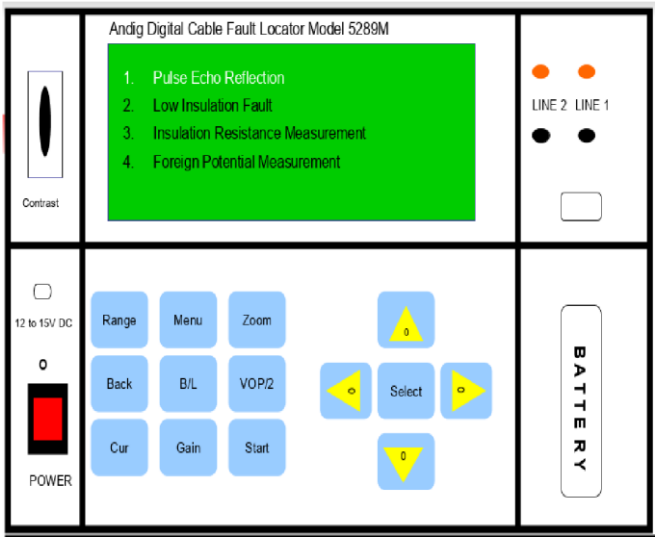
RS 232 : Connector for PC Interface

PRINTER : not used

DC Socket : Socket for Ext DC & for battery charging (12 To 15 VDC)

Note: Following keys are used only in Pulse Reflection mode When pulse (Waveform) is displayed on LCD.

a) RANGE, b) ZOOM, c) GAIN, d) CURSOR.



To choose Testing Mode

When the cable lines have faults, first use testing board, megameter (or megger) or multimeter to find the character and degree of fault, so as to choose most suitable testing mode.

When the fault resistance is smaller than several hundred to several kilo ohms, we call it low insulation fault otherwise it is called high resistance (or bad insulation) fault.

The Pulse Reflection Testing is suitable for testing open circuit (break) faults and low insulation faults. This testing is simple and direct-viewing, requiring no co-ordination at other end.

The Bridge testing method is suitable for high resistance faults of the order of 2 Mega ohms or slightly less. It requires a good line (reference line) and co-ordination from other end. The test preparatory work is also tedious. Sometimes the high resistance faults can also be detected using Pulse Reflection Testing. Hence Bridge Testing method should be resorted to only after confirming that Pulse Reflection Testing cannot detect the fault.

Switching between Pulse Reflection Testing and Bridge Testing

Press **On/Off** key to turn on the instrument, the testing mode will be selected as Pulse Reflection Testing by default. Press **Adjust** until "Press◄ **or** ►to enter into Bridge mode" appears in reverse colour. Press ◄ **or** ► to enter Electric Bridge Testing. Under Electric Bridge Testing press **Pulse** to switch over to Pulse Reflection Testing.

Pulse Reflection Testing

Under Pulse Reflection testing, analog signal is sent to locate the fault in a cable which after reflection is converted to digital pulse for distance measurement.

Preparatory steps

Before commencing the process, disconnect the faulty cable at both ends. Make sure the cable to be tested is free from any supply voltage.

First the instrument should be used to perform Intelligent testing. If the fault cannot be detected with the above process, then it can be changed to Manual testing.

1 Intelligent Testing

Intelligent Testing means Pulse Reflection Testing (Finding Open or short circuit fault) in AUTO mode.

First Power On the instrument.

Connect the cable pair under test to red and yellow test lead lines.

Press AUTO and the instrument will show the result.

Note: The default setting of wave velocity of propagation (VOP) is 200 m/μs. Before performing Intelligent testing, user shall check whether it is required to adjust the velocity. (Refer "Adjust Velocity" in next section).

2 Manual Testing

The relevant setting and parameters to be adjusted are displayed below the display screen. Press Adjust to adjust the following settings and parameters:

(i) Gain

Press Adjust until Gain XX shows reverse colour display.

Then press ◄ or ► to adjust the amplitude (adjustable 199). Press Pulse the screen will display the wave after gain adjustment.

(ii) Range

During manual testing the range value shall be chosen longer than the actual length of cable to be tested. To adjust the range repeatedly press Range until Range XX shows reverse colour display. Then press ◄ or ► to adjust the range.

(iii) VOP

The wave velocity shall be calibrated according to the cable character to improve the precision of testing result. Press Adjust until VOP XX shows reverse colour display.

Then press ◄ or ► to adjust the wave velocity.

Adjust Range and Velocity according to the character and estimated length of cable. Appropriately adjust the wave amplitude to make waveforms on the display screen to be

observed easily. Move the cursor to the inflection (point of rising) of the reflected waveform. The fault distance will be displayed at the bottom of display screen.

(iv) Zoom in & Zoom out

Users can Zoom in or Zoom out when zoom value is not "1". Continuously press Adjust till Zoom is selected. The prompt box will display "press ◄ or ► to zoom the wave". Zoom to the proper size and press Pulse. Users can move the cursor to fix position. Press Pulse to return to original state.

(v) Save waveform to RAM

The waveform should be saved to RAM when comparing the fault line and good line under manual testing. Continuously press Adjust till Save is selected. The prompt box will display "press ◄ or ► to save wave". Users can save the current waveform by pressing ◄ or ►.

v. **Compare Current Wave with stored Wave** in RAM Users can compare the current waveform with the already stored waveform in RAM. Continuously press Adjust till Both is selected. The prompt box will display "press ◄ or ► to both display".

(vii) Save file

Press Adjust until "press ◄ or ► to do file management" appears. Now press◄ or ► to enter into save file mode. One can not only save and test the current file but check and analyze previous wave files.

Saving file to U disk:
When "Current Test" is chosen, press Auto to test the current cable. Press Adjust to save the current file. A display showing "Press ◄ to quit file mode, press ► to save current wave" will appear.
Press ◄ to quit file mode or press ► to save current file to U disk.

Intelligent Bridge Testing

When the insulation resistance of a faulty cable pair is very high (above several thousand ohms) and is much larger than characteristic impedance of cable. In this case the pulse reflection is weak hence it is not easy to detect the fault by Pulse Reflection Testing. At this time Bridge Testing has to be carried out.

Testing principle

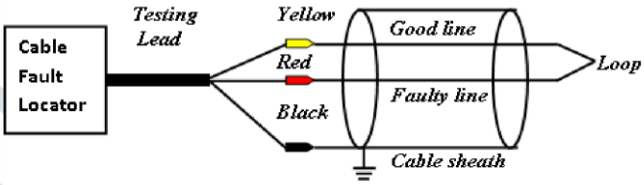
Suppose the resistance of the entire core is R.
The resistance of core from one end (test point) to the fault is Ra
The core length is L, and The fault distance is La , then La = (Ra/R)L
The instrument adopts Intelligent Electric Bridge technique, so the user has to connect lines, input some data such as length and diameter of the core and the fault distance is calculated.

Testing set up Intelligent Bridge Testing

First confirm that the type of fault for example core to earth resistance is low (in thousand ohms) or bad insulation fault between same pair cable (self-crossed) or two conductors of different pairs (other-crossed).
The testing setup for locating the distance of fault, requires two conductors - one consisting earth fault and the other one with good insulation with earth.
One end is designated as testing end and the other as coordination end.
Disconnect both the conductors at either ends from the circuit.

If core to earth resistance is low (in thousand ohms)

Loop the faulty and good line at the co-ordination end. At testing end, connect the black clip of testing lead line to earth, the yellow clip to good line and red clip to faulty line as shown in Figure



Testing procedure

Check the connections and ensure that they are correct and intact.

When everything is ready Press **Auto,** the instrument will give ratio of Fault resistance and Resistance of entire cable span**.** Next input cable span (Length) to get fault distance.

Note: The cable length here refers to the cable length in testing fault sector i.e. length from testing end to coordination end.

To input the known cable length, press **Adjust** the "line span = 0000m" starts blinking. Depending upon the value of known cable length using ◄ **or** ► keys increment or decrement the digits. The instrument will automatically calculate the fault distance during inputting data.

Precautions

- Keep display screen away from direct sunlight. The contrast ratio of LCD will drop when temperature higher than 60°C and it will return to normal when temperature is lower than 60°C.
- Before testing it is better to measure voltage in faulty cable to be tested, in order to avoid test errors or damage to the instrument.
- Avoid damage to LCD screen.

CONCLUSION: I am visting to vadala BEST office to Perform or see how to find under ground fault.

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